19 ORGANISMS & THEIR ENVIRONMENT

YOUR NOTES

CONTENTS:

19.1 FOOD CHAINS & WEBS

Types of Variation

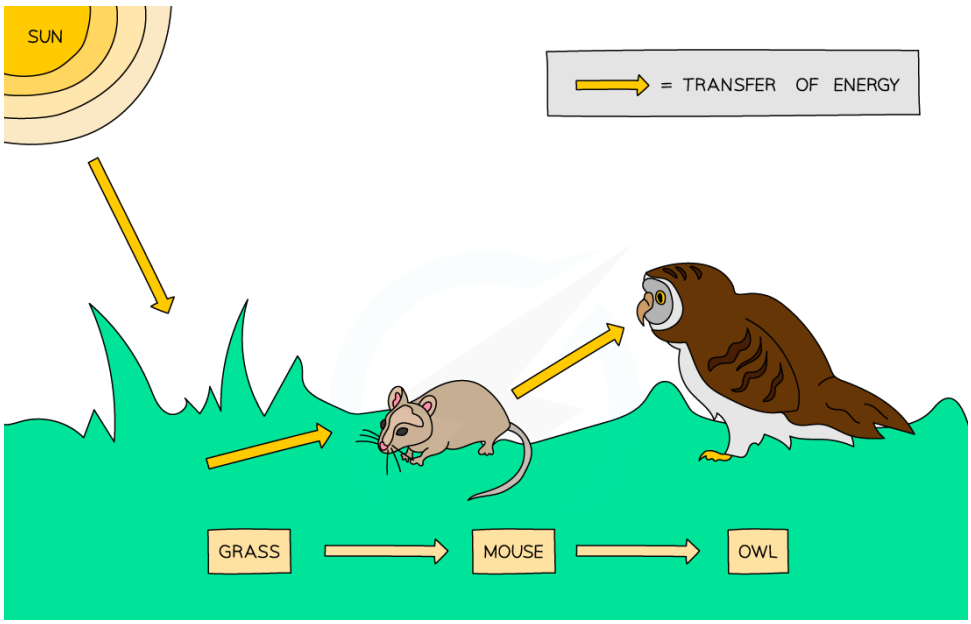
TERM	DEFINITION
PRODUCERS	ORGANISMS THAT PRODUCE **THEIR OWN ORGANIC NUTRIENTS USUALLY USING ENERGY FROM SUNLIGHT.** PLANTS ARE PRODUCERS AS THEY CARRY OUT PHOTOSYNTHESIS TO MAKE GLUCOSE
HERBIVORE	AN ANIMAL THAT GETS ITS ENERGY BY **EATING PLANTS**
CARNIVORE	AN ANIMAL THAT GETS ITS ENERGY BY **EATING 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

19 ORGANISMS & THEIR ENVIRONMENT

19.1 FOOD CHAINS & WEBS cont...

YOUR NOTES

Food Chains



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:

POSITION IN FOOD CHAIN	ORGANISM	EXPLANATION
PRODUCER	GRASS SEED	MAKES ITS OWN FOOD USING ENERGY FROM SUNLIGHT IN PHOTOSYNTHESIS
PRIMARY CONSUMER	VOLE	EATS THE PRODUCER
SECONDARY CONSUMER	BARN OWL	EATS THE PRIMARY CONSUMER

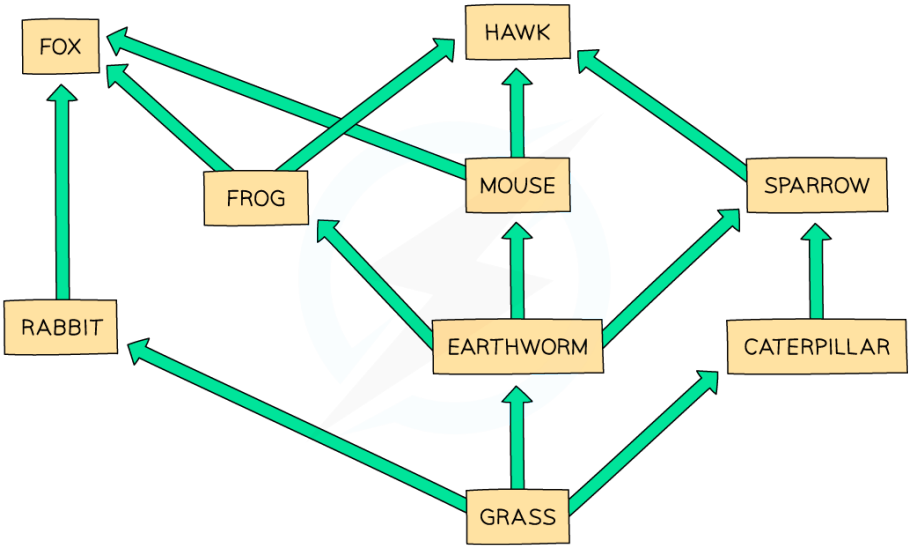
19 ORGANISMS & THEIR ENVIRONMENT

19.1 FOOD CHAINS & WEBS cont...

YOUR NOTES

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**



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 insects decreased**:
  - The population of **grass plants would increase** as there are now less species feeding off them
  - The populations of **frogs and voles would decrease significantly** as insects are their only food source
  - The population of **thrushes would decrease slightly** as they eat insects but also have another food source to rely on (slugs)
- 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 **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

19 ORGANISMS & THEIR ENVIRONMENT

19.1 FOOD CHAINS & WEBS cont...

YOUR NOTES

EXAM TIP

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.

