PRIMED
Teacher resource

Year 8 Science

Department of **Primary Industries and Regional Development**
Department of **Training and Workforce Development**
Department of **Education**

Teaching guide: Life under cover – applying knowledge of cells and systems in food and fibre production

Resources overview

PRIMED mission

To increase student understanding of agriculture, fisheries, fibre, forestry and food (primary industries) careers to enable Year 7–12 students to make informed career-pathway choices.

About the resource set

This series of activities challenges students to engage with the *Western Australian Science Curriculum* by focusing on comparisons of their own cells and organ systems with those of other living organisms commonly used in Western Australian primary industries for food and fibre production.

Through this process, students can gain a deeper understanding of the complexities of the biological and physical world, and how we interact with it to sustainably produce essential food and fibre.

Curriculum links

This resource set is designed to be a learning pathway for Year 8 science students to develop their understanding of the *Western Australian Curriculum* **Biological Sciences** content descriptions:

- Cells are the basic units of living things; they have specialised structures and functions (ACSSU149).
- Multicellular organisms contain systems of organs carrying out specialised functions that enable them to survive and reproduce (ACSSU150).

It also engages students with the **Science as a human endeavour** content descriptions:

- People use science understanding and skills in their occupations and these have influenced the development of practices in areas of human activity (ACSHE136). These include but are not limited to industry, agriculture and marine and terrestrial resource management.
- Scientific knowledge has changed people's understanding of the world and is refined as new evidence becomes available (ACSHE134).
- Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures (ACSHE226).
- Solutions to contemporary issues that are found using science and technology may impact other areas of society and may involve ethical considerations (ACSHE135).

It further allows development of the **Science inquiry skills** integral to the *Western Australian Science Curriculum*.

Resource set structure

The resource set is structured around constructivist learning principles using the 5E model: engage, explore, explain, elaborate and evaluate. It is designed to be flexible so that teachers can use all or parts of the resource that they consider appropriate for their students.

With this approach:

1. Students' interest is **engaged** through the examination of cells and body systems of plants and animals produced by Western Australia (WA) primary producers.
2. Using examples from WA primary production, students:
   - **explore** the preparation and viewing of life under a microscope
   - compare the similarities and differences between animal, plant and fungal cells
   - **explain** in simple terms the function of various cell organelles and structures.

   Specific examples are used to **explain** how various cells and tissues are specialised to perform specific functions. Students examine how WA horticulturalists used their knowledge of mitosis to produce consistent fruit quality for growers.
3. Students **explore** how and **explain** why multicellular organisms have organised body systems. Students carry out dissections of organisms produced by the WA wild-catch seafood industry.
4. Students **elaborate** on their understanding by choosing from a range of case study activities that showcase a variety of scientific processes used in food and fibre production, with a focus on careers in WA primary industries.
5. Students **evaluate** their understanding of the key learning outcomes.

Educational process	Teaching and learning focus	Resources
Engage Engage students and elicit prior knowledge	**Module 1: Introducing cells and systems (2 hours)** Students: • examine a range of animals and plants used by WA primary producers for food and fibre production • work in small groups to identify common features that all these living things share • are introduced to the concept that all living things (including those used by WA primary producers) are composed of cells or their products. For multicellular animals and plants to function, these cells must be organised into coordinated organ systems. Use group and class discussion to elicit key science understandings.	PowerPoint presentation: • 1.0 Introducing cells and systems Student worksheets: • 1.1 Silent card shuffle (print, laminate and cut out as cards) • 1.2 Introducing cells and systems • 1.3 Venn diagram comparing animal, plant and fungal cells
Explore and Explain 1 Provide hands-on experience of the phenomenon, develop scientific explanations for observations and represent developing conceptual understanding. Consider current scientific explanations	**Module 2: Exploring and explaining cells (4 hours)** Within a WA primary industries context, students explore the preparation and viewing of microscopic life. Using specific WA primary industry and production examples in collaborative learning activities, students: • compare the similarities and differences between animal, plant and fungal cells • examine the function of various cell organelles and structures (including how various cells and tissues are specialised to perform specific functions) • examine (through a cooperative learning jigsaw activity) the processes of mitosis and how knowledge of mitotic cell division is used by WA horticulturists to produce consistent fruit quality for growers.	PowerPoint presentation: • 2.0 Exploring microscopic life Student worksheets • 2.1 Exploring cells under the microscope • 2.2 Exploring and explaining cell structure and function • 2.3 Growing quality fruit relies on science • 2.4 Cooperative learning jigsaw template

Educational process	Teaching and learning focus	Resources
Explore and Explain 2 Provide hands-on experience of the phenomenon, develop scientific explanations for observations and represent developing conceptual understanding. Consider current scientific explanations.	**Module 3: Exploring and explaining body systems (3 hours)** Within a WA primary industries context, students explore how and explain why multicellular organisms have organised body systems. In the first practical activities, students: • examine aspects of the WA wild-catch seafood industry • carry out dissections of two organisms (fish and squid). During the process, they learn about: • the importance of the WA wild-catch seafood industry to our economy and food supply • the basic anatomy of an invertebrate and a vertebrate • how these animals are adapted to their marine environment. In an integrated cooperative learning jigsaw activity, they explore the careers involved in bringing seafood 'from ocean to plate'.	Student worksheets: • 3.1 What's inside? • 3.2 Drawing squid • 3.3 From ocean to plate • 3.4 Cooperative learning jigsaw Other resources: • Department of Primary Industries and Regional Development (DPIRD) Marine Waters website resources: ○ *Fact Sheet: Fish Anatomy* ○ *Poster: Bony Fish – External Anatomy* ○ *Poster Bony Fish – Internal Anatomy* ○ *Student Worksheet: Bony fish anatomy – Whiting species SS*
Elaborate Extend understanding to a new context or make connections to additional concepts through a student-planned investigation	**Module 4: Case studies (3 hours each)** Students elaborate on their understanding by choosing one of the case studies showcasing a scientific process used in WA food and fibre production and completing its activities. All activities focus on sustainable production and WA career opportunities. Students examine, in case study: 1. the reproduction and life cycles in animals, plants and pest and disease species, and their importance to food production (eg chickens, beef cattle, sheep, dairy cattle, wheat, honeybees) 2. the life cycle of the black soldier fly (*Hermetia illucens*), and its use by the Future Green Solutions partnership in processing organic waste into proteins and fats for aquaculture and livestock feeds; fertilisers for agriculture; and pharmaceutical and cosmetic ingredients. Students also have practical opportunities to make their own fly farm, carry out a scientific investigation using fly larvae and develop their numeracy skills through a second-hand data exercise	**Case study 1: Reproduction and life cycles in food and fibre production:** Student worksheets: • 4.1.1 Reproduction and life cycles in food and fibre production • 4.1.2 Sexual reproduction and life cycles • 4.1.3 Comparing reproductive systems • 4.1.4 Honeybees – an 'alternative' life cycle **Case study 2: The black soldier fly** Student worksheets: • 4.2.1 The black soldier fly • 4.2.2 Black soldier fly investigation • 4.2.3 Group investigation framework

Educational process	Teaching and learning focus	Resources
	3. how nodulation in legumes and the symbiotic relationships of microbes in the nitrogen cycle are essential for life. In the second example, students compare similarities and differences between digestive systems of ruminant WA primary production animals with those of humans.	**Case study 3: Specialised cells, tissues and systems** Student worksheets: • 4.3.1 Specialised cells, tissues and systems • 4.3.2 Comparing digestive systems of ruminants and humans • 4.3.3 Careers involving knowledge of specialised cells, tissues and systems
Evaluate Students demonstrate their understanding and reflect on their learning journey, and teachers collect evidence about the achievement of outcomes	**Activity 5: What have I learnt? (2 hours)** This module is a student self-assessment focusing on key concepts from this learning sequence. It consists of four different self-evaluations: • a self-checklist for student knowledge, understanding and skills on cells and microscope use • a Venn diagram where students compare the reproductive systems of flowering plants and animals • an investigation of the life cycle of the aphid • a concept map of the overall learning sequence.	Student worksheets: • 5.1 What have I learnt about cells and microscopes? • 5.2 What have I learnt about reproductive systems? • 5.3 What have I learnt about life cycles? • 5.4 Concept map

Learning resources and sequence

Module 1: Introducing cells and systems

Learning intentions

Students will be able to:

- describe how cells are the basic units of living things, with specialised structures and functions
- explain that multicellular organisms contain systems of organs carrying out specialised functions that enable them to survive and reproduce
- give examples of occupations that use science understanding and skills, and how these have influenced the development of practices in industry, agriculture and marine and terrestrial resource management.

Background information

All living things (including the wide range of plants and animals produced by WA primary producers such as farmers, aquaculturists, foresters and graziers) must be able to carry out a range of basic functions. The mnemonic acronym MRS GREN can prompt us to remember all the necessary features of living things: Movement, Respiration, Sensitivity, Growth, Reproduction, Excretion and Nutrition.

Cells are the basic building blocks of all living things. These include the animals, plants and microorganisms used by primary producers for food and fibre production. It was not until the invention of microscopes that cells were first observed.

Cells are of two basic forms – prokaryotic and eukaryotic. The prokaryotic cells of bacterium are more primitive than the eukaryotic cells of animals, plants, fungi and protists.

Plant, animal and fungal cells have several features in common, including:

- being microscopic
- containing cytoplasm
- having their genetic material inside a membrane-bound nucleus
- having a variety of specialised organelles adapted to carry out specific functions.

