Essential Question

How does a ribosome turn an mRNA message into a protein?

The Genetic Code

- A codon is a group of 3 mRNA bases. There are 64 possible codons.
- 61 codons code for amino acids. There are 20 different amino acids. The other 3 codons (UAA, UAG, UGA) are stop codons.
- AUG codes for methionine (Met) and also serves as the start codon.
- Most amino acids have more than one codon, but each codon codes for only one amino acid.
- To read the chart, find the first base on the left, the second base across the top, and the third base on the right.

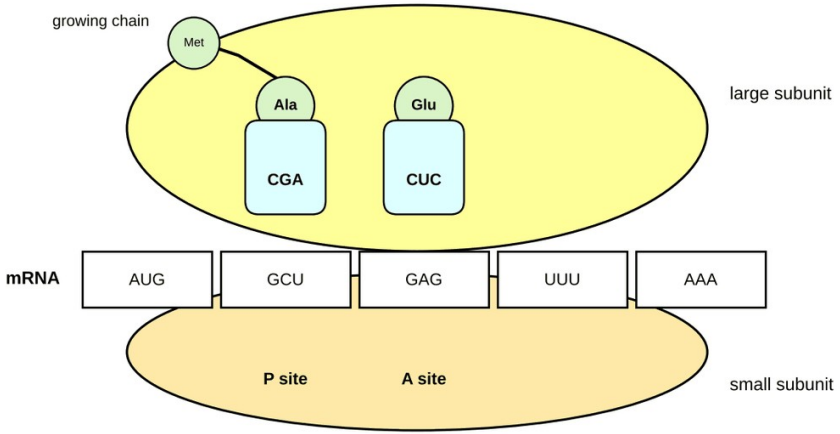
Second base

First base	U		C		A		G		Third base
U	UUU	Phe	UCU	Ser	UAU	Tyr	UGU	Cys	U
	UUC	Phe	UCC	Ser	UAC	Tyr	UGC	Cys	C
	UUA	Leu	UCA	Ser	UAA	**Stop**	UGA	**Stop**	A
	UUG	Leu	UCG	Ser	UAG	**Stop**	UGG	Trp	G
C	CUU	Leu	CCU	Pro	CAU	His	CGU	Arg	U
	CUC	Leu	CCC	Pro	CAC	His	CGC	Arg	C
	CUA	Leu	CCA	Pro	CAA	Gln	CGA	Arg	A
	CUG	Leu	CCG	Pro	CAG	Gln	CGG	Arg	G
A	AUU	Ile	ACU	Thr	AAU	Asn	AGU	Ser	U
	AUC	Ile	ACC	Thr	AAC	Asn	AGC	Ser	C
	AUA	Ile	ACA	Thr	AAA	Lys	AGA	Arg	A
	AUG	**Met**	ACG	Thr	AAG	Lys	AGG	Arg	G
G	GUU	Val	GCU	Ala	GAU	Asp	GGU	Gly	U
	GUC	Val	GCC	Ala	GAC	Asp	GGC	Gly	C
	GUA	Val	GCA	Ala	GAA	Glu	GGA	Gly	A
	GUG	Val	GCG	Ala	GAG	Glu	GGG	Gly	G

AUG (Met) is the start codon. UAA, UAG, and UGA are stop codons.

The Players in Translation

- The ribosome is made of rRNA and proteins, with a large and a small subunit. It holds the mRNA and the tRNAs.
- mRNA carries the codons.
- Each tRNA carries one amino acid and has an anticodon that pairs with a matching codon. The anticodon is complementary to the codon.
- The ribosome holds tRNAs matched to two neighboring codons at a time. It joins their amino acids with a bond and then moves along the mRNA.

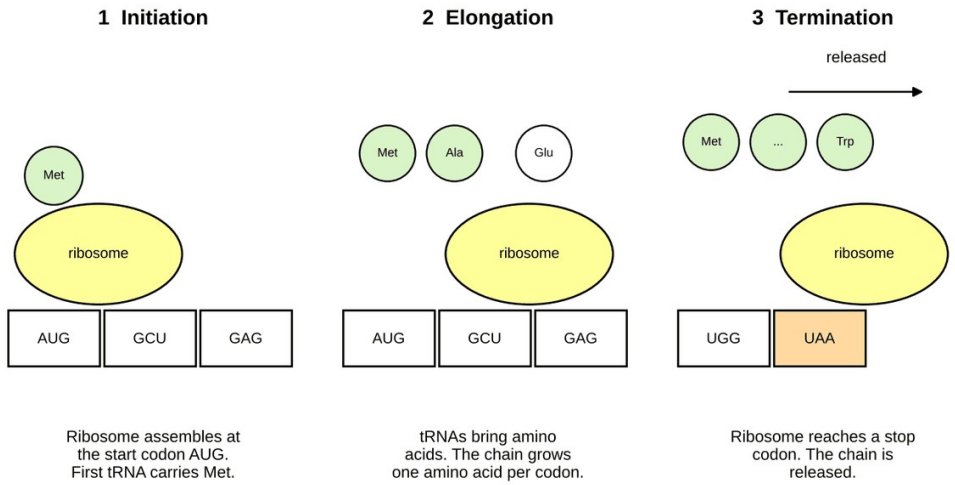


The ribosome moves along the mRNA one codon at a time.

