8.5 - Evolution of Australian Biota:

Prerequisite Knowledge:

- *Identify the role of cell division in growth, repair and reproduction in multicellular organisms:*
  - Living things are made up of cells
  - In multicellular organisms new cells are produced by cell division for growth repair and reproduction
  - In unicellular organisms, cell division divides the organisms into 2 new organisms
- *Relate natural selection to the theory of evolution:*
  - The four main points of Darwin's Theory of Evolution by Natural Selection are:
    - In any population, there are variations
    - In any generation, there are some individuals that do not reach maturity and reproduce; the characteristics of these individuals are removed from the population
    - The individuals that survive and reproduce are well adapted to the environment; they have favourable conditions (survival of the fittest)
    - Favourable conditions are passed on to offspring; they become more and more common in the population
- *Discuss evidence that suggests that crustal plates move over time:*
  - The theory of plate tectonics holds that the continents and oceans are carried on the large crustal plates of the Earth's surface, which move on top of the semi-molten interior
  - Evidence for this includes the age of the sea floor around mid-oceans ridges, the matching edges of continents, and fossils of similar organisms found in different parts of the world.

1. Evidence for the rearrangement of crustal plates and continental drift indicates that Australia was once part of an ancient super continent:

- *Identify and describe evidence that supports the assertion that Australia was once part of a landmass called Gondwana including:*
    - *Matching continental margins*
    - *Positions of mid-ocean ridges*
    - *Spreading zones between continental plates*
    - *Fossils in common on Gondwanan continents, including* Glossopteris *and* Gangamopteris *flora, and marsupials*
    - *Similarities between present day organisms on Gondwanan continents*

- All landforms were originally joined together in a giant landmass called Pangaea
- In the Jurassic, 160 million years ago, Pangaea split into two super continents: Gondwana and Laurasia
- Gondwana: Australia, Africa, Madagascar, New Zealand, South America, India
- Laurasia: Europe, North America, Asia (except India)
- About 60 million years ago, Australia split from Gondwana
- Evidence that Australia was once part of Gondwana:
    - Geological evidence:
        - The rock strata around continental margins match exactly in many places, eg: 1) South Australia & Australia, 2) West Africa & east South America.
        - Mid-ocean ridges are formed where plates are moving apart
        - When plates move apart, molten rock rises up and forms new sea floor.
        - In these areas, called spreading zones, the new rock that forms is older the further it is from the ridge
        - This proves that the plates have been moving apart steadily for a long time
    - Biological evidence:
        - The fossil record and present day organisms provide evidence that Australia was part of Gondwana
        - Fossil Evidence:

  - *Glossopteris* and *Gangamopteris* are fossil plants found in rocks of the same age in Australia, Africa, India, South America, Antarctica and New Zealand
  - Fossils of marsupials have been found on all the continents that were part of Gondwana
  - This is evidence that the continents were once joined
- Extant Organisms:
  - *Nothofagus*, or the southern beech trees, are found in forests of Australia, New Guinea, New Zealand and South America
  - Many plants and animals exist only where the *Nothofagus* still live; e.g. a parasitic fungus, a moss and bugs which depend on the moss
  - Many groups of animals in Australia have close relatives in South America, Africa, India and New Zealand, but not in Northern Asia, Europe or North America
  - These animals include: parrots, ratites (flightless birds), marsupial mammals, chelid turtles, some geckoes, many families of earthworms, terrestrial molluscs, spiders and insects, and the scorpion genus *Cercophonius*

- *Discuss current research into the evolutionary relationships between extinct species, including megafauna and extant Australian species:*
  - Megafauna are large animals, such as elephants and whales
  - Megafauna are not the ancestors of present animals, eg kangaroos didn't come from giant kangaroos, rather they both evolved from a common ancestor.
  - Over the last 50k years most of the world's megafauna have become extinct
  - Two theories have been put forward to explain this:
    - Climate Change: Megafauna were mainly suited to glacial conditions. Their large bodies enabled them to live in extreme conditions. In Eurasia and North America, when permafrost was replaced with forest, the megafauna died out and animals more adapted to forest began to thrive. In Australia, the temperature changed from cold-dry to warm-dry. As a result, water sources began to dry up, and many animals lost their habitat and died out.

