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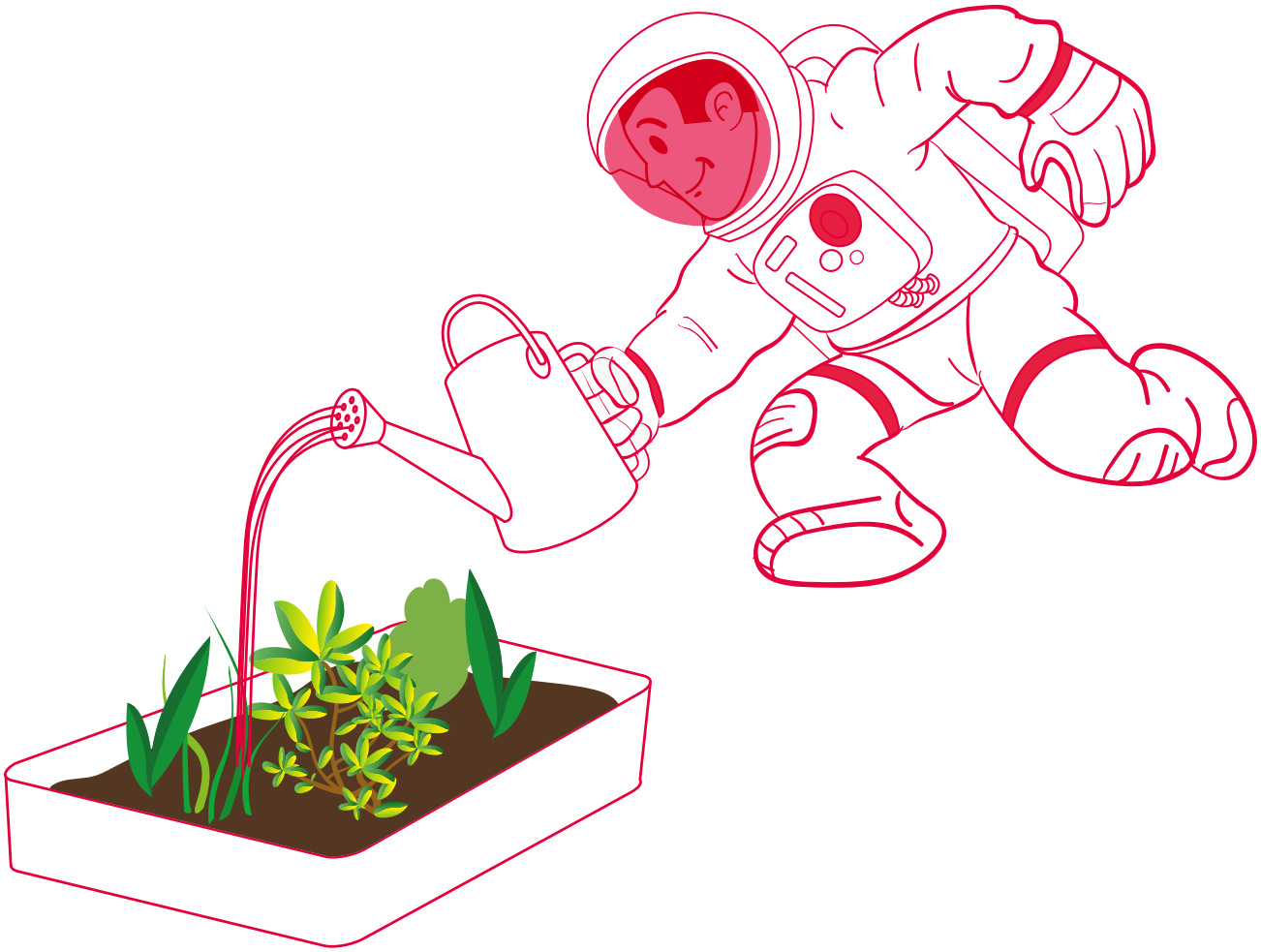
teach with space

→ ASTROFARMER

Learning about conditions for plant growth



teacher guide & student worksheets

European Space Agency

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→ ASTRO FARMER

Learning about conditions for plant growth

Fast facts

Subject: Science
Age range: 8 -12 years old
Type: student activity
Complexity: medium
Lesson time required: 2 hours and 30 minutes
Cost: low (0 -10 euros)
Location: indoors
Includes the use of: cress seeds, radish seeds, white flowers

Keywords: Science, Moon, Plant growth, Environment, Respiration, Photosynthesis, Nutrients, Water, Light, Temperature

Brief description

In this set of six activities, students will investigate which factors affect plant growth, and relate these factors to growing plants in space. Students will learn that plants need air, light, water, nutrients and a stable temperature to grow. Students will observe what happens to plants when they vary some of these factors.

These 6 activities can be done individually or as a set.

Learning objectives

- Learn that plants need water, light, air, nutrients and a suitable temperature to grow.
- Understand that environments can change and pose danger to living things.
- Learn that it is possible to grow plants without soil.
- Conduct simple and fair tests.
- Identify and control variables when necessary.
- Interpret observations and draw conclusions.
- Solve problems.

→ Summary of activities

activity	title	description	outcome	requirements	time
1	Do plants need air?	Studying the respiration and photosynthesis processes in plants.	Learn that plants need air to survive.	None	15 minutes
2	Do plants need light?	Investigating how cress grows in different light conditions: constant darkness and sunlight.	Make predictions and perform comparative and fair tests to investigate if plants need light.	Completion of activity 1 is advised.	30 minutes to complete the activity. Waiting period 1 week.
3	Do plants need water?	Leaving white flowers in water with food dye overnight to observe how plants drink water.	Make predictions and learn that plants drink water and transport it to the leaves.	None	30 minutes to complete the activity. Waiting period 1 day.
4	Do plants need soil?	Planting radish seeds in different materials, to learn that plants can grow without soil.	Make predictions and perform comparative and fair tests to investigate plants need of nutrients that can be found in the soil. Learn that plants do not need soil to grow.	None	30 minutes to complete the activity. Waiting period 1 day.
5	Too hot, too cold	Examining images of plants in different places on Earth and relating the flora to climatic zones.	Learn that plants need mild temperatures to grow.	None	15 minutes
6	Plants in space	Summarising that plants need air, light, water, suitable temperature and nutrients to grow. Studying some Moon facts and relating them to the growth of plants.	Understand that the environmental conditions in space are different to Earth, and that they pose a challenge to growing plants.	None	30 minutes

→ Introduction

Plants are important to the Earth's ecosystem; they are a source of food for animals and convert carbon dioxide into oxygen, through photosynthesis.

In these activities, students will learn what plants need in order to survive and be healthy. Students will discover that the main conditions required for plants to grow are:

- access to air,
- access to light,
- access to water,
- access to nutrients ,
- a suitable and stable temperature.

Students will uncover these factors for themselves by conducting tests to investigate plants' dependence on each factor.

Air

Air is composed of different gases and a small percentage of tiny particles called aerosols, which include dust and pollen. The main component of air is nitrogen (78%), followed by oxygen (21%). Other gases, such as carbon dioxide and argon compose only 1% of the atmosphere. Air also holds water vapour; the amount of water in the air is called humidity.

Plants, like all living things, have to respire to stay alive. **Respiration** allows organisms to produce energy. For plants, oxygen enters the leaves through small openings called stomata. Plants convert sugar (glucose) and oxygen into energy:

sugar + oxygen ——> **carbon dioxide + water + energy**

Plants' respiration releases carbon dioxide and water just like when humans breathe. Carbon dioxide and water vapour exit the leaf through the stomata.

