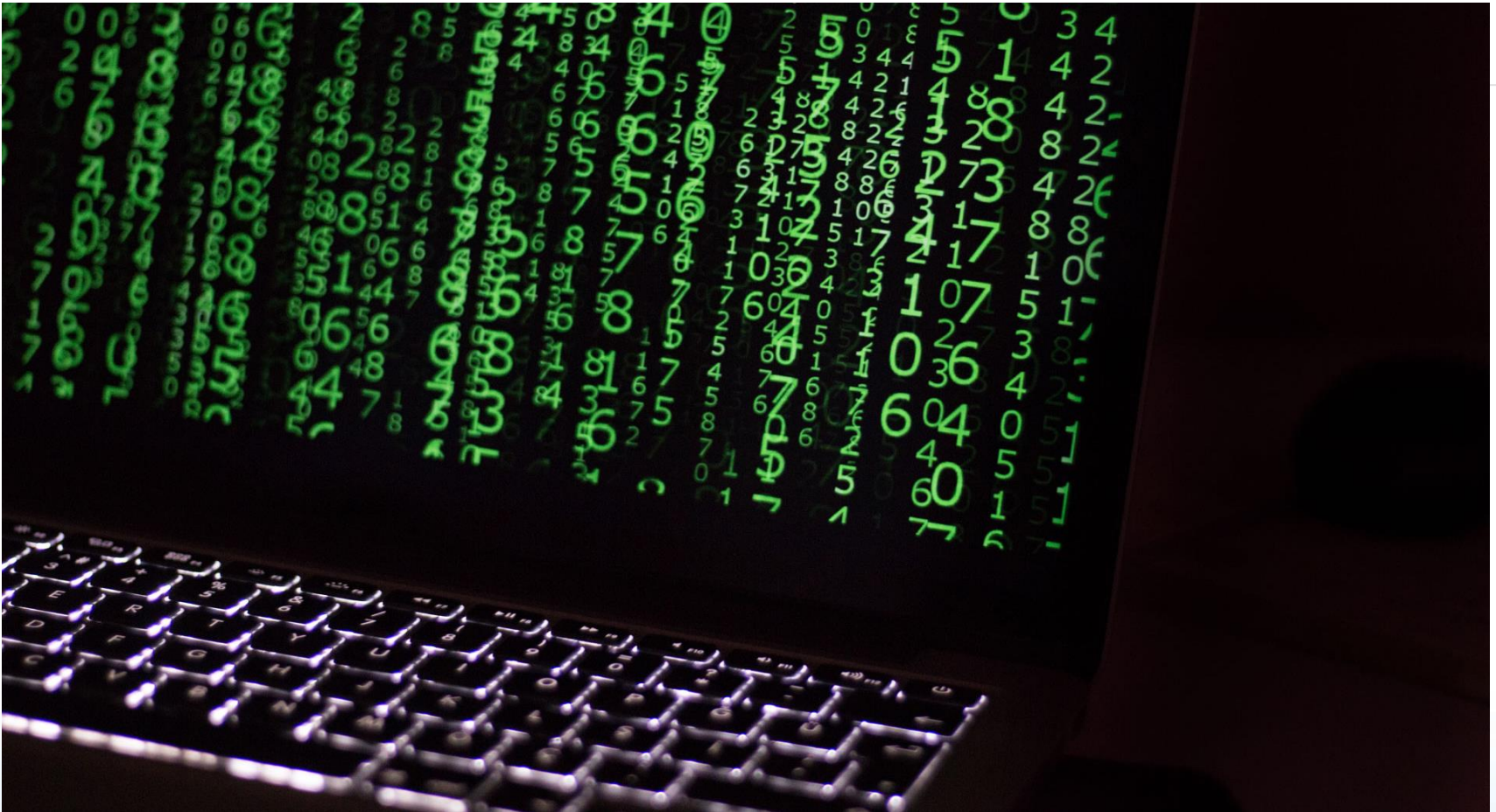


RNA



Learning Objectives

- Describe how RNA differs from DNA.
- Explain how the cell makes RNA.

Comparing DNA and RNA

Watch Amoeba Sisters: RNA,

<https://www.youtube.com/watch?v=0Elo-zX1k8M>

Using your book and the video, create a Venn Diagram comparing DNA and RNA

Comparing DNA and RNA

DNA

- In nucleus
- Double strand
- Deoxyribose (sugar)
- A, T, C, G
- Long strand
- Self replicating

Both

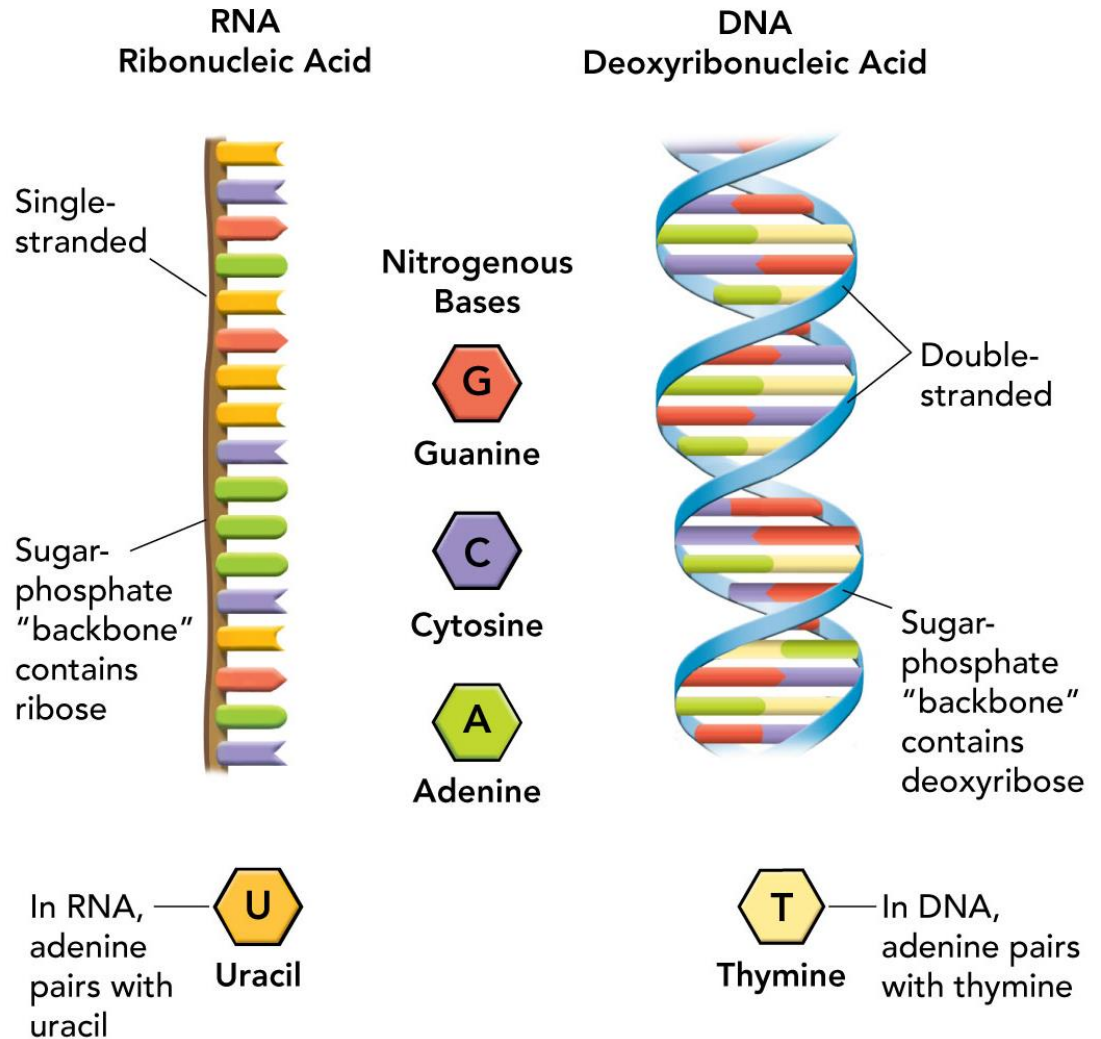
- Nucleic acids
- 4 bases

RNA

- In nucleus and cytoplasm
- Single strand
- Ribose (sugar)
- A, **U**, C, G
- Short strand
- Made from DNA as needed
- 3 Types: mRNA, tRNA, rRNA

Comparing RNA and DNA

- The sugar in RNA is ribose instead of deoxyribose.
- RNA is generally single-stranded, not double-stranded.
- RNA contains uracil in place of thymine.



Types of RNA

The three main types of RNA are:

- Messenger RNA
- Ribosomal RNA
- Transfer RNA

DNA, RNA, and Protein

Messenger RNA (mRNA)

- Form complementary strand to DNA and carry code outside of nucleus

Ribosomal RNA (rRNA)

- Associates with proteins to form ribosomes in the cytoplasm

Transfer RNA (tRNA)

- Smaller segments of RNA nucleotides that transport amino acids to the ribosome

DNA, RNA, and Protein

Central Dogma of Biology

*DNA codes for RNA
which guides the
synthesis of proteins

* *Watch Amoeba Sisters:
Protein Synthesis*

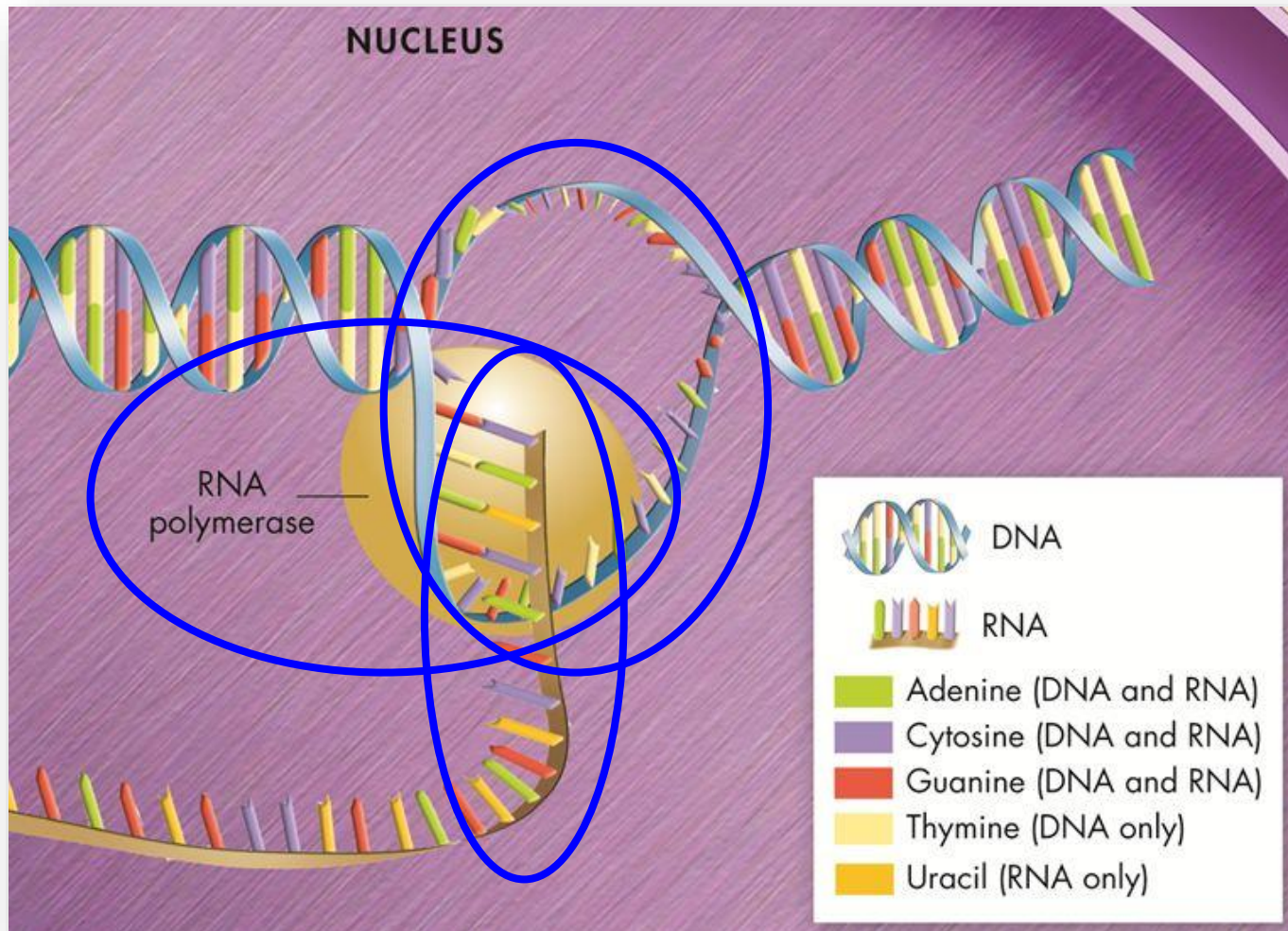
DNA, RNA, and Protein

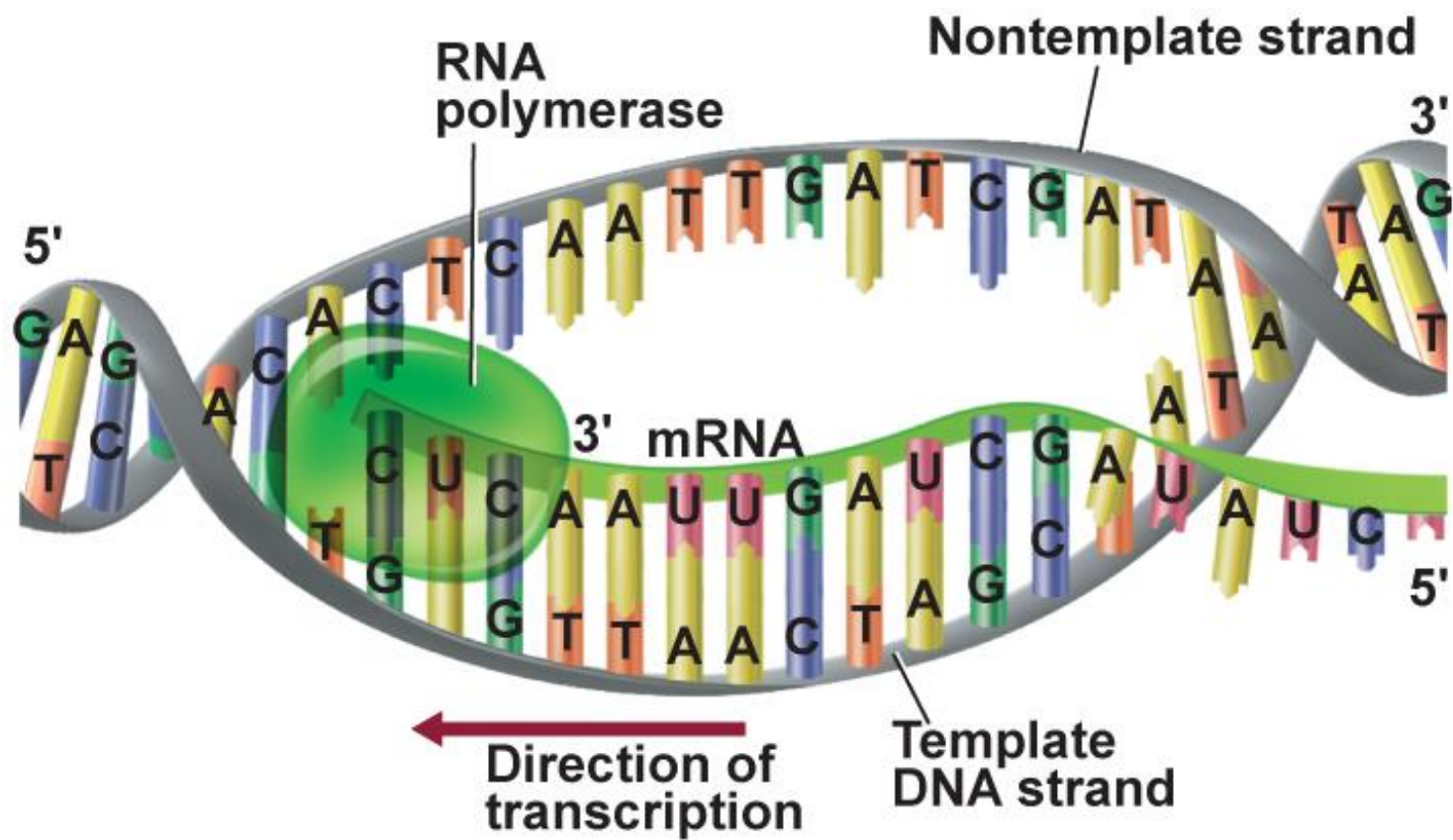
Transcription Steps Simplified

- DNA code is transferred to mRNA in the nucleus. Steps:
 - 1) DNA is unzipped in the nucleus and **RNA polymerase** binds to a specific section where mRNA will be synthesized
 - 2) mRNA strand created-DNA zips up
 - 3) mRNA strand modified-introns removed
 - 4) Modified mRNA strand-exon-leaves nucleus through a pore

RNA Synthesis: Transcription

In transcription, segments of DNA serve as templates to produce complementary mRNA molecules.





