Glenlola Collegiate School

excellence through commitment, contribution and caring

1.7 ECOLOGICAL RELATIONSHIPS & ENERGY FLOW

Booklet B

NAME _____

LEARNING OUTCOMES
CCEA GCSE BIOLOGY: 1.7.15 & 1.7.16 - 1.7.28
UNIT 1.7B: Ecological Relationships and Energy Flow

	LEARNING OUTCOMES	PUPIL SELF-EVALUATION		
	Pupils should be able to:	Good	Average	Requires Attention
1.7.15	Understand the decomposing action of saprophytic fungi and bacteria			
	• secretion of enzymes, extracellular digestion and absorption			
	• in recycling nutrients			
	• the formation of humus			
	• the key factors of the decay process			
1.7.17	Understand the significance of photosynthesis, respiration, combustion, fossilisation, feeding, excretion, egestion and decomposition within the carbon cycle, constantly removing and returning substances from the environment			
1.7.18	Understand that collaborative scientific research suggests that an increase in levels of carbon dioxide leads to global warming and understand the problems associated with this, and realise that there is controversy associated with the recording, sources, modelling and possible solutions to this problem			
1.7.19	Explain the causes, effects and strategies to reduce acid rain			
1.7.20	**understand how scientific evidence informs local**			
	government about the need to implement policies to			
	bring about:			
	• **reductions in carbon emissions**			
	• **increases in renewable energy**			
	• **changes in agricultural practices**			
1.7.21	**Understand the role that microorganisms have in the nitrogen cycle, to include nitrogen fixation, nitrification and de-nitrification (knowledge of the names of specific bacteria is not required) and apply this to different growing conditions**			
1.7.22	Understand that plants need nitrates to form proteins and that they obtain these from the soil through root hair cells by **active uptake**			
1.7.23	Identify root hair cells as specialised cells that are adapted by having an extended shape, providing an increased surface area for increased uptake of water and minerals;			
1.7.24	**Understand active uptake is a process that requires energy to transport the minerals against a concentration gradient**			

1.7.25	Understand why growers add minerals to the soil, to include calcium, magnesium and nitrogen,			
	and compare the use of natural fertilisers (farmyard manure and compost) and artificial fertilisers as a means of replacing nitrates in soil			
1.7.26	**Explain how sewage disposal and fertiliser run-off can cause eutrophication in terms of:**			
	• nitrates stimulating growth of aquatic plants and algae;			
	• the death of aquatic plants and algae due to subsequent nitrate depletion and shading;			
	• the role of aerobic microorganisms in the decomposition of plants and algae;			
	• the consequences of oxygen depletion on other aquatic vertebrates and invertebrates			
1.7.27	Carry out studies or analyse data to monitor environmental change, to include:			
	• biotic data, (for example lichens as indicators of air pollution and blood worms as indicators of water pollution) caused by eutrophication;			
	• abiotic data (carbon dioxide levels, ice density, sea levels);			
1.7.28	Outline the role of international treaties to combat pollution			

Terminology

UNIT TEST RESULT: % GRADE:
COMMENT

DECOMPOSITION

Bacteria and fungi are examples of **decomposers**. Decomposers **break down dead organisms.**

Decomposers are important to an ecosystem because they **return nutrients to the environment.**

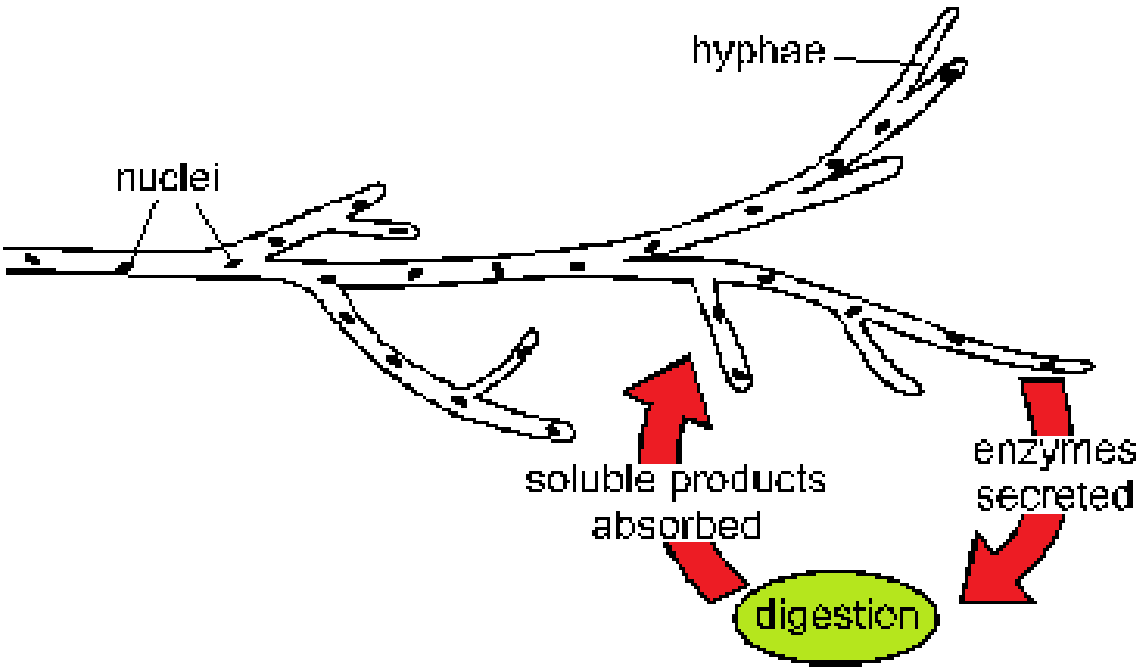
Decomposing action of saprophytic fungi and bacteria

Decomposers carry out **SAPROPHYTIC nutrition.**

Saprophytic bacteria and fungi **secrete enzymes** into the soil or dead organism.

The enzymes break down **(digest)** the organic material and then it is **absorb** by the bacteria or fungi.

Because this occurs outside the animal cells it is known as **extracellular** digestion.



Decomposers use the absorbed nutrients for **respiration to produce new cells.** This requires **glucose and oxygen** and releases **carbon dioxide, water and energy.**

Carbon dioxide is released from the cells into the air

Water is used by the cells as a solvent, as part of the cytoplasm and in chemical reactions.

Energy is used by the cells to convert the absorbed nutrients into carbohydrates, fats for storage and proteins for growth.

FORMATION OF HUMUS

Humus is the organic content of the soil formed from decomposing plant and animal material.