Light

Plants cannot survive in total darkness indefinitely. They require light to produce the sugars (glucose) they need for respiration. This process is called photosynthesis, it uses light to convert carbon dioxide and water into sugar and oxygen:

carbon dioxide + water + light ——> **sugar + oxygen**

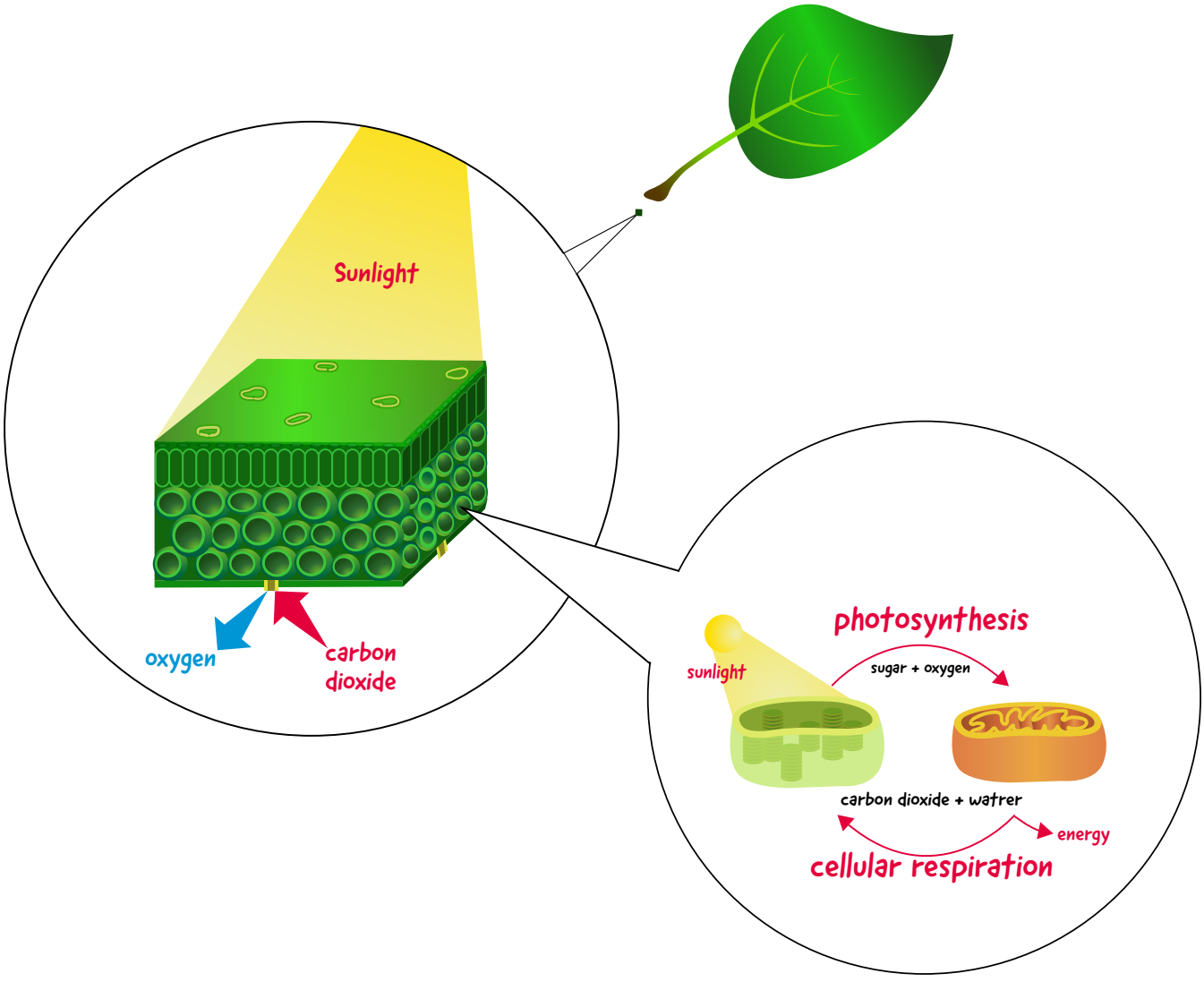
Glucose is the 'food' of a plant and through photosynthesis they obtain it. Glucose is used throughout the plant for growth, flower and fruit formation.

Plants have a pigment called chlorophyll that allows them to perform photosynthesis. Chlorophyll is the reason plants look green. Without chlorophyll, plants cannot survive!

Plants grow towards the light. When they are in total darkness, plants use the energy they have stored, for example in their seeds, in order to grow faster and search for the light that they need. When in total darkness, plants do not produce chlorophyll and are not able to photosynthesise. They will continue to grow until they have run out of energy.

Respiration and photosynthesis are interlinked; the products of photosynthesis are the reactants of cellular respiration (see Figure 1). Photosynthesis only occurs during the day, while respiration occurs day and night.

Figure 1

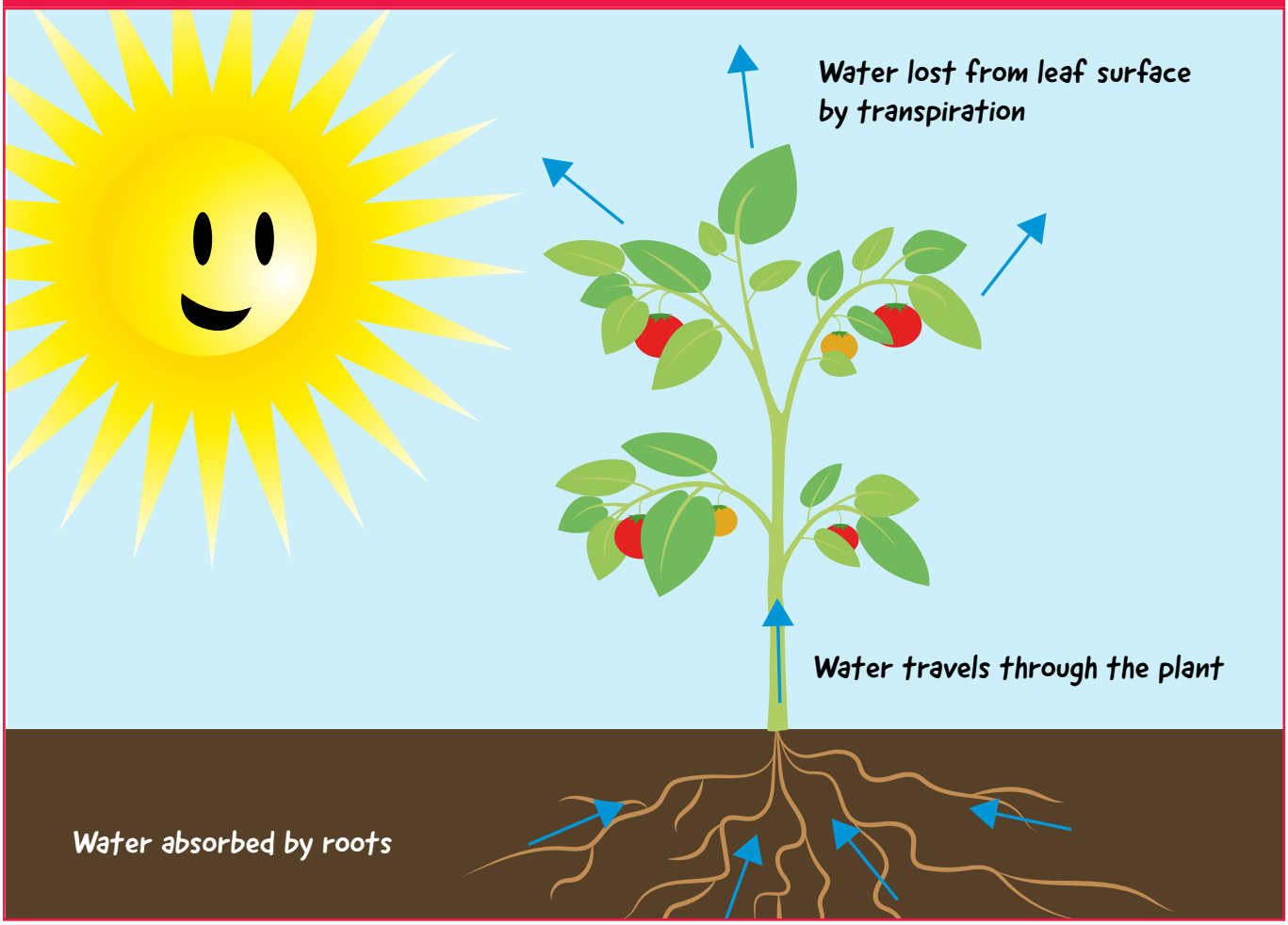


↑ Leaf anatomy

Water

Water is essential for all living things, including plants. Vegetation relies on water in the ground surrounding its roots. Plants get water through the roots and transport it to the upper parts of the plant through small tubes (xylem tubes). These tubes transport water and dissolved nutrients to the entire plant. Plants do not have a heart to pump liquids around their bodies, so they rely on physical forces to move liquid up to the highest leaf. Plants loose water by transpiration and respiration through the leaves (see Figure 2).

