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Objectives

- **Compare** the structure of RNA with that of DNA.
- **Summarize** the process of transcription.
- **Relate** the role of codons to the sequence of amino acids that results after translation.
- **Outline** the major steps of translation.
- **Discuss** the evolutionary significance of the genetic code.

End Of Slide

Decoding the Information in DNA

- Traits, such as eye color, are determined by proteins that are built according to instructions coded in DNA.
- Proteins, however, are not built directly from DNA. Ribonucleic acid is also involved.
- Like DNA, **ribonucleic acid (RNA)** is a nucleic acid—a molecule made of nucleotides linked together.

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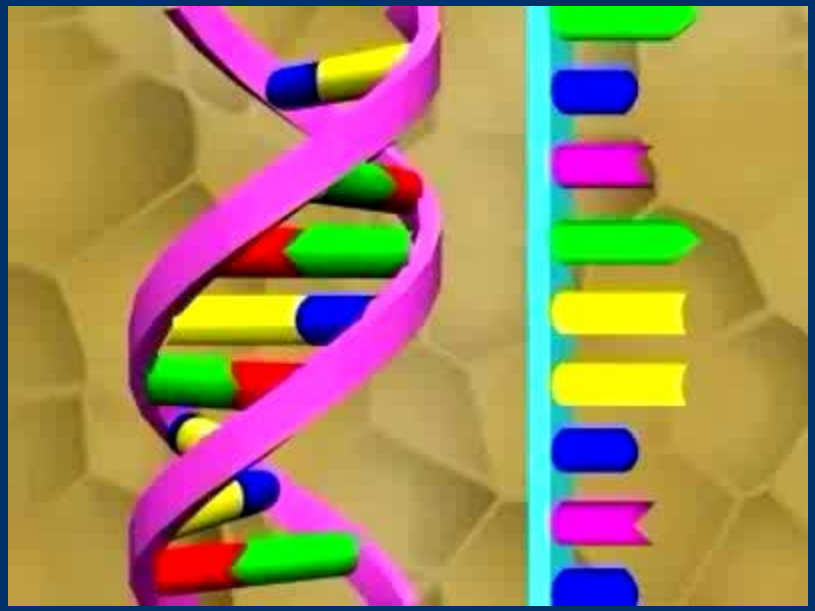
Ribonucleic Acid



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Decoding the Information in DNA, *continued*

- RNA differs from DNA in three ways:

  1. RNA consists of a single strand of nucleotides instead of the two strands found in DNA.

  2. RNA nucleotides contain the five-carbon sugar ribose rather than the sugar deoxyribose, which is found in DNA nucleotides.

  3. In addition to the A, G, and C nitrogen bases found in DNA, RNA nucleotides can have a nitrogen base called **uracil (U).**

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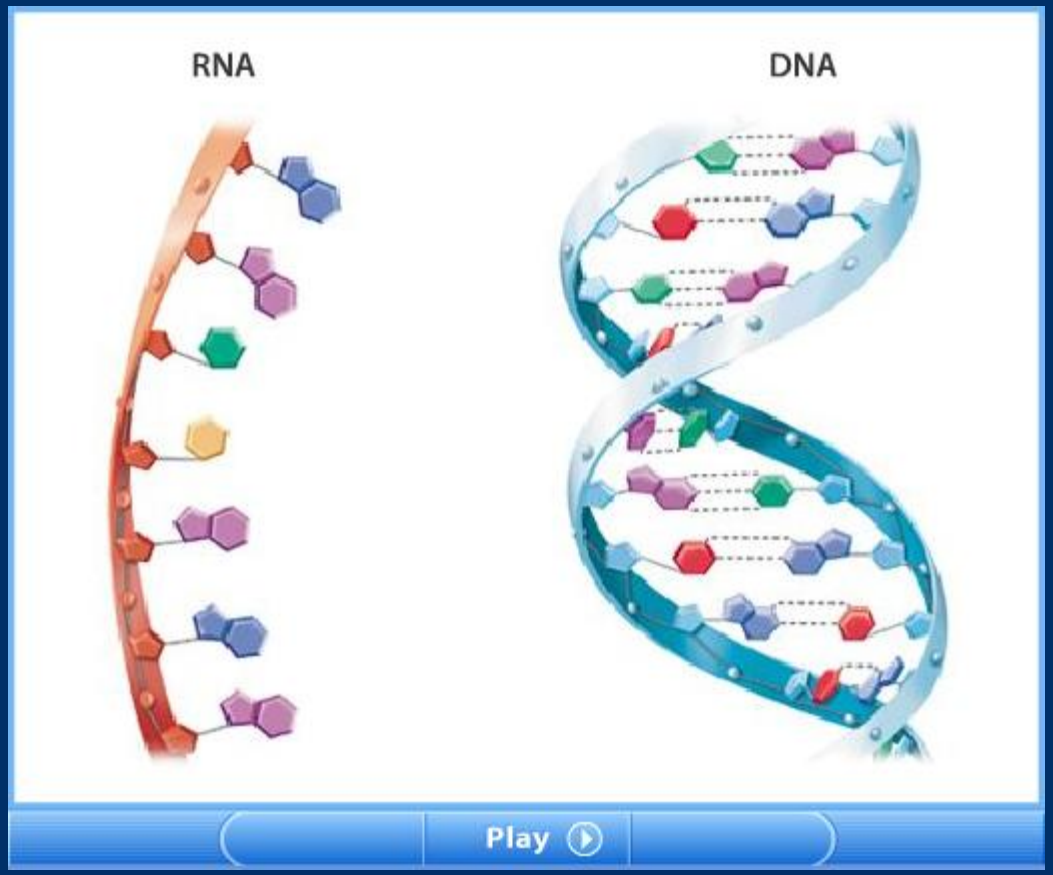
Comparing DNA and RNA



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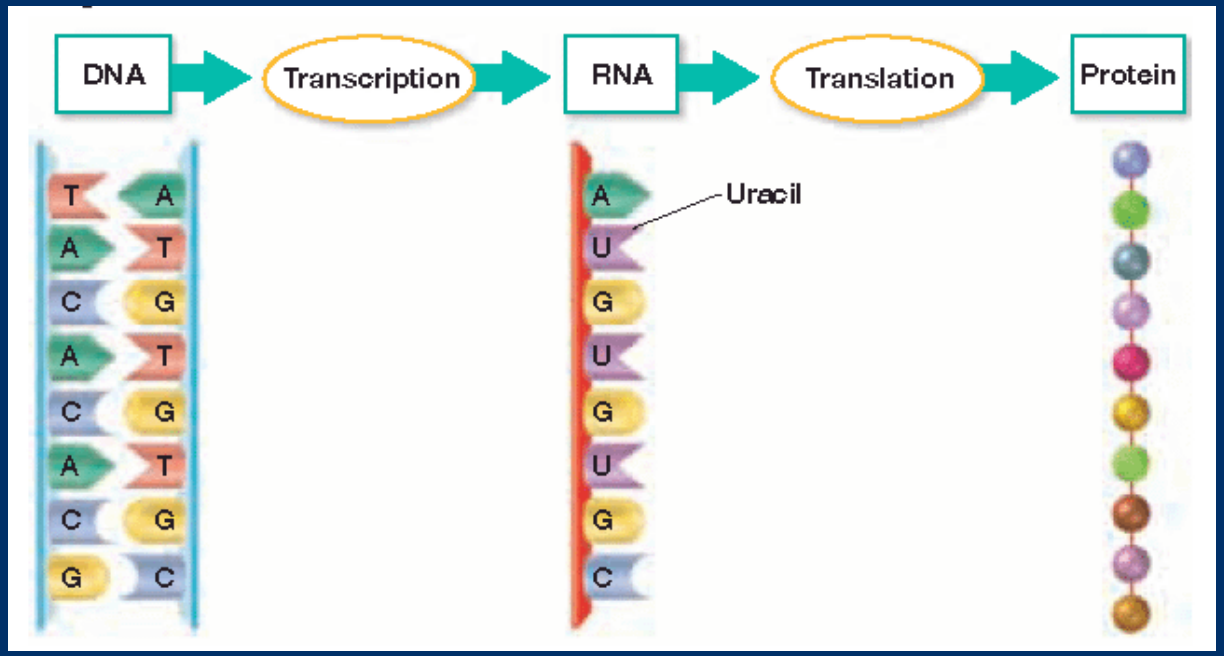
Decoding the Information in DNA, *continued*

- The instructions for making a protein are transferred from a gene to an RNA molecule in a process called **transcription.**

- Cells then use two different types of RNA to read the instructions on the RNA molecule and put together the amino acids that make up the protein in a process called **translation.**

Decoding the Information in DNA, *continued*

- The entire process by which proteins are made based on the information encoded in DNA is called **gene expression,** or protein synthesis.



