CMASTE
Centre for Mathematics, Science, and Technology Education

GlycoNet

UNIVERSITY OF ALBERTA
FACULTY OF EDUCATION

Grade: 10	**Subject:** Science 10	**Unit:** Living Systems

Title: WebQuest: Cell Membranes and Medicine

Rationale

Developments in microscopy have led to a better understanding of cell structure and organelles. The model of the cell membrane, specifically, has allowed for significant research into drug discovery and creation.

Background Information

Protein-carbohydrate interactions are the basis of cell-cell and cell-pathogen interaction. This, of course, occurs at the cell membrane. The Derda Research Group, at the University of Alberta, pioneered a powerful approach for discovery of molecules that block or mimic protein-carbohydrate interactions. This approach is used to identify molecules that can be used as inhibitors of unwanted protein-carbohydrate interaction in drug-resistant tumors, to develop cancer immunotherapies, and to identify improved molecular diagnostics for tuberculosis.

Curriculum Connections

- describe how advancements in knowledge of cell structure and function have been enhanced and are increasing as a direct result of developments in microscope technology and staining techniques
- use models to explain and visualize complex processes like diffusion and osmosis, endo- and exocytosis, and the role of cell membrane in these processes
- identify areas of cell research at the molecular level (e.g., DNA and gene mapping, transport across cell membranes)
- describe how knowledge about semi-permeable membranes, diffusion, and osmosis is applied in various contexts (e.g., attachment of HIV drugs to cells and liposomes, diffusion of protein hormones into cells, staining of cells, desalination of seawater, peritoneal or mechanical dialysis, separation of bacteria from viruses, purification of water, cheese making, use of honey as an antibacterial agent and berries as a preservative agent by traditional First Nations communities)

Lesson Objectives/Concepts

Students will use the website to respond to three tasks.

- Students will watch a video detailing current research from the Derda Reseach Group
- Students will gain an appreciation for glycomics and GlycoNet.
- Students will explore the structure of the cell membrane and spend some time

developing skills in virtual microscopy
- Students will use animations and simulations to explore cell transport processes across the cell membrane.
- Students will investigate cell signaling (how cells communicate with each other) and its importance in biomedical research.

Materials: http://cellmembranerecognition.weebly.com/
Access to the website: laptops, Chromebooks, tablets etc.

Time: 1-2 classes:
15-20 minutes to introduce the WebQuest and engage in a discussion. 60-90 minutes to complete the WebQuest.

Introduction

Engage in a discussion with students around the importance of the cell membrane in the area of biomedical research.

In our bodies, membranes surround every cell. Membrane structure and function wasn't well understood until modern electron microscopy arrived in the late 1950's. For this reason, it is only recently that scientists have discovered the roles membranes play in our bodies. Not only do membranes separate the interior of the cell from the external environment, but it is the surface of the membranes that allows cells to make decisions about what molecules are allowed in or are not permitted to enter.

Possible questions are:

1. Why do you think it is so difficult to transplant organs?

Your body's immune system usually protects you from substances that may be harmful, such as germs, poisons, and sometimes, cancer cells.

These harmful substances have proteins called antigens coating their surfaces. As soon as these antigens enter the body, the immune system recognizes that they are not from that person's body and that they are "foreign," and attacks them.

When a person receives an organ from someone else during transplant surgery, that person's immune system may recognize that it is foreign. This is because the person's immune system detects that the antigens on the cells of the organ are different or not "matched."

Mismatched organs, or organs that are not matched closely enough, can trigger a blood

transfusion reaction or transplant rejection. Reference: https://goo.gl/X1qble

2. Why is Canadian Blood Services is always begging for certain blood types?

The most common blood type in Canada is O Positive (38 per cent). The rarest blood type in Canada is AB Negative (less than 1 per cent). Those with O Negative blood are considered "universal blood donors" because patients of all blood types can receive O negative blood. All blood types are needed. Reference: https://goo.gl/rkevPV

3. Why do you suppose there is a new influenza vaccine every year? This is an interesting blog post from a student on influenza vaccines for the students to read: http://goo.gl/bOshus

Flu viruses are constantly changing and mutating. These changes can happen slowly over time or suddenly. Antigenic drift is when these changes happen slowly over time. These changes happen often enough that your immune system can't recognize the flu virus from year to year. That is why you need to get a new flu vaccine each year. The flu vaccine protects you against that season's three or four most common flu virus strains. Antigenic shift is when changes happen suddenly. This occurs when two different flu strains infect the same cell and combine. This may create a new flu subtype. Because people have little or no immunity to the new subtype, it can cause a very severe flu epidemic or pandemic. Reference: http://goo.gl/5R7KvB

Activities/Procedure

- Students will need access to the internet.
- Students will click on the website and respond to the three provided tasks.
- Students will watch a summary of current research from Ratmir Derda and focus on the role the cell membrane plays in blocking cancer growth.

Summary

Ask students to watch the video, "Dr. Ratmir Derda" and in small groups, discuss the role the cell membrane plays in his research and what his research goal is.

