NGIV | branch out

THE WORLD OF PHOTOSYNTHESIS

Plants and their superpower

AGRICULTURE VICTORIA

Unit Overview

Students will discover the intricacies of plants and their role in our world through photosynthesis. They will develop an understanding of photosynthesis, explore the factors influencing this process and consider how it sustains all life on earth. Students will also investigate the adaptations of plants and ecosystems in different conditions, including the spectacular Otway rainforest. With plenty of hands-on-experience in this unit, there is so much to explore in the wonderful world of photosynthesis.

Contents

It is recommended that this unit is implemented over the course of 8–10 weeks.

This pack contains:

- two pre-incursion lessons
- two post-incursion lessons
- post-unit recommendations
- student and teacher resources.

The facilitated incursion can be arranged through Nursery and Garden Industry Victoria.

Curriculum – Years 7 and 8

Cross curriculum priorities – Learning about Sustainability

Learning about Sustainability allows students to develop the knowledge, skills, values and world views necessary to contribute to more sustainable patterns of living. Learning about Sustainability has an increasing local, national and global resonance. Australia's future prosperity will be impacted by past, present and future decisions, particularly in relation to the environmental, social and economic challenges.

The concept of sustainability is fundamental for students to understand the ways environmental, social and economic systems interact to support and maintain human life. It allows them to critically examine the diversity of views and values that influence sustainable development. The curriculum also provides students with the opportunity to participate creatively and to see themselves as having the capacity to act in ways that will help to establish more sustainable ways of living.

Geography

Spiritual, cultural and aesthetic value of landscapes and landforms for people, including Aboriginal and Torres Strait Islander peoples, that influence the significance of places and ways of protecting significant landscapes (VCGGK119)

Design and Technology

Define and decompose real-world problems taking into account functional requirements and sustainability (VCDTCD040)

Examine and prioritise competing factors including social, ethical, economic and sustainability considerations in the development of technologies and designed solutions to meet community needs for preferred futures (VCDSTS043).

Curriculum – Years 7 and 8

Content descriptions

Sciences

- Cells are the basic units of living things and have specialised structures and functions (VCSSU092)
- Multicellular organisms contain systems of organs that carry out specialised functions that enable them to survive and reproduce (VCSSU094)
- Formulate questions or hypotheses that can be investigated scientifically, including identification of independent, dependent and controlled variables (VCSIS134)
- Use scientific knowledge and findings from investigations to identify relationships, evaluate claims and draw conclusions (VCSIS111)
- Reflect on the method used to investigate a question or solve a problem, including evaluating the quality of the data collected, and identify improvements to the method (VCSIS112)
- In fair tests, measure and control variables, and select equipment to collect data with accuracy appropriate to the task (VCSIS109)
- Communicate ideas, findings and solutions to problems including identifying impacts and limitations of conclusions and using appropriate scientific language and representations (VCSIS113)

Maths

- Recognise and solve problems involving simple ratios (VCMNA249)
- Construct and compare a range of data displays (VCMSP270)

Curriculum – Years 9 and 10

Cross curriculum priorities

Science

- Global systems, including the carbon cycle, rely on the interactions involving the atmosphere, biosphere, hydrosphere and lithosphere (VCSSU128)
- Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (VCSSU121)
- Advances in scientific understanding often rely on developments in technology and technological advances are often linked to scientific discoveries (VCSSU115)

Geography

- The interconnection between food production and land and water degradation; shortage of fresh water; competing land uses; and climate change, for Australia and other areas of the world (VCGGK135)

Design and Technology

- Critically analyse factors, including social, ethical and sustainability considerations, that impact on designed solutions for global preferred futures and the complex design and production processes involved (VCDTS054)

Content descriptions

Sciences

- Multicellular organisms rely on coordinated and interdependent internal systems to respond to changes to their environment (VCSSU117)
- Ecosystems consist of communities of interdependent organisms and abiotic components of the environment; matter and energy flow through these systems (VCSSU121)
- Formulate questions or hypotheses that can be investigated scientifically, including identification of independent, dependent and controlled variables (VCSIS134)
- The theory of evolution by natural selection explains the diversity of living things and is supported by a range of scientific evidence (VCSSU120)
- Construct and use a range of representations, including graphs, keys, models and formulas, to record and summarise data from students' own investigations and secondary sources, to represent qualitative and quantitative patterns or relationships, and distinguish between discrete and continuous data (VCSIS137)

Background Teacher Information

The teaching and learning opportunities in this unit require an understanding of the process of photosynthesis. A student-friendly explanation is below:

Photosynthesis is a process that plants use to make their own food using sunlight.

Plants have a green pigment called chlorophyll that captures sunlight, which gives the plants energy. When the sunlight hits the chlorophyll, it gets absorbed and starts a series of reactions.

First, the plant takes in carbon dioxide gas from the air through tiny openings in their leaves called stomata. They also take in water from the ground through their roots. These two things are needed for photosynthesis.

The sunlight energy then helps split the water molecules into oxygen and hydrogen. The oxygen is released into the air as a gas, which is what we breathe. The hydrogen is used in the next step.

The plant uses the energy from the sunlight to convert the carbon dioxide and the hydrogen into glucose. It's stored in the plant's cells and can be used later when the plant needs energy.

The process of making glucose from carbon dioxide and water is called the Calvin cycle. It happens inside a part of the plant's cells called the chloroplast.

Photosynthesis is important in:

Making Food: Photosynthesis allows plants to make their own food. The glucose they make provides energy for the plant to grow, reproduce, and survive.

Oxygen Production: When plants make glucose, they also release oxygen into the air as a waste product. This oxygen is what we and other animals breathe. It helps us stay alive and is essential for all living things.

Carbon Dioxide Balance: Plants take in carbon dioxide, a gas that is released when we breathe out and when fossil fuels are burned. By absorbing carbon dioxide, plants help regulate the levels of this gas in the atmosphere. This is important for maintaining a healthy planet and reducing the effects of climate change.

The resources below provide additional information:

- **'What is photosynthesis'** (Fuse School)
- **Function of a leaf** (Video)

Important Vocabulary

Photosynthesis: the process by which plants convert radiant energy (light energy) from the sun into chemical energy in the form of glucose (sugar). To do this they use sunlight, water, and carbon dioxide to create oxygen and energy/glucose. A process whereby plants convert light energy into chemical energy

Chlorophyll: a green pigment present in all green plants which is responsible for the absorption of light to provide energy for *photosynthesis*

Vascular bundle: consisting of the xylem and phloem. Provides a transport pathway in the stem for primarily water and nutrients

Stomata: tiny openings, or pores, in plant tissue that allow for gas exchange for *photosynthesis*. Typically found in plant leaves but can also be found in some stems. In Greek '*stoma*' means mouth

Glucose: a simple sugar with the molecular formula $C_6H_{12}O_6$. Glucose provides plants with the needed food through the process called *photosynthesis*

Germination: the process by which an organism grows from a seed or spore

Seedling: a young plant grown from seed

Plant adaptations: specific changes in a plant to help it survive and adapt to their environment. This happens gradually over time as a result of a change in gene expression.

How to use these resources

The *Branch Out* units of learning have been developed for Years 7–10. They have been developed in such a way as to allow for adaptation, differentiation and improvisation. Lessons can be modified to suit the needs of your school and your students, and where desired, teachers are encouraged to 'branch out' and follow their own curiosity and that of the students in their classrooms. It is also encouraged that where possible, teachers adapt or supplement lessons with resources that reflect their community and surrounding area.

Each lesson is structured with an introduction, key learning experiences and a summary. This structure can be modified and adapted to suit different instructional models and lesson durations.

Assessment can be developed at the discretion of the teacher or teaching team. There are many opportunities for rich and meaningful assessment throughout these lessons that has the potential to be formal or informal, formative or summative, and differentiated depending on the assessment and reporting requirements of the schools, student needs and the specific goals of teachers or teaching teams. Teachers should develop assessment in line with the curriculum of the year level in which the units of learning are implemented.

1 REAL-TIME PHOTOSYNTHESIS

LESSON STEPS

Lesson purpose:

- To observe photosynthesis taking place in real time
- To consider the process of artificial photosynthesis in becoming a renewable energy source.

Required prior knowledge for teachers:

Teachers require an understanding of the process of photosynthesis and the chemical equation that represents this process.

The basic equation of photosynthesis is:
$6CO_2 + 6H_2O + \textit{light energy} \rightarrow C_6H_{12}O_6 + 6O_2$

Learning objectives:

Students will:

- understand the essential ingredients for both natural and artificial photosynthesis.

Success criteria:

By the end of the lesson, students can:

- understand the role of the bionic leaf and its similarities to the natural leaf
- consider the possibility and implications of human-made photosynthesis becoming a renewable energy source
- make predictions as to what an experiment is set out to achieve
- graph the results of an experiment.

Key vocabulary:

- **Bionic leaf:** a small man-made solar collector that takes sunlight and water and turns it into any of a variety of usable fuels or fertilisers
- **Artificial Photosynthesis:** a chemical process that biomimics the natural process of photosynthesis.

