**Objective:** You will be able to construct explanations that use the structures of DNA to support the claim that DNA is the genetic material

- **Do Now:**
  - Read through the Enduring Understanding section

**"Heritable information provides for continuity of life"**

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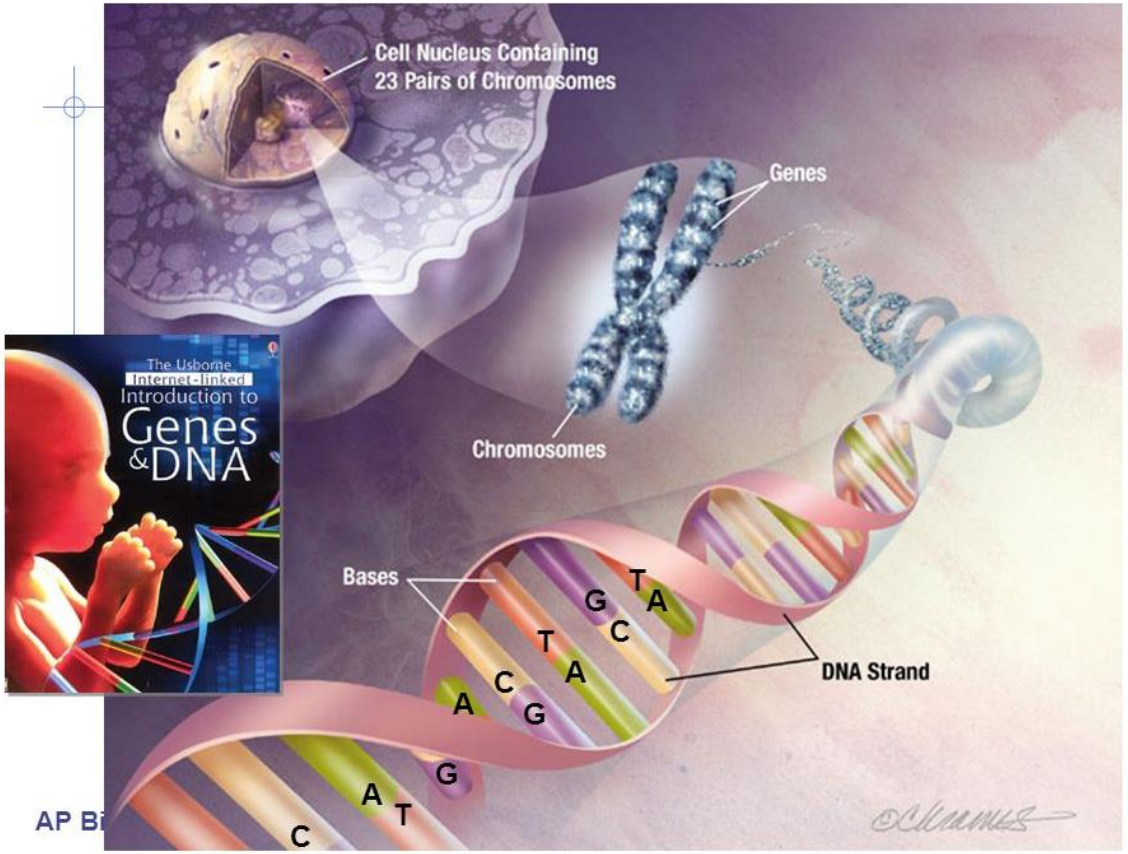
**Essential knowledge:** DNA, and in some cases RNA, is the primary source of heritable information.

- Genetic information is stored and transmitted from one generation to the next through DNA or RNA.

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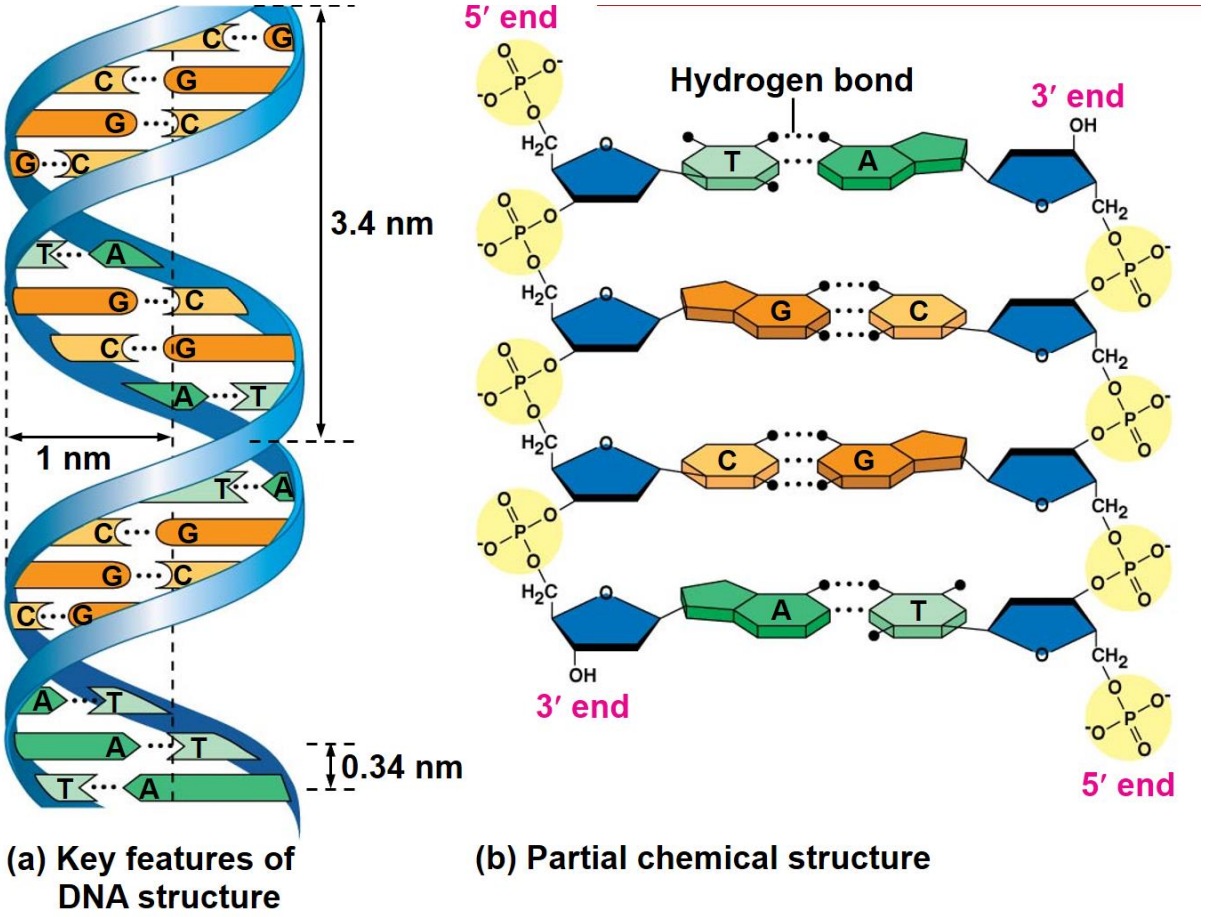
- Information is stored within the DNA molecule due to the sequence of bases.

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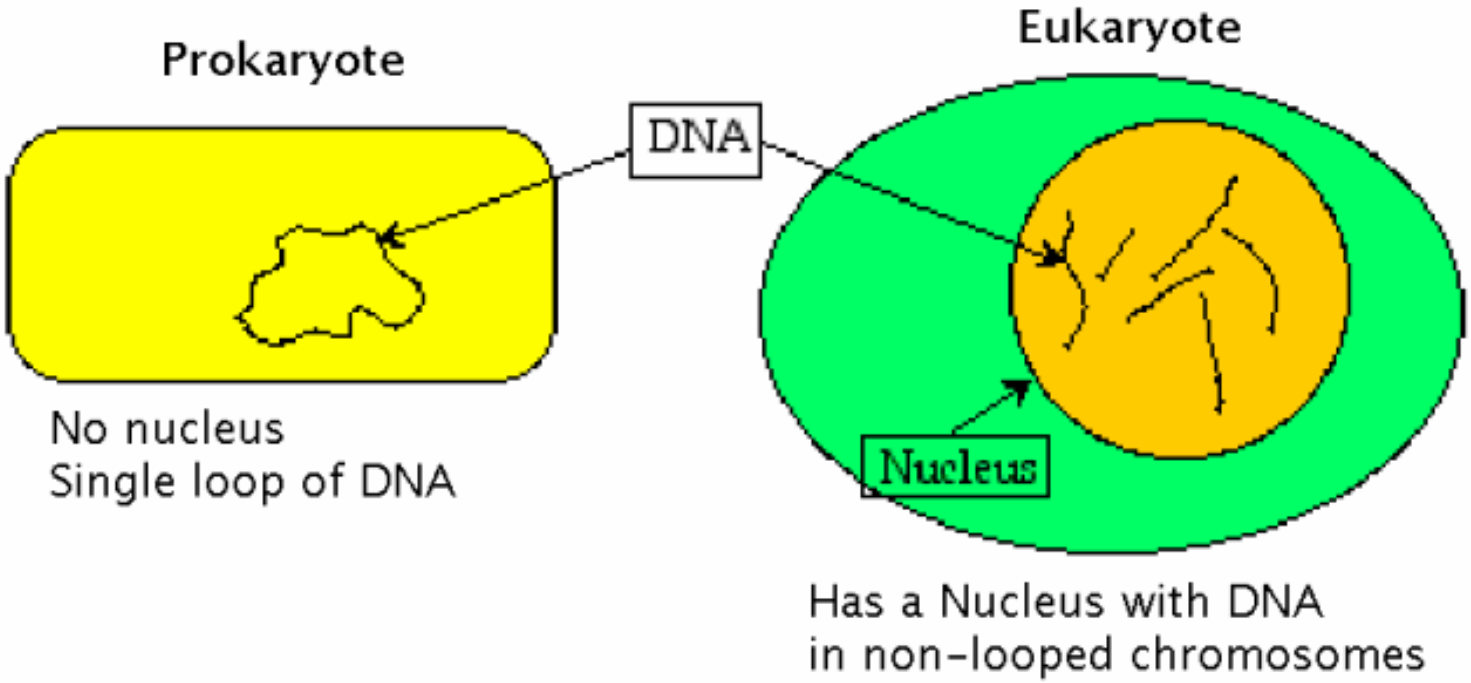
- Noneukaryotic organisms have circular chromosomes, while eukaryotic organisms have multiple linear chromosomes, although in biology there are exceptions to this rule.

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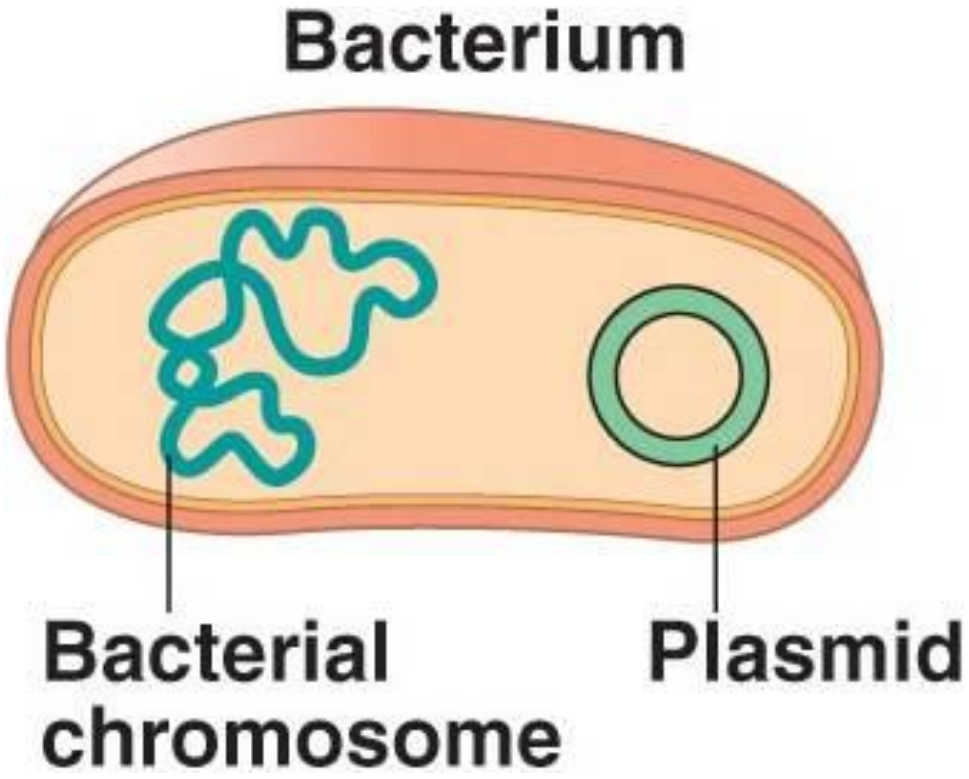
- Prokaryotes, viruses and eukaryotes can contain plasmids, which are small extra-chromosomal, double-stranded circular DNA molecules.

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# Viral Genomes

- Viral genomes may consist of either:
  - Double- or single-stranded DNA, or
  - Double- or single-stranded RNA

- Depending on its type of nucleic acid, a virus is called a DNA virus or an RNA virus (retrovirus)

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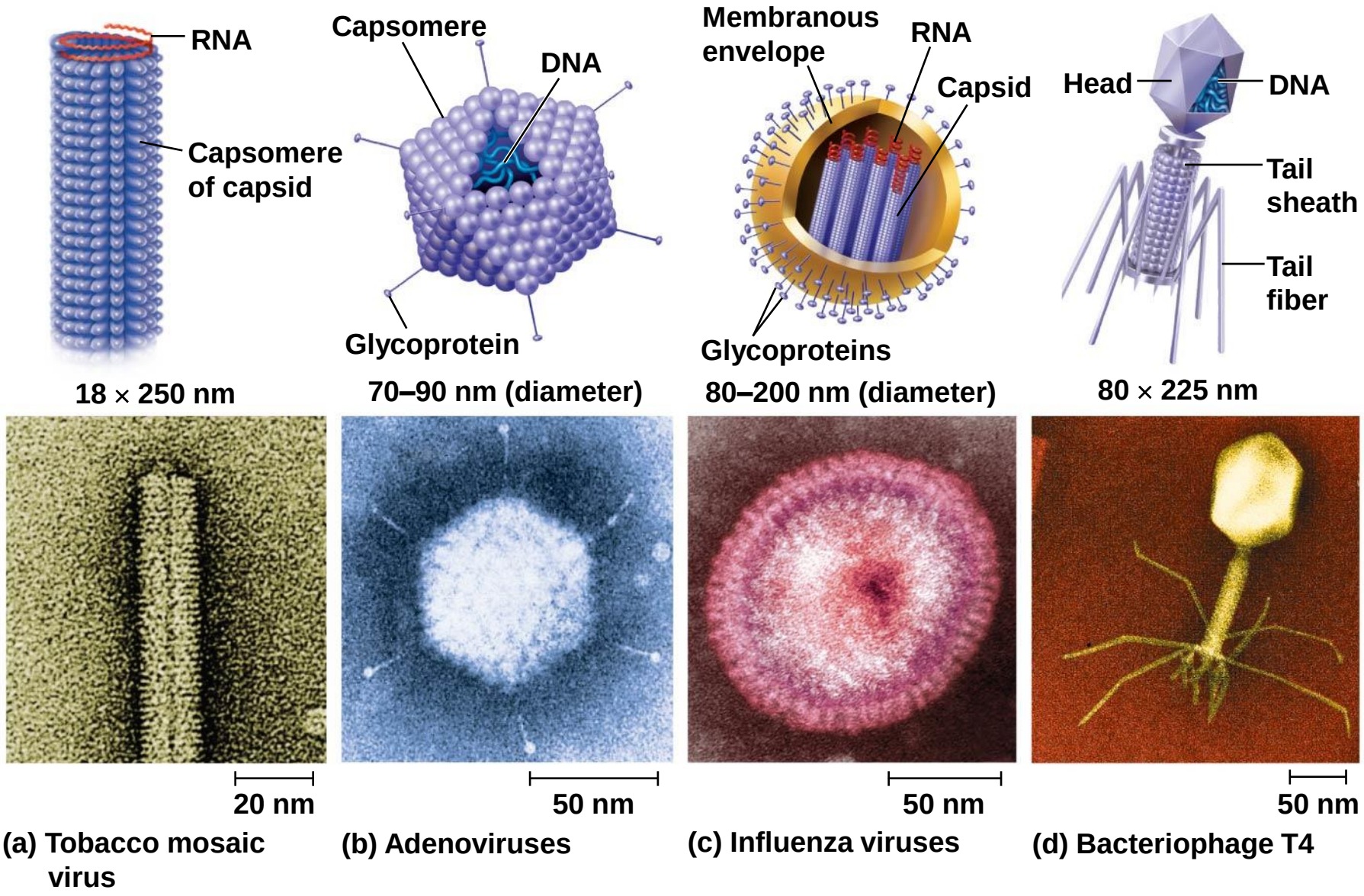
Figure 17.2

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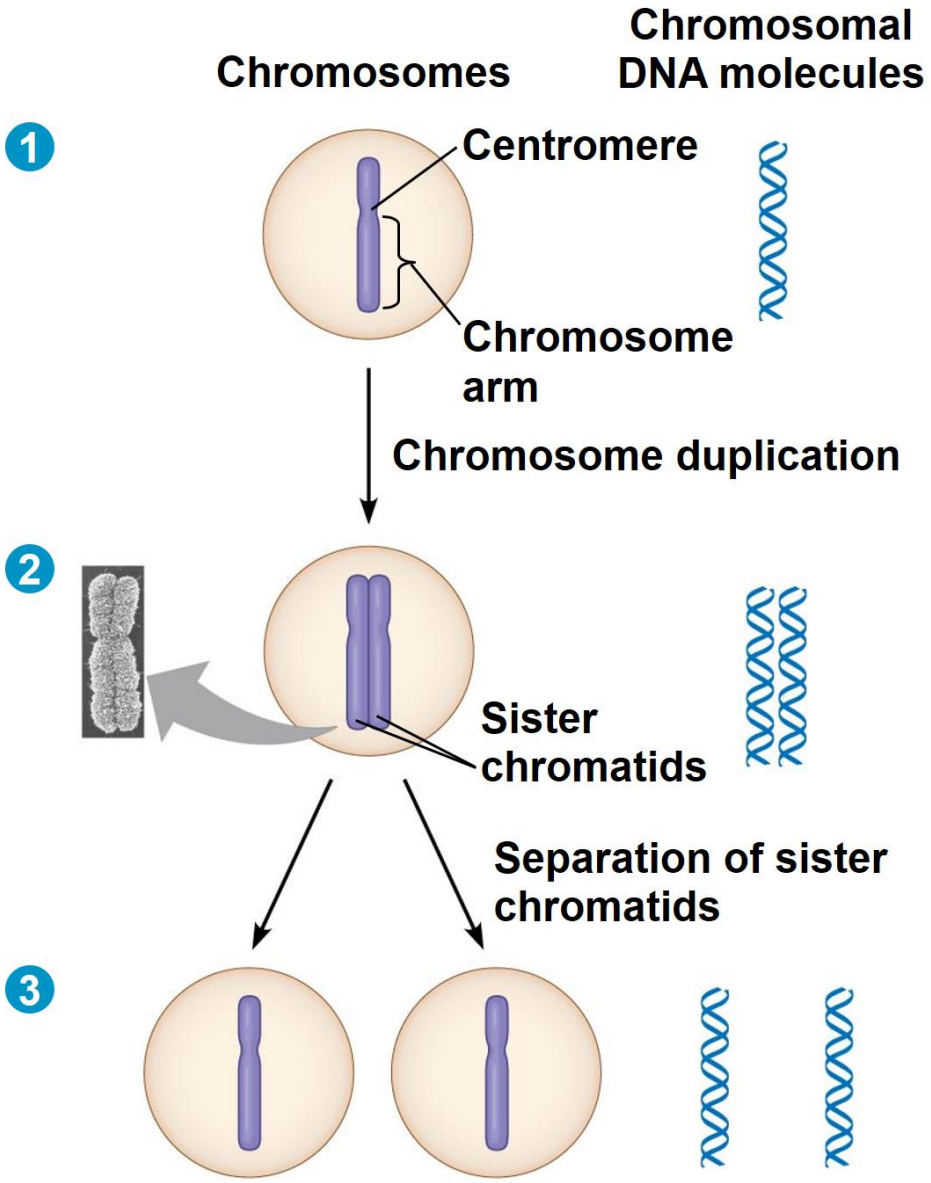
# DNA Replication ensures the continuity of hereditary information.

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**Objective:** You will be able to justify the selection of data from historical investigations that support the claim that DNA is the source of heritable information.

- **Do Now:**

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# What is the Genetic Material?

- Scientists recognized that chromosomes contained the genetic material because they were passed on to new cells in mitosis and meiosis.
- Chromosomes were made up of DNA and protein
- So…which is the genetic material?

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# Show Me the Evidence!

- The proof that DNA is the carrier of genetic information involved a number of important historical experiments. These include:
  - Griffith and the Avery-MacLeod-McCarty experiments
  - Hershey-Chase experiment

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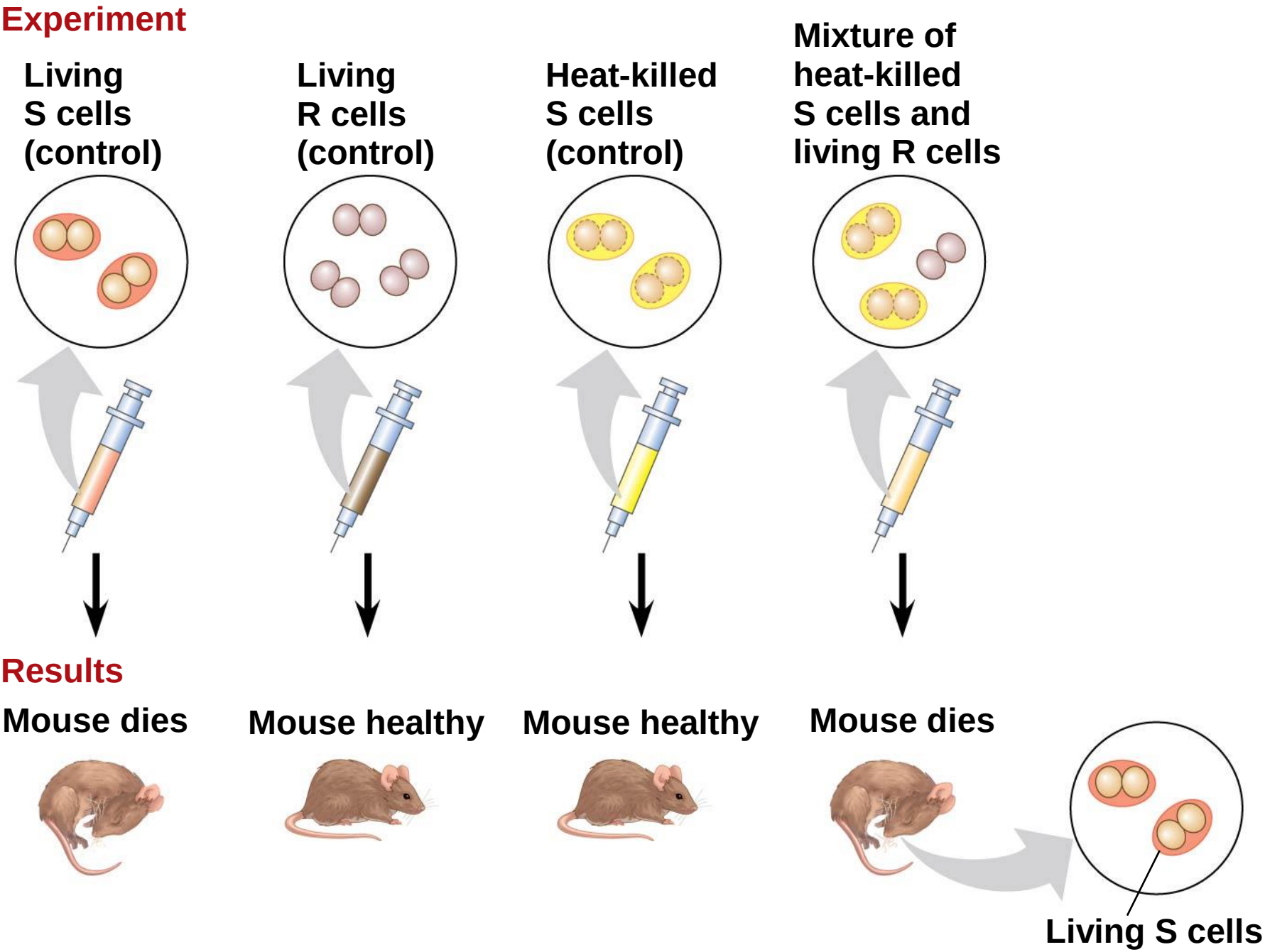
Figure 13.2

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**Transformation** is the change in genotype and phenotype due to assimilation of foreign DNA is called transformation

