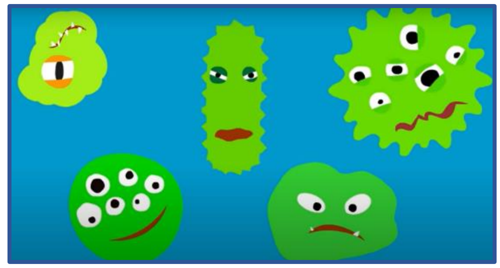
University at Buffalo
Genome, Environment and Microbiome
Community of Excellence

What does your immune system do and how does it work?



Our immune system:

- defends our body from infection – we are surrounded by microbes, including bacteria and viruses, but don't often get sick
- differentiates between our own cells and tissues (self) and foreign bodies (non-self or antigens)
- works to eliminate "intruders"

Our immune system is a complex network of organs, cells and proteins that work together to keep us healthy. Different types of white blood cells secrete chemicals and antibodies to fight infections. While blood cells constantly patrol our body, on the lookout for foreign bodies to eliminate.

There are 2 distinct types of immunity: **innate** and **adaptive**.

Innate immunity

Innate immunity is our first line of defense against infection. Innate immunity is non-specific, treats all foreign the same and responds quickly (within hours) to infection.

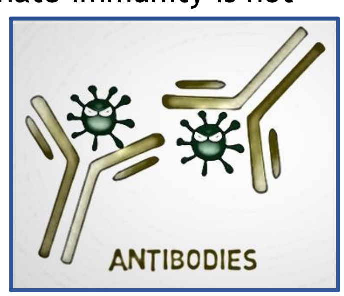
The first step in innate immunity is keeping microbes out of our bodies. Our skin, mucous, acidic stomach pH, tears and saliva are all ways to block the entry of microbes.

If a microbe is able to enter our body, then non-specific white blood cells either kill the microbes by engulfing and then eating them (phagocytosis) or by releasing anti-microbial peptides that are toxic to the microbes.

Adaptive immunity

Adaptive immunity is a specific immune response, adapting to each type of antigen to which it is exposed. It is a slower response and becomes important when innate immunity is not sufficient to clear the infection. It consists of the activity of B cells and T-cells, both specialized types of white blood cells.

B cells produce antibodies that specifically recognize and bind the surface of microbes to prevent them from entering and infecting our cells. They may also recruit innate immune cells to eat the microbes. Our bodies produce a huge number of different B cells that produce distinct antibodies specific to different antigens.



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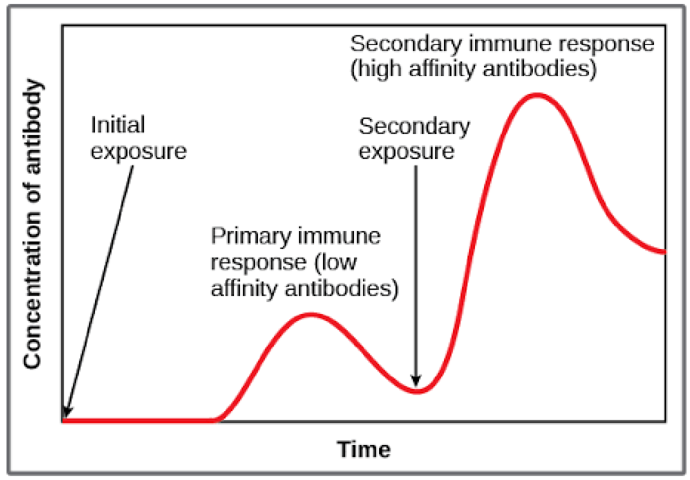
T-cytoxic cells release chemical that break open or kill the infected cells in our body. T-helper cells support both B cell and T-cytotoxic cell functions.

Adaptive immune cells retain a **memory** of every antigen or microbe they have encountered. In this way, a second exposure to an antigen results in faster, more robust adaptive immune response.



