The courage to face empirical reality: a biological perspective

Francois Durand
Department of Zoology, University of Johannesburg,
Auckland Park, South Africa

> The universe is not to be narrowed down to the limits of the understanding, which has been man's practice up to now, but the understanding must be stretched and enlarged to take in the image of the universe as it is discovered (Francis Bacon).

Introduction

Long before the discovery of hominid fossils naturalists realised that humans were not only closely related to primates, but that they were themselves primates. The oldest evidence of this knowledge is attributed to Aristotle and Hippocrates, who, more than 2 200 years ago, recognised the similarities between humans and monkeys. Aristotle argued that there is a transition between the non-living and the living, and that there is a natural tendency for things to progress from a lower to a higher plane and finally become divine. Galen of Pergamum was the first biologist to confirm this claim scientifically by dissecting humans and monkeys. He wrote, approximately 1 800 years ago: "The monkey is closest to the human with regard to internal organs, muscles, arteries, veins, nerves and shape of the bone" (Coxe 1846).

All the evidence − morphological, embryological, physiological, genetic and palaeontological − proves beyond a doubt that humans are animals: vertebrates, mammals, primates, apes and most closely related to the chimpanzee. The discovery that *Homo sapiens* is just one of millions of species on earth conflicted directly with the doctrine that humankind was created in the image of God and was physically, mentally and spiritually distinct from the rest of nature. These two conflicting approaches to the relationship between humankind and nature culminated in the friction between creationists and naturalists that continues to this day.

Discussion

Edward Tyson and the Missing Link

Apes are not indigenous to Europe, North Africa or the Middle East and at the time of Aristotle, Hippocrates and Galen monkeys and humans were the only primates known to the classical world. By the late 1690s chimpanzees were only known from an illustration based on the descriptions of explorers that ventured into the jungles of Central Africa. Although stories of fantastical creatures, some of them human-like, reached the shores of Europe during the age of exploration, the great apes such as the orang-utan and gorilla were not discovered or described by Europeans until the 18th and 19th centuries respectively. The first ape to be scientifically studied was a chimpanzee that was dissected by Edward Tyson in Britain in 1698. Tyson is regarded as the father of comparative morphology because of his extensive comparative studies of the anatomy of many animals. Thus he was the first person to determine that dolphins are mammals (Gribbin 2002).

His study of the chimpanzee culminated in *Orang-outang, sive Homo Sylvestris: or, The anatomy of a pygmie compared with that of a monkey, an ape, and a man. To which was added: A philological essay concerning the pygmies, the*

cynocephali, the satyrs, and sphinges of the ancients. Wherein it will appear that they are all either apes or monkeys, and not men, as formerly pretended (Tyson 1699). In this book he describes the anatomy of the chimpanzee and compares it with that of humans and monkeys, which leads him to conclude that chimpanzees are even more closely related to humans than monkeys. Tyson argues that the pygmy ('*Pygmie*') of Greek mythology and references to the 'man of the woods' in Asia (orang-utan) were based on actual observations of chimpanzees and in his book he uses the terms 'Orang-outang', '*Homo Sylvestris'* (Latin for 'man of the woods'), 'pygmie' and 'chimpanzee' interchangeably when referring to the subject of his study, the chimpanzee (Gould 1985).

Edward Tyson is also credited with the first formulation of the concept of the Missing Link when he defined the chimpanzee as the link immediately before humankind in the "Great Chain of Being". Tyson (1699) writes: "I take him to be wholly a Brute, tho' in the formation of the Body, and in the Sensitive or Brutal Soul, it may be, more resembling a Man, than any other Animal; so that in this Chain of the Creation, as an intermediate Link between an Ape and a Man, I would place our Pygmie." Tyson was the first person to define the concept of evolution, or change over time, in the following statement: "Tis a true Remark, which we cannot make without Admiration; That from Minerals, to Plants; from Plants, to Animals; and from Animals, to Men; the Transition is so gradual, that there appears a very great Similitude, as well between the meanest Plant, and some Minerals; as between the lowest Rank of men, and the highest kind of Animals. The Animal of which I have given the Anatomy, coming nearest to mankind; seems the Nexus of the Animal and Rational."

Carolus Linnaeus and the Primata

The 18th century Swedish naturalist Carolus Linnaeus (Carl von Linné) is considered to be the father of taxonomy (classification of organisms). Linnaeus attempted − almost a parody of Adam − to name and classify all known animals and plants so as to create order in the bewildering array of creatures that were discovered during the age of exploration. He devised a system, which is still in use today, to classify organisms according to their physical characteristics (Linnaeus 1735). The aim of taxonomy is to use shared characteristics of organisms to group them together according to their relationships. The classification system is in fact a formalised representation of the evolutionary tree of life.

Linnaeus coined the term 'Primata' in 1758 when he classified humans (*Homo sapiens*) as part of the Kingdom Animalia. The term 'Primata' implies the first of creation (Latin: *primus*, first), referring to Genesis 2 where Adam is depicted as the first organism to be created by God (the pope's official title is Primate of the Roman Catholic Church). Each of the *taxa* identified by Linnaeus was delimited by a set of unique characteristics, which was common to all members of that group. The set of characteristics used to classify primates includes: a pentadactyl hand with an opposable thumb, enlarged braincase, stereoscopic vision, enclosed orbit, foreshortened muzzle in some, with a tendency towards a reduced dental formula and a reduction in number of nipples.

All these characteristics apply equally to humans, apes and monkeys. Most of them are shared with prosimians (e.g. lemurs and bush babies), which also retained some more primitive ancestral characteristics such as an elongated snout, more teeth, rudimentary groin nipples, et cetera. The plesiomorphic characteristics of the prosimians link primates with tree shrews, which in their turn form the evolutionary link between primates and Insectivora, and so forth.

Linnaeus already explored the concept that the environment has an impact on the morphology of organisms that occur in a particular region. He received many organisms new to science from newly discovered countries all over the world for identification and description. He realised that each region of the world had a great

variety of animals and plants different from those of any other region. Although this may be a truism today, it was a startling discovery in the 18th century. It implied that God did not create species with a cosmopolitan distribution, nor did a particular species settle worldwide after leaving the ark when it ran aground in Turkey.

