Journey of the Blood

Lesson Plan

Subject Area: Science

Grade Level: Grades 6-8

Lesson Summary:
Students investigate the form and function of the circulatory system by analyzing data, completing a hands-on activity, and creating graphic organizers. Students participate in group discussions to develop explanations of heart function and its relationship to blood volume. Groups create visual resources to present their findings and conclusions.

Lesson Duration: Up to two class periods (90 minutes)

Essential Questions:
- What are the primary features and functions of the circulatory system?
- How can we calculate the volume of blood pumped over a given period of time?
- How can we illustrate the volume of blood pumped over a given period of time?
- What is the relationship between the function of the heart and the volume of blood pumped through the body over a given period of time?

Objectives:
Students will:
- Describe primary features and functions of the circulatory system
- Calculate statistics based on observations of the circulatory system
- Model functioning of the circulatory system
- Explain the relationship between heart function and blood volume

Standards:
- ***Next Generation Science Standards***
  - MS-LS1-3 Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

- ***Common Core State Standards***
  - RST.6-8.3 Follow precisely a multistep procedure when carrying out experiments, taking measurements, or performing technical tasks.
  - RST.6-8.7 Integrate quantitative or technical information expressed in words in a text with a version of that information expressed visually (e.g., in a flowchart, diagram, model, graph, or table).
  - RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video, or multimedia sources with that gained from reading a text on the same topic.
  - WHST.6-8.1 Write arguments focused on discipline-specific content.
  - WHST.6-8.2 Write informative/explanatory texts, including the narration of historical events, scientific procedures/ experiments, or technical processes.
  - WHST.6-8.7 Conduct short research projects to answer a question (including a self-generated question), drawing on several sources and generating additional related, focused questions that allow for multiple avenues of exploration.
  - MP.2 Reason abstractly and quantitatively.
  - MP.4 Model with mathematics.
  - 6.SP.A.1-3 Develop understanding of statistical variability.
  - 6.SP.B.4-5 Summarize and describe distributions.
  - 7.SP.A.1-2 Use random sampling to draw inferences about a population.

- 8.SP.A1-4 Investigate patterns of association in bivariate data.

Materials

- **The Journey of Blood reading passage**
- **How Much Blood Does Your Heart Pump? handout**
- **How Much Blood Does Your Heart Pump? Data Collection Sheet**
- Calculator
- Computers with Internet access
- **NSTA: Peer-review sheet used by students during the double-blind peer review [https://www.nsta.org/highschool/connections/200911PeerReviewSheet.pdf]**

Procedure:

ENGAGE

1. Choose a student and ask when he or she last drank a bottle of water.

2. Ask another student the volume of a regular bottle of water. (A regular bottle of water holds 20 fluid ounces or 591 ml.)

3. Ask students to write a sentence comparing the size of a bottle of water to the size of their fist.

4. Ask students to make a fist and place it on the chest where the heart is located.

5. Explain that the heart is only about the size of their fist,[1] but it is responsible for pumping blood to all parts of the body. Explain to students that they will investigate the journey of blood and calculate how much blood their heart pumps in given amounts of time.

EXPLORE

1. Students read the reading passage **The Journey of Blood.**

2. Explain to students that their task is to calculate quantify and illustrate the volume of blood pumped by the heart over various time periods.

3. Ask students the guiding question, "How can you visualize the volume of blood that the heart pumps in an hour, in a day, over a longer period of time?"

4. Students work in small groups to complete the hands-on activity, using the **How Much Blood Does Your Heart Pump?** handout and the **How Much Blood Does Your Heart Pump? Data Collection Sheet.**

5. Students use their data to calculate the volume of blood pumped by the heart in various time periods.

EXPLAIN

1. Still in groups, students develop answers to the guiding question, "How can you illustrate the volume of blood that the heart pumps in an hour, in a day, and over a longer period of time?" Ensure that groups' explanations focus on how to illustrate the volume of blood pumped by the heart in various time periods.

