# Understanding the mRNA Vaccine

COVID-19 has been a primary concern for governing agencies, health officials, and individuals since its discovery in December of 2019. mRNA vaccines seem to appear overnight to help combat the spread of COVID-19 and its variants. Many are concerned about its sudden appearance and the lack of studies done to support the wide usage of this vaccine. What makes it so special and how does it work?

Before we can dive into the merits and workings of mRNA vaccines, we first need to understand a little about the cell. All structures in the cell either exist in the nucleus or the cytoplasm. The nucleus is the core of the cell that contains deoxyribonucleic acid or DNA which contains all the genetic information for an organism. This information is so precious that it is guarded and protected inside the nucleus. Only 1% of our DNA gives instructions for our physical traits: hair color, eye color, etc. The rest of the DNA gives instructions to make proteins that help the body function. If the cell needs a set of instructions, it makes a copy of that section of the DNA. This is where ribonucleic acid or RNA comes in. RNA is a copy of a part of the DNA that provides a code for a particular protein. This copy, specifically called messenger RNA or mRNA, takes the instructions into the cytoplasm to ribosomes where proteins are made. Proteins are what helps the body function and regulate.

Now that we understand RNA and its function in the cell, let's understand a little about viruses. There are two types of viruses: DNA viruses and RNA viruses. DNA viruses insert its DNA into our DNA causing a significant change to the instructions that make us. RNA viruses, like COVID-19, bring its RNA to the ribosomes and trick the ribosomes into replicating its RNA thus creating more copies of itself.  Once it reproduces, it exits the infected cell and continues on to infect other cells. Eventually, killing the cell it infects. Once our body realizes that something is wrong, it sends a signal to the immune system to fight the virus causing symptoms along the way. For COVID-19, these symptoms can include fever, coughs, shortness of breath, fatigue, chills, body aches, headaches, sore throats, congestion, loss of taste, loss of smell, nausea or vomiting, and even diarrhea. If these symptoms become severe enough, it can cause serious diseases like pneumonia, acute respiratory distress syndrome (ARDS), or oxygen loss that causes the kidney, lungs, and liver to shut down.

The immune system launches a two part battle against a virus starting with the innate immune system. The innate immune system is given to us at birth through our genetic inheritance from our parents. It is always there ready to fight and can respond within hours or a few days of infection. Barriers, including the skin, are the first line of defense. If the virus gets past the barriers, white blood cells and other molecules start to attack, label, and ingest anything that may look threatening. The innate immune system can recognize patterns of a group of viruses and reacts to that group. Since it is a general attack, it can often

take out molecules that are not causing us to be sick. The adaptive immune system joins in the battle if anything survives and is causing more harm to the body.

The adaptive immune system develops and grows as we encounter diseases. Once it learns how to fight a disease, it stores that knowledge in case we come in contact with that disease again. It is slower to respond, starting days or weeks after the body is infected, and can target a specific disease by identifying the proteins on the viruses' surface. Viruses have a special shape on its surface that allows us to identify it much like our physical traits. COVID-19 have crown-like spikes on their surface giving it the name of Corona. The adaptive immune system consists of two types of white blood cells called T Cells and B Cells that do different things often at the same time. Any substance that activates the adaptive immune system is called an antigen. The antigen triggers B Cells to make antibodies specific to it. The antibody travels around the body and finds that specific antigen and begins its attack. It binds to that antigen, making it inactive and blocks it from trying to infect cells. The binding also allows the antigen to be easily recognized by white blood cells for ingestion. T Cells identify antigens on the surface of an infected cell and kill the cell before the virus has time to replicate and spread.

The mRNA vaccine is different from other types of vaccines we have seen so far. The mRNA vaccine is made up of mRNA that provides the code for the cell to produce antigens for a specific virus before we even get infected by this virus. This triggers both B Cell and T Cell responses in the body for that specific virus and allows our body to store this knowledge in case we encounter this disease in the future. Remember, this vaccine does this without us needing to get sick first. This eliminates the risk of infection and spread. For the COVID-19 vaccine, the mRNA provides the code to recognize the spike protein delivered to the cell in a ball of fat called lipids. If we are infected with COVID-19 in the future, then our bodies already know how to make the antibodies to fight off COVID-19 and can quickly trigger a more targeted response thus making it effective and efficient for a specific virus.

mRNA vaccines have proven to be a powerful and effective tool to combat the spread and severe effects of COVID-19. The work being done with the uses and effectiveness of mRNA vaccines on COVID-19 have opened up to further studies to fight against rabies, influenza, Zika, HIV, and even cancer.