Nigel Thrift

ELECTRIC ANIMALS

New models of everyday life?

The literature on everyday life has only imperfectly taken to itself the influence of modern information and communications technology, generally through the work of authors like Benjamin and the lettristes like de Certeau and Virilio. Part of the reason for this relative absence seems to be a concern that these technologies are, in some way, inauthentic. But such a reaction is no longer adequate. As software plasters the everyday world with a new and active surface, so the character of the everyday world is being changed. This change is based on theoretical models of the world that are written into software and which have as one of their key roots particular notions of biology. How can one understand this new kind of everyday life in which theoretical models of biology come back to haunt the surfaces that define us as they are incorporated in all manner of increasingly 'lively' devices? Obviously, a series of characterizations could be made but this paper proposes that one of the best of these may turn out to be that of the companion animal. Everyday life is chock full of these animals yet they too are hardly ever remarked upon in the literature: their strange familiarity is so obvious that they are deemed to be unworthy of notice. However, as software makes the world increasingly lively, perhaps we should start to think of its agency, especially as it is incarnated in various increasingly mobile objects, as calling forth similar kinds of relationship of dominance and affection – and a pressing ethical task.

Keywords animality; biological metaphors; companion animals; everyday life; robotics; software

> . . . most of our engineering achievements to date are quite simple, at least in comparison to Nature's.
>
> (Sipper 2002, p. 186)

> Nature (the Art whereby God hath made and governes the World) is by the *Art* of man, as in many other things, so in this also imitated, that it can make an Artificial Animal.
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> (Hobbes 1651, p. 1)

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> Malebranche used to kick his dog in the name of animal-machines. Madame de Sevigné put Descartes and his theory in their place: 'machines that love, machines that make a choice for someone, machines that are jealous, machines that are fearful'. And she added, in a moment of indulgence, 'Never would Descartes have meant us to believe it'.
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> (Grenier 2000, p. 65)

Introduction

Biological metaphors have circulated in society for so long now that they have gradually sunk into the undertow of conscious thought. In this paper, I want to think about how these metaphors have taken root in the everyday life of an increasingly informational society and how that process is currently producing new artificial ethologies in which the biological and informational feed off each other and create new hybrids which demonstrate a certain kind of 'animality'.[1]

My interest in this area has been stimulated by three different but related impulses. One of these impulses is a general dissatisfaction with the literature on everyday life. My concern is that it does not take in recent technological developments in any meaningful way and indeed in some senses actively resists them by concentrating on conventional structures and sites of communication. In particular, its emphasis on a kind of proto-authenticity – as found, for example, in the stress on 'evasive everydayness' (Morris 1998) or the renewed emphasis on rhythm as a practice of feeling right with world, taken from the historically specific accounts of authors like Bachelard, de Certeau and Lefebvre – seems to me to express a yearning for a romantic holism that it has taken a long time to unlearn.[2] The second impulse has been born out of a general interest in the effectivities of software (Thrift 2003, Thrift & French 2002). I believe that software constitutes a new actor in the world: as a kind of mechanical writing, it is gradually producing a whole new informational ecology that is forming a dense undergrowth of muted but potent cause and effect that is present in the background of most events and which, because of its increasing extent and almost baroque complexity, is producing all kinds of large emergences and small hauntings, different densities and queer intensities, whose exact origins we can no longer trace. The third impulse is practical. I have been taken by the degree to which since the 1970s the writers of software have increasingly drawn on biological models more or less exactly based on biological metaphors – genetic algorithms, artificial ethologies and other forms of biomimicry – which express solutions to problems only faintly perceived. In particular, I have been taken by the desire to build electric animals for reasons that do not seem clear to either their inventors or users. In other words, biological metaphors, having become firmly entangled with computer programmes and lines of code, are producing an afterlife of 'artificial' 'organisms' that seem set fair to become companions to everyday practice in much the same way as pets now do.

This paper is a first exploration of this terrain and it can therefore hardly claim to be definitive. However, I hope that by its end I will have been able to achieve the following. First, I hope to have begun to show how software produces an intensely theoretical underlay to the practices of everyday life. Miller (1998) has called the process whereby in contemporary Euro-American societies theories have gradually changed the world to fit to their image 'virtualism' and I agree with this prognosis. Second, I hope to show that the desire to build software-driven entities like electric animals is more than just a bit of fun but reflects the working out in practice of these essentially theoretical dilemmas about what it means to be human and nonhuman, living and nonliving, cultural and natural which have been a constant of writings on both animals and machines. Third, I hope to briefly demonstrate that such projects are at least an indication of new disciplinary models and the kind of everyday life that is therefore likely to arise in the future.

The layout of the paper is in three main parts, which correspond to these three hopes. Thus, the first part of the paper considers the way in which software is producing a new layer of causality in the world which by its very nature is modest in scale but adds up to something more. The second part of the paper is concerned with how software has allowed new kinds of artificial nature to be built, especially electric 'animals'. The final part of the paper considers some of the dilemmas that have arisen or will arise by reference to the world of pets. Some brief conclusions round the paper off. Here, I begin to discuss how new kinds of disciplinarity are becoming possible.

A new underlay to everyday life

As a term in general use, 'software' dates only from the 1950s. Its genesis, of course, was bound up with the invention of the first electronic computers and, more particularly, the first use of these computers for business applications in the late 1950s, a development that, in turn, led to the growth of companies specializing in the supply of software (Hayles 2000). At the time, it referred to just a few lines of code that acted as a bridge between input and output. However, over the last 20 years in particular, software has grown from a small thicket of mechanical writing to a forest covering much of the globe in a profusion of over 200 different languages that now run all manner of everyday devices, from electric toothbrushes to cars (Thrift & French 2002).