Materials:

- a copy of *Real-Time Photosynthesis Student Resource* for each student (digital if preferred)
- spinach leaves
- hole punch or straw
- plastic syringes 10ml (no needle)
- dishwashing liquid
- baking soda
- measuring cup and spoon
- a glass jar/clear cup
- timer
- *Real-time Photosynthesis Teacher Resource*

LESSON STEPS

Introduction

1. Facilitate a class discussion about photosynthesis. Invite students to offer what they know about photosynthesis and the equation that describes the process. Write the equation on the board and balance it as a class. Explain that photosynthesis is the process by which plants convert radiant energy (light energy) from the sun into chemical energy in the form of glucose (sugar). To do this they use sunlight, water, and carbon dioxide to create oxygen and energy/glucose. It is a process whereby plants convert light energy into chemical energy. Explain that scientists have created a bionic leaf that may one day be able to harness the energy created to fuel cars. Provide some time for students to research the bionic leaf and the potential of artificial photosynthesis.

Main body

1. Explain that students will now have the experience of creating photosynthesis by combining ingredients like a bionic leaf in a real-time photosynthesis experiment.
2. Provide students with the **Real-Time Photosynthesis Student Resource**. Students will witness photosynthesis taking place in spinach leaf discs in water after adding carbon dioxide and exposing to sunlight. Give students time to complete the experiment in groups or individually.
3. Ask students to complete blank sections in the table on their **Real-Time Photosynthesis Student Resource**.

Reflection and closure

1. Invite students to share their results. As a class, answer the experiment discussion questions and discuss the conclusion of the experiment.

Optional extension

Experiment with changing other factors that might affect photosynthesis and see what happens. You could:

- experiment with different types of light sources: lower or higher-wattage incandescent, fluorescent, or LED bulbs
- change the temperature of the solution
- increase or decrease the concentration of sodium bicarbonate in the solution.

2 THE INGREDIENTS OF PHOTOSYNTHESIS – LESSON STEPS

Lesson purpose:

- To investigate the roles of sunlight and carbon dioxide in photosynthesis.

Required prior knowledge for teachers:

- an understanding of the process of photosynthesis and the chemical equation that represents this process
- an understanding of the role of the leaf in photosynthesis.

Learning objectives:

Students will:

- understand photosynthesis and the importance of sunlight, carbon dioxide and the function of the leaf in the process.

Success criteria:

By the end of the lesson, students can:

- understand the different components of the leaf and how it photosynthesises
- understand the essential ingredients for photosynthesis
- predict the outcome of a plant with restricted sunlight and air to the plant
- identify independent, dependent, and controlled variables in an experiment.

Key vocabulary:

- **Stomata:** tiny openings or pores in plant tissue that allow for gas exchange for photosynthesis. Typically found in plant leaves but can also be found in some stems. In Greek stoma means 'mouth'
- **Autotroph:** an organism that can produce its own food.

Materials:

- a copy of *Blocking Photosynthesis Experiment Student Resource* for each student
- *Blocking Photosynthesis Experiment Teacher Resource*
- seedlings
- plastic pots
- potting mix
- black A4 paper
- sticky tape
- petroleum jelly (Vaseline)
- paddle pop sticks/skewers
- *Experiment Template*.

Resources:

- 'Photosynthesis at work, The Private Life of Plants' (David Attenborough) Video – YouTube

LESSON STEPS

Introduction

1. Begin the lesson by sharing a quote from David Attenborough: "Leaves are factories in which plants make their food. All animals depend first- or second-hand on the food produced by plants. This is the very basis of life". Facilitate a class discussion about the statements in the quote. Ask students to share what they know about leaves and ask questions, such as:
    - Do we underestimate the role of plants and leaves when it comes to life on earth?
    - What are the ingredients that the leaf uses to make food?
    - Where does a leaf draw in air (carbon dioxide)?
    - What part inside the leaf produces carbohydrate/sugars for the plant?
    - Where do the sugars travel to after being produced in the leaf?
    - Where does the water travel up from?
2. Watch video **'Photosynthesis at work, The Private Life of Plants'** to prompt further discussion.
3. Draw a leaf on the board and ask students to help you to label the diagram based on the discussions earlier in the lesson. See **Blocking Photosynthesis Experiment Teacher Resource** for support.
4. Discuss the importance of a leaf in photosynthesis with reference to the diagram.

Main body

1. Students will conduct an experiment to block photosynthesis. Provide students with a copy of **Blocking Photosynthesis Experiment Student Resource** and encourage them to use their knowledge of photosynthesis and the materials provided to kill their plant. There will be one control plant and one that is altered.
2. Give students time to read the introduction to the experiment. Introduce/review the concept of 'LAWNS' (in both Student and Teacher Resources) and then ask the question:
    - *Considering the materials provided, what ingredients of photosynthesis could we take away?*

    Students will be taking away both **S**unlight and **A**ir. Guide students towards the possibility that the petroleum jelly can create a barrier to substances (not to sunlight), the paper can block, etc.
3. Review experiment variables (refer to **Blocking Photosynthesis Experiment Teacher Resource**) and share the example provided. Students will need to specify what the variables for this experiment are in the table provided.
4. Students conduct the experiment and record their findings in the table.

Closure and Reflection

1. Facilitate a class discussion. Revisit the question from earlier in the lesson:
    - *Considering the materials provided, what ingredients of photosynthesis could we take away?*
2. Ask questions, such as:
    - What was you approach to the experiment?
    - What predictions did you make? Were these reflected in the results?
    - What variables were present in the experiment?
3. Develop a watering schedule to continue the experiment over several days/weeks.

Optional Extension

- Students to write up their own experiment restricting one other component of 'LAWNS' using the **Experiment Template**.

3 RACE TO THE TOP – INCURSION

Lesson purpose:

- To investigate the adaptations that plants undergo to survive.

Required prior knowledge for teachers:

- the process of photosynthesis and the basic photosynthesis equation.

Learning objectives:

Students will:

- understand that plants adapt to optimise photosynthesis.

Success criteria:

By the end of the lesson, students can:

- identify structural, behavioural and physiological adaptations in plants
- identify independent, dependent and controlled variables in an experiment
- alter variables in an experiment to create a behavioural adaptation in a plant.

Key vocabulary:

- **Germination:** The process by which an organism grows from a seed or spore
- **Phototropism:** 'Photo' means light, while 'tropism' means turning. Phototropism is when a plant will move in response to an external stimulus in their environment. Its hormones create this change in behaviour to take action to survive
- **Structural adaptation:** A change in a physical feature that makes the plant better suited to its environment and enhances its chance of survival. Some examples include spines on a cactus or rose to protect from predators or large leaves to better absorb sunlight
- **Behavioural adaptation:** Actions that a plant takes to optimise its chance of survival. Some examples are phototropism, which is growth towards the light or plant roots which grow downwards and towards water
- **Physiological adaptation:** An internal process that increases a plant's chance of survival. An example is creating poison for defence like the night-shade plant
- **Acute angle:** An angle that is between 0 and 90 degrees
- **Right angle:** A 90-degree angle
- **Obtuse angle:** An angle that is between 90 and 180 degrees.

Materials provided by the school:

- One shoe box per student.

4 HERE COMES THE SUN
(THE ROLE OF THE LEAF) – LESSON STEPS

Lesson purpose:

- To learn about the importance of the leaf in photosynthesis.

Required prior knowledge for students and teachers:

- basic understanding of photosynthesis in plants and the basic equation.

Learning objectives:

Students will:

- understand the function of a leaf in photosynthesis.

Success criteria:

By the end of the lesson, students can:

- label the movement of the raw materials of photosynthesis on a plant
- write the balanced equation for photosynthesis
- identify the parts of a leaf responsible for photosynthesis
- identify the plant that the leaf comes from.

Key vocabulary:

- **Waxy cuticle:** The epidermis secretes the waxy layer, the cuticle, on the two surfaces of the leaf preventing evaporation of water from the leaf surface.
- **Epidermis (plant):** A single layer of cells that covers the leaves creating a boundary between the plant and external environment.
- **Palisade mesophyll:** The layer of plant cells in a leaf, right below the epidermis and cuticle, where most of the *photosynthesis* occurs.
- **Vascular bundle:** Consisting of the xylem and phloem. Provides a transport pathway in the stem for primarily water and nutrients.
- **Spongy mesophyll:** Loosely packed tissue for gas exchange.
- **Stomata:** Tiny openings or pores in plant tissue that allow for gas exchange for photosynthesis. Typically found in plant leaves but can also be found in some stems. In Greek '*stoma*' means mouth.

Materials:

- *Peg the Plant Student Resource*
- *What's inside a leaf? Student Resource*
- Paper and pen/pencil
- Pegs
- Scissors
- Optional: iPad (with *Plant Snap* App installed – 7-day free trial).

Resources:

- 'The Structure of the Leaf' Video – YouTube.

LESSON STEPS

Introduction

1. Facilitate a classroom discussion about photosynthesis. Invite students to use their own words to explain the process. Ask students to describe the similarities and differences between the way plants 'eat' and the way other organisms do.
2. Working in pairs, and using the **Peg the Plant Student Resource**, ask students to cut out the cards. Ask them to find a plant (of a substantial size) and peg the cards on the areas that they believe the substances enter or leave the plant ensuring that the arrows are around the right way. Students finish the activity by writing the equation of photosynthesis. This can either be done on the worksheet provided or students can take a photo of the pegged tree and annotate the equation at the bottom of the photo. Encourage students to balance the equation.
3. Bring the class together and share their visual explanation and equations. Remind students of the importance of the leaf in photosynthesis.

