VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
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Diffusion

2018-2019 VINSE/VSVS Rural

Goal: To understand diffusion, the process in which there is movement of a substance from an area of high concentration of that substance to an area of low concentration

TN Curriculum Alignment:

Lesson Outline

I. Introduction

Discuss the motion of molecules using examples such as the smell of cooking from a distance or the smell of perfume in the air when someone wearing perfume walks by.

A. Modeling Semi-Permeable Membranes

One VSVS member will show students how to use a container with a wire-screen separating rye seeds and bean seeds as a model for a semi-permeable membrane. The rye seeds, representing small molecules, pass through the screen but the bean seeds, representing large molecules, do not pass through the screen.

B. Dialysis tubing and Relative Sizes of Molecules

Show students the paper models of iodine, glucose, and starch. Discuss the relative sizes and point out that starch is a "polymer" molecule made up of hundreds of glucose molecules joined together.

II. Testing for Glucose and Starch

A. Glucose Test

Student use glucose test strips to become familiar with the positive test for glucose.

B. Starch Test

Students use iodine to test for starch.

III. Diffusion of Glucose and Starch

A. Glucose Diffusion

A VSVS volunteer should distribute the dialysis tubing (containing glucose and starch) in the cup to each pair of students.

B. Predicting Which Molecules Will Diffuse

While students are waiting, show them the paper models of the molecules again and have the students try to predict which molecules will diffuse through the tubing.

C. Testing for Diffusion of Glucose

Groups test for glucose after 10 minutes.

D. Testing for Diffusion of Starch

After a positive test for glucose outside the dialysis tubing has been obtained, students can add **ALL** the rest of the iodine to the water in the cup. Students should observe a purple/black color form inside the dialysis tubing.

IV. Review

Summarize the glucose and starch dialysis results for the whole class. As part of this review, show the models of iodine, glucose, and starch to make sure students understand the relationship of molecular size to their ability to diffuse through semi-permeable membranes.

Notes on solutions used:

The glucose solution is made to be 30%.

The starch solution is made from soluble starch (a “handful” of starch “peanuts” in 1 L. water plus 1 tsp cornstarch.

The solution mixture inside the dialysis tubing is 80% glucose/20% starch.

Materials for each class

8 16 oz. clear plastic containers with wire screen and two sizes of seeds
16 pieces of dialysis tubing containing glucose and starch
16 1-oz bottles of 30% glucose
1 stock solution starch suspension -pour into 1 oz cups. Keep stock refrigerated. Cups cannot be reused.
1 vial per class containing 16x3 Glucose Test Strips (3 per pair)
16 1 oz cups for glucose/starch solution (students use for filling dialysis tubing) Cups cannot be reused
16 Glucose Test Results Chart (laminated)
16 clear plastic plates
16 6-oz plastic cups
16 tweezers
32 1 oz. cups to use for testing water for glucose or starch (in ziploc bag) – do not reuse
16 1 oz cups for iodine solution DO NOT REUSE
1 Binder containing:
- 1 set of laminated paper models of iodine, glucose, and starch (in binder)
- 16 Instruction Sheets in sheet protectors
- 16 Placement maps
- 1 Observation Sheet – teacher will copy
- 1 Answer sheet
- 1 lesson and powerpoint

1 bottle for tap water
16 dropper bottles of iodine in a protective plastic container. K**eep well separated from the ziploc bags that contain glucose strips**

Notes to Teacher - Set-Up

All glucose, starch, glucose/starch solutions must be kept in refrigerator

Materials needed for set-up for 16 pairs:

16 1 oz cups containing starch/glucose solution (about 2/3 full is enough)
16 6-oz plastic cups
16 pieces of dialysis tubing
16 plastic plates
32 1oz cups tap water

1. Count the number of students and remove enough dialysis tubes for each pair. (Repeat for each class.) Soak tubing in water for about 5 minutes (until soft) or overnight.
2. Have students make their own dialysis tubing by:
   a. Tie off 1 end of the tubing close to one end.
   b. Pour the glucose/starch solution from a 1 oz cup, into the tubing, using a funnel.
   c. Tie off the other end. The knots must be tight. Hold tubing up to observe that it is not leaking.
   d. Place tubing into cup.
   e. Place each cup on a plate. Pour enough water into the cup so that the water JUST covers the tubing. Set aside.

