Cardio Lab Exercise

Helpful Hints

- Circulatory systems can be open or closed. In a closed system, blood does not leave the system unless there is damage or a deliberate decrease of the blood volume.
- In closed systems, if you decrease (increase) the size of the plumbing and leave everything else constant, then the pressure of the fluid should increase (decrease).
- In closed systems, if you decrease (increase) the volume of the fluid and leave everything else constant, then the pressure of the fluid should decrease (increase).
- Occasionally you will be instructed to check a check box on one of the variables. When you do, it freezes the value of that variable while the experiment is run.
- Blood vessels tend to be somewhat elastic, that is, they can stretch or shrink. The typical measurement of elasticity in Cardio Lab is the vessel radius.
Cardio Lab

In this laboratory, you will perform simulations of experiments designed to study the relationships between the various parameters that influence blood pressure and heart rate in humans, and examine how the cardiovascular system responds and functions to maintain blood pressure homeostasis.

The variables that you will manipulate will be **heart rate** (how many beats per minute), **vessel radius** (how wide is the blood vessel), **systolic ventricle volume** (the volume of the left ventricle when the heart pumps), and the **blood volume** (how much blood is in the system). You will also examine the effects of small and large hemorrhages, dehydration, and the effects of hypertension.

Go to [http://www.biologylabsonline.com](http://www.biologylabsonline.com), click on the **CARDIO LAB** button and log in with the username and password that was provided to you (not the one for the Smart Science Lab).

1. Click the **Start Lab** button. When the application opens, click the **To Experiment** button.

2. Click the **Start** button and note the strip charts on the bottom portion of the application. The elapsed time is indicated at the top of the strip charts. The **Mean Arterial Pressure (MAP)** (how much pressure is in the artery), **Heart Rate** (the beats per minute), **Stroke Volume** (how much blood is pumped with each stroke), **Total Peripheral Resistance** (which you can ignore), and **Blood Volume** (the amount of blood in the system) are the parameters that are measured. The actual numeric values are shown on the right of the strip charts.

3. After observing for a period of time (usually about a minute to let the system stabilize), click the **Stop** button and write down the Mean Arterial Pressure, Heart Rate, Stroke Volume, and Blood Volume.

4. Adjust the **Heart Rate** slider control until it appears approximately as . Check the check box on the right side of the slider control, start the experiment and wait for about 30 seconds to let the parameters settle out, then stop the experiment. Notice that the **Blood Volume** remained constant.

**Question 1.** Why would the **Blood Volume** remain constant when the heart rate increased?

a. the experiment represents a closed system  
   b. the experiment represents an open system  
   c. the blood volume was not constant, it did change  
   d. none of the above
Question 2. Why did the **Vessel Radius** slider control increase from **Lower** to **Higher** when the heart rate increased?

a. because the **Blood Volume** remained constant  
b. a greater heart rate means more blood is being pumped over a given amount of time and the elastic nature of the arteries expanded to accommodate the increased flow  
c. a greater heart rate means more blood is being pumped over a given amount of time and the inelastic nature of the arteries expanded to accommodate the greater amount  
d. it’s random variation in the Cardio Lab application

5. Uncheck the check box on the **Heart Rate** slider control and click the [Reset All] button.

6. Set the **Blood Volume** slider control to approximately and check the check box.

7. Click the [Start] button and let the experiment run until the parameters stabilize (about 1 minute), then click the [Stop] button. Notice that the **Heart Rate** increased significantly and the **MAP** has decreased.

**Question 3.** Why would an increase in **Heart Rate** result from a decrease in the **Blood Volume**?

a. there is more carbon dioxide accumulating throughout the body  
b. there is less carbon dioxide accumulating throughout the body  
c. the demand for oxygen doesn’t change and the heart needs to beat faster to provide the oxygen

**Question 4.** Why would **MAP** decrease as a result of a decreased **Blood Volume**?

a. because the heart rate increased  
b. because it’s a closed system and less volume means less pressure on the system  
c. because it’s an open system and less volume means less pressure on the system  
d. because the **Vessel Radius** decreased

8. Uncheck the Blood Volume check box and click the [Reset All] button.
9. Increase the **Heart Rate** slider control to approximately and check the check box next to it.

