## Introduction

Cancer is a devastating disease. To address this worldwide problem, researchers study the disease from many different angles. Some researchers are using an engineering approach to win the battle against this enemy. Engineers can help scientists gain new expertise and develop new technologies for the diagnosis and treatment of cancer. For example, engineered nanoparticles can cause the immune system to react to kill cancer cells or to deliver drug therapies into places where regular drugs cannot reach, such as deep within tumors. The culminating lesson will teach students about how these particles are engineered and the research being done with them to help kill cancer cells.

## Prior Knowledge

In order to teach the culminating lesson, students will require specific background knowledge. The knowledge will be given to students by adding lessons to certain NGSS and Common Core units which are already taught in middle school. The added lessons are described below.

### NGS Standards

MS-PS1-1. Develop models to describe the atomic composition of simple molecules and extended structures.

Objective 1: Students will describe the atomic composition of simple organic molecules.
Organic compounds is the classification given to most compounds containing carbon. Carbon is an important element not only due to its ability to form chains with other carbon atoms, but because all known life on Earth is carbon based. In this lesson, students will discover the versatility of carbon in forming organic compounds.

Objective 2: Students will create models to describe the composition of organic molecules.
In this lesson, students will use molecular model kits to create 3D models of some simple organic compounds such as methane, ethane, propane, butane etc…

Objective 3: Students will create models to describe the composition of lipids.
In this lesson, students will discuss functional groups in general and discuss a few specific ones such as carboxylic acid, alcohol, and ester. They will then create a 3D model of simple lipids.

MS-LS1-2. Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function.

Objective 1: Students will describe the structure and composition of a cell membrane.
The cell membrane is the barrier that separates the inside of the cell from the outside environment. In this lesson, students will discover the lipid bilayer structure of the membrane.

Objective 2: Students will create models to describe a cell membrane's bilayer structure and composition.
In this lesson, students will create 3D models of the lipid bilayer in small groups, using different materials. Some groups will use food, other groups will use crafts and other groups will use a 3D printer.

Objective 4: Students will discuss how one part of the lipid is hydrophobic and another part hydrophilic.
In this lesson, students will use their molecular models of water and methane to discuss the differences between polar and nonpolar molecules and discuss why one part of the lipid is hydrophilic and the other hydrophobic.

MS-LS3-2 Develop and use a model to describe why asexual reproduction results in offspring with identical genetic information and sexual reproduction results in offspring with genetic variation.

Objective 1: Students will describe cell division through mitosis by creating a diagram and showing each step of the cell cycle.
The purpose of this lesson is for students to learn what normal cell growth and division looks like before learning about what happens with cancer cells.

**Common Core Math Standards**

CCSS.MATH.CONTENT.8.F.B.5

Objective 1: Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear).
Objective 2: Sketch a graph that exhibits the qualitative features of a function that has been described verbally.

**CT Technology and Engineering Standards**

DD.02.05 Construct tables, charts, databases, spreadsheets, and graphs to display data.

## The Culminating Lesson

**Standards:**

**NGSS**

MS-LS1-3. Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.
MS-ETS1-1. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

**CT Technology and Engineering**
NT.01.03 Describe how new technologies (products and systems) are developed to solve problems.

DD.02.05 Construct tables, charts, databases, spreadsheets, and graphs to display data.

DD.02.06 Relate the design process beyond the classroom.

**ITEEA Standards**
3. Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.
10. Students will develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving

Time: 90 minutes

Objective 1: Students will research, discover and discuss the results of loss of growth and division control in cells.
Objective 2: Students will discuss some of the methods doctors use to combat cancer.
Students will research specific questions related to cancer and discuss their findings. (The questions will be written in a worksheet).

Time: 120 minutes

Objective 3: Students will use their knowledge of bilayers to construct models of micelles and bicelles

In small groups (2-3), students will design and create models of micelles and bicelles with certain specifications. They will be given the choice of materials to use. The groups will be asked to explain the reasons for their choice of materials and design.

Objective 4: Students will use their knowledge of bilayers to discuss how engineers can use bicelles and micelles to fight cancer.

Students will use their models to discuss the ways in which engineers can use bicelles to deliver medicine to cancer tumors. They will discuss the pros and cons of using this type of delivery system.

*Objective 3: Students will use data from UCONN experiments to learn how scientists determine if a bicelle has been formed.

***Objectives in green are specific to my work at UCONN and therefore, they will only be used by me with my students. These objectives will not appear in the final draft for Teach Engineering.**

## The Lab Activity

Standards

MS-LS1-2. Develop and use a model to describe the function of a cell as a whole and ways the parts of cells contribute to the function.

Objective: Students will explore diffusion through a cell membrane.

In the experiment below, students will encapsulate a colored calcium solution inside a sodium alginate "cell" and let then allow the "cells" sit in a clear calcium chloride solution for about 15 minutes. The calcium with food coloring inside the cell will diffuse out of the cell and will change the color of the solution in the cup. The calcium with paint will not diffuse because the pores in the cell are too small for the paint to diffuse through, so the paint will remain trapped in the cell and the solution will remain clear.

Objective: Students will discuss how encapsulation and diffusion through a bicelle can be used to deliver medicine directly to cancer cells.

**Safety:** Use only food grade and non-toxic materials since the students will be touching the product and it will be safe if anyone decides to put the beads in their mouth).

Time: 60 minutes

Materials:

Food grade sodium alginate

Food grade calcium chloride

Milk frother or blender

Non-toxic paint

Food coloring

Water

2 cups

2 paper plates

Wooden stick (for larger cells) or

Dropper (for smaller cells)

Adapted from:

https://www.cmu.edu/gelfand/education/k12-teachers/polymers/polymer-architecture/gel-beads-and-worms.html

**PREPARATION OF SOLUTIONS:**

5% solution of calcium chloride, CaCl2

- Dissolve 50 grams of food grade CaCl2 in 1 liter of distilled water.

2% Sodium alginate solution

1. Slowly, add 6 grams of food grade sodium alginate to 300 ml of distilled water (If you add it too quickly, it will make clumps that will be very difficult to get rid of). Mix for 15 minutes until all powder disappears. You will need a blender or frother to mix it properly. (It will work better if you allow the unstirred sodium alginate to sit in the water overnight.)

2. Separate a small amount of the solution. Add food coloring to the rest of the solution while mixing.

3. Add non toxic paint to the small amount of solution set aside. Choose a different color than the food coloring used above.

Keep the sodium alginate powder and solutions refrigerated at all times, otherwise mold will form. Do not make the solutions too far in advance, they have a short shelf-life.

**PROCEDURE:**

1. Fill one cup 1/3 full with the calcium chloride solution.

2. Pour enough of the colored sodium alginate solution in the second cup to cover the bottom of the cup.

3. Take a small amount of the sodium alginate solution on the end of a wooden stick or dropper. Let it drip slowly from the stick or dropper into the cup containing the calcium chloride solution. Wait for 20-30 seconds. Remove the beads carefully. Observe and touch the product. Describe its properties. Notice that the beads still contain liquid alginate solution inside the gelled skin. Note that larger beads will take longer to form that smaller ones).

5. Repeat the above step with a sodium alginate solution colored using non toxic paint. Do you notice any differences between the two colored alginate solutions during the experiment?