RNA TRANSLATION

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As a matter of fact, proteins are key molecular "building blocks" for every organism on Earth!
How are these proteins made in a cell? For starters, the instructions for making proteins are "written" in a cell's DNA in the form of genes. If that idea is new to you, you may want to check out the section on [DNA to RNA to protein] (central dogma) before getting into the nitty-gritty of building proteins.
Basically, a [gene] is used to build a protein in a two-step process:

- Step 1: **transcription**! Here, the DNA sequence of a gene is "rewritten" in the form of RNA. In eukaryotes like you and me, the RNA is processed (and often has a few bits snipped out of it) to make the final product, called a messenger RNA or mRNA.

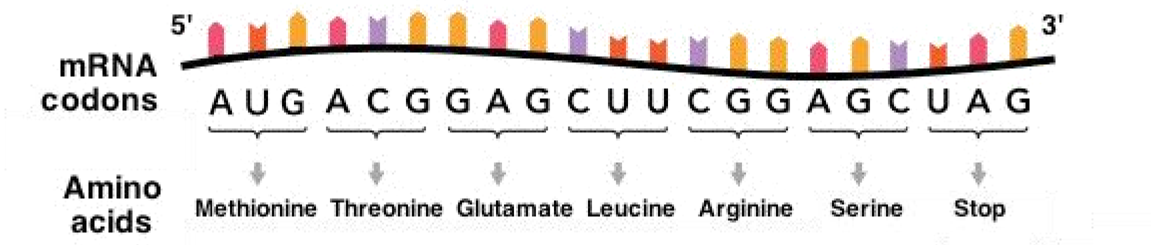
Step 2: **translation**! In this stage, the mRNA is "decoded" to build a protein (or a chunk/subunit of a protein) that contains a specific series of amino acids. In this article, we'll zoom in on translation, getting an overview of the process and the molecules that carry it out.

The genetic code

During translation, a cell "reads" the information in a messenger RNA (mRNA) and uses it to build a protein. Actually, to be a little more techical, an mRNA doesn't always encode—provide instructions for—a whole protein. Instead, what we can confidently say is that it always encodes a **polypeptide**, or chain of amino acids.
In an mRNA, the instructions for building a polypeptide are RNA nucleotides (As, Us, Cs, and Gs) read in groups of three. These groups of three are called **codons**.

There are 61616161 codons for amino acids, and each of them is "read" to specify a certain amino acid out of the 20202020 commonly found in proteins. One codon, AUG, specifies the amino acid methionine and also acts as a **start codon** to signal the start of protein construction.

There are three more codons that do *not* specify amino acids. These **stop codons**, UAA, UAG, and UGA, tell the cell when a polypeptide is complete. All together, this collection of codon-amino acid relationships is called the **genetic code**, because it lets cells "decode" an mRNA into a chain of amino acids.



Each mRNA contains a series of codons (nucleotide triplets) that each specifies an amino acid. The correspondence between mRNA codons and amino acids is called the genetic code.

5' AUG - Methionine ACG - Threonine GAG - Glutamate CUU - Leucine CGG - Arginine AGC - Serine UAG - Stop 3'

Image modified from "RNA-codons-aminoacids," by Thomas Splettstoesser (CC BY-SA 4.0). The modified image is licensed under a CC BY-SA 4.0 license.

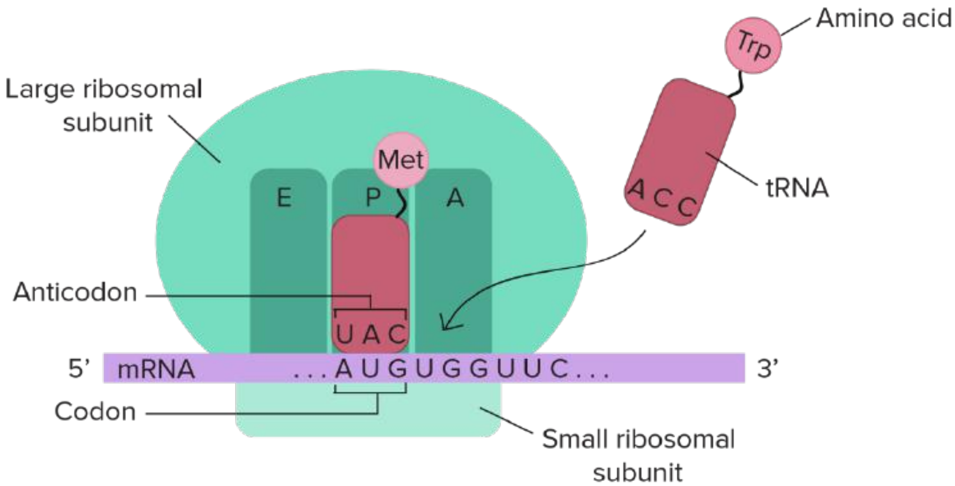
Overview of translation

How is an mRNA "read" to make a polypeptide? Two types of molecules with key roles in translation are tRNAs and ribosomes.