10. Decrease the **Vessel Radius** slider control to approximately and check the check box next to it.

11. Click the **Start** button and let the experiment run until the parameters stabilize (about 1 minute), then click the **Stop** button. Notice that the **MAP** increased.

**Question 5.** Why would the **MAP** increase as a result an increase in **Heart Rate** and a decrease in **Vessel Radius**.

a. because the **Blood Volume** is constant  
b. a greater heart rate means more blood is being pumped over a given amount of time and the elastic nature of the arteries expanded to accommodate the greater amount  
c. a greater heart rate means more blood is being pumped over a given amount of time and the inelastic nature of the arteries expanded to accommodate the greater amount  
d. because a smaller radius and an increased heart rate means that more blood is being pumped over time and the vessel cannot expand

12. Uncheck the check boxes and click the **Reset All** button.

13. Click the **Interventions** tab, select **Small Hemorrhage** from the drop down list then click the **Apply Intervention** button.

14. Click the **Variables** tab then click the **Start** button and let the experiment run until the parameters stabilize (about 1 minute), then click the **Stop** button. Notice that the **Blood Volume** decreased.

**Question 6.** The default **Blood Volume** is 6.2 L. Why did the **Blood Volume** decrease to 5.7 L?

a. because a hemorrhage represents a leak in an otherwise closed system  
b. because a hemorrhage represents a leak in an otherwise open system  
c. because the **Stroke Volume** did not change  
d. because the MAP decreased from its initial setting
15. Click the **Reset All** button.

16. Click the **Interventions** tab, select **Large Hemorrhage** from the drop down list then click the **Apply Intervention** button.

17. Click the **Variables** tab then click the **Start** button and let the experiment run until the parameters stabilize (about 1 minute), then click the **Stop** button. Notice that the **Heart Rate** increased from the initial rate.

**Question 7.** Why would an increase in **Heart Rate** result from a decrease in the **Blood Volume**?

a. there is more carbon dioxide accumulating throughout the body  
b. there is less carbon dioxide accumulating throughout the body  
c. the demand for oxygen doesn’t change and the heart needs to beat faster to provide the oxygen  
d. the demand for oxygen decreases change and the heart needs to beat faster to provide the oxygen

18. Click the **Reset All** button.

19. Click the **Interventions** tab, select **Dehydration** from the drop down list then click the **Apply Intervention** button.

20. Click the **Variables** tab then click the **Start** button and let the experiment run until the parameters stabilize (about 1 minute), then click the **Stop** button. Notice that the **Blood Volume** decreased from its initial volume.

**Question 8.** Why would the Blood Volume decrease as a result of dehydration?

a. dehydration means that there are fewer red blood cells  
b. dehydration means that there are fewer white blood cells  
c. both (a) and (b)  
d. dehydration decreases the total amount of blood plasma (which is essentially water)

21. Click the **Reset All** button.

22. Click the **Cases** tab, select **Hypertension** from the drop down list then click the **Apply Case** button.
23. Click the Variables tab then click the Start button and let the experiment run until the parameters stabilize (about 1 minute), then click the Stop button. Notice that the MAP increased from its initial setting.

**Question 9. Why would MAP increase?**

a. because hypertension increases the pressure on the blood vessels  
b. it shouldn’t without a corresponding increase in Heart Rate  
c. because the Vessel Radius decreased  
d. none of the above

24. One of the treatments for hypertension is to administer medications that decrease the total Blood Volume. These are the so-called “water pills” because they decrease the amount of water in the blood supply.

25. Adjust the Blood Volume slider control until it is approximately and click the check box.

26. Click the Start button and let the experiment run until the parameters stabilize (about 1 minute), then click the Stop button. Notice what the value of the MAP is (it should be approximately 90 mm Hg).

**Question 10.** Before the Blood Volume was lowered, the MAP in the hypertension case of approximately 98 mm Hg. Assuming that this decrease in MAP was a result of the administration of a “water pill,” does it appear that there was some beneficial effect from the drug?

a. yes  
b. no  
c. we can’t tell