Almost since its inception, the biological and the informational have been intertwined in software. Right at the birth of the modern computer, the new machines were framed in biological terms. For example, from the 1940s John von Neumann had been interested in the connections between computational logic and biology. The classic *First Report on the EDVAC* (1945) likened electronic circuits to neurons and the input and output part of the design to organs (Ward 1999). Since those early days, biological metaphors have become, if anything, more prevalent in the world of software and computation. In some senses, this prevalence should not be thought of as surprising. After all, many early cybernetic and systems theory metaphors were in part drawn from reductive notions of the workings of the biological domain and one might argue, as Sedgwick (2003, p. 105) has, that the problem was that the 'actual computational muscle' was not as yet available to operationalize them. Biology itself has seen a long drawn out war between those who believe that the biological domain can be reduced to a set of computations and those for whom the organism cannot be reduced to the sum of its parts. For the former group of biologists at least, cybernetic models were simply a natural extension of machinic thinking that had clear and obvious antecedents in the nineteenth century (but might even be traced further back to the Cartesian separation of man from machine-like animals). This kind of thinking finds its latest incarnation in a 'predictive biology' that hopes to model the behaviour of individual cells (and then tissues, organs and even organisms) in computers.[3]

Thus, software writers' initial flirtations with the biological may be seen as nothing more than business as usual but with a slightly more exotic tinge. However, at the same time, these flirtations were also expressing a need for something more. As software became more complex, reductive models became increasingly inappropriate. Software increasingly resembled a kind of ecosystem in which thickets of new code surrounded stands of legacy code that often stayed unchanged through many versions of a package. As the sheer length of code became a problem in its own right, so all kinds of unexpected interactions and hidden errors came into play. The constant tinkering of numerous programmers started to produce programs large enough and complex enough to make it possible to regard programs as forming their own ecologies, complete with various niches and evolutionary tendencies. The result was that programs have increasingly come to be framed as environments in their own right, motivated by quasi-biological principles. Interestingly, such descriptions are used both by those only interested in programs as manifestations of narrow technique and by those who argue that programs occupy the realm of something more. For example, in the latter camp, Nardi and O'Day (1999) want to argue for the creation of healthy 'information ecologies', which will exhibit several biological principles: systemic interrelation, diversity, co-evolution, keystone species and the importance of local habitation.

Added to this, new algorithms were introduced which were clearly modelled on biological lines. The longest-running tradition of this kind of work is to be found in the so-called genetic algorithm and the more general phenomenon of evolutionary computing (Mitchell 1996). Though there were antecedents, it is generally agreed that genetic algorithms were invented by John

Holland in the 1960s as a way of mixing natural and artificial systems (Holland 1975). Holland introduced a population-based algorithm that ran on evolutionary lines and could therefore produce programs that were able to do massively parallel searches (in which many different possibilities are explored simultaneously), that were adaptive, and that sought out complex solutions. In evolutionary computation, the rules are typically based on an idea of natural selection with variations induced by crossover and/or mutation: 'The hoped-for emergent behaviour is the design of high-quality solutions to difficult problems and the ability to adapt these solutions in the face of a changing environment' (Mitchell 1996, p. 4). However, evolution has not been the only biological metaphor used to motivate computer programs. Another metaphor has come from neuroscience. Connectionism, which includes such models as neural networks, consists of the writing of computer programs inspired by neural systems. In connectionism, 'the rules are typically simple "neural" thresholding, activation spreading, and strengthening or weakening of connections. The hoped-for emergent behaviour is sophisticated pattern recognition and learning' (Mitchell 1996, p. 4). It would be possible to go on but, hopefully, the point is made: in amongst the continual rustle of many computer programs, biological analogy now holds sway.

To summarize, on a whole series of levels, one of the most prevalent descriptions of programming environments is now a biological one. This description operates at a number of levels: as a means of framing programs, as a means of framing wider technological systems and as a means of making assumptions about how the world turns up. Perhaps it is no surprise, then, that the next step should be made: to try to produce 'artificial' 'life' and, in particular, artificial animality.

Electric animals

Lippitt (2000) points out that the first known usage of the term 'anthropomorphism' is dated by the *Oxford English Dictionary* to the second half of the nineteenth century.[4] It is probably no coincidence that at much the same time the history of technology and animals begins to intertwine ever more intimately.

> As they disappeared, animals became increasingly the subjects of a nostalgic curiosity. When horse-drawn carriages gave way to steam engines, plaster horses were mounted on tramcar fronts in an effort to simulate continuity with the older animal-driven vehicles. Once considered a metonymy of nature, animals came to be seen as emblems of the new industrial environment. Animals appeared to merge with the new technological bodies replacing them. The idioms and histories of numerous technological innovations from the steam engine to quantum mechanics bear the traces of

> an incorporated animality. James Watt and later Henry Ford, Thomas Edison, Alexander Graham Bell, Walt Disney and Erwin Schrodinger, among other key figures in the industrial and aesthetic shifts of the late nineteenth and early twentieth centuries, found uses for animal spirits in developing their respective machines, creating in the process a series of fantastic hybrids. Cinema, communication, transportation and electricity drew from the actual and fantastic resources of dead animals. In this manner, technology and ultimately the cinema came to determine a vast mausoleum for animal being.
>
> (Lippitt 2000, p. 187)

One might argue that Lippitt exaggerates in her desire to present a kind of techno-animal crypt – after all, early twenty-first-century cities are still chock full of animals that are very much alive (Amin & Thrift 2002) – but the point is still made: the cultural intersection between technology and animals has grown and continues to grow (Simondon 1958/1989). However, just as the materiality of technology has become an insistent force in the world of animals so the materiality of animals has become an insistent force in the world of technology. There is constant traffic between the two realms to the point where technology and animality have become suspect terms, perhaps better replaced by a standard actor-network theoretic depiction of a number of hybrid networks and other forms of flow that are perennially involved in diplomatic experiments which as one outcome perenially re-define prevailing cultural definitions of 'technology' and 'animal' (Whatmore 2002).[5] Whatever the case, it is clear that a notion of animality is a motivating force in current information technology, as various teams of scientists and programmers vie to produce something closer to biological life than heretofore has been possible.

Perhaps the best way to attempt to begin to show this work of shuttle diplomacy is by attending to the numerous attempts to produce simulations of organic life in computers. The point I want to make here is that these programs are being used to work through what organic life might consist of. They are experiments in action that are unfortunately accompanied by a good deal of hyperbole about 'life', 'virtual organisms' and 'living, breeding software' (Ward 1999, p. 279), which conceals their essentially primitive nature. Attempts to produce artificial life in the form of computer programs date from the 1980s when a series of biologists and programmers like Larry Ray began to produce artificial computer worlds like *Tierra*.[6] These worlds, in part, were born out of a dissatisfaction with the pre-defined and therefore closed system nature of genetic algorithms which meant that they had no independent ability to reproduce – what lives and what dies is decided externally; 'self-replication is critical to synthetic life because without it, the mechanisms of selection must also be predetermined by the simulator. Such artificial selection can never be as creative as natural selection' (Ray 1991, p. 372). Such worlds have undoubtedly been successful in that they exhibit certain evolutionary characteristics but they have also proved to have flaws, most notably that the organisms produced are all made up of fewer instructions than the original ancestor; the simple Tierran organisms have not been able to make themselves into larger creatures. Though there is still considerable optimism that such constraints can be overcome, other tacks seem just as productive.

