

Ecological niches

Revision notes • Niches, oxygen tolerance, modes of nutrition, hominid dentition, herbivory, predation, light harvesting and competitive exclusion. IB Biology B4.2.

For IB Diploma Biology, Standard Level and Higher Level (first assessment 2025). **HL only** is additional higher level content, for HL students only.

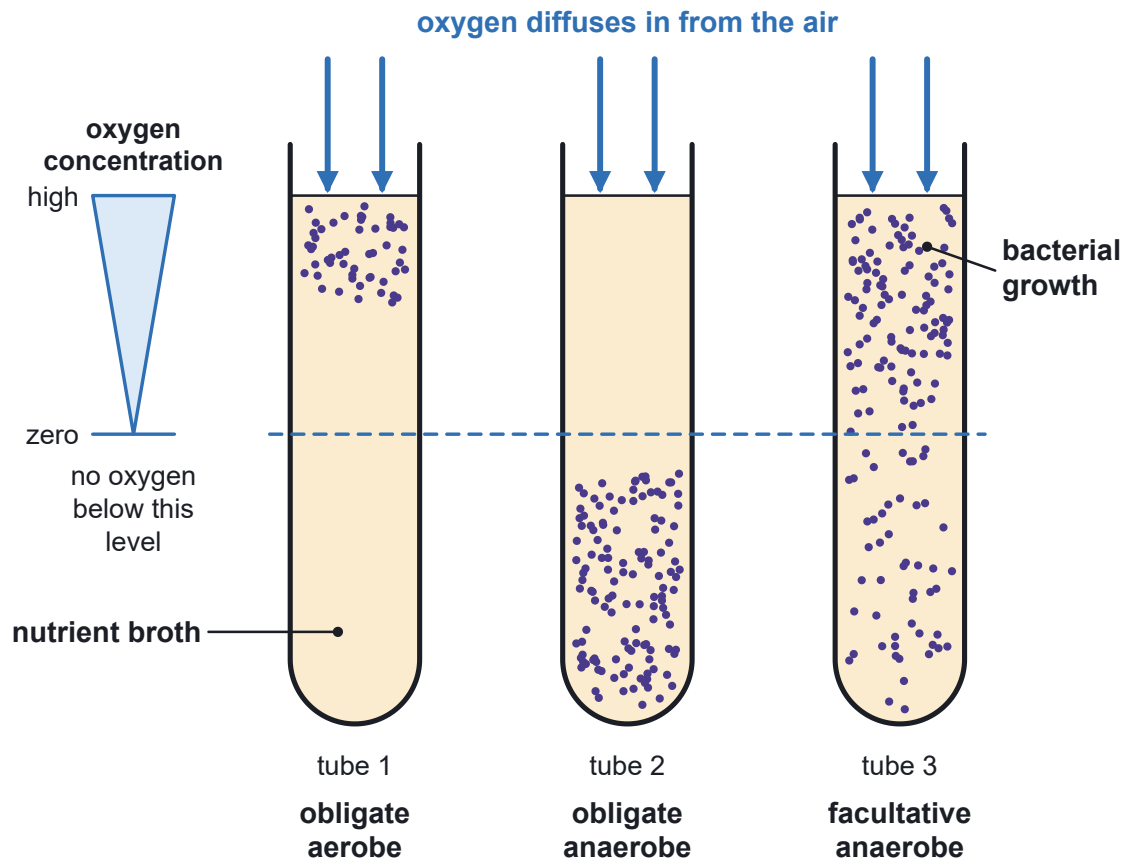
Ecological niches **Spec B4.2**

Ecological niche and tolerance of oxygen **Spec B4.2.1, B4.2.2**

An **ecological niche** is the role of a species in an ecosystem. It includes all the **biotic interactions** (food, predators, competitors, parasites, mutualists) and **abiotic interactions** (temperature, water, oxygen, light) that influence the growth, survival and reproduction of the species, including **how it obtains food**.

One abiotic part of a niche is whether a species can live with or without oxygen gas. Organisms fall into three groups.

