Unit 3: A Level Biology

Populations

Population – a group of organisms of the **same species.**

Population numbers fluctuate depending on:

- births which increase population size
- deaths which decrease population size
- immigration which increases population size
- emigration which decreases population size.

In a stable population:

births + immigration = deaths + emigration

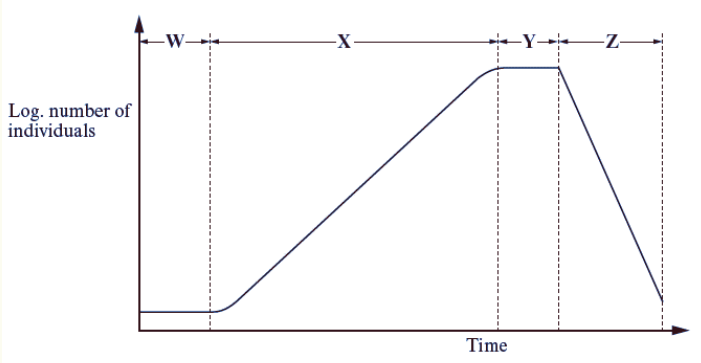
When writing about bacteria or yeast, use **cell reproduction.**

Factors that affect the death rate in populations can be **density independent** or **density dependent.**

Density independent factors are **abiotic** (non-living), for example, a wildfire will kill members of small and large populations to the same extent.

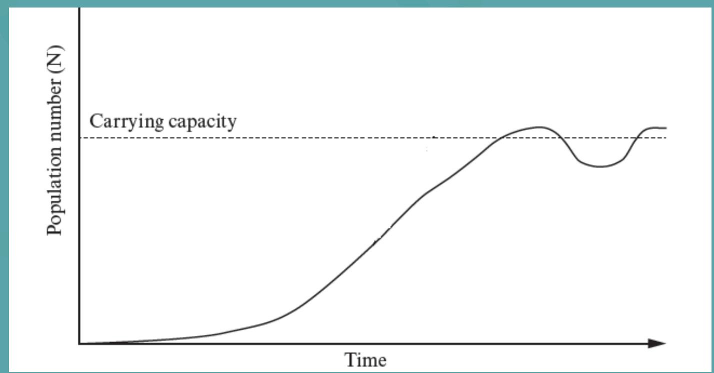
Density dependent factors are **biotic** (living) and affect a greater proportion of the population if the population is larger (and more dense), for example, there is more competition for food in a larger population, more predation and diseases and parasites spread more easily.

A population growth curve for a bacterium or yeast grown in a nutrient broth has 4 phases:



Notice that a **log** scale is used to accommodate the large range of numbers involved, from single figures to millions.

	Phase	What is happening
W	lag	Enzymes are synthesised, DNA is replicated
X	exponential	Population doubles every unit of time; nutrients abundant
Y	stationary	Competition of nutrients means death and cell reproduction happen at the same rate
Z	death/decline	Nutrient depletion and toxin accumulation mean death rate is higher than cell reproduction



Carrying capacity is the maximum number of individuals of a species that the environment can support indefinitely.

If a more complex organism, e.g. a grey squirrel, colonises a new area:
In the lag phase, population is limited by low numbers to reproduce. Exponential phase is a doubling of numbers with abundant resources and low predation. The stationary phase shows fluctuation; as the population increases competition for resources (and probably predation) increases to a point where death rate is higher than birth rate. The population decreases, which reduces competition and the population can increase again. This continues indefinitely. The set point around which the fluctuation takes place is the **carrying capacity** of the environment.

