14.2

The Genetic Code

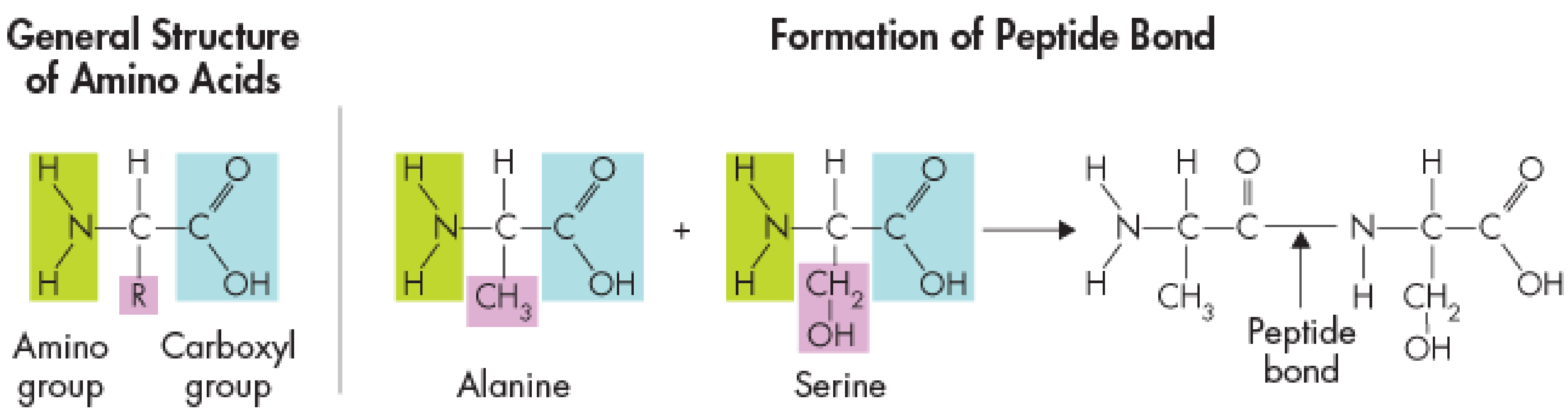
The first step in decoding genetic messages is to transcribe a nucleotide base sequence from DNA to mRNA.

This transcribed information contains a code for making proteins.

The Genetic Code

Proteins are made by joining amino acids together into long chains, called **polypeptides.**

As many as 20 different amino acids are commonly found in polypeptides.



The Genetic Code

The specific amino acids in a polypeptide, and the order in which they are joined, determine the properties of different proteins.

The sequence of amino acids influences the shape of the protein, which in turn determines its function.

The Genetic Code

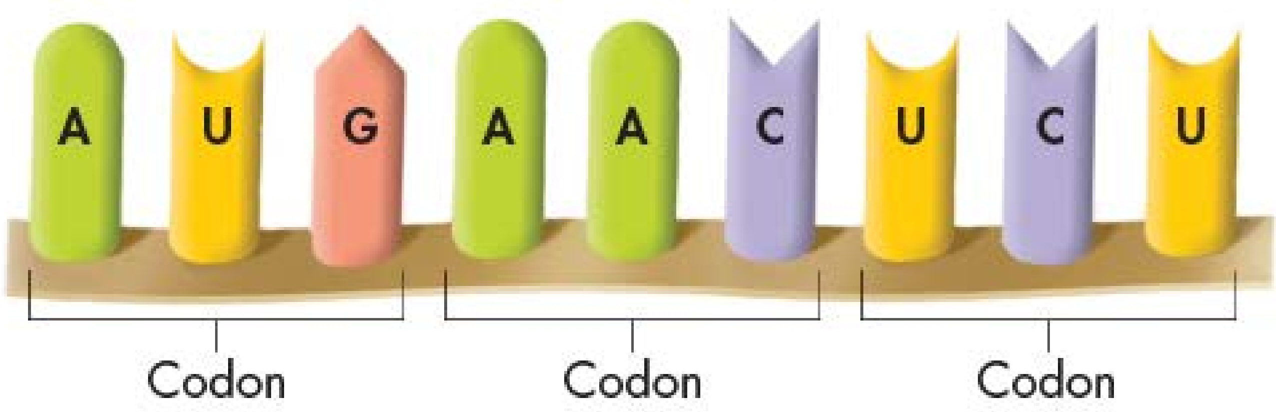
RNA contains four different bases: adenine, cytosine, guanine, and uracil.

