METAPHOR IN EVOLUTIONARY BIOLOGY

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ABSTRACT

The topic of metaphor in science is a much-discussed topic. Using evolutionary thinking (Darwinism specifically) as a case study, I argue that metaphor is essential in science, that it promotes the epistemic values (like predictive fertility) that scientists cherish, and that it cannot be eliminated without significant loss of content. I show that the topic of metaphor also says important things about the much-discussed question of the objective/subjective nature of science, showing that science is necessarily cultural but that this does not mean that cultural values rule supreme. There is still a place for a disinterested view of nature.
Key words: metaphor in science; evolutionary thinking; Darwinism; science and culture; view of nature.

METÁFORA EM BIOLOGIA EVOLUCIONÁRIA

O tema da metáfora na ciência tem sido objeto de várias discussões. Tomando o pensamento evolucionário (o darwinismo, em particular) como estudo de caso, defendo que a metáfora é essencial à ciência, promove os valores epistêmicos (como o da fertilidade preditiva) que os cientistas cultuam e que não pode ser eliminada sem significativa perda de conteúdo. Mostro que o tema da metáfora também nos diz coisas importantes sobre a questão bastante discutida da natureza objetiva / subjetiva da ciência, mostrando que a ciência é naturalmente cultural, mas que isso não significa que os valores culturais sejam supremos na sua determinação. Ainda há um espaço para uma desinteressada visão da natureza.
Palavras-chave: metáfora na ciência; pensamento evolucionário; darwinismo; ciência e cultura; visão de natureza.

METAPHOR AND EVOLUTIONARY BIOLOGY

From the time of Aristotle (*Rhetoric, Poetics*), the topic of metaphor — the taking of an idea or words from one context and using it in another context in a *prima*

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facie contradictory manner — has been a topic of intense philosophical interest, and never more so than today (Johnson 1981; Lakoff and Johnson 1980). It is recognized that metaphor pervades human thinking at all levels and in all dimensions, not excluding — indeed particularly including — scientific thought (Hesse 1966; Kuhn1993). I intend to look at the use of metaphor in evolutionary biology and to discuss its implications for the nature of scientific knowledge. My discussion will be divided into three parts: first, I shall give a brief semi-historical account of the role of metaphor in evolutionary biology; second, I shall take up the oft-discussed question of whether such metaphor is essential or theoretically eliminable; third, I shall turn to the philosophical implications, particularly about whether or not my conclusions on metaphor imply anything about the objectivity or subjectivity of evolutionary thought.

It is convenient when discussing matters evolutionary to make a three-fold division between the fact of evolution, the path of evolution, and the mechanisms or causes of evolution (Ruse 1984). Obviously these three entities are not separate. One could hardly have causes without the fact of evolution, but it is useful conceptually to keep them apart. We shall see that metaphor enters into all three divisions.

Start with the fact of evolution, the very idea of which is a metaphorical transference of individual organic development ("ontogeny") to group organic development ("phylogeny") (Bowler 1975; Richards 1992). Evolutionary biology started in the eighteenth century, and there is good reason why it started then and not before or after (Ruse 1996; Bowler 1984). This was the age committed to the idea of progress, the belief that through human effort it is possible to increase our knowledge, theoretical and practical, and thus improve social and cultural conditions and the lot of humankind. The first evolutionists, people like Erasmus Darwin, the British physician and friend of industrialists (and grandfather of Charles Darwin), were strongly committed to these ideas of social and industrial progress, taking them from the human realm and reading them into the world of organisms (McNeill 1987). They thus saw a kind of progress up from the most simple or primitive organisms to the highest form, namely human beings.

> Organic Life beneath the shoreless waves
> Was born and nurs'd in Ocean's pearly caves;
> First forms minute, unseen by spheric glass,
> Move on the mud, or pierce the watery mass;
> These, as successive generations bloom,
> New powers acquire, and larger limbs assume;
> Whence countless groups of vegetation spring,
> And breathing realms of fin, and feet, and wing.
> Thus the tall Oak, the giant of the wood,
> Which bears Britannia's thunders on the flood;
> The Whale, unmeasured monster of the main,
> The lordly Lion, monarch of the plain,
> The Eagle soaring in the realms of air,

Whose eye undazzled drinks the solar glare,
Imperious man, who rules the bestial crowd,
Of language, reason, and reflection proud,
With brow erect who scorns this earthy sod,
And styles himself the image of his God;
Arose from rudiments of form and sense,
An embryon point, or microscopic ens!
(Darwin 1803, 1, p. 295-314)

I hardly need say how Darwin's thinking is metaphorical through and through. Social progress — a belief that one can improve matters through effort — is being read right into the rocks — a belief that organisms move upwards from the lowest to the highest. That this all occurs in a strongly circular argument having posited biological progressionism, the evolutionists then read this back as justification of their social progressionism — alters the point not at all.

