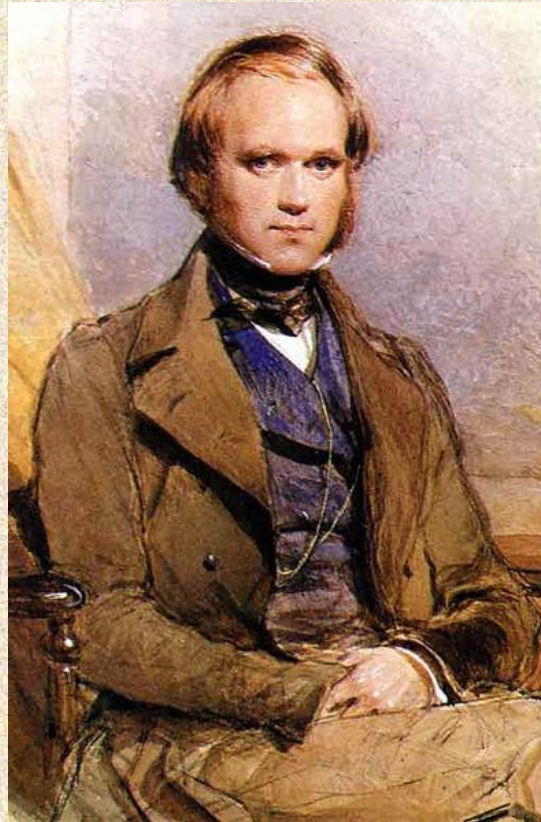




# Evolution



[commons.wikimedia.org/wiki/Image:DNA\\_double\\_helix\\_vertikal.PNG](https://commons.wikimedia.org/wiki/Image:DNA_double_helix_vertikal.PNG)



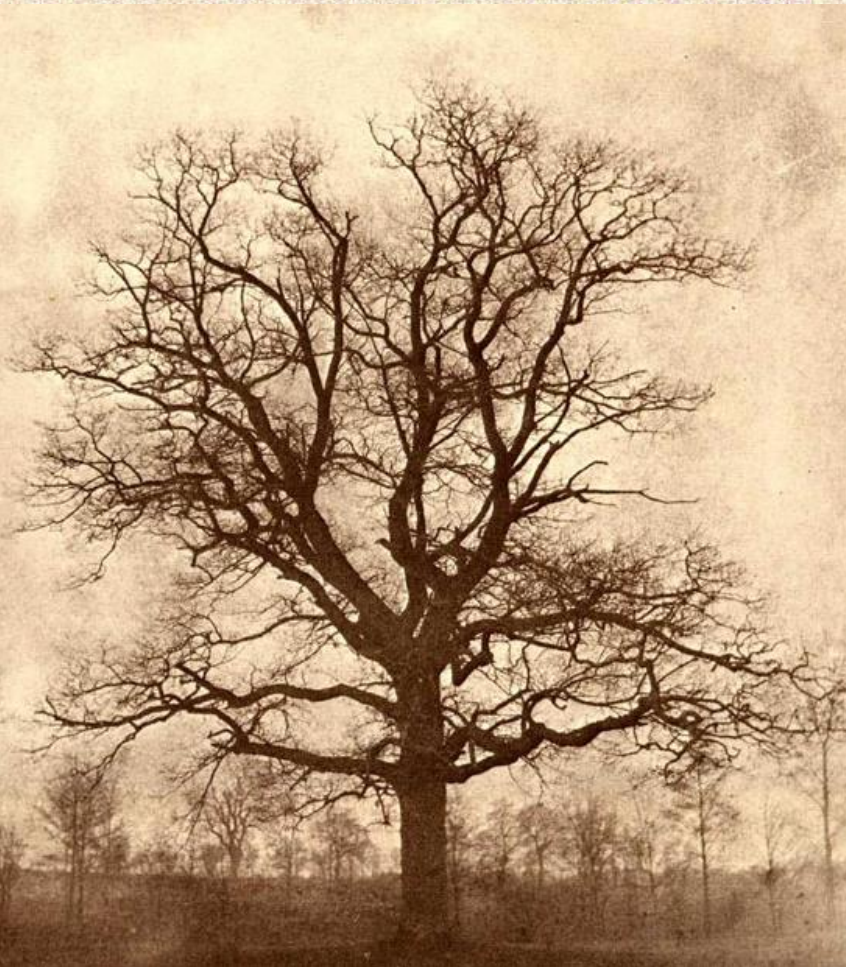
[commons.wikimedia.org/wiki/Image:Charles\\_Darwin\\_1881.jpg](https://commons.wikimedia.org/wiki/Image:Charles_Darwin_1881.jpg)





# The Tree of Life

- All living things share a common ancestor.
- We can draw a Tree of Life to show how every species is related.
- **Evolution** is the process by which one species gives rise to another and the Tree of Life grows







# Evolution as Theory **and** Fact



- Confusion sometimes arises as to whether Evolution is a **theory** or a **fact**. Actually it is both!
- The theory of Evolution deals with **how** Evolution happens. Our understanding of this process is always changing.
- Evolution is also a fact as there is a **huge amount of indisputable evidence** for its occurrence.

Rodin's "The Thinker"



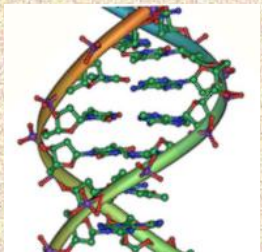


# Talk Outline



Part 1: How was evolution discovered?

**Discussion: Should Creationism and Evolution be given “equal time” in science lessons?**



Part 2: How does evolution work?

**Practical: Natural Selection in the Peppered Moth**



Part 3: What is the evidence for evolution?





# Discovery (1) Fixed species

Michelangelo's fresco on the ceiling of the Sistine Chapel



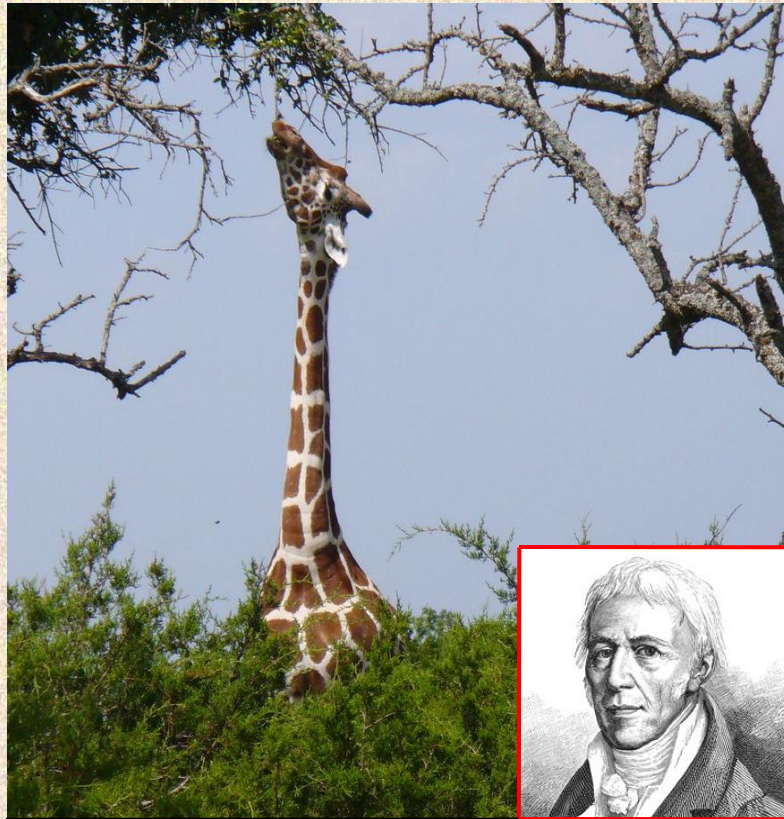
[en.wikipedia.org/wiki/The\\_Creation\\_of\\_Adam](https://en.wikipedia.org/wiki/The_Creation_of_Adam)

From Classical times until long after the Renaissance, species were considered to be **special creations**, fixed for all time.





