Plant growth

Introduction

Plants absorb large quantities of water from their environment. Water is used as a raw material for catabolic reactions such as photosynthesis, as a medium for transport, and to provide support for tissues. When plants are grown in artificial conditions it is important that water supply is regulated – too much and there is a risk of waterlogging; too little and growth rates will be restricted. In this activity the Micro:bit device is used as a moisture monitor for plants grown in containers. It produces an alarm signal if an external sensor detects low water levels. The sensor can be built and fitted by students as part of a STEM lesson.

Space context

Figure 1 Steve Swanson on board ISS carrying out experiments on plant growth

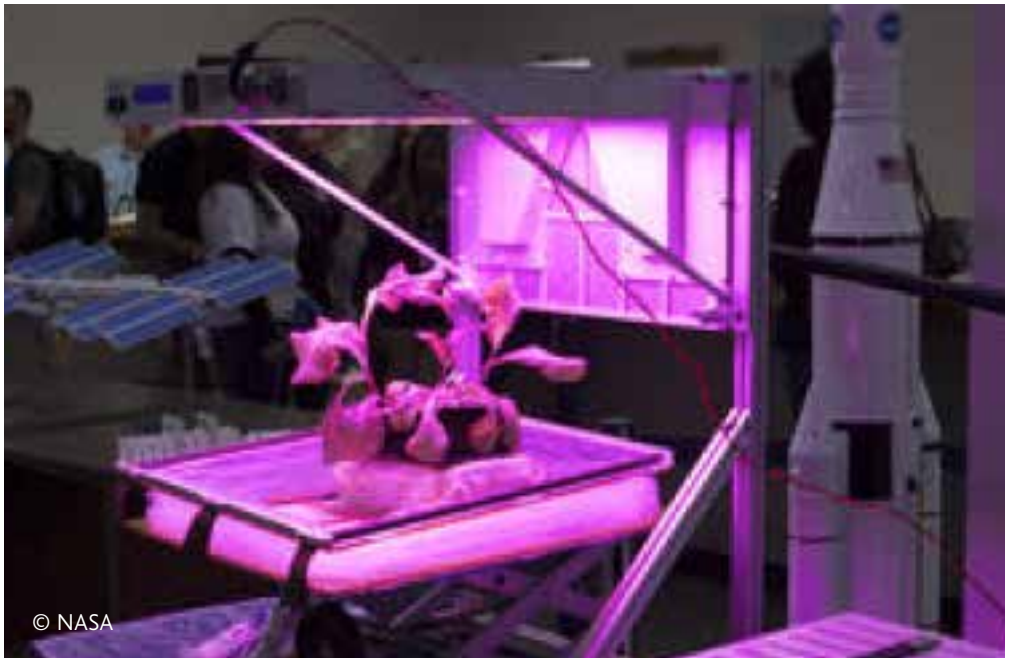


Figure 2 The VEGGIE project explored ways of growing different plants in conditions similar to those found in space. The pink glow is caused by a combination of red and blue LEDs that provide the correct wavelengths of light for photosynthesis.

Extended space travel will require food to be produced by travellers in space. This will help reduce the cost of space travel (by reducing the payload) and will also provide travellers with nutrients that could be lost when food is prepackaged. Experiments into growing plants for food have been carried out on the International Space Station (ISS) and also in simulated space conditions on Earth. One of the problems encountered was the reduced effect of gravity in space, which prevents water from draining down to the plant's roots. One possible solution is to use hydroponics to deliver water to modified root systems, relying on pumps rather than gravity. Other problems include providing sufficient artificial light and problems with pollinating plants that provide food from their seeds and fruit.

Prior Knowledge

Water, along with carbon dioxide, is a raw material used in the production of carbohydrate by photosynthesis. Water is absorbed by root hairs on the roots of plants and conducted up the plant in conducting tissue.

Soil contains water that can be absorbed by root hairs. Water drains down through soil due to the effects of gravity, but soil can also absorb water and transport it by capillarity, in any direction. Pure water does not conduct electricity, but the presence of dissolved soil minerals in water enables an electric current to flow.

Learning intentions

- Plants need a continuous supply of water
- Water is absorbed from soil by roots
- Water containing dissolved minerals is an electrolyte

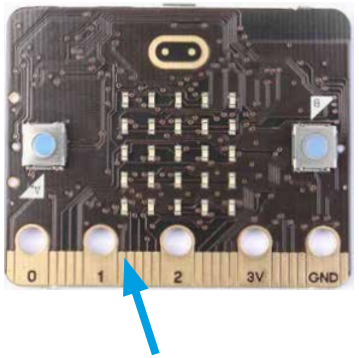
Resources

- Micro:bit and connecting lead to computer
- Battery pack
- Computer with access to Micro:bit web site to download code
- 'home-made' soil moisture sensor
- Container of soil, or compost, and water. An old margarine tub would be suitable
- Cress seeds (optional)

Preparation

Soil moisture sensors work by measuring the level of current flowing between two electrodes immersed in soil. Students can investigate and develop their own moisture sensor using common materials such as aluminium foil, metal roads, insulating tape, foam blocks, insulated wire etc. They can be tested before use by attaching a bulb and cell, checking that the bulb lights up when the electrodes are inserted into damp soil.

The moisture sensor is then attached to the micro:bit edge connector with crocodile clips.



The code for this activity is available here

Once the code has been downloaded it needs to be compiled and flashed to the Micro:bit. Additional help is available here

To start the procedure, press the reset button on the rear of the device.

Lesson activity

Connect the moisture sensor to the Micro:bit device.

When the procedure is first run on the Micro:bit, the LEDs will be illuminated as a warning signal that there is insufficient moisture. Briefly touching the electrodes together should cause the warning LEDs to go out. It is likely some adjustment of the home-made moisture sensor will be needed to make this work satisfactorily.

Fill a container, such as a margarine or ice cream tub with dry soil. Insert the sensor into the soil so that the electrodes are at the bottom of the container. The warning signal will be showing.

Add water to the soil, a bit at a time, until the warning signal goes out. Record the amount of water added. Evaluate the effectiveness of the moisture monitoring system and make recommendations for improvement.

Possible results table

Time / days	Experimental container of soil (with seeds) Volume of water added each day /cm^3	Experimental container of soil (without seeds) Volume of water added each day /cm^3

Place cress seeds on the surface of the soil so that they will germinate and leave the apparatus set up for several days. Add water as indicated by the Micro:bit moisture monitoring system. Compare the amount of water that needs to be added over the course of the investigation into the growth of seedlings with a control: use an identical container of soil and micro:bit monitoring system, without seeds.

Make suggestions for improving the hardware (sensors etc); software (procedure); and how you could automate the watering process rather than just using a warning system.

Assessment opportunities

- Ask students to explain how the sensor detects moisture in the soil.
- Draw a flow chart to explain the workings of a fully automated system that could be used to grow plants in artificial environments. An example of a simple flowchart for a greenhouse heating system is shown at the end of this document.
- Draw a diagram to show how plants could be involved in a closed system to recycle water on a space station.

Taking it further

- Find out about the ESA's MELiSSA project.
- Explore how making changes to the coding used in the moisture sensor procedure could make the device more sensitive to moisture changes, or could provide more detailed information about the water content of soil.

Links

Teacher support on Micro:bit site

ESA site describing different aspects of the MELiSSA project

Animation showing the movement of water through a plant

Example flow chart