DARWINISM AND ECONOMIC THEORY

Peter T. Saunders,
Department of Mathematics,
King's College,
Strand, London WC2R 2LS,
England.

In *Sociobiology and Bioeconomics* (ed P. Koslowski). Springer, Berlin, 1999, pp. 259-278.

Contents

1. Introduction

There has always been a close connection between evolution theory and economics. Both Darwin and Wallace acknowledged their debt to Malthus, whose famous observation that populations have the potential to increase faster than the resources on which they depend became one of the axioms from which the theory of natural selection is derived. The influence of economics did not stop there, of course, but continues to the present day. Terms such as cost-benefit analysis and investment are in common use in evolution, and with their usual meanings. One evolutionist has even described his own book as a "cross between the Kama Sutra and the Wealth of Nations" (Ghiselin, 1974:1). Conversely, many economists, for example Marshall, Veblen and, more recently, Friedman (1953), have looked to Darwinism for ideas.

A particularly striking example is provided by game theory. While this was was originally developed for economics by von Neumann and Morgenstern (1944), much of the economists' recent interest in the subject arises out of its application to evolution theory (Maynard Smith and Price, 1973). Even where the links are not quite so obvious, there can be no doubt that the two subjects have profoundly influenced each other. Indeed, given the sorts of subject matter they address, it would be surprising if they had not.

There are at present debates going on in both evolution theory and economics, and here again there are many similarities. The aim of this paper is to explore these, starting from the situation in biology and noting the parallels in economics*.

2. The Orthodox Theories

It would be easier to describe and compare the debates if each were between two well defined positions, but this is not the case. This is more obvious in economics, in which there are a number of different schools of thought located within the mainstream or orthodox theory. They are sometimes collectively referred to as neo-classical economics, but there has been a great deal of development since the time of Walras, some of it in quite diverse directions.

The vast majority of evolutionists, in contrast, would describe themselves as neo-Darwinists. This does not simplify the issue as much as we might expect, however, because there is no agreed definition of neo-Darwinism, and indeed it is really more a paradigm than a theory.

* For an economist's account of the connections between the theories, though not the current debate, see Hodgson (1993)

The core of neo-Darwinism is, however, not difficult to identify. According to its supporters, it involves the assumption of the "overwhelming importance of natural selection", (Mayr, 1982), and the idea that "mutation, whereby variation arises, and selection, whereby it is shaped into coherent adaptive form, is considered sufficient explanation of the evolutionary process" (Futuyma, 1977). (By *neo*-Darwinism is meant the synthesis of Darwin's original theory with Mendelian genetics. An alternative term is the "synthetic theory".)

The key point is that the direction of evolution is determined not by the organisms (or species) themselves, nor even by the workings of the ordinary laws of physics and chemistry within them, but by the external forces that act on them, *i.e.* the selection pressures. It is these that hold the key to understanding evolution, rather than the organisms themselves.

This is very much like the picture in Newtonian mechanics. To understand why a planet goes around the sun in an approximately elliptical orbit we do not have to know much about the planet itself. The path is determined by an external force, the gravitational attraction of the sun*. What is more, we can make a number of gross simplifications without losing the essence of the problem. We can suppose that the sun and the planets are solid, static and spherical, which they are not, that the planets do not influence each other, which they do, and so on, and while the predicted trajectory will not be exactly what is observed, it will be close. What is more, there are standard techniques for incorporating the factors we neglected as minor adjustments to the model, and hence, by a process of successive approximations, making the predictions as accurate as we like.

Neo-Darwinists believe that evolution can be explained in much the same way. Natural selection can account for almost everything, certainly for all the important features. The role of any other factors (such as 'developmental constraints') is to explain away minor anomalies. The conventional view in economics is similar: while there may be other factors to take into account, the market is the starting point and the focus for explanation.

3. The Alternatives

Many of the critics of both neo-Darwinism and orthodox economics start from what they consider the inherent implausibility of the claim that such simple theories can be adequate to explain such highly complex phenomena. It follows that the alternatives they propose cannot be described in a few short sentences. There is, all the same, more to the critics' case than mere opposition to the present theories, and a brief sketch of one part of what is happening in evolution will serve to illustrate both that alternatives exist and also that they are not mere philosophical quibbles. They can and do lead to research which is capable of explaining important phenomena in a way that is different and, the critics would argue, more satisfactory than is possible within neo-Darwinism.

