Osmosis and Diffusion

Students will explore the concepts of osmosis and diffusion through two days of lessons. Students will build upon prior knowledge of cell structure and function as they consider how cells move molecules in and out through the cell membrane and interact with the environment. They will observe real-life examples of osmosis and diffusion and use concept maps to show relationships. Finally, students will use new knowledge and experience with osmosis and diffusion to design their own experiment that proves how a membrane is semi-permeable.

Audience

Of the four teachers in our study group, three teach seventh grade and one teaches sixth grade science. All of our students are around the ages of 11-13. Two instructors teach in urban areas and two teach in suburban schools. Science class sizes are around 25 pupils. All classes have both male and female children, and all four teachers have heterogeneously grouped ability levels within their classes. The classes are instructed for 45-90 minutes per day. More specific descriptions and modifications for individual classes can be found at the end of the report.

These lessons are appropriate for middle level students for many reasons. They include hands-on activities, which are key for holding the students’ interests. The initial question prompts students to begin thinking about the movement of molecules in and out of the cell. The lesson begins with observations of diffusion/osmosis examples at stations. These allow for student inquiry and reflection on the processes. The whole group discussion at the end of day one/two allows for sharing of ideas and clarification of the actual diffusion & osmosis processes. During the second lesson, the student-created demonstrations of the concept will be an excellent assessment of whether or not the pupils truly grasp the ideas. Regardless of the way the experiment is developed, the students should have the same outcome. Also, the real-world application questions are presented as further evidence that these processes are happening both in our own bodies and throughout the world.

In our experience, when students perform investigations in small groups there is a greater performance on test and quiz grades, an increase in class participation and an increase in student confidence level. Group work also sets an atmosphere where students are skills that are needed in a real world. For group activities to be effective, grouping methods and evaluation are critical. Each student’s learning modality, interests, strengths, and weaknesses should be used to group students heterogeneously. During group activities, the teacher should circulate throughout the classroom while listening and recording student responses and thought processes. Teachers should also correct individual and group misconceptions. After students complete their final group activity, the teacher must collect and analyze results, summarize the lesson and address all misconceptions that he/she recorded.
**Enduring Understanding:**
We can understand biological phenomena by analyzing them at multiple levels.

**Big Ideas:**
1. Molecules move into and out of cells along a concentration gradient
2. Cells have semi-permeable boundaries
3. Molecules are constantly in motion
4. The concentration of cells change with their changing environment

**Importance:** You are what you eat.

**Essential Questions:**
1. Why do we say, “You are what you eat?”
2. Why do cells transport molecules in and out of their membranes?
3. How do cells adapt to their environments?

**What students will need to know and be able to do**
**(knowledge and skills):**
1. Design an experiment proving membranes can be selectively permeable.
2. Explain the process of diffusion.
3. Describe how osmosis occurs.
4. Compare and contrast diffusion and osmosis.
5. Identify a concentration gradient and its relationship to transport.

**What do students typically misunderstand?**

Our combined experiences teaching life science has shown these topics to be difficult for sixth and seventh graders. Research also shows common student misconceptions in these areas. In particular, students have trouble understanding that cells – like multi-cellular organisms – live in an environment and must perform all activities necessary to stay alive. Common student misconceptions also include confusion about the difference between cells and molecules and the size difference between proteins, molecules and cells (Holt 2005).

A 2003 study on addressing student misconceptions – specifically osmosis and diffusion – showed significant change when students were instructed through concept mapping and conceptual change text (Tekkaya 2003). The study was developed to promote meaningful learning in order to address misunderstandings about diffusion and osmosis. Several of the fallacies found by Tekkaya are addressed within the teacher notes of our lesson. The study found that many misconceptions held by students were resistant to change by traditional teaching practices, such as textbook readings and direct instruction with minimal student involvement. When allowed to explore their own ideas and work in collaborative groups, students were found to be more successful in recognizing their false impressions and accepting scientific reasons. Tekkaya used two groups of students to evaluate whether traditional methods or inquiry methods were more effective in leading to a conceptual change. The final result showed a significant difference; the number of experimental group students holding a scientifically correct
view rose 31.6%, compared to a 19.6% gain for students taught with traditional methods (Tekkaya).

