Department of Primary Industries

Industry insights- Plant structure and function

Supporting document

NSW DPI Schools Program

www.dpi.nsw.gov.au

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NSW GOVERNMENT | Department of Primary Industries

Industry insights- Plant structure and function

Contents

Plant structure and function

Angiosperms or 'true flowering plants' are seed-bearing, vascular plants that produce flowers, seeds and fruit through sexual reproduction. They include more than 95% of all species of plants on earth. Most agricultural and food crop species are angiosperms.

Basic structure of a flowering plant

Use the NSW DPI Schools Program's 'Plants in agriculture' poster to answer questions 1-3.

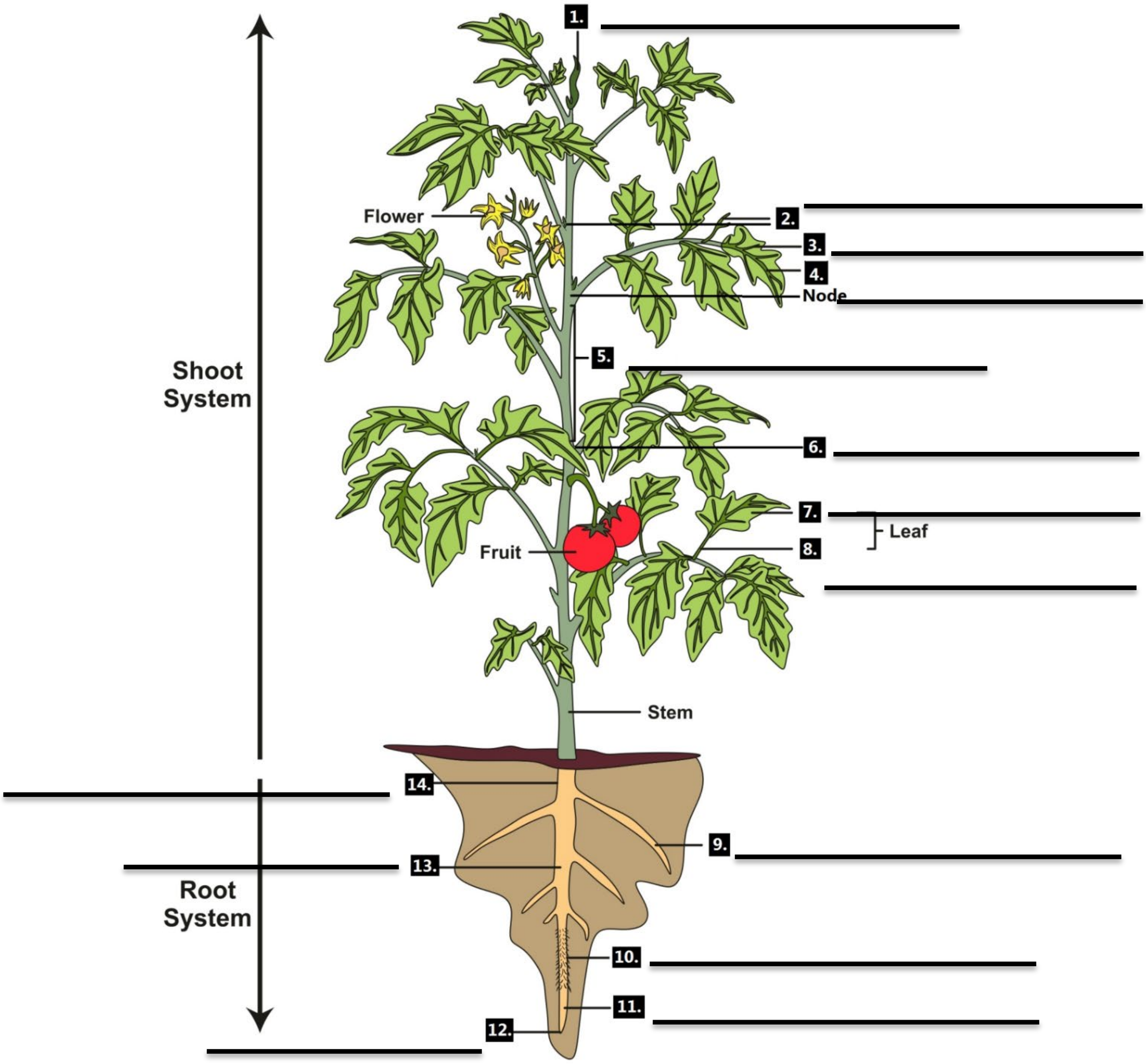
1. **What is an angiosperm? List three characteristics.**

