"BAG OF BONES"

Background:
Weightlessness experienced during space flight causes loss of some bone density. Bone density is measured by how solid and strong bones are on the inside. Bone density is increased and maintained on Earth by the work gravity causes in our everyday in our lives.

The pull of gravity 350 km above our planet's surface -- where the space station and the shuttle orbit -- is 90 percent as strong as it is on the ground. That hardly sounds weightless! But orbiting astronauts nevertheless feel weightless because they and their spacecraft are freely falling together toward the planet below. Just as gravity seems briefly suspended in a downward accelerating elevator, so does the crew in the freely-falling space station experience "Zero-G." In fact, it's not exactly zero -- but near enough. The acceleration they feel is as little as 0.001% of the gravitational acceleration on Earth's surface.

In this mutual free-fall, bones no longer have to fight against Earth's gravity. As a result, less mechanical strain is applied to the skeletal system. This reduced stress on bones is responsible for the bone thinning disease, Osteoporosis.

Like Osteoporosis on Earth, the weight-bearing bones of astronauts on long missions are left weak and less able to support the body's weight. When astronauts return they risk of bone fracture increases.

Materials per Group

- Corn Puff Cereal - approx. 4.5 oz
- Freezer zip lock bags
- 1 text book
- Student Recording Sheet
- Broom and Dustpan for clean up

Activity Preparation:

1. Divide the students into groups of four. Give each group five plastic bags, a sufficient quantity of cereal, a permanent marker, 1 and a recording sheet.

Activity Procedure:

1. Discuss osteoporosis and how good nutrition and exercise are essential for healthy bones. Explain that aging and space flight have a similar effect on the human body; both may lead to Osteoporosis or porous bone. Osteoporosis makes bones weak and fragile, which can make it very easy to fracture or break a bone. The way people on Earth and in space acquire bone loss is different. Talk about the differences.
2. Tell the students that the activity they are about to complete investigates the effects of Osteoporosis in humans and provides important insight for people living on Earth and in space.
3. Explain that each plastic bag represents a bone. The cereal inside the bone will represent the calcium and cells that make the bone strong. Pieces of cereal represent individual units of bone mass.
4. Read over the Student Direction Worksheet with the students and answer questions about the procedure and allow the student to conduct the experiment in groups.
5. Use the questions on the student recording sheet to help the class draw a conclusion.
6. At the conclusion of the experiment, students will see why bone loss causes problems for astronauts and for people on Earth - if the condition is left untreated. Explain that a bone left with mostly whole pieces of cereal is a bone slightly fractured but not broken clean through. The injury is minor and will heal quickly with proper care. The larger the percentage of affected bone, the greater the injury, and the longer the healing time. A bone with 100% damage is a bone fractured in two. This bone might need pins, rods, or even screws in addition to a cast in order to heal properly. Although astronauts eat healthy food and exercise regularly, bone loss still occurs. NASA is still trying to determine how to counter this condition in astronauts for long-term mission in space.

"BAG OF BONES"
Student Directions

Activity Procedure - Part 1:

1. Using a permanent marker, label the bags 1-5, with Bag 1 representing a healthy bone on Earth.

2. Fill Bag 1 with enough cereal so that the bag is very full, leaving as little air as possible in the bag. The bag should not be so full that you cannot close it. Use whole pieces of cereal.

3. Count the number of pieces of cereal you put into the bag and record this number on your worksheet as Normal Bone Density.

4. Close the bag and make sure it's shut; otherwise you may wind up with a very big mess! Call Bag 1: 100% bone mass (normal mass); 0% bone loss.

5. To represent a bone that has lost mass through Osteoporosis, you now need to fill Bags 2-5 with less and less cereal, or "bone mass density", than Bag 1.

   - Bag 2 - 90% of original bone mass; 10% of original bone loss
   - Bag 3 - 80% of original bone mass; 20% of original bone loss
   - Bag 4 - 70% of original bone mass; 30% of original bone loss
   - Bag 5 - 80% of original bone mass; 20% of original bone loss

6. To calculate the amount of cereal in Bag 2, calculate 90% of the Normal Bone Density as shown below. Fill Bag 2 with this amount of cereal, which represents a loss of 10% of the bone mass.

Full Bag Count (Number of Pieces of Cereal in Bag 1)	×	0.9	=	Amount of Cereal in Bag 2 (Bone Mass Density)

7. Use a similar method to calculate 80%, 65% and 50% of the Normal Bone Density, and fill Bags 3, 4, and 5 with these amounts. Record the count of "bone" placed in each bag on your recording sheet.

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

8. In building each bone, be certain that the air is squeezed out of the bag before sealing the bag shut. Otherwise, the air will act as a cushion and the demonstration will not work as intended.

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Activity Procedure - Part 2:

9. Now you are ready to witness the effects of a sudden force on normal bones and on weakened bones.

10. Place Bag 1 on a hard surface. The heavy textbook will provide for an unexpected force like a bump for a fall. Lift the book as high as possible and drop it onto the bag-bone. Turn the bag over and repeat the procedure, being careful to lift the book to the same height a before so that the impact force will remain constant.

11. Using the same height each time to maintain a constant impact force, repeat the previous step for Bags 2, 3, 4, and 5.

12. What happened to the bones? Count the number of whole pieces of cereal left in each bag and recorded this number on your student recording sheet. (Students should keep in mind that cereal pieces that have dust on them from other smashed pieces or only a tiny flake broken off should be counted as "unaffected" or whole.)

13. Determine the percentage of bone mass that was left unaffected by the impact. To calculate this percentage, use the formula:

# of Unaffected Cereal Remaining in the Bag	÷	Original Bone Mass Density of the Bag	X	100	=	Percentage of Unaffected Bone

14. Record the values on your Student Recording Sheet.

15. Now, determine the percentage of bone mass that *was* affected. To calculate this percentage, subtract the unaffected bone value percentage calculated in Steps 5 and 6 from 100.

100	—	Percentage of Unaffected Bone	=	Percentage of Affected Bone Mass

16. Record the values on your Student Recording Sheet.

17. Discuss your results in your group and answer the questions on your Student Recording Sheet.

Name_____

Student Recording Sheet

	Before the Experiment		After the Experiment		
Bag	Bone Loss Represented	Bone Mass Density (# of cereal in bag)	# of Unaffected Cereal	% of Bone Unaffected	% of Bone Affected
1	0%				
2	10%				
3	20%				
4	35%				
5	50%				

1. What happened as bone density decreased?

2. What prevented some bone from being affected by the sudden force of the book?

3. What do you think would happen if the plastic bag and the cereal was a real bone, and a sudden force like a bump or a fall was applied to the bones?

4. How do you think we can prevent bone loss?