19.2 ENERGY

Trophic Levels

- Trophic levels describe the **position of an organism in a food chain, web or pyramid**
- Animals (known as consumers) can be at **different trophic levels within the same food web** as they may eat both primary, secondary and / or tertiary consumers
- Energy flows from the sun to the first trophic level (producers) in the form of **light**
- **Producers** convert **light energy into chemical energy** and it flows in this form from one consumer to the next
- Eventually **all energy is transferred to the environment** – energy is passed on from one level to the next with some being used and lost at each stage
- Energy flow is a **non-cyclical process** – once the energy gets to the top of the food chain or web, **it is not recycled but 'lost' to the environment**
- This is in **direct contrast** to the chemical elements that organisms are made out of, which are repeatedly recycled

TROPHIC LEVEL	REASON
PRODUCERS	THEY **PRODUCE THEIR OWN ORGANIC NUTRIENTS USUALLY USING ENERGY FROM SUNLIGHT**
PRIMARY CONSUMERS	HERBIVORES – THEY **FEED ON PRODUCERS** (PLANTS)
SECONDARY CONSUMERS	PREDATORS THAT **FEED ON PRIMARY CONSUMERS**
TERTIARY CONSUMERS	PREDATORS THAT **FEED ON SECONDARY CONSUMERS**
QUATERNARY CONSUMERS	PREDATORS THAT **FEED ON TERTIARY CONSUMERS**

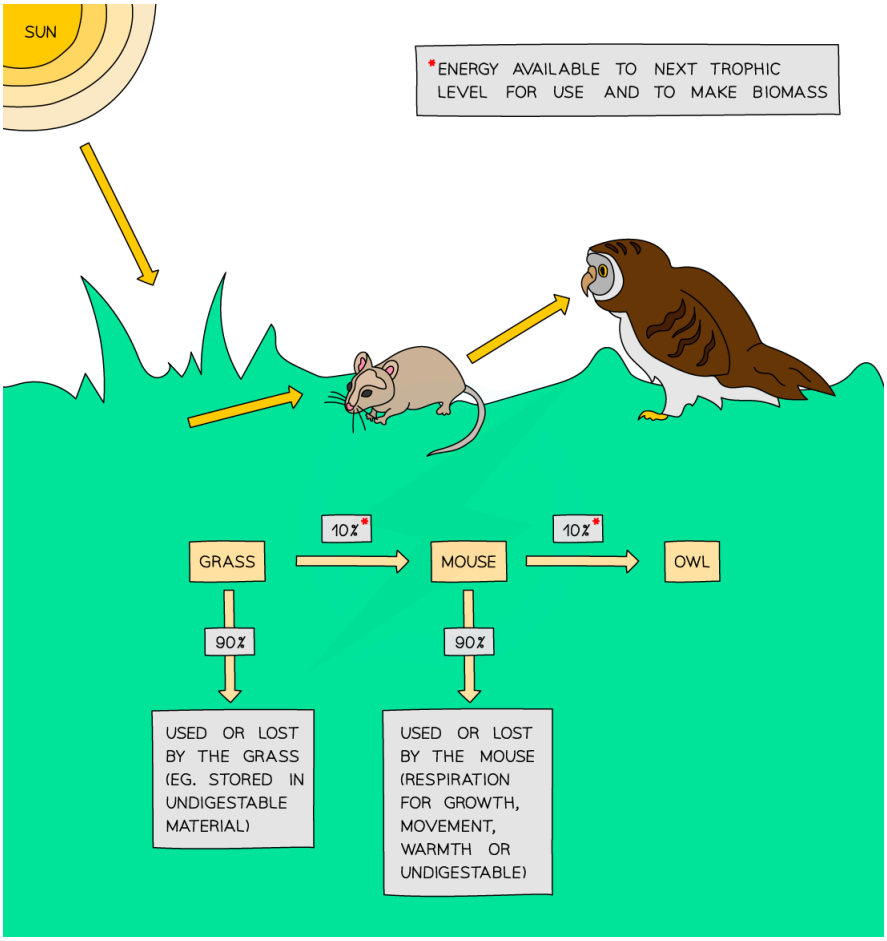
19 ORGANISMS & THEIR ENVIRONMENT

19.2 ENERGY cont...

YOUR NOTES

Transfer of Energy

- At each stage in a food chain only about **10% of the energy received by an organism gets passed on** to the next trophic level:



Energy transfer through a food chain

Why is this?

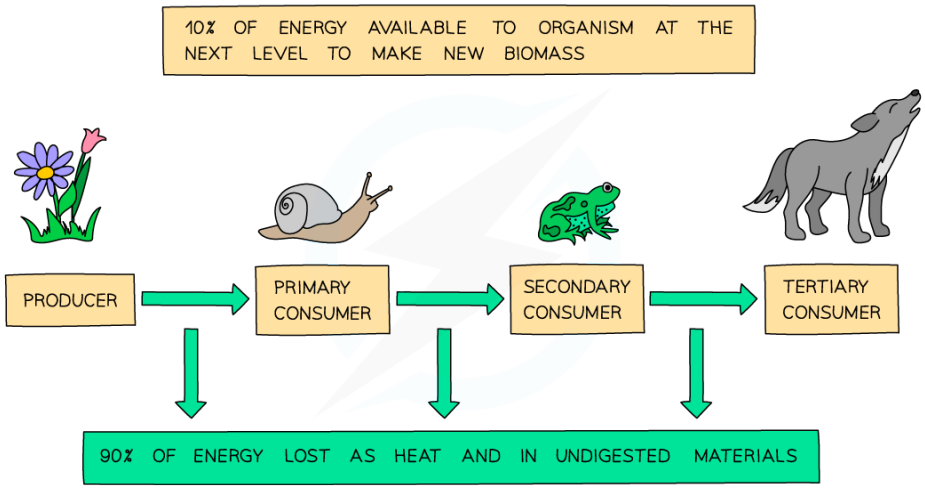
- In order for the energy to be passed on, **it has to be consumed (eaten)**
- However **not all of the energy grass plants receive goes into making new cells** that can be eaten
- The same goes for the energy the vole gets from the grass, and the energy the barn owl gets from the vole
- **Only the energy that is made into new cells remains with the organism to be passed on**
- Even then, some of this energy **does not get consumed** – for example few organisms eat an entire organism, including roots of plants or bones of animals – but **energy is still stored in these parts and so it does not get passed on**