Main body

1. Accompany students on a walk around the school grounds (or elsewhere) and encourage them to acknowledge the different leaves in their environment. Ask them to consider different implications of photosynthesis based on different leaf types/structure.
2. Ask students to choose a leaf. If possible, identify the plant. (Optional: use *Plant Snap* App to identify plant – this works best when you can also take a photo of the flower, blossom, fruit etc.).
3. Ask students to draw their leaf to scale and front and back on the **What's inside a leaf? Student Resource**. Ask them to draw all the details: lumps, colours, shape, veins, etc. Label the leaf with information from *Plant Snap* if used. Encourage students to write down statements and questions that relate to their leaf and leaves in general. Write some of these questions on the board and discuss share any answers.
4. Watch video **'The Structure of the Leaf'** to explore the leaf in more detail.
5. Ask students to label their leaf using the information from the video. Label the following:
    - *Palisade Mesophyll*
    - *Spongy Mesophyll*
    - *Stomata*
    - *Vascular bundle*
    - *Epidermis cells* and *waxy cuticle*
6. Ask students to also indicate on their leaf:
    - the direction and entry of carbon dioxide
    - the direction and entry of water.

Closure and Reflection

1. Facilitate a class discussion. Ask questions., such as:
    - What would happen to life on earth without leaves?
    - How important are leaves for the wellbeing of earth and all living creatures?
2. **Optional:** Watch **'The Photosynthesis Song'** video to end the session.

Optional Extension

Optional Extension

- Read and discuss **'Do All Plants Use Chlorophyll'** article.

5 FINDING LIGHT IN THE OTWAYS – LESSON STEPS

Lesson purpose:

- To consolidate understanding of photosynthesis in the Otways National Park.
- To explore the internetworking nature of plants all existing and surviving together as a rainforest.

Required prior knowledge for students and teachers:

- the process of Photosynthesis and awareness that plants adapt to optimise intake of sunlight

Learning objectives:

Students will:

- understand the adaptation that different plants undergo within a rainforest
- understand the interconnected nature of a rainforest.

Success criteria:

By the end of the lesson, students can:

- identify plants in the emergent, canopy, midstory, understory and ground cover layers of the Otway National Park
- identify an adaptation that plants undergo in the specific layers in the rainforest to best photosynthesise
- use a simple ratio to draw their plant to scale.

Key vocabulary:

- **Rainforest:** A dense forest rich in biodiversity, found typically in tropical areas with consistently heavy rainfall.
- **Otway National Park:** A national park located in the South West region of Victoria, Australia. The 103,185-hectare (254,980-acre) national park is situated approximately 162 km southwest of Melbourne, in the Otway Ranges, a low coastal mountain range. It contains a diverse range of landscapes and vegetation types
- **Ratio:** A comparison of two or more numbers that indicates their sizes in relation to each other
- **Layers of the rainforest:** Refer to *Finding Light in the Otways* Teacher Resource.

Materials:

- A copy of the *Photosynthesis in the Rainforest Student Resource* for each group
- *Finding Light in the Otways Teacher Resource*
- A1 poster paper
- A4 paper for each group
- scissors
- coloured pencils
- glue.

Resources:

- **Back to nature – Episode 6 (Rainforest and Rock)** video – ABC iView (You will need a free iView account)
- **Otway Greening (Australian Native Plant Nursery)** website

Introduction

1. As a class, watch **Back to nature – Episode 6 (Rainforest and Rock)** on ABC iView. This takes place in the Otway National Park. Watch until the end of the California Redwoods (9:27).
2. Invite students to share how they felt 'walking' through the Otway rainforest. Start by reiterating that the presenter felt like the ferns were 'Grandma tree ferns, always arms open, always welcoming' and she felt like she was coming home to her late Grandmother. Ask students which feelings it evoked for them.

Main body

1. Introduce the **Let's build a rainforest** activity. The end product of this activity will be a whole-class poster. Students will work in pairs and each pair will take on a different Otway rainforest plant. They will draw the tree to scale and include some supporting information below their tree.
2. Students will use the **Otway Greening (Australian Native Plant Nursery)** website to choose their plant. The pairs in the class will be divided into 3 groups (i.e. 4 pairs each group) to cover 3 different Otway areas (Otway foothills, Otway Ridge and Coast). Within these three areas each pair will take on a different rainforest layer (Trees, Midstory, Understory, Groundcover and Climbers). If there is an extra pair they can take on Manna Gum in the Emergent layer. Students can choose their tree from their designated layer.
3. If students need assistance with working out the height of their tree (using ratio 2cm human in our forest:170cm human in real life) do the ratio calculations on the board (refer to **Teacher Resource**) and then students can work out the size of their individual plant.
4. Stick each pair's plant on the poster with their supporting information below. See example rainforest poster in **Teacher Resource**.

Closure and Reflection

1. Present the poster to the whole class and invite pairs from each layer to share their adaptation their plant takes on to best photosynthesise.

Optional Extension

Students can research another adaptation their plant (rainforest layer) takes on to optimise photosynthesis.

Post unit ideas

- Visit a local market garden. Learn about the role of greenhouses to enhance sunlight and therefore photosynthesis.
- Visit a local nursery. Learn about different plants and their adaptations for photosynthesis.
- Visit botanical gardens. Learn of the different species of plants and how they best photosynthesise.
- Visit a National Park. Experience the different layers in vegetation and learn how they work together for photosynthesis.

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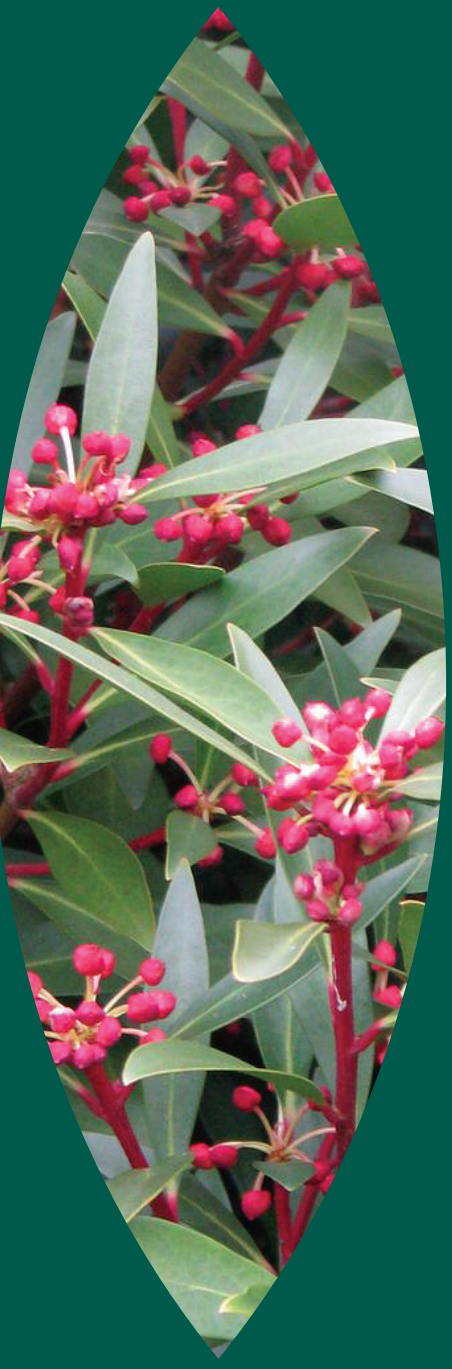
THE WORLD OF PHOTOSYNTHESIS

TEACHER AND STUDENT RESOURCES



AGRICULTURE VICTORIA

1 REAL-TIME PHOTOSYNTHESIS
TEACHER RESOURCE

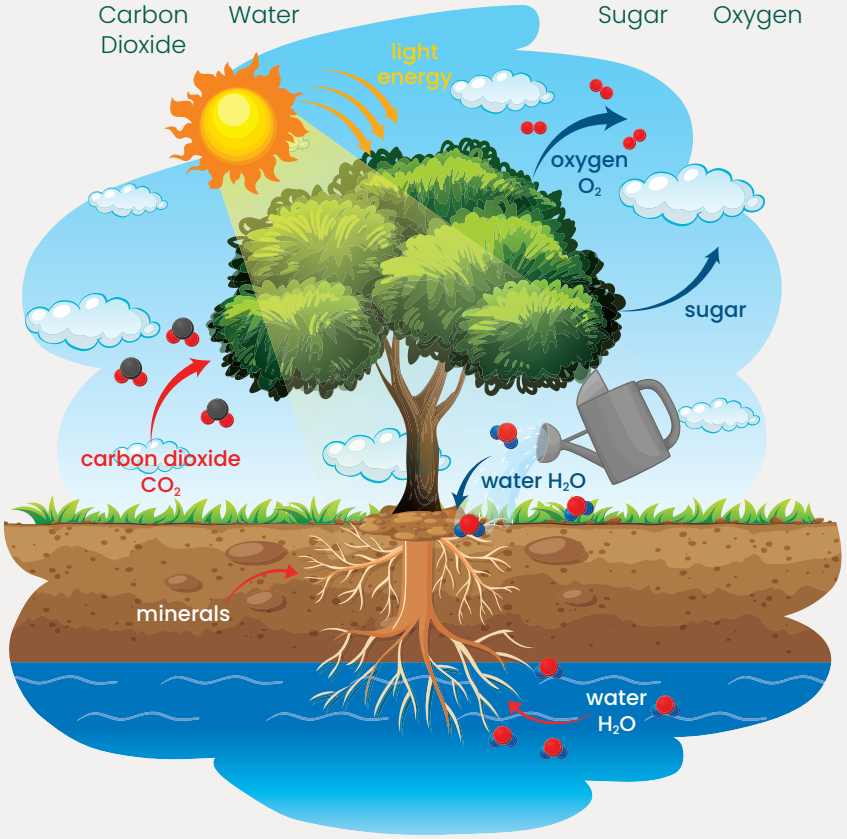
Photosynthesis:

The process by which plants convert radiant energy (light energy) from the sun into chemical energy in the form of glucose (sugar). To do this they use sunlight, water, and carbon dioxide to create oxygen and energy/glucose.

