

ZOOGONY AND EVOLUTION
IN PLATO'S *TIMAEUS*:
THE PRESOCRATICS, LUCRETIUS AND DARWIN

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Apparently there is no limit, Joe remarked. Anything can be said in this place and it will be true and will have to be believed.

Flann O'Brien *The Third Policeman* 1967, 74

Modern critics may try to figure themselves as disinterested scientists viewing ancient texts 'with the shutter open' and simply describing what they find, but in reality we are like Aeneas before the pictures in Carthage, seeing what we want to see and telling a story. Our gaze on the past is always 'the view from somewhere'.

Don Fowler, *Roman Constructions*, p. ix.

There can be few more influential works on cosmogony and zoogony than Plato's *Timaeus*. Indeed a good case can be made for including *Timaeus* as one of the four most influential books on the subject, along with *Genesis*, Lucretius' *De rerum natura* and Darwin's *On the Origin of Species*. The relationship between these four books is complicated and involved, and, apart from *Genesis* perhaps, each has been written in the context of the others, if not entirely as a polemical rebuttal of the others. That is to say the directionality of intertextual reference between them is not simple, and will often be the reverse of what we should expect.¹ The later of the two works of Greek philosophy, the *Timaeus*, may be viewed in some sense as a reply to the ideas contained in the earlier *De rerum natura*, since it is clear that to a considerable degree *Timaeus* is a polemic against the earlier cosmologies of Empedocles and Democritus, and Lucretius follows the Epicurean atomistic tradition derived from Democritus, and is also strongly influenced by Empedocles. But Epicurus, and therefore Lucretius, could not ignore Plato's *Timaeus* and its influence in the Hellenistic period, and so *De rerum natura* is in its turn partly an anti-Timaeian polemic.² Similarly, since our ideas are so strongly influenced by Darwin, whether

we like it or not, when thinking about evolution we can hardly expect ancient texts to be our sole source texts – Darwin will often become our source text, and ancient texts the target texts. Further, although Darwin's knowledge of ancient ideas of evolution seems to have been slight, *Origin of Species* can be seen as a belated continuation of an ancient mechanistic scientific tradition, and so another complication is added.³

I. Lucretius' zoogony

In order to place Plato's *Timaeus* in its ancient context, then, and attempt to disentangle some of the threads of interaction between *Timaeus*, Lucretius and Darwin, I must begin at the wrong end of antiquity with Lucretius' scheme of zoogony and adaptation in *De rerum natura* 5. I shall examine Lucretius' zoogony in some detail since it represents the continuation and culmination of a Greek scientific tradition that *Timaeus* cuts across and interrupts; it is the only detailed account of the atomistic mechanism of adaptation, which is one of Plato's targets for subversion in *Timaeus*.⁴ So, if it sometimes seems that I present *Timaeus* as if arguing against Lucretius, and if Darwin and Lamarck appear to interact diachronically with Lucretius and Plato, it will be, although anachronistic, not too far from the truth. This process of contextualization takes some time, and so I hope the reader will bear with me and persevere until I finally get to *Timaeus*. Like Darwin and the Presocratics, including the atomists, I am mainly concerned here with the mechanisms of the origin of species, and so if I examine *Timaeus* in a thoroughly un-Platonic mechanistic way, I hope Platonic scholars will forgive me. I use the term 'evolution' broadly, to describe (1) 'inter-specific evolution' – the Darwinian model of the origin of species by the gradual accumulation of variation over time leading to the formation of new species, and (2) 'intra-specific evolution' – the accumulation of variation within a species that stops short of crossing species boundaries. I argue that the former is not found in ancient scientific thinking except in *Timaeus*, but that the latter, evolution within fixed species boundaries, is standard in ancient thinking. My approach is informed by my conviction that ancient ideas should not only be studied as exhibits in a museum of the history of 'wrong' ideas, but as living and valuable contributions to a debate that is as topical now as it ever was. The benefits may be twofold in that we may reach a better understanding of both ancient and modern ideas if we understand the source of our preconceptions.

Lucretius describes the creation of the world in *De rerum natura* 5.416ff. as the result of random collisions of a large number of atoms over a long period of time.⁵ Given a large enough supply of atoms and

long enough time, it is inevitable that enough fruitful collisions will take place to produce the atomic compounds that will eventually form a world. The process is entirely chaotic, subject to no plan, design, intelligence, or control (5.419–21), and is governed only by the limit on the number of possible types of atomic combinations, which ensures the regularity of the phenomenal world.⁶

This process of creation by random combinations of atoms is mirrored by the creation of life in 5.772 ff.⁷ We are not given here a microscopic atomic explanation of zoogony, and this must be supplied from 2.700 ff. The random nature of creation is, however, described in macroscopic terms at 5.837 ff. where the earth is said to create many monsters (*portenta* 837) at the same time as viable creatures.⁸ It is clear that no pre-existing pattern for life is available for the earth to follow in her creation. She throws up creatures at random; some without gender (*androgynem*, 839); some without eyes (*sine vultu caeca*, 841); some without feet (*orba pedum*, 840); without hands (*manuum viduata*, 840); without mouths (*muta sine ore*, 841); and some with their limbs not properly separated from their bodies and so unable to move (*vinctaque membrorum per totum corpus adhaesu*, 842).

Clearly, these creatures will die out very quickly. Some will be eaten by others (*nec vitare malum*, 844), some will starve (*nec sumere quod foret usus*, 844, *nec reperire cibum* 848) and all of them will be prevented from breeding, either by lack of the proper organs or by dying before they have a chance, and so will be unable to found a species (*procludere saecula*, 850). Thus we have a scheme of individual extinctions in the first generation of creatures produced spontaneously from the earth. We may assume that Lucretius' list of *portenta* is not exhaustive. If the earth produces creatures without a pattern for life, then anything is possible. We may imagine many other creatures that come together in ways that prevent them living for more than a few moments, perhaps without other essential organs or simply with their organs and limbs wrongly arranged.

The purpose of this scheme of extinctions is clear. It explains the adaptation of animals to their environment without the need for an overarching vitalistic or organizing force to design creatures and to divide them into species. All possible animals came into being at the same time at the beginning of the world, but only some of them were viable, and so were able to breed and continue their line; the others simply died out. Thus we have an anti-teleological scheme of adaptation and the origin of species that denies the operation of providence in the 'design' of animal life of the sort found in Cicero *De natura deorum* 2.120–53,⁹ where the Stoic Balbus uses the apparently perfect conformation of creatures and

their perfect adaptation to their environment as proof of the care of Providence for the world.

However, Lucretius in book 5 does not rely upon these extinctions alone to account for adaptation. At 5.855 ff., we are given a second explanation of adaptation by extinctions. Here Lucretius describes the extinctions of entire species (*saecla*, 855)¹⁰ rather than simply of individual creatures. We must assume that these creatures are viable in themselves and that they are able to find food and to breed, but they die out because they do not have particular physiological or behavioural characteristics to enable them to survive in a competitive struggle for life. We are told that lions survive because of their boldness and strength (*virtus*), foxes because of their cunning (*dolus*), and deer because of their speed in flight (862–3). These qualities enable them to compete and flourish in a survival of the fittest. Lucretius also includes (5.923–4), as we should expect in an Epicurean account, survival by co-operation. He gives the example of the mutually beneficial symbiotic relationship between humans, dogs, horses and sheep (864–70). The dogs, sheep and horses avoid the competition of the struggle for life by the protection and food given them by humans.¹¹

The function of this second phase is not immediately as clear as that of the first. Lucretius has already removed maladapted creatures, and explained the formation of species. However, it seems clear that the extinctions of the *portenta* would account only for broad adaptations, such as having usable limbs. Creatures unviable in themselves because of some fundamental flaw in their make up would die out, but fine adaptations such as the positioning of the eyes on the front of the head, the number of eyes, the number of digits on a hand, and such adaptations as teeth being sharp at the front of the mouth and blunt at the back¹² could not be accounted for in this way. Animals with a reversed tooth configuration could still eat, and having eyes at the back of the head or seven digits would not, on their own, prevent a creature from surviving. Accordingly, extinction by competition becomes necessary. Animals with reversed teeth would not be as successful as those with 'normal' teeth, and so would become extinct in competition for food resources, and in this way the fine adaptation of animals to their environment is explained. To use Lucretius' examples: lions (or creatures who compete with lions) with lesser strength would die out and so the lion's great strength is explained. Creatures with lesser speed than deer would be caught and eaten, and so the speed of the deer is explained. We may imagine a great range of different creatures with different attributes in Lucretius' early world, but only those with the 'correct' attributes and adaptations (the species we see today) would survive. All the others have become extinct. The seeming providential

design of animals, fitting them perfectly for their role in life, is refuted and replaced by a non-teleological process of the interaction of chance and necessity.

This scheme of adaptation by extinctions has led to comparison with the scheme of Darwin and to the assumption that Lucretius is presenting an evolutionary view of adaptation. However, there are fundamental differences between the two. Most importantly, Lucretius insists on the fixity of species. All the 'mutations' necessary to provide the variety of creatures for natural selection to work upon and produce close adaptations of animal form and function to environment, occur in one great burst at the beginning of the world. As soon as creatures begin to breed by sexual reproduction species become fixed, and it is sexual reproduction that ensures species remain permanently fixed and unable to mutate.¹³ We do not have the Darwinian reliance on the mutation of creatures from generation to generation due to sexual reproduction, which fits them ever more nearly perfectly for their role in life. Clearly Lucretius is attempting to account for the perceived regularity of nature rather than arguing against it as Darwin does.¹⁴ In this way, Lucretius' scheme of the origin of species is not only anti-teleological but also anti-evolutionary.

