Teacher Preparation Notes for Regulation of Human Heart Rate

by Dr. Ingrid Waldron, Department of Biology, University of Pennsylvania, 2015[1]

In this activity students learn how to measure heart rate accurately. Then students design and carry out an experiment to test the effects of an activity or stimulus on heart rate, analyze and interpret the data, and present their experiments in a poster session.

This activity for middle school or high school students is designed for two 50-minute periods. If you have only one class period for this activity, you can:

- restrict experimental design to activities that do not require the students to bring any additional equipment or supplies;
- have students design experiments in which each student takes his or her own heart rate, carries out the experimental activity, and then takes his or her own heart rate again, so the data for all subjects can be recorded simultaneously rather than sequentially;
- eliminate the poster presentation.

Learning Goals

Students Engage in Scientific Practices[2]

"Planning and carrying out investigations" – Students should be able to:

- "Decide what data are to be gathered … and how measurements will be recorded."
- "Decide how much data are needed to produce reliable measurements and consider any limitations on the precision of the data."
- "Plan experimental… procedures, identifying… the need for controls."

"Analyzing and interpreting data" – Students should be able to:

- "Analyze data systematically, either to look for salient patterns or to test whether data are consistent with an initial hypothesis."
- "Evaluate the strength of the conclusion that can be inferred from any data set…"

Additional Teaching Points

- need for experiments to have:
  - clear testable hypothesis
  - well-specified methods that vary only one factor and keep other factors constant
  - accurate measurement techniques
- using averages and graphs to summarize data in order to test a hypothesis
- function of heart and adaptive value of changes in heart rate
- interpretation of pulse and ability to measure pulse rate

Supplies needed

- stopwatch or watch that can time seconds (at least 1 per group of four students, or 2 if available)
- graph paper (1 per student plus 1 additional for poster)

---

[1] These Teacher Preparation Notes and the related Student Handout are available at http://serendipstudio.org/sci_edu/waldron/.

[2] Quotations and recommendations for students to engage in scientific practices are from A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (available at http://www.nap.edu/catalog.php?record_id=13165).

- paper for data sheets, tables, and to use in making posters (2-3 per student)
- posterboard, markers and glue sticks (1 per group plus extras)

Suggestions for Implementation and Discussion
If your students are not already familiar with the cardiovascular system, you may want to use the diagrams shown on the last page of these Teacher Preparation Notes in your discussion of the questions on page 1 of the Student Handout.

Groups of approximately four students are optimal for carrying out the Measuring Heart Rate Accurately activity and the experiment. If two groups of students design similar experiments, you may want to encourage them to develop identical protocols so they can have more data for more reliable results, or you may want to encourage them to compare results after they complete their experiments.

In formulating their hypothesis, some students may need to be encouraged to link the stimulus or activity explicitly to the expected response, e.g. in an "If... then..." statement.

In reviewing the students' experimental design, we have found it important to encourage them to think about and specify the details needed for a good experimental design. For example, vary only one factor and keep other factors (such as the posture of the experimental subject or the person who is measuring the pulse rate) constant in the before and after measurements. For students who choose physical activity as their experimental variable, you may want to encourage them to develop a hypothesis concerning the rate at which heart rate will return to normal after the physical activity and then take several pulse rate measurements at different times after the physical activity to evaluate this hypothesis. Other activities which students might want to investigate include:

- discussion of controversial topics
- relaxation exercises (for example, sitting in a relaxed posture with eyes closed and focusing on the feeling of the cool air as you breathe in and the warm air as you breathe out).

We have found it useful to check that each data sheet corresponds to the experimental design and clearly specifies the observations to be recorded.

If some student groups complete the activities for Part 1 before the end of the first lab period, they can begin the Hypothesis and Methods sections of their poster. If there is time for a poster session at the end of the second lab period, students generally enjoy showing off their posters and seeing each other's posters.

Optional Additional Activities

A. Students enjoy using stethoscopes to hear their heart beats. If stethoscopes are available, they can be used for the following optional activity which can be inserted after the second paragraph of the Measuring Heart Rate Accurately section of the Student Handout.

