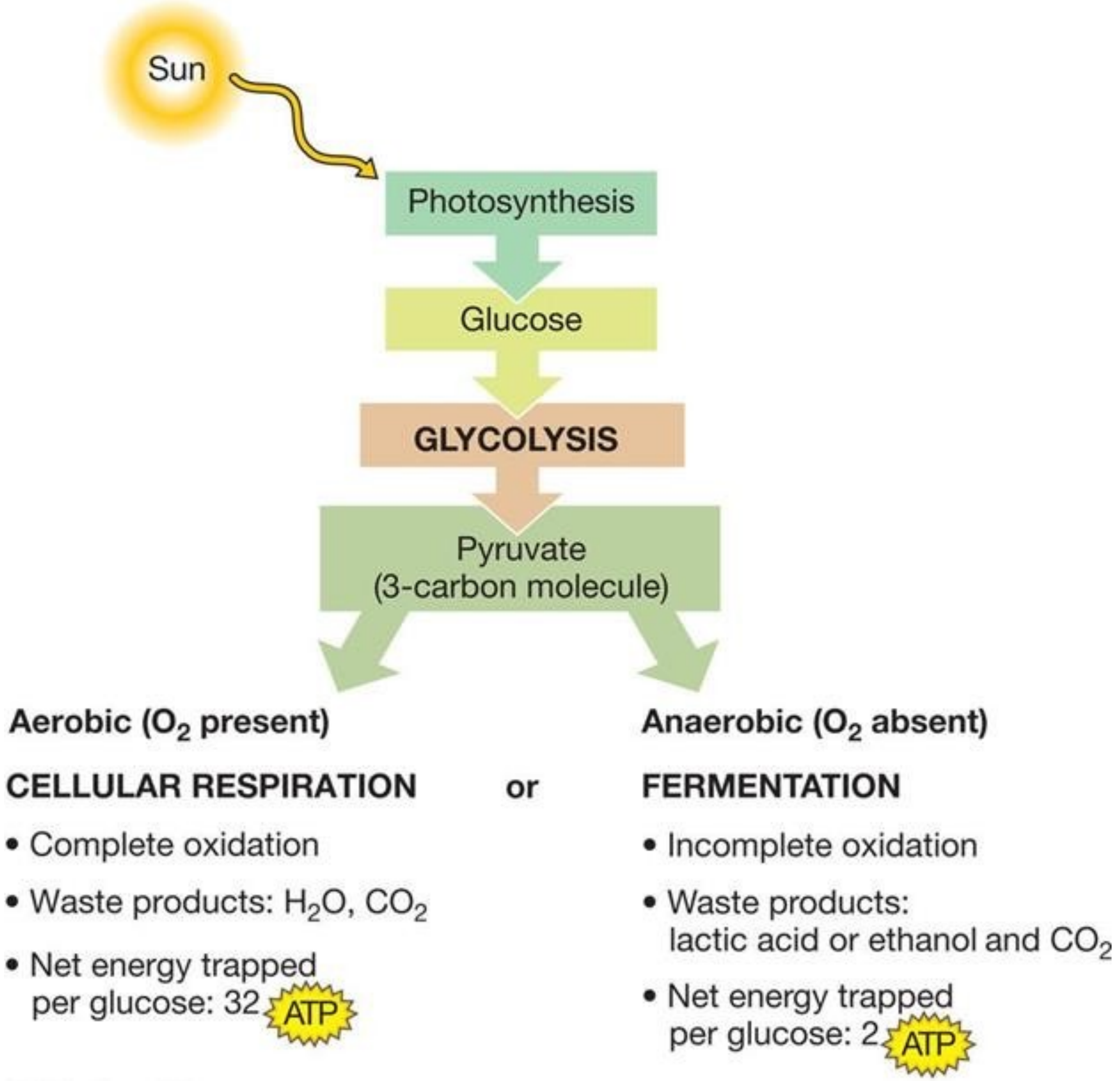
# Cellular Respiration

Chapter 9

# Energy and Metabolism

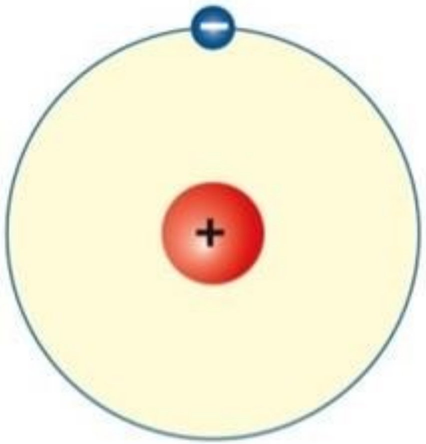


# Oxidation-Reduction Reactions

**Oxidation** is a loss of electrons.

**Reduction** is the gain of electrons.

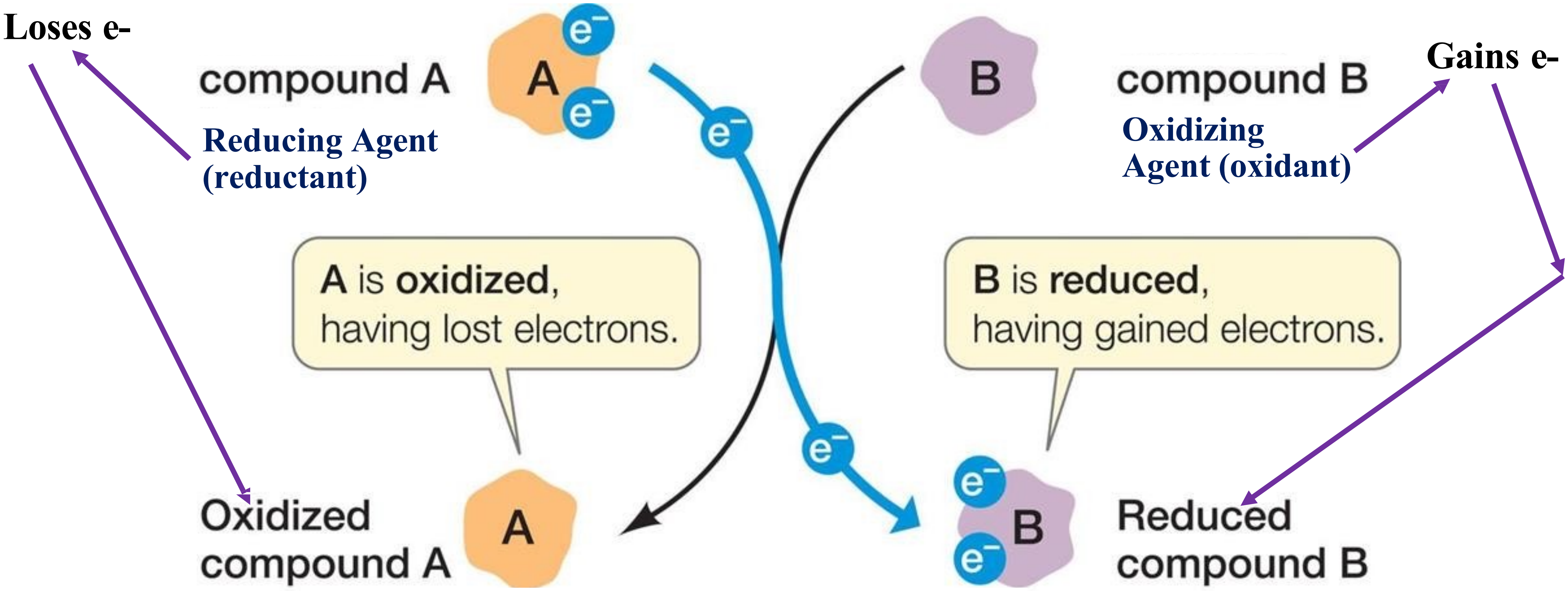
- Electrons may be transferred as:
  - free electrons $e^-$
  - hydrogen atoms ($H = H^+ + e^-$)



