VANDERBILT STUDENT VOLUNTEERS FOR SCIENCE
http://studentorgs.vanderbilt.edu/vsvs

Diffusion

Fall 2018

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: 7.LS1.2

VSVSer **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.

LOOK AT THE VIDEO BEFORE YOU GO OUT TO YOUR CLASSROOM
https://studentorg.vanderbilt.edu/vsvs/lessons/
USE THE PPT AND VIDEO TO VISUALIZE THE MATERIALS USED IN EACH SECTION.

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.

1. Before the lesson:

In the car ride, read through this quiz together as a team. Make sure each team member has read the lesson and has a fundamental understanding of the material.

1. What is diffusion?
2. What is a semi-permeable membrane, and what is the relationship between molecular size and ability to diffuse through a semi-permeable membrane?
3. Which molecule(s) is/are permeable through the dialysis tubing? Which is/are impermeable?
4. Which molecule is a polymer?
5. How can the presence of glucose be detected? How can the presence of starch be detected?

2. During the Lesson:

Here are some Fun Facts for the lesson – for VSVS members

Diffusion is a passive process, meaning that it occurs spontaneously, without the input of energy.
The rate of diffusion is affected by size of molecule, steepness of concentration gradient, and temperature (related to the speed at which the molecules are moving).
Examples of diffusion in everyday life: the contents of a teabag diffuse into hot water, helium diffuses out of a balloon causing it to deflate, the smell of warm cookies diffuses throughout a room
Water, oxygen, carbon dioxide, and various other essential molecules are constantly diffusing across the membranes of our cells.
The diffusion of water is called osmosis. Water molecules move across a membrane trying to achieve equilibrium. Example: a carrot placed overnight in fresh water will swell; a carrot placed in salt water will shrivel.

Set-Up

VSVS members do this while one member starts Introduction

Materials needed for set-up for 16 pairs:
16 6-oz plastic cups
16 pieces of dialysis tubing containing the glucose and starch mixture.
16 plastic plates
32 1oz cups water
Count the number of students and remove enough dialysis tubes for each pair. Place the dialysis tubes into individual 6oz cups and place each cup on a plate. Pour enough water into the cup so that the water JUST covers the tubing. **Set aside – do not give to students until Part III.**

- Take 32 1-oz cups and pour a little water in the bottom of each cup. Save for Section II.

Unpacking the Kit – what you will need for each part

While one team member starts the introduction, another should write the following vocabulary words on the board:

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

Refer to vocabulary words throughout the lesson when you encounter them.

Your Notes:

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For Part IA: Introduction.

16 clear plastic containers with wire screen and seeds, 32 Observation Sheets

For Part IB: Relative Sizes of Molecules

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

For Part II: Testing for Glucose and Starch

For Part IIA. Glucose Test

16 Instruction Sheets, 16 plastic bags each containing 3 Glucose Test Strips (in a small bag) and 1 Glucose Test Results Chart (laminated), 16 1-oz bottles of 30% glucose, 16 1-oz cups of water, 16 tweezers

For Part IIB. Starch Test

Above materials plus additional materials:
16 1 oz. cups of water, 16 dropper bottles of iodine (in a protective plastic container), 16 oz containers of starch suspension (shake well)

For Part III: Diffusion of Glucose and Starch

IIIA Diffusion: 16 pieces of dialysis tubing placed in 6-oz plastic cups, (see set-up) 16 plastic plates,

III B: Predicting Which Molecules Will Diffuse

Paper models of the molecules from IB

For Part IIIC. Testing for Diffusion of Glucose

Glucose strips and tweezers from Part IIA

Part III D. Testing for Diffusion of Starch

Remaining iodine from Part IIB

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

Note: Organize the students into pairs

- 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.

A. Modeling Semi-permeable Membranes

Materials
16 16 oz. clear plastic containers with wire screen and seeds
32 Observation Sheets

Your Notes:

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- 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 **pair** 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.

B. Dialysis tubing and Relative Sizes of Molecules

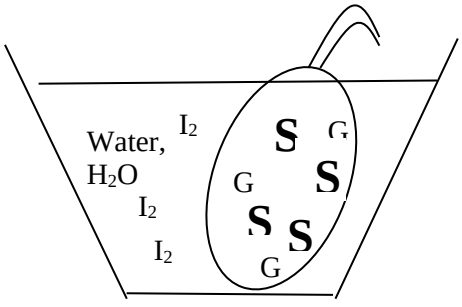
Materials:

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 membrane, 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 **G's.**
    - **Iodine** molecules, represented by **I_2's,** are shown outside the dialysis tubing because they will be added to the outer solution during the experiment.
    - **Water** is **H_2O**



Your Notes:

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- Tell students that they will work in pairs for the following experiments.

