National Aeronautics and Space Administration

NASA eClips™

Educator Guide

NASA's Our World:

Keeping the Beat

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Partner

https://nasaeclips.arc.nasa.gov/

Revised 2025

NASA eClips™ **Keeping the Beat**

EDUCATOR GUIDE

Grade Level:
3-5

Subjects:
Life Science

Teacher Preparation Time:
30-45 minutes

Lesson Duration:
Three 55-minute classes.

Time Management:
This lesson may take longer with younger students or with students who have little prior knowledge about the circulatory system.

National Standards:

Next Generation Science Standards (NGSS)

LS1.A: Structure and Function: Emphasize that organisms have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

LS1.B: Growth and Development of Organisms: Highlight that reproduction is essential to the continuation of every kind of organism and that organisms have unique and diverse life cycles.

International Technology and Engineering Educators Association (ITEEA) Technological and Engineering Literacy (STEL)

STEL 6: Design in Technology and Engineering Education
6A: Apply a design process to develop solutions to problems.
6B: Brainstorm and model multiple solutions to a given problem.
6C: Evaluate solutions based on criteria such as constraints, function, and sustainability.
STEL 7: Design and Troubleshooting
7A: Explain the importance of troubleshooting and maintaining technological systems.
7C: Identify ways to improve or adapt technological tools or processes.
STEL 10: Role of Technology and Engineering in Society
10A: Describe how technologies are created, used, and modified by humans to solve problems.

National Health Education Standards (NHES)

Standard 1: Core Concepts
1.5.1: Describe the relationship between healthy behaviors and personal health.
1.5.4: Describe ways to prevent common health problems (e.g., maintaining cardiovascular health through activity).

Standard 7: Practicing Health-Enhancing Behaviors
7.5.2: Demonstrate a variety of healthy practices and behaviors to maintain or improve personal health.

Lesson Overview:

Students measure and record their pulse rate before and after physical activity to learn more about the heart. Students have the opportunity to use a math model to look for patterns in the pulse rate data. Students participate in a Cardiac Relay to deepen their understanding of the circulatory system. Students make observations of gravity's effects on a water balloon to learn more about gravity's effects on water in the body. Thinking and acting like scientists and engineers, students learn more about the design of exercise equipment to keep astronauts healthy in space. This lesson is developed using a 5E model of learning and utilizes NASA eClips™ video segments.

Icons flag five areas of interest or opportunities for teachers.

- **TECHNOLOGY** highlights opportunities to use technology to enhance the lesson.
- **MODIFICATION** denotes opportunities to differentiate the lesson.
- **RESOURCES** relates this lesson to other NASA educator resources that may supplement or extend the lesson.
- **CONNECTIONS** identifies opportunities to relate the lesson to historical references and other topics or disciplines.
- **CHECK FOR UNDERSTANDING** suggests quick, formative assessment opportunities.

Essential Questions

- How does your heart pump blood through the body?
- What conditions might change the way your heart works?
- How does living in space affect the flow of blood through the body?

Instructional Objectives

Students will

- gain an understanding of the relationship between heart rate and physical activity;
- demonstrate the flow of blood and path for blood to exchange oxygen and carbon dioxide;
- examine the relationship between changes in the heart and reduced gravity environments; and
- make connections between science and engineering as they analyze exercise equipment designed for use on Earth and in space.

Materials List

Engage
Per student

- Student Guide (students could answer all questions and complete work in a science notebook, eliminating the need to reproduce the Student Guide)

Per class

- stop-watch or timer with a second hand

Explore
Per class

- painter's tape or sidewalk chalk to mark the perimeter and path of the Cardiac Relay
- 60 red cards (7.6 cm x 12.7 cm or 10.2 cm x 15.2 cm)
- 30 blue cards (7.6 cm x 12.7 cm or 10.2 cm x 15.2 cm)

Extend
Per group of four students

- balloon half-filled with water, any size and shape other than round
- paper towels
- transparent container half-filled with water large enough to float the balloon (if supplies are limited, one or two tubs could be set up as testing stations)

5E Inquiry Lesson Development

ENGAGE – Jumping Jacks (30 minutes. ENGAGE may take longer if additional activities in steps 4 and 11 are done in class)

During this ENGAGE activity, students discuss their ideas about what they think they know about the heart and blood circulation. They record their pulse rate at rest and after physical activity.

1. Lead a discussion to determine what ideas students may already have about the heart and blood circulation, including the questions below.
   - What does your heart do for you?
     (Answers will vary but may include pumping blood through the blood vessels, helping blood circulate, etc.)
   - What are some obvious signs that your heart is beating?
     (Answers will vary but may include hearing a heartbeat or feeling a pulse.)
   - What can happen to change the way your heart beats?
     (Answers will vary but may include changes related to exercise and health.)

2. Ask students to discuss what they know about pulse points. Practice how to locate the pulse at the carotid artery.

   a. Direct students to look up slightly by asking them to look up to where the wall meets the ceiling.
   b. Have students place the fingers of one hand on the middle of one side of their neck where the stiff trachea meets the thicker neck muscles. Be sure to tell students not to use the thumb because it has a pulse of its own.
   c. **(MODIFICATION)** You can also model how to take a pulse rate at the wrist. See Figure 1.

