Royal Academy of Engineering

THIS IS ENGINEERING

IN THE NATURAL WORLD

The Living Planet

2 ZERO HUNGER

3 GOOD HEALTH AND WELL-BEING

6 CLEAN WATER AND SANITATION

12 RESPONSIBLE CONSUMPTION AND PRODUCTION

BEN CROWTHER

FARMING FUTURIST

CO-FOUNDER OF LETTUS GROW

BEN IS THE CO-FOUNDER OF LETTUS GROW.

He is passionate about the environment, developing a new way to farm using less water to feed more people and reducing the carbon footprint of farming.

Engineering is not all metal and hard hats! You need to enjoy problem-solving and have a creative mindset.

Learn more about how engineers are finding ways to protect the planet by scanning the QR code or visiting the This is Engineering website.

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ACTIVITY 2
THE LIVING PLANET

GERMINATION HAPPENS WHEN A NEW PLANT GROWS FROM A SEED.

All seeds need three conditions to germinate successfully.

Water, Oxygen and Warmth = WOW!

Getting the right balance for conditions is important to grow crops and contribute to a diverse eco-system.

Engineers play an important role in food production, contributing to the productivity, safety, sustainability, and quality of the supply chain.

LINKING TO THE CURRICULUM

Science

Biology: pupils learn about the life-cycles of plants, the conditions necessary for germination and photosynthesis during stages of plant growth.

Geography

Climate and weather: germination, evaporation and photosynthesis are relevant when studying ecosystems, agricultural practices, and how different climate and weather patterns affect plant growth.

Technology and computing

Practical skills: pupils design and build a physical device using tools and materials, understand construction techniques and apply principles of coding and electronics. They learn how to write and test code blocks, developing their programming skills.

ACTIVITY 2.1 GERMINATION

Growing your own plants from a seed requires understanding and controlling several key factors.

Investigate these conditions and record your findings.

Time to investigate

In pairs, begin by discussing your prediction on whether it is possible for corn seeds to germinate (sprout) in water without soil, or in moist or dry cotton wool.

Construct the two-compartment seed observation chamber (in the box).

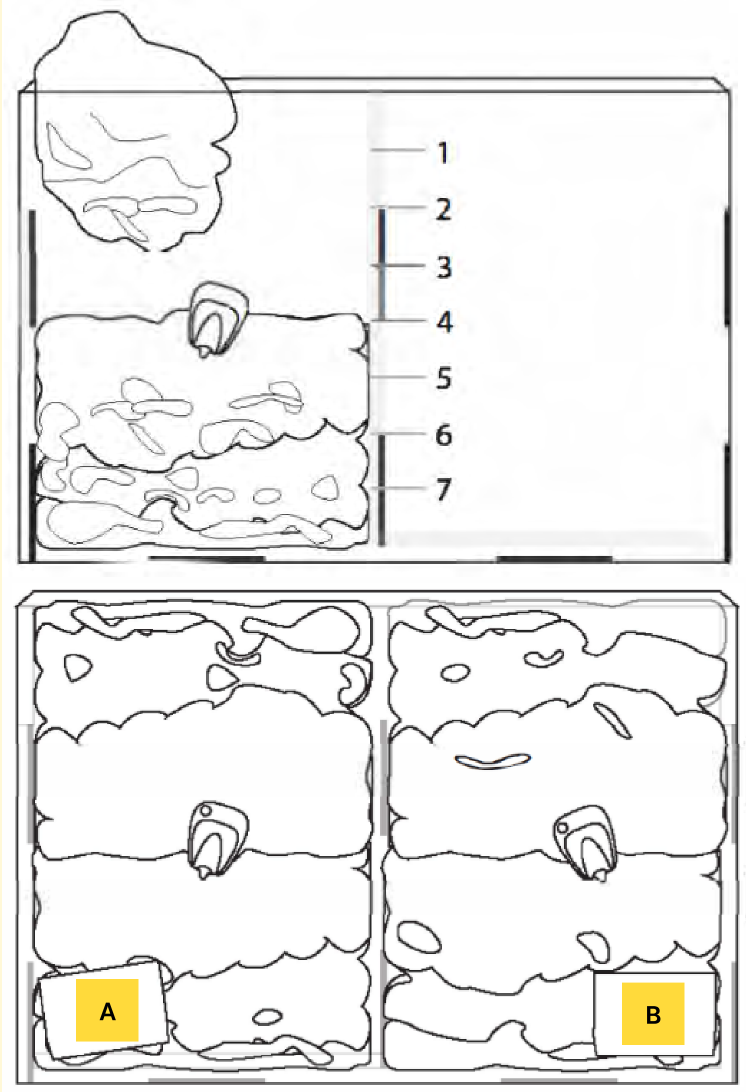
In one compartment, pack the cotton wool halfway down and push one corn seed through the container so it rests on the cotton wool, making sure the hilum (pointed end of the seed) is in contact with the cotton wool.

