Department of Primary Industries
and Regional Development

Industry insights- Soils

Supporting document

NSW PI Schools Program

Answer Guide

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Australian Government

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Industry insights- Soils answer guide

Sample answers have been provided for learning activities where applicable for this document. The following suggested answers should be used as a guide. It should be noted that these sample answers are suggested answers and not necessarily the very best answer, nor are they the only possible answers.

Soils

Introduction to soils

1. List and describe the three main rock groups.

- Igneous rocks originate from molten lava.
- Sedimentary rocks originate from continual deposits of sediment on the floor of oceans or lakes.
- Metamorphic rocks- form when igneous of sedimentary rocks are melted by heat or pressure near a volcano or as the earth's crust moves.

2. Define parent material.
   Parent material includes bedrock (sedentary parent material), unconsolidated rock deposited by wind, water, gravity or ice (transported parent material) and decomposed plant and animal material (organic matter).
3. Explain how soils are formed. Include the three processes involved.
   A soil develops from the breakdown of initial parent material through processes:

- Weathering is either physical (caused by temperature, water, wind and plant roots physically breaking apart or wearing down parent rock); or chemical weathering which is a result of rock minerals chemically reacting with water molecules.
- Leaching translocating or transporting soluble minerals of clay particles through a developing soil profile. Transported material accumulate in the subsoil
- Accumulation of organic matter or newly formed crystals in the surface layers and topsoil

4. List the five, soil forming factors.
   Parent material, Climate, Biological factors, Topography and Time

Soil physical properties

Soil colour

5. Describe how soil colour is in indicator of soil fertility. Give examples.
   Colour is a simple method of classifying soil. Black/dark brown soil usually indicates high levels of decaying organic matter so are generally fertile. Pale brown/yellow soil often indicates that organic matter and nutrient levels are low, and this generally means poor fertility and structure. Pale soil needs large amendments of organic matter, nutrients and mulching and ideally could be drained.

Red soil usually indicates extensive weathering and good drainage, but often needs nutrients and organic matter. The red colour is due to the oxidising of iron compounds ('rusting') in the soil.

6. Apply your understanding of soil colour to identify the colour/s present and characteristics of the soils in each monolith image. A monolith is a mounted soil core which shows the undisturbed soil in profile.
For each monolith image:
    - Label the depth interval of each soil colour
    - Comment on any problems with drainage

   The first has been completed for you.
   Answers will vary but will uses colour descriptions and label depths.

Soil Texture

7. Define Water Holding Capacity.
   Water Holding Capacity is the ability of a certain soil to physically hold water in its soil pores against the force of gravity. It does this by soil particles holding water molecules by the force of cohesion. Water-holding capacity is controlled primarily by soil texture and organic matter.

8. Define soil texture
   Soil texture is a physical soil property and refers to the proportion of the various sizes of the individual soil particles in a soil sample. It is the measure of the relative proportions of sand, silt and clay.

9. Describe how soil texture affects plant growth
   Texture affects soil air and water spaces/pores (porosity), water infiltration (permeability) and the soils ability to hold water and nutrients. Therefore, a soil with good texture e.g. loam with a mixture of sand, silt, and clay will support high levels of plant growth and production. As it incorporates the best features of each of the soil types together- good drainage (sand), high levels of nutrient and water retention (clay and silt), good porosity (sand).

10. Can texture be altered through management?
    No, texture cannot be altered through management. It is the proportions of sand: silt: clay which is determined by parent material. To be noted- texture technically could be changed at a very small scale by e.g. adding clay to a sand but it is not a commercially viable large-scale practice.

11. Use the texture triangle (Figure 8) to identify the texture class of a soil with:

a) 40% sand; 30% silt; 30% clay: clay loam
b) 5% sand; 95% silt; 5% clay: silt
c) 85% sand; 5% silt; 12% clay: loamy sand
d) 49% sand; 14% silt; 39% clay: sandy clay
e) 23% sand; 23% silt; 76% clay: clay

12. Label the components of sand: silt: clay for soils A-E in the diagram

a) 20% sand; 10% silt, 70% clay
b) Approx. 24% sand; 46% silt, 30% clay
c) Approx. 70% sand; 5% silt, 25% clay
d) 10% sand; 70% silt, 20% clay
e) Approx. 91% sand; 3% silt, 5% clay, 5% clay

Soil Structure

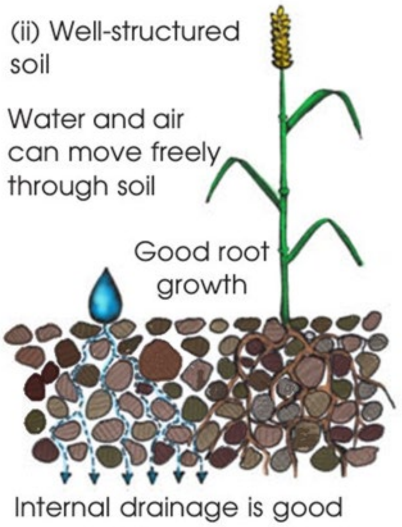
13. Define soil structure.
    Structure is concerned with how soil particles (sand, silt, and clay) and organic matter group together to form aggregates (or peds). The arrangement and size of the aggregates, along with the pores or spaces between the aggregates, is known as structure.
14. Describe characteristics of a well- structured soil
    A well-structured soil, along with having many small aggregates, has ample space within and between the aggregates to allow good penetration of water, air (gas exchange) and plant roots (transmission pores). It also has adequate small pores to store water for use by plants (water storage pores).
15. Describe characteristics of a poorly structured soil

- crusted or hard-set topsoil (massive structure)
- pugged topsoil (damage from stock)
- slaking and/or dispersion
- compacted zones, such as those under wheel tracks or plough pans
- poor establishment and stunted plant growth.

16. Describe two management practices which improve soil structure
    Could include any two of the following in detail:

- Incorporation of organic matter into a soil e.g. green manuring, poultry manure etc. Organic matter has a negative surface area which acts like a 'glue' binding soil particles together to from stable aggregates.
- Pasture phases in crop rotations which allow for the build -up of organic matter content.
- Conservation tillage methods such as the use of direct drills and cover crops in cropping regimes.
- Use of tramlines and roads when using implements in paddocks to reduce soil compaction
- Livestock management practices including no over stocking, over grazing or pugging of soils through compaction.
- Growing deep rooted perennial species which incorporate organic matter deep into the soil profile and encourage biological activity to greater depth than shallow rooted annual plant species.
- Addition and incorporation of agricultural lime (Calcium carbonate- $CaCO_3$). Calcium carbonate displaces hydrogen and aluminium ions located around clay particles with calcium. Calcium then strongly holds (bonds) the clay particles together thus improving soil structural stability and increasing pH.
- Addition and incorporation of gypsum (Calcium sulfate, $CaSO_4$). Gypsum improves soil structure by displacing sodium and magnesium ions in the surface of clay particles with calcium. Calcium then strongly holds (bonds) the clay particles together thus improving soil structural stability and decreasing soil dispersion.

17. and label a diagram to contrast plant growth, water infiltration and gaseous exchange in a well-structured and poorly structured soil.

<table>
<tr><th>Well-structured soil</th><th>Poorly structured soil</th></tr>
<tr><td>


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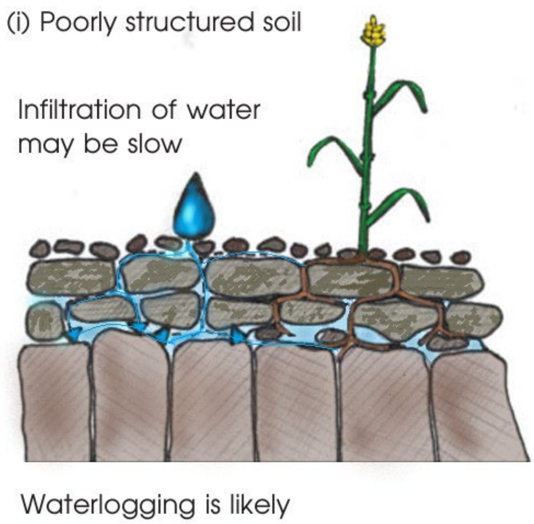

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Soil density and porosity

18. Define soil porosity.

    Soil porosity refers to the arrangement and distribution of pores (spaces) within the soil. Pore spaces are filled with either air or water. The number, size and shape and continuity of soil pores determine soil fertility, water infiltration rates, gas exchange and overall soil health.

