HL IB Biology

Your notes

Adaptation to Environment

Contents

Habitats

Your notes

Habitats

Habitats

- A habitat can be defined as follows

The place where an organism lives

- Any one habitat will contain **many species** which together form a community
- Habitats can be described in terms of
  - **Geographical location**, e.g. polar habitat is located at the North and South Poles
  - **Type of ecosystem**, e.g. grassland habitat occurs in many locations, including prairies in North America and Savannahs in Africa

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Habitats can be described in term of location and ecosystem type, e.g. North American grassland (top left), Arctic polar habitat (top right), Sahara desert (bottom left) and UK wetland (bottom right)

Your notes

Abiotic Factors & Species Distribution

Your notes

Adaptations to Abiotic Factors

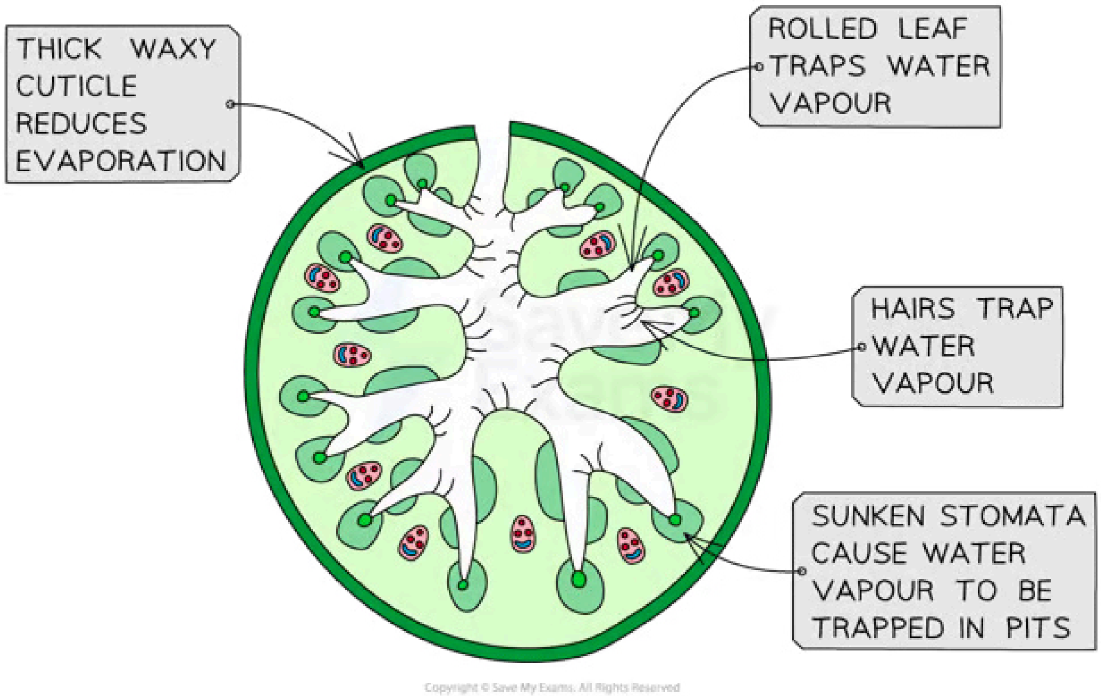
Abiotic factors

- Abiotic factors are **non-living factors** that affect organisms within their habitat e.g.
  - Light intensity and wavelength
  - Temperature
  - Turbidity, or cloudiness, of water
  - Humidity
  - Soil or water pH
  - Soil or water salinity
  - Soil composition
  - Oxygen or carbon dioxide concentration

Adaptions to abiotic factors: sand dune grass species

- Marram grass is commonly found on **sand dunes**, a habitat where **abiotic factors** include:
  - Low water availability
  - High salinity
  - Low nutrient levels
- Marram is an example of a **xerophyte**, a group of plants that are adapted to survive in **dry conditions**; xerophytes need to deal with the following challenges
  - Dry air means that there is a steep concentration gradient between the inside of leaves and the surrounding air; this means that **water evaporates quickly** from the surface of cells in the leaf and is lost to the surrounding environment
  - Soil water availability is low, meaning that any **water lost by evaporation may not be easily replaced**
- Some marram grass leaf adaptations raise the humidity of the air surrounding the leaf, **reducing the steep concentration gradient** and so reducing water loss by evaporation
  - **Leaves are rolled** up to reduce the exposure of surfaces to the wind; this traps water vapour inside the rolled leaf
  - The stomata are **sunken in pits** to trap water vapour
  - The inner surface of the leaf is **covered in tiny hairs** which trap water vapour
- Marram grass leaves also have a **thick waxy cuticle** on their outer surface to reduce evaporation

Marram grass adaptation diagram



Marram grass is an example of a xerophyte, and has adaptations that reduce water loss by evaporation