Living things can be unicellular or multicellular. Multicellular organisms, such as plants and animals, are distinguished by their systems of organs, which work together to carry out the overall functions of the organism.
(Basic Biology website, 2020)

Resources and equipment

You will need:

- PowerPoint presentation 1.0 Introducing cells and systems
- Student worksheets:
  - 1.1 Silent card shuffle (print, laminate and cut out as cards – before the lesson)
  - 1.2 Introducing cells and systems
  - 1.3 Venn diagram comparing animal, plant and fungal cells

Instructions for suggested activities

1. Introduce students to the ideas that:
   - much of the food they eat (and natural fibres) come from animals and plants that have been produced by people involved in agriculture (eg farmers, graziers)
   - WA primary producers are an essential component of the food supply chain.
2. To elicit what your students may already know about primary production in WA:
   - distribute the laminated cards from worksheet 1.1
   - display slide 2 of PowerPoint 1.0. Students, in small groups, follow its instructions and match the images of WA primary production animals and plants with their labels and brief descriptions.

   This silent card shuffle is a common cooperative learning strategy designed to help students classify, understand and analyse information.
3. In their small groups, students use a combination of the laminated photos, slides 3 to 16 of PowerPoint 1.0 and live specimens (if possible) to identify common features that all these animals, plants and fungi share. Instruct each group to refine their list of common features down to only physical features.
4. Through discussion, introduce the concept that all life is composed of cells or their products. For multicellular animals and plants to function, these cells must be organised into coordinated organ systems.
5. Introduce the concept that all living things (and therefore cells) must carry out basic life functions. You may wish to use the mnemonic acronym 'MRS GREN' to help them remember all the necessary features of living things: Movement, Respiration, Sensitivity, Growth, Reproduction, Excretion and Nutrition.
6. Distribute worksheet 1.2. Work through the key concepts in Activity 1, which introduces students to:
   - prokaryotic and eukaryotic cells
   - the concept that plants, animals and most fungi are multicellular, containing organs and systems.
7. Show the Prokaryotic vs Eukaryotic cells [video].
8. Students undertake Activity 2 (which encourages students to think about why knowledge of cells and systems is important to people generally as well as to WA primary producers) in small discussion groups.
9. Students check their understanding by doing Activity 3.
10. Begin Activity 4 by introducing the basic structure of plant, animal and fungal cells as students examine the cell diagrams on the worksheet. Discuss with students the key similarities and differences between the three types of cells.
11. Distribute worksheet 1.3 for students to complete the Venn diagram activity in groups.
12. As a conclusion, students go back to worksheet 1.2 and complete Activity 5.

Module 2: Exploring and explaining cells (4 hours)

ENGAGE → EXPLORE & EXPLAIN 1 → EXPLORE & EXPLAIN 2 → ELABORATE → EVALUATE

Learning intentions

Students will gain an understanding that cells are the basic units of living things, with specialised structures and functions.

They do this by:

- examining a variety of cells (through using a light microscope or digital technology or by viewing a simulation)
- distinguishing plant cells from animal or fungal cells
- identifying structures within cells and describing their function
- recognising that some organisms consist of a single cell
- recognising that cells reproduce via cell division
- describing mitosis as cell division for growth and repair
    - understanding that workers such as agricultural scientists and horticulturists use science understanding and skills in their occupations and that these have influenced the development of practices in areas such as WA industry, agriculture and marine and terrestrial resource management.

Resources and equipment

You will need:

- PowerPoint presentation 2.0 Exploring microscopic life
- Student worksheets
    - 2.1 Exploring cells under the microscope
    - 2.2 Exploring and explaining cell structure and function
    - 2.3 Growing quality fruit relies on science (print the templates in A3 size)
    - 2.4 Cooperative learning jigsaw template
- Microscopy equipment (and specimens listed in worksheet)

Instructions for suggested activities

Lessons 1 and 2

1. Use slide 1 of PowerPoint 2.0 to recap that all living things produced by WA primary producers are made of cells.
2. Discuss with students the idea that current knowledge about cells is organised as ‘the cell theory’ (slide 3).
3. Initiate a discussion on:
    - student perceptions of how scientific knowledge develops
    - how scientific theories (such as the cell theory) need time to be developed, debated and tested
    - how new knowledge is often associated with the development of new technologies.
4. As a class, watch The wacky history of cell theory – Lauren Royal-Woods [video] (slide 4). Students go back through the video and create a timeline or flowchart of the key events that led to, and the people involved in, development of the cell theory.
5. Use slides 5 to 9 to introduce the idea that agricultural scientists assist WA primary producers to maximise their yields of food and fibre. To do this they require an understanding of cells at the microscopic level. They use microscopes of various types to view cells. Explore the idea that there are different types of microscopes suited to producing different types of microscopic images.
6. Display slide 10, which links to an image showing the parts of a typical compound microscope. Alternatively, supply students with a labelled image of a microscope.

7. Distribute student worksheet 2.1. In small discussion groups, students predict the likely function of each part of the microscope and enter their ideas in the worksheet table (Activity 1).
8. Students verify whether they are correct (using the same website with the labelled microscope) and use the information to fill out the final column of the table.
9. Students watch the How to use a microscope [video] as a lead in to the practical component of the lesson.
10. Before students attempt Activity 2 on the worksheet, introduce the idea that WA agricultural scientists regularly prepare biological material for viewing under a microscope. This helps them to provide:
    - scientific advice and research on soil, weed and pest management
    - information on new plant and animal species.

    Explain to students that this activity will teach them some of their techniques
11. Demonstrate to the class the different types of slides (mounts) that can be made for viewing specimens under the light microscope.
    Direct students to read the relevant section of the worksheet about the different types of mounts possible.
    Show students the How to make a wet mount slide [video].
12. When they have made their wet mount slides, show each group how to:
    - set up their microscope to obtain a clear image
    - adjust the image to alter the aperture, focus and magnification.
13. Start Activity 3 on the worksheet by re-emphasising that all living things produced by WA primary producers are comprised of cells visible under the microscope. Then demonstrate how to make:
    - wet mounts of a piece of newspaper and some onion
    - smear mounts of some banana and some tomato

    These are all products produced by WA primary producers.
    Allow students sufficient time to explore the use of the microscope and fill in the various parts of the worksheet.
14. Finish Activity 3 with students drawing (in pencil) the cells they can see (on their worksheet). Ensure that they label any visible parts, such as cell walls, nuclei and vacuoles.
15. Clean up and put away the equipment.
16. If time permits, introduce extension Activity 4 on the worksheet. This cooperative small-group activity explores careers in WA primary industry that are likely to use knowledge of cells and microscopy. Students:
    - brainstorm ideas
    - undertake research on the *Careers in food and fibre* page on the DPIRD website to learn more about careers in WA food and fibre
    - complete a table activity.

Lesson 3

1. Distribute worksheet 2.2.
2. In groups, students start worksheet Activity 1 by discussing: What basic life functions do all living things (and therefore cells) need to carry out to survive and reproduce? Students record their group ideas on the worksheet.
3. Students watch the Characteristics of living organisms – MRS GREN [video] on the seven key processes that all living things can do.
4. Begin Activity 2 by discussing with the class that at the cellular level, particular structures carry out these basic life functions. In a cell, many of these structures are called organelles. Direct students to:
   - download and view the Animal vs *plant cell poster* on the Plant Energy Biology website
   - watch the Virtual plant cell: Cell explore, 2018 [video] by Plant Energy Biology.

   Students use the information to complete the table on the major cell organelles.
5. Start Activity 3 on the worksheet, which focuses on the shapes and structures of cells that are related to the functions that they perform:
   - Introduce the concept of structural adaptations being genetically inherited structures that aid survival.
   - Draw students' attention to the images from the small intestine of a WA sheep showing intestinal villi.
   - Ask students to brainstorm (in their small groups) possible ideas why the enterocytes are shaped as they are – how their shape relates to their function. Discuss how cells need a large surface area for efficient exchange of nutrients, gases and wastes.
6. Start Activity 4 on the worksheet. In their groups, students discuss each of the different cell features in the table and predict how the feature helps the cell do its job. (For the first two cell features, students will need to look back at Activity 1 for the function of the organelles.)
7. Students check their predictions using either textbook or internet resources.
8. As a follow-up activity, direct students to:
   - watch the Specialised cells: Significance and examples [video]
   - make a list of four plant and animal specialised cell adaptations on the worksheet.

Lesson 4

Students complete worksheets 2.3 and 2.4. This is a cooperative learning group jigsaw activity where students examine how bananas, wine grapes and mangoes are produced via tissue culture, cloning and grafting (asexual reproductive methods) by horticulturists in various locations around WA.

They discover that a horticulturist is someone:

- who uses scientific knowledge and skills to cultivate and propagate plants, and provide technical information to farmers and growers
- whose ability to use tissue culture, cloning and grafting to ensure that fruit size, yield and quality is uniform and free from pests and diseases is informed by their knowledge of how cells of fruit (like bananas, wine grapes and mango) multiply asexually to produce identical copies. This type of cell division is called mitosis.

Module 3: Exploring and explaining body systems (3 hours)

Learning intentions

Students are expected to gain an understanding that multicellular organisms contain systems of organs carrying out specialised functions that enable them to survive and reproduce.

They do this by:

- comparing reproductive systems of organisms
- identifying the organs and overall function of a system of a multicellular organism in supporting the life processes
- describing the structure of each organ in a system and relating its function to the overall function of the system
- examining the specialised cells and tissues involved in structure and function of particular organs
- understanding how people such as marine scientists and agricultural scientists use science understanding and skills in their occupations, and that these have influenced the development of practices in areas of human activity such as WA industry, agriculture and marine and terrestrial resource management.

