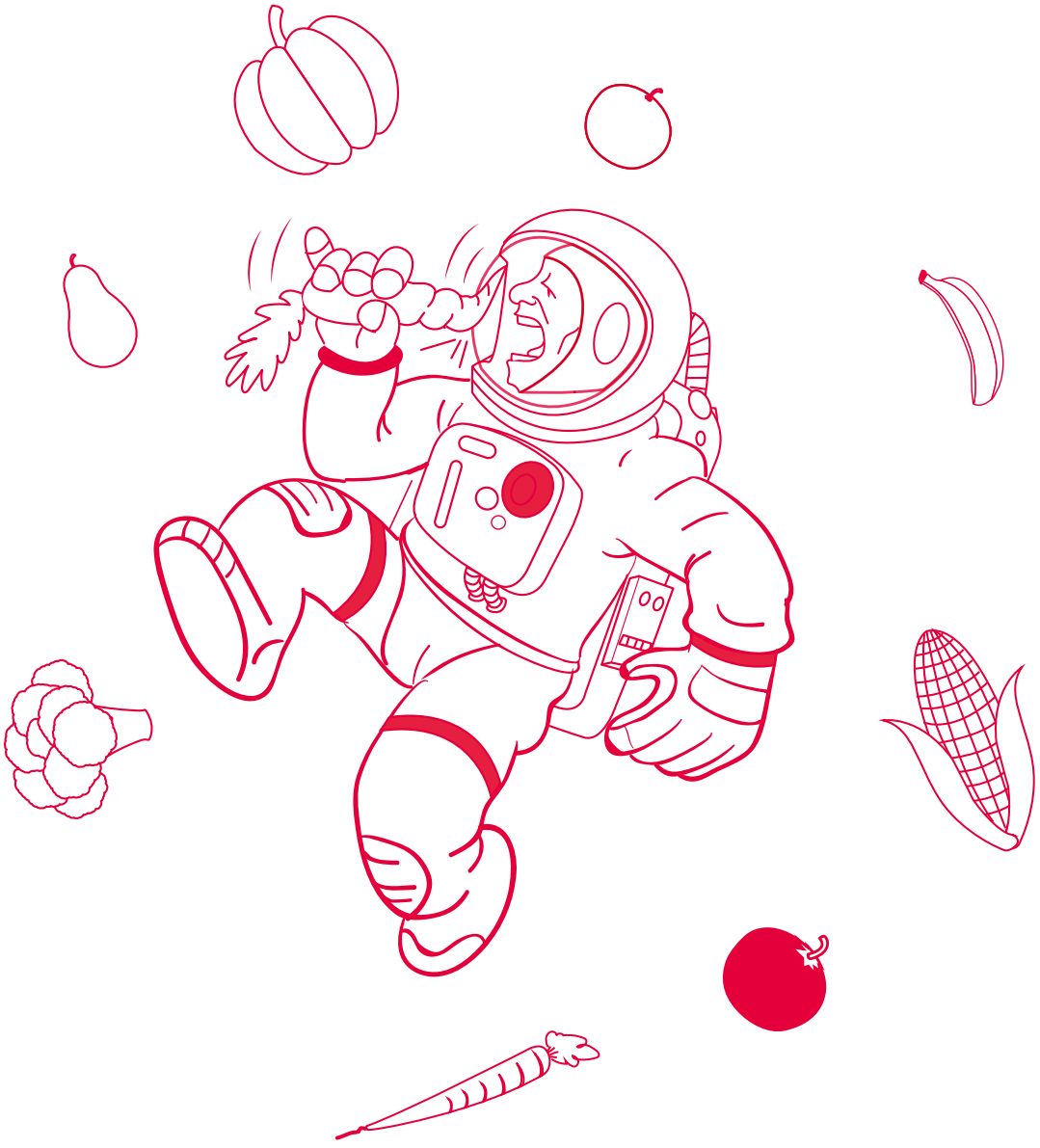
primary | PR41

teach with space

→ ASTROFOOD

Learning about edible plants in Space



teacher guide & student worksheets

European Space Agency

teach with space – astro food | PR41
www.esa.int/education

The ESA Education Office welcomes feedback and comments
teachers@esa.int

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→ ASTRO FOOD

Learning about edible plants in Space

Fast facts

Subject: Science

Age range: 6-10 years old

Type: student activity

Complexity: easy

Lesson time required: 60 minutes

Cost: low (0 – 10 euros)

