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The Origin and Selection of Evolutionary Knowledge:

The Descent and Ascent of Ideas

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Statement on the contribution of others

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Abstract

This thesis investigated the influence exerted by dominant philosophical and scientific paradigms on the interpretation of evidence relating to theories of evolution in general and of human evolution in particular. Several theories of evolution were considered, including that jointly put forward by Charles Darwin and Alfred Russel Wallace which suggested that evolution had taken place gradually by a process of natural selection.

The methodology of Critical Discourse Analysis (CDA) was used to follow three dichotomous discourses as they either rose to dominance or were relegated to a subordinate (subversive) position over a period of 250 years. The first dichotomy was that of evolution *v.* stability of species, the dispute as to whether evolution had taken place at all. The second dichotomy, that of continuity *v.* discontinuity, concentrated on the claim that all evolution took place gradually, which was opposed by those who held that this was process was sufficient to account for micro evolution but insufficient to account for perceived instances of macro evolution. The third dichotomy was that of the religious belief that creation was purposeful and had taken place under Divine guidance, resisted by the secular belief that all creation had occurred by chance, without plan or purpose.

This thesis considered the validity of some earlier conclusions in the light of emerging scientific knowledge and questioned the degree to which science fell short of the high standards normally required in reporting its investigations by allowing the intrusion of philosophical speculation.

Relevant literature from the past 250 years was studied. The conclusions drawn from the data available to the various authors at the time of their writing were reviewed. It was found that, not only did dominant paradigms influence the interpretation of data, but that, in some instances, data were presented in a manner intended to uphold a prevailing paradigm, or to bring about a paradigm change, to support the political or philosophical preferences of the author or his colleagues.

This thesis calls for a complete re-evaluation of the evidence upon which the dominant theory of evolution has been based, concluding that its promotion and perpetuation, at least as far as human evolution is concerned, has been based more upon the requirements of the prevailing philosophical paradigm than upon scientific facts.

Contents

Illustrations

Foreword

In the past few decades, it has become common practice to employ gender neutral language in academic literature and this practice has been followed in this dissertation whenever the author's own views have been presented.

Much of the literature upon which this thesis is based was written long before gender neutral language was introduced and the generic use of male gender terminology is an intrinsic part of the history of the English language. It was felt that to change what was said to what could have been said, should have been said, or even would have been said, would be to change the essence of the discourse being analysed. For this reason, the language used by an author, be it neutral or gender biased, will be the language used when discussing that particular author's work.

The greatest obstacle to the progress of science is not ignorance; it is the illusion of knowledge.

David J. Boorstin, historian

Part I

ANTICIPATION

Before 1850
Thoughts on Evolution before Darwin

Chapter 1
The Great Debate

1.1 Introduction

While Charles Darwin (F. Darwin 1887/1969: 103) described his book, *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*, as "One long argument", others viewed the ensuing debate as "One long war" (see, for example, Brown 1999). There are two sides (at least) to every argument and two sides (at least) to every war, be it physical or verbal. Alliances may be made and remade, as ground is either gained or lost over the course of the battle.

Two battles were fought in the war over control of the theory of evolution. The first was to establish the *fact* of evolution, which battle was largely won by the end of the 19th century, mainly due to the large amount of fossil evidence rapidly accumulating (Huxley 1900). The second was to establish the *means* by which evolution may have occurred, led by Charles Darwin, who proposed that evolution had taken place by the process of natural selection. He was opposed on a variety of fronts, both religious and scientific, his opponents claiming that natural selection failed to explain evolution beyond the level of variety.

In *The Origin* Darwin famously avoided the subject of human evolution, concentrating on that of flora and fauna. However, it was the religious/philosophical implications of human evolution which engendered the greatest debate. Some held that humans were a 'special creation', made in the image of God; others not only denied that humans were 'specially' created by God, they denied anything at all had been created by God, because God did not exist. This battle is still being fought.

Rich finds of early human remains were made in Europe, and later by European researchers in both Asia and Africa. The interpretation of human fossil remains, together with that of numerous artefacts, fell within the discipline of archæology, which came increasingly to rely upon other disciplines for assistance in the evaluation of finds. Physicists provided radiometric dating, geneticists provided DNA analysis and biochemists provided analysis of bone and teeth.

Animals clearly demonstrated an intelligence not present in plants and the evolution of 'animal intelligence' fascinated Darwin. Since European religious thinking of that time held that animals did not possess souls, this 'animal intelligence' was assumed to be instinctive, ingrained as the result of constant reaction to environmental conditions. Humans also possessed instincts and it came to be debated how much human behaviour was instinctive/reactive and how much resulted from free will guided by a reasoning mind. Devoid, as America was, of any ancient human fossils, the evolution of the mind/intelligence became an area of special interest to American researchers, causing them to become leaders in the emerging science of human behaviour, psychology, (Boakes 1984) and the study of human evolution, included within the new discipline of anthropology. This is not to say that European researchers were not also interested in both animal and human intelligence/ emotions/behaviour. Freud's work, for example, was inspired by Darwin's ideas (Ritvo 1994).

The debate as to how much human behaviour was merely animal behaviour, how much was truly under the control of the individual and how much could be attributed to the effects of environment, extended into a debate on how great was the difference, *if any*, between humans and animals. This conflict of opinion lifted evolution from 'debate' to 'Great Debate' for it touched the very core of each person's personal belief system.

1.2 Aim of thesis

The aim of this thesis was to investigate the extent to which pre-conceived, subjective ideas and personal self-interest influenced the interpretation of evidence relating to evolution in general and human evolution in particular over the past two and a half centuries. This investigation followed various discourses as they rose to a position of dominance, were challenged and either resisted, or failed to resist, the assault on their position of power. It considered the validity of some earlier conclusions in the light of emerging scientific knowledge and questioned the degree to which science fell short of the high standards normally required in reporting its investigations into the evolution of the human being.

1.3 Research Methodology

This project was undertaken by qualitative research, the research methodology being selected to align with the research aim to explore the subjective construction of theories of human evolution. The paradigm from which this research was conducted was that of Critical Theory.

The Critical paradigm is informed by the ontological position that reality can be known but it is shaped by ethnic, gender, political, religious, philosophical, cultural and economic factors which have been created by humans and are not, of themselves, 'natural phenomena' (Jørgensen and Phillips 2002: 83). The epistemological position of Critical Theory is that the researcher cannot be distanced from the research being undertaken, can never be entirely impartial. The interpretation of any finding is always value laden. The methodological position of Critical Theory holds that there is a dialogue between the investigator and the subject of the investigation or inquiry. The purpose of this research was to come to a new understanding of how the different dimensions, particularly the political, religious, philosophical and cultural, have informed different beliefs, especially in relation to evolutionary theory.

Critical theory is frequently employed within the social sciences where its purpose is to bring to light ignorance and oppression, transforming them into understanding (Neuman 1994; Sarantakos 1993). This paradigm is not usually applied to the study of human evolution. It was employed in the current research in the anticipation that it would bring a new perspective to the study of an old topic (Phillips and Hardy 2002: 12).

1.4 Critical Discourse Analysis

The methodology used for this research was that of Critical Discourse Analysis (CDA). CDA is used to study the ways in which dominant paradigms (discursive texts) are born, grow, maintained and perpetuated and the means by which they are resisted by the subordinate (subversive) text (Burr 1995; Jørgensen and Phillips 2002; Phillips and Hardy 2002; Van Dijk 2003). CDA is a multi-disciplinary approach and may take as its subject books, articles, speeches, interviews, informal comments, statistics and even material objects, such as art, fashion or architecture and other artifacts.

The Critical approach focuses on the dynamics of power, knowledge and ideology, the privileging of certain discourses and the marginalizing of others (Phillips and Hardy 2002: 25, 30). CDA considers discursive practices in relation to both their construction as a representation of reality and their role in furthering the interests of particular powerful groups (Jørgensen and Phillips 2002: 63). CDA grows from the reading of the works of others (Phillips and Hardy 2002: 81). Whatever the information chosen for analysis, it must be considered in context, historically, politically, religiously and socially, since all ways of understanding are historically and culturally relative (Burr 1995; Jørgensen and Phillips 2002; Phillips and Hardy; 2002; Van Dijk 2003). According to Burr (195: 6, 160) and Van Dijk (2003: 352), while some knowledge gained within the 'hard' sciences, such as physics, chemistry and mathematics, may have been acquired by impartial investigation, the knowledge that forms the basis of the social sciences must always have been acquired by persons viewing their work from a certain perspective, since no person can step outside his or her own humanity. All knowledge has been acquired for a reason and is used to serve a purpose (Burr 1995; Jørgensen and Phillips 2002: 13). Knowledge that is excluded from texts being studied form part of the discourse (Jørgensen and Phillips 2002: 27, 56).

CDA takes a critical stance towards 'taken-for-granted' knowledge, questioning the assumption that knowledge is acquired by objective, unbiased observation (Burr 1995; Jørgensen and Phillips 2002; Phillips and Hardy, 2002; Van Dijk 2003). The nature of any association that is accepted as 'truth' and 'knowledge' is scrutinised (Phillips and Hardy 2002: 12). Ethical validation requires the questioning of underlying moral assumptions and their political implications (Cresswell 2007: 205); authenticity requires the equitable treatment of diverse voices (Cresswell 2007: 206). CDA provides a forum within which a discourse may be deconstructed to reveal internal contradictions, bringing to attention hidden or repressed meaning (Burr 1995: 165). It was this search for hidden or repressed meaning which led Foucault (1972) to title his seminal work *The Archæology of Knowledge.* That which is on the surface, in plain sight for all to see, is the dominant discourse, the generally accepted position or paradigm. The subordinate text requires finding, 'digging up', being brought to the surface, put together to form a coherent whole. "Foucauldian informed work often focuses on unmasking the privileges inherent in a particular discourse and emphasizes its constraining effects, often leading to studies of how grand or 'mega' discourses shape social reality and constrain actors" (Phillips and Hardy 2002: 21).

The purpose of CDA is not to present the hidden, subordinate (subversive), text as a new 'truth' but as a valid position worthy of consideration. The subordinate text is as much subject to personal perspective and bias as the discursive text it is challenging and must be equally open for discussion and analysis.

Power resides with the dominant text (Foucault 1972; Burr 1995; Jørgensen and Phillips 2002; Phillips and Hardy 2002; Van Dijk 2003). This power may be exercised by force of law, invoking punishment for non-compliance, through religious or political ideologies, which may also be enforced by law, through parental authority, through tacit acceptance of standards of behaviour expected within a given society, by expert (elite) opinion, such as that which dictates which art works are to be valued and which considered worthless, or through formal education which may control, not only the topic to be studied, but the text to be read or made available to the student (Van Dijk 2003: 355-356).

For Foucault, knowledge was power (Burr 1995: 70). Power is rarely absolute; rarely does it meet with no resistance (Van Dijk 2003). It may be exercised at the macro, meso or micro level by societies, organizations, groups or individuals. (Van Dijk 2003: 354). Van Dijk (2003: 358) defined 'dominance' as 'the abuse of power' since 'dominance' implies the use of force, physical or coercive, to ensure compliance. "The victims, or targets, of such power are usually the public or citizens at large, the "masses", clients, subjects, the audience, students, and other groups that are dependent upon institutional and organizational power" (Van Dijk 2003: 363). Organizations/persons controlling dominant paradigms and powerful discourses may determine access to different discourses (Jørgensen and Phillips 2002: 74), especially within the education system.

Resistance to the dominant paradigm, the role of the subordinate (subversive) text in challenging the discursive text, is not to be thought of solely in a negative way. Without resistance, no progress can be made, either forward or, indeed, in any other direction. Rather there will be an aimless wandering upon a trajectory predetermined at some time in the past. The defending of the dominant paradigm is an important component of scientific progress, as is a change of direction or the abandonment of a position previously held in favour of another when that action is deemed appropriate (Kuhn 1962/1970).

The critical analyst is required to take a position and that position is in support of the subordinate text (Burr 1995: 35; Jørgensen and Phillips 2002: 64). It is the purpose of the analysis to restore a more even balance of power between the discourses.

Foucault (1972: 35) was concerned with the identity and persistence of themes in 'sciences' open to philosophical and ethical interpretations. He took as his example the theme of evolution from Buffon to Darwin (Foucault 1972: 36):

> In the eighteenth century, the evolutionist idea is defined on the basis of a kinship of species forming a continuum laid down at the outset (interrupted only by natural catastrophes) or gradually built up by the passing of time. In the nineteenth century the evolutionist theme concerns not so much the constitution of a continuous table of species, as the description of discontinuous groups … A single theme but based on two types of discourse.

Whereas Buffon (see Chapter 2) had sought continuity through similarity within the Great Chain of Being, Darwin had sought discontinuity through differentiation between species. These two types of discourse have continued to underpin the thought of evolutionary theorists, as will be shown. Foucault (1972: 35) also drew attention to the fact that Buffon's approach was more philosophical (religious) than biological (scientific). These two differing discourses have driven much of the research and findings published in the literature on the topic of evolution.

These three dichotomies, continuous/discontinuous, religious/secular, evolution/Creationism, have each, at times, held the position of the dominant discourse and have each, at times, held that of the subversive text. CDA has been the method used to follow attempts both to legitimise and to challenge these various discourses.

1.5 Data collection and sampling

Data were collected from text via literature review. Works by prominent evolutionary theorists were studied, since it was these which set the agenda for subsequent discussion and led to the rise to a position of power of that which was to become the dominant discourse of that time. Books were preferred over papers since that form allowed authors greater freedom to explain, not only their work, but the reasons why it was undertaken. The purpose behind the undertaking of a task may be as important as the results obtained in the eventual formulation of the theory presented in the subsequent written account. Books also allow writers greater freedom to express their thoughts and opinions about the work of others. Texts were drawn from the period between the middle of the 18th century, when the possibility of evolution was first made the subject of scientific study, and the first decade of the 21st century.

Many secondary texts were also studied and included where they were seen to have made a significant contribution to the debate. Lesser known works were also studied and included where they were seen to be examples of a subordinate text attempting to challenge the power and authority of the dominant discourse but being ignored, denied or ridiculed, by the 'elite'. Instances of deliberate misrepresentation of the work of others in order to promote or secure a particular position are also reported.

The qualitative sampling method employed was that of purposive sampling which allowed specific texts to be selected pertaining to both the dominant and subordinate discourses (Creswell 2007). It is not possible to study all aspects of discourse; texts must be selected for study (Phillips and Hardy 2002: 10). Initially selected were those which were widely distributed and considered 'important' within the domain of analysis (Philips and Hardy 2002: 73), supplemented by library searches and bibliographical reference chains.

Within discourse analysis there are no formal procedures and explicit research questions are not always required (Jørgensen and Phillips 2002; Phillips and Hardy 2002). It may be beneficial not to proceed within a rigidly predetermined framework but to allow the research to unfold (Phillips and Hardy 2002). This approach, which was followed here, allows a greater possibility for uncovering 'interesting' and 'surprising' perspectives (Phillips and Hardy 2002: 60). Unexpected findings emerged during this work, for example, in respect of Lamarck (Chapter 4), Wallace (Chapter 10) and the role of chromosomes in the emergence of new species (Chapter 25).

1.6 Analysis

Analysis of the text was guided by recurring themes, such as the use of power, privilege, dominance, inequality, use of language and ridicule. The text was studied within five time periods, before, Darwin, Darwin and his contemporaries, first and second halves of the 20th century and the first decade of the 21st. The above themes were applied to the data within each section, with particular reference to the philosophical, political and cultural environment of the time.

1.7 Presentation of research

Presentation has been in a narrative style in accordance with CDA methodology.

1.8 Disadvantages of Critical Discourse Analysis

The impossibility of covering the complete discourse makes the selection of texts for study subjective. Analysis of a large number of texts, especially books, is time consuming and labour intensive. Analysis does not conform to the rigorous standards of quantitative research and the narrative style in which the analysis is presented exceeds the word-length restrictions frequently applied to the reporting of research (Phillips and Hardy 2002). All these 'disadvantages' are integral to CDA and may be seen as strengths in certain research undertakings. The method was selected here as the most appropriate methodology for the project undertaken.

1.9 Structure of thesis

This thesis is divided into five parts. Part I considers the early development of evolutionary theory before the publication of Charles Darwin's epic work, *On the Origin of Species*, (Darwin 1859/1998). Part II considers Darwin's work, and that of his contemporaries, until the close of the 19th century. Part III considers evolutionary theory during the first half of the 20th century and Part IV that during the second half. Part V, which concludes the thesis, considers evolutionary theory during the first decade of the 21st century, making occasional reference to works which appeared subsequent to this time before submission of the thesis.

Part I looks at early theories of evolution, since it is against this background that the impact of Darwin's theory of evolution by natural selection must be judged. Evolution became a popular topic of discussion in Europe following the publication in France of Buffon's works in the second half of the 18th century, and those of Lamarck, also in France, at the beginning of the 19th century. Across the Channel, the work of Hutton and Lyell in relation to geological evolution was changing people's minds about the length of time the world had been in existence. Blyth's papers on his concept of natural selection were published in the 1830s, but received little attention, although Chambers' book, *Vestiges of the Natural History of Creation*, published in 1844, caused quite a stir.

Part II of the thesis is devoted to Darwin, the publication of his major work, *On the Origin of Species* (Darwin 1859/1998), and the controversy it engendered. Particular attention is paid to Alfred Wallace and the debate which still persists in regard to his role in this matter. The work of George Romanes in furthering Darwin's theory, and of August Weismann in formulating the first germ-plasm theory of reproduction, are discussed. The section finishes with an overview of the difficulties with Darwin's theory as put forward by his contemporaries.

Part III covers the time between the rediscovery of Mendel's paper in 1900, which marked the beginning of the modern era of genetics and the BP (Before Present) era, deemed to have commenced in 1950 following the introduction of radiocarbon dating. The synthesis of

Darwinian theory with genetics, which came to be known as the *Evolutionary Synthesis*, was the major achievement of evolutionary theorists during this time. It is pointed out that attention was paid to genes and their DNA, but not to the function of chromosomes within evolution.

Part IV relates to evolutionary theory in the second half of the 20th century. Radiometric dating became established and necessitated the re-evaluation of much fossil evidence. This era saw the introduction of mtDNA analysis which was used to support the hypothesis that a speciation event had occurred in Africa some 150,000 or more years ago, to which all living humans were believed to trace their ancestry. This 'Out of Africa' (complete replacement) hypothesis became the dominant position but was opposed by the Multiregional (continuing evolution) hypothesis. The introduction of new mtDNA evidence in the 1990s indicated that the dominant position had been incorrect.

The issue of how and why changes in chromosome number occurred received surprisingly little attention in the literature on evolution. The work of Professor Michael White from Melbourne University in relation to the possible role of chromosome change in evolution is discussed.

This period saw a steady decline in the perception of the abilities and general level of evolution of the Neanderthals, who had originally been accepted as part of our human ancestry. It came to be suggested that the Neanderthals had little or no ability for speech, little or no ability to think in any substantive way and no social structure. An attempt is made to show that this negative attitude was more the result of prejudice than a true evaluation of the evidence.

Part V looks at the situation in relation to theories of evolution in the first decade of the 21st century. It considers the growing antagonism between the Creationists, whose beliefs were theistic, and the Neo-Darwinists, whose beliefs were secular. This antagonism led to several court cases in the United States, culminating in one held in Dover, Pennsylvania, in 2005. While not all evolutionary theorists held views exemplified by extreme positions, it was those who held extreme positions whose opinions were most publicised and who were called to present their case before the Court.

Recent DNA analyses of Neanderthal remains are discussed, findings indicating that the Neanderthals and modern humans are, in fact, related. Also discussed in Part V is the discovery in 2004 of the remains of a previously unknown hominid on the island of Flores which opened to question areas of human evolution which had been thought secure.

1.10 Philosophical prejudices

As this study progressed, it became increasingly clear that many of the positions taken by writers in the field of human evolution had been influenced by their philosophical beliefs. In some cases, poorly supported propositions seemed to have been adopted merely as the result of inadequate reflection. In other instances, prejudice was thinly disguised, or even openly deliberate.

This thesis questions how securely based upon scientific evidence is the claim that natural selection is the *sole* cause of evolution and calls for a re-evaluation of all the evidence.

This thesis does not dispute the *fact* of evolution, only the interpretation of the evidence.

Chapter 2

The Birth of Evolutionary Theory

2.1 Pierre Louis Moreau de Maupertuis (1698-1759)

The focus of this thesis being theories of *human* evolution, the first person whose work will be considered is Maupertuis, since Maupertuis included human subjects in the formulation of his theories. Until Glass (1955) rediscovered Maupertuis in the 1950s, his work remained virtually unknown. Even now it receives scant attention and little has been translated into English. By profession Maupertuis was a mathematician but, like many scientists and other gentlemen of his time, he was also a naturalist.

A century before Darwin, Maupertuis expressed views which in the 19th century came to be known as 'evolution' and 'survival of the fittest' and which foreshadowed Mendel's work on heredity (Maupertuis 1753/1966). In his work, *Essai de cosmologie*, published in 1750, Maupertuis said (Glass 1955: 103):

> May we not say that, in the fortuitous combination of the productions of Nature, since only those creatures *could* survive in whose organization a certain degree of adaptation was present, there is nothing extraordinary in the fact that such adaptation is actually found in all those species which now exist? *Chance*, one might say, turned out a vast number of individuals; a small proportion of these were organized in such a manner that the animals' organs could satisfy their needs. A much greater number showed neither adaptation nor order; these last have all perished … Thus the species which we see today are but a small part of all those that a *blind destiny* has produced. *(Emphasis added by Glass 1955).*

And again, a year later in *Systems of Nature*, Maupertuis wrote (Glass et al. 1959: 77):

> Could one not explain by that means [mutation] how from two individuals alone the multiplication of the most dissimilar species could have followed? They could have owed their first origination only to certain fortuitous productions, in which the elementary particles failed to retain the order they possessed in the father and mother animals; each degree of error would have produced a new species; and by reason of *repeated deviations* would have arrived at the *infinite diversity* of animals that we see today. *(Emphasis added by Glass et al. 1959).*

Maupertuis made no specific mention of the factor of time, which was to play such an important part in the development of Darwin's theory. However, he clearly suggested that

Chance, rather than Divine Will or Omniscience, was controlling Nature and all its manifestations. He also postulated the concept of common descent.

2.2 Preformation

During Maupertuis' time the commonly held view was that one parent or the other must chiefly be responsible for the continuation of form, the other parent merely providing nutritive materials which could influence the growing embryo, resulting in the offspring bearing a resemblance to the second parent. Opinion was divided as to which parent provided the form and which the nutrient or 'stimulus'. Maupertuis (1753/1966) rejected this concept on the grounds that, if nutritive material could so influence the growing embryo that it would bear a resemblance to the nutrient source, why did the human infant not resemble the fruit, vegetables and other nutritive substances eaten by the mother during her pregnancy?

In relation to eukaryotic species, the concept that semen may have a purely nutritive purpose, or may serve merely to stimulate the female 'form' into growth, was not as outlandish as it may at first appear. Modern geneticists are aware of thelytokous species of animals in which males are either totally absent or very rare and genetically non-functional. Many are simply all-female species, although whether the fact that they are not an interbreeding population precludes them from being described as a 'species' at all is a debatable point (White 1973a). The small freshwater fish, *Poecilioa formosa,* from south Texas and northern Mexico, is genetically all-female, but its eggs need to be activated by the sperm of a male from a closely related species, either *P. latpinna* or *P. shenops*, before they will begin to develop (White 1973a: 154). With the spider beetle, *Ptinus mobilis*, the situation is slightly different; development of the egg in this all-female species does not proceed beyond first metaphase until the egg is penetrated by a sperm from the related bisexual species, *P. clavipes* (White 1973a: 155). In neither case is there any genetic contribution from the male.

2.3 Animalcules

By the middle of the eighteenth century, when Maupertuis was doing his work, the microscope had revealed the presence of 'animalcules' in the male semen. Did the female 'semen' produce anything similar? Maupertuis believed that the female discharged a multitude of eggs, possibly as many as the male 'animalcules', but they were so small that they had yet to be seen, even under magnification. He suggested that these might emanate from the lining of the womb (Maupertuis 1753/1966). Maupertuis believed that these eggs and the 'animalcules' each contained particles responsible for the formation of parts of the body.

Using the principle of 'attraction' (gravitation) as propounded by Newton, Maupertuis believed that each of these particles would gravitate towards, and join with, their most closely related particle, so that all the body part particles would form a whole, which would then take on embryonic form. Once two related particles had combined, any other particle which might have been suitable for that role would have no place and would be discarded. Particles from either parent had equal chance of forming any particular part of the embryo. The child would thus resemble both parents in some degree, although the proportion of representation would vary, some children resembling one parent much more than the other. If the process worked perfectly, a 'perfect child' would result. If some particle was missing, or became damaged, a child deformed by deficiency would be born. If some particle in excess of that required somehow managed to attach itself, then extra body parts would result, even to the extent of producing conjoined twins, infants with two heads or with one head and two bodies (Maupertuis 1753/1966).

2.4 Georges-Louis Leclerc, Comte de Buffon (1707-1788)

Count Buffon was the pre-eminent naturalist of the 18th century, being Keeper of the prestigious *Jardin du Rois* in Paris. He wrote extensively, his works appearing intermittently, but regularly, as a series of more than forty 'volumes' between 1749 and 1804 (Oldroyd 1980), some of which were quite short, but together they comprised a sizeable volume of work. In 1781, Buffon's work was translated into English by William Smellie. In 1834 they appeared as a two volume work under the title *Natural History, General and Particular, including the History and Theory of the Earth, a General History of Man* (Buffon 1781/1834), published by the Chambers family.

2.5 Buffon's *Theory of the Earth*

Buffon's theory of the Earth was that it was very old, and but a small planet in an immense Universe. He believed that the Earth, and the other planets, had been formed from a portion of the Sun, which had become detached. This hot vaporous mass had gradually cooled, becoming first molten and then solid rock. The Moon, Buffon believed, had in turn been formed from a portion of the Earth, probably torn from the region of the Pacific Ocean by some unknown force, possibly that of a passing comet or other heavenly body.

Buffon was a 'Vulcanist', even though he attributed a great deal of the superficial features of the Earth to the action of water. The opposing school, the 'Neptunists', believed that the Earth had once been completely covered with water, much of which had subsequently disappeared, partly through evaporation but mostly by being engulfed in great chasms within the Earth. Buffon attributed to the cooling of the Earth some of the irregularities of its crust, although he also attributed some of these irregularities to the action of volcanoes, earthquakes and erosion by wind and weather (Buffon 1781/1834).

Buffon estimated that the solid matter of which the Earth is comprised weighed some four times that of the matter of the Sun, great changes having taken place as the Earth cooled and solidified. However, what most impressed Buffon was the formation of sedimentary rocks, which had been laid down under water over considerable periods of time, but many of which were now elevated above sea level, in some cases to a great height. He realized that the Biblical account of the deluge was totally inadequate to account for these formations and instead proposed that the account in *Genesis* referred not to 'days' of twenty-four hours duration but rather 'Days' as in 'Ages'. The Biblical deluge occurred in the last, seventh Age, after the creation of Man (Buffon 1781/1834).

Buffon claimed that the land beneath the sea was the same as the land above it – composed of mountains, hills, valleys, even 'rivers', as underwater currents flowed more rapidly in the vicinity of hills and valleys. He claimed that the same factors that operated to wear down rocks in one place and to cause sediment to accumulate in another, operated under the sea as well as on dry land. While waves were a superficial phenomenon caused by the operation of the wind, the tides were caused by the Moon, whose effects would be felt throughout the ocean, no matter its depth. Great volumes of water were constantly being dragged across the bottom of the ocean, wearing down hills and mountains, depositing sediment, etc. (Buffon 1781/1834). Buffon was aware that the climate of some parts of the world appeared to have changed. He attributed this to the movement of land across the surface of the globe. Over immense amounts of time, as rock was worn away in one place and sediment deposited in another, land masses would gradually have 'moved' into warmer or cooler climates (Buffon 1781/1834).

In brief, Buffon's theory of the history of the Earth was one of change over immense periods of time, but change always occurring in conformity with the basic principles of physics, including gravity, which was the new and dominating concept of the time.

2.6 Species

Linnaeus' scheme for the classification of all living things, published between 1735 and 1774, was to have profound consequences for European thought. It became necessary for serious naturalists to label all plants and animals, however large or small, within the Linnaean binomial system of classification. General acceptance within the community of naturalists was essential if naturalists were to understand each other's writings, yet the task of classification was fraught with difficulties and caused much controversy, none more so than which plants and animals were varieties and which were distinct species.

Initially, Buffon thought that all living things graded themselves by imperceptible changes, making classification difficult, but he changed his mind. He came to recognize species as definite entities, the ability to interbreed being the defining attribute, although he also realized that this definition could never be anything but a 'working definition' due to the difficulty in establishing the breeding potential of all creatures (Buffon 1781/1834).

2.7 Evolution

Buffon used a system of argument and counter argument, which left the reader to decide which point of view to accept and the author free from any accusation of promoting heresy. For example, Buffon suggested that the horse and the donkey might be regarded as a single family having a common origin. The same logic would suggest that humans and apes had a common origin and that all animals may have descended from a single animal, but Buffon went on to say: "But no! Certain from revelation that all animals have participated equally in the grace of direct creation" (Lovejoy 1959: 98). His first suggestion was a clear pronunciation of evolutionary theory and was the point of view taken by his younger colleague, Lamarck (see Chapter 4). However, there was one condition which Buffon considered *must* be accommodated before evolution could be accepted as a fact, that condition being the production of a new species by direct descent.

2.8 Buffon's barrier

Buffon was intrigued by mules, those produced by the mating of the horse and the ass and those of other animals, such as the dog and the wolf, the term 'mule' being applied to species crosses, whether they were fertile or not. Some animals from different species could mate and reproduce, resulting in a healthy animal that could live many years but which was not itself able to reproduce. Buffon carried out his own experiments and studied reports of cross-breedings in an attempt to ascertain whether it was possible to produce fertile offspring from different species. He had no success (Buffon 1781/1834, vol.1: 28-36).

Dogs were able to vary so much, yet still constituted one species (Buffon 1781/1834, vol.1: 357). This observation led Buffon to conclude that variation within species, no matter how great, was not sufficient for the formation of new species. Lovejoy (1959: 99) questioned why Buffon should consider the sterility of hybrids proof of separate descent and quoted Buffon's claim that it would need to be assumed that:

> … two animals, male and female, had not only so far departed from their original type as to belong no longer to the same species … that is to say, to be no longer able to reproduce by mating with those animals which they formerly resembled – but had also both diverged to exactly the same degree, and to just that degree necessary to make it possible for them to produce only by mating with one another.

Lovejoy went on to say: "The logic of this is to me, I confess, a trifle obscure; but it is evident that Buffon conceived that the evolution from a given species of a new species infertile with the first could come about only through a highly improbable conjunction of circumstances". Buffon had intuitively perceived the problem posed, for example, by differing numbers of chromosomes, which will be discussed in Chapters 18 and 24.

It was as if Buffon *wanted* to believe in evolution, but his study of hybrid animals and their sterility stopped him fitting the facts to the theory.

2.9 Reproduction

Buffon followed Maupertuis in rejecting 'preformation', believing that reproduction was the result of the coming together of particles from the male and the female. He suggested that in infancy and childhood these particles were used for nutrition and growth. When growth had been completed there were surplus particles, which could then be used for reproduction (Buffon 1781/1834, vol.1: 186):

> There exists, therefore, a living matter, universally distributed through all animal and vegetable substances, which serves alike for their nutrition, their growth and their reproduction … reproduction takes place only through the same matter's becoming superabundant in the body of the animal or plant. Each part of the body then sends off the organic molecules which it can not admit. Each of these particles is absolutely analogous to the part by which it is thrown off, since it was destined for the nourishment of that part. Then, when all the molecules sent off by all the parts of the body unite, they necessarily form a small body similar to the first, since each molecule is similar to the part from which it comes … these two seminal fluids are extracts from all parts of the body; and a mixture of them is all that is necessary for the formation of a certain number of males and females.

There is a clear similarity between Buffon's ideas and those of Darwin when the latter enunciated his theory of *Pangenesis* (see Chapter 7), although it is not suggested that Darwin was aware of this similarity of thought.

2.10 James Hutton (1726-1797)

Were it not for Charles Lyell, whose work paved the way for that of Darwin, history would not remember James Hutton, a contemporary of Buffon. Hutton was a recluse and his writings were little known outside his immediate circle. He was a member of the Royal Society of Edinburgh and it was to a fellow member of that Society, John Playfair, that Lyell owed his knowledge of Hutton's work. In 1795 Hutton published a two volume work entitled *Theory of the Earth*, a small edition of no more than 500 copies (Playfair 1802/1956: v). It made difficult reading. The book has never been reprinted and only a few of the original copies survive. Five years after Hutton's death, Playfair published an abridged version (140 pages) of Hutton's work, together with 'Explanatory Notes and Additions', which ran to 385 pages, a facsimile reproduction of which was published in 1956 (Playfair 1802/1956). The facsimile reproduction of Hutton's book also contained facsimile reproductions of three papers presented by Hutton to the Royal Society of Edinburgh in 1785, 1788 and 1794. A subsequent edition also included a facsimile presentation of the Abstract presented by Hutton to the Society in March and April 1785, summarizing his first paper and a biography of Hutton written by Playfair (Playfair 1802/1956).

2.11 Coal

Hutton was much interested in coal, and other similar natural products such as bitumen and petroleum. He maintained that all were of vegetable origin, although some of his colleagues argued that some grades of coal and oil were mineral based. It was one thing to accept that the bones and shells of sea creatures had become deposited on the sea floor, been compressed into chalk, then raised from beneath the sea to form chalk hills. It was quite another to explain how vegetable matter had become compressed beneath rock and transformed into coal or oil. Clearly the vegetable matter must have grown above ground at one time. Hutton envisaged cycles of land being raised above the surface of the sea, bearing vegetation, then becoming compressed again beneath it. At the minimum he postulated three such cycles, but believed there were probably far more. By extension, he believed that these cycles would continue into the future.

2.12 Hutton's *Theory of the Earth*

It was not only coal which took Hutton's interest. He was fascinated with the origin of veins of metals and minerals which were 'injected' into the rocks of other formations. The 'Neptunists' claimed that these veins were the result of matter which had been held in solution during the Universal Flood which had covered the Earth before any land rose above sea level. As the Earth dried out, these minerals, which had been held in solution, gradually dried out to provide the minerals and metals mined today. Hutton (1788/1970) argued that many of these substances were not water soluble. Furthermore, there was no known solvent which could carry all of the known metals and minerals. They could never have been held in solution.

Hutton was a 'Vulcanist'. He did not deny that water had played an important part in the erosion of land, but he denied that it had played any part in its formation. He argued that organic matter on the sea floor was subject to immense pressure, as also was any non-organic matter beneath the sea. This pressure would cause the temperature to be raised. While it was true that coal, heated to combustion temperature on the surface of the Earth, would burn and turn to ash, in the absence of air such combustion would not be possible. There was no way of knowing at that time exactly what would be the result of heat being applied, under pressure, to matter, but Hutton postulated that it was this which formed metals, minerals and substances such as coal and oil.

In the same way that air and water circulated under the influence of temperature differentiation, so Hutton believed did the substance of the Earth. The movement would be far slower, but it would happen. In some places the heat would cause the surface of the Earth above it to 'bulge'. In this way, great land masses would be raised above sea level (Hutton 1788/1970). This raising of great masses to the surface of the Earth would cause fractures, which would allow molten matter to run as fluids into other structures, forming the metal and mineral veins in which Hutton was so interested. This expansion and fracturing would also explain the tilting of layers of sedimentary rock, which must have been laid down horizontally. Hutton did not rely on volcanoes and earthquakes alone to account for the formation of land, although he did acknowledge that they had a role. Hutton was not prepared to speculate on time, simply stating that, in comparison with human life, it was eternal (Hutton 1788/1970).

2.13 Adiabatic expansion

Erasmus Darwin, Charles Darwin's grandfather, recorded conducting an experiment with Dr. Hutton of Edinburgh in the early 1770s (King-Hele 1963). The experiment was related to E. Darwin's theory that as air rose, it expanded because there was less pressure at a higher altitude. The same amount of heat was now distributed over a greater area, causing the air to cool, without transfer of heat to any other substance. The cooler air would be less able to retain moisture and rain would fall. Clearly, if this were the case, then gases (or any other substance) would increase in temperature when compressed, without addition of heat from any other source. Upon this latter application of the principle much of Hutton's theory depended.

2.14 Erasmus Darwin (1731-1802)

There is one more great mind, that of Erasmus Darwin, whose ideas need to be studied in this review of early evolutionary theorists of the 18th century. To King-Hele (1963, 1999) the modern reader is indebted for a fascinating look at the life and work of Dr. Erasmus Darwin, now best known for being the grandfather of Charles Darwin, but known to his contemporaries as the finest physician and most knowledgeable man in all England. It was the 'Darwin name' which drew attention to the young graduate, Charles, when a naturalist was being sought as a companion for Captain Fitzroy on the voyage of the *Beagle.* Erasmus Darwin married twice, had fourteen children, most of whom survived into adulthood, and like his grandson, Charles, stuttered, an affliction which he did not allow to act as a deterrent in his social or professional life.

Erasmus Darwin was a compulsive inventor and enjoyed the company of others of similar mind, such as Josiah Wedgwood (potter), James Keir (chemist), James Watt (scientist), Matthew Boulton (manufacturer) and William Small, Professor of Natural History from America. Meeting regularly at around the time of the full moon (which gave them light by which to drive home), they became known as the Lunar Society of Birmingham, or, more simply, the Lunatics. This small, illustrious group was later to be joined by others, such as Joseph Priestley (chemist) and Samuel Galton (manufacturer). Darwin's son, Robert, married Susannah, daughter of Josiah Wedgwood, Charles Darwin being the grandson of both Erasmus Darwin and Josiah Wedgwood.

King-Hele (1963) listed some 75 subjects in which Erasmus Darwin might justifiably be considered a pioneer, ranging from artesian wells and artificial insemination to speaking machines and submarines. Darwin assisted James Watt with his work on steam engines and proposed a steam-carriage to replace the horse-drawn variety. He was sure that Priestley's discovery of oxygen would lead to the development of vehicles able to travel underwater. He predicted the development of aeroplanes for both civil and military use. In a paper published in 1788, Darwin gave his account of his work with Hutton and Edgeworth on adiabatic expansion in the *Philosophical Transactions of the Royal Society*.

Only one picture of Erasmus Darwin seems to have survived. His podgy face stares out from the page of many a book on evolution, belying the physical and mental stature of this great man. His somewhat overweight condition may perhaps be explained by the fact that, having realized that the body and brain operate on sugars, he was a great believer in this substance. He campaigned successfully for sugar beet to be grown commercially in England.

2.15 Evolution

Erasmus Darwin's thoughts on evolution were contained in *Zoonomia* (E. Darwin 1974) under the section dealing with *Generation.* It is remarkable how closely the elder Darwin's thoughts anticipated those of his now more famous grandson.

Darwin pointed out the changes which had occurred in animals due to domestication. He made specific reference to horses, dogs, cattle, sheep, camels, rabbits, hares, pigeons and partridges and finished by referring to humans. He spoke of the mode of life of those who labour at the anvil, oar or loom, which increased their strength, as well as circus performers, who increased their agility and the shapeliness of their limbs. He referred also to the adverse effects of alcohol. All these factors he considered capable of affecting future generations, for better or worse. Darwin drew attention to the great changes which took place during the lives of some animals. A crawling caterpillar transformed into an aerial butterfly, an aqueous tadpole into an air-breathing frog. Less dramatic, but equally important, were the changes which transformed the boy into the man, the girl into the woman.

From consideration of the similarity of structure between quadrupeds, birds and amphibious animals, Erasmus Darwin concluded that "all alike have been produced from a similar living filament" (King-Hele 1963: 85).

Darwin addressed three basic 'desires': lust, hunger and security. The first was to become Charles Darwin's 'Sexual Selection', the other two were the basis of 'Natural Selection', being developed according to the species' needs as predator or prey, for defence, security or attack. He concluded:

> … would it be too bold to imagine that in the great length of time since the earth began to exist, perhaps millions of ages before the commencement of the history of mankind, would it be too bold to imagine that all warm-blooded animals have arisen from one living filament, which THE FIRST GREAT CAUSE endued with animality, with the power of acquiring new parts, attended with new propensities, directed by irritations, sensations, volitions and associations; and thus possessing the faculty of continuing to improve by its own inherent activity, and of delivering down those improvements by generation to its posterity, world without end? (King-Hele 1963: 87)

This quotation shows that Darwin's thinking was in accord with that of both Buffon and Hutton regarding the great length of time which all three assumed that the Earth had been in existence.

In the third edition of *Zoonomia*, published in 1801, Darwin outlined a theory of reproduction which was virtually identical to that of Maupertuis, although he may well not have been aware of Maupertuis' work in this area. In suggesting that small particles are produced by bodily organs which are carried by the blood to the sex organs, where particles from both parents unite to form the new offspring, Erasmus Darwin was anticipating his grandson's theory of *Pangenesis.*

2.16 *The Botanic Garden*

Erasmus Darwin's great work, *The Botanic Garden* (E. Darwin 1790), was written as 1,944 lines of rhyming couplets. Darwin pointed out that, while it may be the destiny of plants to be devoured, many lived far longer lives than many animals, during which time they were able to enjoy the benefits of the warmth of the sun, the fresh air, refreshing rain, the absorption of nutrients from the soil and, of course, reproduction. Darwin was convinced that plants experienced *joy* in living. Within this work Darwin took the opportunity to include an incredible variety of topics, from the Solar System, the outer atmosphere, 'shooting stars', lightning, rainbows, refraction, the aurora, phosphoric lights, glow-worms, volcanoes, gunpowder, cannon, steam engines, flying machines, submarines, electricity, electrically driven machines, Wedgwood pottery, coal, America, the Spanish Conquest, the French Revolution – and these are but some.

In the same way that Erasmus Darwin was concerned about the lack of a systematic theory in relation to the human body, so, too, was he concerned about the lack of a systematic theory in relation to plants, their physiology, and their maintenance in a healthy condition. Darwin felt that the dividing line which had been drawn between plants (immobile) and animals (mobile) was an artificial one. Within the animal kingdom, there was a great deal of variation with regard to mobility. Some animals were capable of moving swiftly, others were capable of almost constant movement, while others, such as barnacles, barely moved at all. Darwin observed that a 'bud' from a polyp could grow into a complete animal in the same way that might a bud from a tree or the branching cells of the coral insect.

Darwin proved that plants respire, although by means different from that of animals. He attributed to leaves the functions of both respiration and circulation. Darwin endeavoured to show that plants also had 'muscles', 'nerves' and 'brains' by pointing out that many plants open and close their petals at dawn and dusk, some also in response to changes in weather. Some animals, such as shell fish, move less in a day than many plants, supporting his arguments with special reference to orchids, *Drosera* (Sundew) and *Mimosa* (Sensitive Weed). Charles Darwin also wrote papers on movement in plants such as *Drosera* and *Mimosa*, on the fertilization of orchids by insects, and on the ability of certain insectivorous plants, such as *Drosera*, to consume insects by trapping them in their sticky digestive juices.

From his sometime colleague, James Hutton, Darwin took the knowledge that much of the surface of the Earth owed its existence to previously living matter. While Hutton viewed this fact with the cold eye of the mineralogist, Darwin saw everywhere beneath his feet the evidence of past life – the testimony of past joy. The rocks and the soil were part of the cycle of life, the cycle from soil to vegetable to animals and, of course, to humans. Darwin had a profound feeling for the joy of life, that life was Good.

2.17 Family heritage

Erasmus Darwin died seven years before Charles Darwin was born and, therefore, had no direct influence on his grandson. Charles Darwin made no mention of the work of his grandfather in the first edition of *On the Origin of Species* (1859/1998). The third edition of *The Origin* published in April, 1861, included an eight page addendum acknowledging the work of some thirty previous writers on the subject of evolution. In a footnote to his comments on Geoffroy Saint Hilaire, Darwin added:

> It is curious how largely my grandfather, Dr. Erasmus Darwin, anticipated the erroneous growth of opinion, and the views of Lamarck, in his *Zoonomia,* (I, 500-10), published in 1794 … It is a rather singular instance of the manner in which similar views arise at about the same period, that Goethe in Germany, Dr. Darwin in England, and Geoffroy Saint Hilaire … in France, came to the same conclusion on the origin of species, in the years 1794-5. (Darwin 1859/1998: 371)

While most modern historical sketches of evolutionary thought give place to both Buffon and Erasmus Darwin, in the latter case it is more E. Darwin's relationship to his grandson which is of interest, rather than his own accomplishments. Glass et al. (1959) and Bowler (1984) each devote two paragraphs to the life and work of Erasmus Darwin and in this give him a fairer and more extensive coverage than do most others. Gaylord Simpson was dismissive:

> To say that Erasmus Darwin or Buffon or Maupertuis anticipated Charles Darwin is not much truer than the absurd claim that science fiction writers invented the atomic bomb. (Simpson 1953: 21)

In Simpson's defense, it may be pointed out that he was writing before the publication of King-Hele's (1963) first biography of Erasmus Darwin, but so were Glass et al. (1959).

2.18 Early positions

More than a century before Darwin published *On the Origin of Species* in 1859, all the basic principles of heredity were the subject of scientific investigation. The use by Maupertuis of words such as: "Nature, chance, adaptation, survive, perish, blind destiny, mutation, from two individuals, multiplication, dissimilar species, fortuitous, repeated deviations, infinite diversity" clearly foreshadowed the evolutionary theory of Darwin a century later. Maupertuis' comments were contained within an essay on polydactyly, hardly a topic of consuming interest for the general population of France, and they excited little general interest. Maupertuis made no overt reference, positive or negative, to God or any Supreme Being. If he saw antagonism between his conclusions and Biblical teaching, he drew no attention to it. Maupertuis embraced evolution rather than Creationism, continuity rather than discontinuity and invoked 'chance' as the causative factor driving adaptive change. His approach was scientific, rather than religiously inspired; he embraced change rather than stability and saw change taking place gradually (continuously) over long periods of time rather than suddenly (discontinuously).

By contrast, Buffon's dominant themes were 'religious' rather than 'secular'. At times his theory was clearly antagonistic to that of the position taken by the Bible and this was a concern for him. At least overtly, Buffon took the religious rather than the secular position. Foucault (1972: 36) cited Buffon's work as an example of 'continuity', of noting pre-eminently the similarities between species within the same family and Buffon's suggestions that "all living things graded themselves by imperceptible changes" and that humans and apes may have common descent, certainly supports this view. However, Buffon was aware of the 'discontinuity' between species which prevented interbreeding and to this extent his position in this area was ambivalent. Buffon was the first person whose work suggesting that species might be subject to change aroused scientific interest and public debate. Maupertuis' suggestions were far-reaching, but they were expressed in a few short paragraphs within larger works and passed mainly unnoticed. For all practical purposes, it was Buffon who first offered the possibility of species change, rather than species stability, as a subject for debate.

Like Maupertuis, Hutton did not speculate as to First Causes, the origin of the Solar System or the formation of the Earth itself. Hutton was concerned only with tracing as accurately as possible that which had occurred since the Earth was formed by applying laws currently operative, which ever remained the same. It was through the interpretation of these laws that scientists could draw valid conclusions about the past. It was stability (of natural law) that caused change (of geological features). Hutton saw physical change as a natural process of adaptation in much the same way that Maupertuis viewed biotic change as adaptive.

Hutton had no interest in the evolution of biota. However, his work gave credence to the concept of the Earth being of great age, far greater than that indicated by the Bible, thus supporting the work of his contemporary, Buffon.

Another contemporary of both Buffon and Hutton, Erasmus Darwin, also argued that the Earth was of great age. He embraced the concepts of both 'evolution' and 'continuity'. It is of interest to note that he referred to 'The First Great Cause', rather than 'God'. He made no secret of his anti-Christian views and avoided the use of a word which carried with it connotations regarding Divine Attributes associated by Christians with the (presumed) Nature of God. However, Erasmus Darwin was a God-fearing man and his view of evolution was clearly religious.

As the result of the wide interest in the works of Maupertuis, Buffon and Erasmus Darwin, by the time the 19th century dawned there was already an interest in the concept of living forms becoming changed over time. This concept was replacing that of the sudden appearance and subsequent stability of created forms as portrayed in the Biblical account of Creation given in *Genesis.* As will be seen in the next chapter, Lamarck was already giving public lectures embracing the theory of evolution. Evolutionary theory had started its journey towards becoming the established (dominant) paradigm.

Continuity remained dominant over discontinuity but the dominance of established religion over a more deistic, or even secular, position was beginning to be undermined.

Chapter 3

What Lamarck really said

3.1 Jean-Baptiste-Pierre-Antoine de Lamarck (1744-1829)

A Frenchman, Jean-Baptise de Lamarck, wrote the first book on evolutionary theory. Lamarck's work provides a link between the 18th and 19th century evolutionary theorists in more ways than one. His major work on this subject, *Philosophie zoologique*, was published in 1809 (Lamarck 1809/1963), bringing it into consideration along with that of other 19th century authors, but the work which led to its publication was carried out principally during the 1790s, placing it with 18th century thought.

No image is more firmly attached to the name of Jean-Baptiste de Lamarck than that of the giraffe, its long neck stretched upward to reach the leaves of branches too high to be accessed by other, more lowly, animals. This constant upward reaching is supposed to have allowed the giraffe to grow its neck longer by an infinitesimal amount during its lifetime, passing this acquired characteristic on to its offspring. The giraffe was supposed to illustrate the principle of the inheritance of characteristics, or changes, acquired during the lifetime of one individual being passed on by inheritance to the next generation. However Lamarck, far from believing in the inheritance of acquired characteristics, spoke out against this doctrine (Lamarck 1809/1963).

Lamarck was a botanist of considerable standing, originally employed at the prestigious *Jardin du Roi*, under the directorship of Buffon. The reorganization which took place after the French Revolution saw the *Jardin du Roi* reconstituted as the *Jardin* and *Muséum Nationale d'Histoire Naturelle*. Lamarck was appointed the zoologist responsible for 'inferior' animals – the insects and worms of Linnæus. Lamarck embraced the challenge of his new position, which included the presentation of courses of lectures, which he delivered between 1794 and 1820. These lectures formed the foundation for Lamarck's great masterpiece, *Philosophie zoologique* (Lamarck 1809/1963).

3.2 Basic principles

Although the topic of evolution had been broached by both Maupertuis and Buffon, Lamarck's *Philosophie zoologique*, was the first complete book to be written on the subject

(Mayr 1976: 227). Used as we have become to the concept of evolution as proposed by Darwin, it is perhaps difficult to recognize quite how ground-breaking was the work of Lamarck.

There were many points of similarity, as well as difference, between the theories of Lamarck and the later works of Charles Darwin. Both saw evolution happening over immense periods of time, by imperceptible steps. Both saw the environment in which all animals lived as being subject to slow, but constant, change. Following Buffon, and anticipating Lyell, Lamarck (1809/1963: 45) stated that:

> … nothing on the surface of the earth remains permanently in the same state … elevated ground is constantly denuded by the combined action of the sun, rain-waters and yet other causes; everything detached from it is carried to lower ground; the beds of streams, of rivers, even of seas, change in shape and depth, and shift imperceptibly; in short, everything on the surface of the earth changes its situation, shape, nature and appearance, and even climates are not more stable.

Over his lifetime, Lamarck abandoned Christianity, being a staunch supporter of Napoleon to whom Christianity was anathema, but he retained a belief in a Supreme Creator. He saw this Being as having little direct influence on the development of life, other than having established matter and the laws by which it acted and interacted. As a scientist, Lamarck (1809/1963: 7) was aware of the difference between observation and inference, saying:

> There are then few positive truths on which mankind can firmly rely. They include the facts which he can observe, and not the inferences that he draws from them; they include the existence of nature ... also the laws which regulate the movements and changes of its parts. Beyond that all is uncertain.

Throughout his book he endeavoured only to follow the former and to eschew the latter. Lamarck declined to speculate on anything not certain, such as how change originated, how it became established and how it was passed on to subsequent generations. However, he realised that in order to understand in the most basic way what constituted life, how life itself had originated, how living matter differed from inert, inorganic matter, it was necessary to study the most basic form of life, the cell (Lamarck 1809/1963: 191-192). Lamarck was one of the first scientists to state that cells were the fundamental structure of all living things (Lamarck 1809/1963: lxxiii). He (Lamarck 1809/1963: 230) wrote that:

> It was no new discovery that all organs of animals are invested by cellular tissue, even down to their smallest parts … Yet … nothing more seems to have been said than the mere facts themselves; no one that I know of has yet perceived that cellular tissue is the universal matrix of all organisations, and that without this tissue no living body could continue to exist.

All cells were constituted of two parts: one solid (the cell membrane), the other fluid, contained within the membrane. Plant cells were comprised of mucilaginous matter, that of animals, gelatinous matter (Lamarck 1809/1963: 230).

Lamarck held that both warmth and water were necessary for life. Ancient philosophers had noted that life was more abundant in tropical areas where there was greater warmth. However, in desert areas, there was much warmth, but little or no water and little or no life. At the poles, there was plenty of water, but not much warmth and not much life. Lamarck (1809/1963) acknowledged that some degree of heat was available for potential life even there. However, warmth, water and mucilaginous/gelatinous matter alone were not enough. For a cell to be living, there had to be movement, which Lamarck believed was supplied by a vital energy *(aura vitalis)*, somewhat analogous to electricity, which would permeate mucilaginous or gelatinous matter, if conditions were right. From his microscopic studies, Lamarck concluded that over time, as cells increased in size and complexity and experienced the need to increase their ability to absorb nutrients, they tended to make pathways which (a good deal) later developed into the organs of digestion, respiration, circulation, etc. For Lamarck, the life force was an active presence which helped to mould its surrounding cells according to its needs.

No body that was perfectly dry could be alive. If all moisture were withdrawn from a cell (i.e. if it were desiccated), the potential for life could still be retained and revived when the cell once again received water (Lamarck 1809/1963: 205). In some cases, this could occur after considerable lapses of time, even months. From facts such as these Lamarck drew his conclusion that the *aura vitalis* was present everywhere in nature and could invade/invest simple matter at any time, if conditions were right. Lamarck made clear that his work had been written with the intention of disproving the account of Creation given in *Genesis* (Lamarck 1809/1963: 129). He argued in favour of spontaneous generation on the grounds that there could only be two methods by which life had come into being: by Special Creation or by Natural Law. He rejected Special Creation.

Having adopted Natural Law as his guide, Lamarck reasoned that if life had become established in mucilaginous/gelatinous matter at one point in time, then it must be able become established at another, since the same laws would always be in operation. Lamarck did not appreciate that the atmosphere of the Earth at the time living matter first appeared was so different from that of today, making exact replication of former conditions impossible, except perhaps in a laboratory. He did not advocate spontaneous generation in a sterile environment any more than he supported the spontaneous generation of 'imperfect' animals. Lamarck (1809/1963: 114) recognised that Nature had virtually unlimited time in which to change and adapt: "for her [Nature] time has no limits".

3.3 Recycling and rotating

Lamarck introduced the terms 'vertebrate' and 'invertebrate', and initiated the use of the two divisions, organic and inorganic, to replace the three divisions of animal, vegetable and mineral which had previously been used. If inorganic matter could be incorporated into the organic sphere by ongoing spontaneous generation, why had not all matter become organic over the millions of years of Earth's history? Lamarck (1809/1963: 239) believed that on death all organic matter returned to an inorganic form: "… from the remains left by each of these bodies after death, have sprung the various minerals known to us". The degree to which earth, soil and rock were composed of matter which had previously been organic (living) was being increasingly recognised by writers such as Buffon (1781/1834), Erasmus Darwin (Darwin 1791; 1794) and Hutton (1788/1970). Earth (rock) was part of the cycle of life and death.

3.4 Common descent

Lamarck (1809/1963) held that there had to be a link between all plants, evolved from mucilaginous matter, and all animals, evolved from gelatinous matter. No form could have come into existence in isolation. However, Lamarck did not hold that the beginning of the animal and vegetable kingdoms had occurred only once, as Darwin was later to claim (Darwin 1859/1998: 364). Lamarck was reluctant to accept that any species might have become extinct, other than recently by the 'hand of man', believing rather that fossil creatures no longer existing had evolved into other forms. He believed that links must still exist somewhere on the face of the Earth.

Lamarck (1809/1963: 238-239) established the single-celled infusoria as the most basic of all living forms and claimed that "these extremely small and transparent animals and plants, of gelatinous and mucilaginous substance" had changed over long periods of time so as to increase their complexity, giving rise to all later plants and animals. He did not speculate how or when these changes in complexity had taken place, only stating that they were the result of a combination of life's inner urge to grow and the changing external environment in which the living form, simple or complex, found itself.

3.5 Reproduction

Lamarck's views on the process of reproduction followed those of Maupertuis and Buffon, but they were infused with his own evolutionary thinking. He (1809/1963: 239) accepted excess of nutrition after growth had been completed as being the means by which material for a new being with a similar organisation was engendered. However, if evolution were to be a reality, then it must be possible for improvements to be passed on (Lamarck 1809/1963: 239). This was quite within the scope of the particulate theory of reproduction and inheritance outlined by Maupertuis and accepted by Buffon and, at first sight, appears similar to Darwin's theory of *Pangenesis* (see Chapter 6). However, Lamarck made it clear that he was referring to modifications and developments acquired and attained by *populations*, not by individuals.

3.6 Acquired characteristics

Speaking of adaptations which seemed to him to have come about due to use/disuse of particular body parts (such as poor vision in moles which lived underground), Lamarck (1809/1963: 104) remarked:

> I can, in short, cite a multitude of instances … which bear witness to the differences that accrue … from the use or disuse of any … organs, although *these differences are not preserved in the new individuals which arise by reproduction*: for if they were their effects would be far greater. (Italics added)

Later on the same page, he re-iterated his understanding that change was only passed on according to the laws of inheritance *after* it had become common to the species (Lamarck 1809/1963: 124):

> Now every change that is wrought in an organ through habit or frequently using it, is subsequently preserved by reproduction, if it is common to the individuals who unite together in fertilization for the propagation of their species … In reproductive unions, the crossing of individuals who have different qualities or structures is necessarily opposed to the permanent propagation of these qualities and structures.

At the time that Lamarck was writing, the process of inheritance was not understood. Lamarck did not believe that any change which happened in the individual would be passed on by inheritance to the next generation. It seemed evident to him that were that to be the case, there would be such continual change that there would be no stability and the clearly defined species which were everywhere evident simply would not exist. Lamarck believed that whole populations, being subjected to the same changes in environmental conditions, would adapt in the same way. At some point in time, by some means which Lamarck did not understand, these changes would become so entrenched in the population that they would become subject to the laws of inheritance. Such changes took place over an extended period of time, which could be hundreds or thousands of years.

The belief that nature had endowed her creations with the ability, not only to reproduce other individuals similar to those of the parents, but also to preserve progress towards more complex entities, formed the basis of the doctrine of the inheritance of acquired characteristics, so associated with Lamarck's name. Nevertheless, these two passages show quite clearly that Lamarck did not hold that changes or developments occurring during the life of an individual were passed on to the next generation. The often repeated references to the 'Lamarckian principle of the Inheritance of Acquired Characteristics' is a misrepresentation of the truth. Some authors, such as de Beer (1963/1976: 7), Dawkins (1986: 287-289) and Gould (2002: 170-197) acknowledged that Lamarck has been treated unfairly, but little, if any, acknowledgement is given to the fact that Lamarck did not believe in the inheritance of characteristics acquired by the *individual*, but Darwin did.

3.7 Adaptations

Lamarck recognized that animals belong in an environment adapted to that environment. He cited many pages of examples, including those of domesticated animals, such as ducks and geese that had become too heavy to fly long distances. Towards the end of his examples, he cited that of the giraffe (Lamarck 1809/1963: 122):

> … the giraffe … is obliged to browse on the leaves of trees and to make constant efforts to reach them. From this habit long maintained in all its race, it has resulted that the animals fore-legs have become longer than its hind legs, and that its neck is lengthened to such a degree that the giraffe, without standing up on its hind legs, attains a height of six metres.

In this quotation Lamarck referred to the habit as having been "long maintained *in all its race*" and he referred to "effort and a habit long maintained" but not to "longing" or "willing". If there was any 'volition' involved, it was on the part of the *aura vitalis* of the species, not the individual animal. Lamarck explained (Lamarck 1809/1963: 107):

> *The environment affects the shape and organization of animals*, that is to say that when the environment becomes very different, it produces in course of time corresponding modifications in the shape and organization of animals … whatever the environment may do, it does not work any direct modification whatever in the shape and organization of animals. But great alterations in the environment of animals lead to great alterations in their needs and these alterations in their needs necessarily lead to others in their activities. Now if the new needs become permanent, the animals then adopt new habits which last as long as the needs that evoked them. [Italics in original]

3.8 Spontaneous generation

Lamarck expressed the view that only the simplest of organisms could be utilised by nature in giving rise to life. He was aware that his opinions were opposed by others, who held that life could be generated in many basic worms, fungi, moulds, etc. 'Worm' was a general term applied to grubs and insects which the ancients thought were generated spontaneously through the action of heat, fermentation and decomposition of organic matter. Lamarck (1809/1963: 236-238) rejected this view, arguing that all insects were either oviparous or viviparous and that 'worms' only appear on putrid meat after flies have laid eggs there: "… all animals, however imperfect they may be, themselves have the power of reproducing and multiplying the individuals of their species".

Lamarck (1809/1963: 239) held that "Nature only establishes life in bodies that are at the time in a gelatinous or mucilaginous state". Lamarck stated that an error had been committed when rejection of the idea of the spontaneous generation of "imperfect animals" had led to rejection of the concept of spontaneous generation at all. Lamarck took the view that Nature could only generate life in the simplest of cells and this compelled him to embrace the concept of evolution.

3.9 Physical evolution

Lamarck traced physical evolution backwards from the most complex creatures to the most simple. Mammals had the most complex organization. Besides internal organs such as kidneys, liver and spleen not found in many lower orders, they had a complete diaphragm, a heart with four chambers and they suckled their young. Birds and monotremes were the only other animals which had hearts with four chambers, they cared for their young but not by suckling, and their diaphragm did not completely separate the chest cavity and abdominal areas. Reptiles had only three chambers to their heart, fish had gills instead of lungs, and so on.

Worms were the lowest creatures in this line of evolution. Radiarians had taken a completely separate line of evolution, radiating outwards from a centre or axis. Polyps were another evolutionary line, being gemmiparous, with homogenous bodies, no nervous system and a single opening which served both to ingest food and expel waste. The final category was the infusoria, which fed by absorption, and reproduced by simple cell division. It was this group, and this group only, which Lamarck believed able to be reproduced by direct spontaneous generation.

Lamarck also noted the appearance of organs of special sense. For example, all creatures that had ears also had eyes, but many that had eyes did not have ears, showing that eyes had evolved first. The sense of touch was the most primitive sensory perception, Lamarck believed, and digestion the most primitive system, preceding circulation, respiration and so on.

3.10 Mental faculties

Lamarck mapped the path of evolution of physical forms in reverse, from that of the most complex to the least, noting the disappearance of first one, then another, of their systems of organization. He then, in the third part of his book, turned his attention to the 'mental', or as he called them the 'moral', characteristics of living beings. Here Lamarck worked forward in time, following the progression of forms of animal life from the 'least' perfect to the 'most'.

Lamarck conceded that even the most inferior forms of animal life may, and in many cases did, possess some sort of 'inner feeling', a sensation, an awareness of being alive, perhaps that which we would today call 'consciousness'. However, Lamarck believed logic demanded that we accept the fact that inferior forms which do not possess a nervous system could not experience feelings or pain in any way analogous to that experienced by higher forms. The more complex the nervous system, the more feelings, physical, emotional and intellectual, were experienced.

No muscular movement would be possible without the involvement of a system of nerves. Simple radiarians were developing nerve/muscle fibres and some, such as the starfish, were also developing nerve ganglia allowing for independent movement. As they had as yet no centre of control (brain), they reacted to their environment, rather than made 'conscious' decisions. Insects, however, were capable of complicated muscular movement, of their legs, wings and so forth, and must, therefore, possess a nervous system. Furthermore, they possessed one of the organs of special sense, sight, which meant that they must have the beginnings of an area of central control (brain) and, in fact, a very small 'bulb' was present at the anterior end of the nervous system. Lamarck considered the development of the nervous system in this class of animal to be too simple to permit the production of 'ideas'.

Lamarck recognized that the nervous system throughout the body consisted of two distinct parts, connected by a central area of control, the brain. The first division activated the movement of muscle tissue, the second the sensory system, responsible for the perception of feeling or pain. Lamarck knew that it was possible to have movement without feeling and feeling without movement, so he realised that these two activities of the nervous system must be separate from one another, although connected through the brain. Therefore, he believed that animals with an imperfectly evolved nervous system could be capable of movement without necessarily being capable of feeling pain, although they might be aware of touch.

Despite the presence of a rudimentary brain, Lamarck did not believe that any invertebrate animal had the power of independent thought or action. The lives of all invertebrate creatures were controlled solely by instinct, which he believed to have come about over immense periods of time, during which pathways had been forced by the nervous system throughout the body and brain, directing movement of the nervous fluid into pre-determined avenues.

The evolution of vertebrate animals was accompanied by the appearance of a new organ, which was present in no invertebrate creature: the hypocephalon. This was the name given by Lamarck (1809/1963: 320) to the two soft, wrinkled hemispheres, adjacent to (superimposed upon) but separate from the true brain. Because these two wrinkled hemispheres were soft, he believed them to be inactive, capable merely of receiving impressions. The hypocephalon was therefore capable of receiving impressions, which were stored in minute chambers, impossible to see, but which he deduced to be present at the termination of each tiny canal present in the soft tissue. Over and through these flowed the nervous fluid, which he believed to be a form of electrical impulse.

Even fish, Lamarck believed, had the power of some independent thought. He made this claim because in fish there first appeared the rudiment of the hypocephalon. It was very small and the cranium itself was not completely filled, so the amount of 'thought' or 'learning' possible to a fish must be very limited. The situation was similar with reptiles. They, too, had a small hypocephalon and an incompletely filled cranium. It was in the birds that Lamarck saw the first real progress in intellectual activity, i.e. the ability to choose to vary their actions.

The body was constantly being exposed to many stimuli, sights and sounds, to which no attention was paid. These made no impression on the hypocephalon. Only when attention was being paid was an impression made. These impressions could later be reactivated by the nervous fluid being redirected to them, either deliberately or randomly. Deliberate recall was the basis of memory. Simple 'ideas', according to Lamarck were merely impressions consciously received. When these were recalled and compared one with another, they gave rise to complex ideas, which were the basis of both reason and judgment, contributing to what we know as intellect.

Lamarck maintained that 'moral' (mental) characteristics were subject to the same laws of use and disuse as physical characteristics. Therefore it followed that the more the 'moral' faculties were used, the greater they would become. He stressed the importance of early education, since early impressions were those which carved out the first neural pathways. He deplored those parents or caregivers who were too lenient with young children, forgiving poor behaviour in the fond hope that it would improve as they became older. Making new pathways in older brain tissue was difficult (Lamarck 1809/1963: 370). The more people were educated to pay attention to many impressions and ideas, to recall these impressions and ideas, to compare them, to bring reason to bear and to form sound judgments, the more would the intellect of the human race be elevated (Lamarck 1809/1963: 383-384).

Lamarck deduced that the bigger the hypocephalon, the greater would be the animal's ability to receive impressions, to think, reason and, to some extent, form judgments. He saw dreaming in animals, such as cats and dogs, as evidence for imagination, which resulted from the coming together of previously impressed ideas. However, animals lacked the ability that humans had of directing their attention for a sustained period and were, therefore, limited in their ability to formulate 'new' ideas, which were really new formulations of old impressions.

3.11 Human evolution

Lamarck claimed that a separate family for humans *(Bimanus)* was justified on the grounds that only humans had opposable thumbs on their hands, but not on their feet. Apes with the latter physiology had been named *Quadrumana* (Lamarck 1809/1963: 169). Lamarck (1809/1963: 170-171) believed that if some race of quadramanus were to abandon tree-dwelling for ground dwelling, needed to stand upright for the purpose of seeing long distances, gave up using its jaws for cutting, tearing, grasping, etc., then this race would evolve in a way strikingly different from its fellow apes.

Lamarck further pointed out that apes were quite capable of assuming an upright position for short periods of time, as were humans. Humans alone, of all creatures, were unable to maintain their position of locomotion for extended periods of time while stationary. After a surprisingly short time, humans must either walk, sit or lean for support in order to remain upright. This showed Lamarck (1809/1963: 172-173) that the upright position was not the original position of humans, but that it had been developed as a result of evolution. Lamarck held back from making a definitive statement that humans were evolved from the same stock as apes, but he left his reader in no doubt as to his opinion. Lamarck made it clear that he considered humans part of the animal kingdom, both physically and mentally.

3.12 Different understandings

In his lifetime, Lamarck's ideas were rejected by his peers, largely due to the opposition of his colleague, Baron Cuvier. The rejection of Lamarck's views on evolution by so many later writers is hard to understand since Lamarck's views accorded with the materialistic thinking which became increasingly popular during the 19^{th} century. His belief that thought, even reasoned thought, was but a chance operation of the brain, not the product of a reasoning mind under the influence of an immortal soul, was definitely materialistic.

Recent interpretations of Lamarck's theory have differed greatly. In his *Introduction* to his translation of Lamarck's work, Elliott (1963: xxiv) stated that Lamarck believed:

> All existing animals are on the road of development from Monas to man, and man's ancestors include every existing species of animal. Not only had he bird, reptile and fish ancestors, but also arachnid, insect, worm, starfish, etc. He passed through the stage of being a scorpion and a spider. He traversed in turn every species of insect. He was a tapeworm, a sea-anemone, a polyp and an amœba.

Bowler (1984: 80-81) had an opposing interpretation. He believed Lamarck's teaching to be that each line came into existence as the result of a separate act of spontaneous generation, that the most simple forms of life existing today were the most recently generated, more advanced forms, such as human, having evolved over great expanses of time from the earliest spontaneously generated forms.

Lamarck's old age was one of poverty, exacerbated by blindness. Lamarck died alone and received a pauper's burial – a far cry from the honour accorded to Darwin half a century later, namely burial in Westminster Abbey.

3.13 Lamarck's position

Lamarck published his ideas half a century before Darwin. Unlike Buffon and Erasmus Darwin, his work considered solely the subject of the evolution of biota. It was not concerned with the history of the Earth, or geology as it is now known, apart from noting the cycle of life and death which saw once living things become part of the inanimate rocks and the rocks, via the plants, become part of living things. If anyone should be acknowledged as the 'father of evolutionary theory', it is Lamarck. Those interested in maintaining Darwin's fame and status determined not to allow Lamarck to receive credit for 'the theory of evolution' which came to be associated with Darwin's name. The political turbulence which rocked France at the time of the French Revolution and following that during the time of the Napoleonic Wars, reduced France's influence. England, on the other hand, rose to a position of world dominance and, by the time Darwin's work was published, was enjoying unprecedented peace and prosperity. These factors contributed to the establishment and acceptance of Darwin's work and, once his name had become associated with 'the theory of evolution', a concerted effort was made within English speaking countries to ensure that Darwin's name and work held the dominant position and that that of the Frenchman was ridiculed and silenced (see Part II).

Lamarck, like Buffon, saw continuity and evolution, not Creationism. Like Erasmus Darwin he saw the working of Nature under the influence of a Supreme Being. The distancing of the theory of evolution from the practice of Christianity was taking place on both sides of the English Channel, although evolution was not yet seen solely from a scientific/secular perspective.

Chapter 4

Philosophy and Politics

4.1 William Paley (1743-1805)

Another person whose work spanned the turn of the century was the Rev. William Paley. His last work, *Natural Theology*, published in 1802, was the most influential. It became a compulsory text at Cambridge University for anyone studying there with the intention of entering the Church of England, which was Charles Darwin's anticipated career path while he was studying at Cambridge. Darwin studied, and accepted, Paley's writings.

Paley was born in Peterborough, where his father held a minor position in the Church, later moving to the North Riding of Yorkshire when his father took the position of headmaster at the local Grammar School. Paley performed well academically, graduating from Cambridge University and later returning there, lecturing in metaphysics, morals and the Greek Testament. In 1782, Paley was appointed Archdeacon of Carlisle, a position he held until his death. In 1785, Paley published the first of his major works, *Principles of Moral and Political Philosophy* (Paley 1833). A few years later, in 1799, he published a smaller work, *Reasons for Contentment* (Paley 1833) and then, in 1794, *View of the Evidence of Christianity* (Paley 1833), a book directed against the growing tendency towards theism, evinced his contemporaries such as Erasmus Darwin. It was not until after the publication of *Evidence* that Paley took his degree of Doctor of Divinity at Cambridge.

At the time (1802) that Paley wrote *Natural Theology* (Paley 1833) he was suffering ill health. Unable to perform his preaching duties, he committed his thoughts to paper in a major work, the first part of which is still frequently cited today.

4.2 *Natural Theology*

Paley's *Evidence of Christianity* had been directed against theism. *Natural Theology* was directed against atheism. That he felt such a book to be necessary bespeaks the growing influence of atheism towards the close of the 18th century.

Paley asked his reader to imagine that while out for a walk he knocked his foot against a stone. If asked from where the stone had come, the reader would be entitled to respond that for all he knew the stone had been there forever. Such a response would not be acceptable if the object which had been struck had been not a stone, but a watch. A watch is an organised object, in a way that a stone is not. If there was a watch, argued Paley, there must have been a watch-maker. Where there is design, there is a designer. Suppose the watch was somehow able to reproduce itself, the watch the reader had kicked might not be the original one, but one which had resulted from generations of reproduction. That would not eliminate the watch maker. Paley argued that no one would suppose that the watch was the result of 'the law of metallic nature', so why should anyone suppose that animals were the result of 'the law of animal nature' (Paley 1833: 436)?

Paley then compared another 'man-made' object, the telescope, with a natural object, an eye. After discussing many types of eyes, mammal, bird, fish, etc., Paley moved on to the other senses and from there to other systems of the body. Paley (1833: 448) wrote that he desired "no greater certainty in reasoning than that by which chance is excluded from the present disposition of the natural world", being clearly aware of the growing association, in France if not in England, between a theory of evolutionary change and a position of atheism or agnosticism, as it later became known.