Resources and equipment

You will need:

- Student worksheets:
  - 3.1 What's inside?
  - 3.2 Drawing squid (print in A3 size)
  - 3.3 From ocean to plate
  - 3.4 Cooperative learning jigsaw (print in A3 size)
- DPIRD Marine Waters website resources:
  - *Fact sheet: Fish anatomy*
  - *Poster: Bony fish – External Anatomy*
  - *Poster Bony fish – Internal Anatomy*
  - *Student worksheet: Bony fish anatomy – Whiting species SS*
- Squid, fish and dissecting equipment (see worksheet 3.1 for details)

Instructions for suggested activities

Lesson 1

1. Begin the lesson with a whole-class discussion of foods that students like to eat.
2. Move into a discussion of the types of seafood students will probably have encountered at a fish and chip shop. Discuss with students the origin of the seafood that they eat, introducing the importance of WA's wild-catch seafood industry:
   - to supplying food to the community
   - as an international export commodity.
3. Distribute worksheets 3.1 and 3.2 and explain that the class will be working in groups to dissect a squid.
4. Ask students, in their small groups, to think about questions that they would like answered during the dissection: (students record their ideas in the columns on worksheet 3.1
   - Where are the squid's eyes?
   - Where is the squid's mouth?
   - Do squid have a stomach like yours?
   - Does it have a skeleton and muscles to move around?
   - Are there male and female squid with different reproductive organs?
   - Do squid have lungs to exchange gases (like humans) or gills (like a fish)?
5. Explain the procedure for Activity 1 and the safety protocols they need to follow when performing the dissection.
6. Students examine the external anatomy of the squid (Image 3.1.2 on the worksheet) and make group predictions about the functions of its various.
   They record their ideas in the T-chart.
7. Students identify the sex of their squid, and then make a labelled diagram (in pencil) of the external features of the squid on worksheet 3.2.
8. Before they start the dissection, students watch a video of a squid dissection. Alternatively, you can provide them with a copy of these virtual squid dissection instructions.
9. Students then:
   - follow the procedure steps in worksheet 3.1 to perform a dissection to reveal the internal anatomy of their squid
   - make a labelled drawing (in pencil) of the internal anatomy of their squid on worksheet 3.2
   - clean up and dispose of all equipment and squid remains.
10. Initiate a discussion about the various organs they observed in their squid that have similar functions to their own organs. Discuss adaptations as being inherited survival features and finish the lesson with students recording their group ideas of five adaptations that they observed that can aid the squid in its survival.

Lesson 2

1. Recap key understanding from the squid dissection – namely the location, appearance and functions of major body organs.
2. Explain to the class that they are continuing their exploration of the WA wild-catch seafood industry by performing a dissection of a common locally caught bony fish species – the sea mullet (or suitable alternative).
3. Direct students, in groups, to the first part of Activity 2 on worksheet 3.1. They discuss the possible function of each of the external body parts of the sea mullet (Image 3.1.7 on the worksheet) and enter their ideas in the T-chart.
4. Direct them to go back and check their predictions using the DPIRD Marine Waters website *Fact sheet: Fish anatomy*. Students correct, or add new information to, their T-charts.
5. Students carry out the fish dissection following the step-by-step procedure on the worksheet. (Make sure they can access the DPIRD Marine Waters website resources online or provide them with printed copies.)
6. Clean up and dispose of all equipment and remains of fish.
7. Initiate a discussion about the various organs they observed in both the squid and the fish that have similar functions to their own organs. Emphasise that adaptations are inherited survival features. Finish the lesson with students recording their group ideas of five adaptations that they observed that can aid survival.

Lesson 3

1. Initiate a discussion about how students' local fish and chip shops probably procure their seafood from WA's wild-catch seafood industry or aquaculture. To get these products to the fish and chip shop, different people are employed in many different aspects of the process. These include areas such as:
   - catching the seafood
   - handling and processing
   - scientific research
   - brood-stock production
   - marketing
   - food preparation
   - delivery of the products.
2. Give students a copy of worksheets 3.3 and 3.4 and outline that the object of this activity is to discover how many people or careers are involved in the WA wild-catch seafood industry. In this cooperative group jigsaw activity, each group must:
   - find out key information
   - teach the information to other students.

   In this way they can learn from other students.
3. Allocate each student to a 'home' group of six students (depending on the number of students in the class). Give each member of a group a number (1–6).
4. Students then form new 'expert' groups by finding other students in the class with the same number. Assign each expert group one of the career categories on the worksheet to become 'experts' on.
5. Students brainstorm and discover as many careers as possible that would fit their category. Allow them flexibility in how they find out their information and how they will present it to others. During this time, students may need to access textbook or internet information.
6. Students gather in their home groups. In their home groups, students teach the other members of the group their piece of the jigsaw puzzle.

Module 4: Case studies (3 hours per case study)

Case study 1: Reproduction and life cycles in food and fibre production

Learning intentions

This case study:

- examines the reproductive systems and life cycles in production animals (eg fish, chickens, cattle, pigs and sheep) and their importance to food production
- highlights the relevance of knowledge of reproductive systems and life cycles to careers in WA primary industry is emphasised and embedded in this activity.

Students will be able to understand that multicellular organisms contain systems of organs carrying out specialised functions that enable them to survive and reproduce.

Elaborations:

- distinguishing between asexual and sexual reproduction
- comparing reproductive systems of organisms

Resources and equipment

You will need:

- Dissecting equipment, flowers for dissection
- Student worksheets:
  - 4.1.1 Reproduction and life cycles in food and fibre production
  - 4.1.2 Sexual reproduction and life cycles
  - 4.1.3 Comparing reproductive systems
  - 4.1.4 Honeybees – an ‘alternative’ life cycle

Instructions for suggested activities

Lesson 1

1. In an initial class discussion, introduce the idea that to sustainably produce the food and fibres we need, WA primary producers must have a comprehensive understanding of the:
   - reproduction and life cycles of their crops and livestock
   - pest and disease-causing species that might interfere with production.

   Discuss the key ideas of asexual and sexual reproductive methods.
2. Distribute worksheet 4.1.1. Give students (in their small groups) time to do the first part of Activity 1:
   - research the main methods of vegetative reproduction
   - enter the results in the T-chart on the worksheet.
3. Each group examines the images of asexually produced WA primary industry products. Allow students time to complete the table on the worksheet. (They may need to research cloning.)
4. For Activity 2 on the worksheet, ask students to:
   - individually read the information about apple scab
   - consider why it might be important that WA primary producers understand the life cycles of living things
   - brainstorm some possible answers to this question in their small groups.
5. Ask each group to examine the life cycle diagram (Image 4.1.1.5 on the worksheet) of apple scab. Emphasise that the fungus has a predictable life cycle. Ask students to make a prediction of when they think the fruit grower would best be able to control apple scab disease.
6. Ask each group to compare their answers with those of other groups.
7. Students access the DPIRD website page about managing apple scab in WA to learn more about the life cycle of apple scab and verify their predictions.
8. Ask students to discuss in their groups when, why and how collecting and destroying leaf litter and fallen fruit is likely to be effective.

   They record their ideas in the table on the worksheet.
9. Introduce Activity 3 with a discussion on food and fibre careers that might require knowledge of reproduction and life cycles. Students then:
   - undertake research on biosecurity officers and agronomists
   - complete the table.
10. Students complete Activity 4, using key words and phrases from the worksheet.

Lesson 2

1. Recap asexual reproduction and introduce the idea that most living things used or produced by WA primary producers reproduce sexually.
2. Give out worksheet 4.1.2. In Activity 1, students examine the images of sheep and dairy cattle produced by WA primary producers. In small groups, they:
   - discuss how they think the life cycles of sheep and dairy cattle might be both similar and different
   - record their group responses in the T-chart on the worksheet.
3. In Activity 2 of the worksheet, students use the description of a sheep life cycle to create a labelled drawing showing the various stages it.
4. In small groups, students:
   - research the life cycle of a sexually reproducing farm animal (beef cattle or poultry) or plant (wheat)
   - make an annotated drawing of their allocated life cycle.

   To make the task quicker and easier, website links are included on the worksheet.
5. Instruct students to leave their groups and find other students to trade information with about the other farm animal or plant.
6. For Activity 3, ask students to predict why it would be essential for WA primary producers to know about the life cycle of their animals and plants. Students discuss this question in small groups and record initial ideas.
7. Students examine the specific WA example of dairy cattle. They watch the When do cows make milk [video], by Dairy Australia.
8. Instruct students to write a paragraph on why they now think it would it be useful for a WA dairy farmer to know about the life cycle of their dairy cattle.
9. After a group brainstorm, students create an annotated life cycle diagram of a dairy cow.
10. Finish the lesson with Activity 4 (or set it as a homework exercise). Students explore food and fibre careers that might involve understanding reproduction and life cycles and complete the table.

Lesson 3

1. Recap the key ideas of asexual and sexual reproduction and life cycles.
2. Distribute worksheet 4.1.3. Through class discussion, emphasise that both animals and flowering plants used by WA primary producers reproduce sexually and must have various structural adaptations to allow fertilisation to occur.
3. Direct students to the online resources (Flower dissection! instructions and Flower dissection – STEM activity video) to find out how to dissect and examine the function of some of the key parts of a typical flower.
4. Supply students with a range of flowers, a magnifying glass and a single-sided razor blade so they can dissect out the major parts of a flower. As they do this, they complete the table about the role in reproduction that each flower part plays.
5. Ask students where the fruit forms and why it contains seeds. They record their answers on the worksheet.
6. Students move on to the ‘Humans: a typical animal’ section and:
   - examine the diagrams of human male and female reproductive systems (Images 4.1.3.2 and 4.1.3.3 on the worksheet) for comparison and access the online information on male and female reproductive systems
   - use the information to complete the table about the roles of the reproductive parts.
7. Distribute worksheet 4.1.4 and discuss how honeybees have a more complicated ‘alternative’ life cycle and why it would be important for apiarists to understand it.
8. Students watch the honeybee lifecycle [video].
9. In groups, students prepare an annotated poster of the life cycle of the honeybee, including the roles played by the different castes of bees (queen bees, worker bees and drones).
10. If time permits, students complete the extension exercise about biosecurity in the WA honey industry.

