Curricular Unit: **Keepers of the Gate**

Contributed by: VU Bioengineering RET Program, School of Engineering, Vanderbilt University

Quick Look

Grade Level: 10 (9-11)
Time Required: 250 minutes
(five 50- minute class periods)

The cell and Its gatekeeper, the cell membrane.

Summary

Through two lessons and five activities, students explore the structure and function of cell membranes. Specific transport functions, including active and passive transport, are presented. In the legacy cycle tradition, students are motivated with a Grand Challenge question. As they study the ingress and egress of particles through membranes, students learn about quantum dots and biotechnology through the concept of intracellular engineering.

Engineering Connection

Engineers use nanoparticles, such as quantum dots, in biomedical engineering, bionanotechnology and cancer cell research. Students emulate intracellular engineers as they analyze authentic data and make predictions on cell lysis techniques based on their analyses. Experimental design is employed as a final project as students design protocols and carry out experiments that prove their answers to the challenge question.

Unit Overview

This "legacy cycle" unit is structured with a contextually-based *Grand Challenge* followed by a sequence of instruction in which students first offer initial predictions (*Generate Ideas*) and then gather information from multiple sources *(Multiple Perspectives*). This is followed by *Research and Revise*, as students integrate and extend their knowledge through a variety of learning activities. The cycle concludes with formative (*Test Your Mettle*) and summative (*Go Public*) assessments that lead students towards answering the *Challenge* question. See below for the progression of the legacy cycle through the unit and the suggested order to conduct the lessons and activities. Research and ideas behind this way of learning may be found in *How People Learn* (Bransford, Brown & Cocking, National Academy Press, 2000; see the entire text at http://www.nap.edu/catalog.php?record_id=9853)

The "legacy cycle" is similar to the "engineering design process" in that they both involve identifying an existing societal need, applying science and math concepts to develop solutions, and using the research conclusions to design a clear, conceived solution to the original challenge. Though the engineering design process and the legacy cycle depend on correct and accurate solutions, each focuses particularly on how the solution is devised and presented. See an overview of the engineering design process at https://www.nasa.gov/audience/foreducators/plantgrowth/reference/Eng_Design_5-12.html.

In lesson 1, "The Keepers of the Gate Challenge," students are presented with the *Grand Challenge* question: "*You are spending the night with your grandmother when your throat starts to feel sore. Your grandma tells you to gargle with salt water and it will feel much better. Thinking this is an old-wives tale, you scoff, but when you try it later that night it works! Why?*" From this, they brainstorm to Generate Ideas. As part of the Multiple Perspectives stage, students listen to an audio or video of Dr. Z. L. Wang as he discusses the value of nanotechnology. Students also review an article pertaining to cancer cells illuminated with quantum dots. During this lesson's associated activity (activity 1), "Grand Challenge

Journaling and Brainstorming," students document their thoughts and responses to the questions from the Generate Ideas stage. Questions include "*What are your initial ideas about how this question can be answered? What background knowledge is needed? Have you tried this before?*" After this, the class brainstorms to reach consensus on the main ideas that need to be explored in the unit.

In lesson 2, as part of the *Research and Revise*, students learn about the different structures that comprise the cell membrane. They also relate cell membrane structure with function. One of the best ways to learn about a dynamic model is to view animations. A resource document provides many animations for students to choose from for analysis. After students view animations of cell membrane dynamics online, they observe teacher demonstrations of diffusion and osmosis. Students also witness the effect of movement through a semi-permeable membrane using Lugol's solution.

In the lesson's associated activity (activity 2), "Cell Membrane Color Sheet and Build a Cell Membrane," students color in the outline of structures on a cell membrane color sheet. Another optional activity for lesson 2 is the "Build-a-Membrane" activity found at http://learn.genetics.utah.edu. Both activities begin the *Test Your Mettle* phase with a formative assessment for the cell membrane. Students check their understanding of the basic cell membrane structure and the function of each part.

Activity 3, "Active and Passive Transport: Red Rover Send Particles Over," introduces students to the transport of particles into and out of the cell. Transport (both active and passive) is the emphasis for *Research and Revise* phase. The teacher briefly lectures on active and passive transport to help students define transport and compare and contrast different types of particle transport across a cell membrane. Transport happens across a cell membrane to maintain homeostasis. Two main types of transport exist: passive and active. Passive transport is the movement of substances across the membrane without any input of energy from the cell. Active transport refers to movement of materials from an area of lower concentration to an area of higher concentration (against the concentration gradient). Energy is needed, usually from ATP. Then, students play Red Rover-Send Particles Over—a cell membrane game. Through this kinesthetic learning, students explore relationships within the cell involving the cell membrane. Finally, the students also take a quiz to assess their understanding of the material.

Through the *Research and Revise* and *Test Your Mettle* phases in activity 4, "Quantum Dots and the Harkess Method of Critical Reading," students learn about quantum dots and how they are used in bionanotechnology and cancer cell research. They explore how cell biotechnology research relates to cell membranes. Students read and discuss a professional journal article, using provided "Harkness framing questions" (article: https://www.scientificamerican.com/article/less-is-more-in-medicine-2007-09/). THe "Harkness-method" of discussion helps students become critical readers of scientific literature.

During the final activity (activity 5), "Cell Membrane Experimental Design," which integrates the entire unit through the *Go Public* phase, students take part in experimental design. They design labs that answer the challenge question. Students must have their plans approved by the instructor before beginning. A formal lab write-up is required as part of the laboratory investigation. Students connect the importance of designing an experiment to the engineering design process; they discuss how experimental design helps further the understanding of a naturally occurring phenomenon, which allows engineers to design better solutions to defined problems.

