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Beyond Darwin's vision? : an investigation into criticisms of contemporary evolutionary theory

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BEYOND DARWIN'S VISION?
AN INVESTIGATION INTO CRITICISMS OF
CONTEMPORARY EVOLUTIONARY THEORY

A Thesis
Presented to
The Faculty of the Department of Philosophy
San José State University

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

By
Gerald James Krieger
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BEYOND DARWIN'S VISION?
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CONTEMPORARY EVOLUTIONARY THEORY

by Gerald James Krieger

This thesis examines criticisms of evolutionary theory that have primarily been raised by Michael Denton and Robert Wesson. The criticisms are evaluated and a few are determined to be legitimate insofar as they draw attention to the fact that contemporary neo-Darwinian theory is not without its problematic points. I explore the suggestion made by Wesson, as well as Stuart Kauffman, that chaos or complexity theory may strengthen our existing theory of evolutionary development.

As many critics have pointed out, there are a few problems that are overlooked or simply ignored within current evolutionary theory. Although there have been many criticisms of evolutionary theory, I deal only with a few that appear to have some merit. The primary criticisms that are examined are: the spontaneous emergence of life, the extension of macroevolution from microevolution, the incomplete nature of the fossil record, coordinating evolutionary permutations, and biochemical relationships between organisms.

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Preface

Traditionally, philosophers of science have had very little to do with the biological sciences and relegated their queries to physics, cosmology, and mathematics. Fortunately, this trend has already been replaced with an intense interest in biology and a revival in the "Darwinian" controversy. This thesis will provide the reader with an analysis of some criticisms of the current neo-Darwinian evolutionary paradigm.

Many critics have argued that there is a crisis (in the Kuhnian sense) in evolutionary biology in much the same way as there was a scientific crisis in Galileo's time. The geocentric theory contained many inconsistencies that are avoided in the heliocentric conception of the universe. Copernicus' heliocentric theory, which eventually came to overthrow the Ptolemaic geocentric theory of the universe, was one of the competing theories of how to conceptualize our universe.

In the same vein, many critics have argued that the neo-Darwinian theory of evolution is the "geocentric theory" of the biological sciences. Although there may be a few problems with neo-Darwinism it will be clear that this is not at all true. On the other hand, it does appear to be the case that the theory of evolution might increase its

explanatory power if chaos or complexity theory is found to be legitimate. I will suggest that if this proves to be the case, this would create a redirection for our evolutionary inquiries that may allow evolutionists to answer many questions that heretofore they had been unable to fully explain. However, critics could not be more wrong in maintaining that there are major problems with the neo-Darwinian theory of evolution.

Because of the incipient nature of chaos theory, it is premature to propose a strict mathematical model and parade the greater explanatory power of a theory which is still inchoate. With this in mind, I will attempt to illustrate and elaborate upon a theory which, on the face of it, might help to strengthen our existing evolutionary paradigm.

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INTRODUCTION

The Darwinian theory of evolution has been under attack since Charles Darwin first published *On The Origin of the Species* in 1859 and the attack has not abated. Critics like Michael Denton, Francis Hitching, and Robert Wesson argue that the reason the attacks continue is simple: there are several legitimate criticisms of Darwinism that have not been adequately addressed. In this thesis I will examine some of the criticisms that appear, *prima facie*, to have some legitimacy in order to determine whether there is any merit to them. At best, most of these criticisms will only reveal the fact that there is nothing wrong with our existing theory of evolution proper, but there are a few aspects of our existing theory that could be improved.

The purpose of this thesis twofold: the first is to debunk some of the criticisms that have recently been leveled against evolutionary theory and the second is to explore the possibility that chaos theory might be augmented into our existing theory of evolution. If chaos theory does not suffer the same fate as catastrophism, it may prove to be as important to evolutionary theory as Mendel's theory of transmission genetics. Although it may seem premature, I will also attempt to give the reader an insight into a modified theory of evolution that would incorporate chaos theory.

Critics have been writing about the "Darwinian impending

doom" over the past three decades (Bethell 1989, Denton 1985, Hitching 1982, Wesson 1994). One author writes, "Darwin . . . is in the process of being discarded, but perhaps in deference to the venerable old gentleman, resting comfortably in Westminster Abbey next to [actually, literally at the feet of] Sir Isaac Newton, it is being done as discreetly and gently as possible, with a minimum of publicity" (Bethell 92). In fact, nothing could be further from the truth. The Darwinian paradigm is more deeply entrenched now than it has ever been. However, there are a few criticisms that have continually surfaced in one form or another, as well as a few more recent criticisms that have appeared with the advent of biochemistry which should be investigated. It is, therefore, of some interest to examine these criticisms in order to glean fact from fiction.

Just as some critics of science would argue that the neo-Aristotelian tradition stifled scientific progress in occidental culture until the 16th and 17th centuries, due to dogmatic adherence to Aristotle's theory of the immutability or static nature of the spheres or universe, critics such as Denton, Hitching, and Wesson argue that the existing theory of evolution known as neo-Darwinism has propagated a similar "fraud" and hindered evolutionary theory from further development beyond the basic principles introduced in *The Origin*.

Over the years many critics have continued to allege

that one of the reasons "Darwin's theory" has stifled the progression of evolutionary theory is because he and many of his followers dogmatically adhere to the canon of *natura non facit saltum*. This criticism is not new. It was first suggested by Thomas Huxley in a letter to Darwin before the publication of *The Origin*. Huxley writes, "You have loaded yourself with an unnecessary difficulty in adopting *natura non facit saltum* so unreservedly" (as quoted by Mayr 1991 46). It is not clear whether this is not true or false. Nevertheless, it is only a very small part of what many critics claim is a much larger problem, that is, the inability of neo-Darwinism to properly account for evolutionary development.

On the other hand, evolutionists and critics alike must recognize that Darwin is responsible for a great feat, i.e., his overthrow of the ecclesiastical notion that the earth and species on it were immutable. This public stance Darwin took was diametrically opposed to the religious doctrine of divine creation. This had the unfortunate consequences of unleashing a fusillade against both Charles Darwin, the man, and, what would come to be known as, "his" theory of evolution. Many critics continue to argue that Darwin simply overthrew one fallacious assumption for another. As I will show in the following chapters, Darwin's vision was anything but fallacious.

In chapter one I will give a brief overview of a few of

the giants whose shoulders Darwin stood on to write his *magnum opus*, *The Origin of Species*. By far, two of the greatest influences on Darwin were Charles Lyell and Thomas Malthus. But there were many others that influenced Darwin in more subtle ways. For example, in later editions of *The Origin*, Darwin, in an effort to stave off critics, incorporated some aspects of Jean Lamarck's theory of inheritance of acquired characteristics. Because there is much confusion over what Darwin's actual theory of evolution is, in the first chapter I will briefly outline the argument as he presents it. I will then give examples of different traits that have been cited as examples of Lamarckianism and show how most of these easily fall within the purview of the neo-Darwinian theory. This will lead to many of the common misconceptions of Darwinism and what it really means. Consequently, I will also give a compendium of Darwin's main arguments as presented in *The Origin*. This inquiry will more clearly be understood against the background of how life could have emerged on this planet, the topic of chapter two.

In order to get an idea of how evolution could have ever begun on earth I will discuss the probability of the spontaneous generation of life. This has been found to be a particularly problematic area--ever since William Paley articulated his objection to this possibility in his famous watchmaker argument for design.

I will examine the statistics behind the possibility

that life could have been created by chance. I will then go on to explain one of the ways in which we think life could have erupted by chance. Although it might seem natural to explore the "inorganic mineral" theory of the chemist Graham Cairnes-Smith, I will explore a more traditional approach as presented by Anthony Mellersh.

I will also debunk the argument that life could not have arisen by chance because it is too improbable. Utilizing an approach used by Richard Dawkins in *The Blind Watchmaker* I will suggest that the reason that the emergence of life seems improbable is based on our skewed conception of what is possible in human terms. If we had vastly longer lifespans then, in fact, the emergence of life is not as improbable as we think it to be. After all, the emergence of life does not have to be probable, only possible.

In chapter three I will return to examine what critics have found problematic with Darwin's use of analogy or extension of one case of evolution to another. In essence, one critic, Denton, argues that Darwin is not justified in claiming that new species arise in nature simply because breeders have been able to create different varieties of a species. To put it another way, Denton argues that Darwin's observation that a species can be altered by artificial selection is not sufficient empirical evidence to conclude that large-scale changes can take place. In other words, it does not adequately support the claim that an amphibian can

evolve into a reptile.

Denton presents what he sees as a similar example in the field of meteorology where small weather predictions do not yield long-term weather predictions. I present an example from the world of physics where the description of gravity on earth was accurately used to determine the orbits of the planets as a counterexample. Therefore, examples can be cited either against or in support of the extension of evolutionary theory. However, due to the gradual progression of the appearance of more complex life forms in the fossil record, it would be more probable and prudent to view the extension of minor evolutionary changes to account for global changes as veridical.

The imperfect nature of the fossil record is the focus of chapter four. Darwin was well aware of the absence of "transitional" specimens in the fossil record. In fact, he devoted an entire chapter to this criticism in an effort to respond to the objection. Darwin thought that many "transitional" fossils would be discovered in due time. Unfortunately, critics like Denton, Wesson, and Hitching argue that this has not been the case. To put it another way, they argue that we are not *much* better off today in producing fossils of transitional forms to support a gradualist interpretation than we were in Darwin's era.

Although this may be the case, there are a few specimens that would fall under the rubric *transitional*. Because of

the nature of the fossil record and the contradictory views espoused by paleontologists that the fossil record is both complete and incomplete, I argue that it would be more helpful to adopt a theory that is based upon the gaps in the fossil record.

In chapter five I will introduce the theory of punctuated equilibrium which was first suggested by Stephen Jay Gould and Niles Eldredge to explain the large gaps we find in the fossil record. Although this theory may explain the gaps, there have been a number of criticisms raised against the suggestion itself. Even if we were to adopt this theory of speciation, the fundamental arguments of a gradualistic theory are still an integral part of punctuated equilibrium. Hence, regardless of which theory we adopt, there are a number of criticisms that must be addressed.

In chapter six, the more recent criticisms of evolutionary theory made by Denton in the area of molecular biology and genetics are explored. In essence, Denton argues that evolutionary development should be detectable and evolutionary relationships should be demonstrable upon examination of various proteins. However, this will not prove to be the case, claims Denton. Upon the examination of various genetic materials, one comes to the realization that it is impossible to determine ancestry among different classes or organisms. This criticism must be addressed in order to confidently claim, as many evolutionists do, that

evolutionary theory is completely veridical.

In chapter seven I will explore a criticism of evolutionary theory first articulated by James Mivart. This criticism was later taken up and well argued by Henri Bergson in his book *Creative Evolution*. In essence, Bergson argues that there are many single mutations needed to form a single organ. Because each individual mutation will not by itself convey a benefit Bergson tries to argue that there would be no reason to retain each mutation in isolation. I point out and criticize some of the assumptions that Bergson makes and end up conceding that a coordinating code might make the formation of organs of "extreme perfection" more plausible. I briefly mention the possibility that chaos theory may hold the answers to this problem.

I will briefly summarize the criticisms as well as my responses to them in chapter eight. I reiterate my position that Denton is right in arguing that the issue of biochemical relations is a problematic aspect of contemporary evolutionary theory. I also agree with Bergson that the issue of coordinating permutations may be problematic. This leads to the possibility that the explanatory power of chaos theory might benefit our current theory of evolution.

In chapters nine and ten I explore the idea of integrating chaos theory into our existing theory of evolution which has recently been argued by Robert Wesson and Stuart Kauffman. Although the suggestion of what I will call

chaotic equilibrium is still in its incipient stages, I attempt to present a rough overview of what a theory of evolution integrated with chaos or complexity theory would consist of. Although there is still much that needs to be done in terms of exploring the possibilities of such a theory, it would appear that morphological stasis would be more easily explainable in terms of chaotic attractors.

Because some morphological transitions do not readily suggest intermediate forms, it may be the case that there is a type of "leap" from one form to another, what I will later call "morphological building blocks." This might also explain the gaps in the fossil record.

The problem of what I will call a coordinating and retention code may also be more readily explainable if there were an underlying formula that governs the way in which evolutionary permutations take place. It is now possible to create computer programs that simulate the complex processes and systems that are present within living organisms. Instead of taking the programs many hours to find certain parameters necessary to mimic a living system, researchers have found that within a few iterations the system naturally "falls" into place. This is explained in terms of chaotic attractors that "draw" a system within a certain boundary.

To put it differently, a large number of commands are not required to get the program to replicate living systems. A few general commands are all that is required. This may

allow us to understand how many complex structures have formed. Furthermore, what scientists formerly thought were vestigial organs may simply be a natural step in the formation of another organ.

In this thesis I don't mean to suggest that there are major problems with our existing theory of evolutionary development. However, what I do mean to suggest is that there are still a few smaller problems that should not be dismissed as some evolutionists are prone to do. Furthermore, these same evolutionists seem to want to stay confined to the traditional method of explaining speciation and are not amenable to exploring other avenues that may prove to be more fruitful. This is where I see a problem. Although it would be premature to embrace chaos theory as veridical and use it to supplement our existing theory of evolution, as evolutionists we should not allow ourselves to be confined by Darwin's narrow vision of evolution. Evolutionists should be open to the possibility that there are other mechanisms that may strengthen our theory of evolution. We must continue the legacy that a young man began in 1832 when he first set foot on H.M.S. *Beagle*.

1. A HISTORICAL PERSPECTIVE

In this chapter I am going to offer a brief history behind what came to be known as "Darwin's" theory of evolution. One of the rival theories to "Darwin's" was Lamarck's theory of acquired characteristics. Consequently, I will briefly articulate what Lamarck's own position was and examine some of the work that has been claimed as support for this theory. This will raise the question of what Darwin actually held to be the case in *The Origin*, which is what I will examine near the end of this chapter.

One of the most common misconceptions of Darwinism is the belief that Charles Darwin's theory of evolution is "his theory." Actually, the idea of the "survival of the fittest" dates back to Empedocles of Acragas (c. 433 BC) and preceded Darwin by two thousand years (Durant 67). The idea that species were descended from a common ancestor and that traits were passed on was proposed by his grandfather, Erasmus Darwin. The synthesis of the theories of the survival of the fittest, natural selection, and the idea that current species were descended from a common ancestor formed the basis of Charles Darwin's theory of evolution. Nevertheless, Darwin's unique contribution was to make a compelling scientific case that natural selection is the reason why evolution had produced the myriad forms of life that we now bear witness to (based upon a wide range of observations and inferences) (Sober 11).

Darwin certainly could not have accomplished what he did had it not been for his predecessors, who paved the way for his ideas.¹ Darwin's grandfather had tremendous influence on the culture of the early 19th century. Erasmus Darwin published *Zoonomia*, a famous two volume book on evolution, in 1794 and 1796 (Hitching 196). Erasmus saw that

animals competed with each other--as did plants--and that this was a means of change. He saw that sickness could be inherited, and this could change things too. He saw that the competitive male sexual pursuit of females was another element of evolutionary change. And he anticipated Lamarck . . . in suggesting that acquired characteristics could in some degree be passed on (Hitching 197).

Erasmus bolstered the ideas that would come to make his grandson famous.

Charles Darwin was impressed by evolutionary changes which appeared to be caused by the use and disuse of organs to such an extent that in an effort to isolate a mechanism of change he turned to the Lamarckian theory of acquired characteristics in the later editions of *The Origin*. Darwin writes about the eyes of moles, and indicates that "The state of the eyes is probably due to gradual reduction from disuse, but aided perhaps by natural selection" (Darwin 178). Darwin seems to hedge between the view that the use and disuse of an organ is entirely responsible for its creation or diminution and the position that the use and disuse of an organ aids natural selection.

Shortly after the quotation cited above he writes, "As

it is difficult to imagine that eyes, though useless, could be in any way injurious to animals living in darkness, their loss may be attributed to disuse" (Darwin 178). Here he appears to be embracing Lamarckianism. That is to say, the qualification he had just mentioned regarding natural selection is dropped. But Darwin was hardly a full fledged Lamarckian. He only supplemented his theory of natural selection and evolutionary development with Lamarck's theory because he lacked a mechanism for the inheritance of permutations. Unfortunately, reading the later editions of *The Origin* one does not always get this impression as the following passage makes clear:

With such structures as the above lamellae of horn or whalebone, habit or use can have done little or nothing, as far as we can judge, towards their development. On the other hand, the transposal of the lower eye of a flat-fish to the upper side of the head, and the formation of a prehensile tail, may be attributed almost wholly to continued use, together with inheritance (Darwin 309, sixth edition, emphasis added).

Darwin intimates Lamarckianism in some areas and only supplements it with the theory of natural selection in others. Even where he does espouse the theory of acquired characteristics it is often in conjunction with natural selection. Considering Darwin's flirtation with Lamarckianism, it might be useful to articulate Lamarck's actual theory because, since Darwin, Lamarck has been almost universally misunderstood.

A generation before Darwin, Jean Baptiste de Monet de

Lamarck coined the word *biology* and attempted to relate fossils to creatures that were alive at the time. Lamarck published *Philosophie Zoologique*, in 1809, wherein he advanced a theory known as the principle of inherited characteristics (Hitching 120 ff.). There has long been confusion over what types of traits Lamarck thought could be inherited. Therefore, it is of some use to clarify Lamarck's theory.

Lamarck's reasoning and justification for his theory are not as primitive as many think, and there is, on the face of it, some credence to his theory. Consequently, it is helpful to quote Lamarck at length as he examines the eyes of moles:

Eyes in the head are characteristic of a great number of different animals, and essentially constitute a part of the plan or organization of the vertebrates . . . Yet the mole, whose habits require a very small use of sight, has only minute and hardly visible eyes, because it uses its organ so little . . . Light does not penetrate everywhere; consequently animals which habitually live in places where it does not penetrate, have no opportunity of exercising their organs of sight, if nature has endowed them with one. Now animals belonging to a plan of organization of which eyes were a necessary part, must have originally had them. Because, however, there are found among them some which have lost the use of this organ and which show nothing more than hidden and covered up vestiges of them it becomes clear that the shrinkage and even disappearances of the organ in question are the results of a permanent disuse of that organ (as quoted in Steele 36).

Consequently, many of the experiments done to disprove Lamarck are attacking a view that he did not espouse. For example, chopping off the tails of rats for hundreds of

generations would never produce tailless rats, according to Lamarck. Rather, Lamarck thought that if an organ was used to pursue a creature's *basic needs*, then the use and disuse of that organ could affect its evolutionary development (Hitching 121).

Redeeming Lamarck?

A wide variety of cases are often used as cases for Lamarckianism by small groups of neo-Lamarckians searching for validation for their theories. Historically speaking, the classic case of callosity on an ostrich's legs has often been used as an example of Lamarckianism. It is well known that ostriches have calluses on their legs, but the way in which they develop does suggest a Lamarckian interpretation. For example, a young ostrich still within the egg develops callosity on its knees before it ever has a chance to walk on terra firma. Could this be a case where a characteristic is inherited as a genetic adaptation before the creature has used it? As it turns out, the answer seems to be no.

The calluses can be explained by natural selection because the ostriches' habit of kneeling appears to have set up selective pressures for the preservation of this random permutation (Gould 1982 82). The heart of this solution rests with the apparent fact that ostriches that did not have callosities developed problems walking or were somehow less

well off then those that developed the callosities.

Consequently, the answer falls within the purview of our evolutionary theory and can be explained because it becomes highly plausible that nature simply "selected" for the morphological trait which contains callosity.

Although many seemingly Lamarckian characteristics may be explained by conventional evolutionary theory, there are a few cases that seem to defy explanation. For example, there is mounting evidence that the bacterium *Escherichia coli* may respond to its environment and pass on acquired traits.

