The Ins and Outs of the Cardiovascular System

Target Grade: Elementary
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Site: Emerson Elementary
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Brief Overview

In this lesson, mentees will learn various components about the cardiovascular system. By the end of the lesson, the students should be able to understand unique features of this important body system (such as pulse) and how these features can relate to healthcare/medical topics (such as stethoscopes).

Teaching Goals

- Organs work together with other organs to form **organ systems** that all work in conjunction to keep the body functioning.
- Exercise can increase **pulse**, or **heart rate**, and is key to maintaining a healthy heart in the long run.
- The use and relevance of medical devices in the healthcare field.
- **The heart valves maintain blood flow within the heart.**
- **Engineering Design Process** - Students will be engineering their own medical device used to measure their heart rate. Mentors are encouraged to ask students how they would make their stethoscope more accurate through the engineering design process.

Careers and Applications

Maintaining health is an essential, yet unfortunately commonly neglected (especially with college students!) practice for good physical and mental well-being. Understanding the basic mechanisms of this major ingredient of our bodies can be one step closer to promoting good health.
Doctors are probably the primary people who make use of these concepts on a daily basis. However, engineers who construct medical devices (like the stethoscope, heart rate monitor, or blood pressure cuff) should also have a basic understanding of this material.

Agenda

- Introduction
- Module 1: Measuring Pulse with a Straw (10-15 mins)

- Module 2: Make Your Own Stethoscope! (10 mins)
- Module 3: Building an Effective Heart Valve (15-20 mins)
- Conclusion

Introduction

The body is a complicated system that relies on a smaller subset of structures (organ) that work in conjunction with each other to keep us healthy. Ask mentees what are some of the most important organs you guys can think of? In today's lesson we will be going over the heart: how it works and how we measure if it is healthy or not. Additionally, we will learn how heart works to keep your body alive and healthy.

Module 1: Measuring Pulse with a Straw

Introduction

In this module, the students will be learning about pulse, and how blood moves through the body every time the heart beats. The mentees will also be able to see how exercise can affect the pulse rate by doing some activity, and then comparing their resting and active pulse rates. You will also be able to sneak in some math practice!

Teaching Goals

1. **Pulse**: Throbbing that occurs in the body when the heart contracts and pushes blood through the arteries.
2. **Exercise or physical activity increases heart rate**: during exercise, a person will breathe quicker to inhale more oxygen and excrete more carbon dioxide. In response, the heart will beat faster to help supply the oxygen, which is carried by blood, to the muscles.

Background for Mentors

Pulse is a measure of heart rate. The normal range of a healthy pulse is 60-100 bpm, higher or lower pulse can result in health complications, especially with the heart. If students ask how to maintain a health pulse, emphasize that eating healthy foods and exercising a lot is the #1 way to prevent high pulse later on in life.

Figure 1: An example of some delicious healthy foods necessary to maintain a healthy

lifestyle.

Materials

- Drinking Straw (per student or group)
- Clay (small ball per student or group)
- Watch or timer (per student or group)
- Accurate pulse-measuring device (per class) used for comparison of results

Procedure

1. Have mentees choose a pulse point that they want to measure (the most obvious ones are located at the inner wrist or slightly beneath the jaw bone).
2. Give each mentee (or a group of 3-4 mentees) a small ball of clay to place at the pulse point location (if they chose neck, they should probably lie down).
3. Make sure to **firmly press the clay down** so that it securely sticks to the mentees' skin.
4. Push the straw into the clay so that it points straight up away from the body. The mentees should be able to see the straw moving slightly with each heartbeat.
5. Count the pulse rate (each time the straw moves slightly) for 30 seconds. Multiply the number obtained by 2 to get heart beat per minute.
6. Then, have the mentees exercise by doing push-ups or jumping jacks for a couple of minutes to quicken their heart rates.
7. **Immediately replace the clay and straw against their skin** to remeasure their heightened heart rate for another 30 seconds, and compare the two results.
8. **Use the accurate pulse measuring device** to compare the students' results.

Figure 2: An example of how the clay and straw should look like. Beneath the jaw line (carotid artery) is easiest to see the pulses individually.

Additional Notes for Mentors

Make sure students don't eat clay.

Students should not breathe heavily, talk, or move. Make sure the students find the exact

right spot for measuring the pulse by trial and error.
If there is enough time, have the kids sit down and meditate (if you can get them to actually do this!) to see the contrast in this pulse rate with that of from exercising.

