Lesson 5: Changing Salinity in an Estuary

Focus Question:
How do estuarine animals adapt to changes in salinity?

Objective:
- To understand the concept of osmosis
- To understand the process of diffusion.

S.C. Curriculum Standards:
5-1 The student will demonstrate an understanding of scientific inquiry, including the foundations of technological design and the processes, skills, and mathematical thinking necessary to conduct a controlled scientific investigation.
5-2.3 Compare the characteristics of different ecosystems (including estuaries/salt marshes, oceans, lakes and ponds, forests, and grasslands).
7-2.4 Explain how cellular processes (including respiration, photosynthesis in plants, mitosis, and waste elimination) are essential to the survival of the organism.

Purpose: This is an observation and analysis activity focused on osmosis. Students will investigate how different salinities affect living cells. This leads to understanding of estuarine animals and their ability to handle changing salinities due to tides.

Time Duration: About 15 minutes on one day and 1 hour on another day.

Materials:
- 2 large baking potatoes, (cut into thick French-fry slices)
- 3 bowls or containers (holding ½ qt or ½ liter of water)
- table salt
- ½ cup measuring scoop
- Markers
- Food coloring
- Student Worksheet (Appendix 1)

Vocabulary:
Diffusion: the process in which particles spread through random motion from regions of relative high concentration.
Osmosis: the movement of water across a semi-permeable membrane, like a cell wall, from a higher concentration of water to a lower concentration of water.
Osmoregulation: the process of plants and animals regulate the movement of water and salt concentrations in their cells.
Salinity: the relative amount of salt dissolved in water. (Seawater has about 35 parts of salts dissolved in about 1000 parts of water. Freshwater has less than 5 parts of salts dissolved in 1000 parts of water.
Semi-permeable membrane: a thin cell layer that permits the free passage of water but prevents the passage of solutes like salts.

Procedures:

Hooking Students (2 Demonstrations)

Teacher will set up a two day experiment demonstrating and comparing osmosis and diffusion.

1. **Diffusion Demonstration:** DAY 1
    a. In a clear bowl full of tap water, add 10 drops of food color in one spot. Do not stir. What is happening to the color?
    b. Ask students to predict what the bowl with food coloring will look like the next day.

2. **Diffusion Demonstration:** DAY 2
    a. Retrieve the bowl with food coloring.
    b. What happened with the food color?
    c. Ask the students what happened in the bowl. Describe the chemical change.

3. **Osmosis Demonstration**: DAY 1
    a. In one bowl, mix water and about ½ cup of salt, until dissolved—label "saltwater".
    b. In the other bowl, add water—label "freshwater".
    c. Slice fresh potatoes and let students observe and feel the potato slices. Have them write down their observations on their Student Worksheets.
    d. Put half of the slices in freshwater and half in saltwater .
    e. Ask the students to predict any changes in the potato slices after 24 hours in the two bowls.
4. **Osmosis Demonstration**: DAY 2
    a. Retrieve the two bowls containing potato slices and ask for a volunteer to take a slice from each bowl and describe the difference to the other students.
    b. Now let each student have a turn and feel a pair of the potato slices.
    c. Have students record observations on the student worksheet.
    d. Ask them to explain what happened to the potato. Ask to consider what happened in the potato cells.

Demonstration Discussion:

Osmosis Discussion:

It is very important that they understand the changes in the potato slices were due to "osmosis" or the movement of water through the cell membrane to dilute the lower concentration of water.

(NOTE: The freshwater in the bowl had a greater concentration of water than the potato cell, so water moved from the bowl into the potato cell; therefore, the potato slice felt firmer or more turgid than the day before. In the opposite case of submersion in saltwater, the concentration of water was less in the bowl, so water moved through the cell wall from the potato to the saltwater. The result is that the potato slice felt limp and more flexible.)

Diffusion Discussion:
In the "diffusion" experiment, the food coloring spread throughout the bowl of water moving outward from the original point of concentration.

Student Engagement:
Using what you have learned from the demonstration, set up a KWL Chart to understand how the changing salinities in an estuary affect the cells of animals.

"K" What do you know:
Brainstorm with your students what the effect of salt water and freshwater have on animal cells (refer to the potato slices). Extend their thinking to what might happen to a salt water fish, like a mackerel, if it migrated up a freshwater river. Then consider what might happen to the body cells of a freshwater fish, like a carp, if it were tossed into the sea. (Consider the potato slices). What regulates the amount of water in our cell tissues (our kidneys)? In both cases, these specific fish do not have adaptations to cope with the radical change of salt in their watery environment. However, some fish and other animal do have adaptations to changes in salinities. What does this mean in an estuary. Write these responses on the Chart.

