Ecological Niches

IB Biology - Revision Notes

Ecological Niches

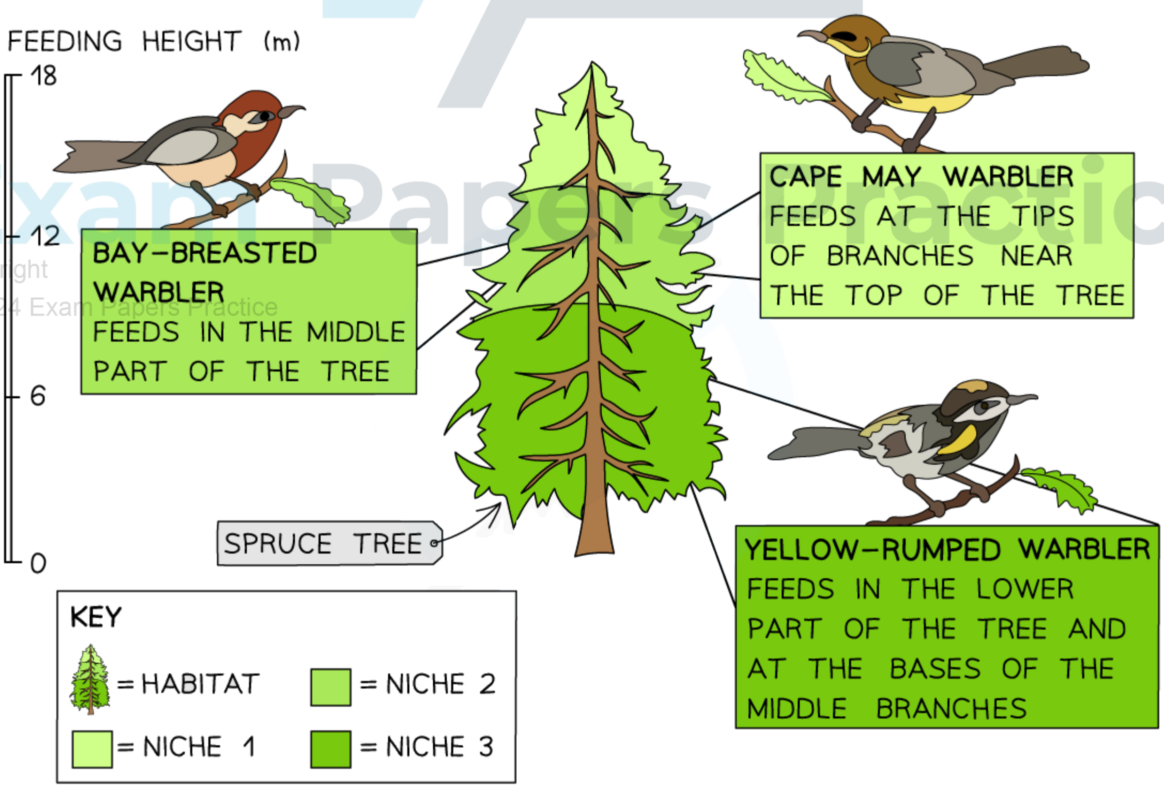
Ecological Niches

- The place where a species lives is known as its **habitat**
- Species will occupy a **specific niche** within a habitat
- The term niche can be defined as

The role of a species within its habitat

- The role of a species includes
  - What it eats
  - Which other species depend on it for food
  - What time of day a species is active
  - Exactly where in a habitat a species lives
  - Exactly where in a habitat a species feeds
- **No two species can fill the same niche within a habitat**; if this ever happens the two species will be in **direct competition** with each other for resources, and one of the two species will **out-compete** the other, causing it to die out in that particular habitat
  - It can sometimes seem as though species are occupying the same niche, but there will still be subtle differences in their role; e.g. they might feed at **different times of day**, or have **different food sources**

Feeding niches diagram



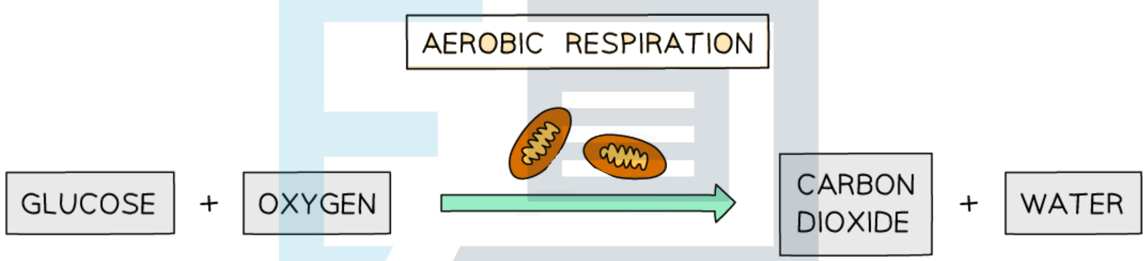
Feeding location is an example of a feature that may differ between niches

Adaptation to ecological niche

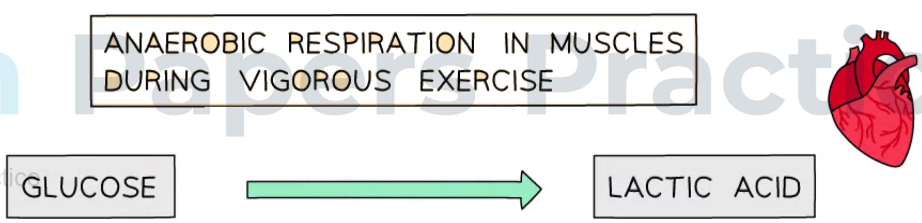
- Species can only survive in habitats in which they are **well adapted to their niche**; they must be adapted to a habitat's:
  - Abiotic factors, e.g.
    - Plants must have enough light for photosynthesis in order to produce carbohydrates
    - Aquatic organisms must be able to absorb enough oxygen from the surrounding water for respiration
  - Biotic factors, e.g.
    - A prey organism being camouflaged to avoid predation
    - A plant growing fast enough to outcompete nearby plants for sunlight