**What is this electron-shell diagram of?**

# Oxidation-Reduction Reactions

**oxidation is usually exergonic, reduction is usually endergonic.**




**Oxidation** is a loss of electrons.

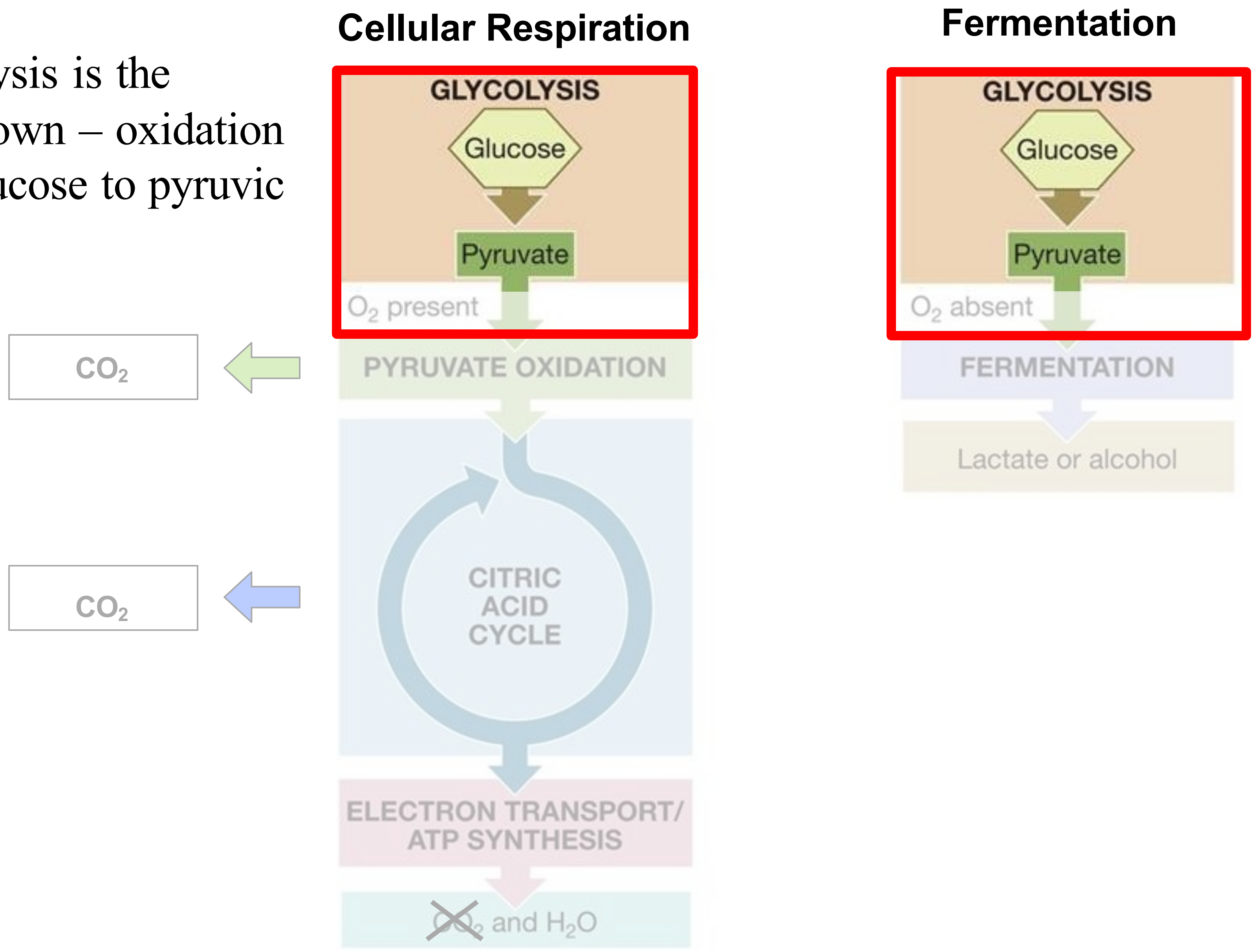
**Reduction** is the gain of electrons.

# Glycolysis

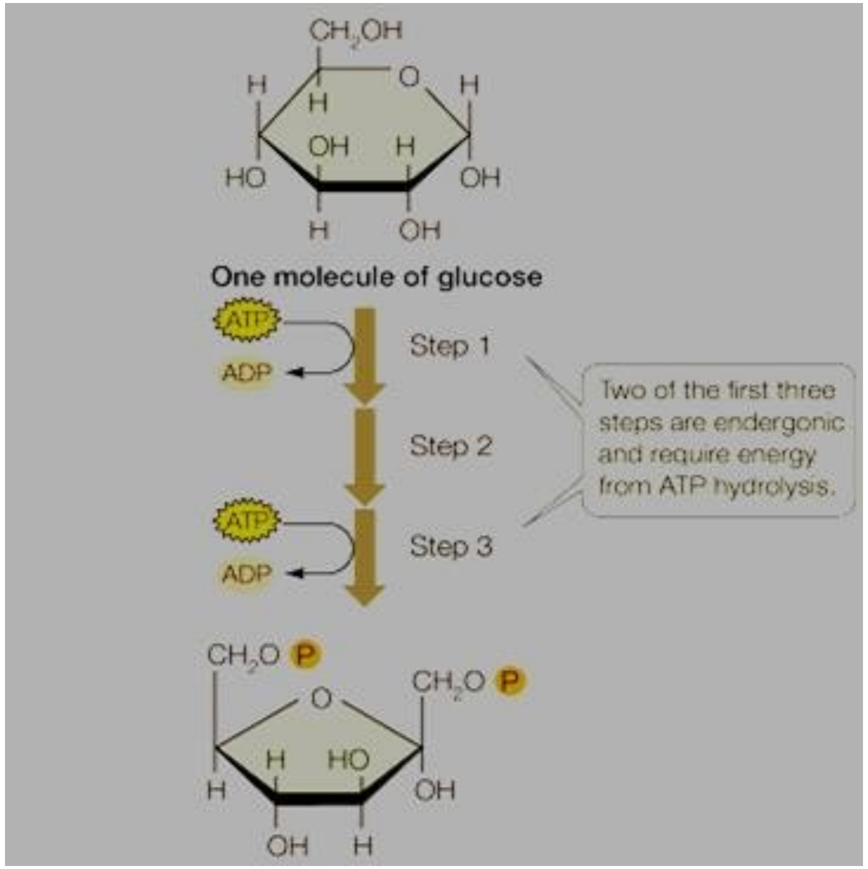
(Gk. glykys = sweet, lysis = unfastening)

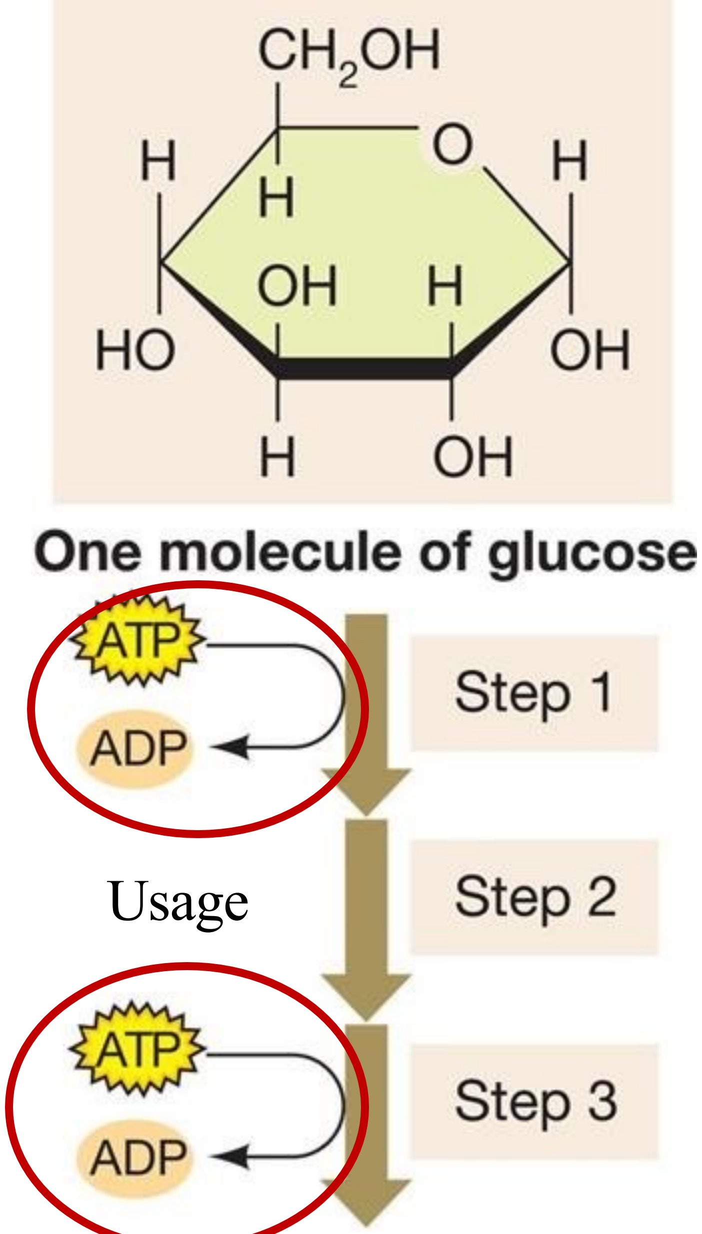
# Energy and Metabolism

Glycolysis is the breakdown – oxidation – of glucose to pyruvic acid.



