PRIMED

Student worksheet

Year 8 Science

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

Student worksheet 1.1

Silent card shuffle

Images

Image 1

Image 2

Image 3

Image 4

Image 5

Image 6

Image 7

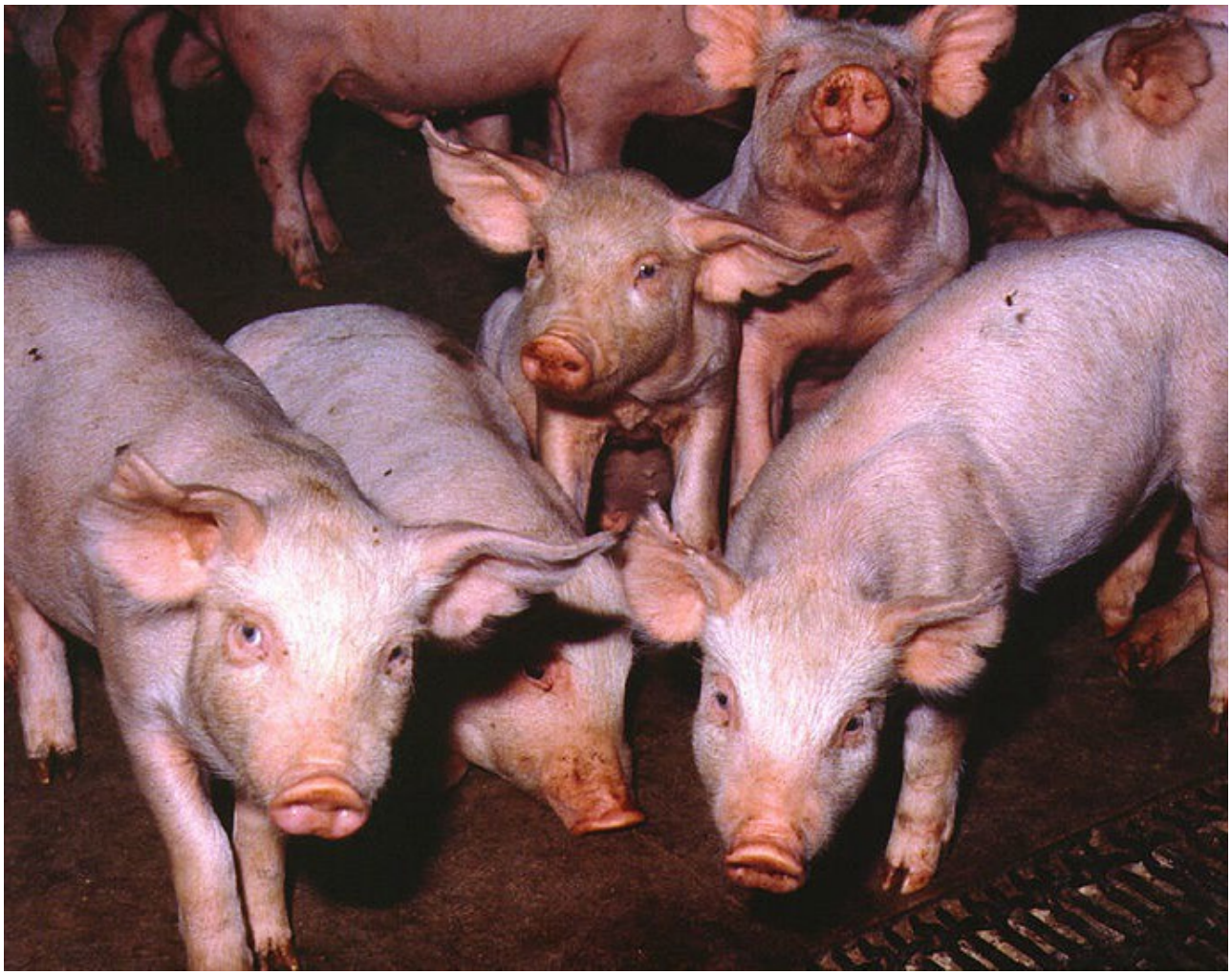


Image 8

Image 9

Image 10

Image 11

Image 12

Labels

Wheat	**Pigs**
Canola	**Western rock lobster**
Cotton	**Rainbow trout**
Sheep	**Pearl oysters**
Beef cattle	**Black truffles**
Dairy cattle	**Grapes**

Brief descriptions

The major grain crop produced in WA. It makes up 65% of annual grain production and generates A$2–3 billion for the State economy each year.	This animal is reared in WA to produce various meat products (eg pork, bacon, ham).
The oil from this crop is used for cooking and baking at home, in restaurants and in food-processing plants.	This animal is the target of WA's most valuable fishery, and has been Australia's most valuable wild-caught crustacean species.
This fibre has been grown very successfully in the Ord River Irrigation Area (ORIA) of WA, using specifically engineered varieties that are pest resistant and don't need herbicides.	This fish is good to eat and a popular target for freshwater anglers in the south-west of WA.
This animal is reared in WA to produce some of the finest lamb, mutton and wool in the world. The State exports its products to over 100 countries.	This animal is the main focus of the pearling industry in WA.

WA exports about one-third of the meat produced from this animal. The other two-thirds are consumed domestically.	This food is the fruiting bodies of soil fungi that live in a symbiotic relationship with the feeder roots of trees.
In WA, some 160 farms use this animal to produce about 350 million litres of milk each year, much of which is consumed locally as either fresh milk or short-shelf-life products.	This fruit grows in diverse areas of WA, including Margaret River, the Swan Valley, Great Southern, Pemberton, Manjimup, Geographe, Blackwood Valley, Peel and the Perth Hills. It is used to produce high-quality wine.

Acknowledgements

References

Information on WA food and fibre production sourced from Government of Western Australia, Department of Primary Industries and Regional Development (DPIRD), available at: https://www.agric.wa.gov.au/

Images

- Image 1: 'Wheat' by Simon Waldherr. Licensed CC BY-SA 3.0, available at: https://commons.wikimedia.org/wiki/File:Wheat_(219038809).jpeg
- Image 2: 'Canola crop with wheat crop in background at Wallandbeen, NSW' image by Carl Davies, CSIRO. Licensed CC BY 3.0, available at: https://commons.wikimedia.org/wiki/File:CSIRO_ScienceImage_3978_Canola_Crop_with_Wheat_Crop_in_Background.jpg
- Image 3: 'Cotton grown in the ORIA' image © Government of Western Australia, DPIRD, available at: https://agric.wa.gov.au/n/3287
- Image 4: 'Sheep eating feed supplements' image by Livestock Industries, CSIRO. Licensed CC BY 3.0, available at: https://commons.wikimedia.org/wiki/File:CSIRO_ScienceImage_588_Sheep_Eating.jpg
- Image 5: 'Red-angus' image by Americasroof at English Wikipedia. Licensed CC BY-SA 3.0, available at: File:Red-angus.jpg - Wikimedia Commons
- Image 6: 'Dairy cattle in pasture, near Bemboka, NSW' by Carl Davies, CSIRO. Licenced CC BY 3.0 available at: https://commons.wikimedia.org/wiki/File:CSIRO_ScienceImage_3255_Dairy_cattle.jpg
- Image 7: 'Pigs at a pig farm' by Livestock Industries, CSIRO. Licenced by CC BY 3.0, available at: File:CSIRO ScienceImage 308 Pigs.jpg - Wikimedia Commons
- Image 8: 'Fisherman measuring Western Rock Lobster catch, Geraldton, Western Australia', image by Robert Kerton, CSIRO, CC BY 3.0 available at: https://commons.wikimedia.org/wiki/File:CSIRO_ScienceImage_199_Measuring_Western_Rock_Lobster_Catch.jpg
- Image 9: Rainbow Trout aquaculture image supplied with permission – Luke Wheat, Future Green Solutions
- Image 10: 'Pearl production in Halong Bay (Vietnam)', image by Ji-Elle, CC BY-SA 4.0 available at: https://commons.wikimedia.org/wiki/File:Pearl_production_in_Halong_Bay_(28).jpg
- Image 11: Western Australian black truffles – image © Government of Western Australia, DPIRD, available at: https://www.agric.wa.gov.au/agricultural-exports/truffle-industry-western-australia
- Image 12: Fer Wine Grapes – image © Government of Western Australia, DPIRD, available at: https://www.agric.wa.gov.au/wine-grapes/fer-wine-grapes-western-australia

Student worksheet 1.2

Introducing cells and systems

Cells

When you look at the wide range of plants and animals produced by primary producers in Western Australia (WA) – such as farmers, aquaculturists, foresters and graziers – you will start to realise that these plants and animals have many things in common. For example, they are all living things.

As living things they:

- have some form of **movement**
- must **respire** (generate energy from food in the process of respiration)
- must be **sensitive** and able to respond to change in their environment
- carry out **growth** by producing more cells
- must have a means of **reproduction** to produce new individuals
- must remove waste products by the process of **excretion**
- require **nutrition** – some sort of food for energy and nutrients to survive.

We often use the mnemonic acronym 'MRS GREN' to help us remember all the necessary features of living things: Movement, Respiration, Sensitivity, Growth, Reproduction, Excretion and Nutrition. (Basic Biology website, 2020)

But did you know that if you examine living things in more detail using a **microscope**, you'll see that they are all comprised of fundamental building blocks called **cells**.

It wasn't until the invention of microscopes that scientists were able to see cells in any detail and discover the existence of **unicellular** living things, such as bacteria and protists.

Image 1.2.1: *Paramecium* – a unicellular protist

Activity 1: Key concepts

Two types of cells – prokaryotic and eukaryotic

Prokaryotic cells (eg bacteria and archaea) and **eukaryotic cells** (eg plants, animals and fungi) are the two basic types of cells.

The biggest difference between them is that eukaryotic cells have a distinct **nucleus** that contains the cell's genetic material, while prokaryotic cells don't have a nucleus – they have free-floating genetic material instead.

Eukaryotic cells are generally more complex and contain several different membrane-bound **organelles** (eg chloroplasts for photosynthesis and mitochondria for energy release), which prokaryotic cells do not.

To learn more about the two basic types of cells, watch the Prokaryotic vs eukaryotic cells [video].

Multicellular organisms

All plants and animals (and many fungi) contain billions of cells. For this reason they are called **multicellular** organisms.

The cells are arranged into various types of **tissues**, which combine to form different **organs** that each carries out a specific **function**. For example, in sheep, cows, pigs and humans, the heart is comprised of muscle cells that make up various types of muscle tissue. These tissues combine to enable the heart to carry out the function of pumping blood around the body. Plants also contain **systems** of cells arranged into tissues that make up organs (eg a tree trunk).

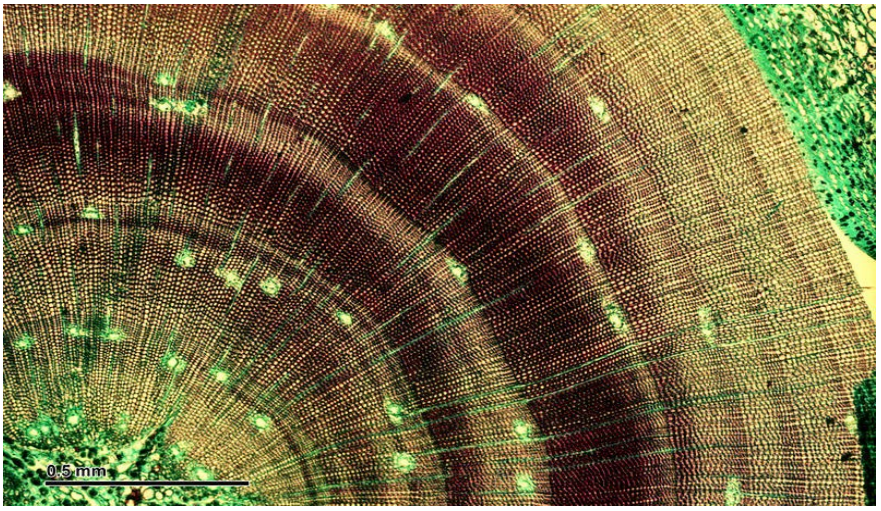


Image 1.2.2: Cross-section of stem of pine tree woody tissue

Activity 2: Group discussion

In your small group, discuss the following questions:

1. In general, why would a knowledge of cells and systems be helpful to people?

2. Why would a knowledge of cells and systems be useful to WA primary producers, such as farmers, graziers, foresters and vignerons?

Summarise your ideas:

Activity 3: Check your understanding

Check your understanding of cells and systems so far by writing 'True' or 'False' for each of the following statements:

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

Activity 4: Comparing plant, animal and fungal cells

The cells of plants, animals and fungi are all **eukaryotic** cells. They have several similarities and differences.

A typical animal cell contains:

- a cell **membrane** (which controls the entry of substances in and out of the cell)
- a **nucleus** (containing genetic material)
- **cytoplasm** (a watery jelly-like substance)
- **small vacuoles** (may contain wastes or chemicals)
- various other smaller **organelles** (eg mitochondrion) in the cytoplasm.

Plant cells have the **same parts as animal cells**, plus some **extra structures**. These include:

- a **cell wall** (to give the cell support and shape), made of **cellulose**
- **chloroplasts** (to carry out photosynthesis)
- a **large vacuole** (filled with sap, water, waste and nutrients).

Fungal cells have the **same parts as animal cells** with the addition of **a cell wall**, made of **chitin**.

