Visualizing Diffusion in Real Time and on a Macroscale

Student Worksheet

NAME: _________________________ PERIOD: ____________ DATE: _____________

Introduction: Diffusion is the movement of molecules down a concentration gradient, which is effected by a number of characteristics (kinetic energy, crystalline structure, atomic radii, etc.). It is further complicated when diffusion occurs through another substance. For this exercise you will explore two variables: atomic radii of molecules and the substances through which they are diffusing. Understanding diffusion is easier when comparing the atomic radius of varying elements and molecules: those with smaller atomic radii are more easily able to diffuse through a substance and vice versa. Additionally, as the radius of the substance through which something is diffusing increases, the diffusion rate decreases. The larger the element or molecule, the more difficult it is to move across a membrane or materials.

This activity has two parts. One uses agarose plates, containing starch, of varying agarose percentages to observe diffusion through varying media. The second is the use of a macroscale version of a permeable membrane to observe diffusion of "atoms" in real time. Diffusion occurs on the nanoscale and the characteristics of nanoparticles vary greatly from those of their macroscale counterparts due to the dramatic difference in surface area to volume ratios. To better understand this small scale, a nano-scale representative is "blown-up" to the macroscale, with some obvious liberties. This model will allow you to tangibly observe "nano-scale" interactions and relate these observations to abstract concepts covered in class.

<u>Part A</u> *Diffusion in Real Time*

Pre-lab questions:

1. Define diffusion. Describe one example of how it is important to life.

2. What determines whether or not something can diffuse across a membrane? Explain

3. What macromolecule does iodine test for? What indicates a positive reaction?

Lab Prediction Questions:

1. Given the three concentrations of agarose plates used (2%, 1%, and 0.5%), predict which one the iodine will diffuse through the quickest. Explain your choice.

2. What is going to happen to the clear agarose as the iodine diffuses through it? Why?

3. Why do you predict that the iodine will move towards the agarose plates? How can this happen?

4. Will the central well of iodine change color? Explain.

Materials per group

- Large dish or tray
- Three (3) starch agar plates (2, 1 and 0.5%)
- Iodine solution
- Dropper
- Ruler (cm)
- Scoopula/scissors

Part A Procedure:

1. Each partner pair will be given a tray with three starch agar plates (2%, 1%, and 0.5%), iodine solution and a ruler.

2. Cut out a 1" in diameter circle of agarose from the center of each plate using a scoopula/scissors. Discard the cut out portion in the trash.

3. Using a dropper, fill the 1 inch void in the center of each plate with iodine (DO NOT OVERFILL so that any is outside the center) and wait 10 minutes.

Development and distribution funded by the **National Science Foundation**

4. While waiting for the reaction, answer the “Lab Prediction” questions. Answer them in complete sentences and provide explanations.

5. At the end of the 10 minute period, measure the migration distance of iodine from the center of each plate in centimeters. Record data in the results table on the back.

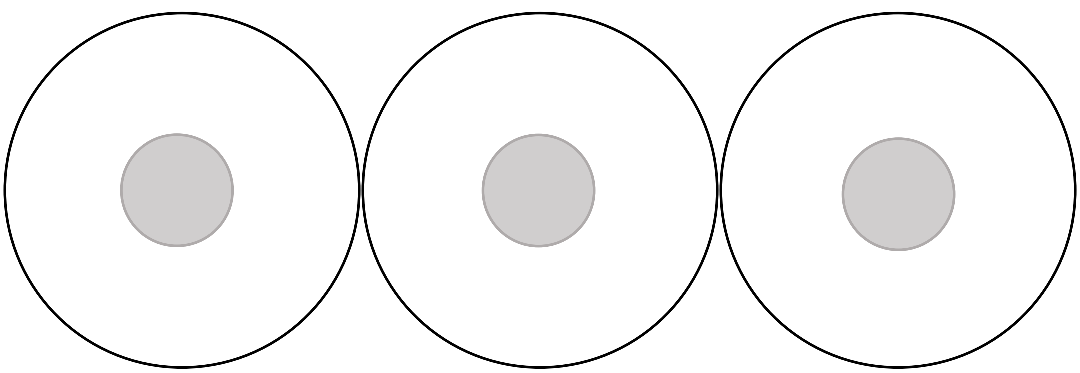
6. Sketch what your agarose plates look like after the 10 minute period. This should be done in the circles in the results section of the worksheet. Make sure to label and color each appropriately.