Linnaeus originally did not did not realise or suggest that common ancestors gave rise to the organisms that he grouped together. He believed in the fixity of species and only accepted that hybridisation may occur between certain plant and animal species. In later life he argued that the original species in the Garden of Eden − the *primae speciei* − gave rise to the extant species on earth. He also commented that nature is a "butcher's block" and that there is a "war of all against all", but he believed that this conflict was part of the natural process to maintain the divine order ordained by God (Waggoner 2000).

The French pioneers

Although Charles Darwin is often depicted as the father of evolution, he was not the first scientist to write about the physical change of organisms over time. In many respects Darwin followed in the footsteps of his predecessor Jean Baptiste Lamarck, who in his turn was a protégé of George Louis Leclerc, Comte de Buffon.

Buffon (1707-1788) suggested that organisms change over time as a result of environmental pressure or through chance. One of the most important premises of this argument was that the earth had to be far older than previously imagined to allow enough time for this change to have happened. The writings of Buffon, one of the greatest scientific thinkers of his time, included everything known about the natural world at that stage and were published in a series of natural history books, *Histoire Naturelle, générale et particulière*. This epic work appeared in 36 volumes between 1749 and 1804, the last eight volumes being published posthumously.

In his writings he reflected on the transformation and adaptation of organisms (now known as evolution). He also observed that every region in the world had different plants and animals (later termed Buffon's Law in the study of biogeography) and suggested that plants and animals, as they spread to other parts of the world from their locus of creation, had to change in order to adapt to the differing conditions. He was the first person to recognise vestigial characteristics and identified these as structures that fell into disuse over time. Buffon is also considered to have pioneered the study of ecology. Interestingly enough, he publicly denied the notion that one species could give rise to another, but paradoxically suggested that humans and apes shared a common ancestry in view of their common characteristics (Roger & Bonnefoi 1997).

His study of the distribution of organisms and their adaptation led him to reject the story of the deluge. He speculated that the earth had to be at least 75 000 years old, much older than the 6 000 years calculated by Archbishop James Ussher in 1654. Despite his denial of charges of atheism his writings incurred the ire of the Roman Catholic Church and his books were burnt.

Jean-Baptiste Pierre Antoine de Monet, Chevalier de Lamarck (1744-1829) was the first person to explore the role of the environment in the morphological transformation of animals (e.g. moles' blindness, birds' loss of teeth and giraffes' long necks). Although he used the term 'transformation' (*transformisme*) rather than evolution and was not the first to recognise evolution in nature, he was the first person to formulate a coherent theory of evolution and propose a mechanism of evolution (Gould 2002).

His study of evolution is summarised in three major publications: *Recherches sur l'organisation des corps vivants* (1802), *Philosophie Zoologique* (1809) and the *Histoire naturelle des animaux sans vertèbres* (7 volumes: 1815-1822). Lamarck proposed that there was a natural force, *le pouvoir de la vie* or *la force qui tend sans cesse à composer l'organisation* ("the complexifying force or the force that continuously creates order"), that drove organisms to transform from simple to more

complex forms over time. He realised that there was a force compelling organisms to adapt to their environment (*L'influence des circonstances*), which caused related groups to differ from one another over time. He also suggested that newly acquired characteristics are inherited by subsequent generations.

Lamarck's contribution to the study of evolution laid the foundation for the next generation of researchers, which included Darwin, Wallace and Huxley, and should not be underestimated. His monumental achievement is sometimes undervalued because of certain errors he made. Long before the work of Malthus, Darwin and Wallace on natural selection, Lamarck already suggested that organisms responded to a need evoked by environmental pressures on them to adapt. He also proposed that these characteristics, altered by its use or disuse, could be passed on to subsequent generations (Gould 2002). Lamarck – like many evolutionists after him, including Darwin – did not know anything about genetics, which is crucial for understanding the mechanism of adaptation and inheritance of characteristics. The study of genetics only got off the ground several decades after the pioneering work done by Gregor Mendel. Although Mendel's research was published in 1866, it went unnoticed until the 1900s, after his death.

Étienne Geoffroy Saint-Hillaire (1772-1844), an expert in comparative morphology, palaeontology and embryology, was one of Lamarck's co-workers and expanded and defended Lamarck's theories. In his *Histoire des Makis, ou singes de Madagascar* (1795) Geoffroy Saint-Hillaire proposed that there is an underlying unity of design in organisms and that transmutation may occur in species over time. He co-authored several publications with Lamarck, in which they classify organisms according to their possession of homologous characteristics (Mayr 1982). Classification by means of homologous characteristics, which would have been inherited from a common ancestor, implies that organisms of any taxon are more closely related to one another than to other similar groupings. Traditionally, before the use of genetics as an additional taxonomic resource, organisms were classified on the basis of a set of these morphological characteristics unique to that group, which set it apart from other similar groupings. To accept the principle of taxonomy implies acceptance of evolution.

If a phylogenetically irrelevant characteristic like colour were used for classification, one would have a green taxon, for instance, in which unrelated organisms such as plants, fungi, frogs, birds, fish and insects are placed in the same group. For the same reason one should not use analogous characteristics (i.e. similar characteristics which evolved independently when unrelated organisms such as fish and dolphins had to adapt to survive in similar conditions) for the classification of organisms. The confusion between homologous (different but related) and analogous (similar but unrelated) characteristics was the reason why the true identity of dolphins as mammals, not fish, was only discovered as late as the 18th century.

Baron Georges Léopold Chrétien Frédéric Dagobert Cuvier (1769-1832) contributed greatly to the establishment of palaeontology (the study of fossils) as a science. He is best known for his studies in comparative morphology and his comparison of extinct fossil species and extant (living) organisms (*Recherches sur les ossemens fossiles de quadrupeds,* 1812; and in the revised edition, *Discours sur les révolutions de la surface du globe,* 1826). Although Cuvier supported the idea of the existence of prehistoric organisms and extinction, he rejected the concept of speciation and believed in the fixity of species. He was highly critical of Lamarck's and Geoffroy Saint-Hillaire's views of the mechanism of evolution and rejected the notion that short-term physical attributes imposed on organisms would be inherited by their offspring. He also rejected the notion that the need to adapt would actually bring about the desired change in an organism and that the organism would rather become extinct than adapt. Based on observations of mummified bodies of humans and animals brought back from Egypt during the Napoleonic conquests, Cuvier concluded that even after thousands of years there were no observable changes in these organisms, which refuted Lamarck's hypotheses. He noted that the fossil

record showed abrupt extinctions and little evidence of the gradual changes that Lamarck proposed (Gould 1987).