Of these alternatives, the most obvious is to build artificial organisms that have genuine physical extension: artificial creatures, in other words. Currently, there are a number of inter-related approaches to this conundrum. The first of these is bio-mimetics. Bio-mimetics is a young discipline that studies models from nature and then imitates or takes inspiration from these designs and processes to solve various problems. It therefore potentially spans a vast range of different scientific areas and processes, only a few of which I will point to here; those that are most relevant to my argument. Though in the past, bio-mimetics has tended to concentrate on areas like materials, more recently considerable effort has been invested in animal mechanics. Many animal organs would display obvious utility if they could be imitated, such as the sticking power of mussels' feet or the ability of spiders to spin immensely strong silk (Benyus 1997). However, interest has also been shown in trying to produce programs that approximate animal brains and are therefore equipped to analyse patterns in ways which conventional programs find difficult or impossible, such as through the use of redundancy to handle or even generate side-effects, to ride unforeseeable as well as foreseeable forces. These programs may use 'tactilizing' processors, which are effectively large biosensors or optical protein processors that detect light absorption at any site and recognize a pattern from that pattern, amongst a host of similar technologies (Benyus 1997). Biomimetic robots range widely, from robots containing sensors that mimic a particular animal body part (for example, an electric analogue of the fly's motion-sensitive compound eye or the ant's polarized light sun compass) to attempts to construct a series of rapid prototypes that allow some degree of co-evolution (Holland & McFarland 2001).

The second approach focuses on imitation. Over the last ten years or so imitation has emerged as a topic of interest in disciplines as different as psychology, ethology, philosophy, linguistics, cognitive science, computer science, biology, anthroplogy and robotics (cf. Zentall & Galef 1988, Cypher 1993, Heyes & Galef 1996, Nadel & Butterworth 1999, Zentall 2001, Dautenhahn & Nehaniv 2002). It is no surprise that a series of attempts have therefore been made to program animal characteristics by imitation, both as a functional approach and as a topic that is interesting and valuable in its own right.[7] Imitation has been found to be one of the principal means of social learning by animals (including human beings) and aspects of its study are clearly able to be transferred to the artificial domain, especially when this domain is thought of as more than just a simple mapping between perception and action, sending and receiving. In particular, much work now revolves around understanding imitation as a property of situated and embodied agents operating in a particular environment that includes other agents as well as other sources of dynamic change (Dourish 2001). So far as the building of artificial animals is concerned, the impetus behind this work is clear: to be able to develop complex affective skills like facial expression.

The third approach is perhaps the most obvious: the construction of actual artificial creatures. Of course, the construction of artificial creatures is hardly a new ambition. It dates from at least the automata of the early eighteenth century, and electronic automata date from the 1940s. For example, in the 1940s and 1950s Walter (1951, 1952, 1953) built a series of artificial creatures ('simple animals') that were intended to display spontaneity, autonomy and self-regulation. Based on a combination of vacuum tubes, actuators and two sensors (light and bump) these creatures exhibited conditioned reflex learning and a wide variety of behaviours.[8] Since that time, large numbers of attempts have been made to build such creatures by roboticists and others culminating in the current vogue for creating artificial ethologies.

> Mobile robots have now existed for some 50 years. During that time, most robots were developed within the technical and conceptual horizons of contemporary engineering, computer science, and artificial intelligence and only a small number, for a variety of reasons, were specifically designed to resemble animals in one way or another. Now it happens to be the case that animals and mobile robots, whether animal-like or conventional, necessarily share so many features that, in many ways, all mobile robots resemble animals to some extent. On the other hand, all robots, whether animal-like or conventional, have things in common that set them apart from animals.
>
> (Holland & McFarland 2001, p. 15)

Most particularly, animals grow and evolve and as a result have to be, to some degree, functionally adaptable. Thus, though simple mimicry may produce animal-like behaviour, behaviour which may well be impressive in its apparent faithfulness, this may simply be because the robot and animal have converged on solutions dictated by the same restricted domain. Whatever the case, it is fair to say that perhaps the largest breakthrough in building artificial creatures has been the result of taking the environment more seriously in recognition of the fact that many animal cognitive tasks are off-loaded onto the environment. The environment provides a host of peripheral devices that store, enhance, streamline and generally re-represent meaning (Dennett 1997). This is the 'subsumption' approach favoured by Brooks (1999, 2002; Thrift 2003b, Arkin 1998). In that approach, an intelligent system is composed of a series of behaviour-producing subsystems, each of which independently connects sensing with action to achieve some particular behavioural competence such as 'avoid', 'wander' or 'explore'.[9] This series of very basic affects could be linked in various ways but were, above all, able to respond to many domains precisely and economically because they did not rely on internal representations but instead used the environment to do much of the 'thinking': in the by-now famous phrase 'the world is its own best model'.[10] This behaviour-based approach has been extended in various directions, and chiefly by making each affect and the entire system subject to evolutionary selection (as represented by genetic algorithms, neural networks and the like), thus introducing a definite learning trajectory. This adaptive approach, usually known as 'evolutionary robotics', is becoming increasingly popular as a means of selecting out and reinforcing particular competencies over time and as a means of co-evolving different kinds of robots (cf. Nolfi and Floreano 2000). In turn, such developments are leading to an interest in 'collective robotics' in which populations of robots are co-evolved and exhibit a distributed intelligence, rather like insect colonies (cf. Bonabeau *et al.* 1999).[11]

The fourth approach is simply to graft a living part of an animal into a robot, thereby producing an organic-artificial hybrid or 'hybrot'. Given the profound difficulties of preserving function in an isolated animal body part, such hybrids remain rare.[12] For example, the antennae from silkworm moths have been dissected out and mounted on a small robot as a means of tracking pheromones. Similarly, the nervous system of a sea lamprey has been dissected out and used to drive motors and register light sensitivity in a small robot (Holland & McFarland 2001, Geary 2002). More recently, a part mechanical, part biological robot has been created that operates on the basis of the neural activity of rat brain cells grown in a dish. This robot has actually gone on the market (through the Swiss robotics maker, K-Team) (Eisenberg 2003). Such experiments, and others like them, might be seen as part of a more general tendency to mix the organic and the digital in ways which take advantage of animal senses that cannot as yet be engineered or as a means of framing new 'bionic' senses or as simply part of further enquiries into animality.[13]

The ambition that underlies each of these kinds of approach is clear enough. Though it is always dangerous to take the writings of ideologues as typical, still their very extremity has its uses in pointing to the dreams and ambitions of those currently attempting to design electric animals. This is, I think, to design a machine nature driven by a 'bio-logic'. This machine nature would display at least the following characteristics: an open-ended evolution or at least emergence, a capacity for learning, very large amounts of problem-solving power arising from large populations of agents. Why? Because 'technology keeps getting more and more complex, which means that our traditional methodologies run up against a wall much sooner than they did before: more and more often they are overstretched . . . That's when we start considering the biological, which often permits us to make do with but a partial design – to be completed through evolution, learning, and other biologically-inspired techniques' (Sipper 2002,

p. 187). Some authors want to go further, of course. For example, Brooks envisages a world not far from now in which there is a burgeoning artificial ecology of machines. These 'machines to live with' will have a hodgepodge of capabilities and will continually scurry about, tending to human needs in all manner of ways.