Paley addressed the issue of teleology (planning or forethought) in nature, considering "*preparation*, i.e. the providing of things beforehand, which were not to be used until a considerable time afterwards as the most certain proof of design" (Paley 1834: 490). He cited the fact that milk was the only excretion of the body which was nutritious: "neither cookery nor chemistry have been able to make milk out of grass" (Paley 1833: 491). Milk was produced in anticipation of the needs of the offspring at a time (end of pregnancy) when it might be thought that the female body would have no nourishment to spare. Also the eye was formed in the womb at a time when it had no function to perform: "an optical instrument made in a dungeon" (Paley 1833: 491).

Paley covered the anatomy and physiology of the human body with a degree of knowledge that might be expected of a physician, not a priest. He stressed the perfect adaptation and correlation of all body parts, and extended this adaptation and correlation to all other living things.

4.3 Robert Malthus (1766-1834)

Robert Malthus was yet another graduate of Cambridge University whose influence is evident in the unfolding saga of human history. Although ordained as a minister, he never took up a 'living', instead spending his life lecturing on political economy, principally at Haylesbury College.

In 1820, Malthus published a two-volume work, *Principles of Political Economy*, based upon these lectures, a second edition of which was published posthumously in 1836 (Malthus 1820/1989). It is for his first work, *An Essay on the Principles of Population: A View of Its*

Past and Present Effects on Human Happiness, published in 1798, that Malthus is most remembered today (Malthus 1798/1816/1890). This work went through six editions during Malthus' lifetime and is the only work which Darwin claimed to have influenced him in the development of his theory of evolution by natural selection.

Although a Minister of the Church, Malthus wrote in direct opposition to the teaching of Christ as given in *The Sermon on the Mount*, that humans should take no thought for the morrow, that God, who took care of the lilies of the field and the birds of the air, would also take care of them (Matthew 6: 25-34). Malthus travelled widely in Europe and Asia and took particular notice of the state of the poor, not only across Europe, including Russia, but in India and China as well. In his opinion the European country in which the poor lived in the most destitute conditions was England, despite the fact that England had the most generous Poor Laws of any European country. Malthus (1816/1890) argued that the Poor Laws enabled the poor to become so destitute by allowing them to reproduce beyond their 'natural' economic capacity.

Malthus' basic proposition was that, unchecked, the human population would increase at a far faster rate than would (or could) food supplies. Even if all possible land were to be cultivated to the greatest possible degree, there was a limit beyond which food production could not progress, but there was no mathematical limit beyond which the human population could not proceed.

Population was known to be controlled by war, famine and pestilence. The number of people killed by war (mostly males), although appearing at times to be high, had very little permanent effect on population levels, which were controlled by female fertility. 'Predation/war' on females generally took place at birth, more females being subject to infanticide than males. Pestilence generally struck most severely when population levels were high and the general health and nutrition of the population low and was, therefore, associated with famine, which struck when population levels exceeded available food supply. No amount of productive human effort could do more than postpone the inevitable – starvation for large numbers of the population. The degree of misery associated with poverty and starvation was immense and it was unconscionable simply to allow this to happen without protest. No responsible government should encourage population increase by means of monetary incentives, such as State Poor Relief given on the basis of the size of the family or, worse still, an undertaking by the State that it would be responsible for the care of any child (or adult) unable to provide for itself. The two countries which Malthus believed best exemplified his philosophy were those of China and Norway, the one with a large population, the other with a small.

4.4 Populate – and perish

The Chinese custom was for land to be passed on from father to all sons, not just the eldest, as was common in Europe. As a result the parcel of land owned by each peasant family had become so small that, despite the Chinese people being the most peaceable and industrious of any country that Malthus knew, they lived in the most abject poverty and, in many cases, a state of actual starvation.

Norway, by contrast, was the only country, as far as Malthus could ascertain, whose people were aware of the perils of overpopulation and which took active steps to prevent the problem. Young men were required to give ten years military service, longer than the requirement of any other country. When their military service was complete, the men returned home and waited for their chance to obtain a job with a house. This only happened when somebody died. The fortunate person who obtained the position became a 'houseman' and could then marry and raise a family. Any male unable to obtain a house was unable to marry and reproduce. No new houses were built and this resulted in a stable population, all of whom could be maintained at a level of subsistence above that of poverty.

4.5 Human rights

Malthus disagreed with the view that every human being had a 'right' to subsistence. He argued that no person had the 'right' to be provided for by others, that each man had the duty to provide, not only for himself, but for his family, should he choose to have one. He cited St. Paul's admonition that if a man will not work, then neither should he eat (Malthus 1816/1890: 504). The only exception was the child, who had a 'right' to be provided for by its own parents. Parents had no right to expect other people to bear the expense of raising their offspring. Malthus knew of instances where the father of a large family had left, believing that this was the best way to ensure that his family was provided for – by the Parish.

Malthus' solution was twofold. He proposed that young people should be encouraged to delay marriage until they were in their thirties. Along with this, Malthus proposed that no people born after a certain date (twelve months after the Proclamation of a new law) should *ever* be entitled to Poor Relief. Malthus' believed that if people knew that no other means of support was available, they would be far more circumspect in procreation. Procreation may be an instinct, but so was eating, and Malthus believed the one should be controlled in the same way as the other.

4.6 Malthus' influence

Notwithstanding the six editions of his book which were published in his lifetime, it has to be said that Malthus had very little influence on nineteenth century England. The Victorian family was the largest in recorded European history.

Of the people mentioned by Bettany in his *Introduction* to the republished 6th edition as having been important in forming and/or disseminating Malthus' views, only one is female: Harriet Martineau (Malthus 1816/1890: ix). Harriet Martineau travelled widely in Britain and America promoting Malthus' teaching. She was a close friend of Erasmus Darwin, the older brother of Charles, being a frequent visitor to the Darwin family home, and it is inconceivable that Charles was not well aware of Malthus' teaching long before his reported reading of Malthus' book. Indeed, it is more likely that Darwin's familiarity with Malthus' teaching was the reason for his late reading of this well-known book, the majority of the pages of his personal copy remaining uncut (Desmond and Moore 1991).

By the time Darwin published *The Origin* in 1859, the nineteenth century passion for the study of nature had convinced most people that, while God might 'care' for the fowls of the air in *general*, he did not 'care' for fowls in *particular*, as individuals. Darwin was far more successful in establishing the truth of the balance of populations in nature by referring to the animal kingdom than Malthus had been by referring to the human kingdom.

4.7 Position of Paley and Malthus

Paley wrote overtly from a religious perspective. Indeed, this was his purpose in writing. By contrast, Malthus virtually ignored the subject of religion, apart from denying that portion of the Sermon on the Mount which implied that human beings need take no responsibility for the future because God would take care of everything. However, Malthus made no effort to overturn other Christian teachings, or to deny the existence of God; his writings fell within a theistic paradigm.

Paley was opposed to the concept of evolution. That plants and animals needed to evolve implied that they must have been deficient, imperfect, in some way and that was surely impossible for something created by God. Everything was perfectly designed; how could anything have been less than perfectly designed for hundreds of millions of years and yet been suitable to live and survive?

Paley did not challenge the concept of the world being far older than previously thought but did not seem to take into account the possibility that conditions had been different in former times, that something which was 'perfect' at one time would be less than perfect at another if it did not change and evolve. Paley did not challenge the existence of former species which, like Cuvier, he accepted had become extinct rather than having changed, as taught by Lamarck. Paley sought discontinuities, the differences not only between species, but between the various parts of a living body, all of which were adapted to perform their specific function. This, he held, could only have happened under the guidance of God.

Malthus was concerned only with extant human populations. He had no interest in evolutionary theory and, therefore, no position on change *v.* stability or continuity *v.* discontinuity. Discussion of his work has only been included in this thesis because of Charles Darwin's (1887) well-publicised comment that it was reading Malthus' work that helped him to understand the importance of population control in nature and of the need to adapt, if necessary, in order to survive.

The thinking of Victorian society, including that of Darwin, was heavily influenced by the philosophical and political writings of both these men.

Chapter 5

Early 19th Century Ideas

5.1 Georges Cuvier (1769-1832)

While the writings of the French theorists, Maupertuis, Buffon and Lamarck, remained little known in England, there was one Frenchman whose works were to have an effect on English writers as they started to become influential in this area.

Baptised Jean Léopold Nicolas Frédéric, Cuvier took the name Georges after the death of his older brother. Born in Montebéliard, in the Duchy of Württenberg, Cuvier was brought up a devout Lutheran, unlike Buffon and Lamarck, who were both French and both of whom had been educated by the Jesuits. Cuvier moved to Paris in 1793, becoming a French citizen (Coleman 1964: 6). His first position, held between 1793 and 1795, was as a secretary/clerk, during which time he made an intensive study of natural history (Coleman 1964: 9). He held a number of public appointments, but his appointment to the position of Professor of Comparative Anatomy at the Muséum National d'Histoire Naturelle in 1802 ensured his place in history. Together with his colleague, Etienne Geoffroy Saint Hilaire, he had published a short work in 1795 on the classification of mammals (Coleman 1964: 11). This was followed three years later by a zoology textbook, *Essays on the Theory of the Earth* (Cuvier 1798/1817/1978) based on a series of lectures he had given on comparative anatomy, which ran to several editions. In 1816, Cuvier published *The Animal Kingdom according to its Organization* (Cuvier 1863/1969).

5.2 Comparative anatomy

Cuvier was undoubtedly the greatest comparative anatomist of his time. It was said that Cuvier could reconstruct a whole animal from a single bone, such was his understanding of the correlation of parts necessary to maintain a complete whole (Bowler 1984). As Cuvier continued his work, he became more and more convinced that other naturalists were placing too much emphasis on comparatively unimportant external features in determining as to whether two or more animals were of the same species. Cuvier pointed out that superficial characteristics, such as colour or thickness of fur, were the most variable. By contrast, the skulls of the wolf and the fox were virtually the same throughout their territories, although there were superficial differences (Cuvier 1798/1817/1978: 117).

Cuvier argued that if species were evolving over time as a result of gradual variation, there ought to be evidence of this fact. Cuvier (1798/1817/1978: 124) studied mummified remains of animals from Egypt: cats, ibises, birds of prey, dogs, monkeys, crocodiles and the head of a bull. He was aware that these creatures were a mere two or three thousand years old, but could discover no sign of major variation or change in that time. He claimed the onus of proof was on those who proposed that change was continually taking place to substantiate their position with concrete evidence.

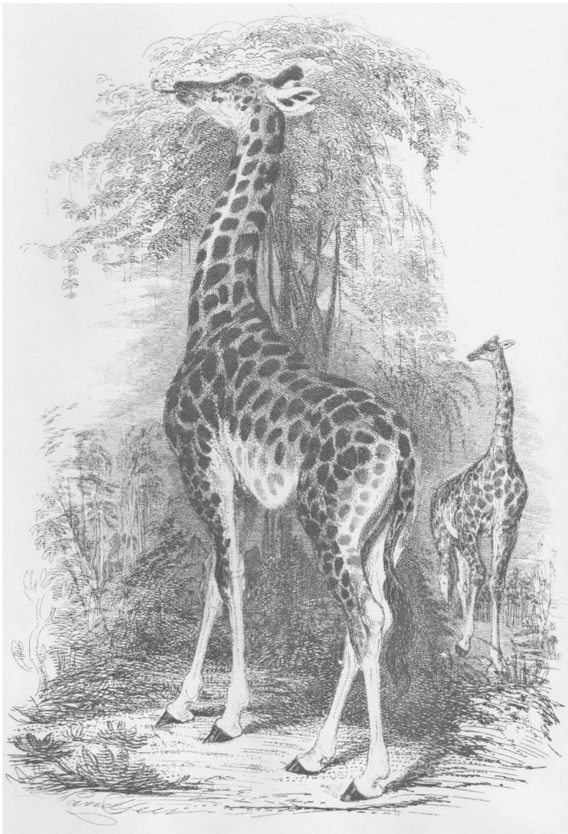

Fig.5.1 Frontispiece: The Animal Kingdom
According to Its Organization.
Cuvier (1863/1969)

Cuvier was the first comparative anatomist to extend his art to the examination of fossils. He endeavoured not only to reconstruct past life forms, but to place them into families, orders, genera and species, where possible. The more he studied, the more he was struck by the fact that *none* of the fossils he examined had *exact* living counterparts, and some were completely different from anything now living. This was true of mammals, birds and fish. Only among the invertebrates, such as snails, was it possible to find fossil shells which seemed to bear close resemblance to their living counterparts today, although Cuvier did not consider external characteristics, such as colour and size, particularly relevant.

5.3 Catastrophism

Cuvier accepted that many species had become extinct and attributed this to geological catastrophes. As an example, he suggested that if New Holland (Australia) were to sink beneath the sea, kangaroos, and other species unique to Australia, would be lost forever. If, at the same time, land were to rise above the ocean north of Australia, it might be possible for animals, such as elephants and lions, to migrate from Africa or Asia to what are now the islands of south-east Asia, and thence to Australia, giving the impression that they were new creations (Cuvier 1798/1816/1978: 125-126).

To Cuvier, each fossil was an historical document (Cuvier 1798/1817/1978, 1863/1969: 54). Without fossils, we would be unaware that different creatures had ever existed. As industrialisation progressed, more and deeper excavations were being made and fossils were being found deep inside the Earth belonging to creatures which clearly must once have lived upon its surface. Cuvier was not satisfied with the concept of fossils merely being covered by sediment. To him, the great depth at which some of these fossils were being found indicated that great upheavals must have taken place, not once but two or three times. Cuvier followed Buffon in believing that there had been a series of epochs and, like Buffon, equated the last with the Biblical Flood.

Cuvier noted that the Hebrew texts placed the creation of the world 5817 years before the year in which he was writing (1813), the Sumerian texts placed it at 6513 and the Septuagint at 7685 years before 1813. To this extent, Cuvier was prepared to allow for some inaccuracy in the biblical account, but that was all. Cuvier agreed with Buffon that the biblical account referred only to events which had occurred since the last geological revolution, but was unable to accept the immense length of time which Buffon believed had elapsed since creation.

One thing remained a mystery – the origin of the human species. As yet, no human fossil bones had been found. Examination of battle grounds had shown that human bones degenerated at a rate equivalent to that of horses, so the lack of human fossil bones could not be attributed to their more ready decay (Cuvier 1798/1816/1978). Cuvier could only suggest that humans had lived on some part of the globe now under water, that a few had survived some cataclysmic event.

5.4 Charles Lyell (1797-1875)

During his lifetime, Sir Charles Lyell was acknowledged in England as the founder of scientific geology, an honour now attributed to Hutton. Geology included the study not only of rocks, but of fossils, and therefore of earlier forms of life. His early work profoundly impressed the young Charles Darwin and the two were later to become firm friends. Indeed, Darwin recorded that he saw more of Lyell than of any other man (Darwin 1887: 71). Due to Lyell's influence, geology became a degree subject at University, rather than an extra-curricular subject or hobby for gentlemen. He was knighted in 1848.

While studying at Oxford, Lyell had been much impressed by the work of James Hutton, of which he had learned by reading Playfair's *Illustrations of the Huttonian Theory* (Playfair 1802/1956). After completing his studies, Lyell travelled in Europe, meeting Cuvier while in Paris. He greatly admired Cuvier's work and absorbed his ideas, subsequently siding with Cuvier against Lamarck, even though Lamarck's theory was much closer to Lyell's own.

While in Europe, Lyell also visited Sicily, where he investigated the Mount Etna volcano. He became convinced that the volcano had been built up gradually as the result of a long series of comparatively small eruptions (Bowler 1984: 127). Lyell concluded that, while specific places on the surface of the Earth had changed over geological time, the uplifting of some areas was counterbalanced by the wearing away of others, so that there was a conformity over time across the globe (Bowler 127-128). Geological change was a continuous event, sometimes incorporating 'catastrophic' events, such as volcanic eruptions of earth quakes. These were but part of the larger picture.

In promoting his views, Lyell adopted a non-confrontational approach, where possible making it appear as if he were in agreement with the point of view of others (Lyell 1830-1833/1997: xxxii-xxxiii). Born a gentleman, Lyell was privately 'anti-establishment', particularly in reference to the Church, becoming a Unitarian rather than remaining a member of the Church of England. Lyell saw no purpose in 'preaching to the converted' and continued to move in Tory circles, where he hoped his less than conservative views might make an impression. Although he was by preference a Whig, he continued to review for the Tory *Quarterly Review* rather than the Whig *Edinburgh Review*, believing he would have more opportunity that way to influence opinion. When it came time to publish his book, entitled *Principles of Geology* in imitation of Newton's *Principles of Physics*, Lyell published with Murray, the Tory publisher, rather than with Knight, the Whig publisher, aiming his work at the upper classes, churchmen and politicians. This he achieved not by the content of his work but by its presentation and price. These gave his ideas respectability. Four years later, a cheaper version of his work was published and this two-pronged strategy was successful in bringing his ideas to the attention of a wider public.

5.5 Uniformitarianism

Having travelled widely in Europe and visited the sites of volcanic eruptions, earthquakes, etc., Lyell came to the conclusion that the geology of the Earth could be accounted for by assuming that present events were similar in type and frequency to past events and that no 'external' cause was necessary as partial explanation. By using the vast amounts of time which were now allowed to the geologists, Lyell calculated that the wearing away of rocks could account for the retreat of land in some areas and the laying down of soil in others, with a resultant shift in land masses. Volcanic lava flows could increase the height of land, sometimes form new islands and also change the flow of rivers, etc. Earthquakes also contributed to the raising and destruction of land, causing some to be lost beneath the sea. Alterations in land formation would change wind flow and sea currents. Events in one part of the world could have far reaching effects on another (Lyell 1830-1833/1997).

5.6 Fossils

Among the increasing number of fossils being found, some were clearly of plants and animals no longer in existence. Two things became apparent: (1) the deeper the fossil was found, the more likely it was to be of a simple form; and (2) there were breaks in the fossil record showing what appeared to be the sudden replacement of previous forms by newer forms.

Lyell attributed the fact that most of the earliest fossils were of fish or other water dwelling creatures to the fact that sedimentation made it far more likely that the remains of water (especially sea) dwelling animals would be preserved. Animals dying on land would be devoured very soon after their death and would not have time to fossilise. Even animals washed downstream in flooded rivers would be eaten very quickly, long before their remains could be fossilised. Just because their remains had not been found was no reason to assume that land animals had not existed in the very earliest times (Lyell 1830-1832/1997).

5.7 Extinctions

The appearance of different forms in the ascending strata of one place could be explained by changes of environment and climate (Lyell 1830-1833/1997). Slight changes in conditions would be tolerated, since it was well known that both plants and animals were able to adjust to changed living conditions within certain limits. Lyell cited animals which changed colour or the thickness of their fur with the season and animals which were known to have made similar changes after being taken by humans to a new environment. However, he claimed, once initial change had taken place, often quite quickly, further change took place only very slowly, if at all. If conditions changed too much, the plant or animal would be unable to adapt and would perish.

5.8 Creations

Having justified extinctions, Lyell was left with the need to explain how new forms had replaced extinct ones. Lyell rejected Lamarck's concept of evolution in favour of continuous replacement by influx from other parts of the world, as had his friend, Cuvier, along with special creation. Lyell saw no reason to suppose that Creation had happened only once, but held that 'Acts of Creation' had produced new forms to replace extinct ones.

Lyell pointed out that if a round figure of one million species be assumed to inhabit the Earth, then, if only one species a year became extinct somewhere, it would take a million years for a complete change to take place. Most of these extinctions would take place unobserved, as would the creation of their replacement. Lyell asked how could it be known that a species had *always* existed, if it had never been observed before and there was no fossil evidence of its earlier existence.

At the time Lyell was writing, the discovery of the Neanderthals was still nearly thirty years away. Although stone tools had been found, there was no fossil history for humans. Lyell concluded that 'Man' was a recent creation. If the 'First Cause' had created 'Man' but recently, was there any reason why it should not also still be creating other plants and animals?

5.9 Lyell's conversion

Lamarck had seen the species boundary as one created by humans to assist them in categorising plants and animals. He held that living forms had an unlimited capacity to change *over time.* By 'time', Lamarck meant millions of years, a point Lyell (1863) later admitted he had not fully grasped. Lyell acknowledged that, while humans had been instrumental in the appearance of countless new varieties, they had not been able to produce even one new species. Furthermore, although variation was easily accomplished early in the process of domestication, further change became increasingly more and more difficult to achieve. There was a limit beyond which a species could not be made to vary (Lyell 1830-1833/1997: 232-233). Gradually converted by Darwin to the concept of evolution, Lyell never fully accepted Darwin's theory of evolution by natural selection. Having reread Lamarck's work, Lyell came to understand the length of time Lamarck had been proposing and eventually retracted his opposition to Lamarck's theory (Lyell 1863: 3):

> In the concluding chapters I shall offer a few remarks on the recent modification of the Lamarckian theory of progressive development and transmutation, which are suggested by Mr. Darwin in the 'Origin of Species by Variation and Natural Selection' and the bearing of this hypothesis on the different races of mankind and their connection with other parts of the animal kingdom.

Interestingly, Lyell here described Darwin's theory as a modification of Lamarck's theory. By the 1860s, human fossils of considerable antiquity, as well as large numbers of stone tools, were being found. Lyell visited a number of sites and became convinced that humans were not a recent creation.

5.10 Edward Blyth (1810-1873)

Born but one year after Charles Darwin, Edward Blyth is Darwin's closest contemporary evolutionary theorist. His writings would be all but forgotten now were it not for the research of Loren Eiseley, whose rediscovery of Blyth's work was published posthumously (Eiseley 1979). Both a literary writer and an anthropologist, Eiseley held the Chair of Anthropology and the History of Science at the University of Pennsylvania. After Eiesley's death in 1977, Heuer, with the help of Eiseley's widow, prepared for publication a compilation of pieces by Eiseley, all but one of which had been written for scientific publication or prepared to be read to a gathering of scientists (Eiseley 1979: x).

Eiseley's first essay was a summary of Darwin's life and work in which he tackled the issue of just how prevalent were theories of evolution in the last part of the 18th and the beginning of the 19th centuries and why Darwin had made so little acknowledgement of the work of his predecessors. While drawing attention to the works of such people as Maupertuis, Buffon, Erasmus Darwin, Lamarck, Cuvier, Hutton, Lyell, de Cabdille, Saint Hilaire, Wells, Matthew and Chambers, as well as a number of others, Eiseley nevertheless remained loyal to Darwin inasmuch as he was prepared to forgive the great man any 'oversight' in making proper acknowledgment as part of the privilege owed to genius.

By the time he wrote his paper on Blyth, Eiseley's attitude had changed.

Blyth had shown a great interest in natural history since his childhood. While still in his twenties, he started contributing articles to journals and corresponding with other leading naturalists. He was part of a team which produced an illustrated translation of Cuvier's work, which was published in England in 1840. His study of the comparative anatomy of birds led Blyth to ponder whether all species had perhaps been derived from one common ancestor (Eiseley 1979: 58). Blyth was interested in changes which had come about under domestication. He noted in particular the Ancon sheep, which had been bred from one deviant animal, born with shorter legs than the rest of the flock. Being less able to jump fences, this ram was used to produce the Ancon breed.

Blyth's health not being good, he was advised to move to warmer climates and accepted a position as curator of a museum in Calcutta, arriving there in 1841. Part of his duties included presenting monthly reports to the Asiatic Society of Bengal, which he did for twenty years, thus becoming one of the best known writers of his day. Blyth also contributed articles to other journals and his work was frequently cited by Darwin in *The Origin of Species* and later works (Eiseley 1979). His health failing, Blyth returned to England, visiting Darwin at Down and corresponding with him. He died 27th December 1873, a few days after his 63rd birthday.

5.11 Blyth and 'selection by nature'

Eiseley's findings in regard to the connection between the theories of natural selection as put forward by both Blyth and Darwin were published in an article in the *Proceedings of the American Philosophical Society* in 1959 (Eiseley 1979). It was perhaps unfortunate that his paper, which quite clearly accuses Darwin of plagiarism, should have appeared in 1959, the centenary of the publication of *On the Origin of Species*, when the rest of the scientific world was celebrating Darwin's great achievement.

Eiseley examined Darwin's works with Blyth in mind and found that Blyth was referred to extensively, especially in *Variation in Animals and Plants under Domestication* (1868/1893) and *The Descent of Man* (1871/1908). Blyth was cited more often than any other authority in *Variation* but not in relation to the central thesis, merely in relation to varieties and species. Darwin made no reference to Blyth in his 'Historical Sketch' included in the 3rd edition of *The Origin* (1861) (Eiseley 1961: 52). In 1842 and 1844, Darwin wrote two unpublished essays (see Chapter 6) which Eiseley found to be very similar to some of Blyth's articles.

Eiseley referred in particular to three articles by Blyth published in the *Magazine of Natural History* in 1835, 1836 and 1837, which he reprinted in full (Eiseley 1979). Darwin was known to have read this journal, receiving copies while on his voyage on the *Beagle*. The January 1837 copy of the journal carries notation by Darwin on Blyth's article, as well as the usual notes pinned to the back cover. Eiseley considered it significant that Darwin started his notebooks on the 'species question' a short time later (Eiseley 1961: 46).

Eiseley pointed out that Blyth discussed natural variation as well as the tendency for variation to be passed on to future generations, the ability for naturally occurring variations to be artificially maintained and increased through domestic breeding, producing new varieties in domestic animals and crops, the possibility that something similar also occurred in nature, the tendency in herd animals for the strongest male to produce the greatest number of offspring, while the sickly and ill-adapted disappeared, 'selection under the struggle for existence in wild nature' (Eiseley 1979: 36). More particularly, Eiseley drew attention to specific examples used by Blyth and Darwin: naturally occurring mutations such as the Ancon sheep, donkey-footed swine, tailless cats, back-feathered, five toed and rumpless fowls, domesticated cattle grazed on poorer mountain pastures being smaller (more degenerate) than cattle grazed in valleys, domesticated fowl regularly supplied with food becoming more bulky and lazy and losing some of their ability to fly (Eiseley 1979: 60-61). While Blyth wrote 'grouse are brown heather' and referred to ptarmigan 'as snow in winter', Darwin wrote of 'red grouse the colour of heather' and referred to 'ptarmigan white in winter' (Eiseley 1979: 61). Blyth discussed at length the role of protective colouration, using as his example the roles of the falcon and its prey. Darwin referred to the hawk and its prey, but both agreed that any ground dwelling bird, or small mammal, whose colouration differed from the optimum would be more subject to destruction. Protective colouration would be kept constant through natural selection (Eiseley 1979: 61). Not all colouration in nature is designed as camouflage. Some is intended to attract attention, especially that of the opposite sex. Blyth foreshadowed Darwin in discussing sexual selection and its possible diversifying effect (Eiseley 1979: 56).

The most convincing piece of evidence that Darwin directly copied from Blyth's work was thought by Eiseley to be the use by Darwin of the obsolete word 'inosculate', which meant *to join, to have a connection with* or *to be interwoven.* This word was used by Blyth in his papers of 1836 and 1837 (Eiseley 1979: 118). Darwin used the less strong word 'osculate', *to touch* or *to join*, once in *The Origins* (Darwin 1859/1998: 324). However, Barlow (1967: 62) pointed out that during his voyage on *HMS Beagle*, Darwin wrote a letter in which he referred to a bird that appeared to be a mix between a lark pigeon and a snipe: 'Mr. MacLeay himself never imagined such an inosculating creature'. The reference here was to the Quinary System of MacLeay, which saw nature, not as a ladder or chain, but as a series of connecting (osculating) circles (see below). Barlow was probably correct in suggesting that Blyth and Darwin both drew on the same original source for their use of this word.

5.12 Common descent

In his paper on *Psychological Distinctions Between Man and Other Animals* (Blyth 1937) Blyth raised the possibility of common descent (Eiseley 1979: 159):

> … as man, by removing species from their appropriate haunts, superinduces changes on their physical constitution and adaptations, to what extent may not the same take place in wild nature, so that, in a few generations, distinctive characters may be acquired, such as are recognized as indicative of specific diversity? … May not, then, a large proportion of what are considered species have descended from a common parentage?

Blyth then said that he need not spend much time considering this possibility since 'able writers have so often taken the subject in hand' (Eiseley 1979: 159). In nature, 'breeding in' within a given locality would discourage the establishment of new variations. Without constant human interference, Blyth concluded, the establishment of new varieties would not be possible. He discussed species distribution and the lack of intermediate types at habitat boundaries, as well as the possibility of sea currents transporting seeds. This latter possibility Blyth rejected on the grounds that water would germinate the seed, which would die before reaching suitable soil.

Blyth argued that if flora and fauna were 'self-adapting' (Eiseley 1979: 160), they would adapt as they reached the outer limits of their natural habitat. They would not become smaller of stature due to poorer nutrition; rather they would reach their full – adapted – potential. Indeed, there would be no centre, no radiation, but a steady change as adaptation occurred. A species infinitely adaptable would be able to inhabit an infinite area – at least in its natural environment of land, sea or freshwater.

Domestic breeders were only able to achieve new varieties by strict segregation of breeding stock, which would not happen in nature. Infinitely varied species, Blyth argued, would be able to breed infinitely and would thus become less and less distinct. They would blend and merge, which was not what his studies had shown to have happened. On the contrary, even the smallest differences were maintained by the species boundary (Eiseley 1979: 106). For these reasons, Blyth rejected the idea of common descent. Darwin was to accept it, but always struggled with the problem of 'blending'.

5.13 Absolution?

Eiseley's study of Blyth's work had clearly made him question Darwin's ethics (Eiseley 1979). There are three sentences in the papers of Blyth that Eiseley reproduced which were rather surprisingly not specifically mentioned by Eiseley. The first occurred in Blyth's (1835) *On Varieties of Animals* in which he discussed the definition of species and varieties (Blyth 1835: 106-107):

> The above is confessedly a hasty and imperfect sketch, a mere approximation towards an apt classification of 'varieties', but if it chance to meet the eye, and be fortunate enough to engage the attention of any experienced naturalist, who shall think it worth his while to follow up the subject, and produce a better arrangement of these diversities, my object in indicting the present article will be amply recompensed.

The second is similar and occurred in the final paragraph of the same article (Blyth 1835: 111):

> Properly followed up, this subject might lead to some highly interesting and important results.

The third sentence of relevance occurred at the beginning of Blyth's (1836) paper on *Seasonal and Other Changes in Birds* (Blyth 1836: 113):

> The subject is both extensive and complicated, and involves a number of other recondite inquiries. I could have wished that some naturalist better qualified than myself had taken it in hand.

Did Darwin take these sentences as both a challenge and a disclaimer? Having brought certain facts and thoughts to the attention of his fellow naturalist, did Darwin assume that Blyth was handing over these thoughts and ideas to anyone who wished to follow them through, without entailment or citation? Bearing in mind Eiseley's earlier work in which he defended Darwin's apparent plagiarism, it is surprising that this possible explanation was not offered by Eieseley. We know that Blyth not only corresponded with Darwin, but met him at Down in Kent (Eiseley 1979). Never does Blyth seem to have made any attempt to claim priority. Why should he, when he knew that so many 'able writers' before him had so often 'taken the subject in hand'?

5.14 Further doubts

Eiseley (1979: 71-73) claimed that Darwin had been aware of Patrick Matthew's book *On Naval Timber and Arboriculture* (Matthews 1831). He drew attention to a paragraph from Darwin's (1844) *Foundation* document which was very similar to one that had appeared in Matthew's work on the subject of the different rates of change which occur between trees growing in their natural state compared with those growing under domestication. This paragraph did not appear in *On the Origin of Species* (Darwin 1859) but a similar paragraph was included in *Variation of Animals and Plants under Domestication* (Darwin 1868/1893: 287) where Darwin included the words: "as Mr. Matthew remarks".

5.15 Robert Chambers (1802-1861)

One more writer's ideas on evolutionary theory needs to be considered before moving on to the better known ones of Charles Darwin: Robert Chambers. Hutton's book had made little impact, Playfair's (1802/1956) *Explanations of the Huttonian Theory of the Earth* had been considerably more popular and by the time British readers had assimilated Lyell's *Principles of Geology* (1830-33/1997), they were well prepared for *Vestiges of the Natural History of Creation* which was published anonymously in 1844 (Chambers 1844/1994), a practice not uncommon in Victorian times.

The Chambers brothers ran a publishing house which specialised in publishing economical books and pamphlets designed to inform the non-University class of reader about a wide variety of topics. Their *Edinburgh Journal* was well respected and widely read. In the process of publishing the works of other people, Robert Chambers became very well read. The work undertaken by Chambers in establishing this business was such that by 1842 he was obliged to take time off to recover from a breakdown. Between the years 1842-1844 Chambers wrote his book, co-incidentally the same years during which Darwin made his first two 'sketches' (see Chapter 6).

The tenth edition of *Vestiges* included an Autobiographical Preface in which Chambers gave an (anonymous) account of how he came to write his book. Being convinced that the world operated under law, suggestions of 'fiats', 'special miracles' and 'interferences' were unsatisfactory to him (Chambers 1844/1994: E204). Chambers was aware of the transcendental approach to anatomy and physiology taken by Cuvier, of which he approved, but he dismissed Lamarck's theory as inadequate since it seemed to deny God any active role in the process of evolution. Chambers wrote from a theistic perspective, rather than an overtly Christian one. He saw God as actively involved in the process of evolution. Although acknowledging Lamarck as a man of the highest character, Chambers considered his work 'among the follies of the wise' (Chambers 1844/1994: V231). He rejected not only Lamarck's concept of evolution as a result of the 'wants' of the animal, but also that these changing 'wants' were precipitated by changing environmental conditions. Chambers' own theory of evolution was a theistic one, relying solely on Design set in motion by the First Cause.

Although Robert Chambers never admitted authorship, he was soon on the list of possible 'suspects'. It was left to his friend, Alexander Ireland, to disclose his authorship after his death, lengthy correspondence between these two co-conspirators confirming the veracity of the claim. To protect his anonymity, Robert's wife, Anne, copied out his work so that his handwriting would not be recognized and the manuscripts were sent to Ireland for printing by the London firm, John Churchill. The book was an immediate success, its popularity being fuelled by the criticism it attracted and discussion it generated. First published in October 1844, by January 1846 it had run to five editions, which increased to eleven during Chambers' lifetime. The twelfth edition was published posthumously and contained the introduction by Ireland confirming Chambers' authorship.

In response to criticisms of his work, Chambers (1845/1994) published (again anonymously) his *Explanations.* Both these books were included in the 1994 facsimile reproduction of Chambers' work, along with three reviews of Darwin's *The Origin*, published by Chambers, together with other additions. Because Chambers' two books were reproduced facsimile, there is a duplication in page numbering. In the *Index*, the editor used the letters 'V' and 'E' before the page number to indicate in which book the reference was to be found. This system has been adopted here.

5.16 Unity of organisation

There is no reason to believe that Chambers was not fully aware of the content of the English translation of Buffon's works which was published by the Chambers family in 1834. His work followed closely the example of Buffon. He aimed to bring together the stories told by fossils and by geology and to meld these with contemporary scientific experiments and opinion, making one grand exposition.

Chambers (1844/1994) commenced his book with an account of that which was known: the position of the Earth as one of a number of 'satellites' orbiting the Sun, forming the solar system; the Sun was but one of a myriad of suns, which we term stars, forming what Chambers called the astral system; the size of the Solar System (3,600,000,000 miles across); the shape of the Solar System (a flat oval); the Milky Way containing a myriad of stars; the existence of multitudes of stars not visible to the naked eye, but only by telescope. Taking the reader through the nebular hypothesis, Chambers proceeded from the conception of the Earth, its geological formation, the commencement of organic life in the ocean, development from fish to reptiles, to birds, to mammals, and eventually to 'Man'.

The organisation and extent of the Heavens led Chambers (1884/1994) to one conclusion – Creation was the work of a Great Being. This was no pandering to political expediency, but a firm acclamation of Chambers' personal belief. He was writing after the manner of Paley, drawing attention to the wonders of the Universe.

5.17 The 'Universal Gestation of Nature'

Chambers' solution to the problem of evolution was simple, and in accord with the slow process of development throughout the Universe in general and of individual growth in particular. The changes which took place at puberty, Chambers argued, were predetermined before the child was born, the process being put in motion at the time of conception. So it was with the Universe. Divine Wisdom had established a principle of gradual, progressive development, in accordance with which gradual advances had been, and were being, made (Chambers 1844/1994: V203). Chambers postulated that all development (evolution, both geological and biological) was predetermined by the Creator, and was not in response to changing environmental conditions or the wants/needs of the animal.

Chambers saw the point of change as occurring during the embryonic stage of growth and development. Only in recent times, said Chambers, had physiologists observed that each animal passed, in the course of its germinal history, through a series of changes resembling the permanent forms of the various orders of animals inferior to it (Chambers 1844/1994: V198). By considering only the embryonic form, it was possible to trace the path of evolution. What, said Chambers, if embryonic development was extended slightly? Would not the embryo then be able to develop to the next stage, as predetermined by the Divine Author? Chambers called his theory 'the Universal Gestation of Nature' (Chambers 1844/1994: E72).

5.18 Spontaneous generation

Chambers supported spontaneous generation not only of the most simple cells, but of moulds, fungi and 'worms' as well. He held that there was present-day evidence of 'occasional workings of the life-creating energy' (Chambers 1844/1994: V178). He cited the practice of farmers mixing together horse and cow dung to propagate mushrooms, rejecting the claim that mushroom seeds were carried in the atmosphere, unperceived, on the grounds that these postulated seeds had never been seen and were, therefore, merely an abstract theoretical formation. Mould and infusoria, Chambers pointed out, increased their numbers by cell division, not by ova, so where did the hypothetical wind-borne seed come from (Chambers 1844/1994: V179)?

Chambers cited the well-known experiments undertaken separately by Crosse and Weekes, involving crystallisation of silicate of potash and nitrate of copper in the presence of a 'powerful voltaic battery'. A gelatinous matter had formed from which Weekes had observed a tiny 'insect' emerge. This was believed to be a species of *Acarus* 'minute and semi-transparent and furnished with long bristles, which could only be seen by the aid of the microscope' (Chambers 1844/1994: V185-187).

Chambers also referred to the case of the alleged transmutation of oats into rye when oats were kept cropped. Chambers' authority, a Dr. Lindley, had asked: "How can we be *sure* that wheat, rye, oats, and barley, are not all accidental off-sets from some unsuspected species?" (Chambers 1844/1994: E111-112). This is close to the concept of polymorphism in plants, especially among cereals (White 1937, 1973, Dobzhansky 1970) which will be discussed in Parts III and IV of this thesis.

5.19 Quinarian System

Chambers had been impressed, not only with the size of the Universe, but also with its order. In the first chapter of his book, Chambers spoke of the mathematical spacing of the planets. It is not surprising, therefore, that Chambers was attracted to the Quinary System of Animated Nature, outlined by MacLeay, to which he devoted a whole chapter of his book (1844/1994: V236-276). MacLeay saw living things not as a chain, or ladder, but as a series of osculating circles, no one part of which was superior to another. The components of these circles were invariably five in number. For example, in the animal kingdom there were five sub-kingdoms: the vertebrates, annulosa, radiata, acrita and mollusca (Chambers 1844/1994: V239).

This artificial combining and splitting of groups in order to bring their number to five was to be the undoing of the theory, a process well underway when *Vestiges* was published. Adherence to this failing theory, as well as to the theory of spontaneous generation, drew the most criticism from the scientific community, although Chambers' chief opponents were the Establishment, especially the Church.

5.20 Time and timing

Although Chambers wrote at length about the vastness of space, he had surprisingly little to say about time. There were only two passages in which he referred to the vast/enormous space of time needed for the 'gestation' of the whole of creation (Chambers 1844/1994: V202, V210).

Unlike Buffon and Cuvier, Chambers made no attempt to equate any part of his theory with the biblical account of creation. Chambers went so far as to suggest that a whole phenomenon of evolution was taking place, not only on this sphere, but on other spheres in space as well (Chambers 1844/1994: V203). Such ideas were not welcomed by the Church as they tended to diminish the uniqueness of humans. At the time of the publication of

Chambers' book, MacLeay's theory was going out of favour. Subsequent editions placed less emphasis upon it and by the final edition, all reference to it had been deleted.

Chambers had postulated a process of gradual, progressive development, guided by Divine Wisdom (see section 5.20). Critics argued that the fossil evidence showed a sudden appearance of new forms at different times, not a gradual evolution (Bowler 1984: 139). Bowler (1984: 139) stated that Darwin noted this criticism, which he attempted to disarm by claiming that the fossil record was imperfect.

That *Vestiges* went to twelve editions is testament to its enduring popularity with the general reader. Although constantly criticised, it undoubtedly paved the way for Darwin's work by being the first British book to espouse the theory of evolution. Lyell had rejected Lamarck; Erasmus Darwin's work, written in verse and 'for pleasure' had never been considered as promoting a serious theory. Since Chambers' book was published after Darwin had already put aside his own essay (see Chapter 6), it cannot be the reason why Darwin decided not to seek publication at that time. As it was, Chambers paved the way for Darwin's longer work which was published fifteen years later.

5.21 Mid 19th century positions

Despite being appointed to an influential position, Cuvier did not renounce his belief in the Bible, as had Lamarck under the Napoleonic regime. He wrote from an overtly religious point of view. He accepted the Biblical account of Creation and made every effort to incorporate his scientific findings within this religious paradigm. For Cuvier, anatomy was transcendental; physical forms were the direct work of the hand of God. He did accept that there had been other life forms at earlier times, which he held had been eliminated by successive floods. Because Cuvier rejected evolution, believing species to be stable from the time of their creation, he held no position on continuity *v.* discontinuity.

Cuvier was a 'Catastrophist' but not a believer in repeated creations (Cuvier 1798/1817/1978, 1863/1969: 171-172). His account did not satisfactorily explain creatures for which there was no exact fossil replica, other than to suggest that their ancestors had once lived on some other part of the globe, possibly now under water.

Despite having been influenced by Cuvier during their meeting in Paris, Lyell nevertheless held views which differed from those of Cuvier. He was among the growing number of people who preferred to refer to a 'First Cause' rather than to 'God'. His position was not secular but he was part of a rising tide of people who were distancing themselves from Christian beliefs. Like Buffon and Hutton before him, he acknowledged the Earth as being of great age; his great work, *Principles of Geology,* (Lyell 1830-1833) was written with the intent of popularising this idea among the British reading public. Despite his interest in geological change, Lyell initially resisted the idea of biological change.

Blyth took an opposing position on both these points. He accepted evolution and was untroubled by any possible conflict with Church teaching, retaining an orthodox position. He was, however troubled by the clear, but often small, differences between species and varieties. According to the theory he was trying to form, these differences should have disappeared but they were maintained. For this reason his theory remained unfinalised and failed to make a lasting impression.

The chief point of interest here is not in the passing over of Blyth's work during the 19th century, but its marginalisation after having been brought to the attention of evolutionary theorists by Eiseley (1979). Blyth had not argued his position as fully as had Darwin. Nevertheless, he deserves to take his place, along with Buffon, Lamarck and Chambers, among those whose work preceded, and may have influenced, that of Darwin.

Chambers saw evolution as having happened under the guidance of God. It was a gradual, continuous process. As will be seen in the following chapters, Chambers was the last person to propose an original, overtly deistic, theory of evolution for nearly a hundred and fifty years. Darwin's theory was to reduce the role of the Creator to such an extent that it was seen by some as being overtly atheistic, by others covertly so.

A paradigm shift was about to occur.

Part II

IMPACT

Before 1900
Darwin's Theory and Its Reception

Chapter 6
Laying the Foundations

6.1 Introduction

As has been seen, religion was not of major importance in the gradual development of early theories regarding evolution. Those, such as Hutton and Lyell whose work related only to geological formations, disregarded the subject altogether. Lamarck, living under the anti-Christian Napoleonic regime that he ardently supported, mentioned a Supreme Creator which was allowed. Buffon was cautious, but whether biblical teaching genuinely influenced his thinking or whether his reservations were expressed for political reasons, it is not now possible to say. Erasmus Darwin was a free thinker. His mind roamed where it would, allowing no pre-conceived religious or scientific boundaries to fetter its explorations. Only Cuvier appears consciously to have moulded his theory to fit his Christian beliefs.

Religion played no part in the thinking of Charles Darwin in the early formulation of his theory. Having aborted his first attempt at a career in medicine, he read, and accepted, Paley's work during his studies at Cambridge, intended to lead him towards ordination within the Church of England. Darwin's later doubts *followed* his theory, rather than guided it, these doubts being exacerbated by the death of three of his children, particularly that of his favourite daughter from scarlet fever (Desmond and Moore 1991).

So dominant did Darwin's theory of evolution by natural selection become, that "Darwin's theory of evolution" is sometimes spoken of as though it were Darwin who first proposed evolution itself, something which was clearly not the case. This thesis is not about Darwinism, *per se,* but about the way in which peoples' preconceived ideas have prejudiced their interpretation of evidence in relation to evolution. Nevertheless, it is inevitable that Darwin and his theory will dominate the remainder of this discussion.

6.2 Charles Darwin (1809-1882)

The story of Charles Darwin's voyage on *HMS Beagle* is too well known to need much attention here, except for the making of two main points.

Firstly, it was the services of a geologist that Captain FitzRoy had requested and it was for this that Professor Henslow had been approached for a recommendation. While at Cambridge, Darwin had attended informal meetings at Professor Henslow's house and participated in some field trips with Professor Sedgwick, so he was probably as well prepared to undertake this task as any other available young man. He was given a copy of the first volume of Lyell's *Principles* (Lyell 1830/1997), this being all that had been published at the time he set sail in 1832, the remaining two volumes being received by him during the course of the voyage. Darwin's primary task was to collect geological samples, any samples of flora and fauna which he collected were solely at his discretion. Henslow had kindly offered to store any material which Darwin shipped back until his arrival home, when it was anticipated that the flora and fauna would be sent to various museums. Unfortunately, the museums were swamped with samples being sent back by travellers from all four corners of the globe and few of Darwin's samples found a ready home.

The second point is that Darwin had little interest in how the various flora and fauna may have evolved until he reached Australia. In 1979, a facsimile copy of Darwin's journal was published, allowing the reader to enjoy Darwin's account of his voyage 'in his own hand', with erasures and corrections, but without any of the changes Darwin made in the year it took him to prepare his journal for publication.

From his journal we know that Darwin hated the Galápagos Islands. Their volcanic nature was too obvious to present Darwin with any opportunity for 'geologising'. Darwin was told that the giant tortoises could be identified as to the island to which they belonged by the shape and markings of their carapaces but he did not ponder how this large land animal, unable to swim between islands, had reached the Galâpagos Islands, which had never been joined to the mainland, nor to each other, for that matter. Not only did Darwin not theorize as to the differences between the finches on the various islands, he did not even recognise them as finches, labelling one a wren, another a blackbird (Steadman and Zousmer 1988: 55).

Only when he reached Australia did Darwin begin to ponder the degree of similarity/difference between fauna in the two hemispheres. Darwin had been watching a lion ant catch its prey in a conical trap and wrote "without doubt this Judacious Larva belongs to the same genus, but to a different species, from the European one" (Darwin 1839/1979: 694). He wondered whether but one Creator could be responsible for such variety – yet how could more than one Creator have "worked over the whole world"? It is perhaps to Australia, not the Galâpagos, that we owe Darwin's later philosophising.

6.3 Foundations

Darwin returned home from his voyage in December, 1836. In 1837, he started keeping notes on his readings and thoughts relating to the 'species question', namely, whether species were invariable. Central to this question was that of inter-specific sterility, which had been used by Buffon as an important criterion in the definition of a species. If the same species was represented by a number of varieties, had they been so created or had variation appeared over time, that is, had they evolved?

In 1842, Darwin wrote up his thoughts into "a very brief abstract in pencil in 35 [hand-written] pages; and this was enlarged during the summer of 1844 into one of 230 [hand-written] pages" (F. Darwin 1887/1969: 84). In fact, the 1844 manuscript had only 189 pages, the remaining number being made up of blank pages, interleaved as though for notes and additions (Darwin 1909/1969: xvi). Darwin intended this book for publication at some time. He wrote a letter to his wife, dated 5th July, 1844, asking that in the event of his death she set aside £400 for the publication of the book. She was asked to find some competent person who would be prepared to "take trouble in its improvement and enlargement" (Darwin 1909/1969: xvi). In addition to the sum of money specified, this person was also to receive the profits from the book.

To assist this editor, Darwin bequeathed this person all his books on Natural History which were either scored or had references, and charged Mrs. Darwin with the task of also handing over "all those scraps roughly divided into eight or ten brown paper portfolios" (Darwin 1909/1969: xvi). The letter ended (1909/1969: xvii-xviii):

> If there should be any difficulty in getting an editor who would go thoroughly into the subject … then let my sketch be published as it is, stating that it was done several years ago, and from memory without consulting any works, and with no intention of publication in its present form.

In 1909, these two essays were published by Darwin's son, Sir Francis Darwin, under the compound title *The Foundations of the Origin of Species* (F. Darwin 1909/1969). In numerous editorial footnotes, Francis Darwin indicated the names of authorities and references which Darwin had put in pencil in the margin of his book. The 1844 essay contained all the arguments which were to form the basis of *On the Origin of Species*, but without the plethora of examples with which the later book was burdened. Consequently, the outline of Darwin's thinking is more easily seen.

6.4 Acquired characteristics

Darwin commenced his Essay of 1844 (hereafter referred to as *Foundations*) with a discussion on variation under domestication. As early as his second sentence, Darwin (1909/1969: 57) declared his belief in the doctrine of the inheritance of acquired characteristics:

> Under certain conditions organic beings even during their individual lives become slightly altered from their usual form, size, or other characters: and many of the peculiarities thus acquired are transmitted to their offspring.

That acquired characteristics could be transmitted to offspring was a cornerstone of Darwin's theory, in *Foundations* (Darwin 1909/1969), in *On the Origin of Species* (Darwin 1859/1998) and in *The Descent of Man* (Darwin 1871/1908). Darwin postulated that the altered conditions of domestication acted on the constitution of animals and plants, making their reproductive systems more 'plastic' (Darwin 1909/1969: 63). Darwin, correctly, gave equal attention to plants and animals, unlike Lamarck who addressed only animal evolution. A general theory of evolution must cover *all* living things, including bacteria and other prokaryotes, although Darwin was not aware of these last categories.

6.5 Crossing

For new varieties to be formed under domestication, both selection and separation were necessary. If crossing were allowed, the variation, even if very distinct, would disappear. Separation and selection must be continued for many generations before a 'true' breed could be considered to have been established. Careful selection would result in further new races/varieties (Darwin 1909/1969: 68). However, Darwin warned, if the two races were allowed to interbreed freely, the two original varieties would disappear, being replaced by one 'mongrel' race, which would become homogenous. In the wild there was rarely more than one race/variety of each species. If they could interbreed, they would (Darwin 1909/1969: 71): "I conclude, then, that races of most animals and plants, when unconfined in the same country, would tend to blend together". This conclusion was similar to that arrived at by both Buffon and Blyth. The line of logic Darwin was following was one which would tend to limit variability in nature, not increase it. This was a point which gave Darwin much trouble.

6.6 Variation under domestication

Darwin held that humans could not create variation. They could only select from that which had occurred. Darwin tended to favour excess of nutrition as the most likely cause of the increased variation which occurred under domestication, but, contra his own argument, pointed out that sheep and cattle, domesticated for thousands of years, were still capable of variation, even though their food supply was not increasing. Whether there was a limit beyond which variation was not possible had yet to be determined.

6.7 Variation in nature

After discussing variation under domestication, Darwin considered variation under natural conditions. Variation in nature was slight compared with that under domestication but could occur if organisms in nature were *occasionally* subject to changing geological, and therefore environmental, conditions. Lyell's theory had postulated very gradual geological change and

Darwin stipulated that organisms would have to be isolated in some way to prevent them simply moving with the gradually changing conditions. This might happen if an isthmus was cut off by rising sea levels, or a new volcanic island appeared. Darwin presented his theory thus (Darwin 1909/1969: 87):

> *What if …* there was a Being of great penetrative insight, who could evaluate the innermost as well as the outer characteristics of any organism?
>
> *What if …* that Being had forethought which could extend over future centuries?
>
> *What if …* that Being, working on several islands, was deliberately to choose from the characteristics thrown up by the creature's plastic reproductive system?
>
> *What …* could that Being not accomplish over vast amounts of time, seeing how much blind, capricious man has actually accomplished over a few centuries?
>
> *What if …* there was a *secondary* means in nature which could accomplish all that this hypothetical Being could accomplish?
>
> I believe such a secondary means does exist.

6.8 Natural means of selection

Then followed the section which was to form the paper read jointly with Wallace's paper before the Linnean Society in 1858. It referred to Malthus' well-known work in relation to the tendency for populations to outstrip their supply of food and of the resultant struggle for survival. Darwin then reverted to speculation (Darwin 1909/1969: 97):

> *What if …* a small population was isolated on an island?
>
> *What if …* the conditions on this island were gradually, but continually, changing, then would not the plastic reproduction system throw up variation?
>
> *What if …* some offspring were favoured by this variation and some hindered? Would not the favoured offspring have a better chance of survival?

'Death' would discard unwanted stock. Over thousands of generations, change would occur. This change would be assisted, in some cases, by sexual selection. One, or a few, males being dominant would sire most of the offspring or the female of some species (mostly birds) would choose the mate which attracted their attention by their display.

6.9 Hybrids

Certain plants, which never crossed in the wild, were known to be capable of crossing under domestication and producing fertile hybrids. Darwin concluded that sterility could not be the factor by which species were differentiated from varieties/races. This conclusion was to be vital to the development of his theory.

Certain animals, such as elephants, bears and hawks, had failed to breed in captivity. These animals could be tamed, but never domesticated. Some 'constitutional peculiarity' made tame species incompatible with their new environmental circumstances and prevented them reproducing. Similarly, the 'constitution' of hybrid animals was different from that of either of their parents and it was this 'peculiarity' which prevented them from breeding. If sufficient time and effort were to be directed towards ascertaining exactly what were the most favourable breeding conditions, there was no reason why tame animals should not breed, nor hybrids, in the same manner as any 'mongrel'. Such breeding could produce new varieties or species (Darwin 1909/1969: 78). This conclusion contradicted Darwin's earlier conclusion that varieties/species allowed to interbreed would merge into one stock. Darwin (1909/1969: 104) argued that it was necessary to isolate breeding stock in order to establish a new variety/species but, once established, varieties/species would breed true and the breeder need not fear the throwing of crosses.

Darwin was clearly struggling to reconcile two different positions and this may explain his reluctance to publish at that time. The potential for diversity distinguished his theory from that of Blyth, but it was the concept of diversification that Darwin found so difficult to uphold (Gould 2002: 232-250).

6.10 Limits of variation

Although it was generally assumed by most breeders that there was a limit to the amount of variation which could be produced, Darwin (1909/1969: 104) was "unable to discover a single fact on which this belief is grounded". It was Darwin's opinion that (Darwin 1909/1969: 104):

> Until man selects two varieties from the same stock, adapted to two climates or to other different external conditions, and confines each rigidly for one or several thousand years to such conditions, always selecting the individuals best adapted to them, he cannot be said to have even commenced the experiment.

Were such careful selection to be made over this amount of time, Darwin argued, the constitution of the organic being, be it animal or vegetable, would be changed and the resulting varieties would be indistinguishable from species.

6.11 Mental characteristics

Darwin's third chapter was devoted to mental characteristics, including instincts. He opened this chapter with a caution (Darwin 1909/1969: 112):

> Let me here premise that, as will be seen in the Second Part, there is no evidence and consequently no attempt to show that *all* existing organisms have descended from any one common parent-stock, but that only those have so descended which, in the language of naturalists, are clearly related to each other. *(Italics in original)*

Darwin then postulated the inheritance of acquired mental characteristics on the same grounds as those he had put forward for physical characteristics. He concluded (1909/1969: 115):

> These facts must lead to the conviction … that almost infinitely numerous shades of disposition, of taste, of peculiar movements, and even of individual actions, can be modified or acquired by one individual and transmitted to its offspring.

As possible examples, Darwin offered birds able to build better nests than their companions having a better chance of survival and passing on their greater abilities; birds that fed grubs to their chicks when they themselves were granivorous might once have been omnivorous and the habits of the adult changed, or a shortage of the correct food might have caused the parent bird to offer alternative nourishment to its chicks. Those chicks able to digest the alternative nourishment, in this case grubs, would pass on this ability to their own chicks. Darwin stressed, by use of italics, that he was suggesting *possibilities*, not *probabilities.*

Darwin believed not only that the eye could have evolved very gradually from a more simple structure, but that some body parts may have evolved from parts originally formed for different functions. Some naturalists believed that part of the ear had metamorphosed into the swimming bladder in fish, one of the rare occasions when Darwin cites prior opinions of other naturalists supporting evolution. Creatures such as bats, seals and gliding squirrels exhibited characteristics and abilities more commonly associated with other families. The jaguar swam and caught fish. Perhaps in time the jaguar would become a water animal? Darwin (1909/1969: 132) asked:

> Who will say what could thus be effected in the course of ten thousand generations? Who can answer the same questions with respect to instincts? If no one can, the *possibility* (for we are not in this chapter considering the *probability*) of simple organs or organic beings being modified by natural selection and the effects of external agencies into complicated ones ought not to be absolutely rejected. [Italics in original]

In the second part of his book, Darwin attempted to convert *possibility* into *probability.*

6.12 Fossil record

Darwin had based his theory of natural selection on three basic propositions: time, isolation and inheritance of acquired characteristics. Time was the first issue he dealt with in the second section of his book. Darwin expounded the theories of Hutton and Lyell regarding the age of various geological formations, of sediments, of the raising and lowering of sea levels consequent upon the raising and subsidence of land masses, of inundation, of formation of islands, of glaciation, concluding that it was a surprise that as many fossils had survived as had been found. The imperfection of the fossil record accounted for the fact that intermediate fossil species were so seldom found. Darwin suggested that animals, such as tortoises and crocodiles, had remained basically unchanged because their conditions had changed little and used this as evidence to contradict Lamarck's theory that there was in animate nature an inherent tendency towards change and development. However, conditions would have changed little in the oceans, which support a multitude of different life forms, even in the 'deep', a point which seems to have received little or no attention in the literature on evolution.

6.13 Isolation

Using mammals as his example, Darwin drew attention to the differences between Australia/New Guinea and the rest of the world. While all areas had their own flora and fauna, there were many resemblances between them, these resemblances/differences being difficult to explain under Divine creation. Why would the Creator bother with small changes? Surely one would expect the Creator either to place the same creatures all over the world, or completely different ones? Although a major barrier had caused Australia to be isolated from the rest of the world, and had allowed a completely different fauna to evolve, namely the marsupials, yet there was a connection with the rest of the world in that Australia was inhabited by vertebrates, mammals, birds, fish, etc. Furthermore, a few marsupials existed in South America.

From major barriers and major differences, Darwin moved to minor barriers and minor differences. Deserts, mountains, rivers, arms of the sea, all could have served to separate one variety or species from another. Fauna and flora on islands which differed from that on the nearest mainland were nevertheless nearly always of a closely allied type, although slight differences could be observed between islands of a group such as the Galápagos. Prior occupation of an area could be sufficient to prevent new arrivals from taking hold. However, not all flora and fauna living in a certain environment were perfectly adapted, as was shown by the rapidity with which introduced European species were out-competing some indigenous species.

6.14 Creation of new species

Before proceeding further with his thesis, Darwin recapitulated his three main points:

(1) repeated changes in conditions over several generations;
(2) steady selection of these slight varieties with a fixed end in view;
(3) isolation.

Darwin's second point, "a fixed end in view", was to become anathema to later Darwinists. As shown in Section 6.7 (above), Darwin had based his theory on the assumption of the existence of a "Being of great penetrative insight" with "forethought that could extend over future centuries".

Thus far, Darwin had attempted to establish the means by which variation could occur within a species, but had not yet shown how a new species might evolve. He argued that a large number of animals on a large area could be expected to produce a 'sport' more frequently than a small number of animals in a small area, such as an island. However, Darwin realized that more interbreeding would take place in a large population, making new characteristics which had appeared by chance more difficult to establish (Darwin 1909/1969: 184):

> If, however, he [the breeder on the mainland] could separate a small number of cattle, including the offspring of the desirable 'sport', he might hope, like the man on the island, to effect his end. If there be organic beings of which two individuals *never* unite, then simple selection whether on a continent or island would be equally serviceable to make a new and desirable breed; and this new breed might be able in surprisingly few years from the great and geometrical powers of propagation to beat out the old breed.

Darwin moved from a 'sport' occurring within a population of interbreeding animals to two groups of animals which *never* united to postulate the start of a new breed. The characteristics of the 'sport' would produce the new race, without reversion to the original type due to interbreeding, simply because the 'sport' was part of a small, isolated population. Darwin drew the picture of an island, or group of islands, gradually emerging from the sea. To this island, plants and animals would gradually arrive, having been transported by a variety of means, such as hurricanes, floods, floating trees or roots, or as seed in the stomach of some animal. Conditions would be different, and 'it might also easily happen that some of the species *on an average* might obtain an increase of food, or food of a more nourishing quality' (Darwin 1909/1969: 185-186):

> We might therefore expect on our island that very many slight variations were of no use to the plastic individuals, yet occasionally in the course of a century an individual might be born of which the structure or constitution in some slight degree would allow it better to fill up some office in the insular economy and to struggle against other species … and if (as is probable) it and its offspring crossed with the unvaried parent form, yet the number of individuals being not very great, there would be a chance of the new and more serviceable form being nevertheless in some slight degree preserved.

This last conclusion is contrary to the evidence Darwin presented in the first part of his book in which he reviewed change under domestication, where he showed that great care had to be taken to isolate the *individual* carrying the desired new trait and to ensure its careful mating.

Darwin then envisaged a geological situation such that several adjacent islands might be formed. These would be stocked by similar or different chance arrivals from the nearest mainland, or by some of the already changed inhabitants of the first island. The islands would grow, possibly merge, eventually forming a large body of land, even a continent. As this happened, conditions would constantly be changing and so would the inhabitants, although isolation would no longer be a factor. As land rose in one part of the world, so it would sink in another. As continents sank, their land would become inundated, mountains become islands, creatures become isolated, and so the pattern would continue (Darwin 1909/1969: 190):

> Let the now broken continent, forming islets, begin to rise … let the islands become reunited into a continent … The oftener these oscillations of level have taken place … the greater the number of species which would tend to be formed.

Since sedimentary materials were not deposited on oceanic islands, the absence of intermediate fossils showing transitional stages was easily understood. Fossils were preserved more readily during times of subsidence. Darwin conceded that enormous lapses of time would be needed for an island to be converted into a continent (Darwin 1909/1969: 194-197).

6.15 Now you see it …

Darwin asked his reader to imagine that a certain species had become divided into six different regions. Conditions being different, they would develop into six different, but related, species. Some might not survive, but suppose half did. Suppose these three related species also became divided into several separate regions, they would develop into further species. These 'cousins' would form a *genus*. If the process were to be repeated, the future generations would form a *family.* The older forms would probably become extinct, but *families, genera, species, varieties* would continue. Darwin glossed over the fact that all varieties of domesticated species continue to be inter-fertile, that they are *not* species, genera or families. He had drawn an analogy which was not sustainable. Darwin (1909/1969: 212-213) went on to claim that:

> It follows from our theory, that two orders must have descended from one common stock at an immensely remote epoch … The existence of genera, families, orders, &, and their mutual relations, naturally ensues from extinction going on at all periods amongst the diverging descendants of a common stock.

Darwin here postulated for the first time that 'orders' have common descent. In the first part of his book, Darwin had stated that "as will be seen in the Second Part, there is no evidence and consequently no attempt to show that all existing organisms have descended from a common stock", yet this was clearly the direction in which his argument was leading him. In the final chapter of *Foundations*, Darwin (1909/1969: 252) referred to this point again:

> No doubt the more remote the two species are from each other, the weaker the arguments become in favour of their common descent … But if we once admit the general principles of this work … we are legitimately led to admit their community of descent. Naturalists dispute how widely this unity of type extends: most, however, admit that the vertebrata are built on one type, the articulata on another; the mollusca on a third; and the radiata on probably more than one. Plants appear to fall under three or four great types. On this theory, therefore, all organisms *yet discovered* are descendants of probably less than ten parent forms. [Italics in original]

6.16 Embryology

Lamarck and Chambers had assumed that evolution always occurred in the direction of greater complexity. Darwin correctly pointed out that this was not always the case. The 'Epizoic' Crustaceans were free swimming in early life, with articulated limbs and eyes, which they lost in maturity as they became attached to a fish upon which they preyed and which they never left.

Associated with this tendency towards increased simplicity as well as increased complexity, Darwin saw vestigial and rudimentary organs, a circumstance which he claimed was completely incompatible with the doctrine of Special Creation. Why would God create a beetle with fused wings or a fish with useless eyes? Over time a 'station' occupied in other districts by less complicated animals might be left unfilled, and be occupied by a degraded form of a higher or more complicated class (Darwin 1909/1969: 227). The arguments Darwin made in this section are among the most logical of his entire book.

As shown in Chapter 5, Eiseley (1979) had shown, by similarity of thought and phrase, that Darwin had drawn from the work of Blyth when he wrote *Origins* (Darwin 1859). Darlington (1959) made a similar examination, and reached a similar conclusion, in relation to Darwin's *Foundation* documents of 1842 and 1844.

6.17 *Journal of Researches*

Having completed his *Foundation* document to the best of his ability, Darwin turned his attention to the reworking of his *Journal*, the first edition of which had been published, as required by the Navy, along with the report of the journey of *HMS Beagle* prepared by Captain FitzRoy (Darwin 1839). Publishing a second edition, retitled *Journal of Researches into the Natural History and Geology of the Various Countries Visited During the Voyage of HMS Beagle round the World* (Darwin 1845), allowed Darwin to fill out his account with thoughts and opinions which had occurred to him during the intervening years. Darlington (1959) had studied Darwin's early writings and had been unable to find any hint of evolutionary thought in the notes and letters Darwin had written while on the *Beagle*, or, indeed, shortly thereafter (see Barrett et al. 1987). This led Davies (2008: 10, 19-22) to the opinion that Darwin had deliberately introduced his new thinking into the pages of the *Journal of Researches* in an attempt to deceive people into believing that these thoughts had occurred to him while on his voyage, thereby enabling him to be perceived as having anticipated the work of Edward Blyth (see Chapter 5) which had been published 1835-1837.

A careful comparison of the first and second editions of the *Journal* revealed that (Davies 2008: 34):

> Throughout the second account, Darwin had inserted paragraphs dealing with evolutionary ideas that could only have been written by Darwin, the evolutionist, and not by Darwin the geologist, as he was on the *Beagle* voyage.

In support of this claim, Davies (2008: 34) cited a paragraph from Gruber (1974: 25):

> Taken out of their hiding places and strung together, they form an essay which gives almost the whole of his thought. He used methods of concealment, fragmentation and dispersal of the relevant passages, a paragraph here and there throughout the book, and omission of one vital ingredient, the principle of natural selection acting to produce new species.

While this latter paragraph does seem to imply intent to deceive on the part of Darwin, it must be pointed out that Gruber (1974) did not expand upon the matter any further. He made no mention of Blyth anywhere in his book.

Some credence may be given to Davies' (2008) claim of deliberate deception by noting that Darwin undertook the task of revising his *Journal* immediately after he had completed his *Foundation* document, even changing its name to *Journal of Researches* (Darwin 1845). It is possible that, realising it may be some time before he was in a position to publish his ideas, Darwin took what steps he could to establish some priority. Darwin thereafter constantly referred in his letters (F. Darwin 1887, 1903) to the length of time upon which he had been working on his big book. If it was Darwin's aim to deceive, there may have been some poetic justice in the fact that it was this second edition which, in 1845, inspired the young Alfred Wallace to set out upon his journeys to distant lands to discover 'the origin of species' (see Chapters 8 and 9).

Chapter 7

On the Origin of Species

7.1 Introduction

Darwin's major work, *On the Origin of Species by Means of Natural Selection or, The Preservation of Favoured Races in the Struggle for Life* (Darwin 1859/1998), hereafter referred to as *The Origin*, was as much an extension of his 1844 Essay as it was an abstract of the longer work he was writing and which he had planned to call *Natural Selection*. *The Origin* was hastily assembled in one year following the receipt of a letter from Wallace which clearly showed that Wallace had reached a similar conclusion to that of Darwin in relation to evolution (see Chapter 8).

Darwin's basic thesis remained the same as expressed in *Foundations*. He commenced with a discussion of variation under domestication, from which he extrapolated to variation in nature. He moved between 'species' and 'variety/race' in a most confusing manner and also blurred the distinction between 'hybrid' and 'mongrel'.

7.2 Varieties and species

For Darwin to extend the concept of common descent beyond variation within species, he needed to break down the distinction between species and varieties and this was the aim of the second chapter of *The Origin.* The supposed boundary, Darwin claimed, could rarely be proved. Where the divide ran depended upon the individual opinion of various naturalists. While acknowledging that the term 'species' was generally applied to populations which appeared to be the result of distinct acts of creation and 'variety' to those which had resulted from common descent, Darwin argued that the application of these definitions was circular. To define species by inter-sterility and then claim that no species were inter-fertile with one another, or that all varieties were inter-fertile simply because that was the definition of 'variety', proved nothing (Darwin 1859/1998: 207).

Darwin's examples were drawn from plants, some insects and brachiopods, which also had polymorphic forms and/or were hermaphrodite. At this stage of his argument, Darwin made no reference to mammals. He claimed the disagreement among naturalists as to whether certain plants were varieties or species as evidence that there was no boundary, not as evidence that the correct boundary had not been found. In Chapter 8, where he discussed 'hybridism', Darwin (1859/1998: 188 and 189) stated:

> The fertility of varieties, that is the forms known or believed to have descended from common parents, when inter-crossed, and likewise the fertility of their mongrel offspring is, on my theory, of equal importance with sterility of species; for it seems to make a broad and clear distinction between varieties and species …
>
> It is certain, on the one hand, that the sterility of various species when crossed is so different in degree and graduates away so insensibly, and, on the other hand, that the fertility of pure species is so easily affected by various circumstances, that for all practical purposes it is most difficult to say where fertility ends and sterility begins … It can thus be shown that neither sterility nor fertility affords any clear distinction between species and varieties.

In consecutive pages, Darwin claimed that fertility/sterility made a broad and clear distinction between varieties and species and that neither sterility nor fertility afforded any clear distinction at all.

Crosses between varieties of animals are generally referred to as 'mongrel' and crosses between species or varieties of plants as 'hybrid'. Darwin used evidence of plant hybridisation to support his contention that animal mongrels and hybrids were essentially no different (see Section 7.3). He further contended that there was no clear demarcation between species and subspecies or between subspecies and well-marked varieties, between lesser varieties and individual differences (Darwin 1859/1998: 42):

> … I attribute the passage of a variety, from a state in which it differs very slightly from its parent to one in which it differs more, to the action of natural selection in accumulating … differences of structure in certain definite directions. Hence I believe a well-marked variety may be justly called an incipient species …
>
> I look at the term species as one arbitrarily given for the sake of convenience to a set of individuals closely resembling each other, and that it does not essentially differ from the term variety … The term variety, again in comparison with mere individual differences, is also applied arbitrarily, and for mere convenience sake.
>
> I look at individual differences … as of high importance … And I look at varieties which are in any degree more distinct and permanent as steps leading to more strongly marked and more permanent varieties, and at these latter as leading to sub-species and to species.

The chief aim of Darwin's second chapter was to claim varieties, strongly marked and permanent varieties, sub-species and species were names of human contrivance, having no reality in nature. He was to return to these claims as he developed his thesis.

7.3 Hybridism

Darwin devoted the whole of Chapter 8 to the problem of hybridism. In *Foundations* (Darwin 1909/ 1969) he had suggested that changed conditions in captivity made the reproductive system 'plastic', producing variation which had led to all the domestic varieties of plants and animals. The failure of some captive animals to breed, let alone cross-breed, was due to lack of suitable conditions. In *The Origin,* Darwin still attributed variability to changed conditions acting on the reproductive system, but he (1859/1998: 64) also included an alternative, that hybrid animals (mules) were infertile due to inbreeding. Attempts to breed mules (horse/donkey, fox/wolf/dog) had nearly always involved the mating of siblings (Darwin 1859/1998: 193). With plants it had sometimes been possible to produce fertile seed, but fertility decreased generation by generation, until eventually it disappeared (Darwin 1859/1998: 188-190). Darwin concluded close interbreeding led to sterility.

In *Foundations,* Darwin had gone to great lengths to postulate ways in which small populations could have become isolated, so that continual inbreeding could result in new varieties/species. In the first chapter of *The Origin,* Darwin had emphasized how important it was for domestic breeders to keep new varieties pure by constant inbreeding, preventing any cross-breeding with old stock or other varieties. Now Darwin took a different position. Interbreeding with old stock became essential to keep the line healthy (Darwin 1859/1998: 190). Darwin invited his reader to consider the pigeon varieties as species (Darwin 1859/1998: 128), pointed out that "The hybrids or mongrels from all the domestic breeds of pigeons are perfectly fertile" (Darwin 1859/1998: 22) but then said "to extend the hypothesis so far as to suppose that species as distinct as carriers, tumblers, pouters, and fantails now are, should yield offspring perfectly fertile, *inter se,* seems to me rash in the extreme" (Darwin 1859/1998: 23). European and Chinese geese, European and Indian cattle, each supposed by some to be separate species, interbred and produced fertile offspring. Some argued that the geese and cattle were each but varieties. Darwin (1859/1998: 194) did not take this view:

> … most of our domestic animals have descended from two or more aboriginal species, since commingled by intercrossing. On this view, the aboriginal species must either at first have produced quite fertile hybrids, or the hybrids must have become in subsequent generations quite fertile under domestication. This latter alternative seems to me the most probable … On this view of the origin of many of our domestic animals, we must either give up the belief of the almost universal sterility of distinct species of animals when crossed; or we must look at sterility, not as an indelible characteristic, but as one capable of being removed by domestication …
>
> There is no reason to think that species have been specially endowed with various degrees of sterility to prevent crossing and blending in nature … There is no fundamental distinction between species and varieties.

