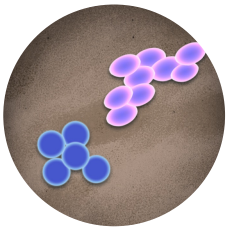

(Not) Sorry to Burst Your Bubble

Passive Transport, Homeostasis, and Antibiotics

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Grade Level	9th – 12th Grade	**Time Frame**	200 minutes
Subject	Science	**Duration**	3-5 periods
Course	Biology I		

Essential Question

How does the cell membrane help cells maintain homeostasis? How does vancomycin work to destroy MRSA bacteria?

Summary

In this lesson, students connect passive transport across a semi-permeable membrane to show how the antibiotic vancomycin works to kill MRSA. Students complete two simple osmosis and diffusion investigations, learn the details of passive transport, and apply their conceptual understanding to create a comic which illustrates vancomycin's mechanism of action against MRSA. Students should already be familiar with cell structure. This lesson can be used in tandem with the "Oh, MRSA Me" LEARN lesson.

Snapshot

Engage

Students compare and contrast plant, animal, and bacteria cells to determine what part of bacteria could be targeted with antibiotics without harming host cells.

Explore

Students complete an osmosis and diffusion lab investigation.

Explain

Students explain the results of their investigation and take notes over passive cell transport.

Extend

Students complete a Card Sort to sequence the steps showing how the antibiotic vancomycin works against MRSA.

Evaluate

Students create a cognitive comic based on the previous Card Sort and their understanding of passive transport, explaining how vancomycin disrupts homeostasis in MRSA bacteria.

Standards

Next Generation Science Standards (Grades 9, 10, 11, 12)

HS-LS1-3: Plan and conduct an investigation to provide evidence that feedback mechanisms maintain homeostasis.

Oklahoma Academic Standards (Biology)

B.LS1.3 : Plan and conduct an investigation to provide evidence of the importance of maintaining homeostasis in living organisms.
B.LS1.3.1: Feedback mechanisms maintain a living system's internal conditions within certain limits and mediate behaviors, allowing it to remain alive and functional even as external conditions change within some range. Outside that range (e.g., at too high or low external temperature, with too little food or water available) the organism cannot survive.

Attachments

- Cell Venn Diagram—(Not) Sorry to Burst Your Bubble - Spanish.docx
- Cell Venn Diagram—(Not) Sorry to Burst Your Bubble - Spanish.pdf
- Cell Venn Diagram—(Not) Sorry to Burst Your Bubble.docx
- Cell Venn Diagram—(Not) Sorry to Burst Your Bubble.pdf
- Cornell Notes Passive Transport—(Not) Sorry to Burst Your Bubble - Spanish.docx
- Cornell Notes Passive Transport—(Not) Sorry to Burst Your Bubble - Spanish.pdf
- Cornell Notes Passive Transport—(Not) Sorry to Burst Your Bubble.docx
- Cornell Notes Passive Transport—(Not) Sorry to Burst Your Bubble.pdf
- Diffusion, Osmosis Investigation—(Not) Sorry to Burst Your Bubble - Spanish.docx
- Diffusion, Osmosis Investigation—(Not) Sorry to Burst Your Bubble - Spanish.pdf
- Diffusion, Osmosis Investigation—(Not) Sorry to Burst Your Bubble.docx
- Diffusion, Osmosis Investigation—(Not) Sorry to Burst Your Bubble.pdf
- Diffusion_Osmosis Investigation Teacher Set Up - Not Sorry to Burst Your Bubble.docx
- Diffusion_Osmosis Investigation Teacher Set Up - Not Sorry to Burst Your Bubble.pdf
- Lesson Slides - Not Sorry to Burst Your Bubble.pptx
- Vancomycin Card Sort—(Not) Sorry to Burst Your Bubble - Spanish.docx
- Vancomycin Card Sort—(Not) Sorry to Burst Your Bubble - Spanish.pdf
- Vancomycin Card Sort—(Not) Sorry to Burst Your Bubble.docx
- Vancomycin Card Sort—(Not) Sorry to Burst Your Bubble.pdf