It can be used as a **fertiliser** It is dark and sticky and gives the soil good **crumb structure**, which helps the soil to hold on to water.

Decomposition takes place more quickly when conditions are optimum. These include

1. **a warm temperature**
2. **adequate moisture**
3. **a large surface area**

Detritivores such as earthworms and beetles break up detritus (dead material) increasing the surface area.

ACTIVITY

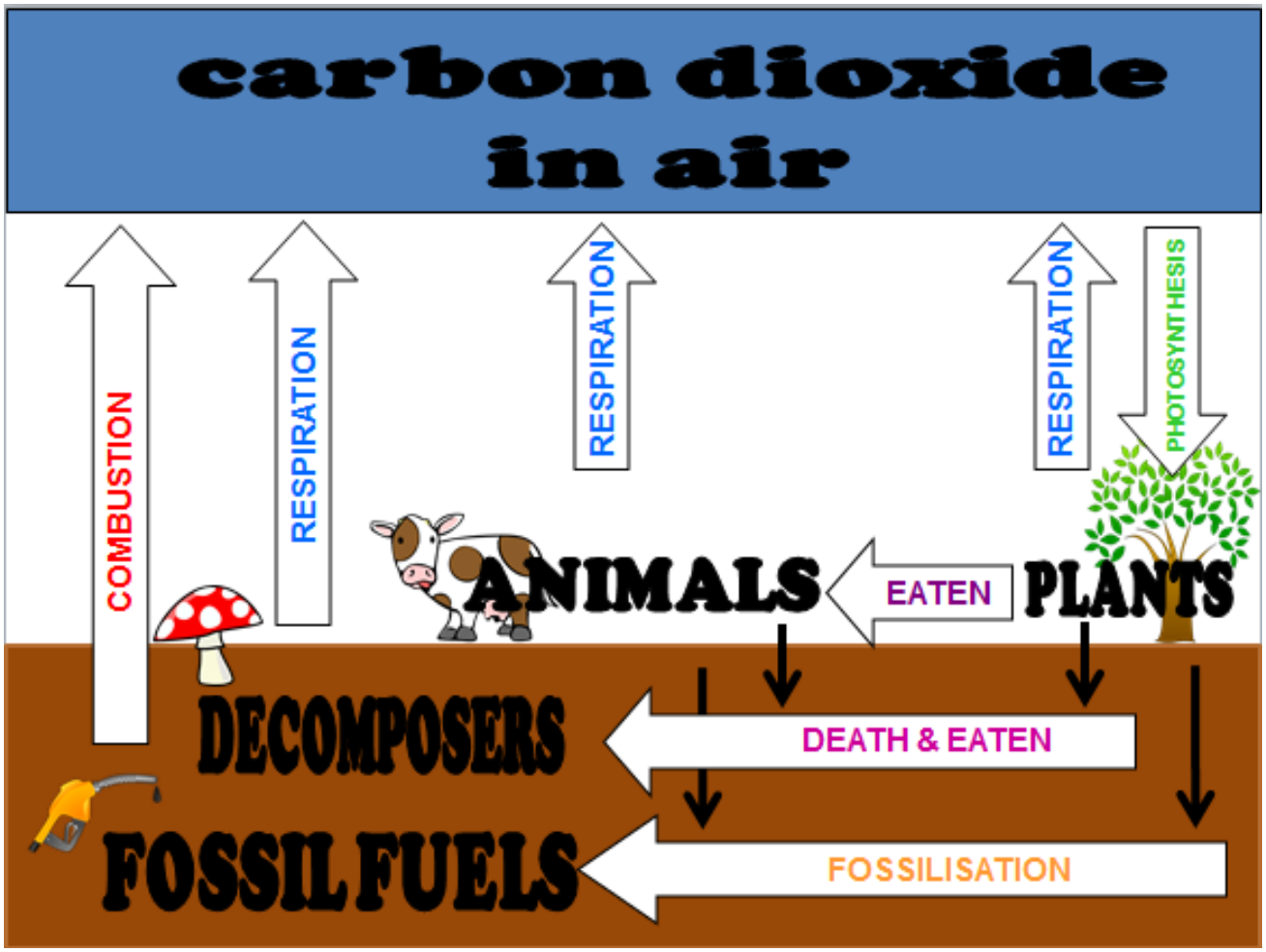
Describe and explain what happens to dead leaves in autumn.
Remember to use processes, detailed biological terminology and sequence.

DECOMPOSITION & RECYCLING

Decomposition is important in the recycling of nutrients, such as **CARBON** and **NITROGEN** found in dead plants and animals and their waste.

