Brittle Bones: A Density Problem

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Part 1: Osteoporosis Stories - the Allen Family

Grandmother Lucy Allen has osteoporosis, a disease where decreased bone density makes her bones brittle and more easily broken. Lucy's daughter, Olivia, is worried that she and her teenage children (Claire and Brad) may also develop brittle bones when they get older.

Base your answers to questions 1 through 6 on the stories in the boxes below and on the Understanding Osteoporosis poster in your lab kit.

Lucy Allen (age 70)

I fell and fractured (broke) my hip last year. My hip is still painful and I can't be as active as I was before my fall. While I was in the hospital, I had a bone density test that indicated my bone density is very low. My doctor says low bone density means that I have **osteoporosis**.

1. What is osteoporosis?

_____

_____

2. What causes a person's bone density to decrease?

_____

_____

3. Which would be stronger—a bone that is more dense or a bone that is less dense?

_____

4. In addition to a broken hip, what else can happen to people who have osteoporosis? List <u>three</u> things.

   - _____
   - _____
   - _____

Olivia Allen (age 40)

My mother has osteoporosis so my doctor told me my family history made it important that I get a bone density test. The bone density test results showed that I have **osteopenia** (pre-osteoporosis). Osteopenia means that my bone density is lower than normal but not low enough to be classified as osteoporosis.

5. How is osteopenia (pre-osteoporosis) different from osteoporosis?

   _____

   _____

6. What could Olivia do to keep her osteopenia (pre-osteoporosis) from getting worse and becoming osteoporosis? List at least <u>five</u> things.

   - _____
   - _____
   - _____
   - _____
   - _____

Base your answers to questions 7 through 11 on the stories in the boxes below and on the A Future Osteoporosis Epidemic news article in your lab kit.

Claire Allen (age 15)

I'm the athlete in the family. I'm on a low-calorie diet and I try to run at least 5 miles a day. I play soccer and tennis. This year I started mountain biking and snowboarding. Because both my mom and grandmother have low bone density, I try to eat lots of vegetables. However, I can't drink milk or eat cheese because I am lactose intolerant.

7. Why should girls like Claire adopt a bone-healthy lifestyle when they are young instead of waiting until they get older to worry about osteoporosis?

_____

_____

_____

8. List three risk factors that Claire has that increase her chances of developing osteoporosis when she gets older.

- _____
- _____
- _____

9. Because Claire is lactose intolerant, she may not get enough calcium in her diet. What could she do to get the amount of calcium she needs to build healthy bones?

_____

_____

_____

Brad Allen (age 17)

Mom read that 1 in every 5 men over the age of 50 will fracture a bone due to osteoporosis. Now she keeps nagging me to get active. She says that I spend too much time playing video games and creating computer animations. Because I'm overweight, Mom keeps trying to get me to eat a healthy diet and exercise. I hate vegetables and like to drink soft drinks instead of milk. Don't tell my Mom, but I smoke and drink alcohol occasionally.

10. Approximately what percent (%) of men over age 50 will fracture a bone due to osteoporosis? Show your work.

_____

_____

_____

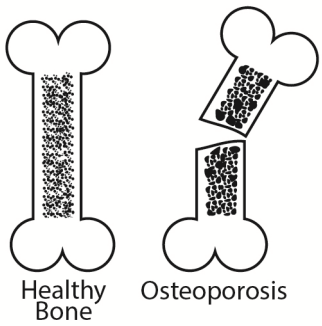
_____

11. List <u>four</u> risk factors that Brad has that increase his chances of developing osteoporosis when he gets older.

- _____
- _____
- _____
- _____

Part 2: Modeling Bone Density

Lucy Allen teaches a class about osteoporosis prevention at her town's community health center. She noticed that many of the people in her class did not understand the difference between healthy bones and bones with osteoporosis.



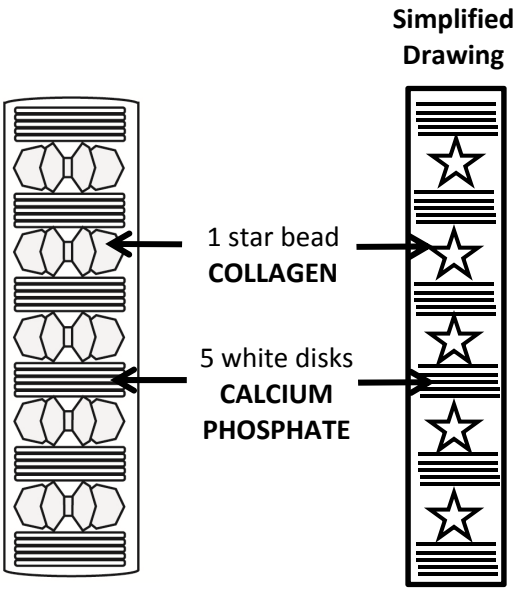
You will use the materials provided in your kit to make bone models for Lucy to use in her class.

