



# Cambridge (CIE) IGCSE Biology



Your notes

## Energy & Feeding Relationships

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# Transfer of Energy

## Transfer of Energy

- The Sun is the principal source of energy input to biological systems
- Energy flows through living organisms
  - Including light energy from the Sun and chemical energy in organisms
  - Energy is eventually transferred to the environment eg. as heat

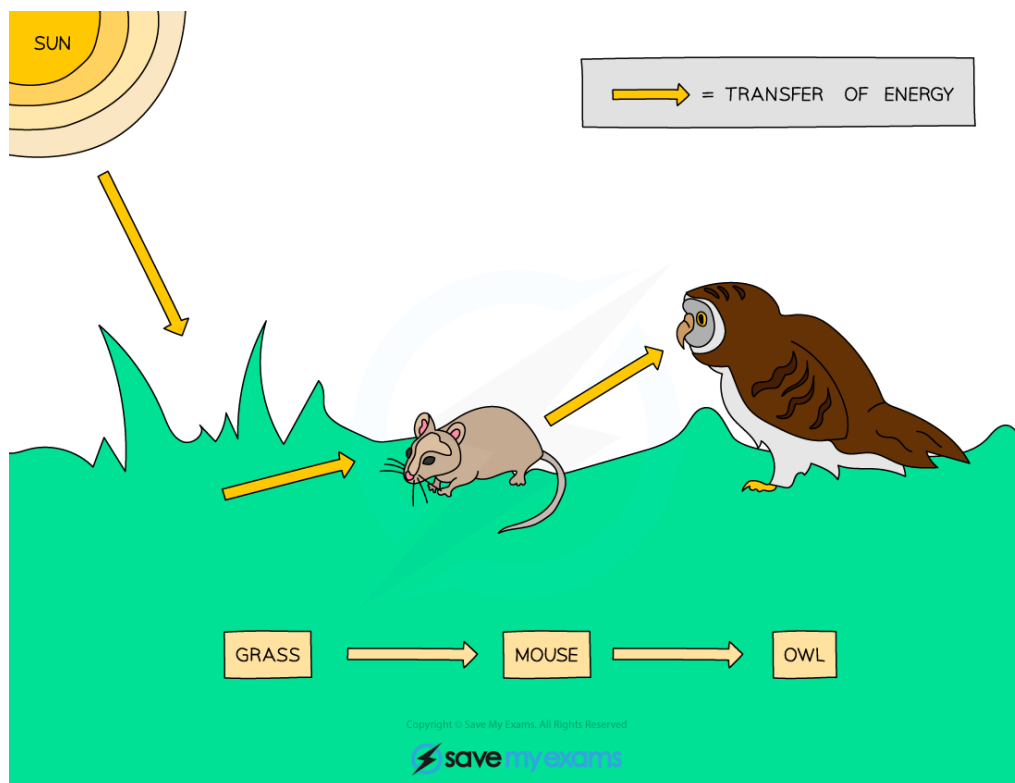


# Food Chains & Food Webs

TERM	DEFINITION
PRODUCERS	ORGANISMS THAT PRODUCE THEIR OWN ORGANIC NUTRIENTS USUALLY USING ENERGY FROM SUNLIGHT. PLANTS ARE PRODUCERS AS THEY CARRY OUT PHOTOSYNTHESIS TO MAKE GLUCOSE
HERBIVORE	AN ANIMAL THAT GETS ITS ENERGY BY EATING PLANTS
CARNIVORE	AN ANIMAL THAT GETS ITS ENERGY BY EATING OTHER ANIMALS
PRIMARY CONSUMERS	HERBIVORES – THEY FEED ON PRODUCERS (PLANTS)
SECONDARY CONSUMERS	PREDATORS THAT FEED ON PRIMARY CONSUMERS
TERTIARY CONSUMERS	PREDATORS THAT FEED ON SECONDARY CONSUMERS
DECOMPOSERS	BACTERIA AND FUNGI THAT GET THEIR ENERGY FROM FEEDING OFF DEAD AND DECAYING ORGANISMS AND UNDIGESTED WASTE (SUCH AS FAECES) BY SECRETING ENZYMES TO BREAK THEM DOWN



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### A food chain with three trophic levels

- A food chain shows the transfer of energy from one organism to the next, starting with a producer
- The source of all energy in a food chain is **light energy from the Sun**
- The arrows in a food chain show the **transfer of energy** from one trophic level to the next
- Energy is transferred from one organism to another by ingestion (eating)
- In the food chain above:

