Plants for Space: Space Bones

Get ready for a plant adventure like you've never experienced before.

Years 3 & 4 Student Guide

Crew Memeber Name:

Australian Government
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Acknowledgments

Plants for Space acknowledges the Traditional Custodians of Country and their deep ongoing relationship with the Land. We pay respect to Elders past, present and future.

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These materials have been developed by the P4S Education and Engagement team with consultation with the P4S researchers, education providers and classroom teachers. LISAF and Melb Uni Botany Foundation.

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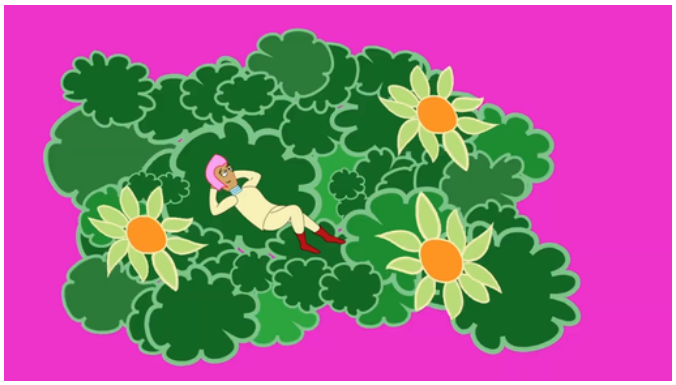
TABLE OF CONTENTS

Mission: Plants For Space

Humans are returning to the Moon and even to Mars. To get there astronauts will travel these very far distances through space for days and months. Space is a very harsh environment for living things and the scientists and engineers will need to make sure the crew members are healthy and happy to complete their mission. Some of the challenges for crew members in space flight include:

- Microgravity
- Living in cramped spaces
- Radiation
- Nutrition



www.youtube.com/watch?v=xTo063Y0roY

Plants for Space
A team of Australian scientists think plants can help astronauts in many ways to explore the corners of the universe. Watch the P4S Video about how growing plants in space might help space travel and farming here on Earth.

Learning Objectives

By the end of this lesson, you will:

- Describe how living in space affects bone health.
- Describe the effects of being in space has on bones.
- Explore why astronauts experience bone loss in space and how they counteract it.
- Conduct an experiment to visualize bone strength and the impact of calcium.
- Explain the role of plants in space can help astronauts and their bones.

Space Travel: Floating in Space

When people are in space, they feel weightless, which makes them float around. It can seem like there is no up or down because gravity feels very weak. This is called microgravity.

In microgravity, astronauts can move very easily. A small push is enough to help them float from place to place, and lifting heavy objects takes very little effort. It can take time to get used to moving this way. While it may look like a lot of fun, living in microgravity for a long time can affect astronauts' bodies. Scientists study space travel to understand how it changes human health.

Watch this video of astronauts floating on the International space station.

www.youtube.com/watch?v=yKplBILQB8o

What happens to our bones in microgravity?

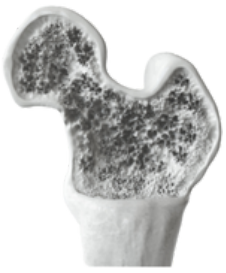
Astronauts bones get weaker the longer they spend in space.

On Earth, our bones stay strong because we walk, run, jump, and move every day. These movements help cells in our bones build new bone.

In space, bones still break down, but they do not rebuild as well because there is no gravity pulling on them. This means astronauts' bones can slowly become weaker.

Astronauts will exercise regularly and eat special diets to help prevent bone loss.

Earth Bones
On earth health bones have many small holes



Space Bones
In space bones large holes form making them weaker.

Watch the following video to see how exercise helps astronauts in space. (https://www.youtube.com/watch?v=SPzFwjTTG3g).

