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PLANTS FOR SPACE
ARC CENTRE OF EXCELLENCE

PLANTS & LIFE IN SPACE

TEACHING RESOURCE: YEAR 6

SCIENCE, HASS, TECHNOLOGY

Acknowledgments

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Contact information

Academy of the Social Sciences in Australia Inc
ABN: 59 957 839 703

3/95 Northbourne Ave Turner ACT 2612
GPO Box 1956, Canberra, ACT 2601

(02) 6249 1788
info@socialsciences.org.au
socialsciences.org.au

ARC Centre of Excellence in Plants for Space (P4S)
p4s_admin@adelaide.edu.au

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Introduction

This resource has been produced collaboratively by the ARC Centre of Excellence in Plants for Space (P4S) and Seriously Social, an initiative of the Academy of the Social Sciences in Australia.

Research experts from these organisations who represent the science and social science fields have informed this learning content and peer-reviewed materials.

The reading articles, educational videos and learning experiences in this learning module provide genuine, real-world learning opportunities that demonstrate various future career options that not all students would otherwise be aware of.

This fact checked school resource is produced at no cost to users and is fully funded by the Academy of the Social Sciences in Australia and P4S.

This booklet provides reading articles and educational videos that present real-world learning about current scientific research to investigate the best ways to grow plants in space, explore the possibilities of life in space and sustainable on Earth Farming.

This real-world learning content is linked to the Australian Curriculum, NSW Curriculum and Victorian Curriculum.

Teacher guidance

This learning module addresses the Year 6 curriculum areas of Science, Humanities and Social Sciences (HASS) and Technology and is aimed at 11- to 12-year-old students. Teachers' knowledge of student learning needs will guide how best to adapt resources provided in this learning module.

Articles and educational videos form the basis of this learning module. Open ended learning experiences complementing these resources offer opportunities for differentiation to support diverse student needs. Questions can be tailored by adding prompts, breaking down instructions, or increasing open-ended opportunities for higher-order thinking. Where tables are provided for students to record information, report or present their ideas, their content can be expanded, reorganised or simplified based on student needs. More able students may benefit from designing their own report templates to capture the extent of their learning.

Assessment guidance is provided on the last pages of this booklet, linked to the Australian Curriculum Version 9.0, NSW Curriculum and Victorian Curriculum. Additional opportunities exist to extend learning experiences to include mathematics, such as creating graphs and tables to report science test results. Teachers may wish to adapt assessment tasks to include written reports, oral presentations, or visual representations, catering to various learning styles and abilities for assessment purposes.

The Seriously Social and P4S websites offer digital versions of this booklet, along with downloadable resources. These include editable Word documents for most learning activities, allowing easy customisation of the materials. This could include modifying font sizes for accessibility, integrating visual aids, picture clues or simplified language for students who need additional support.

How do plants benefit people and planets?

Plants are very important for people. They make the oxygen that we need to breathe, give us food to eat, are the product of most of the medicines we take and produce the fibres we require. Plants clean the air, by taking in carbon dioxide and letting out oxygen. They also help the soil by stopping it from washing away and adding nutrients to it. In space, plants provide food and help keep the air clean, which is required for humans during space travel. Plants are a healthy and lasting food supply. Plants have been shown to reduce stress and improve mood. As humans continue to explore new frontiers, especially in space, the role of plants becomes even more crucial.

Since 1961, humans have ventured into space, with significant, continued research and efforts to progress human space travel and life in space. Australia is doing a lot to help explore space and make it possible for people to live beyond Earth. Learning how to grow plants for food in space is important if people hope to live in space for a long time. Exploring and living in space has many potential benefits, such as creating new science knowledge, inventing new technologies and developing better understanding of human behaviour and health.

P4S is a special Australian research program where scientists are learning how to grow and use plants in space. They are working to invent processes that make sure plants can survive and grow well on the International Space Station, the Moon and even on Mars. Scientists want to make sure that people living and working in space in the future have fresh food during long space missions, and plants to help keep the air clean. This program uses new technology for plants to be able to live in space, helping us explore and live on other planets in the future. The knowledge gained through P4S is to benefit sustainable farming on Earth.