  - Human Expansion: The time of the extinction of megafauna matches very closely the pattern of human migration into these areas. Megafauna are also large and slow, which makes them susceptible to hunting. In Africa, humans evolution occurred there, so hunting increased slowly, allowing animals to adjust. That is why there are still megafauna there. However, in places where humans arrived as skilled hunters, the most extinction occurred.
- Living fossil (or relict species) are organisms that have changed little or not at all since ancient times.
- Australia has many examples of living fossils, such as: 1) Stromatolites, 2) The Wollemi Pine, 3) Crocodiles, 4) Queensland lungfish, and 5) Monotremes.

- *Solve problems to identify the positions of mid-ocean ridges and spreading zones that infer a moving Australian continent:*
  - Mid-ocean ridges occur where continental plates are moving apart
  - Spreading zones are the new areas of floor created at ridges where molten rock rises out from the mantle and solidifies
  - There are spreading zones on the southern side of the Indo-Australian plate, and collision zones on the northern side
  - This implies that Australia is moving north
- *Identify data sources, gather, process and analyse information from secondary sources and use available evidence to illustrate the changing ideas of scientists in the last 200 years about individual species such the platypus as new information and technologies become available.*
  - Over the past 200 years, scientists' attitudes to the platypus has changed greatly
  - A dried platypus skin sent to England 200 years ago, in 1798, was considered to be a fake; the bill was thought to have been stitched on
  - Since then, there has been much debate as to how it should be classified
  - Features that separate it from other mammals: It lays eggs, no true teeth, and an absence of mammary glands, though it can secrete milk
  - It has been shown to be able to regulate body temperature in a primitive way
  - It is a highly specialised animal

2. The changes in Australian flora and fauna over millions of years have happened through evolution

- *Discuss examples of variations within a species:*
  - The small differences between organisms relating to the same species are called variations. These include features such as colour, size, or biochemical differences.
  - Examples of variations include:
    - *The white-naped honeyeater:* In Australia, eastern populations have a short bill and an orange eye-patch. These belong to the race lunatus. Populations in western Australia have larger bills and white or green eye-patches.
    - *The common heath:* This flower show remarkable variations in the colour of the flowers, from pure white, to pink, to deep red.
- *Identify the relationship between variation within a species and the chances of survival of species when environmental change occurs:*
  - According to the theory of natural selection, there will always be variations within species.
  - When environmental change occurs, the individuals that have a variation that allows them to live in the new environment can survive, while those without the variation die out.
  - So, the greater the variation within a species, the greater the chance that it will be able to survive in a situation of environmental change.
- *Identify and describe evidence of changing environments in Australia over millions of years:*
  - When Australia and Antarctica were joined 65 mya, the climate was cool and wet
  - Much of the land was covered in temperate rainforest
  - About 45 mya when Australia moved north and split from Antarctica, Australia became cooler and drier.
  - As Australia moved northward, it became warmer, and rainforests shrank and sclerophyll and grasslands increased
  - As Australia moved north of the Tropic of Capricorn, the northern edge became tropical

- Overall, Australia has become dry and warm, particularly inland
- During the current Quaternary period there have been many dramatic temperature fluctuations, including many ice-ages.
- The last 120,000 years has been a warm period in which fire has become a significant environmental factor.
- Other environmental changes that have shaped ecosystems, besides climate are:
  - Sea levels have risen and fallen; mainland Australia and Tasmania have been joined and parted at least 8 times in the past 30 million years
  - Erosion continues, making Australia the flattest continent
  - 35 mya, volcanic activity created extensive lava flows around the east coast of Australia
  - Around 20 mya, the Eastern Highlands were slightly uplifted