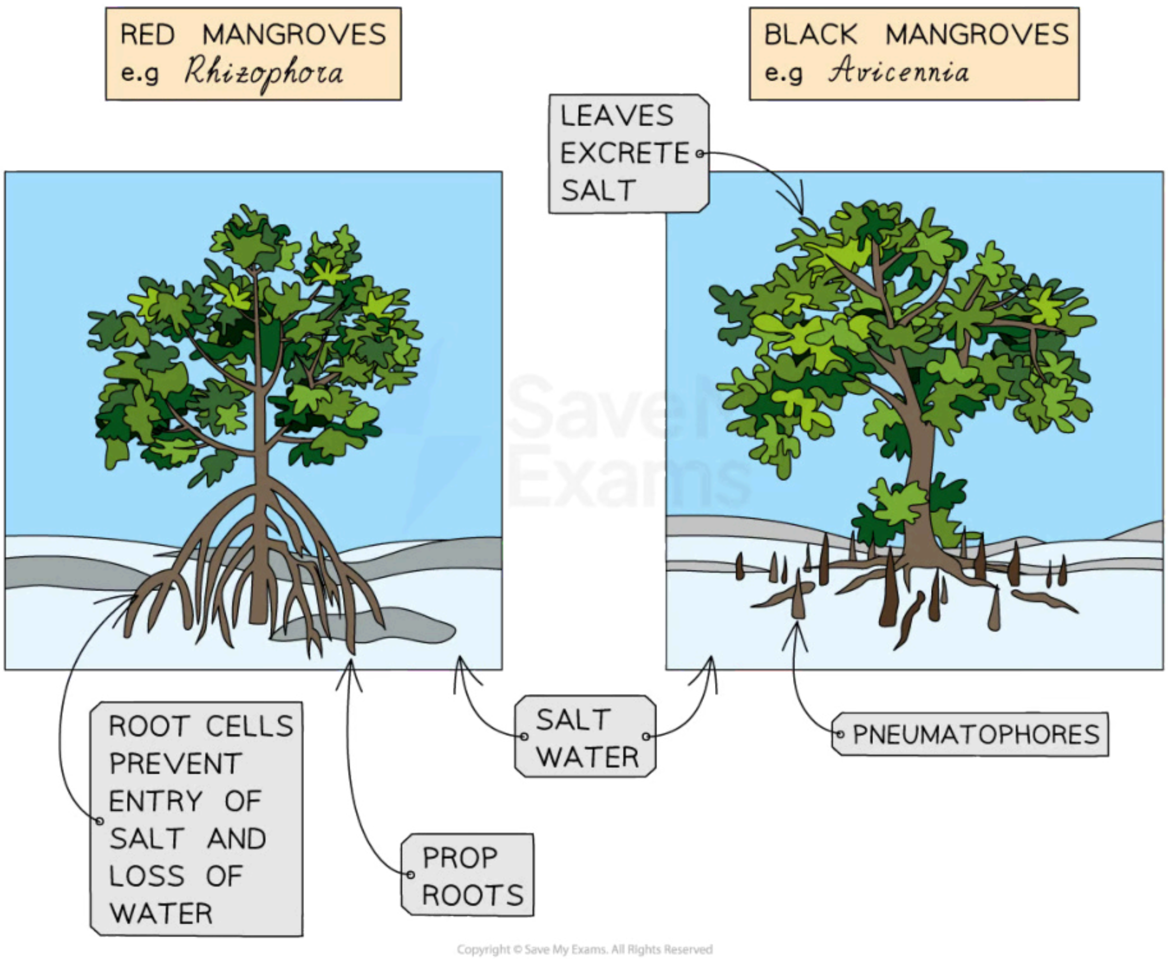
Adaptions to abiotic factors: mangrove tree species

- Mangrove swamps are tropical, coastal habitats that are **frequently submerged in sea water**, so abiotic factors include:
  - High salinity
  - Low fresh water availability
  - Low oxygen availability (due to being underwater)
- Mangrove trees grow with their roots submerged in sea water, so they face challenges such as:
  - The cells of the roots that are underwater are **unable to take in oxygen** for respiration
  - The surrounding salty water means that the **availability of fresh water is low**
  - The surrounding sea water has a higher solute concentration than the contents of the mangrove root cells, so there is **a risk of the mangrove roots losing water** from its submerged roots by osmosis
- Mangroves are adapted to deal with low oxygen levels by having some form of **aerial root system**; the parts of the roots that are above the water **take in oxygen for respiration**
  - Red mangroves have **prop roots**
    - These roots also provide stability in unstable soil
    - Prop roots are partially under the water, and these underwater networks of roots provide crucial shelter for marine animals
  - Black mangroves have structures known as **pneumatophores** that grow vertically upwards out of the water-logged soil
- Mangrove trees also have different methods of dealing with low fresh water and high salinity levels

- Red mangroves have cells that **do not allow the entry of salt** into their water-transport systems, allowing the trees to take up fresh water
  - These cells also prevent the outward movement of water, so prevent water loss by osmosis
- Black mangroves **take salt water into their cells and excrete excess salt** through salt glands in their leaves

Your notes

Mangrove adaptations diagram



Mangroves have adaptations that allow them to survive in environments with low oxygen levels and high salinity

Abiotic Factors & Species Distribution

Your notes

- The abiotic, or non-living, factors in the environment can **influence the distribution of species**
- Abiotic factors affect living organisms in a variety of ways:

Effect of abiotic factors table

Abiotic factor	Effect of factor on living organisms
Light intensity	Light is required by plants for photosynthesis
Temperature	Temperature affects the rate of enzyme-controlled reactions
Water availability	Water is required by all living organisms for survival
Soil pH and mineral content	Different plant species require different pH levels and nutrient concentrations
Wind speed	High wind speeds can increase water loss by evaporation from the leaves of plants
Carbon dioxide concentration	Carbon dioxide is needed by plants for photosynthesis
Oxygen concentration	Oxygen is needed by all organisms that carry out aerobic respiration