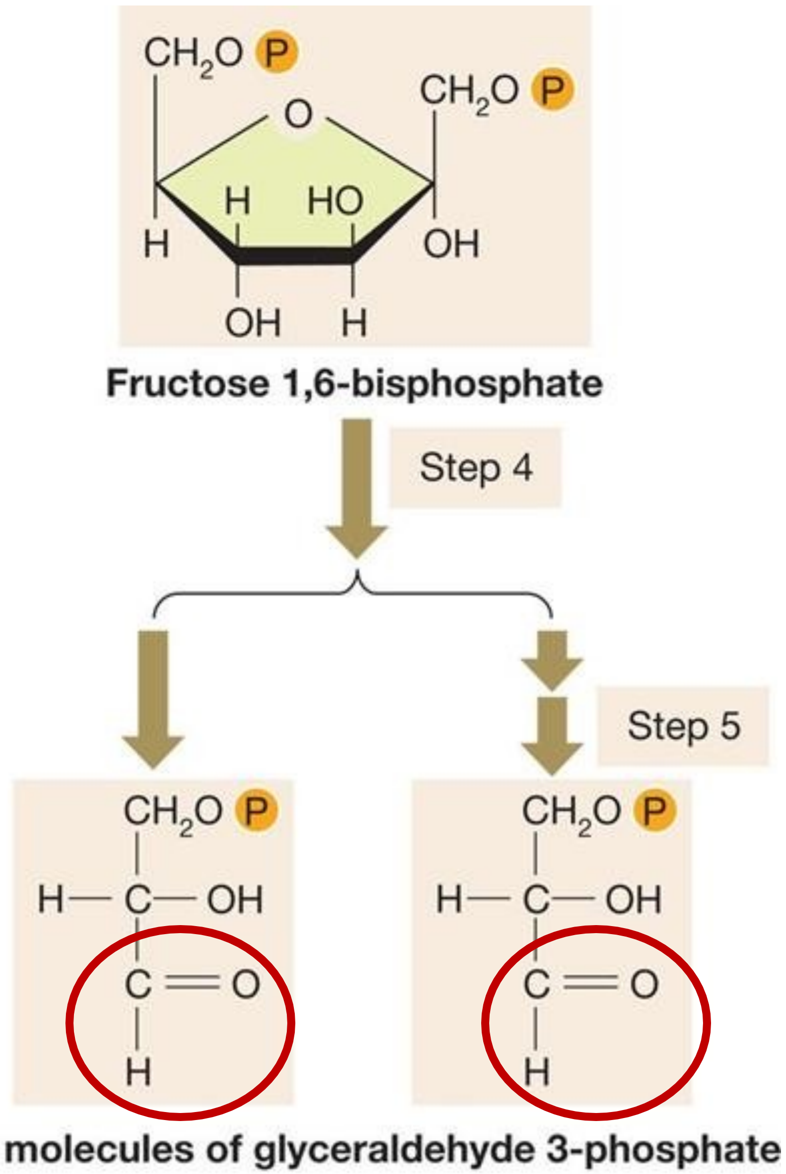
# Glycolysis: Energy Investing Steps

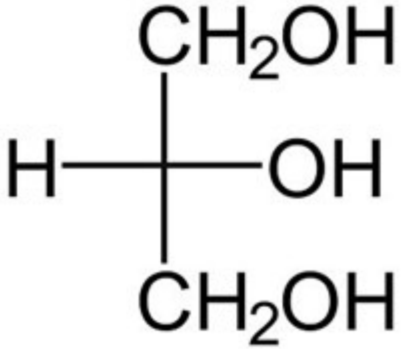


# Glycolysis: Formation of Two 3-Carbon Sugar

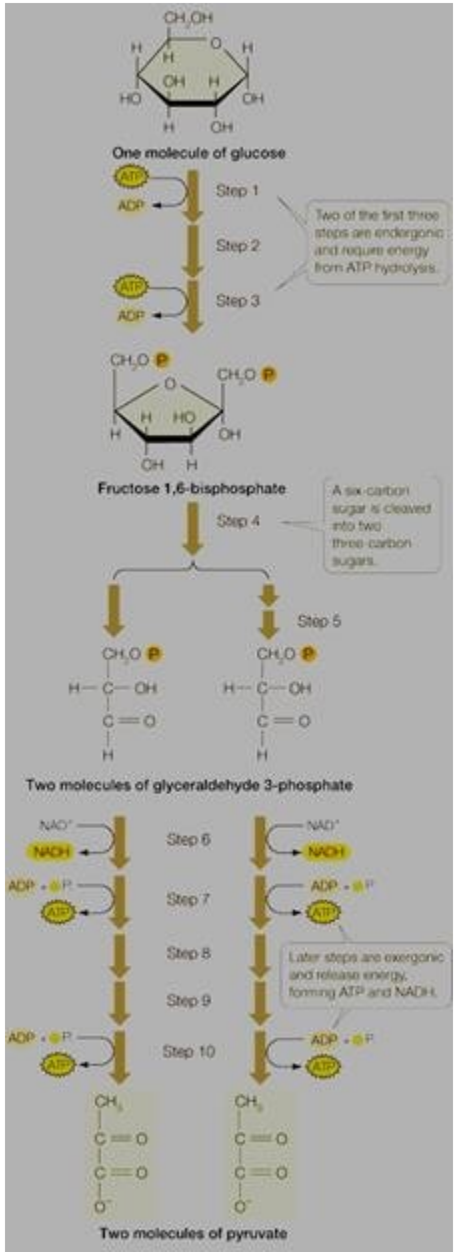
Fructose = 6C sugar

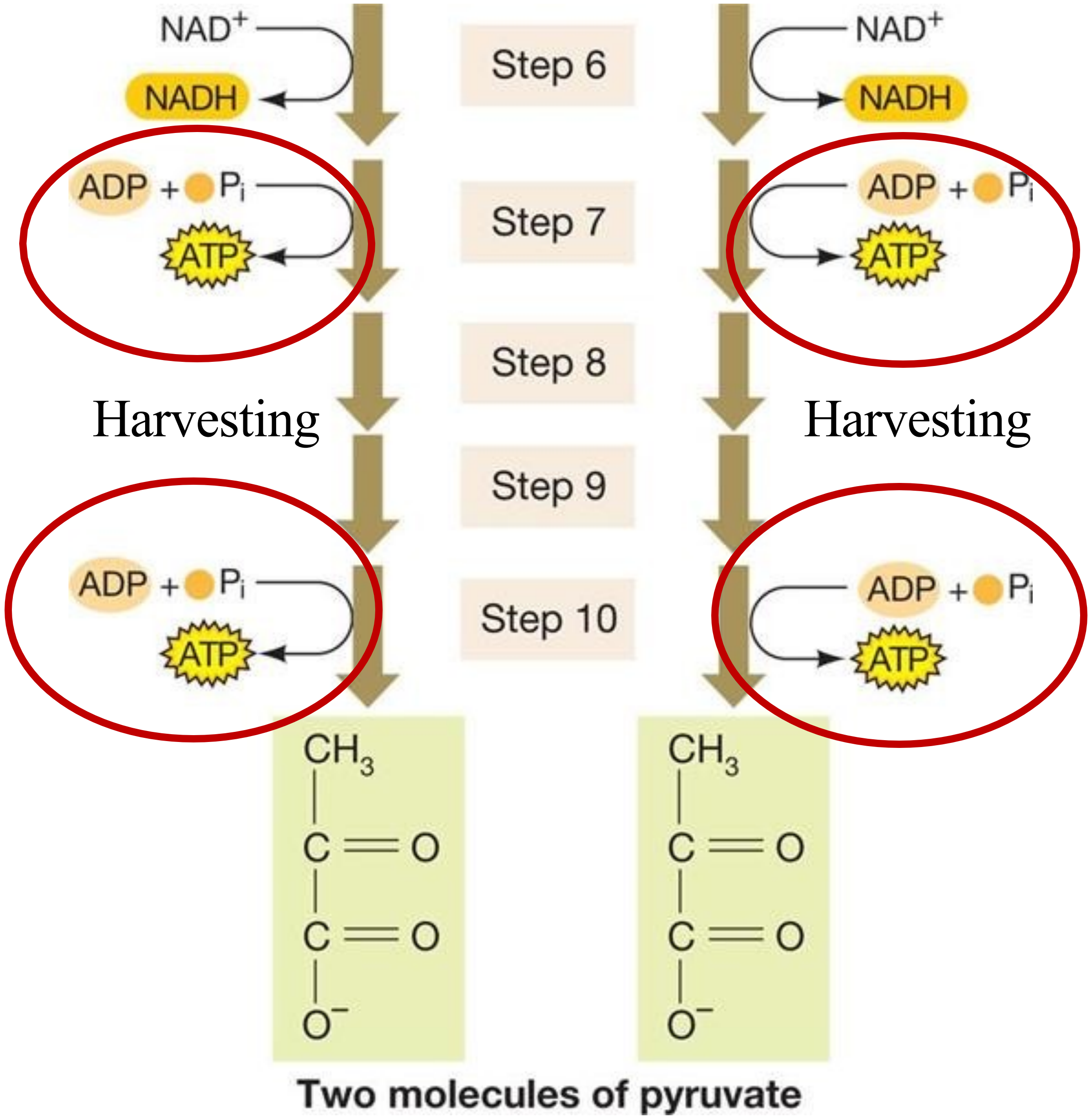


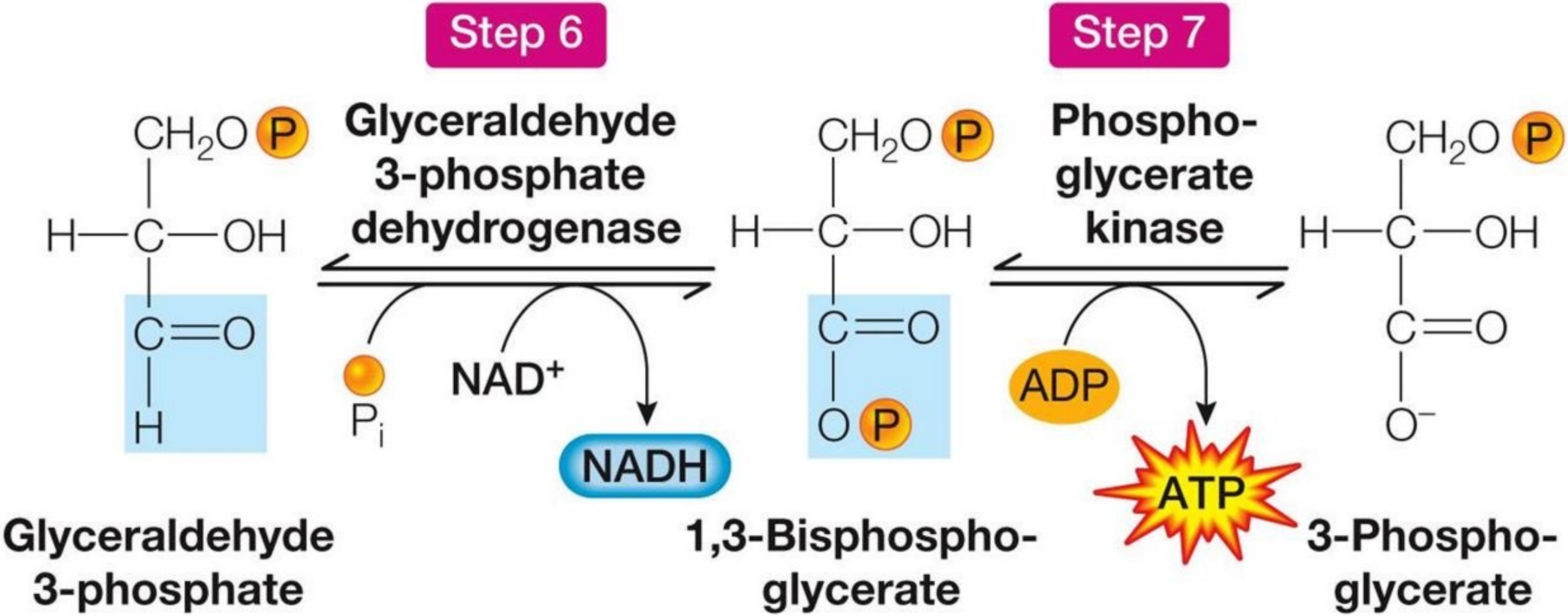



Glycerol

# Glycolysis: Energy Harvesting Steps






*LIFE: THE SCIENCE OF BIOLOGY 11e*, In-Text Art, Ch. 9, p. 177 (1)