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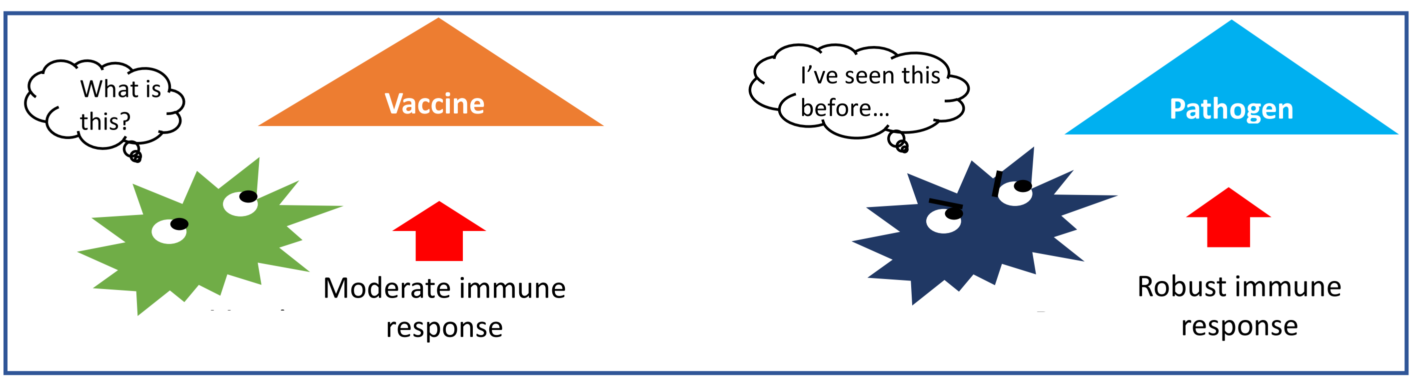
Vaccination is practice for the immune system!

Vaccination is controlled exposure to an antigen to illicit a mild immune response. This initial exposure “trains” the adaptive immune system to quickly recognize the infecting agent and rapidly mount a strong response.

All vaccines work in the same general way – they present a target for the immune system, to “educate” the immune system to recognize a pathogen. Many different “targets” can be used. Sometimes inactivated pathogens are used. Sometimes single proteins are used, typically those on the surface of the pathogen.



The Spike protein is displayed on the surface of SARS-CoV-2 viruses

The spike proteins, on the surface of SARS-CoV-2 virus, recognize the ACE2 receptor protein on the surface of human cells. This provides entry of the virus into the cell. Once inside the cell, the virus coating is removed, the viral RNA genome (genetic material) is copied and viral proteins are expressed. The new genomes are packaged into new virus particles inside vesicles that then expel the new viruses from the cells, leading to spread of the infection. The virus does not enter the nucleus, the cell compartment that contains our genome in the form of chromosomes.

Because it is displayed on the surface of the virus, the spike protein has been used as the target for all vaccines that are currently available and many that are in development. The goal is to train our immune systems to produce antibodies that recognize the spike protein, binding to the spike proteins and neutralizing the virus by blocking entry into our cells.