Figure 2



Nutrients

To be healthy, plants need to have access to nutrients. Nutrients are chemical elements or compounds that are necessary for a plant to grow. The nutrients are normally found in soil and are collected through the plant's roots.

The nutrients that are present in soil come from many different sources: decomposed animals, bacteria, fungus, microscopic organisms, fertiliser, and excrements. Some soils are rich in nutrients and are very good for plants, while others are deprived of nutrients - for example desert sand.
Plants obtain from the soil not only nutrients but also mechanical support. Still it is possible to grow plants using soilless techniques, like for example hydroponics. These techniques use a different growth material, for hydroponics it is water with added nutrients. Mechanical support is provided to the plant artificially.

Temperature

Temperature is a key factor for the health and growth of plants. Combined with the other factors already discussed - light, air, water, and nutrients - it influences the development of the plant.

Plants rely on mild temperatures to perform photosynthesis. Whether it is extreme heat or extreme cold, temperature affects the health of plants. Most plants cannot survive in negative temperatures because the water inside the plant may freeze. Even if the plant can counteract the temperature effect internally, the surrounding ground will also freeze and the roots will not be able to absorb the water ice in it.

In high temperatures, plants can lose large amounts of water through transpiration. Some plants have evolved to minimise the loss of water by having leaves shaped like needles. In addition, the roots will have more difficulty finding water because there may be less available in the soil. However, there are examples of plants that have adapted to survive in extreme environments, such as the cactus, that has adapted to live in desert areas where temperatures can range from +70°C to below zero.

In space

All the things we take for granted on Earth are either absent or different in space.

In space, the five conditions required for plants to grow - light, water, soil, nutrients and suitable temperature - are difficult to meet. In addition, plants would have to grow in a different gravity environment - microgravity for the case of the International Space Station (ISS) or 1/6 of Earth's gravity on the Moon.

Planting seeds in soil would get very messy in the ISS where everything is weightless. The soil could end up floating around the station, get stuck in an important machine or could be inhaled by an astronaut. Soil is also heavy to transport and launch into space.

Figure 3

↑ Special plant growth unit called Veggie at the ISS.

Luckily, in the ISS or on the Moon plants could be grown hydroponically. This method has already been tested in the ISS and has produced its first "space salad" in 2015.

The soil on the Moon is completely deprived of nutrients, also their environmental conditions are very different from the ones on Earth. Therefore, when ESA and other space agencies talk about growing plants on the Moon they plan to grow them in a controlled environment, for example in special greenhouses.

In these activities, students will become AstroFarmers and explore the conditions that plants need to grow in space.

→ Activity 1: Do plants need air?

In this activity, students will learn about respiration and photosynthesis in plants. Students will also learn about the composition of air and understand the role of plants in the production of oxygen.

Equipment

- Student worksheet printed one per student
- Pen or pencil
- Colouring pencils

Exercise

Distribute the student worksheets and ask the students to fill in the blanks in the text with the words provided.

Ask the students to identify which process is represented by each arrow in question 2. They should colour the name of the process in red or blue according to the colours used on the image. Students should understand that photosynthesis only occurs during the day, while respiration occurs day and night.

Results

1. **Air** is a mixture of different gases, that includes nitrogen (78%) and **oxygen** (21%). Other gases, such as carbon dioxide, represent less than 1% of Earth's atmosphere.

Plants, like all living things, have to carry out respiration to stay alive. Respiration converts sugar and oxygen into energy, releasing **carbon dioxide** and water in the process.

Most plants cannot survive in total darkness because they need light to produce the sugars they need to have energy to grow. This process is called **photosynthesis** and uses light to convert carbon dioxide and water into sugar and oxygen. Photosynthesis is the number one source of oxygen in the **atmosphere**.

2.

Respiration

Photosynthesis

Discussion

Depending on the age and ability of the students you could elaborate on the processes of respiration and photosynthesis by providing them with the equations and Figure 1 presented in the introduction.

→ Activity 2: Do plants need light?

In this activity, students will investigate how cress grows in different lighting conditions: constant darkness and normal sunlight. Students should understand that light affects the growth of plants and relate the results from this experiment to Activity 1.

Equipment

- Student worksheets printed one per group
- Cress seeds
- Identical pots/plastic containers (2 pots per group)
- Potting soil
- Small shovel or spoon
- A cardboard box or a dark closet
- A ruler

Exercise

Divide the class into small groups of two to four students. Inform them that they will conduct an experiment to investigate how cress grows in different lighting conditions: constant darkness and normal sunlight.

Note: If you wish to add more complexity to the exercise, you could add a third pot with constant light (for example placed under a lamp).

Distribute the student worksheets, one per group, and the necessary materials: 2 pots per group, cress seeds, and potting soil. Ask the students to follow the instructions in the student worksheets. Assist the students as necessary. Ask the students to label the pots with their names and number them 1 and 2.

Make sure the soil is moist and give both pots approximately the same amount of water.

Next the students should place all the pots labelled “1” in total darkness (a closet or a box) and all pots labelled “2” in a place with a normal day/night cycle, preferably near a window. Discuss the importance of conducting a fair test and ask the students to reflect on why this experiment is a fair test.

Ask the students if they have ever seen a plant that has been left in the dark? What do they think will happen to a plant if it cannot get any sunlight? The students should write and/or draw their predictions in their student worksheets.

Leave the pots for approximately 4-7 days. Cress grows very easily, and it should not need more water during that week.

Results

After one week, the students can retrieve their pots. The cress grown in sunlight should have a normal healthy development with a green colour. The cress grown in constant darkness should be noticeably taller than the cress grown with a normal day/night cycle, but have a white colour with yellow leaves.

Figure 4

↑ Example of two pots of cress seeds planted in the same type of soil and with equal amounts of water. The pot with the white cress (left) was placed in darkness for 4 days, while the green cress (right) received sunlight in the same period.

The cress placed in darkness is taller because the plant has accelerated its growth (using the energy stored in the seed) in order to search for the light. It is not green because it doesn't have chlorophyll (which has not formed due to the absence of light) – it is the presence of chlorophyll that gives plants their green colour.

Discussion

To further analyze the development of the plants with the students discuss with them which one of the two plants is healthier. Discuss with them if plants can be exposed to too much light.

→ Activity 3: Do plants need water?

In this activity students will investigate the transportation of water inside a plant. Through these exercises, students should understand that the roots and stem transport water to the rest of the plant. Afterwards, students will examine how flower petals change colour when dye is added to the plant water.

Equipment

- Student worksheet printed for each student
- White flowers cut at the stem (two per group)
- Food dye (red or blue)
- Transparent water containers (for example the bottom of a plastic bottle)
- (optional) white flower with intact root

Exercise 1

To begin this activity the students identify and label the different parts of the plant in their student worksheets. They should name the leaf, fruit, flower, stem and root. Afterwards, they should complete the maze that transports water from the soil through the root and then through the stem of the plant to the leaves, flowers and fruits.

Ask the students to name three different functions of the roots. These could be:

- Absorption and transportation of water
- Fixation and support of the plant
- Storage of food (for example potatoes and carrots)
- Respiration

Exercise 2

This experiment demonstrates how water is transported from the stem to the petals of the flowers by adding food dye to the plant water.

This exercise can be completed as a group activity or as a demonstration. As a demonstration you will need two white flowers placed in two different water containers. As a group activity you will need two white flowers in two water containers for each group. Instructions for this experiment are provided on the student worksheet. Flowers with hollow stems take up water the fastest and show colour change in the shortest amount of time but nearly any type of white flower can be used.

Divide the class into small groups of two to four students. Distribute the student worksheets and two white flowers per group. Ask them to follow the instructions on the student worksheets. The students should predict what they think will happen to the flowers. Wait for one day and then ask the students to complete questions 2 and 3 of the student worksheet. Were their predictions correct? Ask the students what would happen if the flower still had its roots.

Note: to see the function of the roots you could add a plant with the roots intact to the experiment as a demonstration to see if the colour of the flower is affected.