"W" What do you want to know:
What questions do you have about fish and other animals, like worms, crabs, oysters, that live in the changing salinity of an estuary? Write down questions and ideas.

"L" What have you learned?
Based on your reading and experiences, now describe some of the adaptations that estuarine animals have to survive in an estuary with changing salinities.

Appendix 1: STUDENT WORKSHEET (Teacher copy)

Prediction:

1. State your predictions on what will happen to the potato slices from FRESH container:
   Will vary.

2. State your predictions on what will happen to the potato slices from SALTY container:
   Will vary.

Materials and Methods:

3. List materials used (Be specific and include units when possible):
   8-10 potato slices
   4 medium sized containers
   ½ cup of salt
   Tap water
   ½ cup measuring scoop
   Spoons
   Food coloring

4. Describe what you did:

Results:

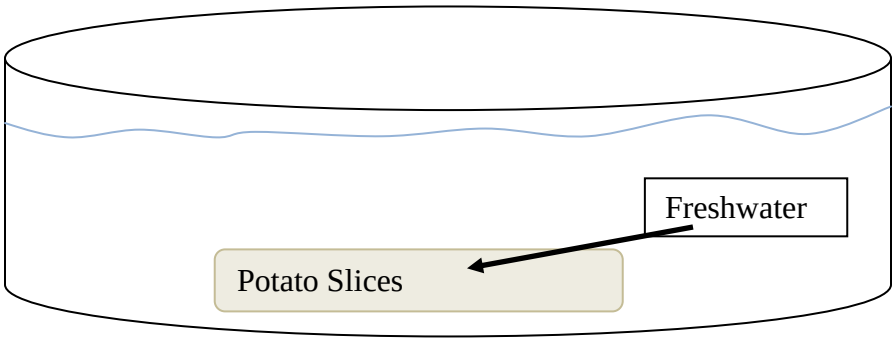
Data Table:

Container:	FRESHWATER	SALTWATER
Day 1: Potato Observation & Description	*All potato slices are white and slightly flexible*	*All potato slices are white and slightly flexible*
Day 2: Potato Observation & Description	*All 5 potato slices had turned brighter white and were stiff (not flexible) at all and broke easily*	*All 5 potato slices had turned brown and were really flexible- we couldn't break them.*

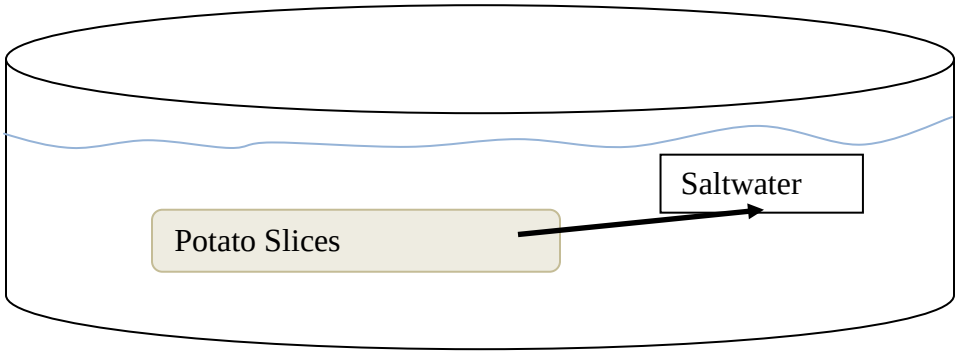
5. Why did the potato slices in freshwater become firmer?
   Water moved from the container to the potato's cell making it firmer.

6. Why did the potato slices in the saltwater become flimsy?
   Water moved from the potato cell to the container's solution.

7. Use arrows to show direction of water movement in or out of the potato slice. Why does water from the potato not flow into the container?
   Because in osmosis, water flows from areas of higher concentrations of water to lower concentrations of water and only water can flow across the semi-permeable membrane of the potato cell.



8. Use arrows to show direction of water movement in or out of the potato slice. Where is the greater concentration of water: in the potato or in the container's solution?
   The greatest concentration is in the potato slices so water flows across the potato's semi-permeable membrane into the jar which cause the potato's cells to collapse.



9. What happens to the cells of a saltwater fish, like a mackerel, if it swims from the ocean into a freshwater river?
   The cells tend to fill with water and the fish does not have the ability to get rid of the excess water.

