A very careful reading and indeed a re-reading of On the Origin of Species is required in order to fully understand Darwin's view on Evolutionary Theory. The one thing that he did not claim is that his theory of natural selection was the full story of evolution. In his own words he states 'I am convinced that natural selection has been the main but not the exclusive means of modification.’ Darwin was a competitive scientist and in his great book he treads a fine line between expounding his theory in order to convince the public of its efficacy and pointing out the fact that it was an incomplete explanation of evolution. He knew that natural selection was a systematic mechanism but in order for it to create new species this mechanism required a constant supply of variation or new design. Unlike neo-Darwinism's reliance on the copying error as the source of variation Darwin was convinced that there was a system for generating variety which was non-random, 'I have hitherto sometimes spoken as if variations were due to chance. This, of course, is a wholly incorrect expression, but it serves to acknowledge plainly our ignorance of the cause of variation.' At many points in his book he admits to this missing link in his theory. In chapter five for example he refers to ' a tendency to vary, due to causes of which we are quite ignorant.' He coins the term 'generative variability' to emphasize his belief in the existence of laws of variety-generation and talks of 'an innate tendency to new variations.' But he admits that 'Our ignorance of the laws of variation is profound'. He is convinced that 'There must be some efficient cause for each slight individual difference.' When discussing the evolution of instincts he speaks of 'variations produced by the same unknown causes which produce slight deviations of bodily structure.'

If the greatest ever thinker on evolution was convinced that there would eventually be discovered the 'laws of variation' why did twentieth century biology completely ignore Darwin on this score? Neo-Darwinism refutes Darwin's ideas and claims that the incredible outpouring of new variety, which acts as the source of the raw material required by natural selection, is due to copying errors, a rather lame, non-scientific claim. The majority of modern thinkers on evolutionary theory seem to ignore the fact that evolution requires both a mechanism and the raw material required by this mechanism. This modern view was summarised by one of the greatest ever advocates for neo-Darwinism, Richard Dawkins, when in an article in New Scientist magazine he wrote, ‘Natural selection is quintessentially non-random, yet it is lamentably often miscalled random. This one mistake underlies much of the sceptical backlash against evolution. Chance cannot explain life. Design is as bad an explanation as chance because it raises bigger questions than it answers. Evolution by natural selection is the only workable theory ever proposed that is capable of explaining life, and it does so brilliantly.’ No, Mr Dawkins, natural selection, by itself, does not explain life brilliantly and no one is saying that natural selection is a random process. With the benefit of Darwin’s insight we can now see that natural selection is an obvious and simple consequence of reproduction and overcrowding. It eliminates the less fit but it does not design or create new organisms. It works on what is already there and leaves behind organisms and their genes that are better survivors. It can only work when it has a variety of organisms to choose from. It does not create those survivors. It merely changes the average characteristics of future generations by eliminating some and letting others continue into the future. It is a pure mechanistic non-random process, but it does not design new organisms.

Biologists are not usually fond of mathematics but we have to accept that the study of evolution should essentially be the study of the algorithmic process. It should be the study of systems and of the logical outcomes of a process that was set in motion possibly 4 billion years ago. This process can now be explored with the help of computers and the job started by Darwin can now only be taken a stage further if mathematicians studying systems and algorithms get together with biologists studying genes and the chemistry of life. Derek Hough has long argued that the original primordial self-replicator was responsible, via the algorithmic process, for the evolution of a system for maintaining and creating variety. His ideas, which have been previously known as the theory of the self-developing genome, are underpinned by arithmetic but are summarised for the non-mathematician at www.evolutionarytheory.co.uk

Towards a new definition of the theory of evolution

There are many excellent text books for undergraduates on the subject of evolution. One of the best is by Douglas Futuyma and is titled Evolution. The book is beautifully written. It is clear, concise, well-argued and all the salient points logically explained. It is almost a latter-day On the Origin of Species written for the genetic age.