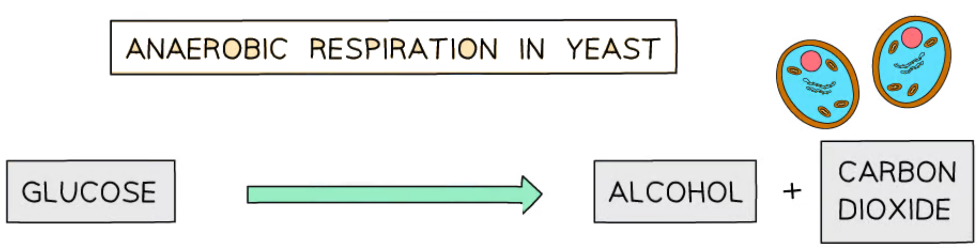
Anaerobes & Aerobes

- All living organisms carry out some form of respiration
  - Aerobic respiration **requires oxygen**:



  - Anaerobic respiration **does not require oxygen**:





- Some organisms can survive using **either aerobic or anaerobic respiration**, while some can only survive using **one type or the other**; organisms are said to be either
  - Obligate anaerobes
  - Facultative anaerobes
  - Obligate aerobes

Obligate anaerobes

- These are single-celled organisms that can **only carry out anaerobic respiration**
  - They **cannot tolerate oxygen**

- Early bacteria were obligate anaerobes; they were able to survive in the atmosphere of early Earth due to its lack of oxygen
- Photosynthesis has since introduced oxygen to the Earth's atmosphere, meaning that obligate anaerobes can now **only be found in oxygen-free environments**, e.g. lower layers of soil, deep water, and inside the bodies of other groups of organisms

Facultative anaerobes

- These organisms **mainly respire aerobically**, but have the ability to **switch fully to anaerobic respiration** in the absence of oxygen
  - The switch to anaerobic respiration has no negative effects for facultative anaerobes
- Examples of facultative anaerobes include
  - Brewers yeast, *saccharomyces cerevisiae*
  - *Escherichia coli*, a species of bacteria

Obligate aerobes

- These organisms **cannot survive in the absence of oxygen**; they rely on **aerobic respiration** to release energy from food
  - They may be able to carry out anaerobic respiration in some cells for short periods, but the damaging effects are too great to do this for longer than a few seconds
- Examples of obligate aerobes include
  - Most animals
  - Most fungi (not yeast)
  - Some bacteria, e.g. *Mycobacterium tuberculosis*

Methods of Nutrition

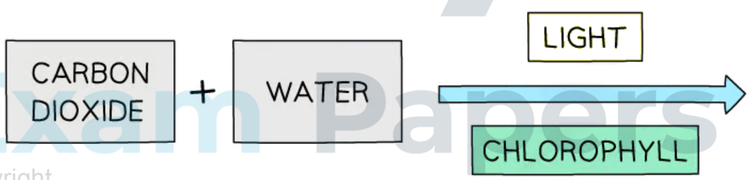
Photosynthesis

Methods of nutrition

- Organisms need energy in the form of **ATP** to survive
- The energy stored in ATP comes from other organic molecules, such as carbohydrates, and is **transferred** during the process of respiration
- The way by which an organism **gains organic molecules to fuel respiration** is known as its method, or mode, of nutrition
- There are two main modes of nutrition; autotrophy and heterotrophy
  - An **autotroph** synthesises, or produces, its own organic molecules from simple inorganic substances in its environment
    - E.g. autotrophs that use light energy are known as photoautotrophs, while those that use energy from oxidation of chemicals are known as chemoautotrophs
  - A **heterotroph** gains organic molecules from the tissues of other organisms

Photosynthesis

- Photosynthetic organisms are autotrophs that **use light energy to convert carbon dioxide from the air into organic molecules** such as carbohydrates
  - **Photosynthetic pigments** such as **chlorophyll** absorb light energy, enabling this process



- Because photosynthetic organisms **make their own organic molecules** without relying on other organisms, they are known as **producers**
  - Photosynthesis is a crucial process because it **transfers light energy into a chemical form** that can be used by living organisms
  - Producers can then be **eaten by other living organisms**, continuing the process of **energy transfer**
- In addition to providing the crucial bridge between non-living matter and living organisms, photosynthesis is also responsible for the **release of oxygen into Earth's atmosphere**, enabling aerobic respiration
- Photosynthetic organisms include
  - **Plants**, both terrestrial and aquatic
  - **Algae**, including single-celled algae and multicellular seaweeds
  - **Photosynthetic bacteria** such as cyanobacteria

> **Exam Tip**
>
> Be careful with your language when discussing energy; you should NEVER say that energy is produced or created, only that it is **transferred from one form to another**. Photoautotrophs do not *produce* energy, they **produce their own food** by **transferring** light energy to chemical energy.

