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Mutate a DNA Sequence

Student Instructions

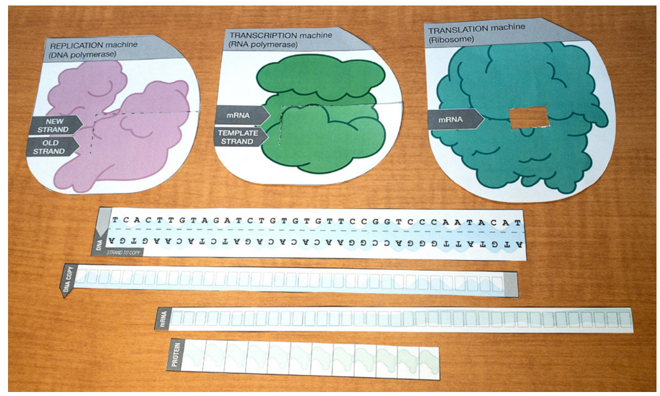
Background

DNA replication happens whenever new cells are made, like during growth or wound healing. Although DNA replication is tightly regulated and remarkably accurate, errors do occur. These errors are called mutations—and when they happen in cells that give rise to eggs and sperm, they are a source of new genetic variations that can be passed on to offspring.

In this activity, you will use a paper model to make a mutation in a gene during DNA replication. Then you'll transcribe and translate the gene to see how the mutation affects the protein it codes for.

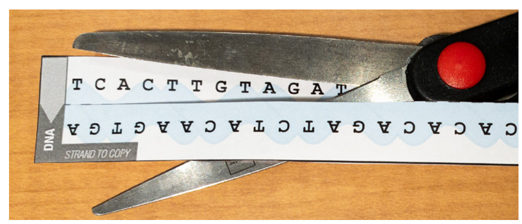
Prepare your materials

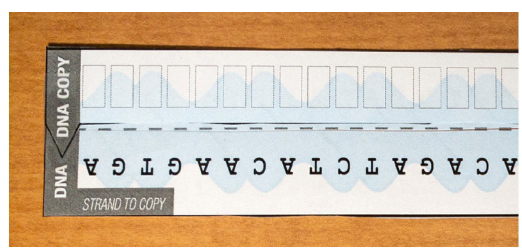
- Cut out the DNA, DNA COPY, mRNA, and PROTEIN strips.
- Cut out the Machines for TRANSCRIPTION, TRANSLATION (If you have done the Transcription and Translation activity, you'll already have these machines), and REPLICATION; cut along the dashed lines.

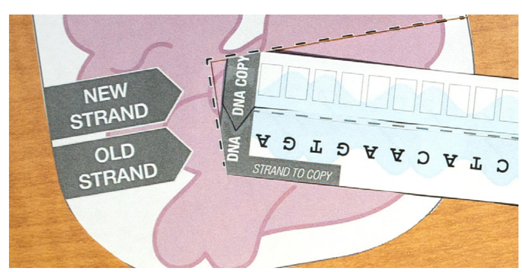


Replication: A molecular machine called DNA Polymerase attaches to DNA and makes a copy.

A cell does this:	**Do this with your model:**
1. DNA polymerase "un-zips" the double-stranded DNA, separating the complementary strands.	Cut the DNA strip along the dashed line, stopping at the gray bar.
2. The cell replicates both DNA strands at the same time, making two double-stranded copies.	You'll copy just one DNA strand (you may want to fold the other strand so it's out of the way). Line up the dark arrow on the DNA COPY strip with the light arrow on the *STRAND TO COPY*. Use tape to hold it in place.
3. DNA polymerase attaches to the DNA strand to be copied.	Slide the strips into the REPLICATION Machine. Line up the DNA COPY strip with NEW STRAND, and *STRAND TO COPY* with OLD STRAND