If fertility of hybrids only occurs under domestication, exactly what conclusion Darwin was trying to reach in relation to wild animals in nature is unclear. Earlier Darwin (1859/1998: 18) had commented:

> … that a race could be obtained nearly intermediate between two entirely different races or species, I can hardly believe … A breed intermediate between *two very distinct* races or species could not be got without extreme care and long-continued selection, nor can I find a single case on record of a permanent race having been thus formed. *(Italics in original)*

Throughout his book, Darwin constantly presents arguments which appear to undermine his own thesis.

7.4 The evolution of instinctive behaviour

Darwin introduced his theory of evolution by natural selection in the third chapter of his book. His basic hypothesis was that individuals having an advantage over others, however slight, would survive and procreate; variation in the least degree injurious would be rigidly destroyed. This principle applied to 'mental' characteristics as well as to physical. For example, under domestication, dogs had been trained to retrieve, herd, guard, etc. (Darwin 1859/1998: 164-165). Those displaying most prominently the desired characteristic had been selected by breeders and passed on to their offspring the 'mental' pattern they had acquired by training during their life time. Gradually these patterns became so ingrained they became instinctive. Instinctive behaviour had been developed in the wild in a similar manner. An advantageous behaviour practised by a parent would be more easily acquired by its offspring until, after a number of generations, that advantageous behaviour became instinctive.

7.5 Social insects

Natural selection could only act through and for the good of each being (Darwin 1859/1998: 63-66). Darwin (1859/1998: 154) started his discussion on social insects by making what at first appears to be a simple statement, but which was, in fact, a crafty one:

> Natural selection will never produce in a being anything injurious to itself, for natural selection acts solely by and for the good of each. No organ will be formed, as Paley has remarked, for the purpose of causing pain or doing injury to its possessor.

By including Paley's name, Darwin was pointing out that inexplicable things seemed to happen even in God's perfect creation, thereby pre-empting criticism of his theory by Creationists. Darwin (1859/1998: 155) then moved on to consider the stings of wasps and bees:

> Can we consider the sting of the wasp or of the bee perfect, which … cannot be withdrawn, owing to the backward serratures, and so inevitably causes the death of the insect by tearing out its viscera? … if on the whole the power of stinging be useful to the community, it will fulfil all the requirements of natural selection.

Darwin had argued both that no organ would be formed by natural selection which would harm its possessor and that an organ which resulted in the death of the individual was perfectly compatible with natural selection. It must be said that why these insects do not possess a retractable stinging apparatus is a problem for both Creationists and Darwinists.

Darwin had commenced his chapter on hybrids by commenting that sterility could not be an advantage to hybrids and could not have been acquired by the "continued preservation of successive profitable degrees of sterility", since there is no profit in sterility (Darwin 1859/1998: 187). Darwin now needed to explain the evolution of classes of sterile individuals (workers) in colonies of social insects. Until this point, Darwin had maintained that variation occurred in individuals and it was *individuals* who survived in the struggle for life. Now he took an alternative position. It was the *community* which was all important – the individual was expendable (Darwin 1859/1998: 155, 181):

> It may be difficult, but we ought to admire the savage instinctive hatred of the queen-bee, which urges her instantly to destroy the young queens, her daughters, as soon as born … for undoubtedly this is good for the community …
>
> If … it had been profitable to the community that a number should have been annually born capable of work, but incapable of procreation … I can see no very great difficulty in this being effected by natural selection … The great difficulty lies in the working ants differing widely from both the males and the fertile females in structure … with the working ant we have an insect differing greatly from its parents, yet absolutely sterile; so that it could never have transmitted successively acquired modifications of structure or instinct to its progeny … how is it possible to reconcile this case with the theory of natural selection?

On the next page, Darwin offered his solution (Darwin 1859/1998: 182):

> This difficulty … is lessened, or, as I believe, disappears, when it is remembered that selection may be applied to the family, as well as to the individual … Thus, a well-flavoured vegetable is cooked, and the individual is destroyed, but the horticulturist sows seeds of the same stock and confidently expects to get nearly the same variety; … [with] breeders of cattle … the animal has been slaughtered, but the breeder goes with confidence to the same family.

Darwin overlooked the fact that he was supposed to be explaining how *different* characteristics of structure or instinct were passed on via sterile insects. Darwin (1859/1998: 182-185), bravely or foolishly depending upon the point of view taken, continued:

> … the neuters of several ants differ, not only from the fertile females and males, but from each other, sometimes to an almost incredible degree … It will indeed be thought that I have an overweening confidence in the principle of natural selection, when I do not admit that such wonderful and well-established facts at once annihilate my theory … I believe that natural selection, by acting on the fertile parents, could form a species which should regularly produce neuters …
>
> I am bound to confess that, with all my faith in this principle, I should never have anticipated that natural selection could have been efficient in so high a degree, had not the case of these neuter insects convinced me of the fact … I am surprised that no one has advanced this demonstrative case of neuter insects against the well-known doctrine of Lamarck.

This thrust at his (perceived) adversary brings the chapter to a close, except for a one page summary, which is best known for its final sentence which ended with the claim that there was (Darwin 1859/1998: 186):

> ... one general law, leading to the advancement of all organic beings, namely, multiply, vary, let the strongest live and the weakest die.

7.6 Isolation

When writing *Foundations*, Darwin (1909/1969) had become convinced of the need for isolation to allow new varieties and species to become established. By the time he wrote *The Origin*, Darwin (1859/1998: 82-83) had changed his mind:

> Although I do not doubt that isolation is of considerable importance in the production of new species, on the whole I am inclined to believe that largeness of area is of more importance … the course of modification will generally have been more rapid in large areas … On a small island the race for life will have been less severe and there will have been less modification and less extermination

Comparing *The Origin* with Darwin's earlier essay, *Foundations*, Steadman and Zousmer (1988: 56) remarked that *The Origin* contained 'voluminous, well-ordered arguments'. Voluminous evidence there certainly was, but it is here claimed that Darwin's arguments were neither well-ordered nor internally consistent.

7.7 *Natura non facit saltum*

Upon one point, Darwin remained steadfast, not only in writing *The Origin*, but for the remainder of his life. Nature took no leaps. Natural selection always acted with extreme slowness; evolution was a gradual process (Darwin 1859/1998: 84). This was a point upon which Darwin and his good friend, Thomas Huxley, did not agree. Huxley felt that Darwin had unnecessarily restricted his theory by denying any evolutionary role to 'sports' or 'monsters' (Huxley 1900).

Paley (1833) had taken the eye as his first example of Divine design. How a nerve ending originally became sensitive to light "hardly concerns us" (Darwin 1859/1998: 144) but in this sensitivity once having been established, Darwin (1859/1998: 144 and 146) saw:

> … no very great difficulty … in believing that natural selection has converted the simple apparatus of an optic nerve merely coated with pigment and invested by transparent membrane, into an optical instrument …
>
> If it could be demonstrated that any complex organ existed which could not possibly have been formed by numerous, successive, slight modifications, my theory would absolutely break down. But I can find no such case.

It was not only individual organs in the process of transition which Darwin was called upon to explain. Darwin (1859/1998: 138, Hull 1973) was also required to explain how a species of animal could have subsisted in a transitional state. Opponents of evolutionary theory had asked how a carnivorous land animal could have turned into an aquatic one. Darwin (1859/1998: 141-142) answered this by pointing to creatures such as the otter and the whale:

> In North America the black bear was seen by Hearne swimming for hours with widely open mouth, thus catching, like a whale, insects in the water. Even in so extreme a case as this, if the supply of insects were constant, and if better adapted competitors did not already exist in the country, I can see no difficulty in a race of bears being rendered, by natural

> selection, more and more aquatic in their structure and habits, with larger and larger mouths, till a creature was produced as monstrous as a whale.

Darwin had been working on his theory for twenty years and had accumulated copious notes and examples. His choosing to include this example in *The Origin* cannot have been the result of haste in compiling his manuscript. It must have been included following much thought over many years.

Darwin evinced a somewhat dismissive attitude towards 'difficulties', seeming to think that because he did not 'see' them, or consider them important, they either did not exist, or were of no consequence (Darwin 1859/1998: 138):

> If a different case had been taken, and it had been asked how an insectivorous quadruped could possibly have been converted into a flying bat, the question would have been far more difficult, and I could have given no answer. Yet I think such difficulties have very little weight.

7.8 Variety of theories

Darwin concluded (1859/1998: 364) that all organic beings that had ever lived had probably descended from one primordial form. This was similar to the conclusion reached by Lamarck and by countless other evolutionary theorists. To the question "Did he *prove* that evolution had proceeded by natural selection?", the answer must surely be "No".

If there were two sides to an argument, Darwin at some point in his book adopted them both. Varieties gave rise to species, species gave rise to varieties; variation started with the individual and spread to the group; variation started with the group and spread to the individual; there were distinct differences between species and varieties, there were no differences between species and varieties; hybrids never gave rise to new species, hybrids were the start of new species; isolation was essential to prevent reversion to the original form, isolation caused inbreeding and led to infertility; nothing could evolve by natural selection which would harm the individual, the death of the individual was of no consequence if its fellows benefited; water acted as an isolating barrier, water acted as a means of dispersal.

It is little wonder than Darwin had been so hesitant to publish his ideas. He had a grand vision, but experienced great difficulty in working out the details.

7.9 The problems of inbreeding

The theoretical part of Darwin's work was contained in the first four chapters of *The Origin,* the remaining chapters having been an extrapolation of his theory, illustrated by numerous examples. These were later expanded into a two volume work, *The Variation of Animals and Plants under Domestication* (Darwin 1868/1893), which was probably the most logically presented of all his theoretical treatises, and a second two volume work, *The Descent of Man* and *Sexual Selection* (1871/1908). While the remainder of Darwin's epic remained uncompleted, it could be said that Darwin did, in fact, complete the theoretical component of his great work.

In *The Variation,* Darwin covered an extraordinary amount of material in relation to both plants and animals under domestication. Voluminous in detail as was this work, it was generally well constructed and most points were made clearly and logically. Writing of the ill-effects of inbreeding, Darwin told how there was an exchange of stags among the deer herds of England's Great Parks and how breeders of birds and dogs, etc., introduced a sire from another breeding stock to keep their line strong and healthy (Darwin 1868/1893: 95). Any breeder trying to develop a certain characteristic would endeavour to obtain an animal with characteristics as close as possible to those which were being developed. In *The Origin*, Darwin had been indecisive as to whether large or small populations allowed the greatest opportunity for variations to arise and become established. In *The Variation* Darwin was quite clear that small, inbred populations were detrimental.

7.10 Unknown changes

Darwin (1868/1893: 170-171) tackled once again the subject of hybrids and what he had to say was interesting:

> But he who would take the trouble to reflect on the steps by which this first degree of sterility could be increased through natural selection to that higher degree which is common to so many species, and which is universal with species which have been differentiated to a generic or family rank, will find the subject extraordinarily complex. After mature reflection, it seems to me that this could not have been effected through natural selection. Take the case of any two species which, when crossed, produce few and sterile offspring; now, what is there which could favour the survival of those individuals which happened to be endowed in a slightly higher degree with mutual infertility and which thus approached by one small step towards absolute sterility?
>
> As species have not been rendered mutually infertile through the accumulative action of natural selection … we must infer that it has arisen incidentally during their slow formation in connection with other and unknown changes in their organization.

Darwin had encountered the same stumbling block as Buffon. Later writers, such as Dawkins (1976 and elsewhere), Dobzhansky (1970 and elsewhere), Gould (2002 and elsewhere), and many more, were to consider natural selection as all sufficient to account for all evolution, citing Darwin as their authority, although Darwin, himself, never made this claim. Here he appears to have reconsidered the argument regarding sterility among insects that he had made in *The Origin*.

7.11 Pangenesis

The final part of *Variations* saw Darwin return to the inheritance of acquired characteristics. He had never doubted that new characteristics acquired during the lifetime of an individual could be inherited and now endeavoured to explain how this might come about. In both

Foundations and *The Origin*, Darwin had put forward the idea that characteristics such as smallness of stature due to adverse growing conditions (Darwin 1859/1998: 36) and variations under domestication due to changed living conditions (Darwin 1859/1998: 165) could be passed on to future generations. Instincts, too, were patterns of behaviour repeated so frequently that they became inherited characteristics and Darwin had extended this principle to the effects of compulsory training to explain how dogs had been bred to point, fetch, guard, herd, etc. (Darwin 1859/1998: 164-165).

Darwin (1868/1893: 369-370) introduced his theory of *Pangenesis* thus:

> It is universally admitted that the cells or units of the body increase by self-division … and … become converted into the various tissues and substances of the body. But besides this means of increase, I assume that the units throw off minute granules which are dispersed throughout the whole system … these … multiply by self-division … [and] may be called gemmules. They are collected from all parts of the system to constitute the sexual elements, and their development in the next generation forms a new being; but they are likewise capable of transmission in a dormant state to future generations and may then be developed.

The last stipulation was necessary to account for reversions or throwbacks. Darwin was, of course, well aware of the work of botanists who had crossed varieties of plants with well-defined characteristics, such as different coloured flowers, and was familiar with the concept that in the first hybrid generation one form dominated (was 'prepotent') over the other, but that when these hybrids were self-fertilized, the proportion of dominant/prepotent forms decreased. Darwin had himself experimented with *Antirrhinum* at about the same time that Mendel was carrying out his experiments with sweet peas (Vorzimmer 1970). Darwin concluded that 'prepotency', while an interesting phenomenon, did not contribute to long-term change, such as was needed to bring about evolution, because it was a force which expended itself over a few generations. Darwin's theory of *pangenesis*, was concerned with how characteristics changed and how these changes were inherited, not with how new characteristics appeared in the first instance.

It is noted that Darwin gave no evidence for the existence of 'gemmules' other than that he 'assumed' they existed. These 'gemmules', Darwin suggested, circulated throughout the body and were able to reproduce themselves. They might remain undeveloped during the early stages of life or during succeeding generations, their development depending on their union with other cells with which they had an affinity (Darwin 1868/1893). Some creatures, such as salamanders, crabs and worms, were able to utilise 'gemmules' to reproduce lost parts; others, such as mammals, could use them only for repair.

At mating, 'gemmules' from both parents would align themselves with similar 'gemmules' from the other partner (and this could be a very refined process), but other 'gemmules' were somehow able to be transferred into the newly forming foetus and continue to reproduce themselves, for generation upon generation, explaining the reappearance after many generations of some family trait.

As his example, Darwin suggested an animal subjected to a changed environment, either naturally or because of domestication. If the climate were cooler, the animal might develop thicker fur and the 'gemmules' from the increased hair follicles would be incorporated into the offspring. If all animals in a population were subject to the same change, it would not take long for the new 'gemmules' to outnumber the old and thicker fur would become an inherited characteristic. Changes in nerve pathway in the brain, brought about by repeated patterns of behaviour, would also be subject to the same law of inheritance, hence the establishment of instincts and of characteristics such as shown by the various breeds of domestic dog.

Darwin (1868/1893: 165) cited numerous examples of experiments carried out on animals, such as those where parts of the body had been excised or amputated to see if regrowth would occur, or where the spur of a cock had been inserted into the ear of an ox, growing to 24 cm. and weighing 396 grammes. Darwin was clearly fascinated by these experiments and this fascination helps to explain his antagonism towards the anti-vivisectionists, who were opposed to experimentation upon live animals (Romanes 1896: 61). None of these acquired 'characteristics' were inherited.

Darwin needed to explain how it was that dogs and sheep, which had had their tails docked for generations, were not born with docked tails, since his theory assumed that an altered body part produced altered 'gemmules'. More than 3,000 years of circumcision had not resulted in the birth of a single Jewish man not in need of the operation. This, Darwin (1868/1893: 391-392) explained, was due to the original 'gemmules' being inherited along with the altered 'gemmules', reproducing themselves more efficiently and therefore out-competing the altered 'gemmules'. Changes made at a specific stage of life would manifest in future generations at the same stage of life (Darwin 1868/1893: 364). Darwin urged that young women should undergo intensive physical and mental training approaching the age of marriage, so that the benefits gained at that time might be transmitted to their offspring.

In the second edition of *Variations,* Darwin inserted a footnote acknowledging that both Aristotle and Buffon had put forward theories similar to *Pangenesis.* He also acknowledged the theory of *Parthogenesis* published by Owen in 1840 and the *physiological units* proposed by Herbert Spencer (1863) in his *Principles of Biology.* None of these theories, Darwin claimed, were the same as his theory. Finally, he acknowledged the work of Mantegazza, which he admitted clearly foresaw the doctrine of *Pangenesis*, but gave no further details.

7.12 Confusion

Confusion continues to exist regarding Darwin's views. Maynard Smith (1982: 91) explained that Darwin not only accepted Lamarck's views on the inheritability of acquired characteristics but that they were essential to his theory. Darwin's rejection of Lamarckism related to Lamarck's concept of progressive evolution driven by the 'needs' of the individual. Darwin was now placing less emphasis on the idea of evolution as a 'driven' process, or one resulting from 'forethought' by some natural force, than he had in *Foundations*, rather envisioning variation as happening randomly, with natural selection replacing God, or the Creative Force, in determining what would survive and what would perish. Unfortunately, some thirty years later, Maynard Smith's elucidation of this point is ignored in the general literature, which still generally equates Darwin's rejection of 'Lamarckism' with a rejection of 'inheritance', not of 'direction'. For example, Fernandez-Armesto wrote (2004: 85):

> As he [Lamarck] formulated it in 1809, biota adapted to their environments and such adapted characteristics were passed on by heredity … Darwin – whose theory of evolution is now recognized to be incompatible with Lamarck's – actually endorsed his predecessor's views. In deference to Lamarck, Darwin advised young women to acquire 'many skills' before starting families. (Nonetheless, one of the advantages of his own account of evolution was that it did not rely on the dubious claim that acquired characteristics are heritable). [Parentheses in original]

Fernandez-Armesto was clearly well aware of Darwin's theory of *Pangenesis,* since it was in the same work Darwin made the suggestion relating to female education. His denial of Darwin's acceptance of the inheritance of acquired characteristics is difficult to comprehend.

As a result of his work as an immunologist, Steele (Steele 1979; Steele et al. 1998) came to the conclusion that separation of somatic and reproductive DNA might not be as absolute as thought. Steele specifically mentioned Darwin's theory of *Pangenesis* as being an early example of this line of thought. Despite these explanations and tentative justifications, most neo-Darwinists still misunderstand/misinterpret Darwin's theory of *Pangenesis*, which they seem to regard as but the unfortunate aberration of an elderly man. Just how unimportant *Pangenesis* is deemed to be by many modern writers is illustrated by Dennett (1995: 321) whose only reference to *Pangenesis* comes in a sentence, itself in parentheses, suggesting that any reader interested in Darwin's "unconstrained imagination about mechanisms of inheritance" should consult "Desmond and Moore 1991, pp.531ff". Referral to Darwin's original work, rather than to the footnote of other authors, would have been more appropriate.

7.13 *Descent of Man*

In 1871, Darwin finally published his long awaited volume on human descent (Darwin 1871/1908). Darwin's apparent reluctance to address this issue has never been fully explained, since the idea was certainly not new. Indeed, he cited Lamarck, Wallace, Huxley, Lyell, Vogt, Lubbock, Buchner, Rolle and Häckel as being among those who had anticipated him, the one occasion upon which Darwin seemed happy for this to have occurred!

Although Darwin did stipulate that humans must have descended from a branch of the anthropoid stock, his book was predominantly about differences between current human races/species and how they had evolved. While Darwin thought Africa was the most likely continent upon which this anthropoid divergence took place, he pointed out that apes had lived in Europe during the Miocene era (Darwin 1871/1908: 273). As to whether humans were all of one species, that question could not be answered until a satisfactory definition of 'species' was forthcoming. However, Darwin (1871/1908: 266-272) tended to think that humans were all descended from the same anthropoid stock and were not different species.

Darwin had gone to great lengths to acquire information on differences between humans. For example, he had learned from the United States Commission that the legs of sailors employed in the recent war were longer by 0.327 of an inch than those of soldiers but their arms were shorter by 1.09 of an inch. "This shortness of the arms is apparently due to their greater use, and is an unexpected result: but sailors chiefly use their arms in pulling, and not in supporting weights" (Darwin 1871/1908: 48). He considered it probable that these modifications would become hereditary.

Humans could hardly have developed the manual skills necessary to make weapons or hurl them accurately had they not become bipedal (Darwin 1871/1908: 77): "... from these causes alone it would have been an advantage to man to become bipedal". This comment implies forethought and planning on the part of evolution (teleology), an idea which he had clearly not completely abandoned, but which was not acceptable to his followers.

On the one hand, Darwin was certain that over time the 'civilized races' would exterminate, not only the apes, but the 'inferior races' as well (Darwin 1871/1908: 242), but on the other hand, Darwin (1871/1908: 206) was forced to admit that, while 'savage races' eliminated their weakest, or recalcitrant, members, 'civilized society' allowed these people to propagate. Furthermore, civilized societies enlisted their fittest men into their armed forces, leaving the less fit at home to procreate (Darwin 1871/1908: 207). These opposing forces led Darwin to two opposing conclusions. The first was that there was no reason why the tendency to do good and to do evil should not be inherited equally readily (Darwin 1871/1908: 189), since the benefits of co-operative behaviour were so obvious (Darwin 1871/1908: 192):

> Looking to future generations, there is no cause to fear that the social instincts will grow weaker, and we may expect that virtuous habits will grow stronger, becoming perhaps fixed by inheritance. In this case the struggle between our higher and lower impulses will be less severe, and virtue will be triumphant.

Darwin's (1871/1908: 216) second conclusion was less optimistic:

> If the various checks specified … do not prevent the reckless, the vicious and otherwise inferior members of society from increasing at a quicker rate than the better class of men, the nation will retrograde.

Post-Darwin social reformers tended to adopt Darwin's first conclusion, arguing that it was human nature to be co-operative and anti-social behaviour in the young stemmed from the failure of society in general, and their parents in particular, to provide them with optimal conditions for their development.

7.14 Sexual selection

Darwin (1871/1908: 328) downplayed the influence of sexual selection in nature, which he concluded was limited. The role of the dominant male among group animals was already covered by the general principle of natural selection. Birds exhibited the most elaborate courtship rituals, yet many birds were monogamous, sometimes for life, so nearly all had equal chance to reproduce, the exception being surplus individuals unable to find a mate, and even these might mate if another individual was killed. However, in some cases the females did seem to exercise a decisive choice. Darwin (1871/1908: 328) concluded that secondary sexual characteristics attractive to the female would develop as a result of sexual selection. Since all females would eventually find a mate, leaving only a very few unpaired males (possibly none), it is difficult to see how the characteristics of the 'favoured' males who found mates first would be any more likely to survive the vicissitudes of life than those which mated a few hours, or days, later.

7.15 Sexual inequality

Darwin was interested in the relative numbers of male and female births. He was aware that some females gave birth exclusively to sons and others to daughters. He believed that "the tendency to produce either sex would be inherited like almost every other peculiarity" (Darwin 1871/1908: 393), ignoring the fact that every human (and every other sexually reproducing species) has the same number of male and female progenitors.

As to female inferiority, Darwin drew conclusions based on his theory of *pangenesis*. Characters acquired would be transmitted to the same sex at the same age. Therefore (Darwin 1871/1908: 860-861):

> … the inherited effects of the early education of boys and girls would be transmitted equally to both sexes … in order that woman should reach the same standard as man, she ought, when nearly adult, to be trained to energy and perseverance, and to have her reason and imagination exercised to the highest point, and then she would probably transmit these qualities chiefly to her adult daughters. All women, however, could not be thus raised, unless during many generations those who excelled in the above robust virtues were married, and produced offspring in larger numbers than other women … men … during manhood generally undergo a severe struggle in order to maintain themselves and their families; and this will tend to keep up or even increase their mental powers, and, as a consequence, the present inequality between the sexes.

It is not clear why the struggle which men underwent should be presumed to increase their mental powers, rather than their physical, since many men undertook physical work, on the land, in the forge or at the carpentry bench, among others. Did not raising a family constitute 'a severe struggle' for women, particularly those raising the large numbers of children which were common in families of the Victorian era in England? Darwin's thinking was constrained by the dominant discourse of his time which assumed male superiority over female, both mentally and physically.

7.16 Darwin's position

There were only two aspects of his theory to which Darwin adhered unswervingly: gradualism and the inheritance of acquired characteristics. Foucault (1972) distinguished between the approach of Buffon and that of Darwin by categorizing Darwin's approach as that seeking 'discontinuity'. While it is true that Darwin did, at times, draw attention to differentiation between species, his theory was built on the claim that there were no absolute boundaries between species as far as fertility was concerned. He attributed failure to interbreed to 'mate recognition' and 'unsuitable conditions'.

Darwin's earliest work relied on a forward looking, forward planning Being. By the time *The Origin* was published, this pro-active Being had been reduced to a 'Creator', mentioned only three times, who appeared to have been active only at the time of creation. Darwin's later works made no mention of 'God', although Darwin insisted that natural selection did not obviate a Creator.

Darwin's uncertainties caused him much trouble and was largely responsible for the delay in the publication of his major work, *Natural Selection*, which was never completed. Darwin's fluid and all-encompassing positions were both his greatest weakness and his greatest strength. Everybody could find something in *The Origin* with which to agree and something else with which to disagree. *The Origin* provided scope for endless debate, which continues until to-day.

The following chapters will follow the rise to dominance of Darwin's theory of evolution by natural selection, the means used to legitimize this theory and to marginalize dissenting opinion.

Chapter 8

Alfred Russel Wallace

8.1 Alfred Russel Wallace (1823-1913)

Although all textbooks that deal with evolutionary theory acknowledge Wallace as co-discoverer of the theory of evolution by means of natural selection, his influence, compared with that of Darwin, is insignificant.

The two men travelled completely different paths to arrive at their common destination. Darwin was born to money and never needed to work to support himself, giving him the freedom to study and write in his own time. Wallace was born into an old family, but declining family fortunes forced him to earn his own keep (Wallace 1905/1969). Wallace's first employment was as apprentice to a master builder. Subsequently he was apprenticed to his brother as a surveyor. After his brother died, he took a teaching position. While employed as a teacher, he took the opportunity to read widely on travel and natural history. He read *Vestiges,* and this book, along with Darwin's *Journal*, (Darwin 1845), inspired Wallace to travel overseas in search of 'the origin of species' (Davies 2008); McCalman 2009).

Wallace's place in history is both certain – and uncertain. He will always be remembered as the man who, unbeknownst both to him and to Charles Darwin, was engaged in a race to complete a theory which explained the 'origin of species'. Currently, he is known as the person who narrowly lost the race, but whose 'charge' at the end spurred Darwin to victory. Some authors, such as Brackman (1980), Brooks (1984) and Davies (2008) are now questioning whether the race was, in fact, won by Wallace or whether Darwin, together with his friends Lyell and Hooker, conspired to falsify the record to ensure Darwin's claim to priority was upheld. Before visiting this complex debate, it is appropriate to consider Wallace, the man and his work, apart from his unwitting entanglement with Darwin.

8.2 Wallace's background

Wallace is usually portrayed as a person of lower class than Darwin, poor financially and poorly educated (see, for example Davies 2008; McCalman, 2009). This was not the case. Wallace was proud of the fact that his family were descended from the Scottish hero, Sir William Wallace, their family crest supporting this contention (Wallace 1905/1969: 3).

Among the family graves in the Churchyard of the small village of Hanworth, Middlesex, (population 750 in 1840) was that of Admiral Sir James Wallace, who died in 1803, although Wallace was not sure of his exact relationship.

One of the minor titles of the local Dukes of St. Albans was that of Baron Vere of Hanworth, the title being taken by a third son of one of the Dukes, although the Baron eventually inherited the Dukedom himself. Wallace's father's name was Thomas Vere Wallace and Wallace, rather modestly, supposed that his father was a tenant of the first Baron Vere (Wallace 1905/1969: 3). It was not customary in England for a tenant to take the name of the local aristocrat – and Wallace must have known this. It was, however, customary for daughters to give their family name to their sons as an intermediate name. Indeed, Wallace's own second name, Russel, was obtained in this way.

Wallace's father had qualified as a solicitor, the Law being an acceptable profession for minor branches of established families. He chose not to practise, being of independent means, but engaged in business enterprises, the first of which was not successful and the second of which resulted in him being defrauded by his partner. This led to a decrease in the family's fortunes. Nevertheless, the young Wallace boys all attended Grammar school. Grammar schools in England were fee-paying establishments, lower in prestige than the famous Public Schools, such as Eton, Harrow or Winchester, but nevertheless well regarded.

Wallace's mother was descended from the Greenells, believed to have escaped from France following the St. Bartholomew massacre of 1572. This family also had a family crest and Wallace's mother owned several oil-paintings of Greenell ancestors. The name 'Russell' came from this side of the family, although lacking the second 'l', due, Wallace thought, to an error at the registry (Wallace 1905/1969: 5-6). Wallace came from 'old blood', whereas the Darwin and Wedgwood families were *nouveau riche.*

Throughout his life, Wallace read extensively and was a prolific writer on many subjects, being a contributor to nearly two hundred different journals (Wallace 1905/1969; Smith 1991).

8.3 Interests and experiences

During his time as apprentice surveyor to his brother, Wallace became interested in geology. His interests were to grow from geology, with its fascinating fossils, through entomology to evolution (past), evolution (present) and possibilities for the future. Wallace became extremely involved in his later life with social issues, land ownership and inheritance, education, especially of females, child and female labour, social and medical issues such as vaccination and pollution and 'junk food' (Wallace 1905/1969; Brackman 1980).

As a young man, Wallace struck up a friendship with William Bates, an ardent entomologist, and the two set in place plans to travel to the Amazon. Wallace wrote to Bates that the prime objective of his proposed travel was to gather facts "towards solving the problem of the origin of species" (Wallace 1889a: iv). By 'origins', Wallace was referring to place as well as time, the distribution of species being a subject of great interest to him. They needed to finance their own expedition but, fortunately, the railway companies were then in urgent need of surveyors. Wallace took up such a position and was able to save sufficient money from his wages by April 1848 to pay for his passage to the Amazon aboard a small trading vessel. Being self-funded, Wallace was able to determine his own agenda. He knew what he was doing, and why, unlike the unfortunate young Darwin who clearly embarked upon his voyage under-prepared, although through no real fault of his own (see Chapter 6).

In April, 1848, Wallace, together with his friend, William Bates, embarked for Brazil upon a journey which was not only to change Wallace's life forever, but possibly that of Darwin (see Chapter 9). This voyage nearly cost Wallace his life on more than one occasion. On 28th December, 1851, Wallace's friend, Richard Spruce, wrote to advise Mr. John Smith of the Royal Botanic Gardens at Kew, that Wallace was "almost at the point of death from a malignant fever, which has reduced him to such a state of weakness that he cannot rise from his hammock or even feed himself" (Brooks 1984: 28). Were Wallace but the insignificant 'butterfly catcher' which he is so often portrayed as being, even by his supporters such as Davies (2008), then it is unlikely that this letter would have been written. After three years' hard work, many fascinating samples sent back to England, and interesting letters read informally at meetings, as had been Darwin's (Davies 2008: 14), Wallace clearly established himself as a naturalist of note while yet in South America.

This first voyage of the young Wallace was of three-and-a-half years' duration and ended in disaster. On the way home, the vessel on which he was travelling caught fire and sank, taking with it all his personal (duplicate) samples, so perilously collected. Wallace and his companions drifted in a lifeboat for ten days before being rescued, finally arriving back in England in October, 1852. Fortunately, Wallace's possessions were insured and he was able to set out in July, 1854, for the Malayan Archipelago, from which he would not return until 1862.

Having lived and worked for so many years among 'savage' people in two very different parts of the world, learning their languages and customs, he wrote as an anthropologist. He soon came to realise that a 'savage' child was no different from a 'civilised' child, who needed to be taught such things as mathematics to acquire any sort of understanding of numbers beyond the most simple (Wallace 1870/1973). He noted the native peoples' love of art, which he was to conclude could not have resulted from natural selection (Wallace 1905/1969; Brackman 1980: 109). He considered native people to be "morally and intellectually our equals, if not superiors" and suggested that they needed to be protected from contamination by "'degraded' classes of civilised" people (Wallace 1905/1969; Brackman 1980: 272-273).

Wallace's growing understanding of the distribution of species, both plant and animal, during his time on the Malayan Archipelago, which led to the formation of his theory of evolution, will be covered in the next chapter, which will also consider Wallace's influence upon Darwin and the role he played in the writing by Darwin (1859) of *On the Origin of Species.* This matter is quite controversial.

8.4 Darwinism

In 1870, Wallace put together a short anthology of what he then considered to be his most important contributions to the theory of natural selection (Wallace 1870/1973). *Contributions* contained his first two papers of 1855 and 1858, together with other pieces. In 1889, he published his only full-length book on the topic, which he titled *Darwinism* (Wallace 1889b/1975). While many people were prepared to accept natural selection as an explanation for variation at specific, or even generic, level, it was the wider groupings of family or order with which most people had problems. Wallace countered this criticism in the same way that he defended Darwin's position against those who asked how rudimentary organs could be of use to an animal while in the process of development (Wallace 1896: 128):

> … [these objections] are really outside the question of the origin of all existing species from allied species not very far removed from them, which is all that Darwin undertook to *prove* by means of his theory … To ask of a new theory that it shall reveal to us exactly what took place in remote geological epochs, and how it took place, is unreasonable.

Wallace's use of italics for the word 'prove' does not change the fact that Darwin did extrapolate from species, to genera, to families, to orders, even if he did 'pretend' he was only hypothesising. Brackman (1980) believed Wallace's loyalty to Darwin could be explained in part by the fact that, until after Darwin's death when biographies, diaries and letters of him and his contemporaries started to be published, Wallace had believed that Darwin was well ahead of him, both in his theory and in his writing, and that it only gradually became apparent to Wallace the effect his papers had had on Darwin. Wallace gave a brief account of this period of his life in his autobiography (1905/1969: 354-363), parts of which are reproduced here as Appendix I.

Wallace formed a close friendship with Lyell, in part because of his (Wallace's) interest in geological formations, particularly those formed by glaciers, to the understanding of which Wallace made original contributions (Wallace 1905/1969: 426-429). Wallace assisted Lyell by proof reading his later books (Wallace 1905/1969: 430). This makes Lyell's possible role in the establishment of Darwin as the primary proponent of natural selection the more poignant.

There is a point upon which both Wallace's and Darwin's logic appears to be open to question. Wallace (1870/1973: 298) stated:

> It is an essential part of Mr. Darwin's theory, that one existing animal has not been derived from any other existing animal, but that both are descendants of a common ancestor, which was at once different from either, but, in essential characters, intermediate between them both.

If evolution is an *ongoing*, gradual process, as suggested by Darwin (1859/1998), there is no reason to suppose that all divergence happened at some unspecified time in the (remote) past, nor is there any reason to suppose that the parent species did not co-exist with the daughter species for at least some period of time. Indeed, since it would be impossible for a 'daughter' species to evolve from an extinct 'parent' species, it is reasonable to assume that both the parent species and the new daughter species *must* have co-existed *at some point in time*, even if but briefly. The claim that no existing animal had been derived from any other existing animal lacked logic. If evolution is an ongoing process, taking place here and now, then there must be, somewhere on the face of this Earth, a daughter species in the process of evolving (separating) from a parent species. To suggest this not to be the case would be to deny the very essence of evolutionary theory as put forward by Darwin (1858/1998), Lamarck (1809/1963) and others mentioned in Part I of this thesis.

Darwin (1871/1908) had suggested that birds and butterflies had acquired their bright colours as a result of sexual selection. Wallace disagreed. He (1889b/1975: 274) pointed out that several male butterflies will pursue the one female and the fittest and fleetest will mate – a simple case of the 'fittest' providing the greatest number of offspring. As for birds, his observations had led him (1889b/1975: 286) to decide that 'female birds had unaccountable likes and dislikes in the matter of their partners'. He concluded (Wallace 1889b/1975: 295):

> [The] … extremely rigid action of natural selection must render any attempt to select mere ornament utterly nugatory, unless the most ornamented always coincide with "the fittest" in every other respect; while, if they do so coincide, then any selection of ornament is altogether superfluous.

Wallace pointed out that the most highly coloured parts of the body were the peripheral teguments. A butterfly can survive with a torn wing if attacked by a bird in flight. Wallace believed that high colour was a form of protection, detracting potential attackers away from vital areas of the body. They could also serve to intimidate, especially when displayed.

In relation to the role of sex, Wallace also disagreed with another view which became increasingly popular as the $19^{th}/20^{th}$ centuries progressed – that the natural role of human males was one of polygamy/promiscuity. In all the time he had spent living among native people, both in South America and on the Malay Archipelago, he had never known any man to stray from his wife (Brackman 1980).

Another area where Wallace disagreed with Darwin was in relation to Darwin's theory of pangenesis, which Wallace (1905/1969: 422) originally accepted but later challenged. He preferred Weismann's theory of 'continuity of germ-plasm', which theory totally rejected the concept that any characteristic acquired during the life-time of the individual could be inherited by that individual's offspring. Weismann's theory will be discussed in Chapter 14.

8.5 Wallace, the spiritualist

Recalling himself as a young man, Wallace (1905/1969: 226-228) wrote that he had been raised in a family with a conventional Low Church philosophy. They attended Church as a matter of form, but with no real conviction. He became convinced by the Unitarian argument that the miracles recorded in the New Testament were invented by over-enthusiastic followers of the early Church and were not historical fact. In retrospect he described himself at that time as having been 'agnostic'. Later, he was to become a spiritualist. In his book, *Miracles and Modern Spiritualism* (Wallace 1896), Wallace wrote that he experienced no difficulty in combining his scientific and spiritual interests. Rather than considering an interest in spiritual matters 'unscientific', Wallace held that it was those who refused to investigate spiritualism because it did not conform with their pre-conceived ideas who were 'unscientific'. By contrast, Darwin set out on his voyage holding orthodox Christian beliefs, but ended his life a non-believer. From such different positions and perspectives, the professional amateur, the amateur professional, the believer, the non-believer, two paths met and upon that meeting point was raised the edifice known as 'evolution by natural selection'.

Wallace considered it unscientific to condemn spiritualism without investigating it. Wallace did investigate, and became a convert, writing a book upon the subject (Wallace 1896). As a spiritualist, Wallace believed that all souls were equal in the sight of God and that all had an inalienable right to equality of opportunity, be they aristocrat or labourer, 'civilized' or 'savage', male or female (Smith 1991). Wallace believed that no person deserved praise or blame for ideas that came to him, since they had come from another source, but only for actions taken as a result of those ideas (Brackman 1980: 224). Darwin and Wallace both became interested in the origin of species at about the same time; both completed the working out of their theory at about the same time. Darwin, however, had put far more effort into publicising the theory than had Wallace and this may have been a factor in Wallace's deference towards Darwin. Wallace also believed that promulgation of ideas should be free, uninfluenced by praise or blame, reward or punishment (Brackman 1980: 224).

Wallace believed that the physical form had been influenced by outside causes (environment). By contrast, mental (spiritual/philosophical/artistic) attributes came from within and they affected the environment – the exact reverse. He believed that humans had mental/spiritual characteristics which separated them from the rest of the animal kingdom (Wallace 1889b/1975).

Wallace rejected the Malthusian doctrine that the poor and weak members of society should be left to struggle and make their own way – hence his work as a social reformer. He was aware of the development in Germany before the First World War of what later became known as 'Social Darwinism'. He rejected eugenics and the idea that dominant (successful) races were entitled to suppress (or eliminate) less successful races.

8.6 Design in evolution

Wallace published his last book in 1910, at the age of 87. It was a scholarly work, covering a wide range of subjects on the topic of evolution. Here he was quite outspoken in relation to those aspects of evolution upon which he and Darwin had disagreed. He recorded that Darwin had been 'quite distressed' that he, Wallace, had rejected Darwin's conclusion that Man's highest qualities and powers had developed from those of lower animals by natural or sexual selection (Wallace 1910: 315). More importantly, Wallace rejected the idea that macro-evolution was the result of natural selection. Rather he had concluded that much of creation could only have come into being as the result of the workings of a far Higher Mind (Wallace 1910: 286-292).

Wallace followed in the footsteps of Paley by citing striking examples as evidence for planning in nature, not just evolution by chance. His first example was that of the feathers of birds (Wallace 1910: 287-291). Having briefly drawn attention to the changes necessary in the bony structure and musculature of birds to support the action of the wings, Wallace described the intricate structure of the feathers themselves, with their hooked barbs and barbules, horny plates which grow obliquely outwards towards the tip of the barb. These produce an air-tight structure when in flight but can be fluffed up when the bird needs extra warmth or to dry its feathers. Each feather is composed of hundreds of thousands of tiny parts, all of which adjust in relation to each other during flight to allow upward/downward movement, etc., yet the matter of which feathers are composed is dead. There is no circulation in any part of a fully grown feather (Wallace 1910: 291). While each feather is a replica of its counterpart on the other side of the bird's body, no two feathers on the one side are exactly the same, since each must fit the exact requirements of its particular position. Wallace saw in the wonderful structure of the individual feather and the complete wing, evidence of an organising Mind (Wallace 1910: 291).

Wallace wrote of the process of insect metamorphosis, which he found to be one of the most marvellous occurrences in the whole organic world (Wallace 1910: 297-304). Much research had by then been carried out on this phenomenon and its processes were well understood.

Rudimentary structures, such as the wings, were already present in the larva, but never developed. The internal structure of the larva – muscles, intestines, nerves, respiratory tubes, etc. - along with these rudimentary structures, were gradually dissolved into a creamy pulp from which the imago developed, the information required for this transformation having remained dormant until required (Wallace 1910: 300).

In this, his last book, written after years of involvement with the spiritualist movement, Wallace himself turned away from the idea that natural selection was the sole cause of all evolution.

8.7 Multiple designers

Wallace rejected the Christian concept of a God who was infinite, eternal and omnipotent (Wallace 1910: 392-394). Wallace did not believe that there was a great chasm between humans and God, filled only by a hierarchy of angels who had little to do except act as attendants and messengers. Rather he envisaged a whole host of spiritual beings of infinite variety, from the highest grade of power down to the lowest level of consciousness, or almost unconsciousness, such as would be manifested in "cell-souls" (Wallace 1910: 393). The Infinite Being would have determined the broad outlines of the Universe, but then the initial great properties and forces, such as ether, light, gravity, etc., would have been brought into being by other, not quite so exalted Beings, and so on down to the creation of matter, atoms, minerals, etc., simple living and more complex cells/beings, such as ourselves (Wallace 1910: 395):

> At successive stages of development of the life-world, more and perhaps higher intelligences might be required to direct the main lines of variation in definite directions in accordance with the general design to be worked out … Some such conception as this – of delegated powers to beings of a very high, and to others of a very low grade of life and intellect – seems to me less grossly improbable than that the infinite Deity not only designed the whole of the cosmos, but that himself alone is the consciously acting power in every cell of every living thing that is or ever has been upon the earth.

Wallace here spoke of "higher intelligences ... direct[ing] the main lines of variation". The image may be likened to that of a global corporation or conglomerate, with each department vying for its share of available resources, while being aware that the needs of the other departments must also be met if the whole enterprise is to be successful. Each contributes to the working of the whole enterprise, whether they are in this world or elsewhere.

Wallace's thought had clear similarities with that of Eastern philosophers. The Hindu religion acknowledges Brahma (God beyond creation) and many 'gods' associated with other aspects of creation. Wallace never visited India but it is possible that his sojourn in S.E. Asia brought him into contact with this type of thinking.

8.8 Wallace's position

At the time of the writing of his Sarawak and Ternate papers, Wallace's ideology was atheistic. His conversion to Spiritualism came later in life, but had a profound influence on the way in which he viewed the process of evolution. Christian belief held that only humans had souls. Wallace eventually concluded that, however similar may be our physical bodies to those of animals, our mental abilities (art, music, mathematics, philosophy) did indeed set humans apart from other animals. These abilities could not have been brought about by the process of natural selection.

Wallace's early position was based on the themes of secularism and continuity. His later ideology changed to one based on religious belief, although not Christian, and the theme of discontinuity. On the lower, physical level, he saw continuity but on the higher, spiritual/mental level, he saw discontinuity.

Chapter 9

Two minds, but a single thought?

9.1 Introduction

The move to establish the name of Charles Darwin as the originator of the theory of evolution by natural selection began even before Darwin published any material on the subject. This chapter examines the controversy surrounding the claim made by Brackman (1980), Brooks (1984) and Davies (2008) that a small group of people conspired to use their position of power and influence in Victorian society to suppress the work of Alfred Wallace and lift that of Darwin into a position of dominance in order to protect their own interests and further their own agendas. It concludes by presenting a new scenario which it is claimed better accommodates all the known facts.

The first cracks in the armour of defence surrounding Darwin's name and his work began to appear at the time of the centenary of the publishing of *The Origin* in 1959. It was shown in Chapter 5 how this had led Eiseley (1961, 1979) to conclude that Darwin had made unacknowledged use of the work of Edward Blyth. As more of Darwin's original journals and notebooks were published and became available for general study, for example the facsimile copy of the journal kept by Darwin on his voyage (G. Darwin 1979) and Darwin's notebooks from 1836-1844 (Barrett et al. 1987), it became increasingly clear that Darwin's thinking had undergone a radical change in the years after certain work by Alfred Wallace was published. This work included, not only Wallace's two major papers, to be discussed below, but other papers (Wallace 1856a,1856b, 1856c, 1857a, 1857b, 1858a, 1858b, 1858c), as well as letters sent to his agent, Stevens, which were read at society meetings. Some of Darwin's letters home during his voyage had similarly been read at meetings and helped to establish Darwin's name before he had returned home (Davies 2008). Hooker (Huxley 1918: 144) was quite annoyed when he learned that his letters were also being read: "I do extremely dislike having my letters shown to those I do not know ...". However, his father, Sir William Hooker, had little choice but to comply when summoned to Buckingham Palace so that Prince Albert might read them.

In the 1980s, two books (Brackman 1980; Brooks 1984) were published which, not only accused Darwin of using Wallace's work without acknowledgement, but which accused him of deliberately holding back a paper of Wallace's (1856c) so that he (Darwin) could make amendments to his own work and falsely claim that he had developed the theory of evolution by natural selection before Wallace. The debate was recently re-ignited by the publication of a book (Davies 2008) which accused Darwin of perpetrating (Davies 2008: xix): "... a deliberate and iniquitous case of intellectual theft, deceit and lies". He (Davies 2008: xix) continued by claiming that Darwin: "... committed one of the greatest thefts of intellectual property in the history of science".

The exact events which unfolded will forever remain a matter of speculation since many of the documents which would have thrown light upon proceedings have been 'lost' – or deliberately destroyed (Brackman 1980; Brooks 1984; Davies 2008). This chapter will outline possible scenarios, as given by Brooks (1980), Brackman (1984) and Davies (2008), none of which appear entirely satisfactory. It will conclude by offering an alternative, which it is believed better covers all the available evidence.

9.2 Wallace's 'Sarawak' paper

In February, 1855, while in Sarawak, Wallace wrote a paper entitled *On the Law which has Regulated the Introduction of New Species*, which was published in September of that year (Wallace 1855, 1870/1973). The Law which Wallace proposed was that "Every species has come into existence coincident both in time and space with a pre-existing closely allied species". He supported his hypothesis by reference to geological changes, citing Lyell and the fossil record to show affinities (close relationships) or analogies (distant relationships) with later species. Wallace demonstrated how his Law could account for rudimentary organs, inexplicable under the doctrine of Special Creation. Wallace also suggested that if one species merely became modified into another 'new' species, then progression would be simple. However, if different populations of a species varied in more than one way, then it would be possible for diverse 'new' species to replace the original form, increasing the number and diversity of life forms.

In November, 1855, Lyell started to keep his own notebooks on the 'species question'. His first entry, dated 28 November, 1855, began with 'Wallace' and referred to Wallace's Law paper. In April 1856, Lyell visited Darwin at Down and his entry for 16th April contained reference to the theories of both Darwin and Wallace, concluding "The reason why Mr. Wallace's introduction of species, most allied to those immediately preceding in Time … seems explained by the Natural Selection theory" (Brooks 1984: 259-260). Wallace's (1855) theory that new species always – and only – appeared in environments in which a closely-related species had previously existed differed from Darwin's belief at that time that new species were specially created following previous extinctions, mostly on newly-formed islands or other isolated places, which was the concept held by both Cuvier and Lyell (Davies 2008: 2).

It appears that this was the first time Darwin had confided his ideas to Lyell, who immediately urged him to publish (F. Darwin 1887, vol.1: 84; vol.2: 67). Darwin had already read Wallace's paper and his notes indicate that he had dismissed the article as containing "nothing of great interest" (Davies 2008: 1). Nevertheless, following Lyell's visit, Darwin started to write a paper. His diary entry for 14th May, 1856, states "Began by Lyell's advice writing species sketch" (Brooks 1984: 260). Darwin found it too difficult to condense his ideas and by mid-June had abandoned the proposed paper in preference for a book. In November, 1856, he confessed to Lyell (F. Darwin 1887, vol.2: 85):

> I am working very steadily on my big book; I have found it quite impossible to publish any preliminary essay or sketch; but am doing my work as completely as my present materials allow without waiting to perfect them. And this much acceleration I owe to you.

On 20th July, 1857, Darwin, who was notoriously secretive about his work, even with close friends, wrote to Asa Gray in America giving a brief outline of his hypothesis (www.darwinproject.ac.uk/ entry2125):

> ... Nineteen years (!) ago it occurred to me that whilst otherwise employed on Nat. Hist., I might perhaps do good if I noted any sort of facts bearing on the question of the origin of species, and this I have since been doing. Either species have been independently created, or they have descended from other species, like varieties from one species. I think it can be shown to be probable that man gets his most distinct varieties by preserving such as arise best worth keeping and destroying others, but I should fill a quire if I were to go on. To be brief, I *assume* that species arise like our domestic varieties with *much* extinction; and then test this hypothesis by comparison with as many general and pretty well-established propositions as I can find made out, - in geographical distribution, geological history, affinities, &. &. And it seems to me that, *supposing* that such hypothesis were to explain such general propositions, we ought, in accordance with the common way of following all sciences, to admit it till some better hypothesis be found out. For to my mind to say that species were created so and so is no scientific explanation, only a reverent way of saying it is so and so. But it is nonsensical trying to show how I try to proceed, in the compass of a note. But as an honest man, I must tell you that I have come to the heterodox conclusion, that there are no such things as independently created species – that species are only strongly defined varieties. I know this will make you despise me …
>
> (Darwin then wrote a few sentences about distribution, especially in relation to climatic and geological changes, Gray's area of special interest, before continuing) … [Omitted in original]
>
> I must say one more word in justification (for I feel sure that your tendency will be to despise me and my crotchets), that all my notions about *how* species change are derived from long-continued study of the works of (and converse with) agriculturists and horticulturists; and I believe I see my way pretty clearly on the means used by nature to change her species and *adapt* them to the wondrous and exquisitely beautiful contingencies to which every living being is exposed … (*italics in original)*

The remainder of the letter was not reproduced, nor was any reply from Gray's reply. F. Darwin 1887, vol.1: 78-79) gave the date of 20th July, 1856, for this letter, but it is clear from Gray's reply of August 1857 (www.darwinproject.ac.uk/entry2129) that the revised date is correct.

9.3 Meanwhile, out on the Archipelago …

Wallace was continuing his study of birds, butterflies, beetles and other interesting fauna, such as the orang-utan and, of course, humans. Living for so many years among so many diverse peoples, Wallace became increasingly interested in the evolution of the various races of human, his conclusions in respect of these then being applied to animal species in the formulation of his theory (McKinney 1966).

Alone (i.e. the only white man) on Aru, Wallace had no one with whom to discuss his ideas. Letters to and from his faithful friend, Bates, took months to exchange. Replying on 22nd December, 1857, to Darwin's first known letter to him of 1st May, 1857, Wallace had confided that he had been disappointed that his paper had not excited discussion or even elicited opposition (Wallace 1905/1969: 355; Brackman 1980: 46; Davies 2008: 3).

Wallace first wrote to Darwin on 1st October, 1856, but the content of this letter is not known, since it is missing. However, in what is presumed to be Darwin's reply to that letter, he wrote (F. Darwin 1887, vol. 2: 95):

> I have acted already in accordance with your advice of keeping domestic varieties, and those appearing in a state of nature, distinct; but I have sometimes doubted the wisdom of this, and therefore am glad to be backed by your opinion.

How likely is it that the very first letter written by Wallace to a person of the standing of Darwin would contain advice about the writing of his book, assuming that Wallace *knew* that Darwin was writing a book, which is extremely unlikely? Is it not more likely that there was some correspondence between these two men which remains unrecorded? Apart from one sentence cut out from one letter, all of Wallace's letters to Darwin are missing (Davies 2008: 101), which makes it impossible to be certain exactly what passed between them.

Davies (2008: 105) noted that Darwin's (presumed) reply to this letter, dated 1 May, 1857, stated that he had received Wallace's letter "a few days ago". Davies (2008) claimed that this attempt at deception had taken place because Darwin had used the intervening four months to incorporate Wallace's ideas into his own work. In support of this claim, Davies (2008: 107-108) pointed out that on 31st March, 1857, Darwin included, for the first time, in the chapter he was writing on 'Extinctions' reference to the principle of divergence. Shortly afterwards, on 12 April, 1857, Darwin (F. Darwin 1887, vol.2: 90-91) wrote to Hooker suggesting that species were but strongly marked varieties. This marked a departure from the view that he had expressed in *Foundations* (Darwin 1909/1969) that species appeared as new entities after extinctions brought about as the result of geological change. This new position was to form the basis of all of Darwin's arguments in *The Origin* (Darwin 1859/1996).

That Darwin would be so naïve as to attempt to deceive Wallace in this way seems unlikely since Wallace would have been well aware of the expected arrival time of his letter. Departure and arrival times of all mail ships were regularly reported in the newspapers. Had there been any delay it would have been reported and Wallace would have become aware of it. Furthermore, it is difficult to understand what benefit Darwin would have gained by such a deception at this stage, since he had only been working on his book for a few months and Wallace's ideas had been contained in his published paper of 1855. If Wallace's letter of 1st October, 1856, was despatched by first class mail, it may have arrived late December, 1856, not January, 1857, as assumed by Davies (2008). An immediate reply by Darwin, arriving late February, 1857, followed by a 'return mail' reply from Wallace, also by first class mail, may have arrived at the end of April, 1857. Nevertheless, Davies' (2008) point that there is no record of Darwin ever having mentioned Wallace's name in any of his voluminous correspondence to his many friends, although he mentioned the names of many others, is worthy of note, as is the fact that it was during the four months during which Davies (2008: 88-89) claimed Darwin was surreptitiously incorporating Wallace's ideas into his own work that he first mentioned some of these ideas in his correspondence with Hooker.

In his (presumed) second letter to Wallace, dated 22nd December, 1857, Darwin told Wallace that he should not think that no notice had been taken of his first paper since both Blyth and Lyell had especially called his attention to it (Wallace 1905/1969: 355; F. Darwin 1887, vol.2: 108). Darwin told Wallace that, while he agreed with his conclusions, he believed he went much further than Wallace with his own theory (F. Darwin 1887, vol.2: 108; Wallace 1905/1969: 358). It is possible that Darwin enclosed with this letter a letter to him from Lyell, referring to the work of both these men, and its similarity (see Section 10.5).

9.4 Time of receipt?

Wallace continued to send articles to journals for publication. After the Sarawak paper, he (Wallace 1856a) published the last of three articles on the orang-utan, suggesting either man [sic] had evolved from an ape-like species or, possibly that apes had evolved from a more man-like one (Davies 2008: 80). He also published (Wallace 1856b, 1857a, 1857b) articles in which he compared the foot structure of birds from the Archipelago with those he had seen in South America, noting that, despite superficial variances, especially in size, there was a basic similarity of structure between those species which caught their prey on the wing and those which scavenged for their prey on the ground, even though they now inhabited lands half a world apart. The progression of Wallace's thinking is clearly shown in his published works.

While on the Aru Islands in February, 1858, Wallace had suffered another bout of malaria and was confined to bed for several days. It was during this period of enforced rest that

Wallace worked out the final details of his theory of natural selection (Wallace 1870/1973, 1905/1969: 361-162). A few weeks previously, (4th January), Wallace had written to Bates that he had prepared the plan and written a portion of a work embracing the 'whole subject' [of the origin of species] (Wallace 1905/1969: 358).

Quite why Wallace made the fateful decision to send his completed paper to Darwin, with the request that he show it to Lyell, rather than sending it directly to *Annals*, which journal regularly published his work, will probably forever remain a mystery. Whatever his reason, Wallace's fateful paper, *On the Tendency of Varieties to Depart Indefinitely from the Original Type,* was despatched from Ternate on 9th March, 1858 (Brackman 1980; Brooks 1984; Davies 2008). When it was delivered to Darwin is a matter of debate. Both the original document, and the envelope in which it was delivered, are missing (Brackman 1980; Brooks 1984; Davies 2008). Brackman (1980) and Davies (2008) both believed that it was delivered to Down House on 6th June, 1858, the same day that a letter sent by Wallace to his friend Bates, for onward forwarding by his brother, Frederick, was delivered in London. Brooks (1984) believed delivery to have been earlier, as will be discussed below.

Brackman (1980) stressed that he was not the first person to suggest that Darwin had received Wallace's paper earlier than generally believed. He drew attention to the fact that John Brooks had given a summary of "his forthcoming work" in the American Philosophical Society's 1968 Yearbook, claiming that the paper had been received by Darwin on 18th May, 1858 (Brackman 1980: 18-19). Presumably Brackman had decided that twelve years was sufficient time for Brooks to complete his "forthcoming work" and published his own account.

Brackman (1980: 343-344) tracked down Wallace's grandsons, John and Richard, then living in Bournemouth, England. They showed Brackman the envelope in which the letters to the Bates brothers had been received (Brackman 1980: 344):

> ... establishing a time frame for Darwin's receipt of it [Wallace's paper] – a time period that does not coincide with Darwin's claim that the essay arrived on June 18. Two weeks earlier is more likely.

Although the letter was dated 2nd March, 1858, Brooks (1984: 256) pointed out that the cancellation marks on the Bates envelope were for 21st April, 1858, (Singapore) and 3rd June, 1858, (London) indicating that this letter had left Ternate two weeks later than generally assumed, since the mail leaving Ternate on 9th March reached Singapore on 7th April, 1858, while that which left on 16th March, 1858, reached Singapore on 21st April, 1858. This situation could have occurred as the result of something as simple as Wallace arriving at the Mail Office and realising that he had left his letter to Bates at home, a not unlikely event if his mind was concentrated on the safe despatch of his letter to Darwin enclosing his valuable work!

Four years later, Brooks (1984) published. He had obtained, and reproduced facsimile, copies of hand-written mailing documents showing that the shipment of letter mail despatched from Ternate on 9th March, 1858, was received in London on Friday, 14th May, 1858, at 10.25 p.m. It should have been delivered to Down House either Saturday, 15th May or Monday, 17th May, 1858. Brooks (1984), while agreeing with Brackman (1980) that Darwin had received Wallace's letter earlier than admitted, thus held that the letter arrived three weeks earlier than suggested by Brackman (1980). Brooks did not refer to Brackman's (1980) work.

9.5 Time of deceit?

After receiving Wallace's second paper, Darwin wrote to Lyell a letter simply dated "18th" (Darwin 1887, vol.2: 116-117):

> Some year or two ago you recommended me to read a paper by Wallace in the "Annals", which had interested you and, as I was writing to him, I knew this would please him much, so I told him. He has to-day sent me the enclosed, and asked me to forward it to you. It seems to me well worth reading. Your words have come true with a vengeance – that I should be forestalled. You said this, when I explained to you here very briefly my views of "Natural Selection" depending on the struggle for existence. I never saw a more striking coincidence; if Wallace had my MS sketch written out in 1842 he could not have made a better short abstract! Even his terms now stand as heads of my chapters. Please return me the MS, which he does not say he wishes me to publish, but I shall of course, at once write and offer to send it to any journal. So all my originality, whatever it may amount to, will be smashed, though my book, if it will ever have any value, will not be deteriorated, as all the labour consists in the application of the theory.

All three of the authors whose work is being considered, agreed that this letter was sent to Lyell on 18th June, 1858, as claimed by Darwin. Brackman (1980) and Davies (2008) believed that it had been written after Darwin had spent two weeks amending his work. Brooks (1984) felt that the poignancy of the letter indicated that it had been written very soon after Darwin had received Wallace's letter, which he (Brooks) claimed had been no later than 17th May, 1858. He suggested that, having decided not to send the letter immediately, Darwin retained the letter until he had finished the 'corrections' to his manuscript, despatching it on 18th June, the co-incidence in the date being purely fortuitous. This explanation is not entirely satisfactory. It is here suggested that Darwin both wrote *and posted* the letter on 18th May, 1858, and that both Lyell and Hooker were aware of the situation in which Darwin found himself for a full month before the events took place which lead up to the joint reading of Wallace and Darwin's work before the Linnean Society on the evening of 1st July, 1858.

If Darwin did indeed receive Wallace's letter on Monday, 17th May, 1958, as shown by Brooks (1984), then the letter to Lyell simply dated "18th" could have been sent the next day, Tuesday, 18th May, 1858, a very reasonable scenario. Darwin asked Lyell to send a copy of his letter, and of Lyell's reply, to Hooker, for his advice. Brackman (1980), Brooks (1984) and Davies (2008) all believed that receipt of Wallace's paper had resulted in Darwin reworking his manuscript to include Wallace's ideas on diversification. They accepted that Lyell had been deceived into thinking that the paper had arrived mid June. Kohn (1981), responding to Brackman's account, refuted this accusation, preferring to trust Darwin than the speed of the postal service. Kohn (1981) pointed out that Darwin had been working on the problem of diversification for a long time, as indicated by Darwin's notes and his letter to Asa Gray. Brooks' (1984) reproduction of the postal records cast doubt on this objection. Not having referred to Brackman (1980), Brooks made no mention of Kohn (1981).

More than a year earlier, Darwin had noted in his diary on 31st March, 1857, that he had completed Chapter 6 of his major work on 'Natural Selection' (Brooks 1984: 230). Darwin's pocket diary contains an entry for 12th June, 1858, stating that he had that day completed correcting Chapter 6 (Brackman 1980: 19; Brooks 198; 230). It was contended by Brackman (1980), Brooks (1984) and Davies (2008) that following the receipt of Wallace's paper, Darwin amended his manuscript to incorporate Wallace's ideas, especially in relation to distribution and diversification.

Brooks (1984) supported this claim by the examination of the eleven chapters of Darwin's proposed major work which still survive, including Chapter 6. The section on 'Distribution', which followed 'Extinction', had been rewritten. The original folio page 26 was missing. In its place were forty-one new pages. These were written on different paper. Further, Darwin numbered the inserted pages using an * for the first addition, i.e., 26, 26*, and then letters, i.e. 26a, 26b, and so on. The inserted pages were numbered up to 26nn. Pages 51-76 were also written on the same alternative paper and their later time is confirmed by a footnote on page 53 which Darwin had dated June 1858. In all, more than sixty pages had been (re)written.

Darwin was a notoriously slow worker. How likely is it that, had he received Wallace's paper around 6th June, as suggested by Brackman (1980) and Davies (2008) that he would have completed such a large amount of work in less than two weeks? This consideration further supports Brooks' (1984) contention that the paper had been received no later than 17th May, 1858.

Darwin wrote a second letter to Lyell (F. Darwin 1887: 116-117), simply dated 'Friday', presumed to have been sent on 25th June, but here believed to have been sent on Friday, 21st May, which showed that he was quite distraught. He claimed there was nothing in Wallace's paper which was not contained in his 1844 sketch, which he had shown to Hooker, which point he was to re-iterate in his Introduction to *The Origin* (Darwin 1859/1998: 3). He told Lyell he had a copy of a letter he had sent to Asa Gray about a year previously, giving a short sketch of his views (F. Darwin 1887, vol.2: 117):

> ... so that I could most truly say and prove that I take nothing from Wallace. I should be *extremely* glad *now* to publish a sketch of my general views in about a dozen pages or so; but I cannot persuade myself that I can do so honourably ... But I cannot tell whether to publish now would not be base and paltry. This was my first impression, and I should have certainly acted on it had it not been for your letter ...

Clearly Lyell had replied to Darwin's first letter of "18th but this letter is missing. Darwin underlined the word 'extremely' once and the word 'now' twice (Brooks 1984: 264). Omitted by Sir Francis (F. Darwin 1887: 117) was the paragraph (Brooks 1984: 264):

> I should not have sent off your letter without further reflection, for I am at present quite upset, but write now to get subject for time out of mind that I confess it never did occur to me, as it might, that Wallace could have made any use of your letter.

This sentence is difficult to understand but may indicate that Darwin, at some time, impulsively sent Wallace a letter he had received from Lyell, presumably referring to their common interest and possibly to Darwin's proposed book. Darwin might, for example, have enclosed this letter with the one he sent to Wallace in which he told Wallace that Lyell and Blythe had both mentioned the Sarawak 'Law' paper to him (see Section 10.3 above). Brooks (1984: 201) mentioned:

> ... a puzzling, undated entry in one of Wallace's notebooks. Under the heading "Sketch of Mr. Darwin's 'Natural Selection' is a list ... of fourteen chapters.

Is it possible that Lyell's letter contained this information and that this is the 'use' to which Darwin was referring?

It is here suggested that Lyell, no doubt believing that Darwin's book was further advanced than it actually was, urged Darwin to make haste with his amendments with a view to forwarding his manuscript to a publisher. It is also suggested that Hooker knew of the situation. When Leonard Huxley published his biography of Hooker, he stated (L. Huxley 1918, vol.2: 465) that it was Hooker's recollection that it was to him that Darwin first confided the receipt of Wallace's unexpected communication. So much correspondence is known to be missing, that it is difficult to be certain exactly what transpired.

The urging of Lyell, and also possibly of Hooker, it is here hypothesized, was the catalyst which spurred Darwin into the flurry of activity which resulted in him completing the revisions, a large amount of work in what was (for him) a small amount of time.

One can imagine the consternation of Lyell and Hooker when it became apparent that, despite Darwin's 'Herculean' effort, his manuscript was far from ready for submission. Two mail boats had already left England for the Archipelago bearing no reply from Darwin to Wallace's letter. A third would be leaving shortly. It had to be assumed that, if Wallace did not receive a reply, he would send his paper elsewhere. Indeed, he might already have done so. Something needed to be done, urgently. The death of the Vice President of the Linnean Society caused their June meeting to be postponed until 1st July, 1858, and this presented the opportunity for Thomas Huxley, another close friend of Darwin, to ask the President to allow Darwin and Wallace's work to be read at that meeting instead of the papers previously announced (Brackman 1980: 63).

9.6 What a tangled web ...

The next recorded letter is one addressed to Hooker dated Tuesday, 29th June, 1858, Darwin (F. Darwin 1887: 119), and this would appear to be the correct date, which, if the scenario being presented here is correct, would mean that no correspondence has survived for a period of a month. However, some took place, because in that letter Darwin (F. Darwin 1887: 119) wrote:

> ... I have received your letters. I cannot think now on the subject but soon will. But I can see that you have acted with more kindness, and so has Lyell, even than I could have expected from you both, most kind as you are.
>
> I can easily get my letter to Asa Gray copied, but it is too short ...

How many letters Darwin had received from Hooker, and their content, is unknown, since they are now missing, but it is clear that Hooker had written to Darwin more than once 'on the subject'. The letter Darwin was referring to may have been the one he sent to Gray on 20th July, 1857, quoted above. It certainly contained more information about his theory than any other preserved letter.

It is difficult to understand how Darwin could have referred to the undated letter (see Appendix II), later read at the Linnean meeting on 1st July, 1858, as 'too short' since it ran to more than five printed pages (F. Darwin 1887: 120-125), even though Sir Francis omitted a section on the variation of large genera, which he did not consider relevant. Whether any of the missing letters from Hooker made any reference to Darwin hurrying to prepare his work for publication, we will never know.

Later that day, Tuesday, 29th June, Darwin wrote a second letter to Hooker (F. Darwin 1887: 119-120):

> I have just reread your letter, and see you want the papers at once. I am quite prostrated and can do nothing, but I send Wallace, and the abstract of my letter to Asa Gray, which gives most imperfectly only the means of change, and does not touch upon reasons for believing that species change. I dare say it is all too late. I hardly care about it ... I send my sketch of 1844 solely that that you may see by your own handwriting that you did read it. I really cannot bear to look at it. Do not waste much time. It is miserable in me to care at all about priority ...
>
> I would make a similar, but shorter and more accurate sketch for the 'Linnean Journal'.
>
> I will do anything. God bless you my dear kind friend.
>
> I can write no more. I send this by my servant to Kew.

This letter is very informative. Darwin was clearly distraught, not just in regard to Wallace's paper, but in regard to the death of his son from scarlet fever, which had occurred on 26th

June, 1858. On the one hand, he said he hardly cared, but on the other, he wrote that he would 'do anything'. How could Hooker not have been moved to compassion for his dear friend? This letter further tells us that Hooker had told Darwin (in one of the missing letters?) that he did not recall the 1844 sketch, which had clearly left no impression. It also tells us that Darwin enclosed this sketch *solely* to remind Hooker that he had, in fact, read this piece of work, the word 'solely' being underlined (Davies 2008: 152). It would seem that the possibility of including an extract from the 1844 Essay had not been discussed at that time. Its subsequent inclusion at the reading would seem to have been Hooker's decision. It is here hypothesized that the copy of the letter to Asa Gray which Darwin enclosed was that which he had sent on 20th July, 1856.

The letter also tells us that the papers were with Hooker forty-eight hours before the meeting. This may well have been Hooker's first opportunity to study Wallace's paper. He would immediately have appreciated that Darwin's ideas, expressed in the letter to Gray (of July 1857), were not to be compared with the well thought-out theory of Wallace.

9.7 Wallace's 'Ternate' paper

In this latest paper, Wallace had (1858c, 1870/1973) built up his argument by referring to the Struggle for Existence, the Law of Population of Species, Adaptation to Conditions of Existence, Increase of Useful Variations and the Survival of Superior Variations. Competition for available resources would occur, not only between individuals, but between species and varieties of species. Wallace suggested that should conditions change, then a variety might find itself better placed to survive than the original species. A new variety might have some slightly increased power of preserving its existence and would inevitably in time acquire a superiority in numbers (Wallace 1858c).

Re-iterating the argument already presented in his Sarawak 'Law' paper (Wallace 1855), Wallace argued that if one variety could thus become established as a species, why should this species not give rise to one or several more new varieties, which might themselves, if changing circumstances permitted, out compete the original species? If one species merely changed its form, or the original form became extinct (shortly) thereafter, there would be no increase in the number of species. The survival of both the original and changed form, with both being able to give rise to further mutant species before eventually becoming extinct (as most ancient forms seem to have done), increased the potential for more species.

Unlike Darwin, who was in the process of amassing large numbers of examples to illustrate his points, Wallace outlined his theory in general terms only, making very few references to specific animals, and none to plants. Nevertheless, he had covered the same principal points.

It was probably after reading Wallace's paper that Hooker selected material from the 1844 essay, including a passage referring to Malthus since Wallace had mentioned Malthus, to be included for reading along with the letter to Gray.

It is suggested that Hooker was concerned that the Gray letter was not sufficient and made the fateful decision to 'rewrite' the letter. It was Hooker who had first introduced Darwin to Gray during the latter's visit to London in 1839 (Brackman 1980: 52) and Hooker regularly corresponded with Gray (L. Huxley 1919: 473-481). However, he would not have known what correspondence had passed between Darwin and Gray since Darwin had written the letter of July, 1857. This, it is here suggested, is the reason the letter read was undated and also accounts for the rather strange manner in which the letter commenced (F. Darwin 1887: 120):

> My Dear Gray, - I forget the exact words which I used in my former letter, but I dare say I said that I thought you would utterly despise me when I told you what views I had arrived at ... Permit me to say that, before I had ever corresponded with you, Hooker had shown me several of your letters (not of a private nature), and these gave me the warmest feelings of respect for you ...

Etiquette demanded an exchange of news regarding family/friends before commencing upon the main purpose of the letter and this would explain the rather strange references to Hooker with which the paragraph concluded. Who better for Hooker to write about that himself?

The second paragraph is also interesting. It commenced by thanking Gray for his last letter and saying that he (Darwin) agreed with every word of it. After a few general comments, and a reference to the futility of Lamarckian concepts, it continued (F. Darwin 1887: 121):

> ... I will enclose (copied, so as to save you trouble in reading) the briefest abstract of my notions on the means by which Nature makes her species ...

We know that the 1844 Essay had been copied 'in fair hand' by Mr. Fletcher, the schoolmaster, (Brooks 1984: 266-267). That the letter to Asa Gray should similarly have been copied would not have been a cause of surprise. Although the comment referred only to the *original* letter, claimed to have been sent to Gray, nevertheless, the Secretary of the Society, who would retain the letter until the Society's *Proceedings* had been prepared for publication, would assume that a further copy had been made for Darwin's records. Thus the Secretary would not question the fact that the letter was not written in Darwin's hand.

However, it would seem that Hooker made an error in stating "I will enclose", implying that Darwin had written his ideas separately from the letter, when they were, in fact, one continuous document. The paragraph ends strangely with a request for Gray not to mention Darwin's doctrine to anyone (F. Darwin 1887: 122):

> The reason is, if anyone like the author of 'Vestiges', were to hear of them, he might easily work them in, and then I should have to quote from a work perhaps despised by naturalists, and this would greatly injure my chance of my views being received by those alone whose opinions I value.

This could be seen as an attempt to pre-empt any question as to why, unlike Wallace, Darwin was yet to publish any work on this subject. It must be remembered that, other than Lyell and Hooker, no one knew that Darwin was working on a new theory or that he had commenced writing a book. His fellow naturalists would have assumed Darwin's many questions to them were based on a general interest, such as was common to them all. This would justify Hooker's decision to include passages from the 1844 Essay which clearly showed that Darwin had been working on a new theory for a long time. The letter concluded with six paragraphs outlining Darwin's theory which, it is here suggested, Hooker gleaned from the information at his disposal, including Wallace's paper, which Darwin had assured him contained nothing which was not included in his own writings.