Food chain example table

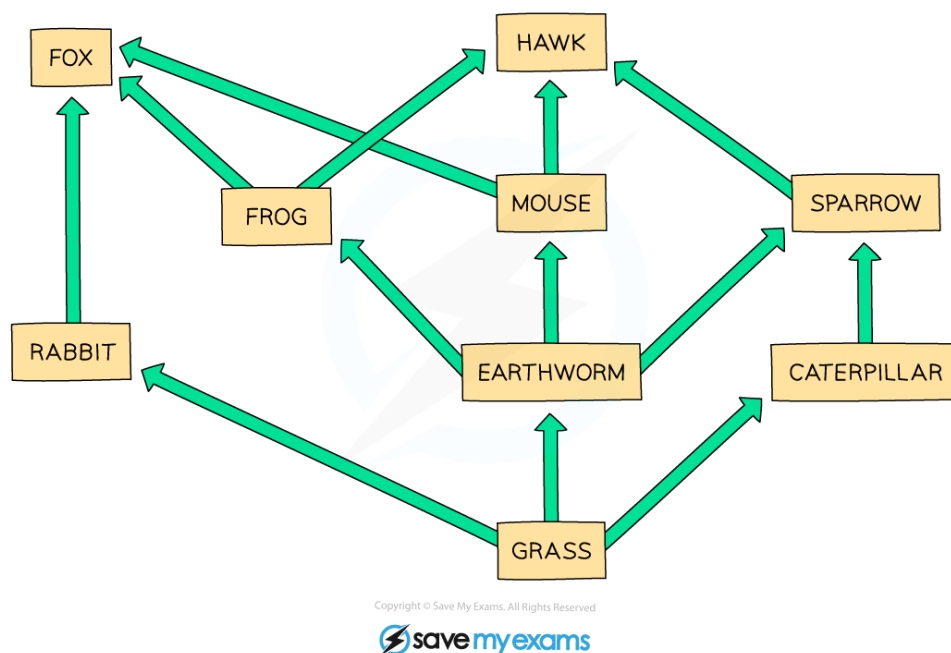
Position in food chain	Organism	Explanation
Producer	Grass	Makes its own food using energy from sunlight in photosynthesis
Primary consumer	Mouse	Eats the producer
Secondary consumer	Barn owl	Eats the primary consumer

## Food Webs

- A **food web** is a network of interconnected food chains
- Food webs are more realistic ways of showing connections between organisms within an ecosystem as **animals rarely exist on just one type of food source**



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#### ***A food web shows the interdependence of organisms***

- Food webs give us a lot more information about the transfer of energy in an ecosystem
- They also show **interdependence** - how the change in one population can affect others within the food web
- For example, in the food web above, if the **population of earthworms decreased**:
  - The population of **grass plants would increase** as there are now fewer species feeding off them
  - The populations of **frogs and mice would decrease significantly** as earthworms are their only food source
  - The population of **sparrows would decrease slightly** as they eat earthworms but also have another food source to rely on (caterpillars)
- Most of the changes in populations of animals and plants happen as a result of **human impact** - either by **overharvesting of food species** or by the **introduction of foreign species to a habitat**
- Due to interdependence, these can have **long-lasting knock-on effects** to organisms throughout a food chain or web



## Examiner Tips and Tricks

Questions about interdependence in food webs are common and easy to gain marks on if you answer them fully and correctly.

Do not say an animal or plant would 'die out' as this is unlikely to happen – stick to using the words decrease or increase. If in doubt, always give your reason for the increase or decrease in population.

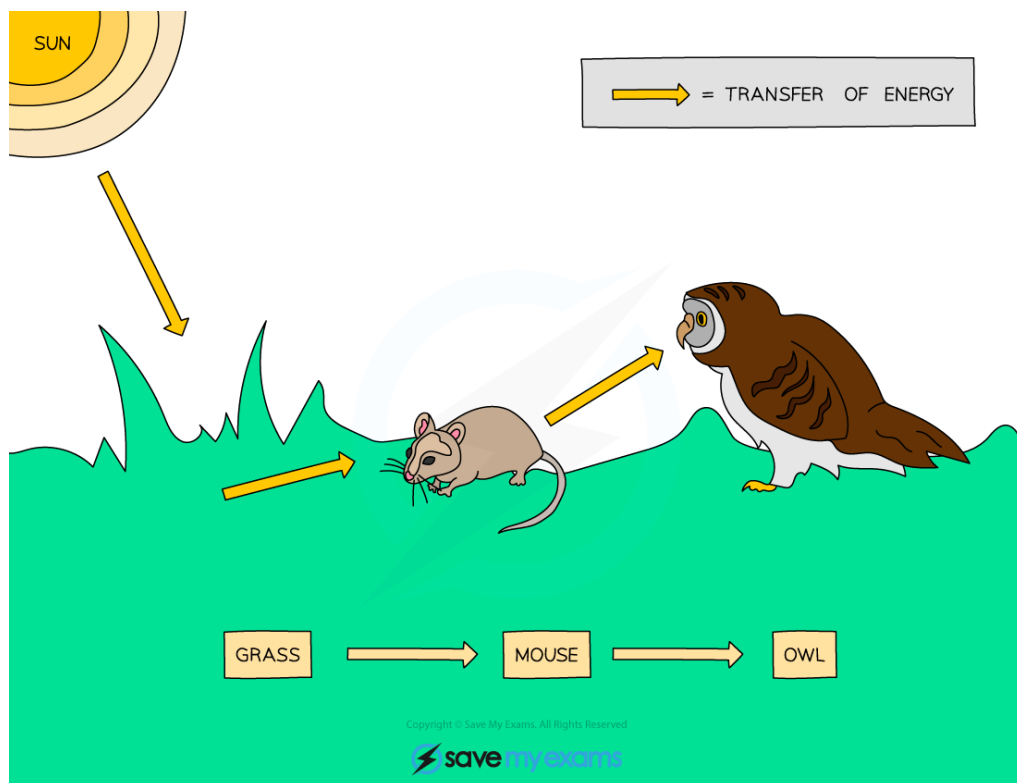


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# Pyramids of Numbers

- A pyramid of numbers shows **how many organisms** are present at each level of a food chain.
- The **width of the box** indicates the **number of organisms** at that trophic level
- For example, consider the following food chain:

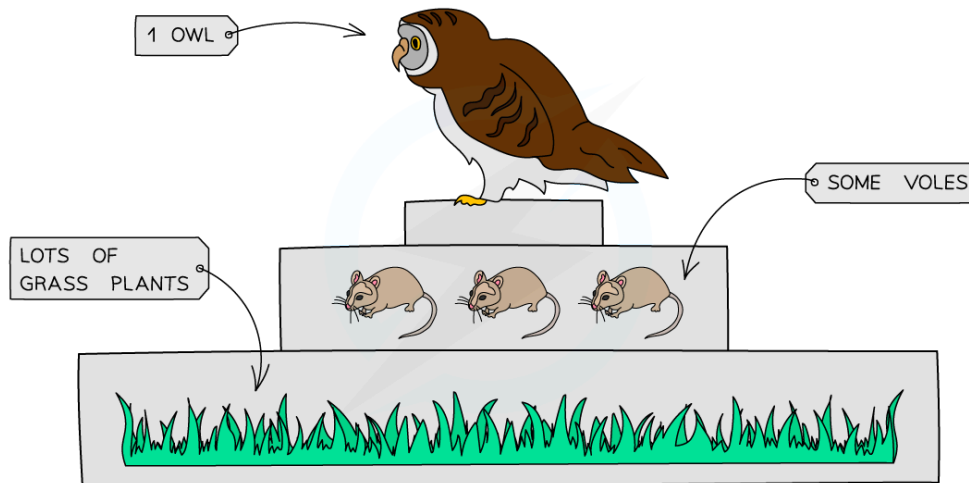


***A food chain shows the transfer of energy***

- A pyramid of numbers for this food chain would look like this:



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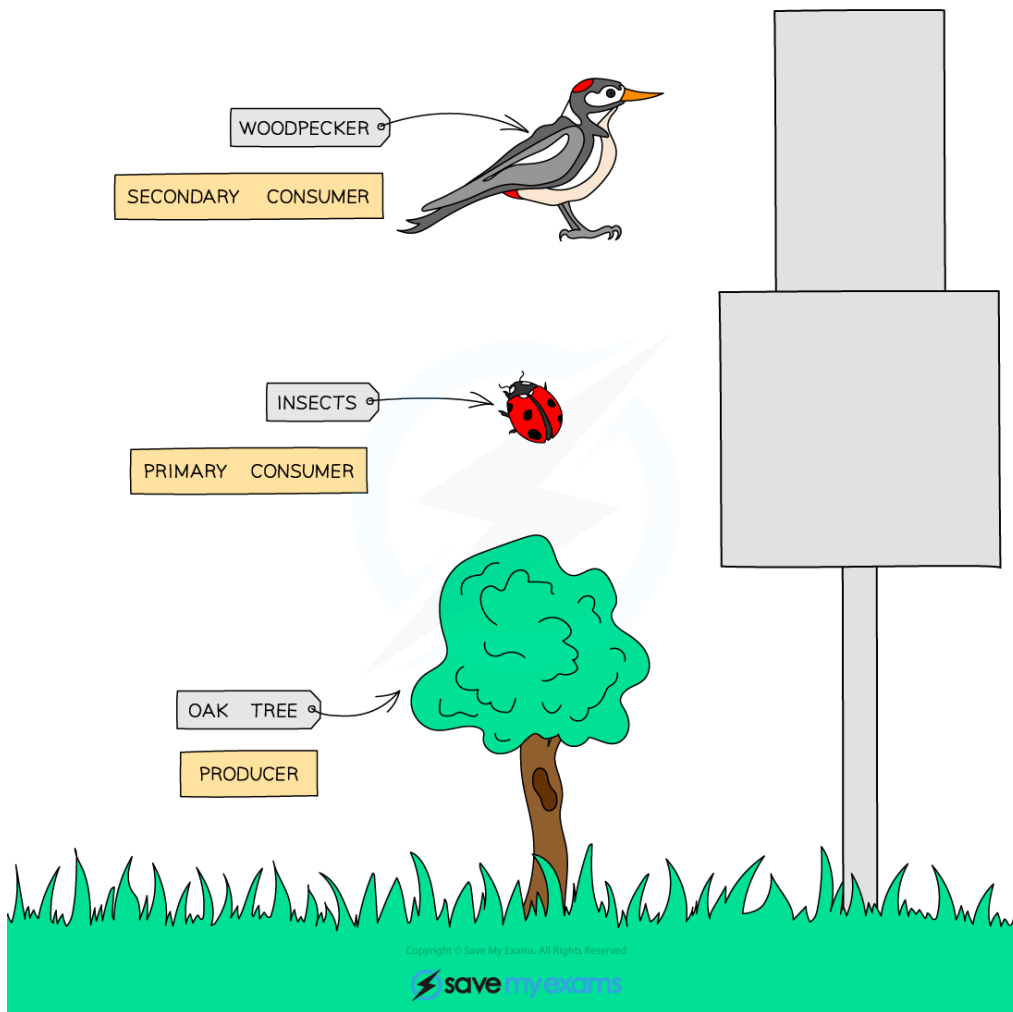