II. Empedocles' zoogony

Lucretius' zoogony is the culmination of a scientific tradition. The details of other Greek scientific theories of adaptation are few, but Empedocles provides us with the other main scientific account of the creation and adaptation of life. It is unfortunately fragmentary and many different interpretations are possible. However, I feel it is safe to say that Empedocles' scheme is significantly similar to that of Lucretius. Empedocles has a double cosmic cycle in which two cosmic forces, Love and Strife, each have both a creative and destructive role, alternately creating and destroying life, and so we have two zoogonies, one under Love and one under Strife.¹⁵ We have only one fragment of the zoogony under Strife (fr. 62), but the zoogony under Love is preserved in some detail. Strasbourg fragment a(ii) 23–30¹⁶ and fragments 57, 59, 61, and 71 give us:

I will show you to your eyes too, where they (i.e. the elements) find a larger body: first the coming together and the unfolding of the stock, and as many as are now remaining of this generation, on the one hand among the wild species of mountain-roaming beasts, and on the other hand the twofold offspring of men,¹⁷ and in the case of the produce of the root-bearing fields and of the cluster of grapes mounting on the vine. From these accounts convey to your mind unerring proofs: for you will see the coming together and unfolding of the stock.

(Strasbourg fr. trans. Martin and Primavesi, 1999, 139)

Here many heads sprang up without necks, bare arms were wandering without shoulders, and eyes needing foreheads strayed singly. (fr. 57)

But as god mingled further with god they fell together as they chanced to meet each other, and many others in addition were continually arising. (fr. 59)

Many creatures with a face and breasts on both sides were produced, man-faced bulls arose and again bull-headed men, [others] with male and female nature combined, and the bodies they had were dark. (fr. 61)

But if your belief about these things in any way lacked assurance, how, from the combining of water, earth, air and sun came the forms and colour of mortal things which have now arisen, fitted together by Aphrodite...

(fr. 71, trans. Wright; cf. Wright ad loc., Furley, 1987, 94 ff.)

For an interpretation of this scheme of zoogony, I turn to Aristotle and his commentator Simplicius. Aristotle discusses and rejects Empedocles' theory at *Physics* 2.8, 198b16–32, in a passage which quotes part of Empedocles fragment 61:

So here the question rises whether we have any reason to regard nature as making for any goal at all, or seeking any one thing as preferable to another. Why not say, it is asked, that nature acts as Zeus drops the rain, not to make the corn grow, but of necessity (for the rising vapour must needs be condensed into water by the cold, and must then descend, and incidentally, when this happens, the corn grows), just as when a man loses his corn on the threshing-floor, it did not rain on purpose to destroy the crop, but the result was merely incidental to the raining? So why should it not be the same with natural organs like the teeth? Why should it not be a coincidence that the front teeth come up with an edge, suited to dividing the food, and the back ones flat for grinding it, without there being any design in the matter?¹⁸ And so with all other organs that seem to embody a purpose. In cases where a coincidence brought about such a combination as might have been arranged on purpose, the creatures, it is urged, having been suitably formed by the operation of chance survived; otherwise they perished, and still perish, as Empedocles says of his 'man-faced oxen'.

(Trans. Wicksteed and Cornford)

Simplicius (*in Phys.* 371.33–372.11) comments on this Aristotelian passage as follows:

Thus Empedocles says that under the rule of love parts of animals first came into being at random – heads, hands, feet and so on – and then came into combination: 'There sprang up ox progeny, man-limbed, and the reverse' (obviously meaning 'man progeny ox-limbed', i.e. combinations of ox and man). And those which combined in a way which enabled them to preserve

themselves became animals, and survived, because they fulfilled each other's needs – the teeth cutting and grinding the food, the stomach digesting it, the liver converting it into blood. And the human head, by combining with the human body, brings about the preservation of the whole, but by combining with the ox's body fails to cohere with it and perishes. For those which did not combine on proper principles perished. And things still happen the same way nowadays. This doctrine seems to be shared by all those early natural philosophers who make material necessity the cause of things' becoming, and, among later philosophers, by the Epicureans.

(Trans. Long and Sedley)

Simplicius makes it clear that Empedocles is putting forward a scheme of creation and adaptation by the chance assemblage of disparate parts of creatures, with Love as a cohesive force. The assembly of the correct parts produces a viable creature, while incorrect assembly ensures the immediate destruction of the creature, and so adaptation is accounted for, just as in Lucretius, by the extinction of maladapted forms.¹⁹ Thus the two schemes are essentially the same: animals arise at random without a pre-existing pattern for life or any guidance, whether divine or biological, about how they should fit together. So Empedocles' scheme is anti-teleological,²⁰ and relies upon a similar combination of chance and necessity to produce species as does that of Lucretius. Empedocles' scheme has also been described as an evolutionary one, but, as with Lucretius, it seems that he is attempting to account for the regularity of species rather than describing mutation between species. Again, all his mutations occur at the beginning of the world, and all except viable species die out immediately. This ensures his theory is non-evolutionary.

Simplicius' statement that the same thing happens 'even today' is a reference to Empedocles' embryology,²¹ which is conceived of in similar terms to his zoogony, with each organ and limb of the parents providing a miniature pre-formed copy of itself. These are then assembled to form the embryo. This, given the traditional analogy between cosmogony, zoogony and embryology (Furley 1989, 229 ff.), makes it easier to understand Empedocles' idea of the original formation of creatures by the coming together of separate limbs. The main difference between Lucretius' and Empedocles' theories is that Empedocles' creatures are assembled, however randomly, from ready-made parts, while Lucretius' creatures are formed randomly at the atomic level. The role of Love (Aphrodite in fr. 71.4, Kypriis in fr. 73.1) in combining the parts of creatures may seem to suggest divine teleology, but it is clear that Love is not an organizing principle but merely a force of attraction, since she is unable to choose the correct parts to fit together. Against this may be brought fragment 84 in which

Empedocles describes Aphrodite constructing the eye for the *purpose* of seeing, i.e. in teleological terms.²² However, the eye with its complexity presents probably the greatest challenge to any anti-teleological account of adaptation, and it is difficult to see how else its creation could be described without an idea of its gradual evolution; even in modern theory the evolution of the eye has been problematic, and is still one of the favourite targets for creationists. Further, modern biology is riddled with teleological language and explanations just as much as ancient biology was, and teleology is even thought of as a useful explanatory device, although few biologists would really accept any form of goal orientation in evolution.²³ For both these reasons, therefore, Empedocles still may be still regarded as an anti-teleologist.

Simplicius ends with the claim that this is a scheme of adaptation common to all the ancient physicists who have material necessity as the cause of generation, and specifically attributes it to the Epicureans. This would place the Epicureans along with Empedocles in a tradition of Greek anti-teleological mechanistic zoogony in which creatures arise by chance and are then adapted by necessity, in the form of extinctions.²⁴ The striking point in Aristotle's comments is his assumption that Empedocles' system would account for fine adaptations such as the configuration of the teeth.²⁵ As I have said above, it seems that the simple extinctions of essentially unviable maladapted forms alone could not account for this. We cannot know whether Empedocles expanded on his theory with a second round of extinctions by competition, as Lucretius does, and thus accounted for fine adaptations,²⁶ but adaptation by natural selection in a struggle for life is not unique to Lucretius in ancient literature. It is found also in the Hippocratic *On Ancient Medicine* 3.26, where the writer gives an anti-primitivistic account of human origins, claiming that the first humans cannot have been healthy, given their wild, spontaneously produced, diet of grasses and roots, and that the majority of them, the weaker, died out leaving only the stronger to pass on their tough constitutions; in this way we have been progressively toughened and adapted to our environment by extinctions. But this seems to represent only one strand of medical thought on the subject. The Peripatetic Dicaearchus (fr. 49 Wehrli) claims, on the contrary, that the most eminent medical writers considered that the first humans were tougher and less subject to disease than their own contemporaries.²⁷

III. Other Presocratic zoogonies

The schemes of adaptation outlined above have been shown to be non-evolutionary, since they describe a process that takes place in the context

of species stability. Species come into existence in their present form rather than, as in the Darwinian and Lamarckian theories, starting as simple creatures which then become more complex as they evolve. There seem to be few hints that any ancient thinker, other than Plato in the *Timaeus*, conceived an evolutionary theory of the origin of species. It is mainly the Presocratic philosopher Anaximander who is reported to have held what sounds like an evolutionary theory. Hippolytus (*RH* 1.6.6, DK12 A11) reports that Anaximander believed:

Originally the human being was similar to another creature – that is to a fish.
(Trans. K.R.S. with alterations).

However, this suggestion that humans had evolved from animals in Anaximander's zoogony is somewhat undermined by other reports of his views, for example Censorinus 4.7 (DK12 A30):

Anaximander of Miletus believed that there arose from water and earth heated either fish or creatures very like fish: in these humans grew, and the embryos were retained inside them until puberty; then at last the fish-like creatures burst, and men and women who were already able to nourish themselves stepped forth.
(Trans. K.R.S.).

Censorinus makes it clear that Anaximander's first humans have not evolved from fishes, but are merely protected inside them. Since Anaximander's view seems to have been that all life arose in water, such an expedient to account for the survival of land animals would be forced upon him.²⁸ Indeed this idea of the first humans being protected inside fishes points strongly to the conclusion that Anaximander envisaged that species had arisen in the traditional way, fully formed by spontaneous generation. There is a strong similarity to Lucretius' use of wombs rooted to the earth in which the first humans grow (5.807 ff.). This would seem to be forced upon Lucretius by a similar need to account for the survival of helpless infants born directly from the earth.²⁹ So it would appear that Anaximander did not have an evolutionary view of the origin of species.³⁰ However, it may be important to note that Hippolytus describes the original fish-like state of humans in a matter of fact way, and so the idea of human evolution from animals may have been current.

