HL IB Biology

Your notes

Stability & Change

Contents

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Stability in Ecosystems

Stability in Ecosystems

- Stable ecosystems have the following features
  - Efficient **nutrient cycling** which allows the system to be **self-supporting**
  - High **biodiversity**
  - **Stability**, i.e. resistance to change
    - E.g. consumer population sizes do not change significantly so resources are not overused
  - High levels of photosynthesis
- Some tropical rainforests, e.g. the Amazon rainforest in South America and the Congo rainforest in Africa, have remained in their current state for **tens of millions of years**; they are
  - Highly **diverse**, e.g. the Amazon rainforest his thought to contain millions of invertebrate species, tens of thousand of plant species, thousands of bird and fish species, and hundreds of mammal species
  - High levels of light and moisture mean that **photosynthesis rates are high**
  - **Organic matter is cycled** by detritivores such as termites, slugs and worms, and by decomposers such as fungi; the nutrients are then taken up again by the trees
  - **Water is cycled** within the ecosystem as it is lost from trees by transpiration before condensing and falling again as rain
- Note that while healthy ecosystems are highly stable, as described above, they are **not entirely static**; natural selection, leading to **evolutionary change**, will always be acting on species

The Amazon rainforest is millions of years old

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Requirements for Ecosystem Stability

- For an ecosystem to be considered stable, there are several features that it must have

Supply of energy

- A reliable source of energy must be present
- For most ecosystems this energy source is **sunlight**
- Light energy is converted into chemical energy by **photosynthesis**
  - Many photosynthetic organisms must be present, e.g. plants or algae
- Stored chemical energy is then passed up food chains through consumption

Recycling of nutrients

- In order for an ecosystem to **support itself**, the **cycling of nutrients** is essential
  - If nutrients are not recycled then the supply of nutrients will run out
- Nutrients are cycled when **decomposers** such as bacteria and fungi **break down the carbon compounds**, e.g. proteins and nucleic acids, in the tissues of dead organisms or waste matter
  - Carbon is released into the atmosphere in the form of carbon dioxide
  - Minerals such as nitrates and phosphates are released into the soil
- The nutrients released by decomposers can then be **taken up again** by producers and re-enter the food chain
- The conditions in an ecosystem must be suitable for decomposers
  - There needs to be enough **oxygen** and **moisture**, and **temperatures** need to be suitable; an ecosystem that is too hot or dry will have reduced nutrient cycling and so will be less productive
- If **nutrients are removed** from an ecosystem then cycling will be interrupted and productivity will be reduced, e.g.
  - Trees that fall are removed for timber rather than left to decompose
  - Crops are harvested

Genetic diversity

- Genetic diversity is one aspect of diversity; it can be defined as

The number of different alleles of genes present in a population

- High levels of genetic diversity mean that **natural selection** can act on **favourable alleles**, providing a population with the potential to adapt to changes in the environment
  - If a population has a limited number of alleles then the chances of one allele being favourable if the environment changes is reduced, and a population will be unable to adapt
- Genetic diversity allows populations to **resist the effects of change** in their environment

Climatic variables remaining within tolerance levels

- Genetic variation will only allow populations to resist the effects of change up to a point; if extreme environmental changes occur then they may be **outside the tolerance levels** of a species
  - Climatic changes to the environment include factors such as **temperature** and **rainfall**
- Changes that are outside tolerance levels will mean that a species needs to either **migrate** or face **extinction**

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- **Human activities** are causing **climate change** at such a rapid rate that climatic variables are changing beyond tolerance levels in some ecosystems

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Investigating Ecosystem Stability

- The stability of an ecosystem can be investigated using a **model ecosystem** known as a mesocosm
- A **mesocosm** is an experimental container in which a **naturally occurring** ecosystem **is simulated**
- Mesocosms can be used to **study the response of an ecosystem to changes in specific factors** such as nutrient and light levels
- Unlike a real ecosystem, it is possible in a mesocosm to **control all of the factors other than the variable being studied**
- Mesocosms can be set up in many different ways for many purposes
  - Water tanks can be set up on land to study the effect of sewage pollution on ponds or lakes
  - Underwater enclosures can be built in coastal waters or lakes to study the effect of temperature change or dissolved carbon dioxide on ocean ecosystems
  - Trees can be planted in large greenhouse-like buildings to replicate a rainforest to investigate the passage of carbon through this ecosystem
- Mesocosm experiments can be **considered unrealistic** due to their enclosed nature and the level of control that can be achieved
  - **Realism can be improved** by designing large mesocosms that share more of the features of a real ecosystem e.g. enabling mixing of layers of water in a large ocean mesocosm

Building a mesocosm in the lab

- It is possible to build small mesocosms in the laboratory
- Factors to consider:
  - The container should be **transparent** to **enable sunlight to reach producers** inside the mesocosm
  - **Autotrophs** should be included so that **light energy** can be converted into **chemical energy** inside the mesocosm
  - Small primary consumers such as zooplankton or other small invertebrates could be included, but it is important to consider whether the mesocosm is likely to be large enough to support them
  - Do not include secondary consumers in a mesocosm because there will not be enough energy in the food chain to sustain them for long, and it could be considered **unethical** to allow the primary consumers to be eaten in this way
- Mesocosms can be set up as open systems, i.e. without a lid, but sealed systems are **more controlled**, and therefore more useful for experimental purposes
  - Sealed systems prevent organisms and substances from entering or leaving
- In the lab, a mesocosm can be set up and then a **known factor can be altered** to assess its effect
  - E.g. different **light** levels, different **temperatures** etc.
- In order to assess the impact of changing one factor, a **control** mesocosm must be set up at the same time
  - A control mesocosm will be **exactly the same** as the experimental mesocosm, **but the altered variable will not be changed**
  - The purpose of this is to demonstrate that any change in the mesocosm is **due to the altered factor and not another factor**

