# Heredity and Evolution

- On another planet, far, far away, there lives a race of intelligent people, just like us, except that…. The planet is called Xargos, and its people are known as Cretaceouscrustaceans.

- These people have tentacles instead of arms, and have several eyes, and – in fact – three brains.
- Their blood is blue.
- But they are intelligent like us and have created a civilisation of which they are very proud – albeit with some major environmental issues.  In fact, they are very similar to us.
- But why don't they look like us?

# Notes to write down!

- Evolution is the idea that living things have changed over time.
- After much study, the main reasons for this change seem to involve:
  - Natural Selection – which is how a species adapts to its environment in order to survive. This acts as a "driver" to change genes.
  - Mutation – sudden changes in genetic material which are passed on from parent to offpring
  - Other random genetic changes known as "genetic drift" which happen over a long period of time
- There is much evidence for Evolution, and most people accept it as a reality.
- Does anyone know who might have a problem with it and why?
- So why don't we look like the Cretaceouscrustaceans of Planet Xargos?

# Write your answers in your book?

Q. So what's evolution? (Roughly)

Q. Are we descended from monkeys?

Q. Roughly how old is the Earth?

Q. Roughly how long ago did bacteria first emerge?

Q. Roughly how long ago did complex life emerge?

Q. Roughly how long ago did the first modern type humans appear?

# A Timeline

- The Earth is around 4.6 billion years old
- Bacteria appeared at around 4 billion years ago
- Complex life didn't appear until ½ a billion years ago (500 million)
- Fish appeared at around this time.
- Complex life appeared in the oceans first.
- After fish came land plants at around 450 mya.
- Then Amphibians at 400 mya with insects soon after.
- Reptiles were at around 350 mya
- Dinosaurs – 275 mya
- Small mammals didn't appear until just over 200 mya
- Birds (some of which evolved from dinosaurs) appeared at around 175 mya.
- Modern humans have only been around for about 200 thousand years.
- https://www.youtube.com/watch?v=55oDyazPdTU

# How did we get such a Variety of Living things

- Some organisms look really similar and some look very different.
- Why is this?
- How did we end up looking and behaving the way that we do?
- If dolphins and sharks aren't closely related why do they have a similar shape?
- Why are animals and plants so different? (Hint the most recent common ancestor of plants and animals was 1.6 bya.)

# How ideas about Evolution have changed

Various ideas about the origin of species existed over time.

- The Dreamtime is used by Aboriginal Australians to describe the creation of Earth and life by Ancestral Beings. In one Dreamtime myth, the well-known Rainbow Serpent is thought by many Aboriginal cultures to have risen out of the ground and created the mountains, rivers, lakes and living things. Recorded in 6000-year-old rock, the Rainbow Serpent is today one of the oldest religious beliefs in the world.
- Greek philosophers (around 500 BCE) thought that life arose from mud when Earth was covered in water, then moved onto dry land.
- In one Chinese myth (recorded in the 3rd century), a hairy giant called Pan-Ku (or Pangu) emerged from an egg-shaped universe. The egg formed the earth and the sky, and the hair on Pan-Ku's body formed trees and plants. Human life came from fleas on his body.

# How ideas about Evolution have changed

- Religious people used to think the Earth was created in 4004 BC.
- In 1735, a scientist called Linnaeus developed the Classification system we use today. He was the first person to group humans with monkeys and apes.
- Lamarck, 1801, thought that giraffes decided to lengthen their neck during their life time in order to reach higher trees. These giraffes passed those traits onto their offspring.
- Charles Darwin went on a voyage on the HMS Beagle between 1831-1836. He is considered the father of Evolution. He wrote "Origin of Species" in 1859. A famous example of Evolution is Darwin's finches which are found in the Galapagos Islands.

# Some Defintions

**Evolution:** The fact that organisms change over time.

**Most Recent Common Ancestor:** If organisms are in a family tree, the point at which we and another species (for example, gorillas) share a common ancestor (like a grandparent).

**DNA:** Full name - deoxyribonucleic acid. DNA is a chemical structure which contains all the genetic material which makes up who we are. DNA stretched out would be about 2 metres long (actually two strands each 1m long).

