

COVID-19 Vaccine: The Truth

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I. Abstract

SARS-CoV-2, known by its familiar terms as COVID-19 or the coronavirus, is a respiratory disease that has taken over the entire world since the beginning of 2020, putting everyone in lockdown for a year and a half. Since the first case of COVID and its effects on humans was discovered and understood, scientists have been scrambling to create a vaccine that is over 90% effective without any drastic side effects. Within a year, scientists have created not one, but two mRNA vaccines that pass this criterion. However, with the production and availability of vaccines on the rise, skeptics argue that the vaccine alters one's DNA once they have been administered the dose. However, scientists have proven that COVID vaccines are entirely based on mRNA, and that it doesn't interfere with DNA. In this scientific communication review, we breakdown the process behind the vaccine, its effectiveness, and how it compares with other leading vaccines.

II. Introduction

Overwhelming. Halting. Fear Striking. Fracturing. Humbling. Reorienting. Pandemic. Outbreak. These are some of the many words describing the dreaded COVID-19 pandemic when it held its strongest grip on Earth for a year and a half, sending all the residents into a globe-mandated lockdown. The virus itself exploits our human cells via the central dogma, the process by which the instructions of DNA are converted into RNA, then RNA into the final product, protein. The central dogma explains the flow of genetic information, from DNA to RNA, to make various functional proteins that ultimately come together to form a pathogen (i.e., SARS-CoV-2). What made, and still does make COVID-19 so difficult to fight is that it can develop immunity to the antibodies the body generates to protect itself from the antigen. Antigens are proteins, typically derived from a pathogen such as bacteria or viruses, that can threaten one's health. The body's specific immune system reacts to fight the antigens, triggering a full body immune response. Antibodies are Y-shaped proteins that are used to fight the antigens by memorizing the antigen after the initial infection, to prepare the body in case of a reinfection. COVID started showing signs of immunity against endogenously made antibodies relatively early in the pandemic. This is due to the virus rapidly spreading, increasing the probability of mutation with every DNA replication round, with advantageous mutations (such as those whose antigen no longer is recognized by the antibody) taking hold and becoming more prevalent in the population. All that changed when the vaccine was developed.

The SARS-CoV-2 vaccine was developed in December 2020 and put into effect in early 2021 when both Pfizer and Moderna pharmaceuticals generated a vaccine that was over 90% effective without any drastic side effects. However, this raised questions from many skeptics who adamantly believed that the SARS-CoV-2 vaccine is entirely made up of genetically modified DNA, and that taking in the dose will completely alter one's DNA. On the contrary, the vaccine is purely mRNA-based and does not possess any DNA editing abilities. mRNA is messenger RNA, which are the instructions carried from the nucleus where the DNA is stored to the ribosome where mRNA is translated into proteins. This means that mRNA vaccines have nothing to do with DNA editing or RNA transcription, as the mRNA will never enter the nucleus where the DNA is located.

Which leaves us with a big question: What consequences does the COVID-19 vaccine have on the central dogma?

III. COVID-19's Origins

COVID-19, the disease elicited by the SARS-CoV-2 virus, is an acute respiratory disease that is passed from person to person through the droplet spread. While it was initially thought to only affect immunocompromised people (sick, elderly, and neonates), that was quickly rebuked as people with competent immune systems succumbed to COVID-19 infection. When it was first discovered and still in its early stages, COVID-19 showed symptoms similar to the flu, causing confusion and panic within the medical community as an increasing amount of people infected started to experience serious respiratory problems. Within a span of a mere few months, the virus was able to spread to the entire globe, causing the World Health Organization (WHO) to declare this as a pandemic and mandated lockdowns were enabled for a year and half (Fig. 1). During this time, a virtual network of epidemiologists brought together public health institutions, ministries of health, and WHO Country Officers to analyze the spread of COVID and take more preventative measures as the virus' grip tightened.

