THE HUMAN HEART
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Abstract

The human heart is one of the most important organs in the human body. The primary goal of this module is to explain the heart. What it looks like, how it functions and what common tests, such as blood pressure, really measure.

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### Content Standards

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### History & Process Standards

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I. Objectives
Students will:
- observe a 3D model of the heart.
- listen to their own hearts through a stethoscope.
- measure their own blood pressures and heart rates.
- observe an EKG/ECG print out.

II. Safety
• Do not allow anyone to inflate the blood pressure cuff to over 170 mm Hg. To prevent this from happening, an adult should always help out when students are using the blood pressure monitor.
• Make sure that your skin will not be pinched in the metal ring on the cuff once you start inflating it. Immediately deflate the cuff with the air release button if the skin becomes pinched.
• Be careful when adjusting the microscope so the lens does not come into contact with the slide and break it.

III. Level, Time Required and Number of Participants

Level
This activity can be adjusted for K-5, 6-12, as well as adults.

Time Required
This activity can take as little as 10 minutes for impatient participants, or as much as 20-30 minutes for curious participants.

Number of Participants
Smaller groups are easier to work with and handle. For groups larger that 5 or 6 people, two instructors should be present.

IV. List of Materials

• Model Heart with stand
• Stethoscope
• Blood Pressure Monitor
• Heart Poster (Two sizes)
• Microscope
• Microscope slides of Heart and Red blood cells
• Extension cord and electricity for microscope
• Rubbing Alcohol (to clean stethoscope)
V. Introduction

The heart is one of the most important organs in the human body. All day and all night, cells take in nutrients and oxygen and excrete wastes. The cardiovascular system, which includes the heart, provides a transport system that keeps blood in continuous circulation to supply nutrients and remove ejected wastes from the cells. The heart is the transport system pump and the blood vessels are the delivery routes. Using blood as the transport medium, the heart continually propels oxygen, nutrients, wastes, and many other substances through the blood vessels that move to and past the body’s cells.

The heart is approximately the size of a person's fist and typically weighs less than a pound. It extends from the second rib to the fifth rib and tips slightly to the left. About two-thirds of the heart is located on the left side of the body. (See heart poster for picture of location within the body)

There are four chambers in the heart: two atria and two ventricles. The atria are small, thin-walled receiving chambers for blood returning to the heart from circulation. They contract minimally to push the blood next door into the ventricles. Blood enters the right atrium via three veins: (1) the superior vena cava brings blood from body regions above the heart; (2) the inferior vena cava brings blood from body areas below the heart; and (3) the coronary sinus collects blood that comes from the heart itself. Four veins enter the left atrium. These are pulmonary veins that transport blood from the lungs back to the heart. The ventricles are the actual pumps of the heart. When they contract, blood is propelled out of the heart and into circulation throughout the body. The right ventricle pumps blood into the pulmonary trunk, which takes blood to the lungs where carbon dioxide is exchanged for oxygen. The left ventricle pumps blood into the aorta, the largest artery in the body, which ultimately delivers blood to all body organs.

The heart is actually two side-by-side pumps. The right side of the heart collects oxygen-poor, carbon dioxide-rich blood from the body and sends it throughout the lungs for oxygenation. The left side of the heart supplies the entire body with oxygen-rich blood. Blood returning from the body, which is oxygen-poor, enters the right atrium and then passes into the right ventricle. The right ventricle then pumps the blood to the lungs to exchange the carbon dioxide for oxygen. The freshly oxygenated blood is returned to the left atrium and then passes into the left ventricle. The left ventricle then pumps the blood into the aorta and from there throughout the rest of the body. In the body tissues an exchange of gases and nutrients occurs and the oxygen-poor blood returns to the right side of the heart.

The flow of blood through the heart is in one direction only; from the atria to the ventricles and out the arteries to the body. This one-way flow is enforced by the presence of four heart valves. There are two atrioventricular (AV) valves, located between the atrial and ventricular chambers on each side of the heart, that prevent back flow into the atria from the ventricles. There are also two valves between the ventricles and the arteries that carry blood away from the heart. These valves prevent the blood from flowing back into the ventricles.
The heart undergoes dramatic writhing movements as it alternately contracts, forcing blood out of its chambers, and then relaxes, allowing its chambers to refill with blood. The term systole refers to the contraction of the heart and diastole refers to its relaxation. These different events (cardiac cycle) that are associated with the flow of blood through the heart during one complete heartbeat can be detected and recorded with an electrocardiogram (EKG/ECG). Because the body fluids are good conductors, the electrical currents generated and transmitted through the heart also spread throughout the body and can be picked up and recorded with an EKG. A typical EKG consists of a series of three distinguishable waves (figure 1). The first wave, the small P wave, is an indication of the contraction (atrial systole) of the atria as they force the blood into the ventricles through the valves. The atria then relax (atrial diastole) and remain relaxed throughout the rest of the cardiac cycle. The second wave, the large QRS complex, results from the ventricles contracting (ventricular systole) forcing the blood through the valve into the aorta. The last wave, the T wave, is caused by the relaxing of the ventricles (ventricular diastole).

Figure 1

During the cardiac cycle two distinguishable sounds can be heard with the use of a stethoscope. The sounds, often described as “lub-dub”, result from the closing of the heart valves. The first sound reflects the closure of the valve between the atria and the ventricle which tends to be louder and longer compared to the second sound; the snapping shut of the valves between the ventricle and the aorta.

Finally, one can relate the events of the cardiac cycle to blood pressure. As the heart pumps blood, the alternating expansion and relaxation of arteries during each cardiac cycle creates a pressure wave, a pulse, that is transmitted throughout the arterial tree of the body. You can feel a pulse in any artery lying close to the body surface providing an easy way to count the heart rate. Blood pressure can be easily measured giving rise to two different values. The first number, the systolic pressure (averages 120 mm Hg) arises when the left ventricle
contracts and expels blood into the aorta, which causes the walls of the aorta to stretch increasing the aortic pressure. The diastolic pressure (averages 70-80 mm Hg) arises when blood is not allowed back into the heart and the walls of the aorta relax and maintain continuous pressure on the reducing blood volume. The pressure differences that occur actually drive the blood through the circulatory system. Without such pressure differences, blood would cease to flow. Blood pressure changes from day to day and minute to minute according to the body's needs. For example, when you are exercising or angry your blood pressure increases, but when you are relaxing or sleeping your blood pressure decreases. These changes are completely normal. The more difficult it is for the blood to flow through the blood vessels, the higher both the systolic and diastolic numbers will be.

The World Health Organization (WHO) has developed the following blood pressure classification. This classification, however, is only a general guideline because blood pressure varies from person to person according to age, weight, and health status.

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<td>Normal</td>
<td>less than 139</td>
<td>less than 89</td>
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<tr>
<td>Borderline</td>
<td>140 to 150</td>
<td>90 to 94</td>
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<tr>
<td>Hypertension</td>
<td>more than 160</td>
<td>more than 95</td>
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There is not a universally accepted definition of hypotension (low blood pressure), but a systolic pressure below 99 mm Hg is usually regarded as hypotension.

IV. Procedure

A. Setup

*Prior to Loading*
- Double check that you have all materials
- Insure that the batteries are not dead in the blood pressure monitor.

*On Location*
- Assemble the blood pressure monitor by attaching the squeeze inflation bulb and the adjustable cuff to the display box.
- Place the heart on its stand.
- Depending on the amount of room available, use either or both of the large and small heart posters.
- Set up the microscope and focus it on one of the slides.

B. Execution

*For Small Groups*
• Start by explaining and showing the different parts of the heart and their functions. Go through the flow of blood through the heart using the model and posters. Make sure to point out the valves that are located between the chambers.