Moving next from the fact of evolution to the path of evolution, we find that it was at the beginning of the nineteenth century that evolutionists start to think of the path of evolution as a kind of branching tree, with stems going out from a single root. To people in the eighteenth century, it was by no means obvious that this was the correct categorization of life's history in portraying relationships, the great naturalist Buffon used nets and chains as much as he used trees (Barsanti 1989). But, as we start to move through the early decades of the nineteenth century, the evolutionists refer more and more frequently to evolutionary trees. This figure, one used by Jean Baptiste de Lamarck in his seminal *Philosophie Zoologique* of 1809, becomes the dominant metaphor used by Charles Darwin for the path of evolution in the *Origin of Species* (1859) (O'Hara 1992). About the so-called "tree of life," Darwin wrote as follows:

> The affinities of all the beings of the same class have sometimes been represented by a great tree. I believe this simile largely speaks the truth. The green and budding twigs may represent existing species; and those produced during each former year may represent the long succession of extinct species. At each period of growth, all the growing twigs have tried to branch out on all sides, and to overtop and kill the surrounding twigs and branches, in the same manner as species and groups of species have tried to overmaster other species in the great battle for life. The limbs divided into great branches, were themselves once, when the tree was small, budding twigs; and this connexion of the former and present buds by ramifying branches may well represent the classification of all extinct and living species in groups subordinate to groups.... As buds give rise by growth to fresh buds, and these, if vigorous, branch out and overtop on all sides many a feebler branch, so by generation I believe it has been with the great Tree of Life, which fill with its dead and broken branches the crust of the earth, and covers the surface with its ever branching and beautiful ramifications. (Darwin 1859, p. 129-130)

Following Darwin we find that other evolutionists likewise thought in terms of trees. Most famously, Darwin's supporter in Germany, Ernst Haeckel (1868), drew many trees: inevitably, with the simplest organism at the base, and the most complex at the top, ending naturally enough with humankind. We move now thirdly to the question of mechanisms or causes. Here, Charles Darwin and his *Origin* really come into their own. It was Darwin who proposed what is today considered to be the absolutely key mechanism of evolutionary change, namely natural selection. Once again we find that metaphor plays a crucial role (Young 1985; Ruse 1999, in press). We start first of all with the very problem that Darwin was facing. He wanted a mechanism of evolutionary change, but a mechanism of a very particular kind. He had been brought up on a steady diet of natural theology, most particularly that to be found in the writings of Archdeacon William Paley (1802). Darwin accepted completely the natural theologian's premise, that the organic world seems as if designed (Ruse 1979a; Browne 1995). The eye is to be seen as a telescope: a classic metaphor if ever there was one. You look at the organic world as if it were an artifact. (The natural theologians of course thought that the organic world is literally an artifact, namely God's artifact; but at the same time they regarded it as a metaphorical artifact, namely as something akin to a human artifact).

Although, Darwin rejected the natural theologians' claim that God had intervened miraculously to design the organic world, he did not reject the claim that God designed the world – at least, he did not do so until later in life (and then because he could not reconcile God's existence with the problem of evil). But the important thing is that neither then nor ever did Darwin reject the theologians' metaphor, namely that the organic world is as if designed. The eye is telescope-like, however it is caused. And so in this respect, Darwin — and let me stress all subsequent Darwinians, down to today's enthusiasts like Richard Dawkins (1986) and William Hamilton (1964a, b, 1996) — took the Darwinian metaphor of design as absolutely crucial. Although I should say that Dawkins rather takes this all as a disproof of God's existence!

> Cheetahs give every indication of being superbly designed for something, and it should be easy enough to reverse-engineer them and work out their utility function. They appear to be well designed to kill antelopes. The teeth, claws, eyes, nose, leg muscles, backbone and brain of a cheetah are all precisely what we should expect if God's purpose in designing cheetahs was to maximize deaths among antelopes. Conversely, if we reverse-engineer an antelope we find equally impressive evidence of design for precisely the opposite end: the survival of antelopes and starvation among cheetahs. It is as though cheetahs had been designed by one deity and antelopes by a rival deity. Alternatively, if there is only one Creator who made the tiger and the lamb, the cheetah and the gazelle, what is He playing at? Is He a sadist who enjoys spectator blood sports? (Dawkins 1995, p. 104-5)

Returning to Darwin, having thus used a metaphor to set his problem, he provided a solution which was no less deeply indebted to metaphor. First, Darwin turned to

Malthus !826) and argued that as the political economist had claimed there is a struggle for existence in the human world, so likewise there is a struggle for existence in the organic world.

> A struggle for existence inevitably follows from the high rate at which all organic beings tend to increase. Every being, which during its natural lifetime produces several eggs or seeds, must suffer destruction during some period of its life, and during some season or occasional year, otherwise, on the principle of geometrical increase, its numbers would quickly become so inordinately great that no country could support the product. Hence, as more individuals are produced than can possibly survive, there must in every case be a struggle for existence, either one individual with another of the same species, or with the individuals of distinct species, or with the physical conditions of life. It is the doctrine of Malthus applied with manifold force to the whole animal and vegetable kingdoms; for in this case there can be no artificial increase of food, and no prudential restraint from marriage. (Darwin 1859, p.63)

As Darwin himself recognized, strictly speaking what he found in the organic world was not necessarily a struggle or indeed for existence. Rather, there is competition of a kind between organisms for space and food and this competition centers more directly on reproduction than it does on existence. But either way, what one has is some kind of transference of a social idea from the human realm to the biological realm, where Darwin made of it a biological idea.

Then after the struggle, Darwin moved to say that, given that there is constant new variation in populations, one will get a natural form of the selection practiced by animal and plant breeders. This leads to ongoing change, but change of a particular kind: change in the direction of adaptive advantage.