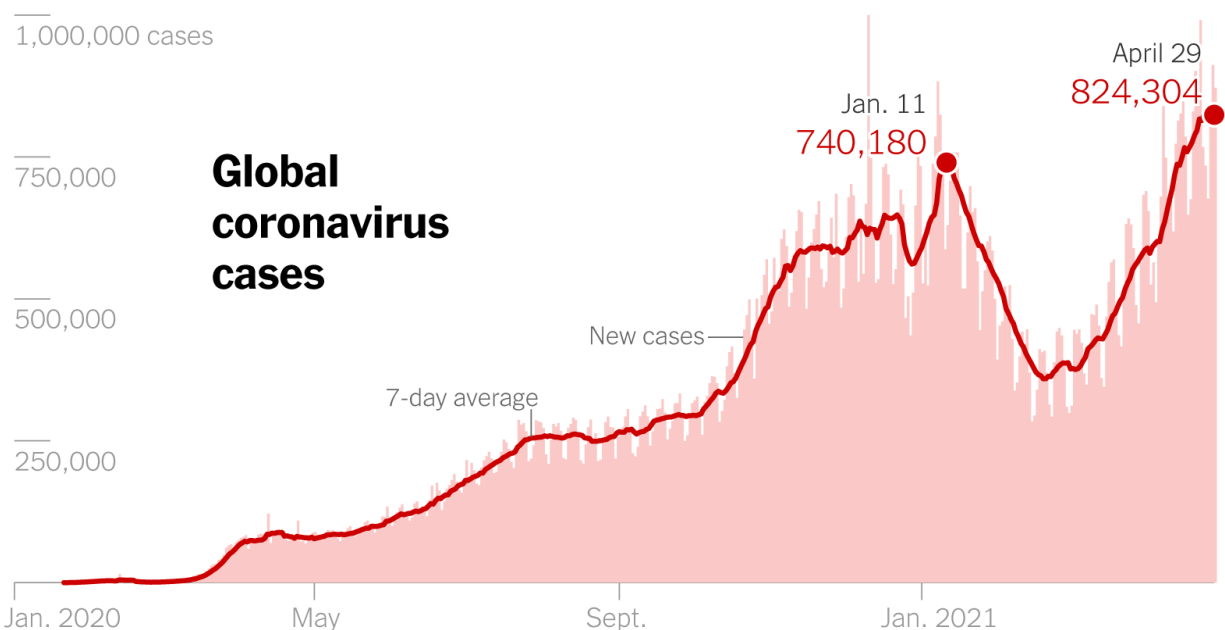


Figure 1. Increase in global coronavirus cases from January 2020 to April 2021. *Gamio and Symonds, New York Times (May 01 2021).*

Of the many preventative measures that were being taken, the main one that was in development was the production of a vaccine. The vaccine had to pass a strict criterion to make sure that it was effective in fighting SARS-CoV-2. In the U.S., a vaccine would typically go through three trials, one at a time. Due to the severity and high-rising cases of COVID, the trials underwent concurrently to race to find an effective preventative. The trials have also involved tens of thousands of volunteers from different races, socio-economic background, and ethnicities to

compare the outcomes of those who took the vaccine and those who didn't. After the volunteers showed no extreme side effects for two months, they were distributed.

With the increase in distribution of vaccines, there was also an increase in those who strongly opposed to take the vaccine. This united both the political far left and far right wings with their opinions on not taking the vaccine. On the far left, anti-vaxxers were found within the “neo-hippie” community, within enclaves of liberal and affluent white people. They argue that a natural and organic lifestyle would be more than sufficient to fight the virus. One notable celebrity in that boat is *Ant Man* star Evangeline Lilly, who put up a controversial post on Instagram of going to a protest that was fighting for “bodily autonomy” and “pro-choice”. In her post, she quoted:

“I believe nobody should be forced to inject their body with anything, against their will,... under any threat whatsoever... #medicalchoice#medicalfreedom#bodilyautonomy”.

In the far right wing, many politicians grouped together, citing mistrust of the government and the “Big Pharma” to avoid the vaccine. Sarah Palin, the ex-senator of Alaska has said that she would get the vaccine “ ‘over [her] dead body’ ”. She then subsequently dines indoors at a restaurant before testing positive two days later and then returned to dine outdoors two days later. However, the main reason that many people are anti-vaxxers is because of the misconception that the vaccine can edit one’s DNA.