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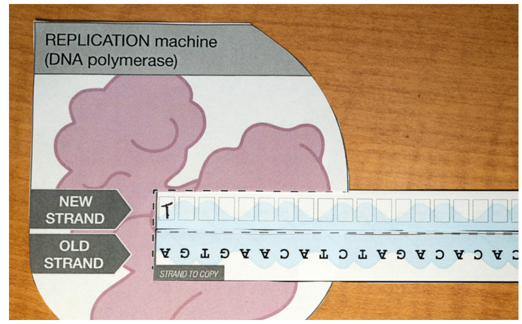
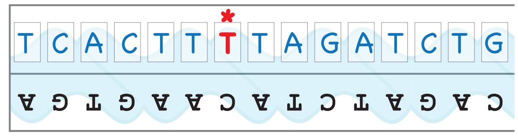
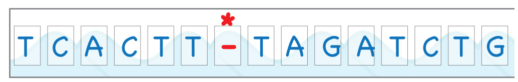
A cell does this:	Do this with your model:
4. DNA Polymerase slides along the DNA strand, adding complementary building blocks to the DNA copy as it goes. ***G*** pairs with ***C,*** and ***A*** pairs with ***T***.	Write the first complimentary base on the DNA COPY strip.
5. Sometimes DNA Polymerase makes a mistake. Most of the time, the cell fixes these mistakes. But when one remains, it is called a mutation.	As you fill in complementary bases, randomly make one of the following errors somewhere along your strip: ***Substitution:*** write in a base that doesn't match. ***Insertion:*** write in an extra base between two boxes. ***Deletion:*** write a "–" instead of the complementary base. Mark the mutation with a *.





Substitution

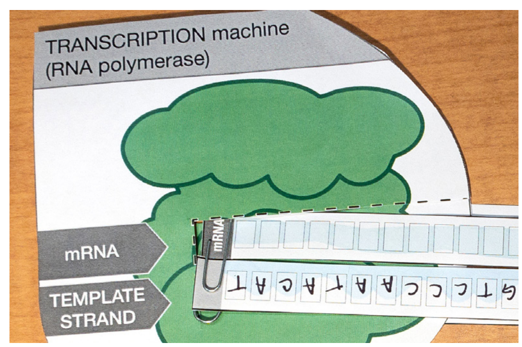
Insertion

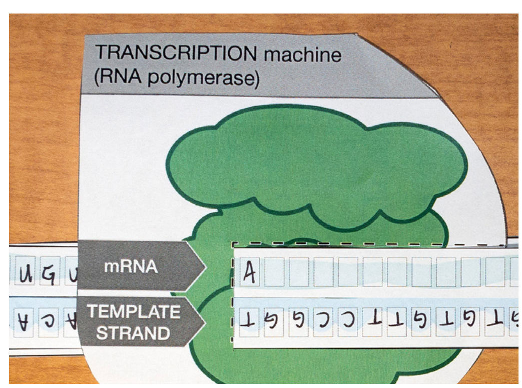


Deletion

Transcription: RNA Polymerase attaches to a gene and makes an mRNA copy.

A cell does this:	Do this with your model:
6. Transcription machinery "unzips" the DNA, temporarily separating the complementary strands.	Turn so the DNA COPY is upside-down. Line up the mRNA strip above it. Use a paperclip or tape to hold it in place.
7. RNA polymerase wraps around the DNA template strand.	Slide the strips into the TRANSCRIPTION machine. The DNA COPY is the Template Strand.
8. RNA polymerase reads the DNA template strand, adding building blocks to the mRNA strand according to the rules of complementary base pairing: **G** (in DNA) pairs with **C** (in RNA); **C** pairs with **G**; **T** pairs with **A**; **A** pairs with **U**.	Write in the complimentary bases on the mRNA strip, sliding the machinery along the strips as you go. If you made an insertion, add its complementary base. A deletion does not get a complementary base. Mark the location of the mutation with a * on the mRNA.