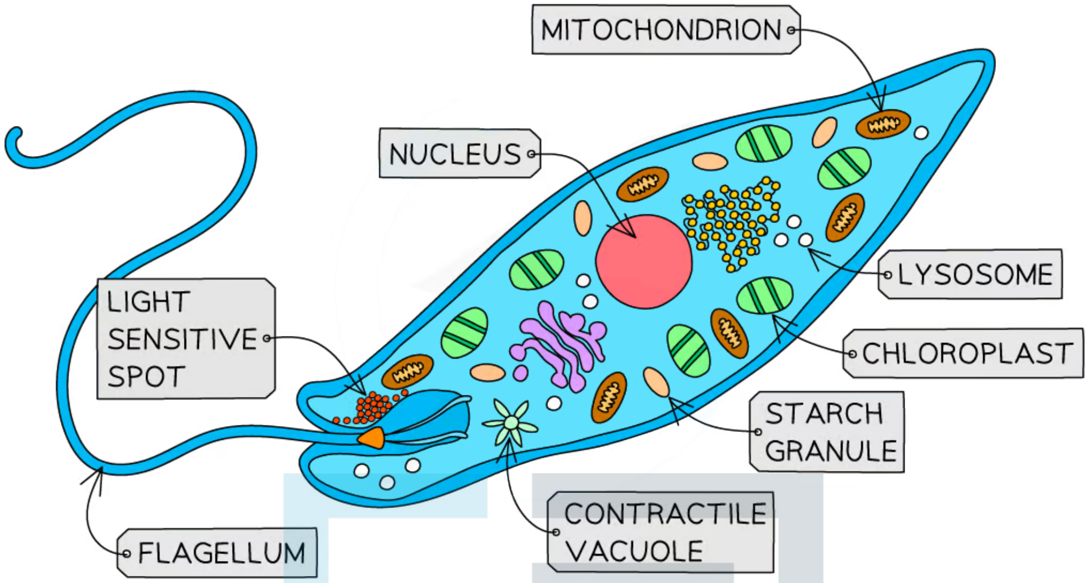
Holozoic Nutrition

- **Heterotrophs** are organisms that gain organic molecules **from the tissues of other organisms**
  - E.g. animals are all heterotrophs
- Organisms that use holozoic nutrition are heterotrophs that gain organic molecules by **ingesting, digesting, absorbing, and assimilating molecules from the tissues of other organisms**
  - Ingestion = eating
  - Digesting = breaking down larger molecules into smaller molecules
  - Absorbing = the transport of molecules from the digestive tract into the cells
  - Assimilation = using molecules to build cells and tissues
- The crucial point to remember here is that **holozoic nutrition involves internal digestion**
  - There are a few examples of animals, e.g. house flies, that secrete enzymes onto their food before absorbing the products; animals like this are heterotrophs, but they do not use holozoic nutrition as digestion takes place externally

Mixotrophs

- Some organisms are able to make use of **more than one method of nutrition**, such as auto- and heterotrophy; these organisms are referred to as **mixotrophs**
- **Obligate mixotrophs** must constantly have access to **both methods of nutrition**
- **Facultative mixotrophs** can survive using one method of nutrition, which is supplemented by the other
- E.g. **euglena** is a single-celled eukaryotic organism found in fresh water that makes use of both **autotrophy and heterotrophy**
  - Euglena cells can take in bacterial cells by endocytosis, and then digest them using digestive enzymes stored in lysosomes
  - Euglena cells also contain a light-sensitive spot that enables them to position themselves so that maximum light reaches their chloroplasts

Euglena diagram



Euglena is a mixotroph that makes use of autotrophic and heterotrophic nutrition

- Other examples of mixotrophs include
  - Carnivorous plants
    - These plants build organic molecules using both **photosynthesis** and using molecules from **the tissues of digested insects**
  - Corals
    - Coral polyps gain organic molecules from their **symbiotic photosynthetic algae**, and by **filter feeding** from the surrounding water
  - Marine plankton, e.g. dinoflagellates
    - These are microscopic organisms that float in the water of the ocean
    - Many are mixotrophs, e.g. **feeding on bacteria** while also carrying out **photosynthesis**

Saprotrophs

- Saprotrophs are heterotrophs that ingest the tissues of dead organisms and waste material by **secreting enzymes onto their food and digesting it externally** before absorbing the products of this digestion
  - Note that this is different to holozoic nutrition as here the digestion takes place **externally**
- Examples of saprotrophs include **fungi** and **bacteria**
  - These organisms can be described as **decomposers**
- Saprotrophs secrete a **wide range of digestive enzymes** that allow them to hydrolyse a large variety of biological molecules, and so to release a large range of products
- Examples of these products include **mineral ions**, such as ammonium ions and phosphate ions
- Importantly, not all of the products of external digestion get absorbed by saprotrophs, **leaving some minerals in the surrounding soil** for absorption by other organisms, such as plants
- Without saprotrophs the nutrients locked up in dead and waste matter **would never be released** and plants would not have access to sufficient minerals
  - This is why saprotrophs are such an **essential component of ecosystems and food webs**

> **Exam Tip**
>
> Note that **decomposers**, such as fungi, do NOT use the same method of nutrition as **detritivores** such as earthworms. Both decomposers and detritivores feed on dead organisms and waste material, but decomposers are **saprotrophs** and use external digestion, while detritivores digest their food internally using **holozoic nutrition**

Nutrition in Archaea

- The archaea are a diverse group of single-celled organisms that make up one of the three domains
- Different groups of archaea vary metabolically, e.g.
  - Phototrophic archaea
  - Chemotrophic archaea
    - This includes chemoautotrophs and chemoheterotrophs
  - Heterotrophic archaea

Phototrophic archaea

- Phototrophic archaea use **energy from light to generate ATP**
- E.g. *Halobacteria* use a pigment called bacteriorhodopsin to absorb light energy and to pump H^+ ions across a membrane; the resulting ion gradient leads to the production of ATP by the enzyme ATP synthase in a similar way to oxidative phosphorylation and photophosphorylation
- Note that this is not the same as oxygen-releasing photosynthesis, and *Halobacteria* are not considered to be autotrophic, but could instead be described as **photoheterotrophs**
  - While they use light energy to produce ATP, *Halobacteria* gain carbon compounds to build their cell structure from other organisms

Chemotrophic archaea

- Some archaea can produce their own carbon compounds using **chemosynthesis**
  - These archaea are **chemoautotrophs**
    - They use energy released from **chemicals** in the environment
    - They produce their **own carbon compounds**
- Chemosynthesis **releases energy from chemicals** which is **transferred to carbon compounds**
  - These carbon compounds can then be used for **ATP production**
- Chemicals that can act as energy sources for chemosynthetic archaea include
  - Hydrogen gas
  - Ammonia
  - Methane
  - Hydrogen sulfide
- Some chemotrophic archaea use energy from chemicals to **directly drive ATP production** in a similar way to the phototrophic archaea described above
  - These archaea are **chemoheterotrophs**; they use chemicals to produce ATP but they gain their carbon compounds from other organisms