Take 16 32 1-oz cups and pour a little water in the bottom of each cup. Save for Section II.
Prepare 16 1oz cups and fill with iodine solution. Set aside.
Prepare 16 1oz cups containing starch solution (shake bottle well before doing this). Set aside.
Fill 1 dialysis tubing so you can show it to the class.

Clean-up and Reusing cups etc

Dialysis tubing can be thrown in trash. Reuse glucose solution in containers- keep refrigerated. Use fresh 1 oz cups of water for each class, unless you are very certain that they have not been contaminated. Discard 1oz cups containing starch and use fresh ones each time.

You

I. Introduction

Learning Goals: Students define the term "semi-permeable membrane," give real-world examples, and demonstrate how they can be used to separate different-sized molecules

- Write the following vocabulary words on the board. Refer to vocabulary words throughout the lesson when you encounter them.

  diffusion, dialysis tubing, glucose, starch, iodine, semi-permeable membrane

- Discuss the motion of molecules using examples such as the smell of cooking from a distance or the smell of perfume in the air when someone wearing perfume walks by.
  - This happens because molecules are in constant motion and gas molecules (perfume, aroma of cooking) mix (diffuse) with the air in the vicinity.

Note: Organize the students into groups of 4 (no more than 8 groups), but groups should not be less than 4. If you have an odd number, add to a group of 4. Students do the experiments in pairs but the "Modeling Semi-permeable Membranes in 8 groups.

A. Modeling Semi-permeable Membranes

Materials

8 16 oz. clear plastic containers with wire screen and seeds

32 Observation Sheets

- Ask students: What is a **semi-permeable membrane**?
- Include the following information in the discussion:
  - A **semi-permeable membrane** is a membrane in a cell that allows materials to pass into and out of a cell.
  - The openings in the membrane are large enough to allow some substances to move in and out of the cell, but are small enough to keep some substances from leaving or entering the cell.
- Give each **student** an observation sheet
- Give each **group** one of the 16 oz. clear plastic containers with lids that contains a wire screen in the middle with rye seeds on one side and bean seeds on the other side. Rye and bean seeds are used to represent molecules of two different sizes. The wire grid screen represents a semi-permeable membrane (such as a cell membrane in plants or animals). The holes represent the pores or openings in the membrane.
- Ask one student to keep the container in view of all group members and shake the plastic container sideways, keeping the lid up and observe what happens.
- Ask students to explain what happened. .
  - The students should observe that the rye seeds can pass through the wire screen (both ways) but the bean seeds cannot.
  - After a few minutes, the levels of seeds will no longer be equal because the side with the bean seeds will have some of the rye seeds as well.

Your Notes:

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B. Dialysis tubing and Relative Sizes of Molecules

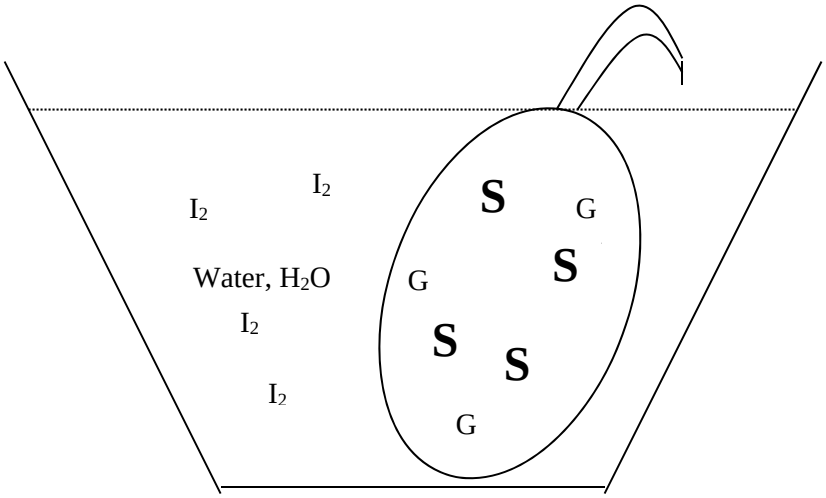
Materials:

1 dialysis tube containing glucose and starch
1 set of laminated paper models of iodine, glucose, and starch

- Show students the paper models of the three molecules, and tell them the names of the molecules. Do not discuss anything about these molecules except to tell them that the solutions they are using today contain these molecules.

- The VSVS instructor should hold up a dialysis tube with glucose and starch so that the class can see it.
    - Have the students observe that there are no fluids leaking out of the tubing.
    - Tell the students that the **dialysis tubing** is similar to a cell wall, and that the students are going to discover which of the three molecules are small enough the pass through the tubing. Show the students the tubing in the prepared cups and point out the water just covering the tubing.

- Tell students to look at the diagram on the observation sheet and point out that the dialysis tubing contains starch and glucose molecules.
    - **Starch** molecules are represented by large **S's** and **glucose** molecules are represented by small G's .
    - **Iodine** molecules, represented by small I_2's, are shown outside the dialysis tubing because they will be added to the outer solution during the experiment.
- Tell students that they will work in pairs for the following experiments.



II. Testing for Glucose and Starch

Materials - distribute to each pair:

1 Instruction Sheet
3 Glucose Test Strips and 1 Glucose Test Results Chart (laminated)
1 1-oz bottle of 30% glucose

Your Notes:

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1 1-oz cup of water
1 pair of tweezers
1 clear plate and placement map

Note: One VSVS volunteer will demonstrate the following procedure and will give the instructions; the other volunteers should monitor pairs to make sure procedures are being followed accurately and to give assistance as needed.
Divide students into groups of 4 (no more than 8 groups, but groups should not be less than 4)
Students can refer back to the instruction sheet as they are doing the experiments but you will still need to guide them through the procedures.

- Tell the students that they need to know how to prove which molecules have moved through the membrane. They need to know how to test for **glucose** and **starch**.

A. Glucose Test

- Ask students if they know about testing for glucose with glucose strips.
  - Diabetics use these strips to monitor their glucose levels.
- Tell the students to put the placement map underneath the clear plastic plate.
- Tell the students to place the 1-oz cup of water and the 1-oz glucose bottle on the appropriate circles on the plate .
  - Take the cap off of the 1-oz glucose bottle.

Tell students not to touch the glucose test strip with their fingers - use the tweezers.

- Dip one end of the test strip into the 1 oz. plastic bottle labeled glucose. Hold the strip above the bottle to remove any excess solution.
  - Place this strip in the rectangle on the observation sheet.
- Then test the water cup with another glucose test strip, following the same procedure.
  Wait a few minutes before checking the results.
- Tell students to compare the color of glucose test strips with the Glucose Results Color Chart, and record the values from the Glucose Results Color Chart on their observation sheets.
  - **Yellow** indicates **no glucose** and shades of **green** indicate the presence of **glucose**. The darker the shade of green, the more glucose is present.
  - Test strips dipped in glucose should be dark green indicating the presence of lots of glucose.
  - Test strips dipped in water should remain yellow.

- Use these strips to verify the final test results later in the lesson.
- Tell students to replace cap on 1-oz bottle of glucose.

Note: The test strip dipped in water should be yellow indicating the absence of glucose. If anyone's strip did turn green, try to determine the reason the strip turned green. This could happen due to contamination if glucose was spilled in the water or if a student touched the pad of the strip after handling the glucose set-up.

