Science Starter Title: Puffy Head, Bird Legs

Subject: Physical Science, Life Science
Grade Level(s): 3-8
Time: 40-50 minutes

Universal Design for Learning:

Representation (Options for presenting content)

- Video clips
- Lab

Engagement (Options for engaging student interest)

- Cooperative work group
- Partner work
- Movement

Expression (Options for students to demonstrate learning

- Written response
- Oral response

Objectives

Students will:

- Investigate the effects of gravity on the human body.
- Make direct observations of their bodies in upright and prone positions, and consider the long-term effects.

Standards

3-PS2-1 Plan and conduct an investigation to provide evidence of the effects of balanced and unbalanced forces on the motion of an object.

3-LS3-2 Use evidence to support the explanation that traits can be influenced by the environment.

Materials

- Accompanying video - Space Lingo: What Is "Puffy-Head Bird-Legs?"
- Clear disposable gloves
- Water
- Clock
- Tape measures

Optional:

- Exercise mat or blanket
- Red food coloring - put a drop or two into the water so students can better observe the fluid

Methods

Introduction:

Vocabulary

- **Heart -** the muscular organ that pumps blood through the body.
- **Vertebrae** - each of the individual bones that together make up the spine.

Guided Practice:

Background for teachers:

The human body is accustomed to experiencing gravity *at all times*. Gravity is a universal experience in the history of life on Earth, to the point that most people have never even thought about what would happen to our bodies if gravity wasn't pulling us to the ground anymore.

The effect can actually be seen and measured by comparing our bodies when upright vs. when prone.

Teacher Demonstration

1. Fill a plastic glove with water, as Marty and Beth have done in the Stem in 30 video. Be sure to tie off or otherwise secure the glove opening. Draw a stick person on the glove as they have done, with the head at the glove's wrist, and the feet on two of the fingers.
2. Hold the glove upright (head up and feet down) and have students observe that the fluid has collected in the "legs" and has caused them to swell.
3. Ask students if they have ever experienced their legs and feet swelling after standing for a long period of time.
4. Ask students what will happen to the glove "person" if it were:
    a. Laid flat on the table.
    b. Held upside-down.
5. Lay the glove on a table. Have students observe the head and legs. Students should compare how swollen the glove is in this orientation with how it was when rightside up.
6. Hold the glove upside down. Have students observe the head and legs. Students should compare how swollen the glove is in this orientation with how it was in the previous two orientations.
7. Ask what is causing the head to swell when upside down, and the legs to swell when rightside up. What force causes the fluid to collect more at the bottom of the glove, no matter how you turn it?

Student Activity:

1. You will be working in groups of 2 to 3 students. One member of the group will be the test subject, and the others will be the data recorders.
2. Use the tape measure to measure the circumference of your test subject's calf while they are standing upright and flat footed. Measure at the largest part of the calf, and be sure to measure at that same point each time. The tape measure should be against the leg all the way around, but not pulled tight enough to squeeze. At this time, data collectors should also observe the shape and hue of the test subject's head. Look especially at the eyes and cheeks.

3. Make a data table of times and measurements, starting with t = 0 minutes (the original measurement) and going up to t = 10 minutes.
4. The test subject will lie down on their back with their legs raised against the wall. For best results, the test subject's feet should be high on the wall. If this is uncomfortable, it may be best to have the test subject lie on their back with their feet raised on a chair.
5. The test subject will remain in this position for 10 minutes. The data recorders will make measurements on the test subject while the test subject is in this position - do not have the test subject get up or lower their legs for measurements.
6. After each minute, the data recorders should measure and record the test subject's calf circumference, being sure the measurement is made in the same place each time.
7. At the ten minute measurements, and before the test subject gets up, the data collectors should observe the test subject's face. Does it appear puffy? Does it appear flush in color?

Wrap up:

Questions:

- How did the test subjects' leg measurements change over time?
- What would be the best way to display the quantitative results of all the groups in the class?
- How did the test subjects feel over the course of ten minutes? Specifically, did their heads or legs feel different from when they are standing or sitting?

Explain:
For those of us on Earth, the normal distribution of fluids throughout our bodies is a balance primarily between the force of gravity pulling them downward and the heart pumping them upward. Lying down changes what percentage of your body is below your heart. Elevating your feet changes it even more.

Astronauts in space experience these changes even more dramatically, because gravity is not able to pull the blood and other fluids down at all. The effect is that those fluids collect more than usual in the areas closer to the heart - the torso and head. Thus, the astronauts appear to have a puffy head and thin, bird-like legs - at least for a few days, until their bodies adapt to the situation by retaining less fluid.

Astronauts report feeling pressure in their sinuses, a feeling like having a stuffy nose. Compare this report to what the test subject students felt over the course of ten minutes.

Upon returning to Earth's gravity, astronauts' heads and legs do return to normal… after a few days.

Extensions

- Data collectors could take further measurements during the experiment, or during a follow-up experiment. Suggestions include heart rate or neck circumference.
- Students may be aware that being upright for hours at a time causes our vertebrae to compress very slightly, and lying horizontally causes them to stretch apart slightly, making each of us a very small amount taller when we first get out of bed and a very small amount shorter at the end of the day. This effect can be more than half an inch.
    - Students can have somebody measure their height first thing in the morning and later in the evening to see if their body changes enough to be seen. Remember that all bodies are different, and some people will experience this effect more than others.
    - Research how much taller an astronaut can get after a long duration spaceflight. How long after returning to Earth does it take for their vertebrae to settle back together again, so they are back

to their normal height?

- Astronauts undergo other changes to their bodies while in spaceflight, including loss of muscle mass and loss of bone density. Discuss in class why this would happen to our muscles and bones, and what could be done about it. Research what astronauts do on the International Space Station to fight muscle loss and bone weakness.

Resources

- **NASA:** How would your body change in space?
  - https://education.jsc.nasa.gov/explorers/p3.html
  - https://www.nasa.gov/audience/forstudents/5-8/features/F_When_Space_Makes_You_Dizzy.html
- **What are NASA "Bed Rest Studies"?**
  - https://www.nasa.gov/analogs/envihab/bed-rest-faqs

To see more instructional content published by The National Air and Space Museum visit our website at Air and Space Learn and our page on Smithsonian Learning Labs.