19. Complete the table to label the missing parts of the soil pore diagram.

Soil pore labels	
a) Humus	e) Air
b) Macropores	f) Water filled pores
c) Mesopores	g) Micropores
d) Fungi	h) Bacteria and protozoans

20. Discuss how soil porosity can be altered through management.

    Answers will vary. Should include:

    Soil porosity refers to the arrangement and distribution of pores (air spaces) within the soil. It plays a crucial role in determining soil fertility, water infiltration rates, and plant growth. Management practices significantly impact soil porosity in both positive and negative ways.

    Discuss

    - Compaction
    - Tillage
    - Addition of organic matter and soil amendments
    - Crop residue management
    - Cover cropping
    - Irrigation and drainage.

21. Define bulk density
    Bulk density is an indicator of soil compaction and is dependent on soil texture and structure (proportion and arrangement of sand silt and clay components).

22. Write the bulk density equation and describe how it is calculated
    Bulk density is calculated as the dry weight of soil divided by its volume. This volume includes the volume of soil particles and the volume of pores among soil particles.

    Bulk Density (g/cm3) = Dry soil mass (g) ÷ Soil volume (cm3)

23. Contrast bulk density and soil porosity
    Bulk density and total porosity have an inverse relationship. Soils with a low bulk density have a high total porosity %; whereas soil with a high bulk density have a low total soil porosity %. Think of the sponge and brick.

Sponge - Low bulk density
high pore space

Brick - High bulk density
low pore space

24. List 5 management practices which maintain or improve soil bulk density
    Answer includes any five of the following:

- Controlled traffic farming (using established traffic lines and lane ways across property)
- Having lower tyre inflation pressure in heavy equipment/implements
- Using equipment with wider tyres or multiple axles, which distributes the weights over a larger area, thus reducing compaction (increased soil bulk density)
- Using laneways and never overstocking or over grazing with livestock production
- Increase soil organic carbon and organic matter
- Inclusion of deep-rooted perennial plant species into crop rotations and pasture systems which improve soil structure and create soil pores.
- Inclusion of cover crops in cropping systems
- Reduced and minimum tillage cultivation
- Minimise traditional cultivation methods
- Retaining ground cover
- Retaining stubble in cropping systems

Soil chemical properties

Soil pH

25. Identify what pH stands for?
    Potential hydrogen

26. Describe the following pH values

a) pH 1-6 Acidic

b) pH 7 Neutral

c) pH 8-14 Basic/Alkaline

27. List the pH range most plants prefer.
    pH between 6.0 and 7.5

28. Complete the table and list at least two examples of agricultural crops/pastures that tolerate the following pH levels

Soil acidity tolerance	Species
Highly sensitive pH 6+	Durum wheat, Schooner and Yerong barley, faba beans, chickpeas, medics, strawberry, Berseem and Persian clovers, Buffel grass, tall wheatgrass
Sensitive pH 5.5+	Canola, Rosella and Janz wheat, O'Conner and Skiff barley, albus lupins, red grass (Wagga), Phalaris, red and Balansa clovers, Caucasian and Kenya white clovers, common couch, Lucerne
Tolerant pH 5.2+	Brindabella barley, Swift and Sunstar wheat, Diamondbird - most acid tolerant wheat, annual and perennial ryegrass, tall fescue, Haifa white and subterranean clovers, wallaby grass (*Danthonia linkii*),
Highly tolerant pH 4.5+	Narrow leaf lupins, oats, Tahara triticale, cereal rye, cocksfoot, kikuyu, paspalum, yellow and slender serradella, Biserrula, Maku lotus, Consul love grass

29. Refer to Figure 21 to complete the following:

a) At <4 pH list all macro and/or micro nutrient deficiencies

- Macronutrients: P, K, S, Ca, Mg and N becoming unavailable
- Micronutrients (Trace elements): Mn, B, Cu, Zn, Mo
- Plus Aluminium toxicity will occur

b) At 8> pH list all macro and/or micro nutrient deficiencies

Micronutrients Fe, Mn, Cu

30. Identify the most accurate pH testing method.
    Laboratory testing using a glass electrode using the pH (CaCl) scale.

31. Describe the effect pH has on nutrient uptake in plants
    Answer will vary, could include:

pH plays a crucial role in nutrient uptake in plants, as it can influence the solubility of essential nutrients in the soil and the overall health of the plant. Here are some of the key effects of pH on nutrient uptake:

Availability of Nutrients

- Nutrient availability is highly dependent on soil pH. Most nutrients are optimally available to plants in a slightly acidic range (around pH 6 to 7.5).
- At low pH (acidic soils, pH below 6), nutrients such as iron, manganese, copper, and zinc become more soluble which is a plant available form, readily adsorbed by plants. However, other nutrients like phosphorus and calcium can become less available due to precipitation or fixation.
- At high pH (alkaline soils, pH above 7.5), essential nutrients like iron, manganese, and phosphorus tend to become less soluble and, therefore, become locked up in a form unavailable to plants, leading to deficiencies.

Microbial Activity

- Soil pH affects the activity and composition of soil microbes, which can influence nutrient cycling. For example, beneficial soil bacteria and fungi that help break down organic matter and make nutrients available often thrive in slightly acidic conditions.
- Extremes in pH can inhibit microbial activity, leading to reduced decomposition of organic matter and slower nutrient cycling and release.

Root Development

- pH can also impact root growth and development. High acidity (low pH) can lead to root damage or reduced root growth, which limits the plant's ability to take up water and nutrients.
- Alkaline conditions may impair nutrient absorption due to physical or chemical stress on the root cells.

Toxicity

- At very low pH levels, toxic elements such as aluminium and manganese may become soluble and reach concentrations that are harmful to plants. These toxicities can impair root function and overall plant health, further hindering nutrient uptake.

Interactions Between Nutrients

- The availability of one nutrient can affect the uptake of another due to competitive interactions. For instance, at higher pH, an increase in calcium availability might reduce magnesium absorption.

In summary, optimal pH levels are crucial for maximising nutrient uptake in plants, and deviations from the ideal range can lead to either nutrient deficiencies or toxicities, ultimately affecting plant growth and productivity. Proper soil management practices, such as pH testing and amendment with lime or sulfur, can help maintain favourable pH levels to support healthy plant growth.

Ion Exchange Capacity

32. Define CEC

    The Cation Exchange Capacity (CEC) is a measure of the negative charge of the soil and therefore that soil's ability to attract, exchange and hold positively charged cations by electrostatic attraction.

33. Define AEC

    The Anion Exchange Capacity (AEC) is a measure of the positive charge of the soil and therefore that soil's ability to attract, exchange and hold negatively charged anions by electrostatic attraction.

34. Complete the table to list the common soil cations and anions. Include the chemical symbol and ionic charge.

Common exchangeable soil cations		Common exchangeable soil anions	
Name	Symbol and charge	Name	Symbol and charge
Calcium ion	Ca^{2+}	Sulfate ion	SO_4^{2-}
Magnesium ion	Mg^{2+}	Nitrate ion	NO_3^-
Potassium ion	K^+	Chloride ion	Cl^-
Sodium ion	Na^+	Phosphate ion	PO_4^{3-}
Ammonium ion	NH_4^+	Hydroxide ion	OH^-
Aluminium ion	Al^{3+}		
Hydrogen ion	H^+		

35. Explain how nutrient leaching occurs in soils.

When fertilisers are applied, they supply nutrients (cations and anions) to the soil in a plant available form, which dissolves into the soil solution. Ions in soil solution are electrostatically held to the surface of soil colloids (clays and humus) and plant roots. The term 'exchangeable' associated with cations describes the ability of cations or anions to be exchanged between colloid surfaces and the soil solution. If there is no ion exchange or adsorption; excess nutrients are leached down through the soil profile.

Soils with high CEC hold larger quantities of nutrients for longer. Hence heavy clay soils have higher fertility. Sandy soils require regular applications of fertilisers to meet plant requirements.

36. List the relative strength of adsorption of common cations from highest to lowest:

$Al^{3+} > H^+ > Ca^{2+} > Mg^{2+} > K^+ = NH_4^+ > Na^+$

37. List the relative strength of adsorption of common anions from highest to lowest:

$H_2PO_4^{2-} > SO_4^{2-} \geq NO_3^- = Cl^-$

38. Explain how CEC is affected by:

a) Soil texture

The CEC of soils varies according the clay %, the type of clay, soil pH and amount of organic matter.

b) Soil pH

The fertility of soils decreases with decreasing pH. The lower the CEC of a soil, the faster the soil pH will decrease with time. Liming soils to higher than pH 5 (CaCl2) will maintain exchangeable plant nutrient cations.

c) Soil depth

CEC can change with depth. Generally, 0-10cm depth (topsoil) has the highest organic matter content so will have high CEC and AEC. At 10 – 30 cm depth, the organic content of the soil is very low, hence the CEC will be low. The CEC of the subsoil layers are governed by clay content and clay type.