> There are going to be more and more robots in our homes. Pretty soon we will stop bothering to count them. They will be a new class of entity, moving about under their own free will, doing their tasks as they decide they need to be done. The ecology of our homes will be visibly more complex than it is today. Just as our houses with their refrigerators, washing machines, dishwashers, stereos, televisions and computers would look sort of like a house but with a whole lot of weird stuff littered about, so too will the houses a century from now look a little strange to us.
>
> (Brooks 2002, p. 126)

This may seem to be a perfect example of the kind of rampant technological hyperbole that typified the late 1990s. Except for these facts: primitive robot vacuum cleaners and lawnmowers are now on general sale in North America and Western Europe; in Japan new generations of consumer robots are becoming generally (if usually very expensively) available; a number of companies have viable plans for combining wireless sensor networks and mobile robots so that the robots will need less brain power because they will be able to share it (Butler 2003); environmental activists are already trying to produce 'feral' packs of AIBOs and other robotic dogs that can participate in staged media events – or just play soccer (Feral Robotics 2003).[14,15] In other words, wherever we look in modern Euro-American cultures, we can see new surfaces and objects appearing powered by the motivating force of software and more and more of these surfaces and objects will be quite literally animated by software. Further, this kind of animality is becoming more and more prevalent (Lupton 2002). It is no longer far-fetched to think that in twenty years or so small machines will scuttle about largely unremarked upon in Euro-American households and workplaces carrying out mundane, specialized tasks or offering all manner of solace. The question that occupies the next section of the paper is what kind of cultural model will be drawn on to describe these new 'wild things'.

Pets and power

So how will the new machines sink into the background of everyday life? Nearly every writer seems to fall back on a quasi-biological analogy in that they agree that the sheer density of informational devices is beginning to create something like a digital ecology. But, thereafter, the accounts diverge, apparently radically.

One account is dystopian: consumers are drawn into a seamless world of electronic interconnectivity and speed that constitutes a kind of 'connective dementia'. Following on from the millenarian accounts of writers like Virilio and Harvey – who foresee a further round of time–space compression in which the real-time instant rules, in which here-and-now becomes all the there that there is – a new generation of dystopians have forecast the end of reflexivity, since time to ponder the alternatives to what presents itself will become increasingly scarce.

> This top-to-bottom, inside-and-out connectivity, uniquely in the history of technological development, has created its own ecology – an ecology based on interconnectivity that is becoming more pervasive. To live in the digital ecology is to live within a chronoscopic temporality of the constant present. This is creating its own form of tyranny, 'the tyranny of real time' (Purser 2000, p. 5). Linear, narrative times, through which we gain a sense of past, present and possible futures are becoming compressed into instantaneity. Those 'multitude[s] of times which interpenetrate and permeate our daily lives' (Adam 1995, p. 12) are themselves interpenetrated and permeated by ICT interconnectivity, digitizing them onto a single, temporal plane. Psychological research into human-computer interaction suggests that we are only able to perceive what we concentrate upon, and when we do not have time to concentrate on a particular thing we suffer from 'inattentional blindness' (Nardi & O'Day 1999, p. 14). In an information ecology based upon real-time chronoscopic temporality, this poses serious problems. If we are effectively 'blind' to that which we cannot devote a durational time-span, in 'the buzz of the flickering present' (Purser 2000, p. 5), then major problems loom as interconnectivity spreads deeper and wider.
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> (Hassan 2003, p. 102)

The other account is utopian. A favourite of 1990s commentators, it sees the emerging digital ecology as a kind of playground for a new and calmer generation of technologies in which everyday life becomes everyday life plus, a playground of augmented association and incidental learning taking place through a new set of cohabitees (Dertouzos 2001). Thus,

> the science of digital ecologies is just beginning. More than just simulations running in the mind of a computer, artificial life has worked its way into the real world, in a variety of robotic forms. From robotic 'insects' to intelligences with faux human bodies, these robots learn from their continuous interaction with the environment, defining goals and changing strategies as they encounter with world. Theses machines have crossed an imaginary line from procedural to unpredictable, which delights their creators. . . . Encountering a quirky, nonhuman, but thoroughly real intelligence is

> thrilling to both children and adults. In some way, it is life, and we instinctively recognize it.
>
> (Pesce 2000, pp. 8–9)

Somewhere in these utopian accounts' future, the artificial and the biological usually become as one. Digital implants will augment the body while computers will increasingly depend on biological substrates. There will be a 'marriage of silicon and steel with biological matter' and, as we move 'beyond cyborgs', the 'distinction between us and robots is going to disappear' (Brooks 2002, p. 233, p. 232, p. 236).

However, both of these accounts are actually rather similar to each other. In particular, they both rely on technological determinism (whether that technology is silicon or cellular) to see them through. Everyday life is a mirror of the qualities of the machines (whether silicon or cellular) that are present. The heterogeneous and often historically accidental archive of practices that take these machines in, rather than vice versa, are ignored or minimized.

Perhaps there is another way of framing the relationships between people and the new generation of biologically-inclined machines, one that draws precisely on our relationship with a particular subset of animals, namely *companion animals* or *pets*. Certainly, it seems a crucial political move at this juncture to think about ways of inhabiting everyday life which can think beyond these two impoverished ways of proceeding towards ways of conceiving the biological and the artificial as not just us but more than just other. Further, companion animals are a key part of Euro-American everyday life that have been widely and oddly ignored. For all the raft of writings about the powers of mundane objects and even of 'wild things' (Attfield 2000), here is a set of entities that have been comprehensively overlooked, even though it would be relatively easy to make a case that companion animals provide a good part of the practical and affective life of many, many households (Wolfe 2003a, 2003b).