Your Notes:

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B. Starch Test

Distribute the following additional materials to each pair:

1 1oz. cup to use for testing water, 1 dropper bottle of iodine and 1 1oz cup of starch suspension

- Tell students to place the 1-oz cup of water and the 1-oz starch cup on the appropriate circles on the plate (on top of the placement map).
- Tell students to add one squirt of iodine to both the 1 oz cup containing water and the 1-oz cup of starch.
- Tell students to check for a color change and record the color, if any, on their observation sheet.

A dark purple/black color indicates the presence of starch in the starch container. The water cup should be a light orange/yellow or amber color which indicates the presence of iodine only.

III. Diffusion of Glucose and Starch

Learning Goals:

- **Students identify different indicators that can be used to systematically test for the presence of various molecules**
- **Students identify different indicators that can be used to systematically test for the presence of various molecules**

Materials:

Distribute the 6 oz. plastic cups containing a piece of dialysis tubing in water (prepared earlier) for each pair. Tell students to put the cups on their plate.

A. Glucose Diffusion

Tell students that diffusion of glucose takes time, but it has already been happening while they have been discussing diffusion. They need to leave the dialysis tubing for another **10 minutes** to allow time for diffusion to occur. Go on with section B while students wait.

Tell the students they must not disturb the cup and the dialysis tubing.

B. Predicting Which Molecules will Diffuse

Materials:

1 set of laminated paper models of iodine, glucose, and starch (paper models are stored in binder)

- Review the relative size of the molecules by showing the students the paper models of the three molecules again.
- Discuss the relative sizes of the molecules, pointing out that the results of today's activities will be dependent upon the different sizes of iodine, glucose, and starch molecules.
- Point out that starch is a "polymer" molecule made up of hundreds of glucose molecules joined together.
- Have the students refer back to their seed containers.
  - Tell the students that this is a good model for a semi-permeable membrane.
  - The small rye seeds represent small molecules, such as water, iodine, or glucose that can pass through a porous membrane both ways while larger molecules cannot.
  - The larger bean seeds represent large molecules such as starch molecules that cannot pass through the semi-permeable membrane.
- Ask the students if they can predict which way the different molecules will move.

Your Notes:

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- The iodine is a small molecule and can move from the water outside the tubing, to inside it.
- The starch is a large molecule and cannot get outside the tubing.
- The glucose is small and should be able to move from inside the tubing to the water on the outside.

- Draw arrows next to a starch (S), glucose (G) and iodine (I) molecule to show the predicted diffusion direction.

Tell students that the molecules of substances have been diffusing in the experiments set up earlier in the lesson and it is time to check on these experiments and investigate what has been happening. Caution students to wait for instructions before they disturb the experiments.

C. Testing for Diffusion of Glucose

After the tubing has been in the water for about 10 minutes:

- Ask students to dip a clean glucose test strip into the water close to the dialysis tubing (it may even touch the tubing) and place the test strip on the appropriate rectangle of the observation sheet.
- While students are waiting for the results of the test, ask them what the results of the glucose test strip will tell them.
  - If the test strip remains yellow, then no glucose was able to pass through the dialysis tubing.
  - If the test strip turns green, then glucose was able to pass through the dialysis tubing.
- Ask students to check the glucose test strip, compare its color with the Glucose Results Color Chart, and record the value on their observation sheet.
- *The glucose test strip should turn green within 1 minute, indicating the presence of glucose in the water. This shows that glucose molecules have passed through the dialysis tubing. If it did not turn green, test again (close to the tube) after several more minutes have passed*
- Ask students to look at the plastic container of seeds. Ask them if this were a model of the glucose experiment, which seeds represent the glucose molecules.
  - *The small seeds are the glucose molecules because they could travel through the dialysis tubing*.
- Ask students to refer to the diagram on the observation sheet and use arrows to show the direction glucose molecules have moved.

D. Testing for Diffusion of Starch

Note: This part should be done after a positive test for glucose has been obtained. **The glucose test strips will not work after iodine has been added to the water. The paper contains starch and will change color if iodine is present.**

- Add **all** the iodine to the water in the cup that is holding the dialysis tubing. The solution should be a light orange/yellow or amber color.