These bases form a “language,” or **genetic code**, with just four “letters”: A, C, G, and U.

The Genetic Code

Each three-letter “word” in mRNA is known as a **codon.**

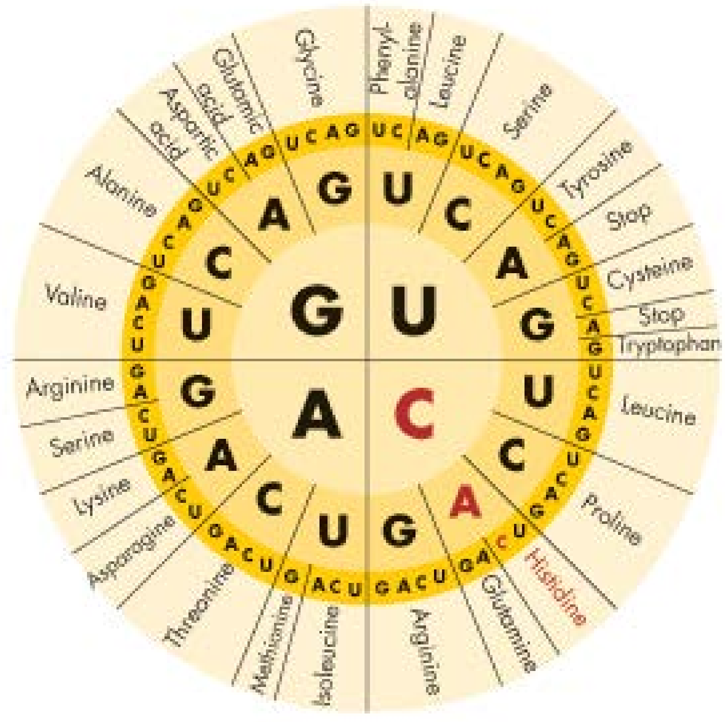
A codon consists of three consecutive bases that specify a single amino acid to be added to the polypeptide chain.



How to Read Codons

Because there are four different bases in RNA, there are 64 possible three-base codons (4 × 4 × 4 = 64) in the genetic code.

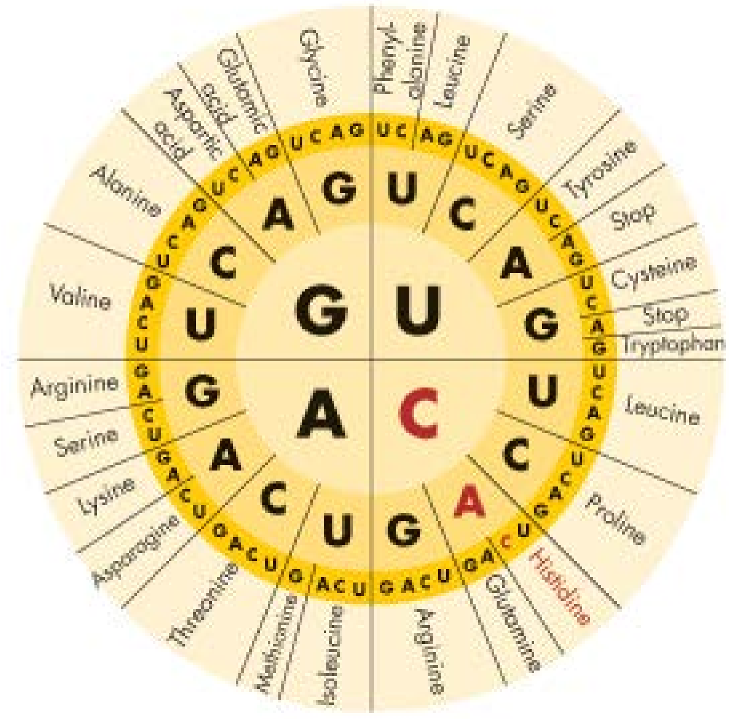
This circular table shows the amino acid to which each of the 64 codons corresponds. To read a codon, start at the middle of the circle and move outward.



How to Read Codons

Most amino acids can be specified by more than one codon.

For example, six different codons—UUA, UUG, CUU, CUC, CUA, and CUG—specify leucine. But only one codon—UGG—specifies the amino acid tryptophan.