Cuvier, in collaboration with the mining geologist Alexandre Brongniart, established that certain fossils were associated with specific geological strata and that these sedimentary layers were set down over vast periods of time. They concluded that over extremely long periods several successions of faunal assemblages had existed on earth, all of which were exterminated by catastrophic events. This observation led to the disturbing notion that God wilfully and arbitrarily periodically killed off large numbers of his creatures. They also determined that their study area was intermittently submerged by the sea and at other times was above sea level, instead of being flooded only once during the deluge. Stratigraphy (the study of fossil assemblages and their spatial and chronological distribution in geological strata) grew from their studies, which were published in 1808 and 1811. Stratigraphy forms the cornerstone of sedimentology and palaeontology.

Although the French were the first major contributors to the study of evolution, the limelight was usurped rapidly by the British during the 19th century in the aftermath of the French Revolution. Many of the French researchers in the field of evolution and palaeontology at the time were noblemen.

The British contribution

Britain, like France decades earlier, was a melting pot of ideas and inspiration, synergy and conflict and it is impossible to discuss the contribution of any one scientist without mentioning the involvement of many other researchers. It was in this intellectually fertile climate in the wake of the French contribution that Charles Darwin and Alfred Russel Wallace independently developed their hypotheses on evolution. Discussions with scientist friends such as Charles Lyell, Thomas Huxley, Asa Grey and Joseph Hooker influenced their thoughts and helped them to synthesise the most comprehensive theory of evolution at the time.

Charles Lyell (1787-1875) was a lawyer, who in later life became a geologist best known for his ground-breaking tome *Principles of geology*, which became a standard textbook and one of the most quoted works in earth sciences. Lyell expressed his views on uniformitarianism, the age of the earth, natural causes of land forms, volcanism, sedimentology, fossils and stratigraphy in *Principles of geology,* first published in three volumes between 1830 and 1833. He died while revising the twelfth edition. Uniformitarianism, first proposed by James Hutton (1785), is the theory that the same natural processes observable today, such as sedimentation, volcanism, floods, erosion and earthquakes, were active in the past and caused the phenomena observed in geology. It is captured by the maxim, “the present is the key to the past”. It also implied that protracted periods were necessary to produce the phenomena we see in nature. Lyell’s observation that earth is very old and continued changing provided a backdrop to organic evolution, adaptation and speciation, which needed long periods of time. Most 19th century British evolutionists referred to Lyell’s work in the course of their research and in publications (Gould 1987).

Robert Chambers (1802-1871), a publisher and author who was interested in geology, anonymously authored *Vestiges of the natural history of creation,* which appeared in 1844. In this book he discussed the concept of evolution and, criticising Lamarck’s proposed mechanism of evolution, he attempted “to connect the natural sciences in a history of creation”. The book was revolutionary in that it implied that God might not be actively involved in sustaining the natural and social hierarchies, which originated without his assistance. He believed that God created distant ancestral groups and put the laws of nature in place, but he then left nature to run according to these laws unaided. Although the book was attacked by certain clergymen, scientists and lay people, who claimed that it would undermine the moral fabric of society, it remained popular, saw many reprints and was a bestseller for decades.

Charles Darwin (1809-1882) was a multidisciplinary researcher and a prolific writer. The bulk of his research was on entomology, earthworms and clams. It was only in later life, prompted by the writings of Alfred Russel Wallace and the encouragement of his botanist friend J.D. Hooker, that he published his theory of evolution in *On the origin of species by means of natural selection, or the preservation of favoured races in the struggle for life* (Darwin 1859). For the sixth edition and all subsequent editions the title was changed to *The origin of species*.

There are a number of curious, little known facts about this seminal work. Firstly: despite the title, Darwin does not discuss the origin of species in this book. He does not discuss the evolution of humankind either: all he says is that "light will be thrown on the origin of man and his history", implying that in time more evidence on the origin of humans will be discovered. The term 'evolution' only appears in the sixth edition of his book – in the earlier editions he used the term 'descent with modification'. Darwin did not coin the term 'survival of the fittest' either. This term was first used in Herbert Spencer's *Principles of biology* in 1864, five years after Darwin's book appeared. By the time Darwin published *On the origin of species* the notion of evolution was hardly controversial any more and was no longer much debated in scientific circles, although details such as the rate of evolution, the origin of life, the origin of species and the mechanism of inheritance were discussed.

Thomas Robert Malthus, a mathematician and professor of political economy, who later qualified and worked as a theologian, formulated the theory of population growth. According to Malthus populations (including humans) produce far more offspring than can survive on the available limited natural resources. In his *Essay on the principle of population* (Malthus 1798) he proposes that famine, disease and competition caused by overpopulation served to cull surplus individuals until equilibrium was reached. Malthus believed, as can be expected from a clergyman, that these natural forces were designed and controlled by God.

Alfred Russel Wallace (1823-1913), who became famous as an explorer, geographer, anthropologist and biologist, contributed greatly to the science of biogeography. Both Darwin and Wallace were independently influenced by Malthus's views. Wallace (1855) recognised the parallels between Malthus's theory and his observations of the plants and animals he studied, which inspired his important paper *On the tendency of varieties to depart indefinitely from the original type,* which he sent to Darwin for commentary in 1858. Darwin recognised the parallels between Wallace's paper and his own research, which he also planned to publish. Later that year they jointly authored a paper on natural selection and adaptation (Darwin & Wallace 1858). In due course Darwin's name became associated with studies of evolution, because from the time of their joint publication onwards he focused on the theory of evolution, while Wallace continued with biogeography, sociology, anthropology and many things besides.