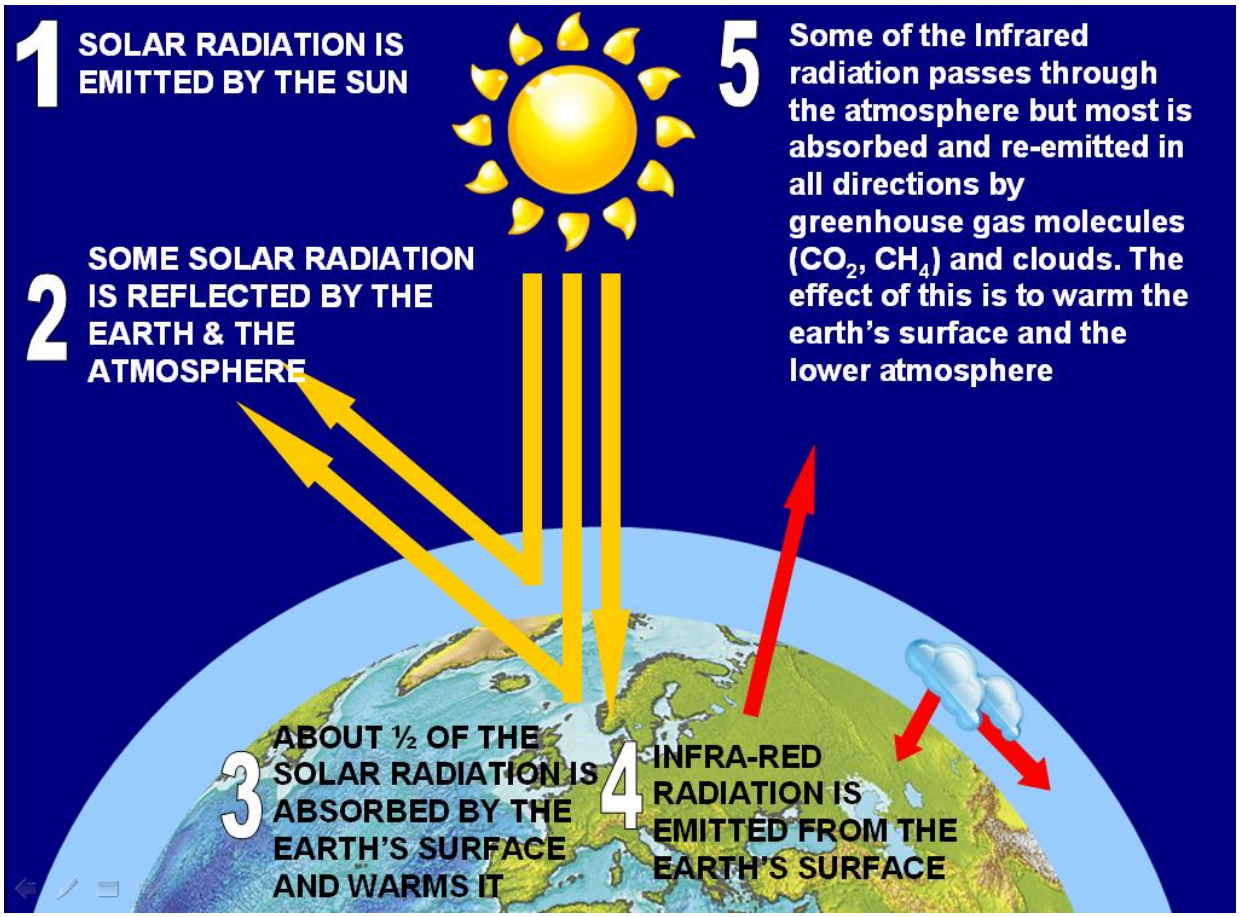
THE CARBON CYCLE

Carbon is found in all **organic molecules**, including **glucose, starch, cellulose, glycogen, fats and proteins.** It is also found in **inorganic compounds** such as **carbon dioxide and the carbon compounds in coal, oil and gas.**



CARBON DIOXIDE & THE GREENHOUSE EFFECT

Carbon dioxide, methane and water vapour in the Earth's atmosphere trap **solar radiation.** This causes the atmosphere to act as an **insulator** keeping the Earth warm. This '**greenhouse effect'** is necessary for life as we know it.



GLOBAL WARMING

The problem in recent years has been an ***increase in the concentration of gases that contribute to the greenhouse effect, including carbon dioxide, methane gas and water vapour*.**

Two main changes have contributed to the rise in carbon dioxide levels and therefore carbon cycling on Earth:

- **Increased combustion of fossil fuels** has added more carbon dioxide to the atmosphere
- **Increased deforestation** has removed many forests, meaning that less carbon dioxide is taken out of the atmosphere by the process of photosynthesis.

The changes mean that the carbon cycle has become unbalanced and has led to an enhanced greenhouse effect, known as **global warming** i.e. ***a rise in the average temperature of the Earth's surface.***

Evidence for global warming

1. **Collaborative scientific research** between scientists in many different countries has recorded changes in CO2 levels in the atmosphere. One method of showing this is by measuring the CO2 levels in **ice cores** collected from polar ice caps. It is possible to analyse the air trapped in the ice thousands of years ago, to determine its composition.
2. Another method used is **computer generated climate models**. By inputting different amounts of carbon dioxide in the atmosphere, it has been possible to produce the same changes as has been observed in the real world.

Scientists have been highlighting the increase in carbon dioxide levels for many years and have been attempting to persuade Governments to take global warming seriously.
There is controversy associated with the recording, sources, modelling and possible solutions to the problem.
It is only recently that many politicians and people have accepted that it is the increase in carbon dioxide levels that are causing global warming.
It is difficult for some nations to accept the link because that also means accepting that human beings are responsible and that we must change our lifestyle to try to reduce our dependence on fossil fuels.

Effects of global warming

The warming of the atmosphere causes:

- **Climate change:** more weather extremes such as droughts and severe storms
- **Melting polar ice and the thermal expansion of sea water:** may cause sea levels to rise and flooding of low-lying coastal areas.
- **Increased flooding:** food shortages, price increases, more imports and therefore transport costs… fuel usage… CO_2 increase; spread of disease as sewers overflow
- **Increased desertification:** less land for growing crops, death/ movement of populations of animals and plants

Reducing global warming

- **Planting more trees:** more PS, more CO_2 **uptake** from atmosphere; decrease atmospheric CO_2 levels
- **Reducing deforestation** more trees for PS… less machinery, less fossil fuels burned, less CO_2 **emitted**
- **Burning less fossil fuels by using alternative fuels:** these include solar & wind energy. They do not release CO_2 in production of electricity, less combustion of fossil fuels, less CO2 **emitted**
- **Becoming more energy efficient:** cycle/walk instead of car; not run hot tap; energy saving appliances (light bulbs…). All waste less energy so less electricity needs to be produced by fossil fuels and less CO_2 **emitted**

Ideas about science – correlation and cause

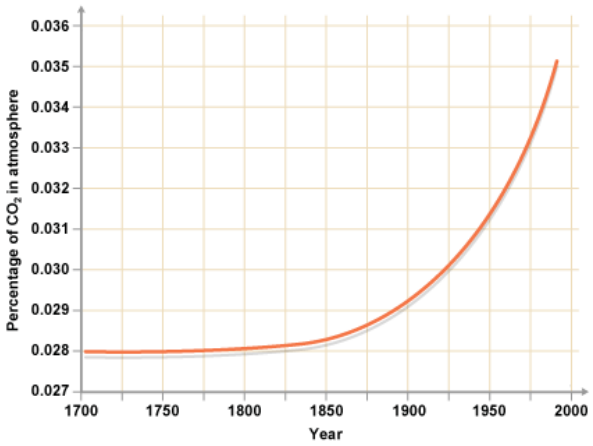
The ideas of correlation and cause are illustrated with the evidence for *global warming* [**global warming**: *The rise in the average temperature of the Earth's surface. In the last 100 years it is believed to have risen by 0.6°C.*].