II. Testing for Glucose and Starch

Learning Goals: Students identify different indicators that can be used to systematically test for the presence of various molecules

Materials - distribute to each pair:
1 Instruction Sheet
1 plastic bag containing 3 Glucose Test Strips (in a small bag) and 1 Glucose Test Results Chart (laminated)
1 1-oz bottle of 30% glucose
1 1-oz cup of water
1 tweezer

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.
Students can refer 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 place the 1-oz cup of water and the 1-oz glucose bottle on the appropriate circles on the observation sheet.
    - 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 paper (below the 1 oz bottle).
- 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.

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.

- Tell students to replace cap on 1-oz bottle of glucose.

Your Notes:

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B. Starch Test

Distribute the following additional materials to each pair:

1 1 oz. cup to use for testing water
1 dropper bottle of iodine (in a protective plastic container)
1 1 oz container of starch suspension (shake well)

- Tell students to place the 1-oz cup of water and the 1-oz starch container on the appropriate circles on the observation sheet.
- They should shake the 1-oz starch container and then remove the cap.
- Tell students to add one squirt of iodine to both the 1 oz cup containing water and the 1-oz container 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.

- Then have students put the cap back on the 1-oz starch container.

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

Learning Goals:

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

III. Diffusion of Glucose and Starch

Materials:
Distribute the earlier prepared 6 oz. plastic cups containing a piece of dialysis tubing in water for each pair and plates.

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.

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.

Your Notes:

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- 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.
  - 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.
- 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 do 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 this 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 MUST 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.**

- Have students unscrew the lid on the iodine bottles and add **all** the rest of 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.

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. (Use the extra bottle of iodine that was provided.) If all else fails, have them observe the results of another group.

Your Notes:

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- 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.
- Tell 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.

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

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. Return all unused tubing.
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.

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

Your Notes:

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Diffusion Instruction Sheet

I. Introduction – VSVS team will discuss the concept of diffusion.

A. Semi-Permeable Membranes - Begins with a discussion. VSVS teams will hand out a bean container to each pair.

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_2".

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 observation sheet. 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 by pulling the strip past the edge of the container to remove any excess solution.
4. Place this strip in the rectangle on the paper (beside the 1 oz container).
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.
7. YELLOW indicates NO GLUCOSE and shades of GREEN indicate the presence of GLUCOSE. The darker the shade of green, the more glucose is present
8. 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 container on the appropriate circles on the observation sheet.
2. Shake the 1-oz starch container and then remove the cap.
3. Add one squirt of iodine to both the 1oz cup containing water and the 1-oz container of starch.
4. Record the color of starch solution on the observation sheet. Then put the cap back on the 1-oz starch container.

III. Diffusion of Glucose and Starch

A. Glucose Diffusion

1. A VSVS volunteer will distribute to each pair a plate holding a cup with dialysis tubing and water.
2. Leave the cup undisturbed until later (wait at least 10 minutes) in the period to allow time for diffusion to occur.

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_2) 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. Look at the plastic container of seeds. Determine which seeds would represent the glucose molecules.
4. Look at the diagram on your observation sheet. Was your prediction for the movement of glucose molecules correct?

5. D. Testing for Starch Diffusion

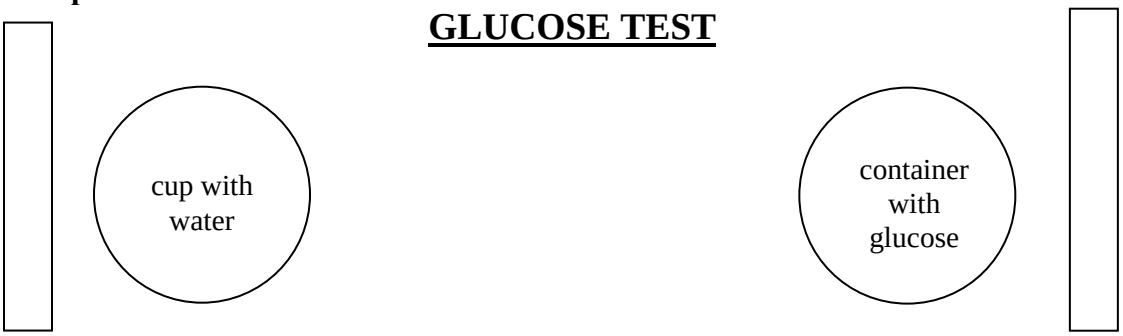
1. Remove the cap from the iodine bottle and add **ALL** the rest of the iodine to the water in the cup holding the dialysis tubing.
2. Observe the solution and record any color change on the observation sheet. The starch /iodine change may take 2-5 minutes to occur.
3. Look at the plastic container of seeds. Determine which seeds would represent the starch molecules.
4. Look at the diagram on your observation sheet. 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?

