3.5.4: Nutrient Cycles

Name _____

Reflection on Learning outcomes	☺ or ☹	**Target**
Describe the stages of the phosphorus cycle, and the ions at each stage		
Explain the role of saprobionts and mycorrhizae in the phosphorus cycle		
Interpret information/data about the phosphorus cycle and apply knowledge.		
Describe the stages of the nitrogen cycle, and the ions/molecules at each stage		
Explain the processes of saprobiotic nutrition, ammonification, nitrification, nitrogen fixation and denitrification within the nitrogen cycle		
Explain the role of saprobionts and mycorrhizae in the nitrogen cycle		
Interpret information/data about the nitrogen cycle and apply knowledge.		
Explain why farmers utilise natural and artificial fertilisers		
Explain how eutrophication is caused, and what the impact is on the ecosystem in which it happens		
Interpret information/data about eutrophication and apply knowledge		

Glossary of terms

Use this page to add the definitions to the key terms found in this booklet. Some key terms have been given some you will need to add yourselves as we work through the booklet.

Producer	
Molecule	
Biomass	
Ion	
Consumer	
Inorganic	
Saprobiont	
Mycorrhizae	

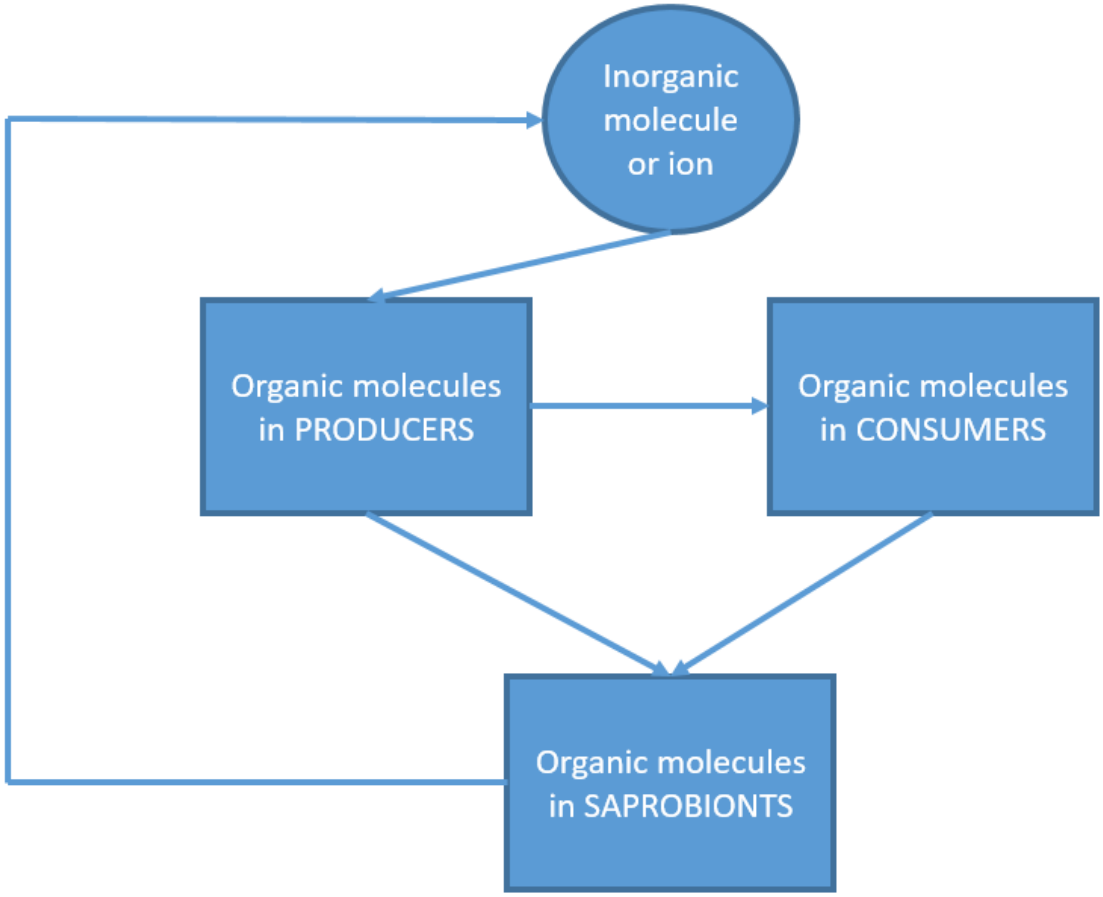
NUTRIENT CYCLES

Learn the common features of all nutrient cycles

Common features of all nutrient cycles:

- ✓ 1. Nutrient taken up by **PRODUCER**. Absorption
- ✓ **2. PRODUCER** uses nutrients forming into complex molecules
- ✓ **3. PRODUCER** is eaten, nutrients passed into **CONSUMER**
- ✓ **4. CONSUMER** is eaten by **CONSUMER** passing on nutrients
- ✓ 5. **PRODUCER** and **CONSUMER** die
- ✓ **6. SAPROBIONTIC** microorganisms breakdown nutrients to be **RECYCLED**.

Add the descriptions above to the diagram on the next page



Answer these quick fire questions