Terrestrial mesocosm

- Place **drainage material** such as gravel in the bottom of a clear container

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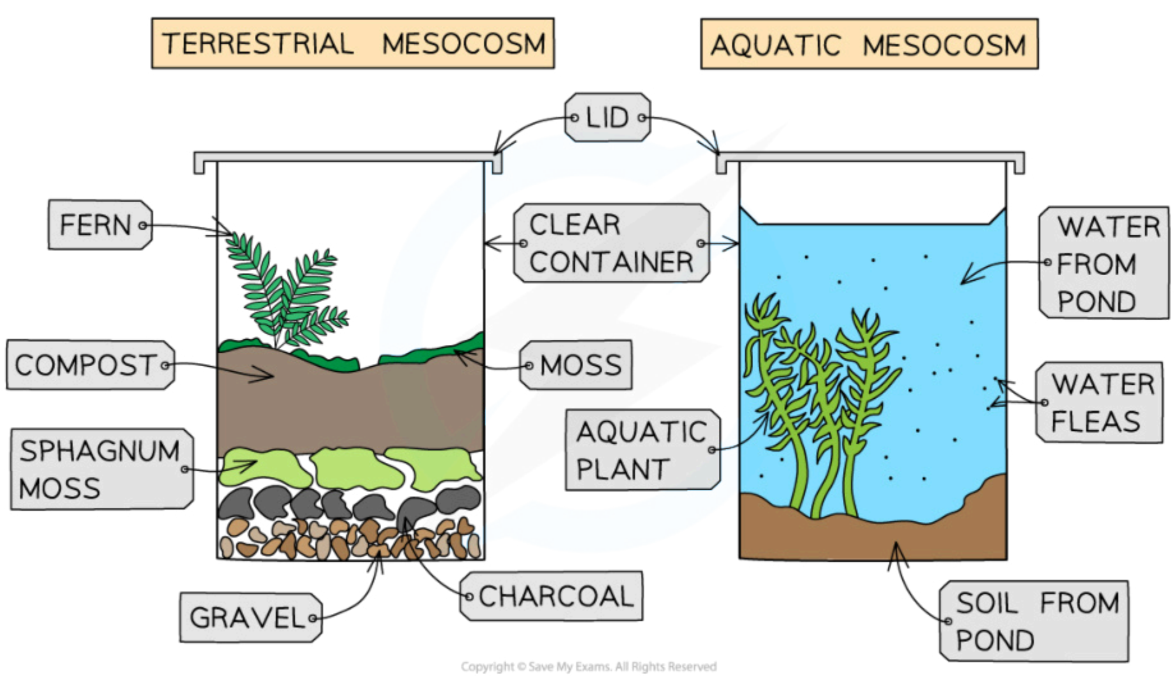
- Add a layer of charcoal on top of the drainage layer; this can help to prevent the growth of mould
- Place a layer of sphagnum moss or filter paper on top of the charcoal to **provide separation** between the base layers and the organic matter above
- Add a layer of soil or compost above the separation layer; this provides **organic material and micro-organisms** to aid with nutrient cycling
- Plant **slow-growing producers** such as healthy mosses and ferns in the growth medium
- Water the growth medium before sealing the container with a lid
  - The mesocosm may need watering while it establishes, but **avoid excessive watering**; once the mesocosm has stabilised, the plants should release enough water vapour during respiration to maintain moisture levels
- Place the container in a **light location**, and ensure that the **temperature is stable**

Aquatic mesocosm

- The base layer of the mesocosm should consist of **organic substrate** from the bottom of a lake or pond; this will provide naturally occurring nutrients and microorganisms
- Add **lake or pond water**; this ensures that it contains the required microscopic organisms and avoids chemicals from tap water
- Add **healthy aquatic plants** to produce carbohydrates and **oxygenate the water**
- Small aquatic organisms such as water fleas or water snails can be added, but not more organisms than the size of mesocosm can support
  - Only primary consumers should be used
- Place the container in a **light location**, and ensure that the **temperature is stable**

Mesocosm diagram



Mesocosms can be either terrestrial or aquatic

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NOS: Care and maintenance of the mesocosms should follow IB experimental guidelines

- The IB policy on animals in schools states that investigations should **only involve animals where no alternative options are available**, and that any investigations that must involve animals **should not be cruel**, and should include **measures that remove potential causes of animal distress**
- For a mesocosm experiment, this may mean **removing animals entirely**
  - This is the most ethical approach, as not all mesocosms need animals to be sustainable
- If animals are required then the guidelines may mean only including **a limited number** of **herbivorous animals** in a **carefully controlled environment**
  - I.e. enough food should be available, the mesocosm should not get too hot or too cold, the investigation should not continue for too long, and the animals must be returned to their natural environment at the end

Ecosystem Stability: Skills

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Deforestation of Amazon Rainforest

- The Amazon rainforest is an example of an ecosystem where **human activities are endangering ecosystem sustainability**
- Deforestation is affecting the self sufficiency of the Amazon ecosystem by influencing its **temperature and rainfall**
  - Transpiration releases water vapour into the air above the rainforest
  - This has a cooling effect which affects air movement and rainfall
  - Changes in the number of trees carrying out transpiration can therefore influence local temperatures and rainfall
- Temperature and rainfall are factors in the rates of **photosynthesis** and **nutrient cycling**, so deforestation could have a knock-on effect on other important ecosystem stability factors
- Scientists are concerned that the Amazon could reach a **tipping point** beyond which it is no longer stable
  - So many trees are removed that temperature and rainfall patterns change significantly
  - Climatic factors may change **beyond tolerance levels** for some species
- There is **uncertainty** around the area of rainforest that would need to be lost for this tipping point to be reached, so we **do not know how close the Amazon rainforest is to losing stability**

Global deforestation map

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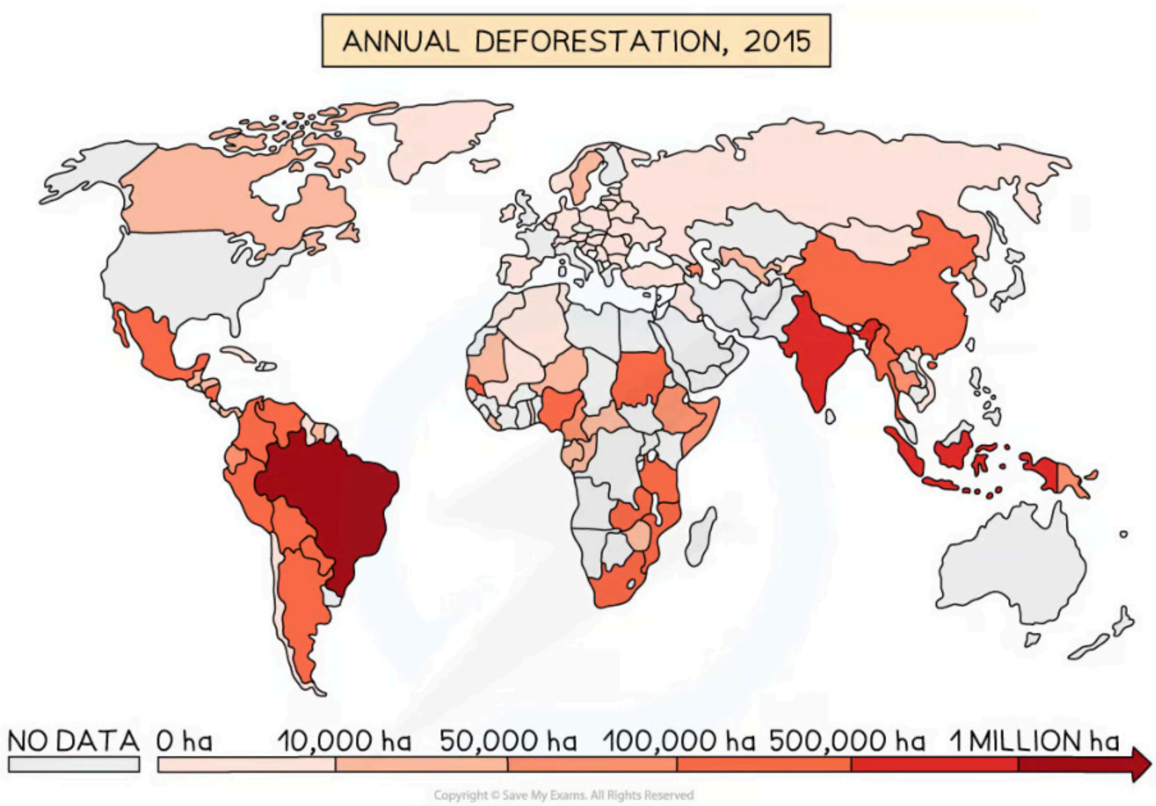

