Geneseo COVID-19 Study Group Report V: Long-Term Pharmaceutical Strategies and Prevention of COVID-19

Mary Bartkus, Jennie Dworkin, Kaylee Hausrath, Anthony Rizzo,
& Dr. Kazushige Yokoyama

What is a vaccine?

A vaccine is a form of weakened or killed virus that is inserted in the body in the method of an injection usually given intramuscularly (IM) in the upper arm. Some vaccines, such as the COVID-19 vaccine, contain only a part of the virus. This stimulates the immune system to produce immunity to a specific disease instead of first experiencing the disease to build that protection.

The COVID-19 vaccine tells our cells how to make a specific protein to trigger an immune response inside our body, thus producing antibodies which protect us if COVID-19 particles do actually enter our bodies.

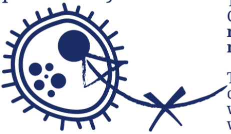
Pfizer-BioNTech and Moderna vaccines are *mRNA vaccines*

Johnson & Johnson's Janssen COVID-19 vaccine is a *viral vector vaccine*

How do they work?

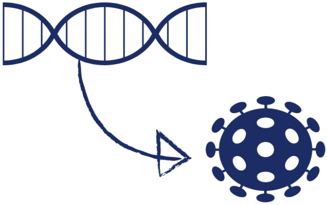
There are currently two types of COVID-19 vaccines that have been authorized for use in the United States: *messenger RNA (mRNA)* vaccines and *viral vector vaccines*.

COVID-19 **mRNA vaccines** work with the body's natural defenses to safely develop immunity to disease.



The mRNA from a COVID-19 vaccine **never enters the nucleus of the cell**.

This means the mRNA cannot affect/interact with our DNA in any way.



COVID-19 **viral vector vaccines** use a modified version of a different, **harmless virus (a "vector") to deliver important instructions to our cells** to start building protection.

The instructions tell your immune system to develop immunity against a **spike protein** that is found on the COVID-19 virus. That way, your body is already trained to fight against COVID-19 if you eventually get exposed.

Central Dogma of Molecular Biology

- **1958** - Francis Crick was credited as the first person to determine the structure of DNA.
- **The Central Dogma of Molecular Biology** is the process by which the instructions encoded in DNA found in the nucleus of human cells
- DNA can be transcribed into an mRNA transcript and later translated into proteins in other parts of human cells.
- mRNA is never found inside the

Side effects?

Sometimes after vaccination, the process of building immunity can cause symptoms, **such as a fever**.

These symptoms are **normal** and are signs that the body is **building immunity.**

nucleus of your cells and therefore, cannot alter your DNA.

Vaccines that use this genetic material cannot affect the genetic makeup of your cells.

Vaccines allow these pieces of mRNA to use your cells to make antibodies.

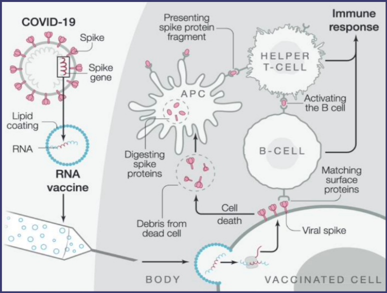
How does mRNA work to help protect against COVID-19 particles?

Since mRNA carries the instructions to make proteins, the mRNA COVID-19 vaccine thus functions to give our bodies instructions to make a specific protein termed the **spike protein.** Spike proteins are found on the surface of COVID-19 particles and are responsible for causing the COVID-19 infection.

After the vaccine is injected into our bodies, we are equipped with the instructions to make spike proteins and these new protein pieces are then displayed on the surface of cells.

However, after we produce these spike proteins, the **mRNA instructions are later degraded by the cells.** Our immune system knows that these spike proteins are not supposed to be there, so it elicits an immune response and thus produces antibodies against COVID-19.

It is important to note that the same process occurs if you naturally pick up the virus. However, with the vaccine, you don't need to actually get infected so no serious health consequences of getting sick arise.



Crotty, S., Dong, Y., &amp; Zhou, A. (2021, February).

Common Misconceptions about the COVID-19 Vaccine

#1

The mRNA COVID-19 vaccine can alter your DNA

mRNA cannot naturally 'backtrack' into DNA so there is no need to worry about this. mRNA simply acts as a copy of instructions to produce proteins that–in the case of the vaccine–produce proteins that are involved in making antibodies against COVID-19 particles.