   ____

   ____

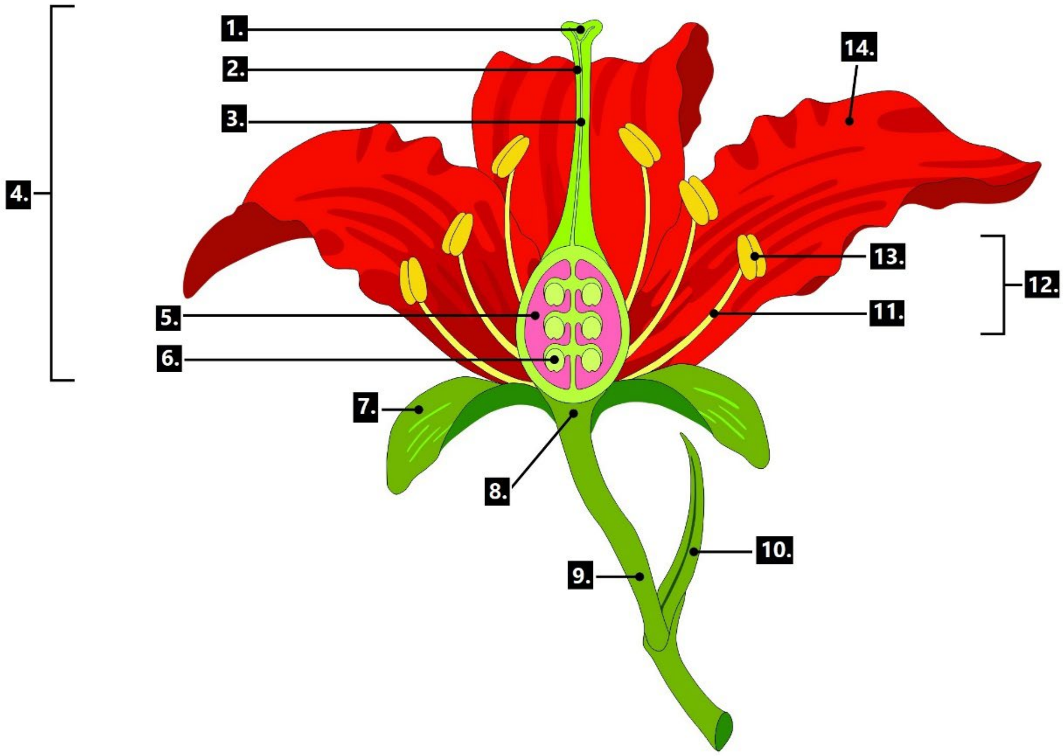
   ____

2. **Label parts 1-14 in the spaces.**



Basic structure of a flower

3. **Label parts 1-14 in the space below.**



Flower structure	
1.	8.
2.	9.
3.	10.
4.	11.
5.	12.
6.	13.
7.	14.

Plant structure - Practical activity

- Conduct a plant and flower dissection - https://www.instructables.com/id/Flower-Dissection/

Reproduction in flowering plants

Sexual reproduction is a way of making a new individual by joining two sex cells, called gametes. In sexual reproduction in plants, the male (pollen cell) and female gamete (ovule) fuse to form a single fertilised cell called a zygote. With correct environmental conditions, the zygote develops into an embryo (seed) and germinates into a seedling. All offspring produced via sexual reproduction are genetically different to the parents. Pollination is the initial process (pollen landing on stigma) which leads to fertilisation in plants. Plants can either be self-pollinators or cross-pollinators.

Many flowering plants are also able to naturally reproduce asexually through various structures such as stolons, rhizomes and tubers. Artificial methods of asexual reproduction include vegetative propagation (e.g. grafting), cloning and tissue culturing. All offspring produced via asexual reproduction are genetically identical to the parent.

4. **Use research to define the following terms. Give examples where possible:**
   - **A) Gamete**
   - **B) Seed**
   - **C) Sexual reproduction**
   - **D) Asexual reproduction**
   - **E) Vegetative propagation**
   - **F) Stolon**
   - **G) Rhizome**
   - **H) Tubers**

5. Describe pollination using the following terms:
    - Pollination
    - Gamete
    - Stigma
    - Style
    - Pollen tube
    - Ovary
    - Ovule
    - Sexual reproduction

Tissue culture micro-propagation is a specialist field of vegetative plant propagation. It is used widely in agriculture for species such as developing and speeding up the development of new plant varieties. See examples for avocado plants, (Could tissue culture meet avocado plant demand on the University of Queensland website), and disease resistant bananas (Establishing tissue culture bananas in NSW under Horticulture on the NSW DPI website).

- Watch "Plant tissue culture 101 with demonstration" on YouTube.

6. Use the internet to research the process of plant tissue culture. Describe what is happing at each stage of the following diagram,

Step	Description
1	
2	
3	
4	
5	
6	
7	
8	

7. **Make a list of benefits of tissue culture compared to sexual plant reproduction.**

Monocotyledons vs. dicotyledons

All angiosperms can be classified as either monocotyledonous or dicotyledonous plants. Identification can only be made with a combination of multiple features, not just a single feature.

8. **Read the passage and complete the activities.**

Angiosperms are divided into two classes - monocotyledons (monocots) and dicotyledons (dicots).

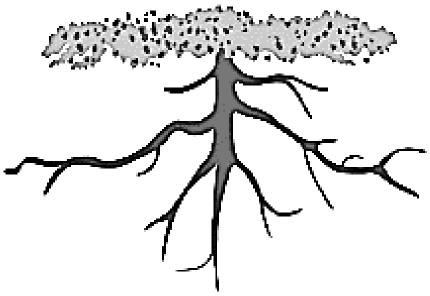
Monocot examples include wheat, barley, ryegrass, rice, triticale, maize, phalaris, oats, cocksfoot, sorghum, kikuyu, wallaby grass and barley grass.

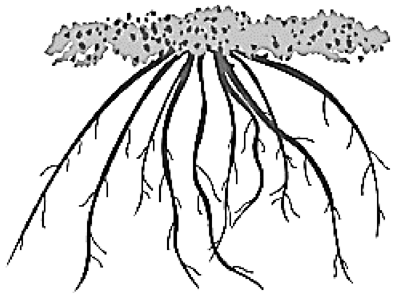
Dicot examples include tomatoes, carrots, potato, Leucaena, salt bush, clover, Lucerne, lupins, canola, thistles and trees.

Monocots and dicots have several different characteristics including:

Root system: Monocots have a fibrous root system whereas dicots have a taproot. A taproot consists of a main root with multiple lateral roots.

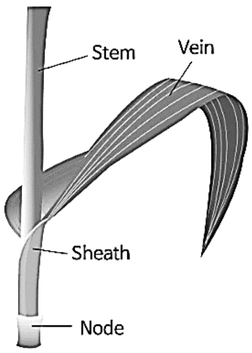
On the diagrams below colour the taproot dark brown and the fibrous root light brown. Identify and label each as either a monocot or dicot.

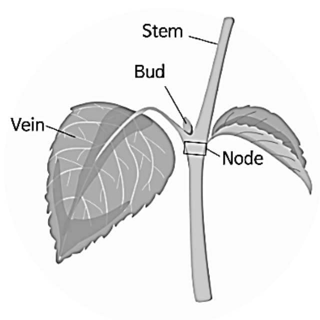




Leaf structure: Adult monocots usually have parallel venation (arrangement of veins), whereas dicots have net-like venation.

