Evolutionary Nutrition and Optimal Human Health: An Integrative Perspective for Contemporary Australia

A thesis in fulfilment of the requirements for the degree of Doctor of Philosophy

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Abstract

What is optimal human nutrition? What dietary parameters offer the greatest potential for human performance and are most healing in their qualities? These questions have driven research agendas in nutrition science and medicine for decades and resulted in a plethora of research. Yet confusion and divergent ideas are endemic both in the scientific community and the general public. The scale and complexity of the modern-day food environment means that most aspects of food and nutrition now demand an exceptionally high level of critical thinking (Nestle & Dixon 2004). Most of us do not have a direct understanding of how our food is produced and what we should ideally be eating.

In response, Eaton (Eaton, Cordain & Lindeberg 2001; Eaton, Eaton & Konner 1997; Eaton & Konner 1985) and Cordain (2008; Cordain et al. 2000; Cordain et al. 2005), among others, have advocated adopting an evolutionary paradigm for understanding human health and optimal nutritional requirements. This approach is intuitively appealing because it utilises the most basic premise of biology, which is that living organisms function optimally when their life circumstances most closely match the conditions to which they were selected and became adapted to over the course of evolution. Contemporary ‘conditions of life’, including our food supply, are changing rapidly and are now markedly different from our evolutionarily tailored context. The majority of the population is disconnected from the process of hunting and gathering food, as well as the characteristics of a wild food menu. The health implications of this, specific to Australia, are examined in the present research. Furthermore, this investigation is focused on guiding interested Australians to make food choices that are more aligned with our evolutionarily adapted history. By doing so, the aim is to enable one to selectively eat like a ‘contemporary’ hunter-gatherer.

The term ‘contemporary hunter-gatherer diets’ does not imply a ‘back to nature’, or regressive agenda. Creating contemporarily relevant health advice based purely on the examination of the conditions of recent hunter-gatherer societies (often eco-romantically
expressed) fails to acknowledge the forward moving process of evolution. We need to recapture this original, primal way of life because it is fundamental to our existence, and we need to incorporate it – to integrate it – into our modern world. Integral theory (Wilber 2000, 2001) provides a methodology with unparalleled depth and scope, and it is the basic skeleton of this theory that draws contemporary relevance from the historic research in this thesis.

Hence, two theoretical frameworks are used to define the boundaries of the current investigation: (i) an evolutionary paradigm and (ii) Integral theory. Both theories are ‘evolutionary’ in their approach – meaning they address change or development through time. However, in this thesis an ‘evolutionary paradigm’ refers specifically to Darwinian theory and the mechanisms of natural selection and adaptation in evolutionary change.

As such, the so named evolutionary paradigm has been used to estimate optimal nutritional requirements (and lifestyle patterns) based on the environment to which we are most genetically adapted. The database for this analysis was primarily derived from records of the subsistence patterns of 20th century hunter-gatherer societies and the nutritional characteristics of wild foods (Brand-Miller & Holt 1998; Cordain et al. 2000; Eaton & Konner 1985; Murdock 1967). This thesis reviews and critiques current core concepts in the field of evolutionary nutrition and argues the merit of viewing contemporary nutritional recommendations within this wider temporal context.

The hypotheses underpinning the field of evolutionary nutrition have been established by only a few researchers, and modern-day interpretation is limited. Furthermore, specific consideration of the contemporary Australian context is absent in the literature. Therefore, the present investigation sought to address this situation by analysing key factors in relation to an ‘optimal’ benchmark based on an understanding of our biologically adapted needs, the dietary (and lifestyle) matrix of recent hunter-gatherer populations, and the nutritional properties of wild foods. These factors included: an examination of average Australian diets and health status; epidemiological associations between dietary factors and disease; characteristics of modern therapeutic diets; the lifecycle of plant and animal foods in their various modern-day production forms (including how to eat like a ‘contemporary hunter-gatherer’ from the modern food supply); an understanding of eating behaviours in Australian culture and our psychological relationship with food; and recognition of the ‘parts’ (e.g. macronutrient composition,
micronutrient content, fatty acid balance, glycaemic index) and ‘wholes’ (overall guiding principles) that constitute ‘optimal’ nutrition.

The scope of this comparative analysis was governed by the drive to model ‘contemporary hunter-gatherer diets’ (and lifestyle parameters) with the greatest degree of authenticity currently possible. This interpretive process was grounded in the cognitive matrix of *Integral theory*. At its most basic level, the theory’s inclusion of the personal (‘I’) (e.g. personal food choice behaviours), the collective (‘We’) (e.g. social attitudes to food and health and collective decisions pertaining to these issues) and the environment (‘It’) (e.g. our agricultural resource base) in the analysis of any issue profoundly enriched the research map. It provides the structure for a comprehensive examination of the inter-related factors involved in human health today and honours the importance of treating health in an increasingly inclusive, holistic and defined way. The consequential integrative synthesis of the evolutionary nutrition data in this way, and the conclusions that are relevant to contemporary Australia are unique and resonate with common sense.

The core conclusion of this thesis differs somewhat to consensus thinking in the field of evolutionary nutrition. It is proposed that the inherent health advantages of hunter-gatherer diets and the wild food supply are not just based in the exclusion of ‘recently’ introduced agrarian and industrial food groups (i.e. dairy, cereal grains, fatty domesticated meats, and refined and processed foods), nor are they necessarily found in the replication of specific hunter-gatherer dietary characteristics (e.g. macronutrient composition, fatty acid balance). Rather, it is suggested that the full therapeutic benefits lie in a whole matrix of nutritive components found in whole foods that are grown and produced with a high index of biological authenticity (which refers to the degree to which food resembles its wild-type counterparts). This requires transparent knowledge of a food’s lifecycle and a deeper awareness of the way food and health decisions are imbedded in the modern Australian psyche.

In response, a simple guiding principle for making nutrition decisions is proposed: Choose the freshest and most unrefined foods available from both plant and animal sources that are themselves optimally healthy, and consume these foods in quantities reflecting their availability in the wild. This is the central message of this thesis. As extensively analysed, this principle unanimously supports human health. The reassuring simplicity of the principle belies the extent of analysis undertaken.
The value of understanding optimal human nutrition and its paramount importance for health needs little justification. Australia is in critical need of a cohesive nutritional and lifestyle intervention approach as obesity, metabolic disorders, chronic degenerative diseases, and mental health issues continue to escalate in the population and affect quality of life and longevity, as well as posing significant social costs.

A key outcome of this research is the development of an illustrative model for guiding and prioritising food choices in contemporary Australia based on an evolutionary perspective. The model is designed to be relevant both to individuals interested in using food as a therapeutic tool and for clinicians across a spectrum of medical, nutritional and allied heath professions. While being cognisant of the use of predictive patterns and unconfirmed assumptions in the present research, what is outlined is viewed as being effective, efficient and of immediate clinical relevance.
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I wish to extend a very sincere thank you to my supervisor, Professor John Patterson, who maintained unwavering enthusiasm, support and clear guidance throughout this research project.

To James Rickard, for the enjoyable experimentation over the years with many different dietary strategies and their effects on our own body’s physiological markers and performance potential in sport at an Olympic level.

I am also greatly indebted to Piers Greville for his creativity in turning my model for a ‘contemporary hunter-gatherer diet’ into a beautiful artwork.

The process of this research has been long. Along the way numerous family members and friends have responded with interest and intrigue, which fuelled the necessary motivation to complete the thesis. Thank you.

On a personal note, this research drew out a range of emotions. I’ve felt the ironic frustration of long hours sitting in front of a computer on sunny days while learning about the physically active lifestyles of our hunter-gatherer ancestors. I’ve laughed at my stress-induced chocolate eating whilst marvelling at the nutrient density of wild berries. I’ve become deeply concerned by the immensity of our rapid human-induced environmental change, its impact on our food, the fragmented factors that underpin it and its future implications.

I’ve also felt immense gratitude in our fortune as Australian citizens that, at present, we do have access to a health-supportive food supply, if we can individually afford to buy it. Finally, I’ve become excited and hopeful in the capacity of the human spirit to act wisely and intelligently, as evidenced by some of the outstanding individuals whose ideas resound in this thesis.
I owe much to the leading evolutionary nutrition researchers, in particular S. Boyd Eaton and Loren Cordain, without whose detailed work this thesis could not have been done. Other profoundly influential academics whose ideas are evident in this work include Ken Wilber, Stephan Cunnane, Michael Crawford, Peter Singer, Helena Norberg-Hodge, several members of the Australasian Integrative Medical Association (AIMA), and Kathryn Anderson; among others.
Declaration

This thesis is submitted in partial fulfilment of the requirements of the degree of Doctor of Philosophy. I declare that this thesis is my own work except where due acknowledgement has been made. This work has not been previously submitted, in whole or in part, for any other academic award and is the result of research undertaken during my period of candidature.

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Clarification of Terminology & Definitions

With regards to the use of various terminologies in this thesis, a few comments for clarification purposes are useful.

The terms *humans* and *Homo sapiens*, and *people, individuals* and ‘man’ (non-gender specific) are used interchangeably in this thesis, depending on the relevant context.

A *hunter-gatherer* society is one whose primary subsistence method involves the direct procurement of edible plants and animals from the wild by foraging and hunting without significant recourse to the domestication of either. Hunting and gathering was presumably the only subsistence strategy employed by human societies for more than two million years, until the introduction of agriculture.

In the literature, the terms *hunter-gatherer diet* and *Paleolithic diet* are used interchangeably. The Paleolithic period was a geological time period that covered the greatest portion of humanity’s time on earth – from around 2.5 million years ago until the introduction of agriculture. The term ‘Paleolithic’ was coined by the archaeologist John Lubbock in 1865, and is derived from the Greek word *paleos*, meaning old, and *lithos*, meaning stone. Therefore, it means ‘stone age’.

*Evolution* is used in this thesis to refer to change through time. More specifically, evolution is conceptualised in this thesis in terms of Darwinian theory. In Darwinian theory, *natural selection* is the core mechanism of evolutionary change. Its operation depends upon four conditions – reproduction, inheritance, genetic variation and competition.

Another consequence of natural selection is *adaptation*. Adaptation refers to how well an individual is suited to its environment. Individuals that are better adapted to their environment will theoretically leave more offspring and hence pass on adaptive traits.
Anatomical, physiological and behavioural traits are all considered to be adaptive. Therefore, from an evolutionary perspective, persisting traits (e.g. insulin resistance, capacity for fat storage etc) in a population can be considered as survival-enhancing and advantageous in certain conditions. As such, the degree of adaptation is always relative to the environmental context in which an individual lives. Our contemporary conditions of life are now becoming increasingly divergent to our evolutionarily adapted past. Consequently, a growing degree of mal-adaptation is increasingly evident as homeostatic mechanisms become chronically strained in environmental contexts (diet and lifestyle) for which we have little evolutionary experience.

**Western foods** is a term typically used in the thesis to describe foods and food groups eaten in Western countries that are the product of intensive agricultural production and industrial processing. These foods typically include a high amount of cereal grains (breads, breakfast cereals, pasta); dairy; refined products (cereals, sugars, vegetable oils); fatty meats from sedentary domesticated animals; salt; and combinations of these foods processed in various novel ways (e.g. biscuits, cakes, chips, soft drinks, ice-cream). These foods are very recent additions to the human diet and played no part in the subsistence equation that genetically shaped human evolution.

**Modern-day/contemporary foods** describe foods which are commercially available today in supermarkets, greengrocers, fish mongers, butchers, markets etc.

**Kilojoules and calories** are at times used interchangeably in the written text to refer to energy intake – a liberty taken to enhance literary flow. All calculations in the dietary models are made in kilojoules for consistency’s sake.

The holistic definition of health provided by the World Health Organization (1948a) is embraced in this thesis and is defined as a state of complete physical, mental and social well-being, and not merely the absence of disease or infirmity.

An integrative perspective is taken in the present research. This simply means that an attempt is made to include, contextualise and assimilate as many truths from a broad range of relevant research fields. Attempting to do so creates the possibility for universal patterns about the human condition (both now and potential) to be recognised.
One final point with regards to terminology is about the way *food groups* have been defined in this thesis.

**Grains, seeds, nuts and legumes:** Botanically speaking, there is no clear distinction made between grains, seeds and legumes because most edible seeds are angiosperms. However, they are also classified into the following categories:

- cereal grains (members of the Poaceae or grass family – e.g. wheat, oats, barley, rye and rice)
- pseudocereals, which are cereal crops that are not members of the grass family (e.g. quinoa)
- beans and legumes
- nuts (however, in botanical terms nuts can also be classed as a specific type of fruit)
- edible seeds (of which a few are gymnosperms rather than angiosperms – e.g. pine nuts, sunflower and pumpkin seeds).

Different to the botanical distinction, in colloquial language ‘grains’, ‘seeds’ and ‘nuts’ are usually referred to as different food groups. This thesis emphasises the practical usability of the information provided and so the colloquial terms have been used. Therefore, ‘grains’ refers to cereal crops that are members of the grass family (e.g. wheat) as well as pseudocereals (e.g. quinoa); ‘seeds’ refers to gymnosperms, including sunflower and pumpkin seeds; ‘nuts’ refers to tree nuts (e.g. almonds, chestnuts, brazil nuts, macadamia nuts); and ‘legumes’ refers to beans (e.g. butter beans, red kidney beans, soybeans including soymilk and tofu) and other legumes including peas and lentils.

**Vegetables** includes all leafy green vegetables (e.g. spinach, lettuce, bok choy); cruciferous species (e.g. broccoli, cabbage, kale, brussel sprouts), roots and tubers (e.g. carrots, sweet potatoes, potatoes); edible plant stems (e.g. celery, asparagus), gourd vegetables (e.g. pumpkin, cucumber), and alliums (e.g. onion, garlic, shallot). Fresh sweet corn is considered in the present research to be a vegetable; however, it is also classed as a cereal grain in the broader literature. Legumes that can be eaten raw, including broad beans, snow peas, green peas and beans, are also often thought of as ‘vegetables’ and are considered as such in this thesis. A distinction between *starchy vegetables* and *non-starchy vegetables* is made in the present research on the basis of
starch content. A high starch content is found in certain root vegetables (e.g. potatoes), particular seeds (e.g. acacia seeds), select species of nuts (e.g. chestnuts), and cereal grains.

Fruits generally describes the sweet, fleshy edible part of a plant growing from the base of the flower and surrounding the seeds.

Although the term ‘meat’ can be used to describe the edible matrices of any animal, in the general literature it more commonly refers to terrestrial animals rather than aquatic species (i.e. fish, shellfish and other aquatic animals) and it is this meaning that is used in the present research. Hence, in this thesis meat refers to all or part of the carcass of any terrestrial animal including sheep, cow, pig, goat, buffalo, camel, deer, rabbit or kangaroo. In our contemporary food supply, ‘meat’ usually refers exclusively to skeletal muscle rather than offal (e.g. liver, kidney, heart, brain) and other traditionally eaten matrices including bone marrow and blood. Poultry is also defined as ‘meat’ in this thesis; however, it more specifically refers to avian birds such as chicken, duck and turkey (but not eggs).

Dairy refers to milks, yoghurts and cheeses, which in today’s world are commonly made from cow’s milk but can also be made from any type of animal milk including goat and sheep milk.
Preface

An Anthropological View of Human Life 40,000 Years Ago

Humans have lived by hunting and gathering wild foods for all but the past 10,000 years, since the agricultural revolution. This way of life has sustained humanity for 99.6% of the 2.4 million years since the first appearance of our Homo genus (Cordain 2000). In some global populations, including Australian Aborigines, hunter-gatherer life has been in existence until far more recently. Humans have biologically changed very little over the past 40,000 years (Eaton, Konner & Shostak 1988), yet our food supply, lifestyle and environmental circumstances have changed significantly. The following excerpt from The stone age health program: diet and exercise as nature intended (Eaton, Shostak & Konner 1988 p.3-4) overly romanticises hunter-gatherer life; however, it is still provides an interesting prelude for the present research investigation.

‘Daily life would abound with the activity of adults and children talking, arguing, laughing and playing. One young couple enjoying their newborn sit close beside one another, watching with amusement as their four-year-old clumsily struggles to hold the new baby. The young girl’s attention suddenly drifts to the sounds of children playing nearby, and she nearly drops the infant in her haste to join the excitement. The mother cradles the startled baby in her arms, and quiets him by putting him to her breast (up to 4 times/hour). The couple roasts meat from a recent kill, to be eaten with an abundance of ripe roots that taste like delicious fresh-roasted potatoes, followed by fruit soup and sweet berries.

The woman’s younger sister, considered quite beautiful, notices the little feast and sits down to join them. She brings news of the women with whom she has gone gathering earlier that day. On their return from a six- or seven-mile walk, they discovered a large cache of honey in a tree not far from home. A discussion ensues as to the best strategy
for obtaining the prize without suffering too many stings. Then talk drifts to a near-
mishap that befell one of the men when out hunting.

He had wounded an unusually large antelope and had been tracking it for several
hours. Tired, somewhat discouraged, and unaware that the animal was resting nearby,
he stumbled into a thorn bush and let out a yelp of pain. The antelope jumped up in
fright, practically under his nose, and lumbered off. The surprised hunter frantically and
rather comically pulled thorns from his leg and foot as he hopped after it. A fresh
animal could have easily escaped such ineffectual pursuit, but because of the spear
wound and its sudden burst of effort, the antelope stumbled and fell, allowing the hunter
to catch up and kill it. Amid peals of laughter over the hunt’s antic conclusions, plans
are made for the next day to gather honey and retrieve the meat – hung safely on tree
branches to dry.

The day ends. Firewood is collected for the night as darkness descends. Talk continues
long after the children are asleep, but gradually thins even among the late-night
stalwarts; at last only the sound of a healer playing a stringed instrument and singing
plaintive songs gives voice to the deep quiet of the night. The stars move imperceptible
overhead, but as the hours pass, their motion is so striking that, in the vast silence, they
seem to make a sound. Figures lie quietly beside the fire, shifting for comfort or
companionship, sitting up momentarily to stoke the fire or quiet a child. Hours later, the
dark becomes ever-so-slightly lighter, heralding the new day.'
Chapter 1: Introduction

1.1 Research Context: Why this project?

What is our optimal human diet? At a time when confusing and divergent ideas are endemic both in the scientific literature and among the general public, a re-assessment of this fundamental question has been undertaken in this thesis, and a suggested pathway for more closely re-aligning our diets with optimal parameters is presented within a contemporary Australian context.

The research is grounded on an evolutionary paradigm. The perspective attempts to view human health within the framework of evolutionary biology. It acknowledges the central role of natural selection and the process of organism adaptation in an environmentally dependent, contextual way. Accordingly, for over 99% of human evolution, we hunted and gathered wild foods in an exercise-dependent way. Proponents of an evolutionary medicine approach hypothesise that significant discordance now exists between our genetically determined human biology and the bio-behavioural circumstances of our contemporary lives (Cordain et al. 2005; Eaton & Konner 1985; Simpoulous 1999). The consequential effects are thought to be escalating rates of obesity, metabolic disorders, cardiovascular disease, certain cancers, mental illness and other chronic degenerative diseases in Australia and other Western nations.

The evolutionary aspects of modern-day nutrition and health have been documented in the scientific literature over the past 30 years (see for example Cordain 2002b; Cordain 2008; Cordain et al. 2000; Cordain & Friel 2005; Crawford & Marsh 1995; Cunnane 2005; Eaton & Konner 1985; Eaton, Shostak & Konner 1988). This body of literature is reviewed, critiqued and in some instances re-analysed in this thesis. In the present investigation, literature was collated from anthropological data detailing the subsistence strategies of recent (20th century) worldwide hunter-gatherer societies (predominant data source was Murdock 1967). This was combined with an analysis of wild food
distribution patterns and their nutritional properties (particularly Australian bush foods), analysis of Australia’s current environment and food production situation, the psychology behind our food choices, and an exploration of current scientific understanding of the biological consequences of various dietary (and lifestyle) characteristics on human health.

The present research differs from research agendas that have tended to prevail in the field of evolutionary nutrition and nutrition science in its de-emphasis of the health effects of isolated and specific nutritional characteristics. Unlike Cordain’s research (2002a; Cordain et al. 2000), this thesis argues that the inherent health advantage of hunter-gatherer diets and the wild food matrix is not only found in the exclusion of agricultural good groups (i.e. dairy, cereal grains, fatty domesticated meats, refined and processed foods) on the basis that they have in theory appeared too recently in human history for evolutionary adaptation to have occurred. Nor is it necessarily found in mirroring average hunter-gatherer dietary characteristics (e.g. macronutrient composition, fatty acid balance) using contemporary foods. Cataloguing and quantifying all the possible nutritional characteristics and correctly ‘matching’ them requires a greater understanding of food – its chemical components and synergistic actions – than is presently available. Making biologically authentic food choices way in today’s world, in a way that best meets our evolutionary adapted needs, does require that attention be given to these specific dietary characteristics, as several researchers have done (Cordain 2002b; Cordain 2008; Cordain et al. 2005; Eaton, Eaton & Konner 1997; Eaton & Konner 1985; Eaton, Shostak & Konner 1988). However, this research suggests that capturing the full therapeutic potential also requires a greater understanding and deeper recognition of the way food-choice behaviours are imbedded in contemporary Australian psyches, and the life-cycle of our modern-day foods relative to natural wild foods.

From this perspective, a relatively simple guiding principle is proposed – choose the freshest and most unrefined food available from both plant and animal sources that are themselves optimally healthy, and consume these foods in quantities reflecting their availability in the wild. While this principle appears overly simple at this point in time, the rationale for it is detailed in the body of this thesis and its penetrating consequences are extensively explored. Consequently, it is argued that this basic principle should take precedence over, for example, subscribing to a particular ‘diet’, or choosing food on the basis of its fat content, glycaemic load, or other specific nutrient value – an approach
which tends to dominate contemporary public attitudes. This does not diminish the importance of, for instance, meeting recommended nutrient intakes or minimising animal-derived saturated fat, but rather extends the biological significance of these specific factors when they are understood in a broader context.

Absent in the literature is a holistic, integrative analysis of optimal nutrition from an evolutionary perspective with specific relevance for contemporary Australia. This is where this research work is positioned. In particular, attention has been directed not only to theoretical analysis, but also to practical interpretation that enables interested Australian readers to best eat like a ‘contemporary hunter-gatherer’ utilising the most biologically authentic foods presently available to us. Therefore, Australian data has been used whenever possible and the depth and scope of the present research has been governed by the drive to examine the necessary extent of information to enable theory to be translated into practice.

In order to achieve this aim, two theoretical frameworks were used to structure the research inquiry:

(i) An evolutionary perspective was taken to explore the nutritional (and lifestyle) conditions to which humans are (theoretically) optimally adapted.

(ii) Integral theory (Wilber 2000, 2001) was used to interpret the evolutionary nutrition data into the present-day Australian context.

Such a holistic analysis, particularly with its evolutionary perspective (because historical ideas are difficult to prove), is challenging due to its potential scope and because an adequately deep temporal frame of reference is required to enable indicative patterns to appear and be conceptually pieced together. This may in part explain its absence in the literature. Furthermore, current research paradigms in nutrition science tend to be oriented towards reductionistic studies. Consequently, extensive data on the metabolic activities of specific nutrients and certain dietary characteristics are available. Along with this narrower focus, a ‘bigger picture’ collective analysis is needed to keep sight of the right ‘goal posts’ for directional momentum for dietary change, which is where this thesis is positioned. By its nature this can not always be a precision-oriented process, and as such, predictive patterns and guiding principles are the valuable research outcomes of this work.
The goal is to enable the reader with the information and skills to utilise evolutionary nutrition knowledge within their current contemporary context. This also holds clinical relevance for many individuals who present for health advice, and for the practitioners who work with them.
1.2  **Thesis Aims and Research Questions**

1.2.1  **Aims**

For the purpose of clarity, with the previously mentioned in mind, the aims of this thesis are summarised as follows:

1. To review and critique current core concepts in evolutionary nutrition. In doing so, this research argues the merit and contemporary value of such a perspective. The inherent premise underpinning this approach is that human physiology and metabolism is adapted to the diet and lifestyle patterns that existed during the evolution of our species. If these dietary and lifestyle patterns rapidly change (in terms of evolutionary time-scales), as is occurring in today’s world, stress manifests. The resulting effect of this ‘stress’ (defined in this thesis as chronically strained homeostatic mechanisms) is hypothesised to be the high prevalence of chronic degenerative diseases in Australia and other Westernised nations. Interpretive differences between several prominent researchers in the field of evolutionary nutrition are discussed, as are similarities and differences between these views and the position expressed in the present research. Particular attention is given to the work of Cordain (including, 2002a, b; Cordain 2008; Cordain et al. 2000; Cordain et al. 2005) due to his prolific publications and the influential nature of his perspective.

2. Absent in the literature is an integrative synthesis of the research field so as to be relevant to contemporary Australians. While extensive data is available on the metabolic activities of specific nutrients in the body and the effects of different dietary parameters on health, very little research has collectively analysed Australians’ relationship with food from an integrative evolutionary perspective. Hence, this thesis contains analysis of several dimensions: the effects of a number of our modern day food production methods on food quality and human health, a critique of what constitutes ‘optimal nutrition’, the average Australian’s diet, our Recommended Dietary Guidelines, our health status, and our inclination towards stress-induced eating and less-than-ideal food choices. All these factors are analysed in relation to an ‘optimal benchmark’ based on an
understanding of our evolutionarily adapted needs, the dietary composition of our recent hunter-gatherer ancestors, and the nutritional properties of wild foods. This type of analysis has perhaps been limited in the existing literature because nutrition science is currently not well grounded as to what is considered to be ‘optimal nutrition’ (Nestle & Dixon 2004) and public understanding is skewed by marketing influences, shareholder interests, a lack of direct knowledge of how many foods are produced, and a lack of understanding of which foods actually meet our physiological requirements for homeostasis. Furthermore, reliance on predictive patterns and biological plausibility, rather than proven facts alone, is required when a heuristic approach to research is undertaken, as is the case in the present investigation. The holistic and integrative interpretation of the evolutionary nutrition literature within the context of the Australian environment uniquely positions this thesis.

3. Held centrally throughout the entire investigative process has been the aim of translating theoretical data into practical application. This intention governed the scope of the research. This thesis presents a model to guide optimal nutrition choices and lifestyle parameters from a holistic evolutionary perspective within the contemporary Australian context. It is a unique interpretation designed for health-care practitioners and interested individuals to guide how to eat like a ‘contemporary hunter-gatherer’ using the most biologically authentic foods currently available to us. Finally, the clinical applicability and therapeutic potential of this approach is discussed.

1.2.2 Research Questions and Propositions

In view of the above aims, the research questions guiding the investigation can be categorised into four sections: relevant question about our evolutionarily adapted past; questions about our present situation; questions about how to best integrate the historical evolutionary data into our modern milieu; and finally, pertinent questions for guiding future research directions.

The important questions about nutritional and lifestyle patterns from our evolutionarily adapted past include the following:
1. What diets have humans eaten throughout evolution?
2. What ancestral time period in human evolution is most relevant to modern-day man?
3. Did the diet and lifestyle patterns of our ancestors support good health?
4. Can, and should, the dietary and lifestyle patterns of our most recent hunter-gatherer ancestors represent a standard for contemporary optimal nutrition?
5. How strong is the evidence pertaining to recent hunter-gatherer subsistence patterns?
6. What are the nutritional properties of the wild food supply?

These questions are not unique to this investigation. Rather, they are used to focus the literature review and direct an appropriate critique of the evolutionary data.

Relevant research questions applicable to our present situation include the following:
1. What do Australians eat and how healthy are we?
2. How strong is the evidence correlating diet and lifestyle factors, and disease?
3. How does the modern Australian diet and our Recommended Dietary Guidelines (NHMRC 2003) compare to the nutritional characteristics of recent hunter-gatherer diets?
4. How should ‘optimal’ nutrition be contemporarily defined?
5. How is our modern-day food produced, and how does it compare nutritionally to the wild food supply?
6. What plausible impacts have the rapid dietary and lifestyle changes of modern life had on the health of Australians today?

Each of these questions are analysed in the present research and the outcomes inform the next section – how to best integrate the data so as to be contextually relevant today.

**Integrating** the nutritional and lifestyle characteristics of our evolutionarily adapted past into contemporary Australian life requires solutions to be found to the following questions:
1. Is it possible to mirror the wild food matrix using contemporary foods?
2. What does an optimal contemporary diet from an evolutionary perspective look like?
3. What food production environment is necessary to support optimal nutrition?
4. What lifestyle factors which are congruent with our evolutionarily adapted past need consideration?

Finally, formulating ideas about a future vision leads to a consideration of the therapeutic potential and clinical relevance of such an approach, along with an exploration of how to engage individuals and society in producing more biologically authentic foods and eating in a way that is supportive of sustainable human wellbeing.

In summary, the key research proposition is that: re-integrating the characteristics of the natural wild food supply using the most ‘biologically authentic’ whole foods available to us today, as well as including other significant lifestyle patterns (e.g. physical exercise, appropriate sunlight exposure, environmental contamination minimisation), and combining modern medicine and technology, proffers a therapeutic framework for health with as-yet largely untapped potential.
1.3 Thesis Overview

Chapter 1 outlines the research context and aims. Also to follow in Chapter 1 is a description of, and rationale for, the methodological frameworks used to guide and focus the investigative process, and address the research aims and questions.

In order to understand the evolutionary history of our human diet and the environmental conditions to which we are most adapted, Chapter 2 is devoted to a review of literature that examines what humans ate throughout relevant evolutionary periods, the diets of numerous hunter-gatherer societies and the nutritional characteristics of wild foods. Also explored in Chapter 2 is the real possibility that food has been a major driving force in human evolution. In this regard, the hypothesised relationship between human brain expansion and the particular nutritional matrix offered by shore-line ecosystems is examined. Broadening an understanding of the ‘conditions of life’ that optimally support human health has entailed an exploration of various hunter-gatherer lifestyle parameters compared to contemporary conditions of life. More specifically, an examination of differences in physical activity, sunlight exposure, reproduction patterns and microbial interactions was selected for discussion. A number of additional factors could also have been explored; however, by necessity the scope had to be limited to this. That being said, predictive patterns could be generalised to other areas on the basis of what is presented.

Chapter 2 also describes significant food-related historical transitions. The transition from procuring wild foods by means of hunting and gathering, to domesticating plant and animal foods, to intensifying agricultural production, major technological developments, food globalisation and neo-agricultural diets are explored to enable an understanding of the timelines involved and the potential effects on nutritional characteristics.

The final component of Chapter 2 looks specifically at the human, ecological and food history of the Australian environment. The uniqueness of the Australian ecology and its impact on food production is discussed. Also explored are traditional Australian Aboriginal diets, the nutritional properties of wild Australian bush foods, and how we can use this information to attune our eating to our evolutionarily adapted requirements.
Both Chapters 3 and 4 focus on the present-day Australian situation in the context of nutrition. Chapter 3 reviews the health status of the Australian population and examines the strength of correlation between key dietary characteristics, other health determinants, and disease. It is established that diet provides a direct pathway for altering the biochemistry of the body and is a useful tool in disease prevention and management. But which contemporary diet is most health promoting, and how do modern ‘therapeutic’ diets compare to the average hunter-gatherer diet? This question is explored in regards to the traditional Mediterranean diet (de Lorgeril et al. 1994; de Lorgeril et al. 1999), the so named ‘French paradox’, vegetarian diets, and diets intentionally used for therapeutic purposes – again, the Mediterranean diet, the Ornish diet (Frattaroli et al. 2008) and the Gawler Foundation diet (Gawler 2008). Also important in this chapter is an exploration of the psychology behind eating behaviours from the understanding that many of us eat, at least some of the time, for reasons completely unrelated to physiological hunger, and our food choices, at times, belie the knowledge we have.

Chapter 4 analyses Australia’s current food-production environment. Both land- and sea-based agricultural systems are examined with the aim of understanding how best to make food selections (i.e. eat like a ‘contemporary hunter-gatherer’) with the highest possible index of biological authenticity.

Chapter 5 identifies markers for an ‘optimal’ diet from an evolutionary perspective: (1) macronutrient composition; (2) micronutrient intake; (3) fatty acid composition; (4) glycaemic load; (5) sodium to potassium ratio; (6) fibre content; (7) acid-base balance; and a final category titled (8) ‘whole foods’. This final category advocates a simplifying stance for looking at food and nutrition that avoids our present tendency to become too engaged in trying to mimic specific dietary characteristics such as macronutrient composition or fatty acid balance, and instead argues that while each of these criteria (1–7) is important, in isolation they do not tell the whole story about the synergistic health potential of foods in their fresh, whole (i.e. minimally refined) state. Chapter 5 also examines the contentious issue of nutritional supplementation within an evolutionary nutrition framework.

Chapter 6 critiques the way three prominent researchers have interpreted evolutionary nutrition theory into present-day contexts. This is an important prelude for the material contained in Chapters 7 and 8, which outline the author’s interpretation of ‘contemporary hunter-gatherer diets’.
Hence, Chapter 7 begins the interpretive process of identifying what a ‘contemporary hunter-gatherer diet’ may look like using the most ‘biologically authentic’ foods commercially available in Australia today (based on the analysis of Chapter 4). In order to achieve this, the dietary characteristics of traditional hunter-gatherer diets are made sense of within the context of our contemporary food supply. A dietary example is then constructed to serve as a model for comparatively evaluating the average Australian diet (and the recommended dietary guidelines) relative to a ‘contemporary hunter-gatherer diet’. Inherent to this comparative process is the need to examine the nutritional status of the average Australian’s diet. Therefore, Chapter 7 also analyses the average Australian diet compared to the recommended dietary guidelines for Australian Adults, and compared to hunter-gatherer dietary parameters.

Chapter 8 continues the interpretive process for how to best eat like a ‘contemporary hunter-gatherer’ and in doing so honour our ancestrally adapted needs within our modern day milieu. A primary aim of this thesis is to stimulate directional momentum towards more optimal food choices. In achieving this – along with the written material presented in the body of the thesis – an illustration (Figure 19) is presented, along with four dietary case studies, which convey how the model can be practically implemented.

Chapter 9 explores how the knowledge contained within this thesis – including a ‘contemporary hunter-gatherer diet’ and other lifestyle factors – can be translated into therapeutic tools in clinical practice. Furthermore, the opportune window of foetal nutrition is highlighted. Subsequently, the second part of Chapter 9 examines the hypothesis that foetuses make irreversible choices in their developmental trajectories by predicting the environment into which they will be born, based on the conditions of their interuterine environment. Maternal nutrition and lifestyle are critical factors in this process.

Chapter 10 broadens out the holistic research picture, exploring how to engage the ‘Big Three’ epistemological approaches of Integral theory – the I (personal), we (our collective cultural agenda) and it (our environment) – in enacting sustainable change in the food we eat and our long term health and wellbeing.
Chapter 11 takes a pragmatic, inward look at the perceived strengths and limitations of this research, as well as outlining potential areas for future research. Finally, the conclusion to this work is presented in Chapter 12.
1.4 Theoretical Framework and Epistemological Perspective

As previously mentioned, two concepts are used in this thesis to organise, filter and interpret information in the literature, and to address the research questions. Both are ‘evolutionary’ in their stance, meaning that they embrace the concept of change or development through time. One is termed an ‘evolutionary paradigm’ which, in this thesis refers to Darwinian theory and the mechanism of natural selection and adaptation in evolutionary change. The other is Integral theory (Wilber 2000, 2001).

An ‘evolutionary paradigm’ offers the understanding that when conditions of life (e.g. food) deviate from those to which we have genetically adapted, biological maladjustment occurs. Chapter 2 is devoted to exploring the essential dietary and lifestyle conditions to which we are most adapted. Much anthropological, archaeological and scientific literature is available in this regard. Knowing the dietary and lifestyle parameters of our evolutionarily adapted past is one thing; making use of it in our contemporary Australian context is another. The process of identifying, interpreting and integrating the knowledge about our nutritional (and lifestyle) ancestry so as to hold relevance for Australians today was shaped by the holistic methodology of Integral theory.

Functionally understanding ‘optimal’ human nutrition today is a clarion call for viewing food and nutrition in contemporary Australian life as a whole. Consequently, holistic analysis was vital. While an evolutionary paradigm provides knowledge about the dietary and lifestyle parameters to which we are most plausibly adapted, Integral theory extends the landscape of analysis, and, in so doing, enables the information to become increasingly relevant and able to be integrated into our contemporary circumstances. This aspect is lacking in much of the existing evolutionary nutrition literature and hence is centrally addressed in this investigation.

The boundaries and parameters of our food (and lifestyle) related history is detailed in Chapter 2 and hence not mentioned further here. Integral theory, on the other hand, requires greater explanation.
Integral theory is used in an applied capacity throughout this thesis. Therefore, a summary of the basic tenets of the theory are outlined in the following section, with explanatory examples relevant to this thesis given. It is hoped that in providing an understanding of the fundamental philosophy of Integral theory (in Section 1.5), the stance of this whole investigation process can be contextualised, even when aspects of its guiding theory are not always directly referred to later in the thesis.

It is rare to find the application of Integral theory as a research framework for nutrition studies because historically nutrition and medicine have been grounded within empirical paradigms that are validated by hypothetico-deductive procedures (often experimentally based) and measured objectively. The present research is broader in this regard. At this point in time, a plethora of nutrition studies are available exacting the metabolic response of various nutrients and chemical interactions – many of which have been useful to the present research. At the same time, conceptual understanding of the ‘big picture’ is also required to provide a directional ‘map’ for action (i.e. how to best make use of the evolutionary information within contemporary Australia). It gives greater meaning to what is meant by ‘optimal’ nutrition and elucidates inter-connected relationships, predictive patterns and pathways for change, and honours the whole health of humans in a more integral way.
1.5 **Integral Theory and Its Application to this Research**

‘The general idea is simply that we need to exercise body, mind, soul, and spirit – and to do so in self, culture, and nature’ (Wilber 2000 p.311)

Examining the deep relationships between diet, lifestyle and optimal health demands a holistic research methodology. The theoretical basis for holistic analysis was first articulated in the literature by Jan Christian Smut in the 1920s (Savory 1999). Following this time, increasing awareness and validation of its role is being progressively appreciated – none more so, than in the writings of Ken Wilber and his Integral theory (Wilber 2000, 2001). At its most basic level, the theory’s inclusion of the personal (‘I’), the collective (‘We’) and the environment (‘It’) offers the scaffolding for a comprehensive examination of multifaceted, inter-related factors involved in whole human health in today’s complex world, as will be discussed.

Core to Integral theory is the basic understanding that any entity is simultaneously a whole and a part of some other whole. As Wilber (2000) states, ‘a whole atom is part of a whole molecule, and the whole molecule is part of a whole cell, and the whole cell is part of a whole organism, and so on’ (p.17). These whole/parts are referred to as holons – a term coined by Arthur Koestler (Koestler & Smythies 1968). Every whole depends on parts (holons). Hence, every holon has to maintain both is wholeness and its partness. As Wilber (2000) states, a holon ‘has to maintain its own wholeness, its own identity, its own autonomy, its own agency. If it fails to maintain and preserve its own agency, or its own identity, then it simply ceases to exist. So one of the characteristics of a holon, in any domain, is its agency, its capacity to maintain its own wholeness in the face of environmental pressures which would otherwise obliterate it. This is true for atoms, cells, organisms, ideas’ (p.19).

Consequently, in regards to human health, we need to maintain the health of all our body systems and eat and live in accord with the needs of all our internal and external ‘holons’ to increase the vitality of our ‘whole health’. Understanding the functional and interconnected nature of individual holons (e.g. our optimal nutrient requirements) and integrating them into a larger holistic picture (e.g. working towards sustainable...
agricultural environments conducive to optimal human diets) increases the vitality of the whole human holon existing interdependently within that system.

All holons emerge in directional evolutionary process. As new holons emerge, they emerge hierarchically – holarchically\(^1\) – because each new entity *transcends* but still *includes* its preceding features. This continual process of evolutionary transcendence produces new emergent qualities not found in the previous dimension. For example, humans contain atoms, but this does not work in the reverse – atoms do not contain humans. Likewise, food contains vitamins and minerals but not vice versa. Hence, the ‘lower’ holons set the possibilities of the ‘higher’; and the ‘higher’ sets the probabilities of the lower. As a result, if a particular holon ceases to exit, all the holons above it but none of the holons below it will be destroyed.

The greater the number of preceding levels (holons) in an entity, the greater its complexity, depth and consciousness. For example, a whole human (holon/whole/holarchy) requires a far more complex support system (depth) for its health than a single cell amoeba, but it also means that more things can go wrong – humans can get diabetes, for example, whereas atoms can’t. This understanding brings into awareness the relative value of various entities (holons) and highlights the value of hierarchical prioritisation.

Effectively addressing what optimal human nutrition means and all its intrinsic complexities requires a methodological framework for prioritising certain elements above others. Not every aspect involved in supporting human health can be seen as equal. Consequently, some therapies, dietary strategies, or lifestyle choices are more advantageous than others. Hence, this research is intent on being holistic and holarchical/hierarchical, not ‘heapastic’ as Wilber (2000) calls it. For example, one dimension of this investigation is to examine Australia’s current food production environment (see Chapter 4) and to hierarchically prioritise food choices that are more aligned with our evolutionarily adapted niche, and thus include more of the essential features which our health depends upon. In other words, certain holons have more

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\(^1\) Koestler and Smythies (1968) suggest that hierarchies should be called holarchies in recognition that natural hierarchies are composed of holons (parts) in orders of increasing holism and wholeness – wholes that become part of new wholes. (Reference: Koestler, A & Smythies, JR 1968, ‘Beyond reductionism, new perspectives in the life sciences,’ *Alphach Symposium*, London : Hutchinson,
**intrinsic value.** The greater the wholeness, the greater the depth, the greater the consciousness, the greater the intrinsic value.

Of critical importance, however, is that a holon of less intrinsic value does not mean no value. Yet, for example, our treatment of intensively farmed animals would suggest they have little value other than for human meat. Removing value from holons is a fundamental mistake because every holon is not only a whole, it is also a part. As Wilber (2000) writes, ‘as a part, it has value for others – it is part of the whole upon which other holons depend for their existence’ (p.302). Intensive animal farming operations acknowledge little of the *intrinsic* value of the animals, and in some cases turn a blind eye to the cascade of *extrinsic* impacts of these operations on wider environmental systems, which consequently destroy some of the ecological services which are necessary for broader optimal human health (see Chapter 4.3). This is but one example.

As a whole, a holon (e.g. a human), has rights which pertain to the conditions necessary to sustain their wholeness. An evolutionary medicine perspective asserts that organisms, including humans, function optimally when their life circumstances most closely match the conditions to which they were selected and became adapted to over the course of evolution. Hence, inclusion of, and access to, these conditions is a right in order to sustain health. As Wilber (2000) puts it, ‘rights express the conditions for the intrinsic value of a holon to exist, the conditions necessary to sustain its wholeness’ (p.302–303). If the rights of holons aren’t met, that holon becomes dysfunctional, and can dissolve (die) and its services are lost.

Humans, with our higher degree of consciousness and greater relative depth than, say, an ant, give us more rights – there are more conditions necessary to sustain whole human health. But this means we also have many more responsibilities. We have responsibilities to all the communities of which our own subholons are a part. We exist within a massive network of holons, and failure to meet the conditions under which our holons and subholons can exist in communion means our own self-destruction. For instance, the action of putting agricultural chemicals into the environment knowing the ecological cascade of this action, or eating sub-optimal diets, or smoking tobacco, denies some of our intrinsic value and extrinsic worth and is ultimately not fulfilling our responsibilities to ourselves. We can not be a *whole*, or achieve optimal whole health without being a *part* of anything. Our ongoing action of eating unsustainable foods will
ultimately result in a collapse of not only individual health but also collective health. A powerful indicator of our lack of care is that 49% of the Australian population are now overweight or obese (Australian Institute of Health and Welfare 2006a). This is a direct result of not paying attention to the relative wholeness of every part that contributes to our whole health. With the use of specific examples in the main body of the thesis, this will become clearer.

The next important point of Integral theory is that all holons have four facets (quadrants) – the interior and exterior of the individual and the collective. In terms of human holons, this means that we all have four aspects to our being:

1. The intentional, internal aspect of individuals that needs to be understood by hearing and interpreting the internal psyche of individuals
2. The behavioral, observable actions of individuals, including our internal physiological functions
3. The collective, cultural worldview in which individuals exist (mutual understanding)
4. The environmental, technological, built systems in which an individual lives [termed ‘social’ by Wilber (2000)]. This includes objective nature and empirical forms, and is understood in terms of observable propositional truths (scientific model).
Figure 1. Integral theory four quadrant map (Sourced from Wilber 2000 p.67)

All four facets need to be considered in addressing optimal human health and attention to each – although not necessarily in equal depth – have been given in this thesis. As seen in the four quadrant diagram (Figure 1), the upper half of the quadrant refers to the individual, and the lower half to the collective. The right-hand side refers to the exterior, which can be ‘seen’/is observable, the left-hand to the interior, which requires interpretation. The idea of the four quadrants is that they help to orientate us more consciously to the reality already in existence. Briefly, the basic characteristics of the four quadrants as they relate to the aspects of human health considered in this thesis are outlined as follows:

Upper Right:
The upper right quadrant acknowledges the individual in its exterior aspect. Information in this quadrant, as with the lower right quadrant, is effectively elicited through use of the scientific method and, in the case of this thesis, knowledge deduced in this way has
provided information on the physiology of human body systems, the biochemical and metabolic effects of various nutrients, and other biological parameters of human health.

*Upper Left:*
The upper left refers to the interior aspect of the individual. The interior world-view cannot be accessed in an empirical objective way, unlike the right-hand quadrants. It is the domain of the intimate, personal and emotional. For example, in the study of optimal diet, we can know from scientific experimentation (upper right) that an abundance of fruit and vegetables in the diet may lower disease risk factors; however, it gives us no indication of the effect of fruit and vegetable intake on a person’s sense of vitality, their perceived sense of health, or whether or not they like fruit and vegetables. In this thesis, the domain of the upper interior aspects of the individual is discussed in terms of our psychological relationship with food (see Section 3.5).

*Lower left:*
This quadrant refers to our shared cultural collective wisdom – the meanings, values, identities and ethics that we share with similar communities (Wilber 2000). In terms of food, different cultures express great diversity in food preferences and food attitudes. Above these differences there are also shared values which are universal – the desire for a clean food-production environment, access to healthy food, the enjoyment of food as part of social activities, and the moral and ethical responsibilities we uphold in protecting the common good and health of all.

*Lower right:*
This is the domain of the external world in which we live – nature and the material base of the world as we know it. It is the exterior, material, institutional forms of our society, from the environmental systems that underpin us to our technological and economic base, population size, statistics about the population’s health etc. These are the visible, exterior forms of our collective lifestyle and the world in which we live. Examination of the effects of the environmental circumstances (lower right quadrant) which supported our evolution as a species has been given great emphasis in this research, as too have the agricultural systems underpinning our contemporary food supply.

The four quadrants can be further simplified to the ‘big three’ (as per Chapter 10): the ‘I’ (upper left), ‘We’ (lower left) and ‘It’ (right-hand sides). As mentioned, every holon has these three aspects. Adequately attending to whole human health requires all three
(or four) aspects to be identified, differentiated and integrated. The tricky thing is that mainstream awareness (including nutrition science and Western medicine) has historically thought of reality purely in terms of that which can be captured and observed in hypothesis-deductive methods (‘it’ language). What this has meant is that the right-hand quadrants – the ‘It’ domains – are all that have come to be seen as ‘real’.

The historical context for the dominance of the right-hand quadrants (‘It’ domain) is explained by Wilber (2000): ‘Within the techno-economic base, a culture unfolds its possibilities. And within the industrial base, an altogether productive and technical and instrumental mentality unfolded, a mentality that, almost of necessity, puts a premium on the it-domain’ (p.242). While some have blamed industrialisation for this mechanistic worldview and for ecological destruction (e.g. agricultural changes and the consequential effects on food quality), in contrast Wilber (2000) articulates a more understandable perspective suggesting that it was the combined process of industrialisation (lower right) and the dominance of the empirical sciences, which tipped the balance into a right-hand quadrant free-fall where only the ‘It’ domains of the world are considered ‘real’. The outfall of this dominance is that moral decisions of our culture have been (and still are) handed over to science and technical solutions. A strong contemporary idea is that science and technology will solve everything. And it is this thinking that is enabling bold moves in biotechnology (e.g. genetically modified food) and other scientific domains as heralding the solutions for human health. Yet, as argued in this thesis, the dominance of this approach is only part of the necessary awareness for good solutions and optimal health.

For example, it’s only partly useful understanding the biological significance of omega 3 fatty acids in the human brain (upper-right quadrant) (see Section 5.2.3). It’s even more relevant if a dietary source of omega 3 fats is available from the oceans and/or from animal organ meats which have not bio-accumulated environmental contaminants (lower-right quadrant) (See Section 4.4). This requires collective effort in maintaining marine biodiversity, ensuring sustainable fishing practices, and minimising environmental contaminants (lower-left quadrant). And for the person who does not eat fish or animal organs, none of this has the same meaning as for those who do (upper-right quadrant). Furthermore, a technological fix alone devalues all the tools we already have for preventative health, for example, re-incorporating key dietary and lifestyle parameters that were an essential part of the environmental milieu which selected our biology.
The aim of an integral vision is to identify and differentiate the quadrants, but then to integrate them so that any one domain doesn’t dominate, leaving others alienated. Hence both scientific reductionism, industrialisation and globalisation – and all the knowledge and effects elucidated from this evolutionary progression – are included, but as components of a more balanced, inclusive and integrated stance, where the potential for dysfunction or dominance are limited. Now, for the first time in history, we have the capacity for a global perspective and as we move forwards from this point the advances of that perspective will now always be included in our base. Hence, idealising the notion of ‘going back’ to hunter-gatherer time is simply regressive. As Wilber (2000) states, ‘this original pristine state had less of the environmental disasters of modernity precisely because it had none of the dignities either’ (p.266). The dietary and lifestyle characteristics of the hunter-gatherer epoch of human evolution are a part of who we are today and incorporating these baseline elements honours them as necessary components of our well-being. However, integrating them within the package of contemporary life is our present reality and needs to be our aim. This is why such emphasis is placed on an appropriate interpretation of the hunter-gatherer dietary knowledge within contemporary Australia in this thesis – a point missing in much of the evolutionary nutrition literature.

We can’t automatically arrive at a point where we can move forwards with the ‘perfect’ model for optimal nutrition and optimal health at an integral level. Ideas, actions and knowledge ebb and flow at different speeds in a relatively messy process. And the work that takes first priority is always at the level of meeting immediate survival needs such as ensuring food security, minimum nutrient intake levels, and access to basic health care. Examining ‘optimal’ nutrition is far less pressing. So why look at optimal nutrition and optimal health in this thesis? Because it gives us a directional map – a bigger picture perspective so that change, no matter how small, can occur in a healthy direction. The details of this map can be filled in according to individual preferences, but to map its broad outline – its orientating generalisations and the supportive evidence – is the aim of this thesis.

Further information on Wilber’s four quadrant approach can be found in his published writings (Wilber 1995, 2000, 2001) and a summary of the basic tenets of Integral theory can be found in Appendix A.
Chapter 2: Our History – Human Diet, Evolution & Adaptation

2.1 Introduction and Chapter Scope

‘When conditions of life for any animal population deviate from those to which it has genetically adapted, biological maladjustment – discordance – is inevitable. The human species is no exception’ (Eaton, Shostak & Konner 1988 p.5)

In examining what constitutes optimal nutrition, it is necessary to understand the nutritional matrix available to humans throughout our evolution. The genetic design of modern day humans has been shaped and selected over hundreds of thousands of years. Dietary patterns, along with other bioenvironmental circumstances, are considered to be major driving forces in human evolution (Crawford & Marsh 1995). As long-living, slowly reproducing animals, our pace of biological change in the face of environmental change is very slow (Flannery 1994). Consequently, 99% of our DNA is shared with our ancestors from some 100,000–200,000 years ago, before we became truly modern Homo sapiens (Lewin & Foley 2004). Of the remaining one per cent, 99% of it is directly shared with our hunter-gatherer ancestors living more than 20,000 years ago (Cordain 2002b; Eaton, Konner & Shostak 1988; Simpoulous 1999). Today, irrespective of ethnicity, people the world over are fundamentally alike in basic bio-physiological and medical characteristics (Eaton & Nelson 1991). Hence, understanding the nutritional (and lifestyle) conditions of recent hunter-gatherer ancestors is of primary relevance to understanding our modern nutritional and health needs. This is the purpose of Chapter 2.

The late Paleolithic period from 35,000 to around 20,000 years ago is considered to be the last time period during which the collective human gene pool existed within the bioenvironmental context typical of that for which it had been selected (Eaton & Nelson 1991). No longer able to directly observe this environment from the vantage point of
modern paleoanthropology and nutritional science, the subsistence patterns of more ‘recent’ hunter-gatherer societies that persisted into the 20th century are examined in this thesis, along with characteristics of the wild food supply in existence today.

For all of history, until around 10,000 years ago and the adoption of agriculture, the human population lived in small nomadic groups hunting and gathering wild foods in an exercise-dependent way. In the traditional view, the adoption of agriculture (i.e. the domestication of plant and animal foods) and sedentism emerged hand in hand. This view tends to ‘blame’ the agricultural revolution – and industrialisation for that matter – as the cause of many contemporary nutritional problems (see for example Cordain 1999; Cordain et al. 2005). However, as argued in this thesis, this view is only part of a more complex picture. Likewise, recent anthropological consensus is verging away from tying together sedentism and food domestication, and instead is recognising the probability that agriculture and a more sedentary existence were possibly separated. Food domestication may have simply aided the ability to settle in location, which enabled a more sedentary lifestyle (Lewin & Foley 2004). Between small nomadic groups and larger agrarian communities there was also likely to be sedentary groups that subsisted on hunting and gathering where consistent food resources permitted (Cunnane 2005).

Hence, sedentism – rather than agriculture per se – possibly lead to the cascade of social and material changes which have progressed with increasing degrees of complexity – or ‘depth’ – as described by Wilber (2000). In this consequential cascade, sedentism is co-observed with increasing social and political complexity, expanding population size, material, ritual and aesthetic culture, long-distance trade, food domestication, and decreases in resource diversity (Lewin & Foley 2004; Norberg-Hodge, Goering & Page 2001). The consequences of these changes need to be teased out, identified and understood in order to more adequately address optimal contemporary nutrition. This is a more difficult task than simply removing novel agricultural/industrial food groups (i.e. grains, dairy, refined and processed foods) from ‘optimal nutrition’ guidelines as is the prevailing notion in much of the existing evolutionary nutrition literature. However, for the time being, the focus of Chapter 2 is on understanding the environment to which we are evolutionarily adapted. From this point of understanding, contemporary differences can be identified and compared – a necessary prelude to moving towards a more optimal direction, as discussed later in this thesis.

As Eaton, Konner & Shostak (1988) state, ‘from a genetic standpoint, humans living today are Stone Age hunter-gatherers displaced through time to a world that differs from
that for which our genetic constitution was selected’ (p.739). The hypothesised consequences of which are considered to act as potent promoters of chronic degenerative ‘Western lifestyle’ diseases including cardiovascular diseases, diabetes, obesity, and certain cancers, among others (Cordain et al. 2005; Eaton & Konner 1985; Simpoulous 1999). Perception of just how ‘rapid’ the shifts have been and the implausibility of adequate adaptation is possible only by examining the long time frames of human evolution and the dietary influences over this period. Consideration of the potential impacts of these factors is possible by understanding the basic principles of natural selection and adaptation. Therefore, the following section (Section 2.2) provides an outline of Darwinian evolutionary theory; a timeline of hominin evolution; a brief overview of the dietary matrix eaten within various hominin evolutionary epochs; and contemplates the discordance playing out in modern-day times.

Section 2.3 goes on to more deeply explore the nutritional characteristics of the wild food supply consumed by recent hunter-gatherer societies (largely 20th century) from around the world – all the while cognisant of the contemporary implications of the yielding knowledge.

In recognising that food has been a major driving force in human evolution, Cunnane’s (2005) hypothesis concerning the relationship between human brain expansion and the particularly rich nutrition matrix offered by shore-line ecosystems is examined with resulting implications for contemporary diets and optimal brain function. This is found in Section 2.4.

Following in Section 2.5 is an overview of the general heath of hunter-gatherer societies compared to contemporary populations. The major counter-argument of the hunter-gatherer model is that traditionally living people never lived long enough to develop the chronic degenerative disease which are so prevalent in Western countries today. This is discussed and then refuted.

Of interest in exploring human history with the purpose of understanding our evolutionarily shaped contemporary needs are broader non-food ‘conditions of life’ that support human health. Section 2.6 examines a select number of hunter-gatherer ‘lifestyle’ patterns and compares them to modern conditions of life. Differences in physical activity levels, sunlight exposure and corresponding vitamin D status,
reproductive patterns, and microbial exposure are each examined for their potential impact on contemporary health.

Understanding the transitional nature of the shifts from procuring foods by means of hunting and gathering to the modern food supply is the task of Section 2.7. The transition from eating wild foods to foods that are the product of agricultural domestication, farming intensification, technological developments and food globalisation are outlined to provide an understanding of the rapid timelines involved and to illustrate the degree of escalating change, which is outpacing any known adaptive mechanism in human physiology. While this chapter offers the timeline of key socio-cultural transitions that have significantly altered the human food supply, a more extensive exploration of modern food production systems and their impact on nutrition and human health is covered in Chapter 4.

The final aspect of Chapter 2 (Section 2.8) focuses on Australia and examines our human, ecological and food-related history. The impact of the Australian ecology on food production is discussed, along with an examination of traditional Australian Aboriginal diets, the nutritional characteristics of wild Australian bush foods and how an understanding of this information can help orientate us to our present reality.

*Homo sapiens* will continue to adapt in the ongoing process of evolution. As mentioned, food and lifestyle patterns can act as key selective pressures on that adaptation process. The effect that our current and future food supply will have on human evolution is the subject of interesting ethical debate, however it is beyond the scope of this research. Of immediate therapeutic relevance today is how we can potentiate optimal health with the genes we are currently born with. Understanding the environmental conditions within which our genetic material evolved and to which it has adapted and re-including as best we can the essential parameters of that environment are considered to offer the greatest protection against chronic diseases and obesity (Cordain et al. 2005; Eaton & Cordain 1997; Eaton & Konner 1985; O'Dea & Sinclair 1983). Hence, the overall broad purpose of Chapter 2 is to examine what is known about hunter-gatherer subsistence patterns,
what changes have occurred away from our ancestral diet, and to hypothesise about the impact of these dietary and lifestyle shifts on disease incidence in Australia.

Figure 2. Evolution: somewhere, something went terribly wrong
2.2 Human Evolution and Diet

‘Though human ingenuity may make various inventions, it will never devise any inventions more beautiful, nor more simple, nor more to the purpose than Nature does; because in her invention nothing is wanting, and nothing is superfluous’

(Leonardo Da Vinci cited in Garrard 1995 p.347)

2.2.1 The basic principle of evolutionary theory

Charles Darwin’s book *The Origin of Species* (1859) encapsulates an understanding of evolution that still stands today. Gradual change through natural selection is Darwin’s evolutionary hypothesis (Darwin 1859; Kretchmer 1980). Its operation depends on four conditions: (i) reproduction; (ii) inheritance through generations (offspring genetically resemble parents more than the general population); (iii) genetic variation within the population at large (which provides diversity in the gene pool for the more ‘advantageous’ genes to be preferentially ‘selected’ from); and (iv) competition (which is the ‘selective pressure’ enabling more advantageous genes to increase in the population at large i.e. ‘differential reproduction’ which is also some times referred to as ‘survival of the fittest’); (Lewin & Foley 2004). The Modern Synthesis of evolutionary theory refines Darwinian theory and centrally acknowledges that gradual (rather than punctuated) evolution is most likely a result of accumulative small changes that amount over long periods of time (thousands of years); (Lewin & Foley 2004).

In other words, natural selection refers to the gradual process by which advantageous heritable traits become more common in successive generations. Individuals expressing traits that are more adaptive for particular environmental circumstances tend to have a greater opportunity for reproduction and thus pass on genetic advantages to offspring. Then, over time, a population will become increasingly more adapted to its environment, unless the environment changes. Hence, adaptation and evolutionary change are the consequences of natural selection. The important point is that adaptation is always relative; relative to other possible traits and environmental conditions.

This inheritance pattern is encoded in our DNA and called the genotype. How the genotype is expressed into the phenotype (e.g. the switching on or off of genes, and
other characteristics of gene expression) is influenced by ‘conditions of life’ (as Darwin put it), also commonly referred to as environmental factors. These environmental factors include climate (temperature, day length, humidity, radiation), predators, diet, physical activity, reproductive patterns and population density (Cunnane 2005; Lewin & Foley 2004). These factors can be considered as selection pressures. These conditions (including diet as relevant to this thesis), can ‘push’ or ‘shape’ evolution in a particular direction. Each of our individual genotypes is slightly different, but collectively, the human species is clustered together under the same ‘species’ name (*Homo sapiens*) in recognition of our prevailing similarities, enabling us to interbreed across all races within the species.

The interplay between genotype, phenotype and environment is complex. Despite mapping of the human genome being completed in the year 2000 (Trueman 2007), the ‘nature versus nurture’ debate persists. Genetic inheritance of disease susceptibility is often not a simple ‘cause and effect’ process, i.e. if you have the gene, you do not necessarily get the disease. For example, inheritance of the breast cancer genes (mutations in BRCA1 and BRCA2) increases one’s lifetime likelihood of developing the disease, however the degree of risk is uncertain and studies show wide-ranging estimates. Inheritance of BRCA1 mutation carries an expectation that 36%–68% of women will get breast cancer by age 70, and BRCA2 mutation inheritance appears to carry a 0%–37% risk by age 70 (Warren & Devine 2003). In total only 6–10% of all breast cancers are associated with BRCA 1 and BRCA 2 gene mutations (Warren & Devine 2003).

Genes contain an array of switches which can be turned ‘on’ or ‘off’ by the way we live (including nutritional chemistry, physical exercise, psychological state, diseases and toxin exposure). This area of study is called epigenetics – ‘epi’ referring to the tags that sit above DNA which can switch on or off gene functions (Trueman 2007). Although scientists are developing the ability to identify, select and reject particular genes with known deleterious effects, the rules of epigenetics remain unknown. An example of how epigenetics and the interplay of environmental factors are changing the way we think about disease mechanisms is provided by Spires et al. (2004) who found that environmental ‘enrichment’ delayed the onset of motor symptoms in transgenic mice expressing the human Huntingtons disease gene. Previously, it was thought that carrying the gene for Huntingtons disease automatically resulted in expression of the disease. Yet, the ‘enriched’ environment, which included interesting objects to play with
significantly delayed disease onset compared to the control group. The lifestyle conditions we subject ourselves to and the choices we make determine actual disease risk on the background of genetic susceptibility. Paying attention to and re-establishing the essential lifestyle conditions of our evolutionarily adapted past is, in all probability, the most profound way we can affect our health and longevity – even within a future culture offering gene altering technologies and pharmaceutical biological agents.

2.2.2 A brief history of hominin evolution

Gaining a temporal understanding of the long time scale of human existence enables us to appreciate how recently and rapidly human ‘conditions of life’ have changed and to begin hypothesising about the impact of such alterations on our health.

_Homo sapiens_ are one of approximately 200 species of living primates (Lewin & Foley 2004). Although having clearly departed in distinctive ways from our primate roots, many of our ‘separating’ characteristics (e.g. intelligence) are extensions of, rather than discontinuities with, the continuum of general primate experience (Lewin & Foley 2004). The importance and impact of this concept is best understood when examined comparatively against contemporary conditions of life. As discussed, we now exist in a bioenvironmental milieu divorced in daily reality from our evolutionarily adapted roots. There is now very little external demand for physical exercise and our food supply is distinctively different to the wild food supply consumed by all other free living mammals. In response, physical limits in human physiology are being reached and overshot, and expressed in obesity and a plethora of non-communicable chronic diseases.

In the scheme of evolution, the first multi-cellular organisms emerged around 800 million years ago; land plants around 400 million years ago; insects and amphibians proliferated around 300 millions years ago; the first mammals appeared about 200 million years ago; and birds and flowering plants became widespread about 100 million years ago. Primates first appeared around 65 million years ago. The last common
ancestor between early hominins and apes existed sometime between 7 million and 2 million years ago (Eaton, Shostak & Konner 1988; Lewin & Foley 2004).

As seen in Figure 3, one of the earliest, clearly recognised radiations of the hominins are the *Australopithecines*, originating in Africa (by consensus view); (Lewin & Foley 2004). This genetically diverse hominin genera include *Australopithecus afarensis*. The fossilised remains of a female from this species were found in Ethiopia in 1974 and named ‘Lucy’. Eaton, Shostak & Konner (1988) describe Lucy’s peoples as ‘smaller than modern humans and with more marked size differences between adult males (above five feet tall) and females (under four feet tall), their bodies were nevertheless remarkably modern in structure, with hips and legs well adapted to upright walking…their skulls, including teeth, jaws and brain capacity, were quite primitive…their brains were one-third the size of the brains of modern humans – more like those of contemporary chimpanzees’ (p.21). *Australopithecus afarensis* were quite successful (in evolutionary terms) relative to other species, existing for around 1 million years.

Figure 3. A walk through human evolution (Sourced from Lertola 2001)

Around 3 to 2.5 million years ago, *Australopithecus afarensis* diverged into at least three coexisting Australopithecus species, one of which evolved into *Homo habilis* around two million years ago. The prevailing view is that divergent evolutionary trends among early hominins probably reflected different foraging strategies – either specialising in fibrous plant foods (like the *Australopithecus*), or increasing the quantity of animal foods (protein and fat) and underground plant storage organs (calorie dense starchy root vegetables) in the diet as the *Homo* species did (Lewin & Foley 2004; Mann 2007b).

2 Hominins are the branch of bipedal primates that led to humans – *Homo sapiens sapiens* (Reference: Cunnane, SC 2005, Survival of the fittest: the key to human brain evolution, World Scientific, Hackensack, N.J.)
Typical in palaeoanthropological literature (see for example Lewin & Foley 2004) is reference to the inclusion of an increasing amount of ‘meat’ in Homo diets. From a nutritional perspective, reference to ‘animal foods’ rather than ‘meat’ more accurately characterises the resulting nutritional matrix provided by such foods. As discussed in Section 2.4, the differential impact of protein, various types of fats, and other nutrients from skeletal muscle and organs were probably significant in shaping hominin evolution – particularly brain expansion. This characterisation is far more comprehensive than the nutritional concept conveyed by ‘meat’, which tends to evoke the notions of exclusive skeletal muscle consumption (protein alone) which was not the case. Hence, from this point forwards the term ‘animal foods’ is used convey consumption of all edible animal matrices (skeletal muscle, organs, fat deposit, marrow, blood) instead of the term ‘meat’.

Homo habilis was the first hominin to be included in our own Homo species. Homo habilis (‘handy man’) lived for over half a million years, at which time the larger and more complex Homo erectus came into being. Homo erectus was similar in height to modern humans although heavier bodied, with a larger and more organisationally modern brain than Homo habilis, but much smaller brain than our own. Homo erectus moved into and exploited the resources of a broad range of ecological niches for food subsistence which they collected through scavenging, hunting and gathering. Homo erectus lived for around 1.3 million years before being gradually supplanted throughout the world by Homo sapiens (Eaton, Shostak & Konner 1988).

The anatomical transformation from Homo erectus to Homo sapiens (our species) involved a decrease in skeletal robustness, modifications of locomotive anatomy and a considerable increase in brain size (Lewin & Foley 2004; van Bergen 2007). The corresponding behavioural transition included the emergence of inventive tool technologies, efficient and diverse foraging strategies, even more complex social organisation, a full repertoire of spoken language, and artistic and creative expression (van Bergen 2007). All of these behaviours characterise intelligent humans as we now self recognise. When and where the transition occurred is a matter of ongoing debate (van Bergen 2007). The debated timeframe stretches between 400,000 years ago to 100,000 years ago (Eaton, Shostak & Konner 1988; Lewin 1988a; Lewin & Foley 2004; van Bergen 2007). Regardless of the debate, it is reasonable to suggest that humans have lived as intelligent, inventive creatures with a diversity of cultures for tens of thousands of years (Suzuki & Dressel 1999). Figure 4 depicts archaeological evidence for ‘modern’ behaviour in Africa.
In further evidence, Figure 5 shows cave paintings found in France and northern Spain which have been dated to some 20,000 years ago. The artworks demonstrate humans’ clear understanding of anatomy, proportion, colour and perspective – all of which we recognise in our creative capacities today (Cunnane 2005). While there is a sense of archaic thinking in hunter-gatherer societies relative to contemporary times (e.g. the Australian Aboriginal dreamtime explanation of environmental circumstances), there is no evidence that humans living as hunter-gatherers had a lower or different intelligence at all. Rather, as explained by Wilber (2000) and seen in his four-quadrant ‘map’ (Figure 1), there is some correlation between hunter-gatherers’ (foragers) tendency toward an archaic-magical worldview (referred to as number ‘9’ in each quadrant) constructed through symbolic understanding. However, this simply reflects the fact that a holon (e.g.
a person) can only respond to those stimuli that fall within it’s worldview. Today, we are simply part of a different worldview.

![Figure 5. Cro-Magnon artwork in the cave of Lascaux, France (Sourced from Ministry of culture and communication 2009)](image)

In terms of where *Homo sapiens* emerged, the most popular hypothesis is that all living humans are probably descendents from a relatively small population, most likely living in east Africa at least 100,000 years ago (Lewin & Foley 2004). Then followed a population expansion into Asia, Oceana and Europe (possibly in that order) (van Bergen 2007) as seen in Figure 6. Hominins living outside of that small population group in Africa are not considered to have contributed significantly in either genotype or phenotype to the modern human form (Lewin & Foley 2004).
Figure 6. The migration of modern Homo sapiens out of Africa by 100,000 years ago; east into Asia at least 50–60,000 years ago, north into Europe around 40,000 years ago, and into the Americas some 15–35,000 years ago (Sourced from van Bergen 2007)

From around 35,000 years ago truly modern Homo sapiens had supplanted all other forms of hominins including Neanderthals (which will shortly be discussed). Modern humans spread across the globe, moving from Asia into Europe and Australia some 40,000 years ago, to the Americas at least by 15,000 years ago, into the Arctic around 10,000 years ago, and more recently into the Pacific Islands some 2,000 years ago (Eaton, Shostak & Konner 1988; van Bergen 2007). Because of their island home, indigenous Australians have the longest continuous cultural history in the world (Eckersley & Willliams 2008).

European Homo sapiens living some 35,000 years ago were named the Cro-Magnon people after the French cave in which some of their remains were found. Cro-Magnon’s would be indistinguishable from Europeans and white Australians living today. Males averaged nearly 5’10” in height and women 5’6” (Eaton, Konner & Shostak 1988). As Flannery (1994) writes, ‘they presumably evolved their distinctive features – such as a long, narrow nose, relatively robust body, pale skin and often partially depigmented hair and eyes – in the 100,000 or so years before they displaced the last Neanderthals’ (p.302).
*Homo sapiens neanderthalensis* appear to have coexisted with fully modern *Homo sapiens* (Cro-Magnons) in Europe and Western Asia for perhaps 10,000 years, before the more advanced Cro-Magnons appear to have pushed Neanderthals from their land, possibly causing their extinction. ‘Neanderthals’ were named after the Neanderthal Valley near Dusseldorf, Germany where their remains were first found. Their greatest time of population density occurred between 90,000 and 30,000 years ago (Flannery 1994; Lewin & Foley 2004).

Neanderthals were adept at coping with the cold European climate where they lived (Flannery 1994). Physically they only averaged 1.6 metres in height; however, they were very muscular. Also, they quite possibly had a longer pregnancy of up to 12 months. This, among other things, suggests that Neanderthals were a different species to modern *Homo sapiens*. Also adding evidence to a clear genetic boundary between *Homo sapiens* and *neanderthalensis* is the lack of gene flow between the groups, in spite of their coexistence in Europe for several thousand years (Flannery 1994). As Flannery (1994) suggests, dressed in a modern suit and tie, Neanderthals would stand out as looking very different in a modern city.

Genetically, modern living Europeans (and white Australians) are more similar to their Cro-Magnon ancestors than they are to modern-day Africans or Asians (Eaton, Konner & Shostak 1988), such is the slow pace of change in the human gene pool (Flannery 1994; Lewin & Foley 2004). The slow movement in our ancestral genetic lines supports the logic of using the long-standing, stable late Paleolithic pre-agricultural phase of human evolution as a reference standard for modern-day nutrition needs.

### 2.2.3 Overview of the dietary patterns through hominin evolution

The following section outlines key dietary changes in the progression of hominin evolution. This provides the historical background necessary for contextual understanding of the subsistence strategies of more recent (20th century) hunter-gatherer societies as analysed in the remainder of the thesis.
Since the divergence of the human and ape lines, ancestral humans included an increasing amount of animal foods in their diet, right up until contemporary times, as illustrated in Table 1. Archaeological evidence confirms that there were large accumulations of animal remains where early humans lived, along with evidence of hunting and scavenging tools (Eaton & Konner 1985). The role that various vegetable foods played in the diet throughout human evolution is more difficult to assess because plant remains are poorly preserved. Nonetheless, it is well established that hominin evolution revolved around an omnivorous wild food diet with a variety of plant to animal food subsistence ratios depending on the geological period and geographical location (Southgate 1991). Subsistence strategies based on 100% plant food (vegetarian) are a very recent contemporary notion, which appear to be in discord with all other human evolutionary epochs.

<table>
<thead>
<tr>
<th>Ancestor</th>
<th>Notes</th>
<th>Million years ago (approx)</th>
<th>Foods: Listed in order of preferential consumption (as a percentage of daily energy intake)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apes</td>
<td></td>
<td>&gt; 15</td>
<td>Specialised leaf / fruit eaters</td>
</tr>
<tr>
<td><em>Australopithecus</em> a<em>farensis</em></td>
<td>Very early hominin – small, upright stance.</td>
<td>~ 4.5</td>
<td>Fruits / Roots / Nuts / Animals (animals &gt;10% energy)</td>
</tr>
<tr>
<td><em>Homo habilis</em></td>
<td>First tool maker</td>
<td>~ 3</td>
<td>Fruits / Animals / Roots / Nuts (animal foods &gt; 20% energy)</td>
</tr>
<tr>
<td><em>Homo erectus</em></td>
<td>Tall, large brain, big game hunter</td>
<td>~ 1.5</td>
<td>Animals / Fruits / Roots / Nuts (animal foods 20–50% energy)</td>
</tr>
<tr>
<td><em>Homo sapiens</em></td>
<td>Organised big game hunters</td>
<td>~ 400,000</td>
<td>Animals / Roots / Fruits / Vegetation / Nuts / Seeds (animal foods estimate &gt; 60% )</td>
</tr>
<tr>
<td><em>Homo sapiens</em> living Australia today</td>
<td>Now</td>
<td></td>
<td>Other* / Grains / Fruit &amp; Vegetables / Animal meats / Dairy / Nuts (animal meat &lt; 15% energy) See Chapter 7 for more details on the modern Australian diet. (* = added oils, fats, sugars, alcohol and other processed foods)</td>
</tr>
</tbody>
</table>

Table 1. Hypothesised dietary changes through human evolution (Significantly modified from Mann 2007b)

Historical evidence strongly suggests that from around 400,000 years ago, and certainly by 120,000 years ago when the Cro-Magnons and other truly modern human beings appeared, big game hunting increased (Flannery 1994). From a nutritional perspective this resulted in an efficient foraging strategy as the higher calorie fat deposits and organ tissues of big animals were included in the diet. This was a time when the human
population was still small in relation to the biomass of available fauna (Eaton & Konner 1985).

However, in the late Pleistocene (50,000 to 20,000 years ago) a great number of large mammalian species and other terrestrial animals became extinct around the world, possibly due to a combination of over hunting by humans and climatic changes (Flannery 1994). After this time, a broader range of subsistence strategies appears to have been employed. Archaeological sites dated from 20,000 years ago to more recently show evidence of fish, shellfish, and small game remains, as well as tools that were useful for processing plant foods including grindstones, mortars and pestles (Eaton & Konner 1985). This broader spectrum subsistence pattern most closely resembles the diets observed in recent hunter-gatherer societies, which have been analysed by Cordain et al. (2000), Eaton et al. (Eaton, Eaton & Konner 1997; Eaton & Konner 1985) and others, as discussed in Section 2.3.

The development of agriculture some 10,000 years ago significantly altered human nutrition. It marked the transition from food collector to food producer (Cavalli-Sforza 1980). The change occurred within a few thousand years and it occurred independently in several parts of the world. Two causative factors have been hypothesised: (i) population pressure (resulting in declining wild food sources) and (ii) climate change – the latter now considered more persuasive (Lewin & Foley 2004). It is the agrarian system from which we now eat, and the nutritional (and lifestyle) implications of this stage of human evolution are discussed in depth throughout this thesis.

### 2.2.4 Evidence of recent adaptive evolution and the discordance hypothesis

Today, the search for adaptive evolution in the human genome is at the beginning of a new era with the ability to do genome-wide surveys of genetic variation (McVean & Spencer 2006). The mapping of the human genome has meant that the search for mutations associated with evolution has shifted from studies of a few loci to genome-wide surveys of up to a million polymorphisms (McVean & Spencer 2006). Consequently, the scale and nature of how evolutionary biologists can now look at adaptive evolution is expanding. Despite these advances McVean & Spencer (2006)
state that, ‘making sense, let alone use, of such experiments is far from straightforward’ (p.654). Given the dynamic interplay between genotype, phenotype and environment, it is to be expected that the information yielded from genome scans is incomplete. Accordingly, McVean & Spencer (2006) emphasise that a good understanding of the functional implications of any observed changes are far more important. Therefore, in ‘functional’ terms, Australians, like other industrialised, populations are not functioning optimally. Our very high prevalence of obesity, metabolic disorders, cardiovascular diseases and other ‘Western lifestyle diseases’ are testament to this (see Chapter 3). In response to these observations, Eaton (Eaton, Eaton & Konner 1997; Eaton & Konner 1985) and Cordain (Cordain et al. 2000; Cordain et al. 2005) proposed the ‘discordance hypothesis’, which refers to discord between modern lifestyle factors and the different environmental conditions that shaped our slowly adapting genome.

The vast majority of our modern genes are still programmed in the same way they have been for at least 40,000, if not 100,000 years or more, irrespective of the rapid changes in environmental ‘selective pressures’ operating in contemporary life. Contemporary environmental changes have simply occurred too recently for adaptive evolution to ‘catch up’. The only clearly recognised examples of genetic change occurring in the past 10,000 years are particular haemoglobinopathies and the retention of intestinal lactase into adulthood in some population groups (Burger et al. 2007; Eaton & Cordain 1997) – the latter example directly correlating with the domestication of animals and dairy consumption. This is an example of how diet can and does act as a distinct selective pressure on evolutionary change, albeit relatively minor in this case.

Despite the slow pace of natural biological evolution, there are instances where technological advances can theoretically speed up evolutionary change. For example, the future of medicine may be dominated by the biotechnology industry which is creating the possibility of removing disease-associated genes in a mere instant – genes which have persisted throughout tens of thousands, if not hundreds of thousands of years of natural selection. Fertility treatments likewise are able to side-step natural laws. Therefore, it could be argued that today’s technological and medical advancements, which are enabling the vast majority of pregnancies to result in viable offspring and for those children to reach reproductive age, could in fact cause a ‘reverse evolution’ by preventing unfit genes from being removed from the gene pool (Douglas 2006). Gregory Cochran, adjunct professor of anthropology at the University of Utah in Salt Lake City states, ‘relaxed selection combined with a high mutation rate is probably causing
gradual deterioration of many functions, especially disease defenses’ (cited in Douglas 2006 p.31). But, at the same time, higher education and contraceptive control is driving ‘ assortative’ mating – for intelligence, personality, physical health, mental health and attractiveness (Miller 2000). The effect of which may increase the frequency of these human features in the population.

As analysed throughout this thesis, our present dietary and lifestyle reality (including declining nutrient density in our diets, sedentism, indoor living and exposure to environmental pollutants) may still be operating at levels that are sustainable for reproduction, however quality of life and longevity are being affected (see Chapter 3). In contrast to contemporary environments, the differences in our ancestral environment – despite variations across time and geographic region – were minor compared with their essential similarities (Eaton, Cordain & Lindeberg 2001).

Eaton, Shostak & Konner (1988) state, ‘ evolution has been shuffling and re-dealing our genetic cards for over a billion years, and as a result, the hands we are likely to have drawn at conception are well-suited for the game of life’ (p.266). We are each subtly unique in our make up. Some of us are dealt a better hand of ‘cards’ than others which means that some can get away with poorer food and lifestyle choices. On the other hand, some people have little latitude for error. Yet, despite individual variability, collectively our lifestyle has changed so significantly that the ‘game’ we’re genetically suited to has rules that were established and finely tuned in an environment quite different to our present-day conditions. Thus, the rules have changed and in the new game many of us have losing hands that contain cards which are susceptible to degenerative disease and suboptimal health. While we will live and die with the genes we are born with, our dietary and lifestyle choices can be changed to more selectively include the essential conditions which supported our evolution.
2.3 **Hunter-Gatherer Diets**

‘The food of the Utes consists of a great variety of articles such as nuts, seeds, fruits, fleshy stalks of plants, bulbs, roots, inner bark of trees; many mammals, birds, reptiles, fishes and insects’ – John Wesley Powell’s ethnography of the Canyon Country’s Ute Indians (USA)

*(Fowler, Euler & Fowler 1969 p.22)*

‘Before European settlement Aboriginal Australian ate rich, exciting and balanced diets of seasonal fruits, nuts, roots, vegetables, meats and fish – all indigenous varieties and species and each totally adapted to this unique environment, the continent of Gondwanaland’ *(Isaacs 1987 p.11)*

2.3.1 **Wild food**

As outlined, wild food and the hunter-gatherer lifestyle have sustained humanity for well over 99% of our existence *(Cordain et al. 2000; Crawford & Marsh 1995)*. Throughout this time humans have lived through periods of profound ecological change that altered the plant and animal food species available for consumption. However, overall there were far greater nutritional similarities in the diets of various worldwide hunter-gatherer societies than there are between our contemporary Western diets and those afforded by the wild food supply *(further discussed in Chapter 7)*. The characteristics of the wild food supply and the diets of 20th century hunter-gatherer societies are examined in this section for comparative purposes.

The wild food menu is most simply categorised into *plant foods* and *animal foods*. Animal foods include terrestrial species such as land-living mammals, insects, reptiles, birds and their eggs, along with aquatic species including fish and shellfish. Plant foods can be recognised with the same categories applied today – fruits, vegetables, nuts, seeds and other vegetation. As a general rule, the energy density of wild foods is low, with some highly sought-after exceptions including high fat organ meats, in-season animal fat deposits and honey (minimal). Correspondingly, the nutrient density of wild food is high, providing a rich source of vitamins, minerals, antioxidants,

In contrast to conventional agriculture, plants and animals living in their natural habitat are in control of their own nutrient intake, and live in the ecological niches to which they are adapted. Therefore, in this thesis, the term ‘wild food’ is used to define foods which are in control of their own nutrient supply and situated in their natural ecological niche. As numerous examples provided throughout this thesis indicate, when animals and plants are living within conditions aligned to their natural state, the nutritional properties derived from such foods tend to be exceptional. ‘Exceptional’ is of course a relative term, indicative of the comparative differences between wild versus contemporary foods. ‘Exceptional’ is therefore ‘normal’ within a wild food frame of reference.

In terms of dietary diversity, the general consensus in the literature is that a greater year round variety of foods were typically eaten in hunter-gatherer diets (Eaton & Konner 1985) than Western diets today – even ‘healthy’ contemporary diets. Suzuki (1990) estimates that around 75,000 edible plants exist in the wild. In contrast, conventional agriculture is based around 20 major crops, with cereal grains contributing by far the greatest percentage (Cordain 1999).

A common notion in some of the historical literature is that hunter-gatherer existence was a treacherous struggle against adverse conditions (Cunnane 2005; Flannery 1994; Wilber 2000). As Lewin (1988a) writes, the perception has been that hunter-gatherer populations were ‘tenuously clinging to survival until the invention of agriculture brought their tedious and hazardous life to an end’ (p.1147). In part this reflects the post colonial times in which Darwin’s (1859) *The Origin of the Species* was written, from which stemmed the prevailing ‘survival of the fittest’ concept. However, from a nutritional perspective, there is little evidence to suggest that hunter-gatherer groups had to endure periodic food scarcity (unlike agrarian societies); (Cordain 1999; Cordain, Miller & Mann 1999). For example, DeVore and Lee’s ethnographic studies of the !Kung3 bushmen of the Kalahari Desert, Africa, showed that they were able to satisfy their material needs with just a few hours work each day (Lee & Daly 2004). This is in

3 The ‘!’ preceding the world Kung denotes a ‘click’ sound in the !Kung language
contrast to the large percentage of each day spent at ‘work’ for today’s average Australian.

Dependence on agriculture and domestication enabled food resources to become more controlled and somewhat more predictable; however, it also created a vulnerability as adverse climatic conditions and uneven distribution systems potentially result in chronic shortages, leaving people without adequate diets (Gordon 1987). In contrast, the greater mobility and more diverse diets of hunter-gatherer societies minimised the risk of losses due to natural fluctuations in the food supply (Cunnane 2005; Lewin 1988; McMichael et al. 2007) – a situation likely aided by low population density and territorial vigilance (Lewin & Foley 2004). Cunnane (2005), among others, hypothesises that while individuals and small groups may struggle to survive in isolation, a whole species doesn’t struggle to evolve. Rather, he suggests that evolution occurs in the context of opportunity, not adversity. If sufficient variation exists in a species, and the environmental opportunity unfolds (such as a nutritional opportunity), a living organism will evolve/change/adapt to its benefit.

What follows is an overview of the nutritional characteristics of edible wild plant and animal food groups with comparative reference to contemporary foods provided. The purpose of doing so is to orientate ourselves towards better utilising the modern food supply to capture the essential features of our evolutionarily adapted wild food diet.

2.3.1.1 Wild plant food

2.3.1.1.1 Fruits

Domesticated fruits (and vegetables) available in supermarkets today are bred for a blemish free appearance, long storage capacity, and robust transportability. They tend to contain high water content, be picked unripe and chemically ripened, and consequently lack flavour complexity. In contrast, wild fruits typically have a high seed-to-pulp ratio, a less pronounced purely sweet taste (i.e. not necessarily as ‘sweet’ but are more complex/diverse in flavour profile) and often have a less perfect appearance (Milton 1999b). Wild fruits (and vegetables) also typically contain more fibre, have higher
average protein levels, and higher levels of micronutrients (vitamins and minerals) than their cultivated counterpart (Brand-Miller & Holt 1998; Milton 1999b; Southgate 1991).

Research also indicates that wild plant foods appear to contain a higher phytochemical content (non-nutritive, biologically active compounds); (see for example Netzel et al. 2006). As more extensively discussed in Section 4.2.1, many phytochemicals have antioxidant properties as well as other disease-protective qualities (Hasler & Blumberg 1999; Holst & Williamson 2008; Hounsome et al. 2008; Netzel et al. 2006). Hence, just as with vitamins, minerals and other nutritive components, the content of health-supportive phytochemicals in wild foods may provide an important reference standard for optimal human requirements.

Hypothesised mineral differences between wild versus cultivated plant foods have also been noted in the literature. Brand-Miller and Holt’s (1998) analysis of Australian Aboriginal bush foods found that mineral concentrations (including iron, calcium, magnesium, copper, potassium, phosphorous and zinc) were significantly higher than in cultivated varieties. This finding is similar to the results of wild food analyses from other global regions (Eaton, Eaton & Konner 1997). Likewise, research by Nelson et al. (cited in Milton 1999b) found that wild fruits from American Samoa showed significantly higher levels of copper, iron, sodium and calcium than cultivated fruits. As seen in Table 2, the average mineral content of several examples of wild plant foods (including fruits, leafy greens and root vegetables) are typically superior to cultivated varieties.

<table>
<thead>
<tr>
<th>Food</th>
<th>Mineral density of wild and cultivated plant foods (mg/g dry weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Ca</td>
</tr>
<tr>
<td>Wild plants in Panama*</td>
<td></td>
</tr>
<tr>
<td>• young leaves</td>
<td>14.9</td>
</tr>
<tr>
<td>• ripe fruits</td>
<td>12.7</td>
</tr>
<tr>
<td>Wild fruits in Samoa*</td>
<td>5.1</td>
</tr>
<tr>
<td>Australian bush foods (average)*</td>
<td></td>
</tr>
<tr>
<td>• fruit</td>
<td>14.2</td>
</tr>
<tr>
<td>• roots</td>
<td>19.5</td>
</tr>
<tr>
<td>• leaves</td>
<td></td>
</tr>
</tbody>
</table>
Additionally, Milton (1999) observed differences in the types of sugars contained in wild versus domesticated fruits. Wild fruits tend to be hexose-dominated (some fructose and considerable glucose) whilst domesticated crops tend to be higher in sucrose (disaccharide of glucose and fructose). The potential impact of this difference on human health has not been discussed in the literature, but future research into the glycaemic index difference and effects on gut microflora and fermentation products would be interesting.

2.3.1.1.2 Leafy greens

Leafy greens are abundantly available in the wild. They were frequently eaten in hunter-gatherer diets (except in Artic regions where snow cover was preventative), providing important sources of calcium, magnesium, folate and fibre (as a few standout nutritive factors); (Brand-Miller & Holt 1998). For example, Gott (1993) describes traditionally living Victorian Aboriginal (Koorie) women returning to camp along the Murray River loaded down with green forage plants including the sow thistle, dandelion yam and trefoil. These plants were often eaten raw as a salad.

2.3.1.1.3 Underground plant storage organs: roots, tubers & bulbs

‘Lengths of the rhizome were softened by roasting in the coals or steaming in an earth oven, then outer cortex was stripped off, the starchy, fibrous inner tissues were then twisted into a simple knot and chewed. The taste and floury texture are like cooked potato...(The Liliaceae family of tubers e.g. murnong) yield large numbers of tubers per
Consumption of root vegetables and tubers has become a contentious issue in the evolutionary nutrition field. Cordain (2002; 2006) advocates the exclusion of starchy root vegetables from modern-day diets on the basis that modern cultivars contain more starch and elicit a higher glycaemic response than their wild counterparts. In contrast, Lindeberg (2007) recommends their intake in his interpretation of a contemporary hunter-gatherer diet. This issue is further discussed in Chapter 6.

Despite Cordain’s interpretation of a ‘contemporary’ hunter-gatherer diet and his exclusion of starchy plant foods, his analysis of historically studied worldwide hunter-gatherer diets demonstrates that wild tubers were a common component of the diet, comprising 23.6% of all the plant food consumed on average (Cordain et al. 2000). Furthermore, Wrangham et al. (1999) hypothesis is that cooked underground storage organs were particularly important to hominin evolution (and human brain expansion) to such an effect that their ‘energy availability played a permissive role in the intensification of hunting – a high-risk, high-gain activity – much the way periods of fruit abundance seem to allow intensification of chimpanzee hunting’ (p.572).

Records of traditional Australian Aboriginal diets certainly suggest that a variety of roots, tubers and bulbs were frequently eaten (Brand-Miller & Holt 1998). Many of these underground storage units were available year-round, unlike fruits and seeds, thus making them an important food source (Gott 1993). In fact, the main vegetable food in Aboriginal diets of south-eastern Australian were roots and tubers (Gott 1993). Heavily consumed species included Dioscorea species (yams), Ipomoea costata (wild potato), Cyperus species (native onion) and Microseris scapigeris (murrnong or yam daisy, as pictured in Figure 7); (Brand-Miller & Holt 1998). The roots of each of these species are easily accessible and collected at relatively shallow depth, and the plants spread rapidly over large areas by means of rhizomes and thus were an abundant food source, particularly in open areas. Cooked starches are highly digestible and their bountiful availability would have made them a favourable food in terms of energy return for energy expenditure for many hunter-gatherer groups.
As Gott (1983) states, ‘it is clear that the labour involved in the collection of murnong was not arduous’ (p.9). Where tubers were ecologically available, Gott (1983) states that it is realistic that about 2kg of yam daisy tubers (*Microseris scapigera*) were eaten per person per day yielding about 5250kJ energy. In other words, a little under half of the day’s energy was obtained from tubers for three quarters of the year (however, these were not eaten in winter as they become dry and bitter). Confirming this, observations of Koorie women in the year 1841 noted them to be conservatively carrying around 8kg of tubers each (Gott 1983). Other sources of starchy foods in the Victorian Aboriginal diet included *Typha sp* root, commonly called ‘bullrush’, which grows in almost any body of fresh water and in seasonally wet areas (Gott 1982). Hence, starch-containing tubers were clearly a major food source in some hunter-gatherer diets. Further evidence of the value placed on tubers as an important food group is provided in the diary of William Buckley, an escapee English convict who lived with Koories on the Victoria Surfcoast (Torquay, Point Addis, Angelsea) who described how his tribe journeyed for fourteen days carrying eels to be traded for roots with another tribe on the Barwon river (Gott 1993).

The starch content of wild roots and tubers varies widely. Some are similar to a potato and others are like carrots (Brand-Miller & Holt 1998). Compared to their cultivated
equivalents, wild tubers tend to be very fibrous (Gott 1993), often contain higher micronutrient values (Brand-Miller & Holt 1998), and have a lower carbohydrate content on a per weight basis (Brand-Miller & Holt 1998). Many contain a higher amylose to amylopectin ratio (amylose is slower than amylopectin to starch digestion) than modern potatoes and sweet potatoes, which lowers their glycaemic index (Thorburn, Brand & Truswell 1987).

Table 3 shows some of the nutritional differences between the two staple tubers of the Koorie diet compared to potatoes and sweet potatoes found in supermarkets today.

<table>
<thead>
<tr>
<th>Tuber/Root (100g)</th>
<th>Energy (kJ)</th>
<th>Protein (g)</th>
<th>CHO (g)</th>
<th>Fibre (g)</th>
<th>K (mg)</th>
<th>Na (mg)</th>
<th>Mg (mg)</th>
<th>Ca (mg)</th>
<th>Fe (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild tubers growing in Victoria*:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yam Daisy (Microseris scapigera)</td>
<td>229-302</td>
<td>1.7-2.5</td>
<td>10-14</td>
<td>7-11</td>
<td>156-251</td>
<td>16-27</td>
<td>16-34</td>
<td>27-65</td>
<td>6.5-1.7</td>
</tr>
<tr>
<td>Bullrush (Typha sp.)</td>
<td>277-288</td>
<td>1.7-2.8</td>
<td>5-14</td>
<td>12-21</td>
<td>51-66</td>
<td>58-70</td>
<td>80-85</td>
<td>44-34</td>
<td>1.2-3.6</td>
</tr>
<tr>
<td>Modern cultivars of tubers available commercially^:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweet potato</td>
<td>273</td>
<td>1.9</td>
<td>14</td>
<td>2</td>
<td>250</td>
<td>10</td>
<td>14</td>
<td>27</td>
<td>0.5</td>
</tr>
<tr>
<td>Potato</td>
<td>273</td>
<td>2.4</td>
<td>13</td>
<td>2</td>
<td>450</td>
<td>3</td>
<td>19</td>
<td>4</td>
<td>0.6</td>
</tr>
<tr>
<td>Parsnip</td>
<td>208</td>
<td>1.8</td>
<td>10</td>
<td>2.5</td>
<td>420</td>
<td>19</td>
<td>24</td>
<td>38</td>
<td>0.3</td>
</tr>
</tbody>
</table>

* Data sourced from Brand-Miller, James & Maggiore (1997)
^ Data sourced from Xyris Software (2007)
All values are for raw food

Table 3. Nutritional comparisons between wild and commercial tubers

As can be seen in Table 3, direct comparison shows that energy, carbohydrate (albeit different carbohydrate composition) and protein is similar between these wild and cultivated varieties. There are some differences in micronutrient density, with the two wild varieties analysed here containing more magnesium and iron. One of the clearest differences is in fibre content. Fibre slows down gastric emptying and reduces the glycaemic index of a food (Brand-Miller et al. 1998). That being said, starchy tubers, whether they are wild or cultivated, are typically eaten within the context of a total meal that also includes protein and fat – factors known to reduce the glycaemic index of the complete meal (see Section 5.2.4). Hence, the inclusion of roots and tubers (sweet potatoes, potatoes, parsnips etc) in a modern-day interpretation of the hunter-gatherer is considered reasonable in this thesis (refer to Chapters 7 and 8 for further discussions of what a ‘contemporary hunter-gatherer diet’ may include).
2.3.1.4  **Nuts and seeds**

Wild nuts and seeds provided an easily accessible source of calories for hunter-gatherers, and are a highly nutritious food, often available in winter months. Most nuts predominate in fat (monounsaturated and polyunsaturated – particularly rich in omega 6 fatty acids) – for example, macadamia nuts, almonds and walnuts. Others are higher in carbohydrate [e.g. chestnuts, acacia (wattle) seeds]. They also provide important dietary sources of micronutrients and trace elements. While not getting too immersed in citing epidemiological research or clinical trials examining the relationship between individual foods and certain diseases, it is interesting to be aware that Jiang et al. (2002) found that nut consumption was inversely associated with risk of type 2 diabetes after adjustment for age, body mass index, family history of diabetes, physical activity, smoking, alcohol use, and total energy intake. Jiang et al. (2002) proposed that the fatty acid profile, fibre content, low glycaemic index and magnesium content, as well as other minerals, vitamins, antioxidants and plant proteins found in nuts, may play an important role in reducing risk of type 2 diabetes. To avoid increasing caloric intake, Jiang et al. (2002), state that regular nut consumption can be recommended as a replacement for consumption of refined grain products or red or processed meats’ (p.2554). This advice, except for the displacement of red meat, fits well within the hunter-gatherer model.

2.3.1.5  **Cereal grains**

Wild ecosystems are diverse and tend not to be dominated by any one species in isolation, certainly not to the extent that is generated by agriculture. In the world today, eight cereal grains (wheat, corn, rice, barley, sorghum, oats, rye and millet) provide more than half of our food energy and 50% of the protein we consume (Australian Institute of Health and Welfare 2006b; Cordain 1999). Contrastingly, in the wild, grass seed – grains – can only be collected seasonally, where available, and the diversity of natural ecosystems in the past placed a natural curb on the quantity that could be consumed. As Cordain (1999) states, ‘there is little or no evolutionary precedence in our species for grass seed consumption’ (p.21) – at least not in the quantity in which it is consumed today, as further discussed in Section 2.7. While archeological findings of grindstones have been dated back as far as 280,000 years ago (see Figure 4), their uses appear to be unrelated to grain consumption (Cordain 1999; Jones 2007).
Further complicating the contemporary nutritional picture is the consumption of refined grains and modern hybridised varieties. As noted in Section 5.1.2, the overall micronutrient diversity and density in grains is lower than vegetables, fruits, seafood and meats. Thus, a high intake of this food group has the capacity to displace nutrients in the diet. In particular, cereal grains contain no vitamin A, or its precursor beta-carotene. In the Australian diet, this is of no great consequence because the diet is varied enough and not solely dependent on grains. However, in global regions where cereal grains are exclusively subsisted off, vitamin A deficiency is widespread, causing blindness and other vitamin A deficiency-related diseases and even death (Mayer 2007). The biotechnology world is heavily invested in a variety of rice (‘golden rice’) genetically modified to produce carotenoids – vitamin A precursors – to avert this problem (Mayer 2007).

Aside from vitamin A, a very high intake of grains, particularly refined grains, is also associated with B-group vitamin deficiencies. In addition, natural antinutrients present in grains tend to reduce the bioavailability of many minerals. Further information on the nutritional analysis of cereal grains from an evolutionary perspective can be found in Cordain (1999).

### 2.3.1.2 Wild animal food

Animal food has been part of human subsistence throughout evolution. A number of lines of evidence, including fossilised stone tools and cut marks on animal bone remains suggest that humans regularly ate animal foods procured either by scavenging or hunting (Lee-Thorp, Thackeray & van der Merwe 2000). Animals provided an invaluable source of protein (skeletal muscle) and fats (adipose tissue, organs and bone marrow) in hunter-gatherer diets.

Wild animal species used as food by hunter-gatherer societies naturally varied around the globe. For example, depending on location, Aboriginal Australians ate a diversity of terrestrial and aquatic animals including reptiles (snakes, lizards), birds, shellfish (oysters, mussels, abalone, crayfish, yabbies etc), turtles, dugong, kangaroo, possum, goanna, fish, insects/snails/worms (Miller, James & Maggiore 1997). The animal foods that predominated in diets of the Canadian Arctic Inuit were also species-diverse and
included seal, caribou (deer), Arctic char, narwhal, walrus, duck, clams, mussels, polar bear, moose, rabbit, rodent (Muskrat), whitefish, beaver, trout, game birds (Ptarmigan), and salmonid fish (Inconnu); (Kuhnlein 1994).

As noted, at some point after hominins and apes diverged and an increasing amount of animal food was incorporated into the diet (until the decline that occurred in contemporary times). The hypothesised rationale behind this shift is explained by the optimal foraging theory (Mann 2000). This theory refers to the idea that food choices in hunter-gatherer times can be explained in terms of a cost to benefit ratio i.e. energy expenditure/risk versus nutritional benefit. Wild fruits and vegetables tend to be of low energy density (Brand-Miller & Holt 1998) and the high physical energy and time spent in collecting them is not as well rewarded in terms of energy return compared to animal foods (Mann 2000). Historical records indicate humans’ preferential use of large mammals over smaller prey. In fact, such was the strength of the preference that Flannery (1994) hypotheses is that humans have probably been directly responsible for the extinction of many of the world’s large mammals, particularly in Australia, as they were preferentially hunted for food.

Why was there a preference for large mammals over smaller prey, like birds, possums or reptiles, given the inherent risk to human life in hunting large, wild animals? The answer is that large animals contain a greater absolute amount of fat than smaller animals (based on size alone). Every calorie of fat yields twice (37kJ/g) the energy of plant material (carbohydrate yields 16kJ/g) or skeletal muscle protein (17kJ/g), and hence, capturing animals with larger fat deposits was advantageous. Furthermore, in the wild, fat – particularly saturated fat – is a limited nutrient. Carbohydrate reserves are plentiful in fruits, root vegetables and other plant material; and protein was abundant in the form of animal skeletal muscle. Excessive protein intakes had to be curbed to avoid toxicity (See Section 5.1.1 for further information on protein toxicity.) Wild animals are very lean and contain on average only one-fifth the saturated fat of domesticated animals because of their free ranging living conditions and indigenous diets (Cordain & O'Keefe 2004; Eaton & Cordain 1997). Hence, fat reserves in the wild were the prized commodity. Large animals provided important fat sources in the form of organ tissues, bone marrow (mono- and poly-unsaturated fats) and minimal quantities of adipose tissue. Other fat sources included nuts, seeds and insects (predominantly mono- and polyunsaturated fats). It may be of some comfort to those in today’s world who enjoy fatty foods that there is an evolutionary basis to it.
Dairy, a commonly consumed animal food today, was never part of the hunter-gatherer diet beyond infancy (breast milk) due to the inherent difficulty of catching a wild animal, holding it still and milking it. Rather, animals were killed and the edible matrices consumed.

2.3.1.3 Beverages

2.3.1.3.1 Water

Water was almost the exclusive beverage in hunter-gatherer societies (O'Keefe & Cordain 2004). Teas brewed from various plants may have also been drunk. As with many plant foods, teas contain high levels of phytochemicals which may offer broad health promoting qualities (Chen et al. 2008).

In contrast, as seen in Table 4, 42% and 32% of the daily fluid intake for Australian men and women respectively is sourced from coffee, soft drinks and other non-alcoholic drinks (e.g. fruit juice). Soft drinks were of course unavailable in our ancestral diet, as were fruit juices, which required the advent of pressing technology for their production.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Males g/person/day</th>
<th>Females g/person/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total fluid intake</td>
<td>2,052</td>
<td>1,917</td>
</tr>
<tr>
<td>Water</td>
<td>855</td>
<td>849</td>
</tr>
<tr>
<td>Tea</td>
<td>345</td>
<td>452</td>
</tr>
<tr>
<td>Coffee</td>
<td>375</td>
<td>379</td>
</tr>
<tr>
<td>Soft drinks</td>
<td>236</td>
<td>126</td>
</tr>
</tbody>
</table>

*Table 4. Australian’s average daily intake of non-alcoholic fluids (Sourced from Australian Institute of Health and Welfare 2006b)*

All biochemical reactions in the body occur in water. Inadequate intake results in impaired physiological responses and impacts on disease susceptibility with known possibilities including increased thrombotic tendency, urinary stones and colon cancer (Australian Institute of Health and Welfare 2006b). Older adults exhibit decreased thirst sensation and reduced fluid intake (Kenney & Chiu 2001). Intake of water decreases with age in the Australian population (Australian Institute of Health and Welfare 2006b) and hence, the elderly are particularly vulnerable to inadequate water intake.
2.3.1.3.2 **Alcohol**

There is little evidence that hunter-gatherers consumed a significant amount of alcohol (Cordain et al. 2005). Theoretically, sugars found in honey, nectars, gums and fruit could have been fermented to yield alcohol, however these foods tended to be eaten fresh. Also, fermentation of fruit and honey sugars produces an alcohol content far lower than that achieved by modern distillation techniques. The earliest known evidence of grapes (from domesticated vines) being made into wine comes from a pottery jar dated to 7,400–7,100 BC from northern Iran (Cordain et al. 2005). There is evidence that Australian Aborigines in Tasmania allowed the sap of *Eucalyptus gunnii* (cider Gum) to ferment (Gott 1993). However, by and large, it is unlikely that alcoholic beverages were a significant contributor to total daily energy intake in the average hunter-gatherer diet.

2.3.2 **Energy intake and nutrient throughput**

Higher energy intake was necessary in hunter-gatherer life relative to the sedentary lifestyle of many contemporary Australians. This, combined with the recent appreciation that Paleolithic humans were as tall as members of current affluent societies (Eaton, Eaton & Konner 1997), means that our ancestors likely had higher metabolic demands and therefore a higher throughput of food. Considering that the hunter-gatherer diet was 100% comprised of nutrient-rich wild vegetables, fruits, seeds, nuts and lean game animal foods (non dairy) – all eaten fresh and minimally processed – the human ancestral diet would have supplied a greater nutrient flow through than the average Australian diet today. Furthermore, the nutrient density of the average hunter-gatherer diet was likely in excess of the recommended Australian Nutrient Reference Values (as further discussed in Chapter 7).

The average hunter-gatherer’s daily energy intake has been estimated to be around 12,500kJ per day (Cordain et al. 2000). Today, Australian’s consume on average 11,050 kJ/person/day for males and 7,481 for females (Australian Institute of Health and Welfare 2006b). This lower figure reflects our more sedentary existence today. Thus, in the context of sedentary lifestyles and therefore lower calorie expenditure, even if
‘hunter-gatherer’ food groups are eaten today, the nutrient throughput would be lower than our Paleolithic ancestors, and therefore theoretically less ideal for optimal nutrition status.

When whole foods are eaten in the wild, as energy intake increases, so too does micronutrient intake. By contrast, in our industrialised Western food supply many foods are nutritionally lacking whilst being calorie dense (e.g. heavily refined and processed foods). This results in a situation commonly referred to as ‘over-consumptive malnutrition’.

Athletes are an interesting population to study in this regard because of their high energy demands. Athletes consuming a typical Western diet, while being able to consume the calories they require, are particularly vulnerable to what the author of this thesis has defined as caloric-balanced malnutrition. Energy needs may be met; however, they are typically done so with a very high intake of cereal grains, which are often refined and processed (e.g. breads, breakfast cereals and pastas).

The Australian Institute of Sport (AIS) has published a booklet titled Current Concepts in Sports Nutrition (Burke et al. 2008) which summarises sports nutrition strategies for elite athletes. The booklet suggests that the requirements of athletes can be met by consuming a diet that (Burke et al. 2008):

- ‘provides adequate total energy’
- ‘balances carbohydrate intake with daily exercise loads’, and
- ‘includes a wide variety of nutrient-rich foods including protein-containing foods’. The top seven food items listed as being good ‘nutrient-rich’ food choices are: ‘liquid meal supplement, milk shake, flavoured low fat milk, flavoured yoghurt, creamed rice, sports bars, breakfast cereal with milk’ (Burke et al. 2008 p.3).

Hence, the AIS recommendations are focused on meeting calorie needs and adequate macronutrient intake. From an evolutionary perspective, their definition of ‘nutrient-rich foods’ listed above is questionable. None of the foods listed were available in a pre-agricultural diet and all are highly processed and loaded with added sugars. A re-conceptualisation of sports nutrition from an evolutionary paradigm would alter
contemporary advice and theoretically provide a more supportive nutritional matrix for athletic performance and general health.

2.3.3  Traditional hunter-gatherer diets: Putting it all together

Having outlined the types of foods available in the wild food supply, this section turns its focus to understanding what meals actually looked like in traditional hunter-gatherer diets including how much plant food and how much animal food was consumed. The historical lines of evidence for determining this information are examined in this section, and further information on the nutritional characteristics of worldwide ‘recent’ hunter-gatherer diets are explored. All this information expands the picture of our nutritionally adapted past and better enables us to identify and integrate essential features when selecting more optimal contemporary diets.

2.3.3.1  Historical lines of evidence for estimating hunter-gatherer diets

Given that hunter-gatherer life in its purest form (i.e. completely unaffected by agricultural influences) is now basically extinct, re-construction of the pre-agricultural diet can now only be evaluated through indirect means (Cordain et al. 2000; Eaton, Cordain & Sebastian 2007). Circumstantial evidence has to therefore be drawn from the following areas:

1. anthropological ethnographic records of the diets of hunter-gatherer societies persisting into the 20th century
2. fossils and archaeological records
3. modern-day nutrient analysis of wild plant and animal foods
4. examination of our metabolic and biochemical pathways
5. studies of other primate diets
Ethnographic records

2.3.3.1.1 Ethnographic records

Ethnographies for 1,267 human societies from around the world were compiled by Murdock in the late 1960s; of which 862 of the more complete studies were included in his Ethnographic Atlas: A Summary (Murdock 1967). The atlas provides the most comprehensive quantitative overview and largest compilation ever published on 20th century hunter-gatherer societies from around the world. The atlas was used by Cordain et al. (2000) in their nutritional analysis of hunter-gatherer diets’ and forms the basis of his contemporary dietary recommendations as outlined in his numerous peer reviewed journal articles and his books The Paleo Diet (Cordain 2002b) and The Paleo Diet for Athletes (Cordain & Friel 2005). Cordain’s interpretation of hunter-gatherer diets is central to driving current ideas in evolutionary nutrition research and hence his work is a particular focus of this research.

Caution is required when interpreting ethnographies from a nutritional perspective, however, this is not to undermine their value as a data source. Ethnographies are almost entirely subjective and no standardised nutrition assessments are used. Anthropologists, in their primary degree, are not trained in nutrition science and historically have been more interested in social structures, gender roles, marital customs, etc than in recording detailed information pertaining to food intake and dietary biochemistry. Other recognised validity issues include the great difficulties faced by anthropologists working in the field, particularly having to learn a new language in a short time and having to tease out subtleties which undoubtedly are coloured by the researchers’ own ideologies (Lewin 1988a).

Furthermore, given the pervasive development of agriculture around the world, recent studies on remaining hunter-gatherer societies that are entered into the Ethnographic Atlas: a summary (Murdock 1967) have quite possibly been influenced by agrarian populations in the historical past (Lewin 1988a). The resultant effect on diet is unknown. Additionally, recent hunter-gatherers and their food sources may not be accurately representative of past humanity because, after 10,000 years of agricultural expansion, many hunter-gatherer groups that did survive into the 20th century would have been more ecologically and geographically remote (Jones 2007). This has certainly been the case among Australian Aborigines and consequently the results of dietary
analysis may be skewed towards less than ideal ecological niches such as desert regions (Brand-Miller & Holt 1998; O'Dea 1991a).

According to Cordain et al. (2000) portions of the *Ethnographic Atlas* (Murdock 1967) have been independently verified, however whether this verification extends to the recorded food intake is not stated by Cordain et al. (2000). One of the authors of the Cordain et al. (2000) paper, Professor Neil Mann from RMIT University, Melbourne commented that he was unaware of any study verifying the validity of the food records in the *Ethnographic Atlas* (N. Mann 2007, pers comm. 25th August).

### 2.3.3.1.2 Fossil and archaeological records

Fossil and archaeological records provide further data, such as the study of cranio-dental features, bone carbon 13/12 isotope ratios, bone strontium/calcium ratio, remains of hunted game, tools and weapons (Mann 2007b; Stanford & Bunn 1999). For example, teeth-wear patterns and jaw structures are well preserved and have been used in estimating the amount of plant versus animal food consumed in various hominin lineages (Cunnane 2005). Compared to the great apes, which are herbivorous animals, hominins had smaller jaws and teeth. Current theory suggests that this was the result of not needing to have as strong jaw muscles and large tooth surfaces to grind fibrous plant food because of the increased proportion of animal foods in the human diet (Cunnane 2005).

We are only able to gain insight into evolutionary changes in hominin hard tissues (i.e. bones, teeth) from fossil evidence, because, although likely, any changes in soft tissues (e.g. organs, muscles, brain) decompose rapidly and are far less likely to leave clear evidence. The same is true when attempting to estimate how much animal versus plant food our ancestors ate. Unlike the hard tissue remains of animals, plant food remains decompose and are rarely fossilised (Eaton & Konner 1985). Thus, fossil records alone are biased towards giving an indication of only the animal proportion of the diet (e.g. fossilised seashells and animal bones are found in middens, but there is rarely any evidence of plants food remains).
2.3.3.1.3 Modern-day nutrient analysis of wild plant and animal foods

Nutrient analysis of modern-day wild plant and animal foods provides a rich source of data for re-constructing the nutritional composition of hunter-gatherer diets. The most comprehensive record of wild food ever compiled was collaboratively carried out in the 1980s by three major scientific centres in Australia: the Human Nutrition Unit at the University of Sydney; the School of Community Health at Curtin University in Perth; and the Defence Science and Technology Organisation in Scottsdale, Tasmania (Brand-Miller & Holt 1998). Numerous edible Australian native fruits, vegetables, animal foods, seeds and nuts were analysed for the presence of protein, fat (non-differentiated), carbohydrate, fiber, ash, energy, minerals and vitamins. The results were published in the book Tables of Composition of Australian Aboriginal Foods (Brand-Miller, James & Maggiore 1997). Further discussion of Australian bush founds can be found in Section 2.5. Brand-Miller, James & Maggiore’s (1997) database was used by Cordain et al. (2000) in their paper estimating plant-to-animal food subsistence ratios and macronutrient compositions of average hunter-gatherer diets. The Cordain et al. (2000) paper is critiqued later in this section.

2.3.3.1.4 Human biochemical and metabolic pathways

Humans have genetically evolved around eating an omnivorous whole foods diet. The morphology of the human gut falls between the largely frugivorous (fruit eating) gut structure of our primate relatives such as chimpanzees and the adaptations of pure carnivores such as cats (Mann 2000).

Evolutionary selection pressure maintains enzymes and metabolic pathways in need and allows for the loss of those not required. Thus, the body is dependent on the dietary supply of certain vitamins, minerals, amino acids and fatty acids, while others can be made endogenously. Nutrients which can not be made endogenously tend to be called essential (e.g. essential fatty acids) because it is vital that they be supplied by diet. On one hand it seems advantageous to be independent of dietary variability. But on the other hand, if the diet can reliably contain nutrients that the body doesn’t have to make, it saves the production of enzymes and metabolic costs of manufacturing those substances (Cunnane 2005). Therefore it is most efficient for the human body to depend on diet for as many nutrients as possible.
For example, the amino acid taurine is not found in any plant food and is an essential nutrient for the human body. As Cordain and Friel (2005) write, ‘herbivores, such as cows, are able to synthesise taurine from precursor amino acids found in plants, whereas cats (who are purely carnivorous) have completely lost that ability’ (p.159). All animal foods are rich sources of taurine. Humans, having eaten an omnivorous diet throughout evolution have been able to afford to relax the evolutionary selective pressure required for endogenous taurine synthesis because it is steadily supplied by diet. We do have some ability to synthesise taurine in the liver; however, the mechanism is limited. Likewise we also have only a very limited ability to endogenously synthesise long chain polyunsaturated fatty acids (LCPUFA) from plant based precursor fatty acids due to our long – two million year – evolutionary exposure to preformed LCPUFA in the diet from both sea and land animal foods (Plourde & Cunnane 2007).

Hence, through evolutionary experience we have become biochemically wired around having a reliable and steady supply of certain nutrients from an omnivorous diet. Failures in this supply chain leave the body operating on limited, inefficient and in some cases inadequate mechanisms (e.g. inadequate omega 3 LCPUFA intake in the contemporary Australian population, as discussed in Section 5.2.3), which creates the potential for health vulnerabilities.

2.3.3.1.5 Other primate diets

Apes are human’s nearest primates. They are mostly plant eaters and have a large gastro-intestinal tract to enable nutrients to be extracted from their fibre-rich diet. As mentioned, after our divergence from the great apes, hominins included an increasing amount of animal food (high energy density, especially fatty tissues) into the diet which allowed natural selection to relax the former selective pressure on requiring a large metabolically active gut, and probably facilitated the opportunity for the expansion of the metabolically ‘expensive’ human brain (Aiello & Wheeler 1995). However, the food choices of our nearest living relatives may still hold nutritional lessons for us today (Milton 1999b).

For example, a recent study by Felton et al. (2009) found that monkeys (herbivores) have a consistent daily protein intake of between 11g and 12g per day regardless of the
season or whether they eat fruit only or higher-protein leaves and shoots. When 100% of the diet was obtained from fruit, these monkeys still got the protein they needed but did it by gorging themselves until they reached their protein needs. In regards to humans, the ensuing hypothesis is whether humans, like monkeys, keep consuming food and energy until we reach our protein target. It may be possible that a similar response plays out for other nutrient targets, and nutrient-deficient contemporary diets may be a risk factor for increased energy intake and part of the current obesity pandemic.

### 2.3.3.2 Nutritional characteristics of ‘recent’ hunter-gatherer diets: How much plant food versus animal food? A critique of Cordain et al. (2000)

The paper by Cordain et al. (2000) ‘Plant-animal subsistence rations and macronutrient energy estimations in worldwide hunter-gatherer diets’, published in the American Journal of Clinical Nutrition, has been a most influential paper on current opinion in evolutionary nutrition and in contemporary interpretations of the Paleolithic diet. As mentioned, Cordain et al. (2000) derived their data on the subsistence patterns of recent worldwide hunter-gatherers societies from the anthropological ethnographies compiled by Murdock (1967).

Murdock’s *Ethnographic Atlas* (1967) was first analysed by Lee (1968) from a nutritional perspective. Lee’s (1968) analysis was in turn used by Eaton & Konner (1985) in their seminal paper ‘Paleolithic nutrition: a consideration of its nature and current implications’ published in the New England Journal of Medicine. Cordain et al. (2000), however, picked up a fault in these early analyses. Both hunted and fish animal foods had not been summed together and included in subsistence ratios and hence, animal food intake had probably been underestimated. Consequently, Cordain et al. (2000) re-analysed the Ethnographic Atlas with the following purposes:

1. To estimate the contribution of plant to animal foods in hunter-gatherer diets.
2. To estimate the macronutrient (i.e. carbohydrate, fat, protein) intake (as a percentage of energy) in hunter-gatherer diets.
3. To determine how differences in the percentage of body fat in prey animals would alter protein intakes in hunter-gatherer diets and how a maximal protein ceiling influences the selection of other macronutrients.

The results were as follows:

1. 73% of worldwide hunter-gatherers derived greater than 50% of their subsistence from animal foods (both hunted and fished).
2. 13.5% of worldwide hunter-gatherers derived greater than 50% of their subsistence from plant foods.
3. No hunter-gatherer population was entirely or largely dependent (86–100% dependent) on plant foods, whereas 20% were highly or solely dependent on fished and hunted animal foods (e.g. the Arctic Inuit).
4. Plant-food intake decreases with increasing latitude (due to snow cover)
5. The most plausible percentages of total energy from the macronutrients were:
   - 19–35% for protein (this does not exceeding protein metabolism ceiling – however 35% is at the upper limit for many people),
   - 22–40% for carbohydrate and
   - 28–58% for fats.

The study sample included more societies that live above 40 degrees north or south latitude (n=133) than below it (n=96) which corresponded to an increased dependence on animal food at the expense of plant foods due to longer winters and snow cover at these latitudes. Eliminating the positive skew towards increased dependence on animal foods out of the median macronutrient values would give rise to projected macronutrient values of 20–31% protein, 31% carbohydrate and 38–49% for fat (as a percentage of total energy intake).

As expected, the findings of Cordain et al. (2000) are different to those of Lee (1968) and consequently Eaton & Konner (1985), the latter concluding that, on average, hunted animal food contributed to 35% of the daily energy in average hunter-gatherer diets (omission of both hunted and fished animal foods); and plant foods made up the remaining 65%. The range of plant to animal subsistence ratios as analysed by Eaton, Konner & Shostak (1988) can be see in Table 5. Despite the methodological errors in Lee’s (1968) analysis, as will be appreciated later in this thesis (in Chapter 7), when
interpreting ‘contemporary hunter-gatherer diets’ using the modern food supply, the subsistence ratios of Eaton & Konner (1985), rather than Cordain et al. (2000), are more closely able to be replicated.

<table>
<thead>
<tr>
<th>People</th>
<th>Environment</th>
<th>Subsistence Pattern (Plant : Animal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazda</td>
<td>Tanzania: inland, semitropical</td>
<td>80:20</td>
</tr>
<tr>
<td>!Kung San</td>
<td>Botswana: desert</td>
<td>65:35</td>
</tr>
<tr>
<td>Aborigines</td>
<td>Australia: variable from extreme desert to swampy to seacoast</td>
<td>90:10 (desert)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25:75 (coastal)</td>
</tr>
<tr>
<td>Ache</td>
<td>Paraguay: forest</td>
<td>50:50</td>
</tr>
<tr>
<td>Agta</td>
<td>Philippines: tropical mountainous forest</td>
<td>40:60</td>
</tr>
<tr>
<td>Inuit</td>
<td>North American Arctic</td>
<td>10:90</td>
</tr>
</tbody>
</table>

Table 5. Plant to animal food subsistence ratios as analysed by Eaton, Konner & Shostak (1998 p.74)

2.3.3.2.1 Methodology used by Cordain et al. (2000) for determining hunter-gatherer subsistence patterns

The paper by Cordain et al. (2000) is complex, and due to the subjective nature of the data sources, is open to a high degree of interpretation – even more so when the data is used to define boundaries for optimal contemporary nutrition.

The following 13 points outline and critique the methodological process and conclusions drawn by Cordain et al. (2000):

1. Five basic subsistence economies are defined in Murdock’s (1967) Ethnographic Atlas: 1) gathering of wild plants and small land fauna; 2) hunting, including trapping and fowling; 3) fishing, including shell fishing and the pursuit of large aquatic animals; 4) animal husbandry; 5) agriculture. Only the first three subsistence categories were utilised in hunter-gatherer societies and hence used in the analysis of Cordain et al. (2000). While the atlas contains ethnographies and literature searches on 1267 of the world’s societies, Cordain et al. (2000) only selected 229 groups to meet their definition of ‘hunter-gatherers’ on the basis that none of the 229 groups used animal husbandry or agriculture in their food subsistence strategies.
2. For each subsistence category (e.g. category one = ‘gathering of wild plants and small land fauna’) Murdock (1967) assigned a score of 0–9. The score correlated to the degree of reliance upon that particular strategy for food acquisition. A score of 0 corresponded with a percentage subsistence-dependence of 0–5%; a score of 1 = 6–15%; 2 = 16–25%; 3 = 26–35%; 4 = 36–45%; 5 = 46–55%; 6 = 56–65%; 7 = 66–75%; 8 = 77–85%; 9 = 86–100%. For example, a score of four in the ‘fished’ category means that subsistence dependence on fish, shellfish and other aquatic animals ranged from 36% to 45%.

3. As stated by Cordain et al. (2000), ‘Murdock’s subsistence-dependence categories (score 0–9), in almost all cases, represent subjective approximations by Murdock of the ethnographer’s or anthropologist’s original observation’ (p.683). Hence there may be considerable room for error in interpreting the results.

4. The *Ethnographic Atlas* does not state whether the food subsistence-dependence categories were based on the energy content or the weight of the foods. Consequently, Cordain et al. (2000) examined the 400 plus original references cited in Murdock (1967) and came to the conclusion that in many cases estimates were made by weight. This seems logical given the inherent difficulties in estimating the percentage of energy that a particular food contributes to the diet. This would be a difficult task for well trained nutritionists, let alone a non-nutritionally trained anthropologist working in the field with presumably little access to food composition data. This lack of objectivity makes definitive conclusions about modern diets based on hunter-gatherer macronutrient intake challenging. In response to this acknowledged difficulty, Cordain et al. (2000) suggest that the *Ethnographic Atlas* data is simply useful in defining ‘reasonable boundaries or limits’ (p.683) to the macronutrient composition and contribution of plant to animal subsistence ratios in hunter-gatherer diets.

5. As just mentioned, Cordain et al. (2000) assumed that subsistence-dependence (i.e. how much fished, hunted, or gathered food contributed to the diet) was recorded in the *Ethnographic Atlas* by weight. Translating food weights into a percentage of daily energy intake requires that nutrition composition data for
wild plant and animal foods be known. To address this issue Cordain et al. (2000) used the ‘Tables of composition of Australian Aboriginal foods’ compiled by Brand-Miller, James & Maggiore (1997). This database of Australian Aboriginal plant foods (n=829) was used because it is by far the largest database available for wild foods eaten by a hunter-gatherer group. The validity of using only Australian bush food composition data for estimating the nutrient intake of worldwide hunter-gatherer groups is questionable given that foods vary significantly by season, latitude and geographic location. However, in justification, Cordain et al. (2000) state, ‘although we used a plant-food database derived entirely from Australian Aboriginal wild plant foods, our mean macronutrient values (62% of energy from carbohydrate, 24% from fat and 14% protein) were similar to those derived from the smaller wild-plant-food databases for worldwide hunter-gatherers’ (p.685). The ‘smaller wild plant-food databases’ which Cordain et al. (2000) are referring to are the ones used by Eaton & Konner (1985) in their original analysis of hunter-gatherer diets.

6. The sample used by Cordain et al. (2000) has been challenged because 20th century hunter-gatherers were disproportionately represented in both Arctic and desert regions (Langdon 2006), probably in response to having been marginalised from their original dwellings (Jones 2007; O'Dea 1991a). Furthermore, the foods analysed by Brand-Miller, James & Maggiore (1997) – the database used by Cordain et al. (2000) – were primarily sourced from central, northern and western Australia. Yet, as Gott (1993) observed, tubers and roots traditionally contributed significantly to the diet of Aborigines living in south-eastern Australia (an area heavily populated by Aborigines) and less so in other regions of Australia, which if included would have elevated the carbohydrate content of the average Australian Aboriginal diet above that of Brand-Miller, James & Maggiore’s (1997) analysis. This omission may explain why Cordain (2002b) shies away from the inclusion of starchy tubers in his modern-day interpretation of the Paleolithic diet (further discussed in Chapter 6).

7. From a practical perspective, it is probably not too important that only food composition data from Australian Aboriginal plant foods was used by Cordain et al. (2000) as long as the conclusions of the study are not applied too rigidly. In reality, very little data is available on hunter-gatherer diets and on the
nutritional composition of wild foods. Hence, piecing the available data together in the way that Cordain et al. (2000) have provides some boundaries for plausible nutrient intake in recent hunter-gatherer diets. In essence, wild food, regardless of the type or global region is nutrient rich and is vastly different to Westernised diets characterised by high quantities of cereal grains, dairy, and refined and processed foods, which were rare or non-existent in all hunter-gatherer diets.

8. Due to substantial variation in the energy density of different plant food types (e.g. starchy tubers like yams, which have a high carbohydrate content, versus macadamia nuts, which are high in fat, compared to edible fern fronds, which have a very low carbohydrate content) the mean energy density of any wild plant food database is influenced by the relative contribution of any given plant food type to the entire database. Cordain et al. (2000) applied mean energy density values. Whether or not this is valid is open to interpretation. In reality, plant foods were not randomly gathered in hunter-gatherer societies. Rather, foods with greater energy density were prioritised as per the ‘optimal foraging theory’ discussed earlier in this chapter. In the database of Australian bush foods, fruit represented 41% of the total number of food items consumed, seeds and nuts represented 26%, and underground storage tubers, roots and bulbs represent 24%. The remaining 9% were leaves, dried fruit, flowers, gums and miscellaneous plant parts (Cordain et al. 2000).

9. In terms of macronutrient intake from animal products, Eaton & Konner (1997; 1985) assumed that muscle tissue was the primary tissue eaten. According to Cordain et al. (2000), other ethnographic reports showed that virtually all the edible carcass was consumed. The study by Cordain et al. (2000) therefore used percentage of total carcass body fat for wild animals as their way of estimating the relative contributions of both protein and fat from animal sources to the average hunter-gatherer diet.

10. Not taken into account in the analysis by Cordain et al. (2000) is evidence that animal organ tissues (rich in fat) were likely eaten preferentially and sometimes exclusively, with wastage of the remaining carcass. While this possible scenario was considered by Cordain et al. (2000), the rationale for its exclusion from analysis was that ‘the selective consumption of fatty portions of the carcass
while discarding leaner portions of the carcass would have been quite costly on the basis of the ratio of energy capture to energy expenditure’ (p.689). Yet, elsewhere Cordain & Friel (2005) state, ‘there is absolutely no doubt that hunter-gatherers favoured the fattiest parts of animals…fossil evidence from Africa, dating back to 2.5 million years ago, shows this scenario to be true. Stone-tool cut marks on the inner jawbone of antelope reveal that our ancient ancestors removed the tongue and almost certainly ate it. Other fossils show that Stone Age hunter-gathers smashed open long bones and skulls of their prey and ate the contents’ (p.167).

Archaeological evidence of more than 250,000 animal bone fragments from the Kutikina Cave on the Franklin River, Tasmania, where humans lived from around 15,000–20,000 years ago, showed that the hind-limb bones of the Bennett’s wallaby (the main prey species) were broken. More specifically, they were split longitudinally, indicating the targeting of fatty bone marrow (Garvey 2007). Furthermore, analysis of wombat bones (the second most common prey species in the area) showed an over-representation of cranial elements compared to other body parts, thus indicating the targeting of the fatty brain (Garvey 2007).

Likewise, Flannery (1994) notes historical evidence of mass slaughtering of large Moa birds by New Zealand Maori whereby, due to such plentiful supply of the birds, organ tissues and marrow may have been eaten in isolation of the rest of the animal carcass. As Flannery (1994) notes, around 600 years ago, 12 species of moa birds were present, weighing between 20 and 250 kilograms each with an estimated population of around 70,000 at any one time. Their extinction, he hypothesises, was due to human hunting. There are hundreds of Maori cooking sites which are packed with moa remains. Flannery (1994) describes one such site:

‘the remains of at least three species of moa, along with 55 other species of bird (many now extinct) have been found in and around ovens...Analysis of the site suggests that the wastage of meat was enormous...Typically about a third of the meat available in moa carcasses was never used.’ (p.195–196).
The situation where fatty animal tissues were preferentially consumed over lean muscle would mean that Cordain et al. (2000) grossly overestimate protein (17kJ/g) intake relative to fat (37kJ/g) intake in their macronutrient analysis. The omission of this possible scenario from the analysis has significant implications when interpreting hunter-gatherer diets as a model for contemporary nutrition. In Cordain’s model, there is a greater potential for very high protein intakes as will be discussed in Section 5.2.1 and Chapter 6.

In support of the methodology used by Cordain et al. (2000), with regard to Australian Aboriginal diets, O’Dea (1994) states that although the most highly prized components were the relatively few energy-dense foods (namely adipose tissue, organ tissue, fatty insects and honey), skeletal muscle provided the bulk of the energy from an animal carcass. Animals were hunted most actively during the times of the year when their fat stores were at their largest (O’Dea 1994), however, even at peak fatness, wild animals are still very lean (Cordain et al. 2002c).

11. Also conferring an interpretive challenge is that Cordain et al. (2000) assumed that gathering only included plant foods, whereas Murdock (1967) included the collection of small land fauna (insects, invertebrates, small mammals, amphibians, and reptiles) in gathering activities. Therefore, Cordain et al. (2000) stated that ‘compilation data may overestimate the relative contribution of gathered plant foods in the average hunter-gatherer diet’ (p.683).

12. Cordain et al. (2000) assumed that hunted terrestrial animal foods contributed 35% of the daily energy needs of average hunter-gatherer diets. When the percentage of animal food exceeded 35% of energy, Cordain et al. (2000) assumed it to be from fish. The validity of assuming 35% of energy intake from animals (whole carcass, not just organs) is discussed as a limitation in the paper however only to the extent that this can ‘subtly and occasionally overtly influence the outcome of our projected estimates’ (Cordain et al. 2000 p.690). This assumption has interpretive issues for a modern-day diet based on Paleolithic food groups, because it assumes that fish and seafood were not consumed in isolation of other animal foods. In reality it is quite plausible that coastal/shore based hunter-gatherer populations did consume marine animals at the expense of land animals for periods of time (Cunnane 2005). However, as
Cordain et al. (2000) write, ‘in the present model, fish food intakes decrease as plant-food intakes increase and hunted animal food intakes remain constant’ (p.686). This may explain Cordain’s lack of differentiation between, or emphasis on, terrestrial animal foods versus aquatic animal foods in his modern ‘Paleolithic Diet’ interpretations (Cordain 2002a, b; Cordain & Friel 2005). This lack of differentiation has contemporary consequences as discussed in Sections 2.4 and 5.2.3, and Chapter 6.

13. The analysis of Cordain et al. (2000) found that no hunter-gatherer population was entirely or even largely dependent (86–100% subsistence) on plant foods whereas 20% (n = 46) were highly or solely dependent (86%–100%) on fished and hunted animal foods (p.687). This suggests that a purely vegetarian diet has not been a feature of human evolutionary history and from this perspective is unlikely to be a strong model for optimal nutrition. The health benefits of animal foods become less clear in the context of modern-day diets, which include fatty animal meats, processed meats and dairy, particularly when compared to a carefully constructed, micronutrient-rich vegetarian diet. However, if wild fish, seafood and wild game meats (e.g. kangaroo) were combined with a vegetable and fruit abundant diet (i.e. a ‘contemporary hunter-gatherer’ diet as proposed in this thesis), the health benefits – based on the theory of evolutionary nutrition – may be superior to a vegetarian diet.

In conclusion, Cordain et al. (2000) state that the ‘macronutrient characteristics of hunter-gatherer diets may provide insight into potential therapeutic dietary recommendations for contemporary populations’ (p.691). However, as can be seen from the above discussion, there are many complexities involved in gaining an objective understanding of the dietary patterns of our pre-agricultural diet. Simply matching contemporary diets to the most plausible hunter-gatherer macronutrient intakes as analysed by Cordain et al. (2000), without further consideration of the quality of the actual foods making up the macronutrient composition, may miss the therapeutic potential of hunter-gatherer dietary patterns entirely. Attention must be given to the actual foods included in the diet, not just macronutrient (i.e. carbohydrate, fat and protein) intake and to how those foods are produced and prepared. Although acknowledging that the results of this research paper can only be used to define ‘reasonable boundaries or limits’ (Cordain et al. 2000 p.683), the macronutrient
parameters and average plant-to-animal food ratios outlined in the paper have formed the basis of Cordain’s interpretations for a modern-day Paleolithic diet (see Chapter 6).

Given the known methodological issues and potential errors in hunter-gatherer dietary studies, the research agenda of this thesis has to move away from getting too immersed in matching plant-to-animal subsistence ratios or macronutrient intakes in modelling ‘contemporary hunter-gatherer diets’ based on the paper by Cordain et al. (2000).
Instead, the focus will be on what is known with certainty, which is that the vast majority of hunter-gatherer populations consumed an omnivorous diet containing fresh, whole foods derived from a mix of healthy, lean, free-living animals and nutrient-dense wild vegetables, fruits, seeds and nuts.
2.4 Human Brain Evolution and Diet: Shore-Based Ecosystems

‘My hypothesis is that key nutritional changes in a new environment permitted human brain evolution because the brains of some hominid species were genetically prepared for such change. There was no selection pressure. Nothing forced the brain to become larger. Nothing forced babies to develop body fat. Hominid survival was not at risk; several survived for million year periods without substantial change in brain size’

(Cunnane 2005 p.102)

2.4.1 Human brain evolution and the ecology of intelligence

The potential of the human brain is extraordinary. It has the function and intelligence to problem solve, be creative, perceive past and future phenomena, and be very adaptable. It is our defining humanistic feature.

Over the past two million years, relative to other primates, the hominin lineage leading to contemporary humans developed significantly larger and more sophisticated brains (Cunnane & Crawford 2003; Lewin & Foley 2004). The human brain is four to five times larger relative to body weight than the brain of other primates and requires up to 10 times more energy than other land-based mammals (Cunnane, Harbige & Crawford 1993; Crawford et al. 1999). Per kilogram, the human brain has a metabolic rate nine times higher than the human body as a whole (Cordain, Watkins & Mann 2001; Mann 2000). The modern day human brain is three fold larger than our earliest forebears (Cunnane 2005; Lewin & Foley 2004; Mann 2000).

Thus, the large human brain is metabolically expensive. How hominins afforded the development of large, metabolically active brains has long been a question of research interest (Milton 1995, cited in Aiello & Wheeler 1995). In explanation for how this phenomenon arose, Aiello and Wheeler (1995) proposed ‘the expensive-tissue hypothesis’, which suggests that the metabolic requirements of relatively large brains
were offset by a corresponding reduction in gut size. The human gut size is small compared to body size, and gut size correlates highly with diet. Small guts are compatible with high-quality, easy to digest food (e.g. animal foods, cooked roots and tubers, and plant foods which are not excessively fibrous). Hominins’ ability to incorporate increasingly greater amounts of these high-quality foods – particularly animal foods [which are also rich in what Cunanne (2005) terms ‘brain selective’ nutrients as soon to be discussed] was probably associated with a reduction in gut size and therefore the energetic cost of the gut (Aiello & Wheeler 1995; Wrangham et al. 1999). As Aiello & Wheeler (1995) state, ‘if this is correct, encephalization in the hominins was able to proceed without placing any additional demands on their overall energy budgets’ (p.211). In other words, Milton (1995) summarised, ‘humans are regarded as having a small gut for their body mass, an unusually large brain, and a normal metabolic level’ (cited in Aiello and Wheeler 1995 p.214).

Aside from being metabolically expensive, the developing human brain is also exceptionally vulnerable. This vulnerability, however, appears to have been an ‘acceptable’ trade-off in an evolutionary sense. As Cunnane (2005) points out, if environmental factors such as oxygen, temperature, and nutrient supply are variable and/or insufficient, the brain must protect itself by remaining small and in control of its essential functions, thus eliminating vulnerability. Clearly this didn’t occur; hence indicating a reliable source of brain favourable conditions.

One hypothesised mechanism for buffering the developmentally vulnerable brain is the adaptive evolutionary trait in which humans evolved fat babies – the fat providing the reserves for managing brain development. As Cunnane (2005) writes, ‘it may seem only moderately difficult to meet the energy and nutrient requirements for a larger brain, but added to the human brain’s remarkable early development is the simultaneous accumulation of considerable body fat before birth. The fat accumulating on a healthy human foetus as it approaches birth is not present in other primates but is, in fact, a prerequisite for full development of advanced brain function in human adults’ (p.xv).

No other animals living on land have babies with such high fat-to-body mass ratio and noticeable subcutaneous fat accumulation (Cunnane 2005). Healthy human babies maintain their fat stores for several years, thus plausibly providing a reservoir of energy for the prolonged period of human brain vulnerability as it develops. It is beyond doubt
that low birth weight and leanness in infants due to premature birth or from under-nourishment *in utero* makes babies much more vulnerable to cognitive delays (Ortiz-Mantilla et al. 2008).

Hypotheses of the reasons underpinning hominin brain expansion differ. The ‘social’ hypothesis suggests that intelligence was favoured in the realm of the complex primate social life (Lewin & Foley 2004). Although the size and composition of primate social groups is seen among other species, the interactions within primate groups are far more complex. For example, when most mammal species engage in conflict, the larger animal will usually win. However, this is not so in primates. As Lewin & Foley (2004) state, ‘individuals devote much time to establishing networks of “friendships” and observing the alliances of others. As a result, a physically inferior individual can triumph over a stronger one, provided…friends are at hand to help…and…allies are absent’ (p.456). In other words, alliances are a complex, intelligent endeavour and primates, including humans, are consummate social tacticians.

However, one cannot lose sight of the ecological aspects of human intelligence. As Lewin & Folley (2004) state, ‘social life is not divorced from the environment…if social complexity drives intelligence, it is ecology that drives social complexity, and so there is a resource-based element to the evolution of human intelligence – it is not just a matter of sociality and interpersonal relationships’ (p.457). It is this ‘resource base’ – specifically the permissive nutritional component of this base – that is of interest to this thesis.

Somewhat different to the ‘social’ hypothesis of human brain expansion, Cunnane (2005) suggests that there was no selective pressure forcing the brain to enlarge. Rather, he hypothesises, the fact that the enlarging brain and corresponding developmental vulnerability was tolerated (i.e. that reproduction or survival were not substantially impaired) indicates that the human organism as a whole was not put at a substantially greater risk. Cunnane (2005) concludes, that this must mean the food and habitat of humans became increasingly secure as brain expansion occurred.

Hence, while hominin genes must have held the genetic potential for improved cognitive capacity, prior to the environmental opportunity (including a sufficient dietary matrix, energy surplus, and importantly sufficient time), the necessary genetic alterations did not occur (Cunnane 2005).
2.4.2  The shore-based human brain expansion hypothesis

The traditional view has been that human brain expansion took place during the time that hominins lived on the African savannahs with its land-based food supply. However, as Crawford (2005) asserts, all land-based mammals proportionately lost brain size relative to body size as they evolved larger bodies in this environment (Crawford 2005). This raises the question of how humans escaped this phenomenon.

The notion that expansion of the human brain occurred within a terrestrially based food supply has been seriously questioned by Cunnane, Crawford and their colleagues (see Crawford & Marsh 1995; Cunnane & Crawford 2003; Cunnane, Harbige & Crawford 1993; Cunnane 2005, 2006, 2007). Their view is that human brain expansion more likely occurred in shore-based ecosystems (shores of lakes, marshes, rivers, sea) on the basis of the different nutritional chemistry and food security available in these environments which provided the chemical matrix permissive of human brain tissue evolution (Crawford & Marsh 1995; Cunnane 2005).

As will be discussed in this section, terrestrial animals (e.g. wild kangaroo and other game meats) and aquatic animals (e.g. wild fish, shellfish and other aquatic species) offer different nutritional properties. Exclusive intake of terrestrial animals (unless adequate organ meats including animal brains are consumed) at the exclusion or minimisation of aquatic animals reduces the supply of pre-formed long chain polyunsaturated fatty acids of the omega 3 family (n-3 LCPUFA) in the diet and misses the mineral and trace element diversity available in seafood. A supply of these nutrients is critical for optimal brain function.

The shore-based human brain expansion hypothesis was first proposed by Sir Alistair Hardy in the 1960s and later expanded by Professors Stephan Cunnane and Michael Crawford. Both Cunnane’s and Crawford’s ideas are eloquently expressed in their respective books The Survival of the Fattest (Cunnane 2005) and Nutrition and Evolution (Crawford & Marsh 1995), as well as numerous journal article publications. It is the ideas of these two scientists that are presented here.
The nutritional matrix available in a shore-based ecosystem and its potential relevance to human brain expansion and cognitive function is the focus of this section because the information yielded is so important to appropriately interpreting our optimal modern-day nutritional needs. On the basis of Cunanne’s (2005) theory, the optimal human food niche is that of shore-based ecosystems. This means that a diet which includes aquatic species (fresh and/or salt water fish, seafood and other species) as well as plant foods and land based animals may be more ideal than a diet that excludes aquatic species.

The shore-based hypothesis potentially carries enormous importance and adds to the evolutionary nutrition arena. Although Cordain (Cordain 2002a, b; Cordain 2008; Cordain & Friel 2005), Eaton (Eaton, Eaton & Konner 1997; Eaton & Konner 1985; Eaton, Shostak & Konner 1988) and other evolutionary nutritionists recommend the consumption of both land and aquatic animals, preferential intake of aquatic animals has not been particularly emphasised. Yet, on the basis of Cunanne’s hypothesis, it may be important, especially for brain health. Current recommendations for modern-day diets based on evolutionary nutrition principles such as those proposed by Cordain (2002b) in his book *The Paleo Diet* and by Lindeberg et al. (2007) in his clinical trial of a modern ‘Paleolithic’ diet, do not differentiate or advise on the relative proportion of aquatic versus land animals in the diet, or place particular priority on aquatic over land animals.

### 2.4.3 Brain selective nutrients: minerals and fatty acids

The shore-based evolutionary hypothesis carries the idea that there are different requirements for body growth (protein and minerals – available in just about any ecosystem) and for brain development (lipids, minerals and trace elements – particularly abundant in shore-line ecosystems). Cunnane’s (2005) term ‘brain selective nutrients’ refers to those nutrients which are essential for normal human brain development and function.

Cunnane (2005) proposes that there are at least five ‘brain selective’ minerals: iodine, iron, copper, zinc and selenium. Additionally, some vitamins, especially vitamin A, are important, along with polyunsaturated fatty acids and amino acids. The human brain cannot develop normally without a reliable supply of these nutrients (Cunnane 2006).
Rather than cataloguing the specific effects of each of these nutrients on normal brain development (these can be readily found in the literature), it is worthwhile thinking about the types of foods and ecological niches that abundantly supply these nutrients thus enabling the construction of health supportive ‘contemporary hunter-gatherer diets’. Fish, shellfish and other aquatic species are particularly rich in iodine, zinc, selenium, essential fatty acids and amino acids.

2.4.3.1 Brain selective minerals

Cunnane (2005) calculated that in order to meet the minimum daily requirements of all the ‘brain selective’ minerals (I, Fe, Cu, Zn, Se), one would have to eat: 900g shellfish, or 2500g eggs, or 3500g fish, or 3700g pulses, or 4800g cereals, or 5000g meat (skeletal muscle), or 5500g nuts, or 9000g vegetables per day. Milligan and Bazinet (2007), using a similar method, estimated that one could also meet the minimum requirements for these minerals by eating 1000g of brain or 1200g of liver per day. Hence, as Cunnane (2005) analysed, based only on the concentration of these five minerals in the 10 main food groups (vegetables, fruit, fish, shellfish, eggs, meat, pulses, nuts, cereals and milk), lower amounts of shellfish than any other food group would be needed to meet the entire daily needs of humans for these ‘brain selective’ minerals. While no food group completely lacks ‘brain selective’ minerals, and diverse diets spread intake opportunity, typical Western diets which are high in cereal grains and dairy and low in aquatic species, are less efficient in ensuring optimal intakes of ‘brain selective’ nutrients.

For example, when examining the iodine content of different food groups (see Table 6) it is apparent how relatively easy it is to obtain a greater amount of this trace element by eating fish and seafood than from consuming terrestrial animals, or for that matter consuming a vegetarian diet (unless eating seaweed). The recommended daily iodine requirement for non-pregnant adults is 150mcg/day (NHMRC 2006).
Food Group  | Iodine Concentrations (micrograms per 100 grams)
---|---
Fish    | 50-110
Eggs    | 53
Shellfish | 10-28 (150 in cockles, mussels)
Meat    | 5-10
Nuts    | 5-10
Cereals | 6
Pulses  | 2
Vegetables | 1-3 (20,000 in dried seaweed)
Fruit   | 1-5
Milk    | 15

Table 6. Iodine concentrations in various food groups (Data sourced from Cunnane 2005 p.127).

Insufficient dietary iodine results in goitre (enlargement of the thyroid) and iodine deficiency in the developing infant results in cretinism (delayed growth and mental retardation). The further away from the ocean, the less available iodine becomes (Fuge 2007). Today, use of iodized salt and legislation allowing foods (mostly processed foods) to be fortified with iodine now largely averts the risk of iodine deficiency regardless of living location – so long as those foods are consumed. However, they are unlikely to be included in a ‘contemporary hunter-gatherer diet.’

2.4.3.2 Brain selective lipids

The human brain contains 600g lipids/kg (Broadhurst, Cunnane & Crawford 1998). Of these lipids, a high proportion are long chain polyunsaturated fatty acids (LCPUFAs) (Sinclair et al. 2007). The brain contains approximately equal proportion of arachidonic acid (AA) and docosahexaenoic acid (DHA) (Broadhurst, Cunnane & Crawford 1998). Lipids are the major components of neuronal synapses and myelin sheaths.

It is impossible to achieve normal human brain development in the absence of body stores of DHA at birth and when DHA is lacking in the diet (from maternal diet, breast milk, and other infant foods); (Cordain, Watkin & Mann 2001; Cunnane 2005). As outlined in Section 5.2.3, in the absence of dietary intake of DHA (of which fish and shellfish are particularly good sources), humans have a very limited ability to endogenously convert the pre-cursor lipid alpha-linolenic acid (ALA), which is acquired from plant food, into DHA (Plourde & Cunnane 2007). Therefore, as it is hard to sustain
normal brain function when DHA is limited, it makes sense that it would be even harder to expand brain size and cognitive capacity without a reliable and sustained dietary source of DHA (Cunnane 2005; Mann 2000). An abundant DHA supply could have been easily achieved in the shore-based environment. While marginal intakes of DHA may not be overtly damaging for brain development, it is unlikely to be supportive of optimal brain function.

Mounting research indicates that diets lacking omega 3 LCPUFAs lead to substantial disturbances in neural function (see Section 5.2.3 for further detail). Certainly in animal models this has proven to be the case and in most circumstances, neural function problems in animal models can be restored by the inclusion of n-3 LCPUFAs in the diet (Gale et al. 2008; Sinclair et al. 2007). There is increasing evidence for the beneficial effects of n-3 LCPUFA supplementation (fish oil) on visual and cognitive development in children (Dunstan et al. 2008; Eilander et al. 2007). Correlations between dietary fish intake and brain and neuro-development are much harder to assess than supplementation trials. However, epidemiological and population studies indicate that maternal consumption of fish in pregnancy tends to be associated with higher IQ scores in offspring and reduced behavioural problems (namely hyperactivity); (Gale et al. 2008). In terms of mood disorders, research indicates a correlation between low n-3 LCPUFA intake and depression in particular (Bourre 2005; Golding et al. 2009; Hibbeln 2007; Hibbeln & Salem 1995; McNamara 2006; Rees et al. 2009; Sinclair et al. 2007).

DHA is the most important fatty acid to discuss with regards to brain expansion (Cordain, Watkins & Mann 2001; Cunnane 2005). Other fatty acids, including arachidonic acid (AA), are important for brain development; however, even when a diet is devoid of AA, the brain does not become depleted of this fatty acid (Cunnane). Furthermore, AA is abundantly available in a diet which is inclusive of animal foods (whether terrestrial or aquatic).

It is not possible to say that without a certain amount of DHA, or any other single nutrient, that the brain of Homo sapiens wouldn’t have expanded. Rather, as Cunnane (2005) states with regards to DHA, ‘at some point, lower intake or synthesis of DHA limits brain function sufficiently that expansion and increased complexity of the brain is much less likely when DHA intake is low’ (p.164). There is little doubt however that the introduction of the right nutritional chemistry matrix could, by virtue of its consistent
presence, either stimulate change or make possible the existence of new genetic expression (Crawford & Marsh 1995).

2.4.4 Critique of the shore-based hypothesis

Potential criticism of Cunnane’s (2005) hypothesis stems from the perceived lack of historical evidence for marine food exploitation at the time of cerebral expansion (Eaton & Konner 1985; Gordon 1987; Milton 2000). The major increase in encephalization in Homo occurred during the Middle Pleistocene (600-150 thousand years ago) and by 150,000–100,000 years ago the Homo brain size was probably within the modern range (Lewin & Foley 2004; Milton 2000). However, according to Milton (2000) the first evidence supporting the systematic use of coastal resources is dated between 127,000 and 57,000 years ago. Therefore, Milton (2000) concluded that the African savannah must have supported large-brained species because the ‘brains, flesh, liver, tongue, marrow and other parts of wild terrestrial mammals would have served as a concentrated source of many essential nutrients required by early humans, including LCPUFAs’ (p.1587). Similarly, on the basis of the lack of historical evidence, Eaton & Konner (1985) concluded that the widespread use of aquatic food is a ‘recent’ phenomenon. However, the exclusion of aquatic foods in the earlier hominid diet is strong refuted by Cunnane (2005) and Broadhurst et al. (1998) who state that in actual fact ‘the earliest occurrences of modern Homo sapiens and sophisticated tool technology are associated with aquatic resource bases’ (Broadhurst et al. 1998 p.3). Cunnane (2005) suggests that the sophisticated skills required for fishing were actually acquired around 500,000 years ago, and that, for instance, catfish were seasonally abundant to early East African hominids living at least two million years ago, as were shellfish.

The lack of historical evidence may be due to differences in the present day sea level. During ice ages the sea level was much lower than it is today due to water being trapped in ice. For example, during the last ice age, around 20,000 years ago, the sea level was around 90 to 100 metres lower than at present (Eaton, Konner & Shostak 1988). Around 18,000 years ago the sea level of Port Phillip Bay, Victoria, was at least 130m lower than it is today, and present sea levels of the bay were not reached until around 5,000 years ago (CSIRO 1998). The effect of this is that any fossil evidence of coastal-based living during time periods when sea levels were lower is now currently submerged.
Fossil evidence certainly indicates that aquatic foods played a significant role in the diet of hominids by the upper Paleolithic period (10,000–40,000 years ago); (Cordain et al. 2000b). Much of the food on shore-lines is easily accessible (e.g. collecting shellfish, small fish, slow-moving turtles, crabs, bird’s eggs, as well as a variety of plant foods), able to be collected by all age groups, available in abundance, on hand year round, and are digested well by humans (allergies excluded). In contrast, the hunting of terrestrial animals for their prized brain and bone marrow (n-3 LCPUFA rich), thyroid tissue (iodine rich), liver (vitamin A rich) and other organs, is a much riskier occupation and the ‘brain selective’ nutrients found in these tissues had to be shared between the whole tribe (Cunnane 2005).

Unequivocal paleo-anthropological evidence indicates that humans evolved in East Africa, and that early humans inhabited the Rift Valley lake shores (Broadhurst, Cunnane & Crawford 1998; Lewin & Foley 2004). Hence, Cunnane (2005) proposes that the shore-based ecosystems of the Rift Valley and other shore-based niches later inhabited around the world enabled a shift in the hominin resource base towards more high-quality, nutrient-dense foods which were nurturing of brain expansion.
2.4.5 Eating from shore-line ecosystems

‘Shorelines are richer in biomass than any other ecological zone on the planet’

(Cunnane 2005 p.216)

Shore-based foods include shellfish, fish, other aquatic species, eggs from birds nesting near water, and seaweed, as well as a variety of plants and land-based animals. Cunnane (2005) notes that where shore-based foods are consumed, brain-selective nutrient deficiencies rarely occur. Furthermore, the message that a shore-based food supply – rather than an exclusive terrestrially based one – is potentially the most supportive environment of human health fits well with epidemiological findings that fish and seafood intake is correlated with health and disease reduction (ISSFAL 2008; Meyer et al. 2003; Nettleton 1995).

There is certainly no evidence to suggest that eating from shore-based niches provides any dietary disadvantage. Importantly, in the modern-day food environment, fish and shellfish remain one of our last wild food sources and, on this basis alone, there is strong argument for the prioritisation of these foods in contemporary diets.

While recent hunter-gatherers and contemporary humans have managed to occupy enormously diverse ecological niches worldwide (Flannery 1994), it is however a different matter as to whether they are optimally supportive of health or whether humans could have actually evolved in regions where food resources were stretched, and conditions were more challenging (Cunnane 2005). On the basis of the arguments presented in this section, shore-line ecosystems were likely – and still are – the environment to which humans are most adapted to and dependent on.

This is why our coastlines and marine resources must be sustainably managed (e.g. promoting biodiversity and minimising environmental contaminants that bioaccumulate in seafood). Human pressure on an environmental niche is now nowhere greater than highly populated coastal regions (CSIRO 1998). The global population is concentrated on coastlines. Australia is no different. Eighty-six per cent of the Australian population live in metropolitan and non-metropolitan coastal zones (Finnigan 1994). Some of the greatest impacts on our coastal waters are from waste disposal, urban and agricultural drainage, fishing and aquaculture, toxicants, recreation, physical habitat destruction, the
introduction of exotic organisms, mineral exploration and extraction, construction and transport (CSIRO 1998). Hence, the prioritisation of *eco-nutritional* research in coastal zones is critical in order to sustainably support human health given our likely inherent reliance on this environment.

### 2.4.6 Are modern diets affecting our brains?

Are today’s diets (which, as seen in the analysis in Chapter 7, are inadequate when compared to the nutritional composition of our hunter-gatherer ancestors’ diets) risking our brains’ ability to function optimally?

Exploration of the relationship between nutrition and brain evolution, development and function has barely been explored within an evolutionary nutrition paradigm in the literature, beyond the work of Cunnane, Crawford and their colleagues. It is plausible that realigning our contemporary diets with the nutritional characteristics that supported our evolution would offer strong therapeutic guidelines for optimal brain development, intelligence and mental health stability. Nutritional factors aside, disease, socio-economic status, and psychosocial circumstances are, of course, also critical in brain development and mental wellbeing and concurrently need to be addressed.

Cunnane (2005) states that there is some evidence suggesting that there has been a small reduction in the brain size of contemporary humans compared to the Cro-Magnon’s over the past 30,000 years. The possibility is therefore, if human brain size is actually decreasing, the genetic and/or environmental circumstances favouring expansion would have to have not only switched off, but be actually reversing (Cunnane 2005). Given that significant shifts in diet have occurred over the past 10,000 years which are affecting the supply of ‘brain selective’ nutrients, it is perhaps necessary to question the potential impact of contemporary diets, on brain function. If the modern human brain is in fact decreasing in size, genetic factors alone are unlikely to be the dominant force responsible for propelling brain expansion and cognitive development in the first place. Hence, as Cunnane (2005) states, ‘the key to hominin brain expansion was environmental permissiveness, which still respects the requirements of natural selection and the role of genes but removes the pressure of survival as a speculating force’ (p.290).
Therefore, without return to the nutrient supply that supported the expansion and development of our large, but vulnerable brains, based on Cunnane’s hypothesis, it is conceivable that over time human cognitive capacity and mental health stability may decline.

If Cunnane’s hypothesis is true, the advantages of a shore-based food supply are likely to extend to multiple body systems. Certainly, epidemiological research points favourably to the intake of fish and shellfish as insurance against the major diseases facing the Western world – obesity, diabetes, other metabolic disorders, cardiovascular disease, certain cancers, and some mental health conditions, to name a few (see Section 5.2.3 for further discussion on the relationship between aquatic animals and human health).

In conclusion, holding Cunnane’s (2005) theory centrally, a modern-day diet for optimal health is one which is sourced from (and emulates) the food groups of shore-based ecological niches. Hence, ‘contemporary hunter-gatherer diets’ as interpreted in this thesis are based on foods available in shore-line environments (see Chapter 8).
2.5 The Health of Hunter-Gatherers and a Common Counter-argument of the Evolutionary Health Model

As a biological rule, organisms are healthiest when their life circumstances most closely match the conditions for which their genes were selected (Eaton, Cordain & Lindeberg 2001). Assuming that a wild food diet and the lifestyle patterns associated with hunter-gatherer life formed part of the environment in which our genes were selected, it is plausible to propose that hunter-gatherers were healthier than contemporary Westerners who lead a sedentary existence and eat foods to which we are not ideally suited. The general health and physiological biomarkers of recent hunter-gatherer populations have been studied, as have the bony archaeological remains of human ancestors. Data on recent hunter-gatherer populations provides the most compelling evidence. Universal characteristics of recent hunter-gatherers show minimal evidence of the chronic degenerative diseases (e.g. cardiovascular disease, type 2 diabetes, osteoporosis, among others); (Cordain et al. 2005; Eaton & Konner 1985; Milton 2000; Walker 2001) which are nearly ubiquitous in the ageing Australian population today. Rather, the disease pattern in hunter-gatherer times was characterised by sudden death and acute illnesses commonly due to accidents, trauma, infection, childbirth and infant mortality (Cordain et al. 2005; Walker 2001). Clearly, the genetic potential for chronic degenerative diseases must have been present in our human ancestors, but it took our current set of environmental influences to un-mask them.

Captain Cook’s observations of New Zealand Maori in 1772 portrays a healthy image of the native people. The following description is not uncharacteristic of other explorers’ accounts and anthropological observations of people living a hunter-gatherer existence:

'It cannot be thought strange that these people enjoy perfect and uninterrupted health. In all our visits to their towns, where young and old, men and women, crowd about us, prompted by the same curiosity that carried us to look at them, we never saw a single person who appeared to have any bodily complaint, not among the numbers that we have seen naked did we perceive the slightest eruption upon the skin, or any marks that an eruption had been left behind....A further proof that human nature is here untainted with disease in the great
number of old men that we saw...appeared to be very ancient, yet none of them were decrepit; and thought not equal to the young in muscular strength, were not a wit behind them in cheerfulness and vivacity’ (cited in Cordain & Friel 2005 p.xvi).

A further example is provided by the Kitava Study which was undertaken in 1989. Kitava is one of the Trobriand Islands in Papua New Guinea’s archipelago. The Kitava people were one of the last populations with indigenous dietary habits relatively unaffected by Westernisation. Lindeberg & Lundh (1993) who lead the study found a complete lack of sudden cardiac death and exertion-related chest pain among the 2,300 inhabitants of Kitava (6% of whom were 60–95 years old), as well as among the remaining 23,000 people on the Trobriand Islands.

Hunter-gatherer people may have been healthy, however in general, they did not live as long as modern-day populations. The reduced life expectancy in hunter-gatherers is the most frequently used criticism of the evolutionary model for health promotion (Eaton, Cordain & Lindeberg 2001), the criticism being that maybe most hunter-gatherers simply did not live long enough to develop degenerative disease.

Life expectancy statistics however tell us little about the health characteristics of living individuals. To illustrate this problem, Cordain (2005) uses the example of two parents who live to the ages of 79 and 72, who were healthy throughout most of their adult lives but had two children who died at birth, thus making the average life span of this group 37.7 years.

While acute serious illness was a great threat to survival, people either recovered quickly, or they died (Eckersley & Williams 2008). Hence, once the vulnerable period of childhood was successfully negotiated those living were usually well, full-functioning humans (Eaton, Shostak & Konner 1988).

By contrast, many contemporary Australians are burdened by ill health for a significant proportion of their life. A set of measures, called disability-adjusted life years (DALYs), has been developed to summarise disease burden (Australian Institute of Health and Welfare 2006a). Measuring DALYs in the population gives prominence to health problems that cause great illness and disability even if they are not fatal. Including both the fatal and non-fatal components of the DALY, cardiovascular diseases are the leading
cause of overall burden of disease in Australia today. This is followed by cancers and mental illness. Mental health conditions are the leading cause of healthy life years lost. Of interest, as noted in Section 2.4, despite the prevalence of mental illness in the Australian community, this issue has not been given a great deal of consideration in the evolutionary nutrition literature.

Chronic degenerative illnesses take years to develop. Abnormal biomarkers develop over time such as obesity, rising blood pressure, insulin resistance, atherosclerosis and low grade chronic inflammation. Age matched comparisons between 20th century hunter-gatherer societies and industrialised countries consistently show that the former rarely demonstrate abnormalities in these biomarkers, which are common among the latter (Cordain 2002b; Eaton, Shostak & Konner 1988).

Chronic degenerative diseases have been described in the literature for several thousand years. For example, as Eaton (1988) writes, ‘Aretaeus described diabetes 2,000 years ago…atherosclerosis has been found in Egyptian mummies…Venus statuettes show that Cro-Magnons could be obese, and the remains of 500 year old Eskimo burials reveals cancer.’ (p.742-743). However, nowadays the prevalence is dramatically increased (see Chapter 3).

We also know that hunter-gatherer populations that have undergone a recent transition to Westernisation experience a rapid increase in the prevalence of chronic diseases such as type 2 diabetes and cardiovascular disease – the aetiology of which are primarily underpinned by dietary and physical activity changes (see Section 3.2.2.2.). Furthermore, groups who migrate to Western countries acquire the disease susceptibility of their new location within a few generations (Eaton, Konner & Shostak 1988); even within a single generation (Deapen et al. 2002; Dyerberg, Bang & Hjorne 1975). For example, Asian women, who commonly have low breast cancer rates in their native countries, typically experience a rapid increase in breast cancer incidence after immigrating to the United States (Deapen et al. 2002).

Likewise, this is evident where indigenous people have become increasingly Westernised in their own countries. Well known examples of this are among the Solomon Islanders, Canadian Inuit, Kalahari Bushmen and Australian Aborigines (Eaton, Konner & Shostak 1988; O'Dea 1991b).
Among Australian Aboriginal populations, O’Dea (1994) states, ‘there is no evidence that Aborigines experienced any Western disease when they lived as hunter-gatherers’ (p.353). However as their diets changed to being based on Western rather than wild foods and they begin leading sedentary lives, Australian Aborigines developed extremely high prevalence rates of obesity, type 2 diabetes and a sequelae of health problems. In fact, the net effect of rapid dislocation from their pre-existing way of life has resulted in Australian Aborigines consuming a diet far inferior to the average Australian’s. A typical urban diet for Aborigines now consist of white flour, sugar, white rice, soft drinks, alcohol, powdered milk, cheap fatty meat, potatoes, onions, and variable and often limited amounts of other fresh fruit and vegetables (O’Dea 1994).

This pattern towards significantly inferior diets and lifestyle conditions (especially lower socio-economic status owing to the loss of traditional ‘job’ roles and self-sufficiency) is shared with other hunter-gatherer populations around the world that have undergone rapid lifestyle changes towards Westernisation, including the Pima Indians and other native American Indians, Pacific Islanders, multi-ethnic groups in Mauritius, and emigrant Indian populations (O’Dea 1994).

The health protection of the hunter-gatherer lifestyle was demonstrated powerfully by Professor Kerin O’Dea in Australian Aborigines in the 1980s. Two studies examined the health impact of a temporary reversion to traditional lifestyle – one lasting two weeks, and the other three months. Health effects were more pronounced in the longer study, however they were clearly evident after a period as short as two weeks. Reversal to a traditional lifestyle involved three factors known to affect insulin sensitivity directly: increased physical activity, reduced energy intake (and weight loss) and changes in dietary composition. Ten diabetic and four non-diabetic full-blood Aborigines spent a seven-week period out in the Kimberley in July and August of 1982. The first 10 days were at a cattle station en-route (beef comprised 75% of energy intake – not a traditional hunter-gatherer diet). The remainder of the trip was spent living a hunter-gatherer existence: two weeks at a coastal location (diet predominantly based on seafood, birds and kangaroo); and the final 3.5 weeks inland on a river. This final move was decided on because there was a lack of vegetable foods in the chosen coastal location. The dietary composition of the inland river location included kangaroo, freshwater fish and shellfish, turtle, crocodile, birds, yams, figs and bush honey (O’Dea 1994).

Over the seven-week period there was a marked fall in plasma glucose concentrations, improved glucose tolerance, weight reduction, a normalisation of triglyceride levels,
reduced blood pressure, and increased bleeding time, which reduces the tendency for thrombosis (O'Dea 1994). This study, combined with other field studies examining the health of worldwide hunter-gatherer populations demonstrates the power of hunter-gatherer foods and lifestyle patterns on health parameters.
2.6 Hunter-Gatherer Lifestyle Patterns

‘The genetic component (of health) is relatively constant over time in contrast to operative lifestyle influences that can change profoundly’ (Eaton et al. 1994 p.354)

2.6.1 Introduction

Beyond dietary factors, in thinking about the ‘conditions of life’ underpinning our present needs, it is useful to be aware of some of the comparative differences between the lives of our recent hunter-gatherer ancestors and modern day Australians. A select few of these lifestyle differences, and their impact on health, are discussed in this section. These are:

1. physical exercise
2. sunlight exposure and vitamin D
3. reproductive patterns
4. microbial interactions (the hygiene hypothesis).

2.6.2 Physical exercise and fitness

With the exception of modern humans, all free living animals need to exercise in order to eat (Cordain et al. 1998), and energy expenditure is a basic biological driver of hunger. However, technological development and social organisation over the past few thousand years have disrupted the basic relationship between energy expenditure and food procurement in humans. For most Australians exercise is no longer tied into meeting fundamental needs such as getting food, transportation or other forms of work. Rather, exercise is an activity that has to be squeezed into leisure time (NHMRC 1997). It is therefore perhaps not surprising that Australians’ top reasons for inactivity are lack of time, simply not wanting to exercise, and physical inability (NHMRC 2006).
2.6.2.1 Hunter-gatherer exercise patterns

Exercise in hunter-gatherer life was essential. Food had to be hunted and gathered, water collected and shelter secured. Physical fitness would have conferred a survival advantage, not only for attaining food, but also for escaping predator danger. Hence, we are genetically and phenotypically well adapted to being very physically active.

Research suggests that our ancestors walked, and sometimes ran, eight to 16 kilometres per day (Cordain, Gotshall & Eaton 1997; O'Keefe & Cordain 2004) often spread over three to five hours (O'Dea 1991a) as food was hunted and gathered. This was often done in small groups for social companionship, to share the work load and also for safety reasons. Food, water and often children were carried over significant distances. Such exercise requires cardiovascular fitness as well as muscular strength and endurance. As Cordain & Friel (2005) write, ‘the more typical manner of “exercise” for the Paleolithic athlete would have involved long, steady hunts and foraging expeditions conducted at a moderate pace until the kill was imminent or the gathered foods were hauled back to camp. At these times their effort would increase, but they would no doubt rest at every opportunity’ (p.161).

Dr Kim Hill, an anthropologist at the University of New Mexico, has spent much time living with and studying the Ache hunter-gatherers of Paraguay and the Hiwi hunter-gatherers of southwestern Venezuela. The following is an excerpt of his description of hunting activity patterns in these groups of people:

>'I have only spent a long time hunting with two groups, the Ache and the Hiwi. They were very different. The Ache hunted every day of the year if it didn’t rain. Recent GPS data I collected with them suggests that about 10km per day is probably closer to their average distance covered during searches. They might cover another 1–2km per day in very rapid pursuit. Sometimes pursuits can be extremely strenuous and last more than an hour. Ache hunters often take an easy day after any particularly difficult day, and rainfall forces them to take a day or two a week with only an hour or two of exercise. Basically they do moderate days most of the time, and sometimes really hard days usually followed by a very easy day.'
The Hiwi on the other hand only hunted about 2–3 days a week and often told me they wouldn’t go out on a particular day because they were ‘tired’. They would stay home and work on tools, etc. Their travel was not as strenuous as among the Ache (they often canoed to the hunt site), and their pursuits were usually shorter.

But the Hiwi sometimes did amazing long distance walks that would have really hurt the Ache. They would walk to visit another village maybe 80-100km away and then stay for only an hour or two before returning.

While hunter-gatherers are generally in good physical condition if they haven’t yet been exposed to modern diseases and diets that come soon after permanent outside contact, I would not want to exaggerate their abilities. They are what you would expect if you took a genetic cross section of humans and put them in lifetime physical training at moderate to hard levels. Most hunting is search time not pursuit, thus a good deal of aerobic long distance travel is often involved.’ (cited in Cordain & Friel 2005 p.181-183).

Although the above description pertains to men and their hunting activities, women in hunter-gatherer societies were also very physically active. Although ethnographic accounts seem to be in absolute agreement that women almost never participated in the hunting of large animals (Lee & Daly 2004), women routinely gathered plant foods and small animals including reptiles, shellfish, eggs, and insects (Farrer 2005). Often these tasks were done while carrying small children, adding to the physical output.

In contrast to hunter-gatherers, Australians today are endemically physically inactive. Physical inactivity has been flagged by the Australian National Health and Medical Research Council (NHMRC) as being the central factor in the aetiology of overweight and obesity in Australia (NHMRC 1997). Data on the physical activity patterns of Australians is lacking. The most recent large-scale data collection occurred between 1984 and 1987. In this survey from over 17,000 Australian adults, 30% reported that they had been totally sedentary in the previous two weeks. Only 15% reported physical activity of an ‘aerobic’ nature which would fit within the Australian recommended guidelines for the minimum amount of physical activity needed to enhance health (NHMRC 1997). The minimum Australian recommendations for physical activity in adults is at least 30 minutes of moderate-intensity physical activity on most, preferable all, days (Australian Government Department of Health and Ageing 2008).
2.6.2.2 Aerobic fitness – VO$_2$ max

Eaton, Konner & Shostak (1988) collected data on the aerobic fitness of recent hunter-gatherers and other traditionally living people and compared it to Westerners. A primary measure of fitness is volume of maximal oxygen uptake (VO$_2$max). VO$_2$max measures maximal cardiac output i.e. how much blood the heart can pump. Physical fitness is the overriding factor influencing VO$_2$max (Laukkanen et al. 2001). Other influences include genetic factors and age (VO$_2$max declines with age); (Levine 2008). As can be seen in Table 7, the VO$_2$max of recent hunter-gatherers and more traditionally living people is far superior to Westerners. The great majority of this disparity is due to differences in physical activity levels, not genetic differences (Eaton, Konner & Shostak 1988).

While hunter-gatherer people have a high VO$_2$max, they don’t compare with some elite endurance athletes today who, owing to their training programs, have developed an exceptionally high VO$_2$max. For example, as seen in the Table 7, Westerners typically record a VO$_2$max of 35–40, and traditionally living people averaged around 57. In contrast, elite-trained male cross country skiers have recorded scores as high as 80 (Montana State University-Bozeman 1998).

<table>
<thead>
<tr>
<th>Subsistence Pattern</th>
<th>Population</th>
<th>Average Age</th>
<th>Maximal Oxygen Uptake (ml/kg/min)</th>
<th>Fitness Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunter-gatherers</td>
<td>Canadian Igloolik Eskimos</td>
<td>29.3</td>
<td>56.4</td>
<td>Superior</td>
</tr>
<tr>
<td></td>
<td>Kalahari San (Bushmen) !Kung</td>
<td>Young men</td>
<td>47.1</td>
<td>Excellent</td>
</tr>
<tr>
<td>Rudimentary horticulturists</td>
<td>Venezuelan Warao Indians</td>
<td>Young men</td>
<td>51.2</td>
<td>Excellent</td>
</tr>
<tr>
<td></td>
<td>New Guinea highland Lufas</td>
<td>25</td>
<td>67.0</td>
<td>Superior</td>
</tr>
<tr>
<td>Simple agriculturists</td>
<td>Mexican Tarahumara Indians</td>
<td>29.8</td>
<td>63.0</td>
<td>Superior</td>
</tr>
<tr>
<td>Pastoralists</td>
<td>Finnish Kautokeino Lapps</td>
<td>25–35</td>
<td>53.0</td>
<td>Superior</td>
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<tr>
<td></td>
<td>Tanzanian Masai</td>
<td>32–43</td>
<td>59.1</td>
<td>Superior</td>
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<tr>
<td>Subsistence Pattern</td>
<td>Population</td>
<td>Average Age</td>
<td>Maximal Oxygen Uptake (ml/kg/min)</td>
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<tr>
<td>Industrial Westerners</td>
<td>Canadian Caucasians</td>
<td>20–29</td>
<td>40.8</td>
<td>Fair</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30–39</td>
<td>38.1</td>
<td>Fair</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40–49</td>
<td>34.9</td>
<td>Fair</td>
</tr>
<tr>
<td>Elite Athletes</td>
<td>Elite cross country skiers</td>
<td>Mid 20s to mid 3’s</td>
<td>Men: 80.0</td>
<td>Exceptional</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Highest recorded</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>94.0.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Women: 70.0</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Highest recorded</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>74.0.</td>
<td></td>
</tr>
</tbody>
</table>

*Table 7. VO2max in various population groups (Modified from Eaton, Konner & Shostak 1988 p.742).*

### 2.6.2.3 Skinfolds

In addition to superior fitness levels, not surprisingly, hunter-gatherer people also tended to have much lower body fat levels than Westerners as measured by skinfold thickness as seen in Table 8.

<table>
<thead>
<tr>
<th>Population</th>
<th>Skinfold Thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditionally living Australian Aborigines</td>
<td>4.7</td>
</tr>
<tr>
<td>!Kung</td>
<td>4.6</td>
</tr>
<tr>
<td>Arctic Inuit</td>
<td>4.4</td>
</tr>
<tr>
<td>Pygmies</td>
<td>5.5</td>
</tr>
<tr>
<td>United States population</td>
<td>10.1</td>
</tr>
</tbody>
</table>

*Table 8. Skinfolds in various population groups (Sourced from Eaton, Konner & Shostak 1988)*

### 2.6.2.4 Anti-diabetic effects of exercise

Exercise increases the body’s sensitivity to insulin and enhances the uptake of blood glucose into the liver and muscles which is strongly anti-diabetic in its effect (Babraj et al. 2009; Brand-Miller & Colagiuri 1999). Furthermore, physical activity stimulates increased muscle mass. Given that muscles are the major site of insulin-dependent glucose disposal, increased muscle mass provides a larger ‘sink’ for glucose thus buffering against high levels of circulating blood glucose and the cascade of resulting problems caused by insulin resistance. As outlined in Chapter 3, Australia has one of the highest recorded prevalence of diabetes for a developed nation and almost one in four
Australian adults has abnormal glucose tolerance (Dunstan et al. 2002). Physical exercise is of central importance to a healthy glucose metabolic response. It is therefore not surprising that serum insulin levels are typically low in hunter-gatherer populations and trained athletes (Eaton, Konner & Shostak 1988) and intramuscular glycogen stores are high (Stannard & Johnson 2004).

2.6.3 Sunlight and vitamin D

2.6.3.1 Vitamin D

Most plants and animals that are exposed to sunlight make vitamin D. It is one of the oldest hormones and has been made in living organisms for over 750 million years (Holick 2003). Hence, it is a very basic, enduring, necessary and central component of health. In contrast to our hunter-gatherer ancestors, modern life is increasingly lived indoors away from sunlight exposure (or sunscreens used when outdoors), and therefore away from our main source of vitamin D. A limited range of foods [e.g. fatty fish, liver, eggs, cod liver oil, fortified foods including margarine and some milks (Working Group of the Australian and New Zealand Bone and Mineral Society; Endocrine Society of Australia; Osteoporosis Australia 2005)] contain some vitamin D; however it is almost impossible to obtain sufficient vitamin D from the diet alone (NHMRC 2006). Vitamin D deficiency is a major unrecognised modern health problem (Holick 2003). A significant number of Australians are vitamin D deficient (Working Group of the Australian and New Zealand Bone and Mineral Society; Endocrine Society of Australia; Osteoporosis Australia 2005).

Vitamin D is made in the skin. Solar ultraviolet B (UVB) radiation beams are absorbed by the cholesterol molecule – 7-dehydrocholesterol – in the skin which is then transformed into pre-vitamin D₃, which is in turn rapidly converted to vitamin D₃, in a temperature-dependent manner. Formed vitamin D₃ is then metabolized in the liver and kidneys to the active hormone 1,25-dihydroxyvitamin D [1,25(OH)₂D] (Holick 2003, 2004).

Numerous body tissues have receptors for 1,25(OH)₂D including the intestines, bones, brain, heart, stomach, pancreas, activated T and B lymphocytes, skin, colon, prostate,
breasts, and gonads (Holick 2003). It is therefore not surprising that vitamin D deficiency has been associated with a very wide array of diseases in epidemiological studies (Vieth 1999).

One of vitamin D’s major roles in the body is in calcium homeostasis. It is on the basis of this biological role that the NHMRC has set the vitamin D nutrient reference value for Australians (NHMRC 2006). Whether or not a recommendation for vitamin D status based on bone health alone is valid is questioned in the literature. In fact, given that vitamin D status probably affects many biological systems Vieth’s (1999) prominent review paper argues that there is presently inconclusive evidence to consider establishing national guidelines.

Nonetheless, given that it has long been recognised that vitamin D deficiency causes rickets in children, and osteomalacia and osteoporosis in adults because of its major role in calcium homeostasis, it is in the area of bone health that adequate vitamin D status continues to be flagged. If there is inadequate calcium in the diet, vitamin D communicates with osteoblasts that then signal osteoclast precursors to mature and dissolve calcium stored in bones (Holick 2003).

Given the role of vitamin D in bone activity, it seems ill-considered to promote a high calcium intake in the absence of examining vitamin D status (a common situation at present).

Aside from bone health, less widely recognised are a variety of other associated adverse health effects of vitamin D deficiency, including multiple sclerosis, type 1 diabetes, other autoimmune diseases, hypertension and cancers of the colon, prostate, breast and ovary (Holick 2003). Vitamin D’s immunomodulatory role and its potential therapeutic implications are currently generating a boom of scientific research (Adorini 2005; Aronsohn, Amital & Shoenfeld 2007).

Although vitamin D production is far more dependent on sunlight exposure than diet, the NHMRC (2006) has set a recommended dietary intake level for adults of 200 IU per day in the absence of sunlight exposure. This is the equivalent of about half a teaspoon of cod liver oil. Vieth (1999) suggests that a more reasonable intake would be around 800 IU per day in order to prevent osteoporosis and an array of other conditions. Recommended guidelines for sun exposure do not exist. Vieth (1999) found that at least
four studies suggest that full body exposure to sunlight to one minimal erythemal dose – which is the amount that produces a faint redness of the skin – can be equivalent to an oral vitamin D intake of 10,000 IU. The Medical Journal of Australia’s position statement on vitamin D status in Australians states similar findings, citing a study in which whole body exposure to 10-15 minutes of midday sun in the Australian summer (about 1 minimal erythemal dose) is comparable to taking 15,000 IU of vitamin D orally (Working Group of the Australian and New Zealand Bone and Mineral Society; Endocrine Society of Australia; Osteoporosis Australia 2005). Somewhere between 10,000 and 15,000 IU is the likely physiological limit of vitamin D production (Vieth 1999). The concentration of pre-vitamin D reaches an equilibrium in white skin within approximately 20 minutes of ultraviolet exposure (Vieth 1999). Exposure beyond the minimal erythemal dose does not increase vitamin D production further (Vieth 1999). Hence, short exposures may be more efficient at producing vitamin D. Of course, a longer duration of exposure to the winter sun, particularly at more southern latitudes (in Australia) will be necessary for the same vitamin D production level. If the vitamin D nutrient reference value (NHMRC 2006) is adhered to, in the absence of natural sun exposure, 200 IU per day could be considered very inadequate.

The present reference range for vitamin D is arbitrary and based on cultural norms (Vieth 1999). Given that we are a society that typically work indoors, wear clothes, and actively avoid sun exposure (via lifestyle and sunscreen use), the current reference ranges do not necessarily encompass or reflect what is natural or optimal for health.

Table 9 outlines vitamin D concentrations in various population groups under different circumstances for comparative purposes.
<table>
<thead>
<tr>
<th>Year, Subjects</th>
<th>Location</th>
<th>Age</th>
<th>1,25(OH)₂D nmol/L serum concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Vitamin D status of Australians:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1994–1997, n = 861 women, randomly selected (Pasco et al. 2001)</td>
<td>Geelong, Australia</td>
<td>20–92</td>
<td>59 (winter) 81 (summer)</td>
</tr>
<tr>
<td>End of 2006 winter n = 126 healthy adults (Kimlin et al. 2007)</td>
<td>Southeast Queensland, Australia</td>
<td>18–87</td>
<td>10% had levels below 25 32% had levels between 25-50 (insufficient)</td>
</tr>
<tr>
<td>2. Sun-rich living conditions: (Vieth 1999)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Farmers</td>
<td>Puerto Rico</td>
<td></td>
<td>135</td>
</tr>
<tr>
<td>Lifeguards</td>
<td>St Louis</td>
<td></td>
<td>163</td>
</tr>
<tr>
<td>Lifeguards</td>
<td>Israel</td>
<td></td>
<td>148</td>
</tr>
<tr>
<td>3. UV light treatment sessions on vitamin D status: (Vieth 1999)</td>
<td></td>
<td>Treatment duration</td>
<td>Basal</td>
</tr>
<tr>
<td>Healthy males n = 24</td>
<td>Frankfurt, Germany</td>
<td>21–37</td>
<td>0.5 months</td>
</tr>
<tr>
<td>Patients with psoriasis n = 8</td>
<td>Hamburg, Germany</td>
<td>20–57</td>
<td>0.7 months</td>
</tr>
<tr>
<td>Psychogeriatric patients n = 14</td>
<td>Netherlands</td>
<td></td>
<td>3 months</td>
</tr>
<tr>
<td>4. Pharmacological dose of oral vitamin D: (Kimball et al. 2007)</td>
<td></td>
<td>Dose of vitamin D (IU)</td>
<td>Basal</td>
</tr>
<tr>
<td>Patients with active multiple sclerosis n = 12</td>
<td>Toronto, Canada</td>
<td>28,000 – 280,000 per week x 28 weeks (progressively increasing dose)</td>
<td>78</td>
</tr>
<tr>
<td>5. Reference ranges for 1,25(OH)₂D:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N/B: Optimal serum concentration levels have not yet been defined (Bischoff-Ferrari et al. 2006). A range of definitions currently in use include:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Reference range for adults based on normative values: 30–91 nmol/L (ARL Pathology 2008)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Mild deficiency defined between 25–50nmol/L (Working Group of the Australian and New Zealand Bone and Mineral Society; Endocrine Society of Australia; Osteoporosis Australia 2005)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Maintaining blood concentrations above 80nmol/l is advised in Holick’s (2004) review paper</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 9. Serum vitamin D concentrations under different circumstances*
2.6.3.2 Sunlight, time of day, exposure duration, skin pigmentation & sunscreen use

Season, latitude, time of day, exposure time, skin exposure surface area, skin pigmentation, aging and sunscreen-use all influence endogenous vitamin D production (Holick 2004). White Australians are not living within their ecologically adapted niche and hence, capacity for skin adapted sunlight exposure is difficult. It is plausible that the intensity of the Australian summer sun is such that fair skin will burn more rapidly than the timeframe required for optimal vitamin D synthesis. There is some evidence to suggest that gradual acclimatisation to the sunlight is important (Cordain 2002b) and a gentle tan creates a relative buffer.

What is the best time of day for sunlight exposure? The Medical Journal of Australia position statement on vitamin D status states, ‘deliberate sun exposure between 10:00 and 14:00 (11:00–15:00 daylight saving time) is not advised’ (Working Group of the Australian and New Zealand Bone and Mineral Society; Endocrine Society of Australia; Osteoporosis Australia 2005 p.281). In contrast, Moan et al. (2008) suggest ‘the best time of sun exposure is noon’ (p.86). Hence, there is no clear consensus in the literature on this issue at present. From an evolutionary perspective, sunlight exposure likely occurred intermittently throughout the day as part of an outdoor lifestyle.

Sunscreens are designed to block both UVA and UVB radiation and reduce skin carcinogenesis. Radiation in the UVB range results in the conversion of 7-dehydrocholesterol into previtamin D3, and hence sunscreens prevent vitamin D formation. However, sunscreens are essential to preventing skin damage during longer periods of sun exposure. It is well established that chronic, excessive sunlight exposure increases the risk of non-melanoma skin cancer (Holick 2004). While sunscreen prevents the symptoms of sunburn and non-melanoma skin cancer, the benefits of their use for the prevention of melanoma is uncertain (Gorham et al. 2007). A systematic review by Gorham et al (2007) of all known studies in the literature between 1966 and 2007 came to the conclusion that use of sunscreen may actually contribute to an increased risk of melanoma in populations at latitudes greater than 40 degrees (Melbourne is situated at 37 degrees latitude). In-vitro studies have found that 1,25(OH)2D inhibits the growth of malignant melanoma cell lines (Eisman, Barkla & Tutton 1987) and hence, inadequate vitamin D status, potentially because of sunscreen
use, may explain the association between malignant melanoma and sunscreen use in higher latitudes. Contributing further evidence to this issue is a recent study by Nurnberg et al. (2008) who found that serum levels of 25-hydroxyvitamin D levels were lower in melanoma patients compared to the control group and concluded that vitamin D status may be of importance for pathogenesis and progression of malignant melanoma; perhaps owing to it’s immune modulating effects.

During prolonged sun exposure (beyond dose required for adequate vitamin D production) the first measure taken should be to cover skin with clothing and shade rather than relying on sunscreen. This is particularly important in the light of recent concerns raised about sunscreen use with the publication of the Hanson et al. (2006) paper which found that when the sunscreen penetrated into the nucleated layers of skin, the level of reactive oxygen species (free radicals which can damage skin cells and contribute to cancer risk) increased above that produced naturally by UV light exposure. Hence, shade and clothing protection should be a first-line preventative measure.

2.6.3.3 Medical conditions associated with vitamin D deficiency

Research in this area is currently booming, with many quality journal articles being published on the topic each year. As mentioned, given the broad physiological basis of vitamin D in the human body, the effects of deficiency are equally broad reaching. Current research interest is predominantly focused on the role of vitamin D in bone health, autoimmunity, and cancer. The findings of key research papers in these areas are summarised here:

- **Bone health:** As stated, vitamin D deficiency causes rickets among children and exacerbates osteoporosis in adults (Holick 2004). Vitamin D supplementation trials are associate with a significant reduction in fractures in the elderly, with the degree of risk correlating with the degree of vitamin D deficiency (Working Group of the Australian and New Zealand Bone and Mineral Society; Endocrine Society of Australia; Osteoporosis Australia 2005). A recent Tasmanian study similarly found that fracture incidence was 31% lower in people with a prior incidence of non-melanoma skin cancer – a marker of cumulative sun exposure
and hence potential vitamin D status (Srikanth et al. 2007). In osteoarthritis, low serum vitamin D levels have been found to increase the activity of metalloproteinase enzymes that destroy articular cartilage and low vitamin D status is associated with osteoarthritic changes in the elderly (Lane et al. 1999). Osteoarthritis progression is mitigated by improved vitamin D status (Vieth 1999).

- **Autoimmunity**: There is mounting evidence in the literature for vitamin D as an environmental factor affecting autoimmune disease aetiology (Cantorna & Mahon 2004). A review article by Cantorna (2006) concluded that genetically predisposed individuals that either do not maintain adequate vitamin D levels or have polymorphisms in genes responsible for vitamin D metabolism, catabolism or function, have an increased likelihood of developing autoimmune diseases, namely multiple sclerosis and inflammatory bowel disease. It has long been recognised that multiple sclerosis is more prevalent in populations living in latitudes greater than 40 degrees who have lower ultraviolet exposure and hence lower concentrations of vitamin D (Vieth 1999). Other autoimmune conditions that have been associated with inadequate vitamin D status include rheumatoid arthritis and type 1 diabetes mellitus (Holick 2004).

- **Cancer**: High vitamin D levels were shown to be a prognostic advantage in prostate, breast, colon, lung cancer and Hodgkins lymphoma (Porojnicu et al. 2007). The interplay between adequate calcium and vitamin D appears to be particularly important in reducing the risk of colon and breast cancers (Garland, Garland & Gorham 1999; Lipkin & Newmark 1999).

### 2.6.3.4 The question of oral vitamin D supplementation

Vitamin D supplementation should only be a compensatory strategy for inadequate ultraviolet light exposure (Vieth 1999). In the natural model, adequate sunlight exposure within the ecological niche to which a population’s skin pigmentation is adapted is the most natural way of ensuring adequate vitamin D status. Given that most diets (including hunter-gatherer diets) contain little vitamin D, sunlight is by far the most
efficient route for vitamin D intake. Hence, the question of whether to supplement or not must only be considered when appropriate UV exposure is not possible. It has been suggested that vitamin D taken orally might carry a greater toxicity potential (Vieth 1999) because it enters the body via a less natural route in an acute dose that lacks the filtering and time-controlled regulation that occurs when intake is through the skin. Oral vitamin D is cleared from the liver within hours, compared to vitamin D absorbed through the skin which takes days to clear (Vieth 1999). There is no evidence in the literature of clinical trials examining the effect of dermal versus oral intake routes on different clinical endpoints.

For evolutionarily dislocated populations, such as white Australians, ‘appropriate’ sunlight exposure may be difficult to achieve. As already suggested, it is plausible to hypothesise that white Australians exposed to the summer sun are likely to burn in the time it is takes to achieve optimal UV exposure for vitamin D synthesis. Hence, a delicate balance and careful vigilance is required.

In terms of supplementation dose, the Working Group of the Australian and New Zealand Bone and Mineral Society (2005) suggest the use of 3,000-5,000 IU daily for 6-12 weeks to replete body stores. They note that oral doses of 10,000 IU per day have been used clinically without adverse effects for at least 90 days. No clinical or biochemical evidence of toxicity has been noted with doses up to 4,000 IU/day (Working Group of the Australian and New Zealand Bone and Mineral Society; Endocrine Society of Australia; Osteoporosis Australia 2005). This is not surprising given that this is a dose the body can easily produce from sensible sunlight exposure. Furthermore, the clinical trial by Kimball et al. (2007) that was designed to assess the safety of the high doses of vitamin D which may be required for therapeutic efficacy (progressively increasing doses of vitamin D$_3$ from 28,000 to 280,000IU/week over 28 weeks were used in this trial), found that while patient’s (n=12) serum 1,25(OH)$_2$D$_3$ concentration reached twice the top of the physiologic range, no hypercalcemia or hypercalciuria was induced. This trial provides circumstantial evidence that pharmacological doses of vitamin D$_3$ beyond the current upper limit may be safe by a large margin.
2.6.4  Women’s health and childbearing

2.6.4.1  Reproductive patterns in an evolutionary context

The reproductive experiences of women in hunter-gatherer societies differ significantly to those of most modern era Australian women (see Table 10). Humanity has exercised conscious control over reproduction throughout time in various ways in order to meet survival and social requirements. Recent technologies e.g. contraception, in-vitro fertilisation, genetic screening and cultural strategies (e.g. education) are significantly influencing reproductive patterns. Unlike the rest of this thesis where the nutritional patterns of hunter-gatherer societies have been put forward as a model for optimal nutrition, the reproductive patterns underpinning our genetically adapted template are difficult to interpret and make relevant use of. Conception and family planning in today’s society is a uniquely personal and socio-culturally sculpted activity, and the health impacts of the biological parameters of reproduction are only one component of women’s whole health with regards to the decision of when, and if, to have children. Hence, this section simply shares comparative differences from an interest-only perspective.

The current consensus is that menarche is likely triggered by a threshold of ‘fatness’ (Stoll 1998b). It is potentially accelerated by the presence of insulin resistance (Stoll 1998a, b) – a situation which is becoming increasingly common in Australian children (Dunstan et al. 2002). The average age of first menstruation in recent hunter-gatherer women was 16 years old (Eaton et al. 2001). In industrialised societies in the mid 19th century, the average age of first menstruation was 17 years, and by the mid 20th century it had reduced to 14 years (Family Planning Victoria, Royal Women's Hospital & Centre for Adolescent Health 2005). Today, first menstruation occurs on average at the age of 12 (Penry-Davey 2003). In recent hunter-gatherer societies, the time interval from menarche to first birth was three years on average (Eaton et al. 2001). By comparison, in Australia in 2003 the average age of first-time mothers was 27.6 (median age of 30.6) which, on the basis that the average age of menarche is 12, means a time interval of 13.6 years between menarche and first child (Australian Institute of Health and Welfare 2006a). Hunter-gatherer women averaged six live births (Eaton et al. 2001), compared to 1.8 for Australians in 2004 (Australian Institute of Health and Welfare 2006a). Even
at the height of the post-war baby boom in 1961, Australia’s total fertility rate stood at 3.56 (Kippen 2001), which is just under half of the hunter-gatherer average.

| Reproductive Milestones Among (Recent) Hunting and Gathering Women compared to Australian’s today |
|-------------------------------------------------|-----------------|-----------------|-----------------|-----------------|
|                                                 | Agta (Philippines) | !Kung (Botswana) | Ache (Paraguay) | Hunter-gatherer (average) | Australia 2004 (Australian Institute of Health and Welfare 2006a) |
| Menarche                                        | 17.1             | 16.6            | 14.3            | 16              | 12              |
| First live birth                                | 20.1             | 19.9            | 18.5            | 19.5            | 30.6            |
| Menarche to first birth                         | 3 years          | 3.4 years       | 4.2 years       | 3.5 years       | 19 years        |
| Birth spacing                                   | 3.05 years       | 4.1 years       | 3.2 years       | 3.45 years      | 1.8             |
| Average number of children                      |                  | 5               |                 |                 |                 |

Table 10. Reproductive milestones in hunter-gatherer women compared to modern-era Australian women (Modified from Eaton, Shostak & Konner 1988 p.220).

2.6.4.2 Breast feeding

Prolonged breast feeding has been a central part of childhood throughout human evolution (Eaton, Shostak & Konner 1988). This pattern has probably been unwavering, barring the past few hundred years in industrial societies. If a mother died in childbirth, the child would have been in grave danger. Anthropological accounts suggest that many societies continued breast-feeding for years (Eaton, Shostak & Konner 1988). For example, the breast feeding patterns of the !Kung San tribe who live in Botswana, Africa have been well documented. As Eaton, Shostak & Konner (1988) write, ‘the average frequency of nursing is four times an hour during the first two years of life. This frequency declines only gradually after that until weaning, at around age three, infants and young children always sleep with their mothers, and sometimes nurse without the mother waking up – an indication of the casual nature of breast-feeding in this culture’ (p.202). In the !Kung tribe, infants are introduced to solid foods at about six months of age which mirrors the age at which solids are recommended to be introduced to infants today (Australian Institute of Health and Welfare 2006a). In Australia today, at six months of age 48% of infants are still breastfed in some capacity and only 32% of infants aged six months or less are fully breastfed (Australian Institute of Health and Welfare 2006a).
According to the Australian Institute of Health and Welfare (2006a), ‘breastfeeding is one of the most important health behaviours to promote the survival, growth, development and health of infants and young children’ (p.269). The health protecting effects of breastfeeding on young children are well documented in the literature and include protection from a diversity of medical conditions including infections (gastrointestinal, respiratory, middle ear), sudden infant death syndrome (SIDS), diabetes, and allergies (Australian Institute of Health and Welfare 2006a; Krishnan & Korzenik 2002).

Breast milk contains a complex matrix of nutritive and non-nutritive factors which are not in entirety mirrored in formula feeds (Makrides & Gibson 2001). Along with nutrients including essential fatty acids, which are required for an infants cognitive and central nervous system development, breast milk also contains immunological proteins such as lactoferrin, immunoglobulin A and lysozyme which exert a protective effect on the infant’s immune system development and disease susceptibility. It is not until around four years of age that a child’s own immune system is fully developed (Eaton, Shostak & Konner 1988). Also of relevance, as discussed in the next section (the hygiene hypothesis), is that patterns of gastrointestinal microflora colonisation differ between formula-fed and breastfed infants (Fanaro et al. 2003), which has immunological consequences. Furthermore, there are the psychological and physical benefits derived from the close physical contact shared between a mother and child which breastfeeding nurtures (Lawrence 2000).

The nutritional composition of breast milk reflects maternal diet. There are consistent differences in the fatty acid composition of human milk between Western and non-Western populations consuming different diets. For example, the breast milk from mothers living on the island of Chloe, Tanzania, who subsist primarily off boiled marine fish, coconut, and other fruits and vegetables, may reflect the dietary fatty acid composition of the diet of our hunter-gatherer ancestors living in coastal regions. Milk from Chloe mothers contained high arachidonic acid (AA) and docosahexaenoic acid (omega 3 DHA), low linoleic acid (omega 6), and high medium chain fatty acids (MCFA) (due to high coconut consumption) (Kuipers et al. 2007). (The physiological functions of the essential fatty acids are outlined in Section 5.2.3.) Furthermore, the AA and DHA content of Chloe mothers breast milk were well above minimum levels recommended for Western formula milks (Kuipers et al. 2007). The total omega 3
content in human milk of Westerners is typically about 1.0–1.5% of total milk fat by dry weight (Langdon 2006). In contrast, Kuipers et al. (2005) and Kuipers et al. (2007) found that the breast milk of non-Western populations contained as much as 3.3% omega 3 fatty acids. The non-Western populations studied by Kuipers et al. (Kuipers et al. 2005; Kuipers et al. 2007) were not pure hunter-gatherers and were eating a diet which is arguably inferior to a true hunter-gatherer diet (use of vegetable oils and cereal grains), but superior to the average Western diet. Hence, the difference in fatty acid content may in fact be an underestimation of optimal requirements. There are also likely to be other qualitative nutritional differences apart from fatty acid composition (e.g. micronutrient differences) in the breast milk of Western populations eating a typical Western diet compared to those eating a more pure diet based on hunter-gatherer food groups, although this has not been widely explored in the literature.

2.6.4.3 Reproductive patterns & cancer

An influential article by Eaton et al. (1994) titled ‘Women’s reproductive cancers in evolutionary context’ examined the reproductive patterns of women in hunter-gatherer societies as a potential benchmark for understanding the genetic programming of the modern female body.

Eaton et al. (1994) hypothesised that the shifts in reproductive patterns in contemporary times may affect reproductive cancer risk factors. As outlined, women today tend to experience earlier menarche, lower parity, later menopause, reduced frequency and duration of lactation and hence ovulate and menstruate approximately three times more frequently than women in hunter-gatherer societies. Combined with other lifestyle parameters such as nutrition [especially excess body fat and hyperinsulinaemia (Stoll 1998a, b)] and physical exercise on reproductive health and cancer risk, calculations based on a theoretical model proposed by Eaton et al. (1994) suggest that to age 60, modern Western women have a breast cancer risk as much as 100 times that of hunter-gatherer women; owing to the differential hormone profile.
2.6.5  Microbial exposure, gastrointestinal microflora and immunity: The hygiene hypothesis

There are large discrepancies between our current Western living environment and our evolutionary template in terms of environmental microbial exposure. For temporal reasons such differences are difficult to precisely characterise. However, it is widely recognized that bacterial and parasitic exposure is very different between Western countries and developing countries, as well as between rural and urban environments.

The fundamental tenet of the ‘hygiene hypothesis’ is that microbial exposure, particularly during infancy, is needed to develop immune tolerance (Varner 2002). The theory is that exposure to innocuous bacteria (be they transitory or colonising) that we have co-developed with since birth is important in programming appropriate immune responses. Such organisms include lactobacillus, helminths and a multitude of inert species found in soil, untreated (but safe) drinking water and vegetable matter (Rook 2007). If there is a relative absence of these innocuous bacterial species, gastrointestinal colonisation with pathogenic/pro-inflammatory bacteria is more likely. The consequence of this is that it can drive an inflammatory response and a cascade of immune effects which may contribute to the development of allergic and autoimmune diseases (Bach 2002).

Environmental changes in general have been implicated in the rise in immune diseases in Western industrialised countries including Australia (Guarner 2007; Noverr & Huffnagle 2005). There has been a dramatic increase in both autoimmune (Th1) and allergic (Th2) immune diseases (Bach 2002; Poulos et al. 2007). As can be seen in Figure 8, the incidence of immune disorders, including asthma, type 1 diabetes, multiple sclerosis and crohn’s disease has escalated since the 1950s (Bach 2002). Furthermore, Poulos et al. (2007) recently observed that hospitalisations due to anaphylaxis more than doubled between 1993 and 2005 in Australia.
The increase in immune disorders in developed countries has been correlated with improved hygiene and vaccinations (and the consequential large decrease in infections), and other factors which go hand in hand with wealthy socio-economic circumstances. One hypothesis is that a trade-off has occurred between an increase in autoimmune/allergic diseases and a decrease in exposure to infectious stimuli (Bach 2002). Other evidence suggests slightly differently (Bloomfield et al. 2006). A growing consensus is now developing around the idea that more fundamental changes in the Western lifestyle have decreased exposure to the types of microbial species which are important for the development of immunoregulatory mechanisms (Bloomfield et al. 2006). Hence, Bloomfield et al. (2006) suggested that it would be more appropriate if the hygiene hypothesis was re-named as the ‘microbial deprivation hypothesis’.

Clearly, there are also key alterations in dietary and other lifestyle factors, as discussed in other sections of this thesis, which are of influence. Therefore, it is likely that a broad combination of factors is contributing to a more ‘pro-inflammatory’ environment today, which in its collective effect may underpin the increase in immune disorders including allergic and auto-immune diseases. The rationale for discussing the hygiene hypothesis is that it in part explains the loss of some of the protective factors which normally suppress or regulate appropriate immune responses (Guarner 2007; Noverr & Huffnagle 2005). For example, the gastrointestinal microflora in allergic infants is characteristically different to that of healthy infants and of therapeutic significance, the
difference precedes the development of allergic disease (Penders et al. 2007; Prescott & Dunstan 2007).

Hence, the current prevailing concept in hygiene hypothesis research is that disease is the result of a loss of tolerance by the immune system to the commensal (residential) microflora of the digestive tract in genetically predisposed individuals (Sonntag et al. 2007). As mentioned, under normal circumstances, the immune system co-evolves with the commensal microflora, and the human host learns to tolerate this microflora matrix and to recognise pathogenic flora as foreign and consequently mount an appropriate inflammatory immune response. Commensal microflora themselves assist in this regulation process by resisting pathogens, competitively binding to the mucosal surface and actively secreting antimicrobial products.

Gastrointestinal microflora are essential for appropriate maturation and maintenance of gastrointestinal immunity (Guarner 2007). Animals which have been kept germ-free undergo significant microflora changes and fail to develop appropriate gut associated lymphoid tissue including secretory immunoglobulin A activity, and importantly, these changes are normalised upon gastrointestinal bacterial colonisation (Guarner et al. 2006). Disruption of the delicate microflora homeostasis e.g. from an influx of pathogenic bacteria, or loss of tolerance to residential flora, results in secretion of pro-inflammatory cytokines, inflammation and potential tissue damage and thus epithelial barrier function disruption (with consequential increased potential for the translocation of dietary and gut-derived antigens into systemic circulation). This may be an important component of local and systemic immune disorders. While there is the possibility that there are specific pathogens that trigger the onset of particular immune disorders, exhaustive research has failed to identify a single causative pathogen and it is now more widely accepted that the whole matrix of indigenous flora is a more important factor (Ott et al. 2004).

Known factors which affect the colonisation and subsequent development of the microflora include birth mode of delivery (Sonntag et al. 2007), breast-feeding and timing of weaning (Fanaro et al. 2003), antibiotic use (De La Cochetie¨re et al. 2005), diet (Bengmark 2007) and environmental microbial exposure (Guarner et al. 2006; Noverr & Huffnagle 2005), especially in infancy and early childhood.
In regards to birth mode of delivery, the digestive tract is sterile in-utero and, during normal vaginal birth, maternal cervical flora and environmental flora quickly colonise the infant’s gut. In Western countries, the environmental flora is significantly influenced by hygienic measures taken (e.g. neonatal hospital ward practices). Additionally, normal patterns of colonisation can be disrupted or delayed in infants delivered via caesarean section or in those of low birth weight (Sonntag et al. 2007). Antibiotic use, particularly in the hygienic conditions of neo-natal intensive care units, has been shown to cause considerable changes in microflora colonisation patterns (Fanaro et al. 2003; Krishnan & Korzenik 2002). This can persist for an extended period of time and likely affect the normal development of gut-associated lymphoid tissue. Even in adults, most antibiotics, by their very purpose, cause major disruption to microflora and some studies have demonstrated that flora does not always return to the pre-antibiotic state following even short-term use (De La Cochetie’re et al. 2005).

Examination of differences in birthing and infant feeding practices, and hygiene measures between the Western world, the developing world and our evolutionary template may provide important information for autoimmune disease and allergy prevention. The therapeutic power of which would likely be enhanced by optimal diet and other lifestyle interventions. There is an abundance of research demonstrating the ability of different diets (although not including a hunter-gatherer diet) to alter the expression of gut microflora through the provision of different substrates to the digestive tract (Bengmark 2007). This is the rationale for the clinical use of probiotics (e.g. lactobacillus found in yoghurt and supplements such as VSL#3) which selectively alter the microflora (Summers et al. 2005).

Another key factor known to affect the composition of an individual’s microflora is genetics. Research has shown that attempts to manipulate microflora are influenced and constrained by the genotype of the individual (Bengmark 2007; Zoetendal et al. 2001). This probably explains the relative inability of probiotic supplements to colonise the intestines in the absence of their continued administration (Bengmark 2007). Stewart et al. (2005) found that in children there is a higher degree of similarity in the microflora composition in monozygotic twins (82% similar) than in dizygotic twins (68% similar), and the difference is greater between genetically unrelated individuals (45%). Environment alone cannot explain the differences between monozygotic and dizygotic twins; however the mean similarity index between microflora composition in monozygotic twins of 82%, not 100%, is still a significant difference which is
potentially attributable to only subtle differences in a largely similar environment – subtle differences which may be of key therapeutic importance.

The hygiene hypothesis provides a framework for attempting to uncover immunological mechanisms and associations behind the relationship between commensal microflora and disease risk and this has therapeutic consequences. Microflora manipulation has attracted and continues to attract research attention (particularly in the treatment of inflammatory bowel diseases) and the use of pre- and pro-biotics (Bibiloni et al. 2005; Chapman, Plosker & Figgitt 2006), along with dietary manipulation (Bengmark 2007) has shown promising, if not somewhat inconclusive results. While recommending that infants play in the mud and drink untreated potable water (e.g. tank water) challenges normal Western lifestyles, it would seem prudent to advocate extended breast feeding, particularly in at-risk populations, and avoidance of unnecessary antibiotic particularly in infancy, along with giving consideration to the other disparities between a Western lifestyle and our evolutionary template that can be modulated, including diet.
2.7 The Transition from Food Collectors to Food Producers: The effect on human health

‘The sheer novelty and glamour of the Western diet, with its seventeen thousand new food products every year and the marketing power – thirty-two billion dollars a year – used to sell us those products, has overwhelmed the force of tradition and left us where we now find ourselves: relying on science and journalism and government and marketing to help us decide what to eat’ (Pollan 2008 p.133).

2.7.1 Introduction

Food production practices have changed in an unprecedented way over the past 10,000 years, and particularly over the last 50 years or so. Since the introduction of agriculture, the scale of catching, gathering and producing food has been greatly expanded and methods intensified at an ever increasing pace (McMichael et al. 2007). Unlike modern conventional agriculture, from around 10,000 years ago until the mid 1900s farming techniques were still low tech, mirroring many of the so called ‘organic’ methods used today. Throughout this time, foods carried a higher index of ‘biological authenticity’ (see Chapter 4) relative to the majority of contemporary foods. Hence, the past 100 years has witnessed the most rapid period of change in the human food supply and dietary habits to date. As discussed, humans respond at a relatively slow tempo in terms of genetic adaptation. Consequently, the rapidly changing gradient of tempos in the modern era is distancing our ability to ‘track’ the natural environment and rhythms essential to our health and existence.

While the human body has had a long-standing relationship with wild food, no such relationship exists with the vast majority of the foods in the average Australian’s diet today. The transition to the intensive, industrialised food supply as we know it has occurred in a mere instant of time in an evolutionary sense. Whereas the hunter-gatherer lifestyle sustained humans for over 100,000 generations, only 500 generations or so have been agriculturalists, and at most, 10 generations have lived in the industrial age (Eaton, Konner & Shostak 1988). Only one generation, almost two, have been exposed to a globalised food market.
Hence, the aim of this section is to provide a brief history of the key socio-cultural transitions that have significantly altered the human food supply from hunter-gatherer times to contemporary Western life and highlights the timelines involved. It also introduces some of the effects of these changes on diet and health, setting the scene for further analysis in Chapters 4, 5 and 7.

### 2.7.2 Key transitions

The transition from hunter-gatherer diets to contemporary Western diets occurred in a series of steps underpinned by technological development. It began with the simple domestication of plants and animal foods (i.e. agriculture) in various global regions. McAllum (2007) defined the historic transitions in agriculture in terms of three key phases:

1. The phase of ‘geographical expansion’, which saw the intercontinental exchange of food species – for example, the movement of potatoes from their native South America to Europe where they became a dietary staple (McMichael et al. 2007). The development of longer trade routes encouraged farmers to increase surplus yields and plant crops with a longer storage and transportation capacity. Cereal grains were the prime crop for this.

2. The next distinct phase was the ‘age of mechanisation’, which took place in the early 1900s. This phase was underpinned by increasing reliance on fossil fuels for the operation of machinery. By and large, farming was still a family business, however, the drive to improve productivity (e.g. plant hybridisation programs) became central to the farming business plan.

3. The third key phase of agricultural development – ‘the age of intensification’ – is the situation we find ourselves in today. Farms are now part of large-scale industrialised supply chains. Synthetic chemical inputs (pesticides and fertilisers) along with intensive breeding programs have enabled high yielding crop strains. Intensive irrigation is often required, mass production of grain is in demand both for human food as well as for animal feeds (in intensive livestock production), bio-mass is being grown for fuel not just food, and rapid changes are imminent through the use of biotechnology (McMichael et al. 2007). This is
unfolding in a cultural milieu which is globally networked (via transportation routes, open markets and information technology including the internet) and subsequently highly responsive to marketing influence. The effect of the large scale on which today’s food supply is now operating is, as Lang (1999) suggests, that the Australian population is being quietly de-skilled in the fundamentals of the food supply. As argued in this thesis, this is a fundamental problem because it prevents individuals from critiquing their food choices and managing their health. At the same time, the unique advantage of such a ‘world-centric’ operation is that, for the first time in history, all of the worlds cultures, past and present, are to some degree available to us, either in historical records or as living entities (Wilber 2001). This inherently holds enormous potential for the necessary integration of what is now a globalised system underpinning chronic disease aetiology.

All the above mentioned technological changes have improved the commodification of food as an agent for economic return. Human health and optimal nutritional considerations have never been forefront in the process (Crawford & Marsh 1995). We are now eating foods produced in a progressively more man-controlled environment, which means that foods are increasingly growing and living in environments outside their ecologically adapted niches and the net quality of the human diet isn’t as fresh, nor as nutrient dense. As examined throughout this chapter, comparative studies analysing the nutrient density of wild foods compared to modernised conventional foods (Brandt-Miller, James & Maggiore 1997; Netzel et al. 2006), and between organic and conventional crops (Brandt & Molgaard 2001; Davis, Epp & Riordan 2004) suggest that with progressively increased human intervention, nutritional quality declines.

There are significant alterations in the food groups, species varieties, and environmental conditions from which we now derive the majority of our foods. Some of the natural limitations have been removed – food can be grown out of season, ripened synthetically, often stored for extended time, hybridised into big ‘soda pop’ varieties (e.g. sweet, aesthetically ‘perfect’ fruits), and grown in more simplified soil chemistry with the aid of chemical inputs. Furthermore, while an achievement of modern agriculture has been the production of large yields within a defined number of crops, overall species diversity has declined (Cordain 1999) with corresponding reductions in dietary diversity.
These food related changes cascade into socio-cultural effects. Intensive agricultural production has enabled massive population expansion, increasingly urbanised living and economic wealth – characteristics known to parallel consumption of processed, energy dense foods and decreases in physical activity (McMichael et al. 2007; Stanton 1999). Also affected are cultural food practices. Today, pre-packaged meals and ‘fast’ foods, along with other influences including the media and internet, are altering the social dynamic in which food is enjoyed and nutrition knowledge is shared (Petrini 2007).

The rapid intensification of food production has also resulted in widespread environmental impacts including chemical contamination and biodiversity loss, all of which broadly affect the quality of contemporary diets and threaten future food resources. The cascading inter-relationships are expressed by McMichael et al. (2007):

‘the expansion of food production is depleting land cover and biodiversity, with diverse consequences for human wellbeing and health; major elemental cycles are being disrupted (e.g. fertiliser use has vastly increased the concentration of bioactive nitrogen compounds in the global environment); industrial food refining, marketing and over-consumption increase the risks of some non-communicable diseases; and fossil fuel inputs to modern food systems, together with other aspects of crop production and animal husbandry, contribute substantially to greenhouse-gas emissions’ (p.1-2).
2.7.3  Agriculture and animal domestication: The introduction of high grain intake and dairy to the human diet

2.8.3.1  Agriculture and grains

Agriculture appears to have arisen in the Middle East around 11,000 years ago (Lewin & Foley 2004), around 8,000 years ago in the Mediterranean and about 5,500 years ago in Britain and Scandinavia (Flannery 1994). Agriculture saw the systematic farming of grains in particular, as well as legumes and other crops; the former two foods offering the favourable qualities in terms of their storage capacity, thus supporting year-round settlement (McMichael et al. 2007). Most advocates of a ‘Paleolithic’ diet (e.g. Cordain et al. 2005) point to this time as the entry point for ‘unadapted’ foods (such as cereal grains and dairy) being introduced into the human diet.

However, the story may not be so clear cut. Archaeological evidence from Ohalo, Lake Kinneret, Israel dated to around 23,000 years ago indicates a high intake of grains; thus doubling the antiquity of this food group in some human diets (Jones 2007). Thick wild stands of grains still exist today in some parts of the Middle East (Gordon 1987) and hence were likely exploited. Furthermore, Simoons (1981) states that the stands of wild einkorn wheat in south-eastern Turkey today are ‘massive, nearly as dense as a field of cultivated wheat’ (p.190). Simoons (1981) estimated that a family could readily harvest ‘enough grain in three weeks or so to supply them for a year’ (p.190). What is meant by ‘enough’ grain in terms of quantity is unspecified; however, it is perhaps unwise to suggest that some hunter-gatherer groups did not have access to significant amounts of wild grains. Whether or not this contributed to optimal nutrition is still worthwhile questioning.

Despite indications that wild grasses were utilised in some regions, it appears unlikely that there is any precedence for contemporary intake levels in pre-agricultural times (Cordain 1999; Jones 2007). Perhaps more to the point, and of relevance to this thesis, is that grains – grass seeds – were part of the human ancestral diet because they existed in the wild food supply. However, they were consumed as a whole food (i.e. not refined), in quantities reflecting their wild distribution, seasonal availability, and the context of a
species diverse diet. No matter which way one looks at it, this is different from the contemporary Australian diet in which, on a year-round basis, grains contribute up to 70% of energy intake (see Chapter 7). These are grains that have often been heavily hybridised and are frequently consumed in their refined form.

Since the introduction of agriculture, grains have increasingly displaced fresh wild foods from the diet and, in so doing, altered numerous nutritional characteristics and lowered the nutrient density of the diet. Further postulated deleterious effects associated with a high grain intake (particularly elevated gluten intakes and anti-nutrient factors such as lectins) include autoimmune disorders, schizophrenia and autism, not to mention celiac disease in genetically pre-disposed individuals (Cordain 1999; Dohan et al. 1984; Jones 2007). Cordain (1999) documents the potential for dietary imbalance and health implications of high cereal grain diets from an evolutionary perspective in his paper, ‘Cereal grains: humanities double-edged sword’, which is worth examining for further information.

The introduction of agriculture was not a dramatic ‘revolution’, but rather a transition that unfolded over several thousand years (Lewin 1988b). The archaeological site of Tell Abu Hureyra in northern Syria tells the likely story.

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4 For example, genetically, wild peas and lentils are closely related to their cultivated counterparts, however the wild progenitors of the broad bean and chickpea have not been clearly identified. Modern wheat has been heavily hybridised, yet ‘ancient grains’ such as spelt, kamut, and quinoa, closely genetically resemble wild-types. Under domestication, cereal grains, lentils, peas, beans and many other foods have increased in size. However, this change has been a gradual one (unless altered by biotechnology) and not a universal one, with some present day cultivated varieties still maintaining small seed sizes. Commonly in the wild, the seeds from grasses and legumes burst from their pods and shed their seed immediately after ripening making their collection variable. (Reference: Zohary, D & Hopf, M 1973, ‘Domestication of pulses in the Old World: Legumes were companions of wheat and barley when agriculture began in the Near East’, Science, vol. 182, no. 4115, 30 November, pp. 887-894.)

5 Higher frequencies of celiac disease are found in people with schizophrenia and a higher incidence of schizophrenia is found in people with celiac disease than in the general population. Experiments suggest that people with schizophrenia generally improve more quickly on diets free of cereals and dairy. Interestingly, the number of new hospital admissions for schizophrenia in Europe decreased when wheat consumption was reduced during World War II (however other explanations for this are also possible because the prevalence of mental health conditions in general have historically declined during wars). Overt schizophrenia is uncommon in societies whose diets include little or no cereal grains. (Reference: Simoons, FJ 1981, 'Celiac disease as a geographic problem', in Walcher, DN and Kretchmer, N (eds), Food, Nutrition and Evolution: Food as an environmental factor in the genesis of human variability, Masson Publishing, NY: USA. pp187.)
Abu Hureyra contains the remains of one of the earliest known village settlements in the world (occupied from 9,500 years ago until around 5,000 years ago). Analysis of this site indicate that the community subsisted on a mixture of hunted and gathered wild food as well as domesticated plants which were genetically the same as wild species (Lewin 1988b). At this particular site, cultivated plants included wild einkorn (primitive wheat), wild rye, and wild legumes. Interestingly, Lewin (1988b) states that these plants ‘would now be considered as weeds of cultivation’ (p.985). In terms of animal foods, the people of Abu Hureyra had access to a large and reliable source of wild meat due to the annual migration of Persian gazelle, which were killed on mass, the meat from which was likely stored (Lewin 1988b).

Hence, the dietary transition from hunter-gatherer subsistence to an early agricultural diet as suggested by analysis of Abu Hureyra was of a much smaller magnitude than that experienced by people today consuming Westernised diets.

Current modern ‘Paleolithic’ diet interpretations (e.g. Cordain 2002b; Eaton, Shostak & Konner 1988; Lindberg 2007) recommend the exclusion of cereal grains and legumes entirely (see Chapter 6). Lacking in these models is the likelihood that grass seeds were intermittently gathered in the wild. Hence, minor inclusion of commercially available grains and rice, especially ‘ancient’ grains (e.g. spelt, quinoa, kamut) which genetically more closely resemble their wild-type counterparts, grown with a high degree of biological authenticity (discussed in Chapter 4), is considered by this thesis to be a reasonable interpretation of a ‘contemporary hunter-gatherer diet’ (See Chapters 8).

2.8.3.2 Animal domestication and dairy

The domestication of animals began around 6,000 years ago (Cordain et al. 2005). This enabled humans to not only eat animal meats, but also start drinking their milk for the first time in history (this excludes the intake of human breast milk in infancy). As stated in Section 2.3, prior to domestication, dairy was not consumed simply because it is impossible to milk a wild, free living animal. Dairy consumption is emphasised in the Australian recommended dietary guidelines for adults primarily as a source of calcium (NHMRC 2003). The challenges of this issue are discussed in an evolutionary context in Section 5.4.
Whilst the overwhelming evidence suggests that genetically we are the same as our late Paleolithic hunter-gatherer ancestors (Eaton, Konner & Shostak 1988), as stated in Section 2.2.4, one of the few clearly recognised examples of more recent genetic adaptation is the retention of intestinal lactase into adulthood in some population groups. Lactase is the enzyme which digests lactose – the sugar present in milk. Prior to animal domestication humans did not ingest lactose after weaning, which is a pattern typical of all land mammals (Simoons 1981). In response, after weaning, intestinal levels of lactase drop to low levels that prevail into adulthood. The persistence of the ability to produce lactase in adulthood has risen to high frequency in people of European ancestry (Burger et al. 2007). This trait, inherited in a dominant Mendelian way, likely conferred some selective advantage (Burger et al. 2007; McMichael et al. 2007). Conflicting hypotheses exist as to whether the lactase persistence allele was rare until the advent of dairying but then rose rapidly in frequency under natural selection, or whether dairying was adopted in populations with a high prevalence of the lactase persistent allele (Burger et al. 2007). The recent work of Burger et al. (2007) suggests that the former was more likely and that lactase persistence was rare in early European farmers. This supports previous research (e.g. Simoons 1981). Today, the incidence of lactose intolerance is low among Europeans. Only 2% of Danes are intolerant to lactose as adults, and 16% of white Americans are intolerant. By contrast, black Americans and Native Americans are highly intolerant with 75% and 95% of adults respectively unable to digest lactose (Kretchmer 1980).

The presence of the lactase persistent allele in adults does not however mean that the body is optimally adapted to the consumption of milk. It simply means that adults can digest lactose.
2.7.3.3 What stimulated the transition from hunting and gathering to an agrarian civilisation?

Several competing hypotheses exist with regards to what caused the shift from hunter-gatherer subsistence strategies to agriculture. Climate change occurring at the end of the Pleistocene around 10,000 years ago has been implicated, as has population pressure. Cohen (1989) suggested that stress on wild food availability (namely widespread extinction of many large game animals) was a prime stimulator of agricultural beginnings and increasing population numbers forced people to intensify food production. Unlike Cohen (1989), Lewin (1988b) suggests that the population was not high enough at the time agriculture began to exert any significant influence. Rather, Lewin (1988b) writes, ‘when you look at the documented cases of early (agriculture) you become more impressed by the local circumstances’ (p.985). Hence, combining the various hypotheses, the shift towards agriculture could have been due to a number of factors including over-hunting and wild food shortages, climate changes, population growth and local environmental food-related opportunities and circumstances. It is also possible that the establishment of villages and the abandonment of nomadic life may not have been inherently due to agriculture at all. Simply, a reliable food source in a centrally available location may have been all that was necessary (Cunnane 2005). In some regions of the world, such as the Middle East where agriculture likely developed, the farming of cereal grains provided that reliable, year round source of food. In other locations, a river for instance may have provided plentiful year round fish, and hence agriculture itself may not have provided the sole mechanism for population growth in a particular location and the stimulus for settled village life.

2.7.4 Neo-agricultural diets

As to be further characterised in Chapters 5 and 7, today’s ‘neo-agricultural’ diets have increasingly become dominated by high grain intake, reduced species variety, dairy foods, and a greatly reduced (now almost absent) intake of wild foods. The net nutritional effect of this is a diet that is higher in carbohydrate, lower in protein, contains less variety, has an altered fat composition, and is lower in micronutrients than pre-agricultural diets. Furthermore, industrial food refining and processing has introduced
novel products into the diet including refined grains, sugars and oils; not to mention
artificial preservatives, colours and flavours.

These changes have occurred within the context of increasing use of chemical inputs in
crop production; intensive livestock production, which is supplying sedentary, fattier
animals; intensive plant and animal breeding programs (e.g. bigger chicken breasts);
agricultural biotechnology; modern food-processing techniques; and an increasingly
polluted environment. The accelerated dietary shifts over the past 50 years have been so
pervasive that human health is being rapidly and significantly impacted.

Figure 9 schematically presents the key transitions in the human diet from wild foods →
agricultural farming (increased grain consumption) and animal domestication
(introduction of dairy and fattier meats in the diet) → industrialisation (refined grains,
oils and sugars) → intensification (use of chemical inputs, intensive animal farming
practices, and increased environmental contamination in food chains) → food
globalisation (homogenisation of diets and the ‘fast food’ boom). As seen in Figure 9,
these changes correlate with distinctive alterations in lifestyle (increasingly urbanised,
indoor based and sedentary) and nutritional characteristics. Also depicted is the time
frame in which these changes occurred. To be noted is the rapid decline in the intake of
whole, fresh, diverse, nutrient dense foods over the past 50 years, and the increase in
animal derived saturated fat intake, glycaemic load of the diet and decrease in long
chain omega 3 fats. The biological significance of these dietary factors is further
discussed in Chapter 5.

Also included in Figure 9 are the nutritional correlates of eating in accordance with the
Australian recommended dietary guidelines (NHMRC 2003) and ‘contemporary hunter-
gatherer diets’ as proposed in this thesis (see Chapters 7 and 8), relative to the wild-food
hunter-gatherer ‘benchmark’; and a mention of the necessary resource base
underpinning a move towards more optimal diets (further explored in Chapter 4).
**Figure 9.** Transition in the human diet and the corresponding effects on nutritional factors relative to time
2.8 **Australia’s Unique Human, Ecological and Food History**

‘Before European settlement Aboriginal Australians ate rich, exciting and balanced diets of seasonal fruits, nuts, roots, vegetables, meats and fish – all indigenous varieties and species and each totally adapted to this unique environment, the continent of Gondwanaland’

(Isaacs 1987 p.11)

2.8.1 **Introduction**

This section looks at the uniqueness of the Australian ecology and how this impacts upon our food resources. Professor Tim Flannery has been particularly comprehensive in examining the issues involved. His work and culmination of ideas, presented in his book *The Future Eaters: an ecological history of the Australasian lands and people* (Flannery 1994), are briefly outlined in this section. Also discussed are traditional Australian Aboriginal diets and the nutritional properties of wild Australian bush foods. Doing this more closely attunes us to the original Australian landscape and its history.

2.7.2 **The Australian ecology**

The relationship between humans and the Australian landscape is unusual. Unlike human origins in Africa, Asia and Europe, Australian Aborigines arrived on their land as fully modern humans, and found themselves within an ecology that had not seen a human before. The same degree of co-evolution and co-adaptation between humans and the land as occurred in many other global regions did not occur (Flannery 1994).

In response to the uniqueness of the Australian environment Flannery (1994) proposed that the Australian Aborigines developed highly specialised responses. A key feature of the aboriginal way of life is the absence of agriculture. It is considered that this was likely an adaptational reaction to Australia’s geology, ecology and climate, which is
relatively un-conducive to agricultural farming. While Australian Aborigines and Papua New Guineans are of the same genetic descent (they were in contact a mere 10,000 years ago), Australian Aborigines persisted in their nomadic lifestyle until very recent times. By contrast New Guineans moved into agriculture probably because, as Flannery (1994) suggests, their deep fertile soils and abundant rainfall were conducive to farming. Furthermore, hunting in the New Guinea highlands would have been more difficult than in Australia.

A strict differentiation between agriculture and wild food harvesting is a hard one to draw. Australian Aborigines did deliberately alter their food supply using a variety of techniques. Fire was used to increase the supply of edible seeds and encourage grass-eating game (Australian National Botanic Gardens Education Services 2000). Native millet was harvested while still green, stacked in heaps and left to ripen and dry. Yams were specifically planted and the tops of tubers left attached so they would grow again. Fruit trees were also purposely sown by spitting seeds of fruit into debris of fish and shells, and water was diverted into channels to water existing trees (Flannery 1994). None of this, however, compares with the scale of technology and mechanical inputs applied to our contemporary agricultural system. The foods harvested by the Aborigines were in primary control of their own nutrient supply and were well adapted to the ecological environment in which they were growing. As is consistently established throughout this thesis, this typically translates into superb nutritional quality.

Since Europeans settled in Australia some 200 years ago, all commercially grown foods are of European descent. However, the ecology of the two continents are very different. The assumption that the Australian ecosystem works like Europe has lead to extraordinary and rapid land degradation (Flannery 1994; Suzuki & Dressel 1999). Unlike Australia, Europe has consistent rainfall and fertile soils which, in some areas, have been enriched by glacial outwash. Whilst Australia does have some fertile soils – for example, the volcanic areas of the Strezleki ranges in Victoria – the productivity of our soils is limited by variable rainfall, especially away from the coastal zone (Birch 2003).

In terms of plant species differences, in Europe, by about 8000 years ago, glacial ice (from the last ice age) had melted and the types of plants that colonised the land were fast growing and suited to regular rainfall and nutrient-rich soils. In contrast, Australian native plants have inhabited the soils for many tens of thousands of years, resulting in
considerably higher biodiversity and evolutionary adaptation to Australia’s drier climate and variable soil types. In terms of animal life, European species such as foxes and rabbits breed rapidly due to their short reproductive cycles. In quite the reverse, Australian native animals are slow breeding and are adapted to make use of brief windows of opportunity in which nutrient and water resources are available. Hence, European plant and animal species have not gone through a long period of co-adaptation, or relied on a web of complex ecosystems like Australia’s native fauna and flora (Flannery 1994). This is why introduced European species have been so destructive to the Australian environment and, with no evolutionarily adapted competition, plague population levels have been rapidly reached. To address this problem, these abundant ‘pests’ (e.g. rabbits, foxes, camels) could be seen as ideal human food (if disease free) for modern day Australians because they are free living animals, in control of their own food supply, and their populations need to be significantly reduced.

By the mid 19th century, European settlers in Australia had found ways to make agriculture work. Breeding programs were relatively successful in producing wheat strains that were resistant to dry Australian conditions, and surface and groundwater irrigation systems were introduced progressively from the 1880s (Flannery 1994). Currently, 22 million hectares of arable land is being used in Australia, however after less than 200 years of use, 70% is degraded and in need of soil restoration (Flannery 1994).

2.8.3 Australian Aboriginal diets

Numerous anthropological and living records have supplied information about the diets of Australian Aborigines. The Australian ecology can be roughly categories into three main divisions: coastal, riverine/plains, and desert. As previously stated, by preference Australian Aborigines were most probably coastal or estuarine based people (O'Dea 1991a). Food abundant coastal regions meant that tribal groups hunted and gathered over a smaller territory (around 500 km²) and sustained larger populations than in arid inland or desert regions (foods gathered from around 100,000 km²); (O'Dea 1991a).
Each Australian ecological niche offers slightly different foods. In all environments Australian Aborigines unanimously used hunter-gatherer subsistence strategies. As mentioned, crops weren’t cultivated, unlike in neighbouring New Guinea and on some Torres Strait islands, and all indications suggest that plentiful food reserves were available (Farrer 2005). If food supplies dwindled, as nomads, Australian Aborigines moved on to new surroundings. With the same division of labour as in other worldwide hunter-gatherer societies, men hunted large marsupials, emus, birds and other animals with woomera, spear, boomerang and throwing sticks; and women gathered plant foods including roots such as yams and water lily roots from billabongs and rivers, fruits, seeds, nuts, pith from ferns, fungi, and possibly also seaweeds. Women also collected animal foods including shellfish, crustaceans, eggs, reptiles, small mammals, insects, worms, snails and honey (Farrer 2005). With hook and line and bone-tipped spears, marine resources were utilised as evidenced by some very large middens from Cape York to Tasmania with fish, shellfish, dugong and turtle (and turtle eggs) remains being found. Marine foods were replaced with river foods in inland regions where fish, shellfish and other crustaceans were often collected in nets made from bulrush fibres (Farrer 2005). As Farrer (2005) writes, ‘ducks, too, were netted over rivers and lakes, and in Victoria very clever and elaborate fish and eel traps were developed, especially in the Lake Condah area where the people seem to have lived a semi-sedentary life in villages’ (p.4). In the desert areas of Australia, large kangaroo and emus were hunted and, as opposed to other ecological niches, a greater variety of grass seeds (e.g. millet) and tree seeds (e.g. acacias) had to be relied upon in the absence of the wider variety of other foods (Brand-Miller & Holt 1998) available in other regions. The present lack of nutrition composition data for southeast Australian bush foods and the bias towards inland/desert foods poses a challenge when making nutritional assumptions about average Australian Aboriginal diets as noted in Section 2.3.3.2. Hence, we don’t necessarily have a true representation of the nutrition composition of the traditional Australian Aboriginal diet. [Despite this, Brand-Miller, James & Maggiore’s (1997) data has been very influential in informing current evolutionary nutrition ideas – particularly those of Cordain et al. (2000), as critiqued in Section 2.3.3.2.]

Foods were freshly harvested and minimally processed and if required, simply cooked before consumption. As there were no cooking pots, foods tended to be cooked in hot ashes rather than boiled in water (Brand-Miller & Holt 1998).
Australian natives offer a rich reserve of edible plants. Cherikoff & Isaacs (1990) identified 245 species of edible plants from rainforest habitats and 231 from dry land areas. The authors note that in the Sydney region alone 208 edible species have been identified. In Victoria, botanical records have been compiled for over 700 plants species used by Koories (Gott 1993). Full information on many individual species of plants used by Victoria’s traditional people is held in the National Herbarium of Victoria, Royal Botanic Gardens, Melbourne. The potential for species diversity in the native food supply is far greater than our contemporary one.

2.8.4  Nutritional quality of wild Australian bush foods

2.8.4.1  Micro- and macro- nutrient density of Australian bush foods

Brand-Miller, James & Maggiore’s (1997) nutrient composition analysis of Australian bush foods is the largest wild foods database presently available in the world. Using this database, Brand-Miller & Holt (1998) analysed the likely nutritional characteristics of average traditional Australian Aboriginal diets from central, northern and western Australia. They suggest that plant foods provided 20–40% of daily energy, with the remainder sourced from animal foods. This resulted in a diet which was low in carbohydrate, high in protein, contained a favourable fatty acid profile (further discussed in Section 5.2.3) and, despite the relatively low intake of plant foods, the micronutrient density (vitamins, minerals, phytochemicals) was remarkably high relative to contemporary Western diets.

On average, the micronutrient content of wild fruits and vegetables is consistently higher than cultivated equivalent species (see Appendix B). Stand out differences are particularly noticeable among the minerals – magnesium, calcium, iron and zinc. In part this may be because the wild foods collected in Brand-Miller, James & Maggiore’s (1997) analysis were predominantly from hot climates and hence, due to water loss, the foods on a per weight basis may have appeared to be more nutrient dense. All the same,
evidence from other studies support the nutritional superiority of wild foods (Eaton, Eaton & Konner 1997; Southgate 1991).

While the nutritional composition of the total diet is far more relevant to health than the isolated study of individual foods, the exceptional nutritional properties of individual Australian bush food examples is still interesting. The Kakadu plum, also called the billy goat plum (*Terminalia ferdinandiana*) contains the highest level of vitamin C ever recorded (up to 5% by weight); (Miller, James & Maggiore 1997). Cooked candle nuts (*Aleurites moluccana*) contain exceptionally high thiamin (vitamin B1) (4mg/100g), and the seeds of *Grevillea leucopteris* contain up to 1.5% calcium. The Bogong moth (copiously available in the Australian high country in spring and early summer) is caloric and nutrient dense (containing 22% protein, 39% fat) and provided a dominant food source for months (Farrer 2005). Some foods including the Bogong moth, as well as the bunya pine (found in the hinterland of Queensland’s Sunshine Coast), and fish and crayfish along the Murray River (O’Dea 1991a) provided food in such plentiful quantities at various times of year as to enable the seasonal gathering of numerous tribes for festivities and cultural activities (Farrer 2005).

### 2.8.4.2 Phytochemicals in Australian bush foods

Increasing research is demonstrating the health promoting effects of dietary phytochemicals. Their impact on human health is discussed in Section 4.2.3.7. As with the nutritive properties of food (i.e. vitamins, minerals, proteins, fats, carbohydrates), non-nutritive components (i.e. phytochemicals) of wild food may also serve as a benchmark for understanding the optimal human diet.

The phytochemical composition of Australian wild food has only recently been analysed. Netzel et al. (2006) examined the phenolic (a type of phytochemical) content and antioxidant activity in Australian native edible fruits for the first time. Total phenolic content strongly correlates with anti-oxidant activity (Netzel et al. 2006). Different groups of compounds such as flavonoids (e.g. anthocyanins, flavan-3-ols) and phenolic (e.g. benzoic and cinnamic) acids contribute to their antioxidant activity (Netzel et al. 2006). Table 11 shows the total phenolic and antioxidant potential of seven
native Australian fruits compared to commercially grown blueberries, which are known for their high antioxidant potential.

<table>
<thead>
<tr>
<th>Fruit</th>
<th>Total phenolic content (µmol of gallic acid equivalents per gram of fresh weight)</th>
<th>Total reducing capacity (= measure of antioxidant potential) (µmol of Fe²⁺/g of fresh weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burdekin plum</td>
<td>100.5</td>
<td>283.38</td>
</tr>
<tr>
<td>Muntries</td>
<td>67.12</td>
<td>267.55</td>
</tr>
<tr>
<td>Cedar Bay cherry</td>
<td>64.95</td>
<td>233.30</td>
</tr>
<tr>
<td>Illawarra plum</td>
<td>68.21</td>
<td>214.79</td>
</tr>
<tr>
<td>Tasmanian pepper</td>
<td>82.51</td>
<td>186.71</td>
</tr>
<tr>
<td>Molucca raspberry</td>
<td>21.91</td>
<td>66.58</td>
</tr>
<tr>
<td>Blueberry (control)</td>
<td>26.00</td>
<td>52.74</td>
</tr>
<tr>
<td>Davidson’s plum</td>
<td>16.75</td>
<td>49.29</td>
</tr>
</tbody>
</table>

Table 11. Phytochemical content & antioxidant potential of Australia bush fruits relative to blueberries (Sourced from Netzel et al. 2006 p.9822)

Fruits are listed in Table 11 in descending order of their total reducing capacity, which is a measure of their antioxidant potential and thus health promoting qualities. As can be seen in the table, most of the Australian native fruits possess considerably higher antioxidant potential than blueberries. Top of the list is the Burdekin plum, which, on the basis of the fresh weight, contains 5.4 times the total reducing capacity of the blueberry control. These preliminary results suggest that wild plants may contain exceptional antioxidant properties. In the study by Netzel et al. (2006), the Australian native fruit samples were commercially grown as opposed to being harvested from the wild. As outlined in Section 4.2.2, different growing conditions influence phytochemical content. At present, the Australian bush food industry is still small and often food is produced under organic/polycultural methods (Dyer 1999), which tends to elevate the phytochemical content of the produce relative to conventional systems. It is possible that over time, if Australian bush foods were hybridised within a conventional agricultural approach (e.g. for specific non-nutritive factors including size, ease of harvesting, transportation suitability), and grown within the standard system of conventional agriculture, the phytochemical content may reduce and become comparable to other conventionally produced fruits.
2.8.5 Using Australian wild foods in contemporary diets

Australian bush foods are a focus of this research because they are the Australian wild food source. The exceptional nutritional quality of Australian bush foods does not stand out as superior compared to wild foods in other global ecological niches. They are just an example.

The rationale for encouraging an Australian bush foods industry is based not only on potential human health benefits but also on environmental considerations. Biodiversity can be preserved and indigenous species can be grown that are appropriately adapted to the Australian environment and thus hold greater sustainability potential. At present, bush foods available for commercial purchase are, for the most part, genetically very true to their wild counter-parts. There is incredible natural biodiversity in seed stock. For example, the genus *Acacia* (seeds) contains over 650 species and the *Solanum* (e.g. tomato) family contains 80 native species (Dyer 1999). Although many of these species are inedible, the genetic variety and hence biological strength of Australian flora and fauna is strong compared to the seed stock from which most conventional agricultural species are selected from – an important issue underpinning food security (Shiva 2000). Appendix C lists some of the Australian native food plant species currently grown commercially in southern Australia. In terms of animal foods, native animals commercially utilised for human food include fish and shellfish, kangaroo (which is harvested from wild living groups), as well as emu and crocodile.
Chapter 3: The Diet-Disease Interface in Australia Today

‘Health is a state of complete physical, mental and social wellbeing and not merely the absence of disease and infirmity’ (World Health Organization 1948b)

3.1 Introduction and Chapter Scope

An overview of the predominant health issues affecting Australians is necessary to identify aetiological points of convergence and therefore more effectively target the therapeutic application of this thesis. As will be explored, importantly, it also helps to appreciate the magnitude and gravity of the need to address sub-optimal nutrition and lifestyle choices, which are the primary cause of premature death and lost quality of life in the Australian population today (Section 3.2). Section 3.3 extends the exploration of health determinants and specifically examines the problem of overweight and obesity which now affects more than one in two Australians – a situation carrying a cascade of health risks.

Whist it is well recognised that diet provides a direct pathway for altering the biochemistry of the body, the common question is: which diet is most effective? Section 3.4 examines some of the epidemiological evidence associating different eating patterns with disease characteristics. Specifically, the Mediterranean diet, the results of the ‘Seven Countries Study’ (Keys et al. 1985), the ‘French paradox’, and vegetarian diets are discussed, relative to the hunter-gatherer model.

When individuals clinically present to health-care practitioners with one or more diet-and lifestyle-related health conditions, several therapeutic options are commonly

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6 This definition has not been amended since 1948.
recommended. Three prominent recommendations – the Mediterranean diet (which has been coined the ‘gold standard’ diet for heart disease), the Ornish program (low fat, vegetarian diet and lifestyle program used successfully in treating heart disease and prostate cancer), and the Gawler Foundation program (a diet and lifestyle program for cancer patients based in the Yarra Valley, Victoria) – are compared and examined within an evolutionary framework (Section 3.5).

The final aspect of Chapter 3 (Section 3.6) is an exploration of our psychological relationship with food. All the knowledge in the world about optimal nutrition doesn’t necessarily effect what we end up putting in our mouths. Today, many of us eat, at least some of the time, for reasons entirely unrelated to physiological hunger. In today’s food abundant environment, food is commonly used in an attempt to soothe and calm stress. As Ornish (2004) states, ‘the real epidemic isn’t just heart disease, obesity or smoking, it’s loneliness and depression’. Hence, the psychology of eating behaviour is a pivotal determinant of health and considered to be a necessary part of discussions about optimal nutrition and health.
3.2 Australians’ Health

‘Homo sapiens sapiens is evolving into Homo sedentarium obesus’

(Jean Mayer cited in Eaton, Konner & Shostak 1988 p.739)

3.2.1 Introduction

An understanding of the types of health issues affecting Australians is necessary to identify potential dietary and lifestyle risk factors underlying their causes. Statistics about Australia’s health status are collated every two years by the Australian Institute of Health and Welfare (AIHW). The most recent report was published in 2006 and it is this data that informs the basis of this section.

The major causes of morbidity, disability and mortality in Australia are chronic diseases (i.e. diseases of slow progression and long continuance, as opposed to illnesses which are abrupt, sharp and brief i.e. acute); (Australian Institute of Health and Welfare 2006a). Of critical importance is that the incidence of chronic diseases is accelerating dramatically in Australia and worldwide, and is pervading all socioeconomic classes (World Health Organisation 2007). The prevalence of chronic disease is now greater than at any other period in human history (Australian Institute of Health and Welfare 2006a). The 2002 World Health Report found that, globally, the major chronic diseases accounted for almost 60% of all deaths and 43% of the global burden of disease (World Health Organisation 2002). Furthermore, by 2020 the estimated projections are that the situation will worsen – 73% of all deaths and 60% of the global burden of disease will be due to chronic diseases (World Health Organisation 2002). Mirroring the worldwide statistics, the three leading chronic diseases affecting Australians are cardiovascular disease (including coronary heart disease, stroke, heart failure and peripheral vascular disease), cancer, and type 2 diabetes (Australian Institute of Health and Welfare 2006a).

As stated by the World Health Organisation, these conditions ‘are linked by common and preventable biological risk factors, notably high blood pressure, high blood cholesterol and overweight, and by related major behavioural risk factors: unhealthy diet, physical inactivity’ (World Health Organisation 2007).
Given that chronic diseases take years, often decades to develop, prevention through a lifetime of healthful habits offers the best protection. Once disease has developed, slowing down progression and even reversing disease processes could be likened to getting a massive ocean tanker to slow down, stop, and then change course. It takes time, and requires considerable effort. But, as to be discussed in Section 3.4, studies such as the Lyon Heart Disease study (de Lorgeril et al. 1999), and the Ornish program (Frattaroli et al. 2008; Pischke et al. 2007) have demonstrated the positive effects of nutrition on disease modification and reversal.

3.2.2 **Major diseases affecting Australians**

The top 10 causes of death for Australian males and females are listed in Table 12.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Males Cause of death</th>
<th>% of all deaths</th>
<th>Females Cause of death</th>
<th>% of all deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ischaemic heart disease</td>
<td>19.2</td>
<td>Ischaemic heart disease</td>
<td>17.8</td>
</tr>
<tr>
<td>2</td>
<td>Cerebrovascular disease (notably stroke)</td>
<td>7.1</td>
<td>Cerebrovascular disease</td>
<td>11.3</td>
</tr>
<tr>
<td>3</td>
<td>Lung cancer</td>
<td>6.9</td>
<td>Other health diseases</td>
<td>6.7</td>
</tr>
<tr>
<td>4</td>
<td>Other heart disease</td>
<td>4.8</td>
<td>Dementia and related disorders</td>
<td>5.1</td>
</tr>
<tr>
<td>5</td>
<td>Chronic obstructive pulmonary disease</td>
<td>4.4</td>
<td>Breast cancer</td>
<td>4.1</td>
</tr>
<tr>
<td>6</td>
<td>Prostate cancer</td>
<td>4.0</td>
<td>Lung cancer</td>
<td>3.9</td>
</tr>
<tr>
<td>7</td>
<td>Colorectal cancer</td>
<td>3.2</td>
<td>Chronic obstructive pulmonary disease</td>
<td>3.5</td>
</tr>
<tr>
<td>8</td>
<td>Diabetes</td>
<td>2.7</td>
<td>Colorectal cancer</td>
<td>3.0</td>
</tr>
<tr>
<td>9</td>
<td>Unknowns primary site cancers</td>
<td>2.6</td>
<td>Pneumonia and influenza</td>
<td>2.9</td>
</tr>
<tr>
<td>10</td>
<td>Suicide</td>
<td>2.4</td>
<td>Unknown primary site cancers</td>
<td>2.7</td>
</tr>
</tbody>
</table>

*Table 12. Top 10 causes of death in the Australian population (Sourced from Australian Institute of Health and Welfare 2006a)*
3.2.2.1 Cardiovascular disease

Cardiovascular disease accounted for 36% of all deaths in Australia in 2004 (Australian Institute of Health and Welfare 2006a). It was also one of the leading causes of disability. One of the main causal mechanisms in cardiovascular disease is atherosclerosis which is a marked build up (plaque) of fat and cholesterol lining the arteries. Should the plaque become large enough that it causes reduced or no blood supply to the heart or brain, a heart attack (or angina in a milder case) or stroke results. The known preventable risk factors cited by the Australian Institute of Health and Welfare (2006a) are smoking tobacco, high blood pressure, very high blood cholesterol, insufficient physical activity, overweight and obesity, poor nutrition and diabetes.

As noted in Section 2.5 clinical and post mortem examination of recent hunter-gatherer populations and people living more traditional lifestyles, including the Arctic Inuit, Kenyan Kikuyu, Solomon Islanders, Navajo Indians, Masai pastoralists, Australian Aborigines, Kalahari San (Bushmen), New Guinea highland natives and Congo Pygmies reveal that they experienced little or no coronary heart disease (Cordain et al. 2002; Eaton, Konner & Shostak 1988; Lindeberg & Lundh 1993). As Eaton et al. (1988) states, ‘these persons are not genetically immune from hypertension (or cardiovascular disease) since, when they adopt a western style of life, either by migration or acculturation, they develop, first, a tendency for their blood pressure to rise with age and, second, an increasing incidence of clinical hypertension’ (p. 744). Hence, diet and lifestyle factors are central to cardiovascular disease.

Serum cholesterol, while not necessarily being a sole risk factor for cardiovascular disease (Plourde & Cunnane 2007), can be used as a ‘marker’ for dietary patterns. For comparative purposes, Table 13 highlights the low serum cholesterol levels of several (recent) hunter-gatherer societies compared to contemporary Australians.
<table>
<thead>
<tr>
<th>Subsistence Pattern</th>
<th>Population</th>
<th>Gender</th>
<th>Cholesterol Value (mmol/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hunter-gatherer populations</strong></td>
<td>Tanzanian Hadza</td>
<td>M</td>
<td>2.9</td>
</tr>
<tr>
<td>(Eaton, Konner &amp; Shostak 1988)</td>
<td>F</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>Kalahari San (Bushman)</td>
<td></td>
<td></td>
<td>2.8 – 3.3</td>
</tr>
<tr>
<td>Congo Pygmies</td>
<td></td>
<td>M</td>
<td>2.6</td>
</tr>
<tr>
<td>F</td>
<td></td>
<td>2.8</td>
<td></td>
</tr>
<tr>
<td>Australian Aborigines</td>
<td></td>
<td>M</td>
<td>3.7</td>
</tr>
<tr>
<td>F</td>
<td></td>
<td>3.4</td>
<td></td>
</tr>
<tr>
<td>Canadian Inuit</td>
<td></td>
<td></td>
<td>3.6</td>
</tr>
<tr>
<td><strong>Australian Adults today</strong></td>
<td>Australian adults (25 years</td>
<td>M</td>
<td>5.5</td>
</tr>
<tr>
<td>(Dunstan et al. 2002)</td>
<td>and older)</td>
<td>F</td>
<td>5.4</td>
</tr>
</tbody>
</table>

Table 13. Comparative differences in serum cholesterol between recent hunter-gatherer populations and contemporary Australians

Dietary saturated fat intake is the main factor that raises blood cholesterol (Australian Institute of Health and Welfare 2006a; Cordain et al. 2002; O'Dea et al. 1990). Exemplifying this, O’Dea et al. (1990) observed that the addition of beef fat (saturated fat) to the human diet, not lean beef itself, was associated with elevations in cholesterol (low density lipoprotein) concentrations. Hence, the higher animal food diets of many hunter-gatherer populations (Cordain et al. 2000), whilst containing a high amount of dietary cholesterol [estimated at around 480mg per day (Eaton, Konner & Shostak 1988)], were also very low in animal derived saturated fat (Cordain et al. 2002; Cordain et al. 2002c) and had a greater proportion of polyunsaturated fat [which again assists in lowering serum cholesterol (Micallef & Garg 2008)] – factors which are protective of atherosclerotic plaque initiation and cardiovascular disease.

### 3.2.2.2 Type 2 Diabetes and diseases of insulin resistance

Type 2 diabetes mellitus is a metabolic disorder characterised by reduced levels of insulin, or the inability to adequately use insulin (Australian Government Department of Health and Ageing 2007). Australia has one of the highest prevalence of diabetes for a developed nation and it is a cause of much disability and poor quality of life in the community. Including those with impaired fasting glucose and impaired glucose intolerance, almost one in four Australian adults has abnormal glucose tolerance.
Type 2 diabetes accounts for more than 85% of people with diabetes in Australia (Australian Government Department of Health and Ageing 2007).

The largest and most recent data source on diabetes in Australia is the ‘1999–2000 Australian Diabetes, Obesity and Lifestyle Study’ (AusDiab) which included 11,247 participants over the age of 25 (Dunstan et al. 2002). This study found that prevalence of full blown diabetes was 8% in men and 6.8% in women. A further 17.4% of men and 15.4% of women had impaired glucose tolerance or impaired fasting glucose (Dunstan et al. 2002). Importantly, as with all chronic diseases, onset is not sudden. Many Australians are experiencing sub-clinical symptoms of insulin resistance and experiencing the sub-clinical damage that this causes. While ‘prediabetic’ conditions were once thought to be related to ageing (so too was cardiovascular disease), the recent epidemic is also afflicting younger populations (Guarente 2006). In the youngest age group in the study by Dunstan et al. (2002) (25 to 34 year olds), 5.7% had abnormal glucose tolerance. Most commonly, type 2 diabetes becomes evident after the age of 40, however the condition is now also increasingly affecting young children between the ages of one and 14 (Australian Institute of Health and Welfare 2006a). Hence, rather than there being an ‘ageing’ component to the condition in the usual sense (i.e. afflicting people in their later years of life), there does seem to be an ‘over-use’ component, whereby metabolic systems (and specifically glucose homeostasis) are chronically strained over an accumulative period of time before dysfunction becomes evidence.

Of critical importance is that diabetes prevalence has more than doubled since 1981, and as stated by Dunstan et al. (2002), ‘this is only partially explained by changes in age profile and obesity’ (p.829). Hence, other features of the Western lifestyle including physical inactivity (e.g. leading to reduced efficiency in, and capacity for, cellular glucose uptake), and poor dietary nutritional density (leading to sub-optimal cellular metabolome function) may be contributory factors. As with cardiovascular disease, a genetic predisposition puts certain individuals more at risk. However, genetic differences alone do not explain the rapid recent rise in diabetes prevalence in the population (Dunstan et al. 2002).

Aside from type 2 diabetes, there is a broad spectrum of diseases in which insulin resistance is a key clinical feature, including obesity, coronary heart disease, hypertension, dyslipidemia, polycystic ovarian syndrome, acne and some cancers (including breast and prostate); (Guarente 2006; Mann 2007a).
The potent effects of diet and physical activity on dysfunctional insulin metabolism was clearly demonstrated by O’Dea (1994) in her study on Australian Aborigines as discussed in Section 2.3. On reversion to their traditional wild food diet, Australian Aborigines demonstrated improved glucose control within a matter of weeks. Likewise in a group of Swedish people, Lindeberg (2007) found that a diet based on hunter-gatherer food groups improved glucose metabolism.

Today, indigenous Australians have a very high prevalence of diabetes – 3.4 times the rate of non-indigenous Australians with prevalence rates of 15–20% and rising (Australian Institute of Health and Welfare 2006a; Daniel et al. 1999). Type 2 diabetes and its sequel events including cardiovascular and renal diseases are major causes of premature mortality in the Australian Aboriginal population. The high risk in Australian Aborigines is perhaps best explained by the rapid transition (over the past 50 years or so) that this population has made from a traditional hunter-gatherer way of life, to a lifestyle characterised by reduced physical activity and a poor diet causing very high rates of obesity and metabolic dysfunction [including impaired glucose tolerance, hypertriglyceridaemia, hypertension and hyperinsulinaemia (O’Dea 1991b)]. It is concerning that diabetes incidence rates in Australian Aborigines are among the highest in the world (Daniel et al. 1999). The high incidence of type 2 diabetes in global indigenous populations who have made a recent transition away from traditional lifestyle patterns has been well documented in the literature, including among Australians Aborigines and Torres Strait islanders (O’Dea 1991), Micronesian and Polynesian Pacific Islanders, Native Americans and Asian Indians (Dunstan et al. 2002).

Obesity is the strongest non-metabolic risk factor for type 2 diabetes and the prevalence of overweight and obesity in Australian Aboriginal populations relates to the degree of Westernisation (O’Dea 1991b). Importantly, obesity prevalence is increasing in all demographic regions of Australia – both in aboriginal and non-aboriginal people. Subsequently, it is not surprising that diabetes and impaired glucose tolerance are becoming increasingly common, whereas in the past it was relatively unusual (Ebbesson et al. 1998).
3.2.2.3  Cancer

Cancer is a large cause of mortality in Australia. It also causes much morbidity and
disability (Australian Institute of Health and Welfare 2006a). Cancer is now Australia’s
leading cause of death among 45–64 year olds and causes more premature deaths and
overall disease burden than cardiovascular disease. The correlation between cancer and
tobacco smoke and exposure to environmental contaminants (e.g. asbestos and
accidental exposure to chemicals) are well documented in the literature. Less easy to
connect is the role between diet and cancer due to the long-term course of cancer
development in the body and the subtle and difficult to characterise effects of a lifetime
of food choices. The current risk of a cancer diagnosis in Australia by the age of 75
years is one in three for males and one in four for females. By the age of 85, the risk
increases to one in two for males and one in 2.6 for females (Australian Institute of
Health and Welfare 2006a). Incidence rates are increasing. A large part of this may be
attributable to improved diagnostic techniques and screening programs. In terms of
cancer types, colorectal cancer tops the list for the greatest number of new cases,
followed by prostate cancer (males), breast cancer (females), melanoma, with lung
cancer rounding out the top five.

Increasing evidence supports the notion that cancer is a disease primarily caused by
environmental factors superimposed on genetic vulnerability. Tobacco smoke and
nutritional factors are considered to be most likely environmental culprits affecting

3.2.2.4  Mental health concerns

Mental health conditions are the leading cause of non-fatal illness in Australia. They
were estimated to have caused about one eighth of the total Australian disease burden in
2003, exceeded only by cancer and cardiovascular disease. Approximately one in five
Australians experience a serious mental health concern at some point in their life and
Australians continue to report increasingly higher psychological distress scores
(Australian Institute of Health and Welfare 2006a).
The cascade effect of psychological distress can easily spiral downwards as enjoyment of meaningful life activities reduces, physical inactivity predominates and relief is sought in a variety of adverse behaviours including substance abuse and sometimes, as explored in Section 3.5, somewhat less harmfully, in food.

There is an abundance of literature available examining the health impact of stress, namely in the fields of psychoneuroimmunology and psychoneuroendocrinology (for example see Keiecolt-Glaser et al. 2002; Kemeny 2009; Rahe 1999; Song & Leonard 2001). The ‘chemistry of thought’ (Hassed 2002) is not localised to the brain because the same neurotransmitter receptors are also found in the gut, on the surface of white blood cells, and numerous other bodily locations, which explains why emotional states cause physiological effects and conversely, why physiological states induce particular moods. The impact of state of mind on cellular and humoral immune surveillance and endocrine function have been of particular research focus. However, the impact of nutrition on mental wellbeing is a relatively under-researched area.

Given the mind-body connection, it is not surprising to find that individuals with mental illnesses have higher rates of physical illness and co-morbidities of physical illnesses, and mental illness are common (Australian Institute of Health and Welfare 2006a).

3.2.3 **Use of health services**

Health service use has increased over the last decade (Australian Institute of Health and Welfare 2006a). Possibly this is in response to the expansion of health and medical knowledge within society (especially aided by the media and internet), public health initiatives (e.g. preventative screening and early intervention programs), and maybe also a more relaxed social attitude to seeking advice for health issues.

The most common reason that Australians visit a doctor is for a general check-up or to get a prescription. Pharmaceutical prescriptions are up 41% over the last decade. The most common reported reasons for doctor visits are high blood pressure, throat infections, depression, blood cholesterol problems and vaccinations (Australian Institute of Health and Welfare 2006a).
3.2.4 Health expenditure

‘Imagine a large river with a high waterfall. At the bottom of this waterfall hundreds of people are working frantically trying to save those who have fallen into the river and have fallen down the waterfall, many of them drowning. As the people along the shore are trying to rescue as many as possible, one individual looks up and sees a seemingly never-ending stream of people falling down the waterfall and begins to run upstream. One of the other rescuers hollers ‘where are you going? There are so many people that need help here.’ To which the man replied, ‘I’m going upstream to find out why so many people are falling into the river’. (Selden 2004)

National expenditure on health is around 10% of the gross domestic product (GDP). Out of this, only 1.7% was spent on disease prevention and health promotion in 2003–04. By comparison, 34.8% was spent on hospital services (Australian Institute of Health and Welfare 2006a).

Prevention strategies inherently cost less than medical/hospital treatments. Also, in many cases, preventative measures do not show up in the GDP or in health expenditure budgets because the time individuals put into, for instance, physical exercise, healthy meal preparation, relaxation activities etc doesn’t necessarily show up as consumable goods and services, and thus is not reflected in GDP statistics. On the other hand, use of medical services, hospital stays, pharmaceuticals (14.4% of recurrent health expenditure), pathology testing etc all register in GDP figures. Therefore, it is perhaps misleading to criticise the 1.7% of recurrent health expenditure spent on health-promotion interventions. However, even with some leeway, government expenditure on ‘life-enhancing’ techniques remains small. Yet, the best tools we have for preventing and managing the major diseases affecting Australians are dietary and lifestyle based and hence, government support of these factors is fundamentally important. The concept of wellness, preventative medicine and holistic health are increasingly being discussed; and the integration of the ‘life-saving’ and the ‘life-enhancing’ techniques of health care (Cohen 2003) is seen as the future of medicine (Phelps 2009).

We already have all the basic tools and knowledge required to significantly reduce our risk of developing chronic diseases and to increase healthy life years. There is no magic
bullet, or great scientific discovery, or technological advancement required. The implementation of a simple framework that supports nutrition choices to which we are best adapted and lifestyle changes that are health promoting could be powerfully effective.
3.3 Determinants of Health and the Obesity Epidemic

‘Post-industrial societies have acquired a systematic imbalance in the energy budget of daily living, with the net energy gain stored as body fat and manifesting as the present obesity pandemic’ (McMichael et al. 2007 p.1255)

3.3.1 Determinants of health

Determinants of health are multi-factorial. For most risk factors, the associated effects are not ‘all or nothing’ (Australian Institute of Health and Welfare 2006a). Rather, health/illness manifests above a certain ‘threshold’. If enough systems or factors are involved, susceptibility towards illness increases, sometimes at an exponential rate. Equally, gaining momentum in a healing direction can also unfold exponentially. The more aspects of our being that we can simultaneously exercise and address, the more likely that healing will occur (Wilber 2001).

Health determinants unfold in a complex interplay. This makes it difficult to measure and assess their individual impact precisely. Therefore, increasing our understanding of the conditions that shaped our biology is vital to moving within the right guiding framework.

Numerous diet and lifestyle-related health determinants are analysed in this thesis from an evolutionary perspective. Some of the factors already discussed include favourable dietary characteristics based on the hunter-gatherer wild food model, the need for consistent physical exercise, and the importance of optimal time spent outdoors to enable vitamin D synthesis. Psychological factors and the role of stress in eating behaviour are also to be discussed in Section 3.6. Other health behaviours not discussed in this thesis, but of central importance include optimal sleep, which ensures maximal opportunity for repair and regeneration, and healthy occupational and leisure activities.

Broader diet-related health determinants include environmental factors. Chapter 4 discusses the resource base required to best support ‘contemporary hunter-gatherer
diets’ and outlines the potential health consequences of increasing agricultural chemical use, biodiversity loss and the impact of natural ecosystem collapses (e.g. wild fish stocks).

Socio-cultural-economic influences are also significant health determinants as discussed at various points throughout this thesis. Nutrition knowledge, attitudes and beliefs are influenced by numerous background factors including cultural values, resources, economic situation, marketing, education, family and social settings (Australian Institute of Health and Welfare 2006a). Within this milieu, health is affected by behavioural and lifestyle choices, and other more global factors. For example, it has been well established in the literature that a low measure of both education attainment, and income and a high level of family dysfunction contribute to a high vulnerability to disease (Rahe 1999), and that social disadvantage often translates into metabolic disadvantage (and sequelae events including type 2 diabetes); (Deed 2009).

Figure 10 offers a conceptual framework for thinking about health determinants, particularly from a diet-related perspective as relevant to this thesis:

![Conceptual framework of health determinants](modified from Australian Institute of Health and Welfare 2006a p.143).
Our political and cultural climate is shifting towards placing more importance on supporting holistic facets involved in determining health in order to manage the chronic disease and obesity epidemic. Existing strategies include directing an increased proportion of the health budget towards health promotion and disease prevention (RACGP 2008); encouraging improved dietary practices, including increased fruit and vegetable intake; promoting physical activity (Australian Institute of Health and Welfare 2006b); reducing the negative influence of fast food advertising particularly to children (Lobstein & Dibb 2005) and minimising fast food temptations in school canteens (Leung 2006); the monitoring of chemical residue in food (FSANZ 2003a); and protecting natural biodiversity (Australian Government Department of the Environment Water Heritage and the Arts 1999). The question remains however, whether enough is happening in time to avert the rapid rise in excessive body weight accumulation and the cascade of chronic illnesses facing Australians.

3.3.2 Overweight and obesity

3.3.2.1 Prevalence of overweight and obesity

The rising prevalence of overweight and obesity is a key health determinant that needs to be critically addressed. It also provides a working example of the interplay between various health determinants.

Excess body weight is not inherently a ‘disease’ and therefore was not directly discussed in Section 3.2. It is, however, a strong causative factor underlying numerous chronic diseases, due to chronic strain placed on the bodies metabolic, endocrine, vascular, and skeletal systems. Obesity is considered to directly cause 10.8% of type 2 diabetes, 14% of hypertension, 12% of cardiovascular disease, and 12% of strokes (Tapsell 2007). This is combined with the social and psychological burden created by the aesthetics of the condition and the physical limitations imposed by the weight burden.
The prevalence of obesity has risen dramatically worldwide. Australia, the USA, Canada and the UK have the highest prevalence (see Figure 11). The problem is now defined by the World Health Organization as a global epidemic (World Health Organisation 2007). Mirroring the global trend, the prevalence of overweight and obesity in Australia has increased rapidly in the past two decades (Australian Institute of Health and Welfare 2006a). The 2004–05 National Health Survey (cited in Australian Institute of Health and Welfare 2006a) found that 53% of the Australian population were overweight or obese. Victorians mirrored the national statistics with 53.3% of the population defined as overweight or obese.

<table>
<thead>
<tr>
<th>Measure</th>
<th>1980</th>
<th>1999-2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proportion of men (25-64 years) who were obese*</td>
<td>9%</td>
<td>17%</td>
</tr>
<tr>
<td>Proportion of women (25-64 years) who were obese*</td>
<td>8%</td>
<td>20%</td>
</tr>
<tr>
<td>Proportion of men (25-64 years) who were overweight^</td>
<td>47%</td>
<td>68%</td>
</tr>
<tr>
<td>Proportion of women (25-64 years) who were overweight^</td>
<td>27%</td>
<td>47%</td>
</tr>
</tbody>
</table>

* Obese defined as a BMI (body mass index) of 30 or more (calculated from measured height and weight)
^ Overweight defined as a BMI of 25 or more

Obesity and overweight in children (under 15 years) and young people is also rapidly rising, and so too is a subsequent increase in the incidence of type 2 diabetes in these age groups in recent years (Dunstan et al. 2002). In 2004–05, 19% of young people (15–
24 years) were overweight and a further 6% were obese. In total, one in four young people and one in two adults carry excess weight (Australian Institute of Health and Welfare 2006a).

Prevalence of overweight and obesity are expected to double from existing figures by 2025 (Tapsell 2007). Currently, the situation is estimated to cost the Australian population $3,767 billion per year (Tapsell 2007). In addition to the impact on the national health budget, back in 1997, it was estimated that Australians spent $500 million per year on weight control programs (NHMRC 1997) – this expenditure may be much higher today given the increased prevalence of weight gain over the past decade.

3.3.2.2 Our obesogenic environment

According to Swinburn (2006), one of the key drivers of obesity (and other chronic diseases) is the structure of our modern economic environment. Obesity is a ‘commercial success’ (Swinburn 2006). Commercial giants of Australian society are companies producing energy-dense foods, cars, labour-saving devices, passive recreation and entertainment, and health commodities (including pharmaceutical drugs). Commercial minors in society include those enabling the consumption of fresh produce, the use of bikes for transportation, public transportation, and other health-promoting lifestyle factors and more wellness-oriented psychological and physical therapies. In contrast to the commercial giants, these minor drivers create less resource consumption, therefore contribute less to the GDP and hence, by comparison, they are not strong short-term economic motivators.

While Australia’s obesity and chronic disease epidemic may be a commercial success, it is a long term health, environmental, social and economic failure. The burden of obesity includes medical complications (diabetes, osteoarthritis, heart disease), psychological issues (self esteem, quality of life), social factors (exclusion, low attainment) and economic impacts (health costs, loss of productivity, shortened life expectancy). Excess body weight is also an ethical issue because it wastes limited resources, adds to pollution and shifts costs onto healthy members of society (Singer & Mason 2006).
On a biological level, energy dense foods tap into our instinctual desire for fatty/sweet/salty foods because of the positive survival advantage they offered in hunter-gatherer times and the rarity of them in the wild food supply. Today, highly refined and calorie dense foods tend to be more readily available than fresh fruit and vegetables (Australian Institute of Health and Welfare 2006a). It is typically easier to access soft drinks, chips, chocolate and ‘fast’ food than it is to find a green grocer or go to a supermarket to get fresh produce, and even if this effort is made, on a kilojoule equivalent basis, fresh produce costs far more and requires preparation time which many Australians state they don’t have (Australian Institute of Health and Welfare 2006a). Combined with physical inactivity, the effectiveness of product advertising (which has now become a major avenue for less than ideal nutrition education) and a shift in social norms of what constitutes ‘normal eating’, this socio-cultural environment acts as a major sustainer of obesity prevalence and poor dietary intake.

As the proportion of calorie dense nutrient poor ‘junk’ foods increases in the diet, more nutrient dense fresh produce is displaced. Hence, in an ironic paradox, due to sub-optimal food choices, Australians are at risk both of becoming overweight and not obtaining enough vitamins, minerals, other nutrients and phytochemicals; all of which predispose to longer term poor health.

In reality the Australian population at large is relatively well educated with regards to basic nutrition information such that most people, for instance, know that eating more fruit and vegetables is health supportive (Lester 1994). In fact, access to reasonably good nutrition knowledge seems to be one of the smallest barriers to healthy eating behaviour. A review article by Pacquette (2005) encouragingly found that the fundamental elements of people’s perception of a healthy diet were: 1) vegetables and fruits, 2) meat, 3) low levels of fat, salt and sugar, 4) quality aspects such as fresh, unprocessed and homemade foods, 5) concepts of balance, variety and moderation. This fits within a typical hunter-gatherer diet model.

In Australia, we do have access to healthy food if the time, effort and income are available to purchase them. Hence, a purely educational approach to improving the population’s nutrient intake is limited. Education needs to be combined with well directed economic input, social, organisational and governmental leadership support, appropriate technologies and recognition of the psychological factors underpinning food choices and eating behaviours. This needs to occur alongside a concerted effort to
establish and maintain sustainable, diverse ecosystems and health supportive agricultural methods. In other words, a truly integrated approach, as is further explored in Chapter 10.

An interesting example of how the socio-cultural environment influences eating behaviour is provided by Pettinger et al. (2008) who compared shopping behaviour and food availability between regions in southern France and England. The study found that food availability was good in both regions, but while the French favoured smaller specialty produce shops and markets, the English were more likely to opt for convenience and snack foods, and to get all their produce from supermarkets. In a different publication by the same author, Pettinger et al. (2006) examined differences in dietary patterns between the same two regions and found that the French more frequently used basic food ingredients, employed traditional cooking methods and engaged in a routine of structured social meal times. In contrast, the English were more likely to eat take-away foods and not follow a regular routine. In both studies the authors concluded that the difference in shopping and dietary patterns could partly explain the higher incidence of obesity in England. Holdsworth et al. (2000) also found that regional diets in the south of France are generally healthier than English diets. Hence, it seems that there is a strong argument for taking pride in quality, basic, regional produce as an insurance against weight gain and diet related chronic disease.

Encouraging regional produce (e.g. supporting local farmers markets, greengrocers, fish mongers and butchers etc) and the decentralisation of food markets (removal of central food control from large supermarket chains) tend to increase transparency and knowledge of food production methods and improve produce quality (Norberg-Hodge, Goering & Page 2001; Petrini 2007). This doesn’t necessarily result in a cheaper product for consumers (due to reduced market control and economies of scale) however costs tend to be more ethically distributed and sustainable in the long run. The end result of such an approach is high quality nutritionally dense produce and increased consumer knowledge of food’s life cycle which enables individuals to critique what they are eating. This goes a long way to facilitating a food culture that enables food to become a positive health determinant.
3.4 Epidemiological Associations Between Diet and Disease

‘The interaction of genetics and environment, nature and nurture is the foundation for all health and disease’ (Simpoulous 1999 p.118)

3.4.1 Introduction

Nutritional epidemiological studies are concerned with finding dietary factors affecting the health of populations as a whole. The results of such studies are frequently used to inform public health policies. Epidemiological studies on the Mediterranean diet, dietary patterns in France, and those examining vegetarian diets are discussed in this section.

3.4.2 The ‘Seven Countries Study’ and the Mediterranean diet

On the basis of epidemiological research, the Mediterranean diet has been heralded as the ‘gold standard’ diet, particularly with regard to protection from cardiovascular disease. Much of the research on the Mediterranean diet was carried out in Crete in the 1950s – an island population with a coastal subsistence pattern that included fish and other marine species, free-range animal meat and offal, an abundance of fresh fruit and vegetables (especially wild greens), along with fresh olive oil, some red wine, and a moderate amount of dairy. This dietary pattern was accompanied by a physically active farming lifestyle. Much of this mirrors a typical hunter-gatherer existence (except the dairy and wine), not just in the Mediterranean region, but worldwide.

Medical interest in the Mediterranean diet began in the late 1960s when Dr Ancel Keys started publishing results of the ‘Seven Countries Study’. The Seven Countries Study compared the diets of Finland, Greece, Italy, Japan, the Netherlands, the United States and Yugoslavia, and examined blood markers, cardiovascular disease incidence and cancer mortality rates among 11,325 men aged 40–59 years over a 15 year period (Keys
et al. 1985). In the study, the Greek Mediterranean diet was associated with the lowest mortality rate from coronary heart disease and death from all causes. In particular, deaths from heart disease correlated strongly with the saturated fat content of the diet and serum cholesterol levels. In response, the public health message was to cut down on red meat intake (and in the process reduce saturated fat intake) and high-cholesterol foods (especially eggs). Compared to hunter-gatherer diets, animal derived saturated fat is only minimally available in the wild and hence, from this perspective, it is plausible that this conferred disease protection in the Seven Countries study. However, the cholesterol content of the average hunter-gatherer diet was likely to be reasonably high due to the unanimous intake of animal foods7 (Eaton, Konner & Shostak 1988).

As Cordain et al. (2002) suggest, it seems paradoxical that hunter-gatherer societies who consume the majority of their energy from animal foods were also relatively free of cardiovascular disease. Instead, hunter-gatherer diets likely elicited a favourable effect on blood lipid profiles and other factors involved in cardiovascular disease due to the hypolipidemic effects of a higher protein, lower carbohydrate diet; a dietary fatty acid composition which was low in saturated fats, and high in mono- and poly-unsaturated fats, particularly of the omega 3 family; and a diet which had high nutritional density and phytochemical content compared with Western diets (Cordain et al. 2002).

Further supporting evidence is provided by Hu and Willett (2002) who reviewed almost 150 studies on the link between diet and cardiovascular health. They found that, despite common misconceptions, there is no strong evidence of a relationship between risk of cardiovascular disease and intake of meat, cholesterol, or total fat. Additionally, a subset population of the Harvard’s School of Public Health Nurses’ Health Study found that over an eight-year study involving almost 50,000 post menopausal women, total fat consumption was unrelated to heart disease risk, provided it was not trans fat (Couzin 2006). Hu and Willett (2002) concluded that eating a diet high in various fruits, vegetables, nuts, whole grains and fish, and avoiding foods with a high glycaemic load were most effective in preventing cardiovascular events. This dietary approach along with regular physical activity, smoking avoidance and maintenance of a healthy body weight, according to Hu and Willett (2002), ‘may prevent the majority of cardiovascular disease in Western populations’ (p.2569). Although not specifically referred to as such

7 All animal foods (except honey) contain cholesterol.
in the Hu and Willett (2002) paper, essentially this recommendation is describing a hunter-gatherer diet and lifestyle pattern.

### 3.4.3 The French paradox

Another epidemiological phenomena commonly mentioned is the so called ‘French paradox’. The paradox refers to the relatively low incidence of coronary heart disease among the French population despite consuming a diet relatively high in saturated fat. Explanations for the French paradox note the marked cultural differences in food-related behaviours. Rozin et al. (2003) commented that compared to the average American diet, in France portion sizes are smaller, total food intake is less, there is a lower incidence of snacking between meals and more time is taken to eat food (Rozin et al. 2003). Rate of eating correlates with body mass index (slower eating = lower BMI) (Otsuka et al. 2006; Sasaki et al. 2003). Furthermore, there is a cultural avoidance of pre-prepared and fast foods (Clower 2003). Although the diet is higher in saturated fat, the human body is still familiar with the metabolism of this type of fat compared to the novel man-made hydrogenated vegetable oils and trans fats, which are common in highly processed foods. Additional explanatory factors for the French paradox include cultural appreciation of food provenance (Honeywill & Byth 2006) which drives greater consumer understanding of how food is produced. This cultural difference in food attitudes was explored in an experiment by American psychologist Professor Paul Rozin in which he found that the main word associated with ‘chocolate cake’ among a group of French people was ‘celebration’, whereas in a group of Americans it was ‘guilt’ (cited in Pollan 2008). Food eaten slowly, appreciated with pleasure and celebrated, rather than eaten with guilt or addictive tendencies, is more likely to be health promoting.

### 3.4.4 Vegetarian diets

There is no precedence in the human ancestral diet or in the diets of recent hunter-gatherer societies for a diet in which 100% of dietary energy is sourced from plant foods (Cordain et al. 2000). Vegetarians can be subdivided into two main groups: lacto-vegetarians (exclusion of meat including fish) and vegans (exclusion of all animal foods
including dairy and eggs); (Dagnelie 2003). The 1995 National Nutrition Survey suggested that 3.7% of Australians considered themselves vegetarian (Lea and Worsley 2003). A much larger percentage of the population restrict meat intake, particularly red meat. Forty percent of Australian males and 48% of Australian females consume red meat three times or less per week (Lea & Worsley 2003).

Interest in vegetarian diets came from the observation that vegetarians living in affluent countries such as Australia appear to obtain unusually good health, have lower disease risk and greater longevity (Willett 1999). Current evidence suggests that three factors appear to be involved in this effect (Willett 1999):

- Compared to non-vegetarians, vegetarians follow more health promoting lifestyles e.g. reduced rate of tobacco smoking, less alcohol consumption, participation in higher levels of physical exercise.
- Vegetarians have a lower intake of harmful dietary components e.g. processed foods.
- Vegetarians, due to their focus on consuming vegetables, fruits and whole grains, obtain higher intakes of beneficial vitamins, minerals and phytochemicals.

Much of the research about the health benefits of a vegetarian eating pattern have come from Seventh Day Adventists, who along with eating an abundance of fresh vegetables and fruit and abstaining from meat, also refrain from drinking alcohol and smoking tobacco thus potentially clouding the true health effects of abstaining from meat alone. Key conclusions from the Adventist health studies include that maintenance of lean body weight throughout life is health protective – this alone, however, is not evidence that vegetarian eating is supportive of optimal health. Other findings of the Adventist studies include an association between red meat and dairy products (likely due to their saturated fat content, as discussed) with cardiovascular disease and cancer (Willett 2003).

Red meat, sourced from domesticated animals (often living in sedentary conditions and consuming grain-based feeds as opposed to their natural grass-based feeds) is very high in saturated fat and low in polyunsaturated fat (Ponnampalam, Mann & Sinclair 2006) compared to wild animals (Cordain et al. 2002c). Hence, it is not surprising that in some research red meat intake is associated with cardiovascular disease and cancer.
Willet’s (1999) paper suggests that on balance there does not appear to be much evidence to suggest that avoidance of meat is a primary reason for the health differences between vegetarians and non-vegetarians (Willett 1999). Rather, as a recent meta-analysis suggests, ‘a prudent, omnivorous diet with moderate amounts of animal products, in which red meat is partly replaced by white meat and fish (especially fatty fish), together with the consumption of ample amounts of unrefined vegetable products, is thought to be just as protective as a vegetarian diet’ (Dagnelie 2003 p.1308). In fact, from an evolutionary perspective, it is likely to be better. Consumption of fish, seafood and wild animals – both red and white meats, as per a shore-based hunter-gatherer diet – supplies the human body with nutritional density superior to a vegetarian diet (which risks deficiencies of vitamin B12, minerals such as calcium, iron, zinc and other trace elements which are sourced primarily from animal foods). In clinical practice, incidence of vitamin B12 deficiency is likely in people only consuming meat or fish once or less times per week (Dagnelie 2003).

3.4.5 Summary

Epidemiological studies typically show that traditional diets, regardless of global region, confer disease protection compared to Western industrialised diets. While effort has gone into trying to identify the particular advantageous dietary components in the Mediterranean diet (e.g. olive oil), or in the Seven Countries studies (e.g. the connection between saturated fat and heart disease), or within the French paradox (food attitudes and emphasis on food providence), the therapeutic power of such diets may lie in their total package and the way food is embedded in cultural and lifestyle traditions.
3.5 Therapeutic Diets

3.5.1 Introduction

The use of carefully selected diets for disease modification and treatment is increasingly being utilised as a therapeutic approach. The prevailing question is which diet is the most therapeutic? A confusing dialogue has paraded medical and lay literature as the multitude of nutrition research cites extensive references validating a range of perspectives.

Key therapeutic diets chosen for analysis in this chapter are the Mediterranean diet, the Ornish diet, and the Gawler Foundation diet. The first two are primarily aimed at cardiovascular disease prevention and management, and are used as a therapeutic tool throughout the world. The Gawler Foundation, based in the Yarra Valley, Melbourne, offers a lifestyle program for the management of cancer. The diets used in these three therapeutic approaches differ somewhat in their emphasis, both from each other and an average hunter-gatherer diet, as will be analysed in this section.

3.5.2 The Mediterranean diet

One of the largest clinical intervention trials which used the Mediterranean diet as a therapeutic approach was the ‘Lyon Diet Heart Study’ (de Lorgeril et al. 1994). In this study, the Cretan Mediterranean diet was chosen because it was associated with a low mortality rate from coronary health disease (and all causes) in the Seven Country Study (Keys et al. 1985) as discussed. The Lyon Diet Heart Study randomised patients who had experienced their first myocardial infarction to either an experimental (n=302) or control group (n=302). They were followed up over five years. The experimental group was advised during a one-hour session to adopt a Mediterranean-type diet based on ‘more bread, more root vegetables and green vegetables, more fish, less meat (beef, lamb and pork to be replaced with poultry), no day without fruit, and butter and cream to be replaced with margarine (canola) supplied by the study’ (de Lorgeril et al. 1994 p.1455). Eating more vegetables, fruit and fish mirrors a hunter-gatherer diet, while consumption of bread and canola oil margarines does not. The advice to eat less meat
and replace beef, lamb and pork with poultry served to reduce the saturated fat content of the diet, which echoes the hunter-gatherer model but does little to actually reflect the true diversity and intake of wild animal foods in the ancestral human diet.

In the study, the control group was advised to follow the American Heart Association prudent diet which suggests that total lipids contribute 31% of daily energy and that saturated fats contribute no more than 10.5% of daily energy. As a result of the dietary advice, compared to the control group, the experimental group eating the Mediterranean type diet had a significantly lower intake of butter, cream, and meat including delicatessen meats such as ham and sausage (de Lorgeril et al. 1994). Intake of antioxidant vitamins was significantly higher in the experimental group consuming the Mediterranean-type diet, due to a higher intake of vegetables and fruits.

The results of the Lyon Diet Heart Study demonstrated a massive reduction of close to 70% in coronary events and cardiac deaths in the Mediterranean diet experimental group. This was achieved without a reduction of serum cholesterol, triglycerides, or an increase in high-density lipoprotein (HDL cholesterol) compared to the control group (de Lorgeril et al. 1994 p.1458). These blood markers have been perceived as important in orthodox medicine, yet in this study the impressive results were observed independent of their change. Figures 12 to 14 show the differences in survival between the experimental group and the control group in the study (de Lorgeril et al. 1999).
Figure 12. Cumulative survival without nonfatal myocardial infarction among experimental (Mediterranean group) patients and control subjects.

Figure 13. Cumulative survival without nonfatal infarction and without secondary endpoints (unstable angina, stroke, heart failure, pulmonary or peripheral embolism).

Figure 14. Cumulative survival without nonfatal infarction, without major secondary end points, and without minor secondary end points.
Hence, intake of core hunter-gatherer food groups including vegetables, fruits and fish correlate with cardiovascular disease protection. While no clinical trial has specifically examined the effects of a ‘contemporary hunter-gatherer diet’ on cardiovascular disease incidence and mortality, Lindeberg et al. (2007) found that a diet based on hunter-gatherer food groups (using contemporary foods) improved glucose tolerance more than a Mediterranean-like diet in individuals with ischaemic heart disease (see Section 6.3 for further discussion of this clinical trial).

### 3.5.3 The Ornish diet

The Ornish program, named after the creator of the program Dr Dean Ornish, recommends a very low fat (less than 10% of calories), plant-based (vegan) diet along with physical exercise and stress management for the rehabilitation of coronary heart disease. The success of this United States based lifestyle program has been impressive. A recent clinical trial demonstrated that within three months, regardless of risk for severe heart failure, significant improvements were obtained in body weight, body fat, blood pressure, resting heart rate, total and LDL-cholesterol, exercise capacity and quality of life (Pischke et al. 2007). The program has also been used with success in patients with prostate cancer. In a recent trial, participants in the Ornish program had lower prostate-specific antigen (PSA) levels, greater inhibition of cancer cell growth and fewer cancer-related clinical events at the end of one year compared to the control group (Frattaroli et al. 2008).

As already mentioned when discussing vegetarian diets, the health protective benefits of the Ornish program may more plausibly be attributable to the very high vegetable and fruit intake, the exclusion of processed/refined foods and the inclusion of physical exercise and stress management techniques, rather than inherently attributable to a very low fat diet or the exclusion of meat. An interesting future study would be one that compared a ‘contemporary hunter-gatherer diet’ with the diet used in the Ornish program in the management of heart disease and prostate cancer.
3.5.4 The Gawler Foundation Cancer diet

The general principles of the Gawler Foundation diet were developed on the basis of personal experience (foundation director, Dr Ian Gawler, is himself a long term cancer survivor), research and clinical experience with thousands of cancer patients (Gawler 2008). The diet is primarily based on fruits and vegetables – ideally 70% eaten raw (which mirrors a hunter-gatherer diet), whole grains and proteins sourced predominantly from vegetable sources (e.g. beans including legumes and soy). Additional protein needs are then satisfied with fish, dairy, eggs and meat (preferably lean white meat) listed in descending order of preference. Avoidance of salt, sugar, refined foods, tobacco, caffeine and chemical additives is advised (e.g. organic produce is suggested). Other recommended food additions include sea vegetables, nuts, seeds and freshly made fruit and vegetable juices (all of which increase the micronutrient density of the diet). The Gawler Foundation’s recommendations sit very comfortably within an evolutionary nutrition paradigm, particularly their emphasis on whole foods, the micronutrient density of the diet and the avoidance of chemical additives. The lack of emphasis on wild (and/or certified organic) animal foods is the main difference between the Gawler Foundation diet and the hunter-gatherer model.

3.5.5 Comparison of therapeutic diets, hunter-gatherer diets and the average Australian diet

Table 15 compares nutritional differences between the three therapeutic diets discussed, hunter-gatherer diets (as per interpretation by Cordain et al. 2000), and the average Australian diet.
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<tbody>
<tr>
<td>Moderate (19–35%)</td>
<td>Moderate (17.2%)</td>
<td>Low (&lt;15%)</td>
<td>Low</td>
<td>Moderate</td>
<td></td>
</tr>
<tr>
<td>Carbohydrate (% daily energy)</td>
<td>Moderate (22–40%)</td>
<td>Moderate (52.3%)</td>
<td>High (80%)</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Total fat (% daily energy)</td>
<td>Moderate (28–47%)</td>
<td>Moderate (30.5%)</td>
<td>Low (&lt;10%)</td>
<td>Low</td>
<td>Moderate</td>
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<td>Saturated fat</td>
<td>Moderate</td>
<td>Low (8.3g/d)</td>
<td>Low</td>
<td>Low</td>
<td>Moderate</td>
</tr>
<tr>
<td>Mono-unsaturated fat</td>
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<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Moderate</td>
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<tr>
<td>Short chain omega 3 fat (alpha-linolenic acid e.g. flaxseed oil)</td>
<td>Low</td>
<td>High</td>
<td>Low – Moderate</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Long chain omega-3 fat (e.g. fish, seafood)</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>Fibre</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Vegetables and fruit</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>Nuts and seeds</td>
<td>Moderate</td>
<td>Moderate</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
</tr>
<tr>
<td>Salt</td>
<td>Low</td>
<td>Moderate</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Refined sugars</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Dietary Glycemic load</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

* This is only an estimate due to the magnitude of methodological issues involved in deducing hunter-gatherer diets as discussed in Section 2.3.

^ As per used in the Lyon Diet Heart Study. This diet was selected for comparative purposes in the table because the trial has carried such weight in the scientific literature and has informed much of the current dietary advice given to patients with coronary heart disease. Essentially, this is the same diet as that recommended by the Australian Heart Foundation.

Table 15. Dietary differences between hunter-gatherer diets, traditional Mediterranean diets, the Ornish diet, the Gawler Foundation diet, and average Australian diets
3.5.6  *Eat more vegetables and fruit*

The clearest similarity which can be drawn between epidemiology findings, each of the therapeutic diets discussed above, and the average hunter-gatherer diets is an abundance of fruit and vegetables. Whether or not an evolutionary paradigm is well received, health practitioners are in universal agreement that increasing fruit and vegetable intake is health protective. The base of a typical hunter-gatherer food pyramid was a bountiful intake of fresh fruits, berries, roots, tubers, leafy greens and other vegetables. By contrast, the base of the recommended food pyramid in Australia is whole grains (e.g. wholemeal bread, brown rice, whole grain breakfast cereals).

A diet rich in vegetables and fruits corresponds with a high intake of disease-mitigating vitamins, minerals and phytochemicals, and is likely to be a fundamental component of the success of the Mediterranean, Ornish and Gawler Foundation diets. By comparison with these therapeutic diets, and with hunter-gatherer diets, the average Australian consumes an inadequate amount of vegetables and fruit. This issue is further discussed in Chapter 7. Inadequate fruit and vegetable consumption is responsible for an estimated 1.4% of total burden of disease in Australia. This compares with 1.3% for physical inactivity, 2.3% for overweight and obesity and 4.1% for tobacco smoking (Australian Institute of Health and Welfare 2006a).
3.6 **Our Psychological Relationship with Food**

‘You ought not to attempt to cure the body without the soul’

(*Plato: Charmides, cited in Hassed 2002*)

### 3.6.1 Introduction

Today, many of us eat – if not all the time, at least some of the time – on the basis of events entirely unrelated to physiological hunger or nutritional need. Rather, emotional events and social/environmental stimuli often dictate eating behaviour which may at times be deemed inappropriate by any standard (Hirschmann & Munter 1989; Kausman & Bruere 2006). In a study looking into the reasons for initiation and cessation of eating, it was found that hunger was chosen as a reason to start eating in only 20% of cases (Tuomisto et al. 1998). Likewise, Kausman et al. (2003) found in a recent Australian population study that non-hungry eating ‘often’ occurred 76% of the time, ‘sometimes’ occurred 24% of the time, and interestingly not one person responded that it never occurred.

It could be argued that we as humans are not well equipped to demonstrate restraint in today’s food abundant environment. In part this may be true. Likely also is that in the process of disconnecting our everyday lives from natural rhythms (including our natural diets) we have become desensitised and confused in our ability to accurately respond to our needs and instincts.

Mind-body medicine research strongly indicates that wellness and healing are optimised when we are attuned and responsive to messages from our body (Bedson 2007; Hassed 2002). Overlying these messages are complex habituated ideas and behavioural patterns which risk camouflaging the body’s feedback signals delivered in the form of sensations, feelings, instincts and intuition. As University of Arizona psychologist Gary Schwartz puts it, our capacity to attend, connect and express (the ‘ACE factor’) is a trait that supports wellbeing (Dreher 1995). When we are able to do this we make the best use of the many feedback mechanisms of the mind-body. In doing this with regards to
eating food, it creates the opportunity to really nourish the unique needs of our individual bodies.

Addressing this issue is a logical area for further research because ultimately the nutrition information contained in the thesis is of little use if underlying eating behaviours and psychological coping mechanisms are not inter-woven. In the end, one of the most important factors determining what we put in our mouths lies in our mind.

### 3.6.2 Cueing in to eating behaviour

Nature’s survival mechanism has been to make food nourishing. We have adapted mechanisms for taste preferences – sweet wild foods are usually safe and bitter/astringent foods are often poisonous (Cordain 2002b); we have physiological mechanisms for attempting to correct nutrient deficiencies by inducing specific food cravings (Pelchat & Schaefer 2000); we have natural preferences for energy dense foods because of the survival advantage they offer; and we have a natural capacity for fat storage, again for survival benefit (Prentice 2005); and so on. In essence, our body is able to provide our minds with very specific signals for meeting nutrition related physiological needs.

In hunter-gatherer times, hunger was satisfied with whatever foods were available. Excesses were naturally curbed by availability limits. Thus, engaging in non-hungry eating, or overeating particular foods simply for the ‘taste’ of it, was a fairly innocuous, if not advantageous, activity (Prentice 2005). However, today’s food milieu is far more complex and potentially dangerous in terms of obesity and diet related chronic disease. Furthermore, non-hungry eating is endemic (Kausman & Bruere 2006). In contemporary times, food is frequently used either consciously or unconsciously to manage anxiety, stress and to bring comfort when lonely, sad or afraid (Hirschmann & Munter 1989). This has nothing to do with good knowledge of nutrition, nothing to do with using food to satisfy physiological hunger, and everything to do with managing emotional stress.

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8 If the nutrient deficit-food craving hypothesis is correct, today’s nutrient deficient diets, compared to the hunter-gatherer benchmark, may well be inducing food cravings. Individuals may simply eat more – more of anything – in an attempt to correct nutritional deficiencies (depending on the nutritional density of foods chosen). In this way a craving cycle may be created.
3.6.3 The stress condition and eating patterns

Stress is a widely prevalent condition that exacts a heavy toll on the quality and possibly longevity of human life (Vitetta & Sali 2007).

The purpose of stress is to preserve life. As such, the body responds to a perceived threat with physiological changes such as increased blood pressure and heart rate, and diversion of blood flow to muscles to enable one to run away from danger, as well as immunological changes such as increasing platelet stickiness and white blood cell mobilisation to prepare the body for potential injury (Hassed 2003). This ‘fight or flight response’ can be entirely appropriate and helpful – if you are about to step on a snake, for example. However, in the absence of living in the wild and hunting and gathering daily food, the vast majority of today’s stressors are typically of a low-grade chronic nature and eliciting an active flight or fight response is not appropriate, nor does it help. In fact it does the opposite.

While the stress response is an appropriate physiological consequence in a situation that demands immediate attention, when the same physiological mechanisms are stimulated for an extended time, even at sub-clinical levels, the mind-body becomes chronically agitated, unfocused and tired. Poor choices and inappropriate behaviours are understandable consequences of this state of being and hence, it is of little surprise that research demonstrates that chronic stress is a contributor to, or a direct cause of, many illnesses (Hassed 2002).

Changes in eating behaviour are strongly correlated with stress (Torres & Nowson 2007). When stressed, some people increase their food intake (Zellner et al. 2006) thus putting this population at risk of stress-induced weight-gain. While other people decrease their food intake when stressed (Stone & Brownell 1994), on balance, in the context of the modern-day food abundant environment, it is widely thought that chronic stress more commonly leads to overeating (Greeno & Wing 1994).

Stress also affects food choice. In one study, the majority (73%) of stressed individuals increased snacking behaviour under stress (Oliver & Wardle 1999). ‘Snack’ foods are typically energy-dense foods (e.g. chocolate). Not surprisingly, an increase in ‘snacking’
correlated with a decrease in ‘meal foods’ (which in the study by Oliver & Wardle (1999) included fruit, vegetables, meat and fish).

3.6.4 **Psychological dynamics underlying stress-induced eating**

*‘The feel-something-do-something trap’ (Hirschmann & Munter 1989 p.205)*

Resisting food desires, sticking to a diet plan, and being slim are considered in today’s society to be praiseworthy and virtuous (Singer & Mason 2006). Failure in these areas can lead to feelings of insufficient willpower, worthlessness, hopelessness and feeling ‘fat’/’bad’. Non-hungry eating is a pattern likely recognisable by the great majority of Australians.

But what if non-hungry eating was not viewed as a failure, but as a sensible ‘self-help’ technique? What if eating is a way of helping yourself in the best way you know how? What if reaching out for food is simply a way of trying to manage a stressful moment in time? Understanding non-hungry eating in this way, as Hirschmann and Munter (1989) suggest, is a powerful way of seeing stress-induced eating behaviour for what it truly is: a mechanism by which food and eating serves to distract one from the emotional impact of a present or nagging problem. As Hirshman and Munter (1989) state many of us ‘have a calming problem, not a food problem’ (p.14).

The negative psychological cycle of stress-induced eating behaviour can look something like the following:

*Something disturbs a person’s sense of emotional equilibrium → the person eats → the person feels ‘fat’/’bad’ and mentally berates themselves for their lack of control and self worth → the person becomes stuck in this point in time and feels helpless, and/or starts mentally mapping out rules to correct the ‘badness’ such as going on a ‘diet’ → rules can be broken, and inevitably are, and hence a cycle of eating behaviour gets intricately tied to self worth.*

Food is one of our earliest known experiences for being comforted. Being held to our mother’s breast, experiencing the mouth feel of the nipple, enjoying the sensation of a
full belly, and the complete mind-body nourishment of such makes it quite understandable that we turn to food when feeling unsettled. Connecting food, discomfort and non-hungry eating can become a learned and then habituated response.

Learning what and when to eat in response to physiological need after years of eating in response to other stimuli such as stress, cravings, because it’s the right time to eat or other social influences, takes patience.

In viewing non-hungry eating in this way, such a pattern can begin to be seen as a useful distress sign; a signal to alert one to an underlying message that needs an appropriate response and thus ultimately it can be seen as an opportunity to engage with a greater reality of one’s true self.

3.6.5 Innate intelligence and intuitive eating

‘It is normal or natural to eat more food on somedays and less of other days. It is normal or natural to overeat occasionally. It is normal or natural to undereat occasionally’ (Kausman 2001 p.56-57)

Diet-related chronic illnesses are not immediate crises, but simply something that may happen far in the future. Such illness will not be a direct result of the next meal eaten. However as stated at various points in this thesis, over the course of a lifetime the effects of food accumulate. The subtleness of the effect is such that it can go under the radar of our awareness. This is perhaps an explanation for why so many individuals struggle to connect what they eat with future health outcomes. We easily become desensitised to very real but distant perils (Suzuki 1990). However, no matter how subtle a change, it is still a change. Heightened awareness of such subtle effects is a powerful tool in affecting the diet-health relationship. We need to listen and respond to our innate natural wisdom that cues us in to health supportive behaviours.

Nutrition education is premised on the idea that humans must be taught what to eat and how much to eat. However, the human body is quite extraordinary in its capacity to self regulate. Cueing in to the body’s natural messages provides much information as to what type of food is needed and when it is needed. Picking up on those signals with
clarity potentially enables optimal, individually appropriate, nutritious food intake. Many Australian adults today have become so habituated in food choice and conditioned to sub-optimal physiological function that accurately reading what the body needs can be difficult (e.g. our sense of ‘normal’ is usually based on relativity).

Back in 1939 an American paediatrician, Dr Clara Davis published a paper on her experiment examining the self selection of diets in 15 newly weaned young children who presumably had little or no social conditioning to alter food choice behaviour (Davis 1939). The infants were left to their own devices and able to choose what and how much to eat out of 33 whole foods representing all the core food groups. For a couple of the children the experiment ran for as long as 4.5 years (Strauss 2006). Davis (1939) found that all the children thrived, no nutrient deficiencies developed and the children chose foods which appropriately met developmental needs. No child made themselves sick such that could have occurred if foods from only one food group were eaten – for example if only meat, fish and eggs were eaten, a likely result would have been scurvy; and equally if only fruit and vegetables were eaten, vitamin B₁₂ deficiency and megaloblastic anaemia would have likely resulted (Strauss 2006).

Unfortunately, no statistical information outlining the specific foods eaten or any other details were ever published and now the original data has been lost (Strauss 2006). The study is frequently criticised on this basis. All the same, the study opened up decades of interest in the innate wisdom of the human body.

Not every meal needs to be nutritionally ‘balanced’ or ‘complete’. In hunter-gatherer times, it would be common to eat a lot of one kind of food in one sitting, depending on what had been collected. For instance, in spring if a person found a dozen birds eggs they may have eaten them all in one sitting (O’Dea 1991a). However, over the course of a whole season, and throughout a whole year, a very diverse spread of foods and nutrients were consumed in a wild diet.

Eating behaviour is a complex mixture of physiological and psychological phenomena. As individuals, combining optimal diet knowledge with awareness of our body’s needs is a powerful prescription for health. As Hirschmann and Munter (1989) state, ‘each time you eat from stomach hunger (physiological/nutritional need) you are taking care of yourself in a direct way’ (p.232). The impact of stress on eating behaviour needs to be placed centre stage in discussions about diet and optimal health in Australia today.
Chapter 4: Australia’s Current Food Production Environment

‘Principles of agriculture have been derived from principles of quantity, and nutrition has had no part except by accident’ (Crawford & Marsh 1995 p.252)

4.1 Introduction and Chapter Scope

To date, much of the work in the field of evolutionary nutrition has centred on the health consequences stemming from the agricultural introduction and widespread consumption of grains, dairy, refined sugars, vegetable oils and alcohol. There has been less focus in the evolutionary nutrition field on other changes in our contemporary food production environment occurring far more recently (particularly in the last 50 years) including the use of chemical inputs in agriculture, the effects of simplified soil chemistry in which food is grown, the nutritional effects of intensive hybridisation programs, intensive animal farming operations, our dwindling ocean biodiversity and other modern farming techniques.

These factors warrant attention within an evolutionary context for two reasons:

1. It helps further our understanding of the aetiological factors underpinning chronic health issues. As outlined in Chapter 3, prevalence of these conditions is escalating rapidly and affecting many more Australians today than a couple of hundred years ago. Hence, the introduction of agriculture (higher grain intake) 10,000 years ago, the domestication of animals (dairy) 6,000 years ago, or the industrial revolution (refined sugars and oils) 200 years ago doesn’t, in isolation, adequately explain the rapid increase in these conditions in the population. As discussed in Chapter 3, there are multifactorial causes underpinning all chronic health conditions. Examining the ways in which we
now produce food and the consequential effects on nutrition and health against a backdrop of many factors is useful.

2. Simply knowing the way humans lived in the late Paleolithic period (as outlined in Chapter 2) is not enough to make practical steps to re-align our anciently developed genome in the modern-day world because that Paleolithic environment is now gone. Our current food production systems need careful examination as they are the resource base for appropriately constructing ‘contemporary hunter-gatherer diets’.

Hence, what follows in this chapter is a broad examination of the issues and impacts of Australia’s land and aquatic based food production methods. Held at the centre of discussions is the notion that the greater the divergence from evolutionarily adapted niches, the more problematic it is to achieve optimal human health.

This chapter aims to increase understanding of the pertinent factors involved, and to highlight options for choosing a diet which is more optimally supportive of health.
4.2 **Plant Food Production**

Mimicking the health promoting qualities of a hunter-gatherer diet and the wild food menu in the context of our contemporary agricultural system requires a diverse range of plant foods to be grown that are nutrient dense. The model for a contemporary hunter-gatherer diet proposed in this thesis (see Chapters 7 and 8) contains a much higher intake of vegetables, fruits and seeds/nuts than both the average Australian diet and the recommended dietary guidelines for Australians (owing to the shift away from cereal grains at the base of the food pyramid). Plant foods in hunter-gatherer diets were derived from a mix of wild plants growing in a comparatively clean environment, in their ecologically adapted niches. They supplied ‘exceptional’ (relative to today) health promoting qualities (Brand-Miller & Holt 1998; Eaton & Konner 1985). Today, our plant food is grown quite differently. Therefore, the purpose of this section is to analyse the potential effects of consuming a high vegetable and fruit ‘contemporary hunter-gatherer diet’ in which the food is produced under modern conventional agricultural systems.

Consequently, what follows is an examination of two key issues:

1. The human health impact of agricultural chemical inputs (pesticide, herbicides and fertilisers) in the context of a high vegetable and fruit diet as per a contemporary hunter-gatherer diet’.
2. The degree of biological authenticity in our modern day plant foods compared to wild foods (influenced by factors including cultivar type, degree of hybridisation and soil nutrition).

A third pertinent issue in the contemporary food supply is that of genetically modified foods. This issue will also be addressed, however more briefly owing to the limited role of such in ‘contemporary hunter-gatherer diets’. It is with this topic that the section begins.
4.2.1 Genetically modified plant food

Agricultural biotechnology, often referred to as genetically modified (GM) food, enables the transference of genetic material between un-related species. This bypasses the boundaries of natural biological reproduction, species barriers and the long time course of contextually dependent evolution (Suzuki & Dressel 1999). Concerns related to GM foods are not of immediate relevance to Australians wanting to eat a ‘contemporary hunter-gatherer diet’ because, except for a minority of potatoes, none of the GM foods available in Australia – soybeans, canola, corn, sugar beet and cotton (cotton seed oil) – are core hunter-gatherer food groups. Hence, it is a discussion topic not furthered extensively in this thesis. With regards to potatoes, there is mandatory labelling of GM foods in Australia (FSANZ 2004a) and therefore informed choices can be made. The use of GM technology is, however, of broader environmental and future food concern and warrants ethical and scientific consideration from the vantage point of an evolutionary view.

Briefly, GM food related issues that potentially threaten the future food supply for optimal human health include:

- The risk of contamination between GM crops and non GM crops. GM crops have the capacity to cross breed within their species in natural ecosystems and spread a patented gene into wild stock. This allows a biotechnology company to

9 To date, the only GM food crops approved for commercial growth in Australia are GM cotton and GM canola (approved for plantation in Victoria and NSW in February 2008). GM canola has been developed to be resistant to the herbicide Glufosinate ammonium – commonly known as ‘Roundup’. Roundup is a pesticide designed to kill weeds i.e. all green leafy plants. A GM ‘Roundup ready’ crop means that it has been genetically modified to resist Roundup such that when the crop is sprayed, the surrounding weeds are killed but the crop remains un-damaged. Hence, spraying can occur all season long, in high doses, because the crop won’t die as would otherwise occur in non GM crops. This avoids the need for other labour intensive and mechanical means for dealing with weeds, and after spraying, all that is left growing is the crop of interest. A monoculture ‘desert’ is the result; biodiversity is lost and increased pesticide use occurs. The patented GM seeds must be purchased exclusively from Monsanto, a large US-based biotechnology company – the same company from which Roundup must also be purchased. Such is the economic monopoly of agricultural biotechnology. A number of different crops are in trial phases in Australia including a trial of GM wheat with altered carbohydrate content which will be studied for its potential to reduce glycaemic response and improve metabolic health. (Reference: CSIRO 2008, Proposed GM wheat trial: OGTR application DIR 092: Food futures flagship, viewed 4 February 2009, http://www.csiro.au/files/files/pnja.pdf.)

10 Mandatory labelling excludes highly refined foods that contain no DNA/protein, and hence theoretically contain no GM material e.g. GM soy and canola oil do not have to be labelled.
claim right to not only the original modified seed, but also the plants which become contaminated. Chapela’s (2001) article published in the journal *Nature* documented the case of wild contamination from GM corn in Mexico, attesting to the fact that wild contamination can and does occur. Contamination risk prevents farmers from saving their own seeds, causes them to pay unintended patent fees (Schmeiser 2008), and to become irreversibly financially bound to biotechnology companies (Shiva 2000).

- The risk of wild contamination becomes extraordinarily concerning with the advent of the GM ‘terminator’ gene which sterilises seeds and requires farmers to pay for new seeds each year (Suzuki & Dressel 1999).
- The phenotypical unpredictability of induced genetic changes (Phelps 2000).
- The risk of reducing biodiversity (Norberg-Hodge, Goering & Page 2001) is a major threat to whole ecosystem and human food security (Shiva 2000).
- The environmental and human health implications of increased pesticide use (Biotechnology Australia 2007)
- Questionable assessment of GM foods’ safety for human health (Carman 2007; Smith 2007). Food Standards Australia and New Zealand (FSANZ) report on the safety of genetically modified foods and approve GM foods for human consumption on the basis of the ‘expressional behaviour’ of new genetic material, a history of safe use of that food, and on the basis of ‘substantial equivalence’ compared to non-GM varieties in terms of amino acid profile, fatty acid composition, carbohydrate, vitamin and mineral content as well as a limited number of phytochemicals (e.g. isoflavone in soy beans); (FSANZ 2005). This is arguably not an extensive methodology for long term comparative analysis. Interestingly, GM foods are able to be deemed as ‘substantially different’ to enable patents to be taken out.

- Direct health concerns are focused on the allergenicity of novel food proteins in GM foods, and the health effects of the potential transfer of new genetic material to bacterial cells in the human digestive tract, such as antibiotic resistant genes (commonly used as markers in transgenic material) which could result in infections that are resistant to treatment with antibiotics (FSANZ 2005).

11 The article was later retracted under duress.
• Concerns over biotechnology companies’ capacity to control food supplies with their monopoly on seeds, chemical inputs, crop choice and private ownership (patenting) of the building blocks of life itself, which potentially threatens basic human rights and utilitarian principles (Garcia 2004; Shiva 2000).

• The ethical concerns of the pharmaceutical biotechnology industry are quite different to agricultural biotechnology because in the pharmaceutical industry experiments are laboratory bound and confined (Garcia 2004) and hence, debate must separate the two.

If the commercialisation of a wider variety of GM crops occurs (e.g. GM fruit and vegetables) the above mentioned issues will be of central importance in the context of ‘contemporary hunter-gatherer diets’. However, at present, this is not the case and hence this challenging topic does not have a direct impact on the outcomes of this thesis. However, it is certainly relevant in terms of caring for the wider ecosystem upon which we depend and therefore the issues have been briefly discussed here.

4.2.2 Pesticide residue

‘Human health and the environment are intimately connected – through the food we eat, the water we drink, and the air we breathe. As a result, what we do to nature, we do to ourselves. Preventing pollutants and toxins from entering our air, water and food would have a profound effect on public health’ (David Suzuki Foundation 2006)

4.2.2.1 Introduction

If one is to eat like a ‘contemporary hunter-gatherer’, intake of vegetables, fruits and seeds/nuts will be much higher than the average Australian diet; higher also than the recommended Australian dietary guidelines (see Chapter 7). Since the 1940s, conventional farming methods have increasingly depended on synthetic biocides (pesticides, fungicides and herbicides), many of which leave chemical residues in food. This leads one to think about potential health implications, particularly in the context of high vegetable and fruit diets. While health professionals and government agencies are in unanimous agreement that increasing vegetable and fruit consumption is health
promoting, the high vegetable and fruit content of ‘contemporary hunter-gatherer diets’ as proposed in this thesis, falls outside the ‘normal range’ and hence outside of ‘normal’ regulatory mechanisms for issues such as pesticide residues.

Therefore, the purpose of this section is two fold:

1. To examine data on pesticide residues on conventionally grown Australian vegetables and fruit to ascertain a likely risk profile for exposure in the context of high vegetable and fruit ‘contemporary hunter-gatherer diets’. From this analysis, a recommendation will be made as to whether or not certified organic produce should be prioritised.

2. To question the validity of pesticide use and the concept of ‘acceptable’ daily intakes of pesticide residues from an evolutionary and optimal health perspective. This discussion will also culminate in the pros and cons of consuming organic produce.

### 4.2.2.2 Pesticides defined

Pesticides are now widely used in Australian agriculture. Pesticides are simply defined as ‘any substance or mixture of substances used to destroy, suppress or alter the life cycle of any pest’ (Department of Environment and Climate Change NSW p.27). They can be chemical substances (usually synthetic), biological agents (e.g. virus or bacteria), antimicrobial factors, disinfectants or any device used against unwanted ‘pests’. Pesticides therefore include herbicides, fungicides, insecticides, fumigants, bactericides, rodenticides, baits, lures and repellents (Department of Environment and Climate Change NSW). As biological agents they are purposely designed to affect (usually kill) living organisms. Humans are of course also living organisms and toxicological experiments are performed to establish ‘safe’ exposure parameters, which take into account our protective larger body mass (relative to an insect) and inbuilt detoxifying mechanisms so that a dose of chemicals that kills a food attacking organism does not result in ‘observable’ human health effects. It is a risk management strategy.

According to FSANZ, pesticides ‘provide important benefits in agriculture, resulting in a number of benefits to society…their use provides the community with year-round
availability of, and improved quality and variety in, our food supply, and leads to the
production of food at a cost to the consumer that would otherwise not be possible’
(FSANZ 2003a p.1). Advocates of organic farming methods seriously question the
validity of this statement.

4.2.2.3  **History of agricultural pesticide use**

The manufacture of nitrogen-based bombs during World War I led to the development
of nitrogen based chemical pesticides. Also, nerve gas, developed during World War II,
was slightly modified to make insecticides. As a result, synthetic pesticides, namely
organochlorines (e.g. dieldrin, chlordane and DDT) and organophosphates (e.g.
malthion, parathion) rapidly came into widespread use (Souter 2007). DDT in particular
was the worldwide hero of its generation. Prior to the 1940s, synthetic pesticides were
not used (Mayer 1997) and traditional ‘organic’ methodologies for insect control were
employed. The new chemical technology was promoted as science’s gift to the
agricultural industry – a breakthrough in wiping out disease, thus promising higher
yields, cheaper prices and greater availability. This led to a huge food boom and the
ability to viably plant massive fields containing only a single crop (monoculture
farming). Pesticides were also seen as a great benefit to the homeowner with the advent
of effective weed sprays for lawns, termite killers, and household insecticides (Souter
2007). At the time, these chemicals were cheap, used in staggering quantities and
perceived as un-harmful (Souter 2007).

