Summary

This activity helps students learn about the three different types of muscles and how outer space affects astronauts' muscles. They will discover how important it is for astronauts to get adequate exercise both on Earth and in outer space. Also, through the design of their own microgravity exercise machine, students learn about the exercise machines that engineers design specifically for astronaut use.

Engineering Connection

Category 1. Relating science concept to engineering Engineers need to understand how the human body works in order to help astronauts stay healthy in outer space. The microgravity of outer space leads to muscle atrophy, so scientists and engineers at NASA work to design special exercise machines to help the astronauts maintain muscle strength.

Contents

Grade Level: 5 (3-5)

Group Size: 4

Time Required: 50 minutes

Activity Dependency :None

Expendable Cost Per Group : US$ 0

Keywords: muscle, movement, human body, exercise, astronaut, cardiac, skeletal, atrophy, smooth, voluntary, involuntary

Related Curriculum :

subject areas	Earth and Space
	Biology
curricular units	Solar System!
	Engineering and the Human Body

lessons Life in Space: The International Space Station
Move Your Muscles!

Educational Standards

- Colorado Science
- b. Analyze and interpret data to generate evidence that human systems are interdependent (Grade 5) [2009]
- c. Assess further scientific explanations regarding basic human body system functions (Grade 5) [2009]
- International Technology Education Association-ITEA STL Standards Technology
- J. Materials have many different properties. (Grades 3 - 5) [2000]
- E. Technological advances have made it possible to create new devices, to repair or replace certain parts of the body, and to provide a means for mobility. (Grades 3 - 5) [2000]

Learning Objectives (Return to Contents)

After this activity, students should be able to:

- Explain the difference between skeletal, cardiac and smooth muscle.
- Explain the difference between involuntary and voluntary muscles.
- Describe what happens to astronauts' muscles in outer space.
- Relate that engineers help astronauts stay healthy in outer space by designing special exercise machines.

Materials List

Each group needs:

- Pencils
- Paper
- Crayons
- Books with images of muscle cells and/or muscle cell slides and microscope

Introduction/Motivation (Return to Contents)

Muscles can be classified in many ways. Can you name a muscle? Well, the heart is a muscle! This muscle is called *cardiac* muscle.

Figure 1. The human heart â a cardiac muscle.

Another type of muscle is *smooth* muscle. This type of muscle lines vital organs, such as your stomach. Lastly, there is *skeletal* muscle. What do you think this type of muscle does? Well, skeletal muscle is

attached to your bones and actually helps your skeleton move. (Teacher: write the three types of muscle on the board; cardiac, skeletal, and smooth.) Muscles can also be classified by their movement. Right now, close your eyes, and think really hard about telling your heart when to beat. Could you do it? No! The beating of your heart is an *involuntary* action. Involuntary means we do it without thinking. Your heart beats without you thinking about it or commanding it to do it. So, your heart muscle, or cardiac muscle, is an involuntary muscle. The same goes for smooth muscle or the muscle lining your stomach. Can you tell your stomach to stop digesting food when you eat? No, you cannot, so smooth muscle is involuntary as well.

Skeletal muscles are some of our largest and most powerful muscles, (like our biceps, triceps, and quadriceps), and they are connected to our bones with tendons. Skeletal muscles are the only muscles that are *voluntary*. Voluntary means the opposite of involuntary. If we think about it, we can do it. Close your eyes again, and tell your arm to move so you are raising your hand. No open your eyes. Did you raise your hand? Yes, you did! That is because skeletal muscles are voluntary muscles!

When astronauts travel into outer space, they live in a *microgravity environment*, or a place with less gravity than on Earth. Gravity on Earth is what holds on the ground and keeps us from floating away. That is why we see pictures of astronauts floating around in space, because there is little gravity to hold them in place. Since there is almost no gravity in outer space, astronauts' muscles do not work as hard as they do on Earth (i.e., through general, daily movement). This leads to muscle *atrophy*, which means that the astronauts' muscles get very weak quickly. When muscles get weak, they do not work as well. Muscle atrophy leads to people not being able to lift heavy things or move very easily. Of course, we do not want that to happen to the astronauts who travel in space!

Because of microgravity, regular exercise machines â the one that work on Earth â do not work in outer space. So, in order to help the astronauts stay healthy, engineers have designed special exercise machines for space travel. In order to effectively design these machines, engineers need to know how muscles work and how microgravity affects them. Today, we are going to learn a little more about different muscles, and consider how we can exercise them. This will help us understand how engineers design machines to help astronauts exercise while in space.

Vocabulary/Definitions (Return to Contents)

Atrophy: To waste away or decrease in size.
Cardiac muscle: Involuntary muscles located in the heart.
Involuntary muscle: Muscle that does not respond to thinking about movement.
Skeletal muscle: Voluntary muscles attached to bone.
Smooth muscle: Involuntary muscles located in the hollow internal organs.
Striated muscle: Muscle that appears to be striped - both cardiac and skeletal muscle are striated.
Tendons: Tough tissue that attaches skeletal muscles to the bone.
Voluntary muscle: Muscle that responds when thinking about movement.

Procedure

Background Information

So that astronauts get adequate exercise while in space, there are three different machines that they use: the RED (Resistive Exercise Device), the CEVIS (Cycle Ergometer with Vibration Isolation System), and the TVIS (Treadmill Vibration Isolation System). This equipment, designed by engineers, allows astronauts to counteract the physical muscle loss due to atrophy (weakening of muscles due to being in a microgravity environment).