1. Why is it important that producers take up nutrients before consumers eat the producers?

   _____

2. Plants are producers. What is the inorganic molecule that plants take up for the process of photosynthesis? What is the organic molecule that plants make from photosynthesis?

   _____

3. To digest the producers consumers need enzymes. Explain the importance of enzymes in digestion.

   _____

4. What is the importance of saprobiontic micro-organisms in the cycle?

   _____

5. Why must nutrient cycles be a cycle?

   _____

Watch the video showing an overview of the two cycles we are going to be looking at in this topic.

http://www.bing.com/videos/search?q=phosphorus+cycle&adlt=strict&view=detail&mid=51A84770C013EE31C0C151A84770C013EE31C0C1&FORM=VRDGAR

Exam questions practice.

Use the information on the previous pages and **APPLY** your knowledge to the question below.

Q1. In an investigation of leaf decay, discs cut from oak leaves were placed in a number of bags. These bags were made from nylon mesh with 1 mm diameter holes. The bags were buried in soil. Each month one bag was removed and the surface areas of the remaining leaf discs were measured.

(a) Suggest **two** precautions that should be taken when carrying out this investigation to ensure a valid comparison between the results from the bags of leaf discs. In each case give a reason for the precaution.

1 .....

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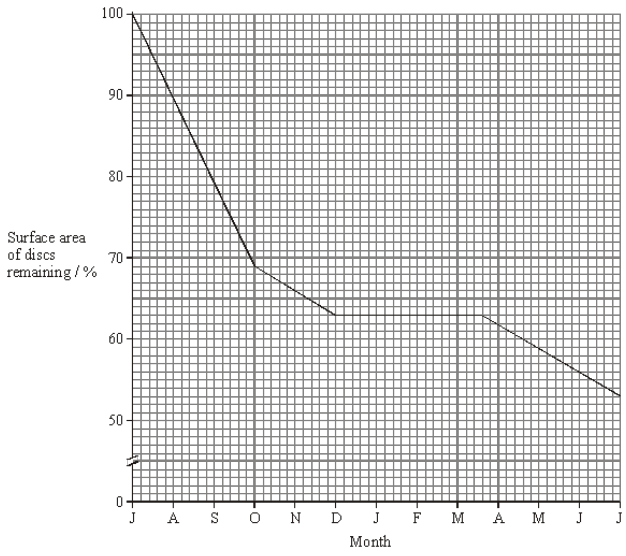
2 .....

.....**(3)**

(b) The graph shows the surface area of the discs remaining each month as a percentage of the area at the start of the investigation.



Describe and explain the shape of the curve.

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(c) Explain how microorganisms obtain the carbon compounds from cell walls.