Figure 1: Taking a pulse rate at the wrist.

3. **(CONNECTIONS)** Ask the school nurse, or a parent volunteer who works in a medical field, to demonstrate how to locate pulse points and how to use a stethoscope.

4. **(RESOURCES)** More activities relating to heart rate can be found on the webpage of the NASA SCIFiles Educator Guide for The Case of the Physical Fitness Challenge: The Case of the Physical Fitness Challenge Segment.
   https://www.nasa.gov/stem-content/the-case-of-the-physical-fitness-challenge-segment-1/

5. Once students have mastered how to locate their pulse and measure their pulse rate, ask them to predict their resting heart rates in beats per minute. Ask students to record their predictions in Table 1 on page 4 in the Student Guide or in their science notebooks.

6. Ask students to sit quietly for one minute and then count the number of heart beats in 15 seconds to observe their resting heart rates. Ask students to record this information in Table 1 on page 4 of the Student Guide. Guide them to use this number to calculate their heart rates for one minute by multiplying the 15-second counts (1/4 of a minute) by 4.

Student pulse rates at rest vary between 60 and 115 beats per minute. Adult rates are lower. This chart is a general guide to the range of heart rates for children and adolescents.

Chart of Ranges and Average Heart Rates for Various Ages

Age (years)	**Range** (beats per minute)	**Average Rate** (beats per minute)
0 - 0.08	100-180	Infant average
0.17 - 0.25	110-180	data is
0.33 – 1 year	80-180	not known
1 - 3	80-160	130
4 - 5	80-120	100
6 - 8	70-115	100
9 - 11	60-110	88
12 - 16	60-110	80
>16 years	50-90	70

7. Ask students to predict how their heart rate will change after doing jumping jacks for one minute and to record their predictions in Table 1.

8. Have students do 20 jumping jacks. Ask them to record their pulse rate for 15 seconds. Guide students to calculate their pulse rates for one minute.

9. **(CONNECTIONS)** Discuss why students are recording their pulse rates for 15 seconds and then multiplying by 4 to calculate their heart rates for one minute. Ask students to consider whether the calculated heart rates might be different if they measured their pulse rates for 30 seconds and multiplied by 2, or measured their pulse rates for a full 60 seconds. *(Answers may vary, but might include discussions about errors in counting or the heart rate changing over time.)*

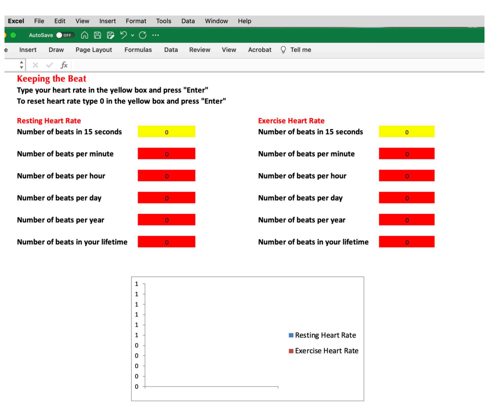
10. **(CHECK FOR UNDERSTANDING)** Use these questions to guide a discussion.

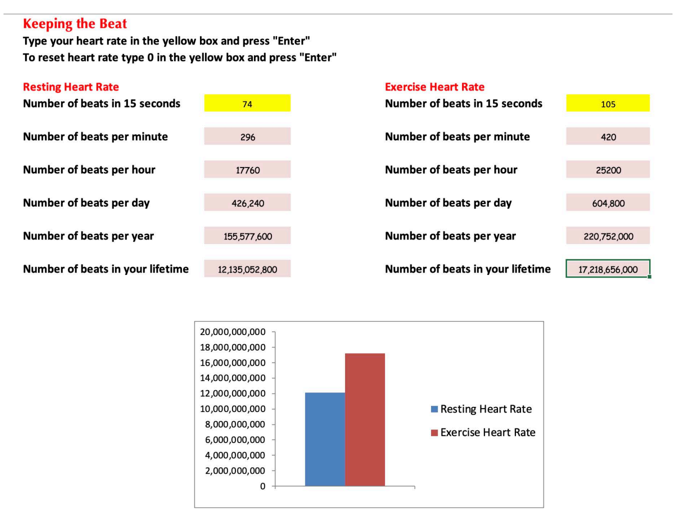
   a. How did your resting heart rate compare to your heart rate after the jumping jacks? *(Students should observe an increase in their heart rate due to physical activity.)*
   b. What have you learned about heart rate? *(Students should observe that the heart rate increases with increased levels of activity.)*
   c. What happened to your breathing during activities that increased your heart rate? *(Students should notice that the breathing rate and volume of air per breath increase as physical activity increases.)*
   d. What is the connection between an increase in physical activity, an increase in heart rate, and a need for more oxygen? *(Students should demonstrate an understanding that oxygen is carried to the cells of the body by red blood cells. When physical activity increases, muscles need more oxygen. Oxygen is carried to the muscles through the red blood cells.)*

11. **(RESOURCES)** You may choose additional physical activities for your students from NASA's Train Like an Astronaut. These activities model the real-life physical requirements of humans traveling in space. The activities and mission journals can be found here: https://www.nasa.gov/stem-content/train-like-an-astronaut/

12. **(CONNECTIONS)** Discuss how to calculate the average heart rate of the entire class.

