

# Modeling an mRNA Vaccine

## Student Instructions

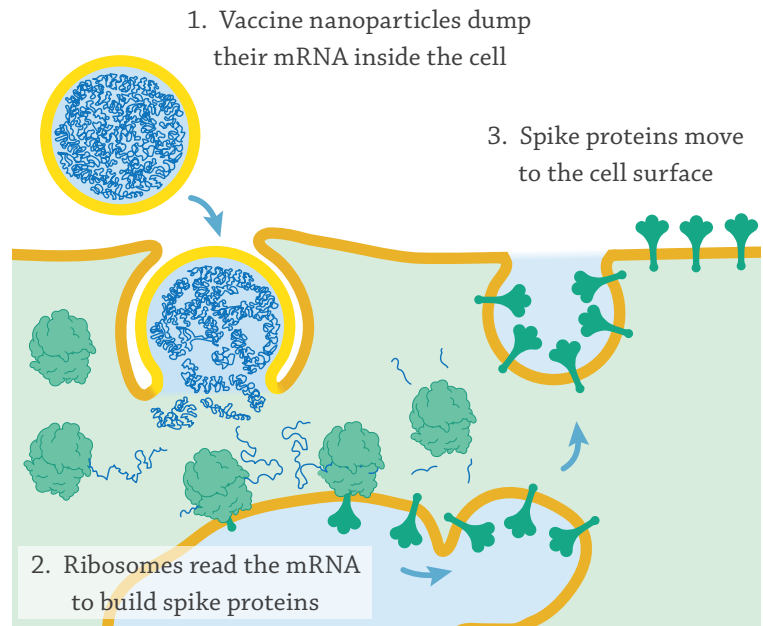
### Background

An mRNA vaccine delivers many copies of a specific mRNA molecule to cells around the site where it is injected.

The mRNA in the vaccine is built to look like an mRNA that your cells would make. It holds coded information that your cells can read to build a whole spike protein.

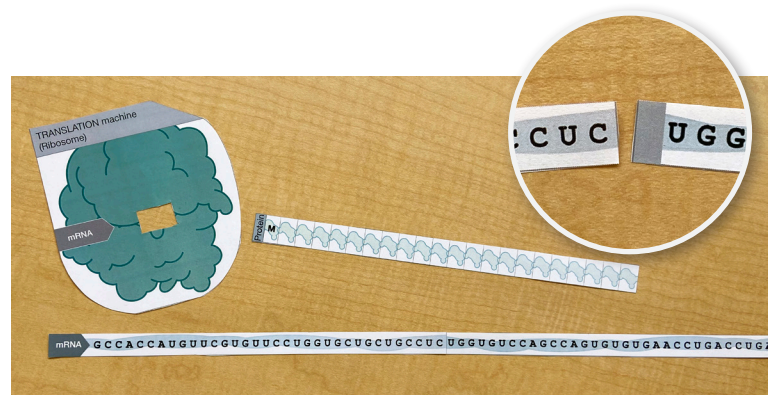
Spike protein is just a small bit of the coronavirus.

In this modeling activity, you will decode some of the information in an mRNA vaccine and build part of a spike protein.



### Prepare Your Materials

- Cut out the mRNA strips. Overlap the ends and tape them together to make one long strand.
- Cut out the Protein strip.
- Cut out the Translation Machine, then cut along the dotted lines to make a window.