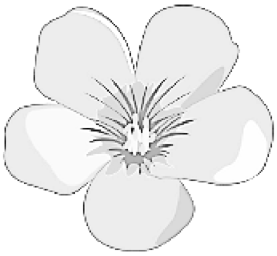
On the diagrams below colour the leaves in green, outline the veins in black and colour the stems in blue. Identify and label each diagram as either a monocot or dicot.





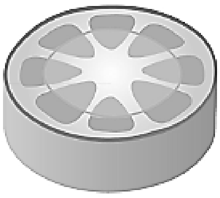
Flowers: The flowers of monocots and dicots differ in the number of petals. Monocots tend to have flower petals arranged in threes. Petals on a dicot flower are usually in multiples of four or five.

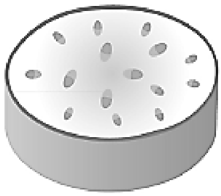
Colour the monocot flower in purple and the dicot flower in pink on the diagrams below, making sure all petals are coloured. Label the diagrams as either a monocot or dicot flower.



Vascular systems: In monocots, the vascular bundles are scattered throughout the stem. In dicots, the vascular bundles are arranged in a ring in the stem. In a monocot root, the xylem and phloem are arranged in a ring and alternate position. In a dicot root, the xylem is arranged in an "X" in the centre with the phloem outside it.

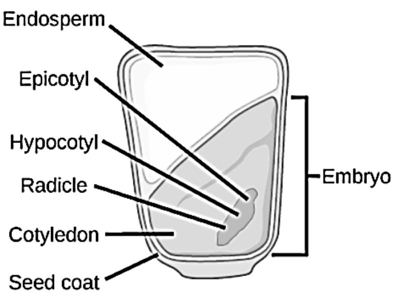
On the diagrams below colour the xylem in purple and the phloem in orange. Label as either a monocot stem or dicot stem.

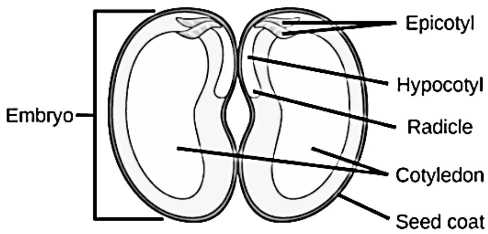




Seeds: The structures of dicot and monocot seeds are shown. Dicots (left) have two cotyledons. Monocots, such as maize have one cotyledon, called the scutellum; it channels nutrition to the growing embryo plant. Both monocot and dicot embryos have an epicotyl and plumules that form the first true leaves, a hypocotyl that forms the stem, and a radicle that forms the root.

On the diagrams below colour the seed coats in blue, the cotyledons in yellow, the epicotyl in green, the hypocotyl in orange and the radicle in brown. Label each diagram as either a monocot or dicot seed.





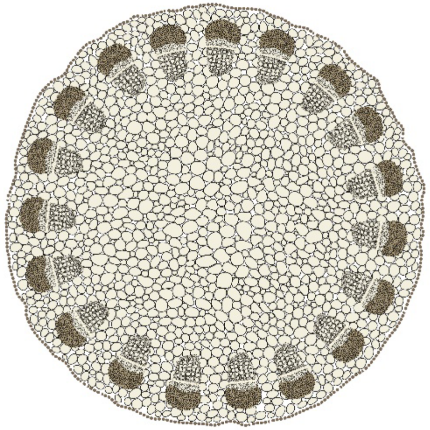
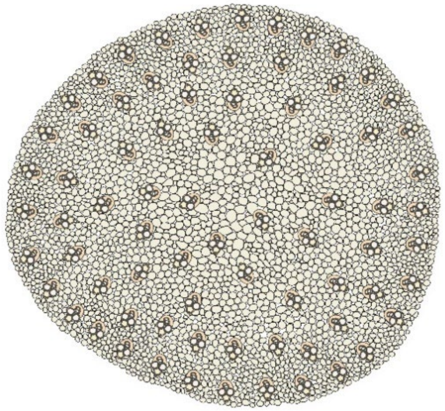
9. **Identify whether the traits listed in the table below are found in monocots, dicots or both by placing a tick in the correct column.**

Trait	Monocotyledons	Dicotyledons	Both
Single cotyledon			
Flowering plants			
Stem vascular system in a ring			
Sheath like leaf			
Branched veins			
Fibrous root system			
Produce seeds and fruit			
Parallel veins			
Two cotyledons			
Seeds covered with protective seed coat			
Root vascular bundles in the centre of the root with xylem surrounded by phloem			
Petals arranged in groups of four or five			
System of transport tubes (vascular system)			
Petals arranged in groups of three			
Broadleaf			
Seed contains a hypocotyl and radicle			
Stem vascular bundles scattered			
Single cotyledon			
Taproot			

10. Classify the following plants or plant parts as either a monocotyledon or dicotyledon in the space below the image. Remember to use multiple characteristics to identify the plants. Include the name of the plant if you recognise it.

			
	**Stem cross section** 	**Stem cross section** 	

Growth and development

Growth (the increase in size and number of leaves and stems) and development (the process of the plant moving from one growth stage to another) in any plant is a complex process. During the life cycle of any plant, many of the growth stages overlap. Growth and development are continuous processes.

After emergence, plant growth and development can be broadly categorised as vegetative or reproductive growth. These phases can be further distinguished into growth stages:

- germination,
- emergence,
- leaf production or tillering,
- stem growth (stem elongation),
- flower and bud development,
- flowering (anthesis),
- seed development and
- death (senescence).

The length and timing of each growth stage is influenced by genetics, species, temperature, moisture, light (day length), nutrition and variety. Light, temperature and moisture available are the most important environmental factors regulating growth and development.

If a plant completes its whole lifecycle within a year it is called an annual species. If it completes its lifecycle over two years plus, it is called a perennial species.