- *Identify areas within Australia that experience significant variations in temperature and water availability:*
  - Temperature variation in Australian inland deserts and grasslands can be very great. In the day the temperature may be over 40º, but fall very quickly at night
  - In winter, temperatures can go from 20º to below freezing
  - Most bodies of water in Australia are unreliable; they fluctuate greatly
- *Identify changes in the distribution of Australian species, as rainforests contracted and sclerophyll communities and grasslands spread, as indicated by fossil evidence:*
  - As Australia became warmer and drier, rainforests shrank, and grasslands and sclerophyll communities increased
  - As a result, those organisms well suited to these conditions undertook 'adaptive radiation', i.e. the change in a species from its original form to a different form adapted to different environments or ways of life.
  - Two groups that are part of the sclerophyll family are eucalypts and acacias
  - Both forms have adapted to survive in dry hot conditions
  - The 950 species of acacia are found almost everywhere, from tropical to temperate, arid and semi-arid.

- The 800 species of eucalypts are found mainly in open woodland and forests
- Another group, Proteaceae, has diversified into banksias, waratahs, grevilleas, etc
- Marsupials, as it got warmer, in Australia diversified to many ecosystems
- Placentals died out, except bats
- Frogs in Australia have developed an independence of permanent water, and many of them now occupy inland arid areas

- *Discuss current theories that provide a model to account for these changes:*
  - Evidence used for the theories of changes to Australian species come from two places: Riversleigh and Naracoorte
  - At Riversleigh, the change from rainforest to dry habitat was observed
  - Fossils from Naracoorte, as well as pollen from Wylie Swamp, indicate that during the Quaternary, inland lakes dried up and vegetation changed from forest to open woodland
  - These two places contribute to the following two theories:
    - Climate: Increase in climate and decline in water availability is shown in the contraction of rainforests and in the expansion of open woodland. The rise and fall of Australian mammals and the radiation of marsupials is also related to climate
    - Human Impact: Humans arrived as an exotic species in Australia. Their actions may have contributed to the megafauna's extinction and use of fire changed the environment. Arrival of Europeans drastically changed the environment, due to unsustainable agricultural methods
- *Discuss Darwin's observations of Australian flora and fauna and relate these to his theory of evolution:*
  - When Darwin travelled around the world in the ship *The Beagle*, the similarities between organisms that he observed convinced him that an evolutionary tree existed
  - He observed that many Australian flora and fauna had similar counterparts from other parts of the world
  - Crows in Australia look like English Jackdaws
  - Another bird looked like an English magpie

- The rat-kangaroo (potoroo) was similar to a European rabbit
- The Australian ant-lion was almost identical to its European counterpart
- The similarities between organisms that Darwin observed provided evidence that organisms are related due to coming from a common ancestor
- Also, Darwin observed that Australian flora were well adapted to Australian conditions, suggesting that natural selection had favoured them
- The great amount of marsupials in Australia, which Darwin considered inferior to placentals, showed that they only existed since there was no competition. No competition meant no natural selection and so marsupials thrived

- *Gather information from a secondary source to describe some Australian fossils, where these fossils were found and use available evidence to explain how they contribute to the development of understanding about the evolution of species in Australia:*
  - Lightning ridge (NSW)
    - 1985 - Steropodon: It was a monotreme similar to the platypus and the echidna. Lived 100 million years ago
  - Riversleigh (North-western Queensland)
    - 6 species of thylacine (Tasmanian tiger) have been found
    - Size ranged from Burmese cat to Doberman
    - Giant Rat-Kangaroo (proleopines) were found in 1888. They were carnivorous.
    - *Ekaltadeta ima*: They had large ridged premolars and sharp forward jutting lower incisors.
    - A jaw from a possum - representing the Striped Possum
    - Diprotodontid: a large cow-sized herbivore
    - A complete skull of monotreme obdurodon
    - Thingadonta, a marsupial with very strange teeth
    - Fangaroo, A small herbivorous kangaroo with huge teeth
  - Murgon (Southern Queensland)
    - First evidences of marsupials in Australia
    - A placental mammal called a condylarth
  - Alcoota (north east of Alice Springs)