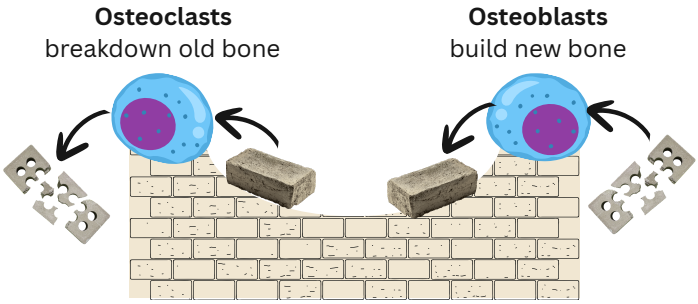
Reading: Bones and Space

Bones are alive. Bones hold a lot of calcium to make them strong. They are continuously being broken down and rebuilt. There are two special bone cells that do this:
Osteoblasts- build new bone
Osteoclasts- break down old bone.

Vitamin D from food and sunlight is needed to help the body build new bone.

Bone Remodeling
If more bone is being broken down than being made, bones get weaker. This can happen with age or illness.

Bone Cells



What Happens to Bones in Space?
In the microgravity of space osteoblasts don't work so well and build bones slower!
So bones get weaker over time. Astronauts can lose bone up to 2% per month! This mostly in the legs, hips, and spine where the body carries most of its weight.

Osteoporosis - Earth and Space
Osteoporosis is a bone disease that results in bones being broken down more than being build up, losing calcium and breaking easily. This is like what happens in space.

How Do Astronauts Protect Their Bones?

Studying bones in space helps doctors learn how to treat bone loss on Earth.

1. **Exercise**: Astronauts do exercises like cycling, lifting, and running on special machines. This helps osteoblasts work and keeps bones strong.

2. **Food**: They eat food with calcium, vitamin D, and protein.

3. **Medicine**: Some astronauts try medicines called bisphosphonates to stop osteoclast cells working and this slows bone loss.

4. **Special Lettuce**: United States researchers have genetically engineered (GE) lettuce leaves to make a human protein (parathyroid) that helps the human body built bones. Astronauts can use eat leaves instead of taking extra medicine.

Why is GM Lettuce Helpful?
1. It grows in space.
2. It is easy to use.
3. It saves space and weight in rockets.
But scientists need to test it more to make sure it's safe.

Reading: Questions

A. True or False circle your answers:

1. Osteoclasts build new bone. True / False

2. Bones need calcium to stay strong. True / False

3. Bones in space break down faster. True / False

4. Vitamin D helps the body use calcium. True / False

5. Astronauts can lose 2% of their bones each month in space. True / False

6. GE lettuce might help stop bone loss in space. True / False

7. Bones are dead and do not change. True / False

B. Short Answer

1. What do osteoblasts do?

2. What happens to bones in space?

3. How does exercise help bones in space?

4. Why could GM lettuce useful in space?

5. What is osteoporosis?

6. What is one more way astronauts could protect their bones in space?

Bones in Space Experiments

Question 1: What happens when bones lose calcium and become thin?
(Egg shell observation)

Background
Bones in space break down more than they build up and this results in bones losing calcium. Egg shells contain lots of calcium like healthy bones. We are using the eggshells to represent bones. The acid (vinegar) will remove calcium from the shell, just like bones without enough calcium nutrition or in microgravity.

We can observe what happens to the egg shell when we remove calcium. We can make predictions and conclusions about the effects that space might have on human bones. Scientists do this all the time; it is called a model. For example, researchers at Plants for Space are making protein medicines in strawberries that will mend bones during surgery (encourage bone making). They are using models from other scientists to try and work out how to put the gene (code to make the protein) into the strawberry.

Materials for each pair/group
· Two raw eggs in their shell
· A transparent glass or container
· A bottle of vinegar

Method
1. Place one egg in a glass and submerge in vinegar (to stimulate ‘weak bones’)
2. Leave the other egg out to represent a healthy bone
3. Leave both eggs for 36- hours (you could change the vinegar after 24 hours)
4. Remove the egg from the vinegar

Results
1. Examine the egg that has been left in vinegar. Describe what you see:

2. Compare the vinegar-soaked egg to a regular egg: What happens when you gently press the soft egg?

3. Discuss: How does this experiment relate to what happens to bones in space?

Question 2: How much weaker are astronauts' bones when they get thin and lose calcium?
(Cheerios Bone Density Experiment)

Materials:
· 200 Cheerios
· 3 plastic sandwich bags
· Scale (if available)
· Heavy book

Procedure:
1. Place 200 Cheerios (or 40g) into a plastic bag.
2. Subtract 40% (remove 80 Cheerios or 16g) and place in another bag.
3. Subtract 60% (remove 120 Cheerios or 24g) and place in a third bag.
4. Press each bag with a heavy book once.
5. Count and record the number of unbroken Cheerios.