The Importance of Development:

In evolution, the alternative is based on two fundamental premises. First, the organisms we see about us today are the products of a process of descent with modification, *i.e.* evolution, and this has occurred by the action of the known laws of science. There are no otherwise unobserved fields or forces. This is in complete agreement with the synthetic theory, and in opposition to Sheldrake's (1981) morphic resonance hypothesis, and, for that matter, creationism. Second, and this is where the difference lies, while natural selection does occur and does play a role in evolution, this is more as editor than as creator. Darwin was not wrong, but his theory, even in its modern form, is not adequate to account for evolution.

This is not a new idea; it has been around for almost as long as Darwinism itself. It was well expressed by D'Arcy Thompson (1917), who wrote in his famous book *On Growth and Form*:

> "The waves of the sea, the little ripples on the shore, the sweeping curve of the sandy bay between the headlands, the outline of the hills, the shape of the clouds, all these are so many riddles of form, so many problems of morphology, and all of them the physicist can more or less easily read and adequately solve: solving them by reference to their antecedent phenomena, and in

* In general relativity, the situation is quite different. In particular there is no such thing as the 'force of gravity'. Biologists and economists who are attracted by the paradigm of physics should study the physics of the twentieth century, not the nineteenth. See Saunders (1989), also Ho (1993).

> the material system of mechanical forces to which they belong and to which we interpret them as being due....
>
> "Nor is it otherwise with the material forms of living things. Cell and tissue, shell and bone, leaf and flower, are so many portions of matter, and it is in obedience to the laws of physics that their particles have been moved, moulded and conformed."

Darwinists accept that physics and chemistry are involved in bringing organisms into being. They can hardly deny that. They do not, however, see them as relevant to explaining why they have the forms they do. For them, developmental biology is the study of construction, not of architecture and design. And this is one of the key points of disagreement between neo-Darwinism and the new approach.

To see what this means in practice, consider how we might explain the shapes of the medusoids illustrated in Fig. 1. A neo-Darwinist account would be concerned with showing that a medusoid gains — or might gain — a selective advantage from such a shape. It might also include a story of how the medusoid could have evolved from a simpler ancestor through a sequence of intermediates, each slightly more complicated and slightly fitter than the one before.

Actually, only two of these are drawings of medusoids. The one on the lower left is not a medusoid. In fact, it isn't an organism at all. It is a drop of fusel oil which has been allowed to fall into paraffin. Now a drop of fusel oil doesn't have ancestors, it doesn't have a genome, and it isn't subject to natural selection. Its shape is determined solely by the physical forces that act on it as it enters the paraffin.

Once you know that, does it still seem that the most important part of the explanation of the shape of the medusoid lies in selective advantage? Surely not. The undirected physical forces between two fluids of appropriate densities, viscosities and surface tensions, and with the right relative velocity, can produce the shape. It is therefore one that can appear relatively easily and reliably in nature, even though that isn't obvious at first sight.

It may well be that this peculiar shape confers some advantage on the medusoid. Certainly if it were a severe handicap it would have been eliminated by natural selection, but this explains only why it has persisted. It tell us neither how it arose in the first place nor why the medusoid doesn't have some other complicated form instead of this one. Are we really supposed to believe that selection has acted on a long sequence of small random variations only to produce one of the relatively small number of forms that are also observed in inert drops of fluid?

Selection was involved in the evolution of the shape of the medusoid, but it is not the most important factor in understanding why medusoids look the way they do. Genetic variation may be effectively random but phenotypic variation is not, and it can play a directing role. (See Saunders, 1984)

The explanation based on physics has more to tell us as well. The shape of an oil drop depends critically on the conditions of the experiment. If the velocity of the drop as it hits the paraffin is below a certain threshold, it will become slightly distorted, but that is all. Above that threshold, there appear not just one or two 'tentacles', but many. This sort of behaviour is common in nonlinear systems, which typically possess one or more so-called bifurcation parameters. Below a certain value of such a parameter, nothing interesting happens; if it increases above that value, a completely different form may be produced. Like the straw that broke the camel's back, the crucial change in the bifurcation parameter need not be dramatic in itself and may be brought about by something very simple, such as slightly increasing the height from which the fusel oil is dropped.