Location: indoors in either classroom or school hall

Keywords: Science, Plants, Seeds, Vegetables, Fruits, Food

Brief description

In this set of activities, students will learn about the different components of plants. They will learn which parts of well-known plants are edible and learn the difference between a vegetable, a fruit and a seed. The students will have to imagine and draw the plant associated with the fruit/vegetable/seed they are observing.

They will also learn that different plants require different growth conditions and will give different yields. Based on this they will consider which plants are suitable for growing in space as a good source of nutrition for astronauts.

Learning objectives

- Learn about the basic structure of common plants.
- Identify and name a set of different plants.
- Understand that living things can be grouped in a variety of ways.
- Identify that humans need the right types and amount of nutrition, and get this from what they eat.
- Understand that living things depend on each other and that plants serve as a source of food.
- Develop skills in identifying, classifying and grouping.
- Recognise that questions can be answered in different ways.
- Understand that drawing can be used to develop and share their ideas.

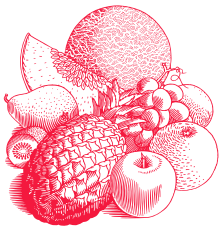
→ Summary of activities

activity	title	description	outcome	requirements	time
1	Gather your AstroFood	Identifying different edible plant parts from picture cards. Grouping the cards in the categories fruits, seeds and vegetables.	• Identify and name a variety of plants. • Identify and describe the basic structure of common plants. • Recognise that living things can be grouped in a variety of ways.	None	20 minutes
2	Draw your AstroFood	Drawing the complete plant associated with a seed, fruit or vegetable. Considering how the size of the plant influences its potential as a food source in space.	• Identify and describe the basic structure of common plants. • Present their observations and communicate their conclusions to the class.	Completion of activity 1	20 minutes
3	AstroFood Olympics	Selecting the top 3 plants to grow in space. Learning that there are pros and cons of different plants. Understanding that growth time, yield and nutritional value are important.	• Identify that humans need the right type and amount of nutrition, and that they get nutrition from what they eat. • Recognise how living things depend on each other and that plants serve as a source of food. • Explore the requirements of plants to grow and stay alive and how these requirements vary from plant to plant.	Completion of activity 2	20 minutes

→ Introduction

Food is one of the most important parts of our lives because it provides the fuel that we convert into energy. When humans venture further into space – to the Moon or Mars - they will not have access to fresh food. Therefore, they will have to grow it themselves.

What is the best food to grow in space? Should it be mango trees, salad, potatoes or strawberries? Would the plants grow differently in space compared to on Earth? Is there even space for trees on a spacecraft at all?



Fruits: scientists think of a fruit as a part of a plant that contains seeds. A fruit is not necessarily sweet. In fact, it might not be edible at all, but it is still a fruit. The fruit gives energy to the seeds and protects them from harm. Sometimes fruits are covered by a hard shell, like a watermelon, which is soft and juicy on the inside but tough on the outside. Nuts are technically fruits.

Seeds contain all the material a plant needs to produce a new plant. Seeds have shells and inside them there are "baby plants". Most seeds "sleep" until they are given water. When that happens, the shell softens and a small plant begins to grow. Some seeds are tiny, about the size of a grain of dust. Other seeds can be as big as a tennis ball!

Vegetables come in lots of different shapes and sizes. Roots, such as potatoes and radishes, grow under the ground. Leafy vegetables grow above ground. In general, you can think of vegetables as the edible parts of plants: roots, leaves, stems, flowers, bulbs, etc.

When ESA and other space agencies talk about growing plants on the Moon or on Mars they always imagine the plants in small, controlled compartments. Each plant must produce as much food as possible while not requiring specialised growing conditions.