> Let it be borne in mind in what an endless number of strange peculiarities our domestic productions, and, in a lesser degree, those under nature, vary; and how strong the hereditary tendency is. Under domestication, it may be truly said that the whole organization becomes in some degree plastic. Let it be borne in mind how infinitely complex and close-fitting are the mutual relations of all organic beings to each other and to their physical conditions of life. Can it, then, be thought improbable, seeing that variations useful to man have undoubtedly occurred, that other variations useful in some way to each being in the great and complex battle of life, should sometimes occur in the course of thousands of generations? If such do occur, can we doubt (remembering that many more individuals are born than can possibly survive) that individuals having any advantage, however slight, over others, would have the best chance of surviving and of procreating their kind? On the other hand we may feel sure that any variation in the least degree injurious would be rigidly destroyed. This preservation of

> favourable variations and the rejection of injurious variations, I call Natural Selection. (Darwin 1959, p. 80-81)

Obviously here again we have metaphor. Literally, there is no selecting going on: rather, there is something akin to what happens in the human realm. In fact, Darwin himself rather worried about his metaphor of natural selection, and later at a time suggested that perhaps "picking" would be a better term (although still obviously metaphorical). He also tried substituting Herbert Spencer's alternative, the "survival of the fittest." (Also metaphorical!) Darwin was tense indeed about the whole use of metaphor, but felt that he had every right to defend himself on this score, since it is something which occurs in the physical sciences.

> In the literal sense of the word, no doubt, natural selection is a false term; but whoever objected to chemists speaking of the elective affinities of the various elements? - and yet an acid cannot strictly be said to elect the base with which it in preference combines. It has been said that I speak of natural selection as an active power or Deity; but who objects to an author speaking of the attraction of gravity as ruling the movements of the planets? Everyone knows what is meant and is implied by such metaphorical expressions; and they are almost necessary for brevity. So again it is difficult to avoid personifying the word Nature; but I mean by Nature, only the aggregate action and product of many natural laws, and by laws the sequence of events as ascertained by us. (Darwin 1959, p. 165 – this passage was added in the third edition of the *Origin* of 1861)

Following on Darwinian selection we find that metaphor remained an absolutely vital ingredient in the evolutionary picture. Indeed, as we move into this century and the melding of Darwinian selection with Mendelian genetics, a whole new set of metaphors were invented. For instance, in the 1930s the American population geneticist Sewall Wright (1932) invented the metaphorical idea of an "adaptive landscape," picturing a situation where organisms sit atop of peaks of genetic fitness, only being dislodged occasionally through such things as (the metaphorically conceived) genetic drift (Ruse 1994). At which point, they try to scale other peaks perhaps even higher than those before. This metaphor underlay much if not all of the theorizing by American biologists in the 1930s and the 1940s, as they formulated what came to be known as the "synthetic theory of evolution". Selection working on Mendelian genes was set firmly in a Wrightian adaptive landscape, and all change was thought to be a function of the rising hills and falling valleys that one finds in such a picture (Ruse 1996).

Jumping very quickly to the present, we find that metaphor is no less important. One of the most exciting areas of contemporary evolutionary biology is so-called "sociobiology": the attempt to understand animal social behaviour from a Darwinian perspective (Ruse 1979b). Metaphors old and new play crucial roles. For instance, one of the most stimulating ideas — formulated by John Maynard Smith (1982) and others

— is that of an "evolutionarily stable strategy". This is the kind of situation one finds in a population where organisms are held in equilibrium, because if they try to step outside certain prescribed paths or patterns, they will thereby lower their own personal fitness. Thus, for instance, in a population we may find that fifty per cent of a population is aggressive (hawks) and fifty per cent of the population is passive (doves). An organism might be tempted to turn from dovish behaviour to hawkish behaviour, thinking that it will thereby improve its lot; but will be deterred by the fact that if it does so turn, the balance between hawks and doves will be changed and under the new situation hawks might well do less well than doves do now. Hence, the best strategy is to stay put (Dawkins 1976).

The whole idea of something being a "strategy" is metaphorical: this is an idea imported from game theory, where one has various opponents trying out certain lines of attack or defense because they seem to be profitable. In sociobiology, there is no question — outside the human realm and perhaps that of the higher animals — that anybody is consciously thinking out the particular paths that they should take. Ants do not plan for the future or present or past, for that matter. Metaphor is at work. In fact, when you think about it, you can see readily that the idea of a strategy is an extension of the whole design metaphor to which we saw Darwin sensitive. It is a nineteenth-century metaphor (Ancient Greek metaphor, if you go back all the way), clothed in the concepts of the twentieth century.

Finally tying together past, present, and (no doubt) future let me mention a metaphor which has a long history, going right back to the beginning of evolutionary thought and which still is very powerful today: the "division of labour" (Ruse 1999, in press). This notion is to be found in the writings of Erasmus Darwin's friend, Adam Smith (1776): it refers to the way in which one can achieve greater efficiency by employing labour specializing in different areas, rather than by having everybody trying to do everything all at once. Charles Darwin made much of the division of labour, both at the individual level and at the group level. It was a major support of his explanation of the evolution of different species. He argued that such species would be able to exploit ecological niches much more efficiently, if they were in fact designed for the different niches, and not identical.

> The advantage of diversification in the inhabitants of the same region is, in fact, the same as that of the physiological division of labour in the organs of the same individual body — a subject so well elucidated by Milne Edwards. No physiologist doubts that a stomach by being adapted to digest vegetable matter alone, or flesh alone, draws most nutriment from these substances. So in the general economy of any land, the more widely and perfectly the animals and plants are diversified for different habits of life, so will a greater number of individuals be capable of there supporting themselves. (Darwin 1859, p. 158-9)

Today also we find that the idea of a division of labour is one which plays a crucial role in biological thinking. For instance, the Harvard entomologist and sociobiologist Edward O. Wilson (1980a, b, 1983a, b) has performed sterling labours showing how the social insects, particularly the ants, are highly specialized users of a division of labour, with the workers doing one thing, and the soldiers doing another, and the queen doing yet another role.