Add more cotton to fill the compartment.

A DXF file to laser cut more germination kits can be downloaded from the **resource website**.

Repeat these steps in the second compartment, but do not add water.

Label the wet compartment as **'A'** and the dry compartment as **'B'**.



TIME TO OBSERVE

Leave the setup to stand for one week, keeping the cotton wool in compartment 'A' always wet.

Record your observations as regularly as possible, taking into account the following:

- The dry seed coat and when it absorbs water to swell.
- Rupturing of the seed coat and sprouting of the root.
- Sprouting of the stem and seed leaves.
- The elongation of the root and stem.

TIME TO REFLECT

1. How did the growing conditions influence seed germination, and how do they interact with each other?
2. In what ways do human activities (pollution, climate change, urbanisation) impact the conditions necessary for seed germination?
3. What enhanced germination processes could be introduced to accelerate the growing conditions?

ACTIVITY EXTENSION

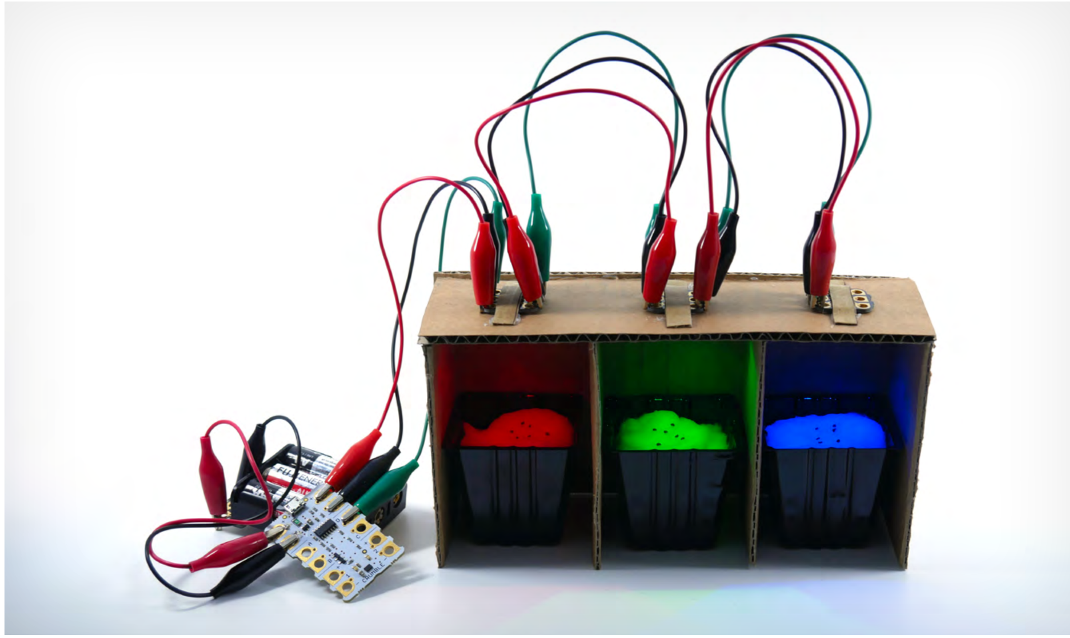
Growing plants under artificial light

Use the Crumble kit and LED pack in the box to grow cress seeds under artificial light. Fill three pots with damp compost and sprinkle the seeds on top.