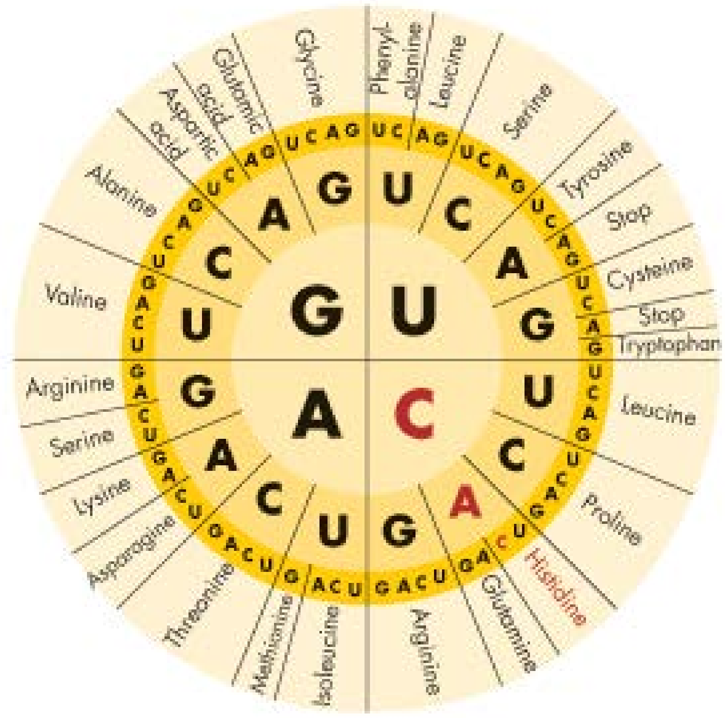


Start and Stop Codons

The genetic code has punctuation marks.

The methionine codon AUG serves as the initiation, or “start,” codon for protein synthesis.

Following the start codon, mRNA is read, three bases at a time, until it reaches one of three different “stop” codons, which end translation.



Translation

The sequence of nucleotide bases in an mRNA molecule is a set of instructions that gives the order in which amino acids should be joined to produce a polypeptide.

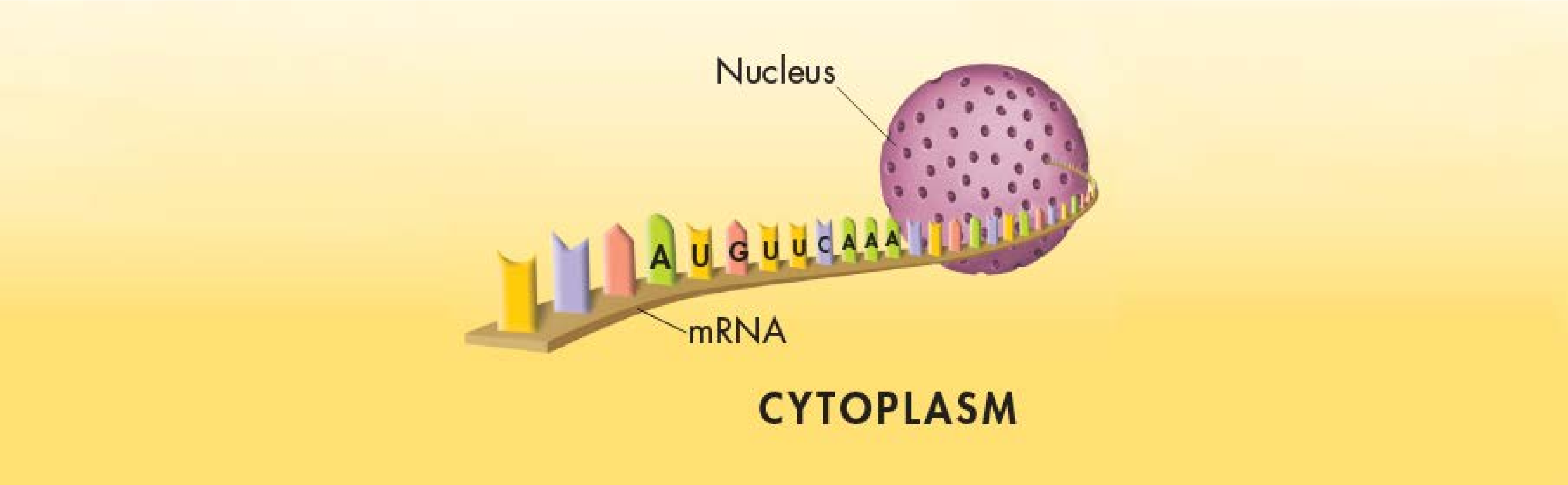
The forming of a protein requires the folding of one or more polypeptide chains.