Heterotrophic archaea

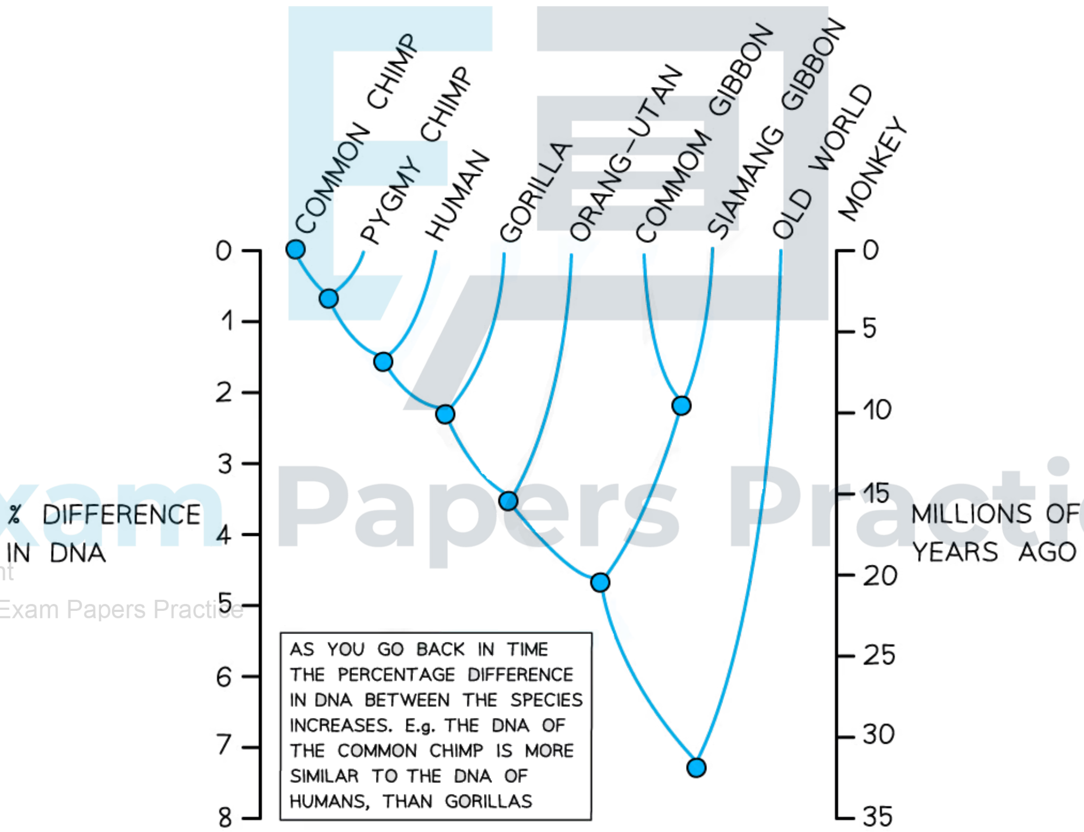
- Heterotrophic archaea gain their carbon compounds **from other organisms**, and then **use these carbon compounds to generate ATP**
- E.g. archaea that break down and absorb carbon compounds in dead plant material

> **Exam Tip**
>
> Note that you are **not** expected to give examples of archaea at the species level.

Nutrition in Hominidae : Skills

Nutrition in Hominidae

- Humans are part of the **Hominidae** family, along with chimps, gorillas, orangutans, and gibbons
  - The evolutionary tree below shows the Primate order, which contains the Hominidae family on the left hand side

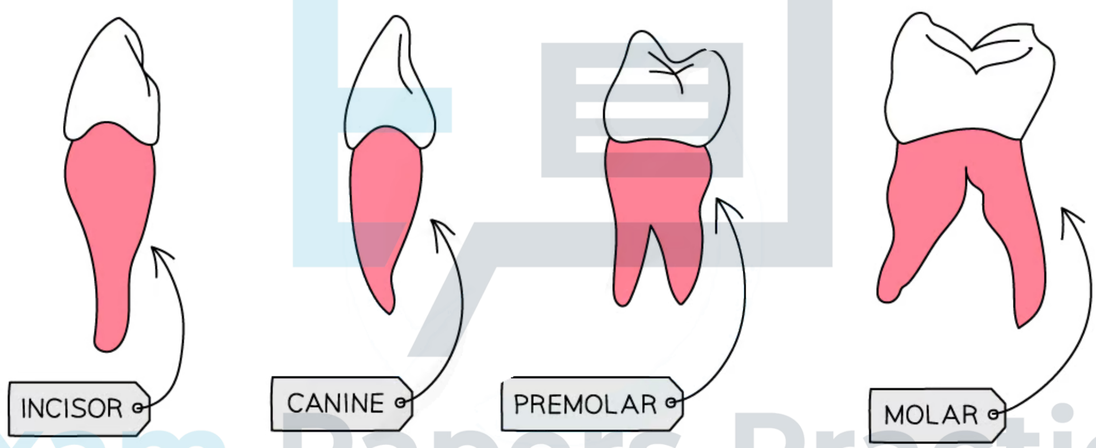


The Primate order (above) contains the Hominidae family

- Most existing hominids are **omnivores**, meaning that their nutrition comes from a combination of animal and plant material, e.g.
  - Chimps are mainly frugivores, meaning that their main diet consists of fruit, though they do eat other plant matter and some small mammals
  - Gorillas are mainly herbivores, feeding primarily on leafy vegetation, though they do sometimes eat insects

- The **study of the skulls** of existing hominid species shows that the **jaw and dentition, or teeth, of each species are specialised for their particular diet**, e.g.
  - Chimps have relatively small jaw muscles which are only strong enough to chew softer fruit and animal tissue, while gorillas have very strong jaw muscles for biting and grinding tough vegetation
  - Chimps have small incisor teeth and long canine teeth, enabling them to bite and tear meat, while gorillas have large molar and premolar teeth for grinding vegetation
    - Incisor teeth are chisel shaped for cutting and biting
    - Canine teeth are pointed for holding and tearing
    - Premolars and molars are flat and ridged for grinding

Types of teeth diagram



Species will often have different combinations of teeth types and sizes to enable them to better chew and digest their diet

- We know that there is a **relationship between diet and the dentition** in currently existing hominid species, and it is possible to apply this principle to **extinct hominid species**
  - The skulls and jaws of extinct species are often well preserved and can be studied
  - This allows scientists to **find out about the diets of these extinct species**, as well as the **ecosystem structures** in which they lived
    - It is worth noting that while dentition can sometimes be clearly linked to diet, **teeth don't always give a perfect indication of what a species eats**, e.g.