Tolerance of oxygen		
Group	Tolerance of oxygen	Where found / example
Obligate anaerobe	Cannot survive in the presence of oxygen; oxygen is toxic to them	Anoxic sediments, deep soil, the gut; e.g. <i>Clostridium</i> bacteria
Facultative anaerobe	Can live with or without oxygen; respire aerobically when it is present and anaerobically when it is absent	Wide range of habitats; e.g. yeast (<i>Saccharomyces cerevisiae</i>), <i>Escherichia coli</i>
Obligate aerobe	Cannot survive without oxygen; needs it for aerobic respiration	Oxygenated air, water and soil; e.g. most animals and plants



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Where bacteria grow in a broth shows their **tolerance of oxygen**.

Common mistake: Facultative means "optional", obligate means "must". A facultative anaerobe does not need to avoid oxygen; it simply copes without it.

Photosynthesis and mixotrophic nutrition Spec B4.2.3, B4.2.5

Photosynthesis is the mode of nutrition in **plants, algae** and **several groups of photosynthetic prokaryotes** such as cyanobacteria. These organisms are **autotrophs**: they use light energy to make their own carbon compounds from carbon dioxide and other simple inorganic substances.

Mixotrophic nutrition

A **mixotroph** is an organism that is both autotrophic and heterotrophic. Some protists do this. *Euglena* is a well-known freshwater example: it has chloroplasts and photosynthesises in the light, but it can also absorb carbon compounds such as sugars from its surroundings. Many other mixotrophic species form part of oceanic plankton.

- **Obligate mixotrophs** need both modes of nutrition to grow and survive.
- **Facultative mixotrophs** can survive using either mode alone, switching to heterotrophy when light is short or to autotrophy when food is scarce. *Euglena* can live heterotrophically in the dark.

Exam tip: Linking question: what are the relative advantages of specificity and versatility? A facultative mixotroph is versatile, surviving changes in light or food that would kill a strict autotroph or heterotroph.

Holozoic and saprotrophic nutrition, and archaea Spec B4.2.4, B4.2.6, B4.2.7

Heterotrophs obtain carbon compounds from other organisms. **All animals are heterotrophic**, and their mode of nutrition is **holozoic nutrition**.

1. **Ingestion:** food is taken into the gut.
2. **Digestion:** large molecules are broken down by enzymes inside the body (internal digestion).
3. **Absorption:** small digested molecules pass across the gut wall into body cells and the blood.
4. **Assimilation:** absorbed molecules are taken up by body cells and become part of the organism's own cells and tissues.

Saprotrophic nutrition

Some fungi and bacteria are **saprotrophs**. They secrete digestive enzymes onto dead organic matter, digest it **outside** their cells (extracellular digestion), then absorb the products. Fungi and bacteria with this heterotrophic mode of nutrition are called **decomposers**: they release mineral nutrients from dead matter for reuse.

Holozoic and saprotrophic nutrition compared		
Feature	Holozoic	Saprotrophic
Organisms	Animals	Some fungi and bacteria
Food source	Other organisms, living or dead, ingested	Dead organic matter
Where digestion happens	Internally, in the gut	Externally, outside the cells
Ingestion	Yes	No; products are absorbed directly

Diversity of nutrition in archaea

Archaea are one of the **three domains of life**, alongside bacteria and eukaryotes. They are very varied in how they obtain energy for ATP production. Different species use **light**, the **oxidation of inorganic chemicals** or the **oxidation of carbon compounds** as their energy source. Archaea that use light do not photosynthesise with chlorophyll: they absorb light with a different pigment, which pumps protons across the membrane, and the proton gradient drives ATP synthase. Many live in extreme habitats, but archaea are also common in ordinary soils and oceans.

Exam tip: You do not need to name archaea species. Do know the three possible energy sources, since a question may ask you to outline their metabolic diversity. No archaea are known to carry out chlorophyll-based photosynthesis.