13. **(TECHNOLOGY)** Use the Heart Rate Math Model (spreadsheet with functions) to calculate how many times your heart will beat in 78 years. This model is found in the Technology Tools section of the NASA eClips™ Teacher Toolbox: http://www.nasa.gov/audience/foreducators/nasaeclips/toolbox/techtools.html
Discuss how the math model works.





EXPLORE – Cardiac Relay (50 minutes)

During this EXPLORE Cardiac Relay activity, students simulate the flow of blood and the exchange of gases in the hemoglobin of the red blood cells. Students exchanging red cards for blue cards symbolizes exchanging oxygen (red card) for carbon dioxide (blue card). The relay does NOT take into account all the other products carried by the blood. You could easily adapt this activity to account for those materials, if needed.

Cardiac Relay Setup

Before class, set up the Cardiac Relay course in an open space such as a gymnasium or on the playground. Follow Figure 2 to set up the relay course, marking spaces to represent the heart, lung, head, and feet. If a gymnasium is used, mark off the parts of the circulatory system with painter's tape. If the playground is used, mark off the squares with chalk. Depending upon the age of your students, you may want to mark the pathways. See Figure 2.

Directions

1. Before beginning, assign students these roles:

    a. Assign two students to collect and distribute cards in the Lungs (Station 1). One student collects blue cards and one student gives out red cards. The student giving out red cards needs at least 60 cards at the start of the relay. The student collecting blue cards does not need any cards at the start of the relay.
    b. Assign two students to the Heart. The student in the left side of the Heart (Station 2) sends every other student to the Head or the Feet. The student in the right side of the Heart (Station 4) directs students toward the Lungs.
    c. Assign two students to the Head. One student collects red cards and one student gives out blue cards. The student giving out blue cards needs at least 30 blue cards at the start of the relay. The student collecting red cards does not need any cards at the start of the relay.
    d. Assign two students to the Feet. One student collects red cards and one student gives out blue cards. The student giving out blue cards needs at least 30 blue cards at the start of the relay. The student collecting red cards does not need any cards at the start of the relay.
    e. All other students are Red Blood Cells.

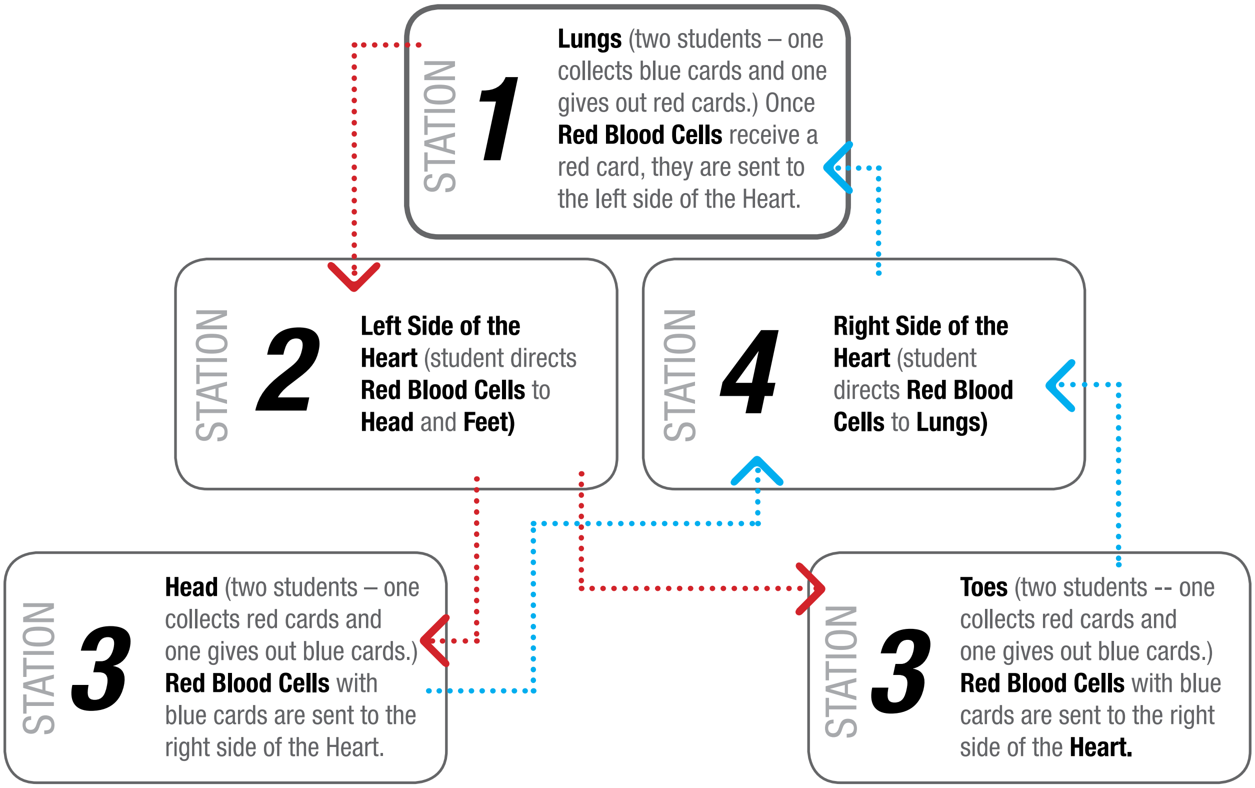


Figure 2: Cardiac Relay Course

2. **(MODIFICATION)** Depending upon your students, it may be helpful to identify their roles in the relay using name tags, armbands, or headbands.