### *A pyramid of numbers*

- A pyramid of numbers **doesn't always have to be pyramid-shaped**; this is because the **size of the organism is also important**
  - One large organism, like the oak tree in the pyramid below, contains enough energy to support many smaller organisms



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*Pyramids of numbers are not always pyramid-shaped*

## Rules to remember when drawing a pyramid of numbers

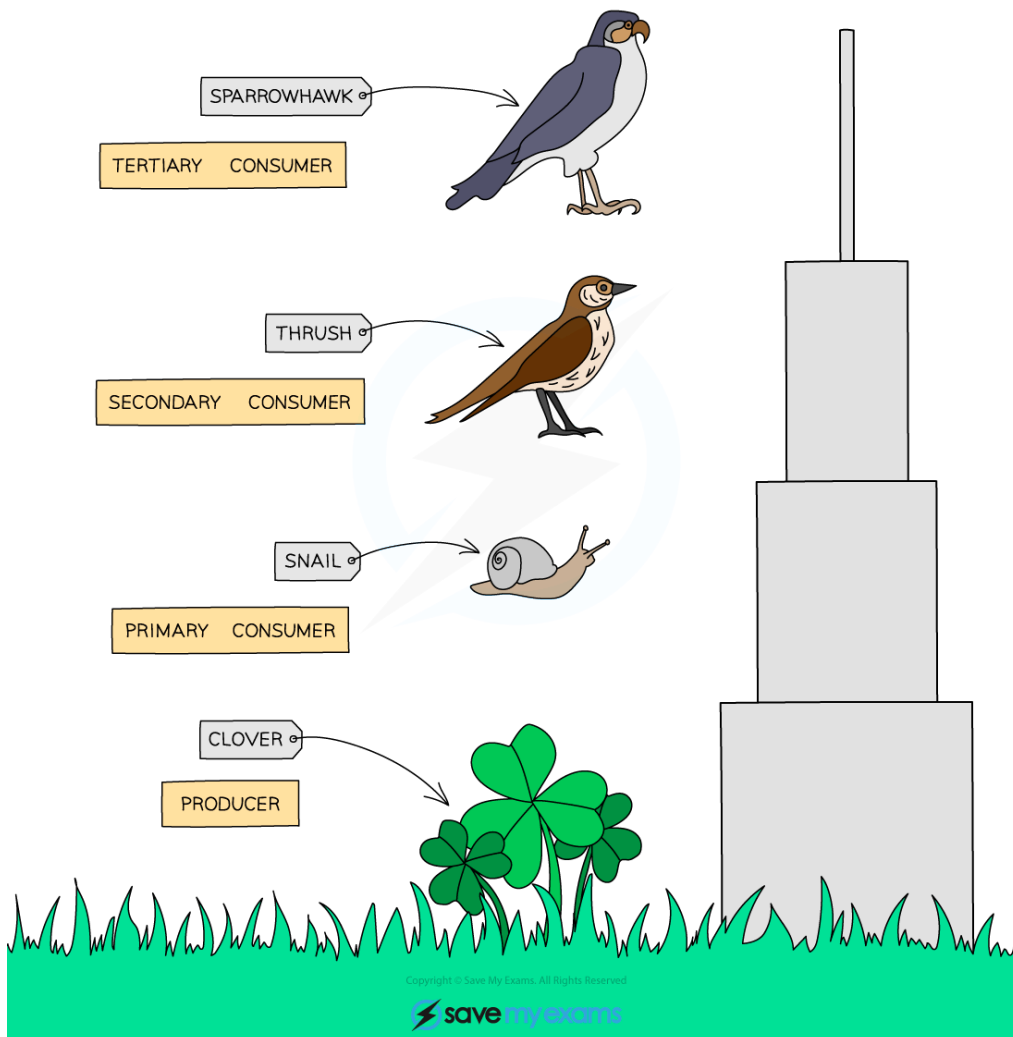
- You **cannot change the trophic level of the organisms** - they must stay in the same order as in the food chain:
  - producers on the bottom,
  - followed by primary consumers,
  - then secondary consumers,
  - then tertiary consumers
- Each bar should be **labelled** with its trophic level
- If graph paper is provided then the pyramid should be **drawn to scale**
- Generally, the **larger an individual organism is, the fewer individuals** there will be

# Pyramids of Biomass



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- A pyramid of biomass shows **how much living matter** is present at each trophic level of a food chain
  - Biomass is often a measure of the dry mass of an organism, once the water has been removed from the tissues
- Pyramids of biomass are **always pyramid-shaped**, regardless of what the pyramid of numbers for that food chain looks like
- This is because the **mass of organisms decreases as you go up a food chain**



**A pyramid of biomass**

- It can be advantageous to use a pyramid of biomass rather than a pyramid of numbers because:
  - pyramids of biomass **take into account the size of organisms** at each trophic level, so provide a more accurate representation of the living matter within an ecosystem

- energy is stored in biomass, so biomass can be used as an **approximate representation of the energy available** at each level of a food chain



### Examiner Tips and Tricks

Pyramids of number can be any shape, so make sure you learn the rules for drawing a pyramid of numbers as it is more common to see unusual shapes in the exam.