    - Existing humans eat quite a lot of meat, but have teeth that are more similar to plant-eaters
    - Orangutans and gorillas have pointed canines but do not eat meat
    - Male chimps have longer canines than females despite not having a different diet
  - Teeth may **play a role in other processes**, e.g. defending territory, or competing for mates, so are not always a perfect indicator of diet, and other factors would have to be considered when drawing conclusions about the diets of human ancestors
    - E.g. scientists can study **fossil teeth under a microscope** to look for **patterns of abrasion** which may indicate diet more clearly
- Examples of extinct hominids include
  - *Australopithecus africanus*
  - *Paranthropus robustus*
  - *Homo floresiensis*
  - *Homo neanderthalensis*
- E.g. fossil evidence from *Paranthrapus robustus* suggests that they had a diet of tough plant material
  - Their skull shape was similar to that of modern gorillas; **robust** in shape, and with **attachment points for large jaw muscles** for chewing tough vegetation
  - **Large molars and premolars** for grinding vegetation
  - **Thick tooth enamel** to protect the tooth from being damaged by tough plant matter
- E.g. fossil evidence from *Homo floresiensis* suggests that they were primarily plant eaters, but that they may have eaten some meat
  - They had **large premolar teeth** and **small canines**
  - Their jaws were **square and robust**; a feature that is similar to plant-eating gorillas
  - **Tooth abrasion** suggests a fibrous, plant-based diet
  - Their **skulls are more similar in shape to humans** that to other human ancestors, suggesting a reduction in the biting forces used
  - Evidence of hunting/cutting tools provides additional evidence of meat eating behaviour
- Some fossils are available to view as part of digital collections, e.g. from the Smithsonian Institution, the Paleontological Research Institution, and the North Carolina School of Science and Mathematics
  - Consider examining 3D specimens of ***Homo sapiens***, ***Homo floresiensis***, and ***Paranthrapus robustus*** to infer diet from anatomical features

CC BY-SA 4.0, via Wikimedia Commons

CC0, via Wikimedia Commons

Paranthropus robustus (left) had a skull ridge for the attachment of large jaw muscles and a robust skull shape similar to modern gorillas, while Homo floresiensis (right) had small canine teeth and a skull similar in shape to modern humans

NOS: Deductions can be made from theories

- Scientists begin their work by **making observations**, e.g. observing how the teeth of existing Hominids relates to their diet
- Observations can then be used to **develop theories**, e.g. that the diet of extinct Hominids can be **deduced** by looking at their dentition
- While such theories and deductions are a valuable part of the scientific process, it is important that **new evidence is taken into account** as it arises, e.g. discrepancies between the dentition and diets of modern hominids tell scientists that their deductions about extinct species may be flawed, and that **additional sources of evidence** may be needed

Nutrition: Adaptations of Organisms

Adaptations of Herbivores & Plants

Adaptations for herbivory

- **Herbivores** are heterotrophs that feed on **plants**
- Different groups of organisms have different **adaptations** that allow them to survive on plant tissues
  - Adaptations are **characteristics** that **aid an organism's survival** in its environment
- Examples of adaptations for herbivory include:
  - **Herbivory in insects**
    - Aphids have specialised mouthparts known as **stylets** that are able to pierce plant tissues to reach the sugary sap inside the phloem
    - Insects such as caterpillars, grasshoppers and beetles have mouthparts called **mandibles** which allow them to cut through leaves
  - **Herbivory in mammals**
    - Grazing animals such as sheep and horses have **flat teeth** for grinding plant matter
    - **Ruminant mammals** such as cattle and deer have digestive systems adapted to improve their digestion of tough plant material; they have **stomachs with several compartments** from which they can **regurgitate and re-chew their food**, breaking down plant matter into smaller pieces to aid digestion
    - Ruminants have **specialised communities of bacteria** that live in their digestive tracts which aid the breakdown of cellulose
      - The bacteria have the enzymes needed to break down cellulose, while the herbivores do not
    - Some mammals have the ability to **neutralise toxins** produced by plants, e.g.
      - Some deer produce proteins in their saliva that bind to toxins called tannins
      - Proboscis monkeys have gut bacteria that can neutralise certain toxins found in leaves
    - Mammals may use '**cautious sampling**' when they first encounter a new plant, meaning that any toxic chemicals will not be consumed in large enough quantities to be dangerous

CC BY-SA 3.0, via Wikimedia Commons

Public domain, via pxfuel

Aphids (left) feed by inserting their stylets into the phloem of plant stems, while caterpillars (right) cut through leaves with their sharp mandibles

Plant adaptations against herbivory

- Herbivory causes damage to plants, reducing their leaf surface area available for photosynthesis and their ability to transport substances
- Plants are unable to move away from herbivores, so they have other methods of deterring animals that might attempt to eat them:
  - **Mechanical deterrents**, e.g.
    - Cacti have **sharp spines** to deter herbivores that might attempt to eat their succulent stems
    - Nettles have tiny hairs that contain **toxins which irritate the skin**
    - **Thick bark** prevents insects such as aphids from piercing plant stems
    - **Many tiny hairs** on leaves may make it more difficult for insects to bite into/pierce plant tissues
  - **Toxic secondary compounds**, e.g.
    - Foxgloves produce a toxic compound known as **digitalis** which can affect the heartbeat of humans and animals
    - Deadly nightshade can produce a toxin known as **atropine** which can cause muscle paralysis by blocking the binding of neurotransmitters
    - Many plants produce chemicals called **tannins** which can deter herbivores by their bitter taste, as well as having a negative impact on the efficiency of digestive processes
    - **Alkaloid chemicals**, such as caffeine and nicotine, can deter insect herbivory, having toxic effects on growth and on nerve impulse transmission

Nettles have tiny hairs (left) which contain skin irritant chemicals, and foxgloves (right) produce toxic secondary compounds

Adaptations of Predators & Prey

- **Predators** are animals that hunt and eat other animals, or that consume the tissues of recently dead animals
- **Prey** are animals that are hunted and consumed by predators
- The features of predators and prey are different, allowing them to **adapt** to their different roles
  - The adaptations of predators assist them in **catching prey**
  - The adaptations of prey assist them in **avoiding predation**
- The adaptations of predators and prey can be either
  - **Chemical**
    - Chemical compounds that assist in the catching of prey or the avoidance of predation
  - **Physical**
    - Physical features, such as specially adapted sense organs, that assist in the catching of prey or the avoidance of predation
  - **Behavioural**
    - Behaviours that aid the catching of prey or the avoidance of predation