Your Notes:

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Note: If a positive test occurs when the iodine is added to the water around the dialysis tubing, the tubing has a leak. If this happens, empty their cup, rinse with water, and place a newly rinsed dialysis tubing in the cup and add iodine again. If all else fails, have them observe the results of another group.

- Ask students to observe the solution inside the dialysis tubing and the water surrounding it for a few minutes.
  - If they observe a color change, they should record it on their observation sheet.
  - *Students should observe a purple/black color inside the dialysis tubing.*
- Ask students what this purple/black color tells them?
  - The purple/black color indicates that iodine molecules have passed through the dialysis tubing and detected the presence of starch inside the dialysis tubing. Since the outside solution is not purple/black, starch molecules have not passed through the dialysis tubing into the water.
- Ask students to look at the plastic container of seeds. Ask them if this were a model of the iodine and starch experiment, which seeds represent the iodine molecules and which represent the starch molecules.
  - The large seeds are the starch molecules because they could not get out of the dialysis tubing; the small seeds are the iodine molecules because they could travel through the dialysis tubing.
- Ask students to refer to the diagram on the observation sheet and use arrows to show the direction iodine molecules have moved.

IV. Review

Summarize the glucose and starch dialysis results for the whole class. Refer to diagram on observation sheet during review.

- Glucose gave a positive test in the water surrounding the dialysis tubing. Therefore, glucose molecules traveled through the dialysis tubing.
- The water in the cup remained yellow (the color of iodine), not the purple color found when starch is present. Therefore, starch molecules did not travel through the dialysis tubing into the water.
- However, there is a purple-black color inside the tubing. Therefore, iodine molecules traveled into the dialysis tubing and reacted with the starch molecules..
- Show the molecule models of iodine, glucose, and starch to the students again to emphasize the relationship between molecular size and the ability to diffuse through a semi-permeable membrane like dialysis tubing.

Collect used dialysis tubing in a large ziploc bag or dispose of them at the school.
Pour contents of water in all cups down the drain. Return all cups to lab in plastic garbage bag. Please do not let glucose solutions leak into lesson box – that makes for a very sticky mess to clean.
Return used 1-oz bottles of glucose and starch and all solution containers to the VSVS lab for re-use.

Reference for Part V: J. G. Morse and E. Vitz, "A Simple Demonstration Model of Osmosis," **J. Chem. Educ**., Vol. 76, pp. 64-65, January, 1999.

Lesson written by Pat Tellinghuisen, Coordinator of VSVS, Vanderbilt University
Dr. Melvin Joesten, Chemistry Department, Vanderbilt University
Susan Clendenen, Teacher Consultant, Vanderbilt University

We gratefully acknowledge the assistance of Ann Orman and Kay Boone, MNPS teachers.

Your Notes:

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Diffusion Instruction Sheet

I. Introduction – discuss the concept of diffusion.

A. Semi-Permeable Membranes - VSVS teams will hand out a bean container to each group.

1. Keep the container in view of all group members; shake the container sideways, keeping the lid up; and observe what happens.
2. Be ready to explain what happened.

B. Diffusion Through Dialysis Tubing

1. Observe the dialysis tubing held up by the VSVS instructor.
2. Look at the diagram on your observation sheet. Starch molecules are S's, glucose molecules are G's, and iodine molecules are I's.

Students will work in pairs for the following experiments.

Put the Placement Map under the clear plate. Place your observation sheet next to the placement map. Do not put cups on the observation sheet.

Students will prepare the dialysis tubing by:

1. Soaking tube in water for about 5 minutes (until soft).
2. Tie off 1 end of the tubing close to the end.
3. Pour about 20 mL (use a 1 oz cup, 2/3 full) of the glucose/starch solution into the tubing, using a funnel.
4. Tie off the other ending. The knots must be tight. Hold tubing up to observe that it is not leaking.
5. Place tubing into cup containing water and set aside on the plate (see placement map for position).