39. Describe what processes are occurring at A-D in the following diagram.

	Description
A.	Clay particle with a negative surface charge exchanges Mg^{2+} cation with Ca^{2+} cation from the soil solution
B.	Roots and root hairs have a variable surface charge (+ve and -ve) which electrostatically attracts and adsorb cations and anions from the soil solution
C.	Clay particle with a variable surface charge exchanges OH^- anion and NO_3^- anion with SO_4^{2-} anion from the soil solution
D.	Excess nutrients that have not been adsorbed or bound up by roots or soil particle leach down through the soil profile.

Soil and plant nutrients and fertilisers

40. Complete the diagram by labelling the nutrients using their symbols (match the colours). Complete the key to identify each nutrient.

Key			
Major elements (macro nutrients)		Trace elements (micro nutrients)	
N	Nitrogen	Zn	Zinc
P	Phosphorous	B	Boron
K	Potassium	Mo	Molybdenum
Ca	Calcium	Fe	Iron
Mg	Magnesium	Mn	Manganese
S	Sulfur	Cu	Copper

41. Complete the table to name the following common fertilisers, identify the nutrient deficiency and identify if that nutrient is a major element or trace element for plant growth.

Common agricultural and horticultural fertilisers			
Formula	Common name	List the nutrient/s deficiency treated	Major or trace nutrient deficiency
$(NH_4)_2SO_4$	Ammonium sulfate	Nitrogen (N)	Major
$(NH_4)_2SO_4$	Ammonium nitrate	Nitrogen (N)	Major
CH_4N_2O	Urea	Nitrogen (N)	Major
$Ca(H_2PO_4)_2$	Superphosphate	Phosphorous (P) and Calcium (Ca) Sulfur (S) (Plus small amounts of N and K)	Major
KCl	Muriate of potash	Potassium (K)	Major
K_2SO_4	Sulfate of potash	Potassium (K)	Major
CaO	Lime	Calcium (Ca)	Major
$CaSO_4 \cdot 2H_2O$	Gypsum	Calcium (Ca)	Major

		Sulfur (S)	
$CaMg(CO_3)_2$	Dolomite	Calcium (Ca) and Magnesium (Mg)	Major
MgO	Magnesite (Magnesium oxide)	Magnesium (Mg)	Major
$MgSO_4$	Epsom salts	Magnesium (Mg)	Major
S	Elemental sulfur	Sulfur (S)	Major
$MnSO_4$	Manganese sulfate	Manganese (Mn)	Trace
$CuSO_4$	Copper sulfate	Copper (Cu)	Trace
$ZnSO_4$	Zinc sulfate	Zinc (Zn)	Trace
$Na_2[B_4O_5(OH)_4]\cdot 8H_2O$	Borax	Boron (B)	Trace
MoO_3	Molybdenum trioxide	Molybdenum (Mo)	Trace
$(NH_4)_6Mo_7O_{24}.4H_2O$	Ammonium molybdate	Molybdenum (Mo)	Trace

42. Select one nutrient deficiency from question 41. For your selected nutrient deficiency, use research to list plant deficiency symptoms and how to treat/prevent the deficiency.
    Answers will vary- Example Nitrogen deficiency - pale yellowish-green plant with reduced growth and reduced tiller development.

Soil biological properties

Soil Organic Matter and soil carbon

43. Contrast SOM and SOC
    Soil organic matter is the term used for all living, or once-living, materials within (or added to), the soil. All organic matter contains carbon (C), but it also contains nitrogen (N), phosphorus (P), sulfur (S), potassium (K), magnesium (Mg), calcium (Ca) and a whole range of micronutrients (e.g. copper, (Cu) and zinc (Zn). Soil organic carbon (SOC) refers solely to the carbon component of soil organic matter.
44. List five advantages of organic matter in soils
    Any five of the following.

    There are many important and beneficial roles that soil organic matter plays in soil:

    - Provides food for soil microbes
    - Provides nutrients to plants (particularly nitrogen, phosphorus and sulfur)
    - Stabilises soil structure and increases water holding capacity
    - Acts as 'glue' holding soil particles and aggregates together due to it's large, negative surface charge (high CEC)
    - Makes it easier for water to enter the soil
    - Reduces run-off and erosion
    - Improves the soil's ability to hold nutrients thereby reducing pollution potential
    - Helps buffer the soil against changes in pH
    - May protect plants against disease
45. Outline five factors which affect the level of organic matter in soils.
    Many factors affect soil organic matter levels:

- Soil depth – the organic matter content generally decreases deeper throughout a soil profile
- Soil type – sandy soils generally have lower soil organic matter than heavier soils such as loams
- Management practices – excessive cultivation reduces organic matter levels
- Temperature – organic matter breaks down quicker in hot climates compared with cool climates
- Soil water content – organic matter breaks down quicker in moist soil (though not permanently saturated) compared with dry soil

46. Complete the table by identifying the OM fraction and describing what each does.

Organic matter fractions	What is it?	What does it do?
Inert organic matter	e.g. charcoal, biochar and coal fragments	Does not breakdown but improves soil structure
Fresh plant and animal residues	Organic matter that has recently been incorporated e.g. manure, crop residues, stubble	Food for microbes, releases soil nutrients
Stable organic matter - Humus	Week decomposed organic matter	Supplies nutrients and improves soil structure
Active (decomposing) organic matter	Root exudates (composed of simple carbohydrates (sugars) and amino acid compounds) and actively decomposing OM	Moves through the soil profile. Binds soil particles, available plant uptake
Protected organic matter	Protected chemically or physically	Can't be decomposed by microbes
Microbial biomass	Bacteria, fungi, protozoans (the living part) and soil fauna	Decomposes organic matter

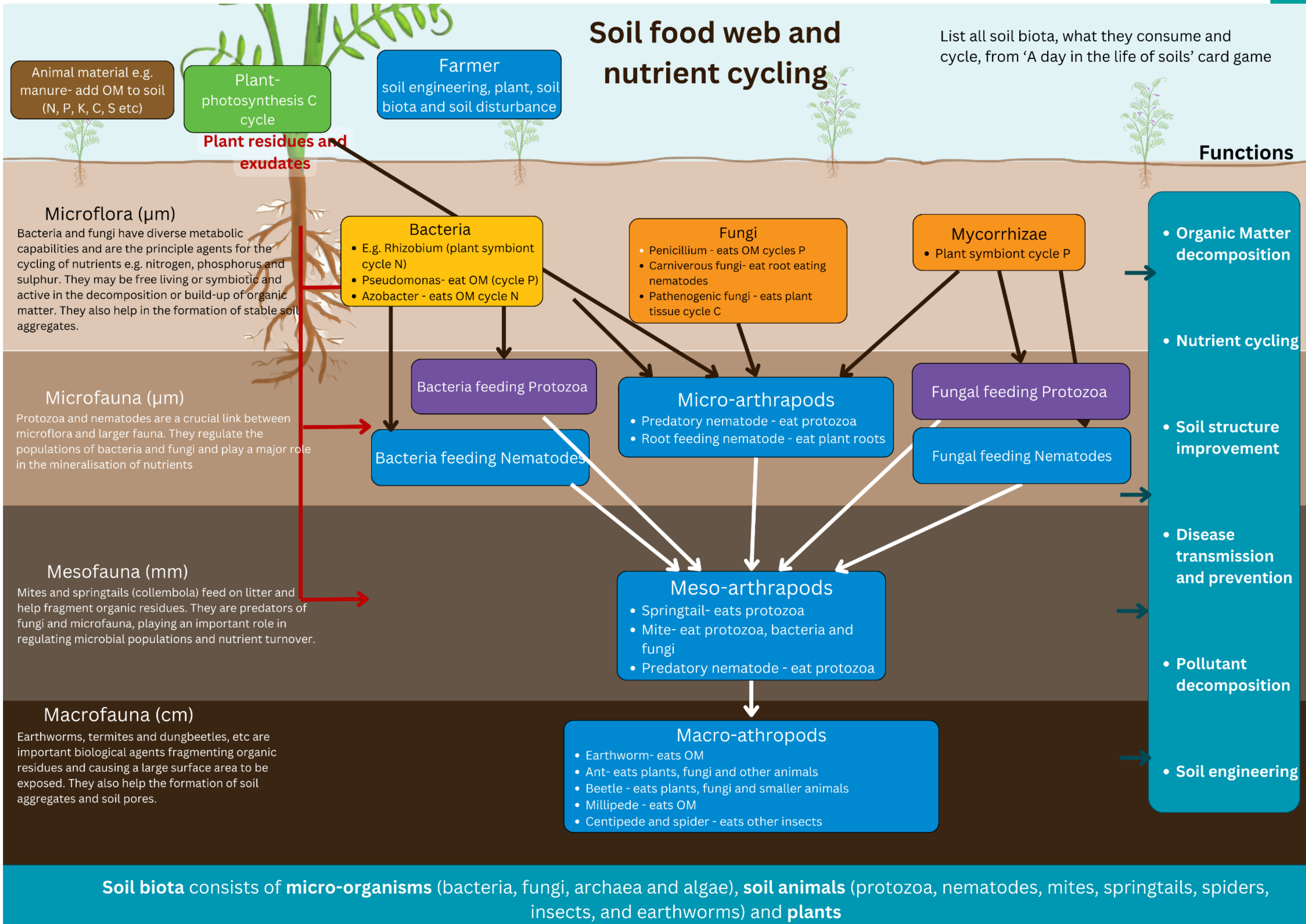
Soil microbes, invertebrates and nutrient cycling

