Lesson Title:

Subject	Grade Level	Timeline
Life Science	2 - 5	45 - 60 minutes

Objectives

This lesson investigates the effects of gravity on the human body. Students will use dry corn puff cereal to model the effects of bone mass loss (osteoporosis) when sustaining injury. Students will be able to explain why healthy bones are important, and the unique difficulties in keeping bones healthy for those who travel to space.

Standards

Next Generation Science Standards
Third Grade Storyline
https://www.nextgenscience.org/sites/default/files/MS%20PS%20DCI%20Combined%206.13.13.pdf

Students who demonstrate understanding can:

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

National Science Education Content Standards:
5-8 Science Content Standards A and C

Materials

- Zip-top plastic bags (5 per group - recommended 6 ½ inch x 3 ¼ inch bags)
- Corn puff cereal
- Permanent markers for labeling bags
- Heavy books (1 per group)
- Broom and dustpan

Vocabulary

- Osteoporosis: the most common disease to affect bones, the word literally means “porous bones.” This disease results in a loss of bone mass, leaving bones more brittle.

- Atrophy: to become less effective due to disuse.

Lesson Plan

Background for teachers: All people lose bone mass due to aging, starting at around 30 years old. It is a natural part of how our bodies age. People also lose bone mass when the body is immobilized. This is called disuse atrophy--an example is when a person wears a cast to allow a broken bone to heal. The healing bone loses mass and, like any immobilized muscles around it, must be re-strengthened when the cast is removed.

Researchers have found that exposure to microgravity causes astronauts of all ages to lose bone mass much more quickly than aging does, creating a condition similar to osteoporosis, especially in the legs and hips. More is still being learned about how the bone loss mechanism for astronauts is different from disuse atrophy in bedridden patients, or from natural aging, or from osteoporosis. But what they are learning about how to prevent any of these conditions is helping to address the others.

On Earth, muscles and bones work a great deal in the regular movements of our daily lives. For example, balancing ourselves upright requires our bones to support our body weight. Astronauts in orbit do not experience this. Even with daily exercise, astronauts’ bones experience less natural wear and tear in space, and calcium leaves the bones faster than the body knows to replace it.

Ask: Have you ever seen muscles become atrophied due to having a cast on?

Explain: Muscles do a lot of work just in everyday life, moving around and holding us up against gravity. When muscles can’t do that, they have difficulty repairing themselves and keeping themselves strong.

Ask: Do you know anyone--grandparents, for example--who suffers from osteoporosis? Do you know what osteoporosis is or what causes it?

Explain: Osteoporosis is a disease in which bones become porous and brittle, more than the natural weakening of bones that comes through normal aging. Astronauts experience a particular kind of osteoporosis when in microgravity. Explain to students the effects of microgravity on bones.

To model the effects of bone loss, students will use bags of cereal to model human bones. Each bag will represent a bone, and the cereal inside the bone will represent the calcium and cells that make the bone strong. Bags with less cereal inside will represent bones that have lost some of their mass. Each bag will experience being slammed into by a heavy textbook, to model a bone experiencing a hard bump or fall.

Students should work in groups of four.

- Distribute cereal, snack bags, and worksheets to students.
- Students should follow the directions on the worksheet.
    - Note about cereal smashing: some of the cereal has natural holes in it. Explain to students that they should examine the cereal before smashing it, so that they have a reference point when counting unaffected pieces after.
    - In addition, one student should be responsible for smashing all of the bags, so that the amount of force will be the same on each bag.
    - Discuss what students should look for when they are counting “affected” pieces of cereal. Pieces that have dust (from other smashed pieces) or only a tiny flake taken off should not be counted as “affected.”
- After the students have completed the activity, bring the group back together. Ask each group to share their results with the class. Discuss the results and the follow-up questions.
- If some groups’ results did not come out as expected (i.e., density did not drop), discuss the possible reasons for this. Answers may include miscounting, uneven force applied when smashing bags, etc. Can students think of another way to test their hypotheses?

Student Activity:

See activity worksheet below.