Thomas Henry Huxley (1825-1895) was a zoologist, anatomist and palaeontologist and one of Darwin's strongest supporters. Whereas Darwin was reclusive and shied away from the limelight, Huxley was an extrovert and had no reservations about public appearances − nor about public confrontations. He even referred to himself as 'Darwin's bulldog'. Huxley, too, excelled in the study of comparative morphology and contributed greatly to invertebrate classification. He also studied the relationship between humans and apes and did research on dinosaurs. His conclusion that birds evolved from small carnivorous dinosaurs is still accepted today. However, he is best remembered for his advocacy of evolution theory and the founding of agnosticism. Huxley contributed to the secularisation of British society by opposing organised religion in any form and promoted science education, which included a heavy dose of evolution, for children as well as adults.

The study of evolution continued after the foundation was laid by these French and British pioneers. In the 19th and 20th centuries researchers from all parts of the world joined in the study of evolution. The Swedish monk and botanist Gregor Mendel

added genetics, and the German physician, anatomist and naturalist Ernst Haeckel added comparative embryology to the pool of knowledge.

Ernst Heinrich Philipp August Haeckel (1834-1919) used the term 'transmutation' (*Transmutations-Theorie*) and his theory of descent (*Desendenz-Theorie*) instead of 'evolution' in his description of the morphological transition from one life form to the next. These theories were essentially elaborations on the work of Lamarck and Darwin, whose contributions he propagated in Germany. He described and named thousands of new species and coined many new biological terms. He invented the terms 'phylogeny' (referring to evolutionary descent), 'ecology', 'phylum/phyla' (for the major zoological taxa) and 'Protista' for the kingdom containing unicellular eukaryotic organisms such as Amoeba and Plasmodium. Haeckel is well-known for his controversial theory of recapitulation, according to which the ontogeny (embryonic development) of an organism recapitulates (repeats) the phylogeny (evolutionary descent) of a species. He wrote *Natürliche Schöpfungsgeschichte* (1868), *Die Welträthsel* (1895-1899) and *Die Lebenswunder* (1904), which expounded his theories on the formation of the world and its creatures and the meaning of life. In *Anthropogenie* (1874) and *Über unsere gegenwärtige Kenntnis vom Ursprung des Menschen* (1898) he describes human evolution. He also wrote *Freie Wissenschaft und freie Lehre* (1877), which advocated the teaching of evolution in schools.

The end of the 19th century also saw the blooming of palaeontology as thousands of fossils were being excavated in Europe, the USA and South Africa. The overwhelming evidence of evolution from the fields of comparative morphology, genetics, palaeontology, embryology and ecology unleashed an irrepressible tide of information that could not be ignored. The time had come for the non-scientific world to adapt to the new order.

Response to the concept of the evolution of humankind

Although the theories of the mechanism of evolution, discoveries of fossils and the age of the earth were tolerated or ignored by many, very few people were apathetic about the notion of human evolution when confronted with it. Few scientific subjects have ever attracted so much animosity than palaeoanthropology or the study of the origins and evolution of humankind. Even today lay people often accept the notion of change over time of all organisms − except humans.

There has seldom been such bitter animosity between two scientists as that between Thomas Huxley and Richard Owen on this matter. Thomas Huxley's views of the relation between humans and apes brought him into confrontation with Richard Owen who, despite the fact that he was a palaeontologist, maintained that humans were unrelated to other animals and belonged in a subclass of their own. Owen claimed that there were major differences between the brains of humans and chimpanzees. This brash statement was refuted during a public dissection of a chimpanzee by William Flower, a friend of Huxley, at Cambridge in 1862, where it was demonstrated that the chimpanzee's and the human brain indeed had the same structures. This demonstration showed that Huxley was a better and more reliable anatomist than Owen and marked the end of Owen's public reputation. In 1862 Huxley described a Neanderthal skull, the first palaeoanthropological study ever. Huxley identified and discussed the morphological affinities between humans and apes in his most famous book, *Evidence as to man's place in nature* (1863), which appeared several years before Darwin's *The descent of man, and selection in relation to sex* (1871). Darwin's book focused more on races and adaptive response to the environment, while Huxley discussed the evolution of humans from apes.

No remains of ape-men and very few remains of primitive humans were known in the late 19th century. Darwin (1871) wrote: "In each great region of the world the living mammals are closely related to the extinct species of the same region. It is therefore probable that Africa was formerly inhabited by extinct apes closely allied to

the gorilla and chimpanzee; and as these two species are now man's nearest allies, it is somewhat more probable that our early progenitors lived on the African continent than elsewhere." We know today that this statement, based on a shrewd interpretation of biogeography rather than a wild guess, turned out to be true.

Eugène Dubois (1858-1940) attended a lecture on evolution by a visiting German scientist in the town of Roermond, Holland where he was at high school. This lecture inspired his decision to find evidence of human evolution in the form of fossils of the Missing Link. He got his training in human anatomy as a medical student in Amsterdam. Dubois, like Darwin and Wallace, reasoned that tropical forests would have offered ideal living conditions for the ancestors of humankind, since our closest relatives, the great apes, still inhabit these regions. Dubois was especially intrigued by a statement by Wallace (1869): "It is very remarkable that an animal, so large, so peculiar, and of such a high type of form as the orang-utan, should be confined to so limited a district − to two islands … With what interest must every naturalist look forward to the time when the caves of the tropics be thoroughly examined, and the past history and earliest appearance of the great man-like apes be at length made known."

Despite Darwin's prediction that evidence of human ancestry would be found in Africa, Dubois decided to go to southeast Asia to look for human ancestors because of the distribution of the orang-utan and gibbon. In 1887 Dubois departed for Sumatra as a medical officer in the Dutch East Indian Army. After discovering many hundreds of fossils Dubois, between 1891 and 1892, found molars, a fossilised skull cap and a femur of a hominid on the Solo River in Java. Ernst Haeckel named it *Pithecanthropus erectus,* later renamed *Homo erectus*. Dubois was convinced that he had discovered the Missing Link and presented his findings at the Third International Congress of Zoology in Leiden in 1895. His presentation triggered a furious controversy in the scientific community: the German scientists argued that it was an ape-like creature with human characteristics, while the British scientists argued that it was a human with ape-like characteristics. The American scientists thought along Dubois's lines, namely that it was the Missing Link with an equal number of ape-like and human characteristics. Dubois was attacked from pulpit to platform as a heretic (Dart & Craig 1959; Gould 1993).