**Gene:** A packet of genetic material composed of DNA. It is passed on from parent to offspring. Each gene or group of genes determines some characteristic in the offspring. We have 20 000 - 25 000 genes in our genome.

**Chromosome:** Groups of genes form one chromosome. Humans have 46 or 23 pairs.

**Adaptation:** The process of change by which an organism becomes better suited to its environment.

# Some More Defintions

**Natural Selection:** Those individuals which traits which are better suited to their environment tend to survive and reproduce more than those which do not.

**Artificial Selection:** The same as Natural Selection, except that humans are doing the selecting of particular traits in plants and animals they think are desirable. Also known as "breeding".

**Species:** A group of animals which share enough genetic similarity such that they recognise each other as potential mating partners.

# Species

Zebras and zebras are the same species.

But what about the Zorse?

# Zorse

# Zonkey

# Liger

# Problems

- But actually many of these species have different numbers of chromosomes.
- For example, humans have 46 chromosomes (or 23 pairs), and chimpanzees have 48 chromosomes (or 24 pairs). Very similar...but.
- Many species hybrids are not successful from the individual's point of view. They often have heritary conditions which reduce their lifespan and cause disease and pain.
- Species hybrids are usually sterile (ie they can't reproduce). In the wild they wouldn't even try to mate as they wouldn't recognise each other as a mating partner.
- Donkeys and horses have been bred together for years however - mules - and, although, infertile produce a healthier, stronger offspring, probably because horses and donkeys are more closely related.
- https://slate.com/technology/2015/06/zonkeys-ligers-the-sad-truth-about-animal-hybrids.html

# Mules

- Horses have 64 chromosomes and Donkeys have 62. Mules have 63.  Most species have an even number of chromosomes as they form two sets of pairs.

# Adaptation and Variation

- Some individuals of a particular species may move into a different environment.
- The different environmental conditions might favour different physical attributes of that species, for example, beak size and shape, or feet, etc.
- Those individuals which contain the right traits for those conditions, or who have enough existing suitable material will adapt to the new conditions.
- Those individuals which adapt the best are the individuals which survive and pass on their genetic material to their offspring.
- Over time, the population will look and act so differently to the original species, that they are said to have speciated, and will not recognise the other species as potential mating partners.
- For example, Darwin's Finches.
- Access Science By Doing, and Register as a Student:  Click Curriculm Units, scroll to the bottom on the Left and Click Evolution and Heredity.  On Activity 1.3, click Student Pages.

# Natural Selection

- Natural selection is the process whereby individuals which are better adapted to their environment (particularly changed) are more likely to survive and pass on their genes to the next generation.
- The important part is that reproduction must take place. If there is no reproduction, then those genes will not be passed on.
- Species have a certain amount of genetic flexibility. If this wasn't the case, most species would die in the face of changing environmental conditions.
- Adaptations can be: physiological, eg. sweating; behavioural, eg moving to the shade when it's hot; or structural, eg. the beaks of Darwin's finches changing over time.

# Evidence for Evolution

There are four main types of evidence for Evolution:

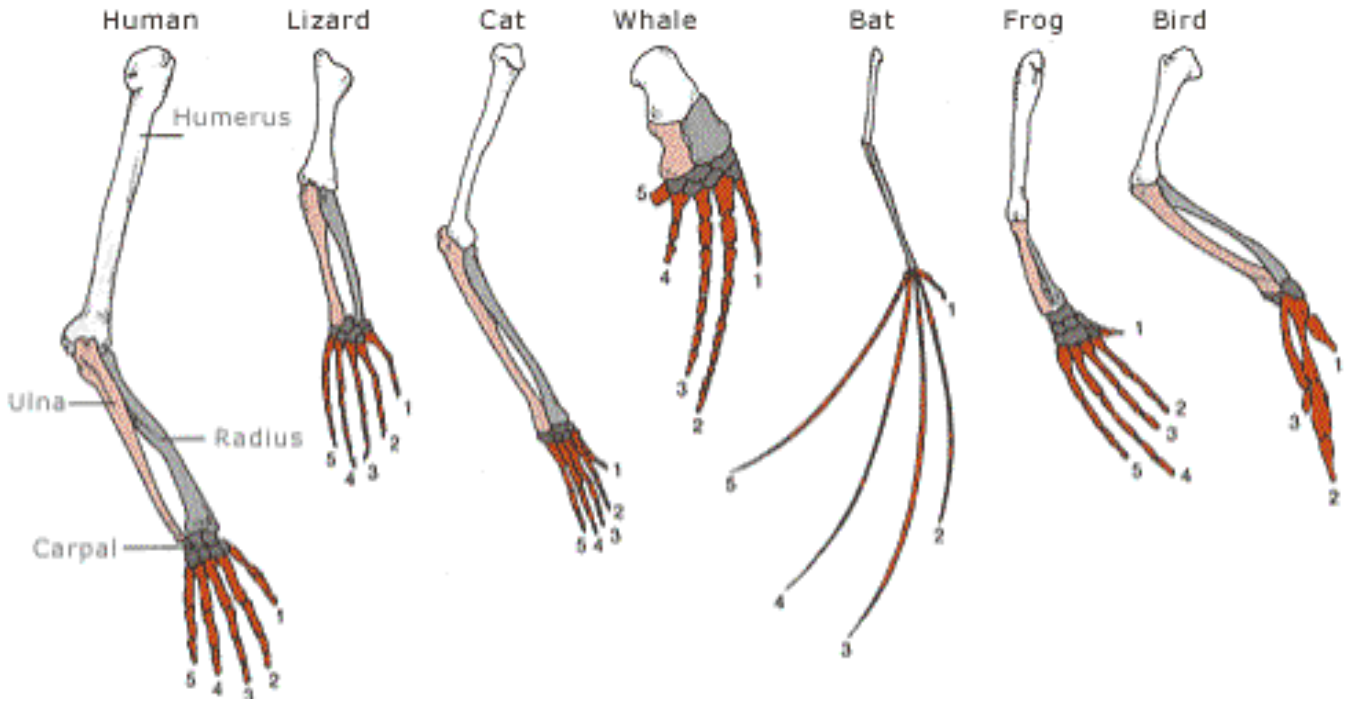
- Fossil Evidence: Fossils show us what animals used to look like. They also show a gradual change over time in some species. We call these transitional fossils. Fossils also show a gradual increase in complexity.
- Anatomical Evidence: Vertebrates such as humans, other mammals and birds share a similar forelimb. These forelimbs have the same bones, which have been modified to fit their environment.
- Biogeographical Evidence: Populations change when their environments change (think Darwin's finches). When the original supercontinent (Pangaea) broke up, species alive today have common ancestors from Pangaea.
- Biochemical Evidence: The structure of common molecules such as DNA and certain proteins is similar in closely related species.

# Evidence for Evolution - Comparative Anatomy

**Comparison of the anatomies of various vertebrate animals has shown great similarity in their limb structure. The fore-arm of various species such as frogs, lizards and humans show that all these animals have a pentadactyl (Greek for five-fingered) limb.**