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..... **(3)**

Outcome:

- Describe the stages of the phosphorus cycle, and the ions at each stage.
- Explain the role of saprobionts and mycorrhizae in the phosphorus cycle.
- Interpret information/data about the phosphorus cycle and apply knowledge.

PHOSPHORUS CYCLE

Starter

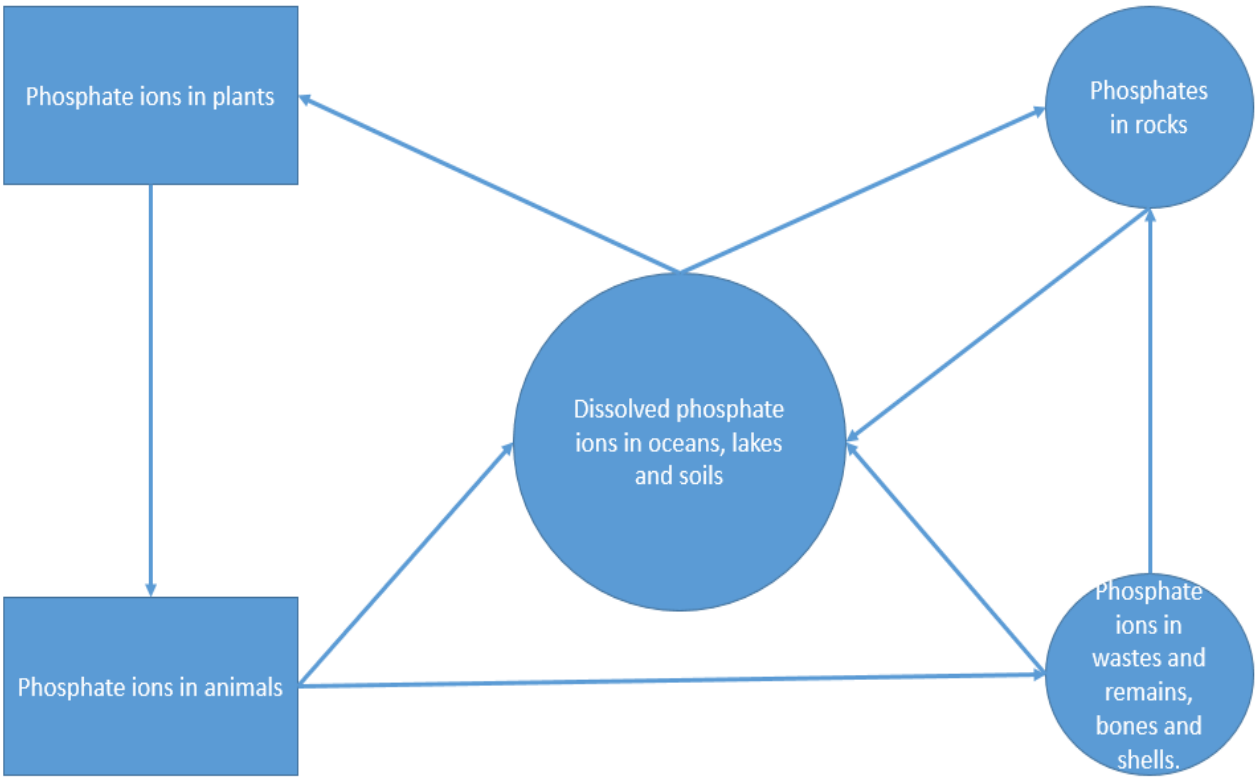
Think back to the video about the two nutrient cycles then answer the questions below.

1. Why are sedimentary rocks so important in the phosphorus cycle?
   _____
2. Why is the majority of phosphates trapped inside rocks?
   _____
3. How do plants get the phosphates?
   _____
4. How many years can phosphates be trapped in a biological cycle for?
   _____
5. What are the main components of fertilisers?
   _____

Note: When we are referring to the element itself we refer to it as phosphorus, when we are talking about the form of phosphorus that is used in the cycle we refer to it as phosphate. Phosphorus is very reactive so is rarely in its element form, it is usually reacted with O so we refer to it as phosphate.