History shows that the British scientists were correct − *Homo erectus* is much nearer *Homo sapiens* in the human family tree than the chimpanzee and could therefore not be considered the Missing Link. On 21 October 1907 a jaw of another hominid species, even more closely related to modern humans, was discovered in a sand quarry near Mauer in Germany. Professor Otto Schoetensack of Heidelberg University noted that it was virtually impossible to tell the difference between this fossil jaw and that of a big anthropoid ape, were it not for the large but otherwise very human-like teeth. This was the first of many prehistoric human fossils, which would later be described and named *Homo heidelbergensis*.

Raymond Dart (1893-1988), originally from Australia, was appointed head of the anatomy department at the medical school of the University of the Witwatersrand in 1923 and word got round that he was interested in fossils. In November 1924 a miner, one De Bruin, discovered a natural endocast of the braincase and a rock containing the skull of a juvenile ape-man at the Norlim limestone mine at Buxton near Taung in South Africa. This fossil was included in two boxes of fossils, which were sent from Norlim to Professor Raymond Dart in December 1924. Dart (1925) described this fossil with its mixture of ape-like and human characteristics as the Missing Link and named it *Australopithecus africanus* in a paper that was widely condemned by both the scientific community and the public. From New York came a news flash: "Professor Dart's theory that the Taungs skull is a Missing Link has evidently not convinced the legislature of Tennessee, the governor of which state has signed an 'Anti-Evolution' Bill which forbids the teaching of any theory contrary to the Biblical story of the creation, or that man is descended from the lower orders of animals. Similar legislation which is at present before other state legislatures marks

the growth of a strict biblicist movement represented by so-called fundamentalist churches whose leading propagandist is the silver-tongued orator, William Jennings Bryan" (Dart & Craig 1959).

There was an overwhelming response to this discovery from the general public, including congratulations from general Jan Smuts. Dart personally received many letters from people all over the world and the newspapers were inundated with letters from readers. Unfortunately a large percentage of these were of a fundamentalist nature. One correspondent warned him that he was "sitting on the brink of the eternal abyss of flame" and is destined to "roast in the general fires of Hell"; from France came a letter telling him he would "roast in the quenchless fires of hell". A correspondent from England said: "I hope that you will be placed in an institution for the feeble-minded"; another expressed the hope that he would be punished by "being unblessed with a family which looks like this hideous monster with the hideous name". A correspondent to the *Sunday Times* wrote: "How can you, with such a wonderful gift of God-given genius − not the gift of a monkey, but a trust from the Almighty − become a traitor to your Creator by making yourself the active agent of Satan and his ready tool? What does your Master pay you for trying to undermine God's word? Or do you not know his wages? Man, stop and think. You with your splendid brain, God's gift to you, have become one of the Devil's best agents in sending seeking souls to grope in the darkness. What will it profit you? The wages of the master you serve is death. Why not change over? What will evolution do for you when dissolution overtakes you?" (Dart & Craig 1959).

There was a mixed but mainly negative reaction from the scientific world. For most of 1925 the correspondence columns of *Nature* were filled with vicious attacks on Dart and his fossil. The most damning criticism came from some of the world's leading anthropologists such as Sir Arthur Keith, Sir Arthur Smith Woodward, Sir Grafton Elliot Smith (Dart's mentor) and W.L.H. Duckworth. Keith was of the opinion that the Taung child was just another anthropoid ape, closely related to gorillas and chimpanzees. Woodward insisted on more examples of the same kind of skull and stated his belief that the new fossil from Africa "certainly has little bearing" on the question of the ancestry of humankind. Smith, on the other hand, insisted that Dart had to supply them with information about "the geological evidence of age, the exact conditions under which the fossil was found, and the exact form of the teeth". Duckworth, the only one of the four experts who was not a peer of the realm or a fellow of the Royal College of Surgeons, was also the most reasonable in his commentary. Duckworth admitted that he could distinguish several advanced human-like features in the Taung fossil, but wondered whether these were the effect of actual evolutionary progress considering the youthfulness of the individual (Dart & Craig 1959).

Robert Broom (1866-1951), originally from Scotland, had a medical practice in the Karoo but was also an outstanding palaeontologist, geologist and biologist. Broom is probably one of the greatest fossil hunters of all time, having discovered, named and described literally hundreds if not thousands of fossils. He was the first to realise that the sequence of geological strata of the Karoo could be subdivided stratigraphically by using the fossil record. In August 1934, at the age of 68 when most people would retire, Broom started a second career as a palaeontologist at the Transvaal Museum in Pretoria. He was one of Dart's greatest supporters (Broom 1925) and, after studying the Taung skull, wrote to the *Cape Times* (25 February 1925): "The skull is … probably the most important ancestral human skull found. In fact, I regard it as the most important fossil ever discovered." Eighteen months after his appointment at the Transvaal Museum Broom launched a search for more ape-man fossils in an attempt to silence the critics and clear Dart's reputation.

On Monday 17 August 1936, nine days after he started working at Sterkfontein north of Krugersdorp, he discovered the first adult ape-man skull (Broom 1936). This species was initially named *Australopithecus transvaalensis*, but was later renamed *Plesianthropus transvaalensis* and finally synonymised with *Australopithecus*

africanus. This skull was very fragmentary and attracted little attention from the scientific world. On 18 April 1947 Broom discovered a beautifully preserved *Australopithecus africanus* skull at Sterkfontein. This skull, later dubbed Mrs Ples, was the first undistorted and virtually complete skull of a sub-adult (the wisdom teeth had not erupted at the time of death) ape-man ever found (Broom & Robinson, 1947). Thousands of ape-man fossils have subsequently been discovered in this region.

A chain reaction followed in the scientific, social and religious spheres in the wake of this discovery. Dart's juvenile Taung skull and Broom's earlier skull fragments could possibly be ignored as annoying anomalies, but now Broom had irrefutable proof of the existence of ape-men. The ape-man skeleton fragments which he had been excavating for a decade suddenly took on new meaning. Dart was vindicated and was proven completely correct while his critics were proven completely wrong. The public reaction to Broom's discovery was far more subdued than the response to Dart 23 years earlier. The reaction of organised Christianity to the discovery of irrefutable proof of human ancestry was interesting. The Reformed Ecumenical Synod accepted evolution, while the Roman Catholic Church rejected it.