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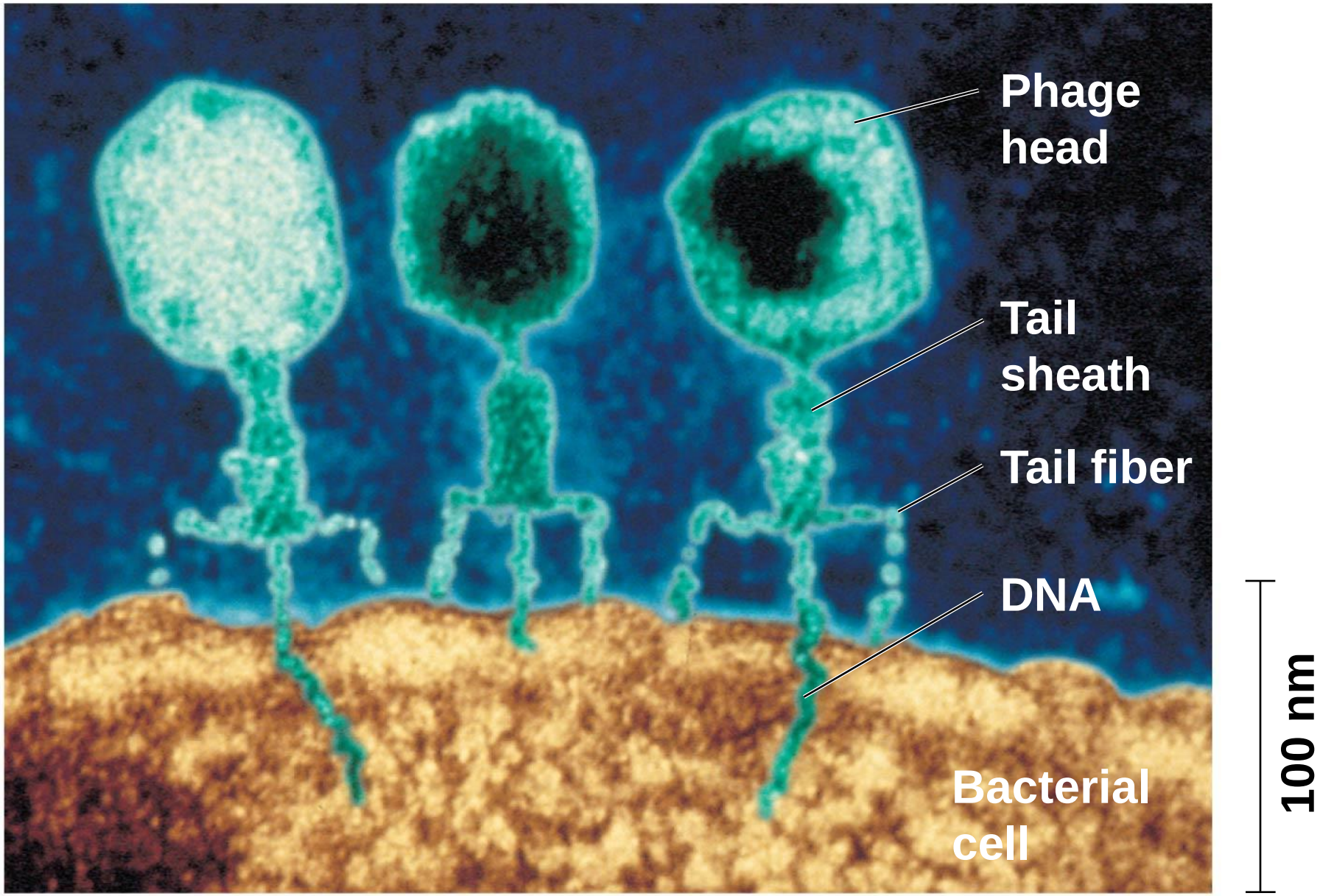
Figure 13.3

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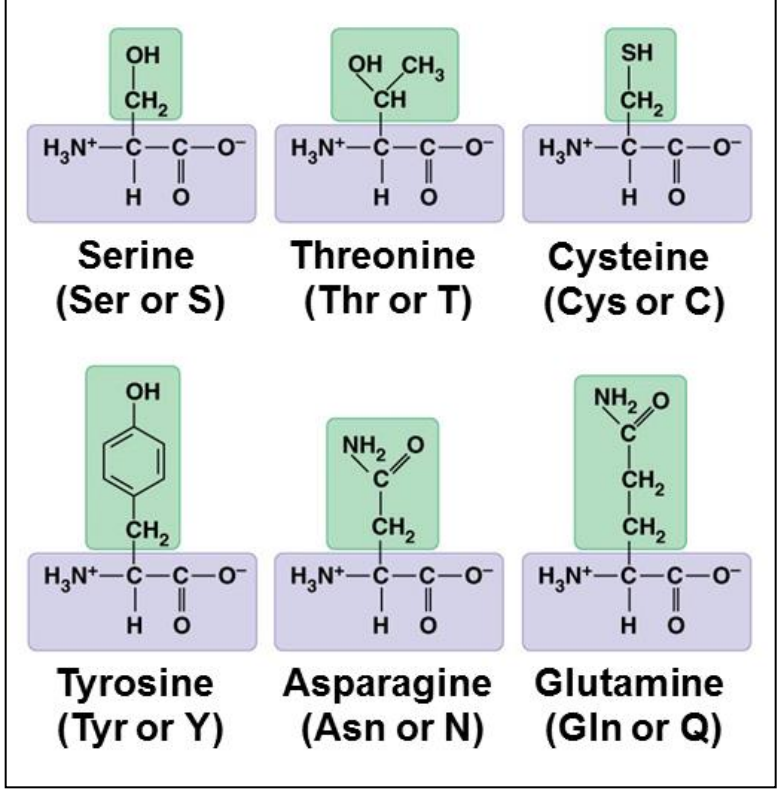
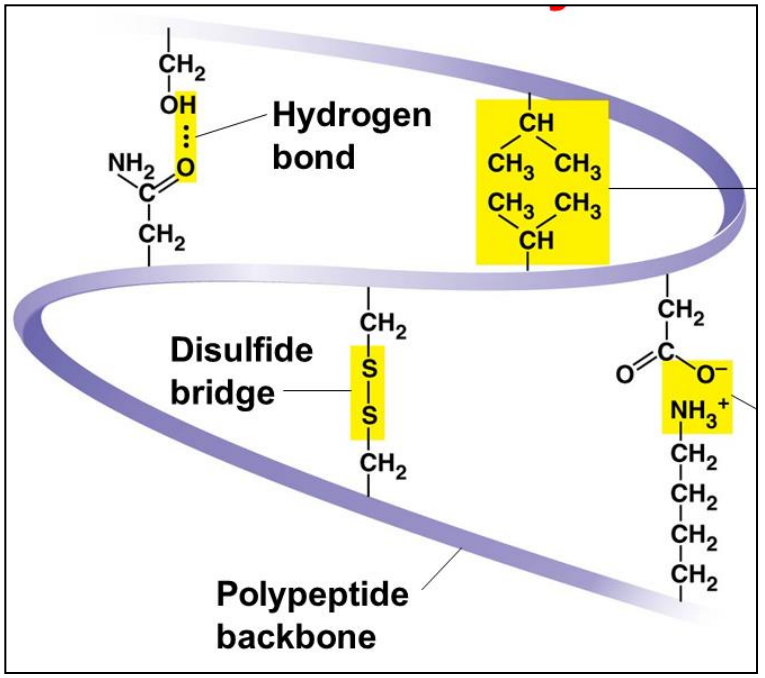



**Protein**



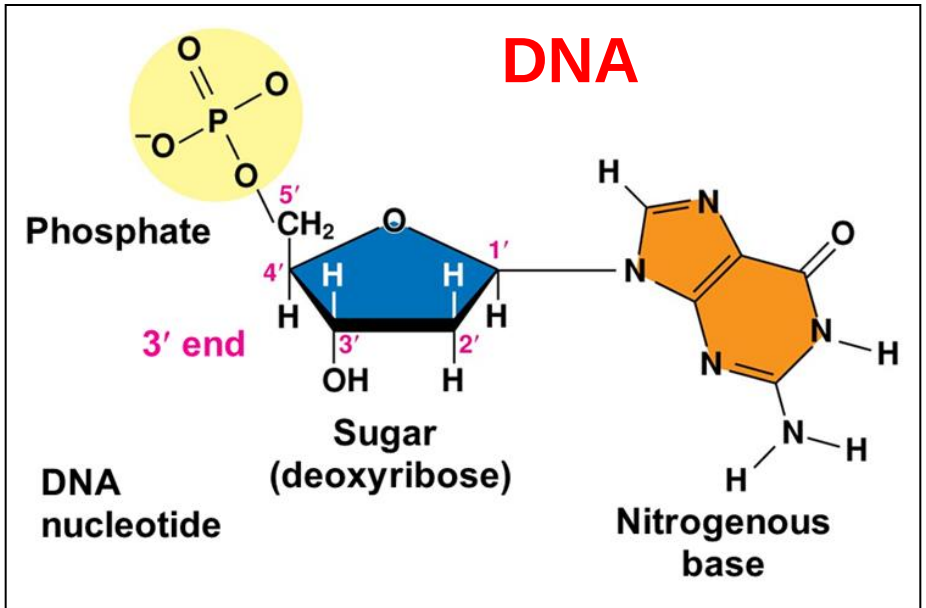




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Figure 13.4a

## Experiment

**Batch 1: Radioactive sulfur ($^{35}S$) in phage protein**

1. Labeled phages infect cells.
2. Agitation frees outside phage parts from cells.
3. Centrifuged cells form a pellet.
4. Radioactivity (phage protein) found in liquid

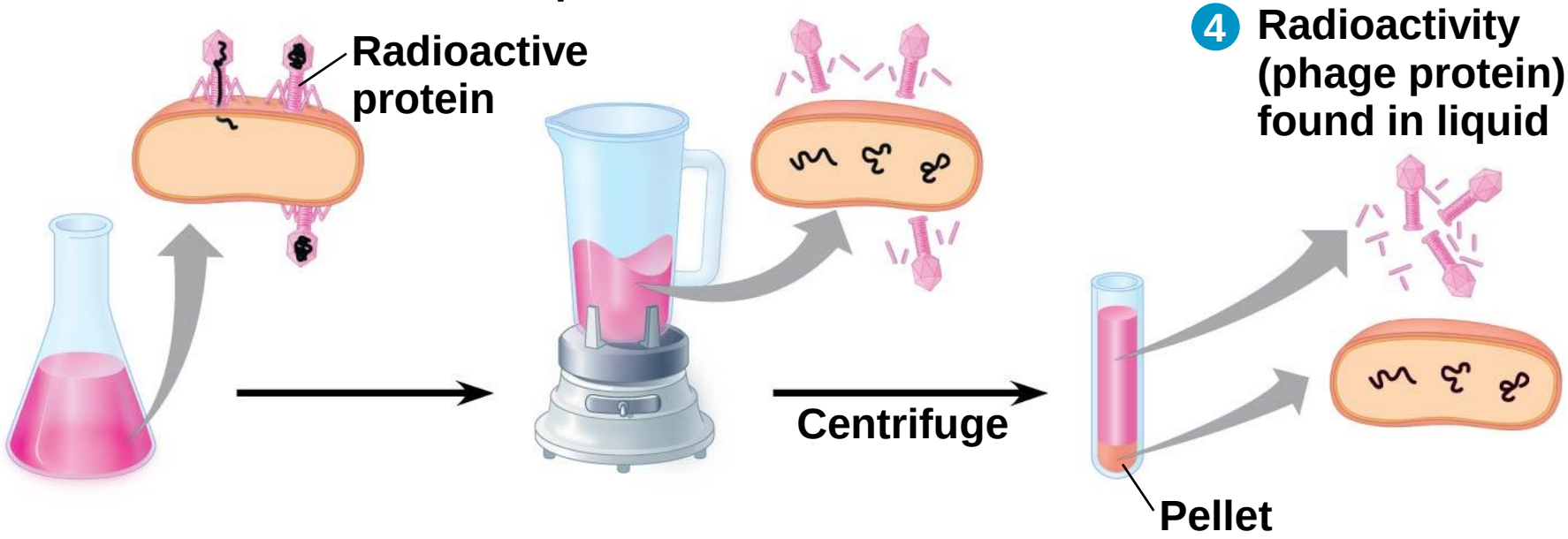


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Figure 13.4b

## Experiment

**Batch 2: Radioactive phosphorus ($^{32}P$) in phage DNA**

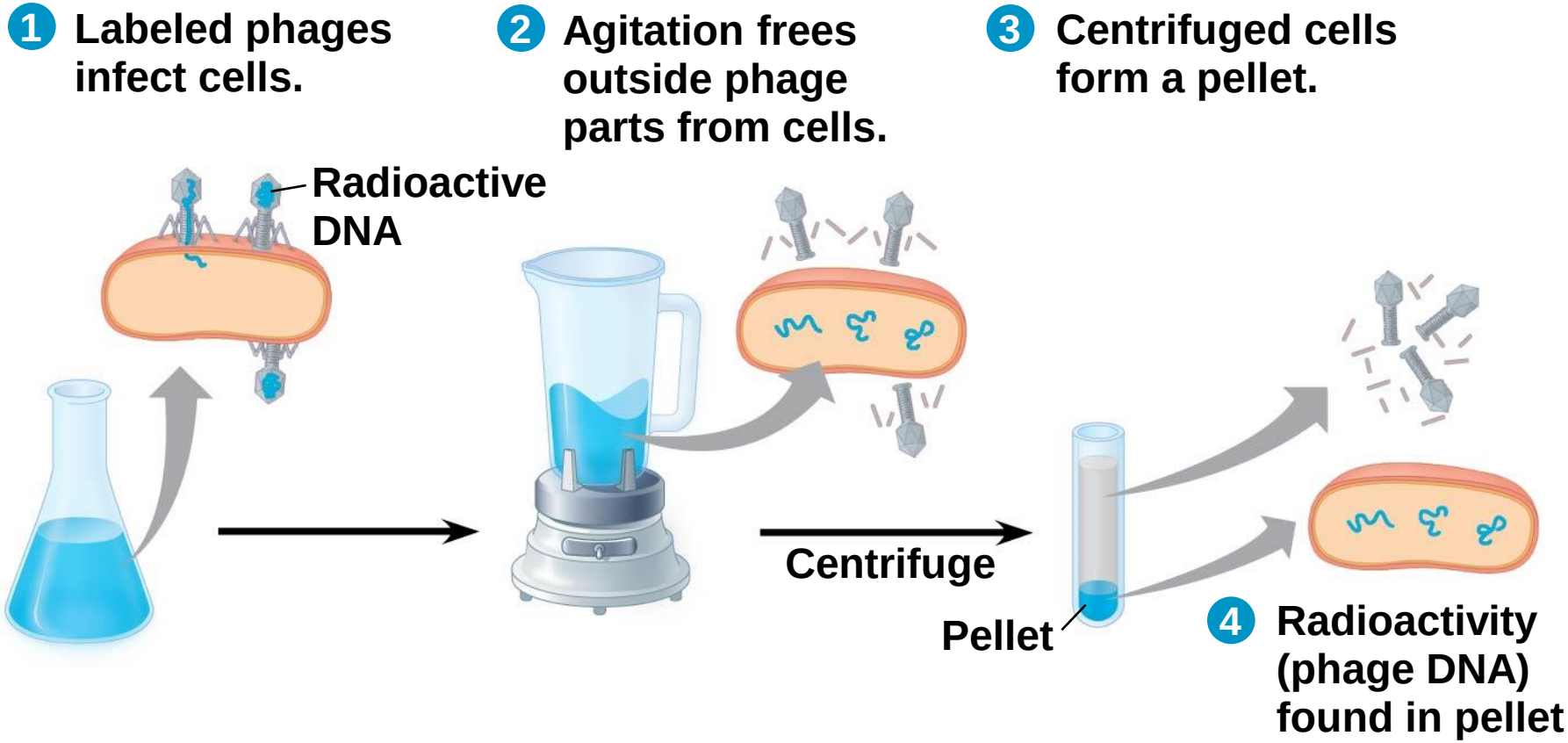


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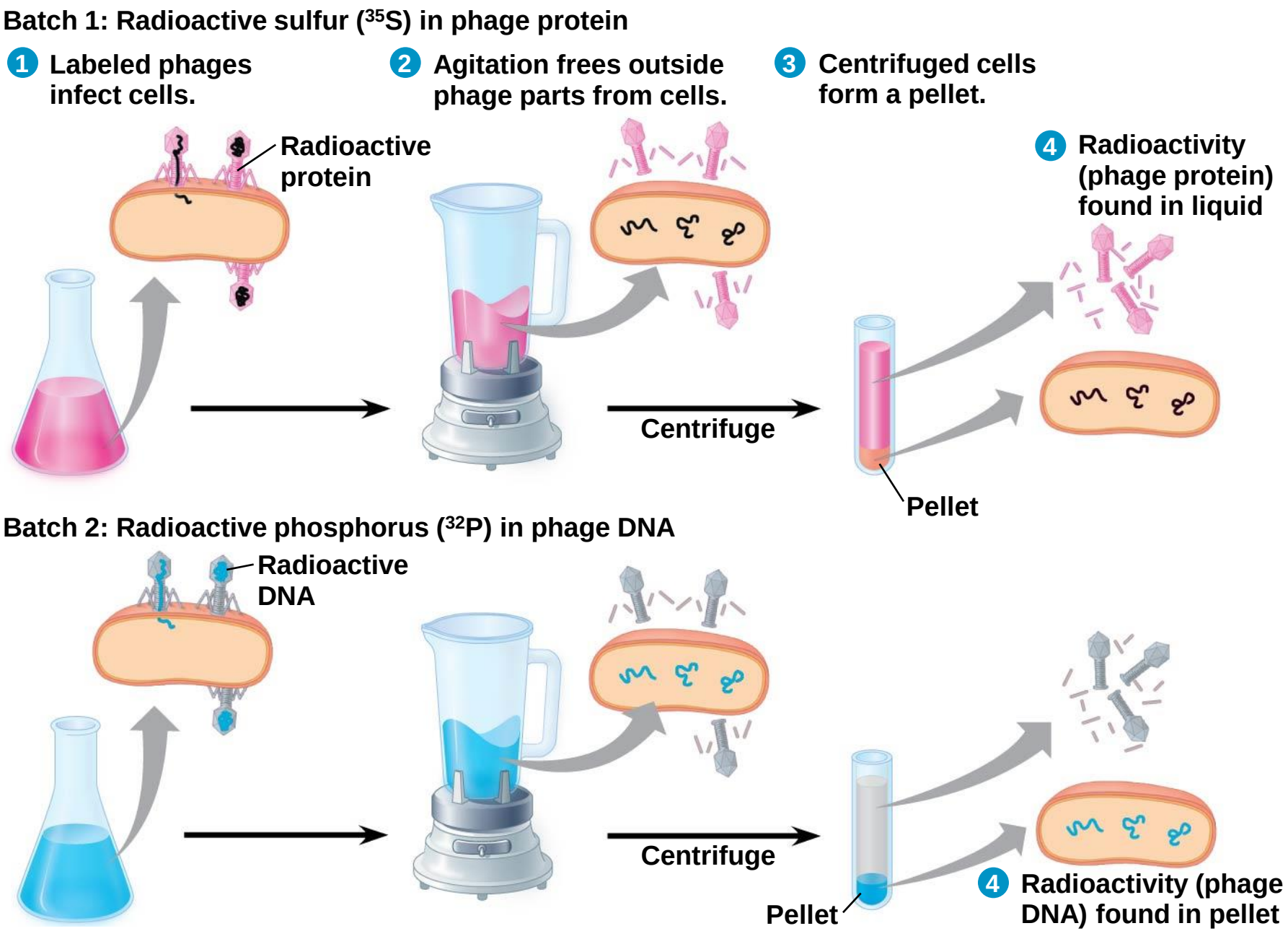
Figure 13.4

## Experiment

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**Objective:** You will be able to explain how work on DNA's structure helped to support the claim that DNA is the source of heritable information.

- **Do Now:**
  - Complete SSE on p. 257

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# Chargaff's Rules

1. DNA base composition varies between species

2. For each species, the % of A and T bases are roughly equal as is the % of G and C bases.

How do these rules support the claim that DNA is the source of heritable information?

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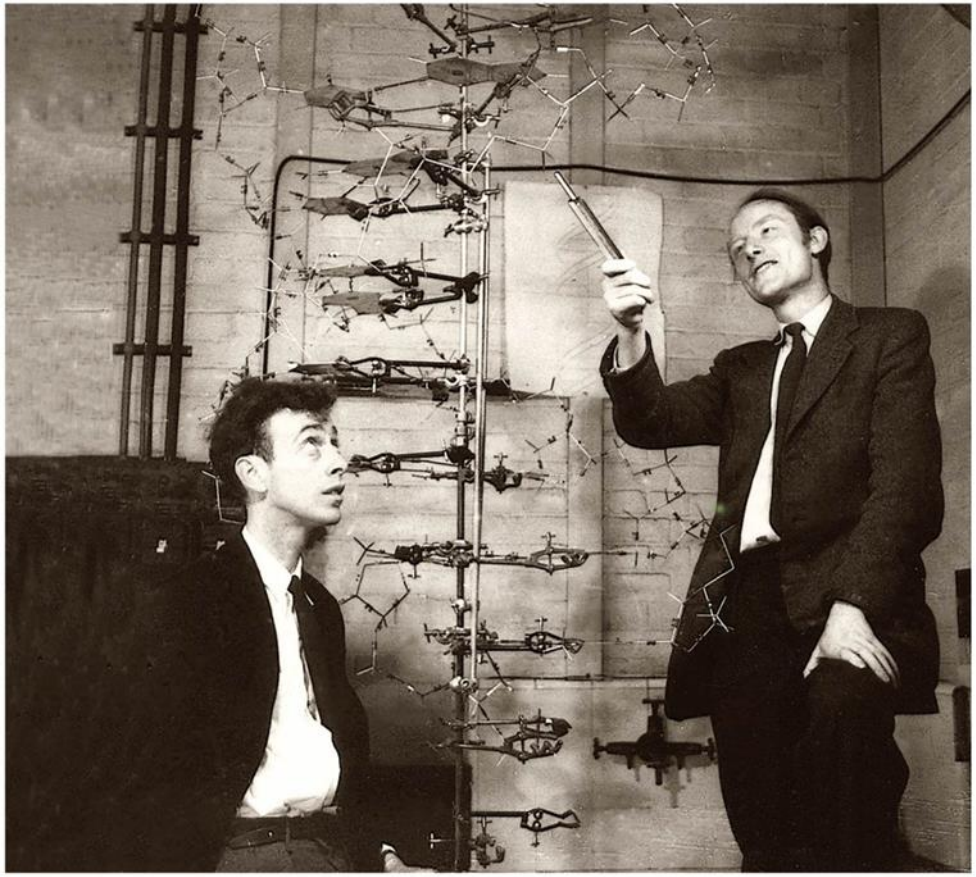
# Watson and Crick



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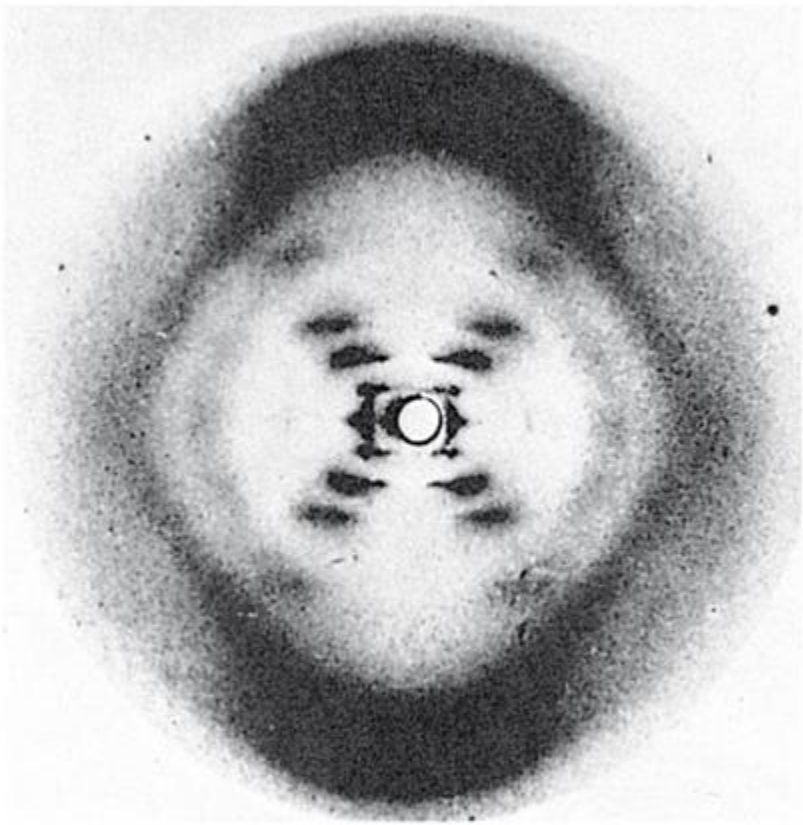
# Where oh Where did Watson and Crick get their ideas?