47. Use research to outline the role of microorganisms and invertebrates in decomposition and nutrient cycling.

Some helpful sites include:

- Decomposition and Nutrient cycling, Ozsoils, UNE Soil science
- Life in the soil, CSIRO
- Organic matter decomposition and the soil food web, FAO
- Soil Organisms and litter decomposition
- The soil biota

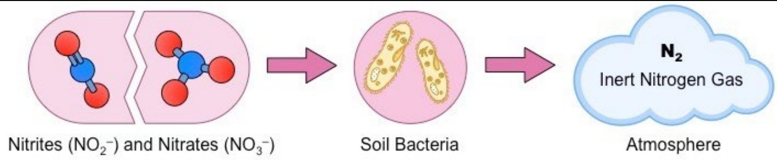
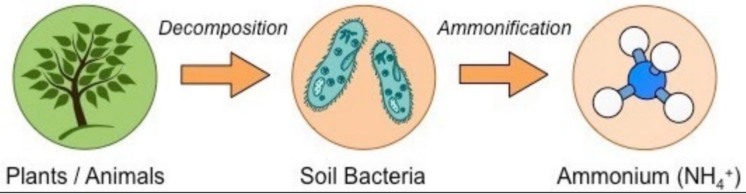
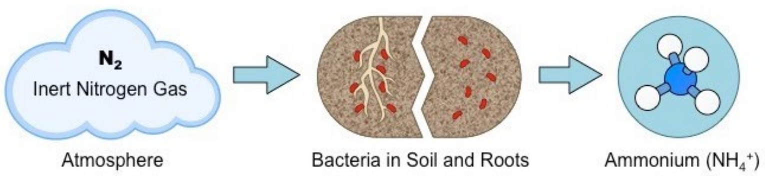
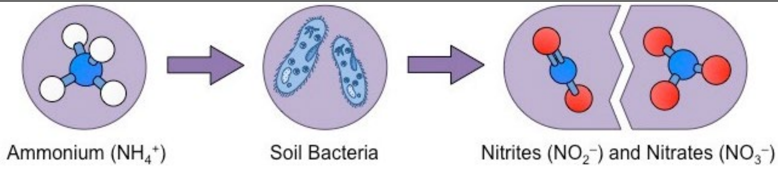
Answers will vary


Soil food web and nutrient cycling
List all soil biota, what they consume and cycle, from 'A day in the life of soils' card game
Animal material e.g. manure- add OM to soil (N, P, K, C, S etc)
Plant- photosynthesis C cycle
Plant residues and exudates
Farmer
soil engineering, plant, soil biota and soil disturbance
Microflora (µm)
Bacteria and fungi have diverse metabolic capabilities and are the principle agents for the cycling of nutrients e.g. nitrogen, phosphorus and sulphur. They may be free living or symbiotic and active in the decomposition or build-up of organic matter. They also help in the formation of stable soil aggregates.
Microfauna (µm)
Protozoa and nematodes are a crucial link between microflora and larger fauna. They regulate the populations of bacteria and fungi and play a major role in the mineralisation of nutrients
Mesofauna (mm)
Mites and springtails (collembola) feed on litter and help fragment organic residues. They are predators of fungi and microfauna, playing an important role in regulating microbial populations and nutrient turnover.
Macrofauna (cm)
Earthworms, termites and dungbeetles, etc are important biological agents fragmenting organic residues and causing a large surface area to be exposed. They also help the formation of soil aggregates and soil pores.
Bacteria
• E.g. Rhizobium (plant symbiont cycle N)
• Pseudomonas- eat OM (cycle P)
• Azobacter - eats OM cycle N
Fungi
• Penicillium - eats OM cycles P
• Carniverous fungi- eat root eating nematodes
• Pathenogenic fungi - eats plant tissue cycle C
Mycorrhizae
• Plant symbiont cycle P
Bacteria feeding Protozoa
Bacteria feeding Nematodes
Micro-arthrapods
• Predatory nematode - eat protozoa
• Root feeding nematode - eat plant roots
Fungal feeding Protozoa
Fungal feeding Nematodes
Meso-arthrapods
• Springtail- eats protozoa
• Mite- eat protozoa, bacteria and fungi
• Predatory nematode - eat protozoa
Macro-athropods
• Earthworm- eats OM
• Ant- eats plants, fungi and other animals
• Beetle - eats plants, fungi and smaller animals
• Millipede - eats OM
• Centipede and spider - eats other insects
Functions
• Organic Matter decomposition
• Nutrient cycling
• Soil structure improvement
• Disease transmission and prevention
• Pollutant decomposition
• Soil engineering
Soil biota consists of **micro-organisms** (bacteria, fungi, archaea and algae), **soil animals** (protozoa, nematodes, mites, springtails, spiders, insects, and earthworms) and **plants**

48. Complete the table to label the processes in the Nitrogen cycle

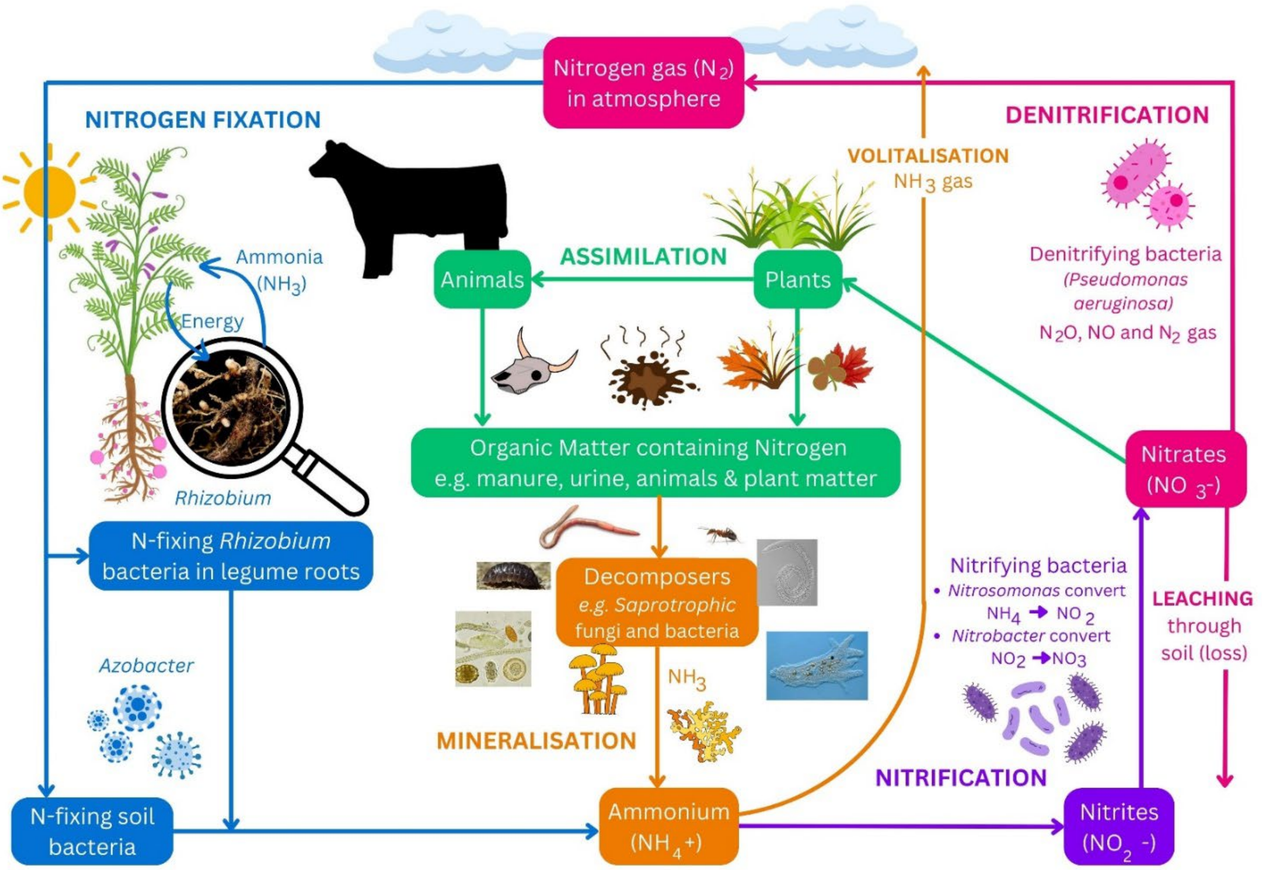
Nitrogen cycle processes			
A	Nitrogen fixation	G	Nitrate (NO_3)
B	Nitrogen fixing *Rhizobium* bacteria in legume roots	H	Assimilation
C	Mineralisation	I	Organic matter containing nitrogen e.g. manure, urine, animals and plant matter
D	Ammonium (NH_4)	J	Denitrification
E	Nitrification	K	N_2 gas in atmosphere
F	Nitrates (NO_2)	L	Volatilisation NH_4 to NH_3 gas