Evolution and religion

Acceptance of evolution burgeoned in philosophical circles in tandem with scientific developments at the time. The eminent German philosopher Immanuel Kant (1724-1804) speculated that similar organisms descended from a common ancestor. He even argued that an orang-utan or a chimpanzee may develop the structures needed for walking, grasping and speaking and continue to develop until it becomes human with the ability to reason. Herbert Spencer and Nietzsche were to follow with their philosophies about human ancestry and the place of humans in the natural world.

The discovery and exploration of evolution did not proceed unopposed, however. With growing public awareness negative sentiments towards evolution increased. Not surprisingly, most attacks were religiously motivated. Many scientists' attitude towards religion changed over time as well. Whereas most 18th century life and earth scientists openly subscribed to (mostly Christian) religion, a tendency developed among 19th century scientists to drift away from mainstream Christian orthodoxy. There were, however, a few scientists such as Charles Lyell who were ambiguous about their true conviction, especially in public, or diehards like Richard Owen who rejected evolution in favour of Christian orthodoxy.

The conflict between religion and evolution continued to escalate and became increasingly bitter. The fields of evolution, palaeontology and geology drew several theologian-scientists such as Andrew Buckland, Charles Darwin, Teilhard de Chardin and Abbé Breuil, who were honestly looking for the truth. On the flip side of the coin were scientists like Richard Owen who purposely misconstrued or ignored empirical facts and conspired with creationist theologians to defend their orthodox beliefs.

Richard Owen (1804-1892) was a physician, comparative morphologist and palaeontologist. After serving as Hunterian professor in the Royal College of Surgeons he was appointed superintendent of the natural history department of the British Museum. He was the prime mover behind the transformation of that department into the British Museum of Natural History, which was established in London in 1881. He authored hundreds of research papers, mostly on comparative morphology and classification of a variety of organisms, both extinct and extant. He is best known for describing and naming the Dinosauria and Synapsida, two of the most important prehistoric animal groups ever found. Despite the fact that birds evolved from dinosaurs and mammals from synapsids, Owen ignored all evidence which supported evolution. In 1863 he acquired a specimen of *Archaeopteryx* for the British Museum of Natural History and proceeded to describe it as a bird, purposely ignoring

the fact that the skeleton of *Archaeopteryx* is indistinguishable from that of a theropod dinosaur.

When confronted with evidence of evolution in comparative morphology Owen interpreted homologous characteristics in species, which is evidence of common descent, as 'archetypes' in the divine mind. He argued that there was an "ordained continuous becoming" in order to explain why more primitive organisms would appear lower down and more advanced ones higher up in the fossil record. He was one of the fiercest opponents of evolution and was openly hostile to Darwin, Huxley and Hooker, whom he attacked in the press. He was also the scientist who primed Bishop Samuel Wilberforce for his famous anti-evolution debate in 1860, when Wilberforce promised to "smash Darwin" at Oxford University. Despite all his good work and solid research, Owen was deceitful, arrogant and sadistic (Cadbury 2000). He plagiarised other researchers' work and took credit for their discoveries. Eventually he was voted out of the councils of the Royal Society and the Zoological Society because of the resultant scandals. Of all Darwin's antagonists Owen was the only one Darwin was known to have hated. After Owen's attempt to stop the government grant for J.D. Hooker's botanical collection at Kew Darwin said: "I used to be ashamed of hating him so much, but now I will carefully relish my hatred & contempt to the last days of my life."

The inescapable realisation that humans were apes forced theistic evolutionists to support the classical philosophical tenet that humans are dual creatures consisting of a physical and a spiritual component. The physical body, which was animal-like and had evolved over time, housed an eternal spirit which was inherited from God. These views were already popular in religious scientific circles in the West long before Charles Darwin's books on evolution were published in 1859 and before the discovery of hominid fossils in the 20th century.

There was also growing support for the philosophy that the physical evolution of hominids paralleled their spiritual evolution and that humankind would over time attain a more godly spiritual state. In *Also sprach Zarathustra* Friedrich Nietzsche (1883-1885) refers to humans as a transitional stage between the apes and the *Ubermensch*. A well-known 20th century proponent of this philosophy was the Jesuit priest and anthropologist Teilhard de Chardin. The view that at one end of this animal/human continuum there were animals with human-like tendencies, while at the other end there were humans with animal-like tendencies, was also gaining favour in the 19th century. These ideas inspired pseudo-scientific discriminatory racial classification and eugenics, as well as popular novels like *Dr Jekyll and Mr Hyde* by Robert Louis Stevenson (1886) and *The Island of Doctor Moreau* by H.G. Wells (1896).

Although many religious people managed to reconcile evolution with their beliefs, there remained some unease when it came to accepting human ancestry. There seems to be a tendency amongst some religious people to attack or ignore evolution or reserve a special place in creation for humankind while accepting evolution as a natural phenomenon. Increasing evidence of human ancestry challenged these tendencies to their foundation and eventually the church could not ignore it any longer.

The Reformed Ecumenical Synod of 1949 accepted evolution as a valid scientific theory not in conflict with the Bible (Du Toit 1968). For the first time a church body publicly embraced evolution instead of denouncing it − although unfortunately this decision was not often propagated from the pulpits. Evolution was accepted as an acceptable scientific explanation of the origin and diversity of organisms − provided it did not detract from the belief that God created everything through the process of evolution. The Dutch theologian Reijer Hooykaas wrote many articles in this period, in which he advocated the accommodation of scientific thought even though it might not be in line with the scriptures (1950). Although the mainstream Reformed churches had a more open approach to evolution than the Catholic Church, powerful stalwarts in the DRC in South Africa such as Johan Heyns (1978)

and Adrio König (1993) continued to reject mainstream evolution and clung to biblical literalism.