**Homologous structure suggests descent from a common ancestor.**

**Analogous structure suggests adaptation a similar environment eg shape of sharks and dolphins.**

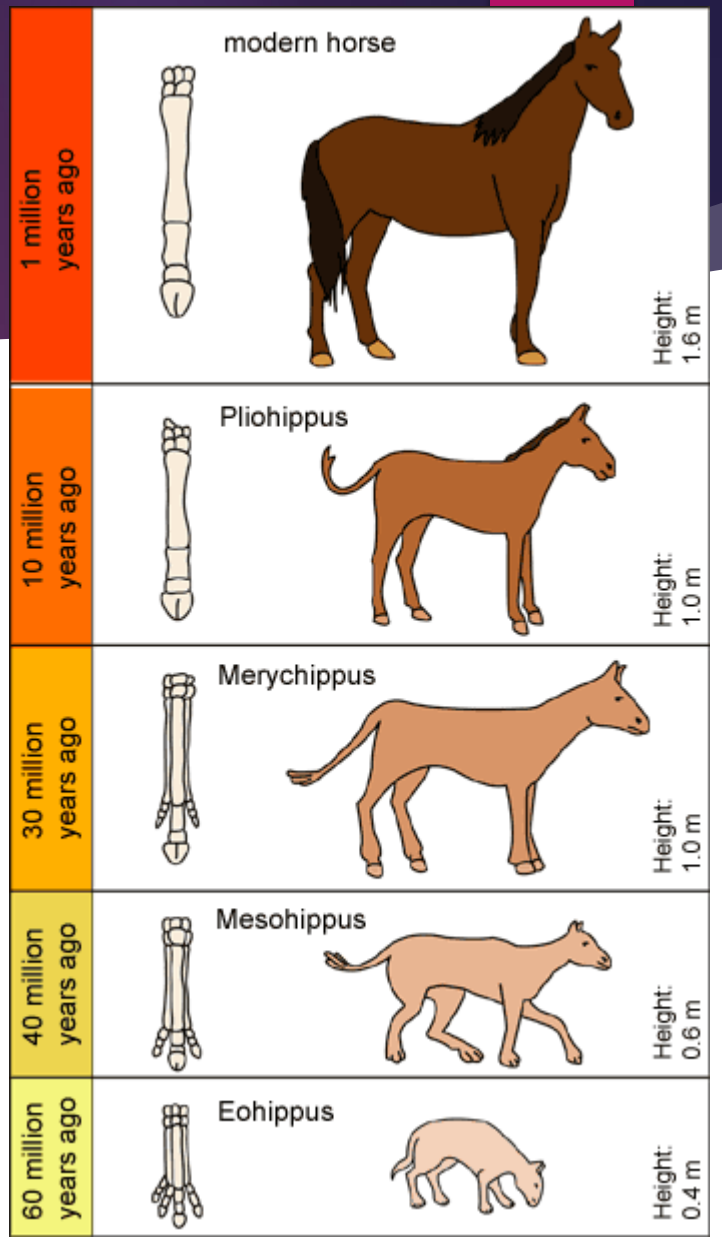


# Evidence for Evolution - Biogeographical

- When super-continents, like Pangaea (and later) Gondwanana were broken up by plate tectonics, the environment changed as new continents moved relative to the equator.
- Species which shared a common ancestor on the supercontinent, have evolved in response to the changing environment.
- At one time all the continents formed a vast super-continent called Pangaea.
- This then started to split at around 250 million years ago into Gondwana and Laurasia.
- Laurasia contained the northern continents - Europe, Asia and North America.
- Gondwana contained: Australia, Antartica, South America, Africa and India.

# Evidence for Evolution - Fossils

- Fossils give us the opportunity to see how certain species have changed over time.
- The classic example is of the horse.
- The horse was about the size of a dog 60 million years ago.
- The destruction of most of the large dinosaurs made a vacuum which mammals grew (literally) to fill.
- Over time, mammals became larger and larger. The horse then had larger predators, and its foot evolved from many toes to a hard hoof, which gave the horse an advantage in speed to escape predators.



# Evidence for Evolution - Biochemical

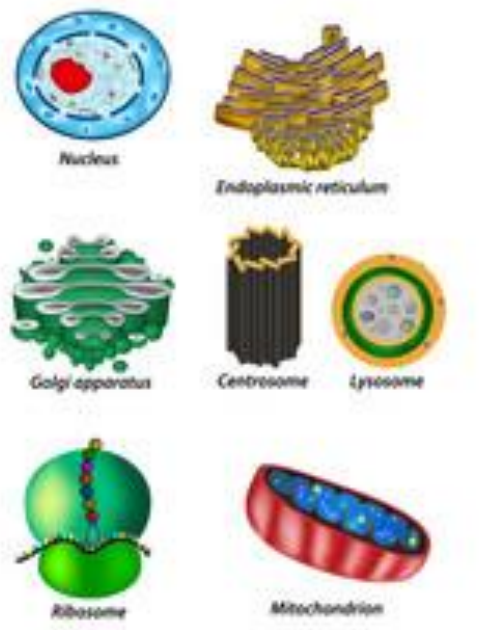
- This leads us to a neat segue (ie transition) into Genetics, the second part of our course.
- Biochemical evidence mostly concerns DNA - the molecule inside the nucleus of our cells which is the means of transmission of heredity.
- DNA is a chemical structure found in the nucleus of our cells, which is often considered to be a program (ilke a computer program) which codes for all that we are and do.
- DNA governs eye colour, hair colour, height, and even aspects of our personality.
- It is important to realise, however, that our environment interacts with DNA, and we can change over our life-time because of our education, health, parental care, etc.