Certainly, the sensory worlds of animals, whether wild or domesticated, are very different from those that humans inhabit, a claim made by von Uexküll in the late nineteenth century and since substantiated by numerous scientific studies (cf. Budiansky 1998). There is no reason why his umwelten approach cannot be applied equally to machines, in that machines also consist of a set of particular affects bound to the world and offering a particular sensing of it. However, it is clear that electric animals are meant to turn up helpfully in a human world, able to at least partially sense its needs and priorities. Given this, perhaps they are best thought of as like domesticated animals and most particularly as something akin to pets. Insofar as these animals are meant to be pet-like rather than simply commensal (that is symbiotic with their hosts), then their chief function seems to be to produce some of the same affective relationships and satisfactions that are best summarized by the now standard term 'companion animals'.

Of course, animals have a very long history of being companions to the everyday lives of humans. For example, cats are thought to have been domesticated for about six thousand years and though it might be that to begin with they were primarily used to keep down rats and mice in grain stores, it is also clear that from an early period they also formed affective relationships with human beings (Sunquist & Sunquist 2002). For example, from early in the Egyptian period, cats were given special respect and by 1000 BC, cats were commonly owned purely as pets, with their own appropriate rites of mourning – including the placing of the embalmed body in one of many vast cat cemeteries. Similarly, dogs can be found from a comparatively early period in human history. It is possible that dogs lived in villages some 12000 years BC.[16] By Neolithic times there starts to be good evidence for the presence of dogs but evidence for dogs as pets dates from rather later: 'By four thousand years ago, there were dogs in abundance, but little evidence of identifiable breeds. By Roman times, two thousand-plus years ago, writers are describing both sheepdogs and hunting dogs, and what sound like village curs are described in the Bible and other works written less than a thousand years before Roman times' (Coppinger & Coppinger 2001, p. 286).[17] In other words, for most of recorded historical time, human beings have had pet-like relations with animals and one of the key components of everyday life has been the rhythms and requirements of these animals. They have become a key element of human inhabiting, something more than passive context, with their own demands and needs adding a vital affective gloss to many people's everyday lives. So, for example, it has been estimated that there are over 50 million household dogs in the USA and a further 35 million in Europe (Coppinger & Coppinger 2001), most of which are pets.[18] In the USA, it has been reckoned that half of all households have a dog or cat, or both (Tuan 1984). So what are the reasons why pets have come into existence?

In recent years, the pleasures and rewards of pet ownership have been the subject of considerable research from a mixed collection of anthropologists, sociologists, biologists and veterinarians with the result that it has become possible to state with some degree of certainty the exact motivations behind pet ownership.[19] First, it is clear that many people gain substantive emotional benefits from pets, benefits that can be shown to exist physiologically (in, for example, lowered blood pressure, better sleep patterns and increased longevity). Second, pets can provide enhanced means of social association, all the way from simply meeting fellow dog walkers to participating in clubs for enthusiasts. Third, pets can give people more confidence, for example, by providing a sense of emotional or physical protection. Fourth, pets can act as style accessories or other indexes of social worth in that how they look can be important for bolstering a person's self-esteem. Finally, pets provide companionship: in societies where single person households are on the increase and many therefore live alone, this motivation is probably growing.

Pets, therefore, can clearly give a positive gloss to being human. However, they are also the subjects of great cruelty. Not only are they regularly shown affection but they are also the object of various forms of domination. They are regularly culled: on one estimate, the majority of North Americans keep their dogs for two years or less and then tire of them (Tuan 1984). Breeding involves selection, which may be quite ruthless. Again, making a pet may require harsh treatment. Dogs are often trained simply 'because power over another being is demonstrably firm when it is exercised for no particular purpose and when submission to it goes against the victim's own strong desires and nature' (Tuan 1984, p. 107). There may even be what Garber (1996) calls an 'erotics of dominance' in which the human portrays herself as falling under the spell of a pet because it is deserving of the human's love, thus valorizing her own actions and giving the pet no space to make difference.

However, all this said, pets clearly can and do inspire affection in and for themselves. Whilst this reaction is clearly part of a developing discourse of sentimentality towards animals whose origins date from the seventeenth century, it cannot be entirely reduced to just this story (Ritvo 1987). For example, writers like Grenier (2000) have taken up the threads of the sensual history of dogs and shown how it intersects with the history of humans, spinning out of that intersection a kind of respectful rapport that recognizes the full range of affective responses to dogs: sincerity, love, disdain, indifference and so on. Most particularly, a certain kind of faithfulness tends to be celebrated. Yet, even here, at the apparent apotheosis of the human-dog relationship, we see an instrumental attitude of sorts, rather well expressed by Lorenz (1964, pp. 194–195):

> The place which the human friend filled in your life remains forever empty; that of your dog can be filled with a substitute. Dogs are indeed individuals, personalities in the truest sense of the word and I should be the last to deny this fact, but they are much more like each other than are human beings. In those deep instinctive feelings that are responsible for their special relationship with man, dogs resemble each other closely, and if on the death of one's dog, one immediately adopts a puppy of the same breed, one will generally find that he refills those spaces in one's heart and one's life, which the departure of an old friend has left desolate.

Finally, there is, of course, the pet's point of view, a view which tends to be placed to one side because that would mean acknowledging that pets have their own umwelts that may still be very far from those of humans.

> The French, perhaps even more than others, talk to their dogs and cats as if they were human. They are totally surprised whenever their pet exhibits a sudden return to animality. When, for example, rediscovering its ancient instinct to camouflage itself for hunting, a dog rolls in shit. How could our favourite conversation partner – one whose wit, wisdom and even (why not?) philosophy we so admire – go so far astray? Baudelaire takes up this

> theme in his prose poem ‘The Dog and the Flask’. The creature described as the unworthy companion of Baudelaire’s sorry existence resembles the reading public. Exasperated by delicate perfumes, it sniffs with delight at carefully selected garbage. Henri Michaux, in *Passages*, remarks that you never see a dog stopping to smell a rose or a violet: ‘They carry a goddam dossier around in their heads, constantly updated. Who understands the menu of stink better?’
>
> (Grenier 2000, pp. 11–12)

Even so, given the rather jolly tone of these kinds of contributions, it might be thought that, for all their differences, the population of pets has been able to arrive at the best kind of commensalism, a generally well-serviced ecological niche. For example, ‘ecologically speaking . . . the domestic dog is an incredibly successful species’ (Coppinger & Coppinger 2001, p. 231), having reached an equilibrium environment that sustains the canine ability to find food, avoid hazards and reproduce. But, equally, pets can be seen as suffering from the worst kind of amensalism (a living together in which one species hurts another, sometimes unknowingly). They are captured animals: animals that we adopt, rather than vice versa. Their lives are manipulated for the human host’s benefit with generally malign results. Take the example of the dog again: ‘When I look at the benefits for the dog [of a] symbiotic relationship with humans, it looks well-nigh hopeless. . . . I believe the modern household dog is bred to satisfy human psychological needs, with little or no consideration for the consequences for the dog. . . . These dogs fill the court-jester model of pet ownership’ (Coppinger & Coppinger 2001, pp. 251–252).