Build a containment centre similar to the one shown in the diagram, and program the Crumble to shine blue, green and red light onto the pots. Leave the seeds to germinate.

- Does artificial light accelerate the germination cycle?
- Which colour of light accelerates the process the most and the least?
- Why is this?

Example of a Crumble program here which turns the Sparkle lights on and then off for four hours. Try different colours/combinations, the length of a simulated day (lights on/off) etc.



ACTIVITY 2.2 DESALINATION

FRESH WATER IS ESSENTIAL TO LIFE AND A HEALTHY ECOSYSTEM. IT'S PART OF OUR EVERYDAY LIFE, OUR HEALTH AND WELLBEING. APPROXIMATELY 71% OF THE EARTH'S SURFACE IS COVERED BY SEAWATER.

Water is in all living things. Our bodies are made up of more than 60% of water, regulating our body temperature, helping us digest food, and getting rid of waste and toxins our bodies do not need.

Plants are made up of between 80 and 95% water. This is essential for their survival and growth.

Engineers play an important role in finding sustainable ways to use water in our interactions with the environment and in developing solutions to address climate change.

TIME TO INVESTIGATE

Some environments are less suitable for farming because of a lack of water resources and extreme high temperatures. In pairs, start by discussing:

- How will climate change affect growing conditions?
- How could crops grow in urban and industrial cities?
- How could an ample source of seawater be used to support growing plants and crops?

TIME TO EXPERIMENT

Seawater contains around 35 grams of salt per litre. If separated, the water can be used to support life on earth and grow crops. The salt can be used to preserve food and in medicines. This scientific process is called:

- **Condensation:** the process where water vapour changes back to liquid.
- **Evaporation:** the process where water changes from a liquid to a gas.

EXPERIMENT 1: CONDENSATION – CREATING SALT FREE WATER

1. Divide pupils into small groups or pairs.
2. Fill a heat resistance cup or glass ¾ full of tap water.
3. Add two tablespoons of salt and two drops of food colouring. Stir until dissolved to create murky seawater.
4. Pour the seawater into a kitchen saucepan and place the cup in the centre of the saucepan. The cup should be empty and clean.
5. Place the saucepan lid upside down on the saucepan so that the handle is positioned directly above the cup.
6. Turn on the stove and heat the seawater to its boiling point (100+ degrees Celsius). Alternatively, place the saucepan in sunlight or on a radiator. This will take longer to see results.
7. Note the water droplets on the underside of the lid and any water collected in the small bowl.

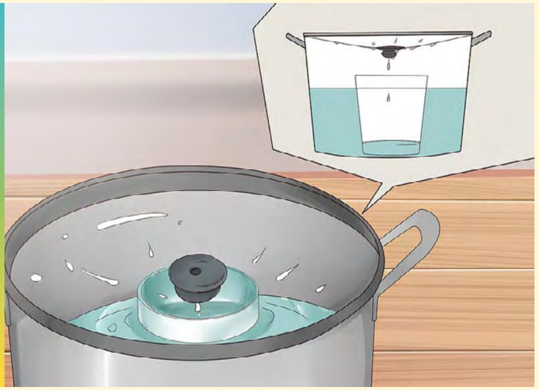
TIME TO REFLECT

Saltwater has a slightly higher boiling point. As it boils, steam condenses on the lid and drips back into the cup.

- Why is the water collected in the cup now free of salt?
- Where did the salt go?
- Can you explain how the salt was extracted?
- Why is the water in the cup colourless?
- How could this experiment be used to sustain crop production?

MATERIALS

- Salt
- Food colouring
- Cup, saucepan and lid



EXPERIMENT 2:
EVAPORATION – SEPARATING SALT FROM WATER

1. Divide pupils into small groups or pairs.
2. Pour a saltwater solution into a Petri dish.
3. Label the Petri dish with the location where the experiment will be conducted.
   For example, In sunlight on a window ledge, next to a lamp with and without a fan, or near a heat source like a hot plate or bunsen burner.
4. As the water evaporates, record any changes.