Some important things to consider when researching how to grow plants in space that we will consider further are:

- How plants grow
- Questions about people living in space
- Designing homes for space

Prior knowledge recall

This section aims to identify students' prior knowledge to provide teachers with an awareness of this and an opportunity to revisit fundamental concepts to assist new learning. The following can be conducted as a class discussion, brainstorm (recorded on a classroom display for future reference) or as an individual writing task.

What features do plants have that help them survive?	
List some of the conditions in the environment that impact plant survival:	
What kind of characteristics may be found in plants from the desert?	

What kind of characteristics may be found in plants from the rainforest?

How do plants benefit humans?

How do we make sure that scientific tests are fair tests?

How plants grow

Plants need several things to grow well. On Earth, this includes sunlight, water, soil, the right temperature, air and nutrients. Growing plants in space is different from growing them on Earth, so scientists are studying how to make plants grow in space.

Human activities can affect plants in many ways. On the positive side, we work to protect endangered species and care for the environment. On the negative side, pollution can harm the air and water that plants need, and the clearing of forests for housing or farming destroys important plant habitats.

Scientists use their knowledge of plant growth to make evidence- based predictions about the best conditions for plants in different environments. They then conduct experiments to test these predictions and gain a better understanding of how plants respond to various conditions.

Biodiversity means having many kinds of living things in one place, like animals, plants, fungi and tiny organisms like bacteria. All these living things work together in nature. Plants need biodiversity. For instance, some depend on insects to reproduce. Animals, insects and fungi help improve the soil. Humans also need biodiversity as we depend on many plants and animals for food, clean water, medicine and shelter.

Plants are the foundation of all human food, providing fruits, vegetables and grains we eat directly, as well as food for animals raised for meat.

Some farming methods use a lot of fertiliser and pesticides to grow crops. New technology has made it easier to spread these chemicals, but using too much can harm the soil and pollute the environment and water. This can also hurt the plants, animals and insects living in these areas.

Scientists are looking for better ways to grow food that doesn't harm the environment. Research on growing plants in space could help us find new, sustainable farming methods for Earth too.

Hydroponics uses nutrient-enriched water to grow plants. There are several types of hydroponic systems, each providing environmental benefits to grow plants. Vertical farms reduce the amount of land, water, energy, pesticides and fertiliser needed to grow plants. Vertical farms are plants growing on large shelves that provide all the requirements that plants need, that are stacked on top of each other. Researchers at P4S are investigating these very important considerations for farming. They are experimenting to improve how we grow plants in vertical farms to grow plants for food in space and on Earth.

Testing seed germination

Seeds germinate then their root breaks open the seed case when they grow into a seedling. This learning experience uses lettuce and/or tomato seeds, to test what helps these seeds germinate. The seeds are placed on a wet paper towel inside a clear snap seal bag so that they can be seen. Some seeds should start to change and germinate within one or two days.

Required materials:	**Procedure (before following instructions, complete the planning table so that all the information is available to prepare for the test):**
• Tomato and/or lettuce seeds (10 seeds per bag is recommended) • 2 pieces of paper towel folded or cut into the same size • 2 snap seal bags • Water • Equipment: dish, cup with millilitres measure, pen	• Place paper towel that is of the same size inside a dish • Measure and pour water onto the paper towel (you will plan for how much water) • Spread approximately 10 seeds onto the paper towel (you will plan what seeds to use) • Label snap seal bags with the date, seed type, your name, the location for the bag and give each bag a letter reference A, B (you will plan where to locate each bag) • Place the bags into locations according to your planning

An example of what your bags with seeds may look like

Test plan

Use the table below to plan for a fair test and give you the information that you need for your instructions.

Answer the questions below to help prepare for testing.

Aim – Select from the options below to decide what your test is trying to find out:

- Do seeds germinate better in full sunlight?
- Do tomato or lettuce seeds germinate quicker?
- Do seeds germinate better with more or less water?