There is also usually more than one way of affecting a bifurcation parameter. In this case, we could also change the temperature of the oil or the paraffin to alter their physical properties. The important point is that it doesn't matter how we change the bifurcation parameter nor exactly how great the change is. If the parameter does not cross the threshold, nothing much will happen. If it does, then there will be a significant change which will be almost totally independent both of the precise size of the change in the parameter and of what brought that change about.

This has many important consequences. One of them is that for the same phenotypic change to occur in different individuals does not require a change in the same gene in each, nor even in the same gene product. This can help to overcome the problem that a mutation that occurs in a single individual is very likely to be eliminated by genetic drift even if it confers a significant selective advantage. It is improbable that the same random mutation will occur in a number of individuals, but if many different mutations will have the same effect, *i.e.* if the variation is a property of the developmental system which all individuals within a species share instead of a particular mutation which is unlikely to occur in more than one of them, then it is much easier to imagine that it will persist.

The bifurcation parameter can also be affected by changes in the environment, which accounts for the frequent occurrence of so-called phenocopies: individuals which, even thought they are genetically normal nevertheless resemble known mutants. This can help to solve the problem of how to explain evolutionary change when the (hypothetical) intermediate stages do not appear to be advantageous even though the end result is. A well known example, pointed out many years ago by Mivart (1871), is that flat fish that swim near the bottom of the sea have both eyes on the same side of the head. If evolution is always gradual, as neo-Darwinists insist it is, one of the eyes must have moved to its present position by a long sequence of small steps, each an improvement on the one before. It is very difficult to imagine what advantage there could have been in having one eye only slightly further forward but still pointing downwards. Yet if there were not, the transition to the modern form could never have begun*.

To see how we can solve this puzzle, consider the simple case in which a useful variation requires two mutations. Each of them increases the bifurcation parameter by approximately half the amount required to take it over the critical value. If either mutation occurs alone, there will be no obvious phenotypic change, and apparently no reason for the allele to spread through the population. It would therefore seem to be only by extreme good fortune that any individual will possess both of the necessary alleles. The variation would be selected if it were to occur; the problem is that it apppears very unlikely ever to occur and be available for selection.

On the other hand, the presence of either mutation reduces the change in the bifurcation parameter required to bring about the variation. It is therefore more likely to occur as a phenocopy. In this way, an individual with only one of the mutations can have a selective advantage. Even if part of a variation is of no benefit, an increased probability of having the whole variation can be. The second mutation, when it occurs, would lock in the variation, which would then no longer require the environmental stimulus: this is the process known as genetic assimilation (Waddington, 1940).

When a bifurcation parameter is increased slowly, typically very little happens for a while, then there is a dramatic change, and after that nothing much happens again. This is just the pattern which many palaeontologists claim is observed in the fossil record and which has been given the name 'punctuated equilibria' (Eldredge and Gould, 1972). There has been a considerable controversy over this in evolution theory because one of the basic tenets of Darwinism is that evolution has to be gradual, not because of the evidence but because the theory predicts there will be no sudden changes. The alternative not only allows them, it actually suggests that the major changes in evolution are likely to have involved some large steps (Saunders, 1993).

Mimicry:

The Viceroy and Monarch butterflies are both foul tasting, so birds quickly learn to avoid them. They are not close relatives, but they look very much alike, and this gives them a distinct advantage. Because the birds have only one pattern to recognize, fewer butterflies of each species are taken while they are learning.

Any variant form of either species that did not have the characteristic markings would not be identified as foul tasting even by experienced predators until it was too late. Unless it had some other compensating advantage, this would make it less likely to survive and leave offspring. Thus natural selection can explain why the similarity persists.

It does not, however, explain how it arose in the first place, which is the more important question for a theory of evolution. It seems very odd that the Viceroy should have gone to such trouble to copy the complicated wing pattern of the Monarch. We can see the advantage once the transition is complete, but how and why did the Viceroy ever start down that path? Its ancestors are generally accepted to have had rather drab markings, as some of its relatives do today. It would surely have been far more effective to have evolved almost any conspicuous coloration at all, than to have changed to looking only slightly more like a Monarch.

---

* In the sixth edition of the *Origin of Species*, Darwin acknowledged this point and suggested that the movement of the eye occurred because successive generations of fish strained their lower eyes to look upwards. His modern successors would dismiss such an account as Lamarckian, but they have no better explanation.