Activity: Read through the terms/description on the next page and fully annotate the diagram on the next page.

Term	Description
1. Erosion/use of fertilisers	• Phosphorus found as phosphate ions in sedimentary rocks • Erosion causes release of phosphate ions • Dissolve in water
2. Absorption	• Dissolved phosphates uptaken by roots of PRODUCER • Dissolved phosphates uptaken by MYCORRHIZAE • Converted to biomass
3. Feeding and digestion	• PRODUCER eaten by CONSUMER passing on phosphate ions
4. Excretion and decomposition	• Excess ions excreted in waste or death of PRODUCER/CONSUMER • Fixed into bones/shells. • Fungi/Bacteria breakdown biomass release phosphate ions
5. Deposition	• Phosphate ions dissolved in water forming sedimentary rocks.



Create your own flow diagram showing the process of the Phosphorous cycle

There are many organisms that play a key role in nutrient cycles two common organisms are;

Definitions

Mycorrhizael Fungi: Mycorrhizae is the symbiotic relationship between plant and fungi

Saprobionts: Organisms that digest their food externally and then absorb the products.

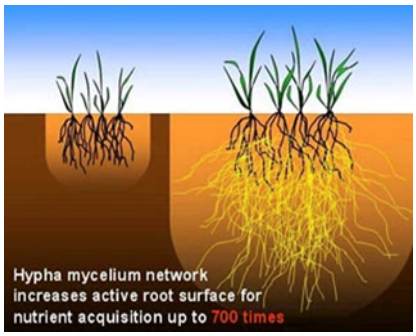
How are Saprobionts and Mycorrizhae involved in the Phosporous Cycle?

Saprobionts

Release hydrolytic enzymes that break down dead organic matter to release phosphate from phosphate containing sources such as DNA and RNA back into the soil.

Mycorrhizae:

- ✓ Association between fungal filaments and the roots of plants.
- ✓ Fungi are extensions of the root system.
- ✓ Fungi increase absorption of water and minerals.
- ✓ Fungi act like a sponge around root system.
- ✓ Fungi and roots have a mutualiastic relationship.



Quick fire questions:

1. The mycorrhizae is a mutualistic relationship. What is meant by a mutualistic relationship?
   _____
2. Suggest the advantage of this relationship for the fungi.
   _____
3. Suggest the advantage of this relationship for the plant?
   _____
4. Suggest why the fungi are wrapped around the roots like a sponge.
   _____
5. Suggest how the structure of the fungi could increase uptake by 700x
   _____
6. Suggest how the fungi are able to survive under ground with little to no light.
   _____

Exam question: Suggest and explain the advantage to tomato plants of transmitting signal protein through mycorrhizal networks, rather than releasing them into the air (2marks)

_____
_____
_____
_____

Outcome:

- Describe the stages of the nitrogen cycle, and the ions/molecules at each stage
- Explain the processes of saprobiotic nutrition, ammonifcation, nitrification, nitrogen fixation and denitrfication within the nitrogen cycle
- Explain the role of saprobionts in the nitrogen cycle**.**
- Interpret information/data about the nitrogen cycle and apply knowledge.