49. Identify the name of the following process being represented from the Nitrogen cycle. For each process list micro-organisms involved.

Nitrogen cycle process	Image
Denitrification *Pseudomonas and Thiobacillus*	
Mineralisation *Saprotrophic fungi and bacteria*	
Nitrogen fixation *Rhizobium bacteria* and *Azotobacter*	
Nitrification *Nitrosomonas and Nitrobacter*	

50. Construct and label a simplified diagram of the nitrogen cycle.

Simplified version of the following



51. Identify the name of the process being represent in the following diagrams.

a) Respiration

b) Photosynthesis

52. Complete the table to write the word and chemical equations for photosynthesis and respiration.

Process	Photosynthesis	Respiration
Word equation	Carbon dioxide + Water $\xrightarrow[\text{Chloroplasts}]{\text{Light energy}}$ Glucose (sugars) + Oxygen	Glucose + Oxygen $\rightarrow$ Carbon dioxide + water + energy (ATP)
Chemical equation	$6CO_2 + 6H_2O \xrightarrow[\text{Chloroplasts}]{\text{Light energy}} C_6H_{12}O_6 + 6O_2$	$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O +$ energy (38 ATP)

53. Complete the table to label the Carbon cycle.

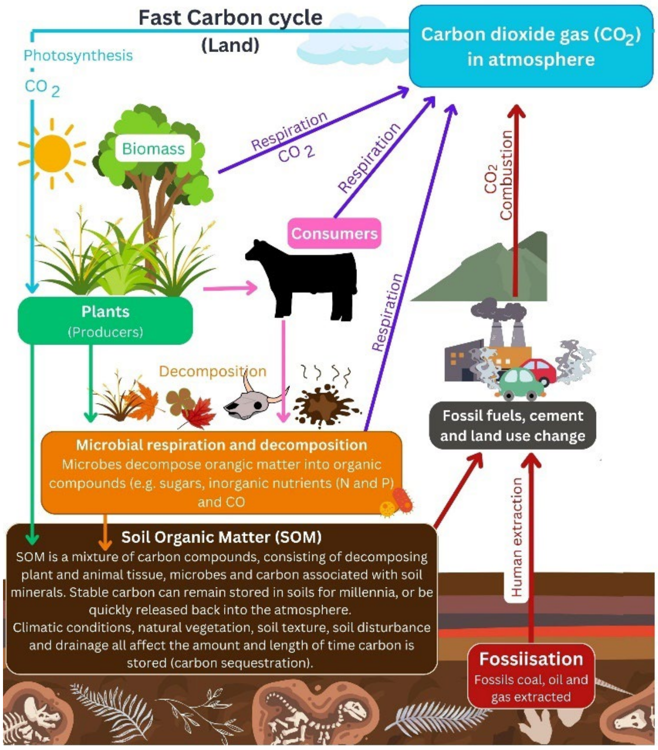
Carbon cycle			
A	Carbon dioxide gas in the atmosphere	F	Photosynthesis
B	Photosynthesis	G	Phytoplankton
C	Plants (producers)	H	Consumers
D	Consumers	I	Microbial respiration and decomposition
E	Microbial respiration and decomposition	J	Fossil fuels, cement and land use change

54. Explain the importance of decomposers in the carbon cycle

Decomposers help break down dead materials from animals and plants in an ecosystem rather than it being immobilised and unable to cycle. By doing so, they release carbon dioxide into the atmosphere, which can then be used by plants, algae and phytoplankton during photosynthesis to create oxygen and carbohydrates (sugars) which are used by heterotrophs/consumers and cycled through the food web/ carbon cycle.

55. Construct a simple, labelled diagram of the carbon cycle (land, fast carbon cycle).

Simplified version of the following



Sustainable soil management

Land degradation issues

56. Briefly outline the following land degradation issues:

a) Soil erosion

Soil erosion is the detachment and movement of soil particles by water, wind and gravity, from an original location to a new location where it is problematic. In addition to sedimentation of waterways and dams, eroded soil carries large amounts of nutrients and organic matter which can pollute surface water (eutrophication) and reduce the productive potential of paddocks.

Erosion is amplified when there is no ground cover (e.g. over grazing, cultivation and land clearing), through poor soil structure (low levels of organic matter in soil) etc.

b) Soil acidity

A soil is acidic when it has a pH below 7 (neutral). Soils with pH below 5.5 have issues with nutrient lock-up and toxicities. Soil acidification is a major soil degradation issue in many Australian soils. Potential indicators of soil acidity are:

- reduced yields

- decline of acid sensitive species (legumes)
- lack of response to fertilisers
- Aluminium toxicity.

Soil acidification may lead to a decline in groundcover and decreased farm productivity. It increases the risk of erosion and pollution of waterways. Australian soils are highly weathered and naturally acidic (pH less than 5.5) throughout the soil profile. However, soil acidification has increased due to agriculture.

The main causes of agriculturally induced acidity are: Nitrate leaching below the root zone; removal of agricultural product and type of nitrogenous fertiliser.

c) Soil sodicity

A sodic soil has high concentrations of sodium (Na^+) (more than or equal to 6 percent of the Cation Exchange Capacity). The sodium ions attach to clay particles and make them disperse and unstable.

Sodicity is often confused with salinity. Sodicity and salinity are both undesirable but have opposite effects on soil structure.

- sodium disrupts soil structure, causing soils to disperse if disturbed
- salt in saline soils prevents dispersion but reduces the ability of plants to take up water.

Sodicity can occur at any depth in the soil but is most common in the subsoil. Signs of sodicity may be more or less obvious depending on where it occurs within the soil profile (i.e. topsoil, subsoil or both), the climate (particularly rainfall), and slope (hilly country may be more susceptible to tunnel erosion).

d) Dryland salinity

Dryland salinity is the accumulation of salt in surface soil in non-irrigated areas, due to rising groundwater tables. As the soil surface dries out, dissolved salts are left behind. These salts impede the ability of plants to extract water from soil, resulting in the loss of pasture and groundcover, and subsequent erosion.

Land management practices have increased the area impacted and the effects of salinity in Australia.

Removing vegetation from landscapes, particularly trees and deep-rooted perennial grasses and shrubs, is a significant cause of rising groundwater tables and associated salinity. Groundwater tables rise when water infiltrating the soil moves beyond the reach of plant roots ('recharge'). Sometimes the water table will 'discharge' above the ground surface (seen as a salt scald).

e) Soil fertility decline

Soil fertility decline occurs when the quantities of nutrients removed from the soil in harvested products exceed the quantities of nutrients being applied.

Nutrients may be removed from the soil by:

- growing and harvesting products (e.g. crops, livestock, wool hay etc)
- soil erosion
- leaching.

Fertility management aims to maintain soil organic matter, soil structure, soil nutrient status and satisfactory soil pH.

57. Select one soil degradation issue. For your chosen issue, carryout research to compile information for a 2-page factsheet. In your factsheet address:

- Name of land degradation issue
- Define the soil degradation issue
- Identify the effect of the issue on land /water and Australian agricultural production
- Include images and diagrams
- Outline agricultural practices that have caused the issue
- Describe how the issue can be prevented through agricultural management
- Describe how to treat/reverse the issue through agricultural management
  Answers will vary, but will address all task requirements

Managing soil fertility

58. Watch Long-term conventional and no-tillage systems compared
59. Complete the table to describe each conservation tillage system. For each give an example of a production enterprise suited to this type of plant establishment.