Barry Hall, a geneticist, has been doing research on an old problem discovered by experiments conducted on *E. coli* several decades ago that left scientists perplexed (the pioneer in this area of research with *E. coli* was Salvador Luria whose work was first conducted in the early 1940s). Hall has conducted experiments with strains of *E. coli* that contain defects in two genes, *trpA* and *trpB* that are responsible for encoding enzymes that are needed to synthesize tryptophan, an amino acid (Symonds 32). In the experiment, a strain of *E. coli* is placed in a tryptophan-based solution that the bacterium needs to survive. Two very specific mutations are needed "to remedy each of the two defects" (Symonds 32). However, Hall found that the frequency of mutations occurred (as a pair) "100 million times more than he expected--as if the bacterium had some way of directing the mutations instead of leaving them to chance"

(Symonds 32). Hall has discovered that

the mutations in the *trpA* and *trpB* genes appear simultaneously, rather than sequentially as theories based on random events would predict. Secondly, the beneficial mutations arise from highly specific genetic changes Most random mechanisms would generate a spread of genetic changes (Symonds 32).

The most unusual aspect of the experiment is that this special adaptive mechanism only appears when the bacterium has been highly stressed due to being starved for 20 days (Symonds 32). Findings have been identical when similar experiments were done with *E. coli* and lactose. Hall's work seems to demonstrate that *E. coli* is able to "leap barriers to certain adaptations" (Symonds 32). Furthermore, these mutations appear to be directed so as to be advantageous (Symonds 33).

Hall's data might, and perhaps should, be explained within the neo-Darwinian paradigm if treated as a case of "stress-induced" natural selection. In other words, when an organism is stressed and facing death this may trigger more mutations than normal. This might account for the results. It is also possible that the first mutation is neither detrimental nor useful but simply lies dormant until the second mutation arises. The answer is not yet clear how or why this would be the case (I will examine mutations later). However, one should not immediately join the neo-Lamarckian camp, nor should one claim that neo-Darwinism is false, when numerous other hypotheses remain.

Critics of neo-Darwinism point to experiments with *E. coli* to argue that many evolutionary mutations do not suggest a neo-Darwinian conception of speciation. There are other problems, they argue, that neo-Darwinians are at a loss to explain. It's true that supporting proof is not always at hand. However, I just attempted to formulate a hypotheses that would fall within the neo-Darwinian framework so it should be noted that answers and suggestions abound.

Wesson attempts to argue that, historically speaking, creatures do seem to lose unnecessary organs and traits "much more rapidly than can be accounted for by any selective advantage of not having them [e.g.] Mexican cave fish have lost vision in about 10,000 years" (Wesson 232). Another interesting case of a diminution of an unneeded structure would be human dentition. Our ancestor's teeth slowly began to diminish in size around 100,000 years ago (Wesson 232). Human dentition is thought to have decreased approximately one percent every 2,000 years, but more recently, one percent every 1,000 years--this makes human teeth approximately half of their original size (Wesson 232).

Surely, Wesson argues, this seems to be an example of Lamarckianism insofar as the increasing disuse of teeth seems to have caused them to diminish in size. The shrinkage is normally "associated with the coming of fire and cooking, the grinding of food, and the invention of pots in which to stew dinner;" and yet, "It would hardly seem, however, that there

would be any substantial selection pressure in favor of small teeth. To the contrary, unless tastes have changed, fine teeth might be advantageous in sexual competition for both males and females" (Wesson 232). The theory of natural selection would stipulate that there is a type of survival advantage to traits that are passed on to offspring. Yet, Wesson argues, that it does not seem clear at all that smaller teeth would favor sexual selection.

On the other hand, just as I did earlier, one can construct a hypothesis that would adequately explain these anomalies. For example, one might speculate that larger teeth would be a burden to an individual because of the extra energy required. Consequently, if a mutant were to develop smaller teeth it would become more successful because it would be more efficient at utilizing its energy and would expend less masticating food because of cooking and the increased usage of tools. Or perhaps, given the number of people whose teeth are too large or too numerous for their jaws--thus requiring the removal of their "wisdom" teeth or, at an early age, of extra teeth so that the orthodontist can ensure that the remaining ones come in straight, there might be a health advantage to smaller teeth, particularly as humans started living beyond 20 or 25 years of age.² Perhaps another creative hypothesis can explain these changes in organisms. However, at this point it should be clear that there are no problems in generating possibilities for how

evolution could have taken place the way it did.

That there are no clear explanations to some objections raised by critics does not imply that they will remain insurmountable in the future. Furthermore, I have attempted to show that the examples cited as claims for neo-Lamarckian inheritance easily fall under the rubric of neo-Darwinian explanation. The rapidity which some changes have taken place in evolution does not pinpoint a particular weakness in our evolutionary paradigm. However, it is an indication that as neo-Darwinians we really should be more amenable to other options.

Darwinian oversights

The terms *evolution* and *Darwinism* are often used as though they were synonymous terms, but it is extremely important to remember just how different they are (Hitching 4). The *evolution* of life over approximately the past 3.5 billion years is a fact if we accept, as we should, the evidence that has been gathered from the fields of geology, paleontology, and molecular biology. Furthermore, in the laboratory we can illustrate the phenomenon of evolution of organisms by bombarding *Drosophila* (fruit flies) with x-rays.³ These experiments reveal that induced mutations may result in two sets of wings growing, along with various other anomalies (Hitching 6). By contrast, Darwinism, or neo-Darwinism, is a

theory that purports to explain evolutionary development *in toto*. Because such a wide array of people claim to be neo-Darwinians it has become difficult to actually ferret out the common Darwinian view of evolution.

Among biologists, paleontologists, geologists and philosophers, one often hears references to "Darwin's theory of evolution" which suggests that Darwin's theory was a unitary entity (Mayr 1991 35). However, the term *Darwinism* has multiple meanings which invariably depend upon the person using the term as well as the context in which the term is used. Darwin's theory as presented in *The Origin* was actually composed of four subtheories: common descent, multiplication of species, gradualism, and natural selection (Mayr 1991 36-37).

Many contemporary scientists and philosophers, among them Recker (1990) and Hull (1985), have claimed that there is not one Darwinian tenet that adequately represents all Darwinians. Mayr (1991) has pointed out that this claim is erroneous (in a trivial way). Mayr states that

There is indeed one belief that all true original Darwinians held in common, and that was their rejection of creationism, their rejection of special creation. This was the flag around which they marched. When Hull claimed that 'the Darwinians did not totally agree with each other, even over essentials,' he overlooked one essential on which all these Darwinians agreed. Nothing was more essential for them than to decide whether evolution is a natural phenomenon or something controlled by God (Mayr 1991 99).

Because a characterization of all Darwinians is almost

impossible, I will emphasize the "traditional" position that stems from Darwin's original work and that attempts to remain faithful to many of Darwin's original tenets.

According to Stephen Jay Gould, any suggestion that neo-Darwinism fully explains evolutionary development is suspect. Evolutionary lacunae, particularly the imperfections of the fossil record, are, to use a phrase suggested by Gould, "the trade secrets of Paleontology" (as quoted by Hitching 12). However, many zoologists and biologists still maintain that "The basic theory of evolution has been confirmed so completely that modern biologists consider evolution simply a fact" (Mayr 1991 162). These types of claims may sometimes be slightly overstated.

As I mentioned earlier, the truth or falsity of what Mayr claims depends on the sense of *evolution* he is utilizing. If Mayr is referring to macroevolution, then his claim is less accurate than he portrays it to be. However, if he is referring to microevolutionary processes then he is certainly correct--even some critics of evolutionary theory would not disagree with him. This raises the issue of what Darwin's argument for evolutionary development actually consisted of. It is to this issue that I now turn.

Darwinism in perspective

Darwin's main objectives in *The Origin* were to prove

that species were not separately created and that natural selection was the chief agent of change. Along these lines, with respect to the development of many creatures arriving at a similarity in structure, Darwin writes,

Natural selection would have had different materials or variations to work on, in order to arrive at the same functional result; and the structures thus acquired would almost necessarily have differed (Darwin 242).

Due to the great similarity of construction in, say, the way different creature's respiratory systems functions and were developed, Darwin felt compelled to conclude that they arose from a common progenitor.

Darwin constructed his explanatory model of evolution through natural selection upon four facts and three inferences. Darwin was aware of three facts that all seemed to lead to one conclusion. First, he was aware of the superfecundity of nature, viz., the exponential increase of populations (fact 1). Consequently, Darwin argues that "There is no exception to the rule that every organic being naturally increases at so high a rate, that, if not destroyed the earth would soon be covered by the progeny of a single pair" (Darwin 91). Additionally, he was also aware of the limited availability of many resources necessary for survival (fact 2--his primary inspiration was the work of Thomas Malthus).

Armed with these two facts, Darwin concluded that there was a struggle for existence among individuals in nature

(inference 1, Mayr 1991 72). To this effect Darwin writes, "More individuals are produced than can possibly survive, there must in every case be a struggle for existence" (Darwin 91). Thus, Darwin's argument is formulated in logical notation as follows: $(F_1 \wedge F_2) \supset I_1$. The most important question, and one of a very controversial nature is, "Between whom does the struggle for existence take place?" (Mayr 1991 79). There have been essentially two different types of answers, one that emphasizes the struggle for existence that occurs between species, the other the struggle among individuals.

Mayr (1991) indicates that one should focus on Darwin's insights that resulted from his reading of Malthus and this will inevitably lead to the "correct" interpretation that the struggle for existence occurs between individuals. He writes, "Only when one applies population thinking to the struggle for existence can one make the crucial conceptual shift to recognizing a struggle for existence among individuals of a single population" (Mayr 1991 79).

To the struggle for existence, Darwin then added two other facts that led him to another crucial inference. Darwin was aware of the unique nature of every individual within a given species (fact 3). Darwin writes

No one supposes that all the individuals of the same species are cast in the same actual mold. These individual differences are of the highest importance for us, for they are often inherited, as must be familiar to every one; and they thus afford

materials for natural selection to act on (Darwin 67).

He was also aware of the inheritance of various traits and characteristics from observations and research he did on various animal breeders (fact 4). In fact, he devoted the first chapter on *The Origin* to a lengthy discussion of breeding pigeons. This, concludes Darwin, suggests that nature "selects" certain animals that possess certain beneficial or favorable traits (inference 2, Mayr 1991 72). Darwin says, "This preservation of favorable individual differences and variations, and the destruction of those which are injurious, I have called Natural Selection, or the Survival of the Fittest" (Darwin 108). We can represent Darwin's entire argument with the following logical notation: $[I_1 \wedge (F_3 \wedge F_4)] \supset I_2$. This is Darwin's theory of natural selection which is which is partly responsible for microevolutionary processes, and a crucial step in his argument.

However, Darwin went one step further and argued that a third inference followed from his second inference. Darwin argued that if animal breeders can alter creatures on a microcosmic level then nature can be considered to select for certain traits as well (inference 2). Darwin writes,

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 occur in the course of many successive generations.

He then went on to suggest that we can envision numerous successive changes continuing indefinitely which would result in one creature being the progenitor to every living organism on earth (inference 3). Says Darwin, "Analogy would lead me one step farther, namely, to the belief that all animals and plants are descended from some one prototype" (Darwin 642). Darwin's argument was strong until this point when he suggested that because creatures change by means of natural selection (microevolution), we can envision numerous successive changes (macroevolution) which would account for the myriad forms of life that now inhabit the Earth (inference 3). It must be admitted that inference 3 is weak, Darwin himself says it is an analogy, as it is simply an assumption based upon inference 2, viz., $I_2 \supset I_3$.

Consequently, critics like Denton are correct insofar as there was no empirical evidence to directly support Darwin's conclusion. On the other hand, Darwin never claimed there was any *direct* evidence to support his conclusion, he only argues that it would be a very plausible account for how evolutionary development took place on earth based upon his proof of macroevolution. Darwin's *goad* (sic) for his *magnum opus* becomes clear near the end of *The Origin* when he writes,

Much light will be thrown on the origin of man and his history When I view all beings not as special creations, but as the lineal descendants of some few beings which lived long before the first bed of the Cambrian system was deposited, they seem to me to become ennobled (Darwin 647).

That Darwin is right almost goes without saying.

Many critics dogmatically insist on pointing out that, despite the almost *natural* extension of Darwin's claim, there really were no empirical facts for Darwin's last inference. After all, it was merely an extension of his previous inference. This is where Darwin's theory of evolution becomes problematic according to many critics. The last and final inference is typically what people think of when they hear the term *evolution*. The critics argue that it is only with this last inference that problems abound.

Unfortunately, when many nonbiologists hear the word *evolution* they often think of macroevolutionary processes and rarely consider microevolution to be a related thesis. It is important to reiterate that Darwin is presenting two distinct theories in *The Origin*. The first theory is known as his "special theory," henceforth referred to as microevolution (inference 2), and is relatively conservative and restricted in scope. As I mentioned earlier, microevolutionary phenomena are widely accepted facts and few scientists or critics question this demonstrable fact of Darwin's theory. However, the second theory, often called the "general theory," or "transpecific evolution," henceforth referred to as macroevolution (inference 3), is far more extensive in breadth. The second theory is a universal application and extension of the first. That is to say, macroevolution has to do with the progression of speciation and life on Earth

from a single organism.

In this chapter I have given a compendium of Darwin's theory of evolution. In chapter two I will give an overview of the emergence of life. The mathematical probability that life arose by chance will also be the focus of the following chapter. Most critics of evolution examine the low probability that life arose by chance and, instead of marveling at what nature has accomplished, decree that some other force or factor(s) must be responsible for the origin of life. Often, they further argue that this other variable is also responsible for the evolution of life on earth. The reason that critics argue that life was so improbable was because they do not have the proper time frame in which to envision the emergence of life.

2. THE PROBABILITY OF SPONTANEOUS GENERATION

In the first chapter I illustrated Darwin's own position on evolutionary development to set the stage for many of the more common criticisms that have followed since his introduction of evolutionary theory in 1859. In this chapter I am going to examine the criticisms that have centered around the probability of life's spontaneous emergence. Most criticisms have focused on the low probability of such an event to argue that a creator must be posited, or an internal metaphysical "life force" is needed, or the creature possesses an internal goal of some ilk, or that the scientific reductionistic inquiries into life neglect the emergent character of life and the organism. I am going to examine the emergence of life as if it arose simply by chance and explain some of the conditions and processes involved behind our existing theories. One of the most complex scientific endeavors has been to properly account for life and evolutionary development. In order to develop a theory of evolutionary development it might be helpful to understand what the emergence of life involved.

An important issue behind the emergence of life is the probability involved in its emergence. Wesson indicates how complex even the simplest organism would have to be:

Almost at their inception, living things had to become able to process materials absorbed or ingested, using them to carry out vital processes, to grow and reproduce. Such an exchange is the essence of animation. A minimum of about 300

biochemical processes are necessary; in the simplest known self-sustaining organisms, there are about 550 (Wesson 54).

The quandary is aptly summed up by asking, "How did a primordial molecule begin to synthesize proteins and begin to replicate itself?" In order to attempt to answer this question one must examine the work of geologists, paleontologists, geneticists, and molecular biologists.

Biochemical reactions drive all living systems and are responsible for the creation and sustenance of living organisms. These chemical reactions need a catalyst to deliver the appropriate chemicals at the proper time and place; in many cases this role is performed by proteins (Mellersh 10). These proteins are long linear molecules that are made up of amino acids.

Stanley Miller and Harold Urey attempted to simulate these conditions in a laboratory setting in 1952. It is thought that the surface of the young Earth was primarily covered by carbon dioxide, nitrogen, and water. Lightning, geothermal heat, and radiation from the sun in the form of Ultraviolet rays would have been sufficiently prolific to serve as a catalyst for molecular reactions. Miller and Urey used a gaseous mixture of various compounds and placed them in a glass container filled with water. They boiled the mixture and simulated lightning with electric sparks, producing organic materials, amino acids, that are the precursors of life.

As a result of Miller and Urey's work, scientists later demonstrated that it was possible to create hydrogen cyanide, formaldehyde, sugars, amino acids, and bases from the primordial elements of the Earth (Kutter 314). These products were the organic molecules that were necessary to produce life. Although creating organic molecules and compounds in a lab is, to put it simply, a far cry from creating life, it is done within time constraints that nature did not have to abide by. This factor makes the results of the experiment even more impressive. Darwin made a few comments regarding domestic breeding and the creation of a new species that seem particularly applicable to the time frame involved in the emergence of life. In fact, they hold an answer for the critics who would ask "Why has life not been created in the laboratory?" or "Why have we not be able to create a creature like a unicorn?" To this Darwin most certainly would have responded:

How fleeting are the wishes and efforts of man!
how short his time! and consequently how poor will
be his results, compared with those accumulated by
Nature during whole geological periods! Can we
wonder, then, that Nature's productions should be
far "truer" in character than man's productions;
that they should be infinitely better adapted to
the most complex conditions of life (Darwin 112).

In other words, nature took millions of years to create the myriad forms of creatures we now bear witness to. Therefore, in our short lifetimes we should not expect to even come close to creating life. It should be considered miraculous

that we have even been able to create organic compounds out of a replicated primordial soup. The results of this experiment lend credence to George Wald's apropos statement regarding the origin of life:

One has only to contemplate the magnitude of this task to concede that the spontaneous generation of a living organism is impossible. Yet we are here-- as a result, I believe, of spontaneous generation (as quoted in Shapiro 120).

The fact that Miller and Urey were able to create these amino acids lends credibility to the spontaneous generation of life. In other words, it becomes more plausible that life arose by chance.

Since we can produce amino acids in scientific experiments, the next issue that one must account for is how to transform amino acids into proteins, a task fraught with problems. The most troublesome issue concerning the linking together of amino acids resides with the structure of the amino acid itself! For example, in order to connect two amino acids together, one must release two hydrogen atoms and the other must release one oxygen atom. That is to say, between the two amino acids, one molecule of water must be lost (Mellersh 10). However, these amino acids are not very liable to form a reaction of this type by themselves as the oxygen and hydrogen molecules are very tightly bound to their respective amino acids (Mellersh 10). This makes the possibility of the spontaneous release of water very improbable. Yet, if conditions were extremely hot and dry

the water molecule might be released, allowing the two amino acids to join together. Unfortunately, under these conditions the two amino acids would follow a path of least resistance and connect their other ends, forming a circle.

However, there are other possibilities, and a branching effect could also be the result. The reactions that would be necessary to produce proteins would have to be linear, viz, non-branching, and they would have to contain hundreds of amino acids long and arranged linearly. I quote Mellersh:

Even if by some enormous stroke of luck, all these hurdles were overcome, and a single copy of an effective protein spontaneously arose, it would be a dead end. It would pass on this fortunate accident to posterity only if it could replicate itself, but proteins cannot (Mellersh 16).

Mellersh thinks that he has solved the problem by not looking at the origin of life in terms of "proteins first," but rather by examining deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). He argues that RNA has more potential as the first "living molecule" because it can replicate and also act as a catalyst (Mellersh 12). He indicates that recent molecular biological theory indicates that if one attaches amino acids to a type of "molecular backbone," then the acids would connect in a linear fashion and avoid the problem of a circular formation that I mentioned earlier. Unfortunately, a problem arises because RNA does not reproduce itself accurately (Wesson 56). In other words, this linear arrangement would still lead to a

dead end. To further complicate the problem, amino acids contained in living matter are nearly always optically left rotating, whereas amino acids can be found in nature with either left or right rotations. If the mechanism we are dealing with is strictly driven by chance, then it would seem natural to assume that there is something special about the optical orientation of amino acids in living creatures. At this point we really do not know.

