Royal Academy of Engineering

THIS IS ENGINEERING

SUSTAINABLE FUTURES
DATAHIVE GREEN EDITION

The greenhouse effect

BEN CROWTHER

FARMING FUTURIST

Through my passion for the environment and love of engineering and design, I have developed a new way to farm using less water to feed more people and reduce the carbon footprint of farming.

Find out more about Ben by visiting
thisisengineering.org.uk

THE GREENHOUSE EFFECT

BEN IS INTERESTED IN 'GREENHOUSE FARMS'

A greenhouse is sometimes known as a forcing structure, that is, an artificial environment in which plants are "forced" to grow, despite the harsh outside climate.

How does a greenhouse work?

Every greenhouse operates on a simple physical principle called **"the greenhouse effect"**.

Sunlight (short waves) passes through transparent or translucent materials such as glass or plastic.

When it strikes an opaque surface inside (plant leaves, greenhouse floor, planters) some of the light energy is changed into heat.

The darker the surface, the more heat is generated. The greenhouse panels are good at transmitting light, but not heat. Therefore, most of the heat stays inside.

Once the short waves hit the ground, they warm it up. Then the warmed air rises and heats up the greenhouse. Then long waves radiate to the atmosphere.

Time to research

Research what we mean by **"the greenhouse effect"**.

How does this link to greenhouses we use for growing fruit and vegetables?

Investigate greenhouses using the DataHive Green

Investigate what happens to the temperature and light intensity when you place your *DataHive* under a transparent jar or glass.

- Using two *DataHives* at the same time, place one under a jar, glass or bowl and one without any cover.
- Leave the *DataHives* in the same place, outside or somewhere where they will get sun exposure, ideally for 24 hours.
- Collect your *DataHives* and connect them to a computer. Visit data.Redfern.uk.

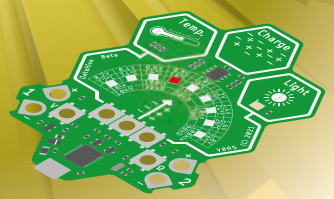
Here you can view logged data. Check out the temperature and light intensity graphs.

Time to reflect

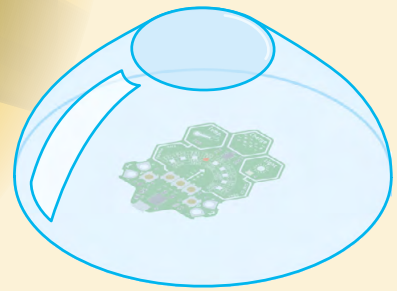
What do you notice? What do you think is happening?

Can you use this information to explain how greenhouses work?

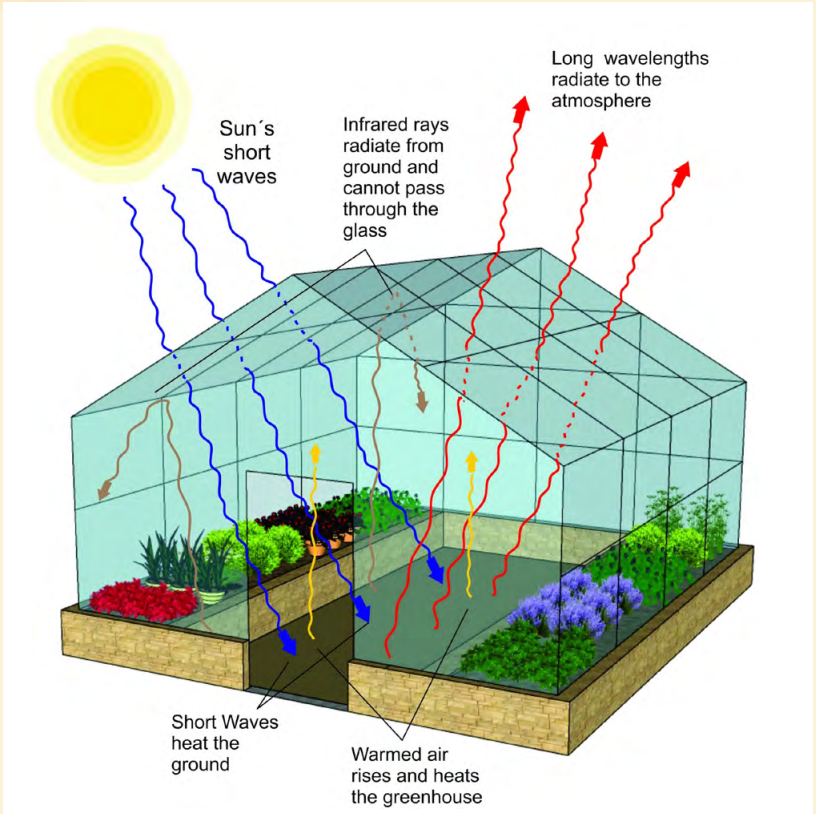
Why do you think you need to use *DataHives* at the same time to get the best results for this investigation?