3. Model the flow of blood by walking one student Blood Cell through this path.

   a. Be sure everyone is in their assigned place.
   b. Line up the student **Blood Cells** behind the **Lung** at **Station 1**.
   c. **Station 1** -- Beginning at the **Lungs** one student in the **Lungs** gives the **Blood Cell** a red card, symbolizing oxygen. The **Blood Cell** travels to **Station 2**, the left side of the Heart.
   d. **Station 2** – The student in the left side of the **Heart** sends the first **Blood Cell** to the **Head** and the next **Blood Cell** to the **Feet.**
   e. **Station 3** -- At the **Head**, one student collects the red card. The other student gives the **Blood Cell** the blue card because carbon dioxide is given off as a waste product, and sends the **Blood Cell** to the right side of the **Heart.**
   f. **Station 4 –** The student in the right side of the Heart claps hands with the Blood Cell and sends the Blood Cell back to the Lungs. One student in the Lungs collects the blue card while the other student gives the Blood Cell a red card, and the process begins again.

4. Once students understand the process, return all cards to the original positions and run the relay for three cycles. Stress that student Blood Cells MAY NOT pass the Blood Cell in front of them.

5. **(CHECK FOR UNDERSTANDING)** Discuss how the simulation compares to what really happens when blood flows through the heart. *(Answers will vary but should include that this simulation models the path blood travels to carry oxygen and carbon dioxide.)*

   Ask students to compare how this simulation relates to the ENGAGE – Jumping Jacks activity. *(Students should be able to understand how the heart rate they measured in the ENGAGE is modeled in this simulation.)*

6. Ask students to suggest how they would modify this simulation to model heart rate AFTER exercise. Recreate the simulation modeling the heart rate AFTER exercise. Change the roles that the students play so they can experience the various tasks of each of the parts.
   (Students should suggest speeding up the flow of student Blood Cells to model an increase in heart rate.)

7. **(MODIFICATION)** Discuss ways to modify the simulation to show the four chambers of the heart.

8. **(CONNECTIONS)** Students may simulate heart-related illnesses such as a heart attack or blood clot. Discuss what happens when vessels or valves collect deposits that narrow or restrict them.

9. **(CONNECTIONS)** “Blue babies” is a term given to babies with a hole between the left and right sides of the heart. This lets the blood with CO_2 and O_2 mix, so that oxygen isn’t efficiently delivered to the different parts of the baby. Demonstrating this could be incorporated into the Cardiac Relay.

EXPLAIN (25 minutes)

1. **(CHECK FOR UNDERSTANDING)** Based upon experiences during the Cardiac Relay, ask students to answer questions on page 5 of the Student Guide.

2. **(MODIFICATION)** Ask students to create a drawing to show the flow of blood through the heart. Ask them to include a key to identify when the blood is carrying oxygen and when it carries carbon dioxide.

3. **(CONNECTIONS)** Ask students to write a creative story following a red blood cell through the circulatory system. Encourage students to include the major parts of the circulatory system as characters in the story.

EXTEND (25 minutes)

1. Before class, prepare for the water balloon activity by filling one balloon half-full of water for each team of four.

2. **(TECHNOLOGY)** Show the NASA eClips™ video segment *Our World: Fluid Shift (5:31)*. This segment can be found on the NASA eClips™ page of the NASA web site:
   https://nasaeclips.arc.nasa.gov/video/ourworld/our-world-fluid-shift

The video may be streamed or downloaded from the nasa.gov web site; a captioned version is also available at the nasa.gov site.

(MODIFICATION) This video may be streamed from the NASA eClips YouTube™ channel: http://www.youtube.com/watch?v=fHqF2sh5qEI

3. **(CHECK FOR UNDERSTANDING)** Ask students to return to question 3 in the EXPLAIN section of the Student Guide. Using a different pen or pencil, ask the students to modify or add ideas to their original answer for this question. (Question 3 asks the students to describe how they think the flow of blood would be affected if they were living in space. After watching the video segment, students should be able to add more details about how the heart does not have to work as hard in space and how reduced gravity changes blood circulation.)

4. Hold one of the water balloons by the knot so that it hangs vertically. Discuss how gravity is changing the shape of the balloon. Ask students to draw and describe what they observe in Table 2 on page 7 in the Student Guide.

5. Ask students to predict how the shape of the balloon will change under different conditions: lying horizontally on a flat surface and floating in water. Ask students to record predictions in Table 2 on page 7 in the Student Guide.

6. Ask students to place their water balloons on a flat surface. Ask students to draw and describe what they observe.

7. Ask students to place their balloons in a tub of water. Ask students to draw and describe what they observe.

8. Under each of the three drawings, ask students to write a brief description comparing and contrasting each shape and explaining gravity's role in creating that shape.

