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Technical Machines and Evolution

Belinda Barnet

> The reproducibility of the technical machine differs from that of living beings, in that it is not based on sequential codes perfectly circumscribed in a territorialised genome.[1]

How does one tell the story of a machine? Can we say that technical machines have their own genealogies, their own evolutionary dynamic? The technical artifact constitutes a series of objects, a lineage or a line. At a cursory level, we can see this in the fact that technical machines come in generations; they adapt and adopt characteristics over time, "one suppressing the other as it becomes obsolete."[2] So are we to understand this dynamic from a biological, a zoological or a sociological perspective? I want to locate a dynamic in technics that stems neither from the soul nor from human societies, which grants the technical object its own materiality, its own limits and resistances, which allows us to think technical objects in their historical differentiations. This calls for a new consideration of technicity, and a new consideration of the human being in relation to technics. The task will be difficult -- "at its very origin and up until now, philosophy has repressed technics as an object of thought. Technics is the unthought."[3]

This essay will be a collection of notes towards such a perspective; it will be a prolegomena to the history of a technical machine, a history which is not included here and which has yet to be written. In this essay I will be exploring the work of Bernard Stiegler in relation to technicity and to human thought, but my task will not be to invert the history of philosophy itself, to "imagine the human as what is invented" by technics.[4] I do not wish to put forward a theory of human evolution. My intention is much narrower, or perhaps more jaded; I want to clear a space in which a technical object might evolve, and in which I might trace such an evolution.

Introduction

Niles Eldredge collects things for a living, and there are two great collections in his life. The public one is on display at New York's Museum of Natural History; its 1000 individual specimens stretch floor to ceiling for 30 metres across the Hall of Biodiversity.[5] There are beetles, molluscs, rotifers and fungi, spiders, fish and birds, all arranged into genealogical groups. The other collection is private; it spans an entire wall in his home in rural New Jersey. This collection contains over 500 specimens, but of the "musical rather than the biological variety."[6] He collects cornets, a type of musical instrument. There are silver and gold ones, polished and matte, large and small, modern and primitive. Ever the biologist, Eldredge has them arranged in taxonomic relationships of shape, style and date of manufacture. Much of the variety in cornet design is based on the way the pipe is wound.

Late in 2002, Eldredge's curiosity got the better of him. He decided to feed these specimens through the phylogenetic computer program he uses for his trilobites, to apply the 'scientific method' to technical evolution for the first time. As usual, he asked the computer to come up with all the possible evolutionary trees and then make a 'best guess' based on the existing specimens.[7] The results were astounding. Compared to the phylogenetic diagram for trilobites, the diagram for a technical machine seemed much more 'retroactive'. Eldredge's musical instruments could defy the laws of evolution.

In the world of living things, there are basically only two ways creatures can obtain a characteristic: by inheriting it from a previous generation, or by evolving it in the present one. This last form of evolution is itself the subject of debate; an organism can't change its DNA in one lifetime. The only proven exception is found in the world of viruses. Biological organisms evolve gradually over hundreds of generations, subject to natural selection. If a species dies out -- biological 'decimation' -- its branch dies with it. But technical machines are different.

> With cultural evolution comes the capacity to co-opt innovations at a whim. Time after time, when the cornets on one part of the tree acquired a useful innovation, designers from other branches simply copied the idea.[8]

Even instruments that were relatively primitive would end up sporting this new design, and if it was a particularly good one, then a 'burst' of rapid evolutionary activity would appear. The lines in the cornet evolutionary tree were thoroughly confused. Instead of a neat set of diagonal V-shaped branches, a 'cone of increasing diversity', you would see flat lines from which multiple machines appeared.[9] Flat lines do not characterise biological phylogenetic diagrams. A flat line indicates that the gradual passage of time and generations has not preceded the development of a particular characteristic. It has happened spontaneously, with no physical precursor. This means that the cornet's relationship to time and inheritance is different than that of biological organisms.

Most striking of all, outdated or superseded machines could re-appear with new designs, as if they were held in memory and only needed a certain innovation to burst into activity again. This is what we mean by 'retroactivity.' Technical machines can reappear, borrow from each other across branches and then rapidly evolve in a single generation. In biological evolution, when branches diverge, they diverge irrevocably; similarly, when branches die out, they cannot reappear. Technical machines are different. There is no biological decimation; nothing is irrevocable. Technical machines can operate on the past.

> Technical structures, ensembles and channels are static combinations in which phenomena of retroactivity appear: by using the steam engine, the steel industry produces better steel, allowing in turn for the production of more efficient machines.[10]

This raises the question of technical 'memory', a topic we will explore in the next section. Why can technical machines retroactivate? What is the relationship of human thought to this? Is it humans that 'remember' previous generations of technical machines and transfer their characteristics between branches? If so, how and where do they remember them? Memory, and in particular technical memory, bridges "not just past and present, but outside and inside, machine and organism"[11] The question of time and inheritance -- of memory -- will be the leitmotif of this essay. It will be the question we pose to history. It will be the question that marks this theory of technical evolution.

