

→ 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.

What do plants need in order to survive and be healthy?

You are right! All of the things below! But why??

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

Study to find out more!

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:



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:

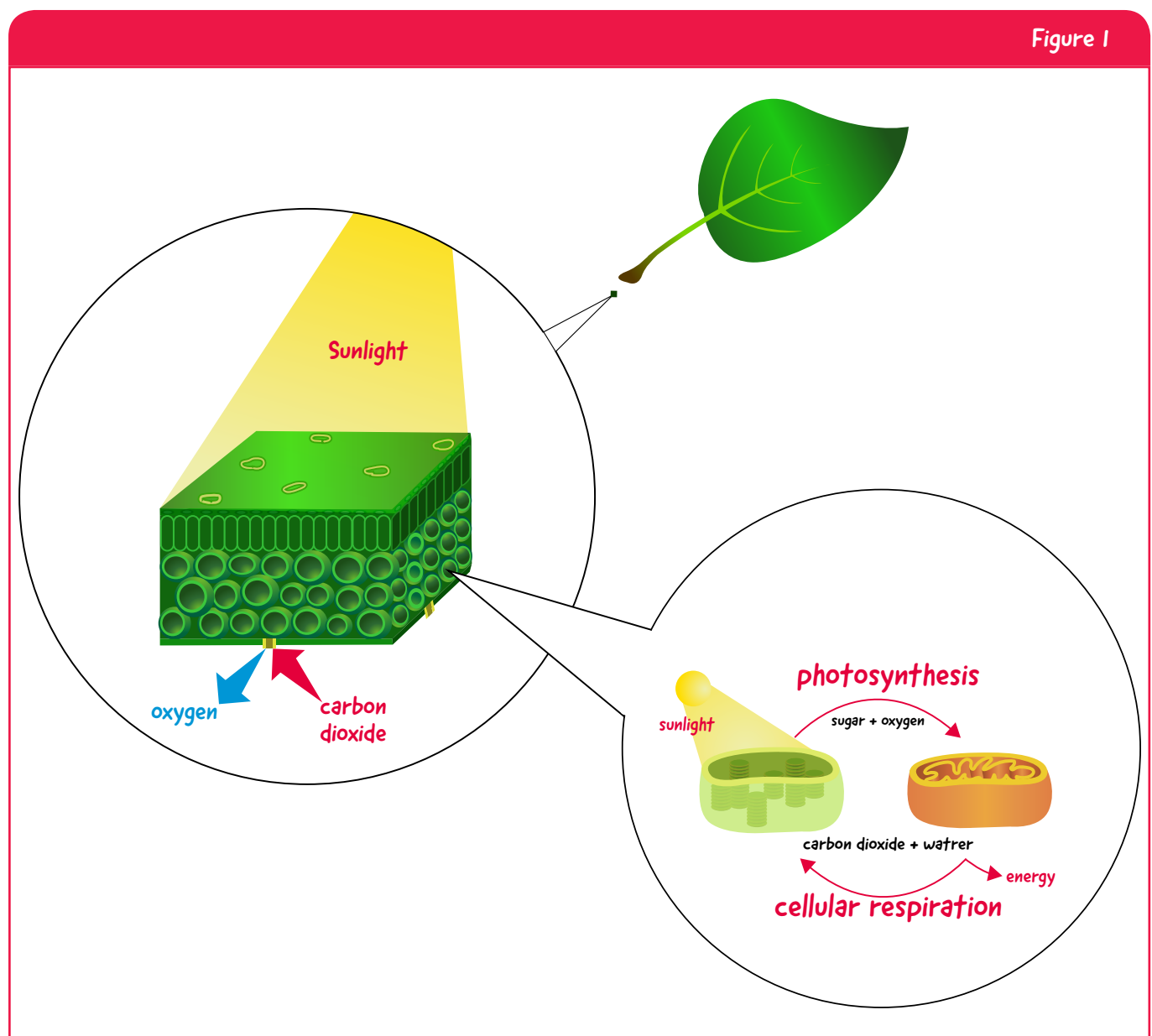


Glucose is the 'food' of a plant and through photosynthesis they obtain it. Glucose is used throughout the plant for growth, flower and fruit formation.