Module 2: Build Your Own Stethoscope!

Introduction

A stethoscope is a type of **medical device** used by professionals in the healthcare industry to check for one of the four **vital signs**: pulse rate. In this module, student will develop a medical device of their own and perform the engineering design process to make their instrument better.

Teaching Goals

1. **Medical Devices:** Various instruments used by healthcare professionals for diagnosis of health conditions. Medical devices can range from stethoscopes to Magnetic Resonance Imaging (MRI).
2. **Vital Indicators:** There are four vital signs to look for: body temperature, blood pressure, heart rate and breathing rate.
3. **Engineering Design Process**: The process of planning, designing, and improving that engineers utilize in creating their products.

Background for Mentors

The advancements of modern day medical devices has allowed for the diagnosis, monitoring, and prevention of common diseases. A stethoscope is a medical device that allows one to measure the pulse of a patient. Measuring the pulse is important as abnormal pulse rate can be a symptom or an early warning of disease.

Figure 3: A stethoscope that healthcare workers usually utilize to listen to heart sounds.

Low pulse leads to fainting, weakness of body, dizzy spells but can also be a sign of more dangerous health symptoms down the road such as high blood pressure and even heart failure. Low pulse, or bradycardia, is when the blood pulse is lower than 60 beats per minute (BPM). While high pulse, or tachycardia, can lead to damaged blood vessels, heart disease, and risk of heart attack. Any abnormalities of pulse tends to be bad, and can be fixed mainly through diet and exercise, while medication may be necessary for some cases.

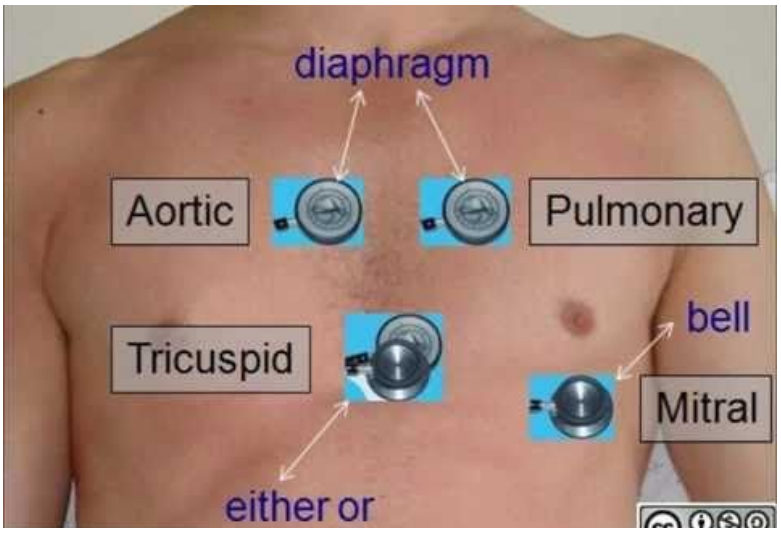

Figure 4: The four spots on the chest to auscultate for heart sounds. Use these points to listen for heart beats.

Materials

- Kitchen roll (paper towel roll) tubes
- Duct Tape
- Funnels of different sizes

Procedure

1. First try to use just the paper towel roll to measure a classmate's pulse (heart rate) *once or twice*.
2. Tape the funnel at one end of the paper towel roll **sturdily**.
3. Now measure your partners resting and active heart rate *once or twice.*
4. Mentors should ask students whether or not they observe any differences in their measurements pre and post funnel.
5. Apply the engineering design process in improving the stethoscopes.

Figure 5: An example of a constructed stethoscope using one of the bigger funnels.

Additional Notes for Mentors

We want the students to learn that more accurate and consistent measurements can be made with better medical devices. Since this module is relatively simple logistically, mentors can ask the students how they would make the device even better:

- Better insulation of the funnel to the site of measurement
- Metal insulation of the sound, instead of plastic (since plastic materials have greater chance of losing sound energy).
- Better hearing device (rubber ear tubes)
- A non-cardboard tubing so that less sound is lost
- Have the students try to measure the pulse with stethoscopes made up with different sizes of funnels.

Module 3: Building an Effective Heart Valve

Introduction

The heart valves are an important feature of the heart. Their existence is essential for the cardiovascular system to properly function. In this module, the mentees will learn about the different heart valves by constructing their own functioning heart valve.