Eldredge is also interested in memory and in technical evolution, but at this stage, he wants to warn against the indiscriminate use of Darwinian metaphors.[12] If innovations are taken from the past and spontaneously appear in another branch in which they have no physical precursor, this constitutes a break from genetic evolution. There is an evolutionary dynamic going on, but its rules of inheritance are not based on Mendelian genetics. We need another explanation for retroactivity, for transfer and borrowing where there is no physical precursor. So I will be thinking the evolution of technical objects in terms of lineages and diagrams; but I will also be interested in precisely where this is different from biological evolution, where it exceeds the biological. Technical machines are ensembles in which phenomena of retroactivity appear, where there is a different relationship to time and inheritance, where there are different material limits and contingencies.

So we need to recognise a limit to genealogical metaphors. But the question remains: what is the relationship between human thought and technics? If there is technical 'remembering', then there must also be a mode of transfer and storage, and a place where this occurs.

> There is no archive without consignation in an external place which assures the possibility of memorisation, of repetition, of reproduction, of reimpression.[13]

Is this place inside or outside? If it is inside human memory, then how does it exceed our biological death as human beings? If it is outside, then where is it located precisely? The relationship between human memory and technics constitutes a tension, a tension that marks the break from genetic evolution. To explicate this tension, I will need to articulate a mode of passage, a logic. Eldredge does not provide one; as a scientist, he has simply pointed out that a dynamic exists, and that this dynamic is different to biological evolution. To articulate this logic, I will be using the innovative thinking of Jacques Derrida and Bernard Stiegler.

Derrida thinks the relation between humans and technics in terms of an 'originary supplementarity': human memory is a prosthesis of the inside. It is neither inside nor outside, but constitutes a 'relative interiority'. Stiegler's thinking may be seen as a radicalisation of this concept. Whereas Derrida is concerned to articulate the tension in terms of a 'logic', the logic of difference, Stiegler is concerned to articulate this logic in terms of its historical differentiations in different technical systems. The logic will only appear in its differentiation; the "interiority is nothing outside of its exteriorisation."[14] This is why Stiegler will be useful to any material genealogy of a technical machine. It will give us descriptive purchase on this logic as it is articulated in technical objects. We will unpack this concept in more detail presently.

For the moment, let us return to the problem raised by Eldredge; technical machines break the laws of genetics. From his perspective, this is because they are subject to intelligent design. Part of the reason Eldredge created these diagrams in the first place was to prove to the Creationists that intelligent design has its own dynamic, and this dynamic is radically different to what we find in nature. Technical machines are invented; this is what distinguishes them from biological organisms. "[N]ot one product of art has the source of its own production within itself", as Aristotle put it two thousand years ago.[15] Or rather, technics do not have the capacity for self-production. Silicon does not automatically rise up into a computer. As an object, it must first be thought in the mind of a human, and then created.

Created objects and artefacts are what most readily come to mind when the word 'technology' is mentioned.[16] The domain of 'technics' is even more restricted; in general, it designates "the restricted and specified domain of tools, of instruments."[17] These objects are not a fact, but the result of human thought. In this sense, technical objects might be taken as by definition human fabrications. Humans create technics; technics do not pre-exist or constitute the human.

This understanding dominates the contemporary thinking of technics, and consequently extant histories of technical machines.[18] It is based on an opposition, an opposition as old as metaphysics. We must address this before any new theory of technical evolution can be discussed.

The aporia of origin: thought and technics

"At the beginning of history", asserts Bernard Stiegler, "philosophy separates tekhne from episteme", and to these two regions of beings two dynamics are assigned: mechanics and biology.[19] It is in the inheritance of this conflict that technical knowledge is devalued as mere supplement, and the human affirmed against the process of technicisation. Human thought (the philosophical episteme) is pitched against the sophistic tekhne (art or craft). At the time, these sophistic 'arts' were primarily mnemotechnics and writing -- techniques of memory. To the ancients, they were a form of bastardised anamnesis, a mechanical incursion on thought. Human memory was "the noblest region of... personality"[20], an originary knowledge for which tekhne served as mere extension. Platonic philosophy was constituted on this opposition between human knowledge, which is transcendental, and technics, which lacks self-production. The reason it is separated is to account for the possibility of access to knowledge, or more precisely, an originary and purely human knowledge. It is the answer to an ancient aporia.

Aporia comes from the Greek aporos, "meaning, 'without issue', or 'without way'...that which thought cannot resolve or untie without forgetting the undecidability which structures the aporia."[21] It is a limit question, a question which is irreducible, and which will consequently reappear in every attempt at an answer. This particular aporia, Plato's Meno and the aporia of memory, is crucial to the history of philosophy[22] and also crucial to the history of technics.

What is human knowledge? Or more precisely, what is purely creative human knowledge? This would be the knowledge that humans draw upon to create technologies; it would not be inherent to the created object or artefact. So in a sense, it could not be acquired by experience, as this would accord the object itself knowledge, if not agency. It would need to be uncontaminated by technics at the beginning. But this presents a problem -- a problem encapsulated in an address by Meno to Socrates in his discourse on the essence. The problem is that such knowledge is impossible. The question is actually formulated in response to Socrates' attempt at founding a human value (Virtue) in the human, as opposed to something acquired in the outside world of objects and experience:

> How will you look for something when you don't know in the least what it is? How on earth are you going to set up something you don't [already] know as the object of your search?[23]

Socrates, in response, rephrases the aporia to highlight the problem:

> [A] man cannot try to discover either what he knows or what he does not know. He

> would not seek what he knows, for since he knows it there is no need of the inquiry, nor what he does not know, for in that case he does not even know what he is to look for.[24]

This aporia is taken up and resolved by Socrates through the myth of reminiscence.[25] Man has access to an originary knowledge, to an originary memory acquired before the fall. Man already knows what he does not know -- it's just that he has forgotten it. Knowledge is an unveiling, a remembering. Human memory is transcendent.