Unit Schedule

Day 1

- Lesson 1 - Keepers of the Gate Challenge
- Activity 1 - Grand Challenge Journaling and Brainstorming
- Lesson 2 - Cell Membrane Structure and Function
- Activity 2 - Cell Membrane Color Sheet and Build a Cell Membrane

Day 2

- Activity 3 - Active and Passive Transport: Red Rover Send Particles Over
- Homework for Day 2 - read the journal article

Day 3

- Activity 4 - Quantum Dots Journal Reading and Harkness Framing Questions

- Homework for Day 3 - reflect on experimental proposals

Day 4

- Activity 5- Cell Membrane Experimental Design
- Homework for Day 4 - write lab report

Day 5

Summary Assessment: Students write their final reflections and answer the challenge question with a one-page paper that includes their conclusions and supporting evidence.

Contributors

Melinda M. Higgins

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Acknowledgements

The contents of this digital library curriculum were developed under National Science Foundation RET grants no. 0338092 and 0742871. However, these contents do not necessarily represent the policies of the NSF, and you should not assume endorsement by the federal government.

Last modified: March 17, 2018

Lesson: **The Keepers of the Gate Challenge**

Contributed by: VU Bioengineering RET Program, School of Engineering, Vanderbilt University

Quick Look

Grade Level: 10 (9-11)
Time Required: 20 minutes
Lesson Dependency : Keepers of the Gate

Does salt water help a sore throat?

Summary

Students are presented with a real-life problem as a challenge to investigate, research and solve. Specifically, they are asked to investigate why salt water helps a sore throat, and how engineers apply this understanding to solve other problems. Students read a medical journal article and listen to an audio talk by Dr. Z. L. Wang to learn more about quantum dots. After students reflect and respond to the challenge question, they conduct the associated activity to perform journaling and brainstorming.

Engineering Connection

The ability to identify a problem and work with others to determine a solution is the core of the engineering design process. Students use their problem-solving abilities and team brainstorm session to figure out how they will solve the challenge: designing an experiment to test their hypothesis. Students recognize a problem and work through different channels to find a way to solve it. Additionally, students learn about bionanotechnology, a field of study that advances biomedical engineering technology.

Learning Objectives

After this lesson, students should be able to:

- Define nanotechnology, nanoscience and biomedical engineering.
- Explain how quantum dots are an example of nanotechnology used to detect cancer.
- Define the challenge associated with this unit.

Introduction/Motivation

Have you ever wondered why certain things work in your body? And, have you ever wondered how you can make things in your body work better? It is interesting to realize that many of the things that we wonder about have a unique scientific reason that makes them possible.

In this lesson, you will be presented with a problem that many of you have probably experienced and you will be challenged to figure out its scientific roots and solutions. The ability to identify a problem and work with others to determine a solution is the core of the engineering design process. In this case, you will ultimately design an experiment to test your hypothesis. You will listen to a doctor and read an article about quantum dots. (This is part of the Multiple Perspectives portion of the legacy cycle.)

This is your **Grand Challenge**: "You are spending the night with your grandmother when your throat starts to feel sore. Your grandma tells you to gargle with salt water and it will feel much better. Thinking this is an old-wives tale, you scoff, but when you try it later that night it works! Why?"

Before you can solve a problem like this, you need to first understand the scientific principles surrounding the problem. This is one of the first steps engineers take: brainstorming and researching content involving the problem. In this case, we will first listen to Dr. Z. L. Wang discuss the importance of nanotechnology and how it can be applied to solving medical problems, such as a sore throat. During this interview, Dr. Wang explains how several disciplines promote the understanding and applications of nanoscience and nanotechnology.

Lesson Background and Concepts for Teachers

Using the Introduction/Motivation content, present students with the *Grand Challenge* question, which they will later use to *Generate Ideas* and brainstorm in the associated activity, "Cell Membrane Journal and Brainstorm."

Show students the following interview and articles so they gain a better understanding of the applications of nanoscience and nanotechnology:

- For *Multiple Perspectives*, play/show the audio/video interview (1 minute long) with Dr. Z. L. Wang at http://www.nano.gatech.edu/about/.
- Have students read the accompanying article (at the same link as the interview), which describes the origin and initial drive for studying nanoscience.
- As a class, read the "Finding Cancer Cells with Quantum Dots" article at http://pubs.acs.org/doi/pdf/10.1021/ac041673t. This article explains how quantum dots are used to detect and target cancer cells—an example nanoscience and nanotechnology application.

Conclude by describing how biomedical engineers use these concepts to help further explore the origins of problems with the human body. Biomedical engineers also develop better nanotechnology that is applied to the detection of diseases within the body. Then relate this back to the challenge question: understanding why saltwater helps our sore throats feel better. Explain how understanding the reasons behind a sore throat and defining possible solutions relies on obtaining a better understanding of the nanoscience involved at a cellular level.

Vocabulary/Definitions

bionanotechnology: The merger of nanotechnology and biology: using nanotechnology to further study the field of biology and control various aspects within organisms.

nanoscience: The study of matter on a nano-scale.

nanotechnology: Tools developed to study and work with matter sized from 1 to 100 nanometers.

quantum dots: Nanoscale semi-conductors that can be used in medical imaging.

Assessment

Pre-Lesson Questions: Evaluate students' prior knowledge by asking them to reflect and respond to a few questions about the lesson topics. Example questions:

- What is nanoscience?
- How might nanoscience help understand why you have a sore throat?
- What do engineers do?
- Why do you need to know about nanoscience?

Homework: Begin brainstorming possible hypotheses for why salt water helps sore throats feel better.

