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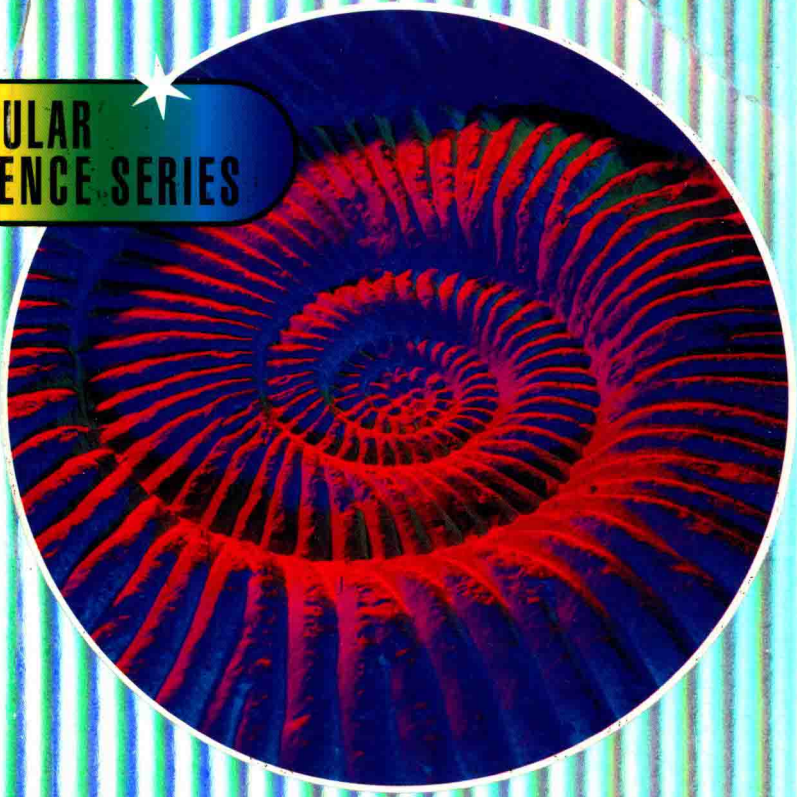

evolution

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Morton Jenkins

TEACH YOURSELF BOOKS

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INTRODUCTION

> It has sometimes been said that the success of the Origin [of Species] proved that the subject was in the air, or that men's minds were prepared for it. I do not think that this is strictly true, for I occasionally sounded out a few naturalists, and never happened to come across a single one who seemed to doubt about the permanence of species ... I tried once or twice to explain to able men what I meant by Natural Selection, but signally failed.
>
> Charles Darwin

Perhaps Charles Darwin was too modest, although cynics have been known to describe evolution as 'the incomprehensible taught by the incompetent'. The challenge is to condense four thousand million years into a book.

We are members of the most exclusive club in our solar system – the dominant species on the third planet from a fairly average star. As thinking human beings we are the only organisms on Earth that can be ashamed of the fact that we are animals. When we look at the living world we can see other forms of life, some commonplace and others so strange that we may gasp in amazement when we encounter them. Yet all the living things on Earth are results of adaptation to trials or benefits provided by selective pressures of the environment. They have obeyed the rule 'adapt or become extinct' and have survived due to the kinds of changes that are encompassed by the term evolution.

The concept of evolution is arguably one of the most important ideas in modern history, so it may seem strange that it is so little understood among what is undoubtedly one of the best educated and most intellectually sophisticated societies of all time. Why is the idea so readily accepted and routinely used by some while

being such anathema to others? Why is such a biological foundation stone the target for so many critics' sledge hammers?

There are probably two major reasons: one is based on some people's perception that it is a theory which is at odds with religious dogma; the second is an uneasiness due to a misunderstanding of its principles. For the first type of critic, matters of faith lie outside the realm of scientific investigation. Arguments aimed by either side clearly and inevitably miss their targets. However, while aiming to provide a scientifically objective and unbiased account of evolution, this book considers the idea of creationism in its own context in the first chapter.

The major aim of the book is to clear up some misunderstandings while building a foundation that will help to clarify the meaning of evolution. In the simplest terms, evolution is change through time – or, as Charles Darwin phrased it, 'descent with modification'. It is important also to keep in mind that, in this context, *individuals* do not evolve; *populations* evolve. So the book is an attempt to present a brief account of what is known or what is postulated about the origin of life and evolutionary changes.