(a) Rosalind Franklin



(b) Franklin's X-ray diffraction photograph of DNA

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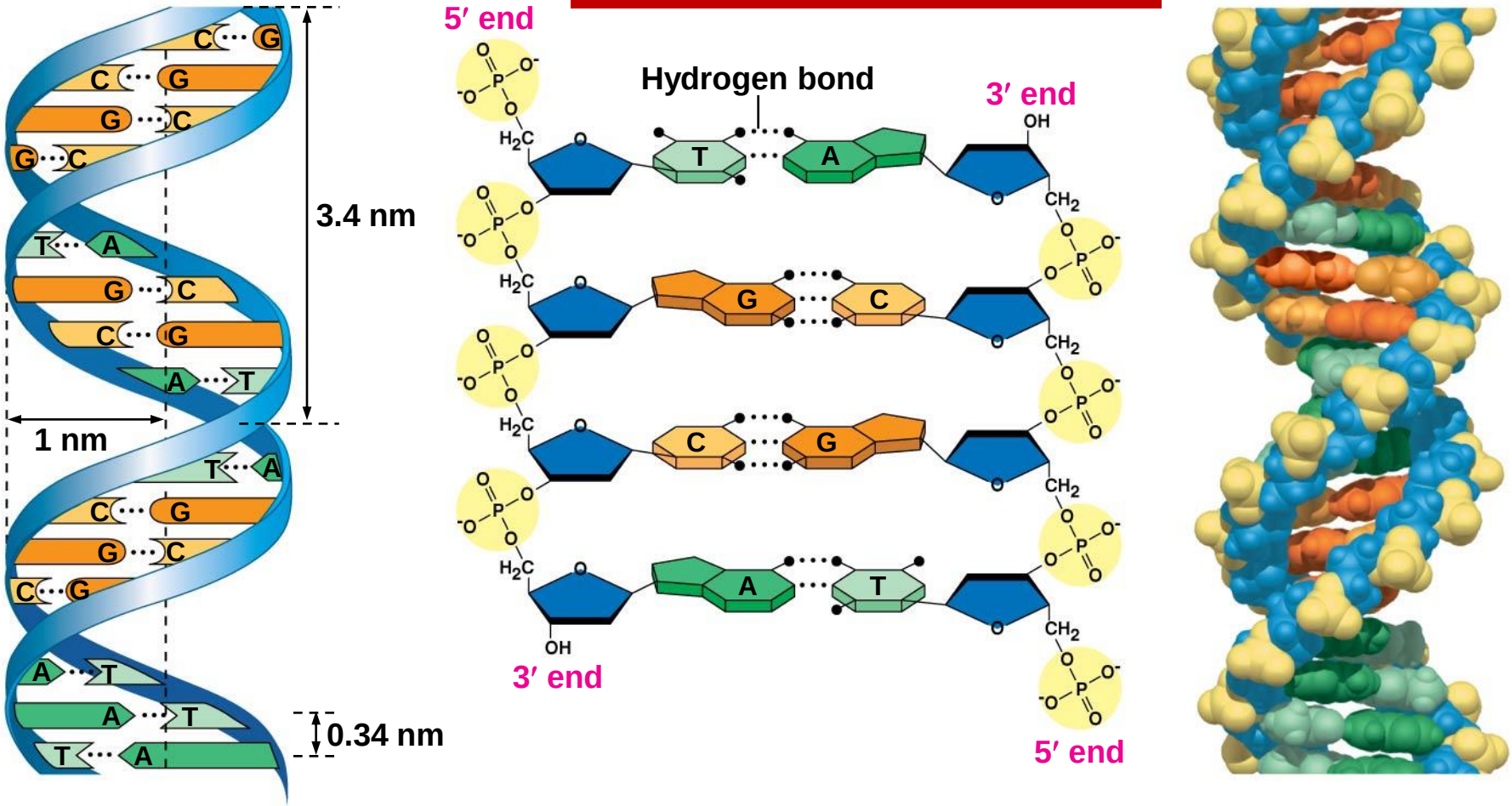
Figure 13.7

**Notice the antiparallel nature of DNA**




(a) Key features of DNA structure

(b) Partial chemical structure

(c) Space-filling model

**Why would it take longer to denature DNA that contained many Guanine bases as opposed to Adenine bases?**

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**Objective:** You will be able to describe the similarities and differences between DNA and RNA.

- **Do Now:**
  - Make a list of what you can remember as the differences between DNA and RNA

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# DNA and RNA molecules have structural similarities and differences that define function.

## Both have:

- A sugar, phosphate group and a nitrogenous base
  - These form nucleotide units that are connected by covalent bonds

- Forms a linear molecule with 3' and 5' ends

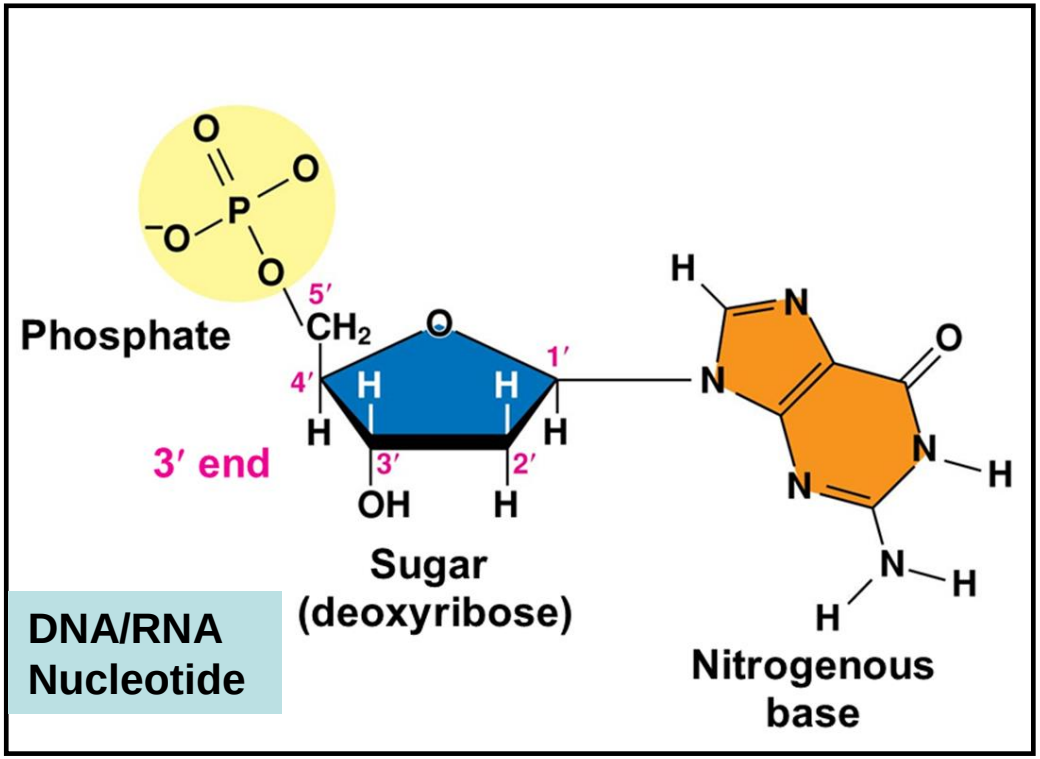


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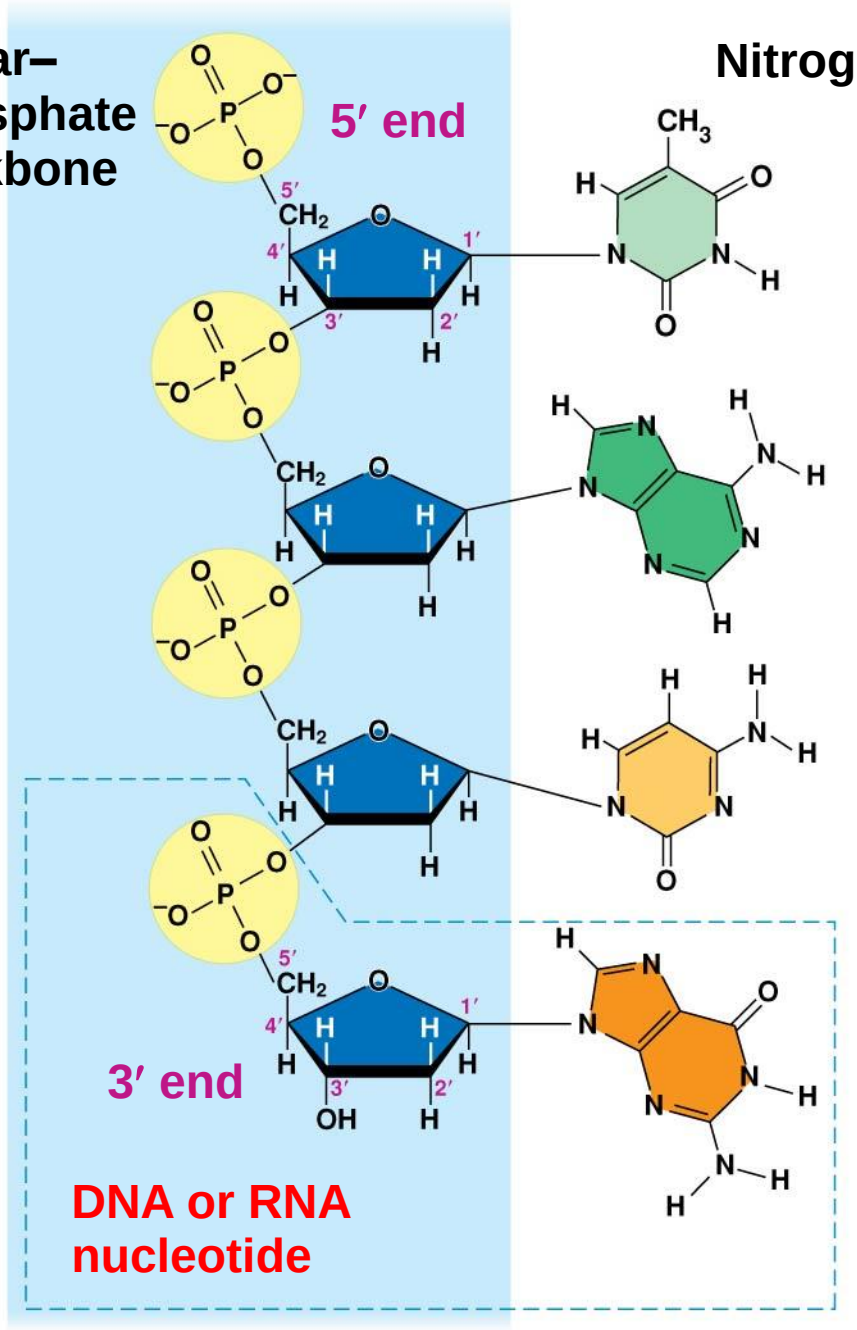
Figure 13.5

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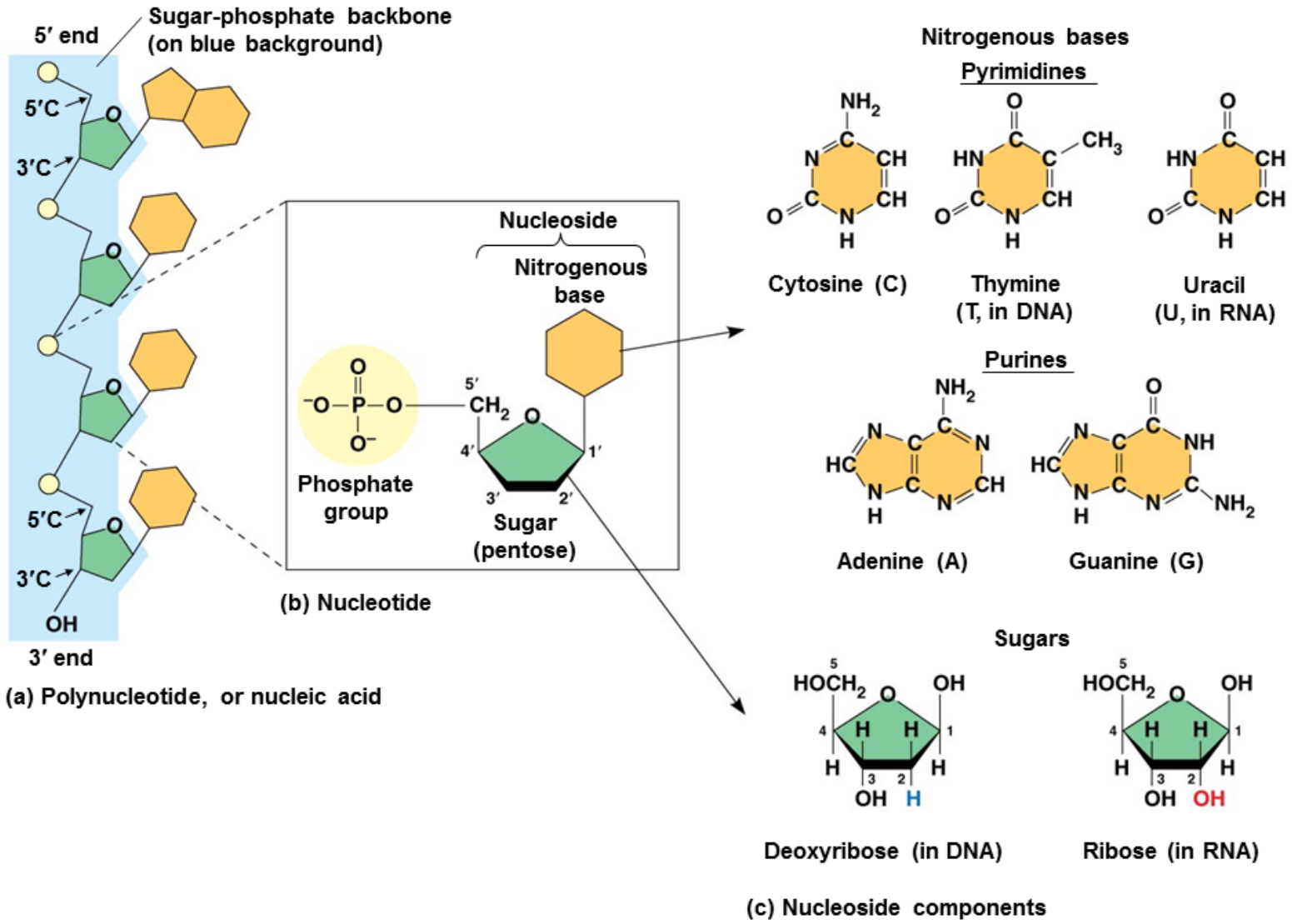
# What differences between DNA and RNA can you identify?

Figure 3.26

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# The basic structural differences include:

- DNA contains deoxyribose (RNA contains ribose).
- RNA contains uracil in lieu of thymine in DNA.
- DNA is usually double stranded, RNA is usually single stranded.
- The two DNA strands in double-stranded DNA are antiparallel in directionality.

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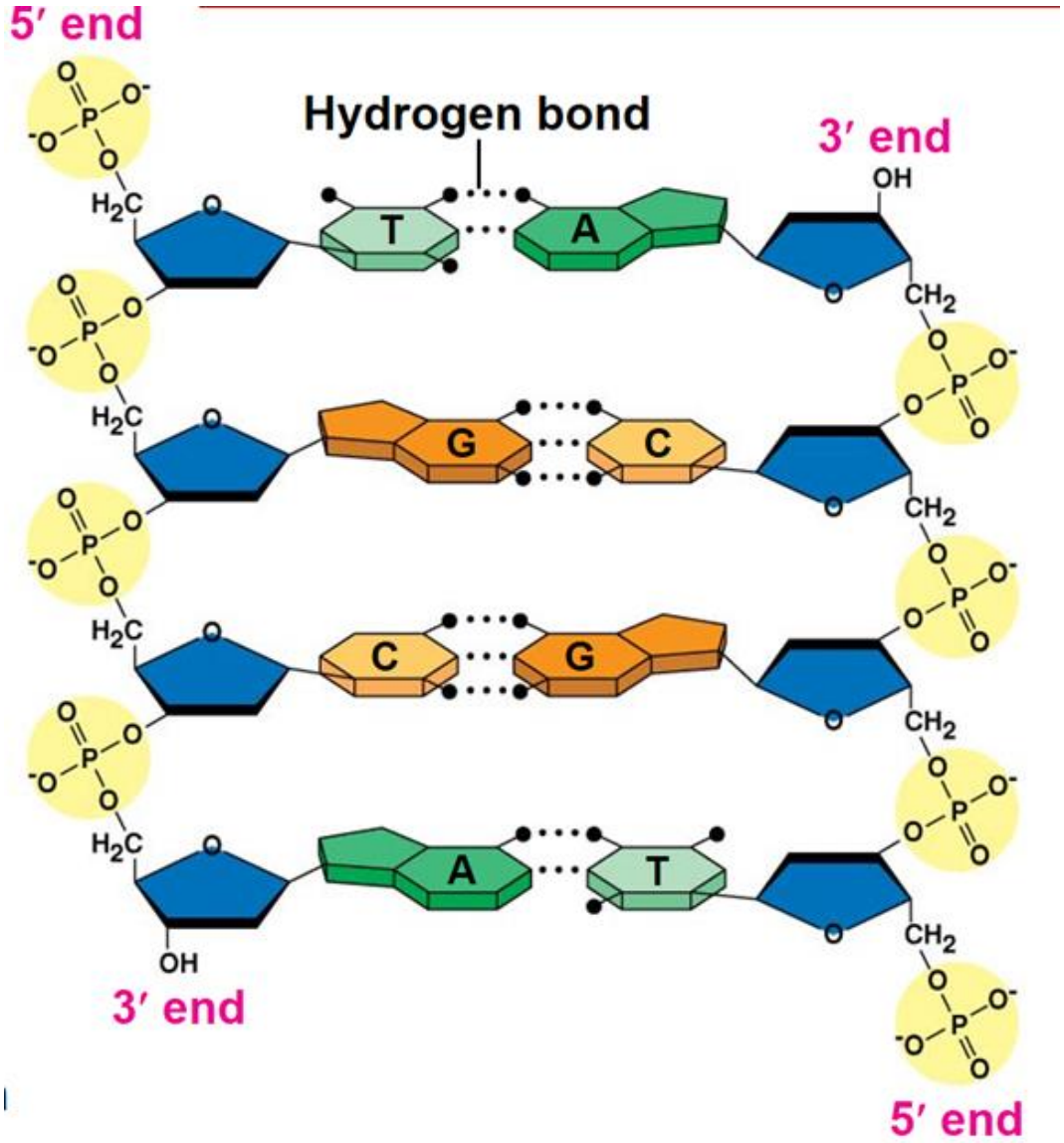


(b) Partial chemical structure

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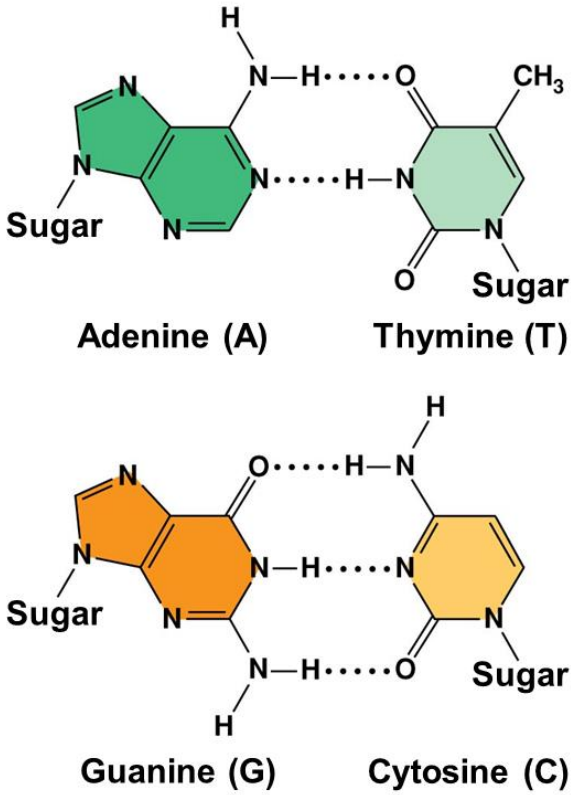
- Both DNA and RNA exhibit specific nucleotide base pairing that is conserved through evolution: (In RNA…A—U)
- Purines (G and A) have a double ring structure.
- Pyrimidines (C, T and U) have a single ring structure.

Figure 13.8

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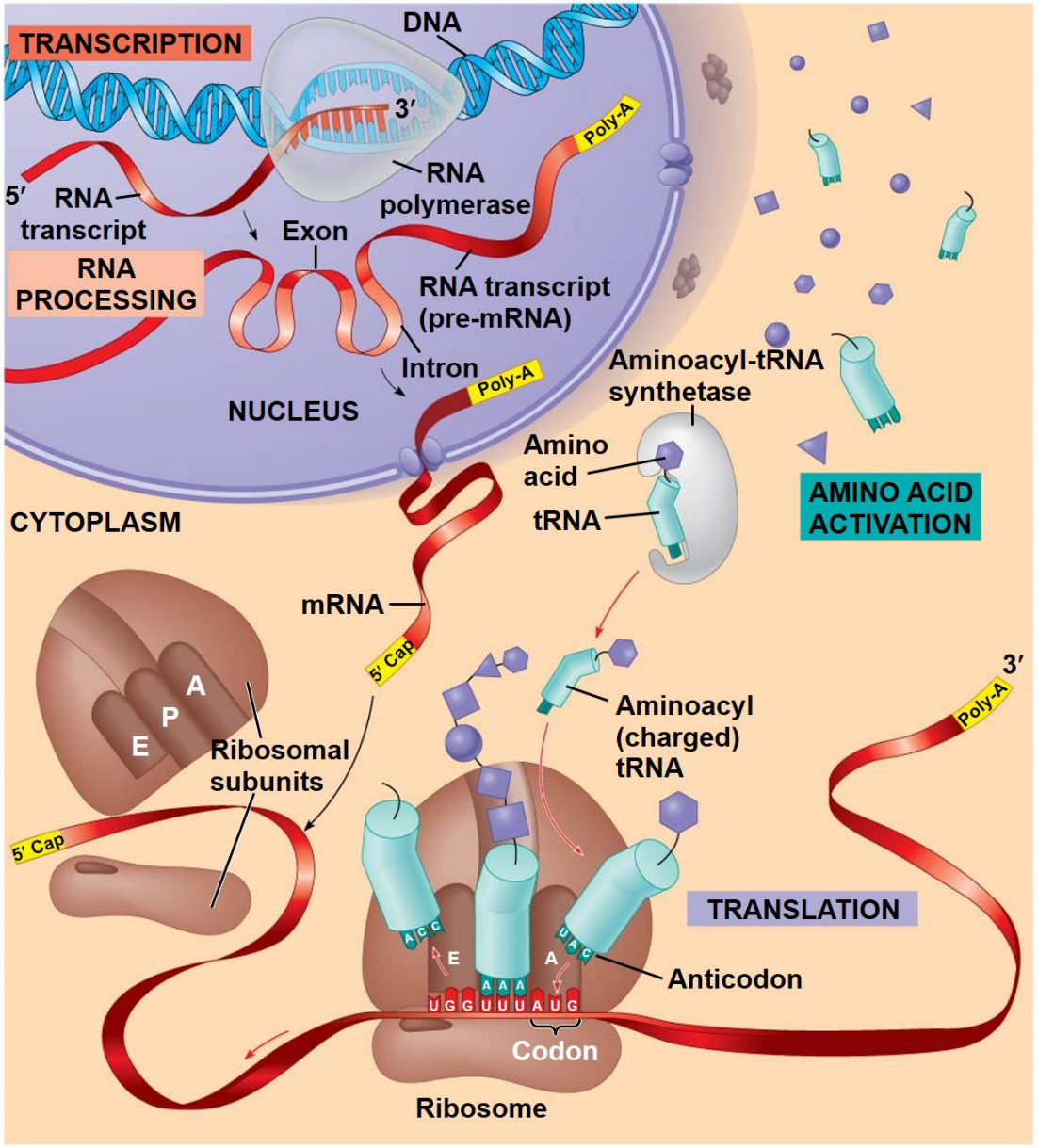
# Roles of RNA

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# Functions of RNA

**The sequence of the RNA bases, together with the structure of the RNA molecule, determines RNA function.**

- mRNA carries information from the DNA to the ribosome.
- tRNA molecules bind specific amino acids and allow information in the mRNA to be translated to a linear peptide sequence.
- rRNA molecules are functional building blocks of ribosomes.
- The role of RNAi includes regulation of gene expression at the level of mRNA transcription.

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**Objective:** You will be able to describe representations and models illustrating how genetic information is copied for transmission between generations.

- **Do Now:**

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# DNA replication ensures continuity of hereditary information.

- Replication is a semiconservative process; that is, one strand serves as the template for a new, complementary strand.

