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**Big Idea:** *Function and structure of the heart*

**Type of Activity:** *Modeling the human heart and its role in the circulatory system; designing an engineering solution to heart valve disease*

**Length of Activity:** *2-3 class periods*

**Group Size:** *Classroom setting, groups vary (individuals, pairs, whole group)*

**Space Needed:** *Classroom*

**Grades:** *Middle school (6-8)*

### Core Concepts:

- The heart's function is related to its structure. Students can learn about properties of the heart by making observations about its shape.
- The heart is a muscle that pumps blood to two locations: the lungs and the rest of the body. The side that pumps to the body has a thicker muscle wall than the side that pumps to the lungs. (Evolutionarily, people born with less muscle were incapable of survival, because their blood wouldn't pump far enough. Please shy away from saying, "We have a thicker muscle wall so that the blood can go farther," which presumes creationism.)
- The valves in the heart allow for one way flow of blood. Many pumps have a one way valve that allows fluid or air to move only in one direction.
- Some people have valves that do not function properly. Bioengineers design solutions for valves that cannot function properly.

### Preparation:

- *Heart Form and Function*
  - Prepare a class set of zip lock bags with clay or play dough.
  - Gather at least three types of pumps (i.e. turkey baster, ear bulb, bicycle pump, camera lens duster, airplane pillow, etc.)
  - Beach ball
- *Bioengineering: Heart Valve Design*
  - Gather materials for designing a heart valve: balloons, straws, fabric, foil, aluminum cans, paint, bubble wrap, plastic wrap, rubber bands, masking tape, etc. (If you do this as a two day assignment, then students could bring things from home based on their design on day 1.)
  - Gather small containers for design project. Suggestions include: 25 ml beakers, film canisters, test tubes, plastic water bottles, pill bottles, yogurt containers, or any other containers with a round opening.
  - Graduated cylinders or other measuring tool
  - Print the heart diagram worksheets
  - Print one labeled heart diagram teacher key.

## Performing the Activity:

### Engage:

- (Slide 2) “What does your heart look like?” Have students make a model of the heart out of clay, based on what they *think* it looks like. They can build it either individually or with a partner. Sketch in science notebooks, labeling any known parts or features.
- (Slide 3) “What is the function of the human heart?” (“What does it do?”) (If students do not say “pump,” lead them in this direction.)

### Explore:

- (Slides 4-5) “Let’s look at some other kinds of pumps.” Using the PowerPoint, show three common pumps. If you have real life examples, demonstrate how the pumps work. Ask the students: “What do the pumps have in common?” Have a discussion of the commonalities between pumps (open chamber, move fluid in and out, flexible walls, valves).
- (Slide 6) Show pictures of valves. Demonstrate how a valve works using a beach ball.
- (Slide 7) Visit the Science Museum of Minnesota’s website: “Habits of the Heart.” <http://www.smm.org/heart/heart/pumping.htm> This website shows an animation of how the blood flows through the heart (“Your Heart Valves at Work”). Click on “Heart” in the top-left corner to go back to the main heart page. It has a very good model that you could make and use for a demonstration or have students make if you have time (“Heart as a Pump”). There is also a short clip of the model in action.
- (Slide 8) Have students modify their original clay models of the heart to fit their new understanding. In their science notebooks, have them sketch and record the changes they made to the model, explaining why they made these changes.

### Explain:

- Show unlabeled cross section of heart diagram using a projector. Use teacher key as a guide. Ask students, “Where do you see chambers or open spaces? Do you see anything that would act as a valve? Where are there entrances or exits?” Students discuss what direction blood flows.
- (Slide 9) Read Kids Health article: Either project for class and read aloud together or print copies for students. This is a great article that describes the heart’s role, its parts, and its function.  
[http://kidshealth.org/PageManager.jsp?dn=KidsHealth&lic=1&ps=307&cat\\_id=20607&article\\_set=54036](http://kidshealth.org/PageManager.jsp?dn=KidsHealth&lic=1&ps=307&cat_id=20607&article_set=54036)
- (Slide 10) Hand out heart diagrams and then together label the atria, ventricles, valves, vena cava, and aorta.
- Using a red and blue colored pencil, draw arrows through the heart illustrating the flow of blood. If colored pencils aren’t available, use symbols for oxygen (O<sub>2</sub>) rich blood and carbon dioxide (CO<sub>2</sub>) rich blood.
- Define boldfaced terms using the Kids Health reading.
- Have students explain to their partners the pathway of the blood through the heart.

