Ready… Set… Capillary Action!

Northeastern University AIChE Student Chapter

Jessica Nemeth, Lina Abu-Absi, Olivia Buraks, and Rachel Poe

Based on what you know about colors and capillary action, what do you think will happen in the walking water experiment? List (or draw) your hypotheses below:

What do you think will happen in the paper chromatography experiment? Will the color spread out or stay in a circle? What will happen if you use different colors? Write (or draw) your hypothesis below.

In the table below, record the number of times you feel your pulse in 10 seconds. Repeat this 3 times for each state, the first being your resting baseline and the second being your heart rate after 30 seconds of exercise.

State	**Trial 1**	**Trial 2**	**Trial 3**	**Average (Trial 1 + Trial 2 + Trial 3) ÷ 3**	**Beats per Minute (Average x 6)**
Resting					
Active					

Now let's calculate the average of the three trials! Start by adding the values you recorded for the three trials.

Resting: Trial 1 + Trial 2 + Trial 3 = _____ + _____ + _____ = _____ beats per 10 seconds

Active: Trial 1 + Trial 2 + Trial 3 = _____ + _____ + _____ = _____ beats per 10 seconds

Next, divide these values by 3.

Resting: _____÷3 = _____ beats per 10 seconds average

Active: _____÷3 = _____ beats per 10 seconds average

Add these values to your table and finish it off by multiplying the averages by 6. This allows you to calculate your average heart rate in beats per minute for your resting and active states. Follow the example calculation below for guidance:

14 beats per 10 seconds x 6 = 84 beats per minute *or…* $\frac{14 \text{ beats}}{10 \text{ seconds}} \times \frac{60 \text{ seconds}}{1 \text{ minute}} = \frac{84 \text{ beats}}{1 \text{ minute}}$

What do you notice about the difference between your resting and active heart rates? Why do you think that is?

Once the rubbing alcohol has reached half an inch from the edge of the coffee filter (or it has stopped moving), list (or draw) your observations below. Do your observations match up with your hypotheses? What does it mean when a color has moved further away from the starting ink circle?

After letting the walking water experiment sit until all three cups have the same water level, record your observations or draw the end result. Do your observations match up with your hypothesis?

<u>Advanced Section:</u>

What calculation could we do to calculate our heart rate per hour if we assume our pulse stays constant? Use the hint below to calculate your heart rate in beats per hour.

$$\frac{\square\square\square\square\square}{1 \square\square\square\square\square\square} \times \frac{\square\square\square\square\square\square\square}{1 \square\square\square\square} = \frac{\square\square\square\square\square}{1 \square\square\square\square}$$

If you found the separation of colors interesting, check out how spinach leaves perform under conditions like our paper chromatography experiment!

If you found it interesting how liquids traveled up the paper towels/coffee filters, you can look into how water interacts with other natural systems, like in the color changing flower experiment!

If you found it cool how our hearts pump blood throughout our whole bodies, compare this to the circulation of water and nutrients in plants from the roots to the leaves!

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I. Objective	Overview: Capillary action is an important property in nature that can be observed in our bodies and everyday household materials. In these experiments, we are showing how capillary action works to drive fluids upwards against gravity through small channels. Objectives: a. Teach students about capillary action and how it relates to the properties of adhesion and cohesion. b. Relate capillary action, adhesion, and cohesion to everyday examples in life, specifically through measuring heart rate, walking water, and paper chromatography experiments.
II. Materials	Observations (per person) a) 1 piece of paper b) 1 pencil Safety (per person) a) Splash goggles b) Clean, empty 5x5 ft space c) 5 paper towels for cleanup Walking Water Experiment (per pair) a) 3 clear cups (preferably wide and short) b) 2 food coloring colors c) 2 paper towels d) 16 ounces of water, additional water as needed Paper Chromatography (per person) a) 1 clear cup (preferably wide and short) b) 2-4 white coffee filters c) 1 black permanent marker and/or 1-3 colored markers

	d) 3 tablespoons rubbing alcohol Pulse Monitoring Experiment (per pair) a) 1 timer b) 1 piece of paper for calculations c) 1 calculator
III. Procedure	Students may participate in all of the steps outlined below. 1) To start the walking water experiment, pour water into two of the three cups so that those cups are ⅔ full. 2) Add a few drops of one food coloring into one of the cups of water and likewise, add a few drops of a different food coloring into the other. Mix the water and food coloring by gently swirling the cups. 3) Fold up two pieces of paper towel accordion style lengthwise (listen for instructions). 4) Place one end of a paper towel in each cup filled with colored water, making sure the ends touch the water. The other ends of the paper towels should then be placed in an empty cup between the two filled cups. 5) Record your hypothesis on what you think will happen to the paper and the colored water in the cups. Set this aside for later. 6) To start the paper chromatography experiment, take one coffee filter and draw a circle along the circular fold. 7) Fold the flattened filter paper in half and then in half again to create a cone shape. 8) Fill a cup with 2-3 tablespoons of rubbing alcohol and carefully place the filter tip-down in the liquid. Pull apart the filter so that it balances against the side of the cup. Make sure only the tip of the cone is in the rubbing alcohol and that the liquid does not reach the marker line. 9) Let it sit and see what happens as the water travels up the paper. Feel free to repeat steps 6-8 with different colored markers and compare the results. 10) While waiting for the walking water and paper chromatography experiments to finish, clean up your work environment and prepare to measure your heartbeat. Make sure you have 5x5 ft of empty space. 11) Place your index and middle fingers on the inside of your wrist with your palm facing upwards *or* on the side of your neck under your jaw. Press lightly to feel your heart rate. 12) Using a timer, count the number of times you feel your heartbeat in 10 seconds. 13) Repeat steps 11 and 12 two additional times. Record the values for each trial. 14) Next, complete 30 seconds of light exercise to prepare for your