How does Futuyma define the currently accepted version of the theory of evolution? Straightaway in chapter one he states that ‘mutation and natural selection together cause adaptive evolution: mutation is not an alternative to natural selection, but rather its raw material’. We could find similar definitions in other literature but it is important here to understand the exact meaning of the word ‘mutation’. When trying to explain the evolutionary route from simple organisms to human beings we clearly need more than a re-mixing of established genes and a crop of regularly re-occurring mutations. What is needed is a steady supply of novel genes which could give rise to novel features. This is where the concept of the ‘copying error’ would come in. In 2009 The Royal Society in London produced a small booklet to celebrate the 150th anniversary of the publication of On the Origin of Species and in this booklet the meaning of ‘mutation’ in this context is made very clear: ‘We know that inherited variation is caused by changes in gene sequences of organisms, called mutations. They can arise from errors introduced when DNA is copied, and from damage due to background radiation or chemical reactions.’ And then as if to re-emphasize the point they go on to say ‘Sometimes errors result in the duplication of a gene….such that new functions can arise. Many examples of this process are known.’ So, we can be in no doubt that the currently accepted theory of evolution is about natural selection acting on the variety created by copying errors. Are there in fact any examples of this process? Let us now return to Futuyma. In chapter eight he states ‘Mutations occur at random.’ He explains that they are random in the sense that they are not influenced by the environment in which they would be advantageous. This is fine. But then he goes on to say ‘ .... although we may be able to predict the probability that a certain mutation will occur, we cannot predict which of a large number of gene copies will undergo the mutation.’ Futuyma gives examples of mutations in the text but all his examples are of regularly re-occurring mutations. Surely, mutations that regularly and reliably re-occur need not be viewed as copying errors? And surely Futuyma is viewing these phenomena at the wrong level? After all, we are not sat around looking at an individual gene in order to measure evolutionary change. We must view the whole population of that gene. This is really one of the very fundamentals of why evolution is so successful. Life’s geneticalgorithms are going forward in parallel in vast numbers and only one of them has to come up with a good idea for that good idea to eventually spread to all the others. This discussion concerning the exact meaning of the word ‘mutation’ may seem like just a case of semantics but this is a vitally important point. Radio-active decay may be a random process when viewed at the level of an individual atom but when a large population of atoms is viewed then radio-active decay proceeds at an incredibly reliable, predictable, non-random rate measured in half-life’s. Surely, Futuyma must have at least considered the idea that the mutations required as the raw material for natural selection are actually non-random in their nature? He could then have considered the possibility that evolution does not rely on copying errors but is in fact an evolved, automated system. He seems to accept most of the tenets of the theory of the self-developing genome. He recognizes that mutations are the raw material of evolution. He accepts that there will be ‘mutator genes’, genes that influence the rate of mutation. He accepts that natural selection can act to maintain variety. He acknowledges that ‘neither natural selection nor genetic drift accounts for the origin of variation.’ He accepts the idea of the varying or variable environment. But he rejects the idea of the universality of mutator genes because ‘the mutator allele is likely to decline in frequency because copies of the allele are permanently associated with the mutations they cause, and far more mutations reduce than increase fitness’. And here is the last hurdle for Futuyma to jump over before entering the brave new world of automated evolution. The theory of the self-developing genome pays no regard to deleterious mutations. In the main these do not affect evolution and usually would get eliminated. The self-developing genome relies on the existence of mutator genes that create useful variation. These mutator genes have been selected because this limited, useful variation, at the lower levels of inheritance, is maintained in order to cope with environmental variation that the heritable unit has previously encountered during its evolutionary history. The selfish, variety-maintaining mutator genes can overcome the selfishness of body-building genes which no longer have it all their own way. Complexity evolves because varying heritable units can combine in unique combinations and could create pre-adapted organisms which will prosper if an empty niche exists to which they are better suited. At least Futuyma concedes that such mutator alleles do actually occur and he cites the example of such genes seen in E. coli.

It is the rate and degree of variation that is being selected and this variation can be maintained in every organismic feature, from protein structure and neural connections to body size. Life on earth now has all the tools and building blocks required to explore all potentially available regions of biological Design Space.

The self-developing genome would lead to a new definition of evolution something like this:

Life on earth constitutes an interrelated network linked by common descent and universal systems. Natural selection has evolved systems that endow organisms and their species with a degree of non-developmental (i.e. evolutionary) plasticity which facilitates adaptation to an ever-varying or variable environment as an alternative to extinction. These systems, which maintain a defensive degree of variation at the lowest level of inheritance, can ultimately lead to increasing complexity and evolution due to the fact that lower level heritable units combine and cooperate within genomes to create functioning organisms. In other words, the genes that code for individual characteristics, which have evolved to exist in a limited and useful variable state, combine at the level of the organism in unique combinations with the potential for the emergence of novel or more complex characteristics. These new characteristics might become established in a vacant niche or could proliferate via natural selection. Evolutionary change is facilitated by the naturally occurring phenomenon of speciation.

The evolution of variety-generating systems was driven by the competition engendered by the exponential increase in numbers of the original primordial self-replicators. These early replicators would have created messy and inaccurate copies of themselves. The initial competitive environment faced by these primitive organisms would have been incredibly variable. The first priority for this early algorithmic search would have been the evolution of characteristics that would enable these organisms to survive in a very variable biosphere. Hough explains that by following the twin axioms of firstly, selfish genes (or systems) which influence the outcome of reproduction and secondly, co-operation between varying heritable sub-units, then evolution as we know it, including the evolution of increasing complexity, is inevitable.