Photosynthesis

$6CO_2 + 6H_2O + \textit{light energy} \rightarrow C_6H_{12}O_6 + 6O_2$

Carbon Dioxide | Water | Sugar | Oxygen



Real-time Photosynthesis Experiment:

Find experiment instructions on the Student Resource handout. If needing more guidance on technique please refer to **Photosynthetic Flotation (Exploratorium)** (Video).

*Please note there are a few different measurements. Using the measurements on the Student Resource will make it easier for students to measure.

Results:

The spinach discs should rise to the surface of the water. The graph will show at what time (x axis) each disc rose the surface (y axis).

$6CO_2 + 6H_2O + \textit{light energy} \rightarrow C_6H_{12}O_6 + 6O_2$

Discussion Questions:

1. **Why was sodium bicarbonate added to the water?**

   To add carbon dioxide to the water

2. **What three things did you give the spinach leaves for them to perform photosynthesis?**

   Carbon dioxide (sodium bicarbonate), water and sunlight

3. **What was the reason the spinach discs rose to the surface?**

   Accumulation of oxygen caused then to rise to the surface

4. **Why did the spinach leaves rise to the surface when first drawn in by the syringe?**

   Leaves naturally have air in them which makes them float

5. **Why was a vacuum applied to the discs?**

   When you apply a gentle vacuum to the leaf disks in solution, this air is forced out and replaced with solution, causing the leaves to sink.

6. **What do you think happens to the spinach discs when you take away the light source?**

   When you put floating leaf disks in the dark, they will eventually sink. Without light energy, no photosynthesis will occur, so no more O_2 gas will be produced

Conclusion:

Due to the sodium bicarbonate giving the leaves carbon dioxide and then exposing them to sunlight the leaves rose to the surface due to the accumulation of oxygen, a product of photosynthesis.

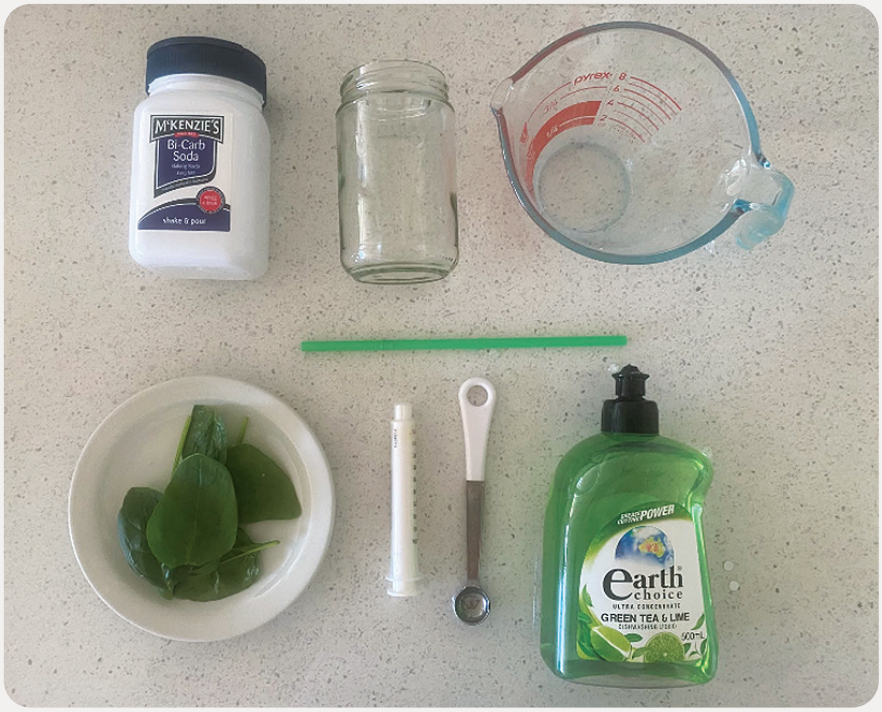
1 REAL-TIME PHOTOSYNTHESIS
STUDENT RESOURCE

Watch photosynthesis happen before your eyes! All we need is a little carbon dioxide, water, and sunlight to see this amazing process take place in our leaf discs. In the future this reaction and conversion of energy might not only be exclusive to plants but to our future solution to making fuel. One day photosynthesis and a bionic leaf may be able to power our cars.

Let's watch this reaction take place.

Experiment Materials:

- Spinach leaves – supermarket bought is fine (make sure they have been in the dark prior to using, e.g. in fridge, container or wrapped in foil)
- Hole punch or hard plastic straw
- Liquid dishwashing detergent (1 drop)
- Bicarbonate soda (sodium bicarbonate)
- 1 measuring cup
- 1 plastic syringe (10ml, no needle)
- 1 jar or clear cup
- 1 measuring spoon
- A timer
- Sunshine ***



Method:

Step 1

Measure 300 ml of water in the measuring cup. Add ⅛ teaspoon of bicarb soda. Mix with the spoon until the bicarb soda has dissolved. Once the baking soda has dissolved it will release *carbon dioxide* which will be used by the spinach for *photosynthesis*.

Step 2

Add a drop of liquid dishwashing detergent to your bicarb and water solution and gently stir. Avoid foam formation in your cup.

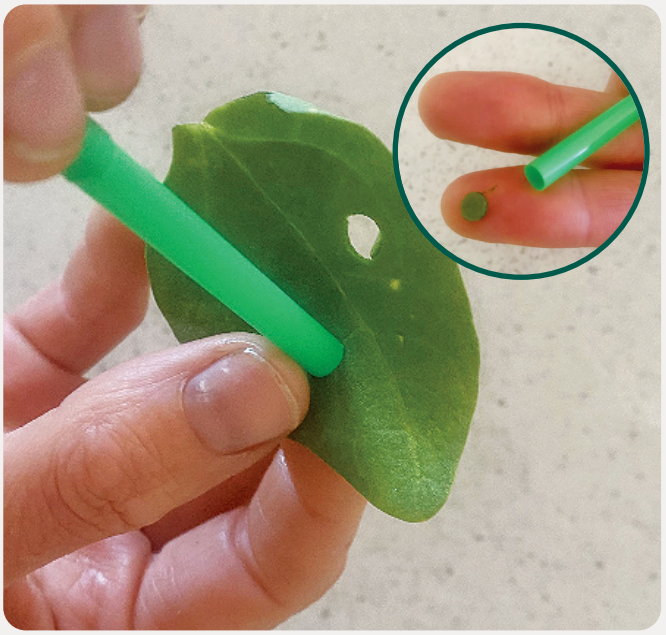
Step 3

Pour half (150mL) of your bicarbonate solution/ detergent/water solution into your jar/clear cup. Do this gently to avoid suds forming.

If the solution forms lots of suds, add more baking soda solution until you stop seeing bubbles.

Step 4

Using the hard straw or hole punch, create 15 discs from the spinach leaves. Avoid the edges of the leaves or major veins. You want smooth, flat disks.



Step 5

Remove the plunger from the syringe and add the spinach discs into the syringe

Step 6

Replace the plunger in the syringe and slowly depress it to expel as much air as you can without crushing the leaves.

Step 7

Dip the tip of the syringe in the bicarbonate/detergent mixture in the measuring cup and pull in about 7 mL of liquid. Gently tap the syringe to suspend the leaves in the solution. Watch as they float to the top. This happens because leaves naturally have air in them.

Step 8

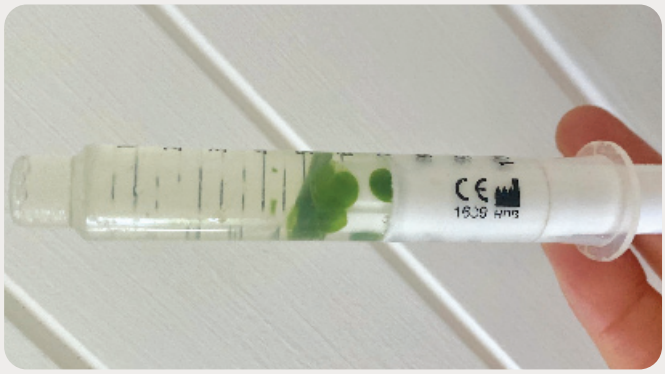
Push the plunger to expel excess air then place your finger over the end of the syringe and pull back on the plunger to create a vacuum. This will take the air out of the leaves and replace it with solvent.