# Discovery (2): Transmutation



Jean Baptiste de Lamarck

- Around 1800, scientists began to wonder whether species could change or **transmute**.
- Lamarck thought that if an animal acquired a characteristic during its lifetime, it could pass it onto its offspring.
- Hence giraffes got their long necks through generations of straining to reach high branches.

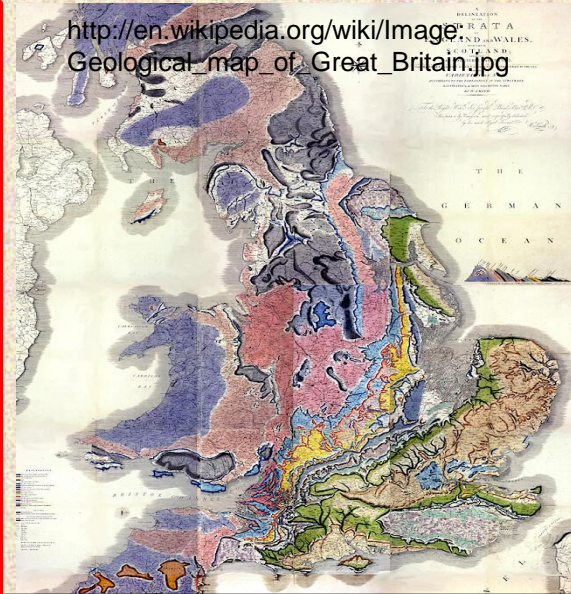


# Discovery (3): Fossils and Strata

[http://en.wikipedia.org/wiki/Image:William\\_Smith.jpg](http://en.wikipedia.org/wiki/Image:William_Smith.jpg)



[http://en.wikipedia.org/wiki/Image:Geological\\_map\\_of\\_Great\\_Britain.jpg](http://en.wikipedia.org/wiki/Image:Geological_map_of_Great_Britain.jpg)



[http://en.wikipedia.org/wiki/Image:Smith\\_fossils2.jpg](http://en.wikipedia.org/wiki/Image:Smith_fossils2.jpg)



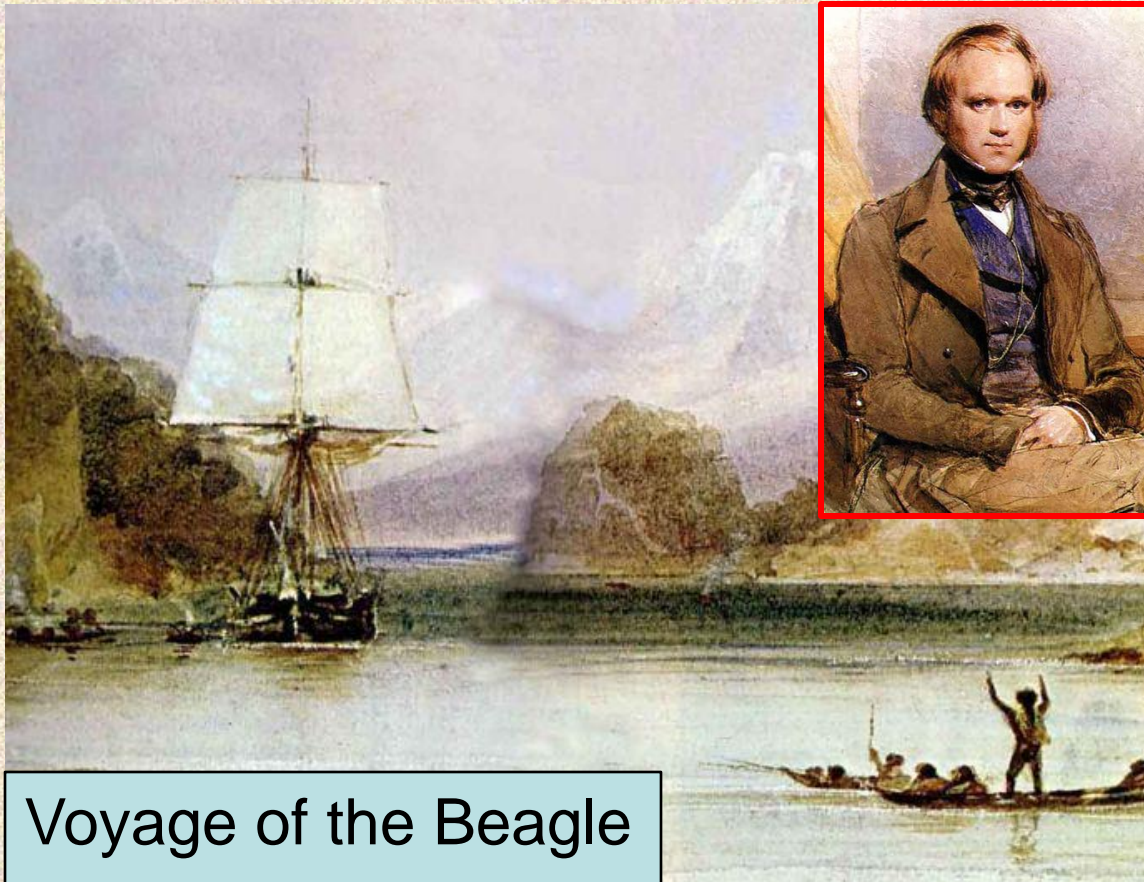
William Smith, his geology map & some of his fossil specimens

At about the same time, geologists like William Smith were mapping the rocks and fossils of Britain. He and others showed that **different species existed in the past** compared with today.





# Discovery (4): Darwin's Voyage



Voyage of the Beagle

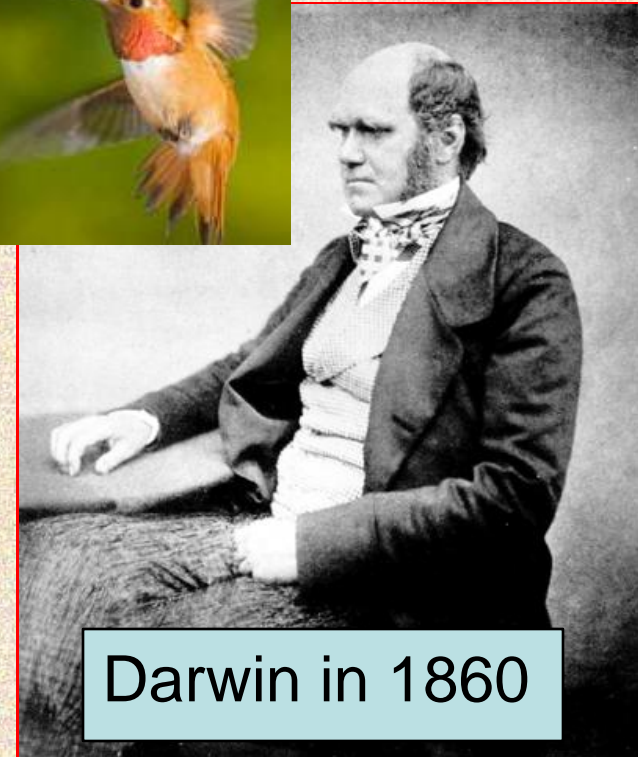
- From 1831-1836, a young naturalist called Charles Darwin toured the world in HMS Beagle.
- He was dazzled by the amazing diversity of life and started to wonder how it might have originated



# Discovery (5): Survival of the Fittest

- In his **Origin of Species**, published in 1859, Darwin proposed how one species might give rise to another.
- Where food was limited, competition meant that only the **fittest** would survive.
- This would lead to the **natural selection** of the best adapted individuals and eventually the **evolution** of a new species.