Information from 2015 shows high rates of annual deforestation occurring in the Amazon rainforest, South America; it is thought that this deforestation could destabilise the ecosystem if it is allowed to continue

Examiner Tip

Note that you could be asked to **calculate percentage change** in the context of ecosystem loss, in order to calculate the **extent of deforestation**.

Percentage loss of rainforest would be calculated as follows:

$$\text{Percentage loss of rainforest} = \frac{\text{change in rainforest area}}{\text{original rainforest area}} \times 100$$

Change in forest cover can be calculated by subtracting the final forest cover from the initial forest cover.

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Keystone Species

Keystone Species

- **Keystone species** are species that have a disproportionate effect on the **structure and function of their ecosystem**
- Their removal can cause **significant changes in the ecosystem**, including the loss of other species and possible ecosystem collapse
- By protecting keystone species, the **stability** of the ecosystem can be maintained, which can in turn benefit other species in the ecosystem
- Examples of keystone species include
  - **Sea otters**, in the kelp forest ecosystem in the Pacific Northwest of the United States, **help to control the population of sea urchins**; without this control the sea urchins can overgraze vegetation and leave no food or habitats for other species
  - **Beavers** build their homes in running water, slowing the water flow and **creating a wetland habitat** which can support many other species
  - **Elephants**, in the grasslands of Africa, consume shrubs and small trees, **maintaining the grassland** and preventing the growth of larger plants; this maintains food for grazers such as zebras, in turn maintaining the food supply for large predators such as lions

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Photo via Unsplash

Sea otters are an example of a keystone species

Sustainability in Ecosystems & Agriculture

Your notes

Assessing Sustainability of Resource Harvesting

- Human activities rely on the **harvesting of resources**, such as food and timber, for which we rely on the natural environment
- A sustainably harvested resource is one which is **replaced as rapidly as it is harvested**, meaning that it does not run out
- In order for a resource to be sustainable, its use needs to be carefully **regulated** and **monitored** to ensure that it is not over-harvested

Terrestrial plant: black cherry

- Black cherry is a species of hardwood tree, found in North America, that is popular for furniture production
- Hardwood tree species grow slowly, so it is especially important that sustainable harvesting methods are used; methods such as **clear felling will leave no timber** for many years to come
- Sustainable harvesting of black cherry timber involves
  - **Selective felling**; choosing specific individual trees to harvest, leaving gaps in the forest canopy that will encourage growth of more plants on the forest floor
  - Leaving enough individuals behind in the forest to **flower and produce seeds**, ensuring that new black cherry saplings will germinate
  - Regular **monitoring** to ensure that new growth is keeping up with logging

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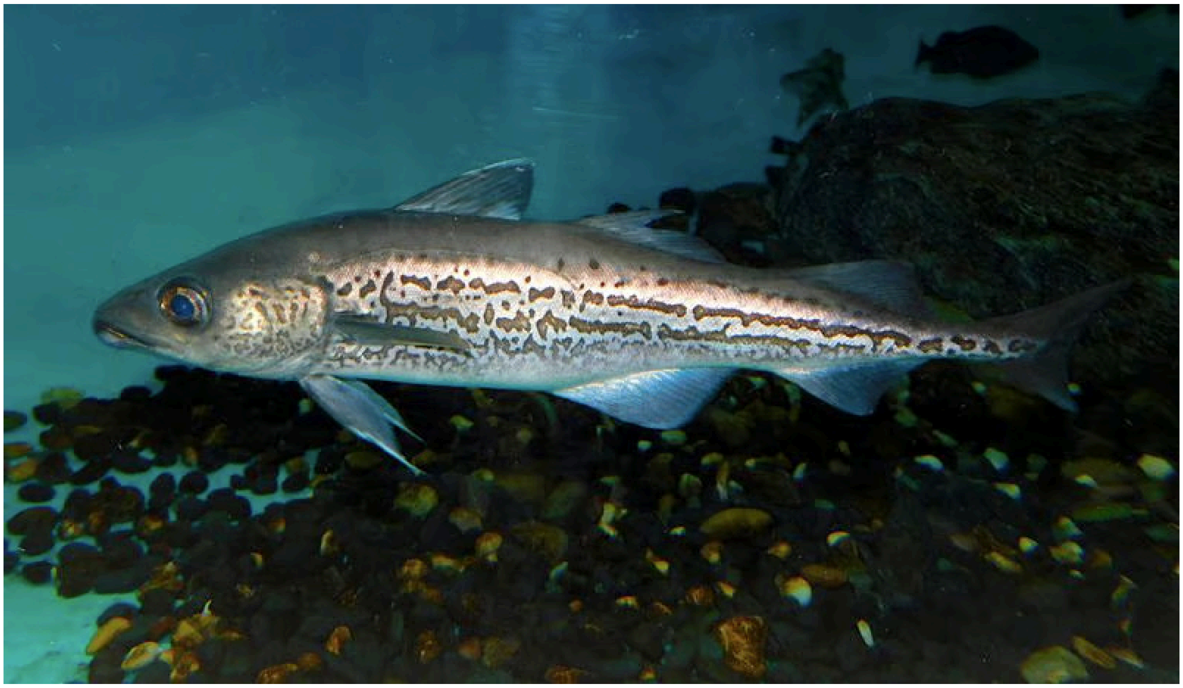
Hardwood forests contain trees that grow slowly, so harvesting must be carefully managed