Officially the Roman Catholic Church did not accept evolution until 1996 (John Paul II, 1996). In reaction to the acceptance of evolution by the Reformed Ecumenical Synod, Pope Pius XII (1950) issued the encyclical, *Humani Generis* in which he warns against the 'doctrine of evolution'. He said: "If such conjectural opinions are directly or indirectly opposed to the doctrine revealed by God, then the demand that they be recognized can in no way be admitted." About the study of the origin of humankind he said: "Some, however, rashly transgress this liberty of discussion, when they act as if the origin of the human body from pre-existing and living matter were already completely certain and proved by the facts which have been discovered up to now and by reasoning on those facts, and as if there were nothing in the sources of divine revelation which demands the greatest moderation and caution in this question."

The majority of mainstream Christian churches do not feel threatened by evolution. The two main creationist and anti-evolution Christian groupings which remain are the neo-Calvinist movement (Stoker 1997, *Die Kerkpad* 2003) and the Pentecostal movement.

Science is an attempt to understand nature. Scientists are trained to search for empirical truth, to design rigorous tests to validate their findings, formulate theories which incorporate all known facts that support a hypothesis and dispassionately reject or change a theory when new data come to light. Both science and religion claim to search for truth, but their methodologies are completely different. Science is exclusively concerned with empirical facts and religion with belief systems. Science cannot comment on the metaphysical realm; by the same token religion may not attack science (Gould 1999). Regardless of these differences, some theologians are morbidly attracted to science and some scientists are attracted to religion. It is important to note that Darwin never used evolution to attack religion. He was also reluctant to debate about religion and evolution. He wrote: "It seems to me (rightly or wrongly) that direct arguments against Christianity and Theism hardly have any effect on the public; and that freedom of thought will best be promoted by that gradual enlightening of human understanding which follows the progress of science. I have therefore always avoided writing about religion and have confined myself to science" (Gould 1977).

Charles Darwin's life is one of the best examples of the spiritual evolution which occurred in the lives of many scientists at the time and probably still happens today. Darwin himself was originally a trained minister of the church. Even in *Origin of species* he states: "There is grandeur in this view of life, with its several powers, having been originally breathed by the Creator into a few forms or into one; and that, whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being evolved." In later life Darwin (1879) wrote a letter to John Fordyce: "It seems to me absurd to doubt that a man can be an ardent Theist and an Evolutionist. Whether a man deserves to be called a Theist depends upon the definition of the term, which is much too large a subject for a note. In my most extreme fluctuations I have never been an Atheist in the sense of denying the existence of a God. I think that generally (and more and more as I grow older, but not always), that an Agnostic would the more correct description of my state of mind."

Both Darwin and Huxley were family men who dearly loved their children. Both lost a child. Darwin's ten-year-old daughter Annie died after a long illness and Huxley lost his son Noel suddenly at the age of three. Both men were friends of the liberal theologian and author Charles Kingsley. Kingsley wrote a compassionate letter to Huxley after the death of his son and urged him to return to the faith because of the comfort he would derive from knowing that he would be reunited with his son in the afterlife. Huxley replied: "My Dear Kingsley − I cannot sufficiently thank you, both on

my wife's account and my own, for your long and frank letter, and for all the hearty sympathy which it exhibits … My convictions, positive and negative, on all the matters of which you speak, are of long and slow growth and are firmly rooted. But the great blow which fell upon me seemed to stir them from the foundation, and had I lived a couple of centuries earlier I could have fancied a devil scoffing at me and them − and asking me what profit it was to have stripped myself of the hopes and consolations of the mass of mankind? To which my only reply was and is − Oh devil! truth is better than much profit. I have searched over the grounds of my belief, and if wife and child and name and fame were all to be lost to me one after the other as the penalty, still I will not lie" (Gould 1999). His view of the arbitrary mercilessness of nature (and therefore, implicitly, the will of God) is best illustrated by this statement: "Of moral purpose I see not a trace in nature. That is an article of exclusively human manufacture" (Huxley 1900).

The acceptance of evolution and the origin of humankind by the church came too late for people like Darwin and Huxley. They realised that the origin and adaptation of organisms could not disprove the existence of God, but they could no longer accept a personal and loving God who controlled the universe and the fate of humankind. Diseases, drought, famine and natural disasters either meant that there was no god or that God was capricious and cruel, and arbitrarily or, even worse, maliciously killed little children or wiped out whole ecosystems with millions of species in an instant. Scientists discovered natural disasters were caused by earthquakes, floods, lightning and drought, that diseases were caused by viruses, bacteria and parasites, and that the just and the unjust alike were killed by these natural phenomena.

To claim that there was a metaphysical power behind natural phenomena is just another form of animism. In a letter to his friend Asa Grey Darwin wrote: "I own that I cannot see as others do, and as I should wish to do, evidence of design and beneficence on all sides of us. There seems to me too much misery in the world. I cannot persuade myself, that a beneficent and omnipotent God would have designedly created the *Ichneumonidae* with the express intention of their feeding within the living bodies of caterpillars, or that a cat should play with mice." This passage illustrates the growing disillusionment with religion when scientists have to face and accept the deeper implications of the facts that confront them, which religion can neither accept nor cope with.

Nature is neither good nor bad − it is merely indifferent to suffering (Dawkins 1995). Thomas Huxley (1900) understood this when he said: "Science seems to me to teach in the highest and strongest manner the great truth which is embodied in the Christian conception of entire surrender to the will of God. Sit down before fact as a little child, be prepared to give up every preconceived notion, follow humbly wherever and to whatever abysses nature leads, or you shall learn nothing. I have only begun to learn content and peace of mind since I have resolved at all risks to do this."

This, then, is the conundrum that every thinking person has to face: would you lie and persecute others who disagree with you to uphold the faith, even though it flies in the face of reason and every empirical fact? Or would you rather graciously slip from the moorings of sheltered religious dogmatism on a voyage of truth, dispassionately following the facts wherever they may lead you, into the untameable and pitiless cosmos where gods are powerless, meaningless and superfluous? If you accept the latter, you will also realise that there is no deity that can or will save us from self-destruction or absolve us from our devastation of the planet. We, the spawn of stardust, sun-energy sustained, self-replicating, carbon-based molecules, multicellular heterotrophs with vertebrae, three middle ear bones and opposable thumbs, have just one mandate: we have to take responsibility for ourselves and we must not deflect that responsibility to a deity who must take care of our deeds, lives and the planet. We have but this one life, and the sooner we accept the empirical reality of our position in nature, our dependence on nature to sustain us, and the responsibility that comes with technology, the better.

