Membrane Transport Lesson Plan
Topic: Membrane Structure and Passive Transport Date: 2/15/2013
NSES: Content Standard A: Students will learn the abilities Grade level: 10
necessary to do and understand scientific inquiry Subject: General Biology

SOLs:

BIO.2 a) water chemistry and its impact on life processes; b) the structure and function of macromolecules
BIO.3 d) the cell membrane model

Daily Question: How does the cell membrane regulate what enters and exits the cell?

SWBAT:

Draw the structure of the cell membrane.

Predict how certain materials would enter and exit the cell.

Describe how the selective permeability of the cell membrane affects the life of a cell.

Compare and contrast types of membrane transport, including diffusion, facilitated diffusion, osmosis, and active transport.

Describe the relationship between a cell’s external solute concentration and its effect on the cell’s internal solute concentration.

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<tbody>
<tr>
<td>Engagement:</td>
<td>What is homeostasis?</td>
<td>Powerpoint to project questions</td>
<td>Checking for understanding and gauging students prior knowledge of the term homeostasis</td>
<td>5 minutes</td>
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<tr>
<td>Pose questions to students:</td>
<td>What are some ways that organisms maintain homeostasis with their behavior?</td>
<td>Students own paper (or mini-whiteboards) for them to write on</td>
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<td></td>
<td>Today we’re going to study how cells maintain</td>
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Engagement:
Pose questions to students: Why do we shiver when we’re cold? Why do we sweat when we’re hot? Why do we breathe faster when we exercise? Why do we drink when we’re thirsty? Have them brainstorm what these behaviors do for us and have them discuss as pairs. As a class, discuss how these behaviors help maintain homeostasis.

Today we’re going to study how cells maintain homeostasis.
homeostasis. The cell membrane regulates what enters and exits the cell in order to maintain homeostasis. We’re going to learn about the structure of the cell membrane and how certain materials move across it into or out of the cell. First, we’re going to start with a discussion on how molecules move in general.

**Exploration:**

*There are powerpoint slides with questions on them that relate to these introductory activities*

Initiate a discussion about diffusion. Ask students to write what they think it means and draw a picture of it. Have a diffuser and ask students why they can smell it from far away and who can smell it most/least – what does that indicate about the concentration at those areas? What would happen over time if we left it there indefinitely?

Then relate to a living organism: We just talked about how molecules move in space. These same concepts apply to molecules moving in and out of a cell. Show an egg that has been soaked in water and one soaked in salt solution. Remind students that an egg is just one cell (and is surrounded by a cell membrane) Tell them these two eggs started out the same size, but you did something different to them. We are going to discuss that more later, but for now you want them to make observations about the two eggs. Then ask them to make inferences from those observations and make predictions about what they think might have caused the differences in the eggs. They should illustrate this as well.
We want to investigate diffusion through membranes on a molecular level, so we’re going to look at a simulation that you can make changes to in order to test your ideas.

In the classroom, open up the two simulation and model the two simulations, just to show students how to interact with them. Pass out the worksheets. Then tell students that we’re going to the computer lab so that they can use these on their own to make some observations.

Membrane channels simulation: 
http://phet.colorado.edu/en/simulation/membrane-channels
*Note: It’s possible that this simulation won’t work on New Kents computers. In that case I could do it as a class simulation and have students answer the accompanying questions in pairs.

Types of membrane transport simulation: 
http://www.teachersdomain.org/asset/tdc02_int_membrane

**Explanation:**

Use powerpoint and **guided notes** to go through fluid mosaic membrane model.
- Make sure to click through to animations!
- After talking about the lipid bilayer, have students get up and make two rows, extending their arms towards someone in the other row.
  Ask students what their bodies represent

| What is the cell membrane made up of? How do those components contribute to its function? | What is homeostasis and how does the membrane maintain it? | Powerpoint

| Internet access | Osmosis Eggs | Interactive notes for |

| Checking for understanding with questioning and monitoring engagement |

| Concepts will be assessed |

30 minutes
(phosphate heads) and what their arms represent (fatty acid tails). If we want to model the mosaic aspect of the membrane, what can we change? Some students become proteins or make desks proteins. Now we want to model the fluidity part, what should we do? Students move around each other but NOT running around, they are still structured.