Step 9

While keeping your finger over the tip to maintain the vacuum, swirl the leaf disks in the syringe. After 10 seconds, remove your finger (release the vacuum).

Step 10

To ensure the leaves take up the *carbon dioxide* from the baking soda solution, repeat steps 8 and 9. You should see the discs sinking to the bottom of the syringe when they are ready for the demonstration. If this does not happen, you may need to start over, using fresh discs and a new solution that has more baking soda.



Step 11

Pour the discs into the jar or cup with the bicarbonate/ detergent mixture and watch them sink to the bottom. Make sure they don't stick to the sides of the cup and gently dislodge any that do.

Step 12

Expose the cup to sunlight for several minutes. This can be on a very sunny windowsill or outside. If it is quite cloudy you can use artificial light here. Start a timer when the jar is placed in the sun. Observe what happens as the spinach discs perform photosynthesis and give off oxygen. Document the time that each disc makes its journey. You will graph this in your results.

Step 13

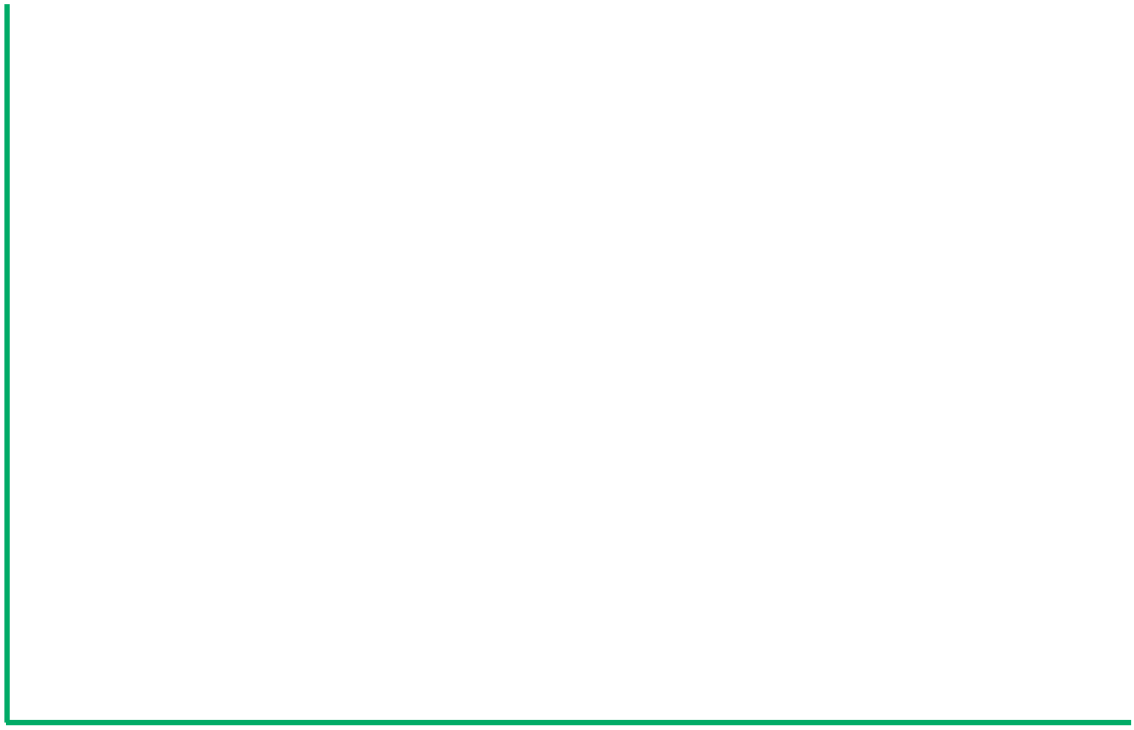
If there is time, try putting the jar in the dark or wrapping it in foil and see what happens!

Results

What happened to your spinach discs?

Graph

Graph the rate of rising of spinach discs. The x axis is time and the y axis is the number of discs.



Write the equation that took place (balanced equation):

Questions

1. Why was sodium bicarbonate added to the water?

2. What three things did you give the spinach leaves for them to perform photosynthesis?

3. What was the reason the spinach discs rose to the surface?

4. Why did the spinach leaves rise to the surface when first drawn in by the syringe?

Questions

5. Why was a vacuum applied to the discs?

6. What do you think happens to the spinach discs when you take away the light source?

Conclusion (write your own conclusion here):

Resource

This experiment was originally described in Steucek, Guy L., Robert J. Hill, and Class/Summer 1982. 1985. "Photosynthesis I: An Assay Utilizing Leaf Disks." *The American Biology Teacher*, 47(2): 96–99.

2 THE INGREDIENTS OF PHOTOSYNTHESIS – TEACHER RESOURCE

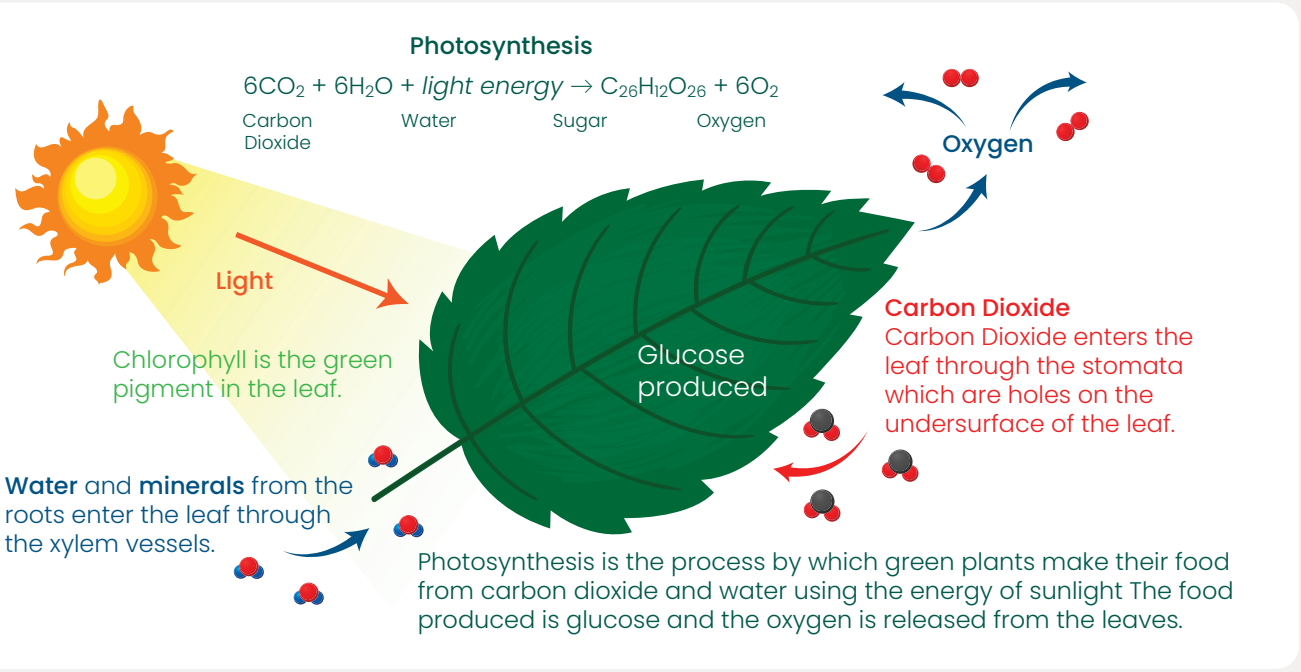
Photosynthesis:

The process by which plants convert radiant energy (light energy) from the sun into chemical energy in the form of glucose (sugar). To do this they use sunlight, water, and carbon dioxide to create oxygen and energy/glucose.