Strategy	Describe the conservation tillage system	Enterprise example
No till	Also called direct -drill, no-till, slot planting and zero-till) the soil is undisturbed by tillage during the entire year which allows for OM accumulation which improves soil structure and fertility. Seed is sown directly into crop residues.	Cropping, pasture production
Strip till	Equipment cuts through crop residue with minimal disturbance and perform non- inversion tillage in a narrow strip long the row. Seed is placed into the strip (combats compaction).	Cropping, pasture production
In -row subsoiling	Practice combats soil compaction to depth while conserving groundcover to minimise runoff and erosion. Equipment cuts through crop residues with minimal disturbance and perform non- inversion tillage in a narrow strip long the row. Seed is placed into the strip.	Cover cropping- pasture and fodder production
Ridge tillage	Seed sown into elevated rows that remain undisturbed after establishment. After ridges are established, all field traffic is controlled trafficked and confined to the furrows between the ridges which minimises compaction. Furrows are cultivated to control weeds.	Vegetable production

60. Describe how soil organic matter management can be used to alter soil fertility. Include two specific management examples.
    Soil OM can have significant effects on soil processes and properties that influence nutrient availability (soil fertility). For example, increasing soil OM increases soil aggregation and decreases bulk density, which improves water infiltration, air exchange, root growth, and crop/pasture productivity. Soil OM levels depend on soil and plant management. If management is changed, a new OM level is attained that may be lower or higher than the previous level. Management systems should be adopted that aim to continually increase soil OM content and productivity. Proper nutrient management will produce high yields, which will increase the quantity of residues and soil OM.

Examples will vary and could include two of the following:

- Perennial pasture
- Cereal crop
- Green manure crops
- Maure spreading
- Use of organic fertilisers
- Minimising cultivation
- Concentrating OM

61. Describe how crop rotations can be used to manage soil fertility. Include two specific crop rotation management aims.
    Crop rotation is the is the practice of planting different crops sequentially on the same plot of land to improve soil fertility by optimising nutrients and water use in the soil, to combat pest, disease and weed pressure and increase soil microbial and invertebrate diversity. Describe two management aims in detail. Answers could include: diverse crop species, deep and shallow rooted species, inclusion of perennials and annuals, legumes and cereals, pest, disease and weed management and controlling soil pathogens.

62. Give an example of a long-phase rotation system:
    Several years of a multi-species perennial pasture phase (e.g. 20 years), followed by a number of years of cropping (cropping phase) (6 years).

63. Give an example of a short-phase rotation system:
    The short-phase rotation involves alternating years of pasture → crop (e.g. medic → wheat) or cereal → pulse (e.g. wheat → lupin)

64. Describe how the inclusion of a pasture ley phase can be used to manage soil fertility.
    A ley pasture (or pasture ley) refers to a non-permanent pasture phase, of one to several years duration, that has the dual objectives of providing forage for livestock and enhancing soil fertility and structure. The pasture ley may contain only annual species, perennials or a mixture of both. Ley pastures in crop rotations can reverse declining soil health and structure, increase soil fertility and nutrient cycling, improve livestock productivity, allow for a pest, disease and weed break, and reduce environmental problems like soil erosion and deep drainage. Pasture leys characteristically include multiple pasture legume species. Examples include lablab, Sulla, lupin, cowpeas, mung beans, burr and barrel medics, subterranean clover, lucerne. Pasture leys provide the opportunity for cover cropping.

    The most important feature of pasture legumes is their ability to fix atmospheric nitrogen due to the symbiotic relationship with the soil bacteria Rhizobium inside root nodules. Soil nitrogen is boosted by the direct accumulation of organic legume residues (tops and roots) and by the return of ingested nitrogen in the dung and urine of grazing animals. During the pasture phase, soil nitrogen increases because the quantity of symbiotically fixed nitrogen exceeds the mineralisation of organic nitrogen. Then, during the cropping phase, nitrogen mineralised from organic matter becomes available to crops.

65. Describe how the addition of organic fertilisers, can be used to manage soil fertility.
    The addition of organic fertilisers, such as compost, manure, green manure and crop residues, significantly improve soil fertility by enhancing its structure, nutrient content, and biological activity. Organic matter increases soil aggregation, improving porosity, water retention, and aeration, which supports healthy root growth. These fertilisers also provide a slow-release supply of essential nutrients, including nitrogen, phosphorus, and potassium, promoting long-term plant growth. Organic fertilisers additionally encourage the growth of beneficial soil microorganisms, which help decompose organic matter, fix nitrogen, and cycle nutrients efficiently.

Furthermore, organic fertilisers enrich the soil with organic matter, improving its cation exchange capacity (CEC) and moisture retention, while also buffering soil pH, which benefits plant health. They reduce dependence on synthetic fertilisers, minimising environmental risks such as nutrient runoff and soil degradation.

66. Describe how the addition of inorganic fertilisers and can be used to manage soil fertility.
    Inorganic fertilisers are chemically manufactured and typically contain specific ratios of essential nutrients like nitrogen (N), phosphorus (P), and potassium (K). They play a direct role in managing soil fertility by providing readily available nutrients to plants. They are often used to address specific nutrient deficiencies in the soil, ensuring that plants receive the necessary elements for optimal growth. Inorganic fertilisers can be applied to meet the immediate nutrient needs of crops, leading to faster growth, higher yields, and improved quality of produce.

    Inorganic fertilisers are highly concentrated, allowing for precise control over the nutrient content in the soil. They are especially useful in soils that are deficient in key nutrients or where nutrient availability is low. By using inorganic fertilisers, farmers can quickly correct deficiencies of macronutrients (such as nitrogen for leaf growth, phosphorus for root development, and potassium for overall plant health) and micronutrients (like iron and zinc). However, incorrect use of inorganic fertilisers can lead to soil acidification, nutrient imbalances, and environmental issues like nutrient runoff and water pollution, which is why they should be used in conjunction with sustainable practices such as crop rotation and organic matter amendments to maintain long-term soil fertility.

Land and soil capability

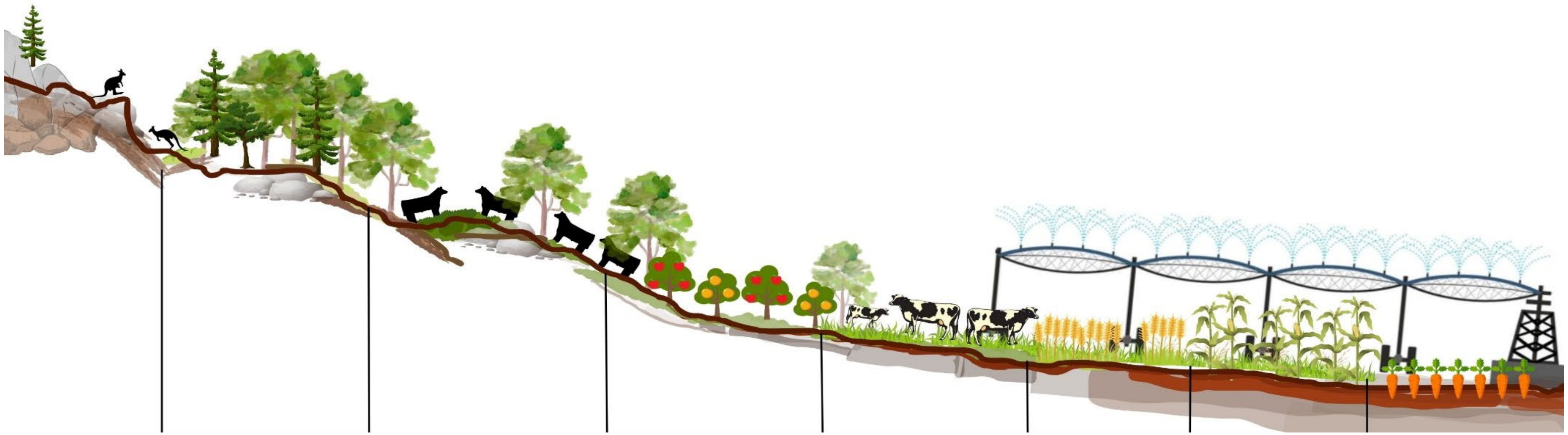
67. Watch: Preparing for drought through Whole farm planning
68. Watch: The importance of Agriculture- Agricultural Land use planning
69. Go to the Tocal Virtual Farm- Land Capability on Tocal, to investigate how Tocal farms enterprises are managed and set out according to Land Capabilities
70. Define land capability
    Land capability is the capacity of the land and soil to sustain a range of land uses and management practices in the long term without degradation to soil, land, air and water. It is influenced by topography (slope), soil and climatic characteristics and their interactions.

