Bay Area Scientists in Schools Presentation Plan

Lesson Name Unblock My Heart!
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CA Science Standards Connections: 5th Grade, Life Science

5-LS-2. Plants and animals have structures for respiration, digestion, waste disposal, and transport of materials. As a basis for understanding this concept:

a. Students know many multicellular organisms have specialized structures to support the transport of materials.

b. Students know how blood circulates through the heart chambers, lungs, and body and how carbon dioxide (CO2) and oxygen (O2) are exchanged in the lungs and tissues.

Next Generation Science Standards Connections: 4th Grade, Life Science

4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

Science & Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models Modeling in 3–5 builds on K–2 experiences and progresses to building and revising simple models and using models to represent events and design solutions. Develop a model to describe phenomena. (4-PS4-2) Use a model to test interactions concerning the functioning of a natural system. (4-LS1-2)	**LS1.A: Structure and Function** Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction. (4-LS1-1)	**Systems and System Models** A system can be described in terms of its components and their interactions. (5-LS2-1)

Common Core Standards:

ELA/Literacy:

W.4.8 Recall relevant information from experiences or gather relevant information from print and digital sources; take notes and categorize information, and provide a list of sources.

Mathematics:

MP.2 Reason abstractly and quantitatively.

FOSS Connections:

3rd Grade Module: *Structures of Life*

Investigation 4: *Human Body*

5th Grade Module: *Living Systems*

Investigation 3: *Transport Systems*

Teaser:
Your heart is one of the most important organs in your body. What happens when the pathways to the heart are clogged? Students will learn about what causes clogged arteries and will have a chance to engineer ways to unblock a model artery.

Objectives: During this lesson students will divide into teams and use everyday objects to design and develop devices to unclog a blood vessel. Through this open-ended design project, they learn about the circulatory system, biomedical engineering, and conditions that lead to heart attacks and strokes.

Vocabulary/Definitions: *3 – 6 important (new) words*

- **Bioengineering/Biomedical Engineering:** a combination of engineering with biology and medicine to improve human health. Can include designing artificial tissues and/or organs
- **Catheter:** a hollow flexible tube to insert in a blood vessel to allow the passage of fluids or expand a passageway
- **Heart attack:** damage to heart muscle caused by lack of oxygen, usually due to the blockage of an artery.
- **Plaque:** a deposit of fatty material on the inner lining of arteries
- **Stent:** A small, expandable tube used for inserting in a blocked vessel
- **Stroke:** When a blockage of a blood vessel to the brain causes inadequate oxygen supply

Materials:
What will you bring with you?
- Model "blocked arteries" (tubing blocked with play dough)
- Materials to unblock arteries (clown balloons + air pump, straws, paperclips, thin wire, pipe cleaners, rubber bands)
- Clearing Blocked Arteries Worksheet
- 2 liter container
- Large bin to catch water
- Timer
- Three Treatment Methods printouts

What should students have ready (pencils, paper, scissors)?
Please have pencils ready and some scratch paper for the students to make their designs.

Classroom Set-up:
- Students will be split into groups of 4 for the design portion.
- We will need a water source
- Also, we will need an area where we can tape the tubes to a surface (counter or desk)

Classroom Visit

1. Personal Introduction: ____3_____ Minutes
We are engineers from Berkeley/UCSF.
Have each volunteer say their name, a little about themselves, and what they do at school. Feel free to talk about why you got into engineering, what you love about it, etc.

Topic Introduction: _____10___ **Minutes**

Today we're going to talk about our hearts and the veins that lead to our hearts. First, what does your blood help you do? (brings oxygen and nutrients to different parts of the body) Do you know anyone who has had a heart attack? (*Ask students to raise their hands*.) Do you think that heart attacks are common? Why or why not? What causes them?

In a properly working human circulatory system, blood vessels are clean and smooth (like clean pipes). However, during the course of a lifetime, sometimes material coats the interior walls of blood vessels. This plaque, whether it hardens and stays in place, or hardens and gets dislodged, can have significant health consequences. Having material blocking the normal blood flow restricts the movement of blood, thus preventing sufficient nutrients and oxygen from reaching all parts of the body. Having plaque material moving though the blood vessels may also result in that material eventually encountering a smaller blood vessel and blocking any blood from going through, which prevents nutrients and oxygen from reaching everywhere they are needed. The problems this can cause are significant, problems such as heart attacks and strokes.

The best way to avoid these medical conditions is prevention via things like healthy eating and exercise. However, at the point when blockage is found, it must be treated to avoid health problems. Engineers and doctors have designed various ways to unclog or unblock plaque-coated blood vessels. That's what we're going to look at today—heart attack and stroke treatment and prevention. How exactly is blood flow restored to the heart when plaque, or a blood clot, is blocking blood flow? Every day biomedical, mechanical, chemical and electrical engineers (and others types, too) work with medical doctors to devise more effective treatments for heart attacks and strokes. Today, we are going to see if we can do the same.