Case study 2: The black soldier fly

Learning intentions

In this case study, students examine the:

- specific WA example of Future Green Solutions as a collaborative and sustainable scientific and technological enterprise
- life cycle and use of the black soldier fly to solve the problem of economically producing feed for aquaculture and produce a variety of other products while reducing farm compost waste.

The relevance of knowledge of reproductive systems and life cycles to careers in WA primary industry is emphasised and embedded in this activity.

Students will be able to understand that:

- Multicellular organisms contain systems of organs carrying out specialised functions that enable them to survive and reproduce (ACSSU150)
- People use science understandings and skills in their occupations, and these have influenced the development of practices in areas of human activity such as industry, agriculture and marine and terrestrial resource management (ACSHE136)
- Scientific knowledge has change peoples' understanding of the world and is refined as new evidence becomes available (ACSHE134)
- Science knowledge can develop through collaboration across the disciplines of science and the contributions of people from a range of cultures (ACSHE226)
- Solutions to contemporary issues that are found using science and technology, may impact on other areas of society and may involve ethical considerations (ACSHE135)

Resources and equipment

You will need:

- Black soldier fly larvae (contact Future Green Solutions, who supply the larvae free of charge to schools)
- Student worksheets:
  - 4.2.1 The black soldier fly
  - 4.2.2 Black soldier fly investigation
  - 4.2.3 Group investigation framework

Instructions for suggested activities

Lesson 1

1. Distribute worksheet 4.2.1 and discuss as a class whether students think flies have any value in the food web. Through discussion, enable students to discover:
   - that flies are important decomposing organisms
   - why decomposers are vital in any food web.
2. Explain that the black soldier fly has been introduced in WA and is being used around the world to compost waste or convert it into animal feed. (Fly larvae are among the most efficient animals at converting feed into biomass.)
3. Direct students to:
   - access the Featured Creatures page on the black soldier fly at the University of Florida website (select the tab 'Description and Life Cycle' at the top of the page)
   - students use the description to draw an annotated life cycle of the black soldier fly. They must include and understand key terms such as mating, eggs, larvae, instar, pupae and adult
   - explain to students that the life cycle of the black soldier fly is an example of a metamorphosis. Ask students, in small discussion groups to predict what this term means and if they think other living things might go through metamorphosis.

- Students enter their ideas on the worksheet then check their ideas are correct : metamorphosis
- ask students to think of which stages of the life cycle could be useful to humans
- follow the link https://en.wikipedia.org/wiki/Hermetia_illucens and read the section 'Human relevance and use'
- summarise (on their worksheet) which stages of the fly's life cycle can be used to produce various useful products
- examine the question: Why don't the adult flies become pests like other flies?

4. Move on to the 'Black soldier fly farming in WA – Future Green solutions' section of the worksheet and introduce the idea that one of aquaculture's biggest problems is its use of more fish (per kilogram) than it produces.
5. Students:
   - access information on the ABC website and Future Green Solutions website to research and write a summary of how farming the black soldier fly by Future Green Solutions will contribute to creating more sustainable aquaculture and farm waste management systems in WA (and around the world).
6. Direct students towards the activity about careers in sustainable agriculture on the worksheet. Students:
   - follow the links and watch the ABC Education videos
   - brainstorm, in small groups, careers that people can pursue to make agriculture more sustainable.
7. As a practical extension project, students undertake the 'Making your own soldier fly farm' activity at the end of the worksheet.

Lesson 2

1. Recap that the fundamental purpose of a scientific investigation is to go through a 'fair testing' procedure to answer or solve a specific research question or problem.
2. Distribute worksheet 4.2.2 and organise students into small research groups. Ensure that each group understands the five stages of any scientific investigation:
   - Stage 1: Questioning and predicting
   - Stage 2: Planning and conducting
   - Stage 3: Processing and analysing data and information
   - Stage 4: Evaluating
   - Stage 5: Communicating
3. Each group spends time identifying a question or problem about the larvae that can be investigated scientifically. Make sure they consider a range of different factors (variables) that might influence the outcome they are looking for, such as:
   - the diet (type of waste) the larvae are using for food
   - environmental factors like humidity, temperature, amount of light, oxygen availability and overall moisture levels.
4. Distribute worksheet 4.2.3 and allow students sufficient time to complete stages 1 and 2.
5. Students go back to worksheet 4.2.2 and do the extension activity 'Building numeracy skills'.

Lesson 3

After sufficient time has elapsed (usually two or three days), students stages 3, 4 and 5 of the investigation on worksheet 4.2.3.

Case study 3: Specialised cells, tissues and systems

Learning intentions

In this case study, students examine the specialised cells, tissues and systems involved in:

1. plants, using the unique WA lupin crop rotation system. Students examine how nodulation in legumes and the symbiotic relationships of microbes in the nitrogen cycle are essential for life
2. animals, by comparing the similarities and differences between the digestive systems of humans and ruminant animals (used in WA primary production).

Resources and equipment

You will need:

- Student worksheets:
  - 4.3.1 Specialised cells, tissues and systems
  - 4.3.2 Comparing digestive systems of ruminants and humans
  - 4.3.3 Careers involving specialised cells, tissues and systems

Instructions for suggested activities

Lesson 1

1. Introduce the key concept that most of the animals and plants farmed by WA primary producers (eg sheep, cows, chicken, wheat and canola) are multicellular organisms whose cells are specialised and work together. Emphasise that this is the result of adaptation to their environment through the process of evolution.
2. Distribute worksheet 4.3.1 and begin Activity 1 by discussing narrow-leaf lupin as an example of evolution by adaptation. Explain that the wheat–lupin crop rotation is a farming practice unique to WA.
3. Instruct small groups of students to consider why they think it might be important for farmers – particularly those in WA – to consider growing lupins as a rotational crop. Students record their ideas on the worksheet.
4. Introduce the key idea that for lupins to be able to capture nitrogen, they need to form a symbiotic relationship with nitrogen-fixing bacteria known as rhizobia. These rhizobia bacteria are found in specialised cells and structures called root nodules.
5. As a class, watch the Nitrogen fixation – Seven wonders of the microbe world [video].
6. Students to write a description (and accompanying diagram) on their worksheet of how the specialised cells in the root nodules of lupin are essential for sustaining life on our planet.
7. Allow students time to finish the lesson by completing Activity 2.

Lesson 2

1. Recap and emphasise key ideas:
   - that lupins need to form a symbiotic relationship with nitrogen-fixing rhizobia bacteria found in root nodules to capture nitrogen
   - of adaptation and evolution.
2. Distribute worksheet 4.3.2 and introduce the example of ruminant animals (such as cattle and sheep) needing specialised digestive systems to live on a diet of grass.
3. Start Activity 1 on the worksheet by watching the Why can't you digest grass? [video],which compares human and ruminant digestive systems.
4. In small groups, students undertake the worksheet procedure by:
   - reading the information on the factsheet Sheep – The wool producers from the Learn About Wool website
   - using the information to build a scale model of a sheep (ruminant) digestive system, using coloured modelling clay, toothpicks, and sticky notes (to correctly label and describe the function of the key parts).
5. Instruct students to consider these questions and record their ideas on their worksheet:
   - Why do sheep only have incisor teeth on their bottom jaw?
   - Why do sheep need to 'chew their cud'?
   - What role do bacteria play in the rumen?
   - Where is methane produced in a sheep's digestive system and why can it be an environmental problem?
6. Move on to the next section of the worksheet and ask students to:
   - brainstorm ideas, in their groups, to reduce greenhouse gas emissions from WA farm animals. They record their ideas in the box on the worksheet
   - read the Reducing livestock greenhouse gas emissions page on the DPIRD website to check that their ideas are correct
   - add extra ideas in the box.
7. In their groups, students:
   - use the internet to research the key differences between ruminant and human digestive systems
   - prepare either a PowerPoint presentation or an infographic to present to other members of the class.
8. Students finish the lesson with Activity 2, using the key vocabulary from this case study.

Lesson 3

Students access the website links on worksheet 4.3.3 to discover more about food and fibre careers involving knowledge of specialised cells, tissues and systems.

Module 5 – What have I learnt? (2 hours)

Learning intentions

This student self-assessment focuses on students revisiting and consolidating key concepts from this learning sequence. It consists of four self-evaluations:

- a checklist on student knowledge, understanding and skills about cells and microscope use
- a Venn diagram for comparison of the reproductive systems of animals and flowering plants
- an investigation of the aphid life cycle
- a concept map of the overall learning sequence

Resources and equipment

You will need:

- Student worksheets:
  - 5.1 What have I learnt about cells and microscopes?
  - 5.2 What have I learnt about reproductive systems? (printed in A3 size)
  - 5.3 What have I learnt about life cycles?
  - 5.4 Concept map

Acknowledgements

References

Module 1

Basic Biology (2020) *MRS GREN*, Basic Biology website <https://basicbiology.net/biology-101/mrs-gren>, accessed 30 April 2021.

RicochetScience (19 January 2015) 'Prokaryotic vs Eukaryotic cells' [video], *RicochetScience*, YouTube <https://www.youtube.com/watch?v=RQ-SMCmWB1s>, accessed 30 April 2021.