Marine fish: Alaska pollock

- Pollock are a species of fish found across the North Pacific
- The Alaska pollock fishery is the **largest sustainably certified fishery** in the world
  - This certification is awarded by the Marine Stewardship Council (MSC)
- The fishery is considered to be sustainable because
  - Pollock are a **fast-growing species** which can reproduce from the age of 3-4 years
  - Nets have **minimal contact with the sea bed**, so do not damage this habitat
  - The proportion of the fish caught that are not pollock, known as **bycatch, is very low**; less than 1 %
  - According to regulation, **any bycatch that is caught cannot be sold commercially**, so it is in the interest of fishermen to avoid catching it
  - **Close monitoring** is carried out by science research vessels and by trained individuals on board commercial fishing vessels
  - Any areas where a higher than normal number of salmon bycatch occurs are **closed off to fishing vessels**



Wild Alaska pollock caught in the US is a sustainably harvested resource

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Factors Affecting Sustainability of Agriculture

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- Agriculture is essential in ensuring that there are **enough food and materials** to supply the needs of humans around the world
- **Sustainability** in agriculture is a complex challenge influenced by many factors

Soil erosion

- In order to grow crops or keep large numbers of grazing animals, **land needs to be cleared** to make space for crops or grass
- The removal of larger trees and shrubs means that the **roots that hold the soil together are lost**, resulting in **less stable soil** that can easily be washed or blown away
  - This is a particular risk for the nutrient-rich upper soil layer, known as **topsoil**
- This leads to **soil erosion**, and a reduction in the availability of soil needed for crop/grass growth
- While crops and grass themselves can aid soil stability, they may only provide partial cover, or they may be removed after harvest, or due to overgrazing/poor weather
  - Farmers sometimes plant 'cover crops' to hold the topsoil together in between growing seasons

Leaching and nutrient run-off

- The use of synthetic fertilisers in agriculture can lead to **nutrient runoff** due to **leaching**
- This occurs when rainfall washes fertilisers out of the soil and **into nearby bodies of water**
  - The minerals in synthetic fertilisers are highly soluble so **dissolve in rainwater** before being washed away
- The problem of leaching can be reduced by applying fertilisers in small volumes, at times when rain is not forecast, and by using organic rather than synthetic fertilisers

Fertiliser supply

- Chemical fertilisers are important for many farmers, but they are not always easy to supply
  - They are **expensive**
  - They are used by many farmers, so **supply may not meet the large demand**
- The process of fertiliser production is very energy intensive, so the **cost of fertilisers is affected by the global energy prices**
- Switching to **organic fertilisers** can help to reduce some of the difficulties associated with chemical fertiliser use

Pollution

- Some types of farming rely on the use of chemicals, known as **agrochemicals**
- The impact of **chemical fertiliser** use has been described above
- Additional examples of agrochemicals include
  - **Pesticides**
  - **Herbicides**
  - **Fungicides**
- These chemicals are used to **improve yield**, which might otherwise be damaged by **insect pests**, competition from **weeds**, or by **fungal disease**

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- These chemicals can **enter the natural environment** and cause problems, e.g. by killing non-target species
- **Biological pest control** can reduce pesticide use
  - This involves the release of a pest's natural predators, e.g. ladybirds that prey on aphids
- Scientists hope that **genetic modification** may allow the introduction of crop varieties that are **resistant to pests and disease**

Carbon footprint

- The reliance on fossil fuels for **transportation**, **machinery**, and the production of **synthetic fertilisers** has significant implications for the sustainability of food production
  - The combustion of fossil fuels releases carbon dioxide into the atmosphere, increasing the carbon footprint of agriculture and contributing to climate change
- Transitioning to **renewable energy sources** and promoting energy-efficient practices can help **reduce the carbon footprint** of food production