Results

1. The white flower in the dyed water should be coloured by the dye. Especially along the rim of the petals.
2. The colouring of the petals happens because the flowers transport the water from their stem to the petals of the flower. Food dye in plant water is an effective way to illustrate this transportation.
3. Roots act like a natural filter. When coloured water is added to the soil the root will not recognise the dye as a necessary nutrient. The roots will filter out the dye and the flower petals should not change colour.

→ Activity 4: Do plants need soil?

In this activity, students will plant radish seeds in different materials to determine which are good for growing plants.

Equipment

- Student worksheet printed for each student
- 16 radish seeds
- 8 small clear pots
- Soil to fill 2 of the small pots
- Sand to fill 2 of the small pots
- Cotton wool to fill 2 of the small pots
- Paper towel to fill 2 of the small pots
- Cling film
- 16 Labels for the pots
- Liquid plant food

Exercise

This activity is structured as a classroom demonstration to investigate if plants can grow without soil. Distribute the student worksheets to the class. Ask the students if they think plants can grow without soil and to explain their answer on their student worksheets.

Explain to the students that they will do an experiment to find out if plants can grow without soil. Ask the students to answer question 2 on their student worksheet, by drawing lines between the materials and the empty pots.

When all the students have finished, fill the eight pots accordingly by following the procedure below:

1. Label the pots 1 to 8.
2. Put **soil** in pots **1** and **2**.
3. Put **sand** in pots **3** and **4**.
4. Put **cotton wool** in pots **5** and **6**.
5. Put **paper towels** in pots **7** and **8**.
6. Add normal water to pots 1, 3, 5 and 7 (the material should be damp).
7. Add water with liquid plant food to pots 2, 4, 6 and 8 (the material should be damp).
8. Add 2 radish seeds to each pot and put cling film over the top.
9. Leave the pots for one week in identical conditions.

Ask the students their predictions for the experiment. Do they think that plants can grow in all of the different pots? In which pot do they think the plant will grow best? Do they think it is a good idea to add liquid plant food? Ask them to write down their predictions by answering questions 3 to 7 in their student worksheets. Discuss with the students the fairness of the experiment.

After a week, present the pots to the students. How has each pot developed? Ask them to take note of the results on their student worksheets (question 8). What is the height of each seedling growing in the different materials and how healthy are the plants. Discuss if plants need soil or not in order to grow. Ask the students to write down their preferred growing material at the bottom of the plant illustration on their student worksheet.

Results

Below are the answers to the questions in the student worksheet:

3. The liquid plant food is there to replace the nutrients that are usually found in soil. Since some plants are being grown without soil the nutrients they need must be added in another way.

4. Adding nutrients to some of the pots will make them grow more than they would in the same material without any nutrients.

5. The experiment is a fair test because we only change one variable at a time. So we can analyse whether the difference is due to the material or the liquid plant food.

6. The radish seeds will grow best in the cotton wool with the plant food mix. It should be better than the seeds growing in soil alone.

7. Students might argue that the plants cannot grow without soil and/or that they cannot grow without liquid plant food. However, the radish seeds should be able to grow in all of the different materials. This is because the seeds already contain some nutrients for the plant to germinate, however, it will grow more slowly and eventually run out of nutrients.

Discussion

Discuss with the students the advantages and disadvantages of growing plants without soil. Students should learn that plants need nutrients but that these can be added to other materials, not only soil.

→ Activity 5: Too hot, too cold

In this activity, students will observe pictures from different places on Earth and link them to the different climate zones. Students will learn that plants can adapt to different conditions but there are extreme environments where they cannot live.

Equipment

- Student worksheet printed for each student
- Scissors
- Glue
- Pen / pencil

Exercise

Start the exercise by asking the students if they have ever been to a place where there were no plants at all. With the students, reflect on the fact that we find plants almost everywhere on Earth.

On their student worksheets, the students will find a map of Earth's three main climatic zones: tropic, temperate and polar. Ask them to look at pictures A to F and work out where they should be placed on the map. They should bear in mind the different climatic zones and what influence this would have on the flora in each region. Pictures A and B do not have any plants at all, ask the students to explain why for each case.

Results

1. 1 - D, 2 - E, 3 - C, 4 - B, 5 - A, 6 - F
2. **Picture A:** This image is of the Sahara Desert. No plants can grow in the areas of desert that are covered completely by sand. Sand is a poor growing material, with little water and nutrients. Plant roots also have difficulty keeping the plant grounded in desert due to the sand and strong winds. Temperatures are extremely hot during the day and extremely cold during the night.

   Picture B: This image is of Antarctica. Antarctica is a cold desert, with very little precipitation. The ground is covered by ice and snow and there is no liquid water. Temperatures can reach -80°C. Cold temperatures freeze the cells in a plant, causing damage and interrupting the pathways for nutrients and water to flow.

Discussion:

Discuss with the students the differences between the different climatic zones. How do plants adapted to each different zone?

Tropic zone: Extends between the Tropic of Cancer at a latitude of 23.5° north of the equator and the Tropic of Capricorn at a latitude of 23.5° south of the equator. Climate in this zone can be extremely hot, causing large evaporation. This creates very hot and humid areas like rain forests, and arid areas like deserts, which have large temperature differences between winter and summer.

Temperate zone: Extends between the Arctic Circle and the Tropic of Cancer in the northern hemisphere, and between the Tropic of Capricorn and the Antarctic Circle in the southern hemisphere. This climate zone experiences the largest temperature variations between summer and winter, with hot summers and cool winters. Most of Europe and North America fall within this climate zone.

Polar zone: Located within the Arctic and Antarctic Circles. It is characterised by long, cold winters and short, cool summers. Temperatures rarely rise above freezing. Precipitation falls in the form of snow; many areas are covered by ice all year-round.

→ Activity 6: Plants in Space

In this activity, students will summarise the most important conditions that are needed for plants to be healthy. Students will consider what conditions on the Moon could pose a problem for plants.

Equipment

- Student worksheet printed for each student
- Pen or pencil
- Colour pencils

Exercise 1

Discuss with the whole class which environmental factors the students think are important for plants to be healthy. If the students have completed Activities 1 to 5, this activity will act as a summary. If the students have not completed the preceding activities introduce this topic relating to their everyday experiences perhaps with plants in their own homes, in the park or in the forest.

Ask the students what happens to a plant if:

- the temperature is too cold or too warm,
- there is not enough water or too much water,
- there is not enough light or too much light,
- there are no nutrients,
- there is no air.

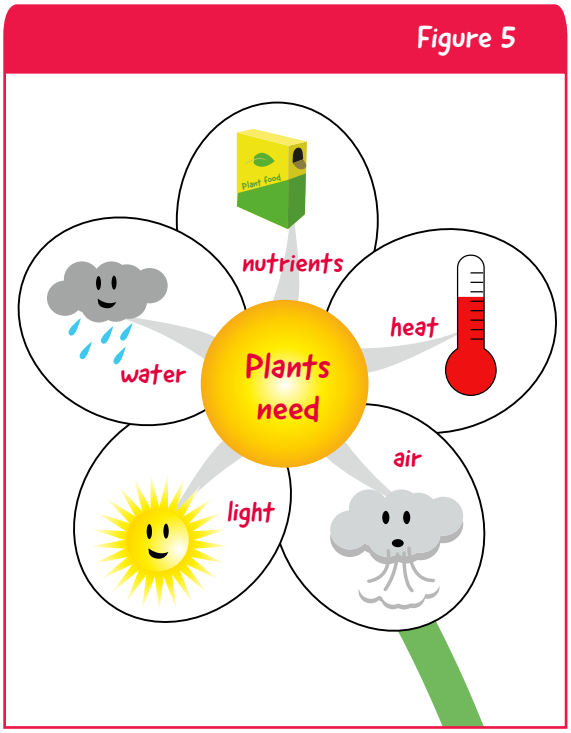
Ask the students to draw the five factors that affect the health of a plant in the petals of the flower on their student worksheet: mild temperature, nutrients, light, air and water. End the exercise by discussing what the students could do to meet the needs of a plant to make sure it survives. Examples could be, placing the plant in a window to receive sunlight, or keeping the plant inside for a constant temperature.