Suggested answers to student worksheets

Life under cover – applying knowledge of cells and systems in food and fibre production

Student worksheet 1.2 Introducing cells and systems

Activity 2: Group discussion

1. A knowledge of cells and systems enables people to better understand the complex biological world they live in.

2. Knowledge of cells and systems enables primary producers in Western Australia (WA) to produce the food and fibres that we need more ethically, sustainably and economically.

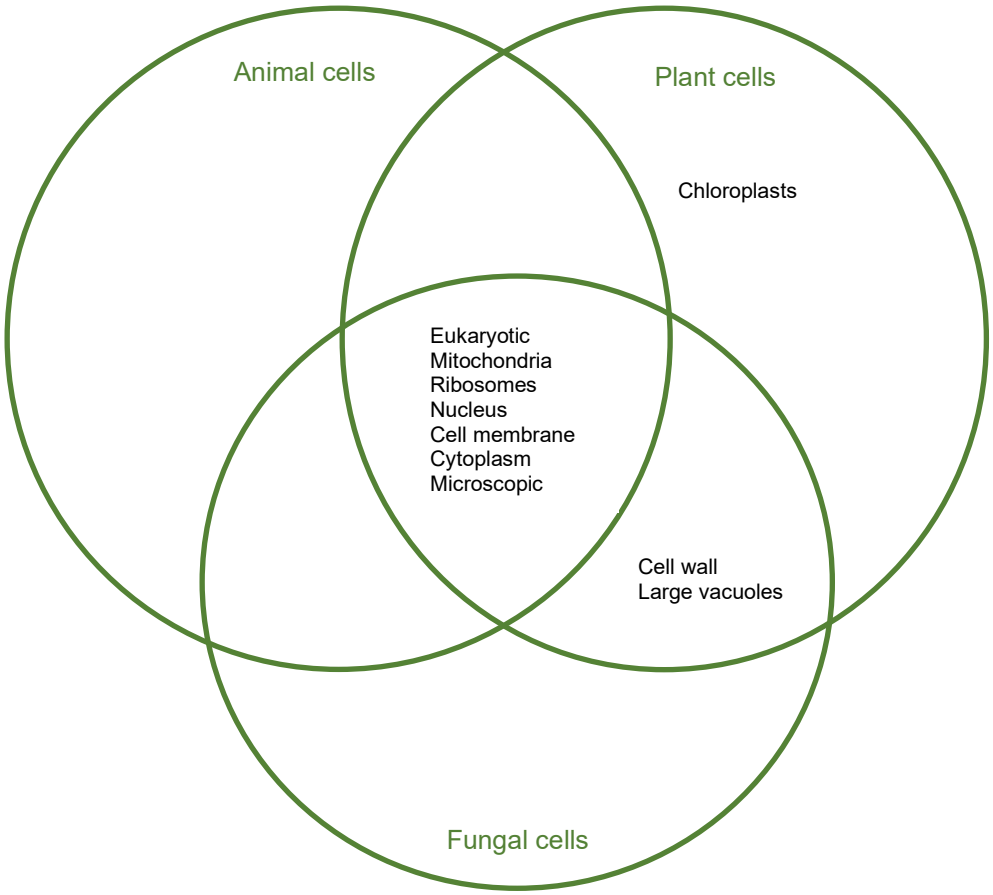
Activity 3: Check your understanding

Statement	True or False
Cells are the fundamental building blocks of all living things.	True
Bacterial cells are eukaryotic cells.	False
Animals are made up of organs and systems, whereas plants are not.	False
Protists are an example of unicellular living things.	True
Eukaryotic cells contain their genetic material inside a membrane-bound nucleus.	True
Cells are generally too small to be seen without a microscope.	True
The bodies of sheep, cows and humans are made up of just one type of cell.	False

Activity 5: Literacy review

		M	E	M	B	R	A	N	E	
	U	N	**I**	C	E	L	L	U	L	A	R
	E	X	**C**	R	E	T	E			
			R	E	P	R	O	D	U	C	E
			O	R	G	A	N	E	L	L	E
N	U	C	L	E	U	**S**					
						C	E	L	L	S	
						O	R	G	A	N	S
		R	E	S	**P**	I	R	E			
				S	**E**	N	S	I	T	I	V	E

Student worksheet 1.3 Comparing animal, plant and fungal cells



Student worksheet 2.1 Exploring cells under the microscope

Activity 1: Group discussion – Parts of a compound light microscope

Microscope part	Actual function
Eyepiece (ocular) and eyepiece tube	The eyepiece (ocular) is what you look through at the top of the microscope. Typically, standard eyepieces have a magnifying power of 10x. Optional eyepieces of varying powers are available, typically from 5x to 30x. The eyepiece tube holds the eyepieces in place above the objective lens.
Objective lenses and nosepiece	Objective lenses are the primary optical lenses on a microscope. They range from 4x to 100x and, typically, include three, four or five lenses on most microscopes. The nosepiece houses the objectives.
Coarse and fine focus knobs	Coarse and fine focus knobs are used to focus the microscope.
Stage / stage clips	The stage is where the specimen to be viewed is placed. A mechanical stage is used when working at higher magnifications where delicate movements of the specimen slide are required. Stage clips are used when there is no mechanical stage.
Aperture	The aperture is the hole in the stage through which the base (transmitted) light reaches the stage.
Illuminator	The illuminator is the light source for a microscope, typically located in its base.
Iris diaphragm	The iris diaphragm controls the amount of light reaching the specimen.
Condenser / condenser focus knob	The condenser is used to collect and focus the light from the illuminator on to the specimen. The condenser focus knob moves the condenser up or down to control the lighting focus on the specimen.

(Source: Microscope.com 'Compound microscope parts' https://www.microscope.com/compound-microscope-parts, accessed 31 May 2021)

Activity 3: Viewing and drawing your cells under the microscope

In the 'Method' section:

7. When a slide is moved, the image appears to move in the opposite direction. This is because the convex lens configuration produces a laterally inverted image.

8. The letter 'e' will be laterally inverted.

Activity 4 (extension): WA primary industry careers

Research it	Grow it	Make it
Some careers where I can carry out research on food and fibre production: 1. Agricultural scientist 2. Meteorologist 3. Agricultural technical officer	Careers involved in growing crops and raising animals: 1. Botanist 2. Agricultural veterinarian 3. Jackaroo/Jillaroo	Some careers where I can design information technology, food technology or engineering: 1. Agricultural engineer 2. Winemaker 3. Agricultural plant mechanic
Some things that I would do in these careers: 1. An agricultural scientist studies animals, plants and farm systems to provide information on productivity and sustainability to farm businesses and agricultural industries. 2. A meteorologist studies the atmosphere to forecast the weather and provide information about our climate. Meteorologists are essential in agriculture as they provide information that can be used to protect and manage crops and livestock. 3. An agricultural technical officer collects samples and works with agricultural scientists to assist with research and testing.	Some things that I would do in these careers: 1. A botanist studies all types of plants. In agriculture, botanists apply their plant knowledge to inform and improve crop cultivation. 2. An agricultural veterinarian specialises in diagnosing, treating and helping to prevent disease and injury in livestock such as cattle, sheep, goats, horses and pigs. 3. Jackaroos (male) and Jillaroos (female) carry out a range of activities on cattle or sheep stations.	Some things that I would do in these careers: 1. Agricultural engineers study and advise on the use of engineering in agricultural production and management of natural resources. 2. A winemaker plans, supervises and coordinates the production of wine. 3. Agricultural plant mechanics deal with the maintenance and repair of agricultural plant machinery and equipment.

Qualifications I would need to work in these careers: 1. To become an agricultural scientist you usually have to complete a Bachelor of Agricultural Science or Bachelor of Science with a major in Agriculture. To get into these university courses, you'll need to complete a Year 12 ATAR pathway. 2. To become a meteorologist you need to complete a Bachelor of Science or Applied Science, majoring in Mathematics, Physics or Meteorology, usually at Honours level. To get into these university courses, you'll need to complete a Year 12 ATAR pathway. 3. To become an agricultural technical officer you need to complete a vocational education and training (VET) qualification in Agriculture, Horticulture or Animal Technology.	Qualifications I would need to work in these careers: 1. To become a botanist you generally need to complete a Bachelor of Science, majoring in Botany, Biology or Plant Science. To get into these university courses, you'll need to complete Year 12 ATAR pathway. 2. To become a veterinarian you need to complete a Bachelor of Veterinary Biology or Science and register with the Veterinary Surgeons' Board of Western Australia. 3. To become a Jackaroo/Jillaroo, you don't need formal qualifications; however, general farming skills and experience are useful.	Qualifications I would need to work in these careers: 1. To become an agricultural engineer you usually need to complete a Bachelor of Engineering. The University of Southern Queensland offers an engineering degree majoring in agricultural engineering. To get into these university courses you'll need to complete Year 12 ATAR pathway. 2. To become a winemaker you usually have to complete a Bachelor degree in Agribusiness with a major in Viticulture and Oenology or a Graduate Diploma in Oenology. 3. To become an agricultural plant mechanic you usually have to complete an apprenticeship in Agricultural Plant Mechanics.

(Source: Government of Western Australia, DPIRD, (2017) 'Careers in food and fibre, DPIRD <https://agric.wa.gov.au/n/1310>, accessed 31 May 2021)

Student worksheet 2.2 Exploring and explaining cell structure and function

Activity 1: What can all living things (and therefore cells) do?

Basic life functions that all living things (and therefore cells) need to carry out can be summarised by the mnemonic acronym 'MRS GREN': movement, reproduction, sensitivity, growth, respiration, excretion (of waste) and nutrition.

Activity 2: Cell structures and functions

5. Cells of living things are often described as being like tiny towns because they are constantly producing and transporting all the things needed for life.

6.

