1. The History and New Theory of Evolution

There is an enormous variety of life on Earth. Scientists estimate that there are 10 million species living at present and that vastly greater numbers are involved if the multitude of extinct species are counted. This huge variety of life posed many questions for scientists. These included how new species developed and how characteristics were passed on to subsequent generations.

Early Ideas

Until the middle of the 18th century, Europeans thought the Earth was only a few thousand years old. The dominant view reflected a Christian Judaist theological perspective that species were created suited to their existence and without changes over time. From 1750, geology emerged as a science. Leading geologists of the time, such as Charles Lyell, revealed that the earth was much older than had been originally suggested. At the same time, fossilised remains of many unfamiliar organisms were being discovered from the deep layers of the earth's surface and the notion of changing species and evolution became prominent.

In 1809, Jean-Baptiste Lamarck, reported his theory of evolution: that life evolved alongside the evolving earth. He believed that the fossil record indicated that changes in the earth and local environments resulted in changes in the structure and behaviour of organisms. He suggested that individual organisms and ultimately species, were able to develop new traits in response to their environmental needs and then were able to pass these new traits on to their young. Over time disuse would cause a structure to shrink or disappear, whilst overuse would cause it to enlarge. Lamarck believed that the unfamiliar species indicated by the fossil record disappeared because they evolved into new species. The notion of species extinction was not considered at this time.

Charles Darwin

In 1831, the idea of change through evolution was not new and scientific thought was ripe for advancement in this field. A 22 year old Charles Darwin joined a 5-year expedition on *HMS Beagle* as the ship's naturalist. The voyage covered 64,000 kilometres charting the South American coastline and visiting Australia, Tahiti and the Galapagos Islands.

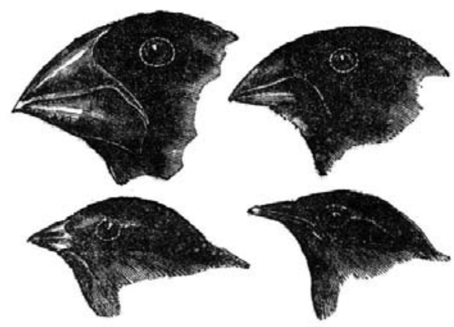
Throughout the journey Darwin collected many specimens and studied a diverse range of animal and plant species. He also investigated many new rock formations. By the time he reached the Galapagos Islands he became aware that similar and therefore closely related species frequently occur in adjacent regions. He discovered many odd species, similar to those on the mainland of South America although they were highly variable and suited to the island environment.

Charles Darwin.
Source: Wellcome Institute Library, London

Darwin's Finches

During his long journey, Darwin observed and collected 13 species of finch. Back in England, he showed these bird specimens to John Gould, a renowned wildlife illustrator. Gould's detailed observations and accurate illustrations showed that the birds were distinguishable by the size and shape of their beaks. They were, in fact, all closely related species with adaptations of the beak perfectly suited to its food source. Why so much variation in such a small area?

Darwin believed that the finches were evidence for evolution. He proposed that the different finch species were descendants of a common ancestor. Over time the birds had evolved very different feeding habits to exploit the range of food sources on each island. He believed that enough variation must have existed within the original finch population to enable the selection of different beak sizes and shapes.

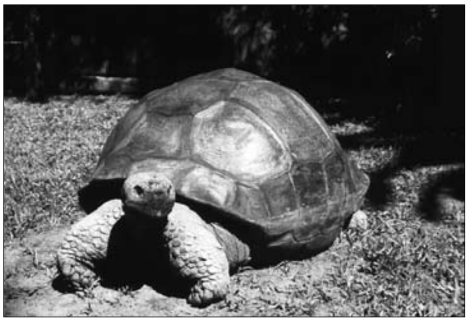


Darwin's Finches.
Artist: John Gould / Source: Museum Victoria

The Galapagos Islands are also home to giant tortoises. Darwin noted that each island had its own variety of tortoise, identified by the shape of its shell. The variation between tortoises led Darwin to question whether species could change over time.

By 1836, Darwin returned from his voyage with his observations and data after studying variation within species and the similarities between fossils and living species. He had come to see evolution as a continuous process. Darwin was sure that evolution came about, and new species evolved from older ones, through a process that he called Natural Selection.

Initially, Darwin was reluctant to publish his findings because he was not able to explain the mechanism by which inherited traits allowed natural selection to occur.



Harriet the Giant Galapagos Tortoise. Charles Darwin is said to have collected her in 1835. She is now 170 years old and lives at Australia Zoo in Queensland. Source: Australia Zoo

Alfred Russel Wallace

During the 1850s Alfred Russel Wallace travelled to South America and South-East Asia in search of the exotic. He funded his adventures by collecting rare and unusual wildlife for museums and private collections. From detailed observations of wildlife he developed similar ideas to Charles Darwin for describing the process of evolution.