19 ORGANISMS & THEIR ENVIRONMENT

19.2 ENERGY cont...

YOUR NOTES

- The majority of the energy an organism receives gets 'lost' (or 'used') through:
  - **making waste products** eg (urine) that get removed from the organism
  - **as movement**
  - **as heat** (in mammals and birds that maintain a constant body temperature)
  - **as undigested waste** (faeces) that is removed from the body and provides food for decomposers
- This inefficient loss of energy at each trophic level explains why **food chains are rarely more than 5 organisms long**
- In the example above, something that preyed regularly on the barn owl would only get 0.1J of energy from each barn owl it ate
- In order to survive, it would have to:
- eat a huge number of them every day to get the amount of energy it needed to survive (are there that many barn owls close together?)
- not expend much energy itself hunting them (is this likely?)



Energy is lost at each trophic level for several reasons

EXAM TIP

This is a complicated concept but by learning the main ways in which energy is lost between trophic levels, you will be able to answer most questions on this topic.

Read the question carefully and tailor your answer to the specific organism you are being asked about – eg plants do not produce urine or faeces so you could not give this as one of the ways in which they use energy that cannot be passed on!

19 ORGANISMS & THEIR ENVIRONMENT

YOUR NOTES

19.2 ENERGY cont...

Energy Transfer in Human Food Chains

- 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

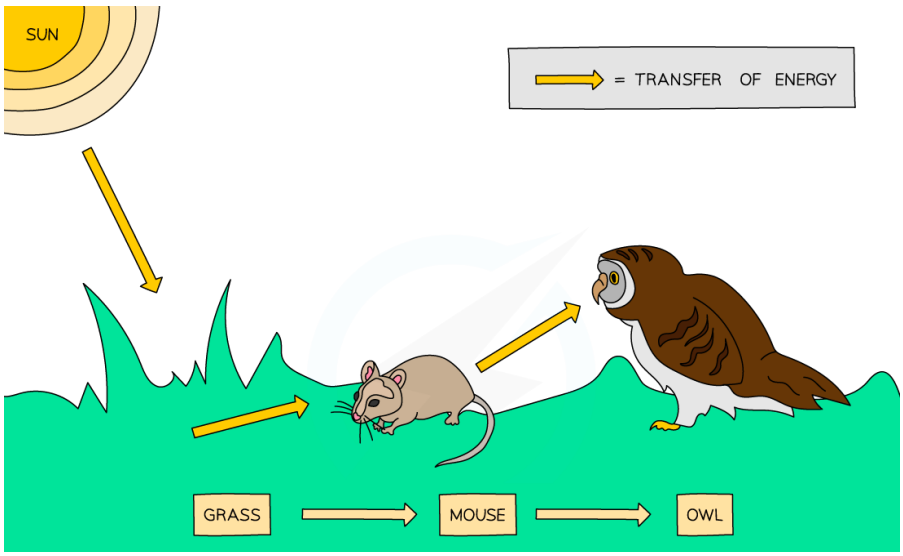
  wheat → human

- 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 within a crop food chain for humans to be the herbivores rather than the carnivores**
- In reality, we often feed animals on plants that we cannot eat (eg grass) or that are too widely distributed for us to collect (eg algae in the ocean which form the food of the fish we eat)

19.3 PYRAMIDS

Pyramids of Number

- A pyramid of numbers shows **how many organisms** we are talking about 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:



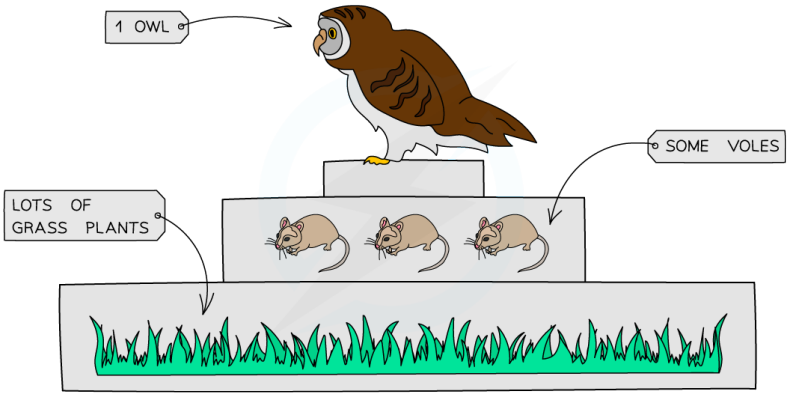
A food chain shows the transfer of energy