Provide students with mini whiteboards (paper is fine too) and as an exit activity have them sketch the phospholipid bilayer and then subsequently add the following structures or actions depending on time availability:

1. Integral proteins
2. Demonstrate diffusion
3. Demonstrate facilitated diffusion
4. Draw where a glycan is found
5. Hydrophobic tail

And so on….

Another option

Using mini whiteboards, ask students to draw just the bilayer of phospholipids. Then all students hand their boards one row over. The next job is to check for accuracy and then draw in integral proteins. Then hand boards one row over. The next job is to check for accuracy, fix if needed, then add peripheral proteins. Then hand one row over, check for accuracy, fix if needed and add glycans. Etc.

Assessment

Students can create a shared Google Doc, or submit on Google Classroom the answers to the questions found with the WebQuest. Answers to these questions are also provided as a document to the teacher.

Alternatively, a quiz can be created to assess learning such as the quiz found at this website: http://goo.gl/6tVmvg where membrane structures and functions are the focus.

Extension: Students can explore the researchers on the Glyconet Website http://canadianglycomics.ca/ click projects, select a project that is of interest, then click on the researcher's contact link.
Derda Research Group http://derda.chem.ualberta.ca/ click research, people and then "contact us" to send questions. Students can also watch the video, "Dr. Derda encourages high school students" for advice on how to choose a path in high school.

Possible questions to ask the researcher:

1. What field of study did you focus on when entering University?
2. What inspired you to study science when you were still in high school?
3. What series of events allowed you to get to where you are today?
4. Was there a specific mentor that shaped your decisions?
5. What advice would you give a high school student interested in science?

Answer Key

Task One: **Wiley Website**

1. Who were responsible for the development of this theory?
SJ Singer and GL Nicolson, 1972

2. A previous model of the cell membrane was proposed in 1932 by Davson and Danielli. What was their contribution and why was their model replaced with the Fluid Mosaic Model?
Their model suggested that there was a lipid center surrounded by protein layers, like a "sandwich" consisting of protein-lipid-protein. Their model stressed the importance of proteins in membranes. The fluid mosaic model replaced this model because experimentation found that the membrane was fluid, and new studies found that proteins couldn't be thin sheets as their shapes were globular and could not fit as thin sheets.

3. Why is the model called "fluid" and "mosaic"?
Proteins are like icebergs in a 2D sea. The '**fluid**' part represents how some parts of the membrane can move around **freely**, if they are **not attached to other parts of the cell**. The 'mosaic' part illustrates the **'patchwork' of proteins** that is found in the phospholipid bilayer.

4. Describe the experiment that shows that the proteins diffuse in the membrane.
Fluorescence photo-bleaching experiments were used where the rates of protein diffusion (movement) are measured. In other words, the proteins are labeled with a fluorescent marker and will fluoresce or glow. But when hit with a laser the protein will get bleached and stop glowing. During the experiment, the glowing proteins replace the bleached ones, showing that the proteins move around.

Use this **animation** to identify the main components and this **resource** to determine the function of the components of the cell membrane.

1. **Phospholipid bi-layer**: double layer of lipid (fatty) tail and phosphate (charged) head
2. **Hydrophobic tail**: lipid tail (does not dissolve in water - water hating)
3. **Hydrophillic head**: phosphate head (dissolves in water - water loving)
4. **Integral protein**: protein found within the membrane
5. **Peripheral protein**: protein found on the surface of the membrane
6. **Oligosaccharide**: carbohydrate used for cell recognition
7. **Cholesterol**: molecule that allows for the fluidity of the membrane

Microscopy Task: The development of the microscope has allowed scientists to understand cell structure. Use this **animation** to explore how a light microscope works. You will find an object on your slide, learn how to properly focus, adjust the light, and care for this sensitive piece equipment.

Assessment: This is a skill-based task which is self-assessed as part of the simulation.

Task Two: Each of these animations/simulations is found in the Glencoe Online Learning Center (A McGraw Hill Company) and after students complete the quiz questions, the responses are submitted for accuracy. Students will get immediate feedback.

Task Three: How do Cells Talk to Each Other

1. In order to trigger a response, these signals must be transmitted across the cell membrane. Sometimes the signal itself can cross the membrane. Other times the signal works by interacting with receptor proteins.

2. Signals most often move through the cell by passing from protein to protein, each protein modifying the next in some way.

3. A signal activates an enzyme, directs a vesicle to fuse with the membrane, allows the cell to change shape, or sends a signal to the nucleus.

4. Each cell receives a complex combination of signals which simultaneously trigger many different signaling pathways. Each step in a signaling pathway provides an opportunity for cross-talk between different signals.

5. What is Glycomics?
Study of glycans.

6. What are glycans?
Carbohydrate chains found within membranes, can attach to proteins or lipids, involved in almost all biological processes.

7. Useful for studying how pathogens (influenza virus, for example) attach to cell membranes. Glycans help in cell-to-cell communication when cells are injured, determine your blood type, can be used in vaccine research and organ transplants, etc.

Cell Signalling
Students will select a cell type (five options to pick from) and then explore the effect of UV light, nitric oxide, growth factor or hormones on the cell's response. This is just an exploration, no assessment required.