Results

The students should draw what a plant needs in order to be healthy in the petals of the flower on their student worksheets. An example is shown below.

1. Mild temperature
2. Water
3. Light
4. Nutrients
5. Air

Figure 5



↑ Example of expected answer for Exercise 1. The five most important requirements for plant growth are heat (constant mild temperature), nutrients, water, light and air.

Exercise 2

Ask the students to analyse the facts cards about the Moon and if they think plants can grow in this alien environment. Ask them to write down their ideas on the student worksheet. Discuss this topic with the class and ask them to share their thoughts and opinions.

Do the students have any ideas of what could be done to overcome some of the conditions found on the Moon. Guide them towards the concept of building a controlled environment, such as a greenhouse.

Discussion

When debating with the students make it clear that there is no life on the Moon. The purpose is to debate the hypothetical idea of how plants brought from Earth to these different environments would adjust. Would they still be able to grow? Would they be healthy? How could we control some of the environmental variables?

The following points are some of the main challenges for growing plants on space missions:

Microgravity: On Earth, we are used to feeling Earth's gravity pulling us down. One of the biggest differences in space is that gravity varies depending on where we are. Travelling in space astronauts will feel weightless, while on the Moon they will experience 1/6 of the Earth's gravity. Plants are used to growing on Earth, transporting them to a place with different gravity may introduce unknown variations in their growth.

Water: On the Moon liquid water would not be readily available in rivers and oceans as it is here on Earth. On the Moon some water is present in the form of ice, but this means that it is more difficult and expensive to access than it is on Earth.

Light: The duration of day and night varies depending of the rotation of the planet or moon. On the Moon days are extremely long, 28 times longer than on Earth. Plants would have to adapt to a cycle of 14 days of light and 14 days of darkness.

Atmosphere: The Moon has basically no atmosphere. There is no protection from radiation, which can affect the health of plants.

Temperature: Most plants grow best at temperatures between 10°C and 30°C. Outer space, because it is a vacuum, has extreme variations of temperature. Similar variations happen on the Moon because it has basically no atmosphere.

Soil: On the Moon the soil is very poor in nutrients and might even be toxic for plants in some regions.

Conclusion

Students should conclude that although on Earth plants grow almost everywhere, on the Moon environmental conditions are different and it lacks some of the most important conditions necessary for plants to grow healthily. For plants to grow in space we would need create a controlled environment with special greenhouses.

→ ASTROFARMER

Learning about conditions for plant growth

→ Activity 1: Do plants need air?

Exercise

1. Complete the following sentences by filling in the blanks. Use the words listed below.

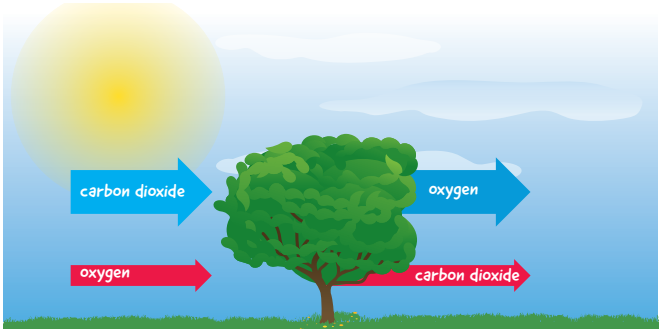
Plants **photosynthesis** **oxygen** **carbon dioxide** **atmosphere** **Air**

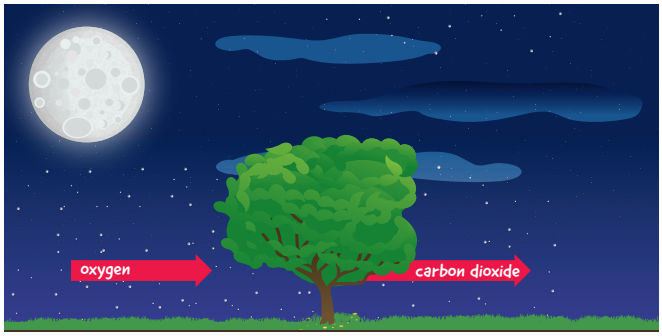
_____ is a mixture of different gases, that includes nitrogen (78%) and _____ (21%). Other gases, such as carbon dioxide, represent less than 1% of Earth's atmosphere.

_____ like all living things, have to carry out respiration to stay alive. Respiration converts sugar and oxygen into energy, releasing _____ _____ and water in the process.

Most plants cannot survive in total darkness because they need light to produce the sugars they need to have energy to grow. This process is called _____ and uses light to convert carbon dioxide and water into sugar and oxygen. Photosynthesis is the number one source of oxygen in the _____ .

2. The arrows in the images below represent two processes that occur in plants: photosynthesis and respiration. Colour in the boxes below with the same colour used to represent each process in the image: red or blue.





Respiration

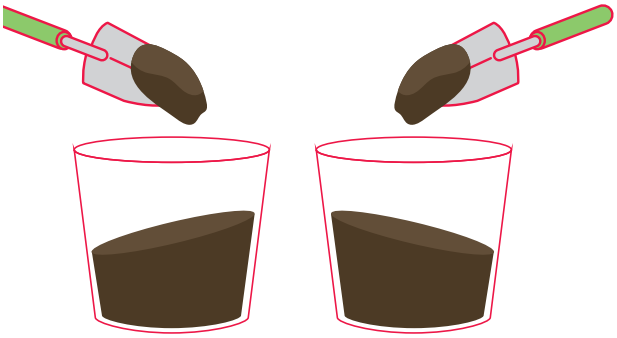
Photosynthesis

→ Activity 2: Do plants need light?

In this activity, you will investigate what happens to plants when they have no sunlight.

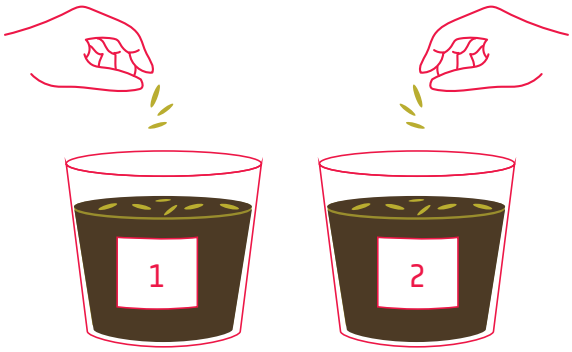
Exercise

1. Put soil in two identical pots.

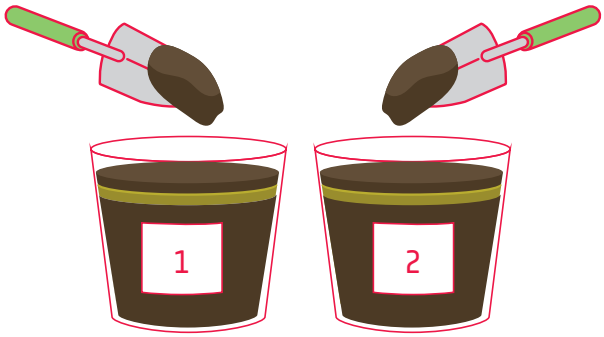


2. Label the pots 1 and 2.

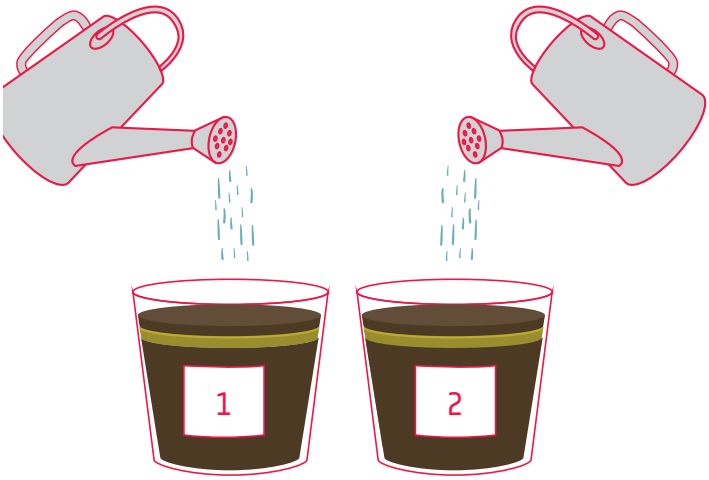
3. Plant approximately the same amount of cress seeds in each pot.



