G R E S H A M

C O L L E G E

CONFLICT AND CONSENSUS IN THE AGE OF THE NEW GENETICS

Lecture 1

EVOLUTIONARY THEORY AT THE MILLENNIUM

by

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Abstract

From Darwin's classical theory of natural and sexual selection to the present day, how far have the new developments in evolutionary theory – contingency, punctuated equilibrium, exaptation and adoptation – changed our understandings of the evolutionary process?

Hilary:

The main focus of today's lecture is *contemporary* evolutionary theory. But before Steven, as the biologist of we two, takes us through the main developments from exaptation to spandrels and all the rest, it seemed useful to begin with a quick resumé of nineteenth century and early twentieth theorising. Such a resumé serves two distinct but linked purposes. First it serves as a reminder of past theory. Second it reminds us of the continuing links between 'science' and 'society'. Although our shared Gresham chair is committed to the exploration of 'genetics and society', and today we take for granted that evolutionary theory and genetics are powerfully linked discourses, Charles Darwin's evolutionary theory had no such link. Even though the great evolutionary theorist and the Abbé Mendel as the founder of genetics were carrying out their meticulous experiments and observations at roughly the same time, the link between genetics and evolutionary theory - which today we take for granted - was not to be made until the Modern Synthesis proposed by Haldane and Fisher in the 1930s.

Using the perspective of social theory, it is often less threatening to look back into the past to see the connections between 'science' and 'society'- or rather scientific ideas and the cultural and social context in which they are forged. A deep part of our western culture and part of the conditions for the immense achievements of modern science has been the belief that science is value free, located outside culture. This is often spoken of as 'the view from nowhere.' The scientific method (though that too becomes more complex on closer examination, as what the physicists do is very different from say the biologists or the social scientists) is supposed to make it possible for scientists and their work to be uninfluenced by their place in the social and cultural world.

The view that social context shapes knowledge is often naively attributed to postmodernism. What post-modernism has done, and that is rather useful culturally and politically speaking, is to ensure that contemporary readers and audiences like to know where people, including scientists, are coming from. There is more than a suspicion that gender, race and class, whether we come from a rich or a poor society, influence our take on the world. In consequence, if only one rather peculiar group, namely white middle class men from the rich countries, gets to construct scientific knowledge, the view, rather than being 'from nowhere' instead will be partial. One policy development associated with this epistemological suspicion, mixed up with an ideology of social justice and economic efficiency, has been the pre-occupation to get women and racialised groups / ethnic minorities' into science. The current intense cultural debate about whether science is somehow outside society or whether it is an active part of culture is unresolved. These debates are not over; there is epistemological diversity and difference even within the small group which constitute the current Gresham professors. What is new is how widespread the debate has become. But as I said before, the debate itself is not new, for the most influential theorists arguing that context shapes knowledge were the nineteenth century pair: Karl Marx and Frederick Engels.

I don't want to rehearse M&E's acute observations relating Darwin's theorising to those of Malthus and Hobbes, simply to say that for today's sociologist such an observation is unexceptional. It doesn't in itself suggest that the theory is either right or wrong. Biologists find that perspective harder to take. As they have to work with Darwinian theory, its rightness matters. What I do want to do here, however, is to pick up a huge common context for both M&E and Darwin. These three lived in the age of progress, or at least in the age of the ideology of progress. Thus the crux of Marxist theory was its theory of change through conflict over the means of production, which together with technological change, brought about new social formations. These new social formations were laid out in an inexorably progressive order. Feudalism under certain conditions would of necessity give way to capitalism and that in its turn to socialism. Each formation was necessarily both different from and better than its predecessor. It is not necessary to have an elaborate grasp of Marxist theory to see that the prison camps of actually existing socialism indicate a weakness, to say no worse, in the inevitable progressivism of M&E's theory.

As an evolutionary theorist Darwin only partially escaped this sense of change being associated with social progress. In brief, when he discussed human nature he all too frequently merged natural selection and the taken for granted superiority of the Victorian gentlemen in the height of Empire. When he discussed his earthworms or the finches of the Galapagos, then his theory of evolution spoke of change and fitness for evolutionary niches. Here the sense of progress is weakened: he still ranks species as higher or lower forms but that every species is getting better and better has dissolved. It is this which marks the rupture between biological and social thinking about evolution.

In political and social policy discourse concerning social reform, 'evolution' clung to its nineteenth century sense of progress. Juxtaposed to 'revolution' 'evolution' suggested (above all in the social democratic project) that societies could change gradually to a form of socialism without violent upheaval. Thus the socially deployed concept of evolution during the mid twentieth century became separated from the biologists' concept. It is to this Steven will now turn.

Steven:

As we discussed in last year's lectures, Darwin's *main solution* (not only) to the problem of how evolutionary change occurred was his theory of natural selection, with its simple syllogism:

1. Like begets like, with minor variations
2. All organisms produce more offspring than can survive to reproduce in their turn
3. Therefore the 'fittest' – those variants best adapted to the environment, are the most likely to survive to breed in turn
4. And therefore there are steady changes in type within a species across generations as a result of this process of natural selection.

As a syllogism, the theory is irrefutable (hence Daniel Dennett's description of it as a 'universal acid'). However it left major problems unexplained. One was that, as Darwin didn't know about Mendel's work, he was unable to explain how variations could be preserved and not simply swamped out – a problem that didn't get resolved until the synthesis of Darwinism and Mendelism under the name of 'the modern synthesis' of neo-Darwinism which Hilary touched on earlier.

