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DNA and RNA vaccines have the same goal as traditional vaccines, but they work slightly differently.Instead of injecting a weakened form of a virus or bacteria into the body as with a traditional vaccine, DNA and RNA vaccines use part of the virus' own genetic code to stimulate an immune response.The mRNA vaccine for COVID-19 co-developed by Pfizer and BioNTech was the first of its kind authorized for emergency use in the United States. On December 11, 2021 the Food and Drug Administration granted emergency use authorization for the messenger RNA (mRNA) vaccine for COVID-19 co-developed by Pfizer and BioNTech. The emergency use vaccine is approved for people ages 5 and older. This article explains what exactly mRNA vaccines are and how they work. It also discusses how RNA vaccines are different from another advancement in disease prevention—DNA vaccines—along with the pros and cons of each type. Traditional vaccines, which expose the body to proteins made by a virus or bacteria, are often made by using weakened or inactive versions of that virus or bacteria. That's how popular vaccines, like the measles, mumps, and rubella (MMR) vaccine and pneumococcal vaccine, work. When you get the MMR vaccine, for example, your body is introduced to weakened forms of the measles, mumps, and rubella viruses that do not cause disease. This triggers an immune response and causes your body to make antibodies like it would with a natural infection. The antibodies in traditional vaccines like these help your body recognize and fight the virus should you be exposed to it later on, preventing you from getting sick. A DNA or RNA vaccine has the same goal as traditional vaccines, but they work slightly differently. Instead of injecting a weakened form of a virus or bacteria into the body, DNA and RNA vaccines use part of the virus' own genes to stimulate an immune response. In other words, they carry the genetic instructions for the host's cells to make antigens. "Both DNA and RNA vaccines deliver the message to the cell to create the desired protein so the immune system creates a response against this protein," Angelica Cifuentes Kottkamp, MD, an infectious diseases doctor at NYU Langone's Vaccine Center, tells Verywell. "[Then the body] is ready to fight it once it sees it again." Research published in 2019 in the medical journal Frontiers in Immunology reports that "preclinical and clinical trials have shown that mRNA vaccines provide a safe and long-lasting immune response in animal models and humans." "So far, there's been no mass production of vaccines based on DNA or RNA," Maria Gennaro, MD, a professor of medicine at the Rutgers New Jersey Medical School, tells Verywell. "So this is kind of new." Unlike traditional vaccines that contain a weak or inactive form of a virus, messenger RNA (mRNA) vaccines instruct cells in your body to build a protein similar to the virus. Your body responds to the protein with an immune response, which prepares your body to fight the actual virus if you encounter it. DNA and RNA vaccines work the same way as each other, but have some differences. With a DNA vaccine, the virus' genetic information "is transmitted to another molecule that is called the messenger RNA (mRNA)," Gennaro says. This means with an RNA or mRNA vaccine, you're one step ahead of a DNA vaccine. Vaccines are evaluated for their effectiveness in what are called vaccine effectiveness studies. No vaccines are 100% effective in preventing disease. But data from these studies shows that the mRNA vaccines developed by Pfizer-BioNTech and Moderna reduce the risk of COVID-19 by 90% or more in people who are full vaccinated. "The mRNA goes into the cell, and the cell translates it into proteins…which are the ones that the organism sees and induces the immune response," Gennaro says. Another difference between a DNA and RNA vaccine is that a DNA vaccine delivers the message via a small electrical pulse, which "literally pushes the message into the cell," Cifuentes-Kottkamp says. "The advantage is that this vaccine is very stable at higher temperatures. The disadvantage is that it requires a special device that provides the electrical pulse," she says. DNA and RNA vaccines are touted for their cost effectiveness and ability to be developed more quickly than traditional, protein vaccines. Traditional vaccines often rely on actual viruses or viral proteins grown in eggs or cells, and can take years and years to develop. DNA and RNA vaccines, on the other hand, can be made more readily available because they rely on genetic code—not a live virus or bacteria. This also makes them cheaper to produce. "The advantage over protein vaccines—in principle, not necessarily in practice—is that if you know what protein you want to end up expressing in the body, it's very easy to synthesize a messenger RNA and then inject it into people," Gennaro says. "Proteins are a little more finicky as molecules, whereas the nucleic acid [DNA and RNA] is a much simpler structure." But with any health advancement comes potential risk. Gennaro says that with a DNA vaccine, there is always a risk it can cause a permanent change to the cell's natural DNA sequence. "Usually, there are ways in which DNA vaccines are made that try to minimize this risk, but it's a potential risk," she says. "Instead, if you inject mRNA, it cannot get integrated into the genetic material of a cell. It is also ready to be translated into protein." Because no DNA vaccine is currently approved for human use, there is still much to learn about their effectiveness. With two mRNA vaccines approved for emergency use, they are much closer to full approval and licensing by the FDA. DNA and RNA vaccines both instruct cells in your body to produce a protein that induces an immune response. Unlike RNA vaccines, DNA vaccines require an electrical impulse to push the genetic message into the cell. And while mRNA vaccines cannot affect your genes, this is a