Food for space missions must weigh as little as possible, take up as little space as possible, be nutritionally balanced, tasty, and preferably fast growing.

From all the plants on Earth, space agencies have to find the best candidates to be grown and eaten in space. Some of the plants that are currently being considered for use in space by the European Space Agency (ESA) include soy bean, potato, basil, soft white wheat, tomato, spinach, lettuce, beetroot, onion, rice and also spirulina which is an edible bacterium.

In these activities students will analyse and select their own AstroFoods!

→ Activity 1: Gather your AstroFood

In this activity, students will learn to identify different edible plant parts. Using pictures or assorted samples they will have to recognise the differences between fruits, seeds and vegetables and group them accordingly.

Equipment

- Student worksheet printed for each student
- Pencil / pen
- (Optional) assorted types of fruits, vegetables and seeds

Health and safety

This activity can be complemented with a tasting of different seeds, fruits or vegetables. Students' allergies and food intolerances should be taken into account when selecting the items for the tasting.

Exercise

Distribute the student worksheets to the class. Ask them to write a description of what seeds, fruits and vegetables are. Then, ask the students to analyse the images in exercise 2 and write down the names of the pictures they recognise.

To complement the activity, you could also show the students a selection of real fruits, vegetables and seeds for them to examine.

Ask the students which pictures or samples they like to eat and which ones they do not. Ask them which one is their favourite. If you have (edible) samples invite the students to taste them, take into account that some students may have food allergies or intolerances. Invite the students to guess which part of the plant it is and where in the world the plants come from.

Ask the students how many fruits/vegetables they eat per day. Talk with them about the importance of eating vegetables and fruits because they contain minerals and nutrients that are good for our bodies and minds.

Ask the students to group the pictures into categories based on which part of the plant people normally eat, the seeds, the fruit, or the vegetables (leaves, roots, flowers, bulbs, etc.). Can we eat more than one part of the plant?

Results

The pictures available in the student worksheet are as follows:

1. Spinach (leaves - vegetable)
2. Watermelon (fruit)
3. Corn (seed)
4. Tomato (fruit)
5. Cabbage (leaves - vegetable)
6. Wheat (seed)
7. Beetroot (root - vegetable)
8. Peach (fruit)
9. Peas (seeds and fruit - pea-pod)
10. Potatoes (root - vegetable)
11. Lettuce (leaves - vegetable)
12. Rice (seed)
13. Broccoli (flower - vegetable)
14. Orange (fruit)
15. Pumpkin (fruit and seeds)
16. Parsley (leaves - vegetable)
17. Carrot (root - vegetable)

Eat the seeds	Eat the fruit	Eat the vegetable	Eat more than one thing
3, 6, 12	2, 4, 8, 14	1, 5, 7, 10, 11, 13, 16, 17	9, 15

Discussion

You can follow up on this activity by explaining that there are many ways that plants can be grouped. They can be grouped by size, colour, country of origin and/or season of harvesting. Categories often have sub categories – for example the vegetables group can be sub-divided into leaves, stems, roots, flowers, etc.

The definitions used for fruit, vegetable and seed will depend on whether you are a botanist or a chef. Botanically speaking, a fruit is a seed-bearing structure that develops from the flowering plant, whereas vegetables are all other plant parts, such as roots, leaves and stems. However, a lot of foods that are (botanically speaking) fruits, but are savoury rather than sweet, are typically considered vegetables. These include botanical fruits such as aubergine, bell peppers, pumpkins and tomatoes.

Discuss with the students that not all plants are edible, some plants are poisonous. It can be dangerous to eat wild plants, fruits or seeds. Even familiar plants can have toxic parts. For example, the leaves of the tomato plant are poisonous.

→ Activity 2: Draw your AstroFood

In this activity, students will imagine and draw the complete plant associated with one of the images from Activity 1. They should consider the characteristics of the plant and if it would be a good candidate for space by taking into account its size.

Equipment

- Student worksheet printed for each student
- Paper
- Colouring pencils or colouring pens
- (Optional) internet access

Exercise

Distribute the student worksheets and assign one of the pictures from Activity 1 to each student. Ask them to draw a picture of what they think the complete plant looks like. Invite some of the students to present their drawings to the class.