TIME TO REFLECT

As the water evaporates, it leaves behind the salt, which begins to crystallize. This process is part of the natural water cycle and contributes to the formation of salt flats in nature.

- Observe and describe the changes that occur as the water evaporates.
- Explain why the salt remains after the water evaporates.
- What do you notice about the shape and size of the salt crystals that form?
- How does temperature, air movement and other factors influence the rate of evaporation?

MATERIALS AND EQUIPMENT

- Petri dishes (or shallow container
- Salt
- Post-it notes (for labelling)
- Magnifying glass (optional)
- Heat plates
- Bunsen burners
- Lamp and fan

Sea salt harvesting on Nin saltpans in Croatia.

ACTIVITY 2.3 PHOTOSYNTHESIS

LIGHT ENERGY FROM THE SUN IS ESSENTIAL FOR ALL PLANT LIFE ON EARTH. THIS PROCESS IS CALLED *PHOTOSYNTHESIS*.

Plants capture light energy using chlorophyll, which gives leaves their green colour. This light energy is converted into chemical energy in the form of glucose, a type of sugar. When combined with water from the soil absorbed through the roots, and carbon dioxide from the air absorbed through leaves, glucose feeds the plant, allowing it to grow.

Engineers find ways to improve plant yields, ensuring food security as we adapt to climate change and rising global temperatures.

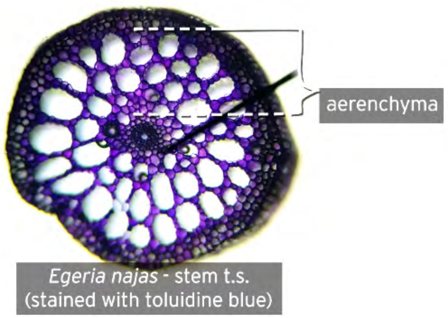
TIME TO INVESTIGATE

Demonstrating oxygen during photosynthesis with leaf cuttings

Plant leaves have spaces/air channels between their cells. This is called **aerenchyma**.

It is a spongy tissue that forms spaces or air channels in the leaves of halophytic plants. When the leaf is cut, gas escapes through these channels and bubbles to the surface when placed in water or a bicarbonate solution

Different types of leaves produce bubbles in varying ways. For this experiment, we recommend using spinach leaves.



Egeria najas - stem t.s.
(stained with toluidine blue)

Watch the video demonstration on how to conduct this experiment, available on the **Science and Plants for Schools YouTube channel** or by scanning the QR code.

TIME TO EXPERIMENT

1. Prepare a sodium bicarbonate solution of 0.2% (or four to six pinches of bicarb in 300ml water).
   The bicarbonate solution acts as a source of dissolved carbon dioxide for photosynthesis.
2. Add in a drop of washing up liquid/detergent.
   The detergent within the solution helps to break down the hydrophobic cuticle layer on the leaf.
3. Stir gently as to not cause any foam (add a little more bicarb if there's foam).
4. Punch 10 discs out of the leaves, avoiding particularly veiny/spiny bits.
5. Put the leaf discs inside the syringe and push the plunger in most of the way (so as to not crush the leaves).
6. Suck up 3 to 4ml of your bicarb/detergent solution.
7. Expel the excess air in the syringe before placing the black cap onto it.
8. Carefully draw on the syringe so as to create a vacuum. You should see bubbles appearing inside the syringe. Swirl the syringe around, keeping the vacuum, for 10 to 15 seconds. Gently release the syringe. The discs should now sink to the bottom of the syringe, rather than float. If they don't, repeat the process.
   **This process replaces the air pockets within the leaves with liquid, enabling them to sink.*
9. Carefully empty the syringe into your clear beaker/container. Top it up with the desired amount of bicarb/detergent solution (4 to 5cm of coverage works well). Your leaf disks should remain at the bottom of the beaker/container.
10. Leave your beaker in a bright area to allow photosynthesis to take place. After a few minutes you should see bubbles appearing on the leaves and they should start floating to the top of the water.