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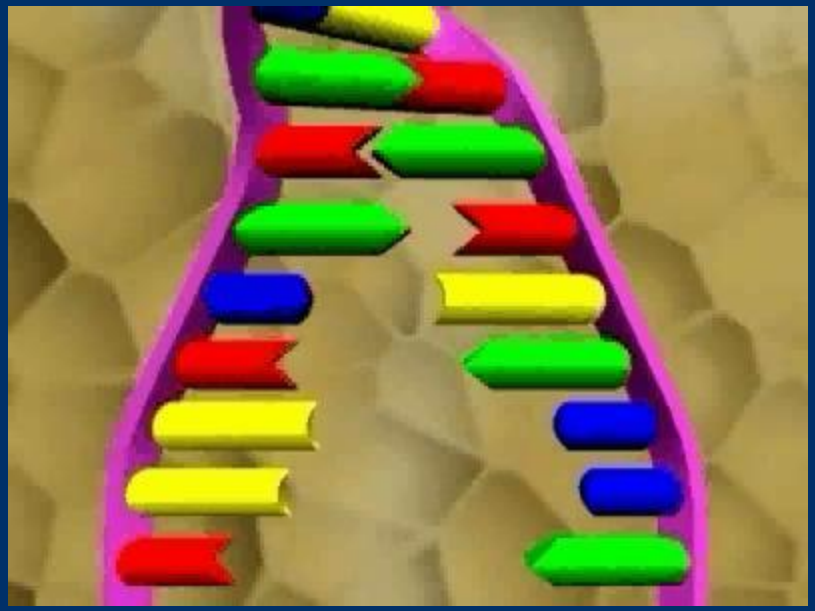
Gene Expression



Transfer of Information from DNA to RNA

- The first step in the making of a protein, transcription, takes the information found in a gene in the DNA and transfers it to a molecule of RNA.

- **RNA polymerase,** an enzyme that adds and links complementary RNA nucleotides during transcription, is required.

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Transfer of Information from DNA to RNA, *continued*

- The three steps of transcription are:

  Step 1 RNA polymerase binds to the gene's promoter.

  Step 2 The two DNA strands unwind and separate.

  Step 3 Complementary RNA nucleotides are added.

Transcription

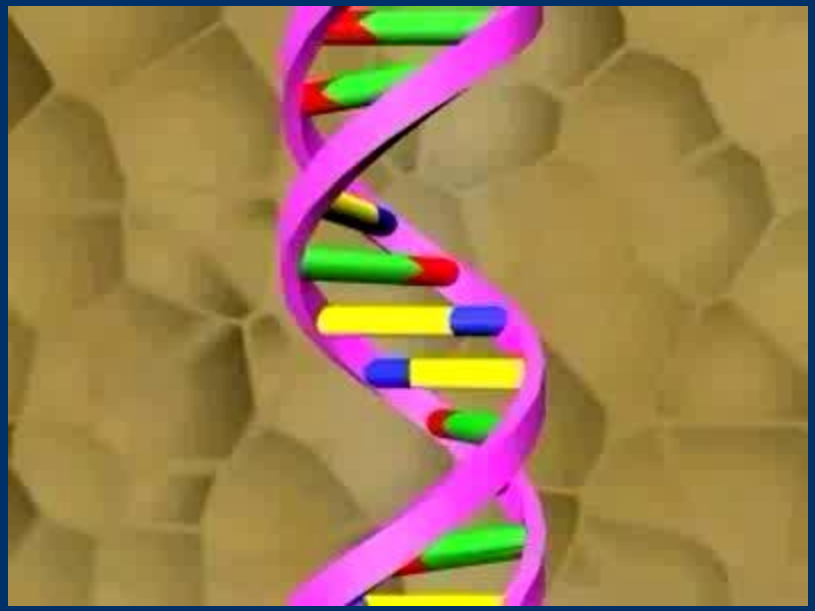
BIO graphic

Transcription: Making RNA

RNA polymerase adds complementary RNA nucleotides as it reads the gene.

1. RNA polymerase binds to the gene's promoter.
2. The two DNA strands unwind and separate.
3. Complementary RNA nucleotides are added.

Transcription



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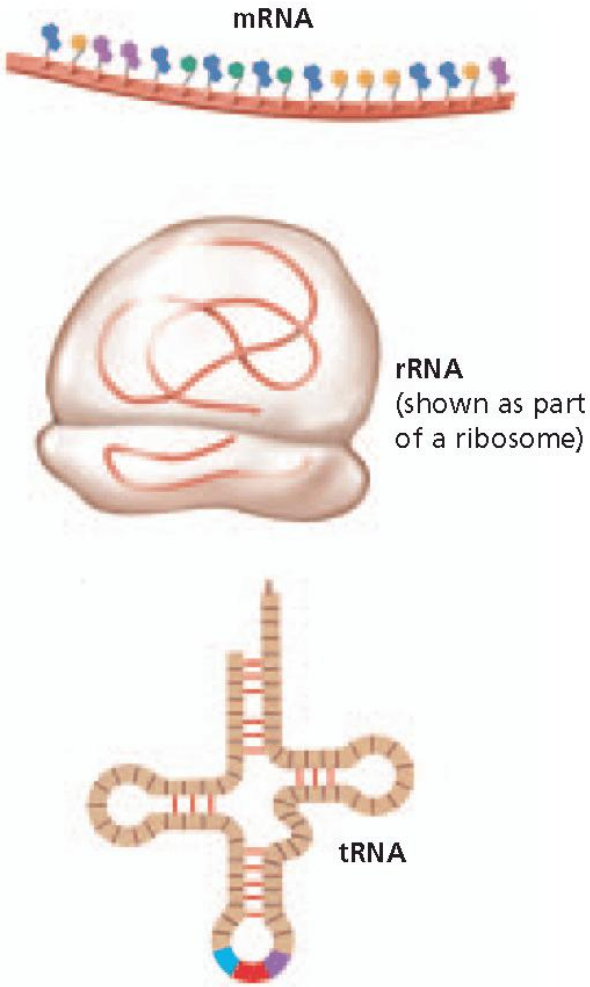
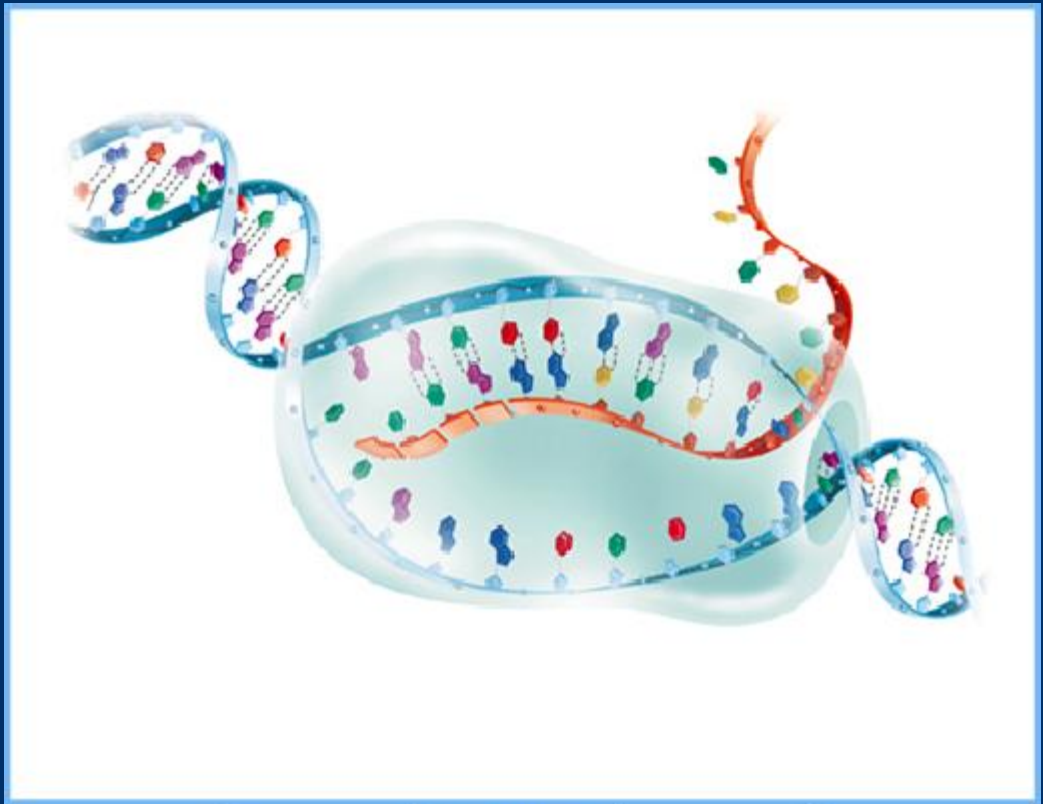
Types of RNA



Types of RNA



The Genetic Code: Three-Nucleotide "Words"

- Different types of RNA are made during transcription, depending on the gene being expressed.
- When a cell needs a particular protein, it is messenger RNA that is made.
- **Messenger RNA (mRNA)** is a form of RNA that carries the instructions for making a protein from a gene and delivers it to the site of translation.

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The Genetic Code: Three-Nucleotide "Words", *continued*

- The information is translated from the language of RNA—nucleotides—to the language of proteins—amino acids.
- The RNA instructions are written as a series of three-nucleotide sequences on the mRNA called **codons.**
- The **genetic code** of mRNA is the amino acids and "start" and "stop" signals that are coded for by each of the possible 64 mRNA codons.