Ask the students to compare their drawings to a real image of the plant. They can search in a book or on the internet for a picture. Alternatively, you could provide pictures of the plants and post them on the classroom wall for the whole class to see.

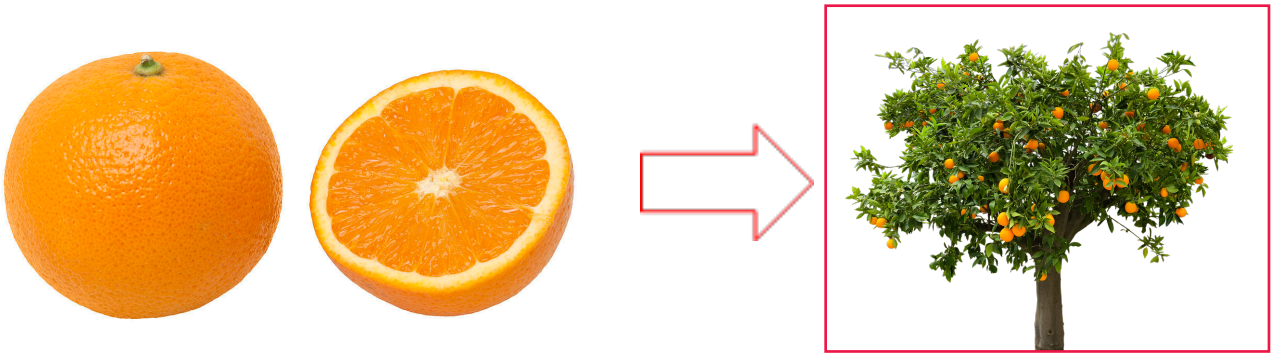
Ask the students about the characteristics of their plant. They should describe different characteristics such as size, structure and colour. Students should then consider whether their plant is a good candidate for growing in space.

Hang the drawings in the classroom and attach the pictures of the fruit/seed/vegetable next to their respective plant drawing.

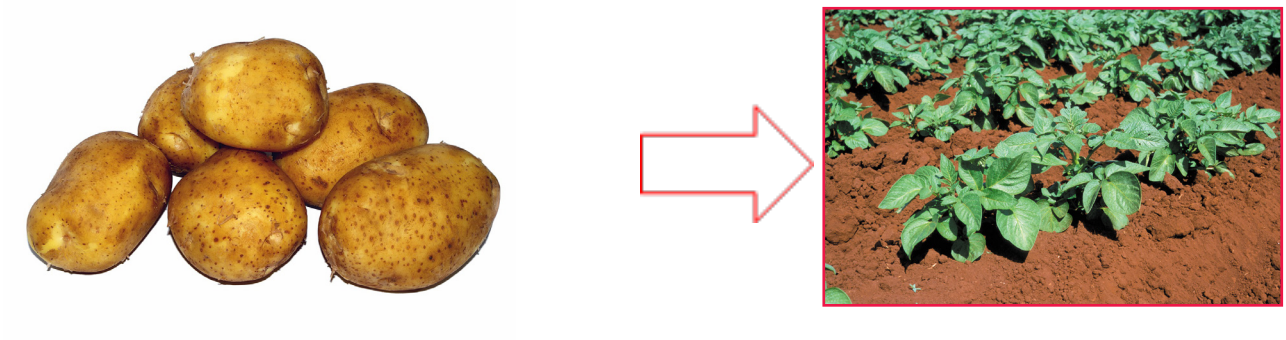
Results

The results will vary depending on the picture selected. On this page you'll find three examples: rice, orange, and potato (a seed, a fruit and a root vegetable).

Rice: It is a grass with green thin leaves. The rice plant can grow to over 1 m tall. Due to its size and the fact the rice needs a large quantity of water, it is not the ideal plant to grow in space. Nonetheless it is one of the space food candidates to be grown in future space greenhouses due to the high value rice can bring to a space crew diet.