        - Giant thunder bird
        - Wolf-sized Powerful Thylacine
        - Alcoota marsupial lion
    - Bluff downs:
        - (northern Queensland)
        - Bluff-downs giant python
    - Naracoorte: (South-east South Australia)
        - Giant short-faced kangaroo
        - A giant snake
- *Present information from secondary sources to discuss the Huxley-Wilberforce debate on Darwin's theory of evolution:*
    - Darwin's book *The Origin of Species* caused great uproar in the community, especially among religious clergy
    - Several debates happened, each side arguing they point of view of evolution
    - The most famous of these is the debate between Thomas Huxley (Darwin's Bulldog) and Bishop Samuel Wilberforce (Soapy Sam).
    - Wilberforce: "Rocks pigeons were what rock pigeons had always been"
    - Wilberforce asked Huxley whether it was his grandmother or his grandfather that came from a monkey.
    - Huxley replied that he would rather have an ape for an ancestor than a person who uses their intelligence to 'introduce ridicule into a grave scientific discussion'.

3. Continuation of species has resulted, in part, from the reproductive adaptations that have evolved in Australian plants and animals

- *Distinguish between the processes of meiosis and mitosis in terms of the daughter cells produced:*
  - Mitosis:
    - cell division, where two daughter cells are produced that are identical to the parent cell
    - It is used for growth and repair
    - Also basis of sexual reproduction
    - Division occurs only once
    - The stages are Interphase, Prophase, Metaphase, Anaphase and Telophase
    - Cells produced are diploid (identical number of chromosomes to parent)
  - Meiosis:
    - Cell division that produces 4 cells with half the number of chromosomes compared to the parent cell (haploid)
    - These cells are sex-cells; also called gametes
    - Gametes are either male or female; produced by both genders
    - Gametes fuse together during fertilisation to form a zygote, which multiplies by mitosis to form a new organism
    - The number of chromosomes found in most normal cells is called the diploid number; in humans, it is 46
    - We say that 2n is the diploid number, n is the haploid number
    - $2n = 46$, $n = 23$
    - Human males produce gametes called sperm, females produce ova or eggs
    - When two gametes join, the normal number of chromosomes is achieved
    - Similar chromosomes can be paired up, and are called homologous
    - In homologous chromosomes, one is from the mother, one from the father
    - Random segregation is, during meiosis, the separation of chromosomes by chance into the resulting daughter cells. This means that the gametes produced can have any combination of chromosomes. This results in increased variation
  - Similarities:

- Both are types of cell division
- Chromosomes are replicated before both types of divisions

- *Compare and contrast internal and external fertilisation:*
  - Fertilisation is the process by which the male and female gametes fuse to form a diploid zygote.
  - Conditions needed for fertilisation:
    1. Both male and female gametes need to be produced and ready at same time
    2. Arrangements need to be bring the gametes in contact with each other
    3. Water needs to be present (male gametes must swim to the female gamete)
  - External Fertilisation:
    - Fertilisation takes place outside the body
    - Most aquatic animals have external fertilisation
    - Male and female gametes are shot into the water in the hope of fertilisation
    - To ensure fertilisation, millions of gametes are released
    - The chances of fertilisation are increased because:
      - Cyclical reproductive behaviours
      - Synchronised timing of gamete production and release
      - The development of courtship and mating behaviours in animals
  - Internal Fertilisation:
    - Occurs inside the body of the female in animals, or in the female part of the plant in sexually reproducing plants
    - The male gamete is transferred directly to the female gamete
    - As a result, the number of female gametes is reduced greatly
    - Number of male gametes produced is still as high
    - Reproductive strategies:
      - Bringing the opposite sexes together with courtship and mating behaviours
      - Having a method of gamete transfer
- *Discuss the relative success of those forms of fertilisation in relation to the colonisation of terrestrial and aquatic environments:*

- External fertilisation is successful in water, as the gametes can spread very far and wide in the water, increasing the chances meeting other gametes from the opposite gender, encouraging fertilisation
- Also, zygotes are able to spread to large areas, enabling successful colonisation of large areas of water.
- External fertilisation would not succeed on land, as there is no water through which the male gametes can swim, and the gametes would not spread very far, as the buoyancy of water is not there to support their travelling.
- Internal fertilisation enabled the colonisation of land, as the watery environment needed is provided by the female's physiology
- Without the need for external water for fertilisation, even the driest environments could be colonised

