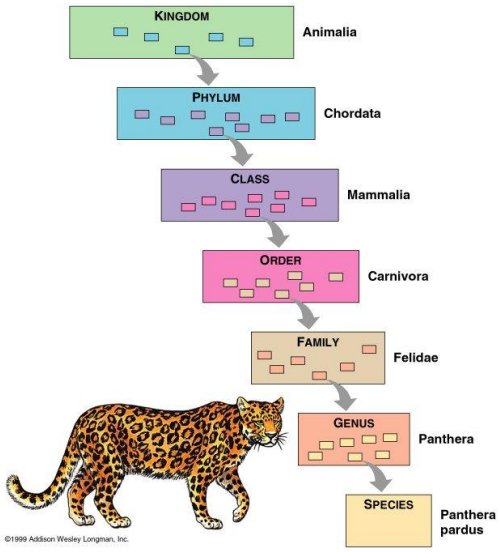
Topic 1 – Classification, variation and inheritance

- **CLASSIFICATION**
- Classification – sorting organisms into groups based on their characteristics (i.e according to how closely they are related to one another)
- At the most basic level, organisms are classified into one of five 'kingdoms'…
    - Animalia (the 'animal kingdom'):
        - Multicellular (made of many cells)
        - Heterotrophic feeders - i.e animals get their food by eating and digesting other organisms
        - No cell walls, complex cell structure with nucleus
    - Plantae (the 'plant kingdom'):
        - Multicellular
        - Autotrophic feeders – i.e plants make their own food through photosynthesis
        - Cell walls made of cellulose (to provide support to plants)
        - Complex cell structure with nucleus
    - Fungi:
        - Multicellular, cell walls not made of cellulose
        - Saprophytic feeders – i.e fungi get their food from dead or decaying matter
        - Complex cell structure with nucleus
    - Protoctista: unicellular (made of one cell), complex cell structure with nucleus
    - Prokaryotae: unicellular, simple cell structure with no nucleus
- Note - there is no kingdom for viruses because...
    - They are non-living
    - They're not made up of cells (no cell organelles)
    - They can only exist inside 'host' cells (e.g inside human cells)
- Living organisms in kingdoms are further divided into 6 sub-categories:
    - Phylum, Class, Order, Family, Genus and Species
    - As you progress from kingdom→phylum→class→order→family→genus →species, the groups are smaller and the organisms share more and more characteristics in common (i.e organisms are more and more alike)
- **Naming species:**
- An organism's scientific name has two latin words, made up of the genus and species name – this is called the binomial system:
    - E.g humans are *Homo Sapiens* – 'Homo' is the genus, 'sapiens' is the species
- The binomial naming system is in latin…:
    - Because common names given to organisms can sometimes be misleading:
        - E.g robins in America (turdus migratorius) and robins in the UK (erithacus rubecula) are different species
    - So that scientists all over the world can communicate clearly, whatever their language

- **VERTEBRATES AND INVERTEBRATES**
- Vertebrates are animals that have a backbone – a supporting rod that runs the length of the body
- All vertebrates belong to the phylum Chordata
- Animals that don't have a backbone are called invertebrates
- Both vertebrates and invertebrates (phyla – plural of phylum) are divided into smaller groups (classes), according to different characteristics…