Natural Selection  
explains adaption

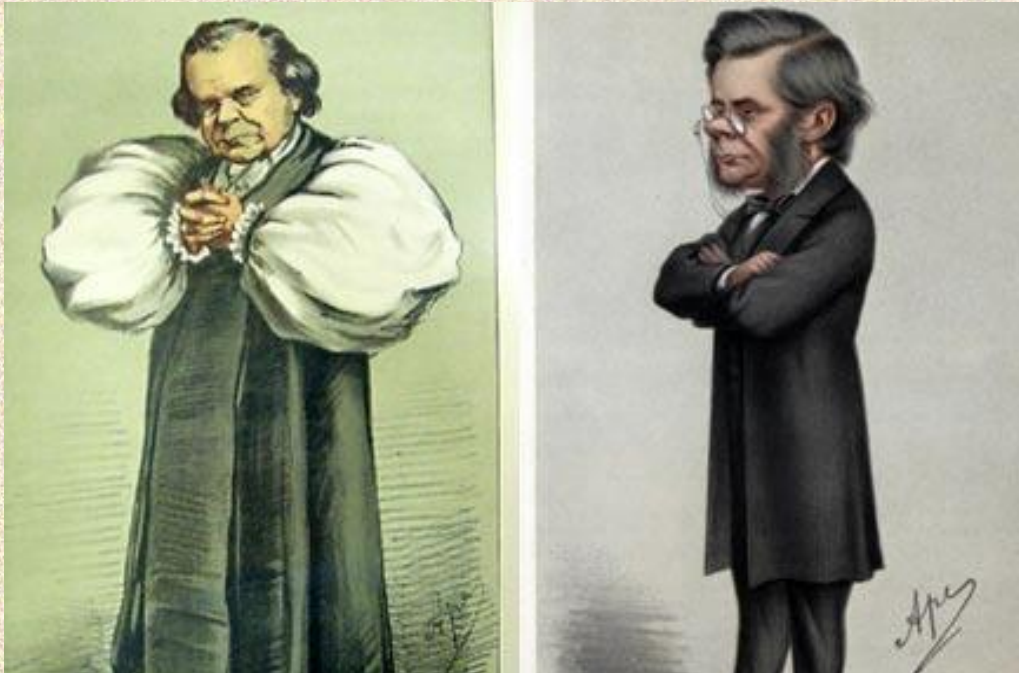


Darwin in 1860





# Discovery (6): Huxley v. Wilberforce



Bishop Wilberforce v. T. H. Huxley

- Darwin's idea of Evolution by Natural Selection was met with **huge controversy**.
- A famous debate in 1860 pitted Bishop Wilberforce against Darwin's bulldog, Thomas Henry Huxley.

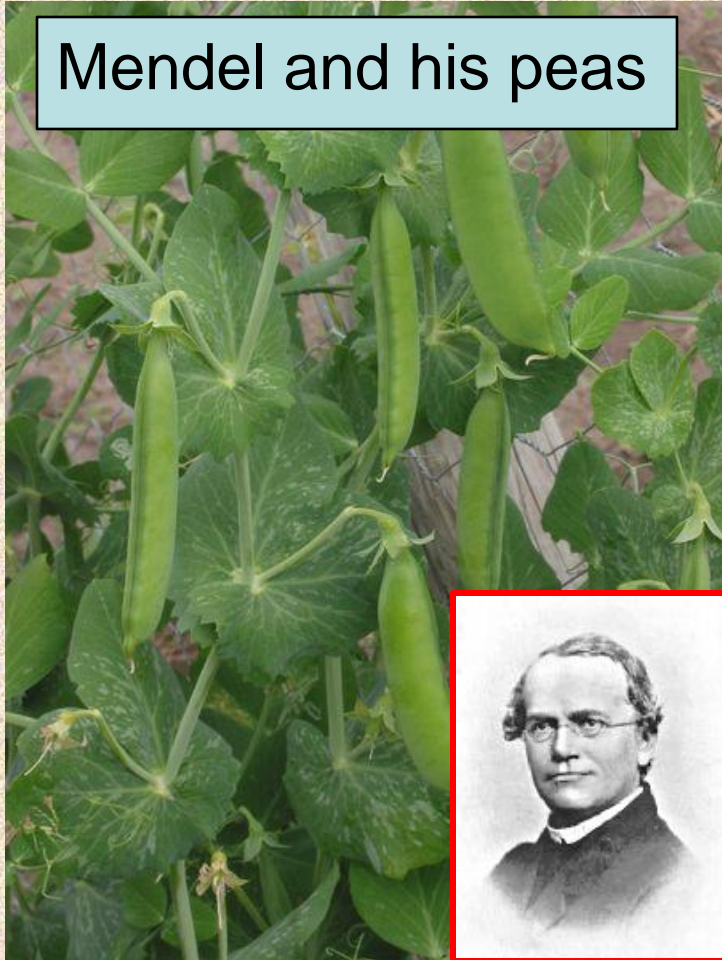
- Evolutionists got the better of the debate, but few were convinced by Darwin's idea of Natural Selection.





# Discovery (7): Genetics

## Mendel and his peas



- From 1856-63, a monk called Gregor Mendel cultivated **29,000 pea plants** to investigate how evolution worked i.e., how characteristics were passed down the generations.
- He figured out the basic principles of genetics. He showed that offspring received characteristics from both parents, but **only the dominant characteristic trait was expressed**. Mendel's work only came to light in 1900, long after his death





# Discovery (8): Making Sense



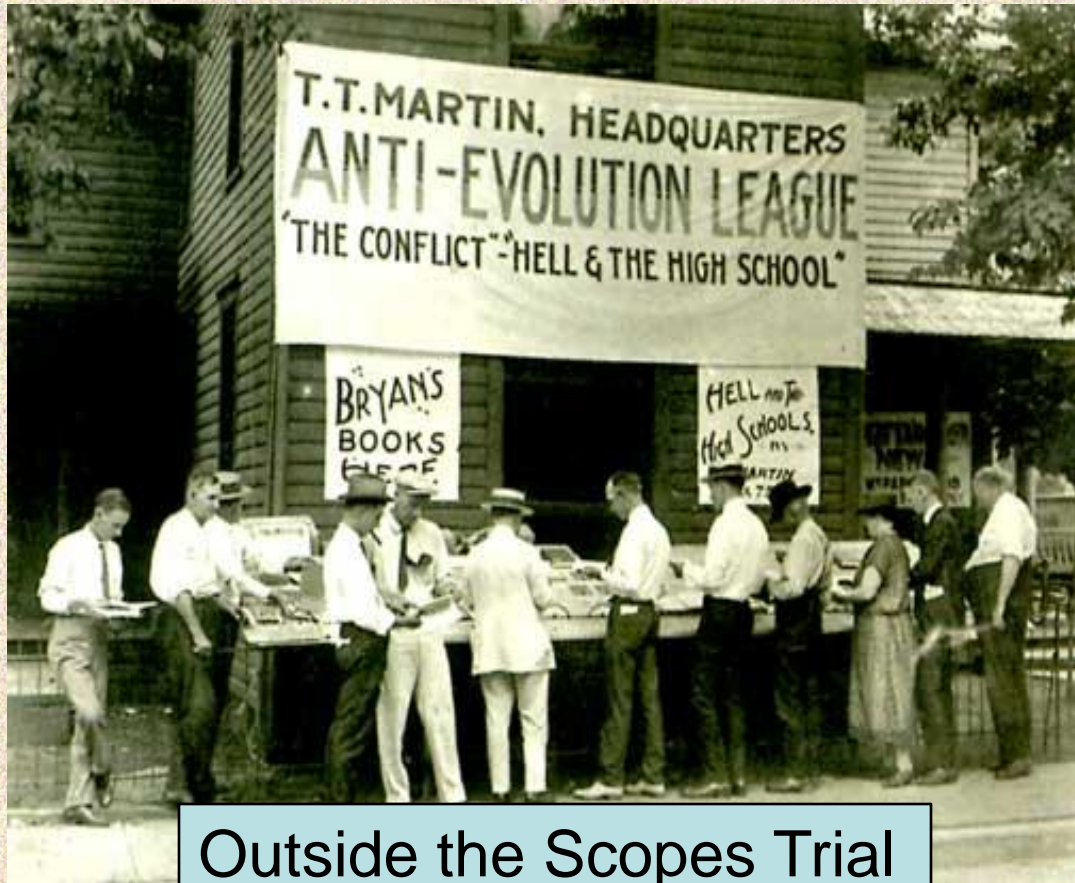
Julian Huxley  
and the  
Modern Synthesis