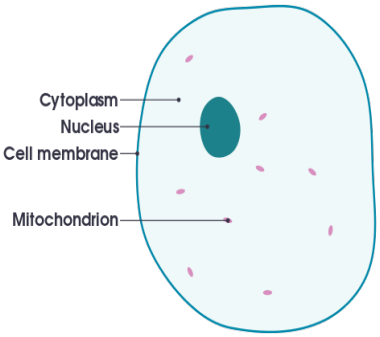


Image 1.2.3: A typical animal cell

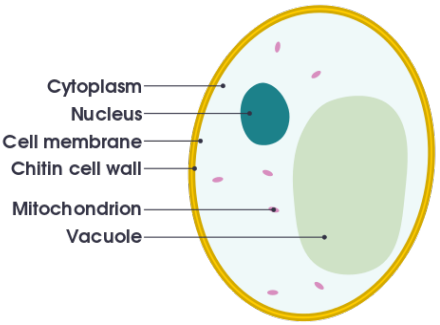


Image 1.2.4: A typical fungal yeast cell

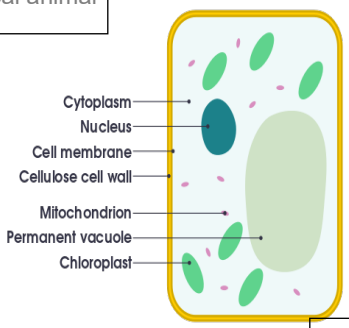
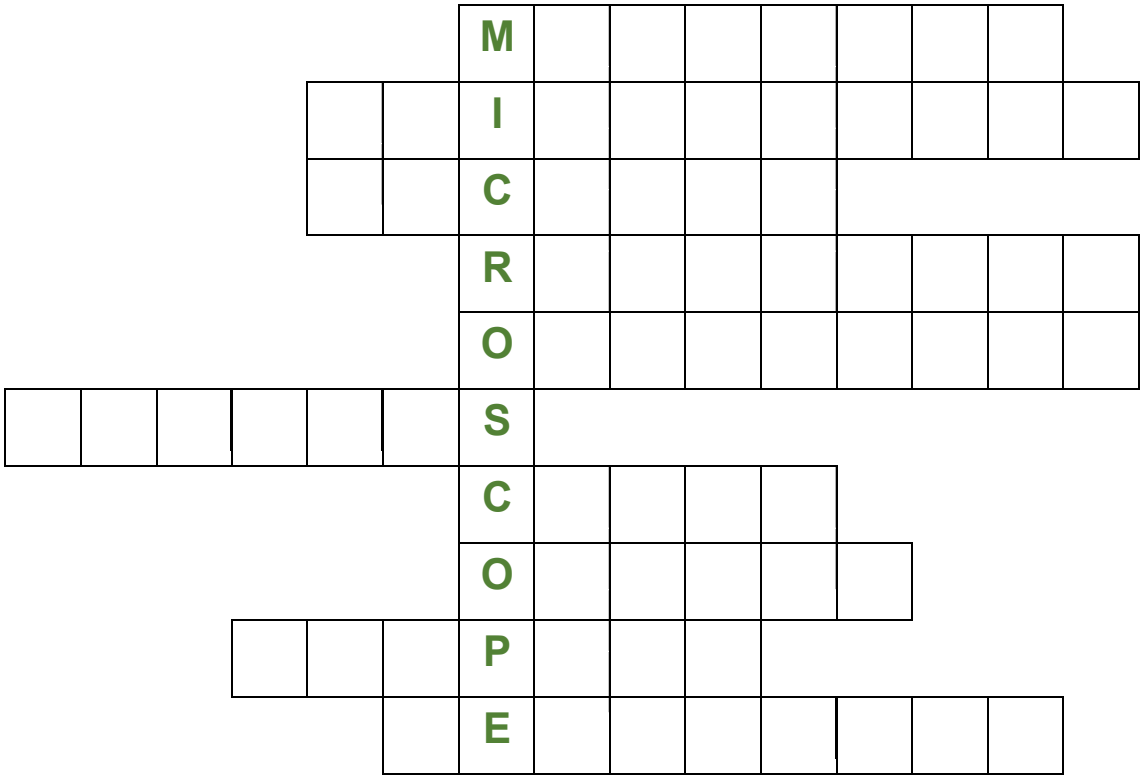


Image 1.2.5: A typical plant cell

In your discussion group, compare the similarities and differences between animal, plant and fungal cells using the Venn diagram provided by your teacher.

Activity 5: Literacy review

Keywords have been bolded in this worksheet. Look at the clues below to complete this crossword with 10 of the keywords. (All words are written horizontally across the crossword.)



1. Structure surrounding cell that allows substances to pass in and out
2. Description of an organism that is made up of only one cell
3. To pass waste out of a cell
4. To produce more of the same kind of cell or organism
5. Small structures found within cells that carry out specific functions
6. The structure within the cell that contains genetic information
7. The fundamental building blocks of all living things
8. Groups of different tissues that work together to carry out a function
9. To generate energy from food
10. To be able to respond to a change in a cell or organism's environment

Acknowledgements

References

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.

Klappenbach L (2020) *Prokaryotes vs. eukaryotes: What are the differences?*, ThoughtCo. website <https://www.thoughtco.com/what-are-prokaryotes-and-eukaryotes-129478>, accessed 30 April 2021.

Images

Image 1.1.1: 'Green *Paramecium*' by Frank Fox. Licensed CC BY-SA 3.0 DE, available at <https://commons.wikimedia.org/wiki/File:Mikrofoto.de-Gruenes_Pantoffeltier_2.jpg>.

Image 1.2.2: 'Plant stem: Cross-section of stem of pine tree (woody tissue) by Doc. RNDr. Josef Reischig, CSc. Licensed CC BY-SA 3.0 available at <https://commons.wikimedia.org/wiki/File:Plant_stem_(255_10)_Cross-section_of_stem_of_pine_tree_(woody_tissue).jpg>.

Image 1.2.3: 'A simple diagram of an unspecialised animal cell, labelled in English' by domdomegg. Licensed CC BY 4.0, available at <https://commons.wikimedia.org/wiki/File:Simple_diagram_of_animal_cell_(en).svg>

Image 1.2.4: 'A simple diagram of a yeast cell, labelled in English' by domdomegg. Licensed CC BY 4.0, available at <https://commons.wikimedia.org/wiki/File:Simple_diagram_of_yeast_cell_(en).svg>.

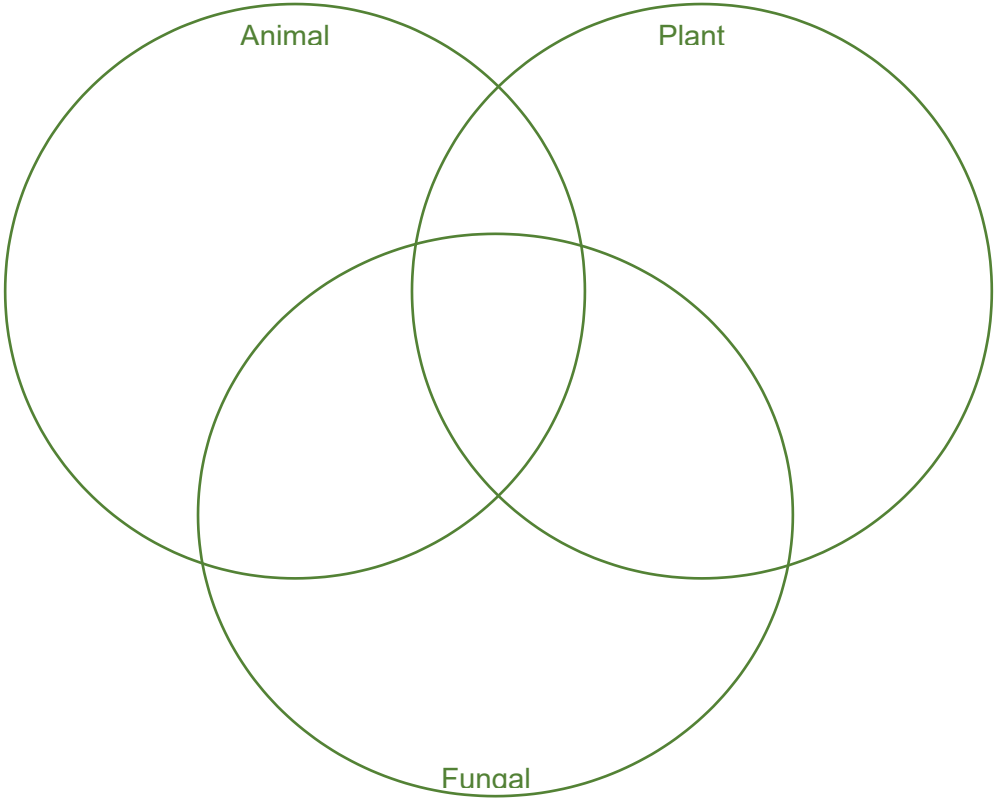
Image 1.2.5: 'A simple diagram of a plant leaf cell, labelled in English' by domdomegg. Licensed CC BY 4.0, available at <https://commons.wikimedia.org/wiki/File:Simple_diagram_of_plant_cell_(en).svg>.

Student worksheet 1.3

Venn diagram comparing animal, plant and fungal cells

In the Venn diagram below, place the words from the list to illustrate the similarities and differences between animal, plant and fungal cells.

Eukar
yotic
Micros
copic
Nucle
us
Cytopl
asm



Student worksheet 2.1

Exploring cells under the microscope

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

Examine a diagram (or an image supplied by your teacher) of a compound light microscope.

As a group, **PREDICT** what you **think** the function of each part of the microscope is **likely** to be. Enter your predictions in the second column of the table.

Access the Compound microscope parts page of the Microscope.com website to check if your predictions are correct. Enter the actual function in the third column of the table.

Microscope part	Predicted function	Actual function
Eyepiece (ocular) and eyepiece tube		
Objective lenses and nosepiece		
Coarse and fine focus knobs		
Stage / stage clips		
Aperture		
Illuminator		
Iris diaphragm		
Condenser / condenser focus knob		

In the next activity you will learn how to use a microscope and prepare cell material to view under the microscope.

First, watch the How to use a microscope [video].

Activity 2: Preparing cell slides to view under the microscope

Part of the role of agricultural scientists in Western Australia (WA) is to provide:

- scientific advice and research on soil, weed and pest management
- information on new plant and animal species.

To do this they regularly need to prepare biological material for viewing under a microscope.

In this activity you need to work with your group so you can learn some of their techniques.

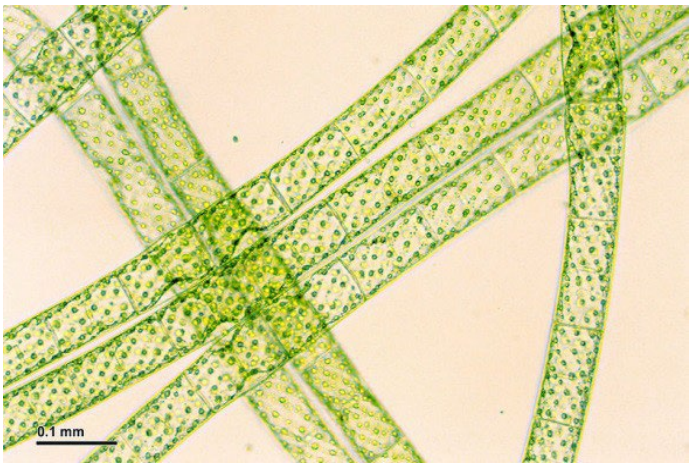


Image 2.1.1: 'Spirogyra'

Types of mount

There are four common ways to prepare (mount) a microscope slide. Your teacher will show which of these techniques you are going to use to prepare your slides of biological material.

Dry mount
In a dry mount, you place the specimen directly on the slide. You can use a cover slip to keep the specimen in place and help to protect the objective lens. Dry mounts are suitable for specimens such as samples of pollen, hair, feathers or plant materials.

Wet mount
In a wet mount, you use a drop of water to suspend the specimen between the slide and cover slip. Place a sample on the slide and use a pipette to drop the water on it. Place one edge of the cover slip over the sample and carefully lower the cover slip into place using a toothpick or equivalent. This method will help to prevent air bubbles from being trapped under the cover slip.

Image 2.1.2: 'Wet mount image'

Section mount
In a section mount, you use an extremely thin cross-section of a specimen. Cut a thin slice of your selected specimen (such as an onion), and carefully set it on your slide. Then follow the instructions for a dry or wet mount.

You can often apply a stain directly to the specimen before covering with a cover slip.

Section mounts are useful for a wide variety of samples that can be cut into small slices, such as fruit, vegetables and other solids.

Smear
You make a smear by carefully smearing a thin layer of the specimen across a slide and then applying a cover slip. Allow the smear to air-dry before applying a stain.

Make your mount

Your teacher will provide you with the necessary equipment to make a wet mount slide. This should include:

- glass slide
- thin glass cover slip
- pipette (or eye dropper)
- toothpick
- staining agent (eg iodine)
- absorbent paper
- pond water or other biological material (eg plant leaves, onion).

Watch this fun How to make a microscope slide [video], then make your slide.

Image 2.1.3: Bananas packed and ready for market

Activity 3: Viewing and drawing your cells under the microscope

Let's now examine some cells from various foods produced by WA primary producers:

- bananas (grown in plantations in Carnarvon and Kununurra)
- tomatoes (grown in a variety of market gardens around WA)
- onions (grown in a variety of market gardens around WA)

Equipment needed

- microscope
- 3 glass slides
- 1 probe
- 1 piece of newspaper
- 1 slice of each of: banana, tomato and onion
- selection of pre-prepared cells
- dropper bottle of iodine for staining plant tissue

Method

1. Turn the nosepiece to select the lowest power objective lens.
2. Cut a 1 cm x 1 cm piece of newspaper (containing text) and place it on a glass slide. Ensure the text is face up.
3. Place the glass slide on the microscope stage so that the text can be read from left to right.
4. Looking at the side of the microscope and use the coarse focus to wind the stage all the way to the top. Make sure the objective lens is not wound through the glass slide.
5. Look through the ocular lens and turn the coarse focus gently until the image is in focus.
6. Move the slide around on the stage as you look through the ocular lens.

   When you move the slide, which direction do the letters move under the lens? Discuss this with your group members and suggest a reason why this happens

7. Move the glass slide to locate a letter ‘e’.

   What do you notice about the way the ‘e’ is facing? Discuss this with your group members and suggest a reason why this happens

8. Take a small piece of the banana and smear it across a clean glass slide.
9. Place a small drop of iodine on a thin section of the smear.
10. Examine the slide under low power, as you did with the newspaper piece.
11. When the banana smear is in focus, turn the objective lens to a higher power. Gently turn the fine focus. Make sure the objective lens is not wound through the glass slide.
12. Locate a group of banana cells and draw them using pencil in the correct space in the table on the next page.
13. Repeat the previous procedure to prepare a smear of the tomato slice.
14. Use the microscope to locate a group of tomato cells and draw them using pencil in the correct space in the table on the next page. Add a title, label parts you can see and write down the magnification.
15. Your teacher will show you how to prepare a thin slice of onion epidermal cells and mount them on a slide.
16. Use the microscope to locate a group of onion cells and draw them using pencil in the correct space in the table on the next page.
17. Select a slide from the pre-prepared slides your teacher has provided. Draw them using pencil in the correct space in the table on the next page.

Labelled drawings of cell mounts

(Add a title, label parts you can see and write down the magnification)

Banana	Tomato
Onion	Pre-prepared slide

Activity 4 (extension): WA primary industry careers

Is knowledge of cells useful for a future career in WA primary industry?

Agriculture isn't just about working on a farm; there are lots of different kinds of careers within the food and fibre chain.

In your group of three or four students, brainstorm ideas about careers in WA primary industry that require an understanding of cells and how they function.

I think some primary industry careers that might involve using microscopes to examine cells are …	The skills I might need to be able to do this include …
Doing this type of work would be beneficial because …	Qualifications I might need include …

Learn more about careers in food and fibre on the Department of Primary Industries and Regional Development website and complete the table:

Research it	Grow it	Make it
Some careers where I can carry out research on food and fibre production are …	Some careers where I can be involved with growing crops and raising animals are …	Some careers where I can design information technology, food technology or engineering are …
Some things that I would do in these careers are …	Some things that I would do in these careers are …	Some things that I would do in these careers are …
Qualifications I would need to work in these careers are …	Qualifications I would need to work in these careers are …	Qualifications I would need to work in these careers are …

Acknowledgements

References

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

FuseSchool – Global Education (7 January 2018) 'How to use a microscope' (video) YouTube https://www.youtube.com/watch?v=xzjowD1KN20 accessed 31 May 2021

Scientist Cindy (29 September 2016) 'How to make a microscope slide' (video) YouTube https://www.youtube.com/watch?v=BmR9XfuHjAI accessed 31 May 2021

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

Images

Image 2.1.1: 'Spirogyra' by Doc. RN Dr.Josef Reischic CSc. Licensed CC BY-SA 3.0, available at https://commons.wikimedia.org/wiki/File:Spirogyra_(248_00)_Native_preparation.jpg

Image 2.1.2: 'A simple illustration of a wet mount on a slide used for microscopy' image by Sarah Greenwood CC BY-SA 4.0 available at: https://commons.wikimedia.org/wiki/File:Coverslip_Graphic.svg

Image 2.1.3: 'Bananas packed and ready for market' © DPIRD, available at https://agric.wa.gov.au/n/2779

Student worksheet 2.2

Exploring and explaining cell structure and function

To maximise their food and fibre production, primary producers in Western Australia (WA) rely on scientists who have a detailed knowledge of plant, animal and fungal cell structures. These include **agricultural scientists**, **agronomists**, **microbiologists, geneticists** and animal and plant **physiologists**.