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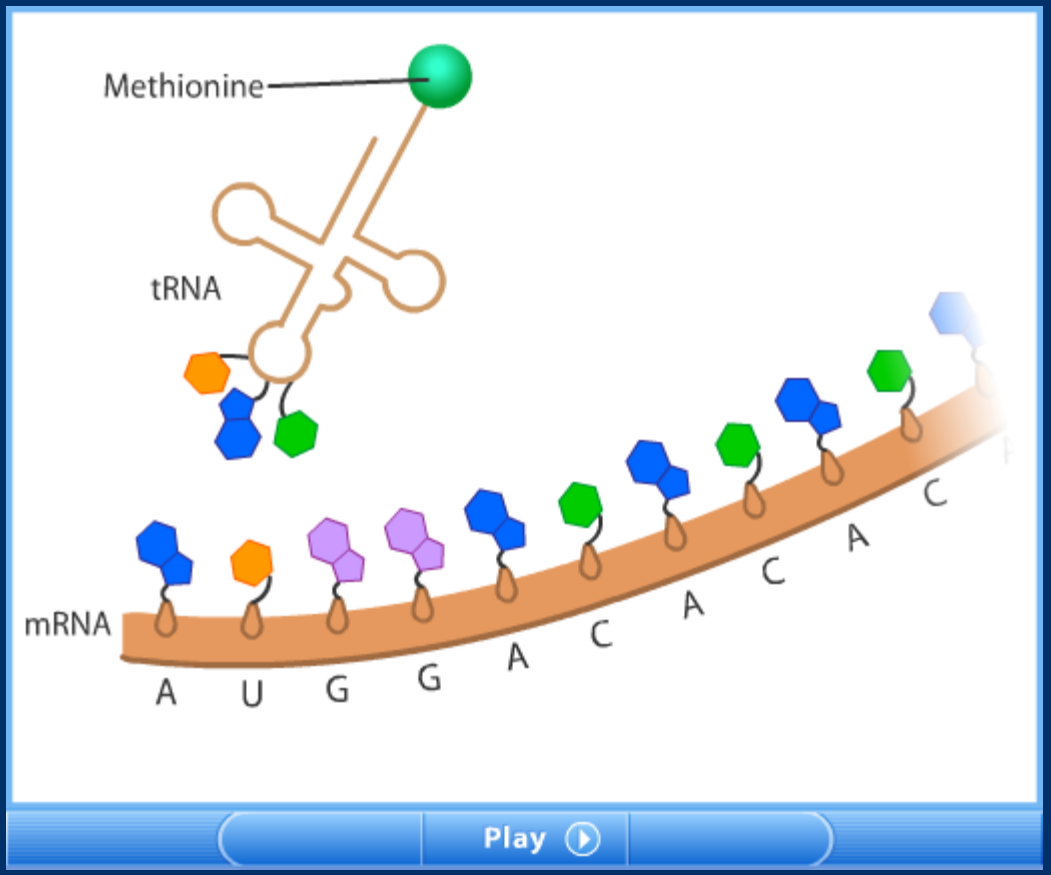
Genetic Code

Codes in mRNA

First base	Second base: U	Second base: C	Second base: A	Second base: G	Third base
U	UUU, UUC — Phenylalanine UUA, UUG — Leucine	UCU, UCC, UCA, UCG — Serine	UAU, UAC — Tyrosine UAA, UAG — Stop	UGU, UGC — Cysteine UGA — Stop UGG — Tryptophan	U C A G
C	CUU, CUC, CUA, CUG — Leucine	CCU, CCC, CCA, CCG — Proline	CAU, CAC — Histidine CAA, CAG — Glutamine	CGU, CGC, CGA, CGG — Arginine	U C A G
A	AUU, AUC, AUA — Isoleucine AUG — Start	ACU, ACC, ACA, ACG — Threonine	AAU, AAC — Asparagine AAA, AAG — Lysine	AGU, AGC — Serine AGA, AGG — Arginine	U C A G
G	GUU, GUC, GUA, GUG — Valine	GCU, GCC, GCA, GCG — Alanine	GAU, GAC — Aspartic Acid GAA, GAG — Glutamic Acid	GGU, GGC, GGA, GGG — Glycine	U C A G

Codons in mRNA



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RNA's Roles in Translation

- Translation takes place in the cytoplasm. Here transfer RNA molecules and ribosomes help in the synthesis of proteins.
- **Transfer RNA (tRNA)** molecules are single strands of RNA that temporarily carry a specific amino acid on one end.
- An **anticodon** is a three-nucleotide sequence on a tRNA that is complementary to an mRNA codon.

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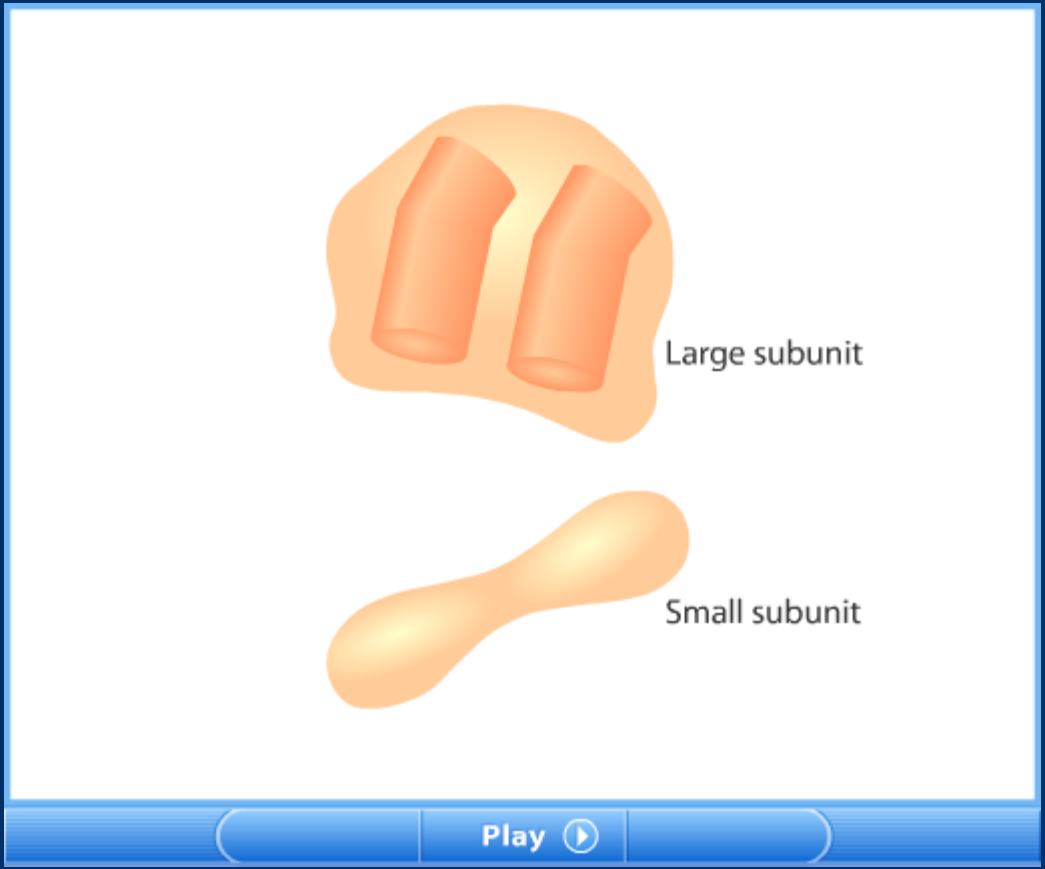
Ribosomes



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RNA's Roles in Translation, *continued*

- Ribosomes are composed of both proteins and ribosomal RNA (rRNA).
- **Ribosomal RNA (rRNA)** molecules are RNA molecules that are part of the structure of ribosomes.
- Each ribosome temporarily holds one mRNA and two tRNA molecules.

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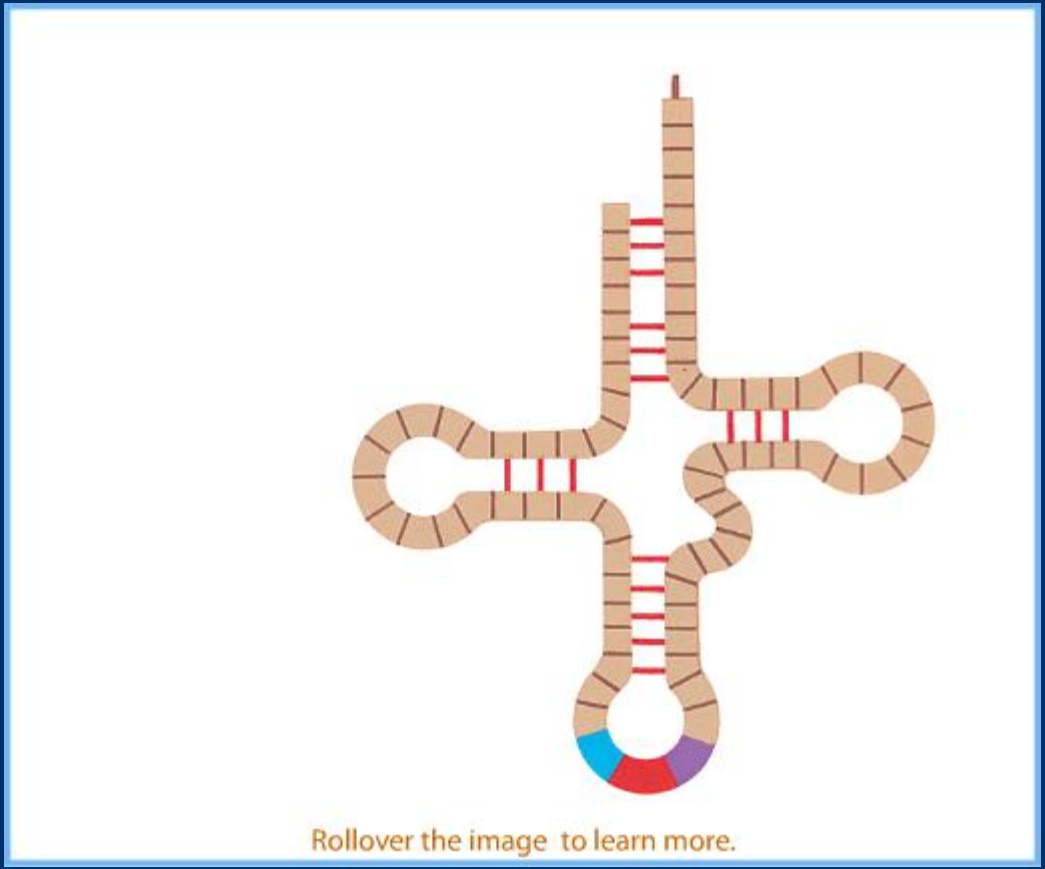
tRNA and Anticodon



RNA's Roles in Translation, *continued*

- The seven steps of translation are:

  Step 1 The ribosomal subunits, the mRNA, and the tRNA carrying methionine bind together.