Use the NSW DPI Schools Program poster 'Plants in agriculture' poster to answer questions 11-13

11. Contrast growth and development in plants.

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12. List the factors that affect the length and timing of each growth stage.

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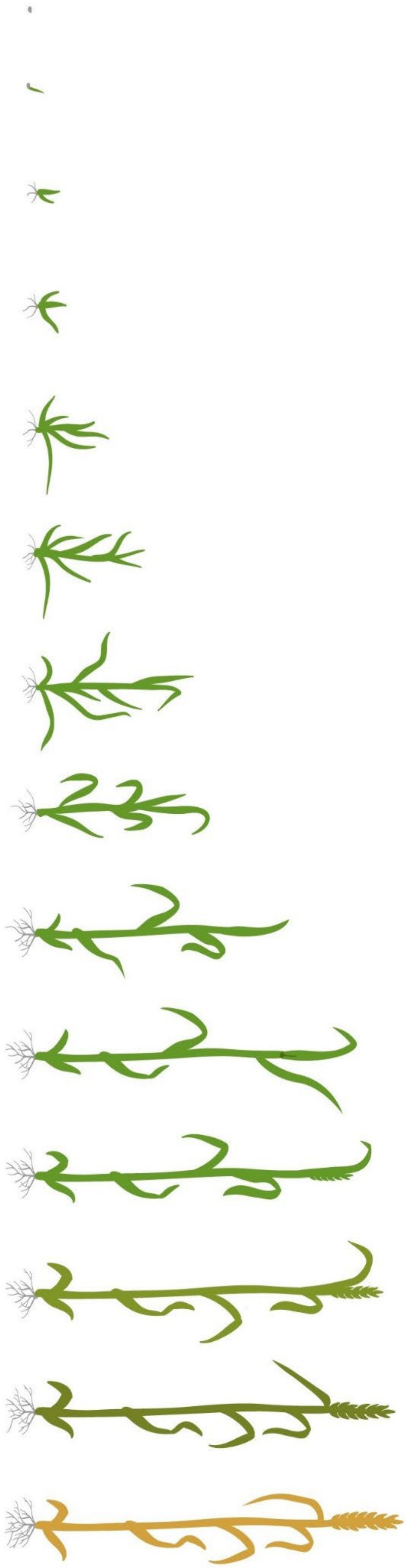
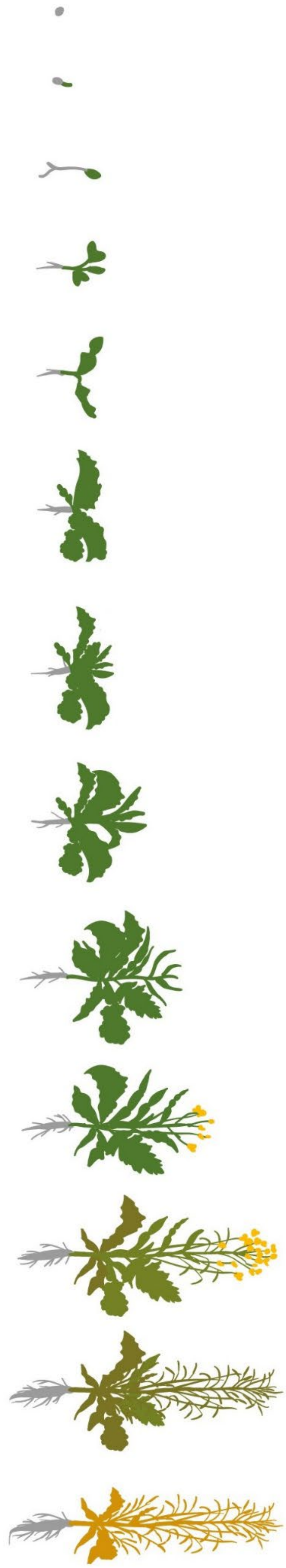
13. Label the following growth and development stage on both images.

- **Germination and emergence**
- **Leaf production and emergence**
- **Tillering (wheat)**
- **Stem extension and elongation**
- **Booting (wheat)**
- **Heading (wheat)**
- **Bud development (canola)**
- **Flowering (anthesis)**
- **Grain growth (wheat)**
- **Podfill (canola)**
- **Senescence**
- **Vegetative stages**
- **Reproductive stages**





Practical activities

- Identify plants in your environment for example, in your garden, school etc as either monocotyledons or dicotyledons.
- Conduct a germination trial using a range of monocotyledon and dicotyledon seeds. Monitor and record seedling growth and development to contrast monocotyledons and dicotyledons characteristics and growth stages.

Photosynthesis and respiration in plants

Photosynthesis

Plants are producers. This means they produce their own energy. Plants are essential in providing all energy to food chains and creating oxygen for all living things. Plants are the basis to all agriculture as all livestock systems depend on plant production.

The process whereby plants produce their own energy from sunlight is called photosynthesis.

Algae and some bacteria can also carryout photosynthesis.

There are two types of photosynthetic processes - oxygenic photosynthesis (with oxygen) and anoxygenic photosynthesis (without oxygen). In junior science and agriculture, you only need to learn about oxygenic photosynthesis which is the most common type seen in plants. In this document photosynthesis refers to oxygenic photosynthesis.

What is needed?

To carry out photosynthesis, plants need the following:

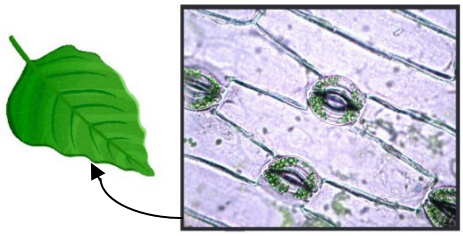


Figure 1 Stomates found underneath the plant leaf allow for gas exchange

- **Carbon dioxide**: from the air passes through small pores (holes) in the leaves. These pores are called stomata and are mainly found on the bottom of leaves to reduce water loss through evaporation. (Figure 1)
- **Light energy (sunlight):** is absorbed by a green chemical called chlorophyll located in specialised organelles found in cells in leaves and stems, called chloroplasts. (Figure 2)
- **Water:** is absorbed by the roots and passes upward through the xylem in the stem to the leaves. (Figure 3)

If any of these elements is missing, plants cannot carry out photosynthesis.