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

In your group, discuss the question:

What basic life functions do all living things (and therefore cells) need to do to survive and reproduce? Record your ideas below.

Our group **thinks** that the basic life functions all living things and cells need to carry out are …

Watch the Characteristics of living organisms – MRS GREN [video] about the seven key characteristics of all living things. Reminder: the acronym 'MRS GREN' is often used to describe and help us remember these characteristics. Use the video to find out if your ideas were correct.

Our group **knows** that the basic life functions all living things and cells need to carry out are …

Activity 2: Cell structures and functions

At cellular level, the basic life functions are carried out by specific structures. In a cell, many of these structures are called **organelles**.

All plant, animal and fungal cells contain various organelles. Some are found in all plants, animals and fungi; others are found only in plant cells. The Virtual plant cell page on the Plant Energy Biology website has lots of useful resources on this subject.

1. Access the Virtual plant cell teaching resources.
2. Scroll down to the Year 8 teaching resource *Animal vs Plant Cell Poster* and download it.
3. Watch the Virtual plant cell: Cell explore, 2018 [video] by Plant Energy Biology.
4. You may also choose to access information in your textbook or other online resources, such as the Inside a cell page on the Genetic Science Learning Center of the University of Utah Learn Genetics website.
5. Use the information you've accessed to help you to describe (in the space below) why the cells of living things are often described as being like tiny towns.
6. Complete **Table 1** with:
   - the names of the various major cell organelles or structures
   - whether these are found in both plant and animal cells or just in plant cells
   - their basic functions.
7. As an extension exercise, you may choose to complete **Table 2**, which has some other organelles found in cells.

Table 1: Major cell organelles and structures

Name of cell structure or organelle	Found in all cells or only in plants	Basic function – what does it do?
Nucleus		
Cytoskeleton		
Mitochondria		
Cytosol		
Cell membrane		
Cell wall		
Vacuole		
Chloroplasts		

Table 2: Extension – other cell organelles

Name of cell structure or organelle	Found in all cells or only in plants	Basic function – what does it do?
Ribosomes and endoplasmic reticulum		
Golgi apparatus		
Peroxisomes		

Activity 3: Cells are adapted to perform specific functions

Image 2.2.1: WA lambs

When WA agricultural scientists examine cells, they find they have shapes and structures related to the functions that they perform. For example, these images show structures from the small intestine of a WA sheep.

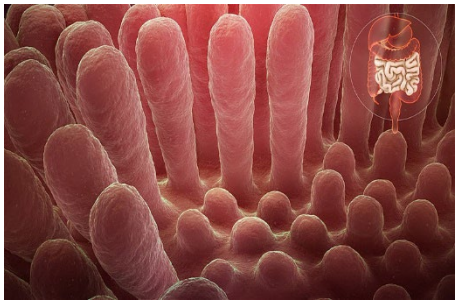


Image 2.2.2: Intestinal villi

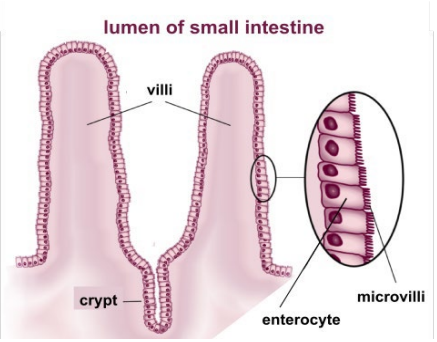


Image 2.2.3: Villi & microvilli of small intestine

The small intestine of sheep is lined with millions of highly specialised cells called **enterocytes** (*entero* = intestine; *cyte* = mature cells).

These enterocytes:

- form the lining cells on many elongated structures called **villi**
- have many tiny finger-like projections called **microvilli**, which dramatically increase their surface area for absorbing materials.

The main function of the small intestine is to absorb broken down proteins, fats and sugars, as well as water, electrolytes, vitamins and bile salts.

In your small discussion group, brainstorm some possible ideas about why the enterocytes are shaped like they are. In other words, how is their shape related to their function?

Our group **thinks** that enterocytes are found on finger-like villi and have thousands of finger-like microvilli to …
Other examples where the cells of plants or animals might find finger-like extensions useful could be …

You have probably worked out that the villi and microvilli increase the amount of **surface area** of the small intestine so that nutrient materials can be absorbed into the sheep's blood supply faster and more efficiently.

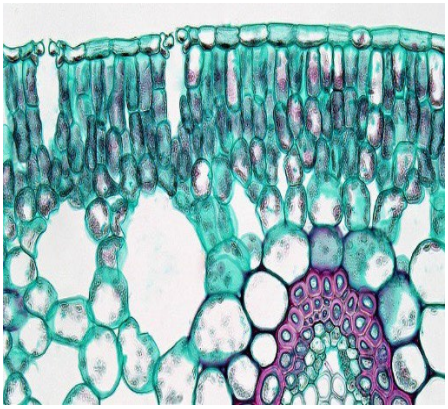
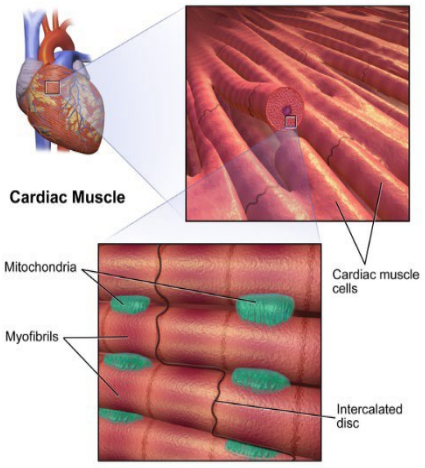
This is just one of thousands of examples of how the structures present, and the shapes and sizes of cells, are **specialised** to carry out specific functions.

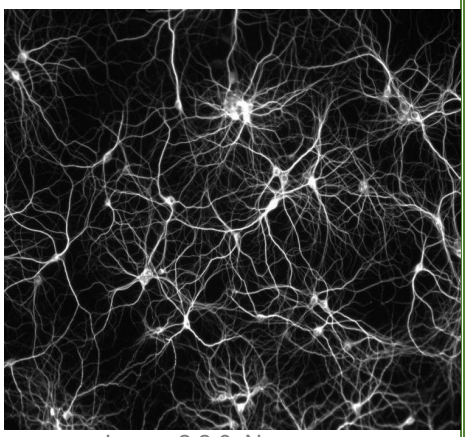
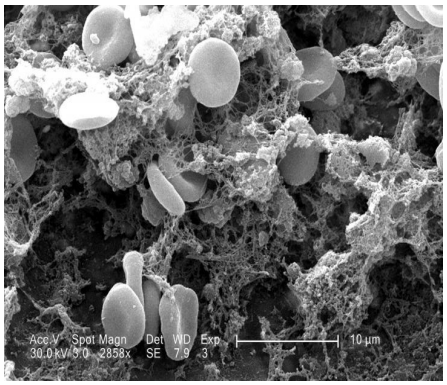
Scientists call any genetically inherited structure in a living thing assisting survival an **adaptation**.

Activity 4: More specialised cell adaptations

In your group, discuss each of the cell features in the next two tables and write how you **think** the feature is an adaptation that helps the cell perform its function.

For the first two you may need to refer to Activity 1 for the function of organelles.

Feature of cell	Image	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.	 Image 2.2.4: Angiosperm leaf mesophyll	
Cells in the heart (cardiac) muscle of sheep have large numbers of mitochondria.	 Image 2.2.5: Cardiac muscle	

Feature of cell	Image	How the feature helps the cell perform its function
Nerve cells (neurones) in the brains of sheep have many interconnecting fibres called axons and dendrites.	 Image 2.2.6: Neurones	
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.	 Image 2.2.7: Red blood cells	

Check your answers

Use your textbook or online resources to check whether your ideas are correct.

Then watch the Specialised cells: Significance and examples [video] and make a list of three plant and three animal specialised cell adaptations in the spaces below.

Plant cell adaptations

1.

2.

3

Animal cell adaptations

1.

2.

3.

Acknowledgements

References

Government of Western Australia, DPIRD, , Agriculture and Food available at: https://www.agric.wa.gov.au/ accessed 31 May 2021

Hartmann, HT & Kester, DE 1975, Plant Propagation Principles and Practices, 3rd ed., Prentice-Hall, Englewood Cliffs, New Jersey accessed 31 May 2021

Science Sauce (20 August 2017) 'Characteristics of living things – MRSGREN' (video) YouTube https://www.youtube.com/watch?v=QHPYRwCWAzM accessed 31 May 21

Amoeba Sisters (2 December 2016) 'Specialised cells: Significance and examples' [video], *Amoeba Sisters*, YouTube < https://www.youtube.com/watch?v=wNe6RuK0FfA>, accessed 31 May 2021

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

Images

Image 2.2.1: WA lambs © Government of Western Australia, DPIRD, available at: https://www.agric.wa.gov.au/management-reproduction/lamb-backgrounding-western-australia?nopaging=1 accessed 31 May 2021

Image 2.2.2: Intestinal villi: 'Inflammation of the intestinal mucosa may lead to villous atrophy of the small intestine' by www.scientificanimations.com. CC BY-SA 4.0 , available at <https://commons.wikimedia.org/wiki/File:Inflammed_mucous_layer_of_the_intestinal_villi_depicting_Celiac_disease.jpg> accessed 31 May 2021

Image 2.2.3: BallenaBlanca, CC BY-SA 4.0 available at: https://commons.wikimedia.org/wiki/File:Villi_%26_microvilli_of_small_intestine.svg accessed 31 May 2021

Image 2.2.4: 'Angiosperm leaf mesophyll', Berkshire Community College Bioscience Image Library, CC0 1.0 available at: https://commons.wikimedia.org/wiki/File:Angiosperm_Leaf_Mesophyll_Arrangement_in_the_Hydrophyte_Potamogeton_(36716450521).jpg accessed 31 May 2021

Image 2.2.5: 'Cardiac muscle'BrucBlaus, CC BY-SA 4.0 available at: https://commons.wikimedia.org/wiki/File:Cardiac_Muscle.png accessed 31 May 2021

Image 2.2.6: Neurones, Author Else If Then, CC BY-SA 4.0 available at: https://commons.wikimedia.org/wiki/File:R%C3%A9seau_de_neurones.jpg accessed 31 May 2021

Image 2.2.7: 'Red blood cells', Pixnio - image is in public domain, not copyrighted, no rights reserved, free for any use. Available at: https://pixnio.com/science/microscopy-images/red-blood-cells-enmeshed-in-a-fibrinous-matrix accessed 31 May 2021

Student worksheet 2.3

Growing quality fruit relies on science

Bananas, wine grapes and mangoes are produced by **horticulturists** in various locations around Western Australia (WA). A horticulturist is someone who uses scientific knowledge to:

- cultivate and propagate plants (plant propagation is the process by which new plants grow from a variety of sources: seeds, cuttings, and other plant parts)
- provide technical information to fruit, vegetable, and flower growers as well as wine makers and farmers.

Horticulturists use the process of **tissue culture** to clone a plant into potentially thousands of exact copies using only a few cells from its stem. Tissue culture or **cloning** is used widely around the world in areas such as horticulture, fruit production, forestry and wine production (viticulture). A clone is defined as 'genetically uniform material derived from a single (mother) individual and propagated exclusively by vegetative means such as cuttings, divisions or grafts' (Hartmann and Kester 1975).

In WA's wine-making regions, different cloned varieties of grapes with different characteristics are used to produce high-quality wine. These include cabernet sauvignon, chardonnay, merlot, shiraz and tempranillo.

Image 2.3.1: Wine grape propagation in WA

Tissue culture is also the best method that horticulturists use for propagating bananas in WA to ensure the bananas produced are of a consistent type and quality and free from pests and diseases.

Image 2.3.2: Banana propagation in WA

Mangoes are often produced by **grafting** – a process to produce uniform yield, fruit size and quality from trees.

Image 2.3.3: Mango propagation in WA

Both tissue culture and grafting rely on horticulturists' knowledge of how the cells (of these fruits) multiply to produce identical copies. This type of cell division is called **mitosis**.

In mitosis one cell divides to form two identical cells. The:

- cell that divides is called the **parent cell**
- cells formed due to division are called the **daughter cells**.

Access these online resources to learn more about the:

- process of mitosis [video]
- cloning of plants.

Cooperative learning jigsaw

This activity is a fun cooperative group activity (called a jigsaw) where your group researches some key information and then teaches it to other people in the class. In this type of activity you also learn from other students.

Your teacher will put you in a 'home' group of four students and give each of you a number.

Once you have your number, find the students in other home groups who have the same number as you. Once you have found one another, you will form a new group called an 'expert' group.

Each expert group is assigned one of the tasks below to become an 'expert' on. Your teacher will allocate you some time to do the research (online or using textbooks) and decide how you will present your findings to others. Use template 1 to record your notes.

At the end of the allotted time, your teacher will ask you to go back to your home group. In the home group, your task is to teach the other members of the group your piece of the 'jigsaw puzzle'. Your home group will use template 2 to make notes.

Expert group tasks

1. Prepare a diagrammatic flowchart of the cell division process of mitosis that WA horticulturists must understand before they can propagate bananas, grapes or mangoes by grafting or tissue culture.

2. Construct a chain of the different careers involved in getting the bananas, grapes or mangoes to a grocery shop.

3. Mangoes can be produced either sexually (by seeds) or asexually (by grafting). Compare the advantages and disadvantages of each method.

4. Both grafting and tissue culture sound like very unnatural processes for producing fruit. Why not just let the bananas, grapes and mangoes grow naturally and pick the fruit when it is ripe? Prepare arguments both for and against these horticulturalist methods.

Acknowledgements

References

Government of Western Australia, Department of Primary Industries and Regional Development, Agriculture and Food available at: https://www.agric.wa.gov.au/

Hartmann HT and Kester DE (1975) *Plant propagation: Principles and practices*, 3rd edn, Prentice Hall, New Jersey.