Return to Passive transport notes through osmosis. After discussion of osmosis but before introducing the vocabulary of hypertonic and hypotonic, go back to the simulation and explain that this time you want to let green dots represent solute (like salt) and the blue diamonds represent water molecules. Ask students how we should set up the simulation to model a real scenario in the cell. (They should figure out that the membrane will be permeable to water but not solute)

Then use the simulation to model a hypotonic solution. Ask students to predict which direction water will move and why. After observations, review what happened (make sure to reinforce that the water moved from high to low concentration) Ask students to make predictions about how the actual cell would be responding to the movements of water (Shrink? Get bigger? Stay the same?). Which egg would it start to look like?

Then introduce the vocabulary of hypotonic and hypertonic solutions. Make connections to the simulation and the egg examples.
Extension:

Tell students that you want to think about how you could use what we learned about hypertonic and hypotonic solutions to find out what the solute concentration is inside of an egg. Have students brainstorm in pairs for 3 minutes. Fill out an experimental design diagram using document camera. This is an opportunity to reinforce concepts of osmosis and how it affects the cell and also to review experimental design.

Distribute worksheet for students to practice with hypertonic and hypotonic solutions, labeling a cell membrane and explaining phospholipid structure.

How can we use the concepts of hypotonic and hypertonic solutions to figure out the solute concentration of an egg?

Solutions worksheet will be collected and checked for completion 15-20 minutes

Notes:

This lesson is part of the unit on cell structure and function. It follows lessons about cellular organelles and will be followed by a lesson on active transport.

Adaptations:

- Students will be given copies of the notes who require notes hand-outs
- I will be walking around and helping students who are having difficulty with
- This lesson presents material in multiple ways: hands-on demonstrations and manipulations, visuals, and oral instruction in order to provide multi-sensory instruction, which is included in several students’ IEPs

Technology Use:

- Interactive manipulations are used both by the students and the teachers in order to allow students to investigate and visualize molecular motion, which wouldn’t be feasible without computer simulation
Inquiry:
- Students answer questions and develop ideas about molecular movement and membrane transport by making observations of computer simulations
- Students develop an experimental procedure that incorporates and extends important concepts from the lesson

Safety Notes:
- Students should be careful when handling the eggs so as not to break them. If an egg does get broken, anyone who came in contact with it should wash their hands thoroughly.
- Students should follow all behavior guidelines when walking to and from the computer lab

Sources:
- **Powerpoints** using resources from Monica Schnautz, Sheila Morris, Kate Ottolini, Mr. Croft (http://www.mrcroft.com/)
- **Egg Osmosis** idea from Sheila Morris
- **Simulations WS** draws questions from Resources on phet site from Trish Loeblein, Christopher Link, and Fred O’Leary
- **Osmosis WS** from http://www.mrcroft.com/
Part 1: Membrane Channels

Google “phet membrane channels” and click the link for Membrane Channels - PhET OR go to http://phet.colorado.edu/en/simulation/membrane-channels and click Run Now! You may have to allow the computer to download something.

Add 20 green particles to the top (this does not need to be exact).

1. Slow the animation down and describe the motion of the green particles. Is it random or do they seem to be moving with a purpose? ________________________________

   What happens when the particles hit each other?

2. What happens when the particles hit the membrane?

3. Click on the show concentrations box. How would you describe the concentration (amount) of the green particles on the top half of the membrane? (High or Low) ____________ How would you describe the concentration of green particles below the membrane? (High or Low) ____________

Add 3 evenly spaced green gated channels to the membrane. Speed up the animation again and then click the Open Channels button.

4. What happens to the concentration of particles on the top? ________________________________ The concentration on the bottom?

5. Does an individual particle always move from the side with higher concentration to lower concentration?

Click on the reset all button and set up the green particles again. This time do the same thing with the blue particles on the bottom. Add 3 green channels and 3 blue channels.

6. Open both gates and observe the concentrations. Wait for at least 1 minute. What happens to the concentration lines on both sides of the membrane?

7. This is called the equilibrium point, when the concentrations even out. Do the concentrations remain exactly the same or do they vary?

Turn over and go to back for second simulation questions.
Part 2: Transport of Materials

Go to http://www.teachersdomain.org/asset/tdc02_int_membraneweb/

Click on the different materials and make observations about how they seem to be moving across the membrane. Write your observations here (you may include sketches as well):

Oxygen:

Carbon Dioxide:

Glucose:

Potassium:

Water:

Enzyme:

Make observations about what the membrane looks like and what it seems to be made up of.