Predator adaptations

Chemical adaptations of predators

- Some predators produce **venom** which can make prey easier to subdue and catch, e.g.
  - **Snakes** can produce venoms that act in different ways to kill prey, e.g.
    - Snakes such as adders and rattlesnakes produce **haemotoxic venoms** that damage the circulatory system, e.g. by interfering with blood clottihg
    - Snakes such as mambas and cobras produce **neurotoxic venoms** which interfere with the passage of nerve impulses
  - **Scorpions** can produce neurotoxic venom which they can use to subdue larger prey animals
  - **Spider venom** can contain various types of toxins, which they may also use to subdue their prey

- Some predators may use a strategy known as **chemical mimicry** to attract prey animals, e.g. bolas spiders release chemical pheromones normally used by female moths to attract mates, enabling them to catch male moths as prey
- A strategy known as 'chemical crypsis', or **scent camouflage**, allows ambush predators to lie in wait for prey without being detected, e.g. the prey of pirate perch fish seem to be unable to detect their presence; scientists think that this could be due to the production of a chemical which acts as camouflage

Physical adaptations of predators

- Predators have **sense organs** that help them to detect the presence of prey, e.g.
  - Birds of prey have **excellent vision** that allow them to detect small prey animal movement from a distance

- The eyes of predators are often located in the fronts of their skulls, giving **good distance perception**
- Snakes have an organ in the roof of the mouth known as the Jacobson's organ that allows them to use their tongues to **detect chemicals that may be released by prey** animals
- Bats can detect and process information generated by sound waves bouncing off prey organisms, allowing them to find prey using **echolocation**
- Predators have **body structures** that allow them to catch and kill prey effectively, e.g.
  - Cheetahs can run at high speeds as a result of their **long limbs** and **flexible spines**
  - Swordfish can swim at 60 mph due to their **streamlined body shape**
  - Mantis shrimps can move their **modified front limbs** at 50 mph to catch their prey
  - Carnivorous mammals have **large canine teeth** which allow them to catch and hold onto prey

Behavioural adaptations of predators

- **Ambush predators** lie in wait without moving for extended periods, e.g.
  - Puff adders can remain motionless for weeks at a time while they wait for prey to come near
  - Mantis shrimps (also mentioned above) hide in cracks between rocks before they reach out and grab prey at high speeds
  - Crocodiles can approach their prey from underwater before bursting out of the water at high speed
- **Pack predators** cooperate with each other to increase their chance of success, e.g. orcas, wolves and lions
- **Pursuit predators** chase after their prey, either using a **burst of speed**, e.g. cheetahs, or **persistence hunting** over long distances, e.g. wolves and painted dogs

CC BY 2.0, via Wikimedia Commons

CC BY-SA 4.0, via Wikimedia Commons

CC BY-SA 3.0, via Wikimedia Commons

Predators may use chemical, physical, and behavioural adaptations to assist them as they hunt and consume prey organisms. Adders (left) produce toxic venom, mantis shrimps (centre) have front limbs specially adapted for speed, and lions (right) co-operate with each other during pack hunting.

Prey adaptations

Chemical adaptations of prey

- Some prey animals produce **toxins that deter predators** by tasting bad, or by causing harm when consumed, e.g.
  - Poison dart frogs produce toxins in their skin that can kill predators
  - Skunks can produce chemicals that smell unpleasant to deter predators
  - Tiger moths contain chemicals that cause them to taste unpleasant to their bat predators
- The **scent camouflage** mechanism described above can also be used by prey animals, e.g.
  - Puff adders (described above as ambush predators) are also prey for animals such as mongooses; they produce chemicals which prevent their predators from detecting them while they lie in wait for prey
  - Harlequin filefish take on the scent of the corals on which they feed, meaning that predators are unable to detect their presence

Physical adaptations of prey

- As with predators, prey have **sense organs that are adapted to detect predators**, e.g. prey tend to have eyes positioned on the sides of their skulls, giving a wide field of vision
- Prey animals have **body features** which allow them to avoid or deter predators, e.g.
  - Prey animals may use **camouflage**; some insects have bodies that allow them to appear to be a leaf or a stick
  - **Mimicry** allows prey animals to look like predators; owl butterflies have wing patterns that resemble the eyes of owls, causing potential predators to avoid them
  - A strategy known as 'aposematism' involves the development of **bright warning colours**, sending predators a message about chemical defences, such as the brightly coloured skin of poison dart frogs
  - Certain types of mimicry allow prey animals to **resemble species with chemical defences**, without needing to invest in the production of toxins, e.g. king snakes mimic the striping colour and pattern of venomous coral snakes
  - Prey animals may use **mechanical defences**, such as tough exoskeletons in insects and crustaceans, tough shells in turtles, and spines in porcupines and hedgehogs

Behavioural adaptations of prey

- Prey animals will sometimes have **innate preferences for dark, sheltered places**, e.g. insects such as woodlice that will move around constantly until they encounter a dark hiding place
- Prey will often **move away** when they detect the presence of predators, e.g. rabbits will run into their burrows when they see birds with the wing shape of predators
- Prey may **avoid locations or times of day where predators are present**, e.g. desert rodents may spend the daytime in an underground burrow and only emerge at night
- Prey animals will often **group together** in large groups; this will reduce their chance of being caught, as well as potentially confusing predators, e.g.
  - Shoals of fish and large groups of birds move together in ways that **make individual animals difficult to pick out**

- Some prey animals will mob a predator, e.g. gulls may group together to **attack a predator and drive it away**
- Some individuals may be able to **warn others in a group** of the presence of a predator, e.g. by using a warning call or by running away
- **Bluffing** techniques may allow prey animals to convince predators that they are not what they seem, e.g.
  - Opossums, some species of snake, and some species of shark may **pretend to be dead**; it is thought that this behaviour causes predators to lose interest
  - Frill-necked lizards may use their large neck frill to **pretend to be larger than they really are**

CC BY-SA 3.0, via Wikimedia Commons

CC BY-SA 2.0, via Wikimedia Commons

CC BY-SA 2.0, via Wikimedia Commons

Prey animals can use chemical, physical, or behavioural defences against predation. Poison dart frogs (left) produce toxins in their skin, owl butterflies (centre) physically resemble a predator, and grass snakes (right) can use apparent death behaviour.