7. Properly dispose of your agarose plates and clean up the lab stations per your teacher’s instructions.

8. With any time remaining work, with your partner, on the post-lab questions.

Results:

Agarose Concentration	**Distance of Iodine Diffusion (in cm)**
2% Agarose	
1% Agarose	
0.5% Agarose	



Label the agarose plates and draw your results for each.

Post-Lab Questions:

1. Did the agarose percentage effect how far the iodine could move through the plate? What would have happened if you had a 0.25% plate? Why?

2. Did the central iodine well turn colors? Why or why not? (Hint: Size matters!) When would it have changed?

3. What is the difference between the agarose plates? What does this have to do with the ability for substances to diffuse through it?

4. Provide an example of how the properties of diffusion observed today apply to the properties of diffusion in animal cells.

5. If the iodine and starch were switched (agarose plates were made with iodine and starch was poured into the 1 inch center of the plate) would the results be the same? Why or why not?

Development and distribution funded by the **National Science Foundation**

NAME: _________________________ PERIOD: ____________ DATE: _____________

Scaling of Nanoparticles and Diffusion on the Macroscale

<u>Part B</u>

Pre-lab Questions:

1. How is a nanoparticle defined?

2. What determines if something will diffuse through a membrane or substrate?

3. What shape do we consider atoms to have? Give an example of something, on a large scale that has a similar shape.

Materials:

- Macroscale Nanoparticles apparatus
- Bag of:
    - Plastic Air soft Pellets or Metal BB's
    - Marbles
    - Golf Balls
    - racquetballs
- Medium sized box
- Ruler (cm)

Part B Procedure:

1. Measure the diameter of each of the different types of spheres you are given, and record the data in the results section. Each of these sphere types will represent atoms of various radii.

2. While one partner holds the Macroscale Nanoparticle Apparatus over the empty box, the other partner will shake and pour the contents of the bag into the top.

3. Allow all the "atoms" to flow down through the apparatus. Evaluate which ones were able to "diffuse" through and which did not. Record how many of each type of "atom" made it through to the box.

4. Repeat step 3 and compare the results of both trials.

Development and distribution funded by the **National Science Foundation**

5. Put the spheres back in the original bag and return all the materials to the original lab space.

6. With any time remaining work, with your partner on the post-lab questions.

Results:

Type	Size (in cm)	Starting Number of Each	Number of Each in Box	Did "diffusion" occur (Y/N)

Post-lab questions:

1. What does the "Macroscale Nanoparticles Apparatus", along with the activity, represent? Using complete sentences explain your reasoning.

2. Which spheres were able to "diffuse" through the apparatus? Which were unable to? Explain why each were/weren't able to.

3. What determines if an atom/molecule can diffuse through a substance?

4. Using what you know, how can the process you observed in this exercise be used in the "real world"? What are potential applications?

5. What is nanoscale about this activity?

Development and distribution funded by the **National Science Foundation**

Challenge Activity:
Assume the spheres represent individual atoms and the tennis balls in the apparatus represent cesium which has a radius of 298 pm. Using an atomic radius chart and a ruler, what elements would the other spheres represent? What is the largest and smallest atoms/molecules that could diffuse throughout the setup?

- Tennis ball → 6.3 cm = 298 pm → Cs
- Racquetball → 5.6 cm = 265 pm → Rb
- Golf Ball → 4.2 cm = 199 pm → Ta or Nb
- Marble → 1.4 cm = 66 pm → C
- BB's → 0.6 cm = 29 pm→ He (smallest option)
- The largest "gap" between the tennis balls in our apparatus would allow a 2.9 cm sphere to pass. This is representative of an element with an atomic radius of 137 pm, or Ga. There is no lower limit.

Development and distribution funded by the **National Science Foundation**