NITROGEN CYCLE

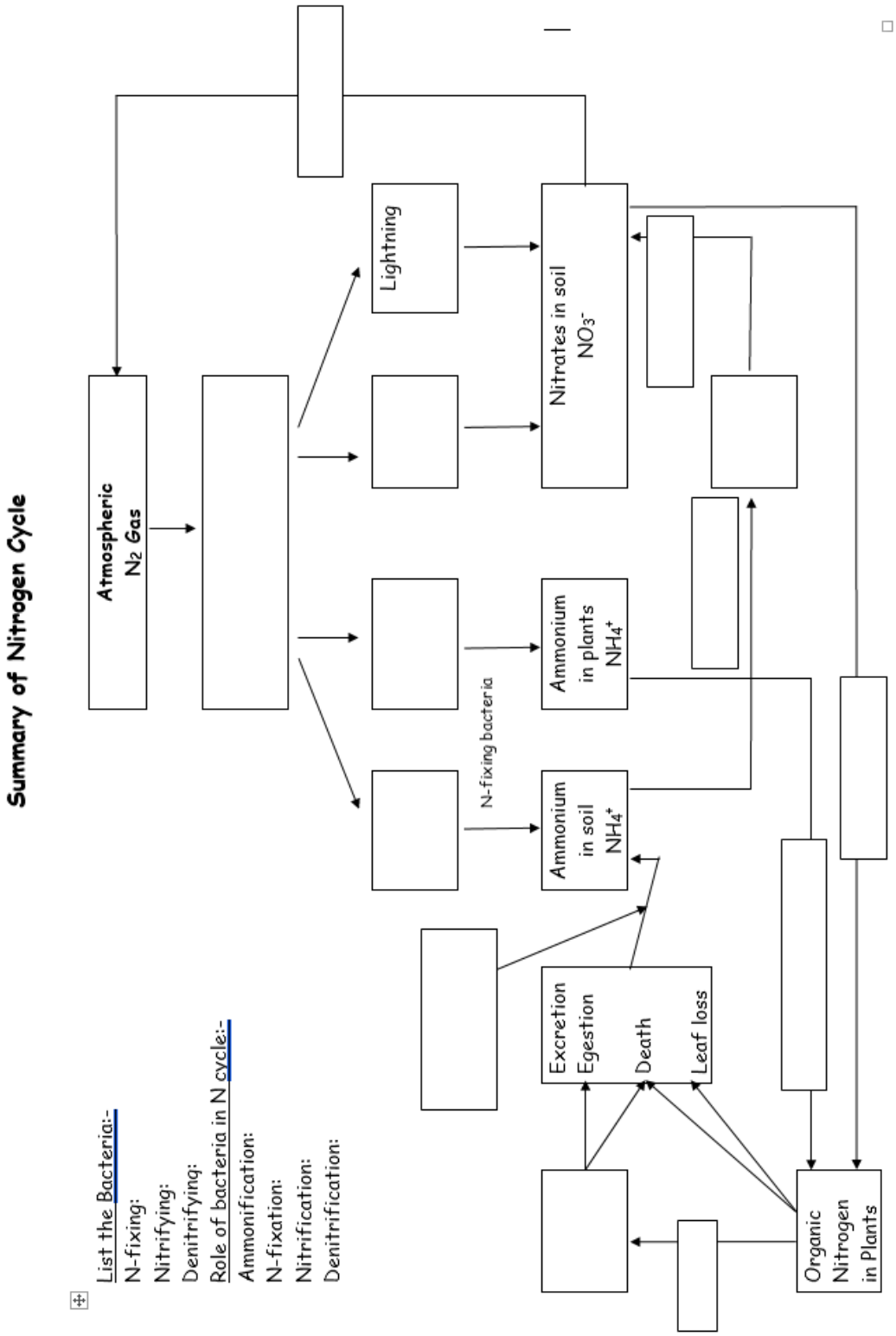
Watch the video on the Nitrogen cycle and copy the diagram into the space below.
https://youtu.be/LS4rAyvmZ3U

Exam note: The names of individual **species** of bacteria are **NOT** required

Activity: Now use what you have just learnt to Fill in the diagram below using pages 307-309 in the Toole and Toole textbook.

Words to use:

Decomposition & Ammonification Free-living soil bacteria Rhizobium in root nodules
Haber process Denitrification Organic Nitrogen in animals Feeding
Transport from root nodules Uptake by roots Nitrification Nitrifying bacteria
Nitrites in soil (NO_{2-}) Nitrification Denitrification Denitrifying bacteria
Nitrogen Fixation.