Bones are living tissue made up of three major components:

- Living bone cells that are constantly removing and replacing bone tissue
- Collagen, a protein that forms a porous framework for building bone
- Calcium phosphate, a mineral that makes bone hard and strong

1. Use the clear plastic tube labeled "Female Teen (age 15)" to make a model to represent bone from a female teen. Fill the plastic tube with alternating layers of 1 white star bead and 5 white disks as shown in the diagrams on the right.

    - The white star beads represent a porous framework of **collagen** protein.
    - The white disks represent **calcium phosphate** that makes bone solid and hard.



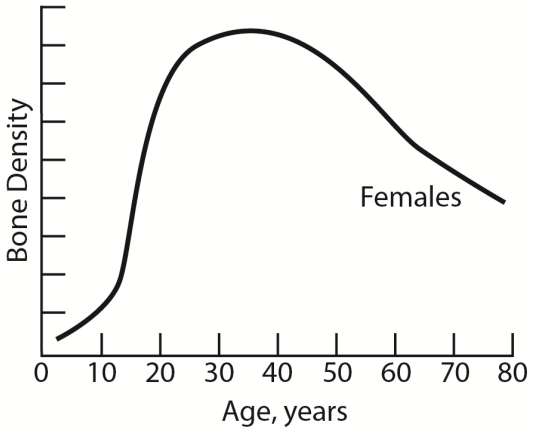
2. Put the lid on the tube.

3. The last page of the student instructions is a **Bone Model Analysis Sheet**. To make recording information on this sheet easier, you should tear this sheet off and put your name at the top.

4. Use the information in the first two columns of the **Bone Model Analysis Sheet** to complete the "Female Teen (age 15)" column.

Cells in bones are constantly removing old bone tissue and replacing it with new bone tissue. Some cells in bones remove the calcium phosphate from old bone. Other cells in bones replace the calcium phosphate to make new bone. The balance between bone loss and bone building determines whether bone density will increase, decrease, or remain the same.

During the teen years and young adult years, bones become denser because the bone building process is greater than the bone loss process. A person's bone density continues to increase until their bone density reaches its highest level. This is called "peak bone density."



5. Based on the information in the box above, at approximately what age would a female reach peak bone density? _____ years

6. Explain what causes bone density to increase during the teen and young adult years.

   _____

   _____

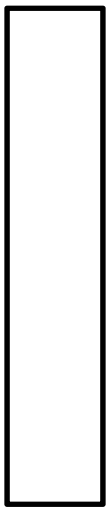
7. Based on the information in the box above, should the density of a bone model for a 30 year-old female be greater or less than the density of the "Female Teen (age 15)" bone model that you made in step 1?

   _____

8. **Design Challenge**: Use the clear plastic tube labeled "Female Adult (age 30)" to make a model representing bone from a female who is 30 years old.
   - Your model should simply reflect the approximate trend shown in the graph above. The kit does <u>not</u> contain pieces that are heavy enough to make your model mathematically accurate.
   - Be sure to alternate white disks (calcium phosphate) and white star beads (collagen).
   - It is OK to have your model be different from the models that other students make.

9. Test your model by completing the "Female Adult (age 30)" column on the **Bone Model Analysis Sheet**. Continue revising your model until it meets the answer that you stated in question 7.

10. In the rectangle on the right, make a simplified drawing to show the beads and disks that you used to make a model bone for a female who is 30 years old.



- Collagen: Draw a star (☆) to represent each white star bead.
- Calcium phosphate: Draw a line (–) to represent each white disk.

11. What makes bone more dense—increasing the amount of collagen or increasing the amount of calcium phosphate? Justify your answer based on your model.

_____

_____

12. Predict what might happen to bone density if a teenager or young adult does not have enough calcium rich food in his/her diet.

_____

_____

After people reach peak bone density, the balance between bone making and bone loss changes. Bone density decreases because both men and women then begin losing more bone than they make. When women reach menopause, their estrogen (female sex hormone) levels drop sharply and this increases their rate of bone loss. People who have greater bone density at the time of peak bone density are less likely to get osteoporosis later in life.