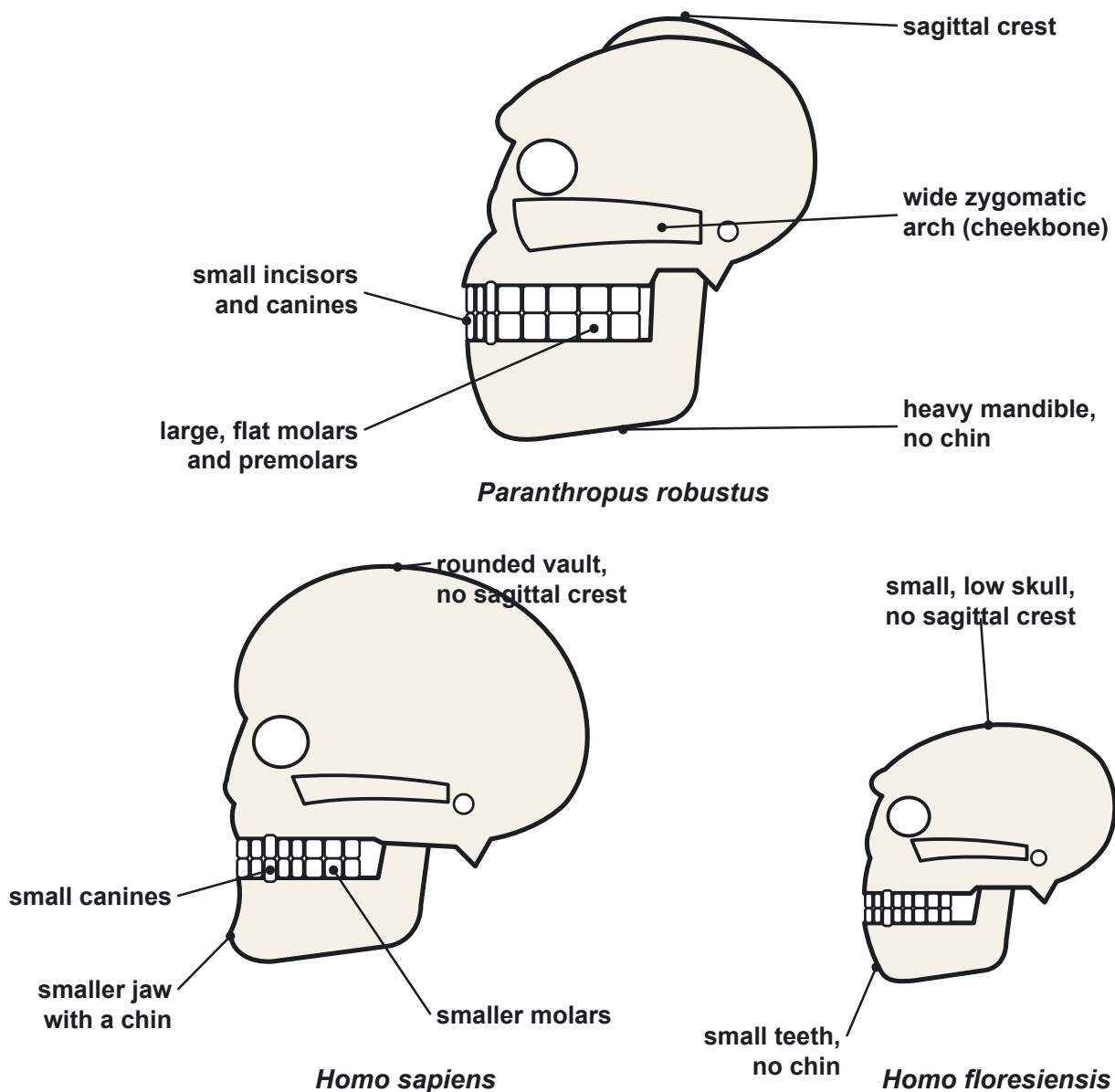
Dentition and diet in the Hominidae Spec B4.2.8

The family **Hominidae** includes humans and their extinct relatives. Comparing teeth and skulls lets biologists infer what each species ate.

Dentition and inferred diet of three hominids

Species	Dentition and skull features	Inferred diet
<i>Homo sapiens</i> (humans)	Small incisors and canines; moderate premolars and molars; smaller jaw and no sagittal crest	Omnivorous: meat and plants, much of it cooked or processed
<i>Homo floresiensis</i>	Small skull; small but robust jaw with no chin; small canines; small molars with features like those of later <i>Homo</i> , including modern humans; no sagittal crest	Omnivorous: small, unspecialised teeth suit a mixed diet, and stone tools and cut-marked bones of <i>Stegodon</i> (a dwarf elephant relative) in the same cave show that meat was eaten, probably often scavenged
<i>Paranthropus robustus</i>	Very large, flat molars and premolars with thick enamel; small incisors and canines; heavy jaw, wide cheekbones and a sagittal crest for large chewing muscles	Herbivorous: tough, hard plant material such as seeds, roots and tubers, ground by the large molars

Large grinding surfaces and powerful chewing muscles point to a diet that needed a lot of grinding. Smaller molars, no sagittal crest and, in fossils, evidence such as stone tools and cut-marked animal bones point to a mixed diet including meat.