Many are concerned about sustainability problems in intensive agriculture

Eutrophication

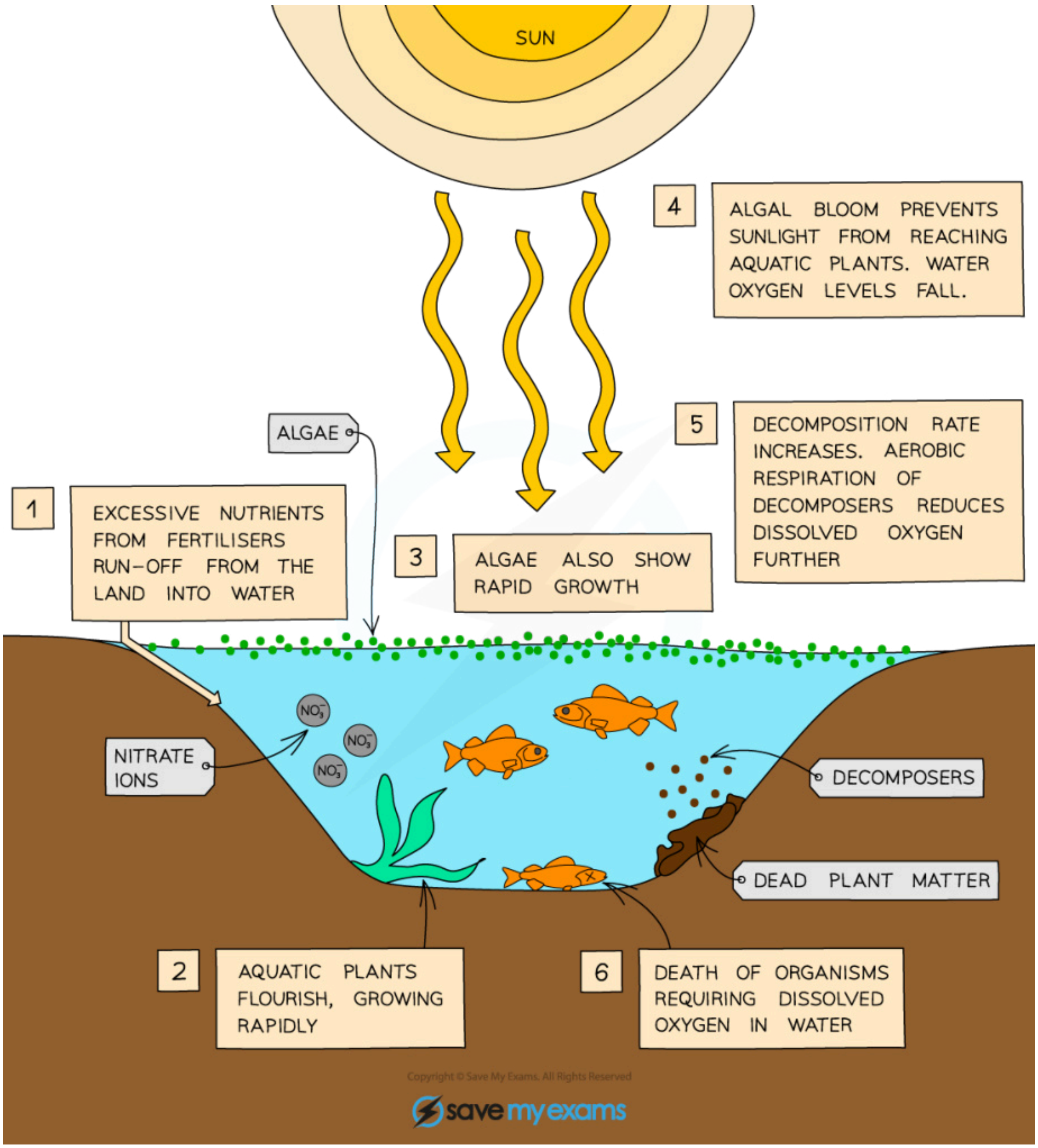
Your notes

Eutrophication

- When lakes, rivers, estuaries and coastal waters receive **artificially large inputs** of **nutrients**, such as nitrates and phosphates, this results in **excess growth** of plants and phytoplankton, e.g. algae
  - For example, when the mineral ions from excess **fertilisers** leach from farmland into waterways
- This growth of algae, known as an algal bloom, can block out sunlight and stop it penetrating below the water surface, so aquatic plants below the surface of the water start to **die** as they can **no longer photosynthesise**
  - The algae also start to die when **competition** for nutrients becomes too intense
- As aquatic plants and algae die in increasing numbers, **decomposing bacteria** feed on the dead organic matter and also increase in number
- As they respire **aerobically**, these bacteria use up the **dissolved oxygen** in the water
  - The respiring bacteria create an increased **biochemical oxygen demand**, or **BOD**
- As a result, the availability of dissolved oxygen in the water **rapidly decreases**, so aquatic organisms such as fish and insects may be unable to survive
  - **Dead zones** in both oceans and freshwater can occur when there is not enough oxygen to support aquatic life

Eutrophication process diagram

Your notes



Eutrophication can result from the leaching of agricultural fertilisers into lakes and rivers

Your notes

The Effects of Pollution

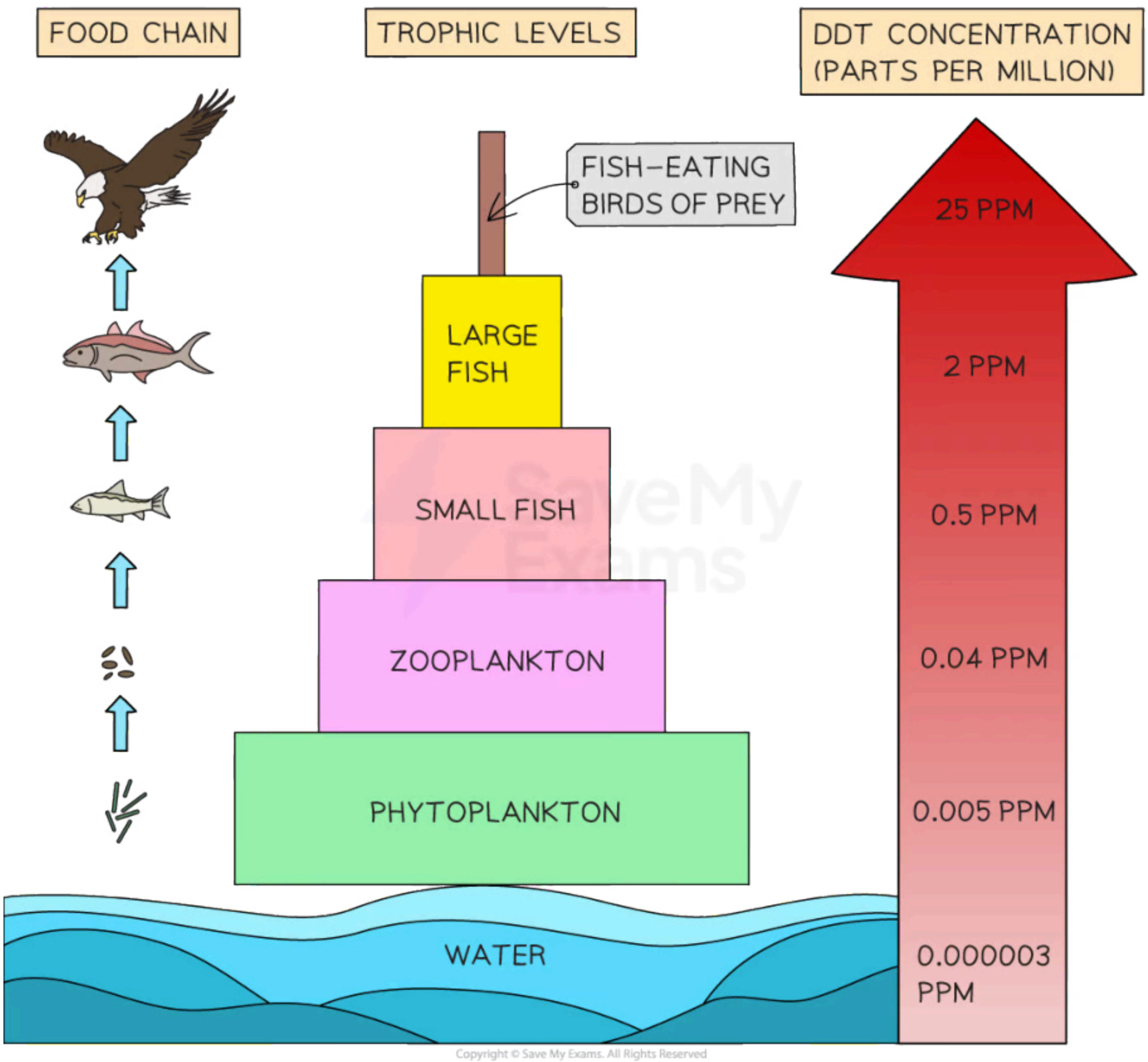
Biomagnification of Pollutants

- **Biomagnification** is the **increase in concentration** of persistent or non-biodegradable pollutants **with ascending trophic level** through a food chain
  - Not to be confused with **bioaccumulation**, which is the **build-up of pollutants** within an organism, or within a single trophic level
- As **pollutants are passed up the food chain** from one trophic level to the next, they can become **more concentrated** due to the decrease in total biomass of organisms at higher trophic levels
  - I.e. the smaller organisms at the bottom of the food chain will **each consume a small volume of pollutant**, and then the organisms at the top of the food chain will consume many smaller organisms and **receive a much larger dose** of pollutant

