

# MedLab: Heart Disease—Atherosclerosis

## AT A GLANCE

Students will create models of plaque formation and atherosclerosis and explore various degrees of arterial blockages.

### OBJECTIVES

Students will be able to:

- Define key vocabulary words.
- Identify the steps involved in atherogenesis.
- Explain how their own lifestyle choices can reduce their risk of developing atherosclerosis.

### KEY VOCABULARY

atherosclerosis, LDL, free radical, foam cell, lumen, plaque, angina, ischemia, myocardial infarction, cardiac arrest, atherogenesis,

### SUGGESTED GRADE

**LEVELS:** 7—12

### IL LEARNING GOALS

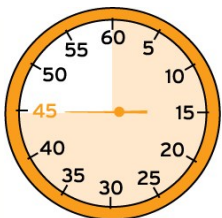
11.B; 11.A;

### NGSS

MS-LS1, HS-LS1

### PACE YOURSELF

TWO 45 MINUTES PERIODS



museum of  
science+industry  
chicago



### ADVANCE PREPARATION

1. Collect paper towel tubes and 2-liter bottles. Put the word out to your students and colleagues to crowdsource these.
2. Students should have a basic understanding of the circulatory system. They should already know arteries, veins, and capillaries, the heart, major components of blood, etc.
3. Print Student Activity Guides. (**Earth friendly tip:** put your activity guides in plastic sleeves so that you can reuse them in multiple classes and for multiple years!)

### MATERIALS



**Technology:** Heart Disease: Atherosclerosis PowerPoint

#### Per Group:

##### Activity 1:

- 1 paper towel tube
- 2-3 pc scrap paper
- Scissors
- Glue
- Small seeds (ie: fennel seeds) (or tiny beads, or glitter if you dare)
- Tape—either clear or masking
- 1 Paper plate (or bin/vessel for catching seeds)

##### Activity 2:

- 1 liter beaker (or any large vessel to measure water)
- 1 2-liter bottle with bottom cut off
- Modeling clay
- 1 stopwatch
- 1 bin (or any large, wide vessel to catch ~2-liters of poured water)

#### Per Student:

- Lab journal

# Heart Disease—Atherosclerosis



## WHAT YOU NEED TO KNOW

Heart disease is a broad term that covers several different cardiovascular (relating to the heart, lungs, and blood vessels) diseases that all affect the heart negatively. Heart disease can be congenital (present from birth) or it can be acquired. Heart disease affects people in our families, our neighborhoods, our cities, and all over the world. It is a huge community health issue. It is the leading cause of death in the world – causing an estimated 375,000 deaths each year in the U.S. alone. In this lesson, we will discuss atherosclerosis. **Atherosclerosis** is a disease of the arteries (vessels that carry blood away from the heart) in which artery walls thicken and restrict blood flow. Your students will learn what atherosclerosis is, how it develops, how it affects the heart, and how to avoid it and treat it.

Atherosclerosis can occur in many of the arteries throughout the body. It has the potential to be especially damaging in the arteries that supply blood to the heart. The heart uses a relatively large percentage of the oxygen and nutrients (glucose in particular) carried by the blood. Atherosclerosis of the coronary (heart) arteries restricts blood flow and decreases the heart's efficiency, which can lead to a number of problems. We will focus on coronary atherosclerosis (aka – coronary artery disease) but the development of atherosclerosis in any artery is the same throughout the body.

Atherosclerosis begins with microscopic damage to the inner wall of an artery. This wall, comprised of endothelial cells, is smooth, allowing the components of blood to flow freely within the vessel. High blood pressure, diabetes, smoking/tobacco use, drug use, inflammatory diseases, and/or high fat/cholesterol diets can cause the damage. When damage occurs, some of the blood components – lipoproteins (LDL and HDL cholesterol), platelets, leucocytes (white blood cells), and fats – can collect at the damage site. In the formation of atherosclerosis, LDL enters the vessel walls through these microscopic tears and gets trapped between the layers of tissue there. (It is important to note that though solid components of blood can collect at the damage site, the LDLs trapped between the vessel walls are the initial cause of atherosclerosis.) This initial development of atherosclerosis is called **atherogenesis**. (**Activity 1**) **LDL** stands for Low Density Lipoprotein is a protein molecule and its attached fats/cholesterols. It is often referred to as “bad cholesterol” because of its ability to transfer fats from the blood stream into the walls of arteries. The transfer of fats from LDL into artery walls (and other cells in the body) is necessary in the right amounts, but when levels are elevated in the blood-stream they increase the likelihood of developing heart disease. Poor diet and lack of exercise as well as genetic factors can increase LDL levels.