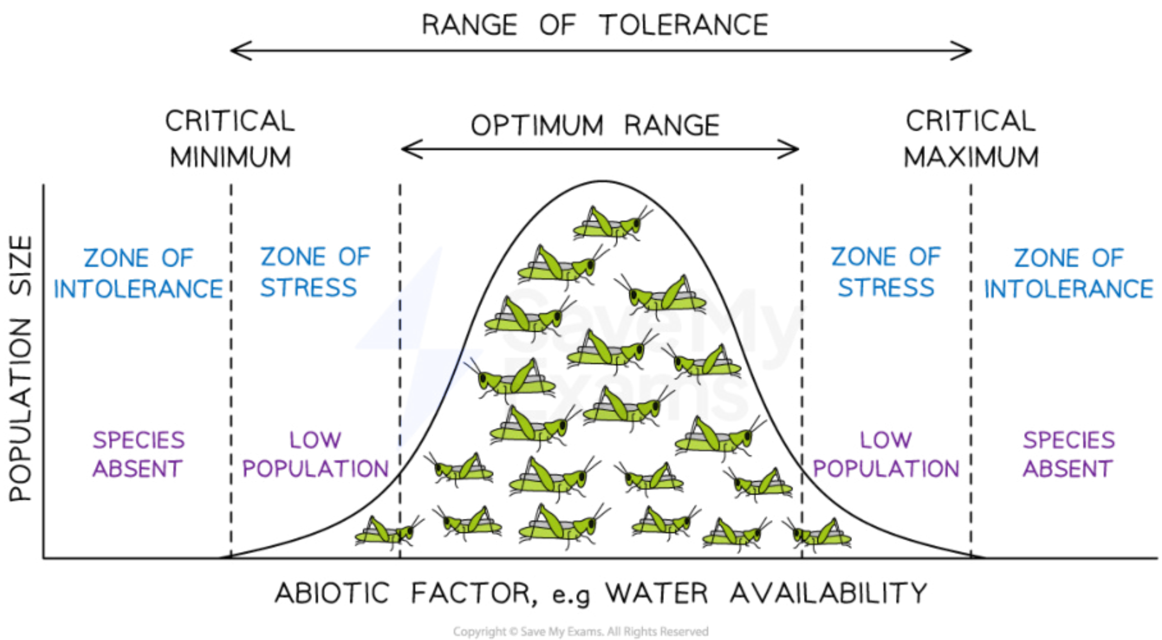
Abiotic factors & species distribution

- Abiotic factors in a habitat can act as limiting factors for species distribution
- Species exist with a **range of tolerance**, meaning that certain conditions are ideal, or **optimum**, but **some amount of variation from these ideal levels can be tolerated**
  - This range within which the environmental conditions are tolerable is known as the **range of tolerance**
  - E.g. mangrove trees grow best in a salinity range between 3–27 parts per thousand (ppt), but they can survive in fresh water, and in salt concentrations of up to 75 ppt
- Species will **not be found** in areas with abiotic conditions that are **outside their range of tolerance**
- Species which are adapted to live in **extreme conditions** may have an **especially wide range of tolerance**, allowing them to live in areas where other species cannot survive
  - Such species will often have an **environmental optimum that is higher or lower than average**, e.g. marram grass has a lower optimum level for water availability than other plant species
  - These extreme species will do well in these extreme environments where **competition** from other species is low
  - Such extreme species may do less well in more moderate environments due to competition from species with an average environmental optimum

- Species will have a range of tolerance for **all abiotic factors**, and while some factors may have a more significant effect than others, the **abiotic factors interact to determine the distribution of a species**

Your notes

Range of tolerance and population size graph



The cricket population shown here will be largest when they live within the optimum range for the abiotic factor in question, e.g. water availability. If the abiotic factor goes below the critical minimum (e.g. not enough water) or above the critical maximum (e.g. too much water) then the crickets will not survive and the population size will be zero

Your notes

Species Distribution: Skills

Species Distribution: Limiting Factors

Limiting factors and range of tolerance

- The term **distribution** refers to
  - **Where a species is found within an ecosystem**
- The distribution of a species is influenced by **limiting factors**, which in this context means
  - **Any biotic or abiotic factor that restricts the growth of organisms**
- Limiting factors will determine the range of tolerance, and therefore distribution, of a species, e.g. if soil water levels become severely limiting, then a plant species will be outside its range of tolerance and will no longer be able to survive in an area

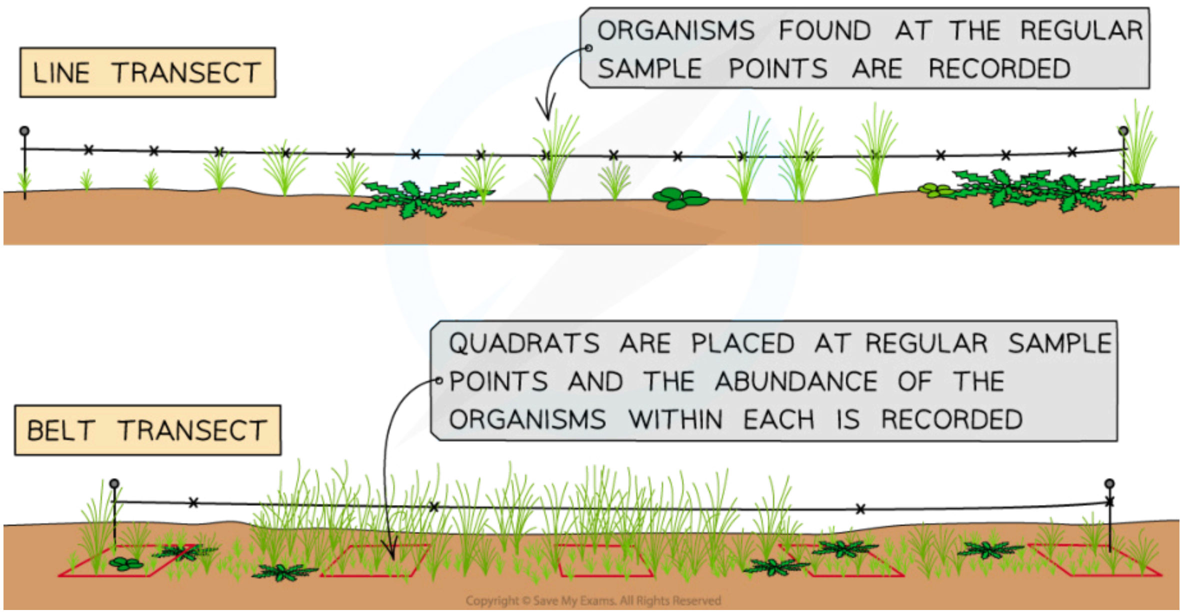
Investigating the effect of limiting factors on species distribution

- It is possible to investigate the effect of a limiting abiotic factor on the distribution of a species using **transect sampling**
  - A **transect** is used to measure the change in species abundance along an **environmental gradient**
    - This gives an estimate of **distribution at different levels of the abiotic factor** in question
    - E.g. if investigating the effect of soil water availability on the distribution of a plant species, the transect would be set up along a high to low soil water gradient, and plant abundance would be measured at different soil water levels
  - **Sampling** is a technique that involves taking measurements from a small area to **represent** the measurements that might be gained across a large area
    - Sampling saves time; it is not possible to count all of the individual organisms in a habitat
    - Samples must be representative of the whole; so a **large enough sample size** must be taken

Transects

- **Transects** are lines laid out across a site that can be used to measure abundance and distribution **across a habitat**
  - Transects are useful for determining **how species abundance and distribution might change along an environmental gradient** e.g. at increasing distances from the water's edge on a rocky shore
- To carry out a **transect**, a tape measure is laid out along the gradient of interest, and samples are taken along the line
- There are different ways of carrying out transect studies:
  - **Continuous line transect**
    - **Every species** touching the tape measure is recorded
  - **Interrupted line transect**
    - Species touching the line **at regular intervals**, e.g. every metre, are recorded
  - **Continuous belt transect**
    - Quadrats are placed **end-to-end** along the line

- **Interrupted belt transect**
  - Quadrats are placed **at regular intervals**, e.g. every metre, along the line



Interrupted line and belt transects can be used to measure the distribution of species at different levels of an abiotic factor across a habitat

Measuring abiotic factors

- When investigating the impact of an abiotic factor on species distribution it is important to **measure the relevant abiotic factor** at each sample site along the transect
  - It is only necessary to record relevant abiotic factors
    - A study may only be interested in one particular abiotic factor
    - Some abiotic factors may not be relevant in certain habitats, e.g. water turbidity (cloudiness) will not be relevant in a woodland habitat
- Abiotic factors can be measured using **specialised equipment** and **techniques**