Additional Multimedia Support

Interview with Dr. Z. L. Wang: http://www.nano.gatech.edu/about/

Link for "Finding Cancer Cells with Quantum Dots" article: http://pubs.acs.org/doi/pdf/10.1021/ac041673t

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Last modified: April 12, 2018

Hands-on Activity: **Grand Challenge Journaling and Brainstorming**

Contributed by: VU Bioengineering RET Program, Vanderbilt University School of Engineering

Quick Look

Grade Level:	10 (9-11)
Time Required:	15 minutes
Expendable Cost/Grp :	US $0.00
Group Size:	0
Activity Dependency :	Keepers of the Gate Challenge

Does gargling work?

Summary

Students journal their thoughts and responses to the questions associated with the grand challenge question presented in the associated lesson. For the Generate Ideas" step, they answer the questions: "What are your initial ideas about how this challenge can be answered? What background knowledge is needed? Have you tried this before?" After students have individually written responses to these questions, the class brainstorms together to reach consensus on the main ideas that need to be explored to solve the challenge question.

Engineering Connection

This activity follows the engineering design process at a very basic level, as students brainstorm, research and work together to gather information and better understand all aspects of a problem. Once several ideas have been investigated, enginees examine what they have learned as a group and develop potential solutions to reach a common goal. This often engages several engineers from different fields who come together to develop a solution.

Learning Objectives

After this activity, students should be able to:

- Compose and write response to a challenge.
- Brainstorm and use cooperative learning to evaluate plans of action regarding a challenge.

Materials List

Each group needs a pencil and a copy of the Journal Worksheet (or else their own writing journals.)

Introduction/Motivation

It is always inviting to have the time to reflect and contemplate a question that has personal relevance to you. Almost everyone has experienced a sore throat. Have you? What does it feel like? (Listen to student descriptions.)

Who is familiar with the prescribed "old" method of alleviating a sore throat by gargling with salt water? Have you tried this? Does it work? (Listen to student answers and experiences.) If it does, why does it work? What is the scientific basis for its success? Is there a better way to cure a sore throat?

The first step in solving a problem the way engineers do it is to brainstorm possible ideas and sollutions. So, following the same process engineers use, it will be up to you to determine a way to explain why salt water can help your sore throat and pose some possible better solutions. (This activity constitutes the Generate Ideas phase of the legacy cycle.)

Procedure

Before the Activity

- Make copies of the Journal Worksheet and make sure each student has a writing utensil.

With the Students

1. Read aloud the Grand Challenge (also on the worksheet): You are spending the night with your grandmother when your throat starts to feel sore. Your grandma tells you to gargle with salt water and it will feel much better. Thinking this is an old wive's tale, you scoff, but when you try it later that night it works! Why?"
2. Give students time to individually reflect and write responses on their worksheets.
3. Then involve each student in responding to the questions by having them share their responses with the class. Write the ideas generated on the classroom board so students can see all of them.
4. As a class, brainstorm, discuss and come to a consensus about how to study this particular problem. Ask the students: Based on what you already know, what other information would you need to find out in order to better understand how salt water helps a sore throat? How might nanoscience and nanotechnology help you understand this better?

Attachments

Keepers of the Gate Challenge Journal Worksheet (pdf)
Keepers of the Gate Challenge Journal Worksheet (docx)

Assessment

Generating Ideas: Have students share their ideas. While there are no correct answers, the ideas should relate to the topic. Also have students share their journal entries from the worksheets.

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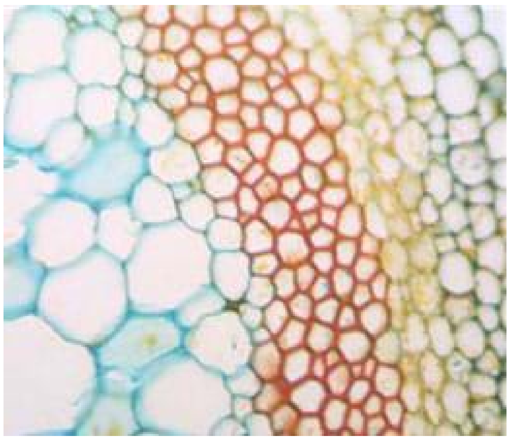
Last modified: April 12, 2018

Lesson: **Cell Membrane Structure and Function**

Contributed by: VU Bioengineering RET Program, School of Engineering, Vanderbilt University

Quick Look

Grade Level:	10 (9-11)
Time Required:	25 minutes
Lesson Dependency :	The Keepers of the Gate Challenge



Students learn about cell membrane structure and function

Summary

Students learn about the different structures that comprise cell membranes, fulfilling part of the Research and Revise stages of the legacy cycle. They view online animations of cell membrane dynamics (links provided). Then they observe three teacher demonstrations that illustrate diffusion and osmosis concepts, as well as the effect of movement through a semi-permeable membrane using Lugol's solution.
This engineering curriculum meets Next Generation Science Standards (NGSS).

Engineering Connection

With the evolution of nanoparticle use for drug delivery and many other applications, the cell has become a main focal point of research, making intracellular engineering a specialized area of biomedical engineering. In order for students to understand what is happening inside cells, they must understand how particles gain entrance to cells. Studying the cell membrane's structure and function provides the details engineers need if they are to facilitate the ease of entrance.

Learning Objectives

After this lesson, students should be able to:

- Identify organelles in a cell and their function.
- Describe how organisms use physical phenomena to actively transport nutrients.
- Construct and identify cell membrane parts.
- Define osmosis, diffusion and semi-permeable membranes and understand how organisms use them.

Introduction/Motivation

Beyond understanding the basic parts of a cell and their functions, what else can get inside of our cells? How about quantum dots and other types of nanoparticles? By understanding the structure and the chemistry of cell membranes, researchers are able to focus on how cells can work for us for medical purposes. Many chemical and biomedical engineers use their understanding of how cells work to develop innovative medical technologies.