9. **(CHECK FOR UNDERSTANDING)** Use these questions to lead a whole-class discussion.

   a. Why does the balloon change shape? *(The walls of the balloon stretch due to the pressure of the water inside the balloon. Gravity pulls the water to the lowest part of the balloon when the balloon is held by the knot and laying on the flat surface. This change does not happen when the balloon is in water.)*

b. How does the water environment simulate conditions in a reduced gravity environment? *(The water balloon floating in the water is similar to an astronaut suspended in a space shuttle or the International Space Station. The water counteracts the pull of gravity on the balloon.)*

c. How is what you are observing with the water balloon similar to what happens to the human body on Earth and in space? *(A human's body weight is about 55-65% water. When the water balloon is held in the air by the knot, the water is pulled to the lowest part of the balloon. This is similar to what happens to fluids in the body on Earth, but these fluids are forced back to the heart. The water balloon floating in the tub of water models what happens to fluids in the body when humans are in a reduced gravity environment.)*

d. Apply what you have learned from this experience to explain how lying in bed for a long time is similar to being in space? *(Answers will vary but may discuss that when someone is in bed for a long time, the heart does not have to work as hard to pump the blood back up to the heart from the body or up to the brain. This would be similar to what happens when the water balloon is lying on the table.)*

10. **(TECHNOLOGY)** Show the NASA eClips™ video segment *Our World: Exercise in Space (3:49)*. This video segment reviews how the body is affected by changes in gravity and can be found on the NASA eClips page of the NASA web site: https://nasaeclips.arc.nasa.gov/videosingular/ourworld/our-world-exercise-in-space

The video may be streamed or downloaded from the nasa.gov web site; a captioned version is also available at the nasa.gov site.

(MODIFICATION) This video may be streamed from the NASA eClips YouTube™ channel: http://www.youtube.com/watch?v=SPzFwjTTG3g

11. **(CHECK FOR UNDERTANDING)** Lead a discussion with students to help compare the experiences in this lesson to what they have observed in both video segments.

12. **(MODIFICATION)** Older or more advanced students may use these questions to ponder about changes in an astronaut's blood volume due to living in a reduced gravity environment.

a. How does a reduced gravity environment affect an astronaut's blood volume? *(Astronauts may lose 10%-20% of their blood volume when in space.)*

b. How could you simulate this change in the Cardiac Relay? Recreate the relay to demonstrate the shift of fluid. *(One way to simulate this change is to have more blood cells go to the head than to the feet.)*

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c. Astronauts drink a lot of fluid just before returning from their space missions. This is called rehydration. Why would astronauts want to drink so much before coming back to Earth? *(This helps to increase their blood volume so they will not experience dizziness, nausea, fainting.)*
d. Discuss how the brain uses the information it collects and sends signals to the rest of the body. *(In a reduced gravity environment, the brain senses an increase in blood since it is getting more blood flow than it typically does. This causes the brain to signal the kidneys, resulting in astronauts needing to urinate more frequently.)*
e. Challenge students to calculate their cardiac output using their heart rate measurements from the ENGAGE activity.

Additional Information About Heart Rate

Cardiac output is the amount of blood (in milliliters) pumped by the heart in one minute. This amount may offer clues to the health of the heart and cardiovascular system. As observed in the NASA eClips™ segment, living in space causes a loss of blood volume.

As observed in the **ENGAGE** and **EXPLORE** sections, if a person is exercising, the body requires more oxygen to fuel the muscles. The heart pumps harder so that the blood flow to the muscles can increase and the needed oxygen can be provided more quickly by the blood.

Cardiac output is the product of the stroke volume and the heart rate.

$$\begin{aligned} \text{Cardiac output} &= \text{stroke volume} \times \text{heart rate} \\ \text{(mL/min)} &= \text{(mL/beat)} \times \text{(beats/min)} \end{aligned}$$

Stroke volume is the amount of blood pushed through the heart during each heartbeat. It is measured in milliliters per beat. The average stroke volume on Earth is 75 mL/beat.

EVALUATE (30minutes)

1. Through discussions and the results of the **ENGAGE**, **EXPLORE**, **EXPLAIN** and **EXTEND** experiences, determine if your students have an accurate understanding of how blood flows through the heart both on Earth and in space.

2. Use this performance assessment as a tool to evaluate your students' understanding of gravity's effects on the heart and blood flow.

   a. Organize students into teams of two. One student takes the role of a scientist while the other student takes the role of the engineer.

b. **(TECHNOLOGY)** Ask students to complete the questions on page 8 and Table 3 on page 7 in the Student Guide as they watch the NASA eClips™ video segment *Our World: Exercise Equipment (5:09)*. This segment can be found on the NASA eClips™ page of the NASA web site: https://nasaeclips.arc.nasa.gov/video/ourworld/our-world-exercise-equipment

The video may be streamed or downloaded from the nasa.gov web site; a captioned version is also available at the nasa.gov site.

