Branching Blood Vessels

Jonathan Borne
Union Springs Academy
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Research Host:
Mary D. S. Frame, Ph.D.
University of Rochester School of Medicine and Dentistry

Branching Blood Vessels

Suggestions for Teachers

Purpose:
To explore some of the factors that affect blood flow in branching vessels.

Objectives:
1. Students will be able to use Poiseuille's Law to determine how blood flow in branching vessels is affected by viscosity, and radius.

2. Students will be able to use mass balance relationships to determine how blood flow in branching vessels affects volume distribution.

3. Students will be able to design and conduct their own experiments.

4. Students will be able to analyze data and make valid conclusions.

Materials:
(2 or 3 students per group)

Rubber or plastic tubing of various lengths and diameters (2 per group)
Y-connector tubing
Funnels that fit snugly into tubing (glass or plastic)
Straws
Water
Pancake syrup
Beakers of assorted sizes/buckets
Graduated cylinders
Spring clamps for tubing
Stopwatch or clock
Ring stand, clamps
Duct tape

Procedure:
This activity is designed for AP Biology, Anatomy & Physiology, and Physics. You may want to do this as activity as a series of labs or you can assign the problems to different groups. After conducting this lab myself, I suggest that you practice it yourself before doing it in class. Be sure that your tubing and funnel fit snugly. Also, make sure that your clamps and Y-connectors fit snugly with the tubing as well.

Background:
Blood flow (F) moves from an area of high pressure to low pressure. The pressure is the force exerted by the blood. Blood flow is typically recorded as volume per unit of time. The pressure difference (ΔP) in the blood vessel determines flow rate. Resistance (R) is the difficulty for blood to flow.

The relationship between each can be expressed as:

$$F = \frac{\Delta P}{R}$$

Resistance can be calculated by using the viscosity of the blood flowing through the vessel, the length of the vessel, and the inner radius of the vessel. The expression showing these relationships is:

$$R = \frac{8\eta L}{\pi r^4}$$

Where η = viscosity
r = radius of vessel
L = vessel length
$8/\pi$ = constant

By inserting the expression for resistance into the previous equation, you arrive at Poiseuille's Law:

$$F = \frac{\Delta P \, \pi \, r^4}{8\eta L}$$

Problem 1:
Students will need to design an experiment that tests how a set volume of a liquid flows through a branching tube. Hopefully, they will compare the volumes of liquid collected to the amount put in. The comparison can be expressed as:

$$F_T = F_1 + F_2$$

Problem 2:
Students will need to design an experiment that tests the viscosity of two or more liquids in branching tubes. They should find that the flow rate is the same for high density liquids (syrup) and low density liquids (water).

Problem 3:
Students will need to design an experiment that tests a tube and its branch at the same diameter and then decrease the size of the diameter of the branching tube. Students should see that the flow rate decreases as the diameter of the branching tube decreases.

Safety:
Students should wear safety goggles; take normal laboratory precautions.

Suggestions for Assessment:
1. Experimental design is valid and complete.

2. Data collection is complete.

3. Graph accurately reflects data record.

4. Conclusions are supported by the data.

5. Group posters and/or presentations can be used for assessment.

Questions to Ask:
1. Does blood flow increase or decrease in tube 1, tube 2, etc.?

2. Does diameter affect blood flow to smaller tubes?

3. How does viscosity and length affect flow to smaller tubes?

4. How does pressure change in smaller vessels?

Where to go from here:
1. This lab can lead to a discussion on resistance in blood vessels of organs (kidneys have least resistance of any organ--has more blood per gram).

2. How does exercise affect constriction or dilation in organs?

3. What is blood flow like in microcirculation?

References:
Powell, F. et. al. 1997. *Physiology of Fitness*. The American Physiology Society.

Seeley, R. et. al. 1992. *Anatomy & Physiology*. Mosby Year Book.

Vander, A. et. al. 1994. *Human Physiology: The Mechanisms of Body Function*. McGraw-Hill, Inc.

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Student Activity Handout

Materials:

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Graduated cylinders
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Stopwatch or clock
Ring stand, clamps
Duct tape

Note: You may or may not need ALL of these materials.

Problem 1:
Design and conduct an experiment to determine the relationship between blood flow and volume of blood in branching blood vessels.

1. Describe your methods.
2. Record your results and produce a graph of your data.
3. Make conclusions based on your data.

Problem 2:
Design and conduct an experiment to determine the relationship between viscosity and resistance in branching blood vessels of decreasing size.

1. Describe your methods.
2. Record your results and produce a graph of your data.
3. Make conclusions based on your data.

Problem 3:
Design and conduct an experiment to determine the relationship between radius and resistance in branching blood vessels of decreasing size.

1. Describe your methods.
2. Record your results and produce a graph of your data.
3. Make conclusions based on your data.

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Student Activity Handout

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Note: You may or may not need ALL of these materials.

Problem 1:

Design and conduct an experiment to determine the relationship between blood flow and volume of blood in branching blood vessels.

1. Describe your methods.
2. Record your results and produce a graph of your data.
3. Make conclusions based on your data.

Data:

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Student Activity Handout

Materials:

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Note: You may or may not need ALL of these materials.

Problem 2:
Design and conduct an experiment to determine the relationship between viscosity and resistance in branching blood vessels of decreasing size.

1. Describe your methods.
2. Record your results and produce a graph of your data.
3. Make conclusions based on your data.

Data:

Branching Blood Vessels

Student Activity Handout

Materials:

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Note: You may or may not need ALL of these materials.

Problem 3:
Design and conduct an experiment to determine the relationship between radius and resistance in branching blood vessels of decreasing size.

1. Describe your methods.
2. Record your results and produce a graph of your data.
3. Make conclusions based on your data.

Data: