In part 14 of our multi-disciplinary Millennium Project series, Stephen McGrail argues that boosting innovation requires us to change our thinking as much as our technology.

Global challenge 14: How can scientific and technological breakthroughs be accelerated to improve the human condition?

We are in the early stages of learning how to harness science and technology – and more broadly, innovation – to help meet contemporary challenges, such as climate change and Australia’s rapidly ageing population.

Transforming our approach to innovation is particularly important for emerging science and technologies. Recent events highlight the issues being grappled with, including: the destruction of CSIRO GM-wheat research crops by Greenpeace; the questioning of the safety of sunscreens containing “nanoparticles”; and UK House of Lords’ conclusion that the reluctance of food and packaging sectors to communicate openly about nanotechnology may create a public backlash.

Existing patterns of innovation are unsustainable. The urgent question is: what approaches should be used to govern “sustainable socio-technical transformations”?

Such transformations will require better involvement of the community in science and technology, coping with the uncertainty inherent in technological change, and adopting “systemic” perspectives – the absence of such approaches has contributed to recent controversies and unmet expectations.

This is the wider context for the challenge of “how can scientific and technological breakthroughs be accelerated to improve the human condition?”. In some ways, progress in Australia is being made in the required transformation of innovation; but in other ways the challenge is not being met. This article provides an outline of Australian trends and related recent developments.

Recent international policy announcements, such as EU Innovation Union and UK Innovation Nation, and new related discourses (e.g. the “transitions” discourse) signal shifts from “science-push” approaches to innovation, to new “challenge-led” models of innovation.

As UK Professor Fred Steward recently asserted, such a shift implies a more diverse “new policy repertoire” that goes beyond traditional fiscal measures and regulation. This also requires a move away from “technology driven theories of innovation”.

New policy instruments are needed to better involve end-users and producers, create and stabilise networks (e.g. to achieve better coordination, facilitate cooperation), and conduct expectations and learning-oriented activities.

In Australia similar thinking and new approaches have recently developed. The National Enabling Technologies Strategy (NETS) was created in 2010 to facilitate responsible development and “industry uptake” of new technologies. An Expert Forum has been established, which examines how biotechnology, nanotechnology and other emerging technologies could help address national challenges. Additionally, the Forum conducts “foresighting” activities to facilitate learning and innovation. A tripartite Stakeholder Advisory Council (SAC) was also established to give concerned parties the opportunity to provide advice to government, along with a new community engagement program (STEP or ‘Science & Technology Engagement Pathways’). Beyond NETS there is recognition of the need to improve collaboration between research and industry, and to better consider Science in Society issues (e.g. at CSIRO).
Despite this, my research on nanotechnology research and development in Australia reveals key challenges. For example, many civil society groups view the SAC and existing public engagement processes as being vastly insufficient – for example one termed these “a slap in the face”.

Further policy challenges have also recently emerged. Expectations and networks have not been maintained, with an associated rise in cautiousness. Many industry players and the Australian Academy of Technological Sciences and Engineering (ATSE) argue that major systemic issues, such as reduced investment by Australian venture capital suppliers (at one-third of the 2007 peak, according to ATSE), hinder research commercialisation.

Linked with these changes, there has been a sharp reduction in new patents. Additionally, although the language of “industry uptake” and activities of NETS suggest an emerging shift towards new models, a “science-push” approach often remains problematically dominant.

Finally, there is policy uncertainty with NETS winding up in 2013 and low levels of State government support despite continued hype.

Expanding scientific and technological potential

The Federal Government recently released a major report by the Australian Institute of Commercialisation (AIC) which considered both new scientific and technology potentials, and commercialisation issues.

The report focuses on biotechnology (application of technoscience to living organisms and the products of organisms to produce new goods and knowledge), nanotechnology (manipulation and control of matter at the atomic scale), and synthetic biology (extending genetic engineering to design new biological systems), which are “considered fundamental to a wide range of R&D across a wide number of areas”, including:

- Health and medicine: advances in genomic information and related healthcare services; drug delivery and diagnostics methods (e.g. use of nanoparticles for molecular imaging techniques); and new therapeutics (e.g. stem cell therapies, regenerative medicine)
- Energy: e.g. use of nanoscience and nanotechnology to improve energy storage, new solar cells such as organic polymer-based photovoltaics and cells integrated in glazing products
- Food and agriculture: e.g. new “nanomaterials” – materials engineered to have changed “nanoscale” properties and forms, adding value to products, such as “smart” packaging that changes if food is spoiled; development of new crops via genetic modification (GM) or non-GM techniques
- The built environment: new functional materials that are responsive to external stimuli (such as “switchable” surfaces, which can alter their properties according to climate conditions), use of green nanophotonics to reduce energy use, and “nanosensors” for improve building safety.