RNA Synthesis: Promoters

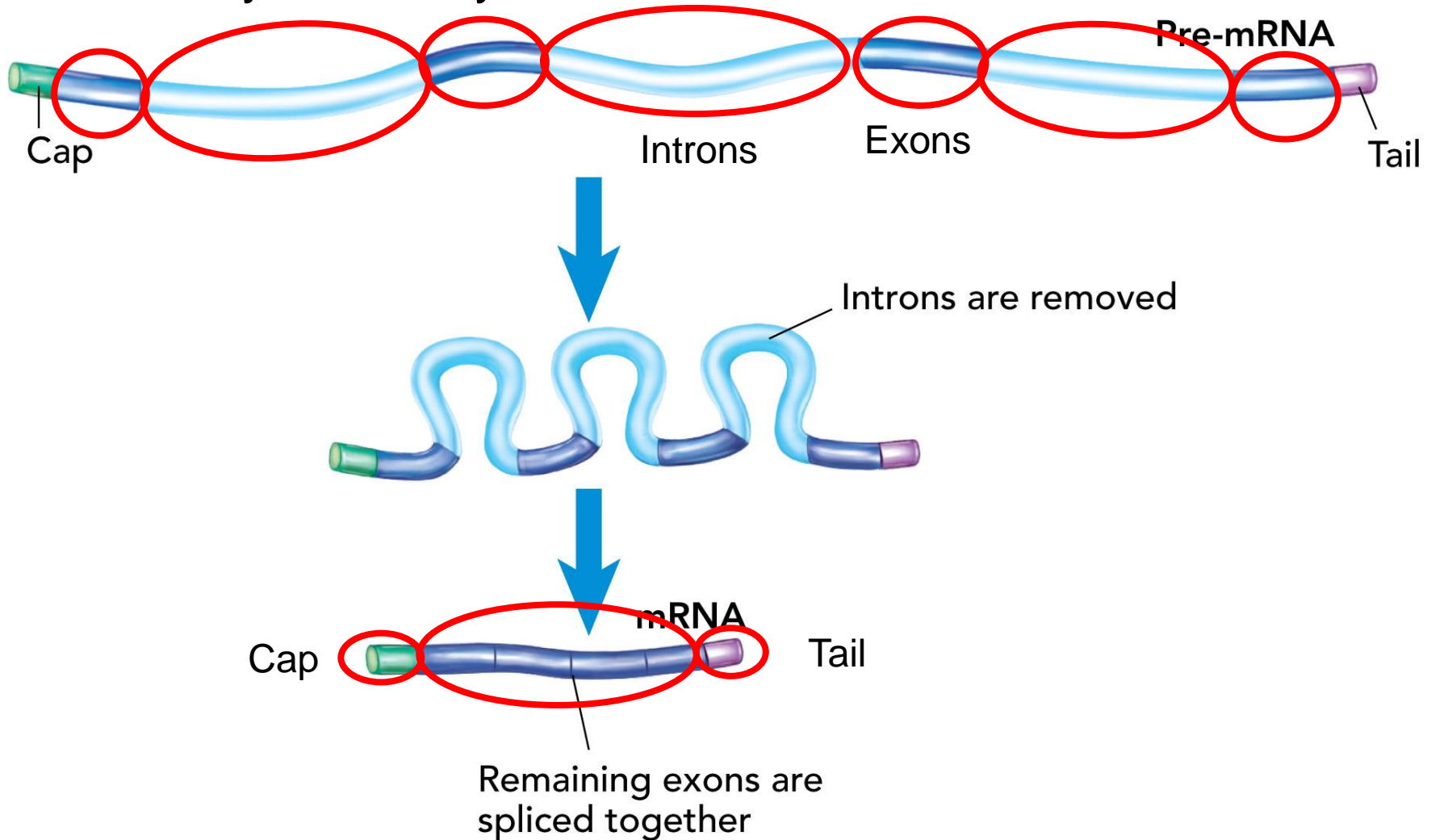
- RNA polymerase binds only to regions of DNA that have specific base sequences.
- These regions are called promoters.
- The promoters signal a starting point for RNA synthesis.

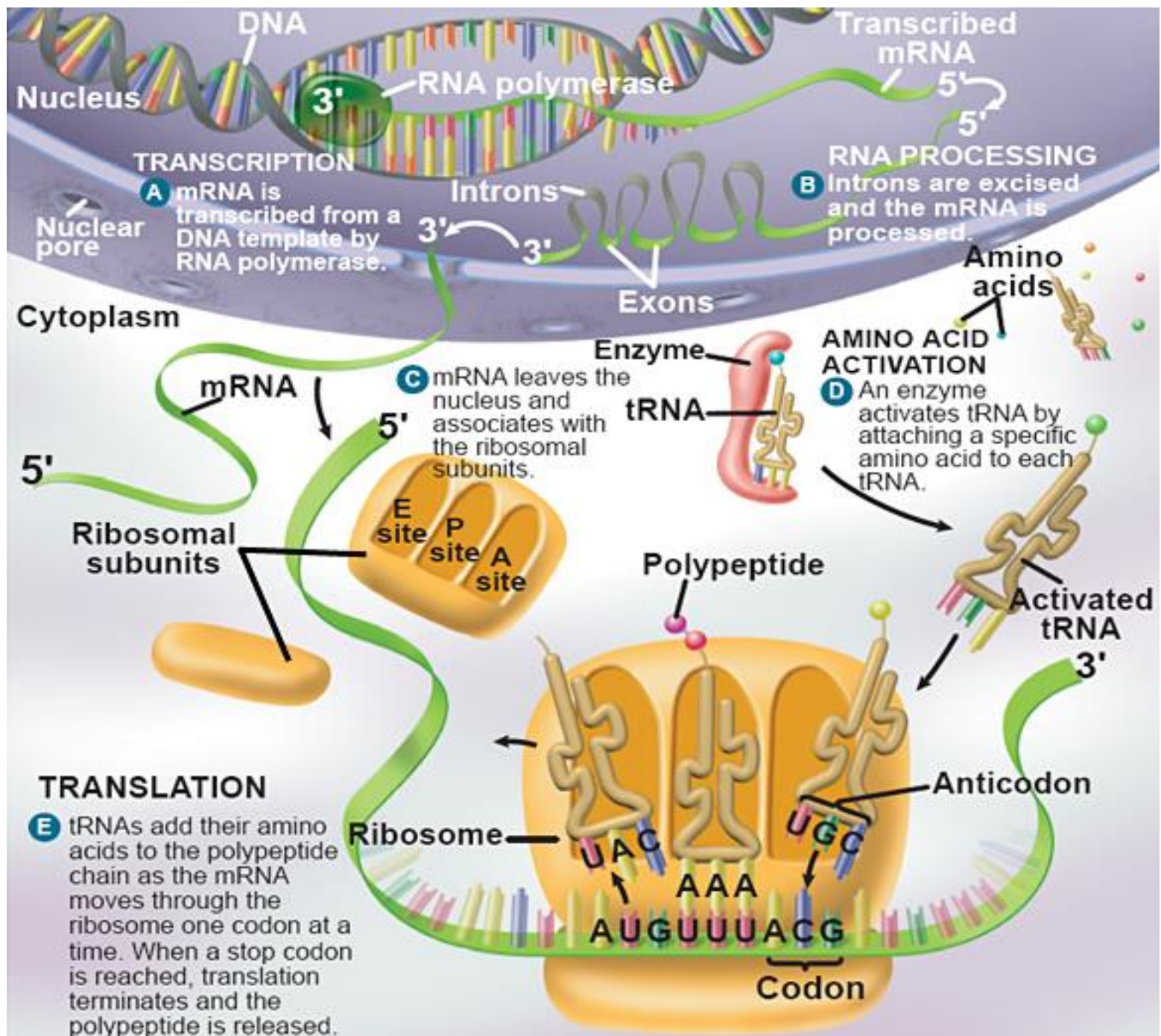
RNA Processing

- The code on the DNA is interrupted periodically by sequences that are not in the final mRNA.
- Intervening sequences are called **introns**.
- Remaining pieces of mRNA that serve as the coding sequences are called **exons**.

RNA Synthesis: RNA Editing

New RNA molecules sometimes require a bit of editing before they are ready to be read.





A close-up, over-the-shoulder view of a person's hands typing on a silver laptop keyboard. The laptop screen displays a code editor with HTML code for a contact form. The code includes form elements like text inputs, a submit button, and a feedback message, all wrapped in conditional rendering tags like `<if (send=2)>`. The person is wearing a light blue long-sleeved shirt. The background is a bright, out-of-focus indoor setting.

Learning Objectives

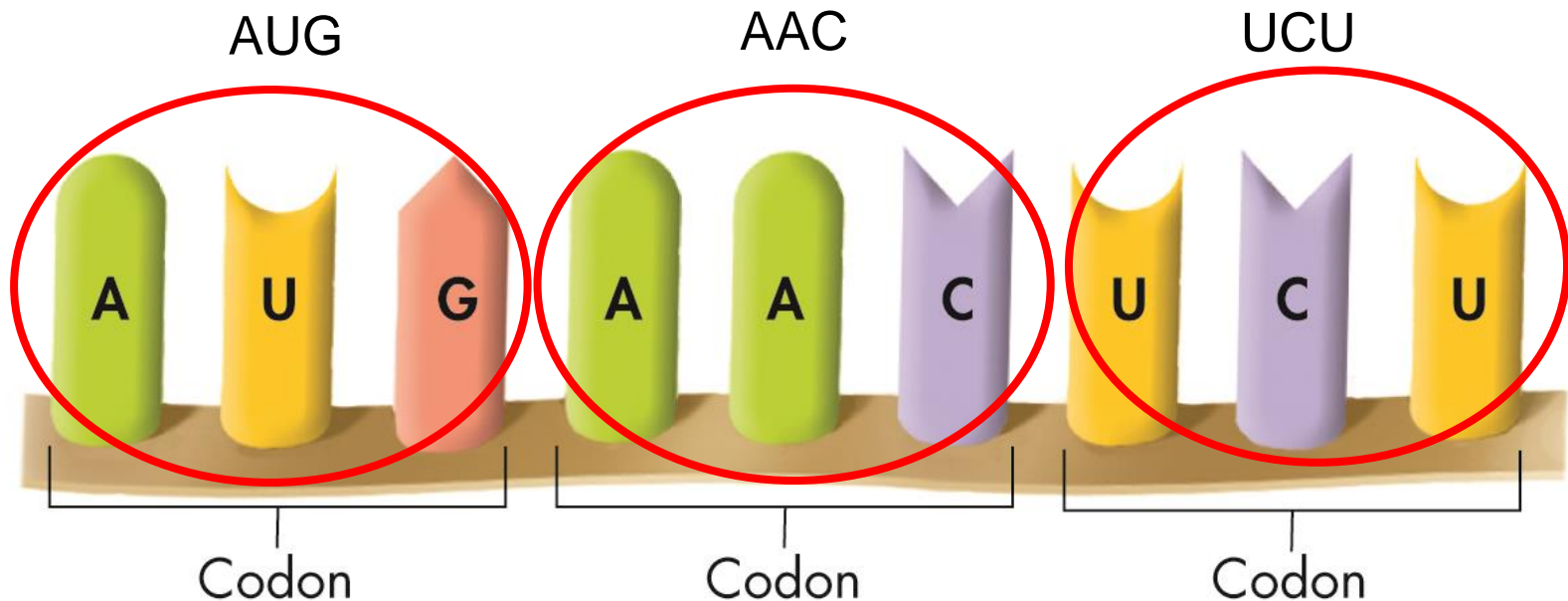
- Explain how the genetic code works.
- Describe the role of the ribosome in assembling proteins.
- Understand how molecular biology relates to genetics.

The Code

- Experiments during the 1960s demonstrated that the DNA code was a three-base code.
- The three-base code in DNA or mRNA is called a **codon**.