- *Describe some mechanisms found in Australian flora for:*
  - *Pollination*
  - *Seed dispersal*
  - *Asexual reproduction*

  with reference to local examples:

- Flowers are the reproductive organs of angiosperm plants
- Flowers are protected in the bud by sepals (usually petal-like)
- Petals surround the male and female reproductive organs
- Male reproductive organ:
  - Called the stamen
  - Made of anther and filament
  - Meiosis occurs in anther and produces pollen grains
  - Pollen grains have a thick outer layer and 2 haploid nuclei
- Female reproductive organ:
  - Called the pistil; made up of a number of carpels
  - Each carpel is made of a stigma, style and ovary
  - Meiosis occurs in the ovules, which are in the ovary
- Pollination and Fertilisation:

- Pollination is the transfer of pollen onto a mature stigma
- Fertilisation occurs after pollination, in the following way:
  1. The pollen on the stigma sends a pollen tube down the style to the ovary
  2. The two haploid nuclei of the pollen grain travel down the tube. One of the nuclei become the nucleus of the new tube cell, while the other nucleus divides again and they both travel down the tube to the ovule
  3. The pollen tube enters the ovule through a tiny hole called the micropyle
  4. One of the nuclei fuses with the ovum to form the zygote
  5. The other nucleus fuses with the two other haploid nuclei to form a triploid cell

- Self-pollination involved pollen going on to the stigma of the same plant
- Cross-pollination involves pollen falling on the stigma of different plants
- Examples of pollination in Australian plants:

Australian Plant	**Method of Pollination**	**Adaptations of Flower**
Wattle	Wind	Large masses of pollen produced - can be carried over many kilometres by wind. Pollen is produced in such large quantities so higher chances of landing on stigma of another flower.
Bottlebrush	Birds	Spectacular bright red flowers attract birds Birds visit flower for nectar, pollen attaches to their bodies and is spread from flower to flower
Melaleuca	Bat	Strong smelling flower, thick nectar, dull flowers
Grevillea	Parrot	Produces lots of nectar; no petals, just masses of stamens
Heath Banksia	Possums	Produces a lot of nectars food supply for possums. No petals
Australian Orchid	Wasp	It flowers and matures during wasp's breeding season Releases scent similar to female wasp, and flowers similar to female wasp, so as the male tries to mate, pollen rubs off.

- Seed dispersal is the spreading of seeds away from the parent plant. Advantages of seed dispersal are:

- Species are more likely to survive dangers such as disease, fire, or environmental change if the seeds are covering a very widespread area. If the seeds are not spread, the entire population can get wiped-out in one go
- Decrease in competition for space, light, or nutrients. Less competition from parent plant, or plants from same generation.

– Examples of seed dispersal in Australian plants:

Australian Plant	**Type of Dispersal**	**Adaptations**
Feather spear grass	Wind	Seeds attached to fine hairs which float in the breeze Seeds can be carried hundreds of kilometres
Sheep's Burr	Animal	Seeds have hooks that attach to the fur of animals, and are carried over large distances
Acacia's Native Raspberry	Ants	The ants carry the fruit away to the nest, but the seed is covered in a coating the ant can't eat.

– Some mechanisms of asexual reproduction include:

- Binary Fission: Every time a single celled organism under goes mitosis, it creates 2 new organisms.
- Spore Formation: Fungi reproduce asexually by producing thousands of single-celled spores. These will germinate if the conditions are right. A type of plant (ferns) also produces spores.
- Budding: The parent produces a replica of itself by mitosis. This replica continues to grow as a new organism, but is attached to the parent. This tends to form large colonies, such as coral
- Vegetative Propagation: Flowering plants produce new plants from points on roots or stems called nodes. Grasses do this.
- Regeneration: It is a process that organisms grow back body parts that have been removed or lost. In some cases, it can be a form of asexual reproduction, of the broken body part grows to form a new organism.