Australia can point to significant scientific strengths of regional (Asia-Pacific) and global significance. Some emerging areas derive partly from uniquely Australian assets such as our tropical location (e.g. tropical health, management of tropical ecosystems such as tropical rivers and reefs); in others we have a significant history of innovation in (e.g. medical bionics).

Specific to emerging science and technologies, the 2010 Excellence in Research for Australia (ERA) assessment found that Australia has world standard or above output in environmental and industrial biotechnology, and nanotechnology (as well as related fields such as quantum physics and computational chemistry).

The ERA assessment also shows Australia research’s strengths are well aligned with the political push to support Asian food security.

Reports recently released by peak Australian scientific and technological bodies also “signal”, and attempt to build support for, new opportunities. These include aged-care technologies (gerontechnology), second- and third-generation biofuels, and renewable and other low-carbon energy technologies.

Increasing governance and management challenges
This potential is coupled with increasing challenges. Over the past decade, four policy and wider governance challenges have emerged:

1) Ethical and societal issues increasingly need to be considered earlier in the R&D process to address public acceptance and values dimensions.

For example, ethical issues are raised by gerontechnology such as privacy and autonomy issues associated with emerging remote health monitoring technologies. Many areas of biotechnology are also contentious. The potential for unintended consequences (e.g. from introducing new crop species) is also now a more prominent consideration.

2) There is an increasing desire to influence technological development in the early stages (e.g. pre-market research stages). Issues include defining the roles of, and mechanisms for, community involvement, and limited knowledge of the eventual future impacts of new technologies. Experiences with biotechnologies and other recent technoscientific controversies indicate that these issues are far from resolved.

3) Slower adoption of emerging technologies, such as nanotechnology, is occurring due to a diverse mix of economic and non-economic barriers. In this respect the Australian experience is not unique, as this has also occurred at an international level. Some issues contributing to a limited “innovation dividend” from Australian research are locally-specific; however, many are not.

The Science and Technology Studies (STS) field is contributing new insights into general systemic issues. The STS concept of innovation “as a process of interactions … [occurring] in "meso-level' social networks” emphasises how it is always socially situated, requiring the alignment of diverse actors, and associated interventions (e.g. to facilitate joint action).

Related dynamics also often influence technology development such as “waiting games” in the context of uncertainty. As UK Innovation Nation notes, such complexities mean “markets often do not function perfectly”.

Some of the above issues suggest important roles for government. Generic strategies include: “technology forcing” through policies that influence the market demand for, and design of, new technologies (e.g. setting new stretching standards via regulation); “alignment activities” that facilitate earlier interactions between the involved actors (e.g. dialogue workshops); and “niche management” activities that orchestrate new “niches” with temporary protection from market pressures, in which actors can learn (e.g. about user requirements) from experiments with new technologies.

ATSE advocates the forcing of emerging technologies through government procurement. Gerontechnology advocates are also calling for new demand-side policies to help accelerate new aged-care solutions. At a national policy level the 2008 Cutler Review has advocated new government actions that similarly “act as a catalyst for private sector innovation”.

But there are dilemmas in this for government. Dual roles of promotion and control can lead to the blurring of boundaries between technology policy and assessment. The government’s public interest role may be seen as being compromised by other roles. Activists often raise these concerns.

4) Finally, incremental innovation is insufficient to address many contemporary challenges. A key issue is the need to understand how to create and govern transformative innovation.

Theory and practice here is a work-in-progress. But it points to a need to shift from the focus from single innovations (e.g. creating a new product, or technology) to a challenge-led approach to innovating larger socio-technical systems (i.e. new systems for fulfilling societal functions such as mobility, aged-care, etc).

Many new forms of governance are required to “steer” the many interconnected changes that are necessary for sectoral-level transformations to address contemporary challenges. There is also an urgent need to develop the capability to better evaluate the potential of scientific or technological advances, as we have both limited resources and time to address many challenges (e.g. climate change). Whilst some dead ends and failures are inevitable in innovation, we can certainly do better.
A mixed report card

New approaches to science and innovation are emerging but remain partial. On the one hand, responses to some governance and management challenges are clearly evident. Major investments have also been made in research infrastructure (e.g. the National Fabrication Facility) and other enabling cyber-infrastructure which provide the opportunity to better utilise scientific knowledge.

On the other hand, systemic issues and intensifying governance challenges constrain our capacity to purposefully harness science and technology.

The capacity of Australian policymakers and others to appreciate and successfully address these issues will influence our capacity to harness science, technology and innovation, helping us meet challenges such as climate change and food security affecting the human condition now and into the future.

Comments welcome below.