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

_____

STARCH TEST

What color is the water after iodine is added?

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What color is the starch solution after iodine is added?

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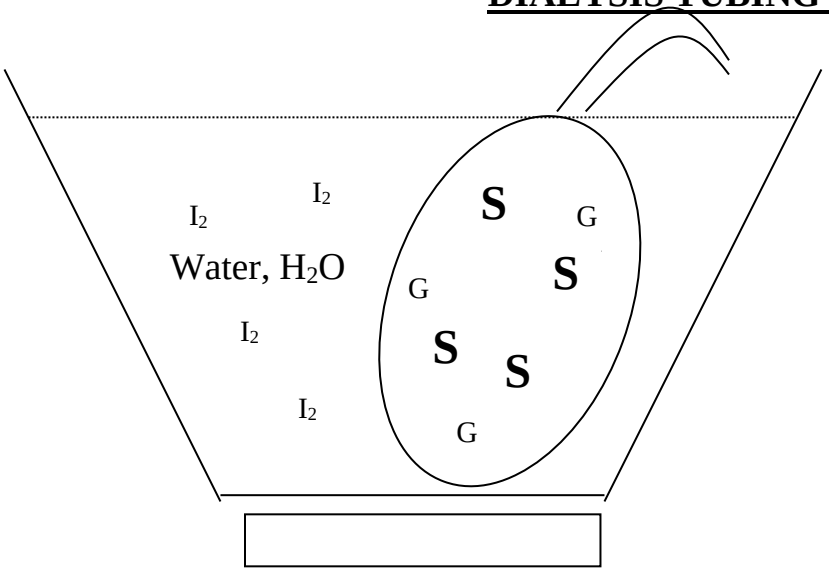
Predict the Direction of Movement of the Molecules:

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 TESTS



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

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

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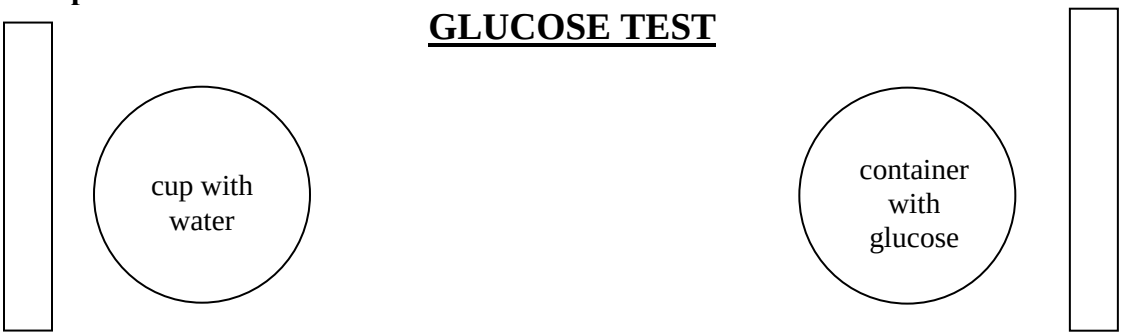
Were your predictions for the movement of the molecules correct?

Observation Sheet - Answers 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

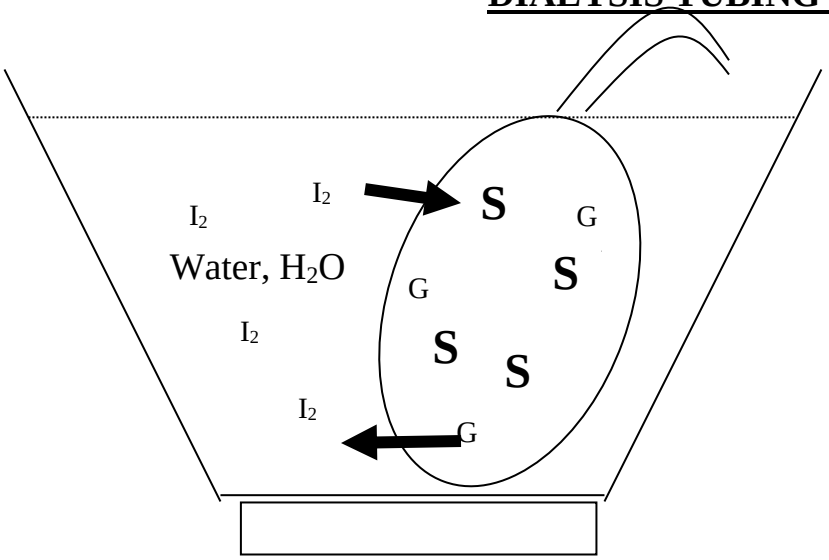
STARCH TEST

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.

DIALYSIS TUBING TESTS



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