This study reinforces our decision to use a variety of strategies to address student misconceptions and ensure meaningful understanding. Through these two lessons, students will be introduced to topics with questions aimed at revealing false impressions. The activities are designed to enhance content, make real life connections and elicit critical thinking, which in turn will lead to deeper content knowledge about passive transport. More specifically, we will use concept-mapping strategies, as suggested in Tekkaya’s article, to help students make connections and “see” relationships between different cell processes as well as within the levels of organization.

**Student Prior Knowledge:**

Students will learn osmosis and diffusion after studying cell structure and function. Before these lessons, it is assumed that students will have the following prior knowledge:

- Cell structure and function
- Molecules are always in motion
- Cell permeability
- Cells turn food into chemicals for energy
- Cells store and use energy for building materials, transport and controlling life processes
- Cells need chemical compounds to perform functions and build structures

**Standards:**

National Standards

Content Standard A: Science as Inquiry

- Ability necessary to do scientific inquiry
- Understandings about scientific inquiry

New Jersey Standards

5.1 All students will develop problem solving, decision making and inquiry skills, reflected by formulating usable questions and hypotheses, planning experiments, conducting systemic observations, interpreting and analyzing data, drawing conclusions and communicating results.

5.5 All students will gain an understanding of the structure, characteristics and basic needs of organisms and will investigate the diversity of life.

Pennsylvania Standards

3.3.7A - Describe the similarities and differences that characterize diverse living things.

3.3.7B - Describe the cell as the basic structural and functional unit of living things.

3.2.7A – Explain and apply scientific and technological knowledge.
3.2.7B - Apply process knowledge to make and interpret observations.
3.2.7C – Identify and use the elements of science inquiry to solve problems.

**Content**

One characteristic that scientists use to identify organisms is the presence of cells. Some organisms are unicellular (having one cell), and others are multi-cellular (having many cells). The structures in cells vary depending on the cell’s function. One structure common among all cells is the cell membrane. The cell membrane forms a boundary of most cells and regulates what enters and exits the cell. It is made of a phospholipid bi-layer that makes it semi-permeable. Within the cell membrane are proteins and carbohydrates that also control what is able to enter and exit the cell.

Inside the cell is cytosol, which is composed of mostly water, as well as other compounds such as salts, proteins and carbohydrates. The materials inside of the cell contribute to a concentration gradient between the cell and its environment. To maintain equilibrium (constant concentration inside and outside of the cell), molecules constantly cross the cell membrane. Small molecules such as water, oxygen and carbon dioxide move across the cell membrane without using energy. Factors that contribute to the movement of these molecules include unequal concentrations inside and out of the cell and the constant movement of molecules. If there is a higher concentration of water on one side of the cell, the water molecules will collide and move across the membrane in the direction of the lower concentration of water. This process is called osmosis. Osmosis will continue until the cell reaches a state of equilibrium. Because molecules are constantly in motion, the water continues to cross the membrane but does not result in a change of concentration. Molecules such as oxygen and carbon dioxide behave in the same manner as water, but the process is known as diffusion.

**Teaching Method(s), Instructional Procedures, and Learning Activities:**

**Day One/Two**

(Teacher might choose to teach this lesson over two days to allow for proper implementation given time constraints).

**Objective:** Students will be able to observe and compare the effects of diffusion and osmosis.

**Anticipatory Set:** Teacher will check for prior knowledge of diffusion and osmosis by having students complete the following questions on an activity sheet:

*Teacher Note:* The activity sheet will be given for the anticipatory set to allow students to visualize the concepts as they are processing an answer. It will also allow the teacher to evaluate the student’s thought process. Students have already studied the structure and
function of cells. They have been told that the cell membrane is semi-permeable and are able to define “semi-permeability.”

1. (picture of balloon with 20 drops of vanilla inside it) Will you be able to smell the vanilla that is inside the balloon? Why or why not?
   a. **Teacher Note:** Can the students apply the concept of permeability? Do students believe that a balloon can be semi-permeable? Do they believe that its semi-permeability will allow them to smell the vanilla through the balloon?

