Rocket Science

Experiment Pack

Royal Horticultural Society
Sharing the best in Gardening

RHS CAMPAIGN FOR SCHOOL GARDENING

UK SPACE AGENCY

esa
European Space Agency

Contents

Crest Award

The Rocket Science experiment and curriculum activities could be used to achieve a CREST or CREST Star Award, which would further celebrate what the students have achieved.

CREST is a UK award scheme for secondary school students that recognises success, and enables students to build their skills and demonstrate personal achievement in project work. It offers educators an easy-to-run framework for curriculum enhancement and is student led, which means that young people take ownership of their projects and choose to undertake them in areas they enjoy or see as relevant. UCAS endorses CREST Awards for inclusion in students' personal statements.

They are well regarded, high-quality and a tangible recognition of success. CREST can also count towards the Skills section at any Duke of Edinburgh Award level.

CREST Star is the primary school award program designed to complement the curriculum and encourage hands on learning and enquiry. The Rocket Science project can count as a MegaStar project.

To find out more about how your students could work towards CREST through Principia related projects visit the British Science Association website or email **crest@britishscienceassociation.org**

You are now ready to start the **Rocket Science** *experiment in the summer term of 2016.*

On 2 September 2015, two kilograms of rocket seed *(Eruca sativa)* travelled from Baikonur, Kazakhstan on the Soyuz 44S rocket to the International Space Station (ISS). The seeds have been stored in microgravity by Tim Peake (the first British ESA astronaut) before their return to Earth in the spring of 2016.

You will have one red packet and one blue packet of rocket seeds each containing a minimum of 100 seeds. One contains seeds that have travelled to space and the other contains seeds that have remained here on Earth. If for any reason you have fewer seeds than this please alert us.

The red and blue seeds should be sown and grown side by side for a period of 35 days on your classroom windowsill. The seeds should be sown on the 19th or 20th April and the experiment should be completed on 23rd or 24th May before half term. This ensures no data needs to be collected over the half term holiday.

This pack contains all the information you need to sow, grow and observe your rocket seeds for the experiment. To get the most from your experiment **please read through all the instructions and information before you start.**

You will need to measure and record similarities or differences in plant growth between the two seed packets and record this on the ***Measurement Chart***. At the end of the experiment, you will be required to enter your results in the national database where the findings will be analysed and published for everyone to see. You will be invited to make a prediction based on the evidence you have gathered as to which packet contains the space seeds, red or blue.

We would like you take a photo of your pupils or students working as space biologists! Please send your photos, which should be less than 1 MB in size to **schoolgardening@rhs.org.uk** and we will feature the most creative and inspiring shots on our website.

Getting the most from your **Rocket Science** *pack*

Rocket Science is one of a number of inspiring projects for schools initiated by the UK Space Agency to celebrate the Principia mission of British European Space Agency astronaut Tim Peake to the International Space Station. The projects harness the expertise of partner organisations in a wide range of fields. Find these educational programmes here: principia.org.uk/get-involved.

We, at the Royal Horticultural Society (RHS) Campaign for School Gardening, are thrilled to be working for the first time with the UK Space Agency. For Rocket Science, we want to encourage children and young people to become space biologists in order to weigh up whether it is possible to grow our own food on other planets, millions of miles away from Earth.

We have designed Rocket Science to introduce pupils to the practice of working to a structured scientific method, as well as showing pupils the fascinating, 'hidden' science behind horticulture. Throughout the experiment pupils will measure and record key data for their seeds as they germinate and grow. At the end of the experiment, we will ask schools to upload their data onto a national database, enabling every school taking part to contribute to our global scientific understanding of growing plants in space.

The experiment will last for six weeks, starting immediately after the Easter holidays in April and finishing by May half term 2016. As a teacher or group leader, you will need to ensure that the data recorded on your classroom ***Measurement Chart*** provided is entered onto the national database by the **17th June**. Details for the national database will be emailed to you in the first week of June 2016. A very exciting, specially recorded video in which Tim Peake reveals the true identity of the space seeds will be released to all participating schools and groups before the end of term. In the meantime we are excited to hear your predictions as to which packet the space seeds are in – red and blue!