The second problem was that of accounting for the persistence in the population of features that seemed to have no obvious survival value – indeed the reverse – the classic example being sexual ornamentation such as the peacock's tail. This led Darwin to introduce a second 'motor' to evolutionary change – that of sexual selection.

The third problem was that although natural selection theory is good at explaining how species get better at doing whatever their species-thing might be, it doesn't explain precisely what the title of *The Origin of Species* implied – that is, how new species are formed. Hence a whole set of additional factors – founder effects, genetic and geographical isolation etc have to be introduced – e.g. the famous Galapagos finches.

Seventy years after the modern synthesis, the challenges confronting evolutionary theory remain deep. Apart from creationists (who still subscribe to the Reverend Paley's view that each organism is the product of God's design) evolution, which simply means change over time, is a fact, not a theory. The theoretical stake (for non-creationists) is the debate over the mechanisms of such change. Lets look at some of the issues.

1. ***What is it that changes?***

For Darwin it was obvious; it was the phenotype – the outward form of the organism. But modern evolutionary theorists often discount this and argue that the proper measure of evolutionary change is not phenotypic at all, but genotypic – evolution is defined as the rate of change of gene frequency in the population. Darwin would have been amazed to discover that for these theorists, organisms seem to have completely disappeared into their own genes!

2. ***How fast does it change?***

Genetic mutation takes place, as a result of background cosmic radiation and other factors, at a fairly constant rate. But many mutations are eliminated by cellular repair mechanisms and other processes, so that within the genome there are regions of rapid change, and others where little appears to have changed over many millions of years (examples, for instance the so-called clock and per genes which I will mention briefly). But more puzzling to orthodoxy is the fact that in some species phenotypes appear to be stable over hundreds or thousands of millions of years despite accumulating genetic change. There are two related theoretical lessons that have been drawn, both controversial. The recognition that there are huge pools of genetic variability within any population led the Japanese geneticist Mooto Kimura in the 1970s to propose his theory of *neutral mutation*, a theory vigorously opposed by selectionists who insist that all genetic variability provides the basis for adaptive differences on which natural selection can act. And the recognition of the stability of the fossil record over aeons of time, for example in the trilobites, led palaeontologists Stephen Jay Gould and Niles Eldredge to suggest that rather than continuous steady phenotypic change, as in the classical Darwinian model, many species showed remarkable stability punctuated by periods of rapid change – this theory they called *punctuated equilibrium.*

3. ***Is all change adaptive?***

Rigid selectionists argue that all observed genetically transmitted phenotypic features must be adaptive, or natural selection would eliminate them. Gould, Richard Lewontin and many others, in part drawing on Kimura, but also on the circular nature of adaptationist theory, insist that it is not easy to determine what constitutes an adaptation (as opposed to a 'spandrel' – a more or less accidental consequence of other aspects of an organism's development – examples – the human chin). The breaking of the link between genotype and phenotype, and the recognition that not everything is adaptive, led Gould to propose that many aspects of an organism were '*exaptations*' – that is the result of accumulated genetic change producing features which then became pressed into a different service from that originally selected for – example bird feathers and flight.

4. ***What is the level of selection?***

'Selfish gene' theorists like Richard Dawkins argue that selection in the narrow sense can only occur at the level of the individual gene. By contrast, pluralists insist that there are many levels of selection - gene, genome, population, species and even socio-ecosystems. The idea of 'group selection' laughed out of court by orthodox evolutionists between the 1960s and 1990s is now making a comeback.

5. ***Competition versus co-operation?***

Orthodox neo-Darwinists argue that the fundamental nature of genetic mechanisms is competition, and that if we see co-operative mechanisms in nature they are merely the products of underlying competitive mechanisms. This is disputed by those who argue instead that genes cannot function in isolation and that co-operative processes between groups of genes, between genes and the cellular environment and between individuals and populations are as intrinsic a feature of living processes as are competitive mechanisms.

6. ***Constraints on evolutionary change?***

For neo-Darwinists, natural selection operates a la carte; anything is possible. Their opponents argue that there are constraints on evolutionary change given by physical and chemical limitations or even (Brian Goodwin) more abstract '*laws of form.*' Example – why humans can't evolve into winged angels.

7. ***Ontogeny and phylogeny***

Many neo-Darwinians ignore the problem of development – it is as if the adult phenotype springs fully-fledged from the genome. This produces profound difficulties for the theory, and we still await a new synthesis of evolutionary and developmental theory – which may build on the insights of C.H.Waddington in the 1950s but is now called 'evo-devo' by fashionable theorists.

8. ***Natural selection versus active organisms***

The metaphor of natural selection is essentially passive. 'Nature' sets challenges which organisms either pass or fail. Yet organisms are not passive – they are actively engaged in complex ways in choosing and changing their environment. Thus they are active players in their own evolutionary destiny (Humberto Maturana and Francisco Varela's theory of *Autopoiesis* and Susan Oyama's *Ontogeny of Information*).

9. ***Contingency***

Accident plays a part in evolutionary change that cannot be predicted. However well-adapted the dinosaurs were, an asteroid collision changed the earth's climate and they became extinct. This leads us to recognise: First that the key concept of 'fitness' only means 'fitness for a specific environment and context' and hence carries no moral value. Second, evolutionary change is essentially blind (Dawkins' *Blind Watchmaker*); it cannot predict change, only track it. So it runs constantly behind environmental change. But as species and environment interact, phenotypic change within a population also results in changes in the environment which in turn affects all other species living in that ecosystem in ways which of their nature are radically unpredictable. Hence the future is under-determined.

10. ***For biological theory is evolution "progressive"?***

No

11. ***Has biological evolution – or even human evolution stopped?***

No.

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