# *The Balance Sheet of Glycolysis*

How many molecules of ATP do we **use** during glycolysis?

**2 ATPs**

How many molecules of ATP do we **gain** during glycolysis?

**4 ATPs**

What is the net gain of ATP from glycolysis?

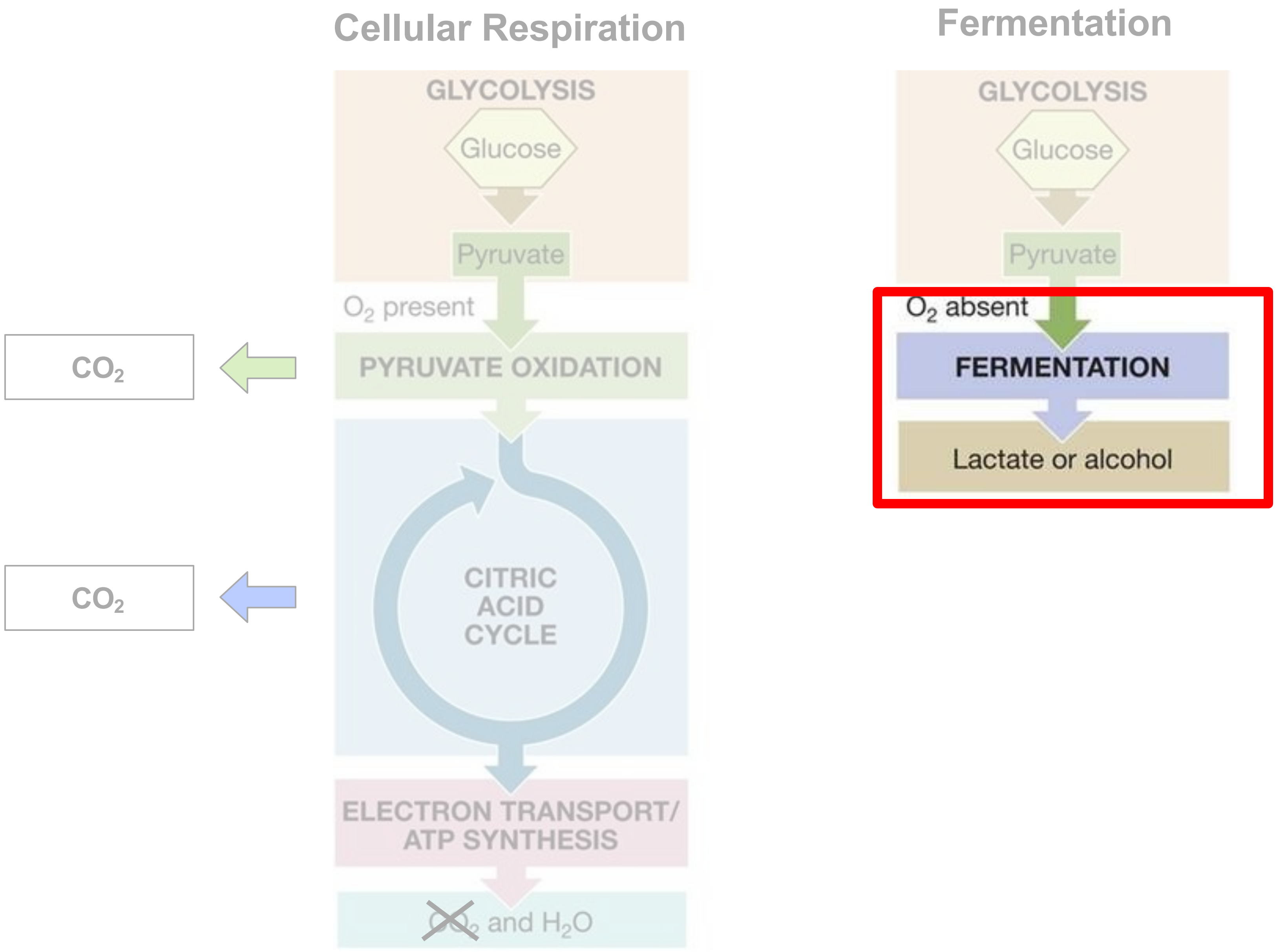
**2 ATPs**

4 - 2 = 2

How many pyruvate molecules produced?

