



Building a Better Pump: Evolution of the Vertebrate Circulatory System

This activity is designed to allow you the opportunity to learn about the evolution of the vertebrate circulatory system. You will be given a physical model of a heart and asked to make adaptations to it that would make it more efficient.

PLEASE READ ALL OF THE FOLLOWING INSTRUCTIONS BEFORE BEGINNING THIS ACTIVITY.

Your group has been given a physical model of a fish's circulatory system. Please examine the system, and identify each of its components. Note that this is a closed system.

Heart (consists of two chambers)

Chamber 1 (atrium)

Chamber 2 (ventricle)

Valves

Arteries (vessels carrying blood away from the heart)

Veins (vessels carrying blood to the heart)

Respiratory Circuit (network of capillaries that exchange gasses in the gills)

Systemic Circuit (network of capillaries that exchange gasses in the tissues and organs of the animal's body)

Point of Gas Exchange and Entry of Oxygen into the Bloodstream

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Why Oxygen?

The red dye in the syringe at the point of entry of oxygen into the bloodstream represents oxygen, a gas that can cross the cell membrane. Oxygen is necessary for all plants, animals, and fungi to be able to convert stored chemical energy (sugars, starch, fat) into ATP. ATP (adenosine triphosphate) is necessary for many essential functions of living things. Without it, living things cannot survive. In vertebrates, oxygenated blood is red in color.

glucose + **oxygen** = water + carbon dioxide + **ATP**

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Try pumping some of the "blood" through the system. Follow the directions below.

Turn the valves so that there is an open flow of blood between the atrium and the ventricle.

Press the plunger of the atrium down, forcing the blood to flow into the ventricle.

Close the valve on the atrium so that the flow of blood between the atrium and ventricle is closed, but the flow between the systemic circuit and the atrium is open.

Open the valve on the ventricle so that the flow between the ventricle and the respiratory circuit is open.

Press the plunger of the ventricle down, forcing the blood to flow into the artery toward the respiratory circuit.

Close the valve so that blood cannot flow back from the artery into the ventricle.

Repeat this process a few times, observing how the system functions.

Now observe how oxygen is transported via this system.

- 1) Assign one or two people to operate the chambers and valves of the heart.
- 2) Assign one person to dispense oxygen, and one person to keep track of time.
- 3) As the heart operators work on pumping the blood through the system, the oxygen dispenser should choose a moment to deliver a small drop of dye into the system.
- 4) Deliver the dye by opening the valve on the syringe, pressing the plunger gently until a small drop of dye enters the capillary, and re-closing the valve.
- 5) At the same time that the drop of dye enters the capillary from the syringe, the timer should begin timing how long it takes for the dye to reach the atrium.
- 6) As soon as a pink color appears in the atrium, stop timing. It may help to see the pink color in the atrium if you place a sheet of white paper behind it.
- 7) Record the length of time that it took for the dye to travel all the way to the atrium.
- 8) You should also count the number of pumps by the ventricle that it took before the dye reached the atrium and record that number.
- 9) Record your results.

Length of time that it took for the dye to travel from the point of entry of oxygen into the body to the atrium = _____ seconds.

Number of pumps by the ventricle during this time = _____.

What modifications, if any, did you want to make but were unable to because the materials were unavailable?

What new modifications would you make using the materials at hand if given the opportunity?

Was your new model more complicated (more pieces, more connections) than the old model or simpler (fewer connections, fewer pieces)?

Can you think of any disadvantages that your new model might have in comparison to the old one?

Prepare a short oral presentation to share your modified model and results with the other groups.

Discuss:

- what modifications you made and your reasons for making them,
- the results of the timed test before and after modification,
- Answers to the six questions listed immediately above,
- Anything else you want to add.