9.8 Aftermath

Four days later, on 5th July, Darwin wrote to Hooker, thanking him for his note telling Darwin that "all had gone prosperously at the Linnean meeting" (F. Darwin 1887: 126). He continued: "I do not at all understand whether my letter to A. Gray is to be printed; I suppose not, only your note ...". There was no mention of the 1844 Essay and it would appear that Darwin was unaware at that time that any part of it had been read. The confusion regarding whether or not the Gray letter was to be printed would have occurred if Hooker had returned Gray's letter with his note. Darwin would have expected the letter to be retained by the Secretary of the Society for the preparation of the *Proceedings.* It is here suggested that the letter which had been left with the Secretary was Hooker's 'reworked' version. What was Darwin referring to when he acknowledged that 'only your note' was likely to be published? Had Hooker told Darwin that he had read something to the meeting that he had prepared himself? We shall never know because the letter Hooker wrote to Darwin after that fateful Society meeting is missing.

On this same day, Darwin is believed to have penned a letter to Gray asking the precise date of the letter he had written to him the previous September/October/November? (Davies 2008: 156). There is no surviving copy of this letter and, what is more curious, there is no copy of Gray's (presumed) reply. In his *Autobiography,* Darwin (F. Darwin 1929: 58) claimed that the letter had been written on 5th September, 1857. This is the date under which it was published by his son, Sir Francis, who clearly had a 'duplicate copy' of the letter in his possession at that time, since he added a footnote (F. Darwin 1887: 120ff):

> The date is given as October in the 'Linnean Journal'. The extracts were printed from a duplicate undated copy in my father's possession, on which he had written "This was sent to Asa Gray 8 or 9 months ago, I think October 1857".

The reply to Darwin's request would have provided vital support for Darwin's case. That this particular letter should be missing is perhaps more surprising than the disappearance of any other letter, and yet it appears to be unremarked upon. It is also noted that, due to Darwin's editing, (F. Darwin 1887: 130, 134), the *Proceedings* were not published until the second half of August. The Atlantic mail was quite speedy, taking 5-6 days. A reply should have been received before the end of July, in time for the correct date to appear in the Society's Journal.

Darwin never wrote explicitly about what happened at the meeting. He thanked both Hooker and Lyell (F. Darwin 1887: 126, 129) for their kindness, but was clearly uncomfortable about *something* that had happened because, in his first letter to Hooker after the meeting dated 5th July, he wrote (F. Darwin 1887: 127:

> Lastly, you said you would write to Wallace; I certainly should much like this, as it would quite exonerate me.

That Hooker should have suggested he write to Wallace is indication that Hooker, himself, felt that there was something that needed to be explained. On 13th July, 1858, Darwin wrote again to Hooker (F. Darwin 1887: 128):

> Your letter to Wallace seems to me perfect, quite clear, and most courteous. I do not think it can possibly be improved, and I have to-day forwarded it with a letter of my own. I always thought it very possible that I might be forestalled, but I fancied that I had a grand enough soul not to care; but I found myself mistaken and punished. I had, however, quite resigned myself, and had written half a letter to Wallace to give up all priority to him, and should certainly not have changed had it not been for Lyell's and your quite extraordinary kindness. I assure you I feel it and shall not forget it. I am *more* than satisfied at what took place at the Linnean Society. I had thought that your letter and mine to Asa Gray were to be only an appendix to Wallace's paper.

This letter confirms that the reading of the extract from the 1844 Essay was a late decision. It is here concluded that Lyell's 'kindness' was the suggestion that Darwin move forward as quickly as possible with his writing and that it was Hooker alone who made the decision to include material from the 1844 Essay and who 'rewrote' the letter.

Further evidence that Darwin never did write to Gray in October, 1857, never sent the letter of 5th July, 1858, and never received a reply from Gray giving the date of 5th September, 1857, may be seen in the letter Darwin wrote to Gray on 11th August, 1858 (F. Darwin 1887: 135):

> Your note of the 27th July has just reached me in the Isle of Wight. It is a real and great pleasure to me to write to you about my notions; and even if it were not so, I should be a most ungrateful dog, after all the invaluable assistance you have rendered me, if I did not do anything which you asked.
>
> I have discussed in my long MS, the later changes of climate and the effect on migration, and I will give you an *abstract* of an *abstract* (which latter I am preparing of my whole work

> for the Linnean Society). I cannot give you facts ...I may just mention, in order that you may believe that I have *some* foundation for my views that Hooker has read my MS, and though he at first demurred to my main point, he had since told me that further reflection and new facts have made him a convert.

The remainder of the letter is about changes during the glacial period, Asa Gray's area of special interest. There is no acknowledgement of Gray having responded to his request regarding the date of previous correspondence, no mention of Natural Selection. Indeed, Darwin writes as guardedly as ever about his 'notions', not as to one who had been his special *confidant*. It would be strange for Gray to write twice to Darwin within the period of a week.

9.9 Wallace's reaction

When Darwin and Hooker wrote to Wallace advising him of their action in publishing his paper, Wallace was pleased. He wrote to his mother on 6th October, 1858, saying how gratified he was and expressing his belief that he was now assured of their assistance when he returned home (Brooks 1984: 201). Far from assisting Wallace, Lyell, Hooker, Huxley and Darwin had already set about establishing Darwin as the true originator of the theory. It is clear that Darwin himself was part of the 'Darwin Movement' by the time he composed his book. From start to finish, in *The Origin* Darwin spoke continually of 'my theory'. Within the body of the book, there was no mention whatsoever of Wallace's paper.

Three brief mentions were made of Wallace in *The Origin.* The first occurred in the Introduction, in which Darwin outlined his long involvement with the theory of evolution and the circumstances leading to the joint reading of his and Wallace's ideas before the Linnean Society. The other two mentions of Wallace both refer to Wallace's earlier paper on Distribution. The first did not occur until Chapter XI (Darwin 1859/1998: 269):

> This view of the relation of species in one region to those in another does not differ much … from that lately advanced in an ingenious paper by Wallace, in which he concludes that 'every species has come into existence coincident both in space and time with a pre-existing closely allied species'. And I now know from correspondence, that this co-incidence he attributes to generation with modification.

Darwin knew Wallace's views on generation with modification, not merely as the result of 'correspondence', but as a result of Wallace's 1858 paper, which he failed to mention. The 'ingenious paper" to which Darwin does refer was Wallace's earlier 'Law' paper, published in 1855 (see Section 10.2). The second reference to Wallace in *The Origin* occurred in the following chapter, overshadowed by reference to the work of a Mr. Earl (Darwin 1859/1998: 299):

> … there is also a relation … between the depth of the sea separating an island from the neighbouring mainland, and the presence in both of the same mammiferous species or of allied species in a more or less modified condition. Mr. Windsor Earl has made some striking observations on this head in regard to the great Malay Archipelago, which is

> traversed near Celebes by a space of deep ocean; and this space separates two widely distinct mammalian faunas … we shall soon have much light thrown on the natural history of this archipelago by the admirable zeal and researches of Mr. Wallace.

Darwin wrote to Wallace in January, 1859, telling him that he had stopped work on his 'big book' and was now engaged in producing an 'extract' for early publication, it being nearly complete. In this letter, he told Wallace that he "had absolutely nothing to do in leading Lyell and Hooker to what they thought was a fair course of action" (F. Darwin 1887, vol.2: 145). This statement indicates that, six months after the meeting, Darwin was still feeling uncomfortable about something that had occurred. In a further letter to Wallace, dated 6th April, 1859, Darwin spoke of the 'abstract' that he was then writing (Brooks 1984: 214):

> The first part of my MS is in Murray's hands … There is no Preface, but a short Introduction, which must be read by everyone who reads my book. The second paragraph in the Introduction I have had copied *verbatim* from my foul copy, and you will, I hope, think that I have fairly noticed your papers in the *Linnean transactions.* You must remember that I am now publishing only an Abstract, and I give no references. I shall of course allude to your paper on Distribution, and I have added that I know from correspondence that your explanation of your law is the same as that which I offer. [Italics in original]

This is an accurate account of what finally happened. Clearly Darwin had planned early what reference he would make of Wallace's ideas - those on 'Distribution', not those on 'Generation with Modification'. This letter was not reproduced in *Life and Letters of Charles Darwin*, although letters to Gray and Murray of 4th and 5th April, 1859, respectively, were (F. Darwin 1887, vol.2: 154-155). Darwin wrote to Wallace on 9th August, 1859, when his manuscript was nearing completion (F. Darwin 1887, vol.2: 161-162):

> I received your letter and memoir on the 7th, and will forward it to-morrow to the Linnean Society … Had I read it some months ago I should have profited by it for my forthcoming volume. But my two chapters on this subject are in type, and though not yet corrected, I am so wearied out and weak in health that I am fully resolved not to add one word, and merely improve style. So that you will see that my views are nearly the same as yours, and you may rely on it that not one word shall be altered owing to my having read your ideas. Are you aware that Mr. W. Earl published several years ago the view of distribution of animals in the Malay Archipelago in relation to the depth of the sea between the islands? I was much struck with this, and have been in the habit of noting all facts on distribution in the Archipelago and elsewhere in this relation.

Wallace wrote two papers on the fauna of the Malayan Archipelago. The second paper, on the zoological geography of the Malay Archipelago was presented to the Linnean Society on 3rd November, 1859 – by Charles Darwin! The paper established the invisible line separating the fauna with apparently Asian affinities from those with apparent Australian affinities as the *Wallace Line*, so it may be assumed that their contemporaries considered Wallace's contribution sufficiently original to warrant this honour over Earl.

9.10 Recent opinions

McCalman (2009: 317-329) rejected the claims of Brackman and Brooks. He accepted the June delivery of Wallace's paper at Down, attributing the delay to the uncertainties of the postal service. McCalman denied that Darwin could have amended his writing on the grounds that the Darwin household was in a state of crisis due to it experiencing an outbreak of scarlet fever. However, Darwin's son, Charles, did not contract the disease until 23rd June (McCalman 2009: 320), *after* the time suggested by Brooks (1984) for the amending of sixty pages of his manuscript. McCalman (2009: 325-327) agreed that arrangements were made with all possible haste for the reading of the Darwin/Wallace papers.

Van Wyhe and Rookmaaker (2012) also rejected any suggestion that Darwin had received Wallace's letter any earlier than the historically accepted dated of 18th June, 1858. They reached this conclusion based on the claim by Davies (2008) that Darwin's letter to Wallace, dated 22nd December, 1857, was delivered to Wallace, not on the late February steamer, but on the steamer which reached Ternate on 9th March, 1858. This, they claimed, would not have allowed Wallace to respond to Darwin's letter with his own despatched by return of mail, which would have seen it delivered to London at the same time as Wallace's letter to Bates, i.e. 6th June, 1858. Rather, the letter to Darwin would have been despatched two weeks later and received mid June, as Darwin claimed.

Davies (2012) responded by denying Van Wyhe and Rookmaaker's (2012) claim that the mail steamer would have been docked at Ternate for a short time, possibly as little as one hour, thereby making it impossible for Wallace to have responded to Darwin's comment about Lyell's interest in Wallace's work by suggesting that Darwin show his draft paper to Lyell. Davies (2012) believed that the ship would have remained docked long enough for Wallace to have read Darwin's letter and scribbled a hasty reply, or even have added a note on the back of the envelope/packet. The research of Van Wyhe and Rookmaaker (2012) led them to discover that the usual transit time from Ternate to Surabaya (Java) was about fourteen days and that this particular mail ship arrived back at Surabaya on Tuesday, 20th April, 1858. This would suggest it left Ternate on 6th April, a whole day after its arrival on 5th April. There would have been ample time for persons receiving correspondence to pen any replies considered to be 'urgent', obviating the necessity of their waiting four weeks for the next mail steamer. This would make good commercial sense. It also supports documented evidence of shipping schedules given by both Brooks (1984) and Davies (2008:) which showed that the usual stop-over time was 1½-2 days. If Darwin had indeed sent Wallace one of Lyell's earlier letters, this alone could account for Wallace's request, irrespective of anything written in Darwin's letter.

9.11 Beyond dispute

There are certain facts of this case which are beyond dispute.

1. Darwin agreed with the suggestion made to him by Lyell and Hooker that he present his

ideas to the Linnean Society by the reading of a letter he had previously written to Asa Gray in America.

2. This letter, the 1844 sketch and Wallace's paper were delivered, by hand, to Joseph Hooker during the evening of 29th June, 1858.
3. Something took place during the meeting of the Linnean Society on the evening of 1st July, 1858, which Darwin had not anticipated, which caused him distress and from which he felt the need to be 'exonerated'.
4. After the meeting, Darwin was very evasive in all his correspondence when referring to this event.
5. After the meeting, Darwin endeavoured, as far as possible, to distance himself from this event and to lay responsibility for it on Lyell and Hooker.
6. This event was not the reading of the extract from his 1844 paper, which was not controversial.
7. This event was not the reading of a letter to Asa Gray previously agreed.

What event could possibly have taken place at this gentlemen's meeting to cause Darwin such embarrassment and shame?

It is here suggested that the only plausible explanation is that the letter read out at the meeting was *not* the one Darwin had written to Gray but a substitute one, written by Hooker. Hooker was acutely aware of the distress Darwin was suffering, not merely as the result of the arrival of Wallace's paper, but, more importantly, as the result of the very recent death of his son. It is here suggested that Hooker was trying to help in the only way he could, that he composed the letter from the material available to him, which included Wallace's paper, fully believing that it contained nothing other than views already held by Darwin and about which Darwin was then writing in his 'big book'.

This explanation does not run counter to any other facts or pertinent assumptions, rather it supports them. These assumptions include the destruction of correspondence between Lyell, Hooker and Darwin pertaining to this time, probably by Darwin himself. It explains the fact that the original of Darwin's undated letter to Gray was not found among Gray's correspondence when he died, nor was there any evidence, either at the Gray or the Darwin establishment, of the reply which Gray would surely have sent if he had received that letter. It helps explain the strange nature of the undated letter, with its abrupt beginning and its unnecessary references to Hooker and other anomalies. It explains why there was found no letter from Darwin to Gray, dated 5th July, 1858, requesting information regarding the date of the undated letter, and the absence of any reply. Since the reply would have been the primary piece of evidence supporting Darwin's claim to priority, the absence of this letter is particularly difficult to explain.

Never explained has been the destruction by Sir Francis Darwin of the 'duplicate copy' of the undated letter, which was clearly in his possession at the time of the publication of *The Life and Letters of Charles Darwin* (F. Darwin 1887). That the undated letter was referred to as a 'duplicate', implied that it had been written in another hand. Had it been in Darwin's handwriting, it would simply have been referred to as a 'copy'. It is here hypothesized that Sir Francis destroyed this copy when he realised that the handwriting was not that of a member of the Darwin household, but that of Hooker.

9.12 Plot, ploy or conspiracy?

There was a clear implication made by Brackman (1980), Brooks (1984) and Davies (2008) that Darwin, Lyell and Hooker, and later Sir Francis Darwin, had been involved in some form of conspiracy to promote the ideas of Darwin above and *before* those of Wallace. A more generous conclusion has here been reached in regard to the first three mentioned above. It is here concluded that Hooker acted in haste, and with honourable intentions, believing that the letter he wrote did, in fact, not contain anything not already written somewhere by Darwin. That this was not the case would have come as a shock to all three men.

The obvious solution would have been for Hooker to say that he had inadvertently not read to the Society the letter Darwin had sent to Asa Gray the previous year but the draft of one which Darwin was preparing to send – hence it being undated. This solution would have needed to have been acted upon immediately. Every day, every hour, that the situation was allowed to continue made any form of retraction more difficult and, it is here held, was never taken, although Darwin's obvious distress is seen as evidence that he was very unhappy with the situation as it unfolded.

It will never be known whether it was Darwin who destroyed the missing correspondence between the three friends or Sir Francis. What is known is that it must have been Sir Francis who destroyed the 'copy' of the letter to Gray read to the Society which in his possession at the time the first volume of Darwin's letters was published (F. Darwin 1880: 120). Inasmuch as Sir Francis would seem to have acted alone, this cannot be considered a 'conspiracy', rather a 'plot' or a 'ploy'. Whatever it may be called, it was regrettable.

Chapter 10

With a Little Bit of Help from his Friends

10.1 Introduction

Darwin was fortunate to be surrounded by a circle of friends who were prepared to offer him their help, support and encouragement, even though they received very little in return. Not that they needed help. Lyell, Henslow, Hooker, Huxley, among others, were authorities in their own right in their own fields and all achieved fame and acclaim by their own efforts. Yet without them, and many others upon whom Darwin relied (mostly by means of correspondence), not only would Darwin never have accumulated the large store of facts with which he bolstered his arguments, it is unlikely that he would ever have completed the manuscript of his theory to the point of publication, nor would his book, once published, have received the acclaim that it did (F. Darwin 1887, 1902/1995, 1929).

Lyell's influence upon Darwin has already been covered (see Chapter 5). This chapter will look at the role played by Henslow, Hooker, Huxley and Spencer in the establishment of evolution as scientific theory and natural selection as its most likely process.

10.2 John Henslow (1796-1861)

At the time Charles Darwin entered Cambridge University, Henslow was Professor of Botany, having previously held the Chair of Mineralogy. He was keen to reform the teaching of science subjects at University at a time when university teaching was mainly classical, theological or medical. Although botany did not become a degree course in its own right until shortly before Henslow's death, it was his approach to the subject which paved the way for reform. Henslow supplemented theoretical lecturing with practical experience. He organised field trips to study geological formations and associated vegetation. Once a week he held 'open house' at his home where informal discussion took place between lecturer and pupils, and anybody else who was interested in attending. Charles Darwin was one of those interested people. Darwin's interest in entomology found a ready place within the circle of Henslow's botanical interests and the two men formed a friendship which was to last the rest of Henslow's life.

It was Henslow who recommended Darwin to Captain Fitzroy as naturalist on *HMS Beagle.* It was Henslow who gave Darwin the first volume of Lyell's *Principles of Geology* (Lyell 1830) to read on his voyage, its principle of gradual change being crucial to Darwin in the development of his theory. It was Henslow who received Darwin's boxes home during the course of the voyage It was Henslow to whom Darwin turned for help on his return home when he realised that no one was interested in his specimens, not even the museums, which were overburdened with specimens sent to them by voyagers from all over the world (Barlow 1967: 118). In retrospect, it was fortunate that Darwin was forced to do so much of this work, but without Henslow's help, Darwin's boxes may well have rotted in some cellar.

Darwin continued to rely on his good friend for help and advice. On 27th June, 1855, Darwin wrote to Henslow, asking whether he considered certain plants to be species or varieties, and why? He asked Henslow to collect seed heads from certain plants so that he could count the number of seeds and lastly, but by no means least (Barlow 1967: 175):

> … busy as you are, can you forgive these several requests? … I fear I am not a little unreasonable … I want to know whether you would & this is the most troublesome job, (though I think it sounds more troublesome than it is) sometime, say in winter [or whenever you have the most leisure *added*] read over the names in the London Catalogue of Plants (& I wd send my copy) pencil in Hand, & mark with cross, *all* those species, which you believe to be [really *added*] species, but which are *close* species; - taking some definition for a "close species", as a form, which even to a [good *added*] Botanist is a little troublesome to distinguish, or which you conceive possible, though not probable, that further research will prove only to be varieties. I am really anxious for this, but I cannot explain my motive, otherwise it might unconsciously cause you to influence the result. I do not think it would take up [much *added*] more time, than [going *del.*] reading slowly over the names.

Self-deprecation was a technique Darwin used frequently and successfully, not only in correspondence, but also in *The Origin.* By pointing out problems and then suggesting that they were not quite as serious as at first supposed, Darwin disarmed opposition and brought people round to his way of thinking (Hull 1973). From his letters alone, it is difficult to assess just how truthfully he wrote, but his biographers were unanimous in claiming Darwin to have been very diffident, even humble, in his personal behaviour (for example, see Darwin 1887/1969; Desmond and Moore 1991), so it may be assumed that he wrote as he spoke. Darwin was very appreciative of Henslow's help (Barlow 1967: 205-207) and continued to consult Henslow regarding botanical questions until Henslow's death in 1861.

10.3 Sir Joseph Hooker (1817-1911)

The Hookers were an old, well-respected English family, with a recorded genealogy stretching back some four hundred years (Huxley 1918). Sir Joseph was born in Suffolk but by the time he was five, the family had moved to Glasgow when his father, Sir William Hooker, took up the position of Professor of Botany at the University of Glasgow. By the age of seven, he was accompanying his father to the University where he 'sat in' on lectures (Huxley 1918).

After leaving school, Hooker took up the study of medicine, qualifying just in time to take up the position of Assistant Surgeon/Naturalist on board *HMS Erebus*, which was to sail to the Antarctic. He was thus on board the ship which was to discover that, unlike the Arctic, the Antarctic was comprised of a large mass of land. He was to make two voyages south, the first to Tasmania and the Antarctic, the second to New Zealand and the Cape of South Africa.

While Hooker was on his first voyage, his father was appointed Director of the Gardens at Kew. When Hooker returned to Britain at the end of 1843, he had more opportunity than ever before to immerse himself in practical botany. At this time Henslow forwarded to Hooker Darwin's collection of flora from the Galàpagos Islands, which had not until that time been examined. Thus started the association between Hooker and Darwin, which was to ripen into a life-long friendship.

Unlike Darwin, Hooker loved being at sea, and remained in the service of the Admiralty for many more years, albeit as a naturalist, having shed the unwanted position of Assistant Surgeon. After the voyage to New Zealand, Hooker made two voyages east, to India and the Himalayas, returning to England in 1851, at which time he married Henslow's daughter, Frances, to whom he had been engaged for three years. His first task on his return was writing up his work. He was able to retire from the Royal Navy in 1853 when a position became vacant at Kew as assistant to his father. On his father's death ten years later, he took over the position of Director (Huxley 1918).

Two of the people upon whom Darwin relied so much for help and information were botanists. One of the main things which separated Darwin's book on evolution from any forerunner was the inclusion of so much evidence from botany, as well as from zoology. Plants were known to vary far more readily than animals, both in nature and under domestication, because they were able to reproduce by roots and shoots, by cuttings and corms; they were not dependent on sexual reproduction, as was most of the animal kingdom. On the whole, sexual reproduction tended to stabilise species, since productive mating could only take place between pairs which were very similar. The boundary between species and variety was far harder to determine with plants than animals and this problem interested Hooker as well as Darwin. Hooker was the only person to whom Darwin confided his views in the early stages of their formation by showing him his 1844 manuscript. It as a further twelve years before Lyell was made privy to Darwin's secret and that only after Lyell had drawn Darwin's attention to Wallace's paper. Hooker was the only person whose help Darwin acknowledged in his Introduction to *The Origin.*

By the time Darwin finally published his theory, Sir Joseph Hooker was an acclaimed botanist who had published books identifying many new species and who held the eminent position at the Royal Botanical Gardens at Kew. Although Hooker's review of *The Origin* in *The Gardeners Chronicle* (31st December, 1859) was anonymous, as were most reviews, its strong endorsement of Darwin's views was no doubt influential (Hull 1973: 82-83):

> … we have risen from a perusal of Mr. Darwin's book much impressed with its importance … It is a book teeming with deep thoughts on numberless simple and complex phenomena of life; that its premises in almost all cases appear to be correct; that its reasoning is apparently close and sound, its style clear … It is also a perfectly ingenuous book … whatever may be thought of Mr. Darwin's ultimate conclusions, it cannot be denied that it would be difficult in the whole range of the literature to find a book so exclusively devoted to the development of theoretical inquiries, which at the same time is throughout so full of conscientious care, so fair in argument, and so considerate in tone.

The above favourable review did not indicate unqualified support. In a letter to Darwin, dated 20th January, 1860 Hooker wrote (Huxley 1918, vol.1: 511):

> I finished Geolog. Evidences Chapters yesterday … You certainly make a hobby of Nat. Selection and probably ride it too hard … that is a necessity in your case. If improvement of the creation by variation doctrine is conceivable, it will be by unburdening your theory of Natural Selection, which at first sight seems overstrained, i.e. to account for *too much.*

Hooker's glowing review appears to have been written *before* he had finished reading Darwin's book. Notwithstanding Hooker having perused the *Foundation* essay, having been Darwin's closest confidant and having been present at the joint presentation of the Darwin/Wallace papers, this letter clearly shows that Hooker had not fully appreciated Darwin's theory. In May of 1860, Hooker wrote to Henslow regarding a recent meeting (Huxley 1918, vol.1: 512-513):

> Sedgwick's address last Monday was temperate enough for his usual mode of attack … I got up, as Sedgwick had alluded to me, and stuck up for Darwin as well as I could … I do not disguise my own opinion that Darwin has pressed his hypothesis too far.

Darwin's friends rallied to his defence motivated as much by their high regard for him as a person as for his hypothesis, which they clearly did not totally support. Although Hooker was yet to be appointed Director of the Royal Botanical Gardens at the time of the publication of *The Origin*, he was an established authority in his own right, an elite member of the informal academic circle which governed much of the thinking then current on the subject of evolution.

10.4 Thomas Huxley (1825-1895)

Born in Ealing, West London, in 1825, of an old, but not wealthy family, Huxley had one thing in common with both Darwin and Hooker: all three launched their careers by means of at least one long sea voyage of discovery. For Huxley, the ship was *HMS Rattlesnake*, and its voyage to Australia and southern New Guinea to map the north-eastern coast of Australia was to be his only one. Nevertheless, the voyage was to have a profound impact on his life.

The young Huxley was an avid reader. His father being a school teacher, many of the books he read were of an educational nature, such as Hutton's *Geology* (Huxley 1900). Huxley enjoyed investigating how things worked and was interested in anatomy and physiology for this reason (Huxley 1900: 7). The marriage of both his older sisters to doctors enabled him to become assistant to a London doctor, whose practice was among the poor in the dock regions of London. Years later he would comment that the slaves he saw on his travels seemed happier with their lot than the poor of England, and these early memories were a driving force in his later campaign to bring education to working men – and women (Huxley 1900).

Huxley was awarded a scholarship to study medicine at Charing Cross Hospital, where he completed his medical studies. He took an interest in botany. He entered a competition at the age of 16 and won second prize. Having determined to enter (Huxley 1900: 17):

> I set to work in earnest … I worked really hard from eight or nine in the morning until twelve at night … A great part of the time I worked til sunrise.

This was typical of the (manic) enthusiasm and dedication which Huxley brought to all his endeavours and which were to ensure him a place of high esteem both among his colleagues and the general public.

On finishing his medical studies, Huxley applied to the medical service of the Royal Navy for an appointment and was eventually appointed to *HMS Rattlesnake* as assistant surgeon. There was an understanding that he would be able to carry out scientific work as time permitted. Like Darwin, he determined to make "one grand collection of specimens" which would be deposited at the British Museum, or some other public place (Huxley 1900: 25). His enjoyment of the voyage was marred by recurrent bouts of severe depression, possibly schizophrenia (McCalman 2009: 186).

By the middle of 1847, the *Rattlesnake* had reached Sydney and Huxley wrote to his sister that he had already sent a paper to the Linnean Society on *Physalia* (Portuguese Man-of-War) and was in the process of writing two more papers on *Diphydæ* and *Physophoridæ* (Huxley 1900: 33-34). These papers were well received and were to be the launching point of his career. They show Huxley's interest in evolution, modification, diversification and common descent.

10.5 Huxley's professional life

Huxley returned home at the end of 1850 and wrote up his papers, as a result of which he was elected Fellow of the Royal Society at the young age of 25. He was later to be

Secretary, then President, and in 1852, the Society honoured him with the award of the Royal Medal in Physiology.

Notwithstanding these honours, Huxley found it impossible to earn a living as a scientist, and seriously considered returning to Sydney 'to set up shop as a trade' as this seemed to be his only hope of being in a position to marry Miss Henrietta (Nettie) Heathorn, to whom he had become engaged while in Sydney, both being aged 22. The Heathorn family returned to England in 1855, and finally, after a six year engagement, the not so young lovers were eventually married, and were to remain so for forty years.

It is not possible here to detail all the positions held by Huxley. One can scarcely turn a page of Huxley's biography without learning of another position, another endeavour, in which he had become involved. Huxley had a passion for improving education, particularly by increasing the science content. He campaigned for universal education and believed society had a responsibility to provide a good technical education for those persons not suited to a professional career. Huxley lectured to the Working Men's Club, as well as women's groups. He was a member of a number of commissions, not only relating to education, but also to the fisheries, he being concerned about over-fishing. His growing family and his modest pay ensured that he was financially 'straitened', at least during the time his family were growing up. When his brother died, Huxley was forced to sell his Royal Society Medal for £50 (the value of the gold) to settle his brother's debts (Huxley 1900).

Huxley became rector of Aberdeen University and received honorary degrees from Oxford, Cambridge and Trinity College, Dublin, quite an achievement for someone who had never attended University. Huxley continued to contribute scientific papers and after his retirement collected his most important essays together into ten volumes. The subjects ranged across Hume, Descartes, Jewish/Christian Tradition, Science and Education, Darwinia, Man's Place in Nature, biology, ethics and much more (Huxley 1893-1917/1968). Huxley was a fierce opponent of the Church, which he did not feel represented what may once have been the teachings of the Nazarene. However, he was not an atheist, inventing for himself the term 'agnostic' (Huxley 1893-1917/1968). Rather surprisingly, Huxley argued for the retention of Bible Study in schools. Without training in morals and ethics, he feared children might grow up to be 'prigs' (Huxley 1893-1917/1968). In keeping with his principles, Huxley declined a knighthood, but accepted a position in the Privy Council, as this was a working position which brought him into contact with the most influential people in the country.

10.6 The 'X-Club'

Huxley and his close friends founded the 'X-Club', although there were nine, not ten, members. They met monthly to dine before attending the meetings of the Royal Society.

They socialized at other times; their wives formed their own club: 'The Yves'. The two groups combined for family outings and holidays, yet the purpose of the X-Club was far from benign. Huxley had been frustrated at his first attempt to see Darwin awarded the prestigious Copley Medal, by what he and his friends perceived as the 'Closed Club' of the Upper Classes, strongly influenced by the Church, which was by no means unreservedly supportive of Darwin's work. 'Oxbridge' graduates influenced religious, academic and political life in Victorian England. The purpose of the X-Club was to undermine this influence (McCalman 2009: 355-357):

> The Xers made friendship a machine of war … They were a meritocratic 'conspiracy' … together they were unstoppable. They nominated each other for awards, refereed each other for jobs, published each other's work, sponsored each other's lecture tours, awarded each other grants, and circulated each other's achievements … The Xers also founded or dominated major scientific journals. Huxley made the *Reader* 'an organ' of the Darwinists from 1863, and in November 1869 co-founded *Nature,* which became one of the most prestigious research journals in the world … They set out to gain access to every major establishment of national power – government, parliament, universities, schools, the Admiralty, the arts, the Church … [They] allied themselves with liberal Anglican clergymen … to promote science in schools, appoint liberal clergymen to universities, and resist the inquisitional attacks of Church Tories.

Huxley embraced the concept of evolution but never accepted that natural selection accounted for more than micro-evolution. He enthusiastically supported Darwin, not because he thought that Darwin's theory was correct, but because it allowed the premise that God was not necessarily the (sole) cause of life as we know it, indeed that there may be no need to acknowledge the existence of God at all.

10.7 Conspirators

There was a clear accusation of conspiracy made by McCalman (2009; 355-357) that Huxley and his friends had their own agenda and that Darwin's theory provided a suitable vehicle by which that agenda might be advanced. This is the only instance of conspiracy uncovered in the preparation of this thesis. People naturally congregate with others of like mind, talk on topics of mutual interest and possibly discuss methods and means whereby their ideas may be promoted. This is not only natural, it is desirable, since open debate is healthy. A conspiracy only occurs when a small group of people plot to further their aims in a covert and underhand manner, involving deception. If McCalman (2009) is correct, this is not only what happened, it was the prime purpose of the X-Club.

10.8 *Man's Place in Nature*

Perhaps the greatest service Huxley paid Darwin was to publish in 1863 a small book entitled *Evidence as to Man's Place in Nature* (Huxley 1863/1959). The purpose of this book was to put before the general public, as well as the scientific community, such evidence as could be gleaned from comparative anatomy regarding the place of human beings within Nature.

Huxley compared the anatomy of apes and humans, with particular reference to the gorilla and the chimpanzee, concluding the gorilla most closely resembled humans. However, he (1863/1959: 123) was at pains to point out that there was not a single bone in the body of the gorilla which could be mistaken for the corresponding bone in a human and that there was now no intermediate link bridging the gap between humans and apes. He concluded that humans might have originated by gradual modification from a man-like ape or "as a ramification of the same primitive stock as those apes" (Huxley 1863/1959: 125). Like Cuvier before him, Huxley's 'conclusions' appear to have been based more on a pre-determined agenda which he was resolved to follow than on the evidence produced by his own work.

Huxley also made a comparative study of the skulls of the Engis and Neanderthal fossils from the valleys of Meuse (Belgium) and Neander (Germany), respectively. Scientific study of these remains was still in its earliest stages. Huxley's views on the Neanderthals helped to shape European thought on this (at that time) earliest of human beings. He concluded that both these skulls were within the range of modern humans (1863/1959: 181-183).

10.9 Problems

Huxley (1893-1917/1968) saw three problems with Darwin's theory: saltation, hybridisation and speciation.

Saltation

Huxley was not happy that Darwin had specifically excluded saltation from his theory. His later writings place less emphasis on this aspect, possibly because Huxley realised that it was subsumed under hybridisation and speciation. Nevertheless, he always remained aware of 'discontinuities' which, in his opinion, could not be explained by Darwinian gradualism.

Hybridisation

Like all naturalists of his time, Huxley was puzzled by the ability of apparently closely related species, such as the horse and the donkey, to produce healthy offspring which were nevertheless infertile. Huxley acknowledged that external conditions could have had a greater influence on the ability to breed than had yet been realised and accepted, conditionally, Darwin's idea that the correct breeding conditions for mules may not yet have been found. He was not entirely happy with this explanation, but if this were the only difficulty with Darwin's theory, then he would not consider that difficulty insurmountable.

Speciation

A cornerstone of Darwin's theory was that variations eventually became species, yet some five thousand years of recorded domestication, and the production of countless varieties, had yet to produce one instance of two varieties, known to be descended from a common progenitor, which had become two completely separate species, i.e. were not inter-fertile.

Bearing in mind the thousands of varieties of sexually reproducing animals which had been produced under domestication, at least *one* should be classifiable as a separate species if Darwin's explanation was the correct one. Until this happened, Huxley maintained that natural selection was an hypothesis, not a theory.

10.10 Herbert Spencer (1820-1903)

Herbert Spencer was not one of Darwin's close circle of friends, although he was a great friend of Huxley and was considered one of the greatest philosophical minds of the nineteenth century. The son of a school teacher, he himself never went to school or university (Spencer 1861/1966).

Spencer's first paid employment was as a worker on the London-Birmingham railway. This sparked his interest in geology and fossils. Reading Lyell's *Principles*, Spencer was unconvinced by Lyell's criticism of Lamarck's theory of evolution, becoming rather a convert to the idea. Spencer's first essay on the subject of evolution, *Progress: Its Law and Cause*, was published in 1857 but, like others before him, he failed to suggest a mechanism by which evolution might have taken place, which was to be Darwin's and Wallace's great contribution the following year. However, Spencer did use the word 'evolution' in place of the more generally accepted 'epigenesis' and later was to suggest 'survival of the fittest' as being a better description of evolution than 'Natural Selection', which was seen by some to imply some conscious selection by Nature (God). Spencer dealt more fully with the subject of evolution in his *First Principles of a New System of Philosophy,* published in 1862 (Spencer 1862). Some, for example Ruse (2006: 19), attribute to Spencer the independent discovery of natural selection, which would raise to three the number of people who had made the same discovery by 1857: Darwin, Spencer and Wallace. Spencer's work, appearing as it did so closely before and after the publication of *The Origin*, was of great assistance to Darwin in establishing the concept of 'natural selection by the survival of the fittest' in the minds of the Victorian public. However, Spencer by no means accepted Darwin's theory unreservedly. Indeed, his doubts seem to have increased as time passed.

10.11 Spencer and 'natural selection'

In 1893, a long article by Spencer (1893) was published in the *Contemporary Review* under the heading *The Inadequacy of Natural Selection.* Spencer contended that the process of evolution by natural selection was applicable only to features which were of 'life or death' importance. He suggested that there was more chance of a new/improved characteristic spreading throughout a group or species, if it were passed on in an acquired form, rather than if its establishment depended upon reproductive success (Spencer 1893). While fossil evidence indicated that human jaws had decreased in size over the millennia, Spencer asserted that there was no reason to suppose that a person with a slightly smaller jaw ever had greater life/reproductive potential than another person with a slightly larger jaw and that there was, therefore, no scientific support for this type of argument (Spencer 1893: 162).

Spencer argued that the long front legs of the giraffe had come about in synchronicity with changes in other parts of the giraffe's body. The bone, muscle, tendon, etc., of the back and hind legs of the giraffe would have had to adjust to accommodate the longer forelegs to allow the giraffe to run, even if with a 'grotesque gallop' (Spencer 1893: 44). Somewhat surprisingly, Spencer did not point out that the giraffe was the only mammal whose forelegs were so long that they had to be splayed outwards in order to allow their possessor to drink. Common sense would seem to suggest that the giraffe's forelegs should have stopped growing, or its neck should have continued to grow, to allow the animal to drink, rather than that the shoulder girdle should adapt in this unique way. (I have yet to see this point addressed in the literature.) In answer to people who claimed that co-operative parts changed together, Spencer pointed out that this would apply just as much in reverse, yet the blind cave crabs of Kentucky had lost their eyes but not the stalks carrying them (Spencer 1893: 439).

Spencer made reference, as had Darwin (1859/1998), to the unusual case of a male quagga (a South African animal related to the zebra) owned by the Earl of Morton, which was mated with a black mare, which, not surprisingly, gave birth to a foal "with decided indications of her mixed origins" (Spencer 1893: 448). The mare was sold to Sir Gore Ouseley, who mated her with a black Arabian horse, but the first two foals of this later union were both bay in colour, like the quagga, and had dark stripes along the ridge of the back and across both the fore and back leg (Spencer 1893: 448). A second case occurred with a pig. A black-and-white sow had been mated with a wild boar of chestnut colour and in some of her litter the chestnut colour of the boar was strongly marked. The sow was subsequently mated with a back-and-white domestic boar, but some of the litter were of chestnut colour (Spencer 1893: 452).

These two cases proved to Spencer's satisfaction that Weismann (see Chapter 12) was wrong in alleging that somatic cells were completely independent of and separate from reproductive cells (Spencer 1893: 454). Spencer held that cells were interlinked by threads of protoplasm, which allowed information to be transmitted throughout the organism and thus characteristics acquired during the life time of an individual, even through a previous mating, could be passed on to the next generation (Spencer 1893: 453). Spencer insisted that his comments were not to be taken as being *contra* Darwin. Rather they supported Darwin, who fully recognized and often insisted on the inheritance of acquired characteristics as an integral part of his theory (Spencer 1893: 453). An alternative explanation was offered by Romanes (1893), that some sperm from the earlier mating survived in the female body and was responsible for the later mating.

The two people considered of greatest intellectual stature during the second half of the nineteenth century, Huxley and Spencer, both accepted evolution, but neither was completely satisfied with Darwin's theory of how it had come about. Huxley was concerned because natural selection did not account for major changes (speciation), while Spencer was concerned because it did not account for minor features, which would not have influenced survival or procreation.

10.12 Spencer and Social Darwinism

Spencer (1879) was interested in the evolution of societies. He believed that the more people lived together in small spaces (i.e. towns), the greater was the amount of (mental) energy circulating among them. Spencer believed that increased mental stimulus was the reason that town dwellers ('civilised' people) had increased intelligence. That having happened, it was inevitable that, as the human population continued to grow, the superior races would replace the inferior (Spencer 1879: 507-510). This formed the basis of Social Darwinism.

Spencer portrayed the path to civilisation as a progression from cruelty and callousness to kindness and caring. He believed there was no need to impose laws upon humans in regard to their behaviour because 'good behaviour' gave pleasure, while 'bad behaviour' resulted in pain. Humans would automatically do what was good, because it was also pleasurable (Spencer 1879). The torture inflicted upon unfortunate victims, especially during Tudor times and under the Inquisition, is evidence to the contrary. This was yet another example of prejudice (in favour of one's own people and way of life) over-riding truth.

Chapter 11

Romanes – Darwin's Protegé

11.1 George Romanes (1848-1894)

In his later life, Darwin formed a close friendship with George Romanes, whose interest in Darwin's work had initially led him to a comparative study of the mental capacities and emotions of animals and humans. Darwin was as interested in the evolution of the mind and the emotions as he was in that of the body. His theories were the impetus for the serious study of human and animal psychology (Boakes 1984). Romanes' first three works were *Animal Intelligence* (1882), *Mental Evolution in Animals* (1884) and *Mental Evolution in Man* (1888).

After reading a contribution which Romanes had made to *Nature*, Darwin invited Romanes to Down House. Romanes assisted Darwin with some of his experiments, undertaken with a view to supporting Darwin's theory of *pangenesis*, and it was from this time that Romanes commenced his work which concentrated on physical evolution. A comprehensive representation of the correspondence which passed between them, as well as accounts of Romanes' visits to Down, were given by Romanes' wife, Ethel, in her *Life and Letters of George John Romanes* (E. Romanes 1896) published after his death. The first volume of Romanes' three volumes on Darwin's theory was completed before his death, the remaining two being edited from notes and published posthumously (1892-1897).

His close friendship with Darwin, and his capabilities as a lecturer, made Romanes a well respected authority on Darwinian theory. Romanes believed the "idea of natural selection is unquestionably the most important that has ever been conceived by the mind of man" (Romanes 1892-1897, vol.2: 256-257). Romanes began the elevation of Darwin and his theory almost to a 'cult' status commenced.

Romanes' books were written as a consequence of his years of lecturing to fill what he saw as a need to clarify Darwin's position, which he believed was already becoming distorted. In particular, he took issue with Wallace who attributed *all* evolutionary change to the process of natural selection, something which Romanes insisted Darwin never did (Romans 1892-1897, vol.2: 1; Darwin 1859/1998: 7). Romanes noted that since Darwin's death, the

Wallacean view of natural selection as the sole cause of organic evolution was receiving more and more support, thanks to the theory of inheritance put forward by Weismann (see Chapter 15), for which Romanes coined the term *Neo-Darwinism.*

11.2 Lamarckism

Romanes understood that Lamarck's whole thesis in regard to evolution revolved around the notion of an inherent force in nature, striving for growth, adaptation and diversification, that the twin theories of use/disuse and inheritance of acquired characteristics must be evaluated within that framework.

Romanes (1892-1897, vol.2: 255) acknowledged that the theory of the 'inheritance of acquired characteristics' should more correctly be associated with the names of Erasmus Darwin and Herbert Spencer than Lamarck, but decided to follow established custom and refer to this hypothesis as 'Lamarckian'. This decision was one of many taken by writers on the subject of evolution which effectively repressed and 'silenced' the true nature of Lamarck's work and opinion.

Both theories, Lamarckism and Darwinism, relied heavily on the concept of 'use and disuse', but Darwin's theory, he claimed, was concerned only with the transmission of *congenital* characteristics, not with characteristics acquired during the individual's lifetime, a position inconsistent with Darwin's theory of *Pangenesis*, in furtherance of which Romanes himself was undertaking a number of experiments on Darwin's behalf (Romanes 1892-1897, vol.2: 223). Romanes' intent was to disprove Weismann's theory of the separation of germ-plasm (Romanes 1892-1897, vol.2: 240). None of the experiments carried out were successful and when asked why he had not published his results, Romanes (1896: 223) replied that he had not wanted to publish anything negative.

11.3 Use inheritance

Romanes was equally as critical of those who believed in use-inheritance as those who believed in natural selection, if they tried to claim their preferred method to be the sole method of *all* evolutionary change. Not enough attention had been paid to the difference between selective and adaptive characteristics. A colour affording protection and thus greater chance of survival was an example of *selective* evolution. The reflex action of removing one's foot from some source of irritation, or of a dog shaking water from its coat, could never have been of life-saving importance. These were examples of *adaptive* evolution, more readily explained by use inheritance. Continual repetition in a certain way to specific stimuli would eventually result in the inheritance of the appropriate reflex (Romanes 1892-1897, vol.2).

11.4 Adaptations

Certain adaptations, such as better eyesight or longer limbs, might evolve in different members of the same species and gradually spread until all members had *both* adaptations. This would be an example of cumulative blending of adaptations. Completely different were the cases of adaptations having no selective value by themselves but which were useful when occurring with other adaptations, such as the lowering of the larynx and the development of the hyoid bone, neither of which had any adaptive value on its own. Adaptive value in such cases could only have been present if two or more adaptations occurred simultaneously in a co-ordinated manner in the same individual, since they were unlikely to have occurred together by chance in more than one. Wallace, and other Neo-Darwinists, did not recognise the problem of co-ordinated adaptations (Romanes 1892-1897, vol.2: 66-67), holding that natural selection alone was sufficient to account for all evolutionary variation.

Romanes was puzzled about the origin of the instinct of the *Sphex* to sting larva precisely on nine separate nerve ganglia, to paralyse and preserve them as food for its young. How many chance times would be needed for the *Sphex* directly to envenomate *one* ganglion that it became ingrained as an instinct? The number of repeated 'chance hits' to establish an instinct accurate enough to envenomate *nine* ganglia were so astronomical that they could not be calculated, although Romanes (1896: 222-223) suggested "unity to one thousand million billion trillions". This was not enough to shake his faith in Darwin's theory.

11.5 Discriminative isolation

Romanes' believed opinion that too much attention had been paid to possible causes of isolation, such as geography, and not enough to type. Geographical isolation was indiscriminate. Pure chance dictated which animals were where when an earthquake caused an influx of water to isolate two pieces of land which had formerly been one. Discriminative isolation meant that some factor had separated out a particular subsection for isolation, such as happened under domestication. In nature, visiting insects could discriminate between various plants. In the higher animals, choice of partner could also be a discriminating factor, possibly effecting secondary sexual characteristics. Since in nature all available females would normally be mated, such evolution of secondary sexual characteristics, if it occurred, would only affect males.

Natural selection was a discriminating factor. The more fit survived, the less fit died out. The effects of discriminative selection were always cumulative. However, due to interbreeding, as the change(s) spread throughout the interbreeding population, they may diverge from their original type, but only one new variety/species would result. On its own, natural selection could only lead to monotypic variation, one parent type being replaced by one daughter type (Romanes 1892-1897). This was a restatement of the problem of divergence which had troubled Darwin for so long.

11.6 Physiological isolation

While physiological isolation (infertility) was recognised by Romanes as essential for establishing a new variety or species, how this came about was unknown. Change needed to occur in the reproductive cells as well as in the soma. If change took place in the reproductive cells of only one plant or animal such that that organism was unable to procreate with any of its fellows, then that variation would not survive. If no change took place in the reproductive cells, then cross-breeding would swamp the variation out of existence (Romanes 1892-1897: vol.3). Romanes postulated that infertility between the old and new variety/species would at first be "… well-nigh imperceptible, and have to proceed to increases stage by stage" (Romanes 1892-1897, vol.3: 43). How the 'well-nigh imperceptible' infertility could increase stage by stage is unclear, since the infertile ones would be eliminated and only the fertile remain.

11.7 Early stages of adaptation

In Romanes' view, a bigger problem was posed by trying to explain the beginning of structures that were useless to the animal until such time as they were at least somewhat developed and thus came under the influence of natural selection. He denied the premise that *all* adaptations had to be useful from the first in relation to their final function. For example, the early change occurring in a forelimb which would eventually become a wing would not have had anything to do with potential flight, but might have been "for increased locomotion of other kinds" (Romanes 1892-1897, vol.3: 355), although he declined to offer any suggestion as to what other kind of locomotion this might be.

One case had been advanced by the Duke of Argyle (Romanes 1892/1897, vol.3: 364), which Romanes agreed was difficult to explain by natural selection – that of the electric organ in the tail of the skate. While a number of creatures were known to possess the ability to discharge an electric current, that of the skate in question (*Rala radiata)* was so mild that it was only discovered because a Professor Sanderson heard electrical interference when he touched a skate in its tank while talking on the telephone. The mild electrical discharge from the skate was too weak to be felt by the hand and certainly too weak to do any damage to either predator or prey. To make the problem even more severe was the fact that electric organs in animals require the transformation of muscle tissue into a special type of nervous tissue, which is far more expensive to maintain from a metabolic point of view than normal muscle tissues, to say nothing of the 'wasting' effect this development had on the propulsive ability of the much thinned tail. Why would this, or any other species of fish or eel, undertake the metabolically expensive and time-consuming task of evolving electric cells at a point when the cells were incapable of actually discharging any electrical impulse at all, let alone continue to select for this feature during the time the discharge was too weak to be felt?

For Romanes, this was the most difficult case yet encountered by the defenders of Darwinism and had there been many other cases like it, he would have been forced to admit that the theory of natural selection would have to be discarded. Since it was a solitary case, Romanes was convinced that a solution would eventually be found under the general law of selection (Romanes 1892-1897, vol.3: 371). Darwin (1859/1998: 146) had been aware of a 'difficulty' in respect of electric organs:

> The electric organs of fishes offer another case of special difficulty; it is impossible to conceive by what steps these wondrous organs have been produced but … their intimate structure closely resembles that of common muscle …. Rays have an organ closely analogous to the electric apparatus and yet do not …. discharge any electricity, we must own that we are far too ignorant to argue that non transition of any kind is possible.
>
> The electric organs offer another and even more serious difficulty; for they occur in only about a dozen fishes, of which several are widely remote in their affinities.

Darwin appears to have been more concerned with the problem of parallel evolution than he was of how evolution itself could be accounted for by the theory of natural selection, which he assumed was capable of anything. In fact, this problem applies to all venoms, both in animals and plants such as the stinging nettle, as well as to all electrical discharges.

Darwin's theory of natural selection had caused what would later become known as a 'paradigm shift' (Kuhn 1962/1970). Popper (1972) held that one piece of contradicting evidence was sufficient to undermine a theory, the 'falsification' with which Popper's name is now indelibly associated. Romanes' suggestion that the theory should be upheld, despite contradictory evidence, was an attempt to put in place a 'protective belt' to 'save the theory' (Lakatos 1970), something that many scientists felt should be allowed while further evidence was being gathered. The number of 'protective belts' around Darwin's original theory has been steadily rising. The Kuhn/Lakatos theory predicts that at some point the number of 'protective belts' will become so large and cumbersome that the paradigm (in this case natural selection) will be abandoned and another paradigm that better explains the inconsistencies will take its place.

11.8 The final word

Romanes' three volume treatise concluded with the following words (Romanes 1892-1897, vol.3: 141):

> Having unanimously agreed that organic evolution is a fact and that natural selection is a cause or a factor in the process, the primary question in debate is whether natural selection is the only cause, or whether it has been assisted by the co-operation of other causes. The school of Weismann maintain that it is the only cause; and therefore deem it worse than

> useless to search for further causes. With this doctrine Wallace in effect agrees, excepting as regards the particular case of the human mind. The school of Darwin, on the other hand – to which I myself claim to belong – believe that natural selection has been to a considerable extent supplemented by other factors.

Romanes acknowledged that the greatest obstacle yet to be overcome in relation to Darwin's 'true theory' was the vexed question of the possible inheritance of acquired characteristics. He hoped that the next ten years would finally bring a solution to this outstanding question (Romanes 1892-1897, vol.3: 142):

> … thus that within the limits of an ordinary lifetime the theory of organic evolution will have been founded and completed in all its parts, to stand for ever in the world of men as at once the greatest achievement in the history of science and the most splendid monument in the nineteenth century.

Romanes was the first person to write of Darwin and his theory with such adulation, a tendency which has been continued over the century since his death. Over a century later, Dennett (1995: 21) went further, stating "If I were to give an award for the single best idea anyone has ever had, I'd give it to Darwin, ahead of Newton and Einstein and everyone else". Unfortunately, such adulation and almost unquestioning acceptance of Darwin's work has hampered the very thing which Romanes so much desired: a deeper look for other causes of evolutionary change and a re-evaluation of 'difficult' cases.

11.9 Romanes' Position

Romanes took no ideological position in relation to a 'Creator'. His work was presented in a scientific manner and, for the purposes of this thesis, must be included within the secular paradigm. He was aware of 'discontinuities' which did not fit within the theory of natural selection. Darwin had insisted on gradualism and his supporters cannot be blamed for following this direction. However, Darwin (1859/1998) did write that natural selection was *one* means by which evolution took place. He did not offer any others, merely left open the possibility that they existed. This flexibility has made the precise interpretation of Darwin's thinking problematic.

Romanes elevated Darwin to a position of esteem higher than that attributed to him by any other of his (Darwin's) friends. Clearly Romanes' personal feelings towards Darwin caused him to support Darwin's theory despite it not being confirmed by his own experiments or arguments. Ideology triumphed over science.

Chapter 12

Reactions to Darwin's Theory

12.1 Introduction

Despite anonymous authorship being accepted practice in Victorian England, and despite the anonymity providing fertile grounds for speculation, it was definitely to the advantage of *The Origin* over *Vestiges* that its author's name was known. Charles Darwin had built upon the good reputation of his family name, not only by his voyage, but also by the quality of his subsequently published work, especially his paper on barnacles, which was acknowledged as being of high calibre. He was to continue to build upon this reputation with his future scientific papers on subjects as diverse as orchids and worms.

The considered opinion of a person so well-respected carried considerable weight with a British public, already becoming more and more convinced of the fact of evolution by the discovery of more and more fossils. Huxley (1893/1917: 352) estimated that between 30,000 and 40,000 fossil species had been discovered. Despite being a strong supporter of Darwin, Huxley nevertheless admitted that if all of Darwin's contributions to the subject of evolution were to be omitted, the reality of evolution would stand on the fossil evidence alone (L. Huxley 1900, vol.2: 12).

During the second half of the nineteenth century, Richard Owen took over from Cuvier as the authority on fossil animals and he acknowledged an evolutionary process, attributing it to the 'active and anticipating intelligence' of the 'Great Cause' (Owen 1890: 450). Owen accepted Lamarck's concept of continuous 'spontaneous generation' as more logically consistent than Darwin's theory of life having been created once only and remained a critic of Darwin's concept of natural selection.

Hull (1973) collected together sixteen of the most important reviews of Darwin's work, including those by Sedgwick, Owen, Jenkin, Mivart and Agassiz. Some were for Darwin, some against, others tried to give both sides equal weight, leaving the reader to decide. Many were lengthy, well-considered critical analyses. The review by Fleeming Jenkin was the one which Darwin found most troublesome, because it was long and well-argued; that by

Mivart was to Darwin the most annoying, because it supported the concept of evolution, but decried Darwin's processes of thought (F. Darwin 1887/1969; Darwin 1903).

Reviews are discussed in the correspondence between Darwin, Huxley, Henslow and Hooker, and between these men and their individual correspondents (Darwin 1887/1969, Darwin and Seward 1903, Barlow 1967, Hooker 1918, Huxley 1900). Naturally, there was a considerable degree of overlap between the writers in regard to their criticisms. The following is a synopsis of the main points (Darwin 1887/1969; Darwin and Seward 1903; Barlow 1967; Hooker 1918; Hull 1973; Huxley 1900; Peckham 1959; Vorzimmer 1970).

12.2 Points frequently raised

Variation

While it was admitted that possibly a greater degree of individual variation existed in nature than was immediately obvious, it was nevertheless questioned whether small degrees of variation were sufficient to make the difference between life and death for the individuals concerned. Such degrees of difference needed to occur not once, but many times, for changes to accumulate such that they would warrant identification as distinct species. Darwin was sensitive to this criticism. In later editions of *The Origin,* phrases such as 'very small' were reduced to 'small' (Peckham 1959, Verzimmer 1970). However, Darwin's critics were not satisfied, inasmuch as these small, cumulative changes did no more than postulate longer legs, stronger wings, etc., which was hardly a novel idea. They did not explain the *origin* of anything.

Speciation

Following from the above, it was pointed out that thousands of years of domestication had failed to result in any new animal (sexually reproducing) species. Pigeons were still pigeons, cows were still cows and, most importantly, dogs were still dogs. No other creature had undergone such a metamorphosis as had the dog, yet, not only were dogs clearly dogs in human eyes, dogs themselves were never deceived (Hull 1973: 145). Selective breeding was able to produce structural divergence as great as those of species, but not physiological divergence (Huxley 1893/1917: 429).

Darwin had used variation under domestication as the main platform for his theory. If speciation could not occur under domestication, could it occur at all? Darwin felt that his critics were asking too much to expect such a speciation to occur during an observable length of time (Darwin and Seward 1903: 225).

Although he acknowledged that Darwin's hypothesis would be 'utterly shattered' if it were to be demonstrated that it was impossible to breed forms mutually sterile from descendants of the same stock, Huxley saw no reason why such mutually sterile forms should not be produced and confidently expected that they would be (Huxley 1893/1917: 464-465). Placing the burden of proof at some time in the future made Darwin's theory impossible to falsify.

Saltation

Leading on from the problem of speciation was that of saltation, which Darwin had denied (Darwin 1859/1998). That 'sports' (unexpected variations) did occur, especially among domesticated plants, was a fact. Huxley accepted that such 'sports' probably did occur in nature. Nevertheless, a 'sport', such as a flower with extra petals, still had produced no new feature.

While Darwin claimed that all life had descended from one, or a very small number, of forms (Darwin 1859/1998), his theory failed to explain the origin of any feature.

Intermittent forms

The problem of intermittent forms fell into two categories, their survival during selection and their survival during fossilization. For example, how did a reptile survive for the thousands, possibly millions, of generations necessary for its forelimb to convert into the wing of a bird, during which time it would be possessed of neither a fully operational forelimb, nor of a wing (Hull 1973: 150)? Of great concern was the lack of intermittent forms in the fossil record. Darwin attempted to counter this criticism by appealing to the imperfection of the fossil record. In this he was not entirely successful. His critics pointed out that it was now acknowledged that certain geological formations, such as chalk cliffs, had taken untold ages to form. However, fossil evidence showed very little change in life forms between those existing during the earliest sedimentation and those of later deposits. If it took so long for even slight changes to take place, how long would it take for the establishment of a new, perfected form? There was no evidence of the evolution of these later forms, which just appeared.

Darwin had suggested that forms new to one area may have arrived from another, but as more and more fossils were found, there was no evidence of the previous homes of these incoming forms. Darwin also suggested that their former homes were now beneath the sea, an hypothesis completely untestable (at that time), which was accepted by his supporters but considered a lame excuse by his detractors (Hull 1973).

Connecting links

Since evolution was ongoing, connecting links (intermittent forms) should be found between varieties and species, etc. Whereas supporters of Darwin were prepared to see links between, for example, fish and birds in the flying fish or the penguin, and between mammals and reptiles in the platypus, others saw these forms as completely separate. The platypus may be an egg laying mammal, but did this connect it to egg laying fish, egg laying reptiles or egg laying birds? Some fish and reptiles gave birth to live young. Which should be considered connecting features and which lines of demarcation? Such 'links' as appeared to exist did not satisfy the full requirements of 'connections' between all families, genera, species, etc.

Simple organisms

It was asked 'If evolution is ubiquitous, why are there still simple organisms?' Darwin claimed that, since there was still a place in nature for simple organisms, not all would have evolved. It was queried why simple organisms should have evolved at all. Agassiz pointed out that earlier fossil forms may have been different from later ones, but they were not necessarily less complex. Indeed, in some instances, more complex forms preceded simpler ones (Hull 1973: 444).

Personification of Nature

It was claimed that Darwin had substituted 'Nature' for 'God' and had spoken as if Nature planned and carried out evolution with intent. There was a discrepancy between the impression given in some parts of his book and the overall impression that evolution was without guidance. While Darwin endeavoured to convince people that he held the latter view, he had difficulty himself with completely letting go of the former. In a letter to Hooker, dated 12th July, 1879, he wrote (Darwin and Seward 1903: 321):

> My theory is a simple muddle. I cannot look at the universe as the result of blind chance, yet I can see no evidence of beneficent 'design', or of design of any kind, in the detail.

Since Darwin was unclear in his own mind, it is not surprising that some of his readers were also unclear.

Spontaneous generation

Darwin rejected Lamarck's concept of spontaneous generation, i.e. the generation of life by 'natural/chemical' means. In the very last sentence of *The Origin*, Darwin wrote of life and its several powers "having been originally breathed into a few forms or into one" (Darwin 1859/1998: 369). Pictet argued that there were only two alternatives: either life had arisen spontaneously (internally) or it had been 'breathed' into matter by some other force (externally). Since Darwin had rejected the first alternative, his final conclusion was a genuine statement of his position, not an attempt to forestall criticism by the Church, as some people believed (Hull 1973: 149).

Mivart and Pictet argued that a belief that generation was ongoing, either spontaneously or through the action of the Creative Force, was less an appeal to the miraculous or supernatural than was a belief that generation of life had happened only once (Hull 1973). Others, such as Owen, also argued for 'continuously operating creative laws' (Hull 1973: 195).

It was argued that Darwin and his supporters had no right to divide people into two groups, Creationists (belief in God and planned creation according to Genesis) and Evolutionists (atheists denying any plan to creation), when many believed evolution was planned and guided by God. This latter group could, and should, be further divided into those who believed that God had set His whole plan in motion from the very beginning and those who believed that God was continually active in His creation.

Unconscious selection

Mivart agreed with Pictet and in 1871 published his own book, *On the Genesis of Species*, suggesting that species evolved through saltation, driven by an innate internal force (Hull 1973). Mivart was a Catholic and endeavoured to show that evolution was compatible with biblical teachings. He believed two forces were at work, one active (generative), the other passive (selective) and claimed that Darwin also postulated two such forces. Natural Selection (passive) could only operate on changes which had appeared spontaneously, i.e. had been brought about by some mechanism within the plant or animal itself (active).

With successive editions of *The Origin,* Darwin came to rely increasingly on what he called 'unconscious selection' where whole populations altered at the same time in the same way due to their being acted upon by changed external forces or conditions (passive change) (Darwin and Seward 1903, vol.1: 311).

Blending

Darwin proposed 'unconscious selection' in response to the problem of 'blending'. Since it was assumed that the characteristics of the two parents were blended, and therefore halved, at each union, it seemed obvious that any new characteristic passed on by inheritance would soon be swamped by the old characteristic at subsequent matings. This posed a big problem for Darwin, one he never completely solved. Suggesting that a whole population would change concurrently due to experiencing the same external changes was an attempt to overcome this problem. Indeed, Darwin argued that blending would actually speed up the process of spreading new characteristics. Blending thereby became a means for maintaining species as well as promoting change.

Covering both sides

Attention has already been drawn to Darwin's tendency to cover both sides of an argument. This was noted by his critics. For example, in one of the most comprehensive of the reviews of *The Origin* published in 1867, Fleeming Jenkin took exception to Darwin citing the same forces as barriers to the spread of variation that he also used to explain distribution (Hull 1973: 342):

> Darwin calls in alternately winds, tides, birds, beasts, all animated nature, as diffusers of species, and then a good many of the same agencies as impenetrable barriers. There are some impenetrable barriers between the Galapagos Islands, but not between New Zealand and South America … However an animal may have been produced, it must have been produced somewhere, and it must either have spread very widely, or not have spread, and Darwin can give good reasons for both results.

So good was Darwin at coming up with explanations, that he earned himself the nickname 'Wriggler', an epithet which seems to have amused, rather than displeased, him (Darwin and Seward 1903).

Limitation of Variability

From the third edition of *The Origin* (Darwin 1861) onwards, Darwin included attempts to address points raised by his critics, to such an extent that by the 5th edition, about half his book had been altered (Peckham 1959, Vorzimmer 1970). Darwin rarely yielded a point completely. For example, in response to Harvey's comment that Darwin had *assumed* variability to act indefinitely, Darwin responded (Vorzimmer 1970: 139-140):

> That varieties more or less different from the parent stock occasionally arise, few will deny; but that the process of variation should be thus indefinitely prolonged is an assumption, the truth of which must be judged of by how far the hypothesis accords with and explains the general phenomena of nature.
>
> On the other hand, the ordinary belief that the amount of possible variation is a strictly limited quantity is likewise a simple assumption.

His opponents rejected this view. Domestic breeders of both plants and animals had found that in the initial stages of breeding to develop a feature, rapid progress could be made. After a few years, it became harder to gain any further ground in that particular direction and attention was then frequently diverted to the production of a new variety. Darwin's critics claimed that the *evidence* supported limitation to variability and that Darwin's claims were merely hypothetical or conjectural (Hull 1973).

Hypothesis or Theory?

One of the issues which Huxley believed prevented Darwin's hypothesis from being accepted as a theory was that of hybridisation. Darwin considered he had 'shown' in *The Origin* that domestic dogs were descended from two or more species of dog (Darwin 1859/1998: 193-194). While Huxley himself concluded that small domestic dogs were probably descended from jackals and large ones from wolves, nevertheless he declined to accept the matter as proven until fertile hybrids between jackals and wolves were produced, something which he was confident would shortly be achieved (Huxley 1893-1917/1963).

Several species combining to produce one, even if that species had several varieties, was hardly the direction by which Darwin was arguing that *diversification* had been produced under natural selection. Quite the reverse.

Darwin partially withdrew hybridisation as a factor in natural selection when he suggested that, while he was sure several of our domestic animals were the result of interbreeding between separate wild species, he conceded that there was probably something in domestication which made the reproductive system more plastic, eliminating the natural sterility of species (Darwin and Seward 1903: 232).

Moral attributes

By 'moral' was meant not only such attributes as altruism, but the ability to philosophise, to construct mathematics and to participate in artistic endeavours such as music, painting and poetry, none of which seemed capable of being explained by natural selection.

Unsound reasoning

Darwin found Mivart's critique the hardest to answer. Mivart himself supported evolutionary theory, following closely the debate surrounding *The Origin.* It was not until after the publication of the 5th edition of *The Origin* and the publication of *The Descent of Man* in 1871, that he finally entered the public debate. He published a scathing attack on Darwin's process of reasoning. With every edition, Darwin was modifying his thesis. Points which Darwin had previously stated 'must be', he now found only 'may be', or admitted were entirely wrong (Hull 1973: 359). Darwin appealed to a 'belief in the general principle of evolution', considered things 'possible', 'probable', that we had 'every reason to believe', 'no doubt', 'almost certainly', 'can hardly be a doubt', etc. (Hull 1973: 359-360).

Nor was Mivart the only person to object to Darwin's method of dismissing difficulties by declaring them not to be insuperable. Hopkins, in a lengthy review published June, 1860, drew attention to Darwin's manner of asserting that "if this be true … then it would not be an insuperable difficulty to my theory if …" when arguing for the existence of former forms, no evidence of whose existence had been found (Hull 1973: 263-264):

> We had not dreamt that because the objections to a theory could not be proved to be absolutely insuperable, we were called upon to accept it as true. We had fancied that the laws of reasoning in such matters … were still in force.

Time

Fossil evidence, such as chalk cliffs, did indeed support the notion that change took place very slowly – if at all. To this length of time had to be added great stretches unaccounted for by 'missing' geological strata and associated fossils. Lord Kelvin had calculated the rate at which it had to be assumed that the Earth would have cooled and concluded that the Earth could not be older than 40 million years. This was far shorter than needed for the Darwinian hypothesis of evolution. Radio-activity is now known to help counter loss of heat from the Earth into space, but Darwin refused to accept the best scientific estimate that was available at that time and this did not help his reputation for basing his hypothesis upon unproven data (de Beer 1963: 174).

12.3 Different languages?

Darwin and his supporters seemed at times to be speaking a different language from that of Darwin's critics, a not uncommon phenomenon during a time of paradigm change (Kuhn 1970). Darwin's critics were asking questions about the *origin* of features, such as the first feather, the first nerve sensitive to light, indeed the first nerve, or the first bone. In reply, Darwin gave suggestions regarding *adaptations,* the thicker fur on the fox or rabbit in colder climes, the longer legs of the deer, the longer neck of the giraffe, the more magnificent horns of the stag. Darwin did not seem to understand that, if he wanted his theory to account for more than variation, then he must provide *extra* information before extrapolating to families, orders, to four or five original types, or even to one.

12.4 General position

As the Victoria era drew towards its close in Britain, the religious ideology still dominated the secular within the general community. Christianity was still largely unchallenged. However, within the scientific community, increasing emphasis was being placed upon the secular position. Owen (1890) was one of the last evolutionary theorists to write from a religious perspective, although he used the term "Great Cause" rather than "God", thereby distancing himself from the established Church. Before the publication of *The Origin* (Darwin 1859/1998), the religious perspective was still dominant, although under threat. By the end of the century, scientists were viewing evolution predominantly from a secular perspective.

The fact of evolution was largely unquestioned. There was no organized dissent.

Contrary to Foucault (1972), Darwin's theory did not seek discontinuities. It was based on continuity and lack of continuity was one of the main criticisms levelled against the theory of natural selection. This was about to change.

The theme that one either accepted evolution by natural selection, without the direction or assistance of 'God', or one believed in creation by God in accordance with the account in *Genesis*, was already being orchestrated by Darwin's supporters. This was not a position taken by Darwin himself. Many people claimed to believe both in evolution and 'God'. Nevertheless, the dichotomy, evolutionism or Creationism, was one which was to become increasingly evident during the 20th century and by the beginning of the 21st century was to be the main area of debate.

Part III

AFTERMATH

Before 1950
Application of Darwin's
Theory and its Ramifications

Chapter 13

The Birth of Genetics

13.1 Introduction

The year 1900 saw the rediscovery of the work of Gregor Mendel, an important event which gave rise to modern genetics. The first half of the 20th century was marked by attempts to meld Darwin's theory of evolution by natural selection with this new knowledge, the emergent theory becoming known as 'The Modern Synthesis', 'The Evolutionary Synthesis' or 'The Modern Evolutionary Synthesis'.

While those, such as Lyell, whose work during the 19th century was focused mainly on geological evolution, had been able to call on increasingly firm scientific evidence for support, Darwin had been forced to argue his case on the basis of what he thought was 'probable', or merely even 'possible'. Fossil evidence may have put the *fact* of change beyond dispute for all but a small minority of people, but how change had come about was still much disputed.

While great interest in the subject had been aroused by the works of Chambers and Darwin, mature reflection as the century drew towards its close had resulted in a falling away of support for Darwin's theory, the problem of blending seeming insurmountable. The concept of discrete particulate inheritance, provided by Mendel's theory, supported by work in both field and laboratory, offered a solution to the conundrum. Mathematics were quickly applied, the results not always being quite what supporters of evolutionary theory might wish, as will be shown in the following chapters.

13.2 Gregor Mendel (1822-1884)

Mendel's life-style within the monastery allowed him plenty of time for gardening, reading and reflection. He was as interested as any other naturalist in the causes of variation and set out to investigate the matter for himself with the plants available to him in his monastery garden. Mendel carefully selected peas *(Pisum)* as the plant of choice for his experiments because they were self-fertilising and he could therefore be sure that the hybrids would be completely protected from any foreign pollen (Mendel 1865/1966: 3). Artificial fertilisation could be achieved by carefully opening the not quite fully developed bud, extracting the stamen and dusting the stigma with the desired pollen (Mendel 1865/1966: 4).

It was the fact that these plants were normally self-fertilising that had given rise to clearly observable characteristics, such as colour, size and shape of the seeds and pods, which Mendel selected to study with such meticulous care (Mendel 1865/1966: 6/7). These conditions were quite rare in nature for plant or animal. Among the latter, an apparent blending was frequently seen to occur, as in human skin colour, or an intermediate characteristic, such as height. If a mutation became established in one population, which later came into contact with another, slightly different population (variety or subspecies) with which it was able to interbreed, such interbreeding would not reduce the amount of genetic variation in the total population but the differences in the formerly discrete groups would be obliterated (Dobzhansky 1937: 123). Particulate inheritance did not prevent the practical appearance of 'blending', while, at the same time, it preserved 'discrete' possibilities.

13.3 William Bateson (1861-1926)

William Bateson was the first evolutionary theorist unreservedly to accept and incorporate Mendelian genetics into the theory of evolution. In 1909, the centenary of Darwin's birth and fiftieth anniversary of the publication of *The Origin*, Bateson published an extensive work entitled *Mendel's Principles of Heredity* (Bateson 1909a). He not only gave a thorough explanation of Mendel's own experiments, but attempted to apply mathematical principles to determine the ratios for any number of pairs of dominant/recessive factors (Bateson 1909a: 59). Bateson recognised that Mendel's theory of particulate inheritance obviated the problem of swamping due to blending. Because the factors, be they dominant or recessive, segregated, no obliteration took place. The recessive factor could continue unexpressed for an unlimited number of generations (Bateson 1909a: 288). Bateson also saw that genetic variation was a phenomenon of individuals – each new character was formed in the germ-cell of some particular individual at some point in time (Bateson 1909a: 289). This position continued to be recognized and to cause problems. Muller (1949/1963: 431) pointed out that:

> It would have to be postulated that several such identical mutants had arisen at once, and, presumably by virtue of some feature conferred upon them by the same mutation, succeeded in finding one another effectively enough and over a long enough period to establish a permanent line.

Without isolation, Muller believed, this could not happen. The mathematics of genetics made the spread of a genetic variation occurring in one individual, even with the help of natural selection, very unlikely.

Also published in 1909, as part of the anniversary celebrations, was a compendium of essays by thirty authors, entitled *Darwin and Modern Science* (Seward 1909). Bateson contributed an abbreviated version of his book, in which he pointed out that, although the characters of living things depended on definite elements or factors, which were treated as units, nevertheless these units did not always act separately. They sometimes interacted with each other, producing varied effects (Bateson 1909b: 92). An understanding of the interactive nature of genetic material was to prove essential to the growing understanding of the mechanism of genetics throughout the twentieth century (Dobzhansky 1937; Fisher 1929/1958; Ford 1931; Goldschmidt 1938, 1940; Haldane 1932; Huxley 1942b; Muller 1949/1963; Simpson 1944; Stern 1949/1963). Notwithstanding his having been one of the three people credited with the rediscovery of Mendel's work, de Vries' contribution on *Variation* was written entirely from a Darwinian perspective, with no mention of Mendel. Sedgwick wrote on the importance Darwin had placed on embryology. There were chapters on Darwin and geographical distribution, religious thought, sociology, in fact, upon just about every aspect of evolution upon which Darwin had written, but, apart from Bateson, there was virtually no reference to Mendelian genetics. The book had, after all, been published in honour of Darwin and a synthesis between Darwinian theory and Mendelian genetics was not achieved without difficulty.

