PLYMOUTH CITY
MUSEUM AND
ART GALLERY

# DARWIN: WORMS, SUNLIGHT & BEANS!

**Explore some of Charles Darwin's scientific experiments**

## Darwin's Voyage of Discovery

**24 January — 18 April**

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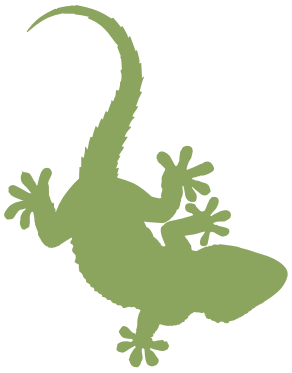


# INTRODUCTION

## Plymouth City Museum and Art Gallery are offering you the opportunity to test experiments first conducted by Charles Darwin over 125 years ago.

Darwin famously sailed around the world on *HMS Beagle*, leaving from Plymouth on the 27th December 1831. On this voyage, Darwin discovered new and exciting plants and animals, and began to realise that species differed as he travelled around. It was on this voyage that the seeds of a new scientific theory were set - '*The Origin of the Species*'. The book was published in 1859, and changed the way that scientists thought about how life evolves of time, the main way being through natural selection.

**In this pack you will find two of Darwin's experiments that are a little easier to test in the classroom:**

- One involves growing seedlings and testing how light effects growing conditions
- One involves building a wormery and discovering how worms convert food waste into compost.

The text in this pack was originally written for a competition open to schools in the Plymouth area.
**If you require any more information about how to use these experiments with your school, please contact Adam Milford or Rob Longworth on 01752 304774, or email beans@plymouth.gov.uk**

# WHY IS DARWIN IMPORTANT?

*"As far as I can judge of myself I worked to the utmost during the voyage from the mere pleasure of investigation, and from my strong desire to add a few facts to the great mass of facts in natural science."*
Charles Darwin

**The above quote from Charles Darwin sums up why many people believe he is so important and why he has inspired many to be questioning, enthusiastic scientists.**

Darwin was a geologist, zoologist, botanist, experimental scientist, observer, recorder, thinker, collector, author and family man. He managed to examine all the available information of his time and came up with a theory that explains how we all came to be here. This was published in his book 'The Origin of the Species'. His breadth of knowledge allowed him to take many different facts and put them together to show how all of nature is inextricably linked back in time.

## Darwin never actually published a theory of evolution. What he did propose was a way that species might change over time...

**Natural selection in a nut-shell**
*The concept is simple, incredibly powerful and based on four main principles:*

- **variation** - individuals in a population vary slightly from one another
- **inheritance** - parents genetically pass on some of their own traits to their offspring
- **selection** - some variants reproduce more than others and not all individuals born can survive
- **time** - successful variations accumulate over many generations

Darwin also came up with many other theories on the natural world, regularly experimenting to test these theories. Among those he published were '*The Fertilisation of Orchids*', '*The Variation of Animal and Plants under Domestication*', '*The Power of Movement in Plants*', and '*Vegetable Mould and Worms*'.