Pyramids of biomass are generally pyramid-shaped, so they are simpler to sketch. Some ecosystems, such as an aquatic ecosystem, may show a different shape or inverted pyramid but it is very unlikely you will see this in an exam.



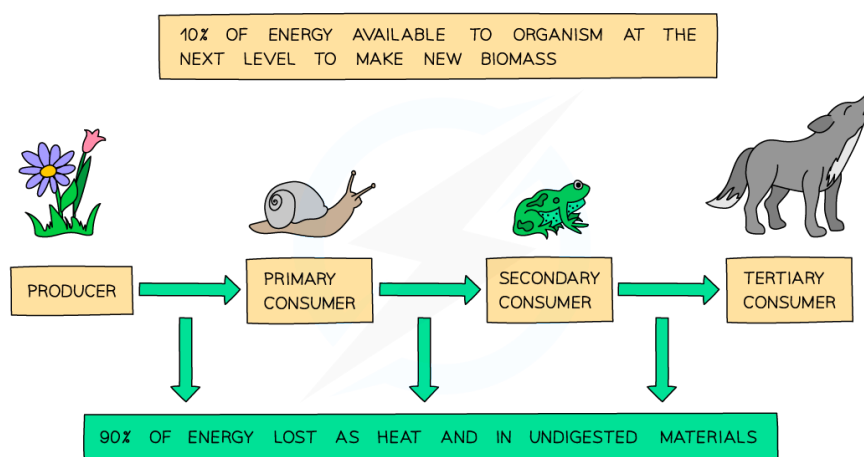
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# Pyramids of Energy: Extended

## Extended Tier Only

- The transfer of stored energy in food chains is not always efficient, and **energy is lost to the environment between each trophic level**; reasons for this inefficiency include:
  - not all of the stored energy consumed by an organism goes into making new cells that can be eaten; energy may instead be transferred to:
    - **excretion of metabolic waste**, e.g. urine that gets removed from the organism
    - **movement**
    - **heat**
  - few organisms eat or digest an entire organism, so any energy stored in the uneaten or undigested parts does not get passed on, e.g.
    - energy stored in **uneaten** parts, such as roots of plants, or bones of animals does not enter the consumer's body at all
    - **undigested waste** (faeces) is removed from the body and provides food for decomposers
- Only **around 10 %** of the energy stored at each trophic level is available to the next trophic level
- This inefficient transfer of energy at each trophic level explains why **food chains are rarely more than 5 organisms long**
  - In order to survive a consumer would have to eat a huge number of prey organisms every day to get the amount of energy needed; this is unlikely to be possible



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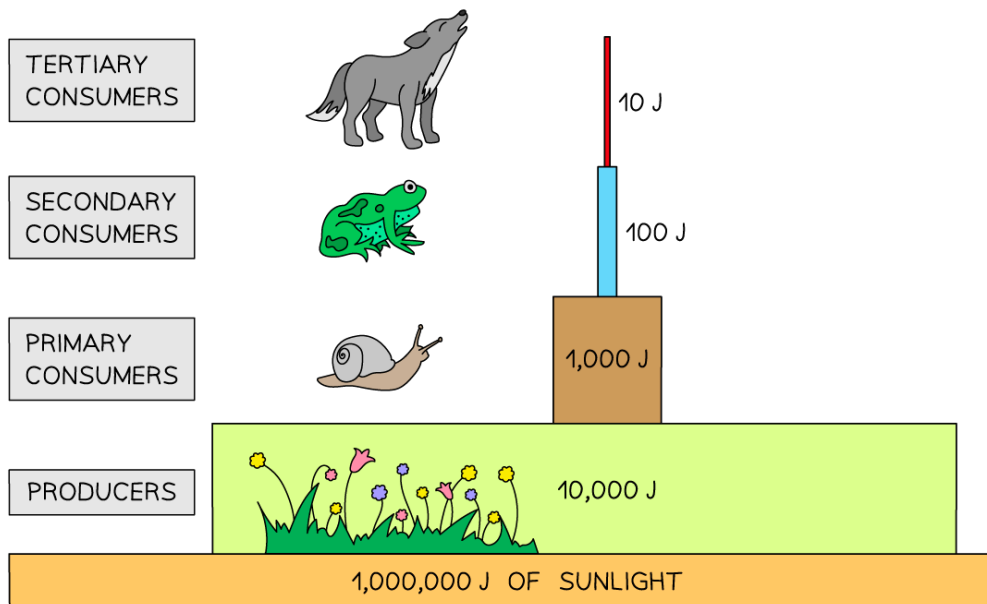


### Energy is lost at each trophic level



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- The energy stored at each trophic level can be represented visually in a **pyramid of energy**



- Pyramids of energy can have advantages over pyramids of biomass because:
  - they highlight the **energy lost** at each trophic level
  - different organisms may not all store the same amount of energy in their biomass, so pyramids of energy allow for **more accurate comparisons**

