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AP Biology Period 1

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Diffusion Lab

I. Introduction

The cell membrane constantly exchanges materials with the environment. Many of these materials are essential for sustainability and function. One process that is essential in the function of cell membranes is diffusion, the movement of molecules from an area of high concentration to one of low concentration. In a cell membrane, small hydrophobic molecules, such as proteins, or other solutes diffuse across the membrane, depending upon the concentration. However, large molecules cannot diffuse across and require active transport, a form of diffusion that requires the use of cellular energy, ATP, to move molecules against and in the opposite direction of the concentration gradient. After some time, an equilibrium is reached, in which the concentration of a solute is equal within an area. The ability of solutes and water molecules to diffuse through permeable membranes and the rate at which diffusion works can be modeled in a lab experiment testing surface area and cell size. From this experiment, the relationship between volume and surface area of a cell and the rate of diffusion, can be determined. It can be stated that as a cell increase in size, the ratio of surface area to volume decreases, and thus the rate of diffusion decreases. A large cell has less surface area to volume than a small cell, and thus the small cell has a faster rate of diffusion. Therefore, the following hypothesis was made: cell size will affect the ratio of surface area to volume and thus, the rate of diffusion. 10

II. Materials and Methods

The following materials were obtained to perform the experiment:

- 2% agar containing NaOH and the pH indicator dye phenolphthalein
- 1% phenolphthalein solution
- 0.1M HCl 10
- 0.1M NaOH
- Squares of hard, thin plastic (from disposable plates); unserrated knives; or scalpels from dissection kits
- Metric rulers
- Petri dishes and test tubes
- 2% agar with phenolphthalein preparation
- Writing utensil and data recording sheet

Once the materials were obtained, the experimental steps were performed as follows:

- Using the scalpel and ruler, the phenolphthalein agar blocks were cut into smaller cubes of 1x1, 2x2, 3x3
- 100 mL of 0.1M HCl and 0.1M NaOH were poured into beakers
- The agar cubes were then placed into the beakers containing the solutions
- The solution was observed and the cubes were occasionally moved around in the solution to make sure the cube was fully saturated
- After 5, 10 and 15 minutes, the agar cubes were removed from the solutions, dried and measured for mass or volume, and the distance the chemical diffused on the cube. Observations and results recorded.
- Results were then quantified

III. Results

0.1M HCl and 0.1M NaOH, individually

Cube Size	Surface Area	Volume	Surface Area to Volume	Distance of Diffusion	Rate of Diffusion
1x1	1x1=1 cm^2	1x1x1=1 cm^3	1:1	0.5 cm	5 min: 0.01 cm/min 10 min: 0.05 cm/min 15 min: 0.033 cm/min
2x2	2x2=4 cm^2	2x2x2=8 cm^3	1:2	0.25 cm	5 min: 0.05 cm/min 10 min: 0.025 cm/min 15 min: 0.017 cm/min
3x3	3x3=9 cm^2	3x3x3=27 cm^3	1:3	0.125 cm	5 min: 0.025 cm/min 10 min: 0.0125 cm/min 15 min: 0.0083 cm/min

IV. Conclusions

After reviewing over the data, it appears that the hypothesis was supported. Cell size affects the ratio of surface area to volume and thus, the rate of diffusion. The smallest surface area to volume ratio, 1:1, which corresponded to the smallest agar block size, overall had the fastest rate of diffusion compared to the larger sizes. The 1x1 agar block had the greatest distance of diffusion. The shape of the cell is significant in diffusion. The small cells, 1x1, can exchange materials with the environment at the fastest rate. However, the larger cells with the small surface area to volume and exchange materials with the environment at the slowest rate. The greatest surface area to volume allows for essential nutrients and gases, such as oxygen to pass through cells. In cells where the significance of the rate of diffusion is essential, temperature and the concentration of materials significantly affect diffusion. As is evident in the data, the rate over time was effected.

There were potential errors in this experiment. Recording and measurement variations were the most significant potential errors in the experiment. Future extensions are different chemicals, different sizes of agar blocks, different durations of experimental time and the use of more precise measurement tools.

Diffusion Lab

I. Introduction

The cell membrane constantly exchanges materials with the environment. Many of these materials are essential for sustainability and function. One process that is essential in the function of cell membranes is osmosis, the movement of water down its concentration gradient through membranes. Water moves from areas of high water concentrations and low solute concentration to areas of low water concentration and high solute concentration.

Solutes can decrease the concentration of water. A hypertonic solution has a higher solute concentration and a lower water concentration compared to the environment and as a result, water will move into the hypertonic solution through the membrane by osmosis. A hypotonic solution has a lower solute concentration and a higher water concentration than the environment surrounding the cell and as a result, water will move down its concentration gradient into the other solution. Isotonic solutions are at equilibrium with water flow. In cells with a cell wall but only a membrane, as water moves out of the cell, the cell shrinks and if water moves into the cell, the cell swells and may eventually burst. In a cell with a wall, there is a resistant of water called turgor pressure. The presence of a cell wall prevents the cells from bursting as water enters; however, pressure builds up inside the cell and affects the rate of osmosis. The action of osmosis can be modeled in an experiment. Model cells are constructed using dialysis tubing to enclose sample solutions containing water, or other molecules. The ability of various solutions, such as sucrose in the experiment, to diffuse across the semipermeable dialysis membrane can be measured based upon hypotonic, hypertonic or isotonic solutions, using percent change in mass. Before the experiment began, the following hypothesis was stated: The concentration of solutes affects the rate of osmosis.