These observations led Alfred Wallace and Charles Darwin to present jointly their theories at a meeting in London in 1858. Both men supported a view that the variation of individuals and the degree to which they are adapted to their environment determine their chance of surviving and reproducing. This new theory of evolution and natural selection provided an explanation of how species changed over time and new species arose.

Darwin was primarily credited with formulating the theory of evolution by natural selection as a result of his subsequent publication '*The Origin of Species by Means of Natural Selection*'.

The Theory of Evolution and Natural Selection remained controversial for many years following Darwin's publication because it conflicted with the theological beliefs of the time. Even today, in some circles the theory is rejected as lacking in conclusive geological or fossil evidence.

However, '*The Origin of Species by Means of Natural Selection*', is regarded as one of the most important books ever written. It changed the way that we regard ourselves in the living world and also provides the foundation of modern biology.

Alfred Russel Wallace.

2. Evolution and Genetics

Darwin's argument in support of evolution by natural selection lacked an adequate explanation of how variation and genetic characteristics were passed on between generations at the cellular level. A full understanding of the mechanism behind natural selection required an understanding of genetics, but this needed further time to unfold.

In the early 1900s, researchers rediscovered the work of Gregor Mendel, published decades earlier in 1866. Mendel had accurately modelled the principles of inheritance with inheritable factors, later called genes, and made predictions about the generational patterns of variation in pea plants. Also at the turn of the century, contemporary scientists such as Thomas Hunt Morgan, contributed to this understanding of genetic inheritance while working with variation in fruit flies by developing the Chromosomal Theory of Inheritance.

It was not until 1956, however, that the inheritable substance, DNA, was actually isolated from cells and its structure determined by scientist such as Rosalind Franklin, James Watson and Francis Crick. We now know that genes are regions of DNA and today we have comprehensive maps of the position and function of genes on chromosomes for many different species including that of our own species, *Homo sapiens.*

DNA and Genes

The genetic information that dictates the characteristics an individual will have is located in a molecule called DNA (deoxyribonucleic acid). DNA occurs within the cells of all living things: plants, animals and microscopic organisms. In most organisms the DNA is contained within the nucleus where it forms chromosomes.

Chromosomes consist of tightly coiled strands of DNA, many thousands of base-pairs long. Each chromosome consists of numerous genes, which are made up of discrete segments of DNA. A gene codes for a single protein. Proteins determine the nature of species and individual characteristics.

The characteristics of an individual are determined by the information carried in their DNA. DNA is a molecular string or sequence of four chemical units called bases. They are guanine (G), adenine (A), thymine (T), and cytosine (C). DNA occurs in double strands where G-C and T-A are always linked. So, if a section of DNA is CTATCCTAG the complementary strand must be GATAGGATC. Information to make proteins is coded in the sequence of bases of DNA.

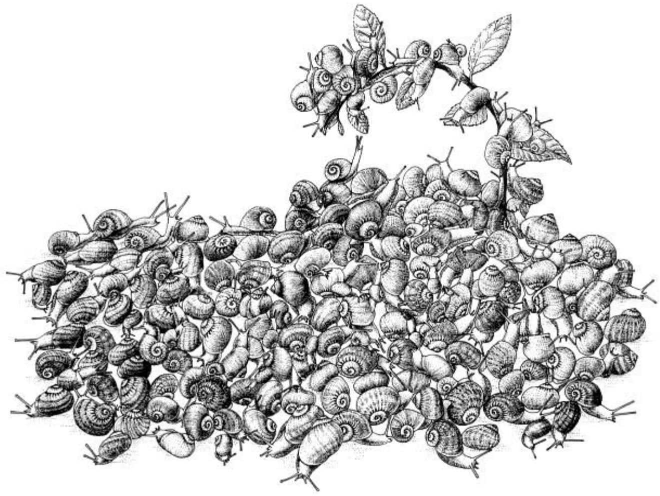
DNA is a biological encyclopedia containing all the information and instructions needed to build an organism – it specifies how different cells develop (muscle, blood, bone, and skin), how cells organise themself (into arms, legs, liver, stomach) and what physical characteristics cells and tissues have (green eyes, brown fur).

DNA double helix molecule.
Artist: Michelle MacDonald / Source: Museum Victoria

3. Natural Selection and Genetic Variation

For evolution to occur there must be variation amongst individuals of a species. Genetic variation may cause differences in appearance, behaviour and abilities. Most individuals of most species die young, without reproducing. All the animals that are born and all the plant seed that is produced cannot live and grow – there is just not enough space and food on earth. For example, a single snail can produce thousands of eggs. If all of them survived, entire cities would quickly become a seething, slippery mass of snails.