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Inferring diet from dentition: large grinding teeth and a sagittal crest suggest tough plant food. Outlines are schematic, not to scale.

Practical skill: Examine models or digital collections of skulls. Note the size of each type of tooth, the thickness of enamel, jaw size and any sagittal crest, then infer the diet from these anatomical features.

Exam tip: Nature of science: observing living mammals led to theories relating dentition to herbivorous or carnivorous diets. These theories allow the diet of extinct species to be deduced.

Adaptations for herbivory and predation Spec B4.2.9, B4.2.10

Herbivores and plants

- **Chewing mouthparts:** leaf-eating insects such as caterpillars and locusts have hard mandibles that bite off and grind leaf tissue.
- **Piercing mouthparts:** insects such as aphids have a needle-like stylet that pierces leaf tissue to reach and suck phloem sap.
- **Physical defences of plants:** thorns, spines and other physical structures such as stinging or tough hairs deter herbivores.

- **Chemical defences of plants:** plants produce **toxic secondary compounds** in seeds and leaves, such as alkaloids (nicotine in tobacco leaves) and cyanogenic glycosides.
- **Metabolic adaptations of herbivores:** some animals can **detoxify** these toxins. Koalas break down the toxic compounds in eucalyptus leaves using liver enzymes, so they can feed on a food few others can eat.

Predators and prey

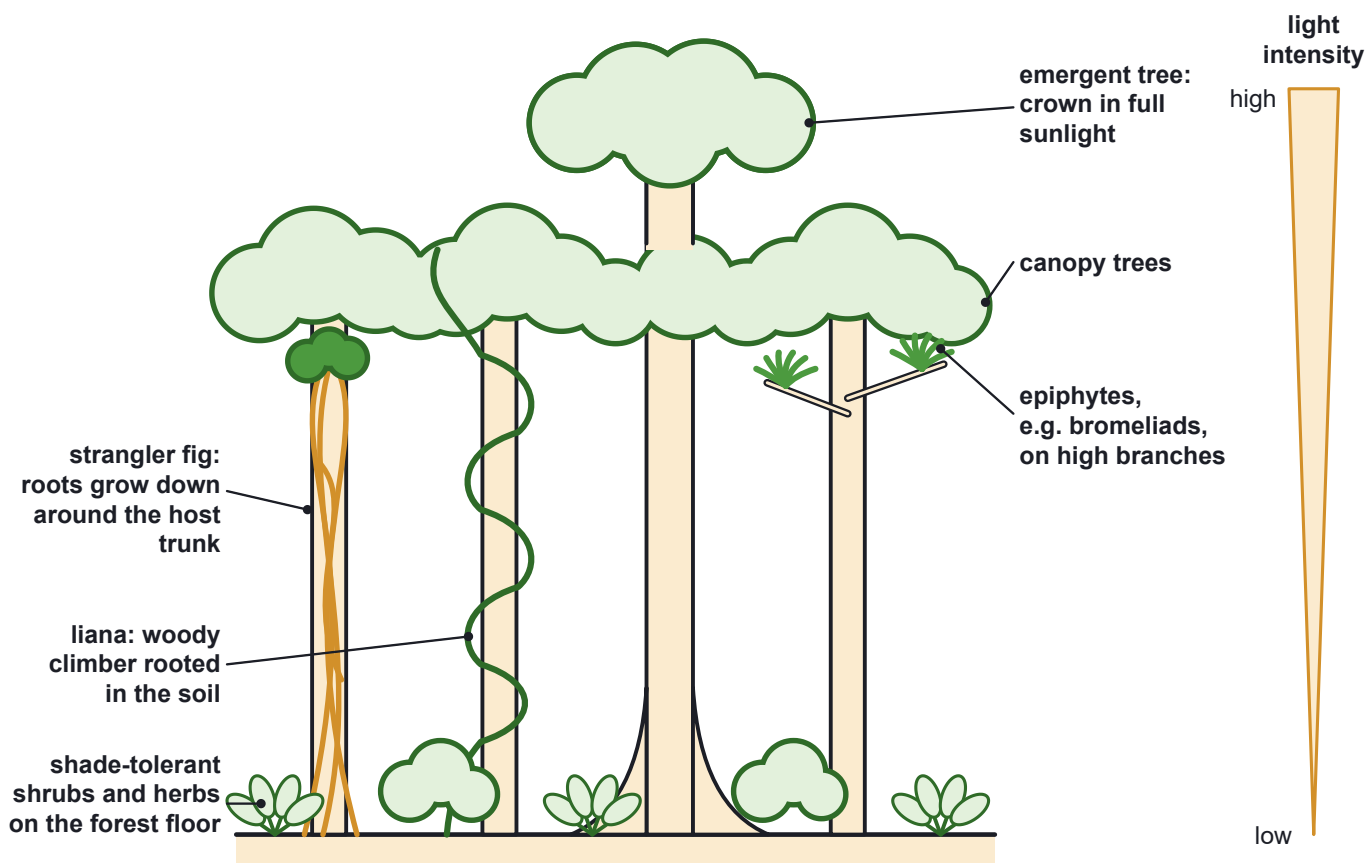
Chemical, physical and behavioural adaptations		
Type	Predators: finding, catching and killing	Prey: resisting predation
Chemical	Venom to kill or paralyse prey (e.g. rattlesnakes); detecting the scent of prey	Toxins and distasteful chemicals (e.g. poison frogs); defensive sprays (e.g. skunks)
Physical	Sharp teeth and claws; speed (e.g. cheetah); forward-facing eyes for judging distance; camouflage for ambush	Camouflage; spines or shells (e.g. porcupines, tortoises); speed; warning colours
Behavioural	Hunting in packs (e.g. wolves); ambush; stalking	Living in herds or shoals; alarm calls; fleeing; playing dead