Teaching Goals

1. **The heart valves maintain blood flow within the heart.**
2. **The four different valves:**
    a. **Tricuspid Valve -** found between the right ventricle and right atrium. Closes the right upper atrium that allows passage of blood coming from the body, and opens to allow flow of blood from top right to lower right chamber.
    b. **Pulmonary Valve -** found between pulmonary artery and right ventricle. Closes lower right chamber, and flow of blood from heart to lungs.
    c. **Mitral Valve -** found between left atrium and left ventricle. Closes upper left chamber that receives oxygen-filled blood from the lungs, and opens to let blood flow from upper to lower left side.
    d. **Aortic Valve -** found between left ventricle and the aorta. Closes lower left chamber full of oxygen-filled blood to be distributed throughout body, and opens to allow blood flow from the heart.

Background for Mentors

The heart is made up of four different chambers: the **lower chambers** (ventricles) and the **upper chambers** (atria). Blood flows through **valves**, which act to inhibit any blood flowing backwards, to leave the heart chambers.

Valves are flaps that are found on the ends of the two lower chambers (ventricles). Their purpose is to let in blood one-way from one side, and to let out blood one-way from the other side of the lower chamber. In fact, each individual valve consists of three flaps (excluding the mitral valve, consisting of only two flaps). As such, the valves are important in maintaining healthy blood circulation to keep your body viable.

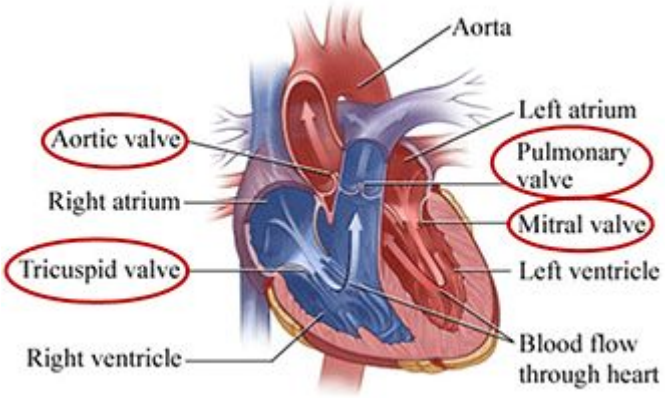

Figure 6: A diagram that visualizes the four different valves essential to the heart.

The mitral valve opens and the aortic valve closes during the contraction of the left ventricle. This promotes blood flow from the left atrium to the left ventricle. Then, the contraction of the left atrium allows for the flow of blood to the left ventricle. As a result, the left ventricle contracts once more, so that the mitral valve closes and the aortic valve opens. This final action results in blood flowing into the aorta.

Materials

- Tape (1 roll per site)
- String (1 roll per site)
- Aluminum Foil (1 roll per site)
- Toothpicks (5 per group)
- Popsicle sticks (5 per group)
- Construction paper (3 sheets per group)
- Marbles (~30 per site, divide number of marbles to groups for *testing*; all ~30 marbles will be needed for one model when artificial valves are individually tested in front of the class)
- Plastic box with middle valve setup (1 per group)
- Cardboard (a couple pieces per group)

Procedure

1. Students should split up into groups (preferably 3-4).
2. Allow time for groups to brainstorm together valve setup (**this should not take more than 5 minutes**).
3. Allow groups to have whatever materials they need for building their own heart valve

model.

4. Through the **engineering design process**, the mentees will construct their own heart valve and test out their arteries.
5. Have each individual group try out their constructed artificial valve in front of the class!
    - To test: ~30 marbles put onto the side of the heart. Tilt the box to represent the pumping of blood and to have the marbles slide through the valve area. Tilt the box back to test if the marbles flow back through the valve. The **goal is to have the most marbles on the right side of the valve.**