Measuring abiotic factors table

Abiotic factor	Method of measurement
Air temperature	Thermometer
Rainfall	Rain gauge; a funnel collects water in a measuring cylinder

Your notes

Your notes

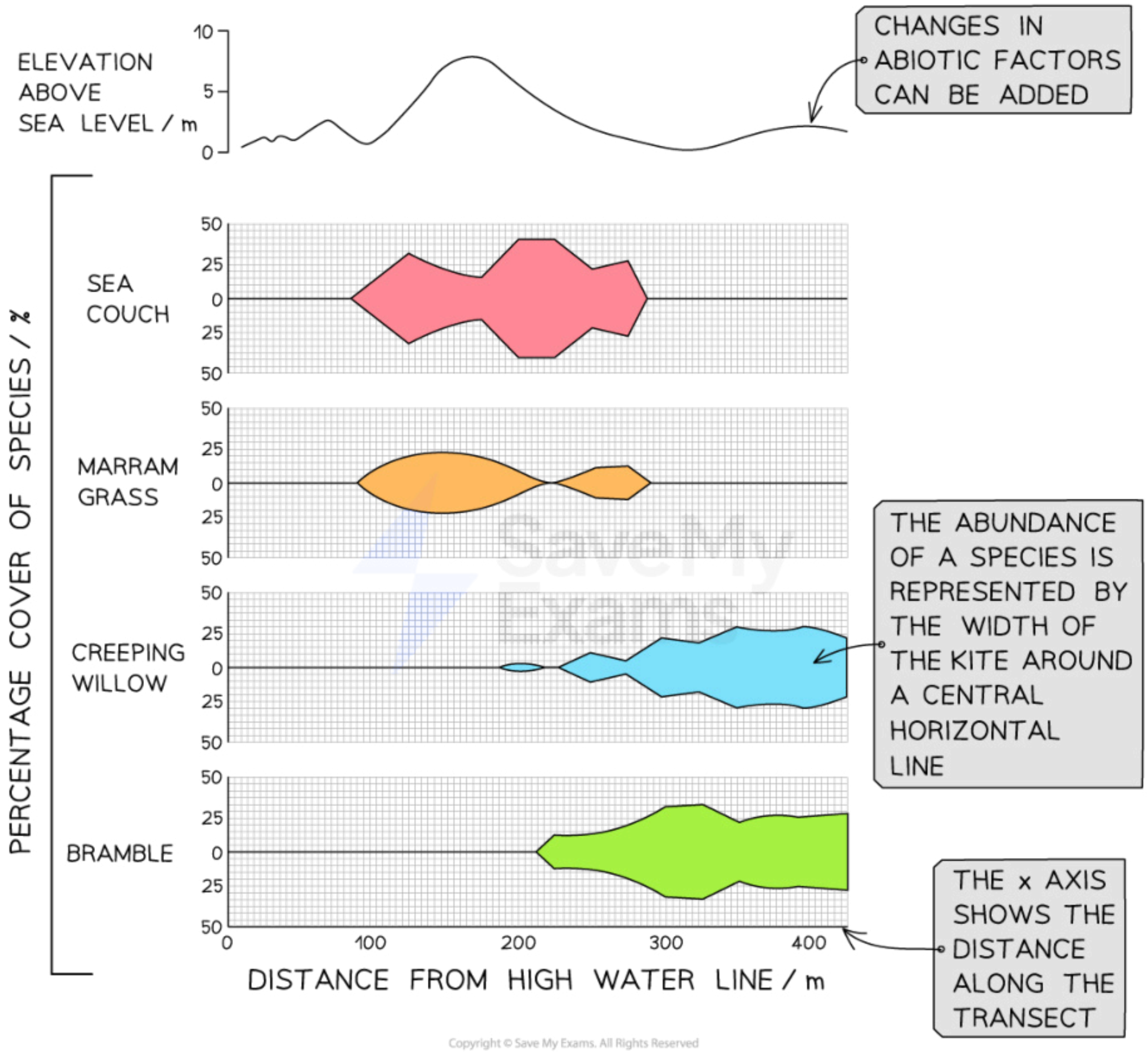
Humidity	Hydrometer; an electronic device that measures water vapour content of air
Dissolved oxygen	Electronic oxygen sensor
Water turbidity (cloudiness)	A turbidity meter measures light scattered by particles in the water, or a Secchi disc is lowered into the water until it is no longer visible and the depth recorded
Light intensity	Electronic light meter
Landscape relief (height of land)	Contour lines on a map or a GPS
Site aspect (direction that site faces)	Compass
Slope incline	Clinometer; a specialised protractor that allows angle to be calculated using trigonometry
Soil or water pH	Indicator solution
Soil water content	Difference in mass between a soil sample and the same soil sample after it has been dried

Representing results

- The results of an investigation into the distribution of organisms in response to an environmental gradient can be represented visually using a type of graph known as a **kite diagram**
- Kite diagrams can show both **distribution** and **abundance**
  - The distribution of a species along a transect can be shown by its **position along a central horizontal line** in each section of a kite diagram
    - Each section represents a different species
    - The **distance along the transect is given on the x-axis**, to which the horizontal line is parallel
  - The abundance of a species can be shown by the **width of the 'kite'** around the central horizontal line
    - The shape is referred to as a kite because it extends an **equal distance** on each side of the central horizontal line
- Additional sections can be added to a kite diagram to show the **changes in abiotic factors** at different points along a transect, e.g. the height above sea level or the pH of soil

Kite diagram

Your notes



Kite diagrams can be used to provide a visual representation of both abundance and distribution of species, as well as changes to abiotic factors such as elevation

Examiner Tip

You should be able to **design and carry out** a study that investigates **the effect of a specific abiotic factor on the distribution of a species**

This can be carried out in a:

- Natural habitat
- Semi-natural habitat, i.e. an area that has been influenced by human activity but still contains wild species