***DataHive* logging data with no cover.**



***DataHive* logging data under a transparent glass bowl.**



How does a greenhouse work?
Image taken from: https://www.backyardgardenlover.com/how-does-a-greenhouse-work/

The darker the surface, the more heat generated

Lets investigate this statement using your DataHives.

- Using two *DataHives* at the same time, place both under a jar, glass or bowl.
- Create a shield using black cardboard for one *DataHive*, and a shield using white cardboard for the other.
- Leave the *DataHives* in the same place, ideally for 24 hours.
- Collect your *DataHives* and connect them to a computer. Visit data.Redfern.uk.

Here you can view logged data. Check out the temperature and light intensity graphs.

Time to reflect

What do you notice? What do you think is happening?
Can you use this information to explain how greenhouses work?

Shrinking ice caps, rising temperatures

What do you think some of the environmental impacts are of melting sea ice and land ice?

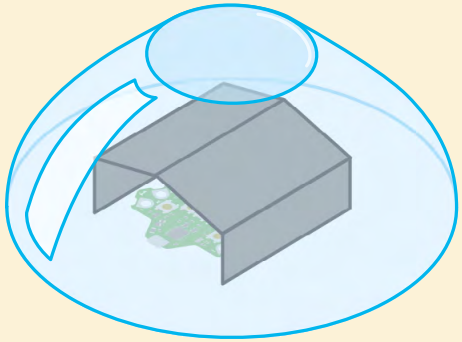
What do you think the difference is between sea ice and land ice?

***Hint:** What do you know about absorption and reflection?

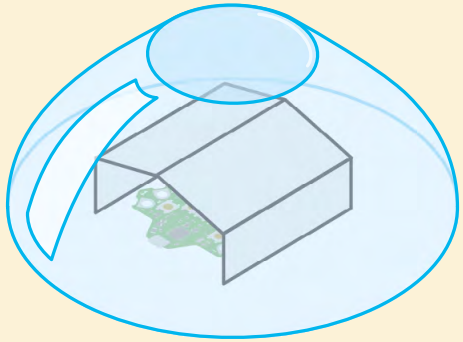
How do you think melting sea and land ice contribute to global warming?

How can your *DataHive* Green experiment show this?

Ben monitors crops in a sustainable indoor farm



***DataHive* under a transparent bowl with a black shield.**



***DataHive* under a transparent bowl with a white shield.**

Time to reflect

What do you think the image below shows?