- In the early 20<sup>th</sup> century, scientist started to make sense of how evolution worked.
- Building on Mendel's genetics, studies showed how characteristics in a population could be selected by environmental pressures.
- This **Modern Synthesis**, as Julian Huxley called it, brought Darwin's Natural Selection back to the centre of evolutionary theory.





# Discovery (9): Opposition



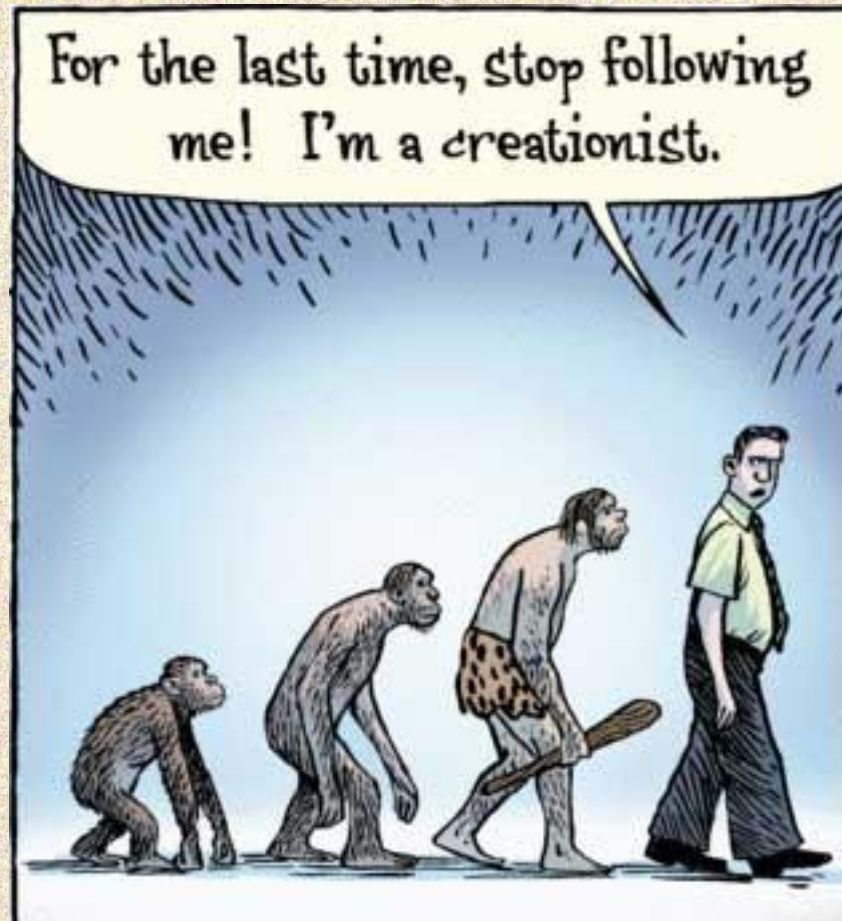
Outside the Scopes Trial

- Despite the achievement of **scientific consensus** on evolution, some Christian groups continued to oppose the concept.
- In 1925, the teaching of evolution was outlawed in Tennessee, USA, resulting in the infamous **Scopes Monkey Trial**





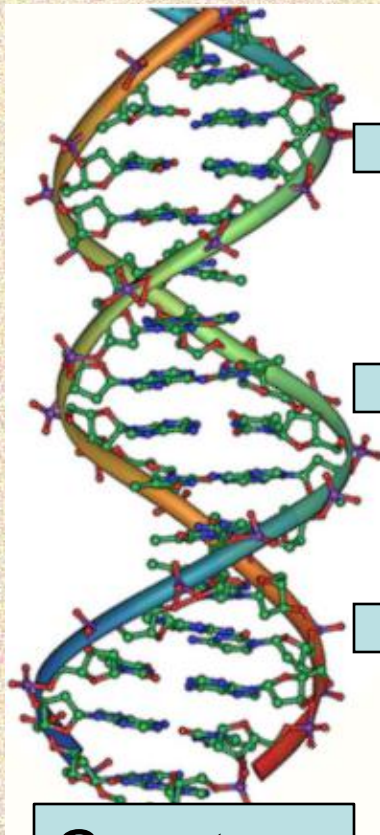
# Discussion: Should Creationism and Evolution be given **equal time** in science lessons?