2. Lead a class discussion of the core idea that there are various ways to present quantitative data.

3. Encourage groups to consider ways to improve the investigation based on scientific inquiry.

4. Each group creates a visual graphic organizer (e.g., concept map, slide presentation, research poster) to present their data. (Data will vary due to different pulse rates measured in the activity.) Encourage groups to use alternative units to express the data. For example, students could present volume of blood pumped in a day in units of water bottles. The heart at rest pumps about 10 water

[1] Cleveland Clinic Heart Facts http://my.clevelandclinic.org/services/heart/heart-blood-vessels/heart-facts

bottles of blood a minute – a bit less than 15,000 water bottles a day. (Calculation: based on an approximate cardiac output of 6 L per minute[2], convert 20 fl oz to liters = 0.5971 L ≅ 0.6 L, therefore 6/0.6 = 10 water bottles per minute, 10 × 1440 minutes in a day = 14,400 bottles a day.)

5. Lead a class discussion to identify explanations for differences in data. If necessary, guide the discussion to emphasize the assumptions around the data (see the Data Collection Sheet) and how these assumptions lead to approximations rather than accurate figures.

ELABORATE

1. In their groups, students investigate details of the circulatory system using online resources.

2. Each group creates a model that shows the circulatory system's four subsystems (arterial, venous, capillary, and pulmonary systems), and the cellular composition of blood. Students' models should use units based on everyday objects to more clearly illustrate quantitative data related to the circulatory system.

3. Groups create a presentation of their findings, using a flow chart to show a blood cell's journey through the circulatory system. Ensure that presentations clearly show quantitative features of their model.

4. Groups share their presentations with the class and describe the unit of measure they used in their models.

EVALUATE

1. Students work individually to write an investigation report based on the activity and their explanations. Reports should include a response to the following questions:
   - What are the primary features and functions of the circulatory system?
   - How can we calculate the volume of blood pumped over a given period of time?
   - How can we illustrate the volume of blood pumped over a given period of time?
   - What is the relationship between the function of the heart and the volume of blood pumped through the body over a given period of time?

2. Students work in groups to double-blind peer review reports. Provide each student a random number. Keep a list of each student's number. Students write their assigned numbers on their reports, but not their names.

3. Write all the numbers on a slip of paper. Each group pulls out a slip and reviews the paper that corresponds to that number. After completing their review, the group pulls out another slip and reviews the paper again.

4. Each group completes the information on the **NSTA Peer Review Sheet.**

5. Continue until all student papers are reviewed.

6. Based on your key of student numbers, return the feedback to individual students.

7. Students revise reports based on feedback then submit for evaluation. Ensure that the reports answer each of the lesson questions.

Additional Resources

- **NSTA: Peer-review sheet used by students during the double-blind peer review** [https://www.nsta.org/highschool/connections/200911PeerReviewSheet.pdf]

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[2] "…at a resting heart rate of 80 beats per minute the resting cardiac output will vary between 4.8 and 6.4 L per min" http://btc.montana.edu/olympics/physiology/pb01.html

Reading Passage: Journey of Blood

Imagine hiking 60,000 miles. You sure would have a lot of blisters! Sixty thousand miles is a long way. It's almost two and half times around the world, or about a quarter of the way to the moon. And yet, that is also about the total length of all the blood vessels in your body. Every time your heart pumps, it is pumping blood around 60,000 miles of arteries, veins and capillaries.[3]

The heart is an astonishing organ. Minute after minute, hour after hour, day after day, it pumps away. And there it sits, thump, thump, thump – pumping for a whole lifetime while you are for the most part completely unaware of it.

Imagine you could shrink to the size of a cell and take the same journey as a red blood cell around the body. What would that journey be like? What kinds of adventures and strange objects and terrains might you encounter? Unlike a typical journey, your journey does not start and end at the same place. Your journey starts in the bone marrow, which produces red blood cells, alongside white blood cells and platelets.

From the bone marrow, you travel to the heart, carried along in deoxygenated blood. You enter a chamber of the heart, then another, before being pumped to the lungs. While in the lungs, you absorb some oxygen molecules. Then you return to the heart, through two more chambers. The powerful heart muscle pumps you through the body's biggest blood vessel, the aorta.

The aorta can send you any number of places in the body since it splits into three more arteries. If you enter one of the carotid arteries, you travel up the neck to the brain. You can feel these arteries on the side of your throat. On the other hand, you might be diverted into one of the less glamorous subclavian arteries. These tubes supply the muscles of the arms, down to the wrists, where you can feel your pulse. Alternatively, you might enter the descending thoracic aorta, which feeds various internal organs and the leg muscles.