> A key feature of *Atta* social life disclosed by these data is the close association of both polymorphism and polyethism with the utilization of fresh vegetation in fungus gardening.... An additional but closely related major feature is the 'assembly-line' processing of the vegetation, in which the medias cut the vegetation and then one group of ever smaller workers after another takes the material through a complete processing until, in the form of 2-mm-wide fragments of thoroughly chewed particles, it is inserted into the garden and sown with hyphae... (Wilson 1980a, p. 150)

Through and through, Wilson's thinking goes back to Adam Smith: Wilson's metaphorical thinking, because there is no question of anybody in the ant world thinking the division through consciously.

We see, therefore, that from the beginning right down to the present, in all areas of evolutionary thought fact, paths, and mechanisms metaphors play a vital and full role.

BUT ARE THEY NECESSARY?

"Metaphor plays a vital role" yes, but just how vital is "vital" in this context? There have long been two schools of thought about metaphor in general. These schools have implications for us here. On the one hand, there are those going back to and including Aristotle himself, who – whilst recognizing that metaphor is very widespread and difficult to eliminate – nevertheless maintain that, at some level, a metaphor says nothing which could not be said literally. Every time one uses a metaphor, one is in fact using shorthand or some such thing for an idea or words which could be spelled out without metaphorical use (Fodor 1996). Then, on the other hand, there are those particularly in this century, most notably in the philosophical community Max Black (1962) — who argue that it is simply impossible to eliminate metaphor. That, in some sense, the use of metaphor changes things for ever. Not only is the idea which is being transferred in some sense changed, but also the very area which is being described. To think or to speak metaphorically is a creative act which cannot simply be translated out into literal language.

Obviously this dispute is important for us in science. We find that there are partisans for both sides of the debate: some want to argue that although scientists use

metaphors, they have no ultimate need of them; others, enthusiasts for the so-called "interaction theory of metaphor," argue that metaphors are here to stay and, whether or not it is a good or bad thing, it is something which we must recognize (Hesse 1966). In our case, the specific question is whether such metaphors as progress or the tree of life or natural selection or the division of labour are simply convenient ways of speaking about things which we could speak of literally. Or whether they are ways which in some sense simply cannot be taken out of the science without irretrievable loss of content.

My suspicion — thinking now specifically about evolution — is that many philosophers and not a few biologists would agree with Aristotle. (From the quotation given earlier, this would include Darwin I suspect!) They would argue that although metaphors are obviously very important in evolutionary biology, ultimately they are things which can be taken out. They are theoretically dispensable. A favourite example, indeed, is of natural selection itself. This in some sense implies, or is taken to be equivalent to, the fact that whilst some organisms survive and reproduce, others do not. In other words, we have a kind of differential reproduction, with those which are by definition the "fitter" surviving and reproducing and those which are by definition less "fit," not surviving and reproducing. (Or, at least, when looking at averages, where the fitter do better than the non-fit. Nobody wants to deny that occasionally, perhaps often, the non-fit will succeed, where the fitter do not.)

Neo-Aristotelians would argue that the concept of differential reproduction is something beyond metaphor. Nobody is talking in terms of design or selecting or intentions or anything like that. It is true that it is a lot easier to talk in terms of selection and certainly more natural. But, if one wanted to be a stickler about these things, we could drop the selection talk. Moreover, continues this line of thought, when we turn to the more professional discussions of evolutionary biology, as for instance can be found in the journal *Evolution*, then we find that everything gets pretty mathematical and there is no need in either theory or in practice to make use of such ideas as struggle or selection. Here, indeed, metaphor has gone.

But I wonder if things can be answered quite this quickly. My experience is that there is still a huge amount of metaphor going on in modern biology: including biology of the most formal kind. One can even argue that the original metaphor of progress is something which is not entirely absent. In the writings of people like John Maynard Smith – not to mention popularizers like Richard Dawkins – one finds more than a hint of progressivist sentiments (Ruse 1993). Dawkins (1988), for instance, talks about the "evolution of evolvability," with certain new techniques or processes (like consciousness) bringing on a new and improved kind of evolution. He certainly thinks that human brains stand on the top of all of this: in this sense, he sees evolution as being deeply progressive. This is about as basic a part of his theory as is possible to have and certainly does not seem like something which could just be taken out. Similarly, Maynard Smith has argued for certain evolutionary "transitions": he sees leaps up from the simple to the more complex and ultimately to the human and cultural (Maynard

Smith and Szathmary (1995). Hence, as I say, I am not at all convinced that even the most basic of evolutionary metaphors has in fact gone with the development of time.

What about natural selection? Although it is certainly the case that one could talk in terms of differential reproduction, and put things into mathematical form, it is not in fact the case that selective talk is absent from the technical evolutionary discussions. The whole idea of natural selection, including the metaphorical aspects, are things much used. For instance, in his seminal study of the dunnocks or hedge sparrows, the British ornithologist Nicholas Davies discusses in some length the selective advantages of the various kinds of breeding arrangements that the dunnocks arrange for themselves: breeding arrangements which go all the way from polygyny where one male will have two or three mates, through monogamy to polyandry where one female will have two or three mates, and even to a form of polygynandrous relationship (the polite name for group sex) where several males mate up with several females. Davies talks explicitly in terms of "selection," here and elsewhere as when he deals with the question of parasitism.