Today, you will conduct research that includes viewing online animations of cell membrane dynamics and observing demonstrations of diffusion and osmosis. You will witness the effect of movement through a semi-permeable membrane using Lugol's solution.

Lesson Background and Concepts for Teachers

As part of the *Research and Revise* phase, students learn about the different structures that comprise the cell membrane. They also relate cell membrane structure with function and how the functions interact with one another.

Begin by either projecting the online animations of cell membrane dynamics (listed on the Cell Membrane Animation Links handout) so the entire class can see them, or have students work at individual computers to view them. Work through some of the animations with the students; explain what they are seeing in each animation.

Give an overview of the concepts of diffusion and osmosis, and explain how a semi-permeable membrane works. Describe how transport happens across a cell membrane to maintain homeostasis. Explain solute concentrations: hyperetonic, hypotonic and isotonic. Use the background information provided below.

Then, have students observe three diffusion and osmosis demonstrations, as described on the Teacher Demonstration Instructions. (Note that one requires 24-hour advance set-up.) Students witness the effect of movement through a semi-permeable membrane using Lugol's solution.

Cell Membrane Concepts

Diffusion is a passive transport method of movement of molecules from higher concentration to lower concentration. This difference in concentration is called the *concentration gradient*.

When the concentrations inside and outside of a cell are the same, the cell maintains dynamic equilibrium.

Cell membranes are selectively permeable, meaning it depends on the size and type of molecule.

It is important to remember that like dissolves like. The phospholipid bilayer that comprise cell membranes are nonpolar; therefore, nonpolar and very small molecules such as carbon dioxide (CO_2) and oxygen gas (O_2) may pass through a membrane uninhibited.

Osmosis refers specifically to the diffusion of water molecules in a solution. Water diffuses across a cell membrane from an area of higher concentration to an area of lower concentration.

The direction of movement of the water depends on concentration of solute on both sides of the membrane.

Hypotonic solution - occurs when the concentration of solute inside a cell is higher than the concentration of solute outside of a cell. Therefore, water diffuses into the cell.

Hypertonic solution - occurs when the concentration of solute outside of a cell is higher than the concentration of solute inside a cell. Water diffuses out of the cell.

Isotonic solution - occurs when the solute concentration inside a cell is equal to the solute concentration outside a cell. Water diffuses at equal rates into and out of the cell.

Facilitated diffusion - Carrier proteins must assist in the movement of molecules that are not soluble in lipids or too large. Glucose is an example of large molecule that is moved into a cell in this manner.

- Movement of substances in or out of the cell depends upon concentration gradient.
- Carrier proteins that assist in movement of these substances are specific for each type of molecule.

Diffusion through ion channels - Allow movement of ions such as Ca^{+2}, Cl^{-}, through the membrane. Because ions are charged and therefore polar, they may not freely move through the membrane. Some ion channels are always open, allowing free flow of ions. Others have specific stimuli that allow them to open, such as stretching of the cell membrane, electrical signals or chemical signals.

Cell membrane pumps - Carrier proteins assist in moving substances UP the concentration gradient. Protein engulfs and transports the molecule across the membrane to the other side.

Na-K pump - To function well, many types of cells must have a higher concentration of Na^{+}outside and higher K^{+} inside.

Endocytosis and exocytosis - These refer to active transport that moves molecules that are too large to move through the other processes, such as macromolecules and food particles. Both use membrane-bound sacs to carry substances into and out of cells.

Endocytosis - Movement of particles into the cell

Pinocytosis - Transport of solutes or fluids

Phagocytosis - Movement of large particles or entire cells

Exocytosis - Movement of particles out of the cell; may be used for large particles such as proteins. (Proteins made on ribosomes and packaged into vesicles by the Golgi-vesicles move to cell membrane and move out of the cell.)

Vocabulary/Definitions

hypertonic: Solute concentration higher on the outside of the cell than on the inside of the cell.

hypotonic: Solute concentration lower on the outside of the cell than on the inside of the cell.

isotonic: Solute concentration equal on the inside and outside of the cell.

semi-permeable: Allows certain substances access to the inner area of the cell.

Attachments

Teacher Demonstration Instructions (pdf)
Teacher Demonstration Instructions (docx)
Cell Membrane Animation Links (pdf)
Cell Membrane Animation Links (docx)

Assessment

Post-Introduction Assessment

Self-Quiz: Administer the Cell Structure and Function Quiz provided at the Biomembranes link at https://www.quia.com/quiz/717688.html.

Lesson Summary Assessment

Modeling: Have students build their sections of the cell membrane and compare to other students' models. Have students put together the different parts of the membrane for a picture of a larger, diverse membrane.

References

http://www.vivo.colostate.edu/hbooks/cmb/cells/pmemb/osmosis.html

http://hyperphysics.phy-astr.gsu.edu/hbase/kinetic/diffus.html#c1

http://www.biologycorner.com/bio1/diffusion.html

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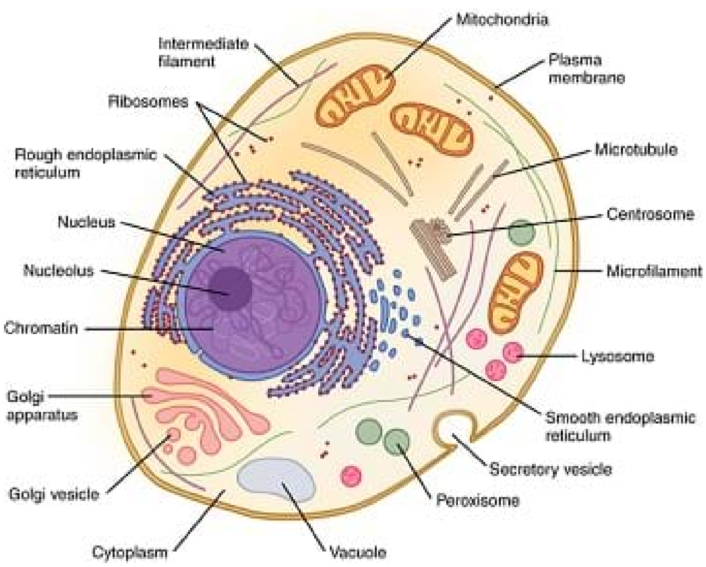
Last modified: January 4, 2018

