

Activity 5.2.3: Bone Remodeling and Repair

Introduction

You might think that bones are lifelong structures that never change once you have stopped growing. In fact, bone is constantly being recycled and rebuilt in a process called *bone remodeling*. This process occurs in response to either the body’s need for calcium or the pull of gravity on muscles and bone.

Bone development is influenced by what we eat, how we exercise, how our hormones function and even how much sun exposure we get. Stress on our bones actually keeps them healthy and strong. Bone can adapt and change to fit the needs of the person. Runners have more bone mass in their legs than swimmers. Tennis players most likely have greater bone mass in their dominant hand. Bones are also able to heal themselves after a break or fracture. Specialized cells work to destroy damaged tissue and replace it with healthy, new tissue. These cells work to break down and build new bone; but if for whatever reason, the rate of building does not match the rate of destruction, severe bone loss can occur. If bones become brittle or damaged, the entire body is at risk for injury.

In this activity, you will investigate the process of bone remodeling and research the factors that can influence this balance of bone. You will read an article about bone changes in astronauts and relate these changes to stress on the limbs. You will also create a feedback loop that shows how hormones control bone remodeling and calcium levels in the blood. We all know calcium is needed to build healthy bones and teeth, but it can do so much more for your body. Work with your team to research the functions of this amazing mineral. Finally, an examination of a broken bone X-ray will allow you to see the healing power of bone. Bone’s ability to heal preserves this precious tissue for movement and for protection of the internal organs.

Equipment

* Computer with Internet access and Inspiration® software
* Laboratory journal
* Broken Bone X-ray image
* Endocrine system graphic organizer
* Colored pencils or markers

Procedure

Part I: Bone Remodeling

1. Note that bone is constantly being broken down and built up by two powerful types of bone cells called *osteoblasts* and *osteoclasts*. Research the specific role of each type of cell in bone remodeling and take notes in your laboratory journal.
2. Read the article “Space Bones” presented by NASA at <http://science.nasa.gov/headlines/y2001/ast01oct_1.htm> to investigate the role stress on muscles plays in bone remodeling. After bone mass has peaked at age 35, new bone formation cannot keep up with the destruction of bone. For this reason, bone mass begins to decrease. In space, this decrease occurs at a much faster rate.
3. Answer questions 1-4.
4. Note that astronauts who experienced a decrease in bone mass experienced an increase in blood calcium. Research the role hormones play in bone remodeling and regulation of calcium in the blood. Use the websites listed in Activity 5.2.2 or search for other credible sources.
5. Use Inspiration software to create a feedback loop that shows how the body maintains a calcium balance. Refer to the loops you created in Lesson 2.3 for ideas of how to describe this interaction and to organize your information.
* Start by thinking about how the body detects high or low levels of calcium in the blood.
* Have descriptions in your feedback loop which include the following words: *bone, calcitonin, parathyroid hormone, osteoclasts, osteoblasts, thyroid gland, parathyroid gland*.
* Show in your feedback loop the involvement of the endocrine system and the skeletal system in restoring a calcium balance. Make sure to reference specific glands and their target organs as well as pinpoint how bone is affected.
1. Add new glands and hormones to your endocrine system graphic organizer. Make sure to draw important target organs and draw an arrow from the releasing gland to the target. Follow the same format you have been using all year.
2. With your partner, use the Internet to research the role of calcium in the body. Surprisingly, calcium is not just used to build healthy bones and teeth. Record a list of functions in your laboratory journal. Make sure to relate calcium to the functioning of other body systems.
3. Meet with another pair and compare ideas. Add any functions you did not think of to your list.

Part II: Fracture Repair

1. Obtain a Broken Bone X-ray image from your teacher. This X-ray shows the leg of a young man after a motorcycle accident. He went in for X-rays at various stages of his recovery.
2. Note that there are four main stages in healing of a bone fracture. As you read a description of each step, make sure to think about the role of bone cells and blood supply in this recovery.
* **Step 1 – Hematoma Formation** Blood vessels that are ruptured during the break swell to form a mass called a hematoma. This mass forms between the broken bones.
* **Step 2 – Fibrocartilage Callus Formation** New capillaries begin to form into the clotted blood in the damaged area. Connective tissues cells form a mass of repair tissue called a *fibrocartilage callus*. This callus contains some cartilage, some bone and collagen fibers and the combined mass closes the gap between the broken bones.
* **Step 3 – Bony Callus Formation** The fibrocartilage callus is gradually replaced by one made of spongy bone. This new mass is referred to as the *bony callus*. Osteoclasts and osteoblasts move to the area and multiply.

* **Step 4 – Bone Remodeling** Over the weeks and months to come, the callus is remodeled with the help of osteoclasts and osteoblasts. The shape of the bones will gradually return to normal and there will eventually be little evidence of the fracture.
1. In your laboratory journal, describe how these steps relate to the sequence of X-rays. Draw pictures on the spaces between the X-rays if desired.
2. With a partner, decide on a timeline for the 3 X-rays. Obviously, the first X-ray was taken right after the injury. How much time do you think has passed between the accident and the 2nd X-ray? How much time do you think has passed between the accident and the 3rd X-ray? Be prepared to discuss your reasoning with the class.
3. Answer the remaining conclusion questions.

Conclusion

1. How does weight-bearing exercise actually help bone?
2. Explain why bone mass is “lost in space.” Make sure to mention specific bone cells in your response. Do you think there is any way to fight this loss?
3. Why did a decrease in bone mass lead to increased calcium levels in the blood?
4. What is osteoporosis? How can a study of what is happening to bones in space potentially help prevent and treat this condition?
5. Why do you think a runner will most likely develop bigger leg bones than a swimmer? How does this happen?
6. Explain how the body will use bone remodeling to repair a fracture.
7. The fetal skeletal is made of cartilage and eventually turns to bone in a process called *ossification*. Given what you know about bone cells, how do you think this occurs?
8. What lifestyle choices help a person maintain healthy, strong bones and prevent bone loss? Explain.
9. Explain why a person who has been in a leg cast for two months will notice a significant change in size and function of the leg. How do you think muscle would be affected?