Cardiovascular Biomedical Engineering (Week 1)

Lesson Type: Engineering
Target Grade: Middle School
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Semester: Fall 2016

Introduction

Students will learn about biomedical engineering as a career and about the cardiovascular system by engineering a solution to a clogged artery. They will learn about diseases of arteries and what they entail, as well as current surgical solutions. By the end of the lesson, students will have practiced working in teams and using the engineering design process.

Teaching Goals

- Understand how blood vessels are blocked and what happens due to the blockage
- Students should be able to describe what kind of current techniques are used to unblock a blood vessel
- Practice using the engineering design process

Careers and Applications

Biomedical engineers focus on advancing human health and health care by combining their knowledge of biological principles and engineering. Other engineers, including mechanical, chemical, electrical, materials, and computer engineers can also work together with medical professionals to solve health problems. Medical devices including catheters, balloon catheters, and stents help people survive heart attacks and strokes due to clogged arteries.

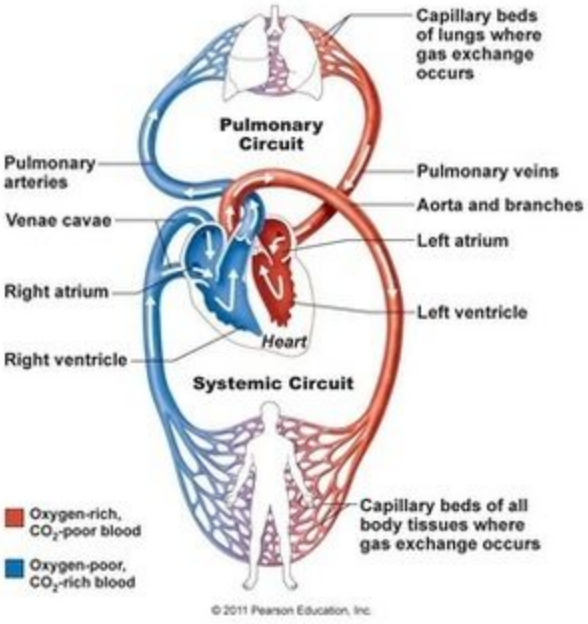
Agenda

- **Introduction**
- **Clearing a path to the heart activity**

Introduction

The circulatory system is a network that carries blood throughout the body and supplies cells with food and oxygen. It also carries away carbon dioxide and other wastes. The circulatory system also regulates body temperature. The circulatory system includes the heart and blood

vessels. In this lesson, focus will be directed on the blood vessels, which are a system of connected tubes that include arteries that carry blood from the heart and veins that return blood to the heart. Capillaries are tiny blood vessels that connect the arteries and veins and oxygen/nutrient exchange usually occurs here.

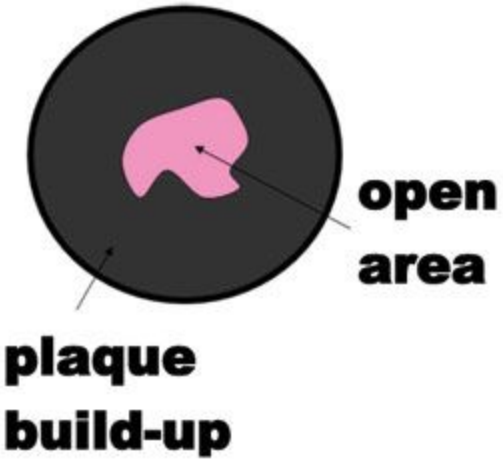


Activity (Clearing a path to the heart)