13. Explain what causes bone density to decrease.

_____

_____

14. Explain why the rate of bone loss in women increases after menopause.

_____

_____

15. Based on the information in the box on the previous page, should the density of a bone model for a 70 year-old female be greater or less than the density of the "Female Adult (age 30)" bone model that you made in step 1?

_____

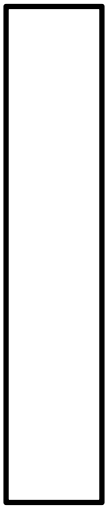
16. **Design Challenge:** Use the clear plastic tube labeled "Female Adult (age 70) Healthy Bone" to make a model representing bone from a female who is 70 years old.

- Your model should simply reflect the approximate trend shown in the graph on page 6. The kit does <u>not</u> contain pieces that are heavy enough to make your model mathematically accurate.
- Be sure to alternate white disks (calcium phosphate) and white star beads (collagen).
- It is OK to have your model be different from the models that other students make.

17. Test your model by completing the "Female Adult (age 70) Healthy Bone" column on the **Bone Model Analysis Sheet**. Continue revising your model until it meets the answer that you stated in question 15.

18. In the rectangle on the right, make a simplified drawing to show the beads and disks that you used to make a model of healthy bone from a 70 year-old adult female.

- Collagen: Draw a star (☆) to represent each white star bead.
- Calcium phosphate: Draw a line (–) to represent each white disk.



19. Based on your model, what makes bone <u>less</u> dense—increasing or decreasing the amount of calcium phosphate?

_____

20. Should a bone model for a 70 year-old female with osteoporosis be less dense or more dense than the "Female Adult (age 70) Healthy Bone" model that you made in step 16?

_____

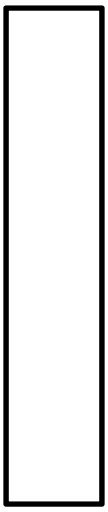
21. **Design Challenge:** Use the tube labeled "Female Adult (age 70) Osteoporosis" to make a model representing bone from a female who is 70 years old with osteoporosis.

- Your model should simply reflect the approximate trend shown in the graph on page 6. The kit does <u>not</u> contain pieces that are heavy enough to make your model mathematically accurate.
- Be sure to alternate white disks (calcium phosphate) and white star beads (collagen), and completely fill the tube.
- It is OK to have your model be different from the models that other students make.

22. Test your model by completing the "Female Adult (age 70) Osteoporosis" column on the Bone Model Analysis Sheet. Continue revising your model until it meets the answer that you stated in question 20.

23. In the rectangle on the right, make a simplified drawing to show the beads and disks that you used to make a model bone for a female who is 70 years old with osteoporosis.

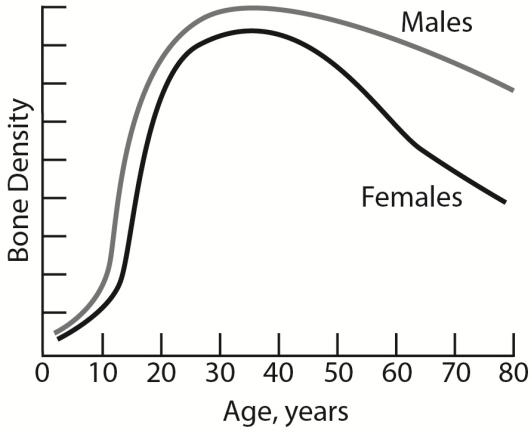
- Collagen: Draw a star (☆) to represent each white star bead.
- Calcium phosphate: Draw a line (–) to represent each white disk.



24. Based on your model, do the bones of a woman with osteoporosis contain more calcium phosphate or less calcium phosphate than healthy bones?

_____

25. Draw a new line on the graph below to show changes in bone density for a female who did not get an adequate amount of exercise and an adequate amount of calcium in her diet when she was in her teens and her 20's.



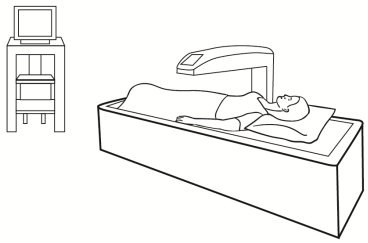
26. Use the trends shown in the graph above to state two reasons why males are less likely than females to develop osteoporosis.

