Cardiovascular Construction Kit

Laboratory Worksheet.

Introductory Notes

The following instructions are purposefully vague! The idea is that the system should be simple and intuitive enough to use without much explanation. Furthermore, my interest is not so much in what or how much you get done; I am interested in how you and your partner collaborate as you proceed.

Mark your answers to the questions directly in the lab workbook.

Do your best and HAVE FUN!

Exercise 1: Constructing a Cardio-Vascular system

The first exercise requires you to construct a simple cardiovascular system, and to observe it running. The system you will construct has a very simple "heart", namely a ventricle plus two one-way valves.
(*Biology note*: Of course, the heart of a human would have two such ventricle-valve structures.)

1. Use the palette of components on the left side of the workspace to construct the cardiovascular system shown in Figure 1 below.

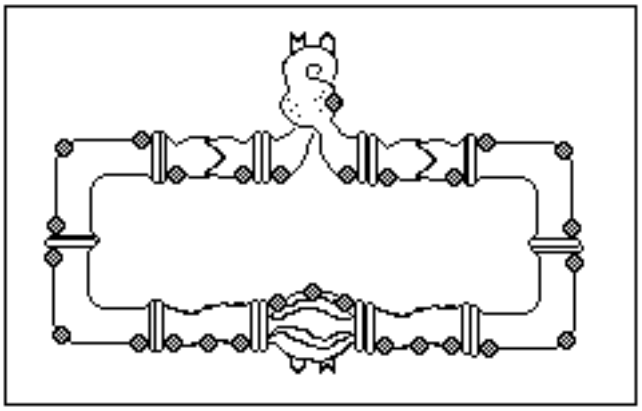

Figure 1: A simple cardiovascular loop with valves.

2. Run the simulation while carefully observing what happens on the screen. Run it as many times as necessary to answer the following questions:

- What is the direction of blood flow? (clockwise/counter-clockwise)

- When blood flows through a valve, is it open or closed?

- Do the two valves open and close at the same time, or do they open and close at different times? Why?

Exercise 2: Measuring Values

Sometimes it's hard to tell what's going on just by looking at the running simulation, since everything is happening so fast. This is especially true when you are trying to compare certain flows or pressures to eachother. This exercise focuses on the use of a gauges to measure and record blood flow or pressure at various places in the construction.

1. Modify the system you originally constructed by attaching gauges at the places marked in Figure 2. Attach a pressure gauge to the heart at point A, and flow gauges at points B and C.

2. Convert the gauges into graphs by double-clicking on each of them. Move the three graphs so that they are aligned vertically, one above the other. This will make them easier to compare.

3. Run the simulation to answer the following questions:

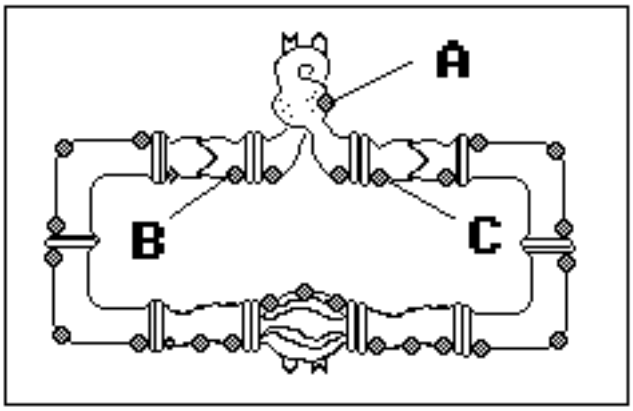

Figure 2: Where to attach the gauges

- Check all of the following statements that are true?
  _____There is never any flow past point B.
  _____There are times when there is flow towards the heart at point B.
  _____There are times when there is flow away from the heart at point B.
  _____Though the amount and direction of the flow may vary, there is always some flow past point B.
  _____There are times when there is no flow at point B.
  _____Blood always flows *towards* the heart at point B, or not at all.
  _____Blood always flows *away* from the heart at point B, or not at all.

- When does blood flow *towards* the heart take place at point B? Check all that apply.
  _____ Never
  _____ As pressure in the heart increases
  _____ As pressure in the heart decreases
  _____ When pressure in the heart is low and steady

- When does blood flow *towards* the heart take place at point C? Check all that apply.
  _____ Never
  _____ As pressure in the heart increases
  _____ As pressure in the heart decreases
  _____ When pressure in the heart is low and steady

Exercise 3: The role of valves

The cardiovascular system you've been working with so far has two valved vessels in it. One of the best ways to understand how these valves work is to simply take them out and see what happens.

1. Remove and discard the two valved vessels from the construction.

2. Replace them with un-valved vessels. Your construction should now look like the one shown in Figure 3 below.

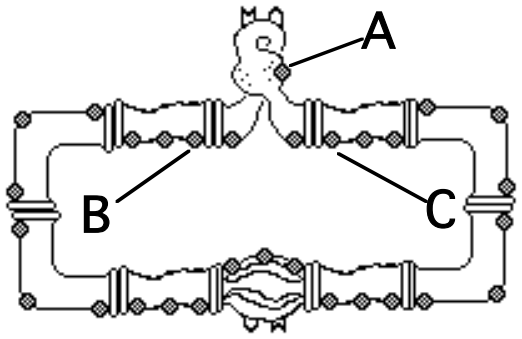

Figure 3: Simple system with no valves.

3. Attach flow gauges to the points B and C shown in the figure. Just as before, turn the gauges into graphs so you can easily compare the behavior of values over time.

4. Run the simulation to answer the following questions once again.

- Check all of the following statements that are true?
  _____ There is never *any* flow past point B.
  _____ There are times when there is flow towards the heart at point B.
  _____ There are times when there is flow away from the heart at point B.
  _____ Though the amount and direction of the flow may vary, there is always some flow past point B.
  _____ There are times when there is no flow at point B.
  _____ Blood always flows *towards* the heart at point B, or not at all.
  _____ Blood always flows *away* from the heart at point B, or not at all.

- When does blood flow *towards* the heart take place at point B? Check all that apply.
  _____ Never
  _____ As pressure in the heart increases
  _____ As pressure in the heart decreases
  _____ When pressure in the heart is low and steady

- When does blood flow *towards* the heart take place at point C? Check all that apply.
  _____ Never
  _____ As pressure in the heart increases
  _____ As pressure in the heart decreases
  _____ When pressure in the heart is low and steady

- Based on your observations, what is the overall behavior of blood flow as the heart beats?
  _____ Clockwise circulation
  _____ Counterclockwise circulation
  _____ Other (describe briefly):

CONGRATULATIONS! You have finished the lab!