Veins transport oxygen-poor, carbon dioxide-rich blood from the different parts of the body and bring it to the right atrium. The **superior vena cava** brings blood from body regions above the heart; the **inferior vena cava** brings blood from body regions below the heart; and the **coronary sinus** collects blood that comes from the heart itself. The right atrium then pumps the blood into the right ventricle. The **tricuspid atrioventricular valve** closes and prevents blood from flowing back into the right atrium. The right ventricle then pumps the blood through the **pulmonary trunk**, which takes the blood to the lungs where carbon dioxide is exchanged for oxygen. The **pulmonary valve** prevents blood from flowing back into the right ventricle.

The oxygen rich blood is then transported back to the heart into the left atrium via the **pulmonary veins**. The left atrium pumps the blood to the left ventricle past the **bicuspid atrioventricular valve**. Once in the left ventricle, the oxygenated blood is pumped into the **aorta** and from there throughout the rest of the body. The **aortic valve** prevents blood from flowing back into the left ventricle. The flow of blood through the heart is in one direction only which is enforced by the presence of the four heart valves.

• Let the students listen to their hearts to hear the opening and closing of the valves (lub-dub) using the stethoscope. Have the participant place the ear tips in his or her ears and place the chest piece (round disk) on his or her chest over the heart. Clean the ear tips of the stethoscope with rubbing alcohol in between uses.

  The first sound (lub) is usually louder and longer and is due to the closure of the valve between the atria and the ventricle.
  The second sound (dub) is due to the snapping shut of the valves between the ventricle and the aorta.

• Using the poster explain an electrocardiogram (ECG/EKG) read out and the events that take place at each wave.

  An EKG detects and records the electrical currents generated by the heart during the cardiac cycle. The first wave, the small **P wave**, is an indication of the contraction (atrial systole) of the atria as they force the blood into the ventricles. The second wave, the **QRS complex**, results from the ventricles contracting (ventricular systole), forcing the blood into the aorta. The last wave, the **T wave**, is caused by the releasing of the ventricles (ventricular diastole). Note: the atrial diastole (relaxation) is usually not observed because it is overshadowed by the ventricular systole.

• Allow each student to take their blood pressure and relate the numbers they obtain to the events that are occurring in the heart. To assemble the blood pressure monitor, attach the pump and cuff to the digital display as shown on the box. Wrap the cuff of the blood pressure monitor around the participant’s arm, just above the elbow. Press
the on button and pump the bulb. It is better to have someone help take blood pressure. Students should not be allowed to do this by themselves.

As the heart pumps blood, the expansion and relaxation of the arteries creates a pressure wave or pulse that is transmitted throughout the body. The pulse that you can feel is an easy way to count the heart rate. Blood pressure can also be easily measured and results in two numbers. The first number, the systolic pressure (averages 120 mmHg) arises when the left ventricle contracts and expels blood into the aorta causing its walls to stretch increasing the aortic pressure. The diastolic pressure (averages 70-80 mmHg) arises when blood is not allowed back into the heart by the aortic valve and the walls of the aorta relax and maintain continuous pressure on the reducing blood volume.

• Show the students the heart tissue and red blood cells under the microscope. Note: The red blood cells are round in shape. The heart muscle is striated and appears long and thin.

**For Larger Groups**

• Go through the heart and how it functions with the whole group.
• Allow the participants to examine the model heart, listen to their own heart, take their blood pressure, and look under the microscope. You will not be able to explain everything to all of them but field any questions they may have.
• Keep an eye on those students taking their blood pressure. Do not allow them to take their blood pressure themselves. If the group is excessively large, leave out the blood pressure.

**C. Cleanup**

• Make sure that the blood pressure monitor is off before putting back in box.
• Carefully place microscope back in its box.
• Clean the stethoscope ear pieces with rubbing alcohol.
• Make sure that everything gets put back in the tub and is in working condition.

**VII. Frequently Asked Questions**

Is my heart really the same size as the model?
The heart is approximately the size of a person's fist and typically weighs less than a pound. It is located between the second and fifth rib and tips slightly to the left. About two-thirds of the heart is located on the left side of the body.

Why is there electric current in the heart?
The current in your heart is not harmful; it is necessary. The contractions of the heart are triggered by a small electric current made by the pacemaker.
VIII. Troubleshooting

- The blood pressure monitor does not work.
  - Make sure that the batteries are good.