The extant fragments of the other Presocratics do not describe the mechanism by which creatures are adapted into species, but they all seem to present a theory of the origins of life similar to that of Anaximander: the spontaneous generation of life from a mixture of water and earth in the presence of heat.³¹ It may therefore be reasonable to assume that, as Simplicius claims, the standard mechanism was similar to that found in Empedocles and Lucretius, of the earth generating creatures at random,

which are then formed into species by the extinctions of maladapted forms. One of the striking features of these Presocratic theories is that humans and animals are given the same origins, as in Archelaus:³²

On the subject of animals [Archelaus] holds that, when the earth was originally getting warm in the lower region, where the hot and the cold were mingled, many animals began to appear including humans, all living the same manner of life and all deriving their nourishment from the slime. But this continued only for a short time; afterwards arose the mode of birth in which one animal is produced from another. And humans were differentiated from the other animals, and so rulers and laws and arts and cities and the like arose. But mind, he says, is inborn in all animals alike. For each of the animals, as well as humans, makes use of mind, though some more rapidly than others. (Trans. K.R.S. with alterations)

Hippolytus does not give us any details of Archelaus' method of the differentiation of humans and animals, but it is clear that humans are regarded as simply another animal species, and we may presume that the differentiation arises, at least in behaviour if not in physiology, from the human possession of mind in greater measure than other animals. This would seem to be an anti-teleological view of creation and the evolution of society, and this is what we should expect from a zoogony that makes little distinction between humans and animals. On the other hand a clear divide is often associated with a teleological view of the world and the assumption of a 'Great Chain of Being' in which each creature has a fixed place in a hierarchy that exists for a purpose, whether divine or biological.³³

IV. Human evolution in Lucretius, Lamarck and Darwin

The closeness of the first humans and animals in both behaviour and physiology is a common theme of anti-primitivist or hard-primitivist prehistories.³⁴ Generally, the acquisition of arts and technologies, whether granted divinely or acquired by human ingenuity through trial and error, increases the differentiation between humans and animals, and leads to the formation of a human race recognizably different from one that was previously not clearly distinguished from the animals.

This process of becoming fully human is also seen in Lucretius 5.1011-27:

inde casas postquam ac pellis ignemque pararunt, 1011
et mulier coniuncta viro concessit in unum
conubium, prolemque ex se videre creatam,
tum genus humanum primum mollescere coepit.
ignis enim curavit ut alsia corpora frigus 1015
non ita iam possent caeli sub tegmine ferre,

*et Venus imminuit viris puerique parentum
blanditiis facile ingenium fregere superbum.*

post 1012 lacunam indicavit Marullus

1013 conubium Lachmann: cognita sunt OQ

Then after they got themselves huts and skins and fire, and woman was joined to man and retired into a single marriage, and they saw that children were created from them,³⁵ then the human race first began to soften. For fire saw to it that their tender bodies were unable to bear the cold under the open sky as they had before, and love lessened their violence,³⁶ and children with their winning ways easily broke the arrogant nature of their parents.

From 5.925 Lucretius had described the first humans (*genus humanum... illud* 'that human race' 925) as physically tougher, stronger, less susceptible to heat, cold or disease, and physically beast-like (*saetigerisque pares subus* 'like bristly boars' 970). They live a 'beast-like life'³⁷ without any arts or technologies, co-operation, marriage or society. Then (at 5.1011) they procure for themselves houses, skins and fire, and begin to live a settled existence with marriage, children, and family life. This leads to a softening, both physical and psychological, that enables them to begin to co-operate with one another and develop the first societies and language. Thus we have here an evolutionary change in human physiology and psychology, but one that comes about in quite a different way from what might be expected, given the scheme of adaptation by extinctions in 5.837 ff. There we saw some of the elements of a seemingly Darwinian scheme of adaptation, but set in the context of species stability. Here Lucretius' early humans evolve in response to their changing environment, but they are still unable to cross the species barrier imposed by the atomic laws of nature (*foedera naturae*); they evolve but remain within their own species. This explains the emergence of fully modern humans from an earlier, more 'primitive' human race, which was however still human – it emerged from the ground fully formed, and did not evolve from animals. This race becomes physically softer due to the effects of fire, softer psychologically from the effects of love and child care, and then, we must assume, these acquired characters are passed on to the offspring, who are born as fully modern humans. Such a mechanism of evolution is closer to that of Lamarck than of Darwin. In Lamarck's system creatures evolve by passing on to their offspring characters they have acquired during their lifetimes by responding to environmental change.³⁸ The giraffe, for example, has evolved its long neck as a result of parent giraffes stretching up to eat high leaves, thus lengthening their necks slightly. They then pass on this acquired extra neck length to their offspring, who are born with

slightly longer necks than their parents had been. They then repeat the process, and so on from generation to generation until we get the very long necked giraffes of today (*Philosophie Zoologique* 1.256–7). As Lamarck says (1.221):

I could prove that it is not at all the form either of the body or its parts that gives rise to habits, to the way of life of the animals, but that to the contrary it is the habits, the way of life and all the influential circumstances that have with time established the form of the bodies and the parts of the animals. With new forms, new faculties have been acquired, and little by little, Nature has arrived at the state where we see her now. (Trans. Burkhardt)

Of human evolution, Lamarck writes circumspectly (*Philosophie Zoologique* 1.349):

If man were distinguished from the animals only by his organization, it would be easy to show that the characters of organization that one uses to form a unique family for man with his varieties are all the product of old changes in his actions and habits that he has taken up, and which have become peculiar to his species. (Trans. Burkhardt)

The similarity to Lucretius' scheme is clear: his early humans first change their behaviour and are then changed physiologically by their new environment. Lamarck's theory was of course, different from that of Lucretius in that Lamarck explained the origins of species in a similar way to Darwin, with life evolving from simpler to more complex creatures. Lucretius' evolutionary adaptation on the other hand takes place within strict species boundaries ensured by the atomic laws of nature (*foedera naturae*). Empedocles also uses the inheritance of acquired characters in his explanation of the form of the backbone: the backbone acquired its flexible jointed nature from being broken while the creature was in the womb, and so from this single event each vertebrate creature has inherited a flexible backbone.³⁹ This example shows that Empedocles may also have used the inheritance of acquired characters to explain human evolution.

Lamarck's system does not rely upon extinctions of less well-adapted forms as Darwin's does, although adaptive mutations may well thrive at the expense of others.⁴⁰ In Darwin's theory, extinctions of non-adaptive mutations are necessary to ensure the passing on of the genes of adaptive forms. Natural selection must work as a filter, removing non-adaptive mutations.⁴¹ Indeed the association of adaptation by extinctions with evolution that we tend to make nowadays is a Darwinian innovation. Lamarck's great rival in zoology, Baron Cuvier,⁴² was a creationist and species fixist who first proved scientifically that species extinctions have

happened in the past, arguing that if creatures were able to evolve and adapt themselves in the face of environmental change we should see no species extinctions in the fossil record. This shows that extinctions were a feature of creationist theories before Darwin. Darwin's achievement was to unite extinctions with Lamarck's evolutionary theory and so devise a plausible mechanism of natural selection.⁴³ This is why we tend to associate, quite wrongly, any theory of adaptation that relies on extinctions with evolution. Before Darwin, the preconception was quite the opposite. As an illustration of pre-Lamarckian and pre-Darwinian thinking, we can see both of Lucretius' forms of adaptation – extinction of maladapted forms, and a direct evolutionary response to environment with the inheritance of acquired characters – in Rousseau's *Second Discourse*, part 1:

Accustomed from their infancy to the inclemencies of the weather and the rigour of the seasons, inured to fatigue, and forced, naked and unarmed, to defend themselves and their prey from other ferocious animals, or to escape them by flight, men would acquire a robust and almost unalterable constitution. The children, bringing with them into the world the excellent constitution of their parents, and fortifying it by the very exercises which first produced it, would thus acquire all the vigour of which the human frame is capable. Nature in this case treats them exactly as Sparta treated the children of her citizens: those who come well-formed into the world she renders strong and robust, and all the rest she destroys.

Again, as with Lucretius, Rousseau presents his early humans evolving in response to their environment, but since he was a creationist and species fixist, in a context of species stability.

This, then, in outline, represents something of the scientific background against which Plato's *Timaeus* should be viewed. It is clear that considerable achievements had been made in zoogony and theories of the origin of species in the fifth century BC, and it seems that a pattern of anti-teleological mechanistic thought can be traced from the extant fragments of the Presocratics and from their successors involving the origins of life by spontaneous generation from a mixture of heated earth and water, random construction of animals, adaptation by extinction of maladapted forms, the close original relationship between humans and animals, and the differentiation of modern humans from an original beast-like state in an evolutionary process that stops short of crossing species boundaries caused by the effects of culture and technology.⁴⁴ It does not seem that there was any clear idea that humans had evolved from animals, and, although evolutionary mutation was known and accepted, it was not used to explain the origin of species *per se*. At the same time humans were clearly seen as a species of animal with particular characters, some inborn

and some acquired, that made them distinctively human.⁴⁵ This remained substantially the rationalist position until the advent of Lamarck's theories in the early nineteenth century.

V. Zoogony and evolution in Plato's *Timaeus*

The above theories derive from Presocratic philosophical cosmogony; they were not of course conceived in a vacuum, but entered a field already well treated in myth. Greek anthropogonic myths shared some of the central features of Presocratic theories, especially the ideas of human origins from the earth⁴⁶ and the formation of life from earth and water.⁴⁷ A detailed study of the relationship between myth and Presocratic cosmology is beyond the scope of this paper, but Plato in the *Timaeus* makes much use of mythological accounts, and exploits the often blurred boundaries and close relationship between them and scientific cosmology. The following examination therefore of the mechanism of the origin of species in the *Timaeus* must also be seen in the context of cosmological myth.