What do you think the main functions are of the parts of the sketch labeled lipids and protein?

Lipids:

Protein:
Functions of The Cell Membrane
- The cell membrane maintains homeostasis in the cell: the ____________________________ between a cell of an organism and its environment. It controls what _______________ and _______________ the cell.
- Provides protection and support for the cell
- Recognizes foreign material
- Communicates with other cells

Structure of the Cell Membrane
- Lipid Bilayer
  - 2 layers of phospholipids
    - Phosphate head is ___________
      - “____________________”: water loving
    - Fatty acid tails are ______________
      - “____________________”: water fearing
    - _______________ are embedded in the membrane

Proteins in the Cell Membrane
- _______________ proteins: Span from one side of membrane to the other
- _______________ proteins: Only on one side of membrane (interior or exterior)

Fluid Mosaic Model
- Scientists used to think the components of membranes were ____________ and unmoving.
  - The updated model is called the Fluid Mosaic Model
    - “____________________” because the membrane is always _______________. Lipids and proteins can move around each other.
    - “____________________” because it is made up of many different parts

Label the missing parts below
- Polar heads __________ water
- Non-polar tails __________ water
- _______________ Protein
- _______________ Protein
• Types of Transport
  o ____________ transport: the cell ____________ energy
    ▪ Diffusion
    ▪ Facilitated Diffusion
    ▪ Osmosis
  o ____________ transport: the cell ____________ energy
    ▪ Protein Pumps
    ▪ Endocytosis
    ▪ Exocytosis

• Passive Transport
  o Cell uses ____________
  o Molecules move ____________
  o Molecules spread out from an area of ____________ concentration to an area of ____________ concentration.

• Diffusion
  o The process by which molecules move from an area of greater concentration to an area of lower concentration
  o ____________: molecules are in a constant state of random motion.
  o ____________: the difference in concentration of a substance across a space
    ▪ We say that a substance diffuses ____________ its concentration gradient (high -> low)
  o ____________: a state that exists when the concentration of a substance is the ____________ throughout.
    ▪ Solvent – ____________ (ex. Water)
    ▪ Solute – Substance that is ____________ (ex. Kool aid mix)

• Diffusion Across Membranes
  o Molecules move from a greater concentration on one side of the membrane to a lower concentration on the other side. Occurs because of random movement of molecules
  o Not all molecules can diffuse through all membranes.
    ▪ The ability of a molecule to pass through a cell membrane depends on the ____________ and ____________ of molecule.
    ▪ ____________ molecules can diffuse through the cell membrane
      • Ex) CO₂, O₂, H₂O, small lipids

• Facilitated Diffusion
  o Diffusion of particles from high to low concentration through ____________ in the membrane
  o Transport Proteins are ____________ – they only allow certain molecules to cross the membrane
  o Transports ____________ or ____________ molecules
    ▪ Ex) glucose, ions

• Osmosis
  o the diffusion of ____________ through a selectively permeable membrane
  o Water moves from an area of ____________ concentrations
  o Membranes are ____________ to water, but not to many solutes
Three types of solutions

- **Hypotonic**: The solution has a _______ concentration of solutes and a higher concentration of water than inside the cell. *(Low solute; High water)*
  - Result: Water moves from the solution to _________ the cell: Cell Swells and bursts open (______________)

- **Hypertonic**: The solution has a _________ concentration of solutes and a lower concentration of water than inside the cell. *(High solute; Low water)*
  - Result: Water moves from inside the cell into the solution: Cell shrinks (__________________)

- **Isotonic**: The concentration of solutes in the solution is _____________ the concentration of solutes inside the cell.
  - Result: Water moves equally in both directions and the cell remains same size! (______________________________
The Cell Membrane and Cell Transport

Homeostasis
- Homeostasis: the biological balance between a cell or an organism and its environment
- Cells maintain homeostasis by controlling and regulating what gets into and out of the cell.