19 ORGANISMS & THEIR ENVIRONMENT

19.3 PYRAMIDS cont...

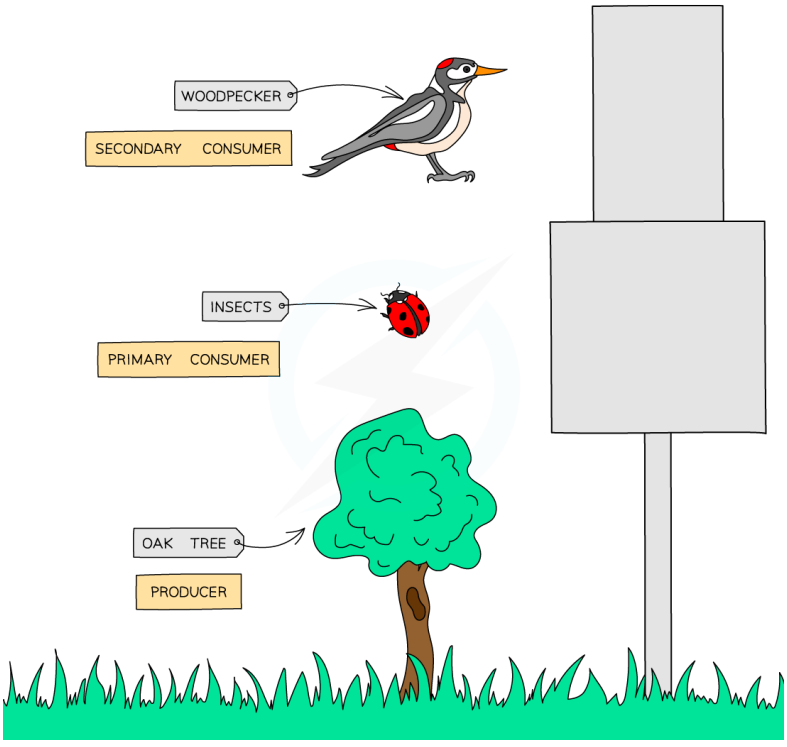
YOUR NOTES

- Ask yourself the following questions:
  - Is it likely that there would be more voles in an area than grass plants?
  - How many voles might one barn owl need to eat per day? If it's more than one, is it likely that there are more barn owls in an area than voles?
- So, a pyramid of numbers for this food chain would look like this:



A pyramid of numbers

- Despite the name (and the example above), a **pyramid of numbers doesn't always have to be pyramid-shaped**, for example:



Pyramids of numbers are not always pyramid-shaped

- This is because the **size of the organism is also important** – one large organism, like the oak tree in the pyramid above, contains enough energy to support many smaller organisms (the insects)

19 ORGANISMS & THEIR ENVIRONMENT

19.3 PYRAMIDS cont...

YOUR NOTES

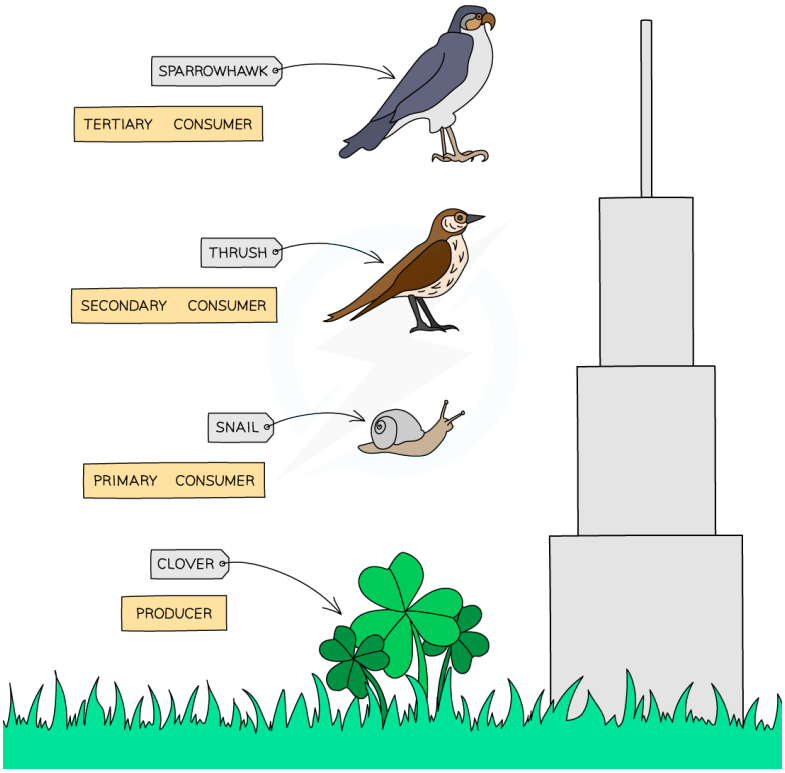
Rules to remember when drawing a pyramid of numbers:

- You **cannot change the trophic level of the organisms** – they must stay in the same order as in the food chain with producers on the bottom, followed by primary consumers, then secondary consumers, then tertiary consumers
- Generally, the **larger an individual organism is, the less of them there are**

EXTENDED ONLY

Pyramids of Biomass

- A pyramid of biomass shows **how much mass the creatures at each level would have without including all the water that is in the organisms** (their 'dry mass')
- 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 has to decrease as you go up a food chain** – if we take our first food chain as an example, it's impossible to have 10kg of grass feeding 50kg of voles feeding 100kg of barn owls



A pyramid of biomass

- Pyramids of biomass provide a much better idea of the **quantity** of the plant or animal material at each level of a food chain and therefore are a better way of representing interdependence within the food chain

19 ORGANISMS & THEIR ENVIRONMENT

19.3 PYRAMIDS cont...

YOUR NOTES

EXAM TIP

Remember that pyramids of biomass are ALWAYS pyramid-shaped, so they are easy to draw, but pyramids of number can be any shape.

Make sure you learn the rules for drawing a pyramid of numbers to get it correct.