> Thus the soul, since it is immortal and has been born many times, and has seen all things both here and in the other world, has learned everything that is.[26]

Thus, argues Stiegler, the aporia is settled in terms of an opposition. Thought has the principle of its creation, of its movement (arkhe), within itself, and this transcends the world of objects. The human being does not receive its knowledge from the outside world, from the finite world of objects, but finds it again and again within himself. The myth of reminiscence thus institutes metaphysical oppositions between soul and body, thought and technics, infinite and finite. For our argument concerning technical objects, this myth places the act of creation squarely on the shoulders of human beings who have access to an originary knowledge, uncontaminated by technics, and consequently by finitude, in the beginning. The history of a technical machine would thus be the history of pure invention, of human beings who have access to a transcendent memory.

This is precisely the divide that Stiegler, and also Derrida, problematise. Derrida argues that memory is always already contaminated by technics. The prosthetic already-there: this is what the myth of reminiscence 'forgets'. Stiegler argues that the prosthetic already-there constitutes a break with genetic evolution; and not only this, it is a break which constitutes the human. Both philosophers put the idea of pure human memory into crisis, and consequently the idea of any access to a realm of thought uncontaminated by technics.

To return to our original question: how does one write the genealogy of a machine, and where would human beings figure in this diagram? It is impossible to deny the role of human thought in the creation of technical artefacts. But where does the knowledge required to create these artefacts come from? Plato maintained that creative knowledge is transcendent, that it is uncontaminated by the world of experience (and by extension, the technical object itself). Creative knowledge doesn't come from the world of objects. To deny a transcendent human memory is to reinstate the ancient aporia: purely human knowledge becomes impossible.

So for now, we should rephrase our question.

> It is impossible to deny the participation of human thought in the essence of machinism. But up to what point can this thought still be described as human?[27]

This, then, will be the subject of the next section. But we will approach it from a different angle, in order to question the relation of memory to technics, and also to question where these memories come from. Is it humans that remember previous generations of machines, and where are these memories stored? We will approach it from the perspective of evolution.

Epiphylogenesis and the aporia of memory

> Humans die, but their histories remain. This is what distinguishes them from animals.[28]

Death is the radical effacement of memory. It is the erasure of our personal experience, our personal histories -- and it is an inevitability that we are aware of. We cannot take death away from each other, any more than we can take upon ourselves someone else's death. Death cannot be transferred, nor can we deliver ourselves from it. It is our "first and last responsibility"[29], and it is this question and this awareness which mark us as human. We are finite beings.

Our awareness of death is what drives us to create archives, technologies of retention and storage. We leave traces of ourselves and our experience in other people's memories, in the memories of our children; but also in the nonliving -- in writing, in objects and artefacts, on cave walls, in woven rugs and on computer screens, in language and culture. We leave traces of our experience outside ourselves as individuals, traces that will not be lost when we die, but will remain.

> Among these traces most have in fact not been produced with a view to transmitting memories: a piece of pottery or a tool were not made to transmit memories, but they do so nevertheless, spontaneously. Which is why archaeologists are looking for them. Other traces are specifically devoted to the transmission of memory: for example, writing [and] photography.[30]

Bernard Stiegler argues that these inscriptions comprise a structure of inheritance and transmission, a structure that accumulates with each successive generation. It is a structure which exists outside our own genetic limitations, outside the finite lifetime of the individual, but which nonetheless carries in it our collective wisdom: the ideas and experiences that we have had, the techniques that we have learned, the tools and artefacts that we have created. For Eldredge, this is what we mean by the word 'culture'. Culture is but a series of memorials. In fact, it is a gift to others -- the gift of death.[31]

Importantly, this structure of inheritance and transmission, the material it contains, is not inherent to us. We are not born with it; it is not a genetic memory. It is inscribed and transmitted outside our genetic programs. In other words, we are born into it, we acquire it through experience. In is in this sense that Stiegler calls the structure epigenetic -- it exists outside and in addition to the genetic, like a surrounding layer. This is a word in use by the scientific community as well, to designate "those characteristics inherited outside of genetic encoding and transmission."[32] We will be using it in the same sense, to designate that which is not coded for in our genes, but which we acquire.

To acquire something outside our genetic programming, then, this thing must exceed the biological. The epigenetic structure must pre-exist us; it must exist beyond our short lives to be subject to inheritance and transmission. We are born into it; it was here before us and it will continue after us. This is what Heidegger calls the already there, this "past that I never lived but that is nevertheless my past, without which I would never have had a past of my own."[33] Language is a perfect example. It is not genetic; it is acquired, and yet it has its own history, its own genealogy, its own memory that exceeds the individual. In entering into language, it creates a past for us, and we acquire this past, which we continue as our own. We might call this acquisition an 'event'. It becomes the interface through which we enter into relation with the world. So when we are born, we acquire something that we have not individually created but which, nevertheless, shapes our experience of the world. And unlike the plant and animal kingdom, this acquisition, this epigenetic event, is not lost when we die. In the case at hand, observes Stiegler, life conserves and accumulates these events.[34] There is history, there is culture, and there are the artefacts which carry them beyond our death -- technics.