Energy flow through ecosystems

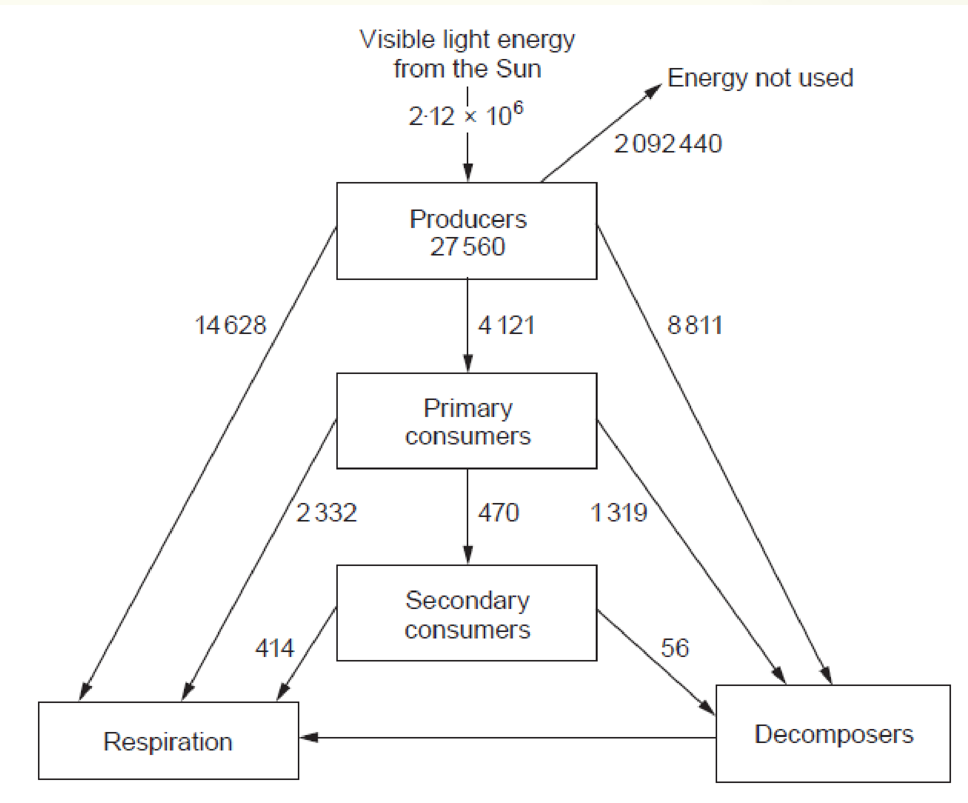
An **ecosystem** is an area that has a particular community of plants and animals interacting with their environment.

A **community** is all of the organisms of all species in an ecosystem.

The place in an ecosystem where an organism lives is its **habitat**.

An organism's role in the **ecosystem** is its **niche**, this applies particularly to its feeding role.

Energy flow can be represented diagrammatically.



Energy flows along food chains in an ecosystem. The arrow in the food chain gives the direction of energy flow. This is from sunlight → producers **(autotrophs)** → primary consumers **(herbivores)** → secondary consumers **(carnivores)**. There may be more **trophic** (feeding) levels, like tertiary and quaternary consumers.

A food web shows the more complex feeding relationships within an ecosystem as some organisms feed on more than one trophic level or consume different types of food.

Photoautotrophs (mainly green plants) use light energy from the sun to **fix** carbon dioxide into organic molecules by photosynthesis. The rate at which this happens is the **Gross Primary Production** (GPP) - the units are kJ m^{-2} yr^{-1}.

Photoautotrophs use some of these organic molecules up in **respiration**; what is left is the **Net Primary Production** (NPP). This is the plant biomass that is available to be consumed by the next trophic level (herbivores).

GPP – R = NPP

Not all sunlight energy is used in photosynthesis; some is the wrong wavelength, transmitted through the leaf or reflected.

All organisms respire so **energy is lost** as heat at every trophic level. This can be graphed as a **pyramid of energy**.

Dead organisms, faeces and urine are fed on by **decomposers** (fungi and bacteria), which also respire.

The number of trophic levels is limited because of energy losses; eventually, there is not enough left to sustain another level.

