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| **Activity Title:** Cell Membrane Engineering Project | **Unit #: 1** | **Lesson #: 1** | **Activity #:1** |

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| **Estimated Activity Duration:** | 2 Class Periods |

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| **Setting:** | Classroom |

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| **Activity Objectives:** |

Upon completion of the activity, students will be able to:

1. Identify the different parts of a phospholipid bilayer
2. Define osmosis, diffusion, and facilitated diffusion
3. Model a semi-permeable membrane
4. Design and build a semi-functional model of the bilayer

**Activity Guiding Questions:**

1. What are the components of a phospholipid bilayer?
2. What is the difference between osmosis, diffusion, and facilitated diffusion in a cell?
3. How can you model a semi-permeable membrane?
4. What ways can you design and build a semi-functional model of the phospholipid bilayer and the proteins involved?

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| **NGSS Practices of Science and Engineering / Crosscutting Concepts** |

**Practices of Science and Engineers (Check all that apply.) Crosscutting Concepts (Check all that apply.)**

 Asking questions (for science) and defining problems (for engineering)  Patterns

 Developing and using models  Cause and effect

 Planning and carrying out investigations  Scale, proportion, and quantity

 Analyzing and interpreting data  Systems and system models

 Using mathematics and computational thinking  Energy and matter: Flows, cycles, and conservation.

 Constructing explanations (for science) and designing solutions (for engineering)  Structure and function.

 Engaging in argument from evidence  Stability and change.

 Obtaining, evaluating, and communicating information

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| **Unit Academic Standards (Ohio State Revised Science Education Standards and/or NGSS Content, Common Core etc.):** |

e. Explain how the cell membrane controls movement of substances both into and out of the cell and within the cell SC-HS-3.4.3 SC-H-UD-S-2

f. Explain how the cell membrane maintains homeostasis SC-HS-3.4.3 SC-H-UD-S-2

g. Describe and contrast these types of cell transport: osmosis, diffusion, facilitated diffusion, and active transport SC-HS-3.4.3 SC-H-UD-S-2

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

**Supplies:**

1. Small fish tank
2. Rubber bands
3. Paper cut outs
4. Cotton Balls
5. Beads
6. Tape
7. Bingo Chips
8. Scissors
9. Beans
10. Marbles
11. Rice

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| **Teacher Advance Preparation:** |

The teacher will have to:

1. Make sure the “cell” is printed out/enough pieces for everyone
2. Make sure the pre/post assignment is printed out
3. Make sure the materials are all available and there is enough for every group
4. Have one piece of each material (marble, cotton ball, bingo chip, bead, bean and rice) in a plastic bag for the students to test their design with

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| **Activity Procedures:** |

Activity 1: Cell Membrane Engineering Project

**Day 1**

1. Students are given a pre-test without any prior background of the cell membrane. This exact same test will be given again after the activity is completed to gage the progress of the students.
2. There is a class discussion of the functions of the cell membrane and what materials need to move in and out of the cell.
	1. What would happen to the cell if everything could move freely in and out?
	2. What prevents certain materials from being able to transport freely through the cell membrane?
3. Students are given instructions to create a functional cell membrane using paper, rubber bands and tape. The cell membrane must allow certain objects to go through the membrane and not allow others to go through the membrane.
	1. The objects that are able to go through the membrane are: cotton balls, beans, rice and bingo chips
	2. The objects that must not go through are marbles and beads.
		1. It is important to stress that these materials cannot go through the membrane at any point. This means that even though specific channels can be made for the permeable items and they can be instructed to be placed at that point, the impermeable items must not be able to go through the membrane at any point.
4. Students will work in groups of 3-4 for their construction of a cell membrane. They will all be given paper cut-outs of a cell membrane including phospholipids, leak channels, and transport proteins. The students will construct their cell membrane over the small fish tank to prevent the objects from rolling all over the place.
	1. Before construction of their membrane, each student will have to individually come up with a unique design for their cell. Once all 3-4 members of the group have an idea, the instructor will check the designs and allow them to proceed and grab their materials.
5. Students will have 30 minutes for the construction of their membrane. Students are able to have each material at their desk to practice their design before going up to the front and officially testing their membrane.
	1. During construction students will be given feedback on their design, but it is important to allow the students to have full design freedom
	2. It is important to note that this membrane is focusing on passive diffusion, meaning that active diffusion is not incorporated in this model. This means that the students themselves cannot physically push the items through the membrane, but flaps that work only with the materials provided are acceptable.
6. After 30 minutes, students are called up to test their design. The instructor will drop each of the objects one type at a time over the membrane at 1.5” height. For the permeable items, the students can state where they want the items to be dropped (if specific channels were created), however, the impermeable items will be dropped all over the membrane.
	1. The instructor will give feedback on each design, stating the positives, the negatives, and what can be improved on.

 **Day 2**

1. The students will be given 20 minutes to re-design based on the feedback from the instructor.
2. The students will then bring up their new design to be tested for grading. The instructor will drop each material as done in step 6 above. It will be noted how much of each item did or did not go through, as well as the progress made from the previous design.
	1. Before testing, make sure to ask the students what they changed from their last design and why they changed it.
3. Following all testing, there will be a group discussion about the different parts of the engineering design process. The students will be asked whether or not they felt re-designing was important, how different their final design was than their initial design, and how they felt the engineering design process could be implemented in the field of engineering.
4. The post test will then be implemented.