Fuseschool – Global Education (30 August 2016) 'What is mitosis?' (video) YouTube https://www.youtube.com/watch?v=22V73bs4FAo accessed 8 June 2021

'Plant life' available at: http://lifeofplant.blogspot.com/2011/05/cloning-of-plants.html accessed 8 June 2021

Images

Image 2.3.1: Wine grape propagation in WA image, © Government of Western Australia, DPIRD, available at: https://www.agric.wa.gov.au/wine-grapes/review-five-wine-grape-variety-clones-western-australia accessed 8 June 2021

Image 2.3.2: Banana propagation in WA image, © Government of Western Australia, DPIRD, available at: https://www.agric.wa.gov.au/bananas/propagation-bananas accessed 8 June 2021

Image 2.3.3: Mango propagation in WA image, © Government of Western Australia, DPIRD, available at: https://www.agric.wa.gov.au/mangoes/propagating-mangoes accessed 8 June 2021

Student worksheet 2.4

Cooperative learning jigsaw template 1: Expert group

My expert group's task is …	Key language or vocabulary I need to use to make explanations more scientific includes …	What I learnt and plan to teach about my task is …
Things to find out about the task before I can write about it include …	Methods I might like to use to present my key information when I am teaching it are …	

Cooperative learning jigsaw template 2: Home group

Task 1: Diagrammatic flowchart of the cell division process of **mitosis**	Task 2: Chain of careers involved in getting bananas, grapes or mangoes to a grocery shop
Task 3: Comparison of the advantages and disadvantages of mangoes being produced sexually (by seeds) or asexually (by grafting).	Task 4: Arguments both for and against using horticultural processes such as grafting or tissue culture for producing fruit

Student worksheet 3.1

What's inside?

Western Australia (WA) has extensive seafood species, such as prawns, squid, lobster, fish, oysters and crabs dwelling in the Indian Ocean off our vast coastline.

The wild-catch fishing industry:

- is worth over $500 million annually to the State's economy
- provides employment to thousands of Western Australians in a diverse range of jobs
- is overseen by the Department of Primary Industries and Regional Development (DPIRD) to ensure it is managed sustainably.

In this activity you will get to examine what's inside two of the living things that the WA wild-catch seafood industry produces – squid and fish.

Image 3.1.1: Squid at Calabas Reef

Have you ever eaten squid? They are healthy, tasty and nutritious. In this activity your group will learn how to dissect one.

Before you start, though, ask yourself a few questions:

- Where are the squid's eyes?
- Where is the squid's mouth? Do squid have a stomach like ours?
- 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 us) or gills (like a fish)?

If squid can be seen without a microscope, then they must have millions of cells. This must also mean that squid have organ systems so that they can:

- find, catch and digest food
- reproduce to create more squid
- excrete wastes to their environment
- have a muscular system so that they can move
- breathe oxygen so that their cells can respire.

And so on… Just like any other multicellular animal or plant, squid must have all the systems necessary to carry out the fundamental life processes.

Before you try to answer any of the questions about squid, discuss your ideas with your group and record your ideas in the columns below:

Things we think we already know about squid:	Things we are not sure about squid, and need to find out more about:

Activity 1: Dissecting a squid

Equipment provided by your teacher

Your group will need:

- Squid
- Dissecting tray
- Sharp scissors
- Forceps
- Dissecting probe
- Bowl (or sink) of water
- Protective equipment – latex gloves, mask, goggles, apron
- Steriliser and beaker
- Plastic bag

Safety procedures

When carrying out dissections it is very important to behave in a safe manner:

- Wear your goggles, apron and latex or nitrile gloves when dissecting.
- Keep your hands away from your face and mouth. Never ingest specimen parts or remove them from the classroom.
- Tie back long hair.
- Make sure you carry any sharp instrument (like scissors or scalpel) with the sharp tip facing down and away from your body. Hold the sharp instrument by its handle. When you use the sharp instrument to cut tissue, cut away from your body, never towards yourself.
- Dispose of the specimen in a separate container, according to your teacher's directions.
- Dispose of razor blades or other cutting blades in a separate container, according to your teacher's directions.
- Wash your hands thoroughly with soap or hand sanitiser after dissecting, and sterilise your work area.

Procedure

- Step 1 Gently rinse your squid in the bowl or sink.
- Step 2 Place your squid on the dissecting tray and inspect its **external** anatomy.

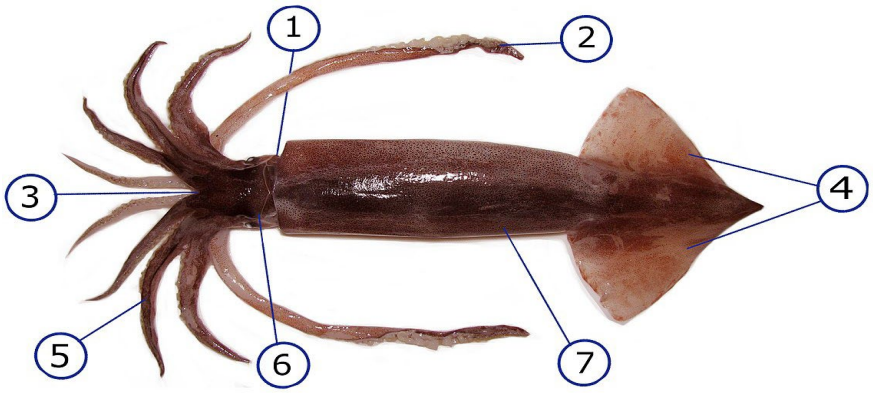


Image 3.1.2: Male squid

Discuss with your group members which labels in the table below probably match the numbers on the picture above. **Describe a** possible function for each external body part.

Body part	Matching number	Possible function
Feeding tentacles (2)		
Eyes (2)		
Arms (8)		
Mantle		
Siphon (water jet)		
Stabilising fins		
Beak		

- Step 3 Check your ideas online at the Museum of New Zealand's website – The anatomy of the colossal squid page and make any necessary adjustments to the table.
- Step 4 Identify the sex of your squid by comparing its two longest tentacles. If each tentacle is the same texture, then it is a female. If one has short bristles or is rougher at the end, then it is a male.

- Step 5 Make a labelled pencil drawing on worksheet 3.2 of the **external** parts of your squid.

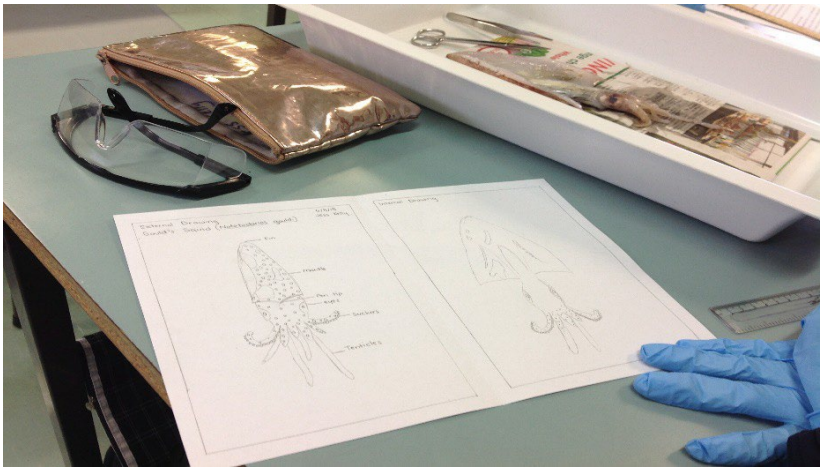


Image 3.1.3: Drawing the squid's external anatomy

Before continuing, watch a video of a squid dissection or access these virtual squid dissection instructions.

Now dissect the mantle to reveal your squid's major organs:

- Step 6 Locate the squid's beak. What do you think this is used for?
- Step 7 Cut the flesh each side of the beak and remove the beak with the forceps.
- Step 8 Open the body and inspect the organs. One organ should be darker and contain ink. What do you think this is useful for?

Image 3.1.4 Squid internal organs

- Step 9 Try to identify as many organs as you can, including eyes, stomach, gills, pen, hearts and siphon.

3.1.5: Examining the squid's organs

- Step 10 Make a labelled pencil drawing on worksheet 3.2 of the **internal** parts of your squid.

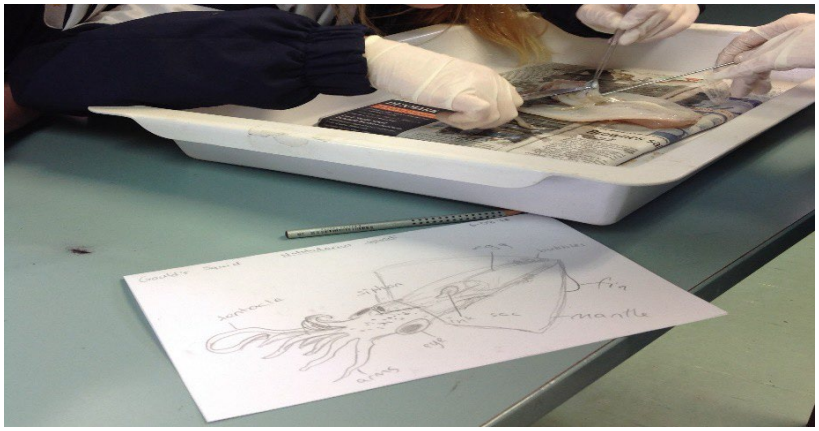


Image 3.1.6: Squid dissection and labelled pencil drawing

- Step 11 Under your teacher's directions, clean up your equipment. Place all used dissecting equipment (pointy ends facing downwards) in the sterilising solution. Wrap the dissected squid parts in newspaper and return to the tray. Wash and sterilise the dissecting tray and your benchtop.

Squid adaptations

Adaptations are genetically inherited features that a living thing possesses to survive and reproduce in its environment.

In your group, compile a list of all the features you think that your squid possesses that could be classed as adaptations. Describe five of them in the table below.

Adaptation	How does it aid the squid's survival?

Activity 2: Dissecting a fish

Now that you have examined what's inside one of the **invertebrate** animals caught as part of WA's extensive wild-catch seafood industry, let's have a look at the most caught **vertebrate** group – fish. A popular commercially fished species is the sea mullet (*Mugil cephalus*).

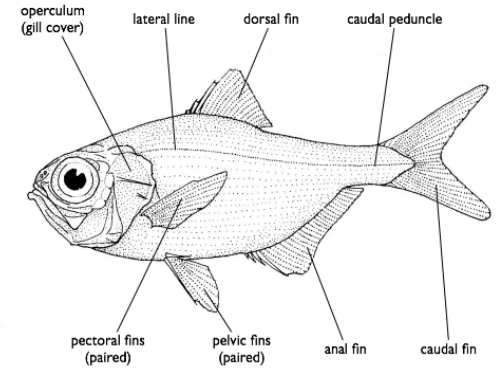


Image 3.1.7: External anatomy features common to bony fish

In your group, discuss the possible function of each of the **external** body parts of the sea mullet. Enter your ideas in the table below.

Body part	Possible function	Additional information
Eyes (2)		
Nostrils (2)		
Mouth		
Operculum (gill cover)		
Pelvic fin		
Lateral line		
Ventral (anal) fin		
Caudal or tail fin		
Second dorsal fin		
First dorsal fin		
Pectoral fin		

When you have finished your list, check your predictions online at the DPIRD Marine Waters website *Fact Sheet: Fish Anatomy.* Go back to your table and correct or add information.

Next your group will carry out a dissection of a sea mullet (or other bony fish).

Equipment provided by your teacher

Your group will need:

- Bony fish (sea mullet or other bony fish, such as whiting, striped trumpeter or herring)
- Dissecting tray
- Dissecting equipment – sharp scissors, scalpel, forceps, dissecting probe, fillet knife
- Bowl (or sink) of water
- Sterilising solution and beaker
- Protective equipment – latex gloves, mask, goggles, apron
- Plastic bag
- 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*
- Newspaper

Safety procedures

When carrying out dissections it is very important to behave in a safe manner:

- Wear your goggles, apron and latex or nitrile gloves when dissecting.
- Keep your hands away from your face and mouth. Never ingest specimen parts or remove them from the classroom.
- Tie back long hair.
- Make sure you carry any sharp instrument (like scissors or scalpel) with the sharp tip facing down and away from your body. Hold the sharp instrument by its handle. When you use the sharp instrument to cut tissue, cut away from your body, never towards yourself.
- Dispose of the specimen in a separate container, according to your teacher's directions.
- Dispose of razor blades or other cutting blades in a separate container, according to your teacher's directions.
- Wash your hands thoroughly with soap or hand sanitiser after dissecting and sterilise your work area.

Procedure

- Step 1 Gently rinse your fish in the bowl or sink.
- Step 2 Place your fish on the dissecting tray and inspect its **external** anatomy. Look for the features that you have already thought about – dorsal fins, lateral line, caudal fin, anal fin, pelvic fin, pectoral fins, operculum, mouth, nostrils and eyes.
- Step 3 Explore the *Poster: Bony Fish – External Anatomy*.
- Step 4 Examine the fish's mouth – does the fish have a tongue? Does this species have teeth? What does this information tell us about the diet of your fish?
- Step 5 Examine the fish's caudal fin. What does its shape tell you about the way your fish moves?
- Step 6 Locate the vent (anus) of the fish (your teacher will show you where it is located). Make a cut, with either a scalpel or a filleting knife, from the anus to near the gills
- Step 7 Pull the adipose (fatty) tissue and gut aside to expose the fish's swim bladder, gonads and kidneys, stomach and intestines.
- Step 8 Explore the *Poster: Bony Fish by referring – Internal Anatomy*.
- Step 9 As a general rule, carnivorous fish have relatively short guts compared with those of herbivorous fish. Examine the gut, and discuss with your group whether you think your fish is likely to be carnivorous or herbivorous.
- Step 10 Identify the reproductive organs (gonads) of your fish. These organs are usually paired. Female gonads are called ovaries and produce eggs. They are pink, red or orange in colour and are covered by numerous blood vessels. Male gonads are called testes and produce sperm. They are usually smoother than female gonads and their colour is a paler/creamier pink.

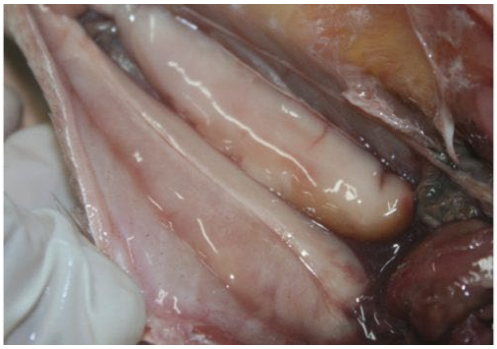


Image 3.1.8: Male fish gonads

Image 3.1.9: Female fish gonads

- Step 11 Examine the swim bladder of your fish. Discuss with your group what you think its function is.
- Step 12 Try to identify your fish's heart. You already know that a heart pumps blood around the body. Discuss with your group whether you think the fish's heart is structured the same as a human heart, and why there may be differences.
- Step 13 Examine the other organs in your fish's gut and see if you can identify the liver, stomach, intestines and kidneys. Think about what these organs do and then check your understanding by referring to the poster.

- Step 14 Find the gills of your fish. These should be behind the operculum. Lift the operculum using forceps, then cut it and remove it. Carefully remove the gills by cutting through the bone at each end of the gill arches. Identify the gill rakers and gill filaments. Place the removed gills into a beaker of water to observe their shape in water. Discuss with your group what the function of the gills and gill rakers are and how the operculum might be involved in helping the gills operate.