### TRANSLATION

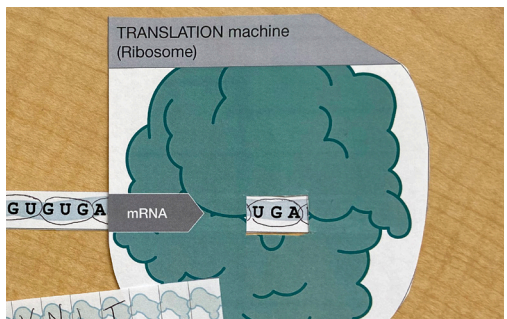
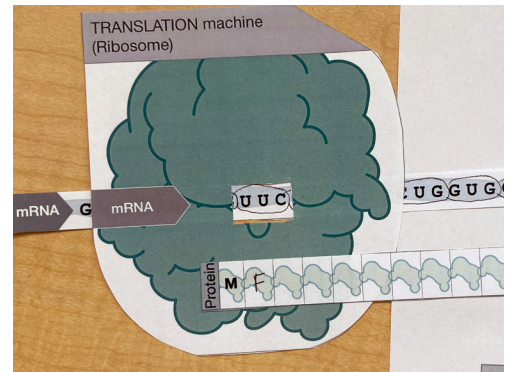
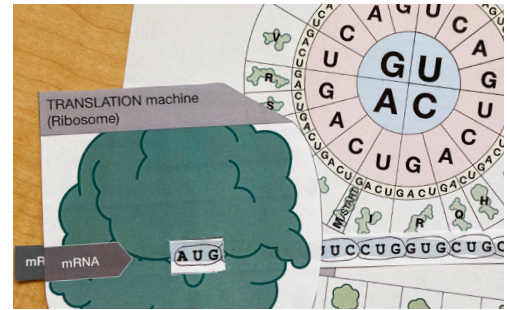
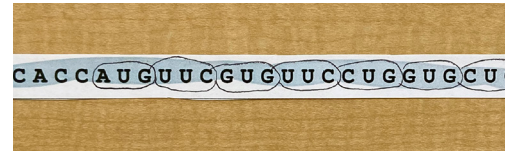
Summary: The ribosome reads the bases of the mRNA, putting amino acids together to make a protein.

A cell does this:	Do this with your model:
1. The mRNA attaches to a ribosome. The ribosome slides along the mRNA until it finds the bases "AUG."	Starting at the beginning of the mRNA, scan along until you find the first "AUG." Circle it.

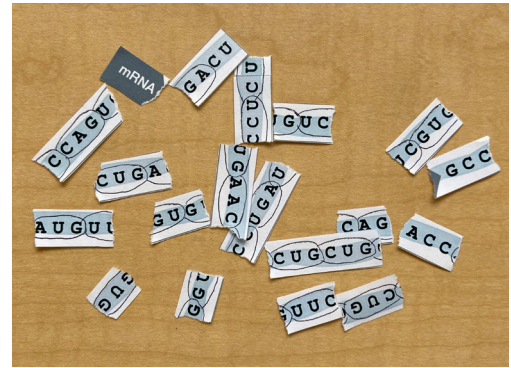


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A cell does this:	Do this with your model:
<p><b>2.</b> AUG is the “start” signal. It sets the reading frame for building the protein.</p>	<p>Along the rest of the mRNA, circle the bases in groups of 3. Each group of 3 bases is called a codon.</p>
<p><b>3.</b> Transfer RNA (tRNA) molecules attach to the 3-letter mRNA codons by complementary base pairing. At the other end, they carry an amino acid.</p>	<p>Put the window of the Translation machine over the first AUG on the mRNA. Look at the Amino Acid Codon Chart; notice that AUG codes for methionine (M). M is already marked in the first box on your protein strip.</p>
<p><b>4.</b> The ribosome slides along the mRNA, moving 3 bases at a time. Inside the ribosome, each codon recruits a tRNA molecule, which brings in the next amino acid. The ribosome links the amino acids together to start building a protein.</p>	<p>Slide the window of the Translation machine to the next group of 3 bases (codon). Look up the codon on the Amino Acid Codon Chart, and write the one-letter code in the next box on the protein strip.</p> <p><i>TIP: To use the chart, find the first letter of the codon in the center and read outward to find the right amino acid.</i></p>
<p><b>5.</b> The ribosome continues along the mRNA molecule, reading codons and adding amino acids to the growing protein chain.</p>	<p>Continue: slide the Translation machine along the mRNA, look up each codon, and add the one-letter code to the protein strip.</p>
<p><b>6.</b> When the ribosome reaches a STOP codon, it releases the mRNA and the finished protein.</p> <p>The vaccine’s full mRNA sequence is 4,284 bases long. It codes for a protein with 1,274 amino acids.</p> <p>(Note: there are bases at the beginning and end that don’t code for amino acids.)</p>	<p>When you reach a codon that codes for STOP, your protein is finished.</p> <p>You have just built a very small piece of spike protein!</p>