Exam tip: If a question asks for chemical, physical and behavioural adaptations, give one clear example of each and say how it helps the predator or prey survive.

Adaptations of plant form for harvesting light Spec B4.2.11

Light is the main resource plants compete for in a forest. Very little light reaches the forest floor, so each plant growth form has its own strategy to **reach light sources**.

Strategies for harvesting light in forests	
Plant form	Strategy
Trees that reach the canopy	Invest in a tall, woody trunk to lift leaves above competitors into full sunlight
Lianas	Woody climbers rooted in the soil that use other trees for support, reaching the canopy without building a thick trunk
Epiphytes	Grow on the branches of trees, high up where light is brighter, with no roots in the soil; they obtain water from rain and humid air
Strangler epiphytes	Start as epiphytes on a branch, then send roots down to the soil; the roots thicken and enclose the host tree, which may die (e.g. strangler figs, <i>Ficus</i>)
Shade-tolerant shrubs and herbs	Grow on the forest floor; large, thin leaves with a high chlorophyll content for their mass, and low respiration rates giving a low light compensation point, let them photosynthesise in dim light



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Plants reach light in different ways: **tall trunks, climbing, growing on branches** or tolerating shade on the forest floor.

Common mistake: Epiphytes are not parasites. They grow on trees for support and light but take no nutrients from the host.

Fundamental and realized niches, and competitive exclusion Spec B4.2.12, B4.2.13

Fundamental niche	The potential niche of a species, based on its adaptations and tolerance limits, in the absence of competition.
Realized niche	The actual extent of a species' niche when it is in competition with other species. It is usually smaller than the fundamental niche.