2. (picture of air freshener with spray coming out of it) If freshener is sprayed in the front of the classroom, will the students in the back be able to smell it?
   a. **Teacher note:** Do the students believe that molecules are constantly in motion? Do students believe that molecules want to spread out? Are students aware of the movement of molecules from a high to low concentration?

3. (picture of beaker of cold water, and one of hot water) If you add food coloring to both of these beakers at the same time, what will happen? Why?
   a. **Teacher note:** Do students believe that molecules are constantly in motion? Do students believe that temperature influences the speed at which molecules move? This question aims at another misunderstanding highlighted by Tekkaya’s study. Students had to identify the process that caused a drop of blue dye to spread throughout a beaker of clear water. Students overwhelmingly answered incorrectly; they explained “the process responsible … because the dye separates into smaller particles and mixes with water” (2003). Students were not aware that molecules are constantly in motion, causing the dye to diffuse.

**Instructional Input:**
1. Review cell membrane permeability.
2. Introduce osmosis and diffusion by demonstrating scenarios presented in the Anticipatory Set, and reviewing the answers.

**Guided Practice:**

*Teacher Note:* This demonstration addresses a misconception highlighted in Tekkaya’s study. Students showed difficulty with the idea of a concentration gradient; they believed that diffusion was dependent upon space available within an area, rather than unequal concentration levels and constant random motion of molecules (Tekkaya 2003).

1. Teacher will introduce the concept of concentration gradient using a stalk of celery in fresh water versus one in salt water.
   a. Celery in salt water: teacher will review the fact that cell’s cytoplasm is composed of a great amount of water. There is a greater percentage of water inside of cells than in the salt water surrounding the cells. This unequal amount of water inside and outside of the cell creates a concentration gradient. The cell wants to be in balance with its environment, so water will leave the cell. Water will leave rather than salt
entering because it is small enough to pass through the membrane. The salt is too large to pass through the membrane.

b. Celery in plain water: The cell is not only made up of water, there are also salts, sugars and proteins. Because there is only water in the beaker, there is a greater water concentration in the beaker than the cells of the celery. This creates a concentration gradient, and to reach a balance, water enters the cells. As stated previously, water moves because it can freely pass through the cell membrane. The other molecules are too large.

2. Teacher and students will discuss differences between the amount of water inside and outside of the cells and its effects on the size of the celery cells.
3. Teacher and students will discuss the impact of the environment on the concentration of molecules in cells.
4. Teacher will set up two sets of each of the three stations. Students will be assigned to groups of 4 members. Directions will be given for the independent practice.

**Independent Practice:**
Have 2 sets of the three stations set-up at tables. Groups of students should be around 4 members.

**Station 1**
**Setup** - pieces of potato in cups of regular water and in salt water

Question for Students to Answer:
1. Describe the flexibility of each of the potato slices.
2. What types of macromolecules would you find in a potato?
3. What is causing the difference in flexibility in each potato?

*Teacher note:* Students will see the difference in concentration gradients between the three samples. Students will see that the potato in salt water will become limp because the water moves out of the cells via osmosis. The one in fresh water will become hard and have minimal flexibility because water will move into the cells.

**Station 2**
**Set-up** – picture of normal slug & one of slug covered in salt
Questions for students to answer:
1. Using the picture or past experience, what happens to a slug when salt is put on it?
2. Knowing that a slug is a living thing, what molecule makes up most of the slugs’ cells?
3. What is causing the appearance of the salted slug?

*Teacher note:* The water in the salted slug’s cells moves out of the cell through osmosis. Be sure to clarify that the slug is not “burning,” and describe why the slug dies.
Station 3

Set-up – microscope with Elodea in fresh water slide

Questions for students to answer:
1. After viewing the slide, draw a picture of what the Elodea cells would look like after being placed in salt water.
2. Draw an arrow showing what happens to the water contained inside the Elodea cell.

Teacher note: For #1, students will observe that cell membrane is close to the cell wall and chloroplasts are spread throughout the cell. In #2, students will draw arrows pointing out of the cell to show movement of water by the process of osmosis. Show an actual slide of Elodea in salt water at the end as proof of osmosis.