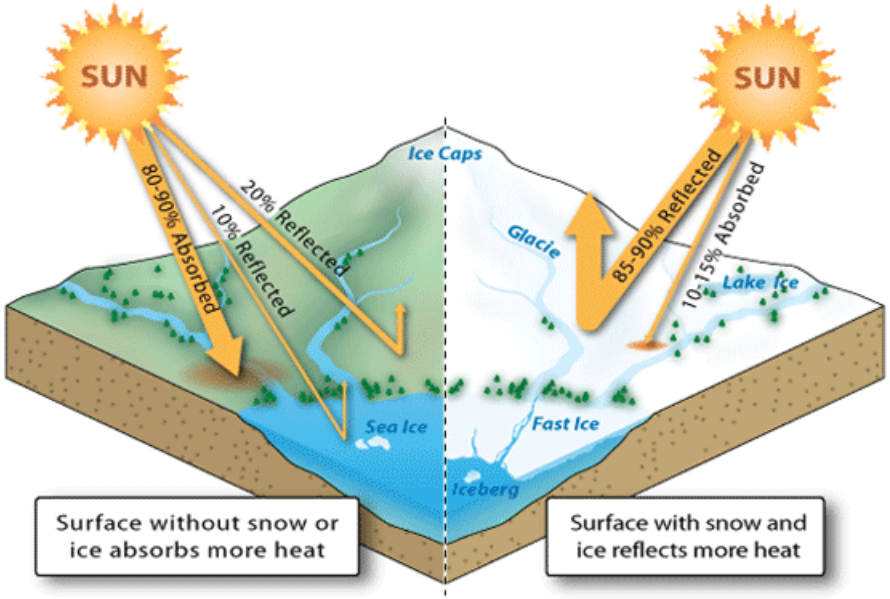


Image taken from: https://forces.si.edu/arctic/02_02_00.html

INVESTIGATING PHOTOSYNTHESIS

PHOTOSYNTHESIS IS A GREAT EXAMPLE OF A HIGHLY EFFICIENT BIOLOGICAL PROCESS THAT IS GOOD FOR THE ENVIRONMENT.

Engineers can use a solid understanding of such biological processes to design more efficient and less environmentally damaging ways of meeting our needs.

In order for plants to grow they make their own food using photosynthesis. It is important for engineers working in food production to know how this process works. We are also learning from the process of photosynthesis to help develop clean fuels and sources of renewable energy.

Photosynthesis is the process used by plants, algae and certain bacteria to turn **sunlight**, **carbon dioxide (CO_2)** and **water** into food (sugars) and oxygen.

What do plants eat? Yes, that's right, just like us, plants also need food to grow!

Plants make their own food using photosynthesis. The food that plants produce is important, not only for the plants themselves, but for the other organisms that feed on the plants.

Time to reflect

What is in the air we breathe? What components of air does our body need? Where do we get this from?

The rate in which photosynthesis happens depends on light intensity, temperature and carbon dioxide concentration.

We can investigate the effect of light intensity on photosynthesis using pond weed (such as Elodea or Cabomba)

MATERIALS

- ☐ Pond weed (easy to buy online from an aquatic shop)
- ☐ A thin transparent beaker (such as a science beaker or olive jar)
- ☐ A lamp with an LED bulb
- ☐ A ruler/tape measure
- ☐ Bicarbonate of soda (sodium hydrogen carbonate – formula $NaHCO_3$
- ☐ *DataHive Green*