A.E. Taylor was firmly against examining the scheme of the origin of species in the *Timaeus* in its scientific context, saying in his commentary (1928, 635):

At any rate it is wholly wrong to suppose that Plato is in deadly earnest, and to raise the question whether there really is an 'ontological significance' in difference of sex or whether anything could really be made of a doctrine of evolution *au rebours*.

However, since Plato does invite a mechanistic analysis of the origin of species from the reader, especially from one, ancient or modern, familiar with the standard Presocratic approach, I feel I should take him at least as seriously as I do Lucretius and Empedocles. Accordingly, it seems to me perfectly reasonable to examine the differences between views expressed in the *Timaeus* and traditional zoogonies, especially since some of the features it contains would, almost inevitably, strike ancient readers as startlingly unusual in a scientific account.

The zoogony presented in the *Timaeus* can be seen to share some features of Presocratic theories but is different in four key areas, suggesting that Plato appropriates Presocratic physical ideas, especially those of Empedocles and Democritus, and then subverts them.⁴⁸ Firstly, the order of creation in the *Timaeus* is unusual with humans created first, before the animals; secondly, animal species are formed by an inter-species evolutionary process of mutation from one to another; thirdly, there are no extinctions, such as we find in Empedocles and Lucretius, and fourthly, we have no spontaneous generation of life from the earth, as in Lucretius, Empedocles, and the other Presocratic zoogonies.

The Presocratics, including the atomists, make little distinction between anthropogony and zoogony, and indeed zoogony is simply a function of cosmogony, and anthropogony is an aspect of zoogony.⁴⁹ In the *Timaeus*, however, we see a strong distinction between humans and animals, and the position is reversed, with the origin of animal species as a function of the origin of humans. Plato's inversion of the traditional human/animal relationship gives a relationship between humans and animals which fits an anthropocentric view of the hierarchy of nature more closely than the Presocratic theories, where humans and animals arise from the same source, either at the same time or with animals first.

However, the cosmogony, zoogony, and anthropogony of the *Timaeus* start normally enough, with the creation of the world, followed by the creation of the stars, and then of life, in the traditional order exemplified by Lucretius at 5.416–836.⁵⁰ Living creatures are created by a demiurge (who makes the souls, *Timaeus* 41d) and the lesser gods (who make the bodies and fasten them to the souls, 42e–43a). The materials used for the bodies are also the traditional ones, matching the Empedoclean elements of earth, air, fire, and water. The resulting creatures are to become the three mortal kinds as yet uncreated (41b8 with 39e–40a). The four forms of living creatures are the stars, birds, water animals, and land animals. Here we find the first inversion, with the astronomy treated as part of the zoogony, rather than, as we should expect from the Presocratics, as part of the cosmogony. Then there is a seemingly traditional picture of the place of humans in the grouping 'land animals', but followed by the statement that the original state of all these creatures is to be human (42a1). Thus, the order of creation is reversed, with humans created first and then animal species.⁵¹ Animal species are formed by a process of degradation from the original ideal creature, the human being (42b ff., 91a ff.) so that animals are human, an inversion of the Presocratic scheme in which humans are animals. The variety of nature, accounted for by Lucretius by the random creation of patternless creatures in the beginning, is thus derived by an evolutionary process from an original singularity of form. Humans who are unable to control the emotions engendered by the tension between body and soul (42a ff.) mutate in the second generation and become women. We are not told of the origins of males, but we may presume that the original humans are not gendered.⁵² Here again we find an unexpected separation when compared to the Presocratics and Lucretius, who describe humans arising as already gendered creatures.

This process of mutation and 'decline' continues until the earth is populated by all the animal species (91d ff.) that are necessary to ensure that it matches the original world of which this world is only a copy. This

makes it clear that we are still in a traditional context of the immutability of species. The animals can mutate one into another, but the pattern for each species is already fixed. No new species that does not already exist in the original world can be created by this process. In the *Timaeus*, we have no extinctions of maladapted forms as in Empedocles, Lucretius 5.837–54, and Darwin. The mutations are caused by a behavioural change, which leads to physical change: bestial behaviour leads to a metamorphosis into a creature with that particular form of bestial nature (42c). Thus this process is Lamarckian in the sense that function precedes form, if somewhat oddly in the Platonic context. The functionalist scheme of evolution is essentially the same as that found in Lucretius 5.1011–27 where modern humans evolve physically in response to behavioural change. Yet the Timaeian scheme is the reverse of those of both Lucretius and Lamarck. Lamarck envisaged an inevitable rise of simpler creatures towards more complex forms on a sort of evolutionary escalator, with the simplest creatures of all being constantly spontaneously generated to fill the gaps left by those who had evolved and moved ‘up’, while Plato gives a descent from the most to the least complex. Lucretius, as is traditional, has a move away from a bestial state towards a fully human one, while Plato’s humans evolve towards the bestial.

The three animal groupings described correspond to three of the four Timaeian constituents of matter, which have long been recognized as perversions of the Empedoclean ‘roots’:⁵³ birds correspond to air, land animals to earth, and fish to water. The fourth ‘root’, fire, corresponds to the fourth of the kinds of living creatures, the stars, whose birth is described at 39e ff. We are therefore again reminded of Presocratic cosmology. Birds are formed by a process of attraction of like to like (91d7 ff.): ‘light-minded men’ grow feathers instead of hair and become birds, i.e. animals who inhabit air, the light element. We find the formation of the world described by such a process of attraction of like to like in Lucretius’ cosmogony (5.449 ff.), where the elements separate out as the world forms, earth sinking down to the bottom because of its weight, water next heaviest forming the sea, air floating above earth and sea, and aether, lightest of all, rising up to form the stars.⁵⁴ Diodorus Siculus 1.7.1–6 gives a picture of the origins of the animal kingdoms by the same process: earthy creatures become land animals, wetter creatures become fish and airy creatures become birds. This viewing of zoogony and cosmogony in the *Timaeus* as part of the same process is very much what we should expect from Presocratic sources,⁵⁵ but Plato plays with this mechanistic idea and subverts it, bringing in the idea of metamorphosis caused by behaviour. We may reasonably assume that ‘light-minded men’

refers, in a mischievous way, to the Presocratic physicists, since we are told that they are 'meteorologists' who rely on their eyes to provide the strongest proofs of their theories.⁵⁶

Land animals are said to have been formed from men who did not study philosophy or cosmology at all, in a process of attraction of like to like similar to that affecting the birds: they are drawn downwards to the earth because of their kinship with it (91e8 ff.). In addition, we are given a further factor in their metamorphosis: the atrophy of the rational faculties in the head from disuse leads to a distortion and elongation of the head, making it more beast-like. This again reminds us of two important factors in Lamarckian evolution: the atrophy and loss of organs from lack of use, and the inheritance of acquired characters.⁵⁷ As the neck of the giraffe has been distorted by stretching in constant use, so organs and limbs may weaken from lack of use and eventually disappear. A straightforward teleological explanation is also added to these two aspects. At 92a1 ff., we are told that god granted four legs to these animals in order that they might be dragged down to the ground further still. The most foolish land animals were granted no limbs at all and became snakes, and so the process of attraction of earth to earth was completed.

Fish and other sea creatures were formed by two processes (92a8 ff.). They, being unworthy to breathe pure air because of their wickedness, were relegated to the sea to breathe the more turgid water. They also were given the lowest geographical position possible on earth to match their lowest position of intelligence.⁵⁸ This again seems a mixture of the teleological and mechanistic. We could reasonably expect that fish, as with land animals, would be formed by the further atrophy of their rational faculties through lack of use, leading to a further flattening and lengthening of their bodies and loss of limbs. But we are told that they were remoulded by the gods in a purposive way to match their wicked natures. Of course, the metamorphosis of creatures into new species is teleological whether or not the process is mechanistic and functionalist, since all species come into being to fulfil the purpose of the demiurge and so complete the perfect match of this world with the original. The derivation of fish from land animals may reasonably be seen as evidence that Plato is inverting Anaximander's theory that all life, including land animals, arose in water (see above, Section III). Lucretius specifically argues against the idea that land animals could have originated in water (5.794), and this is often interpreted as a polemic against Anaximander.⁵⁹ All theories of the spontaneous generation of life are vulnerable on this point of accounting for both land and sea-creatures because of the insistence on the fixity of species, as can be seen from Lucretius' avoidance of the subject

of the generation of fish and Anaximander's expedient of protecting the first humans inside fish-like creatures. Accordingly, Plato is given an easy target, and his evolutionary theory of land animals turning into sea-creatures is a more coherent explanation. From a Darwinian point of view, it would be even more acceptable had he not inverted Anaximander's theory and instead derived land animals from sea-creatures.⁶⁰ However, in Plato's inverse and strictly hierarchical chain of being, this would mean that fish are 'higher' in the scale than land animals, an unacceptable conclusion. Diodorus Siculus, who gives a standard picture of the spontaneous generation of life from the earth (1.7), with the watery creatures becoming marine life, may have solved the problem of fish survival: since some parts of the world were wetter than others, we could perhaps imagine the generation of fish in mud or shallow pools.