13.4 Mutation

Gene mutations were acknowledged to be rare (Ford 1931). They were originally estimated to occur in one in every fifty thousand to one hundred thousand individuals, but this included mutations in body (somatic) cells and these mutations would not have contributed to evolution (Ford 1931: 21). For germ cells, mutation rates of one in 1,000 million individuals, or even higher, were postulated (Huxley 1942b: 54). For animals, such as humans and elephants, with a comparatively slow rate of reproduction, such a low mutation rate posed a problem.

Slow mutation rates were also a problem for scientists in their laboratory work until it was found that they could be increased by the use of radiation. Haldane (1932: 109) suggested an increase of one hundred and fifty times, while Ford (1931: 22) suggested an increase of fifteen to twenty *thousand* percent. Despite such a large measure of artificial interference, results were extrapolated across to Darwinian theory, i.e. that of *natural* selection. Some genes were more liable to mutation than others, opening up the possibility that a mutation might occur in more than one individual, thus considerably increasing its chance of survival (Dobzhanzky 1937; Simpson 1950). The phenotypic effect of a gene was shown to be both local and general (Muller 1949/1963; Simpson 1944; Stern 1949/1963). A gene could act in one combination as dominant and in another as recessive (Goldschmidt 1938: 168). Some genes might control rate of growth of certain tissues which could have profound effects on the entire organism, especially if the tissues affected were hormonal (Goldschmidt 1938: 90) or had their major influence early in the embryonic stage (Goldschmidt 1938: 51/52, 1940:

348-349; Simpson 1950: 217). The effect of genes could be altered by temperature, food or chemical reactions (Goldschmidt 1938: 107). During development, factors such as temperature and moisture could affect the embryo (Ford 1931: 27; Goldschmidt 1938: 99). However, a given gene, or combination of genes, would always give an identical result under identical conditions (Ford 1931: 30). One gene could affect more than one character (pleiotropism) and one character could be affected by many genes, the entire process of branching and anastomoses constituting a complicated biochemical network (Muller 1949/1963; Stern 1949/1963).

However, the blending of discrete populations, both genetically and phenotypically, was the reverse of what was required to establish differentiation/speciation. For differentiation to occur, not only was the production of new (recessive) genes essential, it was necessary for these to occur/be maintained in a small isolated population, so that they could become dominant and, therefore, phenotypically expressed and available for selection (Dobzhansky 1951: 52).

Still unanswered was the question of how much change was needed for selection to occur, whether evolution was as gradual as Darwin had proposed or whether mutation could result in noticeable changes occurring within one generation, i.e. by saltation. Early critics of Darwinism had objected that natural selection was not, of itself, creative. The 'undercover' spread of recessive mutant gene combinations was now seen as being a source of variation (Simpson 1953: 149), although such a variation had never been known to result in a beneficial new character being produced in the laboratory.

In laboratory experiments, mutations were almost invariably recessive, associated with decreased vitality or viability and were often lethal when homologous (Ford 1931). Despite the fact that recessive genes produced during laboratory research were unlikely to establish themselves in nature, Ford (1931: 61-62) claimed that laboratory results could legitimately be used to interpret natural phenomena. Almost all heritable variation owed its origin to such recessive mutations (Ford 1931: 24-25). Although Ford used the word 'almost', neither he, nor anyone else, suggested an alternative cause for heritable variation and it would seem that this word was merely scientific caution. Since single recessive genes are not expressed in the phenotype, and thus not available for 'selection', it was necessary to postulate simultaneous mutations in a population to allow for such recessive characteristics to be expressed, although this point was generally 'assumed' rather than 'expressed'.

Certain characteristics were now known to be inherited together, such as deafness and eye colour in cats. Mutual mutation of genes was seen as the possible explanation for the evolution of disadvantageous characteristics, such as over-burdensome horns borne by some stags or extreme coiling of some snail shells. If the disadvantageous character was associated in some way with an advantageous character, and if the advantage outweighed the disadvantage, then both might continue to evolve together (Simpson 1944: 79, 1950: 146-155).

Julian Huxley maintained that, because there were, for example, no living ammonites, we were unaware of all the circumstances of their existence, making it dangerous to claim that extreme characteristics, such as over-coiling, had no good (natural) explanation (Huxley 1942: 6). Huxley argued that just because no natural explanation for a process had yet been discovered did not mean that one did not exist (Huxley 1942: 6), but rejected the claim of Neo-Lamarckists that some changes were too gradual to be detected as 'a counsel of despair' (Huxley 1942: 459).

13.5 Neo-Lamarckism

One of the most surprising findings of laboratory and field research was the differing effect of environment upon the development of some organisms of the same genotype. For example, it was possible to cause two species of bird, the scarlet tanager *(Piranaga erytherometas)* and the bobolink *(Dolichonyx anyvivorous),* to retain their breeding plumage throughout the whole year by means of fattening food, dim illumination and reduced activity. An increase in temperature could cause pupæ of a variety of butterfly from central Europe to produce butterflies which resembled varieties from Syria or southern Italy while treatment with cold of certain central European butterflies resulted in butterflies resembling varieties from Scandinavia (Dobzhansky 1951: 154; Peake and Fleur 1927: 50). Not only did this show that some 'species' were, in fact, polymorphic varieties, but that environment did affect morphology. Although this phenomenon was not mutation, *per se*, nevertheless its results were highly pertinent to the course of evolution, since one form might be more successful than another in a changing environment (Simpson 1944: 3). These findings lent support to both Lamarck and Darwin in their belief that organisms were affected by their environment, but Neo-Darwinists denied that new mutations adaptive to new conditions were produced in this way. Neo-Lamarckists believed new mutations could occur as an adaptive response to changes in the environment but they did not accept Lamarck's thesis of an inherent progressive evolution (Simpson 1953: 143).

Huxley (1942: 136) believed that polymorphism would be to the long-term advantage of an organism since it could come into play if conditions changed. Simpson (1944: 36) referred to high variability in a population as a sort of 'bank' in which mutations were held on deposit, available when needed, their immediate availability making possible more rapid evolution. Dobzhansky (1951: 110) also considered that no single genotype, however plastic, could function with maximal efficiency in all environments and that natural selection had, therefore, preserved a variety of genotypes, more or less specialised, to render organisms efficient within a range of environments. All these statements contain an element of teleological thinking which is hardly in keeping with the doctrine of purposeless evolution.

13.6 Summary of positions

Mendel was not writing regarding evolution, but inheritance. While it may be assumed that he, as a monk, would have written from a religious perspective had the occasion arisen, the remaining persons mentioned above all wrote from a neutral, scientific position, as was now expected. Huxley was a humanist (Lamont 1949/1965) and was influential in promoting secular humanism as a valid perspective (see Chapters 15 and 20).

During the first two decades of the 20th century, at the time when Mendelian genetics were becoming established and incorporated within Darwinian theory, there was no organised resistance to evolutionary theory. This theory was accepted throughout the scientific community. For the first time, theorists were seeking 'discontinuity' rather than 'continuity'. Discrete particulate inheritance, with the possibility of genetic material being carried forward by an individual even if not expressed in the phenotype, was embraced as the solution to the problem of blending. Science, including mathematics, could be applied to the theory of evolution for the first time.

Chapter 14

Germ-Plasm and Immortality

14.1 August Weismann (1834-1914)

The name of August Weismann was mentioned when discussing the work of George Romanes since they were contemporaries, each advancing the concept of evolution according to their own ideas. While Weismann's work was becoming increasingly well known during the last decade of the 19th century, it was not until the beginning of the 20th century that he published a comprehensive account of his theories (Weismann 1904).

Regrettably, the work of Weismann is little known today except for his refutation of Darwin's doctrine of *Pangenesis* by having cut off the tails of 22 generations of mice in order to show that characteristics acquired during an individual's life were not passed on to the next generation (Weismann 1904, vol.2: 65-66). In fact, few scientists (other than Darwin) had ever believed that the results of trauma were inherited in any way and the docking of the tails of dogs and sheep over many generations was seen as evidence enough for most people that this property was not inherited.

The Origin showed that natural selection only offered a process by which evolution could have taken place *after* change had already occurred in at least one individual. It did not explain why change came about in the first place. Darwin's theory of *Pangenesis* was his attempt to address this problem but it was not generally accepted.

Weismann was a firm believer in 'selection' but worked out a far more comprehensive 'germ-plasm' theory, which was the subject of lectures he gave over twenty years at the University of Freiburg in Breisgau. In 1904, he published these 36 lectures, much as he had given them, believing that retaining the lecture format, which always involved a certain amount of recapitulation, would be helpful to the reader. Weismann's theory was developed before Mendel's theory of particulate inheritance was rediscovered, although he was aware of it by the time his work was published. Together these two theories were to revolutionize evolutionary theory, resulting in the establishment of Neo-Darwinism.

14.2 The current state of knowledge

The use of the microscope had greatly increased understanding of the processes of meiosis and mitosis. Spermatozoa were first observed in 1677 and the fertilisation of an egg in 1875 (Dobzhansky 1964: 21-22). Weismann was mainly interested in invertebrates, particularly butterflies, bees, cockroaches, crabs, *Daphnids* and unicellular organisms. Anything which could be magnified was grist for Weismann's microscope.

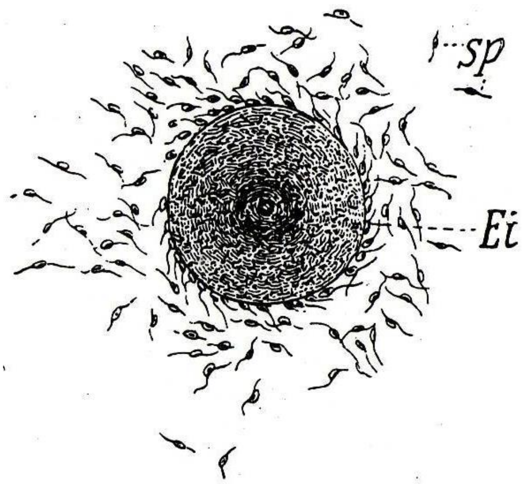

Fig. 14.1: Illustration from Weismann (1904, vol.1: 272) of the ovum of brown seawrack *(Fucus platycarpus)* surrounded by swarming sperm cells.

The presence of chromosomes was well established, but their exact role was not, and Weismann's germ- plasm theory was an attempt to explain the role, not only of the chromosomes, but also of the smaller particles of which they could be seen to be composed. Weismann (1904, vol.2: 56-57) was aware of the work of de Vries, Currens and Tscermak and of their rediscovery of Mendel's earlier paper. While Weismann accepted that Mendel's Law did account for a number of phenomena, he felt that there were some anomalies and that further work needed to be done before it could properly be evaluated.

The process of nuclear cell division was also well known, if not completely understood, by the turn of the century (Fig.14.2). Weismann had correctly identified three levels of participation in the reproductive process, although his terminology was to become obsolete.

14.3 Ids

That there were different numbers of chromosomes in different species of plants and animals had been established, although accurate counting was still half a century or more away. Weismann believed that each individual chromosome contained all the information necessary for the formation of a new individual.

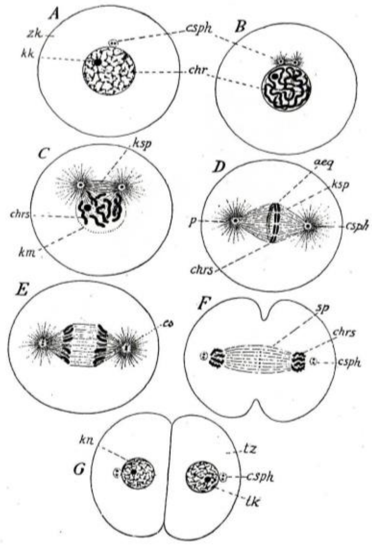

Fig. 14.2: Nuclear Division as illustrated by Weismann
(1904, vol.1: 288)

Division of chromosomes appeared to be random and the apparent chances of a group of chromosomes from one parent, containing only half the necessary information to develop a new individual, combining with a random group of chromosomes from the other parent containing the precise missing information, were so small that Weismann could only assume that all the necessary information was contained within each chromosome.

While some small chromosomes appeared to be single entities, others with a banded appearance he believed to be a combination of several different pieces of chromosome. These pieces he called *Ids.* Since he believed the *Id* was the smallest component containing all the information necessary for the formation of a new individual, he referred to *Ids*, not chromosomes, throughout the remainder of his lectures.

14.4 Determinants

The particles which could be seen beneath the microscope as forming part of the *Ids*, Weismann believed to be responsible for the development of particular cells and parts of the body. In support of his theory, he cited not only small peculiarities that he had seen passed on through the generations in human families, but peculiarities passed on by varieties within the same species, citing the small, but consistent, differences in butterfly markings in different localities. Because these particles determined the nature of the body part for which they were responsible, Weismann called them *Determinants*. These *Determinants* were known to be capable of reproducing themselves, this having been observed during cell division. Weismann (1904, vol.1: 368) concluded that they must, therefore, be living and not only capable of reproducing themselves, but also of taking in nutrients and growing.

14.5 Biophors

Because *Determinants* were capable of taking in nutrients, growing and reproducing, they must themselves have been complex organisms made up of simpler parts. The smallest living particle in germ-plasm could not be seen, but its existence could be deduced. These particles must have been larger than any chemical substance, since they were themselves made up of groups of molecules. Being living, they must also have the properties of movement and sensibility. These sub-microscopic particles, being the 'bearers of life', Weismann (1904, vol.1: 369) termed *Biophors.*

Weismann (1904, vol.1: 371) concluded that *Determinants* were responsible for those parts which were capable of varying *en bloc*, such as blood cells, the cells of the liver or other body parts which must vary in unison if that body part was to alter. This was known as 'hard' inheritance (Mayr 1982). However, he concluded that there had to be another agent capable of making changes to smaller, constituent parts. As examples, Weismann (1904, vol.1: 371) mentioned the specialised odoriferous scales which occurred on the wings of some butterflies, which were adaptations of the normal wing scales, that gave the butterfly its colour. *Determinants*, he decided, determined the form of the wing, but something else was responsible for the individual scale or hair on the wing, or the vein of the wing, and this, he assumed, was the *Biophor.* Individual variation was thought to result from 'soft' inheritance (Mayr 1982). Weismann's *Determinants* bridged the gap between 'hard' and 'soft' inheritance.

14.6 Amphimixis

The process of the 'pooling' of *Determinants* and their *Biphors* Weismann termed *Amphimixis.* The *Ids*, with their *Determinants* and *Biophors*, had been handed down through the generations. There was a natural limit to the number of *Ids* which any germ nucleus could contain. At each *Amixis* (fertilisation), half of the *Ids* failed to be passed on to the next generation. A subsequent mating, even with the same partner, would almost certainly result in a different set of *Ids* being passed on. At *Amixis*, characteristics making up the new individual, for example blue or brown eyes, were controlled by the majority of the *Ids* present. In this respect, Weismann's theory resembled that of Darwin's *Pangenesis.*

Weismann's theory simultaneously answered the problem of the tendency for species to be continued, almost unchanged, and their tendency to vary enough to be acted upon by natural selection. *Biophors* could vary only in a plus/minus (larger/smaller) direction (Weismann 1904, vol.2: 117-119). If N represented the normal (most numerous) form, L represented a larger form and S represented a smaller form, at *Amixis* there would be six possible outcomes: LL, LN, LS, NN, NS and SS. Four of these conjunctions would tend to preserve the species in its present state. LN, LS, NN and NS. NN would bring about no change. LN and SN would retard a potential for change and LS would tend to average out to N. Thus there were only two possibilities for establishing variants, LL and SS. These altered *Biophors* would continue their trend towards variation in subsequent generations, if further LL or SS combinations occurred. 'Unsuccessful' *Biophors* were not eliminated but continued to exist in the germ- plasm pool. Weismann's theory accounted for both stability and gradual change.

14.7 Spontaneous generation

In his final lecture, Chapter XXXVI, Weismann (1904) tackled the difficult subject of spontaneous generation. He dismissed the suggestion that life had been 'seeded' on Earth from other parts of the Universe on the grounds that no living matter, however small, could survive the extremely low temperatures such a journey would involve. Weismann concluded that life on this Earth had originated on this Earth.

The smallest living particles, the *Biophors*, being sub-microscopic, Weismann maintained that it would never be possible to witness their generation, yet generate they had out of inorganic material at some point in time. Any experiment which 'proved' that spontaneous generation had not occurred, only proved that it had not occurred under the conditions of that particular experiment. Since conditions on Earth billions of years ago might have been quite different from those on Earth today, replication of all possible conditions was impossible, even if *Biophors* were capable of being detected, which they were not. Either *Biophors* generated spontaneously, or they generated as the result of the action of some outside 'vital force'. It was not possible to prove that a 'vital force' was involved, anymore than it was possible to prove that it was not. Within science, it would only be necessary to admit the action of a 'vital force' when all possibilities of spontaneous generation without the action of a 'vital force' had been eliminated. This could never happen (Weismann 1904, vol.2: 17).

14.8 Germinal selection

Darwin's theory of natural selection struggled to overcome two major hurdles. First, there was the problem of just how much difference was necessary for a change to be acted upon by natural selection. Second, there was the problem of vestigial organs. As his example, Weismann chose the whale. Many and wonderful were the changes which had been wrought in the body of this large land mammal as it adapted to a marine environment but most could be explained as adaptation. This explanation faltered with the whale's residual pelvis (see Fig.14.3). Darwin's process of natural selection, Weismann believed, could only account for shrinkage, through disuse, of the hind limbs of the whale as far as their disappearance within its body. After that, there would have been no selective pressure upon these bones, yet they had clearly continued to shrink. Weismann attributed such shrinkage to changes in the germ-plasm, that is, to the shrinkage of the relevant *Determinants* and/or *Biophors.*

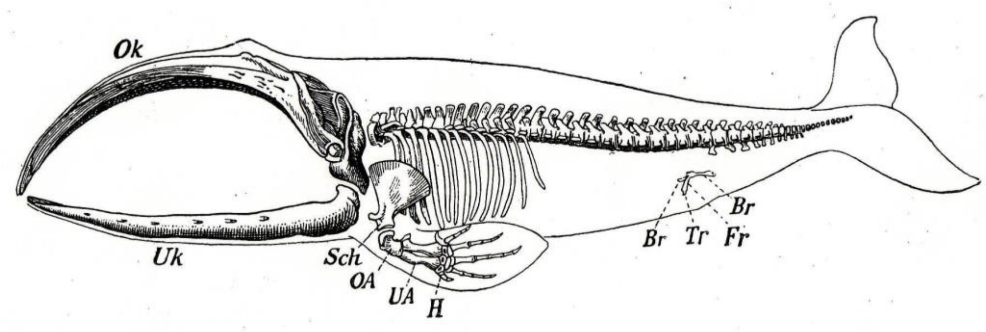

Fig.14.3: Residual pelvic bones of a whale
(from Weismann 1904, vol.2: 313)

Weismann argued that there was no reason to suppose that nutrition at the intra-cellular level was any more evenly distributed than at the inter-cellular or inter-individual level. Some *Determinants/Biophors* would assimilate more nutrition than others. These would grow larger and stronger than their fellows and the parts of the body for which they were responsible would likewise grow larger and stronger. Other nearby *Determinants/Biophors* would be comparatively deprived of nutrition and would grow smaller and weaker. The initial change would be insignificant, but once *Determinants/Biophors* started along the path of receiving more or less than their 'fair share' of nourishment, they would most likely continue on that path. In this way, insignificant changes would gradually become significant ones, which would be acted upon by natural selection.

Weismann thus proposed a two-tiered process, at the level of the germ-plasm and at the level of the soma. The concept of the separation of the germ-plasm from the soma was becoming increasingly popular during the 1890s (Mayr 1982: 812). Like Darwin, Weismann concretised a known concept into a practical theory, with which his name became associated.

14.9 Immortality

Weismann held that each *Id* contained all the *Determinants* and *Biophors* necessary for the development of the individual. There were more *Ids* in the germ-plasm than were needed. These had been inherited from parents and grandparents, who in turn had inherited their *Ids* from their ancestors, in an unbroken line back into the mists of time. The germ-plasm was essentially immortal, since it traced its ancestry back to single celled organisms, which reproduced by simple cell division and were not subject to death by aging, only by trauma.

14.10 Problems with the theory

By a process of deduction, Weismann had arrived at a concept of heredity which closely resembled modern theory in as much as the germ-plasm was a three-tiered structure. *Ids, Determinants* and *Biophors* may be compared to chromosomes, genes and DNA. *Biophors* could only grow or shrink; they could not change their nature. How, then, did a single-celled organism evolve into something more complex? How did mitosis give way to meiosis for the production of new individuals? How did qualitative changes take place?

Weismann's theory needed to be able to account for *qualitative* changes. The fossil record gave a hint of the vast number of different forms which had previously occupied the surface of this planet. More forms would no doubt evolve. Many possible forms may never have eventuated. Thus Weismann (1904, vol.2: 390) concluded:

> … an incredible wealth of animal and plant species was potentially contained in these simplest and lowest 'Biophorids' .. an indefinitely greater wealth than has actually arisen … it will hardly be disputed that *potentially* the first Biophorids contained an absolutely inexhaustible wealth of forms of life.

This is difficult to imagine, but were it not for mutation/duplication of DNA, that would be the same conclusion to which geneticists of today would have had to come in relation to genes.

14.11 Weismann's position

Weismann, writing as an evolutionary theorist which Mendel had not, firmly established discrete inheritance, 'discontinuity', as the foundation upon which Neo-Darwinism was to stand. Weismann proposed a distinct separation between somatic and reproductive cells which could never be breached. According to this theory, the inheritance of acquired characteristics was impossible. As shown in Chapter 11, Romanes was aware of Weismann's work, which he tried, unsuccessfully, to disprove, leaving him in an ambiguous, and highly unsatisfactory, position in regard to Darwin's theory of *pangenesis.*

Romanes was the last theorist openly to acknowledge that Darwin's, rather than Lamarck's, name should be associated with the theory of the inheritance of acquired characteristics (see p.72). The acceptance of Weismann's theory led to the work of Lamarck being systematically misrepresented in order to deflect attention away from Darwin's "mistake". From the perspective of evolutionary theory, this was un-necessary, since Weismann's work could more easily have been associated with that of Lamarck which also denied the inheritance of characteristics acquired by individuals.

As was shown in Part II of this thesis, much effort had been put into establishing Darwin's theory by a number of influential and powerful people in England at a time when England was the most powerful nation on Earth. At the time of the publishing of the work of Mendel and Weismann, this was still the case and it was a matter of national pride that his position should not be overthrown.

Chapter 15

Plenty of Scope

15.1 Evolution and the Law

Until the time of the First World War, religion had not been a predominant feature in evolutionary debate. Possible religious implications were of concern to many individuals, but no denomination of the Christian Church had made acceptance/rejection of Darwin's theory of evolution the subject of doctrinal edict, nor had any government felt it necessary to impose/forbid the teaching of the theory in its schools. The majority of Church-going people increasingly accepted the Biblical account of Creation as allegorical. Those who rejected evolution and accepted the Biblical account of Creation as factual did not present an organized opposition. This was about to change.

In 1925, a famous trial took place in the United States of America, the effects of which reverberated, not only throughout America, but across Europe and other Western nations. Later known as the 'Monkey Trial', *Tennessee v. John Thomas Scopes,* saw a 25 year old school teacher convicted of teaching evolution contrary to a Bill which had been passed by the Tennessee House of Representatives on 18th January, 1925. The Bill was passed by a vote of 71-5 and was signed into law on 21st March, 1925. This law provided (Scopes and Presley 1967: 51):

> … that it shall be unlawful for any teacher [at a State funded educational institution] to teach any theory that denies the story of the Divine Creation of man as taught in the Bible, and to teach instead that man has descended from a lower order of animals.

The law did not proscribe the teaching of evolution *per se*, only the teaching of evolution in relation to humans. Whatever their differences, all Christian denominations accepted that humans were in some essential way different from animals. Humans had been endowed with free will, an ability to choose between right and wrong, to make independent decisions about their behavior in a way not seen in members of other animal kingdoms. Humans were seen as a special creation, as having been made 'in the image of God', with unique potential and unique responsibilities. It was generally accepted that only humans had souls and only humans were capable of earning for themselves the right to 'eternal life', and a place in heaven. This understanding was seen to be under threat from the spread of Darwinism and its associated teaching, that human beings were descended from apes, or a form closely related to the ape line. Even if evolution were accepted as having occurred, and the law certainly did not deny this, Divine intervention must have occurred at some point, namely when 'man became a living soul' (*Genesis II: 7)*.

15.2 William Jennings Bryan (1860-1925)

The person whose campaigning brought about the introduction of this legislation, and similar legislation in other states, was William Jennings Bryan. He was one of the most eminent persons in America at the turn of the 20th century. He stood three times for the Presidency of the United States, the youngest person ever to do so. Although he was never successful, he did hold the position of Secretary of State under President Woodrow Wilson, whose term of office finished in 1916. In this position, Bryan would have been more aware than nearly any other citizen of America of the situation abroad, especially in Germany before, during and after the First World War. He would have known of the Monist League with its atheistic philosophy (Wallace 1910) and of the fledgling Nazi movement, already active by 1925 and of the growing interest in eugenics (Ginger 1958, Grabiner and Miller 1974, Shermer 2006).

Karl Marx (1818-1883) read *The Origin* (Darwin 1859/1998) in 1860 and was struck by how Darwin's views on the evolution of species mirrored his own views on the evolution of human societies (McLellan 1973). He applauded the fact that, in his opinion, Darwin's work had finally disposed of religious teleology (McLellan 1973: 423). Marx equated the struggle of workers to improve their position in society with that of a species struggling to establish itself within its environment. According to Keith (1955: 233-234) and McLellan (1973: 424), Marx wished to dedicate the second volume of his *Das Kapital* to Darwin, an honour which Darwin refused on the grounds that it might suggest his (Darwin's) approval of Marx's work, with which he was not acquainted.

Neither Grabiner and Miller (1974) nor Shermer (2006) mention Russia, Marx' interest in Darwinism, the doctrine of dialectical materialism, or the claim that the 'struggle for existence' by the peasant/working class justified the Russian Revolution and the execution of the Russian royal family on the grounds that these were part of an inevitable social evolution. Bryan was "an educated man who held seven doctorates of law and numerous other degrees" (Ginger 1958: 88). It is inconceivable that a man so well-educated and so politically astute should not have been aware of the communist interpretation of Darwinism, including atheism. Two differing interpretations of Darwin's doctrine of evolution by natural selection had led to devastating social upheaval in Europe and Bryan was determined to do all he could to stop what he saw as a pernicious doctrine from becoming established in America. In addition to being a politician, Bryan was also a lay preacher.

15.3 John Scopes (1900-1970)

To appreciate the saga which unfolded, it will be necessary to understand John Scopes' belief system, which caused him to follow the course that he did.

Born at the beginning of the 20th century, Scopes received his early education in an America for which the memory of the Civil War was still vivid (Scopes and Presley 1967: 18). The Scopes family believed passionately in freedom, both physical and intellectual (Scopes and Presley 1967: 46):

> … early 1920s, after Prohibition had been legislated and the country's morals were taken care of, science became the primary target of those self-anointed crusaders …. They equated evolution with agnosticism, which in turn they made synonymous with atheism … intolerant Fundamentalists, who wanted to foist their beliefs onto everyone else. Here was the crux of the controversy as far as I was concerned. The Fundamentalists had an inalienable right to believe what they did, but when they insisted that others hold those beliefs too, they were violating other people's rights … It was a specific example of the universal conflict of the narrow-minded and intolerant against the broad-minded and tolerant.

Scopes was a 'civil libertarian' and when the American Civil Liberties Union sent out a plea for help, he answered the call.

For a time the Scopes family had lived in Salem, the birth place of William Jennings Bryan. Bryan made regular visits to Salem and Scopes heard him preach a number of times (Scopes and Presley 1967: 19).

As a child, John had been encouraged by his father to read widely and to be an independent thinker. While at University in Kentucky, Scopes had chosen his courses, not because of their subject matter, but for the quality of the lecturers. In his final year, he realized that his unsystematic following of personalities rather than degree plans had precipitated a crisis – his subjects were so scattered that he had insufficient in any one area for a major, or even a minor! During his final year Scopes studied what was in effect first year law, some child psychology and some geology and this strange assortment, together with his previous studies, resulted in him being the only person to graduate from the University of Kentucky with a Bachelor of Arts while majoring in Law (Scopes and Presley 1967: 30).

Career opportunities were somewhat limited. Scopes was offered a temporary placement (September 1924 – May 1925) in Dayton, Tennessee, as sports coach and part-time teacher in algebra, physics and chemistry (Scopes and Presley 1967: 33). Towards the end of the first term of 1925, the headmaster, who taught biology, fell sick and Scopes was asked to take some of his classes, which included revision for the senior boys in biology. There being much work to cover in only two sessions, Scopes omitted the short reference in the school text book that dealt with evolution, so he never, in fact, taught evolution to the boys (Scopes and Presley 1967: 60).

15.4 The die is cast

Scopes had been enjoying a Saturday afternoon game of tennis with some of the boys when he decided to buy a soda drink at the local drug store. Seated at the table by the soda fountain were a group of men engaged in deep discussion. They included Doc Robinson (the owner of the drug store), Mr. Brady (owner of the rival drug store), Mr. Hicks and Mr. Haggard, the town's lawyers and George Rappelyea, businessman, who was to be the moving force in the upcoming events. They were discussing an advertisement which had appeared that day in the *Chattanooga News*, placed by the American Civil Liberties Union (ACLU), which offered to pay the expenses of anyone willing to test the constitutionality of the law forbidding the teaching of evolution in public schools.

They asked Scopes if he had been teaching biology and whether it was possible to teach biology without teaching evolution. Scopes answered the first question in the affirmative, the second in the negative. They then asked Scopes if he would be willing to stand trial in a test case. "At the end of the term I had substituted in the classes of the principal while he was ill; I assumed that if anyone had broken the law it was more likely to have been Mr. Ferguson … to tell the truth I wasn't sure I had taught evolution" (Scopes and Presley 1967: 60). Mr. Robinson walked over to the telephone and called the city desk of the *Chattanooga News* – and so the die was cast.

15.5 The assembled cast

"If I *had* been the regular teacher at Rhea County Central High School, I wouldn't have let the law restrict my teaching the truth" (Scopes and Presley 1967: 53). But 'actions speak louder than words' and clearly this trial was not about truth as far as Scopes was concerned. Scopes had agreed to allow himself to be accused of something he had not done in the name of *freedom*, not truth. Several of his students were called as witnesses. One boy tried to run away, because he did not wish to testify. Scopes followed him to persuade him to take the stand: "I told him to go ahead and testify to what he had been told to say because he would be doing me a favour" (Scopes and Presley 1967: 105). Scopes, armed with his recently acquired legal knowledge, was well aware of the workings of the American legal system. He knew that he would not be required to take the stand. Had he been required to do so, he would either have had to perjure himself or admit that he never actually taught evolution (Scopes and Presley 1967: 134). Nevertheless, Scopes pressured the young boy into doing what he was reluctant to do himself, lie under oath. Scopes mentioned that one of the boys, Harry Shelton, was seventeen years old (Scopes and Presley 1967: 105). These were not primary school children, who might not have understood the situation. They were boys who were nearly adult and who would have understood the meaning of taking the Oath and the requirement to tell the truth.

According to Scopes (Scopes and Presley 1967: 47-49), William Jennings Bryan had descended upon the state of Kentucky in January 1922 "crying out for a return to Fundamentalism … he stumped around the towns and cities of Kentucky with the fervour and energy of a political campaigner". Scopes was at Kentucky University at that time. The University opposed the introduction of the Bill banning the teaching of "evolution as it pertains to man" (Scopes and Presley 1967: 48). A tour of the University was held so that all of the legislators could see the operation of a free educational system (Scopes and Presley 1967: 48-49): "They brought out the university's prettiest co-eds as special guides for the tour and to dazzle the lawmakers … Organized opposition paid off". The Bill was narrowly defeated in both Houses.

When Bryan's campaign hit Tennessee, there was no organized opposition and Bryan and his supporters were triumphant. The Bill, as cited above, was passed into law.

15.6 The trial

The night before the trial began, Bryan addressed a dinner held in Dayton. Scopes (Scopes and Presley 1967: 87) recalled that Bryan said "If evolution wins, Christianity goes. Not suddenly of course, but gradually, for the two cannot stand together". Yet it became clear during the trial that Bryan was no Fundamentalist. He was deeply devout, but much to the chagrin of some of his supporters, admitted on the stand that creation may have taken place over an extended period of time, even millions of years (Scopes and Presley 1967: 178-180). Questioned about some of the myths of the Old Testament, Bryan found himself forced to defend Jonah being swallowed by a 'big fish' and living to tell the tale, to account for the date of the Tower of Babel and explain how long it had taken languages to spread therefrom, to explain from where Cain had found a wife and how the snake moved around before being cursed by God and forced to go upon its belly (Scopes and Presley 1967: 178-181). As a speaker, Bryan had been able to choose his topic. As a witness, he was forced to answer difficult questions, a process which he found not merely difficult, but devastating. When the trial was over he was a 'broken man' and died a few days later (Ginger 1958; Scopes and Presley 1967).

Bryan's adversary, and leader of Scopes' defence team, was Clarence Darrow, an outspoken atheist, who had earned his reputation as a leading defence lawyer by defending two teenage boys who had confessed to abducting a fourteen-year-old boy and clubbing him to death (Shermer 2006: 28). Darrow had argued that the boys were not ultimately responsible for their actions because human volition was fiction: every act followed a cause and the cause in this case was 'environmental influence' (Shermer 2006: 29). Support for the anti-evolution laws had, in part, been fanned by a fear that Darwinism would lead to a break down in ethical standards on the basis that humans were, after all, but beasts by nature (Ginger 1958, Scopes and Presley 1967). ACLU supported the employment of

Darrow as leader of the defence team, but others tried to persuade Scopes to engage someone less controversial. Scopes quietly held his ground – he wanted Darrow (Ginger 1958: 76-77).

Darrow's interest was not in Scopes' innocence or guilt. Although acting as Counsel for the Defence, Darrow urged the jury to convict (Scopes and Presley 1967: 185). A conviction was necessary for an appeal to be lodged. An appeal would be heard in the Federal Court, which would have the authority to determine the legality of the disputed legislation, something which the local court at Dayton could not do (Scopes and Presley 1967: 78).

No sooner had the jury been sworn in than they were asked to leave the Court, while legal arguments were heard regarding the breadth of argument that would be admitted. Was the case merely about whether or not Scopes had taught that Man was descended from a lower order of animals, was it about the validity of evolution in general, of evolution by natural selection in particular, about the (non)compatability of science and religion? The jury did not miss out on hearing the arguments. From their seats on the grass outside the Court House, the jury was able to hear all the arguments from inside the Court, thanks to the heat-wave conditions Dayton was enduring, which had resulted in every available window being fully opened (Scopes and Presley 1967: 99). The front lawn was also the venue for the retirement of the jury while it considered its verdict, which it reached very quickly. In all, the jury was in the Court for only about one hour (Scopes and Presley 1967: 184-185).

This legal wrangling had caused Bryan to take the stand, a position to which he, as a lawyer, was not accustomed. His testimony lasted four days. He expected to cross-examine Darrow the following day, but Judge Raulston decided that only Scopes' innocence or guilt on the charge of teaching evolution was at issue and struck Bryan's testimony from the record. Raulston could have made this decision on the first day of the trial, but he and Rappelyea were determined that the trial would 'put Dayton on the map', increasing business for Rappelyea and prestige for Raulston, whose re-election to the position of Judge was imminent (Ginger 1958; Scopes and Presley 1967). It was in the interests of both men that the trial should attract the maximum amount of attention, last long enough to maintain the interest of the journalists, but not so long that it would lose its place as front page news.

15.7 The last laugh

All the participants in the Scopes trial had their own agendas. Originally from New York, Rappelyea was Dayton's largest employer and was determined to make the trial as profitable as possible. Anticipating at least 2,000 visitors to Dayton for the trial, Rappelyea and other local businessmen set about making preparations for their accommodation. An eighteen-room house, the largest in the County, which had been vacant for a decade, was in a dilapidated state with no lights and no plumbing. It was renovated in a manner suitable to house the lawyers and scientists "with Japanese mats and iron cots" (Ginger 1958: 81-82). The Pullman (railway) Company was asked to sidetrack cars at Dayton to serve as temporary accommodation and the War Department was asked to supply tents (Ginger 1958: 73). The local hotel was repainted and had beds placed in corridors while the Dayton Progressive Club announced that visitors would be given a medal depicting a monkey wearing a straw hat (Ginger 1958: 84). Those who could not be accommodated in Dayton were housed in Chattanooga, from where special trains ran each day to Dayton (Scopes and Presley 1967: 95). There were dance parties every night, amusements galore, hot-dog stands, lemonade peddlers, booths selling books on every relevant topic, Bible preaching and even circus performers who brought with them two chimpanzees (Scopes and Presley 1967: 98-99). Photographers were everywhere and Judge Raulston was happy to pose for pictures, along with the lawyers. Scopes posed for many photographs and on one occasion rode through Dayton sitting on the front of a low yellow racing car, arms linked with an attractive girl (Ginger 1958: 84). Movie cameras and telegraph wires were rigged up in the court room, the first time that this had ever occurred (Ginger 1958: 85).

Neither Judge Raulston nor ACLU were concerned about the verdict. That was a foregone conclusion. For different reasons, both wanted maximum publicity and the carnival atmosphere which surrounded the trial guaranteed that they got it. With so many visitors in town, it would have been unthinkable for the trial to be completed in less than a day. For ACLU, Bryan's four day ordeal on the witness stand was a bonus since it had the effect of making a mockery of Christian beliefs based on a literal translation of the Bible.

Having gone to so much trouble to promote this trial and secure Dayton's place in history, Judge Raulston had no intention of allowing their moment of glory to be eclipsed by a later Federal trial. The jury did what both the Judge and the defence told them they were required to do and duly returned a verdict of 'Guilty'. Raulston asked the jury if they had fixed the fine, to which they replied that they would "leave it to the Court" (Scopes and Presley 1967: 186). The Act provided for a fine of between $100 and $500 and Judge Raulston fixed the fine at $100. The American judicial system differs from that of many other countries in that it gives far greater power to juries in matters of sentencing. In Tennessee, a judge (magistrate) was not allowed to fix a fine of more than $50. Sums higher than that had to be handed down by the jury. As an experienced judge, Raulston must have known this.

On this technicality the verdict was later overturned, thus preventing any appeal being lodged. There was no second trial. Dayton retained its place in history.

15.8 Humanism

The case against John Scopes was initiated and funded by the America Civil Liberties Union. ACLU was the political front of the Humanist movement, which, from the time of Huxley and his X-Men, had been working on both sides of the Atlantic towards the undermining of established Christianity.

The Humanist movement started in the early 16th century under the influence of Desiderius Erasmus (1460-1536). Born in the Low Countries, Erasmus was brought up by the Brethren of the Common Life, an Order that rejected the cult of relics, miracles, the veneration of saints and the ostentation of Catholicism. It was the time of the Reformation, when Eternal Salvation was no longer seen to be dependent upon the good offices of the Catholic Church. Individuals were responsible for their own salvation. Education was seen to be the chief tool for bringing about change, since individuals would be able to read the Bible and interpret it according to their own conscience (Bullock 1985, Todd 1987, Elton 1990).

Erasmus travelled widely throughout Europe before settling in England. He taught Greek at Cambridge University and, due to his influence, humanities were included in the curriculum in addition to classical subjects. Erasmus' contribution to the Reform movement was to stress, not the sinfulness of human beings, but their intrinsic worth as children of God and potential inheritors of the Kingdom of Heaven. Many other Reformist Churches preached "Hell fire and damnation" and imposed extremely severe codes of behavior on their followers. It was no wonder that Erasmus' humanistic approach became increasingly popular. However, it was essentially a Christian movement.

Thanks to the work of Thomas Huxley, his X-Men, and other like-minded persons, an increasingly secular approach began to emerge within the humanistic movement, but it was not until 1933 that it issued its first *Humanist Manifesto* (Lamont 1949/1965: 285-289). The preamble claimed Humanism as 'the religion for today' and the first precept stated: "Religious humanists regard the universe as self-existing and not created" (Lamont 1949/1965: 286). The use of the word 'Religious' was an attempt to raise humanism to the position of an alternative philosophy equal in status to that of established religions.

The American Humanist Association was founded in 1941. The British Humanist Association was not formed until 1963, when it was launched under the Presidency of Thomas Huxley's grandson, Sir Julian Huxley, at a dinner held in the British House of Commons (Lamont 1949/1965: 26). The establishment of ACLU preceded the formal establishment of Humanism. The Scopes trial helped to bring ACLU into prominence and undoubtedly contributed to the furtherance of the Humanist movement in both America and England.

15.9 The rise of Creationism

Before the Scopes trial, Christian teaching had focused on the New Testament. The Old Testament was significant for two main reasons. Firstly, it contained the record of the Ten Commandments, upon which all ethical behavior was seen to be founded. Secondly, it provided evidence of God's special relationship with his 'Chosen People', the Jews, with whom he entered into a Covenant. This special relationship was seen to extend to the followers of the teachings of Jesus under the New Covenant. Apart from these two important factors, there was little concern with whether the tales of the Old Testament were fact, myth or allegory.

The Scopes trial focused attention on the literal interpretation of the Old Testament, especially that pertaining to the story of creation as told in *Genesis.* Whereas before, the Fundamentalism of the Baptist Church related to whether or not complete immersion was necessary at the time of baptism, it now extended attention to acceptance of other biblical scenarios. They accepted that the world was created in six days, as written. They also accepted the age of the Earth as being little more than 6,000 years. This had been worked out during the 19th century by Bishop Usher on the basis of chronologies given in the first five books of the Bible, the Pentateuch. As shown in Part I, increasing fossil evidence undermined this view, but the issue was not overly divisive. The age of the Earth was not a matter of doctrine. It became so for an increasing number of Christian denominations, this belief becoming known as 'Creationism'.

15.10 The entrenching of positions

At the time of the trial of John Scopes, the dominant position in America was held by the religious, not the secular, discourse. The law which had been passed was based on the teachings of the Bible, not on fossil evidence. The 'discontinuity' here upheld had nothing to do with germ-plasm or inheritance. It was the 'discontinuity' between the animal and the human kingdoms which was held to be absolute. The fact of evolution as it pertained to the animal and vegetable kingdoms was not in dispute. Neither of these kingdoms were believed to be possessed of souls. Humans alone had souls and humans alone could inherit the Kingdom of Heaven.

Creation according to *Genesis* later came to be interpreted by the Creationist movement as a total denial of the fact of evolution. This was not the case at the time of the Scopes trial.

Midway through the period under discussion (the first half of the 20th century), the religious paradigm was dominant, at least in the United States of America, discontinuity was dominant over continuity inasmuch as the human race was seen to be a separate creation, not continuous with the animal kingdom and stability was dominant over evolution. Although the Court had considered evolution only in as far as it applied to the human race, the Court's decision had the effect of suppressing the teaching of evolution in general. In Europe, and other parts of the Western world, the concept of evolution was more readily accepted, but political and economic factors took precedence over philosophical debate. Scientific work on the subject of evolution was conducted in a neutral manner, neither supporting nor opposing a theistic position.

Chapter 16

Darwinism in Practice

16.1 The Lysenko affair

Karl Marx (1818-1883) read Darwin's *The Origin* in 1860, soon after its publication, and was struck by how Darwin's views on the evolution of species mirrored his own views on the evolution of human societies (McLellan 1973). He applauded the fact that, in his opinion, Darwin's work had finally disposed of religious teleology (McLellan 1973: 423). Marx equated the struggle of workers to improve their position in society with that of a species struggling to establish itself within its environment. Marx wished to dedicate the second volume of his *Das Kapital* to Darwin, an honour which Darwin refused on the grounds that it might suggest his (Darwin's) approval of Marx' work, with which he was not acquainted (Keith 1955: 233-234, McLellan 1973: 424).

The *Darwinism* which had inspired Marx and his colleagues, and which was adopted by the post-revolutionary Soviet Government under Stalin, embraced the view that change (improvement/progress) occurred, not in the favoured few who had reached the acme of their evolutionary possibilities, but in the lower echelons of society, who were in the process of changing/evolving by the process of struggle, undertaken in response to the external conditions in which the 'mass' of people found themselves. This position was compatible with Darwin's theory of *Pangenesis*, which itself was based on the doctrine of the inheritance of acquired characteristics. It was supported by Trofim Denisovich Lysenko, President of the Lenin All-Union Academy of Agricultural Sciences (L.A.A.A.S.). As a result Russian agricultural policy was based on acceptance of the doctrine of the inheritance of acquired characteristics (Medvedev 1969; Adams 1980; Dobzhansky 1970).

Stalin was more inclined to support, and raise to positions of power, peasants who offered practical solutions to farming (agrobiological) problems, as Lysenko claimed to do, than to support the laboratory work of 'educated scientists', whose status still retained something reminiscent of the bourgeoisie (Joravsky 1970). Lysenko was seen to be giving the Russian people grain while Mendelian geneticists in Western Europe were studying the colour of the eyes of fruit flies (Joravsky 1970: 102).

While the doctrine of evolution had been welcomed in post-revolutionary Russia as an integral part of the 'new world view' (Dobzhansky 1970: 229), not all academics supported Lysenko's position. There was bitter rivalry between academic institutions in the interpretation of *Darwinism* (Dobzhansky 1970: 230). This rivalry continued into the post war years.

Not only were the Soviet hierarchy convinced that their agricultural policies were in accordance with Darwinian theory, they considered that the Western (especially German) interpretation of Darwinism was a bourgeois plot to "justify the fact that, in the capitalist society, the great majority of people, in a period of overproduction of material goods, live poorly" (Medvedev 1969: 107). The Weismann/Mendel theory of genetics seemed to provide a scientific basis for eugenics and race politics, serving as a useful tool for Hitler's elitist, racist theories (Medvedev 1969: 119-120). The engineering of hybrids was a plot by the capitalist firms to produce seeds available to the ordinary farmer only by purchase, at least in the first instance (Medvedev 1969: 180). Medvedev, himself an opponent of Lysenko, appeared to consider Lysenko's claim that his work was rooted in Darwinian theory to be inaccurate and misguided, that Lysenko was, in fact, embracing the ideas of Lamarck. At no point did Medvedev refer to Darwin's theory of *Pangenesis*, of which he appeared to be unaware. Joravsky (1970) asserted that Lysenko claimed his theories were his own, not taken from Lamarck. He made no mention of Darwin at all in relation to Lysenko's work. Either he was not aware of any claim by Lysenko that his work was 'Darwinian' or he dismissed it as irrelevant.

16.2 Vernalization

Lysenko's great discovery was 'Vernalization' (Medvedev 1969; Joravsky 1970). Lysenko believed that the number of hours of daylight a crop received was the crucial factor in its growth. Higher latitudes had a greater number of daylight hours during the summer months, but winter sown seed could not survive the low winter temperatures and reduction in light. According to Medvedev (1969: 24), Lysenko based his 'discovery' on the single planting, in one pot, of two seeds of two varieties of winter wheat. The seeds were planted in March, 1935, kept in a hothouse, but at a cool temperature, until the end of April. One pair of plants died without 'heading' in late autumn. Of the other pair, one plant also died but the surviving plant 'headed' and its seeds were collected for a second planting, which took place in September, 1935. A third generation was planted March, 1936, and Lysenko reported his success upon sowing the fourth generation in September 1936 (Medvedev 1969: 24). Lysenko had been inspired to undertake his small experiment by his father, who in 1929 had soaked some seed to germinate it, stored it over winter under a bank of ice, sown it in the spring and obtained a good yield (Medvedev 1969: 14-15; Joravsky 1970: 83).

The first major trials of 'vernalization' followed the loss of more than thirty million acres of winter wheat during the very severe winters of 1927-1928 and 1928-1929. The winter wheat that Lysenko used naturally germinated in late autumn, suspended its development during the winter frosts, recommencing its growth cycle in spring. If the winter was very severe, a whole crop could be lost. Lysenko instituted his method of soaking the seed for several days under controlled conditions and the germinated seeds were stored by freezing over winter. Lysenko believed that the crops would gradually become adapted, generation by generation, to the changed conditions, but his project had to be abandoned because the labour and expense involved outweighed the advantage gained by the small increase in yield in anything other than a very severe winter (Medvedev 1969: 153). Nevertheless, between 1926 and 1970, Russia registered a greater percentage increase in wheat yield than did America, although Russia did start with a lower yield per acre (Levin and Lewontin 1985: 190). Joravsky (1970) supported the claim that Lysenko's system did bring some measure of success, so Medvedev's condemnation of Lysenko's work may not be totally justified.

Levin and Lewontin (1985: 166, 176-177) mentioned more than thirty scientists whose work, mostly undertaken during the 1920s-1940s, gave credence to at least some measure of inheritance of acquired characteristics. This work was not mentioned by Medvedev (1969), nor was it discussed by proponents of Neo-Darwinism.

Lysenko had been impressed by Darwin's teaching regarding the detrimental effect of inbreeding and the advantages to be gained by regular cross-breeding. Lysenko applied the principle of cross-breeding even to self-fertilizing wheat varieties. He required that the collective farmers removed the anthers from the spikes of their wheat using tweezers so that their crops would be fertilized by wind-born pollen from their neighbours' farms (Medvedev 1969: 159).

Lysenko's interests were not confined to wheat. He also experimented with cattle in regard to the butterfat content of milk. Lysenko believed that populations of plants and animals were, to some extent, self-controlled, that predation and lack of food were not the only factors involved. He believed that if too many young were born, or too many plant seeds fertilized in a given area, some would die in a 'self-sacrificing' way. Lysenko believed that he could predict the outcome of cross-fertilisation through knowledge of the parents' characteristics (Joravsky 1970). For example, if a large bull mated with a small cow, the zygote would sense that, if it developed after the manner of its sire, it might be too big to pass through the birth canal, at least with any ease. It would, therefore, 'choose' to develop after the type of its mother (Medvedev 1969: 189). Therefore, it would be better if a small bull from a line of high butterfat cattle mated with a large cow from a low fat herd, rather than the other way. The offspring could be encouraged to attain the larger size by doubling or tripling the food consumption of the gestating cow, since this would stimulate the growth of the fœtus (although not enough to impede birth), the stimulus to growth continuing in the calf during its post-birth development (Medvedev 1969: 189).

The Soviet Minister of Agriculture banned all genetic research in animal husbandry and the liquidation of all research projects not 'in the spirit of Lysenko'. Only professors teaching Lysenkoism were permitted to graduate students (Medvedev 1969: 116). If this sounds extreme, it must be remembered that Lysenko firmly believed his methods to be in accordance with the teachings of Darwin, whose theories had so impressed Marx. At that time, some States in America had passed laws banning the teaching in State-funded schools of pro-evolutionary teaching and have now passed laws banning the teaching in State schools of anti-evolutionary teaching (see Part V). Government interference with what may or may not be taught in schools and universities is not unique to any particular regime.

The 'five-year agricultural programmes' instituted by the Russian government were based, at least in part, on the belief that this was the length of time needed for a new crop to become established. The failure of Darwinian theory within this context was to have a profound, and detrimental, effect on the Russian economy and be instrumental in precipitating the downfall of communism within Russia.

16.3 A wizard with lizards

To understand not only Lysenko, but the adherence of so many of his Russian colleagues to a belief in the inheritance of acquired characteristics, it is necessary to consider the work of the Austrian, Paul Kammerer, who was the most influential scientist working in this field during the first quarter of the twentieth century.

For the first thirty years of his life, Paul Kammerer (1880-1926) may well have considered that he had been born 'under a lucky star' (Koestler 1971: 2). Vienna during the last two decades of the 19^{th} century was a prosperous and happy place, and Kammerer's family was prosperous, even by Viennese standards. They were a musical family and Kammerer first studied music at the Vienna Academy before studying zoology at the University, where he obtained his Ph.D. He was an accomplished pianist and composer and his employer, Professor Przibram, was later to say that much of the antagonism towards Kammerer's work was due to his being first a musician and second a scientist (Koestler 1971).

As a child, Kammerer developed an abiding interest in the lizards and frogs which he found in the grounds of his family home. He developed a reputation for being 'a wizard with lizards' (Koestler 1971: 13). An article Kammerer wrote on the care of animals in captivity motivated Hans Przibram to employ the young Kammerer in the Institute for Experimental Biology which opened in 1904 (Koestler 1971: 10). The Institute was very modern for its time, being equipped with an early form of air-conditioning which made it possible to keep temperatures in the laboratory constant, as well as to control humidity (Koestler 1971: 11).

Failure of other scientists to replicate Kammerer's work may have been due in part to the lack of equal facilities, but it was also due, according to Przibram (Koestler 1971: 12-13), to Kammerer's devotion to, and affinity with, his experimental animals. He regarded reptiles and amphibians as sensitive creatures and refused to buy animals from dealers, considering them 'spoilt', over or under fed and often unwilling to mate (Koestler 1971: 29). He collected all his laboratory animals himself from the wild. Another factor which impeded other scientists from replicating Kammerer's work was their inability to keep these animals alive in captivity at all. The breeding of even one generation under standard conditions proved almost impossible, let alone the breeding of several generations under abnormal conditions, which was the hub of Kammerer's work (Koestler 1971: 13).

Kammerer (1924) published an account of his work, intended for the general reader. His final chapter, *Darwinism and Socialism*, was devoted to an outline of his belief that the Neo-Darwinism so popular in Germany, Britain and America and other non-socialists countries, was 'aristocratic', not 'democratic' (Kammerer 1924: 63):

> Entirely different from this is the real Darwinism. Like socialism, it is a doctrine of 'upward development' and must concern itself with masses, and not only individuals, or it misses its aim.

16.4 Acquired characteristics

When he was invited to join the team at the newly formed Institute of Experimental Biology in 1904, Kammerer was aware of the new theory of Mendelian inheritance, which he accepted (Kammerer 1924: 20). His initial experiments were intended to throw light on the problem of atavism (Kammerer 1924: 52). The male Midwife Toad *(Alytes obstetricans)* winds strings of eggs around the upper part of his hind legs, so that they develop to the tadpole stage out of water. Kammerer was able to hatch some of the eggs in water, which could be described as atavism – a reversal to a previous habit. Subjecting some eggs, not to immersion in water, but to relative aridity and darkness, caused the tadpoles to remain inside the eggs (which became 'gigantic') until the tadpoles had grown their hind legs (Kammerer 1924: 52):

> These eggs and tadpoles produce dwarf-like toads which now, from generation to generation, produce eggs that are proportionately more limited in number, but are larger and larger, and more rich in yoke. If the environment continues to be warm, rather dry, and quite shady, tadpoles emerge from these eggs with completely developed hind legs. If restored to normal conditions, tadpoles are produced with just the beginnings of the hind legs.

This was just one of the experiments that convinced Kammerer that, by changing the environment, it was not only possible to cause atavism, but also to produce a novel condition, in this case the eggs continuing to develop out of water to an unprecedented degree. While the ability of the organisms to respond to changing environmental conditions was, to some extent at least, what Kammerer had been expecting, what he had not expected was that the new characteristic would be passed on to subsequent generations (Kammerer 1924: 20). The eggs/tadpoles of 'water' and 'air' developed toads that differed in several ways, not just in the development of hind legs. 'Water' egg tadpoles, over several generations, developed three gill arches, instead of the usual one. The eggs became smaller (poorer in yolk) but the gelatinous coating became thicker (Kammerer 1924: 53). Eggs of 'abnormal' Midwife Toads (those which did not take care of their eggs any more but simply deposited them in water) produced specimens in which the instinct to attach the eggs to their thighs was lacking, even though they had themselves passed their period of development on land (Kammerer 1924: 59). Kammerer 'controlled' for his experiments by subjecting some of the toads to reverse conditions (Kammerer 1924: 60):

> The most important variation in the case of the Midwife Toad is the voluntary relinquishing of carrying the eggs and taking to the water at the mating period, even after the influence which brought about these changes of propagation has again been eliminated. The unassailable proof of genuine inheritance was brought about here by the aforementioned controlling tests and strengthened by the fact that, in crossing "abnormal" Midwife Toads and "normal" ones, the hybrids are subject to the Mendelian Rule.

Males of the third or fourth generation also tended to develop a rough, blackish nuptial pad (Kammerer 1924: 53). It was this claim which was to lead to Kammerer's downfall (see below).

Kammerer also experimented with salamanders. The spotted Fire Salamander *(Salamandra maculosa)* naturally inhabits moist woods. The female gives birth in water and the fifty or so young live in water for several months, with clusters of gills for respiration and a finned tail for swimming (Kammerer 1924: 88). Kammerer removed the female from the water, forcing her to birth on land, where the young would have died had he not placed them in water (Kammerer 1924: 88-89):

> Death by drying up would also have been the fate of the next issue – usually born at intervals of six months – had not the mother salamander delivered larger larvæ which, within the womb of the mother, passed the period meant for development in the water. Generally, beginning with the fourth pregnancy, at the conclusion of the second year of experimentation, the young ones, born on land, are no longer in any danger of death by drying up. They are completely developed little salamanders breathing through lungs and, thanks to sturdy little legs and a cylindrical finless tail, they have the ability to move with ease upon solid ground … instead of fifty progeny … only six, four, or even two are born at one time, the salamander's womb allowing space for no more.

These changes took place, not in subsequent generations, but in subsequent pregnancies! Kammerer's work showed that, not only were acquired characteristics inherited, but they might be acquired in a very short time. Time had been a problem for evolutionary theorists ever since Darwin first proclaimed his theory, particularly in the case of large, slow breeding mammals. It might have been supposed that evolutionary theorists would have welcomed Kammerer's work, and many did, but a relentless campaign by Bateson discredited him and his work, not difficult to do bearing in mind the enmity which existed between Britain and Germany during and after the First World War.

The South European Wall Lizard *(Laceria serpa)* lays elongated eggs, covered in a soft onion-like skin (Kammerer 1924: 181). Kept at warmer temperatures, the female lizard laid eggs with a thicker shell, not so elongated, eventually laying perfectly round eggs with calcified shells, similar to the geckos *(Gecconida)* in warmer (tropical) climates. Young female lizards hatching from the hard-shelled eggs laid hard-shelled eggs, even if they were kept at an intermediate temperature, as did the parent lizard when returned to normal conditions (Kammerer 1924: 181). It appeared to Kammerer that once the calcium-secreting glands of the oviduct had been stimulated, the new pattern became fixed (Kammerer 1924: 181-182). Laying eggs with calcium rich shells in a cool climate is not detrimental to the embryo in the same way that is the laying of thin-skinned eggs in a warm climate.

Kammerer also referred to the well-known phenomenon of changes in egg-shell colour under hybridization. If a hen which usually laid white-shelled eggs was mated with a rooster from a line laying brown-shelled eggs, the eggs would be brownish, as would future eggs laid by that hen, even though she was then mated with a 'white egg' rooster. The same phenomenon was known to occur with finches and canaries. Many animal breeders refused to use females which had been mated with another 'line' believing that the female was from then on 'impure' in some way. (Some human societies, even today, have similar views regarding women who have, voluntarily or non-voluntarily, had sexual relations with an 'undesirable' male). Kammerer believed that some of the superfluous sperm penetrated (was absorbed into) the cells of the oviduct and some of the genetic material became integrated with the genetic material of the female bird. Since this material was only integrated with the cells of the oviduct, which produced the material for the shell, and not with the reproductive cells of the female bird, the male characteristics were not truly 'acquired' by the female and were not passed on to the next generation and was not the same phenomenon as the inheritance of an acquired characteristic.

16.5 *The Case of the Midwife Toad*

The ongoing saga of the acquired nuptial pads of the Midwife Toad had its beginnings with Bateson during the 1880. Bateson, enthusiastically embracing Darwin's teachings, tried to find evidence for the inheritance of acquired characteristics, but was unsuccessful (Koestler 1971: 42). He was to find the explanation for his failure in the theories of Weismann and Mendel (Bateson 1909a), which he then enthusiastically embraced. For the next twenty years or more, he rechannelled his energies into disproving the very theory he had once held so dear.

Bateson had some misgivings when he heard of Kammerer's work. In September, 1910, Bateson visited Kammerer at the Institute of Vienna and at that time became openly hostile (Koestler 1971: 5). In a letter to his wife, Bateson wrote (Koestler 1971: 54):

> … there is no denying any longer the extraordinary interest of what he is doing. The *Brauftschwielen* [nuptial pads] cannot be produced. Somehow or other I have hit on a weak spot there … But he has certainly done a very fine lot of things and he comes uncommonly near to showing that an acquired adaptation is transmitted. I don't like it, and shall not give in till no doubt remains.

In a paper published after the war, Kammerer took the opportunity to explain that the Midwife Toad, adapted by him to breeding in water, developed nuptial pads for a short time during the mating season. The mating season was still several weeks away at the time of Bateson's visit (Koestler 1971: 58-59). Kammerer further explained that only a very few of the experimental eggs developed into breeding adults and he had been reluctant to kill a breeding male, during the mating season, simply to preserve such a specimen (Koestler 1971: 58).

During the war, Kammerer had been conscripted to work in one of the Ministries (Koestler 1971: 67). The Institute was unable to maintain its high standards and most of the animals died. One male Midwife Toad survived, developing the nuptial pads even though there was no female present. This specimen was killed and preserved as evidence. After the war, the economies of Germany and Austria collapsed. The Institute was in great difficulties. Kammerer was forced to try to support both himself and the Institute by undertaking lecture tours.

In April 1923, the Cambridge Natural History Society sponsored a visit by him to England at which he displayed the specimen of the male Midwife Toad, with its nuptial pads. By that time, Bateson's belief that these pads neither existed nor were inherited had become a public source of contention. Bateson did not attend the meeting (Koestler 1971: 66). The meeting was so successful that the lecture was repeated in London on 10th May. This time, Bateson did attend and, although he did not remove the specimen from its jar for examination, he did withdraw his charges against Kammerer and accepted his published results as genuine (Koestler 1971: 77).

In September of that year, Bateson expressed a desire to see the specimen again and offered to defray expenses if Kammerer would bring the specimen to England a second time (Koestler 1971: 79). The Institute, in the person of Przibram who owned the specimen, declined to subject the valuable specimen to further travel, but offered to accommodate Bateson at Przibram's house, should Bateson wish to come to Vienna. Bateson declined, and there the matter rested – until 1926.

16.6 The role of Pavlov

After nearly a year's leave of absence, during which Kammerer lectured both at home and abroad, and wrote extensively, Kammerer left the Institute in October 1924 to continue his activities on an independent basis. He lectured in Russia, where his work was well received. Pavlov trained mice to respond to the sound of a bell which announced the arrival of food (Koestler 1971: 24-25). The first generation of mice needed 300 trials, the fourth only five (Koestler 1971: 24). It was Pavlov's hope that mice would eventually be bred that responded to the sound of the bell without any training, i.e. without the arrival of food. However, when attempts to replicate Pavlov's work proved negative, Pavlov withdrew his claims, blaming an assistant for faulty experimentation (Koestler 1971: 25).

The purpose of Pavlov's experiments had been to show the inheritance of learning. Experiments by Harvard Professor, William MacDougall, showed that rats learned the escape route through a water maze more quickly with each generation, but Professor Agar of Melbourne subsequently showed that not only experimental rats learned more quickly with each generation, but so did the controls! It appeared that merely being bred under laboratory conditions improved learning ability (Koestler 1971: 26).

Pavlov's belief in the inheritance of acquired characteristics led him to invite Kammerer to oversee the building of a new biological research laboratory, to be affiliated with Pavlov's Institute (Koestler 1971; Adams 1980). Kammerer was due to take up his position 1st October, 1926 when he was to receive a Professorship and be in charge of a new facility. One week before he was due to commence his new duties, Kammerer was found dead from a bullet wound to the head, with a suicide note in his pocket (Koestler 1971: 1).

16.7 The finale

In February, 1926, Przibram's Institute was visited by Dr. Noble, the Curator of Reptiles at the American Museum of Natural History (Koestler 1971: 94). A known opponent of 'Lamarckism', Noble examined the preserved specimen of the male Midwife Toad and declared that the nuptial pads had been faked by the injection of Indian ink. Przibram examined the specimen and concurred.

Przibram's initial reaction was that someone working at the Institute had noticed that the dark colour of the pads had faded due to exposure of the jar to light, and had tried to help by recolouring the specimen. He changed his mind and concluded that the fraud had been committed with the intention of discrediting Kammerer. He believed he knew who the perpetrator was but had insufficient evidence to make a public accusation (Koestler 1971: 122). Kammerer absolutely denied any involvement and his denial was obviously accepted by Pavlov, since the discovery of the fraud took place at the time Kammerer's contract was being negotiated.

Koestler tried to duplicate the fraud. He found Indian ink gave good results but they were only temporary (Koester 1971: 106-110). With the specimen preserved in alcohol, the ink 'ran'. With the specimen preserved in formaldehyde, the colour faded within two weeks. Mixing the Indian ink with another substance prior to injection gave equally unsatisfactory results. In glycerol, the Indian ink dissolved and 'ran'. Paraffin oil did not take up the ink. With gelatine, the ink did not fade but the patch coagulated, and looked very artificial (Koestler 1971: 110). Koestler concluded that the fraud had been carried out using simple Indian ink shortly before Noble's arrival. Since Kammerer had not worked at the Institute for three years by then, clearly the fraud was not perpetrated by Kammerer. However, Koestler's experiments were not carried out until 1970. None were tried at the time.

According to a news report of the time (Koester: 1971: 6): "Two days before his suicide, Dr. Kammerer visited the Soviet Legation in Vienna and with much zest gave instructions regarding the crating and transport of the scientific apparatus and machines which he had ordered …". What caused such zest to be transformed into suicidal depression? One suggested reason was the refusal of Kammerer's current mistress to accompany him to Russia (Koestler 1971: 117).

Leaving the dispatch of his equipment in the hands of the removalists, Kammerer paid a final visit to his favourite holiday resort, Puchberg, where he arrived in the evening of Wednesday, 22nd September, 1926. The following morning, he went for a walk along a narrow footpath leading from Puchberg to Humberg. He was found at 2 p.m. that day, in a sitting position, leaning against the Theresa Rock on the Schneeberg Pass. Besides the suicide note in his pocket, he had posted four other suicide letters the day before. Or had he?

Although the gun was still in his right hand, the bullet had entered his *left* temple, just above the ear, exiting through the right temple, damaging the right eye, indicating an angle of shot which would surely have needed the abilities of a contortionist? All the suicide notes had been typed with only a signature, which could easily have been forged if the death was indeed a professional 'hit'. The note in Kammerer's pocket suggested that his body be donated to a laboratory for dissection (Koestler 1971: 1):

> I would actually prefer to render science at least this small service. Perhaps my worthy academic colleagues will discover in my brain a trace of the qualities they found absent from the manifestations of my mental activities while I was alive …

This was a strange request from someone planning to blow his brains out! Although the full extent of Hitler's brutal exercise of power was yet to be felt, political assassinations were occurring with increasing frequency in Germany and Austria (Koestler 1971: 113) and it cannot be ruled out that the attempt to discredit Kammerer and thus prevent his being offered the contract by Pavlov having failed, and his defection to Russia being imminent, a resort was made to extreme measures.

Bateson died in February, 1926, just as the 'fraud' was being discovered. Had Bateson lived to know of this new Kammerer controversy, he may not have been as pleased as might have been expected. By 1924, he had come to the conclusion that Neo-Darwinism (the amalgamation of Darwinian theory and Mendelian genetics) was not a sufficient explanation for evolution and that "it was a mistake to have committed his life to Mendelism, that this was a blind alley which would not throw any light on the differentiation of species, nor on evolution in general" (Koestler 1971: 119).

16.8 An idea whose time has come?

The geneticist, Steve Jones (2002) recorded several instances in which changes occurring in the life time of plants or animals due to changed conditions appeared to be inherited by their offspring, even if the conditions were reversed in subsequent generations. Referring to such instances of epigenetic variation, Foder and Piattelli-Palmarini (2010: 67) stated that "this domain has raised perplexities ... caused by the fear that Lamarckism may be making a comeback".

Following upon his early work, (Steele 1979), Edward Steele and his colleagues (Steele et al. 1998) found that, in certain instances, there was evidence of soma to germ-line feedback associated with the immune system. They concluded that the Weisman barrier was not as impenetrable as had been assumed by the Neo-Darwinists. While their work with the immune system was highly specialized, they drew attention (Steele et al. 1998: 191) to some simple examples of what appeared to be acquired characteristics being inherited. Ostriches and warthogs both develop callouses where they sit or kneel and it is difficult to consider these callouses as anything other than an acquired characteristic, yet these callouses are already well-formed in the embryo, implying that these callouses are germ-line encoded.

While accepting that Lamarck believed in the inheritance of acquired characteristics, here disputed, Steele et al. (1998) also made repeated reference to Darwin's theory of *pangenesis*, which they feel may need to be revisited. Steele was inspired by the work of Arthur Koestler (Tynan 1994), who became his mentor. Thus through Koestler and Steele, the work of Kammerer is not totally forgotten.

Chapter 17

The Mathematics of Genes

17.1 Exploring genetics

The new field of genetics engaged the attention of many researchers, not because of any knowledge which might be gained regarding the history of evolution, but because of its potential as a productive area for medical research. Certain conditions, such as hæmophilia and mongolism (as it was then called), were recognised as having an aberrant genetic basis. Understanding how genetic changes came about and, more importantly, how undesirable changes might be reversed, demanded the attention of some of the best minds in medical science. Evolutionary theorists benefitted from this increased understanding.

Much of the research work done in laboratories during the first half of the 20th century was carried out on insects, because of their quick rate of reproduction, their large numbers and their comparative cheapness. Small mammals, such as rats and guinea pigs, were also used, as were amphibians, such as frogs. The most work was carried out on the various species and varieties of *Drosophila,* which possessed particularly large cells in their salivary glands, observed easily under a microscope. However, these cells only underwent *mitosis*, not meiosis. Somatic cells could differ from each other, through mutation, but such somatic mutations were not hereditary (Haldane 1954: 63), and this is still the assumption today, although further research may reveal exceptions. Although drawing some conclusions as to occurrences during meiosis from mitosis, care had to be taken not to extrapolate from the one situation to the other too freely. Huxley downplayed the step between mitosis and meiosis (Huxley 1942: 132):

> The existence of mitosis, of however simple a nature, presupposes the need for accurate mechanical division of the hereditary substance; and this in turn would not be necessary unless the hereditary substance were differentiated into specialized parts, each with their appropriate functions. Thus the mitotic organism has reached a stage of particular inheritance, based on spatial differentiation of the germ-plasm ... Apparently, once the detailed differentiation of the germ-plasm into accurately-divisible chromosomes had been accomplished, it was comparatively simple to alter the timing of the various processes involved in one cell division, so as to produce meiosis; and this was fraught with such advantages that it was all but universally adopted.

No suggestion was offered as to why or how genes and chromosomes came to exist in single-celled organisms, interest being in the evolution of life forms, not their origin. Huxley appeared to blur over not only how, but why, meiosis was first established, possibly because it was difficult to explain why a single-celled organism, able to live and multiply unassisted, should 'choose' to become reliant on another organism. Huxley's terminology is also unfortunate since it gives the appearance of attributing to these simple organisms an ability to evaluate options and to make choices.

17.2 Isolation

Notwithstanding the fact that a single mutation resulting in the formation of a new recessive gene could not be expressed in the phenotype and, therefore, not be available for 'selection', it became accepted that recessive mutations (even if originally disadvantageous) could spread through the gene pool for many generations, forming different combinations, possibly even becoming dominant under certain conditions (Goldschmidt 1938: 168). Eventually conditions might arise such that formerly dis-advantageous mutations might manifest in an advantageous way, making them subject to natural selection. Nevertheless, it was recognised that, while the amount of genetic variation might increase within an interbreeding population, this increase in genetic variation would not, of itself, cause the formation of distinct groups, i.e., it would not cause speciation (Dobzhansky 1951: 52; Goldschmidt 1940: 9).

Darwin had early recognised the importance of isolation in the formation of new species (Darwin 1909/1969). He was later to reduce the importance of geographical isolation by the introduction of sexual selection (Darwin 1871/1908). As the twentieth century progressed, the importance placed on sexual selection was reduced, since it was acknowledged that the number of species in which a dominant male was responsible for most of the offspring was really quite small and in nature all females were mated, no matter how 'unfavoured'. Evolutionary theorists once again turned their attention to isolation as the means of speciation, be it geographical or reproductive (Mayr 1949/1963: 292).

Dobzhansky (1951: 134) argued that geographical isolation and time were all that were required for a species to subdivide into distinct races/varieties. Of particular interest were a number of intergrading subspecies which formed a loop or overlapping circle, the terminal forms of which no longer interbred, even though they existed in the same localities. Mayr (1942: 185) concluded that at some point various subgroups of the original population had isolated themselves from each other as a result of preferences for different ecological niches and that this isolation eventually resulted in speciation. The isolation was not necessarily geographical. Dogs today could be regarded as such intergrading subspecies. All dogs belong to the same species and are theoretically capable of interbreeding but there are physical differences which would make the mating of a St. Bernard and a Chihuahua impossible. If breeders were to decide, for some reason, that they only wanted to breed very large or very small dogs, and all medium sized dogs disappeared, two 'species' would result.

Conversely, geographical isolation could occur over extended periods of time, yet no new species be formed. The connection between the Pacific and Atlantic Oceans at Panama had been broken some two to three million years ago, but some of the species of fish and crustaceans were still the same on both sides of the Isthmus (Mayr 1942: 223). Certain plant species found in eastern Asia and eastern North America, which had probably been separated for millions of years, were still morphologically indistinguishable. Geographical and biological isolating mechanisms were required to work in conjunction (Mayr 1949/1963: 292).

While all theorists were in agreement that geographical isolation was a prerequisite for speciation, just what constituted geographical isolation? A population of butterflies in a meadow? A population of deer in a wood? But might not butterflies be blown to a new meadow, where they might mix with others similarly displaced? Might not deer leave their usual grazing ground in search of food in hard times? Pacific Islands were evidence for long migrations. Even the Galàpagos Islands were home to land turtles. Mayr (1942: 225) argued that, far from enhancing the potential for evolution, islands were evolutionary traps for such species as settled them.