Plant Adaptations for Harvesting Light

- Plants rely on the process of photosynthesis to produce carbon-compounds, and their leaves are well adapted to carry out this process
- Plants also have adaptations **at the level of the whole organism** that **maximise their ability to absorb light energy** for photosynthesis
  - These whole organism adaptations can be described as **adaptations of 'form'**
- Form adaptations in a forest ecosystem allow plants to **compete effectively** with other plants for light

Trees

- Trees in a forest make up the uppermost layer of plants, known as the **canopy**
  - Some trees may grow above the main canopy; these trees are described as being emergent trees
  - Some trees form a layer beneath the main canopy, known as the understory
- The strategy of maximising height allows the tallest trees to **gain the most sunlight**, as there are no other plants between them and the sunlight
- Trees can carry out **photosynthesis at a high rate**, providing them with the molecules that they need to grow quickly and compete effectively with other plants

Lianas

- Lianas are woody vines that **use the trunks of trees as their main supporting structure** to gain height, allowing their leaves to reach the forest canopy where they can **absorb light for photosynthesis**
- Lianas **germinate on the forest floor**, growing toward the base of tree trunks before growing upwards
- The roots of lianas are in the soil, allowing them to **gain their nutrients and moisture from the soil**
- Lianas **compete with trees** for light, and for nutrients and moisture

Epiphytes

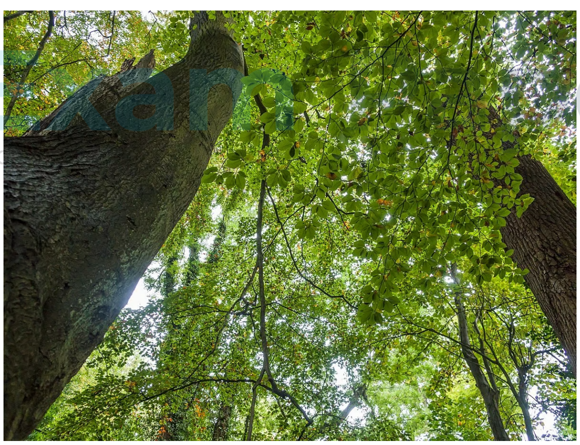
- Epiphytes use the height of trees to increase their absorption of sunlight by **growing high up in tree branches**, but they do not begin their lives on the forest floor, and often **gain their nutrients from high in the canopy**, e.g.
  - Moss gains water and nutrients from rainwater that runs across the tree bark on which it grows
  - Bromeliads collect rainwater in amongst their leaves
  - Some species of orchid have aerial roots which absorb moisture directly from the air
- Epiphytes have the **advantage of height for gaining light energy**, but do not need to expend their energy on upward growth

Strangler epiphytes

- Some epiphytes **grow roots downward to the forest floor**, allowing them to **gain nutrients and water from the soil**, while still taking advantage of **height from trees to absorb sunlight**
  - Note that this is different to lianas as strangler epiphytes begin their lives in the canopy and not on the forest floor
- An example is the strangler fig, which begins its life in the canopy, and is able to grow both upwards and downwards to maximise its access to resources
  - Strangler figs can kill their tree hosts by taking all of their resources

Shade tolerant shrubs & herbaceous plants

- **Shade tolerant plants** grow on the forest floor, and are adapted to **absorb the limited range of light wavelengths** that reach the ground through the leaves of the canopy and understory
  - Shade tolerant plants may contain **different photosynthetic pigments**, allowing them to absorb different wavelengths of light
- Plants that grow on the ground often have especially large leaves, **maximising the surface area** available for light absorption
- Flowers produced by these ground-living plants are often very **brightly coloured** or **strongly scented** to attract pollinators in low light levels
- Note that the terms 'shrub' and 'herbaceous plant' refers to the structure of the plant tissues
  - **Shrubs** are not tall like trees, but they do have **woody stems**
  - **Herbaceous plants**, or '**herbs**', **lack the woody stems of shrubs and trees**, and rely on soft tissues with turgid cells for support



CC BY-SA 2.0, via Wikimedia Commons

Public domain, via pixabay

CC BY 2.0, via Wikimedia Commons *Public domain, via pxfuel*

Trees (top left) use height to maximise their light absorption, epiphytes (top right) grow in the branches of tall trees to gain light, strangler epiphytes (bottom left) grow in the branches of trees but grow their roots down into the soil to allow absorption of light and nutrients, and shade-tolerant herbs have large leaves to maximise surface area for light absorption

Competition Between Species

Fundamental & Realised Niches

Niche

- The niche of a species can be defined as follows:

The role of a species within its habitat

- A species' role takes into account
  - The **biotic interactions** of the species, e.g. the organisms it feeds on and the organisms that feed on it
  - The **abiotic interactions**, e.g. how much oxygen and carbon dioxide the species exchanges with the atmosphere

Fundamental vs realised niche

- The fundamental niche of a species is:

The full range of conditions and resources in which a species could survive and reproduce, based on its adaptations and tolerance limits

- The realised niche is:

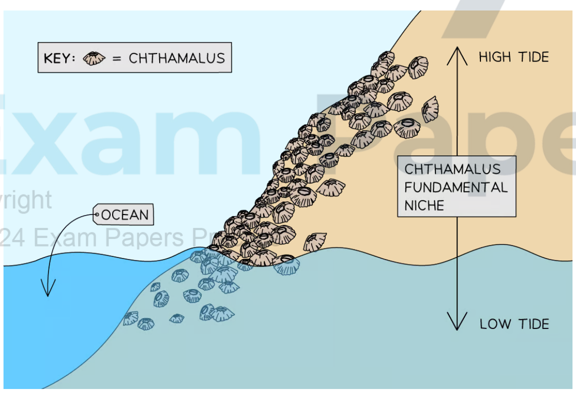
The actual conditions and resources in which a species exists, due to biotic interactions

