**Module 2. Concentrations—Biology**  
*Dr. Hirrel, Mr. Mimms, and Ms Waggoner*

**Diffusion - agar, cell size, vernier probes**

**Principle of diffusion**

**Observation- Engage**

Matter moves by diffusion along energy gradients from areas of high concentration to areas of lower concentration. The rate of diffusion is dependent on (1) temperature, (2) size of the particles, and (3) the size of the concentration gradient. In biology, the selectively permeable cell membrane creates two special forms of diffusion: **osmosis** for the diffusion of water, and **dialysis** for the diffusion of solutes.

Activity (10 -15 min). There are any number of demonstrations that can be done to show the diffusion of matter outside a biological system. Select an appropriate one for your class. Have students make observations before and after.

Activity (15 -20 min). The biology of diffusion can be done to show:

1. The effects of cell size on diffusion:
   - Using a pan of "Agar brownies" cut to different sizes and containing a pH indicator.
   - Using potato plugs cut with 3 -4 different size cork borers and placed in a Lugol's iodine solution for 5 -10 minutes. Cut plug and observe diffusion (starch and iodine form dark blue color).

2. The effect of osmotic balance on tissues using potato plugs or cubes to compare weight changes in distilled water (0% salt) and in 3.5% salt water (salinity of seawater).

   *Teachable Moment: Convert 3.5% NaCl to mM concentration.*

Discussion of what is happening at the cell level. Have students draw what is happening to the cell in terms of osmosis and dialysis. Answer the following:

- Where is the energy (concentration) of water or salts greater?
- Does water or salt diffuse into or out of the cell?
- What happened to the weight of the potato? If the potato increased weight, what happened to the cells; if it lost weight, what happened to the cells?
- What would happen if the potato was placed in 1% salt water instead of 3.5%? Would it happen as fast?
- What would happen, if the potato was kept for 24 hours in the solutions?

RQ: Does the rate of diffusion vary with concentration?

**Hypothesis- Explore**

Activity (10-15 min). Based on RQ, formulate a hypothesis about the rate of diffusion changing with concentration. Predict what would happen to the rate of diffusion if the concentration doubled.

**Experiment- Explain**

Activity (15-20 min). Design the experiment to test the hypothesis.

- What type of “cell” is needed?

*Teachable Moment: Discuss using living cells as models compared to artificial cells, what the pros and cons of them.*

- What are the independent and dependent variables?

- How many experimental and control groups are needed? How many replications of each?

- What data needs to be collected?

Activity (10-15 min). Graph the expected results to support your hypothesis.

Activity (30-40 min). Conduct the experiment. Prepare a data collection table.

*Artificial Cell.* Dialysis membrane tubing is typically used as a model for a cell, and is very inexpensive. Use a nylon thread or dental floss to tie tubing into cells. Size of cell is based on volume of the solutions; 20-25mL is good.

Assembly: Over cut membrane from the size needed, tie one end, fill using large syringe or basting dropper, tie other end at top so there are no air bubbles, and trim extra membrane from ends to make cells a uniform size.

*Gravimetric approach.* Use artificial cells or potato plugs/cubes (plugs are more uniform than cubes). Use a balance (0.1g or better) to measure weight change over time (Note, the more accurate the balance the smaller the potato). A 5-6g piece should be sufficient. Measure weight change 3-5 times during period.

*LabQuest approach.* Use artificial cells. Fill with NaCl solutions (0, 1, 2, and 3% NaCl).

Probe: Conductivity probe set at 0-2000 μS range

Data collection: Time = 300s Sampling = 1 time every 20-30s.

Procedure: The cell is placed in a beaker or bowl of distilled water and the solution is allowed to diffuse out for 5 min taking 10-15 samples of conductivity, μS. Start LabQuest collecting data before placing the cell into
water. Placement of the probe may require gentle swirling the water after each sample to mix solutions for proper reading. A mini stir plate can be used and more samples can be taken.
Results- Evaluate

Activity (20 -30 min). Evaluate and analyze results. Examine the graph and highlight the region with the fastest rate of diffusion. From the ANALZE menu, select curve fit, then select linear fit (m = the rate, μS/s. Graph concentration by rate.

Teachable Moment: Write a caption for the graph and make it a Figure. It should include, what is being depicted?...effect of..., what is the key result?...as the concentration doubles the rate of diffusion...

Conclusion- Elaborate

Activity (15 -30 min). Do the results support or reject the hypothesis? Quantify the difference in the rates of diffusion between concentrations. Does the rate double when the salt concentration doubles?

Teachable Moment: Curve fitting, when to use a Best-Fit-Line.

What is the equation of the line?

Activity (out of class). Write a report.

Extension

Activity (15 -20 min). What is the biological meaning or relevance from the conclusion? If supporting hypothesis, then what is the next RQ to answer? If rejecting hypothesis, then how could the experiment be modified to test the hypothesis better?

Problem 1: Based on the equation of the line from the results figure, what is the diffusion rate if a cell was placed in 3.5% NaCl, the average salinity of seawater.

Problem 2: As the human population grows, there is more need for food. Rivers in the West are increasing in salinity due to over fertilization. From the transpiration investigation, what problems would a plant have with transpiration, if it was watered with salt water?

Problem 3. Kidneys play a key role in osmotic balance in animals. How do the kidneys of saltwater fish compare to freshwater fish? Who urinates more?
Essential Equipment & Materials

Agar
pH indicator
potato
cork borer to form plugs, or knives to cut cubes
distilled water
1,2,3,& 3.5 % NaCl water
Balance (0.1g) or better
Dialysis membrane tubing (Carolina or Nasco)
Nylon thread or dental floss- avoid fishline
Potato
Cork borers or kitchen knives
LabQuest
Conductivity probe
Beakers or bowls
Mini stir plate (optional)