Dobzhansky (1937: 228) held that Romanes' contention that without isolation, evolution was impossible was subject to misinterpretation:

> The difference between individuals and groups may be due to a single gene or a single chromosome change. Such differences can never be swamped by crossing, since in the offspring of a hybrid segregation takes place, and the ancestral traits reappear unmodified. No isolation is needed to preserve the variation.

Recessive genes were both a blessing and a curse. On the one hand, they could not be 'swamped out', they could be preserved through generations, unmodified. However, they did not manifest in their recessive state, so Dobzhansky's claim that "the ancestral traits reappear unmodified" must be seen as referring to a dominant gene which acted as a recessive in certain combinations but which was still preserved and able to resume its dominant position when circumstances changed. The situation was not that of a recessive gene becoming dominant for the first time, but of a previously dominant gene resuming its former status.

Ford (1931: 90) and Simpson (1944: 32) agreed that a small degree of isolation was all that was required for change to become possible within a population, even without mutation, due to chance increase or decrease in the proportion of various genes. However, no basically new types of organisms could arise by this means, nor could new species arise (Dobzhansky 1937: 229; Simpson 1950: 215). Dobzhansky and Simpson rejected Ford's claim that gradual change in the gene-complex alone would be sufficient to "lead to the establishment of genetic incompatibility between them [colonies]. This will be slight at first, but will end in a condition of partial and later of complete 'inter-specific sterility' " (Ford 1931: 90).

Numerous species of fish, many closely related, existed side by side in some of the great African lakes: 171 species of *cichlid* in Lake Nyasa, more than 300 species of *Gamimarid* crustaceans in Lake Baikal (Mayr 1942: 213). It had been suggested that these species had evolved from a common ancestral species by adapting to different ecological niches, a process known as sympatric speciation. Authors such as Mayr (1942) and Muller (1949/1963) considered this was no longer an acceptable solution, since it was apparent that, even between fish occupying quite different parts of the lake, or living at different depths, there was no absolutely isolating barrier. Intermediate areas, with intermediate varieties, must exist and these would serve as a genetic bridge (Muller 1949/1963: 431). They concluded it was more likely that the various species had previously existed in the rivers which were later, as a result of geological movement, to feed into the same lakes (Mayr 1942; Muller 1949/1963). How these fish/crustaceans, having evolved in separate rivers, came to be such closely allied species was not explained.

Goldschmidt (1940: 141) questioned the whole concept of 'incipient' species. Any isolated group within a population would have the same chance as any other of proceeding towards speciation. The only advantage a so-called 'incipient' species would have had would have been that a few mutations had already been accumulated.

In 1943 a committee had been established in the U.S.A. by the National Research Council to consider "Common problems of Genetics, Paleontology and Systematics". The publication in 1949 of *Genetics, Paleontology and Evolution* was the record of this committee's work, aimed at bringing about 'a meeting of minds' in the fields of genetics and palæontology. In this aim they were only partly successful. Of the twenty-two papers included, sixteen were from the perspective of palæontology and/or systematics, which made only passing reference to genetics, and six primarily addressed genetics, with only minor references to palæontology and/or systematics.

On the other side of the Atlantic, attention was also being focused upon a possible synthesis between Darwinian evolutionary theory and modern genetics which was to culminate in the *Evolutionary Synthesis*, as summarised and expounded by J. Huxley (1942).

As the first half of the twentieth century drew to a close, reproductive isolation induced by geographical isolation became established as the essential criterion for the establishment of new species (for example Ford 1949/1963; Goldschmidt 1938, 1940; Lack 1949/1963; Mayr

1942; Muller 1949/1963; Wright 1949/1963). Although Darwin (1859/1998) had noted that large land masses gave rise to the greatest diversity of species and Mayr (1942) had concluded that isolated islands were evolutionary traps, nevertheless the mathematics of evolutionary reproduction led to the conclusion that a new genetic variation would have the best chance of becoming established if it occurred in a small population. But even the assumption of small populations could not provide a complete answer. Dobzhansky (1937: 284-285) summarised the problem:

> It is indeed difficult to conceive how isolation between two groups of individuals might arise through a single mutation. Mutations that change the sexual instincts, or the structure of the genitalia, or the physiology of the gametes, or some other properties of their carriers that are essential for reproduction, may occur. Such mutations may prevent crossbreeding of the modified and the ancestral types, but this is not yet sufficient to produce a workable isolating mechanism. For isolation encountered in nature has always two aspects: the crossing of individuals of Group A with those of Group B is made difficult or impossible, but individuals of A, as well as of B, are fully able to breed *inter se.* A mutation that would produce isolation must therefore not only prevent crossbreeding between the mutant and the original type, but must simultaneously ensure that internal crossability of the individuals carrying the mutations. Such a coincidence can hardly be imagined to be a common occurrence … With mutation rates that are as low as those observed for most genes in the laboratory, the number of mutants produced in each generation would be so small that they could hardly find mates.

17.3 The mathematics of evolution

The rarity of mutations occurring without laboratory interference, most of which were either neutral or detrimental, even lethal, necessitated consideration of the mathematical possibilities and probabilities of the evolutionary consequences of genetic mutations.

Within any inter-breeding population, genetic uniformity would eventually be reached (Dobzhansky 1937: 130). One mathematical law formulated by Hardy in England and Weinberg in Germany, subsequently known as the 'Hardy/Weinberg Law (1908)', stated that if no new genetic material is introduced, the gene frequencies will remain constant from generation to generation indefinitely, the equilibrium of *AA, Aa, aA, aa* in a randomly breeding population being reached in a single generation for a two-allele system (Dobzhansky 1937/1951: 53).

While equilibrium might be the rule throughout a large breeding population, there would be fluctuations within small, local populations. This might result in a mutation becoming 'fixed' (universal) throughout a small population, or being eliminated altogether, both events being possible without the participation of natural selection (Dobzhansky 1937/1951: 131-132). The maintenance of the genetic equilibrium was seen as a conservative, not a progressive, factor (Dobzhansky 1937/1951: 124). Notwithstanding the Hardy/Weinberg Law, which he, himself, had cited, Dobzhansky (1937/1951: 131-132) went on to claim:

> If the heterozygote *Aa* (*a* being a mutant gene decreasing viability) is as viable as the ancestral homozygote, *AA*, the frequency of the gene *a* will be allowed to increase until the *Aa* individuals become so frequent in the population that their mating together is likely to

take place, and the homozygous *aa* are produced. The *aa* being unfavourable, the *aa* individuals will be eliminated, and this will impose a check on the further spread of the mutant gene *a* in the population.

The proportion of *Aa* heterozygotes would remain the same, according to the Hardy/Weinberg Law, yet Dobzhansky assumed that "*a* will be allowed to increase" until the double recessive, *aa*, made its appearance. Dobzhansky assumed that the recessive *a* would be unfavourable, which was in accordance with laboratory findings that most mutations were neutral, unfavourable or lethal. Other theorists, as already discussed, had to assume that some, at least, of the recessives were potentially beneficial, just waiting to be selected. Incipient favourability was the explanation of a mutant gene's ability to overcome the mathematics of genetics according to Hardy/Weinberg. If *aa* were to be lethal, their carrier would die, but *a* would continue in its heterozygous form, a point made strongly by Haldane (1938) when writing in opposition to eugenics.

Gene mutations of detectable magnitude were estimated to occur once in every 100,000 to 1,000,000 individuals (Ford 1931). An advantageous mutation would be very rare, occurring perhaps once in 10^9 (10,000,000,000) individuals (Ford 1931: 445-446). With the entire human population of Africa two million years ago not reaching anything like this number, these figures raised considerable questions as to how positive evolution could have reached the stage it had in slow breeding organisms. Evolution had to be measured in generations, which meant that slow breeding mammals had evolved at a rate many times more rapid than that of quickly breeding animals (Simpson 1944: 63), and even more rapidly when compared with fast breeding insects, such as *Drosophila.*

The apparent slow rate of mutation would be lessened if more than one mutation occurred at the same time, as Haldane (1932: 102-103) suggested would have been necessary for organs such as the human eye or hand. However, the simultaneous appearance of several gene mutations in one individual had never been observed (Simpson 1944: 54):

> Postulating a mutation rate of .00001 and supposing that the occurrence of each mutation doubled the chances of another mutation in the same cell – a greater departure from random incidence than is likely to occur – the probability that five simultaneous mutations would occur in any one individual would be about .0000000000000000000001 (21 noughts). In an average population of 100,000,000 individuals with an average length of generation of only one day, such an event could be expected only once in about 274,000,000,000 years – a period about one hundred times as long as the age of the earth.

These calculations were based on the age of the earth as estimated at that time. The large populations with short generation spans postulated by Simpson were presumably fruit fly, generally used in laboratory experiments. A smaller population of larger animals reproducing annually would considerably inflate the figures. Larger mammals with smaller populations and longer reproductive spans, would have involved figures that were truly astronomical! Human populations may be large now, but during the time that humans were evolving, they were quite small.

Simultaneous mutation, providing several copies of a new gene, would seem to be necessary to allow manifestation of a new, recessive characteristic but (Dobzhansky 1937/1951: 40):

> Mutation changes one gene at a time; simultaneous mutation of masses of genes is unknown … A sudden origin of a species by mutation, in one thrust, would demand a simultaneous mutation of numerous genes. Assuming that two species differ in only one hundred genes and taking the mutation rate of individual genes to be as high as 1:10,000, the probability of a sudden origin of a new species would be 1 to $10{,}000^{100}$ [a further one hundred noughts].

It had originally been thought that genes were either dominant or recessive and Fisher had thought that for a mutation to play any role in evolution, it would somehow have to change from being recessive to being dominant (Fisher 1929/1958). Laboratory work showed that, while most mutant genes were recessive, some were not completely so, i.e. had some immediate influence, helping to give rise to an appearance of 'blending'. According to Huxley (1942: 56):

> A mutation with partial dominance occurring once in 10^5 [100,000] individuals will, if selectively neutral, take a period of somewhat over 10^5 generations to establish itself in half the individuals of a species. If there were the faintest adverse selection against it, it would never increase at all. But if it conferred an advantage of only 1% … then it would establish itself in half the individuals of the species in a period of only about 10^2 generations.

Mendelian genetics *alone* could not account for dissemination of a mutation throughout a population. For that, it was necessary to call upon positive selection, and mathematics was used to estimate its effect. The foremost proponent of this approach was Fisher (1929/1958) whose book was so full of obtuse formulæ, incapable of being understood by anyone not well versed in statistics, that it is frequently mentioned but rarely discussed. Haldane claimed that he could write with authority on the subject of natural selection because he was one of only three people who understood its mathematical theory, the other two being Fisher and Wright (Haldane 1932: 33, 96).

Dobzhansky (1937/1951: 178-179) was by no means convinced that mutation and selection accounted for evolution:

> The number of generations, and consequently the amount of time needed for change, may be so tremendous that the efficiency of selection alone as an evolutionary agent may be open to doubt … Combined with mutation, the process of selection may be either enhanced in speed, or, vice versa, slowed down still further [because mutations are reversible] … Whether the combined forces of mutation and selection are sufficient for a sustained progressive evolution is not immediately clear.

A non-adaptive gene would continue to affect only the same *proportion* of the population as at its first appearance, although if that population were to increase in size, the *number* of those genes would increase. Then, if the size of the population were to be reversed, the spread of non-adaptive genes would be checked, and those of semi-lethal character quickly eradicated (Ford 1931: 75-76). Huxley (1942: 58) believed that repeated mutations and a large *aa* population were necessary for the establishment of an advantageous mutation:

> Even with a definite selection advantage such as 1% … the chances are strongly against a lone mutation surviving in the species … Thus repeated mutation together with a considerable-sized population, are necessary for new mutations to have an evolutionary chance.

Here Huxley was agreeing with Darwin and Mayr that a large population was more conducive to evolution. This was contra Haldane (1932: 138) who argued that mutations had the best chance of becoming established in small populations: "A single mutation will almost certainly disappear … unless the population is highly inbred". Dobzhansky (1937: 130-131), as a result of mathematical calculations, concluded that the majority of mutations would be lost within a few generations irrespective of whether they were neutral, harmful or useful to the organism.

The large *versus* small population conundrum was resolved thus. For advantageous mutations to *occur*, a large population was needed (Haldane 1932: 58) and for such an advantageous mutation to become *established*, it was necessary for the same mutation to occur numerous times (Huxley 1942: 58). Only in a population of infinite size, mating entirely at random, would the proportions decreed by the Hardy/Weinberg Law operate precisely. Since all populations are, in fact, limited and mating is never completely random, gene frequencies in the smaller (sub)populations would be subject to chance variation and offer higher possibility for a particular gene to become fixed or deleted entirely (Dobzhansky 1937/1951: 131-132; Simpson 1950: 227).

Simpson (1953: 121) estimated that it would take some 500,000 years, and often much longer, for one species to change into another. Mayr (1942: 222) estimated that the time required for the formation of a new subspecies in the Holarctic region had been between 5,000 and 15,000 years, concluding that if such long periods of time were generally required for the production of *sub*species, all geological time would not be sufficient to explain the present diversity of animal and plant life.

17.4 The position of genetics

Notwithstanding the statistics cited, all of the above authors continued to support Darwin's theory of evolution by natural selection, their work being the foundation of its synthesis with Mendelian genetics known as the Modern Evolutionary Synthesis.

Ideological belief was not an issue. Mathematics is known as a 'pure' science because it operates under all circumstances, irrespective of the hopes, beliefs or opinions of its human interpreters. The investigators were searching for discontinuity, for the means whereby change had come about, but their searches were largely in vain. Apart from very minor individual variation, reproduction generally produced little significant change. Their own calculations told them of the astronomical amounts of time which would be needed for a beneficial mutation to occur and become established.

Evolution by natural selection had become the dominant paradigm and it was upheld, despite rather than because of the emerging evidence. Within the scientific community there was no subordinate text. Funding for such research was not available outside the established scientific community, leaving religious dissenters with no avenue for debate.

Chapter 18

The Mathematics of Chromosomes

18.1 Introduction

The previous chapter drew attention to the work of a number of theorists, including the mathematician, Ford, and the geneticist, Dobzhansky, whose own work produced evidence of astronomical odds against the viability of natural selection as being the sole, or even principal, means of evolution, yet who still persisted in their support of this doctrine. This chapter considers the work of two more prominent theorists, each of whom had reservations about natural selection, but who nevertheless continued to support Darwin's theory, albeit in its amended form as the *Evolutionary Synthesis.*

18.2 Eugenics

The social implications of evolution by natural selection were immediately recognised (Darwin 1871/1908). While Darwin spoke of superior races replacing inferior ones, his cousin, Francis Galton, pursued the possibilities which presented for the improvement of the civilised races by encouraging reproduction among the more favoured *individuals* and discouraging it among the less, if necessary by a process of sterilization where gross physical and mental disabilities were present (Galton 1892/1962). William Bateson (1909a: 304-305) considered that we [civilised societies] should prepare ourselves for the practical application of genetic science to human affairs, something which many people considered had already become 'urgent'. By the 1930s, compulsory sterilization laws had been passed in both the United States and Germany and were proposed for Britain (Haldane 1938). Haldane was vehemently opposed to eugenics and in 1938 published *Heredity and Politics* in which he pointed out the difficulty legislators had had in defining quite what conditions justified such drastic measures. Many instances of both physical and mental disability were congenital, not hereditary, or were the result of some later misfortune.

Haldane (1938) argued that even in cases known to involve an hereditary component, sterilization would not necessarily eliminate the problem, illustrating his argument with the disease hæmophilia. The gene concerned was completely recessive, not giving any sign of its presence in the heterozygote (always female). The double recessive carriers (always male) usually died before reproducing, this being the most severe form of 'natural selection'. Haldane gave family pedigrees showing how hæmophilia could be passed on, generation after generation, despite the death of double recessive carriers. He gave similar pedigrees for other, less severe conditions: colour blindness, brachydactylism, tylosis, etc., arguing that in order to eliminate these conditions, it would be necessary not only to sterilize the double recessive carrier, but also all the heterozygous carriers as well. The only way this could be achieved was by wholesale sterilization of all family members, whether they appeared affected or not.

In keeping with current theory, Haldane argued that small populations provided the greatest chance for the elimination of negative recessives, but did not state how small these populations would need to be. Keeping with hæmophilia as the example, so long as there was even one heterozygous female, there was a chance that that female would give birth to another, or more than one, heterozygous female child. If one such female were fortunate enough to have only sons, then another, according to mathematical probability, would have only daughters, some of whom were mathematically likely to be heterozygous for the recessive gene. Haldane calculated that one normal X-chromosome gene mutated to the hæmophilia gene in every fifty thousand generations, thus replenishing those recessive genes lost by the death of the double recessive carriers (Haldane 1938: 72).

Haldane argued that if it would be so difficult deliberately to eliminate a lethal recessive gene by eugenics, how much harder would it be to eliminate a merely 'undesirable' trait, one that allowed normal reproduction? This raises the question: if it would have been so difficult to eliminate an 'undesirable' recessive gene by the application of eugenics, how much more difficult would it have been for natural selection to have accomplished this feat? Haldane opposed eugenics. He wrote to that end and having accomplished his purpose, he appears to have been satisfied. He continued to support Darwin's theory as it was being incorporated with genetic theory into the *Modern Evolutionary Synthesis.*

18.3 Goldschmidt's macroevolution

By the time he emigrated to the United States in the late 1930s, Richard Goldschmidt (1878-1958) had earned himself the reputation of being Germany's foremost authority on evolution. He was welcomed by American academia and in 1939 was invited to give the Silliman Lectures at Yale University. Part of the requirement was that an expanded version of the lecture material be made available in book form. *The Material Basis of Evolution* (Goldschmidt 1940) was that book.

If Goldschmidt himself was welcomed by academia, his ideas were not – at least, not by his fellow evolutionary theorists, such as Ford, Fisher, Dobzhansky and Mayr (Brown 1999). Goldschmidt did not believe that the problem of evolution had been solved as far as its genetic basis was concerned (Goldschmidt 1940: 6). He questioned the extrapolation of facts pertaining to microevolution (change observed within the span of a human lifetime) to macroevolution (changes occurring on a geological scale) (Goldschmidt 1940: 8). Despite the fact that very few characteristics similar to those obtained by radiation in the laboratory had ever become established in wild *Drosophila*, yet the rate of *Drosophila* mutation was made the basis of theoretical conclusions (Goldschmidt 1940: 10).

Goldschmidt's book was divided into two parts, the first dealing with microevolution, upon which he was in general agreement with his colleagues. He did dispute the existence of so-called 'incipient species' (Goldschmidt 1940: 143). At some point, he argued, 'incipient' subspecies and distinct species had to be divided by a 'bridgeless gap' (Goldschmidt 1940: 145). He illustrated his point by reference to three species of the butterfly *Lymantria dispar, Lymantria mathura* and *Lymantria monarcha* (see Fig.18.1).

Although believed to be closely related, not only did the caterpillars and the butterflies differ in shape, size, colour and hairiness, their genitalia were different (see Figs.18.2 and 18.3). Furthermore, they had completely different egg-laying habits (Goldschmidt 1940: 144-150). How could micromutations account for differences in reproductive organs? At what point did one generation come to possess generative organs which differed from that of its parents, in however small a degree? Goldschmidt considered these species to be an example of the 'bridgeless gap', that it was not possible to account for their having descended from a common ancestor by the process of micromutation/microevolution (Goldschmidt 1940: 150). Goldschmidt cited the mathematical calculations of Wright, Fisher and Haldane, used by them to support the concept of the accumulation of micromutations as the basis of speciation, as evidence that the process of forming a subspecies, let alone a species, a genus or a family, was so drawn out that he doubted whether this method could ever be anything more than a theoretical possibility (Goldschmidt 1940: 180-181).

Goldschmidt (1940: 193) concluded the first part of his book with the sentence:

> Subspecies are actually, therefore, neither incipient species nor models for the origin of species. They are more or less diversified blind alleys with the species. The decisive step in evolution, the first step towards macroevolution, the step from one species to another, requires another evolutionary method than that of sheer accumulation of micromutations.

The second half of Goldschmidt's book was devoted to macroevolution. He (Goldschmidt 1940: 242-243) argued that gene mutations were insufficient to account for macroevolution, which needed to be considered in the terms of rearrangements of chromosomal patterns. Goldschmidt had come to the conclusion that evolutionary theory was being handicapped by its adherence to a belief in genes as discrete units, e.g. 'beads on a string'. Goldschmidt (1940: 203) maintained that there was no such thing as a particular gene, proposing that chromosomes should be considered as if they were a very long molecular chain. He suggested that genetic material should be considered as letters of the alphabet, whose arrangement and rearrangement could either make complete sense (healthy condition), partial sense (viable but disadvantaged) or no sense (not viable).

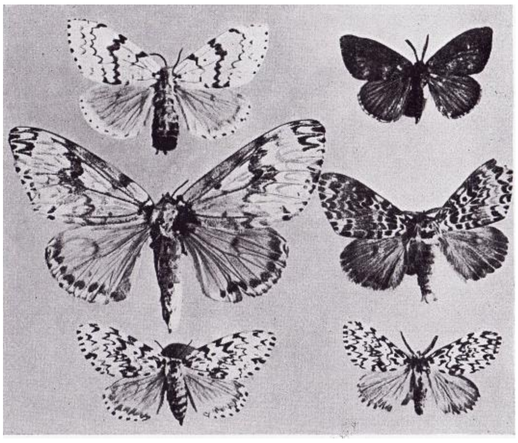

Fig.18.1 Three species of *Lymantria* butterfly.
(from Goldschmidt 1940: 145)

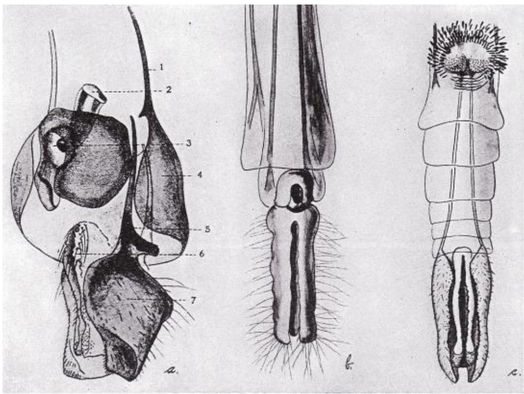

Fig.18.2: Genital armature of female *Lymantria* butterflies shown above.
(from Goldschmidt 1940: 146)

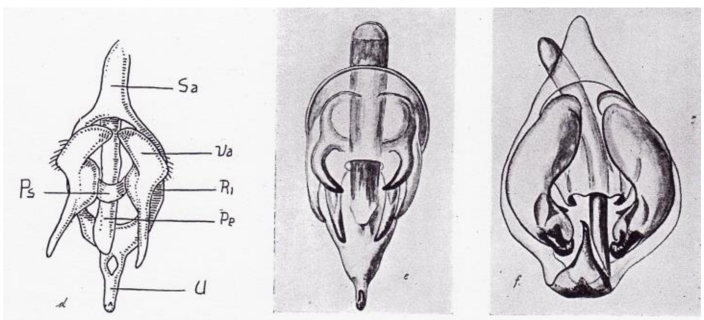

Fig. 18.3: Genital armature of male *Lymantria* butterflies shown above
(from Goldschmidt 1940: 47)

He had come to the conclusion that macroevolution could only come about when there was a complete rearrangement of a chromosomal/molecular chain (Goldschmidt 1940: 249). He was well aware that small genetic changes influencing hormones, etc., could result in large mutations, but still did not believe that these were enough to bridge the 'bridgeless gap'.

Goldschmidt was also concerned about chromosome numbers. He noted that related species or genera often had different numbers of chromosomes. It seemed as if, in some cases, one or more chromosomes had broken into two (which would require the acquisition of a new spindle fibre) or, conversely, some smaller chromosomes had united into a larger one, leaving the spare spindle fibre and its centromere unaccounted for (Goldschmidt 1940: 225). Goldschmidt pointed out these problems, but did not attempt to solve them. This task White (1937) had already undertaken, with mixed success.

18.4 Chromosomes

Michael White lectured in chromosome-cytology at University College, London, before moving to Melbourne in the 1950s. Like so many other lecturers, he wrote a text book to assist his students and others interested in this subject (White 1937). The first edition was a slim pocket-book devoted to basic explanations of mitosis and meiosis. By the time the 6th edition was published in 1973, it had grown considerably (White 1973a).

White was more interested in chromosomes than he was in genes, carefully describing their role during the various stages of mitosis and meiosis: leptotene, zygotene, pachytene, diplotene, prophase, metaphase, anaphase and telophase. He explained how some plants were able to sustain chromosomal deviations, such as polyploidy, which was impossible for sexually reproducing organisms, and also how some Orders, such as insects, had complicated reproductive mechanisms involving several x and y chromosomes, which enabled them to produce 'inter sexes' (White 1937). Mammalian reproduction was, by comparison, simple, involving only two sex chromosomes.

At meiosis, each chromosome (or chromatid as White called the haploid chromosome) was attached to a spindle fibre, which formed during metaphase. For successful reproduction, there had to be one fibre for each chromatid, no more, no less (White 1937: 13). Each chromatid had one centromere, no more, no less. The centromere might be towards the centre of the chromosome, in which case the chromatids would form a "V" shape when their centromeres attached to the spindle and migrated towards one pole. Other chromosomes had their centromeres more towards one end, in which case the chromatid formed a "J" shape (White 1937: 18). The centromeres of some chromosomes were previously thought to be terminal, but it was now realized that all chromosomes had some genetic material, however small the amount, on each side of the centromere (White 1937: 18). The position of the centromere was constant for each individual chromosome (White 1937: 18).

Mutations occurred when a piece of genetic material broke away from its chromosome, its ends being 'sticky' for a short time. It might reattach to its original chromosome but inverted, or change places with another piece of genetic material which had become loose from elsewhere. These changes had to take place before the 'sticky' ends sealed. Neither mitosis nor meiosis would be possible if there were extraneous 'sticky' ends which would cause the whole process to degenerate into a shambles (White 1937).

Of particular interest were the so-called microchromosomes, whose role was not clear. These were found in the *centre* of the spindle. There may be none, or their number may be less than, equal to or more than, the number of chromosomes and, therefore, of the number of centromeres and spindle fibres. Were they extra centromeres, which had somehow come into existence and which might be used at some future time to increase chromosome numbers, or were they discarded centromeres, the result of a reduction in chromosome numbers? (White 1937: 96-97). It is perhaps unfortunate that White's illustration (reproduced as Fig. 18.4) portrayed a nucleus with an equal number of centromeres and microchromosomes, since the text made clear that it was more usual for there to be considerably less microchromosomes than centromeres (White 1937: 17).

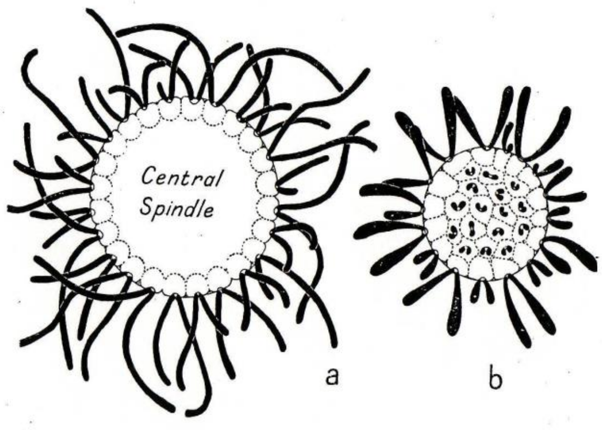

Fig.18.4: (a) Organism with 24 chromosomes attached to spindle fibres. (b) Organism with 16 attached chromosomes and 16 microchromosomes in centre of spindle.
(from White 1937: 16)

White placed great importance on the role of the centromere. When a chromosome was broken as the result of irradiation, the portion with the centromere attached to the spindle fibre, the remaining fragment being lost (White 1937: 18). Sometimes under irradiation, two chromosomes fused so as to form a compound chromosome (White 1937: 30). If the centromeres travelled to opposite poles, the chromatids were stretched and broken. If they travelled to the same pole, they might survive that phase of cell division, but at the next cell division, half would travel to opposite poles and become broken. After a few cell divisions, all would be broken: "such chromosomes stand no chance of becoming permanent" (White

1937: 30). 'Double' chromosomes had never been observed in natural cell division, only under irradiation. Successful cell reproduction (mitosis or meiosis) could only take place with chromosomes which contained but one centromere each.

White discussed at length the exchange of genetic material which took place at meiosis. Hybrids might be formed where the parent species had a different chromosome number or different chromosome sizes (White 1937: 74). Where the chromosome number of the parents of a hybrid species differed, one of the two haploid sets in the hybrid would contain more chromosomes than the other and the 'extra' chromosomes would necessarily be unable to pair at zygotene (White 1937: 74), making the zygote non-viable. Differing chromosome numbers clearly acted as an isolating mechanism, far more efficient than any form of 'sexual selection' envisaged by Darwin, but White was unable to explain how chromosome numbers had come to change in the first place.

18.5 Chromosomes and evolution

In the final chapter of his book, White considered the role chromosomes had/had not played in the process of evolution. White saw all gene mutations, such as inversions, translocations, etc., as being small structural alterations involving a mere rearrangement of genes on a small section of the chromosome, insufficient to cause macroevolution, which he concluded could only have come about as the result of changes in the chromosomes *per se* (White 1937: 89-90). Evolutionary change, such as polyploidy, was simple for non-sexually reproducing organisms, mostly plants, but was more difficult to explain in sexually reproducing organisms.

Yet it was clear from the differences in chromosome numbers which existed throughout nature that some mechanism must exist whereby chromosome numbers could be altered (White 1937: 94-95):

> It used to be supposed that two or more chromosomes could merely fuse together to form a single one, and alternatively that one chromosome could break into a number of pieces, each of which would behave in future as a separate chromosome … We now know, however, that each chromosome contains a single spindle attachment which is a self-perpetuating body; new spindle attachments only arise from pre-existing ones. Moreover, although spindle attachments divide longitudinally at mitosis, they do not appear to be transversely divisible. It is possible that in some cases V-shaped chromosomes have spindle attachments in the middle only separated by a very short interstitial region; in this case the two spindle attachments may be expected to function mechanically as a single unit … breakage of the interstitial region will give two chromosomes with quasi-terminal spindle attachments … Conversely two chromosomes with quasi-terminal spindle attachments may fuse together so as to give a V with two attachments in the middle. Any other kind of fusion will give a chromosome with two widely separated spindle attachments which will break at anaphase and any other kind of breakage will give rise to a fragment with no spindle attachment, which consequently cannot form an independent chromosome. Thus apart from these two special cases, it does not seem possible that 'fusion and fragmentation' have played any part in the evolution of new chromosome numbers.

White was suggesting that two centromeres from two separate chromosomes could combine so closely together that they *appeared* as if they were only one centromere but actually had a miniscule amount of interstitial material between them and that they could then separate again to form two separate centromeres/chromosomes. This had never been observed to happen, even under irradiation, but it was the only explanation which White could offer.

This hypothetical scenario was proposed by White in the case of *mitosis* (see line six of above quotation), applying to somatic, not germinal, cells. It was known that some species of *Drosophila* had somatic material with different chromosome numbers from that of their reproductive organs (White 1937: 97). Since somatic cells reproduced by mitosis, rather than meiosis, it was thought that somatic cells could be more amenable to mutation – as happened with other non-sexually reproducing organisms (White 1937: 99). What White did not explain was how such changes in somatic cells could be inherited, i.e. how this scenario could be extrapolated to *meiosis*. White further did not address the problem of how a sexually-reproducing organism which had achieved a change in the number of its chromosomes could find a mate.

White concluded that the primary origin of new species lay in some accident in the chromosome set, completely unconnected with natural selection, although natural selection was an important factor in the establishment of subsequent morphological change (White 1937: 106-107).

18.6 The position of Goldschmidt and White

Both Goldschmidt and White were clearly dissatisfied with natural selection's ability to explain change beyond the micro/variety level but both nevertheless continued to support natural selection as an important contributor to evolution. They were apparently content to await further developments rather than to attempt to propose any other solution.

Unlike their colleagues, Goldschmidt and White were well aware of discontinuities. It was the problem of how continuity was maintained within evolving (separating) species that most concerned them. Goldschmidt was the last major theorist to raise the possibility of macro-evolution. Neo-Darwinism postulated gradualism. It was accepted that only very small genetic mutations could be tolerated. Larger changes did not result in a viable zygote.

White continued to be a prominent contributor to genetic research into the 1970s and his later work will be considered in the next part of this thesis (see Chapter 24). No other theorist attempted to solve the problem of how change in chromosome numbers came about by natural selection.

The questions raised by Goldschmidt and White were ignored in the literature. By this means the subordinate text was silenced.

Chapter 19

Humans – Ancient and Modern

19.1 Introduction

While mathematicians and scientists were pondering the ramifications of evolutionary theory within the confines of their offices and laboratories, archæologists in England and France were quietly going about their work in the field, uncovering the history of human evolution through the study of fossil remains, which they were finding in increasing numbers. At this time, finds were being made in Europe and Asia. The finds of *Australopithecus* and *Homo erectus* in Africa came later.

19.2 Neanderthals

Once the reality that there had once existed a form of people quite different from those alive today had taken hold in the public imagination, far more care was taken by miners and other excavators, not only with the preservation of any skeletal remains or artefacts they uncovered, but in the noting, and where possible preserving, of the provenance of such finds. The discovery in 1907 of a jawbone in ancient gravel at Mauer, near Heidelberg, confirmed that there had once lived in Europe a people even more primitive than the Neanderthals (Boule 1923: 26). The term *Homo heidelbergensis* came to be used by some to refer to any pre-Neanderthal remains discovered in Europe, and sometimes also in Africa. None of the early writers, such as Boule (1923), Sollas (1924), Vallois (Boule and Vallois 1957) or Keith (1915, 1955), had any doubt that these ancient people were fully human. In 1864 King had created the nomenclature *Homo neanderthalensis* to indicate that archæologists were dealing with a species separate from *Homo sapiens*. He felt that, the skull being so simian, "the thoughts and desires which once dwelt within it never soared beyond those of the brute" (King 1864: 88). At that time, only the one skullcap had been identified, but as more remains were uncovered, together with beautifully worked stone tools, it became increasingly accepted that Neanderthals were fully human. They used fire and buried their dead, often with artefacts and/or food, such as joints of meat (Keith 1915: 117).

The man from La Chapelle-aux-Saints, as well as the people at La Ferrassie, had been buried feet facing west (Keith 1915; Sollas 1924: 253). The westward direction for burial continued into the Azilian (late Magdalenian) period (Sollas 1924: 610) and, indeed, into Celtic times. If the Neanderthal mind was already philosophizing about life and death, then "clearly … Neanderthal man does not represent the human dawn" (Keith 1915: 117). Burials were often protected by slabs of stone, a practice which persists in one form or another until the present. Of particular interest were the cup-hole marks in some of these stones, often presumed to have been associated with grave offerings, or some other ritual, although at La Ferrassie the cup-holes were on the underside of the stones. Early (Neanderthal) man was seen to have been a social being, with males bringing flesh food to the family group and with ceremonies accompanying his last journey to the grave (Sollas 1924: 203; Peake and Fleur 1927: 54).

19.3 Boule's reconstruction

Boule attempted to reconstruct the skeletal remains of 'The Old Man from La Chapelle', these being the most complete. Unfortunately, Boule failed to make allowance for the fact that this man had suffered from degenerative arthritis which had distorted, not only his limbs, but also the angle at which he held his head – something commonly seen in older people. The result of his reconstruction (see Fig. 19.1) was the portrayal of a person unable to stand fully erect. From this he concluded that the Neanderthals still retained many simian characteristics.

Fig.19.1. Reconstruction of the Neanderthal from La Chapelle aux Saints by Boule (1923: 225)

While conceding that Neanderthal brains were comparable to those of modern humans in regard to size, Boule claimed that the design of the convolutions of their brains indicated that they had only rudimentary intellectual faculties and language (Boule 1923: 235/236). Furthermore, the Mousterian stone tools associated with the Neanderthals were considered very primitive which argued against any superiority of the brain (Boule 1923: 228). In fact, the Mousterian tool kit was no more primitive than that of the Australian Aborigines, especially the Tasmanians. Sollas (1924: 128) believed that, were it not for the different stone from which they were made, it would be difficult to distinguish between Neanderthal and Tasmanian tools.

Sollas was far more cautious than Boule in his interpretation of Neanderthal features. He disputed the consistent portrayal of the Neanderthal jaw as prognathous, pointing out that the skull remains from Krapina and Gibraltar were as orthognathous as many white men, while many Australian Aborigines were as prognathous as were some of the Neanderthals (Sollas 1924: 234).

Boule acknowledged the rightful place of Neanderthals within the genus *Homo* (Boule 1923: 239), although he did believe that they were a distinct species (Boule 1923: 244). Nevertheless, he did not deny the possibility that some Neanderthal blood may have entered that of other human groups by way of hybridisation, although such infusion would have had very little overall effect (Boule 1923: 244). Interbreeding would not have been possible if the Neanderthals were a truly separate species, at least not beyond the first generation.

19.4 Age at death

Keith (1948) mentioned that Vallois had claimed only five per cent of Neanderthals had lived over the age of forty, but gave no evidence in support of this claim. Since *Sinanthropus (H. erectus) pekinensis* lived even earlier than *Neanderthalensis*, Keith assumed that the former lived no more than twenty years (Keith 1948). These assumptions are still affecting interpretations today.

Experts can only estimate the biological age of skeletal remains, not their chronological age (Hunter et al. 1996: 110). For an infant or child, the chronological age may usually be estimated with a fair degree of accuracy, based on the development of teeth and ossification of the bone, whether or not the epiphyses have fused, etc. With age, the cranial sutures ossify and these provide a further biological means for making a chronological estimate. Once tooth and bone development are complete and sutures closed, accurate aging becomes increasingly difficult (Hunter et al. 1996: 111).

Under-aged skeletal remains			Over-aged skeletal remains		
Sex	Actual Age	Years under-aged	Sex	Actual Age	Years over-aged
F	56	11.50	M	39	19.49
M	63	11.25	F	47	17.00
F	70	15.00	F	45	15.00
M	70	10.75	M	34	29.50
F	85	26.70	F	43	21.75
F	73	12.75	F	37	26.75
M	71	10.75	M	36	23.76
F	77	17.50	F	19	15.33
M	89	19.80	M	34	23.00
F	86	16.00	F	39	24.00
F	89	23.50	F	50	16.00
M	92	23.00	F	29	39.67
F	88	17.40	F	23	19.00
F	84	12.50	F	35	24.00
F	86	20.00	F	32	28.30
F	68	11.34	M	49	19.91
F	52	15.00	M	32	31.00
F	87	21.00	F	48	20.67
F	79	10.30	F	49	20.33
F	81	10.31	F	81	10.31
F	72	11.67			
F	75	14.67			
F	82	10.84			

Fig.19.2: Discrepancies in estimated age of skeletal remains from Spitalfields cemetery.
(from Molleson and Cox 1993)

When human remains in the Spitalfields Cemetery in London needed to be relocated due to road works, forensic scientists took the opportunity to conduct a study in which the age at death of the individuals was estimated and then compared with the information given on their coffin lid plates. Results showed a tendency to over-age the young and under-age the old (Molleson and Cox 1993; Hunter et al. 1996: 111) (see Fig.19.2).

Hunter et al. (1996) concluded that the theory that the majority of people died young in antiquity might not be true, since people age biologically at very different rates. By 'antiquity' Hunter et al. were referring to the last few hundred or thousand years. Nevertheless, their conclusions are equally true of the most ancient of remains.

Life expectancy during Mediæval times was low for town dwellers, due to overcrowding and poor hygiene. Today's increased longevity is as much due to improved hygiene as it is to improved medicine. The Neanderthals lived in small groups, ate fresh food and breathed clean air. There is no reason to suppose that their life expectancy was any less than ours, except as the result of direct trauma and trauma-induced infection.

19.5 The Tasmanians

All human beings alive today had ancestors walking this Earth in Pleistocene times, but not all people of Pleistocene times have descendants alive today. The question that increasingly occupied the minds of archæologists during the first part of the twentieth century was: to which of the human remains being unearthed could we claim relationship? How much could we learn from modern hunter/gatherer tribes about the possible life-styles of our ancestors and, more importantly, was it possible to glean evidence of direct descent from any Pleistocene people? Sollas (1924) believed that it was.

Sollas looked to the Tasmanians for the closest analogy to the life style of the Neanderthals, although he stressed that he did not postulate any direct blood link between the two (Sollas 1924: 132). If the way of life and stone tool technology of the Neanderthals was similar to that of the Tasmanians, there was no reason to suppose that the Neanderthals were any less human than the Tasmanians. The Tasmanians had certain physical characteristics that distinguished them from other groups of present-day humans but did not isolate them as a separate species (Sollas 1924: 120).

Sollas commented that rafts, presumably used to reach Australia, had not been preserved in the archæological record. There was no way of knowing whether Neanderthals had used any form of water craft. The fact that none had been preserved was not evidence that none had ever existed.

The Tasmanians made a 'wine' by fermenting juice they tapped from a particular gum tree *(Eucalyptus resinifera)* and the Bushmen of South Africa made forms of mead by crushing the bodies of honey ants, from honeycomb or by infusing honeysuckle flowers or the fruits of various trees (Sollas 1924: 282). We have no way of knowing whether the Neanderthals made any form of alcoholic beverage, although the fact than one, and possibly two, of the Neanderthal males from Shanidar suffered from diffuse idiopathic skeletal hyperostosis (DISH) (Crubézy and Trinkaus 1992) may indicate that they did. DISH is a skeletal disease associated with obesity/diabetes that develops in late middle age, rarely before fifty (Forestier and Lagier 1971; Ustinger 1985; Cassim et al. 1990; Crubézy 1990) and is frequently associated with 'high living' (Roberts and Manchester 1997). This evidence suggests that at least some Neanderthal populations lived well (Carrington-Smith 2004) and may even have made themselves some form of alcohol.

19.6 *Pithecanthropus*

Boule (1923) correctly identified the lower jaw bone found at Piltdown as that of an ape, which he believed had mistakenly been associated with the cranium found nearby. He was of the same opinion in relation to the skull found in Java in 1890, questioning whether the femur was necessarily from the same individual as the partial cranium, just because they were found in the same locality (Boule 1923: 104). Nevertheless, most people accepted that the Javan *Pithecanthropus* found by Dubois was a connecting link between the human and ape lines. Brain casts showed development of the area associated with speech, indicating that even at this early stage of human evolution, *Pithecanthropus* was capable of at least rudimentary speech.

19.7 *Sinanthropus pekinensis*

The discovery of *Sinanthropus pekinensis* at Chou K'ou Tien (Peking/Zoukoutien) will be covered in Chapter 21. These discoveries came too late to be included by Boule in his major work but were recognised by evolutionary theorists of this time as having predated the Neanderthals, as had *Pithecanthropus*. Vallois (Boule and Vallois 1957: 144), when he updated Boule's work, recognized *Sinanthropus pekinensis* as having been fully human since he had kindled fire, made hearths and had a stone and bone tool industry.

Inasmuch as *Sinanthropus pekinensis* also walked erect, it became clear that, if Boule's reconstruction of the La Chapelle-aux-Saints skeleton was correct and Neanderthals did not walk fully erect, then they must have been a degenerate species. This view became less and less popular, but was still supported by Vallois (Boule and Vallois 1957) inasmuch as that he did not edit or amend that part of Boule's original work. *Pithecanthropus* and *Sinanthropus pekinensis* both later became known as *Homo erectus.*

19.8 Broken Hill

The discovery in 1921 at Broken Hill, Rhodesia of what appeared to be the remains of an ancient human, which post-dated *Homo erectus*, was the first to be made in Africa and deepened the problem of human evolution, rather than providing any solution. The skull was seen as bearing a degree of similarity with that of the Neanderthals, but was believed to be of a later date because this person, named *Homo rhodesiensis,* walked upright (Boule 1923: 482). Boule believed that the Neanderthals, *H. rhodesiensis* and the Australian Aborigines had a common origin, the Australian Aborigines being their final representatives (Boule 1923: 484-485). Boule did not say that either *H. rhodesiensis* or the Australian Aborigines were descendants of the Neanderthals, merely that they had a common ancestor.

19.9 Modern humans

Although the precise place of ancient humans within the human genealogy was a matter for debate, all writers during the first half of the twentieth century agreed that the skeletal remains found at Cro-Magnon in 1868 were representative of modern humans. The four skeletons were described by Keith (1915: 54) as tall and lanky, their average height of almost 6 ft. (180 cm.) being greater than the average height of Europeans even today and certainly more than that of Europeans during the Middle Ages. The tallest of the Cro-Magnons was estimated to have been 6 ft. 4 ins. (191 cm.) (Sollas 1924: 446). Keith (1915: 67) suggested that they resembled people from the Punjab, or possibly Africa, since there were similarities with Negroid races, such as limb proportions. Their fingers were short compared with the overall size of the hand (Sollas 1924: 448).

A number of skeletal remains were found in the Grotte des Enfants at the Grimaldi Caves, north-west Italy. Some were of the Cro-Magnon type, but at a deeper level remains were found of two people of considerably shorter stature, about 5 ft. (152 cm.). Boule and Sollas both believed that these people were also Negroid, there being two races of modern humans in Europe during Aurignacian times, both with some Negroid affinity (Boule 1923: 285 and 312; Sollas 1924: 453). Evidence for the existence of these smaller people was also seen in small hand prints in the caves at Gargas (Sollas 1924: 453). On the floor of one of the chambers in the Tuc d'Audoubert Cave imprints had been preserved of small human feet (Sollas 1924: 396-397). Notwithstanding the difference in size, Keith saw the Grimaldi people as members of the same race as the Cro-Magnon people (Keith 1915: 67) and this is the opinion generally held today.

As late as 1948, Keith, still reliant upon relative dating techniques, assumed that the Cro-Magnon people had replaced the Neanderthals "quite suddenly, some 100,000 years ago" (Keith 1948: 263). From where had the Cro-Magnon people come? This mystery seemed to be solved when an expedition during the early 1930s discovered the remains of ten people at

Mount Carmel, Palestine, which appeared to be transitional between the Neanderthals and Cro-Magnon. This led Keith to suggest that "if all turns out as we anticipate we may claim that the Caucasians of S.W.Asia still occupy the original area of their evolution" (Keith 1948: 263). The Garden of Eden, if not intact, was still in place!

Boule, conversely, claimed that the Neanderthals could not be the ancestors of *Homo sapiens* since both species were contemporary (Boule 1923: 243). It is difficult to see how one species could give rise to the other *unless* they were contemporary, at least for a short period of time.

19.10 The reindeer people

By the Late Pleistocene, mammoth had generally been replaced in Europe by reindeer. Human dependence on reindeer was such that it led Boule and Sollas to suggest that, as the ice retreated and the reindeer moved north, so, too, did people, eventually following the reindeer into the arctic regions and, possibly, across the Bering Strait and the Aleutian Islands into Canada and other parts of the Americas (Boule 1923: 295; Sollas 1924: 594-600).

Sollas suggested there was a genealogical connection between the Eskimo (Inuit) and the Magdelanian people (Sollas 1924: 583-594). The Eskimo made great use of seal intestines, stretching and drying them, then cutting them into strips which, when sewn together, made extremely lightweight and water-proof overalls. Other pieces were used to make windows (Sollas 1924: 578). These uses serve as a timely reminder that the artefacts which survive in the archæological record need, by no means, be all that were produced.

19.11 Position in the field

The position within the field was confused. The Neanderthals were accepted, if not as the ancestors of modern humans, as a 'race' or 'variety', rather than as a distinct evolutionary line. Indeed, the human race/species was seen to have come into existence with the appearance of *Homo erectus*, there having been no speciation event since that time. Some confusion was introduced by the practice of allocating new names to new finds. The term *Homo* refers to the genus, not the species. Terms such as *heidelbergensis, rhodesiensis* and *neanderthalensis* imply speciation, although the various texts appear to accept all as human.

While scientists within the laboratory were seeking differences, but not always finding them, in the field archæologists were finding differences which they were endeavouring to interpret as similarities. This was to change in the second half of the 20th century.

Part IV

IMPLICATIONS

Towards 2000
All roads lead to Darwin

Chapter 20

The Evolving 'Synthesis'

20.1 Synthesising again

During the darkest days of World War II Huxley (J. Huxley 1942) published his book, *The Modern Synthesis*. It contained no new work but brought together that of previous theorists in such a way that the *'Evolutionary Synthesis'* became accepted as the dominant paradigm.

Many of the major proponents of the evolutionary synthesis continued to be active participants in evolutionary discussion well into the post-war years. Particularly prominent were Dobzhansky (1951, 1959, 1962, 1967, 1970) and Mayr (1963, 1972, 1976, 1977, 1982, 1991, 2001; Mayr and Provine 1980). They were ably supported by writers such as de Beer (1958), Haldane (1951, 1954), Levins and Lewontin (1985), Maynard-Smith (1958, 1982, 1984, 1987, 1989) and Simpson (1950, 1953). It was not just the number of books that increased, but their size. Mayr's (1982) *Growth of Evolutionary Thought* ran to 858 pages of text. New authors, such as Stringer (1985, 1988, 1994, 1996), Tattersall (1998, 1999, 2002), and Trinkaus (1983a, 1983b, 1985; Trinkaus and Smith 1985) made their contributions, but the evolutionary synthesis having been established, they concentrated on other issues, such as the status of Neanderthals. The last of the major books (to date) on the evolutionary synthesis, *The Structure of Evolutionary Theory,* was written by Gould (2002) and exceeded 1100 pages.

20.2 Quantity, not quality

Despite the plethora of words, little that was new was added to the debate. Writers sought to reinforce opinions already voiced by the addition of more and more examples. There was ongoing work on the genetics of quickly breeding laboratory populations, mostly insects and rats. Debate as to how exactly diversification had occurred (sympatric *v* allopatric) continued, but the examples given tended to be very repetitive: gill arches to jaws to ear bones; reduction in the number of horses' toes; swim bladders to lungs, although Mayr

(1976: 99) pointed out that early fish had primitive lungs, which were converted into swim bladders, not the other way around.

Sympatric *v* allopatric speciation was not the only source of confusion in relation to diversification (Dobzhansky 1962: 5):

> To make Darwin's theory as shocking as possible the proposition "man and apes have descended from common ancestors" was garbled into "man has descended from the apes". This, of course, is obvious nonsense, since man's remote ancestors could not have descended from animals which are our contemporaries.

Versions of this statement are common throughout the literature and it is they, not the so-called 'garbled' version, which are 'obvious nonsense'. It matters not whether the human line diverged directly from the ape line, or whether humans and apes both diverged from a common ancestor. The divergent form must have been contemporaneous with the original form. To postulate an hypothetical common ancestor, thus moving divergence one step back, may be psychologically satisfying, but is not scientifically necessary and only goes to prove the resistance there is in the human mind (as much today as in Victorian times) to the notion of the *direct* descent of humans from apes. No line can diverge from an extinct ancestor. The statement by Zimmer (2001: 324) that "The many whales with legs that palaeontologists have now uncovered are probably ancient cousins of today's whales rather than direct ancestors" is a further example of similar thinking.

Where one form *changed into* another form, contemporaneous existence could be for only a short period of time, but where *diversification* occurred, i.e. a genetic mutation led to the establishment of a distinct variety/species, then there was no reason why the two varieties/species should not continue to co-exist, and diversify independently, especially if the parent population were geographically and/or numerically large (Eldredge and Gould 1972).

20.3 Macroevolution

The writings of Goldschmidt (1940) (see Chapter 19) were the last serious attempt to establish macro/mega evolution as separate events. The knowledge that the genetic alphabet contained a mere four letters and that these letters could be repeated in endless combinations, gave the proponents of the evolutionary synthesis all the means they believed they needed to account for evolution. Now that it was known that DNA could replicate itself, as well as rearrange itself by means of inversions, translocations, etc., the genetic 'alphabet' was seen as capable, not only of remodelling a pre-existing part, but of initiating something totally new, purely by chance. Thus macroevolution no longer needed explaining. In response to the self-imposed question: "Is a New Evolutionary Synthesis necessary?", Stebbins and Ayala (1981) answered "No" on the grounds that the only way change was possible was through mutation, which was a gradual process involving small changes. Small changes (microevolution), as postulated by the evolutionary synthesis, were all that was possible and the evolutionary synthesis was all that was needed to explain all evolutionary change.

Some authors, it must be said, dealt with this matter in a less than forthright manner. Haldane (1954: 1) opened his book, *The Biochemistry of Genetics*, by expressing the opinion that:

> Genetics is concerned with differences between similar organisms, and mainly with those differences which are not due to causes acting during the lifetime of the organisms concerned. This distinction works fairly well for higher organisms, but breaks down completely for unicellular organisms. If a cell can divide once an hour, but takes a day to adapt itself to ferment a type of sugar to which it is unaccustomed, a growing population can only adapt if the adaptation (and even the beginning of the adaptive process) is inherited.

Having made this statement, Haldane (1954) concentrated thereafter on higher organisms, despite the fact that by volume, unicellular life exceeds that of multicellular by several orders of magnitude. To admit that the one behaves differently from the other, and then to extrapolate from the one to the other, is not clear thinking.

Major changes, such as the appearance of the first feather, may have been cited at the beginning of a discussion, but later concrete examples examined in some (but not much!) detail, tended to concentrate on structures which could readily be imagined as having resulted from microevolution, such as the size of horses' teeth or the reduction in the number and size of their toes. Mayr (1982: 611) delighted in pointing out that eyes cannot have been very difficult for natural selection to produce since they had appeared at least forty times in separate lines of evolution. Whether this makes their appearance 1/40th as wonderful or 40X's as wonderful depends upon one's point of view.

Feathers were said to have first appeared as a form of insulation, but this 'explanation' merely moved the problem back one stage and invoked teleology, which was not permitted, since it presumed preplanning. It did nothing to explain why a feather should appear instead of (more) hair/fur. Cold blooded animals have neither fur nor feathers, nor fat for that matter. Indeed, since they draw their warmth directly from the sun, it is important for them to have no barrier between their blood supply and their source of heat. There was no reason for a cold-blooded reptile to develop fur/fat/feathers and yet no explanation is offered as to how the first warm-blooded creatures survived before these life-saving 'aids' appeared. Indeed, how did a cold-blood creature evolve into a warm-blooded one at all?

Surprisingly, no author questioned the first appearance of hair. To this day, there are many worms and grubs which are completely hairless. Why did a smooth skinned 'grub' first sprout a hair? Warmth or sensitivity to touch cannot be the *reason*, unless teleology is accepted, yet nowhere in the literature is this problem addressed. Did a single 'hair' develop or did many hairs appear all at once in that first hairy 'grub'? How did the hair grow and penetrate the skin without the assistance of a hair follicle? No hair follicle could have developed and been 'selected' by nature before there was any hair useful enough to be 'selected'. The presence of at least some hair/fur on land mammals is tacitly accepted yet its first appearance invites as many questions as does the appearance of the first feather.

Nowhere in the literature was a satisfactory explanation offered for the initial evolution of butterflies and moths, although Wallace did address the issue (see Chapter 9). Countless 'grubs' reproduce in their 'worm' state, yet a few, such as butterflies, moths, cicadas, etc., transform into totally new forms. This physiologically expensive process is particularly hard to understand in the case of those butterflies which exist in the imago form for only a few hours, long enough to mate but not long enough to need to feed. Issues of polymorphism, of mimicry, are discussed, but not the process of transformation itself, which is far harder to imagine happening by the gradual process of natural selection.

20.4 Highest esteem

If the second half of the twentieth century did little by way of adding new information to support the evolutionary synthesis, it compensated by way of adding stature to Darwin's image. The year 1959 marked the centenary of the publication of *On the Origin of Species* and it was to be expected that this anniversary would be marked by publications eulogizing Darwin's work. The eulogising never stopped. By the turn of the century, Darwin had been elevated almost into a cult figure (for example Dawkins 2006, Dennett 1995, Ruse 2006, Zimmer 2001). Anything which Darwin had said which was seen to have been vindicated by modern science was held up as a great insight, a piece of inspired wisdom, even if it was not original to Darwin, such as the concept of evolution itself. Dennett (1995: 21) wrote: "He [Darwin] would discover the single most important idea in the history of biology", placing Darwin's insights above those of Mendel. Anything that Darwin said which, with hindsight, appeared less than satisfactory, was not mentioned. Darwin's theory of *Pangenesis*, based as it was on the acceptance of the inheritance of acquired characteristics, was either ignored, or attributed to an aberration of old age.

Zimmer (2001: 211) entitled his chapter on disease in the age of evolutionary medicine "Doctor Darwin", as if Darwin himself were in some way responsible for our understanding of the evolution of bacteria in response to modern medicines, such as antibiotics. A pride of lions was offered as an example of "Darwinian family life" (Zimmer 2001: 246). Hardly an aspect of life could not be identified in some way with the *Darwinian* revolution. Dennett (1995: 21) went further:

> If I were to give an award for the single best idea anyone has ever had, I'd give it to Darwin, ahead of Newton and Einstein and everyone else. In a single stroke, the idea of

> evolution by natural selection unifies the realm of life, meaning and purpose with the realm of space and time, cause and effect, mechanism and physical law.

20.5 Establishing position

From the above preview of Part IV of this thesis, it will be seen that the basic tenet of gradual evolution had become so firmly established that it remained unchallenged within the scientific community. When challenge came, it came from a religious/philosophical perspective that was to re-ignite the debate regarding Creationism (see Chapter 27). The following chapters look, not only at how understanding of the evolutionary process changed and adapted during the second half of the 20th century in response to new scientific information provided by radiometric dating and genetic research, but at how Neo-Darwinism became overtly atheistic, rather than ideologically neutral. By the end of the 20th century, the early 19th century paradigm of attributing everything to the province of some 'Divine Creator' or 'Supreme Being' would be completely reversed. Any mention of such a 'Being' became anathema.

Chapter 21

The Mystery of the East

21.1 *Homo erectus*

Even without the benefit of radiometric dating, which was introduced in the second half of the 20th century, the period now being considered, it had always been understood and accepted that the Neanderthal people predated modern humans (i.e. the Cro-Magnon people) in Europe, but not by much. The exact relationship was debated: were the Neanderthals our direct ancestors or were we both descended from a common ancestor? Whatever the answer, the Neanderthals were accepted as our immediate predecessors in Europe.

The same certainty did not exist with *Homo erectus*, initially known as *Pithecanthropus* from Trinil and Solo in Java, South East Asia, and *Sinanthropus pekinensis* from the region of Peking (Chou K'ou Tien/Zhoukoudian), China. The evidence as to the age and place in human history of 'Peking Man' was deliberately manipulated by its finders to obtain political advantage. This incident illustrates how enthusiasm may outweigh integrity, even among scientists. The story began in the first half of the 20th century, but its consideration has been held back until this part of the thesis because its sequel took place in the 1980s and shows that, even at that time, whether for political or personal reasons, the desire to promote and/or maintain a particular position may dominate and control the reporting of evidence.

21.2 *Sinanthropus pekinensis*

In 1914, Johan Gunnar Andersson, a Swedish geologist, was employed by the Chinese Government as a surveyor. He was intensely interested in the fossil record of the earliest forms of plant and animal life, but not initially interested in human fossils. Peking was surrounded to the north and west by mountainous regions which were virtually inaccessible. When he had time, Andersson liked to spend days exploring these unknown regions, knowing that he and his companions were probably the first Europeans ever to set foot there. A local man told him that there were 'dragon bones' at a site nearby and Andersson and his colleagues went to excavate the abandoned quarry at Chou K'ou Tien. They were soon rewarded with bones of pig, hedgehog, beaver, bear and many other species.

While at Chou K'ou Tien, Andersson noticed a narrow vein of quartz and it occurred to him that had Early Man ever lived at Chou K'ou Tien, such quartz would have made useful tools (Andersson 1934: 101):

> This was the train of thought which led me … to knock on the wall of the cave deposits and say: "I have a feeling that there lie here the remains of one of our ancestors and it is only a question of your finding him. Take your time and stick to it till the cave is emptied if need be.

The Crown Prince of Sweden was a keen amateur archæologist and included Peking in his World Tour of 1926. Andersson was entrusted with the task of arranging the archæological and art presentations. He was delighted to learn from one of the excavators, Zdansky, that the molar and pre-molar tooth of a creature resembling a human being had been found (Andersson 1934: 103):

> He had dug out the molar himself and identified it … as belonging to an anthropoid ape … *So the hominid expected by me was found.* [Italics in original]

The scientific meeting before the Prince commenced with a talk on Chinese history, which was followed by a presentation by the Jesuit priest, Teilhard de Chardin, who was also working as an amateur archæologist in the area. Andersson gave the final address and, after talking about finds of fossil animals, showed a lantern slide of the 'hominid' teeth discovered by Zdansky. As a result of this unexpected revelation, Andersson was able to obtain funding from a number of organisations, including the Rockefeller Institute, for excavations to continue, to uncover further information about 'Peking Man'. Teilhard wrote to Andersson that the assumption that the teeth were human was premature (Andersson 1934: 104-105). The teeth were very large by human standards (von Koenigswald 1956: 44-45).

The next year (1927), a third tooth was found. Davidson Black, in charge of the excavations, named the hominid from which these three teeth had come *Sinanthropus pekinensis* (Andersson 1934: 108). The following year, 1928, saw further finds – more than a score of teeth, and parts of skulls of both young and adult individuals which, unfortunately, were so embedded in the limestone that they could not be closely examined (Andersson 1934: 109). The skulls from the Upper Cave were later determined to date from the Upper Pleistocene and not to be directly related to the finds from the Lower Caves, which were of an earlier date. Two fragments of jaw were found and, most importantly, a cranium that Andersson assumed to be approximately contemporaneous with the remains from Trinil (Andersson 1934: 111). In 1932, another skull part was found as well as two fragments.

Excavations were interrupted by the Japanese invasion of China, followed by World War II. Up until the time of the writing of his account, Andersson (1934: 122) listed the following finds as having been made at Chou K'ou Tien: a number of teeth, several jaws, two complete and several fragmentary skulls. Like the teeth, some of the lower jaws were large, although others were of a more moderate size. Since all the cranial fragments appeared to be the remains of one type of hominid only, it was assumed that there was a pronounced degree of sexual dimorphism among these early Peking people, similar to that found in gorillas (von Koenigswald 1956: 51). At this time, these remains were thought to be up to a million years old and represented the first divergence of the human line from apes, so such dimorphism was not unexpected.

The lack of skeletal remains other than teeth and cranium led to the suggestion that *Sinanthropus pekinensis* had been cannibalised. The missing remains were presumed to have been hunted and eaten by other *Sinanthropus pekinensis.* Neither Andersson, nor Weidenreich (who took over after the sudden death of Black), suggested that the base of the skulls had been broken in such a way as to extract brain tissue. This suggestion appeared in many later works, for example von Koenigswald (1956: 50-51) and Birdsell (1975: 305).

A few other skeletal remains were found: a collar bone and an *os lunatum* from the wrist of *Sinanthropus pekinensis*, resembling more closely the *os lunatum* of a modern human than that of a modern ape and four phalanges from a *Sinanthropus pekinensis* foot, one of which was believed to be the top joint of the big toe (Andersson 1934: 125). These phalanges were different from those of a modern human, causing Black to suggest that the foot of *Sinanthropus pekinensis* deviated more from that of a modern human than did the hand (Andersson 1934: 126). Weidenreich (1940) attributed the remains to about forty individuals. Von Koenigswald (1956: 49-50) suggested that this was an 'exaggeration', since many of these supposed 'individuals' were represented only by a few teeth, there being evidence at most for only about a dozen skulls and jaws.

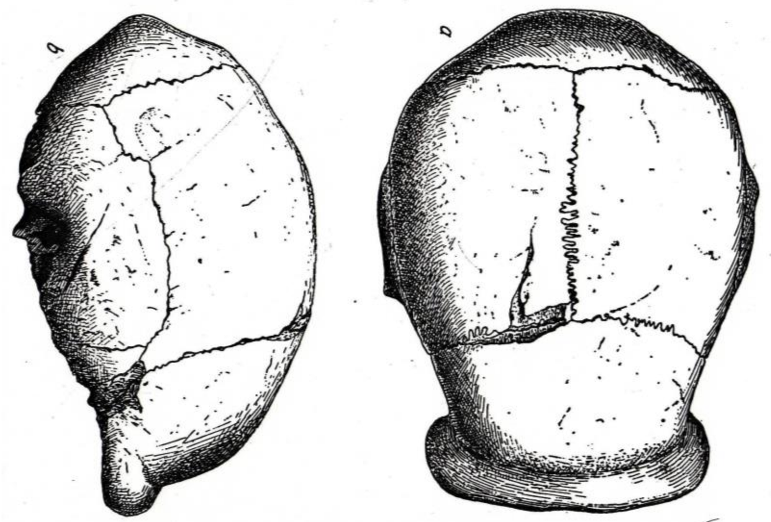

Fig.21.1: *Sinanthropus pekinensis* skull
(from Andersson 1934: 117)

Vallois saw both *Pithecanthropus* and *Sinanthropus pekinensis* as being so closely related that he suggested the Chou K'ou Tien fossils be renamed *Pithecanthropus pekinensis* (Boule and Vallois 1957: 142). Von Koenigswald (1956: 46) noted that the continuous bony supra-orbital ridge found in *Sinanthropus pekinensis* (see Fig.21.1) was only seen among anthropoid apes, and Coon's (1962: 437-458) analysis of the *Sinanthropus pekinensis* remains led him to the conclusion that *Sinanthropus pekinensis* was more ape-like than *Pithecanthropus*. He cited a number of features, including large teeth, bowed legs, anomalous toe bones and the skull with its continuous brow ridge in support of his contention.

Andersson's determination to find early human remains at the Chou K'ou Tien cave led him to make a hasty (and inaccurate) evaluation of the find of the original tooth. Whether funding for further excavation would have been forthcoming had the tooth been shown to be that of an ancient ape, it is not now possible to say. Having received funding to excavate for early human remains, and spurred on by his own conviction that these would be forthcoming, Andersson, his colleagues and later teams, continued to interpret much of the evidence uncovered according to their original ideas.

21.3 New dates, new conclusions

While the earliest Australopithecine finds in Africa during the 1930s, such as the 'Taung child', had been controversial, both as to date and nomenclature, continuing finds after the war, and the advent of radiometric dating, firmly established Africa, not Asia, as the place from which the hominine line had originated. The earliest known *H. erectus* fossil from Africa, KNM-ER 3733 from Koobi Fora, was dated to 1.7 mya. This extended the range of *H.erectus* in Africa to a possible two million years (Swisher et al. 1994).

In 1936, the well preserved skull of a juvenile had been discovered at Mojokerto on the banks of the Brantas River, not far from the Solo River, in Java. Two specimens of a species named *Meganthropus* were found in the late 1970s at Sangiran, further up the Solo River. Radiometric dating gave a surprising age of ~1.8 mya for the Mojokerto calvaria and ~1.6 mya for *Meganthropus* (Swisher et al. 1994). The original find from Trinil was believed to be approximately one million years old. The earliest Asian fossil remains appeared to be older than the earliest African remains, but lack of an intermediate group, such as an Asian *Australopithecine*, precluded any suggestion of *H. erectus* having originated in Asia. *H. erectus* must have evolved in Africa from *Australopithecus* somewhat earlier than had previously been thought if they had migrated to S.E. Asia by 1.8 mya.

21.4 Re-evaluation

In 1983 Wu and Lin published the results of a five year comprehensive investigation of the Zhoukoudian (Chou K'ou Tien) site by more than 125 Chinese scientists. They claimed that up to the year 1966, the fossil remains of more than 40 males and females had been found, along with tens of thousands of stone artefacts. Their investigations had led to the oldest fossils from the tenth layer being dated to 460,000 BP, less than half the age previously believed. The eighth and ninth layers were dated to 420,000 ya, the seventh to 370,000-400,000 ya and the three topmost layers to 230,000 ya (Wu and Lin 1983). These dates place the earliest occupation at Zhoukoudian nearly 1.5 million years *after* the earliest finds in Java and half-a-million years later than *Pithecanthropus* from Trinil. The upper layers (not to be confused with the Upper Cave whose remains were Upper Pleistocene) were dated closer to the end of the time of *H. erectus* than the beginning, as had previously been thought. Zhoukoudian became of interest now, not because it was the home of one of the earliest members of the *H. erectus* species, but one of the latest.

21.5 A fresh examination

Following Wu and Lin's (1983) publication of the radiometric dates for Peking Man, Binford and Ho (1985) made a lengthy re-evaluation of the taphonomy of Zhoukoudian. They disputed the assumption that all the animal bones found at the site were the result of butchering by hominids, believing that much, if not most, of the skeletal remains had been brought to the cave by other carnivores, or washed into the cave after having been killed elsewhere. They questioned whether some of the 'cut' marks on some of the pieces of bone might not be gnaw marks? They suggested that 'burned' bones had become darkened by mineral staining, not burning. They questioned whether there had, in fact, been any fires at Zhoukoudian, whether the 'ash' was not organic detritus, an accumulation of guana left over the millennia by raptorial birds? They pointed out that the 'ash' was some six to seven *metres* thick, extremely thick to have been the remains of hearths. And if hearths, where were the remains of the meals? The only bones found in the 'ash' were those of fossil pellets ejected by the raptorial birds after their meal.

Binford and Ho (1985) believed that of all the bucketfuls of quartz pieces removed from the site, only a small number gave proof of having been worked. They did not deny that there were some stone tools; they merely asserted that most of the quartz pieces had been fractured naturally. Binford and Ho (1985) did not openly dispute the claim by Weidenreich (1949) that Zhoukoudian contained the remains of some 40-45 individuals, but they did make certain comments which clearly showed that they were not happy with the numbers given. They identified the location of the skulls, or skull fragments, which had been found, numbering them up to XIII. Most of the rest of the finds were loose teeth, with occasional fragments of mandibular, wrist or collar bones. They listed the finds from Locus B, which represented 25% of all hominid remains recovered from the site, as being (Binford and Ho 1985: 421):

Teeth:	39
Mandibular fragments	5
Skull	1
Humerus fragment	1
Lunate fragment	1

Following the publication of this paper, Binford visited China for two months, during which time he was able to spend four days examining the Zhoukoudian material (Binford and Stone 1986). The original hominid finds had been lost at the time of the Japanese invasion but Binford had expected to be able to access most of the other fossil fauna. He was surprised that the material available was far less than had been reported. For example, fossil material corresponding to 2,000 animals of the cervid species *Megaloceros* had been reported but only 501 fragments were available and only 333 specimens of *Pseudaxis grayi* were available against 1000 claimed (Binford and Stone 1986: 454). Since Binford had been told that all bones had been made available to him for study, he asked to see the original records but only records from 1935-1938 were available and these he was shown but briefly (Binford and Stone 1986: 454).

Examination confirmed Binford's earlier suspicions that most of the bones previously reported as having been burnt were, in fact, mineral stained. Eleven bones appeared to have been burnt after they had become dry and degreased and had probably been lying on the surface when a fire passed over them (Binford and Stone 1986: 460). Seven specimens, all upper teeth, showed evidence of fresh burning, coming from upper deposits (Levels 3-4). Binford examined the 'ash' and confirmed to himself that it was actually organic material. He was to be allowed to take a sample for analysis in the States, but the sample was reappropriated (Binford and Stone 1986: 467).

As a result of his visit, Binford concluded that the amount of material recovered from Zhoukoudian had been exaggerated, the number of stone tools had been exaggerated (although some did exist), the amount of burnt bone had been exaggerated (although a few such pieces did exist, although not burnt when fresh) and the 'ash' was actually guana detritus. That the caves had been inhabited by early humans was not disputed, but Zhoukoudian was not the rich source of information about the earliest hominids which had originally been thought.

21.6 Chinese checkers

Possibly in response to Binford and Stone's (1986) article, Jia and Huang (1990) retold "*The Story of the Peking Man*", giving their book the subtitle "*From Archæology to Mystery*".

The book recounted the early excavations very much as it had been told by Andersson (1934) but went on to tell the history of the later excavations from the mid 1930s until the 1980s. Jia and Huang (1990: 49) related how, during the first season of digging in 1927, 3000 cubic metres of material was excavated, which resulted in 500 crates of animal fossils. This material also included one 'human' tooth (Jia and Huang 1990: 27), the tooth which Teilhard had disputed. They repeated the claim that the quartz fragments found at the site were tools (Jia and Huang 1990: 7): "Each day during the operation in 1931, large basketfuls of stone artefacts were delivered twice daily to Jia Lanpo at site headquarters". They reiterated the presence of layers of ash and scorched bone (Jia and Huang 1990: 74), continuing to believe that the large numbers of animal remains found at the caves were the result of human predation.

Also restated was the belief that the paucity of post-cranial human remains indicated cannibalism (Jia and Huang 1990: 196). The remains, although fragmentary, were seen as representing "upwards of forty persons" and to "top" all other sites in the world in the abundance of stone artefacts and traces of the use of fire (Jia and Huang 1990: 195). They cited traces of fire at Locality 13 as "the earliest known use of fire on record" (Jia and Huang 1990: 195), yet Locality 13, dated to 600,000 to 700,000 BP contained no human remains. The earliest date given by Wu and Lin (1983) for hominid remains at Zhoukoudian was 460,000 BP, although Jia and Huang (1990: 195) stretched this time to 500,000 BP.

No mention was made by Jia and Huang (1990) of any of the African finds of *Homo erectus* or of *Australopithecus*. Chinese readers, dependent upon this book for their information, might believe that Zhoukoudian was almost the only known home of *Homo erectus*, except for *Pithecanthropus,* which Jia and Huang (1990) claimed to be morphologically similar to Peking Man, ignoring recent dating which showed that the fossils were separated by about half a million years.

21.7 Political position

At the time that Jia and Huang were writing, China was still under the influence of Chairman Mao, and still pursuing a very isolationist path. It is to be hoped that the spirit of international engagement and co-operation which the Chinese authorities are currently exhibiting will allow the whole "mystery" of *H. (erectus) sinanthropus* to be re-evaluated in a scientifically neutral manner.

As was pointed out at the end of Part III of this thesis, while scientists in the laboratory were increasingly seeking out differences, however small, archæologists in the field were still looking for similarities, for evidence of continuity of form. The saga of 'Peking Man' demonstrates an over-enthusiasm in this respect, such that teeth and crania evidencing clear dissimilarities were nevertheless interpreted as portraying species similarity in order to support that which was perceived to be a desirable position

Chapter 22

How Human Were the Neanderthals?