> The dunnock is a favourite host of the cuckoo in Britain, with about 2% of nests being parasitised. Individual female cuckoos specialise on one host species. Experiments with variously coloured model cuckoo eggs show that the degree of host-egg mimicry exhibited by the different cuckoo gentes reflects the degree of egg discrimination shown by their respective hosts. Unlike other gentes, dunnock-cuckoos do not lay a mimetic egg, as expected from the fact that, in contrast to other hosts, dunnocks show no egg discrimination. Nevertheless, dunnock-cuckoos still lay a distinctive egg, different in shade from the other cuckoo gentes. Experiments provide no support for predation as an important selective pressure. Either selection by secondary hosts, or by cuckoos themselves (for an egg which is cryptic in the nest) may be involved. It is unlikely that dunnocks accept non-mimetic eggs because rejection is peculiarly costly for them or of less benefit than for other hosts. Experimental parasitism of species which have no history of interaction with cuckoos shows that before parasitism occurs hosts exhibit no rejection of eggs unlike their own. Dunnocks may, therefore, be recent victims of the cuckoo, lagging behind in their counter-adaptations to a new selective pressure. (Davies 1992, p. 234)

Another area where the use of metaphor continues unabated is in those studies utilizing the notion of a division of labour. Wilson is as enthusiastic a supporter of this idea as any eighteenth-century businessman. Far from the idea being strained out, it exists in as vigorous a form as ever before. Wilson strives to show that there is indeed a division of labour: members of one caste are more likely to perform tasks of one sort than members of other castes (who in turn have their appropriate tasks). In particular, one finds that the smaller workers are those which spend their time right in the nest, working on the fungus fields ("gardening") or grooming the queen or tending to the

young; the mid-range workers are those out foraging and cutting up leaves and returning the pieces to the nest; and the very biggest workers (who can be up to a hundred times the size of the smallest) are the soldier caste, primarily or exclusively concerned with defence.

> The elaborate caste system and division of labor that are the hallmark of the genus *Atta* are an essential part of the specialization on fresh vegetation. And, conversely, the utilization of fresh vegetation is the raison d'etre of the caste system and division of labor" (Wilson 1980a, p. 150).

All of this is done from a fairly simple base, biologically speaking. Instead of redesigning forms for different castes, it is all a question of relative growth (allometry) and behavioral flexibility. In a sense, moreover, this is simply a matter of specializing on functions that are done by all of the members of more primitive ant species. "Most of the monomorphic attines utilize decaying vegetation, insect remains, or insect excrement as substrates, in other words, materials ready made for fungal growth" (Wilson 1980a, p. 153). To utilize fresh leaves, however, one needs specialists. Hence, the evolution of the caste system.

But still you might protest that the fact that people use these ideas is no proof in itself that they must use these ideas. The point is not whether metaphors are used — we all accept that – but whether they have to be used. And here the neo-Aristotelian will argue that even Wilson has no absolute need of his metaphors. He could just simply talk about what the ants are doing in very neutral terms. But the defender of the interaction view will protest. History shows that, far from metaphor being theoretically dispensable, in fact there is no way that evolutionists could have done what they did without the metaphor. Let me give you just one example: the adaptive landscape. When Sewall Wright formulated his neo-Darwinian theory of population genetics, to which he gave the name the "shifting balance theory of evolution," he first published a mathematical version in 1931. Unfortunately, almost no one could follow what he did. Other than the Englishman R.A. Fisher (who held a rival theory), no one was strong enough with the mathematics! So then, in 1932, Wright published a new version of the theory, incorporating the adaptive landscape. At once, all the evolutionists of the day, particularly Theodosius Dobzhansky (1937) and his associates — men like G.L. Stebbins (1950) the botanist, Ernst Mayr (1942) the ornithologist, and G.G. Simpson (1944) the palaeontologist — picked up on the adaptive landscape metaphor and incorporated it into their own theorizing. As I explained in the last section, they used it as the fundamental background to their thinking.

Historically speaking, one can simply say flatly that without this metaphor it would have been quite impossible for modern evolutionary theory, as we know it, to have been formulated. Moreover, let me block off one line of response, before you suggest that Sewall Wright's example shows just how metaphor is eliminable, because it was simply added on to the mathematics after the hard work had been done. Quite

without mention, Sewall Wright introduced a whole new set of ideas with the landscape metaphor. His formalisms in no way suggest, let alone prove, that there would be the kind of continuous fitness surface that is such a crucial component of the metaphor: with organisms able to move smoothly up or down the sides of adaptive mountains (Provine 1986). None of this is in the mathematics. It is all added through the metaphor. And, of course, it is precisely this which the next generation of evolutionists seized on and used in their theorizing. As much as one can say anything definitively about the history of science, one can say definitively that without the landscape metaphor the evolutionary science simply would not have existed.

Yet still the neo-Aristotelian will protest. Surely, he or she will say, whilst the history is interesting and no doubt of pertinence somewhere, it is not obvious that it is so highly pertinent here. Even if one agrees that the adaptive landscape introduced new ideas, it has not been denied that one could in theory explain what is going on in the adaptive landscape without recourse to the metaphor. The neo-Aristotelian's claim is not something about the mathematical limitations of actual working scientists. We all know about these, particularly in biology. The neo-Aristotelian's claim is about the conceptual status of a theory: whether or not, in principle, it is possible to do or not do certain things. When the question is posed in this light, it is by no means obvious that the adaptive landscape is strictly necessary. History does not speak to this.