Focus Question: How do estuarine animals adapt to changes in salinity?

STUDENT WORKSHEET

Prediction:

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2. State your predictions on what will happen to the potato slices from SALTY container:

Materials and Methods:

3. List materials used (Be specific and include units when possible):

4. Describe what you did:

Results:

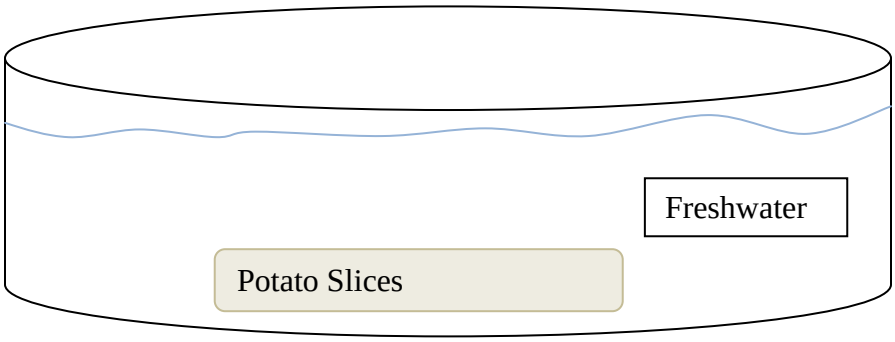
Data Table:

Container:	**FRESHWATER**	**SALTWATER**
Day 1: Potato Observation & Description		
Day 2: Potato Observation & Description		

5. Why did the potato slices in freshwater become firmer?

6. Why did the potato slices in the saltwater become flimsy?

7. Use arrows to show direction of water movement in or out of the potato slice. Why does water from the potato not flow into the container?



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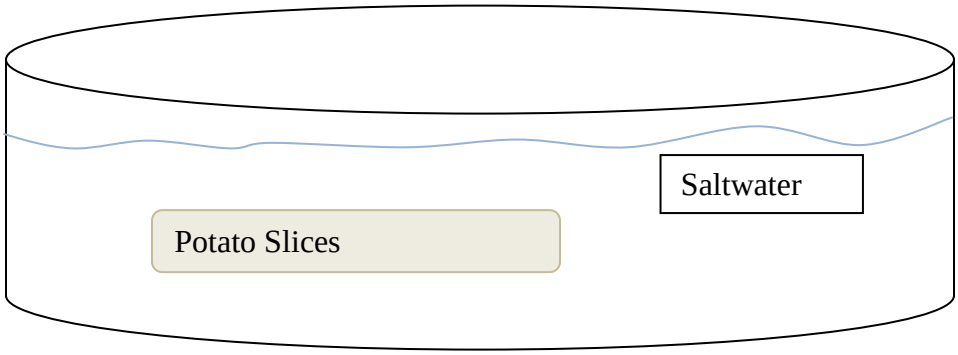

9. What happens to the cells of a saltwater fish, like a mackerel, if it swims from the ocean into a freshwater river?

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Appendix 2: Background Information on OSMOSIS

Copied with permission from L. Spence and D. Frankenberg's NC Marine Education Manual, Unit 3: Coastal Ecology

Osmosis is the passage of water from a region of high water concentration through a semi-permeable membrane to a region of low water concentration. Thus, marine fish with body fluids containing higher concentrations of water than the seawater surrounding them constantly lose water through cell membranes. Freshwater fish with body fluid water concentrations lower than lakes or streams will gain water. Both tendencies must be countered to preserve body fluid water balance. A few fish or invertebrates survive where salinities range both above and below body fluid water concentrations. Most are adapted to only one end of the spectrum and thus are confined to marine or fresh water, and cannot tolerate the variable environment of estuaries.

Marine bony fish (as opposed to cartilaginous fish like sharks) lose water through gills and mouth and would become dehydrated except for adaptations designed to restrict water loss. These adaptations include 1.) drinking seawater and excreting salt through gills to offset the loss; 2.) conserving water usually lost as urine by an elaborate kidney system. Freshwater fish on the other hand, do not drink large quantities of water and do excrete copious amounts of dilute urine. When fish enter estuaries, they must be able to adjust their water balance (osmoregulate). Marine fish have this ability to a greater degree than do freshwater fish. The adaptability of marine fish is largely dependent on low permeability of their body surfaces to water (think scales and mucous membrane) and extraordinary salt regulating activities of gills and kidneys. Most estuarine fish return to the sea for spawning.