Topic 5: Evolution and biodiversity

5.1 Evolution and biodiversity

U1	Evolution occurs when heritable characteristics of a species change.
U2	The fossil record provides evidence for evolution.
U3	Selective breeding of domesticated animals shows that artificial selection can cause evolution.
U4	Evolution of homologous structures by adaptive radiation explains similarities in structure when there are differences in function.
U5	Populations of a species can gradually diverge into separate species by evolution.
U6	Continuous variation across the geographical range of related populations matches the concept of gradual divergence.
A1	Development of melanistic insects in polluted areas.
A2	Comparison of the pentadactyl limb of mammals, birds, amphibians and reptiles with different methods of locomotion.

Evolution: cumulative change in the heritable characteristics of a population

- Cumulative change: small change over many generations
- Heritable characteristics: gene-controlled factors
- These traits cannot be acquired over a lifetime, they are heritable traits or alleles in an organism's DNA

Evidence of evolution:

- Fossil records – sedimentary rocks
- Homologous structure
- Vestigial structure e.g. appendix
- Selective breeding
- Comparative DNA
- Observable change

Fossil records:

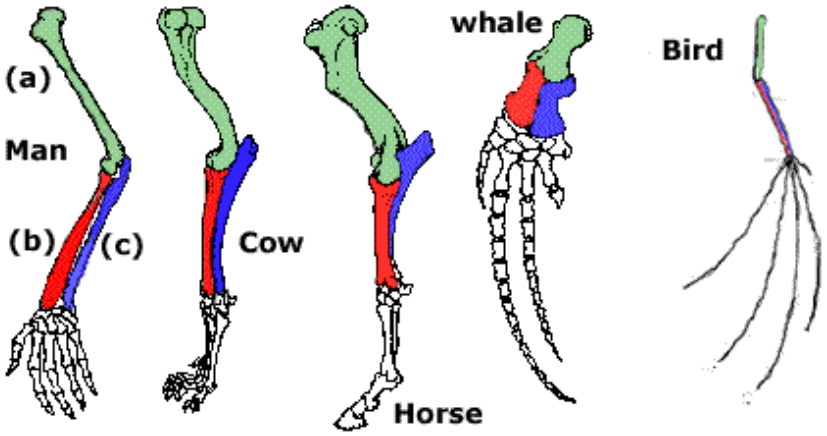
- Fossils are the preserved remains of animals, plants, and other organisms from the past.
- The fossil record shows the **gradual change** of species over time.
- The timeline in which fossils appear are what scientists would expect, with bacteria and algae being the oldest in the fossil record. Followed later by shelled animals and trilobites, then dinosaurs and early reptiles, birds and mammals later still.

Selective breeding:

- Breeding plants and animals for specific genetic traits.
- Shows a good record of recent changes in genetic characteristics over a few dozens of generations that man has selected to breed.
- For example, chickens that produce more eggs or cows that produce more milk are selected to breed, hopefully passing these traits onto next generations.
- Plants can be bred in a similar manner based on useful or beneficial characteristics breeders would like to see in the next generation of plants.
- The evolution of **domesticated dogs** has produced many different breeds through artificial selection

Homologous structure:

- Common **internal structures** that are similar in seemingly dissimilar animals that have evolved from a common ancestor.
- The standard example of homologous structures is the "**Pentadactyl limb**" which is the five digit limb found in animals such as humans, dolphins, bats, and dogs.
- Even though the shape, size and function of this structure vary between species, the general structure and position of the bones in these limbs are the same.



Gradual diverge:

- Within a population there is genetic variation
- If two populations of the same species become separated so that they do not reproduce or interbreed because they become separated by geographical boundaries; for example one group migrates to an island or they became separated by a mountain range, then natural selection will act differently on those two separate populations
- Over time, these populations change so that they are recognizably different and can or do not interbreed if they were to merge together again
- This process is called **speciation**

5.2 Natural selection

U1	Natural selection can only occur if there is variation among members of the same species.
U2	Mutation, meiosis and sexual reproduction cause variation between individuals in a species.
U3	Adaptations are characteristics that make an individual suited to its environment and way of life.
U4	Species tend to produce more offspring than the environment can support.
U5	Individuals that are better adapted tend to survive and produce more offspring while the less well adapted tend to die or produce fewer offspring.
U6	Individuals that reproduce pass on characteristics to their offspring.
U7	Natural selection increases the frequency of characteristics that make individuals better adapted and decreases the frequency of other characteristics leading to changes within the species.
A1	Changes in beaks of finches on Daphne Major.
A2	Evolution of antibiotic resistance in bacteria.