  Step 2 The tRNA carrying the amino acid specified by the codon in the A site arrives.

  Step 3 A peptide bond forms between adjacent amino acids.

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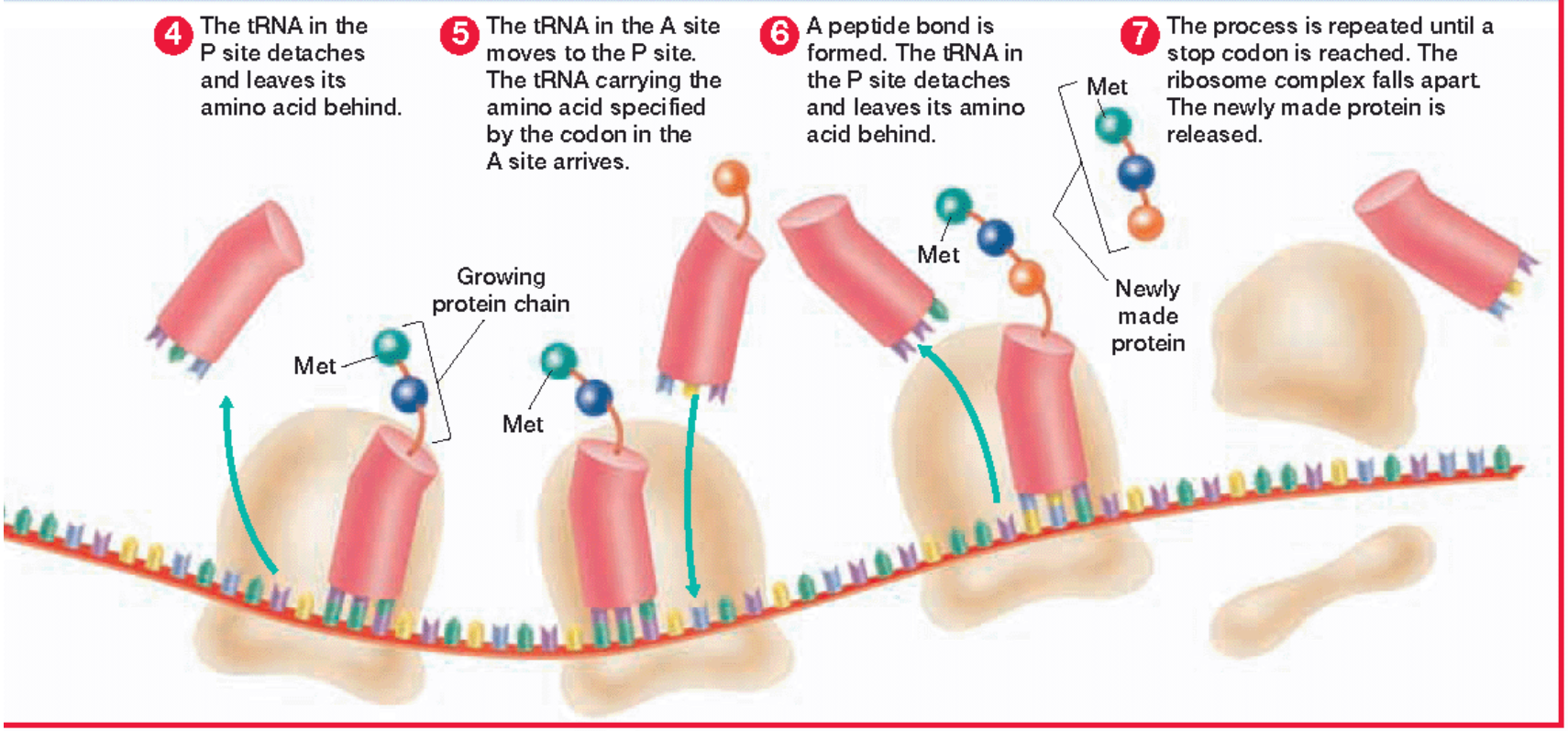
Translation: Forming the First Peptide Bond



RNA's Roles in Translation, *continued*

Step 4 The tRNA in the P site detaches and leaves its amino acid behind.

Step 5 The tRNA in the A site moves to the P site. The tRNA carrying the amino acid specified by the codon in the A site arrives.

Step 6 A peptide bond is formed. The tRNA in the P site detaches and leaves its amino acid behind.

Step 7 The process is repeated until a stop codon is reached. The ribosome complex falls apart. The newly made protein is released.

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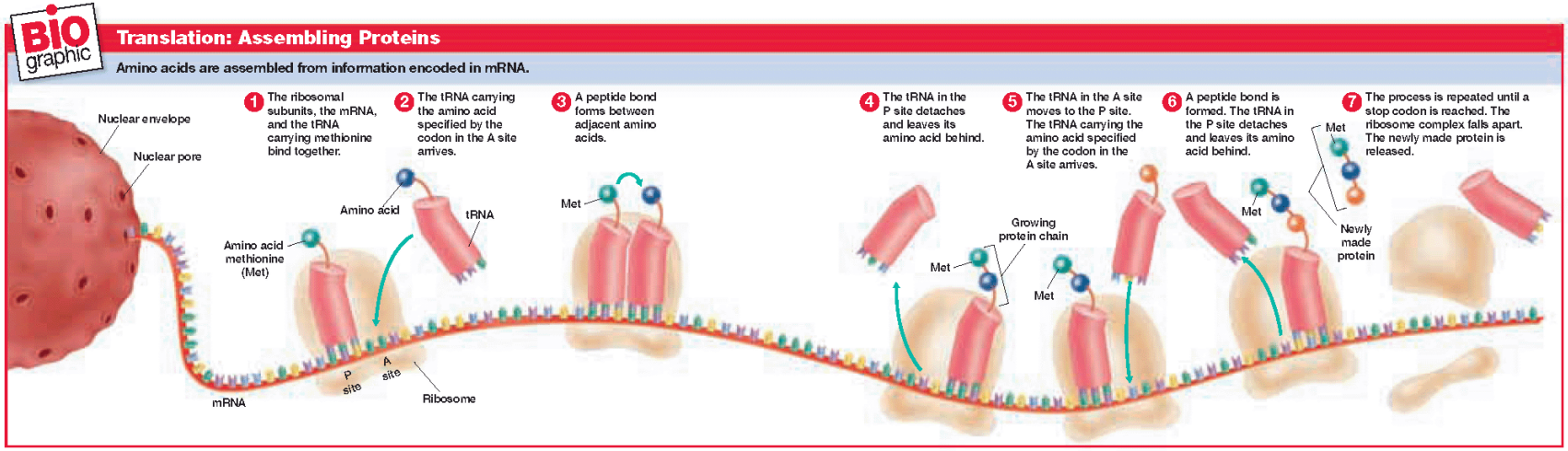
Translation: Assembling Proteins



Translation

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are needed to see this picture.

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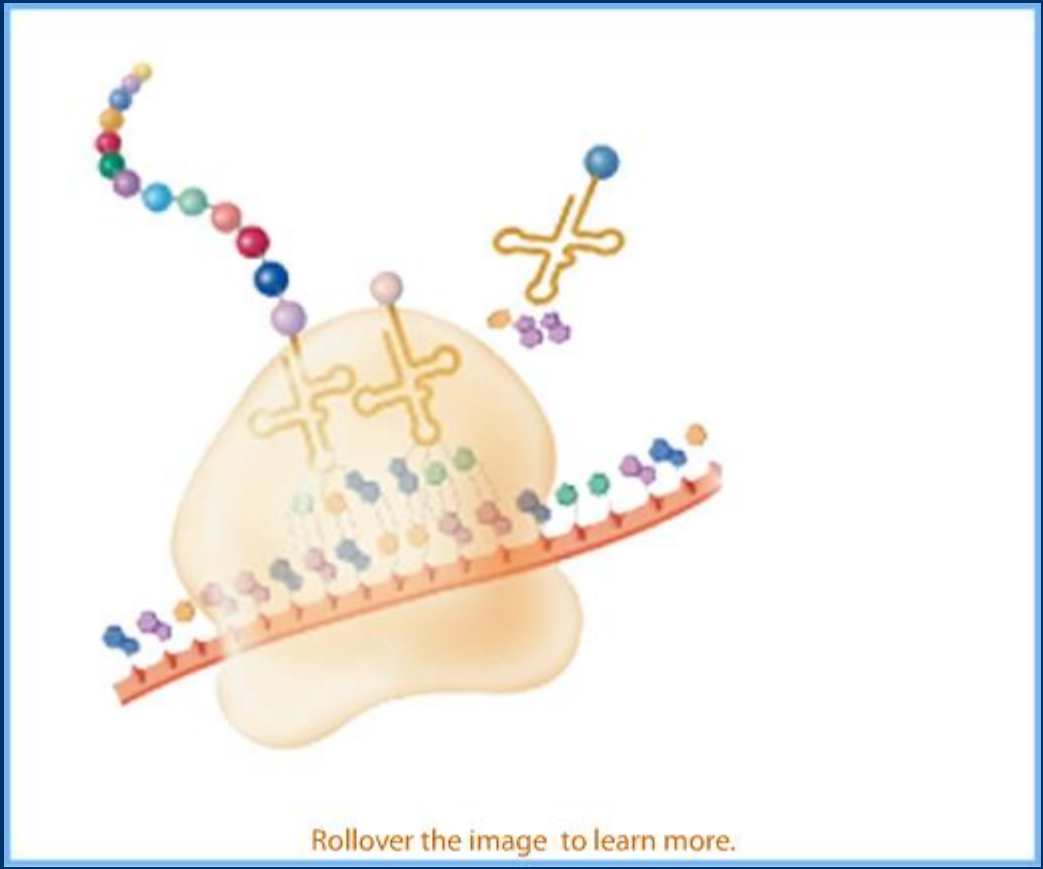
Snapshot of Translation



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Objectives

- **Describe** how the *lac* operon is turned on or off.
- **Summarize** the role of transcription factors in regulating eukaryotic gene expression.
- **Describe** how eukaryotic genes are organized.
- **Evaluate** three ways that point mutations can alter genetic material.