In addition, since mRNA never enters the nucleus since it has already been transcribed from DNA, the vaccine does not affect or interact with your DNA.

#2

The mRNA COVID-19 vaccine can give you the COVID-19 infection.

Since the COVID-19 mRNA vaccine doesn't use the live COVID-19 virus but rather protein pieces (spike proteins), it can not give you COVID-19.

#3

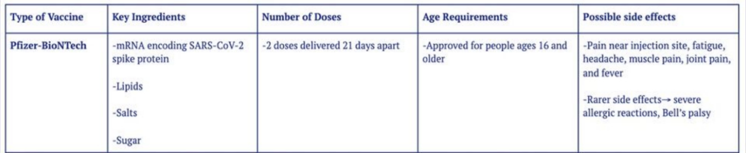
The mRNA COVID-19 vaccine is not 'safe and effective' since it could lead to side effects suck as a fever or headache after injection.

It is important to note that 'safe' does not mean the same things as 'did not hurt at all' or 'no fever' for a little while. The immune system only has the ability to remember things that 'hurt' our bodies in some way.

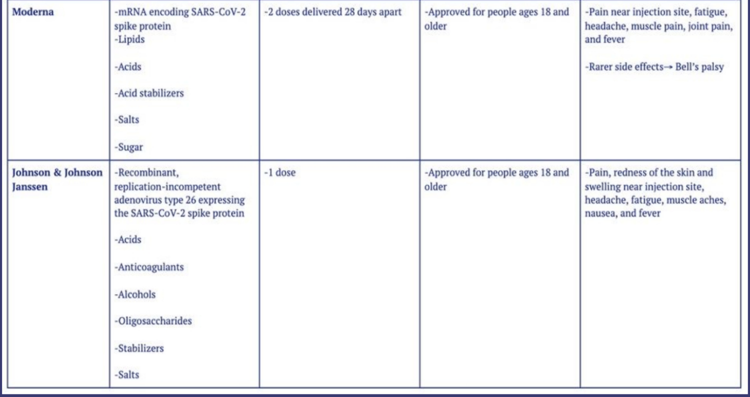
Immunity against any new infection has to be earned, so having a sore arm or a low grade fever is generally taken as a good sign after receiving a vaccine dose since it means that your immune system is working.

However, having no side effects after an injection of the vaccine does NOT mean that it didn't work either. **Everyone's immune systems respond differently.**

Comparing and Contrasting Pfizer-BioNTech, Moderna, and Johnson & Johnson's Janssen COVID-19 Vaccines



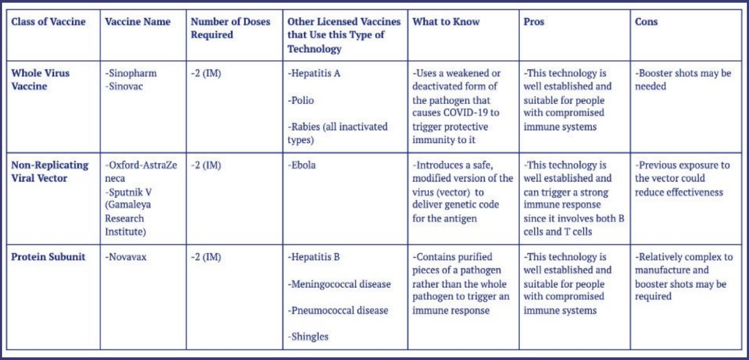
Type of Vaccine	Key Ingredients	Number of Doses	Age Requirements	Possible side effects
Pfizer-BioNTech	-mRNA encoding SARS-CoV-2 spike protein -Lipids -Salts -Sugar	-2 doses delivered 21 days apart	-Approved for people ages 16 and older	-Pain near injection site, fatigue, headache, muscle pain, joint pain, and fever -Rarer side effects→ severe allergic reactions, Bell's palsy



Moderna	-mRNA encoding SARS-CoV-2 spike protein -Lipids -Acids -Acid stabilizers -Salts -Sugar	-2 doses delivered 28 days apart	-Approved for people ages 18 and older	-Pain near injection site, fatigue, headache, muscle pain, joint pain, and fever -Rarer side effects→ Bell's palsy
Johnson & Johnson Janssen	-Recombinant, replication-incompetent adenovirus type 26 expressing the SARS-CoV-2 spike protein -Acids -Anticoagulants -Alcohols -Oligosaccharides -Stabilizers -Salts	-1 dose	-Approved for people ages 18 and older	-Pain, redness of the skin and swelling near injection site, headache, fatigue, muscle aches, nausea, and fever

New Types of COVID-19 Vaccines (not mRNA vaccines) Being Distributed in MENA

There are a few new types of COVID-19 vaccines that don't utilize mRNA. They have been approved for general or emergency use in the Middle East and North Africa (MENA).

