

**SCIENCE WORLD**

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Explore how COVID-19 mRNA vaccines work (such as Moderna and Pfizer-BioNTech) to protect against infection through a fun building activity. You will build a structure using toothpicks and mini marshmallows and try to remember the design so that you can create it a second time as quickly as possible!

This activity models how the immune system activates a response when you are vaccinated (1st time you build the model) and then remembers the threat if you come into contact with the real virus (2nd time you build the structure from memory).

**VOCABULARY LIST**

**Pathogen:** Any organism that causes some sort of disease in the body. One example is SARS-CoV-2, the virus that causes the disease called COVID-19.

**Immune System:** The body's natural defense against pathogens.

**Vaccine:** A substance injected into the human body to help teach the immune system to recognize and fight a threat (such as COVID-19).

**Antigen:** A molecule on the surface of a pathogen that gets the immune system to respond. The antigen from the pathogen will be seen as foreign (not made within our own body).

**Antibody:** A protein that helps fight off the pathogen.

**mRNA (messenger ribonucleic acid):** Genetic material in your cells which give instructions on how to make a protein. In the mRNA vaccines for COVID-19, a synthetic (person-made) version is used.

**Spike Protein:** The 'spikey' part found on the outside of the SARS-CoV-2 virus. The SARS-CoV-2 virus uses these spike proteins to help it enter human cells and spread infection. The COVID-19 mRNA vaccines teach the cells to make harmless spike proteins. These harmless versions activate the immune system, helping it to remember the threat in case the real virus enters the body.

**Memory Cells:** Remembers the virus and can quickly attack any new threat.

**BACKGROUND SCIENCE:**

Vaccines work by introducing a pathogen or a part of a pathogen into your body in a non-dangerous way. There are different types of vaccines. In Canada, two of our approved vaccines for COVID-19 are mRNA vaccines (Moderna and Pfizer-BioNTech). These vaccines deliver genetic material (mRNA) into your body. The mRNA gives your body instructions to make the SARS-CoV-2 spike protein. Your body then breaks down the mRNA to dispose of it.

After you are vaccinated, your immune system creates antibodies against the antigens that were introduced through the vaccine, as well as creating memory cells. These immune cells will remember the antigen. So, if your body is invaded by real pathogens, your immune system will then be able to quickly create antibodies in response.

**FUN FACT:**

Although the Moderna and Pfizer-BioNTech vaccines are the first mRNA vaccines to be fully approved for use in humans, the technology has been researched for decades, and has been studied for use against the flu, Zika, rabies, and cytomegalovirus (CMV).

### **MATERIALS:**

- Toothpicks
- Mini marshmallows (a variety of colours if possible)
- A timer (you might have one on your phone)

### **WHAT TO DO:**

#### **Step 1: Invite a friend**

Invite a friend or family member to build a 3D structure using some of the toothpicks and mini marshmallows.

*The structure built here represents the actual spike protein of the SARS-CoV-2 virus*

#### **Step 2: It's your turn!**

- Get to know their structure by looking closely at it.
- Start the timer.
- Recreate their structure exactly as you see it.
- Stop the timer when you are finished.  
In this step, you are acting as your immune system, coming in contact with the foreign spike protein for the first time and learning to make antibodies against it.

*\*Note: The antibodies your body makes are not identical copies to the spike protein, but rather different proteins that are able to recognize it.*

#### **Step 3: Test your memory**

- Hide their structure
- Start the timer
- Build it again as quickly as you can from memory
- Stop the timer
- Compare your times from step 2 and step 3.  
In this step, you are acting as your immune system, remembering how to make those antibodies again if a real virus appears.

### **WONDERINGS:**

1. Which attempt was easier and quicker for you? Why do you think this was?
2. Can you think of ways to get better at the task?  
Think of ways to simulate getting a booster dose using this activity (i.e., getting another vaccine with the spike protein once again entering your body)