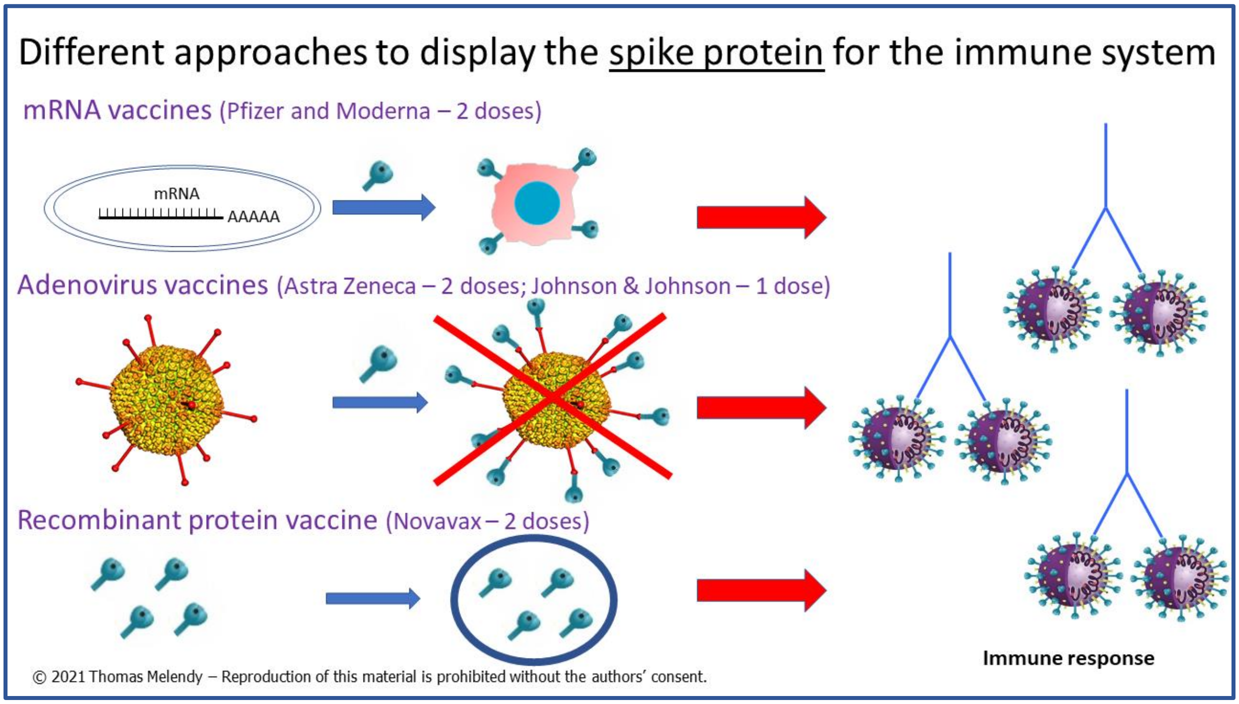
Types of Vaccines against SARS-CoV-2

Three general approaches have been used to develop spike protein-based vaccines.

1. mRNA provides the instructions for making a protein. mRNA vaccines for SARS-CoV-2 use an mRNA for the spike protein. The mRNA is enclosed in a lipid (fatty) vesicle that gets injected and fuses with a few of the muscle cells near the injection site. The mRNA will enter those cells (but NOT the nucleus, where the DNA is!) and the mRNA will be translated into spike protein and displayed on the cell surface. Your immune system will recognize this as foreign and will respond with an adaptive immune response, involving both B calls and T cells.

2. Adenovirus-based vaccines use an inactive (non-infectious) form of an adenovirus, which causes the common cold. The gene for the SARS-CoV-2 spike protein is incorporated into the adenovirus, which will express the spike protein and display it on the viral surface. Again, this will be recognized as foreign and illicit an adaptive immune response.

3. Recombinant protein vaccines use purified spike protein. This is encapsulated in a nanoparticle, a very tiny time-release capsule that will dissolve over time and reveal the spike protein to the immune system. Again, the goal is a robust adaptive immune response.



Herd Immunity

Although the vaccine responses are remarkable, no vaccine is 100% effective. Some people will not develop a robust immune response. Some people won't be able to get vaccinated, for example, if they are immunocompromised. Right now, children can not be vaccinated, although that will hopefully change in the coming months. When a large proportion of a population are immune (vaccinated), this provides indirect protection for those who can't be vaccinated. This is called herd immunity. Essentially, the spread of the disease is kept low, thereby reducing the probability that those unvaccinated or vaccine non-responsive individuals will be exposed to the disease.