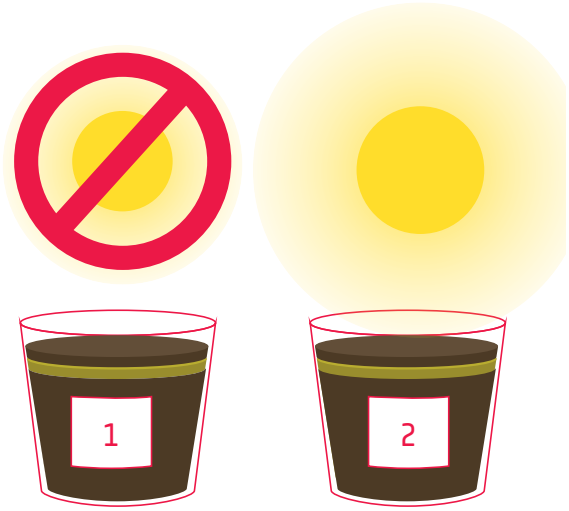
4. Cover the cress seeds with a bit of soil.



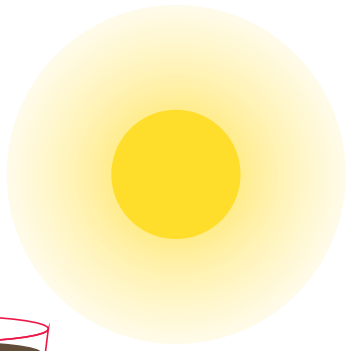
5. Water both plants with the same amount of water.

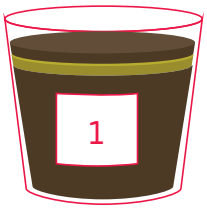


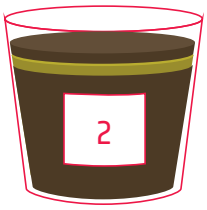
6. Place one pot in darkness and one in light.



1. Predict what will happen to your two pots. Write your predictions below and draw what you think the plants will look like.



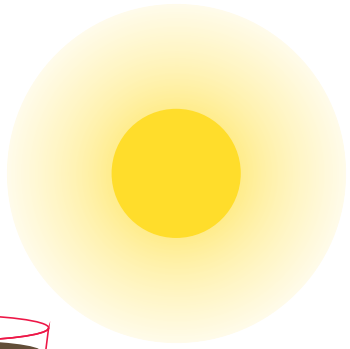


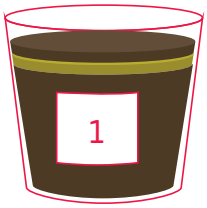


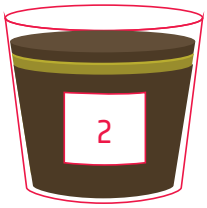
_____ _____

_____ _____

2. After **one week** observe the plants. Draw what the cress looks like in each pot. Note down the colour and height.







Cress height: _____ cm Cress height: _____ cm

Colour: _____ Colour: _____

3. Why do you think we see these differences?

_____

_____

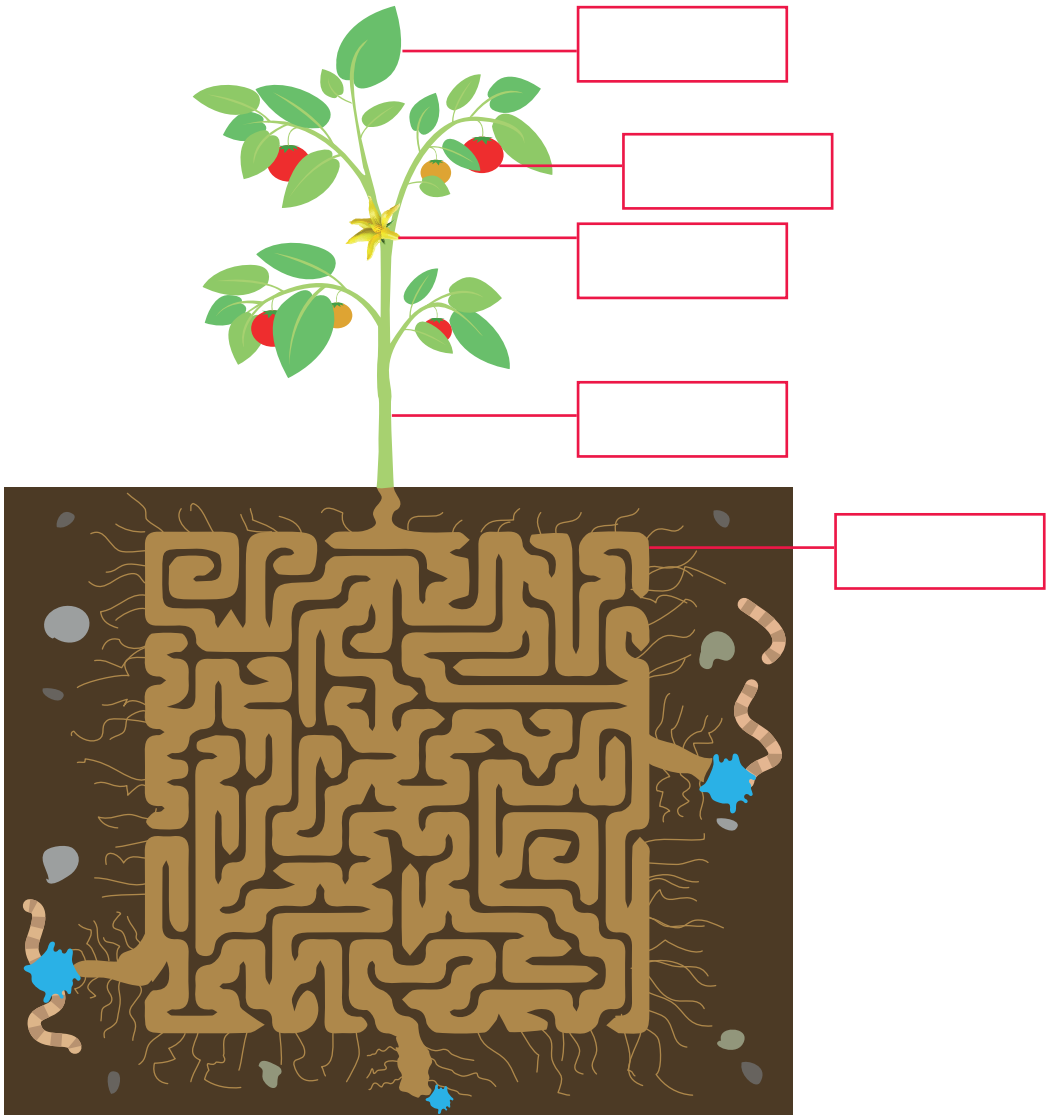
_____

→ Activity 3: Do plants need water?

Water is essential for all living things, including plants. Plants get water from the soil through the roots and transport it to the upper parts of the plant.

Exercise 1

1. Name the different parts of the plant.



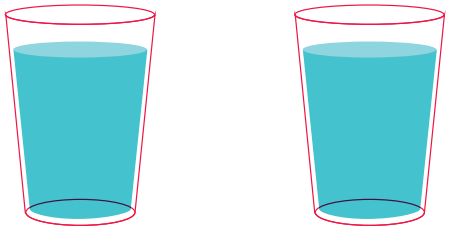
2. Help the plant find the best way through the maze to transport water from the roots to the tip of a leaf. Draw the path in blue.

3. Name 3 different functions of the roots.

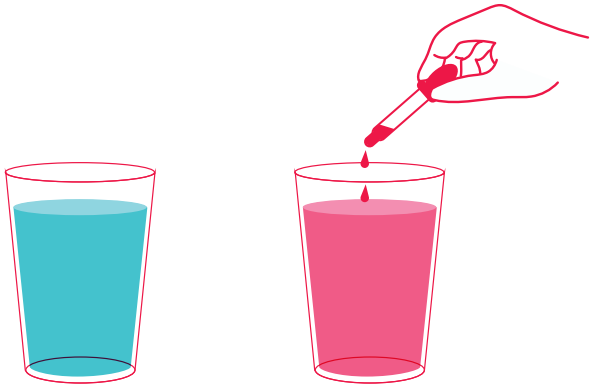
Exercise 2

Let's investigate how water is transported through a plant. Follow the instructions below:

1. Fill two glasses with water.



2. Add food dye to one of the glasses and stir.



3. Place one flower in each glass and wait one day.

1. What do you think will happen to the white flower in dyed water?

2. Were your predictions confirmed? What happened to the white flower in water with dye?

3. Would the result be the same if the plant had its roots intact?

→ Activity 4: Do plants need soil?