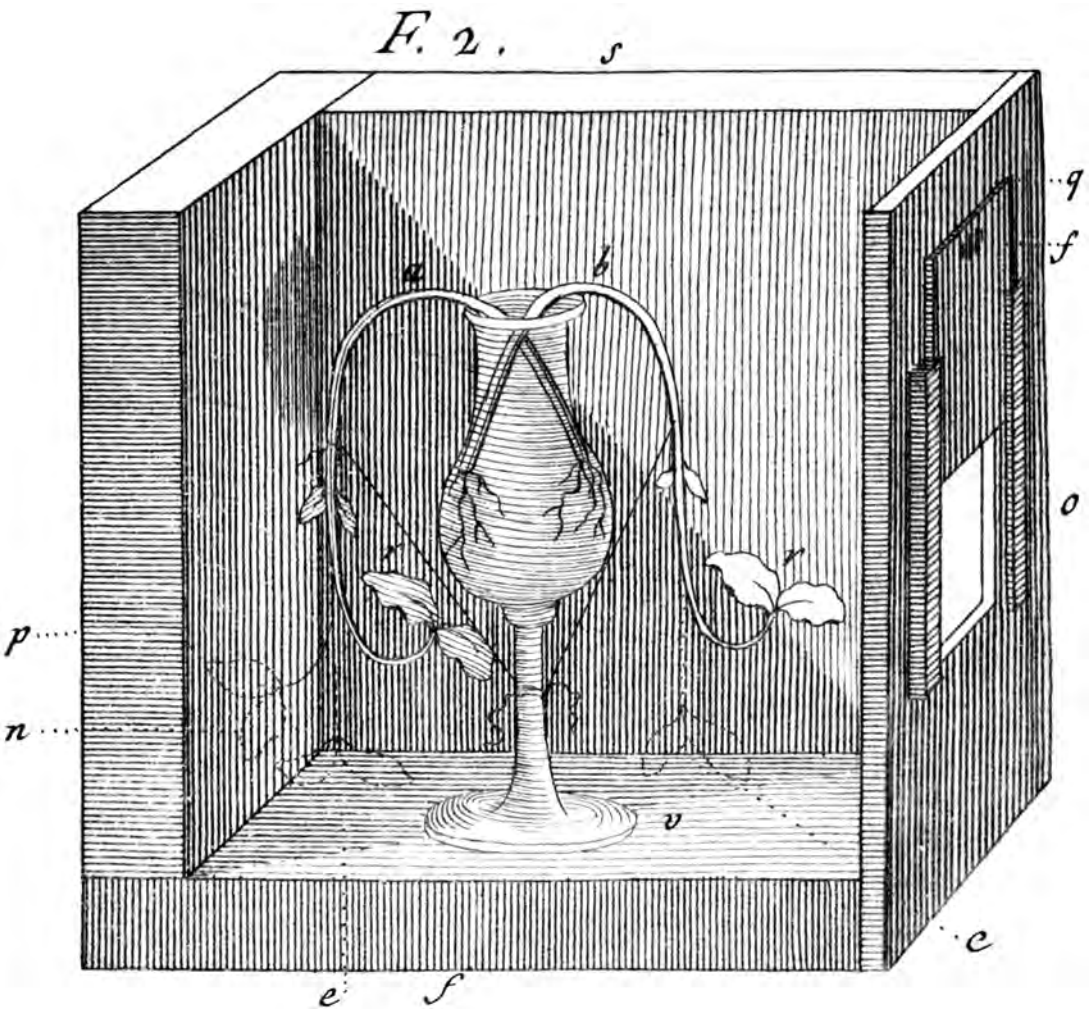
The two processes we now know as phototropism and bioturbation, were first considered in Darwin's publications '*The Power of Movement in Plants*' and '*Vegetable Mould and Worms*'.

# EXPERIMENTS

## Phototropism – the way light effects plant growth

Most plants are phototropic, that is, they grow toward the light. They position their leaves and flowers towards the light, allowing the plant to collect as much energy as possible needed for photosynthesis. Without this, the plant wouldn't grow or reproduce. Charles Darwin conducted several plant growth experiments involving light, and found that the stimulus for growth can be found in one part of the plant, while the response to this may occur on another part of the plant.

**This experiment will test the theory using broad bean seedlings, and will require your pupils to accurately measure the growth of the plants. By taking part in this experiment, your pupils will be able to test one of Darwin's theories.**

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**In order to carry out this experiment, you will need:**

**For the seedlings:**

- Organic Broad Bean ('The Sutton' variety) seeds – available from *'The Organic Gardening Catalogue'*
- Some potting compost
- Two medium sized plant pots for the experiment
- Eight further plant pots for the children to grow seedlings for the School garden

**For the experiment:**

- Two cardboard shoe boxes, roughly the same size and material
- A dark room or cupboard
- Black sugar paper to cover the inside of each box
- Some parcel tape, or black electrical tape if you have it
- A camera, or squared paper for recording results

- Firstly, you will need to start growing your broad bean seedlings. Luckily, broad beans are amongst the easiest of vegetables to grow, so you shouldn't have too much trouble. Fill all ten plant pots with potting compost, and place one broad bean seed into each pot. Push it down into the compost so it's about 5 cm deep, and cover with a little more compost. Water the pot and keep in a warm cupboard, or on a windowsill. After ten days or so, you should start to see shoots appearing from the soil