Ideas to get everyone involved!

- Hold a Rocket Science assembly or event before you start the experiment and again once you have completed it.
- Share your experiment by filming the rocket seedlings' growth using time lapse photography.
- Get the students to create a short play or musical about the rocket seeds or space.
- For Secondary students why not create a hypothesis for the experiment results? Will your hypothesis be correct? A debate or competition could be formed around the creation and discussion of the hypotheses.
- The International Space Station (ISS) is a model of global collaboration. This could provide an interesting topic for discussion.
- Ask pupils to analyse data from their results using an MS Excel© workbook. A template has been created by our bio-statisticians and is available on request via an email to schoolgardening@rhs.org.uk.

Get all pupils in the school involved in Rocket Science by using our brilliant Primary and Secondary Schools' Resource packs found here: www.stem.org.uk/elibrary/collection/4353/rocket-science. The packs have a fantastic range of curriculum-linked activities for all ages and abilities around the theme of growing food in space, as well as key facts to stimulate class discussion.

Estimated time:
6 weeks

Location:
Classroom windowsill indoors

School term:
Beginning of summer term

Level of Experience:
All

Subject(s):
Science, Maths, English

Rocket Science Experiment

*This document explains the methods used to grow the rocket seeds for the Rocket Science experiment. It should be used with the **How to...** guides found in this pack.*

Learning Objectives:

- To learn the horticultural techniques required to grow rocket seeds to 6 week old plants
- Use data from the Rocket Science experiment to ask and answer specific scientific questions

Step by step guide

1. Prepare all the equipment you will need to conduct the experiment as soon as you receive your pack. Make 200 small labels from recycled milk bottles using the guide ***How to make recycled labels.*** Keep the seeds in a cool dry place until you sow them.
2. Choose a Tuesday or Wednesday (the 19th or 20th April) to sow your seeds so you will not need to record data at the weekends. Before the seeds are sown prepare the P40 modular trays into sets of 25 modules and then place these in the standard seed trays as a base. To sow your seeds use the guide ***How to sow rocket seeds***, record the date and number of seeds sown on the ***Measurement Chart*** found in this pack. Make sure you water the seeds and check them every two days.
3. Record the number of days it takes the seeds to germinate on the ***Measurement Chart***. The seeds will now need close monitoring so check them for water every two days as they may dry out faster now they are growing. Be careful not to over water the seedlings as this can lead to seedling death.
4. Continue to water the trays as required. Turn the trays regularly. Record information on days 10,17,21,28 and 35 after sowing, according to the instructions on your wall mounted ***Measurement Chart***. Use ***How to measure and count*** and ***Randomisation methods 1 and 2*** to show you how. Once you have done this, write the results on the ***Measurement Chart***.
5. After day 35, the experiment is finished and you can enter all the results from your ***Measurement Chart*** into the national Rocket Science database website. The website address for the national ***Experiment Database*** will be supplied by e-mail in the first week of June. For health and safety reasons, please do not eat the rocket grown from this seed.

Hints and Tips

- Use a tray to stand your modules in to stop water running out onto the windowsill.
- Rotate the modules daily to allow all the seeds to be exposed to equal amounts of sunlight.

Preparation/equipment

Ensure you have a clear space in which to grow your 200 seeds. Ideally this should be a sunny windowsill where all the seeds will be subjected to exactly the same conditions throughout the experiment. You will need: 5x P40 modular seed trays, 8x standard seed trays act as a base (see picture below), 200x recycled labels, 20 litre bag of compost and a watering can with a fine rose.

Before you start: store your compost indoors for 1-2days to allow it to dry and then prepare your 8 trays using the instructions in the ***How to sow rocket seeds*** guide.

Estimated time:
20 minutes

Location:
Indoors or out

School term:
All

Level of Experience:
None (supervision may be required to use scissors)

How to
make recycled labels

Clean plastic milk bottles are the ideal material to make labels for your seedlings and young plants

Instructions

Use sharp scissors (under supervision) to make the first cut. Children's scissors may be used to complete the activity.