Materials

- Lesson Slides (attached)
- Diffusion/Osmosis Investigation Set Up (attached, 1 per teacher)
- Diffusion/Osmosis Investigation: Student handout (attached, 1 per student)
- Vancomycin Card Sort (attached, 1 per student)
- Cell Venn Diagram handout (attached, 1 per student)
- Animal, plant, and bacteria cell models (optional)
- Paper

  Below are the materials needed for the investigation (amounts vary):
- Powdered glucose
- Corn starch
- Glucose testing strips
- Ruler
- Digital scale
- Gloves and goggles
- Deionized or distilled water (*Do not use tap water!*)
- Dialysis tubing
- String
- Starch (cornstarch or potato starch)
- Glucose (powdered)
- Iodine (as iodine/potassium iodide, e.g., Lugol's Iodine)

- Transfer pipettes
- Spoon/stirring rod
- Beakers (250 mL, 500mL)
- Graduated cylinder
- Small container (e.g., small paper cup, specimen cup, small beaker)

Engage

Introduce the lesson using the attached **Lesson Slides**. Display **slide 3** to read aloud the Essential Questions: *How does the cell membrane help cells maintain homeostasis? How does vancomycin work to destroy MRSA bacteria?* Display **slide 4** to go over the Lesson Objectives. Review these slides with students to the extent you feel necessary.

Display **slide 5.** Have students label their **Cell Venn Diagram** handout to match the slides.

Display **slide 6**. Show students models of animal, plant, and bacteria cells and ask them to fill in a three-way Venn diagram describing the features of each cell.

Display **slide 7** and show students this video of *E. coli* bacteria exploding in the presence of penicillin. Be sure to let them know the left side shows the effects of penicillin and the right side is the no-antibiotic control. Do not tell students why it happens. Instead, move to **slide 8** and ask them to look at their Venn diagram and address the following prompt:

> How could antibiotics like penicillin be used to kill bacteria without harming the cells of the infected organism?

Student Responses

Students should identify that the bacteria have a cell wall and animal cells do not; therefore, penicillin and similar antibiotics might attack the cell wall.

Pathogenic *E. coli* strains can be found on and sometimes in plants, but it does not cause an infection the way it does in humans. It is fine to tell students this if they get stuck on that detail. Likewise, if students wonder why the penicillin does not just attack the less-protected (i.e., no wall) animal cell, it is fine to tell them that penicillin targets molecules found in bacterial cell walls.

Ask students what possible consequences could occur if a cell wall is damaged. Draw their attention to the plasma membrane (also called the cell membrane) which surrounds all of the cells and ask them to recall what the plasma membrane does. Encourage them to consider why plant and bacteria cells need this membrane if they already have a cell wall. It is fine if they do not have a correct answer, but they should offer some ideas.

Explore

Display **slide 9**. On this slide, you can insert the materials and amounts of what you need for the lab. Tell students they will use a model to investigate how the plasma membrane works. Pass out the **Diffusion/Osmosis Investigation: Student** handout. Direct students to gather their materials and get set up for the investigations as is appropriate to your classroom.

Display **slide 10**. Insert directions for the investigation. Go over the instructions with the students. Detailed instructions for completing the investigations are included in the student handouts, but it is advisable to walk the students through the methods before turning them loose to complete the work on their own. The **Diffusion/Osmosis Investigation Set-Up** handout has additional set-up instructions and teacher facilitation notes.

Lab Materials and Virtual Lab Options

The materials for these lab activities can be purchased fairly cheaply, and there are substitutions you can make to reduce cost; however, these substitutions will impact the effectiveness of the investigations. If you are unable to acquire any of the materials to complete the activities, there are many videos on YouTube that show the semi-permeable membrane demonstration in real time. This virtual lab would be a suitable alternative for the Dialysis Experiment.