Seemingly insignificant variation may mean the difference between life and death for individuals or species. An eagle with eyesight just a little better than other eagles will find prey before they do. A tuna which can swim just a little faster than other tuna will catch prey a little more easily. When food is scarce little differences such as these can determine which individuals die and which survive. This is natural selection; death of poorly adapted individuals and survival of better adapted individuals. Individuals with favourable characteristics tend to be more successful than other individuals in the population. The result of this is that they will produce more offspring whose survival will be similarly favoured and thus also produce more offspring. Natural selection results in change over time of a population. We call this evolution.



Population explosion of snails.
Artist: Kate Nolan / Source: Museum Victoria

Speciation

If a small population is separated from the larger gene pool it shares with its species, major changes are more likely to occur. If this population lives under different conditions then the rest of the species then natural selection can push it down a different evolutionary path due to different selective pressures and over time speciation (the development of a new species) may occur. A new species is said to have evolved when the separated population is different enough that it can no longer breed with the original species that it separated from. Small populations require fewer generations to gain enough genetic variation that they become a new species

Natural Selection

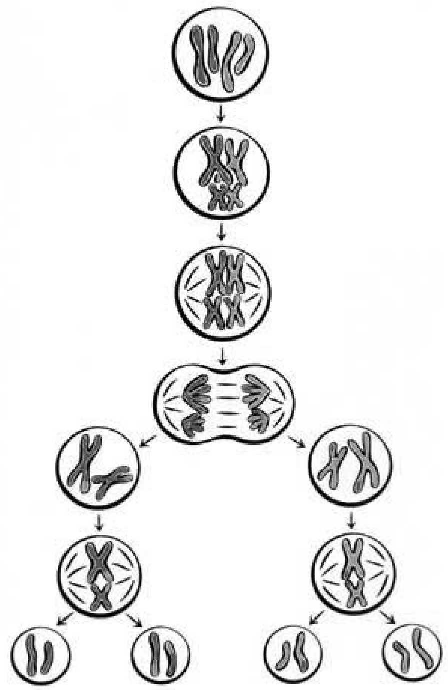
The principles of Natural Selection rely on the following observations:

- That species reproduction always results in populations that are larger than the environment can support. Resources such as food, water and space are limited and there is competition by individuals for these resources which limits the survival of individuals.
- Predation also limits the survival of offspring.
- Individuals best adapted to environment are better able to obtain resources and better able to escape from predators to survive and reproduce, ensuring that those traits that enhance survival become more common in a population.
- Traits, or more specifically inheritable factors (later called genes) that encode them, are passed on to the next generation

Genetic Variation

Genetic variation occurs randomly in a population and results in individuals having a range of characteristics and abilities and degrees of adaptation. It occurs in the following ways:

1. Sexual Reproduction and Genetic Recombination – this is the mixing of parental DNA that creates new genetic combinations in offspring.
2. Genetic mutations – this is when changes occur in the DNA of an individual.
3. Gene flow – this is when new genetic variation is introduced into a population from other populations of the species.

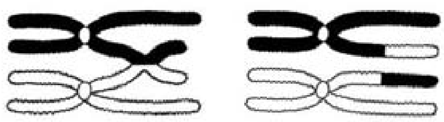


Cell division in sex cells – Meiosis.
Artist: Michelle MacDonald / Source: Museum Victoria

1. Sexual reproduction and genetic recombination

Children resemble other members of their family because they share some of the same DNA. A child's DNA is most similar to that of its parents. Children share increasingly smaller amounts of DNA with their grandparents, great grandparents and so on. The particular mix of DNA inherited by each child in a family is slightly different.

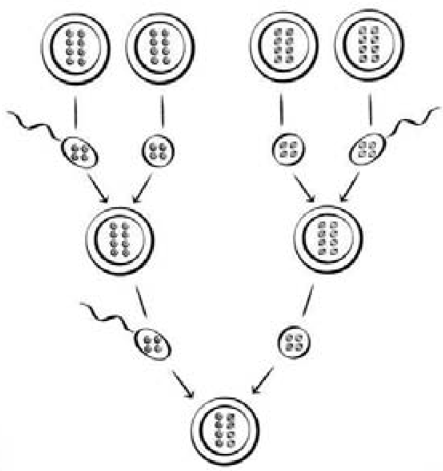
Eggs produced by a female parent and sperm produced by a male parent are known as gametes or sex cells. They are unlike other cells of the body because they only contain a single copy of the DNA code, or one copy of each chromosome, instead of two.



Recombination in chromosomes.
Artist: Kate Nolan / Source: Museum Victoria

During cell division of sex cells, a process called meiosis, chromosomes in the cell are duplicated. The cell divides twice, resulting in four gametes being produced. Each gamete inherits a single unique arrangement of the genetic code.