Nijhout (1978) has shown, however, that the way that butterfly wings develop makes the transition from the pattern of the Viceroy's typical relatives (and hence, we suppose, of its ancestors) to that of the Monarch surprisingly easy, requiring only one or two changes in parameters and so, presumably, only one or two mutations. This makes it much easier to understand how the similarity arose in the first place.

It is not always the case that species that resemble each other gain an advantage from this. *Lexias aeropus* and *Anetia cubana* are two species of butterfly that are not even in the same family, yet the similarity between them is just as close as that between the Monarch and the Viceroy. What is more, they live on opposite sides of the Earth, the former in Indonesia and the latter in Cuba, which makes it highly unlikely that natural selection could have been responsible for the similarity; no birds would ever encounter both species.

Again, the explanation almost certainly lies in development. If most wing patterns are variations on a single theme (the so-called nymphalid ground plan) then it is not surprising if the same one turns up more than once, especially in similar environments. It is interesting that neo-Darwinists refer to this sort of resemblence as pseudo-mimicry, the implication being that any phenomenon they cannot explain is not really a phenomenon at all. It is of course very convenient for a theory if it can avoid awkward cases by redefining them out of existence.

Rational Taxonomy:

One of the tasks of biology is to classify living things into a meaningful order. One obvious way of doing this is by relatedness, and indeed this is what most modern systematists set out to do. They use a number of techniques in their work, and there are strong disagreements among them, but the chief goal is to determine the true phylogeny.

As Ho (1990) argues, however, this begs the question of whether the genealogical classification is necessarily the most natural. Taxonomy arose in the first place because the forms of organisms seem to be arranged in orderly hierarchies of groups. But a taxonomy of forms is not the same as a phylogeny and cannot ultimately be based on comparisons of DNA sequences. It must be based on the forms themselves, and it can only be derived from experimental and theoretical studies of development, the process by which the forms are generated (Ho, 1990; Ho and Saunders, 1994).

The aim of such a taxonomy is to establish a map giving the "transformational distance" between any two forms, rather than a Hamming or other suitably defined distance between genomes. This allows us to make predictions about evolution, because change can be expected to occur between forms that are nearest neighbours on the taxonomic map, rather than predominantly between those that are connected by (possibly long) sequences of individually advantageous mutations*.

There is thus a choice to be made. On the one hand, we can base our taxonomy on DNA and define evolution to be permanent change in gene frequency. Alternatively, we can base our taxonomy on form, which makes evolution effectively the study of phenotypic change. The former is the approach of most orthodox evolutionists (with the notable exception of Ernst Mayr); the latter is what most people outside the field imagine the study of evolution is about; the point is that they are not the same.

Thus the present controversy about evolution is not a matter of playing with words; it concerns real issues and implies a different approach to some of the most important questions the subject should be addressing.

4. Some Parallels

Like evolutionists, economists place their emphasis on an external force, in their case the market. True, you need farms and factories and workers if you are actually going to produce anything, but there is no need to study them closely or put their details into the theory. We can assume that they will appear as and when they are called into play by the market. If there is a demand for widgets, entrepreneurs will set up widget factories and workers will become widget-makers. This is the same sort of confident assumption expressed by Dobzhansky et al (1977) in their textbook Evolution: "If the appropriate genetic variants to face an environmental challenge are not already present in the population, they are likely to arise soon by mutation."

---

* This statement is equivalent to the principle of minimum increase in complexity (Saunders and Ho, 1981).

Not all biologists agree with this, and in economics we find, for example, that Simon (1991) argues that many of the properties of modern capitalism have more to do with the structure and internal relations of non-market organizations than with markets.

In particular, some economists maintain that the future of an economy depends crucially on the presence of an educated workforce and an an appropriate infrastructure, and not just on the classical economic factors. The conventional idea is that the output of an economy depends on the amount of capital and labour employed. The theory also says that if you increase them both you should increase the output proportionately, but if you increase only one of them there is a law of diminishing returns.

It follows that poor countries should find it easier to grow faster than rich ones, so a plot of growth against current output should be a line with negative slope. This works for the Asian dragons and the rich countries, but not for the rest of the world. Underdeveloped countries are unable to respond as the model predicts they should. It's not that the market doesn't operate nor even that the orthodox theory of growth is without foundation. The problem is that there is a crucial factor being overlooked. This is a serious matter, because it has practical implications. A policy that might be appopriate in an advanced economy may be disastrous in a poor country that lacks the infrastructure necessary to make it work.