Ribosomes use the sequence of codons in mRNA to assemble amino acids into polypeptide chains.

The decoding of an mRNA message into a protein is a process known as **translation.**

Steps in Translation

Messenger RNA is transcribed in the nucleus and then enters the cytoplasm for translation.

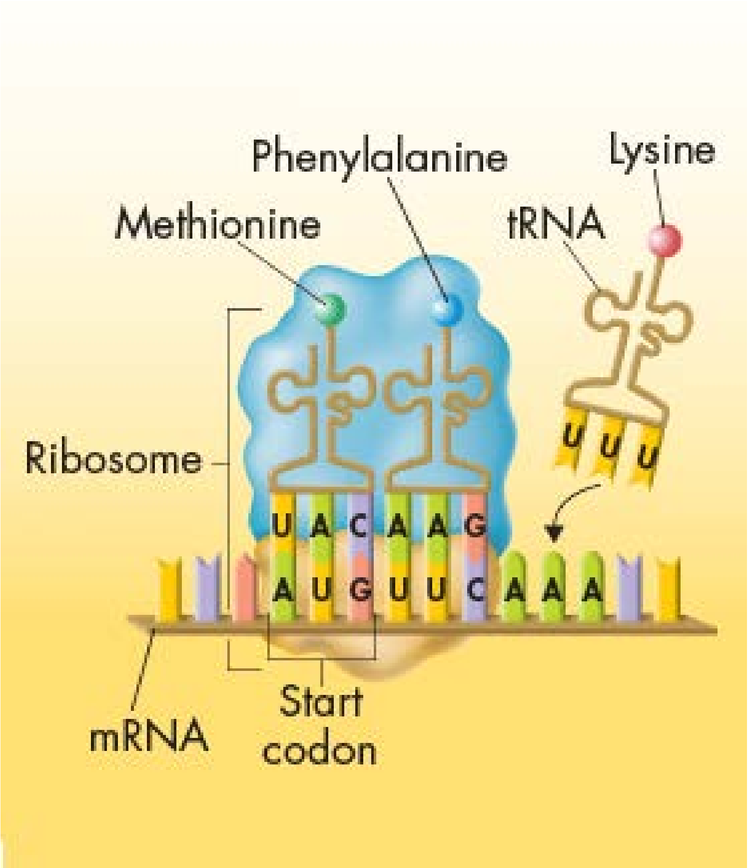


Steps in Translation

Translation begins when a ribosome attaches to an mRNA molecule in the cytoplasm.

As the ribosome reads each codon of mRNA, it directs tRNA to bring the specified amino acid into the ribosome.

One at a time, the ribosome then attaches each amino acid to the growing chain.

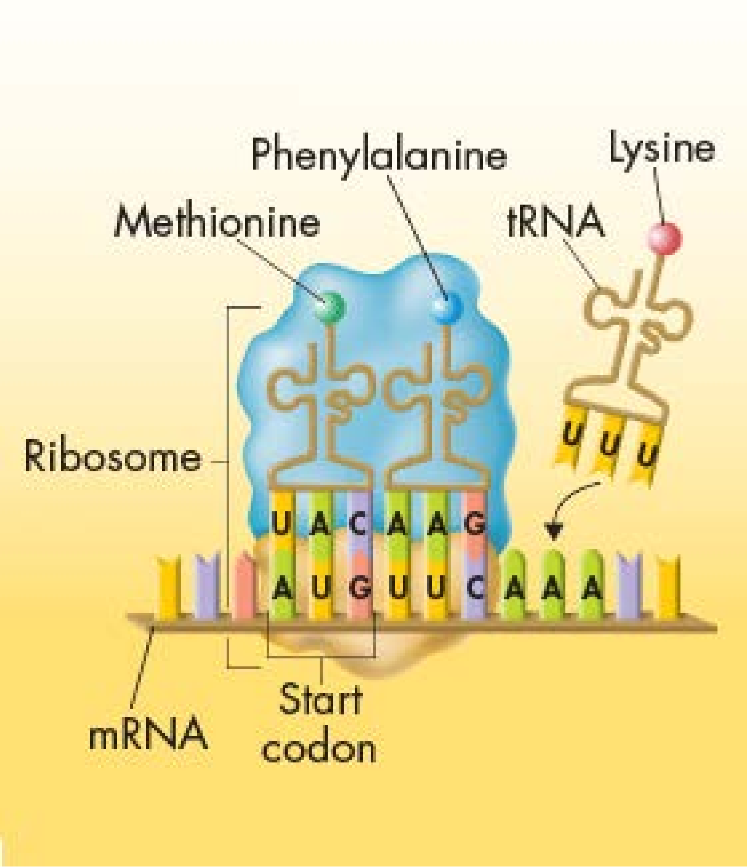


Steps in Translation

Each tRNA molecule carries just one kind of amino acid.