The Cell Membrane
Functions:
- Controls what enters and exits the cell to maintain a balance called homeostasis
- Provides protection and support for the cell
- Recognizes foreign material
- Communicates with other cells

Structure of the Cell Membrane
- Lipid bilayer:
  - 2 layers of phospholipids
  - Phosphate head is polar
  - "Hyrophobic": water loving
  - Fatty acid tails are non-polar
  - "Hyrophobic": water fearing
  - Proteins embedded in the membrane

Proteins in the Cell Membrane
- Integral proteins:
  - Span from one side of membrane to the other
- Peripheral proteins:
  - Only on one side (interior or exterior)
**Fluid Mosaic Model**

- Scientists used to think the components of membranes were static and unmoving.
- "Fluid" because membrane is always moving. Lipids and proteins can move around each other.
- "Mosaic" because it is made up of many different parts.

**Modeling**

**Transport**

- **Passive transport:** the cell doesn't use energy
  1. Diffusion
  2. Facilitated Diffusion
  3. Osmosis
- **Active transport:** the cell uses energy
  1. Protein Pumps
  2. Endocytosis
  3. Exocytosis

**Passive Transport**

- Cell uses no energy
- Molecules move randomly
- Molecules spread out from an area of high concentration to an area of low concentration.
- (High $\rightarrow$ Low)

**Diffusion**

- **Diffusion:** the process by which molecules move from an area of greater concentration to an area of lower concentration.
**Diffusion**

- High concentration → Low concentration
  - **Solute**

**Brownian Motion**

- **Brownian Motion**: molecules are in a constant state of random motion

**Brownian Motion**

- Water molecules
- Barrier

**Concentration Gradient**

- **Concentration Gradient**: the difference in concentration of a substance across a space
  - We say that a substance diffuses down its concentration gradient

**Dynamic Equilibrium**

- **Dynamic Equilibrium**: a state that exists when the concentration of a substance is the same throughout.
  - Solvent – Dissolving agent (ex. Water)
  - Solute – Substance that is dissolved (ex. Kool aid mix)

**Dynamic Equilibrium**
Passive Transport

1. Diffusion
   a. Diffusion: random movement of particles from an area of high concentration to an area of low concentration. *(High to Low)*
   b. Diffusion continues until all molecules are evenly spaced
   c. (equilibrium is reached) Note: molecules will still move around but stay spread out.

2. Facilitated Diffusion
   a. Facilitated diffusion: diffusion of particles from high to low concentration through transport proteins in the membrane
   b. Transport proteins are specific – they only allow certain molecules to cross the membrane
   c. Transports larger or charged molecules like glucose or ions

Diffusion Across Membranes

- Not all molecules can diffuse through all membranes.
- The ability of a molecule to pass through a cell membrane depends on the size and type of molecule.

What will move across the membrane?

- Noncharged molecules
- Charged molecules
- Macromolecules
- Water

Facilitated Diffusion

- Carrier protein
- Facilitated diffusion (channel protein)
Osmosis

- Osmosis: the diffusion of water through a selectively permeable membrane
- Water moves from an area of high to low concentrations

Hypotonic Solution

Hypotonic: The solution has a lower concentration of solutes and a higher concentration of water than inside the cell. (Low solute; High water)

Result: Water moves from the solution to inside the cell: Cell Swells and bursts open (cystolysis)

Hypertonic Solution

Hypertonic: The solution has a higher concentration of solutes and a lower concentration of water than inside the cell. (High solute; Low water)

Result: Water moves from inside the cell into the solution: Cell shrinks (Plasmolysis)

Isotonic Solution

Isotonic: The concentration of solutes in the solution is equal to the concentration of solutes inside the cell.

Result: Water moves equally in both directions and the cell remains same size! (Dynamic Equilibrium)

What type of solution are these cells in:

- Animal cell (red blood cell)
- Hypertonic
- Isotonic
- Hypotonic

A
B
C

Hypertonic
Isotonic
Hypotonic

Vacule
Osmosis Worksheet
20 Points

Below are animal cells placed in beakers of various concentrations.

1. Draw an arrow to show which way the water would move by osmosis.
2. Fill in any missing percentages (water or solute).
3. Identify the type of solution (isotonic, hypertonic, or hypotonic).

- 90% H₂O 10% solute
- 85% H₂O 15% solute
- 40% H₂O 60% solute
- 75% H₂O 25% solute
- 90% H₂O 10% solute
- 80% H₂O 20% solute
- 45% H₂O 55% solute
- 75% H₂O 25% solute
- 63% H₂O 37% solute
- 50% H₂O 50% solute
- 90% H₂O 10% solute
- 82% H₂O 18% solute
- 90% H₂O 10% solute
- 25% H₂O 75% solute
- 80% H₂O 20% solute