potential risk with DNA vaccines. DNA and RNA vaccines contain genetic information that instructs cells in your body to produce a protein with a similar structure to that of the virus. This tricks your body into building an immune response to the protein that prepares your body to fight the real virus if you encounter it. Unlike traditional vaccines, neither RNA or DNA vaccines contain a live virus. For this reason they are more cost effective and can be produced more quickly than traditional vaccines. RNA and DNA vaccines induce a similar immune response, but DNA vaccines require an electrical pulse to reach the cell. Frequently Asked Questions Are mRNA vaccines for COVID-19 safe even though they were developed so quickly? The mRNA vaccines went through all the necessary steps to ensure they are safe and effective, including three phases of clinical trials, FDA authorization and approval, and intense safety monitoring. Do mRNA vaccines alter your DNA? No, mRNA vaccines deliver instructions (messenger RNA) to your cells to build protection against the virus that causes COVID-19. The messenger RNA never enters the nucleus of the cell, which is where your DNA is located. When COVID-19 hit, a tremendous amount of funding and attention poured into mRNA vaccine development. As a result, the highly effective mRNA COVID-19 vaccines became the first of their kind to gain FDA approval and authorization. Messenger RNA vaccines are an important, life-saving advancement that has opened the door to a promising new era in disease prevention. The information in this article is current as of the date listed, which means newer information may be available when you read this. For the most recent updates on COVID-19, visit our coronavirus news page. RNA (or ribonucleic acid) is a nucleic acid that is used in making proteins inside of cells. DNA is like a genetic blueprint inside of every cell. However, cells do not "understand" the message DNA conveys, so they need RNA to transcribe and translate the genetic information. If DNA is a protein "blueprint," then think of the RNA as the "architect" that reads the blueprint and carries out the building of the protein. There are different types of RNA that have different functions in the cell. These are the most common types of RNA that have an important role in the functioning of a cell and protein synthesis. mRNA is translated into a polypeptide. (Getty/Dorling Kindersley) Messenger RNA (or mRNA) has the main role in transcription, or the first step in making a protein from a DNA blueprint. The mRNA is made up of nucleotides found in the nucleus that come together to make a complementary sequence to the DNA found there. The enzyme that puts this strand of mRNA together is called RNA polymerase. Three adjacent nitrogen bases in the mRNA sequence is called a codon and they each code for a specific amino acid that will then be linked with other amino acids in the correct order to make a protein. Before mRNA can move on to the next step of gene expression, it first must undergo some processing. There many regions of DNA that do not code for any genetic information. These non-coding regions are still transcribed by mRNA. This means the mRNA must first cut out these sequences, called introns, before it can be coded into a functioning protein. The parts of mRNA that do code for amino acids are called exons. The introns are cut out by enzymes and only the exons are left. This now single strand of genetic information is able to move out of the nucleus and into the cytoplasm to begin the second part of gene expression called translation. tRNA will bind an amino acid to one end and has an anticodon on the other. (Getty/MOLEKUUL) Transfer RNA (or tRNA) has the important job of making sure the correct amino acids are put into the polypeptide chain in the correct order during the process of translation. It is a highly folded structure that holds an amino acid on one end and has what is called an anticodon on the other end. The tRNA anticodon is a complementary sequence of the mRNA codon. The tRNA is therefore ensured to match up with the correct part of the mRNA and the amino acids will then be in the right order for the protein. More than one tRNA can bind to mRNA at the same time and the amino acids can then form a peptide bond between themselves before breaking off from the tRNA to become a polypeptide chain that will be used to eventually form a fully functioning protein. Ribosomal RNA (rRNA) helps facilitate the bonding of amino acids coded for by the mRNA. (Getty/LAGUNA DESIGN) Ribosomal RNA (or rRNA) is named for the organelle it makes up. The ribosome is the eukaryotic cell organelle that helps assemble proteins. Since rRNA is the main building block of ribosomes, it has a very large and important role in translation. It basically holds the single stranded mRNA in place so the tRNA can match up its anticodon with the mRNA codon that codes for a specific amino acid. There are three sites (called A, P, and E) that hold and direct the tRNA to the correct spot to ensure the polypeptide is made correctly during translation. These binding sites facilitate the peptide bonding of the amino acids and then release the tRNA so they can recharge and be used again. miRNA is thought to be a control mechanism leftover from evolution. (Getty/MOLEKUUL) Also involved in gene expression is micro RNA (or miRNA). miRNA is a non-coding region of mRNA that is believed to be important in the either promotion or inhibition of gene expression. These very small sequences (most are only about 25 nucleotides long) seem to be an ancient control mechanism that was developed very early in the evolution of eukaryotic cells. Most miRNA prevent transcription of certain genes and if they are missing, those genes will be expressed. miRNA sequences are found in both plants and animals, but seem to have come from different ancestral lineages and are an example of convergent evolution.

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