What the literature on pets shows us, therefore, is the wide variety of responses to companion animals that exist in everyday life: domination and cruelty combined with sugary sentiment, a matter-of-fact instrumentalism combined with an awareness of a lurking otherness, and general uncertainty about the costs and benefits of the relationship for either party. As machines are loaded up with software and gain more and more independent mobility, so the same kinds of ethical dilemmas are likely to occur. These dilemmas may become more severe as some machines are invested with a capacity for emotional response, conversational capability, and so on.[20] They will surely begin to demand some of the same kinds of ethical responses as are found in the case of companion animals. But the case of companion animals should also give us pause: indeed, as we have seen, it would be possible to argue that the world of companion animals too often lacks any concerted ethical response. Surely, this underlines once again the case for an everyday ethics of the kind favoured by Varela (2000), but one that does not stop at the ‘human’ world but rather acknowledges other intelligibilities as well.

Conclusions

Deleuze and Guattari's disdain for a culture that is locked into individualistic, possessive concerns is clear, not least in their comments on pets: 'individuated animals, family pets, sentimental, Oedipal animals each with its own petty history, "my" cat, "my" dog. These animals invite us to regress and they are the only kind of animal psychoanalysis understands' (Deleuze & Guattari 1988, p. 240). In their rush to conjure up what is essentially a Spinozan world of prepersonal natural forces, they clearly throw down a challenge to make the comfortable world of everyday life uncomfortable by stripping it of some of its most reassuring denizens. They want to head out in the direction of a wilder animality that is both frightening – and creative. It is possible to have considerable sympathy with this approach whilst at the same time having considerable doubts about it, ranging from the empirical (being scratched by a cat on fairly regular basis) through the anthropological (many cultures through history seem to have kept pets in circumstances that are difficult to equate with Western possessive individualism) through to the ethical (is it necessarily so awful for people with very little in the way of companionship to seek it out in animal form?).

These same tensions are to be found in the construction of electric animals. What kind of culture is to be assumed? A wild electric panorama bereft of human figures but traversed by various lines of affect? A scurrying ecology full to bursting with all manner of informational life? A consumer mall of companions waiting to be sold and played with and as easily discarded? Or a welfare system gently caring for the emotional needs of its charges?

What I have tried to show in this paper is that the advent of software-driven entities modelled on biological assumptions is a significant event that has the potential to decisively change everyday life by adding in a new range of cohabitees. In particular, it offers a new set of ethical dilemmas that have clearly not been solved in the case of companion animals (Gaita 2003).

One might argue that, in certain senses, the issue of electric animals is more pressing because these entities have the potential to discipline conduct in more explicit and rigid ways (Lecourt 2003).[21] They are being socially engineered but, in turn, they can become a part of a new means of social engineering, half way between the disciplinary and the pastoral and combining elements of each. For it is quite clear that these animals can be made more or less lively and more or less threatening by the lines of code that animate them – not just in their capacity for surveillance (which is substantial) but also in their capacity to pass on and inculcate behaviours that may be inimical (for example, all manner of corporate dictates). There is, therefore, a lively politics of interspecies ethics to be pursued that can ensure that new hybrid relationships that will be brought into existence are not malign, or simply vapid (Plumwood 2002), and are able to produce resolution through alliance and mutual assistance rather than domination. For example, there is nothing to stop surfaces and entities being designed that can inculcate values and practices of critical responsiveness by retaining ambiguity, ambivalence and respect of the kind that is sometimes seen in human dealings with companion animals.

Such scenarios have been the bread and butter of science fiction for many years now, of course, but that does not necessarily make them invalid. Rather, because the future has a tendency to turn up not as some kind of gleaming and polished modernity but as overused and battered pieces of equipment our critical senses are dulled and we do not recognize that there are any similarities. However, at this time, that might be a dangerous assumption to make.

Notes

1 Everyday life is often framed as a kind of subterranean force, an intense conglomeration of the countless contingent situations that line the present that has come to be driven by the repetitive demands of capitalism that have gradually come to overlay all other cycles. Though everyday life is often envisaged to be controlled by the routines of capitalism, it is also regarded as somehow oblique to it. Thus, according to Lefebvre (1994, p. 18), it is 'the most universal and the most unique condition, the most social and the most individuated, the most obvious and the most hidden'. In the interstices of everyday life, then, should be expected to be found not just the alienations, reifications and fetishisms pushed by all the agents of a commodified capitalism but also something more; spaces, times and situations that arise from other traditions that are not yet fully attenuated, from the unexpected and eventful nature of the present, and from the highly variable exigencies of particular times and places (Crang & Thrift 2001). I do not wish to dispute this kind of depiction/diagnostic, which is now commonly accepted in large parts of academe and elsewhere. But I do dispute some of the commonly accepted consequences: an inevitable erosion of all relations except those of the commodity, a gradual gridding of space and time so that they follow the contours of capitalist production, distribution and consumption, and an increasingly quietist politics, whose silence is broken every now and then by periodic doomed outbreaks from the dominant ideology. As I hope to show in this paper, all kinds of possibilities are still open, though they will have to be fought for. I therefore lean towards a vision of everyday life that adopts something closer to a Certeauian emphasis.

2 I am convinced that the accounts of authors like these are rooted in the assumptions and practices of another time and have only a limited purchase on the current period (see Thrift 2004).

3 Recently, social scientists have spent considerable time considering the writings of biologists who believe that organisms cannot be reduced to the sum of their parts but it needs to be stressed that, in the context of modern bioscience, these writings are very much in the minority.

4 Until this time, it was used to refer to mistaken attributions of human traits to deities.

5 One good example of this traffic is the increasing prevalence of chips in pets, which will allow them to be easily identified if they get lost. Such chips are now being mooted for children and even adults.