The difficulty is that pesticides are, at best, a short term solution to pest control. Insects
that survive a pesticide attack develop into new ‘improved’ insects which then require a
more potent pesticide; and so forth (Pojman 1994; Tilman et al. 2002). In time,
resistance emerges where spraying is heaviest (Tilman et al. 2002). Furthermore, while
pesticides are designed to target certain insects, they are not that specific in their effect
and thus also kill potentially beneficial insects at the same time. Adding to the problem
is mono-crop farming, which effectively creates very low biodiversity, enticing plague
populations of insects which then require vigorous pesticide application. Hence, farmers
have become trapped in an increasing cycle of pesticide use, producing greater insect
problems than the ones the pesticides were originally designed to combat. Despite an
estimated 2.5 million kilograms of pesticides being released into the environment
worldwide each year, pests still destroy an estimated 37% of all potential food and fibre crops (Bawden 1999). In the United States, despite a 10 fold increase in insecticide use between 1945 and 1989, total crop losses from insect damage have nearly doubled from 7% to 13% (Bawden 1999).

As evidence of the environmental and human health toxicity problems of the first generation pesticides began to emerge, the use of organochlorine pesticides (aldrin, dieldrin, endrin, heptachlor, hexachlorobenzene, chlordane and DDT) were banned in Australia (and widely across the world) in the 1980s (Mueller et al. 2007). It became recognised that such chemicals were persistently lipophilic by nature and as such, biologically magnified up the food chain (accumulation in animal and human fatty tissue); (Carson 1965). Despite their discontinued use, the human body burden of organochlorine pesticides still persists today with a recent study detecting organochlorine pesticides in all samples of human breast milk from 20 regions across Australia (Mueller et al. 2007). The 20th Australian Total Diet Study (ATDS) also detected low levels of these pesticides in fish, seafood, eggs and leg ham (FSANZ 2003a). Such is their enduring nature in the environment.

The types of pesticides in use today tend to be of a less persistent kind. They are also more potent at lower doses (Heaton 2001) and for safety’s sake we have residue testing protocols in place (FSANZ 2003a). However, some Australians are highly uneasy about pesticide exposure and this is the prime reason for consumers switching to organic produce (Palese 2002). Such is the apprehension in the United States that in a survey including over 700 people, the perceived risk of fatality from pesticide residues on food was judged to being similar in magnitude to the annual morality risk from motor vehicle accidents (Williams & Hammitt 2001). As will be discussed, this perception is totally incorrect in terms of individual toxicological risk assessment. It does, however, indicate a level of awareness of the very real, pervasive and long-term effects of man’s ability to rapidly contaminate the environment without heeding precautionary principles or examining alternative options which prioritise human and environmental health over short term economic gain. It may well be that a few generations into the future, man’s impact on the environment – our chemicals, CO₂ and other wastes – will be catastrophically more risky than risk of mortality from motor vehicle accidents.
4.2.2.4 **Dietary pesticide exposure and human health effects**

There is very little evidence in the literature to causally link dietary pesticide exposure to human health problems. Rather, the majority of evidence of the negative effects of pesticides on human health come from environmental and occupational exposure (Heaton 2001), in which very high doses relative to dietary exposure are experienced. In these cases, pesticide exposure has been associated with a broad range of health conditions including cancer, endocrine disruption, immune disorders, neuro-behavioural and neurotoxicity problems, autoimmune disease, allergies and fertility issues (Heaton 2001).

Multi-generational studies would need to be conducted to establish potential causality between low-grade, long-term dietary pesticide exposure and negative health consequences. Even if these studies were performed – which they are not – establishing causality would likely still be difficult due to the extensive multitude of variables involved in determining health. A small number of studies, whose research methodologies can be criticised, have compared health parameters in people consuming organic versus conventional produce. Julner et al. (1999) found that farmers (n=256) who had a higher intake of organic food had higher semen quality than farmers consuming non-organic food. Similarly, again in terms of sperm quality, Abell et al. (1994) found that men (n=30) who belonged to an organic farming association and ate organic food had higher sperm density than blue-collar worker controls. Such differences in both studies could also likely be due to lifestyle differences (Heaton 2001). A study by Kemmeling et al. (2007) found that consumption of organic dairy products was associated with lower eczema risk in infants. However, this is not really relevant in an evolutionary nutrition context given the absence of dairy (except for breast milk) in the ancestral diet.

In reality, pesticide use has occurred so recently that the true effect and long-term nature of its impact can not, as yet, be quantified.
4.2.2.5 Safety in humans: Acceptable Daily Intakes (ADI)

The ADI for humans is assessed to be a level of intake of a chemical over a lifetime without any appreciable risk to health (Richards 2003). In the assessment of agricultural chemicals for human safety, toxicological studies are performed, usually on laboratory animals including mice, rats, rabbits and dogs (Australian Government 2005). Studies typically involve administering various quantities of a pesticide to animals and observing particular clinical parameters. The potential for long-term toxicity (e.g. possible tumour induction) is determined by observing the effects of repeated dosing. Multi-generational and developmental studies are also performed to examine potential effects on DNA (Australian Government 2005). Rarely are humans used as test subjects owing to the obvious ethical concerns of experimenting with safe exposure limits.

The ‘no observable effect level’ (NOEL) is derived from individual toxicity studies (i.e. the assessment of one pesticide in isolation of others), and is the highest administered dose that does not cause any detectable adverse effect. The NOEL for a chemical, determined in the most sensitive animal species, is then used to estimate the ADI for humans (Australian Government 2005).

To account for uncertainties in extrapolating animal studies to humans and variation between humans, a magnitude of safety is used. The safety factor used is generally 100, which allows for humans to be 10 times more sensitive to a chemical than the tested animals, and for any individual to be 10 times more sensitive than the average person (Australian Government 2005).

Take, for example, the pesticide chlorpyrifos. It is a new-age chlorinated organophosphate insecticide, which is currently the most widely used insecticide in Australia. It has a half life ranging from 92 to 341 days depending on the pH of soil it degrades in (Taylor & Di Marco 2003). In the time taken before chlorpyrifos degrades it disperses into waterways, presenting in our drinking water (at levels assessed to be ‘safe’), in the air [it was the most commonly detected pesticide in the air according to a study in Coffs Harbour NSW in 1992-1993 (Beard 1995)], in food residues (currently also assessed as being within safety limits) and bio-accumulates in ‘moderate to high levels’ in fish and other marine species (Taylor & Di Marco 2003 p.196). Chlorpyrifos
is readily distributed in the human body and what isn’t excreted accumulates in fatty tissues.

According to Taylor and Di Marco (2003), the critical study chosen by the Australian Therapeutic Goods Administration (TGA) for determining the ADI of chlorpyrifos was a human based study by Coulston et al. (1972). In this study, conducted for between 9 and 28 days (not a human lifetime), a NOEL\(^{12}\) was established at 0.03mg/kg/day. Hence an ADI of 0.003mg/kg/day was instigated including a safety factor of 10 (not 100 because it was a human study). However, according to Taylor and Di Marco (2003), there has been insufficient information to assess the carcinogenic effects of chlorpyrifos in humans. Hence, we are relying on quite limited data to assess valid safety parameters.

Chlorpyrifos is just one example of the 7,200 biocide products that are registered for use in Australian agriculture (Leu 2004), only a small proportion of which are monitored. Toxicological testing is carried out for each pesticide individually and does not examine synergistic effects of multiple chemicals (which would be extraordinarily complex) or the effects of intermediate chemical breakdown products (Heaton 2001). The ADI limits are for total exposure to a chemical from all environmental sources – not just dietary – and there are gross uncertainties in determining background exposure levels (Taylor & Di Marco 2003). This potentially makes the ADIs for individual pesticides inadequate and misleading (Heaton 2001).

From an evolutionary perspective, exposure to a wide variety of synthetic chemicals in foods as well as from background sources (including air, water, soil, household and personal products) is a totally novel experience for the human body, regardless of whether or not exposure falls within ADI limits. Therefore, how the ADIs are toxicologically assessed, calculated and utilised needs ongoing evaluation. In terms of mimicking a hunter-gatherer diet, activating the precautionary principle (United Nations


Chlorpyrifos is also known to cross the blood brain barrier (BBB) in animal models affecting ChE activity, as well as altering BBB integrity and structure (References: Parran, DK, Magnin, G, Li, W, Jortner, BS & Ehrich, M 2005, 'Chlorpyrifos alters functional integrity and structure of an in vitro BBB model: co-cultures of bovine endothelial cells and neonatal rat astrocytes', Neurotoxicology, vol. 26, no. 1, January, pp. 77-88.; Sinha, C & Shukla, GS 2003, 'Species variation in pesticide-induced blood-brain barrier dysfunction', Human & Experimental Toxicology, vol. 22, no. 12, December, pp. 647-652.)
1992) and consuming organic produce has sound merit given that it is the simplest way to reduce pesticide exposure (Curl, Fenske & Elgethun 2003). However, for many, buying organic produce is cost prohibitive. Therefore, it is still worth estimating exposure risks.

### 4.2.2.6 Australian monitoring of pesticide residue in food

Many agricultural chemicals leave residues in food, and many vegetables and fruit are sprayed with multiple pesticides (Leu 2004). Sixty-five percent of the almost 400 food samples analysed in the Victorian Produce Monitoring Program contained detectable chemical residues (Victorian Government Department of Primary Industries 2006). In order to monitor this, Australia conducts regular surveys. FSANZ is the governing body that assesses the safety of pesticide residues in our food. In particular they examine the significance of pesticide residue in the context of the total diet (rather than just residues on individual foods). The most recent analysis of this nature was the 20th Australian Total Diet Study (ATDS); (FSANZ 2003a). A total diet study is useful for ascertaining dietary exposure risk for the ‘average’ Australian consuming the ‘average’ diet. It does not however address risk in the context of a high vegetable and fruit diet as per a ‘contemporary hunter-gatherer diet’. Therefore, the results of the 20th ATDS have been re-analysed from an evolutionary nutrition perspective in this section.

The Commonwealth government also runs two other surveillance programs – the National Residue Survey and the Imported Food Program, both programs assessing residue in import and export foods. State and Territory agricultural authorities also carry out surveys, however, the primary aim of these survey is law compliance for pesticide residues (FSANZ 2003a ) rather than health effects assessment. The results of the Victorian Produce Monitoring Program 2005 – which tests for residues in individual foods – will also be analysed in this section in the context of a ‘contemporary hunter-gatherer diet’.
4.2.2.7 Pesticide residues in the Australian diet

The 20th ATDS was carried out in 2002. This is the most recent survey estimating the level of dietary exposure to a range of pesticide residues, contaminants and other substances. Food samples representative of the total diet were tested. The ATDS used to be conducted approximately every two years, however, the recommendation from the 2002 study was that monitoring of pesticides be undertaken at a lower frequency in the future given the large amount of data now collected on pesticide residues with estimated dietary exposure well below the ADI (FSANZ 2003a).

In the 20th ATDS, 65 food types were tested from all Australian states and the Northern Territory during July and November 2000 and February and April 2001 to account for seasonal differences in produce. Residues for the following pesticides were tested (this list represents a small proportion of agricultural chemicals used, however it does provide an indicative guide): chlorinated organic pesticides, organophosphorus pesticides, synthetic pyrethroids, carbamates and fungicides. Importantly, foods were examined in their ready to eat form (e.g. peeled banana, cooked potato); (FSANZ 2003a). The 20th ATDS also assessed heavy metal contamination including antimony, arsenic, cadmium, copper, lead, mercury, selenium, tin and zinc, the results of which are presented in Section 4.4 because of their presence in seafood.

Based on estimated dietary modelling, the 20th ATDS concluded that dietary exposure to pesticide residues were all within acceptable safety limits (FSANZ 2003a). In fact, in the context of what the average Australian eats (low vegetable and fruit intake – see Chapter 7), all estimated dietary exposures to pesticide residues were well below (16% below) the respective ADI (FSANZ 2003a). FSANZ (2003a) state that infants and toddlers fall into the highest category of residue exposure risk because of their high food intake relative to body mass. Nonetheless, their exposure still falls within acceptable limits.
Discussion of pesticide residues in plant foods have been limited in this section to vegetables and fruits. Cereal grains have been excluded because of their lack of prominence in the evolutionary diet. Details about residues in cereal crops can however be found in the 20th ADTS report (FSANZ 2003a).

In order to assess the potential effects of consuming a ‘contemporary hunter-gatherer diet’ using conventional (not certified organic) produce, a sample of six common vegetables and fruits which were analysed in the 20th ATDS have been selected for re-analysis in this chapter. The sample included the seven foods that had the greatest number of chemical residues (not necessarily the greatest amount of any particular pesticide) detected in the 20th ATDS. This sample is therefore not comprehensive, but rather it is merely indicative of risk. The advantage (while not necessarily being representative) of selecting the seven foods with the greatest number of different residues detected is that it highlights the potential for cumulative effects from multiple pesticide residues. These seven foods were (FSANZ 2003a):

1. nectarines (13 different pesticides detected)
2. tomatoes (12 pesticides detected)
3. apples (9 pesticides detected)
4. strawberries (7 pesticides detected)
5. celery (7 pesticides detected)
6. grapes (6 pesticides detected)
7. green beans (4 pesticides detected)

In this re-analysis, the pesticide residues in each of these foods has been compared to the ADI [most recent values used – more recent than those applied in the 20th ATDS (Australian Government, Department of Health and Ageing & Office of Chemical Safety 2008)] and the amount of food required to reach the ADI for a hypothetical 70kg person has been calculated. See Appendix D for full results. As can be seen in Appendix D, even in the context of a high fruit and vegetable diet, the likelihood of exceeding the ADI is rare (a tomato sample being the exception). In the following summary table (Table 16), only pesticides detected in the highest dose are listed for each food.
### Table 16. Likelihood of exceeding the ADI for select pesticides in ‘contemporary hunter-gatherer diets’

<table>
<thead>
<tr>
<th>Food</th>
<th>Pesticide contaminant</th>
<th>Amount of food required to reach ADI for a 70kg person</th>
<th>Likelihood of exceeding ADI* in context of contemporary hunter-gatherer diet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nectarines</td>
<td>Propargite</td>
<td>1.4kg</td>
<td>No (except it is a common pesticide with residues found in numerous fruits e.g. it was also detected in apples)</td>
</tr>
<tr>
<td>Tomatoes</td>
<td>Methamidophos</td>
<td>0.4kg</td>
<td>Yes</td>
</tr>
<tr>
<td>Apples</td>
<td>Propargite</td>
<td>2.4kg</td>
<td>No</td>
</tr>
<tr>
<td>Strawberries</td>
<td>Carbaryl</td>
<td>1.3kg</td>
<td>Maybe</td>
</tr>
<tr>
<td>Green beans</td>
<td>Procymidone</td>
<td>2.9kg</td>
<td>No</td>
</tr>
</tbody>
</table>

* Contains a 100 fold safety margin from the NOEL established in animal studies

As can be seen in Table 16, it is quite possible to consume 400gm or more of tomatoes [2.5 medium sized tomatoes (Xyris Software 2007)] and thus in this case risk exceeding the ADI for methamidophos (organophosphorous insecticide) in a 70kg person. Consuming 1.3 kg of strawberries is a stretch even for the most dedicated ‘contemporary hunter-gatherer’ eater! That being said, carbaryl, which was detected in strawberries, is a very common pesticide, also being found in nectarines, apples, celery and green beans in this sample, thus indicating the potential for accumulative exposure from numerous foods.

#### 4.2.2.9 Re-analysis of the results of the Victorian Produce Monitoring Program 2005 in the context of a high fruit and vegetable ‘contemporary hunter-gatherer diet’

Another way to assess pesticide exposure risk is to examine residues on individual foods. The results of the Victorian Produce Monitoring Program in 2005 are seen in Table 17.

### Table 17. Results of the 2005 Victorian Produce Monitoring Program (Sourced from Victorian Government Department of Primary Industries 2006)

<table>
<thead>
<tr>
<th>Produce group</th>
<th>Number of samples collected</th>
<th>Level of compliance for pesticide residues</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruit</td>
<td>80</td>
<td>79 of 80 samples (98.8%)</td>
</tr>
<tr>
<td>Vegetables</td>
<td>278</td>
<td>254 of 278 samples (91.4%)</td>
</tr>
<tr>
<td>Herbs</td>
<td>19</td>
<td>14 of 19 samples (73.3%)</td>
</tr>
<tr>
<td>Nuts</td>
<td>9</td>
<td>100% compliant</td>
</tr>
</tbody>
</table>
Food samples which contained unacceptable residues were (Victorian Government Department of Primary Industries 2006):

- Fruit: strawberries
- Leafy greens: lettuce, salad mix, spinach, baby spinach, radicchio, chicory and herbs (basil, mint, coriander and parsley)
- Vegetables: celeriac, cauliflower, zucchini, beetroot

The Victorian produce monitoring report states that ‘there continues to be a trend for unacceptable residues to be present in herbs and leafy vegetables’ (Victorian Government Department of Primary Industries 2006 p.14). However, in reality, the picture is more blurry. With the exception of strawberries, baby spinach and celeriac, all other vegetables that contained ‘unacceptable’ residues did so because there is currently no maximum residue limits established and hence any detectable residue is considered as unacceptable.

4.2.2.10 Pesticide residues in certified organic produce

The most comprehensive study of certified organic Australian produce was carried out over 2002–03 in Victoria. Out of 300+ samples, including 60 different types of fruits, vegetables, herbs and grains, 99.99% were residue free (Victorian Government Department of Primary Industries & McGowan 2003). Therefore, certified organically grown produce is a relatively simple, albeit more costly, way of reducing dietary pesticide exposure. More on certified organic produce is covered in Section 4.2.3.5.

4.2.2.11 Discussion of pesticide use in a broader evolutionary and optimal health context

Even though a precautionary approach to pesticide exposure is advisable, based on the current frames of reference for ‘acceptable’ pesticide residue exposure [as defined by the Australian Government, Department of Health and Ageing & Office of Chemical Safety (2008)] there is no need to exercise caution, regardless of how high one’s fruit
and vegetable intake is. Hence, at present, the message is definitely not to avoid a high intake of vegetables and fruit from conventionally farmed Australian produce.

All the same, this chapter is about minimising risk, adhering to precautionary principles, and mimicking the environment to which we are biologically adapted. From this perspective, the pesticide issue is very complex and the following points warrant further consideration:

- The cocktail effect of multiple pesticide exposure (from multiple avenues including food, water, air, soil and households). Pesticide toxicity may be different in combination than in isolation (Heaton 2001). ADI are, however, set for each pesticide individually. This methodology for assessing pesticide safety ignores interactions, synergism, multiple effects and feedback loops producing results that are divorced from the reality of living systems (Copeman 1999).
- In the degradation process of pesticides, potentially toxic compounds form both in the human body and in the soil which is currently not monitored or assessed (Heaton 2001; Tabrizian 2009). Similarly, the effects of the other ‘non-active’ ingredients used in pesticide mixes, including solvents and surfactants which help the ‘active’ chemicals adhere to the plants and avoid their wash-off in rain, are not accounted for.
- There is wide unit-to-unit variation of pesticide residues in produce. For example, apples growing near the centre of a tree receive less spray than those on the periphery, therefore there are wide discrepancies in ‘average’ residues (Heaton 2001).
- There are inherent difficulties in connecting low-grade life-long exposure risk with health affects. Therefore, the fact that there is limited research indicating a problem does not mean there is no effect.

4.2.2.12 **Recommendations for managing dietary pesticide exposure**

On balance, the following summary may help manage the risk of dietary pesticide exposure in the context of a high vegetable and fruit ‘contemporary hunter-gatherer diet’:
1. Consume a high intake of vegetables and fruits regardless of whether it is conventionally or organically grown. There is no scientific evidence at present to indicate that current levels of pesticide residues in conventional produce are cause for concern.

2. Consume Australian produce (because it has been subjected to our monitoring programs).

3. Consume certified organic produce where possible as a precautionary approach, as it is the most effective and simplest strategy for minimising dietary pesticide exposure. For example, Victorian certified organic produce is virtually pesticide free.

4. Wash fruit and vegetables before consumption. This, however, may have only limited effect because pesticides are designed to withstand rain in order to maximise their effectiveness. According to Heaton (2001), 50–93% of pesticide residues remain after washing with water. Peeling fruit has been suggested to reduce residues (FSANZ 2003a); however, residues have also been detected right through the flesh of fruit (Heaton 2001). This is because most pesticides are mixed with detergents and other adjuvants that are designed to make the skin of the fruit or vegetable more permeable to the pesticide application (Brandt & Molgaard 2001). However, peeling also removes other health-supportive nutrients.

5. Consider increasing the proportion of organic produce in the diet of infants and toddlers because of their higher food intake per unit body weight compared to adults and because of their immature immune system and detoxification mechanisms. High caloric consuming athletes may also benefit from increasing the percentage of organic produce for similar reasons (high food intake relative to body weight), as well as those at a higher risk of background pesticide exposures from non-food avenues.

6. Avoid rapid weight loss, thus minimising rapid mobilisation of body pesticide burden into circulation; and likewise avoid weight gain, which serves as a storage facility for lipophilic chemicals (Glynn et al. 2003). Also, keeping healthy and optimising nutritional status maximises the body’s detoxification capacity (Tabrizian 2009).
4.2.3  **Plant food quality: The effects of growing conditions of nutrition**

‘Healthy soil, healthy plants, healthy people’ (Balfour 1946)

4.2.3.1  **Introduction**

At present, the majority of our plant foods are farmed under conventional methods. An alternative to this system is ‘organic’ farming, which was the method used prior to the advent of synthetic pesticides and fertilisers (Brandt & Molgaard 2001). There are clear differences in the growing conditions of the two systems with resulting changes in three distinct areas as analysed in this section:

1. nutrient composition, including primary nutrients (macronutrient, micronutrients and trace elements) and secondary nutrients (i.e. phytochemicals)

2. biological authenticity (i.e. the degree to which food resembles wild food counterparts)

3. environmental impacts.

The first two issues are of immediate human health impact and hence are discussed in most detail. There are very few studies comparing the nutritional characteristics of wild foods (which are in control of their own nutrient supply and growing in ecologically adapted niches) with conventional produce. As discussed in Chapter 2, the majority of comparative studies that have been done have used Australian bush foods [because they comprise the largest nutritional database of wild foods available in the world (Brand-Miller, James & Maggiore 1997)]. Also as noted in Chapter 2, in general wild foods have exceptional micronutrient density relative to conventional cultivars. They also have a superior phytochemical content (Netzel et al. 2006) than cultivated varieties, which is hypothesised to be significantly health promoting (Hounsome et al. 2008).

On the basis that wild foods offer a superior nutritional advantage in terms of micronutrient density and phytochemical content, it is plausible to hypothesise that agricultural systems which more closely mimic natural design (e.g. organic agriculture)
will produced foods with greater health promoting properties. Given that we no longer have access to a large supply of wild plant foods, the nutritional differences between organic and conventional systems will be analysed in this section.

### 4.2.3.2 The conventional farming system

As discussed in Section 2.8, the goal of modern agricultural science has been to find practices that can be applied in a standardised way so as to enable economic efficiency. Human nutrition has played no intentional part. When the same hybrid seeds, chemical inputs and labour efficient machines can be used on farms regardless of climate, and all crops can be bred to the same uniform ripening phase for harvesting ease and transportation durability, large supermarket chains can plan well in advance for stock intake and provide ‘aesthetic’ produce (big and blemished free). Rather than the full potential of each individual piece of land and climate being maximised, and regionally adapted species and varieties being encouraged, the services gained through biodiversity are being lost, dietary diversity is dramatically declining and farming land is being reduced to the lowest common denominator (Norberg-Hodge, Goering & Page 2001).

### 4.2.3.3 Declining crop variety

Until recently, a wide variety of agricultural seeds were used worldwide. Each seed type was naturally uniquely adapted to the particular climate and soil characteristics of the region to which it belonged. Historically, humans have used around 7000 species of plant foods in agricultural production. Only around 150 species have ever been grown commercially (Suzuki 1990). Today, approximately 13 plant species make up 90% of the world’s food supply (Cordain 1999). Cereal grains account for the greatest percentage by far; wheat, corn, rice and barley are the world’s top food crops and contribute more food than the next 26 crops combined (including fruits and vegetables); (Cordain 1999). Today, around 97% of the vegetables grown at the beginning of the 20th century are now extinct (Garcia 2004). Knowing this, it is easy to understand how a far

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13 Increasing fruit and vegetable size correlates with decreasing vitamin content (Reference: Heaton, S 2001, Organic farming, food quality and human health: a review of the evidence, Soil Association, Bristol.)
greater variety of species were typically eaten in the average hunter-gatherer diet (Eaton & Konner 1985) than is available in Australia today.

Over the past 30 years particularly, there have been significant reductions in the number of different plant food varieties available. For example, apples are one of the oldest and most popular fruits worldwide (Campbell 2005). At the beginning of the 19th century more than 7000 varieties of apples were grown around the world (Garcia 2004). At the beginning of the 20th century, 15 to 20 different varieties were commercially grown. Today in Australia only nine varieties are commonly available commercially (Campbell 2005). One of the main driving forces underpinning this reduction has been the advent of cool storage facilities, which allowed for longer marketing periods of six to eight months after harvest. The use of synthetic ripening chemicals has also aided this process. Prior to having access to cool rooms and ripening agents, many different varieties were grown so that harvesting could occur in sequences of one to two weeks apart, ready for immediate sale. These changes have increased the time between harvest and consumption. From a nutritional perspective, declining freshness correlates with reductions in certain nutrients, particularly vitamin C (Heaton 2001).

### 4.2.3.4 Biological authenticity

'We take in energy from other life forms in the form of food and liquids, and from the air we breathe. The more alive and full of life force a substance is the more life force we extract from that substance’

*(basic principle of Ayurvedic medicine, Saraswati 2009 p.12)*

The term ‘biological authenticity’ has been coined in this thesis to refer to the way our contemporary food is grown relative to how it would grow in the wild. Agricultural methods have significantly altered many parameters related to biological authenticity and the selective pressures of the two environments (agrarian versus wild) are vastly different. Key changes affecting biological authenticity and potentially altering nutritional characteristics include:

a) The use of synthetic chemicals (pesticides, herbicides, fertilisers)
b) Soil microbiology changes (resulting from the use of synthetic fertilisers, pesticides, continuous cropping and compacting heavy machinery)

c) The intensive hybridisation of plant species

In the wild, it is in plants best interest to maximise their reproductive advantage. As such, wild plants have large pips relative to flesh, demonstrate maximum growth potential in their ecologically adapted niche, and display strong defence mechanisms. Contemporary cultivars are arguably vulnerable by comparison. They have been hybridised for certain characteristics primarily suiting economics, not nutrition. In conventional systems plants’ nutrient supply is a simplified man-provided matrix of sodium, potassium and phosphorus, and defence protection can be de-prioritised by plants as external pesticide applications are used (which reduces the phytochemical content in plants as to be discussed in the next section).

Biological complexity is declining both above and below the ground. There is reduced genetic diversity in crop plantations and biological activity in soil is being destroyed (by chemical inputs, over-cropping and monoculture farming). This means that the symbiotic services (including nutrient exchanges and other complex food web relationships) between plant root systems and biological organisms are being lost (Ingham 2000).

There is concern as to whether or not nutrient levels in plant foods have declined due to the changes in soil conditions under conventional systems and heavy hybridisation programs. In part, this concern was triggered by the publication of Mayer’s (1997) paper comparing the mineral content of 20 fruit and 20 vegetables grown in the United Kingdom between the 1930s with the same produced grown in the 1980s. Mayer (1997) concluded that there had been a significant decline in mineral content, particularly calcium, magnesium, copper and sodium in vegetables and magnesium, iron, copper and potassium in fruit. For example, the average calcium content in vegetables had declined by up to 81% compared to the original level. In terms of calcium alone, this has significant health implications in the context of a ‘contemporary hunter-gatherer diet’, in which dairy foods are excluded (as will be explored in Section 5.4).

A paper by Davis et al. (2004) similarly found that between 1950 and 1999 in the United States, there were statistically reliable declines in calcium, phosphorous, iron, riboflavin, vitamin C and protein in 43 garden crops (mostly vegetables). Davis et al. (2004)
concluded that the decline was most easily explained by genetic changes in cultivated varieties (due to hybridisation).

Regardless of whether the declining nutrient content of vegetables and fruit is due to changes in cultivars or soil characteristics, the bottom line is that there is mounting evidence to suggest a marked nutritional decline in our plant foods due to contemporary farming methods. It can be argued, as Davis et al. (2004) did, that the lies not in being concerned with potential reductions in the nutrient content of contemporary fruits and vegetables but rather the focus needs to be on reducing intake of refined sugars, fats and flours, and increasing fruit and vegetable intake. While absolutely true, this conclusion diverts attention from the problem itself and prevents access to optimal human nutrition.

In response to Meyer’s (1997) study, FSANZ comapred the mineral content of Australian fruits and vegetables grown in the 1980s and in the year 2000 (Cunningham, Milligan & Trevisan 2001). The report found that there does not appear to have been significant changes in the content of potassium, sodium, calcium, magnesium, iron and zinc over this time. Broader mineral and trace element analyses were not performed. The findings do not, however, mean that that over a longer time frame, Australian soils will be immune from soil nutrition decline while farmed under contemporary agricultural methods. Irrespective of farming practices, there is some indication that Australian soils are relatively low in certain trace elements including selenium and iodine, which has consequential flow-on effect to foods (Thomson 2004).

4.2.3.5 Organic farming in Australia

Unlike conventional agriculture, certified organic farmers do not use synthetic chemicals for weed, disease or pest control, or for fertilising soil. Naturally occurring pesticides that can be applied to organic produce include pyrethrins, light oils, copper, sulphur and biological organisms such as Bacillus thuringiensis (Heaton 2001; Victorian State Government 2007). Certified organic produce is not genetically modified, nor exposed to irradiation14 or fumigants (Victorian Government Better Health Channel 2007).

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14 Food is irradiated (x-rays) to destroy micro-organisms that cause decomposition. At low doses irradiation lengthens the shelf life of fruits e.g. strawberries by destroying mould, or inhibiting
Organically farmed animals are free ranging (not kept in feed lots). Also, growth-regulating drugs, steroids, hormones or antibiotics are not used (Victorian Government Better Health Channel 2007). More about animal production is discussed in the next section (Section 4.3).

The regulations of certified organic agriculture do not primarily aim to address optimal human health; rather it is a side effect of production methods. As such, organic produce is not necessarily an authentic mirror of wild food because, for instance, modern hybrid crops are used and varieties can be grown which are not naturally acclimatised to a particular region. Organic farming is simply a system which is more biologically authentic relative to conventional agriculture.

Organic methods were the means by which humans farmed for 10,000 years up until the past 70 years or so when chemical inputs, intensive hybridisation programs and heavy mechanised equipment came into practice. In reality, ‘conventional’ agriculture is the ‘new’ system in our farming history.

Organic farming methods are based on principles of biodiversity (e.g. polyculture cropping, crop rotation, and additions of animal manures) and depend on a strong understanding of, and preservation of, soil ecology for pest control (McMichael et al. 2007). Theoretically, when soil nutrition and biological diversity are optimal, weeds, disease and pests do not predominate. Importantly, the basic premise of an organic approach is one aimed at the health of the living ecosystem, not merely the absence of disease.

While the nutritional impacts of organic produce are of focus in this section, the environmental and social effects are also significant. Briefly, a review by Pimentel et al. (2005) summarises some of the broader advantages of organic methods compared to conventional systems, including:

sprouting in potatoes; at larger doses it kills bacteria e.g. Salmonella that cause food poisoning. Irradiation can change the nutritional composition of food by breaking DNA. FSANZ state that the effect is similar to when food is cooked, with the exception of a couple of compounds of which there is currently little knowledge of the effect.

- The presence of higher soil organic matter in organic farming systems which improves carbon sequestration (which may aid in the mitigation of climate change) and improves water retention (beneficial in Australian drought conditions).
- Lower fossil energy inputs in organic systems (around 30% lower); (Meadows, Randers & Meadows 2004).
- Equal yields to those from conventional agriculture (depending on crop, soil, and climate). Equivalent crop yields between the two systems have also been noted in several studies (see Badgley et al. 2007; Brandt & Molgaard 2001; Meadows, Randers & Meadows 2004; National Research Council 1989; Norberg-Hodge, Goering & Page 2001).
- Potential reduction in nitrogen leaching in organic systems (but not always – depends on how animal manures are used in organic systems) thus minimising eutrophication risk in waterways.
- Labour inputs that, while around 15% higher in organic farming, are more evenly distributed over the year.
- Net economic return is often equivalent to conventional systems due to higher market prices.
- Reduced soil erosion, pest problems and pesticide use due to crop rotations and cover cropping in organic systems.
- Improved nutrient recycling in organic systems (e.g. the recycling of livestock waste).
- Increased biomass (above and below ground) in organic systems which increases the ecological services obtained through biodiversity and provides biological control of pests and insect cross-pollination.

The word ‘organic’ is not regulated in Australia, simply because all food (except salt) is organic matter. However, the term ‘certified organic’ is stringently controlled. A number of organisations have been accredited as organic certifiers in Australia and the use of their name and logos can be used for consumer identification of organic produce. The following is a list of some of those organisations:

- Australian Certified Organic (www.australianorganic.com.au)
- Biodynamic Research Institute (Demeter) (www.demeter.org.au/index)
- National Association for Sustainable Agriculture Australia (NASAA) (www.nasaa.com.au)
In evidence of the effectiveness of Australia’s regulatory process (as mentioned in Section 4.2.2.10), the 2002 Victorian produce monitoring program found that 99.99% of over 60 different types of certified organic fruit, vegetables, herbs and grains contained no detectable synthetic pesticide residues (Victorian Government Department of Primary Industries & McGowan 2003). (This is the most recent survey.)

4.2.3.6 Conventional versus certified organic vegetables and fruit: nutrient differences

There have been few high quality studies comparing conventional versus organic produce. Therefore, little is known about the effects of synthetic chemicals on nutrient composition (Brandt & Molgaard 2001); or on potential changes in nutrient content due to genetic alterations (Heaton 2001), and other changes inherent to modern agriculture. This lack of data makes it hard to quantify just how far removed our modern food supply is from the natural nutrient environment to which our bodies are most adapted.

The two potential areas that indicate differing nutritional characteristics between organic and conventional produce are in term of:

a) micronutrient content (vitamins, minerals, trace elements)

b) phytochemicals (also called secondary nutrients or polyphenols).

Research suggests that there is no significant impact of macronutrient composition (Brandt & Molgaard 2001). Generally, protein content parallels nitrogen uptake and carbohydrate content increases in relation to varying phosphate levels (Brandt & Molgaard 2001). In terms of vitamins, minerals and trace elements, it is known that vitamin C content increases when plants are subjected to stress (including drought, low nitrogen availability, intense sunlight, pest attack and pesticide application), β-Carotene is associated with proliferative growth, and the type and origin of soils significantly influences trace element content (e.g. selenium). These differences can therefore vary
regardless of whether organic or conventional techniques are employed. However, by and large, the greatest nutrient and phytochemical differences are seen between different cultivars than those between the same cultivar grown under different conditions (Brandt & Molgaard 2001). That being said, even if genetic differences cause the largest variation, a smaller but systemic effect of particular growing conditions can still significantly alter average nutrient levels, thus potentially effecting human health. Hence, general trends need to be observed.

4.2.3.6.1 **Micronutrient differences between conventional and organic systems**

The overall trend in the limited research that exists on this topic is that compared to conventionally grown plant food, organic food contains:

- Lower nitrate levels (Heaton 2001), owing to the lack of synthetic fertiliser use [(this can vary, depending on the nitrogen content of animal manures used in organic systems (Pimentel et al. 2005)]. Increased nitrate intake (particularly from drinking-water contamination) is of concern to human health with a risk of methaemoglobinemia in infants (blue-baby syndrome, in which the oxygen carrying capacity of red blood cells is reduced) and because nitrates in the presence of gastro-intestinal micro-organisms are capable of reducing nitrate to nitrite, which may then combine with amines from digested protein and form nitrosamines – a known carcinogen (Joshi et al. 2008; Powlson et al. 2008).
- Higher dry matter (therefore greater nutrient density per gram) (Heaton 2001). High water uptake is common in conventional crops due to high fertiliser use (Mayer 1997).
- Higher vitamin content; particularly vitamin C, vitamin E and β-Carotene (Heaton 2001; Lombardi-Boccia et al. 2004).
- Higher mineral and trace element content (including P, K, Ca, Mg, Fe, S, B, Cr, Cu, Mn, Se, Sn, Sr, Va, Zn). However, results vary in the literature (Heaton 2001).

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15 Heaton (2001) performed one of the most comprehensive literature reviews to date on the comparative differences between organic and non-organic crops. While being potentially biased as it was published by the UK Soil Association – an organic farming association – its scope is impressive, containing a review of 99 published papers (of which 70 were rejected on ground of methodological errors and inconsistencies).
Just how different organic produce is to conventional produce can be difficult to quantify due to variation in cultivars and study results. One review study that attempted to quantify the difference was by Worthington (2001), who found that organically grown fruits, vegetables and grains contained 27% more vitamin C, 21% more iron, 29% more magnesium, 50% more iodine, and 37% more selenium (mean values) than their conventionally produced equivalents. The study also showed that organic produce contained less heavy metal contamination and nitrate.

### 4.2.3.6.2 Phytochemical differences between conventional and organic systems

The impact of non-nutritive plant chemical – commonly called phytochemicals or secondary metabolites – on human health is only recently being appreciated. Unlike the nutritive properties of food (i.e. vitamins, minerals, proteins, fats, carbohydrates), no phytochemical is known to be absolutely necessary for health (Brandt & Molgaard 2001), which likely explains the research lag into their health promoting effects. However, increasing research is demonstrating that dietary intake of phytochemicals plays a profound role in optimising human health and in disease prevention. As Netzel et al. (2006) state:

> ‘Both epidemiological and in vitro studies strongly suggest that polyphenols (phytochemicals) play an active role in the prevention of degenerative diseases such as cancer and cardiovascular diseases. Polyphenols were also found to exert neuroprotective and antidiabetic actions and reduce obesity. Polyphenols protect cell constituents against oxidative damage through scavenging free radicals and thereby avert their deleterious effects on nucleic acids, proteins, and lipids in cells. Recently direct interactions of dietary plant polyphenols with receptors or enzymes involved in signal transduction have also been reported’ (p.9821).

Phytochemicals are chemicals produced by plants to help protect and defend themselves so as to best ensure maturity and successful reproduction. In essence, they are a plant’s ‘immune system’. There are many thousands of phytochemicals, of which, only a small percentage have been functionally identified (Hounsome et al. 2008; Konczak 2006; Stanton 2006). In contrast to the well understood functional roles of vitamins, minerals,
trace elements, amino acids, fatty acids and sugars in the human body, the biological activity of plant chemicals remain largely unknown. Hence, at this preliminary stage of understanding, general trends need to be recognised, rather than individual phytochemicals highlighted (and marketed) in isolation (e.g. resveratrol which is being popularly promoted at present), otherwise the broader impacts and synergistic effects of a potential 200,000 or more phytochemicals (Hounsome et al. 2008) on health will be missed. Consequently, focussing on supporting favourable plant food growing conditions, which broadly elevate phytochemical content is the most effective way of comprehensively nurturing the health-promoting properties of food.

Phytochemicals are synthesised in plants in response to environmental factors including soil microbiology, insect attack, and other stress-inducing factors (Brandt & Molgaard 2001; Hasler & Blumberg 1999). Hence, the hypothesis is that plants left to defend themselves produce higher levels of phytochemicals. Confirming this is the finding that wild foods (and organic produce) have a much richer phytochemical content than conventional cultivars (Netzel et al. 2006). Additionally, there appears to be a trade off between a plant’s efforts to grow versus its efforts to defend itself from pests (Herms & Mattson 1992). A slower growth rate results in greater phytochemical accumulation (in contrast, excessive fertilisation, which is growth promoting, reduces phytochemical content). Conventional agricultural practices reduce a plant’s need for internal defence mechanisms (i.e. phytochemical production) because of external inputs including chemical pesticides and the simplification of soil life, along with the fostering of quick growth.

Similar to the way wild foods grow, organic agricultural methods leave plants to defend for themselves and to co-exist/battle their way through a more complex, biodiverse ecosystem. As such, several studies have demonstrated that organic produce contains more phytochemicals than conventional produce.

- Mitchell et al. (2007) found that flavanoids (a class of phytochemicals) were 79–97% higher in organic tomatoes compared to conventional ones (10 year study).
- Tarozzi et al. (2006) found that organic oranges contained a significantly higher phytochemical content and total antioxidant capacity than corresponding non-organic oranges.
• Young et al. (2005) found that organic pak choi had significantly higher phytochemical content than conventional equivalents (due to greater attack by flea beetles in the organic food).
• Brandt and Molgaard’s (2001) review cited a study in which the resveratrol content was on average 26% higher in organic than conventional wines of the same grape variety.
• Brandt and Molgaard’s (2001) review estimated levels of plant defence-related phytochemicals in organic vegetables to be 10-50% higher than in conventional ones.
• Carbonaro et al. (2002) found increased phytochemical content in organically grown peaches and pears compared with corresponding conventional samples.

There are vast differences in phytochemical content between different plant cultivars. This alone may explain why wild foods are typically so high in phytochemicals relative to contemporary cultivars. Hence it leads one to hypothesise about the importance of maintaining heritage species in our food supply on the basis of their potentially high phytochemical content. Contemporary cultivars used in organic and conventional systems can be genetically very similar16 and several studies have demonstrated that the biggest difference in phytochemical content (as with micronutrients) is seen between cultivars, rather than between different growing conditions (i.e. organic versus conventional); (Chassy et al. 2006; Davis 2007; Tabart et al. 2006). This however does not negate the influence of growing conditions on the phytochemical content of foods of the same cultivar type or variety.

4.2.3.7 Phytochemicals and human health

Of the few phytochemicals which have been studied to date, some have been strongly associated with disease prevention. Others are very toxic (e.g. glycoalkaloids in green potatoes) and can act as anti-nutrients. It is the disease-preventing role of phytochemicals which is of most interest to this thesis. Polyphenolics, a class of phytochemicals, have been studied closely in this regard. Phenolics include flavones (found in many different vegetables and fruit), flavanones (found particularly in citrus

16 However, organic farmers tend to select cultivars that are inherently more insect resistant – a factor which is less of a concern for conventional farmers.
fruit) and anthocyanins (the red, purple or blue pigment found in many fruits and vegetables e.g. berries).

Phenolic levels strongly correlate with antioxidant activity (Netzel et al. 2006) and numerous phytochemicals are associated with a variety of health promoting effects (Hounsome et al. 2008). The schematic diagram presented in Figure 15 outlines some of the possible mechanisms by which plant chemicals are thought to act on disease.

Figure 15. Hypotheses of the links between the working mechanisms of phytochemicals and their effects on disease (NO = nitrous oxide); (Sourced from Nijveldt et al. 2001 p.421)

In terms of cancer, for example, several dietary phytochemicals have been shown to have chemopreventive properties, mediated through anti-inflammatory activity (Nonn, Duong & Peehl 2007). Inflammation is emerging as a risk factor for certain cancers (as well as numerous other chronic diseases); (Aggarwal 2003). Recently, Nonn, Duong & Peehl (2007) demonstrated the anti-inflammatory activities of the phytochemicals curcumin (found in turmeric), resveratrol (red wine, skins of red grapes, other red berries) and gingerol (ginger) on normal prostate epithelial cells and prostate cancer cell lines. Nonn, Duong & Peehl (2007) found that the anti-inflammatory properties of these phytochemicals were mediated through the activity of the mitogen-activated protein kinase phosphatase–5 (MKP5) which is potent inhibitor of inflammation (causing a decrease in cytokine induced nuclear factor kappa-B activation, cyclooxygenase–2,
interleukin–6 and interleukin–8 in prostate epithelial cells). Curcumin, resveratrol and gingerol significantly up-regulated MKP5 in both normal prostate and prostate cancer cell lines, thus demonstrating a direct anti-inflammatory mechanism and potential chemopreventive action.

In other research some phytochemicals, namely anthocyanins, have been found to cross the blood brain barriers in animal models and in doing so reverse age-related declines in memory and motor co-ordination, as well as contribute towards the generation of new neurons in the brain (Joseph et al. 1999; Konczak 2006). Furthermore two recent studies demonstrated that resveratrol mitigated the damaging effects of high calorie diets in mice (Guarente 2006). The effects of phytochemicals on health are likely broad reaching. It is an area being intensively researched at present (Netzel et al. 2006).

4.2.3.8 Certified organic produce in ‘contemporary hunter-gatherer diets’

We no longer have access to wild foods. This leaves us with the choice as to whether or not organic food is a wise choice. There is no clear scientific evidence to suggest that pesticide residue is cause for concern, although a precautionary principle is justifiable. There is also no clear evidence to suggest that organic produce is any richer in micronutrients than conventional produce, however there is a small amount of evidence to suggest a trend in this direction. An apparent difference does however lie in the phytochemical content of organic produce compared to conventional food as discussed in Section 4.2.3.6.2.

Hence, it is on the basis of phytochemical content that there is a clear case for suggesting that organic produce is more health promoting than conventional produce. Also, due to higher phytochemical content, consideration needs to be given to maintaining heritage cultivars (i.e. heirloom varieties which are true to their original genetic make-up and haven’t been exposed to the heavy hybridisation programs) in the food supply and promoting the bush foods industry.

Consumer demand for organic produce is growing at a rate of 20–30% each year and retail sales increased 670% between 1990 and 2001–02 in Victoria (Victorian
This perhaps reflects the public’s awareness of the potential health advantage of organic food (and/or could reflect growing environmental concerns).

While organic production does not automatically mean that food is grown to maximise nutrition, any system that more closely mimics and works within natural ecosystem design inherently tends to serve human health better – both directly by mimicking the conditions (including nutritional matrix) which shaped our evolution, and indirectly by sustaining a biosphere in the condition which human health requires.

Currently, the organic food industry in Australia is predominantly fed by small farms embracing a whole philosophical approach to farming, not just a set of standardised checklists that meet organic certification regulations. However, as big corporations move into organic farming, rules will inevitably be pushed by economic incentives and consequently nutritional quality may decline. Thus, moving towards a greater appreciation of farming systems that are environmentally more sustainable (such as organic), as well as focusing on a food supply in which plants and animals are farmed in a way that nurtures their optimal state of health, will preserve nutritional quality in the human diet and enable us to eat like ‘contemporary hunter-gatherers’.

The organic industry can be supported in a number of ways. At a consumer level, buying power can have a dramatic influence on shaping market behaviour. At a government level, all food needs to reflect its true cost. Thus subsidies need to be removed from conventional farming systems. The resulting impact would be that the inherent costs of different production systems would become visible. Taxes could instead be imposed on pesticides. For example, in Denmark a 3% tax is applied to pesticides to help pay for chemical free pest control (Norberg-Hodge, Goering & Page 2001). Taxes could also be applied to ‘junk’ foods (e.g. heavily processed foods) with the revenue raised again put into sustainable, human-health-supportive agriculture. Tax benefits could also be brought in to reward consumers for purchasing vegetables and fruits, potentially reducing the use of the expensive health care system.

While there is clear recognition of our contemporary shift away from core hunter-gatherer food groups in the evolutionary nutrition field, the impact of our modern food
production systems has not been given much credence. For example, Cordain (2002b) dismisses the claim that organic produce provides any human health advantage, citing studies suggesting that the micronutrient content of conventional versus organic systems do not differ, while overlooking the phytochemical differences and broader implications.
4.3 Animal Meat Production

‘The breeding sow should be thought of, treated as, a valuable piece of machinery, whose function is to pump out baby pigs like a sausage machine’
National Hog Farmer Journal, March 1978
(cited in Norberg-Hodge, Goering & Page 2001)

4.3.1 Introduction

The section examines the impact of modern-day animal meat production systems used for human food consumption. Four systems of animal food production will be examined:
Part I. Conventional intensive farming (pigs, poultry including meat and eggs, cattle, and aquaculture i.e. fish and seafood)
Part II. Conventional extensive farming (e.g. cattle, sheep, ‘free-range’ poultry)
Part III. Certified organic farming (all terrestrial animals)
Part IV. Hunting of wild animals (fish, kangaroo and other free living animals in control of their own food supply).

The three key differences between these four systems are:
- living conditions (free ranging versus confined; indoors versus outdoors)
- animal feed (greens versus grains)
- chemical inputs and residues (used for growth promotion, disease and waste management)

These three factors impact on human health in cascading ways, with direct nutritional effects and indirect environmental costs. The nutritional and human health effects are the primary focus here; however environmental impacts are also briefly mentioned owing to their inextricable link to the big picture of human health. The aim of this section is to outline the impacts of our modern animal food production systems so that informed choice can be made, and animal foods which are more optimally supportive of human health can be preferentially selected.
At present, there is limited data examining nutritional differences in animal foods produced from varying farming systems. The exception to this is in regards to fatty acids and lipids for which clear differences between different farming systems have been established. Hence, in this section, comparative lipid composition data (particularly in terms of saturated fat and omega 6 and 3 essential fatty acids) is analysed as a key nutritional ‘marker’ for more health supportive farming practices. Focusing on fatty acids should not, however, divert attention from examining the issues holistically. Any animal in an optimal state of natural health as defined by evolutionary boundaries (not man-made ‘ideals’) will be optimally supportive of human nutrition regardless of fatty acid particulars.

As discussed in Chapter 2, humans have relied on animal foods continuously throughout evolution. Vegetarian and vegan diets were not consistently part of our ancestral history. That being said, neither were intensive animal factory farms, and therefore some people today would rather remove animal foods altogether from their diet than support intensive farming methods on ethical grounds. An evolutionary nutrition perspective can not however support the notion that vegetarian diets offer superior human health potential (see Chapter 3 for more discussion of this issue). Hence, the focus of this section is to work out which contemporary animal foods best enable us to eat like modern day hunter-gatherer.

Knowledge about the four farming systems outlined in this thesis is important when constructing ‘contemporary hunter-gatherer diets’ because the health and nutritional quality of intensively farmed animals is different to their wild counter-parts. Without careful analysis, gross interpretive errors can be made. Simply exchanging the quantity of animal foods consumed in average hunter-gatherer diets (55% of daily energy on average according to Cordain et al. 2000) with intensively farmed meat cuts commonly consumed today provides a very different nutritional matrix to the way in which wild animals were eaten in hunter-gatherer diets. Doing so can potentially risk a high saturated fat intake, higher omega 6 fatty acid intake (and potentially excessive arachidonic acid intake), reduced intake of long chain omega 3 fats, and excessive protein intake; all of which aggravate inflammatory cascades and have other negative biological consequence in the human body (not to mention the indirect health consequences of the environmental pollution generated by some poorly managed intensive animal systems).
Hence, this chapter will examine the four main types of animal production used in Australia today, and their impact on animal health and consequently on human health. The information will then be viewed from an evolutionary nutrition perspective and an appropriate interpretation for a ‘contemporary hunter-gatherer diet’ outlined.

4.3.2 Part I. Conventional intensive animal farming

4.3.2.1 Introduction

Conventional intensive animal farming is characterised by the confinement of large numbers of animals under controlled conditions. This creates a consistent supply of meat in a minimally labour-intensive way, with maximum profit return. Intensive animal farming is a widespread practice in Australia in the mass production of eggs, poultry, pork and, to a lesser extent, beef.

4.3.2.2 The living conditions of intensively farmed animals

Peter Singer, Professor of Bioethics at Princeton University, has vividly described the conditions of factory farming on animal welfare. A graphic excerpt from his book ‘The Ethics of What We Eat’ (Singer & Mason 2006) outlining intensive chicken farming can be found in Appendix E. This thesis is not premised around animal ethics but rather on optimal human nutrition. However, the issues are not unrelated, as taking care of animal welfare and optimally supporting animal health inherently have flow-on effects for humans consuming these animals. Ecosystems must be managed as a whole. Animal ethics aimed at the welfare of individual species must be viewed within the context of whole ecosystems, and only from that perspective can the right management decisions be made and prioritised. Such systems thinking is necessary to ensure a food supply which is optimal to human health.

The animal welfare conditions of intensive animal farming are concerning. With regards to chickens, the Victorian government’s ‘Code of Accepted Farming Practice for the Welfare of Poultry’ allows 40 kilograms of meat chicken per square metre (Singer & Mason 2006). This is equivalent to less than one A4 sheet of paper per mature bird. The
crowding causes stress, and is a huge risk for infection spread, particularly because these birds are nearly genetically identical, thus equally vulnerable. The birds have been intensively bred to grow big quickly with maximum amount of breast muscle. Excessive body weight causes leg pain and collapse, and insemination has to occur artificially as a consequence of their distorted body size. Similarly, egg laying hens are caged in long rows, sometimes stacked three to four tiers high (Singer & Mason 2006). Australian codes of practice require 550 square centimetres per bird, but as Singer & Mason (2006) state, ‘the code is not adequately enforced and many producers cram more birds into their cages than it allows’ (p34). Artificial lighting is used year round to mimic the longest days of summer, which induces hens to lay the maximum number of eggs. There are approximately 10 million egg-laying hens on 1000 Australian farms (JETACAR 1999).

The Australian pig industry (pork, ham and bacon), like chicken farming, is also highly intensified (Australian Bureau of Statistics 2006). Pigs are kept in pens of concrete and steel, which prevent walking, and even turning around (Singer & Mason 2006). Similar to other intensively farmed animals, chemical inputs are routinely used to increase the utilisation of protein in an animal’s diet (and thus reduce feed costs).

Dairy cows are genetically bred and managed to produce as much milk as possible. They are regularly kept pregnant because, like humans, they only produce milk once their offspring are born. Their calves usually go into the veal industry where they are raised on an iron-deficient diet to ensure the ‘quality’ of their meat’s ‘whiteness’, which is considered a desired characteristic in our society. Cows are often milked in large dairies which can handle up to 800 animals per hour, some operating 24 hours a day with equally spaced milkings every 24 hours (Australian Bureau of Statistics 2004). Victoria dominates the industry, producing over 60% of fresh milk and 75% of manufactured dairy products in the country (Victorian Government Department of Primary Industries 2007). The natural lifespan of a cow is around 20 years, however dairy cows are usually killed at between five and seven years old because they cannot sustain the unnaturally high rate of milk production (Singer & Mason 2006). Their meat does not enter the human food chain. A number of hormones are used in the dairy industry in Australia including:

- prostaglandins (injection) for synchronisation of cows’ fertility cycles and improving fertility (Jemmeson 2000)
• progesterone (vaginal implants, ear implants and intramuscular injection) used for the purpose of improving conception rates, synchronising fertility cycles and stimulating fertility in non-cycling cows); (Segwagwe et al. 2007)
• gonadotrophin-releasing hormone (GnRH) used to improve conception rates (Segwagwe et al. 2007)
• oestrogen for fertility and cycle control (Segwagwe et al. 2007)
• corticosteroids for inducing calves, treating ovarian cysts (Isobe, Yamada & Yoshimura 2007); as well as for treating clinical ketosis and fatty liver disease (Seifi et al. 2007), which are induced by grain-based diets.

The key change in Australian farming of beef cattle has been the introduction of feedlots over the past 30 years (Australian Bureau of Statistics 2005). Feedlots are a confined yard area with watering and feeding facilities. Commercial feedlotting started in the mid 1960s on the Darling Downs in Queensland in response to demands from overseas customers, especially the Japanese, for high levels of marbling, and year round supply (Australian Bureau of Statistics 2005). For the Australian domestic market only about 25 per cent of cattle are fattened in feedlots (Singer & Mason 2006). Cattle are first raised on pastures (eating grass), then ‘finished’ on a diet of grain (commonly barley and sorghum) prior to slaughter or live export (Australian Bureau of Statistics 2005). Cattle have digestive systems evolved to metabolise green grasses, not cereal grains. The high carbohydrate grain diets often result in bloating and acidosis (a factor in the production of liver abscesses in cattle) and can also cause death (Seifi et al. 2007). Antibiotics are thus used prophylactically to maintain the composition of ruminant animals’ gut microflora to manage this problem (JETACAR 1999). Cattle spend varying time periods in feedlots from around 30 days up to 300 days (Ponnampalam, Mann & Sinclair 2006) depending on the ‘marbling’ and weight being sought. Marbling is simply the deposition of intramuscular saturated fat deposits in response to the cattle’s hyper-caloric diet and sedentary situation. A less healthy, fatty animal is the result.
4.3.2.3 Issues common to all intensively farmed animals

4.3.2.3.1 Confinement

Most intensively raised animals are caged so they cannot walk at all. This creates an unfit, sedentary animal. These animals live permanently indoors with no access to sunlight, often existing on concrete floors.

4.3.2.3.2 Waste (manure)

The mass numbers of animals held in intensive systems all produce manure on a large scale. For example, a 20,000-animals piggery in the small village of Corowa NSW produces more manure on a daily basis than all of Canberra (Sillence 2004). This massive amount of manure is concentrated over a small land mass, thus making its environmental management difficult. Without proper environmental management, this waste can wash out on mass into waterways and the nitrogen content of the waste can create eutrophication (nitrogen stimulates algae growth which uses up oxygen in the water thus killing fish and other biota).

4.3.2.3.3 Grain feed

Use of grain feeds (mainly soy and corn, as well as barley and sorghum) instead of an animal’s natural diet (usually grasses, other vegetation and sometimes insects) changes the fatty acid composition of animals. Changing the base of the animal food supply from greens to grains increases intake of omega 6 polyunsaturated fat (PUFA) and reduces intake of omega 3 PUFA (Cordain et al. 2002c; Ponnampalam, Mann & Sinclair 2006). The nutritional differences between confined grain fed animals and free-ranging grass eating animals are discussed in detail in Part II of this section. Feeding grains to animals is grossly inefficient because humans have to grow the food and bring it to the animals as opposed to animals converting material humans can’t eat into food. Thirty-six per cent of the world’s grain harvest goes to livestock (Coghlan et al. 2002) and this extracts a heavy environmental toll as it turns farmers away from polyculture cropping to monocultures of maize and soybean (which are soil depleting). Unfortunately farmers are subsidised for growing corn and soy for animal food, thus further promoting this practice (McMichael et al. 2007). Grain feeding animals is not only a direct human
health issue, but also an ecological problem. The energy expended in growing grain (including fertiliser and pesticide inputs) and transportation is great and results in wasteful use of water, fossil fuels and agricultural land. In this intensive system, as stated by Tilman et al. (2002), ‘the production of 1kg of meat can require between 3 and 10kg of grain’ (p.674). This, combined with the fact that animal manure and enteric fermentation (especially methane) accounts for about 18% of global greenhouse-gas emissions, (McMichael et al. 2007) fuels many a vegetarian’s ethical stance. However, this stance overlooks the role of sustainable non-intensively farmed animal food as a necessary and long standing factor in human health, and the ecological services provided by integrated systems containing biodiverse plant and animal life (Norberg-Hodge, Goering & Page 2001).

4.3.2.3.4 Intensive breeding

Intensive breeding programs have, through artificial insemination, created fast-growing strains of animals with maximum carcass meat. For example, the slaughter age of fast-growing strains of chicken is 35–49 days (Animals Australia 2009), meaning that they have grown from hatchling to full maturation in this timeframe. In contrast, the minimum slaughter age in certified organic systems is 81 days (Castellini 2005). Similarly, the current average dressed carcass weight for cattle and calves stands at 232kgs, which is a 36% increase on the 171kgs in 1950 (Australian Bureau of Statistics 2005).

4.3.2.3.5 Environmental contaminants in animal tissues

Environmental contaminants ubiquitously affect animals (and humans) across all farming systems due to their presence in soil and water. The 2004–05 National Residue Survey (NRS) detected persistent organochlorine pesticides (e.g. DDT and its derivatives) in the adipose (fat) tissue of cattle, sheep and pigs (Australian Government Department of Agriculture Fisheries and Forestry 2004-2005). This has become expected due to the pervasive, persistent, lipophilic nature of these compounds. This provides yet another reason to trim animal fat before consumption. Heavy metals (cadmium, lead and mercury) were also detected in the NRS in samples of liver from cattle, pigs and sheep, and less frequently kangaroo.
4.3.2.3.6 Chemical inputs

Australian intensive agricultural systems depend on the use of a wide range of agricultural and veterinary (agvet) chemicals (Australian Government Department of Agriculture Fisheries and Forestry 2004-2005). Registered agvet chemicals used on animals include the following classes: antibiotics, hormones (including growth hormone, steroids, and anthelmintics to control internal parasites), as well as other veterinary drugs including β-agonists and non-steroidal anti-inflammatory drugs. Each of these chemicals is monitored for residues in food by the Australian Government, the results of which are published in the NRS report as will be discussed.

4.3.2.3.7 Antibiotics

Antibiotics are used for two reasons:

(i) Growth promotion – low concentrations of antibiotics improve weight gain by increasing feed conversion efficiency (antibiotics alter gastrointestinal microflora and aid the digestion of grains which otherwise are difficult for animals to metabolise). See Appendix F for a summary of antibiotic growth promoters approved for use in Australia and the rationale for their use (also for further information see Page 2003).

(ii) Disease prevention and treatment – this is critical in confined living conditions and in animals weakened by un-natural diets. Antibiotic use in this context is approved in intensive as well as extensive systems (free ranging). Antibiotic use is also permitted in some circumstances in certified organic systems where an animal’s life is in danger without such treatment.

Of the 700 tonnes of antibiotics imported into Australia each year, about one third is for human use and two-thirds for veterinary use – mostly for addition to stockfeed for prophylactic and growth-promoting purposes (JETACAR 1999). The use of antibiotics in animals has received increasing attention as a contributing factor in the emergence of antibiotic-resistant bacteria in humans. Antibiotics are becoming less effective and resistance has emerged for all known antibiotics and currently few alternatives are available for the treatment of bacterial infections (JETACAR 1999). In order to assess this issue, the Australian Government established an expert committee – the Joint Expert Technical Advisory Committee on Antibiotic Resistance (JETACAR). The JETACAR
report found that ‘there is qualitative evidence that antibiotics fed to animals leads to resistant bacteria and that these bacteria or their resistance genes are passed on to humans, principally via the food chain’ (JETACAR 1999 p.xxii).

Antibiotic use in food-producing animals can leave residues in meat and milk, and compliance with maximum residue limits (MRL) are assessed through the NRS (Australian Government Department of Agriculture Fisheries and Forestry 2004-2005). The most recent survey in 2004–05 found that out of 14,503 edible meat samples (including cattle, sheep, pig and poultry) only four chemical residues (not just antibiotics) were found to exceed the Australian Standard. Only one of these detections was due to antibiotic residue found in a sample of pig muscle, kidney and liver (Australian Government Department of Agriculture Fisheries and Forestry 2004-2005). In terms of eggs, out of a sample of 75, only two contained residues above the Australian Standard (Australian Government Department of Agriculture Fisheries and Forestry 2004-2005). Hence, the likelihood of ingesting antibiotic residues from conventionally produced animals is very low. Furthermore, as the JETACAR committee concluded, ‘there is no evidence to confirm or refute the selection of resistant bacteria in the human gastrointestinal tract after ingestion of antibiotic residues or of increased resistant bacteria in food due to the presence of residue’ (JETACAR 1999 p.xx). Hence, the problem of antibiotic resistance is an issue of general concern, rather direct dietary concern.

4.3.2.3.8 Hormones

Another issue is the use of hormones in intensive livestock production. Hormones are used as growth promotants and as control agents over fat and lean muscle deposition. Such control over fat and lean muscle deposition is driven by market demands. Growers are penalised when variables such as carcass weight, back-fat thickness and marbling, fall outside the narrow range defined by the abattoir which can vary widely – Japanese and North Koreans want marbelled Australian meat, while our domestic market wants lean meat (Sillence 2004). Production of such precise, consistent variables requires the use of drugs because, like humans, enormous individual variation would naturally otherwise exist. Physical exercise cannot be used to control body composition due to animal confinement in intensive operations, therefore hormones are seen as a viable option.
Like antibiotics, they are also used to increase the efficiency of feed utilisation. Australia licenses the use of a number of hormonal growth promoters (HGPs) for livestock production, including bovine growth hormone, porcine and equine growth hormone and the β-agonist ractopamine (Sillence 2004). Contrary to popular belief, hormones are not used in Australian chicken meat production (Australian Chicken Meat Federation 2006). They are, however, used heavily in pigs, and to a lesser extent in cattle and sheep (Queensland Government Department of Primary Industries and Fisheries 2007). Cattle and sheep are predominantly extensively raised on pastures where improving feed conversion efficiency is not given quite the same priority as when expensive grain is being used in intensive operations (such as in pigs). HGPs are used to increase muscle growth, induce earlier onset of maturation, increase lean muscle yield and delay fat deposition (Queensland Government Department of Primary Industries and Fisheries 2007). For example, when used in cattle, HGPs are implanted as a pellet under the skin of the animal’s ear which slowly dissolves to release the hormone into the blood stream. Implants contain female hormones (such as oestradiol and progesterone) or male hormones (including testosterone and trenbolone acetate).

As with antibiotic residues in food, hormone residues are also tested for by the Australian Government in the NRS. In the 2004-2005 NRS, no hormones residues that exceeded the Australian Standard were detected in edible animal food products (Australian Government Department of Agriculture Fisheries and Forestry 2004-2005)17, hence the likelihood of consuming hormonal residue from intensively produced meat is negligible. Use of most hormonal growth promotants is ceased prior to slaughter to avoid leaving traces of residues.

Anabolic steroids and hormone implants are widely used in Australia as well as in North and South America and Canada. However, the European Union has banned the production and importation of meat derived from animals treated with non-therapeutic hormone growth promoters because their use ‘poses a potential health risk to consumers’ (Higgins 2004 p.217). This risk is not due to dietary exposure, which is negligible, but lies in their accumulation in broader environmental systems, where they have the capacity to act as endocrine-disrupting compounds in humans, as discussed in the next section.

17 In the 2004/05 NRS the limit of reporting was set at 10–20% of the Australian Standards maximum residue limit.
4.3.2.3.9  **Endocrine disrupting compounds (EDCs) – effects on humans**

While little is known about the potential ecological effects of hormonally active substances associated with discharges specifically from intensive animal operations (Durhan et al. 2006), cumulative exposure to numerous environmental synthetic chemicals are hypothesised to cause endocrine disruption in humans and other life forms. Endocrine disrupting compounds (EDCs) are defined as ‘exogenous substances that alter function(s) of the endocrine system and consequently cause adverse health effects in an intact organism, or its progeny or (sub) populations’ (WHO/IPCS 2002). Potential EDCs include synthetic agricultural chemicals (i.e. hormones, antibiotics and pesticides), as well as industrial chemicals (e.g. dioxins, compounds in PVC piping, polychlorinated biphenyls, plasticisers, plastics used in food packaging, detergent breakdown products and biphenol A, which is a compound used in the manufacture of polycarbonate plastics such as those used in drinking bottles), and pharmaceutical hormones (e.g. oral contraceptive pill and hormone replacement therapies); (Cravedi et al. 2007; Falconer et al. 2006; Nilsson 2000). Many of these chemicals can end up as environmental contaminants (particularly through run off into waterways and bioaccumulation in marine life), leading to inadvertent intake with potential resulting effects on human hormones (Nilsson 2000). Research suggests that there is an extraordinary diversity in the number of structurally dissimilar compounds that exhibit some degree of oestrogen receptor binding (Golden et al. 1998). Hence, additive or synergistic effects may be of concern in an increasingly contaminated environment.

Potential sources of endogenous and synthetic EDCs can be seen in Table 18.
### Potential endocrine disrupting chemicals (based largely on animal studies)

<table>
<thead>
<tr>
<th>Synthetic origin</th>
<th>Biological origin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hormones:</strong></td>
<td><strong>Hormones:</strong></td>
</tr>
<tr>
<td>17α-Ethinylestradiol</td>
<td>17β-Estradiol</td>
</tr>
<tr>
<td>Diethylstilbestrol</td>
<td>Estriol</td>
</tr>
<tr>
<td>17β-Trenbolone</td>
<td>Estrone</td>
</tr>
<tr>
<td><strong>Herbicides:</strong></td>
<td><strong>Phytoestrogens:</strong></td>
</tr>
<tr>
<td>Atrazine</td>
<td>Sesquiterpenes</td>
</tr>
<tr>
<td>Simazine</td>
<td></td>
</tr>
<tr>
<td>Methoxychlor</td>
<td>Phytosterols</td>
</tr>
<tr>
<td>2,4-D</td>
<td></td>
</tr>
<tr>
<td><strong>Insecticides:</strong></td>
<td></td>
</tr>
<tr>
<td>DDT</td>
<td></td>
</tr>
<tr>
<td>Dieldrin</td>
<td></td>
</tr>
<tr>
<td>Endosulfan</td>
<td></td>
</tr>
<tr>
<td>Lindane</td>
<td></td>
</tr>
<tr>
<td><strong>Industrial chemicals:</strong></td>
<td></td>
</tr>
<tr>
<td>Phthalates</td>
<td></td>
</tr>
<tr>
<td>Bisphenol A</td>
<td></td>
</tr>
<tr>
<td>p-Nonylphenol</td>
<td></td>
</tr>
<tr>
<td>PCBs</td>
<td></td>
</tr>
<tr>
<td>Tributyltin</td>
<td></td>
</tr>
</tbody>
</table>

*Table 18. Potential endogenous and synthetic endocrine disrupting compounds (Sourced from Falconer et al. 2006 p.186)*

EDCs can affect any hormonal system; however the oestrogen mediated effects have been most widely studies. EDCs with oestrogen-mediated effects are often referred to as xenoestrogens. One of the most comprehensive reviews of the biological evidence for the effect of environmental endocrine modulators on human health was carried out by Golden et al. (1998). In this review, the authors state that ‘it is biologically plausible to hypothesise that exposure (particularly in utero) to environmental oestrogens could adversely affect humans as exposure to oestrogen, whether in utero or in adulthood, can have biochemical, physiological, and specific target organ effects on development, preproduction, behaviour, and metabolism’ (p.114). Health endpoints assessed in the review were breast cancer, endometriosis, adverse effects on the male reproductive tract, male and female fertility, alterations in sexual behaviour, learning problems, testicular cancer, prostate cancer, immune system effects and thyroid function. It is an extraordinarily complex issue and difficult to draw conclusions (Ashby 2000; Cravedi et al. 2007; Falconer et al. 2006; Fenner-Crisp 2000; Golden et al. 1998; Nilsson 2000).

With present techniques for testing estrogenic potential, it appears unlikely that exposure to usual levels of environmental estrogenic substances, from whatever source, would be sufficient to produce many of the hypothesised effects (Golden et al. 1998).
However, caution against definitive conclusions is advisable given that current techniques for assessing the estrogenic activity of chemicals examines interactions with the oestrogen receptor as the basis for measuring biological activity. As Golden et al. (1998) states, ‘it is becoming clear that the mechanism by which oestrogenic effects are ultimately expressed may not necessarily be mediated by the oestrogen receptor’ (p.113). Therefore, a precautionary approach to environmental sources of EDCs is warranted and emissions should be reduced to a minimum. EDCs used in intensive livestock production is only one source of environmental contaminants with endocrine-disrupting properties; however, following the European Union’s lead in banning the use of such agents would be advisable.

Plant food is another major source of exogenous oestrogens (Falconer et al. 2006; Golden et al. 1998; Nilsson 2000). Although unrelated to animal food production in isolation which is the focus of this section, addressing some of the broader sources of EDCs enables the issue of their agricultural and veterinary (agvet) use to be contextualised, and the overall health impacts of EDCs to be more significantly appreciated. Hence, the comparative oestrogenic potency of endogenous hormones, with various sources of environmental xenogestrogens and dietary sources will be briefly explored here.

4.3.2.3.9.1 Phytoestrogens

Plants with some degree of oestrogen receptor binding capacity are referred to as phytoestrogens. Appendix G contains a table comparing the oestrogenic potency of endogenous oestradiol – 17β with various sources of environmental xenogestrogens and dietary phytoestrogens. In Appendix G it can be seen that synthetic oestrogenic compounds from environmental sources contribute an almost insignificant amount to daily intake compared with dietary sources (especially soybeans and cereal grains). Importantly however, as Golden et al. (1998) emphasise, there are difficulties in interpreting biological equivalencies between synthetic and natural compounds, particularly when so many uncertainties remain about the mechanistic action of EDCs. For instance, pharmaceuticals are designed to be biologically active at trace concentrations (Falconer et al. 2006). Table 19 outlines potential daily oestrogen exposure in females.
<table>
<thead>
<tr>
<th>Compound/s</th>
<th>Oestrogen Equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oral contraceptives</td>
<td>16,765</td>
</tr>
<tr>
<td>Hormone replacement therapy</td>
<td>3350</td>
</tr>
<tr>
<td>Plants and food</td>
<td>102</td>
</tr>
<tr>
<td>17 β-oestradiol (most potent endogenous oestrogen)</td>
<td>1</td>
</tr>
<tr>
<td>Organochlorines (pesticides)</td>
<td>0.0000025</td>
</tr>
</tbody>
</table>

Table 19. Estimated daily doses of oestrogen in females in terms of oestradiol equivalents (Sourced from Falconer et al. 2006 p.186).

Soybeans and cereal grains are the two major sources of phytoestrogens in diets today. Their endocrine effects are not insignificant. For instance, in healthy pre-menopausal women, Cassidy et al. (1995) found that an intake of 60g soybean protein per day (45mg isoflavones) for nine months significantly prolonged the follicular phase length of the menstrual cycle, with significant suppression of the mid-cycle surges of the gonadotrophines. Mean menstrual cycle length in Western countries with high breast cancer risk is 28 to 29 days, whereas in Japan (known for higher soy intake) it is 32 days and breast cancer risk is four-fold lower (Greim 2004). Breast cell division is four-fold lower during the follicular phase of the cycle, which is hypothesised to be one of the reasons for the protective correlation between phytoestrogen intake and breast cancer risk (Greim 2004).

However, in terms of food groups available to man throughout evolution, i.e. hunter-gatherer food groups, the two major sources of phytoestrogens in the modern day – soybeans and cereal grains – would rarely have been consumed. Instead, a variety of fruits and vegetables well in excess of modern day intakes were eaten, which contained a host of disease-protective elements. The diet-disease interface is very complex and mechanisms underpinning disease aetiology such as breast cancer therefore require far broader examination than just phytoestrogen intake.

### 4.3.3 Part II. Conventional extensive farming

#### 4.3.3.1 Introduction

The key difference between conventional ‘intensive’ production and ‘extensive’ production is that in extensive operations, animals are free to roam on open grazing
land. This means that the animals can move freely, be physically fitter, and have access to a more natural (grass based) diet. In Australia, around 75% of cattle and the vast majority of sheep spend their lives under extensive conditions. The same genetic breeds and chemical inputs can be used across both systems (extensive and intensive), however disease risk in extensive systems is lower without the confinement issues (McMichael et al. 2007), which mitigates the need for widespread antibiotic use.

4.3.3.2 Grain versus grass: Nutritional differences between grain fed animals and grass eating animals

The natural diet of free living terrestrial animals (e.g. cattle, sheep, chickens, kangaroo) contains a variety of green grasses, other vegetation and sometimes insects. A diet comprised exclusively of cereal grains is not natural for any animal, including humans. Changing the nutritional matrix of the diet changes the biochemistry of the body. In animals, as well as humans, one of the most distinctive and easily assessed markers for such dietary change are alterations in the fat composition of the body i.e. the relative proportions of saturated, mono- and poly-unsaturated fats contained in cell membranes. Numerous studies in a wide range of animals demonstrate that grain fed animals (and eggs) contain higher saturated fat and omega 6 fatty acids and lower omega 3 fatty acids relative to grass eating animals (Cordain et al. 2002c; Lopez-Bote et al. 1998; Mandell, Buchanan-Smith & Campbell 1998; Ponnampalam, Mann & Sinclair 2006; Wood et al. 1999). This alteration is a direct reflection of the fatty acid composition of grains that contain more omega 6 fats relative to omega 3 containing green vegetation. The increased accumulation of saturated fat in grain fed animals is likely confounded by the sedentary existence of intensive operations in which grain feeds are most commonly used. Consumption of these animals passes this skewed fatty acid distribution up the food chain to humans (Langdon 2006). The significance of the dietary effect on fatty acid composition is such that, for example, the ratio of omega 6:omega 3 fat in chicken eggs varies between 1.3 and 19.3 depending on whether they were free-range (more green vegetation in diet and therefore more omega 3 fat) or factory-raised (grain feed and therefore more omega 6 fat); (Langdon 2006).

As with humans, changing the natural lifestyle and dietary patterns of animals results in a broad spectrum of biochemical alterations with functional effects. Fatty acid changes
are only one such nutritional effect, but are the marker that has been most extensively studied. Comparative studies examining micronutrient differences (e.g. zinc, iron, and fat-soluble vitamins) and other nutritional variations between the produce of different farming systems is lacking.

In order to gain a sense of the nutritional impact and potential health consequences of eating grass-fed (i.e. green vegetation) versus grain fed meat in the context of total diet, a prominent and frequently cited Australian journal article by Ponnampalam et al. (2006) is analysed below.

4.3.3.3 The relevance of grass versus grain animal feeds in the context of the total human diet: A critique of Ponnampalam et al. (2006)

Ponnampalam et al. (2006) studied the effects of different feeding systems on fatty acid composition in Australian beef cuts. The study found that grass fed beef contained significantly higher levels of long chain omega 3 and total omega 3 compared to feedlot grain fed beef. The article concluded that on this basis nutritional basis alone, grain feeding should be discouraged.

The fatty acid differences in grass-fed versus grain-fed beef can be seen in Tables 20 and 21.

<table>
<thead>
<tr>
<th>Fatty acids</th>
<th>Grass-fed beef (rump) /100gm lean meat</th>
<th>Long-term grain-fed beef (rump) / 100gm lean meat</th>
<th>Difference</th>
<th>Equivalent intake of the fatty acid from other food sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omega 6 (LA)</td>
<td>190mg</td>
<td>255mg</td>
<td>65mg</td>
<td>1 almond = approx 147mg (USDA 2009)</td>
</tr>
<tr>
<td>Omega 3 (ALA)</td>
<td>49mg</td>
<td>21mg</td>
<td>28mg</td>
<td>1 ml flaxseed oil = 600mg (Melrose Laboratories 2009)</td>
</tr>
</tbody>
</table>

Table 20. Omega 3 & omega 6 fatty acid content of grass-fed versus grain-fed beef relative to other food sources
Despite the conclusions of Ponnampalam et al. (2006), when the data is placed into the context of total diet, the fatty acid differences are in fact very small, and have questionable relevance. As seen in Tables 21 and 22, in terms of omega 6 fat (linoleic acid), the difference between grass-fed and grain-fed meat (per 100g) was equivalent to less than half of one almond. Likewise, the difference in omega 3 fat (alpha-linolenic-acid) was so small that just 1mL of flaxseed oil contains over 20 times the difference between grass-fed and grain-fed meat (per 100g). Furthermore, differences in the long chain polyunsaturated omega 3 (n-3 LCPUFA) content amounts to 30mg/100gm. For comparison, snapper fish contains 3.5 times the amount of n-3 LCPUFA of grass-fed beef for the equivalent serving size. Wild Atlantic salmon, which is very oily, contains 16 times the n-3 LCPUFA of grass fed beef. Hence, in a ‘contemporary hunter-gatherer diet’ where a significant proportion of fish and seafood is eaten, the fatty acid differences between grass-fed and grain-fed meat are inconsequential.

Ponnampalam et al. (2006), however, argue differently stating that ‘total long chain n-3 PUFA levels in beef from grass fed cattle were similar to the values found in white fish… (and) results indicate that grass-fed lean beef can be accredited as ‘a source’ of n-3 PUFA for those who do not consume fish, because the n-3 FA content is similar to that provided by some white fish’ (p.25–26). The ‘white fish’ refers to a sample of Australian fish whose fatty acid composition were analysed by Sinclair et al. (1998) as outlined in Table 22.
Food per 100gm lean flesh | n-3 LCPUFA (EPA+DHA) content/100gm edible flesh
---|---
Grass fed beef (rump) | 48mg
Long term grain fed beef (rump) | 28mg
Australian fish (Sinclair et al. 1998) | • The lowest EPA + DHA was found in orange roughy = 91mg.
• The next lowest was luderick = 123mg.
• Third lowest was rock flathead = 146mg.
• At the other end of the scale, the highest EPA + DHA content was found in Atlantic salmon = 1619mg, and sea mullet = 1604mg.

Table 22. EPA + DHA content of grass versus grain fed beef, relative to various Australian fish species

As seen in Table 22, the n-3 LCPUFA content of ‘white fish’ is not in fact ‘similar’ to grass fed beef. The fish with the lowest n-3 LCPUFA content in the study by Sinclair et al. (1998) contained 1.9 times the amount of EPA and DHA of grass-fed beef. Hence, equating fish with grass fed beef is misleading and for this reason among others, fish is given separate prominence in ‘contemporary hunter-gatherer diets’ as proposed in this thesis.

For so many reasons grain feeding should be discouraged in animals because, above all, it doesn’t support optimal animal health and can cause extensive environmental problems. When fish and shellfish are regularly included in the diet, the marginal differences between grass-fed and grain-fed meat are almost inconsequential. A greater difference might possibly be demonstrated in the fatty acid composition of organs, brain and marrow due to the preferential uptake of fats in these tissues. Or perhaps, due to the preferential uptake of n-3 LCPUFA in organ meats, a relative n-3 LCPUFA deficiency may first show in skeletal muscle. The answer is at present unknown; however, it is of little relevance given the low prominence of organ meats in contemporary human diets. Hence, irrespective of the marginal differences between grass versus grain feeds on the fatty acid composition of skeletal muscle of animals, the human diet still requires a richer source of n-3 LCPUFA fats. In the traditional hunter-gatherer diet, this source was found in animal organs, fish and seafood. Aquatic foods, being readily available today, are therefore emphasised in ‘contemporary hunter-gatherer diets’ in this thesis.
4.3.4  Summary of the human health impacts from conventional systems (both ‘intensive’ and ‘extensive’)

1. Hormone and antibiotic use in intensive livestock productions is an eco-toxicological problem rather than a direct human health issue (insignificant risk of dietary residue consumption). The release of agricultural chemicals (amongst other industrial chemicals) into the environment are suspected to elicit endocrine disrupting features in humans. Furthermore, agricultural use of antibiotics may contribute to antibiotic resistance. The lack of clear evidence concerning the association between exposure to environmental contaminants and adverse health outcomes hampers health professionals’ ability to counsel accordingly. Further research work in this area is required.

2. There is a marginally increased risk (although very small) of dietary chemical residue exposure in consuming adipose (fat) tissue, hence a precautionary approach would recommend minimising animal-derived saturated fat intake. This is in line with an evolutionary nutritional approach, irrespective of contamination issues.

3. The sedentary confinement of intensively farmed animals significantly increases saturated fat deposition. Therefore, as above, consuming only lean skeletal muscle from intensively farmed animals is advisable if attempting to mimic the leanness of wild, free-living animals, which by comparison are very active and fit.

4. There are possibly yet uncharacterised nutritional differences between intensively versus extensively produced animals, apart from fatty acid differences. Fatty acid differences in the skeletal muscle (meat) of grain versus grass (green vegetation) fed animals are negligible, particularly when viewed in the context of total diet (especially when fish is consumed). The reduced health status of animals living within intensive production systems plausibly results in nutritional changes in the animal that are currently unrecognised and may be of relevance as sub-optimal animal nutrition is passed up the food chain to humans.

5. Poorly managed effluent from intensive livestock systems has significant eco-toxicological ramifications, as does the practice of grain feeding animals.
Table 23 summarises the animal farming conditions predominantly operating in Australia today. It also outlines whether feeds are grass or grain based, and whether chemical inputs are used.

<table>
<thead>
<tr>
<th>ANIMAL</th>
<th>Number of animals in Australia</th>
<th>Intensive or Extensive environment</th>
<th>Feed</th>
<th>Chemical inputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle – beef</td>
<td>26 million</td>
<td>75% Extensive (open grazing land)</td>
<td>Grass (some grain in drought conditions)</td>
<td>Minimal antibiotics: for disease treatment if required and prophylactic control of lactic acidosis when on grain feed.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>25% Intensive production for 80-200 days in feedlots to be ‘finished’ (Ponnampalam, Mann &amp; Sinclair 2006)</td>
<td>Grain (barley &amp;/or sorghum as well as cottonseed and protein meals) (Ponnampalam, Mann &amp; Sinclair 2006)</td>
<td>Antibiotics for prophylactic &amp; therapeutic purposes; and for improved growth rate and feed conversion efficiency (FCE).</td>
</tr>
<tr>
<td>Cattle – dairy</td>
<td>2 million</td>
<td>Predominantly intensive</td>
<td>Grain</td>
<td>Antibiotics used prophylactically to prevent lactic acidosis and bloat; also to improve FCE, which increases milk production.</td>
</tr>
<tr>
<td>Sheep – lamb</td>
<td>120 million</td>
<td>Predominantly extensive</td>
<td>Grass</td>
<td>Minimal antibiotic use: usually only on valuable stud animals, as well as for disease treatment if required, and prophylactic control of lactic acidosis when on grain feed.</td>
</tr>
<tr>
<td>Poultry - meat</td>
<td>400 million</td>
<td>Intensive</td>
<td>Grain</td>
<td>Antibiotics extensively used for disease prophylaxis and treatment; as well as for growth promotion and improved FCE.</td>
</tr>
<tr>
<td>Poultry – eggs</td>
<td>10 million</td>
<td>Predominantly intensive, Some extensive i.e. eggs labelled ‘free-range’</td>
<td>Grain (some grass if free-range)</td>
<td>As above. Growth promotants are not used in Australia.</td>
</tr>
<tr>
<td>Pigs – pork</td>
<td>3 million</td>
<td>Intensive</td>
<td>Grain</td>
<td>Antibiotics extensively used for therapeutic and prophylactic use to counter enteric and respiratory disease; also for growth promotion and improved FCE.</td>
</tr>
<tr>
<td>Aqua-culture</td>
<td>Not known</td>
<td>Intensive</td>
<td>Grain, fish meal</td>
<td>Antibiotics. See Section 4.4 for discussion of fish farming.</td>
</tr>
</tbody>
</table>

Table 23. Summary of the animal farming conditions predominantly operating in Australia, along with the feeds & chemical inputs used (Data sourced from JETACAR 1999; unless otherwise stated in the table).
4.3.5  Part III. Certified organic animal farming

Animal welfare is held in high regard in certified organic farming systems. Animals are free ranging on open grazing land with emphasis given to adequate shade from sun and shelter from weather and predators (Singer & Mason 2006). No antibiotics, hormones or artificial inputs are administered (Heaton 2001; Victorian State Government 2007). The emphasis on optimal animal health in organic systems has flow on effects to humans consuming such animals. While not mimicking the full spectrum of living conditions and freedoms experienced by wild animals, organically farmed animals live in a more biologically authentic way compared to those reared in conventional systems.

Similar to extensive farming systems, organically raised animals are free to exercise and eat grass and other vegetation. Genetic breeds can be indistinguishable between the two systems, however faster-growing strains of animals (e.g. chickens) do not fare as well under organic conditions because their massive body weight relative to leg strength renders them highly prone to leg disorders and lameness (Castellini 2005) – an issue of minimal consequence when birds are caged and don’t need to move in order to feed. Hence, slower-growing breeds with greater inherent strength and survival characteristics tend to be chosen in organic systems. The animal welfare consequences of this speak for themselves.

Another advantage of organic systems, particular those in which animals and plants are integrated, is that closed waste management loops can be established whereby manures are used as plant fertilisers (Norberg-Hodge, Goering & Page 2001; Tilman et al. 2002). Effluent (highly nitrogenous) run-off can still be of issue (Pimentel et al. 2005), however stocking density is much lower on organic farms, thus minimising the scale of the issue. For example, Australian certification for organic eggs requires that the stocking rate must not exceed 1000 hens per hectare (Singer & Mason 2006).

4.3.6  Part IV. Harvesting wild animals

We are incredibly fortunate as Australians to have access to a number of wild animals in our contemporary food supply – a number of fish and seafood species as well as kangaroo meat. In contrast to the diversity of wild animals in many hunter-gatherer diets
which ranged from insects to marine life and included all kinds of vertebrate animals, this range of wild animal species is small; however, at this point in time we need to appreciate what we do have, particularly considering that the genetic diversity of conventionally farmed species – cattle, sheep, pigs and chicken – is also very low.

Wild animals live in ecologically adapted niches, consuming indigenously adapted diets. An optimal state of health is fundamental to a wild animal’s survival.

Utilising healthy wild animals in the human food chain exactly mimics our ancestrally adapted diet. Yet many Australians are culturally unaccustomed to using our indigenous animal resources. The kangaroo, along with whales and other indigenous species, is considered sacrosanct by many. However, there is sound conservation and human health value in harvesting native biotic resources if done sustainably. As Flannery (1994) writes:

‘It may seem shocking to some conservationists that anyone should advocate the sustainable utilisation of endangered species. But if it is possible to harvest for example, 10 mountain pygmy-possums or 10 southern right whales per year, why should we not do it? The economic gain made from such utilisation may allow us to ask less of critically over-exploited resources. Is it more moral to kill and consume a whale without cost to the environment, or live as a vegetarian in Australia, destroying seven kilograms of irreplaceable soil, upon which every-thing depends, for each kilogram of bread we consume?’ (p.402–403).

Flannery (1994) goes on to state, ‘I fear that the Australian environment is now in such crisis, our population so large, and our affluence so dearly protected, that it is only by carefully utilising all of our renewable resources that we can hope to avoid further environmental damage’ (p.403). If Australia did enable a conservation oriented policy allowing the sustainable utilisation of all our native animals for human food with the intention of helping Australian’s to tread more softly on the land, what an advantage this would be for those wanting to eat like ‘contemporary hunter-gatherers’ and for optimal human health.

Australian native animals are naturally adapted to our Australian climate and thus are less environmentally destructive compared to European imports of cattle, sheep, pigs
and chickens. If, due to population pressure, sustainable wild harvest of animals was unachievable, extensive (i.e. free ranging, grass eating) farming of native Australian animals such as kangaroos offers a viable alternative, as is next discussed.

4.3.6.1 A special mention on kangaroo meat

It has only been since the early 1980s in South Australia and early 1990s in other Australian States that it has been legal to sell kangaroo meat for human consumption (Auty 2004). At present, wild kangaroos are culled as part of the Australian Government’s policy to reduce their expanding population and therefore only wild not farmed kangaroo meat is available in supermarkets and butchers (now widely available). Kangaroos are a ‘low emission’ marsupial. In contrast, cattle and sheep contribute significantly to methane release; require extensive land clearing; cause soil compaction (due to higher hoof bearing pressure relative to a kangaroo) which leads to loss of soil fertility and increased water run off; and require water-intensive grain growing for their feeds (Savory 1999). Hence, one of the suggestions in the Garnaut (2008) review for future sustainability in Australia is to replace the farming of sheep and cattle with kangaroo. Prior to the Garnaut (2008) review, Flannery (1994) had made the same suggestion. However, as the Garnaut (2008) review states, there are some significant barriers to such a change, particularly in terms of consumer resistance. This is where marrying the discourse between optimal human nutrition as it is defined in this thesis and climate change/sustainable futures is powerful. The human health advantage of eating meat from healthy free-living animals consuming their indigenous diet is apparent; and what better way to engage the population in acting towards minimising climate change than with their own health motivation? This may be the necessary link for a paradigm change in Australian agriculture and attitudes.

In 2007, the Federal Government’s kangaroo cull quota enabled three million kangaroos to be harvested from a wild population of 24 million. This is small business compared to conventional agriculture in which an approximate 445 million chickens, 20 million sheep, nine million cattle and five million pigs were slaughtered in 2007–08 (Australian Bureau of Agricultural and Resource Economics 2008). Much of Australia’s kangaroo meat is exported and sold as expensive game meat, whereas here is it one of the cheapest cuts on the market and, along with wild fish, is one of the last remaining sources of wild animal food that we have access to.
Some researchers question the ecological feasibility of substituting kangaroo for conventional livestock. Russel’s (2005) calculations estimated that the amount of kangaroo meat needed to replace the amount of meat Australians currently obtain from cattle would mean that at present efficiency rates the entire Australian kangaroo population would need to be killed hundreds of times over each year. Given this scenario, two strategies could be employed: (i) kangaroo could be extensively farmed which, from a nutritional perspective, is more supportive of human health than meat from intensive farming operations; (ii) increase utilisation of kangaroo carcasses for human consumption. At present only 30% of the kangaroo meat is regarded ‘prime meat’ fit for human consumption (Russel 2005) and sold as fillet or steak meat. The remainder of the carcass usually goes into the pet food industry. Hence, there is currently a lot of wastage of potential human food. Traditional Australian Aborigines typically consumed all edible parts of the kangaroo.

As noted in the Garnaut (2008) review, consumer resistance to eating our national emblem is not insignificant. One of the key concerns people have, apart from the more gamey taste of kangaroo meat (in large part due to volatile oils from diverse vegetation), is the cruelty of killing such animals. The ethics of killing a wild animal versus one which spends its whole life confined is an important ethical debate. However, regardless of the animal’s life’s circumstances, humane killing is indicated. With regards to kangaroos, the Australian Government’s ‘Shooting Code Compliance’ requires humane shooting. In 2000–02, 95.9% of all kangaroos had been head shot instead of body shot which results in a quick death (RSPCA Australia & Department of the Environment and Water Resources 2007).

Other wild living animals (though not necessarily indigenous species) which could be included in the future human food supply (as long as they are healthy, and parasite- and contamination-free) include camels, rabbits, foxes and possums. All of these currently exist in plague numbers, are in control of their own nutrient supply, live free and offer viable health-supportive human food alternatives.

4.3.7 Animal food choices in ‘contemporary hunter-gatherer diets’
Understanding the various farming methods for animal food production is necessary in order to make informed choices and to more authentically construct a ‘contemporary hunter-gatherer diet’. The diet, lifestyle and health of intensively farmed animals are very different to wild animals which have been consumed throughout most of human history. Intensively farmed animals lead sedentary indoor lives and consume diets they are poorly adapted to, which has negative flow-on effects to the humans eating them, as well as on the environment.

From an evolutionary perspective, an omnivorous diet is a necessary requirement for optimal human health. When selecting animal foods in a ‘contemporary hunter-gatherer diet’, the optimal health status and biological authenticity of the animals should take precedence.

Therefore, the proposed hierarchy for animal food inclusion in a ‘contemporary hunter-gatherer diet’ from an evolutionary perspective is as follows:

1. Wild fish, shellfish and other sea animals (aquatic foods are discussed in the next chapter). Aquatic foods are prioritised over terrestrial animals (not exclusively though) on the basis of the shoreline evolutionary hypothesis (see Section 2.4) and the absence of other major sources of omega 3 long chain essential fatty acids in the contemporary food supply.
2. Wild land animals: kangaroo and other wild animals.
3. Certified organic meats and eggs (consume only lean cuts).
4. Extensively farmed animals that are free ranging on open grazing land e.g. lamb, free-range chicken and other poultry (meat and eggs), goat, rabbit, and most beef in our domestic market\(^\text{18}\) (consume only lean cuts).

\(^{18}\) 25% of beef is feedlot finished and thus grain fed, however much of this goes into an export market (Reference: Ponnampalam, EN, Mann, NJ & Sinclair, AJ 2006, ‘Effect of feeding systems on omega-3 fatty acids, conjugated linoleic acid and trans fatty acids in Australian beef cuts: potential impact on human health’, *Asia Pacific Journal of Clinical Nutrition*, vol. 15, no. 1, pp. 21-29.)
Products from intensively farmed pigs (pork, ham, bacon), intensively farmed poultry (meat and eggs) and intensive aquaculture (fish, as discussed in the next chapter) have been omitted from this list because, while other options are available, their inclusion is considered unnecessary and they are comparatively poorer alternatives when considering the maintenance of optimal human health.
4.4  **Aquatic Species**

‘Once considered inexhaustible, our oceans are now in a state of global crisis.  
So how do we reconcile this grim news with our appetite for fresh, healthy seafood?  
Well, first by accepting responsibility for our part in this web of connections.  
This relates to us and our habits and tastes. But mostly to our expectations.  
Nothing can alter our expectations the way knowledge can.’

*(Tim Winton cited in Bohm, Davey & Neilson 2007 p.3).*

4.4.1  **Introduction**

Our wild marine food harvest is the last environment in which we still behave as hunter-gatherers. However, the scale of our fishing industry and the technologies employed now far exceed those of hunter-gatherers. The foods collected though are still wild. Aquatic species (both fresh and salt water) including fish, shellfish, marine mammals and all sorts of other sea creatures have been an integral part of worldwide hunter-gatherer diets throughout time, so much so that, as hypothesised by Cunnane (2005), human brain expansion may not have occurred without them (see Section 2.4). On-going access to aquatic foods is an integral part of supporting human health. However, wild fish stocks are in rapid decline and fish are increasingly bio-accumulating environmental contaminants. Hence, this section examines a number of issues related to our use of wild aquatic foods in the context of a ‘contemporary hunter-gatherer diet’.

4.4.2  **Fish and human health**

There is a strong correlation in the literature between fish/seafood consumption (long chain omega 3 polyunsaturated fatty acids intake in particular) and health and illness prevention – especially with regard to coronary heart disease, inflammatory and autoimmune diseases, cancer, mental health conditions, and a range of other degenerative conditions (GISSI 1999; Hu et al. 2002; ISSFAL 2006, 2008; Kris-Etherton, Harris & Appel 2002; Simopoulos 2002; von Schacky et al. 2006). Aquatic foods provide a rich source of protein, minerals and trace elements in the human diet,
and it is their essential fatty acid content of the omega 3 series in particular that gives them prominence and has been the focus of much research.

In our evolutionary diet, aquatic animals, along with organ meats provided the main source of long chain omega 3 polyunsaturated fatty acids (n-3 LCPUFA); (Crawford et al. 1999; Cunnane 2005). Still today, fish are the main source of n-3 LCPUFA in the modern Australian diet (Meyer et al. 2003; Ollis, Meyer & Howe 1999), with red meat from grass fed animals providing the next most available source (Ollis, Meyer & Howe 1999; Ponnampalam, Mann & Sinclair 2006). However, red meat is a poor alternative by comparison as discussed in the previous section. In the context of a ‘contemporary hunter-gatherer diet’, unless organ meats are consumed (preferably from organically farmed animals), fish and seafood are the primary sources of essential n-3 LCPUFAs.

The chemical nature and health-supportive properties of n-3 LCPUFA including the biologically significant derivatives, docosahexaenoic acid (DHA), eicosapentaenoic acid (EPA) and docosapentaenoic acid (DPA), are detailed in Section 5.2.3.

### 4.4.3 Australia’s intake of fish & seafood and the recommended guidelines

Fish and seafood consumption in the average Australian diet is a very low 28.9 g/person/day for males and 22.6 g/person/day for women (Australian Institute of Health and Welfare 2006b). The Australian Guide to Healthy Eating recommends that adults eat 1–1.5 serves of ‘lean meat, fish, poultry and/or alternatives’ each day (Australian Institute of Health and Welfare 2006b). No specific recommendation for fish or seafood intake in isolation of other protein sources is made. However, if the Australian Guide to Healthy Eating recommendation was sourced entirely from fish, it equates to 80–120gms cooked fish. By contrast, the majority of recent hunter-gatherers consumed well in excess of this amount (Cordain et al. 2000; Cunnane 2005; Eaton 1992; O'Dea 1991a).

Given that fish is the predominant source of n-3 LCPUFA in the contemporary diet and given Australian’s low intake of fish, it is not surprising that the average Australian diet is deficient in n-3 LCPUFA as seen in Table 24. The human body is capable of
elongating parental omega 3 fatty acid (alpha linolenic acid) found in plant foods (e.g. flaxseed oil) into n-3 LCPUFA, however, only in an extremely limited capacity (Burdge & Wootton 2002; Plourde & Cunnane 2007; Williams & Burdge 2006). The chemistry of this elongation process is outlined in Section 5.3.2. Consequently, fish and other seafood are fundamental aspects of an optimal contemporary diet.

4.4.4  Recommendations for long chain omega 3 fatty acid intake

As outlined in Table 24, various prominent organisations have made recommendations for adequate intakes of n-3 LCPUFA in the light of an increasing body of research evidence indicating crucial physiological roles for these essential fatty acid in the human body. Each of the recommendations is higher than levels presently consumed in the average Australian diet.

<table>
<thead>
<tr>
<th>Recommendations for daily omega 3 fatty long chain polyunsaturated fatty acid intake (EPA+DHA+DPA):</th>
</tr>
</thead>
<tbody>
<tr>
<td>• NHMRC (2006) Adequate Intake recommendation</td>
</tr>
<tr>
<td>• ISSFAL (2008) Adequate Intake recommendation</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>• American Heart Association (Kris-Etherton, Harris &amp; Appel 2002)</td>
</tr>
<tr>
<td>• Estimated average hunter-gatherer intake (Eaton 1992)</td>
</tr>
<tr>
<td>• Average Australian intake (Meyer et al. 2003)</td>
</tr>
</tbody>
</table>

The ISSFAL recommendation of 650mg n-3 LCPUFA intake equates to, for instance, 377g of oily Atlantic salmon or 1609g whiting (low oil); (USDA 2009). Again, for comparative purposes, the most common fish oil capsules in Australia provide 180mg EPA + 120mg DHA (for example Blackmores Australia brand). Hence at least 2 capsules per day would be required to meet adequate intake levels as set by ISSFAL, and 3-4 capsules per day to meet the American Heart Association recommendations for patients with cardiovascular disease or to meet estimated intake in average hunter-gatherer diets in the absence of dietary supply.

Table 24. Recommendations for daily omega 3 long chain polyunsaturated fatty acid intake

In Table 24, only recommendations for elongated (long chain) fatty acids i.e. EPA+DPA+DHA (rather than total omega 3) are listed because of the body’s poor ability to endogenously elongate short chain omega 3 fats (Burdge & Wootton 2002; Plourde & Cunnane 2007; Williams & Burdge 2006).
Alarmingly, despite Australians’ very low intake of fish and seafood, and our inadequate n-3 LCPUFA status, ocean species are on the verge of collapse, largely due to overfishing. There is now a wide disparity between nutritionally optimal intakes of fish and seafood and increasing population growth and rapidly declining ocean stocks.

### 4.4.5 Current state of our oceans

The largest ever analysis of global marine biodiversity and fisheries by Worm et al. (2006) alerted the world to what had been long suspected – our global marine ecosystems are undergoing accelerated loss of species populations and are at imminent risk of collapse. This is the direct result of overfishing, pollution, habitat destruction, coastal development and human induced alterations in ocean biogeochemistry (Worm et al. 2006).

Extrapolated data based on current rates of marine diversity erosion, indicates a global collapse of all marine species currently fished by the year 2048 (Worm et al. 2006) as seen in Figure 16. The key message, however, is that – based on the available data, at least at this point in time – these trends are still potentially reversible (Worm et al. 2006).
Underpinning the stability of all habitats – both land and marine – is biodiversity. Rates of marine species collapse increases and recovery potential decreases exponentially with declining biodiversity (Worm et al. 2006). Conversely, as found in the Worm et al. (2006) analysis, re-establishment of species biodiversity (i.e. increasing marine species, even if numbers within each species remain relatively low) resulted in a four-fold productivity increase. Hence, biodiversity needs to be the key focus for ocean life recovery.

A present, very little is known about the ecology and behaviour of most marine species (Brown, Laland & Krause 2006) or the consequences of marine population collapse (Worm et al. 2006), thus making the task of restoring oceanic biodiversity difficult. One of the effects of marine species collapse is that fish ‘culture’ is disintegrating. When big old mature fish get removed from schools due to fishing, younger fish fail to learn how to migrate, feed, breed and nest with the same success. This destructive pattern has been observed in the North Sea cod fishery (Brown 2007) as well as in orange roughy which don’t reach sexual maturity until age 25 years (human life years) and live to around 150 years old (Singer & Mason 2006). Hence, Brown (2007) suggests that a more sustainable approach would be for middle aged fish to be targeted by fisheries, leaving the old, big fish and small, very young fish (Brown 2007).
4.4.6 Sustainable management of our marine ecosystem services

There are a number of key steps that each Australian can take to assist in the protection of our coastlines and ocean. These were identified at the 2006 Coast to Coast Conference – Australia’s National Coastal Conference (Victorian Coastal Council 2006) – and included the following:

1. Become coast and ocean literate. Given that an estimated 80% of Australians live within 50km of the coastline (Barrie 2003), the majority of us are well placed to become aware of ecosystem services and to be actively involved in changing our buying habits of marine species.

2. Change seafood buying habits. One of the greatest ways we can shape commercial reality is to use our consumer buying power at the market place, in supermarkets and in restaurants. The Australian Marine Conservation Society has released an easy-to-use, independent guide called *Australia's sustainable seafood guide: Guide to choosing your seafood wisely* (Bohm, Davey & Neilson 2007) available from www.marineconservation.org.au, which provides up to date information on the sustainability of over 60 seafood species and guides better choices. In addition to choosing sustainable species, minimising seafood waste is important. For example, buying whole fish rather than fillets (this has the additional advantage that freshness is preserved for longer in whole fish). Broadening our palate to enjoy a wider range of edible ocean foods spreads the ecological impact of fishing across a more diverse range of sustainable species, with flow-on health effects to be gained from dietary diversity.