Group Discussion: Students will reconvene as a whole group after visiting all three stations. Students will be given a concept map (attached) to complete individually. This concept map allows the teacher to check for misconceptions regarding the relationship between diffusion and osmosis. It will also be used as a way for students to see the connection between the scientific concepts and specific examples from class. As noted in Tekkaya, “concept mapping … can result in better understanding of diffusion and osmosis through differentiation, exchange and integration of new conceptions into existing ones” (2003). The teacher will facilitate a discussion based on the answers, using the LCD projector to show the final correct concept map. (See teacher notes above for detailed answers)

Homework question:
Ingrid had a birthday and was able to choose a pet. The pet that she chose was a beautiful clownfish named NancyLee, a common salt water fish. Ingrid already has a tank with goldfish at home. Use your knowledge of diffusion and osmosis to tell Ingrid how to take care of NancyLee.

Day Three/Four
(Teacher might choose to teach this lesson over two days to allow for proper implementation given time constraints. On the first day, students will be given instructions and be required to write a hypothesis and a set of procedures. On the second day, students will set up their experiment and make observations).

Objective: Students will be able to design an experiment proving that membranes can be selectively permeable.

Materials (per group): 20 cm piece of dialysis tubing, 100 mL starch solution, 10 mL iodine solution, beakers, water, two pieces of string (10 cm long)

Anticipatory Set:
Teacher will review homework question regarding clownfish.
**Answer:** Goldfish are freshwater fish, while NancyLee (the beautiful clownfish) is a saltwater fish. Ingrid must put NancyLee in a separate tank with saltwater. If NancyLee is placed in the freshwater, she will expand due to the difference in concentration between NancyLee and the environment. This will kill NancyLee and upset Ingrid.

Teacher will review diffusion by showing students a cube containing pieces that represent a membrane, iodine and starch. Students will answer the question, “What is larger, starch or iodine? How do you know?”

(Students will be expected to know the answer based on prior lessons on molecules, compounds and elements)

**Guided Practice:**
Students will be assigned to groups of 2 or 3.
Teacher and students will discuss the answers to the questions from the anticipatory set. Teachers will instruct students to design an experiment, using the materials, to prove that membranes can be selectively permeable.

**Independent Practice:**
Students work in groups to design an experiment. The procedure must be written and checked by the teacher before setting up the experiment. Students perform their experiment and complete a written lab report. In their observation sections, students will be required to sketch their initial and final set-up and use arrows and labels to show what process is occurring.

**Closure** (by the end of second day of lesson):
Students will report findings to class. Teacher will facilitate discussion about different methods with which students carried out their experiments. Students will use dry erase boards to answer the following question:
“You have a dialysis bag filled with starch solution. The bag is placed in iodine. Will you observe diffusion? Will you observe osmosis? Draw a picture of the process that will take place.”

**Answer:** You will observe diffusion as the size of iodine allows it to enter through the semi-permeable dialysis bag into the starch solution. We know the iodine enters because the iodine turns from purple to black, as it reacts with the starch. This is not an example of osmosis, because iodine is being transported, not water.

**Teacher Note:** Students’ pictures should illustrate the answer given above.

**Assessments:**
Written lab reports
Student dry erase diagrams

* Several general rubrics are attached to this lesson plan. These rubrics should be used as a guide for individual teachers to adapt to fit the needs of their classes.
**Modifications for students with learning disabilities:**

In a period with an in-class support special education teacher, a modification may be made by splitting the students in half for instruction. By having a smaller number of pupils in a group, instruction can be tailored specifically for participants. It is easier to address misconceptions and answer questions in a small group setting. Groups can be constructed by mixed or same ability, depending on the class dynamics. The advantage of having two teachers available is that multiple explanations of the processes can be provided, in the hope that one of them will “make sense” for each of the students. It also allows for the teachers to more successfully assist students in making their lab procedures and prompting their observations during the station activity.

**Extensions**

The concepts addressed in these lessons can also be extended with the “egg-speriment,” in which a raw egg serves as a model for the cell and various substances represent materials moving in and out of the cell. Students will complete this lab in groups, and present a full lab report including their explanations of their results. This is a long-term experiment supplying the chance for peer sharing and visual representation of the same cell undergoing various changes.
References Cited