You need to know about each step of the Nitrogen cycle, it is important that you know the name of the group of bacteria involved. Do not confuse the bacteria with each other you will lose marks.

Stages of the Nitrogen Cycle

You could be asked to describe each of these stages

Fill in the blanks using the words below:

_Anaerobic, Living, Aerobic, Nitrogen gas, Urea, Lightning, Nitrates, Protein, Living, Rhizobium, Nitrites, Nucleic-acids, Nitrates, Oxidation, Haber, nodules, waste, Aerobic, Dead, Ammonia

1. **Ammonification (3 marks)**
   a. Produce ammonium ions from organic nitrogen containing compounds released into soil.
   b. Includes: U_____, P_____, N_____ acids and V_____
   c. Saprobiotic fungi and bacteria- feed on W_____/D_____.

   Exam Tip: You must give a named example of a Nitrogen containing Organic compound such as protein or DNA

2. **Nitrification (3 marks)**
   a. Free-_____ bacteria: Ammonium ions → N_____ → N_____
   b. O_____ reaction
   c. A_____ conditions.

3. **Nitrogen fixation (4 marks)**
   a. L_____.
   b. H_____ process
   c. Free-_____ bacteria: Nitrogen → _____
   d. Mutualistic bacteria: Live in _____ of Legumous plants called R_____ which live in A_____ conditions.

4. **Denitrification (3 marks)**
   a. Bacteria in a_____ conditions.
   b. N_____ → N_____ gas
   c. Waterlogged soil

Quick Questions

Identify the process

1. Lightening converting nitrogen gas into nitrates in the soil. _____
2. Ammonium ions in the soil being converted into nitrites in the soil by soil bacteria._____
3. Worms digesting nitrates into nitrogen gas in the soil. _____
4. The Haber process. _____
5. Cows urinating in a field. _____
6. Rhizobium in plant root nodules. _____

How are Saprobionts involved in the Nitrogen Cycle

Saprobiotic Microorganisms:

Saprobionts – organisms that feed externally on dead or decaying organic material.

Saprobiotic – process by which saprobionts feed.

- ✓ When producers/consumers die their complex molecules are digested
- ✓ Digestion carried out by saprobiotic bacteria/fungi (decomposers).
- ✓ Cause release of nutrients back into the soil in original simple form e.g. ammonium ions
- ✓ Ensure nutrients are released for reuse

Mark scheme perfect answer:

How can dead plant/animal material affect soil content/abiotic factors? You have been given the key terms, can you link them together to produce a 4 mark exam answer?

Terms: Saprobiotic bacteria/fungi aerobic respiration Oxygen Proteins amino-acids ammonium nitrifying bacteria nitrates

Write the mark scheme perfect answer below

_____
_____
_____
_____
_____
_____
_____

Answer these questions to consolidate your knowledge

1. What is the form of N in the air? _____
2. What is N fixation _____
3. Describe the conditions for N fixing bacteria _____
4. Leghaemoglobin is found in legumous plants surrounding the N fixing bacteria. Suggest the function of the leghaemoglobin. _____
5. Give 2 other methods used to fix N
6. What happens when plants and animals die? _____
7. What happens to the ammonia from urea _____
8. Ammonia in the soil is converted to nitrites, which are then converted to nitrates in the soil.
   a. Write the chemical structure for the 3 nitrogen containing molecules ____ _____ _____
   b. Give the name for the type of bacteria required for this process _____
   c. Describe the conditions these bacteria require _____
9. Describe the conditions for the denitrifying bacteria _____

Exam Questions

Q1. In autumn when there is no crop, farm land may be used to grow mustard. The mustard absorbs nitrates which otherwise can leach out of the soil at this time of the year. The mustard is ploughed back into the soil just before sowing of the main crop in the spring.

(a) Nitrogen compounds in the mustard plants are made available for the main crop after ploughing in spring. Describe the role of microorganisms in this process.

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(c) Plants absorb a number of other nutrients from the soil including phosphates. Describe why phosphates are needed by a growing plant.