As another example, in the UK during the early 80's there was a sharp reduction in industrial capacity. The idea was to make industry more productive by forcing the less efficient firms into bankruptcy. Up to a point, this strategy succeeded, although many perfectly good firms were destroyed as well. Unfortunately, in economics as in evolution, "survival of the fittest" is a tautology. The only way we can tell which are the fittest is by seeing which ones actually survive. These need not be the ones with some specific desirable property that we can identify in advance and that we would like to see persist.

Then, in the mid 80's, the British government sharply reduced taxes. According to the theory, there should have been a massive investment in factories to produce all the goods that people were now able to buy. Only that didn't happen. Instead, there was a boom in imports, which led to a huge balance of payments deficit. With so many factories closed and their work forces dispersed, the economy was simply not capable of responding to the market, certainly not fast enough to compete with overseas suppliers*. Modern national economies are, of course, open systems, and, as in thermodynamics (and other fields as well), this can lead to phenomena which appear counter-intuitive if one's intuition has been built up by analysing closed systems. As Lambert et al (1986) point out, Kettlewell's (1973) classic study of industrial melanism in the peppered moth also ignored the significance of movement across the boundaries of the region being studied.

One point that will immediately strike a chord with an evolutionist is the claim made by many critics of orthodox economics (e.g. Ormerod, 1994) that while economic theory may have something to say at the detailed level — the micro-level — its ability to understand the workings of the economy at the overall level — the macro-level — is "manifestly weak".

This is an exact parallel with the debate about macroevolution. No one doubts that the conventional neo-Darwinist theory can be used to explain at least some features of evolution. The question is whether the theory is capable of explaining the major changes. This is why there has been so much controversy surrounding the theory of punctuated equilibria, when you would have thought that only palaeontologists could get so worked up about whether the fossil record shows evolution happened gradually or in bursts.

There is another similarity which is striking, even if it isn't strictly in economics. The most famous of Margaret Thatcher's sayings was her claim that "There is no such thing as society." There are, according to her, only individuals and families. This is exactly parallel with the Darwinian view that the motive force in evolution, selection, acts on individuals, not on groups — even to the point that through kin selection neo-Darwinism too considers the family as the largest unit that is relevant.

The market is also supposed to be the major force in employment. The idea is that an individual has a certain amount of time at his disposal, and he sells this to the highest bidder. This ensures that all jobs should get done and that the most demanding jobs should command premium rates of pay.

Some economists now argue that the idea of a labour market is at best a gross oversimplification†. People are not simply selling their leisure to obtain money to buy other things they value more. Jobs mean more than that; they have to do with status, with social relations, with self esteem. Being unemployed is

* At least one economist, J.K. Galbraith, predicted what would happen, but more on grounds of common sense and the earlier experience of Chile than by using sophisticated theoretical analysis.

† See, for example, *The Labour Market as a Social Institution* (Solow, 1990).

not just failing to sell your labour, and its consequences for the individual are far more than a mere shortage of money. Nor is it true that as an employer you get what you pay for: in general you get either more or less, and which it is depends on non-economic factors such as morale and tradition.

In many countries there is a serious shortage of mathematics teachers, but this has not brought about a sharp rise in their salaries. As for the very high pay of company directors, does that result from the action of the market, or is it more that if some people are allowed to write their own pay cheques they will be tempted to write very large ones?

Labour is an example of a market that fails to clear, *i.e.* one in which prices do not adjust to the point where all the goods are exchanged. You can hardly claim that the labour market has cleared when unemployment rates are running at 10% or more. Once again, it's not that the law is totally wrong, even when applied to labour. The question that must be asked is in how many situations is it the major factor that determines what will happen, and is it enough to tell us how to manage an economy? An even better question would be "Is it enough to tell us how to manage a society?" so as not to prejudge the issue by assuming that economic factors are to be paramount.

5. Nonlinearity in Economics and Evolution

Over half a century ago, the embryologist C.H. Waddington (1940) was struck by the fact that developing embryos have a number of important and, on the face of it, surprising properties. Above all, the process is remarkably stable both against mutations and against environmental perturbations. The stability is of a special kind that biologists call homeorhesis: an embryo that has been perturbed slightly will usually not go back the state it was in at the time of the perturbation but will continue to develop and eventually reach the same state it would have attained had it been left alone. In other words, it is the developmental trajectory that is stable, rather than any individual state along it. If the perturbation is too large, the embryo may die, but it may also be transferred to a different, but also stable, trajectory. As a result, for many features the possibilities form a discrete set, not a continuum.