In attempting to fathom the mysteries of life computers and computer programs are often used as analogues. For example, Marcel J. E. Golay writes in *Analytical Chemistry*,

Suppose we wanted to build a machine capable of reaching into bins for all its parts, and capable of assembling from these parts a second machine just like itself. What is the minimum amount of structure or information that should be built into the first machine? The answer comes out to be of the order of 1,500 bits--1,500 choices between alternatives which the machine should be able to decide. This answer is very suggestive, because 1,500 bits happens to be also of the order of magnitude of the amount of structure contained in the simplest large protein molecule which, immersed in a bath of nutrients, can induce the assembly of those nutrients into another large protein molecule like itself, and then separate itself from it (as quoted in Hitching 79).

One problem with using this analogue is the fact that a self-replicating robot is constructed to reproduce itself copiously, but the biochemical reactions that spawned life must have happened only by chance. Another is that an intelligent creature (a programmer) has created and shaped this program. However, divine guidance is not within the

purview of this investigation.⁴

A mathematical perspective

From a mathematical perspective, the odds that a medium-sized protein of 300 amino acids would fortuitously evolve is about one in 10^{600} (Hitching 50). An example given by Shapiro might explicate the problem more adequately. He quotes the eminent astronomer Sir Fred Hoyle who states that "the likelihood of the event [spontaneous generation, viz., the origin and evolution of life] was that it was comparable to the chance that "a tornado sweeping through a junk-yard might assemble a Boeing 747 from the materials therein" (Shapiro 1987, 127). Shapiro offers an anecdotal story to attempt to get a vague idea of the extremely low probability that we are dealing with when we discuss the spontaneous emergence of life. He says,

Suppose, for example, I saw somebody walking across my community swimming pools, with his feet just touching the top of the water. What conclusion should I draw? A very small but finite possibility exists that the water molecules in some part of the pool, which normally shove about in all directions, will at a given moment simultaneously all thrust upward. The area of this thrust might exactly match the size of the walker's foot and occur in just the place where he steps, to support him. Additional portions of the pool might, coincidentally, act in the same way to support his subsequent steps, until he has finished his stroll. With some effort, I could probably estimate the possibility of this event. I suspect that it would be even less likely than the spontaneous generation of a bacterium. My first inclination, though, if I witnessed the even, would not be to say, "Oh, what

a lucky man!" but to look for some trick, or consider how much wine I'd had to drink (Shapiro 129).

Perhaps his suggestion of "looking for some trick" might merit some consideration.

Jacques Monod provides a trick for conceptualizing the emergence of life. When considering the origin of life on this planet, despite its low probability, Monod has a few useful suggestions. He writes:

At the present time we have no legitimate grounds for either asserting or denying that life got off to but a single start on earth, and that, as a consequence, before it appeared its chances of occurring were next to nil . . . The universe was not pregnant with life nor the biosphere with man. Our number came up in the Monte Carlo game. Is it any wonder if, like the person who has just made a million at the casino, we feel strange and a little unreal? (Monod 145-146).

One can only agree. Simply because an event is improbable does not mean that it is impossible. In this chapter I have shown that the spontaneous emergence of life was possible, though perhaps not probable. Along the same lines, my winning the five million dollar lottery is possible but not probable. If I were to win wouldn't it be nonsensical to attribute my winning to some mysterious principle or god, or furthermore, to deny it altogether? This is the point behind Monod's Monte Carlo game. Criticisms of the improbable nature of the emergence of life simply fail to take into the nature of the improbable or miraculous. To put it another way, although it is very, very unlikely that I will win the

lottery it is not equally unlikely that *someone* will. It is a point that Richard Dawkins makes well in *The Blind Watchmaker*.

Dawkins argues that we should very well be worried if the origin of life did not appear to be miraculous for us as human beings (Dawkins 1987 159). Dawkins own expression of this idea cannot be improved upon:

A miracle is something that happens, but which is exceedingly surprising. If a marble statue of the Virgin Mary suddenly waved its hand at us we should treat it as a miracle, because all our experience and knowledge tells us that marble doesn't behave like that In the case of the marble statue, molecules in solid marble are continually jostling against one another in random directions. The jostlings of the different molecules cancel one another out, so the whole hand of the statue stays still. But if, by sheer coincidence, all the molecules just happened to move in the same direction at the same moment, the hand would move. If they all reversed direction at the same moment the hand would move back. In this way it is possible for a marble statue to wave at us. It could happen. The odds against such a coincidence are unimaginably great but they are not incalculably great The conclusion to this part of the argument is that we can calculate our way into regions of miraculous improbability far greater than we can *imagine* as plausible (Dawkins 1987 159-160).

In essence, the key to Dawkins' response to the improbability of life emerging by chance is the fact that we do not have the imagination to properly conceive of the low probability involved. Suppose there were an alien with the lifetime of a million centuries. Then, argues Dawkins, the alien would be not be surprised to be dealt a perfect hand of bridge on occasion (Dawkins 1987 162). However, "even they will blench

if a marble statue waves at them, for you would have to live dealions of years longer than even they do to see a miracle of this magnitude" (Dawkins 1987 162). The point behind talking about the lifetimes of aliens and humans is that there is a subjective evaluation of what is probable and what is not. That is to say, the short lifespan of a human being is not the proper background by which an understanding of the magnitude of the emergence of life should be understood (Dawkins 1987 162). Consequently, the criticism that the emergence of life was too remote to have ever taken place is ill-founded.

3. THE FACT OF MICROEVOLUTION

Now that Darwin's original theory has been outlined and I have covered some of the basic processes necessary for life, I will examine and elaborate upon criticisms against neo-Darwinism that have been leveled by Denton regarding the extension of microevolution to macroevolution. In essence, Denton argues that microevolutionary processes are well documented and can be observed often in nature whereas this is not the case with macroevolutionary processes. I agree with him on this point but disagree that we have no empirical evidence nor reason to believe in macroevolutionary claims. I think that Denton's conceptual problem may stem from his misuse of an analogous case of, what I coin, the "fallacy of extrapolation." In any case, it should be noted that macroevolution is not as well supported as microevolution in terms of empirical data.

To return to what was said in chapter one regarding Mayr, he is correct in stating that evolution is a clearly demonstrable fact, but of course, only if he means by *evolution* Darwin's weak thesis that organisms undergo morphological changes. However, he fails to stipulate in what sense he is using the term *evolution*, lending more chances for misunderstanding. It is not true that macroevolution (the development of life on Earth from a single organism) is a fact in the same way that microevolution is.

Darwin's special theory of microevolution is now established as an empirically demonstrable fact. Moreover, "Natural selection has been directly observed and there can be no question now that new species do originate in nature" (Denton 85). Science has also advanced by leaps and bounds because "it is now possible to explain in great detail the exact sequence of events that lead to species formation" (Denton 85). According to Denton, this should not be taken to mean that we have conclusive proof that all living creatures have descended from one organism, though it is highly suggestive.

Darwin's primary support for natural selection was multiple cases of artificial selection, viz., selection in artificial settings of private breeders, as well as the similarities of a variety of creatures that he observed. For example, Darwin noted the distinct overall similarity of thirteen types (a fourteenth was later found) of finches on the Galapagos Archipelago where the general morphology of the bird was the same, and yet there were a few noticeable differences such as the structures of the beak which he attributed to feeding habits.

Denton is correct insofar as he states that Darwin had no *direct* empirical evidence for his claim of selection in nature, although, I might add, there was evidence pointing to that conclusion. In fact, the first direct empirical observation of Darwin's actual theory of natural selection

did not come until the early 1950s and stems from the work of the Oxford zoologist Bernard Kettlewell (Wesson 12).

Kettlewell discovered that one species of light colored peppered moth (*Biston betularia*) indigenous to central England which had been abundant previously had suddenly markedly diminished in number (Wesson 12). A dark colored variant that had previously only sparsely populated the area became rather abundant. Kettlewell found that pollution, induced by the Industrial Revolution, had darkened the trees in the area by covering them with soot. Consequently, the lighter colored moths were much easier prey on the soot covered trees than the darker moths; hence, the darker colored moths prospered (Denton 80). Although this discovery was a breakthrough for evolutionists, Denton is correct in maintaining that the discovery only provided support for Darwin's microevolutionary claims.

The more remarkable support for Darwinism has come from experiments with fruit flies. There are multitudes of examples where new species have literally evolved before our eyes! There were one or two original colonizations by the fruit fly *Drosophila* and from this approximately seven hundred Hawaiian species developed *sui generis* (Denton 82). Along similar lines, single colonizations of "snails, moths, beetles and wasps have resulted in the development of large numbers of derived species, all of which are unique to Hawaii" (Denton 82). On the dozen or so larger islands of

the Galapagos, 15 different varieties of tortoises, with slightly different shells, and each existing with the same diet, have developed (Wesson 200). There are also Darwin's 14 finches along with 66 varieties of snails on the Galapagos (Wesson 200). Consequently, there really can be no doubt that new species have originated in nature.

However, Denton is quite right that the evolution of multiple species out of one parent is one thing (1), and extending this variation to trace the lineage and development of the biota on earth (2) is quite another. In addition, there are two other issues that should be seen as distinct from the two mentioned above--namely, whether there are some natural selection driven changes within a species (3) or whether natural selection accounts for the emergence of life on earth (4).

Consequently, Denton's criticisms do warrant some attention because the claim that because certain evolutionary changes occur within a given species in nature is distinct from the conclusion that it is the case that these changes can explain the emergence of life on Earth from one prototype.

According to Denton, simply because natural selection is responsible for evolutionary changes within a species that does not mean that it can explain the evolution of life on Earth. To put it another way, although it may be tempting to extrapolate and extend the findings of microevolutionary

developments to support macroevolution, there is no reason why we should conclude that the former gave rise to the latter. Denton writes,

However attractive the extrapolation, it does not necessarily follow that, because a certain degree of evolution has been shown to occur, therefore any degree of evolution is possible. There is obviously an enormous difference between the evolution of a color change in a moth's wing and the evolution among the fruit flies of Hawaii . . . [and] the differences between a mouse and an elephant, or an octopus and a bee (Denton 87).

Denton attempts to present the case that extrapolating from claim to another is not always successful. He cites an example in the one field of meteorology to bolster his argument that there is no necessity involved in the inferential claims of macroevolution from the fact of microevolution.

The fallacy of extrapolation?

Denton's argument is moot and should not be considered conclusive or damaging to evolutionary theory. He cites one example involved in the potential fallacy of extrapolating. However, I would argue that many more examples would be required to prove that extrapolating is other than indeterminate within any respective field.

Denton argues that in meteorology the fluctuations between high and low pressure systems which are responsible for daily, minute changes in weather patterns are not at all

reliable when extrapolated to account for the drastic changes that occur during the cycle of seasons (macro changes) (Denton 87).

Now it should be very clear that Denton is right in this case. However, he is also wrong. (I will return to explain why shortly.) The changes in day-to-day weather, as we all know, can be predicated fairly accurately for periods of less than a week, in this case micro changes. Yet, the same is not true for macro changes of three to four months at a time. These types of changes can only be explained by invoking astronomical factors, such as the tilt of the Earth's axis which shifts more or less towards the sun as it goes through its orbit of the sun (Denton 87). The important point, according to Denton, is the fact that in many cases it is not valid to extend one's "micro" theory to explain "macro" events.

While part of Denton's argument is true, he glosses over the most obvious point--that is, in some cases extrapolating from micro to macro can also be veridical. For example, there are certain laws of physics that explain terrestrial mechanics. From this knowledge Newton was able to create a universal law of motion that applies to all bodies. With this, he was able to calculate the orbits of the planets more accurately. Einstein then came along with a theory that was able to explain the deviation in the orbit of Mercury that had been problematic in Newton's theory. My point is that

micro processes on earth were described by these laws of physics and their extrapolation to macro processes was valid. I would venture to say that for as many cases as Denton could provide where this method has failed, I could provide equally as many cases where it has been successful.

Evolutionists such as Mayr do treat evolutionary theory as if it was a proven fact while ignoring the problematic aspects of the theory. Mayr writes,

The Darwinian mechanisms of variation and selection, of speciation and extinction, are fully capable of explaining all macroevolutionary developments, whether specializations, improvements, or other innovations (Mayr 1991 64).

Unfortunately, this view is not entirely accurate and critics like Denton argue that this view also shares Darwin's main problem in *The Origin* in that there is "absolutely no direct empirical evidence in the existence of clear-cut intermediates that evolution on a major scale had ever occurred and that any of the major divisions of nature had been crossed gradually through a sequence of transitional forms" (Denton 56). In other words, Darwin's stronger thesis of macroevolutionary change is unwarranted. He had, Denton argues, no reason to conclude that, e.g., a fish can turn into a reptile.

Moreover, according to Denton, "Even today, the origin of a new species from a pre-existing species has never been directly observed" (Denton 81). If, as Mayr states, "speciation is a slow historical process, it can never be

directly observed by an individual observer," then macroevolutionary permutations are simply events that we will never bear witness to (Mayr 1970 279). If we can never witness these events, then perhaps we will never be truly justified in maintaining them and can never prove them in the way we can prove microevolutionary phenomena. We cannot be faulted, however, for attempting to formulate the most coherent theory available to us which suggests that life became more complex as time moved on starting around three billion years ago.

There are facts that Denton fails to mention which support the extrapolation of evolutionary theory. For example, the theory of macroevolution renders intelligible why cows, pea plants, and human beings would all have an almost identical gene, the histone H4 gene (Dawkins 1987 123). Denton virtually ignores the fact that there is evidence in the fossil record that indicates life became more complex as time progressed. This lends some credence to the theory that life evolved and gradually became more complex.

In this chapter I have agreed with Denton that proof of microevolution does not provide direct evidence for macroevolutionary claims. As Denton's example of weather prediction illustrates, it is not true that the mechanisms that produce micro processes in a certain domain also can be utilized to explain macro processes in that same domain. On the other hand, micro processes do sometimes yield macro

processes. Similar genes shared by a variety of creatures and the fossil record does lend support to Darwin's claims of macroevolution. Although there may be no "direct proof" of macroevolution, the information uncovered by microevolution, the fossil record provides strong support for macroevolution.

4. THE FOSSIL RECORD

Darwin appealed to the imperfections in the fossil record to defend his theory of evolution and respond to his critics. In one obvious sense, Darwin was correct in mentioning the imperfections of the fossil record because, by their very nature, fossils are imperfect relics of a living creatures. However, some paleontologists have argued that the fossil record is almost complete. On the other hand, other paleontologists argue that the fossil record is incomplete. In this chapter I will present criticisms of evolutionary theory that deal with the fossil record. The critics are correct in maintaining that evolutionists often speak as if many fossil specimens form a lineage where one fossil gradually blends imperceptibly into another. This is not the case. This will lead to the suggestion of punctuated equilibrium that will be the topic of chapter five.

One of the most difficult aspects of working with fossils is that only the endo or exoskeleton of an organism is preserved. It is of interest to note that "Ninety-nine percent of the biology of any organism resides in its soft anatomy, which is inaccessible in a fossil" (Denton 177). On the other hand, Darwin's appeal to the "imperfect fossil" record may no longer be true. Recent studies have shown, based upon the percentage of living forms that have been found as fossils, that the fossil record is not nearly as imperfect as many scientists would have us believe. One

study concludes that "Of the 329 living families of terrestrial vertebrates 261 or 79.1% have been found as fossils and, when birds (which are poorly fossilized) are excluded, the percentage rises to 87.8%" (Denton 189). In fact, G.G. Simpson, after examining the percentage of living species (primarily larger terrestrial forms) that had been recovered as fossils, *concluded that the record appears to be almost complete* (Denton 189).

Critics argue that although the gaps in the fossil record are few, closer examination of the existing fossils reveals that the gaps are conspicuously consistent. In particular, *"the fossils go missing in all the important places"* (Hitching 10). For instance, museums are full of fossils of early invertebrate sea creatures and ancient fishes. Yet, there should be at least a few fossils that

blend so gently into one another that it would be difficult to tell where the invertebrates ended and the vertebrates began. But this isn't the case. Instead, groups of well-defined, easily classifiable fish jump into the fossil record seemingly from nowhere: mysteriously, suddenly, full-formed, and in a most un-Darwinian way (Hitching 10).

These "gaps" are extremely important because they are all located during periods of major evolutionary transition.

David M. Raup, a curator of a natural history museum talks about the gaps in the fossil record. He states,

Instead of finding the gradual unfolding of life, what geologists of Darwin's time and geologists of the present day actually find is a highly uneven or jerky record; that is, species appear in the

sequence very suddenly, show little or no change during their existence in the record, then abruptly go out of the record (as quoted in Hitching 42).

This is a most curious fact indeed! If anything, it certainly does not suggest a gradualistic conception of evolutionary permutations. In fact, the punctualist account is the only coherent theory that *seems* to coincide with the empirical evidence, yet this account also has its problems. I will return to this point later.

Examining the osseous (bone) system which is the most typical fossilized remains of creatures should help us locate some examples of transitional forms. For example, we know that reptiles have four bones on each side of their lower jaw, but only one bone in each ear. However, every known mammal (both extinct and alive) has a single lower jaw and three bones in each ear (Hitching 11). What is most curious is that if we are to assume that mammals evolved from reptiles shouldn't we find intermediaries between the two classes--that is to say, shouldn't we find fossils of creatures with two or three bones in their lower jaw and two bones in their ear? (Hitching 11). The most remarkable thing is that we find no such cases, which seems to suggest a problem with the theory of gradualism or an imperfect record, or even the more striking possibility that these transitional forms never existed.

One of the most enigmatic things about the fossil record is that for three billion years nothing more complicated than

bacteria and slime lived upon the Earth, and then suddenly life literally erupted into myriads and myriads of forms (Hitching 15). Except for simple algae,

life remained unicellular for five-sixths of history. All but one phylum arose in a single geological whoosh, within some five million years or so, at the dawn of Cambrian times, 530 million years ago (the "lowly" Bryozoa, not our exalted chordate selves, form the single exception of slightly later origin) (Gould 1994 8).

This sudden "eruption" of life seems to suggest anything but a gradualistic account of evolution.

The explosion of life came at the beginning of the Cambrian period and during a period of about ten million years earth became inundated with life:

Billions upon billions of fossils have been found, showing a marine life that suddenly became rich and abundant: clams, snail, octopuses, crustaceans with hard shells and jointed legs, spiny-skinned animals such as starfish, sea urchins and sea lilies (Hitching 15).

What is more surprising is the fact that there are many layers of sediment below that of the Cambrian period which remain uniform and unbroken. The sediment below this Cambrian strata has not produced a single multi-celled fossil specimen (Hitching 15). What this fossil evidence suggests is that there was some type of "metamorphosis of life" which was followed by an inordinate amount of morphological development.

When the first representatives of all of the major classes of organisms appear in the fossil record they are all

very typical, as far as their characteristics are concerned, within their respective class. They seem to appear suddenly in the fossil record as the epitome of their class. This is illustrated exceptionally well with the fossils of invertebrates. The invertebrates, almost upon their inception in paleozoic seas, were already divided into almost every major group that exists today (Denton 163). "Not only was every major invertebrate phyla represented, but a good many of their main subgroups were also present" (Denton 163).

Wesson argues that the first insects looked very similar to modern insects, and the interrelationships of the different orders of insects, dragonflies, cockroaches, flies and so on are not known (Wesson 41). Dragonflies and cockroaches which have been around for over 300 million years have changed very little since their inception (Wesson 207). Each order seems to arise independently and can be traced back 300 million years.

The earliest representatives of the cephalopods (a group that includes the octopus and squid), the molluscs, or of the bivalves (clams and oysters) or "gastropods (snails and slugs), etc. are all highly differentiated when they burst into the fossil record. Neither the phyla nor their main sub-divisions are linked by transitional forms" (Denton 163). The fossil evidence shows the Cenozoic snails and bivalves have not exhibited gradual change in their lineages, but rather they suddenly become replaced by another lineage due

to changes in environmental conditions (Wesson 207). There is no evidence whatsoever of a gradual transition. What further befuddles us is the fact that the plants also appear in this rather spontaneous fashion.