3. Reduce water pollution run-off. The result of increasing urbanisation and industrialisation along Australia’s coastal fringe has increased contamination of both estuarine and marine ecosystems (Fabris, Turoczy & Stagnitti 2006). Consequentially, heavy metal and other contaminants are increasingly bio-accumulating in edible aquatic species, thus posing a human health risk as discussed later in this chapter. Use of natural fertilisers, phosphate-free detergents, non-toxic cleaning products and the responsible disposal of unwanted chemicals, solvents and oils can minimize contamination from urban stormwater run-off into our oceans.
The Australian Government’s *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) provides a legal framework for protecting and managing ecologies of environmental significance (Australian Government Department of the Environment 2008). Commonwealth marine areas fall within this environmental protection act, and this serves to provide some legal control over unsustainable fishing practices in Australian waters. Any development proposal that has the potential to have an impact of environmental significance (e.g. a commercial fishing operation in Australian waters) must be assessed for environmental impacts and requires approval under the EPBC Act. Commonwealth marine area stretches from three to 200 nautical miles from the coastline.

The Australian fishing industry is tightly regulated. The South East Trawl Fishing Industry Association (SEFTIA) is one of Australia’s oldest fisheries operating off the coast of NSW and eastern Victoria and one of the major suppliers of fish into the Melbourne wholesale fish market (Rieniets 2008). The main catches of SEFTIA include mid-water species (a few metres deep) such as flathead and whiting, as well as very deep trawl catches extending down to 1300 metres including orange roughy and oreo dories. Around 400 species are caught, but approximately 20 species make up over 90% of the annual catch, which is around 26,000 tonnes (SETFIA 2008).

Minimising levels of by-catch in commercial trawling operations is paramount. Fishing techniques are not 100% selective, so in attempting to catch the desired target species, other species or other sized individuals get caught. By-catch includes all non-target species that are caught but discarded because they have no recognised value or because regulations prevent them being kept (e.g. because of species/size regulations) as well as including the parts of the catch that are not landed but are killed as a result of interaction with fishing gear [e.g. seals, pipefish and seahorses are the main protected species that occasionally get caught in SETFIA trawls (SETFIA 2008)]; (Department of Fisheries Government of Western Australia 2001).

SEFTIA’s efforts to reduce by-catch levels include avoidance of important fish refuge areas, avoiding the capture of unwanted fish species by using different net mesh sizes, and other gear modifications (SETFIA 2008). However by-catch is still an area of great concern which, at least in Australia, is being closely monitored and legislated.
About a quarter of all fish taken worldwide each year are by-catch (Singer & Mason 2006). Sometimes by-catch goes into fish meal for fish farming operations, and other times it is thrown back into the ocean dead or dying. Prawn fishing is one of the worst culprits and is responsible for the 30% of the world’s by-catch, although prawns only amount to 2% of the global wild seafood catch (Singer & Mason 2006). A great majority of prawns sold in Australia (unless otherwise labelled) are imported from China, India, Indonesia, Thailand and Vietnam (Australian Bureau of Agricultural and Resource Economics 2005) where regulatory control of prawn farming or trawling is not as tight as Australia. Trawling, the method used for prawn fishing, also risks damaging the ocean floor thus disturbing the habitat of other marine species. Over-looking the environmental costs and by-catch statistics in the ratio of 15:1 (prawns to by-catch) (Singer & Mason 2006), Australia’s northern prawn fishing was seen as the most economically valuable Commonwealth managed fishery in 2004-05 (Australian Bureau of Agricultural and Resource Economics 2006).

### 4.4.7 Fish farming – a problematic solution

*The intensive farming of silver perch is promoted in Australia on the grounds that ‘the species has an ability to tolerate high densities, an overall general hardiness, a willingness to accept artificial feeds, (and) a non-cannibalistic nature’*  
*(NSW Department of Primary Industries 2008 p.14).*

Fish farming is seen by many as a solution to declining wild stocks. Yet it is a difficult solution, particularly from an optimal human health perspective, with issues not dissimilar to intensively farmed land animals. Seafood farming is now a huge agricultural business. It is the fastest growing form of food production in the world (Singer & Mason 2006). By weight, farmed fish production now exceeds that of worldwide beef production. In 1970 farmed fish only contributed three per cent of the world’s seafood (Singer & Mason 2006).

Marine aquaculture involves the farming of salt water fish and seafood in either land-based saline water tanks/ponds or in ocean-based cages. Many common species are now farmed in this way including snapper, mulloway, barramundi, Atlantic salmon and silver perch, along with oysters, prawns, mussels and abalone (Australian Marine
Conservation Society 2008). Similar to intensive land-based farming operations, stocking density is high. For instance, barramundi is typically stocked at 50kg per 1000 litres in aquaculture operations (Aquaculture South Australia 2003). This is the equivalent of around 100 fish living in one cubic metre of water [saleable size is between 330g and 600g (Aquaculture South Australia 2003)]. An indicator for differentiating between farmed versus wild fish is often size uniformity. When buying fish, ask if the fish/seafood is farmed or wild, and its country of origin.

An additional system in use involves the capture of wild species, which are then placed into sea-cage ‘feedlots’ to be fattened for a short time before slaughter. Southern blue-fin tuna are often ‘finished’ in this way, having being caught in the wild and then fattened on baitfish and grain-based pellets while being held in confinement so as to enable fattening to occur. This means a greater weight is sold at market (Australian Aquaculture Portal 2008).

The economic return from Australian wild-caught fisheries compared to farmed fisheries is comparable. In South Australia in 2004–05, wild caught fish brought in $188 million and farmed fish $187 million. Similarly, in Tasmania, wild fish brought $164 million and farmed fish $135 million (Australian Bureau of Agricultural and Resource Economics 2006). Hence as wild fish stocks continue to be under stress, in the context of an expanding population, the pressure and perceived advantages of aquaculture are growing.

There are, however, many significant environmental difficulties associated with marine aquaculture including the following:

- Pollution of waters surrounding the sea-cages from faecal and urinary waste, uneaten fish food, antibiotics and drug residues (used to control disease in the high density, close living conditions, with consequential increased risk of residues in the human food chain); (Australian Marine Conservation Society 2008).
- Inherent inefficiency in human labour, time and fossil fuels of catching small wild fish to feed farmed carnivorous species (e.g. salmon) and providing what they would otherwise be doing themselves (i.e. catching their own food). Between two and 12 kg of fishmeal are needed to produce 1 kg of farmed carnivorous fish or prawns (Australian Marine Conservation Society 2008).
• means that millions of tons of small wild fish are being taken from the ocean to supply the aquaculture industry (Singer & Mason 2006).

• Disease transference from caged species to wild populations (Australian Marine Conservation Society 2008).

• Escape of captive species, which further risks spreading diseases common in intensive farming operations to wild populations. Escapees also introduce foreign species into wild stocks (e.g. introduced Atlantic salmon from Australian farming operations have escaped into Australian open waters) (Australian Marine Conservation Society 2008).

• Wild brood stock are used in all marine aquaculture operations, so this doesn’t actually address dwindling wild stock numbers (Australian Marine Conservation Society 2008).

• Other marine species have been known to become entangled and trapped in sea-cage nets, thus creating wider ecological impacts (Australian Marine Conservation Society 2008).

Molluscs, including scallops, oysters and mussels, can also be farmed. This can occur sustainably on ropes suspended in the sea; the removal of which doesn’t disturb the ocean floor or create any significant ecological issues (Singer & Mason 2006). In contrast, trawling operations catching wild molluscs do risk damaging marine physical habitats and stirring up environmental contaminants from the ocean floor.

Freshwater aquaculture offers a more plausible solution, particularly because most species are vegetarian or omnivorous and hence do not rely to the same degree on wild-caught, smaller fish as food. However, be it freshwater or marine farming, fish farming does not necessarily serve human health well, particularly by comparison to free living species, as discussed in the next section.
4.4.8 Fatty acid and lipid composition of wild versus farmed fish

As with grain-fed, intensively farmed land animals, the fatty acid composition of aquatic species is a direct reflection of their food and exercise levels. As noted, grain-based pellet feeds, which are used in farmed fish, are omega 6 predominant, whereas natural aquatic species feed on plankton, small fish and non-grain based vegetation (seaweeds) which are rich in omega 3 fats (Chanmugam et al. 1992). This altered dietary matrix in farmed species, combined with sedentary living conditions, results in higher total fat accumulation (like any sedentary animal), and substantially higher omega 6 fat and lower omega 3 fat in farmed relative to wild fish (Blanchet et al. 2005; Hamilton et al. 2005; Karapanagiotidis et al. 2006; Kaya & Emin Erdem 2008; Weaver et al. 2008). For example, Hamilton et al. (2005) found that farmed Atlantic salmon contained 16.6% total lipid, with an omega 3 to omega 6 ratio of 3–4:1 compared to wild pacific salmon species, which had a total lipid content of 6.4% and a omega 3 to omega 6 ratio of around 10:1.

As to be discussed in Section 5.3.2, inadequate dietary supply of n-3 LCPUFA is a common contemporary human health concern. In response to these concerns, many fish farmers are now starting to change the mix of the oil content and composition in aquafeeds to bolster omega 3 content (Cahu, Salen & de Lorgeril 2004). A recent study by Nichols et al. (2003) found that under current feeding practices, farmed Australian finfish (e.g. Atlantic salmon, barramundi) now have higher omega 3 content than their wild counterparts.

Intentionally altering the fatty acid content of farmed fish in this way arguably places farmed fish into a ‘functional food’ category (fortified foods claiming health-promoting properties). The philosophy behind this thesis is to examine the human health-promoting properties of plant and animal foods which are themselves living in their optimal environment. The thesis is not offering a functional food or supplementation solution – those options are considered to be of secondary importance. As omega 3 fat is just one of the beneficial nutrients found in fish, broader health issues also need to be considered. The fatty acid content of different aquatic species naturally varies widely. Irrespective of the fatty acid differences in farmed versus wild fish, the magnitude of difference in
terms of quantity would have been ‘a drop in the ocean’ in traditional hunter-gatherer diets.

4.4.9  Fish and heavy metal contamination

Mimicking our ancestral diet in today’s more polluted aquatic ecosystems needs careful consideration. Since the Industrial Revolution, billions of tonnes of heavy metals have been liberated from the earth and dispersed into the wider environment. Heavy metal contaminants are discharged through sewerage outfalls, urban stormwater and agricultural and industry run-off, and have the potential to bio-accumulate in aquatic organisms and enter the food chain (Fabris, Turoczy & Stagnitti 2006). In the Australian diet, more than any other food group, consumption of fish and seafood increases one’s risk of heavy metal exposure. Heavy metals do not degrade and hence, once released, they persist, recycling through the environment and living organisms (Cohen 2007; Priest 2006). Metals in their insoluble form are usually inert in their effect on biological organisms; however, in their soluble molecular state (e.g. methylmercury), they are able to penetrate phospholipid cell membranes and have the potential to alter cell function. One heavy metal in particular is of concern to Australians consuming a high fish/seafood diet – methylmercury (MeHg).

Much research has been conducted to test, monitor and advise the public on ‘safe’ levels of seafood consumption to minimise excessive dietary exposure to heavy metals. FSANZ’s assessment of heavy-metal contaminants (including antimony, arsenic, cadmium, mercury, lead and tin) in the 20th ATDS found that Australians’ risk of dietary exposure to all metals was ‘within acceptable health standards’ (p.17) and ‘below the tolerable limit’ (p. 12) (FSANZ 2003a). However, this is in the context of the average Australian diet – a diet very low in seafood. Therefore, in constructing a ‘contemporary hunter-gatherer diet’ in which wild caught fish and seafood are emphasised as primary sources of animal food, the risk of excess heavy metal exposure must be addressed.

The physiological effects of toxic metal accumulation in the human body are well documented in the literature and will not be outlined here; least to say the effects are systemic and involve all body organs. Exposure during critical stages of development poses an increased risk. MeHg in particular is a well-documented foetal neurotoxin at
high enough doses (Davidson et al. 2008). In response, FSANZ advises pregnant women, women planning pregnancy and young children to limit their intake of large, long living fish which accumulate higher levels of toxins (e.g. shark, marlin, swordfish, orange roughy, catfish) to no more than one serve per fortnight, with no other fish consumed during that fortnight (FSANZ 2004b).

The age, size and fat content of organisms all affect the concentration of heavy metals (Fabris, Turoczy & Stagnitti 2006). Large long-living fish bio-accumulate more toxins than smaller shorter-living fish. Fattier fish such as deep sea species also bio-accumulate more toxins due to the lipophilic nature of certain heavy metals including MeHg as well as organochlorine compounds (Foran et al. 2005). Therefore, as a general rule, large deep sea species contain more contaminants than shallower dwelling smaller fish – as long as they are not living in specifically contaminated waters. Humans are a long living predatory species and therefore our potential to bio-accumulate heavy metals is very high and thus requires careful management in today’s world.

A re-analysis of the 20th ATDS data (FSANZ 2003a) from the perspective of a ‘contemporary hunter-gatherer diet’ (rather than the average Australian diet) demonstrates that the risk of dietary exposure to mercury above the tolerable upper limits as specified by the FSANZ code is very likely. Exceeding the tolerable limit for other metals (arsenic, selenium, copper, cadmium, lead) is, however, very unlikely in the context of a ‘contemporary hunter-gatherer diet’. See Appendix H for full analysis. As seen in Table 25, consuming 420g of fish portions (species were not specified by FSANZ 2003a) or 313g tuna per day as the sole source of animal protein is not an unreasonable interpretation of a ‘contemporary hunter-gatherer diet’ as the sole source of animal protein per day (see Chapters 7 and 8 for more details on interpreting ‘contemporary hunter-gatherer diets’). This quantity however exceeds the tolerable upper limit for mercury exposure from all sources – not just food. The arsenic content of many fish portions is also high (FSANZ 2003a), however arsenic in marine fish occurs predominantly in less toxic organic forms (Fabris, Turoczy & Stagnitti 2006) and therefore is considered not to pose as great a health concern.
**Food (FSANZ 2003a)**  

<table>
<thead>
<tr>
<th>MeHg per person per day^</th>
<th>Amount of food required to reach tolerable limit (TL)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fish portions (species not specified)</td>
<td>420g</td>
</tr>
<tr>
<td>Tuna</td>
<td>313g</td>
</tr>
</tbody>
</table>

*TL = 0.2mg/person/day (Queensland Government Public Health Services 2002).

^ Calculation assumes that MeHg is the only form of organic mercury in the Australian diet, which of course it isn’t. However, MeHg is the most common form of organic mercury and hence, it is used as an approximate guide, and therefore these calculations potentially over estimate the dietary contribution of MeHg.

**Table 25. Quantity of fish required to reach tolerable daily limit for MeHg intake**

Drawing more information into this picture, a study by Fabris et al. (2006) examined arsenic, cadmium and mercury concentrations in wild-caught fish species from coastal waters of Victoria, Australia. The fish species examined were snapper, flathead, lobster and abalone. These species are smaller, shallow water species compared with tuna and thus expected to bio-accumulate less contaminants. Surprisingly, Fabris et al. (2006) found that metal concentrations in fish in urbanised Port Phillip Bay, Victoria were not consistently higher than those in other less-populated fishing zones off the Victorian coastline. However, the study was carried out prior to the recent bay dredging operations.

**Table 26. Concentration of heavy metals in Victorian marine species and quantity of fish/shellfish required to reach tolerable daily limit for Mg**

Despite Fabris et al. (2006) finding that metal concentrations in all species complied with the FSANZ Code regulations (typically by a factor of 10) in the context of a ‘contemporary hunter-gatherer diet’ with a high fish content, reaching and possibly exceeding tolerable limits for mercury is not unlikely (see Table 26). Consuming 250g of snapper or 300g of flathead per day as part of this model is quite reasonable which reaches the tolerable limit for mercury intake. Hence, the risk of higher mercury intake has to be weighed up against the benefits of eating aquatic foods and their dense matrix of nutrients which are not easily replaceable with other food groups.
Despite the large body of research work carried out in this area, the balance between the health benefits of fish intake and risks due to MeHg exposure are not well characterised (Domingo et al. 2007). The type of fish, amount and frequency of consumption are essential to understanding this issue.

4.4.10 Risk-benefit analysis of MeHg exposure and fish consumption

Given that all forms of fish today contain at least trace quantities of MeHg, some level of exposure is to be expected (Ralston et al. 2008). Particular concern is focused on maternal exposure (life long accumulation prior to pregnancy and during pregnancy) because MeHg is a well-documented foetal neurotoxin at high enough doses (Ralston et al. 2008). On the other hand, fish also contains nutrients that optimally support brain and central nervous system development, including docosahexaenoic acid (DHA) and arachidonic acid (AA) (Dunstan et al. 2008; Marszalek & Lodish 2005), along with iodine, iron, choline and selenium (Cunnane 2005). Selenium also has a highly active role in counteracting mercury toxicity (Ralston et al. 2008). Several risk-benefit analyses suggest that the benefits of fish’s distinctive nutritional package may outweigh/counter-balance the adverse effects of MeHg (Davidson et al. 1998). In the most comprehensive study to date, Davidson et al. (2008) analysed the high fish diets\(^\text{19}\) of 300 mothers in the Republic of Seychelles, an Indian Ocean archipelago. Their findings found that for some endpoints, enhanced child development was correlated with increasing maternal MeHg levels – an anomaly, hypothesised to be due to the beneficial effects of nutrients in fish (Davidson et al. 2008). If fish is removed from the diet, MeHg exposure is dramatically reduced. However, fish’s beneficial nutrients are also lost and, importantly, other foods need to fill the deficit, and the nutrient package supplied by those foods needs to weigh into the total health equation.

We no longer live in a pristine world and obtaining the benefits of aquatic foods while minimizing exposure to toxic contaminants requires delicate balance (Costa 2007). A

\(^{19}\)Average fish intake was 537g per week (a mix of reef and deep sea species) – this is less than proposed in ‘contemporary hunter-gatherer diets’.
number of factors can be employed to reduce the body’s burden of toxic metals including the following recommendations.

### 4.4.11 Recommendations for minimising MeHg exposure risk

1. Consume Australian aquatic species (tight regulatory control and monitoring of contaminants).
2. Preferentially select small shallow water fish species (e.g. flathead, whiting, trevelly, gurnard) over large deep-sea species (e.g. tuna, swordfish), which accumulate more MeHg and other toxins (including polychlorinated biphenyls and pesticides); (Davidson et al. 2008; Foran et al. 2005). All species recommended in Australia’s sustainable seafood guide (Bohm, Davey & Neilson 2007) fall into the former category and thus it is a useful guide on two fronts – minimising heavy metal exposure and supporting sustainable fishing.
3. Ensure optimal intake of all dietary minerals (likely in ‘contemporary hunter-gatherer diets’) to aid the detoxification and excretion of heavy metals from the body. Heavy metal exposure requires additional nutrient reserves to supply the necessary enzymatic co-factors involved in detoxification pathways. Specific nutrients known to be involved in detoxification include selenium (Ralston et al. 2008), molybdenum, zinc, copper, iron, manganese, calcium and magnesium; as well as numerous antioxidants (including vitamins A, C, E, Co-enzyme Q10, lipoic acid, numerous phytochemicals); (Tabrizian 2009) whose role is to buffer the associated cellular stress hypothesised to be the pathological mechanism underpinning heavy metal related neurological impairment (Ercal, Gurer-Orhan & Aykin-Burns 2001; McGinnis et al. 2008a, b). All these nutrients are supplied most densely in aquatic ecosystems. Animals, including fish attempt to self-regulate and detoxify contaminants (just like humans) and use a variety of exogenous (diet) and endogenous (enzymes) mechanisms to do this. The healthier an animal, the better equipped it is to metabolise and buffer contaminants. This adds further circumstantial evidence to the importance of consuming animals and plants living in their healthiest state. Given today’s more polluted environment, it is worth considering whether the nutrient requirements of inherently more contaminated ‘contemporary hunter-gatherer
diets’ are higher than would be expected in traditional hunter-gatherer diets and therefore whether or not additional supplementation needs consideration. This would be valuable future research.

4. For concerned individuals who don’t want to eat fish (or those who decide to reduce their consumption) and/or those at an increased risk of elevated heavy metal exposure (e.g. occupational or environmental contact, exposure from dental amalgams, those unable to access non-deep sea fish species, young infants, women in a pre-conception or pregnancy phase, and nursing mothers), fish oil supplementation circumnavigates the otherwise likely n-3 LCPUFA deficit with minimal risk of contaminants. All ‘practitioner only’ brands of fish oil supplements sold in Australia are screened for heavy metals and other environmental contaminants (such as pesticides, dioxins and PBCs) (for example see Blackmores Australia 2009; Nutrimedicine 2009; Nutrition Care 2006). Fish oil supplementation could occur within a ‘contemporary hunter-gatherer dietary’ paradigm, in which lean protein could be sourced from terrestrial meats and combined with a range of plant foods to supply a broad spectrum, nutrient dense diet. Fish oil on the Australian market is typically sourced from the liver and tissues of sardines and anchovies (Nutrimedicine 2009) as well as blue grenadier (hoki); (SeaDragon 2004). For the purpose of making fish oil, these fish are usually farmed in ocean cages [or less commonly obtained from by-catch (SeaDragon 2004)] – the environmental ethics of which have been discussed.

5. The clearest recommendation is to minimise environmental contamination in the first place and recognise the potential for synergistic toxicological effects in an increasingly polluted world. Currently, toxicological assessment for both metal contaminants and pesticide residues are assessed individually and in isolation.
Chapter 5: What Constitutes Optimal Nutrition? An Evolutionary Perspective

‘What other animal needs professional help in deciding what it should eat?’

(Pollan 2008 p.2)

5.1 Introduction and Chapter Scope

Hunter-gatherer dietary parameters are used in this thesis as a benchmark for optimal contemporary nutrition. As previously mentioned, there was no single hunter-gatherer ‘diet’. Wild food availability and hence dietary composition varied depending on ecological niche. Therefore, no prescriptive one-type-fits-all optimal diet ‘recipe’ can be outlined. Rather, general characteristics common to all hunter-gatherer diets can be used as markers for an optimal diet from an evolutionary perspective.

Cordain (2006b) defined the universal characteristics of recent worldwide hunter-gatherer diets in terms of seven qualities:
(1) macronutrient composition (protein, fat, carbohydrate)
(2) micronutrient intake (vitamins, minerals)
(3) essential fatty acid composition (omega 6 and 3 fatty acids)
(4) glycaemic index/load
(5) sodium-potassium ratio
(6) fibre content
(7) acid-base balance

These characteristics, common to all hunter-gatherer diets, can be only loosely applied with regards to making dietary recommendations in a modern day context because each
element in itself does not tell the full story, nor necessarily ensure a healthy diet. Rather, they simply provide a framework for breaking down the analysis of what constitutes an ‘optimal diet’. Simply matching the dietary characteristics of an average hunter-gatherer diet may not be possible with contemporary foods and hence adjustments need to be made for the information to have present-day relevance (see Chapter 7).

For example, mimicking the essential fatty acid composition of a typical hunter-gatherer diet with flaxseed oil, fish oil supplements and canola oil as Cordain (2002b) suggests can, on one hand be used to match the total omega 3 content of an average hunter-gatherer diet. On the other hand, such foods provide a very different nutritional matrix to that in which omega 3 fatty acids are supplied by wild organ meats, bone marrow and sea animals, as per the hunter-gatherer model. Thus interpretive errors can be made if these seven characteristics are analysed in isolation and not adequately contextualised into the contemporary food supply.

With regards to each of these seven characteristics, key differences can be noted between typical hunter-gatherer diets and the average Australian diet today. Changes in the macronutrient composition, micronutrient density and fatty acid composition etc have occurred as wild plant and animal foods have been gradually displaced from the human diet since the agricultural and industrial revolutions and with the introduction of novel foods as discussed in Chapter 2 – high cereal grain intake, dairy, refined products (cereals, sugars, vegetable oils), fatty meats, excessive salt, and combinations of these foods processed in various ways (e.g. biscuits, chips, soft drinks and ice-cream).

The ways in which each of these seven dietary characteristic affect human health are outlined in this chapter. The seven characteristics are not given equal weighting in terms of importance. Ensuring maximal micronutrient density in the context of an omnivorous diet which contains adequate essential fatty acids tends to inherently address all seven characteristics. Consequently, more emphasis is placed on the first three characteristics (macronutrient composition, micronutrient density and essential fatty acid intake) with the latter four characteristics being addressed more briefly.

The chapter then moves away from the examination of dietary ‘elements’ towards a more holistic framework for understanding optimal nutrition. Titled, ‘The whole foods argument’, Section 5.3 speaks from the epistemological premise of this thesis. It proposes that the seven dietary characteristics can be condensed into one simplifying
principle for guiding and assessing optimal nutritional choices: *choose a diverse,
omnivorous, fresh, whole foods diet in which the plant and animals are themselves in an
optimal state of health*. As to be discussed, this principle inherently ensures adequate
dietary macronutrient composition, micronutrient density, an appropriate distribution of
fatty acids and lipids, elicits a low glycaemic response, is high in fibre, is base yielding,
and carries a lower potential for a dietary intake of environmental contaminants. It
therefore offers a more simple message.

The final aspect of this chapter analyses the use of nutritional supplements in an
evolutionary context. Evidence for the potential impact of supplement use on health and
disease is outlined, as is their potential role in ‘contemporary hunter-gatherer diets’.
Two nutrients can potentially fall short in ‘non-vigilantly’ maintained ‘contemporary
hunter-gatherer diets’ – long chain omega 3 fatty acids and calcium. The case for
supplementing these two nutrients is discussed in the context of the hunter-gatherer
model.
5.2 ‘Markers’ of Optimal Diets

5.2.1 Macronutrient intake

5.2.1.1 The health impact of diets with varying macronutrient profiles

A plethora of research, both epidemiological and experimental, has been carried out examining the effects of diets with differing macronutrient profiles (proportion of protein, fats and carbohydrates) on various health outcomes, particularly in terms of weight loss, cardiovascular disease markers (including blood lipid chemistry) and type 2 diabetes (including insulin sensitivity and glucose control); (for example see Boden et al. 2005; Luscombe-Marsh et al. 2005; Nordmann et al. 2006).

Confusion over appropriate macronutrient intakes is apparent in the literature. For example, low carbohydrate diets such as the ‘Atkins’ diet have been shown to demonstrate favourable effects on weight loss, blood pressure, blood lipids and glucose tolerance in the short term (Dansinger et al. 2005; Gardner et al. 2007), but often there is long term regression of these improvements (Astrup, Meinert Larsen & Harper 2004). Furthermore, a Cochrane systematic review by Pirozzo et al. (2002) found no significant difference between low carbohydrate and low fat diets over 18 months. Similarly, a meta-analysis by Nordmann et al. (2006) found no significant difference at one year despite a low carbohydrate diet being superior for weight loss after six months. Of particular importance in the Nordmann et al. (2006) review was that the improvements in HDL cholesterol and triglycerides in the low carbohydrate group were also accompanied by an unfavourable increase in LDL cholesterol, thus indicating a mixed effect on blood lipids by the low carbohydrate diet and the need for greater attention to be paid to total dietary quality (e.g. fatty acid composition), not just macronutrient composition alone.

With regards to cardiovascular disease risk, there has been concern as to the long-term safety of low carbohydrate and high protein/fat diets. However, Halton et al. (2006) found in a cohort of 82,802 women studied over 20 years as part of the Nurses’ Health Study that diets lower in carbohydrate and higher in protein and fat were not associated
with increased risk of coronary heart disease. Furthermore, a prominent review study by Willett (1998) concluded that diets high in fat do not appear to be the primary cause of excess body fat, and isolated reductions in fat intake is not a solution.

Popular diets including the ‘Ornish’, ‘Zone’ and ‘Weight Watchers’ diets have proven comparable in their efficacy in achieving weight loss and improving cardiovascular disease risk factors in the short term (Dansinger et al. 2005), despite vastly differing macronutrient profiles. Importantly, however, this conclusion was a relative one using the less-than-ideal standard Western diet as a baseline measure. Any deviation away from an average Western diet, particularly one which induces weight loss, is likely to appear health-supportive in the short term, however, it tells us little about longer term health effects, and about optimally health supportive dietary patterns.

Athletes, particularly endurance athletes, are another population group which has attracted research attention. The effects of various dietary macronutrient ratios on performance have been studied, especially carbohydrate intake. Endurance athletes have been educated on the importance of dietary carbohydrate in maximizing muscle glycogen stores (Minehan & AIS Department of Sports Nutrition 2004). Less recognised, and consequently under-utilised are the performance enhancing effects of the other macronutrients. Enhanced endurance capacity and increased VO_{2}\text{max} has been noted following higher fat diets (38%–70% of daily energy derived from fat) relative to lower fat diets (12%–15% energy from fat); (Lambert et al. 1994; Muoio et al. 1994). The presence of adequate (not necessarily high) carbohydrate intake, particularly if consumed in the immediate post-exercise window, has been demonstrated to sufficiently maintain muscle glycogen stores (Lambert & Goedecke 2003). Protein intake (again, especially if prioritised in the post-exercise period) is known to aid protein synthesis, which is fundamental for training recovery as well as being involved in the restoration of muscle glycogen stores (Lambert & Goedecke 2003). And, not surprisingly, when viewed in an evolutionary context, adequate supply of dietary fat has also been demonstrated to be performance enhancing. As shown in a randomised cross-over trial, Vogt et al. (2003) found that a higher fat diet (53% of energy per day for five weeks) enabled muscle glycogen stores to be maintained and intramuscular triglycerides stores to more than double – thus increasing total usable muscle energy stores. Endurance performance capacity was maintained, including at high intensity.
Hence, a macronutrient balanced meal in the post exercise window is likely to offer the greatest recovery and performance potential for endurance athletes. A high micronutrient dense diet further potentiates performance and recovery owing to the supply of vitamins and minerals that are necessary co-factors for energy production and repair, as well as for their role as antioxidants. Therefore, contrary to many common sports nutrition practices, a balanced ‘contemporary hunter-gatherer diet’ may offer a superior performance advantage.

5.2.1.2 Macronutrient intake from an evolutionary perspective

Amongst this confusing glut of information on the effects of diets with varying macronutrient profiles, a sensible interpretation may be that the macronutrient composition of the diet is not in isolation the key important factor in weight loss, chronic disease risk or optimal health. This notion is supported by the historical presence of a wide variety of hunter-gatherer macronutrient subsistence patterns from the near 100% animal derived diets of the Arctic Inuit populations to the heavy reliance on carbohydrate-rich wild sweet potatoes in the highlands of Papua New Guinea (Tanaka et al. 1980) and south-eastern Australia (Gott 1982, 1993). As Cunnane (2005) states, ‘once minimum nutrient requirements are met, a very wide range of dietary fat intake (or carbohydrate intake for that matter) is entirely compatible with human existence. We should therefore be cautious of developing an excessively specific or narrow range of carbohydrate, protein or fat composition of a single idealised Paleolithic diet that minimize chronic disease risk in present day humans’ (p.208).

Interpreting information about the hunter-gatherer food supply in the context of our contemporary food supply raises pertinent questions about macronutrient factors. As mentioned, the specific macronutrient composition of the diet is possibly unimportant. Should typical hunter-gatherer plant to animal subsistence ratios (such as those estimated by Cordain et al. 2000) attempt to be matched within our contemporary food supply, a high protein intake will result (for more information see Chapter 7). Hence, the potential impact of higher dietary protein will be critiqued in this section. Another anomaly raised in the scientific literature is that of plant versus animal derived saturated fat intake and therefore this point is also specifically discussed through an evolutionary lens in this section. The impact of other fats, namely polyunsaturated fatty acids, is
discussed in Section 5.2.3 and hence will not be covered here. In terms of carbohydrate intake, many contemporary diets quantitatively contain more than average hunter-gatherer diets and importantly it is also qualitatively different. These carbohydrate differences are discussed in Section 5.2.4 and will not be covered further here.

5.2.1.3 Protein: Meat intake and health in an evolutionary context

Animal meat of all types (both ‘red’ and ‘white’) was the primary source of protein in hunter-gatherer diets. It is also the primary source of protein in the average Australian diet today. Concern about meat intake due to epidemiological associations with cardiovascular disease and certain cancers has lead to cautious recommendations for moderating meat intake in recommended dietary guidelines (particularly red meat with its associated saturated fat content in domesticated animals); (Hunt et al. 1995). At the same time, some health professionals, media and popular diet books advise consumption of diets high in protein (Bilsborough & Mann 2006). According to the analysis of Cordain et al. (2000), animal derived foods (supplying both protein and fat) comprised the majority of energy intake in average hunter-gatherer diets. Yet, traditional hunter-gatherers did not display the signs and symptoms of cardiovascular disease (Cordain et al. 2002; O'Dea 1994; O'Keefe & Cordain 2004). The typical hunter-gatherer diet, while probably maintaining high levels of dietary protein (19-35% energy; Cordain et al. 2000), also contained numerous chronic disease protective characteristics: It was low in animal-derived saturated fat; low in carbohydrate content (relative to many modern diets – the great majority of which was from complex carbohydrates which elicit a lower glycaemic index); it had a markedly different fatty acid composition compared to the standard Western diet (including high intakes of mono-unsaturated fatty acids and higher absolute intakes of long-chain omega 3 fat); it contained an abundance of vitamins, minerals and health supportive phytochemicals; it was typically high in fibre and low in sodium; it operated synergistically in an environment in which daily exercise and a degree of outdoor living was inherent (Cordain et al. 2005; Eaton, Konner & Shostak 1988; Mann 2000; O'Dea et al. 1990); and there was minimal exposure to environmental chemicals compared to present-day exposure levels.
Correlating with estimates by Cordain et al. (2000) of the protein intake in recent hunter-gatherer diets (19–35% of daily energy), Speth (1989), an anthropologist, observed that protein intake in some of the few remaining hunter-gatherer societies that existed into the 20th century were as follows:

- Protein intake in the Ache people living in the forests of eastern Paraquay was around 39% of daily energy.
- The Lapps in northeastern Finland had protein intakes ranging from 15% to 17% of daily energy.
- The Alaskan Inuit studied in the early 1970s had a mean protein intake of 29% daily energy (range 22–45%).
- The !Kung people of Africa consumed a higher proportion of plant foods and hence protein intake was lower – estimated to be around 16% of daily energy [this is similar to protein intake in the average Australian diet of around 17% (NHMRC 2003)].

Appendix I outlines animal to plant food subsistence ratios in several other hunter-gatherer diets from around the world (Cordain 2006c). Animal foods supply both protein and fat, and plant foods supply carbohydrate, protein and fat. Hence, without knowing whether animal lipids were preferentially eaten over lean muscle, it’s impossible to estimate the protein intake in traditional diets from analyzing plant-to-animal subsistence ratios alone. Nevertheless, a higher proportion of animal food tends to correlate with a higher protein intake (Cordain et al. 2000).

Protein is unlikely to have been a limited nutrient in ancestral human diets due to the consumption of animals in all hunter-gatherer diets (to varying degrees); (Cordain et al. 2000; Noli & Avery 1988). As such, protein has probably had little influence as a limiting selective factor in human evolution (Speth 1989). Rather, avoiding excess protein intake was likely fundamental to shaping subsistence behaviour (i.e. food selections).

Current suggestions for modern ‘Paleolithic’ (or hunter-gatherer) diets (see Cordain 2002a; Cordain 2002b) are typically very high in protein (further discussed in Chapters 6 and 7), commonly coming close to and in some cases exceeding what is considered to be the safe protein ceiling (less than approximately 35% of total energy from protein), and hence this is an issue needing careful examination.
Recommendations for adequate protein intake are based on the rate at which the gastrointestinal tract can absorb amino acids and the liver’s capacity to deaminate them and synthesise urea, which enables the excretion of the nitrogen component (a byproduct of protein metabolism); (Bilsborough & Mann 2006). Excessive protein intake potentially elevates serum nitrogen and uric acid and thus increases the potential renal acid load – which is buffered with calcium (Hunt et al. 1995), along with other alkalizing minerals. Hence, higher protein diets potentially risk body calcium loss with consequences for bone health (Hedrick Fink, Burgoon & Mikesky 2006). Other food sources that maintain a metabolic acid load similar to meat protein and thus potentially affect calcium balance are cereal grains and dairy (see Section 5.2.7). Hence, a diet heavily based on these three food groups, which is also deficient in counteracting base yielding fruit and vegetables, like the average Australian diet, will subtly result in metabolic acidosis and risk draining calcium stores in the long term.

Excessive protein intake – considered to be greater than 35% of total energy intake – is, however, dangerous and can result in hyperaminoacidemia (toxicity caused when excess amino acids enter the blood stream), hyperammonemia (due to excess nitrogen in systemic circulation), hyperinsulinemia, nausea, diarrhoea and even death (colloquially called ‘rabbit starvation syndrome’); (Bilsborough & Mann 2006).

5.2.1.4 Recommended guidelines for protein intake

Recommended dietary intake for protein depends on absolute intake, intake relative to body weight, and intake as a percentage of total energy (Bilsborough & Mann 2006). Hence, a person with larger metabolic demands, greater body mass and higher energy intake will require more protein. Table 27 outlines protein recommendations from the Australian National Health and Medical Research Council (NHMRC), Australian Institute of Sport (AIS), and the evolutionary nutrition literature.
<table>
<thead>
<tr>
<th>Recommendation</th>
<th>Protein requirements of various groups of people</th>
<th>Grams protein per kilogram body weight per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended intake for Australian adults (NHMRC 2006)</td>
<td>Males</td>
<td>0.8</td>
</tr>
<tr>
<td></td>
<td>Females</td>
<td>0.75</td>
</tr>
<tr>
<td>AIS recommendation (AIS Department of Sports Nutrition 2004)</td>
<td>Athlete undertaking general training program</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>Endurance athlete undertaking moderate to heavy training</td>
<td>1.2–1.6</td>
</tr>
<tr>
<td></td>
<td>Endurance athlete undertaking extreme training program or competition</td>
<td>2.0</td>
</tr>
<tr>
<td></td>
<td>Strength athlete undertaking heavy training program</td>
<td>1.2–1.7</td>
</tr>
<tr>
<td></td>
<td>Adolescent athletes</td>
<td>2.0</td>
</tr>
<tr>
<td>Eaton, Eaton &amp; Konner (1997)</td>
<td>Other primates (e.g. chimpanzees, gorillas) observed in the wild</td>
<td>1.6–5.9</td>
</tr>
<tr>
<td>Bilsborough and Mann (2006) suggestion for protein intake ‘based on bodily needs, weight control evidence and avoidance of protein toxicity’ (p.129)</td>
<td>Australian adults</td>
<td>2.0–2.5</td>
</tr>
</tbody>
</table>

Table 27.  Protein intake recommendations

Comparing the various recommendations highlights wide differences. For example, take a hypothetical, healthy, active, Australian adult who weighs 70kg. According to the NHMRC (2006) recommended dietary guidelines for Australian adults (0.8g/kg/d) this person would need to eat only 56g of protein per day. This is equivalent to 285g fish (whiting species; Xyris Software 2007). Assuming that this adult is undertaking a general base level training program, on the basis of the AIS recommendation (1.0g/kg/d) they should eat 70g of protein or 350g of fish per day. If this same person was trying to emulate a hunter-gatherer diet as estimated by Cordain et al. (2000) (average 3.0g/kg/d) the person would need to eat just over 1kg of whiting fish (1060g). In the context of a 12,000kJ diet, 1060g of fish (whiting) supplies 210g of protein, which represents 30% of energy from protein (17kJ protein/g). As can be seen in this example, recommendations for daily protein intake span from between 56g of fish per day to just over 1kg of fish.
Of course, in a normal ad lib diet, protein would not be sourced from fish alone, and thus protein intake would be distributed between other animal and plant foods. Nonetheless, the wide range in the various recommendations highlights the confusion surrounding the protein level that is optimally supportive of health.

As will be discussed in detail in Chapter 7, mimicking a hunter-gatherer diet with modern-day foods poses several challenges in the absence of a natural wild food menu. Chapters 7 and 8 outline an interpretation of how to eat like a hunter-gatherer in Australia’s present-day food environment. The example given in Chapter 7 contains 163g of protein (from a mix of plant and animal foods) which for a 70kg individual correlates to 2.3 g protein/kg/day. This is slightly lower than estimates of traditional hunter-gatherer diets, but falls within Bilsborough and Mann’s (2006) recommendation for Australians – a recommendation which is, however, mindful of the evolutionary nutrition data.

5.2.1.5 Safety of high protein diets: An evolutionary perspective

Mimicking hunter-gatherer diets will result in a protein intake higher than the recommended dietary guideline for Australian adults (NHMRC 2003). The safety of this recommendation must therefore be questioned.

Several short-term dietary studies have demonstrated that higher protein diets (up to 28% of energy) exert favourable effects on blood lipid chemistry (decreases in LDL and VLDL cholesterol and triglycerides, and increases in HDL cholesterol); (Luscombe-Marsh et al. 2005; O'Dea 1984; Parker et al. 2002; Wolfe & Piché 1999). Higher protein diets (again up to 28%) have also been demonstrated to improve insulin sensitivity and glycaemic control (Layman et al. 2003; Luscombe-Marsh et al. 2005; O'Dea 1984) in conjunction with improving feelings of satiety (Batterham et al. 2006; Layman et al. 2003; Long, Jeffcoat & Millward 2000; Westerterp-Plantenga et al. 1999) and increasing metabolic thermodynamics (due to the inherent inefficiency of gluconeogenesis); (Crovetti et al. 1998; Feinman & Fine 2007; Milton 1999a), which increases potential for weight loss.
Concern over higher protein diets has focused on the effects on calcium balance in the body. However, three recent studies examining higher protein intake (at levels correlating with those consumed in hunter-gatherer diets) demonstrated no negative effect on calcium balance in healthy subjects (Bolster 2001; Farnsworth et al. 2003; Luscombe-Marsh et al. 2005). Luscombe-Marsh et al. (2005) examined the effects of a diet containing 34% protein, 29% fat, 37% carbohydrate (as a percentage of total energy intake) which are macronutrient proportions that fall within estimates of worldwide hunter-gatherer diets (protein range 19–35%, carbohydrate 22–40%, fat 28–58%); (Cordain et al. 2000). Luscombe-Marsh et al. (2005) found favourable effects on insulin sensitivity and a reduction in cardiovascular risk factors compared to a lower protein/higher fat diet (15% protein, 45% fat) and, importantly, there was no effect on bone turn over or renal function. Likewise, Farnsworth et al. (2003) found that increasing energy from protein from 16% to 27% resulted in greater total lean body mass, improved glycaemic control and lower serum triacylglycerol concentrations, while markers of bone turn over and calcium excretion remained unchanged. Interestingly, these positive metabolic effects were independent of weight loss, fruit and vegetable intake (supply of alkalizing minerals) and other lifestyle parameters (e.g. exercise and vitamin D status, which is involved in calcium homeostasis). Similarly, Bolster (2001) compared the effects of a high protein diet (30% daily energy) against a medium protein diet (15% of daily energy) in a group of endurance athletes and again found that there was no difference in nitrogen balance which remained positive for both groups.

Hence, in these studies, protein intakes of around 30% of daily energy appear to elicit favourable metabolic effects while not compromising calcium stores or renal function. This suggests that protein intake in this order falls within normal physiological boundaries. These studies are also supportive of the contemporary relevance of the hunter-gatherer model, given that such protein intakes are in alignment with traditional hunter-gatherer diets.

As to be noted later in the thesis in Chapter 7, a ‘contemporary hunter-gatherer diet’ as interpreted in this thesis is a little lower in protein (although it can vary) than the above mentioned studies. The example provided in Chapter 7 Part 1 contains 23% of energy from protein which falls within hunter-gatherer parameters (according to Cordain et al. 2000), is higher than average Australian diet (around 17% on average; NHMRC 2003), however it is conservative relative to the above mentioned studies. Therefore, the
protein content of ‘contemporary hunter-gatherer diets’ as expressed in this thesis is considered to be very safe.

5.2.1.6 Meat, cooking methods and cancer

Another area of concern with regards to higher protein diets is a potential correlation between meat consumption and cancer. Epidemiological studies have found an association between high intake of animal meat, particularly red meat and cancer, especially colorectal cancer (Joshi et al. 2009; Larsson & Wolk 2006; Norat et al. 2005). With regards to red meat intake and cancer, a combination of the metabolism of the meat itself, the degree to which the meat is cooked, other confounding factors in the standard Western diet (and lifestyle), and genetic susceptibility appear to be at play (Biesalski 2002; Roberts-Thomson, Butler & Ryan 1999). A prominent hypothesis is that DNA damage resulting in cancer development may result from the formation of toxic N-nitroso compounds in the gastrointestinal tract from the heme iron in meat (Joshi et al. 2009). The risk would be further elevated in diets where processed meats are consumed which are preserved in nitrites and nitrates (e.g. commercial salami).

Furthermore, a possible relationship between different cooking methods for meat and fish and the risk of cancer development of different sites has been observed in epidemiological studies (Rohrmann et al. 2002). High temperature cooking methods including frying, grilling and barbecuing cause meat to brown, which leads to the formation of heterocyclic amines and polycyclic hydrocarbons – both of which are suspected carcinogens (Le Marchand et al. 2002).

Accounts of several hunter-gatherer societies indicate that meat was cooked differently to many present-day methods. Traditionally, whole animals were roasted on hot coals, baked on ashes or steamed in a ground ‘oven’ (Isaacs 1987). For example, the cooking methodology used by many Australian Aborigines for a freshly killed kangaroo was as follows:

First the animal was thrown onto the flames of a fast-burning fire to singe off the fur. After 10 minutes or so the intestines were removed, fur scraped off and the animal cooked further on a bed of hot coals. After 20 minutes or so, the animal was turned over
and cooked on the other side. The meat of large animals like kangaroos cooked in this way was eaten near raw on the inside. Smaller animals tended to be cooked through, as did larger animals if cooked in a camp oven for several hours (Isaacs 1987).

In contrast today, high heat (e.g. searing, barbequing) tends to be applied directly onto a cut of meat, thus increasing the risk for heterocyclic amine and other carcinogen formation. The cooking of meat itself, i.e. the denaturing of meat proteins, is unlikely to be an issue, particularly given that cooking partly breaks down the structural integrity of the tissue and reduces the energy costs of digestion (Boback et al. 2007). Rather, the problem may be the application of high temperature heat directly to meat tissues.

Additional confounders include the fact that modern domesticated animals are higher in saturated fat than the wild animals. High saturated fat intake has been correlated with many different diseases including cancer (Boback et al. 2007). Contemporary diets also typically carry a high glycaemic load, eliciting higher insulin levels, which in itself is both growth promoting (insulin-like growth factor 1) and cancer growth promoting (Lajous et al. 2008; Larsson, Mantzoros & Wolk 2007).

Historical evidence suggests that animal derived protein from both aquatic and land animals was central to human subsistence strategies throughout evolution without any obvious deleterious health effects. Animal foods were traditionally eaten in the context of many dietary and lifestyle factors that are cancer preventing. These cancer-protective factors include a high micronutrient, antioxidant and phytochemical intake (Hung et al. 2004); a fibrous diet (Wrick et al. 1983); physical exercise (correlates with an increased metabolism and transit rate for food’s passage through the gastrointestinal tract) (Hardman 2001); a diet that is not inflammatory-providing [e.g. a low glycaemic load diet, appropriate fatty acid profile and health supportive micro-flora matrix (Rescigno 2008)]; and a diet that does not contain excess calories (Saxena et al. 2008). All these factors combine to offer layers of protection including:

a) minimisation of the carcinogen intake
b) reduction in the contact time between food related carcinogens and gastrointestinal mucosa upon intake

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20 This study on bowel transit time at Cornell University showed a mean transit time of 62 hours for subjects on a 0% fibre diet and 41 hours for subjects consuming a diet containing 17% fibre.
c) activation of appropriate defence and repair mechanisms upon carcinogen contact, and minimization of inflammatory processes, which promote cancer proliferation.

Mirroring hunter-gatherer eating patterns may provide an optimal model for human nutrition; however, the model may need to be embraced in its entirety to avoid the potential problems that could arise as a consequence of adopting only one component. For example, increasing meat and consequently protein intake in the context of a micronutrient- and fibre-deficient diet whilst living a sedentary lifestyle may be problematic.

5.2.1.7 **Saturated fat: plant derived versus animal derived and its place in hunter-gatherer diets**

There is convincing evidence in the literature that excessive consumption of animal derived saturated fat is atherogenic (Hu et al. 1999). Due to the correlation between animal derived saturated fat and cardiovascular disease (and a variety of other conditions), the Australian dietary guidelines recommend that saturated fat intake be limited to no more than 8% of total energy (NHMRC 2003).

In the wild, *animal* derived food sources of saturated fat are limited (although not absent) due to the leanness of free living animals (Cordain et al. 2002). However, *plant* derived saturated fat is more accessible, particularly around equatorial countries where coconut palms grow in abundance along shorelines. Coconuts are a fatty nut containing around 33g fat per 100g of which over 90% is saturated fat (USDA 2009). Whether or not coconuts were part of early *Homo sapiens* diets is unknown because no fossilised coconuts have been found in East Africa (Kuipers et al. 2007). However, fossilised coconuts have been found in southern Queensland and dated to about two million years ago. Research suggests that coconuts already had a wide distribution range at that time, particularly given their capacity to germinate after floating in sea water for up to 110 days. Depending on favourable currents, travel between the African East coast and the American West coast was possible (Kuipers et al. 2007).
Prior et al. (1981) investigated the relative effects of saturated fat in determining serum cholesterol levels and cardiovascular disease risk in two island populations in Polynesia— the islands of Tokelau and Pukapuka. When the study was carried out in the early 1980s, the population of both islands basically consumed a traditional diet in which coconuts provided the chief source of energy (63% of daily energy for Tokelauans, 34% of daily energy for Pukapukans). As such, the diets of both island populations were high in saturated fat, but low in dietary cholesterol (due to low animal food intake) and sucrose (in line with other traditional hunter-gatherer diets). As expected, due to the direct relationship between saturated fat (both animal and plant derived) and serum cholesterol (Australian Institute of Health and Welfare 2006a; O'Dea et al. 1990), Tokelauans had serum cholesterol values 35-40mg higher than Pukapukans. However, as Prior et al. (1981) concluded, ‘vascular disease is uncommon in both populations and there is no evidence of the high saturated fat intake (from coconuts) having a harmful effect in these populations’ (p.1552).

Similarly, Kuipers et al. (2007) investigated the milk from mothers living in Chole, a small island in the Indian Ocean close to Tanzania. Inhabitants of Chole consume a high intake of local marine fish, coconuts, an abundance of vegetables and fruit, and have a low intake of carbohydrates from grains. Correlating with the fatty acid composition of the diet, their breast milk contained a high proportion of medium chain saturated fatty acids (MCFA) due to their consumption of coconuts; a high amount of arachidonic acid (long chain omega 6) and long chain omega 3 fatty acids due to fish intake; and a lower amount of linoleic acid (short chain omega 6) due to the low intake of grains and an absence of vegetable oils in their diet. This fatty acid profile, in addition to a micronutrient dense (high vegetable and fruit intake) omnivorous diet as eaten by Chole islanders is probably very similar to most shore-based dwelling hunter-gatherer societies, and mirrors the environment in which the evolution of *Homo sapiens* probably took place (Cunnane 2005). Such a dietary pattern appears to be health supportive to Chole islanders (Kuipers et al. 2007), as it was with other hunter-gatherer societies (Cordain et al. 2000; Eaton & Konner 1985; O'Dea 1991a; O'Keefe & Cordain 2004). Epidemiological data, along with migration studies and short-term intervention studies, support the causality of relationships between fatty acid profiles seen in Western diets and typical Western diseases including cardiovascular disease, certain cancers, type 2 diabetes etc (Kuipers et al. 2007). The health impacts of the polyunsaturated fats are further discussed in Section 5.2.3, so it is saturated fat that is focused upon here.
Different saturated fats are not homologous in their effects on blood lipids. MCFA, including lauric acid, which predominates in coconuts, has properties and metabolism that differs to that of saturated fats from animal origin which predominate in palmitic acid. MCFAs do not undergo degradation and re-esterification processes, are directly used in the body to produce energy (Amarasiri & Dissanayake 2006) and appear to be non-atherogenic (Amarasiri & Dissanayake 2006; Prior et al. 1981). Thus, the popular suggestion that coconuts are ‘bad’ for health is questionable.

This makes sense within a hunter-gatherer paradigm. Coconuts (and other sources of medium chain saturated fats) are part of the wild food supply, and in some regions abundantly so. In contrast, consumption of large quantities of adipose tissue from animal sources is not a characteristic of the wild food supply. Therefore it would appear risky to advocate the reduction of all types of saturated fat in the diet, as per the recommended dietary guidelines for Australians, without appreciation of metabolic properties of the different types of saturated fats. In the process, misconceptions regarding the use of coconuts can be dispelled. Furthermore, it is risky to advocate the change of a diet that has apparently served communities well in a traditional setting. For example, the shift away from a traditional diet (containing coconuts) to a Westernised diet has had devastating effects in the Pacific islands where obesity, type 2 diabetes and cardiovascular disease are now present in epidemic proportions.

In discussing this topic, one has to be mindful that consumption of fresh whole coconut flesh and juice as per the hunter-gatherer model is different to consuming coconut-derived foods which are the product of refining technology such as coconut oil and coconut cream. These latter foods can potentially be consumed in quantities far exceeding the rate at which whole coconut flesh can be eaten, thus potentially affecting their health promoting properties.

5.2.1.8 Summary: The usefulness of macronutrients as an effective ‘marker’ of optimal diets

All chronic diseases by their very nature are the result of a slow accumulation of factors straining homeostatic mechanisms. Numerous dietary, genetic and environmental factors act in concert with one another. Hence, dietary macronutrient composition, fatty acid
intake, micronutrient density, exercise and toxicant exposure can all play a role. To emphasise any one factor (e.g. macronutrient dietary profiles) risks missing the collective therapeutic impact of numerous dietary factors. Grounding nutrition information in an evolutionary context aids the exploration of plausible ranges and limits for health supportive dietary parameters.

5.2.2 Micronutrient intake

‘An optimum intake of micronutrients would tune up metabolism’

(Ames 2004 p.227)

5.2.2.1 Vitamins, minerals and health

Vitamins, minerals and trace elements are vital to health. Their functional roles are broad ranging including acting as co-enzymes\(^\text{21}\) in many and varied metabolic processes involving energy release and cellular activity. Others are involved in the synthesis of DNA (e.g. vitamin B\(_{12}\) and folate), regulate levels of gene activity (e.g. minerals including zinc, cadmium, copper and mercury increase metallothionein messenger RNA), and perform antioxidant functions (e.g. vitamins A, E, C); (Wahlqvist 1997a, b). Hence, nutrient deficiency, along with excessive oxidative stress, dysfunctional cellular metabolome and surplus calories, can cause DNA damage (including strand breaks, chromosome malsegregation, DNA hypomethylation and telomere shortening), which creates human cells with a damaged and unstable genome, thus affecting cellular function and potentiating cellular ageing (Ames 2004; Ames 2005; Fenech 2007). A higher degree of DNA damage correlates with a higher risk of cancer (Bonassi et al. 2007). Highlighting the significance of this relationship is that a moderate folate deficiency has been shown to cause as much DNA damage as the annual radiation exposure limit (Fenech 2007). The demonstrated effect of micronutrient deficiency on DNA damage is not limited to folic acid, but is evident for a range of nutrients. Ames (2005) found during \textit{in-vitro} testing using cultured human cell lines that deficiency of

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\(^{21}\) A co-enzyme is a non-protein chemical compound (often a vitamin or mineral) that is bound to an enzyme to enable its biological activity.
vitamins C, E, B_{12}, B_{6}, B_3, folic acid, iron and zinc all mimic radiation by causing single- and double-strand DNA breaks, oxidative damage or both. He states,

‘if one input in the metabolic network is inadequate, the repercussions are felt in a large number of other systems. This could result in an increase in DNA damage (and cancer), neuron decay (and cognitive dysfunction) or mitochondrial decay (and accelerated ageing and degenerative diseases)’


While classical deficiency diseases such as scurvy (vitamin C deficiency), beriberi (vitamin B_1 deficiency) and pernicious anaemia (vitamin B_{12} deficiency) are now very rare in the Australian population, sub-clinical micronutrient deficiencies are increasing in the context of a paradoxical obesity epidemic. This has massive implications for chronic disease risk.

### 5.2.2.2 Increasing dietary micronutrient density

Table 28 outlines the approximate vitamin and mineral content of various food groups.

<table>
<thead>
<tr>
<th></th>
<th>Whole grains (n=8)</th>
<th>Whole milk (n=1)</th>
<th>Fruit (n=20)</th>
<th>Vegetables (n=18)</th>
<th>Seafood (n=20)</th>
<th>Lean meats (n=4)</th>
<th>Nuts &amp; seeds (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin B_{12} (µg)</td>
<td>0.00 (4)</td>
<td>0.58 (5)</td>
<td>0.00 (4)</td>
<td>0.00 (4)</td>
<td>7.42 (7)</td>
<td>0.63 (6)</td>
<td>0.00 (4)</td>
</tr>
<tr>
<td>Vitamin B_{3} (mg)</td>
<td>1.12 (4)</td>
<td>0.14 (1)</td>
<td>0.89 (3)</td>
<td>2.73 (5)</td>
<td>3.19 (6)</td>
<td>4.73 (7)</td>
<td>0.35 (2)</td>
</tr>
<tr>
<td>Phosphorus (mg)</td>
<td>90 (3)</td>
<td>152 (5)</td>
<td>33 (1)</td>
<td>157 (6)</td>
<td>219 (7)</td>
<td>151 (4)</td>
<td>80 (2)</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>0.05 (2)</td>
<td>0.26 (6)</td>
<td>0.09 (3)</td>
<td>0.33 (7)</td>
<td>0.09 (4)</td>
<td>0.14 (5)</td>
<td>0.04 (1)</td>
</tr>
<tr>
<td>Vitamin B_{1} (mg)</td>
<td>0.12 (5)</td>
<td>0.06 (1)</td>
<td>0.11 (3)</td>
<td>0.26 (7)</td>
<td>0.08 (2)</td>
<td>0.18 (6)</td>
<td>0.12 (4)</td>
</tr>
<tr>
<td>Folate (µg)</td>
<td>10.3 (4)</td>
<td>8.1 (2)</td>
<td>25.0 (6)</td>
<td>208.3 (7)</td>
<td>10.8 (3)</td>
<td>3.8 (1)</td>
<td>11.0 (5)</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>1.53 (3)</td>
<td>74.2 (5)</td>
<td>221.3 (7)</td>
<td>93.6 (6)</td>
<td>1.9 (4)</td>
<td>0.1 (1)</td>
<td>0.4 (2)</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>0.90 (4)</td>
<td>0.08 (1)</td>
<td>0.69 (2)</td>
<td>2.59 (7)</td>
<td>2.07 (6)</td>
<td>1.10 (5)</td>
<td>0.86 (3)</td>
</tr>
<tr>
<td>Vitamin B_{6} (mg)</td>
<td>0.09 (3)</td>
<td>0.07 (1)</td>
<td>0.20 (5)</td>
<td>0.42 (7)</td>
<td>0.19 (4)</td>
<td>0.32 (6)</td>
<td>0.08 (2)</td>
</tr>
</tbody>
</table>
As can be seen in Table 28, cereal grains and milk have a lower overall nutrient density ranking (sum rank score) than vegetables, fruits, seafood and meats. Hence, as cereal grains and diary have increasingly become dietary staples and displaced wild plant and animal foods, the micronutrient content of the human diet has declined. Additionally, the refining of foods (grains, oils, sugars) further removes nutrients and accordingly, contemporary diets containing these foods risk nutritional deficiencies.

In reality, Table 28 can only be used as a general indicator of overall nutrient density. Unaccounted for is the bioavailability of nutrients within various food groups and a broader range of nutrients. For example, as noted by Cunnane (2005), seafood actually has the highest (above vegetables) available content of several minerals (including iodine, iron, zinc, copper, and selenium), yet a lower content of many vitamins. Furthermore, on a kilojoule to kilojoule basis, for example, raspberries could appear to be more nutrient dense than avocados, yet both foods contribute differently and equally to an array of health benefits. Therefore, the concept of foods being acknowledged for their nutritional density is valuable (for example see Drewnowski 2005) as long as they are also contextualised within broader dietary parameters reflecting the wild food supply. A high nutritional density in the diet is a natural consequence of consuming fresh, diverse foods derived from optimally healthy plants and animals in quantities reflecting their availability in the wild.

| Table 28. Mean nutrient density of various food groups (418kJ food samples). Values in brackets represent relative ranking (7 = highest; 1 = lowest); (Sourced from Cordain et al. 2005 p.349). |
|---|---|---|---|---|---|---|---|
| Vitamin A (retinol equiv) | 2 (2) | 50 (5) | 94 (6) | 687 (7) | 32 (4) | 1 (1) | 2 (3) |
| Magnesium (mg) | 32.6 (4) | 21.9 (2) | 24.6 (3) | 54.5 (7) | 36.1 (6) | 18.0 (1) | 35.8 (5) |
| Calcium (mg) | 7.6 (2) | 194.3 (7) | 43.0 (4) | 116.8 (6) | 43.1 (5) | 6.1 (1) | 17.5 (3) |
| Zinc (mg) | 0.67 (4) | 0.62 (3) | 0.25 (1) | 1.04 (5) | 7.6 (7) | 1.9 (6) | 0.6 (2) |
| Sum rank score | 44 | 44 | 48 | 81 | 65 | 50 | 38 |
5.2.3 Fatty acids and lipids in the context of ‘contemporary hunter-gatherer diets’

Fatty acid needs are ‘conditionally dependent’ (Plourde & Cunnane 2007 p.629). They therefore need to be contextualised within whole dietary and physiological characteristics, which can be conceptually simplified through an evolutionary framework.

5.2.3.1 Fatty acid composition of the average Australian diet

The fat composition of the modern Australian diet is no longer consistent with our evolutionarily adapted diet. Compared to estimations of hunter-gatherer diets, the average Australian diet today has a much higher intake of saturated fat (approximately 40% more), a lower intake of mono-unsaturated fat (approximately 22% less), a not dissimilar intake of total omega 6 polyunsaturated fat (approximately 2% higher – however, there are distribution changes within this class of fatty acids), and a significantly lower intake of total omega 3 polyunsaturated fat (approximately 90% lower); (Eaton 1992; Eaton et al. 1998a; Meyer et al. 2003). Total fat intake was, however, possibly much higher in many hunter-gatherer diets, supplying on average between 28 and 58% of total daily energy (Cordain et al. 2000), compared with the average Australian diet in which 32% of daily energy is sourced from total fat (Australian Institute of Health and Welfare 2006b).

Changes in the fatty acid composition of modern diets are the direct result of our shift away from eating from a biologically authentic wild food supply. As discussed, dietary sources of saturated fat are obtained in the wild in minimal quantities from the adipose tissue of wild game as well as some plant foods such as coconuts. The flesh of wild game is typically 2–4% fat by weight with high levels of monounsaturated and polyunsaturated fats and low levels of saturated fat (O'Keefe & Cordain 2004). By comparison, domesticated animals typically contain 20–25% fat by weight, much of it saturated fat (O'Keefe & Cordain 2004). Monounsaturated fats are abundant in the wild food supply being available in both plant (e.g. nuts and seeds) and animal foods (e.g. bone marrow, organs and other tissues). Saturated and monounsaturated fats do not
carry the same dietary importance as polyunsaturated fats because their exogenous (dietary) supply is not essential. The wild food supply contains an abundance of polyunsaturated fats (omega 6 and omega 3). Particularly in shore-line ecosystems there is a rich source of omega 3 fatty acids in fish, shellfish, marine mammals and organ meats from terrestrial animals, and a smaller source from animal skeletal muscle and eggs. Also, there is an abundant source of omega 6 fatty acids from animal muscle tissue, and nuts/seeds.

By contrast, the typical Australian diet contains a high amount of saturated fat from processed foods, dairy and domesticated animal meats; it contains very little seafood; an inconsequential quantity of animal organ meats; and an unprecedented intake of omega 6 rich vegetable oils (e.g. sunflower, peanut, canola, and even olive oil) used in cooking, margarines, confectionary and processed foods (e.g. commercially made biscuits, cakes, fried foods and some chocolate bars). As noted in Section 2.7, vegetable oil intake first increased in the human diet when oil pressing and refining technology came into use during the industrial revolution. The second wave of increased consumption occurred in the 1970s, primarily in response to studies linking dietary saturated fat with cardiovascular disease (see for example Keys et al. 1985), and the understanding that omega 6 polyunsaturated vegetable oils (linoleic acid) lowered cholesterol (Simopoulos 2004). In response, the food industry released a variety of margarines made from vegetable oils. However, cardiovascular health is far more complex than the cholesterol equation alone (Plourde & Cunnane 2007).

5.2.3.2 **Fatty acids and human health**

Both in absolute and relative amounts, the types of fats in the contemporary Australian diet have changed significantly compared to our ancestral diet. The effects of these changes on human health are broad reaching because of the diverse roles of fatty acids in the body.

Most dietary saturated (SFA) and mono-unsaturated (MUFA) fat is beta-oxidised for energy or fat storage (adipose tissue). MUFA is oxidized more readily than SFA (Bergouignan et al. 2009). The polyunsaturated fats (PUFAs), particularly the long chain (LC) PUFAs perform significant functional roles in the body. Cell membranes are
highly responsive to dietary PUFA composition (Hulbert et al. 2005; Mann et al. 2006; Sinclair et al. 1987). Depending on the properties of the fatty acids, they alter cell membrane fluidity, subtly effect membrane function (e.g. receptor function), modulate eicosanoid\textsuperscript{22} production (including prostaglandins, prostacyclins, thromboxanes, leukotrienes, lipoxins etc) involved in inflammatory mechanisms, and act upon intracellular signalling pathways, transcriptional factors and gene expression, among other possibilities (Lands 1992; Langdon 2006; Plourde & Cunnane 2007; Simopoulos 2002; Sinclair, Murphy & Li 2000).

Research into the biological effects of fatty acids, particularly omega 3 (n-3) LCPUFA, has boomed over the past 30 years. To some extent, this was stimulated by studies associating a very high intake of n-3 LCPUFA in Greenland Inuit diets with their very low incidence of cardiovascular disease (Bang, Dyerberg & Sinclair 1980), as well as two highly influential large clinical trials – the Gruppo Italiano per lo Studio della Sopravvivenza nell’Infarto Miocardico (GISSI) Prevenzione study, and the Diet and Reinfarcation Trial (DART).

In the GISSI randomised controlled trial involving 11,323 patients surviving a recent myocardial infarction, those who received a n-3 LCPUFA supplement (850mg/day EPA+DHA\textsuperscript{23}) experienced a 45% reduction in sudden cardiac death and a 20% decrease in all cause mortality during the 3.5 year study period (Marchioli et al. 2002). Similarly, the DART trial demonstrated a 62% reduction in cardiovascular disease related deaths in subjects consuming 450mg/day n-3 LCPUFA (Burr et al. 1989).

The clinical significance of modulating dietary LCPUFA intake is not limited to cardiovascular disease. Rather, the function of these fatty acids in the brain (see Section 2.4) and in inflammatory mechanisms (and limiting the view to these factors alone is incomplete in itself) makes them clinically important in many health conditions.

\textsuperscript{22} Eicosanoids are signalling molecules made from essential fatty acids.

\textsuperscript{23} This is less than the estimated intake in average hunter-gatherer diets of 1100mg/day (EPA, DPA\textsubscript{n-3}, DHA). It is however far more than the average Australian’s intake of 190mg/day, and in-line with the new recommended adequate intake values for Australian adults of 0.9g/day for females and 1.6g/day for males. (References: Eaton, SB, Eaton, S, Sinclair, AJ, Cordain, L & Mann, NJ 1998a, ‘The return of n-3 fatty acids into the food supply. I. Land-based animal food products and their effects’, in Simopoulos, AP (ed) World review of Nutrition and Dietetics, vol. 88, Karger, Basel, Switzerland, pp. 12-23.; Meyer, BJ, Mann, NJ, Lewis, JL, Milligan, GC, Sinclair, AJ & Howe, PR 2003, ‘Dietary intakes and food sources of omega-6 and omega-3 polyunsaturated fatty acids’, Lipids, vol. 38, no. 4, pp. 391-389.; NHMRC 2005, Nutrient Reference Values for Australia and New Zealand, Commonwealth of Australia, Canberra.)
As such, a growing body of epidemiological and experimental evidence is indicating that adequate intakes of n-3 LCPUFA can increase longevity and significantly reduce all cause mortality (ISSFAL 2008; ISSFAL et al. 2006; Meyer et al. 2003; Nettleton 1995). More specifically, a large body of data is available documenting the negative impact of n-3 LCPUFA deficiency/the positive effects of supplementation on numerous clinical conditions including the following few examples:

- A variety of inflammatory and immune conditions (see for example Mori & Beilin 2004)
- Autoimmune diseases (see for example Calder 2008 - rheumatoid arthritis; Mehta, Dworkin & Schwid 2009 - multiple sclerosis; Proudman, Cleland & James 2008 - rheumatoid arthritis)
- Atopic disease (for example, n-3 rich fish intake in 574 Australian children was associated with decreased asthma Hodge et al. 1996)
- Brain development and function (see for example Carlson 2001; Crawford 1993; Cunnane 2005; Gibson & Makrides 1998; Lauritzen et al. 2001; Makrides et al. 1995; Salem et al. 2001)
- Cardiovascular disease (see for example Kris-Etherton, Harris & Appel 2003; von Schacky 2003)

Numerous other references could be cited for any number of chronic diseases, so prolific has research been in this area.

### 5.2.3.3 Fatty acids in the context of whole diet factors

Fatty acids and lipids have been the key nutritional characteristic of focus in the field of evolutionary nutrition (see for example Cordain 2006b; Crawford & Marsh 1995; Cunnane 2005; Eaton 1992; Simopoulos 2006). In part, this is because fat composition in the contemporary diet is so divergent from our ancestral diet, and in part it is because of the increasing amount of research highlighting the crucial functions of fatty acids in human health.
However, as with all other specific dietary characteristics – be it macronutrient composition, micronutrient density, or glycaemic load – authentically mirroring our ancestrally adapted diet and gaining the whole package of health benefits requires more than just matching the fatty acid balance of our evolutionary diet. In a culture heavily invested in reductionistic research findings, we are presently at risk of implementing limited solutions for remedying our omega 3 deficient population, for example by formulating genetically modified grains that contain more omega 3 fat (N. Mann 2007, pers comm. 25th August), supplying children with fish oil containing lollies (for example see Melrose Laboratories & Steinicke 2009), and producing other ‘functional food’ products like omega 3 containing milk and eggs. While this will increase omega 3 intake at a population level, it does so in a dietary matrix that is not necessarily optimally supportive of health, and potentially serves to distract attention and resources away from core issues.

Dietary fatty acids and lipid composition must therefore be seen simply as a marker for adequate intake of the right kinds of foods – not a mechanism for circumnavigating the need to address dietary change at a fundamental level. This is a key message of this thesis.

There is an abundance of literature on the health impacts of fatty acids and lipids, and hence only the most central points are outlined in this section as they are relevant to correctly modelling a ‘contemporary hunter-gatherer diet’.

### 5.2.3.4 Biologically significant fats found in the human food chain, and in human cell membranes

The more biologically significant fats found in the human food chain and in human cell membranes include:

- **Saturates** (14:00 – myristic; 16:00 – palmitic; 18:00 – steric; 20:00 – arachidic)
- **Monounsaturates** (16:1 n-7 – palmitoleic; 18:1 n-9 – oleic)
- **Polyunsaturates**:
  - omega 9 (20:3 n-9 – mead)
  - omega 6 [18:2 n-6 – alpha linoleic (LA); 20:4 n-6 – arachidonic (AA)]
omega 3 [18:3 n-3 – alpha linolenic (ALA); 20:5 n-3 – eicosapentaenoic (EPA); 22:5 n-3 - docosapentaenoic (DPAn-3); 22:6 n-3 – docosahexaenoic (DHA)]

All animals, including humans, can endogenously synthesise SFAs and MUFAs. However, humans avoided the need to endogenously synthesise n-6 and n-3 fatty acids because of their dietary abundance in the evolutionary wild food supply. Hence, they are considered to be ‘essential’ fatty acids (EFA) and therefore need particular attention when constructing any health-supportive diet. Humans can also make mead acid (20:3 n-9) from oleic acid as a source of PUFAs in the less than ideal absence of an adequate dietary supply of both n-6 and n-3 LCPUFAs (Hulbert et al. 2005). The significant presence of mead acid is therefore indicative of n-6 and/or n-3 deficiency (Hulbert et al. 2005; Plourde & Cunnane 2007) and hence is hopefully not relevant in discussions about optimal diet.

Both SFAs and MUFAs are present in cell membranes in relatively constant amounts, which is to be expected given that they can be endogenously synthesised. The greatest sensitivity to dietary change is for the PUFAs owing to their ‘essential’ nature. For example, as noted by Hulbert et al. (2005), in both liver and heart membranes, there is an approximate 25% membrane composition response to 100% variation in dietary n-6/n-3 fatty acids. In synaptosomal membranes, an almost 88% conformity has been observed to correlate with dietary intake. Hence, phosphosolipid membranes (in varying degrees depending on their function) are highly sensitive to dietary n-3 and n-6 fats.

AA is the dominant n-6 PUFA in human cell membranes and DHA is the dominant n-3 PUFA in cell membranes. Both these fatty acids are crucial for optimal cellular function. DHA is especially concentrated in the brain, where it accounts for one third of the fatty acids present (Langdon 2006) and hence the natural gravitation in the research towards examining the role of omega 3 fats in cognitive, psychiatric and neuro-degenerative illnesses.
5.2.3.5 Dietary sources of polyunsaturated fatty acids

In the wild, the broad base of the food-web-pyramid is composed of ubiquitous algae in the sea and green leaf foods on land (O'Keefe & Cordain 2004). The miniscule amount of fat in the phospholipid cell membranes of algae and green leaves is particularly rich in ALA (n-3) [because ALA is the fatty acid common in chloroplast membrane (Hulbert et al. 2005)], as well as containing some LA (n-6). Animals eating this plant food endogenously elongate the ALA into EPA, DPAn-3 and DHA; and the LA into AA. Hence, plant foods are sources of the short chain (SC) PUFA s and animal foods are sources of long chain (LC) PUFA s. The fat content and fatty acid composition of foodstuffs vary widely (Mann et al. 2006). Up through both the land and marine food chains, LCPUFA become concentrated in larger animals (O'Keefe & Cordain 2004).

Therefore in general, the predominant food sources of the various PUFA s are as follows:

- **Long chain omega 6**: skeletal muscle meat and eggs provide an abundant source of AA (n-6 LCPUFA)
- **Long chain omega 3**: aquatic animals and organ meats (especially brain) offer rich sources of n-3 LCPUFA (EPA, DPAn-3 and DHA)
- **Short chain omega 6**: seeds/nuts (and vegetable oils) being plant foods are a rich source of n-6 SCPUFA (LA)
- **Short chain omega 3**: leafy greens (and other green vegetables) are the predominant source of n-3 SCPUFA (ALA) at the base of our food chain that gets elongated and concentrated in animal tissue (into n-3 LCPUFA), which humans then eat. Other sources of ALA include some nuts (e.g. walnuts) and seeds (e.g. flax).

Omnivorous whole food diets sourced from shore-line ecosystems provide a continuous and abundant supply of pre-formed LCPUFA s i.e. AA, EPA and DHA. Extremely high intakes of LA were limited in traditional hunter-gatherer diets due to a lack of vegetable oils. A constant supply of LCPUFA s throughout evolution probably explains our low capacity for endogenous conversion of SCPUFA s to LCPUFA s. Additionally, the

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24 Brain tissue is primarily composed of fat. For example the fatty acid composition of the fat portion of a wild Elk’s brain contains 41% saturated fat, 33% monounsaturated fat and 26% polyunsaturated fat, of which 10% is DHA. (Reference: Cordain, L, Martin, C, Florant, G & Watkins, BA 1997, 'The fatty acid composition of muscle, brain, marrow and adipose tissue in Elk: evolutionary Implications for human dietary lipid requirements', World review of Nutrition and Dietetics, vol. 83, 18-19 September, p. 225.)
dietary abundance of SCPUFA (LA, ALA), as well as EPA, suggests potential roles for these fatty acids in human health that are independent of their metabolism through to AA or DHA endpoints. For example, it has been hypothesised that given that ALA is the preferentially fatty acid substrate for beta-oxidation and ketogenesis, ALA could be used as brain fuel if glucose supply becomes limited (e.g. in the presence of insulin resistance) as a useful, evolutionarily acquired back-up plan (Plourde & Cunnane 2007).

5.2.3.6 Physically distinguishing the different types of fatty acids

Owing to their differing chemical structure, all fats can be readily distinguished by their temperature dependent physical characteristics. This is useful information for any non-biochemist wanting to understand the nature of the fats they are eating. Melting point increases with increasing carbon chain length, decreasing hydrogen saturation and a decreasing number of double bonds in the carbon chain (Lester 1994). For example, the omega 3 fat DHA is chemically abbreviated to 22:6 n-3; where 22 refers to the carbon chain length, 6 refers to the number of double bonds, and 3 refers to the position of the first double bond nearest the methyl end of the chain. By comparison, the saturated fat, palmitic acid is abbreviated to 16:00. Hence, relative to DHA, palmitic acid (like all the saturated fats) will solidify at room temperature, and be far more heat tolerant [melting point of +70 degree Celsius (ARL 2002)]. DHA is very fluid at room temperature with a melting point of at least -50 degrees Celsius (ARL 2002), is highly heat sensitive and hence oxidizes very quickly compared with saturated fat. Therefore, when cooking with high heat (e.g. wok frying) selecting a fat which is more saturated with fewer double bonds will be more heat stable and thus not form as many adverse by-products caused by heat induced oxidation and damage (Turner, McLean & Silvers 2006).

The natural wild food supply reflects the temperature dependent characteristics of fatty acids. For example, saturated fat is the predominant fat in coconuts, which grow around the hot equator; monounsaturated fat is predominant in olives, avocados and macadamia nuts which grow in temperate-warm climates such as the Mediterranean and Australia; shorter chain omega 6 fat are abundant in nuts/seeds such as almonds, wattle seeds and sesame seeds found in temperate zones; and very long chain, highly unsaturated long-chain omega 3 fats are produced in higher quantities in aquatic species living in cold
water where such fats are necessary to act like ‘anti-freeze’ compared to tropical fish species which contain a relatively greater amount of n-6 fats (Sinclair et al. 1998).

5.2.3.7 Main features of polyunsaturated fatty acid metabolism in the human body

Once digested, fatty acids are either incorporated into the phospholipid bi-membrane of every cell or put into storage for later energy production (triglycerides). The metabolic elongation pathways of polyunsaturated fatty acids in the human body can be seen in Table 29.

<table>
<thead>
<tr>
<th>Omega 6 Polyunsaturates</th>
<th>Omega 3 Polyunsaturates</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Linoleic acid</strong></td>
<td><strong>alpha-Linolenic acid</strong></td>
</tr>
<tr>
<td><em>(e.g. vegetable oils, nuts/seeds)</em></td>
<td><em>(green plants – but quantities are very small; some nuts/seeds e.g. flax, walnut)</em></td>
</tr>
<tr>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td><strong>Gamma-Linolenic acid</strong></td>
<td><strong>Stearidonic acid</strong></td>
</tr>
<tr>
<td><em>(e.g. evening primrose oil)</em></td>
<td>↓</td>
</tr>
<tr>
<td>↓</td>
<td><strong>Eisatetraenoic acid</strong></td>
</tr>
<tr>
<td><strong>Dihomo-gamma-linolenic acid</strong></td>
<td>↓</td>
</tr>
<tr>
<td>↓</td>
<td><strong>Eicosapentaenoic acid</strong></td>
</tr>
<tr>
<td><strong>Arachidonic acid</strong></td>
<td><em>(fish, shellfish)</em></td>
</tr>
<tr>
<td><em>(lean red meat, fish)</em></td>
<td>↓</td>
</tr>
<tr>
<td>↓</td>
<td><strong>Docosapentaenoic acid (n-3)</strong></td>
</tr>
<tr>
<td>↓</td>
<td><em>(animal meats)</em></td>
</tr>
<tr>
<td>↓</td>
<td>↓</td>
</tr>
<tr>
<td><strong>Docosatetraenoic acid</strong></td>
<td><strong>Docosahexaenoic acid</strong></td>
</tr>
<tr>
<td>↓</td>
<td><em>(fish, shellfish, especially deep sea species)</em></td>
</tr>
<tr>
<td><strong>Docosapentaenoic acid (n-6)</strong></td>
<td></td>
</tr>
</tbody>
</table>

Table 29: Metabolic elongation pathways of polyunsaturated fatty acids in the human body (note that synthesis of the final fatty acid in both series requires three steps that are not shown, hence, the three consecutive arrows); (Modified from Cunnane 2005 p.154)

Humans are able to convert SCPUFAs into LCPUFAs. That is, we have the capacity to make AA from LA; and EPA and DHA from ALA (Brenna et al. 2009). However, endogenous conversion is extremely limited (Plourde & Cunnane 2007) as follows:

- **omega 3**: approximately 5% of ALA is converted to EPA; <0.5% of ALA is converted to DHA
- **omega 6**: <0.1% of LA is converted through to AA
Despite this limited conversion, the fact that this mechanism exists at all is indicative of the crucial role for LCPUFAs in human health. Conversion rates increase when the diet is low in LA or ALA, or when cell membrane content of LCPUFA is very low. For example, conversion is up-regulated in vegetarians due to limited dietary supply (Kornsteiner, Singer & Elmadfa 2008; Langdon 2006), and also during pregnancy when tissue demands are higher (Burdge & Wootton 2002; Langdon 2006). Nonetheless, when dietary intake and/or tissue levels are too low, up-regulatory mechanisms appear to be inadequate to prevent clinical symptoms (Kornsteiner, Singer & Elmadfa 2008; Plourde & Cunnane 2007).

Therefore, dietary supply of the LCPUFA is absolutely necessary. AA is abundant in contemporary omnivorous diets and therefore not of concern. However DHA deficiency is widespread today due to the limited intakes of aquatic foods and animal organs. Hence the clinical problem today is n-3 LCPUFA deficiency, not AA deficiency, and as such, this is where the research agenda is focused.

Substrate availability and substrate competition affects PUFA conversion (Meyer et al. 2003; Plourde & Cunnane 2007). Hence, if LA (n-6) is in greater dietary abundance than ALA (n-3), LA will preferentially occupy desaturase enzymes leading to increased AA production over n-3 LCPUFA production (e.g. EPA). This is of concern in the context of LA abundant yet n-3 LCPUFA deficient contemporary Australian diets.

Due to substrate competition, the prevailing view has been that high intakes of LA impair the incorporation of n-3 LCPUFA into tissues because n-6 and n-3 use the same desaturase enzymes (for example see Cordain 2002b; Eaton, Eaton & Konner 1997; Hibbeln et al. 2006; Lands 2005). However, in reality the in vivo effect of varying substrate availability and mechanisms by which PUFA influence cellular function is not well characterised (Hulbert 2005; Plourde & Cunnane 2007). It is very hard to precisely quantify endogenous fatty acid conversion because of the many background variables at play, including nutrient, hormonal and genetic factors.

Some of the metabolic conditions involved in fatty acid desaturation and elongation include: numerous nutritional co-factors (various vitamins and minerals – notably vitamin B₆, iron and zinc); hormones (especially insulin and oestrogen – women have higher activity of elongation/desaturation than men, which is protective for a developing
foetus (Burdge & Wootton 2002); and background dietary intake of all fatty acid and lipids e.g. n-3 LCPUFA uptake occurs to a greater extent if background intakes of other fatty acids are primarily monounsaturated (Meyer et al. 2003), among other factors (Plourde & Cunnane 2007). Micronutrient deficiencies and/or insulin dysfunction are known to down regulate/limit the conversion pathways. Again, this highlights the need to look at diet holistically. An omnivorous, whole food, high quality diet is inherently micronutrient dense, carries a low glycaemic load and helps protect against chronic diseases particularly of a metabolic origin such as those involving insulin dysfunction, inflammation and imbalanced redox poise. Hence, fatty acid needs are conditionally dependent (Plourde & Cunnane 2007) and need to be contextualised within complex whole diet/physiological characteristics, which can be conceptually simplified through an evolutionary framework.

Therefore, while fatty acid research in evolutionary nutrition circles has tended to focus on the knowledge that humans evolved on a diet where the ratio of total n-6 to n-3 PUFAs was typically 1:1 (quite different to typical Western diets in which the ratio is often as high as 15:1 – 16:1); (Simopoulos 2003, 2006), this thesis argues that merely focusing on mirroring a 1:1 ratio is an overly simplistic approach because it discounts the myriad of complex endogenous conversion factors and lacks sensitivity to the biological effects of each of the different types of PUFAs, among other dietary factors. Hence, in this section, rather than focusing on total n-6 to n-3 ratios, the potential biological effects of each of the PUFAs are acknowledged and their exogenous supply is accounted for in the modelling of ‘contemporary hunter-gatherer diets’.

In terms of future research, assessing the effects of ‘contemporary hunter-gatherer diets’, optimal hormone profiles, and regular physical exercise on endogenous fatty acid metabolism and clinical endpoints, would make for fascinating authentic research, which, to date, has not been attempted.
5.2.3.8 Polyunsaturated fatty acids and inflammation

While the clinical effects of adequate n-3 LCPUFA intake are increasingly being substantiated, their biochemical mechanisms of action are still not precisely known (Hulbert et al. 2005; Plourde & Cunnane 2007). Their effect on inflammatory markers appears to be one of their key actions in the human body. Their effect may be due to their inhibition of 2-series pro-inflammatory prostaglandins, their stimulation of 3-series anti-inflammatory prostaglandin production, or by their effects on membrane composition affecting cell signal pathways (and gene expression), along with other possibilities (Plourde & Cunnane 2007). Analogously, the n-6 LCPUFA (AA) is generally considered to exert its effect by elevating 2-series prostaglandin production which causes a cascade of inflammatory effects including increased blood viscosity, vasospasm, vasoconstriction, and a decrease in bleeding time (Simopoulos 2007) – all vital components of the body’s natural defence and injury response mechanisms. However, if an excessively prolonged inflammatory response plays out in disproportionate magnitude, it causes undue tissue damage and likely underpins the aetiology of numerous chronic diseases (Hamazaki & Okuyama 2003; Lands 2005).

However, the idea that n-6 LCPUFA are purely pro-inflammatory agents is not clear cut. In contrast to many existing views, new evidence suggests that AA may also have inflammation-resolving properties. ‘Lipoxins’ are mediators generated from AA that exert potent anti-inflammatory effects, including the inhibition of inflammatory cytokine formation [e.g. AA has also been shown to significantly decrease the production of tumor necrosis factor-alpha (Maes et al. 2007)], as well as the reduction of immune cell proliferation and migration (Weylandt & Kang 2005). Hence, scientific understanding in this area is still embryonic. As argued in this thesis, this highlights the need for fatty acid intake (both SC and LC) and numerous background variables (affecting endogenous metabolism) to be contextualised into a unifying paradigm guided by evolutionary principles and the nutritional characteristics of the wild food supply.
5.2.3.9 Polyunsaturated fatty acids in the context of ‘contemporary hunter-gatherer diets’

When certain nuts and seeds are consumed, a substantial intake of LA is to be expected. On the backdrop of other hunter-gatherer dietary variables, a higher intake of LA (in the presence of high n-3 LCPUFA intake) was likely a common dietary fatty acid profile for many traditional hunter-gatherer people, depending on the type and quantity of nuts and seeds consumed (not vegetable oils). This is certainly the fatty acid profile that prevails in ‘contemporary hunter-gatherer diets’ as interpreted in this thesis (see Chapters 7 and 8).

The effect of higher (but not excessive) LA intake in the presence of high n-3 LCPUFA intake has not been extensively researched. This is very surprising given that this is probably a characteristic fatty acid pattern in our ancestral diet and reflects wild food characteristics. This research deficit highlights the importance of contextualising fatty acid needs within a whole food dietary matrix that mirrors our hunter-gatherer history – a perspective that appears to be lacking in many current research paradigms.

The only human study to examine the effect of high LA intakes in the presence of high n-3 LCPUFA intake found that increasing LA did not have any pronounced effect (either alone or in combination with high n-3 LCPUFA intake) on DHA incorporation into blood cells (Damsgaard, Frokiaer & Lauritzen 2008). In the same line of thinking, Hwang et al. (1997) found that absolute amounts of fish oil in the diet – not the relative amounts of n-6 to n-3 PUFAs (ratio) – determined the magnitude of increase in EPA in blood cells membranes. Likewise, Liou et al. (2007) found that while LA did decrease blood cell EPA, it did not influence DPA, DHA or, importantly, have any effect on pro-inflammatory eicosanoid production, platelet aggregation or C-reactive protein (systemic inflammatory marker); (likely due to our very poor ability to endogenously convert LA to AA, and it is AA that is used for eicosanoid production).

Despite contrasting with some existing views, these findings re-enforce the probability that authentically mirroring hunter-gatherer diets in a general sense is more important than being concerned with various ratios for each individual fatty acid in the diet i.e. total n-6:n-3 ratio, LA:ALA, or even the more biologically important AA:n-3 LCPUFA ratio. A high intake of LA rich nuts (e.g. almonds, pine nuts), and adequate AA (from...
meat and eggs) in a balanced ‘contemporary hunter-gatherer diet’ that realistically reflects the composition of our evolutionary diet arguably has no adverse health consequences if consumed in the presence of adequate n-3 LCPUFA intake (e.g. from seafood, organic animal organ meats, especially brain, and/or fish oil supplementation), and other nutritional characteristics of hunter-gatherer diets.

In contrast to ‘contemporary hunter-gatherer diets’ as proposed in this thesis, the average Australian diet is high in LA, low in ALA, high in AA, and deficient in n-3 LCPUFA – a profile which is in discord with our evolutionary template – and alters substrate availability, affects substrate competition for desaturase enzymes, alters end-product formation, and consequently appears to skews eicosanoid production in a pro-inflammatory direction and effects other cellular functions influenced by this PUFA profile. (See Chapter 7, Part I for further details on fatty acid intake in the average Australian diet.)

Hence, adequate dietary supply of end point LCPUFAs is essential i.e. DHA (deficient in contemporary diets) and AA (abundant in contemporary and hunter-gatherer diets). Adequate dietary supply of ‘parental’ and ‘intermediate’ fatty acids including LA and ALA, as well as EPA and DPAn-3 are also likely to be essential in the diet, despite their precise mechanism of actions being at present unquantified.

The message of this section, therefore, simply amounts to a recommendation to increase consumption of n-3 LCPUFAs (EPA and DHA). In terms of quantity, the boundaries for n-3 LCPUFA intake can be defined in a variety of ways: by current recommendations – 650mg/day (ISSFAL 2008), 430-610mg/day (NHMRC 2006); estimated intake in average traditional hunter-gatherer diets – 1100mg/day (Eaton 1992); and by dosages used in randomised clinical trials without significant adverse effects – up to 2.7gm/day²acetKol et al (2007). Additionally, n-3 LCPUFA intake needs to occur within the context of a nutritional matrix that reflects our evolutionary diet i.e. an omnivorous (aquatic and land based animals), whole food, nutrient dense diet and health supportive lifestyle patterns.

²acetKol et al (2007). Equivalent to 8.3 standard fish oil capsules (where each capsule contains 180mg EPA and 120mg DHA).
5.2.4 *Glycaemic index and glycaemic load*

5.2.4.1 *Carbohydrate metabolism and insulin resistance*

The glycaemic index is a tool for assessing the effects of food on endogenous carbohydrate metabolism (Brand-Miller et al. 1998). Carbohydrates need to be broken down into simple sugars during digestion before being released into systemic circulation. As blood glucose levels rise, the pancreas is stimulated to secrete the hormone insulin. Insulin’s role is to take glucose from the blood and deposit it into cells, where it is either directly used for energy production or turned into fat for potential energy use in the future.

The greater the spike in blood glucose, the more insulin that is produced and the more rapidly blood sugar is transported into body cells. Slowing the digestion rate of carbohydrates and thus slowing the absorption rate of glucose results in a lower dose and more sustained release of insulin. Over time, a diet that contains abundant, rapidly absorbed carbohydrates stresses the metabolic system and may lead to chronically elevated insulin levels. The effects of this are multifaceted. Body tissues can become desensitised to insulin (termed insulin resistance) which stimulates even further insulin secretion; blood glucose levels remain elevated; and in some people the pancreas becomes ‘exhausted’ and its ability to produce insulin is reduced (Guarente 2006). Thus, ‘insulin resistance’ means that greater than normal insulin levels are required to elicit a normal glucose response in the body, or physiological concentrations of insulin produce a less than normal biological response (Brand-Miller & Colagiuri 1999).

As noted in Section 3.2.2.2, the metabolic effects of insulin resistance are hypothesised to promote a cluster of diseases including obesity (Brand-Miller 2007), cardiovascular disease (Beulens et al. 2007), type 2 diabetes (Hermansen et al. 2006), hypertension and dyslipidemia (Radhika et al. 2009); ovulatory infertility (Chavarro et al. 2007); polycystic ovarian syndrome (Mann 2007b); several cancers including breast (Sieri et al. 2007), prostate (Lin et al. 2007) and thyroid (Randi et al. 2008); as well as cataracts (Tan et al. 2007), acne (Smith et al. 2007), gout, and myopia (Mann 2007b). The broad range of associated pathologies is not surprising given the central role of carbohydrate metabolism in metabolic chemistry and therefore health status. Chronic overload on the
regulatory mechanisms for glucose concentration homeostasis in the body is probably one of the most disease inducing features of our contemporary Australian diet.

In the early 1980s an understanding of the relative blood-glucose raising potential of various foods emerged and began to be communicated in the nutrition science literature. A large number of papers have been published on the glycaemic index and the information has been brought to public attention in part through the book *The G.I. Factor* (Brand-Miller et al. 1998).

The glycaemic index (GI) is simply a ranking system for carbohydrate foods based on their blood sugar raising effect. Carbohydrate foods that break down quickly during digestion have the highest GI index because their blood sugar response is fast and high. Glycaemic load (GL) is a measure of the glycaemic index multiplied by the carbohydrate content in food portion (grams carbohydrate x GI / 100). GL is commonly regarded as a more appropriate and meaningful variable because, for example, watermelon contains a higher GI than multi-grain bread (72 vs. 43); however, the total carbohydrate content per 100g of watermelon is only around 5g compared to around 33g carbohydrate for multi-grain bread.

### 5.2.4.2 The glycaemic load of various foods

The reference point for the GI ranking system is the effect of ingesting pure glucose on blood sugar levels. Sometimes white bread is used as the reference point because it has the same effect on blood sugar as pure glucose. That reference point has been given an arbitrary number of 100. A sample of the GI and GL of various foods can be found in Table 30. A more extensive list of foods can be found in Foster-Powell et al. (2002).
The glycaemic load of a food is usually a good predictor of the insulin response generated for its metabolism. An exception appears to be dairy foods. Dairy, although maintaining a low glycaemic index (due to its fat content), paradoxically causes a three to six fold higher insulinemic response than expected from the corresponding glycaemic indices value (Ostman, Liljeberg Elmståhl & Björck 2001). Milk and fermented milk products display insulin indices similar to white bread (Cordain 2002a; Cordain 2006a;
Ostman, Liljeberg Elmståhl & Björck 2001) and raise blood insulin concentrations even when added to low glycaemic index mixed meals (Liljeberg Elmståhl & Björck 2001).

5.2.4.3 Factors affecting the glycaemic index of a food

Several food composition factors affect the glycaemic response as seen in Table 31.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibre</td>
<td>Soluble fibre increases the viscosity of the intestinal contents and this slows down the interaction between starch and digestive enzymes.</td>
</tr>
<tr>
<td>Fat</td>
<td>Fat slows down the rate of gastric emptying thereby slowing the digestion of carbohydrates.</td>
</tr>
<tr>
<td>Physical form of food</td>
<td>The fibrous coating around intact (‘whole’) plant cell walls acts as a physical barrier, slowing down access of digestive enzymes to the carbohydrates inside.</td>
</tr>
<tr>
<td>Type of starch: ratio of amylase to amylpectin</td>
<td>The more amylase a food contains, the lower its rate of digestion.</td>
</tr>
<tr>
<td>Sugar</td>
<td>Different sugars break down at different speeds and hence vary in their GI (e.g. glucose = GI of 100; fructose = GI of 20). Hence, the digestion of pure starch (e.g. potato) – a polysaccharide of glucose – yields a higher glycaemic response than fruit which is a disaccharide of glucose and fructose.</td>
</tr>
<tr>
<td>Acidity</td>
<td>Acids in food slow down gastric emptying, thereby slowing the rate of digestion (e.g. lemon juice).</td>
</tr>
<tr>
<td>Degree of starch gelatinisation</td>
<td>The less gelatinized (swollen) the starch, the slower the rate of digestion. The starch in raw food is stored in hard, compact granules which are difficult to digest. Water and heat during cooking expand the granules, freeing the individual starch molecules.</td>
</tr>
</tbody>
</table>

Table 31. Food factors influencing glycaemic response and their mechanism of action (Modified from Brand-Miller et al. 1998)

5.2.4.4 Carbohydrate in evolutionary context

As discussed in Section 2.3, sources of carbohydrate available to hunter-gatherers eating a wild diet were vegetables (including starchy tubers), fruits, and occasionally a small amount of honey and tree saps. Cereal grains, depending of geographical location,
contributed minimally to carbohydrate intake, whereas today they provide the majority of carbohydrate in average Australian diets, along with added sugars (see Chapter 7).

Total carbohydrate intake was likely lower in hunter-gatherer diets than the average Australian diet today. As noted, Cordain et al. (2000) estimated that the most probable range for carbohydrate intake in worldwide hunter-gatherer diet was between 22 and 40% of total energy. In contrast, the average Australian today obtains between 45 and 50% of their daily energy intake from carbohydrates (Australian Bureau of Statistics 1998). This quantitative difference alone places a greater load on the regulatory mechanisms for glucose homeostasis throughout the whole body.

There are also important qualitative changes in carbohydrate intake between contemporary and hunter-gatherer diets. A study by Thornburn et al. (1987) compared the digestibility and metabolic responses of typical Western foods (potato, bread, spaghetti, rice, corn) with traditional carbohydrate-based staple foods of Australian Aborigines and Pacific Islanders. A variety of traditional foods were analysed, including wild roots (e.g. lily), tubers (e.g. yam), corms (e.g. bush onion) and seeds (e.g. acacia/wattle seeds and banya pine seeds). Thornburn et al. (1987) found that the carbohydrate in many traditional wild foods was digested significantly more slowly in vitro than common Western foods. Furthermore, O’Dea (1984) found marked improvements in carbohydrate metabolism in diabetic Australian Aborigines after reversion to their traditional diet.

As a consequence of wild food diets being fibrous, non-refined/minimally processed, and slowly digested and absorbed, they maintain a lower glycaemic index and elicited smaller post-prandial insulin responses. In contrast, the majority of Australian diets today are typically very high in carbohydrate, much of which is refined. Additionally, today’s diets induce a range of risk factors including elevated circulating triglycerides, low levels of high-density lipoprotein and increased inflammatory biomarkers such as C-reactive protein and interleukin-6 – all of which are associated chronic disease aetiology including type 2 diabetes and cardiovascular disease (Sacheck 2008). Research strongly suggests that metabolic risk factors and inflammation are directly modifiable through dietary measures including high intakes of vitamin, minerals and phytochemicals (Harding et al. 2008), adequate intake of omega 3 fatty acids (Hartweg et al. 2008), and lifestyle factors including increased physical exercise as discussed in Section 2.5. These factors are core features of our evolutionary template.
5.2.4.4.1 The thrifty genotype

Within the realm of normal physiological conditions, the body’s ability to become insulin resistance serves an important function. The physiological purpose of insulin resistance is to direct blood glucose away from skeletal muscle towards vital organs like the brain and placenta. As such, insulin resistance is associated with puberty, pregnancy, lactation, low physical fitness and muscle mass, higher body fat, ageing, high-protein/low-carbohydrate diet, trauma and insulin-resistant genotypes (genetic differences); (Brand-Miller & Colagiuri 1999).

In an evolutionary context, Brand-Miller & Colagiuri (1999) and Guarente (2006) suggest that the capacity to elicit insulin resistant tendencies was common throughout human evolution because it provided distinct survival and reproductive advantages (e.g. the ability to conserve glucose necessary for foetal survival and breast milk production). This is the basis of ‘the thrifty genotype’ hypothesis (Neel 1962). The hypothesis suggests that genotypes that are vulnerable to the development of type 2 diabetes are especially efficient (‘thrifty’) at utilising carbohydrates, which is advantageous in conditions of food scarcity (Cavalli-Sforza 1980). When the ‘thrifty genotype’ [which has since been more aptly named ‘the thrifty phenotype’ (Hales & Barker 1992)] is expressed in the context of our present-day food and sedentary lifestyle circumstances, the consequences of chronic insulin resistance and compensatory hyperinsulinemia play out, resulting in cascading health problems.

Indigenous populations that have undergone rapid Westernisation are particularly vulnerable to type 2 diabetes (see Figure 17). White populations of European descent appear less vulnerable; however, the metabolic limits of this population appear now to also be stretched by contemporary diets as evidenced by the escalating prevalence of type 2 diabetes, as discussed in Section 3.2.2.2.
Increased selection of insulin resistant gene(s)
Traditional hunter-gatherer diet: low carbohydrate content, high micronutrient density, appropriate fatty acid balance, regular physical activity

<table>
<thead>
<tr>
<th>Short exposure to agriculture</th>
<th>Long exposure to agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>(intensification of selection pressure)</td>
<td>(relaxation of selection pressure)</td>
</tr>
</tbody>
</table>

Decreased frequency of insulin resistance gene(s)
(Westernisation)

High CHO diet with high glycaemic index

High prevalence of type 2 diabetes e.g. in Australian Aborigines

Decreased frequency of insulin resistance gene(s)
(Industrial Revolution)

High CHO diet with high glycaemic index

High prevalence of type 2 diabetes e.g. in Europeans

Figure 17. The hypothesised evolution of insulin resistance genes (Modified from Brand-Miller & Colagiuri 1999)

5.2.4.5 The usefulness of glycaemic load as a marker for optimal diet

Choosing individual foods on the basis of their glycaemic response can be complicated and in cases misleading. For example, some refined grain products elicit a lower glycaemic response than their wholegrain counterparts [e.g. doongara white rice has a GI index of 59 compared to 76 for brown rice (Brand-Miller et al. 1998) simply due to differing ratios of the starch constituents amylase and amylopectin, which vary in their rate of digestibility (Thorburn, Brand & Truswell 1987)]. Choosing refined products over whole unprocessed equivalents results in a micronutrient-inferior diet. Hence, from a more holistic perspective, it is argued in this thesis that, over the long run, a nutritionally inferior diet may be more detrimental to health than the effects of a slightly variable glycaemic load.
Furthermore the glycaemic load of a whole day’s dietary intake is more relevant than the glycaemic load of individual foods because GL is influenced by numerous dietary parameters including fibre intake and the proportion of fat/protein consumed in conjunction with carbohydrates. Therefore, selecting foods based on glycaemic load alone does not guarantee a healthy diet.

For these reasons, GL is not emphasised as a marker for optimal diet in this thesis. Rather, balanced meals derived from whole foods (non-refined) including vegetables, fruit, fish, meat, nuts and seeds will inherently elicit a low glycaemic response.

### 5.2.5 Sodium/potassium ratio

The sodium-potassium ratio has been dramatically altered in contemporary diets due to a very low intake of potassium-rich fruit and vegetables, and the addition of table salt to foods, especially processed/pre-packaged foods.

In traditional hunter-gatherer diets the main sources of sodium were extracellular fluids from animals (blood in particular); (O'Dea 1994), with fruit and vegetables providing the remainder of this important, but minimally required nutrient.

During evolution, all terrestrial organisms had to endogenously conserve sodium in order to be able to move from the sodium-abundant ocean to the sodium-poor land (Eaton, Eaton & Konner 1997). Humans, along with all other land-based animals, are now reliant on a dietary abundance of potassium and a relatively low level of sodium. Yet humans are the only free-living, non-marine mammal to consume more sodium than potassium.

There is strong evidence to suggest that diets high in sodium and low potassium are implicated in a number of conditions including hypertension, stroke, kidney stones and osteoporosis (Australian Institute of Health and Welfare 2006b).

Interestingly, despite the clear link between dietary sodium intake and elevated blood pressure, cardiovascular disease and osteoporosis, Australia currently has no national data on salt consumption among the population (Australian Institute of Health and Welfare 2006b).
Welfare 2006b). Sodium and potassium intakes in average United States diets, which are likely to be not dissimilar to Australian diets, can be seen in Table 32 compared to estimated consumption patterns in hunter-gatherer diets.

<table>
<thead>
<tr>
<th></th>
<th>Paleolithic intakes (mg/day)</th>
<th>Average intakes in Western diets (mg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium</td>
<td>768</td>
<td>4000</td>
</tr>
<tr>
<td>Potassium</td>
<td>10500</td>
<td>2500</td>
</tr>
<tr>
<td>Sodium: Potassium ratio</td>
<td>0.07</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Table 32. Sodium & potassium intake in average Western diets compared to average hunter-gatherer diets (Sourced from Eaton, Eaton & Konner 1997)

Clinical studies on traditional Yanamamo and Xingo American Indians as well as the Asaro people from New Guinea, whose diets are free of added salt, showed that they had an average blood pressure of 102/62 mmHg (and displayed no age-related blood pressure increases which are so common in Western countries); (Eaton, Eaton & Konner 1997; Oliver, Cohen & Neel 1975). By comparison, the mean systolic pressure of Australians aged over 65 is 143 mmHg (Australian Bureau of Statistics 1998).

The public health message to reduce salt intake has been unanimously delivered and is easily followed when a diet is devoid of processed foods, and added salt is infrequently consumed.