Exercise

1. Do you think plants can grow without soil? Explain your answer.

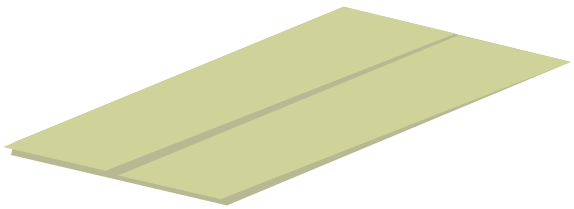
2. Below are eight empty pots.
- Pots 1 and 2 should be filled with soil.
- Pots 3 and 4 should be filled with sand.
- Pots 5 and 6 should be filled with cotton wool.
- Pots 7 and 8 should be filled with paper towel.
- All the **even** numbered pots need to have plant food added.

Draw lines connecting the materials and the pots below.

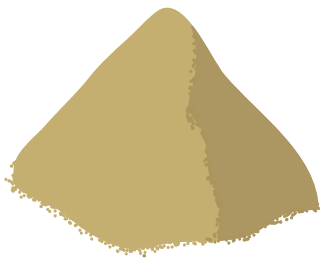
soil

plant food

cotton wool



paper towel



sand

3. Why do you think we add plant food (nutrients) to some of the pots?

4. Do you think the results will be different for the pots with and without plant food?

5. Do you think this is a fair test?

6. In which pot do you think the plant will grow best? Why?

7. Are there any pots where you think a plant cannot grow? Why?

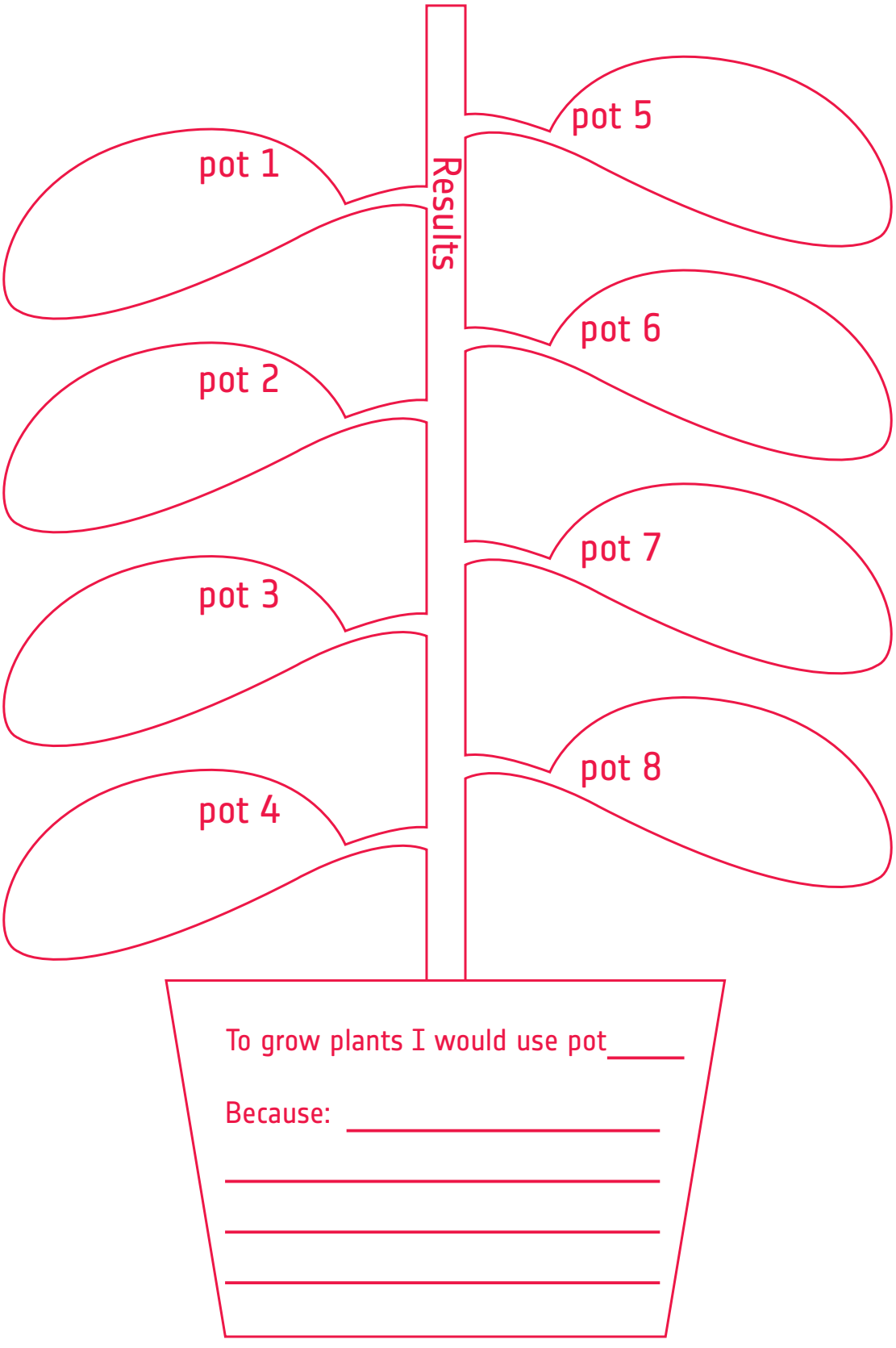
Wait one week for the seeds to grow.

Did you know?

Astronauts have already eaten food grown in space! In August 2015, astronauts on board the International Space Station ate their first space salad – a crop of red romaine lettuce. It was grown in a special plant growth unit called Veggie, which provides the lighting and nutrients. In this image, you can see the lettuce growing.

8. After waiting one week analyse each pot. Fill in the plant below with your comments on whether seedlings have grown, the height of the seedlings, how healthy and green they appear and how many leaves do they have.

   Choose the best pot for growing plants.