Fossils of land plants appear without any recorded ancestors 450 million years ago, with most of the major lineages already clearly differentiated (Wesson 41). The appearance of plants comes with amazing rapidity. "Within only fifty million years, or approximately 12 percent of the entire history of vascular plant evolution, virtually every major plant group currently represented in modern world floras evolved" (Niklas 1994 22). One species of leafless plant without roots, *Psilotum*, is just like the first vascular plants that appeared on land over 400 million years ago (Wesson 207).

Angiosperms (flowering plants) also appear in the fossil record differentiated into the very highly specialized and differentiated classes that we are aware of today. Many of these classes have remained unchanged to this day (Denton 164). The most enigmatic fact about the angiosperms, as is also the case with most other forms of life, is that there are no forms in pre-Cretaceous rocks that indicate ancestral relationships between angiosperms and other plants (Denton 164).

The fossil record tells a very interesting tale. For example, starting around four hundred million years ago, in a

period of less than fifty million years, most of the known fish groups appear in the fossil record (Denton 164). Fifty million years is a tremendously short period of time (geologically speaking) for such copious evolutionary transitions to take place--it is diametrically opposed to gradualistic accounts of evolutionary development based upon genetic drift and natural selection which are assumed to have taken place in the space of a much longer time frame.

Within a period of about fifty million years many extinct fish groups such as the jawless ostracoderms and placoderms, a heavily armored fish, suddenly appear in the fossil record. The fossil evidence shows that the first representatives of the fish groups are so differentiated and isolated when they appear in the fossil record that one cannot be considered ancestral to another (Denton 164).

The often cited transitional fossil of *Archaeopteryx* does appear, at first glance, to be an intermediate with respect to other groups. Yet, Denton argues that flight is the most characteristic feature of birds and in terms of this criterion *Archaeopteryx* is already a modern bird (Denton 175). The creature's feathers are as fully developed as any modern bird, and recent research has determined that *Archaeopteryx* was capable of flight (Denton 175). Cranial endocasts of *Archaeopteryx* suggest that its brain was highly characteristic of avian brains. For example, the standard avian cerebral hemispheres and cerebellum, which are

associated with very complicated motor activities required for flight, is proportionally larger in birds than in other classes and seems to have been present in *Archaeopteryx* (Denton 178) This evidence seems to suggest that *Archaeopteryx* was capable of flight. Arguably, if *Archaeopteryx* was able to fly,

might it not also have possessed, of necessity, a fully avian heart, circulatory and respiratory system to supply the vastly increased demand for oxygen that occurs during powered flight? In other words, might it not have been as avian as any other bird in all important anatomical and physiological characteristics? (Denton 178).

Archaeopteryx may have been fully avian in many other morphological characteristics and, thus, a representative of the avian class.

Recently, a fossil of a crow-sized creature, dubbed protoavis, has been found that is 65 million years older than *Archaeopteryx*! In many respects, this creature appears to have been more avian than *Archaeopteryx*. Furthermore, six skeletons of other primitive pigeon-sized birds have been discovered in fossil strata.

Consequently, the claim that *Archaeopteryx* was a transitional form between reptiles and birds is not as uncontroversial as we once thought. There are a few conceptual problems. For example, how could *Archaeopteryx* appear in the fossil record 65 million years later than protoavis be an ancestor to modern bird? This is a physical impossibility. The fossil evidence suggests that

Archaeopteryx was a dead-end in terms of promoting its progeny, and the ancestor of modern avians is protoavis.

Reptiles are traditionally claimed to have evolved from amphibians, but the recent discovery of a 338 million year old reptile, which is almost as old as the oldest amphibian, has called into question this ancestral relationship (Wesson 41). In fact, "there is no record of a transitional form between bony-finned fish and amphibians" (Wesson 41). Furthermore, despite the depiction of evolution in biology textbooks, there are no fossils that link primitive chordates with the vertebrates that were presumably responsible for their inception (Wesson 41). Vertebrates appear in the fossil record suddenly with brain cases, calcified bones and other specialized organs. The earliest known members of major vertebrate groups are very different from each other. One of the most significant transitions would have been the formation of the jaw, yet there is no known jawless fish that seems to be ancestral (Wesson 41).

Neo-Darwinians often cite the evolution of the horse as proof of a gradualistic transition. Almost a century ago, T.H. Huxley confidently pointed to the fossil series leading from the little four-toed *Hyracotherium* (formerly known as *Eohippus*) that was over 55 million years old to the modern one-toed horses. However, he neglected to point out that even this lineage seems to be characterized by leaps rather than a gradual evolutionary trend and completely overlooks

the fact that modern horses suddenly appear in the fossil record around three million years ago (Wesson 40).

Thus, it appears that the evolution of the horse was not as gradual and "perfect" as many would have us believe.

Moreover, there are numerous myths surrounding the evolution of the horse that are often found in college textbooks. George Gaylord Simpson, a former Professor of Vertebrate Paleontology at Harvard, has the following to say about the supposedly "gradual and perfect" transition of the horse:

The most famous of all equid trends, "gradual reduction of the side toes" is flatly fictitious. There was no such trend in any line of Equidae Eocene horses all had digitigrade padded, doglike feet with four functional toes in front and three behind. In a rapid transition (*not actually represented by fossils*), early Oligocene horses lost one functional front toe and concentrated weight a little more on the middle hoof as a step-off point This type persisted without essential change in all browsing horses (as quoted in Denton 184, emphasis added).

Even if one were to concede, simply for the sake of argument, that the fossil record of the horse is proof for a gradualistic conception of evolution, it remains the case that if we look for transitional species between major divisions like the transition between a land mammal and a whale, which should have gone through far more transitions than *Eohippus* and the modern horse, we do not find fossils that support such a claim. This would tend to support the claim that the fossil record is incomplete.

Whales have diverted from the basic pattern of the mammalia class more than any other mammals and must have completed their specialized evolution in less than 10 million years--however, "10 million years is less than a fifth of the time taken by *Hyracotherium* to become a not extremely different animal, the modern horse" (Wesson 52). This is certainly odd and reinforces the fact that the absence of transitional forms is a "rule" that seems to be universally applicable to all creatures. Denton argues that the fossil record creates many more problems than it solves for evolutionists because transitional forms of many creatures are uniformly absent. He says,

Both those that are poor candidates for fossilization such as insects and those which are ideal, like molluscs. But this is the exact reverse of what is required by evolution. Discontinuities we might be able to explain away in terms of some sort of sampling error but their systematic character defies all explanation. If the gaps really were the result of an insufficient search, or the result of the imperfections of the record, then we should expect to find more transitional forms between mouse and whale than between dog and cat (Denton 192).

Regardless of whether the fossil record is complete or incomplete, we cannot base a theory of evolution exclusively on fossils. Furthermore, it would seem that a more coherent way to develop a theory of evolutionary development would be to create a model that better fits the facts of the fossil record. A theory that takes this approach, punctuated equilibrium, will be examined in the next chapter.

5. THE SOLUTION OF PUNCTUATED EQUILIBRIUM?

One theory that avoids some of the problems and pitfalls of gradualism in terms of the fossil record is the theory of punctuated equilibrium, first suggested by Niles Eldredge and Stephen Jay Gould in 1972. This theory solves the "problem of the fossil record," i.e., the lack of gradual transitional forms, but it still relies on a line of argumentation parallel with the gradualist model. Moreover, many criticisms have been raised against this theory as well. Furthermore, even if one were to adopt this theory there are still issues such as accounting for morphological stasis and coordinating evolutionary permutations that need to be addressed.

According to the theory of punctuated equilibrium, new species undergo long periods of stasis followed by a tremendous amount of permutations. One of the nice aspects of this theory is that it actually fits the fossil record and does not rely on the argument that the fossil record is imperfect. In Gould's own words, punctuated equilibrium "is a theory about ordinary speciation (taking tens or thousands of years) and its abrupt appearance at low scales of geological resolution, not about ecological catastrophe and sudden genetic change" (Gould 1985 233-234). In other words, a punctualist would argue that because of, say, environmental factors, a certain species will undergo a tremendous number of mutations in a very short period of time, geologically

speaking. This period of intense activity would not be recorded because of the rapidity with which it took place. Consequently, we should expect gaps in the fossil record that preclude our finding transitional forms of creatures.

Accounting for Stasis

According to one critic, Robert Wesson, there are numerous examples of creatures that have existed for millions of years with little or no change (1993). The punctualist account of evolution would intuitively require that there be some type of change within the genome over a period of thousands or millions of years that would produce associated external and internal morphological changes. If the genetic material varies slightly due to copying errors and random mutations, one would assume that there would also be associated morphological changes to the creature's structure. This would mean that creatures would gradually change over a few millions of years. In fact, no creatures should remain the same morphologically because of this "random drift." If this is the case, how do we explain the fact the "British beetles have hardly varied in the past million years," and have not significantly changed in the past "57 million years, while mammals have been rapidly evolving?" (Wesson 207). To put the point a different way, Wesson is under the presupposition that all living creatures have similar

environmental pressures to select for certain changes and there should be no reason for one group to evolve more quickly than another. There are countless other examples, argues Wesson. Bats seem to appear suddenly and are almost identical to their modern descendants (Wesson 48). Some ants preserved in amber 25 million years old are almost indistinguishable from their descendants today (Wesson 207). Lungfish and horseshoe crabs have exhibited almost no change in the past 350 million years (Wesson 207). Brachiopods (*Limulus*) and the Coelacanth have remained in a period of stasis, as far as we can detect, for the past 450 million years (Wesson 207). The most impressive creature by far is the peripatus, an animal that is characterized as being between an annelid and an arthropod which has remained in a state of "suspended animation" for 570 million years (Wesson 207). According to either the gradualist or punctualist account of evolution, these periods of stasis should only be present if environmental factors were not changing and genetic mutations were not taking place. However, the environment has changed drastically in the past 570 million years. Furthermore, genetic mutations must also have been quite common. These two factors would suggest that some type of morphological change should have taken place. However, it has not. Then why has the peripatus not gone through the usual process of natural selection? This problem is not readily explicable within either evolutionary framework.

Studies of some groups of vertebrates, for example, the salamanders of the *Plethodontidae* family, indicate that these creatures have persisted with very little change for over fifty million years (Varela, Thompson, and Rosch 192). The species in these particular groups are quite uniform in appearance, notwithstanding pigment differences and size variations. The osseous system has remained practically unchanged. This finding might suggest that these vertebrates are all very closely related. However, these creatures display a tremendous amount of diversity in every genetic parameter that has been measured (Varela, Thompson, and Rosch 192). This is utterly baffling considering their morphological similarities.

Even more remarkable is the fact that punctualists would maintain, along with neo-Darwinists, that environmental factors influences the morphology of an organism, i.e., nature selects for certain traits, and can completely explain the evolution of life on this planet. There are many cases where natural selection falls short of explaining a simple phenomenon. For example, examining fossils of terrestrial vertebrate genera the existed contemporaneously with *Plethodontidae* sixty million years ago reveals that every other creature became extinct (Varela, Thompson, and Rosch 192). Why then didn't *Plethodontidae* become extinct as the environmental conditions should have forced a change, yet *Plethodontidae* remained unchanged? Environmental conditions

obviously have changed in sixty million years, as well as predatory and food sources, but perhaps *Plethodontidae* was able to better adapt to these environmental changes. Then why hasn't it changed morphologically as natural selection would predict? Furthermore, presumably, because there were different predators there would be different environmental pressures that would necessitate morphological changes. Yet, there seems to be no viable explanation.

The nature of classification

It is important to realize that Wesson's claims of stasis in various classes, orders, families, genera, and species must be understood against the background of the difficult practice of taxonomy. One of the most difficult aspects of taxonomic classification is the differentiation among a species, subspecies, and individual variations within each classification. Consequently, to claim that a creature has not changed drastically presupposes that we are only talking about one species that has been continuous through time. Unfortunately, what Wesson is forgetting is that in many cases we are not really sure how to distinguish species differences from individual variations within the same species. Wesson assumes that the samples preserved in amber, for instance, are somehow representative of their species. This is a very large assumption.

Perhaps an example would make my point more clearly. One species of redbacked salamander in North America is broken down into two distinct subspecies based upon stripes on their backs (Wilson 66). The subspecies to the north generally lack stripes and the group to the south generally have stripes (Wilson 66). However, we also notice that individuals that inhabit the western regions are generally larger than individuals in the east (Wilson 66). This discordance would indicate that there are actually four subspecies, namely, those in the northeast, northwest, southeast, and southwest (Wilson 66). If one looks closely enough, he or she can discern a population that has amber eyes in a certain geographic region and another population with yellow eyes in another.

The point is that the more closely we look, argues Wilson, the differentiations become a game in geometrical calculations (66). To put it another way, the classification of subspecies, and some species for that matter, depend on certain arbitrary characteristics that taxonomists key in on while they ignore other features as individuals variations. Certain aspects of the classification of a species and subspecies are broad and unclear--if we wish to eradicate the amorphous categories of species and subspecies we really have to get a set of criteria so specific that we will have to limit our designation to a very small isolated population.

Another way that this type of classification can become

difficult is reflected in our efforts to identify the number of races within the human species. Researchers in the 1950s came up with numbers anywhere between six to more than sixty depending upon the criteria they utilized (Wilson 67). What does this have to do with Wesson's arguments of morphological stasis in different groups of organisms? Well, simply to point to the overall similarity in ants for millions of years fails to consider that a general morphological description is bound to indicate that all ants are roughly the same.

Furthermore, some ant species are differentiated by nuances in morphology. For example, the number of hairs on their backs. What sense does it make to point to overall similarities when many smaller changes go imperceptibly unnoticed? To put it another way, although Wesson might be correct in noting that the overall morphology of ants is the same he neglects the slight variations that would make all the difference to a myrmecologist. (Perhaps, according to Wesson, the more than 20,000 different species of ants that are recognized today may all be, more or less, the same.)

Wesson also fails to indicate the quandary the biological sciences are in regarding the immense diversity of life. He argues that many species have changed little over millions of years and yet fails to consider that some ancestral species could have diverged into several species and one of these could, in turn, diverge into several others while each species could remain remarkably similar to one

another. To return to what I mentioned earlier, we do not even know how many ant species inhabit the Earth with any certainty. However, some estimates indicate that there are more than 20,000 species of ants that range from the Arctic Circle to the very tip of South America (Wilson 5). Moreover, even this estimate must be understood in a certain context. What I am referring to is the fact that we do not even know, with certainty, how many species actually inhabit the biosphere. Wilson continues,

We do not know, not even to the nearest order of magnitude. The number could be close to 10 million or as high as 100 million. Large numbers of new species continue to turn up every year It is a myth that scientists break out champagne when a new species is discovered. Our museums are glutted with new species. We don't have time to describe more than a small fraction of those pouring in each year I recently estimated the number of known species of organisms . . . to be 1.4 million. This figure could easily be off by a hundred thousand, so poorly defined are species in some groups of organisms and so chaotically organized is the literature on diversity in general (Wilson 132).

In 1989 it was thought that there were 4,000 species of bacteria. However, recently one group of researchers conducted a vast array of tests and determined that there were between 4,000 and 5,000 species of bacteria in a *single gram* of beech-forest soil (Wilson 144). This vast scale is something the Wesson systematically ignores when we attacks evolutionary theory with claims of developmental stasis.

However, in defense of Wesson, it must be admitted that the question left unanswered by the punctualist account is

"Why do species persist with little or no morphological change for hundreds of thousands, and in many cases millions of years?" The inability of either evolutionary model to answer this question might suggest, as Wesson argues, that there is something wrong with the model itself or it may merely be an indication that there are still problematic areas that require further investigation.

Another objection to the theory of punctuated equilibrium is that changes within a population that are continuous through time rarely, if ever, yield the significant morphological changes associated with macroevolutionary phenomenon (Ayala 123). That is to say, the phenotypic changes that occur in any given population may produce minor variations within that population but they never yield macroevolutionary phenomena, e.g., the development of a new organ. This is a problematic point. Some evolutionists have also raised the point that punctuated equilibrium does not introduce anything new into the neo-Darwinian paradigm. For example, Wilson argues that "swift evolution was already a cornerstone of traditional evolutionary theory" (Wilson 89).

Neo-Darwinians and punctualists alike would argue that powerful selection *maintains* the "normal" phenotypical form (Kauffman 20). The current evolutionary paradigm contains the view that "since stable species live in stable environments, selection favors the established normal form"

(Kauffman 20). However, as I mentioned earlier, many species have remained in morphological stasis for millions of years. Are we to assume that the environment has remained stable for all of these years? This seems implausible.

The solution of punctuated equilibrium, though fitting the "picture" of the fossil record, still must provide a more lucid account of evolutionary theory than it now proffers and address macroevolutionary phenomena. To put it another way, any theory of evolution must explain why there is stasis and why there are revolutionary periods in evolutionary biology (as well as how these revolutionary periods take place).

There is a growing minority of researchers that think that there may be some missing mechanism that "guides" these permutations in a uniform way, without which evolution would have never taken place. This missing variable would also seem to halt evolutionary development in many cases and be responsible for morphological stasis. It is possible that microevolution plus some mechanism yields macroevolutionary phenomena. I will explore this possibility later.

Because of the different nature of macro and microevolutionary processes it is not unfair to separate them completely by drawing a line of demarcation between the two theories, thus concluding that "macroevolution is autonomous relative to microevolution, much in the same way as biology is autonomous relative to physics" (Ayala 123). This differentiation allows us to examine more clearly the issues

that are obfuscated behind the conflated theories. The two fundamental issues raised with regard to the extension of microevolution to macroevolution can be broken down as follows:

1) Whether microevolutionary changes now operate as they did in the past, and if so, whether these processes are operative "throughout organisms which make up the taxa in which macroevolutionary phenomena are observed" (Ayala 124).

2) Whether microevolutionary changes, viz., mutation, random drift and natural selection, can adequately account for the drastic morphological changes in higher taxa.

Although as evolutionists we may be tempted to downplay the fact that these two theories are distinct, Denton's insistence on the distinction that I spoke of earlier is substantiated by other biologists (though his criticisms may not be).

Although punctuated equilibrium may explain some of the gaps in the fossil record, it would appear that it shares a problem that the gradualist explanation possesses, according to critics, in that it still does not seem to address how, say, an amphibian, could turn into a reptile, i.e., macroevolution. In short, critics argue that the punctualist's model is also in need of some other mechanism(s) to account for evolutionary permutations.

I should mention that the punctualist account still

develops an argument which relies on gradualist foundations.

It can be constructed with logical and probability theory

notion as follows:

G: Via recombination, genetic materials are redistributed and rearranged.

N: The process of natural selection.

S: The struggle of existence over a means of sustenance among individuals.

M_1 : Microevolutionary processes.

M_2 : Macroevolutionary processes.

M_n : An undefined, but very large number of permutations within the genome.

Hence, the "standard" evolutionary picture can be formulated like this, $\{(G \wedge N) \wedge S\} \supset M_1 \wedge (M_n \supset M_2)$. I will later explore suggestions made by Kauffman and Wesson that (if experiments in chaos theory are proven to be veridical) we may be able to add another variable, C: chaos or complexity theory, a boundary condition and guiding principle to strengthen the claim M_n . Hopefully, the probability that macroevolution will adequately account for evolutionary development will be eventually be increased to the following:

$$P[\{(G \wedge N) \wedge (S \wedge C)\} \supset \{(M_1 \wedge C) \supset M_2\}] \gg [\{(G \wedge N) \wedge S\} \supset \{(M_1 \wedge M_n) \supset M_2\}].$$

In this chapter we have seen that punctuated equilibrium can help address the problems of the lack of transitional lineages in the fossil record. However, there are a number of problems that have been raised with this theory. One problem, for example, would be a more concise definition of what mechanism is responsible for morphological stasis. On the other hand, the claims made by Wesson that the general

morphology of various creatures has not changed in millions of years has been demonstrated to be based on an incomplete understanding of the nature of species and the diversity of life.