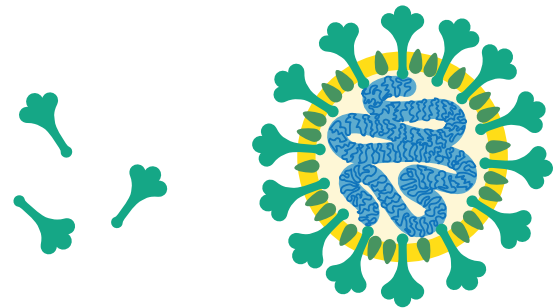


A cell does this:	Do this with your model:
<p><b>7.</b> The cell can read the mRNA again to build more spike proteins. But mRNA is an unstable molecule with a limited lifespan in the cell. Eventually the cell breaks it down and recycles its components.</p>	<p>Tear or cut your mRNA into small pieces.</p>



### Spike proteins cause an immune response

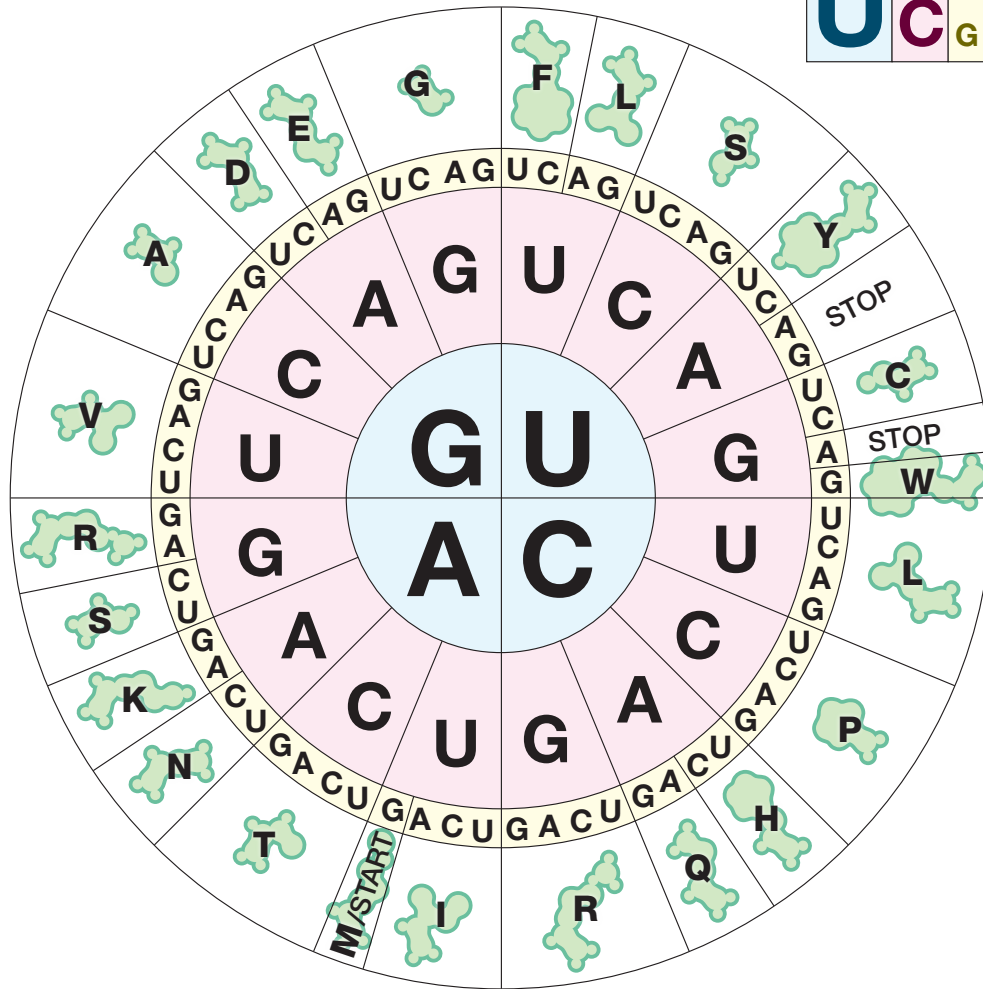
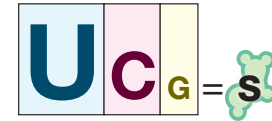
The spike proteins go to the cell membrane, where immune cells find them. The immune system can then learn how to recognize the spike protein. That way, if you are ever exposed to the real virus, your immune system can clear it before it can make you very sick.