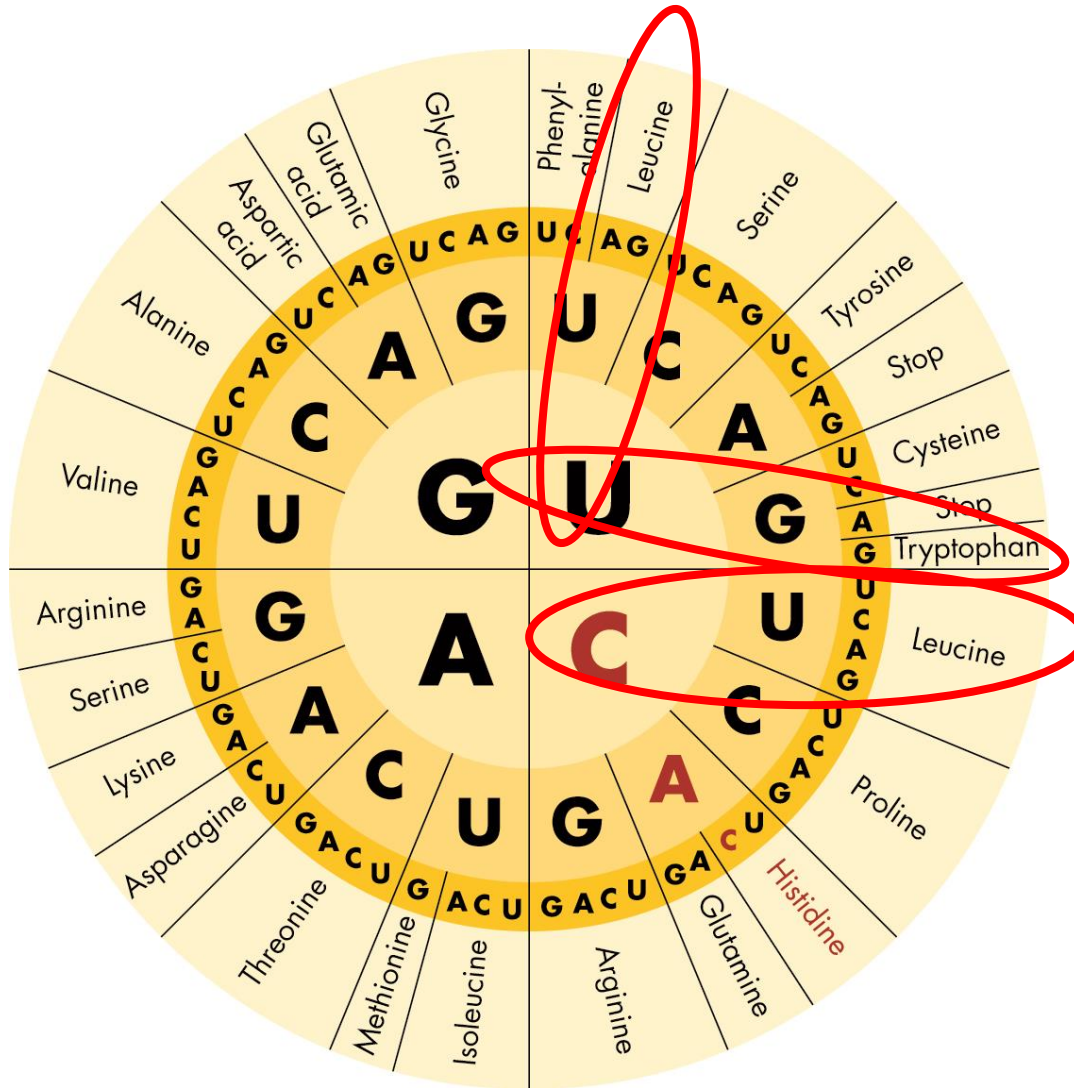
The Genetic Code: Codons

- The genetic code is read in three-letter groupings called codons.
- A codon is a group of three nucleotide bases in messenger RNA that specifies a particular amino acid.



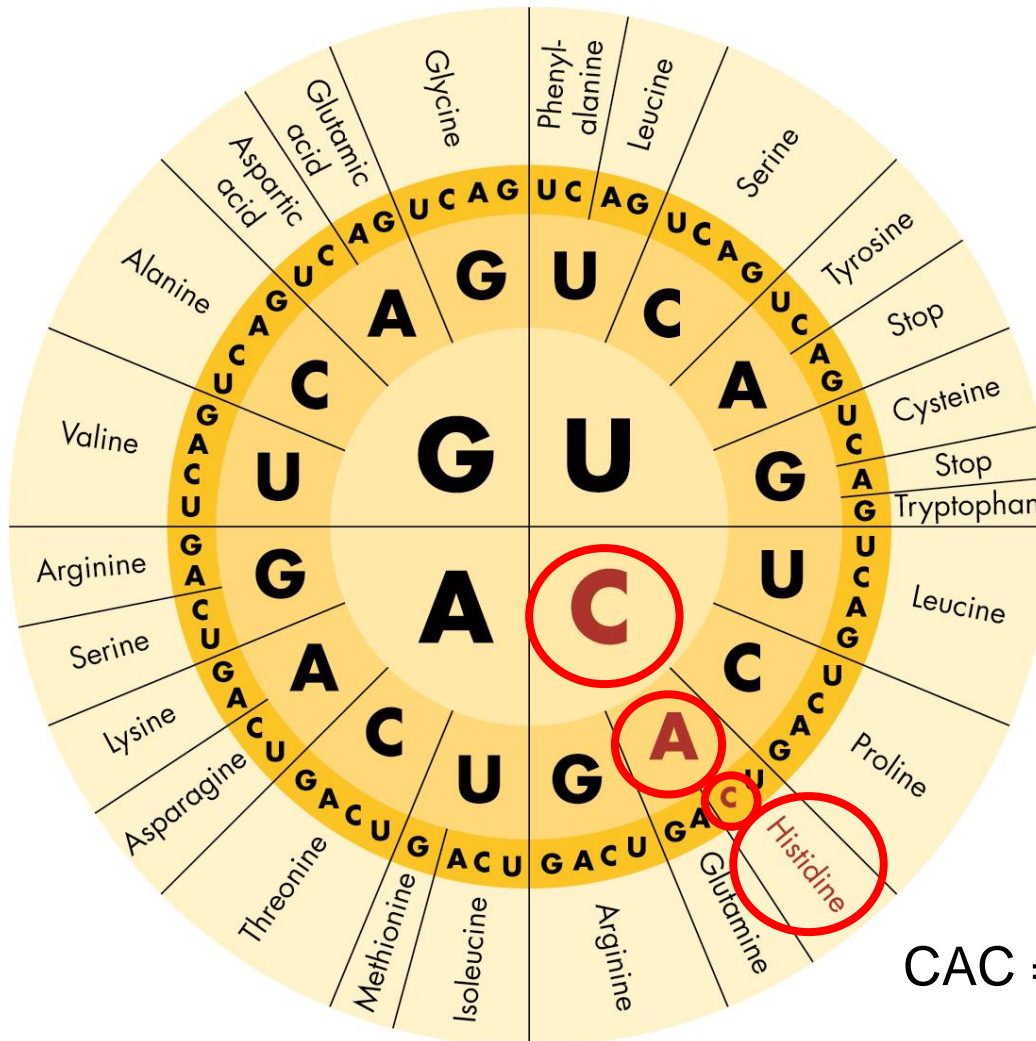
Genetic Code Table

There are 64 possible three-base codons in the genetic code.



Reading Codons

Start at the middle of the circle with the first letter of the codon and move outward.



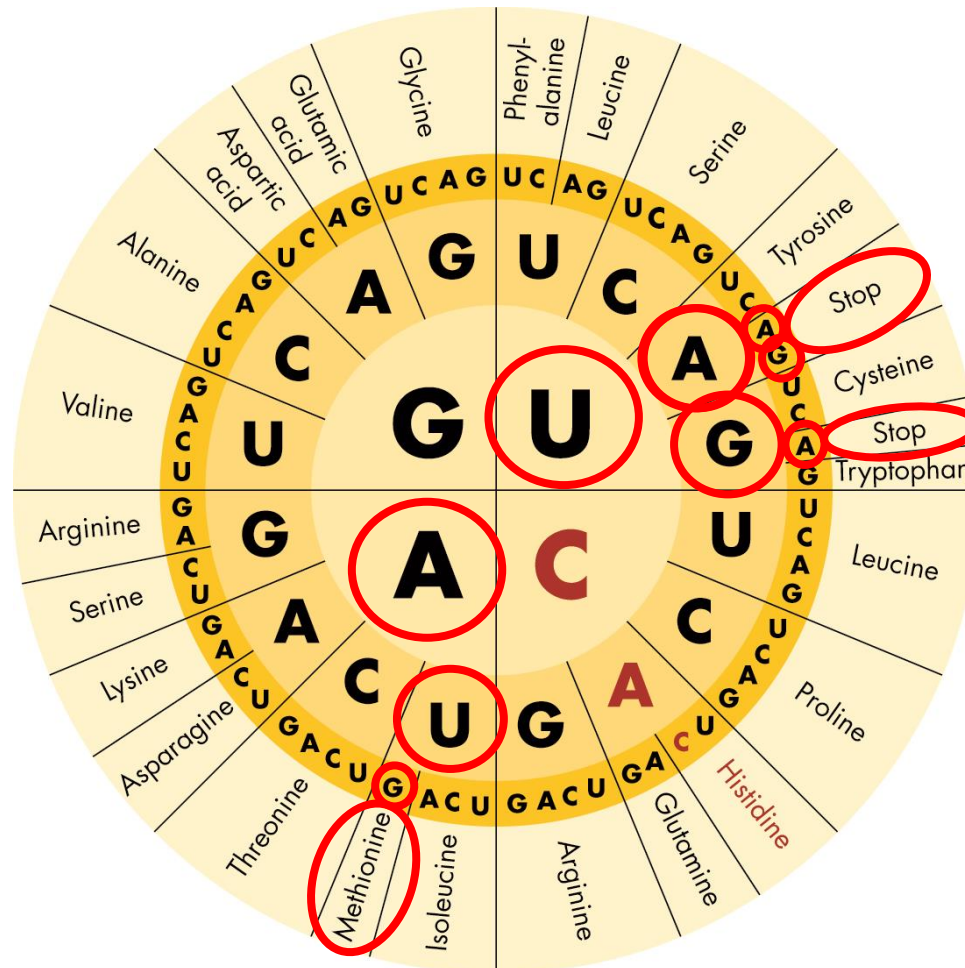
CAC = Histidine

Start and Stop Codons

The methionine codon AUG serves as the “start” codon for protein synthesis. There are three “stop” codons.

UAA, UAG, and UGA are “stop” codons

AUG =
methionine =
“start” codon



DNA, RNA, and Protein

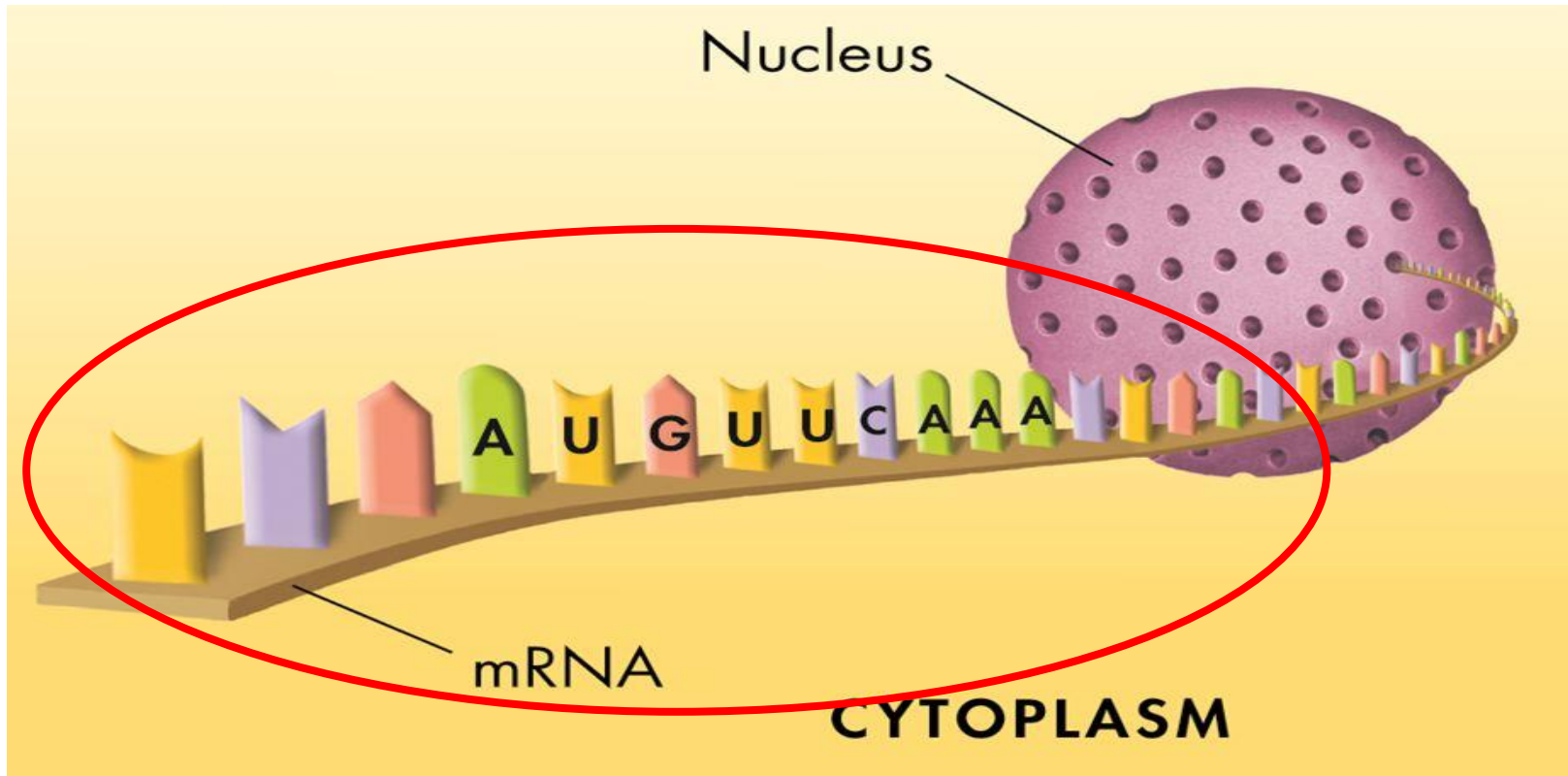
Translation Steps Simplified

- 1) mRNA attaches to the ribosome (2 parts)
- 2) tRNA carries an amino acid to ribosome
- 3) tRNA lines up on ribosome using codon/anticodon sequence
- 4) Leaves amino acid behind to form polypeptide bonds
- 5) Long chains of amino acids make protein

First Base	Second Base				Third Base
	U	C	A	G	
U	UUU phenylalanine	UCU serine	UAU tyrosine	UGU cysteine	U
	UUC phenylalanine	UCC serine	UAC tyrosine	UGC cysteine	C
	UUA leucine	UCA serine	UAA stop	UGA stop	A
	UUG leucine	UCG serine	UAG stop	UGG tryptophan	G
C	CUU leucine	CCU proline	CAU histidine	CGU arginine	U
	CUC leucine	CCC proline	CAC histidine	CGC arginine	C
	CUA leucine	CCA proline	CAA glutamine	CGA arginine	A
	CUG leucine	CCG proline	CAG glutamine	CGG arginine	G
A	AUU isoleucine	ACU threonine	AAU asparagine	AGU serine	U
	AUC isoleucine	ACC threonine	AAC asparagine	AGC serine	C
	AUA isoleucine	ACA threonine	AAA lysine	AGA arginine	A
	AUG (start) methionine	ACG threonine	AAG lysine	AGG arginine	G
G	GUU valine	GCU alanine	GAU aspartate	GGU glycine	U
	GUC valine	GCC alanine	GAC aspartate	GGC glycine	C
	GUA valine	GCA alanine	GAA glutamate	GGA glycine	A
	GUG valine	GCG alanine	GAG glutamate	GGG glycine	G