In addition, each tRNA molecule has three unpaired bases, collectively called the **anticodon**—which is complementary to one mRNA codon.

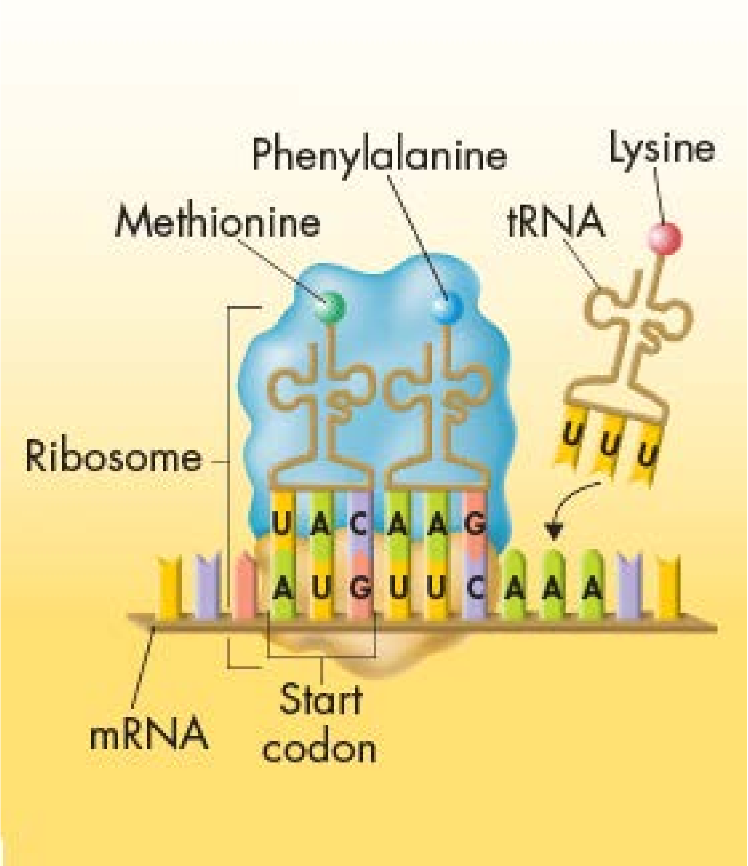
The tRNA molecule for methionine has the anticodon UAC, which pairs with the methionine codon, AUG.



Steps in Translation

The ribosome has a second binding site for a tRNA molecule for the next codon.

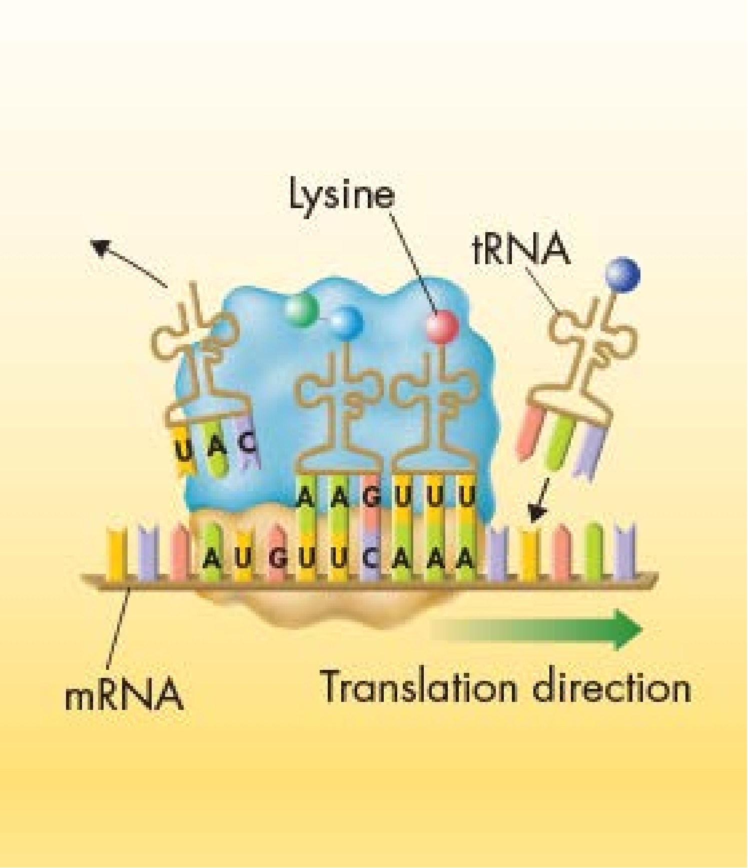
If that next codon is UUC, a tRNA molecule with an AAG anticodon brings the amino acid phenylalanine into the ribosome.