Watch the video to follow instructions
(https://youtu.be/zK-1WRDJA2c)

Results Table:

Bag	Number of Unbroken Cheerios	Percentage Cheerios after Experiment	Change in Percentage
100% (200) Cheerios			
60% (120) Cheerios			
40% (80) Cheerios			

Discussion Questions:

1. What did you notice about the number of unbroken Cheerios in each bag?
   How did the percentage of cheerios change?
   Was there any difference between the bags in percentage of Cheerios and the final percentage of cheerios?

2. What is happening in bones in space to make bone density less?

3. How does this experiment model bone density loss in space and on Earth?
   What conclusions can you make about bone density change depending on original bone density?

Conclusions:

1. Draw below the difference in bone structure before space travel and after space travel

2. What did you learn about how bones are affected in space?

Question 3: How might researchers at Plants for Space help space bones?
Space bones are a problem for long space journeys. Below are examples of studies being done by Plants for Space researchers. Use these studies to explain how Plants for Space can help astronauts maintain strong bones.

How would you use plants in space to help astronauts maintain strong bones?

Making super nutritious Duckweed

Chigozie from the University of Adelaide is working on making Duckweed a nutritional powerhouse.

Making Chloroplasts become biological factories

Leni from the University of Western Australia is using the green part of plants - chloroplasts - to make different proteins that could help with astronaut nutrition and health.

Using the environment to make food more nutritious

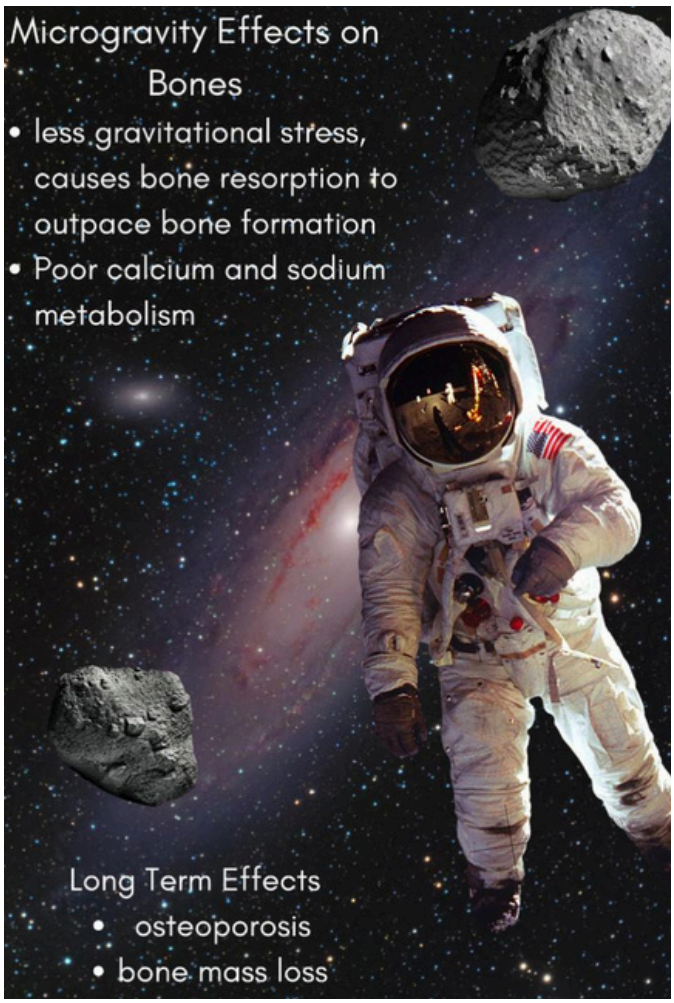
Jiayue from the La Trobe University is working out the best amount and type of light, temperature, plant growth material and fertilizer to grow the most nutritious tomatoes.