Orange: This fruit grows on a tree. The tree is green with many leaves and can grow up to 10 m tall. Due to its size it would not be a good space plant.



Potato: The plant of this root vegetable is about 20-30 cm high, with green leaves. The potatoes grow underground. It provides a large yield. It is a possible space plant.

Suitable for space	Not suitable for space
1, 4, 5, 6, 7, 10, 11, 12, 16, 17	2, 3, 8, 9, 13, 14, 15

Discussion

Invite some of the students to present their findings to the class and ask them if they think that their plant would be a good candidate for space travel. Discuss how the size of the plant influences how well suited it is for space. Discuss how much space would be needed to grow, for example, a plantation of trees and explain that this would mean an enormous spacecraft / greenhouse because plants cannot grow freely in space or on the surface of another planet.

In preparation for Activity 3 discuss some other important factors for food in space. Size is one of the main factors, but other factors need to be considered like for example dietary value (protein and carbohydrates), harvest, processing, medical use, cultural factors, diversity of food, volume of water required, yield, growth timing. A decision of which plants to take to space is a compromise between all these factors.

→ Activity 3: AstroFood Olympics

In this activity, students will select their top three candidate plants for growing in space. The students will learn that factors such as size, growth time, yield and nutritional value are important when choosing what plants to grow.

Equipment

- Student worksheet printed for each student
- Scissors
- Glue
- (Optional) Colouring pencils

Exercise

The students can explore this activity individually or in groups.

To complete this activity, the students will have to analyse the information provided on the fact cards available in Annex 1. The cards describe some of the characteristics of ten fruits and vegetables from Activity 1, including the time they take to grow and a space connection.

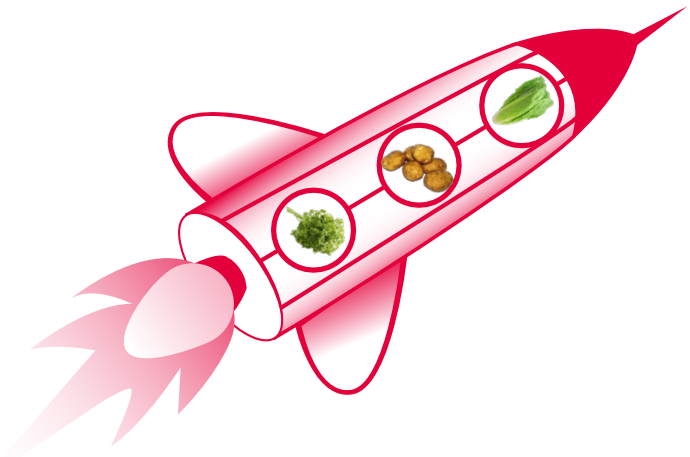
Distribute the fact cards to the students and ask them to analyse the information on them. They should select the three best space foods and place these cards in the circles on the rocket in their worksheet. They can either cut out the respective pictures or draw the fruit or vegetable. Ask the students to present their ranking to the class, and explain why they think these are the best choices.

Results

The students will have different results for this activity. Certain plants are better for specific purposes and all answers are valid if the argument behind their choice is sound.

However, the factors that would generally be beneficial for a crop grown on a space mission are:

- Fast growth
- High yield
- Tasty crop
- Nutrient rich crop
- Easy to grow (i.e. adapts to changing environment)
- Non-toxic
- No thorns
- Inedible parts take up a small volume
- Requires minimal water
- Requires minimal energy



↑ Example answer for Activity 3.

Discussion

Ask the students if they can think of other plants that are better candidates than the ones presented on their student worksheets.

Debate with them which parts of different plants they would combine to have an optimal plant.

→ Conclusion

After completing these activities, students should conclude that different plants have different advantages and disadvantages when considered as potential plants for growing on space missions. The advantages and disadvantages are determined by their size, growth time and yield.

You can also link these conclusions to agriculture and food production on Earth.

→ ASTROFOOD

Learning about edible plants in Space

→ Activity 1: Gather your AstroFood

Exercise

Imagine you are an astronaut on the Moon. Where would you get your food from? You would have to grow it yourself!