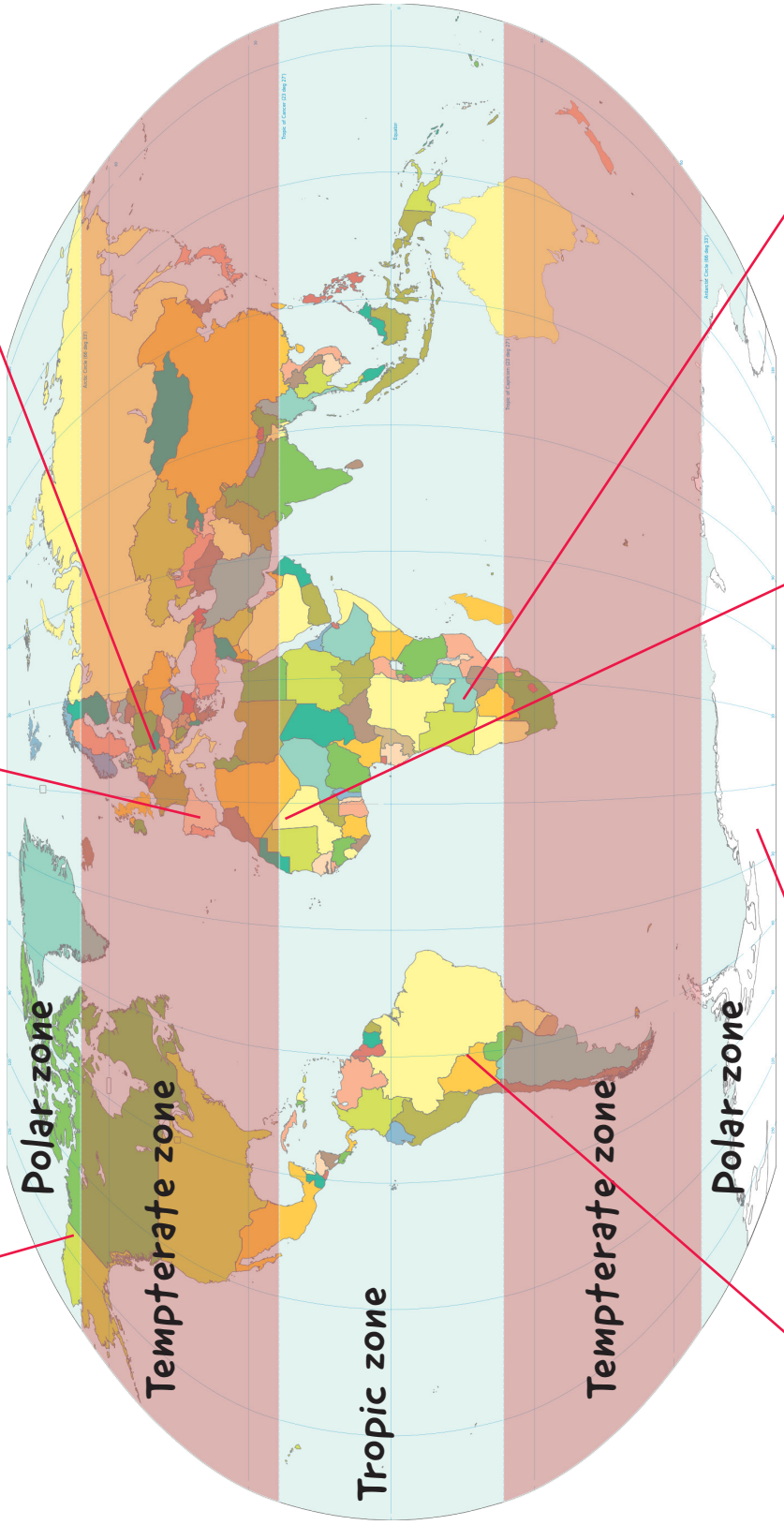


→ Activity 5: Do plants need a mild temperature?

Plants are present almost everywhere on Earth, but they look very different! Plants can adapt to their environment – for example some plants live in warm areas, while others need colder temperatures.

Exercise

1. The map below shows an illustration of the Earth's main climatic zones. Look at the pictures on the following page and place them on the map.



2

1

6

5

4

3

A

B

C

D

E

F

2. Pictures A and B have no plants at all. Explain why for each picture.

A. _____

_____

_____

B. _____

_____

_____

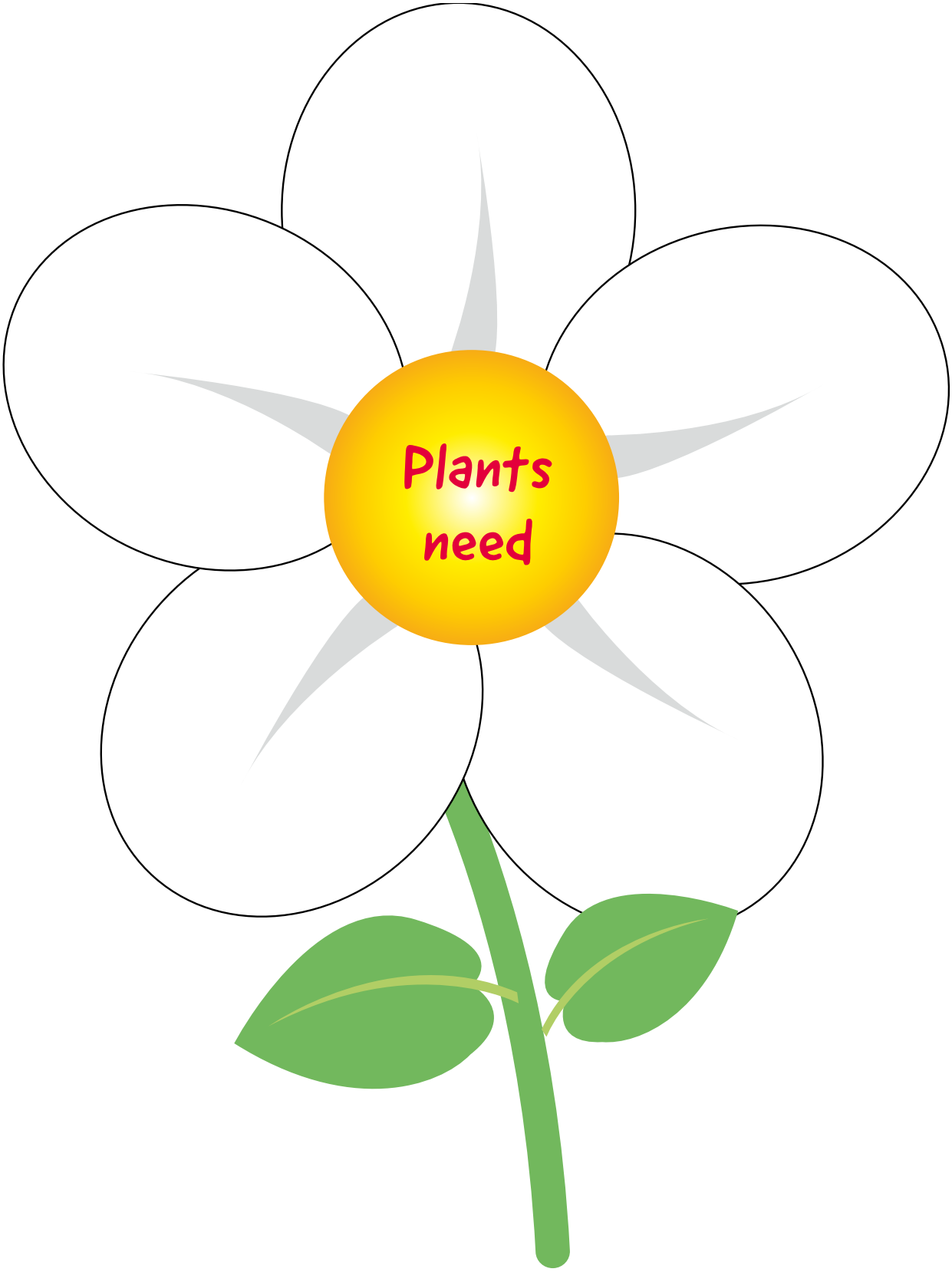
Did you know?

For most plants the optimum temperature for photosynthesis is around 25°C . The effect of temperature on plants varies widely depending on their type. Tomatoes get into trouble when temperatures drop below 13°C or if temperatures exceed about 36°C . Cacti on the other hand can survive in the desert where temperatures range from below zero up to around 70 °C.

→ Activity 6: Plants in space

Exercise 1

1. Draw what plants need to be healthy in the petals of the flower below.



Exercise 2

The planet Earth has evolved to have the ideal conditions for plants to grow.
However, in space environmental conditions are very different!

Analyse the Moon facts below.

MOON FACTS

- **Light:** Daytime lasts about 14 Earth days, followed by 14 Earth days of night (darkness).
- **Water:** Small quantities of water ice at the poles. No liquid water.
- **Atmosphere:** None
- **Temperature:** -233°C to +123°C
- **Soil:** No nutrients
- **Gravity:** 1/6 of Earth's gravity

1. Do you think that plants can grow on the Moon? Why?

2. How would you suggest growing plants on the Moon?

→ LINKS

ESA resources

Moon Camp Challenge
esa.int/Education/Moon_Camp

Moon animations about the basics of living on the Moon
esa.int/Education/Moon_Camp/The_basics_of_living

Paxi animations
esa.int/kids/en/Multimedia/Paxi_animations

ESA classroom resources
esa.int/Education/Classroom_resources

ESA Kids
esa.int/kids

ESA space projects

MELiSSA project
esa.int/Our_Activities/Space_Engineering_Technology/Melissa

A decade of plant biology in space
esa.int/Our_Activities/Human_Spaceflight/Research/A_decade_of_plant_biology_in_space

Extra information

Astroplant, a citizen science project to learn about plant growth
www.astroplant.io

Science at NASA: Space Gardening
youtube.com/watch?v=M7LslyCX7Jg