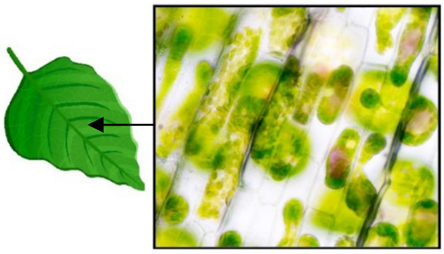


Figure 3 Chloroplasts in plant cells

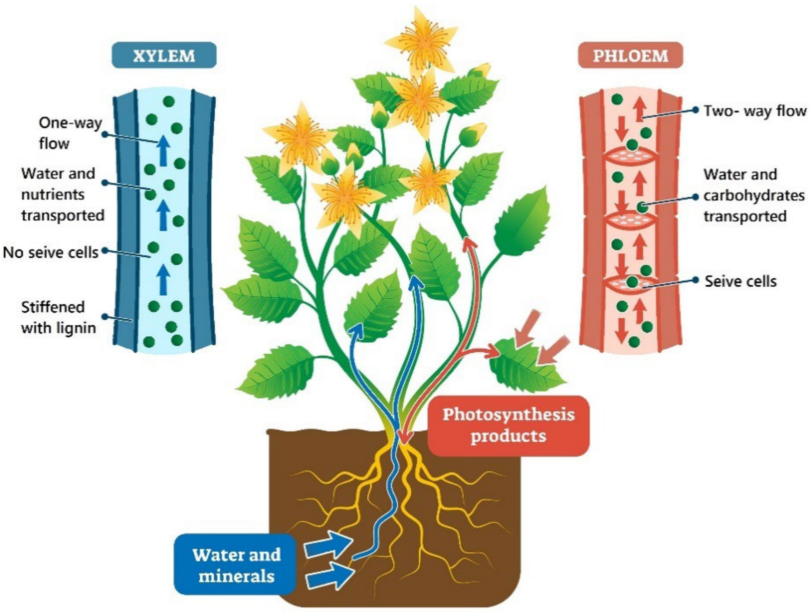


Figure 2 Plant vascular systems - xylem and phloem

What happens during Photosynthesis?

- Photosynthesis takes place in the chloroplasts in the plants leaves and stems. Chloroplasts contain a green pigment, chlorophyll, that absorbs the sun's energy. Light energy is used by the chloroplasts to split water molecules into hydrogen and oxygen (Figure 2).
- **Oxygen** is released from the leaves into the atmosphere through the stomates (Figure 1).
- Hydrogen and carbon dioxide are used to form **glucose** or energy. Glucose is transported up, down and around the plant in the phloem (Figure 3).
- Some of the glucose is used to provide energy for maintenance, growth and development, while the rest is stored in leaves, roots or fruits for later use by plants for growth or maintenance.

Photosynthesis acts as a counterbalance to respiration by taking in the carbon dioxide produced by all respiring organisms and releasing oxygen to the atmosphere. Glucose that is not immediately used for respiration can be converted into starch molecules for later use.

The whole process is summarised in Figure 4.

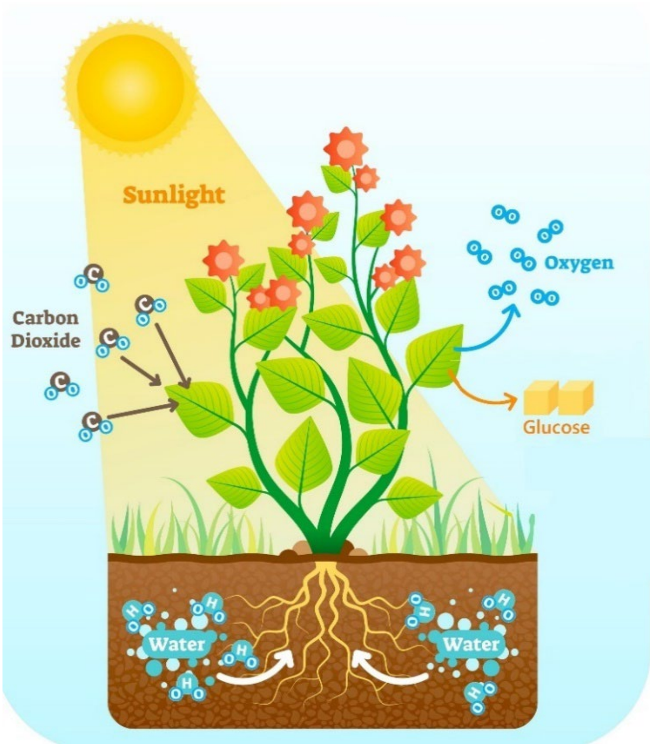


Figure 4 Photosynthesis

The photosynthesis word equation is:

$$\text{Carbon dioxide} + \text{Water} \xrightarrow[\text{Chloroplasts}]{\text{Light energy}} \text{Glucose (sugars)} + \text{Oxygen}$$

The photosynthesis chemical equation is:

$$6CO_2 + 6H_2O \xrightarrow[\text{Chloroplasts}]{\text{Light energy}} C_6H_{12}O_6 + 6O_2$$

Respiration in plants

All living things require a continual supply of energy to function.

Energy is essential for numerous processes, such as growth, repair, movement, reproduction and maintenance.

All living things get their energy from a chemical process known as cellular respiration.

The main type of cellular respiration is aerobic respiration, which involves the breakdown of glucose molecules in the presence of oxygen.

The other type of respiration is anaerobic respiration, which occurs without the presence of oxygen. This document will concentrate on aerobic respiration.

All cellular organisms, including plants and animals get the oxygen required for respiration from their surrounding environment, but they obtain their glucose through very different processes. Plants obtain glucose from photosynthesis and animals through digestion.