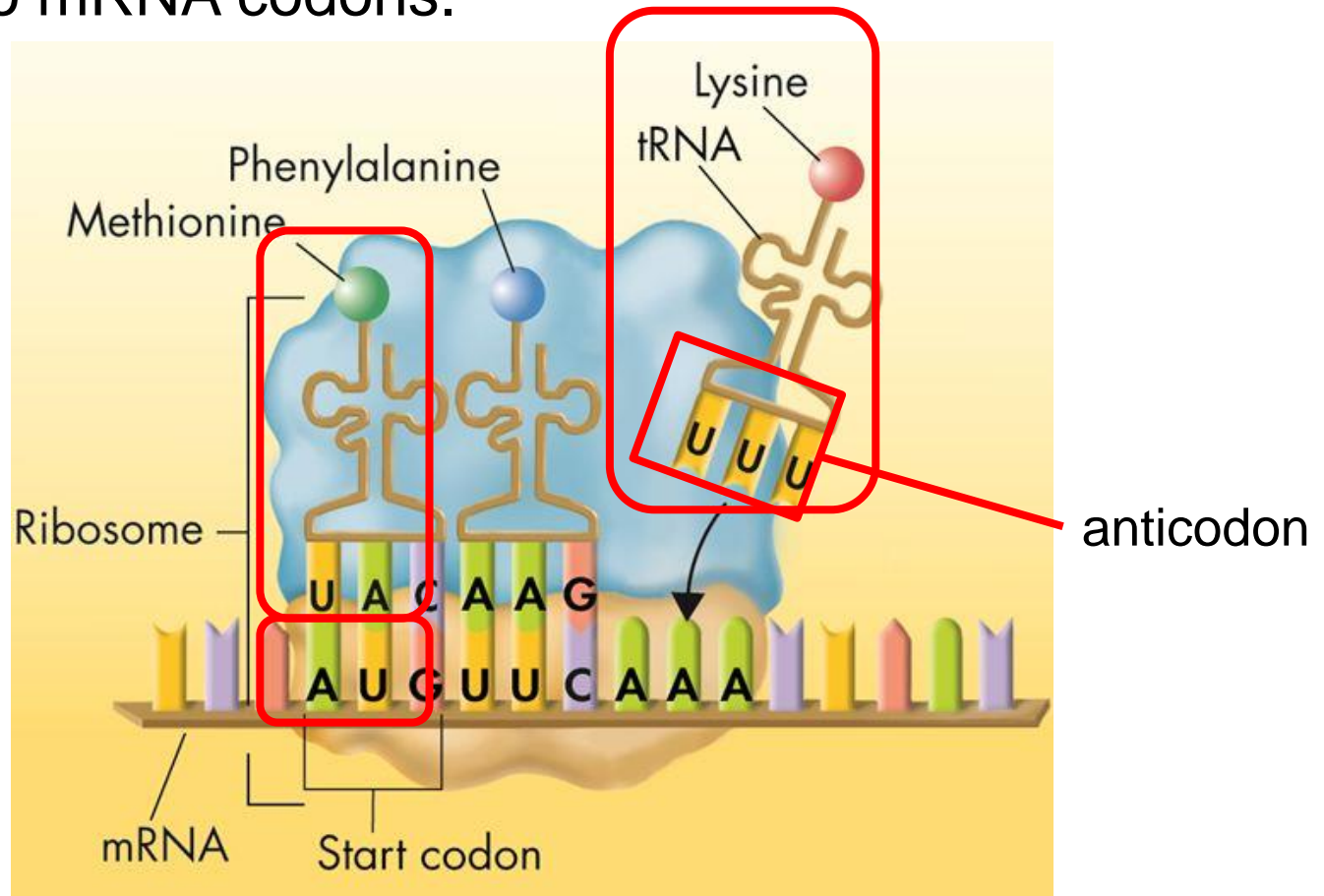
Translation

- Transcribed mRNA directs the translation process.
- Translation is the process that produces proteins by decoding the sequence of mRNA codons.



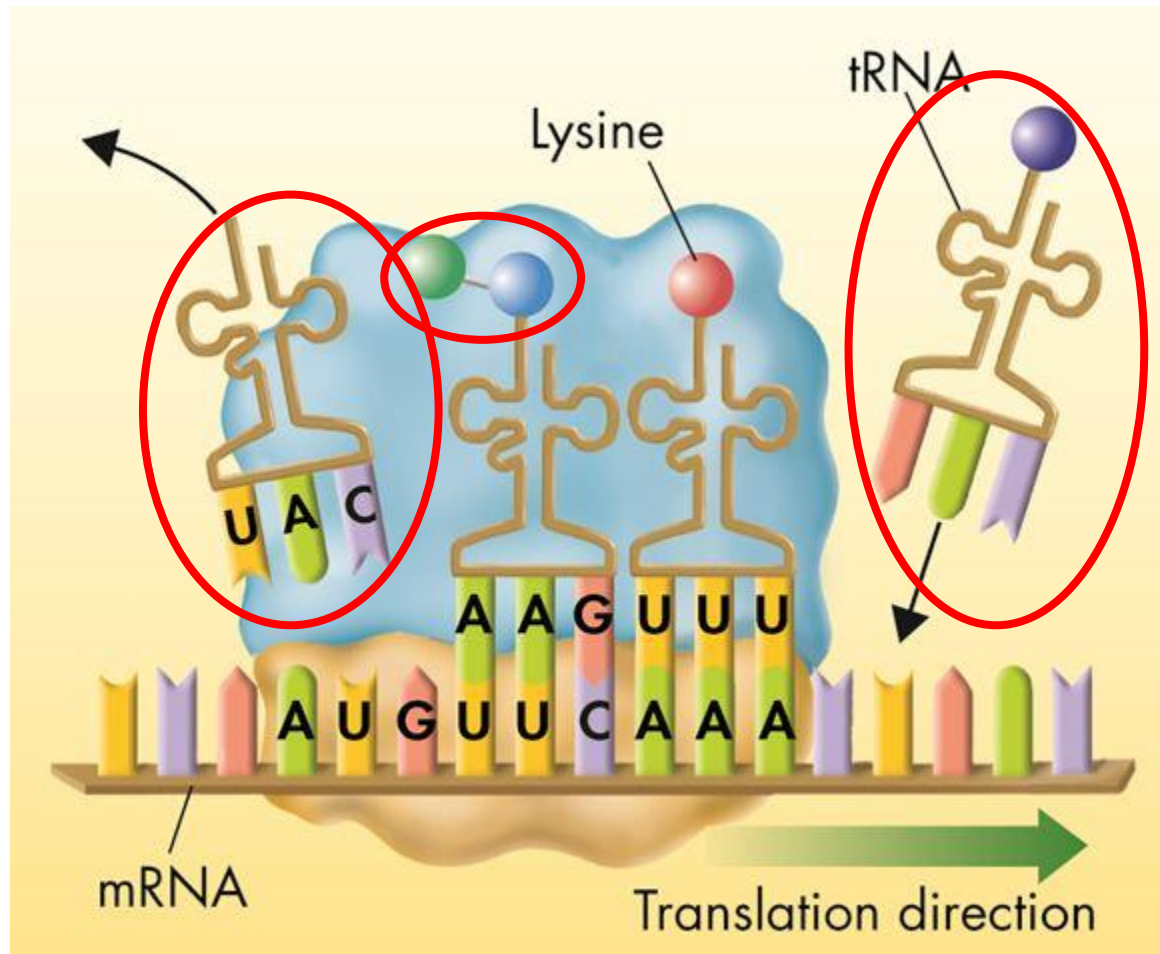
Translation: Transfer RNA

Translation starts when a ribosome attaches to an mRNA molecule. Then, tRNA molecules, carrying amino acids with them, bind to mRNA codons.



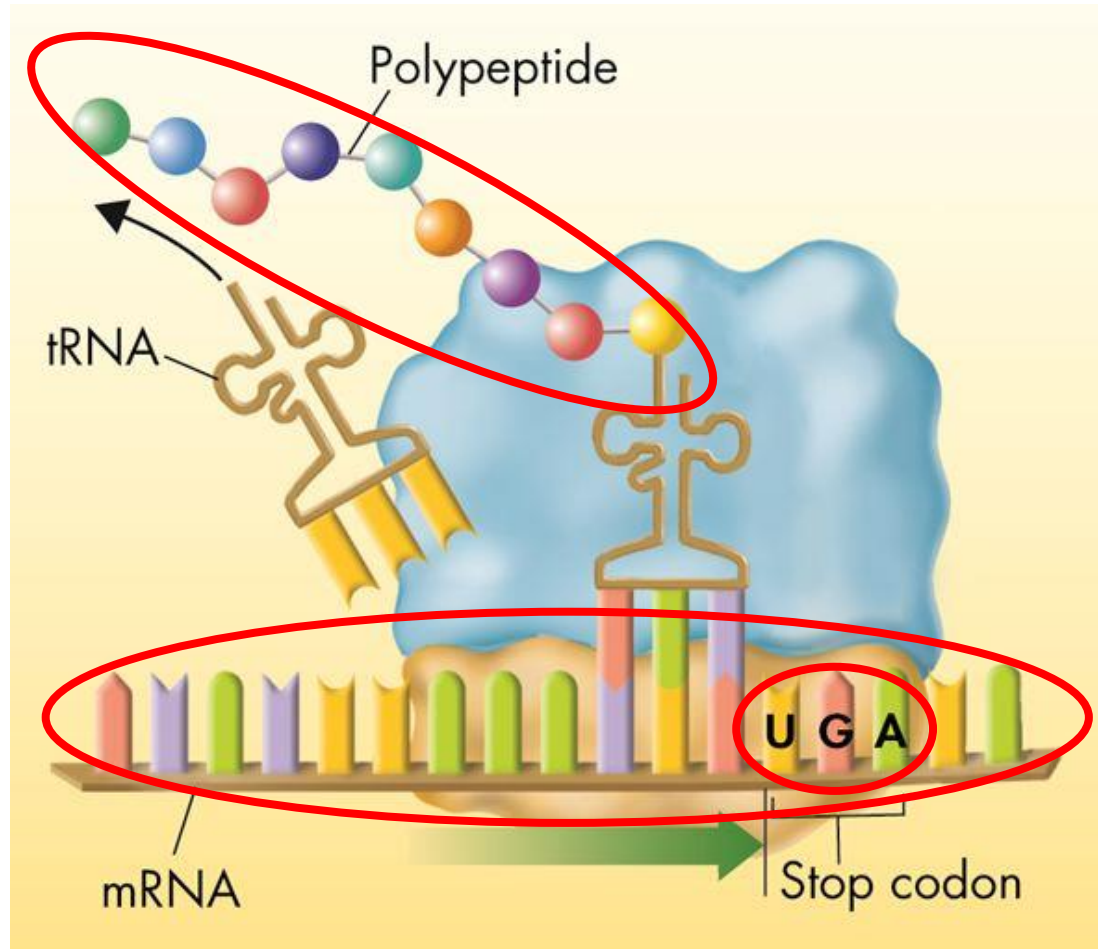
Translation: The Polypeptide Assembly

The ribosome helps form a peptide bond. It breaks the bond holding the first tRNA molecule to its amino acid.



Translation: Completing the Polypeptide

The ribosome reaches a stop codon, releasing the newly synthesized polypeptide and the mRNA molecule, completing the process of translation.



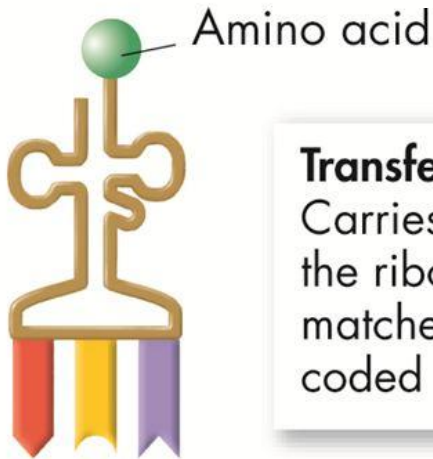
The Roles of RNA in Translation

All three major forms of RNA—mRNA, tRNA, and rRNA—are involved in the process of translation.



Messenger RNA

Carries instructions for polypeptide synthesis from nucleus to ribosomes in the cytoplasm.



Transfer RNA

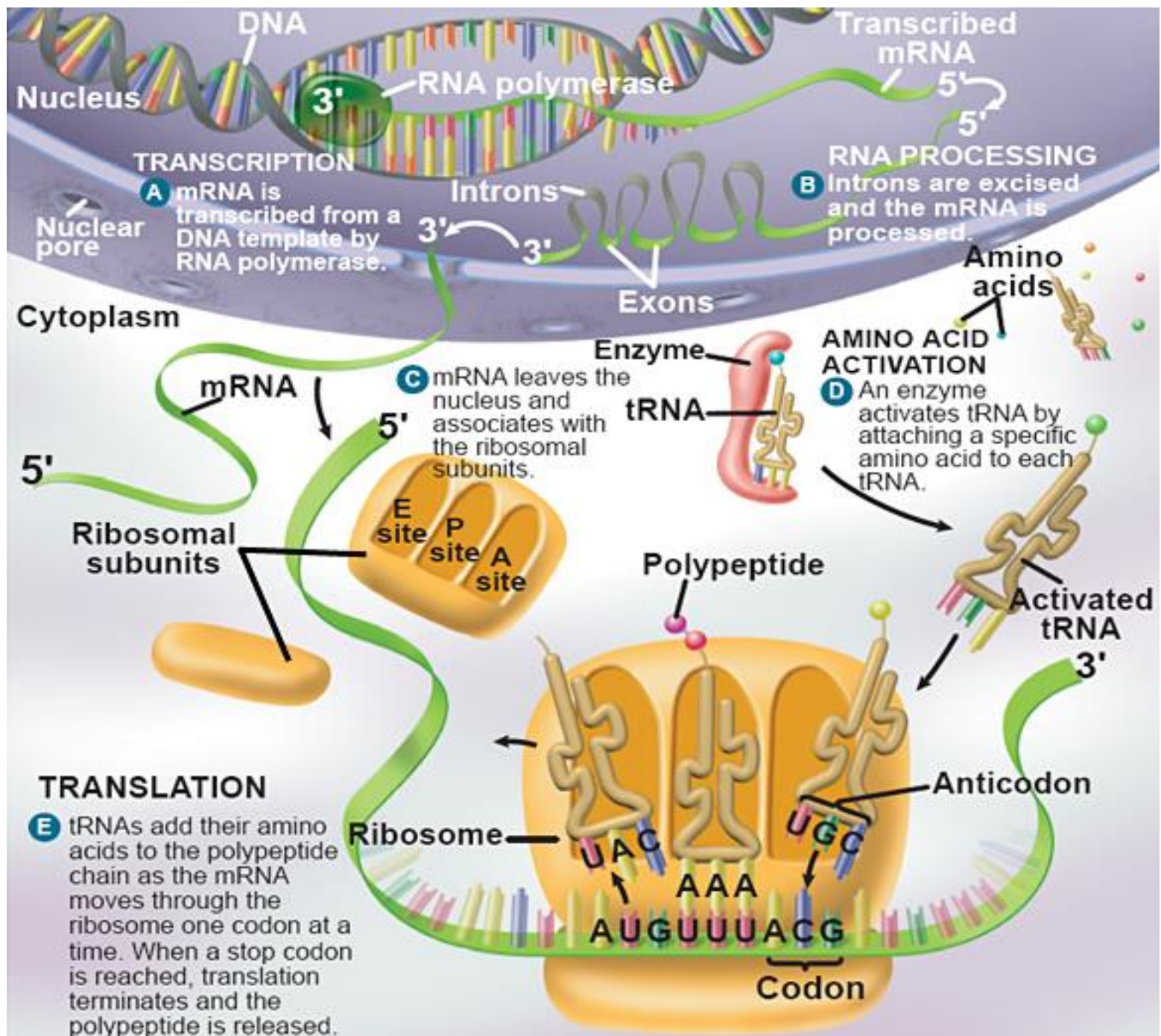
Carries amino acids to the ribosome and matches them to the coded mRNA message.