Sometimes during meiosis a segment of DNA from a chromosome will separate and change place with a segment from its homologous pair. This is known as crossing over and contributes to genetic variation by increasing potential DNA combinations. This process of mixing and sharing DNA across generations is called recombination. It occurs in all sexually reproducing organisms.



Inheritance of genetic material.
Artist: Michelle MacDonald / Source: Museum Victoria

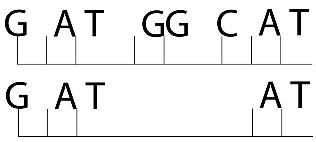
Sexual reproduction ensures that an individual's genetic traits, more specifically their genes and DNA, are inherited from two parents. The diagram below illustrates how genetic material from both parents is transferred to new offspring. Each offspring inherits a random selection of characteristics depending upon the DNA combinations they receive on particular chromosomes. Sexual reproduction involves the random fusion of two parent gametes, an egg and sperm, to form a new fertilised cell that is a combination of both, but contains a genetic profile genetically different than either parent cell. This cell will divide and develop into a unique individual.

This process ensures that variation occurs within populations and that some of these characteristics are passed on to the following generations. As a result, we are all different but also share some characteristics with other members of our families.

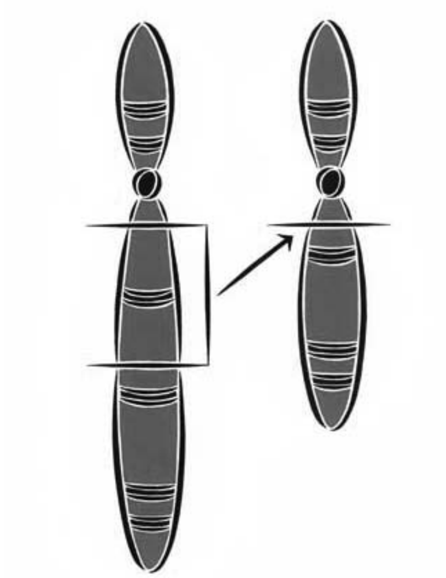
2. Genetic Mutations

Mutations are changes to the DNA that sometimes result in new variation. They result from changes in the DNA during DNA replication that occurs during the life of the cell or during cell division. Mutations can also be induced by external factors such as exposure to radiation. Mutations occur at random and may be beneficial, harmful or have no immediate effect on the genetic characteristics of the individual.

When these changes occur in the egg or sperm cells they can be inherited. Mutations may be of several types: substitutions, additions, deletions and duplications.



DNA deletion



Mutation (chromosome depletion). A deletion this large would result in a non-viable embryo. Artist: Michelle MacDonald / Source: Museum Victoria

3. Gene Flow

Gene flow is the movement of DNA between populations. When an individual migrates to a different population to breed, it can introduce new DNA into that population via sexual reproduction and recombination. Changes due to migration can occur very quickly.

4. Evolution in Action

How does evolution actually work? Individuals in populations vary, and not all individuals survive and reproduce. Natural selection ensures the survival of individuals with favourable genetic variation or characteristics suited to a particular environment. The level of genetic variation within a population is important for future evolution. Without genetic variation populations cannot respond to changing conditions. This, in turn, increases the risk of extinction.

Darwin's book *On The Origin of Species by Means of Natural Selection* explains that evolution is the gradual change in a population over a long period of time. It did not actually explain how new species developed at the molecular, genetic and cellular levels.

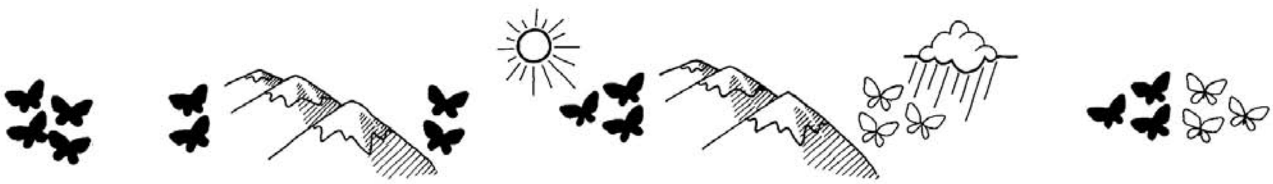
Isolating Factors

Isolating factors separate populations from one another and prevent interbreeding from occurring. Isolation barriers include behavioural, reproductive and geographical barriers.

For example, nocturnal animals will not be able to mate with animals which are only active during the day. Similarly having different breeding seasons or structural differences in the reproductive organs will also mean that organisms cannot physically mate.

Physical barriers such as a mountain, lake or river can also isolate populations. Isolating barriers stop the intermixing of genes and DNA between populations.