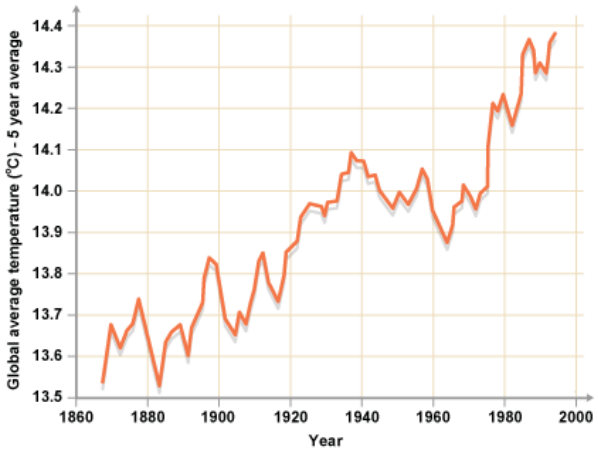
Any process can be thought of in terms of **factors** that may affect an **outcome**.
In global warming, one factor is the amount of carbon dioxide in the atmosphere. The outcome is the mean temperature of the atmosphere.

Establishing a correlation

To establish a correlation between a factor and an outcome, convincing **evidence** is needed. This usually means that enough data must be collected, and that different samples should match.
Compare these two graphs and consider these questions:

I. are the changes reported significantly large?
II. are they properly matched in terms of the times over which they are reported?
III. do these two graphs match well enough?





Other factors

A **correlation** between a factor and an outcome does not mean that the factor causes the outcome. They could both be caused by some **other** factor.
For example: Children with bigger feet (factor) are, on average, better readers (outcome).
There is another factor which affects both of these things: **age**. Older children usually have bigger feet, and older children are usually better readers!
To investigate the relationship between a factor and an outcome, it is important to control all other factors that may affect the outcome.

Other factors affecting global warming

Another factor that may affect the mean temperature of the atmosphere is the amount of energy given out by the Sun. Most scientists agree that this has not changed in the past 200 years.
There are some scientists who agree that global warming is taking place, but **do not agree** that carbon dioxide levels are to blame.

Scientific explanation

Once experiments have shown that there is a definite correlation between a factor and an outcome, it is still not enough to prove that the factor causes the outcome. For this to be proven there must be some **scientific explanation** of how the relationship can happen.
for carbon dioxide and global warming, the explanation is that carbon dioxide is a greenhouse gas. It absorbs infrared given off by the warm Earth, and this infrared cannot then escape into space. This keeps the Earth warmer than it would be if the carbon dioxide did not absorb so much infrared.

GOVERNMENT INITIATIVES TO REDUCE GLOBAL WARMING

Governments must work at international and national and local levels in order to tackle the problems of global warming.

INTERNATIONAL: Reducing carbon emissions

Agenda 21 is an action plan of the **United Nations** (UN) related to promoting sustainable development and was an outcome of a conference on the environment held in Rio de Janeiro, Brazil, in 1992.

It is a recommendation for action to be taken globally, nationally, and locally by organizations of the UN, governments, and major groups in every area in which humans directly affect the environment.

LOCAL: North Down Borough Council

Scientific evidence of human effects on the environment informs our local government about the need to implement policies such as reductions in carbon emissions and increases in renewable energy. Changes brought about by NDBC in recent years include:

- providing ‘brown bins’ to households to increase composting and ‘blue bins’ for recycling paper, some plastics and metal cans
- Fortnightly bin collections to reduce fossil fuel usage (petrol/diesel)
- Building a wind turbine at Balloo to provide energy to run the recycling Centre and Council offices.

the nitrogen cycle

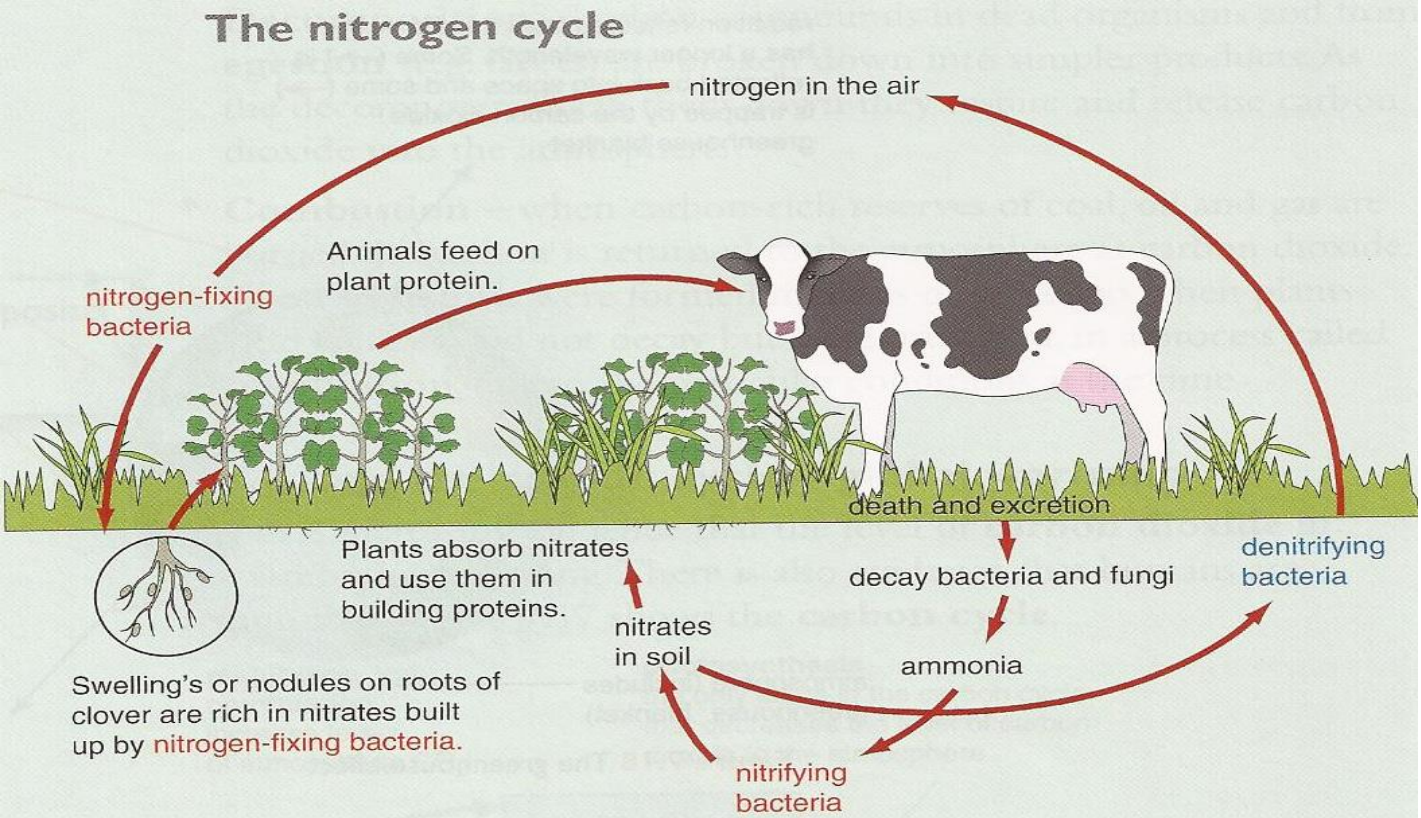


Figure 7.19 The nitrogen cycle

FOUR types of bacteria are involved in the nitrogen cycle.