Activity Worksheet

Get Ready

- 5 zip-top snack bags
- Corn puff cereal
- A very heavy book (like a dictionary)
- A broom and dustpan (for clean-up)
- Permanent marker
- Pen or pencil

Think about it

- Why is it important to have strong, healthy bones?

- What will happen if your bones become weak?

Formulate your hypothesis

What do you think will happen to a bone (in this case, represented by your baggie and cereal) if force is suddenly applied to it? Will the results change if the bone is progressively weakened?

Activity Worksheet

Collect the data and test your hypothesis

1. Using a permanent marker, label the bags 1-5.

2. Bag 1 will represent a healthy bone on Earth. To build a "bone" you will use pieces of cereal to represent individual units of bone mass. Fill the bag with enough cereal so that the bag is very full and there is very little air in it, but not so full that you cannot close it. Keep track of how many pieces of cereal you put into the bag, and record this on your worksheet as **Normal Bone Density**. Close the bag, and make sure it is closed *tightly* -- otherwise you may wind up with a very big mess!

3. To represent a bone that has lost mass as a result of spaceflight or aging, you now need to fill each bag with less cereal (or bone mass) than Bag 1.

Bag 2: 90% of original bone remains; 10% original bone lost
Bag 3: 80% of original bone remains; 20% original bone lost
Bag 4: 65% of original bone remains; 35% original bone lost
Bag 5: 50% of original bone remains; 50% original bone lost

To calculate the amount of cereal you need in Bag 2, you will need to calculate 90% of Normal Bone Density. Fill Bag 2 with this amount. This represents a loss of 10% of the bone mass.

4. Use a similar method to calculate 80%, 65%, and 50% of the Normal Bone Density, and fill the other bags with these amounts. Record the amount of bone left in each bag on your worksheet.

5. Now you are ready to see what effects a sudden force may have on weakened bones. Place Bag 1 on a hard surface. Then, quickly and carefully (but forcefully) smash the heavy book onto the bag. Using the same amount of force, smash the remaining bags.

6. What happened to your bones? Count the number of unaffected cereal pieces left in each bag, and record this on your worksheet.

7. How much of the bone was unaffected? To calculate this, use the formula below and record your values on your worksheet.

$$\left[\frac{\#\text{ unaffected remaining in the bag}}{\text{original density of the bag}}\right] \times 100$$

8. How much of the bone was affected? To calculate this, subtract the Unaffected Bone value from 100%. Record your values on your worksheet.

Bag of Bones Worksheet

Normal Bone Density = _____ pieces of cereal in Bag 1
Density of Bone 2 = 90% of Bag 1 = _____ pieces of cereal
Density of Bone 3 = 80% of Bag 1 = _____ pieces of cereal
Density of Bone 4 = 65% of Bag 1 = _____ pieces of cereal
Density of Bone 5 = 50% of Bag 1 = _____ pieces of cereal

Before the Experiment			After the Experiment		
Bag	Bone Loss Represented	Density (# of cereal pieces in bag)	# of unaffected cereal pieces	% of bone unaffected	% of bone affected
1	0%				
2	10%				
3	20%				
4	35%				
5	50%				

Analyze the results
What happened as the amount of cereal decreased?

Bag of Bones Worksheet

Now imagine that your baggie bone is actually a real bone. If a real bone were built like your baggie bone, what would happen if a sudden force (like a bump or fall) were applied to the bone?

Do your findings support your hypothesis? Why or why not?

How do you think we can prevent bone loss?

Extensions

Graphing Results - Students can make graphs of their data and explore the relationship between bone density and the amount of damage sustained. Compare the results of all groups. Are the results comparable between groups? Are the trends consistent between groups?

Resources

- **Baylor College of Medicine:** The Science of Muscles and Bones - **Teacher's Guide**
  http://ccitonline.org/ceo/home/content_images/TSO_MB_TG_s.pdf

- **NASA:** The quest for a cure for osteoporosis
  https://www.nasa.gov/vision/earth/everydaylife/weak_knees.html