

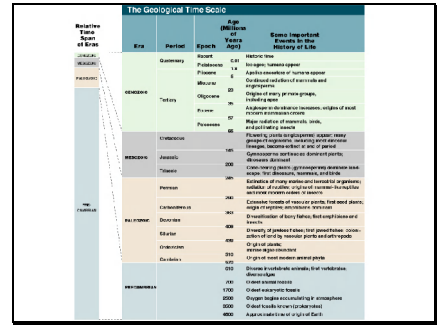
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### Evolution - the history of life

- Faith is the substance of things hoped for, the evidence of things not seen..... By faith.... We understand that the universe was created by God's word, so that what can be seen was made out of what cannot be seen (Hebrews 11:1, 3)
- Evolution has happened and is happening as we can see gene frequencies changing so species are changing. These changes are not directed towards some particular goal – especially not man. The causes of the changes are divers and probably not fully understood.

ps a theory in science is an accepted idea that has been tested – in this case by years of debate of the extensive evidence – not a “theoretical” hypothesis.

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### Variations on a theme

- Special creation
- Spontaneous generation
- Steady state
- Cosmozoan
- Biochemical evolution

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### The earliest organisms

The earth may be 4.5 x 10<sup>9</sup> years old.

The earliest fossils are very difficult to interpret as they are of single celled organisms.


Cambrian rocks (542 – 488 million years ago) contain clear fossils, some fossils before this are difficult to interpret.

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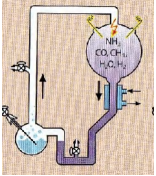
### Biochemical evolution

In 1923 Oparin suggested the chemical nature of the earlier earth and the concept of primeval soup

In 1953 Miller showed a possible mechanism for amino acid synthesis from atmospheric gases



Few amino acids produced in low yields.



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### Fossil Types

Fossils are very rare structures and include –

- Entire organisms in tar, ice, bogs or resin (amber)
- Skeletal material trapped in sedimentary sand and clay e.g. bones and shells
- Moulds of skeletal material dissolve and the space replaced by fine material to form a cast
- Petrification is the gradual replacement by mineral deposits as an organism decays.
- Impressions of feathers and leaves
- Imprints of footprints etc.
- Coprolites faecal pellets compressed in sedimentary rock may contain evidence of food.

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**Horse fossils**

The ancestors of the horse provide one of the most complete fossils records in North America from the Eocene to the present day.

So the textbooks say but maybe it simply shows the kind of variety that can exist at different times due to selection pressures - ah but **this is** evolution. It may not be a specific ordered lineage but it shows a change over time.

Horses belong to the perissodactyle group (odd numbered hoofed animals)

The older fossils have 5 or 3 toes which are reduced to a single hoof in the modern horse.

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**Natural Selection 1**

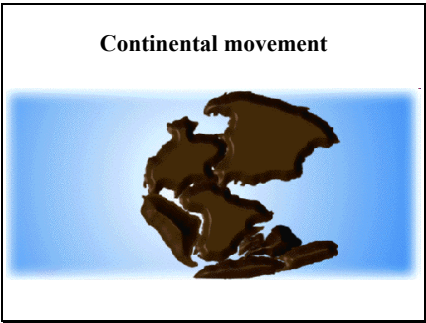
Australasia is thought to have separated in the late Jurassic when only the most primitive of mammals existed.

Australasia has only prototherian and metatherian mammals, no placental (eutherian) mammals – until we introduced them in the 18<sup>th</sup> and 19<sup>th</sup> centuries.

The Hawaiian and Galapagos islands provided Darwin and Wallace with observations of diversity that they thought was due to natural selection by various interacting environmental factors.

NB variation exists in a species due – as we have discussed – to crossing over, mutation, independent assortment and fertilisation. Species do not change i.e. develop a modification **in response to** the environment. They simply survive to reproduce and pass on their genes or not.

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**Natural Selection 2**

Darwin and Wallace observed that –

Individuals have enormous reproductive potential but populations (all the same species) remain roughly the same.

Variation exists within a species.

And deduced that -

there is a struggle for existence and those individuals showing variations that give an advantage survive to reproduce and pass on their genes.

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**Parallel evolution**

Marsupials in Australia	Placental mammals elsewhere
Marsupial mole	Mole
Marsupial mouse	Mouse
Banded anteater	Anteater
Kangaroo	Antelope
Bandicoot	Rabbit
Tasmanian wolf	Hyena

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**Lamarck and acquired characteristics**

Jean-Baptiste Lamarck (1744-1829) was a French scientist and did a lot of very good science. His name is perhaps too often associated with the inheritance of acquired characteristics – the prevalent theory of his time.

So the story goes, if food is short, giraffe ancestors stretched their necks longer to reach higher branches. These long necks were then passed on to the next generation. Well you know that the only thing that is passed on is the DNA sequence of nitrogen basis which code for specific proteins so this can't be right.