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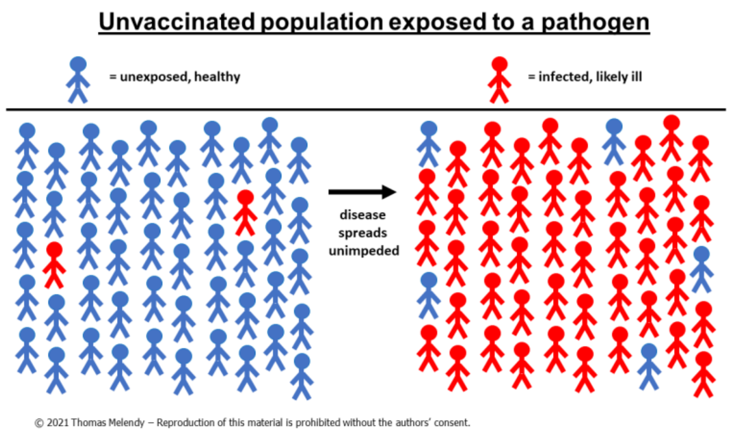

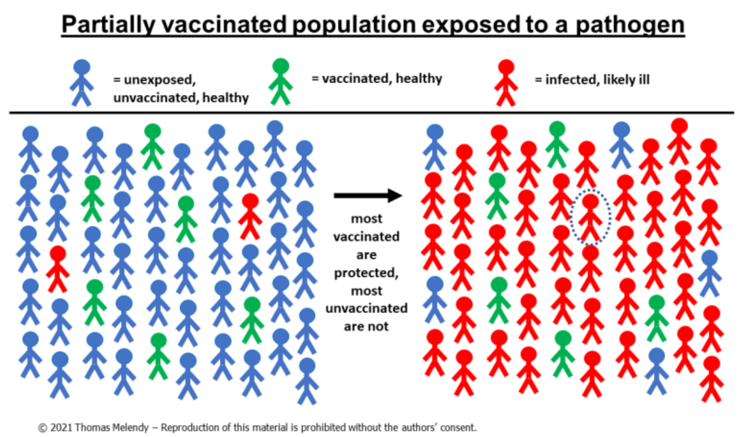

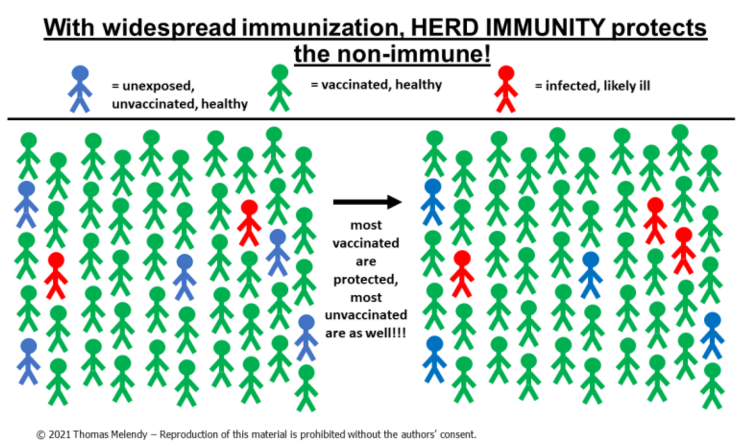

It is estimated that 70-90% of the population will need to vaccinated against SARS-CoV-2 in order to produce herd immunity. This is based, in part, on the transmissibility of this virus.

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Key Concepts:

- COVID-19 vaccines have been extensively tested and have proven to be very safe.
- You may experience side effects, especially after the second dose. This is normal.
- COVID-19 vaccines cannot get into your DNA and change your genetic information.
- COVID-19 vaccines protect most recipients from getting symptoms and have proven very effective at preventing hospitalizations and deaths.
- It is CRITICAL for all people to get their COVID-19 vaccine to protect everyone!
- After you get the vaccine you still need to wear masks – but you can feel less anxious to go out and socialize – safely!