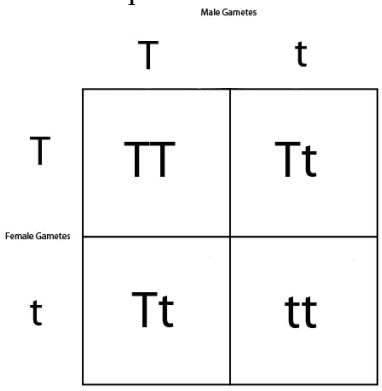
- **Grouping vertebrates into classes:**
- 1. Vertebrates can be grouped into classes according to <u>how they absorb oxygen</u> for respiration:
    - Fish – gills to take in oxygen from the water
    - Amphibians – young amphibians have gills but adult amphibians usually have lungs and can absorb oxygen through their moist skin
    - Other groups of vertebrates (mammals, reptiles, birds) have lungs
- 2. Vertebrates can be grouped into classes according to <u>how they reproduce</u>:
    - Some vertebrates reproduce using external fertilisation – i.e the egg is fertilised outside the body of the female…:
        - Adult female releases eggs into the water, where they're fertilised by the sperm released by an adult male (fish and amphibians)
    - Other vertebrates reproduce by placing sperm inside the female so that the egg is fertilised inside the body – internal fertilisation…:
        - Organisms which reproduce in this way and then lay eggs are known as oviparous (reptiles and birds)
        - Organisms which reproduce in this way and then give birth to live young are known as viviparous (mammals)
- 3. Vertebrates can be grouped into classes according to the way in which they <u>regulate their body temperature</u> ('thermoregulation'):
    - Homeotherms ('warm blooded') e.g mammals, birds – have an internal mechanism that keeps their body temperature <u>constant</u>
    - Poikilotherms ('cold blooded') e.g reptiles, amphibians, fish – their body temperature <u>changes</u> according to the external temperature
- **Some vertebrates are difficult to classify:**
- Some organisms don't fit perfectly into any class
- →even within a class, some species have different characteristics to the rest:
    - E.g axolotls have gills even as an adult but are still classed as amphibians (even though they respire more like fish)
    - E.g2 sharks use internal fertilisation and give birth to live young but are still classed as fish (even though they reproduce more like mammals)
- →it's important to look at many characteristics when deciding which group to place an organism

- **SPECIES**
- A species is defined as a group of organisms that can interbreed (i.e reproduce with one another) to produce offspring that are fertile (i.e able to produce offspring of their own)
- **Difficulties with classification:**
- 1. Variation exists (even within organisms of the same species)
- 2. Asexual reproduction:
    - Some organisms don't need to interbreed to produce offspring
    - If we don't see interbreeding we can't test whether or not two individuals are the same species
- 3. Ring species:
    - Sometimes there's a chain of different populations that can breed with their neighbouring populations but the two populations at the end of the chain can't interbreed
    - The chain often forms a ring shape→these organisms are called ring species - difficult to divide into separate species
- 3. Hybridisation in ducks:
    - Mallard ducks can interbreed with closely related species to produce fertile hybrids
    - Fertile hybrids can in turn breed with other closely related ducks to form other fertile hybrids
    - This interbreeding results in the creation of ring species→difficult to classify
- **VARIATION**
- Differences in characteristics are called variation
- **Discontinuous variation:**
    - Take a fixed set of values – categories (e.g shoe size, blood group, gender)
    - Discontinuous variation is usually caused by instructions within cells→is called <u>genetic variation</u>
    - Discontinuous data is plotted on a bar graph
- **Continuous variation:**
    - Values can be any number within a certain range (e.g height, weight)
    - Characteristics that show continuous variation are often controlled by both genes and the environment…e.g:
        - You may inherit a tendency for being tall from parents
        - But diet and lifestyle are also important in determining height
    - Characteristics influenced by the environment (i.e diet/disease/ lifestyle) are known as 'acquired characteristics' – called 'environmental variation'
    - Continuous data is plotted on a line graph (usually gives a normal distribution of values – i.e bell-shaped curve)
- **Biodiversity:**
- Biodiversity is a measure of the total number of different species in an area
- Areas of greater biodiversity ('biodiversity hotspots') need to be protected because they contain a large variety of species within them
- **ADAPTATION**
- All organisms are adapted to their surroundings – i.e they have variations in their characteristics that allows them to survive in their habitats (places where they live)
- E.g organisms from polar regions (e.g polar bears) are adapted to the cold:
    - Small ears stop heat loss