Steps in Translation

The ribosome helps form a peptide bond between the first and second amino acids—methionine and phenylalanine.

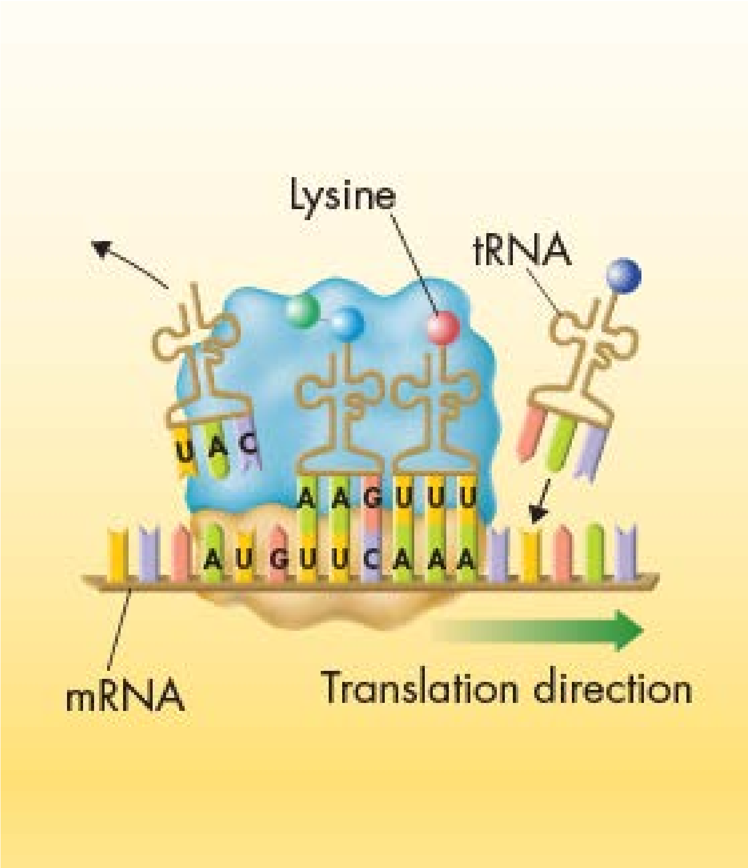
At the same time, the bond holding the first tRNA molecule to its amino acid is broken.



Steps in Translation

That tRNA then moves into a third binding site, from which it exits the ribosome.

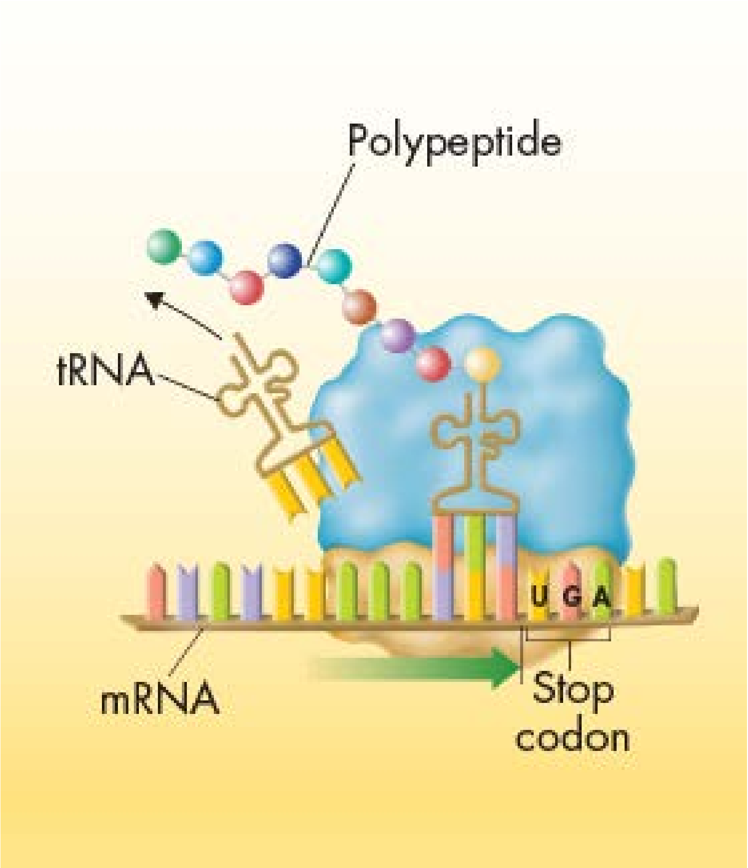
The ribosome then moves to the third codon, where tRNA brings it the amino acid specified by the third codon.