# But first reproduction

- DNA is found in all of our cells, but the way it gets into the next generation is by sexual reproduction.
- In females, DNA is transmitted to offspring in the nuclei of ova (eggs). These are produced in the ovaries. Females have all the eggs they will ever have from birth.
- In males, DNA is carried in the nuclei of sperm. Sperm are produced over the life of a man in his testes.
- At conception, the ovum of the woman meets and fuses with the sperm of a man. Each of these sex cells contains exactly half the required DNA, (ie 23 chromosomes). Put together, the resulting baby will carry all 46 chromosomes (23 pairs) in most of the cells in their body.
- Attached is a handout on reproduction. Please fill in the labels for the parts of the reproductive system in females and males.

# Cells

- Let's refresh our memory of cell structure.
- In the diagram on the right are the major structures inside an animal cell.
- Animal cells - along with plants and fungi are called "eukaryotic". This type of cell evolved over 2 billion years ago from "prokaryotic" cells.
- The first life on earth evolved around 4 billion years ago. Those cells are called "prokaryotic". These cells still exist in the form of single celled bacteria. These first cells lack membranes around organelles (all the structures in the cell like those to the right), and don't have a proper nucleus. Their DNA is different as well.




# Cell Organelles

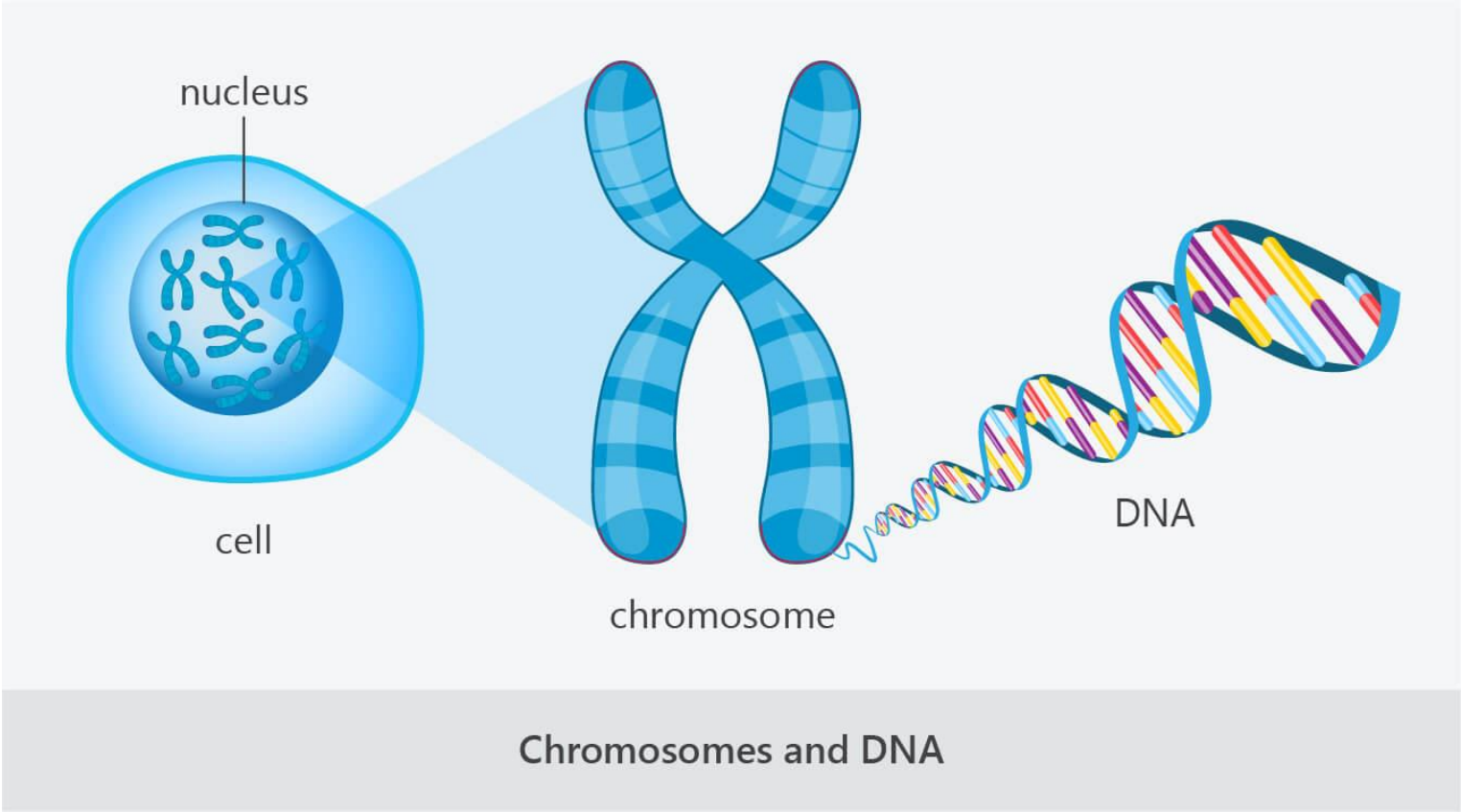
- The structures inside a cell are like the organs in our body. They each have a role to play in the function of the cell.  I will go through each structure. Then please complete the cell worksheet in your package.
- **Cell Membrane** - The cell membrance is like the guard of the cell because it surrounds and protects it.  It allows helpful substances, such as nutrients, to enter, and it also keeps harmful objects and waste out.
- **Cytoplasm** - The cytoplasm fills up the majority of the cell and is made of water and disssolved substances. They jelly-like textuer helps to transport materials around the cell and also breaks down cell waste.  Many chemical reactions take place in the cytoplasm.