What ideas do you have about how we might unclog a blocked artery? (*Listen to and encourage student brainstorming and ideas.*) Currently, three primary treatments for clogged arteries are in common use (*show students Three Methods to Treat Blocked Arteries as printouts*). The first two are types of angioplasty, or recreating of the canal in the blood vessel. The first method is a balloon catheter in which a small balloon is passed through the artery to the clogged area where it is inflated, compressing the plaque and opening the artery to greater flow. The second method is similar to the balloon catheter with the addition of a stent surrounding the balloon, so when the balloon inflates, the stent remains behind to keep the plaque pinned against the walls. The third method is a bypass surgery in which the blocked section of the artery is removed and the artery is reconnected, free of the blockage.

2. Learning Experience(s): _____40____ Minutes

1. Demonstrate that blocked arteries have different flow than clear arteries by having the class time how long it takes for two liters of water to flow through a clear piece of piping at a 45° angle versus through a blocked piece of piping at the same angle. Have students record these measurements on their worksheets.

3. Explain the design project to the student teams: Your challenge today is to create a device that could remove or flatten the built-up plaque material inside artery walls. How are you going to go about doing this? What are the steps a design team of engineers would take? (After students have suggested ideas, write on the board the steps all engineers go through in designing and solving problems. Understand the need, brainstorm ideas, design and plan, create and test a prototype, and review and improve.) Well, first engineers must have a problem or a need. Then, they brainstorm creative ideas and solutions

to that problem or need. Next, they select the most promising idea and create a design that they can draw or communicate to others. They make a prototype of that design and test it to evaluate whether or not the design is successful.

4. Continue with the project instructions: Today, you and your team are engineers working together to create a device that could remove or flatten the built-up plaque material inside artery walls. Your team has two identical blocked arteries and one certain material. Use the material to develop a device to improve the flow in the artery.
5. The last step of the design process is to review and improve on your design. You will be able to access all of the other materials to make the best design possible. You have two model arteries to build, test and then redesign with improvements. Keep in mind that you do not want to just knock the plaque off the wall and leave it in the blood stream, and you do not want to hurt the fragile inside wall of the arteries.
6. Ask students: What ideas do you have for how to unblock your model arteries? (As necessary, share the ideas that were mentioned during the Introduction section of the activity, such as: dissolve the clot or blockage, use a balloon to push the artery open.)
7. Direct students to brainstorm, design (create a drawing with labeled materials), create a prototype and test their designs. Expect the second design to be an improvement of the first.
8. Circulate among the groups as they work, observing and asking questions, as provided in the Assessment section. As students are working, challenge them to think about what happens to the plaque they dislodge, move or scrape away. Remind them that we do not want the treatment to hurt the patient!

With the Students: Communication and Testing

8. Have each team present a description of its two designs and design process to the class.
9. Measure success by timing how fast 2 liters of water flow through a team's cleared arteries after the treatment method. Hold the arteries at 45° angle while the water flows. Have students record these measurements on their worksheets. Compare data. If desired, award prizes for the best team design.
10. Have students complete the questions on their worksheets.

3. Wrap-up: Sharing Experiences ____5____ Minutes

Our model blocked arteries are, of course, not real arteries. What challenges might an engineering team face when creating a similar technology for real arteries? (Possible answers: The real blocked arteries would be in a human body, so they would be hard to get to, slippery, walls might be more elastic, and the plaque would be different.)

While the materials may not be the same, the process that you used to develop your prototype devices is the same used by engineers. And while their devices may be different, they share similarities to your solutions. (Show students the three images of current treatment methods.)

Look carefully at the mechanics of the balloon catheter (angioplasty), coronary bypass surgery, and catheter with stent (angioplasty). What similarities and differences do you see?

4. Connections & Close: _____2___ Minutes

Ask if students have any questions about the circulatory system, what it's like to be a bioengineer, etc.

Total= 60 Minutes

Follow-up – After Presentation

See a good drawing of coronary balloon angioplasty at this National Institutes of Health website: http://www.nhlbi.nih.gov/health/dci/Diseases/Angioplasty/Angioplasty_howdone.html

So that the model designs are more lifelike, have students create catheter devices that could be used while water is flowing through the system.

Have teams create engineering presentations that they would give to manufacturing companies, hospitals or medical personnel highlighting the benefits of their particular medical devices.

Name: _____ Date: _____

Unblock My Heart!

Measurements Worksheet

1. Record your timing measurements in the table below.

Artery Type	Time for 2 liters of water to flow through artery (in seconds)
Clear artery	
Blocked artery	
Cleared artery #1	
Cleared artery #2	

2. Now rank the arteries starting with the one with the most flow:

   1. _____
   2. _____
   3. _____
   4. _____

3. What did you use to clear your artery?

4. Did your artery clearing devices work? If so, how well did it work? If not, why do you think it did not work?

5. How could your design be improved in the future?