Over a long period of time the separate populations, having been exposed to different selective pressures can become so different that they are no longer able to interbreed. When this occurs they have evolved into two different species. Because these changes occur gradually over time the degree of similarity between species is often a clue as to how closely related they are.



Isolation factors, such as mountains, can separate populations from one another and over time two different species can result.
Artist: Kate Nolan / Source: Museum Victoria

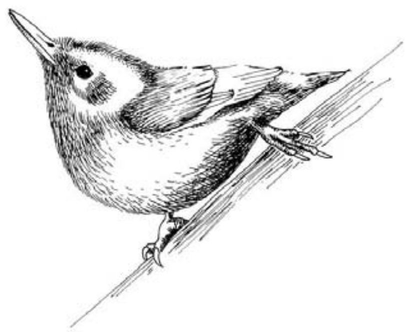
Australia's Geographical Isolation
The Earth Movement Zone in the Forest Gallery at Melbourne Museum describes the two forest types whose evolution resulted from the continental split-up of Gondwana.

The forests just east of Melbourne illustrate the evolutionary results of Australia's geographical isolation. There are a large number of plants which are endemic to Australia, that is, they are not found anywhere else in the world and bear little resemblance to those of other continents. These unique plants (such as many *Eucalyptus sp*.) appear to have evolved in relatively recent times and are adapted to survive and thrive with the irregular occurrence of fire. The forests are also home to another suite of plants, which are virtually identical in form to those found in parts of other southern lands separated by thousands of kilometres of ocean. These 'shared' plants (such as *Nothofagus*) appear to have remained almost unchanged over millions of years and furthermore they exist only where fire is absent. They are remnants of the forests that existed when Australia was part of Gondwana. (See *Fossils as indicators of ancient geography* on page 19).

Convergent Evolution

Environments also guide evolution. Organisms with similar environmental or dietary needs often resemble one another. Convergent evolution is the evolution of similar features in unrelated species, through selective factors such as similar environments or diets. Sharks and dolphins share a number of structural features which enable them to live in water. But they are not closely related.

Australia's sittellas and Northern Hemisphere nuthatches look very similar. Both have evolved feet and beaks that allow them to feed on insects that live under the bark of trees. As well as body shape, they have both evolved the same habit of hopping down the trunks of trees in search of prey. Despite similarities in appearance and behaviour the Australian sittellas are not closely related to the nuthatches.

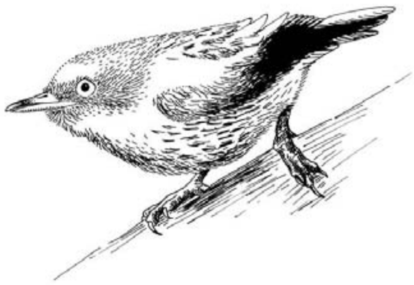


Nuthatch.
Artist: Kate Nolan / Source: Museum Victoria

Divergent Evolution

Closely related species also evolve to look very different from one another if they live in dissimilar environments and have to cope with different conditions, such as temperature or aridity.

Tasmanian Tigers (Thylacines) were extremely 'dog like'. The structure of the Thylacine jawbone suggested that it may be related to an extinct South American carnivorous marsupial, Borhyaena. However, the presence of a pouch and more recent ancient DNA studies show instead that the Thylacines were more closely related to kangaroos and other living Australian marsupials than to dogs. Kangaroos and Thylacines appear dissimilar because of divergent evolution. The superficial similarities in jaw structure of the Thylacine and *Borhyaena* are the result of convergent evolution.



Sittella.
Artist: Kate Nolan / Source: Museum Victoria

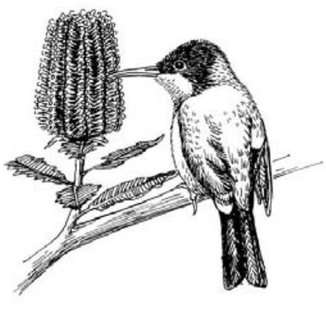
Thylacine.
Mammals of Australia, Gould, J. 1863 Vol 1:54

Co-evolution

The lives of many plants and animals are influenced by other organisms in their environment. Sometimes the interaction is so close that an evolutionary change in one is accompanied by an evolutionary change in the other.

One of the most common forms of co-evolution occurs between flowering plants and the animals that pollinate them. Australian banksias rely on birds, small mammals and insects to transfer pollen from one flower to another. They have evolved flowers that produce nectar and pollen for the animals to eat.

In turn, many of the animals which act as pollinators have evolved brush-tipped tongues and slender snouts or bills, for feeding on pollen or nectar.