Consequently, Stiegler demarcates a third structure, the structure which stores and accumulates our individual epigeneses, which exists beyond our own central nervous systems, beyond our individual genetic and epigenetic memories. This contains what we are for the moment calling culture (past epigenetic events, lessons of experience), but also what we are calling technical artefacts. The structure is at once our own and also transcendental: it is larger than ourselves. It is a store, an accumulation, a sedimentation of successive epigeneses, a thing which evolves, which has its own historicity and dynamic.[35] Far from being lost when the individual human dies, it conserves and sediments itself. Stiegler calls this the epi-phylo-genetic structure, implying by that terminology a material genealogy proper to it.

So he distinguishes here between three types of memories out of which the human develops:

> Genetic memory; memory of the central nervous system (epigenetic memory); and techno-logical memory [epiphylogenetic memory].[36]

Stiegler locates or amalgamates 'language', 'technics', 'technique' and 'technology' within this third type of memory, epiphylogenesis. Not because they are of an essence, but because they are all forms of memory support; they are forms of inscription, transmission and ultimately, transcendence. They are larger than ourselves; they exceed our death as human beings. Technics, however is afforded a special place here; although in common parlance it designates tools and instruments, Stiegler also uses the term in the Greek sense (tekhne). In other words, it designates skill, art and craft. Technical objects are the result of the transmission of these operational chains, which are transformed in time as artefacts. Language itself is also a technique, a skill, a mode of transmission -- and thus it is a form of technics.[37] Technics, for Stiegler, are always memory aids -- whether they have been created explicitly so (for example, language or photography, which are mnemotechnics) or not (pottery and rugs). This is what he means by epiphylogenesis.

Epiphylogenesis, then, designates a new relation between the human organism and its environment. It is technics, as the support of the inscription of memory, which is constitutive of transcendence. The biological human, with its genetic and epigenetic memory, dies. This is the paradox of Man: "a living being characterised in its forms of life by the nonliving"[38], by its relation to death. In other words, epiphylogenesis gives human beings access to transcendence, and thus to time. It is finitude, our constitutive finitude as biological humans (which the myth of reminiscence 'forgets') that propels man to invent himself within this structure. But at the same time, this structure transforms the human as much as it is transformed by it. In Stiegler's terms, the 'what' (technics) invents the 'who' (humans) at the same time that it is invented. Neither term holds the 'secret' of the other -- neither term is originary. In this way, Stiegler develops Meno's aporia into an inextricable relation; it is our inscriptions in the nonliving, in what is dead (technics) which constitutes transcendence.

I will retain several of these concepts in my nascent theory of technical evolution. Firstly, the concept that technics is a memory aid -- and that, unlike pottery or woven rugs, there are certain forms of information storage, communication and display that are also mnemotechnical systems: like the internet, or writing. That this memory aid is in itself nonliving, that it exceeds the biological, will also mean that its description must be of a different order to the biological. There will be a limit to Darwinian metaphors, as Eldredge put it. Technics constitutes its own domain, it has its own relationship to time and inheritance, its own dynamic radically different to what we find in nature.

Consequently, any genealogy of a technical machine will need to recognise that the 'intellectual capital' of the societies in which particular technologies evolve belongs properly to this dynamic. The discourses surrounding the evolution of specialised techniques and procedures (for example, computer engineering), form a part of this system; they are not 'purely' human, as they exceed the biological. They are systems which humans enter into and take on as their own, which are transformed in time as technical artefacts. Together, technics, technique and language constitute a third layer. This is what Stiegler means by epiphylogenesis.

Next, we need to ask how the passage to this 'third layer' is effected. What is the process of 'liberation' that memory pursues? And in an even more practical sense, how do particular elements of a technical system retroactivate or transfer themselves to other systems within this structure?

This emphasis on transfer and retroactivity will distinguish my theory of technical evolution from Stiegler's; Stiegler recognises these two phenomena, but subsumes them back into the logic of epiphylogenesis, the preservation in technical objects of epigenetic experience. I wish to draw them out as the dynamic which distinguishes technical phylogenesis. According to the phylogenetic diagrams we explored in the first section, the phenomena of transfer and retroactivity must be the basis of any theory of technical evolution, if we wish to capture the difference between technics and biology. In the following section I will look at how Leroi-Gourhan, Guattari, Simondon, Gille and also Stiegler approach this dynamic.

The dynamics of technical evolution: tendencies and systems

To account for the passage from the genetic to the non-genetic, Stiegler draws on the work of French anthropologist Leroi-Gourhan. In his book *Gesture & Speech*, Leroi-Gourhan proposes that the evolution of man is characterised by a 'freeing of memory' -- the exteriorisation of human capacities and genetic traits (what he calls 'organs') into technics. For Leroi-Gourhan, this process silently propels our evolution as a species.