IV. The Science Behind the Vaccine

On the contrary to the perspectives of the skeptics, the SARS-CoV-2 vaccine is entirely mRNA based, meaning that the vaccine provides the instructions for the host cell to synthesize proteins that will prepare the human body to fight a SARS-CoV-2 infection. This decision was made due to the complicated nature of COVID being a respiratory disease and using weakened version of the virus as a component of the vaccine would be dangerous to insert and wouldn’t go without any complications within the human body. According to Dr. Karri Haen Whitmer, scientists started to use mRNA as the basis of the vaccine since it:

“[D]eliver[s] a synthetically manufactured genetic blueprint that allows human cells to manufacture its own, harmless viral protein.”

It also helped that the production of mRNA vaccines was already in the making, increasing the speed at which the SARS-CoV-2 mRNA vaccines were created, at about one year, matched up to the scientists’ urgency on finding a vaccine amidst the first and second waves of COVID. This is in comparison to the multiple years it took for vaccines to be developed historically. The vaccine is made up of two processes: RNA transcription and translation, with the former being the how the vaccine is produced and the latter in being how the main component in the vaccine’s effectiveness is produced. RNA transcription is the process of making an RNA copy of a gene’s DNA sequence. Typically, the copy of RNA (mRNA) moves from the cell’s nucleus to the cytoplasm where it synthesizes the encoded protein. In short, through the process of central dogma, DNA is transcribed to a strand of RNA, and the mRNA uses the strand as a protein.

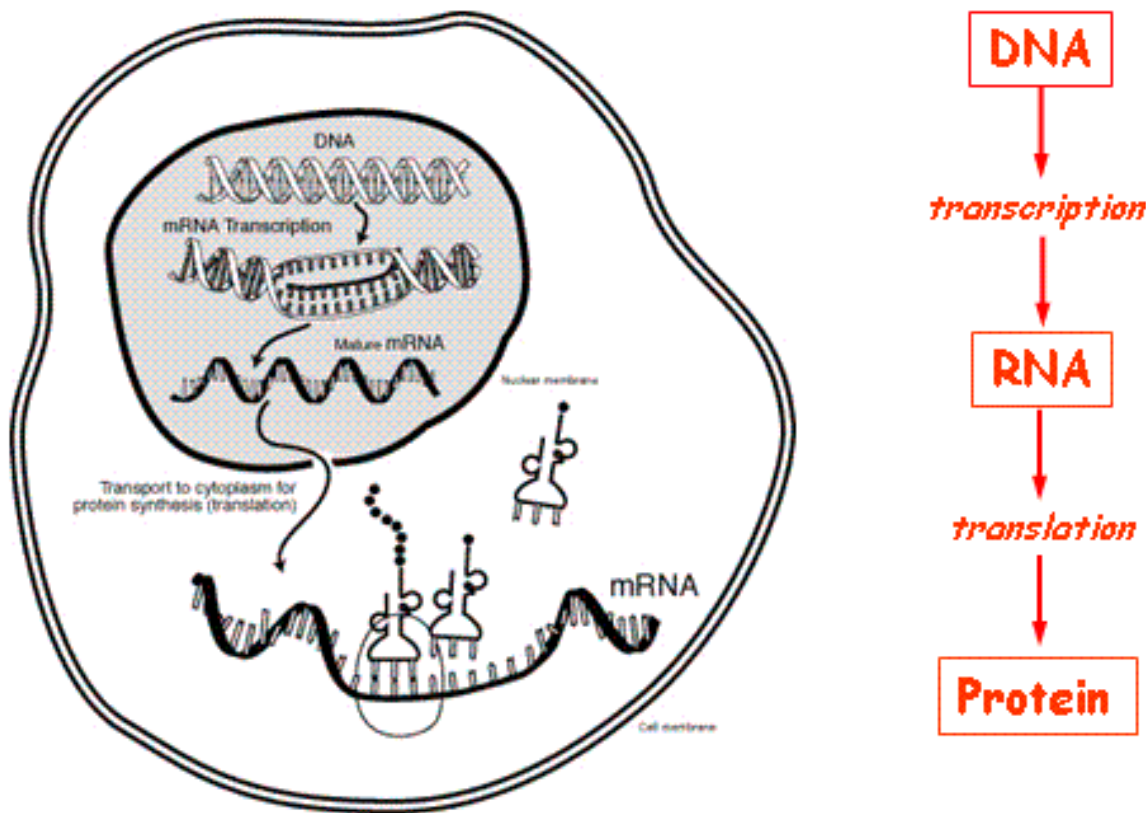


Figure 2. Illustration of the central dogma and where each process (transcription and translation) occurs in the cell. *Chapter 1: The Dynamic Cell, of Molecular Cell Biology. Illustration adapted from the National Human Genome Research Institute (NHGRI).*