Bone stimulating hormone in plants

Ryan from the University of Melbourne is changing the DNA of strawberry leaves, engineering them to make a bone-building protein.

Extension Activity
Are you eating enough calcium for bone health?

You have learned in the Bone Health in Space lesson that calcium is needed for bone building. You also learned that not enough calcium can lead to long-term health problems, such as bone density loss, causing weaker bones and osteoporosis (changes in bone to make them more 'porous' and brittle).



Track your calcium content in food for the next week to see if you are eating enough calcium.

- Fill out the weekly meal table on the next page, writing down the food and quantities of it under breakfast, lunch, dinner and snacks (estimate amounts if you have to).

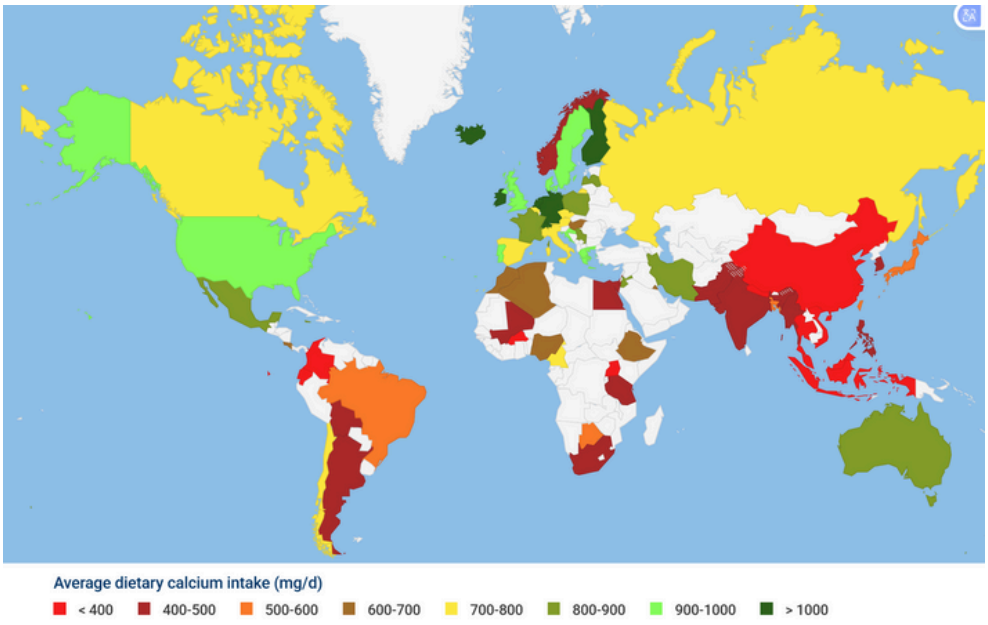
- Use the International Osteoporosis Foundation calculator to work out how much calcium was in each meal.

https://www.osteoporosis.foundation/educational-hub/topic/calcium-calculator)

Weekly Meal Tracker

Day	Breakfast	Ca?	Lunch	Ca?	Dinner	Ca?	Snacks	Ca?
Monday								
Tuesday								
Wednesday								
Thursday								
Friday								
Saturday								
Sunday								

Compare your daily (mg/d) intake of calcium with world standards on the International Osteoporosis Foundation's Calcium Map (https://www.osteoporosis.foundation/educational-hub/topic/calcium/calcium-map)



Does your calcium intake meet recommendations?

Go to the *International Osteoporosis Foundation Recommended daily calcium intakes page* (https://www.osteoporosis.foundation/educational-hub/topic/calcium/calcium-recommendations) to find out if you meet the recommendations for calcium intake.

Recommended daily calcium intakes (IOM, NAM)		
	Age	**Calcium Recommended daily Intake (mg/day)**
Infancy to Adolescence	0-6 months	200
	6-12 months	260
	1-3 years	700
	4-8 years	1000
	9-13 years	1300
	14-18 years	1300
Adulthood	19-50 years	1000
	51-70 years	Females 1200 Males 1000
	Over 70 years	1200

- Find out whether you are getting enough of this important mineral in your daily diet, using the IOF Calcium Calculator.
- Read more about calcium in our Calcium Fact Sheet.