Occurrence of natural selection:

- Within a species, different individuals of that species show genetic variation.
- Individuals that are best suited for their environment will survive and reproduce.
- If there was no variation within a species, then all individuals would be the same and no individual would be favoured over the other and natural selection would not take place

Genetic variation:

- Sexual reproduction can produce variation in a species through fertilization and meiosis.
- Sexual reproduction occurs when two different members of a species create offspring that have a combination of genetic material contributed from both parents.
- During **meiosis** 50% of the females chromosomes will end up in the egg(haploid gamete) and 50% of the male's chromosomes will end up in the sperm (haploid gamete).
- **During meiosis chromosomes *will line up or assort independently*** of each other creating (2^n) possible variations of chromosomes in the sex cells.
- During meiosis, specifically prophase I, crossing over might occur in homologous chromosomes where parts of each chromosome are exchanged.
- **Random fertilization** through sexual reproduction gives millions of sperms a chance at fertilizing the egg. This allows mutations that have occurred in different individuals to come together in their offspring.
- Lastly, **genetic mutations** might occur where new alleles are produced. Genetic mutations are the original source of variation within a species.
- Mutations that give an advantage are selected for.
- Mutations that give a disadvantage are selected against.

Struggle for survival:

- Populations tend to produce more offspring than the environment can support or that could survive in a particular community or ecosystem.
- For example, fish produce thousands of eggs but only few make it to adulthood.
- Plants also can produce hundreds or thousands of seeds to be released into the environment.
- When parents don't spend a lot or even any time caring for their young, they produce many offspring. This is a reproductive method used to make sure **some offspring make it to the next generation**.
- Parents that put a lot of time and energy protecting and raising their young tend to have far smaller litters, i.e. most mammals.
- If there are too many organisms, the demand for resources increases.
- However, there is a limited supply of resources in an ecosystem.
- Overpopulation and a limited amount of resources creates competition within a population.
- They have to compete for mates, food, space, predation, and disease.

- Within a population, there is genetic variation between the individuals in the population.
- The organisms with the **beneficial characteristics** will be able to out-compete the other individuals with the less beneficial or harmful genetic traits for limited resources and mates.
- Therefore, these individuals will survive and reproduce and pass these genetic traits onto the next generation of offspring.
- Organisms with less desirable traits will die or produce less offspring
- Over many generations the **accumulation of these beneficial genetic** traits may result in a change in the population known as evolution.
- For another species to develop, these genetically different individuals eventually have to become reproductively isolated (separated from the general population) where they will only reproduce with individuals with similar genetic traits.
- Acquired characteristics of an individual such as large muscles are not passed on to an organism's offspring

Antibiotic resistance:

- Antibiotics kill bacteria directly or weaken the bacteria so your immune system can fight and destroy the invading pathogen.
- If a patient has a bacterial infection, when antibiotics are given to fight the infection the majority of the original population of bacteria will be destroyed.
- However, some of these bacteria might not die because of changes within their DNA. These changes could be caused by mutations within their genome or the transfer of an **antibiotic resistant** gene from another bacterium.
- Resistance is more likely to occur if the proper amounts of antibiotics aren't taken or if a patient doesn't finish the prescription.
- These resistant bacteria will survive and reproduce, creating more identical resistant bacteria.
- These resistant bacteria will make the person sick again in the future.
- However if given the same antibiotic, these bacteria will no longer be destroyed.
- Another antibiotic can be prescribed to kill these new resistant bacteria.
- Resistance can be passed onto other pathogenic bacteria, creating more species of resistant bacteria.

Finches on Daphne Major:

- Beak shape changes according to the food – environmental change causes change in available food.