Plan for seed germination testing below, making sure three boxes have the same conditions, with one box showing the variable that will be tested.

How much water will you add to your paper towel? *	What kind of seeds will you use?	Where will you locate your bags of seeds (to maintain the same temperature, but change levels of sunlight, consider covering seeds with white paper)?

**It is recommended to do a quick test of pouring water onto paper to get an idea of how much you think you will need. You could decide to set up your test with the same amount of water from the beginning and not water again, or you could add water every few days (consider weekends and how this may impact when you could add more water).*

Reasoned Prediction: What do you think will happen to the seeds?

Recording: How could you measure changes to the seeds?

Reporting: What will decide the best test result for germinating seeds?

Risk assessment: Can you think of anything that could go wrong with your test that you could try to avoid?


First leaves
Seed coat
Root


First leaves
Seed Coat
Root

Recording Results

Each day that you are at school write the below information in the table provided:

- record the date
- note if you can see seeds germinating with sprouts
- count how many sprouts there are
- measure the length of the roots, recording the longest measurement.

If there aren't any roots visible, just write zero. If you make any other observations about the seeds that are of interest or add additional water, make a note of this in the table below also.

When seeds germinate, the roots rarely grow in a straight line. Consider laying a piece of string along the root that can then be straightened against a ruler for a more accurate measure.

Start by describing and drawing what the seeds look like. Think about the colour, shape, size, width and if there are any marks or cracks on the seeds. Do this for the seeds in each bag. If the seeds look different inside the same bag, explain how. If the seeds are the same in each of the bags, then it is okay to give the same description. As you continue to record any changes to the seeds in your table, use the notes section to update your description and drawing of what you can see has changed with the seeds.

	Bag A	**Bag B**
Date:	How many seeds have changed:	How many seeds have changed:
	Length of the longest root in mm:	Length of the longest root in mm:
	Notes:	Notes:

	Bag A	Bag B
Date:	How many seeds have changed:	How many seeds have changed:
	Length of the longest root in mm:	Length of the longest root in mm:
	Notes:	Notes:

	Bag A	Bag B
Date:	How many seeds have changed:	How many seeds have changed:
	Length of the longest root in mm:	Length of the longest root in mm:
	Notes:	Notes:

	Bag A	Bag B
Date:	How many seeds have changed:	How many seeds have changed:
	Length of the longest root in mm:	Length of the longest root in mm:
	Notes:	Notes:

	Bag A		**Bag B**	
Date:	Notes:		Notes:	
	How many seeds have changed	Length of the longest root in mm	How many seeds have changed	Length of the longest root in mm
Date:	Notes:		Notes:	
	How many seeds have changed	Length of the longest root in mm	How many seeds have changed	Length of the longest root in mm
Date:	Notes:		Notes:	
	How many seeds have changed	Length of the longest root in mm	How many seeds have changed	Length of the longest root in mm
Date:	Notes:		Notes:	
	How many seeds have changed	Length of the longest root in mm	How many seeds have changed	Length of the longest root in mm
Date:	Notes:		Notes:	
	How many seeds have changed	Length of the longest root in mm	How many seeds have changed	Length of the longest root in mm
Date:	Notes:		Notes:	
	How many seeds have changed	Length of the longest root in mm	How many seeds have changed	Length of the longest root in mm

Reporting

Once you have monitored your seeds and recorded their germination progress, it is time to report what you found out from your tests.

Word list

Add any words that you can think of that are interesting, new or relate well to your science test to germinate seeds. List them here to reference when you plan your report:

This table provides you with space in the right column to write your report for each of the headings in the left column.

TITLE Think of an interesting question of about six to eight words that explains what your test was about.	
AIM Explain what your test was trying to find out.	
REASONED PREDICTION What did you guess would happen in your tests?	
MATERIALS Write down the materials that you used. You will need to include the exact number of seeds, seed types and measurement of water.	

PROCEDURE

Write a step-by-step guide for what you did to set up the test.