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

Since the project will involve students working in a group, each student individually has to come up with their own unique design before materials are handed out to the table. These designs will be checked by the instructor and approved/disapproved of. It is important to make sure these designs are not copied from each other and the students learn to understand and appreciate the engineering design process.

Each group will be given a chance to come up and test their design and have the chance to make modifications based on critique. The instructor should give constructive advice to what was done well and what could be done better. It is then up to the students to make the necessary changes and re-test their design.

At the end there will be questions about their overall design including: Did you go with your original design, what do you think you could have done better, and what modifications did you make throughout the design process.

**Summative Assessments:** Create and administer a pre and post test on the content taught in this activity.

See attached.

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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.Refer to Activity Template for details. |

Due to the structure of the class and this being an advanced class, students are in the top 25% percentile and there should be no differentiation needed for this activity.

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| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

I believe that this activity went well and the students really enjoyed competing with their designs. There were some successful portions of the activity as well as some things that could have been improved on. I think this activity really highlighted each part of the engineering design process well, with the students each coming up with designs on their own before starting construction, being able to test the design throughout the process with materials at their desk, and finally redesigning after seeing the successes and failures in a mock test. It was fun to see the students be so involved in the design process and see the very unique designs that they came up with. There were some things that could have been improved. Originally the activity was planned for one day, but with the redesign it was better suited for two class periods, which was implemented during the activity. Also there was some poor communication between me and Emily, which prevented me from introducing the full activity to the students. Also there were some pipe cleaners sitting out on the materials table and some of the students started designing with them, which were not in the materials list, but it was not discovered the students were using them into they were too far into their design. Finally some of the students did not understand that although there could be certain channels for the materials that were supposed to be permeable to the cell and you could instruct where they be dropped, the materials that were not supposed to go in could not enter the cell at any point. This caused some of the students to make extra large holes for the cotton ball, but did not put together that the marbles and beads would try to enter the cell at that point. Finally I think it would be more helpful for the students to relate the activity back to biology if each of the permeable materials (beans, rice, bingo chips and cotton ball) were given a name of a particle that could freely diffuse through the membrane (such as water, oxygen, carbon dioxide, etc.) and the non-permeable materials (marbles and beads) were given names of a particle that cannot freely diffuse (ions and polar charged molecules). This activity proved to be successful after analyzing the data from the pre and post assessments. The average score on the test increased from 7.48 to 8.58, which is a 14.6% increase in score from pre to post test. Also every question in the post test assessment increase in the number of correct answers. Below is a graph comparing the number of correct answers pre-assessment to post-assessment.

The most striking increase in number of correct answers from pre to post assessment was on question 1, which involved identifying a type of protein that allows a molecule to freely cross the plasma membrane. I think this activity really embedded into the students the different types of proteins and what each of them allows molecules to do. While there is an increase, the pre-assessment scores were already very high, which can be attributed to a snow day occurring the day I was supposed to teach my lesson. I was not able to get back into the classroom until 3 days later, which meant some of the content was already taught to the students, so they were not going in without knowledge of some of the content.

Summative Assessment:

Pre/Post Assessment

Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. What type of protein allows a particular molecule to freely cross the plasma membrane?
	1. Channel Protein
	2. Receptor Protein
	3. Carrier Protein
	4. Enzymatic Protein
2. What are the two components of a phospholipid?
	1. Polar head/Nonpolar tail
	2. Nonpolar head/Polar tail
	3. Nonpolar head/Nonpolar tail
	4. Polar head/Polar tail
3. Water passes into and out of cells through the \_\_\_\_\_\_\_\_\_.
	1. Phospholipid bilayer
	2. Water carrier proteins
	3. Water receptor proteins
	4. Water channel proteins
4. Which of the following statements is not correct about the phospholipid molecules in the plasma membrane?
	1. Each phospholipid molecule has one polar head
	2. Each phospholipid molecule has four nonpolar tails
	3. The phospholipid tails are not attracted to water
	4. The phospholipid heads face outward
5. When a molecule enters a cell via the proteins on its membrane, it has undergone \_\_\_\_\_\_\_\_\_.
	1. Facilitated Diffusion
	2. Active Transport
	3. Osmosis
	4. Adhesion
6. Which statement best describes the plasma membrane?
	1. It is freely permeable to all substances
	2. It is selectively permeable
	3. It is non-permeable to all substances
7. What type of particles cannot freely diffuse through the bilayer?
	1. Water
	2. Large hydrophilic molecules
	3. Non-polar lipids
8. Osmosis is a special type of diffusion dealing exclusively with \_\_\_\_\_\_\_\_.
	1. Oxygen
	2. Blood Cells
	3. Protein
	4. Water
9. The cell membrane is made up of a \_\_\_\_\_\_\_\_\_ bilayer.
	1. Carbohydrate
	2. Lipid
	3. Protein
	4. Nucleic Acid
10. Molecules naturally move from areas of \_\_\_\_\_\_\_\_\_\_\_\_ concentrations to \_\_\_\_\_\_\_\_\_\_ concentrations.
	1. Strong, weak
	2. Weak, strong
	3. High, low
	4. Low, high