AUDIENCE WITH AN ASTRONAUT
SPACE FOUNDATION

# STEM ACTIVITY LESSON

# BONE DENSITY: ON EARTH VS. IN SPACE

**Grade Level**
6th - 12th

**Focus Areas**
Biology and Engineering

**Standard**
MS-LS1-5

## BACKGROUND INFORMATION

Living in space poses challenges for the human body, especially due to microgravity, which causes bones to weaken over time. Without gravity, the skeleton doesn't have to support body weight, leading astronauts to lose up to 2% of bone density each month in areas like the hips and spine. This isn't a big issue on short trips, but it can become serious on long missions to places like Mars or the Moon. Weakened bones increase the risk of fractures and long-term problems like early osteoporosis once astronauts return to Earth. To prevent this, astronauts exercise regularly using special equipment and follow carefully planned diets to keep their bones healthy in space.

## STUDENT REAL-LIFE CONNECTIONS

- Think about what happens when you stop doing something physical—like sports, dance, or even playing an instrument—for a long time. You get rusty, your muscles feel weaker, and it takes time to get back into shape.
- Imagine what would happen if your backpack floated through the hallways every day instead of you carrying it—no weight on your back, no strain on your legs. At first it might seem fun, but over time, your bodies would weaken from not having to carry or support anything.

## LESSON OBJECTIVES

- Identify the impact microgravity has on bone density.
- Participate in a challenge to identify negative impacts of lower bone density on the human body.

# STEM ACTIVITY LESSON

## BONE DENSITY: ON EARTH VS. IN SPACE

MATERIALS

## LIST

- Quantities listed are for a classroom of 30 students.
- Gallon Ziplock bags (12)
- Box of Spaghetti, dry/uncooked (2)
- Poster Sized Chart Paper (3)
- Astronaut Stress Toy 2 Pack (3)
- Bone Density work page (30)
- Masking Tape Roll (1)
- Internet Capable Devices (30)
- Printer Paper Sheet (30)
- Coloring Supplies (30)
- Paper Toll Roll (1)

ACTIVITY

## DIRECTIONS

### Prepare

- Plan to split students into six groups.
- Separate the spaghetti into six piles, one for each group. Once separated, prepare the dry and wet spaghetti samples:
  - For the dry spaghetti, put half the spaghetti for each group into a Ziplock bag. Label the bag as “High Density”.
  - For the wet sample, place a damp paper towel and the rest of the spaghetti into the other Ziplock bag. Label the bag as “Low Density”.
  - The damp paper towel will soften the spaghetti without making it as soft as boiling would. Leave the damp paper towel in until the Spaghetti feels softer and slightly more flexible. It helps to wrap the paper towel around the spaghetti.
  - Repeat until you have a “High” and "Low" density bag ready for each group.
- Label a piece of chart paper with each category, or write them on a whiteboard in table format:
  - What we see
  - What it might be
  - Why it exists
- If using 3D design for the Elaborate piece, have students practice 3D design skills first prior to the lesson. For an easy and free CAD platform, consider: TinkerCAD (https://www.tinkercad.com/dashboard).

### Excite

- Show students a picture of the treadmill on the International Space Station. Do not tell them what it is, but instead ask students to list as many things as they notice about the picture on a scratch piece of paper.
- Have students share a few of the things they listed aloud to the whole class. As they share, write some of the answers under the categories on the labeled chart paper.

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# DIRECTIONS (CONTINUED)

### Excite (cont.)

- For example, if a student says 'they are exercising', that fits under the 'why it exists' category.
- Tell students we will return to the picture and what it is later in the lesson, but first they need to know why this mystery object was even invented.

### Explore

- Ask for a volunteer to jump as high as possible. Once the student has demonstrated their jump, ask the class: Why did they come back down?
- Explain that on Earth gravity constantly pulls us back towards the Earth. Our body has to push back against gravity and our bones have to hold us in a human shape despite gravity. However, in space astronauts float due to lower gravity.
- Ask students to discuss with a partner: What do they think might happen to the human body if it isn't always fighting against gravity?
- Once students have a chance to discuss, have a few share their thoughts aloud.
- Tell students that gravity is important for the human body. Share the following facts:
  - In space the human body doesn't have to work as hard to fight back against gravity. This means that you're not exercising your bones and muscles as much.
  - If you don't use your bones, they can lose bone density. In space, astronauts can lose up to 2% of their bone density every month.
- Show students the bags of spaghetti and tell them they are doing a challenge today to see why bone density is so important. Explain the challenge:
  - Each group gets the following:
    - A bag of spaghetti that represents structures with high density
    - A bag of spaghetti that represents structures with low density
    - One astronaut stress ball
    - 1 foot of masking tape
  - Lay out the conditions and constraints:
    - Groups must work together to build a bridge that can hold up their astronaut.
    - Bridges must span a gap that is at least seven inches wide.
      - *To create the gap, consider placing two desks near each other, or using flat objects like books to make raised platforms on a table.*
    - Bridges must only be made with the spaghetti and tape allotted. No other objects can be used to support or secure the ends of the bridges.
  - Students are challenged to use as little spaghetti as possible.