Translation

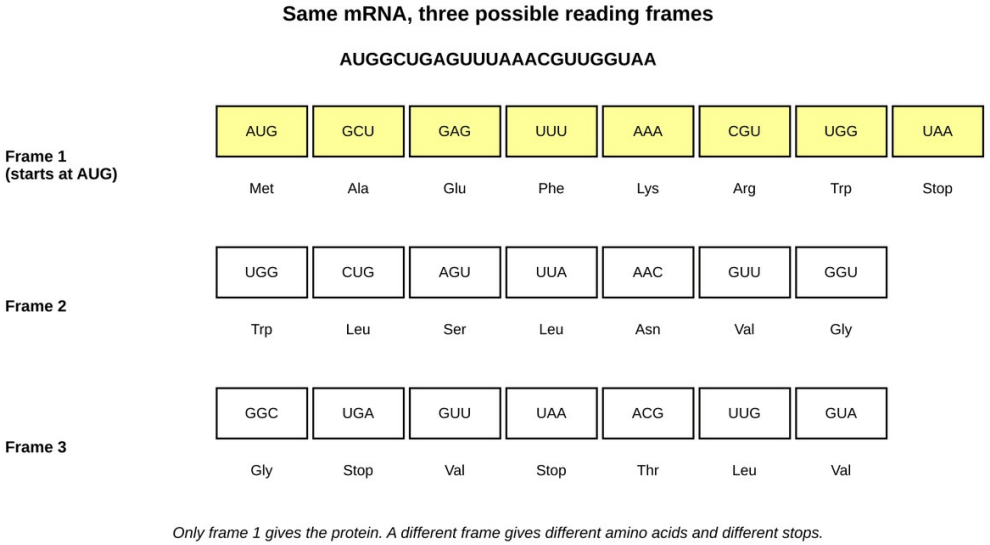
Three Stages of Translation

- Initiation: the small ribosomal subunit attaches to the mRNA and finds the start codon AUG. A tRNA carrying Met pairs with it, and the large subunit joins.
- Elongation: a tRNA with the matching anticodon brings the next amino acid. The ribosome joins it to the chain and moves one codon along the mRNA. This repeats for each codon.
- Termination: when the ribosome reaches a stop codon, no tRNA matches it. The chain of amino acids is released, and the ribosome comes apart.
- The finished chain is a polypeptide. It folds into a protein, and its shape determines its function.



Reading Frame

- The ribosome reads the mRNA in groups of three, starting at AUG. The groups do not overlap.
- The first AUG sets the reading frame. A different starting point gives different codons.
- The same mRNA read in a different frame gives different amino acids and may hit a stop codon early.
- Number of amino acids = number of codons - 1 (for the stop codon).



Only frame 1 gives the protein. A different frame gives different amino acids and different stops.

Example: Translate an mRNA

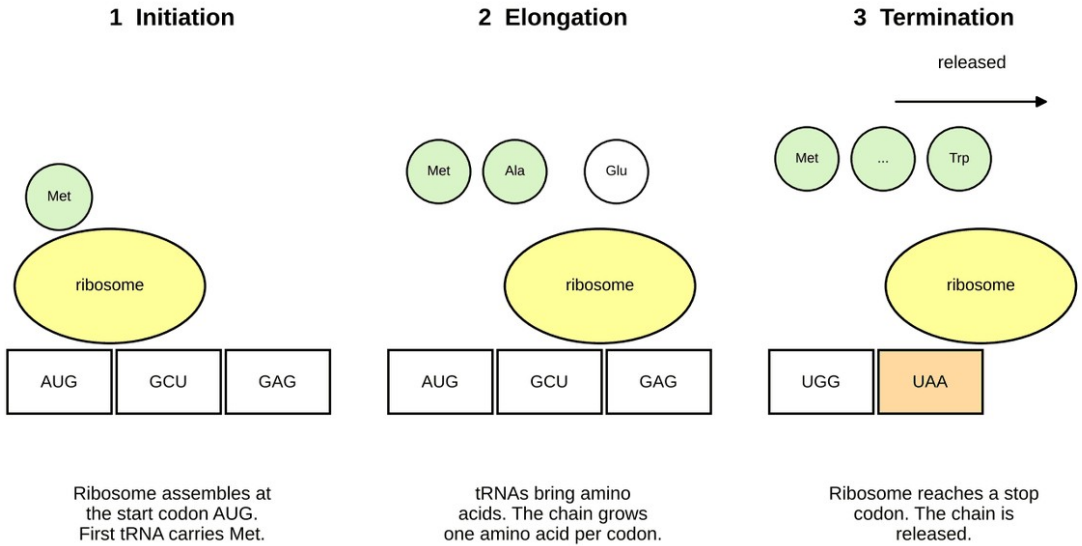
Use the genetic code chart to translate this mRNA, starting at the start codon:

AUG GCU GAG UUU AAA CGU UGG UAA

mRNA codons	AUG	GCU	GAG	UUU	AAA	CGU	UGG	UAA
Amino acids	???	???	???	???	???	???	???	???

Example: How Many Nucleotides?

A protein has 150 amino acids. How many nucleotides are in the mRNA from the start codon through the stop codon?



Example: Find the Anticodons

Write the tRNA anticodon that pairs with each of the first four codons of the mRNA: AUG, GCU, GAG, UUU.

mRNA codons	AUG	GCU	GAG	UUU
tRNA anticodons	???	???	???	???

Translation

Big Ideas

- Translation builds a protein from the codons of an mRNA.
- A codon is 3 bases. AUG is the start codon, and UAA, UAG, and UGA are stop codons.
- tRNA anticodons pair with codons and bring the matching amino acid to the ribosome.
- Translation has three stages: initiation, elongation, and termination.
- The reading frame is set by the start codon, so shifting it changes every amino acid after the shift.