In the Timaeian scheme we find both the traditional species stability and an evolutionary origin of species by transformation from one to another, resulting in a theory of evolution within a fixed system of species similar in some ways to that found in Lucretius 5.1011–27 (discussed in section IV). However, Plato approaches the problem quite differently from Lucretius. Lucretius has all species, including humans, arising fully formed by spontaneous generation, but then the humans, at first physically and psychologically beast-like, undergo an evolutionary change that stops short of crossing species boundaries. These boundaries are provided by the passing from parent to offspring of a fixed atomic genetic pattern that ensures the continued integrity of the species.⁶¹ Plato's species boundaries are also fixed, but they arise from the patterns of the animals that the demiurge has already created. Thus, the animal species in this world exist both potentially and by necessity: they must come into existence to ensure the perfect match of this world to the demiurge's model (41b8–c1).⁶² It should thus be impossible for any species to come into existence that does not already exist in the creation of the demiurge, and no species extinctions are allowable for the same reason. Accordingly, we should expect the period of metamorphosis of animals one into another to be limited strictly to the period before all species have come into existence. After this, no new forms can be created, and it would seem unnecessary for there to be continued physical change when the process of decline and rise through the hierarchy can be achieved by metempsychosis. The description of the continued metamorphosis of animals 'both then and now' (92b9–c2) seems to be a conflation of the two ideas of metamorphosis and metempsychosis of the kind often found in mythology, especially in Ovid's *Metamorphoses*.

VI. Metamorphosis and metempsychosis

The scheme of origin of species given in Plato's *Timaeus* may well be unparalleled in scientific philosophy, but it is of course familiar from Greek mythology. The *Metamorphoses* of Ovid is a rich source of aetiological transformation myths, in which the origin of a particular species of animal is explained as a process of transformation undergone by a human being.⁶³ The aetiologies are clearly intended to account for a particular characteristic of the species, behavioural or physiological, by the presence of that characteristic in the human and its retention in the new species. Further, certain humans become animal species because of the possession of a particular characteristic. In this, the thinking would seem to be very similar to the Platonic assumptions in the *Timaeus*, of a behavioural causation of physiological mutation, much in the Lamarckian manner. People start behaving in a certain way and then become a creature that matches their behaviour. The theory is clearly circular in Ovid: bestial behaviour leads to transformation into bestial shape, but the beast did not exist before to provide a pattern of shape or behaviour. The *Timaeus* avoids this circularity by having all species, and so a pattern of bestiality, already existing in the demiurge's model. The origins of birds, Plato's first example of an origin of species by transformation (91d7 ff.), are known to have been explained by such processes of metamorphosis by Boios in his *Ornithogonia*,⁶⁴ one of Ovid's sources among others, and so the theory was well known and comfortably accepted in mythography. The status of these schemes of origin of species as Pythagorean is doubtful. On the one hand Plato's and Ovid's accounts of species origins have a strong Pythagorean colouring,⁶⁵ but on the other we are told by Porphyry that Pythagoras held a very standard materialist view of cosmogony (*Life of Pythagoras* 44):⁶⁶

...when the first origin and birth of all things was in confusion, and many things were at the same time mingled together, sown together, and rolled together in the earth, birth and separation gradually took place, animals being born and plants growing up at the same time. Then from the same putrefaction men were born and beans sprouted.

This theory of the origins of life by the spontaneous generation of fully formed species is very much what we would expect of a materialist physicist, and would seem to have no place in it for the origin of species by evolutionary metamorphosis as we find in the *Timaeus*. In Plato's Pythagorean account all creatures are formed by a process of metamorphosis, and it would seem that the two processes of metamorphosis and spontaneous generation are mutually exclusive in a scale of descending

evolution.⁶⁷ But the reconstruction of Pythagorean physics is highly speculative, given the paucity of independent sources and the influence of the *Timaeus* on later commentators,⁶⁸ and the question of whether the Pythagoreans had such a scheme of the origin of species by transformation, or whether Plato has grafted a mythological scheme onto Pythagoreanism, is an open one. Empedocles has always been closely associated with Pythagoreanism (see Wright, 1995, 4 and 275, Furley, 1987, 79). This seems partly based on evidence for his vegetarianism (fr. 139), belief in transmigration (fr. 117) and praise of Pythagoras (fr. 129), and partly upon an association of the four-element theory with Pythagoreanism. It is possible, however, that the Pythagoreans did not have a four-element theory and that the confusion arises from the *Timaeus* itself (so Burkert, 1972, 69–71 and 356), according to Aristotle *Met.* 990a16:

They have not said anything at all about fire or earth or the other material things of this sort, because, I suppose, they did not have anything distinctive to say about perceptible things.

However, it can now be seen from the Strasbourg fragments that Empedocles' religion and physics are not mutually exclusive (reinforcing Wright 1995, 57–69). The proem to the *Physics* may have contained the Pythagorean material formerly attributed to Empedocles' other poem the *Καθαρμοί* (*Purifications*), in particular the praise of Pythagoras for recalling his past transmigrations (fr. 129), an explanation of transmigration (fr. 115), and the entailed horror of meat eating, exemplified by a father sacrificing his transmigrated son as an ox (fr. 137).⁶⁹ This gives a much stronger link between the physics and the daemonology, but there is no sign of Empedocles accounting for the origin of species by blending transmigration with physical mutation as Plato does.

It may well be that we see Plato in the *Timaeus* adopting a similar technique to that of Vergil, who remythologizes the cosmology and aetiology that Lucretius had previously appropriated and demythologized. Plato remythologizes cosmology previously appropriated from myth by the Presocratics.⁷⁰ Ovid in the *Metamorphoses* achieves the same end by the use of scientific terminology applied to mythological cosmology and aetiology.⁷¹ Empedocles' presentation of physics in a Pythagorean context would make Plato's task easier since, with divisions between religion and physics already eroded, Plato can make the last move towards producing the blend of mythology and physics we find in the *Timaeus*. According to this analysis, Plato would be appropriating certain features of Presocratic physics and Pythagorean psychology, available to him ready blended in Empedocles' *Physics*; he then further blends them with mythological

transformational aetiologies for the pattern of species to produce an inversion of scientific zoogony, which reclaims zoogony for the teleological view of the universe and has a gloss of scientific respectability. In this he would be greatly aided by Empedocles' close association with Pythagoreanism, and especially with the theory of metempsychosis. The transition from metempsychosis, the migration of souls between creatures in an 'upward' or 'downward' progression, to the idea of the physical formation of species by transformation of one into another is not too great a conceptual leap, and seems almost inevitable.⁷² The relationship between metempsychosis and metamorphosis is left ambiguous by both Plato and Ovid. In *Metamorphoses* 15.60–478, Ovid's Pythagoras never quite says that the aetiologies of species' origin by metamorphosis presented earlier in the poem are strictly analogous to the transmigration of souls, but strongly suggests this.⁷³ Plato similarly leaves the exact relationship between the origin of species by evolutionary metamorphosis and Pythagorean metempsychosis vague, especially at *Timaeus* 42b3–d3, 90e8–91a1, 91d7–8, 92b9–c2.

VII. Conclusion: Plato's *Timaeus* as subversive text

We can therefore see that Plato has taken scientific cosmogony and zoogony and subverted it for his own teleological purposes. The bodies of living creatures are formed from Presocratic ingredients, but they are not generated spontaneously from the earth. The four types of living creatures are analogous to the four Empedoclean 'roots' of matter. Species are at one and the same time fixed *and* able to metamorphose into one another. The origin of species is achieved by an evolutionary process, without extinctions. The order of creation and the relationship between humans and animals is inverted to produce a more anthropocentric cosmology. A scientific gloss is given to a fundamentally mythological zoogony by the appropriation of scientific themes and language, and, finally, the introduction of Pythagorean metempsychosis returns us, via Empedocles, to links with mythological cosmogonies in Presocratic science. The whole is achieved with a thoroughly comprehensive grasp of scientific cosmology.

To bring my argument back to where I began, I hope I have shown in this partial and selective study that it is worthwhile attempting to examine the *Timaeus* in a mechanistic context, that we inevitably view ancient theories of evolution from a Darwinian perspective, and that recognition of that fact can yield a clearer view of antiquity. To put it another, Fowlerian, way: from Darwin to Plato's *Timaeus*, Lucretius, and Empedocles, the directionality of intertextual reference is reversed.

Whether we like it or not, Darwin will be our source text and *Timaeus*, Lucretius and Empedocles our target texts, and so knowledge of Darwinism becomes crucial.⁷⁴

Finally, just as Plato's *Timaeus* appropriates and subverts a tradition of Presocratic scientific cosmology, it is itself part of a subversive tradition. This finds modern expression especially in 'Scientific Creationism', which seeks to undermine Darwinism by the appropriation of its very scientific basis.⁷⁵ As part of this tradition, atomism in particular has been the subject of many accusations over the centuries that it cannot account for the stability of the universe or the ontological stability of creatures. A history of these attacks must wait for another day, but in the meantime, my favourite subversion of atomistic cosmology is in Flann O'Brien's *The Third Policeman*. O'Brien brilliantly plays on the idea of the 'law' of nature. In the parallel universe of 'The Parish', it is necessary for three policemen to control and set limits to the damaging effects of the workings of the atomic theory by the use of complicated and mysterious machinery. However, as people ride their bicycles, the atoms of human and bicycle become exchanged, and so Sergeant Pluck also takes more direct action to limit the damage done to people's atomic integrity by stealing their bicycles on a regular basis and then 'finding' them again after a few days. This theft slows down the metamorphosis into bicycles, but of course, there are similar dangers involved in walking and horse riding.⁷⁶ *The Third Policeman* 1967, 72 ff.:

'The Atomic Theory' I sallied 'is a thing that is not very clear to me at all.' 'Michael Gilhaney' said the Sergeant 'is an example of a man that is nearly banjanxed from the principle of the Atomic Theory. Would it astonish you to hear that he is nearly half a bicycle?' ...

'Are you certain about the humanity of the bicycle?' I inquired of him. 'Is the Atomic Theory as dangerous as you say?'

'It is between two and three times as dangerous as it might be' he replied gloomily. 'Early in the morning I often think it is four times, and what is more, if you lived here for a few days and gave full play to your observation and inspection, you would know how certain the sureness of certainty is.' ...