19.4 NUTRIENT CYCLES

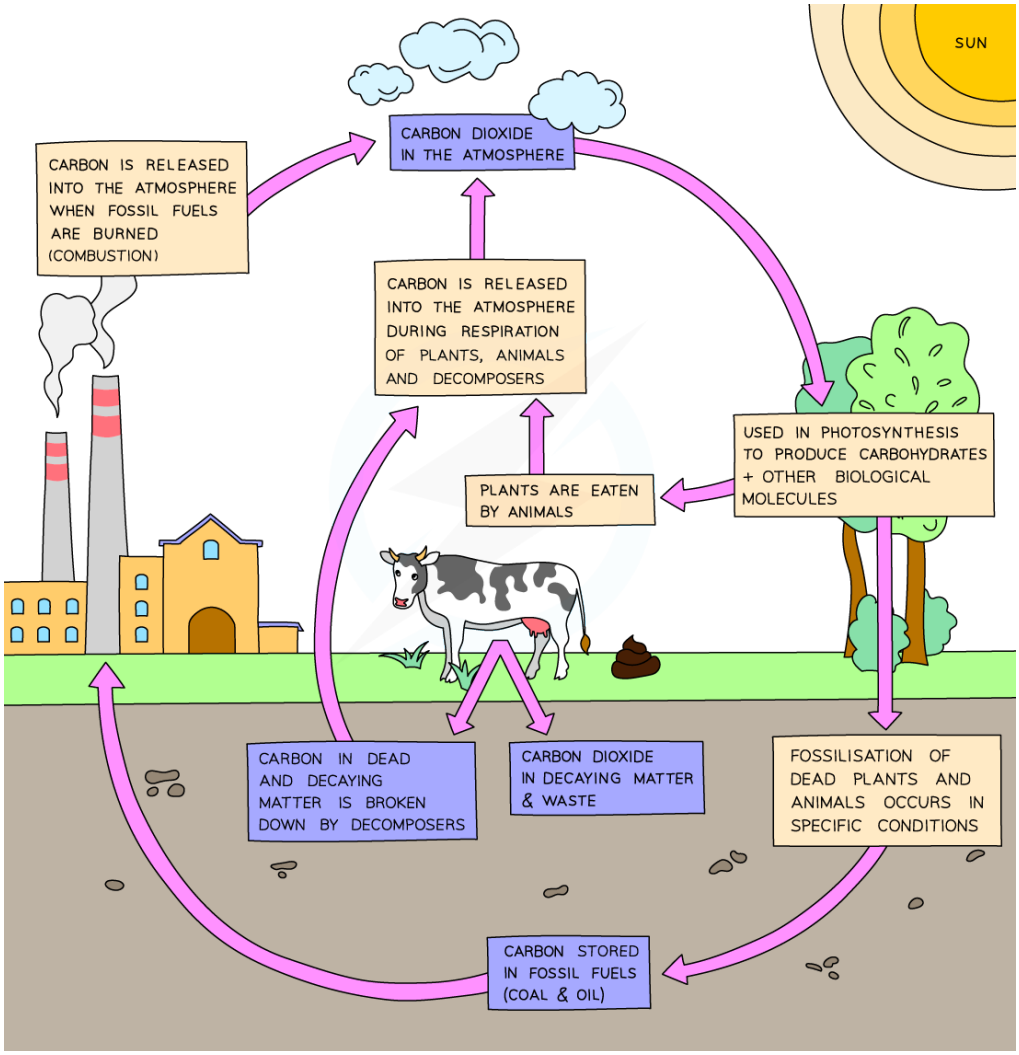
The Carbon Cycle

- 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**

19 ORGANISMS & THEIR ENVIRONMENT

19.4 NUTRIENT CYCLES cont...

YOUR NOTES



The carbon cycle

EXAM TIP

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

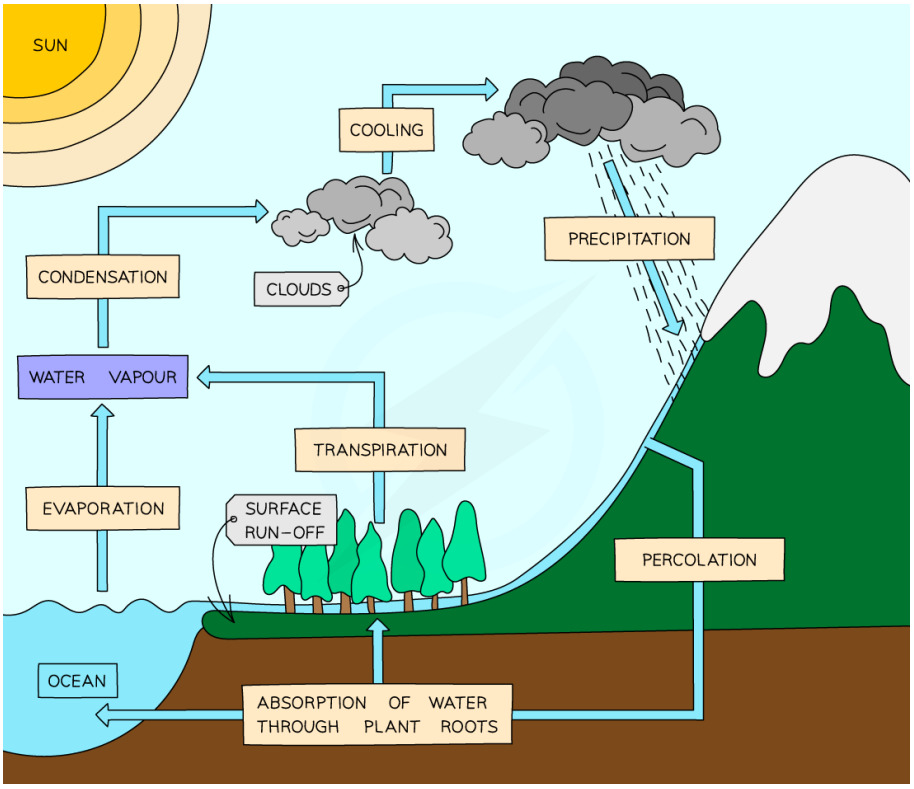
19 ORGANISMS & THEIR ENVIRONMENT

19.4 NUTRIENT CYCLES cont...

YOUR NOTES

The Water Cycle

- Water molecules move between various locations – such as rivers, oceans and the atmosphere – by specific processes
- This is possible because water changes state at a relatively low temperature