> The whole of our evolution has been oriented toward placing outside ourselves what in the rest of the animal world is achieved inside by species adaptation. The most striking material fact is certainly the "freeing" of tools, but the fundamental fact is really the freeing of the word and our unique ability to transfer our memory to a social organism outside ourselves.[39]

From the appearance of Homo Sapiens, the constitution of this external social memory dominates all problems of human evolution.[40] Technology has, in this sense, created the human as a species; humanity is nothing but a process of 'exteriorisation', a process in which our access to time and culture is accomplished through external supports which transfer our memories. Tools are 'exuded' by humans in the course of their evolution; they spring, literally, from the nails and teeth of primates, and in turn give us an non-genetic advantage over other species, who are condemned to hunt without weapons, to feel the cold against their skin without clothes. As a species, we are characterised by our physical and mental non-adaptation. Our memory is transferred to books, our "strength multiplied in the ox, our fist improved in the hammer."[41] For Leroi-Gourhan, we can trace all contemporary technologies back to this process of exteriorisation. Tool and gesture are now embodied in the machine; operational memory (technique) now embodied in automatic devices; the capacity to correlate recollections in the punched-card index.[42]

Consequently, Leroi-Gourhan understands technological evolution as a relation of the human to matter, where the human exteriorises technical forms. Further to this, he contends that technics is itself in perpetual transformation; it evolves in its organisation. It is at once its own milieu, separate from that of the human animal. This evolution is parallel to the evolution of the human, but it also organises itself. We can see here the inspiration behind Stiegler's concept of epiphylogenesis; there is a systematicity to the evolution of technics, a kind of techno-logic which is not entirely human. For Leroi-Gourhan, there is an inherent dynamism to technics, itself productive of new lineages and machines. When we look at particular machines in retrospect, it would appear that they were inevitable in some sense; as if they were guided by 'archetypes'.

> Everything seems to happen as if an ideal prototype of fish or of knapped flint developed long preconceivable lines...from the fish to the amphibian, to the mammal, or to the bird, from form-undifferentiated flint to the knapped tool, to the brass knife, to the steel sword.[43]

Everything seems to point to a universal technical 'tendency'. This tendency is the essence of technics; there is a necessity proper to it as a milieu. Consequently, the evolution of technics will have its own phylogenetic limits; as in the evolution of biological animals, there are only a given number of possibilities. Differentiation, the creation and development of new machines, artefacts and tools, is silently propelled by technical tendencies down certain lines. For Leroi-Gourhan, the human inventor is always guided by archetypes. He is but a combinatory genius[44], selecting from and giving culturally specific embodiment to these archetypes. Technical continuity, its evolution as a milieu, is transcendent. This continuity, and its presence as archetypes, excludes "pure invention, ex nihilo."[45] So the human has a particular relationship to technics -- that of exteriorisation -- but at the same time, the technical milieu has its own dynamic which guides the process of invention itself, which exists beyond and before the inventor. The inventor is moved by technical tendencies.

The concept of allocating technics its own tendency is not new. Numerous theorists have explored technology from this perspective; among them, Guattari (1995), and even earlier, Simondon (1958), whose concept of a the progressive 'concretization' of technics is important for the development of Stiegler's argument. For Simondon, the technical artefact constitutes a series of objects, a lineage or a line; at a cursory level, we can see this by the fact that machines appear across generations. At the origin of the lineage is a synthetic act of invention, constitutive of a technical essence.[46] This essence is recognised by the fact that it remains stable throughout the evolutional lineage, and not only stable, but productive of new structures and functions by progressive saturation. Machines speak to machines before they speak to man, as Guattari puts it[47], and the language is not human.

But Leroi-Gourhan's technical tendency is universal; it is transcendent. And if there is a universal logic driving the evolution of technics as a system, how can we explain technical diversity? Evolution is all about diversity; it is in fact only in the process of differentiation that the logic of evolution is discovered. Similarly, Stiegler maintains that it is only in technical differentiation that the logic of epiphylogenesis can be discovered. For Stiegler, there is no 'ghost' in the machine, no platonic essence we are striving towards. "The organizing principle of the technical object is in this object qua tendency, aim and end."[48]

Confronted with diversity, Leroi-Gourhan posits two other dynamics at work at the lower, "ethnic" level, which diffract or instantiate the technical tendency: invention and borrowing. Invention, of course, does not occur in a vacuum; it is guided by technical archetypes. The inventor is really just combining the best technical forms for its realisation. Similarly, borrowing -- from other cultures, from existing technical forms -- is guided by archetypes. In fact, as Stiegler points out,

> Whether this evolution occurs by invention or by borrowing is of minor importance, since this....in no way contradicts [the] systemic determinism in its essence.[49]

What is important for Leroi-Gourhan is whether or not the invention is acceptable and necessary to that group of people. Human societies have a "characteristic capacity" to "accumulate and preserve technical innovations"[50], and also to discard or forget them. This is connected with his concept of the social memory. To put it simply, technical objects are either stored or they are forgotten. In a sense (and here I am diverging from Leroi-Gourhan's thesis) society constitutes an 'adaptive pressure' on the technical lineage. An invention is either taken up or it dies.

But how far can we take this essentially zoological analogy? For at base, technical evolution marks a break with genetic evolution. At some level, and at some point, the analogy must stop. For Eldredge, as we have seen, it stops at intelligent design. So how are we to understand this dynamic - from a biological, a zoological or a social perspective? For Leroi-Gourhan, the dynamic is essentially zoological.

Stiegler wants to abandon the zoological metaphor altogether. He wants develop a theory of technological evolution which is not the 'partner' of animals, of society or of human beings. It is not the partner of any other system. For Stiegler, the technical object lays down its own laws; its logic is entirely and radically its own, and it is to be discovered only in its historical differentiations. The inventor, for Stiegler, is not even a 'combinatory' genius; if he exists at all, he is but a passive observer, reading a message that already exists in the technical object. But before we come to Stiegler's thesis, I would like to conclude this section by briefly exploring the work of Bertrand Gille.