Although Darwin's concepts regarding evolution, published in 1859 in *The Origin of Species*, were eventually accepted by most of the scientific community of his time, critical questions arose immediately. In particular, people asked, 'just how can natural selection be driven? What are the mechanisms?' The answers lay directly in the area of genetics that the first 'mathematical biologist', Gregor Mendel, was to elegantly elucidate in 1865, after twenty years of research. Just how close did Darwin come to learning about Mendel's original research? The journal in which Mendel's work was published was found in Darwin's library; however, whereas the adjacent article was heavily marked with Darwin's annotations, Mendel's paper was left in pristine condition. Apparently Darwin was not looking into anything of a mathematical nature for an explanation of mechanisms of natural selection and simply did not grasp Mendel's conclusions. Instead, with each subsequent edition of *The Origin of Species*, Darwin retreated more and more towards explanations which hinted at inheritance of acquired characteristics, the approach that so deeply flawed the theory of Darwin's predecessor, Jean Baptiste de

Lamarck. While in school, Darwin once wrote that he was 'mired firmly in the mud of mathematics' and that is where he would remain!

After the rediscovery of Mendel's principles at the very beginnings of the twentieth century, there followed an upsurge of intrigue in Mendelian genetics. People began to see that the Mendelian principles provided an explanation of the mechanism for natural selection that had eluded Darwin and other evolutionists for so long. By the 1940s, Darwin's original theory was firmly established and integrated with Mendelian genetics, forming what is now called 'neo Darwinism'. This book focuses on neo Darwinism but takes the reader through the long – and, at times, frustrating – history of its development. However, before natural selection can take place, there must be a starting point on which selective pressures can work.

About four thousand million years ago a unique phenomenon took place which changed the face of the Earth: the emergence of life. This book attempts to address questions such as what sparked off the creation of living forms and why the evolutionary process did not stop after reaching the first types best suited to the environment. Perhaps the most talked-about ideas of evolution refer to explanations of the emergence of humans and whether there will be further progression. These ideas and an explanation of how birds and mammals managed to overtake reptiles provide material for one of the chapters together with an account of the roles played by the great geological catastrophes which have influenced the history of the Earth.

1 FACT OR FICTION?

The fact of change

Imagine if our planet was visited by aliens from other galaxies. Their observations of human behaviour during the last century might read as follows:

> They kill the largest living land animal, make balls from its teeth and knock them into holes in a table with sticks. They call it snooker.
> They take the gut of small animals, stretch it on a wooden frame and knock rubber balls backwards and forwards. They call it tennis.
> They take leaves from a plant, dry them, roll them into paper, put them in their mouths and set fire to them. They call it smoking.
> Their technology is advanced enough to carry them to the moon in space ships. They call it progress.

The very complex brain of the human is capable of creating all of the above activities. However, if aliens had visited our planet several millions of years ago, they would have reported very different facts about human activity. Perhaps their report would have been something like this:

> They are covered in hair. They kill animals with sticks and eat them raw. They sometimes walk on two legs but usually crawl on all fours with their hands touching the ground.

Was this animal the same as humans of the twenty-first century? It took about six million years for this ancestor of humans to develop or change into our present-day form. This process of gradual change is called evolution and has continued to take place throughout the history of Earth. Plants and animals are continually

changing as a result of selective pressures of their environments, so that the best-adapted types survive to breed and pass on their genes. Those that fail to adapt become extinct and at best remain as fossils.

How are these changes taking place?

The history of an idea

Throughout human history new scientific ideas regularly appear. Some of these prove to be erroneous but often provide at least a framework for the development of knowledge. However, many of the embryonic ideas which have been expressed by scientists and which have progressed into basic scientific principles that we take for granted today, began with less than total peer enthusiasm. The formation of hypotheses that did not fit into current knowledge, often faced antagonism and blatant hostility. Science has not progressed smoothly up a gradient from the ancient world to the present.

Writings from the early civilizations of Babylon, Egypt and Greece show evidence that the great minds of the time debated the origins of life. Dusty parchments found in monasteries showed that the ancient scholars increasingly sought answers to thought-provoking questions in the religious authorities of the time. Some attempted to explain the nature of life in a world that was beyond the understanding of mere mortals. Consequently, science and religion soon became inextricably entangled. The age of investigation to verify predictions had not yet dawned. Statements that were not testable often became dogma and were therefore not questioned. Thus the Church became the seat of higher learning on one hand, and on the other an opponent of new ideas which went against religious doctrines.