1. Did you know we eat different parts of plants? What is a seed, a fruit and a vegetable? Write your description of each below

Seed: _____

Fruit: _____

Vegetable: _____

2. Look at these pictures. Which ones do you recognise? Write down their names.

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

8. _____

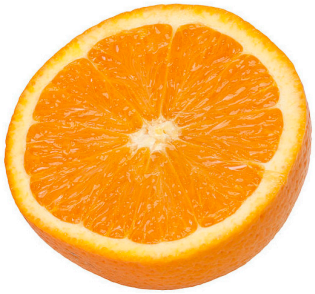
9. _____

10. _____

11. _____

12. _____

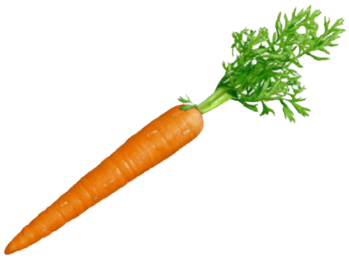
13. _____



14. _____

15. _____

16. _____



17. _____

3. Of these, which one is your favourite to eat?

_____

a. Which part of the plant do you think it is? _____

b. Do you know where it comes from? _____

4. How many fruits/vegetables do you eat per day: _____

5. The pictures on the previous pages show different parts of plants. Write the numbers of the pictures in the box you think they belong in:

Eat the seeds	Eat the fruit
Eat the vegetable (leaf, root, stem, flower, etc.)	**Eat more than one thing**

→ Activity 2: Draw your AstroFood

Exercise

1. Analyse the image from Activity 1 that your teacher assigned to you. In the box below, draw what you think the complete plant looks like.

2. Compare your drawing to an image of the plant.

3. Describe the plant. Is it as you imagined it to be? Is it bigger or smaller? Does it have leaves? What is its colour?

4. Would you grow this plant in space? Explain why.

Did you know?

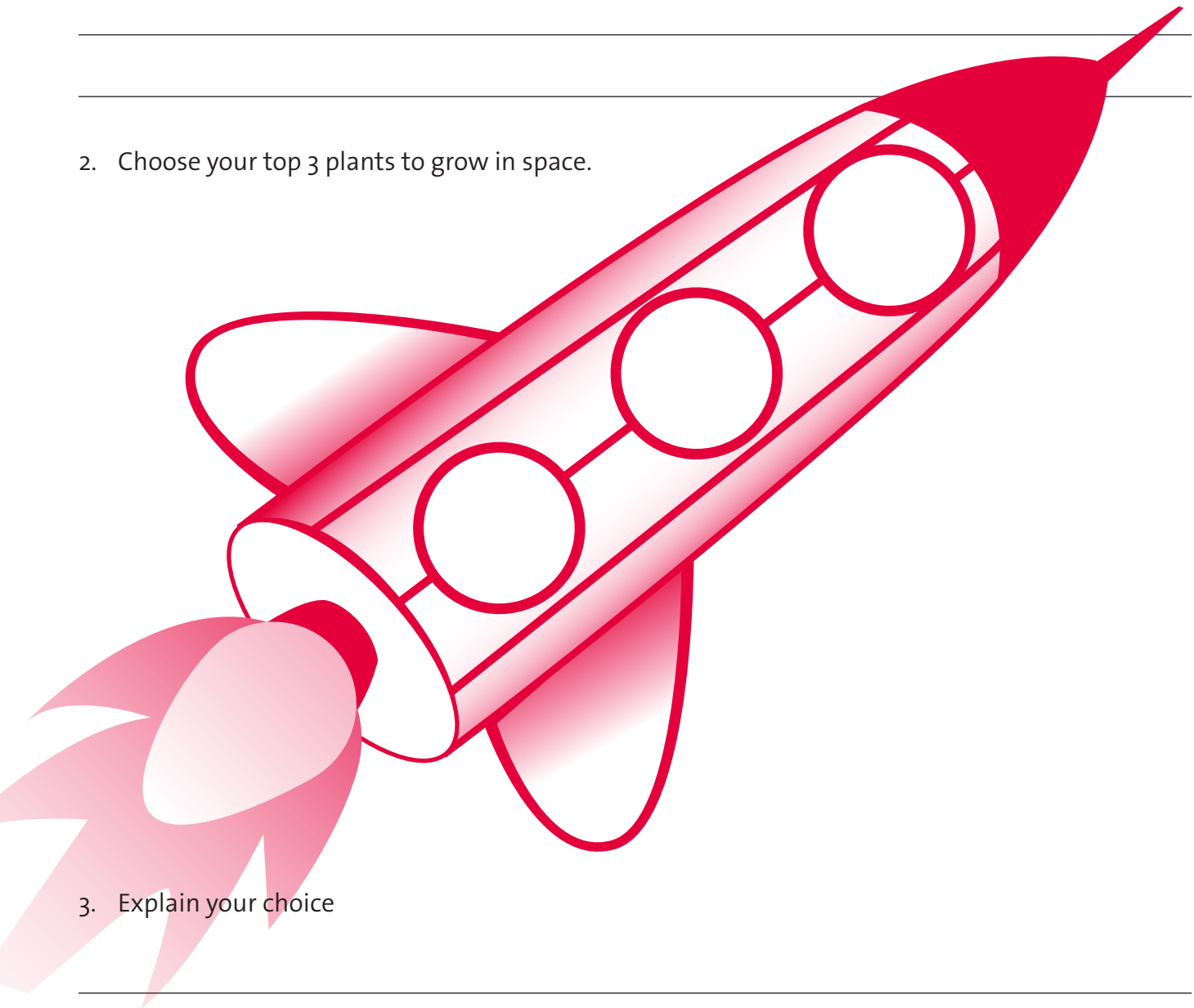
There are more than three hundred thousand (300 000) identified plant species on Earth and the list is growing all the time! Humans use around two thousand (2 000) different types of plants from all over the world to produce food! Do you know where all the groceries in the supermarket come from?

