Gene expression and the function of mRNA vaccines

Genes are individual pieces of genetic information that accumulate into DNA

Proteins are pivotal for the cell to carry out tasks and to maintain its integrity. Cells store all the information needed to make proteins within their DNA.

DNA is separated into individual segments known as genes, with each gene containing all the information needed to make one protein.

Gene expression defines the pathway of using the information stored within a gene to make a protein. The two key stages of the gene expression pathway are transcription and translation.

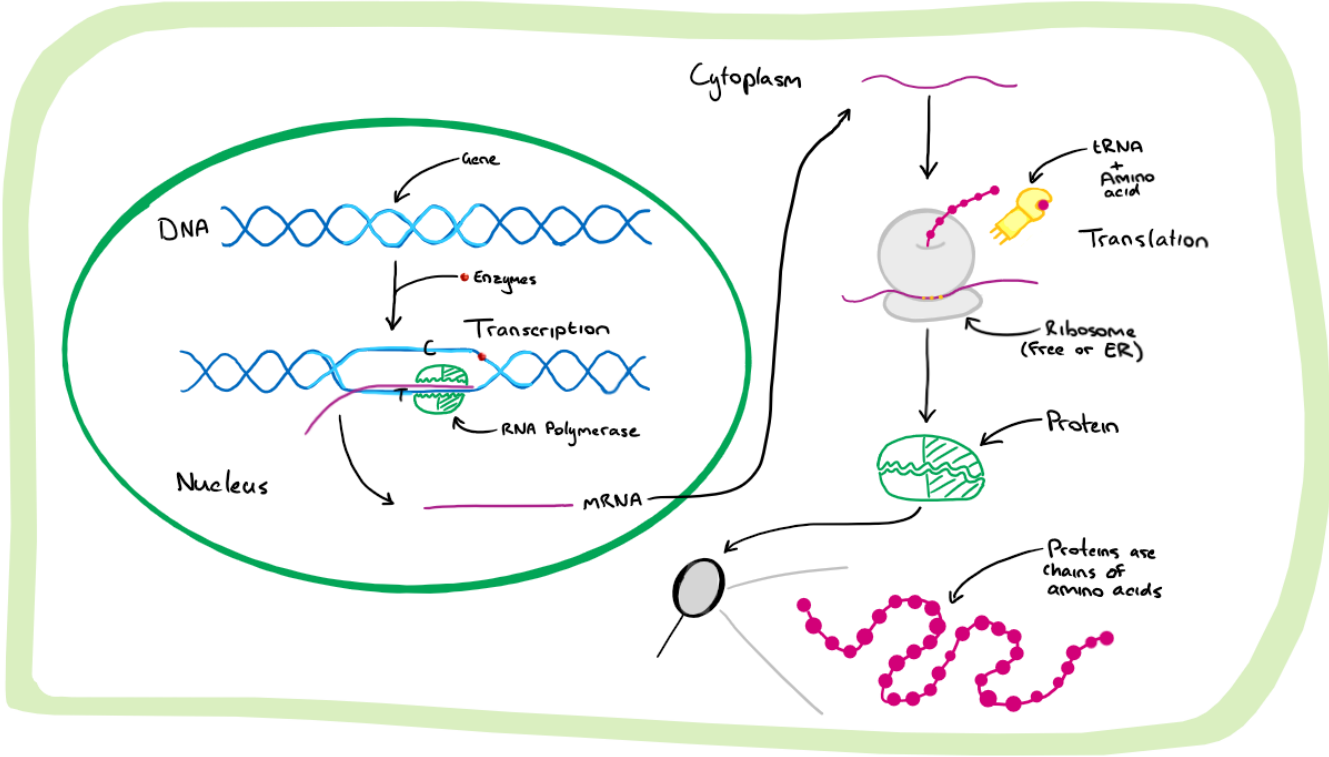


Image demonstrating the process of gene expression.

Transcription

The process of transcription is carried out by the enzyme, RNA polymerase.

DNA consists of two strands, but only one strand of DNA can be translated by RNA polymerase. Therefore, additional enzymes separate DNA into its two strands: the coding and template strand.

The coding strand contains all the information needed to make the desired protein. Yet, to make an mRNA copy of the coding strand, RNA polymerase reads from the template strand.

Once the enzyme has bound to the template strand, it scans the DNA sequence to find the first base of the gene. Once RNA polymerase has found the first base, the enzyme begins transcription.