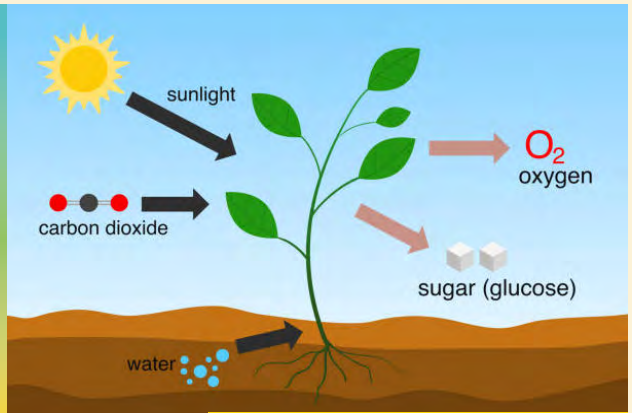
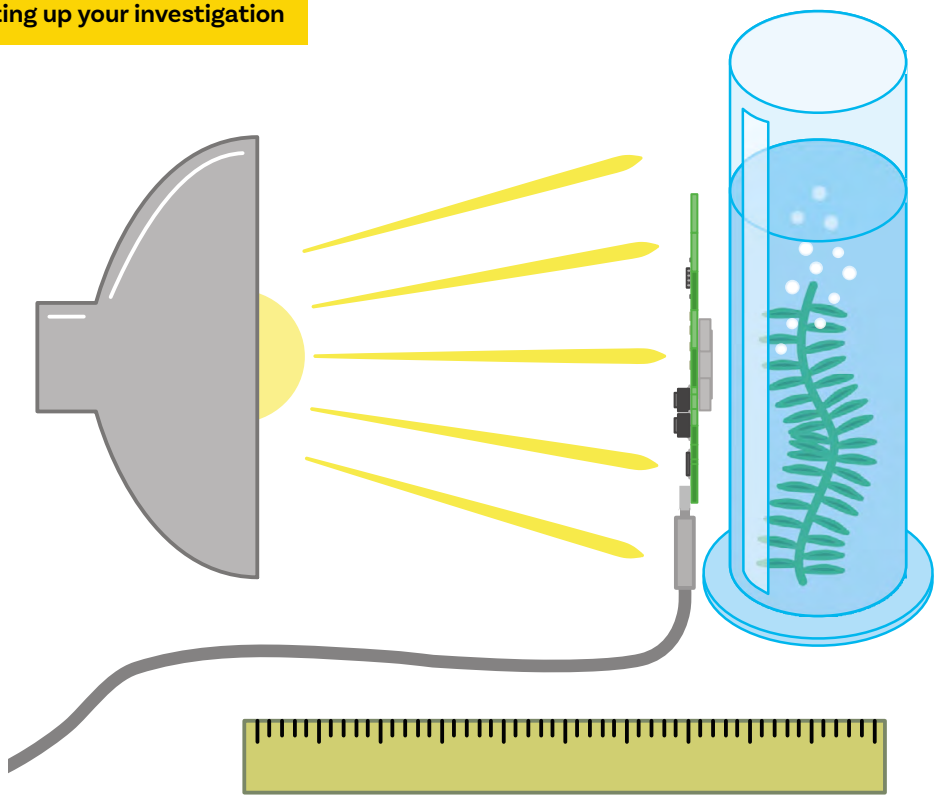


Diagram showing photosynthesis

Setting up your investigation



Investigating photosynthesis

- Fill your beaker with water, but a leave a gap at the top. Make a note of the volume of water in your beaker.
- Place a strip of the pond weed into your breaker, ensuring that there is about a few centimetre gap between the surface of the water and your pond weed. Use forceps to pick up your pond weed so you do not contaminate your sample. Make a note of the length of your pond weed.
- Add a teaspoon (**stretch and challenge:** or 1% of the volume of your water) of bicarbonate of soda to the water to create a new solution.
- Place the lamp 5cm away from the beaker. Allow the beaker to stand for five minutes.
- Turn on your light source.
- Use your *DataHive Green* to measure the light intensity at the beaker. Make sure that the sensor is facing the light source. Record this data on your table.
- Set a timer for one minute, and count the number of bubbles emerging from the cut end of the stems in this time. You can use your *DataHive Green* to do this.
- Repeat this five times. Record your results.
- Take an average number of bubbles produced per minute.

What do you think will happen as you increase the distance between the light source and the beaker?

Repeat the experiment at different distances away from the light source.

Using your *DataHive Green* for this investigation

As well as measuring the light intensity, you can also use your *DataHive green* to count the bubbles, to record your results and to plot a graph.

Visit data.Redfern.uk where you can find the 'Investigating photosynthesis' project page and you will find an interactive guide for this investigation, bubble counter, a table to record your results and a graph plotting function.

Time to reflect

What do you think the bubbles show?

What do you think is happening? Why?

What do you think would happen if you left some plants in a completely dark closet for two or three weeks? Why do you think that?

Why is it important for crop plants to receive enough rainfall?

The Earth's atmosphere did not always contain as much oxygen as it does now. In fact, at one time it probably contained no oxygen at all.

How do you think the oxygen in the Earth's atmosphere got there? Why do you think that?

Table to record results of photosynthesis investigation

Distance	Rate (average number of bubbles per minute)
5cm	

Graph to record your results for the photosynthesis investigation

Number of bubbles per minute

Distance between pondweed and light in cm