The RED allows astronauts to complete weight-training exercises, the CEVIS (see Figure 2) is similar to an exercise bike, and the TVIS (see Figure 3) is a free-floating treadmill.

Figure 2. An astronaut uses an exercise bike to get needed exercise in outer space.

Figure 3. An astronaut uses a treadmill to exercise while in outer space.

As shown in Figures 2 and 3, the astronaut has to be strapped down or attached to the machines to prevent him from floating away!

Before the Lesson

The focus for this activity is on skeletal (voluntary) muscle. Visit the library and get books with pictures of muscles and musculoskeletal systems. If possible, get slides of muscles and set up a microscope for students to view the slides.

With the Students

1. Briefly discuss the different types of muscles (cardiac, smooth and skeletal). Talk about voluntary movement (the ability to tell a part of the body â our arms and legs â to move), vs. involuntary (we cannot control our heart by thinking about it). Discuss how muscles work in teams, just like engineers and astronauts. (For example, the face uses over forty different kinds of muscles to make expressions.)
2. Discuss the problem of muscle atrophy in space (muscles grow weaker in space because, due to microgravity, they do not have to support the weight of the body; in a microgravity environment, the body is almost completely weightless).
3. Discuss the challenges of exercising in microgravity (exercising in space is tough if the body is weightless; for example, lifting weights does not help your muscles get stronger because the weights themselves are nearly weightless. This is why NASA engineers designed special exercise machines for astronauts to use while in space).
4. Show students pictures of actual exercise machines that NASA designed for astronauts to use and discuss how they work in microgravity conditions. (See Figures 2 and 3.)
5. Group the students into teams of 6. Have the students look up different kinds of skeletal muscles from the library books and, if possible, examine slides of muscles under the microscope.
6. Have teams choose one skeletal muscle for which they would like to design a microgravity exercise machine (leg, arm, back, etc.). Ask students to write that muscle down at the top of a sheet of paper.
7. Have each team brainstorm what type of exercise activities might be used to strengthen that muscle (sit ups, push ups, running, walking on your hands, etc.).
8. Have the students design a machine to strengthen that muscle, using at least one of the exercises they came up with (in step 7 above). Have them draw a picture of their machine and write a sentence to explain how it works. Encourage the teams as they design and draw their machine. (Teachers: encourage students to carefully consider and include the modifications needed in a microgravity environment in their designs.)
9. If time permits, have student teams review their design with the entire class. If time is short, ask a just a few student teams to volunteer to show their design to the class.

Assessment (Return to Contents)

Pre-Activity Assessment

Brainstorming: As a class, have the students engage in open discussion. Remind students that no idea or suggestion is "silly." All ideas should be respectfully heard. Have the class brainstorm a list of all the things our muscles enable us to do. Write all the ideas down on the board and guide students towards ideas they may not have considered (walk, run, jump, smile, laugh, eat, go to the bathroom, cry, frown, giggle, play hopscotch, swim, ski, snowboard, do ballet, play basketball, pump blood through our body, breath, etc.). Next, talk about voluntary and involuntary muscles, and write an "I" (involuntary) or a "V" (voluntary) next to each action.

Activity Embedded Assessment

Describe It In Words: Have the students write next to their machine which muscle (or muscles) it will exercise. Have the students write two sentences about these muscles (where they are located, voluntary vs. involuntary, cardiac vs. smooth vs. skeletal) on a sheet of paper.

Post-Activity Assessment

Job Interview: Tell the students you are a senior engineer from NASA, and that you are looking for some trained biomedical engineers to prepare exercise machines for the next space shuttle. However, in order to get the job, they must be able to correctly answer the following five questions:

- How many kinds of muscles are there? (Answer: three)
- What are the names of the kinds of muscle? (Answer: smooth, skeletal, cardiac)
- Which ones are voluntary and which are involuntary? (Answer: Skeletal is voluntary; cardiac and smooth are involuntary)
- What happens to astronauts' muscles in outer space? (Answer: They atrophy, or get weaker, because of the microgravity environment.)
- Who helps the astronauts exercise in space and what do they design and build? (Answer: Engineers! They design and build special exercise machines that work in outer space to help the astronauts keep their muscles strong.)

Congratulate the students on passing their job interview and being hired to work for NASA!

Activity Extensions (Return to Contents)

- Show students pictures of astronauts exercising in outer space. Have them discuss which muscles the individual machines are exercising.
- Talk about how aging on Earth is similar to what the astronauts experience in space. Explain that our muscles atrophy as we get older - just like the astronauts' muscles get weak while in outer space. Ask the students what we need to do to keep our muscles strong on Earth. (Answer: exercise)

Activity Scaling

- For upper grades, have students figure out the weight of their muscles on Earth as a math extension. (Note: 2/5 of the body is made of muscle, so if a person weighs 100lbs, 40lbs of their body weight is muscle.)
- For lower grades, have students draw one of the muscles from the library books and label it.

References (Return to Contents)

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National Aeronautics and Space Administration (NASA), Biological and Physical Research Enterprise, NASAexplores, Express Lessons and Online Resources, *Saving Muscles in Space*, February 5, 2004 (accessible online at NASA.gov).

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Supporting Program (Return to Contents)

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