Biomagnification of DDT

- Toxins such as **DDT** (dichlorodiphenyltrichloroethane) are persistent pollutants that can enter food chains
- DDT was a **widely used insecticide** in the mid-20th century that was found to have **harmful effects on top predators** such as birds of prey
  - When DDT was sprayed on crops, it would leach into waterways and eventually enter freshwater and marine ecosystems
  - DDT would then **enter food chains via plankton** and **accumulate in the bodies of fish**
  - These fish would then be eaten by birds, which would **accumulate higher concentrations of DDT**
- Because DDT is persistent and does not break down easily, it can **continue to accumulate in the bodies of animals at higher trophic levels**, leading to harmful effects such as thinning of eggshells and reduced reproductive success
  - The thin eggshells could not withstand the weight of the parent bird during incubation, so the eggs would break and fewer young birds would hatch
  - Over time this resulted in reduced bird populations
- DDT has now been banned worldwide, with the exception of its use in areas where it is essential in dealing with mosquitos that transmit malaria

Biomagnification of DDT diagram



Through the process of biomagnification, the concentration of DDT in the tissues of organisms increases at successively higher trophic levels in a food chain

Biomagnification of mercury

- **Mercury** is another example of a pollutant that can accumulate through food chains
- Mercury is released into the environment through activities such as coal-fired power plants and gold mining
- Once in the environment, mercury can be converted by microorganisms into a highly toxic form called **methyl mercury**, which can accumulate in the bodies of fish
- As larger fish eat smaller fish, **the concentration of methyl mercury within the tissues of these fish increases**, leading to potential harm for **humans** who eat large predatory fish such as tuna or swordfish

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Effects of Plastic Pollution

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- Plastics have a large negative impact on both land and water habitats due to their **non-biodegradable** nature
- Plastics that can cause pollution problems include
  - **Macroplastics**; these are plastic items that are more than 5 mm in length, and include plastic bags, bottles, food packaging, and fishing nets
  - **Microplastics**; pieces of plastic that are less than 5 mm in length
    - Microplastics come from macroplastics that have been broken into smaller pieces by, e.g. wave action or UV rays
- In marine habitats:
  - Animals often try to **eat plastic**, e.g.
    - Turtles may attempt to eat a plastic bag that resembles a jellyfish
    - Albatrosses may accidentally consume plastic when they fish, giving it to their chicks when they regurgitate food; the chicks may later starve due to their stomachs being full of plastic
  - Animals **become caught in plastic**, such as fishing lines, leading to injuries and death
  - As the plastic breaks down it can **release toxins** that can lead to **biomagnification** in the food chain
  - Once it has broken down into **very small particles**, it is commonly ingested by animals and **enters the food chain**

NOS: Scientists can influence the actions of citizens if they provide clear information about their research findings

- The impacts of plastic pollution have become very well understood by the public in recent years due to **effective communication** of the findings of scientists
  - E.g. Popular wildlife documentaries have shown footage of sea birds feeding plastic to their chicks
- This type of **clear science communication can change public behaviour**
  - People have petitioned food companies and supermarkets to reduce their plastic packaging
  - People may shop at stores that use less plastic
  - People may get better at household recycling and taking their rubbish home
  - People may opt for non-plastic items in their home, such as bamboo toothbrushes or paper straws for drinking

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Restoring Ecosystems

Restoring Ecosystems

- **Human activities**, such as deforestation and overharvesting of resources, can **destabilise ecosystems**
- Conservation efforts at the ecosystem level aim to improve ecosystem stability by **restoring natural ecosystem processes**
  - This type of ecosystem restoration project is sometimes known as **rewilding**
- Restoration strategies may involve
  - **Species reintroductions**
    - Reintroduction of **apex predators** will control populations of herbivores and allow the restoration of habitat vegetation; this can increase the diversity of plant species, which will in turn **boost overall biodiversity**
    - Reintroduction of keystone species can alter the structure of an ecosystem
  - **Improving habitat connectivity**
    - The establishment of **wildlife corridors**, e.g. by planting hedgerows throughout farmland, can connect small pockets of habitat
    - When habitats are connected organisms can roam over larger areas; this gives access to **more resources** and allows populations to increase in size
  - **Limiting human influence**
    - This may involve **preventing the harvesting of resources** by, e.g. logging, fishing, or agriculture
    - **Ecological management techniques**, e.g. controlled grazing or burning, may be used to restore a habitat

Restoration of Hinewai Reserve, New Zealand

- Hinewai Reserve was once farmland, but is now privately owned, with the aim of **restoring the natural ecosystem** of the area
- Some initial human intervention was involved, with the **removal of non-native species**, but the area is now managed with **minimal human intervention** to allow native communities to be restored by succession
- Human activities are limited in the area, though the public can enjoy walking in the Reserve

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Hinewai Reserve in New Zealand is considered to be a an example of successful rewilding

Ecological Succession (HL)

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Causes of Ecological Succession

What is ecological succession?

- Ecosystems are dynamic, meaning that they are constantly changing
- This process of change in an ecosystem is known as **ecological succession**
- Succession can be defined as

Progressive change in the species that make up an ecological community over time

What can trigger succession?

- The process of succession can be triggered by abiotic and biotic factors
  - An abiotic factor could be volcanic activity that creates **new land** on which an ecosystem can develop, or a fire that destroys part of an existing ecosystem, leaving **unfilled** niches for the development of a new community
  - A biotic factor could be the death of an organism, followed by its decomposition, altering the soil and **allowing a new series of species to survive**

Primary Succession

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- **Primary succession** is succession that occurs when **newly formed** or **newly exposed** land is inhabited by an increasing number of species
  - Newly formed land can be created by, e.g.
    - The magma from erupting **volcanoes** cooling and forming **new rock** surfaces or new rocky **islands** in the sea
  - Newly exposed land can form by, e.g.
    - A **landslide** that exposes bare rock
    - A **glacier that retreats** to reveal bare rock
- The arrival of organisms on bare land is known as **colonisation**, and the bare land is said to be **colonised**