Hands-on Activity: **Cell Membrane Color Sheet and Build a Cell Membrane**

Contributed by: VU Bioengineering RET Program, School of Engineering, Vanderbilt University

Quick Look

Grade Level:	10 (8-11)
Time Required:	15 minutes
Expendable Cost/Grp :	US $0.00
Group Size:	0
Activity Dependency :	Cell Membrane Structure and Function



Students learn about the animal cell and its components

Summary

Students color-code a schematic of a cell and its cell membrane structures. Then they complete the "Build-a-Membrane" activity found at http://learn.genetics.utah.edu. This reinforces their understanding of the structure and function of animal cells, and shows them the importance of being able to construct a tangible model of something that is otherwise difficult to see.
This engineering curriculum meets Next Generation Science Standards (NGSS).

Engineering Connection

To understand intracellular engineering, students must have a basic understanding of the cell and cell mechanics. Through this activity, students take a hands-on approach by identifying and shading cell components on a cell diagram, as well as building a cell membrane model. Through this exercise, they relate building and design with science structure. Buiding models is a common approach used in the engineering design process, especially to study or manipulate objects that are at scales too difficult to see. Engineers often build models of cells to better study and understand how their structure and functions are related.

Pre-Req Knowledge

Students should have completed the associated Cell Membrane Structure and Function lesson and have a basic understanding of cell structures and their functions.

Learning Objectives

After this activity, students should be able to:

- Define the relationship between the structure and function of a cell membrane.
- Describe the different types of membrane proteins.
- Build a model cell membrane.

Materials List

Each group needs:

- colored pencils
- tape and scissors
- different colored paper
- Animal Cell Coloring Sheet, one per student, available at https://www.biologycorner.com/worksheets/cellcolor.html

To share with the entire class:

- Build-a-Membrane template and instructions, available at http://teach.genetics.utah.edu/content/cells/BuildAMembrane.pdf

Introduction/Motivation

Ever wonder why things are arranged as they are? Is there a reason for it or are arrangements, such as cell organelles, just random?

In this activity, you will construct a cell membrane. You will also color-code a schematic of a cell and its organelles. Doing this will help you to understand where things are in a cell and why they are in specific positions.

Cells are the basis unit of life. Chemical and biomedical engineers study cells and their composition as part of designing innovative technologies to advance the medical health industry. However, cells are difficult for us to see, so engineers often build models of cells to better study and understand how their structure and functions are related.

Vocabulary/Definitions

cell membrane: A semi-permeable membrane that encapsulates a cell's cytoplasm.

membrane protein: A protein molecule attached to the membrane of a cell or organelle.

organelle: A structure in a cell that performs a specified task or function. Found in eukaryotic cells.

Procedure

Background:

Nanoparticle research has become a focus in the field of biomedical engineering due to its use for drug delivery and other applications. To understand what is happening inside of the cell, students must understand how the particles enter the cell as well as its structure. A model of the cell helps students see how cell membrane structure and function, and also provides the level of detail needed by engineers to facilitate ease of entrance in their designs. First, students use colored pencils to shade in a cell diagram. As they write down the functional part of each organelle, they begin to understand placement and arrangement. Taking this a step further, students construct their own models of cell membranes. These "membrane-pieces" assemble with those from other groups in the class to form a large cell membrane model.

Before the Activity

- Gather materials and make copies of the Animal Cell Coloring Sheet, available at https://www.biologycorner.com/worksheets/cellcolor.html.
- Obtain from the University of Utah's Teach Genetics website the instructions and templates for the Build-a-Membrane activity at http://teach.genetics.utah.edu/content/cells/. Make enough copies of the templates for all students. Either print out the instructions, or have students read them online.

With the Students

1. Distribute the materials and worksheets for the cell coloring page.
2. Make sure all students read the instructions carefully. This is a wonderful student-directed activity, so let them investigate and only provide instructions and guidance as they ask questions.
3. Once students have completed the coloring portion, divide the class into small groups and direct them to the Build-a-Membrane exercise, following the instructions found at http://teach.genetics.utah.edu/content/cells/BuildAMembrane.pdf.
4. Conclude by assembling together the "membrane-pieces" with those from other groups in the class to form a large cell membrane model. Ask students the Investigating Questions.

Investigating Questions

- What are some of the structures within a cell?
- What are their functions?
- What is nanoscience, and how does it relate to studying cells?
- Why is it important for engineers to build models of cells?

Assessment

Cell Membrane Models: At activity end, grade students on their final cell membrane product.