Table 1: Major cell organelles and structures

Name of cell structure or organelle	Found in both plant and animal cells or only found in plants	Basic function – what does it do?
Nucleus	Both plant and animal cells	Contains genetic information (DNA) and controls the cell's activities
Cytoskeleton	Both plant and animal cells	Helps transport cargo (organelles, proteins etc.) around the cell
Mitochondria	Both plant and animal cells	Power the cell by making energy available to use
Cytosol	Both plant and animal cells	Gel-like solution of molecules that holds the organelles
Cell membrane	Both plant and animal cells	Provides a wrapping for the cell but allows exchanges between cells
Cell wall	Only found in plant cells	Protects plant cells and helps hold the plant up, as a plant has no skeleton
Vacuole	Only found in plant cells	A 'storage bin' for food, water and wastes
Chloroplasts	Only found in plant cells	Convert light energy and CO_2 into sugars and oxygen in photosynthesis

Table 2: Extension – other cell organelles

Name of cell structure or organelle	Found in both plant and animal cells or only found in plants	Basic function – what does it do?
Ribosomes and endoplasmic reticulum	Both plant and animal cells	A network of machines and sacs for making and activating proteins
Golgi apparatus	Both plant and animal cells	Collects, packages and distributes proteins and other molecules made in the cell
Peroxisomes	Both plant and animal cells	Break down oils for energy

(Source: Plant energy biology: Virtual plant cell teaching resources available at: PEB.outreach.resources (plantenergy.edu.au), accessed 31 May 2021)

Activity 3: Cells are adapted to perform specific functions

Enterocytes are found on finger-like villi and have thousands of finger-like microvilli to increase the surface area available for absorption of materials

Other examples where the cells of plants or animals possess finger-like extensions to increase surface area include the root hair cells of plants and non-motile (primary) cilia.

(Source: Nguyen, D, Seattle pi 'What cell structure increases the membrane surface area?' Available at: https://education.seattlepi.com/cell-structure-increases-membrane-surface-area-5607.html) accessed 10 June 2021

Activity 4: More specialised cell adaptations

Feature of cell	How the feature helps the cell perform its function
Cells in the upper layers of leaves (the palisade layer of cells) have large numbers of chloroplasts.	Increased density of chloroplasts on the upper surface of the leaf maximises photosynthetic activity.
Cells in the heart (cardiac) muscle of sheep have large numbers of mitochondria.	Large numbers of mitochondria are required to generate sufficient energy for the cardiac muscle to be constantly functioning.
Nerve cells (neurones) in the brains of sheep have many interconnecting fibres called axons and dendrites.	Many interconnecting axons are required for nervous impulse transmission within the brain.
Red blood cells in the blood of sheep carry oxygen to their body cells. They are in fact larger in diameter than the capillaries they need to travel through to reach the cells. They also contain a red pigment called haemoglobin and are shaped like flattened discs.	The shape of red blood cells maximises their surface area for carrying oxygen attached to the pigment haemoglobin. It also allows them to change shape in order to fit through the narrow-diameter capillaries.

Plant cell adaptations	Animal cell adaptations
1. Waxy cuticle layer on leaf for protection 2. Leaf epidermal layer for protection against environmental extremes 3. Guard cells on leaves open and close stomatal pores to regulate gas and water exchange 4. Trichomes (hair cells) are specialised epidermal cells with a variety of functions – protection from insects, light reflection, capture of insects (eg sundew)	1. Red blood cells for maximising oxygen transport 2. White blood cells are specialised for protective functions, such as phagocytosis and antibody production 3. Muscle cells adapted for contraction and relaxation 4. Neurons adapted for nervous transmission (eg myelin sheath)

(Source: Amoeba Sisters (2 December 2016) 'Specialised cells: Significance and examples' available at: https://www.youtube.com/watch?v=wNe6RuK0FfA accessed 10 June 2021)

Student worksheet 3.1 What's inside?

Activity 1: Dissecting a squid

Body part	Matching number	Function
Feeding tentacles (2)	2	Attach to prey and bring it close to the squid's mouth
Eyes (2)	6	Vision
Arms (8)	5	Contain suckers for grasping prey
Mantle	7	Main body of the squid. Made of muscle and skin. Contains chromatophores
Siphon (water jet)	1	Used for propulsion through the water
Stabilising fins	4	Made of muscle and used for swimming and changing direction
Beak	3	Mouth and first stage of the digestive system

(Source: Museum of New Zealand 'The anatomy of the colossal squid', available at: https://www.tepapa.govt.nz/discover-collections/read-watch-play/science/colossal-squid/anatomy-colossal-squid accessed 9 June 2021)

Squid adaptations

Adaptation (some possible examples)	How does it aid the squid's survival?
Highly developed eyes	Catching food in a variety of aquatic light conditions
Siphon	Jet propulsion mechanism
Ink production	Adaptive mechanism for predator avoidance
Chromatophores	Ability to camouflage in different backgrounds
Tentacles	Feeding

Activity 2: Dissecting a fish

(Source: Government of Western Australia, DPIRD, 'Marine Waters Factsheet – Fish Anatomy', available at: https://marinewaters.fish.wa.gov.au/resource/fish-anatomy/ accessed 8 June 2021)

Body part	Function and additional information
Eyes (2)	Most bony fish have excellent colour vision. For many, their bodies are accordingly brilliantly coloured and patterned. These bright colours communicate a range of things including showing aggression and fear, attracting the opposite sex and signalling territorial ownership. Colour patterns may also be used for camouflage and disguise to hide from or deceive predators
Nostrils	Fish have a keen sense of smell and can detect small changes in water chemistry. They have a pair of nostrils (called nares) that are used to detect odours in water and can be quite sensitive. In sharks, the nostrils are on the underside of the head rather than on the dorsal surface as in most bony fishes
Mouth	The size and shape of a fish's mouth provides a good clue to what they eat. The larger it is, the bigger the prey it can consume. The position of the mouth can also indicate whether a fish consumes prey from the surface, sea floor, or in front of it
Operculum (gill cover)	The operculum covers the gills. Although they live in the aquatic environment, fish do require oxygen. Fish extract oxygen in the water and diffuse out carbon dioxide using gills. Gills rely on water flowing over them to ensure maximum oxygen uptake.
Pelvic fin	The pectoral and pelvic fins are paired fins – they are the same on both sides of the body. Pectoral fins can be used individually to manoeuvre the fish up, down and sideways. Together, these fins act as brakes and the fish can also use them to swim backwards. The pelvic fins are used for braking and steering.
Lateral line	The lateral line is a sensory organ that runs along the sides of the fish's body, under the skin. It consists of a series of tiny, sensitive cells called neuromasts, which are housed in mucus-filled canals. Small pores in the fish's skin and scales allow vibrations in the water to pass through to the lateral line. This enables the fish to detect differences of pressure and movement in the water
Ventral (anal) fin Caudal or tail fin Second dorsal fin First dorsal fin	Fish also have single (unpaired) fins along the centre line, such as the dorsal (back) fins, anal fin and caudal (tail) fin. The dorsal and ventral (anal) fins play an important role by acting as stabilisers – without them the fish would roll over on its side.
Pectoral fin	The pectoral and pelvic fins are paired fins – they are the same on both sides of the body. Pectoral fins can be used individually to manoeuvre the fish up, down and sideways. Together, these fins act as brakes and the fish can also use them to swim backwards. The pelvic fins are used for braking and steering.

Fish adaptations

Students may include a variety of different behavioural or structural adaptations here. Descriptions of fish body shape adaptations are available from the DPIRD, *Marine Waters Factsheet – Fish Anatomy.*

Case study 1: Reproduction and life cycles in food and fibre production

Student worksheet 4.1.1 Reproduction and life cycles in food and fibre production

Activity 1: Asexual reproduction in agriculture

Vegetative method	Plants that show this	Notes
Runners	Grasses, strawberries, ivy	Stems run along ground surface, sending down roots at intervals
Stem tubers	Potatoes, sweet potatoes	Swellings called tubers are attached to the stem underground, for food storage
Bulbs	Onions, garlic, daffodils	Underground leaves full of stored food
Underground stems	Bamboo, bracken fern	Stems run along underground
Root suckers	Some eucalypts	Roots send up stems near the surface
Tap roots	Carrots, parsnips	Swollen roots full of stored food

Even though black truffles and potatoes both reproduce asexually, we think they use different methods of asexual reproduction because … Black truffles reproduce by spores; potatoes are a vegetative stem tuber	
We think that blue gum trees produced by asexual **cloning** may have an advantage over sexually produced trees because … They are quick to produce. All plants are potentially of the same quality.	Cloned trees, however, may be at a disadvantage if … … environmental conditions change (eg drought) or disease occurs, all plants will be affected.

Activity 2: Apple scab – an asexual reproducing fungal disease

Why is it important that WA primary producers understand the life cycles of living things? (Brainstorm)

Ideas should include effective opportunities to interrupt pest and disease lifecycles and maximise crop yield.

When do you think the fruit grower would best be able to control the apple scab disease?

The season of the year when the spread of apple scab disease is more easily controlled is autumn/winter. This is because leaf litter can be collected and destroyed.

Collecting leaf litter and fallen fruit in late autumn / winter prevents infected leaves from ejecting ascospores during spring.