Changes during primary succession

- **Primary succession** can occur on any type of bare land, including sand dunes at the edge of the ocean, and on exposed rock
- Primary succession on bare rock involves the following stages
  - **Seeds** and **spores** that are carried by the **wind** land on exposed rock and begin to grow
    - The first species to colonise the new land, often **mosses** and **lichens,** are known as **pioneer species**
    - Pioneer species can **germinate easily** and **withstand harsh conditions** such as low nutrient and water availability
  - As new organisms die and decompose, the dead **organic** matter forms **soil**
  - Seeds of **small plants and grasses** land on this soil and begin to grow
    - The plants at this early stage of succession are **adapted** to survive in **shallow**, **nutrient-poor** soils
  - The **roots** of these small plants form a network that helps to **hold the soil in place** and prevent it from being washed away
  - As these small plants die and decompose, the soil becomes **deeper** and more **nutrient-rich**
  - **Larger plants and shrubs**, as well as **small trees** can now begin to grow
    - These larger plants and small trees also require **more water**, which can be stored in **deeper soils**
  - Over time the soil becomes sufficiently deep, contains enough nutrients, and can hold enough water to support the growth of **large trees**
  - The **final species** to colonise the new land become the **dominant species** of the now **complex ecosystem**
  - The **final community** formed, containing all the different plant and animal species that have now colonised the land, is known as the **climax community**
    - The type of climax community that forms depends on the location of the original bare land; in the tropics the climax community would be a rain forest, while in temperate regions it might be deciduous woodland
    - A climax community is not always the most biodiverse stage of succession, but it is a **stable** community

Succession diagram

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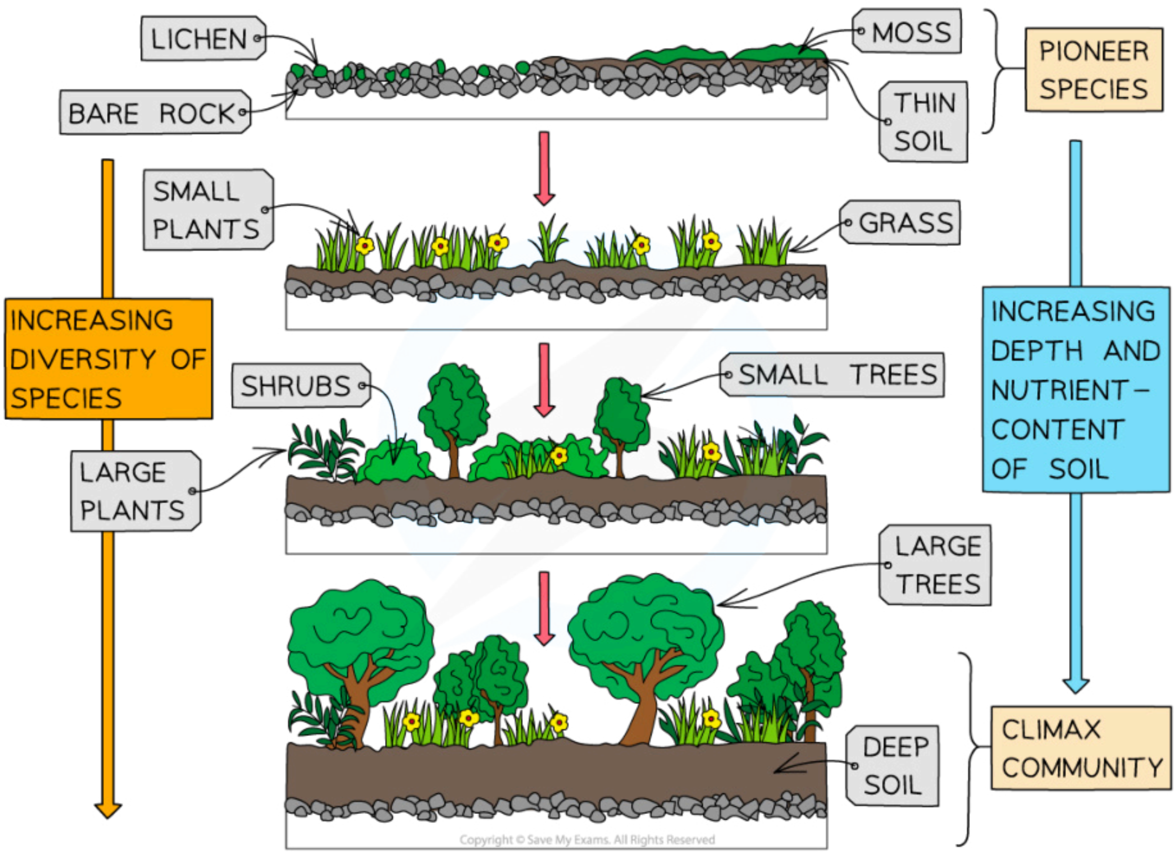

Primary succession is the process of ecosystem change over time, beginning with newly formed or newly exposed land

Succession changes the biotic and abiotic conditions

- At each **stage** in **succession** the newly arriving species **change** the **local environment** so that it becomes **more suitable** for **other species** that have not yet colonised the new land, e.g.
  - **Pioneer species** such as **lichens** help to slowly **break apart** the top surface of bare rock; this fragmented rock, along with the dead organic matter left behind when the lichens die and are broken down, forms a **basic soil**
  - Species such as grasses grow roots that **stabilise the soil**, enabling it to hold more moisture and nutrients
- Often the new colonising species then change the environment in such a way that it becomes **less suitable** for the **previous species**, e.g.
  - Lichens cannot grow on soil so they **disappear** from the **ecosystem** once soil begins to form; the new species change the environment in such a way that it becomes **less suitable** for the lichens
    - Pioneer species may not be found in a climax community as they will be **out-competed** for light and other resources by the species that arrive during the later stages of succession
    - Pioneer species are well adapted for harsh conditions but are often poor competitors

- As soil deepens and **trees** are able to grow, they may block out the light to shrubs and other smaller plant, out-competing them and causing them to die

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The general principles of primary succession

- As succession progresses, the following can always be observed:
  - **Larger plant species** can be supported
  - There is an **increase in the** primary production of a community
  - Species **diversity** increases
  - The **complexity of food webs** increases
  - Increased **nutrient cycling**

Secondary succession

- There is also a type of succession called **secondary succession** which takes place on previously occupied land, e.g. after a wild fire or deforestation
  - Secondary succession is very similar to primary succession except that **soil is already present** so the process begins at a later stage

Examiner Tip

You could be presented with an example of succession other than the one provided here, e.g. succession on a sand dune. As long as you understand the principles of the stages of succession you should be able to apply your knowledge to any example that an exam question might throw at you.