Gille's work describes the transfer of technical functions between technical systems, and also the transfer of technical knowledge between human beings. It has a pragmatic aspect to it, and although it does not mobilise this 'tension' which exists between human beings and their memory supports as a productive logic, it is useful on a diagrammatic level. Like Leroi-Gourhan, he accords technics its own dynamic, yet he articulates this dynamic in relation to those 'other' systems -- social, economic, industrial, cultural and political. For Gille, these other systems are not mere afterthoughts, they do more than locally diffract a universal technical tendency. They at once shape, and are shaped by, the technical system itself. In fact, these 'other systems' belong properly to it.

The notion of a 'technical system' belongs to Gille -- it exists in various forms in other authors' work, but it is not used explicitly.[51] So far in this essay, I have been using the term to refer to a lineage of technical artefacts. For Gille, however, a technical system does not end at the physical boundaries of a particular technology; it includes a number of interdependencies, related systems which have stabilised in a particular historical epoch, solidified around this technology. These include its related social, industrial and economic systems, and also a system of associated 'techniques' -- means for the practical application of knowledge.[52] Techniques are what is transferred between technical systems. The technical system is a constellation of interdependent systems, and these move towards a progressive solidarity. The concept gives us descriptive purchase on the dialogue taking place between constitutive systems in any given historical epoch.

Integral to this concept of the system is that it will have its own limits. The limits of the system order its dynamism. Limits will take a variety of forms, and it should be possible to develop an historical schema to determine these. They can be detected in "the problem of increasing quantities, or in the impossibility of reducing production costs, on in yet another impossibility, that of diversifying production."[53] Such limits in turn can be either endogenous or exogenous to the system itself; exogenous limits can come in the form of government policy or taxation law, for example, and endogenous limits in the form of technical obsolescence within its component parts.

For Gille, technical progress consists in a successive displacement of these limits. When there are enough limits to a system, the entire system becomes 'blocked' and a major crisis ensues. A decision to evolve takes place, to move to a new technical system. "There are two essential poles of 'technical progress': the technological lineage on the one hand, and technical blockages on the other."[54] New technical systems are born from the limits of preceding systems, and hence progress is essentially (and brutally) discontinuous. Systemic shifts mean the rapid loss, and also the creation, of entire political and socio-economic structures. The technical system moves faster than the other systems, and a period of 'adjustment' ensues, which progressively stabilises. Stiegler has a problem with this last point; for him, the contemporary technical system does not appear to be stabilising. Are we not living through a period of permanent adjustment, he asks? This is the nature of modern teletechnologies.

For now, we have one last point to address: the way in which transfer and retroactivity take place within and between these technical systems. For both Gille and Leroi-Gourhan, this is the role of human thought, this is the role of the inventor. The inventor is not a divinely inspired genius, however; he or she is a 'combinatory' genius, selecting the best technical forms effected along limited combinatory possibilities, to embody a technical tendency. For Gille these possibilities are even further limited by economic and social systems: "the inventor has less importance than the entrepreneur who decides and establishes the junctions between families of innovations."[55] But regardless, the combinatory act itself requires a unique perspective on the part of the inventor; the ability to see the technical phylum from a more global level. It requires a degree of foresight, an awareness of what exists and what does not exist, of what is possible at this point in time. This is what we mean by the word, 'anticipation.' The inventor anticipates new technical forms from limited possibilities within a particular technical system and a particular historical epoch.

Manuel De Landa has a similar conception of the human inventor: the inventor is not a divinely inspired genius, he or she is "influenced by certain machinic paradigms that [are] prevalent at the time."[56] Such paradigms are analogous to Gille and Leroi-Gourhan's technical tendencies, though these tendencies are not transcendent as they are for Leroi-Gourhan. The machinic paradigms are immanent to the objects themselves, a concept we shall explore in the next section. They have an element of reality to them nonetheless, and the inventor literally "tracks" the machinic phylum to detect critical points which indicate potential bifurcations.

> [A] robot historian would see processes in which order emerges out of chaos as its own true ancestors, with human artisans playing the role of historically necessary 'channelers' for the machinic phylum's 'creativity.'[57]

So the human inventor has been sidelined, and technics itself has taken on its own dynamic. Human thought merely selects the best possible forms for the realisation of technical tendencies: he 'channels' them in the manner of a medium (De Landa) or "combines" in the manner of a bricoleur (Gille and Leroi-Gourhan). He anticipates technical forms.

> Between humanity and nature a techno-geographical milieu is created which only becomes possible with the help of human intelligence...an inventive function of anticipation found neither in nature nor in already constituted technical objects.[58]

To return to our original diagram, and the break from genetic evolution -- retroactivity and transfer are processes that take place within human thought and human thought alone. They also take place from a privileged perspective, a perspective which is closer to the machine, which has a more 'global' view of the combinatory possibilities and the technological lineage. The engineer or the scientist, for example, is closer to the machine; they have a privileged perspective on the lineage in this sense.

Anticipation and the technical object

But does this capacity of anticipation not itself presuppose the technical object, asks Stiegler?[59] Think of the discourses describing and explaining specialised techniques and procedures (engineering discourse, for example) -- do these not presuppose the technical object?