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.

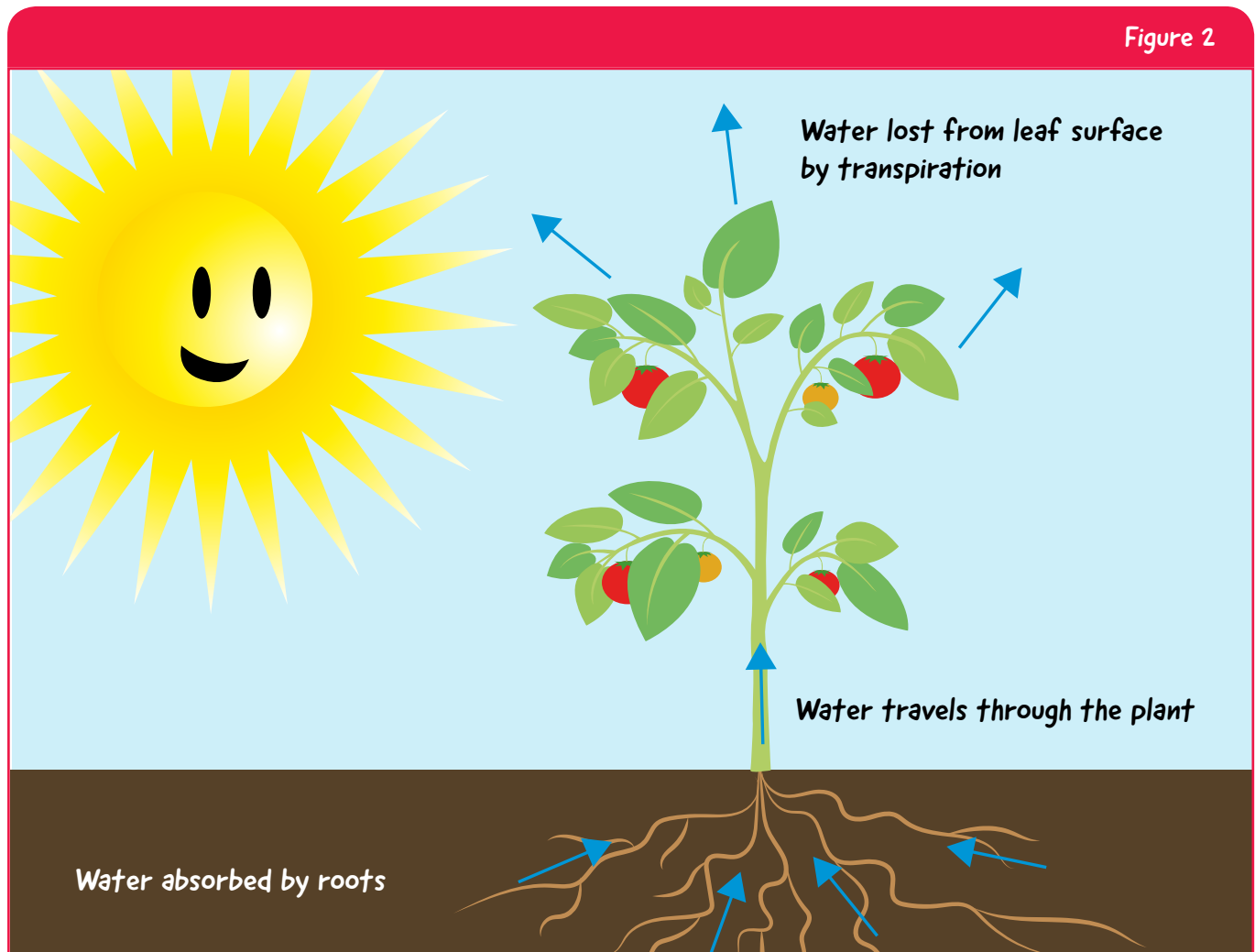
Respiration and photosynthesis are interlinked; the products of photosynthesis are the reactants of cellular respiration (see Figure 1). Photosynthesis only occurs during the day, while respiration occurs day and night.



↑ 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 lose water by transpiration and respiration through the leaves (see 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.

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.



↑ Special plant growth unit called Veggie at the ISS.