Activity 4: Key vocabulary exercise

1.					A	G	**R**	O	N	O	M	I	S	T	
2.						S	**E**	X	U	A	L				
3.							**P**	E	S	T					
4.					F	E	**R**	T	I	L	I	S	A	T	I	O	N
5.					S	P	**O**	R	E	S							
6.							**D**	I	S	E	A	S	E				
7.			A	S	E	X	**U**	A	L								
8.	A	P	P	L	E	S	**C**	A	B								
9.			V	E	G	E	**T**	A	T	I	V	E					
10.						L	**I**	F	E	C	Y	C	L	E			
11.					C	L	**O**	N	I	N	G						
12.	S	U	S	T	A	I	**N**	A	B	L	Y						

Student worksheet 4.1.2 Sexual reproduction and life cycles

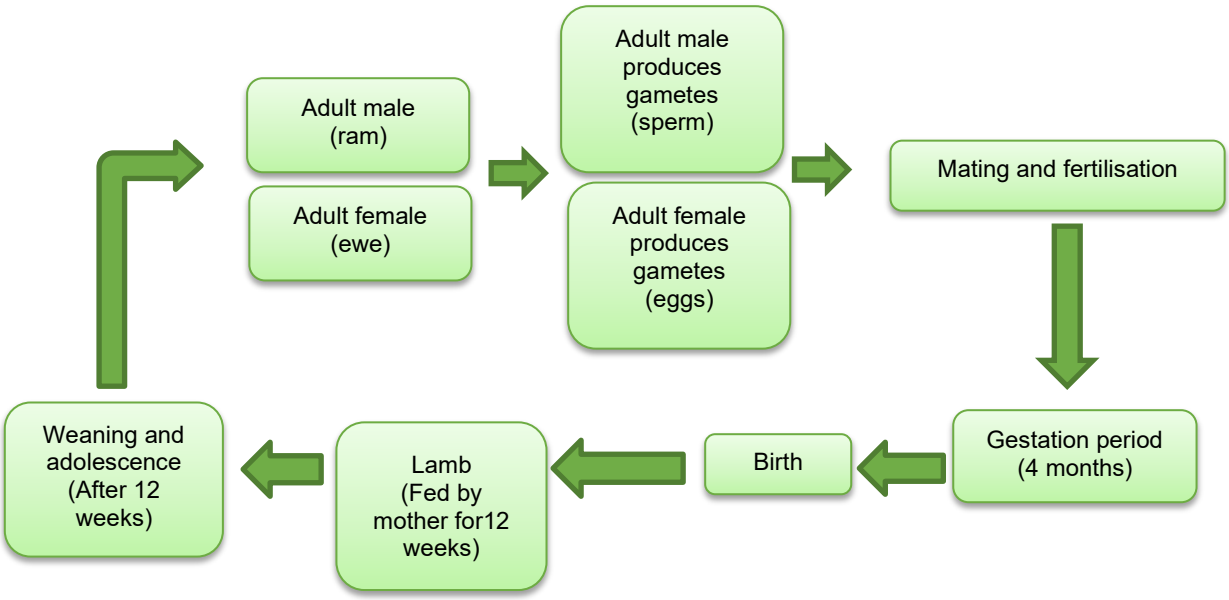
Activity 1: Sexual reproduction in Western Australian agriculture

Comparison of sheep and dairy cattle life cycles:

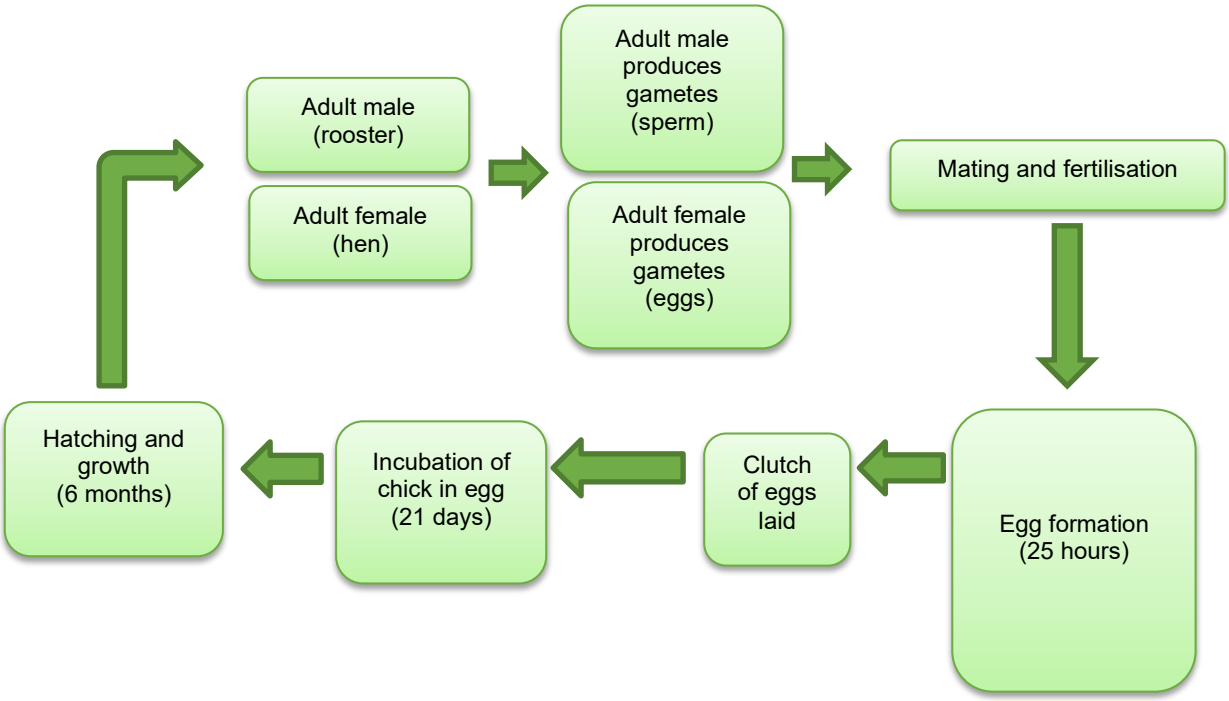
Similarities	Differences
Both have males and females Both produce gametes Both involve fertilisation Both have body structures associated with gamete production, fertilisation and gestation	Gestation periods are different Period of growth to adulthood is different

Activity 2: A sheep's life cycle

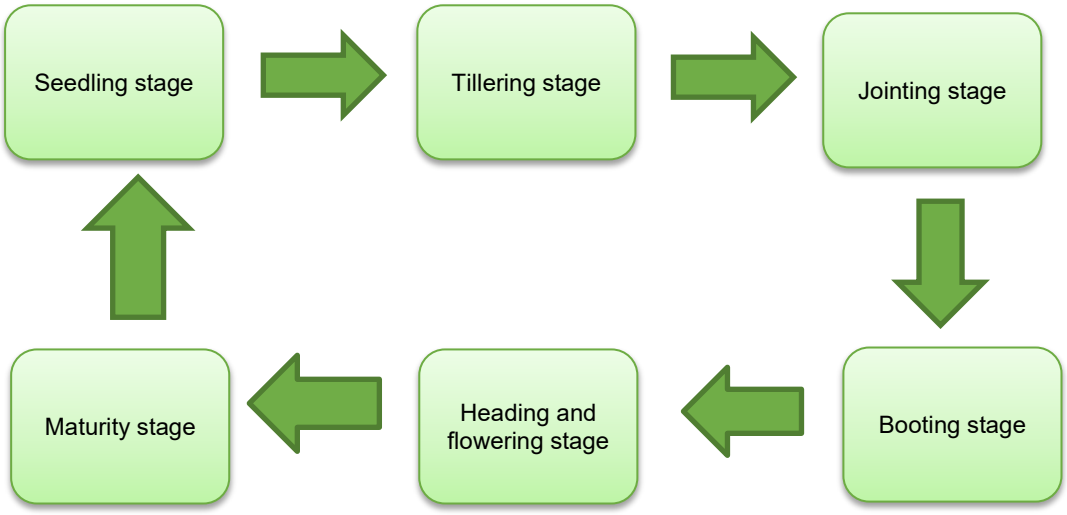
The average sheep lives for around 10–12 years.



Chicken life cycle: younger hens are called pellets and may be ready to lay as young as 18 weeks. A healthy and productive female will lay eggs until they are around 72 weeks old.



Six stages of wheat life cycle (brief)

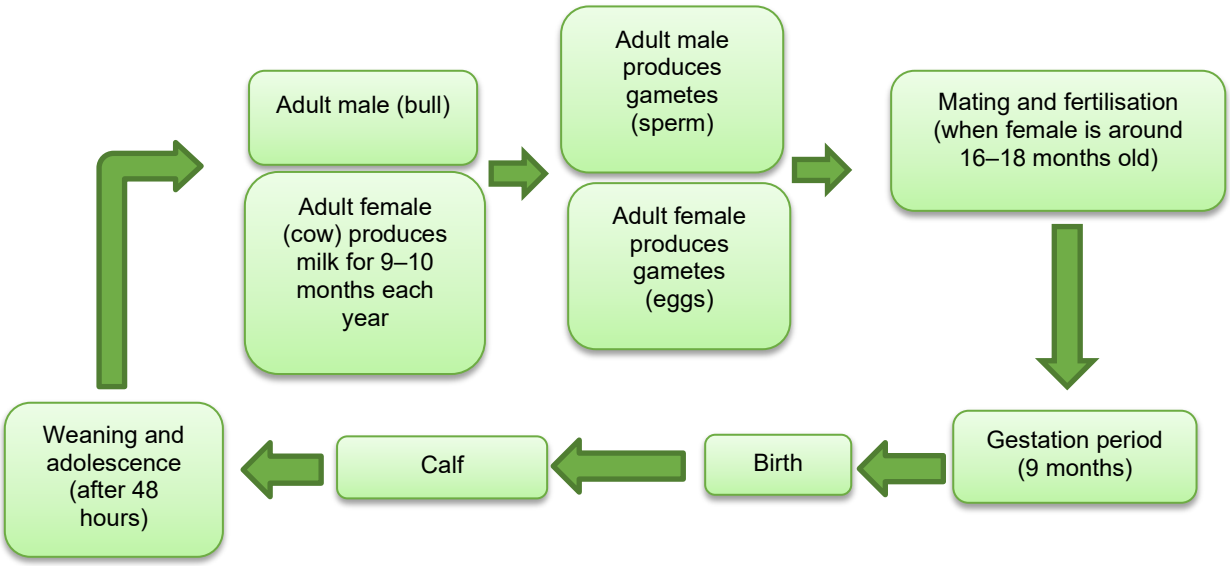


Activity 3: Why is it important for WA primary producers to understand life cycles?