Life on earth, as we now have it, could not be possible without the evolution of variety-generating systems. Copying errors are destructive and perfect copying fidelity is the road to extinction. There are still unknowns to be explained if we are to fully understand evolution. Firstly, how did the original primordial replicator come into existence and secondly, how did it evolve into the incredible DNA-based duplicating machine that is first seen in the fossil record? It is said that we are within fifty years of solving the first problem and then the solution to the second problem might be amenable to simulation by computer.

Thomas Kuhn, the philosopher of science, might have had something interesting to say about the reluctance of the academic establishment to let go of the copying errors theory and he might have suggested that we will have to wait for the next generation of bright young biologists before encountering the inevitable “paradigm shift”.

The following critique has been copied from www.evolutionarytheory.co.uk

Critique of Futuyma’s book “Evolution”

Futuyma’s book is one of the best text books ever written on the subject of evolution. It is a work of immense scholarship. It covers evolution in great detail and does not hesitate to introduce the reader to some difficult arithmetic concepts. But nowhere in this great book does he mention the all-important phenomenon of the algorithmic process. Hough claims that it is only by studying the outcome of a competition between millions of separate genetic algorithms that we can understand where this process leads to. Hough’s conclusion is that this competition leads to the very thing that we refer to as evolution. His contention is that systems for variety-generation and variety-maintenance were evolved at a very early stage in the history of life on earth. These systems, which endow organisms and their species with a degree of plasticity, allow them to morph their way to survival. Copying errors or random mutations are simply not necessary (although chance and probability play a part). The really complex part of evolution ended way before the pre-Cambrian explosion when systems were evolved which allowed organisms, over time, to change from one form to another in an attempt to avoid extinction. Futuyma’s book is littered with examples of the ability of organisms and their species to morph from one form to another and he lists the numerous ways in which genomes can rearrange themselves but he refuses to acknowledge that an evolved system may be behind this plasticity. He often describes the ease with which new species can evolve in rapid radiations or can repeatably converge on the same idea but he does not recognize thatsystems exist to facilitate these phenomena. He accepts that the existence of variety within a population is vital for evolution and even quotes Lewontin and Hubby who asked “Do forces of natural selection maintain this variation?” but he refuses to acknowledge that there exists a system that automatically creates this variety and therefore makes evolution possible. He sticks to the opposite idea that mutations are random and “are generally thought to be not an adaptation, but a consequence of unrepaired damage” Futuyma is wrong to state that Darwin believed in “random, purposeless variation”. Darwin was convinced that there were unknown “laws of variation”

Futuyma recognizes all the evidence for the existence of variety-generating systems; “many populations contain enough genetic variation to evolve rapidly when environmental conditions change, rather than having to wait for new favorable mutations” and furthermore he says, “Species contain genetic variation that could easily serve as the foundation for the evolution of many characteristics and that many or most characteristics should be able to evolve quite rapidly - far more quickly than Darwin ever imagined” He even talks of the evidence for “evolution of mutation rates”.

Futuyma’s book chronicles the reliability of variety-generation when viewed from different perspectives. Surely he can see that this phenomenon of variety-generation must be explained by a most fundamental characteristic of all living organisms?

His book describes the classic experiment on penicillin-resistance but Hough’s theory would say that this experiment does not demonstrate how a genetic copying error endows anti-biotic resistance but it demonstrates that E.coli learnt the trick way back in its evolutionary history when it was previously exposed to this enemy. The variety-generating system created by evolution then ensures that anti-biotic resistance will always occur occasionally as a safeguard against the species being entirely eliminated. Similarly, the classic study of black and white moths in industrial Britain, as cited by Futuyma, is not an example of evolution at all. It merely demonstrates the existence of a system for variety-maintenance created by evolution.

Hough’s ideas give no hint of Lamarckian-type evolution. There exists no design goal or aim but what has evolved is a tool kit to enable change to happen in any possible direction. The types of building blocks are limited; what creates complexity is the fact that individual cells co-operate to build organisms and sometimes this co-operation can create new and unique combinations.

Futuyma’s book does not tackle the most important overall question of how life navigates from simple single-celled organisms to things like humans and butterflies in a step-by-step process in which each useful step has to hit on a target which is hidden within an unimaginably large number of possibilities. The question of why evolution inevitably climbs a ladder from simple organisms is not answered in Futuyma’s book but at least he provides every possible clue to the solution to that problem.