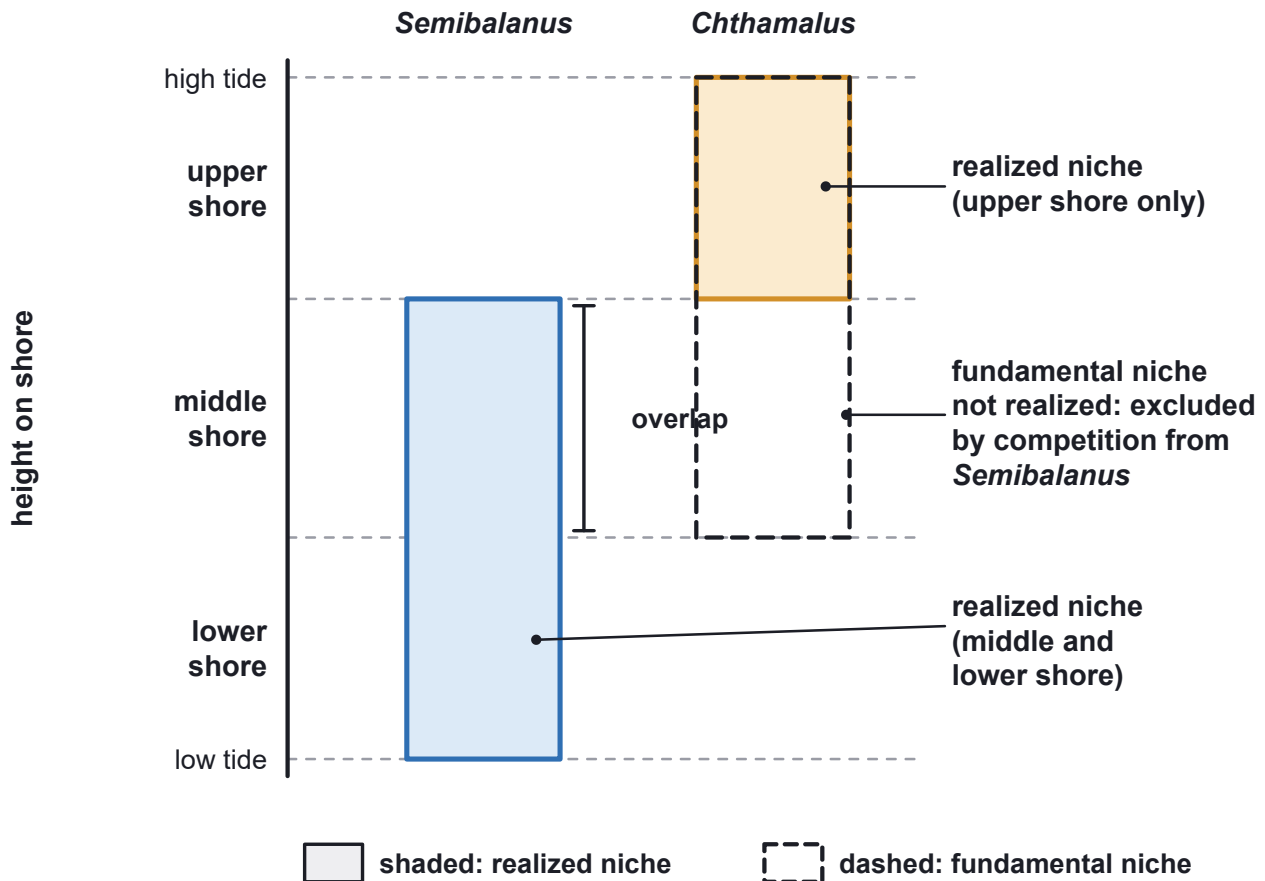
Example: on rocky shores two barnacle species, *Chthamalus stellatus* and *Semibalanus balanoides* (formerly *Balanus*), grow at different heights. *Chthamalus* can survive lower on the shore when its competitor is removed, so its fundamental niche is larger than its realized niche. Where both are present, faster-growing *Semibalanus* crowds it out of the lower zone, and *Chthamalus* is restricted to the upper shore, where it tolerates drying out better.

Competitive exclusion

The **competitive exclusion principle** states that two species with the same niche cannot coexist indefinitely in the same place. When two species compete, there are two possible outcomes:

- **Elimination** of one of the competing species from the area, because the other uses the shared resources more efficiently.
- **Restriction of both** species to a part of their fundamental niche, so that each uses a slightly different part of the resources (their realized niches no longer overlap fully).

So **each ecological niche is unique**: no two species in an ecosystem occupy exactly the same niche.



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Competition from *Semibalanus* restricts *Chthamalus* to a **realized niche** smaller than its fundamental niche.

Exam tip: When data show a species spreading after a competitor is removed, say the species had moved from its realized niche towards its fundamental niche.

Quick check

1. Define ecological niche.
2. What is a facultative anaerobe?
3. List the four stages of holozoic nutrition in order.
4. Name an example of a mixotrophic protist.
5. State two possible outcomes of competition between two species.

Quick check answers

Ecological niches

1. The role of a species in an ecosystem, including the biotic and abiotic interactions that influence its growth, survival and reproduction.
2. An organism that can live with or without oxygen, respiring aerobically when oxygen is present and anaerobically when it is absent.
3. Ingestion, digestion, absorption, assimilation.
4. Euglena.
5. One species is eliminated, or both are restricted to part of their fundamental niche.