For example, butterflies that have certain mutations or have been raised at different temperatures fail to develop the normal wing pattern. The pattern that does appear, however, is not a random modification of the usual one, but one of a small number of known alternatives, which can be quite different from that usually observed.

The features that Waddington identified in developing embryos are characteristic of complex nonlinear systems as a whole. Since embryos are certainly members of that class, they are almost bound to have them. That's not to say that we should cease to wonder that there are such things as organisms, only that once we know that there are, we should not be surprised that they have these properties. It would be astonishing if they did not. (See Saunders, 1993)

Homeorhesis, for instance, is just another name for what a mathematician would call the stability of an orbit. The existence of alternative trajectories is also a common feature of nonlinear systems. (Recall that a linear algebraic equation has a single solution but a quadratic has two.)

It follows that we cannot extrapolate our understanding of a small part of a complex nonlinear system to the whole. Each of the separate trajectories behaves for the most part very much like a linear system. As long as we are following one of them, there is nothing to warn us that the others exist. Yet we can go very wrong if we do not realize that they do. We are like one of the blind men in the story, each of whom had his own limited view of what an elephant is like. That is one of the major reasons why micro- and macro- are different in both economics and evolution.

We are also freed from the fatalism that conservative economists so readily embrace, the belief that any interference in the free market can only make things worse and will ultimately prove futile anyway. The slogan "There Is No Alternative" does not apply to nonlinear systems. For example, many economists now maintain there is a choice to be made between becoming a low skill/low pay economy and a high skill/high pay economy. A country, at least a relatively advanced economy like those of the EU, can decide which of the alternatives it will adopt by the decisions it takes about education and infrastructure and industrial policy. The market will certainly influence what happens, but only within the parameters which the nation may have the power to set.

Nonlinearity often provides an alternative explanation for phenomena that previously seemed to require the action of some external force, whether God, natural selection or the market. Heating a shallow pan of water from below produces the characteristic Bénard convection cells, the Beloussov-Zhabotinsky chemical reaction can create the same complicated patterns that we observe during aggregation by the cellular slime mold Dictyostelium discoideum, and so on. We now know that complex effects do not require complex causes*. In mathematics, the Mandelbrot set, a figure of immense complexity, can be generated by a computer program barely a dozen lines long.

Nonlinear systems can exhibit self-regulation, one of the properties that is considered characteristic of life and so commonly believed to be achievable only by conscious design or natural selection. (Watson and Lovelock, 1983; Saunders, 1994). Their internal dynamics make them far less sensitive than linear systems to short term external influences, whether natural selection or the immediate demands of the market. Nonlinear systems often behave in ways that seem paradoxical to the naive theorist; think of how a gyroscope tends never to move in the direction in which you push it. But while most real systems are nonlinear, linear systems are easier to model, and so it is on linear systems that most of our intuition is based.

6. The Problem of Good

Humans are not just passive entities, subject to market forces and nothing else. We are influenced by many other things as well. In fact, a good case can be made that if everyone acted as the market model would suggest, society would collapse. Rockefeller may have been right to say that to get one splendid American Beauty rose we have to cut off all the other buds, but he forgot about the rest of the plant, on which that single surviving rose depends. Not only can we not all be Rockefeller, society depends on the fact that most of us aren't trying to be.

It is interesting that Adam Smith did not take the same view as those who today see themselves as his successors and have adopted him as their patron saint. He did not see economic forces as the only determinant even of how an economy operates. And if morality and ethical behaviour did not come out of his model, Smith did not consider that a reason either for denying they exist or for claiming that the world would run better if they didn't. On the contrary, in *The Theory of Moral Sentiments* he explicitly stated his belief in a natural human tendency to act in a way that is acceptable to society. It is interesting that modern research shows that people really do value fairness: whether they will accept a certain wage or not, for instance, may depend as much on whether they think it is fair rather as on market forces as such.

Similarly, if evolutionists were not convinced that the theory of natural selection can explain every significant aspect of organisms, they would not find it so hard to understand why humans do not always act selfishly. Christian theologians have had to cope with the problem of evil: how can there be evil in a world created by a God who is both good and omnipotent? Sociobiologists, on the other hand, have to cope with what we might call the problem of good: how can there be anything but selfishness in a world created by natural selection? E.O. Wilson (1975) himself describes altruism as the central theoretical problem of sociobiology.