II. Testing for Glucose and Starch

A. Glucose Test

1. Place the 1-oz cup of water and the 1-oz glucose **container** on the appropriate circles on the plate (see placement map positions). Remove the cap of the 1-oz glucose container.
2. Take one of the glucose strips, but **do not to touch the glucose test strip with your fingers. Use tweezers.**
3. Dip one end of one test strip into the 1 oz. container holding the glucose solution and remove from the container.
4. Place this strip in the rectangle on the **observation** sheet. Do not put it on the plate.
5. Then test the cup containing water with another glucose test strip, following the same procedure.
6. Wait a few minutes before checking the results and then compare the color of the strips with the Glucose Results Color Chart. Record the value on the observation sheet.
    a. YELLOW indicates NO GLUCOSE and shades of GREEN indicate the presence of GLUCOSE. The darker the shade of green, the more glucose is present

7. Replace the cap on the1-oz container of glucose.

B. Starch Test

1. Place the 1-oz cup of water and the 1-oz starch **cup** on the appropriate circles on the plate (see placement map for positions).
2. Add one squirt of iodine to both the 1 oz cup containing water and the 1-oz cup of starch.
3. Record the color of starch solution on the observation sheet.

III. Diffusion of Glucose and Starch

B. Predicting Which Molecules Will Diffuse

1. Think about the seed containers. Remember what size beans crossed the wire screen.
2. The dialysis tubing is a semi-permeable membrane like the wire screen. The larger beans are like large molecules such as starch molecules. The rye seeds are like small molecules such as water, iodine, and glucose.
3. Predict which molecules will diffuse in what direction in the experiment. Draw arrows next to a starch (S), glucose (G) and iodine (I) molecule to show the predicted diffusion direction.

C. Testing for Glucose Diffusion

1. Dip a clean glucose test strip into the water close to the dialysis tubing (it may even touch the tubing) and place the test strip on the appropriate rectangle of the observation sheet.
2. Compare the strip from glucose test with the Glucose Results Color Chart and record the value on the observation sheet.
3. Was your prediction for the movement of glucose molecules correct?

D. Testing for Starch Diffusion

1. Teachers will pass out the **1oz cup** of iodine to each pair.
2. Add **ALL** the iodine to the water in the cup holding the dialysis tubing.
3. Observe the solution and record any color change on the observation sheet. The starch /iodine change may take 2-5 minutes to occur.
4. Was your prediction for the movement of iodine and starch molecules correct?

IV. REVIEW

Observation Sheet

Name _____

Vocabulary Words: diffusion, osmosis, dialysis tubing, glucose, starch, iodine, semi-permeable membrane

Glucose test

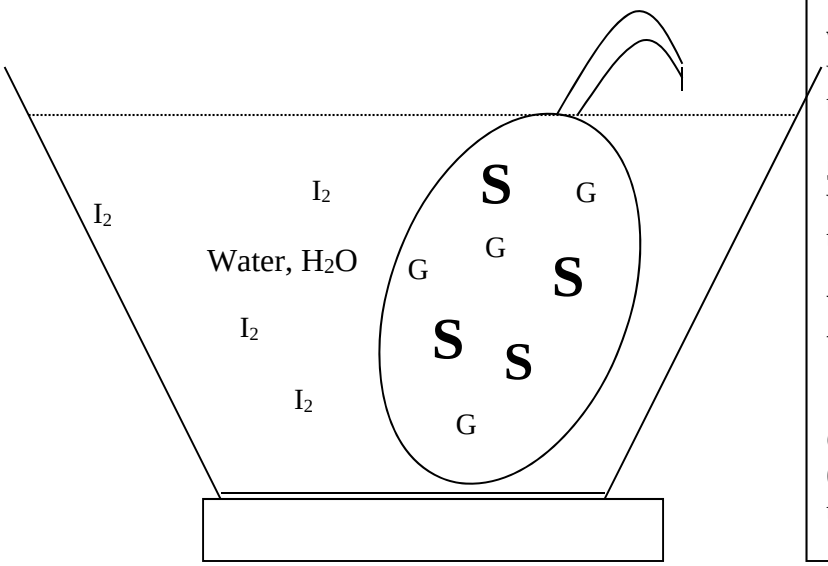
What color is the glucose strip after it is dipped in water?	**What color is the glucose strip after it is dipped in glucose solution?**
_____	_____