RESULTS

Explain what you found out from your test. This may have changed over the days that you recorded changes to the seeds. You can explain the results in different ways such as by using words, photos, drawings, charts or tables.

DISCUSSION

Describe why you think your test results turned out the way they did. Consider what you already know about how seeds grow. If the results didn't match your expectations, explain any possible reasons why.

CONCLUSION

Write a short reminder about what the aim and hypothesis were. Finish by explaining what the test showed and if this matched the aim and hypothesis or not.

Questions about people living in space

As humans start travelling to space more often and plan to live there, we need to think about many important things. These includes how space affects our health, the environment, costs and ethical choices. Some questions we should ask are: How will living in space impact people physically and mentally? How will space travel impact the health of Earth and space?

Living in space isn't always good for our health. In space, there's low gravity, which can make our bones weaker. There is also harmful radiation and toxic materials that can be dangerous for humans. The environment in space is very different from what we know on Earth. For example, the Moon has no atmosphere, which means there's no sound. This makes it completely silent. Mars has a thinner atmosphere made of gases, so while you can hear sounds there, they are not the same as those we hear on Earth. People may find it hard to adjust to these big changes, which can affect their mental health during space travel.

Another big challenge is waste management. On Earth, we already struggle with waste, and we try to reduce, reuse and recycle. In space, we must also manage waste such as food scraps, packaging, and human waste like toilet waste and carbon dioxide we breathe out. When rockets launch, they also release a lot of carbon dioxide, which adds to pollution on Earth.

Space travel costs a lot of money. This raises questions about fairness. Is it okay for governments to spend so much on space travel when many people on Earth need help with basic things? How can we decide what is a fair amount to spend on exploring space?

Ethics are about understanding how our decisions and behaviours impact others. As we grow up, our ideas about ethics can change. This is true for individuals, groups and countries. Making decisions can be hard, especially when not everyone will benefit. Ethics helps us consider our actions and the impacts that our actions can have on others.

When thinking about living and travelling in space, we need to ensure that it benefits both people and the environments we explore. The Outer Space Treaty of 1967 is a key agreement that says space should be used for peaceful purposes and benefit all people. As we explore space more, these rules may need to be updated to reflect our growing activities and ethical concerns.

As space travel becomes more common, important questions can be asked:

- Who gets to go to space?
- How do we make space travel psychologically and physically safe for people?
- Should space travel only be for wealthy individuals and big companies, or should everyone have a chance?

By thinking ahead, using ethical guidelines, and considering the needs of people and the environment, we can make sure that space is safe and beneficial for all.

Ethical Questioning

List questions that could help you consider the ethics involved with people traveling or living in space. Thinking about who owns space, who goes to space, rules in space, being born in space could help you to create ethical questions.

1.

2.

3.

4.

5.

List below the answers that different people in society may give to these questions.

	Scientists	Government	You
1.			
2.			
3.			
4.			
5.			