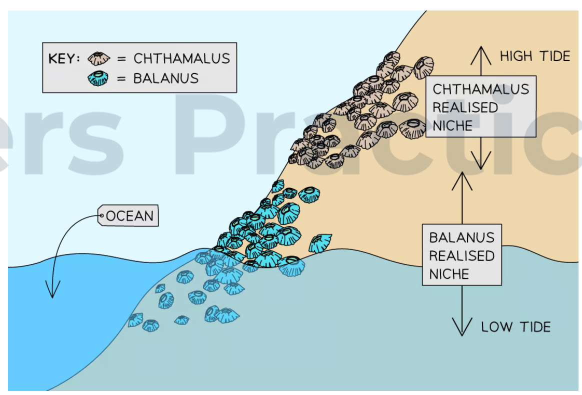
- An example of a fundamental niche compared to a realised niche can be seen in the case of the barnacle species *Chthamalus dalli*
  - Its fundamental niche includes a wide range of rocky intertidal areas in the Pacific Northwest, where it can attach to a variety of substrates and tolerate a wide range of temperature and salinity conditions
  - However, in reality, the realised niche of this species is much smaller due to **competition** with other barnacle species, such as *Balanus glandula*, for space and resources
  - As a result the actual range of *Chthamalus dalli* is **restricted** to areas where *Balanus glandula* is absent or scarce, such as higher up on the shore, where it is exposed to air for longer periods of time and can avoid competition with *Balanus glandula* for **space** and **resources**
  - Therefore, the realised niche of *Chthamalus dallia* is smaller than its fundamental niche due to the **biotic interactions** with other species

Fundamental niche vs realised niche table

Fundamental Niche	Realised Niche

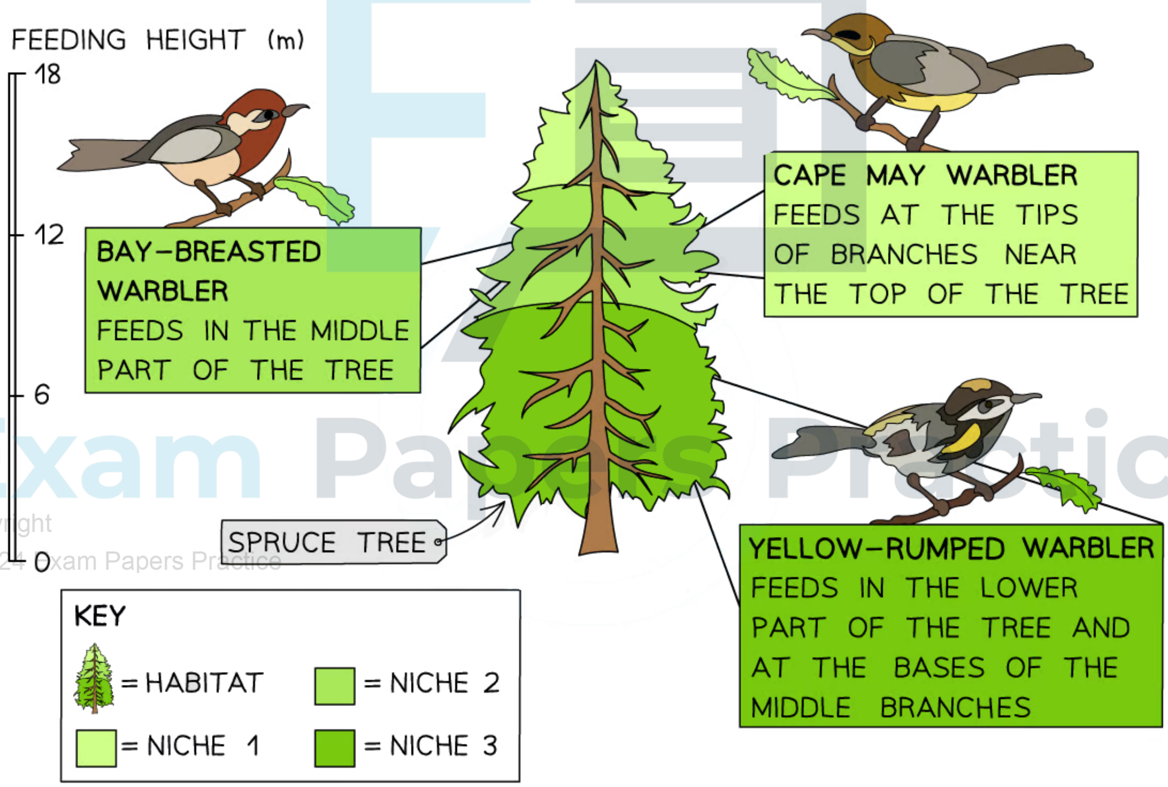
<table>
<tr><td>The niche a species would occupy if there were no limiting factors in the environment or resources the species could use</td><td>The niche that a species actually occupies, in the presence of competitor species</td></tr>
<tr><td>The potential distribution of a species</td><td>The actual distribution of a species</td></tr>
<tr><td>No competition for resources, no predation</td><td>Competition for resources and predation occurs</td></tr>
<tr><td>Large in size</td><td>Small in size</td></tr>
<tr><td>E.g. for Chthalamus:


</td><td>E.g. for Chthalamus:


</td></tr>
</table>

Competitive Exclusion

- A **niche** can only be occupied by **one species**, meaning that every individual species has its own unique niche
- If two species try to occupy the same niche, they will **compete with each other** for the same resources
- The eventual result of this competition will be that:
  - **One of the species** will be more successful and **out-compete** the other until the second species is either:
    - Forced to occupy a new, **slightly different niche**
    - Made **locally extinct**
  - **Both species** are forced into **a smaller part of their fundamental niches**
- The elimination of a competing species from its niche is known as **competitive exclusion**



A possible consequence of different species of warbler competing for the same resources is that the most successful competitor will exclude other species from their niche, pushing them into slightly different niches, e.g. the location in which they feed may change

Competitive exclusion example

- A classic example of competitive exclusion is between two species of single-celled free-living protozoans
  - *Paramecium aurelia*
  - *Paramecium caudatum*
- When each species is **grown separately from each other both species will thrive**
- When the two species are **grown in the same habitat** they compete for resources and eventually *P. aurelia* outcompetes *P. caudatum* for these resources, which **leads to *P. caudatum*'s elimination**
  - It is worth noting that this example involves both species being grown under laboratory conditions; it is rare in nature that two species will occupy exactly the same niche