The water cycle

- **Water enters the atmosphere as water vapour in one of two processes:**
  - Energy from the Sun heats the Earth's surface and water **evaporates** from oceans, rivers and lakes
  - **Transpiration** from plants releases water vapour into the air
- **The warmer air of the lower atmosphere rises, taking the water vapour with it**
  - The moist air cools down as it rises
  - Water vapour **condenses** back into liquid water, forming **clouds**
- **Water returns to Earth in the form of precipitation**
  - As the water droplets in the cloud get **bigger and heavier**, they begin to fall as **rain, snow and sleet**
  - This is called precipitation

19 ORGANISMS & THEIR ENVIRONMENT

19.4 NUTRIENT CYCLES cont...

YOUR NOTES

EXAM TIP

Make sure you can **identify each of these processes on a diagram** as this is a common multiple choice question.

EXTENDED ONLY

The Nitrogen Cycle

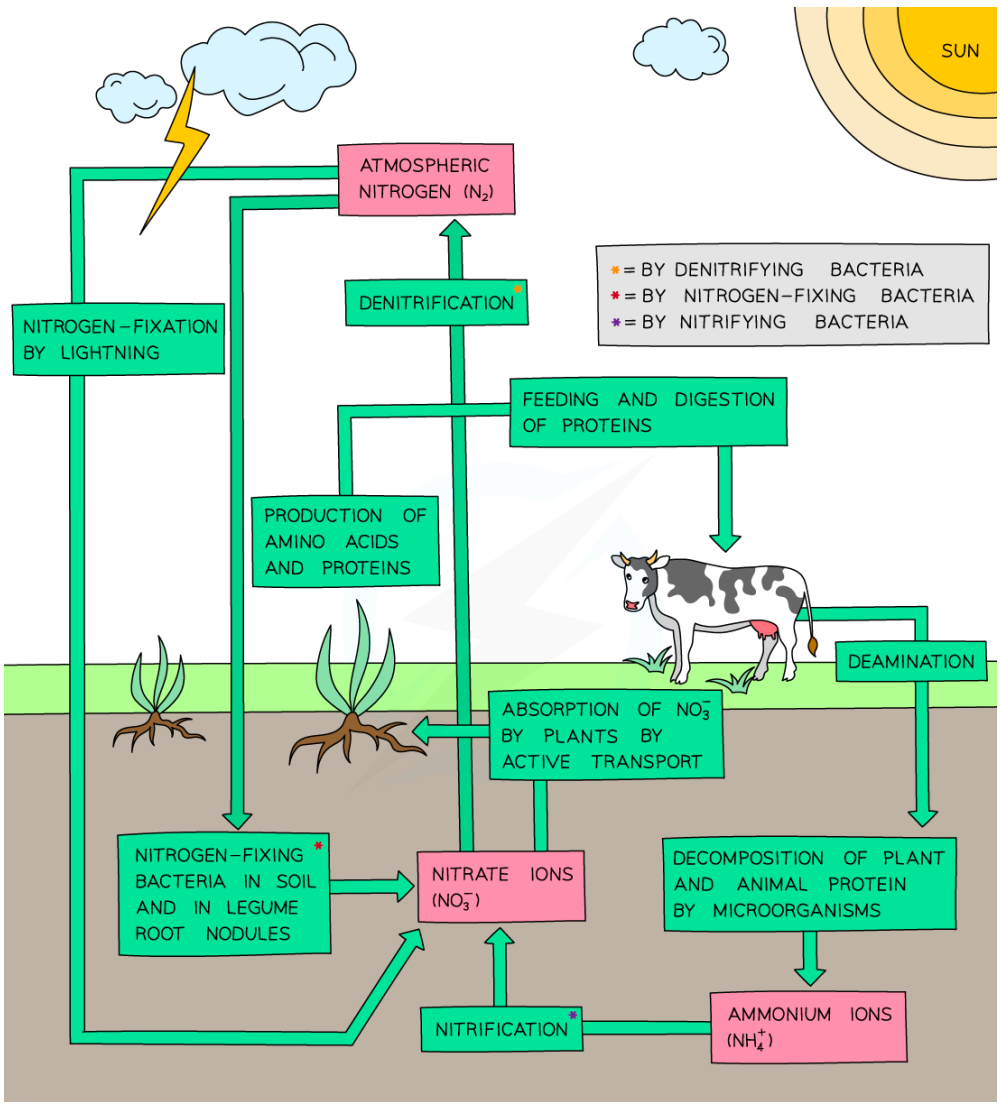
- **Nitrogen** as an element is required to make proteins
- **Neither plants nor animals can absorb it from the air** as N2 gas is very stable and the bonds holding the nitrogen atoms together would need massive amounts of energy to break (the two nitrogen atoms in a nitrogen molecule are held together by a triple covalent bond)
- However, there are two ways it can be taken out of the air and converted into something easier to absorb:
  - **Nitrogen fixing bacteria** found 'free living' in soil and also in the root nodules of certain plants (peas, beans, clover – we call them leguminous plants) take N2 gas and change it into nitrates in the soil
  - **Lightning can 'fix' N_2 gas**, splitting the bond between the two atoms and turning them into nitrous oxides like N_2O and NO_2 that dissolve in rainwater and 'leach' into the soil
- Plants absorb the **nitrates** they find in the soil and use the nitrogen in them to make proteins
- Animals **eat** the plants (or other animals) and get the nitrogen they need from the proteins in the plant or animal
- **Waste** (urine and faeces) from animals sends nitrogen back into the soil as ammonium compounds (the urea in urine contains nitrogen)
- When the animals and plants die, they **decay** and all the proteins inside them are broken down into ammonium compounds and put back into the soil by decomposers
- The plants can't absorb ammonium compounds though, so a second type of soil bacteria, **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
- Finally, there is a third, unhelpful type of (anaerobic) bacteria called **denitrifying bacteria** found in poorly aerated soil (ie not much oxygen)
- These bacteria take the nitrates **out of the soil** and convert them back into N_2 gas
- Farmers can help reduce the amount of these unhelpful bacteria by ploughing and turning over soil