6 *Tierra* is only one of many of these artificial worlds. Others include variations on *Tierra* like *Avida*, *Evita* and *Bugs* as well as rather different worlds like Holland's *Echo* and Taylor's *Cosmos*.

7 The programs produced are usually connectionist.

8 Expanded accounts of Walter's work at the Burden Neurological Institute in Bristol can be found in Ward (1999), Holland and McFarland (2002) and Brooks (2002). In time-honoured fashion, Walter is now being claimed as a founding father of robotics.

9 The use of a Deleuzian terminological universe might be highly appropriate at this point since in a number of ways this kind of work is an engineered conception very similar to certain aspects of Deleuze's thought.

10 That said, the issue of internal state does not disappear and still causes certain problems for this kind of approach (cf. Holland & McFarland 2001).

11 Note that the vocabulary of life is absolutely crucial to the claims made for these creatures as both standard and justification (see Doyle 1997).

12 Never mind the ethical implications!

13 I do not here go into the attempts to produce biological computers, though there are now a number of these.

14 Robot vacuum cleaners include the Roomba produced by iRobot, Rodney Brooks's company and the Electrolux Trilobite. Other major vacuum cleaner manufacturers like Hoover, Matsushita and Dyson are working on similar projects. Husqvarna, a subsidiary of Electrolux, sells two different models of robot lawnmower.

15 I am not concerned here with demonstrators like the four feet high Honda Asimo but rather with genuine mass market products like the new Sony humanoid SDR-4X II, which at 7 kg has all the features that might now be expected (such as bipedal movement, conversational capabilities based on speech recognition of about 20,000 words, and so on), the Toshiba ApriAlpha (which also has face and speech recognition and looks like R2D2) and, of course, the by now familiar Sony Aibo dog in its various incarnations (Thrift 2003, Wray 2003). Whereas the SDR-4X II is the price of a luxury car, the Aibo is coming down rapidly in price. Another development is the growth of relatively cheap do-it-yourself robotics kits like the Evolution ER-1, which work with laptops to allow the performance of a large number of tasks and can be built as one of several standard variants or customized.

16 The evidence is difficult to interpret: 'one can't tell whether a woman was buried with a choice lunch to take her to the happy hunting grounds or whether she was taking her pet puppy to heaven with her' (Coppinger & Coppinger 2001, p. 277).

17 Indeed, genetic evidence suggests that dogs may first have appeared about 50,000 to 15,000 years ago (Haraway 2003).

18 One should not, of course, over-sentimentalize the relationship. In the USA, for example, about five percent of dogs are culled ('put to sleep') each year (Coppinger & Coppinger 2001).

19 This account would be deemed hopelessly human-centric by some since there is good evidence to suggest that in the recent evolutionary record animals in certain senses chose to become pets, filling a new and more secure niche without having to make significant compromises. However, since the emphasis of this paper is on the derivation of electric animals I do not think that this is a besetting sin, although at some point future informational versions of bio-ethicists may start to invest these animals with rights.

20 I have considered this issue in more detail by reference to toys. See Thrift (2003b).

21 The issue has become much more pressing since the recent announcement of injectable radio frequency identifier chips that can be used as human bar codes (Murray 2002, Thrift 2004).

References

Adam, B. (1995) *Timewatch. The Social Analysis of Time*, Polity Press, Cambridge.

Arkin, R. (1998) *Behavior-Based Robotics*, MIT Press, Cambridge, MA.

Attfield, J. (2000) *Wild Things. The Material Culture of Everyday Life*, Berg, Oxford.

Baker, S. (2000) *The Postmodern Animal*, Reaktion, London.

Beck, A. & Katcher, A. (1996) *Between Pets and People: The Importance of Animal Companionship*, Purdue University Press, West Lafayette, IN.

Bentley, P. (2002) *Digital Life: A New Kind of Nature*, Headline, London.

Benyus, J. M. (1997) *Biomimicry: Imitation Inspired by Nature*, William Morrow¸ New York.

Bonabeau, E., Dorigo, M. & Theraulez, G. (1999) *Swarm Intelligence: From Natural to Artificial Systems*, Oxford University Press, Oxford.

Brooks, R. (1999) *Cambrian Intelligence: The Early History of the New AI*, MIT Press, Cambridge, MA.

Brooks, R. (2002) *Robot: The Future of Flesh and Machines*, Allen Lane, London.

Budiansky, S. (1998) *If a Lion Could Talk: Animal Intelligence and the Evolution of Consciousness*, Free Press, New York.

Butler, J. (2003) 'Mobile robots as gateways into wireless sensor networks', [online] Available at http://www.linuxdevices.com/articles/AT2705574735.html

Coppinger, R. & Coppinger, L. (2001) *Dogs: A New Understanding of Canine Origin, Behaviour and Evolution*, University of Chicago Press, Chicago.

Crang, M. & Thrift, N. (eds) (2001) *TimeSpace*, Routledge, London.

Cypher, A. (ed.) (1993) *Watch What I Do: Programming by Demonstration*, MIT Press, Cambridge, MA.

Dautenhahn, K. & Nehaniv, C. (eds) (2002) *Imitation in Animals and Artifacts*, MIT Press, Cambridge, MA.

De Waal, F. & Tyack, P. (eds) (2003) *Animal Social Complexity: Intelligence, Culture, and Individualized Societies*, Harvard University Press, Cambridge, MA.

Dennett, D. (1997) *Kinds of Minds: Towards an Understanding of Consciousness*, Phoenix, London.

Dertouzos, M. (2001) *The Unfinished Revolution: Human-Centred Computers and What They Can Do For Us*, Harper Collins, New York.

Dourish, P. (2001) *Where the Action Is: Embodied Interaction*, MIT Press, Cambridge, MA.

Doyle, R. (1997) *On Beyond Living: Rhetorical Transformations of the Life Sciences*, Stanford University Press, Stanford.

Dyson, G. (1997) *Darwin Among the Machines*, Allen Lane, London.

Eisenberg, A. (2003) 'Wired to the brain of a rat, a robot takes on the world', *New York Times*, 15 May, pp. 13–26.

Feral Robots (2003) 'Feral Robotics: Dog Report', [online] Available at http://xdesign.eng.yale.edu/feralrobots/

Gaita, R. (2003) *The Philosopher's Dog*, Routledge, London.

Garber, M. (1996) *Dog Love*, Simon and Schuster, New York.

Geary, J. (2002) *The Body Electric: An Anatomy of the New Bionic Senses*, Weidenfeld and Nicolson, London.