Potential risks and benefits of space travel

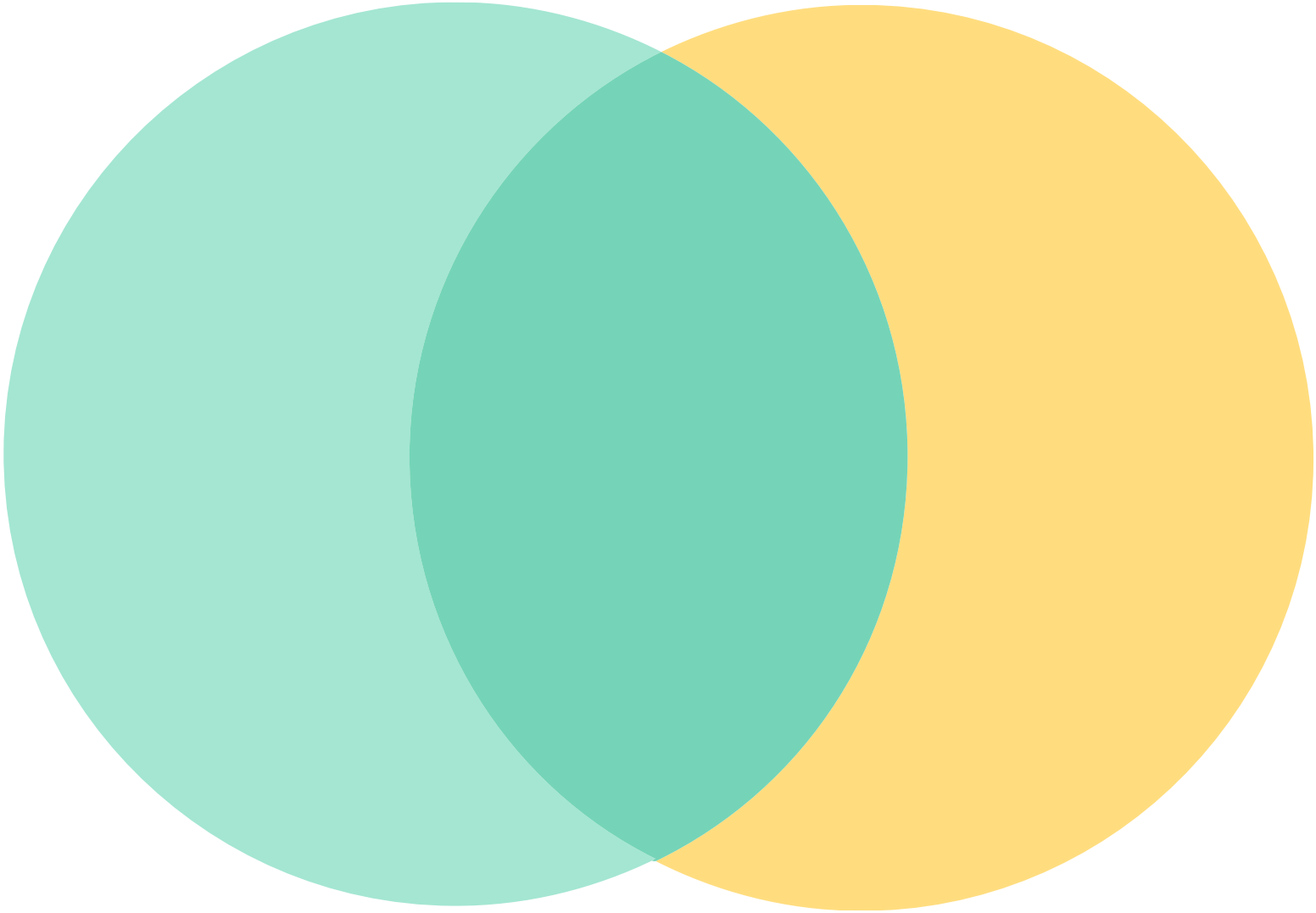
Complete the table below showing the different risks and benefits that influence people's decisions to be involved in space travel.