19 ORGANISMS & THEIR ENVIRONMENT

19.4 NUTRIENT CYCLES cont...

YOUR NOTES

EXTENDED ONLY cont...



The nitrogen cycle

EXAM TIP

Students often find the nitrogen cycle quite difficult, but if you make an effort to **learn the three types of bacteria and what they do** it becomes much simpler.

19 ORGANISMS & THEIR ENVIRONMENT

19.5 POPULATIONS

YOUR NOTES

Definition of Population

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

EXTENDED ONLY

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)

Factors Affecting 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**

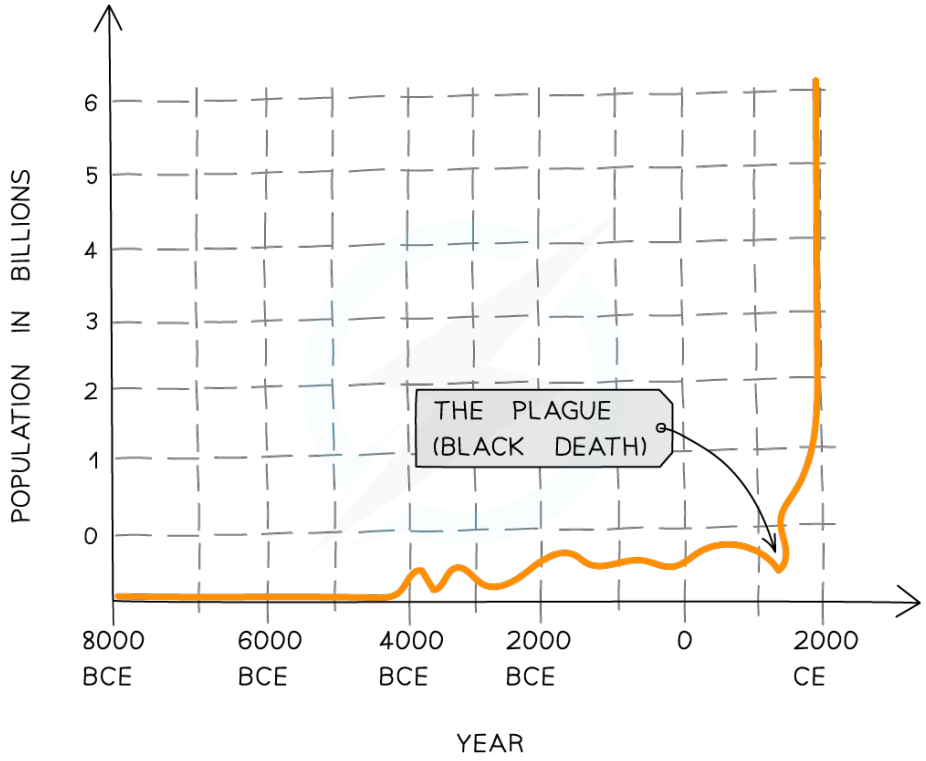
19 ORGANISMS & THEIR ENVIRONMENT

19.5 POPULATIONS cont...

YOUR NOTES

Human Population Growth

- Human population growth globally has been increasing **exponentially** for the last 150 years



Human population growth is growing exponentially

- There are many reasons for this exponential growth, including:
- **Improved technology** leading to an **abundance of food** = rapid increase in birth rate
- **Improved medicine, hygiene and health care** = decrease in death rate

EXAM TIP

There are many different ways of showing human population growth.

In an exam, **look carefully at the data to figure out the trend** it is showing and think about **how that links to social implications**, locally and globally, of the growth of the human population.

19 ORGANISMS & THEIR ENVIRONMENT

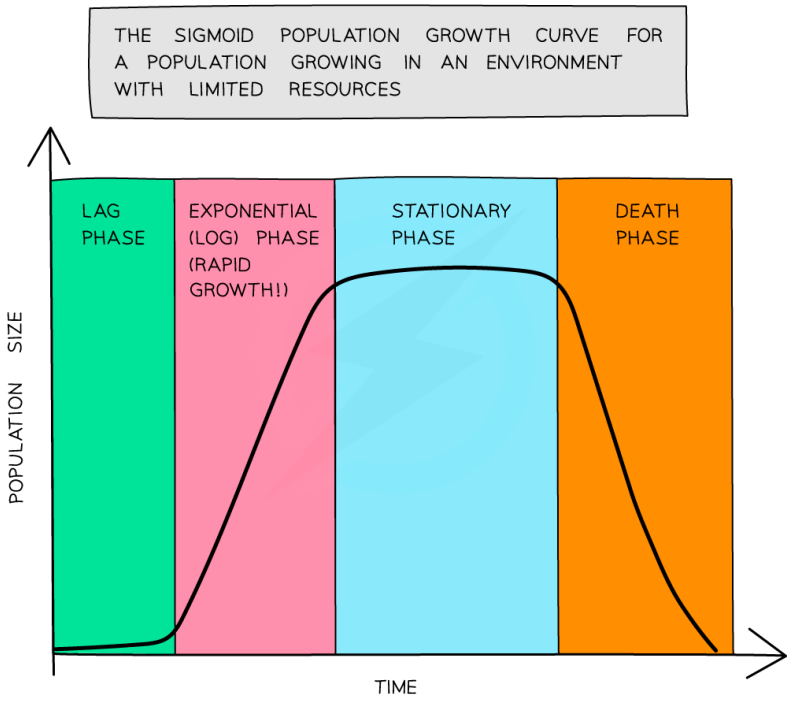
19.5 POPULATIONS cont...