6. INCONSISTENCIES?

In this chapter, I present Denton's argument that the typical conception of evolution progressing gradually with morphological changes blending indistinguishably into one another appears to be fictitious and inconsistent with what we now know about internal morphology and biochemistry. It begins to appear, at least on the face of it, that in many cases there are no intermediate stages of morphological development. This opens the door for the suggestion that these intermediate steps never occurred. Using various biochemical experiments, proteins do support the common clear cut cases of ancestral relationships that are often depicted in textbooks. However, Denton argues that the only relationship that we can determine between groups of organisms is sisterly. I concede that this does seem to be problematic.

Although it is claimed in most biology textbooks that the vertebrate classes form a series of gradually increasing complexity in physiological characteristics, when we examine their morphological characteristics, the evidence for this clear sequential arrangement is far from clear (Denton 111).

The morphology of living creature's internal anatomy suggests that there are no intermediate stages *for some* organs and systems. Denton argues that transitional forms seem to be remarkably absent. For example, the morphology of the vertebrate heart and aortic arches is normally thought to

form a series from fish, lungfish, amphibians, reptiles, and mammals (Denton 111). However, examinations of the aortic arches from amphibians to reptiles to mammals do not support these sequential claims. For example,

The major vessel leaving the left ventricle which in a reptile is the major vessel carrying aerated blood from the fourth right aortic arch, while in a mammal it is derived from the left aortic arch (Denton 113).

The problematic aspect of the circulatory system for neo-Darwinistic claims are how to account properly for the shift from the right aortic arch in reptiles. Any suggestion of the gradual mutations that slowly, over a period of many generations, shifted the vessel containing aerated blood seems unnecessary complicated. Furthermore, the punctualist model is even more problematic as the permutations occur more rapidly and a coordination problem among various permutations is created. (I will return to this point later.)

The "traditional" morphological model of evolutionary development, instead of being reinforced by internal morphology, is further called into question by it. For example, Denton argues that "Instead of arranging them in a sequence: amphibia → reptile → mammal we might just as easily arrange them circumferentially with reptile and mammal equidistant from amphibia" (Denton 113). With this in mind it would appear to be inconsistent to argue that the evolution of the vertebrate heart from fish to mammals occurred gradually. Yet, the problem of how evolution took

place (as it is obvious that it did, the question is only how) still remains.

The biochemical relationship of living creatures

The traditional morphological classification seems to be validated insofar as the various classes of organisms seem to be clearly delineated. However, there are many proteins, Cytochrome C for example, that appear to vitiate the traditional classification. Cytochrome C plays a vital role in biological oxidation and hence occurs in a wide variety of organisms from bacteria to mammals (Denton 278). One can compare the sequences of Cytochrome C between various species and determine the percent of difference in order to verify the classifications that have been constructed on morphological grounds (Denton 278). Surprisingly we find that

The sequential divergence becomes greater as the taxonomic distance between organisms increases, a finding that would again have been predicted from traditional taxonomic considerations. For example, between horse and dog (two mammals) the divergence is six percent, between horse and turtle (two vertebrates) the divergence is eleven percent, and between horse and fruit fly (two animals) the divergence is twenty-two percent. However, the most striking feature of the matrix is that each identifiable subclass of sequences is isolated and distinct No sequence or group of sequences can be designated as intermediate with respect to other groups. All the sequences of each subclass are equally isolated from the members of another group. Transitional or intermediate classes are completely absent from the matrix (Denton 279-280).

When we examine the molecular distance between Cytochrome C₂ of *Rhodospirillum rubrum* (a bacterium) and all eukaryotic organisms we discover that the eukaryotic cytochrome sequences are almost the same distance from their "bacterial relative" (Denton 280). For example, the percentage of difference between Cytochrome C in *Rhodospirillum rubrum*, a bacterium, and various mammals is as follows: human 65, monkey 64, pig 64, horse 64, dog 65, whale 65, rabbit 64. In birds it is as follows: chicken 64, penguin 64, duck 64, pigeon 64. In reptiles: turtle 64, rattlesnake 66. In amphibians: Bullfrog 65. Insects: fruit fly 65, silkworm 65. In angiosperms: Sesame 65, Castor 69, Sunflower 69, Wheat 66. In yeasts: Baker's yeast 69, *Debaryomyces kloerckeri* 67, *Neurospora crassa* 69 (after Denton 280).

The observation might be raised that the differences are all approximately five percent, which provides clear support for descent from a common ancestor. However, what we are interested in determining is the ancestry of each lineage. Considering that there is an extraordinary degree of variation between eukaryotes, such as unicellular yeasts and multicellular creatures like mammals, and the fact that eukaryotic cytochrome sequences can vary simply among themselves by about forty-five percent, one would certainly expect the percentages of difference to be far greater than what has been found. For all intents and purposes, the

findings of molecular biologists indicate that not one eukaryotic cytochrome is a viable intermediate between a bacterial and a eukaryotic cytochrome. To put it another way, all eukaryotes are equally related to the bacterium (Denton 281).

Perhaps the genetic material or proteins that we are examining has been erased somehow. Yet, the lack of information to determine ancestry is ubiquitous. If one examines other proteins, and even other creatures, this conclusion is only strengthened. For example, researchers have found that if they compare the percent sequence of difference between a lamprey's (cyclostome) hemoglobin and other species, the results exactly parallel the other experiments. We find that the percentage of difference between lamprey hemoglobin and other classes are all approximately within a nine percent difference: carp (fish) 75, frog (amphibian) 81, chicken (bird) 78, kangaroo (marsupial) 76, human (placental) 73 (Denton 284). How do the results of the hemoglobin tests directly compare to the Cytochrome C? Examining the percent of difference between Cytochrome C in carp (fish) and other vertebrates is as follows: horse and rabbit (mammals) 13, chicken (bird) 14, turtle (reptile) 13, bullfrog (amphibian) 13, results in the same conclusion (Denton 285). Notice that

There is not a trace at a molecular level of the traditional evolutionary series: cyclostome →

fish → amphibian → reptile → mammal. Incredibly, man is as close to lampreys as are fish! None of the higher jawed vertebrate groups is in any sense intermediate between the jawless vertebrates and other jawed vertebrate groups (Denton 284).

Moreover, if we compare DNA or RNA of various species the results are still the same. This is the reason that Denton concludes that

There is no evidence at all for evolutionary transformations in this sequencing data. The RNAs tell the same story as the proteins! On the basis of their RNA sequences, the three primary kingdoms [eubacteria, archaebacteria, eukaryotes] stand equidistant apart," and consequently, they are each equally distanced from their theoretical common primordial ancestor (Denton 288).

Based upon the aforementioned findings, at least at the molecular level, each class seems to be equally isolated. Molecular biology has revealed two primarily clues about the evolution of life. The first is that *in some cases* there are no intermediate forms in terms of internal morphology. The second is that molecular biology gives us no clues about the ancestry of organisms. At a molecular level, no organism is ancestral compared with others (Denton 288).

The molecular clock

In order to reconcile the findings of molecular biology with any evolutionary theory one must explain why and how the biochemical relationships of species do not provide conclusive evidence, or even suggestive evidence, for the

identification of ancestry. I must admit that I agree with Denton that the results of molecular biology are enigmatic. The most basic or fundamental issue is how to explain this lack of information with regard to determining ancestry. On the face of it, attempting to argue that the degree of biochemical isolation of the major groups was drastically less in the past than it is currently may be a possibility. However, it is not clear why this would be the case. A principle of uniformitarianism would seem to be prudent in this situation.

Nevertheless, if we want to press the issue, the faulty dynamics of the argument are readily apparent. For example, there is no reason why we should assume that biochemical processes in the present are any different than those of the past. One would have to assume, for example, that ancient lungfish were much more closely related biochemically to amphibians than their present day ancestors. However, there seems to be no empirical evidence to suggest that this is the case.

The only support for the assumption that the degree of biochemical isolation of sentient creatures would be the same would be, of course, if evolution were true; yet this is exactly what we are trying to prove. This is simply an argument that is an ad hoc hypothesis introduced to explain away an apparent anomaly (the hypothesis itself has no biological motivation other than to square the theory with an

awkward fact). Furthermore the argument begs the question because the only way to accept that creatures were more closely related (biochemically) in the past is to assume that evolution is true. Furthermore, if evolution is true then quite obviously creatures must have been more biochemically related in the past--and yet, this entire project becomes seriously flawed because we are required to postulate the theory of evolution as veridical simply to prove that evolution is true. This entire project then becomes tainted by dubious reasoning.

However, there is another possible solution which seems to warrant investigation. What if, as some have suggested, proteins and RNA/DNA molecules evolve at a continuous rate via some molecular clock? This would mean that all "biochemical" relationships have been slowly drifting away from one another. Consequently, we would expect to find, for example, that ancient lungfish were more closely related (biochemically) to amphibians than their ancestors are. Surely, this might be a plausible explanation. In other words, this would mean that, say the protein Cytochrome C in living creatures, would all undergo the same rate of change.

Unfortunately, there are even more problems with this solution because we know that some groups of creatures diverged from others much more recently than others. We should then expect that biochemical relationships will indicate that some creatures are more closely related to

others simply because their "molecular clocks" have been isolated and ticking longer than others. Unfortunately, the evidence clearly indicates that this is not the case.

Further complications arise when we look at the overall differences between hemoglobin sequences and Cytochrome C sequences. For example, "hemoglobin sequences differ by fifty percent between man and carp; Cytochrome C differs by only thirteen percent" (Denton 297). We must then postulate a different molecular clock that has been operative for hemoglobin than for Cytochrome C to explain why the sequence difference varies by thirty-seven percent. Thus, the molecular clock for hemoglobin should have been moving at a much faster rate than that of Cytochrome C. To put it another way, the only way that this solution can be a remote possibility is if there is a different molecular clock for each protein.

Once we consider that there are "hundreds of different families of proteins and each family exhibits its own unique degree of interspecies variation, some greater than hemoglobin, some far less than the cytochromes" we begin to realize what a Pandora's box we have opened up (Denton 297). The only way to reconcile the variations of the hundreds of molecular clocks is to suggest that each protein family has its own highly specialized and unique molecular clock (Denton 297). However, this begins to create an extremely unwieldy system. Unfortunately, this may be the only solution that we

have at the moment.

Evolution by genetic drift?

Could evolution via genetic drift have produced the uniform rate of evolution in various proteins? Unfortunately, considering the vastly divergent life cycles of various creatures, this suggestion is easily eliminated as even a remote possibility.

Proteins of various mammals are essentially all equally divergent when compared to, say, reptiles (of course, only when we are dealing with the same protein), and yet, the generation times between mammals, for example, varies greatly. That is to say, a mouse may go through four to five generations in one year, whereas a human being may go through one generation in 70 years. The rate at which a creature reaches adulthood further exacerbates the issue; maturity rates can differ drastically, for example, an elephant, man and a chimpanzee reach maturity in fourteen, ten, and seven years, respectively (Denton 297).

The current generation times of some mammals can vary by a factor of one hundred. Since the rodent order diverted from the primate, the lineage that leads to mice has probably undergone over one hundred times as many reproductive cycles than the line that leads to man (Denton 398). If these mutations were to occur at a constant rate then how could

genetic drift have generated approximately equal values of genetic differentiation in mice and men, for example? (Denton 297). It appears that genetic drift could not possibly account for the similar genetic variations found in any creatures. Perhaps the solution may be soon be found in chaos theory. I will explore this possibility later.

The exact time in which modern insect orders, families, and genera originated is not known, but we do know that many insect species are almost identical to their ancestors found in Scandinavian amber fifty million years old (Denton 298).

If the differential generation times observed in modern species had only been maintained for as much as fifty million years, the fruit fly would have undergone fifty thousand million more generative cycles than the Cicada [There are two known species of Cicada which either have a thirteen or seventeen year life cycle.] Yet the proteins of different insect orders are equally divergent from those of vertebrates! But many organisms have vastly different generation times and all the evidence suggests that mutation rates per unit time are often very different in different species, varying by at least one to three orders of magnitude. Only if the rate of mutation in homologous proteins in different organism, was for some mysterious reason adjusted so that it was constant with respect to absolute time would uniform rates of drift occur Unfortunately, all the evidence suggests that in different groups of organisms the mutation rate per unit of absolute time is vastly different and this effectively excludes drift as a mechanism for the generation of uniform rates of evolution (Denton 298).

How then, are we to account for the uncanny similar differences in the genetic makeup of all living creatures? Denton does not propose a solution.

In this chapter we have examined the evolution of

protein and nucleic acids. This evidence has been startling because the only ancestry that can be determined is sisterly. Positing a theory of a molecular clock does not help issues because the sequence variation between different classes of organisms varies dramatically. Furthermore, due to the number of proteins the suggestion of a molecular clock becomes hopelessly complicated. However, there is also general support for macroevolution that should count as some type of validation because the traditional taxonomic classifications are confirmed.

Denton thinks that he can confidently conclude that, although we may be inclined to draw a picture as to which organism is ancestral to another, we must keep in mind that these "sequential" arrangements "provide no evidence whatsoever for believing that one type of organism was ever converted gradually into another through a series of intermediate forms as Darwin's model of evolution requires" (Denton 116). Simply because we have no direct evidence for the way in which the changes have taken place at *this time* does not mean that we will never know how to explain this piece of unusual data.

Furthermore, traditional classification by taxonomists can be bolstered by molecular biology. Yet, examining the protein Cytochrome C, a protein that is connected with the production of cellular energy, reveals some very interesting relationships between species and exposes our inability to

draw adequate inferences with regard to ancestral relationships. The evidence that seems to support the traditional classifications of living creatures also destroys the possibility of determining the lineage, or line of progression that is normally associated with evolutionary development. In other words, the standard evolution of creatures is thought to be from fish to amphibians to reptiles and then to mammals. However, given more time scientists may be able to account for this anomaly. One must concede that, at this point, this issue is problematic and solutions do not seem to abound. On the other hand, Denton appears to downplay the importance of the fact that molecular biological findings support the claim that there was a gradual progression from fish to amphibians to reptiles and then to mammals. As far as I can discern, this seems to be quite a bit of support for the fact that macroevolutionary changes have taken place, though the nuances of how it has taken place may still be a mystery.

7. COORDINATING EVOLUTIONARY PERMUTATIONS?

What I will coin "the coordination of stochastic mutations" is considered a problematic point by many critics. In fact, it is a common criticism and one which Darwin himself attempted to respond to. In this chapter I will explore this issue and agree, albeit to a limited degree, that it may pose a problem if mutations are viewed as driven strictly by chance. A coordination or retention code would be useful and make the emergence of complex organs less complex. It is possible that the real issue behind this criticism is that we do not have the proper frame of reference for knowing what is probable and what is not. (If you recall, this was the response I presented in chapter two regarding the spontaneous emergence of life.) Nevertheless, many of the attempted responses to such objections appear to simplify the processes involved and utilize analogues that are misleading. This will lead to the following chapter where I explore the recent suggestion that chaos theory may hold the answers to problems like this.

Many versions of the problem of coordinating evolutionary permutations were compiled and present by the zoologist St. George Mivart. His objections are based on the assumption that successive mutations were needed in many situations and that most were otiose in isolation as well as the fact that many advantageous mutations would be coupled with disadvantageous mutations who argued that (Darwin 275

ff.). Darwin quoted Mivart's objection to the development of baleen in Greenland whales:

[If baleen] had once attained such size and development as to be at all useful, then its preservation and augmentation within serviceable limits would be promoted by natural selection alone. But how to obtain the beginning of such useful development? (as quoted in Darwin 285).

With respect to the development of both eyes on one side of a flatfish, Mivart voices the same criticism:

If the transit was gradual, then how such transit of one eye a minute fraction of the journey towards the other side of the head could benefit the individual is, indeed, far from clear. It seems, even, that such an incipient transformation must rather have been injurious (as quoted in Darwin 290).

Mivart's key assumption, of course, is that the harmony of a organ would be precariously balanced and even small changes would seem to disrupt the integrity of the system. Yet, Mivart reasons, if one mutation were to appear and convey some survival benefit, the system that this mutation was an integral part of would be precariously balanced. In other words, subsequent mutations would serve to disrupt this harmony of the system unless there is some type of coordinating and retention code for each individual permutation, viz., some reason for the individual mutations to be retained. Before I elaborate upon this criticism I will offer a brief explanation for the way that many evolutionists conceptualize the process of evolution and speciation.

Those faithful to Darwinism would maintain that external conditions work indirectly, through favoring various traits in organisms within a species that are better adapted to the environment. Moreover, some neo-Darwinians are divided between external factors causing these genetic variations and external factors simply eliminating the less advantageous mutations. To put it another way, nature can have either a *positive* or *negative* influence on evolutionary development. Both of these theories are similar in that they rely on some form of a mechanistic "catalyst." (For the purposes of this chapter a distinction between these two views will be conflated.)

It is important to remember that mutations are random and natural selection is not; the nature of the phrase "natural selection" suggests that much. Darwin and Darwinians ever since have stipulated that natural selection is not a theory about randomness (Gould 1987 232). Chance only describes the origination of permutations, but the agent of change, natural selection "is a conventional deterministic process that builds adaptation by preserving favorable variants" (Gould 1987 232). The process of natural selection addresses certain prototypical characteristics, i.e., physiological, morphological, behavioral and so on, that are either deleterious or advantageous to an organism, hence the term "natural selection." Furthermore, some advocates of Darwinism would maintain that selection operates at the level

of the individual organism.⁵

Convergent evolution

A "standard" explanation of evolution, notwithstanding the nuances that have been mentioned, would indicate that evolution occurred through a series of fortuitous accidents "superimposed" upon one another, while requiring that natural selection preserve each preceding mutation. Henri Bergson, a philosopher and famous vitalist, was highly critical of evolutionary theory and continued to elaborate upon the criticisms posed by Mivart. Although his work may seem dated, he does raise issues regarding the issue that I call the coordination of stochastic mutations that need to be addressed. In essence, he argues that the accumulation of accidental or chance mutations working in conjunction with natural selection is not sufficient to account for evolutionary development.

Bergson is not convinced that different creatures could arrive at similar organs through completely different means. Furthermore, he does not find Darwin particularly convincing when he makes a case for an incipient structure being used for another purpose. Examples of what is known as convergent evolution would be the wings of bats, insects, pterosaurs (i.e., pterodactyls and pteranodons), protoavis,

Archaeopteryx, and avians. Bergson says,

What likelihood is there that, by two entirely different series of accidents being added together, two entirely different evolutions will arrive at similar results? The more two lines of evolution diverge, the less probability is there that accidental outer influences or accidental inner variations bring about the construction of the same apparatus upon them, especially if there was no trace of this apparatus at the moment of divergence. (Bergson 54).

Essentially the issue that Bergson finds problematic is how life can create a like apparatus by unlike means and "on divergent lines of evolution" and "the strength of the proof would be proportional both to the divergence between the lines of evolution thus chosen and to the complexity of the similar structures found in them" (Bergson 55). Bergson offers, what he sees as, an analogue to the standard account of evolutionary convergence. Says Bergson,

That two walkers starting from different points and wandering at random should finally meet, is no great wonder. But that, throughout their walk, they should describe two identical curves exactly superposable on each other, is altogether unlikely. The improbability will be the greater, the more complicated the routes; and it will become an impossibility, if the zigzags are infinitely complicated. Now, what is this complexity of zigzags as compared with that of an organ in which thousands of different cells, each being itself a kind of organism, are arranged in a definite order? (Bergson 57).

Bergson's "walkers" represent two cases of convergent evolution. For example, the wings of insects and bats. He refers to the walkers superposable paths as akin to the mutations that would be necessary to achieve the fully

functional organs. Bergson uses this criticism as a foundation for his argument that there must be a metaphysical force responsible for the convergence.