'The gross and net result of it is that people who spend most of their natural lives riding iron bicycles over the rocky road-steads of this parish get their personalities mixed up with the personalities of their bicycle as a result of the interchanging of the atoms of each of them and you would be surprised at the number of people in these parts who are nearly half people and half bicycles.' ... The Sergeant's face clouded and he spat thoughtfully three yards ahead of him on the road. 'I will tell you a secret' he said very confidentially in a low voice. 'My great-grandfather was eighty-three when he died. For a year before his death he was a horse!'

'A horse?'

'A horse in everything but extraneous externalities. He would spend the day grazing in a field or eating hay in a stall'...

'I suppose your great-grandfather got himself into this condition by too much horse riding?'

'That was the size of it. His old horse Dan was in the contrary way and gave so much trouble, coming into the house at night and interfering with young girls during the day and committing indictable offences, that they had to shoot him...but if you ask me it was my great-grandfather they shot and it is the horse that is buried up in Cloncoonla churchyard.'

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Notes

¹ For the relationship between Plato's *Timaeus*, the book of Genesis and Lucretius, see Pelikan, 1997.

² On the reversal of the directionality of intertextual reference see Fowler 2000, 115–35. On Lucretius and Plato see de Lacy 1983, Solmsen 1951, Sedley 1998, 62–9, Cole 1990.

³ Lucretius was the main focus for creationist attacks until Darwin's *Origin of Species* took over the role of chief exponent of an anti-teleological view of creation. See Townsend 1889, part 6, 'The Revolution Against Evolution' <<http://www.rae.org/>> with the comments of D. Sharp ad loc. in *Origins & Design* 18:1 <<http://www.arn.org/docs/odesign/od181/editor181.htm>>. See also Karen Bartelt on Lucretius' place in the anti-Evolutionist exhibition at the Institute for Creation Research, 'A Visit to the Institute for Creation Research' <<http://www.utm.edu/research/iep/e/evolutio.htm> (all November 1999), and Jones, 1989. Like the Presocratics and Atomists Darwin is principally concerned with the mechanism of adaptation, but his lack of knowledge of ancient ideas is shown by the 'Historical Sketch' prefacing *Origin of Species* (6th edn, 1872, xviii–xix) where he wrongly attributes an evolutionary theory to Aristotle on the strength of *Physics* 2.8 198b. It is indicative of the extent to which we view ancient theories through a Darwinian filter that Edelstein felt called upon to set the record straight. He rightly shows that Aristotle was not an evolutionist (see Edelstein, 1943/4, and Blundell, 1986, 62 ff.). I spare the reader my discussion

of this Darwinian dominance of our thinking in terms of Dawkins' 'memes', but meantime see Dennett 1995, 342–69.

⁴ This may be an unduly polarized view, but Furley 1989, 225, speaks of a 'crisis' in cosmology, and identifies 'just two fundamentally and comprehensively different ways of interpreting the cosmos. On the one hand, the atomic theory of Leucippus and Democritus, later adopted by Epicurus and his followers; on the other the theory of Plato, later adopted and modified by Aristotle, and again modified by the Stoics.' I suggest that the atomic theory is not a crucial prerequisite for an anti-teleological mechanistic view of creation, and that Empedocles, at least, of the other non-atomist Presocratics is also an anti-teleologist.

⁵ It is important to point out that Lucretius is describing the creation of this world rather than the entire universe. For the Epicureans the universe is infinite in time and space, while this world (including sun, stars, moon and planets) is mortal and will one day perish (see Solmsen, 1953). The Epicurean universe is made up of an infinite number of worlds constantly coming into being and dying, see Epicurus *Ep. Hdt.* 45, and 73, *Ep. Pyth.* 88, Lucretius 2.1048–89, and 5.91 ff.

⁶ For the Epicurean idea of limit as the 'law' that ensures the regularity of the universe see Blundell, 1986, 92–3, and Long, 1977, 63–88. The key texts are Epicurus *Ep. Hdt.* 42–3, Lucretius 2.478–531, 661–79, 5.440–2 and 923–4. The need for 'law' to prevent the atomic theory causing cosmic chaos is brilliantly satirised by Flann O'Brien in *The Third Policeman*, in which three policemen are needed to control and restrict the workings of the atomic theory; see section VII.

⁷ Furley, 1989, 229 ff. points out the traditional nature of the analogy drawn between cosmogony, zoogony and embryology, in which the three are viewed as essentially similar processes of birth. For Lucretius' zoogony in general see especially Schrijvers 1999.

⁸ 5.836–7 reads *multaque tum tellus etiam portenta creare | conatant...* I take *tum* as 'at that time' rather than 'next' in a sequence of creation (see West, 1964 on *tum* at 5.805). Schrijvers 1996, 842–3, interprets the line as 'the earth also produced monsters (as women sometimes do now)'. Professor Stephen Simpson has suggested to me that perhaps this production of monsters by the earth is due to her increasing senescence. I feel however that this would require there to be a pre-existing pattern for a norm of species, in the Platonic manner, which the earth was no longer able to follow due to old age, and I cannot think that this is an Epicurean view.

⁹ See esp. the commentary of Pease ad loc. for details of ancient providentialism.

¹⁰ Lucretius uses *saecla* interchangeably with, and as the plural of, *genus*: 5.862 *genus acre leonum saevaue saecla*, 5.431 *generisque animantum*, 5.925 *genus humanum*, 5.988 *mortalia saecla* (of humans), 5.982 *saecla ferarum*. Aristotle uses *eidos* for species, *PA* 644a24–5, and *genos* for genus, *PA* 644a33. But see Pellegrin 1982 and 1985, who points out that Aristotle is not particularly

concerned with establishing an accurate system of taxonomy, and this would seem to be true also for Lucretius.

¹¹ Survival by cooperation is crucial to the Epicurean view of the evolution of society, see Lucretius 5.1011–27 (Section IV), with Algra 1997, 141–50, and Blickman, 1989, 157 ff.

¹² I am here deliberately anticipating Aristotle's discussion of Empedocles' theory in *Physics* 2.8 198b. It seems that the Epicurean theory would ascribe the 'norms' of nature such as four limbs and five digits entirely to chance, and that these 'norms' need not necessarily obtain in other worlds where conditions may be different, see *Ep. Hdt.* 74, *Ep. Pyth.* 88.

¹³ 5.923–4: *sed res quaeque suo ritu procedit et omnes | foedere naturae certo discrimina servant* ('but each thing proceeds after its own fashion and all things preserve their distinctions by a fixed law of nature'). See 2.700 ff., Blundell 1986, 92–3, Schrijvers 1974, 249 ff., O'Brien 1968, 311 ff., and note 7 above.

¹⁴ The fixity of species was an accepted fact in nearly all ancient scientific thinking on zoogony, see Furley 1987, 98. Interestingly, the traditional Darwinian insistence on the constant mutation of species under the influence of environmental change has recently come under question. Palaeontologists such as Gould and Eldredge put forward a theory of 'punctuated equilibrium' in which species stay much the same for millions of years and will not evolve except under special conditions. When faced with environmental change they will first move location ('habitat tracking'), secondly they will become extinct, and only thirdly will they evolve to adapt themselves to a new environment (see especially Eldredge 1995, 57 ff.). At the extreme end of the Darwinist spectrum is the 'Red Queen' hypothesis of van Valen 1974, in which species will constantly evolve even without environmental change, in an attempt to retain their relative positions in a competitive hierarchy.

¹⁵ Empedocles fr. 17 with new Strasbourg fr. a(ii) in Martin and Primavesi 1999. The Empedocles fragment numbers are those of DK 1952. Although Martin and Primavesi (88 ff.) consider that the new fragments of Empedocles show conclusively that he has this double cosmic cycle, others are still unconvinced. For the different ancient interpretations see Wright, 1995, 49 ff., and for various modern interpretations see O'Brien, 1969, 196–236, Osborne, 1987.

¹⁶ See Martin and Primavesi, 1999, 138–9 (commentary on p. 226–46). They consider that this passage introduces the zoogony under Strife; however, the phrase 'coming together and unfolding of the stock' a(ii) 23 and 30 suggests that both zoogonies are here introduced, and 'as many as are now remaining of this generation' a(ii) 25 suggests the role of extinctions, which are certainly involved in the zoogony under Love but may or may not be part of the zoogony under Strife. Accordingly, I have placed a(ii) 23–30 as an introduction to the zoogony under Love.

¹⁷ i.e. male and female, a phrase borrowed by Lucretius, compare 2.1081–2: *sic montivagum genus esse ferarum | sic hominum geminam prolem*, 'thus is the mountain-roaming race of wild beasts, thus the twin stock of humans'. See Martin and Primavesi ad loc.

¹⁸ Compare Aristotle *PA* 661b7 and Xenophon *Mem.* 1.4 where the configuration of the teeth is presented as evidence of design in nature.

¹⁹ See Furley 1987, 94–8, 1989, 115–20, and Sorabji 1980, 180 ff. There are some striking intertextualities between Lucretius' *portenta* and Empedocles' monsters; cf. 5.839 *androgynem* and Empedocles fr. 61.3–4 μεμυμένα τῆ μὲν ἀπ' ἀνδρῶν | τῆ δὲ γυναικοφύη..., 5.842 *vinctaque membrorum per totum corpus adhaesu* and fr. 60 ἀκριτόχειρα 'with hands not properly articulated or distinguishable' Wright, 1995, ad loc. (so also Bollack, 1969, vol. 3.2, 421).

²⁰ Sorabji 1980, 180–1, concludes that Empedocles presents a non-teleological theory. Sedley 1998, 18–21, and Long and Sedley 1987, 2, 64 consider that Empedocles' scheme is not necessarily anti-teleological and that Aristotle chooses it simply to illustrate what an anti-teleological theory would look like if there were one. Against this, see my review of Sedley, Campbell 1999. Aristotle's criticisms are in the context of his proof of biological teleology as a final cause.