Steps in Translation

The polypeptide chain continues to grow until the ribosome reaches a “stop” codon on the mRNA molecule.

When the ribosome reaches a stop codon, it releases both the newly formed polypeptide and the mRNA molecule, completing the process of translation.



The Roles of tRNA and rRNA in Translation

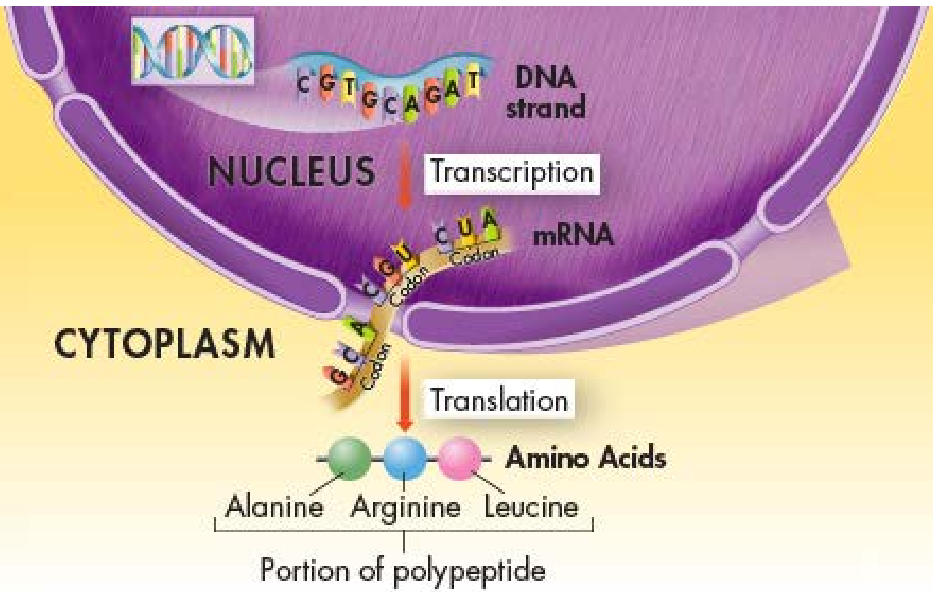
Ribosomes are composed of roughly 80 proteins and three or four different rRNA molecules.

These rRNA molecules help hold ribosomal proteins in place and help locate the beginning of the mRNA message.

They may even carry out the chemical reaction that joins amino acids together.

The Molecular Basis of Heredity

Most genes contain instructions for assembling proteins.



The Molecular Basis of Heredity

Many proteins are enzymes, which catalyze and regulate chemical reactions.

A gene that codes for an enzyme to produce pigment can control the color of a flower. Another gene produces proteins that regulate patterns of tissue growth in a leaf. Yet another may trigger the female or male pattern of development in an embryo.

Proteins are microscopic tools, each specifically designed to build or operate a component of a living cell.

The Molecular Basis of Heredity

Molecular biology seeks to explain living organisms by studying them at the molecular level, using molecules like DNA and RNA.

The central dogma of molecular biology is that information is transferred from DNA to RNA to protein.