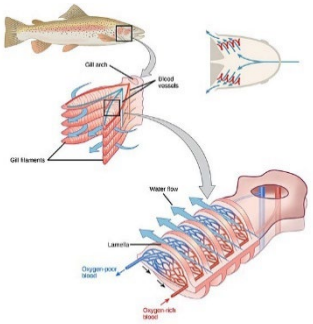


Image 3.1.10: Fish head showing gills and movement of water

- Step 15 Complete the *Student Worksheet: Bony fish anatomy – Whiting species SS*.
- Step 16 Under your teacher's directions, clean up your equipment. Place all used dissecting equipment (pointy ends facing downwards) in the sterilising solution. Wrap the dissected fish parts in newspaper and return it to the tray. Wash and sterilise the dissecting tray and your benchtop.

Complete the following sentences or descriptions during your fish dissection:

1. We think that our fish is more likely to have a diet which is …	5. We think that the fish's heart will be like a human heart in ways such as …
2. We think that the sex of our fish is ...	6. We think that the fish's heart will be different to a human heart in ways such as …
3. We think this because its gonads are …	7. We think that the function of the gills is to …
4. The swim bladder in a fish helps the fish to …	8. The operculum might be involved in helping the gills …

Can fish hear you coming?

Discuss this question in your group.

- When you think you have an answer, read the information and watch the short video embedded in the section called 'Otoliths' in the Marine Waters *Fact Sheet: Fish Anatomy*

Fish adaptations

In your group, compile a list of all the features you think that your fish possesses that could be classed as adaptations. Remember – adaptations are inherited reproduction and survival features. Describe five of them in the table below.

Adaptation	How does it aid the fish's survival and reproduction?

Acknowledgements

References

Biology Corner (N.D) 'Virtual squid dissection' https://www.biologycorner.com/worksheets/squid_virtual.html CC BY-NC-SA 4.0 accessed 8 June 2021

Government of Western Australia, DPIRD Marine Waters website resource, *Fact Sheet: Fish Anatomy* , accessed 8 June 2021

Government of Western Australia, DPIRD Marine Waters website resource, *Poster: Bony Fish – External Anatomy* , accessed 8 June 2021

Government of Western Australia, DPIRD Marine Waters website resource, *Poster Bony Fish – Internal Anatomy* , accessed 8 June 2021

Government of Western Australia, DPIRD Marine Waters website resource, *Student Worksheet: Bony fish anatomy – Whiting species SS* , accessed 8 June 2021

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

Sarah Warren (5 March 2015) 'Squid Dissection Full' (video) YouTube https://www.youtube.com/watch?v=DpcqXivpTnY accessed 8 June 2021

Images

Image 3.1.1: 'Squid at Calabas Reef off the Divi Flamingo hotel pier, Island of Bonaire' by David Burley. Licensed CC BY-SA 1.0, available at <https://commons.wikimedia.org/wiki/File:Bonaire_Squid.jpg>

Image 3.1.2 Male squid – Author almandine Creative Commons Share Alike 3.0, 2.5 Generic, 2.0 Generic, 1.0 Generic, available at: https://commons.wikimedia.org/wiki/File:Calmar1.jpg

Images 3.1.3 to 3.1.6 © Department of Education WA 2020

Image 3.1.7: External anatomy features common to bony fish: https://commons.wikimedia.org/wiki/File:Fish_anatomy_(berycid).png

Image 3.1.8: 'Male fish gonads' © Government of Western Australia, DPIRD Marine Waters available at: <https://marinewaters.fish.wa.gov.au/resource/fish-anatomy/> accessed 8 June 2021

Image 3.1.9: 'Female fish gonads' © Government of Western Australia, DPIRD Marine Waters available at: https://marinewaters.fish.wa.gov.au/resource/fish-anatomy/accessed 8 June 2021

Image 3.1.10: 'Fish head showing gills and movement of water': File:Figure 39 01 04.jpg - Wikimedia Commons accessed 12 November 2021

Student worksheet 3.2

Drawing squid

In the spaces below, create labelled biological drawings (in pencil) of the **external** and **internal** anatomy of your squid.

Squid **external** anatomy	Squid **internal** anatomy

Student worksheet 3.3

From ocean to plate

Careers in Western Australia's wild-catch seafood industry

When you go to your local fish and chip shop next time, you will more than likely buy seafood produced by the wild-catch seafood industry or from aquaculture in Western Australia (WA).

To get these products to your fish and chip shop, many different people are employed in the 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.

Image 3.3.1: A mobile fish and chip wagon

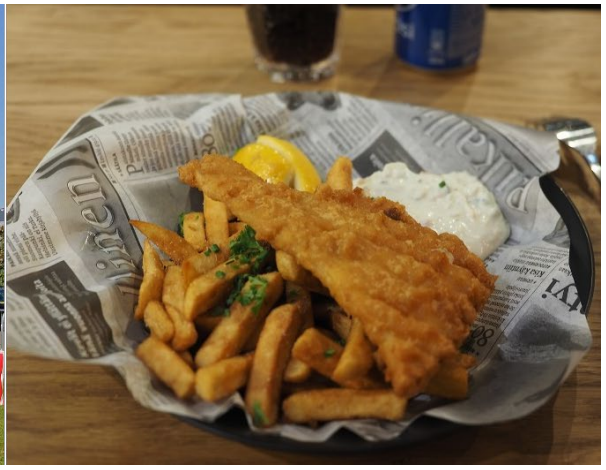


Image 3.3.2: A plate of fish and chips

Cooperative learning jigsaw

This activity (called a jigsaw) is a fun group activity where your group:

- refreshes this information to other people in the class (and learns from other students).

Your teacher will put you in a 'home' group of four students and give each of you a number.

Once you have your number, find the students in other home groups who have the same number as you. Once you have found one another, you will form a new group called an 'expert' group.

Each expert group is assigned one of the career categories:

- catching
- handling and processing
- scientific research and breeding
- advertising and marketing
- safe handling and transportation
- food preparation and retailing.

In your expert group, brainstorm and discover as many careers that fit in your category as you can. Your teacher will allocate you some time to do the research (online or using textbooks) and decide how you will present your findings to others. Use template 1 to record your notes

At the end of the allotted time, your teacher will ask you to go back to your home group. In the home group, your task is to teach the other members of the group your piece of the 'jigsaw puzzle'. Your home group will use template 2 to make notes.

Acknowledgements

Images

Image 3.3.1: 'A mobile fish and chip wagon' by Stefan Schafer, Lich. Licensed CC BY-SA 3.0, available at: <https://commons.wikimedia.org/wiki/File:Mobile_Fish_and_Chips.JPG> accessed 8 June 2021

Image 3.3.2: 'A plate of fish and chips' by JIP. Licensed CC BY-SA 4.0, available at <https://commons.wikimedia.org/wiki/File:Fish_and_chips_in_Kamppi.jpg > accessed 8 June 2021

Student worksheet 3.4

Cooperative learning jigsaw template 1: Expert group

My expert group's task is …	Key language or vocabulary I need to use to make explanations more scientific includes …	What I learnt and plan to teach about my task is …
Things to find out about the task before I can write about it include …	Methods I might like to use to present my key information when I am teaching it are …	

Cooperative learning jigsaw template 2: Home group

WA wild-catch seafood careers in:

Catching	**Handling** and **processing**	**Scientific research** and **breeding**
Advertising and **marketing**	**Safe handling** and **transporting**	**Food preparation** and **retailing**

Student worksheet 4.1.1

Reproduction and life cycles in food and fibre production

To **sustainably** produce the food and fibre that we need, Western Australian (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 may interfere with production.

Asexual vs sexual reproduction

In humans, no two individuals are identical. Even in identical twins, there will always be some differences. This is because humans are the result of **sexual reproduction**, where a sperm from a male and an egg from a female join in a process called **fertilisation**.

The same applies to most animals and many of the plants used by WA primary producers to produce our food and fibre.

There are, however, many organisms that require only a single parent to reproduce. This type of reproduction is called **asexual reproduction**. Asexual reproductive methods are used by many WA primary producers.

Activity 1: Asexual reproduction in agriculture

In plants and fungi, asexual reproduction can occur by **vegetative** reproduction or by **spores**. In your group, research the main methods of vegetative reproduction – online or using your textbook.

Vegetative method	Plants that show this	Notes
Runners		
Stem tubers		
Bulbs		
Underground stems		
Root suckers		
Tap roots		

In your group, examine these images of asexually produced WA primary-industry products.

Image 4.1.1.1: Black truffles

Image 4.1.1.2: Potatoes

Image 4.1.1.3: Cloned blue gum trees

You may need to do some research before you can complete the following sentences as a group.

Even though black truffles and potatoes both reproduce asexually, we think they use different methods of asexual reproduction because …	
We think that blue gum trees produced by asexual **cloning** may have an advantage over sexually produced trees because …	Cloned trees, however, may be at a disadvantage if …

Activity 2: Apple scab – an asexual reproducing fungal disease

Apple scab (or black spot) is caused by the fungus *Venturia inaequalis*. This fungus reproduces asexually by spores.

Image 4.1.1.4: Apple scab disease

Apple scab is a relatively new disease in WA that can have a significant impact on apple production if not managed appropriately. Below is the **life cycle** of the apple scab fungus.

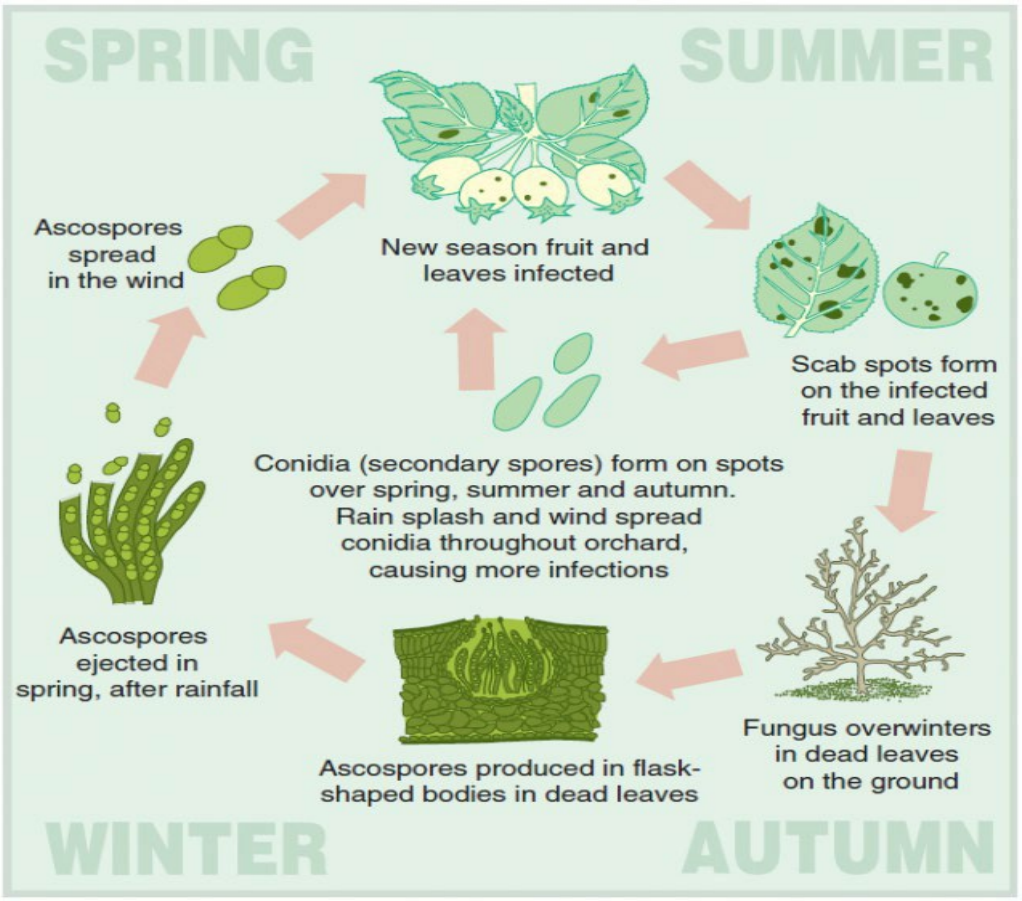


Image 4.1.1.5: The life cycle of apple scab fungus, *Venturia inaequalis*

Why is it important that WA primary producers understand the life cycles of living things?
In your small group, brainstorm some possible answers to this question.

Brainstorm

Next, examine the life cycle diagram of **apple scab**. The fungus has a predictable life cycle. Because of this, apple scab is vulnerable and more easily controlled during different stages of its life cycle. When do you think the fruit grower would best be able to control the apple scab disease?

We think that the spread of apple scab disease is more easily controlled in (the season of): We think this because …

Compare your answers with those of other groups.

Access the Department of Primary Industries and Regional Development (DPIRD) website page on managing apple scab in WA to find out if you were correct.

Successful management of apple scab relies on orchard management practices that target the disease at various stages of its life cycle. Creating conditions unsuitable to development of the disease will lower the need for chemical applications. One such practice is collection and destruction of leaf litter and fallen fruit.

In your group discuss when, why and how collecting and destroying leaf litter and fallen fruit is likely to be effective.

Effectiveness of collecting and destroying leaf litter and fallen fruit	
When most effective	**How** and **why** most effective

Activity 3: Food and fibre careers involving reproduction and life cycles

Many people are employed across WA to prevent or minimise the damaging effects of pests and diseases, such as apple scab, on crops and livestock. Let's examine two such roles.

Biosecurity officers (also known as quarantine inspectors):

- work at checkpoints across WA to prevent unwanted pests, weeds and diseases being brought into the State
- control the movement of agricultural and horticultural produce, and examine incoming and outgoing animals, plants, food, people and machinery
- may screen and inspect mail parcels, baggage, cargo containers and ships entering WA to identify anything that poses a biosecurity risk. These items may be confiscated or destroyed. (Source: Jobs and Skills WA)

Agronomists:

- are scientists who are experts in the use of scientific methods to improve farming
- must have a thorough understanding of the life cycle of the pest organisms or diseases before they can give advice to primary producers

Find out more about the vital:

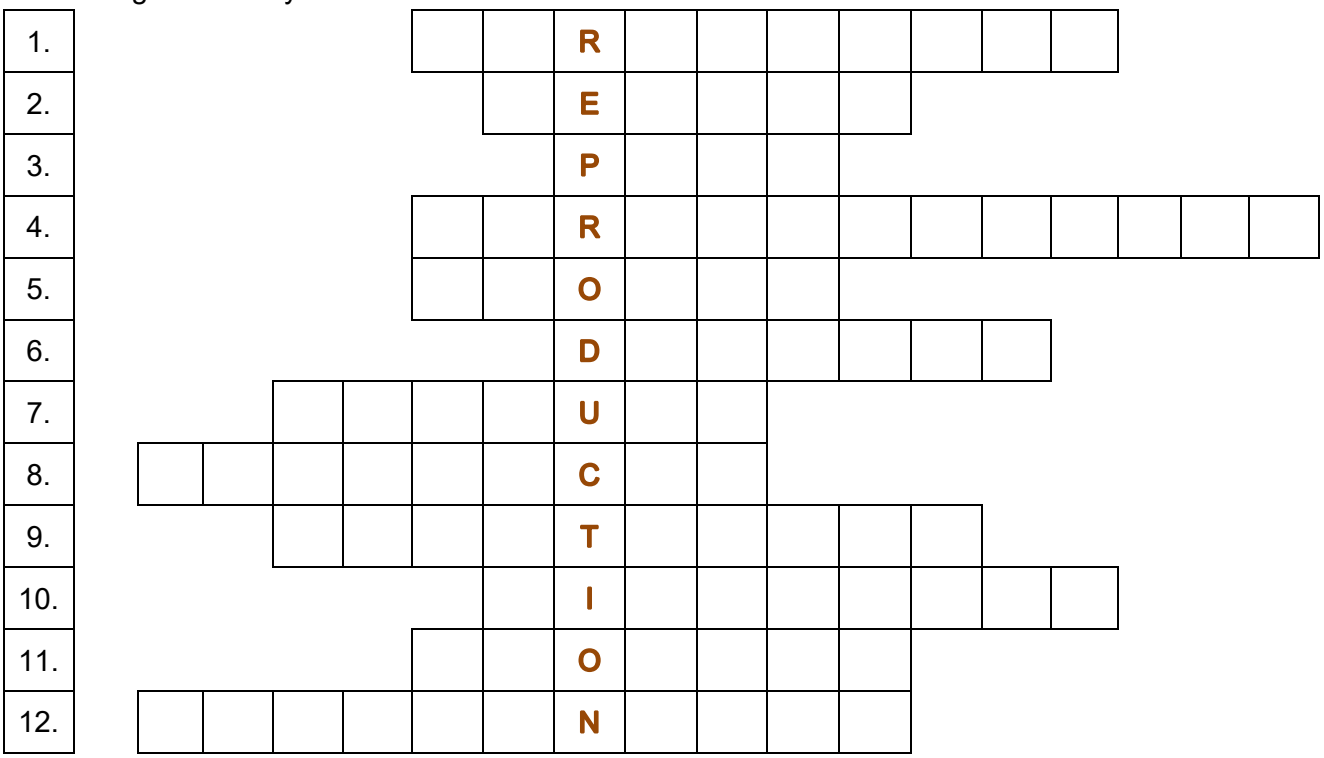
work of biosecurity officers

work of agronomists.