BACTERIUM	PROCESS	WHERE FOUND	SUBSTRATE	PRODUCT
NITROGEN FIXING BACTERIA		soil & root nodules of legumes	nitrogen gas	nitrates & amino acids
DECAY OR PUTRIFYING BACTERIA		aerated soil	N containing compounds, amino acids & proteins, in urine & dead plants & animals	ammonia
NITRIFYING BACTERIA		aerated soil	ammonia	nitrates
DENITRIFYING BACTERIA		anaerobic & live in waterlogged & compacted soils without oxygen	nitrates	nitrogen gas

how do farmers aid the N cycle?

Crop rotation

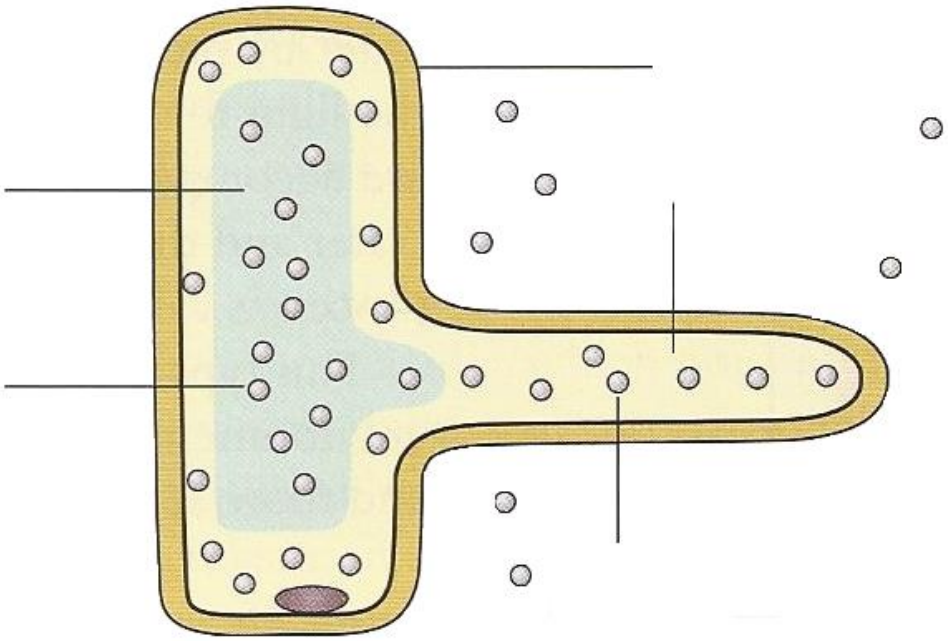
Farmers rotate their crops, planting legumes such as peas and beans in an area one year and root vegetables, potatoes or cabbages in the same area the next year.
This is because crops like potatoes and cabbages remove nitrates from the soil to make amino acids and proteins for growth. We harvest these crops and prevent the nitrogen from being recycled into the soil. Recycling is reduced and so nitrate levels are reduced.
Peas, beans and clover are legumes, which have N fixing bacteria in their root nodules. They convert N gas in air in the soil to nitrates. Farmers harvest the crop but roots and many nitrates are dug back into soil. This increases nitrate levels for future crops.

Ploughing

Soil becomes compacted over time, which has an effect on the growth of crops. Ploughing adds air into the soil, which is important for:

- providing oxygen for aerobic decomposers and nitrifying bacteria. This speeds up decay and nitrate formation.
- providing oxygen to root hair cells to speed up respiration and active uptake of nitrates.
- space for roots to grow through.
- drainage, which prevents waterlogging and the action of denitrifying bacteria.

ROOT HAIR CELLS AND ACTIVE UPTAKE



Plants need **nitrates** to form **proteins** and they obtain these from the soil through root hair cells by **active uptake.**

The diagram above of a root hair cell shows the adaptations of the cell:
An **extended shape** (a 'cytoplasmic extension'), provides an **increased surface area** for **increased uptake of water and minerals.**

Active uptake is a process that requires **energy** to transport minerals **against** a concentration gradient.
This is because there are more nitrate ions inside the cell compared with outside in the soil.
This process requires oxygen for aerobic respiration to produce the energy needed to transport the nitrates against the concentration gradient.

MINERALS

To stay healthy plants need specific mineral ions which they absorb from the soil by active transport.
Important minerals include:

- **Nitrates:** needed for **protein production**
- **Magnesium:** needed to make **chlorophyll**
- **Calcium:** needed to make **cellulose in cell walls**

Active transport needs energy from respiration. Plants growing in soil which has low oxygen levels, e.g. waterlogged or compacted soils, are unable to take up sufficient minerals for healthy growth.

FERTILISERS

When farmers harvest crops, or animals are taken to the abattoir, the nutrients they took from the soil are not replaced. The crops do not decay and decompose back into the soil to recycle the nutrients. For this reason, soil needs to be fertilised on a regular basis.