Let me say two things at this point. Let me concede that, perhaps in principle, it is possible to get rid of the metaphors in evolutionary biology. I am not really convinced that this is indeed the case; but, for the sake of argument, let us agree that it can be done. The point is that it is only going to be done by ripping out a huge amount of what actually physically exists in the theory at any given moment. Whether or not one wants to argue that this material to be eliminated is good or bad or indifferent, the fact is that it will have to be taken out. In order to produce a metaphor-free evolutionary biology, some significant pruning (at the least) is going to have to take place. But, as I say, for the sake of argument let us agree that in principle this could be done.

The second point I want to make is that no scientist in his or her right mind, whatever. They may say when they wax philosophical, would ever dream of doing such a thing. The actual theory itself would have to be gelded, in significantly depriving sorts of ways. In particular, one would lose one of the strongest virtues of any forward looking theory. (The kind of virtue which philosophers refer to as a "epistemic value" (McMullin 1983).) One would no longer have the *predictive fertility* that one seeks in the best kind of theory. One could as it were stay with the way that things are; but hopes of pushing forward into new areas of inquiry, and of coming out with new solutions, would be put to a virtual — most probably, complete — standstill.

Let me illustrate what I mean by reference again to the metaphor complex of design/struggle/selection. And let me take an example much discussed by evolutionists, namely the function or purpose of the plates which are to be seen on the back of the dinosaur stegosaurus (Lewontin 1978). Why does the brute have these plates of this kind? If one insists on not using metaphor all, one can say presumably that dinosaur

ancestors with the plates, or proto-plates, survived and reproduced and dinosaur ancestors without the plates or proto-plates did not. Hence, there was a differential reproduction. But, as to the reason why the plates exist or what function they play, one is in complete and continuing ignorance. Indeed, one is even ignorant that one is ignorant! One has to reintroduce the metaphors to see one's limitations. Without the metaphor of design, one has no question to ask — What function do the plates serve? and without the metaphors of struggle and selection, one has no answers to give.

In fact, various functions have been proposed. The one which is generally favoured now is that the plates serve the goal or end of heat regulation: in many respects, the plates seem much akin to the kinds of plates or blades that one finds in hydro-electric turbos, plates which are used for carrying away heat. The shape of the plates and the ways in which they are constricted, and the materials that they were made from, seem all to serve the end of heat transfer and ultimately of heat regulation. In other words, the function seems to be that of thermal regulation. (As opposed to other proposed functions, which include a display either for sexual attraction or for putting fear into would-be attackers.)

I do not want to say that this is necessarily the definitive answer to the plates on the stegosaurus; but, you can see straight away how by thinking of the stegosaur's plates as being artifacts, ones which were selected for some reason, one can start to pose questions and with luck come up with answers to these questions. Thus evolutionary biology moves forward as one hopes and expects. The point I am making therefore is that, whatever else, metaphors have an absolutely vital heuristic or predictive role in evolutionary biology. Without the metaphors, the fertility of the theory falls right away, and one is stuck simply with a fancy description of what there is. So, at least in this sense – which I would argue is an absolutely crucial sense – one can see that the metaphors of evolutionary biology are essential. If more proof be needed, then one should turn to other metaphors which I have mentioned, like the division of labour. Again and again, one sees evolutionists peering into the unknown through their metaphors in a way which would be quite impossible were they not right there in the theory. Without the division of labour, Ed Wilson would be just another bug collector.

IMPLICATIONS FOR OBJECTIVITY/SUBJECTIVITY

What does this all add up to about the nature of science in general, and the nature of evolutionary biology in particular? The fear will be that, since metaphors are so obviously rooted in their culture — the division of labour is a metaphor of the industrialism of the eighteenth century, no less than evolutionarily stable strategies are metaphors of social and intellectual forces of the twentieth century — this means that science is nothing but an epiphenomenon on culture (Gross and Levitt 1994). Metaphors are essential; metaphors are part of culture; science is part of culture. It would seem that the so-called philosophy of "social constructivism" has been given a major support.

Rather than seeing science as some objective phenomenon, a value-free description of disinterested reality, science now seems to be a cultural phenomenon with all the subjectivity that one finds in like phenomena (Collins 1985; Latour 1987; Latour and Woolgar 1979). It is on a par with religion, or politics, or even philosophy. Science has lost its distinctive status as the paradigm of objective knowledge: what Sir Karl Popper (1972) referred to as "knowledge without a knower." It has now become little more than a pawn of social or cultural currents. A sad conclusion indeed!

There is some truth in this conclusion, but I do not see all of the unfortunate consequences which are being implied. My arguments do indeed point to science taking on a cultural aura. Although, the claim that this is generally so of science and specifically so of evolutionary thinking is no new finding. One of the most acute commentators on evolutionary theory, Karl Marx, spotted this fact immediately. He expressed his opinions in letters to his coworker Frederick Engels (Marx and Engels 1965). On any reasonable reading, one must admit that evolutionary biology is indeed a reflection of culture. Indeed, I would go even further and suggest that had the cultural ideas of the eighteenth century not arisen in the way that they did, referring specifically to ideas of progress, it is hardly likely that biological evolution would have developed in the way that it did. Likewise, I find it hard to see that, had Darwin not been able to draw on such notions as the Malthusian struggle or artificial selection, anyone — Darwin or another — would have come up with the kinds of mechanisms that he did. (The codiscoverer of natural selection, Alfred Russel Wallace (1858), drew on such notions as the Malthusian struggle — where he did not follow the same metaphorical path as Darwin, he did not arrive at the same end as Darwin (Ruse 1989).)