Eastern Spinebill feeding on banksia.
Artist: Kate Nolan / Source: Museum Victoria

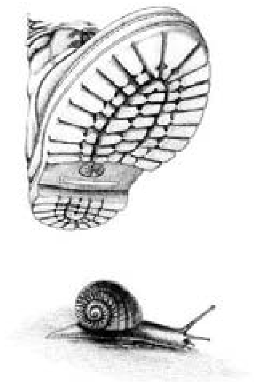
Genetic Drift

Evolutionary change through chance events is called genetic drift. Genetic drift can produce random patterns of variation in a species due to environmental or unforseen events.

The survival of an organism and whether it reproduces is sometimes due to random and unforeseen circumstances. It may or may not have implications for the evolution of its species.

A snail on a footpath may be stepped upon, a cow may be swept away by a flood or a leading scientist may be killed in a car accident. These events have nothing to do with the organism's genetic variability and potential (genotype) or its expression (phenotype). A snail being stepped upon is a random event which occurs purely by chance whereas predation is often selective because some snails are better camouflaged than others. The cow being lost may be of no evolutionary consequence, but the death of the scientist may be significant if she was about to discover a cure for a widespread disease.

Predation, a form of natural selection, causing the death of a snail.
Artist: Kate Nolan / Source: Museum Victoria



Drift: chance event.
Artist: Kate Nolan / Source: Museum Victoria

Sexual selection

Many individuals have evolved elaborate characteristics that increase their chances of mating and thus contributing to the next generation. These genetic characteristics can be physical or behavioural, and give the individual a better chance of attracting a mate.

Commonly, female animals choose strong and virile mates, which ensures that their offspring are also likely to be strong. It may also mean that the female and her offspring are protected when they are vulnerable. Occasionally sexual selection may be based on characteristics that do not necessarily ensure an evolutionary advantage. Sexual selection is responsible for the elaborate plumages of male Birds of Paradise. In most Birds of Paradise the male is brilliantly coloured, with long, ornate feathers. These feathers are used in courtship displays. Females often choose to mate with the biggest or showiest males ensuring his characteristics are passed on to the next generation. However, paradoxically, the bright plumage may make individuals more vulnerable to predators.

Bird of Paradise.
Artist: Kate Nolan / Source: Museum Victoria

5. Extinction and Diversity

The history of life on Earth over the past 3,500 million years has been characterised by a dramatic increase in biological diversity. This increase in diversity did not occur in a steady and gradual way over time; rather, it is the cumulative outcome of a number of rapid evolutionary bursts or radiations followed by episodes of mass extinction. This ebb and flow of extinctions and radiations over time has resulted in an overall increase in biological diversity.

Mass Extinctions

The term 'mass extinction' refers to an episode on a global scale during which biological diversity markedly decreases through large numbers of species dying out over a relatively short period of time. Mass extinctions are distinguished from the normal, low-level extinctions that have occurred throughout geological time, such as those that occur when one species evolves into another, the ancestral species becoming extinct in the process. Mass extinctions are often followed by episodes of diversification, during which biological diversity is restored and eventually increased. This occurs by the rapid evolution of the survivors of the extinction, which adapt to repopulate the environmental space vacated by the extinct organisms. This process is called 'adaptive radiation'.

Palaeontologists recognise a number of episodes of mass extinction that have occurred since life began. The following were the most significant:

- The end of the Ordovician Period, 434 million years ago
- The end of the Devonian Period, 354 million years ago
- The end of the Permian Period, 251 million years ago
- The end of the Triassic Period, 205 million years ago
- The end of the Cretaceous Period, 65 million years ago.