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..... **(4)**

Q2. (a) Farmers who grow wheat sometimes leave a field fallow for a year by not growing a crop in it. The concentration of nitrate ions in the soil decreases when a field is left fallow.

(i) When grass is grown in the field, fewer nitrate ions are lost than when the field is left with bare soil. Explain why.

.....**(1)**

(ii) A crop of leguminous plants such as clover may be grown in the field and then ploughed in. Explain why less fertiliser would be needed for the wheat crop in the following year.

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..... **(2)**

(b) The table gives information about the yield and profitability of a wheat crop grown using different amounts of fertiliser.

Nitrogen fertiliser applied / kg ha^{-1}	**Grain yield / tonnes ha^{-1}**	**Grain protein / %**	**Value added by using fertiliser / £ha^{-1}**	**Cost of using fertiliser / £ha^{-1}**	**Benefit : cost ratio**
0	2.4	11.7	–	–	–
25	2.5	12.5	19	11	1.7 : 1.0
50	2.5	12.9	25	22	1.1 : 1.0
75	2.5	13.3	31	33	0.9 : 1.0
100	2.5	13.5	37		

(i) Describe the effects of increasing fertiliser application on the yield and protein content of the grain produced.

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(2)

(ii) Use the data in the table to estimate the benefit: cost ratio for a fertiliser application of 100 kg ha^{-1}. Write your answer in the table.

(1)

Outcome:

- Explain why farmers utilise natural and artificial fertilisers
- Explain how eutrophication is caused, and what the impact is on the ecosystem in which it happens
- Interpret information/data about eutrophication and apply knowledge

FERTILISERS AND EUTROPHICATION

Fertilisers can be used to provide plants with minerals, particularly nitrates, to support their growth
In agriculture systems, the harvesting of crops prevents the reintroduction of minerals to the soil so we need to replenish those lost minerals and nutrients using fertilisers.

There are;
Natural fertilisers which consist of dead and decaying remains of plants, animals and their waste

Artificial fertilisers which are mined from rocks before being converted into different forms with their composition tailored for specific crops.

Read page 311 and 312 in your textbook to complete the questions below.

1. Explain why fertilisers are needed in an agricultural ecosystem.

   _____

   _____

   _____

2. Using Figure 1, determine what concentration of fertiliser you would advise a farmer to apply to a field of wheat.

   _____

   _____

3. Suggest a reason why, after a certain point, the addition of more fertiliser no longer improves the productivity of a crop.

   _____

   _____

4. Distinguish between natural and artificial fertilisers.

   _____

   _____

   _____

How fertilisers increase productivity

- Nitrogen is need to make proteins and DNA.
- Where there are more nitrates available, plants are likely to develop earlier, grow quicker and taller and cover a greater area with their leaves.
- This therefore increases the rate of photosynthesis and also increases productivity.
- Artificial fertilisers have been very beneficial in providing cheaper food.

Now Complete the questions on page 312.

1. State which forms of nitrogen used in the investigation are natural fertilisers.

   _____

2. Suggest why the investigation included a plot to which no nitrogen-containing fertiliser was added.

   _____

3. Suggest how the addition of nitrogen-containing fertiliser, in whatever form, increased productivity.

   _____

4. The mass of each fertiliser used was different in each case. Suggest why this was necessary.

   _____

5. It is sometimes claimed that nitrogen-containing fertilisers in the form of ammonium salts increase productivity of crops better than other forms of nitrogen-containing fertilisers. State, with your reasons, whether or not you think the results of this experiment support this view.

   _____

   _____

6. The increase in productivity when manure was applied was lower than for other forms of nitrogen-containing fertiliser. This is because the manure has to break down before its nitrogen is released and this process takes a few months. Suggest how a farmer who spreads manure on his/her crops, might use this information in order to improve productivity.