    - Thick fur for insulation…white fur for camouflage in snow
    - Thick layer of fat for insulation from cold
    - Large spread out feet→stop it from sinking into the snow
- E.g2 Organisms living near deep-sea hydrothermal vents (e.g deep-sea Pompeii worms) have the opposite problem:
    - Top fluids come out of these vents and cool quickly
    - →deep-sea Pompeii worms must cope with big temperature changes, complete darkness and huge pressures:
        - Body is adapted to cope with very high pressures
        - No eyes (doesn't need them because its habitat deep under the sea is in complete darkness – it does have sensitive tentacles, though)
        - Body is covered in a thick layer of bacteria that helps protect it from the heat
        - Spends lots of time inside a paper-like tube to hide from predators
- **EVOLUTION**
- **Darwin's theory of evolution by natural selection:**
- Organisms produce more offspring than the environment can support:
    - Limited resources (e.g limited food and space) means there's <u>competition</u> for survival between individuals
    - →Most offspring die before reaching adulthood
- Even within the same species, organisms show variation in their characteristics…:
    - Individuals who are well adapted to their environment are more likely to survive, breed, and pass on their genes to their offspring
    - Individuals who are less well adapted to their environment are more likely to die→less likely to breed and pass on their genes to their offspring
    - →Over generations, there is a gradual shift in the variation of characteristics in a species – this is evolution
        - E.g if an environment becomes drier, then individuals better suited to drier conditions survive→over time, species becomes better suited to the drier conditions
    - This process is called 'survival of the fittest' or 'natural selection'
- If the environment changes too rapidly and no individuals have adaptations that help them survive, they all die and the species may become extinct
- **New evidence for Darwin's theory:**
- Resistant organisms:
    - In the 1940s and 1950s, warfarin was used to poison rats
    - However, within 10 years, most rats were resistant to warfarin (i.e rats were not affected by the poison)
    - Explanation using Darwin's theory:
        - As a result of variation, there were a few rats that by chance had always been resistant to warfarin poison
        - As non-resistant rats were killed by poison, the only ones left to breed were the warfarin resistant rats
        - →their warfarin resistance characteristic was passed on to their offspring→over some years most rats became resistant
- DNA research has shown how characteristics are passed on to offspring→this also supports Darwin's theory of natural selection
- **Speciation:**
- The formation of a new species as a result of geographical isolation

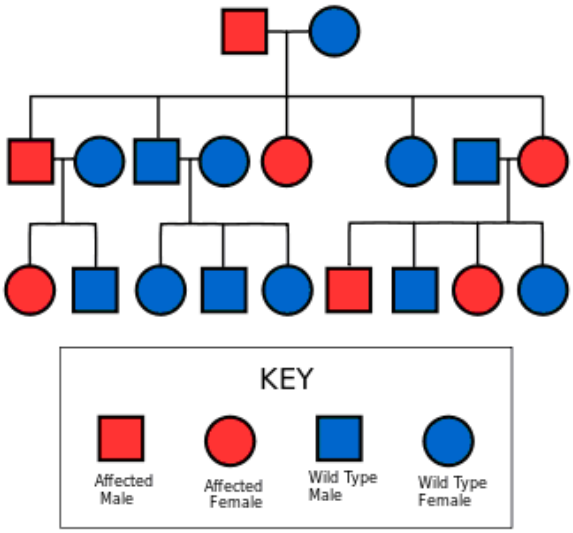
- **Example of speciation:**
- Darwin noted that although mockingbirds on different Galapagos islands were very closely related, each island had its own species of bird
- Darwin guessed that originally individuals from one species of mockingbird had reached the Galapagos islands
- The environmental conditions on each island were different...→
    - On each island, those with successful adaptations survived, bred, and passed on their genes to their offspring
    - →Each island population of mockingbirds evolved in a different way (to adapt to the specific conditions on each island)
- Over time, the mockingbirds on each island became so different that they could no longer interbreed with birds from other islands to produce fertile offspring
- →new mockingbird species were formed – this process is called speciation
- **GENES**
- Animal cells have a cell membrane, cytoplasm and a nucleus
- Inside the nucleus are long strands of a substance called DNA
- Each strand of DNA forms a structure called a chromosome
- Human body cells contain 23 pairs of chromosomes (→46 in total) in their nuclei
- Each chromosome carries a large number of genes
- Each gene does a particular job…e.g:
    - Many genes control variations in our characteristics – e.g how we look like
    - Other genes contain information about how likely we are to get certain diseases
- Variation caused by genes is called inherited variation because genes are inherited from our parents
- **Alleles:**
- There are two copies of every chromosome (23 pairs) in a body cell nucleus →there are two copies of every gene
- These gene pairs may contain slightly different instructions for the same characteristic:
    - E.g may code for brown eye colour instead of for blue eye colour
- These different forms of the same gene are called alleles
- Each of us can inherit a different set of alleles from our parents (see punnett square below)→giving each of us slightly different characteristics (this explains why twins can sometimes be very different)
- **EXPLAINING INHERITANCE**
- Plants and animal cells produce gametes (sex cells)
- Male gametes – sperm in animals, pollen grains in plants
- Female gametes – egg cells in both animals and plants
- Gametes are different from other body cells because they only have one copy of each chromosome (i.e 23 chromosomes in their nucleus…not 46)
- →Gametes only have one allele for each gene
- In sexual reproduction the male and female gametes fuse together→organism formed has 46 chromosomes (23 pairs) in their body cells, with two alleles for each gene (one from the male parent, one from the female parent)
- **Inheritance terminology:**
- Dominant alleles - have an effect even if there is just one copy of it
- Recessive alleles - need to be present as a pair to have an effect