# Mechanism (1): All in the Genes



Genotype

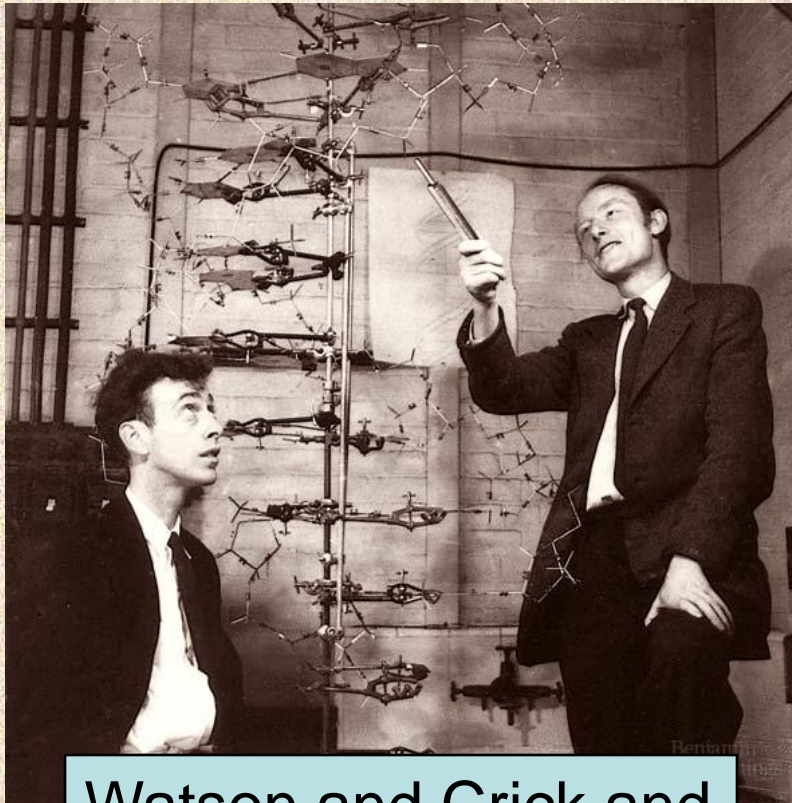


Phenotype

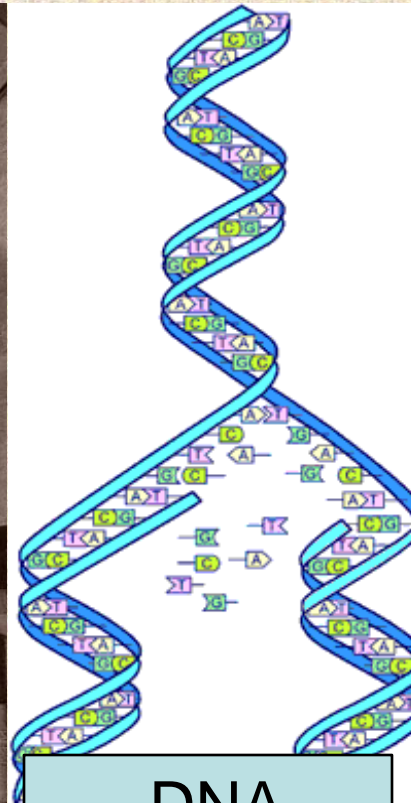
- The genetic make-up of an organism is known as its **genotype**.
- An organism's genotype and the environment in which it lives determines its total characteristic traits i.e. its **phenotype**.



# Mechanism (2): DNA



Watson and Crick and  
their model of DNA



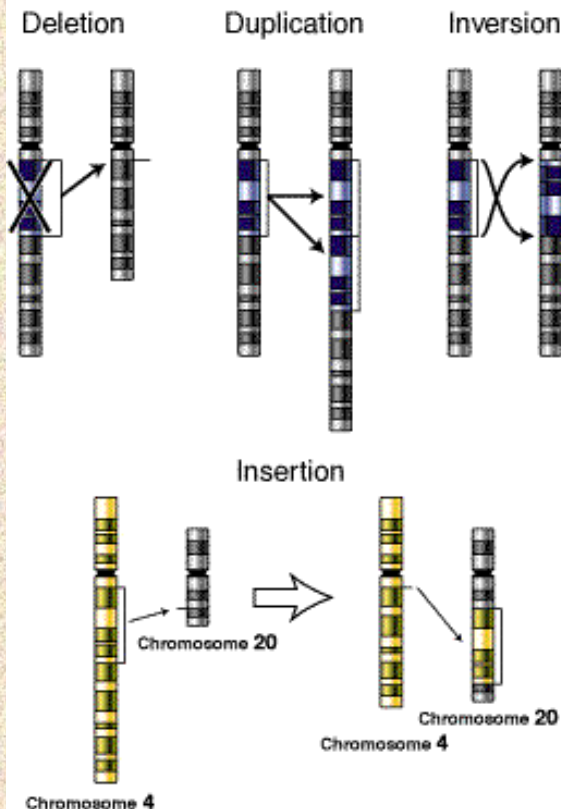
DNA  
replication

- The **double-helix** structure of DNA was discovered in 1953.
- This showed how genetic information is transferred from one cell to another **almost** without error.



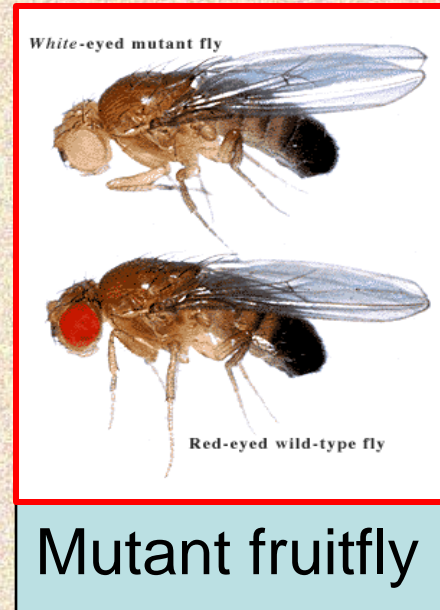
# Mechanism (3): Mutation

## Types of mutation



- However, occasional mutations or **copying errors** can and do occur when DNA is replicated.

- Mutations may be caused by radiation, viruses, or carcinogens.



Mutant fruitfly

- Mutations are **rare** and often have **damaging effects**. Consequently organisms have special enzymes whose job it is to repair faulty DNA.





# Mechanism (4): Variation

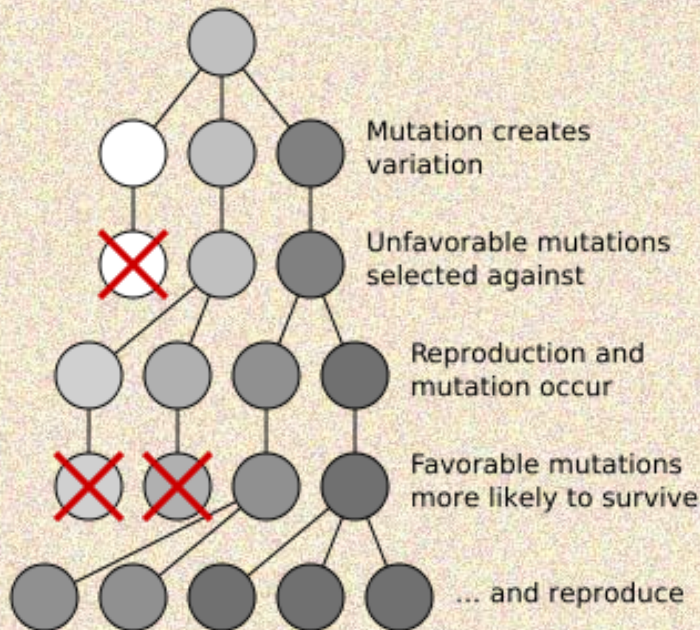


- Nevertheless, some mutations will persist and increase genetic **variation** within a population.
- Variants of a particular gene are known as **alleles**. For example, the one of the genes for hair colour comprises brown/blonde alleles.



# Mechanism (5): Natural Selection

## Selection of dark gene



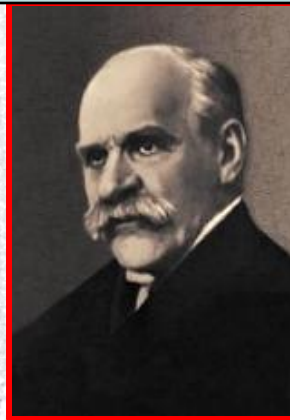
- Mutant alleles spread through a population by **sexual reproduction**.
- If an allele exerts a **harmful** effect, it will reduce the ability of the individual to reproduce and the allele will probably be removed from the population.
- In contrast, mutants with **favorable** effects are preferentially passed on

[en.wikipedia.org/wiki/Image:Mutation\\_and\\_selection\\_diagram.svg](https://en.wikipedia.org/wiki/Image:Mutation_and_selection_diagram.svg)



# Mechanism (6): Peppered Moth

Haldane and the peppered moth



- The Peppered Moth is an example of **Natural Selection in action** discovered by Haldane
- During the Industrial Revolution the trees on which the moth rested became soot-covered.
- This selected against the allele for pale colour in the population (which were poorly camouflaged from predators) and selected for the dark colour allele.