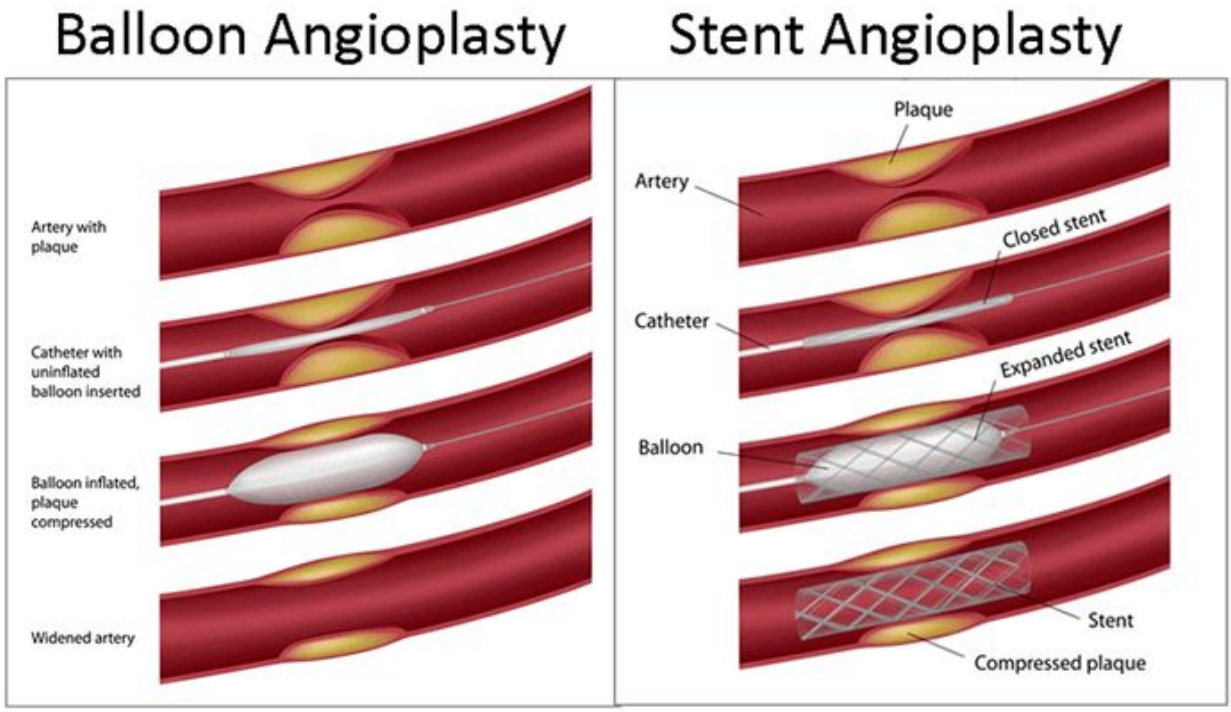
Introduction

Coronary heart disease is the second leading cause of death for people 15-59 years old. The major established contributors to coronary heart disease include tobacco use, alcohol use, high blood pressure, high cholesterol, physical inactivity, poor nutrition, and obesity.

A common illness of the circulatory system is **arteriosclerosis**, the accumulation of fatty deposits, causes arteries to be blocked. These deposits stiffen/thicken the walls of arteries. This slows down or stops the flow of blood which can lead to high blood pressure, blood clots, heart attacks, and strokes. Treatment involves rest, exercise, diet changes, and various medications. In some cases, surgeons may remove clots or replace blood vessels.



There are three main ways of dealing with arteriosclerosis, two different kinds of coronary angioplasty and coronary bypass surgery. **Angioplasty** is the surgical repair of a blood vessel using an inflatable balloon. A catheter, which is a hollow, flexible tube, is used in angioplasties. In the case of the balloon catheter, a catheter with an inflatable tip is used to expand a partly closed artery. In the second case, a stent is placed on top of the balloon catheter, which is then inflated in the artery. The stent expands and keeps the artery open. A Coronary artery bypass surgery uses a piece of a vein from the leg or artery from the chest or wrist. The piece of artery/vein is attached to the coronary artery above and below the blockage so the blockage can be bypassed.



In this activity, students will be using everyday materials to design and develop devices to unclog blood vessels. They will be performing an “angioplasty” on pvc pipes clogged with playdough.

Background for Mentors

Blood consists of plasma and three types of solid particles known as formed elements. Plasma is made up of water, proteins, and minerals. Formed elements include red blood cells, white blood cells, and platelets. Red blood cells carry oxygen and carbon dioxide throughout the body, white blood cells protect the body from disease, and platelets enable blood to clot.