Grenier, R. (2002) *The Difficulty of Being a Dog*, University of Chicago Press, Chicago.

Haraway, D. (2003) *The Companion Species Manifesto: Dogs, People, and Significant Otherness*, Prickly Paradigm Press, Chicago.

Harootunian, H. (2000) *History's Disquiet: Modernity, Cultural Practice and the Question of Everyday Life*, Columbia University Press, New York.

Hassan, R. (2003) 'The MIT media lab: techno dream factory or alienation as a way of life', *Media, Culture and Society*, vol. 25, pp. 87–106.

Hayles, N. K. (2002) *Writing Machines*, MIT Press, Cambridge, MA.

Heyes, C. & Galef, B. (1996) *Social Learning in Animals: The Roots of Culture*, Academic Press, San Diego.

Hobbes, T. (1651) *Leviathan; or, The Matter, Forme, and Power of a Commonwealth Ecclesiasticall and Civill*, Andrew Crooke, London.

Holland, J. (1975) *Adaptation in Natural and Artificial Systems*, University of Michigan Press, Ann Arbor, MI.

Holland, O. & McFarland, D. (2001) *Artificial Ethology*, Oxford University Press, Oxford.

Lecourt, D. (2003) *Humain, Posthumain. La Technique et la Vie*, Presses Universitaires de France, Paris.

Lippitt, A. (2000) *Electric Animal: Toward a Rhetoric of Wildlife*, University of Minnesota Press, Minneapolis.

Lorenz, K. (1964) *Man Meets Dog*, Penguin, Harmondsworth.

Lupton, E. (2002) *Skin: Surface, Substance, Design*, Princeton Architectural Press, Princeton, NJ.

Mackintosh, J. (2003) 'Robots lose out to human touch', *Financial Times*, May 1, p. 11.

Mitchell, M. (1996) *An Introduction to Genetic Algorithms*, MIT Press, Cambridge, MA.

Murray, C. (2002) 'Injectable chip opens door to human bar code', *EETimes*, 7 January, [online] Available at http://www.eetimes.com/story/OEG20020104S0044

Nadel, J. & Butterworth, G. (eds) (1999) *Imitation in Infancy*, Cambridge University Press, Cambridge.

Nardi, B. & O'Day, V. (1999) *Information Ecologies: Using Technology with Heart*, MIT Press, Cambridge, MA.

Nolfi, S. & Floreano, D. (2000) *Evolutionary Robotics: The Biology, Intelligence and Technology of Self-Organizing Machines*, MIT Press, Cambridge, MA.

Pesce, M. (2000) *The Playful World: How Technology is Transforming Our Imagination*, Ballantine Books, New York.

Plumwood, V. (2002) *Environmental Culture: The Ecological Crisis of Reason*, Routledge, London.

Podberscek, A., Paul, E. & Serpell, J. (eds) (2000) *Companion Animals and Us: Exploring the Relationships between People and Pets*, Cambridge University Press, Cambridge.

Purser, R. (2000) 'The coming crisis in real-time environments: a dromological analysis' [online] Available at online.sfsu.edu/~rpurser/revised/pages/DROMOLOGY. htm

Ray, T. (1991) 'An approach to the synthesis of life', in *Artificial Life II*: *Santa Fe Studies in the Sciences of Complexity*, Volume XI, eds C. Langton, C. Taylor, J. D. Farmer & S. Rasmussen, Addison Wesley, Redwood City, CA, pp. 371–408.

Ritvo, H. (1987) *The Animal Estate: The English and Other Creatures in the Victorian Age*, Harvard University Press, Cambridge, MA.

Rothfels, N. (ed.) (2002) *Representing Animals*, Indiana University Press, Bloomington, IN.

Schwarz, M. (1997) *A History of Dogs in the Early Americas*, Yale University Press, New Haven.

Scott, C. (2002) *The Lives of Things*, Indiana University Press, Bloomington, IN.

Sedgwick, E. K. (2003) *Touching Feeling: Affect, Pedagogy, Performativity*, Duke University Press, Durham, NC.

Serpell, J. (1986) *In the Company of Animals*, Cambridge University Press, Cambridge.

Simondon, G. (1958/1989) *Du Mode d'Existence des Objets Techniques*, Aubier, Paris.

Sipper, M. (2002) *Machine Nature: The Coming Age of Bio-Inspired Computing*, McGraw Hill, New York.

Stafford, B. M. and Terpak, F. (2001) *Devices of Wonder: From the World in a Box to Images on a Screen*, Getty Research Institute, Los Angeles.

Sunquist, M. & Sunquist, F. (2002) *Wild Cats of the World*, University of Chicago Press, Chicago.

Thrift, N. (2003a) 'Driving in the city', *Theory, Culture & Society*, forthcoming.

Thrift, N. (2003b) 'Closer to the machine? Intelligent environments, new forms of possession and the rise of the supertoy', *Cultural Geographies*, forthcoming.

Thrift, N. (2004) 'Remembering the technological unconscious by foregrounding knowledges of position', *Environment and Planning D: Society and Space*, forthcoming.

Thrift, N. & French, S. (2002) 'The automatic production of space', *Transactions of the Institute of British Geographers*, vol. 27, pp. 309–335.

Tuan, Y.-F. (1984) *Dominance and Affection: The Making of Pets*, Yale University Press, New Haven, CT.

Varela, F. (2000) *Ethical Know-How*, Stanford University Press, Stanford.

Walter, W. (1950) 'An imitation of artificial life', *Scientific American*, vol. 96, pp. 123–137.

Walter, W. (1953) *The Living Brain*, Penguin, London.

Ward, M. (1999) *Virtual Organisms: The Startling World of Artificial Life*, Pan, London.

Whatmore, S. (2002) *Hybrid Geographies*, Sage, London.

Wolfe, C. (2003a) *Animal Rites: American Culture, the Discourse of Species and Posthumanism*, Chicago University Press, Chicago.

Wolfe, C. (2003b) *Zoontologies: The Question of the Animal*, University of Minnesota Press, Minneapolis.

Wray, R. (2003) 'Our new best friend', *Guardian*, 4 April, p. 23.

Zentall, T. (2001) 'Imitation in animals: evidence, function and mechanisms', *Cybernetics and Systems*, vol. 32, pp. 53–96.

Zentall, T. & Bennett G. (eds) (1988) *Social Learning: Psychological and Biological Perspectives*, Lawrence Erlbaum Associates, Hillsdale, NJ.