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ACTIVITY

# DIRECTIONS (CONTINUED)

### Explore (cont.)

- Students are challenged to use as little spaghetti as possible.
- Students should first build a bridge using the spaghetti that represents high density. As they build, they will record their results on the bone density work page.
- Then, students should try again, this time using the spaghetti representing lower density. Once again, students will record their results on the work page.
- Provide students at least 15 minutes to conduct the experiments.
- As students work, circle the room to ask guiding questions and provide clarification as needed.

### Explain

- Have students clean up their tables and return the astronaut.
- Ask students to share: How many pieces of spaghetti did they need for the higher density bridge? What about the lower density bridge? What differences did they see?
- Tell students to imagine that instead of spaghetti bridges, they are looking at bones. Ask them to discuss with a partner:
  - If they want to be strong and healthy on Earth, do they want to have a higher or lower bone density? Why?
  - Have students record what they discuss on their work page.
- Have students fill in the bottom of the Bone Density work page as you explain:
  - Density is a term for how tightly packed together something is. Higher bone density means your skeletal system is stronger, while lower bone density means it's weaker, like seen with the spaghetti.
  - Exercise can help humans maintain a healthy bone density.
  - As they learned earlier, gravity is constantly holding us down to Earth, which causes our bodies to have to work hard against it. Humans are basically exercising all the time as they resist gravity. However, in space, there's not as much gravity. People float, and because of that, their bodies don't have to work as hard. This can cause them to start losing bone density over time.
  - Loss of bone density might not matter as much while in space itself, but it will cause astronauts to have problems when they return to Earth. It can lead to the risk of bone fractures and other major health issues.
  - Astronauts can counteract the loss of bone density by doing special exercises and by eating healthy and nutritious meals.

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## DIRECTIONS (CONTINUED)

### Explain (cont.)

- Ask students to look at the picture of the treadmill on the space station again. Explain that this is a treadmill made to be used in microgravity, or places with almost no gravity. Knowing that, what do they see that makes it different from a regular treadmill?
  - Have students brainstorm some thoughts with a partner.
  - After students have a chance to brainstorm ideas, point out a few details, such as the straps to hold the astronaut down so they don't float away.

### Elaborate

- Tell students that now they will design their own exercise equipment for in space.
- For this challenge, students will work independently or in pairs.
- They must create some sort of exercise equipment that can help astronauts in space avoid losing bone density. Designs must meet the following constraints:
  - Must allow for exercise that can help with bone density.
  - Must be able to fit in small spaces, like how some exercise equipment on the ISS can be folded or shifted out of the way as needed.
  - Consider microgravity. Designs must have something to stop the exercise equipment from floating away.
- Have students draw a diagram or create a 3D model of an invention that can meet the design constraints. Give students the remaining time to work.
- If students are unsure what to create, let them research exercises that can keep bones healthy, then take inspiration from what they find.

### Evaluate

- Have students share their designs with their group.
- As they share, encourage them to explain:
  - How will their design work in space?
  - How will it counteract bone density loss?

# STUDENT WORKSHEET

## BONE DENSITY: ON EARTH VS. IN SPACE

## Astronaut on Bike in Space Image

*Image Credit: NASA – Astronaut Mark T. Vande exercising on the Combined Operational Load Bearing External Resistance Treadmill in the International Space Station.*

# Bone Density Student Worksheet

1. Why does gravity matter for the human body?

2. Build a bridge using the high-density spaghetti. Fill out the chart to record the results. Then repeat the process with the low-density spaghetti.

| Spaghetti Bridge Density Test | | |
|---|---|---|
| **Spaghetti Type:** | **Pieces Needed:** | **Sketch of Bridge Design (include tape used):** |
| | | |
| | | |

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# Bone Density Student Worksheet (cont.)

3. Imagine that instead of spaghetti, you're looking at Bone Density. If somebody wants to be strong and healthy on Earth, do they need to have a higher or lower bone density? Why?

_____

_____

4. After listening to your teacher's explanation, fill out the following:

- Density is... _____
- What happens to bone density when you're in space?

  _____

  _____
- Why is this a problem?

  _____

  _____