Not only are the problems similar, so are the solutions that have been proposed. The natural theologian William Paley, one of the scholars who most influenced Darwin, was careful only to write of "cases of apparent evil" (presumably it would have been sacrilege to accuse the Creator of allowing real evil into the world) and he argued that they were due to "the thwartings and crossings of laws whose effects are for the most part beneficient" (Paley, 1819:436). For sociobiologists, good is also only apparent — Ghiselin (1974:247) writes, "Scratch an 'altruist' and watch a 'hypocrite' bleed" — and is explained as the occasionally subtle workings of laws whose effects are for the most part selfish. (For a critique of sociobiology, see Saunders, 1988.)

Evolution theory and equilibrium economics each provide a means of justifying the status quo as the inevitable outcome of the workings of an Invisible Hand or, which is much the same thing, the Blind Watchmaker. In economics it is the market that determines what will be produced and at what price; in evolution it is natural selection that has created organisms and made them what they are. The individual agent or organism acts in accordance with these pressures in much the same way that the Earth follows the orbit determined by the gravitational field of the Sun.

Such beliefs allow us to reduce our personal responsibility for the way the world is and indeed for our own actions. True, as philosophers are constantly reminding us, "is" and "ought" are logically distinct.

---

* This is in contrast to the so-called Curie principle of classical physics, according to which if effects manifest a certain symmetry, then this symmetry will be reflected in the causes that give rise to them. See Stewart and Golubitsky (1993).

That does not, however, mean that they are not connected, nor that the ideas do not, rightly or wrongly, get conflated. The company director may not claim that his astronomical salary is morally justifiable — or, then again, he may — but it is very convenient for him that the theory says that it is necessary for the effective operation of the economy. The large tax reductions in Britain in 1987 were appropriate according to some interpretations of orthodox economic theory, but 1987 was also a year in which there was a general election.

It is also convenient for those of us who are, by world standards, very successful and affluent, to believe that this is because of our superior genes, and not largely a result of the exceptionally favoured environment into which we had the good fortune to be born. A person who knows he is behaving badly can rationalize his actions with the thought that they are, after all, natural. And how critical can the rest of us be if what he is doing is "only human nature"?

The trouble with an optimization theory is that it can be read backwards. If systems strive to move to the optimal state, then surely we must be in the best of all possible states, or at least well on the way towards it. Whether in economics or in evolution, this is a very attractive idea for those who are doing very nicely out of the world as it is.

7. Conclusion

With the model of Newtonian mechanics very much in mind, if only implicitly, both biologists and economists have sought overarching theories that promise to explain a wide range of highly complex phenomena from a few basic principles. It is not by accident that we read of Darwin as the Newton of the grass blade, or Marxism as the laws of motion of society. The alternatives that are being proposed take the view that no such theories exist. Now that we know that there are solid mathematical reasons for doubting we can ever have three week weather forecasts even with excellent mathematical models, massive computers and dense networks of weather stations, why should we expect to be able to treat organisms or economies like the solar system? And even that, we are told, can exhibit chaos.

It is hard to imagine anyone ever trying to explain evolution without invoking natural selection, though we may come to speak more of selective constraints on development than of developmental constraints on selection. Equally we cannot ignore the effects of the market. The present parlous state of the former Soviet Union demonstrates simultaneously what happens both if you take the market too seriously and if you try to ignore it. The question is how far these concepts can explain the most important phenomena in their respective subjects and, consequently, how far they should be used as the unique basis for deciding policies.

When a young actor first joins a classical company to play in Shakespeare, he is often given the role of a "spear carrier". This is a minor character, often with no lines to speak, who may be necessary for the action but who has no influence on the way the plot unfolds. What is happening in both economics and evolution is that some of these spear carriers are being brought to the centre of the stage. Of course, the play will look quite different when they are.

Acknowledgments: I am grateful to Mae Wan Ho and Ulrich Witt for comments on an earlier draft of this paper.

References

Dobzhansky, Th., Ayala, F.J., Stebbins, G.L. and Valentine, J.W.: *Evolution*, San Francisco (W.H. Freeman) 1977.

