Building Immunity

Total time to complete activity: 45 minutes

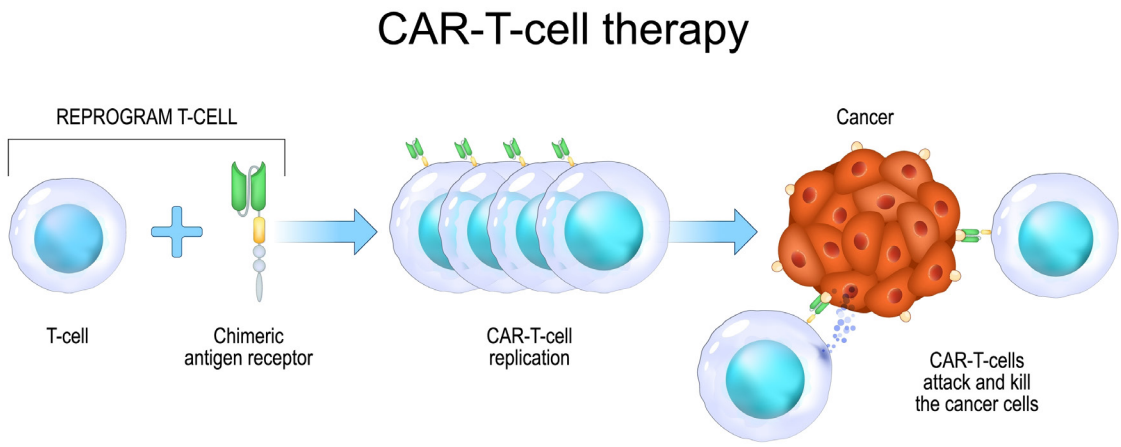
NGSS STANDARDS

MS-LS1-3

Use argument supported by evidence for how the body is a system of interacting subsystems composed of groups of cells.

BIG IDEA

Students will explore how the body responds to infected cells, invading bacteria, and cancerous cells. They will take on the roles of different immune system cells and use communication, teamwork, and engineering design principles to come up with a solution.



IN THE FILM

In *Superhuman Body,* doctors use genetic modifications to give killer T-cells new chemical receptors called chimeric antigen receptors (CAR) to attack cancerous cells. These modified killer T-cells are called CAR T-cells. While this is a major advancement, the body already trains itself to fight a myriad of threats by identifying receptors on the exterior of cells and then forming new receptors that can fight off new threats.

OBJECTIVES

1. Students will act as B-cells and T-cells to identify an antigen and create an antibody from Legos.
2. Students will communicate and work together in groups.

MATERIALS

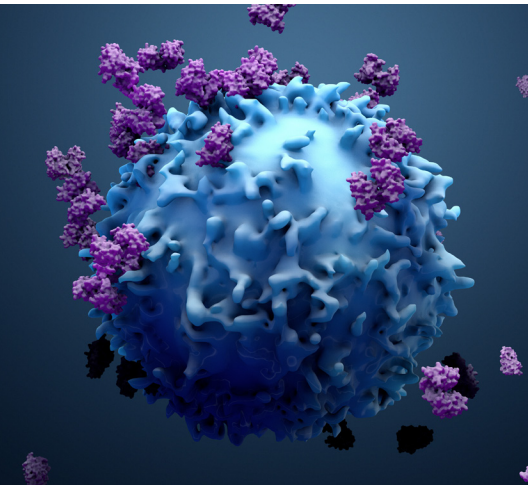
- ☐ Lego bricks or similar toy building materials. Teacher will need a supply, as well as each student group.
- ☐ Containers for student Legos
- ☐ Divider screen
- ☐ Sketch paper
- ☐ Pencils
- ☐ Clock, timer, or stopwatch

LESSON PREPARATION

Before students arrive, make sure to review the lesson materials. Review background information. Gather materials and set up the classroom.

Material preparation:

- Before the lesson, build the model antigen out of Legos, or whatever building materials that you have. The antigen should stand less than a foot tall and have multiple points where the students can build an antibody that can attach to the antigen.
- Once the antigen has been built, put it behind a privacy screen, or in another room to keep the students from seeing the antigen model.
- Separate antibody building supplies (student Legos) into containers and set them to the side.



Lymphocytes attack a cancerous cell

BACKGROUND INFORMATION

Lymphocytes: A type of white blood cell involved in the immune system. They play a crucial role in recognizing and responding to foreign substances in the body, such as pathogens or abnormal cells. There are two main types of lymphocytes: B-cells, which produce antibodies, and T-cells, which play various roles in immune responses.