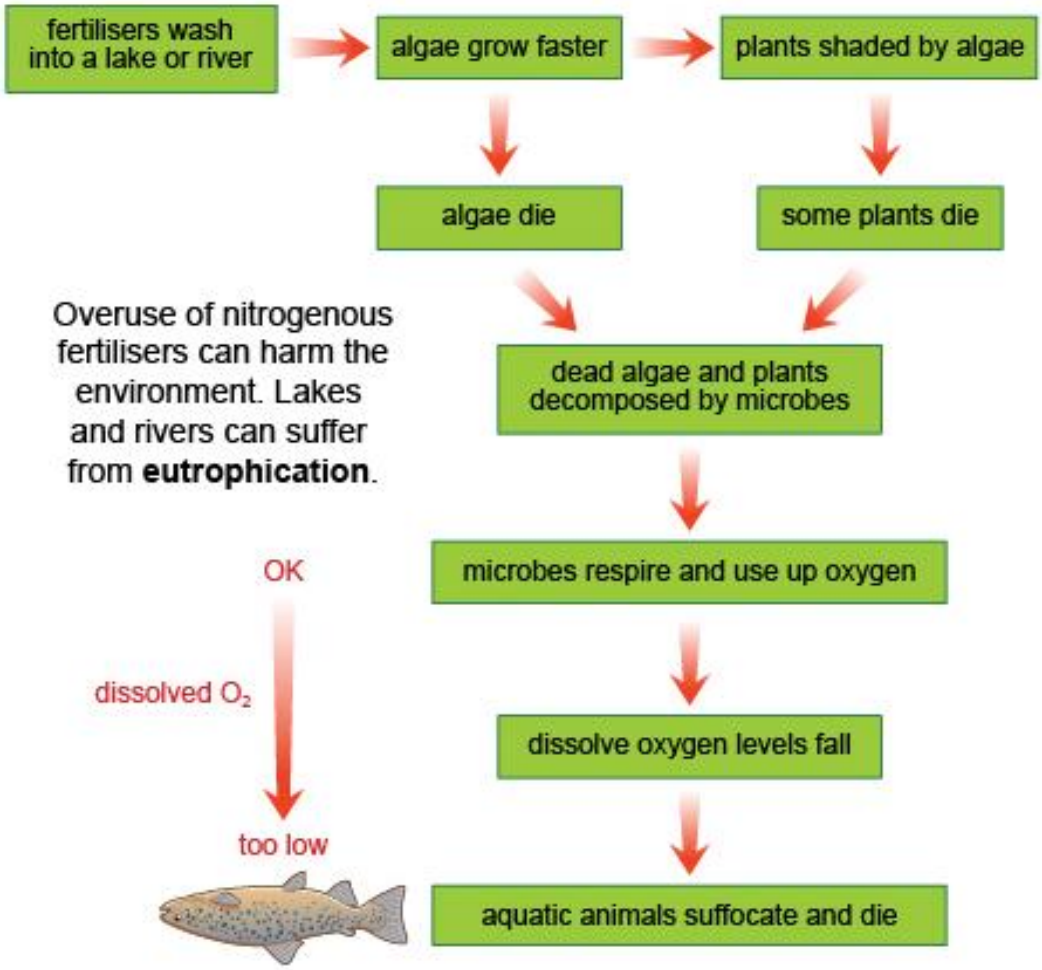
Both natural fertilisers and artificial fertilisers may be used to replace minerals lost from the soil.

	Natural fertilisers	**Artificial fertilisers**
Examples	Recycled waste e.g. manure, compost, slurry	Made artificially from fossil fuels, e.g. NPK, expensive to buy.
Speed of action	Slow to break down and release nutrients, but improves soil structure	Very soluble, but excess leach into waterways
Application	Difficult to apply evenly & need large quantities; heavy machinery causes compacts soils	Easy to spread evenly
Mineral content	Can't control mineral content	Known mineral content

Highlight advantages for each in green and disadvantages in red

EUTROPHICATION

The problem with using fertilisers is that not all the nutrients sprayed onto fields get used by plants. Fertiliser is washed off the land by rainwater into rivers and lakes. This is called **run-off**.



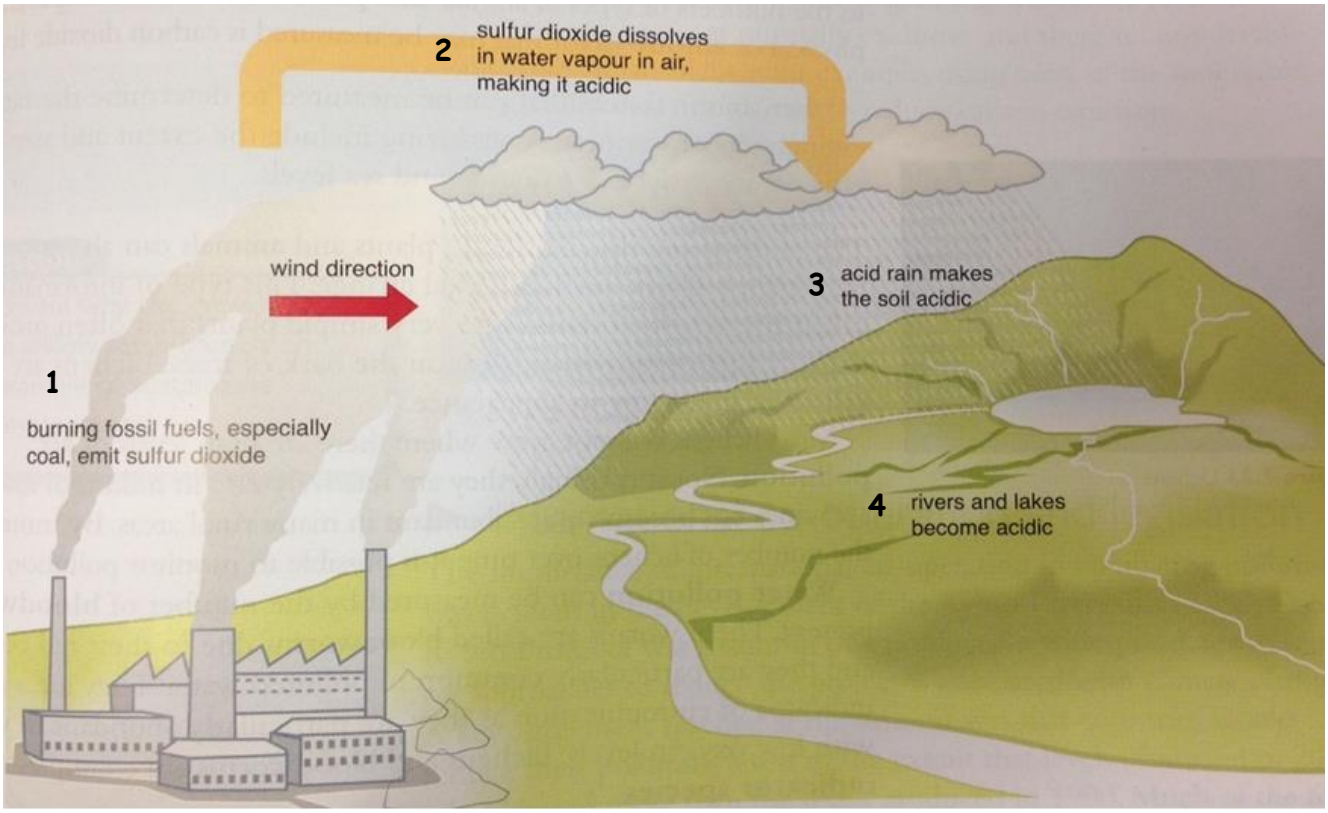
Arrange sentences into the correct sequence and write them onto the next page.