### 5.2.6 Fibre content

Fibre intake is naturally high in most traditional hunter-gatherer diets. Many wild vegetables and fruits are more fibrous than modern cultivated equivalents. Irrespective of this difference, fibre intake in fruit and vegetable abundant ‘contemporary hunter-gatherer diets’ is well in excess of recommended adequate intakes (see Chapter 8).

The average Australian’s daily intake of fibre is 26g and 20g per person for males and females respectively, much of it derived from cereal grains (Australian Institute of Health and Welfare 2006b), not vegetables (including starchy vegetables) and fruit as per the hunter-gatherer model. Recommended adequate intake levels for Australian adults are 25–30gm per day (NHMRC 2006). By comparison, the author’s example of a ‘contemporary hunter-gatherer diet’ outlined in Chapter 7 Part I, contains 67.5gms of
fibre – over double the recommended intake level. Depending on the amount and type of plant food consumed, some hunter-gatherer diets may have had an even higher fibre intake than this. Excessive fibre intakes could become problematic by reducing mineral bioavailability; however, this is not a risk with fruit- and vegetable-derived fibre in the context of ‘contemporary hunter-gatherer diets’ as proposed in this thesis. Supporting evidence for this comes from the NHMRC (2006), which has not set an upper intake level for fibre because ‘we are of strong conviction and can find no convincing evidence that any dietary fibre, even when consumed in large amounts (i.e. 50g total dietary fibre per day), has or should have any adverse effect on mineral absorption or nutrition in humans’ (NHMRC 2006 p.48).

Adequate fibre is essential for a range of physiological functions including normal bowel function, gastrointestinal mucosal integrity, its ‘mop and sponge’-like action in reducing total and LDL cholesterol, providing fermentation byproducts and slowing gastric emptying which improves glycaemic control, among other health effects (James et al. 2003). Fiber intake in isolation doesn’t need to be further emphasised in this thesis because it is inherently taken care of in the context of the ‘contemporary hunter-gatherer diets’ proposed.

### 5.2.7 Acid-base status

Dietary composition is an important influence on endogenous acid-base balance; as are other factors including respiratory function (breathing), high intensity exercise (lactic acid production) and the functional capacity of the kidneys and liver (Remer 2001). While multiple homeostatic mechanisms operate in the body to mitigate deviations in our body’s systemic acid-base equilibrium, on average, blood acidity is subtly increased and plasma bicarbonate (buffer) is decreased in proportion to the magnitude of the daily net acid load (Sebastian et al. 2002).

The body modulates acid-base status by determining intestinal absorption rates of acid producing substrates, metabolic activity in the liver, respiratory compensation, and through urinary excretion (elimination of acid producing substrates); (Remer 2001). Despite these powerful compensatory mechanisms, increasing evidence suggests that chronic, low-grade acidosis is common in the population, and the on-going operation of
responding homeostatic mechanisms results in depletion of body stores of alkalizing minerals including calcium from bones, and low-grade kidney damage, which worsens over time (Sebastian et al. 2002). Hence, acid-base status is pathologically implicated in the aetiology of osteoporosis, hypertension, kidney stones and renal insufficiency (Dawson-Hughes, Harris & Ceglia 2008; Frassetto et al. 2001; Sebastian et al. 2002; Welch et al. 2007) – all of which are age related (time related), potentially resulting from long term ‘wear and tear’ on endogenous acid-based homeostatic mechanisms. In addition, low grade acidosis activates nociceptors and produces a feeling of achiness (Wemmie, Price & Welsh 2006). A study by Vormann et al. (2001) found that the simple addition of an alkaline multi-mineral supplement significantly reduced pain symptoms in patients with chronic lower back pain.

Diet can be consciously used to modulate/buffer endogenous acid-base status. After digestion, absorption and metabolism, foods including fish, shellfish, meat, eggs, dairy foods and cereal grains are net acid producing. Fresh fruit and vegetables (including root vegetables – a carbohydrate alternative to grains) are net base yielding. Legumes yield neutral values, and sodium chloride (table salt) is acid producing due to the chloride ion (Cordain et al. 2005; Frassetto et al. 2001); (see Table 33). Therefore, in a simplified way, the high alkali excesses of fruits and vegetables – predominantly their abundance of potassium – ‘off set’ acid-yielding protein foods (Manz 2001; Vormann & Daniel 2001). This is further enhanced by reductions in table salt. Generally, the ratio of potassium to protein is indicative of endogenous acid-base balance (Mann 2007b). Dietary supplements of potassium bicarbonate have been demonstrated to improve calcium balance, reduce bone resorption and, interestingly, mitigate the normally occurring age-related decline in growth hormone secretion (Frassetto et al. 2001), which suggest that acid-base status has far reaching physiological consequences. This is not surprising given that the pH of bodily fluids is a central determiner of metabolic activity and functional capacity.
The ratio of fruit and vegetables to protein is considered in this thesis as the most practical way to think about acid-base status. Hence, while protein is the primary determinant of dietary-derived net endogenous acid production (along with dairy foods and cereals grains to a lesser extent), it is protein intake relative to alkalizing mineral intake (i.e. fruit and vegetables) that is important. As such, modern high-protein diets that are devoid of fruit and vegetables risk a significant daily net acid load.

To understand what the estimated net systemic acid load of average modern diets are relative to pre-agricultural diets, Sebastian et al. (2002) modelled estimated net endogenous acid production for various plant-to-animal subsistence ratios. In this informative study, the authors estimated that the average United States diet yields a net endogenous acid production of +48 mEq/day. This level of acid production would not be dissimilar in the average Australian diet. In contrast, for example, based on the

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26 Calculations based on the daily net acid load for a 10,460kJ hypothetical diet, for which a single food group is solely consumed. Included in each calculation is an additional 32.9mEq/day to account for diet-independent organic acid production (an estimate only). For example, the total net endogenous acid production for a 10,460kJ diet entirely comprised of cereal grains = 25.5 mEq/day + 32.9 mEq/day = 60.4 mEq/day. Refer to original article for further information on calculation methods.

27 This is the sum of endogenous production rates of sulfuric and organic acids minus bicarbonate.
Paleolithic dietary modelling done by Eaton and Konner (1985) in which the average animal-to-plant food energy ratio was 35%:65% and animal fat supplied 26% of the animal food energy, the estimated net endogenous acid production would have been -78 mEq/d. Our evolutionarily adapted diet was base yielding. The estimated acid load (according to the modelling performed by Sebastian et al. 2002) of the ‘contemporary hunter-gatherer diet’ example provided in Chapter 7 Part I (also see Appendix N for its nutritional composition) is exceedingly base yielding: approximately between -170 mEq/day and -195 mEq/day.

Consequently, our contemporary shift away from consuming alkali-rich fruit and vegetables to consuming acid-producing cereal grains and dairy foods, as energy-dense-nutrient-poor foods, in the presence of current protein intakes is acid yielding and in discord with our ancestral history. This problem is further compounded by high intakes of sodium chloride (table salt), and modern processing and preparation techniques which can lead to considerable losses of base-forming nutrients such as potassium, magnesium and calcium (Remer & Manz 2003; Tucker et al. 1999). In the face of all this complexity, the message is very simple: eat an abundance of fruit and vegetables grown in nutrient-dense conditions in the context of a diet comprised of hunter-gatherer food groups.
5.3  **The Whole Food Argument**

‘We cannot construct biological complexity that is faithful to the natural order of things, no matter how precisely we measure and know the component parts of these complex systems’ (T. Colin Campbell cited in Cordain & Campbell 2007)

5.3.1  **The whole food perspective**

The foundation of nutrition science as we currently know it has been built upon research examining the biological effects of specific nutrients and dietary components including macro and micronutrient intake, fatty acid composition, glycaemic load, sodium-potassium ratio and acid-base balance as analysed in this chapter. While each of these components is important, alone they do not tell the whole story about the synergistic healing potential of foods. Hence, as argued throughout this thesis, rather than getting too immersed in detail such as the glycaemic load of bread versus potatoes, or even the specific health effects of omega 3 fatty acids, the therapeutic potential of diet lies in a whole matrix of nutritive components found in natural foods that mirror our wild food supply. This is the whole food argument.

As discussed in Chapter 1 of this thesis, the word ‘whole’ is derived from the Greek word ‘holon’, which means both a single entity and the entire universe i.e. single entities are whole in themselves and also entwined synergistically into greater wholes (Wilber 2000, 2001). The word ‘food’ is derived from the Middle English word ‘fode’, which means to foster (Farlex 2009). Therefore, philosophically, ‘whole foods’ describe an integral perspective in which foods contain the fullest possible spectrum of synergistic nutrients that, when eaten, foster vitality and wholeness.

Looking at the question of ‘what constitutes optimal diet’ from a whole foods perspective enables us to hold reductionistic nutrient-by-nutrient knowledge and contextualise it into a more ultimate reality. The full function of a food is far greater than its specific nutrient effects and therefore needs to be holistically understood within a food environment that is far more complex than anything that can be matched with an equal proportion of isolated nutrients. We simply do not understand enough about all the...
interactive components of food’s effect on the human body and will be very limited and slow in addressing questions like ‘what is an optimal diet’ if nutrition is only viewed through the same lens as that used for assessing pharmaceutical drugs.

For example, high fruit and vegetable intake is associated with reduced cancer incidence in epidemiological studies (Hung et al. 2004; John et al. 2002). Vegetables like carrots are rich in β-carotene and this led researchers to hypothesise about the effects of β-carotene itself on cancer prevention. Yet it was found that synthetic β-carotene in supplement form offered no protection at all, and in fact may have increased mortality in the study cohort (ATBC 1994); (see Section 5.4 for more information). In a reductionistic science framework, creating long-term clinical trials that enable an understanding of how eating carrots effects health in free living humans is virtually impossible. Hence, it is understandable that the effect of β-carotene or any other nutrient in supplement form has, by necessity of the prevailing scientific paradigm of our times, taken precedence in research.

Consequently, as a culture we are poor at recognising the advantages of real whole foods, such as vegetables, for example, over a box of cereal, which has been refined and processed, has had vitamins and minerals added, and is packaged with advertising labels promoting benefits including, ‘high in fibre’, ‘added B groups vitamins’ and ‘low in saturated fat’ – all of which, from a marketing perspective, speak of a highly nutritious food. Yet, the lack of packaging around fresh vegetables, fruits, fish, meat and nuts (all the main hunter-gatherer food groups) leaves little opportunity for their inherent health benefits to be promoted and understood. Simply adding individual nutrients to processed foods that are recognised by scientific research as offering health promoting qualities does not in any way render that food superior compared to a whole food. We simply do not know enough to create any processed food with a nutritional equivalency to any whole food eaten in their natural form.

While at first glance it may seem daunting to attempt an integrated understanding of food from scientific, environmental, personal and cultural perspectives (i.e. as per integral theory); it is also relieving to be able to look beyond detailed debates such as, ‘How much vitamin B1 is in the muesli bar I’m about to eat in relation to the recommended daily intake?’; ‘How much and what type of carbohydrate should I eat?’; ‘Are there too many kilojoules in this handful of macadamia nuts?’; and ‘What’s the
glycaemic index of a grape?’ etc. A holistic evolutionary perspective opens the opportunity for us to settle on a more simplifying frame of reference.

Eating like a ‘contemporary hunter-gatherer’, as it is interpreted in this thesis, simply asks us to eat foods in their most unadulterated, natural state in patterns reflecting their availability and distribution in the wild food supply. The term ‘biological authenticity’ has been used to convey this concept. Therefore it means selecting a variety of hunter-gatherer food groups – fresh and unprocessed vegetables, fruits, fish, shellfish, unprocessed meats, eggs, seeds and nuts, and a very small quantity of honey. Other ‘whole’ foods include wholegrain cereals and dairy products. Non whole foods, as defined in this thesis, refer to highly processed products including refined grains, sugars and oils, and many packaged foods.

Understanding food from this perspective can happen incrementally towards greater authenticity. For example, a large component of the cardiovascular protective effects of the traditional Mediterranean diet have been attributed to the higher percentage of monounsaturated fat intake, predominantly from olive oil. However, new research is indicating that the antioxidant content of olive oil appears to be more important than the monounsaturated fat content in improving cardiovascular disease markers (Perez-Jimenez et al. 2007; Ruano et al. 2007). Antioxidant and other phytochemical characteristics are highest in the least refined, freshest, non heat-affected, extra virgin olive oils (and other fresh foods for that matter); (Nicoli, Anese & Parpinel 1999). In reality we are simply talking about olive ‘fruit’ juice which, as with any other juice, the fresher and least processed, the better its nutritional content. Hence, when seen from the most ‘biologically authentic whole foods perspective’, freshly pressed, minimally refined extra virgin olive oil more closely matches natural olives and is thus more health promoting. This way of thinking can then be further extended towards aiming for a greater degree of biological authenticity in the growing conditions of the olive trees themselves.
5.3.2 Food processing

Most food processing techniques are for preservation purposes. Without the use of some food processing techniques, at room temperature, fresh food spoils within days (e.g. meat, fruit and leafy vegetables) to weeks (e.g. root vegetables, nuts and seeds). For example, the reason that grains began to be refined was that it became apparent that the removal of the germ (sprouting part of the grain) and the bran (protective layer encasing the sprout) led to improved shelf life. This occurred because there was less water content and less net nutritional value left for bacteria to consume and hence spoil.

Use of the term ‘food processing’ usually implies the use of technology; however, no clear-cut definition is in place. Food processing techniques include preliminary operations such as cleaning, sorting, grading and packaging; processes including peeling, cutting, freezing; techniques which make water unavailable to micro-organisms and restricts growth and hence spoilage including drying, brining, adding sugar, restricting oxygen, freezing, the addition of preservative chemicals and irradiation; more complex techniques including grain milling, sugar refining, milk pasteurisation; and highly sophisticated techniques used in the production of ‘highly processed’ snack foods, breakfast cereals, biscuits, bread, confectionery etc (Lester 1994; Little 1994).

Lester (1994) summarised the benefits of food processing:

- waste reduction and hence cost thus allowing for efficient large-scale production
- a broadening of the geographical availability of foods
- improved food safety due to the eradication of pathogens and de-activation of natural toxins
- reduced time spent on food preparation in the home and increased convenience
- improved aesthetic qualities of food (appearance, flavour, appeal, palatability, variety).

All these points are true barring the last, due to its subjective nature. However, the down side is that as the complexity of food processing technology increases, levels of heat-labile and easily oxidized nutrients tend to decline. As such, the health-promoting capacity of many foods is wholly dependent on their processing and storage-life history. Studies have clearly shown that various processing techniques and storage times affect the content, activity and availability of many bioactive compounds (many decrease,
while others increase e.g. lycopene, an antioxidant in tomatoes, is unaffected by cooking and so as a result is more concentrated in tomato pastes and sauces). For example, the anthocyanin (an antioxidant phytochemical) content of commercial orange juice declines with increased storage time (Fiore et al. 2005). Industrially manufacturing prunes, by dehydrating fresh plums at 85–90 degrees for 18 hours destroys anthocyanins, significantly decreases flavonols (another class of phytochemicals) and drastically reduces vitamin C in relation to the temperature applied (Piga, Del Caro & Corda 2003). Similarly, commercial cold-storage periods reduces the antioxidant content of apples (Tarozzi et al. 2004). These aspects of food quality have generally been neglected in many nutritional and epidemiological studies, despite an increasing number of researchers recommending that the effects of cold-storage and the fate of natural and process-induced compounds be taken into account when examining the health protective benefits of foods (Nicoli, Anese & Parpinel 1999; Tarozzi et al. 2004).

5.3.3 Cooking with whole foods

Wild foods collected by hunter-gatherers were generally consumed within hours of being gathered or hunted, typically with minimal or no processing (Eaton, Eaton & Konner 1997). Many plant foods were eaten fresh and raw (O'Dea 1991a). Any processing was done with the purpose of detoxifying potential poisons (e.g. leaching techniques were commonly used to remove toxic/bitter compounds from wild tubers and other foods), increasing digestability, or increasing palatability (Bhandari & Kawabata 2004; O'Dea 1991a). Unlike modern food-processing technology, the food preparation techniques employed by hunter-gatherers tended to result in minimal loss of micronutrients (O'Dea 1991a).

As an example, the traditional preparative choices for various types of Australian bush plant foods are listed in Table 34.

<table>
<thead>
<tr>
<th>Edible portion</th>
<th>Preparative choices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruits</td>
<td>• discard seed and sometimes skin</td>
</tr>
<tr>
<td>Grass seeds</td>
<td>• wet mill and eat as a paste</td>
</tr>
<tr>
<td></td>
<td>• mill dry and use as a flour</td>
</tr>
<tr>
<td></td>
<td>• mill dry, add boiling water and soak overnight, and use as dough</td>
</tr>
</tbody>
</table>

295
<table>
<thead>
<tr>
<th>Edible portion</th>
<th>Preparative choices</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shrub seeds</td>
<td>• green seeds – steam in pods, split and eat seeds</td>
</tr>
<tr>
<td></td>
<td>• dry seeds – heat treat seeds, mill and use as a flour</td>
</tr>
<tr>
<td>Nuts</td>
<td>• shell and eat raw</td>
</tr>
<tr>
<td></td>
<td>• roast in coals, shell and eat</td>
</tr>
<tr>
<td></td>
<td>• some require leaching</td>
</tr>
<tr>
<td>Leafy greens</td>
<td>• boil and discard water</td>
</tr>
<tr>
<td></td>
<td>• roast in hot ash</td>
</tr>
<tr>
<td>Nectar</td>
<td>• suck from flowers</td>
</tr>
<tr>
<td></td>
<td>• wash from flowers with water</td>
</tr>
<tr>
<td>Gum</td>
<td>• eat raw</td>
</tr>
<tr>
<td></td>
<td>• soak in water and eat jelly</td>
</tr>
<tr>
<td>Mangrove fruits</td>
<td>• roast, soak in water, repeat if necessary</td>
</tr>
<tr>
<td>Flowers</td>
<td>• eat whole</td>
</tr>
</tbody>
</table>

*Table 34. Traditional preparative choices for various types of Australian bush plant foods (Modified from Cherikoff & Isaacs 1990 p.187)*

As can be seen in Table 34, if plant food wasn’t eaten fresh and raw, the most common form of food preparation for traditional Australian Aborigines was roasting on hot coals, baking in ashes or steaming in an earth ‘oven’ (Isaacs 1987). We can use this knowledge in ‘contemporary hunter-gatherer diets’ by eating a proportion of our fruits and vegetables raw (as appropriate), and using simple cooking methods such as low to moderate heat baking, roasting, boiling and steaming for other foods.
5.4 Vitamin and Mineral Supplements within an Evolutionary Framework, Including a Specific Focus on Calcium

5.4.1 Vitamin supplements in an evolutionary context

Nutritional supplements are widely used in the Australian population today. Contextualising their use within an evolutionary framework is the focus of this section. Our hunter-gatherer ancestors, of course, only had foods as a means for taking in nutrients, not supplements. Hence, the isolated doses of individual nutrients available today in supplement form do not have any precedence in human evolution. This section examines patterns of supplementation use in Australia, their potential impact on health and disease, and most importantly, their potential role, if any, in a ‘contemporary hunter-gatherer diet’.

As will be observed through Chapters 7 and 8, there are only two nutrients that potentially fall short in a ‘contemporary hunter-gatherer diet’ (as proposed in this thesis) compared to the recommended nutrient reference values (NHMRC 2006):

1. Long chain omega 3 fatty acids (because we no longer typically eat organ meats, especially animal brains, in addition to a reasonable intake of aquatic species)
2. Calcium (due to the absence of dairy products)

Omega 3 fatty acid intake in the context of ‘contemporary hunter-gatherer diets’ is extensively explored in Section 7.2.3.4 and hence there is not need to extrapolate further here. Suffice to say that there is sense in supplementing with one (maybe two) fish oil capsules per day in a ‘contemporary hunter-gatherer diet’.

Calcium is given special consideration in this section because it is a mineral that is sourced from very different food groups in traditional hunter-gatherer diets compared to many modern diets. In the contemporary Australian diet the predominant sources of calcium are from dairy foods (milk, cheese, yoghurt) and their consumption is strongly
promoted on the basis of calcium’s role in bone health (NHMRC 2003). By comparison, sources of calcium in wild foods available to hunter-gatherers were from a broader array of animal and plant foods, including vegetables (particularly all types of leafy greens and wild tubers), nuts (e.g. almonds are a rich source), fruit (e.g. citrus fruits are reasonably high in calcium), insects and meat (and from animal bones if boiled up). As illustrated in Chapter 7, Part I (also see Appendix N), calcium intake in an example of a ‘contemporary hunter-gatherer diet’ can meet and can slightly exceed recommended levels; however, this can only be achieved by paying careful consideration to food choices.

Estimates of calcium intake in hunter-gatherer diets have ranged from 691mg (in a 9,200kJ daily diet) (Cordain 2002a) up to 1,500–2,000mg (Eaton & Konner 1985; Eaton, Konner & Shostak 1988; Eaton & Nelson 1991). The recommended dietary intake (RDI) for calcium for Australian adults is around 1000mg/day (NHMRC 2006).

Hence, this chapter will specifically examine calcium intake in traditional hunter-gatherer diets, the role of calcium in bone health, other factors involved in the aetiology of osteoporosis, and assess whether or not calcium supplementation may be indicated in the context of ‘contemporary hunter-gatherer diets’. All other vitamins and minerals are present in abundant quantities well in excess of recommended levels in contemporary hunter-gatherer diets (see Chapter 7, Part I & Section 8.3).

O’Keefe and Cordain (2004) state that ‘the hunter-gatherer diet is high in beneficial phytochemicals and antioxidants, thus rendering multivitamin and mineral supplements superfluous’ (p.103). The idea that an adequate, well-balanced diet meets all the recommended nutrient intakes, thus making supplementation unnecessary, is a common ideology in evolutionary nutrition circles as well as among many clinical nutritionists. However, there are several issues that need consideration in regards to this statement which are not commonly discussed. Firstly, evidence suggests that wild foods contain a higher micronutrient and phytochemical content than equivalent foods grown under conventional agricultural methods (Brand-Miller & Holt 1998; Netzel et al. 2006). Secondly, in contrast to our hunter-gatherer ancestors, we are now living in and consuming foods from an increasingly contaminated environment, which arguably may increase our micronutrient and antioxidant needs above hunter-gatherer requirements. Thirdly, through medical science and research it is increasingly possible to determine
genetic differences between individuals that might be responsive to specific nutritional changes, and in so doing enable the modulation of more favourable genetic expression.

It is undisputed that obtaining optimal nutritional status from food is the first priority. Evidence justifying the use of supplements to make up for dietary inadequacies, or as an ‘insurance policy’, or with the intention of modulating disease, is at present lacking. Some of the evidence that is available will be outlined in this section.

The limitation of nutritional supplements is that they contain isolated nutrients. The nutrients do not come embedded in their complex natural chemical matrix as they are present in food (even when several nutrients are combined together into multivitamin and mineral supplements). The potential effects of this divorce between nutrients and foods are not well understood, and may partly explain why many large supplementation trials have been unable to demonstrate clinical effects. Hence, opting for supplements before adequately addressing diet is very limited because in avoiding this critical step, the complex mix of health supportive dietary factors is lost, which in totality, can not be replaced by supplementation alone.

5.4.2  Vitamin and mineral supplements in the Australian population

A large percentage of the Australian population use supplements. The 1995 National Nutrition Survey (the most recent nation-wide survey on food and nutrient intakes) collected information on whether or not vitamin or mineral supplements were taken on the day prior to interview. Twenty-seven per cent of females reported taking a supplement compared with 15% of males. In terms of what supplements were taken, vitamin C was the most common (10% of females and 7% of males). Other supplements frequently taken were vitamin B (8% of females, 4% of males), multivitamins (6% of females and 4% of males), calcium (7% of females) and vitamin E (5% of females); (Australian Bureau of Statistics 1998).

Since the emergence of supplement products in the 1950s, their use has rapidly increased. The statistics quoted above are now over 10 years old. During the last decade the range and availability of nutritional supplements has dramatically increased and they
can now be readily purchased in supermarkets, pharmacies and from health care practitioners. Today there is widespread usage of vitamin, mineral, herbal and other natural products in the Australian community (Brownie 2005), however current quantitative national-wide data is lacking. Therefore it is likely that the 1995 National Nutrition Survey data now under-estimates the prevalence of supplement use. Smaller scale surveys confirm this likelihood. A study by MacLennen, Myers & Taylor (2006) found in a South Australian cohort that 52.2% used complementary and alternative medicines, the most common being vitamins, herbal medicines and mineral supplements. Interestingly, in this cohort, 46% of people used vitamins, minerals and/or herbal treatments for their mental wellbeing. Certainly in terms of expenditure, supplement use is big business. Vitamins are the second fastest growing packaged grocery category (AC Nielsen 2005), and an estimated $1,060 million was spent by Australians on complementary and alternative medicines in 2000 (MacLennan, Myers & Taylor 2006). By comparison the pharmaceutical benefits scheme expenditure in 2004–05 on Atorvastatin and Simvastatin – both cholesterol-lowering drugs which were the top two most prescribed medications – was $508.3 million, and $389.0 million respectively (Australian Institute of Health and Welfare 2006a).

5.4.3 **Potential clinical indications for nutritional supplementation**

There are five main perspectives from which nutritional supplementation can be viewed:

1. To correct classical specific nutrient deficiency states (e.g. treating scurvy with vitamin C).
2. To match recommended nutrient reference values (NRV) in the case of inadequate dietary intake.
3. To match estimated nutrient intakes for optimal nutrient status.
4. To treat specific individual nutrient needs. This could range from buffering exposure to increased environmental contamination; managing genetic polymorphisms [which generally lead to reduced metabolic activity and increase nutrient requirements (Gruner 2009)]; to treating nutrition-related illnesses, both sub-clinical and overt, that place a higher demand on nutrient usage e.g. diabetes, cardiovascular disease, cancer, obesity, inflammatory diseases etc.
5. To treat disease, with pharmacological dosages. Quantities used are often very high (several times the recommended levels) and used in short-term doses [e.g. using intravenous magnesium to assist in converting atrial fibrillation to normal sinus rhythm (Coleman et al. 2009); or high dose vitamin D supplementation in multiple sclerosis (Kimball et al. 2007); or intravenous vitamin C in cancer treatment and a variety of other conditions (Pauling & Moertel 1986)]. In these cases, nutrients are used like drugs and should be treated as such. Hence, this area is well beyond the scope of this thesis.

Many factors affect nutritional status. The nutrient content of the food we eat is the major player, but numerous other individual factors are involved including (Simopoulos 1994):

- appetite (including food choices)
- digestion (affected by issues such as gastro-intestinal microflora dysbiosis and disease such as inflammatory bowel disease)
- absorption (affected by factors including gastro-intestinal mucosal integrity, intestinal permeability, gastro-intestinal inflammation, transit time etc)
- nutrient utilisation (influences include genetic factors, age, enzyme activity, illness, and various synergistic effects e.g. nutrient ↔ nutrient and nutrient ↔ hormone/neurotransmitter).

In Australia today we rarely see acute nutritional deficiency syndromes. However, subtle, low-grade, chronic deficiencies are widespread – particularly if a hunter-gatherer model is used as a benchmark for optimal health (see Chapter 7). Over time, the body’s tissues become nutritionally de-saturated, which in turn compromises nutrient-dependant metabolic pathways and tissue function, which in turn results in an overt clinical lesion. This is the way in which the great majority of chronic diseases unfold and why they are considered to be diet-related conditions.
5.4.4  Substantiating evidence for the role of supplements in health and disease

Despite the frequency of their use in the population, as mentioned, conclusive experimental data attesting to their effectiveness is lacking. Research suggests that nutritional supplement users as a collective cohort are healthier than the population at large (Lyle et al. 1998). Supplement users tend to be more highly educated and health conscious, eat better, and be more affluent – all factors that are health protective in their own right (Lyle et al. 1998).

Much nutritional supplementation research has targeted the antioxidant vitamins (particularly vitamin E, C and β-carotene/vitamin A). Disturbances in redox poise (Linnane, Kios & Vitetta 2007a, b, c) and oxidative stress is involved in many chronic disease pathologies and therefore it has been hypothesised that antioxidant vitamins may be of benefit (Bjelakovic et al. 2008; MRC/BHF Heart Protection Study 2002; Simopoulos 2008). Dietary studies have consistently supported a positive trend between fruit and vegetable intake (rich in antioxidant vitamins) and chronic disease aetiology (for example Lin et al. 2009) as discussed elsewhere in this thesis. However the effectiveness of antioxidant vitamins used in supplement form appears to be far less clear, with confounders arising from variations in background dietary intakes and lifestyle patterns (e.g. smoking), which distort biochemical reality. Furthermore, because many antioxidant vitamins work in synergy and seem to be more effective when taken together in a pattern reflecting their natural occurrence in diet (Willett & Stampfer 2001), their use in supplementation form has been questioned.

While it is known that supplementation can increase serum levels of the intended vitamins or minerals (for example see GISSI 1999; MRC/BHF Heart Protection Study 2002), many large scale studies have not demonstrated significant differences in clinical endpoints. This is typical of much epidemiological or large cohort nutrition research because it is very difficult to prove the effect of individual nutrients and individual foods on health, particularly over a lifetime. This is not to say that all trials have shown no effect (e.g. a positive effect was found in GISSI 1999), but on balance, a lack of effect is more common than otherwise in the literature.
Some of the prominent large clinical trials assessing this issue include:

- The Heart Protection Study (HPS) in which over 20,000 high risk adults (in the United Kingdom) received antioxidant vitamin supplementation (600mg/day vitamin E, 250mg/day vitamin C and 20mg/day β-carotene) over five years. There was no significant difference in all cause mortality, vascular events, cancer incidence or any other disorder, and hence the authors concluded that although these antioxidant vitamins appear to be safe, they did not affect health outcomes (MRC/BHF Heart Protection Study 2002).

- Similarly, in the randomised Primary Prevention Project (PPP) 4,500 people without diagnosed vascular disease were given a daily supplement of 300mg synthetic vitamin E. However it had no effect on cardiovascular outcomes over a mean follow up time of 3.6 years (de Gaetano 2001).

- Likewise, in the Alpha-Tocopherol Beta-Corotene (ATBC) trial, 29,000 Finnish men who were smokers were given 50mg/day synthetic vitamin E or 20mg/day β-carotene. The synthetic vitamin E appeared to have no apparent effect on total mortality, however there was an 8% higher mortality among those men taking the β-carotene (from lung cancer and ischemic heart disease) (ATBC 1994). This trial raised significant concerns about the potential adverse effects of antioxidant supplements, particularly among those whose bodies are under very high oxidative loads (in this case from smoking). A negative association between β-carotene supplementation and those exposed to asbestos (a significant source of oxidative stress) has also been observed (Huang et al. 2006). The negative association between β-carotene (and other antioxidant supplements including retinol, lycopene and leutin) and smokers was recently confirmed in the VITamines And Lifestyle (VITAL) cohort study (Satia et al. 2009). The other issue that was raised partly in response to the ATBC trial was the potentially questionable safety of synthetic supplements.

- Nonetheless, the non-effect trend continued with the use of natural supplements. The randomised controlled Physicians Health Study found that over an eight-year period neither natural vitamin E (400 IU/every 2nd day) or vitamin C (500mg/day) supplements reduced risk of prostate or total cancer in over 14,000 males physicians (aged over 50 years) (Gaziano et al. 2009). Likewise, in females, the randomised controlled Women’s Health Study found that vitamin E (600 IU/every 2nd day) had no benefit on cardiovascular disease or cancer in almost 40,000 apparently healthy women (aged 45 years+); (Lee et al. 2005).
In much the same way, the Heart Outcome Prevention Evaluation (HOPE) trial used 400IU natural vitamin E in over 9000 high-risk patients and found no evidence of positive effects on vascular or other health outcomes (Yusuf et al. 2000).

Confirming all the above was a recent Cochrane review assessing the effect of antioxidant supplements (β-carotene, vitamins A, C, E and selenium). They found no evidence to support their role for primary or secondary prevention of mortality from various diseases (Bjelakovic et al. 2008).

Extending the examination of supplements trials beyond the antioxidant vitamins, the clinical picture is no clearer. A large review study looking at this issue broadly found that in the general adult population multivitamin/mineral supplements may prevent cancer in people with a suboptimal nutritional status, but aside from this situation they were of no apparent benefit (with limited exceptions); (Huang et al. 2006).

Of relevance to the next section of this chapter is the effect of calcium supplementation on bone density. Grant et al. (2005) found in a randomised placebo-controlled trial that routine oral supplementation with calcium (1000mg/day) and/or vitamin D3 (800 IU/day) did not prevent secondary fractures in over 5,000 elderly people (70 years+). Likewise, a meta-analysis by Bischoff-Ferrari et al. (2007) of 12 prospective cohort studies and randomised controlled trials suggested that calcium intake is not significantly associated with hip fractures in either men or women.

Hence, the overall picture of the scientific literature suggests that nutritional supplements in the doses studied offer no clear benefit to health. If anything, when the body is under high oxidative stress (e.g. from smoking) they may have adverse effects. From an evolutionary perspective it is difficult to interpret the findings of many supplementation trials because doses tend to be in excess of those found in typical hunter-gatherer diets. For example, it is almost impossible to consume the 400 IU dose of vitamin E (equivalent to 267mg natural d-alpha tocopherol) used in many clinical trials from food, as it would require the consumptions of approximately 1 kg of almonds (which are one of natures richest sources of vitamin E), or around 64 avocados per day (USDA 2009).
Supplementing to a dose that fits within dietary parameters that match our evolutionary/wild food experience may, however, be a different story in terms of health benefits. While little data is available to assess this situation, it is known that supplements are of most benefit to individuals whose diets are deficient (Huang et al. 2006). Therefore, within this thesis, the position taken is that using nutritional supplements to a dose that reflects the nutritional boundaries of wild food diets may be useful if it is not possible to obtain that nutrient level from the contemporary food supply. This approach can be modified to meet individual requirements including differences in food preferences, and biochemical individuality. Using supplements in doses beyond their plausible dietary availability sits outside the scope of this thesis. Calcium is used to exemplify this stance in the following section.

5.4.5 Calcium intake in ‘contemporary hunter-gatherer diets’

In any diet lacking dairy products there is much concern over calcium intake. As is demonstrated in Chapter 7 Part I and Section 8.3, the RDI for calcium can be met in ‘contemporary hunter-gatherer diets’ in the absence of dairy foods. However, in order to achieve this, careful attention needs to be paid to selecting non-dairy calcium-rich foods. If such attention isn’t paid, and dietary selection is more ad lib, which is advocated by philosophy in this thesis, the potential exists to be on the low end of the recommendation for calcium intake. Also, for some individuals, particularly if sedentary, daily calorie intake may be very low thus reducing the opportunity for nutrient flow through the body and may mean that recommended calcium intakes (along with other nutrients) are not met.

The RDI for calcium and estimated calcium intake in traditional hunter-gatherer diets are similar. As mentioned, the recommended dietary intake for calcium for Australian adults is around 1000mg/day, with a range of range 800–1500mg, depending on life stage (NHMRC 2006). Estimates of calcium intake in hunter-gatherer diets have ranged from around 700 to 2000mg/day (Cordain 2002a; Eaton & Konner 1985; Eaton, Konner & Shostak 1988; Eaton & Nelson 1991). Calcium intake stands out as the one nutrient for which the wild food supply does not supply well in excess of the recommended dietary intakes as set by the NHMRC for Australian Adults. In otherwise ‘exceptionally’
nutrient dense hunter-gatherer diets, calcium intake appears to be just ‘adequate’ by contemporary standards. As such, calcium has attracted more discussion and debate by evolutionary nutritionists and broader interested parties than any other single micronutrient (Nordin 2000). The recommended dietary intake level is designed to provide individuals with the protection against a negative calcium balance (and hence bone loss); (Gueguen & Pointillart 2000). However, surprisingly, the nutritional characteristics of the wild food supply and the quantities in which foods have been traditionally eaten throughout human evolution have played no part in the evidence base used in formulating recommended nutrient intake values.

5.4.6 Wild food sources of calcium: Australian native food sources

In hunter-gatherer diets, calcium was sourced from a wide range of plant and animal foods (beyond being breastfed as infants). As discussed elsewhere in this thesis, the largest wild food nutrition composition database available is comprised of Australian bush foods. Hence, calcium intake in traditional Australian Aboriginal diets provides fascinating insights into the sources of calcium in traditional diets. Clearly, wild food sources of calcium varied around the world depending on the type of food and the quantities in which they were eaten, so the dietary pattern of traditional Australian Aborigines simply provides an example. That being said, worldwide hunter-gatherer dietary characteristics were universally more similar than the difference between Western diets and hunter-gatherer diets. As discussed, diets were nutrient dense (no nutrient displacement with refined foods), the nutritional quantity (including calcium content) in wild food was typically high compared with contemporary cultivar equivalents (see for example Brand-Miller & Holt 1998), and hunter-gatherer lifestyles were protective against many chronic diseases, including osteoporosis.

Hence, the calcium content of Australian native foods can be used to highlight possible boundaries for calcium intake from an uncultivated wild food supply. The average calcium content in 829 wild plant foods consumed by Australian Aborigines is 104mg/100g (Brand-Miller & Holt 1998). Given that it has been estimated that Australian Aborigines living as traditional hunter-gatherers derived on average 20–40% of their food energy (depending on living location) from plant foods (this is a low
amount of plant food, typical of inland dwelling Aborigines from central and northern Australia – a low amount which is unable to be sensibly mirrored within our contemporary food supply – see Chapter 7 Part I), the average intake of calcium from plants would have been approximately between 374mg and 749mg per day in the context of a 12,500kJ average daily diet. Adding in the contribution of calcium from wild animal foods (non-dairy) which provide a mean calcium content of 22.7mg/100g (Eaton & Konner 1985) and a subsistence pattern assuming 60–80% of energy from animal foods, total calcium intake from both plant and animal foods would have ranged between 728mg and 1176mg per day. The upper range of some traditional Australian Aboriginal diets would therefore just fall within the NHMRC (2006) recommended guidelines.

Interestingly, using the same way of modelling the data in the context of traditional Australian Aboriginal diets, the average daily intake of magnesium would have ranged between 313mg/day and 626mg/day in the context of a 12,500kJ diet, assuming 20–40% subsistence from plant foods [Average magnesium content in 829 wild Australian plant foods is 87mg/100g magnesium (Brand-Miller & Holt 1998)]. The recommended dietary intake of magnesium for Australian adults in 400–420mg/day for males and 255–265mg/day for women (non-pregnant); (NHMRC 2006). Therefore, unlike calcium, wild Australian bush foods provide well in excess of the recommended daily intake of magnesium, despite a very low intake of plant foods in this example (plant foods are predominant sources of magnesium in the diet). Similarly, vitamin C levels in the traditional Australian Aboriginal diet are likely to range from between 90 and 180mg per day [this doesn’t include the Kakadu/green plum (Terminalia ferdinandiana) because of its extremely high vitamin C content (Brand et al. 1982). Yet the recommended daily vitamin C intake for Australian adults is only 45mg per day (NHMRC 2006). The pattern of nutritional ‘abundance’ – relative to contemporary recommended nutrient intakes – in the wild food supply follows for all nutrients except calcium.

One could argue that the calculations used here are based on a much higher kilojoule intake than that consumed by the average Australian today [i.e. 12,500kJ/day rather than

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28 Assuming 22.7mg calcium per 100g animal foods and 60%–80% subsistence from animal foods (60% = 1560gm calcium in a 12,500kJ diet; 80% = 2080gm calcium in a 12,500kJ diet) thus yielding a calcium intake of approximately 354–472mg/day from animal foods. Calcium content in animal foods however varies, thus making this an estimate only.
the average intake in the Australian population of 7,481kJ/day and 11,050kJ/day for females and males respectively (Australian Institute of Health and Welfare 2006b)], which allows for greater nutrient opportunity. However, this is not the point. Nowadays, relative to our hunter-gatherer ancestors, we are very sedentary and our nutrient flow is low both because there is a high degree of nutrient displacement in modern diets (less optimal food choices) and because the nutritional quality of contemporary cultivars tends to be lower than wild foods (Brand-Miller & Holt 1998).

For comparative purposes, the calcium content of various foods – both traditional Australian bush foods and commercially available foods – can be seen in Table 35.

<table>
<thead>
<tr>
<th>FOOD (raw unless stated as otherwise)</th>
<th>CALCIUM (mg/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wild foods:</strong></td>
<td></td>
</tr>
<tr>
<td>Mean calcium content of Australian native plant foods (n=236) (Brand-Miller &amp; Holt 1998)</td>
<td>103</td>
</tr>
<tr>
<td>Mean calcium content in Animal foods (n=85) (Eaton, Eaton &amp; Konner 1997)</td>
<td>22.7</td>
</tr>
<tr>
<td><strong>Non-commercial wild animal foods:</strong> (Brand-Miller, James &amp; Maggiore 1997)</td>
<td></td>
</tr>
<tr>
<td>Possum (wild northern brushtail - Trichosurus arnhemensis) (flesh, cooked)</td>
<td>25.0</td>
</tr>
<tr>
<td>Snake (Acrochordus species) (flesh)*</td>
<td>478.0</td>
</tr>
<tr>
<td>Magpie goose (Anseranus semipalmata) (flesh)</td>
<td>7.0</td>
</tr>
<tr>
<td>Magpie goose egg</td>
<td>34–62</td>
</tr>
<tr>
<td>Bogong moth (insect)*</td>
<td>126</td>
</tr>
<tr>
<td><strong>Commercially available wild animal foods:</strong> (Xyris Software 2007)</td>
<td></td>
</tr>
<tr>
<td>Whiting (fish)</td>
<td>37.0</td>
</tr>
<tr>
<td>Flathead (fish)</td>
<td>63.0</td>
</tr>
<tr>
<td>Abalone (shellfish)</td>
<td>30.0</td>
</tr>
<tr>
<td>Mud crab</td>
<td>40–360</td>
</tr>
<tr>
<td>Kangaroo</td>
<td>3.0</td>
</tr>
<tr>
<td><strong>Commercial domesticated animal foods:</strong> (Xyris Software 2007)</td>
<td></td>
</tr>
<tr>
<td>Lamb (chop, fat trimmed)</td>
<td>5.0</td>
</tr>
<tr>
<td>Egg</td>
<td>39</td>
</tr>
<tr>
<td>Milk (reduced fat)</td>
<td>137</td>
</tr>
<tr>
<td>Cheese (cheddar, reduced fat)</td>
<td>805</td>
</tr>
<tr>
<td>Cheese (fetta)</td>
<td>325</td>
</tr>
<tr>
<td>Yoghurt (reduced fat, plain)</td>
<td>160</td>
</tr>
<tr>
<td><strong>Uncultivated wild plant foods:</strong> (Brand-Miller, James &amp; Maggiore 1997)</td>
<td></td>
</tr>
<tr>
<td>Wattle (Acacia) seeds</td>
<td>100–213</td>
</tr>
<tr>
<td>Yam</td>
<td>9–18</td>
</tr>
<tr>
<td>Bush potato</td>
<td>4–116</td>
</tr>
<tr>
<td>Wild fig</td>
<td>70–176</td>
</tr>
<tr>
<td>Prickly pear</td>
<td>230</td>
</tr>
<tr>
<td>Bush tomato</td>
<td>38–130</td>
</tr>
<tr>
<td>Munyan leaves (leafy green)</td>
<td>29–333</td>
</tr>
</tbody>
</table>
FOOD (raw unless stated as otherwise) | CALCIUM (mg/100g)
---|---
Commercial cultivated plant foods: (Xyris Software 2007)
Sweet potato | 27
Orange | 25
Kale (cooked) | 154
Broccoli | 31
Almonds | 235
Avocado | 20
Fig | 38
Seaweed (dried) (100g is a huge quantity to eat though!) | 663

*Reptiles and insects are a particularly rich sources of calcium

Table 35. The calcium content of various foods, including Australian bush foods and commercially available foods

As can be seen in Table 35, the calcium content of dairy foods is superior to many plant and animal foods, and hence the rationale behind the inclusion of dairy in modern diets. Using a variety of methods, no research has demonstrated that the calcium in milk is more efficiently absorbed than most calcium salts from other food sources (Gueguen & Pointillart 2000). Hence, obtaining adequate calcium from non-dairy food is viable.

### 5.4.7 Calcium and bone health

Adequate calcium intake is promoted primarily on the basis of bone health (Australian Institute of Health and Welfare 2006b). However, several prominent studies have failed to find any correlation between dairy consumption, or dietary calcium intake in general for that matter, on bone mineralisation (Lanou, Berkow & Barnard 2005) and protection against fractures (Feskanich et al. 1997). Similarly, epidemiological research indicates that hip fracture rates in many developing countries are much lower than in the West despite lower calcium intakes (Nordin 2000; Simpoulous 1999), which is testament to the multitude of broader factors involved. Skeletal analysis of ancestral humans living during the Paleolithic period as well as more recently studied hunter-gatherers found them to be free from signs of osteoporosis despite no dairy food intake after weaning. Skeletal remains are noted to have prominent muscular insertions sites, large articular surface area size and significant cortical thickness, which indicates that hunter-gatherers were stronger and more muscular than many Westernised people today (Cordain 2002a; Eaton, Konner & Shostak 1988).
Optimal calcium intake, like all other nutrients, is thought to reduce the risk of a number of chronic diseases. However, the relationship between calcium and osteoporosis is the most studied aspect of calcium’s biological activity in the body (Bryant, Cadogan & Weaver 1999). Calcium’s direct role in osteoporosis is however not clear cut. Osteoporosis is a complex disorder with several known diet-lifestyle-genetic interrelating factors underpinning its aetiology (Simpoulous 1999). It is a disease that affects many Australians. In 2004–05, almost 600,000 Australians had osteoporosis (Australian Institute of Health and Welfare 2006a) and it is estimated that approximately 60% of women and 30% of men over the age of 60 years will suffer an osteoporotic fracture in their remaining lifetime (Pocock 2007).

Therefore, calcium intake, especially for the protection of bone health, cannot be viewed in isolation of a broad range of dietary and lifestyle factors. Not only are dietary sources of calcium different in modern diets (compared to hunter-gatherer diets), so too are a range of other confounding factors. Some known factors which support calcium homeostasis and optimal bone mineralisation include the following;

- Physical exercise. Weight-bearing exercise stimulates osteoblast activity (Adami et al. 2008; Rector et al. 2009).
- Adequate sunlight (vitamin D status); (Holick 2004; North American Menopause Society 2006; Working Group of the Australian and New Zealand Bone and Mineral Society; Endocrine Society of Australia; Osteoporosis Australia 2005).
- A high fruit and vegetable intake. The alkaline-producing properties of fruit and vegetables contribute to the maintenance of bone mineral density (Tucker et al. 1999).
- A net base yielding diet and the minimisation of systemic metabolic acidosis (Sebastian & Morris 1994; Tucker et al. 1999). Skeletal calcium is used to buffer metabolic acidosis, as discussed in Section 5.2.6. A base yielding diet is achieved in ‘contemporary hunter-gatherer diets’ by consuming a high intake of fruit and vegetables and a low intake of acid yielding grains and dairy. Protein is the primary source of dietary derived endogenous acid production. However, it is not protein intake per se that is of concern, but rather protein intake in relation to alkalizing mineral intake i.e. from vegetables and fruit. Hence, a high protein intake combined with a lack of fruit and vegetables, along with inadequate vitamin D status and physical inactivity – all of which are commonly seen in
many Australians (irrespective of calcium intake) – is problematic for optimal bone health.

- Low glycaemic load diet. Poor glycaemic control may lead to increased bone resorption (Yasuda & Wada 2001).
- A lower sodium intake. High salt intake increases obligatory loss of urinary calcium (NHMRC 2003) and this is ameliorated by potassium intake (Harrington & Cashman 2003) – preferably from increasing fruit and vegetable intake.
- Adequate long chain omega 3 fatty acid intake is associated with higher bone mineral density (Griel et al. 2007; Hogstrom, Nordstrom & Nordstrom 2007).
- Adequate, but not excessive, protein intake (Bilsborough & Mann 2006; Stanton 2005). Protein is an important structural component of bones and adequate intakes are associated with a reduced incidence of fracture (Munger, Cerhan & Chiu 1999).
- A lower intake of anti-nutrients (e.g. phytates from grain and legumes including soy), which reduces mineral bioavailability (NHMRC 2003).
- Avoidance of excessive phosphorous intake (particularly from carbonated cola soft drinks); (NHMRC 2003). Phosphorous to calcium balance is critical for optimal bone mineralisation.
- Low caffeine intake (Derbyshire & Abdula 2008; Wahlqvist & Wattanapenpaiboon 1997).
- Normal menstrual patterns in women (oestrogen stimulates bone mineralisation) (Stanton 2005) and maintenance of body mass index (Cole, Dennison & Cooper 2009).
- Minimisation of chronic stress. Reduced bone mineral has been noted in women with depression (possibly due to cortisol’s calcium depleting effects) (Michelson et al. 1996).
- Avoidance of environmental contaminants including tobacco smoke, alcohol, heavy metals and nutrient depleting drugs (Berlin 2009; Cole, Dennison & Cooper 2009; Kozuka 1995; Olszynski et al. 2004; Rapuri et al. 2000).
5.4.8  Is there a role for calcium supplementation in the context of dairy-free ‘contemporary hunter-gatherer diets’?

In the context of a dairy-free ‘contemporary hunter-gatherer diet’, if a range of calcium-rich foods are not actively sought out and consumed in adequate quantities, a calcium intake lower than the recommended dietary intake (which also matches estimated intakes in hunter-gatherer diets) is probably to be expected. Hence, a calcium supplement may be sensible in order to reach the recommended dietary intake. A quality supplement, taken in divided doses [i.e. low dose, frequently taken (North American Menopause Society 2006)] best mirrors calcium’s steady availability in the natural food supply. Both background dietary intake and supplemental dosage needs to be considered in relation to the recommended daily intake level.

Combining this dietary approach with other protective lifestyle factors including being physically active, maintaining a lean healthy body mass, achieving optimal vitamin D status, and managing stress (cortisol levels) will collectively be very advantageous in supporting good bone health throughout life.
Chapter 6: Translating Theory into Practice – A Critique of Prominent Interpretations of Modern ‘Paleolithic’ Diets

6.1 Introduction and Chapter Scope

The theory of evolutionary nutrition and its relevance to our modern-day needs is compelling. How to best interpret the theory within the context of our contemporary food supply is of most interest to this thesis. The interpretations of three leading evolutionary nutrition researchers who have widely published their versions of eating like a ‘contemporary hunter-gatherer’ are critiqued in this chapter.

This chapter, along with the analysis found in Section 2.3 (examination of the available evidence on hunter-gatherer subsistence patterns) and the dietary modelling work in Chapter 7 Part I, sets the scene for the authors’ interpretation of ‘contemporary hunter-gatherer diets’ that best fit within our modern Australian food supply, which are presented in Chapter 8.

Interpretations of the following three researchers are critiqued:

1. **S. Boyd Eaton**, is a United States medical doctor and was the principle author of the seminal paper, ‘Paleolithic nutrition: a consideration of its nature and current implications’ published in the New England Journal of Medicine (Eaton & Konner 1985). While anthropological and archeological interest in our hunter-gatherer ancestors has always been strong, Eaton has been prominent in bringing the information into the medical arena. The collective ideas of Eaton, Shostak and Konner are published in their book *The Stone Age Health Program: diet and exercise as nature intended* (Eaton, Shostak & Konner 1988). It is the
interpretation of a modern hunter-gatherer diet as presented in this book that is critiqued in this chapter.

2. **Loren Cordain**, PhD, likewise lives in the United States and is an academic at Colorado State University. Having published several papers with Eaton, Cordain’s early theoretical grounding is not dissimilar. Cordain has furthered Eaton’s work in the area, and his interpretation for how to eat in accord with our evolutionary needs using contemporary foods (based on the USA food supply) is the most extensive to date. The synthesis of his work is presented in his book, *The Paleo Diet: lose weight and get healthy by eating the foods you were designed to eat* (Cordain 2002b). The crux of Cordain’s interpretation as it is presented in this book along with his research paper *The nutritional characteristics of a contemporary diet based upon Paleolithic food groups* (Cordain 2002a) is analysed in this chapter.

3. **Staffan Lindeberg**, PhD and Swedish medical doctor has also worked with Eaton and Cordain. His work in the late 1980s with the people of Kitava (an island in Papua New Guinea’s archipelago) – one of the last remaining hunter-gatherer populations with indigenous dietary habits – provides an authentic perspective. Lindeberg was also the principle researcher of the first randomised clinical trial of a modern ‘Paleolithic Diet’ (Lindeberg et al. 2007). Both the information contained on Lindeberg’s website (Lindberg 2007) and his clinical trial are analysed in this chapter.

As will be seen in the following analysis, despite these well-known researchers’ similar theoretical grounding and their collaborative research papers, their individual versions of modern ‘hunter-gatherer’/‘Paleolithic’ diets vary. Sometimes differences are a consequence of the extent of the scientific knowledge available at the time of publication. For example, the majority of Eaton’s work was published prior to Cordain’s, and prior to some developmental leaps in fatty acid research. At other times the variations perhaps just highlight differing personal views and interpretations.
6.2 S. Boyd Eaton

Eaton et al. (1988) outlined a hierarchy of nutritional principles to help people achieve a modern Paleolithic diet\(^{29}\). He outlines three priority levels, which are presented here (written in italics) with evaluative notes from the author of this thesis following in plain text.

**Level A – highest priority in making food choices:**

- *Total Fat Content:* ‘if two food items differ in fat content, the one with less fat is almost always the better choice’ (p.136). The simplicity of this statement risks an inappropriate interpretation. On the basis of this recommendation, one may choose to exclude fatty avocados, nuts, coconuts, organ meats etc – all of which are authentic natural whole foods consumed in traditional hunter-gatherer diets. Specifying a low intake of animal derived saturated fat would perhaps be more apt. According to Cordain et al. (2000), total fat content in traditional hunter-gatherer diets may have varied widely (28–58%), but animal-derived saturated fat intake was unanimously low.

- *Polyunsaturated versus Saturated Fat intake:* ‘fats that are more polyunsaturated and/or monounsaturated are preferable’ (p.136). This statement still holds true; however, since the late 1980s when Eaton’s book was published, fatty acid research has evolved and there is now an understanding of the different physiological functions of the various types of polyunsaturated fats. This has culminated in more specific advice to increase omega 3 fat intake, reduce omega 6 fat intake and to ensure adequate monounsaturated fat (as discussed in Section 5.2.3).

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\(^{29}\) In the literature, ‘hunter-gatherer diets’ and ‘Paleolithic diets’ are used inter-changeably. The three authors presented in this chapter all use the term ‘Paleolithic diet’, unlike in this thesis which uses the term ‘hunter-gatherer diets’. The language choice of the presented authors is however used in this chapter.
Level B – moderate priority:

- **Sodium and Potassium**: ‘the less salt the better...foods with more potassium than sodium are preferable’ (p.136). Reducing salt intake naturally occurs when processed and ‘take away’ foods are avoided and table salt is not added to food. Intentionally choosing foods with more potassium than sodium is perhaps unnecessary attention to detail because in a whole food diet, when abundant fruit and vegetables are consumed, sodium to potassium ratio appropriately takes care of itself.

- **Fibre Content**: ‘the more the better’, but not from supplements (p.136). A whole foods diet rich in plant food inherently provides plenty of fibre and hence probably doesn’t need to be a primary focus.

- **Cholesterol content**: ‘foods containing less cholesterol should generally be chosen’ (p.136). Understanding has now shifted to the awareness that dietary cholesterol intake need not be excessively emphasised for most individuals in comparison with reducing animal derived saturated fat intake and modulating inflammatory markers.

- **Calcium content**: ‘high calcium foods are better choices’ (p.136). As discussed in Section 5.4, non-dairy sources of calcium foods do need to be carefully chosen in order to meet daily intake recommendations.

Level C – supplemental priority:

- **Macronutrient composition**: ‘with all other priorities satisfied, a carbohydrate: protein: fat pattern of 60:20:20 is ideal’ (p.136). Carbohydrate should be sourced from fruits, vegetable and whole grains. Protein should be derived from low fat sources, and fat should be from polyunsaturated rather than saturated sources. In a general sense, these characteristics are an outcome of ‘contemporary hunter-gatherer diets’ as interpreted in this thesis.

- **Caloric content and nutrient density**: ‘foods combining fewer calories and greater bulk are better choices’ (p.136). This characteristic is natural in whole food diets.

As discussed in Section 5.3 (whole foods argument), emphasising any one particular dietary component (e.g. macronutrient composition, calcium content, potassium content) has the potential to make food selection overly complex, and risks missing a more
important bigger picture. Each of these individual factors are inherently addressed in
diets containing diverse plant and animal foods that are grown in their most biologically
authentic state and eaten in quantities reflective of their availability patterns in the wild.

Eaton et al. (1988) also outline what foods to include in our modern diets (written in
italics; with comments from the author of this thesis in plain text):

- **Meat and fish**

- **Fresh fruit and vegetables.** ‘It’s hard for a diet to contain too many fruits or
vegetables’ (p.138). This concept is echoed in this thesis. In contrast to the
views presented in this thesis, Eaton cautions against the use of avocados
because the fat ‘is largely saturated’ (p.139). However, per 100g, avocados
contain only 2g saturated fat, 10g monounsaturated fat and 2g polyunsaturated
fat (USDA 2009). Eaton’s concern about plant-derived saturated fat is possibly
unfounded as discussed in regards to coconuts in Section 5.2.1.7. Plant-derived
fats in the quantities present in whole foods (not refined into oils) are used
reasonably liberally in interpretations of ‘contemporary hunter-gatherer diets’ as
presented in Chapters 7 and 8.

- **Nuts.** Eaton calls for discretion when including them in our modern diet, stating
that ‘some, especially macadamias and coconuts, are unacceptably high in
saturated fat. Walnuts, sunflower seeds, and to a lesser extent pecans, hazelnuts,
and almonds, have good polyunsaturated to saturated fat ratios and can be
eaten with moderation’ (p.139). Preferentially selecting one type of nut over
another is arguably in discord with the hunter-gatherer model whereby food
choice was simply governed by location and seasonal availability. For example,
macadamia nuts were abundantly eaten in the diets of some Australian
Aboriginal tribes. Being overly concerned with isolated nutritional
characteristics, e.g. the fat content or fatty acid ratios of individual foods,
exposes the tendency to get swayed by reductionistic conclusions even if they
are in discord with overall more holistic guiding principles. As such, now that
fatty acid research is de-emphasising omega 6 intake (in the context of modern
diets), Eaton may nowadays have been inclined to eliminate sunflower seeds,
pecans, hazelnuts and almonds from his list because they are so rich in omega 6
fats. The scientific literature will continue to ebb and flow in understanding and
emphasis. Working with a dietary paradigm which is more stable than this will
help reduce confusion. This point of stability can be found – as concluded in
this thesis – in selecting a diverse omnivorous whole food diet from plant and animal foods that are themselves living in an optimal state of health.

- **Low fat dairy products**: ‘although pre-agricultural people had no milk products after early childhood, this is not reason enough for us to avoid them’ (p.140). In contrast to Eaton, given that dairy is a very recent inclusion in the human diet it has been excluded from ‘contemporary hunter-gatherer diets’ in this thesis. The impact of doing so on calcium intake is discussed in Section 5.4.

- **Eggs**: In the wild, eggs are a seasonal food, unlike in modern diets. Eaton is concerned about the saturated fat and cholesterol content of eggs and his solution is to *discard half or more of the yolks or use egg substitutes*. This recommendation is of course contradictory to authentic hunter-gatherer diets and doesn’t subscribe to a whole food argument which is promoted in this thesis.

- **Wholegrain bread and cereals**: Eaton recommends their inclusion on the grounds of their ‘excellent nutritional properties...and good source of fibre’ (p.141). In contrast, this thesis recommends their inclusion in modern diets only in quantities reflecting their availability in the wild (limited and seasonal).

- **Fats and oils**: ‘butter, cream, lard, coconut, chocolate, and palm oil are to be avoided’ (p.141). This is on the basis of their saturated fat content. The differentiation of whether it is plant (e.g. coconut flesh) versus animal (e.g. butter, cream) derived is not made. As alternatives Eaton suggests soft margarines/oil made from vegetable oils – safflower, sunflower, soybean, or corn oil. Each of these oils are rich in omega 6 fats. These alternative recommendations are now somewhat outdated in the light of recent fatty acid research attributing a plethora of health problems to very high omega 6 intakes on the backdrop of low omega 3 intakes in modern diets, as previously discussed. In hunter-gatherer times the technology was of course not available to extract oils and make margarines, hence averting the problems of over-consuming plant oils.

While the theory behind Eaton’s work is in accord with the approach of this thesis, his recommendations for contemporary diets based on evolutionary nutrition principles are a compromise. His sample menus include many non-hunter-gatherer food groups. For example, breakfast options include the following: fruit juice, fruit, whole wheat toast or
muffins, cereal (e.g. porridge, shredded wheat), pancakes or waffles (buckwheat or whole wheat), frozen fish fillets, jams, walnuts, dried fruit, and skim milk (p.148). This analysis highlights the opportunity for increased authenticity in translating theory into practice. Loren Cordain’s work has markedly added to this area.
6.3  **Loren Cordain**

Cordain (2002a) states, ‘it is entirely possible to consume a nutritionally balanced diet from commonly available contemporary foods that emulate the food types available to Paleolithic hunter gatherers’ (p.18). His interpretation for how to best do so follows.

Food groups included in Cordain’s (2002b) contemporary ‘Paleolithic diet’ are:

1. Fruit
2. Non-starchy vegetables
3. Lean meat (only turkey and chicken breast, pork loin trimmed of fat and beef sirloin tip trimmed of fat are included so as to mirror the leanness of wild animals)
4. Seafood (fish, shellfish)
5. Nuts/seeds

Exclusions:

1. Grains (e.g. bread, cereals, rice, pasta and corn)
2. Dairy
3. Legumes [dried beans and lentils. In Cordain’s (2002b) book, he extends this interpretation to excluding fresh beans, snowpeas, sugar snap peas etc]
4. Starchy root vegetables (e.g. potatoes, yams, sweet potatoes, cassava/tapioca)
5. Processed food (fried foods, commercial baked goods and most packaged and snack foods)

None of the three researchers whose work is presented in this chapter place any emphasis on preferentially including aquatic animals. Rather, both lean meats and fish/seafood are recommended equally. This is in contrast to the interpretation presented in this thesis, in which aquatic foods are preferentially weighted as per Cunnane’s (2005) hypothesis (see Chapter 8).

Unlike in the Cordain model (2002a, b), wholegrains (in minimal quantities reflecting their availability in the wild) are included in ‘contemporary hunter-gatherer diets’ as interpreted in this thesis. Similarly, fresh legumes such as fresh broad beans, snowpeas, sugar snap peas, as well as fresh corn (grain), are also included and classed as fresh vegetables and consequently used as per seasonally appropriate. Dried legumes (e.g.
dried lentils, chickpeas, kidney beans) are included in quantities reflecting their wild availability, however they are not given the same priority as their fresh counterparts. Dissimilar to Cordain, starchy root vegetables are utilised (see Chapters 7 Part I and Chapter 8).

Cordain (2002b; O'Keefe & Cordain 2004) also suggests incorporating various plant oils into the diet – specifically olive, canola and flaxseed oils (suggesting up to 4 tablespoons per day). Inclusion of these oils is on the basis of attempting to mirror the fatty acid content of hunter-gatherer diets. These plant oils are used by Cordain in addition to him recommending other dietary sources of polyunsaturated fats from fish, animal livers, game meats (and other meats from grass fed animals), eggs enriched with omega 3 fatty acids30 (this ‘functional food’ approach is not taken in this thesis), walnuts and macadamia nuts (lower content of omega 6 fats relative to many other varieties of nuts), fish oil capsules and flaxseed oil (however, being plant derived, flax is rich in short chain omega 3 fats and given our limited endogenous conversion capacity flax cannot be considered a substitute for long chain omega 3 fats – see Section 5.2.3).

Olive oil is chosen by Cordain because of its high content of monounsaturated fats and thus it has been used to attempt to mirror the high monounsaturated fat intake in hunter-gatherer diets. Unlike this thesis, canola oil is also recommended by Cordain because of its monounsaturated fat content as well as its omega 6 to omega 3 ratio of 2:0 (USDA 2009). Cordain uses omega 6 to omega 3 ratios in his dietary modelling, unlike the approach taken in this thesis for reasons discussed in Section 5.2.3. While incorporation of olive oil and canola oil in contemporary diets enables Cordain to approximate the fatty acid intake of hunter-gatherer diets, this thesis suggests that the use of these two oils – particularly canola oil – is not necessarily the most authentic solution.

When being ultimately guided by principles of freshness, whole foods and consuming optimally healthy plants and animals, as is suggested in this thesis, it is difficult to be in favour of Cordain’s approach of emphasising oil consumption purely on the basis of its ‘favourable’ lipid composition. For example, most commercially available oils – including ‘extra virgin’ – are pressed some 12 months prior, and once opened are exposed to oxygen and thus slowly oxidize. Weighing up plant oils against, for example, a handful of fresh pine nuts (despite their very high omega 6 fat content), a fresh

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30 Omega 3 enriched eggs are the result of feeding fishmeal and flaxseed to chickens. These foods are not part of a chickens indigenous diet.
avocado or handful of macadamia nuts (both very high in monounsaturated fats) or fresh coconut flesh (high in saturated fat), highlights how interpretive differences can result when information isn’t contextualised into broader guiding principles and more holistic frames of reference. As per the ‘whole foods argument’ in Section 5.3, whole foods are given preferential weighting in this thesis over refined foods, including oils. This doesn’t mean that oils shouldn’t be used. It simply encourages their use to be contextually understood.

Canola oil is used in Cordain’s model, as he recognises it as a good source of omega 3 fatty acids (9g alpha linolenic acid per 100g). However, like flaxseed oil, as mentioned, being a plant oil it only contains short chain omega 3 fats, and given humans’ extremely limited capacity for endogenous conversion through to the biologically active long chain omega 3 fatty acids (see Section 5.2.3) – the type so deficient in contemporary diets – canola does not provide an entirely adequate substitute. Cordain’s grounds for including canola oil, other than on the basis of his fatty acid composition rationale, are difficult to grasp. On one hand he excludes cereal grains and dairy because they are novel food groups (along with starchy tubers), yet on the other hand he includes canola oil, which was only developed in the 1970s after extensive hybridisation so as to reduce mildly toxic levels of erucic acid and glucosinolates (bitter tasting) naturally present in rapeseeds (canola). [Hence, how the name was derived – Canadian oil low acid (Biotechnology Australia 2007). It was in Canada where low erucic acid canola was developed.] In justifying their use of canola, Cordain and Friel (2005) state that, ‘canola oil comes from the seeds of the rape plant, which is a close relative of broccoli, cabbage, brussels sprouts and kale…humans have eaten cabbage and its relatives since prior to historical times’ (p.207). However, this argument loses strength, particularly when held up against their exclusion of starchy tubers on the basis that contemporary hybridised cultivars carry a higher glycaemic index than wild counter-parts. Following this line of thinking, one could argue that heroin is a hunter-gatherer food because it is the highly refined isolate from poppy seeds. Clearly, an extracted, highly refined, isolate from a natural plant does not offer the same protection to human health as when it remains in its whole form. Canola oil, extracted from the heavily hybridised rape plant, is thus not included in ‘contemporary hunter-gatherer diets’ as interpreted in this thesis.

In reality, the inclusion or exclusion of canola oil is fairly irrelevant in the bigger picture (especially in the low quantities recommended by Cordain), particularly when so many other health promoting dietary aspects are operating e.g. dramatically increased fruit and
vegetable intake as advocated by Cordain. Rather, the canola oil ‘anomaly’, along with his inclusion of ‘diet’ soft drinks (despite Cordain himself cautioning that they contain artificial sweeteners), is indicative of the need for on-going critical evaluation of food from a more holistic perspective, not just on the basis of isolated nutritional characteristics e.g. fatty acid composition, or glycaemic response (the case of diet soft drinks), or specifics about macronutrient composition.

Cordain does, however, emphasise the macronutrient composition of diet in much of his work. He states, ‘consumption of low-fat dietary protein at the expense of carbohydrate is the nutritional pattern that is consistent with our species’ evolutionary history and represents a viable dietary option for improving health and well-being in modern people’ (Cordain 2002b p.1590). This is particularly the case if starchy root vegetables are eliminated from the diet. Unlike Cordain’s approach, for reasons discussed in Section 5.2.1, macronutrient proportions are de-emphasised in this thesis, beyond the recommendation to include an omnivorous diet.

The sample one day food menu presented by Cordain (2002a) in his paper, ‘The nutritional characteristics of a contemporary diet based upon Paleolithic food groups’ follows. It was designed for a 25-year-old female with a daily energy intake of 2200kcal (9,208kJ). In modelling this sample, Cordain has applied the assumption that animal foods contributed slightly more than half (55–65%) of the daily energy intake in average hunter-gatherer diets, and plant food contributed the remaining 35–45%. This breakdown was derived from his paper Plant-animal subsistence ratios and macronutrient energy estimations in worldwide hunter-gatherer diets (Cordain et al. 2000) as critiqued in Section 2.3.3.2. On this basis, Cordain (2002a) apportioned the daily energy of his contemporary Paleolithic diet in the following way:

- Vegetables = 15% of total energy
- Fruit = 15% of total energy
- Nuts/Seeds = 15% of total energy
- Lean Meats = 27.5% of total energy
- Seafood = 27.5% of total energy

Two key factors are not accounted for in this breakdown:

(i) In Cordain’s (2002a) example, a total of 55% of energy is derived from animal foods, but all of it is from lean meats and seafood, and thus omits fatty
(calorie dense) organ meats, bone marrow, fatty insects and fat deposits from what would otherwise be a more authentic subsistence equation. Directly substituting contemporary lean meats and seafood for the equivalent energy intake from animal foods in average hunter-gatherer diets supplies more protein than would naturally have been the case. Hence, this issue needs further interpretive work.

(ii) Starchy tubers are omitted from the sample. However, starch intake from root vegetables was a significant contributor to energy intake in many hunter-gatherer diets as established in Section 2.3. This opens up the question as to where these calories should then best be sourced in the absence of starchy vegetables. This issue is not adequately addressed in Cordain’s work. See Chapter 7 Part I for more details.

The sample menu presented by Cordain (2002a) follows in Table 36.

<table>
<thead>
<tr>
<th>MEAL</th>
<th>Food Quantity (g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Breakfast</td>
<td></td>
</tr>
<tr>
<td>Cantaloupe</td>
<td>276</td>
</tr>
<tr>
<td>Atlantic salmon (broiled)</td>
<td>333</td>
</tr>
<tr>
<td>Lunch</td>
<td></td>
</tr>
<tr>
<td>Vegetable salad with walnuts:</td>
<td></td>
</tr>
<tr>
<td>• shredded romaine lettuce</td>
<td>68</td>
</tr>
<tr>
<td>• sliced carrot</td>
<td>61</td>
</tr>
<tr>
<td>• sliced cucumber</td>
<td>78</td>
</tr>
<tr>
<td>• quartered tomatoes</td>
<td>246</td>
</tr>
<tr>
<td>• lemon juice</td>
<td>31</td>
</tr>
<tr>
<td>• walnuts</td>
<td>11</td>
</tr>
<tr>
<td>Broiled lean pork loin</td>
<td>86</td>
</tr>
<tr>
<td>Dinner</td>
<td></td>
</tr>
<tr>
<td>Vegetable avocado/almond salad:</td>
<td></td>
</tr>
<tr>
<td>• shredded mixed greens</td>
<td>112</td>
</tr>
<tr>
<td>• tomato</td>
<td>123</td>
</tr>
<tr>
<td>• avocado</td>
<td>85</td>
</tr>
<tr>
<td>• slivered almonds</td>
<td>45</td>
</tr>
<tr>
<td>• sliced red onion</td>
<td>29</td>
</tr>
<tr>
<td>• lemon juice</td>
<td></td>
</tr>
<tr>
<td>Steamed broccoli</td>
<td>468</td>
</tr>
<tr>
<td>Lean beef sirloin tip roast</td>
<td>235</td>
</tr>
<tr>
<td>Dessert – strawberries</td>
<td>130</td>
</tr>
<tr>
<td>Snacks</td>
<td></td>
</tr>
<tr>
<td>Orange</td>
<td>66</td>
</tr>
<tr>
<td>Carrot sticks</td>
<td>81</td>
</tr>
<tr>
<td>Celery sticks</td>
<td>90</td>
</tr>
</tbody>
</table>

Table 36. Sample modern ‘Paleolithic diet’ menu as interpreted by Cordain (Sourced from Cordain 2002a)
Cordain (2002a) recommends this diet, stating that its macronutrient composition is similar to that of average hunter-gatherer diets. It is, however, significantly lower in carbohydrate compared to his estimate of hunter-gatherer diets – due to the absence of root vegetables – as well as being higher in protein. It is high in fibre, low in saturated fat, high in omega 3 fatty acids (salmon) and contains all micronutrients in considerably higher amounts than recommended daily allowances (other than calcium). Calcium intake is lower (691mg) than the recommended intake, despite his inclusion of calcium rich non-diary foods – almonds, broccoli, orange and animal skeletal muscle. Calcium intake would be even lower if almonds, broccoli and an orange had been swapped to macadamia nuts, green beans and an apple. See Section 5.4 for more discussion about calcium intake in a dairy-free ‘contemporary hunter-gatherer diet’.

Some reference is made in Cordain’s work to the wider health impacts of our contemporary food production environment, however in general, his focus in this regard is not extensive. For example, unlike in this thesis, based on research indicating no significant differences in vitamin and mineral content, Cordain and Friel (2005) recommend not to worry about buying organic produce. Similar to this thesis, although for different reasons31, Cordain (2002b) recommends grass-fed animals, as well as only eating calves’ liver ‘because virtually all calves slaughtered in the United States (and Australia) haven’t found their way to the toxic feedlot environment’ (Cordain & Friel 2005 p.200). He also recommends minimising mercury intake by avoiding large, long-living fish species. Analysis beyond these issues is, however, limited.

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31 Cordain recommends grass-fed meat on the basis of its increased omega 3 fatty acid content relative to omega 6 content. As analysed in Section 4.3.3, the fatty acid difference is however very small and of little significance in a total diet context. Rather, grass-fed animals are recommended in this thesis because the animals are able to exercise in free-range conditions and tend to be healthier compared to those kept in intensive feedlot conditions.
6.4 **Staffan Lindeberg**

The core elements of Cordain’s approach are echoed in Lindeberg’s interpretation – an abundance of vegetables, fruits, nuts, seafood and lean meats; and an absence of grains and dairy (Lindberg 2007; Lindeberg et al. 2007). Different to Cordain, Lindeberg includes starchy root vegetables. The time that Lindeberg spent living in Kitava enabled him to gain first-hand experience of what eating like a hunter-gatherer is like in that particular region of the world. Hence, his interpretation carries a strong degree of authenticity. It is his interpretation that is most similar to that offered in this thesis. Similar to Eaton, Cordain, and this thesis, Lindeberg emphasises the importance of combining dietary factors with other Paleolithic lifestyle parameters including physical exercise.

Lindeberg’s website (2007) outlines his interpretation of a modern-day Paleolithic diet which is re-iterated here:

- **Breakfast:**
  - Eggs
  - Roast beef, leftovers of chicken or pork
  - Shellfish, fish
  - Avocado
  - Fruits (bananas, oranges, apples, melon, watermelon, pears, kiwi, dried fruits, fruit salad)
  - Nuts (walnuts, almonds, hazelnuts etc, not peanuts)

- **Lunch and Dinner:**
  - Lean meat, mainly domestic meat from pork, chicken and beef
  - Fish, shellfish
  - Vegetables (including root vegetables)
  - Some potatoes
  - Spices

- **Snacks:**
  - Fruits (fresh and dried)
  - Nuts (except peanuts - legumes)

Lindeberg was the principle researcher of the first randomised clinical trial of a ‘modern Paleolithic diet’ in humans. The remainder of this chapter is devoted to examining this trial.

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[32] A nice series of photographed meals are included on the website, which are worth looking at.
6.5  **Paleolithic diet clinical trial in humans: A critique of Lindeberg et al. (2007)**

6.5.1  **Dietary intervention**

This was the first randomised clinical trial of a modern ‘Paleolithic’ diet in humans. In the study, 29 older males with ischemic heart disease and glucose intolerance or type 2 diabetes were randomised to either a ‘Paleolithic diet’ or a Mediterranean-like diet. The Paleolithic group were educated in principles of evolutionary health promotion and were advised to eat lean meat, fish, fruit, leafy and cruciferous vegetables, root vegetables (including potatoes – two or fewer medium-sized per day), eggs (one or fewer per day), nuts (preferentially walnuts – based on their fatty acid composition) and one or fewer tablespoons of canola or olive oil per day; and to avoid all kinds of dairy products, cereals (including rice), beans, sugar, bakery products, soft drinks and beer. No advice was given with regard to proportions of animal versus plant food. The Mediterranean group was educated on the possible benefits of a Mediterranean-like diet and the positive results of the Lyon Diet Heart study33. They were advised to consume a diet based on wholegrain cereals, low-fat dairy products, potatoes, legumes, vegetables, fruits, fatty fish and refined fats rich in monounsaturated fatty acids and alpha-linolenic acid. Both groups were advised not to consume more than one glass of wine per day.

6.5.2  **Results**

After 12 weeks, blood sugar rise in response to carbohydrate intake was markedly lower in the Paleolithic group (-26%) compared to the Mediterranean group (-7%). All patients in the Paleolithic group had blood glucose levels within normal parameters at the end of the trial (assessed by oral glucose tolerance test). Of significance, the improved glucose tolerance in the Paleolithic group was independent of energy intake and macronutrient composition, and was unrelated to weight loss or a decrease in waist circumference.

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33 The Lyon Diet Study was discussed in Section 3.5.2.
The rationale given by the authors for this finding was that avoiding Western foods (processed foods, grains and dairy) was more important than counting calories, fat, carbohydrate or protein intake. This provides strong evidence to support the ‘whole foods’ epistemology of this thesis. A whole food diet which, as closely as possible resembles a wild-type diet may provide a more effective intervention strategy than one primarily aimed at manipulating carbohydrates, glycaemic load, fat, protein or calories.

### 6.5.3 What participants ate

Table 37 outlines the dietary composition of participants’ diets, as estimated from a four-day weighted food record.

<table>
<thead>
<tr>
<th>Food Group</th>
<th>Paleolithic diet group (g/day)</th>
<th>Mediterranean-like diet group (g/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fruits</td>
<td>493</td>
<td>252</td>
</tr>
<tr>
<td>Vegetables (including root vegetables, but excluding potatoes and beans with pods)</td>
<td>327</td>
<td>202</td>
</tr>
<tr>
<td>Potatoes</td>
<td>51</td>
<td>77</td>
</tr>
<tr>
<td>Nuts</td>
<td>11</td>
<td>2</td>
</tr>
<tr>
<td>Meat, fresh</td>
<td>143</td>
<td>97</td>
</tr>
<tr>
<td>Meat products</td>
<td>65</td>
<td>58</td>
</tr>
<tr>
<td>Fish</td>
<td>119</td>
<td>77</td>
</tr>
<tr>
<td>Eggs</td>
<td>29</td>
<td>19</td>
</tr>
<tr>
<td>Beans, peas</td>
<td>8</td>
<td>15</td>
</tr>
<tr>
<td>Cereals</td>
<td>18</td>
<td>268</td>
</tr>
<tr>
<td>Milk and dairy products</td>
<td>45</td>
<td>287</td>
</tr>
<tr>
<td>Oil, margarine (butter was not consumed by either group)</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Sauce</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Pastry</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>Jam</td>
<td>1</td>
<td>6</td>
</tr>
<tr>
<td>Total amount of food</td>
<td>1,311</td>
<td>1,382</td>
</tr>
<tr>
<td>Wine</td>
<td>59</td>
<td>37</td>
</tr>
<tr>
<td>Beer (light)</td>
<td>11</td>
<td>27</td>
</tr>
<tr>
<td>Sweet beverages (excluding juice)</td>
<td>18</td>
<td>53</td>
</tr>
<tr>
<td>Juice</td>
<td>38</td>
<td>88</td>
</tr>
</tbody>
</table>

*Table 37. Dietary composition of the intervention diet used in the clinical trial of a modern ‘Paleolithic Diet’ by Lindeberg et al.(2007)*
Table 38 outlines the daily intake of macronutrients, dietary fibre, cholesterol and sodium, as estimated from the four-day weighed food record:

<table>
<thead>
<tr>
<th></th>
<th>Paleolithic diet group</th>
<th>Mediterranean-like diet group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (kJ/d)</td>
<td>5,600</td>
<td>7,500</td>
</tr>
<tr>
<td>Protein (g/d)</td>
<td>90</td>
<td>89</td>
</tr>
<tr>
<td>% of energy</td>
<td>28%</td>
<td>21%</td>
</tr>
<tr>
<td>Total fat (g/d)</td>
<td>42</td>
<td>50</td>
</tr>
<tr>
<td>% of energy</td>
<td>27%</td>
<td>25%</td>
</tr>
<tr>
<td>Fatty acids</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturated (g/d)</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td>Monounsaturated (g/d)</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>Polyunsaturated (g/d)</td>
<td>10</td>
<td>9</td>
</tr>
<tr>
<td>Carbohydrate (g/d)</td>
<td>134</td>
<td>231</td>
</tr>
<tr>
<td>% of energy</td>
<td>40%</td>
<td>52%</td>
</tr>
<tr>
<td>Glycaemic load (glucose as reference food)</td>
<td>65</td>
<td>122</td>
</tr>
<tr>
<td>Fibre (g/d)</td>
<td>21</td>
<td>27</td>
</tr>
<tr>
<td>Cholesterol (mg/d)</td>
<td>397</td>
<td>295</td>
</tr>
<tr>
<td>Salt (g/d)</td>
<td>6.6</td>
<td>10.1</td>
</tr>
</tbody>
</table>

Table 38. Macronutrient composition of intervention diet used in the clinical trial of a modern ‘Paleolithic Diet’ by Lindeberg et al. (2007)

As can be seen in the two tables above (Tables 38 and 39), reported food composition differed between the two groups. It is important to analyse this data because it shows the way study participants interpreted the Paleolithic diet. The Paleolithic group did follow the advice to eliminate cereals, dairy and refined oils and had a much lower intake of these foods compared to the Mediterranean group. Intake of vegetables, meat and fish didn’t differ significantly between the two groups. Consequently, the Paleolithic group, with their limited intake of cereals, dairy and refined oils made up the resulting calorie deficit with a higher intake of fruit and nuts.

Total energy intake in the Paleolithic group (5,600kJ/d) was lower than the Mediterranean group (7,500kJ/d) on the recorded days. In fact, energy intake in both groups was particularly low. The four-day weighed food records were registered early in the trial, and not discussed in the paper is the real possibility that participants may have simply been under-eating. For the sake of comparison, intake in the average Australian diet is 11,050kJ per day for males and 7,481kJ per day for females (Australian Institute of Health and Welfare 2006b). Study participants were of an older age group (average age of 65 years in Paleolithic diet group and 57 years in Mediterranean diet group) with
significant health conditions, which would naturally limit exertion levels and thus energy requirements. Nonetheless, both diets resulted in an average weight loss of 5kg over the 12 week intervention, therefore indicating a calorie deficit.

After a lifetime of habitual use of cereal grains and dairy, to suddenly remove these foods from the diet is likely to leave people wondering what to eat. In this trial, the Paleolithic group used fruits and nuts to supply extra calories. These foods are readily accessible, don’t require preparation before consumption, and are thus a quick and easy way to fend off hunger. Hence, when implementing the hunter-gatherer model, it is worthwhile being aware that fruit and nuts may be the two food groups that people use to make up a calorie deficit and may become a source of excesses, relative to other vegetables and animal foods.
6.6 Summary

While the research work of prominent evolutionary nutritionists has provided great theoretical insights into hunter-gatherer diets, the way the data is being interpreted into a modern-day context requires ongoing development and integration work. Various translation differences have been discussed in this chapter and inconsistencies in applying guiding principles are highlighted. With its emphasis on Australia, a primary aim of this thesis is to present a model for guiding more optimal food choices that fit within our ‘blueprint’ dietary needs and use the best of our contemporary food supply. The author’s interpretation of ‘contemporary hunter-gatherer diets’ is presented in Chapters 7 and 8. As a result of this chapter, comparative differences between the model presented in this thesis and the work of Eaton, Cordain and Lindeberg can be noted.
Chapter 7: Modelling Hunter-Gatherer Diets in Contemporary Australia; & Comparative Analyses between Average Australian Diets, Recommended Dietary Guidelines, and Hunter-Gatherer Diets

7.1 Introduction and Chapter Scope

The aim of this chapter is two fold:

1. Firstly, to make sense of the hunter-gatherer dietary data in the context of the modern-day Australian food supply. This is necessary for modelling ‘contemporary hunter-gatherer diets’ i.e. dietary patterns which carry the highest possible degree of biological authenticity and best meet our genetically adapted requirements using foods presently available. Eating from the contemporary food supply instead of the wild food supply does result in nutritional differences. These differences are outlined, and strategies for negotiating them are discussed.

2. The second aim of this chapter is to examine Australians’ nutrient intake compared to the recommended dietary and nutrient guidelines (NHMRC 2003, 2006); and to compare this data with estimates of hunter-gatherer nutrient intakes (as per Figure 18). As will be explored, average hunter-gatherer diets (and ‘contemporary hunter-gatherer diets’) are far more nutrient dense than the average Australian diet, as well as typically exceeding the nutritional quality of the recommended dietary guidelines and nutrient reference values.
The average Australian diet

**Figure 18.** Diagrammatic framework for comparative analysis of the average Australian diet, the recommended dietary guidelines, and hunter-gatherer diets

The chapter is divided into four parts. Part I examines the estimated nutritional composition of hunter-gatherer diets and translates this data in the context of our modern food supply. In response, a dietary example is constructed to serve as a model for interpreting the evolutionary nutrition data for contemporary relevance. This example is then used as a reference point for comparing the modern Australian diet with a ‘contemporary hunter-gatherer diet’.

Part II discusses Australia’s recommended dietary guidelines and nutrient reference values (i.e. specific recommendations for vitamins, minerals and trace elements). The strengths and limitations of the dietary guidelines are analysed from an evolutionary perspective.

Part III looks at the data sources assessing Australia’s food and nutrient intakes. Finally, Part IV comparatively addresses how the average Australian’s diet compares with the recommended dietary guidelines (NHMRC 2003); and in turn how they compare with hunter-gatherer dietary parameters.

This chapter sets the scene for Chapter 8, which outlines ‘contemporary hunter-gatherer diets’ from an Australian perspective.
7.2 Part I. The Hunter-Gatherer

Benchmark: Making sense of the traditional hunter-gatherer dietary information in the context of the contemporary Australian food supply

The objective of Part I is to make sense of the hunter-gatherer dietary data in the context of the modern-day Australian food supply. To aid this process, a possible interpretation of a ‘contemporary hunter-gatherer diet’ is outlined, which is used as a reference point for comparative purposes.

As discussed in Section 2.3, the paper by Cordain et al. (2000), *Plant-animal subsistence ratios and macronutrient energy estimations in worldwide hunter-gatherer diets*, provides the most comprehensive nutritional analysis of recent worldwide hunter-gatherer diets. Consequently, this paper is used as a central reference point for understanding hunter-gatherer diets in this chapter. As previously acknowledged, the paper does carry methodological issues. Nonetheless, it still serves as one of the most relevant reference papers in the literature at present.

Cordain et al. (2000) concluded that the majority of recent hunter-gatherer people consumed 56–65% of daily energy from animal foods, and the remainder from plant foods. The corresponding macronutrient breakdown was in the range of 19-35% for protein, 22–40% for carbohydrate and 28–58% for fats. Translating these hunter-gatherer plant-to-animal food subsistence ratios and macronutrient calculations in the context of the contemporary Australian food supply follows.

7.2.1 Animal foods in ‘contemporary hunter-gatherer diets’

In the context of daily food intake, if 60% of energy is sourced from animal foods [average in hunter-gatherer diets (Cordain et al. 2000)], it would mean that in a 12,500kJ diet [estimated average energy intake in hunter-gatherer people (Cordain et al. 2000)]
and a reasonable requirement for physically active Australian adults], 7500kJ must be sourced from animal foods. Animal foods supply both protein (17kJ/g) and fat (37kJ/g) to the diet. The human body’s comfortable upper limit for protein metabolism sits at around 35% of daily kilojoules (with varying degrees of individual difference); (Bilsborough & Mann 2006; Hedrick Fink, Burgoon & Mikesky 2006). Therefore, 2625kJ (154g) of protein is the upper limit, and the remaining 4875kJ (at least) must be taken from animal sources of fat in order to meet the 60% figure in a 12,500kJ diet. Whether or not this level of protein intake is optimal was discussed in Section 5.2.1.

Animal foods that could be used to make up this maximal protein intake (2625kJ/154g in a 12,500kJ diet) could include, for instance, 350g flathead fish plus 350g of kangaroo fillet (2533kJ) (Xyris Software 2007); or two large (415g) tins of red salmon (e.g. Paramount brand; Xyris Software 2007). This amount of animal protein is well in excess of what the average Australian typically eats today, and is higher than the amount recommended in the Australian dietary guidelines.

Once protein intake is capped, animal food options for obtaining the remaining energy balance must come from fat i.e. adipose tissue, organ meats and fatty insects (or honey – however it wasn’t necessarily eaten in significant regular quantities and hence is omitted from analysis here). Given that fat supplies 37kJ/g, 132g of fat (in a 12,500kJ diet) from animal food sources is needed to match the estimation of Cordain et al. (2000) (i.e. 60% of energy was from animal foods). This could be found for example in 338g of Bogong moths34 (39g fat/100g); or 132g of adipose tissue (but wild animals are very lean, therefore this is probably unlikely); or 2.2kg kangaroo liver (6g fat/100g); or 1.5kg brain (lambs brain = 9g fat/100g) (this quantity is unlikely!); or 1.2kg red salmon – fatty fish (11g/100g) (Xyris Software 2007). However, this quantity of salmon, would exceed the protein limit, as would the kangaroo liver.

Clearly a mix of wild foods containing fat would have been traditionally used rather than one source alone as modelled here, and animal foods commonly contain a reasonable portion of both protein and fat together. However, as gleaned from this analysis, when put into the context of contemporary foods, it does appear very difficult to source 60% of kilojoules from animal foods. The Arctic Inuit comfortably achieved greater than 60% of their daily energy from animal foods – in fact, they were close to

34 Sourced from Victorian and Southern NSW alpine regions in summer.
100%, which they achieved by consuming fatty whale blubber (Bang, Dyerberg & Sinclair 1980). Other hunter-gatherer societies may have done it by preferentially eating organ meats, fatty deposits and wasting some of the remaining carcass meat (Eaton et al. 1998b), as well as by consuming fatty insects.

However, making use of this information in the context of our contemporary food supply in which fatty insects and organ meats are rarely, if ever, consumed, it is evident that mimicking hunter-gatherer plant-to-animal subsistence rations as estimated by Cordain et al. (2000) is very hard, if not impossible, without exceeding the protein ceiling. Contained in Appendix J is the closest dietary model the author could devise that falls within the plant-to-animal ratios and macronutrient parameters provided by Cordain et al. (2000) using modern Australian foods. The plant to animal subsistence ratio and macronutrient breakdown of the example in Appendix J is as follows:

- energy intake of 12,526kJ (matches hunter-gatherer average intake)
- animal foods supply 58% of total energy (hunter-gatherer average was 56–65%)
- plant foods supply 42% of total energy (hunter-gatherer average was 35–44%)
- protein supplies 35% of total energy (hunter-gatherer range was 19–35%)
- fat supplies 39% of total energy (hunter-gatherer range was 28–58%)
- carbohydrate supplies 22% (hunter-gatherer range was 22–40%).

A combination of the following animal foods were included to achieve this:

- fish (flathead species) 200g
- kangaroo fillet 200g
- 3 medium eggs
- 10 medium sized mussels (shellfish)
- scallops (6 individual)
- red salmon, 1 large tin (415g)
- sardines, 1 tin (110g)
- fish oil (10g = 10 capsules)

It was intentional that this list of foods included fattier sources of animal foods (i.e. fatty red salmon fish, sardines, eggs and fish oil) without including saturated fat so as to mirror the wild food supply, and in so doing enable the total kilojoule load from animal foods to be high whilst not exceeding protein limits. All the same, for many people today, even those consuming more than 12,500 kJ per day (e.g. athletes), this quantity of...
animal foods in Appendix J would likely feel excessive. Certainly the quantity of animal protein in this example (35% of total energy) sits on the upper limit of protein intake in hunter-gatherer diets (19–35% of total energy).

It is worth noting at this point that many of the dietary examples published by Cordain (for examples see Cordain 2002a, b; Cordain & Friel 2005) contain protein intakes beyond 35% of daily energy intake. For example, Appendix K contains one of Cordain’s recommended daily diet examples based on his interpretation of a modern-day ‘Paleolithic diet’ (2002b p.26-27), which has been re-analysed using the well regarded Australian Xyris ‘FoodWorks’ software (2007) and found to have a protein intake of 40% of daily energy intake (not 33% as stated by Cordain 2002b). Part of this discrepancy would be due to slightly different foods and food composition data being used (and some minor food substitutions had to be made); however, the discrepancy is unusually large. Recognition of the improbability of matching hunter-gatherer plant to animal subsistence ratios as estimated by Cordain et al. (2000) without exceeding the protein ceiling (when using contemporary foods) has not been extensively explored in the evolutionary nutrition literature.

Therefore, to make use of hunter-gatherer dietary data in the context of our contemporary food supply, attention needs to shift to which foods should be included in the diet once protein requirements have been met. A modern Australian wanting to eat a ‘contemporary hunter-gatherer diet’, a protein intake of around 20% of daily energy intake [this value just falls inside the estimated protein range of recent hunter-gatherer diets – 19-35% (Cordain et al. 2000)] can be met in the context of a 12,500kJ diet by consuming approximately 250g flathead fish, 200g kangaroo fillet, 20 medium sized mussels, and 2 large eggs [147g protein x 17kJ/g = 2500kJ (Xyris Software 2007)]. Whilst still appearing to be a lot of animal food relative to a typical Australian’s diet, it is possible to be at ease consuming this quantity in a 12,500kJ diet. In saying this, one needs to be mindful that in a balanced omnivorous diet, plant foods will also supply additional protein to the diet.

Hence, once 20% of the daily energy budget has been spent on protein intake, the next question becomes: What foods should make up the remaining 80% of the diet? As we know, animal foods supply both protein and fat. Assuming that protein intake has been satisfied with the above list of foods (fish, kangaroo, shellfish and eggs), the inclusion of any further kilojoules from animal foods must be from fat. As already mentioned,
sources of fat from animal foods are adipose tissue (mostly saturated fat), bone marrow [mostly mono unsaturated fat; 32kJ/g (Cordain et al. 2000b)], organ meats (they also contain a reasonable amount of protein), and fatty insects. These latter two food groups are rarely consumed or even available in our modern-day food supply, and inclusion of adipose tissue would not be a true reflection of a hunter-gatherer diet because of the low percentage body fat in wild animals (Cordain et al. 2002c).

Therefore, three options are left for using hunter-gatherer food groups to deliver the remaining daily energy needs, all of which are plant foods:

(i) non-starchy vegetables and fruits
(ii) fatty plant foods (e.g. nuts, seeds and fatty fruit such as avocados, coconuts and olives), and
(iii) starchy tubers and root vegetables (e.g. sweet potatoes).

7.2.2 Plant foods in ‘contemporary hunter-gatherer diets’

Firstly, in terms of non-starchy vegetables (e.g. leafy greens, broccoli, carrots, zucchini) and fruit, there is a natural limit in how much can be consumed each day because of the fibrous bulk of such foods. For example, an upper limit for daily intake of non-starchy vegetables and fruit in a 12,500kJ/d diet may include the following:

- vegetables: broccoli (1/2 head), kale (1 cup), green beans (20 beans), carrots (2 medium), zucchini (1 medium), asparagus (6 medium spears).
- fruit: apple (1 medium), blueberries (1 cup), oranges (2 medium), and tomatoes (2 small)

This equates to 1.7kg of non-starchy plant food, 41g fibre and 2,290kJ which, in a 12,500kJ diet, would represent 18% of daily energy intake (Xyris Software 2007). This quantity is probably the upper limit for reasonable daily consumption. Therefore, after

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35 By comparison, the average Australians intake of fruit, vegetables and juices is around 0.5kg per day. However, this includes starchy vegetables such as potatoes, which is the predominant vegetable in the average Australian diet. This comparative difference is further discussed in Chapter 7 Part IV. (Reference: Australian Institute of Health and Welfare 2006b, Towards national indicators for food and nutrition: an AIHW view. Reporting against the dietary guidelines for Australian adults, AIHW, Canberra.)
protein requirements have been met (assuming approximately 20% daily energy), and non-starchy plant food intake has been met (assuming a maximum of approximately 18% daily energy), at least 62% of kilojoules must come from elsewhere. The two remaining options for sourcing these kilojoules are fatty plant foods and starchy tubers.

Readily available fatty plant foods in the contemporary food supply include nuts, seeds and fatty fruit (e.g. avocados, coconuts, olives) as well as plant oils (although whole foods take priority). As explained, fat supplies 37kJ/g compared to starch (carbohydrate), which supplies 16kJ/g, which makes fatty plant foods an energy efficient way of sourcing kilojoules. For example, eating one avocado plus 100gm of macadamia nuts and one tablespoon of olive oil (e.g. in a dressing with lemon juice for salad/leafy green vegetables) provides 140g of fat and 5484kJ (44% of daily energy). In fact, an intake of fatty plant foods greater than this amount is easy to consume. This leaves a remaining 18% or so of daily energy unaccounted for.

Starchy roots and tubers are the remaining avenue for obtaining this outstanding 18% (or less if a greater intake of fatty plant foods occurs) of daily energy needs. Cordain et al. (2000) estimated that wild tubers would have been a common component of traditional hunter-gatherer diets, comprising an estimated 24% of all plant food consumed. This is confirmed by other researchers’ findings (see Gott 1982, 1983, 1993; Lindberg 2007; O'Dea 1991a). For example, as discussed in Section 2.3, Victorian Aborigines used underground parts of plants (rhizomes, corms, bulbs and tubers) as a ‘staple’ year round food source, unlike seasonal fruits and seeds (Gott 1982). Despite this knowledge, Cordain (2002b) suggests excluding starchy vegetables (e.g. potatoes, sweet potatoes, yams, cassava) and starchy fruits (e.g. bananas) in modern ‘Paleolithic diets’ on the grounds that modern hybridised varieties of these starchy foods now carry a higher glycaemic load than their wild equivalents (see Chapter 6). Modern cultivated tubers do typically yield a higher glycaemic index, principally because they are less fibrous and have a slightly different starch composition (Thorburn, Brand & Truswell 1987); (see Section 5.2.4). However, simply removing them from the diet is not a satisfactory solution for it begs the question: What should fill the caloric deficit created in their absence? In Cordain’s (2002b) model, this deficit would have to be made up with animal protein, fruit, non-starchy vegetables or nuts/seeds. Yet, in reality, this nutritional profile does not authentically mimic hunter-gatherer diets because starch did contribute significantly to energy intake. Therefore, in interpreting hunter-gatherer dietary information so as to be used in the milieu of our modern food supply, it seems
unrealistic and implausible not to include starchy tubers as a nutritious and vital source of daily kilojoules. For example, the remaining 18% of daily energy in a 12,500kJ diet could be sourced from 5.5 medium sized sweet potatoes (5cmx13cm) which supplies 2195kJ and 113g carbohydrate (Xyris Software 2007).

7.2.3 An example of a ‘contemporary hunter-gatherer diet’ using modern Australian foods: The author’s interpretation

Putting all this information together using contemporary Australian foods, daily food intake may look something like the following (for full nutrition composition data on this data see Appendix L):

- **Non-starchy vegetables**: broccoli (0.5 bunch), kale (1 cup), and green beans (20 beans, 10cm long), carrots (2 medium), zucchini (1 medium) and asparagus (6 medium spears)
- **Fruit**: apple (1 medium), blueberries (1 cup), orange (2 medium), banana (1 medium), tomato (2 small)
- **Starchy vegetables**: 5 medium sweet potatoes (5cm diameter, 13cm long)
- **Fatty fruit**: avocado (1 whole), olive oil (1 tablespoon)
- **Nuts**: macadamia (50g), almonds (50g)
- **Animal foods**: flathead fish (250g), kangaroo fillet (150g), 2 small eggs

This diet supplies 12,490kJ, 161g protein (23% of daily energy), 155g fat (48% daily energy), and 206g carbohydrate (29% daily energy). The plant to animal subsistence ratio of this example diet is 83% plant foods to 17% animal foods.

In terms of vegetable intake (non-starchy and starchy), the above list of foods represents a likely upper comfortable intake range. If consumption of these foods is decreased, a parallel increase in fatty fruit and nuts/seeds would be an effective strategy.

Further exploration of how the evolutionary nutrition knowledge can be interpreted in the context of the modern day Australian food supply is expressed in Chapter 8. The
dietary example outlined here is for exemplar purposes only, and is used as a comparative model for gauging the relative nutritional deficiency of average Australian diets today.

### 7.2.3.1 Plant to animal subsistence ratio of the example ‘contemporary hunter-gatherer diet’

Compared to traditional hunter-gatherer diets as analysed by Cordain et al. (2000), the example diet contains a low quantity of animal foods. In the analysis by Cordain et al. (2000), only 13.5% of hunter-gatherer societies collected greater than 50% of their subsistence from plant foods; and 73% derived greater than 50% of their subsistence from animal foods (56–65% of energy from animal foods was the most common range).

In the context of our contemporary food supply, it is not impossible to match the median plant-to-animal subsistence ratios of traditional hunter-gatherer diets as estimated by Cordain et al. (2000). However, as discussed, the reason that the dietary example provided is relatively low in animal foods is because once protein intake requirements have been met from animal food sources, the remaining calories from animal foods must be sourced from fat. Our modern day food supply does not enable ready consumption of fatty insects, fatty organ meats from optimally healthy animals, and consuming fatty domesticated meats (saturated fat) is not the solution because this is not reflective of the wild food supply. One thing that is available to us today to increase our intake of ‘healthy’ fats from animal sources is fish oil supplementation. All the same, even if a dose of 10g (10 capsules) were taken per day, which is the upper limit of recommended dosage, this only supplies an additional 370kJ to the diet. This has little impact on plant-to-animal subsistence ratios, although it does improve the supply of essential long chain polyunsaturated omega 3 fatty acids to the diet which are potentially lacking if fatty fish and organ meats (especially brain tissue) are absent from the diet.

Hence, in the modern diet, in order to not exceed the protein ceiling, the quantity of plant food (relative to animal food) must be increased to levels greater than average hunter-gatherer diets. This essential point is often missing in the way evolutionary nutrition principles are currently being interpreted in a modern day context.
7.2.3.2  Macronutrient composition of the example ‘contemporary hunter-gatherer diet’

Although the dietary example does not fall within estimations of plant-to-animal subsistence ratios in recent worldwide hunter-gatherer societies, the macronutrient composition sits comfortably within hunter-gatherer boundaries: 19–35% protein, 28–58% fat and 22–40% carbohydrate (Cordain et al. 2000). The example diet supplies 23% of daily energy from protein, 48% from fat and 29% from carbohydrate.

7.2.3.3  Micronutrient composition of the example ‘contemporary hunter-gatherer diet’

The example diet is exceedingly rich in vitamins and minerals. As can be seen in Appendix M, the example diet meets at least 100% of all the Australian recommended dietary intakes (RDI) [based on an adult male with a reference body weight of 76kg (NHMRC 2006)], including calcium, despite the absence of dairy foods. In fact, the example diet provides an exceptional 21 times the recommended daily intake for vitamin C and 12 times the nutrient reference value for vitamin A. This pattern is common when constructing modern diets using contemporary foods based on hunter-gatherer principles because of the nutrient density of the food groups used. Also, as noted in Appendix M, the example diet is micronutritionally superior relative to the average Australian diet.