This document will cover plant respiration; however, the basic concepts are the same in all cellular organisms. Respiration converts the energy stored in glucose (a type of sugar) to a form of energy that cells can readily utilise. Although respiration produces chemical products, such as carbon dioxide and water, its primary purpose is the conversion of energy (to a form known as ATP).

What is needed?

To carry out respiration, plants need the following:

- **Glucose:** produced by the plant through photosynthesis and stored in leaves, stems and roots.
- **Oxygen:** obtained through the stomates.

What happens during respiration?

While photosynthesis takes place in the leaves and stems only, respiration occurs in the leaves, stems and roots of the plant.

Respiration uses the glucose produced during photosynthesis plus oxygen to produce energy for plant growth. In many ways, respiration is the opposite of photosynthesis.

Respiration occurs in specialised organelles found within plant cells called mitochondria.

- Mitochondria split **glucose** and **oxygen** molecules.
- **Carbon dioxide, water** and **energy** are released. The energy is called adenosine triphosphate (ATP). ATP energy is used by all living things for maintenance and growth.
- **Carbon dioxide** and **water** are released from the leaves into the atmosphere through the stomates.

Plants carry out respiration through daylight hours (photo respiration) and at night (dark respiration). Both processes are the same, however the respiration rate in plants at night is greater than throughout the day.

The process of respiration is summarised in Figure 5.

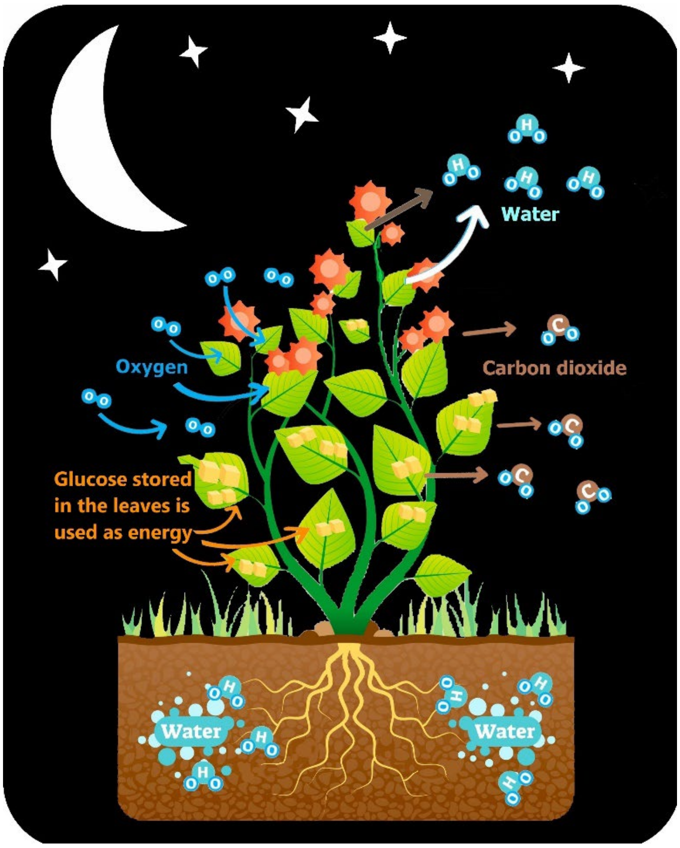


Figure 5 Respiration

The respiration word equation is:

Glucose + Oxygen → Carbon dioxide + water + energy (ATP)

Note that respiration is the reverse of photosynthesis without the energy!

The respiration chemical equation is:

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{energy (38 ATP)}$$

Comparing photosynthesis and respiration

- Animals obtain glucose for respiration by digesting food that they eat.
- Plants obtain glucose for respiration by producing it through a process known as photosynthesis.
- Photosynthesis uses the energy of sunlight to convert carbon dioxide and water into glucose and oxygen.
- Respiration allows living organisms to breakdown glucose in their cells to obtain energy.
- Photosynthesis can be summarised as:
  carbon dioxide + water + sunlight energy and chlorophyll → glucose + oxygen
- Respiration can be summarised as:
  Glucose + oxygen → carbon dioxide + water + energy
- Mitochondria are the cell organelles where respiration takes place.
- Photosynthesis takes place in cell organelles called chloroplasts. These occur in the cells of plants, green algae and some bacteria; therefore, photosynthesis only takes place in these organisms.
- Both photosynthesis and respiration need glucose, oxygen, carbon dioxide and water.
- Both involve energy conversions.

- Respiration is an exothermic process that releases energy (from glucose), whereas photosynthesis is an endothermic process that absorbs energy (from sunlight).
- Photosynthesis requires light, so it naturally only occurs through daylight hours.
- Respiration occurs all the time and does not require light.