<http://en.wikipedia.org/wiki/Image:Biston.betularia.7200.jpg>  
[en.wikipedia.org/wiki/Image:Biston.betularia.f.carbonaria.7209.jpg](http://en.wikipedia.org/wiki/Image:Biston.betularia.f.carbonaria.7209.jpg)  
[en.wikipedia.org/wiki/J.\\_B.\\_S.\\_Haldane](http://en.wikipedia.org/wiki/J._B._S._Haldane)



# Mechanism (7): Microevolution



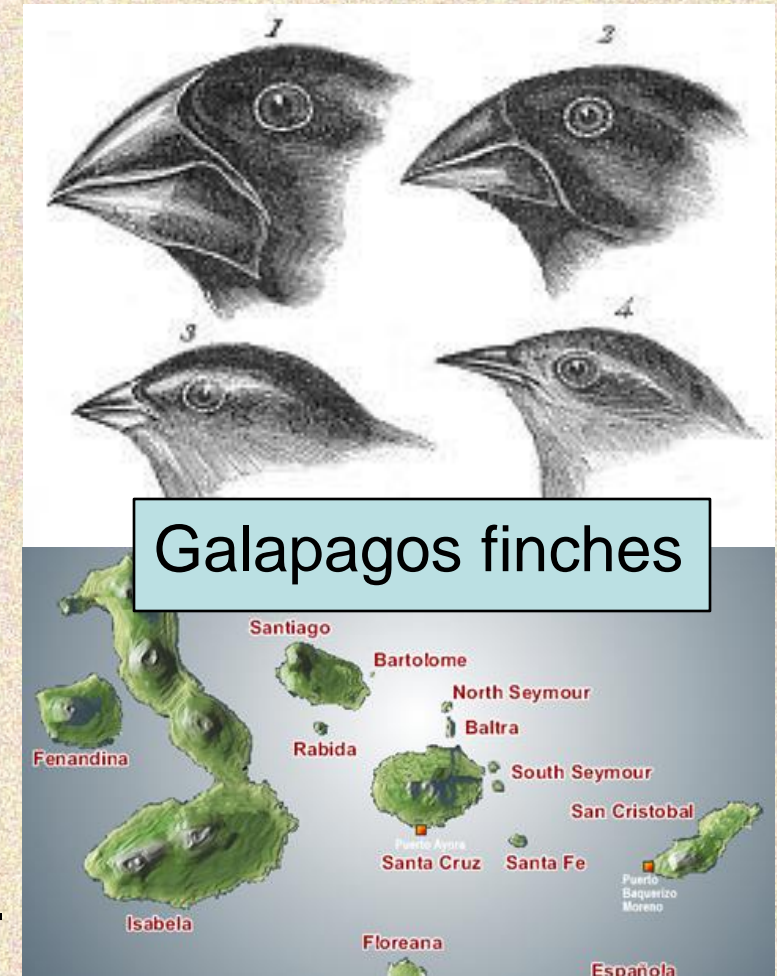
Dogs are  
wolves

- The dog is another example of how selection can change the **frequency of alleles** in a population.
- Dogs have been **artificially selected** for certain characteristics for many years, and different breeds have different alleles.
- All breeds of dog belong to the same species, *Canis lupus* (the wolf) so this is an example of **Microevolution** as no new species has resulted.



# Mechanism (8): Macroevolution

- However, if two populations of a species become isolated from one another for tens of thousands of years, genetic difference may become marked.
- If the two populations can no-longer interbreed, new species are born. This is called Macroevolution.
- Darwin's **Galapagos finches** are an example of this process in action.





# Mechanism (9): Speciation Today?



London Underground Mosquito



- The mosquito was introduced to the London Underground during its construction around 1900.
- It became infamous in the War for attacking people sheltering from the Blitz.
- Studies indicate several genetic differences from its above-ground ancestors. Interbreeding between populations is difficult suggesting that speciation may be occurring.





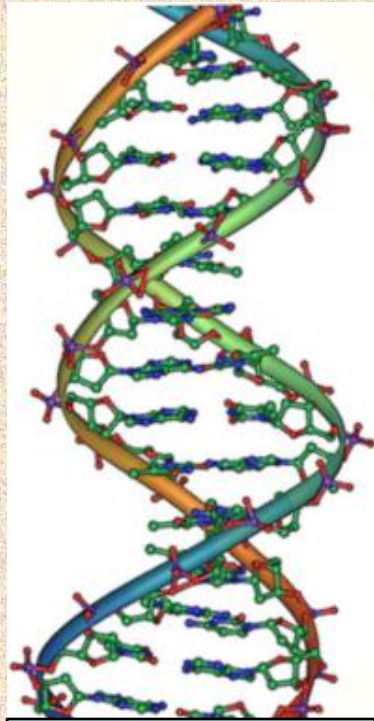
# Activity

## Natural Selection in the Peppered Moth



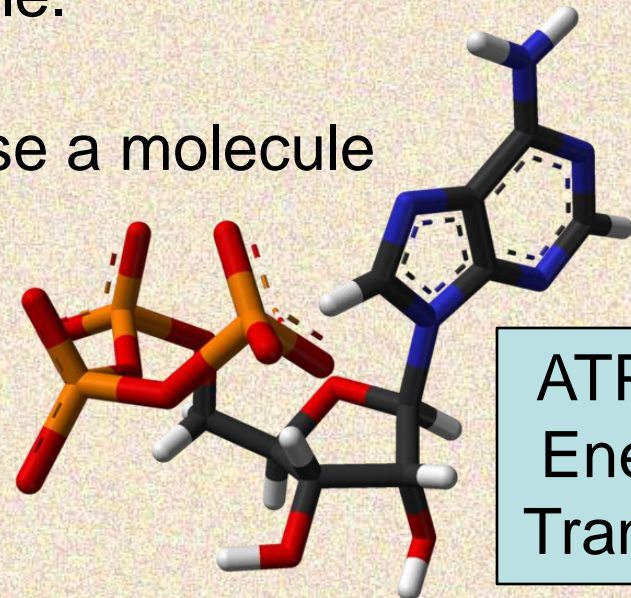


# Evidence (1): Biochemistry



DNA for  
Information  
Transfer

- The basic similarity of all living things suggests that they evolved from a single common ancestor.
- As we have already seen, all living things pass on information from generation to generation using the DNA molecule.
- All living things also use a molecule called ATP to carry energy around the organism.



ATP for  
Energy  
Transfer



# Evidence (2): Similar Genes

HUMAN	CCAAGGTCACGACTACTCCAATTGTCACAACCTGTTCCAACCGTCACGACTGTTGAACGA
CHIMPANZEE	CCAAGGTCACGACTACTCCAATTGTCACAACCTGTTCCAACCGTCA <b>T</b> GACTGTTGAACGA
GORILLA	CCAAGGTCAC <b>A</b> ACTACTCCAATTGTCACAACCTGTTCCAACCGTCACGACTGTTGAACGA