Starch test

What color is the water after iodine is added?	**What color is the starch solution after iodine is added?**
_____	_____

Predict the Direction of Movement of the Molecules:
Remembering what size beans crossed the wire screen, predict which molecules will diffuse in what direction in the experiment. Draw arrows next to a starch (S), glucose (G) and iodine (I_2) molecule in the cup diagram below, to show the predicted diffusion direction.

Dialysis tubing test results

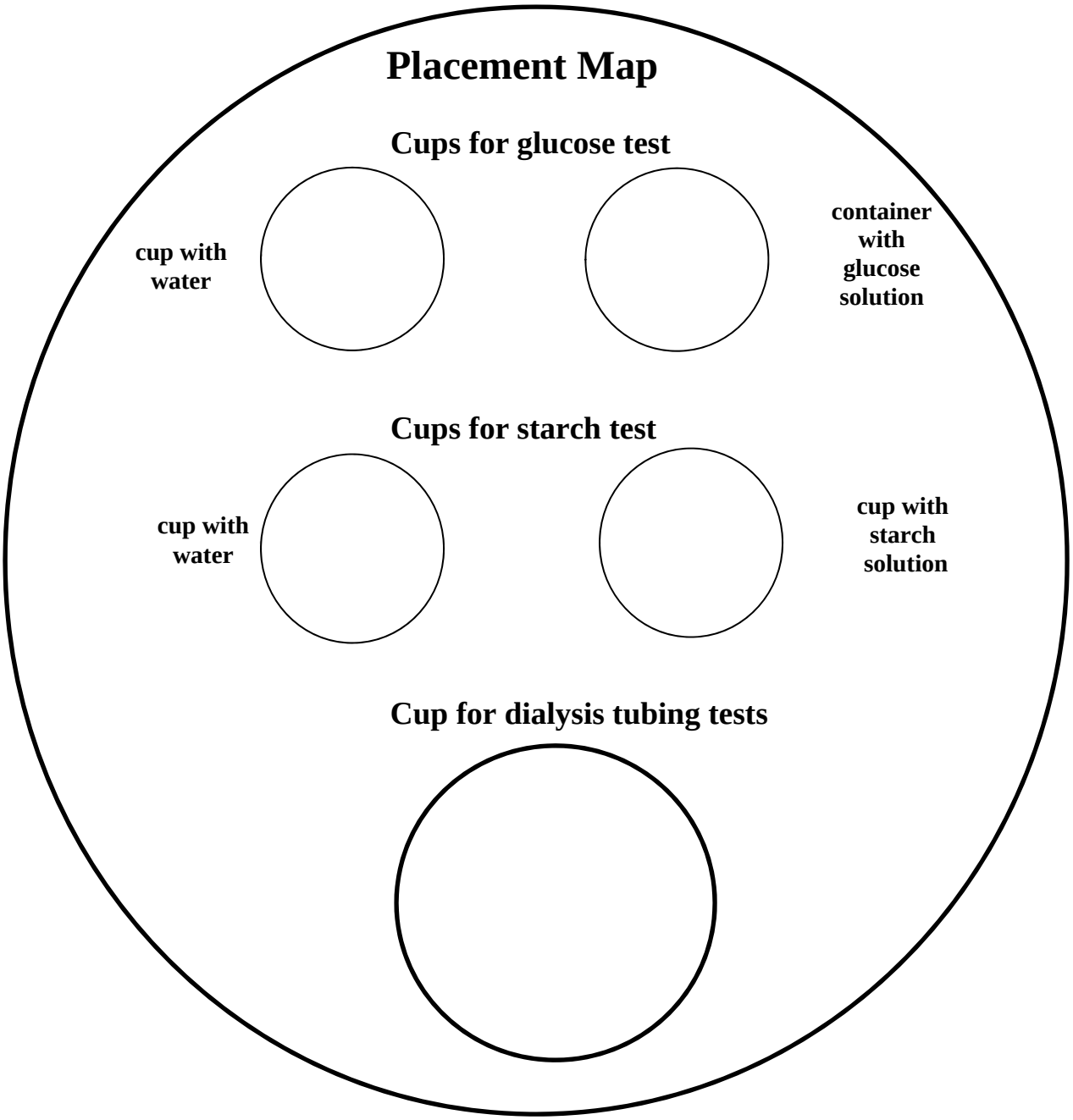


10 minutes after dialysis tubing is added to water: What is the color of the glucose strip when it is dipped into the liquid **close to t**he tubing?_____

5 minutes after the iodine is added:
What is the color of solution **inside** dialysis tubing _____

Were your predictions for the movement of the molecules correct?

Optional - 30 minutes after iodine was added (or next day): What is the color of the water in the cup? _____


Placement Map
Cups for glucose test
cup with water
container with glucose solution
Cups for starch test
cup with water
cup with starch solution
Cup for dialysis tubing tests

Answer Sheet

Name _____

Vocabulary Words: diffusion, osmosis, dialysis tubing, glucose, starch, iodine, semi-permeable membrane