    Land capability is based on an assessment of the biological and physical characteristics of the land, the extent to which this will limit a particular type of land use, and the current technology that is available for the management of the land.

71. Explain how land capability assessment can be used to improve the long-term sustainability of Australian farms.
    Land capability assessment involves using a classification system to gain knowledge regarding the suitability of a piece of land for specific agricultural activities (enterprises) and to identify land that is not suitable for farming.

    The land and soil capability (LSC) assessment scheme was initially developed by the Department of Infrastructure, Planning and Natural Resources to assist in assessing the environmental impact of clearing native vegetation. The eight-class system evaluates the physical, social and historical factors specific to the land under investigation. The resulting land class (from 1-8) indicates the range of agricultural practices that can safely be carried out on that land. For example, only land classified as class 1 or 2 can be cultivated regularly. Cultivation of land classified 3 or more is likely to lead to erosion problems. Hence land classification systems enhance sustainability by ensuring that land use is closely matched to the capacity of the land to withstand detrimental effects associated with farming.

72. Complete the table to label and summarise the eight Land and Soil Capability classes. Give examples of suitable agricultural enterprises for each LSC class.

Land and Soil Capability classes, enterprises and general definitions								
Image								
	Land generally incapable of agricultural land use		*Land capable for limited land uses*	*Land capable of a variety of land uses*		*Land capable of a wide variety of land uses*		
LSC class	8	7	6	5	4	3	2	1
LSC Class name	Extremely low capability land	Very low capability land	Low capability land	Moderate-low capability land	Moderate capability land	High capability land	Very high capability land	Extremely high capability land

Description	Limitations are so severe that the land is incapable of sustaining any land use apart from nature conservation. There should be no disturbance of native vegetation.	Land has severe limitations that restrict most land uses and generally cannot be overcome. On-site and off-site impacts of land management practices can be extremely severe if limitations not managed. There should be minimal disturbance of native vegetation.	Land has very high limitations for high-impact land uses. Land use restricted to low-impact land uses such as grazing, forestry and nature conservation. Careful management of limitations is required to prevent severe land and environmental degradation	Land has high limitations for high-impact land uses. Will largely restrict land use to grazing, some horticulture (orchards), forestry and nature conservation. The limitations need to be carefully managed to prevent long-term degradation	Land has moderate to high limitations for high-impact land uses. Will restrict land management options for regular high-impact land uses such as cropping, high-intensity grazing and horticulture. These limitations can only be managed by specialised management practices with a high level of knowledge, expertise, inputs, investment and technology	Land has moderate limitations and is capable of sustaining high-impact land uses, such as cropping with cultivation, using more intensive, readily available and widely accepted management practices. However, careful management of limitations is required for cropping and intensive grazing to avoid land and environmental degradation.	Land has slight limitations These can be managed by readily available, easily implemented management practices. Land is capable of most land uses and land management practices, including intensive cropping with cultivation.	Land has no limitations. No special land management practices required. Land capable of all rural land uses and land management practices
Example enterprises	Examples of selective forestry and nature conservation	Examples of selective forestry and nature conservation	Examples of grazing, forestry and nature conservation, some horticulture	Examples of cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation	Examples of cropping with restricted cultivation, pasture cropping, grazing, some horticulture, forestry, nature conservation	Examples of cropping, grazing, horticulture, forestry, nature conservation	Examples of cropping, grazing, horticulture, forestry, nature conservation	Examples of cropping, grazing, horticulture, forestry, nature conservation

Tensions between sustainability and short term profitability

73. Select one of the following topics

- Green manuring
- Conservation tillage practices e.g. direct drilling (zero -tillage)
- Pasture ley phase
- Matching enterprises to Land use capabilities
- continual application of artificial N fertilisers
- Increasing pHCaCl to 5.5 - 5.8

Use research to complete the following

- Briefly describe the practice
- Identify and describe the long- term effects on sustainability
- Identify and describe the short - term effects this practice has on sustainability

Answers will vary, but will address all task requirements

Soil systems careers

74. Use the internet and other sources to investigate a plant production-related career of your choosing. For this career find out the following:

- Title of the career/job
- Role description
- Personal qualities
- Skills required (if formal courses or education is required, find out where you could train and the timeframe to complete the course)
- Salary or wage range
- Identify opportunities for job progression in the role

Answers will vary, but will address all task requirements

Soils revision – past HSC questions (2013-2023 papers)

Past HSC questions and answers are sourced directly from the NSW Education Standards Authority, Agriculture HSC exam packs.

Multiple choice

1. B
2. C
3. A
4. D
5. C
6. C
7. D
8. B
9. D
10. C
11. B
12. D
13. B
14. C
15. C
16. Row D
17. A
18. B
19. A
20. C
21. C
22. C
23. A
24. D
25. B
26. D
27. C
28. B
29. Row C
30. A
31. B

Short Answer responses

32. (2014 HSC Exam pack Q21) (8 marks) Answer parts (a), (b) and (c) in relation to an identified soil degradation problem

Name of a soil degradation problem……………………………………………………………………………

a) Outline an effect of this soil degradation problem on agricultural production. 2 marks

Soil compaction results in reduced plant growth due to root growth being impeded and so the plant has less access to water and nutrients.

b) Explain how a farming practice can lead to this soil degradation problem 2 marks

Continuous cultivation with heavy machinery compresses the soil particles. This results in a layer of compacted soil below the soil surface.

c) Describe procedures which can be used to alleviate or prevent this soil degradation problem. 4 marks

Soil compaction can be prevented by adopting minimum tillage techniques. This reduces the amount of compaction by limiting the number of times heavy machinery passes over the soil. Compacted soils can be rehabilitated by first deep ripping them with a tyned cultivator and then increasing the organic matter content of the soil to improve the soil structure.

33. (2015 HSC Exam pack Q22) (6 marks)

a) Describe the effect of organic matter (soil carbon) on a physical characteristic of soil. (2 marks)

Sample answer: Organic matter cements or binds the sand, silt and clay particles together to form aggregates. It is the aggregates which give the soil structure. Answers could include:

- Water-holding capacity
- Nutrient-holding capacity

b) Explain how conservation tillage assists in maintaining soil fertility. (4 marks)

Conservation tillage assists in maintaining soil fertility by decreasing the destruction of soil aggregates that occurs when soils are cultivated repeatedly. It also assists in maintaining soil organic matter levels, thus assisting in the development of soil structure and improving the nutrient and water-holding capacity of the soil.

Answers could include:

- Nutrient cycling
- Biological activity.

34. (2015 HSC Exam pack Q23) (8 marks)

a) Explain how soil texture influences the water-holding capacity of soils. 2 marks

Clay soils have a greater water-holding capacity than sandy soils due to their greater total volume of pore spaces between the soil particles. The smaller pores in clay soils also hold water more strongly against the force of gravity.

b) Explain how land capability assessment can be used to improve the long-term sustainability of Australian farms. 6 marks

Land capability assessment involves using a classification system to gain knowledge regarding the suitability of a piece of land for particular agricultural activities and to identify land that is not suitable for farming.

The five-class system that has been developed by the NSW DPI evaluates the physical, social and historical factors that pertain to the land under investigation. The resulting land class placed on the land (from 1-5) indicates the range of agricultural practices that can safely be carried out on that land. For example, only land classified as class 1 or 2 can be cultivated regularly. Cultivation of land classified 3 or more is likely to lead to erosion problems. Hence land classification systems enhance sustainability by ensuring that land use is closely matched to the capacity of the land to withstand detrimental effects associated with farming.

35. (2016 HSC Exam pack Q22)

a) Describe TWO techniques that farmers can use to improve or maintain soil organic matter (soil carbon) levels. 4 marks

A pasture ley phase in a cropping system will add plant material in the form of dead leaves, stems and roots. When the pasture is grazed, organic matter is added to the soil via manure. The level of soil organic matter builds up over time if the soil is left undisturbed. Litter from poultry sheds or bedding from livestock sheds includes materials such as straw, manure, wood shavings and rice hulls. When added to soils, either in raw form or after being composted, they decompose and add organic matter to the soil.

Answers could include

- Green manure crops
- Minimum tillage
- Zero tillage
- Stubble retention

36. (2017 HSC Exam pack Q22) (7 marks)

a) Outline the beneficial roles played by microbes in soils. 3 marks

Microbes play a role in the breakdown of plant and animal remains into organic matter in soils. They release humus into the soil and also release plant nutrients, which plants can take up through their roots.