- After planting your seeds, you can start creating 'phototropic chambers' in which to conduct your experiment. Cover the inside of each shoe box with the black sugar paper using glue. Covering the inside thoroughly will minimise any unwanted light that may affect your experiment

- If you wish you could also decorate the outside of each box - include the words 'light box' and 'dark box' so you know which one is which. In your 'light box', cut a small rectangular hole in the lid section of the shoe box, towards the top, and in the middle. It should be the same size as a credit card. The shoe boxes will be stored upright for the experiment. Cut a piece of black sugar paper that is just larger than the hole, and tape this on lightly, as it will be removed at a later date

- When the seedlings are around 2cm tall, you are ready to begin the experiment. Place both plant pots into their boxes, making sure they have been watered

- If you have access to a digital camera, take a photo of each seedling in its box. Place a ruler behind the seedling so you can record its height. If you are recording the experiment on paper, place a ruler behind the plant and carefully measure its height. You can also make a drawing of the plant at this stage

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- If at this stage there is any curvature in the plant stem, older students may be able to record this using a protractor. If not, try to make an accurate drawing
- Seal the lids of the boxes using the tape. Try to avoid any light other than that coming through the hole you cut earlier, as it may affect the experiment. The 'dark box' shouldn't have any light getting into it at all
- Place both boxes on a window sill, with the hole cut in the 'light box' facing the glass
- Wait for one week before reopening the boxes. Ask the pupils not to peek! This will affect the experiment and will produce false results
- Open the boxes one at a time. Place a ruler behind each plant as you did at the start of the experiment. Repeat the recording of your data using digital photographs or drawings. How have the seedlings grown? How have the seedlings grown differently?
- If your seedlings do not show the differences that are expected with phototropism, consider extending the experiment for another week. Remember to water the plants again!

# EXPERIMENTS

## Bioturbation - the way worms turn over soil

The term bioturbation means the reworking of soil through biological activity. Worms and other invertebrates burrow deep into the soil, moving around different layers that allow plants to grow. Charles Darwin conducted experiments into how worms move soil layers around, and wrote a book called 'The Formation of Vegetable Mould through the Action of Worms, with Observations on their Habits' to explain his findings. The experiment listed below will not allow you to see how the worms move soil, only the end result. You can buy cheap, glass-sided wormery's for the classroom that will demonstrate how soil is moved by worms from *The Organic Gardening Catalogue*.

Soil is formed by the action of plants and animals. Plants start the process with their roots slowly breaking up the underlying rock (called biological weathering). Some animals will eat the plants, and their waste falls to the ground. If a plant isn't eaten, it dies and other animals will eat it. The waste produced contains lots of nutrients needed for more plants to grow, and for more animals to eat.

**Worms play an important role in the formation of soil, as they move up and down through the various layers. This experiment will test how useful worms are at turning some old vegetables into nutrient rich soil.**

### In order to carry out this experiment, you will need:

- Enough untreated plywood to build a box 60cm high x 60cm deep x 120cm wide
  The base should be made with 12mm thick plywood, while the sides and lid can be 8mm plywood. Perhaps the school caretaker or a helpful parent could help with building this
- Two or three blocks of wood to sit the box on, 60cm long
- A drill to make 12mm wide holes
- Hinges if you wish to hinge your lid
- Something heavy, such as a brick, if you don't wish to hinge your lid
- Some scraps of newspaper
- Uncooked vegetable or fruit food waste - only use vegetable or fruit waste to avoid rats or other scavengers from trying to break in. Never use cooked food waste or dairy products, and never ever put meat scraps in a compost bin. Perhaps your school kitchen could help with this, otherwise pupils could save their fruit waste from break time or lunchtime, or bring in food waste from home
- Worms! The best worms to use are Dendrobaena worms -
  available from *Buckets of Worms.*