To see that each heart beat does produce a pulse in the artery in the wrist, work with a partner to do the following.

(1) Clean the earpieces of the stethoscope, and put them in your ears, with the earpieces pointing slightly forward. Have your partner place the flat part of the stethoscope over his or her heart so you can hear the heart beat sounds.

(2) Compare the heart beat sounds with the pulses you feel in your partner's artery. You should feel one pulse for each heart beat sound.

If stethoscopes are available, some students may prefer to use them for measuring heart rates during their experiment. If your students use stethoscopes, you should provide alcohol and swabs to clean the earpieces.

You may also want to obtain a heart rate monitor from a sports store for the students to compare their heart rate measurements with the heart rate monitor readings.

B. To increase student awareness of the importance of controlling all aspects of experimental procedure and changing only the specific variable to be studied you can use the following discussion activity or mini-experiment.

This discussion activity can be used at the end of the Introduction or at the beginning of the Designing Your Experiment section.

Does being in nature reduce your heart rate?
A group of student researchers has tested the hypothesis that being in a natural environment reduces people's heart rate. First, they measured their heart rates while sitting in their laboratory classroom and found an average heart rate of 72 beats per minute. Then they walked to a nearby park where they found an average heart rate of 81 beats per minute. They concluded that, contrary to expectation, being in a natural environment increases heart rate.

1. Do you agree with their conclusion? What are some other possible interpretations of their results?

2. What additional information would you want to have about their experiment in order to evaluate which interpretation is probably correct?

3. What procedures could these students adopt so their experiment measured just the effects of being in nature without the confounding effects of other possible variables such as physical activity, posture, being in an unfamiliar environment, etc.?

This mini-experiment can be used at the end of the Measuring Heart Rate Accurately section.

It is important to recognize that small changes in procedure can significantly influence heart rate. The following experiment will test the effect of walking around the room vs. sitting still before a heart rate measurement. Have each person sit still for 3 minutes and then measure his or her heart rate. Then, have the person walk around the room once and measure his or her heart rate as soon as he or she sits down. Add your data to the class graph. What effect does walking around the room have on heart rate?

For the analysis of this experiment, I recommend using graphs with Before versus After Walking Around the Room on the X axis and Heart Rate on the Y axis. Have the students plot the Before and After data points for each individual and connect each pair of data points with a line. This type of graph can help students see the trends in change in heart rate after walking around the room.

C. The following paragraph describes a procedure to increase accuracy of the experimental results. It should be noted that some students find this procedure very frustrating.

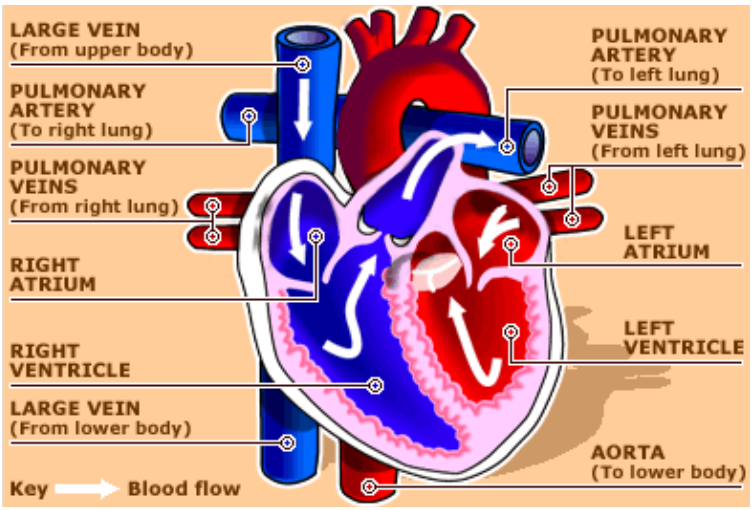
To ensure the accuracy of heart rate measurements, plan to have each subject's heart rate measured by two people simultaneously during each stage of the experiment. Each heart rate measurer should record his or her results in writing before comparing results with the other heart rate measurer. If there is significant disagreement between the two measurements of the same heart rate, it will be necessary to repeat the experiment for that subject in order to ensure the accuracy of your results.