Wherever you go, you give up your precious oxygen molecules. Chances are you give up oxygen to the brain or digestive organs. Together, these use about three-quarters of the body's energy while resting[4]. As you come closer to oxygen-hungry tissues, you pass through capillaries. Your oxygen molecules diffuse into tissues, and you absorb some carbon dioxide, the main by-product of metabolism. You enter a vein then travel back to the heart. You end up in one of the main veins entering the heart, the superior or inferior vena cava. From here you start your journey all over again!

After about four months, your journey comes to an end. A red blood cell typically lasts about 120 days[5]. Traveling at almost two miles per hour[6], you might travel one-tenth of the total length of the 60,000-mile circulatory system. Most likely, your destiny is to be engulfed by white blood cells in lymph nodes, the liver, or the spleen. Alternatively you might just disintegrate while in the blood stream. Again, ever-vigilant white blood cells would mop up the fragments. Whatever your fate, it was certainly an amazing journey!

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[3] Cleveland Clinic How Does Blood Travel Through Your Body https://my.clevelandclinic.org/services/heart/heart-blood-vessels/how-does-blood-travel-through-body

[4] McClave SA, Snider HL (2001) Dissecting the energy needs of the body. Curr Opin Clin Nutr Metab Care 4(2):143-7. http://www.ncbi.nlm.nih.gov/pubmed/11224660

[5] Life Cycle of the Erythrocyte. Retrieved from http://faculty.ucc.edu/biology-potter/life_cycle_of_the_erythrocyte.htm

[6] Calculated from a figure of 92 cm per second, given by Gardin JM, et al. (1984) Evaluation of blood flow velocity in the ascending aorta and main pulmonary artery of normal subjects by Doppler echocardiography. Am Heart J. 107(2):310-9. http://www.ncbi.nlm.nih.gov/pubmed/6695664

How Much Blood Does Your Heart Pump?

Work with your group to complete the following tasks. Use the **Data Collection Sheet** to record your data and calculate the average heart rate of your group!

1. Measure resting heart rate by counting the carotid or radial pulse.

2. To locate the carotid pulse, do the following:
   - Place index and middle fingers of right hand directly under right ear (or left hand under left ear).
   - Next slide fingers down until they are directly under the jawbone, pressing lightly. Each pulse is a heartbeat.

3. To locate the radial pulse, do the following:
   - Place index and middle fingers on the outside of opposite wrist, just below the base of your thumb. Each pulse is a heartbeat.

4. Measure pulse rate.

5. Count the number of beats in 10 seconds. Multiply that number by six to calculate the average number of heart beats per minute. Record the results in the **Data Collection Sheet.**

6. Repeat for each group member.

7. Do jumping jacks (or another vigorous physical activity) for one minute and repeat the procedure for measuring and calculating the heart rate. Repeat for each group member.

8. Immediately after the jumping jacks physical activity, continue to measure the pulse every 15 seconds. Record on the **Data Collection Sheet** the total time needed for the pulse rate to return to the resting activity pulse rate.

9. Complete the calculations on the worksheet and enter the average resting heart rate and the average heart rate with vigorous physical activity.

How Much Blood Does Your Heart Pump?
Data Collection Sheet

Group Name: _____

Group Member	Resting		Vigorous Physical Activity	
	# beats	x 6	# beats	x 6
TOTAL				
GROUP AVERAGE (TOTAL/ #GROUP MEMBERS)				

GROUP AVERAGE RESTING HEART RATE _____ beats per minute (BPM)

GROUP AVERAGE VIGOROUS PHYSICAL ACTIVITY HEART RATE _____ BPM

Calculate Volume of Blood Pumped
Assumptions:
- Heart at rest pumps 70 ml with each beat.
- Heart during vigorous physical activity pumps 120 ml with each beat.
- To calculate yearly and lifetime volumes, assume one hour of vigorous physical activity per day.

	Heart rate (bpm)	Volume per beat (mL)	Volume per unit time				
			Per minute	Per hour	Per day	Per year	Lifetime
Resting		**70**					
Vigorous Physical Activity		**120**					