MATERIALS AND EQUIPMENT

- ☐ Syringe with cap
- ☐ Measuring jug/cup
- ☐ Clear container
- ☐ Spoon/stirrer
- ☐ Sodium bicarbonate
- ☐ Washing up liquid
- ☐ Fresh spinach leaves (or some from a bush/tree (make sure they are smooth and not furry)
- ☐ Hole punch


Prepare a sodium bicarbonate solution in a measuring jug.

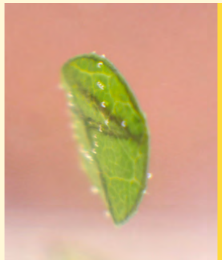

Add 1 drop of washing up liquid/ detergent.


Punch 10 discs out of the leaves.


Pour the sodium bicardonate solution into the beaker.


Put the leaf discs inside the syringe and push the plunger in most of the way. Suck up 3 to 4ml of the bicarb/detergent solution.


Empty the syringe into the clear beaker/ container.


Bubbles should start to appear on the leaves.

EXPERIMENT ONE: COUNTING GAS BUBBLES AT DIFFERENT LIGHT INTENSITIES

Count the bubbles within a set time to investigate the rate of photosynthesis under different conditions.

Position the test tubes at various distances from the lamp and count the number of bubbles emerging from the cut end of each tube.

Create a data table similar to this example to record the number of bubbles per minute in relation to the distance of the lamp from the tube.

Lamp distance from plant (cm)	Number of bubbles per minute		
	Test 1	Test 2	Average
0			
2			
4			
6			
8			

TIME TO REFLECT

- What conclusions can be drawn from the data presented in your table?
- Were there any variables that were unable to be controlled, despite efforts?
- Did temperature influence the results of the investigation?
- Were the bubbles of uniform size throughout the experiment?

EXPERIMENT TWO: COUNTING OXYGEN BUBBLES AT DIFFERENT WAVE LENGTHS OF LIGHT

Conduct the experiment again, this time investigating how the wavelength (colour) of light affects the rate of photosynthesis.

Wrap each of the different coloured acetates once around the tube, securing them with sticky tape. Ensure the sticky tape is facing away from the lamp.

Place the test tube containing the leaf cuttings at a set distance (such as 5 cm) from the lamp.

Record the number of bubbles produced within a set time (for example, one minute) under each light condition.

Create a data table to record the number of bubbles per minute in relation to the colour of light reaching the tube.