22.1 The ongoing debate

Increasing numbers of fossil finds showed that the Neanderthals had lived in Europe alongside our Cro-Magnon ancestors for thousands of years as a distinct population. The question became whether they were the same species as us or had they diverged at some point in time to form a completely new species? This was the first time that the humanity of the Neanderthals had been brought into question and occurred at the same time as Binford was questioning the relationship of Asian finds, as outlined in the last chapter. Early (>500,000 ya) European fossils, with their surprisingly 'modern' features, known as archaic *Homo sapiens*, gave credence to the concept of divergent descent from a common ancestor.

22.2 Riding high

While some fossil Neanderthal remains seemed to be of people who had been buried accidentally by rock falls, for example Shanidar I, II and III, the body of Shanidar IV from Iraq appeared to have been placed in a 'crypt' scooped out among the rocks in the cave and then covered with earth (Solecki 1971: 238). Others seemed to have been deliberately buried, such as at La Ferrassie, Le Moustier and La Chapelle. The Neanderthals were the first people to practise intentional burial (Birdsell 1975: 325; Wolpoff and Caspari 1997: 99). Furthermore, at least one grave at Shanidar contained pollen from eight different species of Spring flowers, the pattern of the pollen grains being consistent with careful placement rather than indicating that they had been blown into the cave by the wind (Solecki 1971: 245-247).

The presence of red ochre, tools and bones in the graves, was seen by some as indicative of philosophical/religious thought. Others considered that the practice of burial might have been merely an hygienic measure, copied from 'modern' *H. sapiens* in the Levant, and the apparent grave goods merely backfill (McBrearty and Brooks 2000: 519-520). Digging a grave takes time and effort, even in cultivated soil with the aid of a metal spade or shovel. It must have taken considerably more time and effort when carried out in uncultivated soil with the aid only of stone, or possibly bone, implements. Why the Neanderthals forsook the simple method of disposal of the dead by abandonment to predators in favour of this time and labour expensive method is unknown, but it was generally accepted that this was evidence of human thinking.

The remains of Shanidar I were of a male who had suffered serious injuries, possibly quite early in life, including the loss of an eye and the lower half of his right arm (Solecki 1971; Trinkaus 1983a). Despite his injuries, which would have been disfiguring and disabling, Shanidar 1 must have been accepted as a member of his community, since he lived to an old age, leading Solecki to conclude that the Neanderthals were of a compassionate and caring nature. Solecki called the Shanidar Neanderthals "The First Flower People" (Solecki 1971). Never before or since have the Neanderthals been so highly regarded.

With evaluations such as Solecki's, it was becoming increasingly difficult to differentiate between the Neanderthals and modern humans. In every detectable respect, *H. sapiens* >40,000 BP and their Neanderthal contemporaries, were indistinguishable (Stringer and Grün 1991; Klein 1998; Speth and Tchernov 1998). At one time, it was thought that the European Châtelperronian tool industry heralded the arrival in Europe of a population with superior lithic skills, but as Neanderthal remains started to be found in association with Châtelperronian tool sites, it was acknowledged that these tools, together with the beads and other ivory objects associated with them, were part of the Neanderthal culture and exclusive to them (Harrold 1983: 127; d'Errico et al 1998: S2). Reynolds (1990: 272-273) concluded that much of the perceived difference between the Mousterian/Châtelperronian and Aurignacian complexes was one of classification which gave an impression of increased complexity and innovation that was not sustainable. Reynolds (1990: 273) suggested that the Neanderthals were associated with the process of change itself and that the Middle-Upper Palæolithic transition may have been a Neanderthal phenomenon.

No fossil remains had been found in association with Aurignacian tools. Indeed, no adult fossil cranial remains were known from the early Aurignacian period in Western Europe (Wolpoff 1989b: 102). The famous Cro-Magnon remains were not only the first found (1868), but are the earliest 'fully modern' European fossil remains, dated to around 30,000-32,000 years. There is no fossil evidence that modern humans were in Europe at the time that the first Aurignacian tools were produced. These tools were as likely to have been produced by the Neanderthals as by the Cro-Magnon people (Reynolds 1990).

The apparently deliberate placement of bear skulls in certain caves suggested a primitive religion or 'bear cult' (Birdsell 1975: 325; Shackley 1980: 85-86, 110). At Arcy-sur-Cure, nearly a hundred and fifty bone and ivory tools were found, along with ornamental pieces, such as grooved/perforated tooth pendants (d'Errico 1998: S2; Farizy 1994: 99). The only items which d'Errico et al. (1998: S2) conceded may possibly have been traded were some ivory rings, which they saw resulting from cultural interaction similar "to that observed between neighbouring modern and submodern human groups". By "sub-modern" it is assumed that d'Errico et al. (1998) were referring to groups less technologically advanced, not less human.

The use of ochre was well attested in Europe at sites as ancient as Terra Amata, France, (300,000 ya) as well as later by Neanderthals, but not, at that time, in places outside Europe (Marshack 1990: 459). While the number of beads and pendants found at Neanderthal sites was less than that found in Upper Palæolithic European sites, it was more than that found in Upper Palæolithic sites elsewhere. Marshack (1990: 460) drew attention to engraved bone fragments dating to 100,000 ya found at Tata, Hungary, and to even earlier (110,000 ya) pendants made from wolf bone found at Bocksteinschmiede, Germany.

22.2 Going down

These positive assessments were counterbalanced by others of a more negative nature. From the time of Boule, the Neanderthal stocky build had been associated with smallness of stature, as if an inferior stature was associated with an inferior intelligence. Coon (1962: 548) stated that the Neanderthal was "a squat, stunted fellow, about 5 ft. tall, or 155 cm.", although von Koeningswald (1962: 97) gave their height as up to 5 ft. 4 in. (155 cm.). The Shanidar Neanderthals' height averaged 5 ft. 7 in. (162 cm.) (Trinkaus 1983a). These heights are not much different from that of the average European a few centuries ago, or even of South Mediterranean people today.

Lithic evidence of habitation in the European Arctic region as early as 40,000 BP has been found but absence of fossils leaves open the question of to whom this belonged: the Neanderthals or the newly arrived Cro-Magnon people? (Pavlov et al. 2001: 84). Pavlov et al. (2001: 96) concluded that these early occupants were *H. sapiens* since survival in such an environment would have required long-term planning and an extended social network, neither of which they believed were within Neantherthal capabilities.

Life expectancy is another area in which Neanderthals are generally considered to have fared less well than current humans. This has already been discussed (see Section 19.4)

22.3 Technology

The use of the term 'submodern human' to refer to groups of people not as technologically advanced as others (see Section 22.1) was interesting since it reflected so well the assumption, which seems to be almost automatic, that technology is an indicator, not only of increasing intelligence, but of increasing 'humanness' and, *ipso facto*, of speciation. If that were the case, should not a new 'speciation event' be postulated for ~35,000 ya, which saw the advent of the cave art of Western Europe, for ~28,000 ya, which saw the first firing of clay and the production of the Venus figurines at Dolne Vestonice, again at 10,000 ya with the introduction of agriculture, ~300 ya with the Industrial Revolution and 50 ya with the introduction of the Age of Electronics? Speth (2004: 524) pointed out that if we were to apply the same criteria to the native populations of Africa, Australia and South America that we apply to the Neanderthals, then these native people would have had to be considered "cognitively challenged" .

Roth (1899), an early ethnologist, lived among the Tasmanian Aborigines people for a considerable period of time during the middle of the 19th century. The men carried only two weapons: a long, thin spear of some ten to twelve feet (3 metres) and a waddy, a form of cudgel similar to a baseball bat. The men carried nothing but these two items, everything else, including children and any items worth the effort, being carried by the women. The women made grass bags for collecting shell fish and carrying their few belongings (see Fig.22.1).

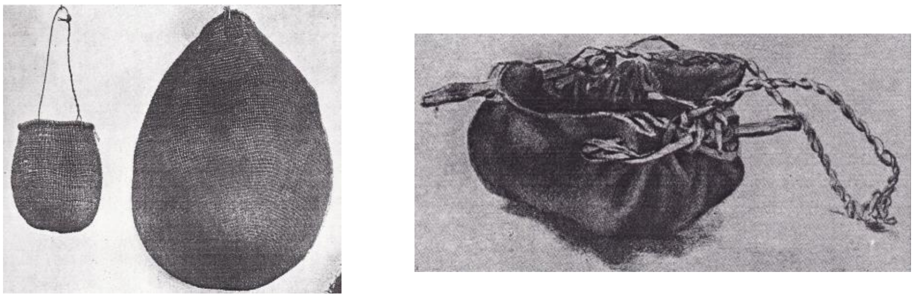

Fig. 22.1: Grass bags made by Tasmanian aboriginal women.
(from Roth 1899: 142, 153)

The Tasmanians had no throwing sticks or boomerangs and only used flints for cutting their flesh for ornament (Roth 1899: 126), keeping the wounds open by filling them with grease or ash to enhance scarification. They wore thin strips of animal fur or sinew as bands around various parts of their body, neck, ankles, arms, legs, which they sometimes coloured with red ochre, and adorned themselves with feathers and shells (Roth 1899: 114 and 131). These Tasmanian Aborigines appeared to have no religion or ritual, taking these two items out of consideration when defining 'human'.

The Tasmanians were able to make fire and ate well (Roth 1899: 86). They did not know how to boil water but made an alcoholic beverage from the sap of the "cider-tree", which was collected in a hole at the bottom near the root of the tree and allowed to remain until it fermented, being "rather intoxicating if drunk to excess" (Roth 1899: 94-95). Armed only with the evidence of their very simple tools (the spears, waddies and grass bags of the Tasmanians would have decomposed), an hypothetical future archæologist, applying to these people the same criteria which are applied to early hominids, might well attribute them with only meagre intellectual abilities, even less than the Neanderthals, since the Tasmanian tool kit was considerably more simple, but no one denied them complete humanity, with full linguistic and philosophical capabilities.

22.5 Rock bottom

By the end of the century, opinion of Neanderthal abilities had reached its lowest point since King, at least according to Jordan (1999: 94-95):

> Neanderthal folk may have been prone to live for the day, indeed cut out by Nature for nothing else … their diets must always have been poor … meat may have been largely consumed away from "home" (by hunting males?) and only a small proportion of it brought back on the bone (for women and children), otherwise faring meagrely? … it is possible to see a picture of women and children around the cave fire preparing plant food and animal scraps with their simple tools and of men dropping by with proper cuts of meat acquired by hunting … The males, moreover, may have often eaten much of their meat out in the wilds and not brought so much back with them to share … It would not really be appropriate to speak of 'home' … for family life, with nuclear families and extended kin relationships … would not have existed for the Neanderthalers … Sex might have been less a prominent, certainly less a routine, aspect of Neanderthal life … It is possible to see in meat sharing by hunting males … [what] has been rather directly called the 'sex-for-meat' contract … Neanderthals would indeed be much closer to our ape ancestors … than to us in terms of behaviour.

And again (Jordan 1999: 112):

> … they lived every day like the first day of their lives … Their own bones are thick from heavy labour, as if they lacked the wit to make life easy on themselves … they got their food … opportunistically and stored none of it against a snowy day … they wore no personal decoration … a cloud hangs over their very humanity … they were in some respects more like all their primitive forebears and indeed the ape-like ancestors of the human line than they were to us.

Jordan did acknowledge that care appeared to have been extended by Neanderthals at both La Chapelle and Shanidar, but suggested "perhaps their survival can be attributed relatively more to toleration than to active concern, for poorly individuals can scrape along even among chimpanzee groups" (Jordan 1999: 97).

Tattersall's opinion of Neanderthals was little better. He described burial as being merely a way Neanderthals dealt with "a rather distressing kind of clutter or … of dealing with obscure emotions" (Tattersall 1998: 161; 2002: 123; Tattersall and Schwarz 2001: 213-214). Tattersall was prepared to admit that Neanderthals may have caught fish, "bears do, after all", but believed that they would have eaten them at point of catch, rather than bringing them back for sharing "which is typical human practice" (Tattersall 2002: 129). Tattersall (1998: 166, 187) considered that Neanderthals were not inferior humans because they were not humans at all. Mithen (2005) concluded that since the Neanderthals were incapable of speech, they must also have been incapable of thought.

Opinions expressed regarding the abilities of *Homo erectus* fared little better. Following a similar line of argument to that used by Mithen, Walker and Shipman (1996) concluded that

Nariokotome Boy, (1.7 mya – 1.6 mya) was speechless, and therefore probably without thought. Earlier, Walker et al. (1982) determined *H. erectus* in its early stages of evolution had not yet evolved to the stage of having learned which were their correct foods, accounting for the vitamin A toxicoses evidenced in the remains of the female KNM-ER 1808, also dated to 1.6 mya.

Tattersall (2002) had a similarly poor opinion of *H. erectus*. Vultures wheeling overhead might have been an indication of the availability of material suitable for scavenging but "to go further than this and to suggest, for example, that the early hominids were reading animal spoor, probably goes much too far in the direction of viewing these creatures as junior-league versions of ourselves" (Tattersall 2002: 94-95). Surely the closer our ancestors were to their animal origins, the *more* developed would have been their 'animal intelligence'. Why should it be assumed that early humans, alone of all creatures which have ever called this planet home, would have been devoid of both human *and* animal intelligence?

22.6 Ideological position

What had precipitated this change in attitude? Brace (1964: 12) identified 'sociopolitical ideology' as being as important in the acceptance of some theories as basic biology and more than thirty years later, d'Errico et al. (1998: S22) were to lament an 'anti-Neanderthal prejudice' which they believed was hindering correct interpretation of evidence. Trinkaus and Shipman (1992: 322-324) concluded that the 1960s were a time of "outspoken moralizing … ostensibly fighting prejudice and stereotype, [but with] a stony undertone of political correctness" which an entire generation of anthropologists soon learned not to question or transgress. "Race was not only not a fit subject to study, *it didn't even exist*" (Trinkaus and Shipman 1992: 324, italics in original).

Wolpoff and Caspari (1997) wrote a book on the politics of social theory with particular reference to evolution, recalling how, as the generations had passed, many people had felt compelled to present their views in ways which conformed to the current paradigm, not necessarily because that was what they genuinely believed but because that was the way they wanted their views to be seen, possibly for reasons of promotion or funding. "We see things not as they are, but as we are" (Wolpoff and Caspari 1997: 323), or are not, as the case may be.

The change in attitude towards the Neanderthals, and other early *Homo* people is difficult to understand, since it is not supported by physical evidence, either fossil or artifactual. On the contrary, physical evidence was narrowing the gap between the Neanderthals and modern humans. Trinkaus and Shipman (1992), Wolpoff and Caspari (1997) and d'Errico et al. (1998) identified this trend as having been motivated by a form of 'political correctness' but why 'political correctness' should be brought to bear in connection with the Neanderthals is difficult to understand. It would seem to have been a case of certain influential scientists stating a position, which they then defended against increasingly negative evidence. The subordinate text, that the Neanderthals were fully human, was suppressed, as will be shown in the next chapter.

Chapter 23

The Swing of the Pendulum

23.1 Regional continuity

Humans are the most polytypic species ever to inhabit the planet. King (1864) had attempted to deny the Neanderthals a place in the genus *Homo*, but all other authors, gradually becoming aware of the increasingly ancient line to which we belong, accepted all members of the genus *Homo* as members of the species *sapiens*. Indeed, the further back our origins were seen to have happened, the earlier we were shown to have spread across the globe, the more time and space was available to account for our great diversity. This was certainly the opinion of writers such as Weidenreich (1939, 1940, 1949), Howells (1959) and Coon (1962).

A number of authors (such as Hublin 1985; Radovčić 1985; Aiello 1993; Frayer et al. 1993; Trinkaus et al. 2001) cited evidence for mosaic features in skeletal remains from Europe at the time of archaic *H. sapiens* and others (such as Arsuaga et al. 1993) argued for the presence of Neanderthal type features on remains such as the ‚Broken Hill fossil from Africa.

This position, known as Multiregionalism, was particularly strongly supported until the end of the century by Thorne and Wolpoff (Wolpoff et al. 1994; Wolpoff and Thorne, 1991; Thorne and Wolpoff 1992a; Thorne and Wolpoff 1992b; Wolpoff and Caspari 1997 and elsewhere). They argued that the number of Neanderthal features which continued to be found in later European populations, even up to the present time, was evidence of the continuance of the Neanderthal heritage, even if as a minor component.

In many Neanderthals, the opening of the mandibular neural canal was covered by a broad bony ridge, but in others the ridge was absent (see Fig. 21.1). Fifty-three percent of known Neanderthals have the bridged form, as did forty-four per cent of the earlier Palæolithic occupants of Europe (i.e. the pre-Neanderthals), while in Upper Palæolithic, Mesolithic and recent times the incidence gradually drops to below six per cent (Thorne and Wolpoff 1992b, Wolpoff et al. 1994). The bridged form of neural canal is rarely found in fossils from Asia or Australia and appears to be missing from Africa post *Homo erectus.* Since the bridged form of neural canal has no known evolutionary benefit, its development among the pre-Neanderthals is hard to explain, but not as hard as to explain its development *twice* in the same geographical area, which must be done if it is to be argued that there was no interbreeding between Neanderthals and the incoming anatomically modern humans (Thorne and Wolpoff 1992b).

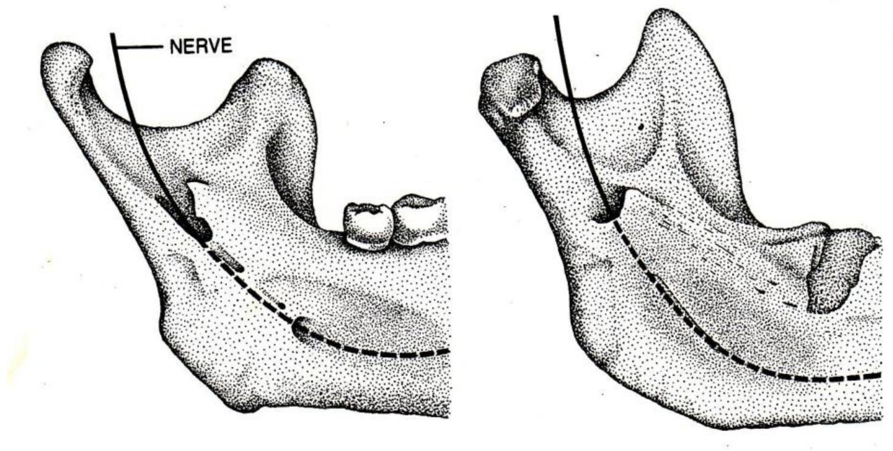

Fig.23.1: Grooved and ridged mandibular nerve canal openings in Neanderthals.
(from Thorne and Wolpoff 1992b: 30)

Remains from the Middle East (the Levant), such as Skhul 4 and Qafzah 6, have a mosaic of archaic human and Neanderthal features (Frayer et al. 1993: 37-38) and Stringer (1998: 33) admitted that the Late Middle Pleistocene remains from Zuttiyeh, Israel, were difficult to classify, although he generally supported the view that Neanderthals were a distinct species.

Trinkaus and Shipman (1992) believed that classic European Neanderthals evolved out of more archaic human ancestors in Europe and western Asia (the Levant) at the same time that archaic *H. sapiens* were evolving from *H. erectus* in eastern Asia and Africa. There were similarities between early European Neanderthals and contemporary people in Africa and Asia, sometimes referred to as African or Asian Neanderthals (Trinkaus and Shipman 1992: 412). Having considered both the fossil and the mtDNA evidence, Trinkaus and Shipman (1992: 414) concluded that modern humans had evolved from Neanderthals in Europe sometime after 100,000 BP, when the Neanderthals, *per se*, first appeared. Trinkaus and Shipman (1992: 414) then saw the two lines as being divergent, culminating in the later 'classic' Neanderthals and modern humans.

Stringer (Stringer and Grűn 1991: 70; Stringer and Gamble 1993: 72-80) acknowledged that modern humans and Neanderthals had probably been sufficiently closely related to allow hybridisation, citing taurodontism among Neanderthals and the Inuit and the presence in about a quarter of Cro-Magnon of the Neanderthal form of the mandibular foramen.

23.2 The species question continues

In the early 1960s, Brace compiled a lengthy review of the, then, past and current literature, which he entitled *The Fate of the "Classic" Neanderthals* (Brace 1964). He sought to demonstrate the way in which the same evidence could be interpreted to support opposing views. Brace (1964: 4) believed that "the climate of opinion" at the time of the discovery of Neanderthal remains had had a profound and lasting effect upon the interpretation of that fossil material, namely that there had been a reluctance to acknowledge Neanderthals as ancestral to present-day humans. Pushing the first appearance of humans further back in time was a way of rendering human ancestry "out of sight, out of mind" (Brace 1964: 11).

Brace argued that for modern humans successfully to have invaded Europe from another continent, they would have needed technology superior to that of the resident population, something they clearly did not have (Brace 1964: 14). Brace concluded that it had been the "fate" of the Neanderthals to give rise to modern humans (Brace 1964: 19).

The situation was further complicated by the fact that, although the number of early hominine remains in Europe was not large, those that had been uncovered tended to suggest that the early form had been closer to the modern type. For example, the Swanscombe skull, dated to approximately 300,000 BP, could not, as far as the occipital and left parietal bones were concerned, be distinguished from *H. sapiens* (Day 1965). The Neanderthals were seen as a local specialization evolved from European 'archaic' *H. sapiens* who had lived in Europe between about 800,000 and 200,000 BP (for example, Radovćić 1985; Trinkaus and Smith 1985; Stringer 1985), occurring mostly in Europe from *circa* 120,000 to 30,000 BP, but also living in the Levant from *circa* 100,000 to 40,000 BP. This scenario made it difficult to deny the Neanderthals *sapiens* status without postulating that they had undergone a form of degeneration or 'reverse evolution'.

23.3 The 'complete replacement' hypothesis

The point of view referred to by Brace (1964) as 'Catastrophism' became known as the 'Out of Africa' or 'Complete Replacement' hypothesis because it proposed that all hominids throughout the world were replaced by a new species of hominid, early modern *H. sapiens,* who evolved in Africa ~200,000 ya, or possibly later, and spread from there to inhabit the rest of the world.

The discovery in Ethiopia in 1969 of the anatomically modern human skeletal remains known as Omo I, tentatively dated on the basis of associated mollusc shells to 130,000 BP, strengthened the case for the replacement of all *Homo* species by the more evolved new species of human (Leakey et al. 1969), although Trinkaus and Shipman (1992: 361) stressed that the dating of Omo I was insecure, ranging between 130,000 and 40,000 BP.

Insufficient fossil evidence precludes theorists from being clear as to whether it was only a small population of *H. erectus* within the large continent of Africa which made the transition to archaic *H. sapiens*, or whether the transition took place over the whole continent before the proposed exodus. Uncertainty as to exact dating makes it difficult to establish whether fossil remains bare evidence for rapid change over the whole continent or of gradual spread. The remains from Herto have been dated to 160,000-154,000 BP, Omo I to ~130,000 BP, Klaisies River Mouth to between 120,000 and 75,000 BP and Border Cave to 80,000 to 70,000 BP (Johanson and Edgar 1996, White et al. 2003), a possible time range of 90,000 years.

Lahr and Foley (1994) argued that, although there was no clear Rubicon for modern *Homo sapiens*, their evolution had taken place in Africa. Africa, being a large land mass, had allowed the development of diverse morphologies, and these had dispersed 'Out of Africa' on several different occasions.

23.4 Cladogenesis

Whereas anagenesis assumes one species gradually changes into another, cladogenesis assumes one species diverges into two. Stringer (1998: 30) adopted the cladogenic view of evolution, claiming the date of the origin of the one clade (Neanderthal) would date the origin of the other *(H. sapiens).* Stringer (1998: 32-35) postulated that divergence had taken place about 250,000 to 300,000 years ago, the two clades becoming isolated and the African isolate giving rise to *H. sapiens.* Stringer's adherence to a cladistic interpretation forced him into an illogical position. He was obliged to claim that the Neanderthal and modern human line both started at the same time because they diverged from a common ancestor, yet he claimed that the Neanderthals originated in Europe and modern humans originated in Africa. The Multiregional approach allowed *H. erectus* to continue living in Africa after part of its population migrated to Europe, resulting in archaic *H. sapiens* and *H. heidelbergensis*, who, like the Neanderthals, were also classified minus *'sapiens'. H. erectus* was seen to continue after the emergence of archaic *H. sapiens* in Europe, as evidenced by Chou K'ou Tien.

Stringer (Stringer and McKie 1996: 128-129) turned for support to work being carried out on nuclear DNA. Chromosome 12 had been found to contain two variations among its 'junk' DNA. The first was a simple deletion present in some people. The second variation involved repetition of five bases, CTTTT. Some people have between four and fifteen copies of this 'little stammer' (Stringer and McKie 1996: 129). People living in sub-Saharan Africa may or may not have the deletion and may have any variation of the number of CTTTT repeats. Elsewhere in the world, chromosomes with the deletion have a sixfold CTTTT repeat, while non-deletion chromosomes have between five and ten repeats (Stringer and McKie 1996: 129):

> There is only one feasible explanation: that the small wave of settlers who set off from their African home to conquer the world was made up of a tribe or group of African *Homo sapiens* among whom only those who possessed a chromosome 12 had a sixfold CTTT repetition. They carried this combination out to the world 100,000 years ago.

Since everyone has a chromosome 12, it would appear that a printing error has occurred and the sentence should have read "who possessed a chromosome 12 deletion". What were Stringer and McKie implying about sub-Saharan Africans of today? If their ancestors were not part of the wave of settlers who left Africa to conquer the world, what are they? Remnants of *H. erectus*?

23.5 The evidence of mtDNA

A seminal paper by Cann, Stoneking and Wilson (1987) claimed that mitochondrial DNA evidence proved that all humans alive today had a common (female) ancestor who lived in Africa some 200,000 BP. This tended to harden attitudes in favour of the evolution of a new species in Africa around that time, a species that subsequently colonized the whole world.

Through their studies of mitochondrial DNA, Cann et al. (1987) concluded that all humans alive today had a common female ancestor (nicknamed 'Eve') who had lived in Africa between 140,000 and 280,000 years ago, a time referred to as approximately 200,000 BP for the purposes of simplicity. Although Cann et al. (1987: 35) further concluded that this particular mtDNA had migrated from Africa to all other parts of the world, they stated:

> Our placement of the common ancestor of all human mtDNA diversity in Africa 140,000-280,000 years ago need not imply that the transformation to anatomically modern Homo sapiens occurred in Africa at that time. The mtDNA data tells us nothing of the contribution to this transformation by the genetic and cultural traits of males and females whose mtDNA became extinct.

Despite this caution, Cann et al. (1987) did refer in their paper to the two competing models of human evolution, 'Out of Africa' and 'Multiregional Evolution'. The similarity of the time of the existence of 'Eve' with that proposed by 'Out of Africa' theorists for the second exodus of hominids from Africa was sufficient to lead Cann et al. (1987: 365-366) to "propose that *Homo erectus* in Asia was replaced without much mixing with the invading *Homo sapiens* from Africa". They made no comment in relation to Europe and the Neanderthals, presumably because Neanderthals had not at the time under consideration evolved into their classic form, although pre-Neanderthals were already in existence. The use of the words 'without much mixing' leaves open the possibility of some interbreeding. A few months later, Cann (1987) published a paper on her own in which she referred to *Homo sapiens neaderthalensis* as a variant of archaic *Homo sapiens*, which she nevertheless considered not to have been ancestral to modern humans, who had evolved elsewhere concurrently. In this paper, Cann (1987: 37) elaborated on the cautions she and her co-workers had previously given:

> The mitochondrial evidence indicates that archaic *Homo sapiens* evolved into *Homo sapiens* about eighty thousand years earlier than the fossil evidence suggests. Yet it is possible that Eve herself belonged to the archaic subspecies and contributed her mitochondrial DNA to those who, perhaps many generations later, evolved into *Homo sapiens sapiens …* In fact, Eve's descendants could have maintained their archaic form for thousands of years before taking on fully modern characteristics. There is no evidence to suggest that people today have retained any of Eve's particular physical features. We know only that we have inherited her mitochondrial DNA; she might have contributed very little to the surviving pool of human nuclear DNA … It is important to note that unlike her biblical namesake, mitochondrial Eve was not the only woman alive during her time. She merely is the only woman of her age whose descendants have included some females in every generation. Some of her contemporaries, no doubt, also have progeny alive today who carry traces of the ancestral nuclear DNA … That the world's races evolved from multiple lineages implies that early modern humans moved back and forth around the world several times, intermixing with one another along the way, before they settled down in sufficient isolation to develop racial features.

It would seem that while the team of researchers collectively favour the Complete Replacement hypothesis, Cann herself favoured the Multiregional model. A divergence of opinion was evident in a paper co-authored by Wilson and Cann (1992) in which it was stated (p.22) that "modern humans arose in one place and spread elsewhere" and (p.24) that "the farther back the genealogy goes, the larger the circle of maternal relatives becomes, until at last it embraces everyone alive … she [Eve] did not necessarily live in a small population … or constitute the only woman of her generation", which begs the question of what precise use is information regarding our last common ancestor? Despite his co-authorship of the above comments, Wilson came to see the mtDNA evidence as supporting the 'Out of Africa' theory so strongly that he even suggested that modern humans had language, while the Neanderthals and other early people did not, because the gene for language was carried in the mtDNA (Frayer et al. 1993: 21).

In another article, Cann (1988: 136) once again stressed that "to claim all living humans can trace their mitochondrial genomes back to a single female founder is not to say that we all come from a single female ancestor … the extent of admixture of modern humans with humans who may have migrated out of Africa at an earlier stage of human evolution, even at the *Homo erectus* stage, can be judged only indirectly from the mitochondrial DNA". Depending upon the length of time between generations, 1200 years ago (800 AD) each of us had the statistical possibility of between 4 billion and 17 billion ancestors (Cann 1988: 136) but only one would have been our 'mtDNA mother'. Clearly every potential (distant) ancestor must have many places in any ancestral tree, but only from one male and from one female could an unbroken line of same gender descent be traced (Wolpoff and Thorne 1991: 37; Cann et al. 1994: 138). Furthermore, every one of us does have an unbroken line of same gender descent which is traceable back through our male or female ancestral line, not just to 800 AD, but to 80,000 BP, 800,000 BP, and so on throughout evolutionary time. We each have an astronomical number of potential ancestors, but only two lines of same gender descent, all other lines being interrupted by an ancestor of the opposite gender, which nevertheless had an equal chance of contributing their nuclear DNA. Four years later, Cann, in collaboration with Wilson, reiterated her position (Wilson and Cann 1992: 24):

> ... that all humans today can be traced along maternal lines to a woman who lived about 200,000 years ago, probably in Africa … The further back the genealogy goes, the larger the circle of maternal relatives becomes until at last it embraces everyone alive … all human mitochondrial DNA must have had an ultimate common female ancestor … she did not necessarily live in a small population or constitute the only woman of her generation.

This was accepted even by those promoting the Complete Replacement model (Stringer and McKie 1996: 119). Common ancestors within any community are to be expected and if genealogies are traced back far enough, inevitably a common ancestor will be found (Thorne and Wolpoff 1992b; Cavalli-Sforza et al. 1994; Klein and Takahata 2002: 45). Vigilant et al. (1991: 1506) supported the "contention that all the mtDNA's found in contemporary human populations stem from a single ancestral mtDNA that was present in an African population approximately 200,000 years ago" and that "the mtDNA evidence is thus consistent with an origin of anatomically modern humans in Africa within the last 200,000 years". They thus represent the school of thought that evidence for a common *mitochondrial* DNA ancestor was evidence for the origin of anatomically modern humans (common *nuclear* DNA), a position not taken by Cann et al. (1987), Cann (1987, 1988) or Wilson and Cann (1992).

Reanalysis of the mtDNA data (Templeton 1992: 737, 1993: 52) resulted in the finding of 10,000 trees more parsimonious by five steps than the mtDNA tree cited by Cann et al. (1987) and 100 more parsimonious by two steps than that given by Vigilant et al. (1991), some having non-African origins. The possible range of time at which the postulated 'event' had taken place ranged from 33,000 to 675,000 years ago (Templeton 1993: 57). Templeton (1992: 737, 1993: 65) and Hedges et al. (1992: 739) interpreted the mtDNA research as supporting a model of restricted but recurrent gene flow. Klein (1994: 6) considered the mtDNA results "as flawed as the fossil record they were meant to complement" and concluded that there were no statistical grounds for preferring an African to a non-African origin for humans.

At one time it had been thought that anatomically modern humans (AMH) had arrived in Europe at the time of, or shortly before, the extinction of the Neanderthals some 40,000 to 30,000 years ago. However, the discovery of skeletal remains in the Levant which were classified as AMH and dated to around 80,000 BP, and the dating of the first human occupation of Australia between 60,000 to 50,000 BP (Roberts et al. 1990; Adcock et al. 2001) caused this time to be extended backwards.

23.6 The Australian story

Stringer and Andrews (1988: 1267) noted that some Australian fossils looked decidedly more 'archaic' than their counterparts elsewhere. The first *H. sapiens* to arrive in Australia should have been no more archaic than *H. sapiens* people anywhere else. If they were "this would need explaining … Perhaps Australia was a special case where local differentiation, cultural practices, or pathologies led in some cases to apparent evolutionary reversals" (Stringer and Andrews 1988: 1267). This may have been a reference to the opinion of Thorne and Macumber (1972: 316-317) who pointed out that the Kow Swamp crania displayed archaic cranial features not seen in recent Aboriginal populations, which suggested to them that *H. erectus* might have survived in Australia until as recently as 10,000 years ago. An 'evolutionary reversal' might have explained this discrepancy. Today the robusticity of the Kow Swamp people is not viewed as an indication of their being an archaic people. Adcock et al. (2001) pointed out that just because their robust morphology has not survived does not mean that they do not have modern descendants. Their mtDNA indicates this possibility. Conversely, just because the mtDNA of the ancient Lake Mungo man has not survived does not mean that his people have no modern descendants. His gracile morphology indicates this possibility.

Redating of fossils from Ngandong and Sambunmacan, Java, has given ages of 27,000 to 53,000 years, bringing forward the survival of *H. erectus* in Asia by some 250,000 years (Swisher et al. 1996: 1870). Perhaps a late survival of *H. erectus* in Australia is not so inconceivable after all. In any event, *H. erectus* was living in south-east Asia contemporaneously with *H. sapiens* in Europe.

23.7 Ideological positions

The same evidence was given widely differing interpretations, depending largely upon the ideological orientation of the writer. While Rebecca Cann made constant efforts to divorce herself from the claim of a speciation event having occurred, other scientists, who seemed to have drawn an over hasty conclusion from the initial work of Cann, Stoneking and Wilson (1987) continued to defend their position. Chris Stringer, who held a prominent position at the Natural History Museum in South Kensington, London, who was the author of numerous papers and who made frequent appearances in documentaries on human evolution, did much to establish 'Out of Africa' as the dominant paradigm, which held its position for several decades. Further mtDNA analysis proved this position to be untenable.

Those supporting the dehumanisation of Neanderthals sought differences and invented them where they did not exist. Those seeking to re-establish the humanisation of Neanderthals saw similarities but were 'silenced' by those supporting the dominant paradigm. Those supporting the 'Multi-regional' hypothesis found it increasingly difficult to obtain opportunities to publish their work, which, in turn, affected their careers, even to the point of terminating them (A. Thorne 2004. Personal communication).

Chapter 24

Chromosomes Revisited

24.1 Introduction

Great strides were made at this time in the application of genetics to understanding human evolution through the study of mtDNA. This chapter takes up the important subject of the role chromosome change must play in ongoing evolution, which was introduced in Chapter 19.

24.2 Michael White (1910-1983)

Michael White had a cosmopolitan upbringing. Born in London, his family moved to Italy during the First World War. White returned to London in 1927 to attend university, where he studied botany, turning to entomology during his third year of study. After graduation, White remained at University College, London, as assistant lecturer, gaining the post-graduate qualification of Doctor of Science (DSc). During this time White associated with people such as Fisher and Haldane (Atchley 1981: 6).

After the war, White spent some time (1947-1953) in America where he accepted a position as professor of zoology at the University of Texas, at which time he formed a lifelong friendship with Dobzhansky (Atchley 1981: 8). In 1953, White migrated to Australia, taking up a position as senior research fellow with the CSIRO in Canberra, where he remained until 1956. He then took up the Chair of Zoology at Melbourne University. Following the establishment of the Department of Genetics at Melbourne University in 1964, White occupied this Chair until his retirement in 1975. During his career, he published several books and a large number of articles.

24.3 Evolution and chromosomes

White asserted that evolutionary theorists concentrated too much on the role of genes and DNA in the evolutionary process and too little on the role of chromosomes (White 1973b). For example, Dobzhansky (1964) in his book, *Heredity and the Nature of* Man, mentioned chromosomes only as the carriers of genetic material. Dobzhansky's interest was in proteins, amino acids, nucleic acids, DNA and RNA. He never addressed the issue of how species had acquired their differing numbers of chromosomes. Unlike most evolutionary theorists, Dobzhansky was a geneticist, making his lack of interest in chromosome change the more remarkable. The role of chromosomes themselves in evolution appeared to be of little interest, except to White.

Initially, White (1937) had thought that chromosome change was a major cause of changing phenotypes. As more was learnt about chromosome numbers, it became clear that this was not the case (White 1973a, 1973b, 1978). Some families, such as the Big Cats and the Great Apes, had the same number of chromosomes (38 and 48 respectively) although members of the family were clearly phenotypically differentiated. Conversely, some birds and mammals had different chromosome numbers but were so phenotypically similar that, prior to the establishment of their chromosome numbers, they had been considered the same species. Different species, genera, families, etc., might have the same number of chromosomes, for example humans and guppies both have 46. Thus, identity of chromosome number signified nothing when attempting to trace speciation. However, once a difference in chromosome numbers had been identified, then more than one species was involved, no matter how similar the species might be in appearance.

Considering the millions of species alive on the Earth today, as well as the millions of species now extinct, the variation in chromosome numbers is not large. The number and size of chromosomes is limited by the size of the nucleus in which they occur (White 1973b: 407). While insects and crustaceans exhibit a wide variation in chromosome numbers, the haploid number of most vertebrates lies between n = 6 and n = 20. Thus, *Homo sapiens* with n = 23 is above the average number, although numbers double this are known in some vertebrates (White 1973b: 409). All primates appear to have fairly high chromosome numbers and there are more metacentric chromosomes in the gorilla and chimpanzee than in humans (White 1973b: 449).

24.4 How things had changed

Although the sixth edition of *Chromosomes* (White 1973a) and the third edition of *Animal Cytology and Evolution* (White 1973b) were large by comparison with their first editions, very little had changed as far as the understanding of the basic workings of chromosomes, in particular their role in reproduction, was concerned. The increased volume was brought about by an escalation in examples, especially in relation to insects and other invertebrates, which were White's area of expertise.

While polyploidy had clearly played a role in the evolution of some plants and non-sexually reproducing members of the animal kingdom, polyploidy was not viable in sexually reproducing plants and animals and played no part in their evolution. Chromosomes occurred in pairs and this pairing was essential for meiosis to occur. All diploid chromosome numbers in sexually reproducing species are 'even', although the haploid number may be 'odd' or 'even' (White 1973a, 1973b). Fusion of two chromosomes had been observed under irradiation. However, fusions thus produced, even though they may survive one or two cell divisions, were invariably fatal.

All chromosomes had one centromere (White 1973a, 1973b). During meiosis, each centromere attached to a spindle fibre, there being the same number of spindle fibres as centromeres. Thus, if a centromere was to duplicate itself by some chance, the extra centromere (and any chromosomal material which had duplicated itself along with it) would have no spindle with which to attach. If two centromeres somehow fused, there would be a spare spindle. Both these circumstances would impede meiosis. In his earlier work, White (1937) had thought that 'microchromosomes' might be centromeres discarded after fusion or that they might be 'spares' awaiting utilization when numbers were to be increased (see Chapter 17). White made no mention of the 'microchromosomes' in his later works and clearly no longer thought them of any evolutionary importance.

The terms 'metacentric' (V-shaped), 'acrocentric' (J-shaped) and 'telocentric' (rod shaped) were retained. White (1973b) was still of the opinion that telocentric chromosomes contained a small amount of genetic material on a second micro-arm, although he acknowledged that this was unproven.

24.5 Chromosome abnormalities in humans

A number of chromosomal abnormalities are known to affect the human sex chromosomes. Turner's syndrome is a condition in which there are only 45 chromosomes instead of 46, there being no Y chromosome. The person presents as female, but is sexually underdeveloped, the ovaries being merely fibrous streaks (White 1973a: 55). Females with XXX (47 chromosomes) occur as frequently as 1:500 female births. These people are often mentally defective, but may be fertile, since two of their chromosomes appear to be partially 'switched off' (White 1973a: 56). XXXX and XXXXX females are also known and one was known to give birth to a daughter. Unfortunately, White (1973a: 56) did not record the chromosome count for this child, but if the extra X chromosomes were 'switched off', then it may be presumed that the daughter's count was normal?

Klinefelter syndrome (XXY and XXXY) occurs in about 1:500 'male' births. These people are generally tall, long-legged, with small testes, abnormal testicular histology, atrophy of seminferous tubules and usually some degree of gynæcomastia. They may be sexually active, but sterile (White 1973a: 57). A variation of Klinefelter's syndrome is the XYY male, affecting about 1:550 live male births.

Polyploidy may have played no part in mammalian evolution but that is not to say that it does not occur in humans. The most well-known polyploid condition in humans is that of

Trisomy 21, otherwise known as Down's Syndrome. The condition is caused by the non-disjunction of the number 21 chromosome, either at meiosis or in one of the first cleavage mitoses after fertilisation (White 1973a: 58-59), which results in the person being born with 47, instead of 46, chromosomes. This is the only human trisomy which allows the affected individual to survive into adulthood, although the person is sterile, uneven numbers of chromosomes not being viable at meiosis.

Trisomy 13 may also occur on rare occasions and is known as Patau's syndrome. The individual has harelip, cleft palate, polydactyly, heart and kidney defects, extreme mental retardation and viability is very low, the individuals rarely surviving long after birth (White 1973a: 60). Another rare trisomy is that of chromosome 18, which causes severe heart defects and profound mental deficiency. Those afflicted die in infancy. Other trisomies appear to be lethal in utero and are believed to be responsible for many spontaneous abortions (White 1973a: 60-61). Extremely rarely a live birth may be recorded exhibiting complete trisomy ($3n = 69$) but none survive more than a few days (White 1973a: 61-62).

None of the above named anomalies contributed in any way to human evolution, since they all result in infertility.

White (1973a: 62) believed that the human metacentric chromosome 2 was formed by the fusion of two acrocentric chromosomes from the chimpanzee. White made no suggestion here that the fusion occurred in a hypothetical common ancestor.

24.6 Possible scenario

None of the evolutionary theorists ever postulated a possible mechanism by which karyotypes (chromosome numbers and arrangements) could be permanently changed. Fissions and fusions were assumed to have taken place. White (1973a, 1973b) was more cautious than most in that his books are full of modifiers – 'might have', 'possibly', 'it seems that' and so on. He felt that the proponents of the evolutionary synthesis had paid too much attention to DNA itself, especially the quantity, ignoring the manner in which the DNA was transferred from generation to generation, i.e. the chromosomes (White 1973b), yet he, himself, never explained precisely how fissions and fusions might have occurred. An attempt will now be made to do this by the use of hypothetical scenarios.

The first stage of meiosis involves the doubling of chromosome numbers, in chimpanzees resulting in $4n = 96$ ($2n = 48$). If fusion such that $n = 23$ was to be obtained, then it would be necessary for four chromosomes to fuse, which is deemed unlikely. If it did occur, the further stages of meiosis would not be viable. By the second stage of meiosis, cell division has reduced the number of chromosomes in each of the two 'daughter' cells to the original number, which for the chimpanzee is $2n = 48$. At the third stage of meiosis, the number of chromatids in each of the four daughter cells has been reduced to $n = 24$. The fusing of two chromatids in the final stage of meiosis would result in n = 23, and this would appear to be the only stage at which such a fusion might be possible.

In the female, three out of the four 'daughter' cells produced during meiosis become 'polar bodies' and are lost. Let it be assumed that this reduction by the fusing of two chromatids took place in the fourth 'daughter' cell, which was destined to be fertilised. In the male, all four 'daughter' cells produced during meiosis become spermatozoa. However, the assumed fusion would only have occurred in one of these four cells, meaning that only one sperm out of the hundreds of thousands – millions – produced would carry the new formation. The chance of this one being the one to fertilise the female egg is extremely small.

Let it be assumed that two of the chimpanzee's telocentric (rod-shaped) chromosomes combined. For this to happen, an arm would have to dislocate itself from the centromere of both telocentrics, in order that 'sticky' ends would be available for a new attachment. If the dislodged arms merely reattached themselves to other chromosomes, a translocation would have occurred, but there would have been no reduction in chromosome number. For a reduction to occur, it is necessary to postulate that two of the long arms, with their centromeres, fused, and that the two short arms were lost.

It will be remembered from Chapter 18 that White held that telocentric (rod shaped) chromosomes did, in fact, possess a small amount of DNA material on the 'micro' arm, even though this had not yet been demonstrated. If White was correct, then the two ends of the rods would be sticky and could join, but the two centromeres would be separated in a very small degree. It is hard to envisage that these two newly joined telocentric chromosomes would not pull apart at cell division. This is what had been observed in the laboratory (see Chapter 18). This scenario could be postulated for two acrocentric (J-shaped) chromosomes, or one telocentric and one acrocentric chromosome, provided the small arm of the acrocentric chromosome was very small and the amount of the DNA material it carried was not so great that its loss would be lethal.

If White was incorrect and there was no DNA material, no second arm, however small, on a telocentric chromosome, then it must be assumed that the centromeres themselves became 'sticky' and that the two centromeres attached to each other, lying side by side. White never explained exactly why he believed that telocentric chromosomes must have had at least a very small second arm, but it may have been that he believed that this was necessary to 'seal' the end of the chromosome. If centromeres could become sticky and adhere to each other, meiosis would become a complete shambles.

On fertilisation, the two telocentric chromosomes from the other parent are assumed to pair with the two arms of the newly formed metacentric chromosome. The two short arms must have been lost, not joined with each other, otherwise there would have been no change in chromosome number. For a permanent reduction in chromosome numbers to occur, it is necessary to assume that the two centromeres remained attached to each other and acted as one, i.e. migrated to the one spindle. This would leave an imbalance and almost certainly be unviable, as laboratory tests had shown (see Chapter 18).

However, for the purpose of this scenario, it is necessary to assume that further cell division took place. It would have been necessary for the reproductive cell which had undergone the reduction in its number of chromosomes to have formed a gamete with a reproductive cell from a mate which had undergone an *identical* reduction, not merely a reduction involving different chromosomes. It is further necessary to assume that the loss of DNA from the abandoned short 'arm' did not cause any deformity. Some change may have occurred, possibly early in embryonic life, such that some new feature might have evolved. However, it would also be necessary to assume that this feature was not so extreme as to interfere with mate recognition, since it would have been essential for evolution that this new embryo be born healthy, be accepted by its community, matured and reproduced.

Let it be assumed that this foetus, the first *Australopithecus*, was born healthy, with the new karyotype n = 23. Let it further be assumed that this *Australopithecus* mated with a chimpanzee (the only mate which would have been available). There is no reason to suppose that this union would not be fertile, in the same way that the union between a horse and a donkey is fertile. The first 'chimp-man-zee' would have been born. This 'chimp-man-zee' would have had 47 chromosomes and been sterile.

For an ongoing line to become established, it is necessary to assume that a second *Australopithecus* was available, in the same location, at the same time, of opposite sex, which happened to have, by chance, an *identical* chromosomal mutation. In order for this to have happened, it would have been necessary, not only for a second chimpanzee to have undergone a fusing of two telocentric/acrocentric chromosomes into one metacentric chromosome, but the fused chromosomes would have had to be the same two that fused to produce the first *Australopithecus.* This rare occurrence must not have happened only once – producing the first *Australopithecus* – it would have needed to occur again, in the same breeding group, to produce a viable mate, and these two would have needed to select each other as mates for there to be any chance of a new line becoming established. Such changes must have happened, not once, but millions of times to account for all sexually reproducing plants and animals.

While it is generally assumed that, in the case of the hominine line, the number of chromosomes had been reduced, in other cases evolution must be assumed to have occurred as a result of an increase in chromosome number. Centromeres are known to be capable, not merely of duplicating themselves (along with their attached DNA arms), but of over-replicating themselves in a manner that produces polyploidy. In non-sexually reproducing organisms, this may give rise to a new form, without any complications. However, in sexually reproducing organisms, polyploidy is not viable, as already explained. It sometimes happens, is always detrimental, usually fatal before birth, and never viable in the long term. The only way that chromosome numbers could be increased would seem to be for the centromere to divide itself in half. Such a division would result in two rod shaped telomeres, with no second arm, however small. White resisted this concept, since no such splitting of a centromere had ever been witnessed in the laboratory. "Although spindle attachments divide longitudinally at mitosis [and meiosis], they do not appear to be transversely divisible" (White 1937: 94). The only way for an increase in centromere numbers to occur was by polyploidy (trisomy) and, while that had been shown at times to result in a viable fœtus, it had never been known to give rise to a permanently fertile line. Combinations such that a chromosome temporarily possessed two centromeres had been witnessed, but this was never viable for more than one or two cell divisions (see Chapter 18).

The method by which chromosome change is achieved, as well as what role, if any, such change plays in the process of evolution has been sadly neglected. This neglect has provided a potential opportunity for future research.

24.7 White's position

Clearly White's work was directed to detecting difference, not only in the genetic material itself, but in the way which the carriers of that material, the chromosomes, differed from each other, both within the individual and between species, genera, families and orders. No other person, not even Goldschmidt, addressed this issue. It is difficult to account for chromosome change within the framework of natural selection and the lack of possibility of a 'successful' outcome to such research could be a factor contributing to lack of research in this area.

A 'successful' outcome would be one supporting the dominant paradigm, natural selection. Romanes did not publish research that was negative (see Chapter 11). Not undertaking the research, not encouraging students to undertake it, or denying funding, are all ways of suppressing/silencing possible dissenting opinion. The fact that White did not pursue the subject in his later work could have been due to his having nothing further to report. However, it is strange that he did not even mention the subject in his later books (White 1973a, 1973b, 1978).

Lack of concern in this interesting subject is difficult to explain. If the answer is known, why is it not mentioned in the texts? If the answer is not known, why is that fact not mentioned in the texts? Either way, this topic needs to be addressed.

It is not the purpose of this thesis to suggest that evolution has not happened. On the contrary, it has been written from a perspective which holds that it has. If evolution has happened, then it would seem self-evident that there has to be some mechanism by which chromosome numbers change. This particular aspect of evolution has not been satisfactorily addressed in the literature.

Chapter 25

Out of the Mainstream

25.1 Introduction

Before closing this part of the thesis, a brief account will be given of the work of four people, Teilhard de Chardin, Niles Eldredge, Stephen J. Gould and Richard Dawkins, which was published during this period but which differed in some way from that of their colleagues. The first and last came from either end of the religious/atheist spectrum, while the remaining two combined to offer a further insight into the process of evolution which, while interesting and the subject of debate for about two decades, ultimately did not add anything of substance to our understanding of evolution. Without their inclusion, this part of the thesis would be incomplete.

25.2 A 'Noo' theory of evolution

Pierre Teilhard de Chardin (1881-1955) was at the same time a palæontologist and a Jesuit priest and, one might add, a free thinker, this latter quality rarely being seen developed to such a degree in someone so faithful to the Catholic Church. Born in 1881, the fourth of eleven children, he was sent as a boarder to a Jesuit college at the age of ten. It was during his school years that he became interested in geology and mineralogy, which interests later expanded to include the study of fossils and, inevitably, human evolution.

Before being ordained, Teilhard spent time teaching in Cairo, which served to enhance his interest in archæology. He was ordained in 1912, served as a stretcher-bearer in World War I and took his final vows in 1918. He was awarded a doctorate in geology in 1922 and, being forbidden to teach in Paris because of his unorthodox views, was sent to China, where he became actively involved in archæological excavations. While not directly involved in the discovery of 'Peking Man', he was involved with the interpretation of the finds (see Chapter 21). During World War II, Teilhard was detained in China by the Japanese, not returning to Paris until 1946. By that time he had written many essays and books, but Rome refused him permission to publish. None of his major works were published during his lifetime.

While others had attempted to predict the possible future direction of *physical* human evolution, Teilhard was concerned with the evolution of the non-material aspect of humans, their minds and, in particular, their capacity for reflection, since he saw this as the one feature which distinguished the human species from any other which exists, had ever existed, or which might exist in the future. It was Teilhard's aim to approach his subject, human evolution, from a position as free as possible from preconceived ideas, religious or secular. In addition to avoiding reference to religion, Teilhard avoided almost all reference to other evolutionary theorists. There were minimal references to Darwin and Lamarck.

Teilhard contended that it was impossible for inert matter to *become* living. Life must be present in some latent manner for it to be able to produce a living cell. Life was latent in inorganic or 'dead' matter. The natural order of things was for degeneration to take place, for carcasses to rot, for vegetable matter to compost, for rocks to wear away and break down. Only in response to 'pressure' from 'life', Teilhard argued, would it have been possible for molecules to form the macromolecules which, in turn, formed the cells which hosted the most basic form of life (Teilhard 1951/1955, 1955/1961, 1956/1966).

Teilhard (1955/1961) held that evolution took place in response to an internal 'pressure' from 'life'. The very shape of the Earth, round, was important. It 'trapped' everything associated with it, preventing anything from expanding indefinitely. Gravity also was important, because gravity exerted pressure on the very substance of the Earth, leading to the formation of compound elements and minerals beneath its surface. Pressure caused elements to combine, forming simple molecules and macromolecules (Teilhard 1955/1961: 49): "The stuff of the universe goes on becoming concentrated into ever more organized forms of matter", a process that Teilhard referred to as 'complexification' (Teilhard 1955/1961: 48). Once 'pressure' had built up to such an extent that life broke through the barrier holding it trapped within 'inanimate' matter, the dam had been breached. The life force was now free to expand, via the biosphere, across the whole surface of the Earth and into the atmosphere as well. While individual expressions of life (species) could disappear, new expressions would constantly be formed.

The physical Earth, itself a sphere, comprised a number of spheres: the barysphere, lithosphere, hydrosphere, atmosphere and stratosphere. Eventually the pressure of 'complexification' caused the life energy to burst forth into a new sphere, the *biosphere* (Teilhard 1955/1961: 68), the sphere of all life, from the most simple to the most complex. Teilhard de Chardin was the first theorist to attempt to incorporate within his theory the evolution of inanimate substances, as well as the very first forms of life. However, he did not do this in detail, only by the painting of a larger picture.

Every living cell had a *Within* (living or spiritual energy) and a *Without* (material form) (Teilhard 1955/1961). The *Within* energy exerted its influence in two directions: *tangentially*, which caused each element to link with others of the same order, and *radially*, which caused greater complexity and centricity. The two energies were balanced. As living matter increased in complexity, it increased in both tangential and radial energy. Radial energy exerted both outwardly and inwardly directed pressure at the same time – since the one form of pressure cannot take place without the other. The inwardly directed pressure led to the evolution of the 'inner person', the thinking, rational, philosophical, spiritual beings that we are today.

Teilhard de Chardin was the first theorist to attempt to incorporate mental and spiritual evolution within his theory. Wallace had been unable to reconcile the development of mental and philosophical abilities within the province of natural selection and had eventually allowed these aspects of humanity to be special creations.

At some point, at the beginning of the hominid line, radial pressure became so strong that it caused another 'dam' to burst and the hominids moved from instinct to reason, operating for the first time within the *noosphere*, Teilhard's term for the 'sphere' of the reasoning mind (Teilhard 1955/61). Although Teilhard believed the Neanderthals were an extinct species with no living descendants, he did believe that they were thinking beings, because they had evolved after the 'break through' into the *noosphere* had occurred.

In the same way that inorganic matter had been 'left behind' once life had manifested as cellular organisms, so other living organisms had been 'left behind' once humans had claimed the *noosphere*. In the same way that inorganic matter had been 'left behind' once life had manifested as cellular organisms, so other living organisms had been 'left behind' once humans had claimed the *noosphere*. For humans, the pressure of evolution operated solely in the *noosphere*. Within the *noosphere,* humanity was not merely leading the evolutionary way, it was the only traveller. The lack of a build up of pressure in the human equivalent of the biosphere explained to him why the human form had changed little since humans became reasoning beings.

Teilhard de Chardin was a respected archæologist, having been working in the Peking area at the time of the discovery of *Peking Man* (see Chapter 21). Although his name is frequently mentioned in the literature, there is no elucidation of his theory. His spiritual approach was not in keeping with that of other archæologists. His evolutionary approach was not in keeping with that of Rome. His courage in writing from an evolutionary perspective while an ordained minister of the Catholic Church, together with Rome's refusal to allow his work to be published during his life time, may have protected him from attacks such as those which were to be launched against Michael Behe (see Chapter 27).

25.3 Punctuated equilibrium

The theory of 'punctuated equilibrium' was the brain-child of two completely different personalities, the punctilious and methodical Niles Eldredge and the outgoing and expansive

Stephen Gould. It was first presented as a paper read at a symposium, the symposium papers later being published in book form (Eldredge and Gould 1972). Gould (2002: 774-775) explained that, when asked to present a paper on speciation, he realized that work being undertaken by his friend and graduate associate, Niles Eldredge, would provide a good basis and asked that they present a joint paper. Gould wrote most of the paper, and coined the term 'punctuated equilibrium', but both were based on Eldredge's work.

Eldredge and Gould (1972) proposed that species remained stable for millions of years and these periods of stasis were punctuated by times of evolutionary change. While stasis may have continued for millions of years, evolutionary change took place comparatively quickly, possibly taking as little as tens of thousands of years. When their paper was published, an impression was given that the periods of change were quite short, leading some to believe that they were proposing some form of macro-evolution. This Eldridge denied (Eldredge 1979, 1985a, 1985b, 1991a, 1991b, 1995, 1999).

Misunderstanding regarding punctuated equilibrium was due in part to the fact that Eldredge and Gould themselves appeared not to be completely at one on this point. Eldredge insisted that periods of stasis were punctuated by episodes of evolution which *appeared* swift or sudden in the geological record but which had actually taken place over thousands, if not millions, of years (Eldredge 1979, 1985a, 1985b, 1991a, 1991b, 1995, 1999), whereas Gould (1977) at times seemed to imply that saltation had occurred. By the time punctuated equilibrium 'came of age' twenty-one years later, Eldredge's view that punctuated equilibrium was never meant as a saltational theory had prevailed (Eldredge and Gould 1993).

25.4 Eldredge's contribution

Once the theory of punctuated equilibrium had been launched, Gould appeared to take little further interest in it, whereas it continued to form the basis of Eldredge's future work (Eldredge 1979, 1985a, 1985b, 1991a, 1991b, 1995, 1999). Eldredge became as interested in the reason for the extinction of existing species as he was in the evolution of new ones. He concluded (Eldredge 1991b) that extinctions occurred after periods of global cooling (ice ages). Following major, or mass, extinctions there were periods of diversification, which took place as temperatures rose.

A major cooling event occurred 6.5-5 mya (Kennet 1995: 54), the time at which the human line is generally believed to have diversified from that of the chimpanzee. This was followed by a period of significant warming *circa* 5-3 mya (Kennet 1995: 54), during which time Vrba noted that pigs, monkeys and giraffids, dependent upon wooded environments, first appeared (Vrba 1995: 34). Of interest is the late arrival of monkeys in the fossil record, which appeared about the same time as the chimpanzees and *Australopithecines.*

A cooler period occurred 2.7-2.4 mya (Vrba 1995: 34). This time saw the disappearance of the *Australopithecines* in favour of *Homo habilis*, if *H. habilis* is to be considered as distinct from the *Australopithecines.* There was another period of cooling about a million years later, *circa* 1.6 mya (Eldredge 1991a: 188) at the time that *Homo erectus* became established. Vrba (1995: 406) concluded to her own satisfaction that climate change had been a significant factor in human evolution but was of the opinion that there were insufficient human remains for any definitive conclusion to be drawn.

Of interest was another 'explosion' in mammalian life which occurred in Africa during the Lower Pleistocene. The leopard and the cheetah both appeared between 2-1.6 mya and the lion a little later, about 1.5 mya (Walker 1984: 142-143), at about the same time as *H. Erectus.* Clearly the hominoid line was not the only one undergoing rapid change between 2-1.5 mya.

One climatic event not mentioned by Vrba was the very warm interglacial which occurred about 120,000 ya, the time by which *H. erectus* is believed finally to have been transformed into early *Homo sapiens.* It was at this time that the Neanderthals started to evolve into their well-documented form.

25.5 Gould's contribution

The only solo contribution made by Gould to the subject of punctuated equilibrium, entitled *The Return of the Hopeful Monster* (Gould 1977), served to confuse the issue rather than clarify it. Gould found his niche publishing, over a period of years, monthly articles that were later published in a series of books, in which he explored all manner of weird, wonderful and controversial topics, most, but by no means all, of which had some connection with evolution. Like Eldredge (1985a: 46), Gould (1991: 144) was critical of 'facile Just-So' stories invented to explain certain adaptations, yet he made the 'Just-so' story his style of writing for twenty years. Gould (1991: 297-305) was guilty of suggesting one of the strangest 'Just-So' stories of all.

In November, 1973, two Australian scientists discovered a species of frog *(Rheobatrachus silos)* which swallowed its eggs. The eggs developed in the stomach of the female until she gave birth to juvenile frogs through her mouth after some eighteen days (Gould 1991: 297-298). Later a second species *(R. vitellimus)* was found which did the same thing. The female's normal digestive enzymes were suppressed during this time, due to the presence of prostaglandins. The presence of prostaglandin could not be the result of 'foresight' in anticipation of this particular adaptation, since natural selection is random and does not allow 'foresight'. (Gould 1991: 304) explained:

> One cannot seriously believe that ancestral eggs actively evolved prostaglandin because they knew that millions of years in the future a mother would swallow them and they would need some inhibitor of gastric secretion … Prostaglandin provided a lucky break … a

> historical precondition fortuitously available at the right moment … a female *Rheobatrachus* must have swallowed its fertilized eggs (presumably taking them for food, not with the foresight of evolutionary innovation) – and the fortuitous presence of prostaglandin suppressed digestion and permitted the eggs to develop in their mother's stomach.

It is difficult to believe that Gould was seriously suggesting that forever after one female frog accidentally swallowed its own eggs, all female *Rheobatrachus* would reproduce by this new method? But if not, what was the point of suggesting this scenario at all? Even allowing for the fact that the original article was intended for general reading, it is difficult to understand how a serious scientist could have offered such a piece of writing to be published under his name, let alone allow it to be reproduced, along with his other articles, in book form (Gould 1991).

While Eldredge was generally circumspect in his criticism of opinions which differed from his own, Gould, writing for a more general audience, allowed himself a freer rein. He referred to Creationists as 'Yahoos' on at least three occasions (Gould 1991: 156, 417, 427). On two of these occasions, he was referring to William Jennings Bryan, the lawyer who led the prosecution in the Scopes trial, an eminent man who had three times run for the presidency of the United States (see Chapter 15). The word 'Yahoo' was introduced by Jonathan Swift (1735/1961) in his famous work *Gulliver's Travels.* The Yahoos were a degenerate type of creature bearing some resemblance to humans, parts of their bodies being covered with frizzled or lank hair. 'Gulliver' described the Yahoos as filthy, odious and abominable creatures, attributing their flat broad noses to their practice of allowing their infants to lie groveling in the dirt. They were the most unteachable of all brutes.

With hindsight, it seems surprising that, even within the light-hearted, humorous approach to evolutionary theory afforded Gould by his writing of feature articles, that any reputable scientist could so overtly denigrate other theorists. Fortunately for his memory, shortly before he died he wrote a lengthy, scholarly work, *The Structure of Evolutionary Theory* (Gould 2002), which ran to some 1100 pages, free from witticisms.

25.6 Richard Dawkins (1944-)

While Gould was the most well-known evolutionary theorist on one side of the Atlantic, Dawkins was the best known on the other. As had Gould, Richard Dawkins found that writing books for the general public allowed him the freedom to express his views without the restraints imposed by supporting these views with scientific data which would have been required for publication in a scientific journal. Dawkins was a prolific writer with great popular appeal. His frequent appearances in television documentaries on the subject of nature, as well as those specifically dealing with evolution, made him one of the most influential authorities on the subject of evolution since Darwin himself. Dawkin's first book,*The Selfish Gene,* (Dawkins 1976) caught the public attention in a way that the work of other writers on a similar topic had not. From the outset, Dawkins used a form of ridicule to dismiss the work of other writers, describing their work as "totally and utterly wrong" (Dawkins 1976: 2) and "wrong, gloriously and utterly wrong" (Dawkins 1986: 5). By the time he wrote *The God Delusion* (Dawkins 2006), Dawkins had progressed so far as to call all people who did not hold his atheistic beliefs "delusional". The popularity of his many books elevated his status to one of authority, although he was writing outside his area of expertise, he not being a geneticist. Frequent mention of his association with the University of Oxford was used to enhance his status and authority. That his work received the recognition that it did was evidence of the degree of dominance which the paradigm of natural selection by gradualism without plan or purpose had achieved.

Hamilton (1964) had been the first writer since Weismann to redirect attention towards the gene itself as a unit of selection. Williams (1966/1992: 187-188) had noted that among many herding mammals, an orphan trying to suckle from another female was rejected, although in obvious distress. It seemed these mammals were more concerned with the survival of their genes than they were with the survival of the species. Wilson (1975: 3-4) took an opposite view. He argued that kinship encouraged altruistic behaviour between two organisms of common descent. The survival of the group, which he termed *Sociobiology*, was of more importance than the survival of the individual. Nevertheless, Wilson (1975: 3) wrote:

> In a Darwinist sense the organism does not live for itself … Its primary function is not even to reproduce other organisms; it reproduces genes and it serves as their temporary carrier … the individual organism is only their vehicle … the organism is only DNA's way of making more DNA.

These were ideas which Richard Dawkins had been including in lectures at Berkeley, California, during the late 1960s and which he was planning to publish in book form (Brown 1999: 26-27).

25.7 *The Selfish Gene*

Dawkins' concept of the selfish gene caught the attention of the public and the profession alike. He (1976: 1) started by advising his reader to approach his book as though it were science fiction, that talking about genes as if they had conscious aims was a linguistic ploy which could be changed into "respectable terms if we wanted to". Dawkins never did and used the same licence in all his books. Previous authors, Dawkins (1976: 2) claimed, had "got it totally and utterly wrong" when they "made the erroneous assumption that the important thing in evolution was the good of the species (or group) rather than that of the individual (or the gene)". He explained that the predominant quality to be expected in a successful gene was ruthless selfishness and that selfishness in the gene would usually give rise to selfishness in individual behaviour, although this selfishness was sometimes best served by a limited degree of altruism (Dawkins 1986: 2).

The original replicator was some form of DNA or RNA, which only needed to arise once since its novel characteristic was its ability to replicate itself (Dawkins 1976: 16, 2004: 470). Replicators increased their own success by constructing containers, "*survival machines* for themselves to live in … They are in you and me, body and mind ... they go by the name of genes, and we are their survival machines" (Dawkins 1976: 21. Italics in original). The need to simulate possible scenarios culminated in the evolution of consciousness (Dawkins 1976: 63). Genes exerted ultimate power over behaviour (Dawkins 1976: 64). Expressed in different terms, this was the same position as that taken by Clarence Darrow in defence of the two teenage boys who killed a younger child 'for fun' (see Chapter 15).

Sometimes a gene promoted its own survival by promoting the welfare of another 'vehicle' containing the same gene (Dawkins 1976: 95):

> The albino gene should be quite happy if some of the bodies which it inhabits die, provided that in doing so they help other bodies containing the same gene to survive. If the albino gene could make one of its bodies save the lives of ten albino bodies, then even the death of the altruist is simply compensated by the increased numbers of albino genes in the pool.

Dawkins did not explain how an albino gene in one vehicle was aware that it was sacrificing itself for the welfare of albino genes in other (more numerous) vehicles.

Dawkins advocated Darwinian gradualism (Dawkins 1986: 85): "No matter how improbable it is that an X [a certain feature] could have arisen from a Y in a single step, it is always possible to conceive of a series of infinitesimally graded intermediates between them". An inability to conceive an infinitely small progression was a failure of the imagination, not of the theory.

A similar opinion was promoted by the geneticist, Steve Jones (1999), who also held that natural selection acted through DNA, rather than the flesh of those that bear it, kinship sometimes leading an individual to reduce its own chances if such behaviour improved the prospects of other members of its family (Jones 1999: 171).

25.8 Macro-evolution

Dawkins generally maintained Darwin's position that all evolution took place gradually, but admitted that there may be "special occasions when macroevolutions are incorporated into evolution" (Dawkins 2003: 86). Dawkins defined macro-mutation (macro-evolution) as "change in a single generation" but nevertheless considered all change gradual, even that which was punctuational (Dawkins 1996: 93) because of the co-operative nature of genetic activity, through the influence of Hox genes (Jones 2002), during development of the embryo. As his example of macro-evolution, Dawkins chose the different number of vertebræ in various species of snake, which vary between 200 and 350. When a species of snake gained (or lost) one or more vertebral segments, that was macro-mutation (Dawkins

1996: 93). Dawkins (2004: 502) admitted that it was difficult to imagine how the first creature having two segments instead of one could have survived, let alone found a mate and reproduced, but "it evidently happened".

25.9 Religion

By the turn of the $20^{th}/21^{st}$ century, personal ideological views were not merely intruding as if by accident (for example Levins and Lewontin 1985), evolutionary arguments became the vehicle for their promotion (for example Behe 1996, 2004; Dembski and Ruse 2004; Dawkins 2006). Religion, or its lack, had never been far beneath the surface of evolutionary debate. While Creationist writers had always publicized their position, other writers traditionally endeavoured to hide their personal views behind a cloak of neutrality as was deemed seemly in scientific writings. Dawkins had never hidden his ideological position and became one of the most outspoken critics of all things 'supernatural' (Dawkins 2006). Dawkins (2006: 36) made his position clear:

> I decry supernaturalism in all its forms … I am not attacking any particular version of God or gods. I am attacking God, all gods, anything and everything supernatural, wherever and whenever they have been or will be invented.

Dawkins (1996: 4, 208) maintained that people who thought they saw evidence of purposeful design in nature were "wrong" and that "All questions about life have the same answer … natural selection". In the same way that Paley had developed his argument to support the existence of God, Dawkins developed his to prove God's non-existence.

Referring to Paley's famous argument in favour of the existence of God based upon the existence of the eye, Dawkins (1986: 5) wrote:

> Paley's argument is made with passionate sincerity … but it is wrong, gloriously and utterly wrong … A true watchmaker has foresight: he designs … with a future purpose in his mind's eye. Natural selection, the blind, unconscious, automatic process which Darwin discovered, and which we now know is the explanation for the existence and apparently purposeful form of all life, has no purpose in mind. It has no mind and no mind's eye. It does not plan for the future. It has no vision, no foresight, no sight at all.

Dawkins' opinion was expressed with an equally passionate sincerity, but, while it may have *disagreed* with Paley's position, it did not *disprove* it.

25.10 Statistics of evolution

However statistically unlikely it was that a certain factor, or series of factors, would occur such that life, as we know it, could evolve, the fact that it had evolved showed that life was 'statistically' probable, however long the odds (Dawkins 2006: 137-138, 139):

> It is estimated that there are between 1 billion and 30 billion planets in our galaxy and about 100 billion galaxies in the universe … A billion billion is a conservative estimate of the number of available planets in the universe. Now suppose the origin of life, the spontaneous arising of something equivalent to DNA, really was a quite staggeringly

> improbable event. Suppose it was so improbable as to occur on only one in a billion planets … life will still have arisen on a billion planets … a chemical model need only predict that life will arise on *one* planet in a billion to give us a good and entirely satisfying explanation for the presence of life here.

Dawkins (2006: 139) continued:

> This statistical argument completely demolishes any suggestion that we should postulate design to fill the gap … Even so big a gap as this [origin of life] is easily filled by statistically informed science, while the very same statistical science rules out a divine creator

Dawkins (2006: 139-141) then gave the following explanation for the origin of life:

> The origin of life was (or could have been) a unique event which had to happen only once … We can deal with the unique origin of life by postulating a very large number of planetary opportunities. Once that initial stroke of luck has been granted … natural selection takes over … Nevertheless, it may be that the origin of life is not the only major gap in the evolutionary story bridged by sheer luck … The origin of the eukaryotic cell … was an even more momentous, difficult and statistically improbable step than the origin of life. The origin of consciousness might be another major gap whose bridging was of the same order of improbability.
>
> … Natural selection … needs some luck to get started … Maybe a few later gaps in the evolutionary story also need major infusions of luck … But whatever else may be said, *design* does not work as an explanation for life. [Italics in original]

25.11 Summary of positions

Teilhard followed what he believed was the course of evolution from a framework which put life (spirit) first. He believed that humans were not the centre of Creation, as had been claimed in earlier times, but the forefront. Humans were not the leader, because no other creature would be able to follow in our path, but the unique result of an evolutionary process whose aim had always been the evolution of the mind.

Teilhard's approach was that of 'discontinuity'. As each form broke through the barrier of the sphere containing it (barysphere, lithosphere, hydrosphere, atmosphere and stratosphere, eventually into the noosphere), it was separated from the forms remaining in the earlier sphere(s). No form could later follow. Evolution took place only of the form(s) which had broken through into the new sphere, that sphere currently being the noosphere. Only the human mind was now evolving.

Eldredge (1995) had started his research looking for evidence of evolutionary change in trilobites, which he failed to find over long periods of time. He came to realize that it was the *lack* of change over vast periods of time that was significant. While he still claimed evolutionary change to be gradual, he did not see evolutionary change as being *continual.* While the theory of punctuated equilibrium excited debate for some years, once the gradualness of the change being proposed became apparent, it was not seen to add anything very much to the understanding of evolution. Change depended upon changed environment, a concept which was already well established. Eldredge's position became integrated within that of classical Neo-Darwinism.