Additional Multimedia Support

Source of Animal Cell Coloring Sheet: https://www.biologycorner.com/worksheets/cellcolor.html

Source of Build-a-Membrane activity: http://teach.genetics.utah.edu/content/cells/

References

Dictionary.com. Lexico Publishing Group, LLC. Accessed June 21, 2010. http://www.dictionary.com

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Acknowledgements

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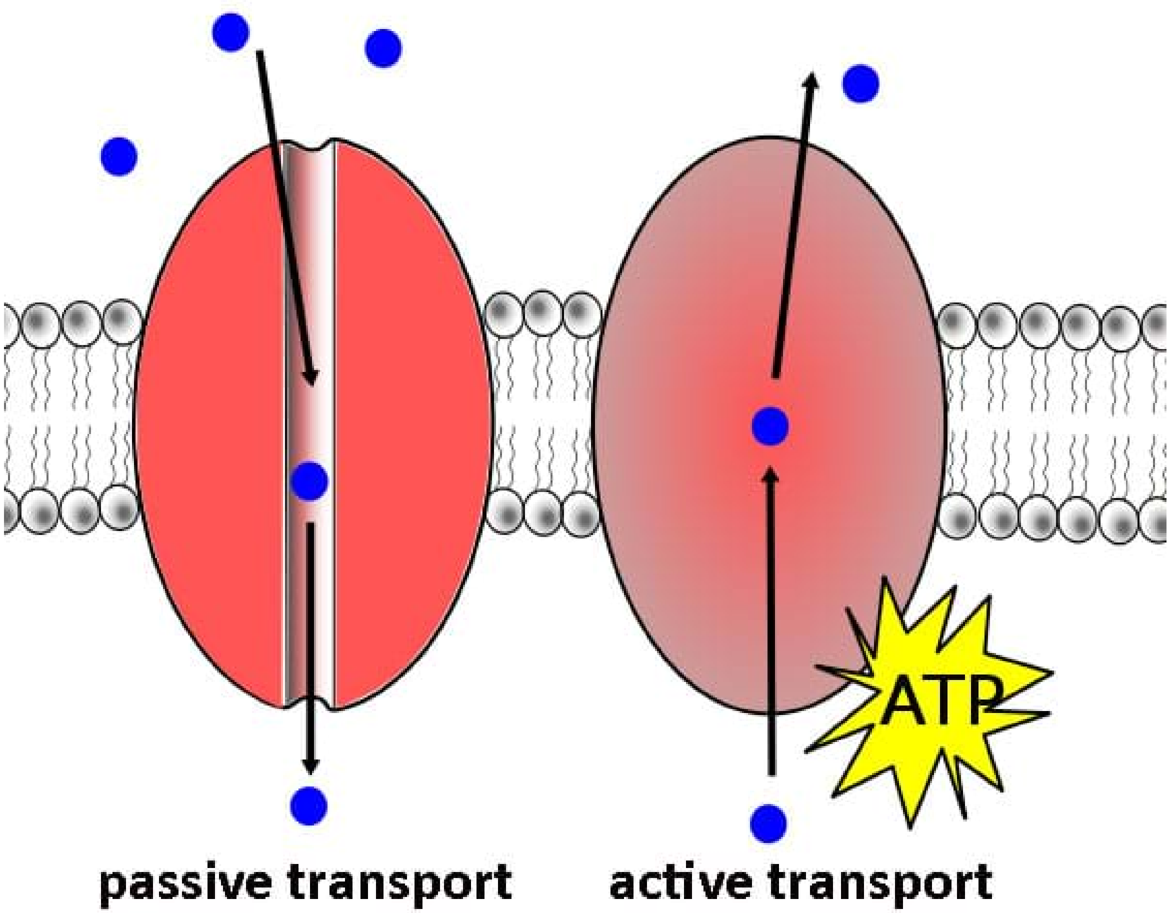
Last modified: March 21, 2018

Hands-on Activity: **Active and Passive Transport: Red Rover Send Particles Over**

Contributed by: VU Bioengineering RET Program, School of Engineering, Vanderbilt University

Quick Look

Grade Level:	9 (9-12)
Time Required:	40 minutes
Expendable Cost/Grp :	US $0.00
Group Size:	1
Activity Dependency :	Keepers of the Gate



Students model active and passive transport in a cell.

Summary

Students compare and contrast passive and active transport by playing a game to model this phenomenon. Movement through cell membranes is also modeled, as well as the structure and movement typical of the fluid mosaic model of the cell membrane. Concentration gradient, sizes, shapes and polarity of molecules determine the method of movement through cell membranes. This activity is associated with the Test your Mettle phase of the legacy cycle.

This engineering curriculum meets Next Generation Science Standards (NGSS).

Engineering Connection

Engineers use models to represent and better understand the world at various scales. To better understand cells, engineers construct and manipulate models. In this activity, students construct a cell membrane and provide areas for specific transport. A molecule's ability to permeate through a cell membrane is one of the main focuses of intracellular engineering. A great deal of research is being done in the field of biomedical engineering to learn about the inner-workings of cells in order to develop new forms of medical technology.

Learning Objectives

After this activity, students should be able to:

- Act as a different particle or part of the cell membrane to model active and passive transport.
- Explain how particles are transported from one side of the cell membrane to the other.
- Explain why engineers use models.

Materials List

Materials needed for this activity include:

- yarn (or string)
- scissors
- hole punch
- Types of Transport Activity Page, one per student
- Red Rover Game Pieces (use the hole punch and yarn to make these game cards into student role identification placards; optional: laminate them so they are re-usable)
- Cell Membrane Quiz, one per student

Introduction/Motivation

Today you are all going to participate in a cell membrane game called "Red Rover- Send Particles Over." This kinesthetic learning allows you to model and explore relationships within the cell involving the cell membrane. Active learning helps you to model what is happening on a molecular level so you can better understand processes that you are unable to visualize. You should have a chemical and biological understanding of the fluid mosaic model of the cell membrane and be familiar with the structure and polarity of molecules that will transport across the membrane. The act of modeling processes is a tool used by many engineers as they follow the steps of the design process in to solves problems and find good solutions.

Let's review passive and active transport:

Passive transport is the movement of substances across the membrane without any input of energy from the cell. Osmosis and diffusion (the focus of the previous lesson) are two examples of passive transport.

Active transport refers to movement of materials from an area of lower concentration to an area of higher concentration, against the concentration gradient. To do this, energy is required, usually from ATP. Cell membrane pumps, endocytosis and exocytosis (the focus of the previous lesson) all aid in active transport.