You should use sensors to measure abiotic factors

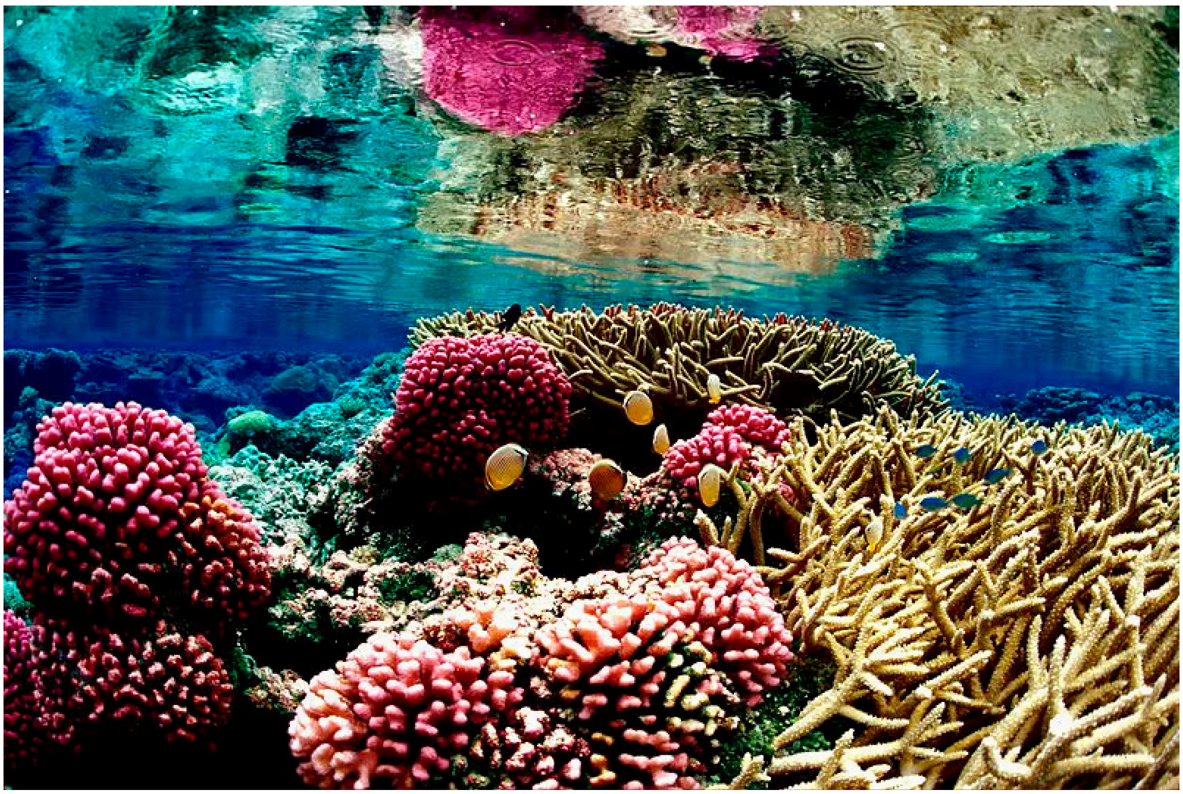
Your notes

Abiotic Factors: Marine & Terrestrial

Your notes

Coral Reef Formation

- Corals are the result of a symbiotic relationship between an animal known as a coral polyp, and a zooxanthellae algae
  - The polyp provides shelter and protection
  - The algae carry out photosynthesis and produce carbon compounds such as carbohydrates
- Some species of coral polyps **secrete calcium carbonate** which builds up in layers to form a hard outer structure; over time these deposits from thousands of individuals can form a **coral reef**



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Some coral species secrete layers of calcium carbonate that forms the hard structure of coral reefs

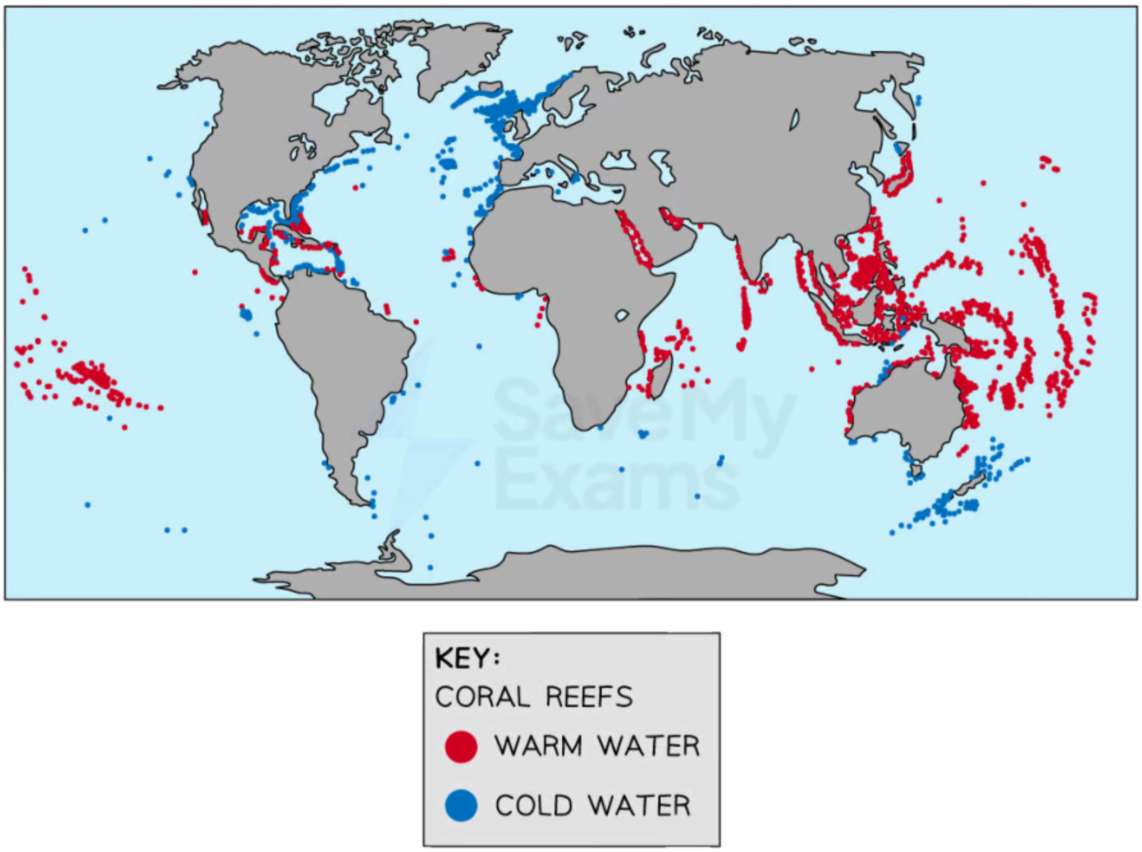
Distribution of coral reefs

- The **distribution** of reef-building corals is **limited to the topics and subtropics**
  - Non reef-building species can be found in other regions
- The formation of coral reefs is limited by **abiotic factors**, including:
  - Water depth
  - pH
  - Salinity (salt concentration)

- Water clarity
- Temperature
- Coral has a **narrow range of tolerance** for all of these abiotic factors, resulting in its **limited distribution**