### Elaborate:

- (Slide 11) Students apply what they learned from pump to real heart. “How can any of the pumps fail? What can go wrong with your heart as a pump?” Brainstorm ideas after

students have time to create and ponder individually. (Possible answers include: heart attack, hole in the heart, faulty valves, clogged blood vessels, irregular heartbeat, etc.)

- (Slides 12-14) Read design scenario from the PowerPoint, hand out Heart Valve Design template, and explain to students that in teams they will design and test an artificial valve for the heart.
- (Slides 15-17) Show images of damaged valves on PowerPoint and also some examples of artificial valves. Information from these slides can be written on the design template in the “gather information section.”

### **Evaluate:**

- Students test their design solutions in front of the class by pouring a designated amount of water through the valve and then measure the amount of water that comes out of the valve when inverted over a beaker or another measuring tool. The group with the least amount of leakage wins!
- Have students discuss feasibility of designs showing their understanding of how a heart works.
- Reflection: Have students write a paragraph that includes: strengths and weaknesses of their model, and changes they would make to a future design. Have them describe why they would make those changes.

### **Differentiation:**

*For older, more sophisticated levels:*

- Research current heart valve repair
- Research different types of heart valve disease
- Explore connection to dental health (i.e., pericardial infection)
- Find connections between bone development and clues for understanding why tissues become abnormally calcified

*For younger, challenged level students:*

- Use pre-labeled heart diagram

### **Learning Links:**

- *Youth Take Heart Online Lessons*  
This is a collection of lessons that have been created to educate students about the structure and function of the heart, heart disease, and how lifestyle choices can affect heart health. These lessons outline activities that can be done using minimal materials. The “Lifestyle choices” and “Heart anatomy and function” lessons also include PowerPoint presentations. [[link to all](#)]
  - Lifestyle choices
  - Heart anatomy and function
  - Fat and sugar in fast food
  - Sheep heart dissection
  - Nutrient exchange
  - Meditation
  - Blood pressure
  - Salt
  - Case of the Ailing Heart <http://depts.washington.edu/simplant/>
  - “Case of the Ailing Heart” allows students to problem solve and help Guy, a secret agent, recover from his ailing heart. Students help him exercise, eat well, and install a stent in his blood vessel!

- *Heart Habits: Science Museum of Minnesota Heart Interactives and Animations*
  - <http://www.smm.org/heart/heart/top.html>
  - *This website has additional lessons on pumps and valves of the heart and also includes lessons that link the circulatory and respiratory systems*
- *Nova Online*
  - Electric heart: <http://www.pbs.org/wgbh/nova/eheart/facts.html>
  - Interactive heart transplant activity:  
<http://www.pbs.org/wgbh/nova/eheart/transplantwave.html>
  - *The “Artificial Human” has examples of many parts of the human body that are being replaced by artificial parts and a list of companies that supply them.*

## Background Information:

Chamber	What happens in this chamber?
Right Atrium	The deoxygenated blood comes from the body to the heart through the superior and inferior vena cavae (largest veins in the body) and empty into the right atrium.
Right Ventricle	The blood flows through the tricuspid valve into the right ventricle. The function of the valve is to keep blood from being pushed backwards when the heart muscle contracts. The blood is then pumped by the muscle of the right ventricle through the pulmonary valves and the pulmonary arteries to the lungs.
Left Atrium	The blood is then pumped from the left atrium, through the mitral valve, into the left ventricle
Left ventricle	The large muscle of the left ventricle pumps the oxygenated blood through the aortic valve and out through the aorta (the largest artery in the body) to all parts of the body.

