

Heart Valve Replacement

Make a prototype that replaces the mitral valve in a human heart.

Instructions

Students design and implant prototype replacement mitral valves for hypothetical patients' hearts.

PREPARATION:

- Construct a model heart for each group of students. Divide space inside each box into 2 sections by making a dividing wall with a gap in it. The sections represent the left atrium chamber and the left ventricle; the gap is the space for a one-way mitral valve. See photo.
- Organize whole class materials so that groups have ready access; they will have to return to the materials several times as they refine their ideas. Optional: assign a cost for each material that students choose to use for designing their valves; the least expensive prototype that works properly will be considered the most successful.



Materials

MODEL HEART MATERIALS,
ONE MODEL PER GROUP:

- 1 cardboard box, approximately 10" x 12" wide x 15" deep (copy paper boxes work well). No lid needed.
- Divider wall made from cardboard and packing tape
- Scissors or box cutter
- Marker (optional) to identify heart chambers
- Red spray paint (optional)

ACTIVITY:

- 1** Review the functioning of a healthy heart with students, ensuring that they understand the direction of blood flow through the chambers and how the valves work. For this activity, it is important for students to remember that the mitral valve is the only one that has two flaps that open and close; it is also called the bicuspid valve.
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- 2** Divide students into groups and show them the model hearts. Explain that their challenge is to design and construct a replacement mitral valve that allows blood cells (marbles) to flow from the left atrium to the left ventricle, but not back in the other direction when the box is tipped. The sign of success is how many marbles pass through the left ventricle when the box is tipped, and then how many marbles remain there when the box is tipped the other way.
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- 3** Demonstrate the ease with which marbles currently pass both ways by tipping the box. Show them the materials they can use (and note their cost, if you choose that option).
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- 4** Give each group pencil and paper and instruct them to sketch ideas. They can choose several designs to test. Note that they can change their ideas as they go, based on whether their designs need improving.
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- 5** To each group, distribute a model heart box, 30 marbles, and a pair of scissors. Tell each group to gather materials according to the first design they will try. Remind them that they can use more materials and to return any that they don't use so that the materials are available for other groups.
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- 6** Once a valve is ready to test, students implant it between the two chambers and test their model by placing marbles on the left atrium side and tipping the box toward the left ventricle. Tell students to note how many marbles went through and how many were blocked from returning when the box is tipped the other way.

PER GROUP OF 3 STUDENTS:

- Paper and pen or pencil
- 1 pair scissors
- 1 model heart (prepared in advance by activity leader)
- 30 marbles (representing blood cells)

PER CLASS:

- 1 pack tissue paper
- Scrap cardboard
- 1 pack construction paper
- Brown paper grocery bags
- Popsicle sticks
- 1 pack index cards
- 1 box wooden toothpicks
- 1 roll of string (approximately 280 feet)
- 1 box aluminum foil
- 3 rolls duct tape
- 5–10 rolls transparent tape

ACTIVITY (CONTINUED):

- 7 Students use the results of this test to redesign their valve and retest it if their first try wasn't as successful as they'd hoped.
- 8 When time is up, have each group explain their valve, how successful it was, and what they would try next time.

Engineering & Science Connections

-  The mitral valve is the valve between the left atrium and left ventricle, with two leaflets. Also known as the bicuspid valve because it is the only valve in the human heart with just two flaps.
-  Artificial heart valves are a leading area of research for biomedical engineers, because diseases of the heart and circulatory system are a leading cause of death. Replacement valves can keep patients alive. The 5-year survival rate for a valve replacement is about 91%.
-  To increase the survival rate with artificial heart valves, engineers and doctors are collaborating to design valves that are made of materials more compatible with the human body, that will function longer, and that cause less trauma to implant.

Guiding Questions ?

What have you seen that only opens one way and not the other that might be adapted for this activity?

Which of the materials provided have both flexibility and enough strength to create a flap that moves but also stays shut?

If the flap were used as constantly as an actual mitral valve, what would keep it sturdy and functional?