Glucose test

What color is the glucose strip after it is dipped in water?
No color

What color is the glucose strip after it is dipped in glucose solution?
Green

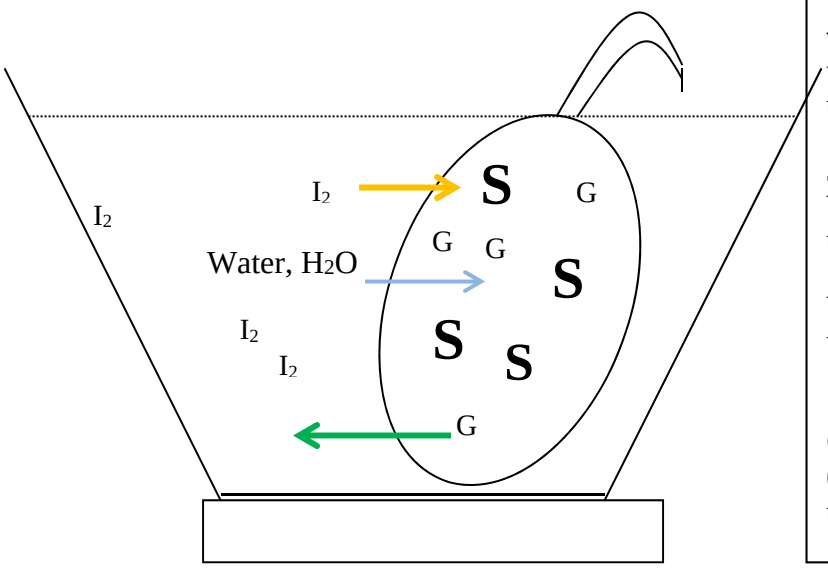
Starch test

What color is the water after iodine is added?
pale yellow – the color of dilute iodine

What color is the starch solution after iodine is added?
Blue/Black

Predict the Direction of Movement of the Molecules:
Remembering what size beans crossed the wire screen, predict which molecules will diffuse in what direction in the experiment. Draw arrows next to a starch (S), glucose (G) and iodine (I_2) molecule in the cup diagram below, to show the predicted diffusion direction. *See arrows below.*

Dialysis tubing test results



10 minutes after dialysis tubing is added to water: What is the color of the glucose strip when it is dipped into the liquid **close to t**he tubing? *Green*

5 minutes after the iodine is added:
What is the color of solution **inside** dialysis tubing *Blue/Black*

Were your predictions for the movement of the molecules correct?

Optional - 30 minutes after iodine was added (or next day): What is the color of the water in the cup? *Clear*