Protein Synthesis in Prokaryotes

- Both prokaryotic and eukaryotic cells are able to regulate which genes are expressed and which are not, depending on the cell's needs.
- The piece of DNA that overlaps the promoter site and serves as the on-off switch is called an **operator.**
- In bacteria, a group of genes that code for enzymes involved in the same function, their promoter site, and the operator that controls them all function together as an **operon.**

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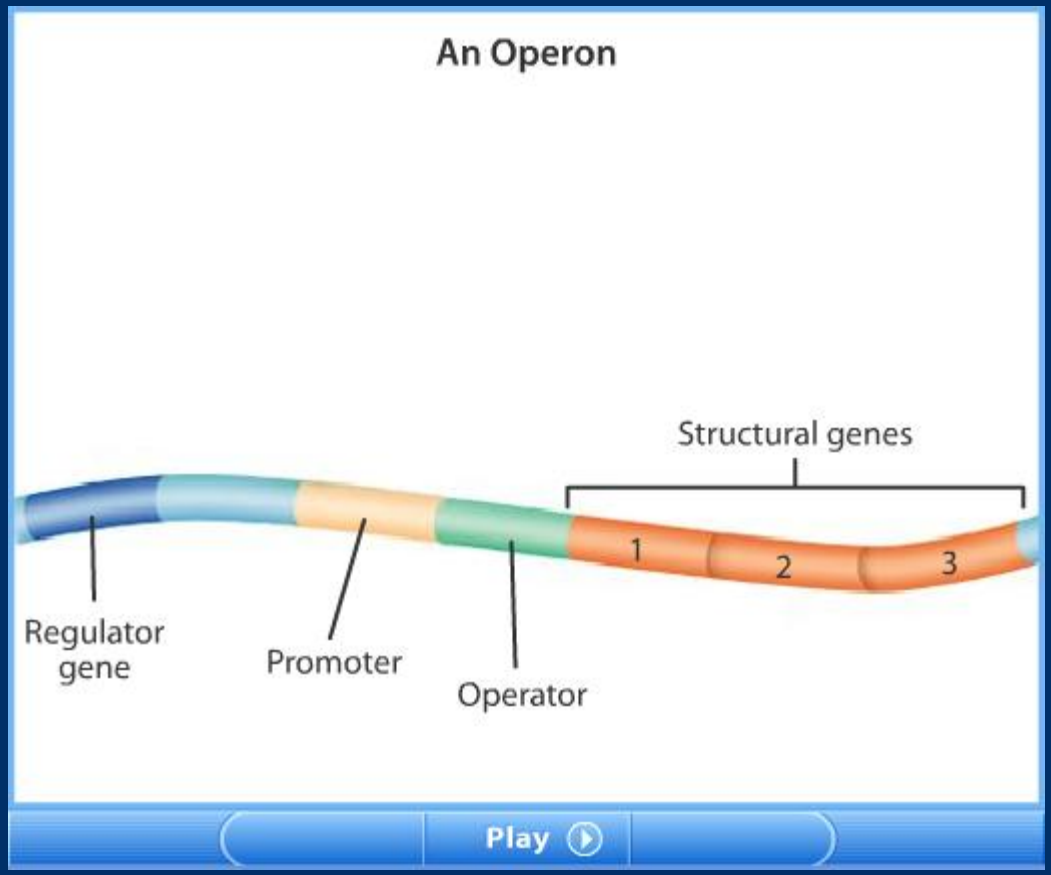
Operon



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Protein Synthesis in Prokaryotes, *continued*

- The operon that controls the metabolism of lactose is called the ***lac* operon.**
- When there is no lactose in the bacterial cell, a repressor turns the operon off.
- A **repressor** is a protein that binds to an operator and physically blocks RNA polymerase from binding to a promoter site.

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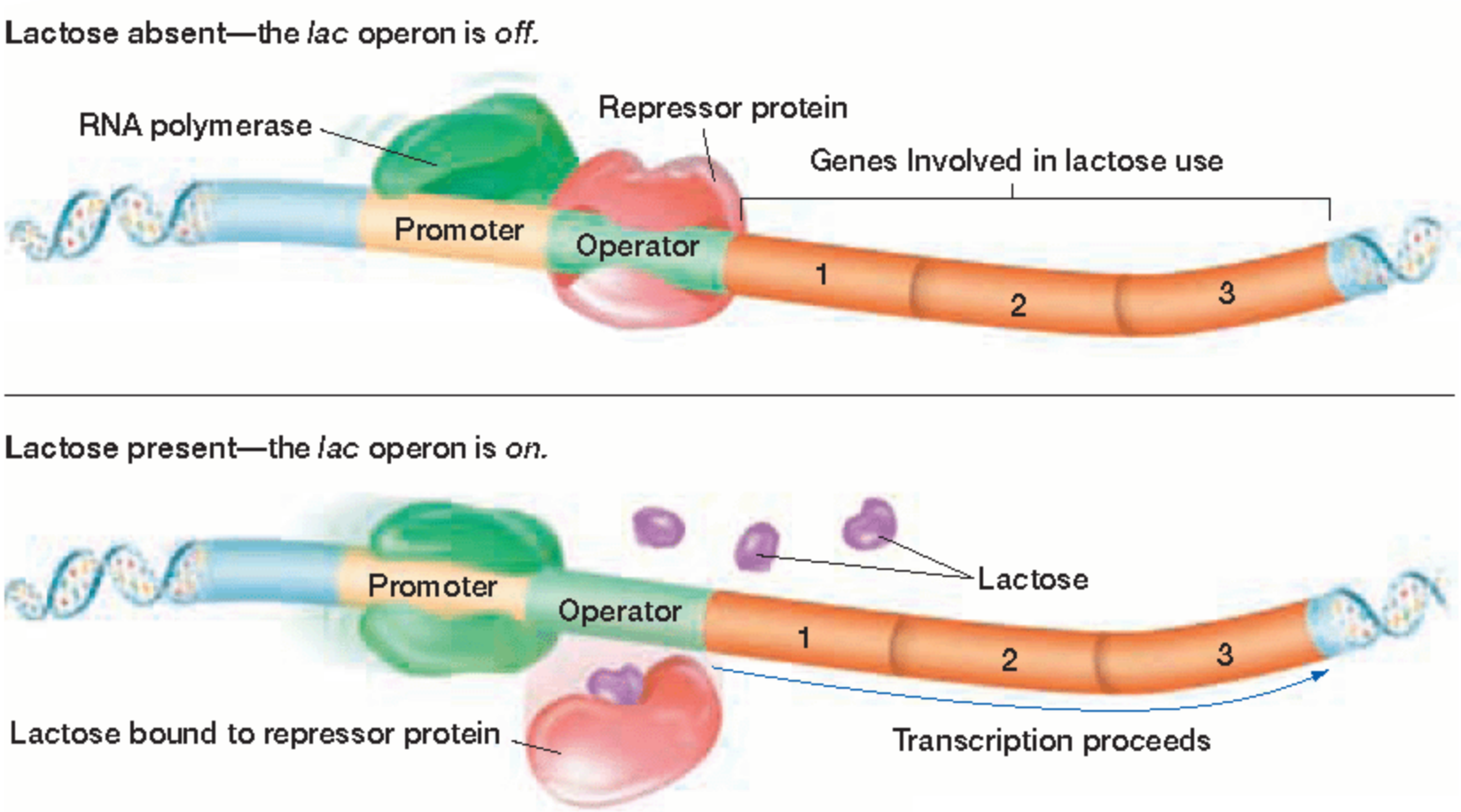
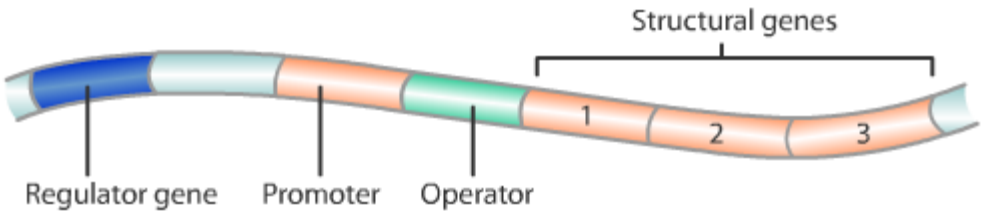
Mechanism of *lac* Operon