One response to Bergson's criticism might be that in some cases of convergent evolution "nature" has not *exactly* traveled in two superimposable paths. For example, a response of this ilk can be gleaned from the work of Gould (1980). Gould argues that very imperfect organs are an indication that natural selection has not always produced the most efficient organs because natural selection builds upon what materials are available, i.e., natural selection doesn't start with a clean slate. For example, the giant panda has paws with five digits, though it strips the leaves from the bamboo branches with a jerry-rigged apparatus that has evolved from its wrist to form a sixth "finger." The panda's extra "thumb" is actually composed of a small bone in the wrist, the radial sesamoid (Gould 1980 22). This evolutionary jerry-rigged structure is support for the development of homologous organs.

Bergson fails to consider situations where convergent evolution is not superimposable. He continually refers to similar examples. Bergson points out that an organism must

make the best of these circumstances, neutralize their inconveniences and utilize their advantages-- in short, respond to outer actions by building up a machine which has no resemblance to them. This may explain why different evolutionary processes resulted in similar forms: the same problem, of course, calls for the same solution. . . [that is]

an intelligent activity, or at least a cause which behaves in the same way (Bergson 58).

Bergson's point is directed at convergent evolution wherein a similar organ develops through completely different evolutionary lines. Unfortunately, due to Bergson's vitalistic inclinations he not only anthropomorphizes the creature by attributing a conscious intelligent activity to the inception of an organ, but he also intimates teleological processes. However, when we look at various creatures it becomes apparent that there cannot be a *telos* or goal to evolution because they do not possess consciousness and can not be aware of the direction of their evolutionary innovations. He also errs when he speaks of causes behaving in the same way. Bergson fails to notice that the cause (environmental and selective pressures) is only sometimes the same and may be different. For example, the cause of the retention and selection for the trait of wings in bats may have been due to the survival advantage associated with escaping predation for those that had the primordial wings. On the other hand, in insects the cause for the retention of the trait of flight may have been due to benefit associated with traveling large distances to escape from food shortages. This would allow for a greater dispersal of insects and would alleviate some of the demand of food sources associated with overcrowding populations. In these situations different causes would have led to similar effects.

Furthermore, Bergson attempts to incorporate vitalism (his theory of a life force) in order to explain convergent evolution simply because he finds it impossible that there is no common thread behind evolutionary development. In other words, it appears that if we pose the problem of how to detect predators or prey and increase survivability one would assume that the problem would have a similar solution for every creature. However, if one looks at the myriad forms of, say eyes, it is astonishing to note the similarity, and it becomes obvious, according to Bergson, that each of these sets of mutations within an organism seem to have "directed themselves" through some type of internal program to maximally utilize the environment. However, what Bergson has failed to consider is that there is a common mechanism responsible for evolutionary innovations and convergent evolution. This mechanism that he overlooks is natural selection.

The problem of convergent evolution aside, Bergson does seem to pose a legitimate question regarding whether each sequence of changes would be otiose in itself. It appears as though they would be in many cases. On the other hand, one certainly does not want to maintain the saltational position that the whole *opus perfectum* has been achieved concomitantly.

It is obvious that there will be intermediate steps required to achieve any organ. However, Bergson argues if a

number of mutations are required to form an organ then each mutation will be otiose by itself. The thrust behind this criticism is based on the fact that a particular organ, say an eye, is not going to appear spontaneously on an organism that previously was devoid of such an organ. This particular organ would have had to come about over a period of time and would undoubtedly have been gradually built up over an incredible number of generations. Bergson would argue that these generations upon generations of fortuitous mutations enhancing the variation in the precedent strand of DNA is a mathematical impossibility.

Problematic permutations

One typically thinks of evolutionary changes occurring and, if they are useful for an organism, enabling the creature to survive and benefit from the mutation. Nevertheless, because we can view the utility of an organ *ex post facto* it does not mean that we can explain how it came to be. An organ, presumably, would develop over a period of time, in which case the mutations would have to "build" upon one another. This "layering" of mutations is the Darwinian notion of gradualism.

However, an organism would have no reason to retain a particular trait that developed through a mutation unless it served a purpose for the organism, viz., increasing the

survivability ratio, which presupposes a fully formed and functional organ if the organ is to be kept by the organism for the following generations. For example, the formation of an organ that detects light in very simple organisms could quite easily be formed based on the simplicity of the design and function of the organ. Although the benefits of such a mutation are obvious, extending the application to the formation of the vertebrate eye is not as easily done.

For example, the complexity of the vertebrate eye is amazing. The human eye has better resolution of detail than any camera of a comparable size (Wesson 61). The retina is continually processing color images and is specially "constructed" so that the periphery is ultrasensitive to movement. The structure of the eye is done to a startling degree of complexity and detail--there is a black pigment that lines the retina to eliminate unreflected light while the "inner layer of the retina is pulled back around the center of vision, or fovea, to permit maximum acuity" (Wesson 61). The retina can also increase or decrease its sensitivity a millionfold (Wesson 61).

Human beings are thought to be nature's crowning achievement, but it is the octopus's eye that wins the award for the most efficient design, and the eyes of the owl and cat that are the most powerfully designed. Most vertebrate eyes are constructed with the photocells oriented away from the incoming light, but the eye of the octopus actually has

its photocells oriented in the proper direction (Dawkins 93 ff.). Moreover, owls and cats possess very sensitive eyes and can see in light with only a tenth to a hundredth of that required by human beings (Wesson 61). An organ like the vertebrate eye is amazing:

Two points are equally striking in an organ like the eye: the complexity of its structure and the simplicity of its function. The eye is composed of distinct parts, such as the sclerotic, the cornea, the retina, the crystalline lens, etc. In each of these parts the detail is infinite. The retina alone comprises three layers of nervous elements--multipolar cells, bipolar cells, visual cells--each of which has its individuality and is undoubtedly a very complicated organism: so complicated, indeed, is the retinal membrane in its intimate structure, that no simple description can give an adequate idea of it. The mechanism of the eye is, in short, composed of . . . [numerous] mechanisms, all of extreme complexity (Bergson 88).

Moreover, the various parts of the eye must harmonize in order to work properly, and this balance is precarious. If the slightest degree of error is present, if one slight mutation is introduced, the integrity of the entire system is jeopardized.

Recent research has only served to illuminate how much more complex vision is than we had previously thought. Indeed, we have *only begun* to understand the complex processes behind vision. For example, in a recent book Francis Crick (1994) mentions that the visual parts of the brain are so complex that we are still unclear about many aspects of visual processes. The visual parts of the brain, says Crick, "all receive their input from some of the million

or so neurons, the so-called ganglion cells, at the back of each eye" (121). The internal components of the eye are equally complex, though today we have a greater understanding of their function. Crick states:

The lens focuses the image of the visual field onto a thin sheet of cells, the retina, at the back of the eye. In one of its layers are located the four kinds of photoreceptors that respond to the photons of the incoming light. These are the rods and the three types of cones . . . of which there are over 100 million in each eye, respond mainly in dim light and are of only one type. The cones, of which there are about 7 million, are active in bright light. There are types of them, each type responding to a different range of wavelength of incoming light (Crick 122).

Would someone advocating a gradualistic view suggest that each of the rods arose individually? If so, then evolution would never have taken place. However, the only other solution would be to suggest that all of the cones erupted at one time and, perhaps, gradually became more refined. Yet why would an organism choose to retain only the cones, for the cones alone do not allow an organism to see? Bergson is right that only many systems working together and finely-tuned would allow vision to function effectively.

Darwin was also troubled by the complexity of the eye. He, along with others that have carried on his tradition, think that the gradations of various viable stages of the formation of the eye (as they appear in living creatures) can account for the formation of the eye. The typical evolutionary model of the formation of the eye would go

roughly like this: certain protists have light-sensitive spots that might be considered a "primordial eye." It is but a short step to suppose "that this could have been the basis for the flatworm's pigmented cup-like cavity. If this opening were to be narrowed, it would form a very crude image. Furthermore, if this opening were covered with a transparent skin, a rudimentary lens might be formed" (Wesson 62).

This type of account overlooks a very important issue-- because we can imagine the existence of numerous viable stages that seem to form a lineage does not explain how it was possible for numerous genes to be introduced (that only or primarily produce one effect) while maintaining the integrity of the existing rudimentary organ. That is to say, the gradualist would argue that a series of random mutations built up over a very long period of time would allow for *only* the elimination of deleterious genes while maintaining the *precarious* harmony of the preestablished system or organ. Critics of gradualism find it difficult to imagine how the correct sequential mutations could have come along in the required order. It would appear that some type of organizational system or unifying code is needed to coordinate the many permutations that form complex structure such as an eye, that is, a retention or coordination code to help arrange and organize these mutations.

On the need for a "retention code"

While gradualists attempt to explain evolution, the hypothesis of a retention or coordination code that would coordinate the various parts of a system is ignored. In other words, critics such as Denton and Wesson are right in maintaining that evolutionists do not consider the possibility that there may be an underlying principle behind the coordination or integration and retention of mutations within the genome. The reason that they do not consider any alternative theories is because they do not see any problems or they see certain aspects as problems that will be explained sometime in the future.

A mechanism is required to explain how the mutations are coordinated. However, it is not enough to simply postulate such a hypothesis because then we have a problem insofar as each individual system must be coordinated. Are we then to posit another, higher-level coordinating code? We begin to develop a more complex theory than we need to, i.e., unless an underlying mechanism is established. To suggest that one system of the eye will develop and wait for the others to develop is impossible unless a benefit is conveyed. However, at least as far as the vertebrate eye is concerned, each individual mutation would convey no plausible benefit and certainly no benefit in terms of vision without the other mutations needed to form a rudimentary eye. In other words,

the eye must function to convey at least a minimal benefit. One point is certain with respect to the development to the vertebrate eye:

The organ will be of no use and will not give selection a hold unless it functions . . . the minute structure of the retina may develop, and however complicated it may become, such progress, instead of favoring vision, it will probably hinder it if the visual centers do not develop at the same time, as well as several parts of the visual organ itself. If the variations are accidental, how can they ever agree to arise in every part of the organ at the same time, in such a way that the organ will continue to perform its function? For a difference which arises accidentally at one point of the visual apparatus, if it be very slight will not hinder the functioning of the organ; and hence this first accidental variation can, in a sense, wait for complementary variations to accumulate and raise vision to a higher degree of perfection. Granted How, in that case, can the variation be retained by natural selection? (Bergson 64).

Bergson is right, each part of an organ is of no use to an organism independently and must wait for others to accumulate before utility will be a retaining factor. (This is the primarily area of contention between neo-Darwinians and their critics.) The fundamental problem remains:

How do all the parts of the visual apparatus, suddenly changed, remain so well coordinated that the eye continues to exercise its function? For the change of one part alone will make vision impossible, unless this change is absolutely infinitesimal. The parts must then all change at once, each consulting the others (Bergson 65).

However, to suggest that each system must coordinate with one another seems to be the only way to account for evolution. This seems to require some "unifying retention code" to unite

and organize the various systems.

For the sake of argument, if a flatworm were to possess a light-sensitive spot, a second mutation of a lens would seem to increase the efficiency of light detection. How would a critic like Bergson respond? He might say something along the following lines: If the second mutation of a lens were to appear over the light sensitive spot of a flatworm the chances are that it would be translucent or opaque, thus letting *less* light through than had formerly been the case. In other words, statistically speaking, it would more likely be opaque or "cloudy" in character. If the lens were transparent then it *might* convey a benefit.

However, it might be the case that natural selection had already "selected" for the "optimum" light detecting organ before this mutation of a lens appeared. To say it another way, Bergson might argue that improvement was impossible. In all likelihood, so the argument would go, wouldn't it be prudent to suppose that nature eliminated all of those creatures that did not detect light well enough to survive? A lens would not assist in the gathering or detection of light unless it were properly focused. Moreover, if the lens were focused, this would only effect the sensitivity of the organ, which, presumably, nature had already selected for. Creatures with hypersensitive organs possibly would have already died. Why then, would we want to argue that the introduction of another mutation that had already been

eliminated be introduced? If there were a clear benefit from possessing a very sensitive light detecting organ would it not have already been selected for in a similar way that most creatures unable to detect light had been eliminated?

In response, evolutionists would argue that if it were the case that nature had already selected the most adequately adapted and could go no further, then the introduction of a lens might allow the creature's organ to go beyond a certain limitation or barrier. Bergson might query "What then, would be the chances that the lens was properly focused?" Although I am not a statistician, I would venture to say the chances would be quite slim. On the other hand, perhaps the improbable might happen. The lens might focus light very well, perhaps too well. In fact, the lens might, like a young child with a magnifying glass burning holes in leaves, burn a hole right through the organism, or perhaps only scorching it. What benefit, then, would a lens have been?

How could 5% of an eye develop?

What if, simply for the sake of argument, a creature were to possess a "primordial" eye that was only 5% effective? How would this primordial organ have developed? Would this organ increase the creature's chances of survival? This question was raised by Mivart and is known as the argument "against incipient stages of useful structures"

which he coined in 1871 (Gould 1987 233). Darwin's response to this criticism in the sixth edition of *The Origin* was to suggest that the intermediate stages perform different functions. The feathers on an incipient wing, for example, may be useful as thermoregulators (Gould 1987 233). There are other theories espoused by neo-Darwinists that stipulate that a certain percent of an eye is better than none at all.

Consider the difficulties of Richard Dawkins' mechanistic gradualistic theory of evolutionary development. Dawkins indicates that if an eye is formed on an organism and is only 1% effective it is still better than no eye at all. This is true, but only if 1% of an eye would be effective under these circumstances. He seems to liken ineffective eyes to a myopic who would walk around and, perhaps, bump into things, but still be able to survive nonetheless. This example is overly simplistic and really does not serve his purpose because it oversimplifies such a complex process. To grant Dawkins such an example assumes that we have worked out the problem of coordinating permutations. However, a critic would point out that this is not the case.

A person in opposition to Dawkins' view would not claim that the eye functions as a whole or not at all, but rather that one system cannot function on its own. The only way to avoid this would be to assume that many of the systems of the eye formed at once and thus were able to convey some primitive form of vision. If this were the case or Dawkins

could specifically demonstrate how an eye could get to a state in which it functioned at 1% efficiency, then one would be forced to agree with him and from this point think that any permutations would simply allow the organ to become more refined.

A "redirection" for evolutionary theory

The problem, however, is that we first have to get a few of the systems to "coordinate" before we can have an eye that would convey even, say 1%, efficiency as far as detecting light. I understand Dawkins to mean that an eye functioning at 1% efficiency would contain rudimentary forms of the following parts: iris, pupil, ciliary muscle, osseous system, sclera, fovea, retina, rods, cones, the optic nerve, and so on. This does not even include the relevant aspects of the brain required to process the visual information! The issue of whether a small percent of an eye would convey a benefit to an organism, viz., would it be able to see or do anything beneficial for the creature, is not open to debate because it obviously would convey a benefit.

I tend to agree with the critics that it might not be prudent to assume that the eye evolved strictly by chance, taking into account the criticism that the organism would have no reason to retain the primordial eye if it did not function as a light detecting organ. Furthermore, there is a

growing minority of evolutionists who maintain the view that if we were to treat the world as if it were akin to a Mandelbrot set then there would be an intrinsic connectedness between all parts that would lend themselves to the "coordination code" that seems to be such a necessary part of a evolutionary paradigm. In other words, an organ as complex as the eye is able to evolve because each of the systems of the eye is, for lack of a better phrase, "in tune" with the other systems. This allows a very primitive eye to convey minimal vision. This is not too far removed from the traditional neo-Darwinian account. This minority of evolutionists argue that an organism develops organs which are created by the build up of generations of mutations simply because the organism has the "internal" mechanism or formula that governs all of the animate and inanimate matter in the universe. This formula is found in chaos theory. I will explore this avenue shortly.

Multiple mechanisms

A gene is pleiotropic when it is responsible for producing multiple effects, and in some cases genes produce a dozen or more multiple effects. The deafness of white male cats with blue eyes is an example of a pleiotropic effect. Only in very rare cases will the presence of a gene result in the manifestation of an isolated trait; for example, this is

the case with eye color in human beings (Varela, Thompson, Rosch 188). Because of pleiotropism, permutations rarely, if ever, result in a beneficial change within an organism. The fact that genes are interdependent serves to illustrate that the genome is not simply a linear assortment of individual traits, but rather a complex web of reciprocal effects that are "mediated through repressors and derepressors, exons and introns, jumping genes, and even structural proteins" (Varela, Thompson, Rosch 188).

Critics argue that the traditional neo-Darwinian explanation of evolutionary development is undermined because if, as they maintain, a phenotype is selectively optimized to increase fitness in nature, there are a host of complications. For example, if genes produce multiple effects, how can "nature" select for one particular phenotypic trait when there are multiple traits associated with any given gene? Selective pressures might select for a particular trait which would cause the decrease in the frequency of one gene, but it would also decrease multiple necessary traits that "nature intended" to select for.

Difficulties such as these demonstrate how genes do not produce the nice linear progression that Dawkins depicts, but rather, genes form a very complex web of relationships. To use an analogue of a spider's web, to pull one corner of the web (introducing one mutation) will have the consequences of moving the rest of the web out of place, possibly breaking

the web (and hence, killing the organism).

Advocates of the theory of natural selection insist that nature "selects" for certain traits when there is no mechanism to explain how mutations are coordinated. Of course, there are some mutations that are more beneficial than others, but this does not explain how they become coordinated and integrated. Mainstream scientists are not amenable to the possibility or hypothesis that permutations within an organism are not complex arrangements intended to fill some grand design, but rather serendipitous designs that arise simply because they are a possibility!

The genetic code

Critics of evolution like Wesson argue that the intricacy of life should be impossible given that 100,000 genes are too few genes to specify all of the facets of a structure as complex as that of human beings (Wesson 142). Wesson holds the position that genes only specify a general arrangement and the specific aspects of a living organism. This may make sense because, as far as human DNA is concerned, only as little as one percent is actually utilized, the rest is unused (Wesson 231). This point is bolstered by that fact that with respect to the human genome about "forty percent of the genome is not expressed and simply repetitive" (Varela, Thompson, Rosch 191). This large

amount of "junk" DNA is of interest because it serves no function. Critics of evolution such as Varela, Thompson, and Rosch argue that "From a classical standpoint, such a massive amount of genetic material is totally inactive and so simply should not be there" (Varela, Thompson, and Rosch 191). What they do not seem to glean from this fact is that if this inactive DNA is not harmful there would be no reason to eliminate it. The specification of the phenotype from the genotype is something that might make more sense in terms of following a specific rule or formula. I will explore this issue in chapters nine and ten.

Anomalous cases?

Some evolutionists do admit of a few problematic areas in evolutionary theory. For example, Richard Dawkins (1987), a devout gradualist, talks about the problem traditional neo-Darwinism has with explaining certain anomalies in nature. For example,

The swimming mollusc *Nautilus* . . . has a pair of pinhole cameras for eyes. The eye is basically the same shape as ours, but there is no lens and the pupil is just a hole that lets the seawater into the hollow interior of the eye Why, in all the hundreds of millions of years since its ancestors first evolved a pinhole eye, did it never discover the principle of the lens The system is crying out for a particular simple change. In genetic hyperspace, *Nautilus* appears to be sitting right next door to an obvious and immediate improvement, yet it doesn't take the small step necessary Is it that the

necessary mutations cannot arise, given the way *Nautilus* embryos develop? I don't want to believe it, but I don't have a better explanation (Dawkins 1987 85-86).

Then why hasn't the *Nautilus* evolved a lens? This question has troubled evolutionists like Dawkins, and so it should, because traditional Darwinism explicitly stipulates that permutations can go on indefinitely, and yet, many seem to stop far short of very needed changes. Of course, this should not be taken to mean that there are no limitations to the phenotype. For example, nobody would want to argue that a horse could be bred to run over 100 miles per hour. The muscular and bone structure as well as the additional amount of energy required to attain such a feat would outweigh the benefits.