**2**

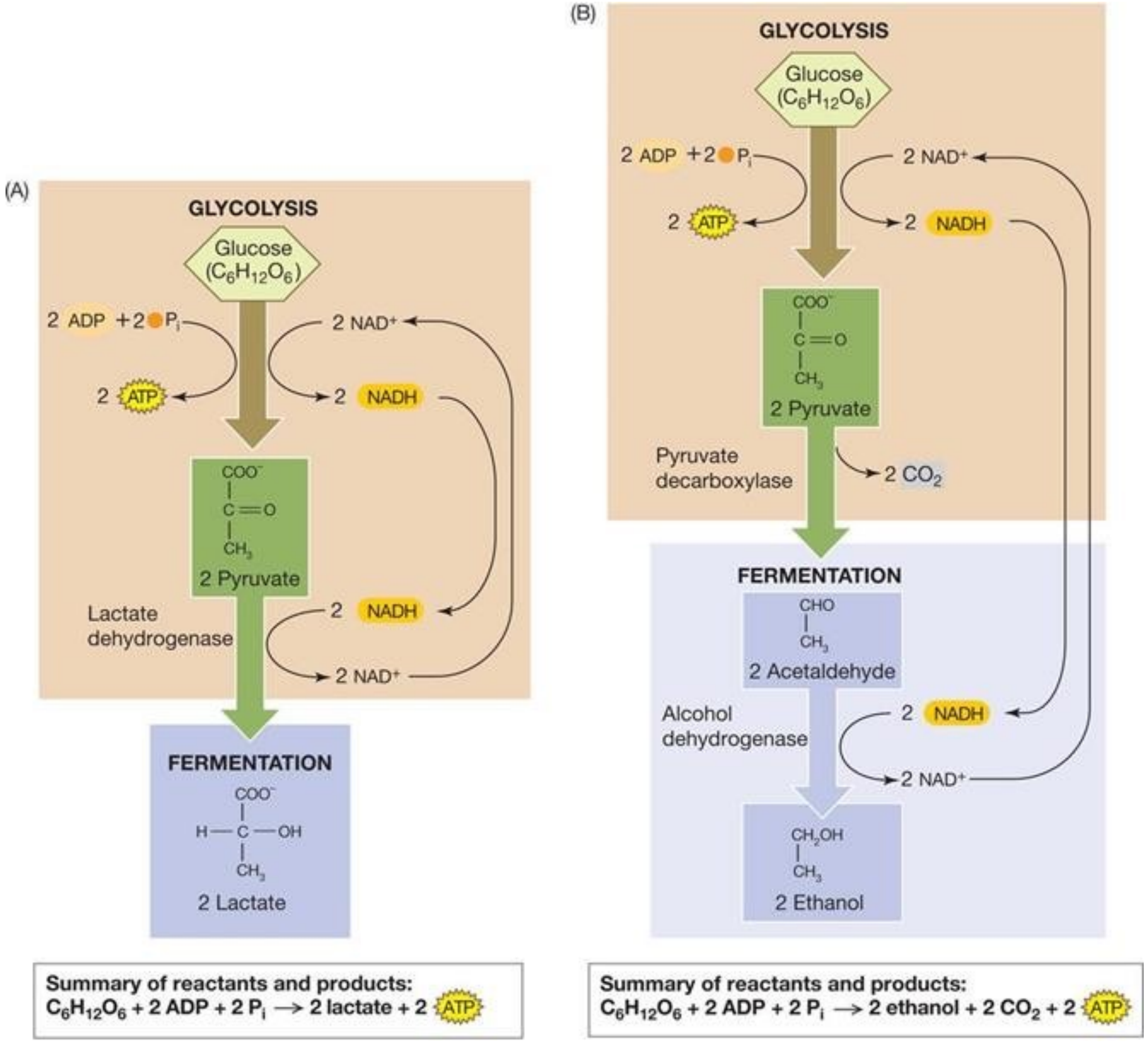
# Energy and Metabolism



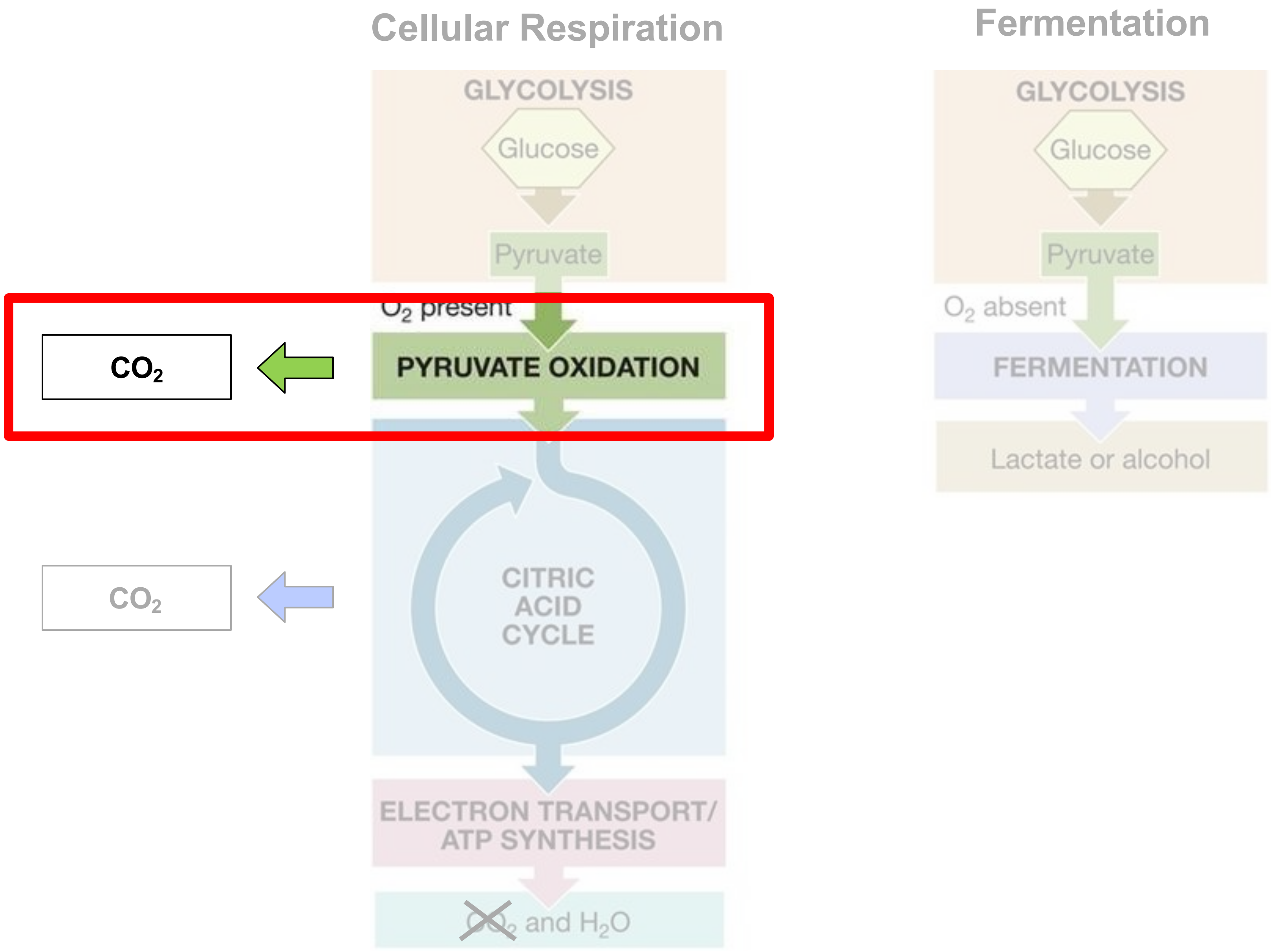
# Fermentation (Anaerobic)

# What is the Function of Fermentation?

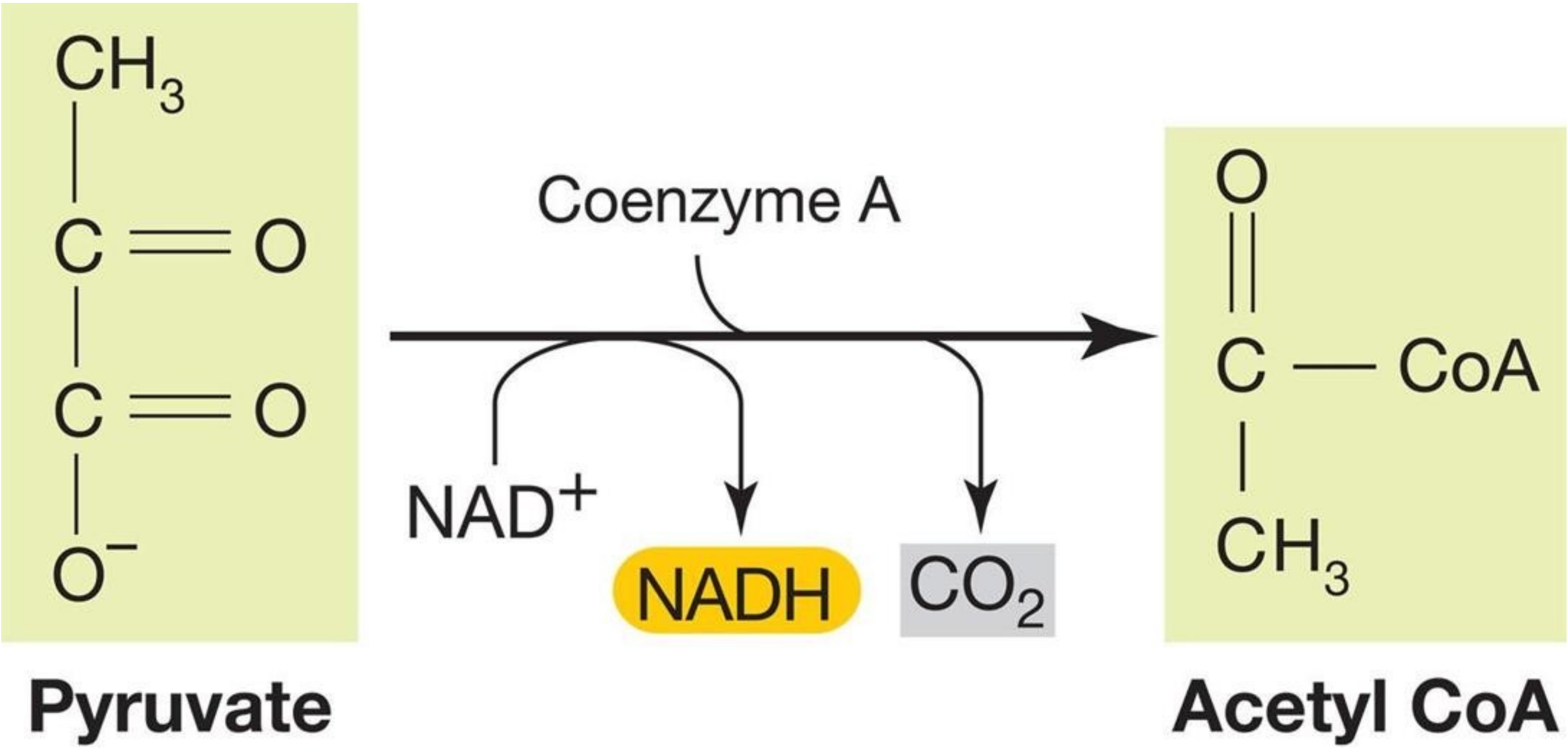
- Some cells use **fermentation** to regenerate the $NAD^+$ to keep glycolysis going.
- Fermentation uses pyruvate to oxidize NADH and regenerate $NAD^+$. Pyruvate is reduced to lactate or ethanol.