Pam Ayres might say –

There once was a man called Lamarck  
 Who dared make a novel remark  
 About evolution, though not the solution  
 It gave fame to necks of giraffe

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### Ontogeny recapitulates phylogeny 1

In 1866, the German zoologist Ernst Haeckel wrote –

“.....history of the embryo (ontogeny) must be completed by a second, equally valuable, and closely connected branch of thought - the history of race (phylogeny). Both of these branches of evolutionary science, are, in my opinion, in the closest causal connection; this arises from the reciprocal action of the laws of heredity and adaptation... 'ontogenesis is a brief and rapid recapitulation of phylogenesis, determined by the physiological functions of heredity (generation) and adaptation (maintenance).”

While this is now seen to be untrue phylogeny and ontogeny are clearly connected eg vertebrates go through similar stages in embryonic development and only in the later stages can be distinguished from one another.

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### Comparative anatomy 2

The pentadactyl limb is a homologous structure – the different types have the same embryonic development - found in vertebrates in various forms for different functions. It suggests that a common ancestor perhaps a fish had the basic structure that then became modified in different ways by different groups. This is known as **adaptive radiation** and has enabled **divergent evolution** – changes that allow a population to survive in different environments.

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### Ontogeny recapitulates phylogeny 2

Fish Salamander Turtle Pig Rabbit Human

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### Comparative biochemistry

Similarities in the genetic code, proteins sequence and biochemical processes may be taken as evidence for common ancestors and evolution. Though there are many who see the small differences as evidence for other philosophies like “intelligent design”

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### Comparative anatomy 1

The pentadactyl limb of the tetrapod vertebrates has been extensively adapted for modifications for different environments. Types of a modified pentadactyl limb.

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### Gene Pool

The gene pool is the total variety of alleles in a sexually reproducing population.

Allele frequency. Consider pigmentation in humans. N = normal pigmentation and n = the albino allele. The frequency in the population is respectively 99% and 1%

p = dominant allele frequency and q = recessive allele frequency

$$p + q = 1$$

So  $0.99 + 0.01 = 1$

Only the frequency of one allele is required

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### Genotype frequencies -1

If a population is large, mating is random and we assume no mutations occurs we can get some idea of the frequency of a genotype in a population.

So in our cross of heterozygous genotypes say Aa and Aa  
The results are – as you will recall – AA, 2Aa and aa.

Using the allele frequency idea  $AA = p^2$   $Aa = 2pq$  and  $aa = q^2$

So  $p^2 + 2pq + q^2 = 1$

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### Types of Selection

**Stabilising selection:** This occurs when phenotype features in the population coincide with environmental conditions. It tends to eliminate the extremes.

**Directional selection:** Here the environmental condition favours one phenotypic extreme (eg thick fur as average temperatures fall).

**Disruptive selection:** Probably the rarest type and favours the presence of more than one phenotype or polymorphs.

**Artificial selection:** Man chooses the characteristics he wants. Using those individuals with these characteristics for breeding he increases the chances of getting the offspring he "wants" through directional selection. Detailed record keeping now exists, for example all cattle and rare animals in zoos.

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### Genotype frequencies -2

Disorder	$q^2$	$2pq$
Albinism	1 in 10000	1: in 50
Diabetes	1 in 200	1 in 7.7
Phenylketonuria	1 in 10000	1 in 50

NB. mutation can result in an individual having a condition but not having inherited it from either parent.

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### Polymorphism

The banded snail *Cepaea nemoralis* comes in a number of colour types or polymorphs. They are found in a variety of habitats from sand dunes to woods. The colour variation makes them more or less obvious to birds like thrushes. This means that there is a selection pressure depending on the environment.



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### Genetic drift

In small isolated populations alleles can quite easily be lost due to accidental death of an individual eg if  $q = 0.01$ , in a population of 100000, 1000 individuals will have the allele but in a population of 100 only 1 will have it and its loss is much more likely.

A phenomenon associated with genetic drift is the founder principle. If a small population splits from a larger one, the allele frequency may be different in the pioneer population. Some alleles may be missing and others unusually common. Continued mating with the small population decreases heterozygotes and increases homozygotes. Studies of religious sects in America showed this effect eg –

	Blood group A
American population	42%
West German Population	45%
Religious sect (Dunker)	60%

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### Speciation

Speciation – not really dealt with by Darwin – is the process by which a new species arises from another. There are two main types, intraspecific speciation and interspecific hybridisation.

Isolating mechanisms, some examples –

Seasonal: flowering a different times of year.

Ecological : *Viola arvensis* grows on calcareous soil and *V. tricolor* on acid soil.

Behavioural: different courtships displays.

Geographic: a population may become separated and subsequently the 2 groups subject to different environmental pressures.

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### Ring Species

Gulls of the genus *Larus* form a continuous population between latitudes 50-80 degrees N around the North Pole.

A ring of ten recognisable races exists along the range. There is free interbreeding except where the "ends" of the ring meet in the British Isles. Here the herring gull *L. argentatus* and the lesser black-backed gull *L. fuscus* rarely interbreed

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### Interspecific Hybridisation

Here two unrelated species cross to produce a hybrid – in Orchids this can occur between different genera.

*Cattleya* x *Laelia* you would have the new generic hybrid *Laeliocattleya*.



If when the hybrids fertilise one another the chromosomes cannot pair up, the hybrids will be sterile, but if non-disjunction (non separation of the chromosomes in meiosis) occurs this can lead to polyploidy where fertilisation does occur and the resulting hybrid is fertile.