That is to say, if the existing systems of a horse were not modified the additional stress created by speeds in excess of 100 miles an hour would shatter a horse's bones and destroy its muscle system as well as all of the tendons attaching the muscles to the bones and the ligaments holding the bones together. The additional "reinforcements" required would add a considerable amount of weight to the horse and would then require an increase in the energy consumed. This would further required that the animal consume much more food.

This wonderful horse that we have imagined might eat more than twice as much as an "average" horse. This burden

would place severe limitations on such an achievement and might outweigh the benefits associated with greater speed. Do we want to maintain, as evolutionists, that the example of the horse is an analogue to the *Nautilus*? The answer is far from clear.

Critics argue that some of the "so called" transitional specimens do not support the gradualist argument as well as they seem to point to a redirection of our inquiries. The putative absence of transitional forms is another anomaly. For example, the most common examples that are hailed as transitional forms, i.e., an intermediate stage of morphological development between one group of creatures and another, are the lungfish, *Archaeopteryx*, and the platypus. For example, the lungfish has fins, gills, and an intestine containing a spiral valve like all fish, but it also has a heart, lungs and goes through a larval stage exactly like an amphibian (Denton 109). Does the lungfish provide us with a transitional example? Well, yes and no. Although, *prima facie*, the lungfish does seem to possess transitional characteristics, it nevertheless does not contain individual characteristics that are transitional themselves. What I take Denton to mean is that there do not appear to be "transitional" stages between the development of a heart in fish and those of most terrestrial vertebrates.

The duck billed platypus lays eggs like a reptile but has hair, mammary glands, and three ear ossicles like a

mammal (Denton 109).

Where they [platypuses] are reptilian in, for example, the reproductive system and in the structure of their eggs, they seem almost fully reptilian, while where they are mammalian, as for example in the construction of their middle ear, or in the possession of hair, they are fully mammalian. Instead of finding character traits which are obviously transitional we find them to be either basically reptilian or basically mammalian, so that although the monotremes are a puzzle in terms of typology they affirm little evidence for believing that any of the basic character traits of the mammals were achieved gradually in the way evolution envisages (Denton 109-110).

One possibility is that there are levels, much like the shells of an electron, which seem to govern the stochastic processes behind all permutations in the evolution of living creatures. For example, physicists know that the electron can be on level 1 or 2, but never does it go through a transitional phase, e.g., 1.1, 1.2, 1.3, 1.4, etc. Some evolutionists would argue that there is evidence that the evolutionary development of creatures follows a similar pattern. Critics of the standard neo-Darwinian account would argue that the world of physics, and chaos theory in particular, can be applied to all matter in the universe. Consequently, they would argue that we should integrate the "laws" that govern the universe if they are applicable to living systems.

In chapter seven I introduced the problem of coordinating evolutionary permutations. Because of the

complications of coordinating evolutionary mutations, chaos theory, in particular complexity theory, might hold the key to understanding some of the enigmas behind the emergence and evolution of life. It may be the case that just as there are laws in biology and evolution akin to the laws of physics and chemistry. This is what will be explored in the subsequent chapters.

8. TAKING A CLOSER LOOK AT CHAOS THEORY

Because so much ground has been covered it would be useful to give a brief summary of the criticisms and the assessments that I have offered in the preceding chapters.

The first criticism of evolutionary theory regarding the improbability of life emerging by chance was found to be vacuous. Because we have been able to create organic compounds in the laboratory, it appears that a plausible account can be given for how life began. We have gathered a pretty good understanding of the way in which life is a very complex interaction of numerous processes. Dawkins suggests that our conceptual frame of reference, and hence our evaluation of what would be probable or improbable, is skewed due to our short lifespans. Furthermore, although my winning the lottery is improbable, someone winning the lottery is very likely. Consequently, although life may have been improbable, given approximately one billion years it was certainly probable.

The second criticism that I examined was raised by Denton who argues that the extrapolation of microevolutionary to macroevolutionary phenomena is problematic. I examined his example of meteorology, where this type of reasoning has not been efficacious, and cite a counterexample from the world of physics, i.e., the laws of motion, that have allowed us to better understand how forces work on our planet as well as to predict planetary orbits in our solar system. In other

words, I argue that what Denton takes to be a clear case of "the fallacy of extrapolation" may not be a fallacy at all. Furthermore, due to the appearance in the fossil record of creatures that gradually became more complex the plausibility of an extrapolation from micro to macroevolutionary processes is strengthened.

The most frequently leveled criticism of neo-Darwinism is the imperfect nature of the fossil record. The assumption that Darwin first made regarding the incomplete nature of the fossil record may or may not still be valid. One can find paleontologists who argue that the fossil record is still incomplete and the others who argue that the record is almost complete. This is a contentious issue that does not lend itself easily to resolution.

Evolutionary theorists suggest that creatures gradually arose from fish to amphibians, to reptiles, and then to mammals. Many of the systems necessary to sustain life do not seem to lend themselves to the development of viable transitional stages. This stands in contradistinction to the traditional neo-Darwinian explanation. Denton argues, for example, that the circulatory system of reptiles is so utterly different from mammals that intermediate circulatory stages which should have formed the "bridge" from reptiles to mammals are not something that appears to be a possibility. It should be noted that this differs from the neo-Darwinian view that all evolutionary developments can be explained in

terms of numerous gradual changes within a given system or organ. Denton's position leads us to the conclusion that some organs or systems do not have intermediate forms.

Traditional taxonomic classifications are supported by findings in molecular biology. Unfortunately, as Denton argues, molecular biologists have discovered that the only ancestry that is revealed is sisterly. For example, the protein Cytochrome C, although supporting the traditional taxonomic classification of creatures, does not allow us to infer anything about the ancestral relationships between classes. Although I view this as a problem, I find that this information is also further support for our overall conception of the evolution of life on earth, viz., macroevolutionary claims, though Denton does not recognize it as such.

The problem of "coordinating stochastic processes" stems from the criticisms of Mivart and Bergson. The presupposition behind the criticism is that each mutation, in isolation, would appear to be otiose without the other mutations required to form a particular organ. Pleiotropic effects further exacerbate this issue. Either the series of mutations required to form an organ all arose concomitantly (and this saltational solution is untenable), or the mutations are the result of blind chance, or there is a coordinating and retention code which "helps" subsequent permutations avoid disrupting the beneficial mutation that is

already established. I view this as primarily a problem of ascertaining what the exact mechanism is that is responsible for evolutionary changes and not as a major problem with the theory of neo-Darwinian evolution. (I will explore the possibility that chaos theory may provide the solution in the next two chapters.)

Unfortunately, some evolutionists such as Mayr and Dawkins do not admit of any weaknesses in the neo-Darwinian paradigm at all. This is where I see a problem. As critics argue, a more coherent, and perhaps helpful, way of conceptualizing evolutionary development can be established by creating a theory that addresses the organization of all animate and inanimate material in the universe. Recent work in mathematics may have revealed an underlying order in the universe that is governed by chaos theory. If so, then the application of this theory would encompass the biological sciences and may allow evolutionists to explain evolutionary development in more detail to quell critics of evolutionary theory proper.

Towards a theory that accords with the facts

Denton may be right that the fossil evidence of transitional forms such as *Archaeopteryx*, for example, are revealing in that the morphological or physiological characteristics that it exhibits are not *sui generis* in

themselves. In other words, they possess a combination of traits that already exist individually in other creatures, but they do not contain any characteristics that have arisen *de novo*. For example, Denton argues that *Archaeopteryx* is considered to have the teeth and bony tail of a reptile and the wings of a bird.⁶

What is being suggested is that the fossil evidence is pointing to the fact that all of the known morphological characteristics are not transitional in the truest sense of the word. To put it another way, when we find fossils, the characteristics or structures are never found to exist in the "developmental stages." When we find a creature, for example, we find that it may possess a fully avian circulatory system and feathers with the tail and teeth of a reptile.

I understand Denton to be implicitly stating that the fossil record does not suggest that there was any type of gradual transition from one to the other, but a wide array of "morphological building blocks," for lack of a better phrase. These blocks are thrown together, if you will, not because they produce the most adequate arrangement for a living creature, nor is it the case that creatures have gradually evolved through numerous successive stages, but rather because this combination is not a detrimental combination it has come into existence. At this point it may be helpful to review the way in which morphological changes do take place.

Exploring chaos theory

A more lucid example might make the point about genetic possibilities more clearly. I take Denton to be arguing that there seem to be regularly occurring forms in nature that can be viewed (in a very rudimentary way) like pieces in a puzzle or legos (this is akin to Wesson's argument). These legos can be combined with numerous other legos to create viable arrangements. However, the important point is that you can't have half a lego any more than you can have half an eye (as the neo-Darwinists would attempt to argue).

For example, there are only several possibilities or styles that the development of wings can take; we might have four "blocks" for wings, the type of pterosaurs (W1), the type for insects (W2), the type for bats (W3), and the type for avians (W4). These are the only possibilities! The "blocks" can be combined only with certain body types, and the certain body types can only be "constructed" out of other parts that are themselves possibilities. Moreover, all of these "blocks" can be combined in certain arrangements. Many arrangements, say, the feathers of an avian are not conducive to other "blocks" such as the circulatory system of another class of living creatures.

That is to say, a creature could be "constructed" with one of several endocrine, circulatory, osseous, respiratory

systems and so on. However, it is important to recognize that the traditional theory would indicate that there was a gradual development from one system to another. In contradistinction, I have followed Denton's arguments to their end and maintain that there are jumps from one system to another, that is, species A "jumps to" species B, and that the laws of chaos theory, which I will mention shortly, dictate what types of systems these jumps will gravitate towards.

An analogue might be especially useful here. If we had a mountain with all sorts of spurs, saddles, and valleys and were to drop water on the top of this mountain, the water could only go down the mountain a certain number of ways. It would not travel along the crest of a ridge, but would travel in the valleys and troughs, and some valleys will not lead to other valleys. Once the water has gone down one valley, it must continue down that valley until it is possible to cross over to another valley through some sort of channel. This is a rough overview of how evolutionary permutations may take place, with the valleys representing possible morphological characteristics.

This "mountain" would correspond to the basic prototypical characteristics of all creatures, particularly morphological. For example, avians do rather well with their light osseous system but would not be viable if they were to have shells. Hence, to jump from "their" valley, which does

not contain that possibility, to another valley which does will be fatal. These jumps are not terribly drastic but the results, *prima facie*, appear to be a blending of characteristics. The duck-billed platypus is an excellent example.

The making of new species seems to require breaking away from some type of a chaotic attractor (Wesson 180). An attractor "is in a multidimensional phase space; it is a set of permitted states of a system" (Wesson 144). With respect to biology, an attractor's boundaries are governed by a certain set of mutations. In other words,

The genome is a system of linked attractors at all levels of genetic stability, from the basics of cell physiology to the body plan of the phylum to the characteristics of a species Any self-reinforcing pattern, or a self-ordering part within the self-ordering whole of the organism, such as the brain, a limb, or the liver, may be attractor. Any taxonomic group, as far as it represents a set of organisms that belong together, represents an attractor at its level (Wesson 146).

After a certain number or rearrangements or changes take place within the organ, system, or creature, the possibilities decrease. In essence, I am arguing that the information contained within genes only specifies a general pattern for how an organism is to be constructed (Wesson 144).

To put it another way, genes are *not* always directly responsible for all of the organs, systems, and processes that go on within an organism. The attractors are

responsible for the stability of the system, organ, or creature. In other words, the chaotic attractors, *de facto*, form a homeostatic or negative feedback system. However, because of random anomalies the integrity or harmony of the "system" becomes disrupted on occasion. This results in the trajectory escape of the attractor, whereby it escapes the stability of the previous chaotic system only to, once again, settle down to another period of "suspended animation" in another system. If we examine evolutionary development this type of pattern seems to be present as far as morphological development is concerned. To put it another way, because a creature's genome's character can both exhibit an amazing degree of stability as well as go through a tremendous number of permutations, attractors may offer insight into the way speciation takes place and the reasons behind morphological stasis. However, before I go too far, it would be helpful to explicate chaos theory.

The laws of chaos theory

Although chaos is not easily defined, the general concept itself is easy enough to understand. Chaos theory is not about events that repeat previous states, but rather, it is about the inherent tendency of systems to deviate and disturbances to proliferate on larger scales. Edward Lorenz, a meteorologist, first brought attention to this field by

researching the unpredictable nature of the weather. The famous example of a butterfly flapping its wings in the Amazon and creating a hurricane in Florida aptly illustrates the most basic law of chaos theory, positive feedback; small differences or effects increase exponentially leading to much larger outcomes (Wesson 32). Fractals, patterns with nonintegral dimensions and unpredictable variations, can be treated as akin to chaos in that the "values are subject to repeated subdivisions on a smaller scale" (Wesson 33).

However, it is important to keep in mind that chaos is

indefinitely detailed and unpredictable disorder that is at the same time deterministic and held within a general pattern, repeated with infinite variety. In chaos, variation is irregular but bounded, as it is in living creatures (Wesson 34).

Chaos is disorder that is structured within certain boundaries or confines, as I mentioned earlier, by what are known as chaotic attractors, or "strange attractors" as they are more commonly labeled. The attractors describe the limitations of the cycling within the system. For example, this may be centered around a point, a cycle, or a space (Wesson 34).

Life is unique in that there is an influx of energy that allows chaos to generate new and unpredictable order. Wesson argues that "This is the way of entropy-defying life, and there must be large elements of chaos in something so dynamic and governed by feedback as evolution" (Wesson 34-35). The discovery of chaos theory demands that we view life, self-

regulating and self-organizing systems, in terms of this meta-organizing principle to explain the highly order patterns and myriads of forms of life. The guiding force behind these changes are the so-called "strange attractors" of chaos theory.

These "strange attractors" of chaos theory may be the underlying principles behind the evolution of living creatures. As the geneticist Theodosius Dobzhansky once remarked, "Nothing in biology makes sense except in the light of evolution." The following chapters may allow us to revise this to "Nothing in biology makes sense except in the light of chaos or complexity theory."

9. THE SUGGESTION OF "CHAOTIC EQUILIBRIUM"

Modern evolutionary theory (neo-Darwinism) reduces the study of the individual organism to the study of its constituent parts such as genes, molecules, and the essential components of the organ or system that is being examined (Lewin 35). The traditional neo-Darwinian would examine a creature and attempt to explain the existence of various organs using a functionalist approach, viz., explaining the development of an organ by the function that it serves. This may be adequate for some organisms, but in other cases it falls short of offering an explanation. In this chapter I will explore the suggestion that chaos or complexity theory, if found to be veridical, might strengthen our existing theory of evolution and provide answers to questions that have been found to be problematic in our traditional view.

An excellent example of one of the mysteries of modern evolutionary theory that has been unveiled by chaos theory is the evolution of a species of alga known as mermaid's cap (*Acetabularia acetabulum*) that possesses a disk-like organ that resembles a mushroom cap in appearance. However, unlike the mushroom cap the organ does not appear to serve any purpose and has biologists mystified (Lewin 37). The neo-Darwinian would contend that we have failed to discover its function or that it is a remnant of a vestigial organ.

However, recent advances in chaos theory indicate that there may be a more novel way to approach the problem. Using

a sophisticated computer program that models aspects of calcium regulation in cells, the different responses of cell walls, and changes in the elasticity and viscosity of the cytoplasm, it is possible to model *Acetabularia acetabulum*, a biologically complex creature (Lewin 37-38). Furthermore, the program is actually mathematically quite simple. When the computer went through the program it was thought that it would take numerous trials before the parameters could be found to simulate the development and morphology of *Acetabularia* (Lewin 38). However, the model found the parameters necessary to replicate the creature in a few iterations. In fact, one of the researchers, Brian Goodwin, realized that the development of the creature seemed to follow very simple mathematical laws. Using this program he was able to determine (what biologists had never understood) that the conical tip flattens out before the short formed. He says,

The gradient of calcium with a maximum at the pole becomes unsteady as growth proceeds, and transforms into an annulus with a ring of elevated calcium and increased strain. The wall softens in this ring, because of the coupling between cytoplasmic strain and wall elasticity, so the wall develops maximum curvature in the region of the annulus and flattens toward the tip The reason why all members of the *Dasycladaceae* make whorls may be because they are a natural form that arises from the dynamic principles embodied in the organization of the cell. Some species use them, some do not, but all generate them (Lewin 38).

This particular example is one of many that researchers in chaos theory have discovered using complex computer

simulation. They all seem to illustrate the way in which chaotic attractors operate in morphogenetic space. In other words, many organs that evolutionists are unable to explain in terms of their function now appear to be a natural stage in the development for other organs. What is most remarkable is that a very simple program is used to replicate the processes in this biologically complex organism.

The reason that this example of the development of mermaid's cap is remarkable is because the mechanism that we once thought to be a necessary aspect of explaining any organ is now found to be unnecessary. Simple chaotic attractors have been found that may enable us to more adequately understand and explain, not only the development of a particular organism, but speciation for all living creatures.

Another example of how a simple formula can be very helpful in understanding evolutionary permutations can be found with the human genome. There are one hundred thousand genes in the human genome that are responsible for the generation of 254 different cell types that are in turn responsible for 254 different processes or patterns of activity within the respective cells (Lewin 27). There is a potential for $10^{30,000}$ different types of activity states for the human genome (Lewin 27). Neo-Darwinians would argue that natural selection is responsible for the selection of the specific 254 active patterns in the human body. This explanatory account should seem impossible!

However, simple sets of rules like chaotic attractors will make this development much more probable and understandable. Using computer programs to model complex systems has revealed that in a system of 100,000 elements like the human genome will produce approximately 370 attractors (Lewin 30). (The details are unimportant so I will only offer a rough overview.) This is not too far from the actual number of known cell types which is 254. This experiment has been run for fungus, yeast, algae, and so on. It now appears to be the case that "the number of cell types in each organism is the square root of the number of genes" (Lewin 30).

This information is revelatory in that we are able to replicate living systems with computer programs that we thought were simply the result of a layering of accidental mutations. Merely serendipitous designs are actually naturally occurring processes. Researchers have found that these natural self-ordering systems are created with a very simple formula. Consequently, instead of wondering in awe how the humane genome is responsible for such a diversity of complex systems with the small amount of DNA, we realize that the DNA does not have to specify, e.g., each individual capillary, but merely a simple formula which governs the formation of capillaries.

The previous discussion is applicable to the issue of the development of the eye that was examined earlier. As a

reminder to the reader, the neo-Darwinian view was that the eye formed because it was a useful and beneficial organ for the creature. An advocate of, what I will call, chaotic equilibrium would take into account the fact that eyes have evolved independently more than forty times (Lewin 40). Consequently, a plausible case can be made for the presence of a morphogenetic or a strange chaotic attractor that specifies the kind of morphology an eye can have (Lewin 40). The eye thus conceived can be viewed as a "product of high-probability spatial transformations of developing tissues" (Lewin 40). In other words, the arrangement of the systems and tissues that constitute an eye may be specified by a simple formula that would almost necessitate the mutations required for eyes to develop.

Moreover, neo-Darwinians would argue that natural selection ultimately produces creatures that are ideally suited for their environmental conditions. However, this is not always the case. For example, one species of Darwin's finches in the Galapagos does not seem to have developed a very needed morphological change, a long beak to extract insects, and must rely on an instrument to get its meal. Why hasn't this species evolved this needed organ that other closely related species have easily acquired? Neo-Darwinians are left perplexed when they must explain why generations of permutations have not left this creature with the organ that it so obviously needs.