It is best to have students complete the Semi-Permeable Membrane Demonstration for themselves. If, however, time is a serious concern, it can be done as a teacher demonstration. During the 15-minute wait time in the demonstration, introduce the Dialysis Experiment. If students are deciding on glucose concentrations for themselves, have them choose and calculate the necessary quantity of glucose and water at this time (see Teacher Notes on test sensitivity in the Diffusion/Osmosis Investigation Set Up).

After completing each investigation, display **slide 11** and have students answer the analysis questions on their lab handout.

Teacher's Note: Addressing Student Misconceptions

Two common misconceptions about osmosis and diffusion are that (1) osmosis is only the movement of water (it is the movement of a solvent), and (2) that only one process happens at a time (both solutes and solvent can move simultaneously to equilibrate a solution if the solutes can cross a semi-permeable membrane). Having students test for the presence of glucose inside and outside the dialysis tube in the semi-permeable membrane demonstration serves as a proof of concept for this when paired with the change in mass of the tubes. While they are not likely to detect a change in glucose concentration in the dialysis experiment, students should be able to draw the conclusion that glucose and water are both moving based on what they discovered in the Semi-permeable Membrane Demonstration.

Explain

Teacher's Note: Activity Choice

You have two options below for student note taking. Prior to the lesson, choose which methods you will use with your class.

Display **slide 12**. As a class, review the post-investigation questions for each activity. See the note below for additional probing questions to help students draw conclusions about how the semi-permeable membrane works.

Go to **slide 13** to reinforce the idea that the size of the molecule is related to whether or not it can pass through a semi-permeable membrane.

Student Responses

- Was the starch able to pass through the membrane? How do you know? (No, the contents of the tube turned blue/black.)
- If it had made it through the membrane, how would you know/what would you expect to see? (The solution outside the tube would have turned blue/black.)
- Was the iodine able to pass through the membrane? How can you tell? (Yes, because the contents of the tube turned blue/black. Starch can't leave, so the only way it could react is if iodine moved inside.)
- Why could glucose and iodine pass through, but starch could not? (Glucose and iodine are smaller molecules than starch and can fit through the pores in the membrane.)

Display **slide 14** and have students use the Cornell Notes System format (see **Cornell Notes Template**).

You may consider displaying **slide 15** for student to take notes in a less structured Star Notes strategy to organize the upcoming information. Encourage them to specifically add details about how the lab connects to the new concepts.

Go through **slides 16-22** and briefly cover the following information:

- **Slides 16-18**: Brief review of the fluid mosaic model.
  - It is okay if students can't remember *hydrophilic* and *hydrophobic* as long as they understand that the lipid bilayer separates the water inside from the water outside of the cell.
- **Slide 19**: Passive transport (simple diffusion: solutes, osmosis: solvent).
  - The two investigations demonstrate passive transport (diffusion and osmosis).
- **Slide 20** Show this video. It shows a very simple animation of both processes (play to 0:57).
- **Slide 21: (Hidden slide)** Passive Transport supporting video. (See Teacher's Note below.)
- **Slide 22**: Facilitated diffusion.
- **Slide 23**: Tonicity (hypo-, iso-, hypertonic).
  - Ask students to identify under what conditions passive transport occurs.
  - Have students add the tonicity diagrams in addition to their written notes, taking care to include labels and draw arrows in the correct directions.
- **Slide 24** and **25**: Hidden slides with Osmosis and Water Potential and Cell transport supporting video. (See Teacher's Note below.)
  Before continuing, pause and display **slide 26** to have students answer the first Essential Question: "How does the cell membrane help cells maintain homeostasis?" from their Cornell Notes "summary" or as part of their "add" in STAR notes. It is recommended that students write this individually before having a class discussion about the answer.

Optional Supporting Videos

Consider using video explanations to support or in lieu of a lecture. The following Amoeba Sisters videos provide clear, concise explanations of the relevant concepts and include animations which can further support student understanding of the cellular mechanisms. Timestamps are provided for targeted explanations if you do not want to show the entire video(s). For this lesson, it is recommended that you skip coverage of active transport and water potential/osmotic pressure near the end of the videos. You will need to unhide the slides in the powerpoint to use in your lesson.