(MODIFICATION) This video may be streamed from the NASA eClips You Tube™ channel: http://www.youtube.com/watch?v=1of

Related videos:

Real World: Physically Fit on Earth and Beyond (6:11)

This Real World video features Corey Twine, a conditioning specialist from NASA's Astronaut Strength, Conditioning, and Rehabilitation (ASCR) group, sharing how he helps astronauts use the equipment on the International Space Station to stay strong for life in reduced gravity and their return to Earth's 1G environment. https://nasaeclips.arc.nasa.gov/videosingular/realworld/real-world-physically-fit-on-earth-and-beyond

Ask SME: Astronaut Strength and Conditioning Specialist - Corey Twine (3:08)

In this close-up video, Corey Twine, Astronaut Strength and Conditioning Coach at NASA's Johnson Space Center, shares how he helps to keep astronauts physically fit for work on Earth and while working in space. Watch this video to learn what inspires him to do the work he does. https://nasaeclips.arc.nasa.gov/videosingular/asksme/astronaut-strength-and-conditioning-specialist-corey-twine

c. Keep students paired so one scientist works with one engineer. Take the class on a “Playground Walk” analyzing playground equipment. Use these questions to guide their work.

   a. For scientists:

      i. How does using this equipment help strengthen the body?

      ii. How would this equipment work in space?

   b. For engineers:

      i. How could you change this equipment to work in space?

      ii. What new equipment could you design to help astronauts stay fit in space?

4. **(MODIFICATION)** Use the Engineering Design Packet for Elementary Students found on the NASA eClips™ Engineering page: https://nasaeclips.arc.nasa.gov/resources/guides#Engineering_Design_Packet.

This packet will help guide students through the engineering design process to design or improve playground equipment for use in space.

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Keeping the Beat

Essential Questions

- How does your heart pump blood through your body?
- What conditions might change the way your heart works?
- How would living in space affect the flow of blood through your body?

Background

Living in space is not the same as living on Earth. Many things are different. Our bodies change in space.

On Earth, our lower body and legs carry our weight. This helps keep our bones and muscles strong. In space, astronauts seem to float. They do not use their legs as much as they do on Earth. Their lower backs and leg muscles begin to lose strength. The bones begin to get weak. How do astronauts help their muscles and bones? They must exercise in space every day.

The heart and blood change in space, too.

When we stand up on Earth, blood goes to our legs. The heart has to work hard against gravity to move the blood all around the body.

In space, with reduced gravity, the heart does not have to work as hard. Much of the blood moves to the upper body and head. Water in the body does the same thing.

This shift of fluids can be seen in the astronauts' legs and faces. The astronauts legs become skinny and are sometimes described as "chicken legs." Their faces may look round. Astronauts often feel congested in their ears and noses. See Figure 1.

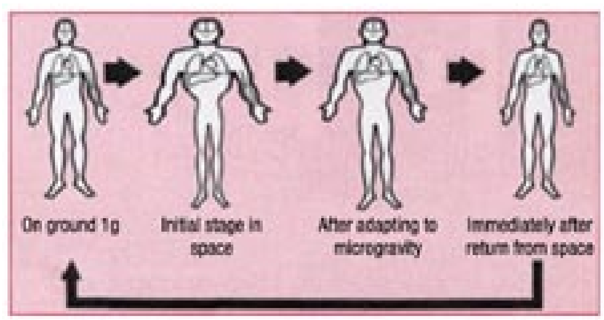

Figure 1: Fluid shifts caused by spaceflight. Image credit: NASA

In space, when fluids shift, the brain thinks that there are too many fluids. It will tell the body to get rid of extra fluids and make less fluids. Astronauts may lose 10% - 20% of their blood volume during a space mission. Before returning to Earth, astronauts must drink extra fluids to rehydrate.

While living and working is space, it is important for astronauts to exercise. Exercising helps the astronauts keep their muscles, bones, and heart strong.

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Resources

Our World: Sleeping On-Board the International Space Station:
https://nasaeclips.arc.nasa.gov/videosingular/ourworld/our-world-sleeping-on-board-the-international-space-station

21st Century Explorer: How Would Your Body Change in Space?
https://www.nasa.gov/stem-content/21st-century-explorer/

Vocabulary

arteries - Arteries are blood vessels that carry blood away from the heart.

astronaut - An **astronaut** is a person who is trained to travel into space.

blood vessels - Blood vessels are tubes that carry blood. They include arteries, veins,and the capillaries that connect them.

capillaries -Capillaries are the thinnest blood vessels. Nutrients and gases can pass through capillary walls. Capillaries connect veins and arteries.

carbon dioxide - Carbon dioxide (represented by CO_2) is a gas that is given off by cells as a waste product.

contracts - When the heart **contracts**, or gets smaller, the heart muscle is squeezing a larger space within the heart into a smaller space.

expands - When the heart **expands**, or gets larger, the heart muscles stretch and the spaces within the heart spread out.

fluid shift - While in space, fluids in the body move from the lower part of the body toward the head. This movement is **fluid shift.**

gravity - Gravity is a force between objects based on their masses and the distance between the objects. The force of gravity on the moon is less than the force of gravity on Earth because the moon has only 1/6 the mass of Earth. Earth's gravity is described as 1g.

microgravity - The condition of **microgravity** (a small amount of gravity) exists when objects are in free fall, like the space shuttle and other objects orbiting the Earth. The objects would actually fall to the Earth if they weren't moving very quickly in a different direction.

nutrients - Nutrients are materials that cells need to live.

oxygen - Oxygen is a gas found in air that cells need to live (represented by O_2).

pulse rate - A **pulse rate** is how many times a heart beats in one minute.

reduced gravity - **Reduced gravity** is less gravity than normally experienced on Earth, or less than 1g.

rehydrate - To **rehydrate** is to put water back into the body that is removed during spaceflight or after exercise on Earth.

veins - Veins are blood vessels that carry blood back to the heart.