	POTENTIAL RISKS	BENEFITS
Psychological		
Physical		

Environmental		
Financial		

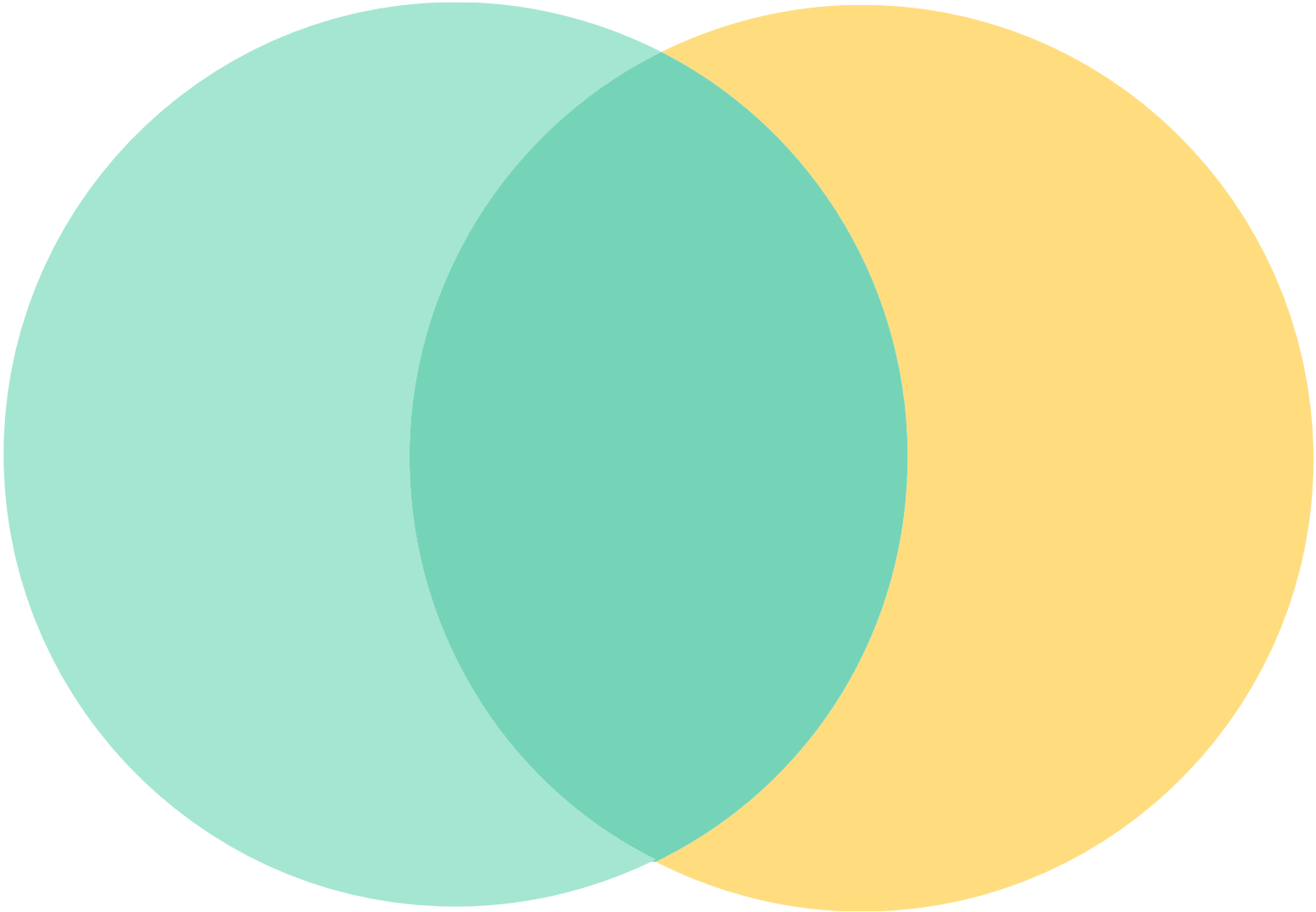
Venn Diagram

Use the Venn Diagram below to show what you understand about the positive and negative things to consider for space travel for the environment.



Venn Diagram

"Use the Venn Diagram below to compare the positives for space travel and sustainable farming against the negatives considerations for space travel and sustainable farming.



Designing homes for space

Building homes in space is very different from building homes on Earth. The houses we have on Earth wouldn't work on the Moon or Mars, where people have already travelled. Scientists, architects and engineers are creating ideas and models of what buildings in space might look like. They must think carefully about what would be needed for these buildings to work well. New technology and human creativity are helping this work.

One of the most important things to consider is how to make the buildings meet human needs. Space is a harsh environment, and it can affect people's mental and physical health. Plants play a big role in making space more liveable for humans. Having green spaces with plants helps people feel more comfortable because it reminds them of Earth. Plants also provide food and clean the air by providing oxygen and getting rid of carbon dioxide.

Homes in space also need special materials to protect people from radiation and heat. They must be designed to manage waste properly. Everything in space must be used efficiently and rubbish and recycling need to be planned for in building designs.