It might be the case that an organism's morphological traits are not fully determined by the constraints of survival and reproduction. An advocate of the theory of chaotic equilibrium would maintain that the various "parts" of an organism are arranged in complicated arrays, not to fulfill some ideological design but because they are viable possibilities (Varela, Thompson, and Rosch 196).

The spontaneous emergence of order and occurrence of self-organization is central to re-conceptualizing evolutionary progression. To use an analogue, just as we know that oil droplets in water and the symmetrical nature of snowflakes are not achieved without the help of natural selection, living organisms may show a similar tendency towards self-organization, albeit natural selection does become operative once the morphological pattern has developed (Kauffman xiii).

The homologies between the various forms of the vertebrate limb, viz, where they can be seen as a transitional series of gradations transformed through some type of mutation, can be viewed in terms of chaotic laws. If this idea appears to stretch the point too far, consider another analogue with crystalline structures. Crystals of multifarious forms, e.g., tetrahedrons, dodecahedrons, icosahedrons, and so forth, have been found to all obey certain simple laws of form and achieve their diverse forms by recombinations of only a few underlying principles

(Kauffman 5). These underlying principles that govern inorganic matter also govern organic matter. Consequently, it would seem unnatural to deny the application of chaos laws to evolutionary speciation.

Chaotic laws drive evolution and there are niches that various morphological permutations "fit" into. Consequently, there should not be gradual changes between one class and another, but one should expect to find large gaps in the fossil record. This is exactly what we find. *Archaeopteryx* is an example of the type of integration one would expect, as is the duck-billed platypus, where instead of a gradual transitional phase a large mutational jump occurs and you get a conglomeration of morphological patterns.

Fractals

We get a very interesting and revealing theory of evolution and nature if we examine the chaotic forces behind any natural forces. What we find is that chaos is really order of a very special type. For example, a

Mandelbrot set obeys an extraordinarily precise scheme leaving nothing to chance whatsoever As points flash across the computer screen, no one can guess where the next one will appear; that depends on the flip of the machine's internal coin. Yet somehow the flow of light always remains within the bounds necessary to carve a shape in phosphorous. To that extent the role of chance is an illusion (Gleick 239).

To return to our mountain example, we can think of the

boundary of phosphorous as the ridges and valleys of our mountain.

Because chaos drives evolutionary changes one should expect similar morphological patterns to appear. This is exactly what we find if we examine the bone structure of various creatures. The divergent developmental histories of wings illustrate this point exceptionally well because we know that wings have evolved independently, i.e., through different evolutionary lineages, several times. Due to the application of chaos theory and the similarities between countless reiterations of Mandelbrot sets, in evolutionary theory we might also expect to find biochemical relations with respect to all creatures to appear (roughly) similar.

The patterns in nature

On the face of it, chaos theory may seem to preclude the very possibility of life because of the inherent disorder involved in chaos and the apparent order involved with living systems. As far as biology is concerned, organic substances are very ordered and highly structured and seem to be anything but chaotic. We might even want to go so far as to say that randomness would seem to produce death for living creatures. For example, if everything were simply chaotic, how would a creature maintain a uniformity--how would its cells maintain their structure?

Actually, although the laws of chaos that govern the development of creatures are chaotic, and naturally not ordered, there is a very special organization and form to chaos. Perhaps it would be better to call it "tamed chance." The type of "chaotic order" found in living creatures is remarkable. For example,

Blood vessels, from aorta to capillaries, form another kind of continuum. They branch and divide and branch again until they become so narrow that blood cells are forced to slide through single file. The nature of their branching is fractal . . . The language of anatomy tends to obscure the unity across scales. The fractal approach, by contrast, embraces the whole structure in terms of the branching that produces it, the branching behaves consistently from large scales to small (Gleick 108-109).

Moreover, the entire evolutionary quandary begins to make sense and we can picture how DNA operates in order to internally direct an organism's development. Although DNA does contain an inordinate amount of information, it would almost be impossible for it to specify the myriads of bronchi, bronchioles, and alveoli in the human lungs (Gleick 109). What has become increasingly more probable is that DNA is not directly responsible for these numerous structures, but rather they "specify a repeating process of bifurcation and development" (Gleick 109). They provide a formula, if you will, which "guides" evolutionary development.

This is the most efficacious way to approach the problem of evolutionary development simply because one does not have to view evolution as exclusively being driven by stochastic

processes. We get a shaping mechanism, "tamed chance," that is responsible for the development of life. This takes the place of the metaphysical principles that the vitalists and organicists have been searching for. We can see that nature behaves in a very regular way and seems to have a "hard wired" code that "coordinates" genetic mutations. This indicates that evolution did not progress "by chance," in a certain manner of speaking, but rather followed a certain set of chaotic laws that seem to dictate the way organic materials will be put together, i.e., speciation have taken place due to "tamed chance."

To put it another way, chance only plays a role in the initial mutation, i.e., a mutation may be induced into the genes because of a gamma ray. Chance does not play a role in the subsequent alteration of the phenotype because of the alteration in the genotype. These morphological changes in the phenotype follow certain pathways dictated by chaotic attractors.

Further investigations into the structure of living creatures and their organs reveals an uncanny similarity in structures that perform similar functions in drastically different creatures. For example, cilia, the tiny microscopic hairs that project from the surface of cells, occur in numerous types of cells from "The respiratory epithelium in mammals to the gill surfaces in molluscs" (Denton 107). Furthermore, they can be found in nearly all

animal species as well as some protozoans and plants (Denton 107). The most revealing fact about the structure of cilia is that they are all structured the same way, almost if by design! This observation is readily explainable in terms of the laws that direct the formation of every living system.

Many scientists remain in awe over the complexity of nature. One scientist, A. Frey-Wyssling states,

One of the most fascinating discoveries of electron microscopy disclosed that all cilia, from the flagellates and ciliates to the lower plants with antherozoids and through all phyla of the animal kingdom up to the mammalian including angiosperms and ciliated epithelia are of the 9+2 stranded type . . . what we must recognize is an amazing conservatism which clings, so to speak, indefinitely to an established and approved structure (as quoted in Denton 108).

This is an example of how the simple formulae that govern all organic processes in nature and how they have coordinated various organs so efficiently.

There are numerous other examples, all Cytochrome C molecules are approximately one hundred amino acids long and have the exact same 3D conformation. Moreover, they all have an identical active site or "hydrophobic pocket specifically designed to complex tightly with the small iron-containing organic compound haem" (Denton 278). "Nature" has gone to great lengths to develop the complex organisms on this planet and the formative cause of stochastic processes advocated by neo-Darwinians does not seem to be as extensive in scope in terms of identifying the underlying processes involved.

Chaotic equilibrium, in terms of simplicity and explanatory power, may help to strengthen our theory of evolutionary development.

The most distinguishing feature of chaotic equilibrium would be the fact that chance *only* plays a role in the initial mutation that a creature undergoes. Chaotic equilibrium would have the phenotype follow a very simple formula to create myriads of phenotypes. This process would be governed by a simple formula much like a Mandelbrot set. As we shall see in chapter ten, this may ultimately help extend the explanatory power of our existing theory of evolution.

10. THE EXPLANATORY POWER OF CHAOTIC EQUILIBRIUM?

In this chapter I will continue to explore the ways in which chaos theory may hold the answers to many longstanding questions. However, the theory that I am calling chaotic equilibrium is still in the experimental phase and further research is needed before it can be fully confirmed or disconfirmed. Nevertheless, chaos theory may provide neo-Darwinism with the boost that has been needed to elevate it to the status of unquestioned laws as in physics. This is the focus of this chapter. Furthermore, if chaos theory is verified it will provide our existing theory of evolution with a much greater explanatory model that will quell many critics and answer questions that heretofore had posed problems.

A chaotic punctualist would maintain that many permutations will finally reach an equilibrium and cannot continue without certain changes. Simply put, in the case of the *Nautilus* that I mentioned earlier, the genome does not have the genetic material that will allow for the formation of a lens. A drastic *change in the constitution* of the genome is required for further permutations to take place. To return to our analogue of the mountain, the water has reached the bottom of the mountain and can go no further unless geological processes alter the topography.

Chaos theory may reveal that nature follows a certain pattern. Much like a Mandelbrot set, living creatures obey

very specific laws and operate within certain boundaries. Chaotic equilibrium has this predicative power because it parallels principles that have been discovered to be operative at every level in nature. Perhaps a more concrete analogue will make this point clearer. Just as an electron can only orbit on a finite, determined number of levels, a living organism can only mutate to a set threshold. Neo-Darwinians would argue that there are "gradations" to the levels that "electrons" can orbit. However, a chaotic punctualist would argue that morphological changes occur in jumps, hence the saltational aspect or nature of the theory. The "orbits of the electron" represent the point of equilibrium for morphological development.

According to a chaotic punctualist, the development of the eye might be explained along the following lines. Chaotic strange attractors "propel" mutations to occur in any and all possible patterns. Some morphological patterns are beneficial and convey more of a "survivability ratio." The creatures that possess these morphological characteristics are able to prosper and pass on more viable offspring. (So far, this is very much in keeping with the neo-Darwinian account.)

Ciliated *Infusoria* might now possess only a light-sensitive organ. Now the explanation of the development of the organ begins to incorporate terminology and concepts foreign to most traditional biologists. The attractors cause

a cycling within the system. What this means amounts to this: further deleterious mutations will be eliminated and the "cycling" will be centered around the "harmonious" systems of the creature. This will be represented by morphological homeostasis.

This process will be iterated once the attractor has escaped the cycling system. The exact reason why the attractors escape from their "orbit" is not exactly clear. It would appear *prima facie* that the attractor would be disrupted from its "orbit" due to environmental changes, though this is not a necessary and sufficient condition.

However, what is clear is that once the attractor "escapes" its previous system it reestablishes another homeostatic system. In other words, our ciliated *Infusoria* suddenly goes through a mutation and develops a "cup-like" cavity. Many neo-Darwinians would argue that this cup would serve a purpose and be beneficial to the organism because it would assist in directing the light-sensitive cells. However, chaotic equilibrium would not require that this mutation convey any benefits whatsoever. In fact, the mutation may be otiose, and hence irrelevant to the creature's survival. This is fine because the strange attractors are able to configure the organism's development and will eventually force any and all systems that could operate together to do so. Eventually, the most efficient creatures will prosper.

Unlike neo-Darwinism, the chaotic model would allow organs to occur simply because they are a possibility and not necessarily because they convey a survival benefit. According to the chaotic model, many mutations can be retained simply because they are not deleterious. Deleterious mutations allow the cycling iterations to continue undisturbed. When a mutation begins to convey a benefit, this can trigger the shift of a chaotic attractor.

If the harmony of the strange attractors is not disturbed, then the result is millions of years of morphological homeostasis. This is what we have found in the fossil record. In this situation, a point of equilibrium has been reached and the "attractor" makes it almost impossible for further morphological changes to take place. To put it another way, the genetic material has been "pushed" to its maximum allowable configurations. Unless we radically alter the structure of the genome further mutations will not occur. It is almost as if we have put a puzzle together and we are trying to add "new" pieces to the puzzle. The puzzle has already been completed. Unless we mix the puzzle up again or reconfigure the pieces we are unable to work with the puzzle any further. This is analogous to the genome with the entire puzzle representing the genome.

This extension of the point of equilibrium becomes obvious when we examine the work of breeders who breed for a particular trait and finally reach a threshold, or maximum

tolerance for particular changes when they attempt to "push" the genetic makeup of a creature to the limit. For example, the development of different cell types progress along very restrictive pathways (Lewin 31). Once a cell proceeds down a certain pathway it will leave behind many options. The farther down the path the cell goes the fewer options are available.

More lucid examples of what I mean by equilibrium may be helpful. The last few centuries of controlled breeding of the wolf, for example, have produced amazing results and "the wolf has given rise to hundreds of breeds of dogs, from whippets to pekinese" (Wesson 178). The limitations of animal breeding also shows some very interesting features and limitations of change--controlled breeding heightens our awareness of these limitations. It is not possible, for example, to breed a dog that can run a hundred miles an hour. It would be comparable to getting our drop of water to "jump" from one valley to an adjoining valley or, to return to the example of the electron, it is akin to trying to "excite" an electron with a photon that contains too much energy. A feat that is simply impracticable and not even a possibility.

Although many of the details of this new theory are not solidified, it does offer hope for a new theory of evolution that will provide our current theory of evolution with greater explanatory power than our existing theory of neo-Darwinism. This new theory may represent a crossroads or

turning point in the way that we conceptualize evolutionary development and even in our evolutionary paradigm.

A turning point?

Darwin's claim with respect to variations that are preserved and accumulated through natural selection was that he could see no limit to the "power, in slowly and beautifully adapting each form to the most complex relations of life" (Darwin 624). On the other hand, experience has taught us that there are limits to the changes that some creatures can go through. After all, the experience of breeders seems to illustrate that there are many obvious limitations. For example, dogs cannot be grown as large as cattle or as small as mice. Nor can they grow horns or curly tails or sprout wings.⁷ As morphologically different as various breeds of dogs may be, they do not become a new species and interbreed as far as size permits (Wesson 178). Breeders usually select for a certain trait and find that numerous other traits, some deleterious, accompany the desired trait. For example, dogs are typically bred to maximize certain behaviors, such as hunting or aggressiveness, but often suffer from, say, hip problems, when this, or a similar trait, is maximized.

Cats, another good example, appear to have much "less pliable" genetic material because "Despite 5,000 years of

domestication, they have hardly changed in morphology from the wild type, differing mostly in their coats" (Wesson 178). Again, breeders have come up against very obvious limitations. Another example would be the speed of greyhounds and horses, which has reached a plateau for the past eighty years, despite tremendous improvements in training, genetics, and veterinary care (Wesson 179).

The same genetic limitations are also applicable to plants as a visit to your local grocery store will make you fully aware. For example, it is inane to think that we can grow apples which are as large as watermelons. On the face of it, it does seem easier to genetically manipulate plants, yet the same limitations are still present. Consider the plight of American chestnut trees, for example.

American chestnut trees have not developed immunity to the imported blight that killed billions of them; scientists were unable, even with x-rays and mutagens, to evoke the needed mutation--the more surprisingly because closely related species are resistant (Wesson 179).

With regard to selective breeding for particular traits, there appears to be a period of stasis, a plateau that is reached within 30 to 50 generations in plants and animals--yet, surprisingly, there is sometimes a shift to another plateau after numerous more generations (Wesson 179). This shift from one plateau to another is comparable to an electron jumping from one level to another. However, this process cannot go on indefinitely. There are a set number of

levels that a creature can traverse.

The extensive and intensive breeding of creatures often is accompanied by extremely deleterious side effects. For example, the breeding of some dogs for a particular muzzle is many times accompanied by defective hips or weak kidneys (Wesson 179). Furthermore, even if dogs have been bred for a variety of traits once they are released into the wild they revert back to their previous stable form.

Domestic breeds, if allowed to reproduce without selection, revert in not many generations more or less to the wild type, as Darwin noted. Feral dogs lose the exquisite features of various breeds and tend to a nondescript brown or blackish medium-sized mongrel type that is about the same the world around Fanciers have bred more than a hundred varieties of goldfish, many rather grotesque, with growths around the head, bulging eyes, and the like. Placed in a pond and left to themselves, they soon revert to their ancestral shape (Wesson 179-180).

This is an example of the way that nature strives to maintain some point of equilibrium for the development of some prototypical, i.e., morphological, characteristics.

There has been a plethora of research done on the mutation of fruit flies, and yet they still remain of the genus *Drosophila*. In one experiment, they were selected

For dark or light (negative or positive phototaxis), and widely divergent strains were produced. But when the two strains were no longer subjected to selection, both reverted to type as rapidly as they had diverged under very strong selection. It would seem that without selection the attraction of the old pattern was as powerful as the intervention of the experimenter. *Drosophila* sometimes mutates to eyeless, and a homozygous eyeless strain (without recessive genes

for eyes) can be bred. But if allowed to breed freely, it will recover almost normal vision in 8 to 10 generations (Wesson 180).

Until the genetic makeup of a creature changes significantly, further evolutionary advances seem to be impossible and the morphology of the organism settles into a point of equilibrium in nature.

On the other hand, neo-Darwinians would argue that genetic drift gradually produces a build-up of genetic mutations. This would suggest that the genetic materials should be changing "all the time," for this is the definition of genetic drift. However, one would certainly think that will all of this genetic drift going on there should be some associated morphological changes. Shouldn't this be a reasonable inference? However, the examples given earlier indicate that some creatures have not changed morphologically, as far as we can tell, for millions of years. Given chaos theory, these periods of stasis are rendered more explainable because the stasis can be explained in terms of attractors which keep morphology and mutations in a period of stasis that I mentioned earlier.

Although investigations into chaos theory are still being conducted, many evolutionists have been attempting to explain speciation in terms of chaotic laws. Although this possible solution is only provisional, one must keep in mind that research is only at an incipient stage. Our current evolutionary theory may be on the threshold of a modified

theory of evolution which should be treated as an extension of neo-Darwinism in much the same way as Darwinism was extended to incorporate findings in genetics in the early 19th century.

Neo-Darwinism may be augmented with chaos or complexity theory in much the same way as Mendel's theory of transmission genetics was integrated with Darwin's theory of evolution. Chaos theory may offer some hope for evolutionary theory and may be able to quell the critics that have been haunting Darwin since he first made public his theory in 1859. If this is not the case, another theory may come along in the near future to supplement and solve the problems or gaps in the neo-Darwinian paradigm.

Perhaps in deference to the old sage resting in Westminster Abbey we should continue down the road that he began. And yet we should not let the spectacular road Darwin carved for us bind us to old ideals. We must continue to see beyond Darwin's vision. I hope that Gould would not mind my borrowing his favorite quote from *The Origin*:

There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved (Darwin 648-649).

I only hope that we can continue the brilliant legacy that Darwin began with those words.

ENDNOTES

¹As a slight aside, it may be of some interest to note that Issac Newton was not the originator of the expression "I stand on the shoulders of giants." This expression was originally used by Bernard of Chartres who said in 1100 A.D. "We, like dwarfs on the shoulders of giants, can see more and farther, not because we are keener and taller, but because of the greatness by which we are carried and exalted."

²I am indebted to William Shaw for this example.

³Another very important fact is that these experiments only confirm microevolutionary phenomena. They are not direct evidence for macroevolution, though they may often be used as direct empirical evidence.

⁴Of course, this is excluding creationistic accounts which are outside the realms of scientific inquiry, and hence, outside the scope of this paper. Although it may be premature, I will later suggest that nature may have a "programmer" qua formulae that are operative in the laws of chaos theory.

⁵However suggestions have been made that genes might be the actual units of selection, viz., selection can operate at the genotypic level. This is a suggestion made by Richard Dawkins, for example, who argues in *The Selfish Gene* that every case of natural selection should be viewed as a case of genetic selection and that considerations of parsimony or niggardliness make it reasonable that evolution is a battle among genes. Stephen Jay Gould in an essay entitled "Caring Groups and Selfish Genes" criticizes Dawkins and continues to reaffirm the position that individuals are the units of natural selection. I am mentioning these points to illustrate how controversial some of the details of evolutionary theory are.

⁶Yes, *Archaeopteryx* was an unusual creature, it had claws on its feet and feathered forelimbs, but this does not mean or suggest that the creature was an intermediary. Fully avian creatures have already been found that predate *Archaeopteryx* by millions of years. Many modern birds, for example, have claws on their forelimbs, the hoatzin in South America, the touraco in Africa, just to name a few. The well-known ostrich has three claws on its wing, but the fact that this may be "reptile-like" is never even considered. In fact, the ostrich is certainly not considered a "transitional form" in any sense of the phrase.

⁷However, I must reiterate that this is only applicable to the current limitations as expressed by the genome of particular organism. Further changes within the genome will allow for other changes to take place within the genome. However, I do not stipulate at exactly what point the genetic material will be sufficiently altered to allow for further mutations.

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