- Replication requires:
  - DNA polymerase plus many other essential cellular enzymes
  - Occurs bidirectionally

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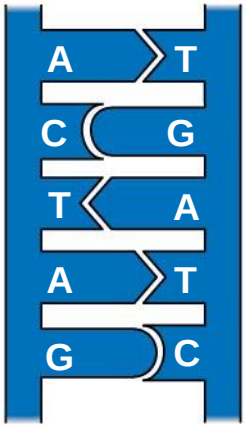
Figure 13.9-1

# Semiconservative Replication




**(a) Parental molecule**

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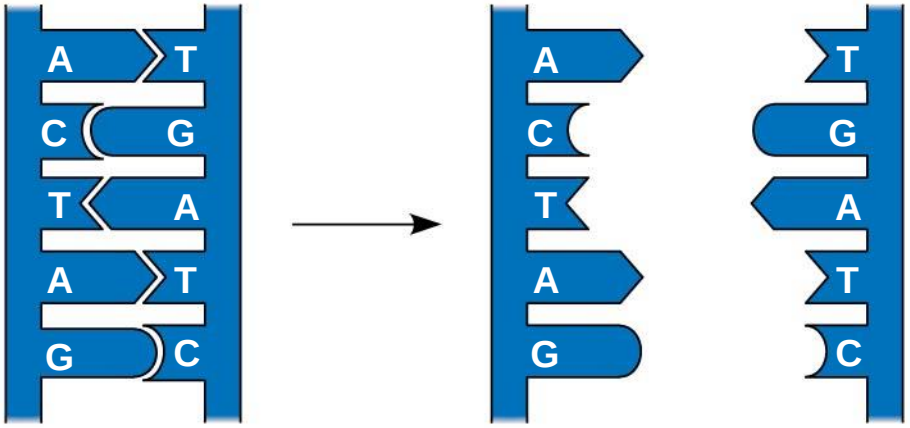
Figure 13.9-2

# Semiconservative Replication




**(a) Parental molecule**

**(b) Separation of parental strands into templates**

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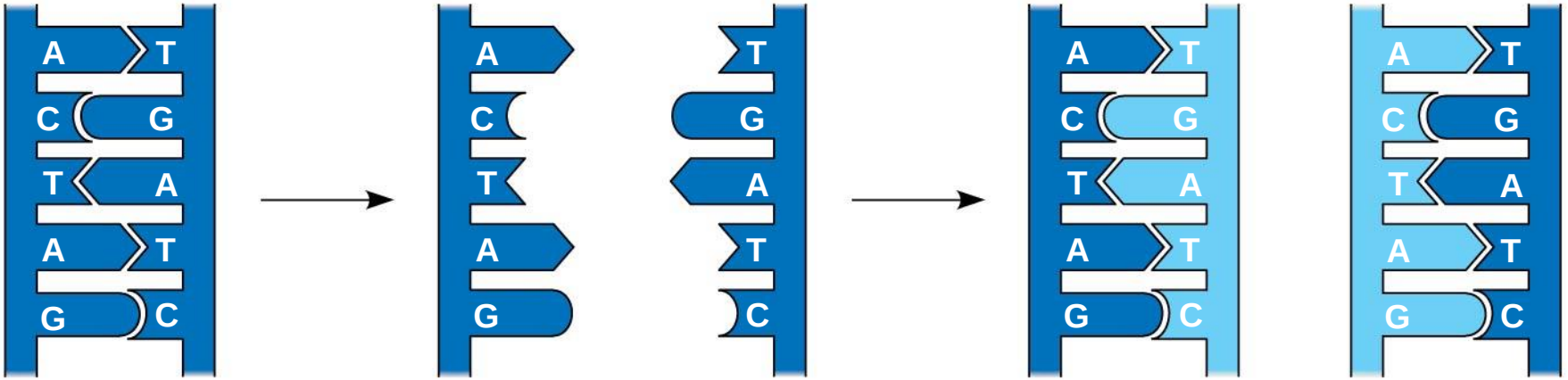
Figure 13.9-3

# Semiconservative Replication




**(a) Parental molecule**

**(b) Separation of parental strands into templates**

**(c) Formation of new strands complementary to template strands**

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Figure 13.14

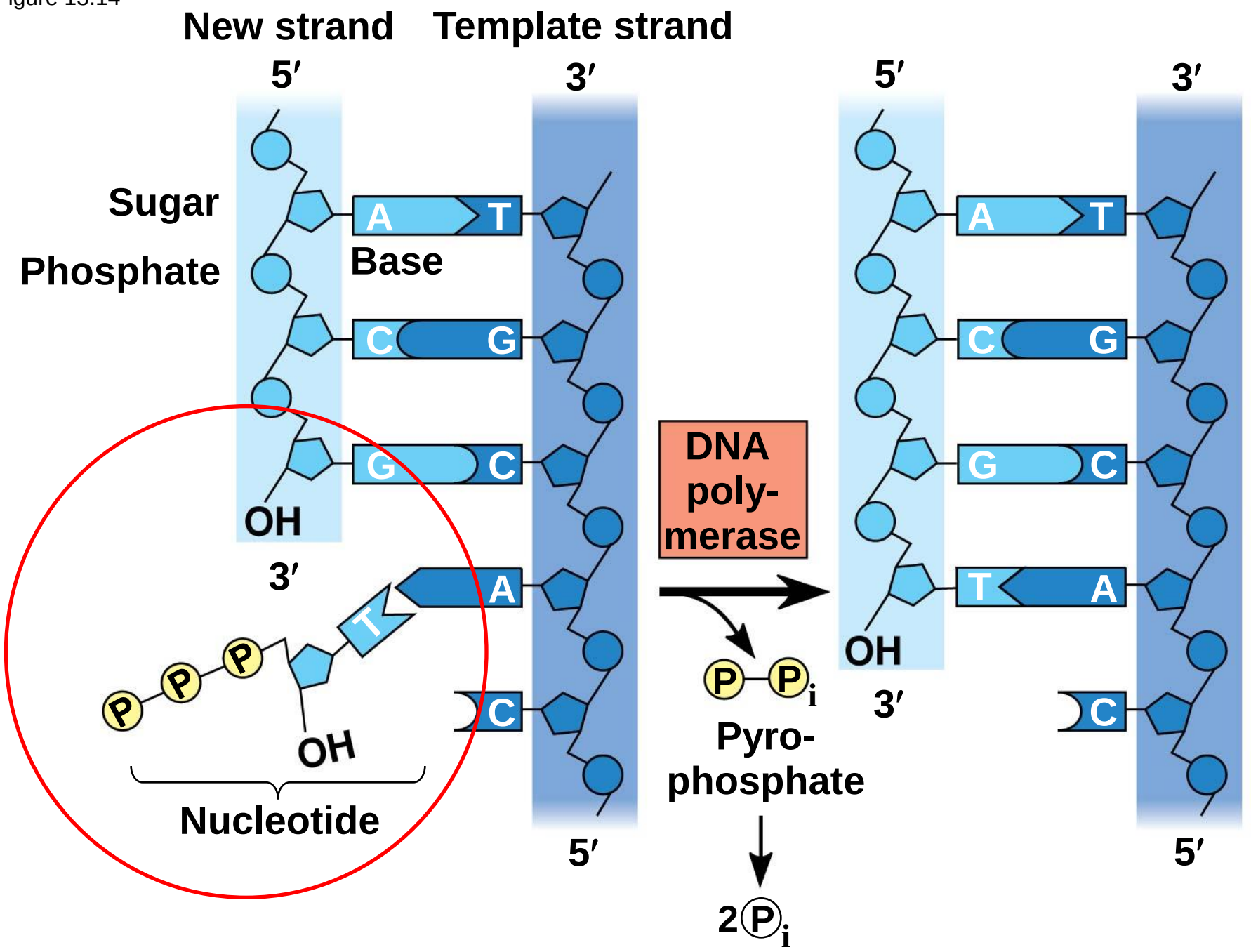


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Figure 13.17

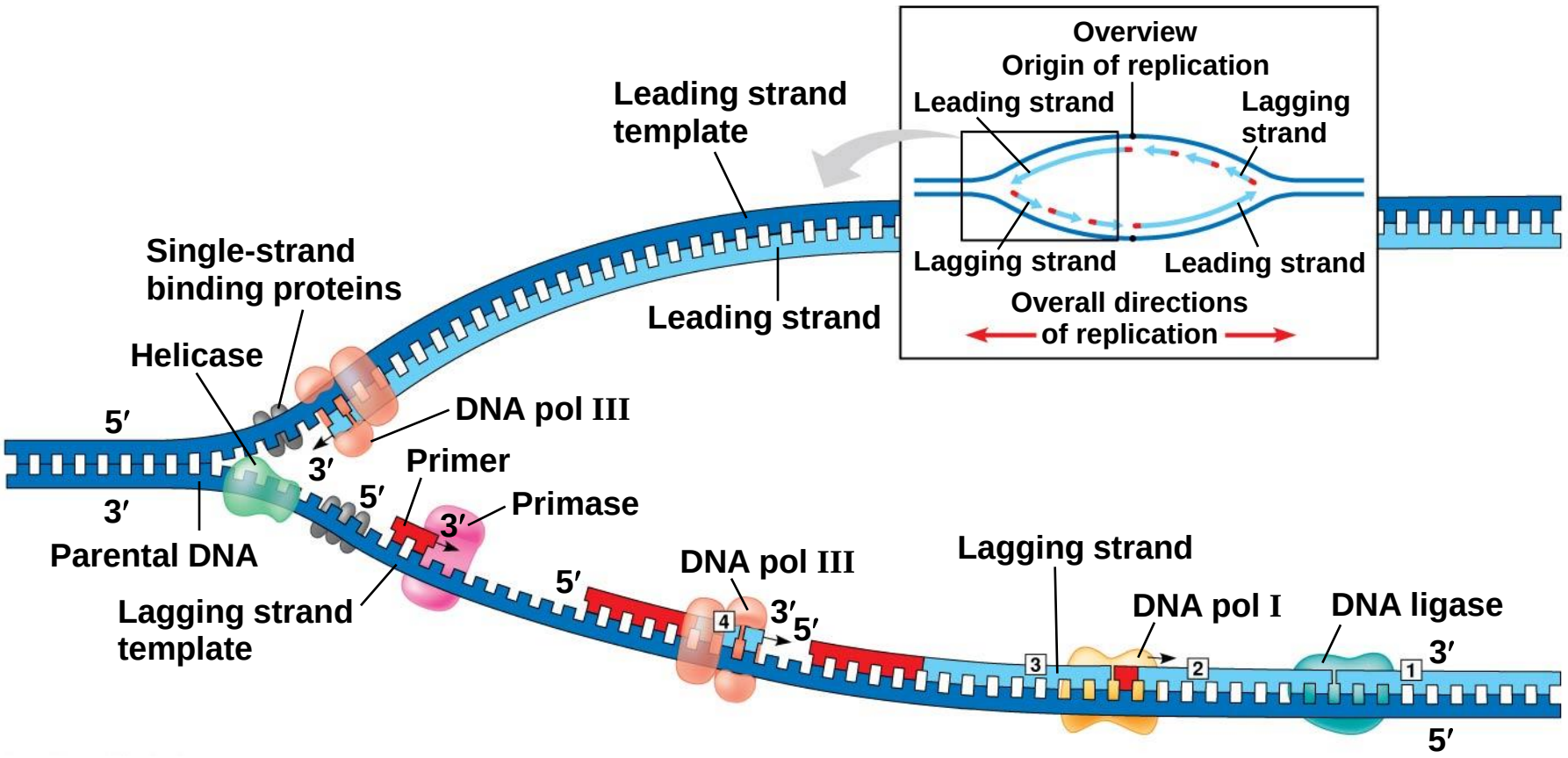


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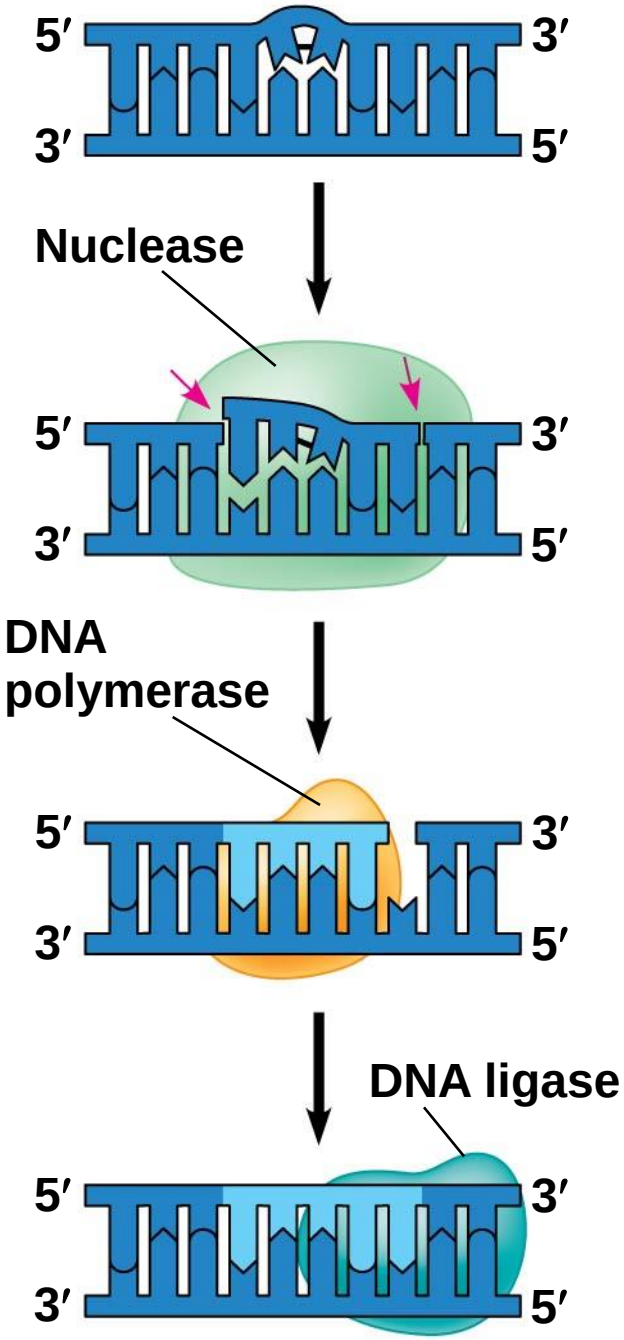
Figure 13.19-3

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- Genetic information in retroviruses is a special case and has an alternate flow of information:
    - From RNA to DNA
    - Made possible by reverse transcriptase, an enzyme that copies the viral RNA genome into DNA.
        - This DNA integrates into the host genome and becomes transcribed and translated for the assembly of new viral progeny.

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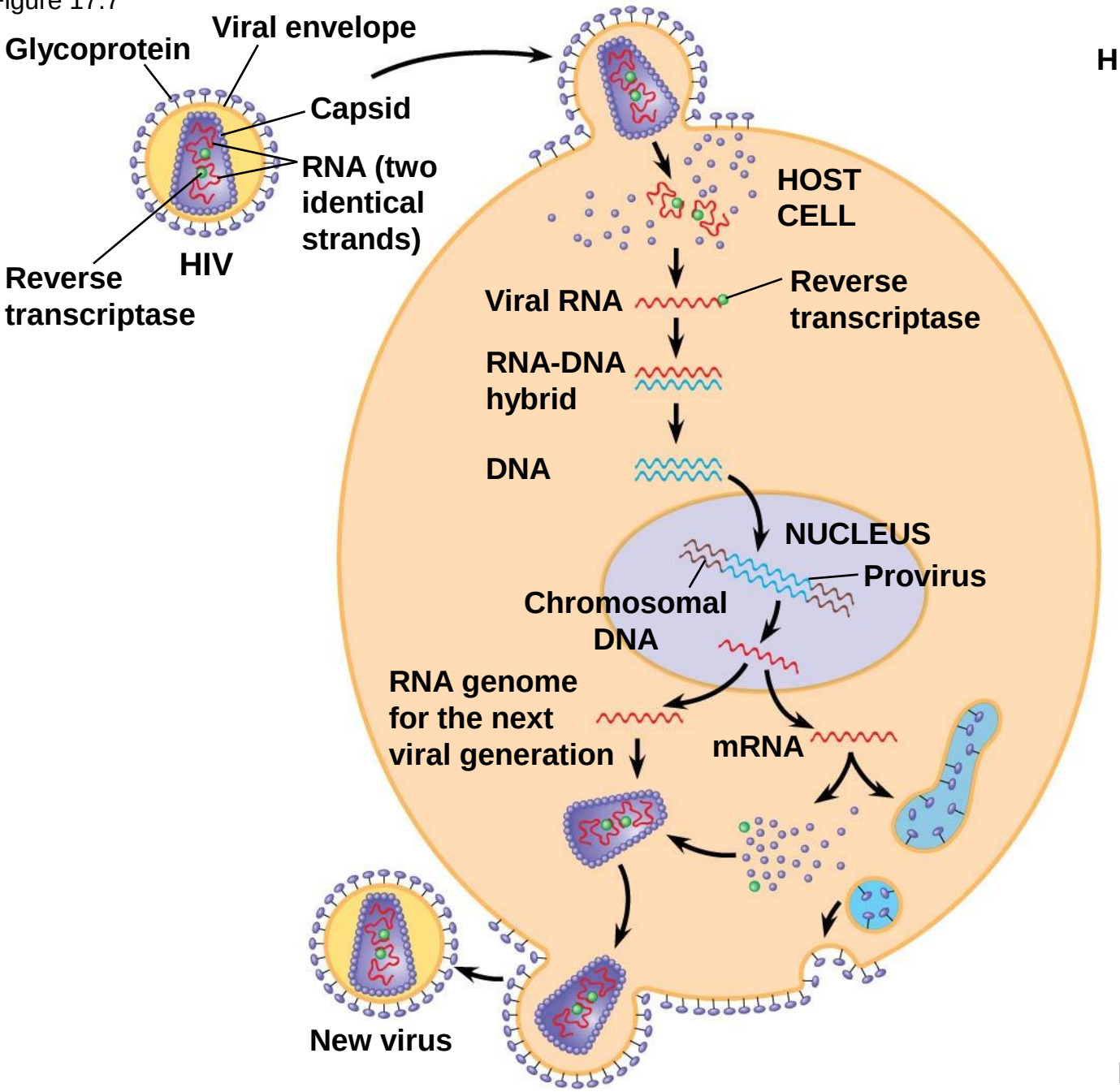
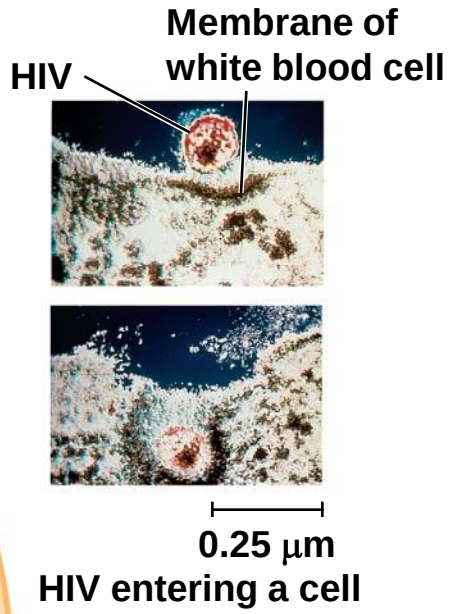
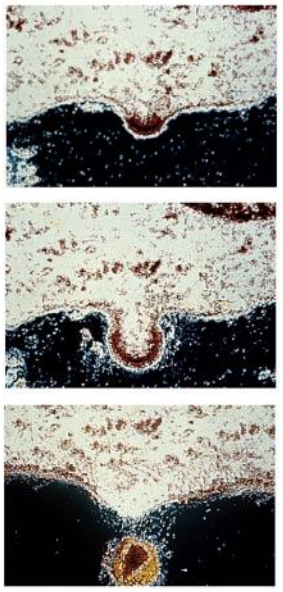
Figure 17.7




HIV entering a cell



New HIV leaving a cell

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**Objective:** You will be able to design a representation that illustrates how genetic information is transferred from DNA to RNA

- **Do Now:**

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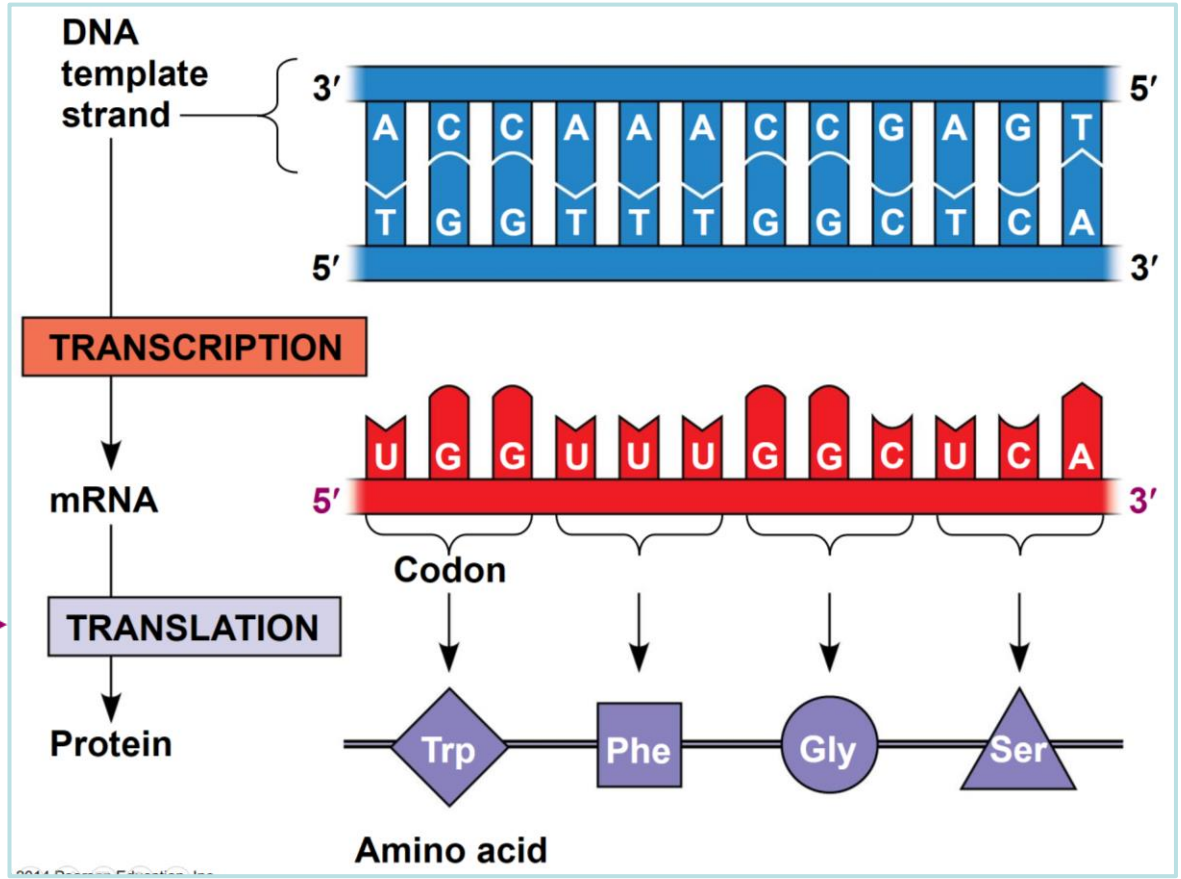
Genetic information flows from a sequence of nucleotides in a gene to a sequence of amino acids in a protein.

How would you define transcription?

How would you define translation?