SEWAGE

This also leads to eutrophication.

- **Sewage spills** often occur into rivers and lakes
- **Bacteria** rapidly **digest** the **organic material** in the sewage
- There is a **dramatic increase** in the **population** of these **bacteria**
- The bacteria **use up oxygen** from the water for **respiration**
- **Oxygen** levels **decrease**
- Other **organisms die** due to **oxygen depletion**

ACID RAIN



ACID RAIN	
Causes	Combustion of fossil fuels Fossil fuels (coal, oil & natural gas) contain sulfur. This reacts with oxygen in the air to form sulfur dioxide. Sulfur dioxide dissolves in rain water to form sulfuric acid. Cars produce nitrous oxides when they burn petrol/diesel. This reacts with water to form nitric acid. This lowers the pH of rain water.
International concerns	Acid rain produced in one country can be carried by the wind into other countries, who suffer the effects.
Effects	**Soil**: acidic soil causes trees to lose their leaves; they are not able to photosynthesis and die. **Waterways**: fish and other invertebrates are poisoned and die.
Solutions	**Scrubbers**: chemicals placed inside chimneys of power plants which remove sulfur dioxide from exhaust gases. **Catalytic convertors**: placed in the exhausts of cars to remove sulfur dioxide and nitrous oxides. **Renewable energy sources** to generate electricity: solar and wind power do not produce sulfur dioxide or nitrous oxides.

Protecting the environment and tackling climate change – 5 ways

1. Changes in agriculture

The **government is responsible** for the regulations to limit fertiliser application and maintain river quality. They also encourage sustainable development by providing finance and other support for projects, such as biofuel. These areas are not exclusive and there is considerable overlap between them, for example using renewable energy sources will help reduce carbon emissions

2. Methods of monitoring change in the environment

It is important that governments monitor the environment very closely weather they are physical changes or changed to the numbers of animals. An important abiotic factor/physical factor that may be measured is CO_2 levels. The number and distribution of plants and animals can also provide information about environmental change called biotic data.

To show changes in the environment you need to sample, for example to see if there is a high level of **air pollution** you can measure the amount of **lichens**. If there is a high amount of pollution there will be fewer lichens because they will not grow, but if there is not as much air pollution there will be a high amount of lichens. To show the levels of **water pollution** you would measure the amount of **bloodworms** present, more worms means more pollution in the water. Organisms that are used to inform scientists of how healthy the environment is are called **indicator species**.

3. The role of the Government in conserving the environment

The development of a framework for conservation is one of the responsibilities of the Government.

4. Reduction of carbon emissions & Increasing renewable energy

The reduction of carbon emissions is encouraged by legislation; e.g. decisions on energy sources, limits on carbon dioxide emissions, regulation on minimum standards for house insulation and grants for installing solar heating. They advertise and try and educate individuals to play their role in reducing carbon emissions.

It is the Governments choice to make decisions that encourage an increase in **renewable energy**, it includes key planning on nuclear power stations and other forms of renewable energy, e.g. wind power. They also fund research into the development of different types of renewable energy sources.

5. International co-operation and legislation

The **Kyoto Protocol** was created in 1997 as a worldwide agreement to tackle the problems leading to climate change. Countries agreed to reduce their **carbon dioxide emissions** by 2010 to 1990 levels. One idea was for developed/rich countries to purchase "carbon credits" from less developed countries so that they could maintain a high CO_2 output while the poor/less industrial countries had a low pollution level i.e. a global reduction.

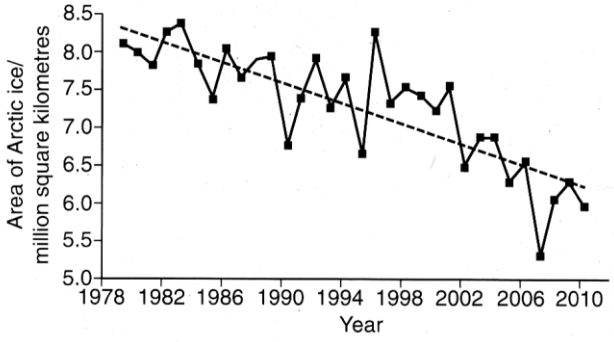
The agreement was hard to enforce though, shown by the USA pulling out in 2003. Others objected to the Western/rich countries trying to halt the industrial progress of the developing countries. The conflict between economic progress and conservation means that it is a slow process to reduce carbon emissions.

Other international treaties include the **"European Nitrates Directive"**.
This states that farmers should

- store their farmyard manure and slurry safely,
- not spray some fertiliser types in the winter months (wetter), and during the fertiliser "closed season".

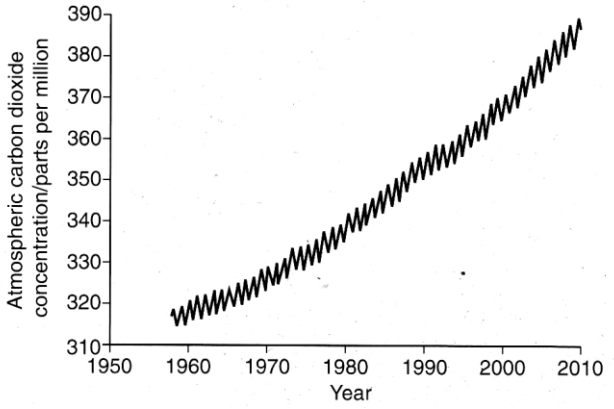
This helps avoid fertiliser run off and eutrophication, also ensuring that fertiliser is only added when the plant are growing and need it.

5 The graph below shows changes in the area of Arctic ice.



Scientists are researching reasons for these changes. The research suggests that an increase in levels of carbon dioxide leads to global warming.