Ribosome

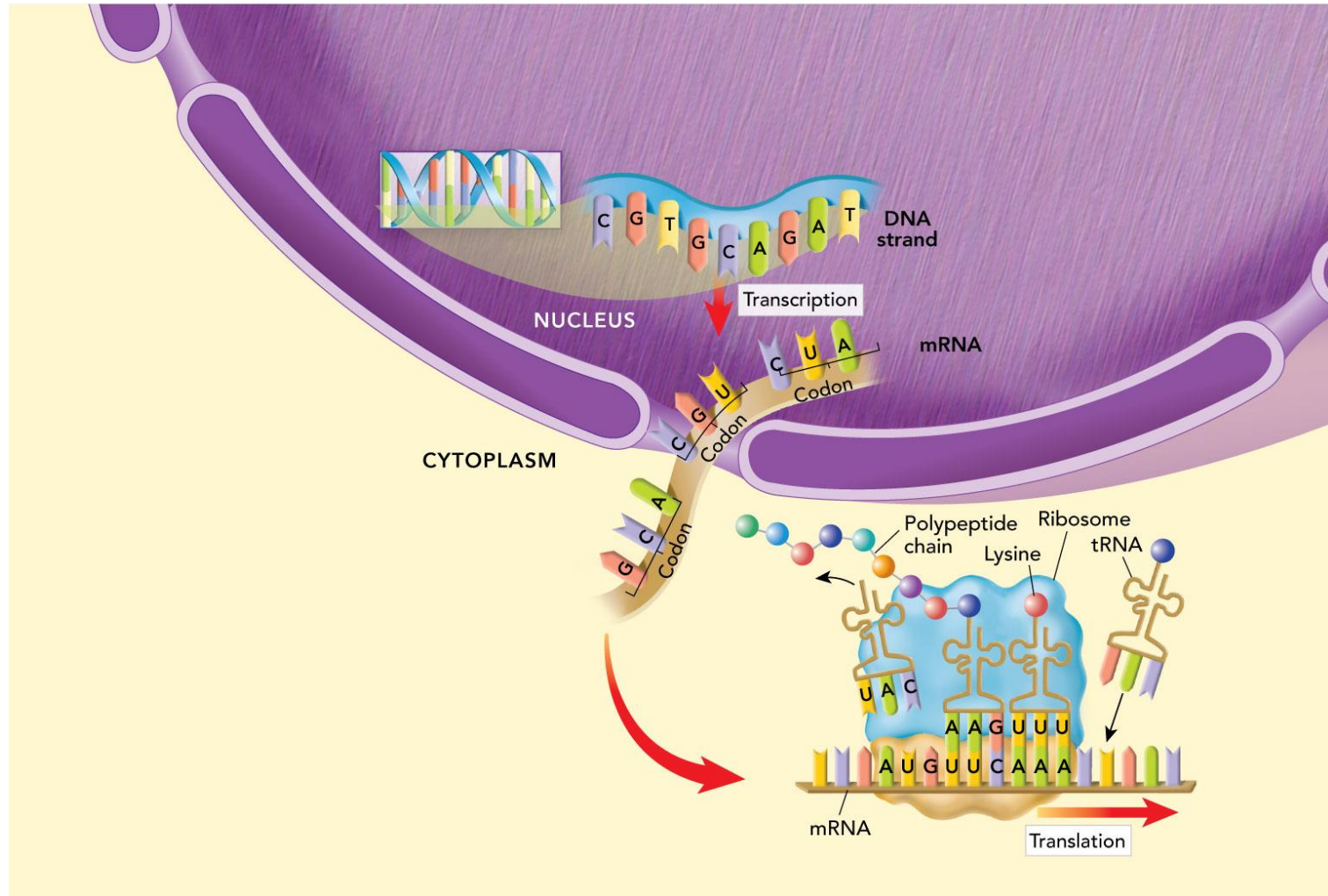
Ribosomal RNA

Forms an important part of both subunits of the ribosome.



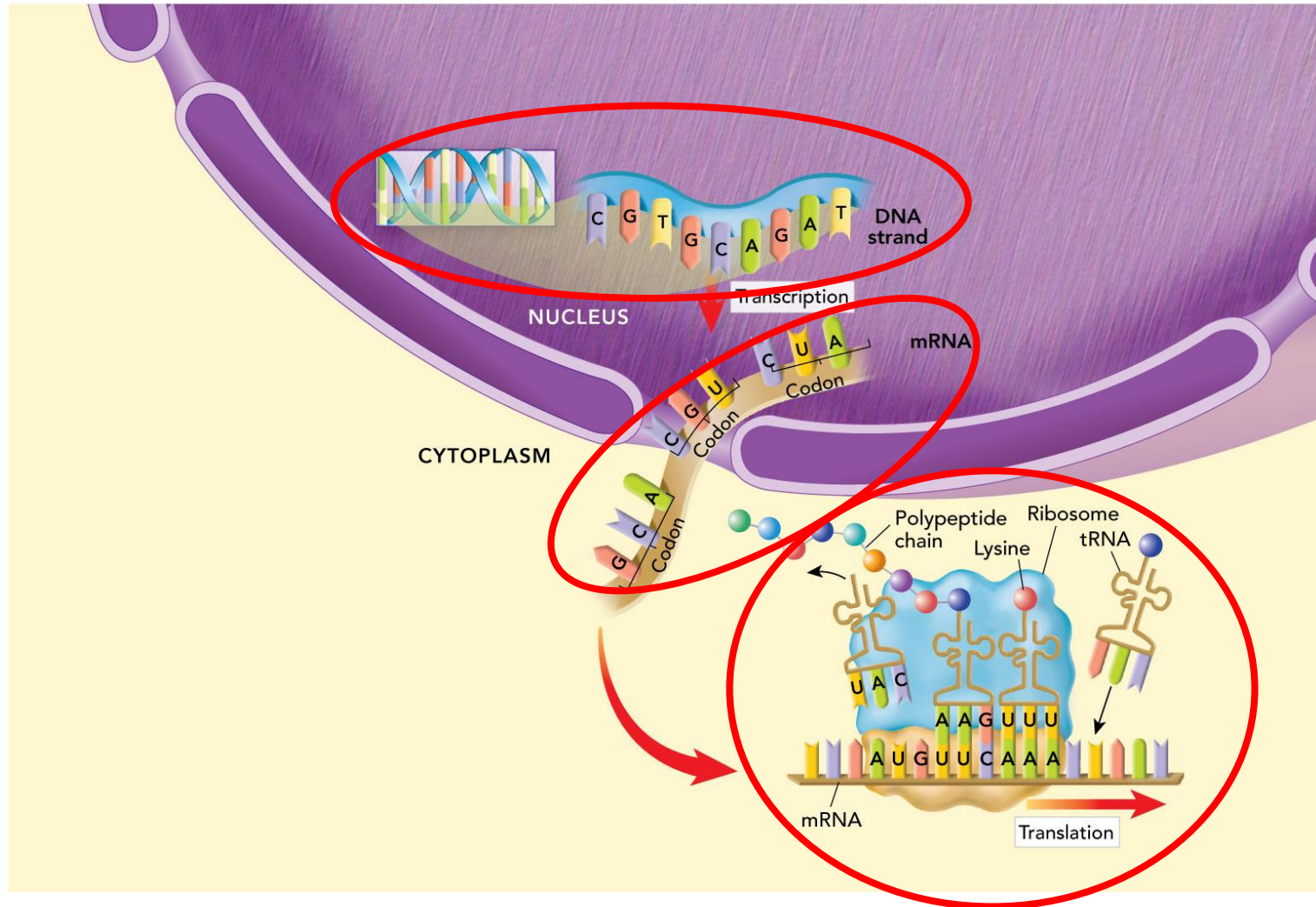
Molecular Genetics

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



Gene Expression

When a gene (segment) of DNA code is used to build a protein, scientists say that gene has been expressed.



A photograph of a large, multi-tiered bookshelf filled with numerous books, primarily related to architecture, design, and art. The books are arranged in dense stacks across several shelves, with some titles clearly visible, such as 'ART AT AUCTION 1966-67', 'A MAN'S GARDEN', 'THE PERFECT GARDEN', and 'THE HOUSE BOOK'. The books are of various sizes and colors, creating a vibrant and textured display.

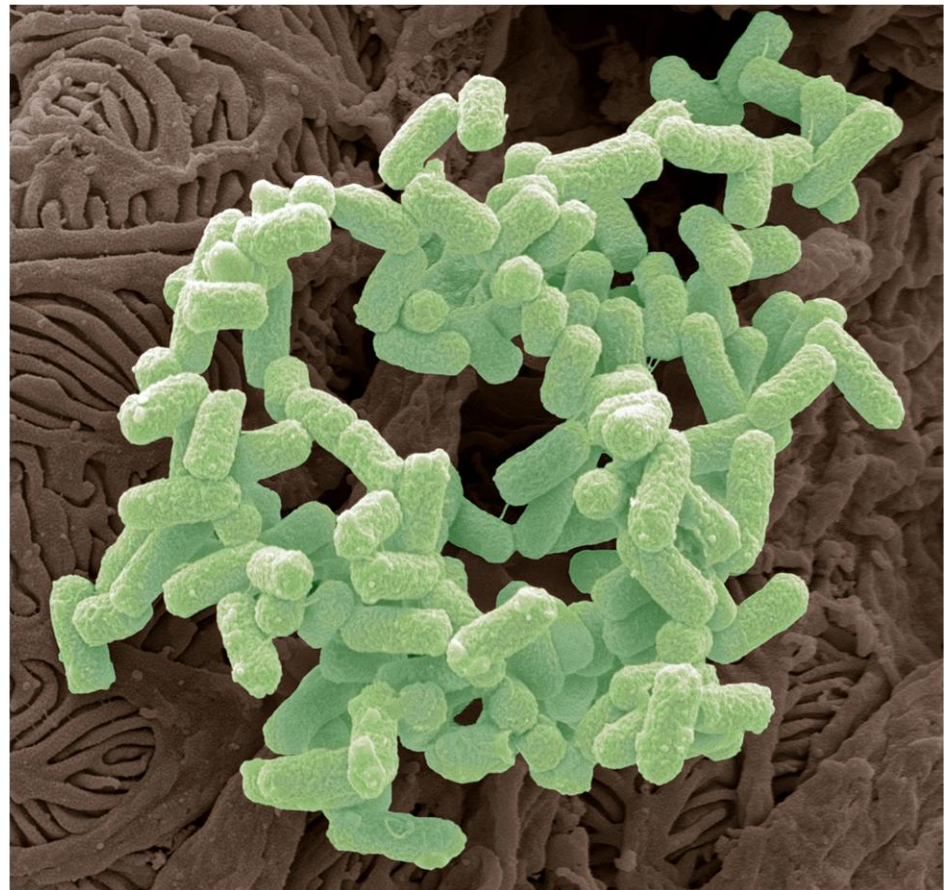
Learning Objectives

- Explain how prokaryotic genes are regulated.
- Describe how genes are regulated in eukaryotic cells.
- Identify what controls the development of cells and tissues in multicellular organisms.

Prokaryotic Gene Regulation

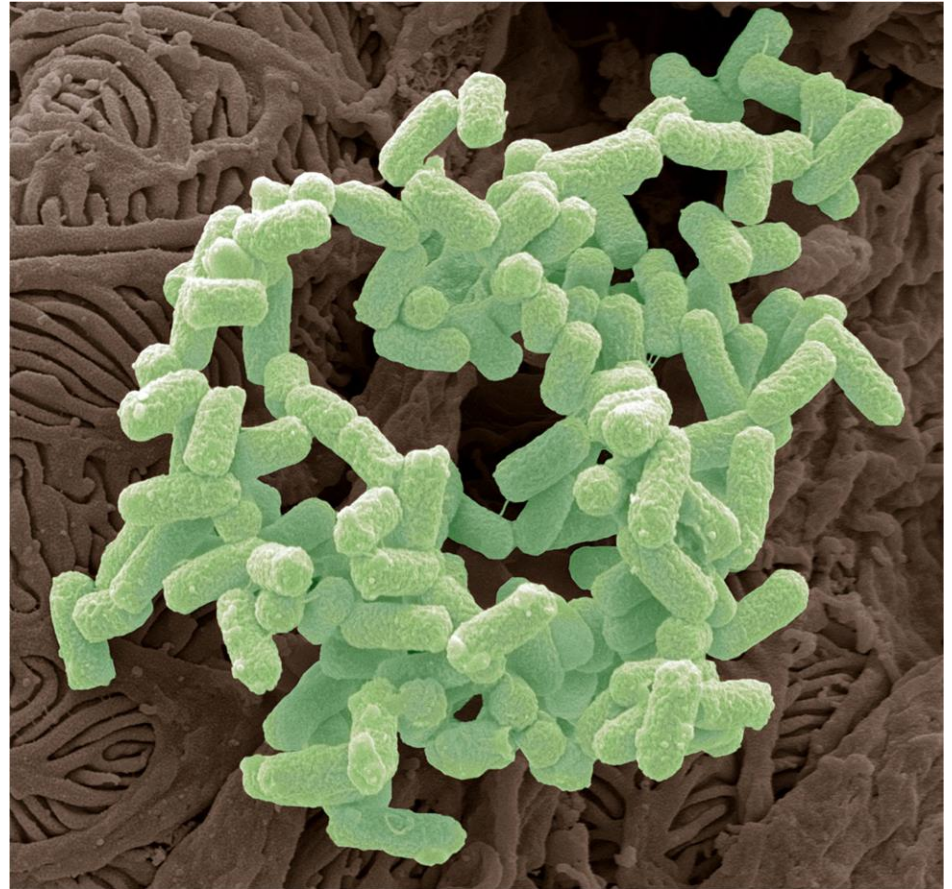
DNA-binding proteins in prokaryotes regulate genes by controlling transcription.

One of the keys to gene transcription in bacteria is the organization of genes into operons.