In the red rover game, you will physically "move" your body through a cell with either ease or constraints, depending on the type of transport specified.

Vocabulary/Definitions

active transport: The movement of substances through the cell membrane that requires energy.

passive transport: The movement of particles through the cell membrane that does not require energy.

Procedure

Background

Before starting the game, students review the activity sheet to familiarize themselves with the transport types and related topics. The teacher serves as the game facilitator, announcing the type of transport and summing up what has happened at the end of each session. During the activity, remind students about the concentration gradient and dynamic equilibrium.

Before the Activity

- Make copies of the Cell Membrane Quiz and Types of Transport Activity Sheet, one each per student.
- Print out the game cards that illustrate ions, molecules and cell membrane members. Hole-punch the cards on the top two corners and tie yarn through each to make placards for each student to wear during the activity, illustrating their roles. Use the pink atoms as potassium or another ion and write the ion element and charge on each. Have students write the charges on the sodium and chlorine atoms. (Tip: To make these cards re-usable, copy them onto card stock and laminate before punching the holes. Dry erase marker wipes off the laminated surface so the blank atoms can be easily changed.)
- Move aside desks and tables to clear a space to conduct the game. Or arrange to go outside or to the gym.
- Give students the activity sheet prior to the activity so they may familiarize themselves with the various types of transport being studied. Also have students review shape and structure of molecules to determine their polarity and method of movement into and out of the cell membranes.

With the Students

1. Offer students the stack of game cards, face down, and have them randomly choose their roles in the game by choosing a card. Have them place the placards around their necks so everyone knows their roles in the game.
2. Direct students who have drawn similar cards to group together to talk about their strategy for movement into the cell membrane. Suggest they look over the activity sheet to review what type of transport they are able to participate in each time. Likewise, have members of the lipid bilayer and the proteins discuss placement of their proteins within the membrane.
3. Begin the game by announcing which transport type will be illustrated. Similar to playing "Red Rover," the particles try to enter the cell and still be aware of the dynamic equilibrium that takes place in conjunction with the concentration gradient. Have the cell membrane hold hands so as to be "fluid" enough for small particles such as water, carbon dioxide and oxygen gas to enter and exit the cell at will, while charged particles must enter and exit the cell only through their specific channel proteins. Have the channel proteins announce which specific ion they allow to enter and exit. Have the carrier proteins also announce their specific molecule, such as glucose or amino acids.
4. Periodically stop to discuss what the students are modeling. Transition to new games by summarizing and discussing what happened. Restart new games, announcing different transport types. Periodically allow students to switch roles during the game so that they gain perspective for different parts of the process. Remind students about the concentration gradient and dynamic equilibrium.
5. At activity end, administer the quiz.

Attachments

Red Rover Game Pieces (pdf)
Red Rover Game Pieces (docx)
Types of Transport Activity Sheet (pdf)
Types of Transport Activity Sheet (docx)
Cell Membrane Quiz (pdf)
Cell Membrane Quiz (docx)

Assessment

Quiz: At activity end, administer the Cell Membrane Quiz. Review students' answers to gauge their comprehension of the concepts.

Contributors

Melinda M. Higgins

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Supporting Program

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Acknowledgements

The contents of this digital library curriculum were developed under National Science Foundation RET grant nos. 0338092 and 0742871. However, these contents do not necessarily represent the policies of the National Science Foundation, and you should not assume endorsement by the federal government.

Last modified: December 13, 2017

Hands-on Activity: **Quantum Dots and the Harkess Method of Critical Reading**

Contributed by: VU Bioengineering RET Program, School of Engineering, Vanderbilt University

Quick Look

Grade Level: 9
Time Required: 65 minutes
Expendable Cost/Grp : US $0.00
Group Size: 0
Activity Dependency : Keepers of the Gate

Working together in engineering.

Summary

Students explore the applications of quantum dots by researching a journal article and answering framing questions used in a class-wide discussion. This Harkness method discussion helps students become critical readers of scientific literature.

Engineering Connection

Nanomedicine is the cutting edge in bioengineering. This field has grown by leaps and bounds in the last 20 years due to the advent of new detection technologies. A combination of biology and nanotechnology, bionanotechnology is of great interest in the biomedical industry. It is commonly used when many fields (such as biology, chemistry, nanomedicine and engineering) overlap. The journal article introduces students to advanced scientific writing and reading, important skills for engineers.

Learning Objectives

After this activity, students should be able to:

- Critically read and analyze scientific literature.
- Review and discuss a journal article.
- Explain how bionanotechnology encorporates quantum dots.

Materials List

Each student needs:

- Less is More in Medicine journal article
- Harkness-Based Discussion Questions

Introduction/Motivation

When you hear the word nanotechnology, do you really know what people are talking about? Why is it so important? When we refer to nanotechnology, "nano" signifies the unit prefix meaning 10^{-9}, a billionth of a unit. Although such a small unit may seem insignificant, many fields of science and engineering use this measurement to design and create new materials.

This activity will provide you with a basic understanding of a few topics related to science and engineering. You will receive information on quantum dots and how they relate to biology. Then you will read a journal article in order to learn more about nanomedicine before we hold a class discussion about the what we've read.

Vocabulary/Definitions

bionanotechnology: A combination of biology and nanotechnology.

cell lysis: The dissolution or destruction of cells.

nanomedicine: Medical application of nanotechnology largely used for drug delivery.

quantum dots: Semi-conductors with excitons that consist of a core, semiconductor shell, polymer coating and biomolecule.

Procedure

Background

Bionanotechnology has become one of the fastest growing fields in the medical industry. With doctors, engineers and scientists working together on this new technology, complex devices and processes are being made at an extremely small scale.