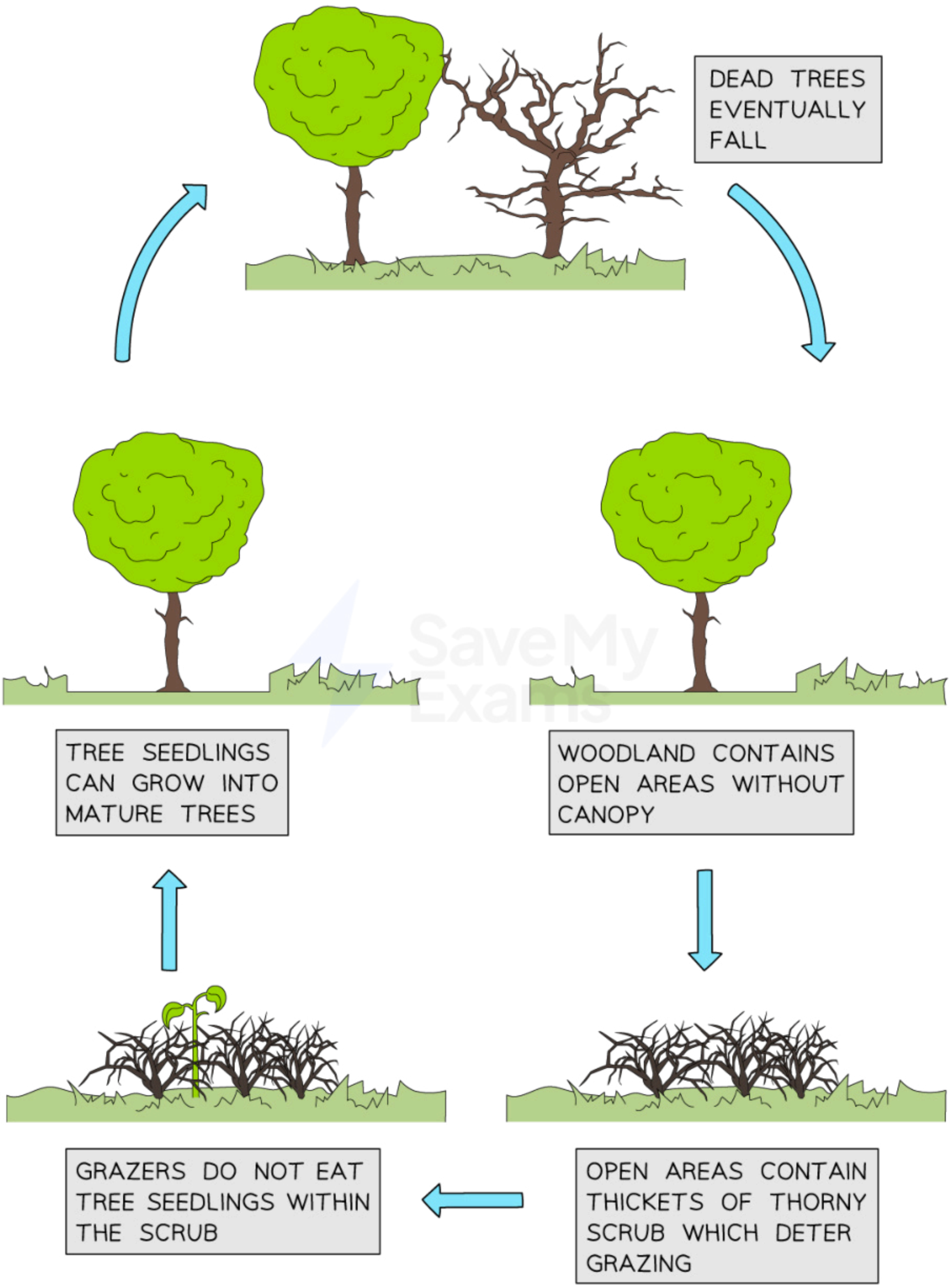
Cyclic Succession in Ecosystems

Your notes

- The succession process described above results in a **stable climax community** that, if left undisturbed, will remain unchanged over time
- In some ecosystems, however, this stable equilibrium state does not occur and there is a **changing cycle of communities** rather than a single, unchanging climax community; this is known as **cyclical**, or **cyclic**, **succession**
  - Note that these cycles occur over long time periods, e.g. the lifetime of an oak tree, which can be hundreds of years
- An example of cyclical succession can be seen in **grazed woodlands**, which can contain a **changing mosaic of grassland, woodland, and scrub**
  - This habitat can be described as **wood pasture**
- In a grazed wood pasture, the following cycle of events can be observed
  - **Grazers**, such as cattle, graze on pockets of open grassland within a woodland, where they **consume tree seedlings** and prevent the growth of trees
  - Fast-growing thorny species, such as brambles, may arise in some areas within the grassland, creating a **mosaic of thorny scrub**
  - **Tree seedlings can survive** within the thorny vegetation, which **deters grazers**
  - **Trees grow** up through the thorny scrub, which will eventually fail to get enough light through the tree canopy and die off
  - At the end of its life the **tree dies and falls**, creating an open area where grass can grow, and restarting the cycle

Cyclic succession diagram

Your notes


DEAD TREES EVENTUALLY FALL
WOODLAND CONTAINS OPEN AREAS WITHOUT CANOPY
OPEN AREAS CONTAIN THICKETS OF THORNY SCRUB WHICH DETER GRAZING
GRAZERS DO NOT EAT TREE SEEDLINGS WITHIN THE SCRUB
TREE SEEDLINGS CAN GROW INTO MATURE TREES

Succession can occur in cycles over many hundreds of years, e.g. within a grazed woodland

Your notes

Human Influence on Succession (HL)

Your notes

Human Influence on Succession

- Given any specific environmental conditions, ecological succession tends to lead to a **particular type of climax community**, but **human activities** often prevent or **interrupt the process of succession**
  - The type of climax community that develops will depend on the biome
  - E.g. in a temperate climate we might expect any succession to eventually result in temperate forest
- This means that human activities can **prevent a climax community** from developing, e.g.
  - The **grazing activity of livestock** such as sheep and cattle prevent tree seedlings from establishing, meaning that a forest community may not develop
  - **Drainage of wetlands** will prevent the formation of peat bogs
    - Wetlands may be drained to provide fertile agricultural land, land for development, or peat for fuel
- In some instances the interruption of succession is **important for the maintenance of certain types of ecosystem**, e.g. without grazing, important habitats such as heathlands, meadows, and chalk grasslands will be lost

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Human activities can interrupt succcession, e.g. grazing prevents the development of woodland, instead leading to habitats such as chalk grassland (left), while draining wetland using ditches (right) prevents the formation of peat bogs