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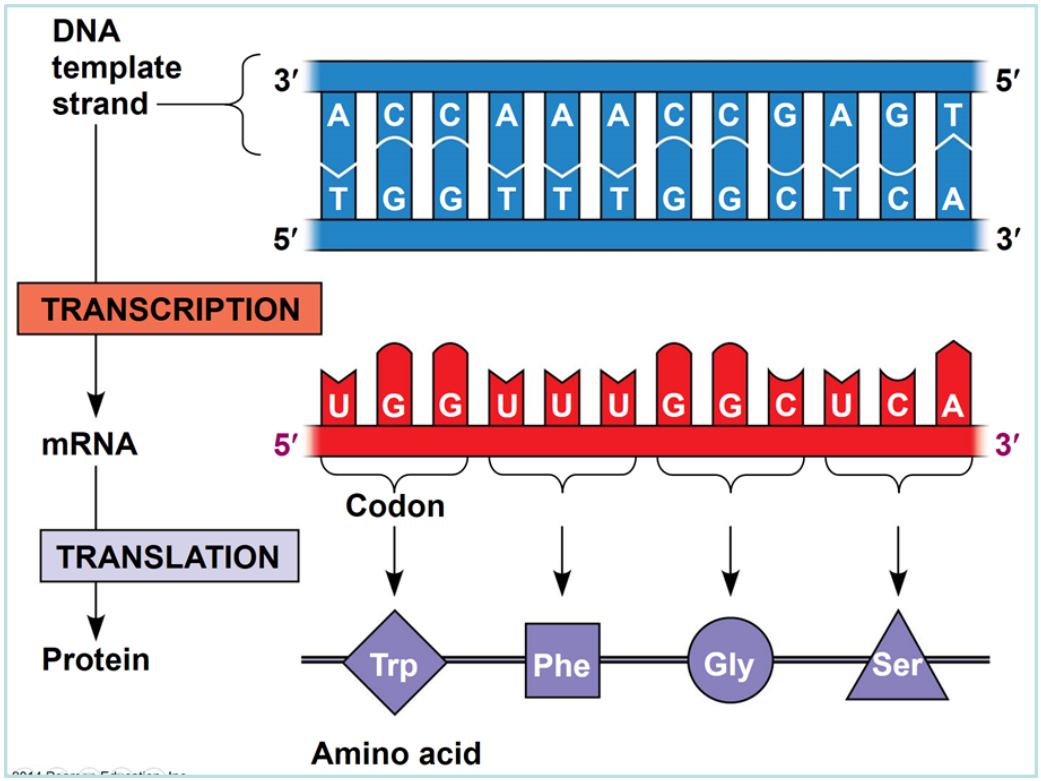
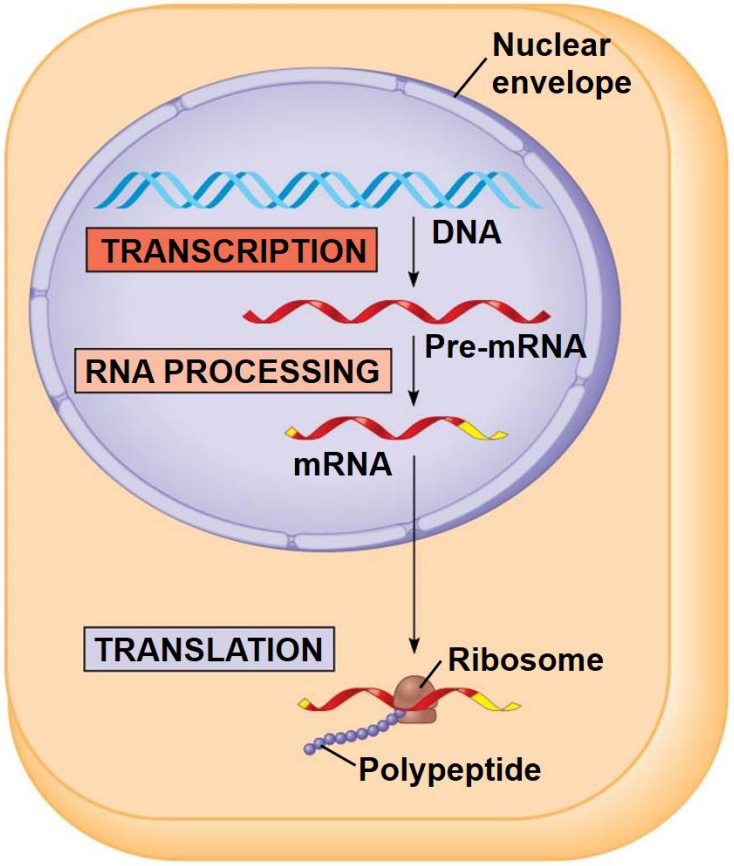
- **Transcription** is the synthesis of RNA using information in DNA
  - Transcription produces **messenger RNA (mRNA)**

- **Translation** is the synthesis of a polypeptide, using information in the mRNA
  - **Ribosomes** are the sites of translation




(b) Eukaryotic cell

# Transcription

The enzyme **RNA-polymerase** reads the DNA molecule in the 3' to 5' direction and synthesizes complementary mRNA molecules that determine the order of amino acids in the polypeptide.

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Figure 14.8-1

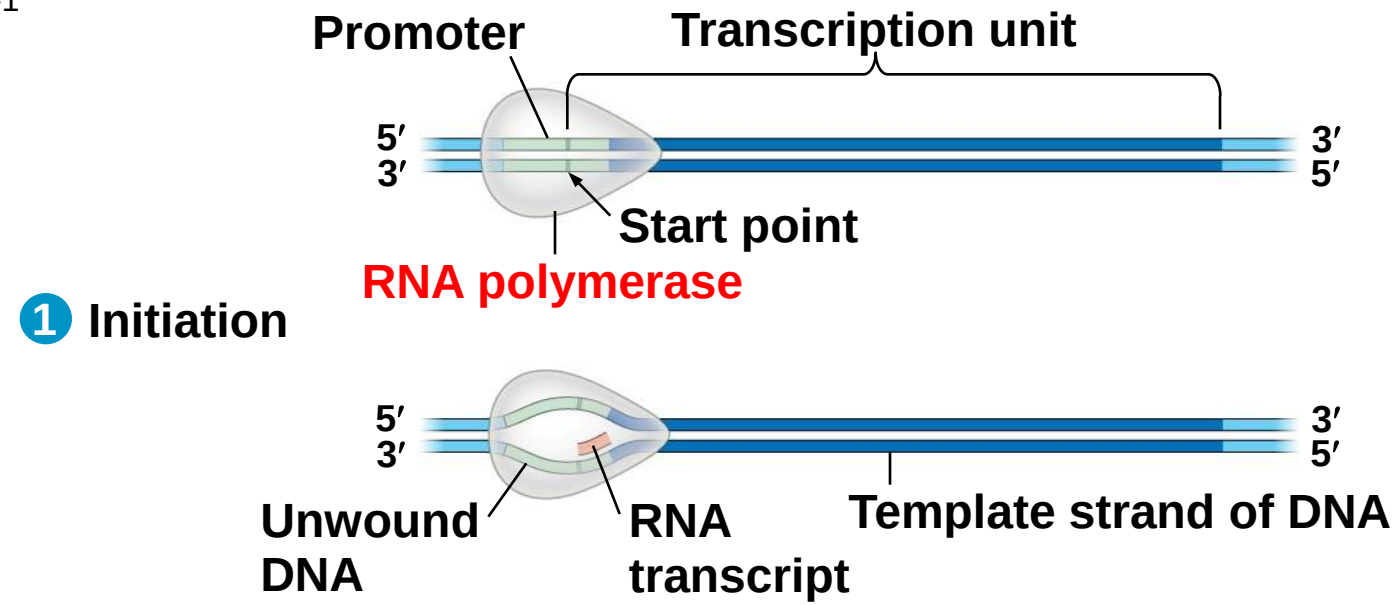


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Figure 14.8-2

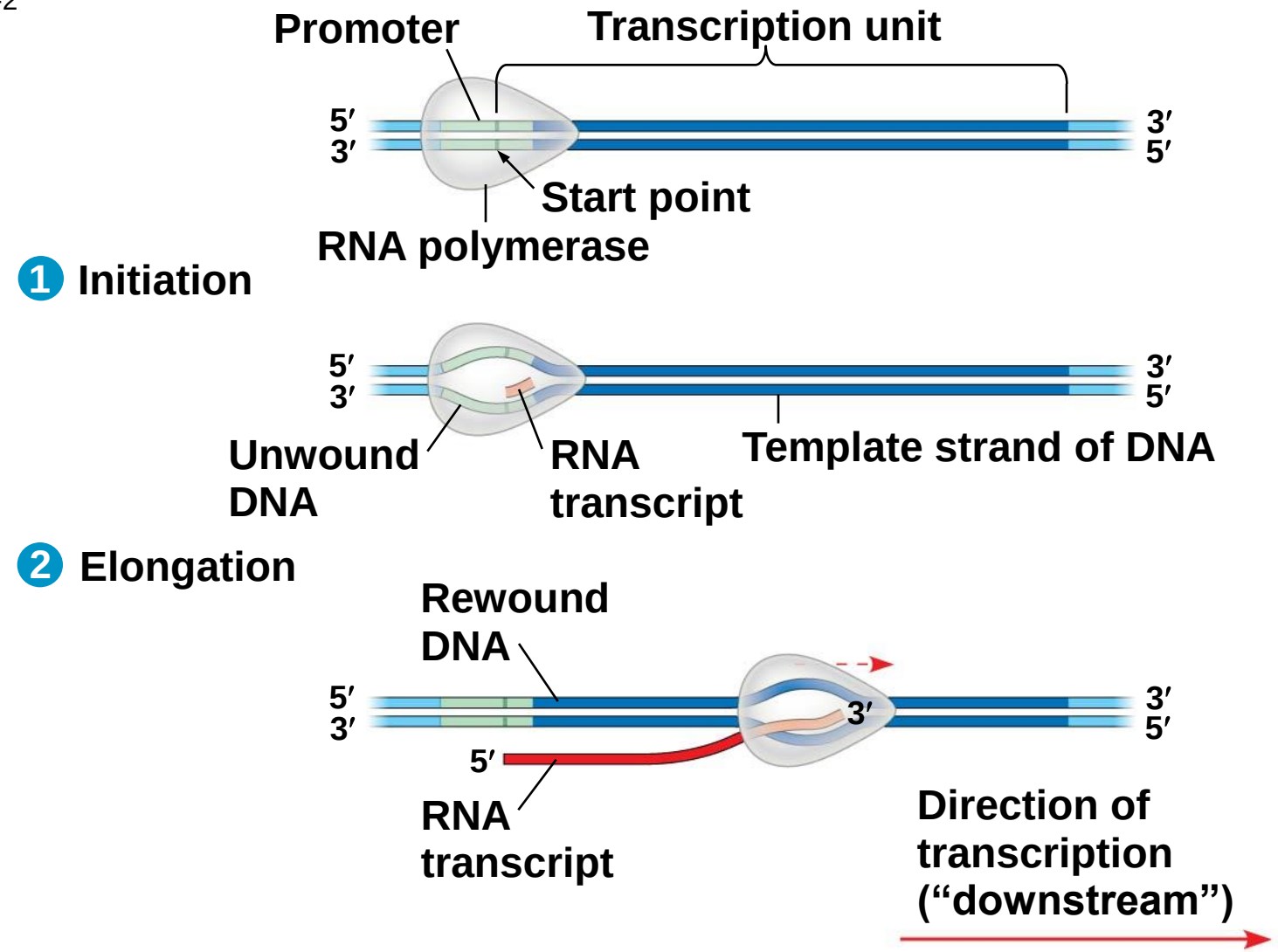


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Figure 14.8-3

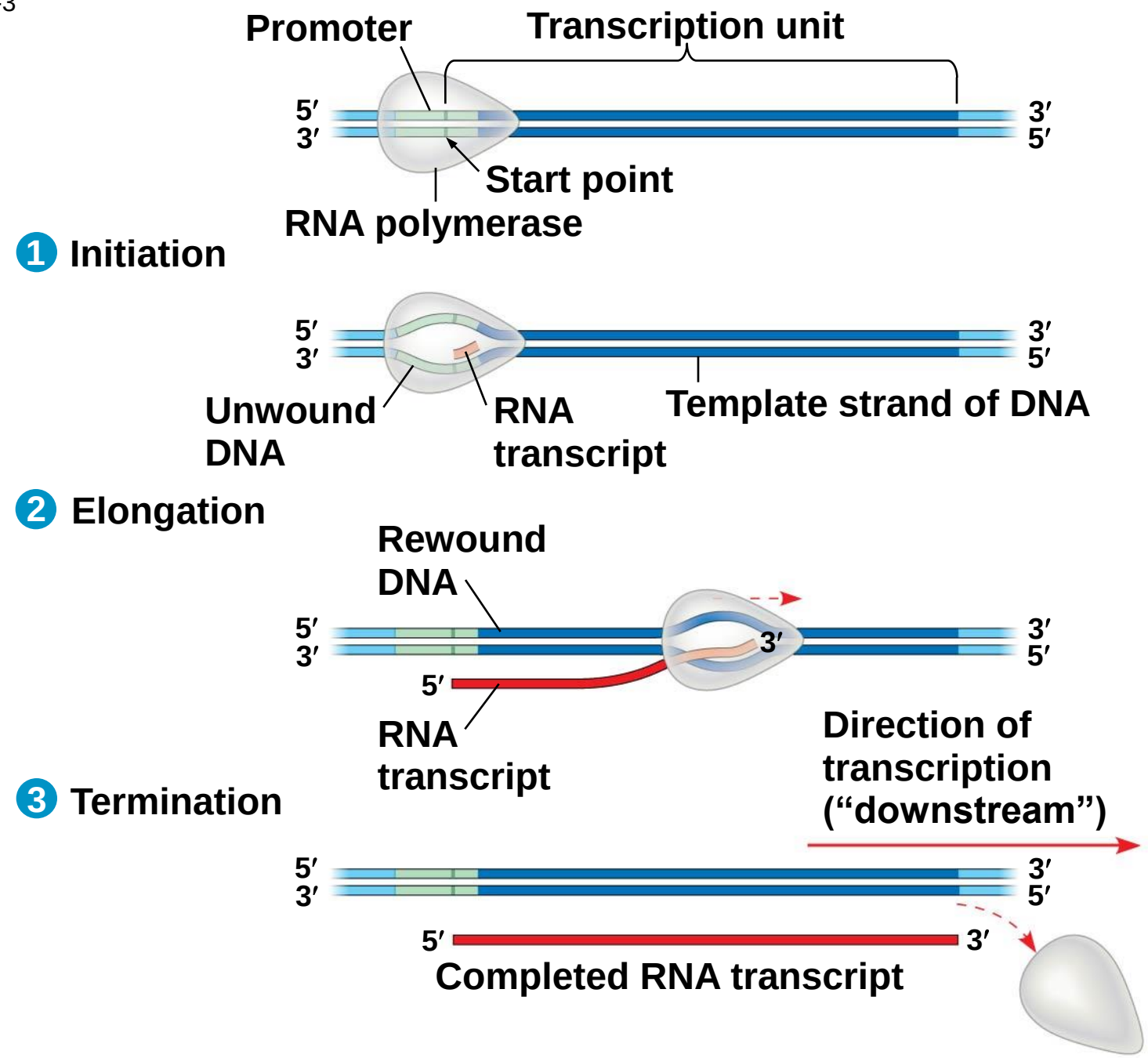


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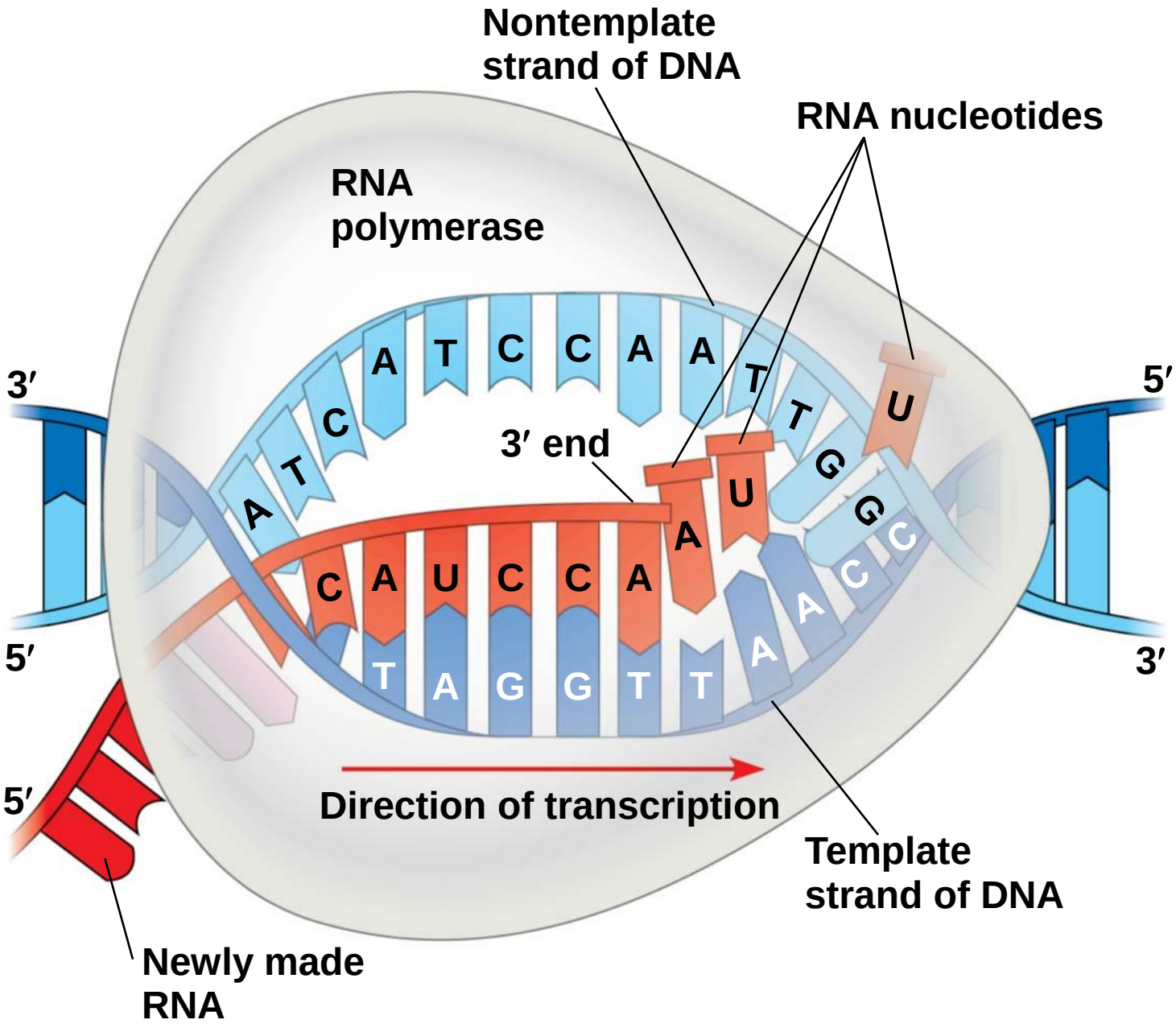
Figure 14.10

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**Objective:** You will be able to design a representation that illustrates how genetic information of RNA is modified to form mRNA.

- **Do Now:**

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# RNA Processing

- In eukaryotic cells the mRNA transcript undergoes a series of enzyme-regulated modifications.
    - Addition of a poly-A tail
    - Addition of a GTP cap
    - Excision of introns

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Figure 14.11

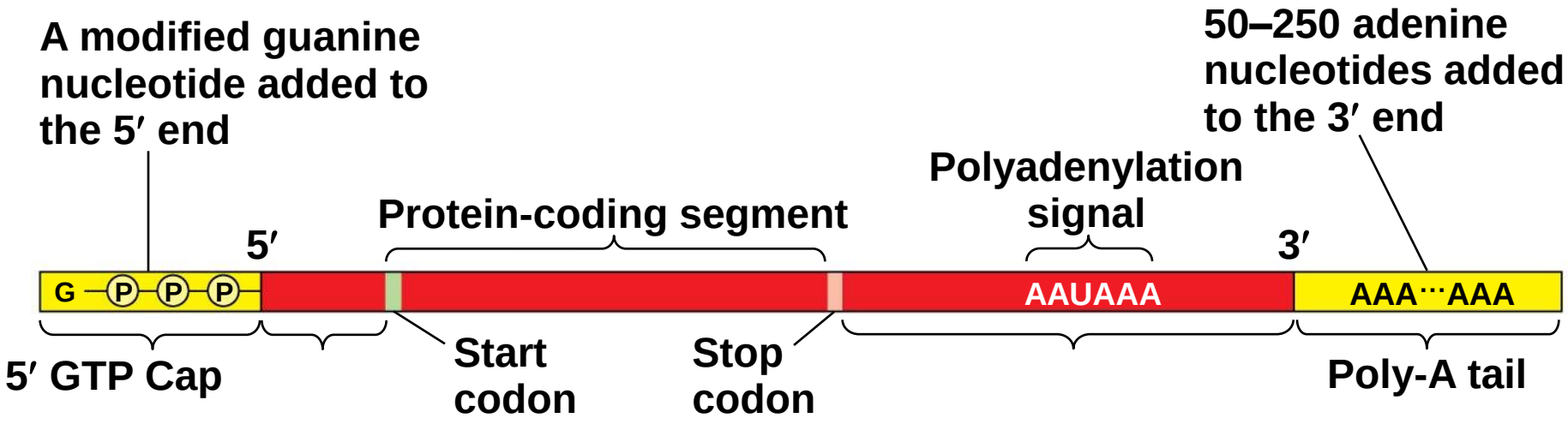


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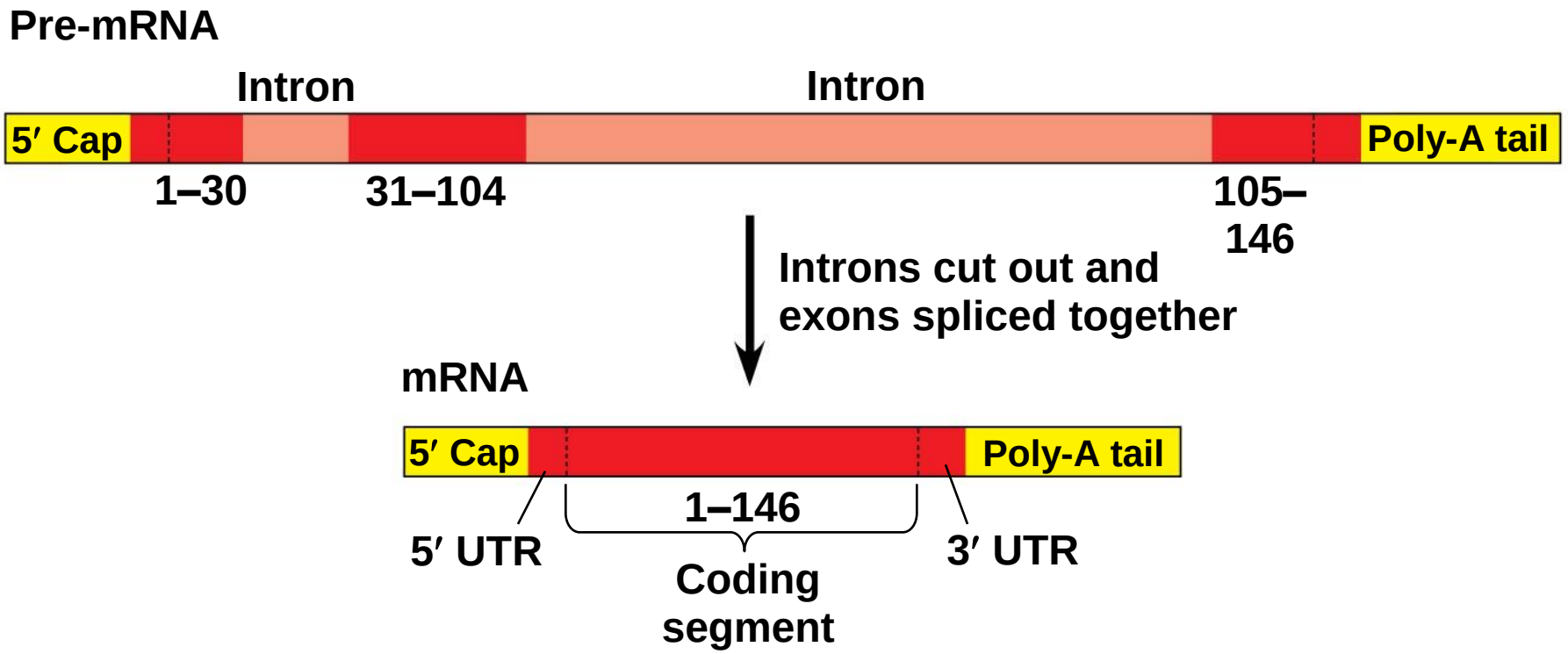
Figure 14.12

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**Objective:** You will be able to design a representation that illustrates how genetic information of mRNA is translated into a sequence of amino acids

- **Do Now:**

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# Translation

- Translation of the mRNA occurs in the cytoplasm on the ribosome.

- Translation involves energy and many steps, including initiation, elongation and termination.

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# Salient Features of Protein Synthesis: Part 1

- The mRNA interacts with the rRNA of the ribosome to initiate translation at the (start) codon.
- The sequence of nucleotides on the mRNA is read in triplets called codons.
- Each codon encodes a specific amino acid, which can be deduced by using a genetic code chart.
  - Many amino acids have more than one codon.