I would go further than simply resting with natural selection and say that, had Darwin not had the natural theology of his day to draw on, then evolution with respect to cause would have been very different from the way that it is. Stephen Jay Gould (1977a, 1989) has remarked repeatedly how Darwinian evolutionary theory is imbedded in the natural theology of the day, and that this was not a necessary event. Gould (1977b, 1982) himself prefers a much more morphologically based evolutionism, one which draws attention to the isomorphisms between organisms, the so-called homologies, and which does not put heavy emphasis on adaptation. He deplores the continuing influence of what is often known as "the utilitarian argument from design," that favoured by Paley which put such an emphasis on function. In Gould's opinion, whether rightly or wrongly, evolutionary biology would be far better were it not as deeply rooted in the culture of its day. His theory of "punctuated equilibria," which has a much diminished role for adaptation, is intended to redress the balance (Eldredge and Gould 1972; Gould and Eldredge 1977).

Likewise, today, sociobiology as we know it would be impossible had not people, during and after the Second World war, developed game theory in the way that they did. The whole notion of an evolutionarily stable strategy is deeply rooted in the advances made by mathematicians during and in the post war period. It is very much a child of the military-industrial complex. The same is true also of the new instrumentation available

to the scientists, particularly computers, which have made such a significant difference to the ways in which they are able to conceptualize their theories. Without machines capable of the brute arithmetical and algebraical computations necessary for working out consequences of possible strategies, sociobiology as we know it today would simply not exist.

Although it is controversial to say, I myself would go as far as to say the whole idea of evolution is in some sense an epiphenomenon of Western Civilization (Almond et al 1962). Evolution is a theory which speaks to origins and histories in a unidirectional way, very much in a tradition of the Christian perspective on history. (I am not saying that evolution simply mimics Christianity, but rather that it picks up and asks the kinds of questions that Judaeo-Christian thought thinks pertinent.) Were one in a society which always thought in a cyclical way, for instance, or in terms of eternity without significant change, as is found in significant respects back at the time of Ancient Greece, I doubt that evolutionary questions would seem pertinent. Do not misunderstand me. I do not mean that the fact that evolution would then become false, or that the fact of evolution is in some sense is just a construction on society. Rather, questions about origins — which evolution like Christianity tries to answer — would be the kinds of question which we would not find particularly interesting. Nor would we feel the need to find solutions with respect to causes and that sort of thing. It is not that we would all become Creationists, or antievolutionists. It is that we would not think that these were important issues. (An analogy would be if one had a society which was not particularly mathematical. Such a society would not think that two plus two equals five, because that is our society, only wrong. Rather, such a society would not really find the addition of two plus two to be itself a matter of any great import. To be honest, I am not so sure that one could have a society without elementary mathematics, but one obviously could have a society without evolutionary knowledge.)

If, then, evolutionary theory is so culturally imbedded, does this mean that it is just subjective? I am not sure that this conclusion follows at all. Subjectivity means that one can go any way that one wants, and nobody is saying this here about evolutionary thought. What I am saying is that one is going to go ways which are, as it were, seen through the lens of our own society (metaphor!) or constrained by the thinking of our society. But this does not mean that we are just free to do whatever we like. The whole point about using metaphor is that one is trying to generate ideas which are predictively valuable, or fertile. Obviously if the metaphors do not do this, or if the fertility only leads to dead ends, or to incorrect answers — as one discovers by going out and testing generated hypotheses — then one is going to drop the metaphors pretty quickly (Ruse 1999, in press). This has certainly happened in the past, even in the history of evolutionary theory. For instance, many evolutionists used to think that selection can work at the level of the group and, particularly in Russia at the end of the last century, the selection metaphor was interpreted in these terms simply because as a vast pre-industrial nation selection between individuals made little or no sense. Hand to hand struggle of this kind was not part of the culture, as it was for people in Britain. Listen to Prince Petr Kropotkin:

> The terrible snow-storms which sweep over the northern portion of Eurasia in the later part of the winter, and the glazed frost that often follows them; the frosts and the snow- storms which return every year in the second half of May, when the trees are already in full blossom and insect life swarms everywhere; the early frosts and, occasionally, the heavy snowfalls in July and August, which suddenly destroy myriads of insects, as well as the second broods of birds in the prairies; the torrential rains, due to the monsoons, which fall in more temperate regions in August and September – resulting in inundations on a scale which is only known in America and in Eastern Asia, and swamping, on the plateaus, areas as wide as European States; and finally, the heavy snowfalls, early in October, which eventually render a territory as large as France and Germany, absolutely impracticable for ruminants, and destroy them by the thousand – these were the conditions under which I saw animal life struggling in Northern Asia. They made me realize at an early date the overwhelming importance in Nature of what Darwin described as "the natural checks to overmultiplication," in comparison to the struggle between individuals of the same species for the means of subsistence. (Todes 1989, p. 128-9, quoting Kropotkin 1902, p. vi-viii)

Clearly the only way that people — or organisms — could survive was by banding together against the elements. It was no chance that it was Kropotkin, living in exile in London, who penned the greatest-ever paean to a natural form of altruism: mutual aid.