1. Carefully cut into the plastic and along the straight sides of the milk bottle

2. Cut into long strips approximately 15mm wide

3. Trim the labels to the size you require

4. Finish one end off into a point by cutting two diagonals

5. Use marker pen to write on the labels. For blue seeds write B1 - B100 and red seeds R1 - R100

6. Label the cells in the module tray as required

Estimated time:
15-30 minutes
(depending on skill level)

Location:
Indoors

School term:
Summer

Level of Experience:
All

How to
sow rocket seeds

Use this guide to fill your 'P40' module trays and sow your rocket seeds. Sow one seed in each 'cell' and place the trays on a windowsill using the guide ***Randomisation Method 1****.*

Instructions

Bring your compost inside a few days before seed sowing (in case it's cold & wet). Organise the workspace and break up any lumps in the compost before you begin.

1. Cut up 25 cells from the P40 modular tray (5x5) and place them in the 8 standard seed trays for sturdiness

2. Using your hands fill the cells evenly to the top with compost, tap the tray down on the table to settle the contents

3. Using the labels you have already made from the milk bottles, place a label in each cell

4. With a pencil or dibber make a hole approximately 2cm deep in the middle of each cell

How to sow rocket seeds

5. Continue making holes until you have completed the whole tray

6. Very carefully empty the blue seed packet of rocket seeds into your hand or into a container and let children select one seed at a time to sow. Carefully repeat this process with the red seed packet. Be careful not to spill any seeds

7. Using your index finger and thumb carefully put one seed in each hole, it should fall to the bottom

8. Complete the entire tray and repeat the same process with the other colour packet of seeds

9. Tap the tray on the table top 2 or 3 times to settle the compost. The holes will fill in and the seeds will be covered

10. Place the seed tray in a tray of water for a few hours, only fill this to a depth of around 2cm of water and allow it to be soaked up. Alternatively water from above using a fine rose and gently moving this back and forth across the tray to evenly water

Estimated time:
6 weeks

Location:
Classroom windowsill indoors

School term:
Beginning of summer term

Level of Experience:
All

Subject(s):
Science, Maths, English

Randomisation method 1

*This document explains the methods used to randomly select the seed tray layout for the Rocket Science experiment. It should be used with the **How to sow rocket seeds** guide found in this pack.*

Learning Objectives:

- Learn how to carry out the scientific method of random selection.
- To understand why randomisation is fundamental to scientific experiments.

Step by step guide

1. Start by following the ***Rocket Science Experiment*** guide to set up and start your Rocket Science experiment. When writing each label name them B1-B100 (blue seed packet) and R1-R100 (red seed packet). For each of the blue and red seed packets there will be four trays of 25 cells in which to sow the seeds. Each cell and seed needs a label so for both the red and blue seeds there will be trays labelled 1-25, 26-50, 51-75 and 76-100 making eight trays in total.
2. To make the experiment unbiased and to allow all the rocket seedlings an equal opportunity to grow, the seed trays for each colour 1-8 (eight replicates) need to be randomised.
3. Place one label from each of the eight trays in a container. Mix these up and without looking, select the labels and lay them out in the order that they are removed from the container, left to right.
4. Put the trays on the windowsill from left to right in the order the labels were removed from the container. Once the replicates have been randomly placed, put the labels back in their corresponding trays.
5. After this has been done the seed trays will need to be turned 180° every two days. This is to ensure that all seedlings get an equal amount of light. This will help reduce differentiation in the seedlings growth.
6. Each tray must be given the same amount of water to ensure that all seedlings get an equal amount of water. This will help reduce differentiation in seedling growth.

Hints and Tips

- Have Rocket seed monitors to turn the trays and to ensure labels do not go missing. There could be two monitors on duty each week during the experiment.
- Do not worry if the placement of seed trays on the windowsill seems odd. For example you may have Red (1-25) Red (51-75), Red (26-50), Blue (26-50), Red (76-100), Blue (51-75), Blue (1-25), Blue (76-100) as a result of the randomisation.