Transfer RNAs (tRNAs)

Transfer RNAs, or **tRNAs**, are molecular "bridges" that connect mRNA codons to the amino acids they encode. One end of each tRNA has a sequence of three nucleotides called an **anticodon**, which can bind to specific mRNA codons. The other end of the tRNA carries the amino acid specified by the codons.

There are many different types of tRNAs. Each type reads one or a few codons and brings the right amino acid matching those codons.



Ribosomes

Ribosomes are the structures where polypeptides (proteins) are built. They are made up of protein and RNA (**ribosomal RNA**, or **rRNA**). Each ribosome has two subunits, a large one and a small one, which come together around an mRNA—kind of like the two halves of a hamburger bun coming together around the patty.

The ribosome provides a set of handy slots where tRNAs can find their matching codons on the mRNA template and deliver their amino acids. These slots are called the A, P, and E sites. Not only that, but the ribosome also acts as an enzyme, catalyzing the chemical reaction that links amino acids together to make a chain.

Steps of translation

Your cells are making new proteins every second of the day. And each of those proteins must contain the right set of amino acids, linked together in just the right order. That may sound like a challenging task, but luckily, your cells (along with those of other animals, plants, and bacteria) are up to the job.

To see how cells make proteins, let's divide translation into three stages: initiation (starting off), elongation (adding on to the protein chain), and termination (finishing up).

Getting started: Initiation

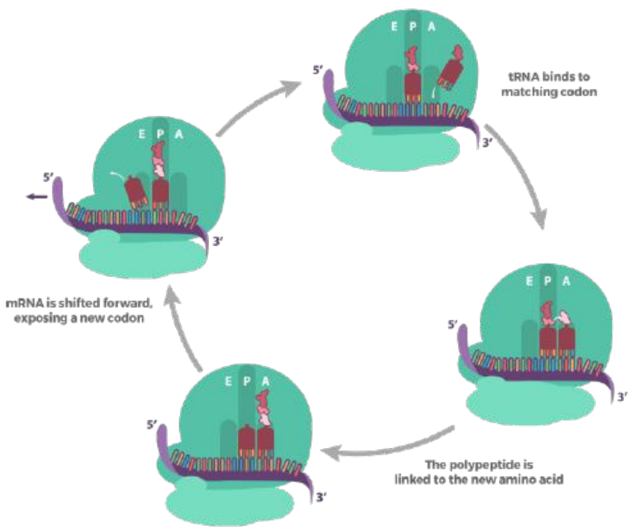
In **initiation**, the ribosome assembles around the mRNA to be read and the first tRNA (carrying the amino acid methionine, which matches the start codon, AUG). This setup, called the initiation complex, is needed in order for translation to get started.

Extending the chain: Elongation

Elongation is the stage where the amino acid chain gets **long**er. In elongation, the mRNA is read one codon at a time, and the amino acid matching each codon is added to a growing protein chain.

Each time a new codon is exposed:

- A matching tRNA binds to the codon
- The existing amino acid chain (polypeptide) is linked onto the amino acid of the tRNA via a chemical reaction
- The mRNA is shifted one codon over in the ribosome, exposing a new codon for reading



During elongation, tRNAs move through the A, P, and E sites of the ribosome, as shown above. This process repeats many times as new codons are read and new amino acids are added to the chain.

For more details on the steps of elongation, see the stages of translation article.

Finishing up: Termination

Termination is the stage in which the finished polypeptide chain is released. It begins when a stop codon (UAG, UAA, or UGA) enters the ribosome, triggering a series of events that separate the chain from its tRNA and allow it to drift out of the ribosome.

After termination, the polypeptide may still need to fold into the right 3D shape, undergo processing (such as the removal of amino acids), get shipped to the right place in the cell, or combine with other polypeptides before it can do its job as a functional protein.