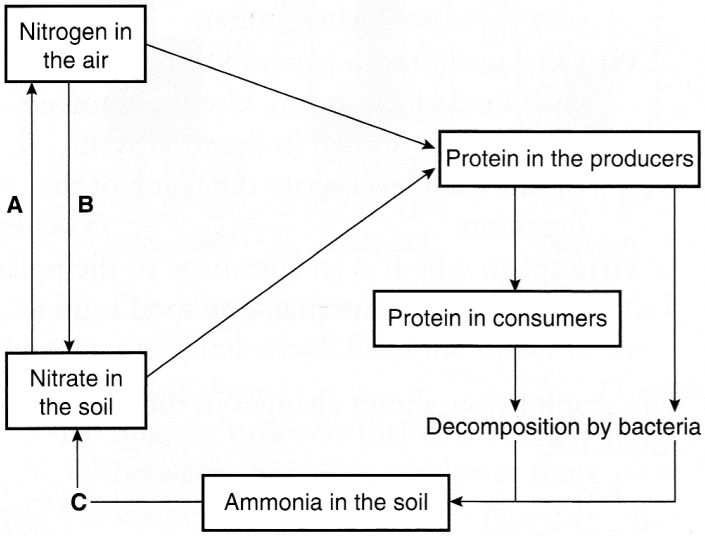
The graph below shows the concentration of carbon dioxide in the atmosphere.



Describe the trends shown in each graph. Explain how these trends provide evidence for the theory that changing levels of carbon dioxide in the atmosphere are linked to the changes in the area of Arctic ice.

In this question you will be assessed on your written communication skills including the use of specialist science terms. *(6 marks)*

6 The diagram shows the nitrogen cycle. A, B and C are processes carried out by bacteria.



Use the diagram and your knowledge to answer the following questions.

a) Bacteria are decomposers. Name another type of decomposer. *(1 mark)*

b) Name the types of bacteria that carry out the following processes: A, B, C. *(3 marks)*

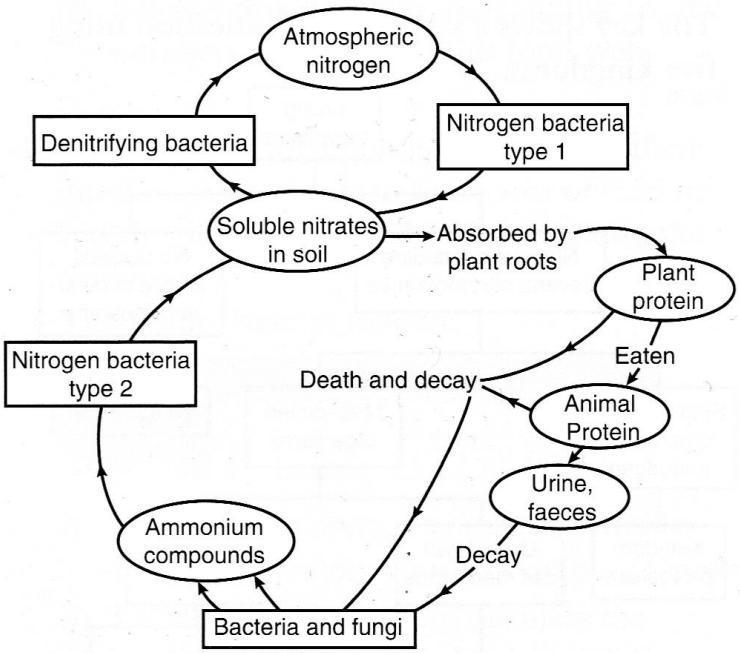
c) If a farmer is growing a crop, which of these types of bacteria is not helpful? *(1 mark)*

d) Planting clover increases the number of type B bacteria as these bacteria are found in swellings in clover roots. Suggest the benefit to the soil of planting clover. *(1 mark)*

7 a) The following diagram shows the nitrogen cycle.

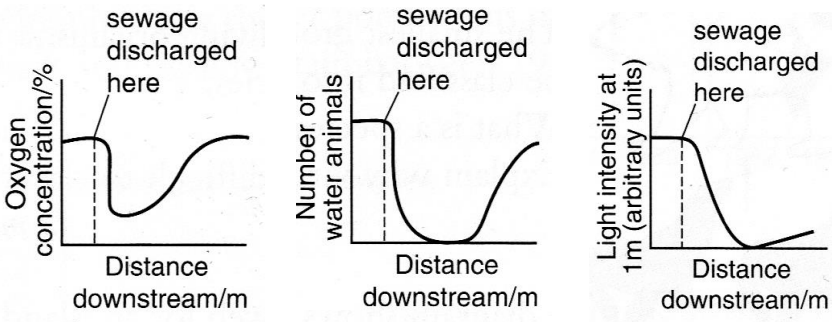
i) Using the diagram and your knowledge, name the nitrogen bacteria type 1 and type 2. Describe each of their roles in the nitrogen cycle. *(4 marks)*

ii) Explain the effect on plants if nitrogen bacteria type 1 and type 2 were not present in the soil. *(2 marks)*



iii) How are plant root cells adapted for absorption of nitrates? *(1 mark)*

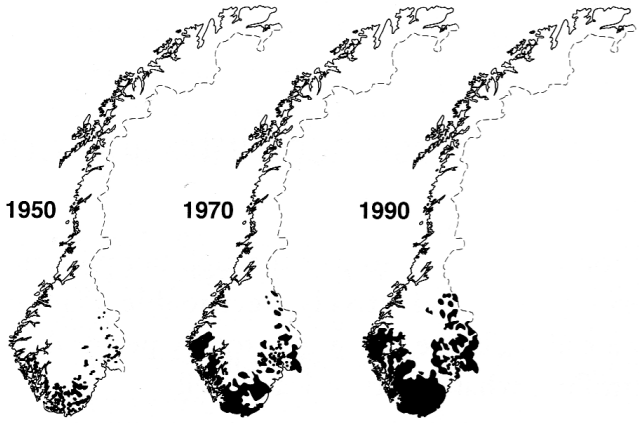
b) Water pollution occurs when substances such as fertilisers or raw sewage enter rivers. The graphs show some of the effects of raw sewage on rivers.



i) Using **graphs 1** and **2** to help you, describe and explain the effect of the raw sewage on the number of river animals. *(3 marks)*

ii) Using **graph 3** to help you, describe and explain what causes the change in light intensity and how it affects the water plants near the sewage discharge. *(3 marks)*

8 The shaded areas on the maps show the distribution of lakes in Norway where fish stocks have been killed by acid rain.



a) Describe the trend shown in the maps. *(1 mark)*

b) Give **one** other biological effect of acid rain. *(1 mark)*

Sulfur dioxide, produced when fossil fuels are burned in other parts of Europe, is an important gas involved in the formation of acid rain.

c) Explain how sulfur dioxide forms acid rain which reaches lakes in Norway. *(2 marks)*

Since 2000 the number of lakes affected has reduced. Surveys of fish populations are one way of monitoring such environmental change.

d) Give **one** other example of biotic data which can help monitor pollution. *(1 mark)*