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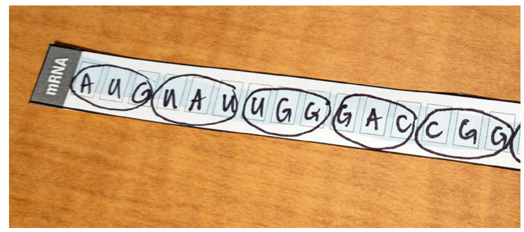
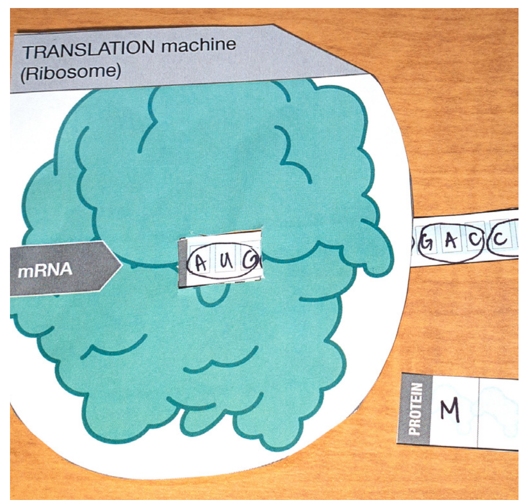
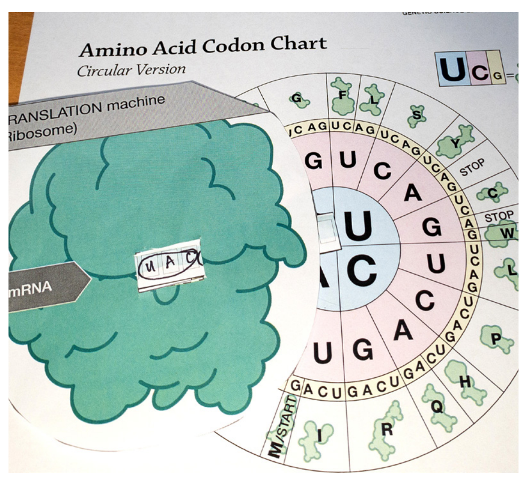
Translation: The ribosome reads the mRNA, putting amino acids together to make a protein.

A cell does this:	**Do this with your model:**
9. The mRNA attaches to the Ribosome. The ribosome slides along the mRNA until it finds the bases "AUG."	Detach the mRNA strip. Starting on the left, circle the first three bases: "AUG." If your mutation changes this codon, translation cannot begin. This is your last step.
10. AUG is the "start" signal. It codes for the amino acid methionine (M, or Met), and it establishes the reading frame for the rest of the protein.	Working from left to right, circle the bases in groups of 3 along the rest of the mRNA strip. Each group of 3 bases is called a codon.
11. Transfer RNA (tRNA, not shown) molecules attach to the 3-letter mRNA codons by complementary base pairing. At the other end, they carry an amino acid.	Put the window of the TRANSLATION machine over the AUG on the mRNA. Look at the Amino Acid Codon Chart; notice that AUG codes for M. M is already marked in the first space on your PROTEIN strip. *TIP: To use the chart, find the first letter of the codon in the center and read outward to find the right amino acid.*
12. 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 build a protein.	Slide the window of the TRANSLATION machine to the next group of 3 bases (codon). Look up the codon on the chart. Write the one-letter code in the next space on the PROTEIN strip. Mark the location of the mutation with a * on the protein.
13. When the ribosome reaches a STOP codon, the mRNA and the finished protein are released.	When you reach a codon that codes for STOP in the chart, your protein is finished.