5.3 Classification of biodiversity

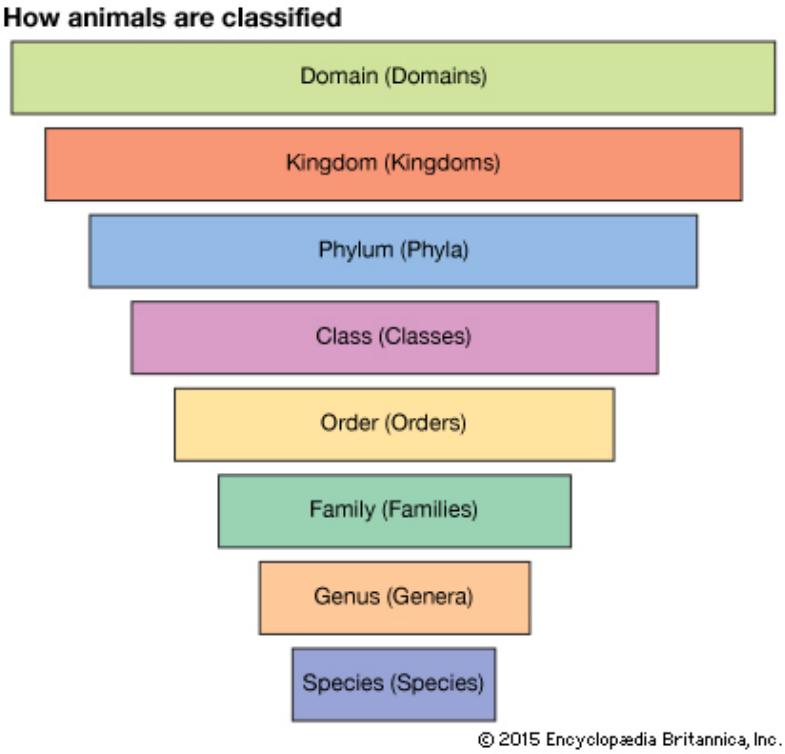
U1	The binomial system of names for species is universal among biologists and has been agreed and developed at a series of congresses.
U2	When species are discovered they are given scientific names using the binomial system.
U3	Taxonomists classify species using a hierarchy of taxa.
U4	All organisms are classified into three domains.
U5	The principal taxa for classifying eukaryotes are kingdom, phylum, class, order, family, genus and species.
U6	In a natural classification, the genus and accompanying higher taxa consist of all the species that have evolved from one common ancestral species.
U7	Taxonomists sometimes reclassify groups of species when new evidence shows that a previous taxon contains species that have evolved from different ancestral species.
U8	Natural classifications help in identification of species and allow the prediction of characteristics shared by species within a group.
A1	Classification of one plant and one animal species from domain to species level.
A2	Recognition features of bryophyta, filicinophyta, coniferophyta and angiospermophyta.
A3	Recognition features of porifera, cnidaria, platylhelmintha, annelida, mollusca, arthropoda and chordata.
A4	Recognition of features of birds, mammals, amphibians, reptiles and fish.
S1	Construction of dichotomous keys for use in identifying specimens.

Binomial Nomenclature:

- The first name in the binomial naming system is called the **genus** and is always capitalized.
- The second name starts with a small letter and is called the **species**.
- The name must be written in italic. (in handwriting, underline the name), for example: *Escherichia coli*
- Genus name abbreviation can be used if the full name is already used, for example *E.coli*
- Species: is a group of organisms which can **interbreed** and produce **fertile** offspring.
- Sub-species: species might potentially interbreed if a barrier (e.g. geographical) or other challenge was removed.

Taxonomy:

- A taxon means a group of something
- Scientists arrange or organize species in to a hierarchical set of groups in order to organize organisms into specific similar groups based on similar characteristics
- As one goes higher up on a classification chart, the greater the number of species are included into the group



- All organisms are classified into three domains: eukaryota, bacteria, archaea
- The Archaea and Bacteria domains are **prokaryotes**. These are organisms that do not have a membrane bound nucleus and their DNA is not associated with proteins.
- The Eukarya domain includes eukaryotes, or organisms that have a membrane bound nucleus.
- Groups organisms primarily based on differences in ribosomal RNA structure. Ribosomal RNA is a molecular building block for ribosomes.

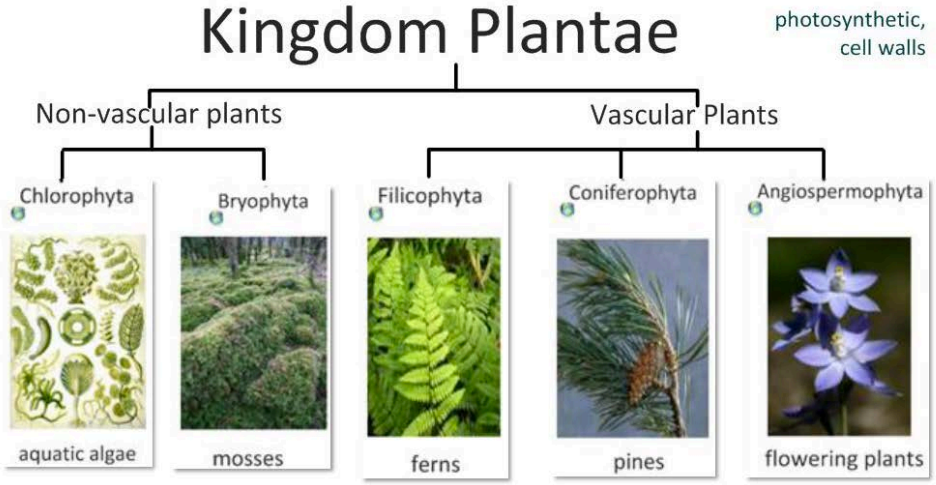
Identification of species:

- Natural classification is very useful for research into biodiversity
- Easier identification for new species that do not obviously fit into a specific
- A **dichotomous key** could be used to put an organism into a classification that fits that organism the best
- This would not work as well for artificial classification (e.g. Colour of flower petals)
- Since organism evolved from a common ancestor, new species would share similar characteristics (likely internal), allowing for easier identification and classification. For example the pentadactyl limb, or mammary glands in mammals

Plantae Classification:

- **Bryophytes**: no vascular tissue, very small, use spore to reproduce e.g. moss
- **Filicinophytes**: has vascular tissue, use spore to reproduce e.g. fern
- **Coniferophytes**: has vascular tissue, use naked seeds to reproduce, woody
- **Angiospermophytes**: has vascular tissue, produce flowers

Phylum name	Vascular tissue	Means of reprodcution	Roots and stems	Examples
Bryophytes	None	Spores	No roots, simple leaves and stems	Mosses
Filicinophytes	Yes	Spores	Has root, short non-woody stems	Ferns
Coniferophytes	Yes	Naked seeds	Has roots, woody stmes	Pines
Angiospermophytes	Yes	Flowering	Has roots, variable leaves and stems	Peach tree



Animalia classification:

- **Porifera**: sponges, no mouth or anus, filter food from current, attached to rocky surface
- **Cnidaria**: jellies, radical symmetry, has mouth but no anus, many has stinging cells
- **Platyhelminthes**: flatworms, bilaternal symmetry, mouth but no anus, no segmentation
- **Annelida**: segmented worms, bilaternal symmetry, has mouth and anus
- **Mollusca**: squid, bilaternal symmetry, has mouth and anus, usually has a shell
- **Arthropoda**: inserts, bilaternal symmetry, has mouth and anus, jointed, has exoskeleton and joints

Phylum name	Anus	Mouths	Symmetry	Segmentation	Other features	Examples
Porifera	None	None	None	None	Attach to rocks	Sponges
Cnidaria	None	Yes	Radical	None	Stinging cells	Jellies
Platyhelminthes	None	Yes	Bilaternal	None	Flatten body	Flatworms
Annelida	Yes	Yes	Bilaternal	Yes	Bristles	Earthworms
Mollusca	Yes	Yes	Bilaternal	None	Have shells	Squids
Athropoda	Yes	Yes	Bilaternal	Yes	Exoskeleton and joints	Insects

Use this dichotomous key to identify the 6 main phyla of invertebrates

Give the common name and latin name of one example of each

1. Is it symmetrical?	Yes	go to Q2
	No	Phylum Porifera e.g.
2. Symmetry is	Radial	Phylum Cnidaria e.g.
	Bilateral	go to Q3
3. Gastric tube	Mouth & anus	go to Q4
	Mouth, no anus	Phylum Platyhelminthes e.g.
4. Segmentation	Yes	Go to Q5
	No, or not visible	Phylum Mollusca e.g.

Classification of vertebrate class

	Limbs	Gas Exchange	Reproduction	Other features
Mammals	4 Pentadactyl limbs	Lungs with alveoli	• Internal fertilization • Give birth to live young • Mammary glands secrete milk	• Hairs growing from the skin • Teeth including living tissue
birds	4 Pentadactyl limbs, 2 limbs modified as wings	Lungs with parabronchial tubes	• Internal fertilization • Hard shells around the eggs	• Feathers growing from skin • Beak but no teeth
reptiles	4 Pentadactyl limbs	Lungs with extensive folding	• Internal fertilization • Soft shells around eggs	• Dry scaly impermeable skin • Simple teeth – no living tissue
amphibians	4 Pentadactyl limbs	Simple lungs with small internal folds and moist surfaces	• External fertilization in water • Protective jelly around eggs • Larval stage lives in water	• Soft moist permeable skin
fish	Fins	Gills	• External fertilization in most species	• Scales grow from the skin • with a single gill slit • Swim bladder for buoyancy

Dichotomous key:

- A dichotomous key is a key constructed from a series of statements arranged into pairs.
- The two descriptions should represent separate choices or characteristics that determine the difference between two organisms.
- Both choices are read and compared with the organism to be identified.
- If the first characteristic is present in the organism to be identified follow the instructions at the end of the statement. If the characteristic is not present go to the second statement as this should be true.
- Once a choice is made, that selection directs you to another pair of descriptive statements.
- One statement might identify the organism or lead you further on in the key.
- This process is repeated until a successful identification is obtained.