YOUR NOTES

EXTENDED ONLY

Growth Curves

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



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

19 ORGANISMS & THEIR ENVIRONMENT

19.5 POPULATIONS cont...

YOUR NOTES

EXTENDED ONLY cont...

- **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)

> NOW TRY SOME EXAM QUESTIONS

19 ORGANISMS & THEIR ENVIRONMENT

EXAM QUESTIONS

YOUR NOTES

QUESTION 1

The diagram below shows a food chain

grass → locusts → snakeseagles

If the number of snakes decrease due to disease, what will happen to the number of other organisms in the food chain?

	grass	locusts	eagles
A	increase	increase	increase
B	increase	decrease	increase
C	decrease	decrease	decrease
D	decrease	increase	decrease

QUESTION 2

Which of the following is a correct example of a population?

A All the animals in a forest.

B All the goldfish in a pond.

C All the species of animals in Europe.

D All the people born in Scotland over 150 years.

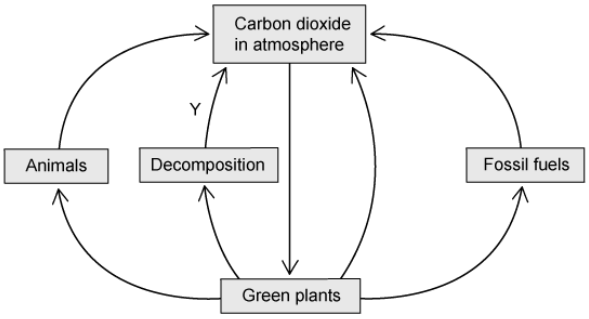
19 ORGANISMS & THEIR ENVIRONMENT

EXAM QUESTIONS cont...

YOUR NOTES

QUESTION 3

The diagram below illustrates part of the carbon cycle.



Which process is shown by the arrow labelled Y?

A Photosynthesis

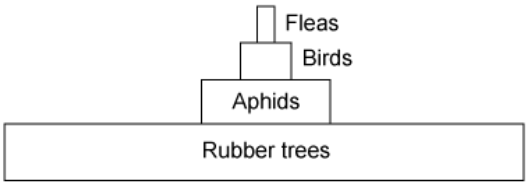
B Feeding

C Respiration

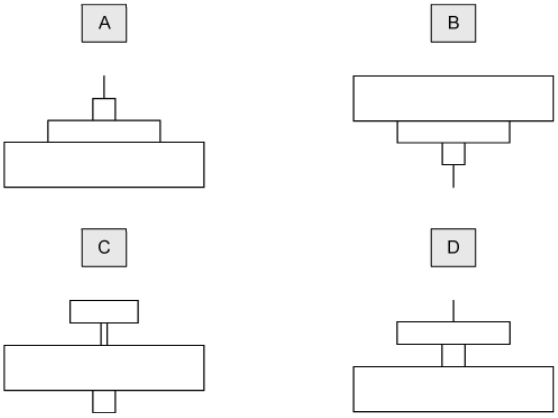
D Combustion

QUESTION 4

The image below shows a pyramid of biomass for a food chain in a rainforest ecosystem.



What would be an appropriate pyramid of numbers for this food chain?



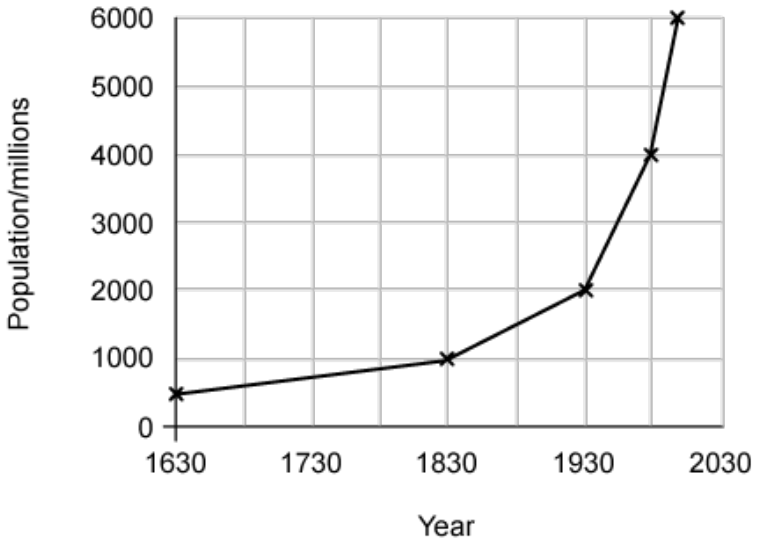
19 ORGANISMS & THEIR ENVIRONMENT

EXAM QUESTIONS cont...

YOUR NOTES

QUESTION 5

The graph below shows the growth of the human population globally since 1630.



Which of the following options represents the longest time period taken for the population of humans to double?

A 100 years

B 200 years

C 300 years

D 400 years

> CHECK YOUR ANSWERS AT SAVEMYEXAMS.CO.UK