Definitions

Randomisation reduces the risk of bias occurring when carrying out an experiment thus drawing incorrect conclusions. Randomisation techniques must be used with this experiment to ensure conclusions drawn from the data collected throughout are scientifically valid.

Replication is the term used by scientists when referring to the existence of separate repeats of the same test conditions. Here we have 4 trays of each seed (blue and red) and therefore we are said to have 4 replicates of each.

Bias is the outcome of an unfair comparison. For instance where one set of seeds has been treated preferentially over others.

Equipment needed

Plant labels
Pens or pencils
Container (a hat or tub could be used)

Estimated time:
15 minutes

Location:
Indoors

School term:
Summer

Level of Experience:
All

How to
measure and count rocket seedlings

This guide will show you how to take measurements and count your rocket seedlings. Use this How to guide with ***Randomisation Method 2****.*

Instructions

Seedling measurements and leaf counts are an essential part of recording for the Rocket Science experiment.

1. The first task is to state the day the first seedling germinates – this is when it shows the first pair of seed leaves

2. If you have accidentally sown 2 seeds per cell remove the smaller seedling so there is only one seed per cell

3. Next count the number of seeds that have germinated in each tray after 10 days. Convert this into a percentage

4. Record and count how many days it has taken the first seedling in each tray to grow two true leaves (see seedlings pictured above)

How to measure and count rocket seedlings

5. How many seedlings are alive on day 17? Turn this into a percentage

6. Measure the height in mm of the tallest plant from each tray on day 21

7. On day 28 randomly select five seedlings from each tray and count the leaves on each. Then calculate the average (mean) number of leaves per tray and write this result on to the ***Measurement Chart***

8. Count how many plants are alive on day 35. Plants that have shrivelled, browned or are diseased should not be counted. There is a Frequently Asked Questions page on the Campaign for School Gardening website to help

Estimated time:
6 weeks

Location:
Classroom windowsill indoors

School term:
Beginning of summer term

Level of Experience:
All

Subject(s):
Science, Maths, English

Randomisation method 2

This document explains the methods used to randomly select seedlings in order to count the number of leaves for the Rocket Science experiment. It should be used with the ***How to measure and count*** *guide found in this pack.*

Learning Objectives:

- To learn how to carry out the scientific technique of randomly selecting plants for data collection.
- Understand why randomisation is fundamental to scientific experiments.

Step by step guide

1. Start by reading the ***How to measure and count*** guide and the questions on the ***Measurement Chart*** found in this pack.
2. On day 28, five plants from each tray must be selected at random to have their leaves counted.
3. Ask pupils to cut up 200 small strips of paper. Mark the strips with the individual seedling numbers B1, B2, B3 and so on keeping each batch of strips separate for each replicate (tray) of the blue seeds. Once all the blue strips are ready place these in separate containers (one for each replicate) ready to mix. Continue to do the same for the red seeds. Once you have all 8 batches of 25 strips in their 8 separate containers mix each batch up well.
4. Select five strips of paper from each container at random. These five will identify the plants whose leaves are to be counted. **Alternatively get pupils to use a random number generator by using a MS Excel © spreadsheet.**
5. Once the leaves have been counted, calculate the average (mean) number of leaves on the five randomly selected seedlings from each replicate. To do this, add all five leaf numbers counted together and divide the total by 5. For example 12+5+8+9+3=37 then 37÷5= 7.4. In this case, 7.4 is the mean number of leaves per plant.
6. The results should then be recorded on your ***Measurement Chart***. At the end of the experiment enter all the information on your chart into the online ***Experiment Database*** by the 17th June 2016.

Definitions

There are a number of variables in this experiment that cannot be controlled. To make this a fair test the different groups of seedlings need to be arranged randomly so they have an equal chance of being influenced by changes in levels of light, humidity and temperature.

Bias is the outcome of an unfair comparison. For instance where one set of seeds has been treated preferentially over others.