It is important for WA primary producers to understand the life cycles of their crops and livestock to maximise their yields, to maintain economic viability, to understand and manage diseases, and to ensure they are produced ethically and sustainably.

Life cycle of a dairy cow

It would be useful for a farmer to know about the life cycle of their dairy cows so that they can maximise milk production.



Activity 4: Food and fibre careers involving reproduction and life cycles

Agricultural scientist	Agricultural technical officer
Skills needed to do this job could include: Sampling skills Research skills Communication skills Problem-solving skills	Skills needed to do this job could include: Equipment setup Sample collection Recording and interpreting data Research and advice
Some of the day-to-day tasks of an agricultural scientist include: - collecting samples of crops, animal feed and soil and conducting tests in laboratories and greenhouses - researching cultivation techniques, soils, insects, plants, crop production, pasture growth and animal breeding - advising farmers and farm managers about better ways to produce crops and livestock, control weeds and pests, and improve farming practices - developing procedures and techniques for solving agricultural problems and improving the efficiency of production.	Some of the day-to-day tasks of an agricultural technical officer include: - setting up equipment and collecting samples from crops or animals so testing can be performed - recording and interpreting information from experiments - interpreting aerial photographs and preparing maps of soil and vegetation patterns - assisting with the laboratory experiments to test plants, animals, soils and farming techniques - researching and providing advice about various technical issues.

(Source: Government of Western Australia, DPIRD, 'Careers in food and fibre' available at: https://www.agric.wa.gov.au/biosecurity-quarantine/careers-food-and-fibre?page=0%2C1#smartpaging_toc_p1_s3_h3 accessed8 June 2021)

Student worksheet 4.1.3 Comparing reproductive systems

Flower part	Role in reproduction
Stamen	The stamen is the pollen-producing reproductive organ of a flower
Anther	The part of the stamen that contains the pollen
Filament	The stalk that holds the anther
Stigma	Part of the female reproductive organ (pistil) of a plant that receives pollen
Style	The stalk of the pistil
Ovary	The enlarged basal portion of the pistil – the female organ of a flower. The ovary contains ovules, which develop into seeds upon fertilisation. The ovary itself will mature into a fruit
Sepals	Sepals typically function as protection for the flower bud, and often as support for the petals when in bloom
Petals	Petals are modified leaves that surround the reproductive parts of flowers. They are often brightly coloured or unusually shaped to attract pollinators

(Source: 'Glossary of biology' available at: https://en.wikipedia.org/wiki/Glossary_of_biology accessed 10 June 2021)

Where does the fruit form and why does it contain seeds?

Fruit forms from the ovary of a flower; the fertilised eggs develop into seeds.

Humans: a typical animal

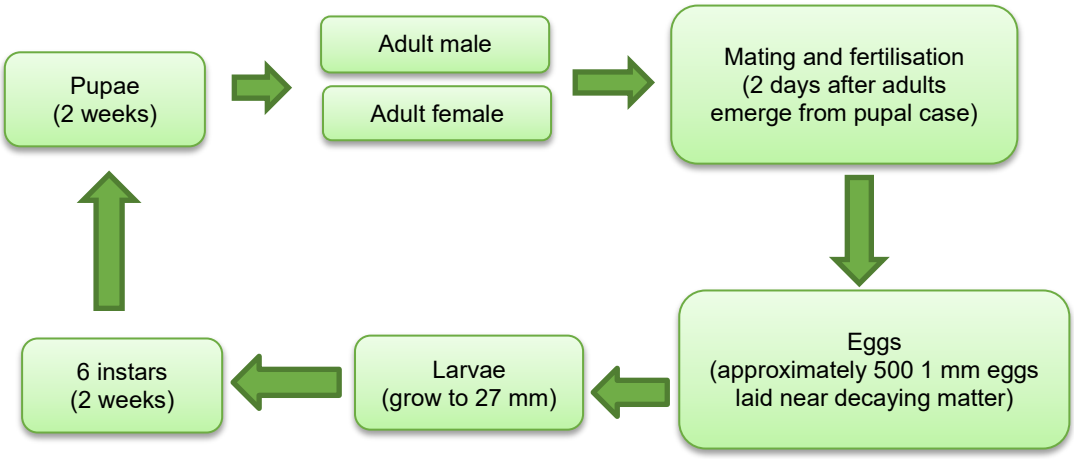
Term	Role in reproduction
Ovaries	Female organs that produce oocytes (egg cells), as well as oestrogen, progesterone and other hormones
Fallopian tubes	A pair of tubes attached on either side of the top of the uterus that the eggs are released into. Fertilisation usually occurs in these tubes
Uterus	A muscular organ where the embryo implants and grows during pregnancy
Cervix	The lower, narrower end of the uterus
Vagina	The canal that goes into to the cervix
Testes	Male organ for production of sperm
Penis	Male organ for delivery of sperm
Vas deferens	The vas deferens pushes the sperm up over the bladder and down toward the prostate gland
Gamete	The sperm and the egg are gametes. They each contain half the genetic information necessary for reproduction. When a sperm cell penetrates and fertilises an egg, that genetic information combines

(Sources: Glossary of the reproductive system available at: https://www.visiblebody.com/learn/reproductive/glossary ; Glossary of terms, Centre for reproductive medicine available at: https://medicine.umich.edu/dept/crm/patient-resources/health-library/glossary-terms accessed 8 June 2021)

Case study 2: The black soldier fly

Student worksheet 4.2.1 The black soldier fly

Life cycle of the black soldier fly (*Hermetia illucens*), adapted from the description on the Featured Creatures page on the black soldier fly at the University of Florida website.



What do you think metamorphosis means? There are other types of animals that also go through this process, can you name any?

In biology, metamorphosis is a process which many insects go through where their life cycle involves distinct changes in body structure through cell growth and differentiation.
Other organisms which also go through metamorphosis include some fish, amphibians, molluscs, crustaceans, cnidarians, echinoderms and tunicates.

(Source Biology Dictionary "Metamorphosis' available at: https://biologydictionary.net/metamorphosis accessed 9 June 2021)

Which stages of the black soldier fly life cycle are useful to us?

1. The main useful stage of the black soldier fly is the larvae.
2. Adult soldier flies do not become pests like other flies as they do not feed – they only reproduce.

Student worksheet 4.2.2 Black soldier fly investigation

Extension activity: Building numeracy skills

If a 10 mL sample of larvae was taken from the large (500 L) growth container and was found to contain 200 larvae, calculate (show your working):

1. Density = Number of larvae per volume of sample
   200 per 0.01 L (10 mL)

   200 x 100 = 20,000 larvae per litre

2. Estimated total number of larvae in 500 litres = 20,000 x 500 = 10,000,000

Case study 3: Specialised cells, tissues and systems

Student worksheet 4.3.1 Specialised cells, tissues and systems

Activity 1: Exploring nitrogen fixation

2. Write a description of how the specialised cells in the root nodules of plants (like lupin) are essential for sustaining life on our planet.

Lupins are essential components of the nitrogen cycle. Nitrogen is an essential element for the formation of amino acids and protein. Atmospheric nitrogen is relatively inert and therefore is not utilised directly by animals. For lupins to be able to capture atmospheric nitrogen, they need to form a symbiotic relationship with certain species of nitrogen fixing bacteria known as rhizobia. These rhizobia bacteria are found in specialised cells and structures called root nodules. The bacteria convert atmospheric nitrogen into nitrate compounds for use by the lupin plant. When the lupin is consumed by animals, dies or produces waste leaves these nitrates sheep are made available to other members of the food chain.

(Source: Open University (30 November 2011) 'Nitrogen fixation – seven wonders of the microbe world' (video) YouTube available at: https://www.youtube.com/watch?v=4NKGS4bj7cc accessed 9 June 2021)

Student worksheet 4.3.2 Comparing digestive systems of ruminants and humans

Activity 1: Digestion in ruminants

3.

- Sheep only have incisor teeth on their bottom jaw because they eat predominantly vegetation.
- After food has been in the rumen for about an hour it is regurgitated as cud, which sheep chew to extract more nutrients before it passes into the reticulum (second stomach) for further digestion.
- Bacteria in the rumen are involved in digestion of cellulose.
- Methane is produced as a by-product in the rumen. It could possibly become an environmental problem as methane gas is a contributor to greenhouse gas emissions and therefore to possible climate change.

(Source: Learn About Wool 'Sheep-The wool producers' factsheet available at: https://www.learnaboutwool.com/globalassets/law/resources/factsheets/secondary/gd3270-secondary-fact-sheet_2019_b.pdf accessed 9 June 2021)

Brainstorm: Reducing livestock greenhouse gas emissions

There are four main approaches to mitigating livestock greenhouse gas emissions:

- husbandry (animal breeding, feed supplements, improved pastures)
- management systems (stocking rates, biological control)
- numbers of livestock
- manure management

(Source: Government of Western Australia, DPIRD, 'Reducing livestock greenhouse gas emissions', available at: https://www.agric.wa.gov.au/climate-change/reducing-livestock-greenhouse-gas-emissions accessed 9 June 2021)