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Figure 14.5

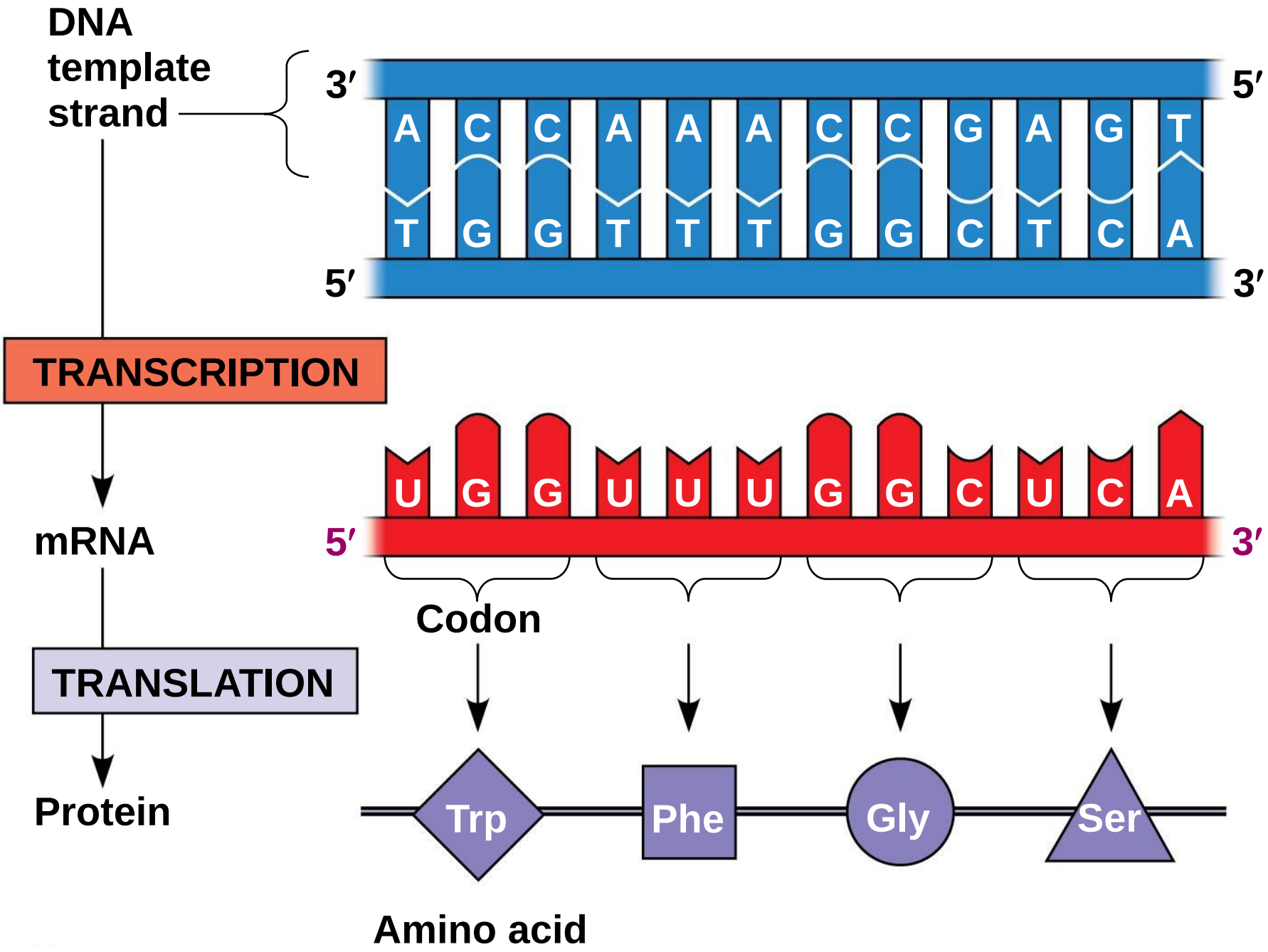


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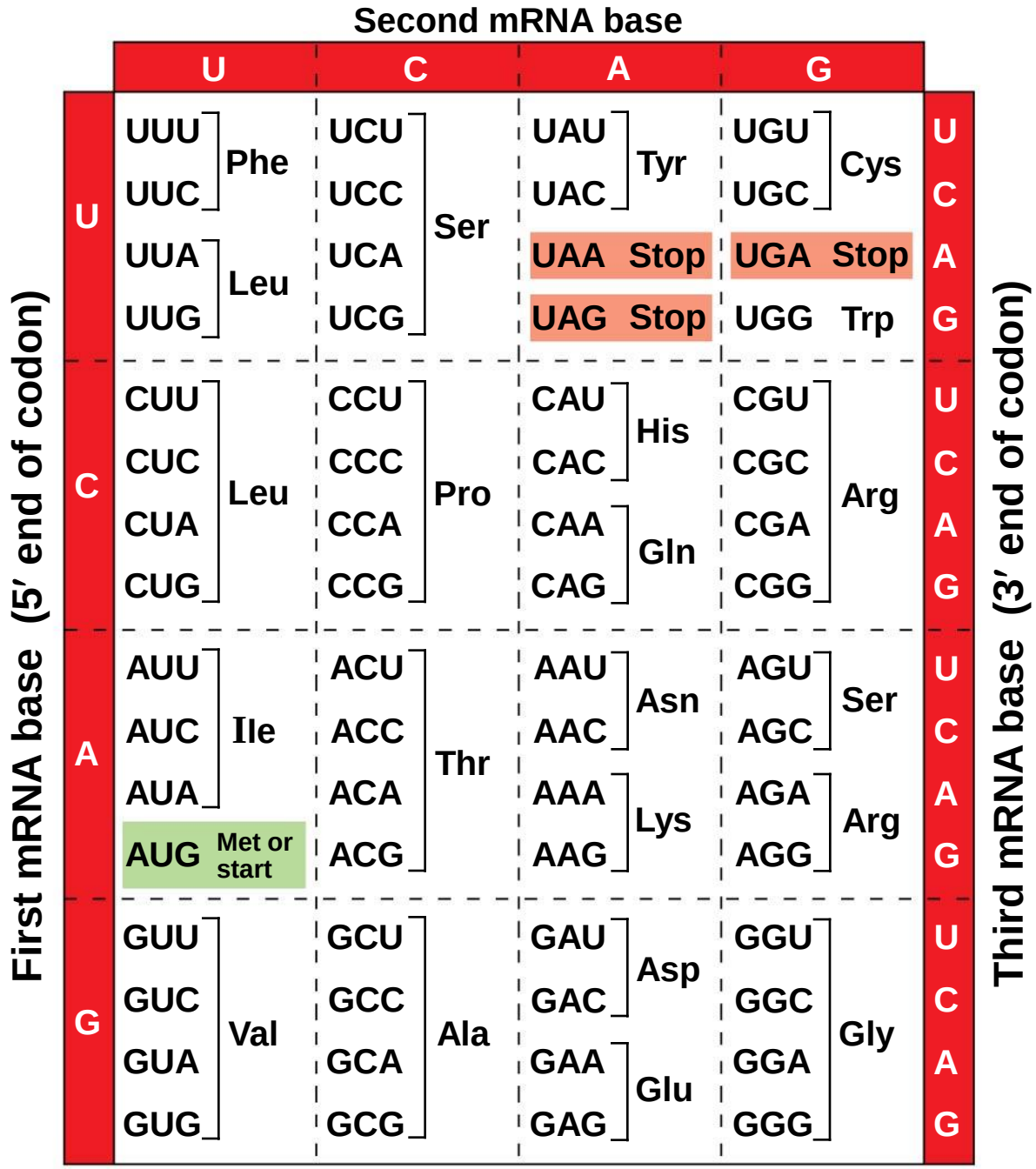
Figure 14.6

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# Salient Features of Protein Synthesis: Part 2

- tRNA brings the correct amino acid to the correct place on the mRNA.
- The amino acid is transferred to the growing peptide chain.
- The process continues along the mRNA until a "stop" codon is reached.
- The process terminates by release of the newly synthesized peptide/protein.

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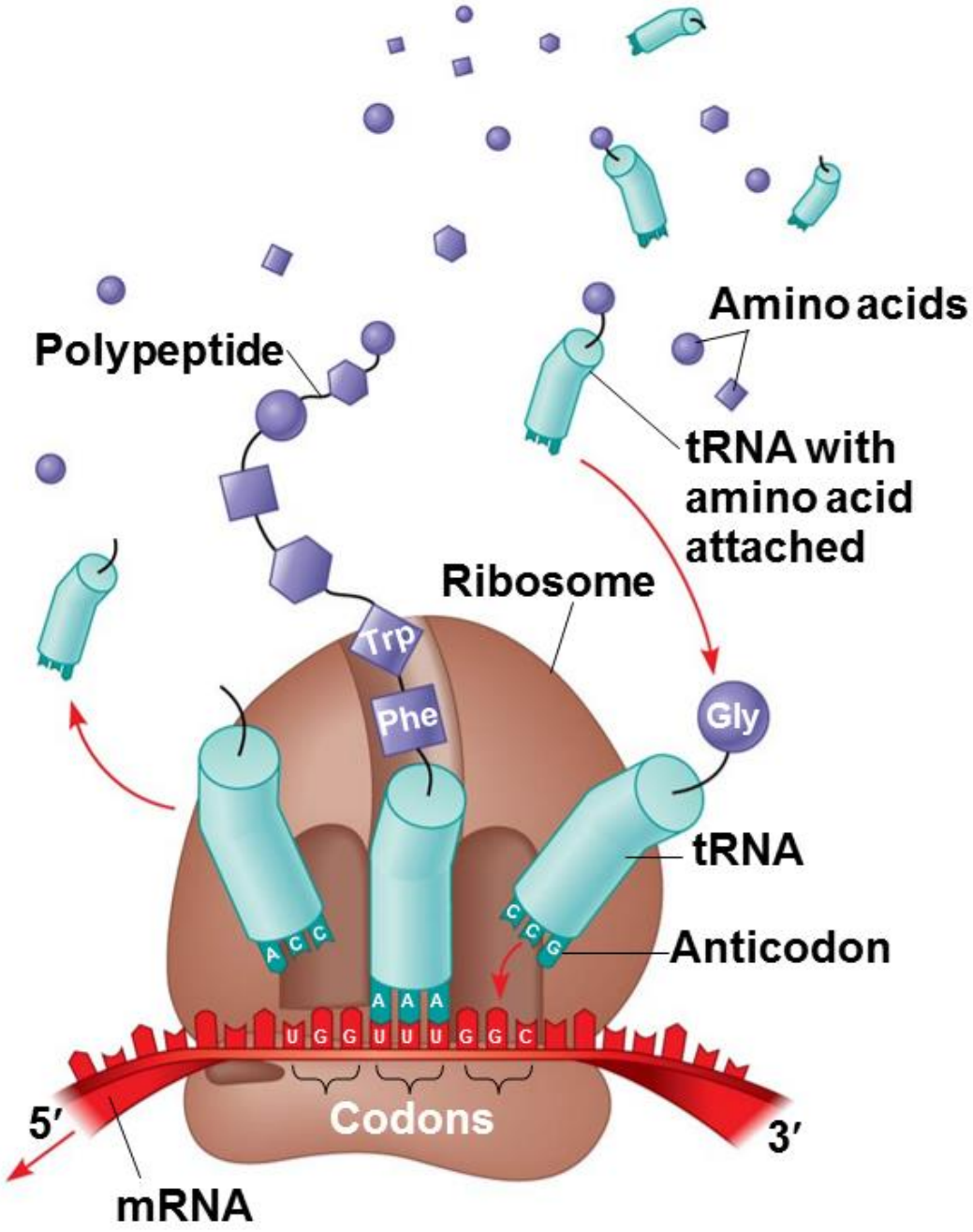
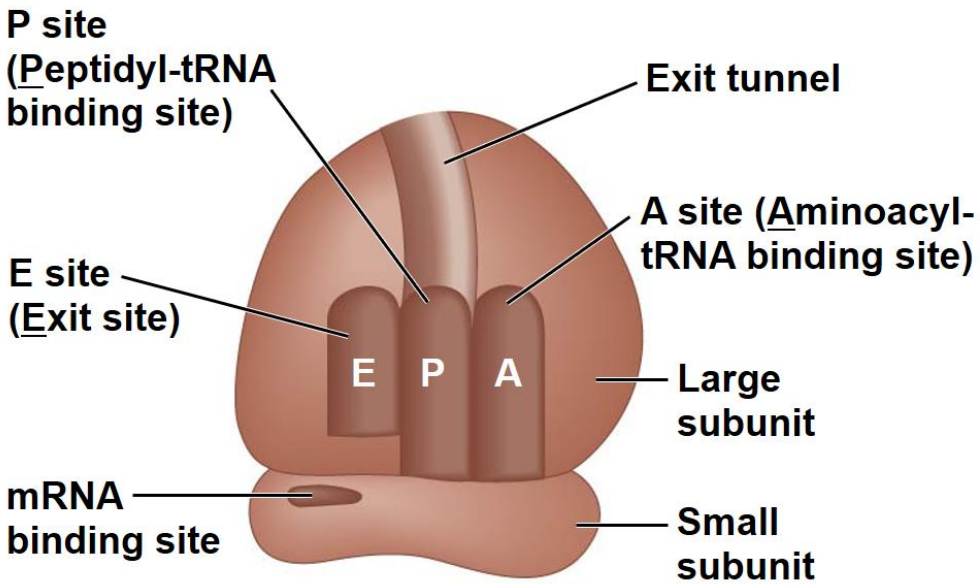
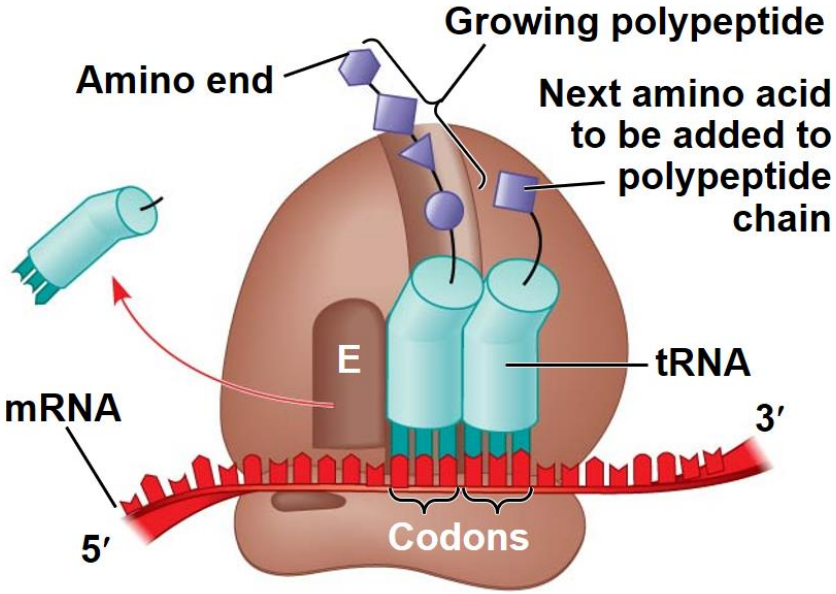

Amino acids
Polypeptide
tRNA with amino acid attached
Ribosome
Trp
Phe
Gly
tRNA
Anticodon
A C C
C C G
A A A
U G G U U U G G C
Codons
5′
3′
mRNA




(b) Schematic model showing binding sites




(c) Schematic model with mRNA and tRNA

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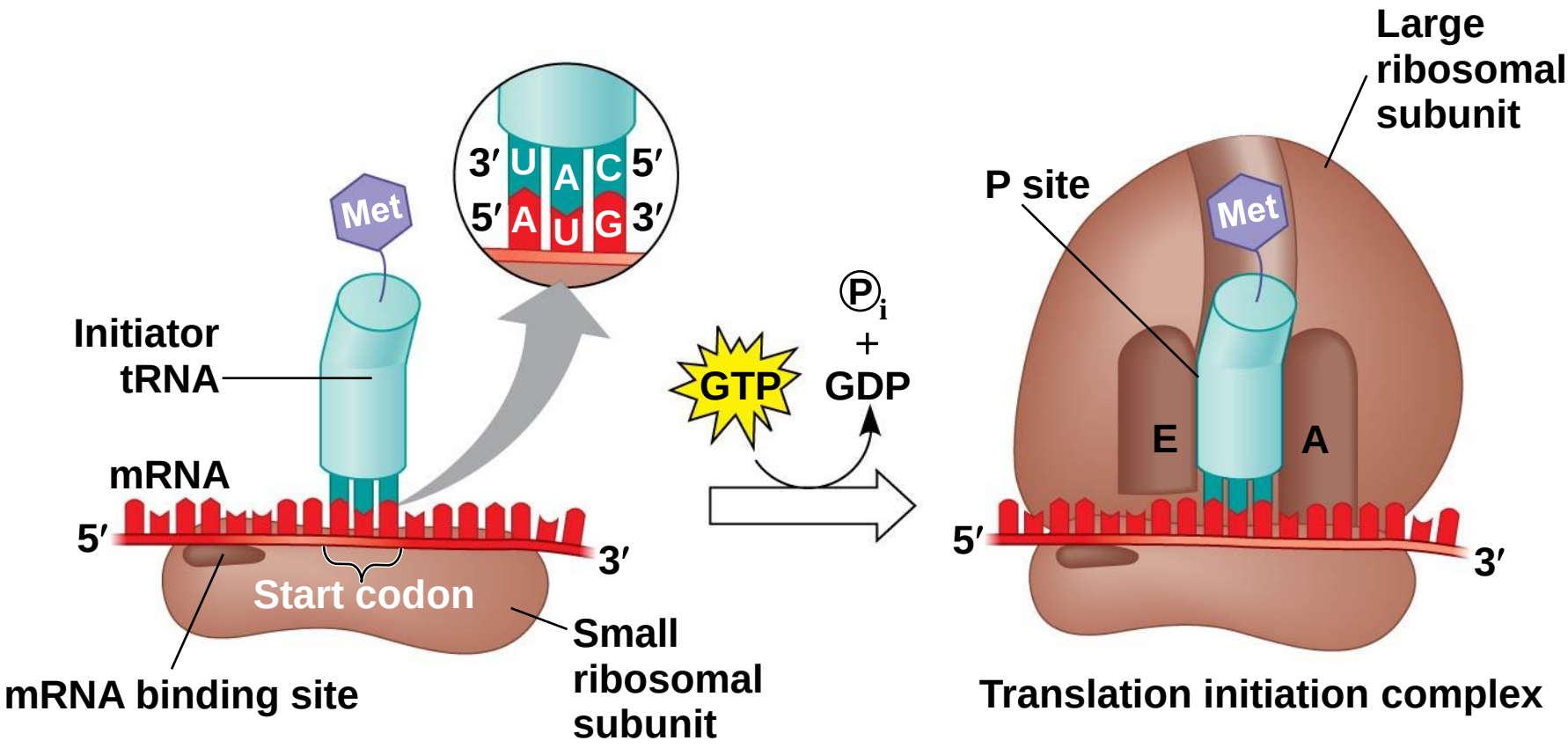
Figure 14.18

# Initiation




1 Small ribosomal subunit binds to mRNA.

2 Large ribosomal subunit completes the initiation complex.

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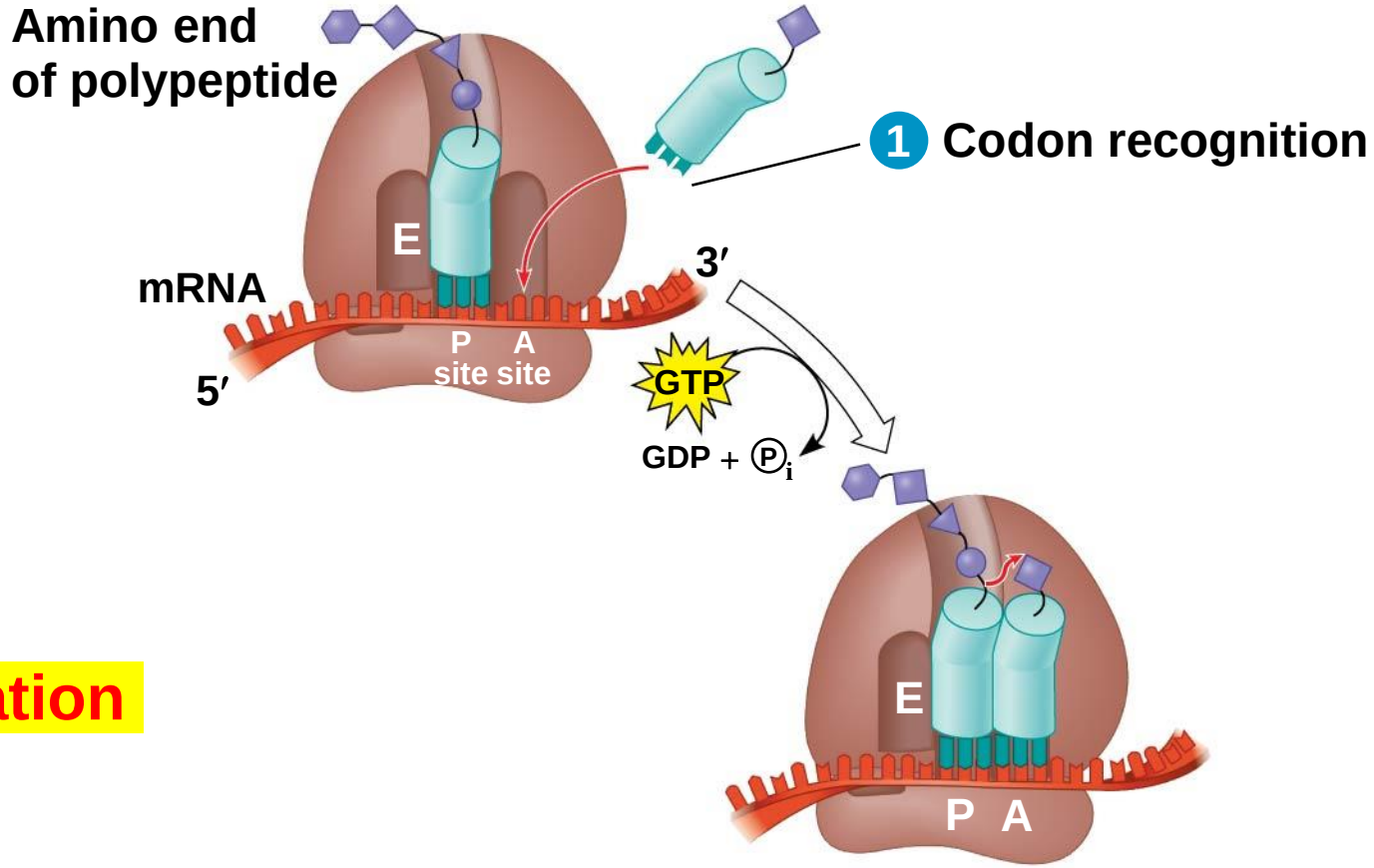
Figure 14.19-1