The main part of the central dogma that the mRNA vaccine utilizes is RNA translation: the process by which a protein is synthesized from the information contained mRNA (Fig 2). Through translation, mRNA vaccines introduce an mRNA transcript that encodes a viral protein. The cells use the blueprint to produce a harmless portion of the virus, the spike protein alone, mimicking the spike protein found on the surface of COVID-19. The cells then display the spike protein on the cell surface and the immune system responds by producing antibodies to “fight off” the harmless protein. Therefore, this mimics what the body would do if it was infected with COVID. This phenomenon of a mRNA vaccine translating to a harmless protein is carried out by the cell host machinery (Fig 2). The mRNA vaccines are based on the principle that mRNA is an intermediate messenger that will be translated to an antigen after delivery into host cells via various routes. This parallels the host machinery mechanism that the COVID-19 vaccine functions, making mRNA the most convenient method of delivery for antigen immunity for the SARS-CoV-2 vaccine.

V.The Vaccine’s Effectiveness

By introducing mRNA vaccines, protein translation increases and modulates innate and adaptive immunogenicity to improve delivery. mRNA vaccines have elicited potent immunity against infectious diseases in animal models of influenza, Zika virus, and others. After a series of

advancements that mRNA was used to prevent triple-negative breast cancer and lung carcinoma, mRNA has started to become a more integral part of various treatments and scientists are finding ways to make it more effective. In general, after the impact it had on the COVID-19 vaccine, mRNA will likely become a frontrunner as the foundation for many more vaccines and medical breakthroughs in the future.

Like traditional vaccines, mRNA vaccines also use RNA to generate the antigen for an immune response stimulation. This results in teaching the body the correct way to react for when that specific virus invades the body. The most important difference between mRNA vaccines and older vaccines is that mRNA is empirically non-infectious and poses no serious threat to the immune system or to editing the blueprints of the cell, DNA, mainly since it doesn't have access to the nucleus. mRNA also rapidly degrades in the body and cells usually don't take up foreign mRNA without a delivery device, such as the liposomes used in the SARS-CoV-2 vaccine. Due to its efficiency, mRNA can be scaled to adapt to different pathogens as well. The versatility and efficiency of mRNA vaccines is what makes the SARS-CoV-2 vaccine so effective.

Compared with the four leading vaccines, the SARS-CoV-2 vaccine has a greater efficacy than flu and measles, but less than the polio vaccine. The side effects for all four vaccines are very similar with sore arms and colds. While SARS-CoV-2 vaccine is entirely mRNA based, the other three vaccines utilize some of the deadened, or attenuated, virus within the vaccine to enter the bloodstream. Scientists decided to use an mRNA-based vaccine for COVID-19 as it is prevalent in the respiratory system and utilizing a deadened virus would be more harmful than helpful. The different approaches with the SARS-CoV-2 vaccine and the other vaccines make them effective in their own way and across the board doesn't produce any drastic side effects.

VI. Conclusion

The COVID-19 vaccine is an effective vaccine utilizing mRNA and the host machinery to strategically teach the body to quickly eradicate the virus upon infection. The central dogma allows the DNA to transcribe its base pair counterpart to a strand of RNA which then allows mRNA to translate into a protein. The scientists came up with the ingenious way of using RNA translation to synthesize the spike protein in the body. With previous research being done on mRNA vaccines, scientists were able to efficiently develop a new mRNA vaccine within a year compared to the years that other historical vaccines were being developed. Bottom line, the SARS-CoV-2 vaccine is safe and effective due to the mRNA never invading the nucleus so it doesn't go near DNA to "edit it" and the mRNA allows a quicker translation process to present the harmless spike protein on the cell to allow the body to recognize and eliminate the virus upon exposure in the future.

VII. Acknowledgements

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VIII. References