The *Lac* Operon

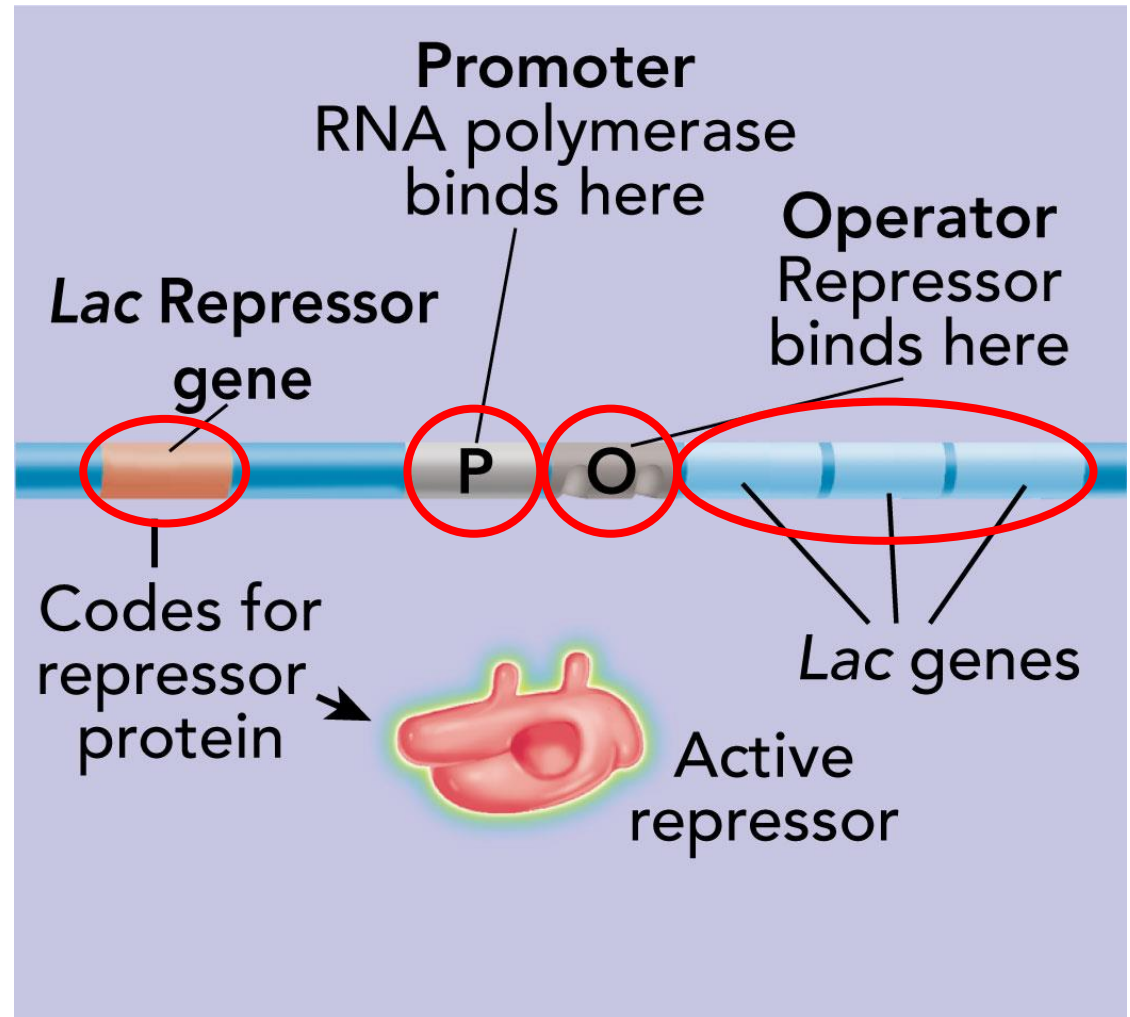
When lactose is not present, the *lac* genes are turned off by regulatory proteins that bind to DNA and block transcription.



Promoters and Operators

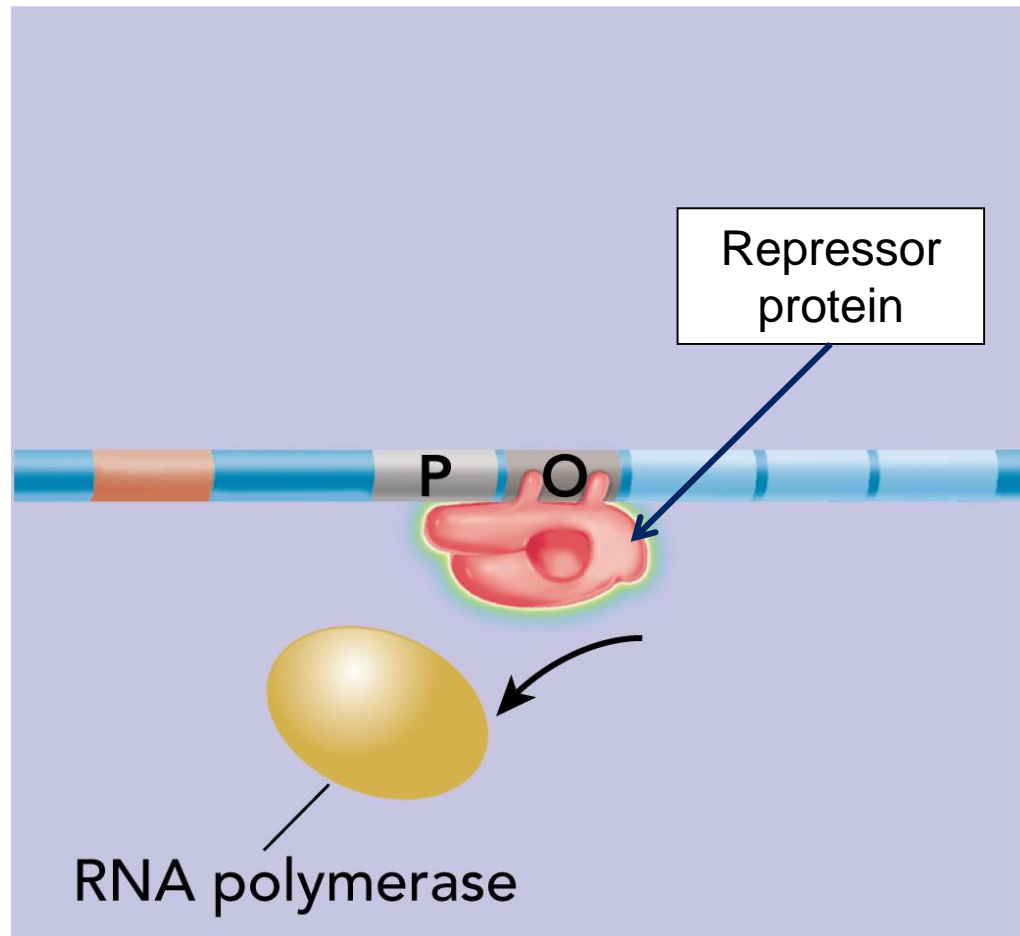
Located in front of the operon's three genes are two regulatory regions:

- A promoter
- An operator



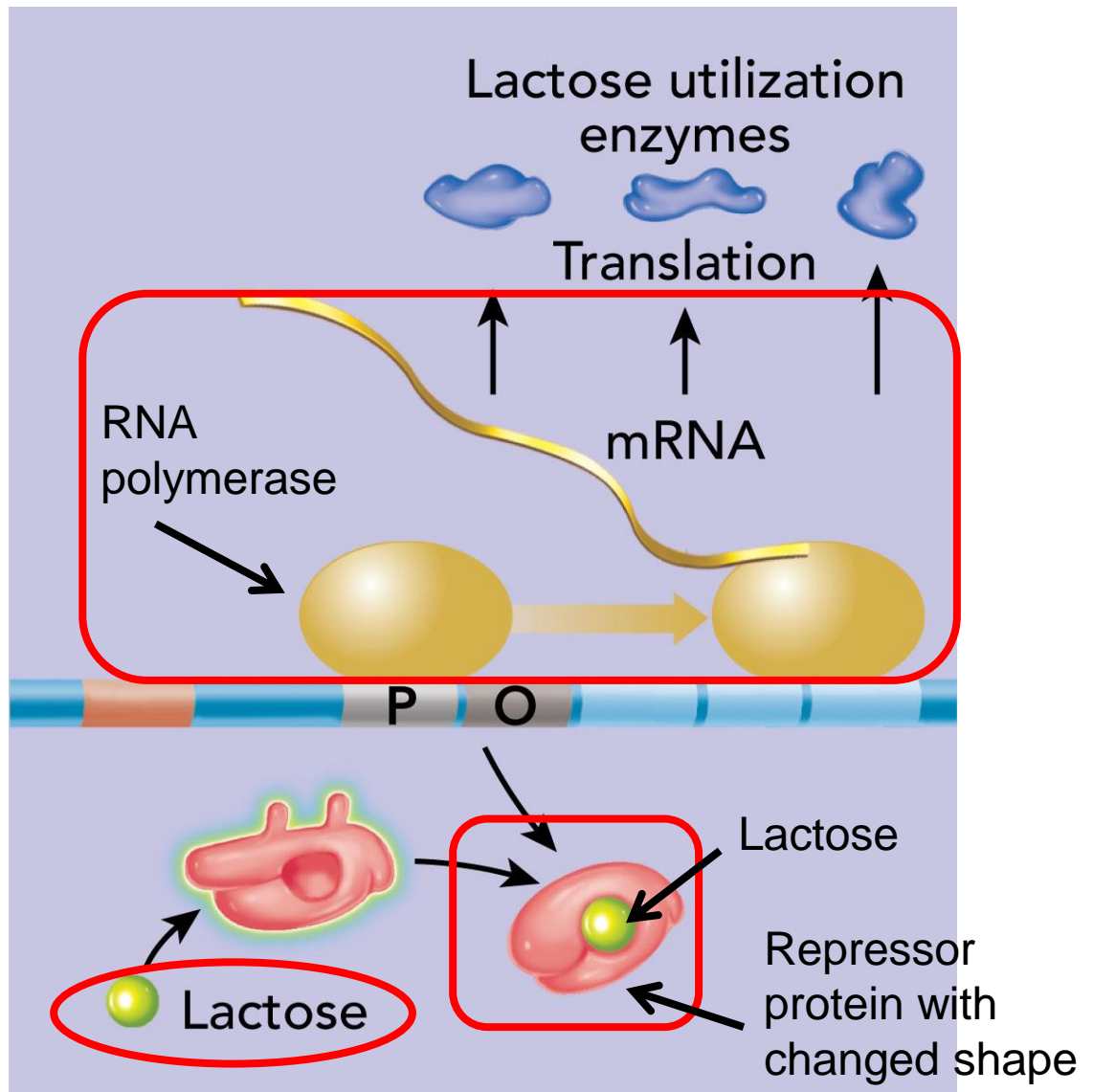
The *Lac* Repressor Blocks Transcription

When the *lac* repressor binds to the O region, RNA polymerase cannot reach the *lac* genes to begin transcription.



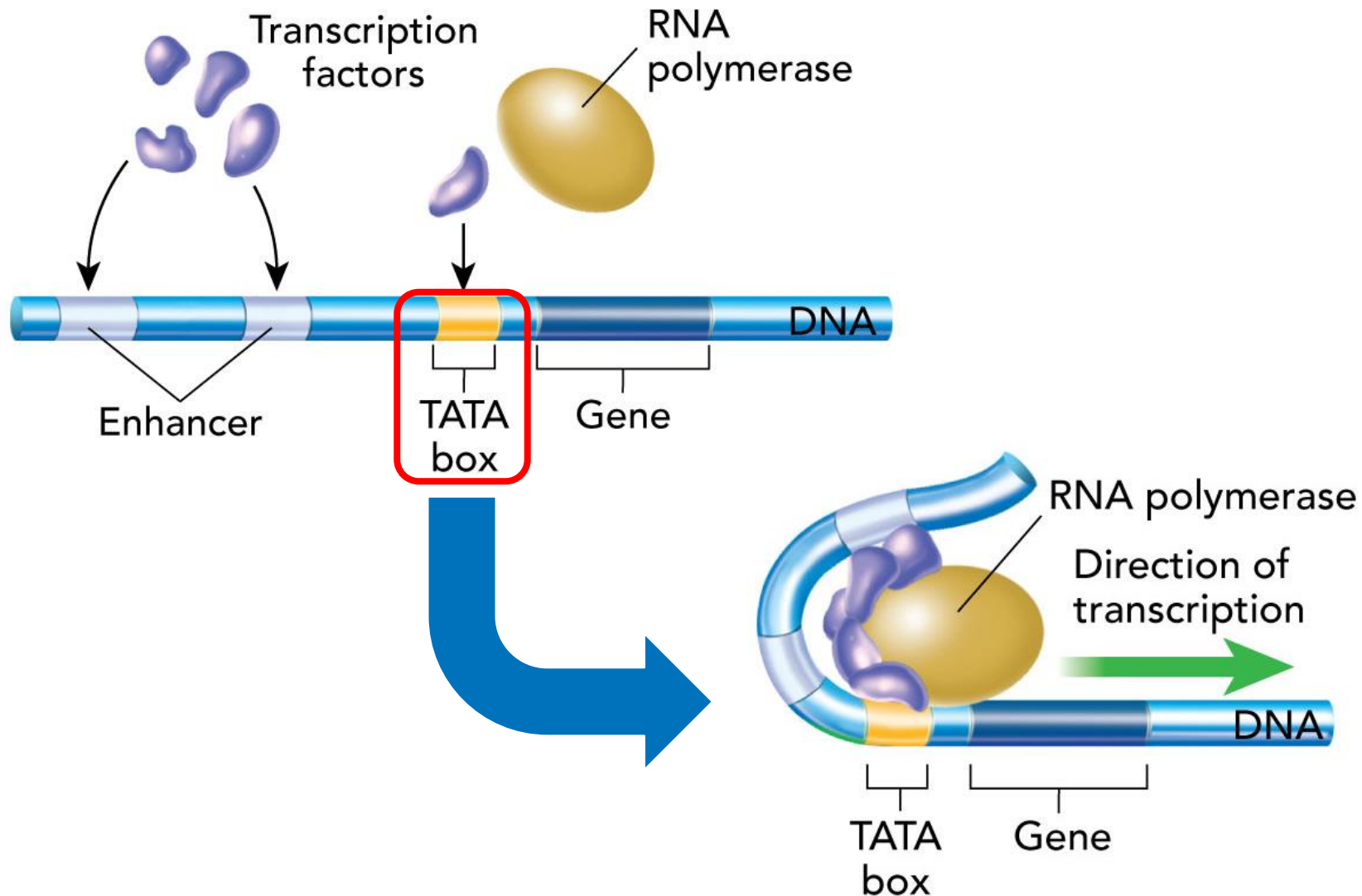
Lactose Turns On the Operon

When lactose is added to the medium, it diffuses into the cell and attaches to the *lac* repressor.