- _____
- _____

Part 3: Bone Density and Fracture Risk

A bone density test is painless and only takes about 15 minutes to perform. During the test, a scanner passes over the person's body taking X-ray images of bones in the hip. A computer then analyzes the data to determine the bone density in the spine, hip or wrist because these are the most common locations for fractures.

Bone Density Scanner



Bone density test scores are reported as "T-scores." The diagram below relates T-scores with normal bone, osteopenia (pre-osteoporosis), and osteoporosis.

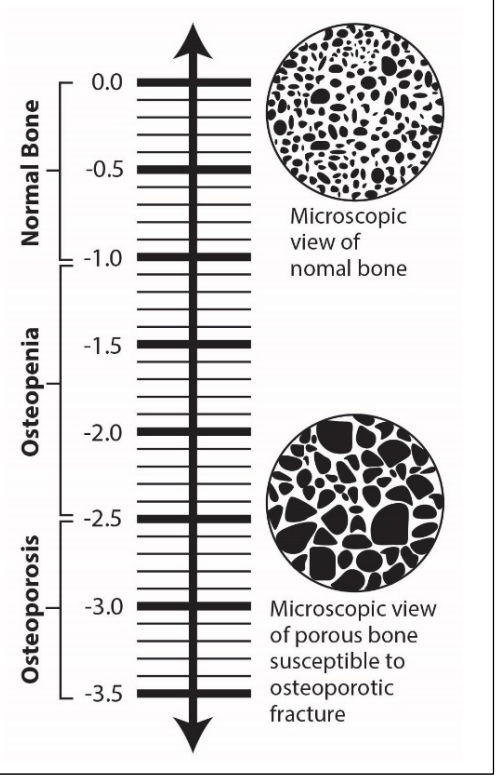
1. According to the Bone Density and T-Scores diagram on the right:
   - As bone density decreases, the T-score (increases, decreases, or stays the same):

     _____

   - A woman is diagnosed with osteoporosis if she has a T-score below _____.
   - A woman with healthy bones has a T-score that is above _____.

2. Hypothesize: If a woman has a low T-score, she is _____more ***or*** less (circle one)___ likely to have a bone fracture in the future.

Bone Density and T-Scores



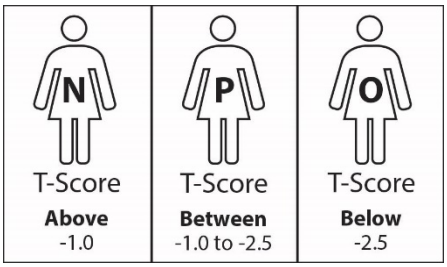
To test your hypothesis, you will use data collected from forty 70-year-old women who participated in a 10-year research study. At the beginning of the research study, each woman was given a bone density test and her T-scores were recorded.

3. Your lab kit contains a diagram sheet entitled **Forty 70 Year-Old Women Who Participated in Research Study.** This sheet shows the T-scores for the forty women in the research study.

   - Women with normal (healthy) bones have T-scores above -1.0. Write an "**N**" in the symbol for each woman in the research study who has normal healthy bone. *See the example in the diagram below.*

   - Women with osteopenia (pre-osteoporosis) have T-scores from -1.0 to -2.5. Write a "**P**" in the symbol for each woman on in the research study who has osteopenia. *See the example in the diagram below.*

   - Women with osteoporosis have T-scores below -2.5. Write an "**O**" in the symbol for each woman in the research study who has osteoporosis. *See the example in the diagram below.*



4. Complete Column 1 in the Data Table on the next page by counting and recording the number of women in the research study who have normal bone (N), osteopenia (P), and osteoporosis (O). *Note: You will complete columns 2 and 3 later in this activity.*

Ten years later, each of the forty women in the research study was interviewed and their medical records were checked to determine if they had suffered bone fractures.

5. Place the colored plastic sheet entitled **Women Who Had Bone Fractures** on top of the diagram sheet entitled **Forty 70-Year-Old Women Who Participated in Research Study**. Be careful to match the lines in the two diagram sheets.

6. A pink or orange color on the plastic sheet indicates women who had bone fractures. Count the number of women in each category (healthy bone, osteopenia, and osteoporosis) who had bone fractures. Record the numbers in Column 2 of the Data Table.