Building homes in space is not easy. The materials and parts must fit inside rockets, which means they must be light and compact. Once in space, these homes need to be able to be constructed, work in low gravity and expand over time if needed.

Space buildings must provide the basics like shelter, food, places to use the bathroom, and spaces to relax and do research. Creating safe, comfortable and functional homes that allow for socialisation in space is a challenge. There are many people and organisations on Earth who are working hard to make this possible and there are beliefs that it won't be too long before people are living in space.

Just as homes for humans need to be adapted for life in space, container designs for growing plants also need to be changed to suit space. In space, containers for plants to grow inside need to be small, include light that can be turned on and off, hold water in the absence of gravity and maintain temperatures of between 10 and 30 degrees Celsius.

Design brief for plant containers

Problem definition	Create a container to grow a lettuce that takes into consideration the temperature on Mars. The average temperature on Mars is -65 degrees Celsius. This is very cold compared to the average temperature of 15 degrees Celsius on Earth. Most lettuce grow well in temperatures of about 20 degrees Celsius.
Requirements	• Temperature needs to stay near 20 degrees Celsius. • Lettuce need access to sunlight, which is limited during dust storms • Lettuce is 15 cm high and wide • Lettuce needs protection from wind and dust during storms • Container needs to be compact and take up little room • Container needs to have very little or no soil • There is no gravity in space, so the container needs to keep water, seeds and lettuce inside • Container needs to be as sustainable as possible and avoid waste • The container needs to look good to help make the area feel appealing
Planning steps	• Research possible design ideas for plant pots • Research possible materials and tools • Consider the safe use of any required tools and research how to use tools safely and plan for this • Think and speak with friends, teachers and family members about your ideas, checking if they consider the design requirements • Aesthetics • Take notes and make sketches of ideas • Test your drawings and ideas against the requirements to see if everything is considered • There is the option to make the container

Planning

List of required materials	List of tools needed

Checklist of requirements

- ◯ Temperature needs to stay near 20 degrees Celsius
- ◯ Lettuce need access to sunlight, which is limited during dust storms
- ◯ Lettuce is 15 cm high and wide
- ◯ Lettuce needs protection from wind and dust during storms
- ◯ Container needs to be compact and take up little room
- ◯ Container needs to have very little or no soil
- ◯ The container looks appealing
- ◯ There is no gravity in space, so the container needs to keep water, seeds and lettuce inside
- ◯ Container needs to be as sustainable as possible and avoid waste
- ◯ Have safety considerations for making design been researched and are planned for?

Notes about missed requirements or needed changes

Draw and label design

Glossary

WORD	MEANING
Biodiversity	The variety of living things in a particular area, including plants, animals, fungi, and microorganisms.
Carbon dioxide	A gas that plants use to make food and people breathe out.
Endangered species	Any type of plant or animal that is in danger of disappearing forever.
Ethics	Ideas about morality, including the difference between right and wrong, how actions affect others and whether to consider the needs or rights of others before making a decision.
Fertiliser	A natural or chemical thing put on soil or plants to help them grow.
Habitats	The place where a plant or animal lives. It gives them food, water, shelter and space to stay alive.
Hydroponics	A way to grow plants using water with nutrients, instead of soil.
International Space Station	A large spacecraft in orbit around Earth, in which scientists from several countries complete research to learn more about living and working in space.
Nutrients	Substances that provide nourishment essential for growth and the maintenance of life.
Oxygen	Oxygen is one of the main elements that make up air, and it is necessary for the survival of all plants and animals.

WORD	MEANING
Pesticides	A chemical used to kill or deter insects or small animals from feeding on plants or crops.
Plants for Space	An Australian research program working on discovering ways to grow plants in space.
Pollution	Pollution happens when the environment is contaminated, or dirtied, by waste, chemicals, and other harmful substances.
Psychologically	Relating to the human mind or feelings.
Vertical farms	A way to grow plants on stacked shelves, using less land, water, energy, and chemicals.