- *Describe some mechanisms found in Australian fauna to ensure:*
  - *Fertilisation*

➢ *Survival of the embryo and of the young after birth*

- To ensure fertilisations, sexually mature individuals need to be brought together
- This process is called mating
- Many factors influence mating behaviour: temperature, food, phases of moon, etc
- Some adaptations of Australian species to ensure fertilisation include:
  - Bower Bird: They lack showy plumage, so the male decorates its nest with bright blue objects to attract the female. They have elaborate courtship rituals
  - Australian Brolgas: Performs an elaborate dance before mating
  - Common Trout: They come together during the full moon of their mating season and release their gametes into the water
  - Sharks: The male gametes are transferred directly into the female through claspers, which go into the female's opening, called a cloaca.
  - Whales, Seals and Dolphins: All have internal fertilisation, where the male gametes are deposited directly into the female. They often have spectacular courtship rituals.
- The survival of the embryo and of the young after birth is very important.
- Examples of Australian animals include:

Animal	**Survival of Embryo**	**Survival of Young after Birth**
Platypus	Embryo develops inside the egg within the uterus for 4 weeks. Incubation for 10 days. Eggs are stuck to the fur of abdomen	After hatching, young platypus remains in the burrow for several months, obtaining nutrients by suckling on mil. Young leave nest when they have grown fur
Kangaroo	Internal fertilisation Partial internal development Very short gestation period in the uterus	After birth, underdeveloped young crawls into mother's pouch and continues development while feeding on milk, for 4 months.
Gastric brooding frog	After external fertilisation, the female swallows the eggs, and they are	The larvae develop in the stomach, which acts as a uterus. The developed froglets leave the

	incubated in the stomach. All digestive processes stop for 6-7 weeks	stomach through the mouth

- *Explain how the evolution of these reproductive adaptations has increased the chances of continuity of the species in the Australian environment:*
  - These adaptations have developed as a result of natural selection, and thus these are the 'fittest' for their environment.
  - Since these reproductive adaptations are well suited to their environment, chances if continuity are increased for the plant.
- *Discuss the conditions under which asexual reproduction is advantageous, with reference to specific Australian examples:*
  - Asexual reproduction results in the production of offspring genetically identical to the parent
  - If the environment is unchanging, and the characteristics of a particular organism are well suited to the environment, then asexual reproduction would be advantageous, since all the offspring will have the advantageous characteristics
  - An example would be *Sphagnum* in the Australian Alps. It has managed to colonise whole valleys through asexual reproduction
  - Asexual reproduction is also advantageous when the parent plant can provide nutrients to the newly developing plant (Spinifex). Also the parent plant can provide water to the small plant (darling lily).

4. A study of palaeontology and past environments increases our understanding of the possible future range of plants and animals

- *Explain the importance of the study of past environments in predicting the impact of human activity in present environments:*
  - The knowledge gained from palaeontology (fossils) and the study of past environments can help us to understand present day ecosystems
  - This knowledge can be used to predict and determine the future for Australia's plants and animals
  - Palaeobiologists gain knowledge about the long term changes that have occurred in ecosystems over millions of years. At Riversleigh, fossils are being used to see how Australia's biota evolved
- *Identify ways in which palaeontology assists understanding of the factors that may determine distribution of flora and fauna in present and future environments:*
  - The main findings of palaeontology in Australia are:
    1. Loss of biodiversity over time - reduction in rainforest
    2. Thylacine - numbers were already declining, Europeans finally killed them all
    3. Analysis of plant and animal fossils can allow palaeontologists to create a picture of the ecosystems at the time.
  - Main causes of extinction: climate → drier, agriculture and hunting
- *Explain the need to maintain biodiversity:*
  - Biodiversity is essential for maintaining the natural functions of the Earth
  - Such as providing clean water, air, productive soil, and recycling matter
  - Many human activities rely on biodiversity: agriculture, forestry, fisheries, tourism, textiles, etc
  - The general health of the planet depends on biodiversity