Once LDL is trapped between the layers of the artery walls, it can oxidize. One way in which it oxidizes, is by picking up a **free radical** - an atom or molecule with unpaired valence electrons. In this case, most of the free radicals are in the form of a superoxide anion,  $O_2^-$ , which is normally used in the body by the immune system to destroy unwanted microorganisms. The oxidized LDL molecules stimulate inflammation and an immune response. Macrophages – white blood cells – are sent to the site between the

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vessel wall layers to destroy the invading LDL molecules. Once engulfed by the macrophages the oxidized LDLs limit the movement of macrophages. These LDL-laden macrophages (and, later, LDL-laden smooth muscle cells) are called **foam cells**. As more macrophages are sent to the site, a “pile up” of molecules forms in the artery wall and may cause the **lumen** (open pathway of the vessel) to narrow depending upon if the swelling occurs on the inside or the outside of the artery wall. **(Activity 2)** This “pile up” of materials in the artery wall is often referred to as a **plaque**, atheromata, or an atheromatous plaque. At this point, the inter-wall smooth muscle cells, stimulated by the invading material, synthesize collagen, which forms a fibrous tissue cap on the plaque and leads to a rigid layer surrounding the plaque. This rigid layer and deposits of calcium cause the plaque to become “hardened”.

Over time, the plaque grows as more and more material becomes trapped and/or develops in the artery wall. In cases where the plaque grows toward the inside of the artery wall, the lumen narrows. This narrowing may progress for a relatively long period before causing any severe symptoms. Shortness of breath is typically the first symptom when the plaque occurs in the coronary arteries. As the problem progresses, sufferers may experience chest pain or pressure during physical exertion called **angina**. In very severe cases, the arteries can become blocked enough to cause **ischemia** (aka— myocardial ischemia) - a condition in which the heart cannot get enough oxygen and nutrients, eventually causing heart muscle damage and reduced function. Ischemia is also accompanied by chest pain and pressure. A complete blockage of coronary arteries can severely damage or destroy heart muscle and cause **myocardial infarction**, or heart attack. Myocardial infarction is typically accompanied by severe chest pain, numbness/tingling/pain in the left arm, jaw and/or neck, and shortness of breath - classic heart attack symptoms. In extreme cases, the plaque can rupture into the artery and form a blood clot. This can lead to **cardiac arrest** – a complete stopping of the heart – or a number of other problems, such as stroke.

Atherosclerosis is a serious issue that often goes undetected or ignored because of its slow and “silent” development. Sufferers may not even know they have coronary heart disease until they have ischemia or worse! So, what can we do to prevent it? Diet and exercise are key. (See: MedLab: Heart Disease – Exercise and MedLab: Heart Disease – Nutrition lessons) As with most medical issues, atherosclerosis is not a clear-cut “Nature or Nurture” question though. Some people are predisposed to heart disease. Those with a family history of heart disease have a higher likelihood of developing it themselves. There are even some people who have genetic conditions, such as familial hypercholesterolemia, that cause very high levels of cholesterol in their blood, leading to increased risk of atherosclerosis. BUT, for most people, eating a healthy diet including high-fiber, low-fat, low-cholesterol foods, avoiding tobacco products and recreational stimulants, and exercising regularly will be enough to prevent coronary artery disease. A healthy diet and regular exercise is also a very effective way of reducing the severity of heart disease in those who already suffer. Some sufferers take “blood thinners” such as aspirin to improve blood flow through narrowed vessels. There are also medicines, called statins, that reduce LDL in the blood and slow the progress of atherosclerosis

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considerably. Taking steps to avoid or treat heart disease just might save your own life! Our actions can improve our overall community health and that improvement begins with the individual.



### WARM UP

Ask students what heart disease is. Have them discuss the question in small groups before sharing their answers. Record their answers on large paper to post in each class throughout the lesson. (Of course, you could do this on the chalk/whiteboard or via computer projector.) Ask follow up questions such as: What are some examples? What parts of the body are affected? What are some symptoms? Who can be affected by heart disease? How do you know?

This will serve as a good informal pre-lesson assessment of the students' prior knowledge on the subject and it will get the "gears turning" in your students' minds. You can formalize this a bit more by treating it as a pre-lesson assessment quiz that individuals take and hand in if that suits you better. Or you could use this as a "bell ringer" activity by writing the question on the board before students enter and have them work on it individually in their lab journals first thing.