Your notes

Coral reef distribution map



The distribution of reef building corals is limited by abiotic factors

Abiotic factors affecting coral reef formation table

Abiotic factor	Effect on reef formation
Water depth	Corals can only grow at shallow depths where light can penetrate the water at high enough levels for the zooxanthellae to photosynthesise.
pH	The hard outer layer secreted by coral polyps is made from calcium carbonate, which dissolves when the pH is too low. Corals need carbonate ions to build calcium carbonate. The H^+ ions that are present at lower pH levels combine with carbonate ions to

	form hydrogen carbonate ions, reducing the availability of carbonate ions for reef-building. Increased carbon dioxide released from the burning of fossil fuels dissolves in the oceans and lowers the pH pf the water, reducing coral growth.
Salinity	Since corals are marine animals they need salty water, within a 32–42 % range, to survive. Freshwater run-off from land can reduce salt concentrations and limit coral growth.
Water clarity	Water clarity must be good for light to penetrate through the water. Sediment from land run-off, and water pollution, can reduce water clarity and limit coral growth.
Temperature	Corals have a range of tolerance of roughly 20–28 °C, though they grow best in water temperatures above 23 °C. While they can withstand short periods of higher temperatures, rising sea temperatures causes the polyps to expel their algae symbionts, leading to coral bleaching.

Your notes

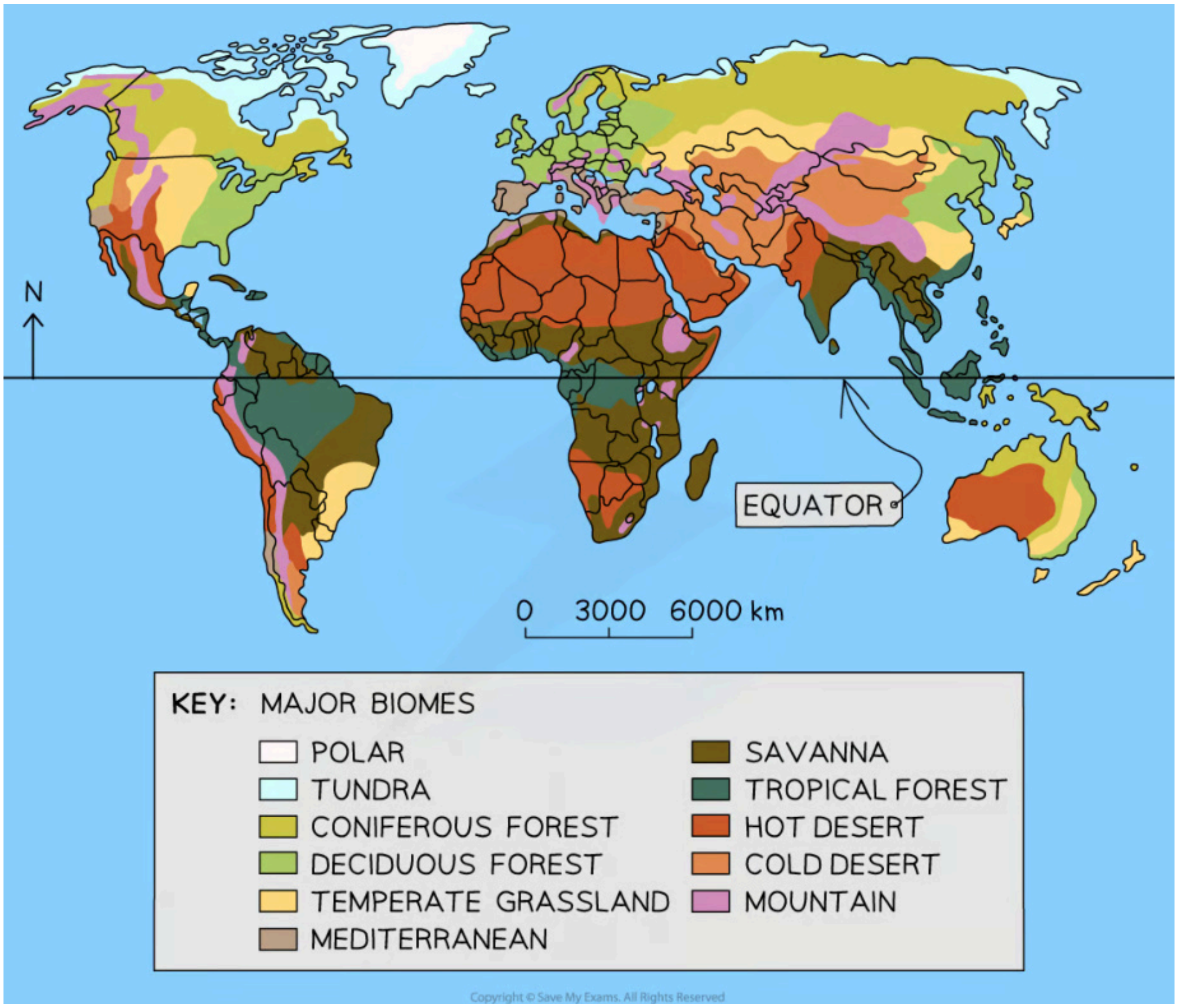
Terrestrial Biome Distribution

Your notes

- The term **biome** can be defined as follows:
  A large community of plants and animals that has occurred as a result of environmental factors
- Biomes occur over **large geographical areas**, and are usually **named after their dominant vegetation type**, e.g. a geographical area dominated by tropical rainforest will be a tropical rainforest biome
- Examples of biomes include:
  - Temperate rainforest
  - Tropical rainforest
  - Temperate deciduous forest
  - Boreal, or coniferous forest, sometimes known as taiga
  - Grassland, e.g. temperate or savanna
  - Tundra
  - Desert, e.g. hot desert or cold desert
- Biome distribution is affected by **abiotic factors** in the environment