# Energy and Metabolism



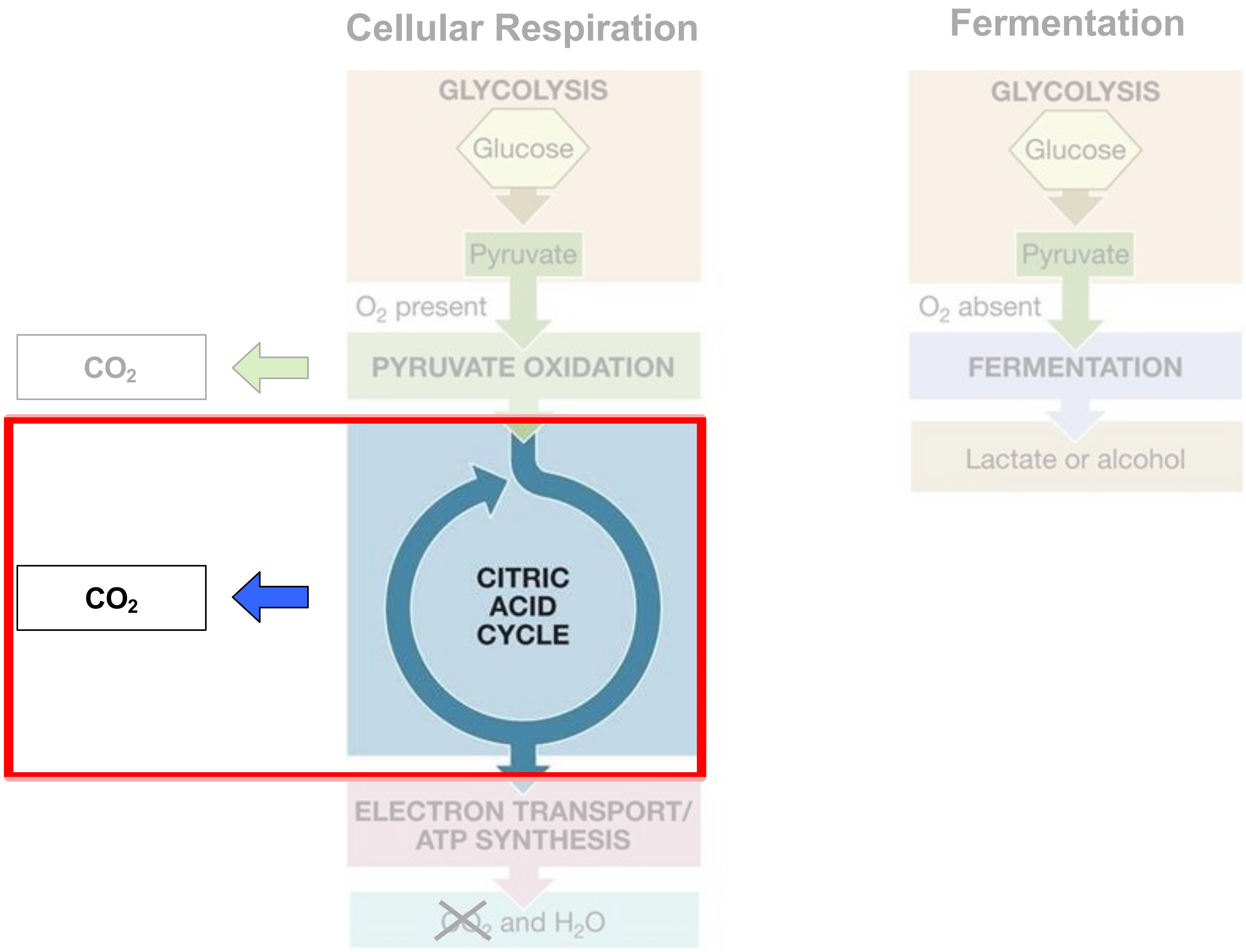
# Pyruvate Oxidation



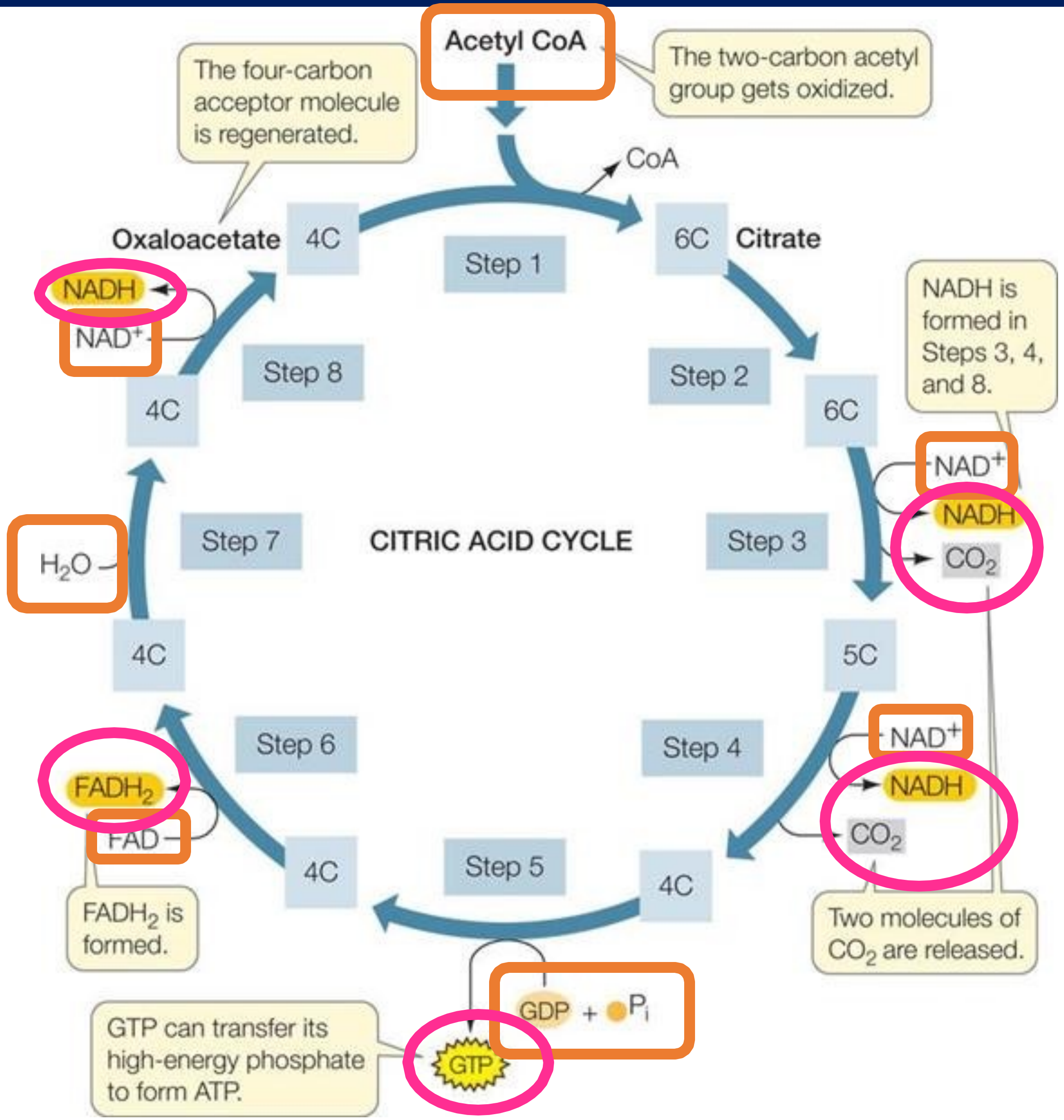
# The Krebs Cycle

## (Citric Acid Cycle; Tricarboxylic Acid)

# Energy and Metabolism



# Summary




- **INPUTS:**
  - Acetate (Acetyl CoA)
  - Water
  - GDP
  - Oxidized e- carriers (NAD+ ; FAD)
- **OUTPUTS:**
  - CO2
  - Reduced e- carriers (NADH; FADH2)
  - Small amount of GTP
    - **Energy in terminal phosphate transferred to ADP to form ATP!**