- The microscope will not focus.
  - Try to focus with the lowest power lens first. Once that is focused switch to a higher power and focus.
IX. Glossary

**Aorta** The largest artery in the body which arises from the left ventricle of the heart and ultimately delivers blood to all body organs.

**Aortic valve** Valve that is at the junction of the aorta and the left ventricle.

**Atria** Small, thin-walled chambers at the top of the heart that receive blood returning to the heart.

**Atrioventricular valves (AV valves)** Valves located at the junction of the atrial and ventricular chambers on each side that prevent backflow into the atria when the ventricles are contracting.

**Bicuspid valve** Valve between the left atrium and left ventricle that prevents backflow into the atrium when the ventricle is contracting.

**Cardiac cycle** Sequence of events encompassing one complete contraction and relaxation of the atria and ventricles of the heart.

**Cardiovascular system** The cardiovascular system includes the blood vessels which transport blood carrying oxygen, carbon dioxide, nutrients, wastes, etc. and the heart which pumps the blood.

**Coronary sinus** Blood vessel which empties the blood into the right atrium.

**Diastole** Period of the cardiac cycle when either the ventricles or the atria are relaxing.

**Electrocardiogram (EKG)** Graphical record of the electrical activity of the heart.

**Hypertension** High blood pressure.

**Hypotension** Low blood pressure.

**Inferior vena cava** Vein that returns blood from body areas below the heart to the right atrium.

**Pulmonary trunk** Blood vessel which takes blood from the right ventricle to the lungs.

**Pulmonary valve** Valve that guards the opening between the right ventricle and the pulmonary trunk.

**Pulmonary veins** Transport blood from the lungs back to the left atrium.

**Systole** Period of the cardiac cycle when either the ventricles or the atria are contracting.
**Superior vena cava**  Vein that returns blood from body regions above the heart to the right atrium.

**Tricuspid valve**  Valve between the right atrium and right ventricle that prevents backflow into the atrium when the ventricle is contracting.

**Ventricle**  Chambers at the bottom of the heart that function as the major blood pumps.

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**X. Masters**

Key for the parts of the model heart on page 13.
Key for Heart of America Model Heart

1. Right atrium
2. Right auricle
3. Coronary sulcus
4. Right ventricle
5. Anterior interventricular sulcus
6. Left ventricle
7. Left atrium
8. Pulmonary veins
9. Pulmonary trunk
   a. Right branch of pulmonary artery
   b. Left branch of pulmonary artery
10. Ligamentum arteriosum
11. Ascending aorta
12. Aortic arch
13. Brachiocephalic trunk
14. Left common carotid artery
15. Left subclavian artery
16. Superior vena cava
17. Right brachiocephalic vein
18. Left brachiocephalic vein
19. Descending aorta
20. Esophagus
21. Trachea
22. Annular ligament
23. Tracheal cartilages
24. Left bronchus
25. Right bronchus
26. Inferior vena cava
27. Coronary sinus
28. Great cardiac vein
29. Left coronary artery
30. Fatty tissue
31. Right coronary artery
32. Sinoatrial node
33. Orifice of inferior vena cava
34. Valve of inferior vena cava
35. Tricuspid valve
36. Atrioventricular node
37. Pulmonary valve
38. Right branch of Bundle of His
39. Purkinje fibers
40. Chordae tendineae
41. Bicuspid valve
42. Papillary muscles
43. Left branch of Bundle of His
44. Interventricular septum
45. Aortic valve
46. Small cardiac vein
47. Posterior vein of left ventricle
48. Apex of heart
49. Circumflex branch of left coronary artery
50. Anterior interventricular branch of left coronary artery
51. Left auricle
52. Pectinate muscle
53. Crista terminalis
54. Posterior left ventricular branch
55. Fossa ovalis
56. Limbus of fossa ovalis
57. Valve of coronary sinus
58. Opening of coronary sinus
59. Azygous vein
60. Middle cardiac vein
61. Posterior interventricular branch
62. Trabeculae carnae
63. Marginal branches on right coronary artery