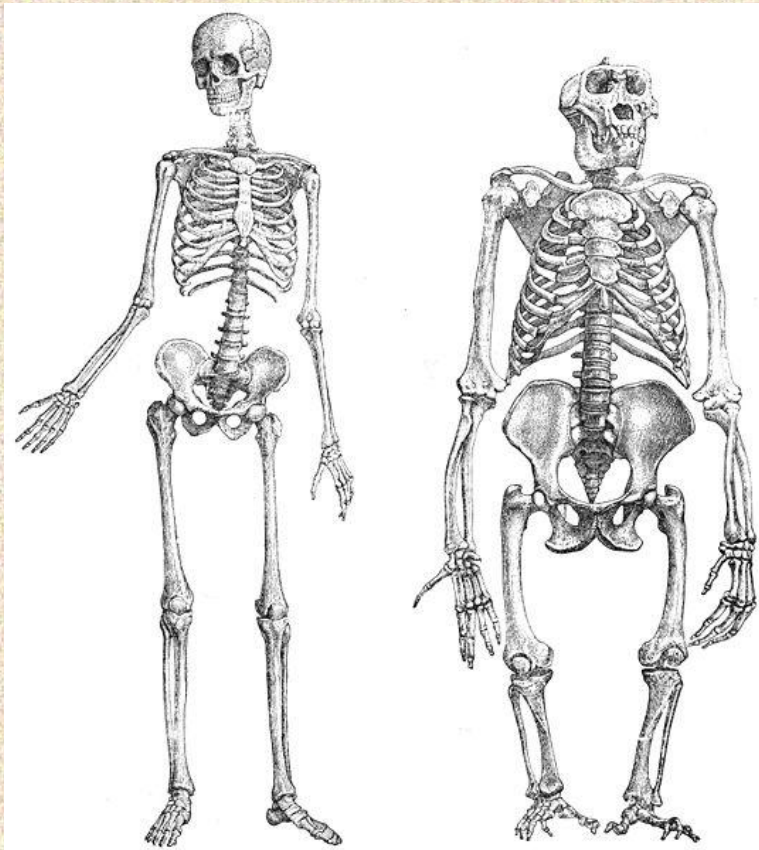
Genetic code of chimps and gorillas is almost identical to humans

- If evolution is true then we might also expect that closely related organisms will be more similar to one another than more distantly related organisms.
- Comparison of the human genetic code with that of other organisms show that chimpanzees are nearly genetically identical (differ by less than 1.2%) whereas the mouse differs by  $\approx 15\%$ .





# Evidence (3): Comparative Anatomy



Human and  
Gorilla

- Similar comparisons can be made based on anatomical evidence.
- The skeleton of humans and gorillas are very similar suggesting they shared a recent common ancestor, but very different from the more distantly related woodlouse...

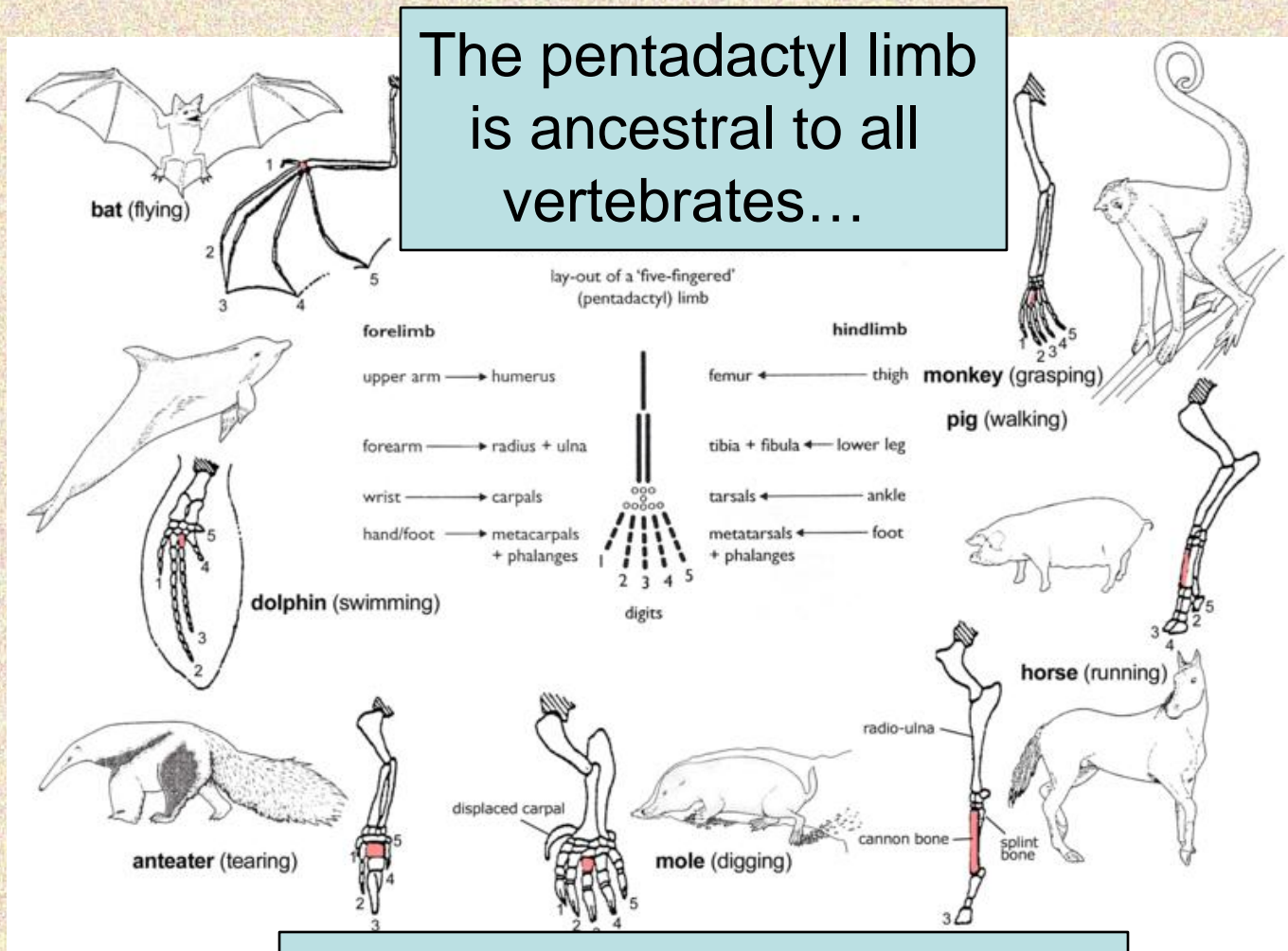
yet all have a common shared characteristic: bilateral symmetry