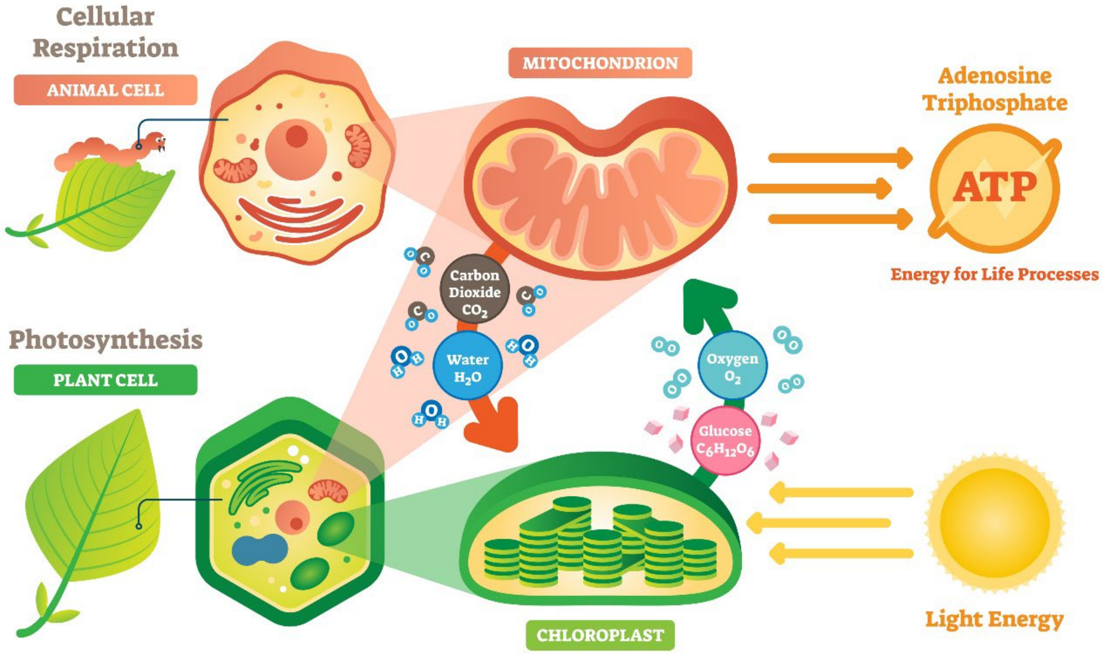


Figure 6 Photosynthesis and respiration

Watch "[Virtual plant cell: cell explore, 2018. VPC 360 video by Plant Energy Biology]" to virtually investigate a plant cell.

Photosynthesis and respiration - Learning activities

14. **List the living things photosynthesis occurs in?**

15. **Name the specialised organelles that carry out photosynthesis?**

16. **Name the chemical in specialised plant organelles that allows photosynthesis to occur?**

17. **Name the chemical that makes plants appear green?**

18. **Write the word equation for photosynthesis.**

19. **Write the chemical equation for photosynthesis.**

20. **What energy source is essential for photosynthesis to occur?**

21. How could you manipulate a plants' environment to make photosynthesis occur for longer periods?

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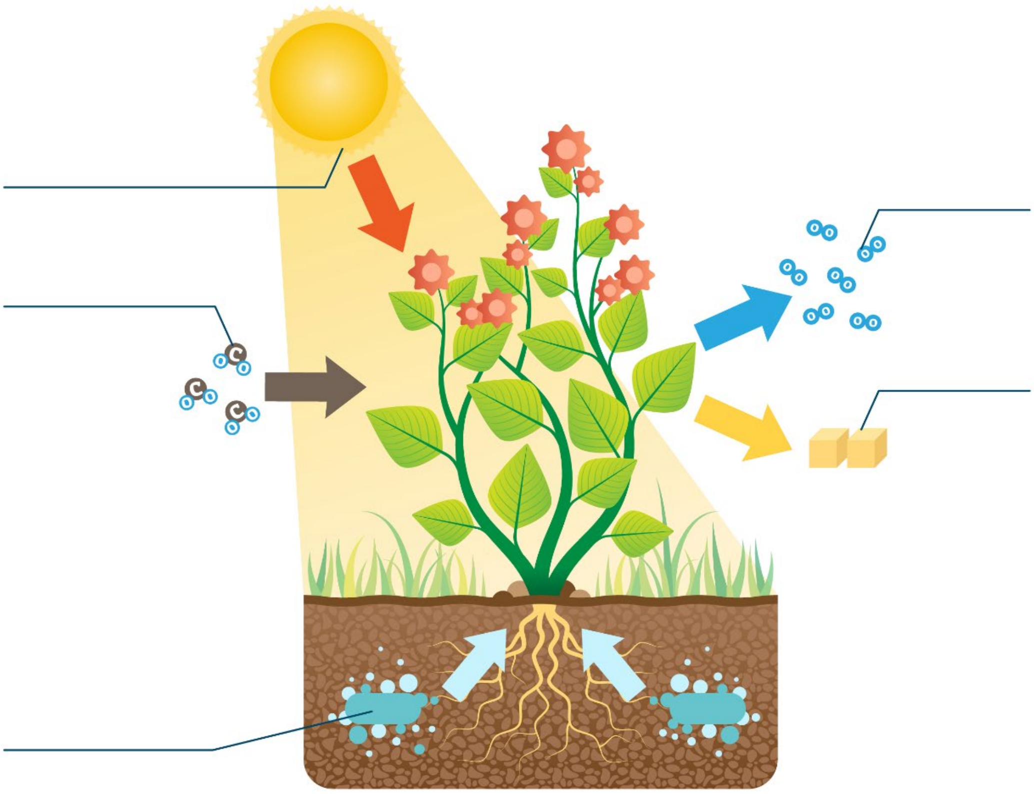
22. Label the parts of the diagram. (Figure 4)



23. Name the structures that allows the transfer of gases into and out of a plant?

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24. Describe the role of the xylem.

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25. Describe the role of phloem