   _____

Environmental consequences of using fertilisers

The effects of nitrogen fertilisers

Nitrogen containing fertilisers can have detrimental effects such as:

Reduced species diversity – nitrogen favours the growth of rapidly growing species such as grasses, nettles and weeds. Some species grow quickly and out compete the others.

Leaching – leads to pollution of watercourses

Eutrophication – caused by leaching of fertilisers into watercourses

Leaching

- Rain water can dissolve soluble nitrates and carry them deeper into the soil beyond the reach of plant roots.
- The nitrates may travel to water courses and into water that is used for human consumption.
- High levels of nitrates in water can cause inefficient transport of oxygen to the brain.

Eutrophication

Eutrophication consists of the following sequence of events:

1. In most lakes, there are very few nitrates and so this is limiting factor on plant/algae growth
2. **Nitrate/ Nutrient levels increase due to leaching**, there is no longer a limiting factor, and so plants/algae both grow exponentially
3. **Algae grow and cover the upper layers of the water. This is called "algae bloom**".
4. **The algae on the top of the water, absorbs sunlight, preventing it from reaching the bottom of the lake.**
5. **Light becomes a limiting factor for plants/algae at the bottom of the lake and so they die**
6. **Saprophytic algae can now grow exponentially feeding on the decaying plant matter.** More aerobic saprophytic bacteria, **more oxygen used up in respiration** and more nitrates produced from decaying organisms.
7. **Oxygen is a limiting factor for aerobic organisms such as fish and so they eventually die**.
8. Without any aerobically respiring organisms, **anaerobically respiring organisms no longer have to compete and so they begin increase in number.** Anaerobic organisms further breakdown other dead material thus producing more nitrates as well as some toxic wastes such as, hydrogen sulphide which makes the water putrid

Use the box to draw and annotate a diagram describing the stages of eutrophication.

Exam Questions:

Q1. Answers should be written in continuous prose, where appropriate.

A large lake is surrounded by fields. These fields are separated from each other by hedges. One hundred years ago the lake was a habitat for many plants, invertebrates and fish. Today the lake has no fish and few plants or invertebrates. Explain how increased use of inorganic fertilisers on the fields may have led to these changes.

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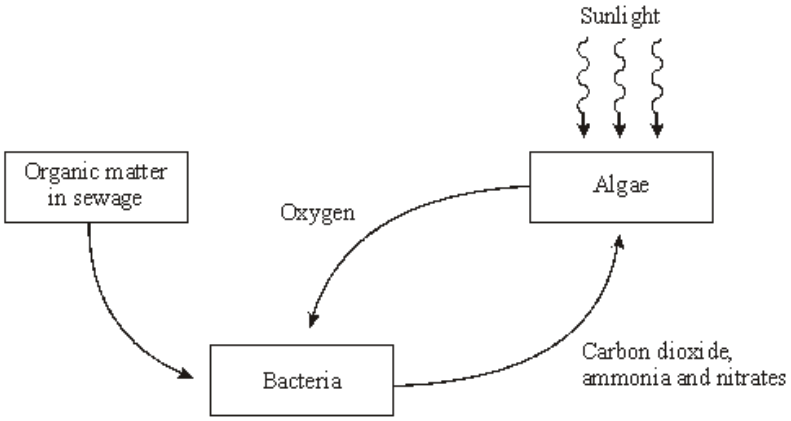
.....**(5)**

Q2. Purification ponds can be used in warm climates to break down sewage. The ponds are about 1m deep and contain bacteria and green algae. The diagram summarises the processes involved in the breakdown of sewage in a purification pond.



(a) Explain the advantage of having both algae and bacteria in a purification pond.

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..... **(4)**

(b) Purification ponds only work efficiently when they are shallow and warm. Explain why.

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..... **(4)**

Read through pages 313-314 of the Toole & Toole text book Then complete the poster below. The skill you are practising is to condense information into concise, precise information. **MAX 50 WORDS PER B0X**

Effects of nitrogen-containing fertilisers

Reduced species Diversity

Leaching

Eutrophication (*You could draw a flow diagram)*