Biosecurity officer	Agronomist
Skills needed to do this job could include …	Skills needed to do this job could include …
Job conditions could include …	Job conditions could include …
Some things I like about this job could be …	Some things I like about this job could be …

Activity 4: Literacy review

Key words and phrases have been **bolded** throughout this worksheet. Use them to complete the following vocabulary exercise.



Clues

1. Scientists who are experts in the use of scientific methods to improve farming
2. Reproduction involving two parents (male and female)
3. Destructive insect or other animal that attacks crops, food, livestock
4. When an egg and a sperm unite
5. Microscopic, single-celled reproductive unit capable of giving rise to a new individual without sexual fusion
6. A disorder of structure or function in animals or plants
7. Reproduction involving only one parent
8. A disease needing management by WA apple producers
9. Reproduction or propagation achieved by asexual means (budding, rhizomes, runners, bulbs, etc.)
10. The series of changes in the life of an organism, including reproduction
11. To make identical copies of an animal or plant
12. Producing food and fibre in ways that avoid the depletion of natural resources to maintain an ecological balance

Acknowledgements

References

Government of Western Australia, Department of Primary Industry and Regional Development, , https://www.agric.wa.gov.au/ >accessed 8 June 2021

Government of Western Australia, DPIRD 'Managing apple scab in Western Australia' <https://agric.wa.gov.au/n/947> accessed 8 June 2021

Government of Western Australia, Department of Training and Workforce Development, https://www.jobsandskills.wa.gov.au/jobs-and-careers/occupations accessed 8 June 2021

Images

Image 4.1.1.1: Black Truffle image © Government of Western Australia, DPIRD available at: https://www.agric.wa.gov.au/new-horticulture-crops/cultivation-black-truffles-western-australia accessed 8 June 2021

Image 4.1.1.2: Potato image © Government of Western Australia, DPIRD available at: https://www.agric.wa.gov.au/potatoes/potato-virus-y-potato-crops accessed 8 June 2021

Image 4.1.1.3: Cloned Blue-gum trees image: Author Johnson waithaka Creative Commons Share Alike 4.0 International available at: https://commons.wikimedia.org/wiki/File:Eucalyptus_trees_in_Njoro_kenya.jpg accessed 8 June 2021

Image 4.1.1.4: Apple scab disease - © Government of Western Australia, DPIRD, image available at: https://www.agric.wa.gov.au/pome-fruit/managing-apple-scab-western-australia accessed 8 June 2021

Image 4.1.1.5: The life cycle of apple scab fungus, *Venturia inaequalis* - © Government of Western Australia, DPIRD, image available at: https://www.agric.wa.gov.au/pome-fruit/managing-apple-scab-western-australia?page=0%2C1#smartpaging_toc_p1_s0_h2 accessed 8 June 2021

Student worksheet 4.1.2

Sexual reproduction and life cycles

Activity 1: Sexual reproduction in Western Australian agriculture

Most living things used or produced by primary producers in Western Australia (WA) reproduce sexually.

Image 4.1.2.1: Ewes and lambs

Image 4.2.1.2: WA dairy cattle

Examine the images of sheep and dairy cattle produced by WA primary producers. In your group, discuss how you think the life cycles of sheep and dairy cattle might be both similar and different.

Similarities	Differences

Activity 2: A sheep's life cycle

Sheep have been domesticated as farm animals for nearly 15,000 years. Like all other animals, sheep have a life cycle: changes they go through over the course of their lives.

The life expectancy of a domesticated sheep is about 10 to 12 years. Very much like humans, sheep go through basic stages in their lives.

Young sheep are called **lambs**. The baby lamb develops and grows inside its mother for approximately four months until it is born. After they are born, lambs live on their mother's milk for food until their 'adolescence'. The Department of Primary Industries and Regional Development (DPIRD) advises WA sheep farmers that a lamb should be weaned (withdrawn from its mother's milk) 12 weeks from the start of lambing – sooner if the season has been poor. Weaning at this time will help with the ewe's recovery and allow her to get back into shape before next year's mating. It is essential to provide weaning lambs adequate nutrition to meet their growing needs. Feeding the ewes while they have lambs at foot is a great way to 'imprint feed' the lambs. This means that they will learn to feed like their mothers do, and will take to grain/pellets easily and quickly at weaning.

Once a young sheep is old enough to reproduce, it is considered an 'adult' and can also produce wool and milk. A grown female sheep (called a **ewe)** only produces young for about seven years.

Ewes become pregnant from one **ram** (male sheep). The ram tends the whole flock. Ewes usually give birth to one lamb or twins. When a lamb is born, it will try to stand and walk within 30 minutes and soon begins nursing from the mother's first milk. This first milk, called **colostrum**, has extra nutrients and helps to grow a very healthy lamb.

Use the description of a sheep life cycle above to create a labelled, annotated drawing showing the various stages of a sheep's life cycle. Draw your life cycle on the following page.

Small group research jigsaw

Your teacher will ask you, in your small groups, to research one of the following sexually reproducing farm animal or plant life cycles. You will be given some time to research and make an annotated drawing of your life cycle.

Access these websites as part of your research:

- Life cycle of chickens (poultry)
- Life cycle of wheat.

After your allocated time, you need to split up and find other people to trade information with about the other farm animal or plant.

Farm animal and plant life cycles annotated diagrams

Sheep life cycle

Chicken life cycle

Wheat life cycle

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

Why do you think it would be essential for WA primary producers to know about the life cycle of their animals and plants? Discuss this question in your group and record your initial ideas below.

Initial ideas:

Now let's look at a specific WA example – dairy cattle. The WA dairy industry is located in the far south-west of the state, mainly along the west coast between Perth and Albany. Some 160 dairy farms produce about 350 million litres of milk each year, much of which is consumed locally as either fresh milk or short shelf-life products. Despite its relatively small size, WA's dairy industry is reputed for its innovation and high-quality products.

Before you can really answer the question of why it would be important for dairy producers to understand the life cycle of their cattle, you need to know more about how dairy cows are bred to produce milk by WA primary producers: watch the When do cows make milk [video], by Dairy Australia .

Bannister Downs Dairy is one example of a WA dairy producer that uses knowledge of a dairy cow's life cycle to produce its milk. This extract is from the Bannister Downs Dairy website:

Our calves all remain with their mothers for a minimum of 48 hours, so they receive a good feed of colostrum, before their mums head off to be part of the dairy herd.

Similar to other cows, a Jersey cow will be first mated when she is around 16–18 months old. This will be followed by a 9-month gestation period, after which she has her first calf.
A cow's milking life begins once she has calved. At approximately 65 days she will be mated again. Cows will typically milk for around 9–10 months of the year, with 2–3 months being a restful dry period. Most cows will continue this life cycle for many years. At Bannister Downs our oldest Jersey cow, Mrs Grey, is 18 years old and we have just retired her on the farm."

Write a paragraph below on why you now think it would it be useful for a WA dairy farmer to know about the life cycle of their dairy cattle:

Group brainstorm – life cycle of a dairy cow

Now that you have more information about dairy cattle, in the space below create an annotated life cycle diagram of a dairy cow.

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

Image 4.1.2.3: Viticulture research officer

Use these websites to find out more about research science careers in WA primary industry involving reproduction and life cycles and then complete the table below:

- Role of the agricultural scientist
- Role of the agricultural technical officer.

Agricultural scientist	Agricultural technical officer
Skills needed to do this job could include …	Skills needed to do this job could include …
Day-to-day tasks could include …	Day-to-day tasks could include …
Some things I like about this job include …	Some things I like about this job include …

Acknowledgements

References

Bannister Downs Dairy, https://bannisterdowns.com.au/ accessed 8 June 2021

Career Harvest https://www.careerharvest.com.au/ accessed 8 June 2021

Dairy Australia – Discover Dairy (11 December 2018) 'When do cows make milk?' (video) YouTube https://www.youtube.com/watch?v=sBPIfb9W3K4 accessed 8 June 2021

Government of Western Australia, DPIRD, available at: https://www.agric.wa.gov.au/ accessed 8 June 2021

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

Kassandra Smith, Chicken Life Cycle (backyardchickencoops.com.au) accessed 8 June 2021

What Are the Six Stages of the Life Cycle of a Wheat Plant? (sciencing.com) accessed 8 June 2021

Images

Images 4.1.2.1: Ewes and lambs image © Government of Western Australia, DPIRD available at: https://www.agric.wa.gov.au/livestock-biosecurity/pregnancy-toxaemia-and-hypocalcaemia-ewes accessed 8 June 2021

Image 4.2.1.2: WA dairy cattle image © Government of Western Australia, DPIRD available at: https://www.agric.wa.gov.au/feeding-nutrition/selenium-deficiency-cattle accessed 8 June 2021

Image 4.1.2.3: Viticulture research officer image (© 2020, Government of Western Australia, DPIRD) available at: https://www.agric.wa.gov.au/biosecurity-quarantine/careers-food-and-fibre?page=0%2C1#smartpaging_toc_p1_s0_h2 accessed 8 June 2021

Student worksheet 4.1.3

Comparing reproductive systems

Most plants and animals produced by primary producers in Western Australia (WA) reproduce sexually. Sexual reproduction requires cells from a male and a female to come together for fertilisation to occur.

A typical flowering plant

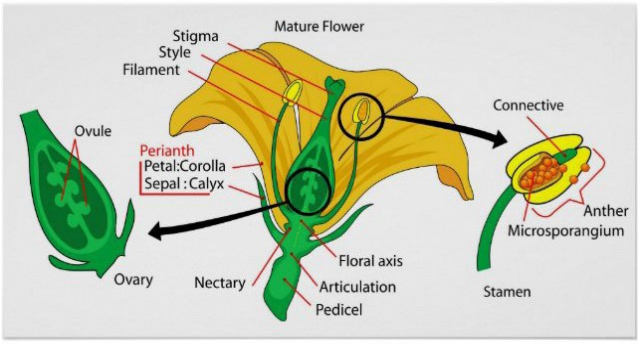


Image 4.1.3.1: Mature flower diagram

Dissect a typical flower

A flower is the principal reproductive organ of flowering plants. The flower usually (but not always) contains both male and female parts. Use these online resources to find out how to dissect and examine the function of some of the key parts of a typical flower:

- Flower dissection! instructions
- Flower dissection – STEM activity video.

Your teacher will supply you with a range of flowers, a magnifying glass and a single-sided razor blade. Once you have dissected your flower, fill out the table below.

Flower part	Role in reproduction
Stamen	
Anther	
Filament	
Stigma	
Style	
Ovary	
Sepals	
Petals	

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

Humans: a typical animal

Humans are typical of most animals in that our reproductive systems are separated in male and females.

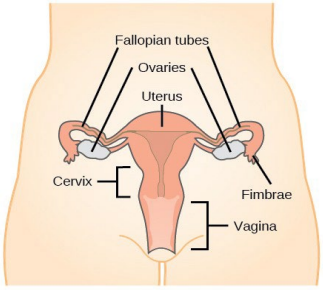


Image 4.1.3.2: Female reproductive anatomy

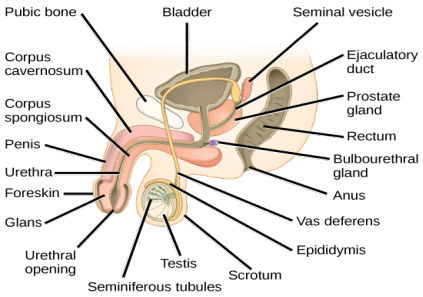


Image 4.1.3.3: Male reproductive anatomy

Use the online information on male and female reproductive systems to complete this table.

Part	Role in reproduction
Ovaries	
Fallopian tubes	
Uterus	
Cervix	
Vagina	
Testes	
Penis	
Vas deferens	
Gamete	

Acknowledgements

References

Instructables workshop 'Flower Dissection!' available at: https://www.instructables.com/Flower-Dissection/ accessed 8 June 2021

Science Buddies (3 May 2019) 'Dissecting Flowers' (video) YouTube: Flower Dissection – STEM Activity – YouTube accessed 8 June 2021

Kahn Academy "The reproductive system review' available at: https://www.khanacademy.org/science/high-school-biology/hs-human-body-systems/hs-the-reproductive-system/a/hs-the-reproductive-system-review accessed 8 June 2921

Images

Image 4.1.3.1: 'Mature flower diagram' svg @ Wikimedia commons repository, CC BY-SA 3.0 available at: https://commons.wikimedia.org/wiki/File:Mature_flower_diagram.ml.svg accessed 8 June 2021

Image 4.1.3.2: Female reproductive anatomy and Image 4.1.3.3: Male reproductive anatomy from *OpenStax*, CC BY 4.0 available at: https://openstax.org/books/concepts-biology/pages/18-3-human-reproduction accessed 8 June 2021

Student worksheet 4.1.4

Honeybees – an 'alternative' life cycle

Honey producers are called **apiarists**. The Department of Primary Industries and Regional Development (DPIRD) assists apiarists in Western Australia (WA) by ensuring apiary products are clean, safe and free from chemical contamination. There is a strong focus on research in honeybee nutrition, life cycles and queen-bee breeding.

Image 4.1.4.1: WA apiarist

The life cycle of bees is more complicated than many other animal life cycles. Honeybees rely on an important social structure that is:

- highly organised
- self-replenishing
- unique.

The colony itself, taking up residence in the hive and journeying for food and water, consists of three types (or castes) of honeybee:

- queen bees (egg producers)
- worker bees (infertile females)
- drones (males whose purpose is to find and mate with a queen bee).