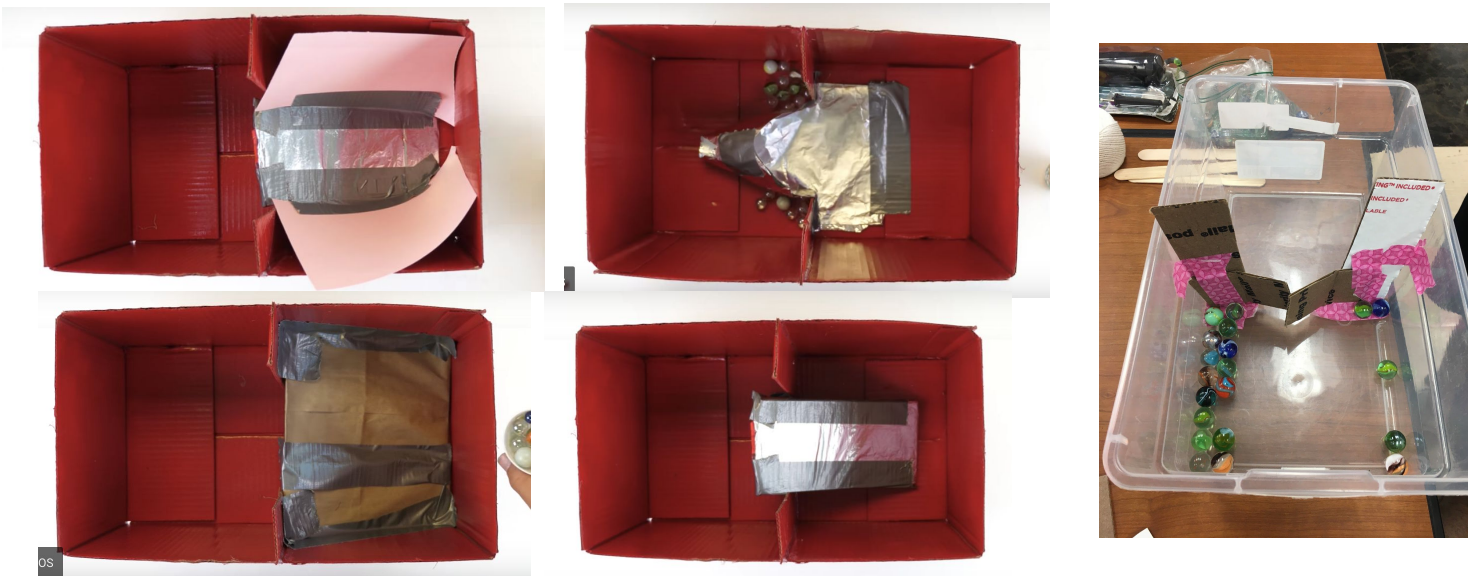

Figure 7: Different examples of potential heart valve models.

Additional Notes for Mentors

Make sure that the students come up with their own ideas for the heart valves. If they can't think of anything, guide them with some of the examples shown above. If the models don't work, encourage them to redesign them and follow the **engineering design process**!

Conclusion

The body relies on various organs to keep itself healthy and functioning. One of the most important organs is the **heart, as it allows blood to flow through the body to transport oxygen, a vital resource**. We can measure the health of this and other organs through various medical devices, such as the **stethoscope**. These medical devices were made using the **engineering design principles**. Health relies on the functioning of these organs, and the number one way to prevent unhealthy organs is to **exercise and eat healthy foods**.

References

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- Make a Stethoscope. Emma Vanstone. Science Sparks.

https://www.science-sparks.com/make-a-stethoscope/

- Cardiovascular Biomedical Engineering (Week 2). Lindsey Zhang. BEAM Fall 2016.
- The Lungs and Respiratory System. Kimberly Besst, Deborah Rauchwerger, Karen Hauser, Robbie Ruelas. Science & Health Education Partnership. http://seplessons.ucsf.edu/node/3607
- Hands on activity: Heart Valve Replacement https://www.teachengineering.org/activities/view/cub_heartvalves_lesson01_activity1

Summary Materials Table

Material	**Amount per Group**	**Expected $$**	**Vendor (or online link)**
Drinking (normal, bubble, narrow) Straws	Per student	0	Inventory
Clay	Small ball per group	0	Inventory
Timer or stopwatch	Per group	0	Timer on mentor's phone
Paper	Per group	0	Inventory
Plastic box with middle valve setup	1 per group	0	Inventory
String	One piece per pair	0	Inventory
Marbles	30 per site	0	Inventory
Paper towel rolls	Per 2 students	0	Inventory
Duct Tape	1 or 2 rolls	0	Inventory
Plastic funnels of different sizes	Per 2 students	0	Inventory
Tape	One or two rolls	0	Inventory
Toothpicks	5 per group	0	Inventory
Popsicle Sticks	5 per group	0	Inventory
Construction Paper	3 sheets per group	0	Inventory

Aluminum foil	A sheet per group	0	Inventory
Cardboard	A couple pieces per group	0	Inventory
Pulse measuring Device	One per site	$17.95 + tax	Amazon