Gould found an opening writing for the general public which gave him freedom to express his unique points of view under the cover of humour. Despite, or because of (?), this style of writing, Stephen J. Gould became one of the best known writers on evolution. His monthly articles were reprinted annually in book form. Some of the 'Just-so' scenarios that he presented were so ludicrous that it might be thought that it was his intention to discredit evolution, but this was not the case (see 25.5, above). He used humour to reach a general public which might otherwise not have been interested in the subject matter of his articles. It was the Creationists he was ridiculing. His final contribution (Gould 2002) showed that he upheld the standard Neo-Darwinist position of gradual change through natural causes without Divine intervention.

The position taken by Dawkins epitomized that of extreme Neo-Darwinism. He supported gradual evolution and denied any form of superior intelligence. His position was the exact reverse of that of Teilhard who held that evolution was discontinuous and operated under the guidance of God. Like Gould, Dawkins used humour/sarcasm to dismiss the opinions held by perceived adversaries. Eldredge, Gould and Dawkins were all Neo-Darwinists; only Teilhard believed in a Superior Being.

Part V

RAMIFICATIONS

Beyond 2000
Truth - the Daughter of Time?

Chapter 26

New finds and new findings

26.1 Introduction

The first half of the 20th century had been marked by a flurry of finds of Neanderthal bones, mostly in France, but earlier bones, clearly human, had also been found elsewhere in Europe. The second half of the 20th century saw a reduction in the number of European finds which was compensated for by an increase in finds in Africa, especially by Louis Leakey and his team in Kenya. This trend continued into the beginning of the 21st century. In addition to *H. idaltu*, already mentioned, other finds from far earlier times were filling in the gaps in our story, much as expected. *Ardipithecus ramidus kadabba* from Ethiopia, dated to over five million ya (Wong 2003; Leakey and Walker 2003), *Orrorin tugenensis* from Kenya dated to approximately six million ya and *Sahelanthropus tchandesis* dated to nearly seven million ya, (Pickford et al. 2002) all showed mosaics of human and chimpanzee features. Perhaps it would be more correct to say that they are presumed to show a mosaic of chimpanzee and human features, because no chimpanzee fossil remains from these times have been found. We do not actually know what chimpanzees were like at this time, assuming they existed at all.

Fossils were now being interpreted in the light of advancing science, especially in the field of DNA analysis

26.2 Neanderthal mtDNA

Towards the turn of the century, sequencing of Neanderthal mtDNA was attempted. This was not without difficulties, due to the amount of handling specimens have received. It was considered expedient for all modern mtDNA recovered during this work to be considered 'contamination'; only residual mtDNA, not found in modern humans, could definitively be considered endemic to the Neanderthals (Krings et al. 1997; Krings et al. 2000; White et al. 2003; Green et al. 2006). Krings et al. (1997) first isolated mtDNA from the original Neanderthal type specimen, now referred to as Feldhofer, and calculated that Neanderthals had evolved separately from modern humans for between 550,000 and 690,000 years. However, they did caution that, while their results indicated that Neanderthals had not contributed mtDNA to modern humans, it could not therefore be assumed that they did not contribute nuclear DNA. Since any 'modern mtDNA had been eliminated from their study, their results were not unexpected.

A second mtDNA sequence from a Neanderthal child from the Mezmaiskaya Cave in the Northern Caucasus, dated to ~42,000 BP, was found to be similar to that of the type specimen (Krings et al. 2000). Krings et al. (2000) found that this DNA was no more similar to that of modern humans from Europe than it was to DNA from any other part of the world, strengthening their belief that the Neanderthal population had been an isolated one. However, they did repeat their caution in regard to extrapolating from mtDNA to nuclear DNA, reiterating that Neanderthals may have contributed to the contemporary human gene pool in a way not shown by mtDNA.

Ovchinnikov et al. (2000) undertook a further analysis of the Neanderthal mtDNA from Mezmaiskaya Cave, which they reported had been reliably dated to ~29,000 BP, making it one of the latest known Neanderthals. They estimated that divergence from modern humans had occurred between 365,000 and 853,000 BP and further estimated that the most recent common ancestor of the eastern (their sample) and western (Feldhofer specimen) Neanderthal lived between 151,000-352,000 years ago (Ovchinnikov et al. 2000). This is a long time for genetic isolation over what is quite a small geographical area and would indicate that the Neanderthals were very insular. Hawks and Wolpoff (2001) believed the Mezmaiskaya Cave burial to have been intrusive, since the remains dated to 29,000 ya but were found in a Mousterian layer with animal bones dated to >45,000 ya. They argued that the child had few Neanderthal features and any similarity of mtDNA with that of the Neanderthals argued more strongly for the occurrence of interbreeding than it did for the Neanderthal population having been an isolated one, as claimed by Krings et al. (2000) and Ovchinnikov et al. (2000).

26.3 Further Neanderthal DNA analysis

An attempt was made to retrieve DNA from eleven Neanderthals from central Europe. Contamination with modern DNA was found in amounts varying between 99% and 1%, the 1% being that of one of the bones dated to 38,000 BP from the Vindija Cave, Croatia (Green et al. 2006). This one bone was used for further analysis. The estimated time of divergence of the Neanderthals from archaic humans was found to be between 461,000 and 825,000 years (Green et al. 2006: 322). The ancestral population was estimated between 0 and 12,000 persons (Green et al. 2006: 325). They concluded that their results could suggest gene flow between modern humans and Neanderthals (Green et al. 2006: 325). The conclusion that some interbreeding had taken place between the Neanderthals and the newly arrived Cro-Magnon people (*Homo sapiens*) was confirmed by Green et al. (2010).

Genetic research had shown that at least fifteen different groups of people had populated Australia, all of African origin (Jones 1993), but there was no clear scientific evidence that any of the Aboriginal people living in Australia today were direct descendants of the first arrivals. Archaic *H. sapiens* were assumed to be incapable of building and navigating an ocean-going watercraft, leading to the conclusion that the first arrivals in Australia were modern *H. sapiens* but DNA analysis of a 60,000 year old skeleton from Lake Mungo, New South Wales, raised some doubts.

26.4 The continuing Australian story

Adcock et al. (2001) analysed the mtDNA of ten ancient skeletal remains from Australia – a Pleistocene (gracile) skeleton from Lake Mungo, western New South Wales, known as LM3 dated to 60,000 BP (Thorne et al. 1999; Grün et al. 2000), three Holocene (robust) skeletons also from Lake Mungo and six individuals from Kow Swamp, Victoria, dated to 13,000 to 9,000 BP. The robust morphology of the Kow Swamp individuals was outside the range found among modern Australian Aborigines. However, their mtDNA was not. In contrast, mtDNA analysis showed that the sequence from gracile LM3 (60,000 BP) and one of the robust Kow Swamp fossils (KS8) resembled that of Feldhofer, the Neanderthal type specimen, analysed by Krings et al. (1997), all belonging to a lineage which had diverged from that of modern humans prior to the time of their most recent common ancestor, at least 150,000 years ago, possibly far longer.

Adcock et al. (2001: 540) felt that the data relating to KS8 was insecure and thus did not pursue a claim for a separate lineage for KS8 but did conclude that mtDNA and nuclear DNA, as evidenced by anatomical features, may have different evolutionary paths (Adcock et al. 2001: 542). This difference would limit the use of ancient DNA in tracing human evolutionary history (Adcock et al. 2001: 542). Thus the work of Krings et al. (1997) which showed that mtDNA extracted from the Neanderthal type specimen was outside modern human mtDNA variation, and that of White et al. (2003) which supported an early divergence of the Neanderthal line from that of modern humans, did not mean that the Neanderthals did not contribute other genetic material to the modern human gene pool.

While it was a surprise that the remains of LM3 were dated to 60,000 BP, it was generally accepted that this man from Lake Mungo was anatomically modern (Stringer and McKie 1996: 110). If this assumption is correct and the LM3 mtDNA does show that he belonged to a lineage which diverged *before* the time of our most recent common ancestor (150,000 or more years ago), then mtDNA of a type distinct from that of modern *H. sapiens* is not evidence of a separation of species. Just because the mtDNA of LM3 indicates descent from an ancestor who lived 150,000 or more years ago, it cannot be assumed that human occupation of Australia took place 150,000 years ago. No conclusions can be drawn as to migration patterns from mtDNA alone.

It is politically correct to assume that all human remains found in Australia are ancestral to current Aboriginal people, different mtDNA notwithstanding, and on the basis of this early dating, as well as of lithic remains found in northern Australia dated to 50,000 ya (Roberts et al. 1990), it was claimed that Australian Aborigines had occupied Australia for some 60,000 years. More recent authors, such as Finlayson (2010) now suggest a more recent date (45 ,000-50,000 ya), without making reference to the LM3 remains. If the different mtDNA of LM3 were accepted as 'modern' on the grounds that mutations would have occurred over the intervening time, is there any reason for denying that mutations may account for the differences observed between Neanderthals and modern human mtDNA? The work of Green et al. (2010) would indicate not. The similarity between the mtDNA of the Kow Swamp fossil, KS8, and the Neanderthal type specimen, Feldhofer, is of particular relevance in this regard. 'Modern' humans could have arrived in Australia before they arrived in Europe. As noted earlier, there are no definitive fossil remains of Cro-Magnon people before about 30,000 BP.

An obvious exercise, if it were possible, would be the comparison of DNA from Neanderthals and LM3 with that of the Cro-Magnon remains. Stringer and Davies (2001: 792) commented that it had not been possible to extract the necessary DNA from any Cro-Magnon but, even if that were to be achieved "it will be far trickier to tell whether Cro-Magnon, as opposed to Neanderthal DNA, is contaminated with our own DNA", implying that Cro-Magnon DNA would be closer to that of modern humans and therefore less able to be distinguished – which surely is to be proven, not assumed? DNA from the Abrigo do Lagar Vehlo remains, dated to ~25,000 BP, which show a mosaic of Neanderthal and early modern features (Trinkaus et al. 2001) would also be of great interest.

It was becoming apparent that the Multiregional model of human evolution, supported almost solely for about thirty years by Alan Thorne from Canberra and Milford Wolpoff from Michigan, may, in fact, have been correct, that people of European descent do carry Neanderthal DNA in their genes (Adcock et al. 2001; Green et al. 2006; Green et al. 2010).

26.5 Hobbits

In October 2004, the discovery was announced of a female hominine skeleton on the island of Flores, which was named *Homo floresiensis.* This female was very small, being only about one metre tall, with a cranial capacity of 380cm² (Brown et al. 2004). A second article, co-authored by fourteen people, gave an account of the context of the find and its implications (Morwood et al. 2004).

Having satisfied themselves that these remains were not those of an exceptionally small *H. sapiens*, pathological or not, Brown et al. (2004) and Morwood et al. (2004) suggested that these were the remains of a descendant of *H. erectus.*

The following October, four more articles relating to Flores appeared in *Nature*, Morwood et al. (2005), Dalton (2005), Kemp (2005) and Lieberman (2005) announcing further finds. Further work was carried out on the *H. floresiensis* wrist bones (Tocheri et al. 2007) which found that the wrist bones of *H. floresiensis* were descended from a hominine ancestor that migrated out of Africa before the evolution of the wrist morphology shared by *H. erectus*, the Neanderthals and *H. sapiens.* That no similar remains have ever been found anywhere else may be accounted for by the depth at which the Flores remains were found, six or more metres, compared with the African fossils, which were found quite close to the surface, or protruding from rock escarpments.

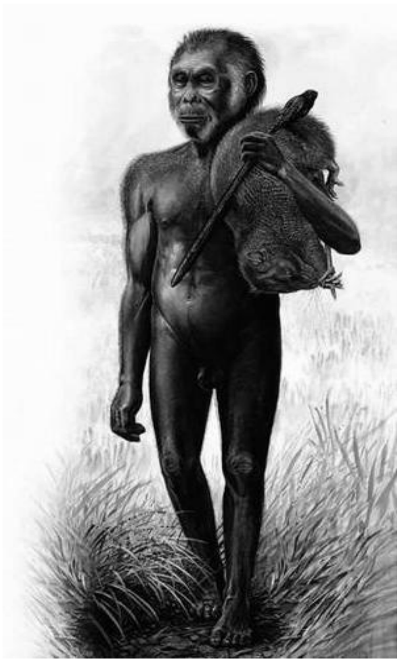

Fig.26.1 Illustration of male 'Hobbit'
(from Kemp 2004: 555)

Flores lies east of the Wallace line. These people must have arrived by sea. The sophistication of the stone tools, the use of fire and the use of watercraft, all fall within expectations for humans living between 12,000 and 38,000 ya (the dates of the Flores remains) (Brown et al. 2004; Morwood et al. 2004; Morwood et al. 2005). However, lithic evidence of occupation of Flores as early as 840,000 ya stretched the time at which our ancestors first used watercraft considerably further back than had been assumed to account for the arrival of people in Australia/New guinea, which was estimated at not more than 60,000 years. Now the possibility was being raised that, not merely a *H. erectus*, but an earlier Australopithecine-type people had crossed the sea into Flores. Furthermore, these Australopithecine- type people had retained their small cranial capacity for nearly a further two million years after they had been thought to be extinct, and they, with this tiny brain capacity, had produced tools and controlled the use of fire, in a way commensurate with other stone tool cultures surviving into the nineteenth/twentieth centuries.

On a light-hearted, but nevertheless serious, note, Kemp (2004) drew attention to a further example of prejudice. To coincide with the publication of the first find in October, 2004, a 'portrait' had been prepared of "The Hobbit". It showed a small man returning from a successful hunt (Fig. 26.1). Kemp pointed out that early women were rarely depicted in such illustrations, unless in a family context. In this case, the prejudice was particularly blatant, since the original Flores find was that of a female.

Coon (1962: 112) in a footnote, mentioned that two Dutch anthropologists had in 1955 found six or more fossil skeletons of small people in a cave in the island of Flores. Were these also Hobbits?

26.6 Methodological naturalism

While geneticists were continuing their work in the laboratory and archæologists were continuing their work in the field, evolutionary theorists were continuing their debates on paper. 'Methodological naturalism' (Ruse 2006: 48) was defined as "the working assumption that all physical events can and must be explained by laws". By "laws" were meant Natural Law, not God's Law. In an attempt to explain the origin of life (organic matter) by this means without recourse to the concept of spontaneous generation, Ruse (2006: 66-67) maintained:

> Life is not dead material plus something else. Life is better thought of as a matter of organization and functioning ... No one today thinks that spontaneous generation is plausible ... with the shift from thinking of life as implying vital forces to seeing it as implying organization ... [i]t is the order itself that is important, and all scientists concur on this.

Scientists have been unsuccessful in 'creating' life in the laboratory. From the above, it would seem that (some) scientists have attempted to redefine 'life' rather than to admit that something once happened billions of years ago which cannot happen today, even in a laboratory. If 'life' is not seen as having come into being by 'an Act of God' or by spontaneous generation under 'Natural Law', perhaps redefining 'life' is the best solution to a difficult problem.

There is general agreement that for life to be considered to be present, there must be the ability to replicate. Attention has turned from viruses to viroids to DNA and RNA, and even crystals (Hollick 2006; Ruse 2006). DNA and RNA are crystalline substances (Hollick 2006) and crystals are known to have a specific affinity for energy, as shown by the crystal radio and the silicon chip. However, DNA and RNA cannot replicate in the absence of some form of protein/nucleic acid 'envelope' and proteins/nucleic acids cannot replicate without RNA/DNA. How the two distinct elements came to work together in this very special way is still a mystery (Ruse 2006: 64-65).

Ruse was undoubtedly correct in stating that no scientist today believes in the spontaneous generation of 'worms' and other small creatures, such as mice. Nevertheless, attempts to produce life from its smallest known component accords with the Lamarckian belief that life will materialize in its smallest components, if the correct conditions are present. Lamarck believed these components to be mucilaginous/gelatinous material, not 'warm mud' as stated by Ruse (2006: 59). Astrobiologists, who ardently examine any matter available to them from outer space, be it from meteorites or rocks brought back from the Moon, to see if there is any nucleic acid/protein present, do so in the belief that if early Earth-like conditions were once replicated elsewhere in the Universe, then life could, and probably would, have been produced. This could be called 'Universal' spontaneous generation as distinct from 'Particular' spontaneous generation, such as Lamarck suggested had occurred when a frozen pond thawed in Spring. Whatever its name, the process of 'Universal' spontaneous generation can be incorporated into the philosophical beliefs of theists and atheists alike.

While admitting that scientists still have a long way to go in their quest to form life in the laboratory (Ruse 2006: 68), Ruse (2006: 71) denied that it was unscientific to rely on results which had not yet been achieved: "The researchers' conviction that answers will come – that naturalistic answers will come – is not misplaced ... There are Nobel prizes to be won. The critics and naysayers are wrong." Ruse (2006) was expressing 'faith' in his naturalistic philosophy, which he is as entitled to do as is a person expressing faith in a theistic position.

26.7 Molecular homology

Early evolutionary theorists made much of 'archetypes', the six legs of all insects, the four limbs of all vertebrates. Later they were able to draw support for their theories by the realization that, during their embryonic stage, mammals have gills before they develop lungs, a sure indication that we once all lived in water. Now 'molecular homology' creates a link between life forms as disparate as humans and fruit flies, since all incorporate DNA (Ruse 2006: 138). The extension to this line of thinking would be that *all* life forms, plant as well as animal, came from the one original source.

If life (organization) started but once, could this be regarded as 'Universal' spontaneous generation, or methodological naturalism, both of which assume that if conditions are replicated, the same results will be obtained, in accordance with Law? If the necessary conditions occurred but once, if life (DNA) started but once, is this not a 'Special' event? This concept can be incorporated into theistic belief (God's Law) but is not so easily accommodated into atheistic belief (Natural Law) since there seems to be very little ‘natural’ about what would appear to be a ‘once only’ ‘Special’ event.

26.8 Confused position

Within the field, archæologists were still identifying differences inasmuch as they were creating new nomenclatures for each new find separated by either time or place from previous finds. In so doing, they implied speciation. At the same time, some of their written reports were denying speciation. If *Homo floresiensis* was either a dwarfed form of *Homo erectus* or a late surviving branch of *Homo habilis*, then should not these remains have been named either *H. erectus floresiensis* or *H. habilis floresiensis*? The finding of these remains south of the Wallace line had implications for a continuity of mental development reaching far further back in time than had previously been considered.

Despite initial claims that DNA analysis differentiated between the Neanderthals and modern humans at a species level, later work confirmed that there had been interbreeding between Neanderthals and *H. sapiens*, once again showing an unexpected degree of continuity, unexpected, at least, by recent writers, although some continuity had been accepted by earlier theorists.

The insistence by some theorists on approaching evolution solely from a secular/atheistic position was creating difficulties with the definition of ‘life’ itself. Spontaneous generation within the law of nature was rejected by them, as was special creation by some unknown force or energy.

In view of this confusion, it was not surprising that there was another attempt to re-introduce the concept of some unknown force or energy, be that force or energy known as ‘God’ or by any other name, into the evolutionary debate.

Chapter 27

The Trial at Dover

27.1 Reversing Scopes

The conclusion of the trial of John Scopes in 1925 (see Chapter 16) was perceived to be an occasion in which everybody had won. Bryan had achieved the result he wanted: the law which had been passed had been upheld. The doctrine that humans had descended from a lower form of animal would not be permitted to be taught in public schools within the State of Tennessee. Bryan may have been exhausted, but one may think he died a happy man. The American Civil Liberties Union had achieved the result it wanted: a conviction that it intended to appeal and which appeal it was confident would lead to the removal of the law from the statute books. Judge Raulston was happy because he had achieved the publicity he was seeking before standing for re-election and George Rappelyea had seen thousands of people flock to Dayton and had, no doubt, reaped a sizable reward for his financial outlay.

The overturning of the verdict on a technicality (see Section 15.7) had a profound effect. There was no appeal and the statute remained unchanged. Evolution remained a proscribed subject within Tennessee public schools and many other parts of America.

27.2 Aftermath

A comprehensive analysis was made by Grabiner and Miller (1974) of the effect which the Scopes trial had on education in America. They contended that an impression had been given in the general literature that the Dayton trial had resulted in a *de facto* victory for the evolutionists, which they concluded was not the case. They undertook an extensive analysis of the text books used in public schools in America both before and after the trial and found that the teaching of evolution at high schools had *declined* after the trial.

Before 1925, school text books generally contained a short introduction to Darwin's theory, such as that contained in the text book used at Dayton High. After the trial, the word 'evolution' disappeared from the indexes and glossaries, replaced in some cases by the world 'development' or 'change'. Grabiner and Miller (1974) stressed that the books they reviewed were not specially 'expurgated' text books for use in southern schools, but were those in use throughout America, including New York State. Not only had the evolutionists' lobby lost at Dayton "they did not even know they had lost" (Grabiner and Miller 1974: 836).

Grabiner and Miller (1974) drew attention to an unexpected long-term consequence of the Dayton trial. After the Second World War, many German scientists earned immunity from prosecution for War Crimes by agreeing to work for either the Russians or the Americans. By the 1960s, most of these scientists were coming to the end of their careers. Russia had beaten America in the race to put the first satellite into space. The Americans feared they were slipping behind in the training of their future scientists and undertook a review of the state school science curriculum, which included a review of biology. It was clear that if new biology texts, which included evolution, were to be approved for use in state schools, the legislation enacted in several states during the 1920s would have to be repealed.

27.3 Creationism defined

In 1968, following a court case in Arkansas, the U.S. Supreme Court ruled that the prohibition of the teaching of evolution was unconstitutional because it arose from a conflict with a particular religious doctrine (Scott 2004: 104). Creationists responded that their children should not be required to be taught something (evolution) which conflicted with their core beliefs. Their children were not only required to attend such classes but to answer examination questions professing something in which they did not believe, in order to acquire a pass mark in the subject (Numbers 1982). If the teaching of evolution could no longer be prevented, then, they reasoned, equal time should be given to the presentation of an alternative view (Numbers 1982; Scott 2004).

By the early 1980s, twenty-seven states had introduced 'equal time' legislation, most of which was rejected, Arkansas and Louisiana being the exceptions (Shapiro 1986; Scott 2004). Their legislation was overturned by the Supreme Court, the Arkansas case being heard first and, having been decided, the Louisiana case was but a formality.

The Arkansas legislation had called for equal time to be given to Evolution Science and Creation Science and these two sciences had needed to be defined This had been done in six points. Those for Creation Science included sudden creation of the Universe, relatively recent appearance of the Earth (within the last 10,000 years) and the insufficiency of natural selection to account for the development of all living things from a single cell. Evolution Science was defined by the same points in reverse (Scott 2004: 107), the Universe had achieved its current state over an extended period of time, Earth had come into existence (considerably) more than 10,000 years ago and natural selection was sufficient to account for all evolutionary change.

27.4 Religion and the American Constitution

The Justices made their decision based upon their interpretation of the First Amendment of the American Constitution. The Religion Clause stated that "Congress shall make no laws respecting the establishment of religion, nor inhibiting the free exercise thereof"; the Establishment Clause prohibited the State from promoting religion and the Free Exercise Clause prohibited the State from inhibiting or restricting religion (Scott 2004: 105). In an earlier case, the Justices had ruled that "to withstand the strictures of the Establishment Clause there must be a secular legislative purpose" for an act to be constitutional, which ruling seemed to overshadow the Free Exercise clause which required "a primary effect that neither advances nor inhibits religion" (Scott 2004: 105 and 194). Since Creation Science postulated a Creator, such legislation was deemed to have no secular purpose and therefore to be unconstitutional. The decision also found that the Act failed by 'not advancing or inhibiting religion', which it was seen to advance (Scott 2004: 107). The secular approach to natural selection was not seen to fail the 'inhibiting' criteria.

During the middle of the 20th century, Humanists claimed that Humanism *was* their religion (Lamont 1949/1965, LaHaye 1980). This claim was dropped when their *Manifesto* was revised in 1973 (LaHaye 1980). The United States Supreme Court had, in 1961, recognized that a belief in God was not a necessary component of religion: "Among religions in this country which do not teach what would generally be considered a belief in the existence of God are Buddhism, Taoism, Ethical culture, Secular Humanism and others" (LaHaye 1980: 128). Withdrawing the claim that Humanism was the Humanists' religion from their manifesto did not change the legal definition of Secular Humanism as a religion.

A law similar to that which had been enacted in Arkansas in regard to 'equal time' had been passed in Louisiana in 1982. This was also appealed on the grounds that it was impossible to teach 'Creation Science' unless a religious view was also taught. The Court of Appeals agreed and the case was referred to the Supreme Court in 1987, which ruled that "The preeminent purpose of the Louisiana Legislature was clearly to advance the religious view point that a supernatural being created humankind" (Scott 2004: 109). Following this ruling, 'equal time' was no longer a legal option in State schools in America.

27.5 Alliances

Positions on evolution fell roughly into three groups. The first group, the Creationists, upheld the biblical account of Creation, as told in *Genesis*, that the world was made by God only a few thousand years ago within the period of six days. These people generally accepted micro-evolution (variation) but denied macro-evolution (that species could change into different species, genera, families, etc.). The second group believed that the Universe had been created by a Superior Being, accepted that the world and the Universe were of great age and that evolution had occurred, either gradually or intermittently, under Divine guidance. This position was identified, for the purpose of the case, as 'Intelligent Design'. 'Intelligent Design' had been proposed by Michael Behe (1996) as an intermediate position. It accepted the existence of a Divine Being and supported the concept of gradual evolution. However, while some evolutionary change was accepted as having occurred by 'natural' means, as suggested by Darwin, there were some evolutionary steps which Behe (1996) held could only have occurred by some form of Divine 'input' or intervention. The gradualism of natural selection was unable to account for the evolution of complex structures, particularly those of microscopic size, which would cease to function if one part was removed (Behe 1996, 2000, 2004; Dawkins 2006, Dennett 1995). Michael Behe testified in Court on behalf of the Creationists and for the purpose of the case, Intelligent Design/Creationism was taken as representing any philosophical view which allowed for, or upheld, a belief in the involvement of a Creative Force in the establishment/evolution of life on Earth. The third group were atheists or secular Humanists (see, for example Dawkins 2006; Miller 1999, 2004; Ruse 1999, 2006) who denied the existence of any Superior Being, held that the existence of the Universe, and any life in it, had resulted from natural forces operating over long periods of time, without any plan or purpose.

Traditionally the second and third groups had allied themselves against the first, the Special Creationists. Following the restrictions placed on the teaching of alternative views during the 1980s, the first two groups, both professing belief in a Creator, combined forces to oppose the third group, who denied the existence of any creative force or Superior Being (Menuge 2004). Attempts were made to introduce legislation so worded that it would avoid reference to religion. For example, in 1996, a Bill was proposed in Ohio which required that (Scott 2004: 129):

> Whenever a theory of the origin of humans, other living things, or the universe that might commonly be referred to as 'evolution' is included in the instructional program provided by any school district or educational service center, both evidence and arguments supporting or consistent with the theory and evidence and arguments problematic for, inconsistent with, or not supporting the theory shall be included.

The Bill was defeated.

28.6 Dover Area School District

In 2004, the Dover Area School District agreed to representations by some parents that the required biology textbook be supplemented by another (Creationist) textbook. In November of that year, the School Board issued a statement to be read to all ninth-grade biology classes at Dover High (Shermer 2006: 102):

> The Pennsylvania Academic Standards require students to learn about Darwin's theory of evolution and eventually to take a standardized test of which evolution is a part.

> Because Darwin's Theory is a theory, it is still being tested as new evidence is discovered. The Theory is not a fact. Gaps in the theory exist for which there is no evidence. A theory is defined as a well-tested explanation that unifies a broad range of observations.
>
> Intelligent design is an explanation of the origin of life that differs from Darwin's view. The reference book, *Of Pandas and People*, is available for students to see if they would like to explore this view in an effort to gain an understanding of what intelligent design actually involves.
>
> As is true with any theory, students are encouraged to keep an open mind. The school leaves the discussion of the origins of life to individual students and their families. As a standards-driven district, class instruction focuses upon preparing students to achieve proficiency in standards-based assessments.

No attempt was made to introduce Creationism into the classroom. A book was made available which could be accessed by any student interested enough to read it. Nevertheless, this policy was immediately challenged through the Courts.

27.7 Opposing forces

On 14 December, 2004, eleven parents filed suit against the District, with the backing of the American Civil Liberties Union (ACLU) and Americans United for Separation of Church and State (AUSCS). Dover High School was defended by the Thomas More Law Centre (TMLC) which, since its founding in 1999, had challenged the ACLU on a number of issues ranging from assisted suicide, pornography, gay marriage to nativity scenes and Ten Commandment displays (Shermer 2006: 100-102). The case was heard between 26 September and 4 November, 2005, the decision being handed down on 20th December, 2005.

27.8 Creationism redefined

At the time of the Dover trial, 'Creationism' received a new legal definition. It was deemed no longer to refer to the belief that the Earth was only 6,000 years old and had been created in six days. 'Creationism' now referred to any concept of a supernatural force having created the Universe, while the new definition of 'Special Creationism' was introduced to refer to the belief that God created living things in their present form (Scott 2004: 51).

The several Court cases that were heard over a period of nearly twenty years were mostly conducted quietly, with no cameras and very little publicity. The Arkansas case was over in two hours and the subsequent Appeal ruling by the Arkansas Supreme Court delivered in two sentences (Scott 2004: 104).

The purpose of the prosecution in the Dover case was to show that Intelligent Design was just another name for Creationism, which had already been banned from curricula of State Schools. The prosecution showed that *Of Pandas and People* had first appeared in 1983 under the title *Creation Biology*, had been renamed *Biology and Creation* in 1986 and retitled yet again in 1987 when it appeared as *Biology and Origins.* The word 'Creation' had been replaced by 'Intelligent Design' (Shermer 2006: 102-103). In his ruling, Judge Jones stated that Intelligent Design could not be uncoupled from Creationism and thus from an implication of religious doctrine (Shermer 2006: 204). Judge Jones further found that there was nothing antithetical about the theory of evolution itself, but upheld that the teaching of any theistic point of view within the State School system was contrary to the Constitution (Shermer 2006: 104). Judge Jones was scathing in his appraisal of supporters of Intelligent Design theory, deeming the changed words to be a surreptitious attempt to evade the law (Shermer 2006: 105):

> The citizens of the Dover area were poorly served by the members of the Board who voted for the ID policy. It is ironic that several of these individuals, who so staunchly and proudly touted their religious convictions in public, would time and again lie to cover their tracks and disguise the real purpose behind the ID policy.

During the trial a witness had given evidence that a significant majority of Americans thought Creation Science should also be taught in schools (Numbers 1982; Scott 2004). The Judge ruled that whether the proponents of an Act constituted the majority or a minority was irrelevant: "No group, no matter how large or small, may use the organs of government … to foist their religious beliefs on others" (Scott 2004: 198). Nevertheless, it would seem that the interpretation of the law had been influenced by the growth of secularism within American society, which now formed the dominant discourse. It is not unusual for the dominant position in society to be held by a numerical minority, as, for example, the European after the settlement in Africa. Indeed, numerical inferiority may lead to more stringent enforcement of the dominant discourse.

Judge Jones' decision was based on a point of law in accordance with the American Constitution, as it had been interpreted by Judge Overton in Arkansas twenty years earlier. Judge Raulston's decision 80 years earlier had likewise been based solely upon the law. This is as it should be, indeed *must* be. It is not the place of the Court to adjudicate between different philosophical, religious or scientific opinions. Its role is solely to interpret and enforce the law.

Dawkins (2009: 429) cited figures from a Gallup poll conducted in America in 2008 which showed that 36% of those polled held that humans had evolved under the guidance of God, 14% believed that God had no part in the process and 44% believed humans were much the same now as they were when created within the last 10,000 years. Dawkins (2009: 429) further stated that Gallup Polls conducted in 1982, 1993, 1997, 1999, 2001, 2004, 2006 and 2007 had shown similar results. While Dawkins had been prepared for a high percentage of what he referred to as 'History Deniers' in America, he had been less prepared for findings from a poll conducted in 2005 in thirty-two European countries. Asked whether they believed that human beings had developed from earlier species of animals, 20% or more respondents in twenty-three of the countries surveyed responded in the negative (Dawkins 2009: 452-453). The highest number (51%) was from the Islamic country of Turkey. These results show that evolution is far from being universally accepted. With the spread of Islamic influence into Western countries, as well as an increase in Christian fundamentalism, it may be anticipated that negative responses will increase rather than decrease.

27.9 Open and above board

There may have been much planning for the presentation of evidence before the Court, but there was no conspiracy. All participants openly declared their positions, both before and during the trial. A trial is a battle between two opposing sides and plans, ploys and plots take place in secret before the event, but the date and time of the battle are known to both sides, the rules of 'warfare' are strictly applied and all salvos are fired in the open. The Darwinians won a resounding victory in this battle.

27.10 Postscript

During the Scopes trial in 1925, Clarence Darrow had been ably supported by his 'second chair', Mr. Dudley Malone. Malone gave an impassioned speech, which Scopes (Scopes and Presley 1967: 154) reported in detail, saying that the Court room "went wild when Malone finished … the judge futilely called for order. The Chattanooga policeman applauded too, pounding a table with a night stick that must have been loaded with lead; he split the table top". The central theme of Malone's argument had been that both points of view should be taught (Scopes and Presley 1967: 152-154): "give the next generation all the facts … all the theories … let the children have their minds kept open … Make the distinction between theology and science. Let them have both. Let them both be taught. Let them both live … The truth is no coward. The truth does not need the law … The truth is imperishable, eternal, and immortal, and needs no human agency to support it".

In a postscript to his account of the trial, Scopes (Scopes and Presley 1967: 276-277) summarized the feelings which he still had forty years after the trial. He wrote of the repulsiveness of any law restricting the constitutional freedom of teachers, of how such limitations would make robot factories out of schools. He claimed that tolerance was essential, that (Scopes and Presley 1967: 276-277):

> … we, as individuals and as a society, must respect the other man's point of view, no matter how far out he seems and no matter how vigorously we disagree with him … there is more intolerance in higher education than in all the mountains of Tennessee. There is a tendency for educated people to insist that others less schooled should think as they themselves think … the Tennessee hillbilly and the Harvard professor have the same rights to their viewpoints as I, whether theirs coincide with mine or not.

Scopes wrote his autobiography just as the new legislation was being introduced. Was this a coincidence? The statements with which Scopes finished his book give cause to wonder, had Scopes been called to the stand in later trials, for which side would he have spoken?

27.11 Legal position

The position of the dominant and subordinate discourses had been completely reversed from that which pertained in pre Darwinian times. The two dichotomous discourses, Religious/secular and Evolution/Creationism, became redefined as Religious Creationism/Secular Evolution. Behe had failed to satisfy the Court that gradual evolution could not account for all change at a sub-cellular level and continuity retained its dominant position over discontinuity.

Chapter 28

Discussion and Conclusions

28.1 Overview

Within the methodology of Critical Analysis, it is acknowledged that it is rarely possible for the researcher to cover all the texts available on the subject being considered and that the selection of texts chosen for study must inevitably be value laden. Critical Analysis also holds that no reader/ researcher can ever be entirely impartial, but must bring to the task their own view of reality, shaped by ethnic, gender, political, religious, philosophical, cultural and economic factors. It has been impossible here to cover all of the thousands of books which have been written on the subject of evolution, both before and after Darwin. An attempt has been made to select the most important texts representing both the dominant discourse and the subordinate text, bringing both before the reader for consideration. As stated in Chapter 1, the task of the Critical Analyst is to take a position in support of the subordinate text with the purpose of restoring a more even balance to the discussion, to create a more constructive environment in which the relevant texts may be reconsidered and forward progress may be made.

Three major dichotomies were followed in this thesis and their relative position as dominant discourse or subordinate text changed over time. The text that retained its dominant position for the greatest amount of time was that of evolution, which rose to dominance before *On the Origin of Species* (Darwin 1859/1998) was published and continues its dominance today. Nevertheless, there is resistance to the dominant discourse and the theory of evolution is far from having achieved complete acceptance. Within the dominant paradigm of evolution, there has arisen a further dichotomy, that of evolution 'under God' with plan and purpose, and evolution by natural means without plan or purpose. The second dichotomy, religious/secular, has become entwined with the first in such a manner that it is currently very difficult to separate them. The least controversial of the dichotomies followed was that of continuity v. discontinuity. The position of irreducible complexity (Behe 1996) is one of discontinuity and it is anticipated that more attention will be given to this dichotomy in the future.

A further requirement of critical analysis was to place the material studied within its historical, political, religious, philosophical and cultural setting. This necessitated a more comprehensive coverage of the lives of the various theorists than is normally given in books on evolutionary theory, as distinct from biographies. While the narrative style of writing favoured by Critical Analysis was of great assistance in this, nevertheless choices had to be made regarding what was to be included and what was to be excluded and these reflected the researcher's values.

28.2 Starting out

The first appearance of evolutionary thinking, that of Maupertuis, was uncontroversial because it was not perceived as a threat to any established paradigm. The eighteenth century was one of great scientific advancement within the fields of physics, chemistry and astronomy. With progress being made in so many other areas, Maupertuis' early musings on the possible evolution of life on this Earth passed almost unnoticed. His theory of evolution remained unrecognized for what it was, although it is now possible to see that it incorporated all the major components of Darwin's own theory: that the 'products of Nature' deviated, adapted and either survived or perished, thereby giving rise to the infinite diversity of creatures existing today, under the action of 'blind chance'. Its significance unrecognized, Maupertuis' theory of evolution was neither condemned by the Church nor applauded by the scientists.

Only as evolutionary thinking began to emerge as a force, through the work of such people as Buffon and Lamarck, was it met with resistance. While Buffon's interests were those of a Naturalist, his comprehensive theory of how the Earth had been formed, of the gradual appearance of plants and animals over vast amounts of times, brought the theory of evolution into conflict with Biblical teaching regarding the Creation of the world. Buffon's writings showed evidence of a reluctance to say anything which might provoke the disapproval of the Church and gave the first indication of what was to become an epic battle between the Church (or segments thereof) and evolutionary theorists. At this time the religious paradigm was dominant. Life was seen as a continuum, reaching downwards from God and his angels, via 'Man' to the animals and other lower forms of life. The religious, Creationist and continuous discourses were dominant.

By the time Lamarck wrote, there had been a paradigm shift. Napoleon banned Christianity although he allowed a belief in a 'Supreme Being'. As a supporter of Napoleon, it may be assumed that Lamarck's reference to a 'Supreme Being' was a genuine expression of his belief. Lamarck also saw life as a continuum, but in this case the continuum stretched from the lowest forms of life upwards to 'Man', but no further, the Supreme Being being separate from creation. Lamarck's position of evolution, continuity and secularism was to become the dominant position from the middle of the 20th century onwards. For a time, Lamarck's work was influential, but another paradigm shift was to occur which displaced his work from the dominant to the subordinate position. Napoleon's self-elevation to the position of Emperor, and the acceptance by the French people of a Napoleonic dynasty, allowed a return to the notion 'from above, downwards'. By the time Cuvier wrote, religion had returned, if not to the unassailable position it had once held, at least to a position of dominance over secularism.

Cuvier worked from a religious position, upholding the teachings of the Bible even though he found it difficult to incorporate them in his scientific findings. Cuvier accepted change inasmuch as he acknowledged that many former species no longer existed. He wrote from the position of discontinuity, seeing change as having been abrupt, the result of catastrophies. He did not reject Lamarck's theory on scientific grounds, since he made no attempt to address it, point by point. He rejected Lamarck's theory because it did not conform to his religious philosophy. Cuvier was successful and his work achieved the recognition that it did because it conformed with the prevailing tide of opinion of the time.

Cuvier's acceptance of a religious rather than a secular position, his support for Creation not evolution and for discontinuity rather than continuity, were positions opposite to those taken by Lamarck.

As was shown in Part I of this thesis, by the time Chambers (1844) published his work, the concept of evolution was well accepted. It was seen to have happened under the guidance of God, there being no overt opposition from the Church for this position. Chambers embraced a position of continuity more extreme than that of any previous theorist inasmuch as he saw continuity across creation, between species and families, not only from above down. At the time Darwin published his theory, religion, evolution and continuity were the dominant discourses.

28.3 Further along the road

Part II of this thesis considered the work of Darwin and Wallace, who were the last two evolutionary theorists of the 19th century. It followed the rise to dominance of the former over the latter and the reasons that this position came about.

Throughout this time, the religious paradigm was dominant. Its dominance had led to a certain complacency which allowed for the vigorous growth of the subordinate text, initiated and supported by Lyell, Huxley and their colleagues. Darwin insisted that his theory could be interpreted in a manner consistent with religious belief but even his voice was not enough to silence the rising tide of secularism among the 'elite', those controlling the discourse from positions of power within the scientific and academic communities. Until the turn of the 20th century, the religious paradigm remained dominant, but there was a more equal balance of power between the two discourses.

Wallace originally wrote from a secular position. His views on natural selection were more in keeping with those of Lyell and Huxley but his physical location (on the Malay Archipelago) delayed the friendship which was later to exist between him and Lyell. This accident of location may well have changed the history of evolutionary theory since, by the time Wallace returned to England, Darwin's position had become established. Wallace changed his position from secular to religious after his conversion to Spiritualism but continued to support the dominant paradigms of evolution and continuity. Wallace did not change his view of the evolution of the physical body, be it plant, animal or human, which supports Darwin's contention that the theory of evolution by natural selection is not, of itself, a secular position. However, Wallace's insistence that 'mental' characteristics could only be accounted for by an acknowledgement of some form of Superior Being, brought into sharp relief the difference between their two positions. As far as 'mental' characteristics were concerned, Wallace's later position was religious (dominant paradigm), but also discontinuous (subordinate), since it advocated a discontinuity between the physical and mental spheres, the one being subject to evolution by natural means, the other evoking Divine involvement. The Darwinian insistence that *all* evolution, both physical and mental, had resulted from the action of natural selection, and the increasing dominance of the Darwinian position, prepared the way for the rise of secularism in the 20th century. During the second half of the 19th century, the 'anti-establishment' secular discourse of Lyell and Huxley was representative of the subordinate text.

Initially, Darwin and Wallace both argued from a position of continuity. Contrary to the opinion of Foucault (1972), Darwin (1859/1998) placed great emphasis on 'species' being a human construct, on there being no essential difference between species and varieties. Continuity was essential for change to have come about.

Darwin's theory was actively promoted in a way that no other theory of evolution had been before. Buffon tentatively included his theory of evolution under the cover of his comprehensive work on nature. Blyth, writing from India, submitted a few journal articles which excited little comment. He was not able to be present at any of the meetings at which his work might have been discussed, so, like Wallace, his theory suffered a substantial disadvantage. Chambers wrote anonymously which, again, was to his disadvantage within the scientific community, despite the popularity of his work with the general reader. Darwin was not only from a well-respected family, he had established himself as a person of consequence in his own right as the result of his well-publicised voyage on the *Beagle* and the excellence of the papers he had published since his return. Personal fame, social class, race, gender, money, status and the support of the 'elite' all combined to establish Darwin's theory in its position of dominance, notwithstanding well-recognised weaknesses within the theory itself.

The dominant discourses at the end of the 19th century were the same as they had been throughout the century: evolution, religion and continuity.

28.4 The fork in the road

There were many ideological changes during the first half of the 20th century, both in politics and religious belief. Darwin's theory of evolution by natural selection was co-opted in support of these changes, by Hækel, Hitler and Stalin, with disastrous results for millions of people. The political use of Darwin's theory neither validated, nor invalidated it. The theory itself is a-political.

Of the three dichotomies under consideration, the one which underwent the greatest change during this time was that of continuity/discontinuity. The discovery of particulate inheritance was seen to solve the problem of continuous blending which had been a stumbling block within the theory of natural selection. Weismann's (1904) theory of the complete separation of the somatic and germ cell systems of reproduction (mitosis and meiosis respectively) was accepted and remained unquestioned throughout this period.

As was pointed out in Chapter 17, the work of Dobzhansky, Fisher, Ford, Haldane, Mayr, Simpson and others, consistently showed the statistical unlikelihood of random change becoming established and spreading throughout a population. Nevertheless, evolution as a fact was accepted throughout the scientific community and natural selection was the only theory which had been proposed to account for evolution by 'scientific' means, i.e. without the interference of a Superior Being. The insistence that 'scientific' knowledge may only be uncovered by applying known physical laws, such as those of physics, chemistry and mathematics, known as 'positivism', was so dominant that all of the above-named people continued to accept the theory of evolution by natural selection, despite their own findings. Discontinuity failed to rise to the position of dominance, despite its early promise. Goldschmidt alone continued to advocate macro-evolution and White questioned the role in evolution of chromosome change (see Chapter 18). Their concerns were ignored and eventually silenced.

During this time the third dichotomy became firmly established, that of evolution (by any means) *v.* that of Creation, as recorded in the Bible in the book of *Genesis.* Legally, Creation became the dominant discourse, at least in America, following the Scopes trial. The combined authority of the law and of the education system was brought to bear to suppress the theory of evolution, as it pertained to human beings. The past geographical isolation of America meant that no human fossils from the palæolithic era were found on that continent and news of finds in Europe during this time were less highly publicised than such finds today due to lack of electronic media. These historical accidents assisted in perpetuating the dominance of the religious and discontinuity paradigms in America. Many within the general population may have accepted evolution, if only for living forms other than human. For the first time there was a clear distinction between the positions of authoritative bodies, such as the Courts and the education departments, and public opinion.

Secular Humanism became formally established in America, openly and definitively claiming that Darwinism supported its atheistic ideology. The religious ideology was numerically dominant among the general population, and supported by the Courts at this time, but the secular/atheistic ideology was dominant among the scientific community.

In Europe, continued finds of fossil humans, especially of Neanderthals, supported the paradigms of evolution and continuity and there was no restriction placed upon teaching these positions within schools. In Protestant countries, the religious paradigm was dominant, evolution being assumed to have occurred under Divine guidance. While some persons of authority within the Vatican prevented the publication of Teilhard's theories on evolution, the Vatican itself took no official position on evolutionary theory in general or on Darwinism in particular. No legal or religious position, either for or against evolution, was imposed on any system of education within Europe.

At the middle of the 20th century, as the world recovered from the Second World War, the religious, evolutionary and discontinuity paradigms were dominant but all three were being resisted in some manner.

28.5 The rift widens

During the second half of the 20th century, considered in Part IV, discontinuity became the dominant paradigm within the academic community. Increasing numbers of fossil finds were being given separate nomenclatures, implying speciation, and the suggestion that a speciation event had occurred in Africa less than 200,000 years ago, giving rise to *Homo sapiens,* gained majority acceptance. The Neanderthals were dehumanised, removed from human ancestry.

Discontinuity remained the dominant paradigm, although support was being sought not from study of the mutation of genes but from DNA analysis, including mtDNA analysis. The decision to exclude any modern DNA identified during studies of Neanderthal DNA on the grounds that it must be a contaminant helped support the claim that Neanderthal DNA was different from that of modern humans. The discontinuous 'Out of Africa' hypothesis was opposed by the continuous hypothesis of 'Multi-regional evolution', which became the subordinate discourse. This was silenced by the simple expedient of peer review, which increasingly declined to provide publication opportunities for the dissenting opinion. The discontinuity proposed by the 'Out of Africa' hypothesis was extended to that of language, the assumption that the Neanderthals had limited communication skills becoming increasingly dominant.

This thesis noted the disappearance from the literature during the second half of the 20th century, not only of discussion of the part which may have been played in evolution by genetic mutation, but of the role of chromosomes themselves, particularly their changing numbers. None of the texts studied from this time considered this matter, which is seen to be important, since any comprehensive theory of evolution must account for this discontinuity.

While academic opinion favoured discontinuity, general opinion was favouring continuity, thanks to the popular writings of Richard Dawkins and Stephen J. Gould. While academic acceptance of the *Evolutionary Synthesis* (J. Huxley 1943) had allowed the difficult subject of discrete genetic inheritance to be disregarded as a topic in need of further consideration, genes themselves were by no means neglected, thanks to the publication of *The Selfish* Gene (Dawkins 1976). Darwin (1859/1998) had, for the most part, portrayed evolution as 'selfish', with each biological form striving for its own survival at the expense of others, but, on occasions, Darwin had allowed altruism to be the predominant influence, particularly among insects. Dawkins also categorised the gene as selfish for the most part, but allowed it altruistic tendencies when necessary. Like Darwin, Dawkins also took a broad perspective, seeking continuity in evolution. Gould wrote in a similar manner. As had Darwin before him, Gould drew imaginary scenarios depicting what might have happened. These scenarios depended upon a broad concept of continuity, since they completely disregarded any difficulties which might be encountered in respect of genetic or chromosomal change. While academic opinion was supporting discontinuity, popular opinion was once again embracing continuity.

During this time, neutrality in regard to religious belief increasingly fell from favour within the texts studied. Humanism had been formalised in England and was supporting the positivist approach within science and academia which required a neutral or atheistic approach to science. Only 'scientific' texts were sanctioned within academia. Resistance came both from the Creationists who refused to accept evolution and from a growing number of scientists who, while accepting evolution, rejected methodological naturalism (see Chapter 26). While the co-operation of these two groups coalesced in the final decade of the 20th century, their challenge to the dominant academic atheistic paradigm did not take place until the first decade of the 21st century.

Its rejection of evolution on the grounds that evolution did not uphold creation as taught in the Bible had placed the Catholic Church in the subordinate position for nearly a hundred years. The Catholic Church finally endorsed evolution, but found itself once again holding the subordinate position, this time in relation to the religious/secularism dichotomy.

While atheism dominated within academia, the majority of the general population held some form of religious belief (Scott 2004; Dawkins 2009). Academia supported discontinuity and atheism; popular opinion supported continuity and belief in a Creator. Both academia and popular opinion supported evolution, which was still denied by a small minority of dissidents.

28.6 Torn apart

This thesis concluded in Part V with a study of texts from the first decade of the present century. Much was recorded during this short period of time. Most important from the perspective of evolutionary theory was the discovery that modern humans, especially those of European descent, do, in fact, carry a small percentage of Neanderthal DNA. There is now acknowledged to be less genetic discontinuity than once claimed. The Neanderthals have been re-instated within the human family. This opens up the possibility that there has been no speciation since *Homo erectus* appeared approximately 1.7 mya, supporting a greater degree of continuity in human evolution than had been thought during the latter part of the 20th century.

While this finding contributed nothing to our understanding of the continuity/discontinuity of evolution in regard to all other biota, microscopic studies of flora and fauna revealed a high degree of similarity at the cellular level. This supported the theory of common descent for all living forms. The theory of irreducible complexity put forward by Behe (1996) provides the dissenting position, not as it relates to the theory of evolution itself, but as it relates to the theory of evolution by natural selection *v.* purposive design.

Of great importance also during this time was the discovery of *Homo floresiensis.* Whether these fossils are eventually determined to be diminutive *H. erectus,* late *H. habilis* or *Australopithecus*, they are evidence of a higher degree of mental continuity than had previously been attributed to other hominids simply by reason of their very presence south of the Wallace Line which necessitated some form of craft sufficient to make an open water crossing. This degree of mental sophistication and ability to communicate had not previously been considered possible.

In America, the religious/secular debate once again found itself before the Courts, this time evincing a resounding victory for secularism, which became the dominant discourse endorsed both by the Courts and academia, reversing the situation following the Scopes trial of 1925.

While there may have been a legal victory for atheism within the United States of America, the decision handed down by the Court at Dover will have done nothing to change the thinking of those persons party to the dispute. It is unlikely that any evidence presented by proponents from either side will change the thinking of persons committed to the opposing view.

28.7 General conclusions

Opposition to Darwin's theory of evolution lay not in his support for the *fact* of evolution, which none of his contemporary critics disputed, but centred on his theory's religious/philosophical implications. A surprising outcome of over a century of argument has been the *rise* in opposition to the fact of evolution itself following the spread in America of Christian Fundamentalism (Dawkins 2009). As leader of the Western world, any position held in America has the potential to influence thinking in many other countries.

Following the American Revolution, the 'Founding Fathers' in America saw wisdom in the separation of Church and State. This application of this ideology has not been without difficulty. Even the definition of what constituted 'religion' was problematic (see Chapter 27). Following the Scientific Revolution, the 'Founding Fathers' of science in Europe saw wisdom in the separation of Science and Religion. The application of this ideology has also not been without difficulty. The difference between politics and science is that, at least under the Western democratic ideology, the former is subject to public debate while the latter is determined by an 'elite' formed by scientists of acknowledged expertise in their chosen discipline. The *application* of science may become a matter of public debate, such as happened with eugenics during the 20th century and is currently happening with the new practice of eugenics *in utero* in the present century, but 'science' itself is not open to public debate. The 'elite' determine what shall be taught in schools and universities and, to a large degree, what will be disseminated via the media. Even that which is published in scientific journals is subject to review by an elite group, those persons chosen by the editors of the journals to perform this task.

The separation of science and philosophy (religion) is strictly enforced within academic journals. Fossil finds are described in great detail but no philosophical explanation is offered for their presence. DNA and mtDNA are analysed and compared and results presented in the relevant journals without philosophical implication. Under the cover of books, writers have the opportunity to express their personal opinions. They have the right to 'freedom of expression'. Problems have arisen when ideological positions expressed in books have been presented in the classroom, integrated with scientific findings relating to evolution in general and human evolution in particular.

Philosophy and science are both areas worthy of study at the highest level within academia, the one within the Faculty of Arts, the other within the Faculty of Science. There is no place for philosophy within the science classroom, either at school or at University. There is a place for the philosophical discussion of issues arising from science within curricula offering subjects such as 'Philosophy of Science'.

Rather than arguing for 'equal time' for Creationist and Humanist approaches to evolution (see Chapter 27), it is here argued that 'no time' should be given to the presentation of either of these philosophical positions within the science classroom.

As previously stated, the continuity/discontinuity dichotomy has been subject to least dispute. Continuity was essential to Darwin's discourse and attempts to articulate a subordinate text were silenced by the simple expedient of denying them space within the journals, except inasmuch as they provided publicity for Darwin's theory (see Chapter 10). Attempts to reverse the dominance of continuity by the application of Mendelian genetics proved not to be as successful as had been anticipated (see Chapters 17 and 18). Attempts to prove discontinuity within the human line of evolution were also less successful than anticipated when Neanderthal DNA was shown to exist, albeit in very small amounts, within living human populations (see Chapter 26).

The continuity discourse currently holds dominance in relation to physical evolution. However, the continuity/discontinuity discourse in relation to 'mental' characteristics is commanding attention. The question of whether humans, physically and mentally, are nothing more than highly evolved animals or whether they are in some essential way different from all other material creation is highly contested. This issue provided the basis for a number of Court cases, most notably the Scopes and Dover trials (see Chapters 15 and 27). Notwithstanding the Court's decision in 2005, and the dominant position this decision holds within the scientific community, the subordinate position is unlikely to be silenced. As pointed out in Chapter 27 (Dawkins 2009), not only is there a large percentage of people resident in the United States of America who reject any theory of evolution, especially where it implies the animal nature of humans, there is also a large percentage of people in Europe who hold similar views, and this percentage is likely to increase, rather than decrease, in coming years with the influx of people of Islamic faith into Europe. While it is too early yet to assess the impact of the 2005 Court ruling on the philosophical position of school students currently reaching maturity, the figures cited by Dawkins (2009) suggest that past attempts to impose a particular philosophical position upon unwilling recipients has not produced the intended results.

The discontinuity discourse needs to be addressed by science. Many questions remain unanswered. Not only have exponents of evolution by natural selection not yet satisfactorily explained the *origin* of any completely new feature, they have yet to determine the degree of genetic mutation which may be sustained by a zygote, without detrimental effect. This degree must be compatible with change which is not only beneficial, but beneficial at a level sufficient to be 'selected'. This change must be 'dominant' rather than 'recessive' if it is to be expressed in the phenotype and thus be available for selection. The mathematical calculations made by theorists in the first half of the 20th century (see Chapter 18) which cast doubt on some assumptions made regarding both the initiation and spread of change throughout a population, also need to be addressed.

The stability of the number of chromosomes across families such as the Big Cats and Great Apes, indicate that a change in chromosome number is a very rare event, occurring, perhaps, once in 10,000,000 years or less. This discontinuity also requires addressing if evolution by natural selection is to justify the position as the all-sufficient explanation for evolutionary change which it currently claims. This is considered to be the most pressing problem to have emerged from this study.

The continuity discourse has held its dominant position for most of the time under consideration, not because it offers the best explanation for what is observed to have happened, but because it offers the simplest.

28.8 Difficulties with thesis

The volume of material available for study made it impossible to cover every possibility, every point of view which has been expressed on the topic of evolution. Concentrating on the topic of human evolution, rather than that of other fauna and flora, reduced the field of study but it remained immense. A further difficulty was the multi-disciplinary approach which has now become necessary. During the 19th century, an archæologist who uncovered a fossil was responsible for its description and evaluation. Today, the archæologist is dependent upon the physicist, the chemist, the biochemist, the micro-biologist, the geneticist, the radiologist and even the mathematician to assist in uncovering the full story of each fossil find. Nobody can be expert in all fields and interdisciplinary misunderstandings do occur. A misunderstanding occurred when the work of Cann, Stoneking and Wilson (1987) was interpreted as suggesting that a speciation event had occurred in Africa ~200,000 years ago, which was not the case. Genetics is a field in which the writer of this thesis is not specialized. Of necessity, limited knowledge was brought to bear upon the topic of chromosome change, which was seen to be a subject of great importance for further research by more suitably qualified persons.

The intermingling of science and philosophy was seen to have raised ethical issues within the classroom. It also raised ethical issues in the presentation of this thesis. A need to remain as objective as possible was counterbalanced by a need to advance the subordinate text, as required under the methodology of Critical Discourse Analysis.

28.9 Future research

A possible area for future study would be to evaluate what, if any, effect the decision handed down by the Court in Dover, 2005, had in influencing thinking on evolution by students attending state educational faculties in America. Any such research could also address the issue of the ethics of attempting to impose a philosophical position upon school children and whether the humanist (ACLU) driven move to do so contradicts the Universal Declaration of Human Rights.

Of greater importance is the need to address the discontinuity discourse, particularly as it relates to the science of genetics and the way in which chromosome change is effected.

28.10 Conclusion

Our understanding of the process of evolution is far from complete. There are many areas, particularly those in the field of genetics and micro-biology, which require investigation. Current literature concentrates upon the repetition of previously stated positions. If progress is to be made, there must be a willingness to examine other possibilities, even those previously rejected. No research possibility should be rejected *solely* upon ideological grounds.

Science must be divorced from any philosophical position, not only because association with a philosophical position may impede research, but for ethical reasons. Any scientist should have the right to determine his/her ideological position without fear of recrimination or discrimination.

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Appendix I

Extracts from *My Life* (Wallace 1905/1969: 354-363)
relating to the writing and reception of Wallace's two papers.

... I must refer to an article I wrote while in Sarawak, which formed my first contribution to the great question of the origin of species ... I had in a letter to Darwin expressed surprise that no notice appeared to have been taken of my paper, to which he replied that both Sir Charles Lyell and Mr. Edward Blyth ... especially called his attention to it. I was, however, rewarded later, when in Huxley's chapter, "On the Reception of the Origin of Species," contributed in the "Life and Letters," he referred to this paper as ... "his powerful essay," adding – "On reading it afresh I have been astonished to recollect how small was the impression it made" ...

The only letter I possess which indicates something of my opinions and anticipations at this period of my travels is one to Bates, dated Amboyna, January 4, 1858, from which I shall make a few extracts ... I then touched on the subject of my paper ...

"To persons who have not thought much on the subject I fear my paper on the 'Succession of Species' will not appear so clear as it does to you. That paper is, of course, merely the announcement of the theory, not its development. I have prepared the plan and written portions of a work embracing the whole subject, and have endeavoured to prove in detail what I have as yet only indicated ... I have been much gratified by a letter from Darwin, in which he says that he agrees with 'almost every word' of my paper. He is now preparing his great work on 'Species and Varieties,' for which he has been collecting materials twenty years. He may save me the trouble of writing more on my hypothesis, by proving that there is no difference in nature between the origin of species and of varieties; or he may give me trouble by arriving at another conclusion ... "

This letter proves that at this time I had not the least idea of the nature of Darwin's proposed work nor of the definite conclusions he had arrived at, nor had I myself any expectations of a complete solution of the great problem to which my paper was merely the prelude. Yet less than two months later that solution flashed upon me, and to a large extent marked out a different line of work from that which I had up to this time anticipated ...

It was while waiting at Ternate in order to get ready for my next journey, and to decide where I should go, that the idea referred to occurred to me. It has been shown how, for the preceding eight or nine years, the great problem of the origin of species had been continually pondered over ... [I was] certain that the changes had taken place by natural succession and descent – one species becoming changed either slowly or rapidly into another. But the exact process of the change and the causes which led to it were absolutely unknown and appeared almost inconceivable ...

The problem then was, not only how and why do species change, but how and why do they change into new and well-defined species, distinguished from each other in so many ways; why and how do they become so exactly adapted to distinct modes of life; and why do all the intermediate grades die out ... and leave only clearly defined and well-marked species, genera, and higher groups of animals.

Now, the new idea or principle which Darwin had arrived at twenty years before, and which occurred to me at this time, answers all these questions and solves all these difficulties ...

At the time in question I was suffering from a sharp attack of intermittent fever, and every day during the cold and succeeding hot fits had to lie down for several hours, during which time I had nothing to do but to think over any subjects then particularly interesting to me. One day something brought to my recollection Malthus's "Principles of Population," which I had read about twelve years before. I thought of his clear exposition of "the positive checks to increase' – disease, accidents, war, and famine ... It then occurred to me that these causes or their equivalents are continually acting in the case of animals also; and as animals usually breed much more rapidly than does mankind, the destruction each year from these causes must be enormous ... Vaguely thinking over the enormous and constant destruction which this implied, it occurred to me to ask the question, Why do some die and some live? And the answer was clearly, that on the whole the best fitted live ... Then it suddenly flashed upon me that this self-acting process would necessary *improve the race*, because in every generation the inferior would inevitably be killed off and the superior would remain – that is *the fittest would survive ...* The more I thought over it the more I became convinced that I had at length found the long-sought-for law of nature that solved the problem of the origin of species ... I waited anxiously for the termination of my fit so that I might at once make notes for a paper on the subject. The same evening I did this pretty fully, and on the two succeeding evenings wrote it out carefully in order to send it to Darwin by the next post, which would leave in a day or two ...

I was, of course, very much surprised to find that the same idea had occurred to Darwin, and that he had already nearly completed a large work fully developing it ... In reading it now it must be remembered that it was but a hasty sketch, that I had no opportunity of revising it before it was printed.

Appendix II

Letter from Charles Darwin to Asa Gray dated 5th September, 1857,
read to the meeting of the Linnean Society, 1st July, 1858.
(F.Darwin 1887: 120-125)

My Dear Gray – I forget the exact words which I used in my former letter, but I dare say I said that I thought you would utterly despise me when I told you what views I had arrived at, which I did because I thought I was bound as an honest man to do so, I should have been a strange mortal, seeing how much I owe to your quite extraordinary kindness, if in saying this I had meant to attribute the least bad feeling to you. Permit me to tell you that, before I had ever corresponded with you, Hooker had shown me several of your letters (not of a private nature) and these gave me the warmest feeling of respect to you; I should indeed be ungrateful if your letters to me, and all I have heard of you, had not strongly enhanced this feeling. But I did not feel in the least sure that when you knew whither I was tending, you might not think me so wild and foolish in my views (God knows, arrived at slowly enough, and I hope conscientiously) that you would think me worth no more notice or assistance. To give one example; The last time I saw my dear old friend, Falconer, he attacked me most vigorously, but quite kindly, and told me. "You will do more harm than any ten Naturalists will do good. I can see that you have already *corrupted* and half spoiled Hooker!!" Now when I see such strong feeling in my oldest friends, you need not wonder that I always expect my views to be received with contempt. But enough and too much of this.

I thank you most truly for the kind spirit of your last letter. I agree with every word of it, and think I go as far as almost any one in seeing the grave difficulties against my doctrine. With respect to the extent to which I go, all the arguments in favour of my notions fall *rapidly* away, the greater the scope of forms considered. But in animals, embryology leads me to an enormous and frightful range. The facts which kept me longest scientifically orthodox are those of adaptation – the pollen-masses in asclepias – the mistletoe, with its pollen carried by insects, and seed by birds – the woodpecker with its feet and tail, beak and tongue, to climb the tree and secure insects. To talk of climate or Lamarckian habit producing such adaptations to other organic beings is futile. This difficulty I believe I have surmounted. As you seem interested in the subject, and as it is of *immense* advantage to me to write to you and to hear, ever so briefly, what you think, I will enclose (copied, so as to save you trouble in reading) the briefest abstract of my notions on the means by which Nature makes her species. Why I think that species have really changed, depends on general facts in the affinities, embryology, rudimentary organs, geological history, and geographical distribution of organic beings. In regard to my Abstract, you must take immensely on trust, each paragraph occupying one or two chapters of my book. You will, perhaps, think it paltry of me, when I ask you not to mention my doctrine; the reason is, if any one, like the author of the 'Vestiges,' were to hear of them, he might easily work them in, and then I should have to quote from a work perhaps despised by naturalists, and this would greatly injure any chance of my views being received by those alone whose opinion I value. [Here follows a discussion on "large general varying" which has no direct connection with the remainder of the letter].

I. It is wonderful what the principle of selection by Man, that is the picking out of individuals with any desired quality, and breeding from them, and again picking out, can do. Even breeders have been astonished at their own results. They can act on differences inappreciable to an uneducated eye. Selection has been *methodically* followed in Europe for only the last half century. But it has occasionally, and even in some degree methodically, been followed even in the most ancient times. There must have been also a kind of unconscious selection from the most ancient times, namely, in the preservation of the individual animals (without any thought of their offspring) most useful to each race of man in his particular circumstances. The "roguing," as nurserymen call the destroying of varieties, which depart from their type, is a kind of selection. I am convinced that intentional and occasional selection has been the main agent in making our domestic races. But, however this may be, its greatest power of modification has been indisputably shown in late times. Selection acts only by the accumulation of very slight or greater variations, caused by external conditions, or by the mere fact that in generation the child is not absolutely similar to its parent. Man, by this power of accumulating variations, adapts living beings to his wants – but *may be said* to make the wool of one sheep good for carpets, and another for cloth, etc.

II. Now, suppose there was a being, who did not judge by mere external appearance, but could study the whole internal organisation – who never was capricious – who should go on selecting for one end during millions of generations, who will say what he might not effect! In nature we have some *slight* variations, occasionally in all parts; and I think it can be shown that a change in the conditions of existence is the main cause of the child not exactly resembling its parents; and in nature, geology shows us what changes have taken place, and are taking place. We have almost unlimited time: no one but a practical geologist can fully appreciate this: think of the Glacial period, during which the whole of the same species of shells at least have existed; there must have been during this period, millions on millions of generations.

III. I think it can be shown that there is such an unerring power at work, or *Natural Selection* (the title of my book), which selects exclusively for the good of each organic being. The elder de Candolle, W. Herbert, and Lyell, have written strongly on the struggle for life; but even they have not written strongly enough. Reflect that every being (even the elephant) breeds at such a rate that, in a few years, or at most a few centuries or thousands of years, the surface of the earth would not hold the progeny of any one species. I have found it hard constantly to bear in mind that the increase of every single species is checked during some part of its life, or during some shortly recurrent generation. Only a few of those annually born can live to propagate their kind. What a trifling difference must often determine what shall survive and what shall perish!

IV. Now take the case of a country undergoing some change; this will tend to cause some of its inhabitants to vary slightly; not but what I believe most beings vary at all times enough for selection to act on. Some of its inhabitants will be exterminated, and the remainder will be exposed to the mutual action of a different set of inhabitants, which I believe to be more important to the life of each being than mere climate. Considering the infinitely various ways beings have to obtain food by struggling with other beings, to escape danger at various times of life, to have their eggs or seeds disseminated, etc., etc., I cannot doubt that during millions of generations individuals of a species will be born with some slight variation profitable to some part of its economy; such will have a better chance of surviving, propagating this variation, which again will be slowly increased by the accumulative action of natural selection; and the variety thus formed will either coexist with, or more commonly will exterminate its parent form. An organic being like the woodpecker, or the mistletoe, may thus come to be adapted to a score of contingencies: natural selection, accumulating those slight variations in all parts of its structure which are in any way useful to it, during any part of its life.

V. Multiform difficulties will occur to every one on this theory. Most can, I think, be satisfactorily answered – "Natura non facit saltum" answers some of the most obvious. The slowness of the change at any one time answers others, The extreme imperfections of our geological records answer others.

VI. One other principle, which may be called the principle of divergence, plays I believe, an important part in the origin of species. The same spot will support more life if occupied by very diverse forms; we see this in many generic forms in a square yard of turf (have counted twenty species belonging to eighteen genera), or in the plants and insects, on any little uniform islet, belong to almost as many genera and families as to species. We can understand this with the higher animals, whose habits we best understand. We know that it has been experimentally shown that a plot of land will yield a greater weight, if cropped with several species of grasses, than with two or three species. Now every single organic being, by propagating rapidly, may be said to be striving its utmost to increase in numbers. So it will be with the offspring of any species after it has broken into varieties, or sub-species, or true species. And it follows, I think, from the foregoing facts, that the varying offspring of each species will try (only few will succeed) to seize on as many and as diverse places in the economy of nature as possible. Each new variety or species when formed will generally take the place of, and so exterminate its less well-fitted parent. This, I believe, to be the origin of the classification or arrangement of all organic beings at all times. These always *seem* to branch and sub-branch like a tree from a common trunk; the flourishing twigs destroying the less vigorous – the dead and lost branches rudely representing extinct genera and families.

This sketch is most imperfect; but in so short a space I cannot make it better. Your imagination must fill up many wide blanks. Without some reflection, it will appear all rubbish; perhaps it will appear so after reflection.

C.D.

P.S. This little abstract touches only the accumulative power of natural selection, which I look at as by far the most important element in the production of new forms. The laws governing the incipient or primordial variation (unimportant except as the groundwork for selection to act on, in which respect it is all important), I shall discuss under several heads, but I can come, as you may well believe, only to very partial and imperfect conclusions.

*The date is given as October in the 'Linnean Journal'. The extracts were printed from a duplicate undated copy in my father's possession, on which we had written "This was sent to Asa Gray 8 or 9 months ago, I think October 1857.

Glossary

acrocentric	chromosome with unequal length arms; 'J' shaped
adiabatic expansion	cooling of a gaseous substance (air) during expansion without transfer of heat to another substance
allopatric	separate habitats, reproductive isolation
amixis	fertilization
ammonites	extinct shelled sea creatures
amphimixis	mixing of generative materials
anagenesis	one species gradually changes into another
anastomoses	interconnecting pathways allowing diffusion
atavism	expression of an ancestral line not observed in more recent progenitors
bases	subcomponents of DNA molecules
bimanus	having two hands; humans
biophor	sub-microscopic particle responsible for reproducing life
brachydactylism	short fingers, short stature
calvaria	top portion of skull
centromere	region of chromosome to which spindle fibre attaches during cell division
cervid species	deer
cladogenesis	the divergence of one species into two
determinant	microscopic particles responsible for development of cells and body parts
dimorphism	different physical appearance within same species, especially between sexes
DNA	deoxyribonucleic acid: a large molecule which carries hereditary instructions that determine the formation of all living organisms
eukaryotic	species in which both the male and female contribute genetic material during the process of reproduction

evolutionary synthesis	synthesis of Darwinian theory of evolution by natural selection with Mendelian genetics
foramen	space in bone for passage of blood vessels and nerve fibres
gemmiparous	reproducing asexually
gemmules	particles which Darwin postulated circulated throughout the body carrying information about acquired change to the reproductive material, thus bringing about change in the next generation
germ-plasm	reproductive material
gynæcomastia	enlarged breast tissue in male
heterozygote	having both X and Y chromosomes (female)
hybridization	crossing of species/varieties other than that which normally occurs in nature
imago	adult form of caterpillar, either butterfly or moth
infusoria	amorphous animals reproducing by fission or budding with no special organs, even of digestion
karyotypes	number and arrangement of chromosomes
metacentric	chromosome with two arms of (approximately) equal length; ‘V’ shaped
metaphase	stage of cell division at which spindle fibres attach to chromosomes
microchromosomes	very small chromosome with no known function
monotreme	egg-laying mammal
mtDNA	DNA found in the mitochondria of cells, inherited through the maternal line
multi-regional evolution	theory that humans had evolved in many areas of the world after an initial diaspora from Africa about one million years ago
Neanderthals	occupants of Europe and western Asia 120,000-30,000 BP

noosphere Teilhard's terms for the sphere of the reasoning
mind

orthognathous jaw in 'normal' alignment, neither protruding nor
receding

os lunatum a bone from the wrist

Out of Africa theory that the species *Homo sapiens* evolved in
Africa approximately 150,000 years ago before
spreading to the rest of the world

oviparous egg-laying

pleiotropism single gene responsible for more than one
characteristic; single
characteristic influenced by more than one gene

polydactyly more than five digits on hand or foot

polyploidy an extra one, or more, complete chromosomes
produced during
cell division

polyps gelatinous animals which reproduce by budding; no
internal organs
other than an alimentary canal

prognathous having jaw that projects forward to a marked
degree

prokaryotes single celled organism with asexual reproduction

protoplasm most simple form of organic material capable of
sustaining
life

uadrumanus having four hands; primates

radiarians suboviparous animals with regenerating bodies; no
head, eyes
or jointed legs; mouth on inferior surface. (star
fish, sea urchin).

radiometric dating absolute dating method that measures the decay of
radio-active material

saltation evolutionary change by 'jumps' or 'leaps; sudden
change

seminiferous tubules tubules for the passage of semen

skeletal hyperostosis overgrowth of bone

speciation establishment of a new species

spontaneous generation life form which appears without parent

'sport'	distinct variation between parents and offspring, usually in plants; for example, double the number of expected petals
sympatric	living in the same area; two or more species whose habitat partly or largely overlap
taphonomy	history of fossil bones in the ground before discovery
taurodontism	enlarged pulp cavities found in some fossil human teeth
teleocentric	chromosome with one arm; 'rod' shaped
thelytokous	process of reproduction in which males play no part
Tory	British Conservative Party supported principally by the aristocracy and landed gentry
trilobites	extinct sea-floor dwelling species, with multiple eyes and a body segmented into three sections
tylosis	thick soles and palms
vernalization	increasing growth and reproduction by increasing warmth and light
viviparous	giving birth to live young
Whig	British Liberal Party, principally supported by financial and mercantile interests