Present students with the lecture information on quantum dots and how they relate to biology. Then have students read the journal article. Then conduct the Harkness Framing Questions activity, which requires students to research more about nanomedicine and respond to questions regarding the article. By doing this, students are on the track towards becoming more critical readers of scientific literature.

Before the Activity

- For the students, make copies of the Less is More in Medicine journal article by A. Paul Alivisatos, and the Harkness-Based Discussion Questions.
- For the teacher, make a copy of the Teacher's QDot Technology Lecture Notes.

With the Students

1. With the class, present the background information, as provided on the teacher's lecture notes.
2. Hand out the Alivisatos journal article for students to read and interpret.
3. After reading, arrange desks in a circle and facilitate a class discussion in the Harkness method. Refer to the discussion questions handout. In this method, all participants sit in a circle and freely express their thoughts and observations regarding the article. By sharing their ideas as well as listening to those of the other participants, students become critical readers and thinkers regarding scientific literature, which are essential skills for engineers.

Attachments

Less is More in Medicine Journal Article (pdf)
Harkness-Based Discussion Questions (pdf)
Harkness-Based Discussion Questions (docx)
Teacher's QDot Technology Lecture Notes (pdf)
Teacher's QDot Technology Lecture Notes (doc)

Assessment

Embedded Assessment: Assess students on the extent of participation and knowledge in the discussion.

Additional Multimedia Support

Less is More in Medicine Article

References

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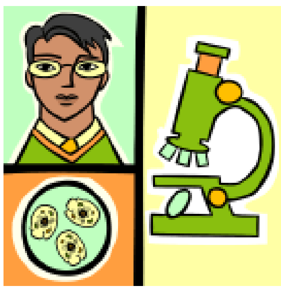
Last modified: April 12, 2018

Hands-on Activity: **Cell Membrane Experimental Design**

Contributed by: VU Bioengineering RET Program, School of Engineering, Vanderbilt University

Quick Look

Grade Level:	9 (9-12)
Time Required:	50 minutes
Expendable Cost/Grp :	US $5.00
Group Size:	0
Activity Dependency :	Keepers of the Gate



Thinking about experimentation.

Summary

The final activity of this unit, which integrates the Keepers of the Gate unit through the Go Public challenge, involves students taking part in experimental design. They design a lab that answers the challenge question: "You are spending the night with your grandmother when your throat starts to feel sore. Your grandma tells you to gargle with salt water and it will feel much better. Thinking this is an old wive's tale, you scoff, but when you try it later that night it works! Why?" Students must have their plan approved by the instructor before they begin. A formal lab write-up is due as part of the laboratory investigation.

This engineering curriculum meets Next Generation Science Standards (NGSS).

Engineering Connection

Students design a lab using all the expertise they have gained through the unit. The lab analysis must help them answer the Grand Challenge question. By formulating their own plans for the lab, students are participating in the engineering design process: engineers use their previous knowledge and personal experience to aid the design of novel solutions to problems. Engineers also utilize experimental design to further test their solutions. Students use their previous knowledge from the earlier lessons and activities to facilitate their lab design process.

Learning Objectives

After this activity, students should be able to:

- Design and conduct an experiment to help answer the challenge question.
- Write a formal lab report for the experiment.
- Explain how the designed lab furthers their understanding of the engineering design process.

Materials List

Each group needs:

Possible materials:

- potato slices (8 per group)
- 4 cups
- 4 concentrations of salt (NaCl) dissolved in water: 100 ml of each per group

  0 % - pure distilled water

  5% - 5 g NaCl/ 100 g solution

  10% - 10g NaCl/ 100 g solution

15% - 15g NaCl/100 g solution

- balances
- Keepers of the Gate Design Challenge Student Worksheet, one per student

Introduction/Motivation

At the start of this unit, you were presented with a challenge question: *You are spending the night with your grandmother when your throat starts to feel sore. Your grandma tells you to gargle with salt water and it will feel much better. Thinking this is an old wive's tale, you scoff, but when you try it later that night it works! Why?*"

Now, like an engineer, you will apply what you know about cells to design an experiment to further answer the challenge question. What experiment can you design? How will your results support your answer? These are questions you must ask yourself in the scientific process. Engineers must utilize previous knowledge and personal experience to aid in the design process.

Engineers often perform scientific experiments to gather research pertaining to a phenomenon they are studying as part of finding solutions to a real-life problem. In this case, the problem is a sore throat. Your job is to figure out why salt water can help a sore throat and to propose a possible better solution than salt water. The information that you have just learned during these past few lessons and activities will greatly help you in your thinking process when you attempt to design your plan for the lab in this Go Public portion of the legacy cycle.

Procedure

Background

Students work together in research teams to design experiments that show both the qualitative and quantitative effects of osmosis. They include demonstrations of solutions that are hypotonic, hypertonic and isotonic. A formal lab report is due at the conclusion of the experiment.

Before the Activity

- Gather materials necessary for the lab.
- Make copies of the Keepers of the Gate Design Challenge Student Worksheet.

With the Students

Using strands of potatoes and different concentrations of NaCl solutions, have students design experiments to explore osmosis in raw potatoes. Explain that this closely models what happens to cells in their throats when gargling with salt water. Use controls in the experiments and collect and organize the data in meaningful ways.

Attachments

Keepers of the Gate Design Challenge Student Worksheet (pdf)
Keepers of the Gate Design Challenge Student Worksheet (docx)

Assessment

Worksheets: Have students use the worksheet to guide their lab experiments. Review their answers to the worksheet questions to evaluate their comprehension of the concepts.

Lab Report: Require students to prepare formal lab reports to turn in at the conclusion of the lab. Review their reports to assess their mastery of the subject matter and concepts.

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