	"active" trials. This could be jumping jacks, running in place, ski jumps, or anything that you can safely do in your environment that will raise your heart rate. 15) Again, count the number of times you feel your heartbeat in 10 seconds for a total of three times and record the values. 16) Now, calculate the average values for the resting and active states by adding the three values together and dividing the sum by 3. 17) To calculate your heart rate in beats per minute, multiply your average values by 6. Handout 2 guides you through the steps for all the necessary calculations. 18) Write a conclusion about your resting compared to active heart rate. 19) Once the rubbing alcohol has reached half an inch from the edge of the coffee filter (or it has stopped moving), record your observations about what happened during the paper chromatography experiment. 20) Finally, for the walking water experiment, wait until the water level in all three cups is equal. Record your observations and note any color changes that occurred.
IV. Theory	a. Capillary Action - liquid can flow up narrow spaces against gravity, like up a straw, through the small channels in paper towels/coffee filters or blood through veins back to your heart. b. Adhesion - molecules are attracted to other molecules or substances. In these experiments, the liquids are attracted to the channels of the paper towels and coffee filters, so they are able to "stick" to those substances. c. Cohesion - molecules of the same substance are attracted to each other. In the walking water experiment, we see that water molecules are attracted to each other. As they travel up channels of paper towels, the water molecules also pull along other water molecules, allowing the liquid to climb up the channel. The same is true for the rubbing alcohol and the coffee filters in the paper chromatography experiment. i. This is due to properties within the molecule that cause them to attract each other. d. Blood travels through veins in your body against gravity to get back to the heart. Measuring your pulse is an easy way to show that your heart is pumping blood through your body and it uses capillary action to make its way back to the heart. After exercise, your heart rate rises to accommodate the extra need for oxygen and energy sources - which students can measure.

Safety Assessment Form

Basic Information:

AIChE Community Affiliation: *Student Chapter Name, Local Section Name, Other AIChE Community Name (Technical Entities, Divisions, Forums, Committees, Operating Councils, etc)., Undergraduate Student Member(s), Graduate Student Member(s), Professional Member(s)*	Northeastern University AIChE Chapter Undergraduate Student Members: Rachel Poe, Olivia Buraks, Lina Abu-Absi, Jessica Nemeth
Primary Contact Name:	Jessica Nemeth
Primary Contact Email Address:	nemeth.j@northeastern.edu
Name of Module:	Ready... Set... Capillary Action!
Brief Description of Module:	In this module, students learn about capillary action and how it relates to the properties of adhesion and cohesion. Applications to examples in everyday life are shown, specifically through measuring heart rate, and demonstrating walking water as well as paper chromatography.
Does your module have a demonstration or experiment component?	Yes
Briefly describe any interactive portions of your module:	Encouraging students to partake in experiments demonstrating walking water and paper chromatography with the use of cups, small amounts of liquid, and dyes. Enabling students to engage in light physical activity to understand connections to the importance of capillary action in the human body.

Materials Used/Waste Generated:

	Item *Include concentration where applicable*	**Chemical State** *Where applicable, specify solid, liquid, or gas. Otherwise write "N/A"*	**Estimated quantity used** *Include units where applicable*	**Estimated amount of waste generated** *Include units where applicable*	**Waste Classification** *Where applicable, specify Acid, Base, Organic, Metal, Oxidizer, Other (include explanation if other), or Regular trash*
1	paper towels	liquid	7 paper towels	7 paper towels	Regular trash
2	coffee filters	solid	4 coffee filters	4 coffee filters	Regular trash
3	clear cups	solid	4 clear cups	0 (if cups can be repurposed following experiment)	Regular trash
4	water	liquid	16 ounces	16 ounces	Regular trash
5	rubbing alcohol	liquid	3 tablespoons	3 tablespoons	Regular trash
6					
7					
8					
9					
10					
11					
12					
13					
14					

Access to 120V power outlet:

Access required? *Respond Yes/No in the space provided*	No
If yes, specify reasoning/any equipment it will be used for: *Please note that outlets requested to plug in laptops/monitors will not be granted*	N/A

Hazard Identification & Mitigation:

Please ask yourself the following questions prior to completing the below table. 1) What can go wrong? (Identification of Hazards); 2) How bad can it be? (Severity of Hazards); 3) How easily or often can it happen? (Frequency or Likelihood); 4) How is the risk managed? (Both preventive & mitigation safety measures)

Hazards: *Describe any hazards associated with the above list of materials used and waste generated and any other hazards associated with the execution of the module*	Participants' phones or computers placed nearby fluids used in experiments. Risk of spillage of liquids onto electronics. Ingestion of rubbing alcohol or other fluids. Risk of difficulty breathing and irritation. Possible eye or nose irritation if safety glasses are not worn.
Safety Measures: *Describe any safety measures that will be taken to mitigate hazards identified above*	Identify a 5x5 ft area where physical activity (jumping jacks, etc.) may be executed. Ensure electronics are physically distanced from workspace for experiments. Ensure safety glasses are worn for experiments involving fluids. Avoid ingestion of any experiment materials, especially liquids.
Required PPE: *Specify required PPE, who is required to use it, and within what proximity*	Safety glasses are required for students participating in experiments. Closed toed shoes are required for students participating in experiments.

Certification:

I certify that this module is safe for presentation to K-12 community members (including students, parents, and educators) and to AIChE volunteers and community members. I additionally certify that this module is safe for presentation by K-12 community members (such as parents & educators) and by AIChE volunteers and community members.

Jessica Nemeth		8/31/21
Primary Contact Name	**Primary Contact Signature**	**Date**