Label a Leaf Activity:

Questions:

- **What are the ingredients that the leaf uses to make food?**
  Air (carbon dioxide), water, sunlight and minerals
- **Where does a leaf draw in air (carbon dioxide)?**
  Through the surface of the leaf (underneath), through the stomata
- **What part inside the leaf produces carbohydrate/sugars for the plant?**
  Chlorophyll
- **Where do the sugars travel to after being produced in the leaf?**
  To the body of the plant
- **Where does the water travel up from?**
  Up through the stem, through the vascular bundle/xylem vessels
- **Write the equation of photosynthesis below your leaf.**



Blocking Photosynthesis Experiment

Choosing seedlings:

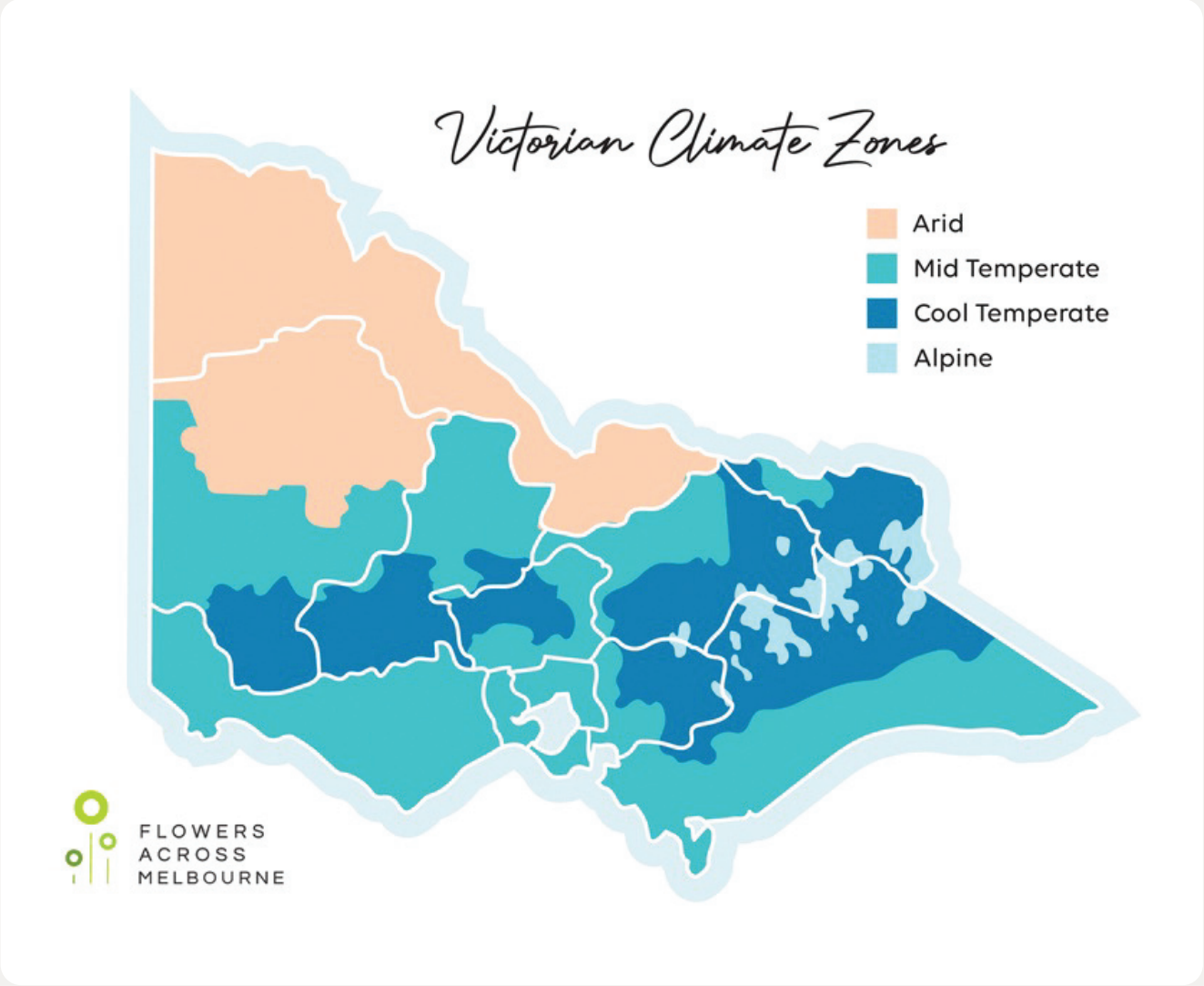
As per the experiment, it recommends either using a common bean plant seedling or a brassica seedling. You will have to be mindful of your climate zone (refer to diagram below) and the time of you when it comes to choosing the correct seedling.

Green bean seedlings available:

- Temperate climate: Sept - Feb
- Arid - Aug - Feb
- Cool - Nov -Jan

Brassica seedlings available:

- Temperate climate: March - Aug
- Arid - Feb - Sept
- Cool - April - Aug



Information sheet

Plant's essential ingredients to survive can be remembered using the following:

L - Light

A - Air (Carbon Dioxide)

W - Water

N - Nutrients

S - Soil

This experiment poses the challenge - Who can kill their plant the fastest?

With the materials given, students should be restricting both **Light** and **Air**. The black paper can be used to cover the leaves and plant (in the form of a box or closed cylinder) and the vaseline can be put on the bottom side of the leaves to restrict air flow into the leaf.

Variables

- Independent – The variable that is changed – **Sunlight and air reaching the plant.**
- Dependent – The dependent variable is 'dependent' on the independent variable. If you change the independent variable, the effect on the dependent variable is observed and recorded - **The growth of the seedling.**
- Controlled – Any variable that is kept constant/not changed – **Water and location**.

Example – An experiment to see the amount of water necessary for a basil plant to survive. The amount of water is changed by the scientist. This is the independent variable. How the plant reacts to the different water amounts (survival or not) would be the dependent variable. The controlled variable would be the same location/same amount of sunshine.

2 BLOCKING PHOTOSYNTHESIS EXPERIMENT– STUDENT RESOURCE

Who can kill their plant the fastest?

Plants use sunlight, water and carbon dioxide to create oxygen and energy in the form of sugar (glucose). The amazing process is photosynthesis. The leaf is the powerhouse of this creation of energy, soaking up sunlight and drawing in air through the stomata which are the tiny holes on the surface underneath. Unlike animals, plants are autotrophs which means that they create their own food source. But what will happen when we take away two of the main ingredients?

The essential ingredients that plants need to survive can be remembered using the following:

L - Light

A - Air (Carbon Dioxide)

W - Water

N - Nutrients

S - Soil

Here's your challenge

Try and race your fellow classmates to kill your plant! All you have is one piece of black A4 paper, four ice cream sticks or two skewers, petroleum jelly, scissors and tape, along with your knowledge of photosynthesis and the importance of sunlight and the leaf.

But there are a few rules. You can't harm your plant in any way, it cannot change shape (bend) and the amount of water and the location of the plant has to stay the same.

Before we begin, let's think about this question:

Considering the materials given, what ingredients of photosynthesis do you think we can take away?

EXPERIMENT

Observe the differences in the growth of seedlings when two very important ingredients are taken away.

Hypothesis

What do you think will happen to your seedling when taking on this challenge? What will the process be?

Materials:

- Green bean seedling or brassica seedling (broccoli, cauliflower or cabbage)
- A small plastic pots/cups
- Potting soil
- Petroleum jelly (Vaseline)
- Scissors
- 1 A4 piece of black paper
- Masking tape or sticky tape
- Four ice cream sticks or two wooden skewers

Method:

Step 1:

Working in pairs, fill your pot with potting mixture and plant a seedling in the pot. Make sure that each plant is similar in size. If you are using brassica seedlings, decide as a class how many leaves the plant should have and carefully remove any of these excess leaves if needed (4 leaves is generally enough). There will be one control plant planted for the whole class. This can be done by the teacher or a student.

Step 2:

Now it's up to you! Using your materials, do what you feel is the best way to restrict sunlight and air to your plant. The sticky tape is just to adhere to the paper, not the plant, and remember you cannot harm your plant.

Step 3:

Place in a sunny spot so that each plant gets the same amount of sunlight reaching it. This could be at school or home. Water the plants every couple of days (everyday if hot) with a small amount of water to keep the soil moist and observe what happens.

EXPERIMENT TEMPLATE

Title

You should make sure you title tells the reader what the experiment is trying to achieve.

For example, if the experiment is to determine the amount of water necessary for a sunflower growth your title would be 'The amount of water necessary to grow a sunflower'

Purpose

This section gives a little more information about the experiment. What is the point of the experiment? What are you trying to find out? Is there a scientific theory linked to this experiment?

Hypothesis

What do you think your results will show?

Equipment

List equipment used.

Variables

Independent- The variable that is changed

Dependent – The dependent variable is 'dependent' on the independent variable. If you change the independent variable, the effect on the dependent variable is observed and recorded.

Controlled - The variable that is kept constant.

Example – An experiment to see if the brightness of light has any effect on a moth being attracted to light. The brightness of the light is changed by the scientist. This is the independent variable. How the moth reacts to the different light levels (distance to light source) would be the dependent variable. The location of the light is constant which is the controlled variable.

Independent

Dependent

Controlled

Method

What you plan to do. Write your step-by-step instructions.

Results

What happened? Attach measurements, tables or graphs to this sheet.

Conclusion

What you found out doing the experiment.

3 RACE TO THE TOP
Incursion

Prediction	Result	Variables
Illustrate what you think your plant will look like in two weeks when removing materials.	Illustrate what your plant looks like in two weeks.	Let's list our variables: **Independent** **Dependent** **Controlled**

Conclusion

What was your end result?

4 HERE COMES THE SUN
(THE ROLE OF THE LEAF) – STUDENT RESOURCE

Peg the plant

1. Cut out the four labels below.
2. Find a plant (of a substantial size) and peg the cards on the areas you believe the substances enter or leave the plant. Ensure the arrows are around the right way.
3. Write the equation of photosynthesis.

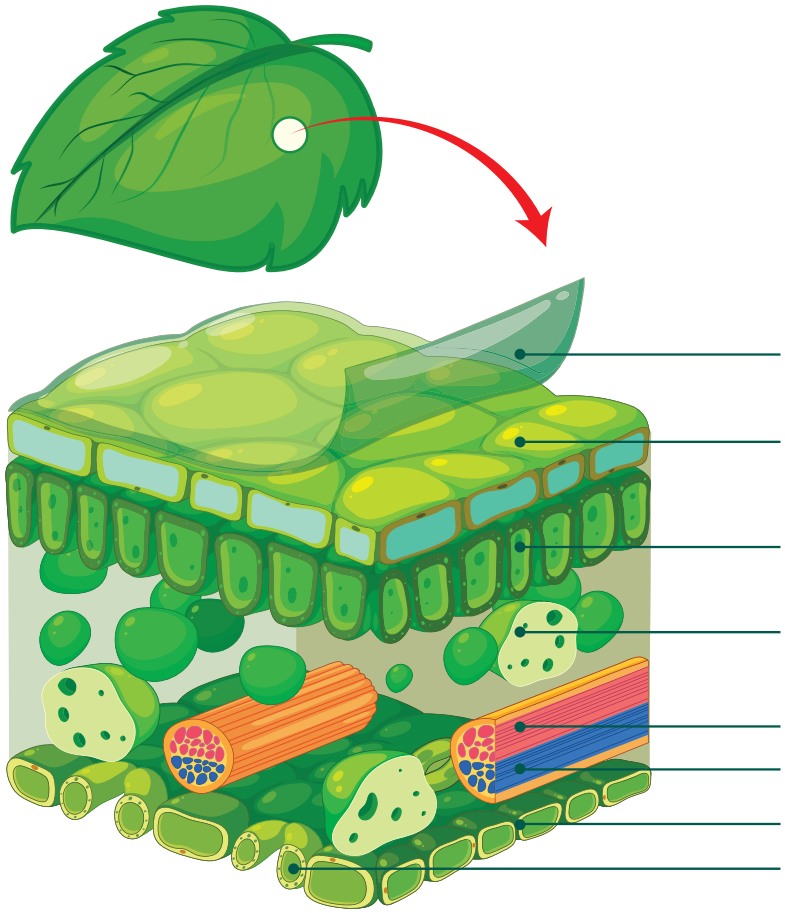
Oxygen O_2 →	Carbon Dioxide CO_2 →
Water H_2O →	Glucose $C_6H_{12}O_6$ →

4 HERE COMES THE SUN
(The role of the leaf)

What's Inside a Leaf?

Illustration of a leaf (front and back)

Inside the leaf



Name of plant	**Flowering time** (if applicable)

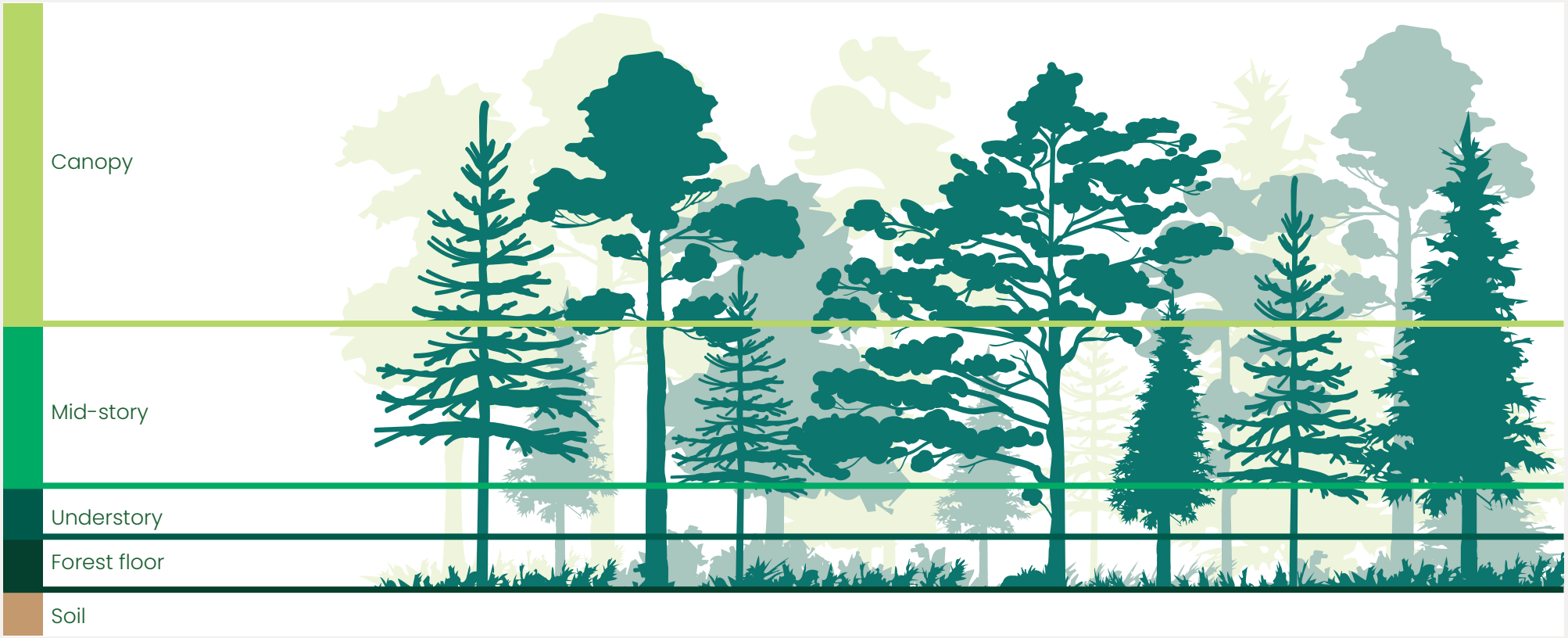
5 FINDING LIGHT IN THE OTWAYS

'Let's Build the Otways Rainforest' activity

Ratio calculations:

- Ratio is – 2cm human in our rainforest (170cm human in real life)
  - 170cm/2 = **85**
  - Students to find height of tree on Otways Green website and convert to cm as this is easier (100cm in 1m). Example 25m tree = 2500cm tree
  - Divide their tree (in cm) by 85. 2500/**85** = 29cm
  - Students, for this tree, to draw with a height of 29cm

Rainforest layers



5 FINDING LIGHT IN THE OTWAYS

'Let's Build the Otways Rainforest' activity

Rainforest layers

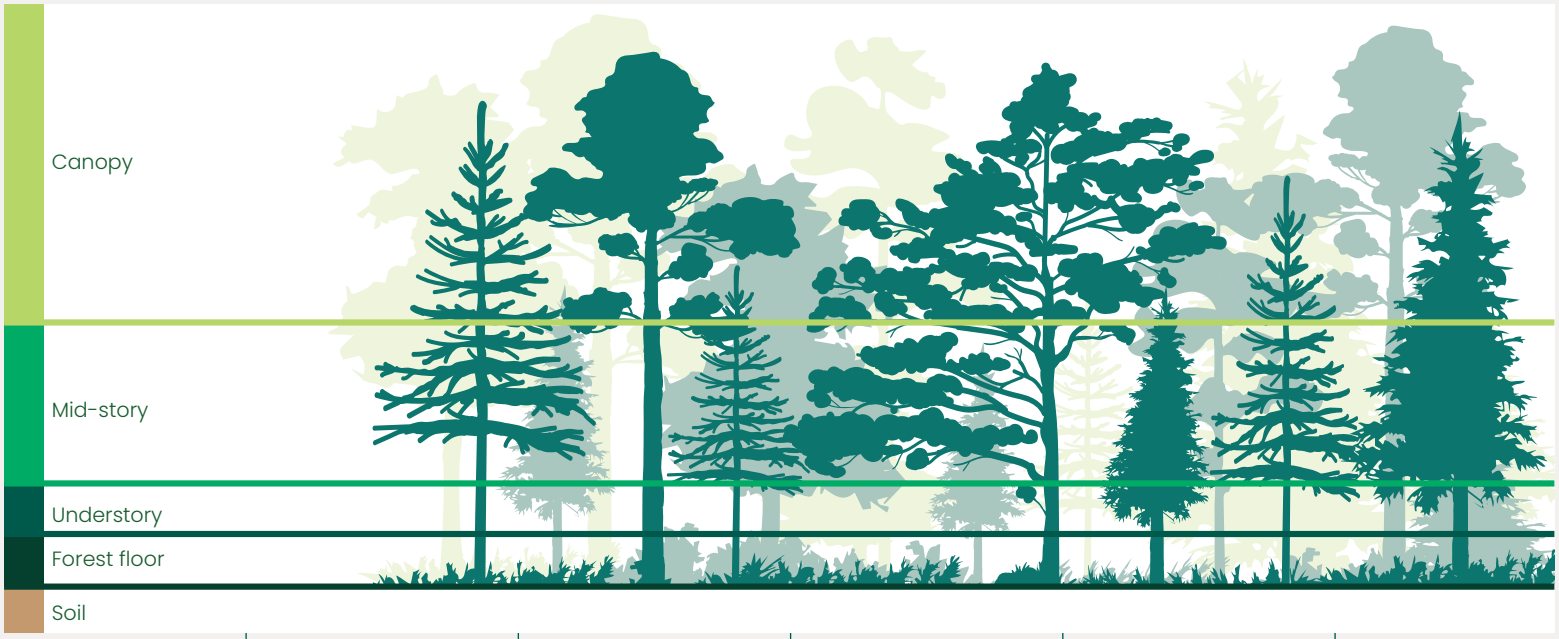
Emergent layer	Canopy (upper tree)	Mid-story/substory	Understory	Forest floor/Ground cover (where climbers originate)
Trees whose crowns emerge above the rest of the canopy. These trees can grow 70-100m from ground level. These trees stretch to the top of the rainforest, not wasting energy on producing branches until they reach the canopy and above.	The top layer of forest formed by the leaves of the tallest trees. Up to 35% of the rain falling on a forest is intercepted by the canopy. A healthy forest canopy is better able to provide ecosystem services, like absorbing carbon and air pollutants from the atmosphere. An interlocking network of sun-hungry leaves. The solar panels of the rainforest. Only between 3–15% of sunlight penetrates the canopy and reaches the midstory. Not all light is captured by the upper leaves. So as not to be sun damaged the top leaves are often held more upright and the bottom leaves more horizontal to catch the light.	Trees found one layer lower, the next generation of trees for the canopy. Provides a sheltered space for birds and small animals to travel. Only between 3–15% of sunlight penetrates the canopy and reaches the midstory. Leaves are held more horizontal to catch the light that comes through the canopy.	Smaller trees, saplings, shrubs, vines, and other vegetation. This layer is what can thrive despite the fact that not much light gets through the canopy and midstory (2–5%). These plants also help keep the soil below moist so it's easier for more new plants to grow. This limited light encourages the plants to create unique ways to survive. Ferns in the understory have large and deeper green leaves to attract more sunlight for photosynthesis.	Ground cover includes moss, flowers, mushrooms, twigs, fallen trees, animal scat and leaf litter. Insects, bacteria, earthworks, fungi breakdown waste material to reuse throughout the forest system. Very little sunlight filters through this area. Research shows that forest floor plants switch their photosynthesis on quicker when sunflecks (patches of sunlight that hit the forest floor for a few seconds) hit them and continue to photosynthesise longer after the light has gone.