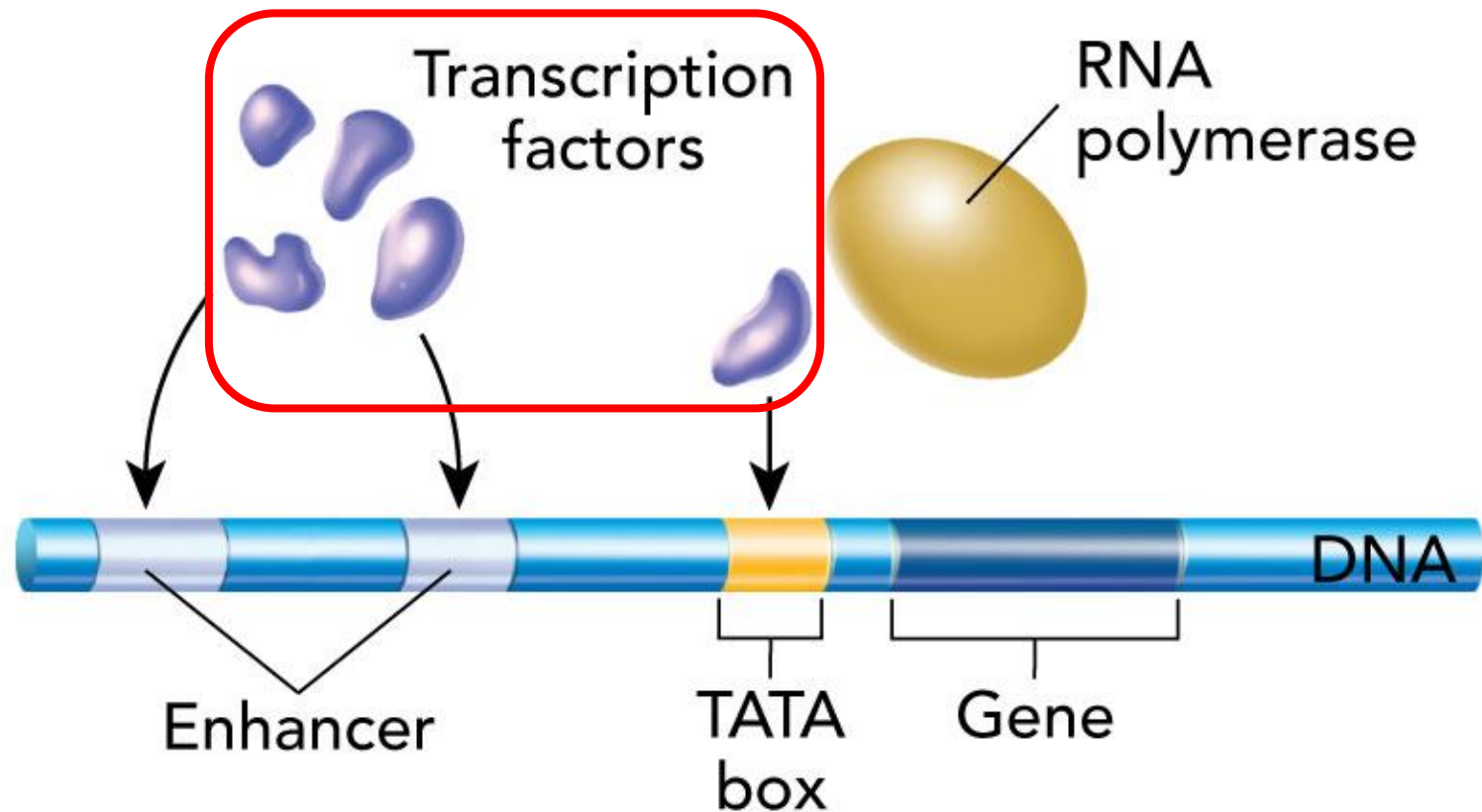
Eukaryotic Gene Regulation

A typical eukaryotic gene has a TATA box.



Transcription Factors

By binding DNA sequences in the regulatory regions of eukaryotic genes, transcription factors control the expression of those genes.



Cell Specialization

Complex gene regulation in eukaryotes is what makes differentiation and specialization possible.

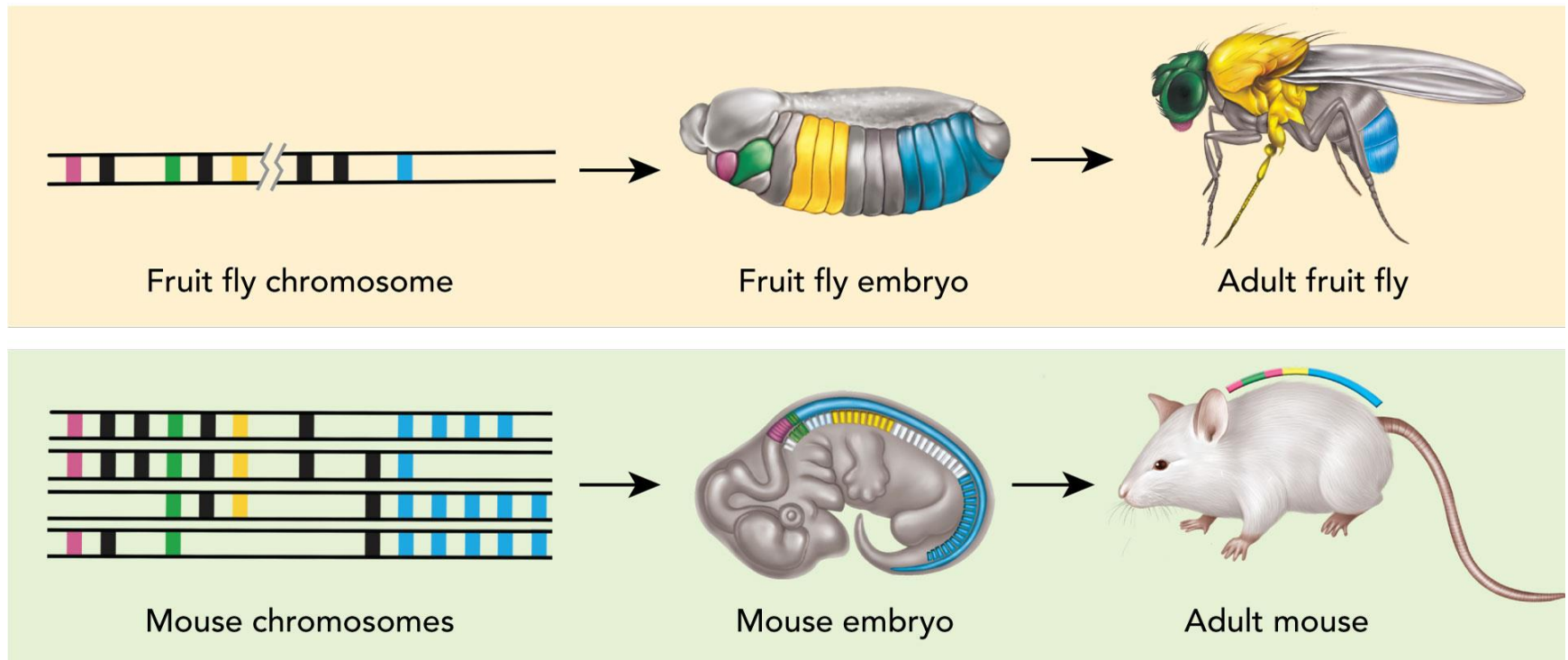
Genetic Control of Development

Regulating gene expression is important in shaping how a multicellular organism develops.

Each of the specialized cell types found in the adult originates from the same fertilized egg cell.

Homeotic, Homeobox, and Hox Genes

- Homeotic genes regulate organ development.
- Homeobox genes code for transcription factors.
- Hox genes determine the identities of each body segment.



Epigenetics-the study of changes in organisms caused by modification of gene expression rather than alteration of the genetic code itself.



Epigenetic mechanisms control which genes are on and which are off during each stage of an insect's life cycle.

Environmental Influences

Environmental factors can affect gene regulation.

Environmental factors such as diet, temperature, [oxygen levels](#), humidity, light cycles, and the presence of mutagens can all impact which of an animal's genes are expressed, which ultimately affects the animal's phenotype.

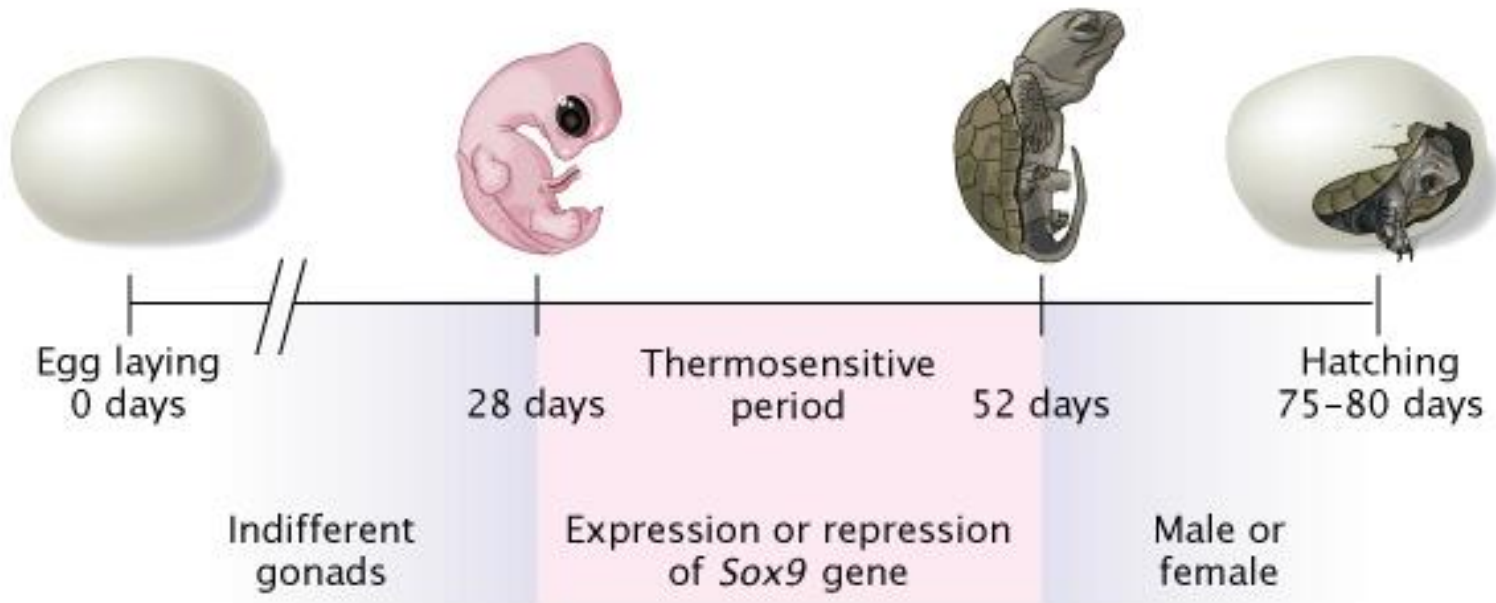


Raised at temperatures below 25°C



Raised at temperatures above 30°C

Environmental Influence on Phenotype



At 30 degrees, offspring will be female, at 25 degrees, the offspring will be male

Mutations



Learning Objectives

- Describe how mutations change genetic information.
- Explain how mutations affect genes.

Watch the video and listen for the following information

AS: [Mutations Video](#)

What are mutations?

Do mutations occur in chromosomes or within the base pairs (genes)?

What is the difference between somatic cell mutations and sex cell mutations?

Where do they occur?

When do they occur?

What can cause mutations?

Types of Mutations

Mutations are heritable changes in genetic information.

Mutations fall into two basic categories:

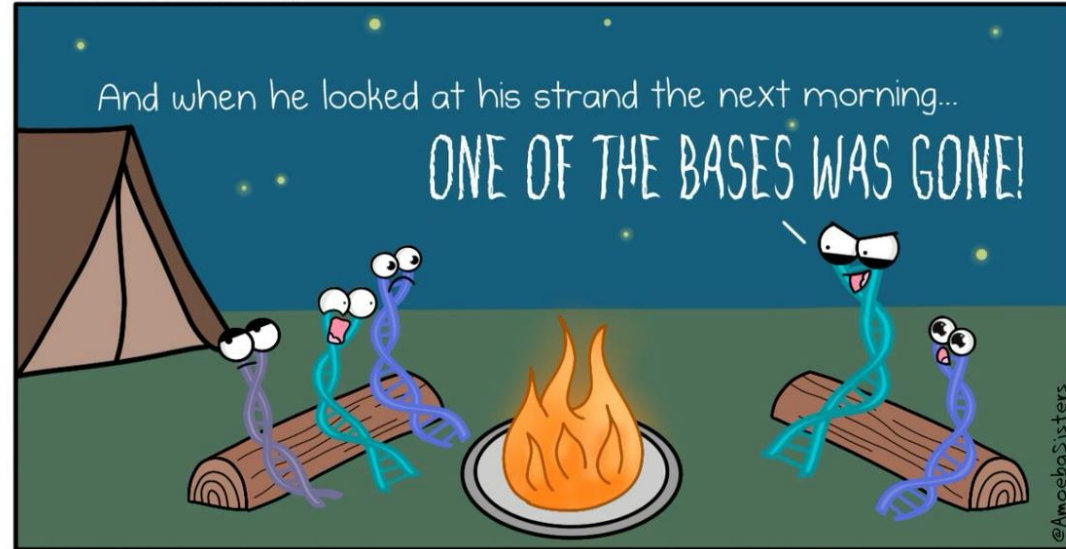
- Gene mutations
- Chromosomal mutations

Types of Gene Mutations

- Point/Substitution
- Insertion
- Deletion

Insertion and deletion of bases cause frameshift of the codons-which will possibly code for the incorrect amino acid

The Paramecium Parlor

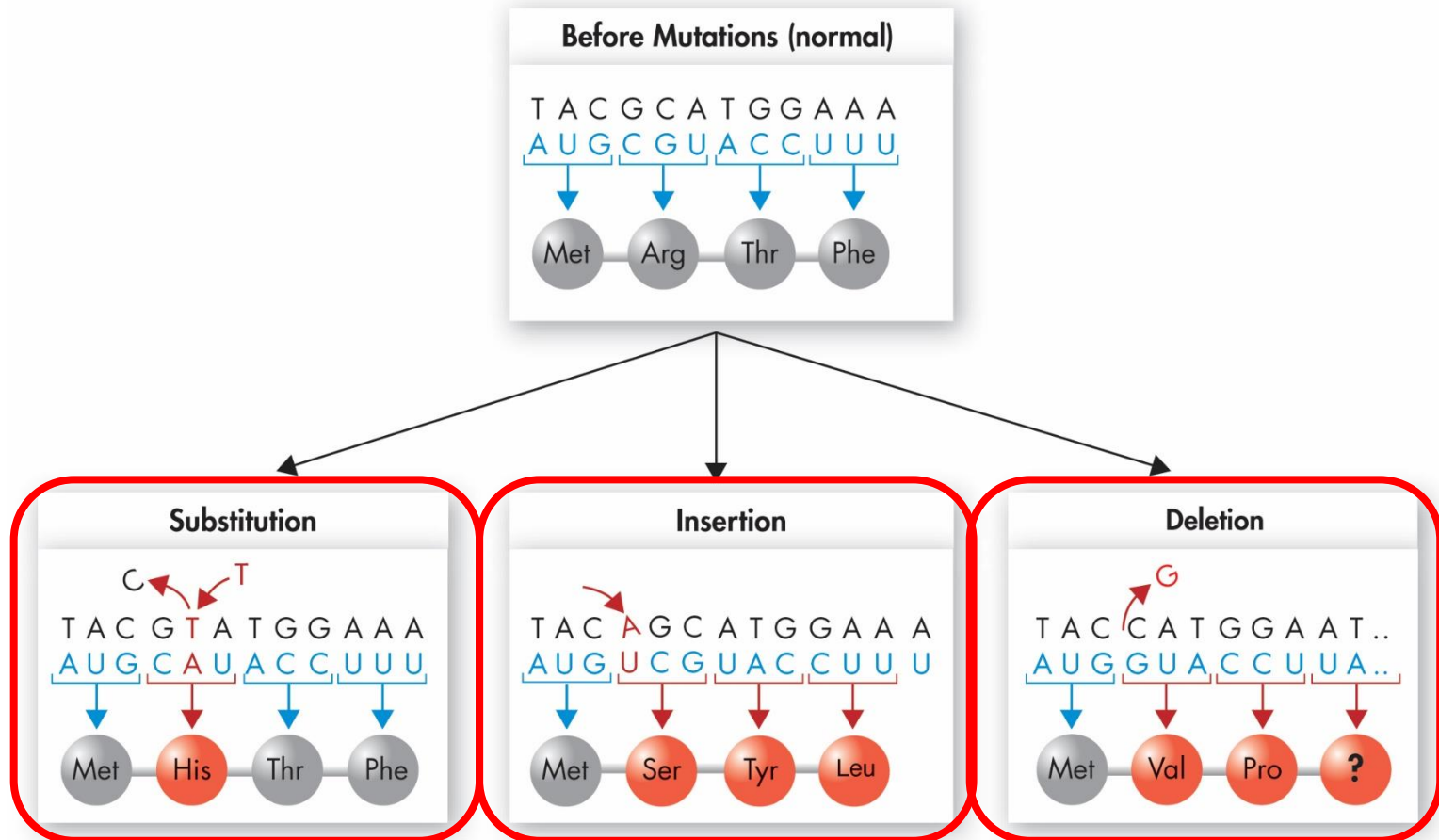


Sharing mutation stories was a DNA camping tradition.