## Energy transfer in a human food chain

- Humans are **omnivores**, obtaining energy from both plants and animals, and this gives us a **choice of what we eat**
- These choices, however, have an **impact on what we grow** and how we use ecosystems
- Think of the following food chains, both involving humans:

wheat → cow → human

wheat → human

- Given what we know about **energy transfer in food chains**, it is clear that if humans eat the wheat there is **much more energy available** to them than if they eat the cows that eat the wheat
  - This is because **energy is lost from the cows**, so there is less available to pass on to humans
- Therefore, it is **more energy efficient for humans to be the herbivores rather than the carnivores**

- In reality, we often feed animals on plants that we cannot eat (e.g. grass) or that are too widely distributed for us to collect (e.g. algae in the ocean which form the food of fish we eat), so the situation is more complex than for the example shown above



### Examiner Tips and Tricks

Make sure you read the question carefully and tailor your answer to the specific organism you are being asked about – e.g. plants do not produce urine or faeces so you could not give this as one of the ways in which they transfer energy to the environment!



Your notes

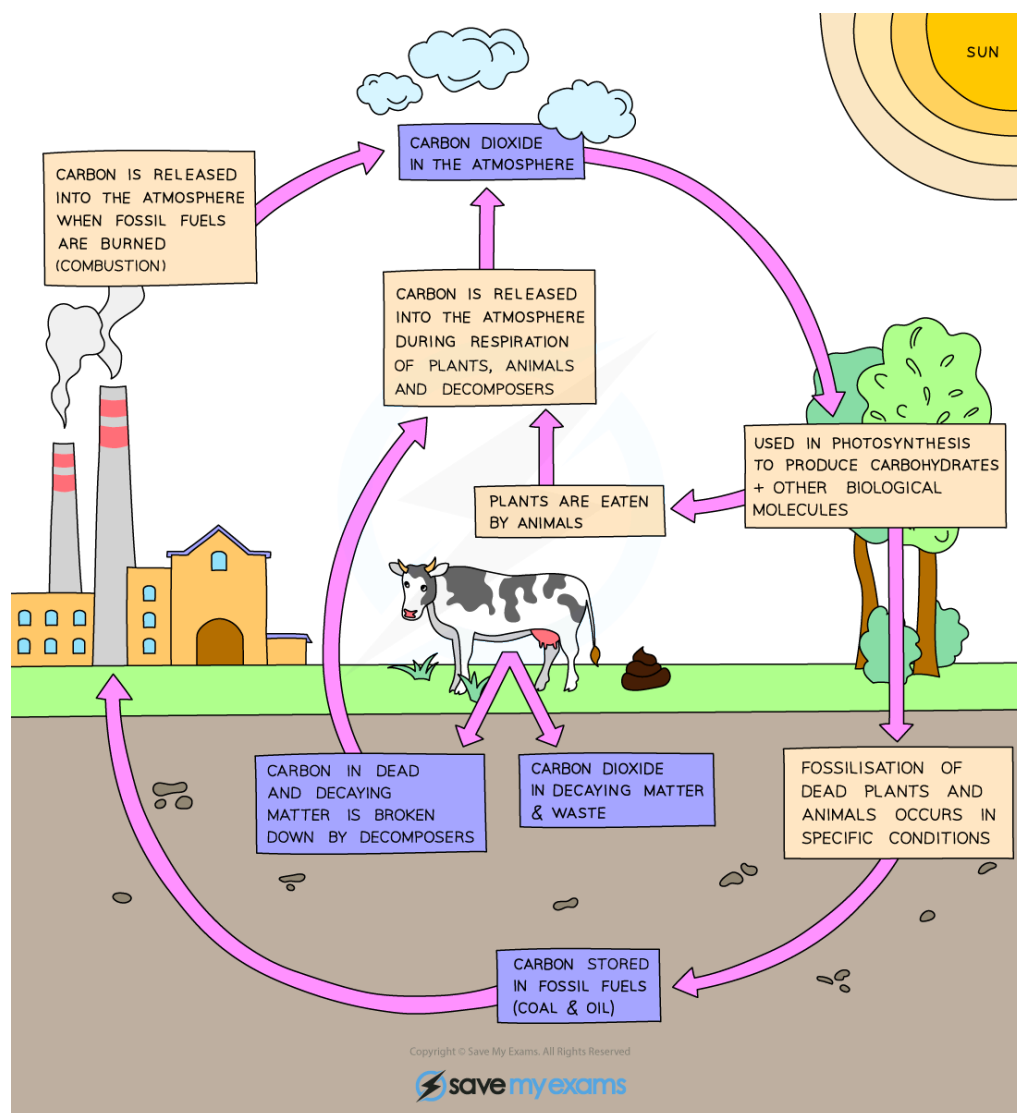


# The Carbon Cycle

- Nutrients such as carbon and nitrogen are not endless resources
- There is a finite amount of each element on the planet and as such, they need to be **recycled** in order to allow new organisms to be made and grow
- **Carbon** is taken out of the atmosphere in the form of **carbon dioxide** by plants to be used for photosynthesis
- It is passed on to animals (and microorganisms) by **feeding**
- It is returned to the atmosphere in the form of **carbon dioxide** by plants, animals and microorganisms as a result of **respiration**
- If animals and plants die in conditions where decomposing microorganisms are not present the carbon in their bodies can be converted, over millions of years and significant pressure, into **fossil fuels**
- When fossil fuels are burned (the process is known as **combustion**), the carbon combines with oxygen and **carbon dioxide is released** into the atmosphere
- **Increased use of fossil fuels** is contributing to an increase in the carbon dioxide content of the atmosphere
- In addition, **mass deforestation** is **reducing the amount of producers** available to take carbon dioxide out of the atmosphere by photosynthesis
- This problem is exacerbated by the fact that in many areas of the world, deforestation is taking place for land rather than for the trees themselves, and as such they are **burnt down, releasing yet more carbon dioxide into the atmosphere**