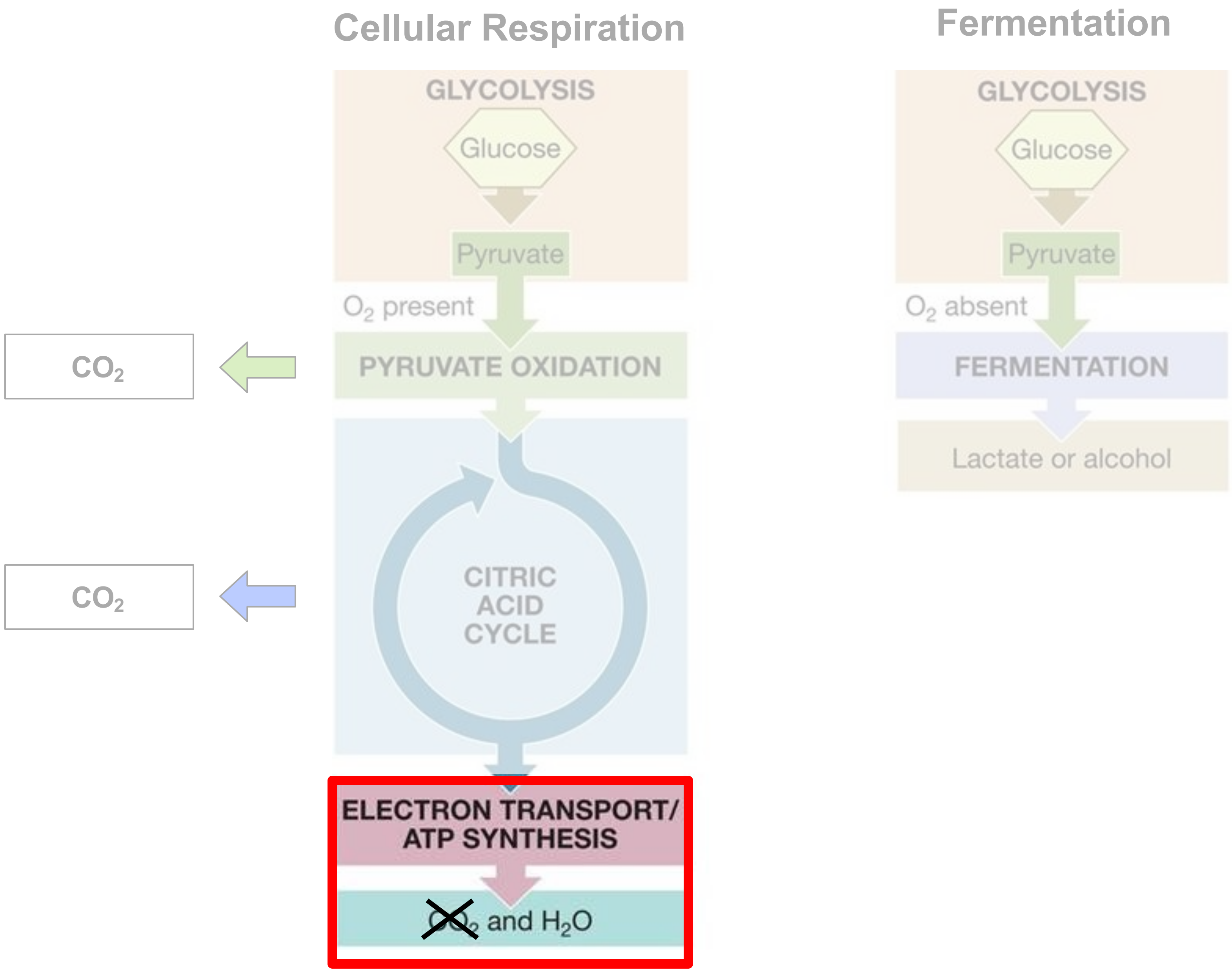
**GPPP + APP □ GPPX + APPP**

**GTP + ADP □ GDP + ATP**

# The Electron Transport Chain

(Oxidative Phosphorylation forming ATP)

# Energy and Metabolism

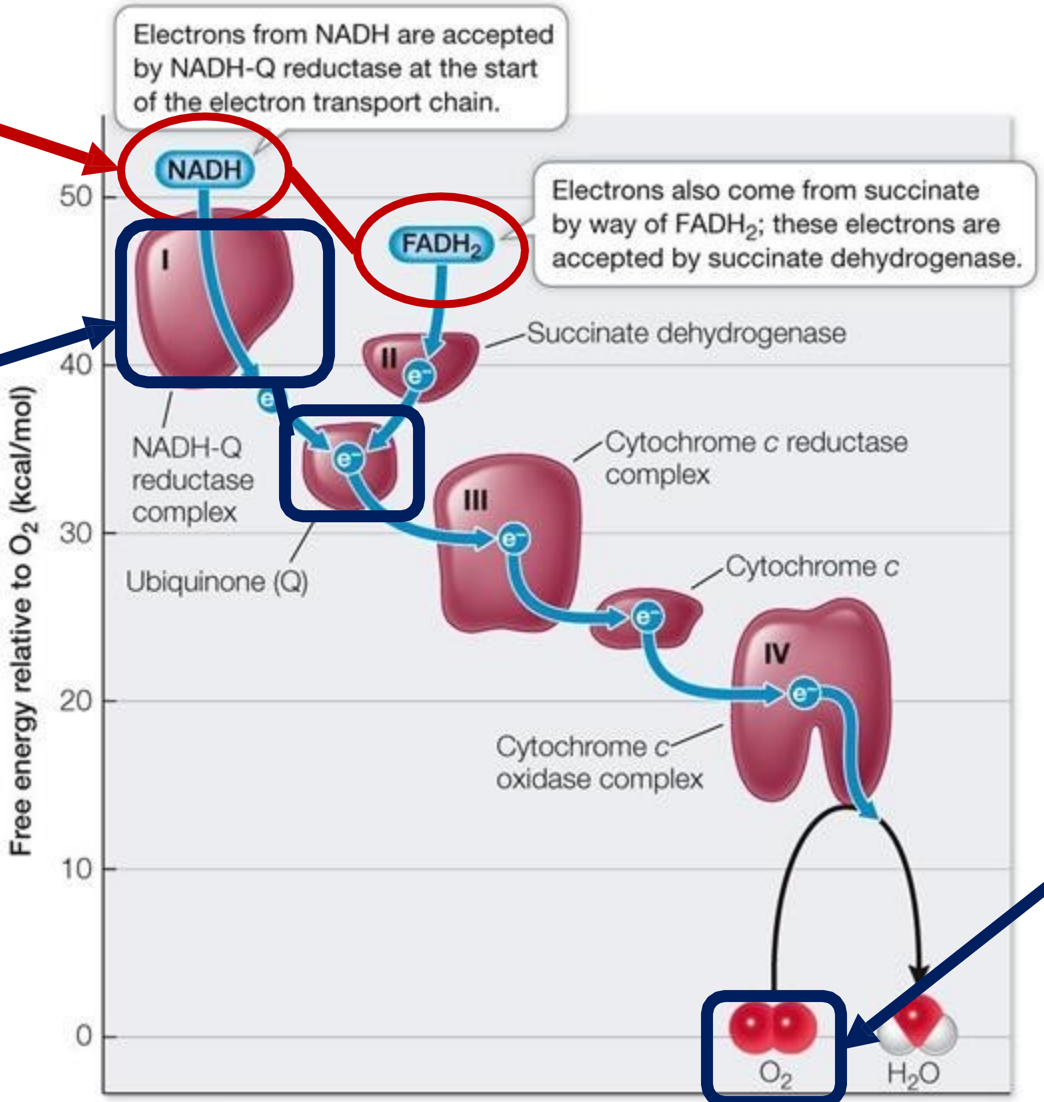


# Electron Transport Chain

e- transferred from NADH & FADH2 (we acquired from citric acid cycle)

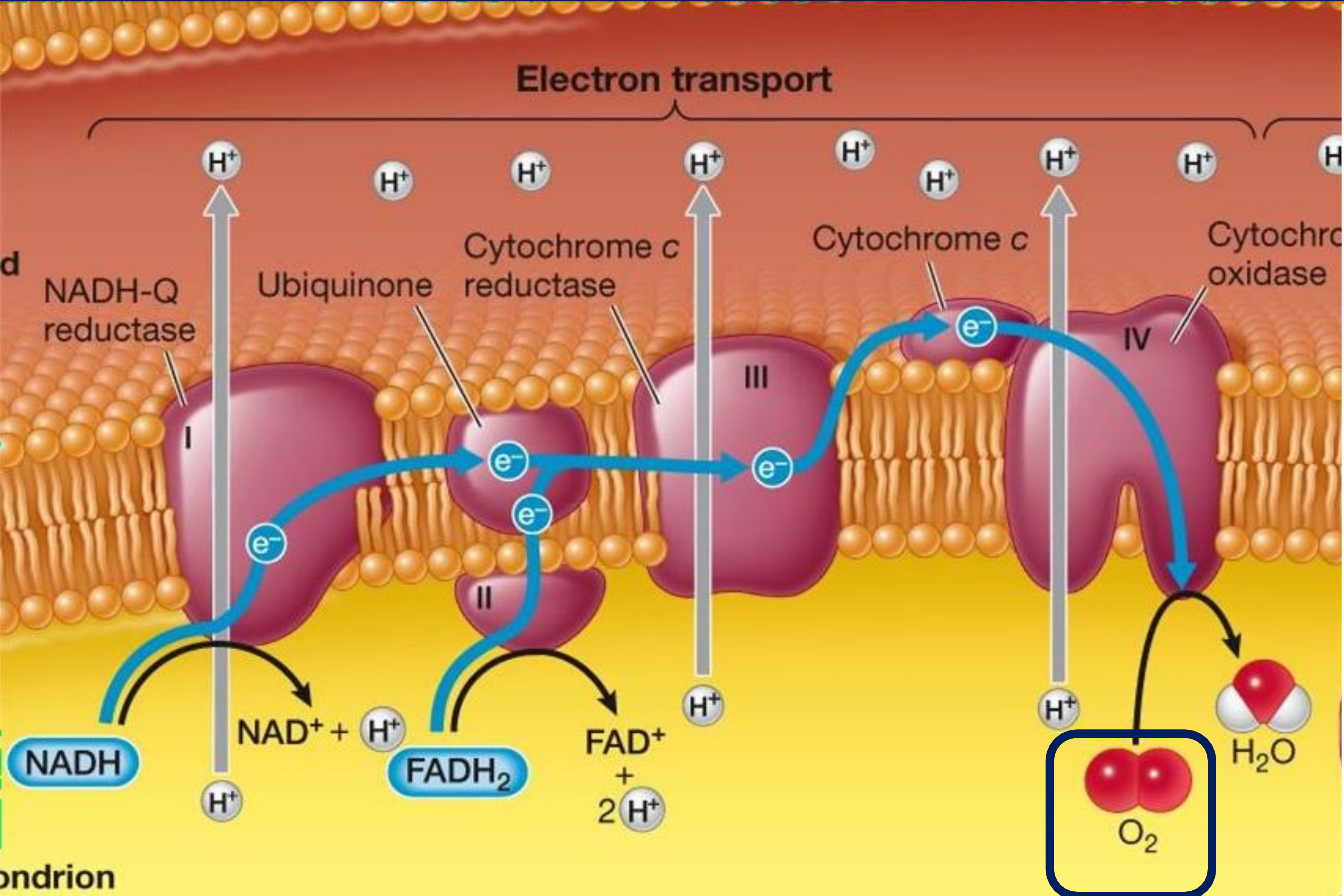
Coupling of Redox-Reactions

Each successive station, oxidizes the previous station, and then becomes reduced.