5 FINDING LIGHT IN THE OTWAYS

'Let's Build the Otways Rainforest' activity

Example of the rainforest poster

Layers of therainforest



Instructions

- A1 paper
- Leave 22–25cm height for the green rectangle at the bottom for information
- Label the rainforest layers on the left-hand side as above. No need to label soil
- 10cm x 10cm white information boxes
- Heading at the top.

5 PHOTOSYNTHESIS IN THE RAINFOREST– STUDENT RESOURCE

The rainforest in the Otway National Park is an amazing network of plants. There is fierce competition for sunlight and vital energy and all plants take on many adaptations to optimise the absorption of sun. They are hungry for sunlight!

The canopy of the forest is a huge collection of solar panels, so efficient that only 3–15% of sunlight penetrates it. If you walk through a rainforest and look closely you will see trees growing up straight without branching outwards until they reach the canopy, the leaves of ferns in the understory are large to absorb more sunlight and saplings spiral out from the trunk with each new layer avoiding shading lower layers.

Almost all the oxygen in earth's atmosphere has been derived from photosynthesis over the past two billion years. And during a day, a hectare of forest can cycle 500,000 litres of carbon dioxide. Our rainforests are so very precious, not only providing a home for thousands of species of animals but vital in giving us the air we breathe.

STUDENT RESOURCE

Let's build a rainforest together

As a class collectively make a poster of our amazing Otway forest by using the information provided. Working in pairs, each one will take on one Otway forest plant and you will make a cut out diagram to stick on the whole class Otway forest poster accompanying it with some information about how it fights for light!

Use the **Otway Greening (Australian Native Plant Nursery)** site to find your plant.

https://otwaygreening.com.au/plant_lists.html

Step 1:

1/3 of the class pairs can choose a plant from each of the following areas:

- Otway Foothills (this area is on the edge of the Otways forest)
- Otway Ridge
- Coast

Click on the area to find the lists of plants.

Step 2:

Within the Otway area that you have been designated make sure that there is one pair that takes on each of the following rainforest plant types:

- Trees
- Midstory
- Understory
- Climbers and Groundcovers

There is an amazing tall tree called the Manna Gum that is in the emergent layer (above the tree top canopy) in the Otway Ridge. Definitely one of koalas' favourite trees. If there is an extra pair needing a plant this is a great one to add.

- Emergents (Manna Gum)

Otway Green – Manna Gum Factsheet

Step 3:

Let's draw our trees to scale. We will draw in proportion to a human. In your forest a human is 2cm tall. In real life the average height of a human is approximately 170cm. Use your ratio calculations to work out the height of your tree **Ask you teacher to assist with these calculations if needed.*

Draw your tree the correct size on your A4 piece of paper and cut it out.

Step 4:

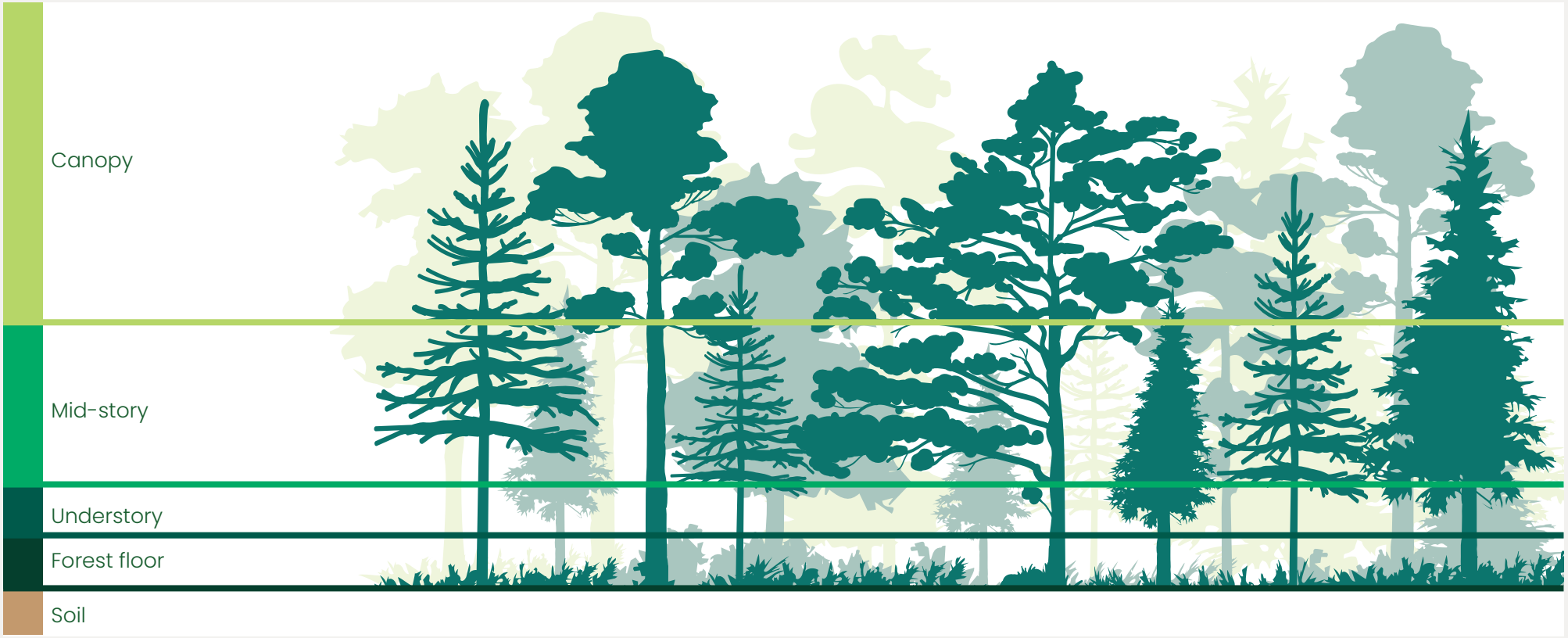
Now it's time to add your information. In an information block under your tree (10cm x 10cm white box) include the following:

- The name of you plant – Common name and Botanical name
- Height of your plant
- Its environmental conditions
- One fact about an adaptation that your plant takes on to optimise absorption of sunlight. This can be a general fact about the rainforest layers.

5 FINDING LIGHT IN THE OTWAYS

'Let's Build the Otways Rainforest' activity

Rainforest layers



5 FINDING LIGHT IN THE OTWAYS

'Let's Build the Otways Rainforest' activity

Rainforest layers

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Nursery & Garden Industry Victoria

Unit 3. 307 Wattletree Road, Malvern East VIC 3145

E: ngiv@ngiv.com.au | **T:** (03) 9576 0599 | **ngiv.com.au**

AGRICULTURE VICTORIA

This project is supported by the Secondary Schools Agriculture Fund, which is funded by Agriculture Victoria as part of the Victorian Government's four-year $50 million Agricultural College Modernisation Program.