### *Sites that explain heart valves and valve disorders*

- Your Total Health: contains an animation of heart valves, and descriptions of mechanical valves and patients’ issues <http://yourtotalhealth.ivillage.com/mechanical-heart-valve.html?pageNum=1#1>
- National Heart, Lung, and Blood Institute: [http://www.nhlbi.nih.gov/health/dci/Diseases/hvd/hvd\\_what.html](http://www.nhlbi.nih.gov/health/dci/Diseases/hvd/hvd_what.html)
- Medicine Net: [http://www.medicinenet.com/heart\\_valve\\_disease/article.htm](http://www.medicinenet.com/heart_valve_disease/article.htm)
- Wikipedia: Although we cannot vouch for the accuracy of wikipedia, it has a nice summary if you type in “mechanical heart valves.”

## Misconceptions:

- When looking at the heart movie or a picture of the heart, students may realize that the right side is labeled “left” and vice-versa. The heart is always labeled according to the owner’s perspective, not the viewer’s. It can help to hold a picture of the heart up to the teacher’s chest to illustrate.
- Students may not realize that heart muscle cells (cardiac cells) need their own blood supply. Some think that the blood flowing through the heart provides the oxygen and

nutrients for the cardiac cells. The coronary arteries, located throughout the heart muscle, provide blood supply to cardiac cells.

- Students can confuse the arteries and veins. They often think that all arteries carry oxygen-rich blood, and veins carry oxygen-poor blood. In fact, arteries carry blood **away** from the heart, and veins carry blood **to** the heart. Pulmonary arteries carry oxygen-poor blood away from the heart, to the lungs. Pulmonary veins carry oxygen-rich blood to the heart, away from the lungs.
- Deoxygenated blood is not really blue. Oxygen-rich blood is closer to a cherry kool-aid, and oxygen-poor blood is closer to red wine (or real cherry juice).

### **National Standards:**

The following National Science Education Standards are covered in this lesson.

The Science Content Standards of the National Science Education Standards

can be accessed at the following website:

<http://books.nap.edu/readingroom/books/nses/>.

### *Structure And Function Of Living Systems*

- Living systems at all levels of organization demonstrate the complementary nature of structure and function. Important levels of organization for structure and function include cells, organs, tissues, organ systems, whole organisms, and ecosystems.
- Disease is a breakdown in structures or functions of an organism. Some diseases are the result of intrinsic failures of the system. Others are the result of damage by infection by other organisms.

### *Understanding About Science And Technology*

- Technological designs have constraints. Some constraints are unavoidable, for example, properties of materials, or effects of weather and friction; other constraints limit choices in the design, for example, environmental protection, human safety, and aesthetics.

### *Understandings About Scientific Inquiry*

- Different kinds of questions suggest different kinds of scientific investigations. Some investigations involve observing and describing objects, organisms, or events; some involve collecting specimens; some involve experiments; some involve seeking more information; some involve discovery of new objects and phenomena; and some involve making models.
- Current scientific knowledge and understanding guide scientific investigations
- Scientific explanations emphasize evidence, have logically consistent arguments, and use scientific principles, models, and theories. The scientific community accepts and uses such explanations until displaced by better scientific ones. When such displacement occurs, science advances.
- Science advances through legitimate skepticism. Asking questions and querying other scientists' explanations is part of scientific inquiry. Scientists evaluate the explanations proposed by other scientists by examining evidence, comparing evidence, identifying faulty reasoning, pointing out statements that go beyond the evidence, and suggesting alternative explanations for the same observations.
- Scientific investigations sometimes result in new ideas and phenomena for study, generate new methods or procedures for an investigation, or develop new technologies to improve the collection of data. All of these results can lead to new investigations.