Proteins: Large organic molecules that regulate many functions in the body.

Antigen: A molecule or molecular structure that is recognized by the immune system as foreign or non-self. Antigens can be found on the surface of pathogens, cancer cells, and foreign substances. The presence of antigens triggers an immune response.

Antibody: Proteins produced by B-cells in response to the presence of antigens. Antibodies bind specifically to antigens killing the harmful cell.

Cytotoxin: A substance, often a protein or chemical, that has toxic effects on cells. Cytotoxic T-cells are a type of T-cell that can release cytotoxins to induce the death of infected or abnormal cells.

BACKGROUND INFORMATION (continued)

Innate Immune System: The first line of defense against pathogens. It provides immediate, non-specific responses to infections or injuries.

Adaptive Immune System: Also known as the acquired or specific immune system, responds to specific pathogens and develops memory to provide long-lasting protection. It involves the activation of B-cells and T-cells, leading to the production of antibodies and the elimination of specific pathogens.

Vaccines can contain dead or weakened viruses that allow the body to build antibodies safely.

Cells in our bodies have strands of **proteins** on their exterior called antigens. An **antigen** is a signaling marker that informs your immune system whether a cell is harmful or harmless to the body. These markers are present on virus-infected cells, bacteria, tumors, and normal human cells.

The immune system, made up of various cells, has two main systems: the innate system, which provides general defense, and the adaptive system, which responds specifically to threats. The **innate immune system** includes cells like neutrophils and macrophages that quickly respond to invading threats like bacteria, fungi, and allergens. The **adaptive immune system** involves specialized cells like lymphocytes. These **lymphocytes** are often called B-cells and T-cells. When B-cells encounter a cell with unfamiliar antigens they produce **antibodies** to aid in the immune response. Antibodies can kill harmful cells outright when they attach to an antigen. In other cases, T-cells search for antigens that they recognize and attach themselves to the harmful cell. They then attack it with **cytotoxins,** a compound that instructs cells to act differently, or even shut down and die. These lymphocytes are crucial in viral infections and even destroying cancer cells.

One member of each team will observe the antigen that is hidden behind the divider screen. Once observed, the team member will return to their team. The observer can use words and draw diagrams to communicate to their team how to construct an antibody using Lego bricks to flawlessly attach to the proteins on the infected cell.

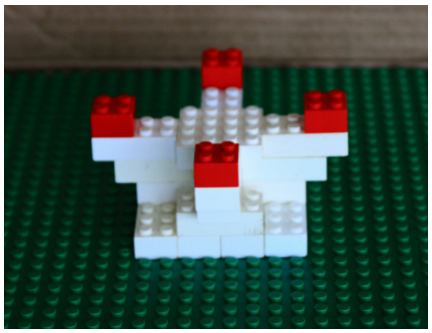
PROCEDURE
ANTICIPATORY SET

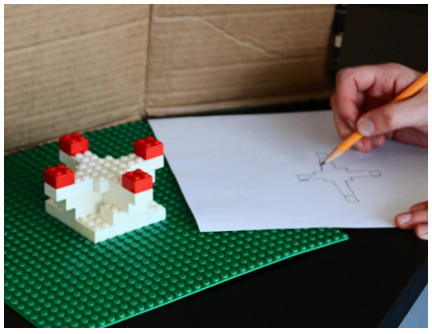
Provide an overview of the following information:

1. Think of the immune system as our body's defense team, with different players working together to keep us healthy. There are two main squads: the innate team, which provides general protection, and the adaptive team, which tackles specific threats.

2. Today, you are all going to be a part of the adaptive team and take on the role of the B-cells and T-cells. These cells have specific missions. B-cells look for strands of proteins that stick out from organic cells called antigens. If they recognize an antigen as harmful, they produce antibodies. These antibodies match up to the antigen and kill the harmful cell. Activated T-cells directly attack harmful cells by recognizing their antigens and attaching to them. The T-cell then releases cytotoxins that will shut down the harmful cell.

3. One member of each team will observe the antigen that is hidden behind the divider screen. Once observed, the team member will return to their team. The observer can use words and draw diagrams to communicate to their team how to construct an antibody using Lego bricks to flawlessly attach to the proteins on the infected cell.





ACTIVITY

ANTIBODY CONSTRUCTION:

1. Divide students into groups of 4-5 students.

2. Have students select which group member will be the observer. This student will take on the role of the B-cell. This group member will be the only group member who can observe the antigen.