7.2.3.4  Fatty acid composition of the example ‘contemporary hunter-gatherer diet’

As seen in Table 39, total fat intake in the example diet falls within hunter-gatherer diet estimations by Cordain et al. (2000). It is, however, higher than the hunter-gatherer diet estimations made by Eaton (1992). Furthermore, it is higher than intake levels in the average Australian diet (Australian Institute of Health and Welfare 2006b). In terms of saturated fat, the quantity in the example diet is lower than the average Australian diet,
but comparable with hunter-gatherer diets. *Monounsaturated* fat intake is higher in the example diet than the average Australian diet, and likely similar to hunter-gatherer diets. Eaton (1992) consistently reports a lower total fat intake than other researchers (such as Cordain et al. 2000), which may explain the relatively low intake of monounsaturated fat (11% of daily energy) in his estimate of hunter-gatherer diets in Table 39.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total fat (g) (% of total energy intake)</td>
<td>155g 48%</td>
<td>82g 25%</td>
<td>28-58%*</td>
<td>76g 25-38% (32% average)</td>
</tr>
<tr>
<td>Saturated (g) (% of total energy intake)</td>
<td>26g 8%</td>
<td>19.5g 6%</td>
<td>-</td>
<td>32g 11-16%</td>
</tr>
<tr>
<td>Monounsaturated(g) (% of total energy intake)</td>
<td>100g 30%</td>
<td>34.5g 11%</td>
<td>-</td>
<td>27g 9-13%</td>
</tr>
<tr>
<td>Polyunsaturated(g) (% of total energy intake)</td>
<td>17g 5%</td>
<td>28.2g 9%</td>
<td>24g^ 7%</td>
<td>12.2g 4-6%</td>
</tr>
</tbody>
</table>

* Sourced from Cordain et al. (2000)
^ Percentage calculations based on the average daily energy requirement for Australian adults of 11,050kJ for males and 7,481kJ for females (Australian Institute of Health and Welfare 2006b)
^ Sourced from Eaton et al. (1998b)

Table 39. Fat intake differences between a ‘contemporary hunter-gatherer diet’, a traditional hunter-gatherer diet and modern Australian diets

Polyunsaturated fat (PUFA) intake in the order of 17g per day (5% daily energy) in the example ‘contemporary hunter-gatherer’ diet is slightly lower than estimated retrojections of most traditional hunter-gatherer diets. More importantly, the differential PUFA content (i.e. omega 6 and omega 3 short chain and long chain PUFAs) is significantly different. The Australian FoodWorks nutrition composition software program (Xyris Software 2007) used to analyse the example diet doesn’t determine the breakdown of omega 6 and omega 3 fatty acids. Hence, the diet example was re-analysed through the United States Department of Agriculture (USDA) nutrition software database (USDA 2009) as seen in Table 40. See Appendix N for full details of this analysis.
### Table 40. Differential PUFA intake between a ‘contemporary hunter-gatherer diet’; traditional hunter-gatherer diets; and modern Australian diets

<table>
<thead>
<tr>
<th>Fat (g/day)</th>
<th>Traditional hunter-gatherer diet (Eaton 1992)</th>
<th>Example ‘contemporary hunter-gatherer diet’</th>
<th>Australian dietary intake (Meyer et al. 2003)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total PUFA</td>
<td>24.34</td>
<td>17.57*</td>
<td>12.2</td>
</tr>
<tr>
<td>LA</td>
<td>8.84</td>
<td>15.56</td>
<td>10.8</td>
</tr>
<tr>
<td>ALA</td>
<td>12.61</td>
<td>1.25</td>
<td>1.17</td>
</tr>
<tr>
<td>AA</td>
<td>1.81</td>
<td>0.47</td>
<td>0.05</td>
</tr>
<tr>
<td>EPA</td>
<td>0.39</td>
<td>0.28</td>
<td>0.06</td>
</tr>
<tr>
<td>DPA</td>
<td>0.42</td>
<td>0.10</td>
<td>0.03</td>
</tr>
<tr>
<td>DHA</td>
<td>0.27</td>
<td>0.38</td>
<td>0.11</td>
</tr>
<tr>
<td>Total n-6 (LA+AA)</td>
<td>10.65</td>
<td>16.03</td>
<td>10.85</td>
</tr>
<tr>
<td>Total n-3 (ALA+DPA+DHA)</td>
<td>13.69</td>
<td>2.01</td>
<td>1.37</td>
</tr>
<tr>
<td>Total LC n-3 (EPA+DPA+DHA)</td>
<td>1.08</td>
<td>0.76</td>
<td>0.2</td>
</tr>
</tbody>
</table>

*Very similar value given for total PUFA in both the Xyris FoodWorks software (2007) and the USDA data base (2009), indicating good correlation between the two programs.

In terms of omega 6 fats, as deduced from Table 40 above, traditional hunter-gatherer diets – as estimated by Eaton (1992) – contained more animal meat, and hence AA, than the example ‘contemporary hunter-gatherer diet’ as well as the average Australian diet. In terms of LA, traditional hunter-gatherer diets and the average Australian diet were not markedly dissimilar; however, sources of LA in the average Australian diet are predominantly from vegetable oils and cereal grains whereas in hunter-gatherer diets they came primarily from nuts and seeds. This difference is also reflected in the example ‘contemporary hunter-gatherer diet’, whereby a high LA intake resulted from the inclusion of one avocado and 50g of almonds (which are LA rich). As discussed in Section 5.2.3, this highlights the probable insignificance of emphasising upper limits for omega 6 intake when natural whole foods are being consumed (i.e. whole nuts rather than vegetable oils); when consumed in the presence of adequate dietary intake of n-3 fats.

As discussed in Section 5.2.3, the relative deficit in omega 3 fats in contemporary diets has triggered a plethora of research. Consequently, omega 3 intake is being promoted and a reduction in n-6 intake is encouraged. As argued in this thesis, a more informative
solution may be to simply recommend an adequate intake of omega 3 fats (e.g. via fish intake and/or fish oil supplementation) on the backdrop of a fresh, omnivorous, whole food diet in which omega 6 intake will be variable but sourced from nutrient dense nuts, seeds, fatty fruit (e.g. avocados) and animal meats, rather than vegetable oils, processed foods and heavy cereal grain intake.

Also as analysed in Section 5.2.3, the contemporary deficiency in n-3 LCPUFA is particularly concerning. As seen in Table 40, according to Eaton (1992; Eaton et al. 1998a; Eaton et al. 1998b) our hunter-gatherer ancestors consumed an estimated 1.1g of n-3 LCPUFA (DPA+EPA+DHA) per day. This quantity is in line with recommended adequate intake values for Australian adults of 0.9g per day for females and 1.6g per day for males (NHMRC 2005). By contrast, mean intakes of n-3 LCPUFA in the contemporary Australian population are 0.19g (Meyer et al. 2003). Hence, we are now consuming 83% less n-3 LCPUFA than we are theoretically genetically adapted to require. Even the dietary example outlined in this chapter based on hunter-gatherer principles using contemporary available foods only contains only 0.76g n-3 LCPUFA because of the absence of fatty fish species and organ meats. Hence, compared to likely intakes in hunter-gatherer diets, even the best planned ‘contemporary hunter-gatherer diet’ is likely to be relatively deficient (around 30% less) in n-3 LCPUFA. This is where n-3 LCPUFA supplementation in the form of fish oil has a sound theoretical basis.

Making up the n-3 LCPUFA deficit in the example ‘contemporary hunter-gatherer diet’ can easily be achieved with a single capsule (1000mg) of fish oil per day, which typically contains 180mg EPA and 120mg DHA (Blackmores Australia 2009). Adding one single 1000mg capsule of fish oil into the example diet would supply a total of 3760mg n-3 LCPUFA to the daily diet. While this amount is slightly higher than estimated average intakes in hunter-gatherer diets (1100mg per day), there would have been wide variations in n-3 LCPUFA intake depending on geographic region and subsistence behaviour. The issues pertaining to appropriate fatty acid intake levels and their impact on health were discussed in Section 5.2.3.
7.2.3.5 Other dietary characteristics of the example 'contemporary hunter-gatherer diet': glycaemic load, sodium-potassium ratio, fibre content, acid-base balance

Consideration of other dietary factors in the example of the ‘contemporary hunter-gatherer diet’ is not overly important as they are inherently addressed in the recommended food choices. This is because the model is based on the consumption of whole, minimally processed foods (low glycaemic load), no added salt (low sodium), and a high intake of vegetables and fruit, and is therefore high in fibre, rich in potassium and net base yielding.

Based on the modeling work of Sebastian et al. (2002), the estimated net endogenous acid production of the example diet would be somewhere between -170 mEq/day to -196 mEq/day (with its 161gm of protein, a plant-to-animal energy subsistence ratio of 83%:17%, and 13gms of fat from animal foods). Hence, despite a higher intake of protein than the average Australian diet, the abundance of plant foods makes this dietary strategy exceedingly base producing. As noted in Section 5.2.7, the average United States diet yielded a net acid load of around +50 mEq/day; a pattern which would not be dissimilar to the average Australian’s diet.

7.2.4 Summary of Part I

It is important to note that it is not intended for the proffered ‘contemporary hunter-gatherer diet’ to be rigidly applied. It is simply illustrative. In Australian today it is possible to select from a wide variety of foods within core hunter-gatherer food groups and such dietary diversity opens up the greatest potential for optimising nutrient intake. Further information for eating like a hunter-gatherer in the context of our modern Australian food supply is outlined in Chapter 8.
## Part II. Australia’s Recommended Dietary Guidelines and Nutrient Reference Values

### 7.3.1 The recommended dietary guidelines for Australian adults

The Dietary Guidelines for Australian Adults are (NHMRC 2003):

<table>
<thead>
<tr>
<th>Enjoy a wide variety of nutritious foods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eat plenty of <strong>vegetables, legumes and fruits</strong></td>
</tr>
<tr>
<td>Eat plenty of cereals (including breads, rice, pasta and noodles), preferably wholegrain</td>
</tr>
<tr>
<td>Include <strong>lean meat, fish, poultry</strong> and/or alternatives (<strong>eggs, nuts, seeds, legumes</strong>)</td>
</tr>
<tr>
<td>Include milks, yoghurts, cheeses and/or alternatives: reduced fat varieties should be chosen, where possible</td>
</tr>
<tr>
<td>Drink plenty of <strong>water</strong></td>
</tr>
</tbody>
</table>

**And take care to:**

- Limit saturated fat and moderate total fat intake
- Choose foods **low in salt**
- Limit your alcohol intake if you choose to drink
- Consume only moderate amounts of sugars and foods containing added sugars
- Prevent weight gain: be **physically active and eat according to your energy needs**
- Care for your food: prepare and store it safely
- Encourage and support **breastfeeding**

In the box above, underlining indicates the recommendations that are also a feature of our ancestral diet and lifestyle patterns. For socio-cultural, political and economic reasons, cereal grains and dairy foods are now recognised as core food groups and are relied upon to supply specific nutrients to the diet (e.g. calcium from dairy). Defined as ‘core foods’ in the contemporary Australian diet are bread, beef, eggs, milk, orange juice, margarine, potatoes and tomatoes (FSANZ 2003a).
7.3.1.1 Strengths and limitations of Australia’s dietary guidelines

The current dietary recommendations are made in an attempt to ensure adequate energy and nutritional status to support growth and reproduction, promote health and prevent disease (Nestle 2004). The recommendations are made in the context of our contemporary food supply, meaning that the recommended foods need to be available, affordable and palatable so that people will consume them. If the whole Australian population were able to eat in accord with the guidelines, nutritional status would vastly improve. The guidelines are not however necessarily intended as ‘optimal’ dietary guidelines, which is where this thesis is aimed.

Australia’s dietary recommendations have historically followed those of the USA. When in the 1960s and 70s it became increasingly recognised that diet-related chronic diseases (especially heart disease, high blood pressure, type 2 diabetes) were escalating, guidelines were established to encourage the population to reduce culprit dietary factors – which were deemed to be fat, cholesterol, sugar, salt and alcohol (Willet 2004). Australia followed suit with its dietary recommendations.

From an evolutionary nutrition perspective, key features of Australia’s dietary guidelines which need critical analysis include:

- the inclusion of plentiful cereal grains
- the essentiality of dairy products
- the lack of differentiation between protein from animal sources and protein from plants
- a lack of a rationale for ‘moderate fat intake’ (NHMRC 2005), given the wide variations in hunter-gatherer diets who may have consumed anywhere between 28–58% of daily kilojoules from fat (Cordain et al. 2000), however, with minimal amounts from animal derived saturated sources
- the lack of mechanisms for ensuring adequate essential fatty acids intake, particularly long chain (animal derived) omega 3 fatty acids so lacking in contemporary Australian diets. For example, fish and seafood are not emphasised separately to other sources of lean meat including red meat, poultry and plant food ‘alternatives’ such as legumes and nuts
• while overall the guidelines recommend ‘a wide variety of nutritious foods’, there is no additional emphasis on including a diversity of vegetable/plant species in the diet so as to avoid excessive consumption of, for instance potatoes at the expense of leafy greens, as this would serve to reduce the nutrient density of the whole diet

• the limited emphasis on minimally processed foods – while the recommendations do state ‘eat plenty of cereals, preferably wholegrain’ (NHMRC 2005), the idea of consuming minimally processed foods is not extended to other food groups, such as preferentially consuming fresh vegetable and fruits rather than juiced, canned or processed ones

• the limited reference to food production processes (e.g. agricultural techniques, cold storage times) and food quality characteristics (e.g. nutrient density, phytochemical content). As such, there is no clear mechanism for consumers to understand the lifecycle of the foods they are eating, and to preferentially select fresh, optimally healthy plant and animal foods.

As mentioned, the Australian dietary guidelines are made purely on the grounds of ensuring adequate nutrient intake in the context of the available, accessible food supply. Broader recommendations for embedding individual, socio-cultural and environmental health-supportive food-related behaviours are not covered in the guidelines. As such, food-related factors pertaining to ethical standards, food traceability, production processes, environmental management (e.g. to minimise heavy metal contamination in marine species), animal welfare and psychological-behavioural factors (e.g. non-hungry eating) are not mentioned. This is despite many of these attributes being nominated as ‘most’ important to Australian consumers in research conducted by the Department of Primary Industries (Sully 2006). In reality, these factors are as fundamental to ensuring good nutritional intake and health as are the guidelines themselves. Hence, broader and more holistic guidelines related to food and its pivotal role in our lives are also needed in order to more fundamentally address the factors involved in diet-related chronic diseases and the problem of excess body weight in Australian society today.
7.3.2  Recommended nutrient reference values (NRV)

In addition to the recommended dietary guidelines, Australia has recommended nutrient reference values (NRVs); (NHMRC 2006) to provide guidelines for adequate intake of specific nutrients including the macronutrients, vitamins, minerals and trace elements.

The NRVs are the product of extensive review of the highest levels of evidence available – considered to be systematic reviews of relevant randomised controlled trials (NHMRC 2003). The NRVs are designed to cover the needs of nearly all healthy Australians. NRVs are set at a level greater than what is considered to be the average physiological requirement to ensure against deficiency symptoms with a safety margin (Nestle 2004; Wahlqvist 1988). They do not, however, necessarily take into account optimal nutrient requirements which may be capable of mitigating chronic disease risk and/or affecting longevity. As Ames (2005) suggests, a micronutrient intake that maximises healthy lifespan is likely to be higher than the amount needed to prevent acute deficiency disease.

The scientific body of evidence used to determine the NRVs is incomplete. Just as with the evidence base used to assess the efficacy of vitamin and mineral supplements (Section 5.4) or to establish acceptable exposure levels to pesticide residues in food and other environmental toxicants (Section 4.2.2), the data used to determine NRVs and adequate micronutrient intakes is often limited by study population size, other sub-population variables (e.g. individual biological variability), and factors such as differences in the bioavailability of nutrients from various foods. Thus, the NRVs are best ‘guess’ extrapolations intended to be used as guidelines. The supporting evidence base for Australia’s NRVs can be found in the NHMRC (2006) document Nutrient reference values for Australia and New Zealand.

The scientific body of evidence used in the development of the NRVs is not necessarily able to account for the levels of micronutrients required for lifelong optimal healthy, simply because such long term studies have not been done and epidemiological results are too generalised for specific conclusions to be drawn. In addressing the question of what are optimal micronutrient intake parameters, estimated intakes in wild-food hunter-gatherer diets may yield useful information.
7.4 Part III. Assessing Australia’s Food and Nutrient Intakes

The strong correlation between diet and health is well established in the literature. Despite this, there is limited ongoing nutrition monitoring in Australia and hence a lack of data available (Australian Institute of Health and Welfare 2006b).

The Australian Institute of Health and Welfare (AIHW) is the central government agency for food and nutrition monitoring (Lester 1994). The 2006 AIHW report, ‘Towards National Indicators for Food and Nutrition: Reporting Against the Dietary Guidelines for Australian Adults’ (Australian Institute of Health and Welfare 2006b) provides the most recent compilation of data on nutrient intakes among Australians. In reality however, much of the data used in this report is quite old. The most recent apparent consumption data is from 1998–99 (foods) and 1997–98 (nutrients) (Australian Bureau of Statistics 2000). Food frequency data was collected as part of the ‘Australian Diabetes, Obesity and Lifestyle (AusDiab) study’ in 1999–2000 (Dunstan et al. 2002). The National Health Survey collected data on fruit and vegetable consumption in 2001 (Marks et al. 2001), and the National Nutrition Survey was the first and last Australian survey of food and nutrient intakes obtain through a 24-hour dietary recall (McLennan & Podger 1998). Hence, up-to-date information is lacking and the data may over-estimate nutrient intakes today if the average Australian diet has mirrored trends in other Western countries over the past few years towards increasing consumption of energy-dense, nutrient poor foods i.e. processed and pre-packaged foods.

The most recent 2006 AIWH food and nutrition report expressed a dismal picture of Australian diets and health. More than 50% of adults did not meet the minimum recommendation for fruit and vegetable consumption, and the trend towards increasing levels of obesity and physical inactivity continues to rise (Australian Institute of Health and Welfare 2006b). Despite declining physical activity, among children (aged 10–15 years), average energy intake has risen by 15% for boys and 12% for girls between 1985 and 1995 (Australian Institute of Health and Welfare 2006a). Likewise in adults, average energy intake has also increase by around 350 kJ between 1983 and 1995 (Australian Institute of Health and Welfare 2006a).
An additional problem is that this 350kJ per day is unlikely to be sourced from nutrient dense foods such as fruit and vegetables. Hence, it is likely to be a kilojoule increase that is not accompanied by a requisite parallel increase in nutritional status. The body still requires nutrients to metabolise all foods and to support health, and hence, when they are not supplied in the foods themselves, the body’s own reserves are taxed and over time, depleted.

In light of this picture, the current dietary priorities of the Australian Government are to promote fruit and vegetable consumption, healthy weight status, and good nutrition for mothers, babies and school-aged children (Australian Institute of Health and Welfare 2006a). Increasing the nutrient intake of the average Australian’s diet towards ‘optimal levels’ is far beyond the current national agenda. In reality, any small move that encourages increased fruit and vegetable consumption or moves the population closer to meeting the recommended dietary guidelines will improve nutritional status and pay noticeable health dividends in the population. Yet, as stated in Chapter 1, examining ‘optimal’ parameters is also required because it establishes the goal posts for implementing incremental steps in the right direction. This is the rationale behind comparing nutrient intakes in the average Australian diet with the recommended nutrient guidelines and in turn comparing them to estimated nutrient intakes in hunter-gatherer diets which, in this thesis, have been used to model boundaries for optimal nutrition.

Hence, the next section (Part IV) discusses how the Australian population measures up to the recommended dietary guidelines and in turn compares this to estimates of typical hunter-gatherer diets.
7.5 Part IV. Comparative Analysis: The average Australian diet compared to the recommended dietary guidelines; and compared to hunter-gatherer dietary parameters

This section is detailed, but necessary to demonstrate the significant differences between the recommended Australian dietary guidelines (NHMRC 2003) and plausible hunter-gatherer dietary parameters. The information is presented and structure in relation to each of the NHMRC recommended dietary guidelines.

7.5.1 Dietary guideline: Eat plenty of vegetables and fruits

The Australian Guide to Healthy Eating recommends consumption of four to eight servings of vegetables and legumes, and two to four servings of fruit. One serve of fruit is 150g and one serve of vegetables or legumes is 75g (Australian Institute of Health and Welfare 2006b). Therefore, the recommended total amount of fruit and vegetable intake per day is between 600g and 1.2kg.

By comparison, estimated daily fruit and vegetable intake in our ancestral diet was possibly upwards of 1.6kg per day (Eaton, Eaton & Konner 1997). All interpretations of modern day ‘hunter-gatherer’/ ‘Paleolithic’ diets are exceedingly rich in vegetables and fruit. The example ‘contemporary hunter-gatherer diet’ outlined in Chapter 7 Part I, contained 2.6kg of fruit and vegetables; and even Cordain’s (2002b) interpretation with its very low carbohydrate intake still contained 1.4kg of vegetables and fruit (see Appendix L & K respectively).

In relation to average energy intakes among Australians (11,050 kJ/person/day for males; 7,481 kJ/person/day for females), the recommendation of four to eight serves of vegetables and two to four serves fruit represents between 11 and 22% of daily energy intake for males and 16–32% for females. In contrast, the author’s interpretation of a
‘contemporary hunter-gatherer diet’ (Chapter 7 Part I), supplies 7598kJ from vegetables and fruit (in the context of a 12,491kJ diet), or 61% of daily energy from these food groups. Cordain’s (2002b p.26-27) modern ‘Paleolithic diet’ example, owing to its very high protein content, is lower in vegetables and fruits which supply 32% of daily energy (2549kJ in the context of a 8083kJ diet); (see Appendix K). Nonetheless, it is at the upper end of Australia’s recommended dietary guidelines.

Australians’ actual intake of fruit and vegetables in 1995 (most recent data), excluding fruit and vegetable juices but including potatoes and legumes, was on average 295.6g per day for males and 242.4g per day for females (see Table 41). This is less than half the recommended intake and is significantly less than average hunter-gatherer intakes.

Only 27% of Australian males and 34% of females managed to consume the minimum recommended intake of vegetables, and 47% of males and 58% of females managed it for fruit (Australian Institute of Health and Welfare 2006b). The 2004–05 National Health Survey found that 26% of young people aged 15–18 years ate one or less serves of vegetables per day, and 49% ate one or less serves of fruit per day. Equally concerning were the low levels of fruit and vegetable intake in 19–24 year olds, of which 57% ate one or less serves of fruit and 79% ate three or less serves of vegetables per day (Australian Institute of Health and Welfare 2006a).

<table>
<thead>
<tr>
<th>Measure</th>
<th>Males* (g/person/day)</th>
<th>Females* (g/person/day)</th>
<th>Food equivalency^</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average intake of fruit products and dishes</td>
<td>141.3</td>
<td>145.7</td>
<td>1 apple = 166g (medium 6-8cm diameter)</td>
</tr>
<tr>
<td>Average intake of vegetable products and dishes (inc potatoes)</td>
<td>295.6</td>
<td>242.4</td>
<td>2 potatoes = 294g (medium 6-8cm diameter)</td>
</tr>
<tr>
<td>Average intake of fruit and vegetable juices and drinks</td>
<td>139.5</td>
<td>109.4</td>
<td>150 mL orange juice = 157.5g (commercial, unsweetened)</td>
</tr>
<tr>
<td>TOTAL (kJ)</td>
<td>12% (11,050kJ/d)</td>
<td>19% (7,048kJ/d)</td>
<td>1,346kJ*</td>
</tr>
</tbody>
</table>

* Data sourced from Australian Institute of Health and Welfare (2006b)  
^ Data sourced from Xyris Software (2007)

Table 41. Average intake of fruit and vegetables in Australia

If we are to mimic a hunter-gatherer way of eating as a model for optimal nutrition today, then daily intake of fruit and vegetables would need to increase by at least four
fold. As can be seen in Table 41, the equivalent of just one apple, a couple of potatoes and a glass of orange juice is the total quantity of fruit and vegetables consumed each day in the average Australian’s diet. This is minimal and supplies a very small percentage of daily energy requirements and vitamin, mineral and phytochemical needs for optimal health. Furthermore, as discussed in Section 4.2, the nutritional density of contemporary fruit and vegetables tend to be comparatively lower than their wild plant equivalents (Brand-Miller, James & Maggiore 1997; Eaton 1992; Mayer 1997), thus further lowering the opportunity for adequate nutritional status today.

### 7.5.1.1 The impact of low vegetable and fruit intake on micronutrient intake

Vegetables and fruits are a major source of vitamins, minerals and other phytochemicals in the Australian diet. Yet, the deficiency of this food group in the average diet highlights Australian’s poor micronutrient status – particularly in comparison to the hunter-gatherer model. This is exemplified by vitamin C intake.

The primary sources of dietary vitamin C are fruit and vegetables, and hence it is a useful nutrient to critique in isolation to exemplify comparative differences. Using the data in Table 41, in which the average Australian’s daily fruit and vegetable intake is equivalent to one apple, two potatoes and a glass of orange juice. These foods collectively supply 149 mg of vitamin C (the glass of orange juice particularly contributing to vitamin C intake). The recommended NRV for vitamin C is 45mg for adults (NHMRC 2006) and hence the average Australian is easily meeting this value.

However, vitamin C intake in hunter-gatherer diets has been estimated to be well in excess of 45mg or 149mg. Eaton et al. (1997) estimated that vitamin C intake in traditional hunter-gatherer diets was around 600mg/day. The example ‘contemporary hunter-gatherer diet’ presented in Chapter 7 Part I contains 952mg vitamin C – a higher value still owing to the diet’s higher plant food content than average hunter-gatherer diets (see Appendix L). Hence, neither the average Australian diet nor the recommended NRV mirror the nutrient density of wild food diets.
7.5.2 **Dietary guideline: Eat plenty of cereals (including breads, rice, pasta and noodles), preferable wholegrain**

The *Australian Guide to Healthy Eating* suggests a minimum of seven serves of cereals per day for adults, where one serving is equivalent to two slices of bread; one cup of cooked rice, pasta or noodles; one cup of prepared porridge; one-and-one-third cups of breakfast cereal; or half a cup of muesli (Australian Institute of Health and Welfare 2006b). As an example, obtaining the minimum recommended seven serves per day from four slices wholemeal bread, one cup cooked brown rice, one cup cooked wholemeal pasta, and 1.5 cups untoasted muesli yields approximately 4850kJ (Xyris Software 2007). Given that the average daily energy intake for Australian adults is 11,050kJ for males and 7,481kJ for females (Australian Institute of Health and Welfare 2006b), following the minimum recommended guideline for cereal consumption would occupy 44% of the daily energy budget for males and 65% for females. This is a very large percentage of the diet being drawn from a food group which didn’t feature heavily in our evolutionarily adapted wild food diet (see Chapter 2).

However, the rationale given for the inclusion of cereal grains as a key component of the dietary guidelines is because they ‘are an important source of carbohydrate, dietary fibre and protein’ (Australian Institute of Health and Welfare 2006b p.11). The evolutionary absence of significant cereal grain consumption in the human diet is commented upon by the NHMRC (2006) however they state that ‘it is difficult to base conclusions about desirable dietary patterns for modern societies simply from an assessment of traditional eating patterns of hunter-gatherers’ (p.32). In the average hunter-gatherer diet, complex carbohydrates were sourced from root vegetables, other vegetables, fruits and nuts, with minimal intake from cereal grains in reflection of their natural distribution and availability in the wild.

From an evolutionary perspective, it is perhaps somewhat reassuring that the average daily intake of cereals among adults is much lower than recommended levels. Only 34% of males and 21% of females reported meeting the recommended target of seven servings per day (Australian Institute of Health and Welfare 2006b). Males on average consumed 250g per day and females 181g per day (Australian Institute of Health and
Welfare 2006b). By comparison, using the example in which the recommended seven servings per day were hypothetically met by eating four slices wholemeal bread, one cup cooked brown rice, one cup cooked wholemeal pasta, and 1.5 cups muesli, this would yield 575.5g per day (Xyris Software 2007) – over half as much again as what was actually consumed by the average Australian.

If the average male intake of 250g/d was, for example, comprised two slices wholemeal bread (sandwich slice), one cup muesli (untoasted) and 0.5 cup cooked pasta this yields 2560kJ (Xyris Software 2007) and represent 23% of kilojoule intake in the average male’s daily diet. For females, their average intake of 181g/d could include for example include two slices wholemeal bread (sandwich slice), 0.75cup muesli and just 0.25 cup pasta, which yields 1955kJ (Xyris Software 2007) or 28% of kilojoule intake in the average female’s daily diet.

However, as discussed, in reality the nutritional density of the average Australian’s diet would markedly improve should the recommended dietary guidelines for Australian adults be followed, including following the recommended intake of cereal grains, particularly if they are wholegrains. This is because, at present, many ‘healthier’ foods including wholegrains are being displaced from the diet by processed and refined foods, which are energy dense but nutrient poor and are therefore very costly in terms of daily energy budget compared to wholegrains.

Nevertheless, in terms of optimal nutrition from an evolutionary perspective, the recommendation to include cereal grains in such large quantities serves to displace more nutritionally dense hunter-gatherer food groups from the diet.

7.5.3 Dietary guideline: Include lean meat, fish, poultry and/or alternatives

In terms of lean meat, fish, poultry and/or alternatives, the ‘Australian Guide to Healthy Eating’ recommends 1.5 serves per day for men, and 1–1.5 serves per day for women where one serve equates to 65–100g of cooked meat or chicken; 0.5 cup (cooked) dried beans, lentils, chick peas, split peas or canned beans; 80–120g cooked fish fillet; two
small eggs; one-third of a cup of almonds; or a quarter cup of sunflower or sesame seeds (Australian Institute of Health and Welfare 2006b).

The rationale for this dietary guideline is made on the basis that meat, fish and poultry are good sources of minerals including bioavailable iron and zinc, vitamin B_{12}, and omega-3 fatty acids (Australian Institute of Health and Welfare 2006b).

Based on the upper limits of this recommendation, 180g of fish, for example, supplies approximately 877kJ (steamed flathead fish; Xyris Software 2007). As a percentage of daily energy (average 11,050kJ for males and 7,481kJ for females) this represents 8% of the daily energy budget for males and 12% for females. By contrast, Cordain (2002a) estimated that terrestrial animals supplied an average of 27.5% of daily energy and sea animals supplied a further 27.5% in average worldwide hunter-gatherer diet (providing a mix of both protein and fat). Hence, the amount of animal foods included in the average Australian diet and the recommended dietary guidelines are significantly lower than what was likely eaten on average in our evolutionary past.

The dietary guidelines do not differentiate or prioritise protein intake from animal sources versus ‘alternatives’ from plant foods (e.g. pulses, nuts and seeds). In a hunter-gatherer diet, it is unquestionable that animal foods were the primary source of protein for the human body. Although the dietary guidelines can be met by consuming protein from plant food ‘alternatives’ alone (e.g. soy, lentils), plant foods supply a different (usually incomplete) amino acid profile (Lappe 1975), which is unlikely to support optimal human nutrition from an evolutionary perspective. Additionally, excluding animal foods from the diet means that other health-supportive nutritional factors are also removed e.g. long chain fatty acids and certain minerals.

Animal food intake in the average Australian diet is lower than the median estimates of hunter-gatherer intakes. Totalling animal muscle meat, poultry, fish and seafood, eggs and organ meats, Australian males consumed 223g/person/day. Females consumed 140g/person/day. Processed meats supplied an additional 22g/person/day for males and 10g/person/day for females. As a percentage of daily energy, including processed meats, this represents less than around 15% of daily energy intake for males and less than around 12% for females (See Appendix O for these calculations).
7.5.4 **Dietary guideline: Include milks, yoghurt, cheeses and/or alternatives**

As stated by the Australian Institute of Health and Welfare (2006b), the key rationale for emphasising the consumption of dairy foods in the dietary guidelines is their ‘role as a rich source of calcium, as dairy foods are the main source of calcium in the Australian diet’ (p.22). Many commercial dairy products are also additionally fortified with calcium which serves to further increase calcium intake in the population. Section 5.4 critiques calcium intake from an evolutionary nutrition perspective. Hence, dairy consumption rather than calcium intake per se is the focus here.

As discussed in Chapter 2, dairy is a very recent addition to the human food supply. In our evolutionary diet calcium was derived from non-dairy sources, namely leafy green vegetables, other vegetables (including roots, tubers and cruciferous vegetables), fruits (especially citrus), nuts and seeds, insects, animal meats and calcium dissolved from animal bones.

The ‘Australian Guide to Healthy Eating’ recommends two to three serves of milk and milk products or alternatives each day for females, and two to four serves for men. A serve is equivalent to a cup of milk, 40g of cheese or 200g of yoghurt. For ‘alternatives’, a serve equals a cup of soy milk (calcium fortified), a cup of almonds, five sardines or half a cup of pink salmon (with bones) or a cup of calcium-fortified breakfast cereal (Australian Institute of Health and Welfare 2006b). Following this recommendation meets the recommended dietary intake for calcium of 1000mg for adults (requirement increases for females during pregnancy and when lactating); (NHMRC 2006).

The recommended guidelines could, for example, be met by consuming one cup of milk (reduced fat), a piece of cheese (low fat, 40g) and a tub of yoghurt (reduced fat, fruit flavoured 200g) which supplies 1,638kJ (Xyris Software 2007). In the context of average daily energy intakes for Australian males (11,050kJ/person/day) and females (7,048kJ/person/day), consuming this amount of dairy foods contributes 15% and 23% of daily energy intake for males and females respectively. This is a large proportion of the daily energy budget to be sourced from a non hunter-gatherer food group.
If the recommended guidelines for both dairy and cereal grain consumption are followed, for males approximately 60% of their daily energy budget would contain these foods, and 90% of females’ energy budget would be occupied with these foods. This markedly skews the contemporary diet away from our evolutionary template in which the great proportion of not only energy intake, but also nutrient composition was not sourced from grains and diary, but rather from vegetables, fruits, nuts and animal foods.

In terms of actual intakes, only 16% of Australian males and 10% of Australian females consume the recommended three or more serves of dairy per day (Australian Institute of Health and Welfare 2006b). As can be seen in the calculations in Appendix P, dairy foods provide approximately 10% of the average Australian’s daily energy intake.

### 7.5.5 Dietary guideline: Limit saturated fat and moderate total fat intake

The National Heart Foundation of Australian recommends that saturated fat should contribute no more than 8% of total energy (National Heart Foundation of Australia 2009). Similarly, the NHMRC (2003) dietary guidelines recommend that it contribute no more than 10%. In reality, the average Australian diet is very close to this containing 12.7% saturated fat (Australian Institute of Health and Welfare 2006b), with a range of 11 to 16% (Meyer et al. 2003).

Eaton (1992) estimated that saturated fat intake in the average hunter-gatherer diet contributed around 6% of total energy. However, as previously mentioned, Eaton’s estimates included a lower intake of animal foods (and saturated fat intake) compared to other researchers (e.g. Cordain et al. 2000). Nonetheless, animal derived saturated fat intake would have been lower than contemporary levels because of the leanness of wild animals compared to domesticated meats (e.g. beef, lamb, pork), as well as the inclusion of dairy foods, and a combination of other processed foods in modern diets.

While there is no precedent for very high intakes of animal-derived saturated fat in the human evolutionary diet, there is a precedent for moderate to high intakes of other fats (i.e. mono- and polyunsaturated fats) depending on the global region in which various hunter-gatherer societies lived (Cordain et al. 2000; Cunnane 2005). This is somewhat in
contrast to the recommended guideline to ‘moderate total fat intake’ (Australian Institute of Health and Welfare 2006b).

Currently there is no nation-wide monitoring of dietary intakes of monounsaturated and polyunsaturated fatty acids (omega 6 and omega 3) in Australia despite clear recognition in the literature of the essential nature of such fats to human health. The only data available is on the average contribution of total fat as a proportion of energy intake in the average Australian diet, which sits at 32.4% and 32.5% for males and females respectively (Australian Institute of Health and Welfare 2006b).

Compared to estimates of recent worldwide hunter-gatherer societies as analysed by Cordain et al. (2000), the most plausible range for total fat intake was between 28 and 58%. Hence, the average Australian’s intake of total fat is at the lower end of the hunter-gatherer range.

The very wide range of total fat intake in hunter-gatherer diets is testament to the adaptability of humans to a diversity of macronutrient intakes. However, importantly, the distribution of fatty acids in hunter-gatherer diets was typically very different to the average Australian diet – the former containing more omega 3 fatty acids, more monounsaturated fats and less animal derived saturated fat. In light of the contribution of various fats to hunter-gatherer diets, the recommendation to ‘moderate total fat intake’ is questionable. From an evolutionary nutrition perspective, in the context of modern diets, it would be more appropriate to re-title the recommended dietary guideline to ‘limit animal-derived saturated fat and increase consumption of omega 3 fats’, and in so doing, disregard a recommendation for total fat intake.

### 7.5.6 Dietary guideline: Consume only moderate amounts of sugars and foods containing added sugars

Sugar is divided into ‘natural sugars’ and ‘added sugars’ (i.e. table sugar) by the Australian Institute of Health and Welfare (2006b). Principle sources of natural sugars in the hunter-gather diet were starchy root vegetables, fruits, honey and tree saps (e.g. maple syrup, chewing on stalks of cane sugar). Added sugars are those which have been added during processing, cooking or preparation which were, of course, unknown in
hunter-gatherer diets, as too was lactose (milk sugar) intake in adulthood. Given that the average Australian male and female obtains 10.4% and 9.4% respectively of their daily energy from added sugars (Australian Institute of Health and Welfare 2006b), this represents a significant displacement of more nutrient-dense foods from the diet.

There is no national data on average intake of different types of sugars. The most recent and relevant information available that provides an indication of average daily intake of glucose, lactose, fructose, maltose and sucrose is the New Zealand National Nutrition Survey in 1997 (Ministry of Health 1999). Australia and New Zealand share very similar dietary patterns. The average total sugar intake per person per day in New Zealand is 139g and 105g for males and females respectively. In Australia it is similar – 134g per person per day for males and 97g for females (Australian Institute of Health and Welfare 2006b). Hence, New Zealand data can reasonably be used to approximate Australian intakes of different sugars.

Sucrose (a disaccharide of fructose and glucose) supplies the majority of kilojoules from sugars in the contemporary New Zealand diet – 69g/person/day for males and 49g/person/day for females. While the major source of sucrose in the contemporary diet is table sugar, other foods, especially fruits also contain a certain amount of sucrose. In order to achieve this level of sucrose intake using hunter-gatherer food groups one would need to consume for example 19.22kg carrots per day or 16kg of cantaloupe (USDA 2009). Clearly one food group wouldn’t be consumed alone, but this highlights the fact that we have a limited evolutionary history for this very high level of sucrose intake.

Compared to modern Australian diets, hunter-gatherer diets would have contained much lower intakes of sucrose primarily due to the absence of table sugar and the inability to consume very high quantities of fruit juices which elevates the intake of sugar relative to eating fruits whole.

7.5.7 Summary of Part IV

Table 42 contains a summary of Chapter 7 Part IV. The data presented in the table contains approximate figures only, derived from interpreting the recommended dietary
guidelines (NHMRC 2003) into actual foods as done in this section. The nutrition composition of these foods was then analysed using the Australian FoodWorks software (Xyris Software 2007). The values presented in the table are marginally different (less grains, more vegetables & fruit) to the breakdown presented in the *Australian Guide to Healthy Eating* pie chart (Australian Government Department of Health and Family Services 1998); (see Appendix Q for a picture of the pie chart), indicating the potential for interpretive differences in using the dietary guidelines.

As seen in Table 42, according to how the dietary guidelines have been interpreted in this section, meeting each of the guidelines results in a food intake greater than 100% of an average female’s energy requirements, thus risking energy imbalance. Conversely, for males, the guidelines under-supply energy needs, which may consequently promote energy intake from less nutritious foods.

<table>
<thead>
<tr>
<th></th>
<th>Vegetables and Fruit</th>
<th>Dairy</th>
<th>Cereal Grains</th>
<th>Nuts</th>
<th>Meat (&amp; Poultry &amp; Seafood)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Recommended Dietary Guidelines:</strong> (as interpreted in Chapter 7 Part IV)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Males</strong></td>
<td>11-22% (av 16%)</td>
<td>15%</td>
<td>44%</td>
<td>(grouped with meat)</td>
<td>8%</td>
<td>83%</td>
</tr>
<tr>
<td><strong>Females</strong></td>
<td>16-32% (av 24%)</td>
<td>23%</td>
<td>65%</td>
<td>(grouped with meat)</td>
<td>12%</td>
<td>124%</td>
</tr>
<tr>
<td><strong>Australian Guide to Healthy Eating pie chart^:</strong> (approximate figures)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>39%</td>
<td>11%</td>
<td>39%</td>
<td>(grouped with meat)</td>
<td>11%</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Average Australian diet#:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Males</strong></td>
<td>12%</td>
<td>10%</td>
<td>23%</td>
<td>1%</td>
<td>15%</td>
<td>61% *</td>
</tr>
<tr>
<td><strong>Females</strong></td>
<td>19%</td>
<td>10%</td>
<td>28%</td>
<td>1%</td>
<td>12%</td>
<td>70% *</td>
</tr>
<tr>
<td><strong>‘Contemporary hunter-gatherer diet’ example:</strong> (as presented in Chapter 7 Part I)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>61%</td>
<td>0%</td>
<td>0%</td>
<td>22%</td>
<td>17%</td>
<td>100%</td>
</tr>
</tbody>
</table>

* The remaining energy intake adding up to 100% in the average Australian’s diet comes from other food groups including oils and fats, added sugars, alcohol, and other processed foods.
^ Sourced from the Australian Government Department of Health and Family Services (1998); (displayed in Appendix Q)
# Data sourced from the Australian Institute of Health and Welfare (2006b)

*Table 42. Percentage of daily energy sourced from core food groups: in the recommended dietary guidelines, versus the Australian guide to health eating, versus the average Australian diet, versus a ‘contemporary hunter-gatherer diet’*
Table 42 shows that the average Australian sources the great majority of daily energy needs from non hunter-gatherer food groups – 10% from added sugars; 10% from dairy; an estimated 44% (males) and 65% (females) from cereal grains; and a varying percentage from other processed and snack foods including processed meats, added sugars and alcohol. There is not much room left in daily energy budgets for core food groups reflecting our evolutionarily adapted diet.

Compared to the average Australian diet, a diet based on hunter-gatherer principles (such as the example ‘contemporary hunter-gatherer diet’ proffered in Chapter 7 Part I) typically contains three times more fibre, two times more monounsaturated fat, around 40% less saturated fat, three times more long chain omega 3 fats, higher protein, lower carbohydrate (and more slowly absorbed), nine times more vitamin C, seven times more vitamin A, three times more folic acid, and twice as much potassium, and contains calcium at levels that meet the recommended nutrient reference value despite the absence of dairy foods. This makes for a therapeutic diet with strong properties for preventing, managing and treating diet-related chronic disease.

All in all, as seen in this chapter, the average Australians diet is markedly divergent to the ancestral hunter-gatherer dietary pattern. There is clear evidence of nutrient displacement relative to a diet sourced from hunter-gatherer food groups i.e. vegetables, fruits, sea and land animals and shellfish, nuts and seeds. Over a lifetime, the resulting nutrient deficit and compositional differences must take its toll on health potential because it is so different to the dietary niche that supported our evolution and has been the food supply for over 99% of our species’ existence on earth.
Chapter 8: A New Guiding Model – ‘Contemporary Hunter-Gatherer Diets’: An Australian Perspective

‘New knowledge comes when you simply bear in mind what you need to know. Keep holding the problem in mind, and it will yield’

(G. Spencer Brown cited in Wilber 2001 p.39)

8.1 Introduction and Chapter Scope

This chapter is about understanding how to eat like a ‘contemporary hunter-gatherer’ in modern Australia. It provides the practical details (e.g. dietary examples) for designing optimal diets carrying the highest index of biological authenticity presently possible (i.e. consuming foods that are in their best possible state of health in quantities mirroring wild food distribution patterns). The author’s interpretation of ‘contemporary hunter-gatherer diets’ is presented in both illustrative (a ‘pyramid’) and written form. Thus, the purpose of the chapter is to demonstrate how the theory contained within the thesis can be realistically implemented. At the same time, it is not prescriptive or rule-based – rather the intention is to highlight the variable qualities of the wild food supply and encourage individuals to move towards more fluidly working within these natural boundaries (e.g. fresh, seasonal, diverse whole foods).
8.2 Contemporary Hunter-Gatherer Diets: An illustrated model

8.2.1 A new model

A key aim of this thesis is to initiate momentum towards more optimal present day food choices – choices that are more in line with our natural physiological needs and make the best use of our contemporary Australian food supply. In achieving this, an illustration is presented in this chapter along with the written material presented in the body of the thesis (Figure 19).

The illustration’s basic shape is derived from the archetypal image of a pyramid. A pyramid has become widely recognised as symbolic of a healthy diet message. The base of the food pyramid indicates which foods to eat most of, and the top represents the foods to eat in the smallest quantities.

In the late 1990s the Australian government’s presentation of the nutrition guidelines moved away from a pyramid structure to a pie diagram. This was done to de-emphasise the notion that any one particular food group is any more important than another. Rather, proportional ‘slices’ of a pie chart indicate how much of a food group should be eaten. See Appendix Q for the pie diagram titled, ‘The Australian Guide to Healthy Eating’ (Australian Government Department of Health and Family Services 1998). This is an important philosophical concept; however, it is not necessarily essential. There is also merit in thinking about food choice in a hierarchical way, as is done so here.

When a pyramid is divided into horizontal layers, each preceding base layer represents a foundational matrix which, if missed, is significantly destabilising for health. For example, the pyramid base of ‘contemporary hunter-gatherer diets’ presented in Figure 19 contains a wide variety of plant foods. In the context of our modern food supply, greater health is afforded to an individual who is vegetarian compared to one who skips this foundational layer and only includes animal foods in their diet (for example, amongst a plethora of problems, this would risk protein toxicity in the absence of heavy consumption of ‘healthy’ animal fats from organ meats, marrow, and other
minimal/non-saturated fat sources e.g. insects). This was not always the case for our hunter-gatherer ancestors. As mentioned, for example, traditional Arctic Inuit thrived on close to 100% subsistence from animal foods (Bang, Dyerberg & Sinclair 1980). Their wild food supply made this possible as handfuls of whale blubber were consumed alongside lean whale meat so as to avoid protein poisoning during long winter months. However, our modern food preferences makes eating in this way seem unpalatable and nonetheless our available food supply makes it impossible.

The pyramid is not intended to convey an ‘either/or’ message in relation to plant versus animal food. Rather, the guiding principle is that optimal nutritional status is achieved by including each predeccessing layer and the next layer (Wilber 2000, 2001). As such, a diet that includes vegetables and fruit (1st layer) and aquatic foods e.g. fish (2nd layer) is more health supportive (it is more micronutrient dense, has adequate protein and fatty acid composition, and a lower glycaemic load) than one which includes vegetables and fruit (1st layer) and grains (4th layer), and skips the 2nd and 3rd layers. It cannot be emphasised enough that this is not an absolute representation of traditional hunter-gatherer diets. Rather, it is a hierarchy that best utilises the contemporary Australian food supply. As such, it presents an integration of the knowledge of traditional hunter-gatherer diets, the nutritional properties of a wild food menu, and the realities of our contemporary food supply.

The model is intended to guide and prioritise more optimal food choices. It is the author’s interpretation. It is not intended to be prescriptive – a concept portrayed by the free-form shape of the ‘pyramid’ in the illustration. This is important because while on one hand people need to be equipped with the right information, on the other hand they need flexibility to incorporate relevant elements in the matrix of their own food preferences, individual needs, cultural background, and other socio-cultural-environmental factors (e.g. financial situation, time availability, and accessibility of particular foods including seasonal variations).
8.2.2 The Illustration: ‘Contemporary Hunter Gatherer Diet: An Australian perspective’

Figure 19 (over page)
Contemporary Hunter-Gatherer Diet
An Australian perspective

From ‘eat most’ to ‘eat least’:

**Plant foods**
- Include:
  - Vegetables (non-starchy),
  - Root vegetables,
  - Fruits, and
  - Oily plants (nuts, seeds & oily fruit e.g. avocado)
  (preference for certified organic produce)

**Aquatic animals**
- Australian wild caught sustainable species
  - fish, shellfish & crustaceans
  (minimize large, deep sea species)

**Land animals**
- Preference:
  1. wild sustainably harvested game animals
     (e.g. kangaroo)
  2. certified organic meats & poultry
     (lean cuts, offal, eggs)
  3. free-range, grass fed animals
     (e.g. lean cuts of lamb, beef, free range poultry & eggs)

**Wholegrains**

**‘Sweets’**
- Honey & free syrups (e.g. maple syrup)
8.2.3 Description of the illustration

Set in an estuarine environment, a free-form pyramid floats. Representationally contained in the pyramid are some of the potential foods found in wild shore-line ecosystems that are able to be mirrored with the Australian food supply today. Shore-line ecological niches offer the greatest diversity of foods and potential for the richest nutrient diversity and density (Cunnane 2005). Food sources include a variety of plant foods (non-starchy vegetables, root vegetables, fruits, nuts, and small quantities of wholegrains) and animal foods (aquatic and terrestrial animals, their eggs and a small quantity of honey). Water is the primary beverage. In our evolutionarily adapted diet, the vast majority of foods were eaten very fresh, and simple preparation techniques were employed before their consumption – a concept depicted by the illustration of ‘whole’ foods in Figure 19.

The ‘pyramid’ is laid out in the following way: the top of the pyramid representing foods to ‘eat least’, downwards to foods to ‘eat most’:

<table>
<thead>
<tr>
<th>LEVEL</th>
<th>PREFERENCE (hierarchy) &amp; comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>5th layer: Honey</td>
<td>Minimal quantities. Other ‘sweet’ wild foods include tree saps e.g. maple syrup</td>
</tr>
</tbody>
</table>
| 4th layer: Whole grains | 1. Certified organic  
2. Conventional  
*Prioritise less hybridised varieties such as the ‘ancient grains’ (e.g. spelt, quinoa, kamut) and rice* |
| 3rd layer: Land animals | 1. Wild sustainable harvest (e.g. kangaroo meat)  
2. Certified organic (meat, eggs and organ meats)  
3. Free-range and grass fed conventional (e.g. lamb, eggs from free-range chicken) |
| 2nd layer: Aquatic animals (fish, shellfish and other seafood) | Australian wild caught sustainable species (refer to Australian Marine Conservation guide by Bohm, Davey & Neilson 2007; available www.amcs.org.au $10AUD)  
*Minimise consumption of large, deep sea species to reduce mercury intake* |
| 1st layer: Plant foods | 1. Certified organic (homegrown, or equivalent)  
2. Conventional produce |

Plant foods are further divided into 4 categories: (all of which should be included in the diet)

(i) Vegetables (non-starchy)
- leaves (e.g. leafy greens, herbs)
- stems (e.g. asparagus, celery)
- flowers (e.g. broccoli, cauliflower, zucchini flowers)
- bulbs (e.g. onions, garlic)
- fruits (e.g. cucumber, capsicums, tomatoes, pumpkin)
- non starchy roots (e.g. carrots, parsnip, ginger)

(ii) Starchy vegetables (a carbohydrate alternative to grains)
- starchy roots and tubers (e.g. sweet potato, potato)
- other starchy vegetables (including fresh beans and peas, fresh corn on the cob)

(iii) Fruits, including
- berries (e.g. raspberries, blueberries)
- citrus (e.g. orange, lemon)
- stone (e.g. apricot, plum, cherry)
- pome (e.g. apples, pears)
- bananas

(iv) Oily plants
- Nuts (e.g. macadamia, brazil, almond, coconut)
- Seeds (e.g. pumpkin, sunflower, sesame)
- Oily fruit (e.g. avocado, olive)

Additional nutritional considerations:
- fish oil supplementation
- calcium supplementation

Supporting lifestyle factors, which enhance the therapeutic potential of ‘contemporary hunter-gatherer diets’ including:
- sleep
- physical exercise
- adequate sunlight (optimal vitamin D status)
- emotional wellbeing
- relaxation
- social support etc

Table 43. Written description of ‘contemporary hunter-gatherer diets: an Australian perspective’ as proposed in this thesis

For the sake of clarity, the pyramid is diagrammatically represented in simplistic form in Figure 20:

Eat least

Wholegrains
Land animals
Aquatic animals
Oily plants: nuts, seeds & oily fruit (e.g. avocado)
Fruits
Root vegetables

Eat most

Non-starchy Vegetables

Figure 20. Basic elements of the ‘contemporary hunter-gatherer diet’ pyramid
Diagrammatically the pyramid in Figure 20 is a representation of which foods to eat most and which to eat least (not a percentage of daily energy intake drawn from each food group). By area, Figure 20 is however representative of the plant to animal subsistence ratios modeled in Chapter 7 Part I, for ‘contemporary hunter-gatherer diets’ (a little over 80% daily energy from plant foods and a little under 20% energy from animal foods – although these do not necessarily have to be fixed values).

Capturing the qualities of the wild food supply and traditional hunter-gatherer diets with the greatest degree of authenticity is aided by the following guiding principles:

- Preferentially consume foods that are in an optimal state of health, grown in biodiverse ecosystems and fertile soils. For example, wild kangaroo meat instead of intensively farmed chicken meat, or certified organic fruit and vegetables in preference to conventionally produced ones (assuming all other quality factors are equal e.g. freshness).

- Foods need to be eaten in accordance with the seasons and natural patterns of food availability in the wild. For example, as O’Dea (1991a) observed in traditional Australian Aboriginal diets, several dozen eggs may be collected in a single day in spring and it was not uncommon for a person to sit down to a meal of a dozen eggs in one go. Likewise, 200gms of honey may have been eaten at a time if found. However, on average, only around 2kg of honey would have been eaten per year (Cordain et al. 2005). In many traditional hunter-gatherer diets, some foods would have been eaten in quantities we would now consider ‘excessive’, and ‘balanced’ meals as we know them today were probably far from ‘normal’. The ebb and flow of seasonal food availability, along with location moves placed a natural curb on on-going dietary excesses and imbalances in traditional hunter-gatherer diets. What this suggests is that in our contemporary diets, with awareness of what overall nutritional balance means, we can take a more fluid approach to individual meals and not necessarily be concerned with the ‘ideal balanced meal’, if that is not one’s preference, as long as an overall day to day, week to week, season to season diversity is achieved. This also enables individuals to become more in tune with what their body feels like eating while being guided by an overall healthy supportive framework.

- Consume minimally processed, fresh, whole foods where possible. This includes eating a significant proportion of fruit and vegetables raw, which
mirrors they way they were traditionally eaten as they were gathered in the wild.
When cooking, use simple cooking methods such as baking, roasting and steaming.

Consequently, the full therapeutic potential of this approach is not just about excluding agriculturally induced food groups (e.g. heavy consumption of grains, dairy and processed foods) or matching up our modern diets with the average macronutrient or fatty acid composition of typical hunter-gatherer diets (which as mentioned, has to date been the predominant stance in the evolutionary nutrition literature). While these factors are not unimportant, analysis of the way we produce our foods, the health of whole ecosystems, and our attitude to food choices and health behaviours also need to be examined and interwoven. In doing so, the therapeutic potential derived from a more holistic, integrated approach will be increased. Appendix R contains a recommendations summary of the food (and lifestyle) matrix for best meeting our evolutionarily adapted needs (which is considered useful as a clinical tool).

Of course, in any representational presentation there are limitations as to what can be conveyed. The most important aim of the illustration is to engage people’s attention in the hope that this will then stimulate interest and discourse. Therefore, in essence, it is not a stand alone illustration. Instead, its intricate layers of rationale are best understood when contextualised into the body of written work contained in this thesis.

The next section outlines four dietary examples to convey how the model can be practically implemented.
8.3 Dietary Examples of Eating like a ‘Contemporary Hunter-Gatherer’ in Australia Today

‘Biologically speaking, man is still a wild animal and there is no reason to suppose that his biology is adapted to anything other than wild foods’
(Crawford & Marsh 1995 p.232)

8.3.1 Introduction

There are numerous ways in which hunter-gatherer food groups can be combined to create delicious meals. Four examples are presented here. One has been constructed to approximate the average Australian male’s daily energy needs (11050kJ), one to mirror the average female requirement (7048kJ), one to suit pregnancy (9500kJ), and one that meets the needs of a young child (3500kJ). Fresh foods commonly available to Australians are used and for interest’s sake, each example is set in a different season of the year (summer, autumn, winter, spring). Basic nutritional comparisons (selected vitamins, minerals and macronutrients) are made with the life-stage appropriate recommended dietary intakes (RDI) as set by the NHMRC (2006). Brief comments about the rationale for various food inclusions and other points needing consideration are made.

These examples are not designed to be prescriptive, recipe-based ‘diets’. They are simply examples to illustrate options for how one could eat like a ‘contemporary hunter-gatherer’ in Australia today, as interpreted by this thesis. The quality of each of these dietary examples could be enhanced in numerous ways including the addition of herbs and spices, along with including organic produce. Such options would elevate the phytochemical content and therefore the antioxidant potential of the diet. A full description of the foods included in the dietary examples, their specific quantities and a full nutritional analysis can be found in Appendices S–V. Not mentioned in these examples is the need for adequate hydration (preferably with water).
8.3.2 ‘Contemporary hunter-gatherer diet’ example:

Adult male

Adult male, 11,085kJ, Reference body weight 76kg, Season – Winter

Breakfast:
- Omelette (2 eggs) with cooked leek
- Sweet potato (x1)
- Almonds (50g)

Lunch:
- Fish (flathead) (200g)
- Potatoes (x3)
- Kale or cavolo nero (leafy green winter vegetable)
- Salad of fennel, celery, carrot and sultanas with flaxseed oil or olive oil and lemon juice dressing

Dinner:
- Kangaroo mince (150g) bolognese (mince, onion, tomato, garlic, mixed herbs, small amount of olive oil if required)
- Pumpkin
- Broccoli

Dessert/Snacks throughout day:
- Macadamia nuts (50g) with honey
- Oranges
- Mandarins

<table>
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<tr>
<th>Analysis Summary</th>
<th>Quantity in diet</th>
<th>RDI (NHMRC 2006)</th>
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</thead>
<tbody>
<tr>
<td>Protein (g)</td>
<td>161</td>
<td>64</td>
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<tr>
<td>Fibre (g)</td>
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<td>30</td>
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<tr>
<td>Thiamin (mg)</td>
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<td>1.2</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>3.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Niacin (gm)</td>
<td>32</td>
<td>16</td>
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<td>Vitamin C (mg)</td>
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<td>Folate (µg)</td>
<td>754</td>
<td>400</td>
</tr>
<tr>
<td>Vitamin A (µg)</td>
<td>7946</td>
<td>900</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>928</td>
<td>460-920*</td>
</tr>
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<td>3800</td>
</tr>
<tr>
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<tr>
<td>Calcium (mg)</td>
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</tr>
<tr>
<td>Phosphorus (mg)</td>
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### Analysis Summary

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<td>8</td>
</tr>
<tr>
<td>Zinc (mg)</td>
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<td>14</td>
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<tr>
<td>kJ from Protein (%)</td>
<td>26</td>
<td>-</td>
</tr>
<tr>
<td>kJ from Fat (%)</td>
<td>40</td>
<td>-</td>
</tr>
<tr>
<td>kJ from Carbohydrate (%)</td>
<td>34</td>
<td>-</td>
</tr>
<tr>
<td>Energy intake from animal food (%)</td>
<td>27</td>
<td>-</td>
</tr>
<tr>
<td>Energy intake from plant food (%)</td>
<td>73</td>
<td>-</td>
</tr>
</tbody>
</table>

**Table 44. Nutritional analysis, ‘contemporary hunter-gatherer diet’ example: Adult male, 11085kJ/d, reference body weight 76kg, seasonal winter foods**

**Comments:**

Analysis shows a marginally higher intake of sodium than the RDI (highlighted by asterisks in red). However, the sources of sodium are all from natural whole foods, not added salt, and hence not considered to be significant especially in the presence of such a high potassium intake (2.5 times the RDI). This issue was discussed in regards to sodium/potassium ratio and endogenous acid-base status in Sections 5.2.5 and 5.2.7.

**8.3.3 ‘Contemporary hunter-gatherer diet’ example:**

**Adult female**

*Adult female, 7,063kJ, Reference body weight 61kg, Season – Autumn*

**Breakfast:**
- Pseudo-cereal made from a couple of grated apples, slithered almonds (50g), fresh dates, sunflower seeds (10g), pumpkin seeds (10g), honey, blueberries, and 100mL of soy milk (small amount, not regularly consumed)

**Lunch:**
- Fish (flathead) (180g)
- Sweet potato (x1)
- Avocado with squeeze of lemon juice
- Figs
- Persimmon

**Dinner:**
- Kangaroo fillet (100g)
- Parsnip
- Dark leafy greens (e.g. cavolo nero); (1.5 cups from fresh)
- Field mushrooms
### Analysis Summary

<table>
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<th>Quantity in diet</th>
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</tr>
</thead>
<tbody>
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<td>46</td>
</tr>
<tr>
<td>Fibre (g)</td>
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<td>25</td>
</tr>
<tr>
<td>Thiamin (mg)</td>
<td>1.0</td>
<td>1.1*</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>2.6</td>
<td>1.1</td>
</tr>
<tr>
<td>Niacin (gm)</td>
<td>26</td>
<td>14</td>
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<tr>
<td>Vitamin C (mg)</td>
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<td>45</td>
</tr>
<tr>
<td>Folate (µg)</td>
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<td>400</td>
</tr>
<tr>
<td>Vitamin A (µg)</td>
<td>2281</td>
<td>700</td>
</tr>
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<td>Sodium (mg)</td>
<td>394</td>
<td>460-920*</td>
</tr>
<tr>
<td>Potassium (mg)</td>
<td>4929</td>
<td>2800</td>
</tr>
<tr>
<td>Magnesium (mg)</td>
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<td>310-320</td>
</tr>
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<td>Calcium (mg)</td>
<td>924</td>
<td>1000*</td>
</tr>
<tr>
<td>Phosphorus (mg)</td>
<td>1795</td>
<td>1000</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>kJ from Protein (%)</td>
<td>27</td>
<td>-</td>
</tr>
<tr>
<td>kJ from Fat (%)</td>
<td>39</td>
<td>-</td>
</tr>
<tr>
<td>kJ from Carbohydrate (%)</td>
<td>34</td>
<td>-</td>
</tr>
<tr>
<td>Energy intake from animal food (%)</td>
<td>22</td>
<td>-</td>
</tr>
<tr>
<td>Energy intake from plant food (%)</td>
<td>78</td>
<td>-</td>
</tr>
</tbody>
</table>

*Table 45. Nutritional analysis, ‘contemporary hunter-gatherer diet’ example: Adult female, 7063kJ/d, reference body weight 61kg, seasonal autumn foods

**Comments:**

A lower kilojoule intake in this example tends to reduce the opportunity for meeting RDI. Consequently, calcium intake just falls below the RDI. This is despite calcium rich non-dairy foods being intentionally included, including leafy greens and almonds, along with animal meats. In terms of sodium intake, unlike the example in adult males, sodium intake in this example appears to be too low. In reality, it all depends on the natural sodium content in various foods. In the context of a diverse whole foods diet, sodium intake does not need consideration (as long as no processed/canned foods are included). Thiamin content also falls just below the RDI. The avenue by which most Australians meet the RDI for B group vitamins is via fortified grain products (e.g. bread), which are absent from this example. However, a varied contemporary hunter-gatherer dietary pattern would naturally resolve this marginal issue.
8.3.4  ‘Contemporary hunter-gatherer diet’ example:

Pregnancy

Pregnancy, 9,403kJ, Season – Summer

Breakfast:
- Apricots
- Peaches
- Cherries
- Walnuts (50g)
- Honey (2tsp)

Lunch:
- Scrambled eggs (3 eggs) with basil, cherry tomatoes, chives and a little olive oil
- Asparagus spears

Dinner:
- Fish (whiting) (180g)
- Mussels (x10)
- Sweet potato (x1)
- Zucchini
- Fresh peas
- Salad of lettuce, capsicum, avocado (half) and flaxseed/olive oil and lemon juice dressing

Dessert/Snacks throughout day:
- Raspberries
- Blueberries
- Fresh Sweet corn (on cob)
- Banana
- Brazil nuts (20g)

<table>
<thead>
<tr>
<th>Analysis Summary</th>
<th>Quantity in diet</th>
<th>RDI (NHMRC 2006)</th>
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<tbody>
<tr>
<td>Protein (g)</td>
<td>123</td>
<td>60</td>
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<td>Fibre (g)</td>
<td>44</td>
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<tr>
<td>Thiamin (mg)</td>
<td>1.4</td>
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<tr>
<td>Riboflavin (mg)</td>
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<tr>
<td>Niacin (gm)</td>
<td>28</td>
<td>18</td>
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<tr>
<td>Vitamin C (mg)</td>
<td>385</td>
<td>60</td>
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<tr>
<td>Folate (µg)</td>
<td>605</td>
<td>600</td>
</tr>
<tr>
<td>Vitamin A (µg)</td>
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<td>800</td>
</tr>
<tr>
<td>Sodium (mg)</td>
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</tr>
<tr>
<td>Potassium (mg)</td>
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<td>2800</td>
</tr>
<tr>
<td>Magnesium (mg)</td>
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<td>350-400</td>
</tr>
<tr>
<td>Calcium (mg)</td>
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<tr>
<td>Phosphorus (mg)</td>
<td>2077</td>
<td>1000</td>
</tr>
<tr>
<td>Analysis Summary</td>
<td>Quantity in diet</td>
<td>RDI (NHMRC 2006)</td>
</tr>
<tr>
<td>------------------</td>
<td>-----------------</td>
<td>------------------</td>
</tr>
<tr>
<td>Iron (mg)</td>
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<td>27</td>
</tr>
<tr>
<td>Zinc (mg)</td>
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<td>11</td>
</tr>
<tr>
<td>kJ from Protein (%)</td>
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</tr>
<tr>
<td>kJ from Fat (%)</td>
<td>45</td>
<td>-</td>
</tr>
<tr>
<td>kJ from Carbohydrate (%)</td>
<td>31</td>
<td>-</td>
</tr>
<tr>
<td>Energy intake from animal food (%)</td>
<td>27</td>
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</tr>
<tr>
<td>Energy intake from plant food (%)</td>
<td>73</td>
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</tr>
</tbody>
</table>

Table 46. Nutritional analysis, 'contemporary hunter-gatherer diet’ example: Pregnant female, 9403kJ/d, seasonal summer foods

Comments:
A calcium supplement could be considered advisable in this example, as intake is only 75% of the RDI. Also, needing consideration in this example is that the consequences of heavy metal contamination may be higher during pregnancy and as discussed in Section 4.4. It is not uncommon for pregnant women to be advised to limit seafood intake. Being mindful of these concerns, whiting fish has been included in this example because it is a relatively short-living, shallow-water species commonly fished in the relatively clean waters around south eastern Australia and contains less mercury compared to tuna, for example. Whiting is of course not the only (nor least expensive!) species that could have been included in this example. Fish is included to emphasise the importance of adequate long chain omega 3 polyunsaturated fatty acid (n-3 LCPUFA) intake, which is essential for a developing foetus. This dietary example contains 1624mg n-3 LCPUFA. Adequate intake according to the NHMRC (2006) is 430-619mg n-3 LCPUFA. Simply to convey an idea, brazil nuts – which are particularly rich in selenium36 – have been included in this example to initiate thinking about the selenium content of the diet as one of the possible means for buffering increase mercury exposure from fish intake.

36 Brazil nuts contain around 1900mcg selenium/100g; fish contains around 30-40mcg/100g; and two large eggs contain around 30mcg. (Reference: USDA 2009, National Nutrient Database, viewed 2009, http://www.nal.usda.gov/fnic/foodcomp/search/.)
8.3.5  ‘Contemporary hunter-gatherer diet’ example:

*Child*

**Breakfast:**
- Mashed up mix of avocado (half), banana, honey (1tsp) and cinnamon

**Lunch:**
- Potato/Sweet Potato (x1)
- Fish (whiting) (50g)
- Cherry tomatoes

**Dinner:**
- Lamb chop (1 lean chop)
- Cucumber slices
- Carrot sticks
- Broad beans

**Dessert/Snacks throughout day:**
- Oranges
- Fresh dates

**Analysis Summary**

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Quantity in diet</th>
<th>RDI (NHMRC 2006)</th>
</tr>
</thead>
<tbody>
<tr>
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<td>14</td>
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<tr>
<td>Fibre (g)</td>
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<td>14</td>
</tr>
<tr>
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</tr>
<tr>
<td>Riboflavin (mg)</td>
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<td>0.5</td>
</tr>
<tr>
<td>Niacin (gm)</td>
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<td>6</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
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<td>Sodium (mg)</td>
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<td>Magnesium (mg)</td>
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<tr>
<td>Calcium (mg)</td>
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<td>500*</td>
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<tr>
<td>Phosphorus (mg)</td>
<td>557</td>
<td>460</td>
</tr>
<tr>
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</tr>
<tr>
<td>Zinc (mg)</td>
<td>5.7</td>
<td>3</td>
</tr>
<tr>
<td>kJ from Protein (%)</td>
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<td>kJ from Fat (%)</td>
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<tr>
<td>Energy intake from carbohydrate (%)</td>
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<td>-</td>
</tr>
<tr>
<td>Energy intake from animal food (%)</td>
<td>21</td>
<td>-</td>
</tr>
<tr>
<td>Energy intake from plant food (%)</td>
<td>79</td>
<td>-</td>
</tr>
</tbody>
</table>

*Table 47. Nutritional analysis, ‘contemporary hunter-gatherer diet’ example: Child, 3 year old boy, 3540kJ/d, reference body weight 14kg, seasonal spring foods*
**Comments:**
Calcium intake is *significantly* lower than the recommendation for this age group. For the average Australian child, dairy foods are the key source of calcium, which are absent in ‘contemporary hunter-gatherer diets’. Other sources of calcium excluded from this dietary example include nuts/seeds (potential safety issues for young children) and leafy greens. Children will typically not eat leafy green vegetables due to their slightly ‘bitter’ taste. From an evolutionary perspective, this is not to be unexpected because in the wild, bitter foods are often also poisonous foods (Cordain 2002b) and hence, a natural aversion during this young phase of life when experimentation is high would offer distinct survival advantage. Calcium intake in hunter-gatherer children was likely much higher than in this example owing to the higher calcium content of many wild plant foods (not just leafy greens, but also root vegetables, and seeds); (Brand-Miller & Holt 1998; Eaton & Nelson 1991). Hence, if dairy foods are going to be excluded, calcium supplementation is required to meet the RDI. For children, this means grinding a supplement tablet and mixing it with some food…or including some dairy.

**8.3.6 Summary**

In each of these dietary examples, all RDIs – except calcium – are met and usually significantly exceeded (sodium aside). Nutrient intakes were, however, not above the recommended *upper limits* as specified by the NHMCS (2006). Hence, nutrient intakes could be considered ‘optimal’ based on the NHMRC (2006) frame of reference.

Calcium intake was lower than the RDI in the above example diets (except ‘adult males’) due to the absence of dairy foods, which raises several points for consideration, as discussed in Section 5.4. Calcium supplementation may be advisable to bridge the deficit compared to the RDI. The other form of supplementation that may be required in ‘contemporary hunter-gatherer diets’ is n-3 LCPUFA as analysed in Section 5.2.3 & 7.2.3.4.

A more comprehensive nutritional analysis, including fatty acid intake, trace element content, phytochemical quantities and antioxidant potential is not presented because: a) in many cases the data simply isn’t available and b) the extent of the nutritional analysis
presented in this chapter was governed by what is available in the Australian Xyris FoodWorks software program (2007) which was used for the dietary analysis. The extent of analysis presented for the four dietary examples in this chapter is however indicative of the nutritional quality of ‘contemporary hunter-gatherer diets’.

One additional point worth mentioning is that whiting and flathead are the only two fish species used in the dietary examples. However, in reality a diversity of sustainable fish species would be encouraged in an ad lib diet.

Less significant but of interest is that the macronutrient composition of each of the four examples fall within traditional hunter-gatherer parameters as estimated by Cordain et al. (2000); (19–35% protein, 22–40% carbohydrate, and 28–58% fat). The percentage of energy sourced from plant versus animal foods is heavily weighted towards plant foods, which is in contrast to average hunter-gatherer diets (owing to the absence of fatty organ meats, marrow, fat deposits and fatty insects in these example diets); (as discussed in Chapter 7 Part I).

The calcium issue aside, eating like a ‘contemporary hunter-gatherer’ as it is interpreted in this thesis supplies a very nutrient-dense diet and utilises high quality foods which are available to modern-day Australians. The key constraints are the increased cost of such quality food and the time involved in frequently shopping for fresh produce and meal preparation.
Chapter 9: Clinical Integration

“We have within us matter, body, mind, soul and spirit. In any disease, it is extremely important to determine on which level or levels the disease primarily originates – physical, emotional, mental, or spiritual. It is most important to use a ‘same-level’ procedure for the primary (but not necessarily sole) course of treatment. Use physical intervention for physical diseases, use emotional therapy for emotional disturbances etc. If a mixture of causes, then use a mixture of appropriate-level treatments. This is important because if you misdiagnose the disease by thinking it originates on a level higher than it in fact does, then you will generate guilt; if on a level lower, you will generate despair. Either way, the treatment will be less than effective.’

(Wilber 1991 p.261)

9.1 Introduction and Chapter Scope

The aim of this chapter is to re-enforce the ways in which the material contained within this thesis and its general guiding framework can be used in clinical practice. The merit of dietary and lifestyle factors in determining health, wellbeing and disease prognosis can not be under-estimated, as established throughout Chapters 2 and 3 in particular.

The intention of an integrated perspective is, as stated in Chapter 3, to combine the ‘life-saving’ and the ‘life-enhancing’ techniques of health care (Cohen 2003). Western medicine’s surgical and pharmaceutical treatments will be maximised and better directed within a framework also addressing the fundamental components of health, including diet and lifestyle elements.

This chapter further explores some of the common denominators underpinning chronic disease states, including cell metabolome dysregulation, inflammation and excessive oxidative stress, and how dietary factors (and lifestyle factors) can be consciously used in their mitigation. Also presented is a brief example for how evolutionarily informed
dietary characteristics can possibly assist in buffering some of the endogenous
dysregulation and inflammation concurrently present with mental health conditions,
namely depression.

The final aspect of this chapter examines the important area of foetal nutrition.
Targeting nutrition and lifestyle interventions peri-natally is hypothesised to create
significant life-long positive health effects in off-spring. The theory is based on the
premise that human genetics are programmed in-utero on the assumption that the
optimal postnatal environment is one the matches the evolutionary environment to
which our species is adapted. However, as now recognised, the contemporary Australian
food and lifestyle landscape is very different and, consequently, Gluckman & Hanson
(2005) suggest that foetal predictions, and hence cellular programming, are likely to be
inappropriate.
9.2 Clinical Application

Irrespective of background dietary factors, the temptation in some forms of clinical nutrition practice is to use individual nutrients – often in supplement form – with the rationale of regulating biochemical pathways by altering quantities of various nutritional co-factors. As discussed in Chapter 5.4, this approach has been driven by the directional pull of reductionistic research findings. This approach is useful for treating some specific conditions such as those caused by individual nutrient deficiencies (e.g. scurvy), or for attempting to match recommended dietary intakes such as calcium or those requiring regulation of specific biochemical pathways (e.g. reducing elevated homocysteine levels with vitamins B₆, B₁₂ and folic acid as a component of cardiovascular health management), and those requiring management of specific genetic polymorphisms [e.g. gene polymorphisms in folate metabolising enzymes leading to the depletion of reduced folates in circulation which is hypothesised to elevate risk of cancer and cardiovascular disease (Cortese & Motti 2001; Xu et al. 2007) and significantly elevate requirements of this nutrient].

However, by and large, the vast majority of today’s illnesses are slow and subtle in their development, chronic in duration, involve multiple systems and numerous biochemical pathways and, compared to the above mentioned examples, are complex in ways well beyond what current scientific models can, at present, entirely account for. Hence, at this point in time, a more general guiding paradigm must also be operational for informing clinical interventions. This then enables reductionistic research findings to become even more valuable and targeted when viewed within a larger, contextualising framework. Then from this perspective, nutrition related pathology tests (e.g. red blood cell magnesium content, phospholipid fatty acid composition) and nutrition related endogenous molecules (e.g. homocysteine, cholesterol, serum glucose, C-reactive protein) can serve as ‘markers’ for elevated disease risk and/or the efficacy of treatment strategies.

Various dietary and lifestyle characteristics have been identified in this thesis as being different to our ancestrally adapted environment. Discussed in this section are core endogenous commonalities (not exclusive) shared by all chronic diseases – a long term systemic state of cell metabolome dysregulation, inflammation, and excessive oxidative stress (Holst & Williamson 2008; Linnane, Kios & Vitetta 2007c; Nijveldt et al. 2001;
Nonn, Duong & Peehl 2007; Simopoulos 2008) – and how diet and lifestyle factors can be consciously used in their mitigation. In all avenues of medical practice, focus is increasingly turning towards addressing inflammation, optimising sub-cellular metabolic function and addressing undue oxidative stress/balancing redox poise in treating all of the major chronic diseases. Dietary and lifestyle factors are major players in this process.

The traditional theory has been that oxidative stress (free radical damage) underpins ageing and chronic disease states including cancer, cardiovascular disease, diabetes and numerous inflammatory diseases. The oxygen free radical theory of ageing has been around since the mid 1950s (Linnane, Kios & Vitetta 2007c). Dietary antioxidants have consequently been considered likely to reduce chronic disease risk and modulate pathogenesis (Holst & Williamson 2008; Nijveldt et al. 2001).

The ‘oxidative stress ↔ cellular damage ↔ antioxidant buffer equation’ is however currently being re-characterised into a more holistic, contextually dependent model (see Linnane, Kios & Vitetta 2007b, c). The formation of free-radicals (e.g. superoxide anion/hydrogen peroxide and nitric oxide) do not lead to random damage under normal physiological conditions (Linnane, Kios & Vitetta 2007c). Excessive and continued free-radical production does unquestionably have deleterious effects, and cellular damage/ageing are known to accelerate in the presence of insufficient antioxidant mechanisms (Dreosti 1994; Holst & Williamson 2008). However, oxidative systems per se, are a vital component of normal cellular function (e.g. in the necessary mechanism of apoptosis). Furthermore, as hypothesised by Linnane, Kios & Vitetta (2007c) free radical damage alone is not the major player in the ageing process relative to the multiple and systemic effects more widespread cellular metabolome malfunction (Linnane, Kios & Vitetta 2007c). Again, this re-enforces the theoretical and epistemological perspective of this thesis, emphasising the need to value (and examine) holistic dietary and lifestyle factors rather than just limiting the focus to dietary factors with antioxidant potential.

Irrespective, regardless of the role of oxidative stress and antioxidant systems in disease pathogenesis and the ageing process, from a clinical perspective, the message to increase dietary antioxidant status is useful. A diet which is high in antioxidants will inherently be high in fruit and vegetables and highly nutrient dense – factors known to be health supportive and disease preventing.
A cascade of cellular metabolic dysfunction is unanimously associated with wide ranging chronic disease pathologies as well as the ageing process. Such effects include alterations in cellular bioenergy systems, proteolysis regulation, transcriptional factors, enzyme activation, mitochondrial DNA changes, redox regulation and cell differentiation (Linnane, Kios & Vitetta 2007c). Cell metabolome systems are impacted upon by an array of conditions including an individual’s genes, and a variety of intrinsic and extrinsic factors including metabolic function, nutritional milieu, hormonal balance, immune system function, protein glycations, physical exercise, insufficient/excess sunlight exposure, radiation exposure, sleep quality, environmental contaminants (e.g. inhaled air quality, heavy metals, pesticides, other industrial chemicals, smoking, drugs) etc (Linnane, Kios & Vitetta 2007c).

Cell metabolome dysregulation commonly initiates inflammatory cascades and consequently, most biochemical/physical lesions are accompanied by a degree of inflammation. If damage out paces repair mechanisms, or a cell’s intrinsic defences are overwhelmed, a chain of events leading to clinical disease progressively unfolds. The process can be subtle at first and escalate over time. Hence, sub-clinical dysfunction usually appears long before major disease takes effect. Recognising the signs and symptoms of subtle homeostatic imbalance/strained homeostatic mechanisms for which a commonly felt sense is ‘fatigue’, and knowing what to do about it at this subtle level, is the challenge for today’s clinical practitioner and client. ‘Fatigue’ is therefore a very useful indicator for gauging health. Generally speaking, in subtle ways each of us can begin by recognising the immediate signs of optimal health, for example, mental clarity following a sound night’s sleep, the sense of calm vitality induced by nutritious food, or the contentment of being centred in our authentic self. These are some of the daily (and hourly) signs we need to attune ourselves to.

The food we eat is one of the most direct ways in which we can alter the chemistry of our body on a daily basis, and many endogenous biochemical processes can be intentionally affected by nutritional factors. Some of the therapeutic aims of consciously using food (and lifestyle factors) include: improving digestion (e.g. via eating calmly, chewing food well) and hence assimilation of nutrients; treating gastrointestinal dysbiosis (e.g. via altering diet to affect substrate availability to gastro-intestinal bacteria); improving metabolic function (e.g. glucose control), optimising cell signalling (e.g. optimal LCPUFA incorporation into cell membranes); minimising inappropriate inflammation (e.g. altering fatty acid profiles, lowering the glycaemic load of the diet,
increasing nutritional density, optimising vitamin D status); elevating antioxidant status to ensure a buffer against excess oxidation (e.g. increasing intake of fruits and vegetables which have been grown with a high index of biological authenticity and therefore, for instance, will have a higher phytochemical content, among other health supportive factors); protection of neuronal function (e.g. adequate n-3 LCPUFA, anthocyanins from red berries and a vast range other phytochemicals); optimising DNA expression (and many other factors involved in regulating cell metabolome); regulating the hypothalamic-pituitary axis and other hormonal factors (e.g. through sleep, exercise, sunlight exposure, adequate protein). All of these factors, and a great many more, impact on disease expression.

Being guided by an evolutionary framework when intentionally attempting to balance biochemical pathways seems common sense given that in many cases, manifestations of chronic disease are not inherent defects in bodily mechanisms, but are sophisticated adaptations designed to operate in the environment in which our evolution took place (e.g. the ability for fat storage, insulin resistance, ‘fight or flight’ stress responses); (Nesse 1999). Hence, chronic disease states can be seen as a logical response to our contemporary environment to which we are unadapted. Therefore treating these conditions with evolutionarily informed clinical interventions (i.e. hunter-gatherer diet and lifestyle parameters) is an essential starting point and basic priority.

An example of the how this approach can be applied in the clinical setting is provided here with the complex case of mental health. As mentioned in Section 2.5, mood disorders haven’t been given much prominence in the evolutionary nutrition literature and hence, given their prevalence in the population, they are discussed here (albeit brief). Mood disorders, such as depression, involve a multifaceted interplay of bio-psycho-social-environmental influences. As part of a multi-disciplinary approach, nutritional and lifestyle factors can play their therapeutic role and it is these factors that are briefly outlined here.

The traditional biological model of depression has focused on neuro-transmitter dysregulation (including genetic polymorphisms e.g. in serotonin receptor function/enzyme regulation in serotonin production pathways). Research is now also increasingly focusing on the inflammatory hypothesis of depression (Maes 2008). Multiple pro-inflammatory cytokines, high indices of excessive oxidative damage and neurodegenerative biomarkers are evident in depressed individuals compared to non-
depressed people (Kenis & Maes 2002; Maes et al. 2009). External stressors (e.g. psychosocial stressors, inadequate sunlight, inadequate diet, poor sleep, and environmental contaminants) and internal stressors (e.g. elevated inflammatory markers and reactivity in the hypothalamic-pituitary-adrenal axis including cortisol hyper-reactivity) all exacerbate inflammation. Furthermore, gastrointestinal-derived inflammation in particular is hypothesised to predispose towards depression. Impaired digestion (dyspepsia, gastrointestinal dysbiosis) and increased gut permeability contribute to both localised and systemic inflammation (Lydiard 2001; Maes et al. 2009). Irritable bowel syndrome, while being present in 10–20% of the general population, is evident in 70–90% of patients with psychiatric conditions, particularly mood and anxiety disorders (Garakani et al. 2003).

Most antidepressants (e.g. selective serotonin re-uptake inhibitors) have specific anti-inflammatory effects (Maes et al. 2009). Hence, Maes et al. (2009) hypothesise that supporting mental health from an anti-inflammatory perspective offers avenues for new treatments (including treating gut-derived inflammation which can be assisted by supporting better digestion, modulating the gastrointestinal microflora matrix and maintaining mucosal gut wall integrity). Selective use of anti-inflammatory agents may also be beneficial (Maes 2009); (e.g. COX2 inhibitors such as asprin/celebrex/fish oil/phytochemicals37, as well as the possibility of utilising selective cytokine inhibitory drugs). And, in a more general capacity, treating from the perspective of reducing inflammation and improving cellular function by using nutrient dense, protein adequate, fatty acid appropriate, low glycaemic load, base yielding, ‘contemporary hunter-gather diets’ – on the backdrop of health supportive lifestyle factors – offer untapped treatment potential.

Homeostasis, in mind and body, underpins health and happiness. Programmed deep into our DNA are the dietary and lifestyle conditions of our hunter-gatherer ancestors. We are optimally adapted to the nutritional characteristics of a wild food supply, towards physical exercise, a degree of outdoor living, and to be curious, creative social beings. These are human needs. Gaining experiential knowledge of our body’s natural state of

37 For example, the anti-inflammatory activity of the phytochemicals curcumin, resveratrol and gingerol (among a potential numerous others), as discussed in Section 4.2.3.7 (Reference: Nonn, L, Duong, D & Peehl, DM 2007, 'Chemopreventive anti-inflammatory activities of curcumin and other phytochemicals mediated by MAP kinase phosphatase-5 in prostate cells', Carcinogenesis, vol. 28, no. 6, June, pp. 1188-1196.)
homeostasis requires both a general guiding frame of reference (evolutionary paradigm) and individually sculpted actions/interventions.

Thus, integrating the theory of this thesis into clinical practice can happen on two fronts:

1. Using an evolutionary paradigm to guide optimal dietary and lifestyle parameters that are common and fundamental for all.
2. Therapeutically sculpting the guiding paradigm to meet individual requirements e.g. to suit genetic and biochemical individuality, specific disease processes, dietary and lifestyle preferences, and psycho-social considerations.

Life-long preventative measures offer the greatest therapeutic potential. However, a stand-out arena for targeting shorter term dietary and lifestyle interventions is the realm of foetal nutrition, as discussed in the next section.
9.3 Key Intervention Window: Foetal Nutrition

Normal foetal development involves the rapid maturation of specific structural and biochemical pathways (Barker 2004, 2007; Cunnane 2005). The sensitivity of these pathways to external modification usually has a finite critical window before or after which the potential for modification quickly declines (Barker 2004; Crawford & Marsh 1995; Cunnane 2005). Traditionally the intrauterine environment has been casually related to signs and symptoms immediately evident in a new-born baby, such as birth weight, conditions like spina-bifida and the teratogenic effects of particular drugs.

Examples of the more immediate effects of the intra-uterine environment that directly relate to material in this thesis are the findings of Prescott & Dunstan (2007), who suggest that modern maternal diets, which are increasingly rich in omega 6 fats and relatively deficient in omega 3 fats (particularly n-3 LCPUFA), exert a pro-inflammatory influence over the developing foetal system. Human studies demonstrate that higher maternal intakes of n-3 LCPUFA are associated with a reduction in neonatal oxidative stress, reduced production of inflammatory leukotriene B4, altered T cell function and reduced T cell cytokine production (a conditional milieu protective against allergic disease); (Prescott & Dunstan 2007). These immunological changes are evident at birth or in the first months of life (Prescott & Dunstan 2007).

The effects of maternal nutrition have also been examined in young offspring. For example, the follow on from Prescott & Dunstan’s (2007) work is that preliminary findings suggest that fish oil supplementation during pregnancy has a positive effect on allergy prevention in young children (Prescott 2006; Prescott & Dunstan 2007). The same research group also found that maternal fish oil supplementation (2.2g/d DHA + 1.1g/d EPA) from 20 weeks gestation until delivery significantly improved hand and eye co-ordination in offspring at 2.5 years of age (Dunstan et al. 2008; Prescott 2006; Prescott & Dunstan 2007).

However, unlike the above examples, the impact of the intrauterine environment on much later life adult risk of developing major chronic diseases including insulin
resistance, diabetes, obesity, heart disease, cancer, osteoporosis, depression etc is a new frontier in medicine.

It is particularly the work of Gluckman & Hanson (2005, 2007, 2008; Gluckman, Hanson & Beedle 2007a, b; Gluckman et al. 2008; Gluckman et al. 2005) that has focused research in this direction. Their hypothesis is that early in foetal life, mammals make irreversible choices in their developmental trajectories by predicting the environment into which they will be born based on the conditions of their intrauterine environment (Gluckman & Hanson 2005). Hence, the peri-natal period theoretically presents an outstanding opportunity for targeting relatively short-term nutritional (and lifestyle) interventions with potential life long effects on offspring health.

While maternal nutritional and endocrine (e.g. cortisol) influences can affect the development of single organs or systems, more commonly (particularly in Western societies where severe nutritional deficiencies are uncommon) they only induce subtle changes in the maturing phenotype of the foetus in a process underpinned by epigenetic mechanisms (Chavatte-Palmer et al. 2008; Gluckman, Hanson & Beedle 2007a; Henriksen et al. 2005). Yet, the effects on latter-life disease risk may be significant.

Human genetics are programmed on the assumption that the optimal postnatal environment is one that matches the evolutionary environment to which our species is adapted. Our contemporary Australian food and lifestyle environment is, however, now very different and consequently Gluckman & Hanson (2005) suggest that foetal predictions are bound to be inappropriate. As Gluckman et al. (2007) state, ‘the greater the mismatch, the greater the consequences’ (p.1).

Among several examples, Gluckman & Hanson (2005) present a case study on osteoporosis to demonstrate their hypothesis. They propose the following potential cascade of events:

Maternal hormonal stress → elevated foetal exposure to cortisol → a foetus born with a subtly altered hypothalamic-pituitary-adrenal axis → offspring secretes more cortisol in response to a situation perceived as stressful compared with an ‘unstressed’ foetus (due to a reduction in cortisol receptors being laid down in the developing foetal brain, thus affecting negative feedback) → the foetus has ‘logically’ predicted that the postnatal environment will be stressful
requiring increased cortisol for survival → chronic long term exposure to elevated cortisol throughout life leads to a cascade of effects including reducing bone mineral density → osteoporosis manifests in later life as the potent bone mineralising effects of oestrogen (particularly in women) decline.

Little is presently known about the actual pathways, mechanisms and windows of plasticity in a developing foetus (Gluckman & Hanson 2007). Nonetheless, addressing optimal maternal nutrition during pregnancy offers a powerful intervention strategy for potentially altering chronic disease susceptibility.

This concept does not negate the life-long effects of dietary and lifestyle strategies on chronic disease prevention. It simply opens a window of opportunity where increased vigilance may create long-term echoes. Hence, implementing a ‘contemporary hunter-gatherer diet’ and health supportive lifestyle parameters that reflect our evolutionarily adapted conditions, theoretically, provides a developing foetus with its anticipated intrauterine environment and the potential for nurturing normal development.
Chapter 10: Future Directions – An Integral Vision

‘It will take a much more integrated and international approach to have a significant impact on the diabetes epidemic (and other chronic diseases). We must accept that type 2 diabetes (for example) is not just a disease, but a symptom of a much larger global problem – the effect on human health of environmental and lifestyle changes’
(Zimmet, Alberti & Shaw 2001)

10.1 Introduction and Chapter Scope

In its broadest capacity, with its historical and holistic approach, this thesis highlights some of the inter-related factors underpinning our health symptoms – how the health crises facing us are systemic and rooted in the vast scale of industrialised-economic imperatives, population pressure, overshooting the physical limits of the earth (and its waste-sinks) and changing the biological landscape of our daily activities at an unprecedented rate. Taking a holistic approach to the connections between problems and the points at which they converge can shape our strategies to more effectively address them at a fundamental level.

From an external perspective, the problem is scale. For many of us, we no longer see the cause and effect of our actions; for example, we have little insight into the way our food is produced. This exacerbates and furthers our ignorance, distances lines of responsibility and prevents us from the necessary transparency required to critique what it is that we are eating.

In managing degrees of ignorance, society establishes rules, regulations, ethics and cultural norms to provide a central gravitation pull towards the ‘greater good’. Yet, day-to-day food choices are not commonly seen as a matter of ethics (Singer & Mason
What one chooses to buy and eat is seen as a relatively autonomous decision. One’s state of health is commonly seen as a state of ‘good fortune’ without a great deal of personal responsibility (Singer & Mason 2006). Whilst the achievement of an aesthetic body shape is considered virtuous in Australian society, beyond that, little emphasis is place on the virtues of broader health supportive behaviours. Yet, the interconnected nature of all things means that even if an individual wants to make unhealthy food choices and knowingly accept the risks of such, that person’s decisions still impact on others.

Where does personal responsibility start and ‘collective’ responsibility end? Zimmet et al. (2001) states, ‘one of the myths of the modern world is that health is determined largely by individual choice’ (p. 786). However, dichotomously debating the polarities of individual responsibility versus collective responsibility risks missing the point. The aim is to work towards an integrated perspective for health in a more holistic way.

In order to do this, this research has been formulated around two guiding frameworks:

(i) An evolutionary paradigm which was used to establish the necessary knowledge base for our optimal nutritional needs and lifestyle patterns, and

(ii) Integral theory (Wilber 2000, 2001) which has been used as a filter for interpreting the evolutionary nutrition data so as to be useful in our modern-day environment.

Knowledge of the dietary and lifestyle conditions of our ancestral history is enormously helpful in understanding our modern needs. The Paleolithic period was, and is, part of our contemporary make-up. Future directions are not about turning back time or about idealizing the hunter-gatherer period as a ‘pristine state’ for optimal health. For doing that would deny all the health promoting advances in medicine, science and technology today; and is misguided.

Rather, an integrated approach to health care is one which includes knowledge of the basic conditions that shaped our contemporary needs and one which moves beyond this place to include and appropriately respond to the developments of our current times. This is the nature of forward moving functional evolution (Wilber 2000).

Such an integral vision for health can not be found in reductionistic research alone, which is where much of nutrition science and models of Western medicine have
historically been located. Currently, the number of clinical trials assessing the effects of single nutrients, often in supplement form, far outweigh studies of whole diet, especially over the long time frame (i.e. decades) in which diet takes to act as a subtle yet powerful factor in chronic disease development. Not surprisingly, within this culture, it has been argued that it is easier to prescribe drugs than to change the dietary habits of patients (de Lorgeril et al. 1999). However, this is not a sensible justification for such a limited, and likely ineffective, approach. Broadening our examination of the factors involved and integrating nutrition science with sustainable agricultural practices, an understanding of psychological factors underpinning eating behaviours, awareness of the way food is imbedded in our culture, the ethics of what we eat, and nutrition education – all grounded within a wider temporal perspective – will go a long way in enacting change in the health and well-being of Australians and addressing our obesity and chronic disease epidemic.

Using the methodology of Integral theory (Wilber 2000, 2001), this chapter re-focuses on some of the ways in which a future integral vision for health can be aimed for by examining and engaging the perspectives of individuals (‘I’), collective society (‘We’), and the environment (‘It’).
10.2 Our Internal Individual World (‘I’): Engaging individuals in optimal eating behaviours

For many of us today, our eating behaviours and food choices are often unrelated to true physiological need (as discussed in Section 3.6). Many of us have lost direct knowledge of what good nutrition and health homeostasis feels like. Instead, we have come to know a sub-optimal state of vitality and understand our body’s signals relative to that state of being.

With knowledge of our ancestral eating patterns, the necessary financial and time resources, and food supply availability, each of us do now have an opportunity to explore what it feels like to eat in a way which is more aligned with our physiological needs and to experience the rewards of that.

Knowledge is one thing. Behavioural change is another. Therapists have long worked from the unproven premise that ‘understanding’ precedes behavioural change (Yalom 1991). While not necessarily having a full understanding of what an optimal diet entails, in reality, most Australians know that eating more fruit and vegetables is healthy, yet still don’t do it. So what really motivates people to change eating behaviours to be more health supportive?

No one is perhaps more receptive to learning about eating optimally than a person facing a life threatening condition such as cancer. Yet sadly, the therapeutic effect of diet plays its greatest role in a preventative capacity, over many years (which is perhaps why its day-to-day therapeutic value tends to be overlooked). This is not to say that diet is ineffective in chronic disease management as demonstrated by the Ornish diet and lifestyle program in treating and reversing disease progression in patients with cardiovascular disease and prostate cancer (Frattaroli et al. 2008; Ornish et al. 1990; Pischke et al. 2007); (see Chapter 3).

For the rest of us, developing an intuitive awareness about our body and our health appears to be a tricky process. We all are capable of using various tools, be it food, alcohol, cigarettes, caffeine, working too hard, or watching TV to help us get though not feeling ‘great’. There is a tendency to numb down and avoid feelings of discomfort.
If this is so, the remedy to Australians’ sub-optimal eating habits is not just simply more ‘two dimensional’ education on what foods are or aren’t healthy to eat (be they hunter-gatherer food groups or not). Knowledge of our ancestrally adapted diet and the wild food supply simply gives us the boundaries for containing our frame of reference. Rather, the approach needs to be holistic and address the multifaceted ways we use and produce food.

As Suzuki & Dressel (1999) explain, as biological beings we evolved sense organs to see, hear, smell, touch, and taste the physical world. This capacity has been essential to our survival. Yet today, in our contemporary world, there is a huge quantity of sensory information to process. But rather than imploring us into action (e.g. as the smell of smoke or the crack of a twig used to do), we are pacified by it. Most of the information bombarding our lives demands little output – watching TV, using a computer, eating ‘junk’ food which takes no preparation time and often barely requires much chewing. The Western lifestyle is very undemanding on the physical body and in this process we are loosing awareness of what a vibrant state of optimal health actually feels like. As biological creatures whose evolutionary wiring is designed to being able to respond to the natural world, this passive observatory effect of contemporary life is particularly destructive. Consequently, for example, most of us are barely aware of just how different the nutritional matrix of the wild food supply is compared to the conventional one, or the pervasiveness and accumulation of environmental contaminants. As Suzuki & Dressel (1999) state, ‘this sense of impotence may explain why the public often seems unable to act in response to those stories that seem so central to our well-being, to our very survival’ (p.77).

Many of us avoid honestly examining our lives, including the food we buy and eat, for fear of exposing our contribution to global problems. As Stanford psychiatrist Irvin Yalom states, ‘one of the great paradoxes of life is that self-awareness breeds anxiety’ (Yalom 1991 p.11). Dissolving the questioning lonely ‘I’ into the ‘We’ averts the anxiety but risks the loss of one’s autonomous voice. This is both risky and reasonable. It is risky because it can excuse individual inactivity. It is also reasonable because by recognising that we are all part of a whole inter-related system we can collectively work together towards change instead of condemning ourselves or other individuals within that system. For example, in addressing the epidemic of excess body weight in the population, this perspective ensures that a blame game does not play out in which individual esteem is eroded in being judged as ‘weak willed’ around food, lazy or inept
in some other way. In reality, the goal is to examine both our intra-personal (‘I’) and inter-personal (‘We’) relationships of our thoughts and consequential actions.

A key proposition of this thesis is that reconnecting individuals in a very direct, personal, passionate and enjoyable way with optimal nutrition (and its the health advantages), methods of food production, health-supportive lifestyle factors and calmer eating behaviours may go a long way in remedying poor dietary choices. Furthermore, experiencing the vitality and well-being qualities created by eating in greater accord with our genetic design will hopefully generate on-going motivation for good food choices and stimulate a more passionate Australian food culture.

Unquestionably it costs more to eat like a ‘contemporary hunter-gatherer’. It is also more time consuming. Presently, this cost is born entirely by the individual. Whether this is ethically right is questionable given that a healthy individual costs society less and contributes more. Consciously spent consumer dollars have flow-on effects to society at large as well as the environment, and this can be deliberately used to elicit change. In every example examined in this thesis, foods which are most healthy for humans are also less environmentally impacting (e.g. consuming sustainable wild-harvest kangaroo meat instead of intensively farmed pork, or eating organic fruit and vegetables instead of pre-packaged breakfast cereals from mono-culture crops). This understanding is echoed in the words of Pojman (1994), ‘nature provides the life support system for culture and therefore what is good for nature is often good for culture’ (p.xv).

The bottom line message for individuals is to tune in to their body’s cues, true health needs, and the cause and effect of their food choices. This will awaken a richer, direct connection with self, others and nature. The body has a natural capacity to heal itself, and sometimes quite quickly when momentum develops in the right direction. The more facets that can be addressed, the greater the gravitational momentum. The dietary and lifestyle interventions suggested in this thesis are very simple, effective and accessible to most Australians with the necessary financial and time resources.
Our Cultural Centre of Gravity (‘WE’)

As Wilber (2000) writes, ‘every society has a certain centre of gravity…around which the culture’s ethics, norms, rules and basic institutions are organised, and this centre of gravity provides the basic cultural cohesion and social integration for that society. This cultural centre of gravity acts like a magnet on individual development’ (p.126–127).

Among Australians, there is a growing body of cultural awareness that recognises the need for human health to be examined in a more integrated way. By way of evidence, the top two trends in Australians food preferences are sustainable food production (including carbon neutrality, reduced packaging, local sourcing, and organic produce – the fastest growing section of the food industry) and ethical food production (including ‘Fair Trade’ and improving animal welfare); (Honeywill & Byth 2006; Marks 2007).

On an environmental front, the battle for public awareness of the global climate impacts of human behaviour has been won. However, just a few years ago this was not so. The same kind of collective awareness needs to be reached with food and nutrition in order to establish a total food system that is conducive to optimal human health and to begin ameliorating the mass of preventable chronic diseases experienced by Australians. Linking climate change discussions with our obesity and chronic disease epidemic would be a useful strategy because central to both problems is the need to address excessive consumption, which has been underpinned by short-term economic incentive rather than human health potential.

Hence, the collective question for society is: How do we bring the perceptions of the population into alignment with the real things that keep us alive, support our optimal health and underpin a good quality of life?

According to Norberg-Hodge (2009), one of the best solutions to this is to establish locally based food systems. In smaller communities it is easier to see the effects of one’s actions and take responsibility for them. At present, our more ‘virtual’ world of cities, supermarkets, factory farms etc, removes the great majority of us from directly seeing and knowing how our food is produced and the relationship between diet and health. Moving towards smaller-scale communities engages farmers directly with their neighbours and improves food quality because accountability becomes a matter of
trusting relationships instead of regulation, labelling or legal liability (Pollan 2008). In part this is the motivation behind campaigns encouraging people to buy locally produced food and developing relationships between food producers and consumers so that questions can be asked and answered.

This concept does not imply moving away from the world-centric viewpoint which we are now part of (Wilber 2000). However, it does separate global thinking from global control.

Counter arguments suggest leaving the food supply system as it is (i.e. centralised control) and letting consumer buying power in free trade markets shape our desired food supply. The argument being that, for example, the more people who buy organic food, the more an organic industry will prosper. Free trade laws are an integral component of the global industrial food system. The idea of free trade laws is that the reduction of taxes and tax-free exemptions increases competition and efficiency, releases productive resources for growth, and in so doing increases the standard of living (Norberg-Hodge, Goering & Page 2001). However, these same laws have also contributed to negative environmental and human health costs because commodity producers have freedom in finding places where legal regulations for labour, environmental and health standards are the weakest, and hence commodities can be produced for the lowest economic cost. For example, in Australia, it is ironically much cheaper to purchase garlic grown in China than in Queensland, and peas grown and frozen in Poland than fresh from Victoria.

At present, small-scale, local farmers simply cannot economically compete with transnational corporations because of economies of scale and differentials in labour costs. Subsequently, there has been a shift away from thousands of diverse locally adapted farms to a reduced number of very large farms, which feed into large agricultural markets controlled by a few national corporations. There is now a great distance between food producers and consumers – the effect of which is that consumers have very little understanding of how their food is being produced, the quality of their food, and hence lack a degree of control over their health.

Furthermore, the true price of industrially produced food is artificially lowered because costs are shifted onto the environment, or are subsidised from taxes that support large-scale trade infrastructure. If all foods reflected their true costs, it would be impossible,
for example, that for a processed breakfast cereal with wheat transported from western Victoria to a manufacturing plant on the outskirts of Melbourne, with added dried apricots from Turkey, sultanas from the USA, sugar from Queensland and almonds which have been processed into slithers, all of which is packaged in plastic, put into a cardboard box and transported to supermarket shelves; to cost much less than seasonal, locally grown fruit, which requires no processing and travels only a short distance.

As Norberg-Hodge (2009) states, the problem of our industrial scale and globalised economy is that, ‘it makes everyone dependent on the same resource(s)... globalization creates efficiency for corporations, but it also creates artificial scarcity for consumers, thus heightening competitive pressures...allow(ing) for a few to prosper at the expense of the many...conflict increase(s)...(and)...individual and cultural self-esteem are eroded by the pressure to live up to media and advertising stereotypes’ (p.5-6). This situation underpins the elusive Western dream...for example, a fantasy in which drinking coca-cola makes you feel bubbly and happy, surrounded by your friends like the advertisements convey. Yet it is far removed from reality. The metabolic stress caused by such a drink, the psychological discord, the collective waste, and the misdirected use of finite resources displaces the actual elements that truly create a bubbly, vibrant, healthy feeling.

Major shifts in public policy that are oriented towards protecting genuine human health over short term economic wealth are necessary to create an environment in which individual behavioural initiatives can succeed (Zimmet, Alberti & Shaw 2001). At present this is to some extent difficult given the framework of our economic system. Every time a product is bought or a service is used it strengthens the GDP (Gross Domestic Product). Hence, a sick patient with a high utilisation of medical services and pharmaceutical drugs, or agricultural methods that use more pesticides, are more valuable to the GDP than a person who eats food from their garden and meditates. Hence, governance structures are not set up to be particularly supportive of life-enhancing intervention strategies, which are non-financial or non-service orientated transactions. As Suzuki (1993) writes, ‘we need a completely different accounting and value system that can bring us back into balance with the realities of the earth (and our health)’ (p.126).

However, change is possible. Policies could be encouraged to: support biodiverse, sustainable agriculture; create tax breaks for health supportive behaviours (including
increased taxing of ‘junk’ foods) (Zimmet, Alberti & Shaw 2001); legislate against non-health-supportive advertising and marketing of poor food choices (and accept the short term economic costs of such a stance); support appropriate infrastructure; and sensibly legislate agricultural chemical use, biotechnology and other environmental controls within a precautionary framework (United Nations 1992). While fraught with potential political hazards, collectively such initiatives may aid in the prevention of a large proportion of chronic diseases and support greater population health.
10.4 Moving Towards an Environment That is Sustainably Supportive of Health: Managing our population-economic-technological-environment resource base (‘IT’)

‘This we know:

We are the earth, through the plants and animals that nourish us.
We are the rains and the oceans that flow through our veins.
We are the breath of the forests of the land, and the plants of the sea.
We are human animals, related to all other life as descendants of the firstborn cell.
We share with these kin a common history, written in our genes.
We share a common present, filled with uncertainty.
And we share a common future, as yet untold.’