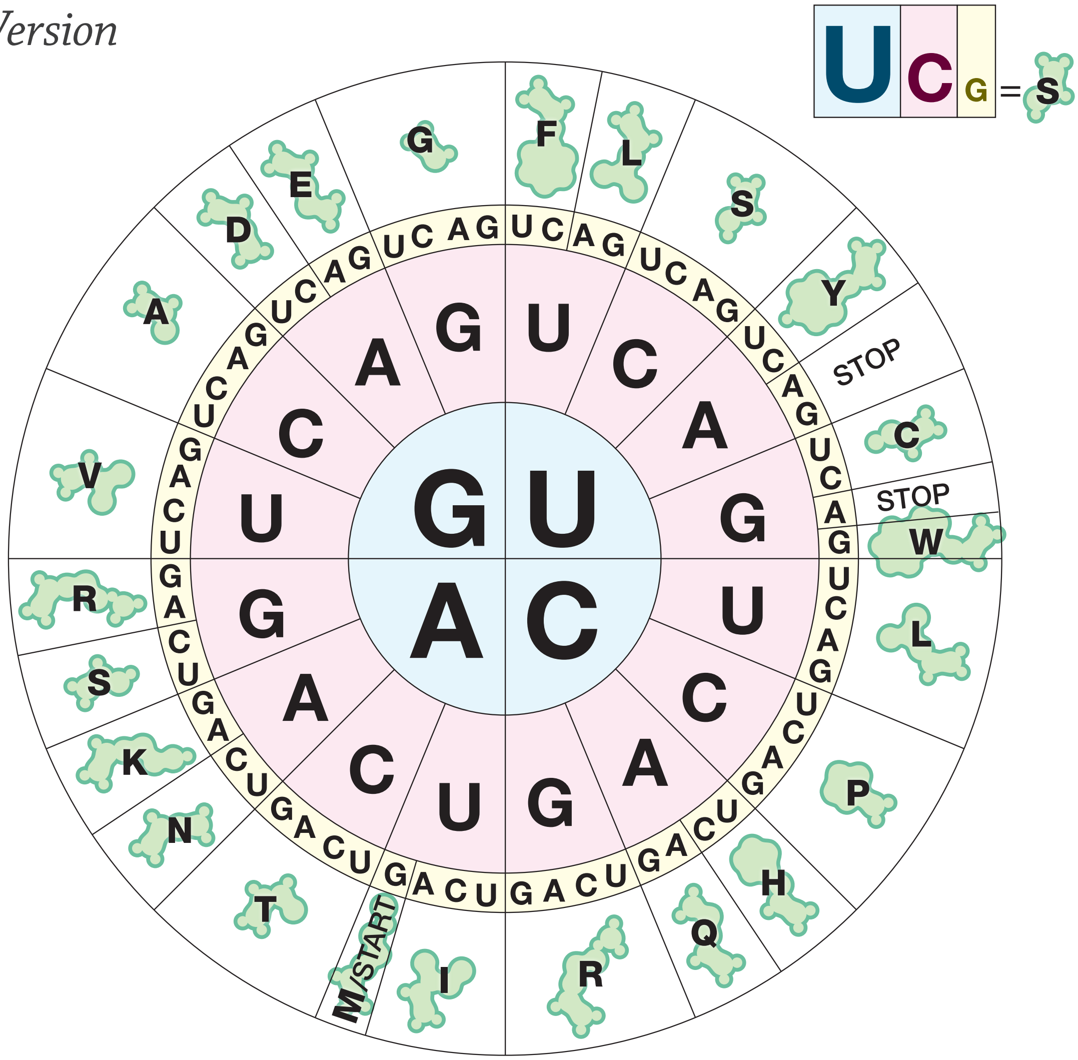




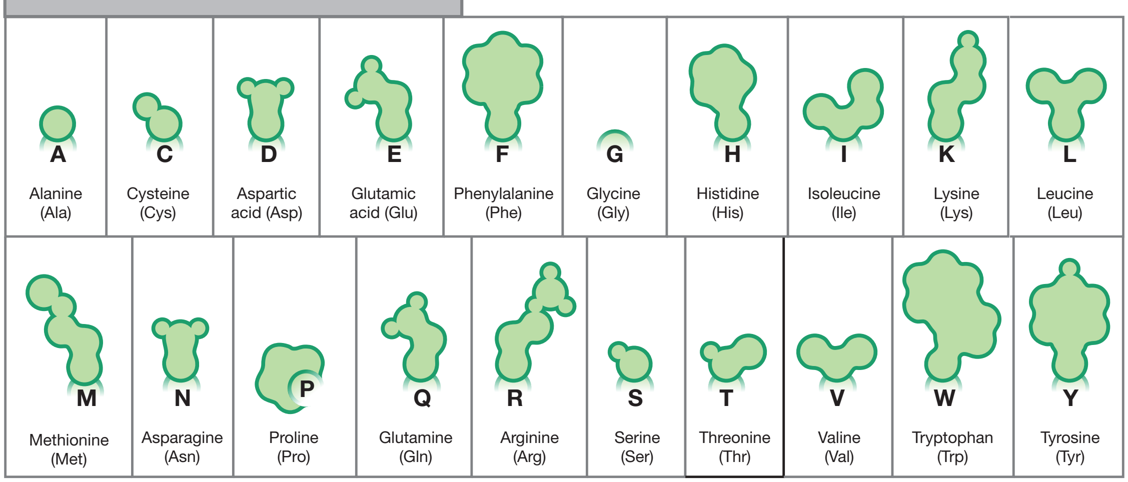
To learn more about the gene you just mutated, read the Information Sheet. Compare your protein to the reference protein. What differences does your mutated protein have? What changes in the DNA sequence led to those differences?

Amino Acid Codon Chart

Circular Version



Amino acid side chains



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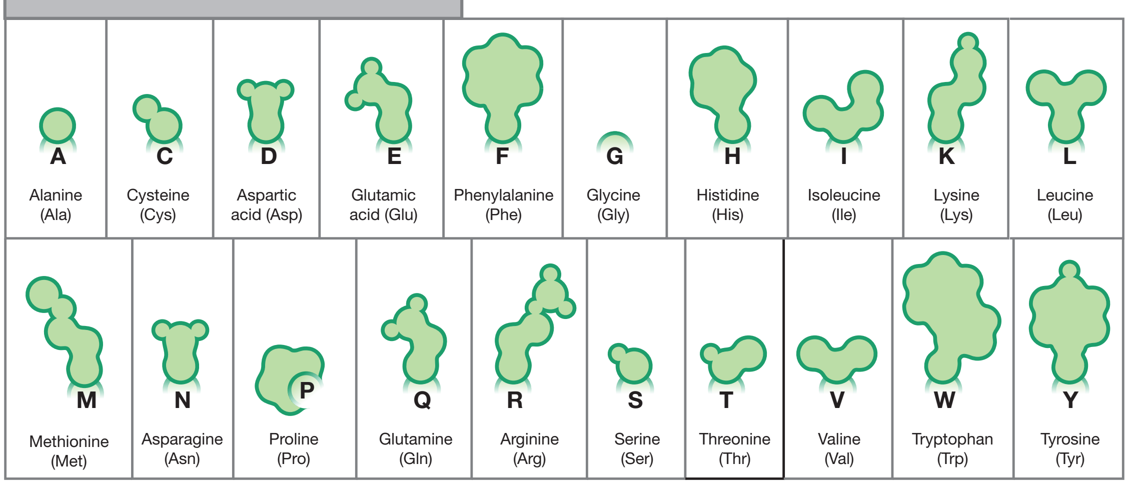
Amino Acid Codon Chart

Square Version

Second Letter

First Letter	U	C	A	G	Third Letter
U	UUU F UUC F UUA L UUG L	UCU S UCC S UCA S UCG S	UAU Y UAC Y UAA STOP UAG STOP	UGU C UGC C UGA STOP UGG W	U C A G
C	CUU L CUC L CUA L CUG L	CCU P CCC P CCA P CCG P	CAU H CAC H CAA Q CAG Q	CGU R CGC R CGA R CGG R	U C A G
A	AUU I AUC I AUA I AUG M START	ACU T ACC T ACA T ACG T	AAU N AAC N AAA K AAG K	AGU S AGC S AGA R AGG R	U C A G
G	GUU V GUC V GUA V GUG V	GCU A GCC A GCA A GCG A	GAU D GAC D GAA E GAG E	GGU G GGC G GGA G GGG G	U C A G

Amino acid side chains



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