II. Materials and Methods

The following materials were obtained to perform the experiment:

- Water and 5 colored solutions, sucrose, to serve as model solutions in the experiment
- Dialysis tubing, 6 strips of tubing to serve as membranes
- 200 mL beaker for water and containing the dialysis bags
- Distilled water
- Macropipette to transfer the 5 different colored solutions and water
- Electronic scale for weighing the dialysis tubing
- Weighing boat to place the tubing into on the scale
- Writing utensil and data recording sheet

Once the materials were obtained, the experimental steps were performed as follows:

- The beaker was obtained and distilled water was added
- 6 pieces of dialysis tubing, approximately 20 cm long, was obtained and soaked in the water to allow the easiness of opening the tube
- Each piece of tubing was opened on one end and twisted closed ion the other end
- 10 mL of each of the five colored solutions and water was transferred into each of the dialysis tubing using the macropipette
- The top end of the dialysis tubing was twisted and closed
- After the solutions were added to the dialysis tubing, excess water was removed from the bags (exterior) and each tube was measured using the electronic scale
- After each tube was weighed, the tubes were placed into the beaker
- After 24 hours, the tubes were removed from the beaker and weighed
- Results were then quantified

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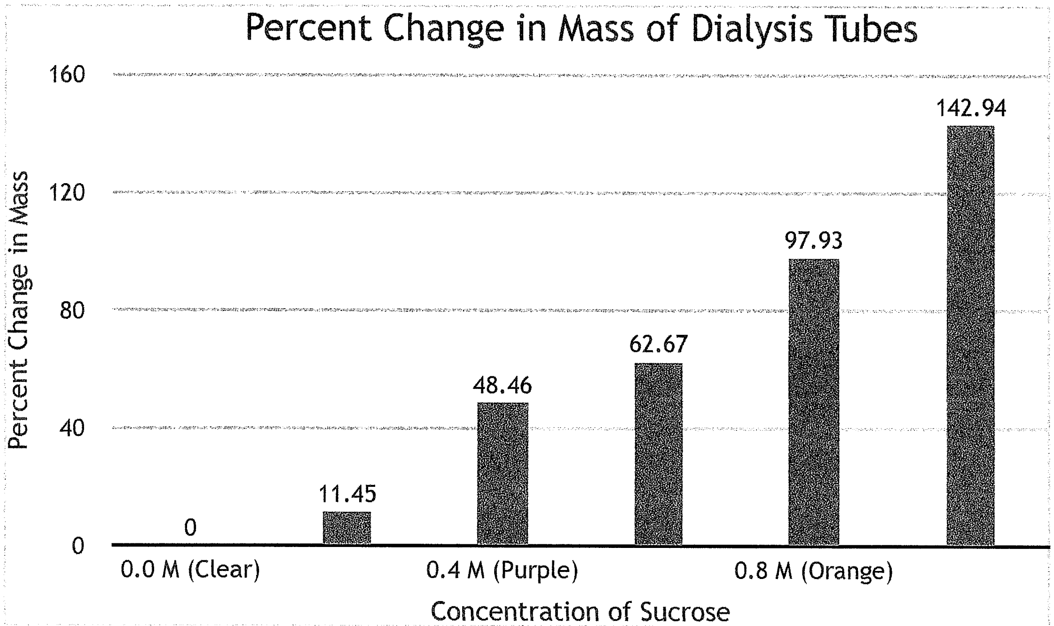
III. Results

Percent change = (Final mass – Initial mass) / Initial mass x 100%

Color	Concentration of Sucrose	Initial Mass	Final Mass	Percent Change in Mass
Clear	0.0 M	12.10 g	12.10 g	0%
Yellow	0.2 M	11.18 g	12.46 g	11.45%

Purple	0.4 M	12.30 g	18.26 g	48.46%
Blue	0.6 M	12.35 g	20.09 g	62.67%
Orange	0.8 M	12.05 g	23.85 g	97.93%
Green	1.0 M	12.11 g	29.42 g	142.94%



IV. Conclusions

After reviewing over the data, it appears that the hypothesis was supported. The concentration of solutes affects the rate of osmosis. It appears that the dialysis tube containing the highest concentration of sucrose, which was identified by the green color, experienced the largest percent change in mass. Since the concentration was high, the hypotonic solution of the environment compared to inside the dialysis tubing, resulted in water rushing into the dialysis tubing. As the concentration of sucrose continued to decrease, the amount of water entering the tube decreased because of the less hypotonic environment. The water solution had no percent change in mass because of no solute and, thus an isotonic environment. The rate of osmosis is effected by the types of materials, such as proteins or lipids, and the permeability of the tubing. However, the sucrose solution was effectively able to diffuse across the membrane.

There were limitations or potential errors in the experiment. The use of the dialysis tubing limited a study of how different material membranes effects the diffusion of different solutions or molecules. Others include recording and measurement errors, and technique errors with pipettes. Further extensions to the lab include the use of other membranes, different solutions, different duration of experiment time and the use of more precise measurement tools.

The enduring understandings in this experiment were one, growth, reproduction, and dynamic homeostasis require that cells create and maintain internal environments that are different from their external environments, stating that cell membranes are selectively permeable due to their structure and growth and dynamic homeostasis are maintained by the constant movement of molecules across membranes. These understandings are evident in the study of how solutes and water are able to diffuse across specific membranes, establishing hypertonic, hypotonic or isotonic environments to establish equilibrium.