Calculations: Efficiency of transfer is a % (little number ÷ big number x 100)

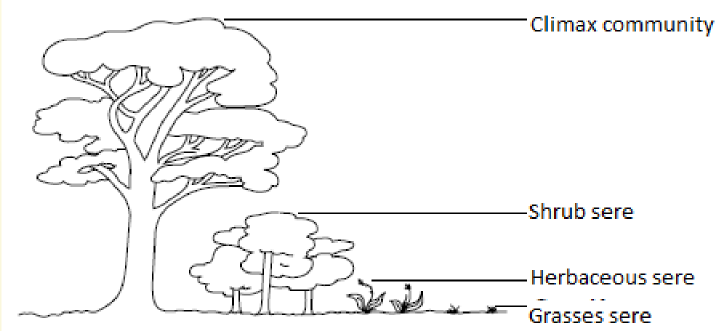
Number on top of one of the arrows – remember the numbers on the arrows leaving a box add up to the arrow going in.

Efficiency of transfer from sun to plant is about 0.2%, from plant to herbivore is about 10%. Herbivores consume mainly cellulose, relatively indigestible, and lose a lot of energy as faeces. Transfer from herbivores to carnivores is often more efficient as less energy is lost as faeces. Endotherms have higher respiratory rates to produce heat and are less efficient than ectotherms. This is one reason that aquatic food chains can be longer. In **agriculture**, farmers keep animals warm, **reduce movement** and give **high protein feed** to **reduce energy losses.**

Succession

Succession is a change in community and species composition over time.

Secondary succession starts from cleared land where communities have lived before. It is faster as there are seeds, roots and soil to support the plants. This happens after forest fires.



Each stage of a succession is a **sere** characterised by particular communities, e.g. grasses.

Succession can be **deflected** by grazing, mowing and burning, maintaining particular subclimax communities.

Primary succession starts from bare rock, where no organism lives.

Pioneer species colonise the rock blown in as spores, these are lichens which erode the rock. When they die, they decay.

When the eroded rock builds up in cracks, mosses can colonise, blown in as spores.

Enough soil accumulates to allow grasses to become established, then herbaceous plants, then shrubs then woodland (the **climax community**).

The climax community is the stable end point of succession; no further changes take place.

Climax communities have high species diversity and many habitats and niches.

The speed of succession depends on temperature and proximity to a source of spores and seeds to be blown in.

Practical work

Random Sampling:

Use when the area is uniform like a field.

Grid the area.

Generate random numbers to select co-ordinates to avoid **bias.**

Place quadrat at co-ordinates and use to assess % cover/ count organisms/ ACFOR scale.

Transect:

Use when there is a change in conditions, like tidal areas/ moving out from under a tree.

Line: place quadrats at regular intervals along the line and use to assess % cover/ count organisms/ ACFOR.

Belt: assess vegetation by continuous quadrats along the line.

Measure:

Abiotic factors that may be affecting distribution like pH/ light intensity/ soil water.

Calculate: Simpson's diversity index if you have counted organisms and species.

For transects: present data as **kite** diagrams.

Points to consider:

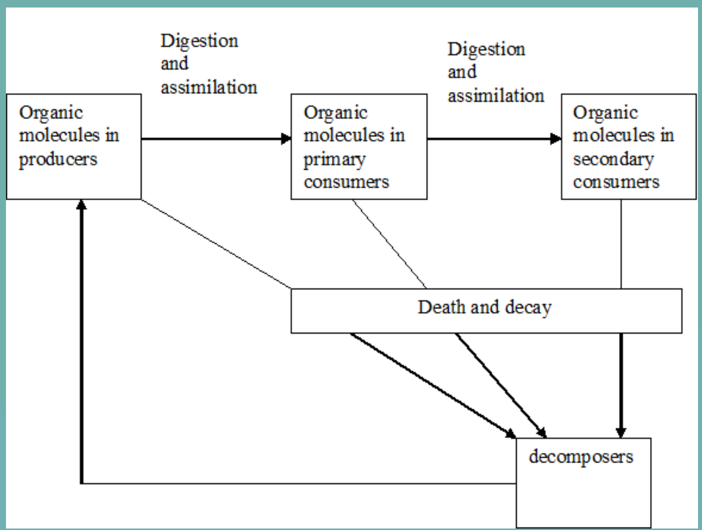
Risk assessment: hazards are biting insects/ stinging plants; cover skin and use insect repellent. Slippery conditions can cause sprains and breaks from falls; walk not run, wear footwear with a grip. Weather conditions can cause sunburn/hypothermia; wear appropriate clothing for the conditions.