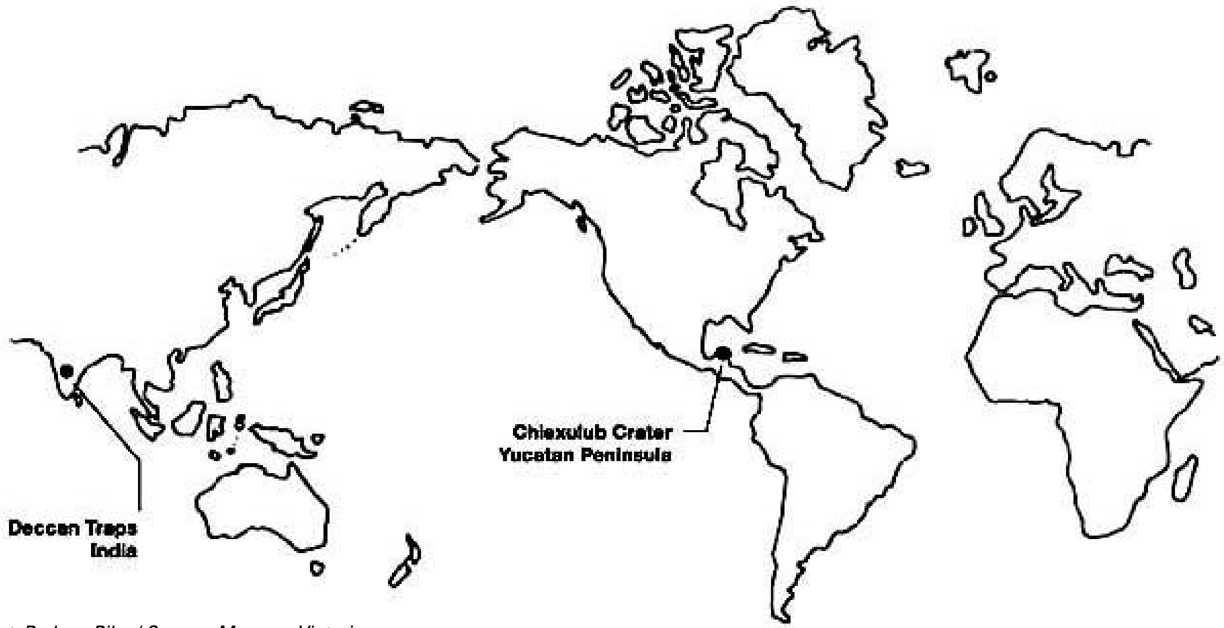
At the present time, the destruction of habitat by human activity is threatening the existence of many species. The rate of extinction has increased over the last century, and unless something is done to change the trend, the 21st century may well mark the beginning of another mass extinction.

Permian Extinction
Towards the end of the Permian Period, about 251 million years ago, many groups of organisms suffered great reductions in diversity or became extinct. This was the most severe mass extinction to occur in the Earth's history, with more than 50% of all families of marine animals and 70-90% of all marine species dying out. Major groups of marine invertebrates that completely disappeared include tabulate and rugose corals, trilobites, eurypterids, conulariids, fusulinid foraminifera, goniatitic ammonoids, and some types of echinoderms. Groups that declined dramatically in diversity included brachiopods, bryozoans, gastropods and ammonoids. The effects of the extinction on land organisms were less dramatic. The cause of these extinctions is not known. It has been suggested that they may have been caused by a reduction in marine habitats due to a lowering of sea level, or by climatic alteration owing to a massive outpouring of basalts in Siberia.

K-T Extinction
65 million years ago, at the end of the Cretaceous Period, many groups of organisms became extinct. Among them were dinosaurs, pterosaurs, ammonoids and rudistid molluscs. Other groups such as marsupials suffered severe losses but survived into the Cainozoic. This extinction event is known as the K-T extinction, from the Greek *Kreta* (chalk) which is the origin of the word Cretaceous, and from Tertiary, which is the name for the first 63 million years of the Cainozoic Era.

It is generally accepted at present that the Earth was hit by an asteroid at this time. The remains of a large crater on the Yucatan Peninsula in Mexico can be seen from satellite images, and debris from the impact has been found in rocks of this age around the world. At the same time, there was huge volcanic activity in India, with thousands of square kilometres covered by basalt lava flows. It is possible that one or both of these events triggered the K-T extinctions. More puzzling is why some groups of animals died out but others survived.

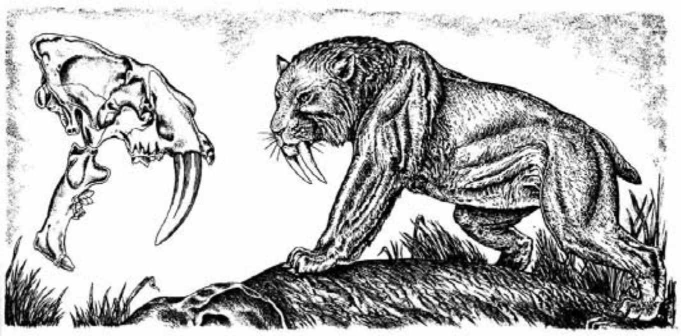
Groups of animals that became extinct at the end of the Cretaceous were frequently very similar to groups that survived into the Cainozoic. The ammonoids, for example, were similar in shape and habitat to the nautiloids, which can still be found today. We have an idea as to what may have triggered the KT extinctions; what we do not know is why certain groups became extinct, and others survived.



Artist: Rodney Pike / Source: Museum Victoria

Ice Age Animals and Their Extinction

Millions of years after the extinction of the dinosaurs, a range of giant mammals, birds and reptiles lived on Earth. These creatures lived especially during the Pleistocene Epoch, and included the woolly mammoth, sabre-toothed tiger, and giant deer in the Northern Hemisphere, and giant marsupials like *Diprotodon* in Australia. There are several reasons why the megafauna are of particular interest. The fossils of these creatures are found much more frequently than the fossils of the more popular dinosaurs, especially in Australia.