Woodlouse



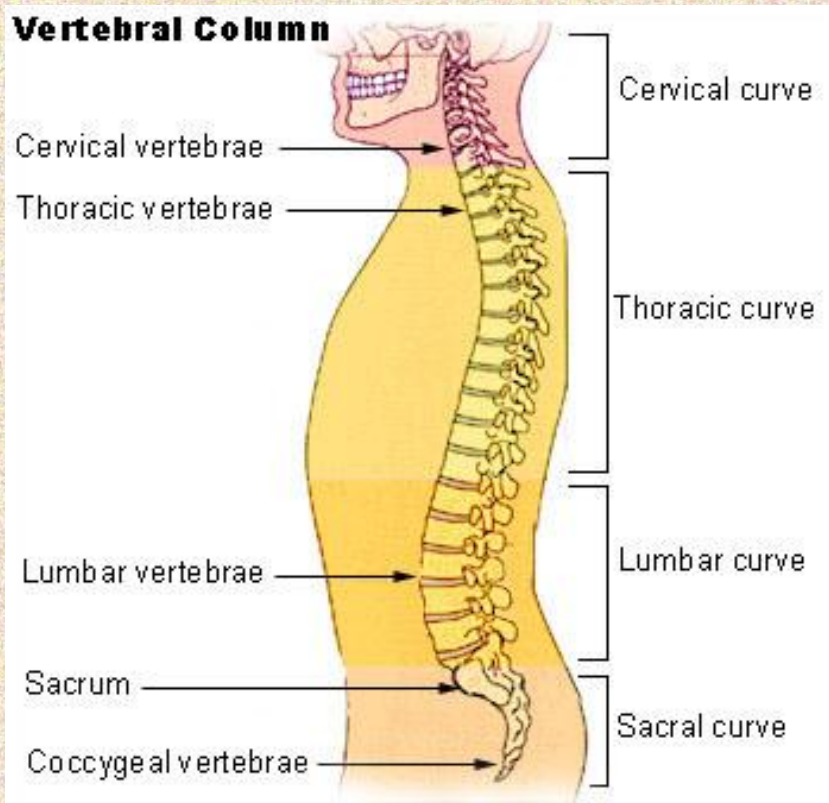
# Evidence (4): Homology



but modified for different uses



# Evidence (5): Vestigial Structures



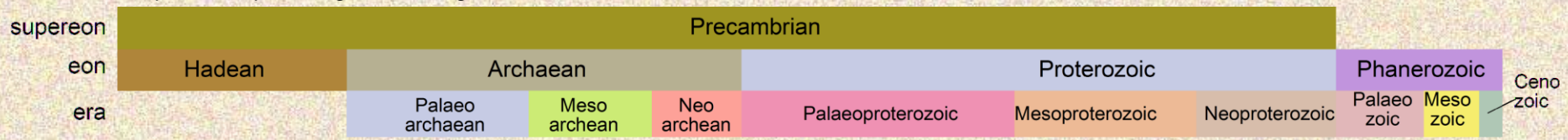
The coccyx is a vestigial tail

- As evolution progresses, some structures get side-lined as they are not longer of use. These are known as vestigial structures.
- The **coccyx** is a much reduced version of an ancestral tail, which was formerly adapted to aid balance and climbing.
- Another vestigial structure in humans is the **appendix**.



# Evidence (6): Fossil Record

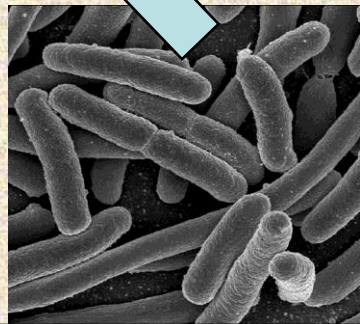
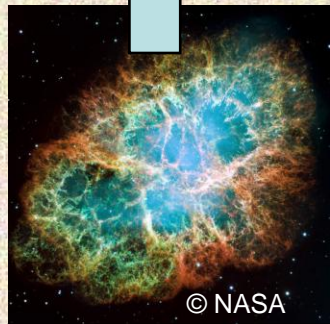
[http://en.wikipedia.org/wiki/Geologic\\_time\\_scale](http://en.wikipedia.org/wiki/Geologic_time_scale)



millions of years

© World Health Org.

[en.wikipedia.org/wiki/Image:Eopraptor\\_sketch5](http://en.wikipedia.org/wiki/Image:Eopraptor_sketch5)



origins

bacteria

complex cells

dinosaurs

humans

The fossil record shows a sequence from simple bacteria to more complicated organisms through time and provides the most compelling evidence for evolution.





# Evidence (7): Transitional fossils



*Archaeopteryx*

- Many fossils show a clear transition from one species, or group, to another.
- **Archaeopteryx** was found in Germany in 1861. It share many characteristics with both dinosaurs and birds.
- It provides good evidence that birds arose from dinosaur ancestors



# Evidence (8): Geography



■ Distribution of marsupials today



**Jurassic Period — 160 mya**

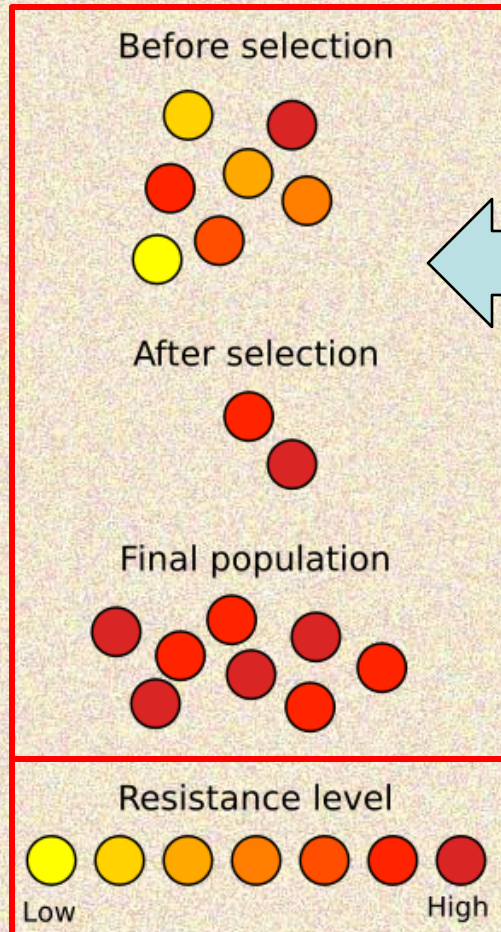
## Marsupials



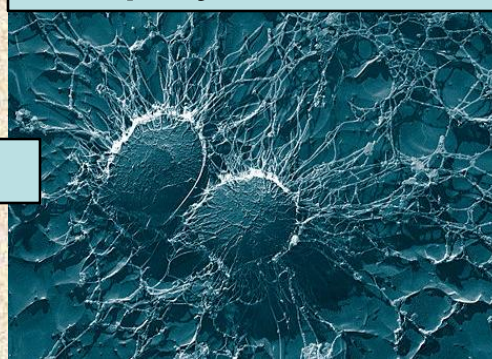
- Geographic spread of organisms also tells of their past evolution.
- Marsupials occur in two populations today in the Americas and Australia.
- This shows the group evolved before the continents drifted apart



# Evidence (9): Antibiotic resistance



Staphylococcus



- We are all familiar with the way that certain bacteria can become resistant to antibiotics

- This is an example of natural selection in action. The antibiotic acts as an environmental pressure. It weeds out those bacteria with low resistance and only those with high resistance survive to reproduce.

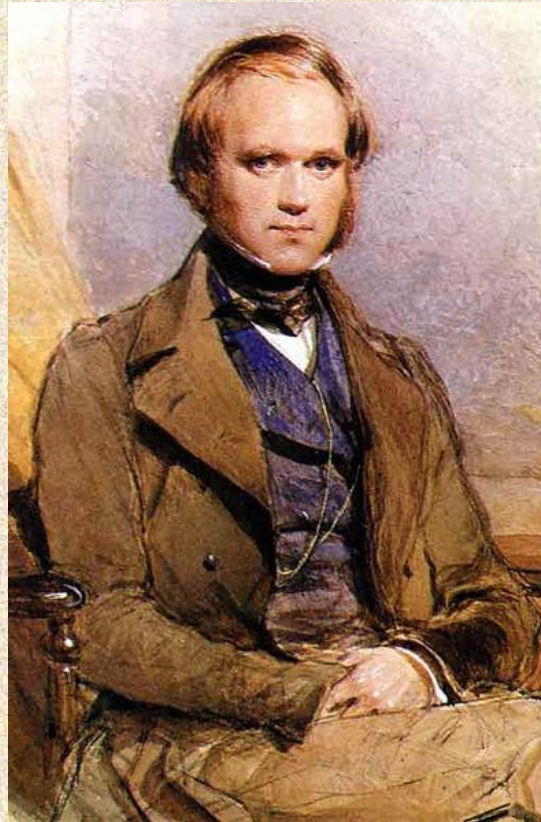




# Evolution



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[commons.wikimedia.org/wiki/Image:Charles\\_Darwin\\_1881.jpg](https://commons.wikimedia.org/wiki/Image:Charles_Darwin_1881.jpg)