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____

26. Name the specialised organelles that carry out respiration?

____

27. Write the word equation for respiration.

____

____

28. **Write the chemical equation for respiration.**

____

____

29. **Does respiration only occur during a specific time of day?**

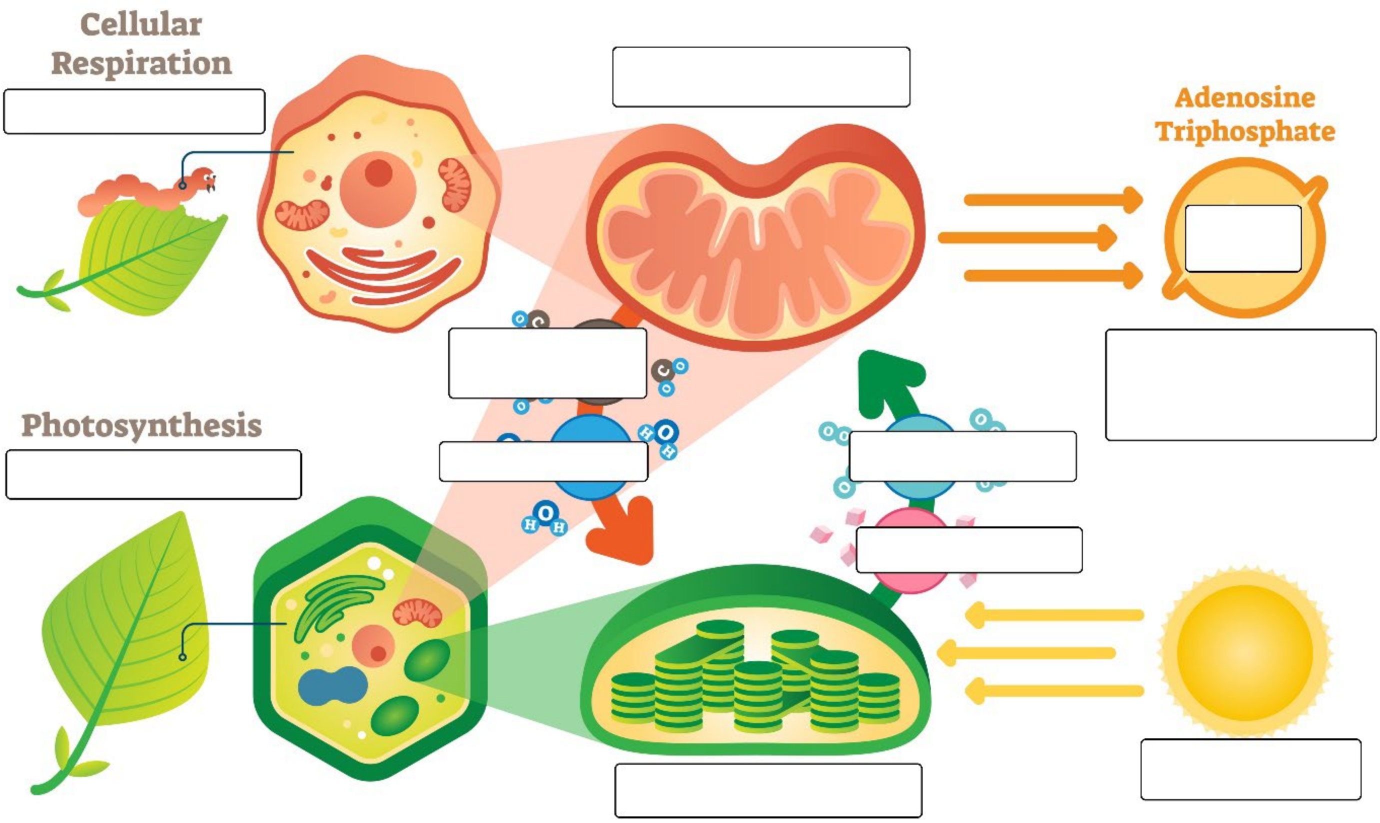
____

30. **Label the diagram. (Figure 5)**

31. **Use the information from the 'Comparing photosynthesis and respiration' section to complete the table.**
Match each dot point into the following table using the headings 'Photosynthesis', 'Respiration' or 'Similarities'. The first two dot points have been included.

Photosynthesis	Respiration	Both
Plants obtain glucose for respiration by producing it through a process known as photosynthesis.	Animals obtain glucose for respiration by digesting food that they eat.	

32. **Label the parts of the diagram. (Figure 6)**



Photosynthesis and respiration - Practical activities

- Observe chloroplasts under the microscope using, for example Elodea, algae, moss or prepared slides.
- Observe stomata under the microscope using, for example a leaf peel or prepared slides. Example procedure found at 'Experiment to Observe Temporary Mount of a Leaf Peel to Show Stomata' - http://www.biologydiscussion.com/experiments/experiment-to-observe-temporary-mount-of-a-leaf-peel-to-show-stomata/1733
- Observe xylem and phloem tissue. This practical activity could involve observing prepared slides with a microscope or observing 'Water movement through Xylem vessels in celery' - http://www.biologybynapier.com/uploads/4/0/3/7/40376393/plant_transport_option_2.pdf
- Observe photosynthesis in plants. Submerge a living plant part in an airtight container and fill with water to observe oxygen production. Example procedure found at 'How do plants breath experiment' - https://www.rookieparenting.com/do-plants-breathe-science-experiment/
- Observe starch in leaves. An example experiment could involve two plants; place one plant in full sunlight and the other in a dark cupboard for a week. Take leaf material from both plants and conduct the iodine/starch test. Example procedure found at "Investigating photosynthesis – starch and chlorophyll' - https://www.bbc.co.uk/bitesize/guides/zq239j6/revision/6
- For a list of other plant practical ideas go to: Plant Energy Biology - PEB Teaching resources. - https://plantenergy.edu.au/outreach/resources

NSW Syllabus outcomes

Agricultural Technology Years 7-10 Syllabus, 2019

Outcomes	Content
AG5-1 explains why identified plant species and animal breeds have been used in agricultural enterprises and developed for the Australian environment and/or markets **AG5-9 evaluates management practices in terms of profitability, technology, sustainability, social issues and ethics**	Plant Production 1 • identify plants relevant to agricultural production, for example: – important plant crops in Australia, eg wheat, barley, oats – importance of legumes in pastures – commercially grown bush plants eg wattle, sandalwood • explain the function and structure of plants related to the enterprise, for example: – the role of leaves, stems, roots – the role of fruits and flowers Plant Production 2 • investigate timing and impact of relevant operations in a plant production cycle, for example: – application of fertiliser – pruning – sowing – irrigation

Science Years 7-10 Syllabus, 2018

Outcomes	Content
SC4-14LW relates the structure and function of living things to their classification, survival and reproduction	LW1 There are differences within and between groups of organisms; classification helps organise this diversity (ACSSU111) • classify a variety of living things based on similarities and differences in structural features LW3 Multicellular organisms contain systems of organs that carry out specialised functions that enable them to survive and reproduce (ACSSU150) • describe the role of the flower, root, stem and leaf in maintaining flowering plants as functioning organisms • identify the materials required by multicellular organisms for the processes of respiration and photosynthesis