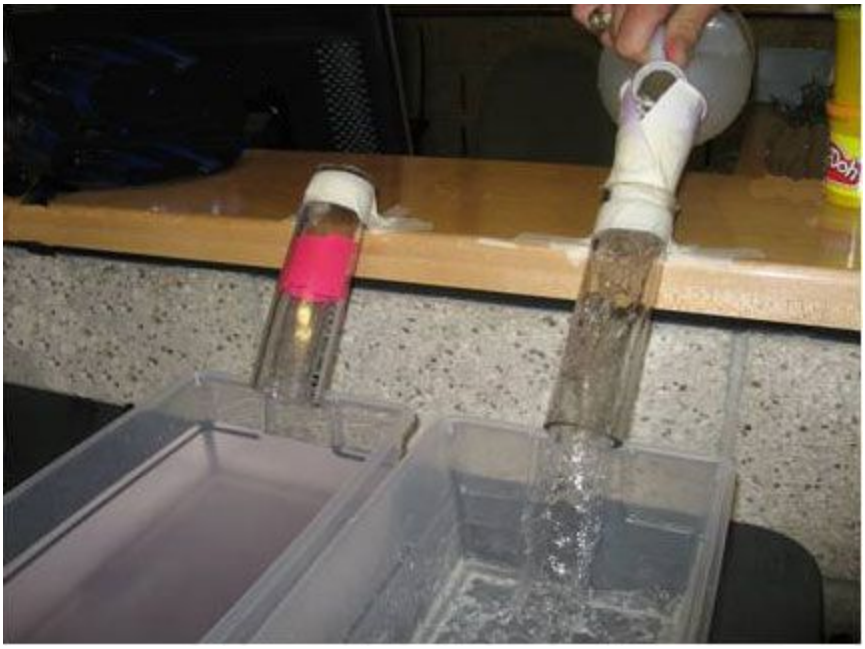
Materials

This is the list of total materials that should be provided depending on the size of the class but keep in mind that groups will be using points to “purchase” the materials themselves.

- 1 model artery per group
- Long and thin balloons with pump
- Straws
- Paper clips
- Thin wire
- Pipe cleaners
- Rubber bands
- Tape
- Foil

Procedure

- Split students into groups of 4
- Brainstorm ideas on paper (5 minutes)
- Allow groups to come up one at a time to “purchase” materials (5 minutes)
    - Keep track of how many points they spend based on the attached materials list and point values
- Groups build their artery declogger and test on their own test artery, allow students to “purchase” more materials as necessary (25 minutes)
    - For example, students could build a stent using the wire and fit it over a balloon. Then, the balloon is inflated within the clogged artery and stretches the stent, fitting it into the artery.
- One by one, groups test their declogger in front of everyone else, 1L of water is poured through and timed. The winning group has the fastest time with a reasonably low point expenditure (allow mentors to decide on this). (10 minutes)



References

- https://www.teachengineering.org/activities/view/cub_biomed_lesson03_activity1
- http://content.teachengineering.org/content/cub_/activities/cub_biomed/cub_biomed_lesson03_activity1_images.pdf
- http://content.teachengineering.org/content/cub_/lessons/cub_biomed/cub_biomed_lesson03_introreading.pdf

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Summary Materials Table

Material	Amount per Group	Expected $$	Vendor (or online link)
Clear PVC Tubing	1 tube per group and 2 extras for end of class competition	$9.02 per 2’	https://www.amazon.com/Polycarbonate-Tubing-Wall-Clear-Color/dp/B00193UNBI/ref=sr_1_2?ie=UTF8&qid=1477901866&sr=8-2&keywords=clear+pvc
Long, thin balloons	4 per group	$11 for 260	

Play-Doh	Enough to make clogged arteries for each PVC tube	$8 for 10 pack	
Balloon pump	2 per site	$9.69 each	
Straws	5 per group	--	
Wire	Enough for site	--	
Paper Clips	5 per group	--	
Pipe Cleaners	5 per group	--	
Rubber Bands	5 per group	--	
Tape	Enough for site	--	
Foil	Enough for site (1 roll)	--	

Material Point Sheet

Material	“Cost”
Long, thin balloons	3 points per
Straws	1 point per
Wire	2 points per foot
Paper Clips	1 point per 2
Pipe Cleaners	2 points per
Rubber Bands	1 point per 2
Tape	2 points per foot
Foil	2 points per square