²¹ See Dean-Jones 1994, 162 ff.; Sorabji 1980, 176–7; Wright 1995, 10 and 49–52.; Gotthelf 1987, 215–6 (in Gotthelf and Lennox 1987). Aristotle *GA* 722b17–30 describes Empedocles' theory as pangenetic and preformationist, with the preformed miniature limbs of the embryo provided separately by each of the parents' organs (see Balme ad loc.). The Hippocratic theory is also pangenetic but less preformationist, e.g. *Nat. Puer.* 17 (vii 496.19–20). Lucretius is also a pangeneticist, but his theory avoids the necessity for preformation of tiny limbs and organs by having each species pass on to its offspring an immutable atomic pattern, which presumably contains all the information necessary for guiding the formation of the embryo (2.700 ff.), see Balme on *GA* 722b3 ff. The ancient debate on embryology was mirrored in the eighteenth century in the arguments between the Preformationists and the Epigeneticists. The Preformationists considered that each embryo must begin as a tiny homunculus within the egg or the sperm since, as mechanists, they denied the possibility of an overarching 'vitalistic' force to organize separated parts of an embryo into the correct configuration. The Epigeneticists argued that the material for the embryo must be supplied by both parents if inheritance of characteristics from either parent were to be accounted for. The Epigeneticist Pierre Louis de Maupertuis attempted to solve the difficulty from a mechanistic point of view in his *Vénus physique*, 1745, by arguing that the disaggregated parts of the embryo contained within the seed of both parents were brought together by a kind of gravitational attraction between correctly fitting parts. The similarity of this system to Empedocles' is clear: Maupertuis has simply replaced Empedocles' Love with 'gravity' as a combining power. See Gould 1985, 150.

²² See Sedley 1998, 19–21.

²³ As an example, my 8-year-old daughter recently asked me 'Why do trees have leaves?' I replied without thinking, 'So they can make their food', an answer which satisfied her. Then I realized the explanation was teleological and tried to put it properly: 'Well, no, they can make their food because they have leaves...' After ten minutes of this she was thoroughly confused. For the evolution of the eye see Dawkins 1996 and Nillson 1989. For teleology in biology see especially

Mayr 1961, and Gould and Lewontin 1979. Mayr allows that teleological thinking may be useful in certain circumstances, Gould and Lewontin fiercely attack any form of teleology.

²⁴ It appears that we may trust Simplicius since he seems to have worked directly from Empedocles' text and, although he and Aristotle agree, Simplicius explains Empedocles more clearly and provides more detail. See Wright 1995, 51.

²⁵ Aristotle (*Physics* 198b33–99a8) rejects Empedocles' theory only because it relies upon the sort of chance that is not seen in nature, and not because it could not account for fine adaptations.

²⁶ However Strasbourg fr. a(ii)25 may possibly suggest extinctions of viable creatures rather than unviable ones such as the 'man-faced ox creatures': ὄ[σ]α τε νῦν ἔτι λοιπὰ πέλει τοῦτοιο τ[όκοιο] 'and as many as are now still remaining of this generation'.

²⁷ The idea of the greater toughness, size, and strength of early humans is very common throughout ancient, medieval and modern literature, and is found in both soft and hard primitivistic contexts, e.g. *Iliad* 1.260 ff., 5.303 and 12.381–3; Hesiod *Op.* 143 ff., Herodotus 1.68; Lucretius 5.925 ff.; Vergil *Georg.* 1.63 and *Aen.* 12.899–900; Ovid *Met.* 1.414–5 and *Ars* 2.473 ff.; Pliny *NH* 6.30 and 7.15; 1 *Corinthians* 15; Aulus Gellius 3.10; Augustine *Civ. Dei* 15.9; Pseud. Clementina *Homilia* 8.10–17; Rousseau *2nd Discourse* pt. 1. Curiously, it is actually true that early-modern humans were larger and more robust than we are. The stature and robustness of *Homo sapiens* decreased dramatically between 10,000 and 5,000 years ago. See Lewin 1999, 60 ff. For disease resistance and natural selection see Ridley 1997, 48 ff. and Skelton 1993, 927 ff.

²⁸ Compare also the other reports of Anaximander in DK12 A10 and A30 (Ps. Plutarch *Strom.*, Plutarch *Symp.* 8.730e, Aëtius 5.19.4) discussed by Blundell 1986, 26–32. See also Guthrie 1957, 32 ff.

²⁹ That this was a problem for proponents of the original spontaneous generation of life is shown by the criticisms of the Peripatetic Critolaus (reported by Philo *Aetern. Mun.* 55 ff) who argues that if humans were originally born as adults they would still be born that way today, or if they were born from the earth as infants they would not have survived. For spontaneous generation see Waszink 1964; Guthrie 1957, chaps. 1 and 2; Louis 1968; Schrijvers 1974.

³⁰ See Loenen 1954.

³¹ Blundell 1986, 48, 'no other basic hypothesis, so far as we know, was ever put forward in scientific philosophy'. A similar outline of cosmogony is found in Lucretius' contemporary Diodorus Siculus 1.7. He has life originating by a process of fermentation, from wet clay heated by the sun, inside membranes that protect the embryos until it is time for them to be born. The separation into fish, birds and land animals is achieved by an attraction of like to like: wetter animals become fish, earthier ones land animals, and warmer ones birds. He does not however give a mechanism of adaptation into species. The relationship between Diodorus and Lucretius is complicated, but it is probable that they each derived their cosmogonies independently from Presocratic sources. See Spoerri 1959, 1–33, and Blundell 1986, 68 n.22 for a bibliography of the

controversy.

³² from Hippolytus *RH* 1.9.1 (DK60 A4.5–6).

³³ See Blundell 1986, 74 ff., Lovejoy 1936, chs. 1 and 2, and Dubois 1982.

³⁴ See Lovejoy and Boas 1935, 9–11 and Gatz 1967.

³⁵ Or 'saw the children which were created from them'; both readings must be from the male point of view: either that the men had simply not been in contact with their children before in the wandering phase, or, as I prefer, in the manner of the Trobriand Islanders, they did not realize that children had anything to do with sex until they started living permanently with the women (see Malinowski 1932). This latter realization would perhaps be a more profound psychological shock. Marullus emends *videre* to *dividere*, 'they distinguished the children who were born from them', i.e. they could now tell which children were theirs.

³⁶ The effects of Venus in 5.1017 are probably both a physical weakening and a psychological softening, compare 4.1121: (of lovers) *adde quod absumunt viris pereuntque labore* 'in addition they use up their strength and perish from the effort', and Ovid *Ars* 2.473–7: *tum genus humanum solis errabat in agris | idque merae vires et rude corpus erat | ... blanda truces animos fertur mollisse voluptas* 'then the human race wandered in the lonely fields | and they were of undiluted strength and rough body | ... sweet pleasure is said to have softened their savage spirits'.

³⁷ 5.932 *vulgivago vitam tractabant more ferarum*, 'they lived life in the wandering manner of wild beasts'. Many ancient writers refer to the first humans living a life like wild beasts, commonly a θηριώδης βίος in Greek, cf. for example Diodorus Siculus 1.8.1, Euripides *Suppliants* 195 ff., Critias *Sisyphus TrGF* 1.43 frs. 19 and fr. 25.1.

³⁸ See Lamarck 1809 and 1835 with Løvtrup 1987, 39–55, Burkhardt 1995, and University of California Museum of Palaeontology <<http://www.ucmp.berkeley.edu/history/lamarck.html>> November 1999. Note that the inheritance of acquired characters was standardly accepted in ancient thinking, e.g. Empedocles fr. 97, Aristotle *GA* 721b18 ff. (see Balme on Aristotle *GA* 721b7 ff.), but is no longer thought to be possible. However, neo-Lamarckism long provided an alternative mechanism to Darwinian natural selection, especially in the Soviet Union under Lysenko, with disastrous results for Soviet agriculture. See Bowler in Fox Keller and Lloyd 1992, 188 ff.

³⁹ Aristotle *PA* 640a19–22 quoting fr. 97. There is argument over whether this was an isolated chance event, or whether Empedocles means that this is how the backbone normally is formed in each creature. The latter would not rely upon the inheritance of acquired characters; see Sorabji, 1980, 180. Aristotle *GA* 721b7 ff. rejects pangenesis with special reference to Empedocles, and he gives the inheritance of acquired characters as one of the arguments traditionally used in favour of pangenesis (*GA*. 721b18 ff.). He accepts that characters may be inherited but explains the phenomenon differently, see Balme ad loc. who compares Anaxagoras fr. 10 on pangenesis.

⁴⁰ *Zoologie philosophique*: 1.37 (Løvtrup, 1987, 47–8).

⁴¹ *Origin of Species* (6th edn, 1872), 132: '...as new forms are produced, unless

we admit that specific forms can go on indefinitely increasing in number, many old forms must become extinct'. See Bowler loc. cit. 106 ff.

⁴² Cuvier 1799, 12. See Burkhardt 1995, 128–9 and 193–4. For the relationship between Cuvier and Lamarck see Daudin 1926–7.

⁴³ Bowler loc. cit. 107: 'During this period, however, extinction was considered by many to be a fact opposed to evolution... Darwinism reconciled extinction and transformation by viewing the termination of lineages as merely a failure of certain poorly adapted lines to provide descendants... Extinction became a crucial part of the mechanism of evolution. For Darwin, evolutionary change by natural selection required the elimination of inferior [*sic*] varieties – the termination of their lineages.'