The spike protein (left) is just a small part of the whole SARS-CoV-2 coronavirus (right). The spike protein on its own cannot cause a viral infection.

# Amino Acid Codon Chart

Circular Version



## Amino acid side chains





















 <b>A</b> Alanine (Ala)	 <b>C</b> Cysteine (Cys)	 <b>D</b> Aspartic acid (Asp)	 <b>E</b> Glutamic acid (Glu)	 <b>F</b> Phenylalanine (Phe)	 <b>G</b> Glycine (Gly)	 <b>H</b> Histidine (His)	 <b>I</b> Isoleucine (Ile)	 <b>K</b> Lysine (Lys)	 <b>L</b> Leucine (Leu)
 <b>M</b> Methionine (Met)	 <b>N</b> Asparagine (Asn)	 <b>P</b> Proline (Pro)	 <b>Q</b> Glutamine (Gln)	 <b>R</b> Arginine (Arg)	 <b>S</b> Serine (Ser)	 <b>T</b> Threonine (Thr)	 <b>V</b> Valine (Val)	 <b>W</b> Tryptophan (Trp)	 <b>Y</b> Tyrosine (Tyr)



# Amino Acid Codon Chart

Square Version

		Second Letter					
		U	C	A	G		
U	U	UUU	UCU	UAU	UGU	U	
		UUC	UCC	UAC	UGC	C	
		UUA	UCA	UAA	UGA	STOP	A
		UUG	UCG	UAG	UGG	STOP	G
C	C	CUU	CCU	CAU	CGU	U	
		CUC	CCC	CAC	CGC	C	
		CUA	CCA	CAA	CGA	A	
		CUG	CCG	CAG	CGG	G	
A	A	AUU	ACU	AAU	AGU	U	
		AUC	ACC	AAC	AGC	C	
		AUA	ACA	AAA	AGA	A	
		AUG	ACG	AAG	AGG	G	
G	G	GUU	GCU	GAU	GGU	U	
		GUC	GCC	GAC	GGC	C	
		GUA	GCA	GAA	GGA	A	
		GUG	GCG	GAG	GGG	G	

Amino acid side chains									
 A Alanine (Ala)	 C Cysteine (Cys)	 D Aspartic acid (Asp)	 E Glutamic acid (Glu)	 F Phenylalanine (Phe)	 G Glycine (Gly)	 H Histidine (His)	 I Isoleucine (Ile)	 K Lysine (Lys)	 L Leucine (Leu)
 M Methionine (Met)	 N Asparagine (Asn)	 P Proline (Pro)	 Q Glutamine (Gln)	 R Arginine (Arg)	 S Serine (Ser)	 T Threonine (Thr)	 V Valine (Val)	 W Tryptophan (Trp)	 Y Tyrosine (Tyr)