Biome distribution map

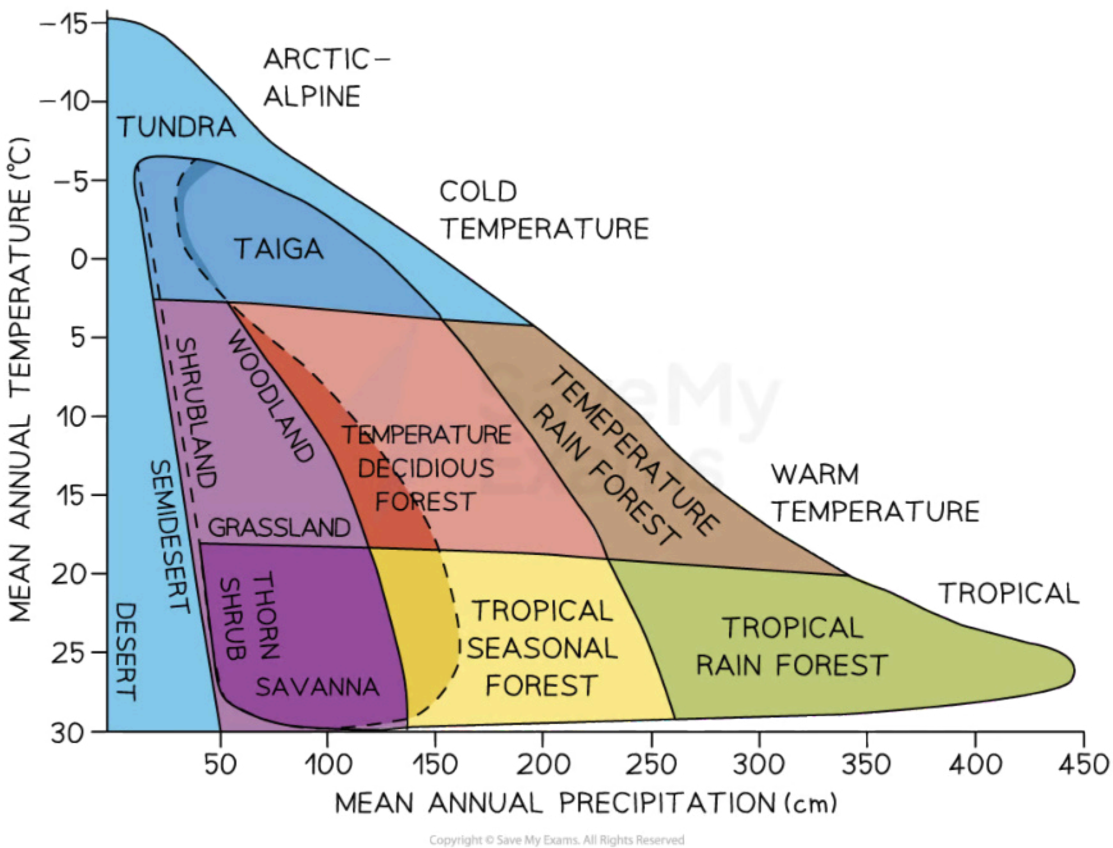
Your notes



The distribution of biomes is affected by abiotic factors

- **Average temperatures** and **rainfall patterns** are significant factors in determining the development of a biome
  - For any given combination of these two factors, a specific biome will result
- Biome development can be plotted on a graph known as a **climograph**, with mean annual rainfall and temperature on its axes

Biome development graph



For any given temperature and rainfall pattern, a particular biome will develop

- The **likely biome** at any given rainfall and temperature can be determined from the climograph, e.g.
  - At a mean average rainfall of 200 cm and mean average temperature of 25 °C, tropical seasonal forest will develop
  - At a mean average rainfall of 300 cm and mean average temperatures of 15 °C, temperate rainforest will develop
  - At a mean average rainfall of 100 cm and mean average temperatures of 0 °C, taiga, or boreal forest, will develop
- Bear the following points about climographs in mind when drawing conclusions:
  - Climographs shows a distinct boundary between biome types, but the reality is that there will be a **gradual shift from one biome type to another**
  - Rainfall and temperature are **not the only factors that influence biome development**; the dotted lines in the graph above show situations where other variables, such as soil type and animal grazing, may play an important role
  - Because neither rainfall or temperature can be described as being an independent variable or a dependent variable, the **allocation of temperature and rainfall to the graph axes may vary**
    - The graph above has rainfall on the x axis and temperature on the y axis, but this could just as correctly be plotted the other way around

- The graph above has temperature plotted from high to low on the y axis, but this could be plotted from low to high

Your notes

Examiner Tip

Be sure to **read the axis labels and values carefully** before drawing conclusions from climographs.