Repression of Transcription in the *lac* Operon



lac operon

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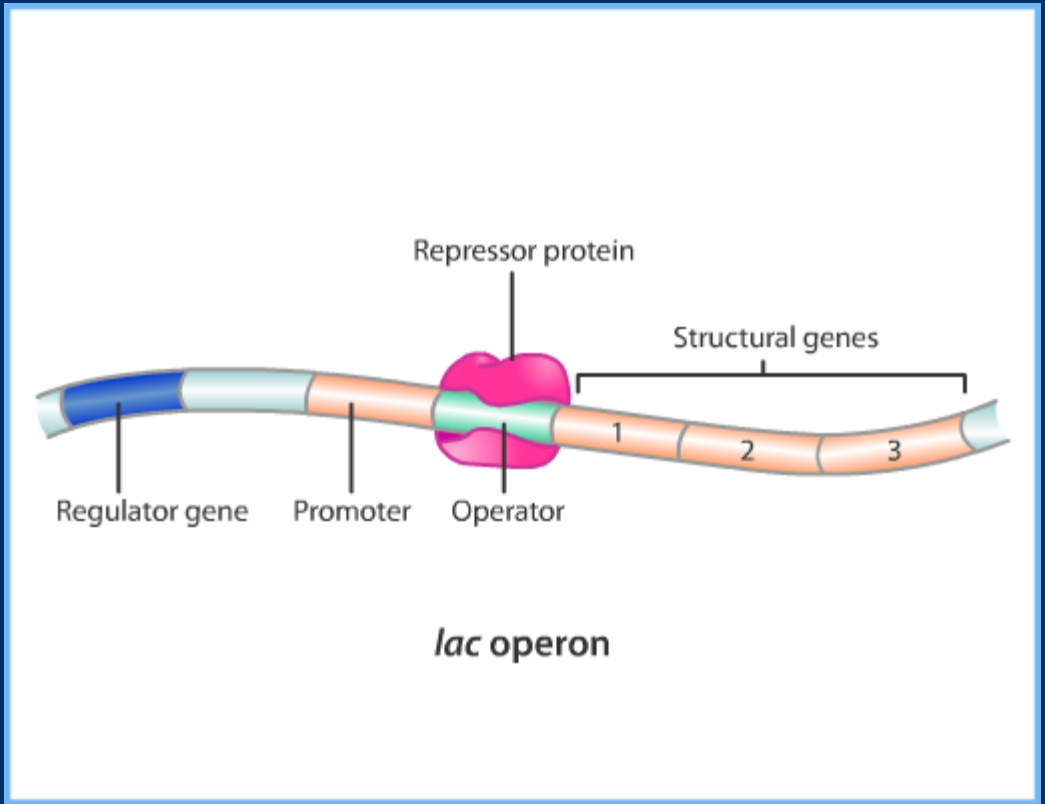
Activation of Transcription in the *lac* Operon



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Protein Synthesis in Eukaryotes

Controlling the Onset of Transcription

- Most gene regulation in eukaryotes controls the onset of transcription—when RNA polymerase binds to a gene.
- Transcription factors help arrange RNA polymerases in the correct position on the promoter.
- An enhancer is a sequence of DNA that can be bound by a transcription factor.

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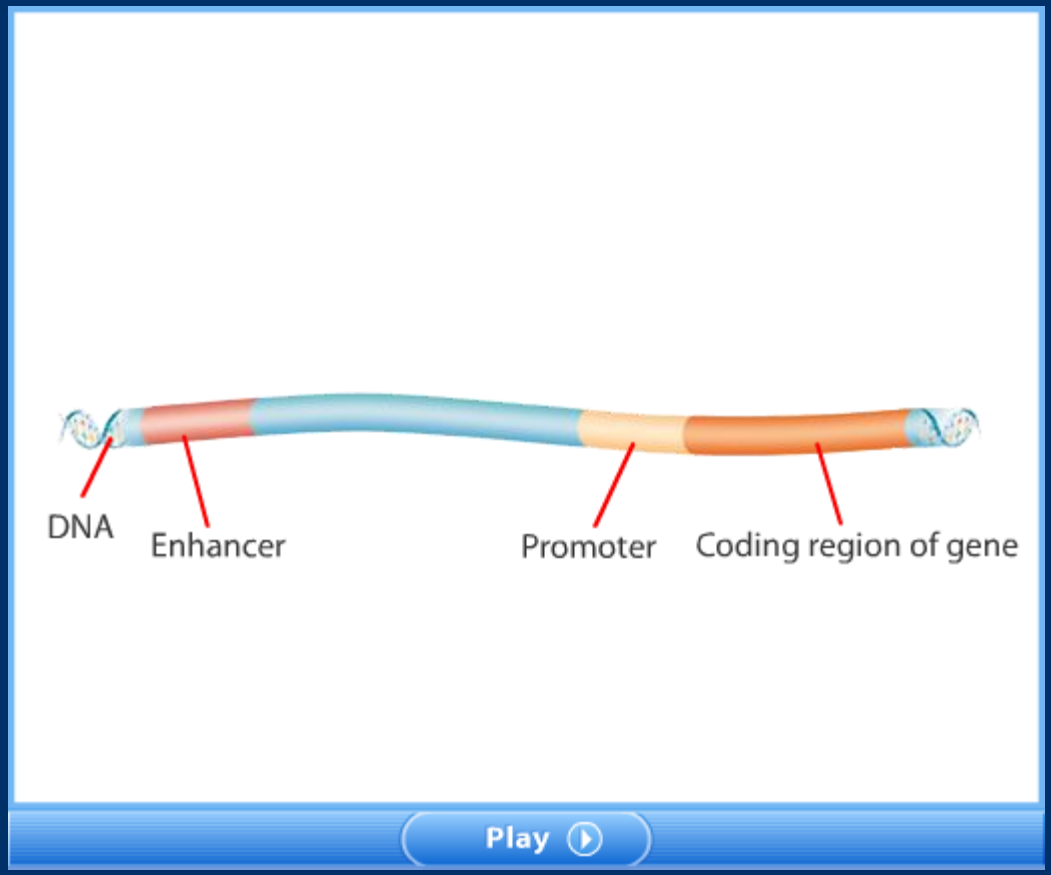
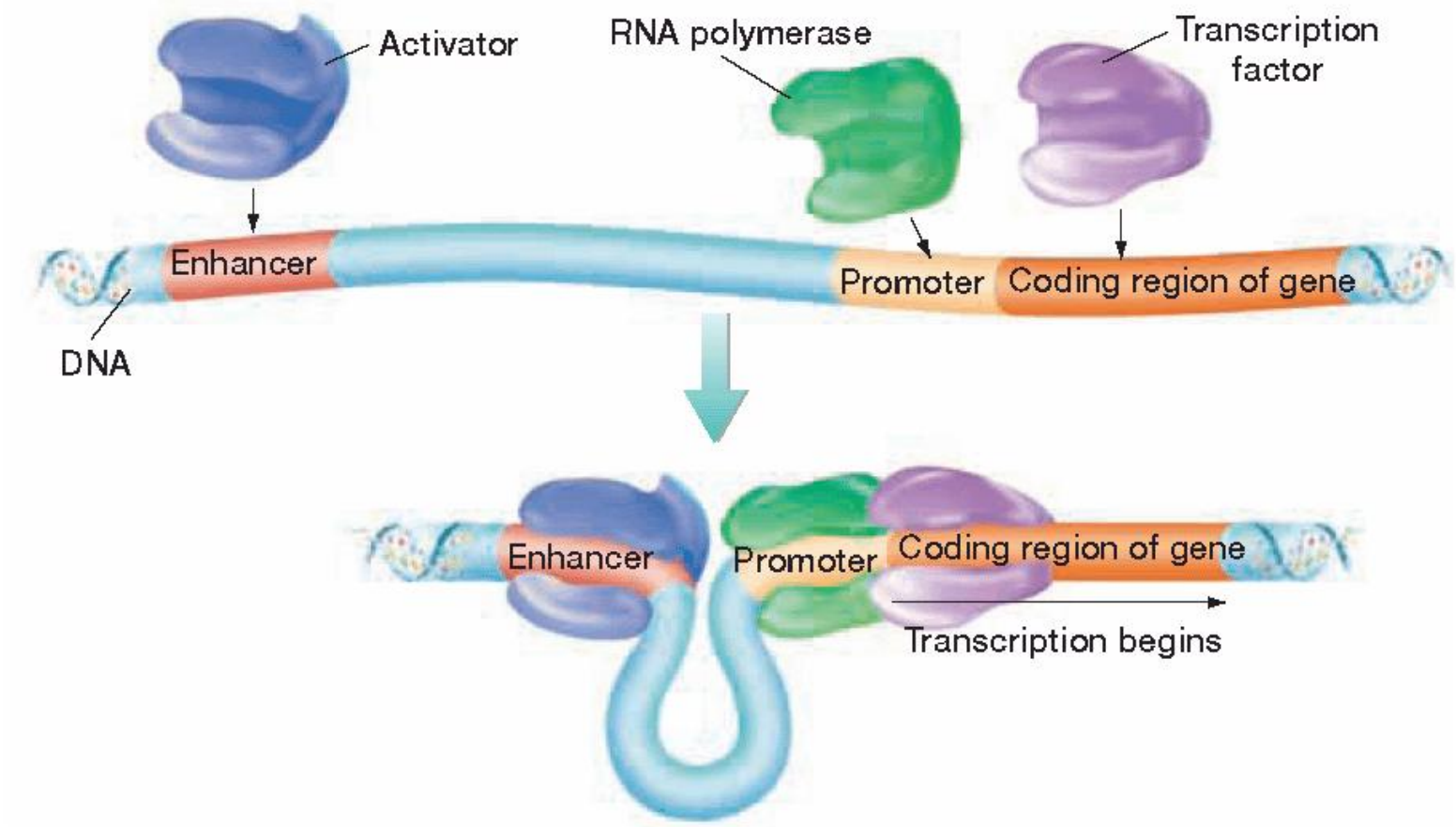
Enhancers for Control of Gene Expression



Controlling Transcription in Eukaryotes



Intervening DNA in Eukaryotic Genes

- In eukaryotes, many genes are interrupted by **introns**—long segments of nucleotides that have no coding information.
- **Exons** are the portions of a gene that are translated (expressed) into proteins.
- After a eukaryotic gene is transcribed, the introns in the resulting mRNA are cut out by complex assemblies of RNA and protein called spliceosomes.