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ENGAGE

Your heart is a strong muscle. It is about the same size and shape as your fist. Each time the heart expands and contracts, it pumps blood through blood vessels. The number of times your heart beats in one minute is your heart rate, or pulse rate. Your heart rate changes in response to your body's need for blood. When physical activity increases, muscles need more oxygen to produce extra energy. The heart rate increases to bring more oxygen to the muscles.

There are two ways the heart can meet the body's need for oxygen during exercise. It can beat faster or it can beat harder, moving more blood per pump. The heart can only beat harder if it has been strengthened through regular exercise.

The pulse can be felt and counted at several points on the body where the arteries are just under the skin. The pulse can be felt at the temples, neck, crook of the elbow, wrist, back of the knee, and the inside back of the ankle. Normal pulse rates vary with age.

Procedure

You will measure your pulse rate. Each pulse that you feel in your wrist represents one heartbeat.

1. Practice taking your pulse. Your teacher will model how to do this.
2. Once you know how to measure your pulse rate, predict how many times your heart will beat in one minute. Record this number in Table 1.
3. Sit quietly for one minute. Then, measure your resting heart rate for 15 seconds. Record this number in Table 1.
4. Multiply that number by four to calculate your heart rate for one minute.
5. Predict what your heart rate will be after completing one minute of jumping jacks. Record your prediction in Table 1.
6. Complete one minute of jumping jacks. Then, measure your heart rate for 15 seconds. Record this number in Table 1.
7. Multiply that number by four to calculate your heart rate for one minute.
8. If time permits, choose another activity and record your heart rate after completing that activity.

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Table 1. Heart Rates Before and After Jumping Jacks

Activity	Heart Rates		
	Prediction Beats/minute	Beats/15 seconds	Beats/minute = previous number x 4
Resting			
After Jumping Jacks			
After other exercise			

1. Compare your resting heart rate to your heart rate after doing jumping jacks. Why do you think there is a difference?

2. What other activities might increase your heart rate?

3. What activities might decrease your heart rate?

EXPLORE

One of the jobs of the lungs is to move oxygen into red blood cells in your blood. Once the blood cells have picked up oxygen, this blood is carried to the heart. The heart then pumps the blood to other parts of the body. The blood vessels that carry the oxygen-rich blood are called arteries.

Arteries become smaller vessels called capillaries. Oxygen and nutrients from food and drink are carried by the blood and pass through the capillaries into cells. The blood in capillaries also picks up carbon dioxide and other waste materials from the cells.

The blood carrying carbon dioxide and waste materials travels back to the heart through blood vessels called veins. This blood travels to the lungs to trade oxygen for carbon dioxide.

Then, the cycle begins again.

Your teacher will guide you through the Cardiac Relay. You and your classmates will pretend to be body parts and red blood cells to get a better idea of how this cycle works.

STUDENT GUIDE

Procedure

1. You will be assigned a role for the Cardiac Relay.
2. Your teacher will demonstrate each person's job and how to run the relay.
3. Pay attention to what all of the other students are doing. You may be asked to switch with somebody to carry out their job in the cycle.

EXPLAIN

1. Read the sentences below. Based on what you have learned in the Cardiac Relay, number the sentences so they are in the correct order of the path blood travels through the body. The first sentence has been numbered for you.

   _1_ Blood gets rid of carbon dioxide and picks up oxygen in the lungs.
   ___ Blood carrying carbon dioxide travels from the heart to the lungs.
   ___ In the head, blood gives oxygen to cells in the head. Blood also picks up carbon dioxide (waste material) from cells in the head.
   ___ Blood carrying oxygen travels from the heart to the head.
   ___ Blood carrying carbon dioxide travels from the head to the heart.
   ___ Blood carrying oxygen travels from the lungs to the heart.

2. What conditions might change the way your heart works?

3. Describe how you think the flow of blood would be affected if you were living in space.

STUDENT GUIDE

EXTEND

Procedure

1. Complete Table 2 based upon your observations of the water balloon.

Table 2: Water Balloon Observations

	Balloon held Vertically	Balloon on a flat surface	Balloon in water
Predictions			
Observations			
Compare the shapes. Explain how gravity causes these shapes			

EVALUATE

Round faces and skinny legs do not last once astronauts return to Earth. Within three days of returning to Earth, astronauts' fluid levels are back to normal. While in space, astronauts exercise and eat healthy meals to stay strong.

For this next activity, you will be paired with a classmate. One of you will be a scientist and one of you will be an engineer. Your teacher will tell you which role you should take. You will focus on making observations through the eyes of a scientist OR an engineer.