Representative sampling: use the correct sized grid/ quadrat for the area, a **preliminary investigation** may be needed to determine this. Carry out enough **repeats**.

Seasonal/time differences. Sampling may need to be done at different times of year/ day to accommodate differences in visible plants or animals at different times of year. To investigate succession, it may be necessary to return to the same location in successive years.

Nutrient Cycles 1

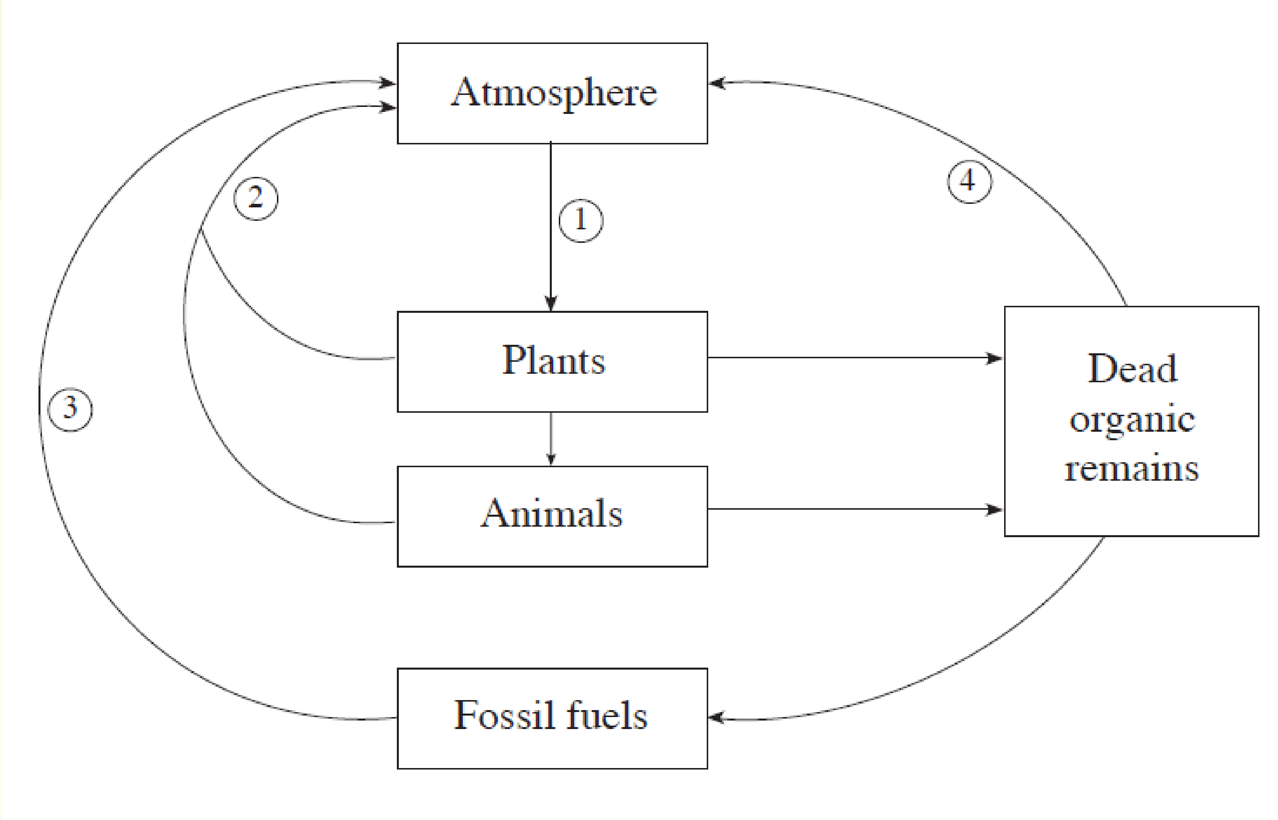
Nutrients are recycled in ecosystems by decomposers – **bacteria** and **fungi**. All nutrient cycles have the same general principle:



Autotrophs use energy from sunlight or chemicals to convert inorganic compounds into organic ones. Organic molecules are passed along **food chains**. **Decomposers** use organic molecules and convert them to inorganic compounds.