The David Suzuki Foundation Declaration of Interdependence, written in 1992 for the United Nation’s Earth Summit in Rio de Janeiro  (Suzuki 1993)

Industrialisation profoundly changed human behaviour and the environment. The industrial revolution occurred because humans became capable of releasing vast amounts of energy in the form of fossil fuels – non renewable resources that accumulated long before our species appeared. In response to the energy surplus, machines, rather than human labour, became the central means of production. This fostered a global population explosion as well as lifestyle (more sedentary and indoor based) and nutritional changes. Humans increasingly modified their environment, including food production, and a capitalist philosophy took hold. The impacts of which are recognisable:

‘The capitalists...promised that, through the technological domination of the earth, they could deliver a more fair, rational, efficient and productive life for everyone...That meant teaching everyone to treat the earth, as well as each other, with a frank, energetic, self-assertiveness...People must...think constantly in terms of making money. They must regard everything around them – the land, its natural resources, their own labour – as potential commodities that might fetch a profit in the market. They must demand the right to produce, buy, and sell those commodities without outside regulation or interference...As want
multiplied, as markets grew more and more far-flung, the bond between humans and the rest of nature was reduced to the barest instrumentalism’ (Donald Worster cited in Meadows, Randers & Meadows 2004 p.268)

The Australian way of life, as with other Western nations, is now based on cultural ideologies that have been shaped around this access to abundant, non-renewable, cheap energy (Flannery 1994). The unsustainability of such energy use is clearly recognisable. The systematic imbalance in the energy budget of our daily living is presenting in significant chronic ill health and obesity (McMichael et al. 2007). The human body has become one of the bio-living ‘sinks’ for our excesses, including our energy-dense-nutrient-poor foods, our sedentary, technologically based lifestyle and environmental toxic residues e.g. as noted in Chapter 4 organochlorine pesticides were recently detected in all samples of human breast milk taken from 20 regions across Australia (Mueller et al. 2007). We have to move towards greater sustainability because our current system is propped up by an increasing environmental resource debt and accumulating human disease burden. The more value we place on achieving optimal human health, the more value we must inherently place on ensuring that our human activities work within ecological systems in a way that acknowledges our co-evolution in the natural world.

As such, the philosophical underpinning of a sound model for optimal human health is the same as for a sound environmental ethic. We need to honour the intrinsic and extrinsic value of every holon. It is not that humans are sacrosanct, for the majority of other holons in the world would thrive without us. Rather, moving towards greater sustainability is simply for our own good, our own health. Wilber’s (2000) suggestion for a pragmatic rule of thumb for environmental ethics – and for that matter, human health ethics – is: In the pursuit of our vital needs and condition for optimal health, we need to consume or destroy as little depth as possible (i.e. maintain life’s biodiversity), and do the least amount of harm to consciousness as possible (i.e. appreciate the intrinsic and extrinsic services of all). In regards to our agricultural resource base, this requires several considerations including the following.

Given that the environment, as a living system, requires cause and effect to be understood over a long time frame, a precautionary approach (United Nations 1992) needs to be applied to assess the impacts of short-term decisions (e.g. agricultural chemical use, genetically modified foods). Hence, political and economic structures
need to be created that ensure that policies take into account long term environmental and human health considerations in conjunction with short-term economic growth. This requires that health, sustainability and education are our highest cultural values (Meadows, Randers & Meadows 2004). Decentralising control of economic power, political influence and scientific expertise serves to preserve greater diversity in thought and action and is a necessary requirement for this process.

It means protecting and promoting biodiversity (e.g. supporting clean, diverse polyculture agriculture, which will assist in maintaining dietary diversity). Biodiversity increases the potential for recovery from any impact (e.g. as discussed in Chapter 4 in regards to our global fish stocks), and hence provides the most vital means of security for us (including food security). The range of services offered by biodiverse ecosystems are unparalleled by anything technology is capable of offering (including providing purification, water storage, pollination, natural pest control, seed and nutrient dispersal, carbon sequestration, mitigation of climate change, provision of a wide variety of food, fibre and medicinal products, lessons in evolution and diversification strategies that have proved themselves over three billion years, and un-matchable aesthetic qualities); (Meadows, Randers & Meadows 2004; Tilman et al. 2002).

It also requires efficient use of renewable energy systems and closed loop natural system design (Meadows, Randers & Meadows 2004) to reduce our ecological impact. In our food system, lowering our ecological impact means buying locally produced foods where possible to reduce transportation. It also means minimising food waste, for example by reducing ocean by-catch or eating the by-catch (which oceanic species are deemed ‘fit for human consumption’ are typically culturally, not nutritionally defined), reducing fresh produce wastage and increasing the utilisation of whole animal carcasses from clean healthy animals for human food. It also entails encouraging agricultural methods that are more climate appropriate [e.g. increase utilisation of Australian fauna and flora (Dyer 1999; Garnaut 2008)], diverse (so as to spread ecological load), supportive of soil ecology, and use natural mechanisms to restore nutrients and control pests (Flannery 1994; Garnaut 2008; Tilman et al. 2002). These changes will support a food supply that is more sustainable, nutrient dense, diverse, less contaminated and better aligned with our evolutionarily adapted needs.

Lowering population numbers would naturally lessen pressure on environmental resources (Flannery 1994; Lowe 2008; Meadows, Randers & Meadows 2004) and
reduce the impact of many of our current agricultural practices. The hunter-gatherer lifestyle supported about 4 million people globally. Modern agriculture now feeds around 6,000 million people and it is generally agreed that it could feed up to 10 billion people (Tilman et al. 2002), but there is little consensus on how this could be achieved sustainably (Tilman et al. 2002). However, reducing the population alone is a limited answer. Unsustainable use of our agricultural resource base has occurred as a consequence of both the rapid expansion of population, and from poor farming techniques (Flannery 1994; Tilman et al. 2002). As outlined in Section 2.7, our entire food supply is based on European species poorly suited or adapted to the Australian climate, and land has been overgrazed, over cropped, over irrigated, polluted with agricultural chemicals and there has been little understanding of soil ecology (Flannery 1994; Tilman et al. 2002). As Meadows, Randers & Meadows (2004) suggest, economic rewards for short-term production rather than long term stewardship have taken priority. Once productive land has now been lost to erosion, salinity and desertification, as well as to urbanisation. As Suzuki (1990) explains, of the eight million hectares of forest that existed in Australia prior to European occupation some 200 years ago, six million has been cleared. Following this clearing, there has been a mass extinction of flora and fauna; 97 species of native plants are extinct, 209 are endangered. Sixteen mammal species are extinct and 22 of the total 273 are threatened (Flannery 1994; Suzuki 1990). Introduced species (e.g. rabbits, cats, foxes, rats, cane toad, pigs, camels) now have a major foothold. Along with this rapid loss of natural resources has been a massive loss in ‘free’ ecosystem services.

Integrated plant and animal organic agricultural methods offer a viable alternative (Meadows, Randers & Meadows 2004). Systems such as organic farming aim to increase nutrient and water-use efficiency by better matching temporal and spatial nutrient supply with plant demand; maintaining/restoring soil fertility; and utilising pastoral livestock to make more extensive use of ecosystem services and thus eliminate many of the problems of confinement production, including concentrated waste management and disease (Tilman et al. 2002). Sustainable agriculture is essential and sensible given that the goal is to maximise the net benefits that society receives from agricultural production of food and fibre and from ecosystem services (Tilman et al. 2002). It will require that farmers are financially rewarded for the production of both food and ecosystem services. This currently does not occur. If a fraction of the money spent on chemical inputs, agricultural biotechnology, and ‘junk’ food marketing was redirected (e.g. through high taxing of these products) to support diverse, sustainable,
organic agriculture, human health would benefit enormously and more sustainable use of environmental resources would result.

Our hunter-gatherer ancestors were, by necessity, more ecologically oriented than the majority of us today because their food supply depended upon it. However, there is little evidence to suggest they had a greater ecological knowledge in a generalised sense. Rather, in hunter-gatherer times, the technology capable of inflicting damage was limited, both because of the inherent nature of the technology itself (e.g. spears, boomerangs) and a lower population density. Science and technology have for the first time in history created a way to overcome some of our ignorance at precisely the same time that we have created the technology to inflict damage on a global scale (Wilber 2000). Through technological advancement (including internet and transportation infrastructure) we are at a unique point in history where we have access to information about worldwide cultural practices and the ability to look back with the advantage of historical understanding. Thus we are in a fortunate position to be able to integrate this knowledge to inform better health interventions and more sustainable practices – an approach which is difficult, but necessary to instigate in our economic growth oriented culture.
10.5 **Summary: An integral vision**

As individuals, we can use knowledge of hunter-gatherer diets and work to sensibly interpret them in the context of our contemporary food supply. This needs to be backed by the necessary resources including motivation, information, time, money and agricultural/environmental capital. We can buy Australian produce, buy certified organic produce when possible, ask questions about how food is grown, be guided by an evolutionary nutrition paradigm, develop a passion for food and our health and, in doing so, operate from an ethics of care. This inherently requires attentiveness, responsiveness, competence and responsibility (Carrasco 1999). We can recognise the cycles of the seasons and learn about the health characteristics of the plant and animal foods we eat. We can come to know the benefits of establishing a better nutritional homeostasis in our bodies. And we can join with others to work for public policy changes that support a clean, wild-mimicking, nutrient dense, affordable, localised, accessible and ultimately more sustainable food supply.
Chapter 11: Strengths and Limitations of the Research & Future Research

‘The real voyage of discovery lies not in seeking new lands but in seeing with new eyes’

(Marcel Proust cited in Suzuki & Dressel 1999)

Some research work unfolds experimentally, and some conceptually, as is predominantly the case in this thesis. Understanding in this research has come from the re-examination of existing data, from thinking about the available data from new angles, and from a new understanding of inter-connected relationships and patterns. This is an important process because the human body, our gene-environment interactions, our disease mechanisms (particularly chronic disease) are so complex. Our curiosity to know exactly how the human body functions, its components, and its biochemical building blocks, is fascinating. Fueling this intrigue is the idea that we may come to know enough to fix any part of us that breaks – and to date we have achieved remarkably on this front.

Obtaining ‘proof’ and exacting what works and what doesn’t is a very slow process, and one that will possibly be forever incomplete because of synergistic effects and confounding factors. Therefore the question is: Do we really need to spend research funds on exacting the individual health-promoting components of various nutrients, different diets and other lifestyle factors in isolation when they merely confirm common-sense wisdom?

It would, of course, be fascinating to assess the clinical effects of intervention programs guided by an evolutionary framework using ‘contemporary hunter-gatherer diets’ as outlined in this thesis in combination with other supportive lifestyle factors including physical exercise, optimal vitamin D status, adequate sleep, stress management
strategies etc. This kind of integrated study has never been done. However, it would be impossible to know precisely what factors were responsible for which consequential health effects.

The ultimate success or validity of the proffered outcomes of this research work are virtually impossible to quantify. Even if particularly supportive dietary factors were isolated out of a more integrative health intervention program, the impacts of diet on disease take effect over decades and possibly even longer due to the potential for intergenerational consequences. The difficulty is that clinical trials do not tend to span 80+ years!

While the true magnitude and ultimate lifetime effects of eating like a ‘contemporary hunter-gatherer’ and living more in accord with evolutionarily adapted lifestyle factors are unlikely to be identified in an absolute sense, there is still merit in predicting that such interventions will elicit health responses in a much shorter time frame. For example, targeting dietary and lifestyle interventions peri-natally may be particularly rewarding in affecting life-long health outcomes in offspring (Chapter 9), and future clinical research in this area is recommended. For instance, experimental diets and lifestyle strategies could operate over a 12-month duration (three months pre-pregnancy and nine months of pregnancy), and off-spring could be followed up over a number of years, with clinical endpoints including chronic disease susceptibility, cognitive function and general wellbeing.

There is also compelling evidence in the literature that positive dietary change can improve metabolic function in a matter of weeks in people with impaired glucose tolerance (and type 2 diabetes); (de Lorgeril et al. 1999; Lindeberg et al. 2007; O'Dea 1984; Simopoulos 2001), and possibly a range of other conditions not as yet studied. There is no reason that ‘contemporary hunter-gatherer diets’ as described in this thesis will be any less effective in this capacity and, if the interpretation adequate, potentially even more beneficial. Other recommendations for future research have also been mentioned elsewhere in this thesis as they have arisen in their relevant chapters.

In the absence of unequivocal evidence for the propositions outlined in this thesis, a dilemma is presented: Do we wait for clinical trials to prove to us that eating a ‘contemporary hunter-gatherer diet’ is equal, better or more universally applicable than, for instance, a Mediterranean diet? Or do we act on basic common sense and the logic of
evolutionary theory, and start changing clinical practice now? The therapeutic tools to implement these changes are simple and accessible without obvious associated risk, which reduces the need for extensive clinical evaluation. We have relied on these tools for all of our eternity – whole healthy food, biodiverse ecosystems, physical exercise, appropriate sunlight exposure, adequate sleep, social support, relaxation etc. To consider these factors as the most effective tools of medicine today in preventing chronic disease seems somehow too basic and not detailed enough to be ‘valid’. But the need to address chronic disease in Australia is an immediate one. In reality, we do not have the time to wait for extensive future research before taking some new (‘old’) directions.

This is not to say that future research work in this area is not important. It absolutely is. There is no reason not to start quantifying the clinical effectiveness of the above-mentioned intervention tools and in doing so better craft their application. However, the body of research examined and presented in this thesis highlights that there is already substantial evidence demonstrating their effectiveness. Waiting for more evidence before implementing them is both counter-intuitive and time consuming.

As argued in this thesis, we are in critical need of a guiding framework to steer an appropriate course for immediate action. This thesis is not unique in expressing this perspective. Evolutionary theory is a strong paradigm for grounding human health research. As Eaton et al. (1988) state, ‘more important than any single investigative lead is the integrative, theoretical framework provided by the concept that the human genome was selected through evolutionary experience for the bio-behavioural circumstances of ancestral life and that contemporary chronic diseases arise, in large measure, from the discordance that has been created between our genes and our lives’ (p.133). Shaping clinical interventions through the lens of an evolutionary framework enables the core aspects of our health requirements to be addressed in the most fundamental way.

As with any theoretical propositions, including those outlined in this thesis, they can only be considered as supportive rather than definitive evidence. The use of data that has speculatively attempted to reconstruct the likely dietary patterns of recent hunter-gatherer societies is a limitation in this thesis and concern over this issue has been repeatedly stated so that readers can understand the relevance of the data presented in a contextually dependent way. To ignore such data because it is somewhat circumstantial and unable to be verified risks missing its significance. There is only patchy evidence available on the subsistence patterns of recent hunter-gatherer societies, and that
evidence has principally come from non-nutritionally trained anthropologists and archaeologists. We do, however, have a strong understanding of the biological probability that genetically we are so minimally different from our hunter-gatherer ancestors living 10,000–40,000 years ago that we are still optimally adapted to eating wild food. An increasing body of evidence is proving the nutritional superiority of numerous wild plant and animal foods both in absolute terms and relative terms compared to average Australian diets today. Combining the available data, both circumstantial and proven, and then checking the plausibility and usefulness of this data in the context of the contemporary Australian food supply is the strength of this unique research. The data is by no means complete, but there is sufficient evidence presented to stimulate a deeper consideration of the broader biological significance of its historical perspective.

While evolutionary theory is strongly accepted, it has only been moderately used to frame therapeutic interventions in modern medicine. A few individuals including Professors Boyd Eaton and Loren Cordain have devoted their life’s work to bridging aspects of this gap and consequently their work has been analysed in this thesis. While the theory behind shaping clinical interventions within an evolutionary framework is very strong, the present practice is still a work in progress, evidenced by the variations in researchers’ contemporary interpretations (as discussed in Chapter 6). It is a complex puzzle to interpret within our modern-day Western milieu. This thesis adds to the body of research attempting to do this, and it does so in a holistic integrated way, focusing on the modern-day Australian situation and environment.

More than anything, the drive behind this thesis has been to interpret the theory for clinical application i.e. to help people eat better, feel better and live with more vitality. This has collectively required an understanding of evolutionary theory, an understanding of the available data on the dietary patterns of recent hunter-gatherer societies, and a strong sense of the nutritional characteristics of our wild food environment. Authentically interpreting this data so as to be relevant to contemporary Australians has also meant that Australia’s food production systems needed to be analysed. It is not a complete presentation, but rather a suggestion for how the available knowledge can currently be best interpreted in the modern Australian environmental-cultural landscape with the greatest degree of biologically authenticity possible. The integration of this breadth of data is the strength of this thesis.
Chapter 12: Conclusion

‘There is a subtle, slow, relentless evolutionary drift, a migratory current of unfolding events, that, in the very long run, unfolds higher and deeper connections’

(Wilber 2001 p.130)

Forward moving functional evolution requires firstly the identification and secondly the integration of all that we are: our past and the essential features that are deeply programmed into our DNA – and our present, which contains the medical, technological, cultural, psychological and environmental resources of the world in which we live. This approach honours the whole health of humans in a more integral way (Chapter 1).

From this perspective, the aim of this thesis was to examine and define optimal contemporary nutritional needs. Inherent to the process was an exploration of the dietary and lifestyle factors to which we are biologically most adapted and still reliant upon (Chapter 2). Amongst the plethora of sometimes contradictory modern diet and health advice, the appreciation of a wider temporal view has been found to be not only informative, but simplifying and unifying. Importantly, it highlights predictive patterns and pathways for positive change.

Any animal living in its evolutionarily adapted ecological niche typically presents as fit, vigorous and for the majority of time, nutritionally (and behaviourally) unstressed. Move that same animal into a foreign, incompatible environment and distress and disease often manifest. Modern Australian’s food and lifestyle landscape has rapidly and increasingly become divergent from the environment that shaped and maintained our evolution. As a result there has been a profoundly rapid increase in chronic diseases which has escalated over the past few decades. Obesity and diseases including cardiovascular disease, type 2 diabetes, certain cancers and mental health conditions are prevalent and result in significant losses in quality of life and longevity. Furthermore,
subclinical pathologies (including the accumulation of excess body weight, insulin resistance, atherosclerosis, elevated blood pressure, loss of bone mineral density, increased inflammatory markers etc) are endemic in the population. These physiological states are so widespread that there is a tendency to consider them to be a natural part of the ‘normal’ ageing process when in reality they should not be regarded as such, particularly in light of the hunter-gatherer evidence (Chapter 3).

Although we live in a culture heavily invested in end-stage drug treatment options, it is long-term sub-optimal diets, physical inactivity and other lifestyle conditions (e.g. sleep deprivation, stress, toxin exposure and various other psycho-social-economic-environmental factors) that are the primary aetiological determinants of the major diseases (Chapters 3 and 7). Hence, one of the outcomes of this thesis is a clarion-call to start to recognise that these conditions are ‘long latency deficiency diseases’. This approach re-enforces the subtle yet highly significant effects of life-long, day-to-day food and lifestyle choices (with an opportune intervention window being present perinatally). This empowers the therapeutic application of the findings presented in this research (Chapters 8 and 9).

The average Australian’s diet contains many novel food groups, is micronutrient and phytochemically deficient, is skewed in its fatty acid profile, elicits a high glycaemic load, is lacking in fibre, contains high levels of sodium and is acid yielding (particularly when compared with average hunter-gatherer diets). However, as concluded in Chapter 5, rather than merely reducing dietary analysis to these elemental components (with the corresponding potential for marketing persuasions), this research demonstrates that the full therapeutic benefit lies in the complete matrix of nutritive components found in whole foods grown and produced with the highest possible index of biological authenticity (i.e. wild food mimicking); (Chapter 4).

Appropriately interpreting the evolutionary nutrition data within the modern-day food milieu is challenging (Chapter 6) owing to the lack of conclusive historical data and, more significantly, as found in this research, because of the breadth of confounding issues related to the way our food is now grown and produced (Chapter 4). This has been compounded by the quiet de-skilling of the population in the fundamentals of our food supply (and natural biological rhythms), which has distanced us from the information required to critically appraise our diet and manage our own health.
Governing the research scope was the aim of translating theory into practical, useable information for interested Australians. Consequently, a key contribution of this work is the presentation of a unique model: ‘Contemporary hunter-gatherer diets: An Australian perspective’ (Chapter 8). Its purpose is to enable individuals to better match their food choices to the way we have evolved to eat. In its illustrative form (Figure 19), it is intended to be eye-catching and to instigate discussion of the broader biological significance of its content. The illustration contains some of the potential foods found in wild shore-line ecosystems that are able to be echoed within the Australian food supply today. Shore-line ecological niches offer the greatest opportunity for nutrient diversity and nutrient density which optimally supports human health.

Underpinning the model is the guiding principle of choosing the freshest and most unrefined whole foods available from both plant and animal sources that are themselves optimally healthy, and consuming these foods in quantities reflecting their availability in the wild. As analysed extensively in the thesis, the application of this principle tends to universally resolve cascading human health and environmental food-related problems. The obvious simplicity of the principle in no way diminishes its pervasive power.

The project was first and foremost undertaken with a therapeutic context in mind. At the same time, the findings are also informative for industry educators, in government policy planning, and other broader education applications. However, as a starting point, it is intended to be of use to medical and allied health professionals. It proposes an integrative framework within which to establish effective interventions (both preventative and treatment-oriented) that are cognisant of the realities of modern Australia, and works towards a more sustainable future, underpinned by diversity and depth in the health of all holons contained within.
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Appendices
Appendix A

Summary of the basic tenets of Integral Theory:
Tendencies of evolutionary systems

1. Reality as a whole is not composed of things or processes, but of holons (wholes that are parts of other wholes; eg whole atoms are parts of whole molecules, which are parts of whole cells, which are parts of whole organisms, and so on).
2. Holons display four fundamental capacities: (a) self-preservation, (b) self-adaptation, (c) self-transcendence, and (d) self-dissolution.
3. Holons emerge.
4. Holons emerge holarchically.
5. Each emergent holon transcends but includes its predecessor(s).
6. The lower sets the possibilities of the higher; the higher sets the probabilities of the lower.
7. The number of levels that a holarchy comprises determines whether it is ‘shallow’ or ‘deep’; and the number of holons on any given level we shall call its ‘span’.
8. Each successive level of evolution produces greater depth and less span. The greater the depth of a holon, the greater its degree of consciousness.
9. Destroy any holon, and you will destroy all the holons above it and none of the holons below it.
11. The micro is in relational exchange with the macro at all levels of its depth.
12. Evolution has directionality: (a) increasing complexity, (b) increasing differentiation/integration, (c) increasing organization/structure, (d) increasing relative autonomy, (e) increasing telos

Sourced from (Wilber 2000 p.313)
Appendix B

Nutrient composition of plant foods consumed by Australian Aboriginal people from northern, central and western Australia

<table>
<thead>
<tr>
<th></th>
<th>Energy (kJ)</th>
<th>Water (g)</th>
<th>Protein (g)</th>
<th>Fat (g)</th>
<th>Carbohydrate (g)</th>
<th>Fibre (g)</th>
<th>Vit C (mg)</th>
<th>Mg (mg)</th>
<th>Ca (mg)</th>
<th>Fe (mg)</th>
<th>Zn (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wild fruit* (n=317)</td>
<td>397</td>
<td>73</td>
<td>2</td>
<td>1</td>
<td>21</td>
<td>8</td>
<td>25</td>
<td>74</td>
<td>78</td>
<td>2</td>
<td>0.6</td>
</tr>
<tr>
<td>Cultivated fruit (n=21)</td>
<td>171</td>
<td>86</td>
<td>1</td>
<td>0</td>
<td>8</td>
<td>3</td>
<td>21</td>
<td>12</td>
<td>14</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Wild roots (n=65)</td>
<td>392</td>
<td>71</td>
<td>2</td>
<td>0.6</td>
<td>17</td>
<td>8</td>
<td>11</td>
<td>65</td>
<td>142</td>
<td>23</td>
<td>1</td>
</tr>
<tr>
<td>Wild tubers (n=86)</td>
<td>406</td>
<td>70</td>
<td>2</td>
<td>0.4</td>
<td>22</td>
<td>6</td>
<td>46</td>
<td>42</td>
<td>48</td>
<td>12</td>
<td>0.6</td>
</tr>
<tr>
<td>Cultivated roots and tubers (n=8)</td>
<td>379</td>
<td>74</td>
<td>1</td>
<td>0.2</td>
<td>21</td>
<td>2</td>
<td>14</td>
<td>14</td>
<td>24</td>
<td>0.5</td>
<td>0.4</td>
</tr>
<tr>
<td>Wild bulbs (n=30)</td>
<td>677</td>
<td>56</td>
<td>2</td>
<td>0.5</td>
<td>38</td>
<td>8</td>
<td>8</td>
<td>49</td>
<td>61</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Cultivated bulbs</td>
<td>97</td>
<td>91</td>
<td>2</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>15</td>
<td>10</td>
<td>24</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Wild acacia seeds (n=55)</td>
<td>1472</td>
<td>6</td>
<td>23</td>
<td>8</td>
<td>48</td>
<td>32</td>
<td>no data</td>
<td>194</td>
<td>195</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>Cultivated legumes (dried) (n=7)</td>
<td>1153</td>
<td>10</td>
<td>23</td>
<td>10</td>
<td>31</td>
<td>13</td>
<td>140</td>
<td>106</td>
<td>6</td>
<td>3</td>
<td>395</td>
</tr>
<tr>
<td>Wild nuts (n=74)</td>
<td>1280</td>
<td>27</td>
<td>13</td>
<td>29</td>
<td>30</td>
<td>11</td>
<td>6</td>
<td>138</td>
<td>89</td>
<td>7</td>
<td>17</td>
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<tr>
<td>Cultivated nuts (n=6)</td>
<td>2578</td>
<td>4</td>
<td>17</td>
<td>56</td>
<td>7</td>
<td>7</td>
<td>0.2</td>
<td>202</td>
<td>87</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Wild leaves (n=28)</td>
<td>256</td>
<td>80</td>
<td>3</td>
<td>0.7</td>
<td>12</td>
<td>5</td>
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<td>0.8</td>
</tr>
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<td>Cultivated leaves (n=5)</td>
<td>256</td>
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<td>3</td>
<td>0.7</td>
<td>12</td>
<td>5</td>
<td>41</td>
<td>54</td>
<td>61</td>
<td>3</td>
<td>0.4</td>
</tr>
<tr>
<td>Wild miscellaneous vegetables (pith, stalks, buds) (n=14)</td>
<td>382</td>
<td>78</td>
<td>3</td>
<td>0.7</td>
<td>15</td>
<td>8</td>
<td>1</td>
<td>57</td>
<td>108</td>
<td>3</td>
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</tr>
<tr>
<td>Cultivated miscellaneous vegetables (n=7)</td>
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<td>91</td>
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<td>0</td>
<td>2</td>
<td>3</td>
<td>61</td>
<td>14</td>
<td>21</td>
<td>0.6</td>
<td>0.4</td>
</tr>
</tbody>
</table>

* Terminalia ferdinandiana (Kakadu plum, green plum) was excluded from the analysis because of its exceptionally high content of vitamin C.

Table modified from Brand-Miller & Holt (1998 p.10-13). Mean values presented in table.
### Appendix C

Some of the Australian native food plant species growing commercially in southern Australia

<table>
<thead>
<tr>
<th>Food</th>
<th>Common name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Berries</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kunzea pomifera</td>
<td>Muntries</td>
<td>Perennial shrub with small berries</td>
</tr>
<tr>
<td>Billardiera cymosa, B scandens</td>
<td>Appleberries</td>
<td>A climbing vine like plant with small berries</td>
</tr>
<tr>
<td>Rubus parvifolium, R rubifolia</td>
<td>Native raspberry</td>
<td>Similar to European varieties</td>
</tr>
<tr>
<td>Austromyrtus dulcis</td>
<td>Midim berry</td>
<td>Low shrub with small sweet but sharp berries</td>
</tr>
<tr>
<td>Solanum centrale</td>
<td>Bush tomato</td>
<td>Small shrub with small raisin-like spicy, piquant fruits</td>
</tr>
<tr>
<td><strong>Condiments and Flavours</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Backhausia citriodora</td>
<td>Lemon myrtle</td>
<td>A medium tree whose leaves are wonderfully lemon flavoured; usable fresh or dried</td>
</tr>
<tr>
<td>Backhausia anisata</td>
<td>Aniseed myrtle</td>
<td>Similar to lemon myrtle but with aniseed tasting leaves and flowers</td>
</tr>
<tr>
<td>Backhousia myrtifolia</td>
<td>Cinnamon myrtle</td>
<td>Similar to the other myrtles but with cinnamon flavourings</td>
</tr>
<tr>
<td>Tasmannia lanceolata</td>
<td>Native pepper</td>
<td>Medium shrub whose leaves and berries have complex and strong pepper flavours</td>
</tr>
<tr>
<td><strong>Fruits</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capparis mitchellii</td>
<td>Native orange</td>
<td>Small bush with small citrus-like fruit</td>
</tr>
<tr>
<td>Leichhardtia australis</td>
<td>Native pear</td>
<td>Medium bush with small tasty fruit</td>
</tr>
<tr>
<td>Podocarpus elatus</td>
<td>Illawarra plum</td>
<td>Medium to large tree that produces fruit with an external seed which has a pine/plum flavour</td>
</tr>
<tr>
<td>Santalum acuminatum</td>
<td>Sweet quandong</td>
<td>Small tree which produces small spicy fruit</td>
</tr>
<tr>
<td>Eremocitrus glauca</td>
<td>Dessert lime</td>
<td>Small bush that can withstand severe droughts. A genuine citrus with small pleasant flavoured fruit</td>
</tr>
<tr>
<td>Microcitrus spp</td>
<td>Wild, finer lime</td>
<td>Small bushes with good flavoured fruit</td>
</tr>
<tr>
<td>Achronychia acidual</td>
<td>Lemon aspen</td>
<td>Small to medium tree producing small, exceedingly acidic fruit</td>
</tr>
<tr>
<td>Davidssonia pruriens</td>
<td>Davidsons plum</td>
<td>Tall tree producing a fruit exceptionally rich in vitamin C</td>
</tr>
<tr>
<td><strong>Nuts</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macadamia integrifolia</td>
<td>Macadamia</td>
<td>This nut which has been planted extensively for commercial production</td>
</tr>
<tr>
<td><strong>herbs and Leaf crops</strong></td>
<td><strong>seeds</strong></td>
<td><strong>roots and tubers</strong></td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Athertonai diversifolia</strong></td>
<td>Blue almond</td>
<td>Medium tree which produces a nut with some similarities to macadamia</td>
</tr>
<tr>
<td><strong>apium prostratum</strong></td>
<td>Sea parsley</td>
<td>Low ground cover. Its taste is closer to celery than parsley but has similar uses</td>
</tr>
<tr>
<td><strong>tetragonia tetragonoides</strong></td>
<td>Warrigal spinach</td>
<td>Low leafy ground cover plant. It is similar to European spinach with a wide range of uses.</td>
</tr>
<tr>
<td><strong>prostantheria rotundifolia</strong></td>
<td>Native mint</td>
<td>Similar uses to European mint</td>
</tr>
<tr>
<td><strong>ocimum tenuiflorum</strong></td>
<td>Native thyme</td>
<td>Low shrub, strong aromatic flavours</td>
</tr>
<tr>
<td><strong>hibiscus spp</strong></td>
<td>Rosella</td>
<td>Low bushes. The petals and buds can be used to make jams, spreads and for other flavouring</td>
</tr>
<tr>
<td><strong>alpina caerulea</strong></td>
<td>Native ginger</td>
<td>Low bush. The berries can be eaten and the leaves used for cooking</td>
</tr>
<tr>
<td><strong>acacia spp, aneura, nurrayana, pycnantha, retinodes, victoriae</strong></td>
<td>Mulga, golden wattle, wirilda etc</td>
<td>The wattles are all medium sized trees. The seed can be ground into flour and carry a coffee-like flavour</td>
</tr>
<tr>
<td><strong>brachychiton populneus</strong></td>
<td>Kurrajong</td>
<td>Large tree with edible seeds. Can be used as a coffee substitute and as flavouring</td>
</tr>
<tr>
<td><strong>araucaria bidwillii</strong></td>
<td>Bunya pine</td>
<td>Large tree with large pine type cones. The nuts are about the size of Brazil nuts</td>
</tr>
<tr>
<td><strong>microseris lanceolata</strong></td>
<td>Murnong, yam daisy</td>
<td>One of the staples of the Australian Aboriginal diet</td>
</tr>
<tr>
<td><strong>dipogon spp</strong></td>
<td>Chocolate lily</td>
<td>Can be used for seasoning</td>
</tr>
<tr>
<td><strong>bulbine bulbosa</strong></td>
<td>Native leek</td>
<td>Can be used for seasoning</td>
</tr>
</tbody>
</table>

*Table modified from Dyer (1999)*
### Appendix D

**Re-analysis of the 20th Australian Total Diet Study to assess pesticide exposure risk in high vegetable and fruit diets**

<table>
<thead>
<tr>
<th>Food</th>
<th>Pesticide Contaminant</th>
<th>Mean (mg/kg)</th>
<th>Maximum (mg/kg)</th>
<th>ADI (mg/kg of body weight/d)</th>
<th>Amount of food (kg) required to reach ADI for a 70kg person*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nectarines</strong> (n=21)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tomatoes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nectarines (n=21)</td>
<td>Azinphos-methyl</td>
<td>0.003</td>
<td>0.030</td>
<td>0.0250</td>
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<td>Bifenthrin</td>
<td>0.004</td>
<td>0.040</td>
<td>0.0100</td>
<td>175.0</td>
</tr>
<tr>
<td></td>
<td>Carbaryl</td>
<td>0.083</td>
<td>1.400</td>
<td>0.0080</td>
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<tr>
<td></td>
<td>Chlorothalonil</td>
<td>0.005</td>
<td>0.040</td>
<td>0.0100</td>
<td>140.0</td>
</tr>
<tr>
<td></td>
<td>Dimethoate</td>
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<td>0.070</td>
<td>0.0200</td>
<td>466.7</td>
</tr>
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<td>Fenthion</td>
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<td>0.010</td>
<td>0.0020</td>
<td>140.0</td>
</tr>
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<tr>
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<td>0.140</td>
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<tr>
<td></td>
<td>Propiconazole</td>
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<td>0.060</td>
<td>0.0400</td>
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<tr>
<td></td>
<td>Tebufenpyrad</td>
<td>0.008</td>
<td>0.080</td>
<td>0.0020</td>
<td>17.5</td>
</tr>
<tr>
<td><strong>TOTAL = 13</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Tomatoes</strong> (n=28)</td>
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<td>0.010</td>
<td>0.0005</td>
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<td>Endosulfan</td>
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<td>Mean (mg/kg)</td>
<td>Maximum (mg/kg)</td>
<td>ADI (mg/kg of body weight/d)</td>
</tr>
<tr>
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<td>-------------</td>
<td>-------------</td>
<td>--------------</td>
<td>-----------------</td>
<td>------------------------------</td>
</tr>
<tr>
<td>Apples (n=21)</td>
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<td>0.016</td>
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<td>Chlorpyrifos</td>
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<td>0.040</td>
<td>0.0030</td>
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<td>Strawberries (n=21)</td>
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<td>0.270</td>
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<td>0.030</td>
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<td>Celery (n=21)</td>
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<td>0.022</td>
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<td>TOTAL = 7</td>
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</tr>
<tr>
<td>Food</td>
<td>Pesticide Contaminant</td>
<td>Mean (mg/kg)</td>
<td>Maximum (mg/kg)</td>
<td>ADI (mg/kg of body weight/d)</td>
<td>Amount of food (kg) required to reach ADI for a 70kg person*</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------</td>
<td>--------------</td>
<td>----------------</td>
<td>-----------------------------</td>
<td>-------------------------------------------------------------</td>
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<td>0.0300</td>
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<td>TOTAL = 7</td>
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<td></td>
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<td>0.018</td>
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</tr>
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<td>0.430</td>
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<td>65.1</td>
</tr>
<tr>
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<td>Metalaxyl</td>
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<td>Procymidone</td>
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<td>0.130</td>
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<td>Pyrimethanil</td>
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<td>0.0080</td>
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<td>Permethrin</td>
<td>0.024</td>
<td>0.062</td>
<td>0.0500</td>
<td>145.8</td>
</tr>
<tr>
<td></td>
<td>Procymidone</td>
<td>0.718</td>
<td>2.200</td>
<td>0.0300</td>
<td>2.9</td>
</tr>
<tr>
<td>TOTAL = 4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes:
- Food data sourced from FSANZ 2003a (Supplementary information – Part 3).
- ADI = acceptable daily intake.
- * = Amount of food (g) required to read the ADI [based on the mean quantity of pesticide detected in terms of mg/kg, not maximum amount; which is consistent with the 20th ADTS (FSANZ 2003a)].
- Coloured shading indicates the detection of the same pesticide across multiple foods.
- Full-line coloured shading indicates where the possibility exists for a pesticide ADI to be exceeded. For example, it is conceivable – albeit unlikely – for a 70kg person to consume 1.4kg nectarines and in the process reach the ADI for the pesticide propargite in the 20th ATDS sample.
Appendix E

‘Enter the chicken shed’

Enter a typical chicken shed and you will experience a burning feeling in your eyes and your lungs. That’s the ammonia – it comes from the birds’ droppings, which are simply allowed to pile up on the floor without being cleaned out, not merely during the growing period of each flock, but typically for an entire year, and sometimes for several years. High ammonia levels give the birds chronic respiratory disease, sores on their feet and hocks, and breast blisters. It makes their eyes water, and when it is really bad, many birds go blind. As the birds, bred for extremely rapid growth, get heavier, it hurts them to keep standing up, so they spend much of their time sitting on the excrement-filled litter – hence the breast blisters.

Chickens have been bred over many generations to produce the maximum amount of meat in the least amount of time. They now grow three times as fast as chickens raised in the 1950s while consuming one-third as much feed. But this relentless pursuit of efficiency has come at a cost: their bone growth is outpaced by the growth of their muscles and fat. One study found that 90 per cent of broilers had detectable leg problems, while 26 per cent suffered chronic pain as a result of bone disease. Professor John Webster of the University of Bristol’s School of Veterinary Sciences has said: ‘Broilers are the only livestock that are in chronic pain for the last 20 per cent of their lives. They don’t move around, not because they are overstocked, but because it hurts their joints so much.’ Sometime vertebrae snap,

38 H.L. Brodie et al, ‘Structures for Broiler Litter Manure Storage’, Fact Sheet 416, Maryland Cooperative Extension, www.agnr.umd.edu/users/bioreng/fs416, refer, without any suggestion of criticism, to delaying manure cleanout for three years. See also Anon., ‘Animal Waste Management Plans’, Delaware Nutrient Management Notes, Delaware Department of Agriculture, vol. 1, no. 7 (July 2000), where the calculations are based on 90 per cent of the litter remaining in place for two years.
causing paralysis. Paralysed birds or birds whose legs have collapsed cannot get to food or water, and - because the growers don’t bother to, or don’t have time to, check on individual birds - die of thirst or starvation. Given these and other welfare problems and the vast number animals involved - nearly 9 billion in the United States and more than 400 million in Australia – Webster regards industrial chicken production as, ‘in both magnitude and severity, the single most severe, systematic example of man’s inhumanity to another sentient animal’.

Criticise industrial farming, and industry spokespeople are sure to respond that it is in the interests of those who raise animals to keep them healthy and happy so that they will grow well. Commercial chicken-rearing conclusively refutes this claim, Birds who die prematurely may cost the grower money, but it is the total productivity of the shed that matters. G. Tom Tabler, who manages the Applied Broiler Research Unit at the University of Arkansas, and A. M. Mendenhall, of the Department of Poultry Science at the same university, have posed the questions: ‘Is it more profitable to grow the biggest bird and have increased mortality due to heart attacks, ascites (another illness caused by fast growth) and leg problems, or should birds be grown slower so that birds are smaller, but have fewer heart, lung, and skeletal problems?’ Once such a question is asked, as the researchers themselves point out, it takes only ‘simple calculations’ to draw the conclusion that, depending on the various costs, often ‘it is better to get the weight and ignore the mortality.

Breeding chickens for rapid growth creates a different problem for the breeder birds, the parents of the chickens people eat. The parents have the same genetic characteristics as their offspring – including huge appetites. But the breeder birds must live to maturity and keep on breeding as long as possible. If they were given as much food as their appetites demands, they would grow grotesquely fat and might die before they became sexually mature. If they survived at all, they would be unable to breed. So breeder operators ration the breeder birds to 60 to 80 per cent less than their appetites would lead them to eat if they could. The National Chicken Council’s Animal Welfare Guidelines refer to ‘off-feed days’; that is, days on which the hungry birds get no food at all, This is liable to make them drink ‘excessive’ amounts of water, so the water, too, can be restricted on those days. They compulsively peck the ground, even when there is nothing there, either to relieve the stress, or in the vain hope of finding something to eat, As Mr Justice Bell, who examined this practice in the McLibel case, said: ‘My conclusion is that the practice of rearing breeders for appetite, that is to feel especially hungry, and then restricting their feed with the effect of keeping them hungry, is cruel. It is a well-planned device for profit at the expense of suffering of the birds.’

The fast-growing offspring of these breeding birds live for only six weeks. At that age they are caught, put into crates, and trucked to slaughter, A Washington Post journalist observed the catchers at work: ‘They grab birds by their legs, thrusting them like sacks of laundry

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into the cages, sometimes applying a shove.’ To do their job more quickly, the catchers pick up only one leg of each bird, so that they can hold four or five chickens in each hand. (The National Chicken Council’s Animal Welfare Guidelines, eager to avoid curtailing any practice that may be economically advantageous, states: ‘The maximum number of birds per hand is five.’) Dangling from one leg, the frightened birds flap and writhe and often suffer dislocated and broken hips, broken wings and internal bleeding46.

Crammed into cages, the birds then travel to the slaughterhouse, a journey that can take several hours. When their turn to be removed from the crates finally comes, their feet are snapped into metal shackles hanging from a conveyor belt that moves towards the killing room. Speed is the essence, because the slaughterhouse is paid by the number of pounds of chicken that comes out the end. Today a killing line typically moves at 90 birds a minute, and speeds can go as high as 120 birds a minute, or 7200 an hour. Even the lower rate is twice as fast as the lines moved twenty years ago. At such speeds, even if the handlers want to handle the birds gently and with care, they just can’t.

In the United States, in contrast to other developed nations, the law does not require the chickens (or ducks, or turkeys) be rendered unconscious before they are slaughtered. As the birds move down the killing line, still upside down, their heads are dipped into an electrified water bath, which in the industry is called ‘the stunner’. But this is a misnomer. Dr Mohan Raj, a researcher in the Department of Clinical Veterinary Science at the University of Bristol, in England, has recorded the brain activity of chickens after various forms of stunning and reported his results in such publications as World’s Poultry Science Journal. We asked him: ‘Can the American consumer be confident that broilers he or she buys in a supermarket have been properly stunned so that they are unconscious when they have their throats cut?’ His answer was clear: ‘No. The majority of broilers are likely to be conscious and suffer pain and distress at slaughter under the existing water bath electrical stunning systems.’ He went on to explain that the type of electrical current used in the stunning procedure was not adequate to make the birds immediately unconscious. Using a current that would produce immediate loss of consciousness, however, would risk damage to the quality of the meat. Since there is no legal requirement for stunning, the industry won’t take that risk. Instead, the inadequate current that is used evidently paralyses the birds without rendering them unconscious. From the point of view of the slaughterhouse operator, inducing paralysis is as good as inducing unconsciousness, for it stops the birds from thrashing about and makes it easier to cut their throats.

Because of the fast line speed, even the throat-cutting that follows the electrified water bath misses some birds, and they then go alive and conscious into the next stage of the process, a tank of scalding water. It is difficult to get figures on how many birds are, in effect, boiled alive, but documents obtained under the Freedom of Information act indicate that in the


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United States alone, it could be as many as three million a year\textsuperscript{47}. At that rate, 11 chickens would have been scalded to death in the time it takes you to read this page, but the real figure might be much higher. An undercover videotape made at a Tyson slaughterhouse at Heflin, Alabama, shows dozens of birds who have been mutilated by throat-cutting machines that were not working properly. Workers rip the heads off live chickens that have been missed by the cutting blade. Conscious birds go into the scalding tank. A plant worker is recorded as saying that it is acceptable for 40 birds per shift to be missed by the backup killer and scalded alive\textsuperscript{48}.

If you found the last few paragraphs unpleasant reading, Virgil Butler, who spent years working for Tyson Foods in the killing room of a slaughterhouse in Grannis, Arkansas, killing 80,000 chickens a night, mostly for Kentucky Fried Chicken, says that what we have described ‘doesn’t even come close to the horrors I have seen’. On an average night, he says, about one in every three of the chickens was alive when it went into the scalding tank\textsuperscript{49}. The missed birds are, according to Butler, ‘scalded alive’. They ‘flop, scream, kick, and their eyeballs pop out of their heads.’ Often they come out ‘with broken bones and disfigured and missing body parts because they’ve struggled so much in the tank’. When there were mechanical failures, the supervisor would refuse to stop the line, even though he knew that chickens were going into the scalding tank alive or were having their legs broken by malfunctioning equipment.

In January 2003, Butler made a public statement describing workers pulling chickens apart, stomping on them, beating them, running over them on purpose with a forklift, and even blowing them up with dry ice ‘bombs’. Tyson dismissed that statement as the ‘outrageous’ inventions of a disgruntled worker who had lost his job. It’s true that Butler has a conviction for burglary and has had other problems with the law. But eighteen months after Butler made these supposedly ‘outrageous’ claims, a videotape secretly filmed at another KFC-supplying slaughterhouse, in Moorefield, West Virginia, made his claims a lot more credible. The slaughterhouse, operated by Pilgrim’s Pride, the second largest chicken producer in the nation, had won KFC’s ‘Supplier of the Year’ Award. The tape, taken by an undercover investigator working for People for the Ethical Treatment of Animals, showed slaughterhouse workers behaving in ways quite similar to those described by Butler: slamming live chickens into walls, jumping up and down on them, and drop-kicking them as if they were footballs. The undercover investigator said that, beyond what he had been able to catch on camera, he had witnessed ‘hundred’ of acts of cruelty. Workers had ripped off a bird’s head to write graffiti in blood, plucked feathers off alive chickens to ‘make it snow’, suffocated a chicken by tying a latex glove over its head, and squeezed birds like water balloons to spray faeces over other birds. Evidently, their work had desensitised them to animal suffering.

The only significant difference between the behaviour of the workers at Moorefield and that described by Butler at Grannis was that the behaviour at Moorefield was caught on tape.

Unable to dismiss the evidence of cruelty, Pilgrim’s Pride said that it was ‘appalled’ 50. But neither Pilgrim’s Pride nor Tyson Foods, the two largest suppliers of chicken in America, have done anything to address the root cause of the problem: unskilled, low-paid workers doing dirty, bloody work, often in stifling heat, under constant pressure to keep the killing lines moving no matter what so that they can slaughter up to 90,000 animals every shift.

**Appendix F**

*Antibiotic growth promoters approved for use in Australia & their ‘benefits’*

*Antibiotic growth promoters approved for use in Australia:*

<table>
<thead>
<tr>
<th>Generic Name</th>
<th>Cattle</th>
<th>Sheep</th>
<th>Pigs</th>
<th>Poultry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avilamycin</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacitracin</td>
<td></td>
<td>✔</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Bambermycin</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Lasalocid</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Monensin</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Narasin</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Salinomycin</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Kitasamycin</td>
<td>✔</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oleandomycin</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>✔</td>
</tr>
<tr>
<td>Tylosin</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Virginiamycin</td>
<td>✔</td>
<td></td>
<td></td>
<td>✔</td>
</tr>
</tbody>
</table>

*Table sourced from Page (2003 p.2)*
### Summary of the benefits* of antibiotic growth promoters:

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Avilamycin</th>
<th>Bacitracin</th>
<th>Bambermycin</th>
<th>Lasalocid</th>
<th>Menamsin</th>
<th>Narasin</th>
<th>Salinomycin</th>
<th>Kitasamycin</th>
<th>Oleandomycin</th>
<th>Tylosin</th>
<th>Virginiamycin</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Environmental Benefits</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced methane emission (primary ruminants)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced nitrogen excretion (all species)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced phosphorus output (all species)</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Performance Improvements</strong></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Increased rate of bodyweight gain</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower feed requirements for each unit of grain</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved carcass yield</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Improved sow performance</td>
<td>✓</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Improved piglet survival and growth</td>
<td>✓</td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
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<tr>
<td>Increased dairy cow milk production</td>
<td>✓</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Increased wool growth</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Disease Control</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Necrotic enteritis in poultry</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clostridial enteritis in pigs</td>
<td>✓</td>
<td>✓</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Porcine proliferative enteropathy</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Swine dysentery</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute pneumonia in cattle</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coccidiosis in claves and sheep</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Toxoplasmosis in ewes</td>
<td>✓</td>
<td></td>
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<tr>
<td><strong>Prevention of metabolic and fermentative disorders</strong></td>
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<td></td>
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<tr>
<td>Decreased lactic acidosis</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<tr>
<td>Decreased laminitis</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Decreased ketosis</td>
<td>✓</td>
<td></td>
<td></td>
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<td></td>
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<td></td>
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<td></td>
<td></td>
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<tr>
<td>Decreased ruminal bloat</td>
<td>✓</td>
<td>✓</td>
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<td></td>
<td></td>
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</tbody>
</table>

*Table sourced from Page (2003 p.4)*

These factors are viewed as ‘benefits’ in the context of intensive animal farming. As argued in Chapter 4, intensive animal production is not optimally healthy for animals, humans or the environment, and hence, what qualifies as a ‘benefit’ should only be...
considered as such when understood in relation to other farming methods and possibilities. The table above also provides a clear summary of the diseases suffered by intensively farmed animals - the digestive problems caused by feeds which are foreign to the animals’ natural diet; and the drive to increase carcass yield, growth and milk production because of the increased economic return this generates. The environmental ‘benefits’ of antibiotic growth promoters are highly controversial when viewed in a more holistic context. The amount of animal waste from intensive systems is great and so highly concentrated due to the high number of animals housed in such a confined space, which means that any reduction in methane emissions, nitrogen and phosphorous outputs can only be perceived as a ‘benefit’ within a system that is polluting to the environment to begin with.
### Appendix G

**Comparing the oestrogenic potency of endogenous oestradiol - 17β with various sources of environmental xenoestrogens and dietary phytoestrogens**

<table>
<thead>
<tr>
<th>Endocrine modulator</th>
<th>Approximate oestrogenic potency*</th>
<th>Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oestradiol - 17β</td>
<td>1.0</td>
<td>Endogenous</td>
</tr>
<tr>
<td>Coumestrol</td>
<td>0.03-0.2</td>
<td>Plant food - sunflower, alfalfa, legumes (inc soy)</td>
</tr>
<tr>
<td>Zearalenone</td>
<td>0.1-0.001</td>
<td>Mould infestation of cereal crops: wheat, barley, oats, corn</td>
</tr>
<tr>
<td>Zearalanol</td>
<td>0.1-0.001</td>
<td>Agricultural hormonal growth promoter - Metabolite of zearalenone used in beef cattle</td>
</tr>
<tr>
<td>Genistein</td>
<td>0.001-0.01</td>
<td>Plant food - barley, oats, rye, rice, wheat, soybean, beer</td>
</tr>
<tr>
<td>Daidzein</td>
<td>0.002</td>
<td>Plant food - barley, oats, rye, rice, wheat, soybean, beer</td>
</tr>
<tr>
<td>Equol</td>
<td>0.001</td>
<td>Plant food - soybean products (bacterial degradation in GI tract)</td>
</tr>
<tr>
<td>Biochanin A</td>
<td>0.0001-0.001</td>
<td>Alcoholic beverages (bourbon)</td>
</tr>
<tr>
<td>β-sitosterol</td>
<td>0.0001</td>
<td>Alcoholic beverages (bourbon)</td>
</tr>
<tr>
<td>Di-n-buty phthalate</td>
<td>0.0001</td>
<td>Residue in food from plastic wrappers etc</td>
</tr>
<tr>
<td>Chlorinated insecticides (eg DDT, dieldrin, endosulfan)</td>
<td>0.000001</td>
<td>Pesticides (e.g. residues in food)</td>
</tr>
<tr>
<td>Apple/Cherry/Plum</td>
<td>Weakly oestrogenic; potency unknown</td>
<td>Plant food</td>
</tr>
<tr>
<td>Potato</td>
<td>Weakly oestrogenic; potency unknown</td>
<td>Plant food</td>
</tr>
<tr>
<td>Rhubarb</td>
<td>Weakly oestrogenic; potency unknown</td>
<td>Plant food</td>
</tr>
<tr>
<td>Beets</td>
<td>Weakly oestrogenic; potency unknown</td>
<td>Plant food</td>
</tr>
<tr>
<td>Parsley</td>
<td>Weakly oestrogenic; potency unknown</td>
<td>Plant food</td>
</tr>
<tr>
<td>Coffee</td>
<td>Weakly oestrogenic; potency unknown</td>
<td>Plant food</td>
</tr>
<tr>
<td>Garlic</td>
<td>Oestrogenic; potency unknown</td>
<td>Plant food</td>
</tr>
<tr>
<td>Endocrine modulator</td>
<td>Approximate oestrogenic potency*</td>
<td>Sources</td>
</tr>
<tr>
<td>-------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>Licorice (glycyrrhiza glabra)</td>
<td>Oestrogenic; potency unknown; 100-400mg glycyrrhizin acid (50g-200g licorice strip) induces clinical signs of adrenocortical hormone disruption after 7 days</td>
<td>Plant food/Herbal medicine</td>
</tr>
<tr>
<td>Panax and Eleutherococcus Ginsng</td>
<td>Oestrogenic; potency unknown</td>
<td>Herbal medicine</td>
</tr>
<tr>
<td>‘PC-SPEC’ containing chrysanthemum sp., Isatis tinctoria, Scutellaria sp., Glycyrrhiza glabra (licorice), Ganoderma lucidum (a mushroom sp), and Serenoa repens (saw palmetto).</td>
<td>Oestrogenic; potency unknown; documented cases of decreased serum testosterone concentrations (competitive androgen receptor binding – particularly with Serenoa repens), nipple tenderness, loss of libido and venous thrombosis</td>
<td>Herbal medicine used in the management of prostate cancer</td>
</tr>
</tbody>
</table>

* calculated from values relative to 17β-oestradiol (most active oestradiol) based on in vitro assays as approximate indicators of oestrogenic activity.

_Data compiled from Golden et al. (1998) and Nilsson (2000)_
# Appendix H

## Exposure risk to heavy metals via the diet

### DIETARY EXPOSURE TO METALS

#### INORGANIC ARSENIC (TL = 0.003mg/kg bw/day) (More toxic than organic)

<table>
<thead>
<tr>
<th>Food</th>
<th>Median (mg/kg)</th>
<th>Maximum (mg/kg)</th>
<th>Food per day required to reach TL*</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seafood</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish fillets</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n=21)</td>
<td>No detections</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish portions</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n=21)</td>
<td>No detections</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prawns</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n=21)</td>
<td>No detections</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuna, canned</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n=9)</td>
<td>No detections</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### ORGANIC MERCURY (MeHg is most common form and hence the TL for MeHg is applied = 0.2mg/person/day)

<table>
<thead>
<tr>
<th>Food</th>
<th>Median (mg/kg)</th>
<th>Maximum (mg/kg)</th>
<th>Food per day required to reach TL*</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seafood</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish fillets</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n=21)</td>
<td>No detections</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish portions</td>
<td>0.475</td>
<td>0.808</td>
<td>420gm</td>
<td>TL able to be exceeded in contemporary HG diet</td>
</tr>
<tr>
<td>(n=21)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prawns</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(n=21)</td>
<td>No detections</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuna, canned</td>
<td>0.640</td>
<td>0.918</td>
<td>313gm</td>
<td>TL able to be exceeded in contemporary HG diet</td>
</tr>
<tr>
<td>(n=9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### SELENIUM (TL = 0.0125mg/kg bw/day) (limit of reporting 0.1mg.kg)

<table>
<thead>
<tr>
<th>Food</th>
<th>Median (mg/kg)</th>
<th>Maximum (mg/kg)</th>
<th>Food per day required to reach TL for a 70kg male*</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal food</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef, minced</td>
<td>0.13</td>
<td>0.24</td>
<td>6.7kg</td>
<td>Exceedence in contemporary HG diet not likely</td>
</tr>
<tr>
<td>Chicken breasts</td>
<td>0.24</td>
<td>0.31</td>
<td>3.6kg</td>
<td></td>
</tr>
<tr>
<td>Lamb chops</td>
<td>0.19</td>
<td>0.46</td>
<td>4.6kg</td>
<td></td>
</tr>
<tr>
<td>Liver pate</td>
<td>0.39</td>
<td>0.68</td>
<td>2.2kg</td>
<td></td>
</tr>
<tr>
<td>(chicken)</td>
<td>(n=21)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eggs</td>
<td>0.27</td>
<td>0.47</td>
<td>3.2kg</td>
<td></td>
</tr>
<tr>
<td>(n=28)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Seafood</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish fillets</td>
<td>0.26</td>
<td>0.45</td>
<td>3.4kg</td>
<td></td>
</tr>
<tr>
<td>(n=21)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish portions</td>
<td>0.64</td>
<td>1.20</td>
<td>1.4kg</td>
<td></td>
</tr>
<tr>
<td>(n=21)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prawns</td>
<td>0.58</td>
<td>0.87</td>
<td>1.5kg</td>
<td></td>
</tr>
<tr>
<td>(n=21)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tuna, canned</td>
<td>0.87</td>
<td>1.10</td>
<td>1.0kg</td>
<td></td>
</tr>
<tr>
<td>(n=9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vegetable</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mushrooms</td>
<td>0.16</td>
<td>0.28</td>
<td>5.5kg</td>
<td></td>
</tr>
<tr>
<td>(n=21)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Copper (TL = 0.2mg/kg bw/day) (limit of reporting 1.0mg/kg)

<table>
<thead>
<tr>
<th>Food</th>
<th>Median (mg/kg)</th>
<th>Maximum (mg/kg)</th>
<th>Food per day required to reach TL for a 70kg male*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vegetables</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Almonds (n=9)</td>
<td>10.0</td>
<td>11.0</td>
<td>1.4kg</td>
</tr>
<tr>
<td>Grapes (n=21)</td>
<td>1.2</td>
<td>2.3</td>
<td>11.7kg</td>
</tr>
<tr>
<td>Mushrooms (n=21)</td>
<td>3.7</td>
<td>5.7</td>
<td>3.8kg</td>
</tr>
<tr>
<td>Peas, frozen (n=9)</td>
<td>1.2</td>
<td>1.5</td>
<td>11.7kg</td>
</tr>
<tr>
<td>Sultanas (n=9)</td>
<td>3.5</td>
<td>5.9</td>
<td>4.0kg</td>
</tr>
<tr>
<td>Kiwifruit (n=9)</td>
<td>1.3</td>
<td>1.4</td>
<td>10.8kg</td>
</tr>
<tr>
<td><strong>Animal food</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lamb chops (n=21)</td>
<td>1.8</td>
<td>2.4</td>
<td>7.8kg</td>
</tr>
<tr>
<td>Liver pate (chicken)</td>
<td>2.3</td>
<td>7.1</td>
<td>6.1kg</td>
</tr>
<tr>
<td><strong>Seafood</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prawns (n=21)</td>
<td>6.8</td>
<td>16.0</td>
<td>2.1kg</td>
</tr>
</tbody>
</table>

Exceedence in contemporary HG diet not likely

### Cadmium (TL = 0.007mg/kg bw/week)

<table>
<thead>
<tr>
<th>Food</th>
<th>Median (mg/kg)</th>
<th>Maximum (mg/kg)</th>
<th>Food per day required to reach TL for a 70kg male*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Seafood</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prawns</td>
<td>0.078</td>
<td>0.5</td>
<td>0.9kg</td>
</tr>
</tbody>
</table>

Exceedence in contemporary HG diet not likely

### Lead (TL = 0.025mg/kg bw/week)

<table>
<thead>
<tr>
<th>Food</th>
<th>Median (mg/kg)</th>
<th>Maximum (mg/kg)</th>
<th>Food per day required to reach TL for a 70kg male*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Vegetable</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sultanas</td>
<td>0.03</td>
<td>0.06</td>
<td>8.3kg</td>
</tr>
<tr>
<td>Lamb chops</td>
<td>not determined</td>
<td>0.17</td>
<td>1.5kg (based on maximum detection level)</td>
</tr>
</tbody>
</table>

Exceedence in contemporary HG diet not likely

**Notes:**
- * Median values chosen by FSANZ (2003a) for the 20th ATDS because it is a ‘more stable central statistic and is not sensitive to skewing by chemical detections above the normal range’ (p. 8)
- Food group exclusions: non hunter-gatherer food groups (e.g. bread, cereals, processed foods, dairy). Only wholefoods are included in table
- TL = Tolerable Limit, as used by FSANZ (2003a) in 20th ATDS
- The TL – not recommended dietary intake (RDI) - for selenium and copper is used so as to measure toxicity parameters
- HG = hunter-gatherer
- Yellow highlighting indicates foods which can be eaten in quantities that could exceed the tolerable limit per day for heavy metal exposure
Appendix I

Plant and animal food in hunter-gatherer diets

<table>
<thead>
<tr>
<th>Population</th>
<th>Location</th>
<th>Latitude</th>
<th>% animal food</th>
<th>% plant food</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australian Aborigines (Arnhem Land)</td>
<td>Australia</td>
<td>12S</td>
<td>77</td>
<td>23</td>
</tr>
<tr>
<td>Australian Aborigines (Anbarra)</td>
<td>Australia</td>
<td>12S</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>Ache</td>
<td>Paraguay</td>
<td>25S</td>
<td>78</td>
<td>22</td>
</tr>
<tr>
<td>Efe</td>
<td>Africa</td>
<td>2N</td>
<td>44</td>
<td>56</td>
</tr>
<tr>
<td>Inuit</td>
<td>Greenland</td>
<td>69N</td>
<td>96</td>
<td>4</td>
</tr>
<tr>
<td>Gwi</td>
<td>Africa</td>
<td>23S</td>
<td>26</td>
<td>74</td>
</tr>
<tr>
<td>Hadza</td>
<td>Africa</td>
<td>3S</td>
<td>48</td>
<td>52</td>
</tr>
<tr>
<td>Hiwi</td>
<td>Venezuela</td>
<td>6N</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td>!Kung</td>
<td>Africa</td>
<td>20S</td>
<td>33</td>
<td>67</td>
</tr>
<tr>
<td>!Kung</td>
<td>Africa</td>
<td>20S</td>
<td>68</td>
<td>32</td>
</tr>
<tr>
<td>Nukak</td>
<td>Columbia</td>
<td>2N</td>
<td>41</td>
<td>59</td>
</tr>
<tr>
<td>Nunamiut</td>
<td>Alaska</td>
<td>68N</td>
<td>99</td>
<td>1</td>
</tr>
<tr>
<td>Onge</td>
<td>Andaman islands</td>
<td>12N</td>
<td>79</td>
<td>21</td>
</tr>
</tbody>
</table>

Table sourced from Cordain (2006)
Appendix J

**Attempting to match the plant to animal food subsistence ratios and macronutrient composition of average hunter-gatherer diets as estimated by Cordain et al. (2000) using contemporary Australian foods**

<table>
<thead>
<tr>
<th>FOODS</th>
<th>Weight/Mass/Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flathead, Raw</td>
<td>200g</td>
</tr>
<tr>
<td>Kangaroo, Loin fillet, raw</td>
<td>200g</td>
</tr>
<tr>
<td>Egg, Whole, Raw</td>
<td>3 medium egg (55-64g)</td>
</tr>
<tr>
<td>Mussel, Raw</td>
<td>10 medium</td>
</tr>
<tr>
<td>Salmon, Red, Canned In Brine</td>
<td>415g</td>
</tr>
<tr>
<td>Sardine, Canned In Water</td>
<td>110g</td>
</tr>
<tr>
<td>Scallop, Raw</td>
<td>6 scallop (4.5x3.5x1.5cm)</td>
</tr>
<tr>
<td>Fish oil</td>
<td>10g</td>
</tr>
<tr>
<td>Banana, Common, Raw</td>
<td>1 medium (12-17cm long)</td>
</tr>
<tr>
<td>Mango, Raw</td>
<td>1 mango</td>
</tr>
<tr>
<td>Blackberry, Raw</td>
<td>2 serve (10 berries)</td>
</tr>
<tr>
<td>Date, Raw</td>
<td>5 medium</td>
</tr>
<tr>
<td>Macadamia, Raw</td>
<td>1 serve (10 nuts)</td>
</tr>
<tr>
<td>Sweet Potato, NS Colour, Dry-Baked</td>
<td>3 medium (5cm dia, 13cm long)</td>
</tr>
<tr>
<td>Pumpkin, Dry-Baked</td>
<td>0.5 cup</td>
</tr>
<tr>
<td>Broccoli, Chinese, Cooked, Fat Not Added</td>
<td>0.5 cup (cooked)</td>
</tr>
<tr>
<td>Zucchini, Raw</td>
<td>1 medium (11-16cm long)</td>
</tr>
<tr>
<td>Carrot, Raw</td>
<td>2 medium (17cm long)</td>
</tr>
<tr>
<td>Bean, Broad, Cooked, From Raw, Fat Not Added In Cooking</td>
<td>3 serve (10 beans)</td>
</tr>
<tr>
<td>Cabbage, Bok Choy, Raw</td>
<td>0.5 cup (chopped)</td>
</tr>
<tr>
<td>Avocado, Raw</td>
<td>0.5 whole (11x7.5cm dia)</td>
</tr>
</tbody>
</table>
### ANALYSIS SUMMARY (Xyris Software 2007)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Avg/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g)</td>
<td>2845</td>
</tr>
<tr>
<td>Energy (kJ)</td>
<td>12156 + 370kJ fish</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>260</td>
</tr>
<tr>
<td>Total Fat (g)</td>
<td>122 + 10g fish oil</td>
</tr>
<tr>
<td>- Saturated Fat (g)</td>
<td>30 + fish oil</td>
</tr>
<tr>
<td>- Polyunsaturated Fat (g)</td>
<td>21 + fish oil</td>
</tr>
<tr>
<td>- Monounsaturated Fat (g)</td>
<td>60 + fish oil</td>
</tr>
<tr>
<td>Cholesterol (mg)</td>
<td>1228</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>174</td>
</tr>
<tr>
<td>Sugars (g)</td>
<td>120</td>
</tr>
<tr>
<td>Starch (g)</td>
<td>54</td>
</tr>
<tr>
<td>Water (g)</td>
<td>2194</td>
</tr>
<tr>
<td>Alcohol (g)</td>
<td>0</td>
</tr>
<tr>
<td>Dietary Fibre (g)</td>
<td>41</td>
</tr>
<tr>
<td>Thiamin (mg)</td>
<td>1.51</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>4.10</td>
</tr>
<tr>
<td>Niacin (mg)</td>
<td>55.35</td>
</tr>
<tr>
<td>Niacin Equivalents (mg)</td>
<td>108.07</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>389.02</td>
</tr>
<tr>
<td>Total Folate (ug)</td>
<td>590.32</td>
</tr>
<tr>
<td>Total Vitamin A Equivalents (ug)</td>
<td>8877.32</td>
</tr>
<tr>
<td>Retinol (ug)</td>
<td>586.95</td>
</tr>
<tr>
<td>Beta Carotene Equivalents (ug)</td>
<td>49625.21</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>4398.86</td>
</tr>
<tr>
<td>Potassium (mg)</td>
<td>8002.72</td>
</tr>
<tr>
<td>Magnesium (mg)</td>
<td>720.42</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>1970.29</td>
</tr>
<tr>
<td>Phosphorus (mg)</td>
<td>3739.31</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>45.21</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>24.50</td>
</tr>
</tbody>
</table>

### NOTES

Energy intake: 12526kJ  
Animal foods: 6907kJ + 370kJ (from fish oil) = 58% energy intake  
Plant foods: 5249kJ = 42% energy intake  

Protein = 260g (x17) = 35%  
Fat = 122g + 10g – fish oil (x37) = 39%  
Carbohydrate = 174g (x16) = 22%

This example matches plant to animal food subsistence ratios in average hunter-gatherer diets as estimated by Cordain et al. (2000) and falls within estimated macronutrient parameters of 19-35% protein, 28-58% fat and 22-40% carbohydrate.
### Appendix K


#### FOODS

**Breakfast**

- Rockmelon/Cantaloupe, Raw 0.5 whole (15cm dia)
- Salmon, Raw 340g

**Lunch**

- Prawn, King, Raw 0.8 serve (10 prawns)
- Spinach, English, Raw 3 cup (chopped)
- Carrot, Raw 1 medium (17cm long)
- Cucumber, Lebanese, Raw 1 whole (unpeeled)
- Tomato, Raw 2 medium slice (1cm thick)
- Juice, lemon, home squeezed 1 tb
- Oil, Olive 5g

**Dinner**

- Pork, Chop, All Cuts, Raw, Fat Trimmed 2 medium chop
- Broccoli, Raw 2 cup (flowerets)
- Lettuce, Cos, Raw 2 cup (shredded/chopped)
- Tomato, Raw 0.5 cup (chopped/sliced)
- Onion, Mature, Raw 0.25 cup (sliced)
- Avocado, Raw 0.5 whole (11x7.5cm dia)
- Juice, lemon, home squeezed 1 tb

**Dessert**

- Blueberry, Raw 0.5 cup
- Almond, Raw 0.25 cup (flaked)

**Snack**

- Pork, Chop, All Cuts, Raw, Fat Trimmed 1 small chop
- Almond, Raw 0.25 cup (flaked)
### ANALYSIS SUMMARY (Xyris Software 2007)

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Avg/Day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (g)</td>
<td>2249</td>
</tr>
<tr>
<td>Energy (kJ)</td>
<td>8083</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>199</td>
</tr>
<tr>
<td>Total Fat (g)</td>
<td>99</td>
</tr>
<tr>
<td>- Saturated Fat (g)</td>
<td>20</td>
</tr>
<tr>
<td>- Polyunsaturated Fat (g)</td>
<td>21</td>
</tr>
<tr>
<td>- Monounsaturated Fat (g)</td>
<td>50</td>
</tr>
<tr>
<td>Cholesterol (mg)</td>
<td>614</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>45</td>
</tr>
<tr>
<td>Sugars (g)</td>
<td>44</td>
</tr>
<tr>
<td>Starch (g)</td>
<td>0</td>
</tr>
<tr>
<td>Water (g)</td>
<td>1840</td>
</tr>
<tr>
<td>Alcohol (g)</td>
<td>0</td>
</tr>
<tr>
<td>Dietary Fibre (g)</td>
<td>28</td>
</tr>
<tr>
<td>Thiamin (mg)</td>
<td>4.08</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>3.22</td>
</tr>
<tr>
<td>Niacin (mg)</td>
<td>55.60</td>
</tr>
<tr>
<td>Niacin Equivalents (mg)</td>
<td>91.23</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>442.41</td>
</tr>
<tr>
<td>Total Folate (ug)</td>
<td>474.75</td>
</tr>
<tr>
<td>Total Vitamin A Equivalents (ug)</td>
<td>2463.63</td>
</tr>
<tr>
<td>Retinol (ug)</td>
<td>44.37</td>
</tr>
<tr>
<td>Beta Carotene Equivalents (ug)</td>
<td>14437.94</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>1095.20</td>
</tr>
<tr>
<td>Potassium (mg)</td>
<td>6962.66</td>
</tr>
<tr>
<td>Magnesium (mg)</td>
<td>575.66</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>704.51</td>
</tr>
<tr>
<td>Phosphorus (mg)</td>
<td>2702.56</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>17.24</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>17.81</td>
</tr>
<tr>
<td>kJ from Protein (%)</td>
<td>43</td>
</tr>
<tr>
<td>kJ from Fat (%)</td>
<td>47</td>
</tr>
<tr>
<td>kJ from Carbohydrate (%)</td>
<td>10</td>
</tr>
<tr>
<td>kJ from Alcohol (%)</td>
<td>0</td>
</tr>
<tr>
<td>kJ from Others (%)</td>
<td>0</td>
</tr>
<tr>
<td>Fat as Mono (%)</td>
<td>55</td>
</tr>
<tr>
<td>Fat as Poly (%)</td>
<td>24</td>
</tr>
<tr>
<td>Fat as Saturated (%)</td>
<td>22</td>
</tr>
</tbody>
</table>
NOTES

A few food listed in the example given by Cordain’s (2002b) were not available in the FoodWorks software database hence substitutions have been made for foods with similar nutritional characteristics within the same food group.

Plant food: 3461kJ = 38% daily energy
Animal food: 5733kJ = 62% daily energy

As estimated by Cordain et al. (2000), 73% of recent world-wide hunter-gatherer societies obtained greater than 50% of daily energy from animal foods. Only 13.5% obtained greater than 50% of daily energy from plant foods.

While this dietary example matches hunter-gatherer plant to animal subsistence ratios according to Cordain et al. (2000), the macronutrient composition is skewed. The macronutrient breakdown of this dietary example is:

Protein = 40% daily energy
Fat = 47% daily energy
Carbohydrate = 10% daily energy

Macronutrient composition of the average hunter-gatherer diet according to Cordain et al. (2000) was 19-35% protein, 28-58% fat and 22-40% carbohydrate.
Appendix L

An example of a ‘contemporary hunter-gatherer diet’ using modern Australian foods: the author’s interpretation

FOODS

Non-starchy vegetables

<table>
<thead>
<tr>
<th>Food Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broccoli, Raw</td>
<td>0.5 bunch</td>
</tr>
<tr>
<td>Kale, Cooked, Fat Not Added In Cooking</td>
<td>1 cup (from fresh)</td>
</tr>
<tr>
<td>Bean, Green, Raw</td>
<td>2 serve (10 beans, 10cm long)</td>
</tr>
<tr>
<td>Carrot, Raw</td>
<td>2 medium (17cm long)</td>
</tr>
<tr>
<td>Zucchini, Raw</td>
<td>1 medium (11-16cm long)</td>
</tr>
<tr>
<td>Asparagus, Raw</td>
<td>6 medium spear (13-18cm long)</td>
</tr>
</tbody>
</table>

Fruit

<table>
<thead>
<tr>
<th>Food Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apple, Green, Raw, Unpeeled</td>
<td>1 medium (6-8cm dia)</td>
</tr>
<tr>
<td>Blueberry, Raw</td>
<td>1 cup</td>
</tr>
<tr>
<td>Orange, Navel, Raw</td>
<td>2 medium (6-8cm dia)</td>
</tr>
<tr>
<td>Banana, Common, Raw</td>
<td>1 medium (12-17cm long)</td>
</tr>
<tr>
<td>Tomato, Raw</td>
<td>2 small (&lt;6cm dia)</td>
</tr>
</tbody>
</table>

Starchy vegetables

<table>
<thead>
<tr>
<th>Food Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweet Potato, Orange, Dry-Baked</td>
<td>5 medium (5cm dia, 13cm long)</td>
</tr>
</tbody>
</table>

Fatty fruit

<table>
<thead>
<tr>
<th>Food Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Avocado, Raw</td>
<td>1 whole (11x7.5cm dia)</td>
</tr>
<tr>
<td>Oil, Olive</td>
<td>1 tb</td>
</tr>
</tbody>
</table>

Nuts

<table>
<thead>
<tr>
<th>Food Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macadamia, Raw</td>
<td>50g</td>
</tr>
<tr>
<td>Almond, Raw</td>
<td>50g</td>
</tr>
</tbody>
</table>

Animal foods

<table>
<thead>
<tr>
<th>Food Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flathead, Raw</td>
<td>250g</td>
</tr>
<tr>
<td>Kangaroo, Raw</td>
<td>150g</td>
</tr>
<tr>
<td>Egg, Whole, Raw</td>
<td>2 small egg (45-54g)</td>
</tr>
<tr>
<td></td>
<td>Avg/Day</td>
</tr>
<tr>
<td>----------------</td>
<td>---------</td>
</tr>
<tr>
<td>Weight (g)</td>
<td>3207</td>
</tr>
<tr>
<td>Energy (kJ)</td>
<td>12491</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>161</td>
</tr>
<tr>
<td>Total Fat (g)</td>
<td>155</td>
</tr>
<tr>
<td>- Saturated Fat (g)</td>
<td>26</td>
</tr>
<tr>
<td>- Polyunsaturated Fat (g)</td>
<td>17</td>
</tr>
<tr>
<td>- Monounsaturated Fat (g)</td>
<td>100</td>
</tr>
<tr>
<td>Cholesterol (mg)</td>
<td>527</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>206</td>
</tr>
<tr>
<td>Sugars (g)</td>
<td>137</td>
</tr>
<tr>
<td>Starch (g)</td>
<td>68</td>
</tr>
<tr>
<td>Water (g)</td>
<td>2554</td>
</tr>
<tr>
<td>Alcohol (g)</td>
<td>0</td>
</tr>
<tr>
<td>Dietary Fibre (g)</td>
<td>68</td>
</tr>
<tr>
<td>Thiamin (mg)</td>
<td>2.00</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>4.03</td>
</tr>
<tr>
<td>Niacin (mg)</td>
<td>37.11</td>
</tr>
<tr>
<td>Niacin Equivalents (mg)</td>
<td>68.45</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>952.49</td>
</tr>
<tr>
<td>Total Folate (ug)</td>
<td>1046.21</td>
</tr>
<tr>
<td>Total Vitamin A Equivalents (ug)</td>
<td>11061.43</td>
</tr>
<tr>
<td>Retinol (ug)</td>
<td>147.20</td>
</tr>
<tr>
<td>Beta Carotene Equivalents (ug)</td>
<td>65396.95</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>669.46</td>
</tr>
<tr>
<td>Potassium (mg)</td>
<td>9129.61</td>
</tr>
<tr>
<td>Magnesium (mg)</td>
<td>713.22</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>1109.23</td>
</tr>
<tr>
<td>Phosphorus (mg)</td>
<td>2444.51</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>26.82</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>18.80</td>
</tr>
<tr>
<td>kJ from Protein (%)</td>
<td>23</td>
</tr>
<tr>
<td>kJ from Fat (%)</td>
<td>48</td>
</tr>
<tr>
<td>kJ from Carbohydrate (%)</td>
<td>29</td>
</tr>
<tr>
<td>kJ from Alcohol (%)</td>
<td>0</td>
</tr>
<tr>
<td>kJ from Others (%)</td>
<td>0</td>
</tr>
<tr>
<td>Fat as Mono (%)</td>
<td>12</td>
</tr>
<tr>
<td>Fat as Poly (%)</td>
<td>18</td>
</tr>
<tr>
<td>Glycemic Index ()</td>
<td>43</td>
</tr>
<tr>
<td>Glycemic Index Level (Diet)</td>
<td>Low</td>
</tr>
<tr>
<td>Glycemic Index Level (Food)</td>
<td>Low</td>
</tr>
<tr>
<td>Glycemic Load</td>
<td>80</td>
</tr>
<tr>
<td>Unassigned Carbohydrate (%)</td>
<td>9</td>
</tr>
<tr>
<td>Assigned Carbohydrate (g)</td>
<td>186.2</td>
</tr>
<tr>
<td>Glycemic Index of Assigned Carbohydrate</td>
<td>43</td>
</tr>
<tr>
<td>Glycemic Load of Assigned Carbohydrate</td>
<td>80</td>
</tr>
</tbody>
</table>
Appendix M

Nutrition composition of the example ‘contemporary hunter-gatherer diet’ provided in Chapter 7, compared with recommended dietary intakes and the average Australian diet

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Protein (g)</td>
<td>161</td>
<td>64</td>
<td>115</td>
</tr>
<tr>
<td>Fibre (g)</td>
<td>68</td>
<td>30</td>
<td>26</td>
</tr>
<tr>
<td>Thiamin (mg)</td>
<td>2.0</td>
<td>1.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Riboflavin (mg)</td>
<td>4.0</td>
<td>1.3</td>
<td>-</td>
</tr>
<tr>
<td>Niacin (gm)</td>
<td>37</td>
<td>16</td>
<td>54</td>
</tr>
<tr>
<td>Vitamin C (mg)</td>
<td>952</td>
<td>45</td>
<td>33</td>
</tr>
<tr>
<td>Folate (µg)</td>
<td>1046</td>
<td>400</td>
<td>311</td>
</tr>
<tr>
<td>Vitamin A (µg)</td>
<td>11061</td>
<td>900</td>
<td>1306</td>
</tr>
<tr>
<td>Sodium (mg)</td>
<td>669</td>
<td>460-920</td>
<td>-</td>
</tr>
<tr>
<td>Potassium (mg)</td>
<td>9130</td>
<td>3800</td>
<td>3818</td>
</tr>
<tr>
<td>Magnesium (mg)</td>
<td>713</td>
<td>400-420</td>
<td>393</td>
</tr>
<tr>
<td>Calcium (mg)</td>
<td>1109</td>
<td>1000</td>
<td>989</td>
</tr>
<tr>
<td>Phosphorus (mg)</td>
<td>2445</td>
<td>1000</td>
<td>1867</td>
</tr>
<tr>
<td>Iron (mg)</td>
<td>27</td>
<td>8</td>
<td>17</td>
</tr>
<tr>
<td>Zinc (mg)</td>
<td>19</td>
<td>14</td>
<td>15</td>
</tr>
<tr>
<td>KJ from Protein (%)</td>
<td>23</td>
<td>n/d</td>
<td>17*</td>
</tr>
<tr>
<td>KJ from Fat (%)</td>
<td>48</td>
<td>n/d</td>
<td>34*</td>
</tr>
<tr>
<td>KJ from Carbohydrate (%)</td>
<td>29</td>
<td>n/d</td>
<td>43*</td>
</tr>
<tr>
<td>Energy intake from animal food (%)</td>
<td>17</td>
<td>n/d</td>
<td>n/d</td>
</tr>
<tr>
<td>Energy intake from plant food (%)</td>
<td>83</td>
<td>n/d</td>
<td>n/d</td>
</tr>
</tbody>
</table>

Notes:
- n/d = not determined.
- # Based on an adult male with a reference body weight of 76kg
- ^ Data is available on other age groups in both males and females (see NHMRC 2003 p.7)
- * The percent of energy from fat, carbohydrate and protein doesn’t quite add up to 100%.

The remaining source of energy in the 1995 National Nutrition Survey is for a large part likely due to alcohol intake. The average Australian consumes on average 18.5g alcohol/person/day (Australian Institute of Health and Welfare 2006b) which is the equivalent of around one can of beer (375mL, 4.5% alcohol weigh/volume).
Appendix N

**Fatty acid composition of the example ‘contemporary hunter-gatherer’ diet presented in Chapter 7**

### Polyunsaturated fatty acid composition

<table>
<thead>
<tr>
<th>Foods</th>
<th>18:2 LA</th>
<th>18:3 ALA</th>
<th>20:4 AA</th>
<th>20:5 EPA</th>
<th>22:5 DPA</th>
<th>22:6 DHA</th>
<th>Total n-6 (LA+AA)</th>
<th>Total n-3 (ALA+EPA+DPA+DHA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broccoli (raw) (304g)</td>
<td>0.05</td>
<td>0.06</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.05</td>
<td>0.06</td>
</tr>
<tr>
<td>Kale (cooked) (137g)</td>
<td>0.10</td>
<td>0.14</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.10</td>
<td>0.14</td>
</tr>
<tr>
<td>Beans (raw) (100g)</td>
<td>0.03</td>
<td>0.04</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.03</td>
<td>0.04</td>
</tr>
<tr>
<td>Carrot (raw) (157g)</td>
<td>0.18</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.18</td>
<td>-</td>
</tr>
<tr>
<td>Zucchini (raw) (101g)</td>
<td>0.03</td>
<td>0.05</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.03</td>
<td>0.05</td>
</tr>
<tr>
<td>Asparagus (raw) (80g)</td>
<td>0.03</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.03</td>
<td>0.01</td>
</tr>
<tr>
<td>Apple (166g)</td>
<td>0.07</td>
<td>0.02</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.07</td>
<td>0.02</td>
</tr>
<tr>
<td>Blueberries (158g)</td>
<td>0.14</td>
<td>0.09</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.14</td>
<td>0.09</td>
</tr>
<tr>
<td>Orange (262g)</td>
<td>0.06</td>
<td>0.02</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.06</td>
<td>0.02</td>
</tr>
<tr>
<td>Tomato (238g)</td>
<td>0.19</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.19</td>
<td>0.01</td>
</tr>
<tr>
<td>Banana (101g)</td>
<td>0.05</td>
<td>0.03</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.05</td>
<td>0.03</td>
</tr>
<tr>
<td>Sweet potato (dry baked) (570g)</td>
<td>0.34</td>
<td>0.02</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.34</td>
<td>0.02</td>
</tr>
<tr>
<td>Avocado (242g)</td>
<td>4.05</td>
<td>0.30</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>4.05</td>
<td>0.30</td>
</tr>
<tr>
<td>Olive oil (18g)</td>
<td>1.76</td>
<td>0.14</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>1.76</td>
<td>0.14</td>
</tr>
</tbody>
</table>

---

51 Fatty acid composition data for each food sourced from USDA (2009)
52 LA = Linoleic acid; ALA = Alpha-linolenic acid; AA = Arachidonic acid; EPA = Eicosapentaenoic acid; DPA = Docosapentaenoic acid; DHA = Docosahexaenoic acid
<table>
<thead>
<tr>
<th></th>
<th>18:2 LA</th>
<th>18:3 ALA</th>
<th>20:4 AA</th>
<th>20:5 EPA</th>
<th>22:5 DPA</th>
<th>22:6 DHA</th>
<th>Total n-6 (LA+AA)</th>
<th>Total n-3 (ALA+EPA+DPA+DHA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macadamia nuts (50g)</td>
<td>0.65</td>
<td>0.10</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>0.65</td>
<td>0.10</td>
</tr>
<tr>
<td>Almonds (50g)</td>
<td>6.03</td>
<td>0.00</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>6.03</td>
<td>0.00</td>
</tr>
<tr>
<td>Fish (whiting)(^{53}) (250g)</td>
<td>0.5</td>
<td>0.08</td>
<td>0.2</td>
<td>0.23</td>
<td>0.05</td>
<td>0.33</td>
<td>0.7</td>
<td>0.69</td>
</tr>
<tr>
<td>Kangaroo fillet (150g)</td>
<td>0.36</td>
<td>0.11</td>
<td>0.15</td>
<td>0.05</td>
<td>0.05</td>
<td>0.02</td>
<td>0.51</td>
<td>0.23</td>
</tr>
<tr>
<td>Eggs (82g)</td>
<td>0.94</td>
<td>0.03</td>
<td>0.12</td>
<td>0.00</td>
<td>0.00</td>
<td>0.03</td>
<td>1.06</td>
<td>0.06</td>
</tr>
<tr>
<td>TOTAL(g)</td>
<td>15.56</td>
<td>1.25</td>
<td>0.47</td>
<td>0.28</td>
<td>0.10</td>
<td>0.38</td>
<td>16.03</td>
<td>2.01</td>
</tr>
</tbody>
</table>

TOTAL n-3 LCPUFA (EPA + DPA + DHA) = 0.76g

---

\(^{53}\) Substitution of whiting fish for flathead because fatty acid composition data for flathead was not available in the USDA (2009) database. Both fish are southern Australian fish species who dwell in similar ecological niches and have a very similar fatty acid profile which makes such a substitution reasonable. Furthermore, the intent of this example diet is not to be prescriptive, but rather demonstrate nutritional parameters and hence, in a real life dietary context, a diversity of fish species would be utilised which makes the substitution in this case just one of theoretical value only.
## Appendix O

**Meat intake in the average Australian diet: calculated estimates**

<table>
<thead>
<tr>
<th>Measure</th>
<th>Average intake Males* (g/person/day)</th>
<th>Food equivalency - Males^ (% of daily energy; average 11,050kJ/day)</th>
<th>Average intake Females* (g/person/day)</th>
<th>Food equivalency - Females^ (% of daily energy; average 7,481kJ/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Muscle meat and dishes</td>
<td>125</td>
<td>lamb chop, fat trimmed (125g = 781kJ) = 7%</td>
<td>70</td>
<td>lamb (70g = 438kJ) = 5% kangaroo (70g = 289kJ) = 4%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>kangaroo fillet (125g = 516kJ) = 6% (less than lamb because it contains less fat)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Poultry and other feathered game, and dishes</td>
<td>52</td>
<td>chicken breast (without skin) (52g = 352kJ) = 3%</td>
<td>35</td>
<td>chicken (35g = 215kJ) = 3%</td>
</tr>
<tr>
<td>3. Fish and seafood products and dishes</td>
<td>29</td>
<td>wild caught flathead fish (29g = 115kJ) = 1%</td>
<td>23</td>
<td>flathead fish (23g = 91kJ) = &lt;1% oysters (23g = 71kJ) = &gt;1%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>oysters (89kJ) = 1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Sausages, frankfurts, saveloys and processed meats</td>
<td>22</td>
<td>frankfurts (22g = 229kJ) = 2%</td>
<td>10</td>
<td>frankfurts (10g = 104kJ) = 1%</td>
</tr>
<tr>
<td>5. Egg products and dishes</td>
<td>16</td>
<td>whole boiled eggs (16g = 95kJ) = &gt;1%</td>
<td>11</td>
<td>whole boiled eggs (11g = 65kJ) = &gt;1%</td>
</tr>
<tr>
<td>6. Legumes and pulse products and dishes</td>
<td>12</td>
<td>lentils cooked (12g = 35kJ) = &gt;1%</td>
<td>8</td>
<td>lentils cooked (8g = 23kJ) = &gt;1%</td>
</tr>
<tr>
<td>7. Seed and nut products and dishes</td>
<td>5</td>
<td>pumpkin seed (5g = 117kJ) = 1%</td>
<td>4</td>
<td>pumpkin seed (4g = 93kJ) = 1% macadamia nuts (4g = 121kJ) = 2%</td>
</tr>
<tr>
<td></td>
<td></td>
<td>macadamia nuts (5g = 151kJ) = 1%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Organ meats and offal, products and dishes</td>
<td>1</td>
<td>chicken liver (1g = 5kJ) = &gt;1%</td>
<td>1</td>
<td>chicken liver (1g = 5kJ) = &gt;1% macadamia liver^ (1g = 7kJ) = &gt;1%</td>
</tr>
</tbody>
</table>

* Data sourced from Australian Institute of Health and Welfare (2006b)

^ Food composition data sourced from Xyris Software (2007)
# Appendix P

## Dairy intake in the average Australian diet: calculated estimates

<table>
<thead>
<tr>
<th>Foods</th>
<th>Average intake Males* (g/person/day)</th>
<th>Males % of daily energy (average 11,050kJ)</th>
<th>Average intake Females* (g/person/day)</th>
<th>Females % of daily energy (average 7481kJ)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dairy milk</td>
<td>223 (≈424kJ low fat milk)</td>
<td>4%</td>
<td>184 (≈350kJ low fat milk)</td>
<td>5%</td>
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<tr>
<td>Frozen milk products</td>
<td>23 (≈214kJ ice cream)</td>
<td>2%</td>
<td>13 (≈121kJ ice cream)</td>
<td>2%</td>
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<tr>
<td>Flavoured milks</td>
<td>28 (≈91kJ regular fat chocolate flavour)</td>
<td>1%</td>
<td>11 (≈36kJ regular fat chocolate flavour)</td>
<td>0.5%</td>
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<tr>
<td>Cheese</td>
<td>16 (≈212kJ reduced fat, cheddar*)</td>
<td>2%</td>
<td>13 (≈178kJ reduced fat, cheddar)</td>
<td>2%</td>
</tr>
<tr>
<td>Other dishes where milk is the major component</td>
<td>13 (≈25kJ regular milk)</td>
<td>0.2%</td>
<td>12 (≈23kJ regular milk)</td>
<td>0.3%</td>
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<tr>
<td>Yoghurt</td>
<td>11 (≈43kJ reduced fat)</td>
<td>0.4%</td>
<td>17 (≈66kJ reduced fat)</td>
<td>0.8%</td>
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<tr>
<td>Milk substitutes (soy milk used as the example here)</td>
<td>5 (≈9kJ low fat soy milk)</td>
<td>-</td>
<td>5 (≈9kJ low fat soy milk)</td>
<td>-</td>
</tr>
<tr>
<td>Cream</td>
<td>3 (≈50kJ)</td>
<td>0.5%</td>
<td>3 (≈50kJ)</td>
<td>0.7%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td><strong>Approx 10%</strong></td>
<td><strong>Approx 10%</strong></td>
<td></td>
</tr>
</tbody>
</table>

* Data sourced from Australian Institute of Health and Welfare (2006b)
Food composition data sourced from Xyris Software (2007)
Appendix Q

The Australian Guide to Healthy Eating Pie Chart

Appendix R

Recommendations summary: The food (& lifestyle) matrix for best meeting our evolutionarily adapted needs

<table>
<thead>
<tr>
<th>Hunter-gatherer food groups</th>
<th>Eating like a ‘contemporary hunter-gatherer’ means including an omnivorous mix of Australian grown vegetables (including root vegetables), fruits, nuts/seeds, fish/seafood, lean animal meats (and organs &amp;/or fish oil) and eggs. Minimal use of whole grains (choose less hybridized varieties e.g. ‘ancient’ grains) and honey in very small quantities. Eating in this way inherently results in a diet that is exceptionally nutrient dense, is macronutrient balanced, carries a low glycaemic load, contains adequate essential fatty acids, is high in fibre, and above all provides a whole matrix of nutrients which are optimally supportive of human health.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Select foods in their most biologically authentic state</td>
<td>Preferentially select foods which are living in their optimal state of health, grown in bio-diverse ecosystems, nutrient dense soils, without the aid of synthetic chemicals and with low environmental contamination (e.g. certified organic produce, sustainable wild-caught seafood, wild kangaroo meat). Making these choices requires knowledge of the lifecycle of the food we eat.</td>
</tr>
<tr>
<td>Eat in accordance with the seasons and natural patterns of food availability in the wild</td>
<td>The wild food supply is extraordinarily diverse, and varies depending on season and geographic location. Let your diet mirror these patterns. A diversity of foods from shoreline ecosystems (e.g. coastal) provides the opportunity for the greatest nutrient spectrum.</td>
</tr>
<tr>
<td>Prepare food in an evolutionarily authentic way</td>
<td>Consume minimally processed, fresh, whole foods where possible. Consume a significant proportion of fruit and vegetables raw reflecting the way they would have been traditionally eaten as they were gathered in the wild.</td>
</tr>
<tr>
<td>Establish nutritional homeostasis in your body</td>
<td>Only from a point of authentic balance can we directly know what we truly need, including what foods suit us best. Strengthen your body from the ideology of achieving vibrant health rather than disease management/weight loss.</td>
</tr>
<tr>
<td>Eat with awareness</td>
<td>Be guided by taste and smell - our inbuilt mechanism for understanding food quality. Touching, smelling and tasting food is both an act of pleasure and a means for satisfying physiological need. Tune-in to the difference between physiological hunger and eating for stress relief. Eat slowly, when calm. Taste it. Enjoy it.</td>
</tr>
<tr>
<td>Modify for individual need</td>
<td>Modify for individual requirements (e.g. illness). Nutrient supplementation may be advisable depending on individual biochemistry, food preferences and dietary choices.</td>
</tr>
<tr>
<td>Hydrate</td>
<td>Drink plenty of water (at least 2 litres per day). However, minimise excessive fluids during meals as this dilutes digestive acids and enzymes required for good digestion.</td>
</tr>
<tr>
<td>Use an evolutionary template to inform lifestyle parameters</td>
<td>Aim for quality sleep, appropriate exercise, adequate sunlight, relaxation, a socially supportive network and emotional wellbeing in your healing matrix.</td>
</tr>
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</table>
Appendix S

‘Contemporary hunter-gatherer diet’ example: Adult male, 11085kJ/d, reference body weight 76kg, seasonal winter foods

<table>
<thead>
<tr>
<th></th>
<th>Description</th>
<th>Amount</th>
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<tbody>
<tr>
<td><strong>FOODS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Adult male (19-70 years old) – winter</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Breakfast</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Egg, Omelette, Fat Not Added In Cooking</td>
<td>1.5 serve (2-egg)</td>
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</tr>
<tr>
<td>Sweet Potato, Orange, Dry-Baked</td>
<td>1 large</td>
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</tr>
<tr>
<td>Almond, Raw</td>
<td>50g</td>
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</tr>
<tr>
<td>Leek, Cooked, Fat Not Added In Cooking, (with omelette)</td>
<td>1 leek (~17cm long, 3cm dia)</td>
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<tr>
<td><strong>Lunch</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flathead, Baked/Grilled, Fat Not Added In Cooking</td>
<td>180g</td>
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</tr>
<tr>
<td>Kale, Cooked, Fat Not Added In Cooking</td>
<td>1 cup (from fresh)</td>
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</tr>
<tr>
<td>Potato, Boiled, Without Added Salt, With Skin (Unpeeled)</td>
<td>3 medium (6-7.9cm dia)</td>
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<tr>
<td>Fennel, Raw</td>
<td>1 cup (chopped)</td>
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<tr>
<td>Celery, Raw</td>
<td>1 cup (diced)</td>
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<tr>
<td>Juice, lemon, home squeezed</td>
<td>0.5 from 1 lemon (5cm dia)</td>
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<tr>
<td>Oil, Olive</td>
<td>1 tsp</td>
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<tr>
<td>Carrot, Raw</td>
<td>1 cup (grated)</td>
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<tr>
<td>Grape, Green, No Seeds, Raw, (saltanas)</td>
<td>15 grape (nfs)</td>
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<tr>
<td><strong>Dinner</strong></td>
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<tr>
<td>Kangaroo, Loin fillet, raw, (minced)</td>
<td>150g</td>
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<tr>
<td>Onion, Mature, Cooked, Fat Not Added In Cooking</td>
<td>2 medium</td>
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<tr>
<td>Tomato, Canned, In Tomato Juice, No Added Salt</td>
<td>1.5 cup</td>
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<tr>
<td>Oil, Olive</td>
<td>1 tb</td>
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<tr>
<td>Garlic, Cooked</td>
<td>2 clove</td>
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<tr>
<td>Pumpkin, Dry-Baked</td>
<td>1.5 cup</td>
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<tr>
<td>Broccoli, Cooked, Fat Not Added</td>
<td>1 cup (flowerets)</td>
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<tr>
<td><strong>Dessert/snacks</strong></td>
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<tr>
<td>Macadamia, Raw, (macadamia nuts + honey)</td>
<td>50g</td>
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<tr>
<td>Honey, All Types</td>
<td>1 tb</td>
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<tr>
<td>Orange, Navel, Raw</td>
<td>2 medium (6-8cm dia)</td>
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<td>Mandarin, Raw</td>
<td>2 medium (5-6cm dia)</td>
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<td>Nutrient</td>
<td>Value</td>
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<td>Protein (g)</td>
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<td>- Monounsaturated Fat (g)</td>
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<td>Sugars (g)</td>
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<td>Starch (g)</td>
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<td>Water (g)</td>
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<td>Dietary Fibre (g)</td>
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<td>Thiamin (mg)</td>
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<td>Zinc (mg)</td>
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<tr>
<td>kJ from Protein (%)</td>
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</tr>
<tr>
<td>kJ from Fat (%)</td>
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<tr>
<td>kJ from Carbohydrate (%)</td>
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<tr>
<td>kJ from Alcohol (%)</td>
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<tr>
<td>kJ from Others (%)</td>
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<td>Fat as Poly (%)</td>
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<td>Fat as Saturated (%)</td>
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<td>Glycemic Index of Assigned Carbohydrate</td>
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<td>Glycemic Load of Assigned Carbohydrate</td>
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</table>
Appendix T

‘Contemporary hunter-gatherer diet’ example: Adult female, 7063kJ/d, reference body weight 61kg, seasonal autumn foods

FOODS

Adult female (19-70years) – autumn

Breakfast

- Apple, Green, Raw, Unpeeled, (grated) 2 medium (6-8cm dia)
- Almond, Raw, (slithered) 50g
- Date, Raw, (medjool) 2 medium
- Seed, Sunflower, Raw 10g
- Seed, Pumpkin, Kernel, Raw 10g
- Honey, All Types 2 tsp
- Soy Beverage, Fluid, Low Fat, Fortified 100 mL
- Blueberry, Frozen, Unsweetened 0.5 cup

Lunch

- Flathead, Baked/Grilled, Fat Not Added In Cooking 180g
- Sweet Potato, Orange, Dry-Baked 1 small
- Fig, Raw, Unpeeled 2 medium (6cm dia)
- Avocado, Raw 0.5 whole (11x7.5cm dia)
- Juice, lemon, home squeezed 0.5 from 1 lemon (5cm dia)
- Persimmon, Raw 1 whole (6cm dia, 9cm high)

Dinner

- Kangaroo, Loin fillet, raw 100g
- Parsnip, Cooked, Fat Not Added In Cooking 1 medium
- Kale, Cooked, Fat Not Added In Cooking 1.5 cup (from fresh)
- Mushroom, Raw 1 cup (sliced)
**ANALYSIS SUMMARY (Xyris Software 2007)**

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<th>Avg/Day</th>
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<tr>
<td>Protein (g)</td>
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<td>- Polyunsaturated Fat (g)</td>
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<td>- Monounsaturated Fat (g)</td>
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<tr>
<td>Cholesterol (mg)</td>
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<td>Riboflavin (mg)</td>
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<td>kJ from Fat (%)</td>
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<td>kJ from Alcohol (%)</td>
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<td>kJ from Others (%)</td>
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<td>Glycemic Load of Assigned Carbohydrate</td>
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</table>
Appendix U

‘Contemporary hunter-gatherer diet’ example: Pregnant female, 9403kJ/d, seasonal summer foods

FOODS

Pregnant female – summer

Breakfast
- Apricot, Raw: 2 apricot
- Peach, Raw, Unpeeled: 2 medium (5.5-7.5cm dia)
- Cherry, Raw: 16 cherry
- Walnut: 50g
- Honey, All Types: 2 tsp

Lunch
- Egg, Scrambled, Fat Not Added In Cooking: 3 medium egg (55-64g)
- Basil, Raw: 1 cup (torn leaves)
- Tomato, Cherry, Raw: 10 cherry
- Oil, Olive: 1 tsp
- Chives, Raw: 0.25 cup
- Asparagus, Cooked, Fat Not Added In Cooking: 6 medium spear (13-18cm long)

Dinner
- Whiting, Baked/Grilled, Fat Not Added In Cooking: 180g
- Mussel, Steamed, Without Added Salt: 10 mussel
- Sweet Potato, Orange, Dry-Baked: 1 large
- Lettuce, Cos, Raw: 1 cup (torn leaves)
- Capsicum, Red, Raw: 0.5 medium
- Avocado, Raw: 0.5 whole (11x7.5cm dia)
- Oil, Olive: 1 tsp
- Juice, Lemon, Home Squeezed: 0.5 from 1 lemon (5cm dia)
- Pea, Green, Cooked, From Raw, Fat Not Added In Cooking (fresh): 0.25 cup
- Zucchini, Raw: 1 medium (11-16cm long)

Snacks
- Raspberry, Raw: 0.5 cup
- Blueberry, Raw: 0.5 serve (50 berries)
- Corn, Raw, (Sweetcorn on cob, fresh): 1 large ear (20cm long)
- Banana, NS Type, Raw: 1 large (>17cm long)
- Brazil Nut: 20g
## ANALYSIS SUMMARY (Xyris Software 2007)

<table>
<thead>
<tr>
<th>Component</th>
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<td>Sugars (g)</td>
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<td>kJ from Others (%)</td>
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Appendix V

‘Contemporary hunter-gatherer diet’ example: Child, three-year-old boy, 3540kJ/d, reference body weight 14kg, seasonal spring foods

FOODS

Child - boy (3 years old) – spring

Breakfast

<table>
<thead>
<tr>
<th>Food</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>Avocado, Raw</td>
<td>0.5 whole (11x7.5cm dia)</td>
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<tr>
<td>Banana, Common, Raw</td>
<td>1 medium (12-17cm long)</td>
</tr>
<tr>
<td>Honey, All Types</td>
<td>1 tsp</td>
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Lunch

<table>
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<tbody>
<tr>
<td>Potato, Boiled, Without Added Salt, With Skin (Unpeeled)</td>
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<tr>
<td>Whiting, Baked/Grilled, Fat Not Added In Cooking</td>
<td>50g</td>
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<tr>
<td>Tomato, Cherry, Raw</td>
<td>6 cherry</td>
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Dinner

<table>
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<th>Food</th>
<th>Quantity</th>
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<tbody>
<tr>
<td>Broccoli, Cooked, Fat Not Added</td>
<td>1 spear (13cm long)</td>
</tr>
<tr>
<td>Cucumber, Common, Raw</td>
<td>1 piece (3.5cm dia, 2.6cm l)</td>
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<tr>
<td>Carrot, Raw</td>
<td>1 small (14cm long)</td>
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<tr>
<td>Bean, Broad, Cooked, From Raw, Fat Not Added In Cooking</td>
<td>1 serve (10 beans)</td>
</tr>
<tr>
<td>Lamb, Chop, NS Cut, Raw, Fat Trimmed</td>
<td>1 medium chop</td>
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Dessert/snacks

<table>
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<tr>
<td>Orange, Navel, Raw</td>
<td>2 medium (6-8cm dia)</td>
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<td>Date, Raw</td>
<td>2 medium</td>
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<td>Nutrient</td>
<td>Avg/Day</td>
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<td>--------------------------------</td>
<td>---------</td>
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<tr>
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