Assessment

(underlined content from achievement standards are covered in this learning module)

Achievement standards: Year 6

Science subject achievement standard

By the end of Year 6 students explain how changes in physical conditions affect living things. They model the relationship between the sun and planets of the solar system and explain how the relative positions of Earth and the sun relate to observed phenomena on Earth. They identify the role of circuit components in the transfer and transformation of electrical energy. They classify and compare reversible and irreversible changes to substances. They explain why science is often collaborative and describe different individuals' contributions to scientific knowledge. They describe how individuals and communities use scientific knowledge.

Students plan safe, repeatable investigations to identify patterns and test relationships and make reasoned predictions. They describe risks associated with investigations and key intercultural considerations when planning field work. They identify variables to be changed, measured and controlled. They use equipment to generate and record data with appropriate precision. They construct representations to organise and process data and information and describe patterns, trends and relationships. They identify possible sources of error in their own and others' methods and findings, pose questions for further investigation and select evidence to support reasoned conclusions. They select and use language features effectively for their purpose and audience when communicating their ideas and findings.

HASS Subject achievement standard

Students develop questions, and locate, collect and organise information and data from a range of primary and secondary sources. They evaluate sources to determine origin, purpose and perspectives. Students evaluate a range of information and data formats to identify and describe patterns, trends or inferred relationships. They evaluate evidence to draw conclusions. Students propose actions or responses and use criteria to assess the possible effects. Students select and organise ideas and findings from sources, and use a range of relevant terms and conventions, to present descriptions and explanations.

Technology Subject achievement standard

By the end of Year 6 students explain how people design products, services and environments to meet the needs of communities, including sustainability. For each of the 3 prescribed technologies contexts they explain how the features of technologies impact on design decisions and they create designed solutions. Students select and justify design ideas and solutions against design criteria that include sustainability. They communicate design ideas to an audience using technical terms and graphical representation techniques. Students develop project plans, including production processes, and select technologies and techniques to safely produce designed solutions.

Assessment

SCIENCE				
Pages	**Student checklist**	✓	**Teacher checklist**	✓
9	Show how you kept all procedures the same, except for one variable.		AC9S6I02, ST3-PQU-0, ST3-PQU-01, 1VCSIS084 Plan and conduct investigations to answer questions including, the variables to be changed, measured and controlled in fair tests	
11	Report on results that you measured during testing.			
11	Explained the variables in your tests.		AC9S6U01, ACS9S6U02, ACS9S6U03, VCSSU075 Investigate the physical conditions of seeds and analyse how the germination and survival of living plants is affected by different conditions	
11	Explain what you know about what affects plants to survive and how this may have influenced your test results.			

Teacher comments

Assessment

HASS				
Pages	**Student checklist**	✓	**Teacher checklist**	✓
12	Develop and responded to questions to consider why people may be interested to travel into space.		AC9HS6S01, AC9HS6S03, AC9HS605, AC9HS06, HS3-CWT-01, VCEBE010, VCECD012 Students develop questions to investigate people, events, developments, places and systems. They evaluate a range of information and data formats to identify and describe patterns, trends or inferred relationships. They evaluate evidence to draw conclusions. Students propose actions or responses and use criteria to assess the possible effects.	
13	Show what you understand about the impact of space travel on people and the environment.			
14	Show the different potential risks and benefits that influence people's decisions to be involved in space travel.			

Teacher comments

Assessment

TECHNOLOGY				
Pages	**Student checklist**	✓	**Teacher checklist**	✓
17 & 18	Show how building designers might adapt plans to consider different things that buildings need to cope in space.		AC9TDE6P04, ST3-DDT-01, VCDSCD038 Negotiate design criteria including sustainability to evaluate design ideas, processes and solutions	

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ACADEMY OF THE SOCIAL SCIENCES IN AUSTRALIA

Academy of the Social Sciences in Australia Inc

3/95 Northbourne Ave Turner ACT 2612
GPO Box 1956, Canberra, ACT 2601

(02) 6249 1788
info@socialsciences.org.au
socialsciences.org.au