Eldredge, N. and Gould, S.J.: "Punctuated Equilibria: an Alternative to Phyletic Gradualism", in T.J.M. Schopf (Ed.): *Models in Paleobiology*, San Francisco (Freeman Cooper) 1972, pp. 82-115.

Friedman, M.: "The Methodology of Positive Economics", in M. Friedman (ed.): *Essays in Positive Economics*, Chicago (Chicago University Press) 1953, pp. 3-43.

Ghiselin, M.: *The Economy of Nature and the Evolution of Sex*, Berkeley (University of California Press) 1974.

Ho, M.W.: "An Exercise in Rational Taxonomy", *Journal of Theoretical Biology*, **147** (1990) pp. 43-57.

Ho, M.W.: *The Rainbow and the Worm*, Singapore (World Scientific) 1993.

Ho, M.W. and Saunders, P.T.: "Rational Taxonomy and the Natural System as Exemplified by Segmentation and Phyllotaxis", in (Eds) R.W. Scotland, D.J. Siebert and D.M. Williams: *Models in Phylogeny Reconstruction*, Systematics Association Special Volume No. 52, Oxford (Clarendon) 1994, pp. 113-124.

Hodgson, G.M.: *Economics and Evolution*, Cambridge (Polity) 1993.

Kettlewell, H.B.D.: *The Evolution of Melanism.* Oxford (Clarendon) 1973.

Lambert, D.M., Millar, C.D. and Hughes, A.J.: "On the Classic Case of Natural Selection". *Rivista di Biologia* **79** (1986) pp. 11-49.

Maynard Smith, J. and Price, G.R.: "The Logic of Animal Conflict", *Nature*, **246** (1973) pp. 15-18.

Mivart, St G. J.: *The Genesis of Species*, London, 1871.

Ormerod, P.: *The Death of Economics*, London (Faber and Faber) 1994.

Paley, W.: *Natural Theology* (16th edition), London (F.C. and J. Rivington and others) 1819.

Saunders, P.T.: "Development and Evolution", in (Eds) M.W. Ho and P.T. Saunders: *Beyond Neo-Darwinism: An Introduction to the New Evolutionary Paradigm*, London (Academic Press) 1984, pp. 242-263.

Saunders, P.T.: "Sociobiology – a House Built on Sand", in (Eds) M.W. Ho and S.W. Fox: *Evolutionary Processes and Metaphors*, Chichester (Wiley) 1988, pp. 275-294.

Saunders, P.T.: "Mathematics, Structuralism and the Formal Cause in Biology", in (Eds) B.C. Goodwin, G.C. Webster and A. Sibatani: *Dynamic Structures in Biology*, Edinburgh (Edinburgh University Press) 1989, pp. 107-120.

Saunders, P.T.: "The Organism as a Dynamical System", in (Eds) F. Varela and W. Stein: *Thinking about Biology*, SFI Studies in the Sciences of Complexity, Lecture Notes Vol. III, Reading (Addison Wesley) 1993, pp. 41-63.

Saunders, P.T.: "Evolution without Natural Selection: Further Implications of the Daisyworld Parable", *Journal of Theoretical Biology*, **166** (1994), pp. 365-373.

Saunders, P.T. and Ho, M.W.: "On the Increase in Complexity in Evolution", *Journal of Theoretical Biology*, **90** (1981) pp. 515-530.

Sheldrake, R.: *A New Science of Life*, London (Paladin) 1981. Simon, H.A.: "Organizations and Markets", *Journal of Economic Perspectives*, **5**(2) (1991), pp. 25-44.

Solow, R.M.: *The Labour Market as a Social Institution*, Oxford (Blackwell) 1990.

Stewart, I. and Golubitsky, M.: *Fearful Symmetry*, Oxford (Blackwell) 1992.

Thompson, D'Arcy W.: *On Growth and Form*, Cambridge, (Cambridge University Press) 1917.

Von Neumann, J. and Morgenstern, O.: *Theory of Games and Economic Behaviour*, Princeton (Princeton University Press) 1944.

Waddington, C.H.: *Organizers and Genes*, Cambridge, (Cambridge University Press) 1940.

Watson, A.J. and Lovelock, J.: "Biological Homeostasis of the Global Environment: the Parable of Daisyworld", *Tellus* **35B**, (1983) pp. 284-289.

Wilson, E.O.: *Sociobiology*, Cambridge, Mass. (Harvard University Press) 1975.