Biomes

Your notes

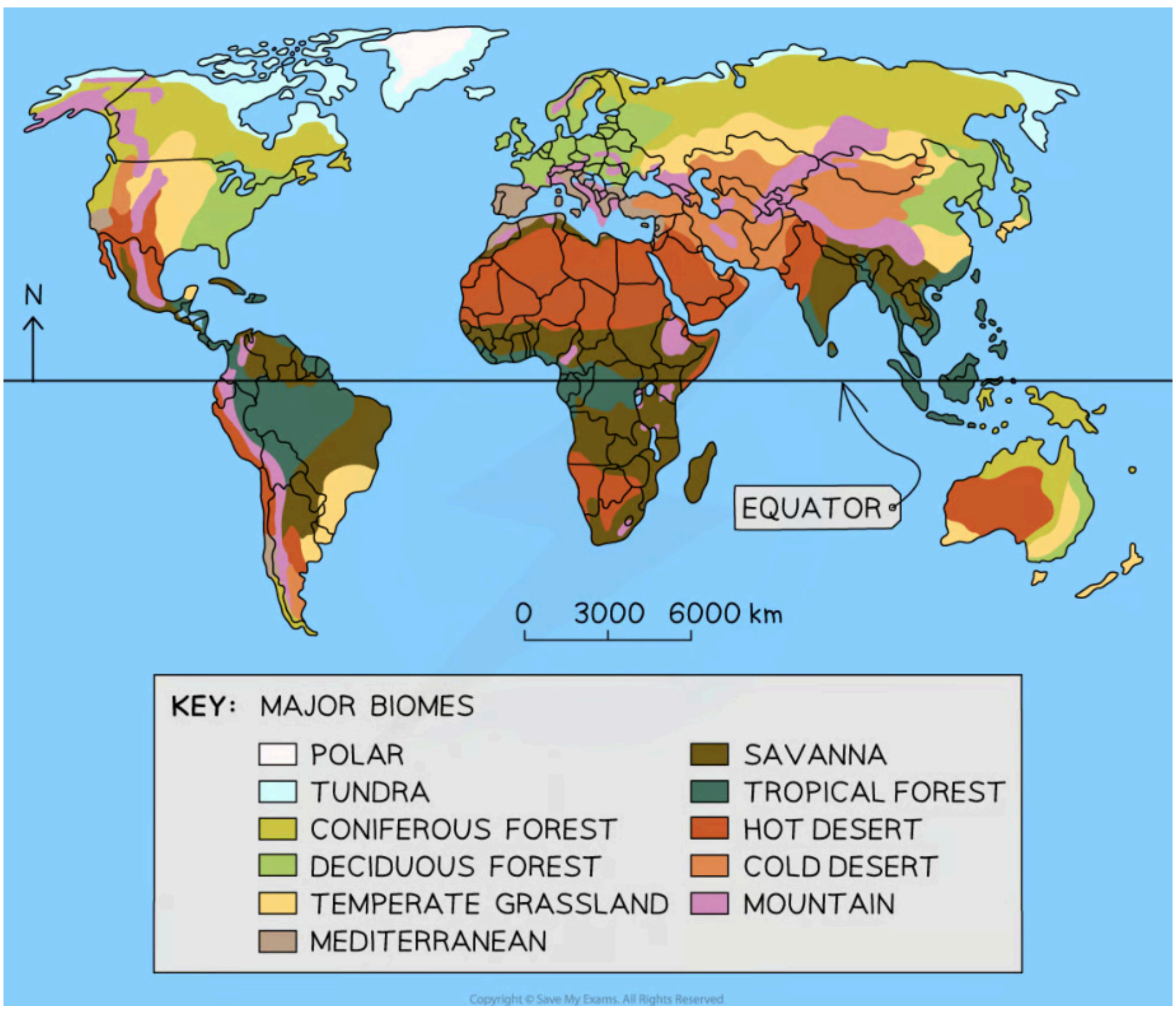
Biomes

Biomes

- The term **biome** can be defined as follows:
  A large community of plants and animals that has developed as a result of environmental factors

- **Abiotic environmental factors**, such as rainfall and temperature patterns determine which biome develops in a particular location
- Regions of the world that experience **similar abiotic factors** will contain **the same biome**, e.g. desert occurs in parts of Africa, North and South America, and Australia

Biomes map



Regions of the world that experience similar abiotic factors will contain the same biome

Your notes

- Biomes contain many ecosystems
- The ecosystems found in **equivalent biomes** in different parts of the world contain **similar** communities, even if the species are not exactly the same
  - E.g. the ecosystems in the deserts of South America will contain similar communities to those in the deserts of Africa
- These similarities exist due to **shared abiotic factors** and resultant **convergent evolution**
  - Species face similar selection pressures, so similar features provide a **survival advantage**
  - These advantageous features become **more common in the population** due to natural selection
- This means that these communities are similar **not because they have all evolved from a recent common ancestor**, but because they have **independently adapted to have similar features**
  - Species that are adapted to survive in the deserts of South America will not be close genetic relatives of those found in the deserts of Africa, though they may have similar morphology

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The cacti of the South American deserts (left) and the euphorbias of the African deserts (right) share spines and succulent stems as adaptations to their desert biome environments, but the two plant groups are not closely related

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Climate conditions of major biomes table

Biome	Climate conditions	Community features
Tropical forest	Annual rainfall 2000 - 10 000 mm Temperatures consistently between 20 - 25 °C Nutrient poor soil due to lack of seasonal leaf fall	Layers of vegetation, e.g. canopy and undercanopy Highly productive, i.e. high levels of photosynthesis Very high levels of biodiversity
Temperate forest	Annual rainfall 750 - 1500 mm Seasonal, but no extremes temperatures Fertile soil due to leaf fall each autumn	Dominant deciduous trees Productive during part of the year High levels of biodiversity
Taiga (conifer forest)	Annual rainfall 300 - 900 mm but high snow fall Very short summer growing period Temperatures between -40 - 20 °C	Dominant coniferous (evergreen) trees Low productivity A small number of well-adapted species
Grassland	Annual rainfall 500–950 mm Dry and wet seasons Temperatures between -20 - 30 °C (differs depending on region)	Dominant grasses Not enough water for significant tree growth; low productivity Grazing animals and a small number of top predators
Tundra	Annual rainfall 150–250 mm Dark winter periods and frozen soil Temperatures between -50 - 18 °C	Not enough water, light, or warmth for tree growth; low productivity Hibernating or migrating animal species
Hot desert	Annual rainfall less than 250 mm Hot days (up to 49 °C) and cold nights (down to 0 °C)	Productivity very low due to lack of water A small number of well-adapted species

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Tropical forest (top left), temperate forest (top right), taiga (middle left), grassland (middle right), tundra (bottom left) and hot desert (bottom right) are all examples of biomes

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Adaptations to biomes

Adaptations

- Adaptations are traits, or characteristics, that **increase survival chances in a specific environment**
- Adaptations come about by the process of **natural selection**
- Species are adapted to the **abiotic** and biotic features of the biome in which they live, e.g.
  - Species living in hot desert biomes have adaptations to hot, dry conditions
  - Species living in tropic rainforests are adapted to deal with competition and predation

Hot desert adaptations

Saguaro cactus

- The saguaro cactus (*Carnegia gigantea*) is native to the hot deserts of North America, and is adapted for survival in **dry conditions**
  - Its stem has a **thick waxy cuticle** to reduce water loss by evaporation
  - It has **spines instead of leaves**; this reduces the surface area from which water can be lost by transpiration, and reduces grazing
  - Cells in the stem can **expand to take on and store water**
  - A **deep tap root** enables access to water deep under the ground, and **shallow surface roots** allow fast absorption of any water from rainfall

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Kangaroo rat

- Kangaroo rats (*Dipodomys* sp.) are small rodents found in the hot deserts of North America
- They spend daylight hours in **underground burrows**, a behavioural adaptation that allows them to avoid the high daytime temperatures
- Kangaroo rats are able to **extract enough water to survive from their diet**, and can produce **highly concentrated urine**, so can go without drinking water for extended periods

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Tropical rainforest adaptations

Kapok tree

- Kapok trees (*Ceiba pentandra*) form parts of the upper canopy in the tropical rainforests of Central and South America
- **Rapid growth** allows Kapok trees to outcompete other species by growing tall very quickly; this height allows them to **absorb enough sunlight** in a densely forested habitat
- **Wide buttress roots** provide a sturdy base to support the trees during their rapid growth

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Kapok trees have wide buttress roots to provide stability

Orchid mantis

- The orchid mantis (*Hymenopus coronatus*) is an insect found in the tropical rainforests of southeast Asia
- The adult female mantis **looks very similar to an orchid flower**, enabling it to attract insect pollinators which then become its prey; this is an example of **mimicry**
  - Scientists believe that orchid mantis are 'aggressive mimics', meaning that they are more attractive to insects than the surrounding orchid flowers
- The male orchid mantis is much smaller and plainer in appearance, allowing it to **camouflage** in amongst the stems and branches of plants

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The orchid mantis is camouflaged on the surface of the orchid