The line between heretical thinkers and searchers of the truth was cobweb thin, as was demonstrated by the fates of several radical scholars of the sixteenth century. **Copernicus** (1473–1543) expressed his idea that the Earth was not, after all, the centre of the universe. As a consequence, he escaped the ultimate in retribution only by dying shortly after publication of his work. The evidence of **Galileo** (1564–1642) that the Earth actually orbited the Sun was

considered so outrageous by the Roman Catholic Church that he was forced to publicly deny his belief before the Inquisition in Rome. He was not officially forgiven until the 1980s!

Mysticism and magic played a big part in the minds of the world's most important decision makers well into the eighteenth century but a surge of scientific thinking had begun at the time of **Isaac Newton** (1642–1727), with the formulation of laws of motion based on the ideas of gravitation. Until the 18th century, science was largely limited to disciplines involving what we now know as mathematics, astronomy and physics: the word **biology** was yet to be invented. Indeed, the study of living things was thought to be more suitable for the minds of philosophers and religious thinkers. To probe the essence of life would elicit dreadful consequences according to theologians. Churchgoers were told that life must have a special purpose and some grand design. The human race was simply not ready to consider itself as just another physical phenomenon.

Most scientists of that era also believed that all species were created in their present form – that is, they had not changed during their time on Earth. However, more and more people were observing the variety of living things. Herbalists and 'quacks' were in abundance and needed names for their products. The rudiments of the systematic study of living things goes back to **Aristotle** (384–322 BC), who made an attempt at classifying organisms into groups, the members of which had certain features in common. Although this was a crude division largely based on superficial features, Aristotle's system was logical and had some fundamental principles which can still be used today. It was the Swedish botanist, **Carl von Linne** (1707–1778), who devised a system of classification for all known organisms, naming them in Latin. This proved to be the basis of an international method of naming every living thing. Incidentally, his love of the Latin language influenced von Linne to change his own name to **Carolus Linnaeus** in his published works. Linnaeus also envisaged species as being unchangeable and thought of them as products of the divine creation. He attempted to describe species in precise terms and in doing so became aware of the difficulties created by the fine details which distinguish closely related varieties that appear via hybridization. The seeds of thoughts which challenged the immutability of species had already

been sown and were beginning to germinate in the minds of certain revolutionaries.

Most of his contemporaries accepted Linnaeus' views but there was an exception, the Frenchman **George-Louis Leclerc de Buffon** (1707–1788), who proposed that, in addition to those animals that were the products of creation, there were types 'conceived by Nature and produced by time'. He explained that changes of this kind were the results of imperfections in the Creator's expression of the ideal. He suggested that the donkey had developed from the horse by a sort of degeneration, and likewise monkeys from men. In fact, he had dipped his toes in very cold water. The theologians of the day reminded him succinctly and crisply of the words of Genesis and so he removed his toes to a drier and more comfortable place in haste! If his ideas had come to the attention of the papacy a century earlier, it is likely that de Buffon would have been tried for heresy.

A decade later in 1763, **Erasmus Darwin** (1731–1802), the grandfather of arguably the most famous biologist of all time, added impetus to the idea that all species were not immutable. Considered to be a brilliant man, he earned a lucrative living as a physician and excelled as a naturalist and poet. It is possible that he acted as a catalyst for the future development of the revolutionary ideas of his grandson, Charles Darwin, because his financial success enabled Charles to have '... ample leisure from not having to earn [his] own bread' (F. Darwin, 1958). He recognized the importance of competition in the formation of species, the effects of the environment on changes in species, and the possibility of the inheritance of these changes. Charles Darwin was born eight years after his grandfather's death but, despite this gap, Charles lived much of his life in the intellectually broad shadow of Erasmus.

Others also began to think that species could change and that the changes could be inherited. In France, **Jean Baptiste Lamarck** (1744–1829) was a protégé of de Buffon. One of his claims to fame is the invention of the name biology but his major contribution to science was his work on evolution. He suggested that not only had one species arisen from another but that humans had arisen from another species. Again, here was a bold statement that would have been considered outrageous a few decades before. Lamarck