In fact, they not only presuppose the object itself; they presuppose its past, its current state, its limits and its possibilities. Technical objects belonging to different 'branches' of the evolutionary tree and 'dreamed-of' technical objects are part of the same evolutionary structure. The privileged perspective, in this sense, is not purely human. Anticipation is itself a technology, acquired like any other. As Guattari puts it, technico-scientific thought, the process of invention, presupposes a "certain type of mental or semiotic mechanism"[60], and this mechanism has its own limits and trajectories. For example, the invention of the first third-generation (3GL) computer language presupposed not only the computer itself, but an extant machine language, an extant assembly language, an extant 'natural' language, the limits and the logic for combining these, and also the technical necessity for combining them.[61] Technics constitutes its own law.

This is the thrust of Stiegler's argument: if it is explicitly as technical consciousness that man invents himself, and it is within this consciousness that anticipation of the technical object occurs, then the technical object is anticipated by none other than itself. This is what he means by epiphylogenesis. The epiphylogenetic structure is not engendered by the human subject in the course of its evolution, as it is for Leroi-Gourhan, it is "engendered by the object in the course of its evolution."[62] Technics has engendered its own milieu, and this milieu both describes its past and circumscribes its future.

To return to our argument from the last section: retroactivity and transfer appear as none other than anticipation itself, the process of invention within circumscribed trajectories. They are not a 'problem' for technical evolution; they are its mode of inheritance, a techno-logical maieutic. Stiegler, then, is pushing this concept further; the ability to anticipate presupposes the technical object in that anticipation is itself a discourse, an acquired technology. This calls for a new definition of technology; technology is:

> ...therefore the discourse describing and explaining the evolution of specialized procedures and techniques, arts and trades -- either the discourse of certain types of procedures and techniques, or that of the totality of techniques inasmuch as they form a system: technology is in this case the discourse of the evolution of that system.[63]

The definition necessitates, in my hypothetical genealogy of a technical object, an appreciation that the discourses describing and explaining specialised techniques and procedures (engineering discourse, for example) both anticipate and mark a limit to the technical object. It also necessitates an awareness of what has already come to pass, and how this past circumscribes any future object. In our theory, we will keep the inventor's role, but it will be qua an actor listening to cues from the object itself, "reading from the text of matter."[64] The inventor will be situated between heterogeneous Gillean systems: economic and political discourse, industrial discourse; but most importantly, the inventor will be situated within the evolution of technology itself.

De Landa has a similar project: to explore the history of intelligent machines from the perspective of the machines themselves, to trace the externalisation of mental or semiotic processes which are themselves already techno-logical. This transfer will take place within an extant technical system. He posits the figure of a 'robot historian' tracking the machinic phylum for 'bifurcation' points:

> [the robot historian] would, for example, recognise that the logical structures of computer hardware were once incarnated in the human body in the form of empirical problem-solving recipes....these may then be captured into a general-purpose, 'infallible' recipe (known as an 'algorithm'). When this happens we may say that logical structures have 'migrated' from the human body to the rules that make up a logical notation (the syllogism, the class calculus) and from there to electromechanical switches and circuits.[65]

This concept of a 'traceable' migration path from humans to technical objects is quite similar to Leroi-Gourhan's concept of exteriorisation, the freeing of memory. Yet De Landa does not offer a logic for the human drive to invent ourselves in the technical; nor does he offer a specific explanation of how technical phyla are different from biological phyla. It is precisely these differences which will be of interest to us, and it is precisely these differences which have in fact given us the logic of technical remembering (epiphylogenesis).

So we have established a logic to articulate the evolution of a technical object. But one question remains -- what is a technical object?

Defining the technical object: form, function and operational process

Niles Eldredge demarcates lineages for his trilobites on the basis of shell shape. Certain shapes emerge at certain points in time, and these shapes diverge irrevocably into different branches of the phylogenetic diagram. This technique is called comparative anatomy, and it works under the assumption that similar morphological structures in different organisms have a common evolutionary origin. Aside from comparative anatomy, there are several other ways to determine evolutionary relationships: comparative embryology, molecular, behavioural, physiological, chemical and fossil data are also used. A particularly popular technique involves DNA sequencing, which compares the precise sequence of nucleotides in two samples of DNA.

This is how biology builds the concept of a species. It locates certain recurrent and inherited characteristics that distinguish it from other species. For example, human beings have 46 chromosomes, we have an upright posture and a pronounced temporal cortex. This distinguishes us from chimpanzees, who have 48 chromosomes and a smaller brain. For certain biologists (Eldredge and Stephen Jay Gould in particular) you can hence call the resulting species an 'entity' -- a large-scale system. The individual is nothing outside of its history and its inherited characteristics.

> What we're saying is that species are entities. They have histories, they have origins, they have terminations, and they may or may not give rise to descendent species. They are individuals in the sense that human beings are individuals, albeit very different kinds of individuals. They're large-scale systems that have an element of reality to them, and that's a big departure in evolutionary biology.[66]

But to regard a species as a large-scale system, biologists must necessarily assume that particular morphological or genetic characteristics constitute its unity. These characteristics are inherited by each generation, they become 'entrenched', they constitute a lineage or a line.

The analogy cannot be so easily transferred to technical machines, however. If we define technical lineages by their form (as Eldredge has done by collecting a particular kind of musical instrument based on the way the pipe is wound) then the lines become tangled. The form is simply not maintained in any sensible fashion over time -- it jumps around and changes depending on the technical innovations available to it. The bell jumps from right to left, the bell jumps across to the right, the pipe changes from silver to brass, the valves disappear. It becomes difficult to "rank them in any sensible order of ancestors and descendents."[67] The same applies to computing, for example. If we define a computer by its form -- an electronic machine conveying information encoded as binary logic across silicon circuits, then the analogue computers from the late 30's and early 40's seem completely unrelated. They used neither silicon nor binary logic, and were based on brass gears, wheels and shafts that had more in common with Eldredge's cornets.