→ Activity 3: AstroFood Olympics

Select your top 3 space foods!

Exercise

1. Besides size, what other factors do you think are important when choosing a space plant?



2. Choose your top 3 plants to grow in space.

3. Explain your choice

→ LINKS

ESA resources

Moon Camp Challenge
esa.int/Education/Moon_Camp

Mission X - train like an astronaut
www.stem.org.uk/missionx

Moon animations about Moon exploration:
esa.int/Education/Moon_Camp/The_basics_of_living

ESA classroom resources
esa.int/Education/Classroom_resources

ESA Kids
esa.int/kids

ESA Kids, Back to the Moon
esa.int/kids/en/learn/Our_Universe/Planets_and_moons/Back_to_the_Moon

Paxi on the ISS, Food in Space
esa.int/kids/en/Multimedia/Videos/Paxi_on_the_ISS/Food_in_space

ESA space projects

MELiSSA project
esa.int/Our_Activities/Space_Engineering_Technology/Melissa

Eden ISS
https://eden-iss.net

Extra information

Astroplant - citizen science project, supported by ESA
www.astroplant.io

→ ANNEX

Potato

Solanum tuberosum

Characteristics:

- Good source of energy.
- Contains vitamin C (which is important to keep skin healthy, help the body heal cuts and fight off colds).

Growing potato:

- Germination time: 2-3 weeks
- Yield: 3 kg/m²
- Growth time: 10-12 weeks to harvest

Space Connection:

Five small potatoes were grown from tubers in the laboratory on board the space shuttle Columbia in 1995.

Beetroot

Beta Vulagaris

Characteristics:

- Contains iron (which helps transport oxygen throughout the body). If we do not have enough iron, we will start feeling tired and worn out.
- Contains calcium and vitamin A (which keeps bones strong and healthy).

Growing beetroot:

- Germination time: 15-21 days
- Yield: 1.5 kg/m²
- Growth time: 13-15 weeks to harvest

Space Connection:

European Space Agency scientists suggest beetroot as one of their top 10 crops to take on long term space missions.