Bibliography

Broom, R 1925. Some notes on the Taungs skull. *Nature* 115, 569-571.

Broom, R 1936. A new fossil anthropoid skull from South Africa. *Nature* 138, 486-488.

Broom, R & Robinson, J 1947. Further remains of the Sterkfontein ape-man, *Plesianthropus*. *Nature* 160, 430-431.

Cadbury, D 2000. *Terrible lizard: the first dinosaur hunters and the birth of a new science*. New York: Holt.

Chambers, R 1844. *The vestiges of the natural history of creation* (published anonymously until the 12th edition in 1884). London: John Churchill.

Coxe, J R 1846. *The writings of Hippocrates and Galen − epitomised from the original Latin translations*. Philadelphia: Lindsay & Blakiston.

Dart, R 1925. *Australopithecus africanus*: The man-ape of South Africa. *Nature* 115, 195-199.

Dart, R & Craig, D 1959. *Adventures with the Missing Link*. London: Hamilton.

Darwin, C 1859. *On the origin of species by means of natural selection, or the preservation of favoured races in the struggle for life*. London: Murray.

Darwin, C 1871. *The descent of man, and selection in relation to sex*. London: Murray.

Darwin, C 1879. Letter to John Fordyce. *Darwin Correspondence Project.* ttp://www.darwinproject.ac.uk/darwinletters/calendar/entry-12041.html

Darwin, C & Wallace, A R 1858. On the tendency of species to form varieties; and on the perpetuation of varieties and species by natural means of selection. *Proceedings of the Linnaean Society of London, Zoology* 3, 46-50.

Dawkins, R 1995. *River out of Eden*. London: Weidenfeld & Nicolson.

Die Kerkpad, 7(4), September 2003. *Opvoeding en onderwys. Standpuntstelling teen evolusionisme in skole.*

Du Toit, S 1968. *Bybel, skepping, evolusie*. Johannesburg: Voortrekkerpers.

Gould, S J 1977. *Ever since Darwin*. London: Burnett Books & André Deutsch.

Gould, S J 1985. *The flamingo's smile*. New York: Norton.

Gould, S J 1987. *Time's arrow, time's cycle*. Cambridge Mass.: Harvard University Press.

Gould, S J 1993. *Eight little piggies*. New York: Norton.

Gould, S J 1999. *Rocks of ages: science and religion in the fullness of life*. New York: Library of Contemporary Thought.

Gould, S J 2002. *The structure of evolutionary theory*. Cambridge, Mass.: Harvard University Press.

Gribbin, J 2002. *Science − a history 1543-2001*. London: Lane.

Heyns, J A 1978. *Dogmatiek*. Pretoria: N.G. Kerkboekhandel.

Hooykaas, R 1950. Dominees en evolutie. *Bezinning-Gereformeerd Maandblad tot Bewaring en Bevordering van het Christelijk Leven* 5, 74-88.

Hutton, J 1785. *Concerning the system of the earth, its duration, and stability*. Abstract of dissertation read in the Royal Society of Edinburgh, Edinburgh, 30pp.

Huxley, L 1900. *The life and letters of Thomas Henry Huxley*. London: Macmillan.

Huxley, T H 1863. *Evidence as to man's place in nature*. London: Macmillan.

John Paul II. 1996. *Address to the Pontifical Academy of Sciences*, no. 1, 28 October 1986, L'Osservatore Romano English edition, p. 22. Vatican Information Service.

König, A 1993. *Menslike mense: gelowig nagedink*, Deel 5. Halfway House: Orion.

Linnaeus, C 1735. *Systema naturae per regna tria naturae, secundum classes, ordines, genera, species, cum characteribus, differentiis, synonymis, locis*. Magdeburg: Holmiae, Impensis Direct, Laurentii Salvi.

Lyell, C 1830-1833. *Principles of geology*, vol.1-3. London: Murray.

Malthus, T R 1798. *An essay on the principle of population*. London: Johnson.

Mayr E 1982. *The growth of biological thought: diversity, evolution and inheritance*. Cambridge, Mass.: Harvard University Press.

Nietzsche, F 1883-1885. *Also sprach Zarathustra – ein buch für Alle und Keine*. Chemnitz: Verlag von Ernst Schmeitzner.

Pius XII. 1950. *The Encyclical "Humani Generis", concerning some false opinions threatening to undermine the foundations of Catholic doctrine to our venerable brethren, patriarchs, primates, archbishops, bishops, and other local ordinaries enjoying peace and communion with the Holy See*. St Peter's, Rome, August 12, 1950. http://www.vatican.va/holy_father/pius_xii/encyclicals/documents/hf_p-xii_enc_12081950_humani-generis_en.html.

Roger, J & Bonnefoi, S L 1997. *Buffon: a life in natural history*. New York: Cornell University Press.

Spencer, H 1864. *Principles of biology*. London: Williams & Norgate.

Stoker, P 1997. *Bybelgefundeerde grondslae vir primêre en sekondêre skoolonderwys*. Vereniging vir Christelike Hoër Onderwys.

Tyson, E 1699. *Orang-outang, sive Homo Sylvestris: or, The anatomy of a pygmie compared with that of a monkey, an ape, and a man. To which was added: A philological essay concerning the pygmies, the cynocephali, the satyrs, and sphinges of the ancients. Wherein it will appear that they are all either apes or monkeys, and not men, as formerly pretended.* London: Bennet & Brown.

Waggoner, B 2000. *Carl Linnaeus. 1707-1778*. http://www.ucmp.berkeley.edu/history/linnaeus.html.

Wallace, A R 1855. On the law which has regulated the introduction of new species. *Annals and Magazine of Natural History*, 16(2), 184-196.

Wallace, A R 1869. *Malay Archipelago, the Land of the Orang-utan and the Bird of Paradise: Narrative of Travel with Studies of Man and Nature*. http://www.authorama.com/malay-archipelago-1-1.html