# Cell Organelles - Continued

- **Vacuoles** - Vacuoles are storage bubbles in the cell. They might contain food or waste any given time. Animal cells usually have several small vacuoles, while plant cells have one large vacuole.
- **Golgi Apparatus** - The Golgi apparatus works with the endoplasmic reticulum - it combines and distributes proteins and lipids to the rest of the cell.
- **Mitachrondia** - (Singular: mitachondrion). These are the powerhouses of the cell. They are structures where respiration place.
- **Endoplasmic reticulum** - The endoplasmic reticulum acts as a sort of factoy for the cell, making the proteins and lipids which the other structures need to function.

# Cell Organelles - Continued

- Which brings us to the "star" of our story:
- **Nucleus** - The nucleus of a cell contains chromosomes on which genes are located.
- **Chromosome** - This is a piece of DNA. Chromosomes hang out in pairs when the cell is about to divide. Otherwise the DNA lies coiled in a messy tangle. Inside the human cell, there are 23 pairs of chromosomes.




Chromosomes and DNA

# DNA

- As mentioned before, each strand of DNA inside our cells is about 1 metre long. There are two strands, each with 23 chromosomes.
- In total we have around 20-25 genes.
- A gene is a piece of DNA which carries particular instructions. Basically DNA codes for proteins. What is difficult for us to understand is how protein building blocks are put together in incredibly complex ways to produce us!
- Most traits (characteristics) are coded for by more than one gene. But we will start by looking at traits coded by a single gene - such as blue eyes versus brown eyes.
- Cells undergo asexual reproduction. Asexual reproduction involves only one parent which literally just splits inhalf. Humans like us undergo sexual reproduction - which involves two parents each with unique genetic material (DNA) which merges in the resulting offspring.