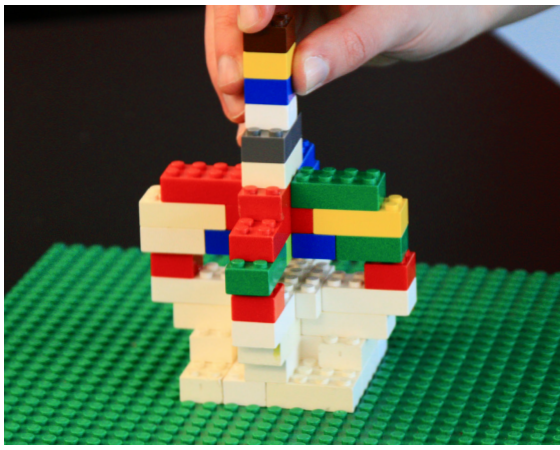
3. Tell the remaining group members that their goal is to listen carefully to the observer and follow their instructions. Their task is to build an antibody that will attach to the antigen flawlessly and destroy the harmful cell. The observer may instruct the other B-cells but may not touch the building materials. There may be multiple ways to make the antibody, and at the end of a set time, the group members will need to test their designs.

4. Once they have selected a team member to observe the antigen, give the observer a pencil and sketching paper.

5. Allow the observer to check out the model antigen. Start the timer.

6. Encourage the observers to make multiple trips to the antigen and to use the paper and pencil to communicate their design.
7. If the students are having difficulty communicating, encourage the students to take a breath and identify the core part that is giving them difficulty.
8. Circulate among the teams, providing guidance, answering questions, and ensuring safety protocols are followed.

TESTING AND PRESENTATION:



9. Once time is up, reveal the antigen model to the whole class.
10. Have each team pick a member, not the observer, to bring the antibody up to the front and then attach it to the antigen model.
11. How well does the antibody fit with the antigen?
12. Does the antibody connect with every part of the antigen?
13. If the antibody does not fit, what changes would need to be made to the design?

WRAP-UP

Review and Discussion Questions:

What were the challenges of making a model of something without all the information?
What part was the most difficult? What would have improved the experience?
Observers, what could you have done to better communicate what you saw?
What tools might have helped you?

Encourage students to consider how this activity relates to real-life scenarios in the human body.

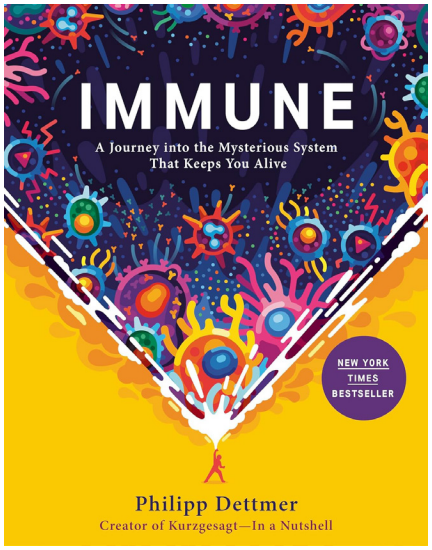
What problems arise if our immune system cannot develop new antibodies?
What conditions can you think of that can inhibit the immune system?

Help the students think about the story from *Superhuman Body* in which the doctors designed the CAR T-cells to attack cancer cells. A component of this work was providing the T-cells with the genetic data that would allow them to connect to receptors on the exterior of the cancerous cells. Our body's ability to adapt in this way allows doctors to engineer new solutions for problems that have been lethal for centuries, from cancer treatments to new vaccines.

EXTENSION ACTIVITY

If time and preparation allow, have the groups go again with a different antigen model. Ensure that they choose a new observer. Allow them to try new strategies for communication. Compare this to our immune system that adapts overtime to recognize and respond to threats better over time.

ADDITIONAL LEARNING



READ

Immune: A Journey into the Mysterious System That Keeps You Alive by Philipp Dettmer uses wit, wisdom, and well-designed images to take readers on a funny but extremely informative ride through their own immune system.

WATCH

"How does your immune system work?" by Emma Bryce provides an overview on how our immune system works including a breakdown of the kind of immune cells that travel through the body.

DO

Adapt to Mutations

Run the activity again. This time, halfway through the building phase, add an extra piece to the antigen that represents a mutation. This can represent how different viruses or cancers can mutate. Inform the teams that the antigen has changed, then have the observers return to record the new branch of proteins.