⁴⁴ Aristotle criticizes the Presocratics for failing to take account of any final cause in creation, *PA* 640b5 ff.: 'Now those who were first to study nature in the early days spent their time in trying to discover what the material principle or the material cause was, and what it was like: they tried to find out how the universe is formed out of it; what set the process going (Strife it might be, or Friendship, Mind or Spontaneity)... in a like manner they describe the formation of animals and plants...' See Balme ad loc.

⁴⁵ I do not mean to suggest by this that these are proto-Darwinian theories of adaptation, rather that each is a fully worked up scheme that shares some ideas with Darwin.

⁴⁶ This is a very common idea in myth. See Guthrie 1957, ch. 1, and Loraux 1993, 196–207 on autochthony.

⁴⁷ Especially in the myths of Prometheus moulding the first humans from clay. See Blundell 1986, 10–11, and Bömer on Ovid *Met.* 1.80–3.

⁴⁸ For a study of Empedoclean influences on the *Timaeus* see Hershbell 1974.

⁴⁹ Empedocles fr. 17 plus Strasbourg fr. 'a', Lucretius 5.772 ff., Anaximander DK12 A30 (Censorinus), Archelaus DK60 A4 (Hippolytus), Democritus DK68 A139 (Censorinus) = Usener Epicurus fr. 333. Censorinus attributes the same theory to both Democritus and Epicurus, see Blundell 1986, 79 ff.

⁵⁰ Sedley 1998, 152–4, considers that the order of topics in Lucretius 5 derives from book 12 of Epicurus' *On Nature* and that Epicurus follows the order in the *Timaeus* to argue against Plato point by point. I suggest that Plato in the *Timaeus* appropriates the Presocratic and Democritean order of topics the better to subvert scientific cosmology, and that Epicurus and Lucretius follow Democritus and the other Presocratics, thereby implicitly re-appropriating the order of topics for the anti-teleological mechanistic view of cosmogony. Compare the order of presentation suggested by Parmenides fr. 10, Leucippus DK67 A1, and Archelaus DK60 A4. See my review of Sedley, Campbell 1998.

⁵¹ See Pelikan 1997, 17 ff. The traditional order of creation is found in *Genesis* 1.11 ff., (but note the inverse order in *Genesis* 2.4 ff.), Archelaus DK60 A4, Anaximander DK12 A11 and A30, Pythagoras (Porphyry *Life of Pythagoras* 44), and Ovid *Met.* 1.73 ff. Pelikan 1997, 19–20, also sees this same order of creation in Lucretius. This certainly is implied by the manner of Lucretius' presentation, but he does make it clear that humans are created at the same time as the other

animals at 5.821–5. See West 1964, 100–1 and Schrijvers 1974, 245–7.

⁵² Against this see Dubois 1988, 169 ff., who takes the original Timaeon humans as male. She investigates the misogynistic implications of this and other Platonic theories.

⁵³ See Hershbell 1974: 147 ff.

⁵⁴ For the attraction of like to like compare Empedocles frs. 37 and 62, Epicurus *Ep. Pyth.* 89, Leucippus DK67 A1 (DL 9.31).

⁵⁵ See Blundell 1986, 67 and Furley 1989, 229 ff.

⁵⁶ Compare Aristotle's criticism of the Presocratics for concentrating on the material cause and neglecting teleology in *PA* 640b5 ff. David Sedley, in conversation with me, argues that these 'light-minded men' are mathematicians rather than empiricists.

⁵⁷ The atrophy of organs due to disuse is Lamarck's 'First Law'; it is not wholly rejected by Darwin, who hedges his bets here, cf. *Origin of Species* ch. 5 'Laws of variation' and 'Effects of use and disuse'.

⁵⁸ From Lucretius' cosmogony at 5.495 ff., we should expect earth to be lowest, then sea, air, and aether. Perhaps the discrepancy may be explained by the different shape of the worlds described. Lucretius' world is the traditional atomists' flat earth, while Plato's is a sphere (see Furley, 1989, 223 ff.). In the flat earth model, earth must be below sea to support it. In the spherical model, there is no absolute up and down from the point of view of the demiurge, but from the human point of view on earth, sea will inevitably be thought of as lower than the land.

⁵⁹ See also Schrijvers 1974, 249 ff.

⁶⁰ Compare the Oparin-Haldane theory of the origin of the first life from a sort of warm chemical soup in the oceans (Skelton 1993, 847–8).

⁶¹ I assume that the evolution undergone by humans could also apply to other animal species. Indeed it would seem necessary in any theory of adaptation to account for the vast variety of form *within* the same species. Anyone familiar with stockbreeding would know about intra-specific evolutionary change by artificial selection.

⁶² The demiurge speaks only of broad animal groupings rather than individual species, i.e. birds, sea creatures, and land animals (39e1–40a), but Timaeus himself describes the creation also of snakes (92a–8), shellfish and all sea creatures (92b–7).

⁶³ See Myers, 1994, 27–60, at esp. 39–40: 'Ovid's primary interest in his metamorphoses...seems to have been to construct a narrative...leading naturally and often humorously to an aetiological metamorphosis that explains a prominent feature of the animal or plant into which the person is transformed. The appearance of the forms of the adjective *novus* or the word *nuper* does not always guarantee the aetiological status of the story...when Ovid tells us that Cynus (2.377), the Pierides (5.300–1, 5.674) and Picus all become 'new' birds, it is unclear whether this newness refers to the species as a whole or to these individuals, especially since he gives us three versions of swan metamorphosis (2.367–80, 7.371–2, 12.144–5) and two hyacinth *aetia* at 10.207 and 13.396. This lack of certainty does not weaken the aetiological focus of Ovid's

metamorphoses: if the transformations are only of individuals, they nevertheless function emblematically, as the identical names suggest⁶⁴.

⁶⁴ Myers 1994, 31.

⁶⁵ See Ovid *Met.* 15.60–478, with Myers 1994, 133: 'In his long disquisition, Pythagoras frequently mentions examples from the natural world that are included as metamorphoses earlier in the poem. These echoes reinforce the similarities between Pythagoras' *causae* and the mythological aetiological metamorphoses we have been considering in the rest of the *Metamorphoses*'. See also Barkan, 1986, 86 ff. For the Pythagorean status of *Timaeus*, see Burkert, 1972, 5, 64 ff., and 84 ff.

⁶⁶ The accuracy of Porphyry's report is doubtful, and this paragraph is omitted by DK58 C6, see Blundell 1986, 34–5 and Burkert 1972, 97 ff. It does seem to go against Aristotle's view (*Met.* 990a16) that the Pythagoreans had little interest in the physical nature and origins of the universe.

⁶⁷ Lamarck's ascending scale has constant spontaneous generation of the simplest creatures to replace those species lost at the bottom of the scale as creatures inevitably evolve and become more complex. In a descending scale, the problem would be why, if the simplest creatures were formed by spontaneous generation, the process of metamorphosis does not go all the way down the scale? On the other hand, if humans, the most complex creatures, were formed by spontaneous generation, then why could not the earth also create simpler creatures? Ovid manages to have both human origins by metamorphosis and animal origins by spontaneous generation (*Met.* 1.397 ff.) by giving separate origins for each.

⁶⁸ See Burkert 1972, 64 ff. and 84 ff.

⁶⁹ See Martin and Primavesi 1999, 61 ff., and Sedley 1998, 1–34. Sedley very plausibly reconstructs the proem to Empedocles' *Physics* along the lines of Lucretius' proem to book 1, but see my review, Campbell 1999.

⁷⁰ For example *Aen.* 12.921–3. and Lucretius 6.328–9; see Hardie 1986, 176 ff.

⁷¹ For example *Met.* 1.416 ff. See Barkan 1986, 27 ff. and Myers 1994, 54–7 ff.

⁷² See Barkan 1986, 86–7, and Myers 1994, 134–5. I am aware that this does not prove that it was Plato in the *Timaeus* who first made the transition from metempsychosis to metamorphosis, and that the conflation of the two may possibly be Pythagorean. In South American Amazonian cosmologies we often find accounts of the origin of particular species by the metamorphosis of a human into that species, and humans even in the present day are thought to be subject to metamorphosis into animals according to their behaviour, while at the same time animal spirits may be reborn in humans even though there was a primordial bifurcation between humans and animals. In short, the ontological stability of humans may be undermined by both metamorphosis and metempsychosis. See Griffiths 1998 and Viveiros de Castro, 1998.

⁷³ For example at 15.160 ff.; see Myers 1994, 133.

⁷⁴ See especially Fowler 2000, 138–55. This is true also of the relationship

between Darwin and Lamarck, who is frequently viewed through Darwin-tinted spectacles. The anti-Darwinian vehemence of Løvtrup 1987 arises from an attempt to redress the balance. Burkhardt 1995 gives a more balanced account of Lamarck's significance in the history of evolutionary thinking.

⁷⁵ Modern Creationism is extraordinarily prevalent, especially in the United States. The Internet is full of Creationist web sites, some saner than others; see especially Seth Kroger's 'Creationist Web Links' <<http://www.slonet.org/~skroger/evolution/c-pages.html>> November 1999. For the other side of the argument, and very stimulating debates on Darwinism and Creationism, see the 'Talk Origins Archive' <<http://www.talkorigins.org/>> November 1999.

⁷⁶ Flann O'Brien, 1967, *The Third Policeman*, London. See Hopper 1995, esp. Ch. 6, 226–69: 'O'Grady Says...' (*Boston Irish Reporter* June 1998) online at <<http://omega.cc.umb.edu/~irish/june1998.htm>> November 1999, who notes the links between bicycle riding and centaurs (cf. Lucretius' vehement rejection of centaurs in defence of the atomic theory's ability to account for the regularity of species 5.878 ff.), and 'The No-Bicycle Page' <<http://www.hellshaw.com/flann/index.html>> September 1999.

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