believed that every organism has its position on the **scale of Nature**, with humans established at the top. He also observed that the fossils found in older layers of rock did not seem to be as complex as those in more recently deposited rock. His observations led him to conclude that older species had gradually given rise to more recent ones. In his attempt to explain this process of change, Lamarck's hypothesis was flawed because he suggested that an organism could generate new structures or organs to meet its needs. He went on to state that, once formed, such structures continue to develop through use and that their development in the parents was inherited by the offspring. The classic Lamarckian example of a scientific error was his theory of how the giraffe developed its long neck. He maintained that the long neck evolved as each generation of giraffes stretched to reach the leaves at the top of trees and that this characteristic was passed on to future generations. For this he was derided by the scientific fraternity of the day – an academic élite which was already steeped in the tradition of special creation. So Lamarck's name has come to be associated with failure and discredit, but in writing off Lamarck we write off the first serious modern attempt at a unified science of biology – and, indeed, Lamarck was a biologist *par excellence*. Many of his works remain impressive over two centuries after their publication. Perhaps his greatest contribution to the history of biology was that he put evolution 'on the map' to an extent which would in due course help the general acceptance of the ideas of Charles Darwin. He died at 85, a blind pauper, and was buried in an unmarked trench, with his daughter providing the poignant epitaph 'Posterity will remember you.'

One reason that Lamarck had little influence on his contemporaries was because his views were opposed strenuously by the most powerful and influential scientific figure in France, if not in Europe, at the time – the famous **Georges Cuvier** (1769–1832). Cuvier strongly supported the doctrine of **special creation**, to which he added the theory of **catastrophism**, which held that the Earth had been the scene of a number of violent cataclysms, each of which wiped out all life, and that new life was created following each of these upheavals. Each cataclysm buried the plants and animals of the preceding era and this accounted for the fossils of many extinct species with which Cuvier was familiar.

By now, you might be curious about the obvious 'French connection' with studies into evolution in the eighteenth century. It was at that time that French science, encouraged by public interest in natural history, was enjoying a period of great vitality. The *Jardin du Roi*, established in Paris in 1640 by Louis XIII, had grown into a centre of botanical and zoological excellence of some repute. Also, as it approached revolution, France had become the European centre of philosophy, with the result that the natural world assumed an importance not conceivable in earlier times.

The intellectual climate in Britain was more conservative than in France. Atheists were viewed as evil cranks and dismissed out of hand. It was against this background of extreme potential antagonism to the idea of evolution that the scene was set for one of the most important scientific theories ever to be put forward. *The Origin of Species by Natural Selection* shook the scientific and non-scientific world to its very core. The ownership of the theory belongs to one of the most famous scientists the world has ever known – **Charles Darwin** (1809–1882).

The great British naturalist

In the 1830s few would have regarded Charles Darwin as being destined for fame. His father was a physician of some note and had thought that his son would want to pursue a similar career. He therefore arranged a medical school education for Charles when he was 16 years old. Legend has it that he fled from the operating theatre during his first experience of the horrors of nineteenth-century surgery and never returned. Charles Darwin decided that he would never become a doctor but was persuaded to study theology. He spent three years at Cambridge University with a view to becoming an Anglican clergyman. As a member of the British upper class, Darwin spent most of his time indulging in horse riding, hunting, good food, and the occasional game of blackjack rather than in his studies. He joined the many amateur naturalists of Georgian society whose wealthy backgrounds enabled them to indulge in such hobbies. He became well liked by his many friends but did not please his father with his non-studious behaviour. His father often wondered aloud about his son, whose academic

prowess had been so appallingly unremarkable that he is quoted as shouting 'You care for nothing but shooting, dogs, and rat catching, and you will be a disgrace to yourself and all your family!' What was to become of him?

It is ironic to think that but for a chance turn of fate Darwin might have become an inconspicuous pastor, tending his parish and studying botany in his spare time. The window of opportunity opened when Darwin's friend and mentor, Professor Reverend John Henslow, informed him of an offer of free passage on a survey ship, HMS *Beagle*, which was to chart foreign waters on a world-wide voyage of oceanographic discovery. In 1831, Henslow wrote to Darwin telling him that Captain Robert Fitzroy was willing 'to give up part of his own cabin to any young man who would volunteer to go with him without pay as a naturalist to the voyage of the *Beagle.*' The voyage was intended to last for five years. In some ways, the position looked unattractive – no pay and sleeping in a hammock in a crowded chartroom – but hesitation is rare in youth and Darwin was no exception. After all, he was 22 years old with the whole world in front of him – literally.