If we define a technical lineage based on function, the problem recurs. Let's return to computing as an example. At the end of the nineteenth century, the word 'computer' meant a human operating a calculator. Early in the twentieth century, these 'computers' became large group of mostly female humans performing mathematical calculations by hand or on slide rules, housed in large warehouses.[68] At the time, these groups were organised for one express purpose: to perform calculation-intensive operations for the military, primarily ballistic analysis and the creation of artillery ranging tables. The 'function' of a computer was to produce mathematical data for the military. This changed radically over the next 50 years, going through several stages we will explore in more detail through the course of this manuscript. The result today is that a computer has a multitude of different functions -- the very least of which is the production of artillery ranging tables. For a start, computers are personal devices that manage and create our everyday working environment. They are nodes in a greater network -- the internet. They are the engines of a new form of capitalism, and arguably, a new social order. The list goes on, but the fact remains: the function of the 'computer' has changed beyond recognition since the turn of the twentieth century. To trace a phylogenesis based on human function would result in a greater mess than Eldredge's retroactive cornets.

So if we can't trace a lineage based on form or function, how can we distinguish one technical system from another? As Eldredge himself discovered by applying the scientific method to technical evolution for the first time, there is an undeniable evolutionary dynamic going on. Technical machines come in generations, they transform themselves in time, they adapt and adopt characteristics. We have established that this dynamic is not genetic, that its mode of transfer in fact constitutes a break from genetic evolution. We have established that this break revolves around transfer and retroactivity. We have demarcated a 'third milieu' to which both the technical artefact and techno-logical memory belong, based on Stiegler's concept of epiphylogenesis. But the problem remains: which entity, or which group of 'characteristics' are we tracing here?

For Gilbert Simondon, we need to understand the genesis of technical objects independently of the human functionings which establish use behaviour. For if one seeks to establish a lineage based on use "no set structure corresponds to a defined use."[69] The object will invent itself independently of any fabricating intention. For example, Tim Berners-Lee invented HTML to organise the text documents of a single corporation -- CERN. It is now the lingua franca of a global mnemotechnical system, the Internet, and its uses have proliferated beyond Berners-Lee's wildest dreams. It has adapted and evolved, and it has both incorporated and engendered new functions and new material technologies in the process.

The uses and functions of a technical object can never be known, these will only be realised in the evolution of the object itself. The technical object is not concrete, it is not determined in its uses. This is why the influence of 'working prototypes' on the engineering community is so important; the fabricating intention has little relationship to the object itself, and it is the object as a working prototype that will engender new structures and functions. Technical machines, maintains Simondon, evolve by a process of functional overdetermination. After they have been given a materiality, after the "synthetic act of invention" has taken place,

> each component in the concrete object is no longer one whose essence is to correspond to the accomplishment of a function intended by the constructor, but a part of a system in which a multitude of forces operate and produce effects independently of the fabricating intention.[70]

Subsequent evolution is accomplished by a process of 'concretization,' the condensation of various functions in a single structure oriented toward efficiency: the base of a light bulb must seal it for operation within a certain range of temperatures and pressures while also fitting in standard sockets[71] But we are still left with a problem: how do we identify the lineage of machines themselves? How do we identify their family resemblance?

In evolving, the technical object constitutes a series of objects, a lineage or a line. This lineage, of which the synthetic act of invention is the ancestor, cannot be identified by a particular material form or human use. For Simondon, it can only be identified by a group of procedures or processes that remain stable throughout the evolutional lineage. It is these procedures, implemented in the most diverse domains of use, that constitute the unity of the lineage. This is why there is more real analogy between "a spring engine and a crossbow than between the latter and a steam engine."[72] Both are implementations of procedures to work with tensile forces, both are the externalisation of an originary heuristic. There will be a variety of such procedures embodied in any given object -- it is not a matter of locating one. Nevertheless, that which resides in machines is certainly only "human reality, the human gesture set and crystallised into functioning structures."[73] To demarcate a technical object or family of objects, one must first locate these procedures and processes.

So where does this leave us in our prolegomena to the history of a machine? We have established that technical objects transform themselves in time, they engage in transfer and retroactivity. We have established that this dynamic constitutes a break from genetic evolution, and that this break in turn constitutes its own milieu. We have defined the technical object based on a group of techniques or processes that have remained stable throughout its evolutional lineage. And after Leroi-Gourhan and De Landa, we have suggested that these techniques originate in human processes, human processes which are themselves already technological. The family resemblance will only be seen in the workings of the technical object itself, and not its intended human function. However, any technique, once externalised into technical artifact, will engender new structures and new techniques. If a technique may be defined as itself a technical being, then its incarnation qua material artefact may be seen as "the being passing out of step with itself"[74], a becoming individualised.

What remains to be created is a practical example of this theory, the story or the diagram of a particular technical machine. This story has yet to be written.

Notes
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Belinda Barnet is Lecturer in Media and Communications at Swinburne University of Technology, Melbourne. She has published widely on new media theory and culture and has an irrational obsession with technics and evolution.