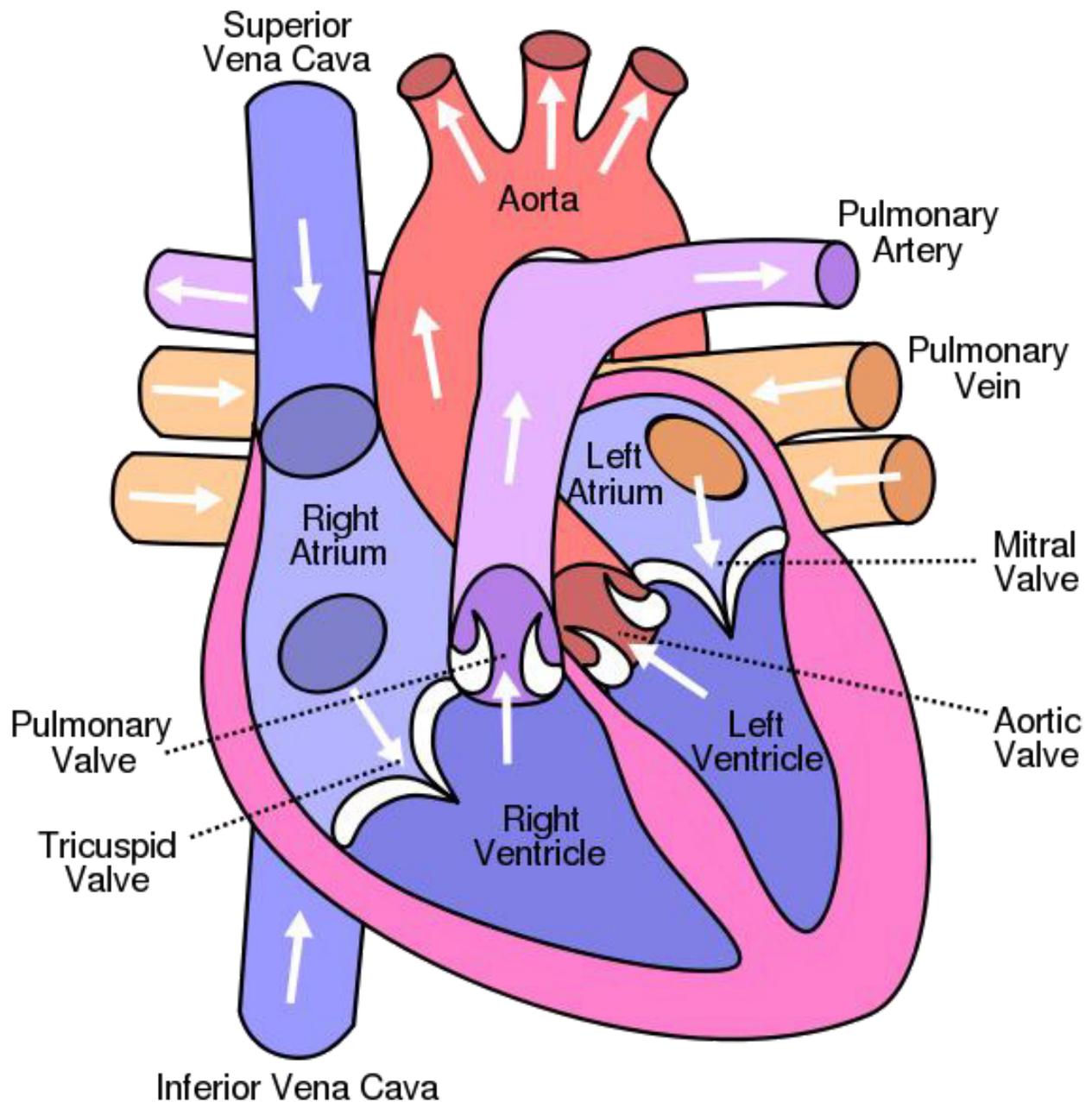
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Saving a Life: Heart Valve Replacement Activity— Human Heart Visual Aid



Arrows show the path of blood flow in the human heart. The blood enters the heart from the body through the superior vena cava and the inferior vena cava. Then the blood enters the right atrium chamber of the heart. The blood then moves through the tricuspid valve (shown as two white flaps) into the right ventricle chamber of the heart. Then the blood moves through the pulmonary valve (shown as two white flaps) into the pulmonary artery (one on each side of the heart). The blood re-enters the heart through the pulmonary veins (two on each side of the heart), and travels into the left atrium. The blood then passes through the mitral valve (shown as two white flaps) and into the left ventricle chamber of the heart. The blood then moves through the aortic valve (shown as two white flaps) and into the aorta.