One group of microbes is able to fix nitrogen from the atmosphere and make nitrogen compounds available to plants.

Answers could include:

- Mycorrhiza
- Rhizosphere microbes
- Breakdown of toxins

b) Explain how TWO soil management techniques can increase the population of microbes in the soil (4 marks)

Stubble retention and green manuring both result in an increase in the level of soil organic matter (soil carbon). The increased organic matter content of the soil results in an increase in the amount of nutrition available to microbes and invertebrates thus allowing their populations to increase.

Answers could include: ·

- Reduced tillage ·
- Addition of animal manures ·
- Reduction in chemical application ·
- Use of pasture leys ·
- Liming of soil ·
- Inoculation of legumes.

37. (2017 HSC Exam pack Q23 C)

a) Explain an advantage and a disadvantage of ONE method farmers can use to improve soil moisture (4 marks).

Available soil moisture can be manipulated by irrigating the crop. The advantage is that this is a very effective technique for regulating the amount of water according to the needs of the plant. It is only appropriate for crops where there is a suitable source of water available (for example, dams and rivers) and the topography is suitable. A disadvantage is that excessive irrigation can cause water tables to rise, which can cause salinity problems.

Answers could include:

• Mulching

• Fallowing

• Soil structural modification (eg gypsum)

• Addition of compost

• Stubble retention.

38. (2018 HSC Exam pack Q21 C)

a) Explain ONE strategy that can be used to alleviate a soil degradation problem. 4 marks

Name the soil degradation problem ………………………………………………………………

Soil erosion

Planting trees or groundcover (pasture) will prevent the soil moving from one place to another. The roots from plants hold the soil together and maintain its structure against the effects of wind and water.

Other examples could include salinity/sodicity, etc.

39. (2019 HSC Exam pack Q22)

a) Name TWO physical characteristics of soil. (2 marks)

Sample answer: • Bulk density • Soil porosity, texture, structure (combination of any 2)

b) Describe a method that can be used to test ONE specific physical or chemical characteristic of soil (4 marks)

Method for texture analysis:

1. Collect a sample of soil, approximately the size of a 50-cent coin.

2. Moisten the soil to the consistency of dough

3. Rub between fingers to determine grittiness 4. Form a ball to check cohesion

5. Roll into a cylinder between your hands and try to form it into a ring.

6. Compare your observations to the texture class key – supplied by the teacher

7. Determine the texture class.

Answers could include: • Structure • Bulk density • Porosity • pH

40. (2019 HSC Exam pack Q24 C)

a) Explain how TWO techniques are currently used to sustainably manage soil fertility on farms. (6 marks)

Conservation tillage reduces the number of times soil is disturbed by ploughing, thereby improving soil structure. Structure can also be improved by the stubble that remains and the organic matter added to the soil. Some nutrients are returned as organic matter decomposes. Improved organic matter improves structure and water-holding ability, and combats soil erosion and compaction.

Green manure cropping involves growing a crop, usually a legume, then ploughing it back into the ground. This increases the organic matter content within the soil and improves soil structure. The chemical fertility of the soil is improved by the addition of nutrients from the legumes and as the organic matter breaks down. This is more sustainable than the use of chemical fertilisers, which can acidify the soil.

Answers could include: • Crop rotation • Stubble mulching • Pasture ley phase

41. (2020 HSC Exam pack Q21)

Answer parts (a)–(c) with reference to a soil degradation problem you have studied.

Name of problem..................................

a) Outline the named problem (2 marks)

Dryland salinity is an accumulation of dissolved salts moved to the plant root zone, carried by rising water tables.

Answers could include:

• Erosion • Structural decline • Acidification • Loss of soil organic matter.

b) Explain how a land use practice has led to this problem. (3 marks)

The land management practice of clearing trees for pasture or cropping has led to dryland salinity. Deep-rooted trees will take up groundwater, keeping the water table at a lower level. Clearing these trees results in the rise of the water table, which brings dissolved salts closer to the surface. This causes an accumulation of salts in the plant root zone.

c) Explain how a sustainable management practice can alleviate this problem (4 marks)

A sustainable management practice is to plant salt resistant perennial crops or pastures. Suitable species could include saltbush (medium rooted perennial) or tall wheat grass (shallow rooted perennial grass). As these plant root systems develop in the soil, they increasingly access soil water which they remove through transpiration. This lowers the water table over time leaving salt in a non-soluble form, not available to plants.

42. (2021 HSC Exam pack Q21)

a) Outline how ONE management practice has contributed to a soil degradation problem. 2 marks

The removal of vegetation can reduce the ability of soil particles to be bound together and therefore erosion can occur.

b) Explain how ONE procedure alleviates a soil degradation problem and ensures the long-term sustainability of the soil. 4 marks

The use of minimum tillage assists with reducing the incidence of soil erosion. The stubble left in the paddock reduces wind velocity or water flow at the soil surface, removing the erosive power of these factors.

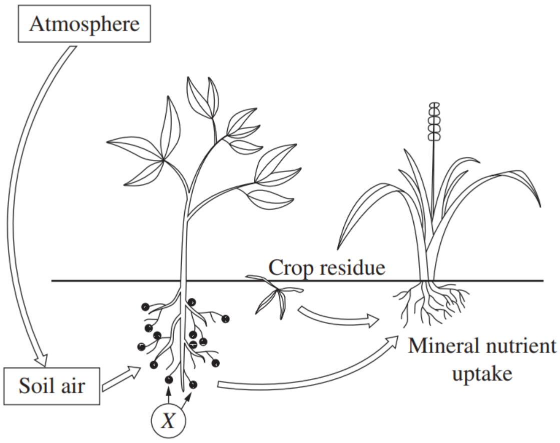
Minimum tillage contributes to long-term sustainability of a soil by improving the structure of the soil and increasing the amount of organic matter in the soil.

43. (2022 HSC Exam pack Q21)

a) Describe the role of ONE invertebrate in decomposition within the soil. 3 marks

Earthworms physically fragment organic matter into smaller pieces increasing the surface area, which enhances microbial chemical action, and they incorporate residues in the soil. Earthworms also improve soil aeration to the benefit of aerobic decomposer microbes.

b) The following diagram depicts part of a nutrient cycle.

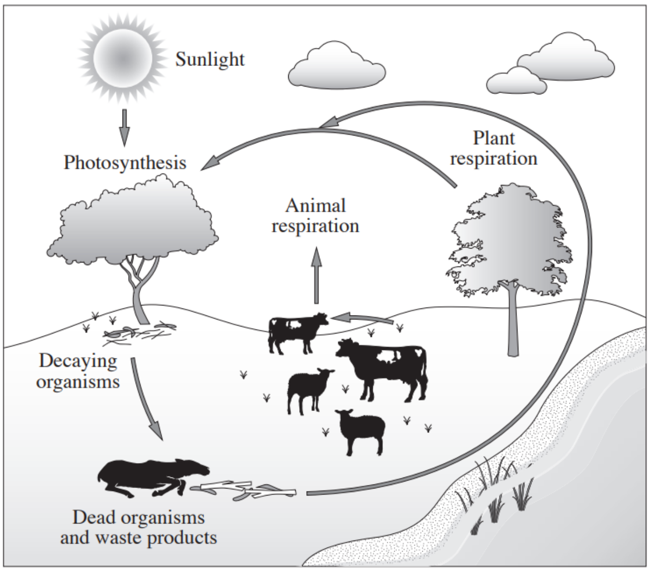


Identify the process occurring at X and explain how this process contributes to the cycling of the nutrient. 4 marks

Nitrogen fixation occurs at X. Rhizobia bacteria cause nodules to form on the roots of legume plants and convert atmospheric nitrogen into a form the legume plant can use. When residues from the legume plant are decomposed, usable nitrogen compounds are released for uptake by other plants. Plants grown in close proximity to the legumes may also have access to usable nitrogen.

44. [(2023 HSC Exam pack]Q21)

Use the diagram to answer parts (a) and (b)



a) Identify the nutrient being cycled in the diagram. (1 mark) Carbon or C

b) Outline the role of soil nutrient cycles in agriculture. (2 marks)

The role of nutrient cycles in agriculture is to move nutrients through the ecosystem using various processes between soil, air, water and living things.

c) Describe the importance of invertebrates in both decomposition and nutrient cycling. (3 marks)

Invertebrates help to decompose dead animals, plant matter and manure by physical breakdown of the material and moving the organic components around and into the soil. Invertebrates help to move material from the surface into the soil by pulling it into the cracks or burrows breaking it down into smaller pieces and increasing the surface. This allows microbes to access it, decompose and cycle nutrients making them available for plant growth.