These three castes form an integral system (or superorganism) where different bees take on different roles for the colony to thrive.

Apiarists must understand this life cycle thoroughly to maximise their production of honey and other products.

Watch the honeybee lifecycle [video].

Small group task

In your group, prepare an **annotated poster** of the life cycle of the honeybee, including the roles played by all the different castes of bees (queen bees, worker bees and drones). Your teacher will supply some poster paper for your group to use.

Extension: Biosecurity in the WA honey industry

WA honey is among the best in the world. The industry is notable for its freedom from important bee diseases and its exportation of bees to countries such as Canada each year.

The protection of our economy, environment and health by preventing the outbreak of exotic animal and plant pests and diseases is known as **biosecurity**.

Biosecurity also includes the eradication or control of those pests and diseases already present. Increasing standards of biosecurity are necessary to maintain market access and market competitiveness for agricultural products. Apiarists must adopt measures to:

- minimise the entry and spread of harmful diseases or pests into their apiaries
- help safeguard their businesses.

Image 4.1.4.2: Healthy bee brood

WA honeybee pests, diseases and biosecurity

In your small group, explore the information about bees on the DPIRD website.

Using the title 'WA honeybee pests, diseases and biosecurity', prepare a **presentation** to the class on the following pests and diseases of WA's honey industry. Be imaginative – your presentation could be in the form of a pamphlet, a short script for a play, a stop motion video/animation, a PowerPoint presentation, a poster or a flip book.

Pests and diseases:

- Small hive beetle
- European foulbrood disease
- American foulbrood disease
- Sacbrood disease
- Varroa mite

Image 4.1.1.3: Small hive beetle

Acknowledgements

Images and information courtesy of DPIRD <https://www.agric.wa.gov.au/>

Delci (28 August 2019) 'Honey Bee Lifecycle (video) YouTube available at: https://www.youtube.com/watch?v=q_xbT65GzDo accessed 8 June 2021

Student worksheet 4.2.1

The black soldier fly

In summertime aren't flies just so annoying?! They swarm over our food and buzz around our faces when we're outside. They also spread disease. Some types of fly even attack our fruit while it's still on the tree – making it inedible. Shouldn't we eliminate flies?

Image 4.2.1.1: Queensland fruit fly

Have you ever thought, though, that flies could be incredibly useful? What if we could get them to do good things for us, like turning our rotting food scraps into useful products? There is a business partnership in Western Australia (WA) servicing primary industry where this is becoming a reality.

Black soldier flies (*Hermetia illucens*) are:

- black and approximately 15 mm long (they look like a small black wasp)
- an introduced species in WA, but now occur worldwide.

Image 4.2.1.2: Black soldier fly

Image 4.2.1.3: Black soldier fly larvae

Black soldier fly larvae (BSFL) can be used to compost waste or convert the waste into animal feed. Fly larvae are among the most efficient animals at converting feed into biomass.

Life cycle of the black soldier fly

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). Use the description to draw an annotated life cycle of the black soldier fly. Make sure that you include and understand key terms such as: mating, eggs, larvae, instar, pupae and adult.

Life cycle of the black soldier fly (*Hermetia illucens*)

Insects such as the black soldier fly undergo what is called a **metamorphosis**.

In your group, discuss what you think metamorphosis means. There are other types of animals that also go through this process, can you name any? Enter your ideas in the space below.

Our group thinks that a metamorphosis is …	Other organisms that might go through metamorphosis are …

Check your ideas are correct by following the link: metamorphosis.

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

To answer this question, read the section 'Human relevance and use' on the Wikipedia page about the black solider fly. Use the space below to summarise:

1. which stages of the black soldier fly life cycle can be used to produce various useful products
2. why the adult flies don't become pests like other flies.

Image 4.2.1.4: Wax and soap produced by Future Green Solutions

1. Stages of the black soldier fly life cycle that can be used to produce various useful products:

2. Why don't the adult flies become pests like other flies?

Black soldier fly farming in WA – Future Green Solutions

Now that you have some understanding of how useful the black soldier fly can be, let's examine how a local WA company, Future Green Solutions, is using the fly to deal with a big issue in aquaculture (the breeding, rearing, and harvesting of fish, shellfish, algae, and other organisms in a water environment).

Its black soldier fly farm system uses organic waste to produce larvae to feed fish in aquaculture farms instead of fishmeal. It is currently running a long-term trial on barramundi and rainbow trout diets.

"Australia imports large amounts of fishmeal every year. In aquaculture, this means we take about 10 tonnes of fish out of the ocean to produce about one tonne of a carnivorous species. So this makes it environmentally better," said Dr Craig Lawrence, Department of Fisheries.

Image 4.2.1.5: Environmental scientist Luke Wheat, one of the founding directors of Future Green Solutions

The initial trial was conducted in partnership with the University of Western Australia. Various other organisations, including DPIRD are also part of the partnership.

The soldier fly farm system:

1. converts household food and farm waste into feed for the black soldier fly larvae. This reduces waste to landfill and ongoing greenhouse gases from that waste in landfill
2. produces larvae as an alternative to fishmeal and fish oil. This dramatically reduces reliance on wild-caught fish. And for food security, it allows the production of aquaculture from a sustainable protein source.

Research task

Research and write a summary of how the farming of the black soldier fly could contribute to creating more sustainable aquaculture and farm waste management systems in WA (and around the world).


Images 4.2.1.6 and 4.2.1.7: Rainbow trout at Future Green Solutions' research facility

Use these online resources to help with your research:

- ABC News article: 'Fish feed study finds insects could improve aquaculture's environmental sustainability'
- Future Green Solutions webpage: Closing the loop: Black Soldier Fly technology to convert agricultural waste into high quality fertilisers and soil improvers

Do you want to make a difference? Why not look at a career in sustainable agriculture?

Future Green Solutions' work is just one way of making our food and fibre production more sustainable.

Watch the following ABC Education videos. Then, in your group, brainstorm all the careers that people can pursue to make agriculture more sustainable.

- Sustainable fish farming
- Sustainable food farming that uses solar power
- A sustainable vineyard – with sheep!
- From the garden to the plate

Practical extension project: Making your own black soldier fly farm

This is a fun and relatively easy way to sustainably dispose of your vegetable food scraps.

You can build a purpose-built black soldier fly farm to encourage the fly to lay eggs in your food scrap container or compost.

The flies and larvae are more likely to occur in the warmer weather. They are eating machines – turning scraps into compost much more rapidly than worms. They are good to have in your compost and can process (eat!) large amounts of scraps very quickly.

Images 4.2.1.8: Black soldier fly

Image 4.2.1.9: Feeding the black soldier fly larvae

Find out how to build a black soldier fly farm using instructions and the video on the ABC Gardening Australia website.

Acknowledgements

References

ABC Education (14 August 2018) 'Sustainable fish farming' (video) available at: https://education.abc.net.au/home - !/media/3023654/sustainable-fish-farming accessed 9 June 2021

ABC Education (2020) 'Sustainable farming that uses solar power' (video) available at: https://www.abc.net.au/news/2018-09-13/aquaculture-industry-expert-say-insect-fish-feed-more-efficient/10231032?section=good-news accessed 9 June 2021

ABC Education (01 February 2013) 'A sustainable vineyard – with sheep!" (video) available at: https://education.abc.net.au/home - !/media/153078/a-sustaEducation.%20inable-vineyard-with-sheep- accessed 9 June 2021

ABC Education (01 February 2013) 'From the garden to the plate' (video) available at: https://education.abc.net.au/home - !/media/152946/from-the-garden-to-the-plate accessed 9 June 2021

ABC Gardening Australia Fact Sheet (Series 30, episode 19) ' Love your larvae' available at: https://www.abc.net.au/gardening/factsheets/love-your-larvae/11184864 accessed 9 June 2021

ABC News (13 September 2018) ' Fish feed study finds insects could improve aquaculture's environmental sustainability' available athttps://www.abc.net.au/news/2018-09-13/aquaculture-industry-expert-say-insect-fish-feed-more-efficient/10231032?section=good-news accessed 9 June 2021

Future Green Solutions 'Closing the loop: Black soldier fly technology to convert agricultural waste ito high quality fertilisers and soil improvers' available at: https://www.futuregreensolutions.com.au/closing-the-loop-black-soldier-fly-technology-to-convert-agricultural-waste-into-high-quality-fertilisers-and-soil-improvers/ accessed 9 June 2021

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

University of Florida, Featured Creatures 'Black soldier fly – *Hermetia illucens*' available at: https://entnemdept.ufl.edu/creatures/livestock/black_soldier_fly.htm accessed 9 June 2021

Wikipedia '*Hermetia illucens*' available at: https://en.wikipedia.org/wiki/Hermetia_illucens accessed 9 June 2021

Images

Image 4.2.1.1: Queensland fruit fly © Government of Western Australia, DPIRD available at: https://www.agric.wa.gov.au/plant-biosecurity/biosecurity-alerts-queensland-fruit-fly-updates accessed 9 June 2021

Image 4.2.1.2: Black soldier fly Beatriz Moisset CC BY-SA 4.0International available at: https://commons.wikimedia.org/wiki/File:Hermetia_illucens._Black_Soldier_Fly.jpg accessed 9 June 2021

Image 4.2.1.3: Black soldier fly larvae image © Department of Education WA 2021

Images 4.2.1.4 to 4.2.1.9 courtesy of Future Green Solutions available at: https://www.futuregreensolutions.com.au/about-us/

Student worksheet 4.2.2

Black soldier fly investigation

Purpose

Your group will be carrying out a scientific investigation of a question or problem you have designed using live black soldier fly larvae and other equipment supplied by your teacher.

Image 4.2.2.1 Black soldier fly larvae

Procedure

In this investigation you have the opportunity to think and work like a scientist. Your teacher will give you:

- a list of available equipment that you can use
- worksheet 4.2.3 – a framework to assist you with the different stages of the investigation.

When investigating a scientific question or problem, scientists go through a set of logical stages. These are summarised below.

Stage 1 Questioning and predicting	Identify a question or problem that can be investigated scientifically Make predictions based on scientific knowledge
Stage 2 Planning and conducting	Plan a group or individual investigation to explore your question or problem Measure and control variables using appropriate equipment Collect data accurately
Stage 3 Processing and analysing data and information	Use graphs, keys and models to display your data Analyse the data, looking for patterns and relationships Use scientific understanding to identify relationships and draw conclusions
Stage 4 Evaluating	Reflect on the quality of the investigation and data collected Suggest improvements Use scientific knowledge to evaluate claims based on evidence
Stage 5 Communicating	Communicate your ideas and findings using scientific language

Questions or problems about the larvae that could be investigated scientifically

Identifying a question or problem that can be investigated scientifically involves considering a range of different factors (variables) that might influence the outcome you are looking for. These could include variables such as:

- the performance (growth, time to maturity, feed conversion efficiency) of larvae on different waste substrates
- environmental factors like humidity, temperature, amount of light, oxygen availability and the overall moisture.

An example of a typical research question might be:

What is the optimal (best) temperature for black soldier fly larvae to convert household waste most efficiently?

In your small group:

1. Brainstorm some ideas and try to formulate a question to research scientifically.
2. Enter your research question on worksheet 4.2.3.
3. Begin your investigation.

Extension activity: Building numeracy skills

Research scientists need to be able to perform mathematical calculations on the data they are collecting to establish whether the hypotheses they are investigating are supported or disproved.

One of the tasks that researchers at Future Green Solutions do is estimate the density and total number of black soldier fly larvae in one of their large growth containers (capacity 500 litres). It would be almost impossible to count the total number of larvae present, so the researchers:

- take a sample from the container
- count the larvae in the sample
- calculate the density and estimated total from this sample.

If a 10 mL sample of larvae was taken from the 500 L container and contained 200 larvae, **calculate** (show your working):

1. the density of the larvae (larvae per litre):

2. the estimated total number of larvae in the 500 litre growth container:

Acknowledgements

Image 4.2.2.1: Black soldier fly larvae courtesy of Future Green Solutions, available at: https://www.futuregreensolutions.com.au/product/live-bsf-larvae-40-00/ accessed 9 June 2021

Student worksheet 4.2.3

Group investigation framework

Black soldier fly investigation

Stage 1: Questioning and predicting

What **research question** or **problem** about black soldier flies is your group planning toinvestigate?

What does your group **already know** about this topic from your personal experience and studies?

Predict what you think will be the outcome of your investigation into black soldier flies. Include your reasoning.

Stage 2: Planning and conducting

What **variables** may affect what your group is investigating about black soldier flies? Have you considered both **biotic** (living) and **abiotic** (non-living) factors?

What is the **independent variable** in this investigation about black soldier flies? (The factor that you are going to make different.)

What is the **dependent variable** in this investigation about black soldier flies? (The factor you are looking for as your result.) How will you **accurately measure** the dependent variable?

What variables in your black soldier fly investigation must be **controlled** to make it a **fair test**?

What **equipment** will your group need to carry out your investigation?

Describe in a set of **steps** what your group will be doing at each stage of your investigation. Include a **labelled diagram** to illustrate your set-up.

What **special safety precautions** do you need to follow during your investigation? Why are these safety precautions important?

Stage 3: Processing and analysing data and information

What **data** did your investigation produce? Describe your **observations** and record your **results**. If possible, organise your data for the different factors you tested into a **table** format.

Is it possible to represent your data in a **graph**? If so, what **type of graph** would best suit this type of data? Construct your graph on a separate piece of graph paper and paste it here.

What are the **relationships, patterns or trends** in your group's black soldier fly data?

What do the results of your group investigation tell you about the **research question** or **problem** you were investigating? Try to use some science ideas to **explain** your results.

Did your results match your group predictions? Explain.

Stage 4: Evaluating

What **difficulties** did your group experience in doing your investigation?

Does your group have confidence in the **quality of the data** it has produced? (Are you confident your data is **valid** and **reliable**?)

What **changes** would your group put in place if you did this investigation again or carried out further investigations into black soldier flies?

Stage 5: Communicating

Discuss with your group the best way of communicating the findings of your investigation to the other members of your class. Some suggestions you might like to consider are a science report, a PowerPoint presentation, a poster, a leaflet or a short video. Use the space below to plan.

Student worksheet 4.3.1

Specialised cells, tissues and systems

Most of the animals and plants that primary producers in Western Australia (WA) farm (eg sheep, cows, chicken, wheat and canola) are **multicellular** organisms.

In multicellular organisms, all the cells work together, but they do not all work to do the same thing. Cells are **specialised**. This means that they have a special job to do in the body. Their cell structures have **evolved** to carry out their job more efficiently.

In this case study, we will examine some specialised plant and animal cells and how they are **adapted** to specific functions.

Lupins in WA farming

Narrow-leafed lupins are a grain **legume** crop specifically developed for the deep, sandy, acidic soils of WA. Lupins are a critical component of a uniquely Western Australian farming system, the wheat–lupin **crop rotation**.

Grain legumes have played an important part in WA agriculture. As part of a rotation, they provide both an economic yield to the farmer and a break in weed/disease cycles. They make an important contribution to the **nitrogen** balance of the cropping system by biologically capturing or 'fixing' nitrogen from the atmosphere and converting it into nitrogen compounds (eg ammonia, nitrates) for the plant.