Carbon cycle

1. plants take in CO_2 and use it in photosynthesis to make organic molecules passed through food chains
2. plants and animals respire and excrete CO_2
3. combustion releases CO_2
4. decomposers respire excreting CO_2



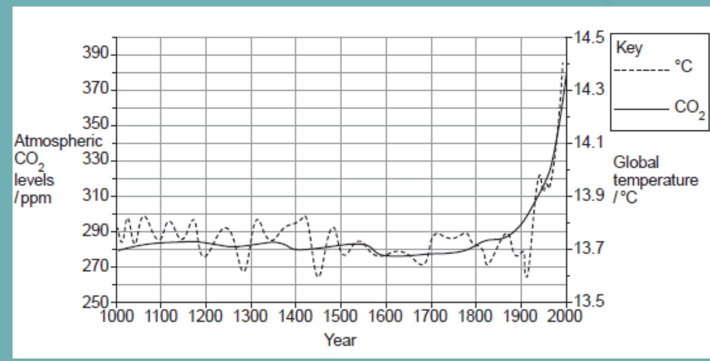
Carbon footprint is the total amount of CO_2 released attributable to an individual, product or service over the course of a year.

Human Impact on the Carbon Cycle

Deforestation removes trees and therefore less photosynthesis takes place, so less CO_2 is absorbed from the atmosphere.

Combustion of fossil fuels and wood releases 'locked in' CO_2 to the atmosphere.

CO_2 is a 'greenhouse gas' trapping heat and raising global temperatures causing global warming.



Global warming affects species distribution, as regions further north and south of the equator are warmer so the range where species can live pushes further north and south. Artic and Antarctic species are put at risk of extinction.

Agricultural practices may have to alter to accommodate climate change. Some areas may become drier and need drought resistant crops. Other areas may become wetter and need crops that can survive in those conditions.

Decomposition rate is affected by:

Temperature – slower when cold

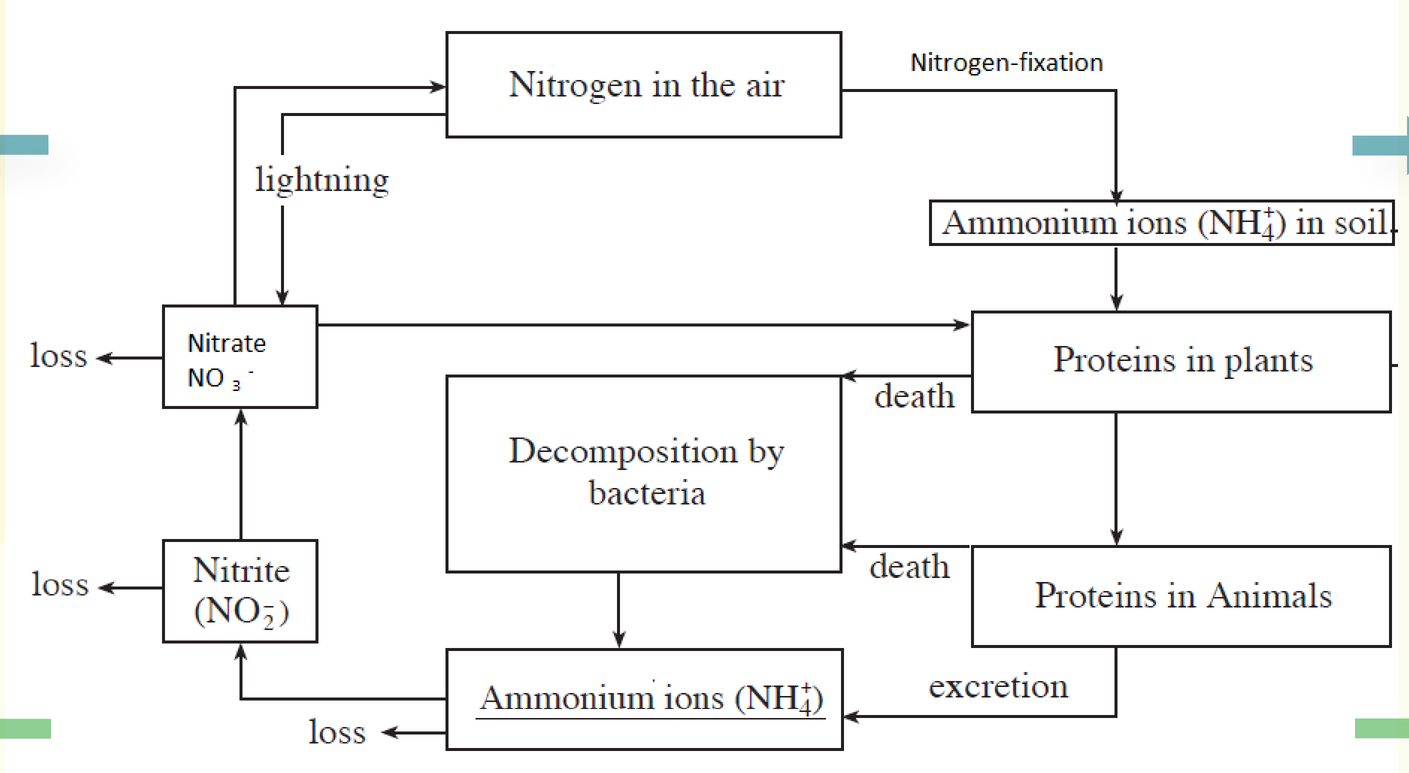
pH – slower when acidic

O_2 availability – slower when less oxygen available

Nutrient Cycles 2

The Nitrogen Cycle

Water-logged soils lack O_2; this **favours denitrification** and slows nitrification. This leads to nitrate poor soil. **Insectivorous plants** live in water-logged areas. They digest insect protein to gain amino acids. In agriculture, **ploughing** introduces air to the soil, encouraging nitrification. **Drainage** ditches reduce waterlogging and reduce denitrification.



Rhizobium has a symbiotic relationship with **legumes**. It fixes nitrogen gas into ammonium ions and makes amino acids which it exports to the legume. The legume makes a root nodule for the *Rhizobium* and provides carbohydrates and micro-anaerobic conditions needed for nitrogen-fixation. Legumes can live in relatively nitrate poor soils as a result. In agriculture, legumes like clover are often planted to provide extra nitrogen.

Losses are through **leaching**, soluble ammonium, nitrite and nitrate ions dissolve in ground water and drain away.

Plants absorb nitrates and ammonium ions and use them to synthesise nitrogen containing compounds. The nitrogen atoms are key components of **amino acids**, and therefore proteins, **nucleotides**, and therefore nucleic acids, and **chlorophyll.**

Excess nutrients in lakes and rivers from leaching cause **eutrophication**. Microscopic algae undergo a population boom, called an **algal bloom**. This blocks light from bottom dwelling plants which die. When the algae die, the **decomposer** population increases and as they are aerobic, utilise more oxygen than usual out of the water. There is an **increased biological oxygen demand**. Fish and aquatic invertebrates die and are decomposed.

Bacteria involved:

Nitrifying bacteria

Nitrosomonas – convert ammonium to nitrite

Nitrobacter – convert nitrite to nitrate

Nitrogen-fixing bacteria – convert nitrogen gas to ammonium

Azotobacter – free living in soil

Rhizobium – in root nodules of legumes, symbiotic

Denitrifying bacteria – convert nitrate to nitrogen gas

Pseudomonas – thrive in water-logged soils

Draining agricultural land means that species rich wetlands are lost. This loss of habitats and niches **reduces species diversity.**

Many native grassland wild flowers favour poor soil. Enriching soils with fertiliser to enhance grazing is causing a reduction in wild flowers, their pollinators and reducing species diversity. Some farmers leave wide borders around fields to support wild flowers and beneficial species like pest predators and pollinators.