**Elongation**

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Figure 14.19-2

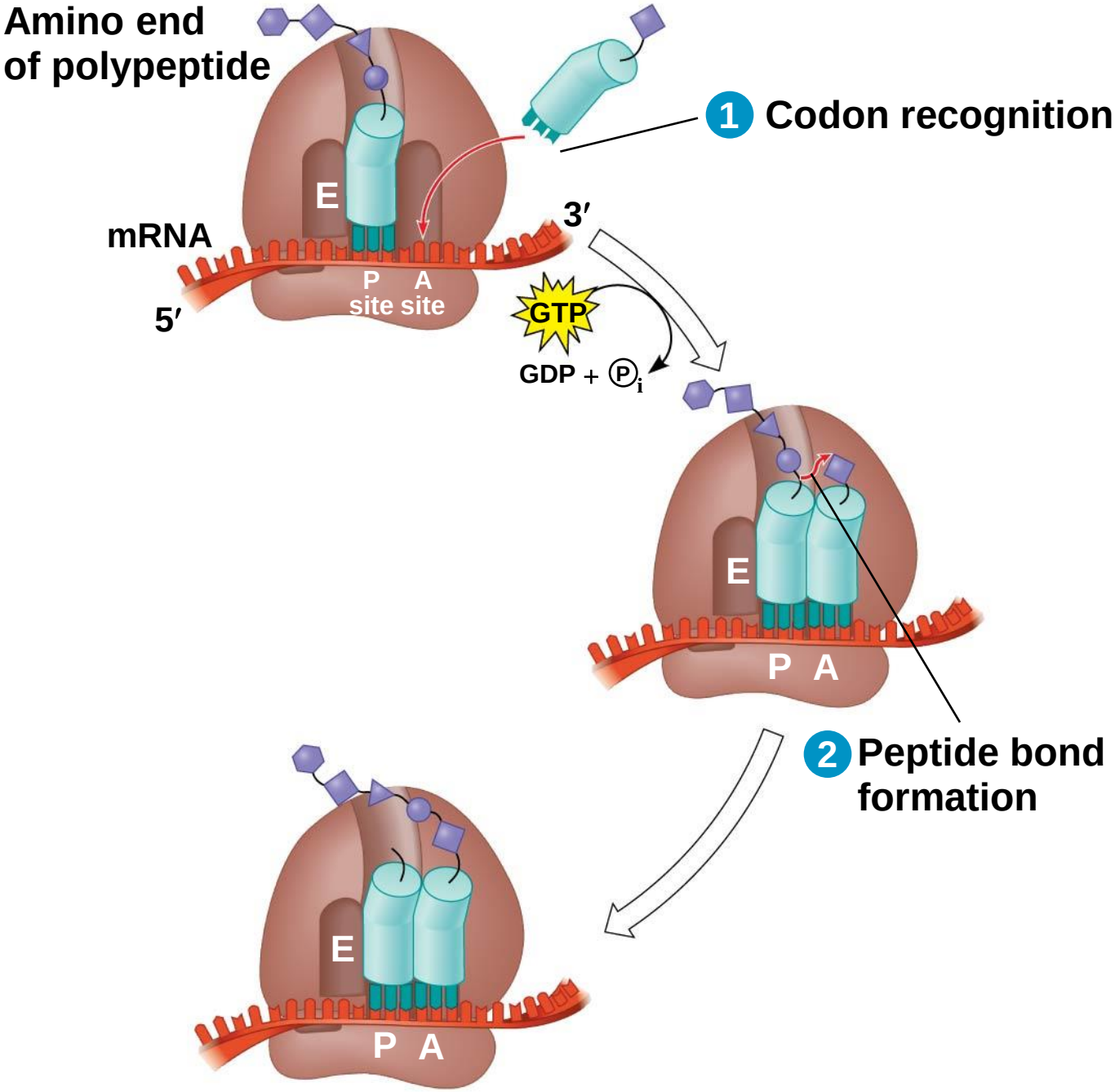


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Figure 14.19-3

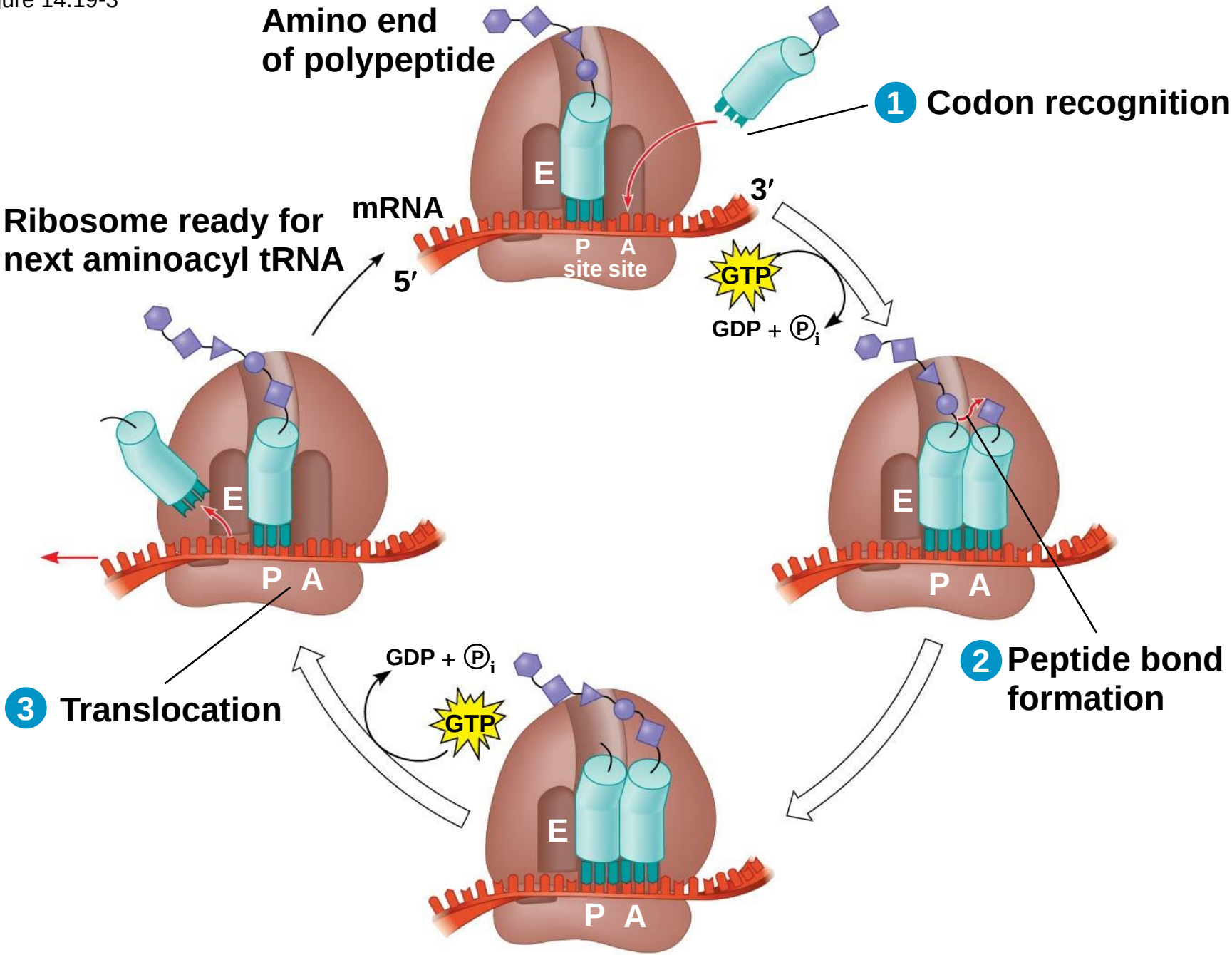


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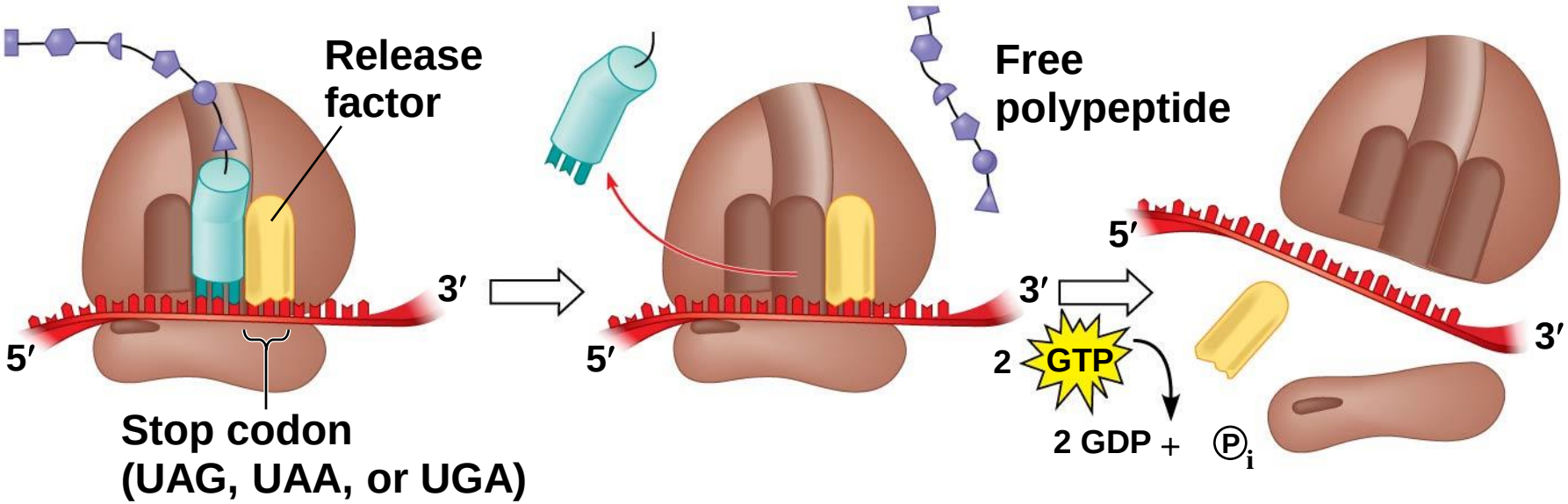
Figure 14.20-3

# Termination




1. Ribosome reaches a stop codon on mRNA.
2. Release factor promotes hydrolysis.
3. Ribosomal subunits and other components dissociate.

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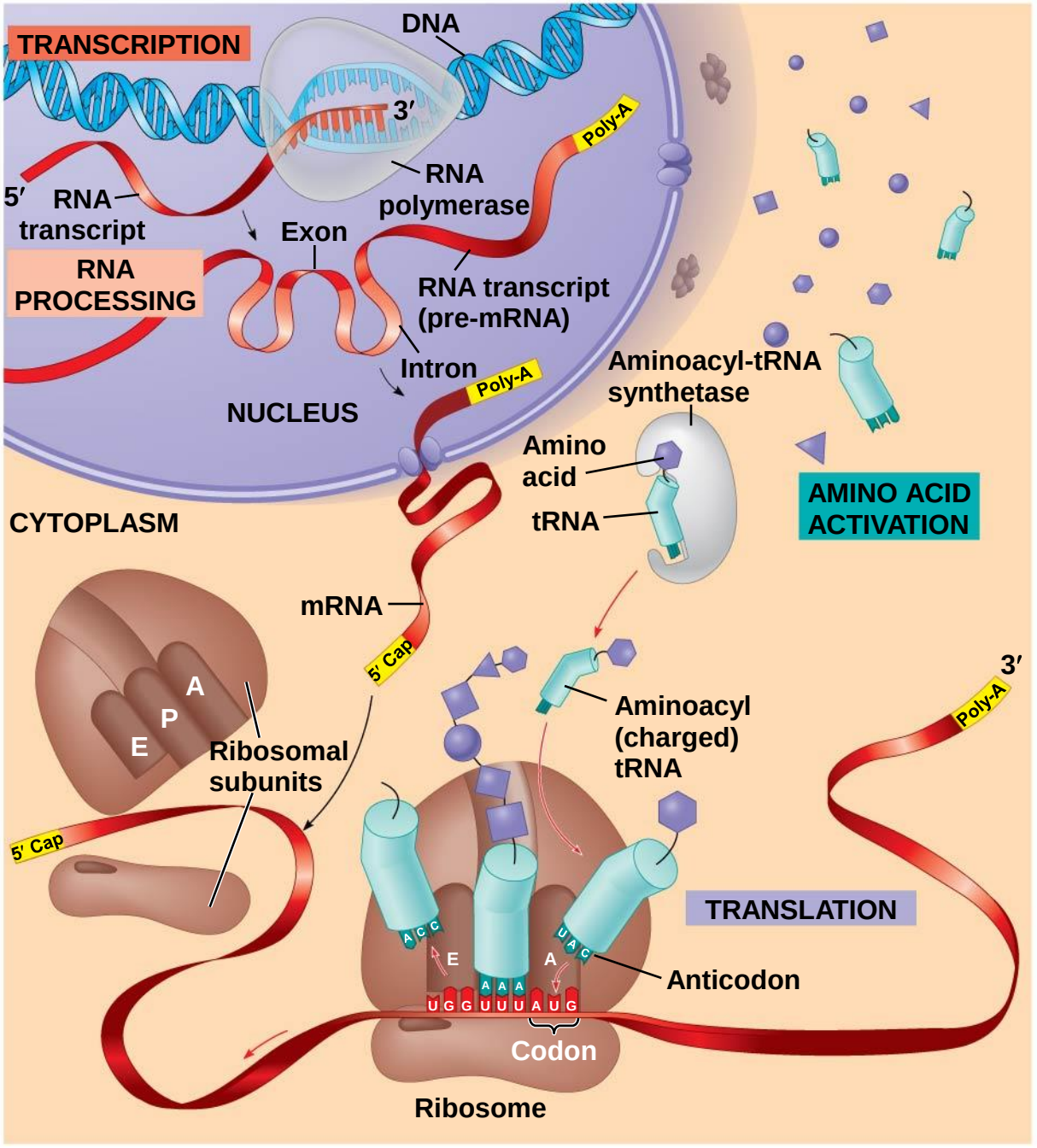
Figure 14.24

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**Objective:** You will be able to compare and contrast protein synthesis in eukaryotic and prokaryotic cells.

- **Do Now:**

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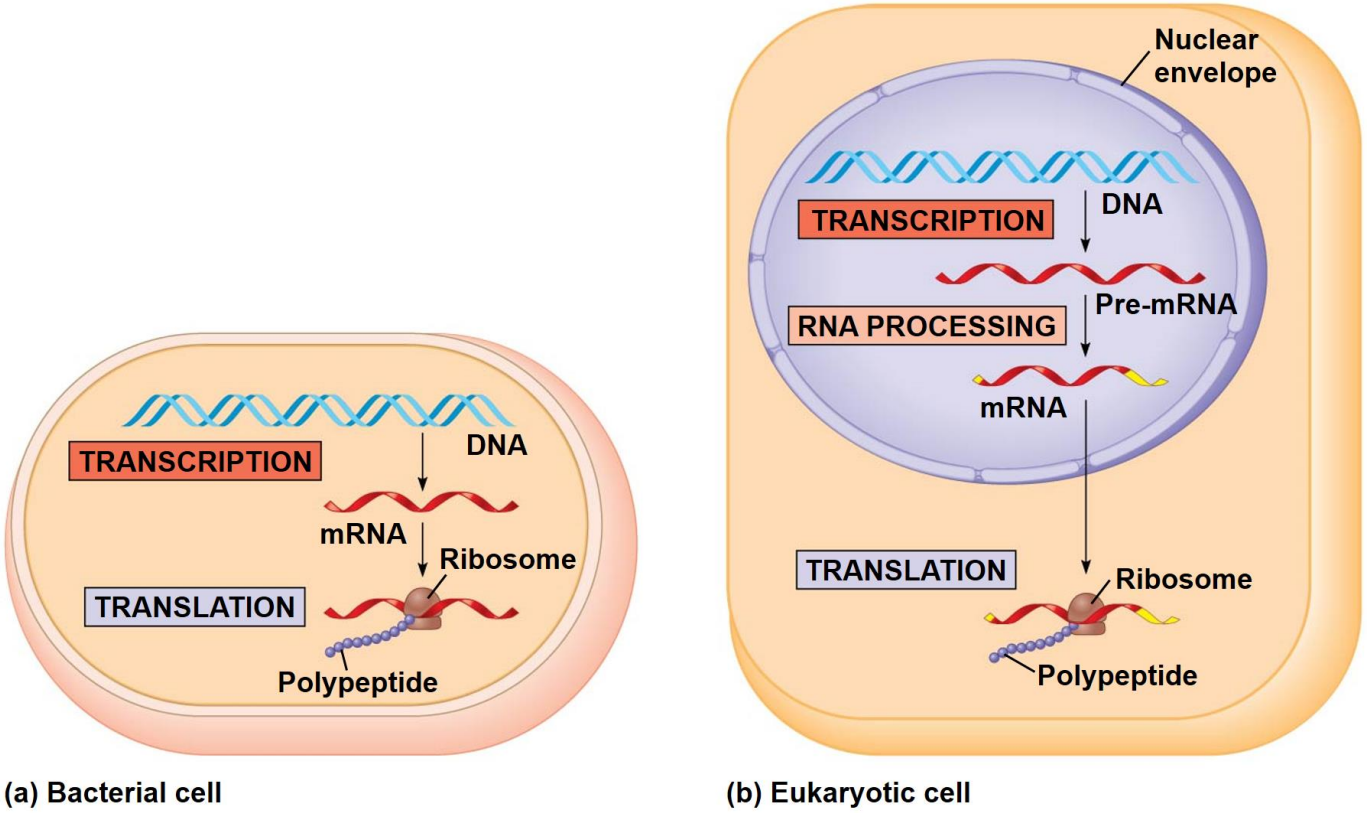
# Prokaryotic vs. Eukaryotic Protein Synthesis




- Compile a lost of similarities from your notes and t diagram above
- Compile a list of differences.

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# Differences

- In prokaryotic organisms, transcription is coupled to translation of the message.

- In eukaryotic cells the mRNA transcript undergoes a series of enzyme-regulated modifications.
    - Addition of a poly-A tail
    - Addition of a GTP cap
    - Excision of introns

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**Phenotypes** are determined through protein activities.

- Synthesis
- Transport by proteins
- Enzymatic reactions
- Degradation

➢ Using your knowledge of biology, how would you explain the difference between eye color in humans?

➢ Sickle cell RBC versus normal

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**Objective:** You will be able to explain how heritable information can be manipulated by using restriction enzymes and gel electrophoresis.

- **Do Now:**

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Genetic engineering techniques can manipulate the heritable information of DNA and, in special cases, RNA.

- Restriction enzyme analysis of DNA
- Electrophoresis
- Plasmid-based transformation
- Polymerase Chain Reaction (PCR)

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# Using Restriction Enzymes to Make Recombinant DNA

- Bacterial **restriction enzymes** cut DNA molecules at specific DNA sequences called **restriction sites**

- A restriction enzyme usually makes many cuts, yielding **restriction fragments**

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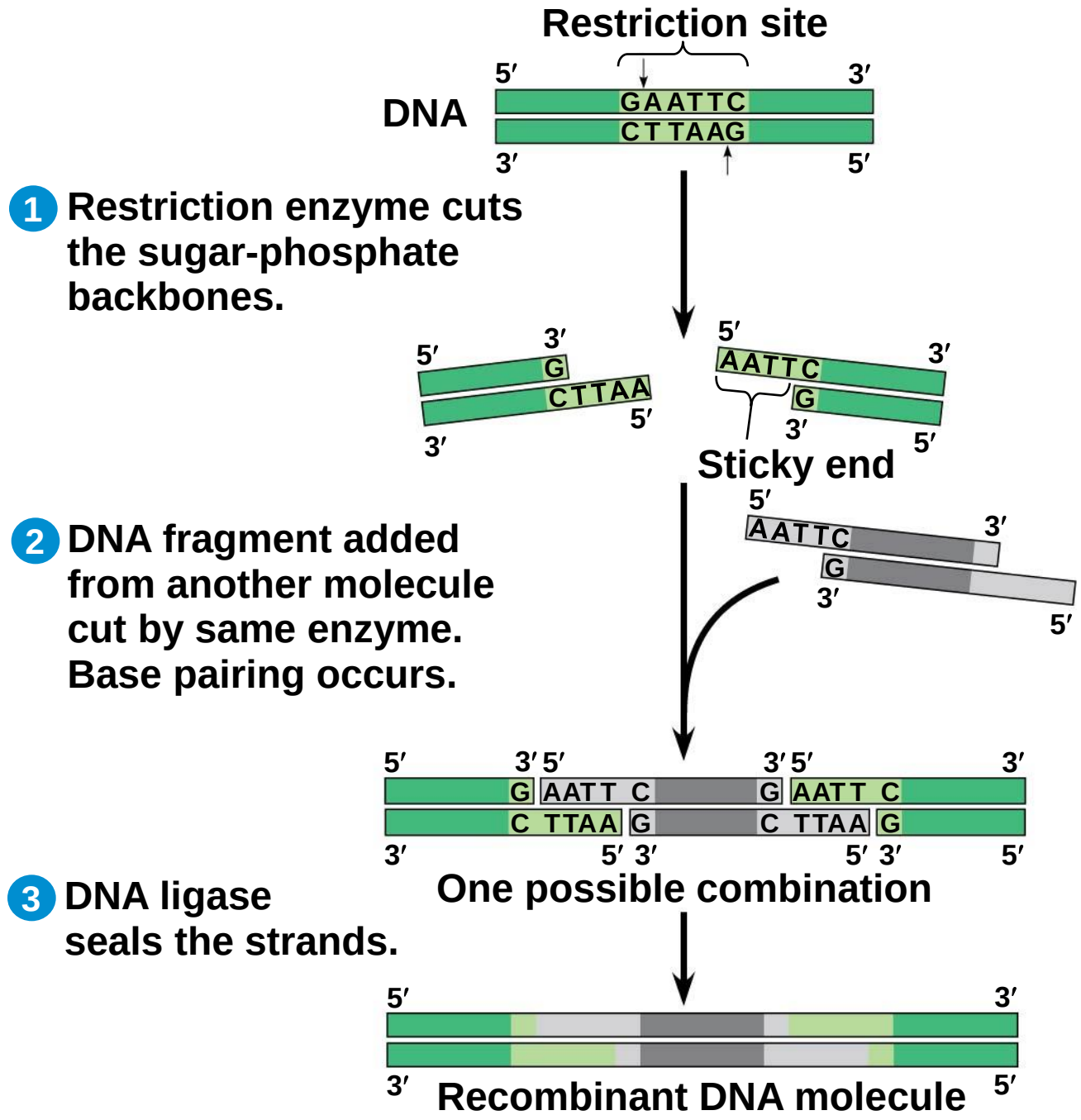
Figure 13.23-3

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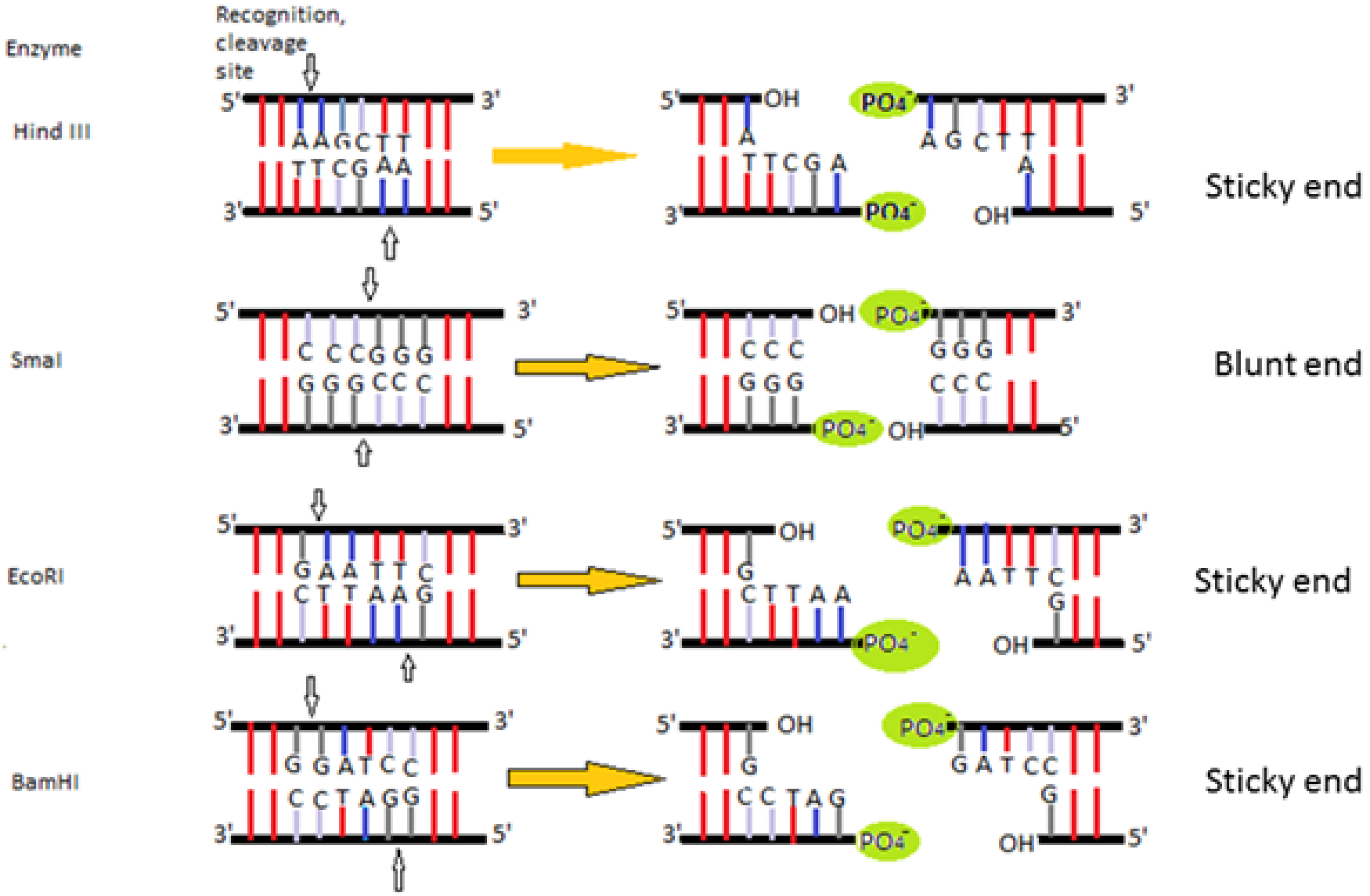


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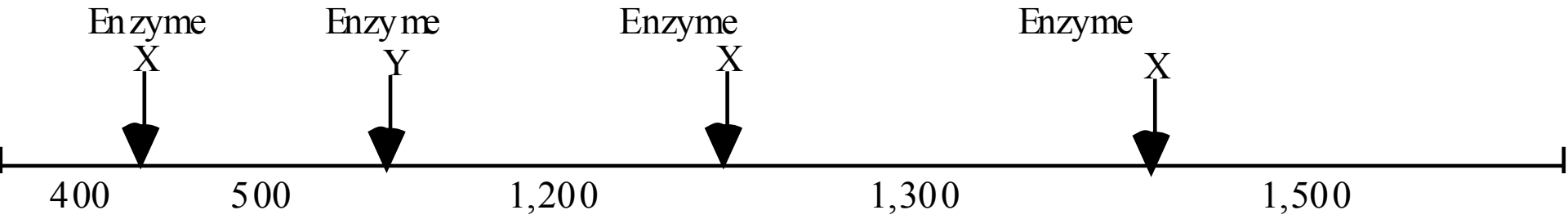


(A) Explain how the principles of gel electrophoresis allow for the separation of DNA fragments.

(B) Describe the results you would expect from the electrophoretic separation of fragments from the following treatments of the DNA segment above. Assume that the digestion occurred under appropriate conditions and went to completion.

I. DNA digested with only enzyme X
II. DNA digested with only enzyme Y
III. DNA digested with enzyme X and enzyme Y combined
IV. Undigested DNA

(C) Explain both of the following.

(1) The mechanism of action of restriction enzymes.
(2) The different results you would expect if a mutation occurred at the recognition site for enzyme Y.