Wheat

Triticum

Characteristics:

- It is an important source of carbohydrates.
- It can be ground to produce flour.
- It is the main ingredient of many types of food such as bread, porridge, crackers and Muesli.
- It is an extremely adaptable plant, it grows almost everywhere on Earth.

Growing wheat:

- Germination time: 0 to 2 days
- Growth time: 4 to 8 months to harvest
- Germination may occur between 4° and 37°C.

Space Connection:

For future space missions, wheat grain could be easily stored and converted into flour to produce diverse food products.

Tomato

Solanum lycopersicum

Characteristics:

- Sweet flavour.
- Consists of 95 % water.
- Contains high levels of lycopene (which may help prevent cancer and heart disease).

Growing tomato:

- Every part of the tomato plant, except the tomato fruit itself is toxic to eat.
- Grows best between 21-24 °C.
- Germination time: 7-16 days
- Growth time: 10-16 weeks to harvest

Space Connection:

An early NASA study investigated whether tomato seeds that had been in space would grow just as well as on Earth. They did!

Parsley

Petroselinum crispum

Characteristics:

- Good for the digestive system.
- Contains vitamin C (three times more than oranges).
- Contains iron (two times more than spinach).
- Adds flavour to space meals.
- Natural breath freshener.

Growing parsley:

- Grows best between 22–30 °C.
- Germination time: 4-6 weeks
- Growth time: 10 weeks to harvest

Space Connection:

Parsley was one of the first plants grown in space by the Russian cosmonaut Valery Ryumin on the Salyut 6 space station.

Cabbage

Brassica Oleracea

Characteristics:

- One of the oldest vegetables in existence.
- Contains vitamin K (which is good for the bones).
- Full of fibres which are good for our stomachs.

Growing cabbage:

- Germination time: 10 days
- Growth time: 30 weeks to harvest

Space Connection:

Cabbage is prized by space nutritionists for its high content of vitamin K contributing to bone health and dietary fibre giving a healthy digestion.

Romaine lettuce

Lactuca sativa

Characteristics:

- Contains vitamins A and K.
- The darker the lettuce, the more nutrients it has.
- Resists cold weather (not badly damaged by light frosts).
- Is hard to preserve – must be eaten fresh.

Growing romaine lettuce:

- Grows best between 16-18 °C
- Germination time: 9 days
- Growth time: 11 weeks to harvest

Space Connection:

When NASA grew red romaine lettuce under red and blue light, it had much more anthocyaning – good for astronauts health.

Spinach

Spinacia oleracea

Characteristics:

- High levels of iron, zinc, and vitamins A and C.
- Plays a role in the slowdown of the aging process.
- Helps keep the brain sharp.
- Resists hard conditions (can withstand temperatures as low as -4°C.)

Growing spinach:

- Germination time: 16 days
- Growth time: 11 weeks to harvest

Space Connection:

Students in Greece developed a solar-powered greenhouse to grow spinach on Mars called 'Popeye on Mars'.

Rice

Oryza sativa or Oryza glaberrima

Characteristics:

- Rich in carbohydrates.
- Contains moderate amounts of vitamin B, iron, and manganese.
- Needs a large quantity of water to grow.
- It is one of the most widely consumed foods in the world.

Growing rice:

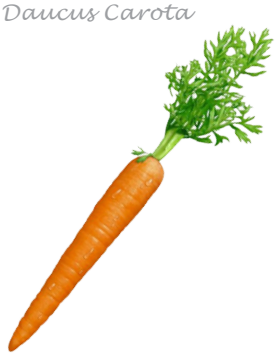
- Germination time: 1 to 5 days
- Growth time: 3 to 6 months to harvest

Space Connection:

Rice is one of the space food candidates to be grown in future space greenhouses.

Carrot

Daucus Carota



Characteristics:

- Sweet flavour and crunchy texture.
- Contains vitamins A, C and B6 and potassium (which can benefit your eyes, your skin and your heart).

Growing carrot:

- Germination time: 17 days
- Yield: 1.5 kg/m^2
- Growth time: 16 weeks to harvest

Space Connection:

The high carotenoid content of carrots provides valuable antioxidants to astronauts exposed to cosmic radiation on the ISS.