Gene Mutations: Point Mutations

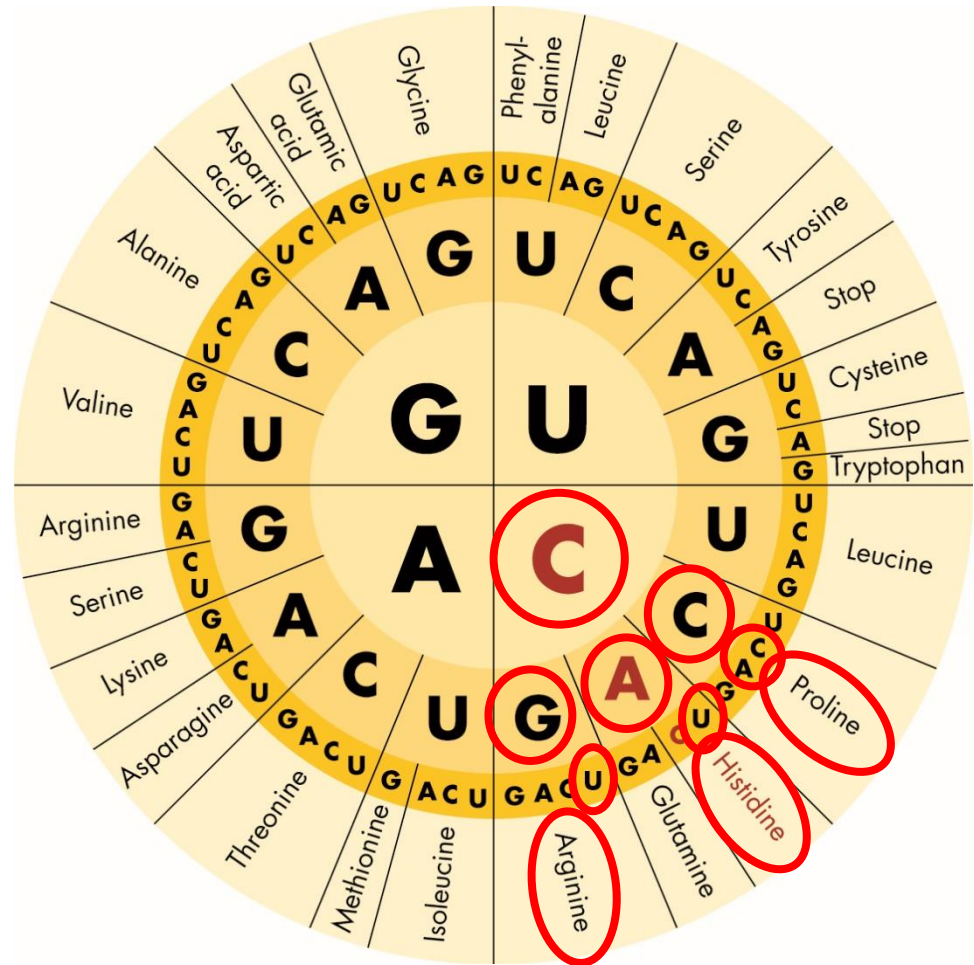
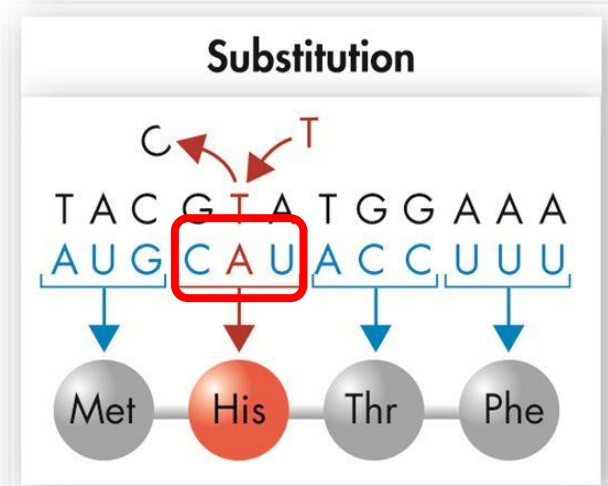
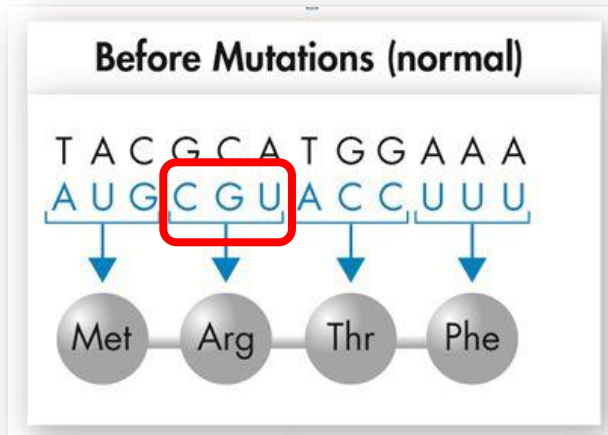
A point mutation is a change in a single nucleotide.

There are three types of point mutations:



Point Mutations: Substitutions

In a substitution, one base is changed to a different base.



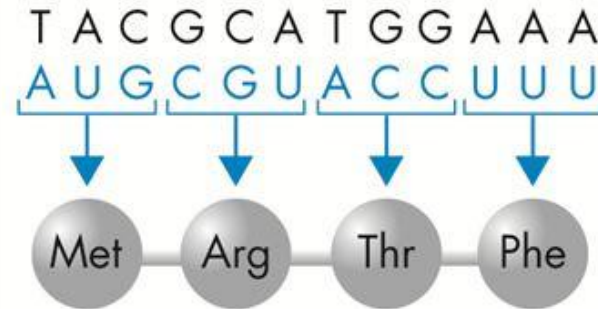
Point Mutations: Insertions and Deletions

Insertion mutation: when a single extra base is added into the code

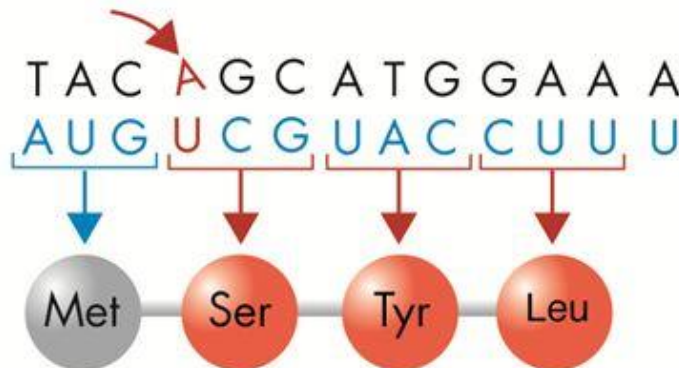
Deletion mutation: when a single base is removed from the code

*Note that the codon is altered thus possibly changing the amino acid (**frameshift**)

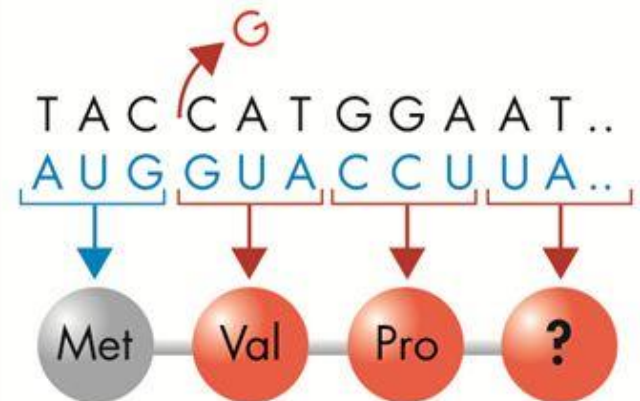
Before Mutations (normal)



Insertion



Deletion



Examples of Mutation using Analogy Sentence

Mutations		
Mutation Type	Analogy Sentence	Example of Associated Disease
Normal	THE BIG FAT CAT ATE THE WET RAT	
Missense (substitution)	THE BIZ FAT CAT ATE THE WET RAT	Achondroplasia: improper development of cartilage on the ends of the long bones of arms and legs resulting in a form of dwarfism
Nonsense (substitution)	THE BIG RAT	Muscular dystrophy: progressive muscle disorder characterized by the progressive weakening of many muscles in the body
Deletion (causing frameshift)	THB IGF ATC ATA TET HEW ETR AT	Cystic fibrosis: characterized by abnormally thick mucous in the lungs, intestines, and pancreas
Insertion (causing frameshift)	THE BIG ZFA TCA TAT ETH EWE TRA	Crohn's disease: chronic inflammation of the intestinal tract, producing frequent diarrhea, abdominal pain, nausea, fever, and weight loss
Duplication	THE BIG FAT FAT CAT ATE THE WET RAT	Charcot-Marie-Tooth disease (type 1A): damage to peripheral nerves leading to weakness and atrophy of muscles in hands and lower legs
Expanding mutation (tandem repeats) Generation 1 Generation 2 Generation 3	THE BIG FAT CAT ATE THE WET RAT THE BIG FAT CAT CAT CAT ATE THE WET RAT THE BIG FAT CAT CAT CAT CAT CAT CAT ATE THE WET RAT	Huntington's disease: a progressive disease in which brain cells waste away, producing uncontrolled movements, emotional disturbances, and mental deterioration

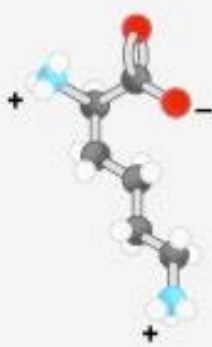

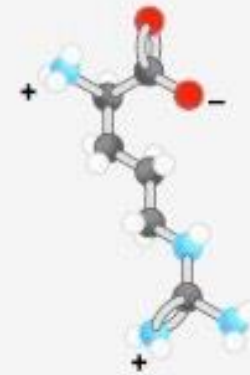
Mutation Effects

Mutations can be:

Beneficial-affects the organism in a positive way

Harmful-affects the organism in a negative way-produce wrong amino acid (**Missense**) or insert a stop codon producing no amino acid (**Nonsense**)

Neutral-neither help nor harm organism-we call these **Silent** mutations

	No mutation	Point mutations		
		Silent	Missense	Nonsense
DNA	TTC	TTT	TCC	ATC
mRNA	AAG	AAA	AGG	UAG
Protein	Lys	Lys	Arg	STOP
				

Chromosomal Mutations

- Deletion
- Duplication
- Inversion
- Translocation

Original
Chromosome

A B C D E F

Deletion

A B C D E F
A C D E F

Duplication

A B C D E F
A B B C D E F

Inversion

A B C D E F
A C B D E F

Translocation

G H
A B C D E F
A B G H C D E F

Effects of Mutations

Mutations can harm, help, or have no effect on an organism. Some mutations arise from mutagens—chemical or physical agents in the environment.



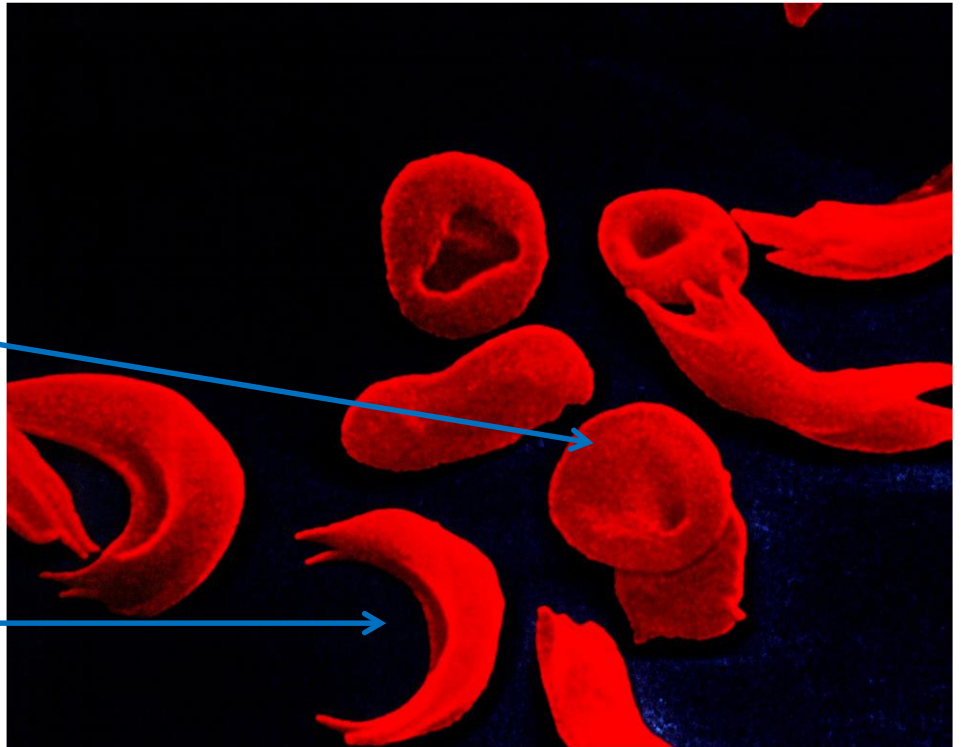
Effects of Mutations: Harmful

Some of the most harmful mutations are those that dramatically change protein structure or gene activity.

Example: Sickle cell disease affects the shape of red blood cells.

Normal red blood cell

Sickle cell



This disease is caused by a substitution mutation in one of the polypeptides found in hemoglobin, the blood's principal oxygen-carrying protein.

Among the symptoms of the disease are anemia, severe pain, frequent infections, and stunted growth

Effects of Mutations: Beneficial

Mutations often produce proteins with new or altered functions that can be useful to organisms in different or changing environments.

Body-cell v. Sex-cell Mutation

- Somatic (body) cell mutations are not passed on to the next generation.
- Mutations that occur in gametes (sex cells) are passed on to the organism's offspring and will be present in every cell of the offspring.