Nitrogen is an important building block of protein. Crops like lupins, that can capture nitrogen, will contribute to soil nitrogen **fertiliser** and have a high **protein** content

Image 4.3.1.1 Narrow-leafed lupin crop at flowering

Image 4.3.1.2 Lupin pods

In your group, discuss why you think it might be important for farmers, particularly in WA, to consider growing lupins as a rotational crop.

We think it might be beneficial for farmers to grow lupins because …

Activity 1: Exploring nitrogen fixation

For lupins to capture 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**.

Image 4.3.1.3 Nitrogen fixing nodules in legumes

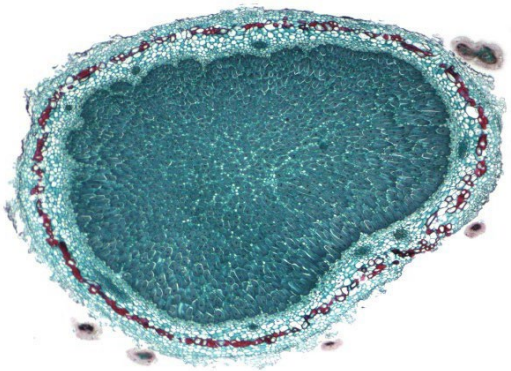


Image 4.3.1.4 Root tubercle legume

1. Watch the Nitrogen fixation – Seven wonders of the microbe world [video].
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. Use diagrams to illustrate your description.

Activity 2: Key vocabulary concept map

Throughout this case study about specialised cells, tissues and systems, key words or phrases have been **bolded** because they are important to understand.

multicellular, specialised, evolved, adapted, legume, crop rotation,nitrogen, fertiliser, protein,

In the space below construct a **concept map** which links all these key words or phrases.

Acknowledgements

References

Government of Western Australia, DPIRD, 'Lupin in Western Australian farming' available at: https://www.agric.wa.gov.au/lupins/lupin-western-australian-farming accessed 9 June 2021

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

Images

Images 4.3.1.1 and 4.3.1.2 © DPIRD images available at <https://www.agric.wa.gov.au/lupins/lupin-western-australian-farming> accessed 9 June 2021

Image 4.3.1.3: 'Nitrogen-fixing nodules in the roots of legumes' by Terraprima. Licensed CC BY-SA 3.0, available at <https://commons.wikimedia.org/wiki/File:Nitrogen-fixing_nodules_in_the_roots_of_legumes..JPG> accessed 9 June 2021

Image 4.3.1.4: 'Root tubercle legume' by Jon Houseman. Licensed CC BY-SA 4.0, available at <https://commons.wikimedia.org/wiki/File:Root_tubercle_legume.jpg> accessed 9 June 2021

Student worksheet 4.3.2

Comparing digestive systems of ruminants and humans

The Western Australian beef herd consists of approximately two million head:

- half of which range free on extensive pastoral stations in the northern rangelands
- the remainder roam the lush pastures of the agricultural region of the south and south-west.

The gross value of beef production in Western Australia (WA) is estimated at $517 million annually.

Have you ever considered how difficult it must be to live on a diet of grass?

Livestock such as beef cattle, sheep, buffalo, goats, deer and camels have a highly specialised digestive system. Their fore stomach (or **rumen**) contains **microbes** which aid in the digestion process. For this reason, these animals are called **ruminants**.

Activity 1: Digestion in ruminants

Watch the Why can't you digest grass? [video], which compares human and ruminant digestive systems.

Sheep: another ruminant

When you compare the body system of a human with that of an animal (such as a sheep used by WA primary producers), you find there are many similarities and differences.

These similarities and differences are almost always related to how an animal has evolved to obtain and use energy. For example, the similarities and differences in digestive systems are all related to eating a certain diet:

- A sheep is **herbivorous** – eating mainly grass or grain.
- A human is **omnivorous** – adapted to eating both animal and plant material.
- Other animals (eg dogs) are classified as **carnivorous** because their diet is almost exclusively meat.

Let's compare the digestive systems of a human and a ruminant in more detail.

Procedure

1. In your group, read the factsheet Sheep – The wool producers from the Learn About Wool website.
2. Use the information on the factsheet to build a scale model of a sheep (ruminant) digestive system, using coloured modelling clay, toothpicks and sticky notes for labelling and describing the function of the key parts:
    - Mouth
    - Oesophagus
    - Rumen
    - Reticulum
    - Omasum
    - Abomasum
    - Intestine
    - Anus

3. Consider the following questions and record your group ideas:
   - 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?

We think sheep only have incisor teeth on their bottom jaw because …	Sheep need to 'chew their cud' so that they can …
Bacteria in the rumen …	Methane is produced in the …. It can become be an environmental problem because …

Brainstorm: Reducing livestock greenhouse gas emissions

In Australia, direct livestock methane gas emissions account for about:

- 70% of **greenhouse gas** emissions by the agricultural sector
- 11% of total national greenhouse gas emissions.

How do you think we can address this problem? Brainstorm ideas in your group.

We think that we might be able to reduce greenhouse gas emissions from WA farm animals by …

When you have finished your brainstorm:

1. read the Reducing livestock greenhouse gas emissions page on the DPIRD website
2. add extra ideas to your brainstorm box.

How do humans compare?

In your group, use the internet to research the key differences between ruminant and human digestive systems.

Use a table to order the information you discover.

After you have gathered your information, use your table to prepare either a PowerPoint presentation or an infographic to present it to other members of the class.

Activity 2: Key vocabulary concept map

Throughout this case study about specialised cells, tissues and systems, key words or phrases have been **bolded** because they are important to understand.

microbes, ruminants, herbivorous, omnivorous,carnivorous,

In the space below, construct a **concept map** which links all these key words or phrases.

Acknowledgements

References

Government of Western Australia, DPIRD, 'Beef cattle', available at: https://www.agric.wa.gov.au/livestock-animals/livestock-species/beef-cattle accessed 9 June 2021

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

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

SciShow (10 September 2016) 'Why can't you digest grass?' (video) YouTube available at: https://www.youtube.com/watch?v=9-z-0f5GnSs accessed 9 June 2021

Student worksheet 4.3.3

Careers involving knowledge of specialised cells, tissues and systems

Image 4.3.3.1 Careers in food and fibre - Grower Group Network Project Officer

Discover more about careers as a botanist, agricultural veterinarian and Jackaroo/Jillaroo on the Department of Primary Industries and Regional Development (DPIRD) website. These are all careers in the food and fibre industry.

The Career Harvest website has further details:

- Botanist
- Agricultural veterinarian
- Jackaroo/Jillaroo

Use the information to complete the table.

Botanist	Agricultural veterinarian	Jackaroo/Jillaroo
Skills needed to do this job include …	Skills needed to do this job include …	Skills needed to do this job include …
Job conditions could include …	Job conditions could include …	Job conditions could include …
Some things I might like about this job include …	Some things I might like about this job include …	Some things I might like about this job include …

Acknowledgements

References

Government of Western Australia, DPIRD, 'Careers in food and fibre' available at: https://www.agric.wa.gov.au/biosecurity-quarantine/careers-food-and-fibre accessed 9 June 2021

Career Harvest – A project of the Primary Industry Education Foundation, available at: https://www.careerharvest.com.au/ accessed 9 June 2021

Images

Image 4.3.3.1 Government of Western Australia, DPIRD, 'Careers in food and fibre – Grower Group Network Project Officer', available at: https://www.agric.wa.gov.au/biosecurity-quarantine/careers-food-and-fibre accessed 9 June 2021

Student worksheet 5.1

What have I learnt about cells and microscopes?

Consider each of the statements in the tables below and rate yourself on your knowledge, understanding and skills by placing a tick (√) in one of the columns.

Knowledge and understanding	I really don't understand this very well	I only understand some of this	I understand most of this	I understand this very thoroughly
I can correctly identify the key similarities and differences between animal, plant and fungal cells				
I can identify the different cell structures and organelles in animal and plant cells				
I understand the basic function of key structures and organelles within plant and animal cells – nucleus, cell membrane, cell wall, cytoplasm, vacuoles, mitochondria, chloroplasts and ribosomes				
I understand the key differences between prokaryotic and eukaryotic cells				
I understand the key differences between unicellular and multicellular organisms				
I understand and can name the key life processes that all cells perform				
I understand that cells are specialised and have various structures to enable them to carry out their function, and I can use examples				

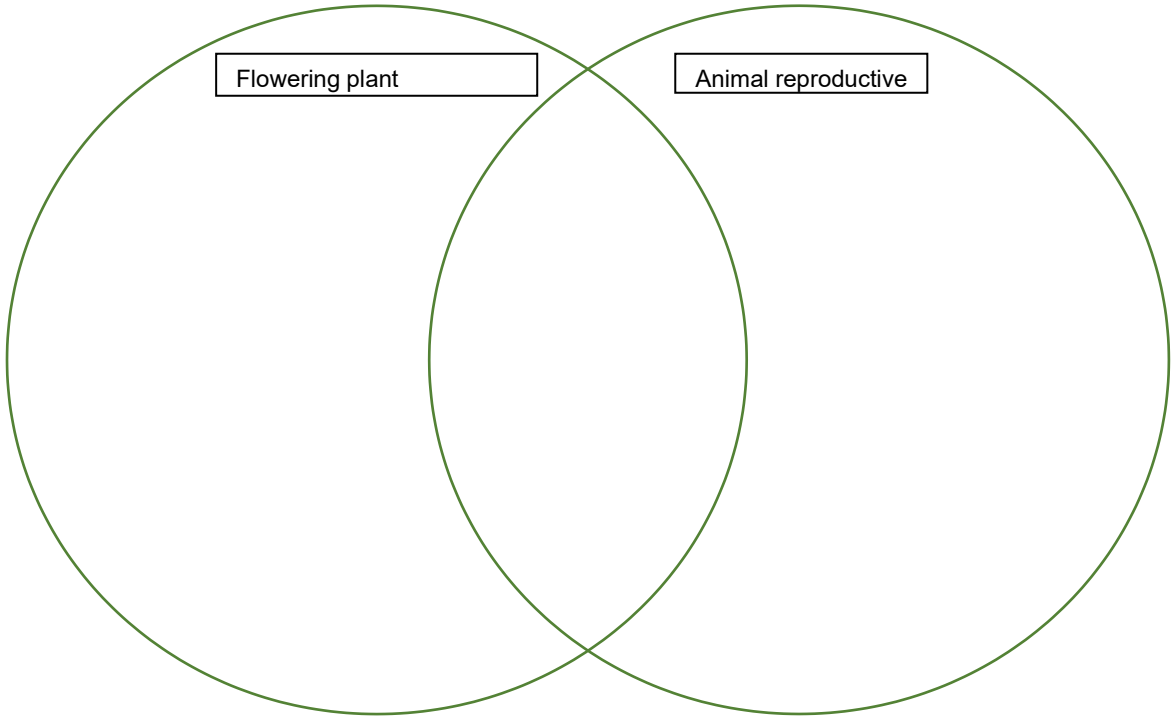
Skills	I can't really do this very well	I can only do some of this	I can do most of this	I can do this very thoroughly
I can label the parts of a compound light microscope				
I can set up a compound light microscope correctly so it is ready to use				
I can adjust the focus and amount of light on a compound light microscope to obtain clear images at different magnifications				
I can prepare various types of mounts of cells for viewing under a microscope				
I can calculate the magnification of what I see under a microscope				
I can make accurate labelled diagrams of cells and tissues that I see under a microscope				

Student worksheet 5.2

What have I learnt about reproductive systems?

Use this Venn diagram to compare the reproductive systems of plants and animals by writing the words for the reproductive parts in the correct space according to whether they belong exclusively to flowering plants or animals, or both. Some words to use are suggested in the box below, but you will need to add others to make a complete picture.

Anther
Ovary
Petal
Stigma
Testes
Uterus
Gamete
Pollen
Vagina
Ovum
Penis



Student worksheet 5.3

What have I learnt about life cycles?

Amazing aphids

Aphids are a regular pest for cereal growers in Western Australia (WA). They attack various cereal crops including wheat, barley and corn.

Adult and nymph (young) aphids suck sap from the growing plants. Large populations of aphids can limit grain yield and size, especially during winter and spring infestations. Cereal aphids also spread barley yellow dwarf virus (BYDV) that reduces cereal yield.

The two main species of aphid are the corn aphid and the oat aphid.

Image 5.3.1: Cereal aphids

Aphids also attack young citrus trees (such as orange and mandarin trees) in WA. Like other sap-sucking insects (such as mealybugs and scales), aphids produce a sticky substance (honeydew) as they feed on the plant.

Image 5.3.2: Spirea aphids attacking a young citrus tree

Life cycle of the aphid

Aphids have amazing life cycles. They can reproduce both sexually and asexually – a strategy which allows them to:

- be highly adaptable to changes in their environment
- breed very rapidly into very large numbers.

Females don't need to mate to produce young and they don't lay eggs. Live young are produced through a process termed **parthenogenesis**.

Activity

1. Watch the Study.com video Aphids: Reproduction and life cycle.
2. Read the *Aphids in citrus* article on the DPIRD website.
3. In the space below, construct a **life cycle diagram** for an aphid. Be sure to include key terminology, such as: sexual, asexual, male, female, parthenogenesis, winged, wingless, adult, nymph, egg.

Acknowledgements

References

Government of Western Australia, DPIRD, 'Pest insects', available at: https://www.agric.wa.gov.au/pests-weeds-diseases/pests/pest-insects accessed 9 June 2021

Government of Western Australia, DPIRD, 'Aphids in citrus' available at: https://www.agric.wa.gov.au/citrus/aphids-citrus accessed 9 June 2021

Study.com 'Aphids: Reproduction and life cycle' available at https://study.com/academy/lesson/aphids-reproduction-life-cycle.html accessed 9 June 2021

Images

Image 5.3.1: 'Cereal aphids' © DPIRD, available at: https://agric.wa.gov.au/n/2157 accessed 9 June 2021

Image 5.3.2: 'Spirea aphids attacking a young citrus tree' © DPIRD, available at: https://agric.wa.gov.au/n/1120 accessed 9 June 2021

Student worksheet 5.4

Concept map

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

This learning sequence has focused on how Western Australian primary producers use and apply key understanding that:

- cells are the basic units of living things; they have specialised structures and functions
- multicellular organisms contain systems of organs carrying out specialised functions that enable them to survive and reproduce
- people use science understanding 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.

Create your concept map

A **concept map** is a visual representation of the relationships between different concepts and understanding.

Go back through the various activities and review the key ideas. Consider what linking words you will need to use to connect the different ideas.

The basic steps to create a concept map are:

Step 1: Brainstorm (individually or in a group) to identify your focus (if working in groups, know how to take turns and how to disagree agreeably).

Step 2: Identify and create a list of your initial key concepts.

Step 3: Group your key concepts into broad hierarchical levels – you can use different colours to help highlight your levels.

Step 4: Link your key concepts. Place linking words on the lines to state the relationships between concepts.

Step 5: Look for ways to enhance your concept map by adding such things as cross-links, examples and additional concepts.

Step 6: Proofread and review your concept map.

Acknowledgements

References

Killian S (4 August 2019) *How to make a concept map easily – with examples*, Evidence-based teaching website <https://www.evidencebasedteaching.org.au/concept-mapping-complete-guide/>, accessed 1 June 2021.