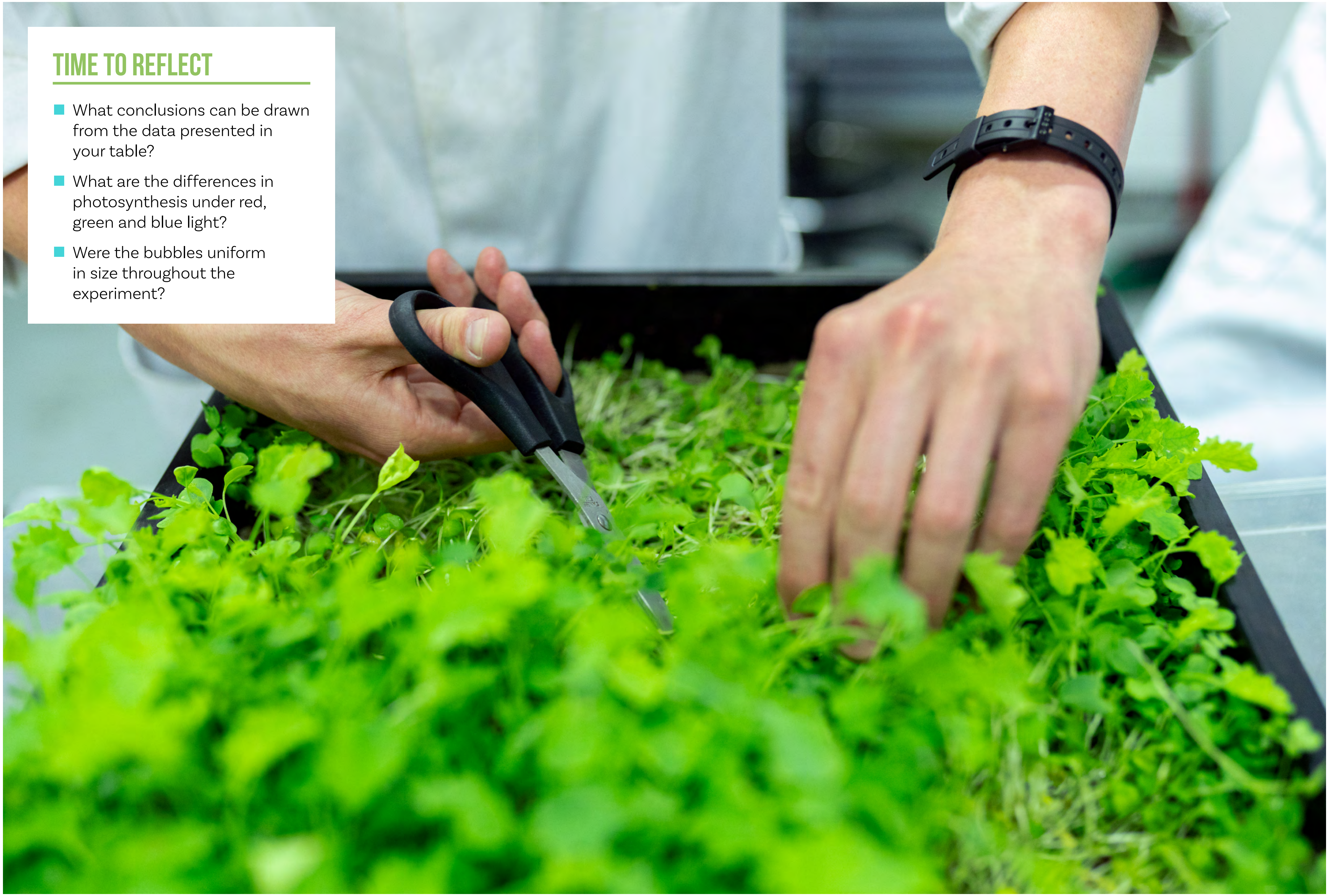
MATERIALS AND EQUIPMENT

- Scissors
- Sticky tape
- Acetate film in red/blue/green
- Lamp (for heat source)

Filter (acetate) colour	Colour of light getting into the boiling tube	Number of bubbles per minute		
		Test 1	Test 2	Average
Red		3	6	5
Blue				
Green				

TIME TO REFLECT

- What conclusions can be drawn from the data presented in your table?
- What are the differences in photosynthesis under red, green and blue light?
- Were the bubbles uniform in size throughout the experiment?



Royal Academy of Engineering

The Royal Academy of Engineering is harnessing the power of engineering to build a sustainable society and an inclusive economy that works for everyone.

In collaboration with our Fellows and partners, we're growing talent and developing skills for the future, driving innovation and building global partnerships, and influencing policy and engaging the public.

Together we're working to tackle the greatest challenges of our age.

What we do

Talent & diversity

We're growing talent by training, supporting, mentoring and funding the most talented and creative researchers, innovators and leaders from across the engineering profession.

We're developing skills for the future by identifying the challenges of an ever-changing world and developing the skills and approaches we need to build a resilient and diverse engineering profession.

Innovation

We're driving innovation by investing in some of the country's most creative and exciting engineering ideas and businesses.

We're building global partnerships that bring the world's best engineers from industry, entrepreneurship and academia together to collaborate on creative innovations that address the greatest global challenges of our age.

Policy & engagement

We're influencing policy through the National Engineering Policy Centre – providing independent expert support to policymakers on issues of importance.

We're engaging the public by opening their eyes to the wonders of engineering and inspiring young people to become the next generation of engineers.

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