D. The following question can be incorporated at the end of the lab write-up on the poster or used as a basis for discussion.

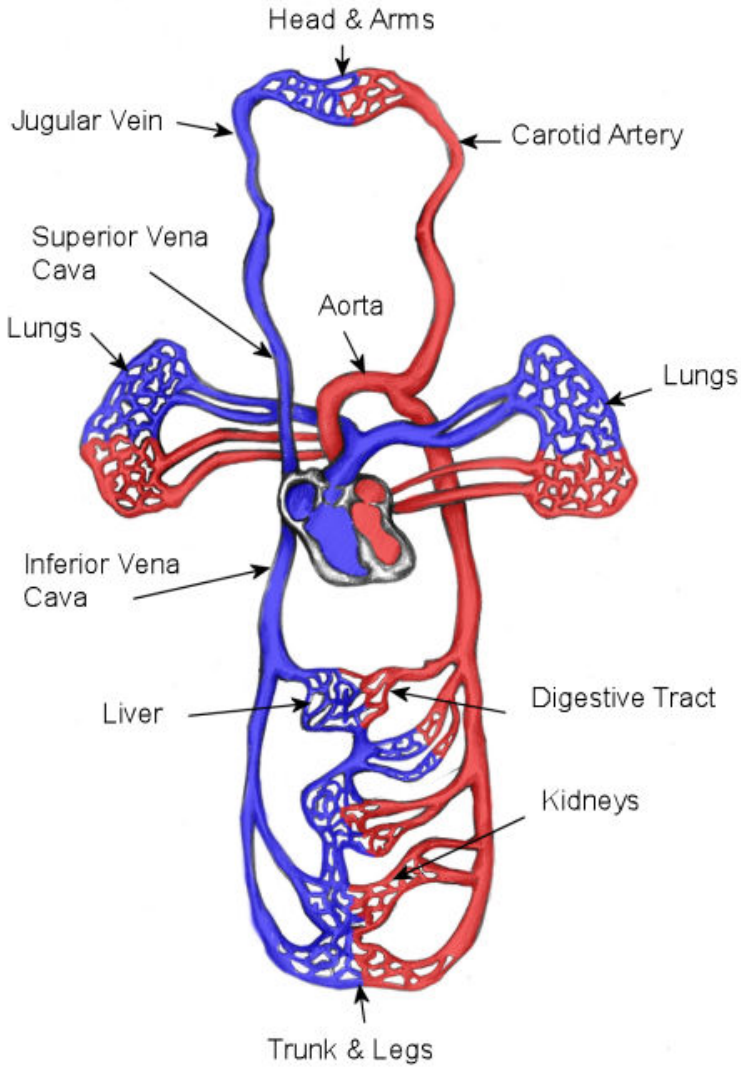
If you were going to repeat your experiment, how could you improve your experiment?

Alternative Activity

A recommended alternative activity is "Homeostasis and Negative Feedback – Concepts and Breathing Experiments" (available at http://serendipstudio.org/sci_edu/waldron/#breath). This minds-on, hands-on activity includes analysis and discussion questions and two experiments. Students develop a basic understanding of negative feedback and homeostasis, the difference between negative and positive feedback, and how the respiratory and circulatory systems cooperate to provide the O_2 needed for cellular respiration and remove CO_2 for all the cells in the body. Then, students carry out, analyze and interpret an experiment which investigates how negative feedback regulation of blood levels of O_2 and CO_2 affects the rate and depth of breathing. Finally, students formulate a hypothesis or question concerning effects of exercise on breathing, design and carry out a relevant experiment, analyze and interpret their data, and relate their results to homeostasis during exercise.



http://couldvebeentahoe.files.wordpress.com/2013/02/labeled1.gif



http://www.teachpe.com/images/circulatory_system.jpg