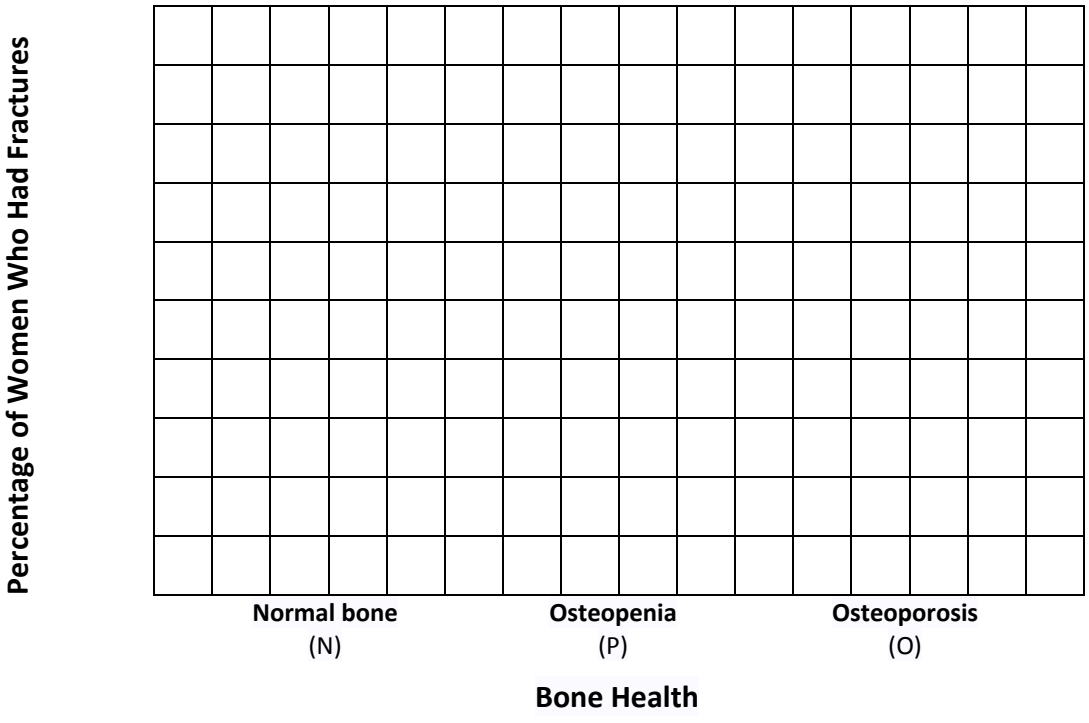
7. Complete the Data Table by calculating the percentage (%) of women in each category (normal bone, osteopenia, and osteoporosis) who had bone fractures. Record the percentages in Column 3 of the Data Table. *Hint: For each category (N, P, or O) divide the number of women with fractures by the total number of women in that category, then multiply by 100.*

Data Table: The Relationship between Bone Health and Bone Fractures

	Column 1	Column 2	Column 3
Bone Health T-Scores	Number of Women	Number of women who had bone fractures	Percentage (%) of women who had fractures
Normal Bone (N) Above –1.0			
Osteopenia (P) –1.0 to –2.5			
Osteoporosis (O) Below –2.5			

8. Use the graph grid below to make a bar graph that summarizes the relationship between bone density and bone fractures.
   - Write an appropriate title for the graph.
   - Write an appropriate scale (numbers) on the vertical (y) axis.
   - Plot the percentages of women who had bone fractures in each category (the data from Column 3 on the Data Table).

   Graph Title: _____



9. State at least two conclusions that you can draw from the information in the bar graph.

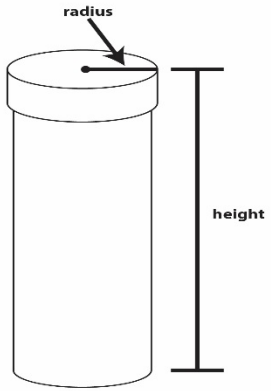
   - _____
   - _____

10. Does the data from this research support your hypothesis in question 2 on page 11? Explain why or why not.

    _____
    _____
    _____
    _____

Student Name _____

Bone Model Analysis Sheet

		Female Teen (age 15)	Female Adult (age 30)	Female Adult (age 70) Healthy Bones	Female Adult (age 70) Osteoporosis
Mass (grams)	Use the balance provided by your teacher. Measure mass to the nearest tenth of a gram.				
Radius (cm)	Measure in centimeters using the metric ruler provided in your lab kit. Measure to nearest millimeter. 				
Height (cm)					
Volume (cm^3)	Calculate Volume = π x $radius^2$ x height *Note: π = 3.14*				
Density (grams / cm^3)	Calculate Density = Mass / Volume				