- Diffusion: 1:46-3:27 (diffusion and passive transport); 3:45-4:18 (facilitated diffusion)
- Cell transport: 0:41-1:06 (homeostasis); 1:07-1:37 (membrane structure); 1:39-5:34 (simple and facilitated diffusion)
- Osmosis and water potential: 0:03-9:49 (osmosis)

Extend

Display **slide 27** and return students' attention to the exploding *E. coli* video from the Engage. You may want to show it again to refresh their memory. Ask them how passive diffusion through the plasma membrane could be related to what happened to the *E. coli* in the video.

Display **slide 28**. Continue by introducing students to MRSA (methicillin resistant *Staphylococcus aureus*) as strains of *S. aureus* that have developed resistance to the antibiotic methicillin. *Methicillin* is an antibiotic similar to penicillin, which is used to treat *E. coli* infections. Due to the resistance of *S. aureus*, doctors have to prescribe *vancomycin*, a stronger antibiotic with more serious side effects, to get rid of a MRSA infection. Tell students that they will be figuring out how *vancomycin* kills MRSA.

Display **slide 29** and introduce students to the Card Sort instructional strategy. The activity can be completed independently or in groups of 2-3. Provide each student with a set of the **Vancomycin Card Sort Cards**. Students should sort the cards to map out the major steps of *vancomycin's* mechanism of action. Make sure they know that there is a missing step, and they should identify where the gap appears in the card order. Prompt them to think about what they have learned about passive transport while they work through the card sort.

Once most students have completed the Card Sort, display **slide 30**. Ask them to discuss what role passive transport plays in the process within their groups, or with an Elbow Partner, if students worked independently.

Teacher's Note: *Vancomycin* Mechanism of Action

Students do not need to understand the full scope of how *vancomycin* works since the important point for this lesson is that it damages the cell wall, exposing the cell membrane to the environment. However, it may be valuable for you to understand a more detailed explanation, as follows:

1. *Vancomycin* binds to the end of a specific portion of the growing peptidoglycan cell wall. This prevents the other necessary wall-building molecules from binding.
2. The cell detects the abnormality in the wall formation and makes more peptidoglycan building blocks in an attempt to repair the wall.
3. The increase of building blocks to excess begins a positive feedback loop where enzymes that break down peptidoglycan are released. These enzymes will break down the building blocks and may, in some cases, further break down the existing cell wall too.
4. When the cell divides, the lack of a cell wall leaves the cell membrane exposed. This allows fluid from the environment to flow in across the membrane.
5. The cell takes in too much fluid and eventually bursts.

For a more technical explanation, see this video (begin at 17:10) and this article.

Evaluate

Display **slide 31** and inform students they will be working to answer the second Essential Question.

Display **slide 32**. Have students work independently for the final activity. Using the cards from their card sort, students will create a Cognitive Comic. Students should draw their own "card(s)" or panels to fill in the gap in the card's explanation. A comic strip format is the most straightforward but see the Teacher's Note below. Students' added card(s) /panel(s) should illustrate how passive diffusion works as part of *vancomycin's* mechanism and should include a caption to support their art. Some students will be uncomfortable with drawing because they worry about it being "bad." Assure them that they are not being assessed on their skill and emphasize that they can and should use their caption to explain anything they think their picture does not make clear.

Teacher's Note: Student Choice

While you can provide students with a template for how to structure their comic, this is a good opportunity to integrate student choice into the lesson. As long as the order of the "story" is clear, then students should be given some freedom to design it how they would like. Consider offering suggestions for features (e.g., numbering the steps, drawing arrows to indicate what order to read in, etc.) or showing visual examples of comic structures that are easy to follow.

Resources

- AmoebaSisters. (2016, June 24). *Cell transport [Video]*. YouTube. Retrieved August 1, 2022, from https://www.youtube.com/watch?v=Ptmlvtei8hw
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