- A dominant characteristic is seen even if just one allele is dominant
- A recessive characteristic is only seen if both alleles are recessive
- This can be shown by drawing a punnett square (see below):
    - A dominant allele is shown by a capital letter (e.g T)
    - The recessive allele has the lower case version of the same letter (e.g if dominant allele is 'T', then recessive allele is 't')
- The alleles in an organism are its genotype
- What an organism looks like is its phenotype
- If both alleles in an organism are the same, the organism is homozygous (e.g TT)
- If the alleles are different, the organism is heterozygous (e.g Tt)
- **Punnett squares:**
- Possible genotypes produced when two organisms breed can also be shown in a Punnett square



- Parents have the genotype Tt (one dominant allele and one recessive allele)→they are heterozygous dominant
- T is dominant→both parents are tall (the phenotype)
- When gametes fuse, alleles can come together in different combinations:
    - 25% TT (genotype - homozygous dominant, phenotype - tall)
    - 50% Tt (genotype - heterozygous dominant, phenotype - tall)
    - 25% tt (genotype - homozygous recessive, phenotype - short)
        - →there's a 3 in 4 chance (75%) that offspring will be tall
        - →there's a 1 in 4 chance (25%) that offspring will be short
- **GENETIC DISORDERS**
- Genetic disorders such as sickle cell anaemia are caused by faulty alleles
- Sickle cell anaemia:
    - It's a genetic disease that causes red blood cells to clump together
    - The allele that causes sickle cell anaemia is recessive→both copies are needed for people to suffer from the disorder
    - Symptoms:
        - Sufferers become easily tired and short of breath
        - Painful joints (because their red blood cells stick together and block blood vessels – can sometimes be fatal)
- Another genetic disorder caused by a recessive (faulty) allele is cystic fibrosis:
    - Lungs get clogged with thick mucus, making breathing difficult and leading to infections
    - Mucus also blocks some of the tubes that carry enzymes to the small intestine to digest food
    - Lack of enzymes able to digest food can result in weight loss
- **Family pedigree charts:**

- Family pedigree charts show how a genetic disorder is passed on in a family



- **Carriers:**
- Doctors can use family pedigree charts to work out the probability of a person inheriting a genetic disorder from their parents – this is pedigree analysis
- Carriers are individuals who don't have the disease themselves but can pass it on to their offspring if their partner is also a carrier for the same disease:
    - E.g a person who is Cc is a carrier for cystic fibrosis because they have a copy of the faulty allele
    - They don't have the disease, though, because cystic fibrosis is recessive (both recessive alleles need to be present - cc)
- If both parents are carriers (can find this out by genetic screening), doctors can help couples decide whether to try for a baby or not