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- Researchers use **gel electrophoresis** to separate restriction fragments
    - Fragments separate based on length
    - Occurs because DNA has a negative charge

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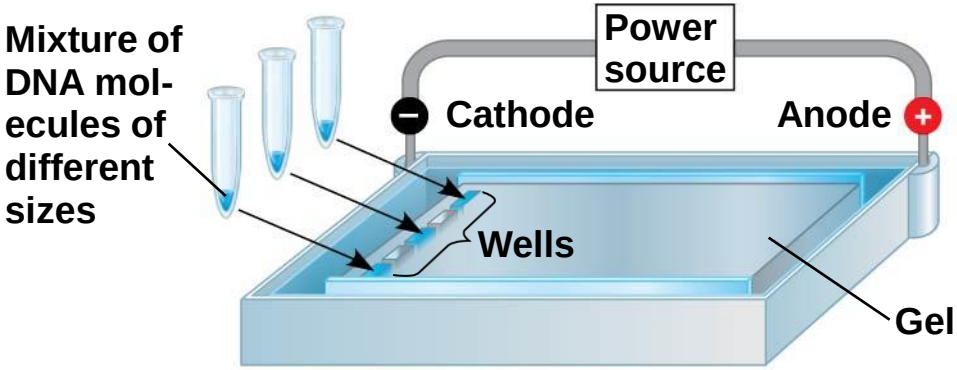
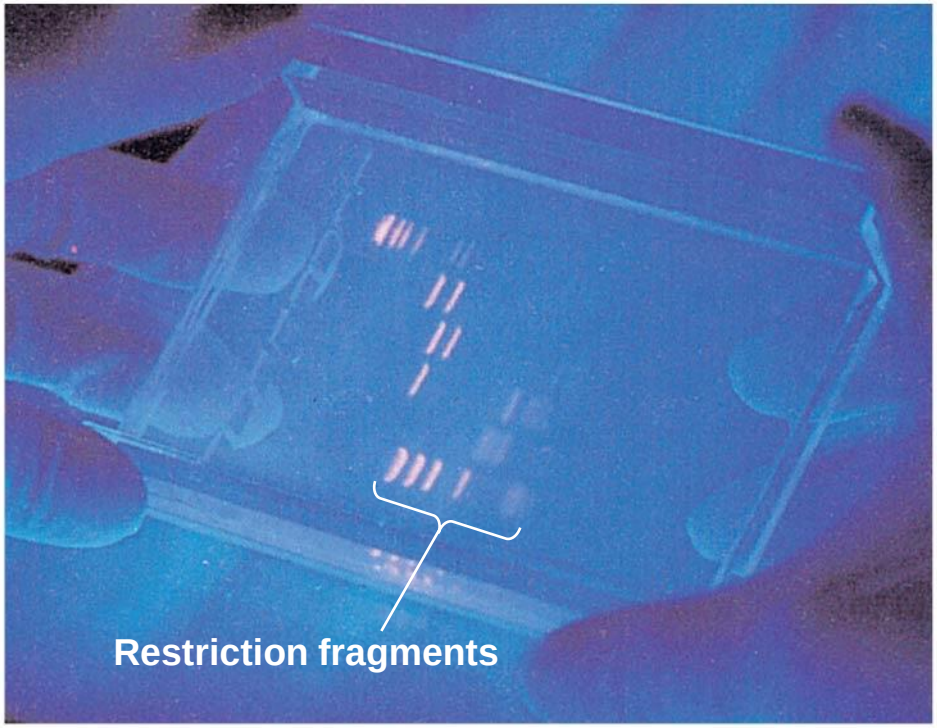
Figure 13.24




(a) Negatively charged DNA molecules will move toward the positive electrode.




(b) Shorter molecules are impeded less than longer ones, so they move faster through the gel.

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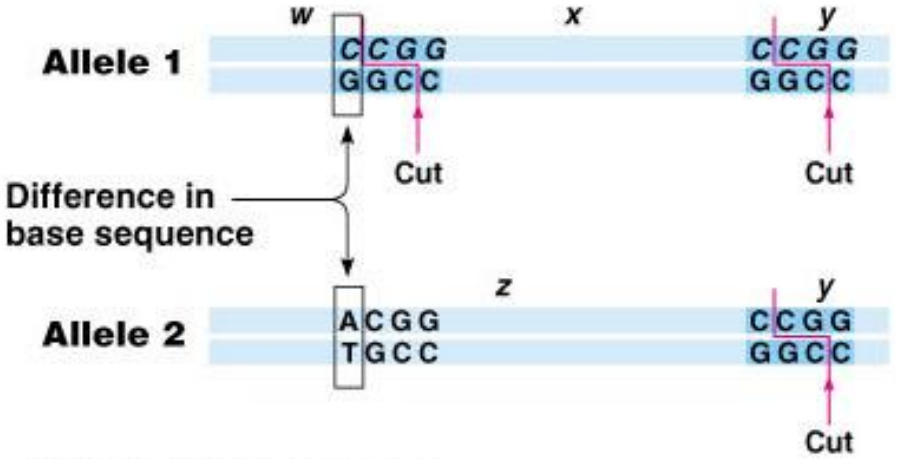
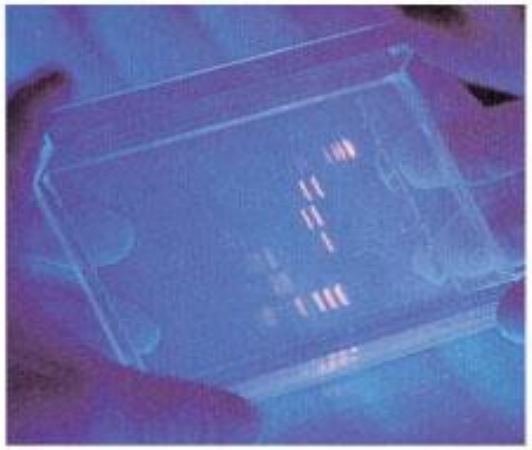
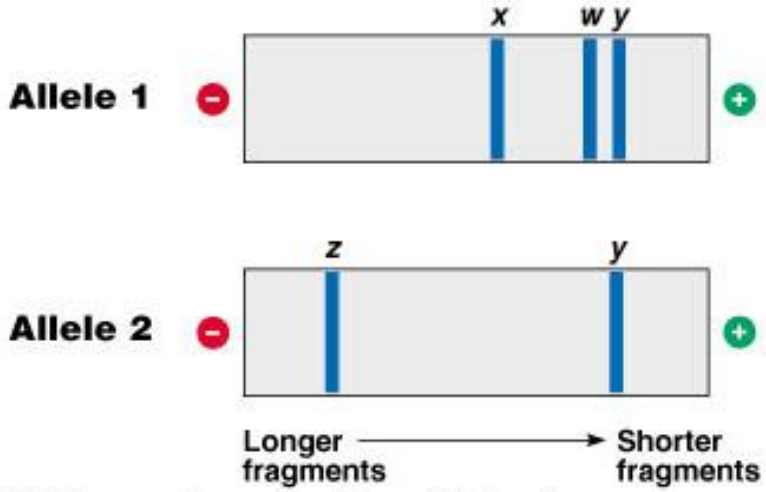
Figure 20.9 Using restriction fragment patterns to distinguish DNA from different alleles




(a) DNA from two alleles



(c) Completed gel




(b) Electrophoresis of restriction fragments

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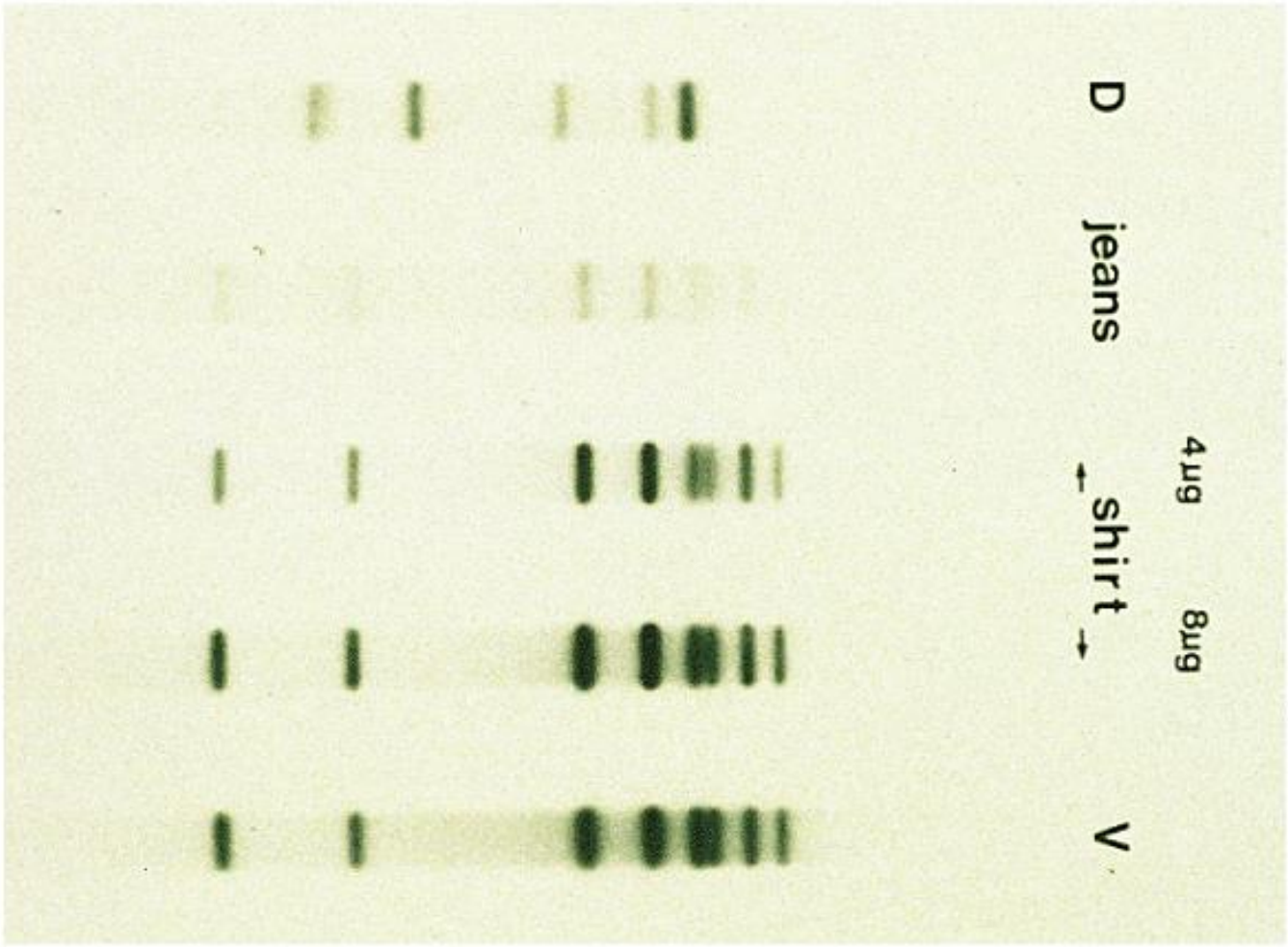
Figure 20.17 DNA fingerprints from a murder case

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**Objective:** You will be able to explain how heritable information can be manipulated by using the polymerase chain reaction.

- **Do Now:**

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# The Polymerase Chain Reaction (PCR)

- The **polymerase chain reaction**, **PCR**, can produce many identical copies of a fragment of DNA

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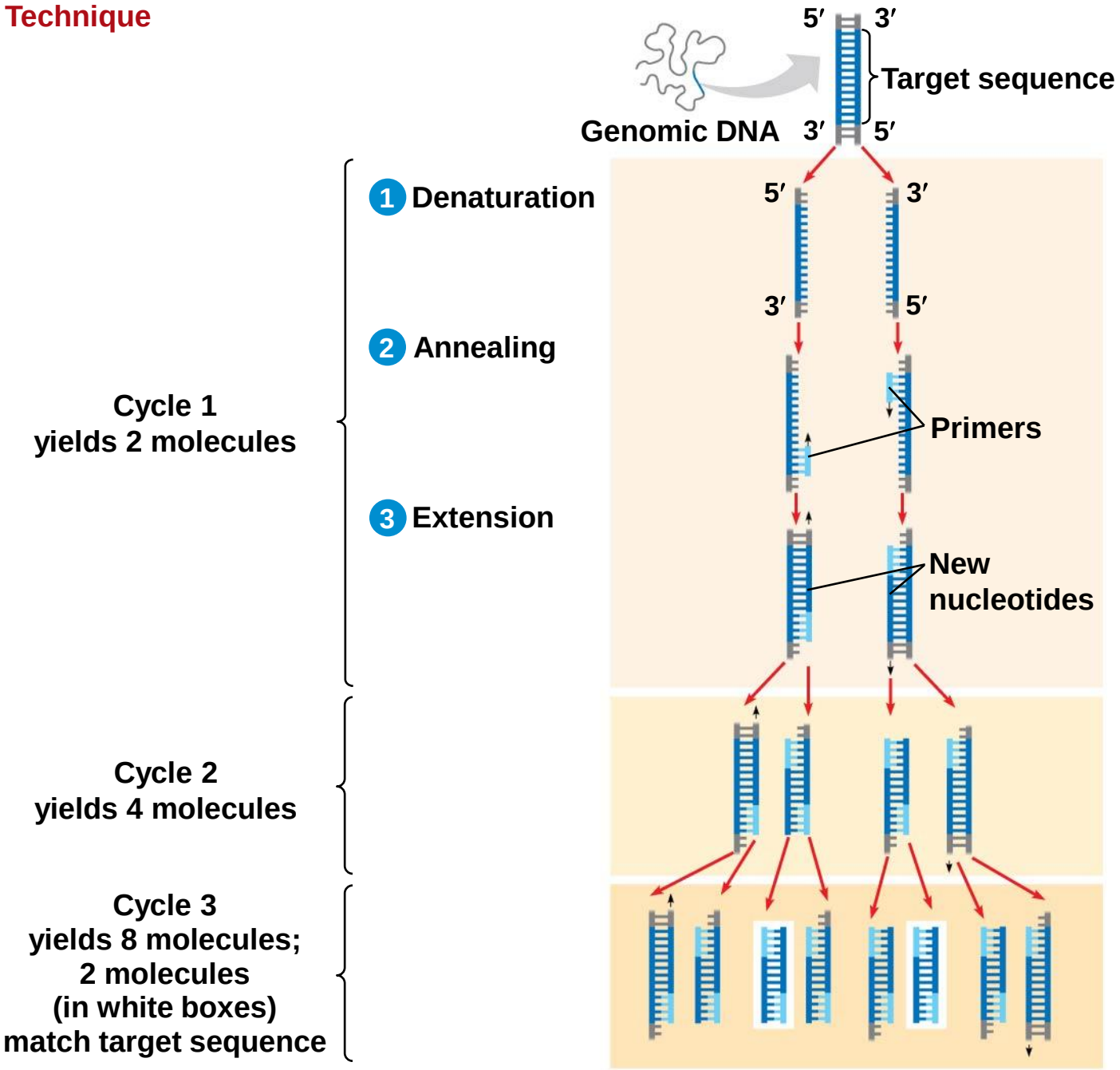
Figure 13.25

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**Objective:** You will be able to explain how heritable information can be manipulated by plasmid-based transformation.

- **Do Now:**

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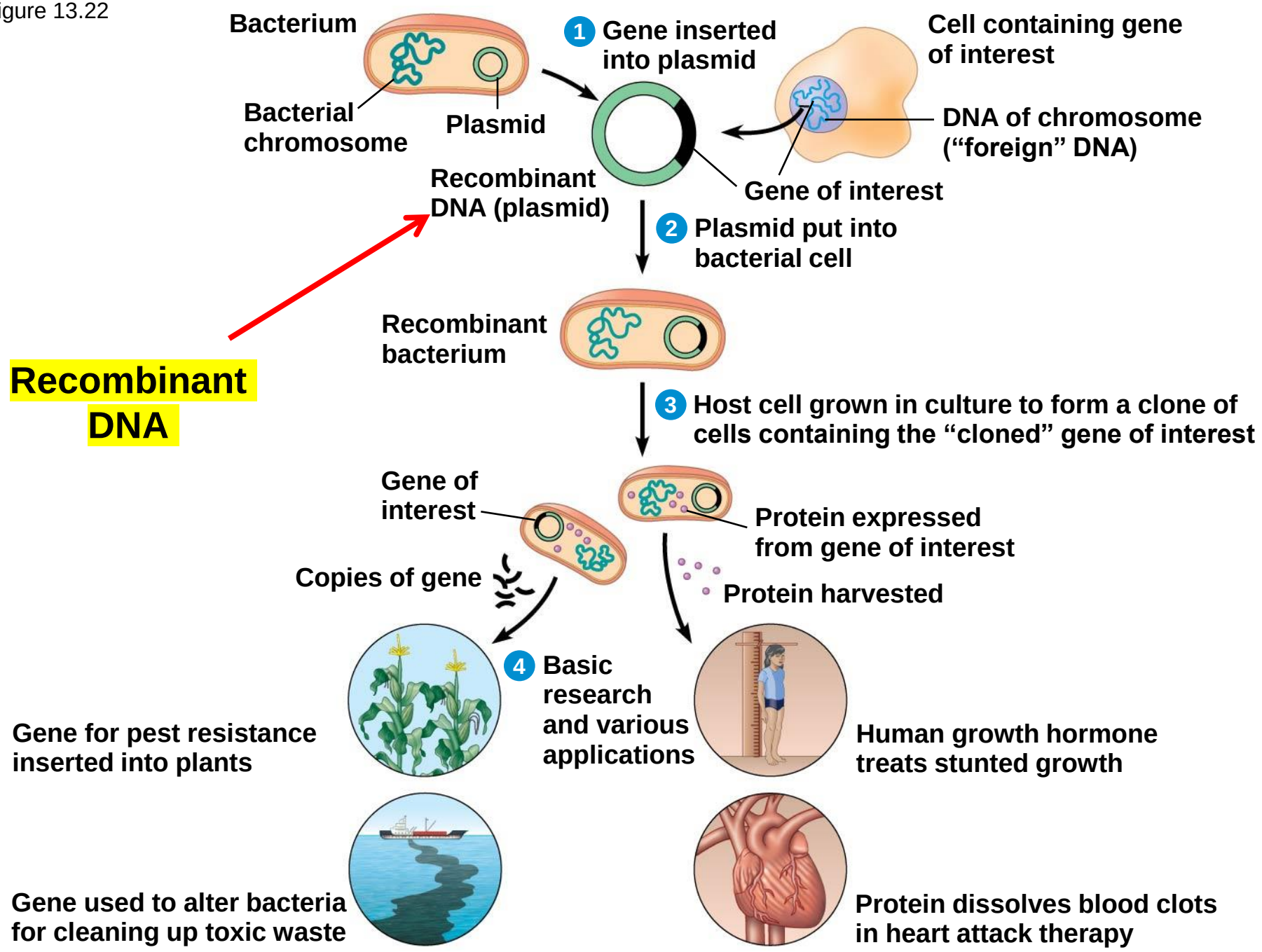
Figure 13.22

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# Examples of products of genetic engineering include:

- Pharmaceuticals, such as human insulin
- Genetically modified foods
- Transgenic animals
- Cloned animals

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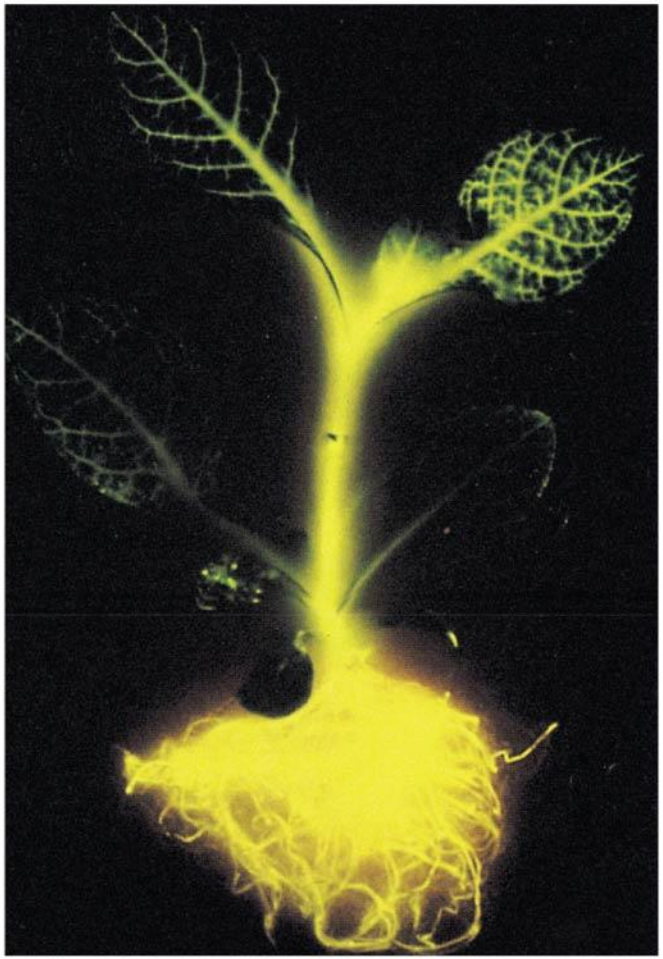
Figure 14.7

# Transgenic Organisms



(a) Tobacco plant expressing a firefly gene

(b) Pig expressing a jellyfish gene

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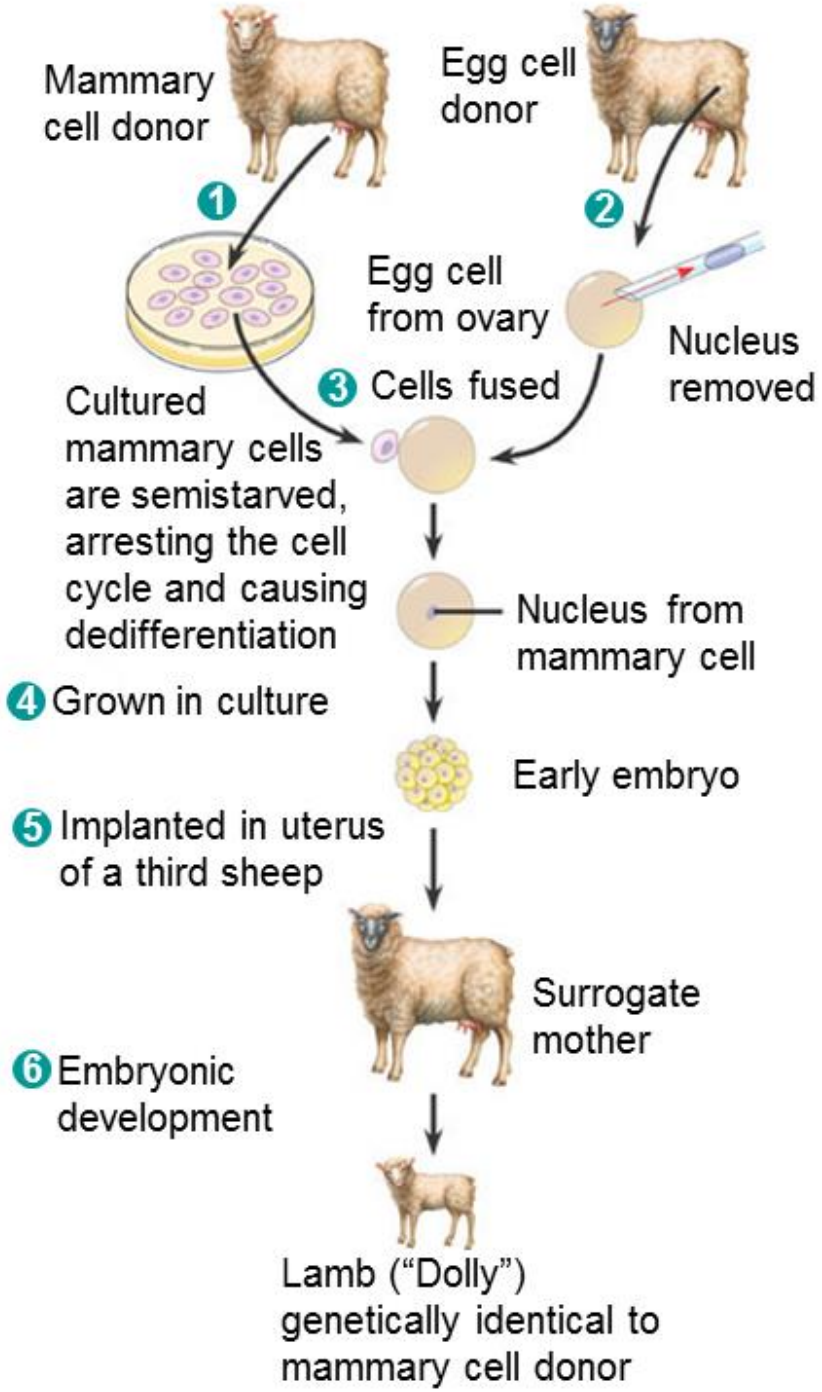
# Reproductive Cloning of a Mammal by Nuclear Transplantation

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