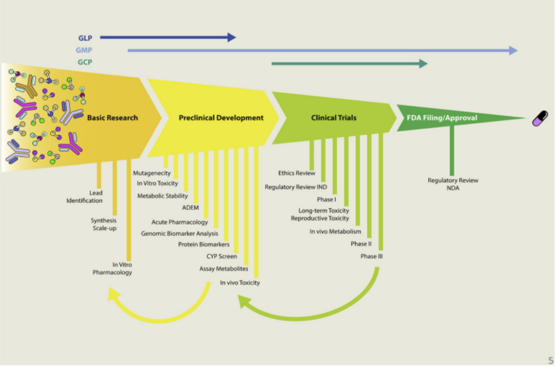


Class of Vaccine	Vaccine Name	Number of Doses Required	Other Licensed Vaccines that Use this Type of Technology	What to Know	Pros	Cons
Whole Virus Vaccine	-Sinopharm -Sinovac	-2 (IM)	-Hepatitis A -Polio -Rabies (all inactivated types)	-Uses a weakened or deactivated form of the pathogen that causes COVID-19 to trigger protective immunity to it	-This technology is well established and suitable for people with compromised immune systems	-Booster shots may be needed
Non-Replicating Viral Vector	-Oxford-AstraZeneca -Sputnik V (Gamaleya Research Institute)	-2 (IM)	-Ebola	-Introduces a safe, modified version of the virus (vector) to deliver genetic code for the antigen	-This technology is well established and can trigger a strong immune response since it involves both B cells and T cells	-Previous exposure to the vector could reduce effectiveness
Protein Subunit	-Novavax	-2 (IM)	-Hepatitis B -Meningococcal disease -Pneumococcal disease -Shingles	-Contains purified pieces of a pathogen rather than the whole pathogen to trigger an immune response	-This technology is well established and suitable for people with compromised immune systems	-Relatively complex to manufacture and booster shots may be required

Pharmaceutical View:

Treatment for COVID-19

Drug Discovery Timeline:



https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5725284/

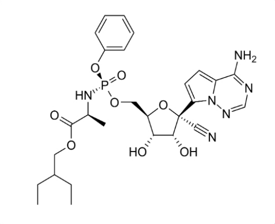
- Preclinical phase lasts for **6-8 years**.
- The drug development process is set up to fail at early stages to save money.
- Before even considering using a drug on humans, there is usually a toxicological study on **2 animal species** first.

15%

of drugs created make it through all stages of development and onto the market.

Remdesivir: FDA Approved

- RNA polymerase inhibitor - **blocks replication process of the virus in human cells.**
- Can only be administered if patient is over 12 years old and >40kg (88 lbs).
- Commonly known on the market as "**Veklury**."



https://en.wikipedia.org/wiki/Remdesivir

Looking ahead: Future strategies for COVID-19

Epidemiology and Public Health

> *"Epidemiology is the method used to find the causes of health outcomes and diseases in populations."*
> \- CDC

Significance

Epidemiologists and other public health professionals are the people that study trends and observe **social, physical, and environmental determinants that affect our health outcomes.**

The work of these professionals will eventually help us return to a normal lifestyle.

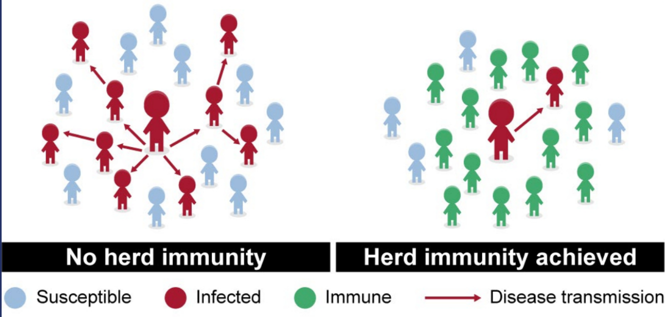
Herd Immunity

The process by which a population is at low-risk for infection, **usually the easiest way to achieve is through vaccination.**

Those who cannot get vaccinated for medical purposes may still be protected by herd immunity, which allows the prevalence of a disease in a population to be very low.