Your notes



### The Carbon Cycle



#### Examiner Tips and Tricks

The carbon cycle is simple:

- Carbon is taken out of the atmosphere by photosynthesis
- It is passed on to animals and decomposers by feeding
- It is returned by respiration; in plants, in animals and in decomposing microorganisms

In addition, it is returned (in increasing amounts) by combustion of fossil fuels. You should be able to identify what each arrow represents in any diagram of the carbon cycle.

# The Nitrogen Cycle: Extended

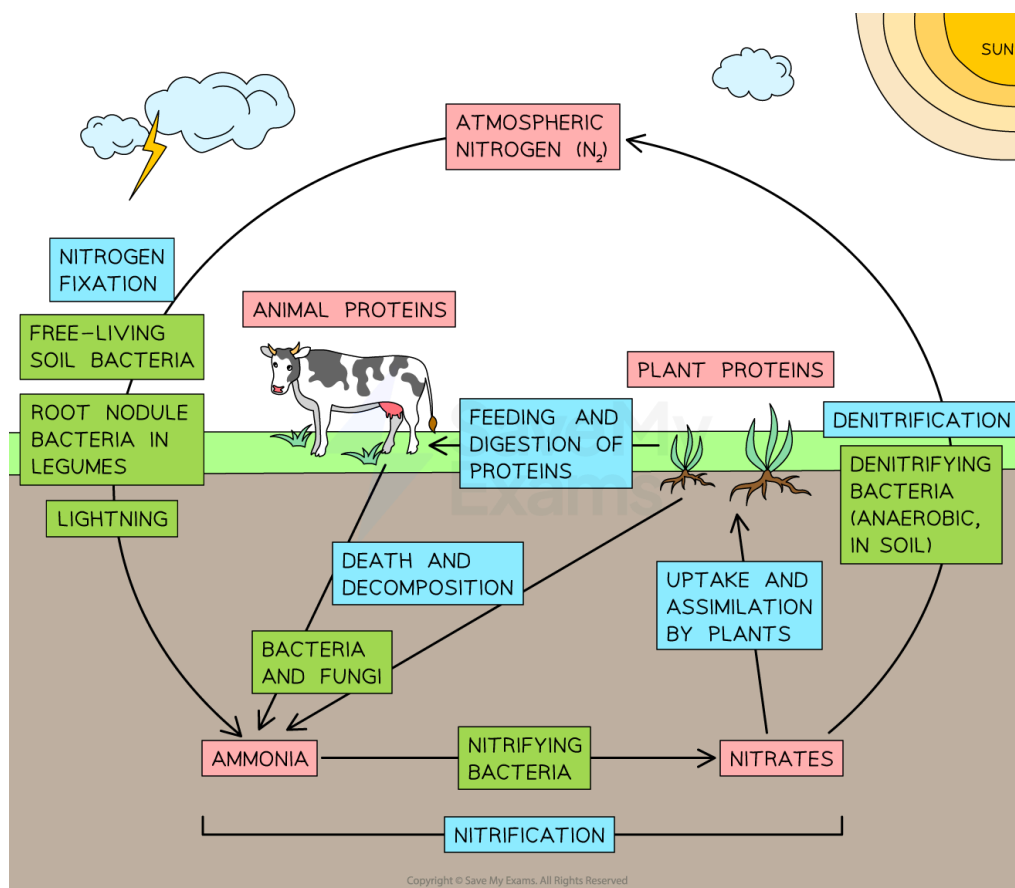


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- **Nitrogen** as an element is required to make proteins
- Neither plants nor animals can **absorb it from the air** as  $N_2$  gas is very stable and cannot be easily broken down
- Two ways that Nitrogen gas in the air can be converted into a usable form are:
  - **Nitrogen fixing bacteria** convert  $N_2$  gas into ammonium compounds, which can then be converted to usable **nitrates**
    - Nitrogen fixing bacteria can be free-living in the soil or can live within the root nodules of some plants
  - **Lightning** can split the bond between the two N atoms, turning them into nitrous oxide  $N_2O$  and nitrous dioxide  $NO_2$  that dissolve in rainwater and leach into the soil
- Plants absorb nitrogen from the soil in the form of **nitrates** and use it to build proteins
- Animals **eat** the plants and get the nitrogen they need from the plant proteins
  - This nitrogen is **passed up the food chain** when secondary consumers eat primary consumers, etc.
- **Waste** (urine and faeces) from animals sends nitrogen back into the soil in the form of ammonium compounds
  - E.g. the urea in urine contains nitrogen
- The bodies of dead plants and animals **decay** and all the proteins inside them are broken down into ammonium compounds by decomposers
- The plants can't absorb ammonium compounds, so **nitrifying bacteria** convert the ammonium compounds to nitrites and then to nitrates, which can then be absorbed by plants – and so the cycle goes on
- **Denitrifying bacteria** take nitrates **out of the soil** and convert them back into  $N_2$  gas
  - This process **reduces soil fertility** and is bad for plant growth
  - Denitrifying bacteria are anaerobic so aerating the soil, e.g. by reducing waterlogging and turning over the soil during ploughing, can reduce the rate of denitrification



