Macrophages engineering design challenge

How might the engineering design process help to design an immune cell to "capture" an invader (bacteria, virus, etc.)? How is the immune cell affected when a mutation occurs?

You are walking through the cafeteria at lunch with friends. A freshman (of course!) let loose a *huge* sneeze, and never covered their face! Gross! You have been studying the immune system in Biology and know that your body is built to withstand the invasion of foreign microbes. You wonder how your macrophages will engulf the potential viruses or bacteria.

Your challenge: engineer an immune cell with the correct protein, using a precise sequence of amino acids—the building blocks of all proteins—to make a working macrophage. If your design is correct, the macrophage will recognize the invading bacteria perfectly and engulf the microbe. If it's wrong, the defense fails. You're not just building a molecule, you're building hope—a chance for your body to keep you healthy and withstand the occasional unprotected sneeze!

Your DNA has the instructions to make immune cells, which have proteins on their surface that can recognize non-self, but what if one key part is missing or damaged? Without that piece, the invaders cannot be recognized and attacked. We will build a new model as a result of a mutation.

Numerous types of immune cells work to keep us healthy and invaders at bay. Today, we will focus on macrophages. They are part of our innate immune system. The innate immune response provides the body's first line of defense against pathogens.

Materials

- Masking tape, 1 roll
- Scissors
- Ruler
- Twine or string, up to 1 foot (~30 cm)
- Construction or brown wrapping paper
- Aluminum foil, up to 1 foot (~30 cm)
- 1 paper bag
- 1 balloon, small or medium size
- 5 popsicle sticks
- Paper plate

Procedure

Day 1

1. **Empathize:** After seeing the sneeze in the cafeteria, you remember that you have been studying the immune system in Biology and know that your body is built to withstand the invasion of foreign microbes. You wonder how your white blood cells will engulf the potential viruses or bacteria.
2. **Define:** What is the problem we are trying to solve? How do we get sick? What mechanisms do our bodies have to help combat this invasion?
3. **Ideate:** Write down ways "materials" can be captured, attacked, or removed. Where have you seen materials being collected in your daily life? Make a sketch or model of a design that might work to capture, attack, or remove the invaders. Clearly draw and label a diagram for your design so that someone could easily recreate it.
4. **Prototype:** Choose the materials that will work best for your model from the materials provided. Your protein model will be tested in a 3-by-5-foot area covered with mini marshmallows (bacteria). Your model must pick the bacteria off the table. You may not sweep the bacteria into a pile and pick them up from a pile. You may not use your hands other than to move your model.

Prediction

I estimate that my protein model will capture _____ bacteria

because _____.

Approval

Before you start building, have your teacher sign.

Teacher signature: _____

Build

Build your protein according to your design. Remember, the function of your immune cell is to keep a child free of bacteria by collecting the most microbes.

5. **Test and evaluate:** Conduct at least two trials with your model and your teacher present. Record your results in a table. Iterate to "improve" the design. Record or draw any changes you made. Do two more trials. Record your results in your table.
6. **Implement:** Ask other teams to try out your design. Examine the data for all teams. What does the data tell you? What was the class average amount of bacteria collected?

Day 2

1. A mutation occurred in the DNA. Roll a die and replace materials accordingly (your teacher has the master list).
2. Go back and brainstorm again. How will your mutation affect how this immune cell is built? How will it affect the operation of the cell?
3. Use the engineering design process to build another immune cell with the mutations and see how it performs.

Reflection

1. Did your unmutated models pick up as many bacteria as you thought it would? Explain why it did or did not meet your expectations.

2. How effective was your protein model? Did your protein drop any bacteria?

3. Did you encounter any other problems?

4. How did your protein perform compared to the other proteins that were built?

5. What is a different idea from a protein that you could have incorporated into yours, and why would you use it?

6. Explain how the mutation affected your macrophage model. Was the mutation helpful or harmful? Explain how this may affect future generations.