Scientists use systematic methods to study the world around them. They use an organized approach to observe and study the world. They ask questions, look for patterns, and try to find general rules for the natural world. As a scientist, you will investigate the effect gravity has on the human body.

Engineers use math and science to design new tools and devices to solve practical problems. As an engineer, you will research and recommend exercise equipment designed for astronauts to use in space.

1. Watch the NASA eClips™ video, “Our World: Exercise Equipment”. As you watch this video, record information you learn from the video in Table 3.

2. You and your partner will tour your playground, analyzing the playground equipment. Record answers to the questions in Table 3.

Table 3: Thinking Like Scientists and Engineers

	Scientist	Engineer
NASA eClips™ *Exercise Equipment*	How do changes in gravity affect the human body?	What equipment has been designed to help astronauts exercise in space?
Playground Walk	How does this playground equipment help strengthen the body? How would this equipment work in space?	How could you change this equipment to work in space? What new equipment could you design to help astronauts stay healthy in space?

STUDENT GUIDE

ANSWER KEY

ENGAGE

Table 1. Heart Rates Before and After Jumping Jacks

Answers will vary but resting rates should be less than rates after completing jumping jacks.

Activity	Heart Rates		
	Prediction Beats/minute	Beats/15 seconds	Beats/minute = previous number x 4
Resting	*80*	*22*	*x 4 = 88*
After Jumping Jacks	*100*	*24*	*x 4 = 96*
After other exercise	*120*	*25*	*x4 = 100*

1. Compare your resting heart rate to your heart rate after doing jumping jacks. Why do you think there is a difference?
   Answers will vary, but should recognize that the heart rate increases with physical activity. Students should be able to see that more energy is used and the body needs more oxygen.

2. What other activities might increase your heart rate?
   Answers will vary but may include running in place, push-ups, dancing, etc.

3. What activities might decrease your heart rate?
   Answers will vary but may include sleeping, resting, etc.

EXPLAIN

1. Read the sentences below. Based on what you have learned in the Cardiac Relay, number the sentences so they are in the correct order of the path blood travels through the body. The first sentence has been numbered for you.

   __1__ Blood gets rid of carbon dioxide and picks up oxygen in the lungs.
   __*6*__ Blood carrying carbon dioxide travels from the heart to the lungs.
   __*4*__ In the head, blood gives oxygen to cells in the head. Blood also picks up carbon dioxide (waste material) from cells in the head.
   __*3*__ Blood carrying oxygen travels from the heart to the head.
   __*5*__ Blood carrying carbon dioxide travels from the head to the heart.
   __*2*__ Blood carrying oxygen travels from the lungs to the heart.

2. What conditions might change the way your heart works?
   Answers will vary but may include discussions about hearts that are weakened or diseased. Students may also discuss hearts that have been strengthened due to exercise.

3. Describe how you think the flow of blood would be affected if you were living in space?
Answers will vary, but it is unlikely that students know much about how the heart is affected by reduced gravity environments. Use this opportunity to address misconceptions after watching the video.

EXTEND

Table 2: Water Balloon Observations

	Balloon held Vertically	Balloon on a flat surface	Balloon in water
Predictions		*Answers will vary, but students may realize that the bottom of the balloon will be flat.*	*Answers will vary, but students may realize that the balloon will not be stretched as much as it is when held vertically or on a flat surface.*
Observations	*Answers will vary but may include: --the knot of the balloon is stretched --gravity is pulling the water down --the balloon is bulging*	*Answers will vary but may include: --the balloon is flat against the table --the balloon is stretched as the water is pulled flat on the table*	*Answers will vary but may include: --the balloon isn't stretched the same way it was --the water is holding the balloon up --the water balloon is floating*
Compare the shapes. Explain how gravity causes these shapes	*Answers will vary but may include: --the balloon is stretched and long Gravity is pulling on the water and stretching the neck of the balloon.*	*Answers will vary but may include: --the balloon is stretched and flattened Gravity is pulling on the water and flattening the balloon.*	*Answers will vary but may include: --the balloon isn't stretching in any one direction Gravity isn't pulling on the balloon as much because water is making the balloon float.*

ANSWER KEY

EVALUATE

Table 3: Thinking Like Scientists and Engineers

	Scientist	Engineer
NASA eClips™ *Exercise Equipment*	How do changes in gravity affect the human body? *Answers will vary but may include that the heart does not have to pump as hard in space, body fluids shift toward the head and chest, muscles are weakened because they don't have to overcome the force of gravity as they do when simply walking on Earth.*	What equipment has been designed to help astronauts exercise in space? *Answers should include a special treadmill, stationary bike, and resistive exercise equipment. Harnesses are needed to keep astronauts from floating out of position as they exercise.*
Playground Walk	How does this playground equipment help strengthen the body? *Answers will vary but may include that the heart does not have to pump as hard in space.* How would this equipment work in space? *Answers will vary depending upon the equipment that is available. Examples may include: a slide would not work in space, because gravity is needed to ride down the slide.*	How could you change this equipment to work in space? *Answers will vary depending upon the equipment that is available.* What new equipment could you design to help astronauts stay healthy in space? *Answers will vary.*

ANSWER KEY