Your notes



The nitrogen cycle involves nitrogen fixation, decomposition, nitrification and denitrification



# Definition of Population

- A population is defined as **a group of organisms of one species, living in the same area at the same time**

## Other important definitions

- A community is defined as **all of the populations of different species in an ecosystem**
- An ecosystem is defined as **a unit containing the community of organisms and their environment, interacting together** (eg a decomposing log, a lake)

# Population Growth

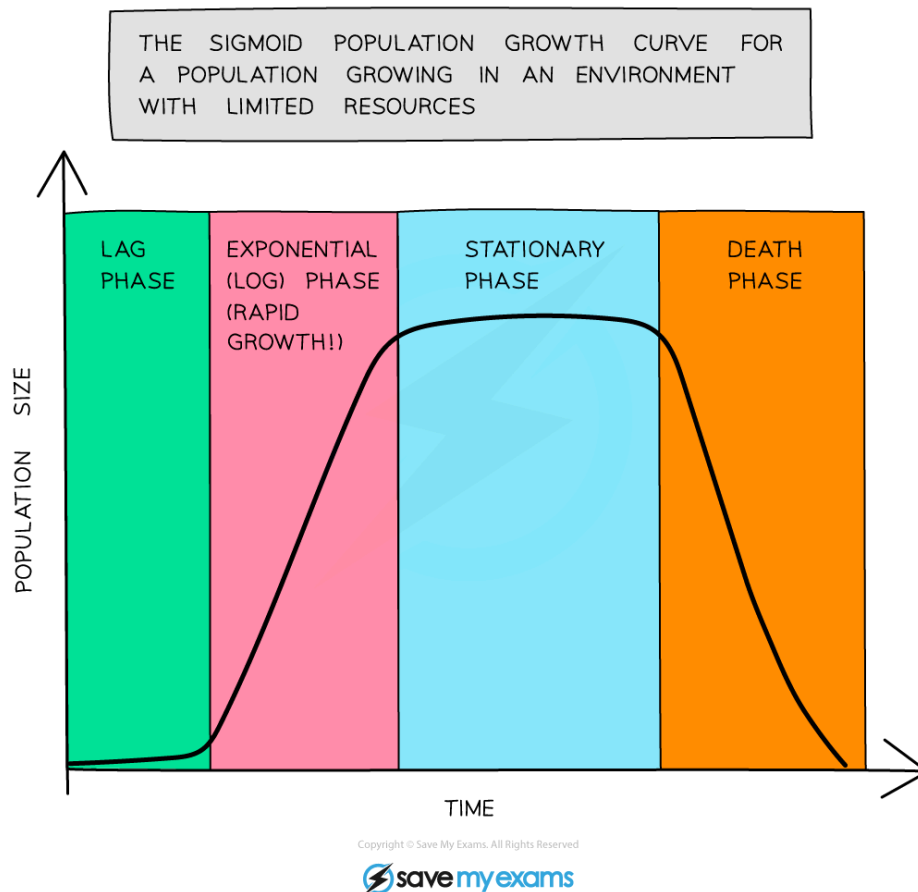
- All living organisms compete with each other for **food, water and living space**
- Those which are the best adapted to their environments generally increase their populations at the expense of those less well adapted
- Population growth in most organisms is controlled by the following three factors:
  - **Food supply**
  - **Predation**
  - **Disease**

# The Population Growth Curve: Extended

- If the growth of **microorganisms in a fermenter** is measured over time, the population growth looks like the graph below



Your notes



#### *A typical growth curve for a population in an enclosed environment*

- The shape of this curve (a little like an 'S'), gives it its name - a **sigmoid growth curve**
- The curve has four distinct phases:
  - **Lag phase** - organisms are **adapting to the environment** before they are able to reproduce; in addition, at this stage there are very few organisms and so reproduction is not producing larger numbers of offspring
  - **Log phase** (aka **exponential phase**) - **food supply is abundant**, **birth rate is rapid** and **death rate is low**; **growth is exponential** and only limited by the number of new individuals that can be produced
  - **Stationary phase** - population **levels out** due to a **factor in the environment**, such as a nutrient, **becoming limited** as it is not being replenished; birth rate and death rate are equal and will remain so until either the nutrient is replenished or becomes severely limited
  - **Death phase** - population **decreases** as death rate is now greater than birth rate; this is usually because **food supply is short** or **metabolic wastes produced by the population have built up to toxic levels**
- Organisms in a natural environment are **unlikely to show population growth like a sigmoid growth curve** because they are affected by many other factors, including:

- **changing temperature or light**
- **predators**
- **disease**
- **immigration** (individuals moving into the area)
- **emigration** (individuals moving out of the area)



Your notes