Smilodon, last of the sabre-toothed cats.
Artist: Caroll. L. Fenton / Source: Professor Patricia Vickers-Rich

The Pleistocene Epoch began about 1.6 million years ago and ended 10,000 years ago. It was characterised by a series of ice ages the last peaking about 18,000 years ago. The large, extinct animals of this time are therefore termed Pleistocene or Ice age mammals, although the term 'Megafauna' is also sometimes used, particularly for the giant marsupials that lived in Australia at this time.

Palaeontologists are very interested in the ice age mammals. Many of these creatures coexisted with humans towards the end of the Pleistocene, with the last of them becoming extinct less than one thousand years ago. The cause of their extinction is of considerable interest to palaeontologists, who suggest that climatic fluctuations, human hunting, or a combination of the two were responsible. The part played by humans in the extinction of the megafauna is unclear. Many researchers believe that the migration of humans into various parts of the world (such as North America) subjected the local megafauna to sudden hunting pressure, and so contributed to the extinction of many large animals. However, clear evidence of humans actually causing megafaunal extinctions is only present in Madagascar in the case of the giant lemurs, and in New Zealand in the case of the extinction of some of the moas (giant birds) about 500 years ago.

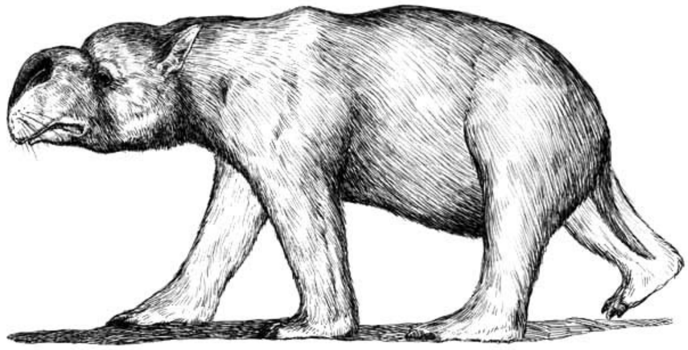
Extinction of Australian Megafauna

Evidence of the former existence of the Australian megafauna was known by the Aborigines, and was soon discovered by the earliest European settlers. A large collection of fossils from Wellington Caves, west of Sydney, was sent to England by Major Thomas Mitchell in 1831 for examination by the renowned Sir Richard Owen. Other specimens were sent by Leichardt, Strzelecki and Goyder, and Owen was progressively able to identify a number of large extinct marsupials and birds. The newly established Australian museums became involved in subsequent decades, and their work has continued to the present, with major excavations of fossils from sites in most states.

Much more research is needed to get a clear picture of the diversity of megafauna species which lived in Australia during the Pleistocene Epoch. However, a representative list of the species found so far would include the following:

- *Diprotodon optatum* was the size of a rhinoceros, and is thought to have been the largest marsupial ever to exist.
- *Zygomaturus trilobus* was a bullock-sized relative of *Diprotodon*, and may have had either rhinoceros-like horns or a short trunk.
- *Palorchestes azael* was the size of a bull, with long claws and a longish trunk. Imaginative writers have suggested it as the inspiration for the Aboriginal bunyip.
- *Procoptodon goliah* was the largest kangaroo ever, and had a shortened flat face and forward-looking eyes.
- *Thylacoleo carnifex*, the so-called 'Marsupial Lion', was a leopard-like animal, and was almost certainly carnivorous and a tree-dweller.
- *Zaglossus hacketti*, a sheep-sized echidna whose remains were discovered in Mammoth Cave in Western Australia, was probably the largest monotreme ever.
- *Dromornis stirtoni* was a huge flightless bird; with a height of at least three metres and a weight of over half a tonne, it is the heaviest bird known.
- *Megalania prisca* was an enormous goanna-like carnivore, at least 7 metres long, and with a weight of about 600 kilograms.

Most of the megafauna species mentioned above became extinct late in the Pleistocene Epoch, perhaps 20,000 years ago. Some groups of Aborigines arrived in Australia at least 60,000 years ago, and so probably shared the continent with many megafauna species for millennia. Whether the Aborigines had a role in the final extinction of these creatures, however, remains unclear. Aboriginal hunting, or Aboriginal use of fire which led to an increase in grasslands and dry forests may have been partly responsible, but it is likely that the prolonged drought conditions which occurred at the peak of the last glaciation about 18,000 years ago was also involved.



Diprotodon optatum*, evolved about a million years ago and may have become extinct as recently as 15,000 years ago, has the distinction of being the largest marsupial ever. It was the size of a rhinoceros—three metres long, almost two metres high at the shoulder, and weighing as much as two tonnes. It had pillar-like legs and broad footpads, a little like those of an elephant.*
Artist: Frey Micklethwait / Source: Museum Victoria