### ACTIVITY

**Activity 1** (see student activity guide)

- 1 paper towel tube
- 2-3 pc scrap paper
- Scissors
- Glue
- Small seeds (ie: fennel seeds) (or tiny beads, or glitter if you dare)
- Tape—any kind
- 1 Paper plate (or bin/vessel for catching seeds)

#### Part 1

1. Gather materials. You will need a cardboard tube, scissors, paper, glue, and tape.
2. Cut the paper towel tube lengthwise (from one opening to the other) in a straight line.

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3. Cut a piece of scrap paper to fit the INSIDE of their cardboard tube.
4. Next, cut the paper in half, along the narrow width, into pieces “A” and “B”.
5. Glue “A” into the inside of the tube, aligning it with the top half of the tube.
6. Put a crease in “B” and glue it into the bottom half of the tube. Glue it on all sides BUT be careful not to glue the crease. The crease should leave a small opening in the center of the tube. (Think of it as making a little tunnel in the paper that begins at the center of the tube and ends at the bottom of the tube where the paper is glued to close the exit.)
7. Tape the completed model back into a tube. Paper A is at the top. This models an artery with a damaged wall.
8. Make a large-mouth funnel by twisting another piece of paper in on itself and taping it. The opening should be only SLIGHTLY smaller than the tube.

### Part 2

1. Gather materials. You will need your artery model, seeds (or any tiny, numerous materials), a paper plate or bin, and your paper funnel.
2. Place a paper plate (or bin) on your table/desk under the artery model to catch seeds as they fall through.
3. One student holds the model upright while another holds the funnel with the mouth as closely aligned to the top of the tube as possible.
4. Pour the seeds through the funnel quickly.
5. Repeat as many times as necessary depending upon how many seeds you have. (You want to pour about a liter of seeds through.)
6. Open up your model (peel or cut the tape) and observe what happened. What do the seeds represent? What does the crease represent? What happened in the crease? Why?

**NOTE TO TEACHERS:** The seeds represent the solid components of the blood. The crease represents the damaged artery wall. Damage in the wall allows materials, such as LDL, to be trapped between the layers of the wall. Not everything in the blood is small enough to fit into the tear and many molecules pass right over the damage without touching it at all, but the large volume of blood pumping through arteries allows some materials to interact with the tear.

### **Activity 2**

- 1 liter beaker (or any large vessel to measure water)
- 1 2-liter bottle with bottom cut off

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- Modeling clay
  - 1 stopwatch
  - 1 bin (or any large, wide vessel to catch ~2-liters of poured water)
  - 1 student data sheet
1. Gather materials. You will need a 2-liter bottle with the bottom cut off, a large beaker, modeling clay, a stopwatch, and a bin to catch water poured through your model.
  2. One student should hold the 2-liter bottle upside down (mouth of the bottle pointing down) with his/her palm covering the mouth tightly.
  3. Another student should fill the bottle with 1.5 liters of water.
  4. The student should quickly remove his/her palm from the mouth of the bottle and the stopwatch should be started.
  5. As soon as the water empties out of the bottle, stop the stopwatch.
  6. Record the time on your student data sheet.
  7. Repeat steps 1-6 two more times and record the times on your data sheet.
  8. Add a small lump of clay to the mouth of the bottle. The clay should block approximately 25% of the opening.
  9. Repeat steps 1-6 with the 25% blockage three times. Record the times on your data sheet.
  10. Add more clay to the mouth of the bottle to block approximately 50% of the opening.
  11. Repeat steps 1-6 with the 50% blockage three times. Record the times on your data sheet.
  12. Add more clay to the mouth of the bottle to block approximately 75% of the opening.
  13. Repeat steps 1-6 with the 75% blockage three times. Record the times on your data sheet.



### DIFFERENTIATED INSTRUCTION

(Coming soon.)

# Heart Disease—Atherosclerosis



## DIGITAL RESOURCES/SOURCES

<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3022060/>

<http://www.webmd.com/cholesterol-management/cholesterol-and-artery-plaque-buildup>

<https://www.youtube.com/watch?v=Na6-kP9VYCU>

<http://www.mayoclinic.org/diseases-conditions/arteriosclerosis-atherosclerosis/basics/causes/con-20026972>

[http://www.heart.org/idc/groups/ahamah-public/@wcm/@sop/@smd/documents/downloadable/ucm\\_470704.pdf](http://www.heart.org/idc/groups/ahamah-public/@wcm/@sop/@smd/documents/downloadable/ucm_470704.pdf)

<http://www.mayoclinic.org/diseases-conditions/heart-attack/basics/definition/con-20019520>

<http://circ.ahajournals.org/content/107/24/3109.long>

<http://www.nlm.nih.gov/medlineplus/ency/article/000392.htm>

## RELATED EXHIBITS



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