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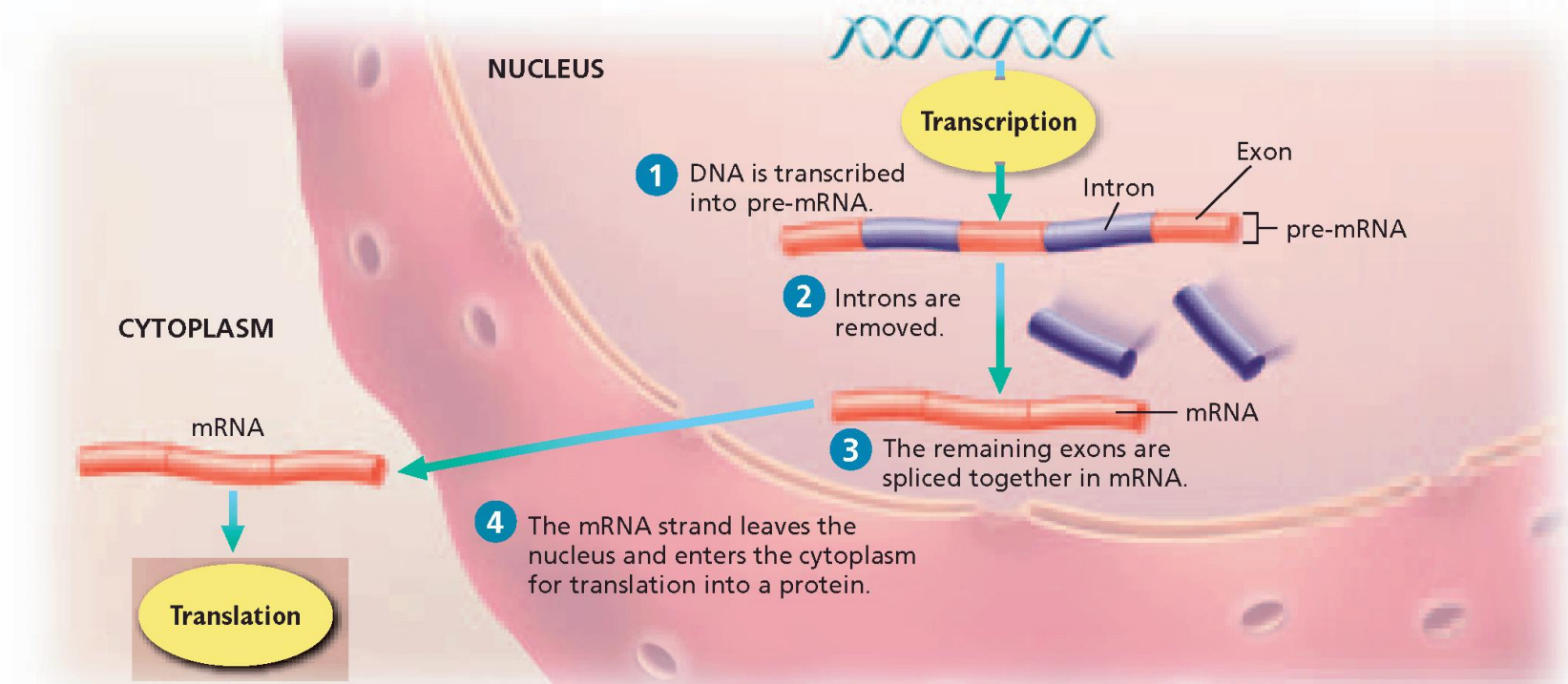
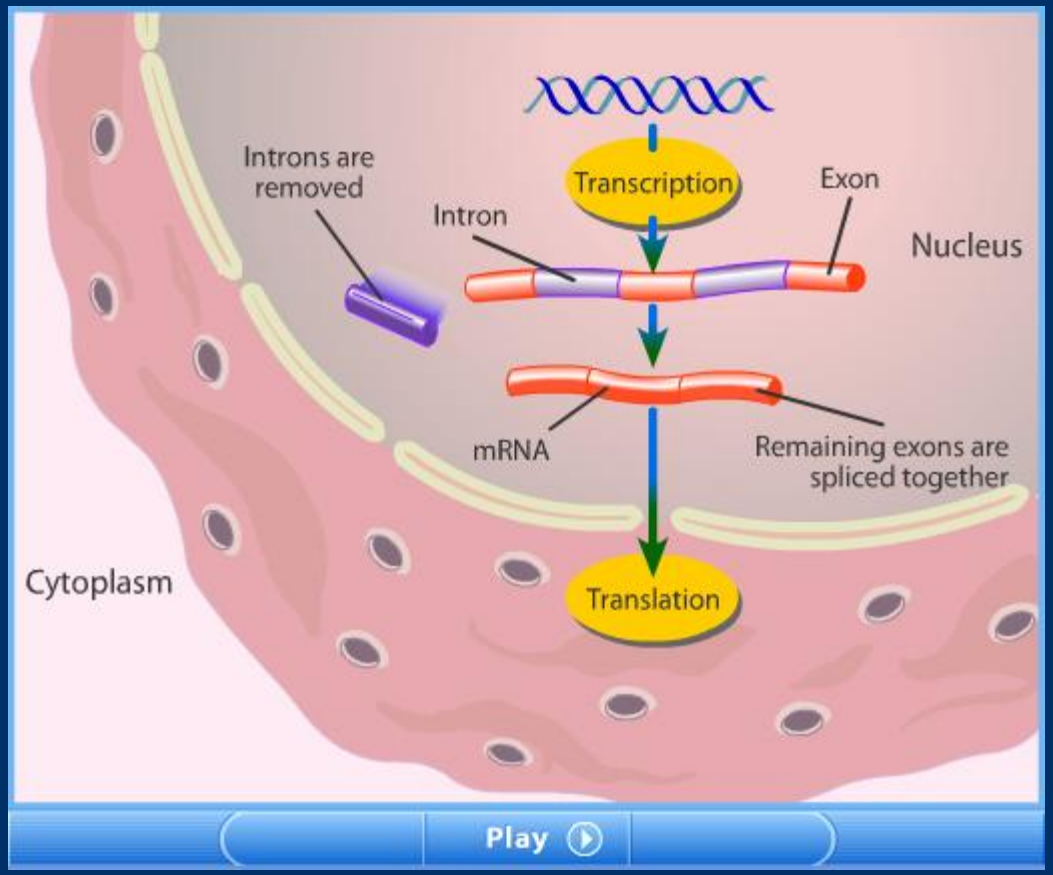
Removal of Introns After Transcription



Comparing Introns and Exons



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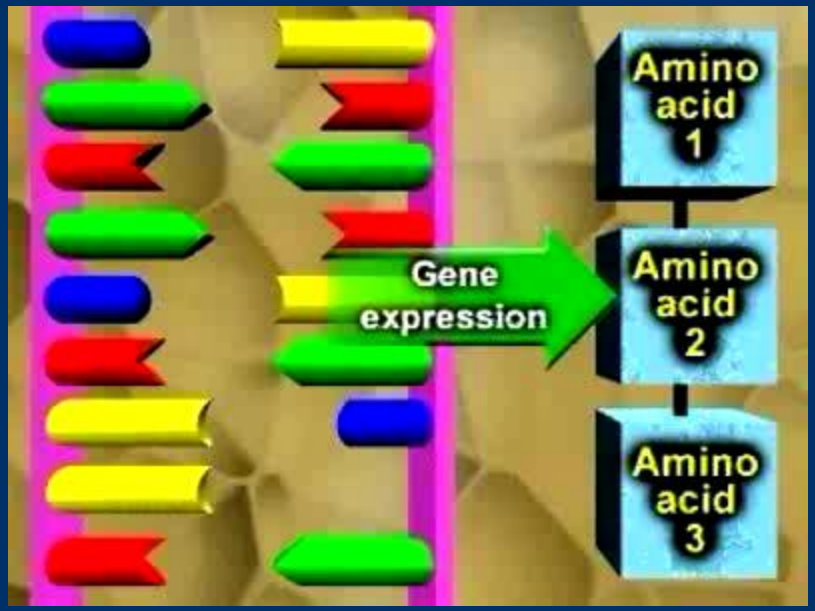
Mutations



Mutations

- Mutations that move an entire gene to a new location are called gene rearrangements.
- Changes in a gene's position often disrupt the gene's function because the gene is exposed to new regulatory controls in its new location.
- Genes sometimes move as part of a transposon. Other times, the portion of the chromosome containing a gene may be rearranged during meiosis.