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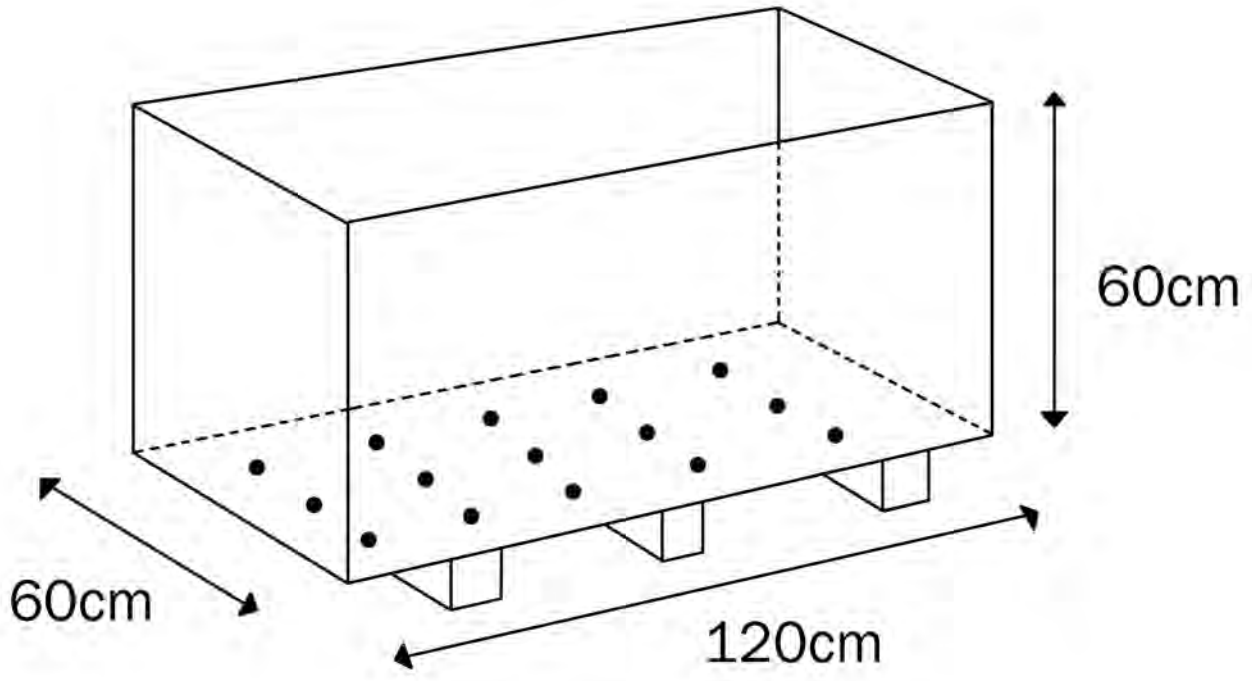
- To make the plywood box into a viable wormery that produces compost, drill around 20 holes into the base to allow moisture to drain out
- Site your wormery in a shaded area. Worms will die in hot temperatures
- If you think you will struggle to accumulate the necessary vegetable waste, partition the inside of your box into three sections using some leftover plywood, or any other solid material you have that can be shaped to fit. Drill plenty of holes in these so your worms can go wandering!
- If you are placing your worms into an empty wormery, you will need to cover the inside base with two or more sheets of newspaper, to stop the worms from escaping before they start making your compost
- Occasionally add dampened, shredded newspaper to the food scraps. Newspaper is extremely thin wood pulp and will compost down relatively quickly. Don't add anything too 'woody' though, as this takes a very long time to compost
- If the wormery starts to smell, or gets too wet, try adding scraps of dry cardboard
- The worms need oxygen to survive, so every four to six weeks you should turn the compost using a garden fork
- If you follow this advice, you should be producing good compost within three months

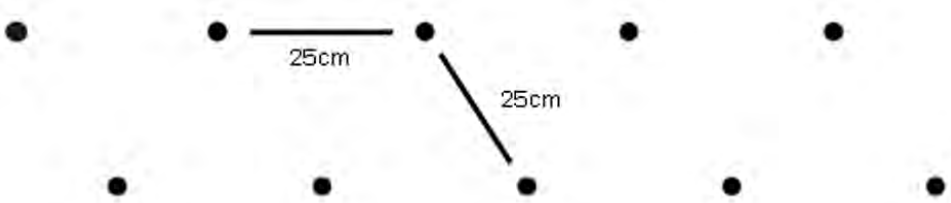


# GROWING TIPS

**Broad bean plants can be put into the ground as early as February, any earlier and they might perish in the cold weather. You will need to dig over some of your school grounds for this experiment. If you already have a vegetable patch - perfect - if not, you will need to borrow some spades and forks. Dig out as much of the grass and weed roots as possible, and try to pick a sunny spot that is quite sheltered from the wind.**

If you did try the bioturbation experiment, dig some of your compost into the soil. You can do this in advance of planting the seedlings. If not, it might be worth investing in some good organic compost for planting.