Randomisation using a sample from the whole population of plants will provide sufficient evidence to make a conclusion, without having to measure every plant. Enough plants need to be chosen to be representative and to make sure that the plants chosen are not influenced by human bias.

Replication is the term used by scientists when referring to the existence of separate repeats of the same test conditions. Here we have 4 trays of each seed (blue and red) and therefore we are said to have 4 replicates of each.

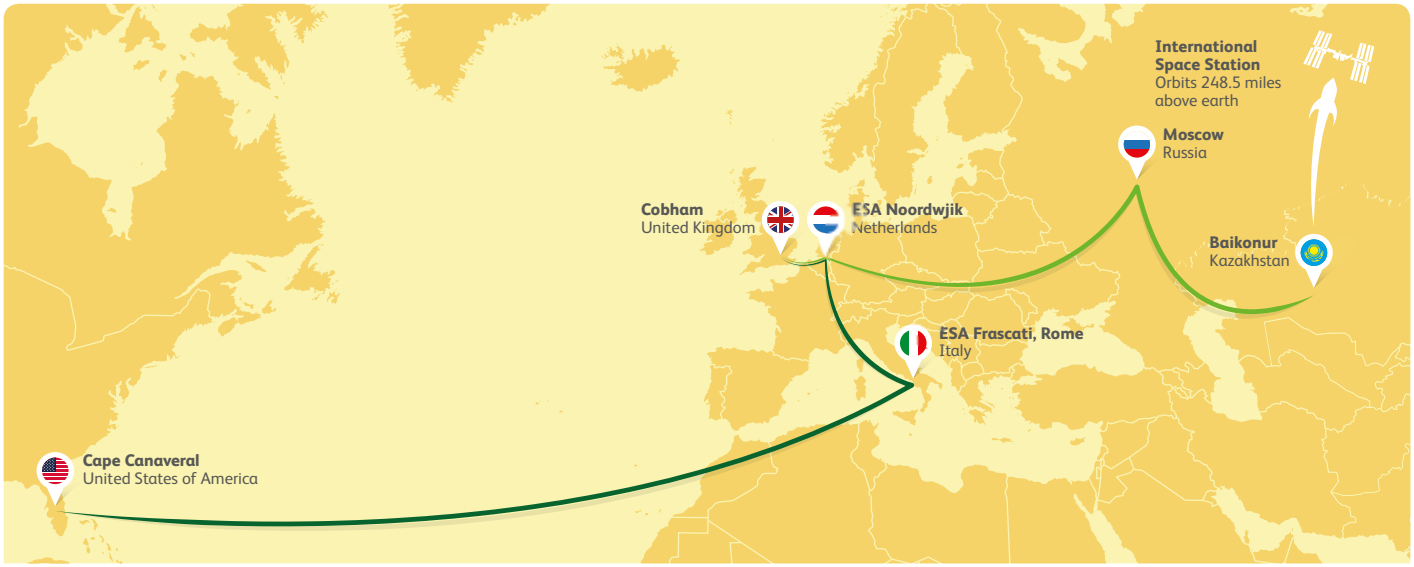
Hints and Tips

- Split the class or group into teams with one tray of rocket seeds each. In their teams they can then gather the data, carry out the calculations and then enter results on to the ***Measurement chart***.

Equipment needed

Rocket Science Measurement Chart
Permanent markers
8x Container

Rocket Seeds' Journey to the ISS and back



- 1st Attempt (dark green) = Cobham, Surrey UK > ESA Noordwjik, Netherlands > ESA Frascati, Rome, Italy > Cape Canaveral, USA > Space X 7 cargo spacecraft exploded shortly after launch on 28 June 2015
- 2nd Attempt (light green) = Cobham, UK > ESA Noordwjik, Netherlands > Moscow, Russia > Baikonur, Kazakhstan > Soyuz 44S > International Space Station

We want you to map out the seeds' journey from the International Space Station back to Earth and to your school. To find out where the seeds travelled on their journey back to the UK go to the Campaign for School Gardening Website.

Rocket Science Notes

Please use these pages for any notes or extra data recordings you wish to make for the experiment.