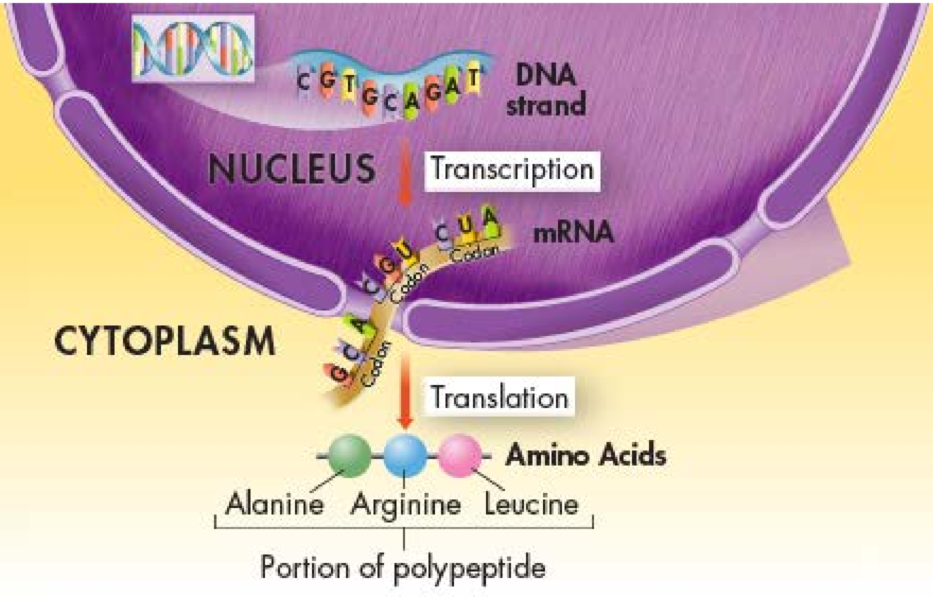
There are many exceptions to this “dogma,” but it serves as a useful generalization that helps explain how genes work.

The Molecular Basis of Heredity

Gene expression is the way in which DNA, RNA, and proteins are involved in putting genetic information into action in living cells.

DNA carries information for specifying the traits of an organism.

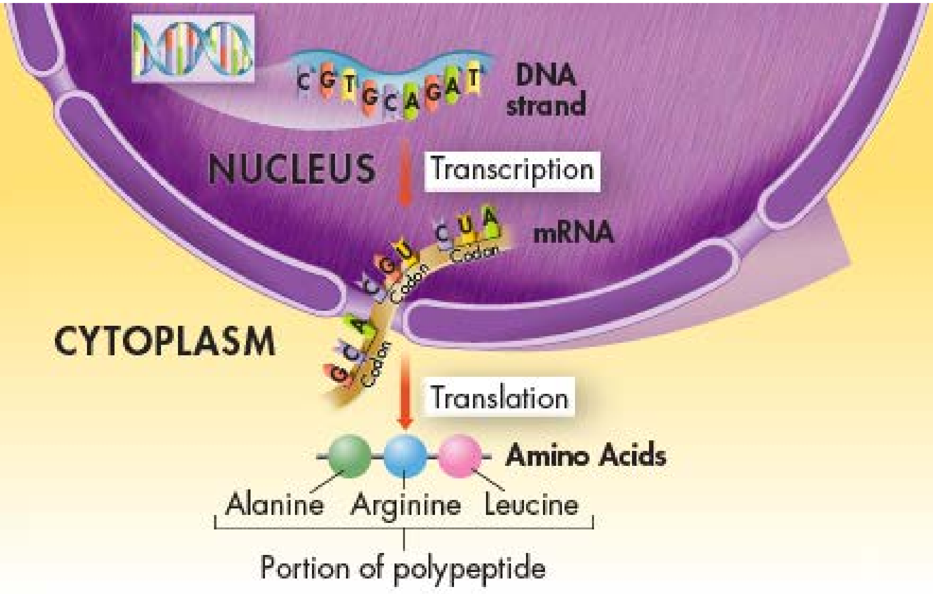
The cell uses the sequence of bases in DNA as a template for making mRNA.



The Molecular Basis of Heredity

The codons of mRNA specify the sequence of amino acids in a protein.

Proteins, in turn, play a key role in producing an organism's traits.



The Molecular Basis of Heredity

One of the most interesting discoveries of molecular biology is the near-universal nature of the genetic code.

Although some organisms show slight variations in the amino acids assigned to particular codons, the code is always read three bases at a time and in the same direction.

Despite their enormous diversity in form and function, living organisms display remarkable unity at life’s most basic level, the molecular biology of the gene.