70-80%

of people in a population need to be vaccinated to achieve herd immunity.



Source: GAO adaptation of NIH graphic. | GAO-20-646SP

Prevention and Protection

What are people doing to stop the spread?

Individual Behaviors

How long are we masking?
Social distancing?
Hand washing?

Due to what we know about **herd immunity**, it will take still a bit of time of masking and social distancing before safely resuming to life as normal.

Keeping up with general hygiene like **hand washing** and **regular disinfecting** will continue to be important to prevent other disease spread, not just COVID-19.

Keep up with hygiene and disinfecting.

Wear your mask.

Be patient as we get closer to normalcy.

Vaccine Distribution Progress

There is current progress with trials for **safety** and **effectiveness for kids**.

Pfizer put in a request for FDA approval for children aged 12-15 years for vaccination as of April 9th.

May 1

All adults will be eligible for the COVID-19 vaccine, as directed from the President of the United States.

16+

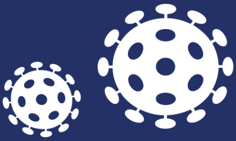
aged New Yorkers are eligible for the COVID-19 vaccine as of April 6th.

International Progress

Many countries are reopening and others still have much work to do.

Recipe for Reopening:

- Fast action from the government
- Isolation facilities for infected people
- Travel restrictions
- Testing
- Masking
- Improved ventilation in public spaces
- Social distancing
- Efficient contact tracing
- A bit of patience



Open for Business
Top Countries Controlling COVID-19

- Australia
- Barbados
- Belize
- Bhutan
- Brunei
- Fiji
- Haiti
- Iceland
- Laos
- Monaco
- New Zealand
- Samoa
- Taiwan
- Vietnam
- Micronesia
- Marshall Islands
- and many more are getting close!

Sources:

https://www.cdc.gov/coronavirus/2019-ncov/vaccines/different-vaccines/mrna.html.

https://www.hackensackmeridianhealth.org/HealthU/2021/01/11/a-simple-breakdown-of-the-ingredients-in-the-covid-vaccines/.

https://www.cdc.gov/coronavirus/2019-ncov/vaccines/different-vaccines/janssen.html.

https://www.chop.edu/centers-programs/vaccine-education-center/making-vaccines/how-are-vaccines-made.

US Food and Drug Administration. (2021). Fact Sheet for Recipients and Caregivers. Silver Spring, Maryland; FDA.

https://www.yourgenome.org/facts/what-is-the-central-dogma

Crotty, S., Dong, Y., &amp; Zhou, A. (2021, February). Covid-19 Vaccine Update: Emerging Questions &amp; Future Applications. American Chemical Society

https://www.healthcareitnews.com/news/emea/four-types-covid-19-vaccine-snapshot

https://pubchem.ncbi.nlm.nih.gov/compound/Remdesivir#section=Drug-and-Medication-Information (Links to an external site.)

https://www.frontiersin.org/articles/10.3389/fmicb.2020.01723/full (Links to an external site.)

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5725284/ (Links to an external site.)

Beigel, John H et al. "Remdesivir for the Treatment of Covid-19 - Final Report." The New England journal of medicine vol. 383,19 (2020): 1813-1826. doi:10.1056/NEJMoa2007764

https://www.cdc.gov/

https://www.whitehouse.gov/briefing-room/statements-releases/2021/03/11/fact-sheet-president-biden-to-announce-all-americans-to-be-eligible-for-vaccinations-by-may-1-puts-the-nation-on-a-path-to-get-closer-to-normal-by-july-4th/

https://www.prnewswire.com/news-releases/nih-covid-19-treatment-guidelines-strongly-recommend-use-of-regen-cov-casirivimab-with-imdevimab-in-outpatients-at-high-risk-of-clinical-progression-301265805.html

https://www.endcoronavirus.org/countries

https://people.com/health/pfizer-requests-fda-approval-covid-vaccine-kids-ages-12-15/

powered by
PIKTOCHART