Planting the seedlings is very easy. You can either plant them in one long line of ten, or two rows of five. Either way, plant the seedlings 25cm apart as they grow quite large.
Please see the diagram included here:




# RECIPES

**Hopefully you'll have produced a bumper crop of big juicy broad beans at your school. What should you do with them all? Eat them of course!**

You can either eat them as you go, or dry the beans out to store them for later in the year. You can find how to do this on the internet. If you do dry them, they will need to be soaked in water to re-hydrate them before cooking.

Maybe your school cooks could put on a broad bean feast for the pupils, or perhaps you can dish them out to all the children to take home. Either way, the recipes below may be useful. Healthy eating as well as healthy learning!

Remember, any uncooked vegetable waste, such as broad bean shells, or lemon skins can be put back into the school wormery to make more compost.

## Tasty Broad Bean Soup

**What ingredients do I need?**
1 tbsp vegetable oil
1 medium onion, finely chopped
225g (8oz) fresh broad beans, skins removed
500ml (18fl oz) vegetable stock
1 tbsp fresh mint, chopped, plus a few leaves for garnish
Black pepper
2 tbsp reduced fat plain yoghurt

**How do I make it?**
- Heat the oil in a pan and fry the onion gently until soft
- Add the beans and the stock and simmer for about 15-20 minutes
- Add the chopped mint and pepper
- Remove most of the mixture to blend, leaving some beans in the pan
- Blend the mixture in a food processor until smooth
- Pour the mixture back into the pan, reheat and stir in the yoghurt before serving
- Garnish with a few mint leaves and serve with wholemeal bread or toast

# RECIPES

## Easy Broad Bean Salad

**What ingredients do I need?**
85g/3oz broad beans, cooked, skins removed
¼ red onion, peeled and chopped
1 tbsp chives, chopped
1 tbsp olive oil
½ lemon, juice only
salt and freshly ground black pepper

**How do I make it?**
- Mix the broad beans, red onion and chives in a bowl
- Drizzle over the olive oil and lemon juice and then add the salt and freshly ground black pepper
- Toss together and then transfer to a serving plate

# ROCKET GARDENS

**Rocket Gardens is aiming to get one million children growing their own vegetables over the next two years by offering organic plant packs to more than 5,000 schools across the country. The move is part of Rocket Garden's "Dig For Their Future" campaign, which aims to teach children about the benefits of growing their own food and how it can help to save money, improve their health and the environment.**

A Rocket Garden is a box brimming full of baby vegetable plants packed in golden straw and delivered direct to the school. All children have to do is pop the baby plants into the ground to begin growing their own school's organic vegetable garden. Two types of garden are available for schools to buy from the company, Spring Gardens and Autumn/ Winter Gardens.

Rocket Gardens makes it easy for any school and teacher to implement this initiative - even those with no gardening experience as we provide full growing guides and lesson plans, which are linked to key stages of the National Curriculum.

Alan Titchmarsh, who promoted Rocket Gardens on his show, said: "Food bills are set to Rocket this year so here is a great way to save yourself a fortune and grow your own. A Rocket Garden is a great start for any would be vegetable gardener."

Organic plants from Rocket Gardens were used in the winning garden at this year's Hampton Court Palace Flower Show, Chelsea Flower Show, Grand Designs Live Sustainable Garden, Greenpeace Garden at Glastonbury, and the Eden Project. Rocket Gardens are also fully accredited as organic growers by the Soil Association.

The company are based in Camborne, Cornwall.

Visit the Rocket Gardens website *www.rocketgardens.co.uk* for further information.

PLYMOUTH CITY MUSEUM AND ART GALLERY

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01752 304774 *www.plymouthmuseum.gov.uk*

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