Confident, with Henslow's recommendation and his recently obtained degree in theology, Darwin eagerly applied to the equally young Captain Fitzroy for the post. Fitzroy had been placed in command of the *Beagle* in 1829 after its previous commander, Stokes, had committed suicide – a fate that destiny had in store for Fitzroy many years later. He was a strict believer in the words of the Bible and was convinced that any observations and conclusions that Darwin would make on the voyage would add to his faith in the wonders of life created by the Almighty. It is said that he almost turned down Darwin for the position because of the shape of his nose (he believed that the shape of the nose reflected the character of its bearer and that Darwin's nose was weak)!

When Darwin approached his father with the proposal, his father's reaction was, perhaps, predictable. He thought that the idea was scarcely suitable for a prospective clergyman and agreed only if Charles could find a sponsor to provide money for his keep. It so happened that one of Darwin's uncles was Josiah Wedgwood, of pottery fame and wealth, and he agreed to provide the necessary funds. Even when all the arrangements had been made and his

voyage about to begin, Darwin still showed some unease, which is clear in this letter to his sister, Susan:

> Fitzroy says the stormy sea is exaggerated: that if I do not choose to remain with them, I can at any time get home to England, and that if I like, I shall be left in some healthy, safe and nice country, that I shall always have assistance; that he has many books, all instruments, guns are at my service. There is indeed a tide in the affairs of men, and I have experienced it. Dearest Susan, Goodbye.

After being driven back twice to harbour by heavy seas, on 27 December 1831 HMS *Beagle* finally weighed anchor and set out on a journey which was to be the spark for a flame that would set the scientific world alight. The retreating shoreline of Devonport blushed as the rising sun painted it, and the 25-m, 242-tonne solid barque-rigged brig creaked its way towards South America. It was then that Darwin's worst fears materialized. The romantic morning departure changed into a nauseous routine of tough shipboard life and endless seasickness. He sometimes spent whole days below deck, but fortunately Fitzroy treated Darwin's lack of sea legs with sympathy, allowing him to share his table for meals and giving up his cabin when Darwin later became afflicted with a tropical disease.

The Enchanted Isles

When Darwin set out on the voyage of the *Beagle*, he had no disagreement with the current belief that life had originated through special creation and that species were fixed for ever more. He was conscious of the fact that many scientists believed that they should be discovering how nature worked and that they should use their observations to show the wisdom of the Creator. The physical sciences were less restricted by religious dogmas and there were hints in these disciplines to show that some scientists would later find it relatively easy to fall in line with Darwin's train of thought. Among these scientists was **Charles Lyell** (1797–1875), who developed bold ideas in his *Principles of Geology*, the first volume of which was published before the *Beagle* set sail. Darwin took it on the voyage and arranged for Volume II to be sent to him while he was away. These classic works of science greatly influenced

Darwin in his thinking. Lyell rejected the biblical view that the Earth had been created in 4004 BC, proposing that it was very much older. He suggested that the Earth's changing form was a result of slow, steady processes that took place over an exceedingly long period. Darwin realized the implications of this statement. The whole concept of time was changing. This is probably the most difficult concept of all for the human mind to comprehend. Modern methods of dating rocks can be used to tell us that the true age of the Earth is of the order of four thousand million years. But what does four thousand million years really mean? Can we imagine such a length of time?

On arrival in several South American ports or landfalls, Darwin eagerly went ashore to explore. He was fascinated by the variety of animals and plants that he observed together with rich fossil beds. Early in his explorations, he was struck by how living things could vary so much from one place to the next. For example, shells from the Atlantic coast were not like those from the Pacific shoreline. He noted that in some cases species of birds and mammals changed gradually from one place to another, one type giving way to another almost unnoticeably. In other cases, one kind of organism would suddenly disappear, another having appeared in its place.

It was his visit to the **Galapagos Islands** in 1835, however, that proved to be most important when it came to proposing his theory of natural selection. The Galapagos or 'Enchanted Isles' comprise a chain of islands, 580 miles (about 900 km) off the coast of Equador. The islands became the cradle of an idea that history would most closely associate with Darwin. Captain Fitzroy was concerned with charting the relatively unknown waters and harbours to prepare for potential trade with Britain, although very few true oceanographic observations were made from the *Beagle*. Fitzroy made extensive observations of tides in the Pacific while Darwin collected many biological samples in shallow waters and developed his ideas on the origin and development of coral reefs. On the morning of 17 September, they anchored off San Cristobal, one of the more rugged and barren islands, and soon Darwin was on his way with his collecting gear and note books. His enthusiasm continued while landing on as many of the islands as he could possibly visit.