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Mutations, *continued*

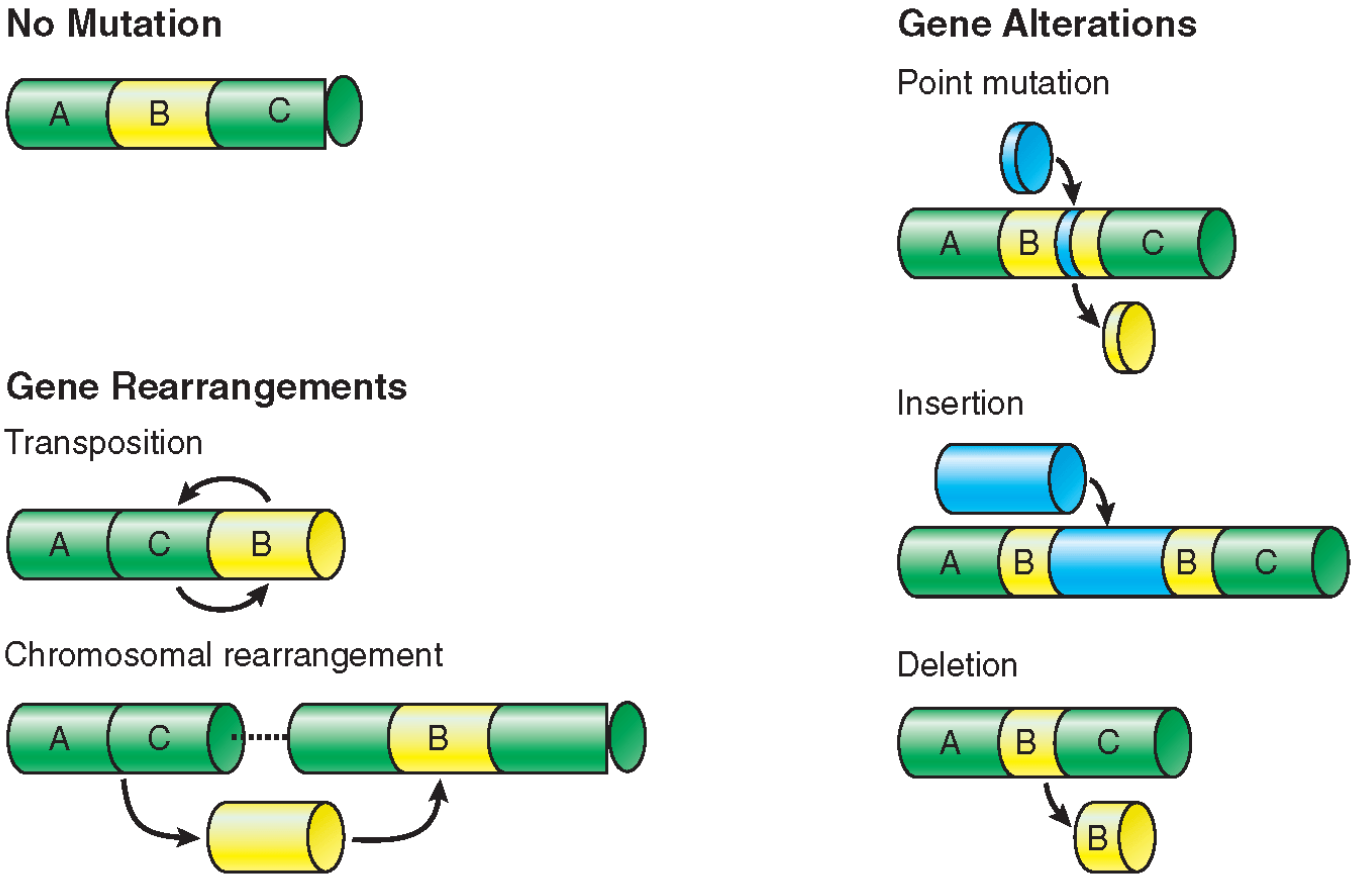
- Mutations that change a gene are called gene alterations.
- In a **point mutation,** a single nucleotide changes.
- In an insertion mutation, a sizable length of DNA is inserted into a gene.
- In a deletion mutation, segments of a gene are lost, often during meiosis.

End Of Slide

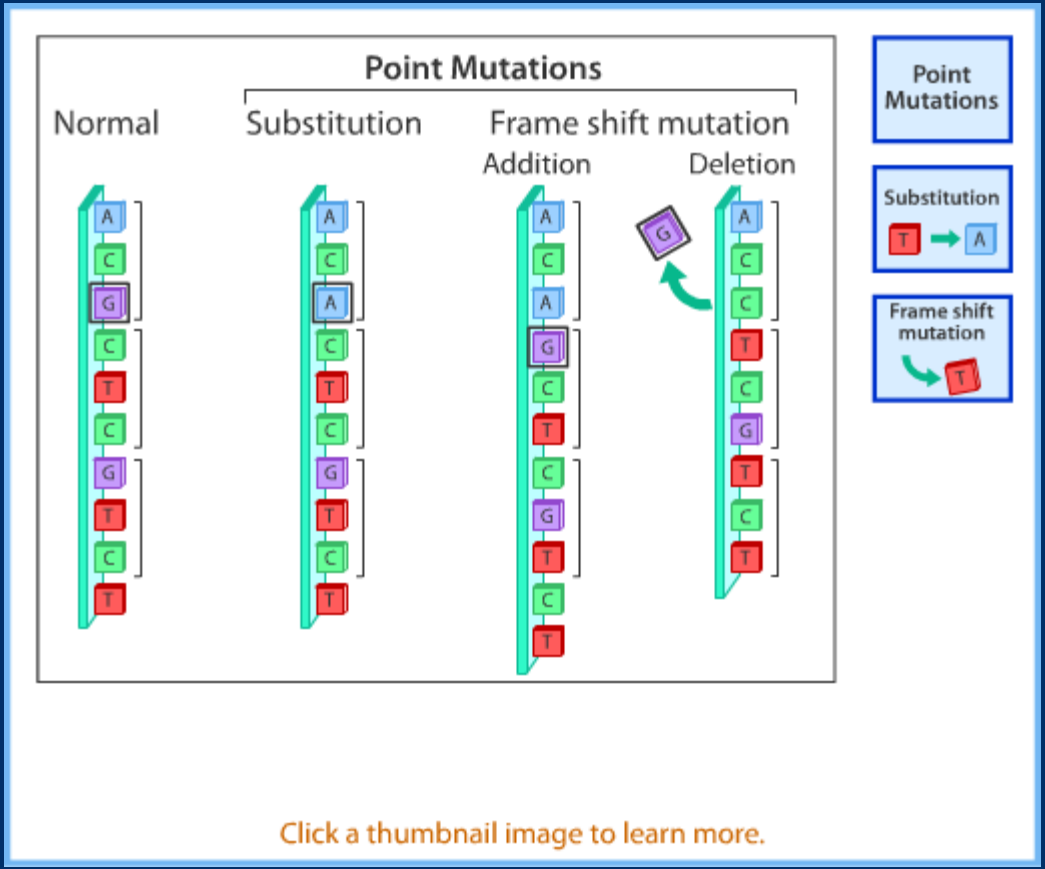
Mutations, *continued*

- Because the genetic message is read as a series of triplet nucleotides, insertions and deletions of one or two nucleotides can upset the triplet groupings.
- A mutation that causes a gene to be read in the wrong three-nucleotide sequence is called a frameshift mutation.

Major Types of Mutations



Types of Gene Mutations



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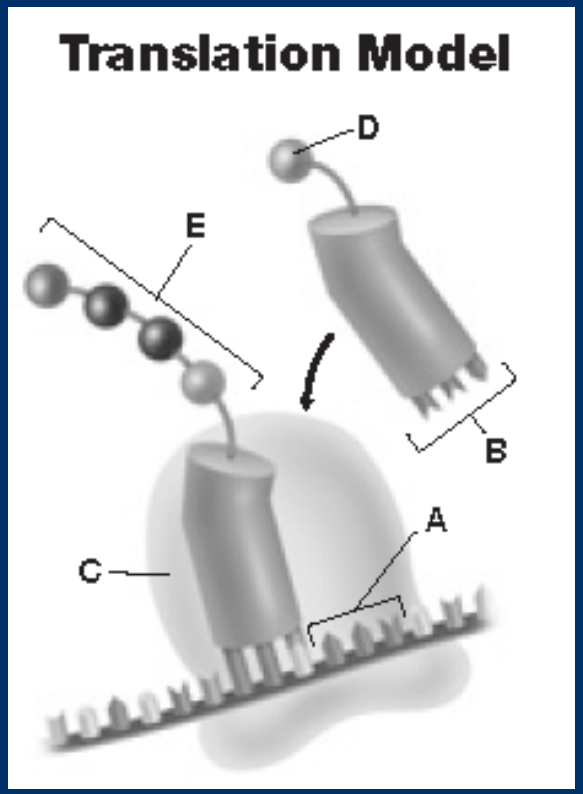
Multiple Choice

Use the figure below to answer questions 1–3.



Multiple Choice, *continued*

1. Which cellular function does this model represent?

   A. Transcription
   B. Translation
   C. Transformation
   D. DNA Replication

Multiple Choice, *continued*

1. Which cellular function does this model represent?

A. Transcription
B. Translation
C. Transformation
D. DNA Replication

Multiple Choice, *continued*

2. Which part of the model represents a codon?

F. *A*
G. *B*
H. *C*
J. *D*

Multiple Choice, *continued*

2. Which part of the model represents a codon?

F. *A*
G. *B*
H. *C*
J. *D*

Multiple Choice, *continued*

3. What does the part labeled *E* represent?

A. Ribosome
B. Growing protein chain
C. Messenger RNA
D. Transfer RNA

Multiple Choice, *continued*

3. What does the part labeled *E* represent?

A. Ribosome
B. Growing protein chain
C. Messenger RNA
D. Transfer RNA