This involves RNA polymerase moving forward along the template strand whilst matching an mRNA base to every DNA base it reads. This results in the continuous production of an mRNA strand.

Once RNA polymerase reads the last DNA base from the template strand, the enzyme stops transcription and releases itself from the DNA.

This allows both DNA strands to re-unite, and the newly formed mRNA is released into the nucleus.

Translation

Protein synthesis occurs at organelles called ribosomes. mRNA must exit the nucleus to be translated as ribosomes are only found within the cytoplasm.

mRNA bases are segmented into triplets, and each triplet is known as a codon. mRNA binds into the ribosome so that only one codon is ever visible. The first codon visible is always the START codon.

tRNA molecules supply the ribosome with the components it needs to translate mRNA. There are various tRNAs and all have a unique triplet of bases known as an anticodon. This tRNA anticodon corresponds to a particular amino acid that the tRNA carries.

tRNAs interact with the mRNA strand by matching their anticodons to mRNA codons. Yet, there is only one mRNA codon visible to the pool of tRNAs at one time. Like trying to find that one piece of the jigsaw puzzle that just won't fit, many tRNAs try matching their anticodons with the visible codon until one perfectly fits.

One tRNA will correctly match its anticodon to the START codon and subsequently give up its amino acid to the ribosome. The mRNA strand then moves forward along the ribosome by three bases to reveal the next visible codon. The process of a tRNA matching the next visible codon then repeats.

One by one, ribosomes link amino acids gifted by tRNAs together to form an amino acid chain. The matching of a tRNA to the STOP codon causes translation to end.

After the termination of translation, the long chain of amino acids rearranges itself into a new protein. This marks the completion of gene expression.

Vaccines and the Immune Response

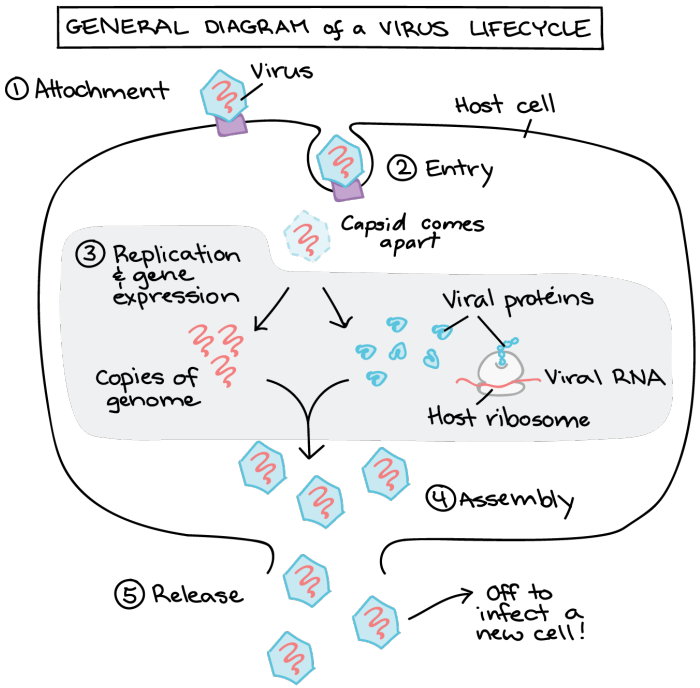
Upon encountering a target cell, a virus injects its RNA into the cell's cytoplasm. Viral RNA consists of instructions telling the cell to make replicate copies of the virus. These new virus replicates then move on to other cells in the body and repeat the process.

While this is happening, the immune system is trying to attack the virus, as it is recognized as foreign to the body. However, this is a slow process as the immune system must first learn how to destroy the virus. This is where vaccines come in handy.

Vaccines are vital for diseases and help prevent a larger outbreak. In particular, the effects worldwide from the Covid-19 pandemic have been significantly reduced by mRNA (messenger RNA) vaccines. But how do mRNA vaccines work?

An mRNA vaccine works by introducing a version mimicking the virus's RNA into cells. This RNA is translated by the body into protein antigens. This causes an immune response where antibodies are made to attack the antigens, thereby allowing the immune system to learn how to attack this type of virus.

These antibodies created remain in the body on the cell surface, and when they recognize the same RNA sequence in the future the antibodies can destroy the virus before it can replicate too much and have detrimental effects on the body.



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