1. a. Organism has a backbone.....go to 2
1. b. Organism does not have a backbone.....go to 5

2. a. Organism has wings.....go to 6
2. b. Organism does not have wings.....go to 3

3. a. Organism has legs.....go to 4
3. b. Organism does not have legs.....Snake

4. a. Organism has a shell.....Turtle
4. b. Organism does not have a shell.....Frog

5. a. Organism has antenna.....Insect
5. b. Organism does not have antenna.....Spider

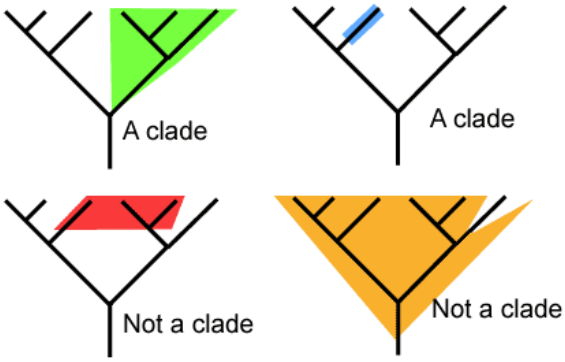
6. a. Organism has feathers.....Bird
6. b. Organism has hair.....Bat

5.4 Cladistics

U1	A clade is a group of organisms that have evolved from a common ancestor.
U2	Evidence for which species are part of a clade can be obtained from the base sequences of a gene or the corresponding amino acid sequence of a protein.
U3	Sequence differences accumulate gradually so there is a positive correlation between the number of differences between two species and the time since they diverged from a common ancestor.
U4	Traits can be analogous or homologous.
U5	Cladograms are tree diagrams that show the most probable sequence of divergence in clades.
U6	Evidence from cladistics has shown that classifications of some groups based on structure did not correspond with the evolutionary origins of a group or species.
A1	Cladograms including humans and other primates.
A2	Reclassification of the figwort family using evidence from cladistics.
S1	Analysis of cladograms to deduce evolutionary relationships.

Cladogram:

- Cladogram is a tree diagram showing the similarities and differences between different species
- Branching points on the cladgram is called **nodes**
- Nodes denote a speciation event when a common ancestor splits into two or more species
- These groups of species evolved from a common ancestor, that have shared characteristics is called a **clade**
- Sometimes determining which species are part of a certain clade is difficult
- The most accurate evidence is derived from amino acid sequences of certain proteins, such as *Hemoglobin and Cytochrome C* and from base sequences of genes



Time correlation:

- Differences in the base sequence of DNA are caused by mutations. These gradually accumulate over time.
- Rate at which mutations occur can be used as a **molecule clock** to calculate how long ago specie diverge.
- By sequencing nuclear DNA and mitochondrial DNA, we can establish a biochemical phylogeny between species to show common ancestry
- The difference in the sequences can be used to deduce when a certain species split from a common ancestor

Analogous structure:

- Some animals belonging to different groups live in the same or similar habitat
- This can lead to development of similar superficial structures for organisms that live in a similar manner
- The structures look comparable anatomically from the outside; however, are not alike on the inside (do not share a common ancestor)
- They are similar traits but not from a common ancestor

Homologous structure:

- Common internal structures that are similar in seemingly dissimilar animals that have evolved from a common ancestor.
- The standard example of homologous structures is the “pentadactyl limb” which is the five digit limb found in animals such as humans, dolphins, bats, and dogs.
- Even though the shape, size and function of this structure vary between species, the general structure and position of the bones in these limbs are the same.

Reclassification:

- Since evidence from base and amino acid sequences only became possible in the mid to late 1900’s, some changes have occurred in traditional classifications of certain plants and animals based solely on morphology
- Cladistics has provided evidence that shows some morphologies do not match the evolutionary origins of the groups of organisms they were put in to
- As a result some groups have been reclassified, some groups have merged or divided, and in some cases, some species have been moved to another group
- This process is time consuming; however, the new classifications based on cladistics, give a clear and more concise view of an organism’s true natural classification
- An example of the reclassification of an organism is the Family Scrophlahulariaceae
- At one point this family consisted of over 275 genera and 5000 species
- Scientists recently used cladistics to reclassify the Figworts family
- They focused on the base sequences of three **chloroplast genes** and discovered that the species in the Figwort family were not one clade but five clades and had been incorrectly grouped together into one family