> In the animal world we have seen that the vast majority of species live in societies and that they find in association the best arms for the struggle for life: understood, of course, in its wide Darwinian sense — not as a struggle for the sheer means of existence, but as a struggle against all natural conditions unfavourable to the species. The animal species, in which individual struggle has been reduced to its narrowest limits, and the practice of mutual aid has attained the greatest development, are invariably the most numerous, the most prosperous, and the most open to further progress... The unsociable species, on the contrary, are doomed to decay. (Todes 1989, p. 134, quoting Kropotkin 1902, p. 293)

Now however the group selection perspective is almost entirely rejected in favour of a perspective which centres on struggle between (even within) individuals — the selfish gene perspective (Dawkins 1976; Williams 1966). This is not because of the collapse of the Soviet Empire Kropotkin wrote in pre-Revolutionary times but because the group perspective simply does not prove as fertile and as well confirmed as the individual perspective. Culture may count for much, but it is not the decisive factor. The fact that something is embedded in culture, and then gets transferred into science, does not mean that one is powerless in the face of it. By the usual methods of testing, and checking and so on and so forth, one can judge the virtues of metaphors and stay with

them or not as one wishes. So, because of the use of metaphor, one certainly does not get complete subjectivity in science in general or in evolutionary biology in particular.

Let me go further. A fear which is often expressed about any kind of constructivism any philosophy which points to the place of culture in society — is that one is going to accuse science of simply incorporating the values that society (or segments of society) finds attractive. Thus, on this view, science becomes no more than a fancy (and very expensively produced) ideology or secular religion. One often finds the claim by constructivists that modern science (including evolutionary biology) is no more than an apology for sexist and patriarchal thinking in various ways: it is a "justification" for those who would show preference for males over females, not to mention the old over the young, the white over the coloured, the Protestant over the Catholic, the Gentile over the Jew, the heterosexual over the homosexual, and more (Fausto-Sterling 1985; Harding 1986; Haraway 1989; Gould 1981; Levins and Lewontin 1985). And anybody who thinks that this is not undermining the status of science is clearly not from the science side of the campus.

This charge about constructivism may or may not be true. Yet, whatever constructivists may claim, I would point out that there is a strong culture of science — values within science itself, if you please — to avoid the simple endorsement of societal values (Ruse 1996). And this is so, whether or not scientists are always successful at cleaning out society values. In the case of evolutionary biology, whilst one might concede that many of the metaphors may originally have been brought in because they incorporated values that their users thought valuable, it is by no means necessarily true that these values persist -- or that these values must persist. For instance, there is no question but that when people like Adam Smith and Erasmus Darwin used the metaphor of the idea of a division of labour, they were thereby expressing approbation. They really thought that a division of labour was a good thing and ought to be promoted as much as possible. However, I do not see that this is necessarily the case today. When Edward O. Wilson uses the division of labour to try to decipher the activities of his ants, he is not necessarily showing that he himself thinks that the division of labour is a good thing — a good thing for humans, that is to say.

In fact, it is quite possible that Wilson thinks that the division of labour in the human realm is a truly dreadful phenomenon: something deadening the spirit, as humans stand all day by a conveyor belt, simply putting screws in holes in an automatic way, without any conscious thought whatsoever. Wilson might for instance endorse Japanese methods of work, where often a team is put together to work collectively on a project: people playing different and ever-changing roles, thereby being able to supplement each others weaknesses, but also being able to keep a lively interest in the activity and in the end product and quite possibly producing a superior product. But while Wilson may think that in the human realm all of this applies, he may equally think (one rather hopes that he would think) that none of this has any application to the ant world. There, the whole question of boredom and creativity simply does not come into play. The ants perform as automata and there is no cause for any concern about

their feelings. Hence, in this insect realm, the division of labour operates very efficiently: even more efficiently than in an eighteenth-century British factory. Obviously therefore, in using this idea, and in thinking that it applies to the ants, Wilson is in no sense making a commitment to the virtues of such a division, and particularly not to the virtues or the work of such a division as applied to humankind. Hence, what I would argue is that there is simply no need to worry necessarily that values enter into science through the introduction of metaphor. One might use cultural elements, but this is not at all the same thing as saying that science is no more than culture or that culture rules science. It is certainly not the same thing as saying that science simply reflects and endorses the values of the culture within which it finds itself.

CONCLUSION

My conclusion then is that metaphor is a vitally important element in evolutionary biology, both in the past and today. I argue that in an important sense it is indispensable. Even if it is theoretically eliminable, no acting evolutionist would really want to get rid of metaphor, for then the heuristic power of his or her work would be broken right off. Without metaphor, the vital epistemic value of epistemic fertility cannot be achieved. The consequence of this I argue is that in important respects evolutionary theory has been and still is, and will always continue to be, cultural. In this sense, it is specific to the people who produced it and the society or societies in which they live or lived. However, my final conclusion is that this does not mean that evolutionary biology is in some irretrievable or deplorable sense subjective, meaning that it is simply open to the whims of its practitioners. Nor does it mean that one can and does incorporate any societal or personal values that one wishes. I argue that the very fact that metaphors lead epistemic virtues (like predictive fertility) means that they are going to be checks and balances on the work that is produced. Through this, I would argue that one achieves the highest level of objectivity that one could hope for in this human-culturally dominated world of ours.

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