Final e- acceptor – final oxidizing agent.

# Electron Transport Chain

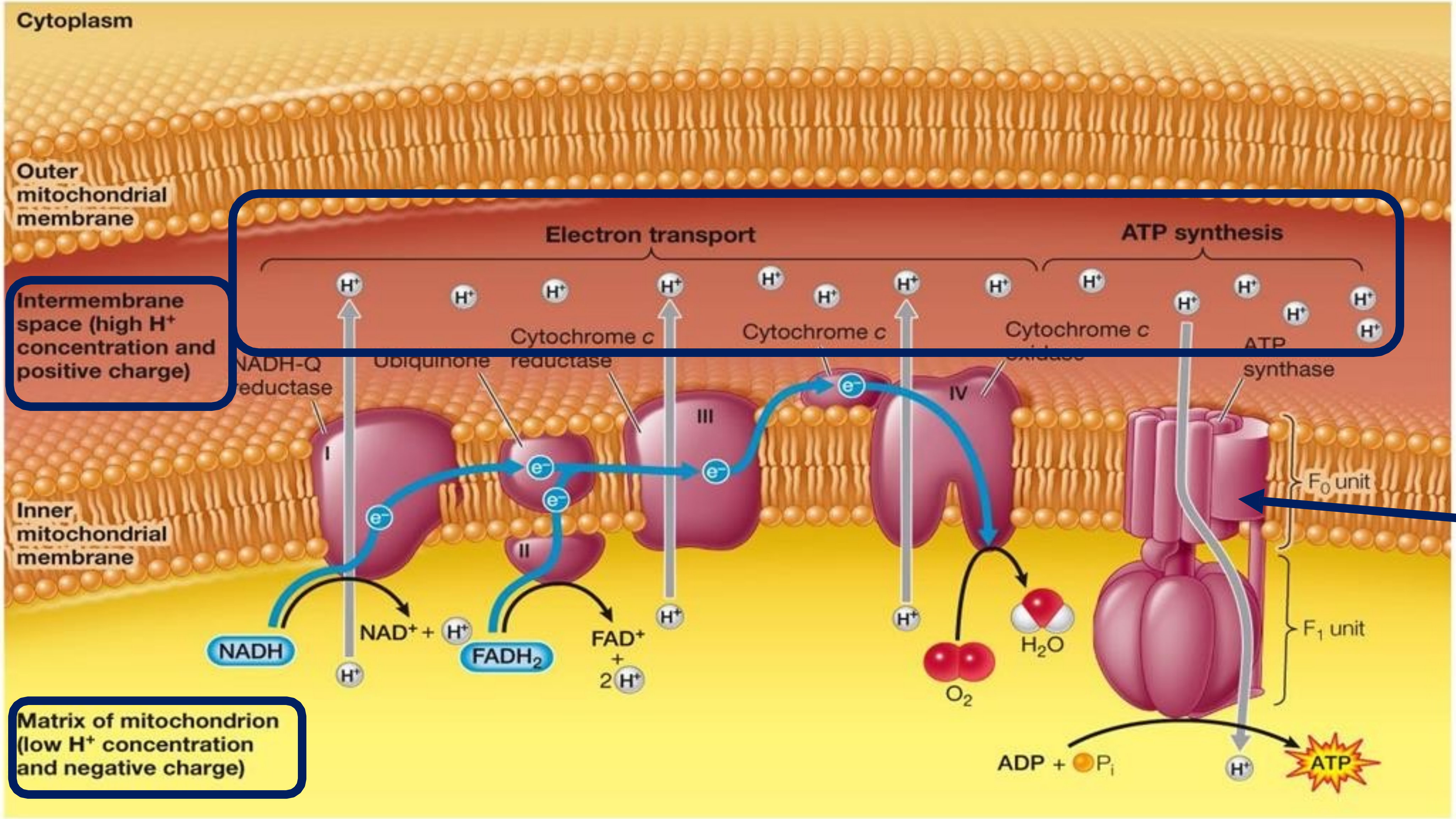



**Electrons enter the transport chain at complex I (from NADH) and complex II (from $FADH_2$), and converge onto ubiquinone.**

**Oxygen is the final electron acceptor. Without oxygen, the transport relay stops.**

**<u>Question</u>: what is carrying the e- that O2 accepts?**

# Electron Transport Chain




*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 9.8 (Part 3)



**Creation of charge across a membrane when H+ transport through synthase**

**ATP Synthase: ATP via Oxidative Phosphorylation**

# CHAPTER 10: PHOTOSYNTHESIS: ENERGY FROM SUNLIGHT

# PHOTOSYNTHESIS PATHWAYS

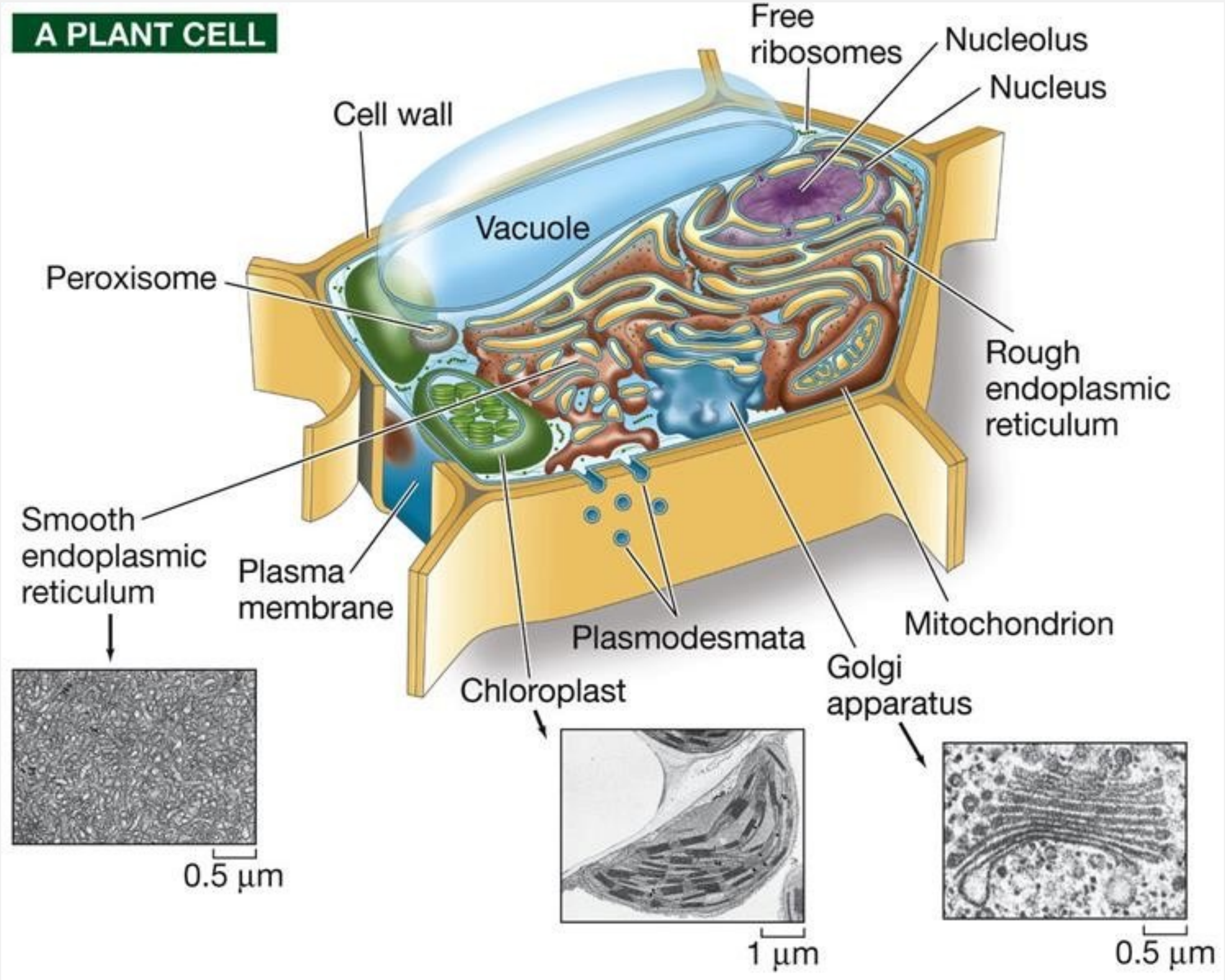
- Pathways of photosynthesis:
  - **Light reactions (Solar energy into chemical energy)-**
    - Driven by light energy captured by chlorophyll
    - It consumes $H_2O$, and produces $O_2$, ATP, and NADPH + $H^+$
  - **Calvin–Benson Cycle** (Carbon-fixation reactions; Synthesis)-
    - Does not use light directly
    - It uses ATP, NADPH + $H^+$, and $CO_2$ to produce sugars

Reduced

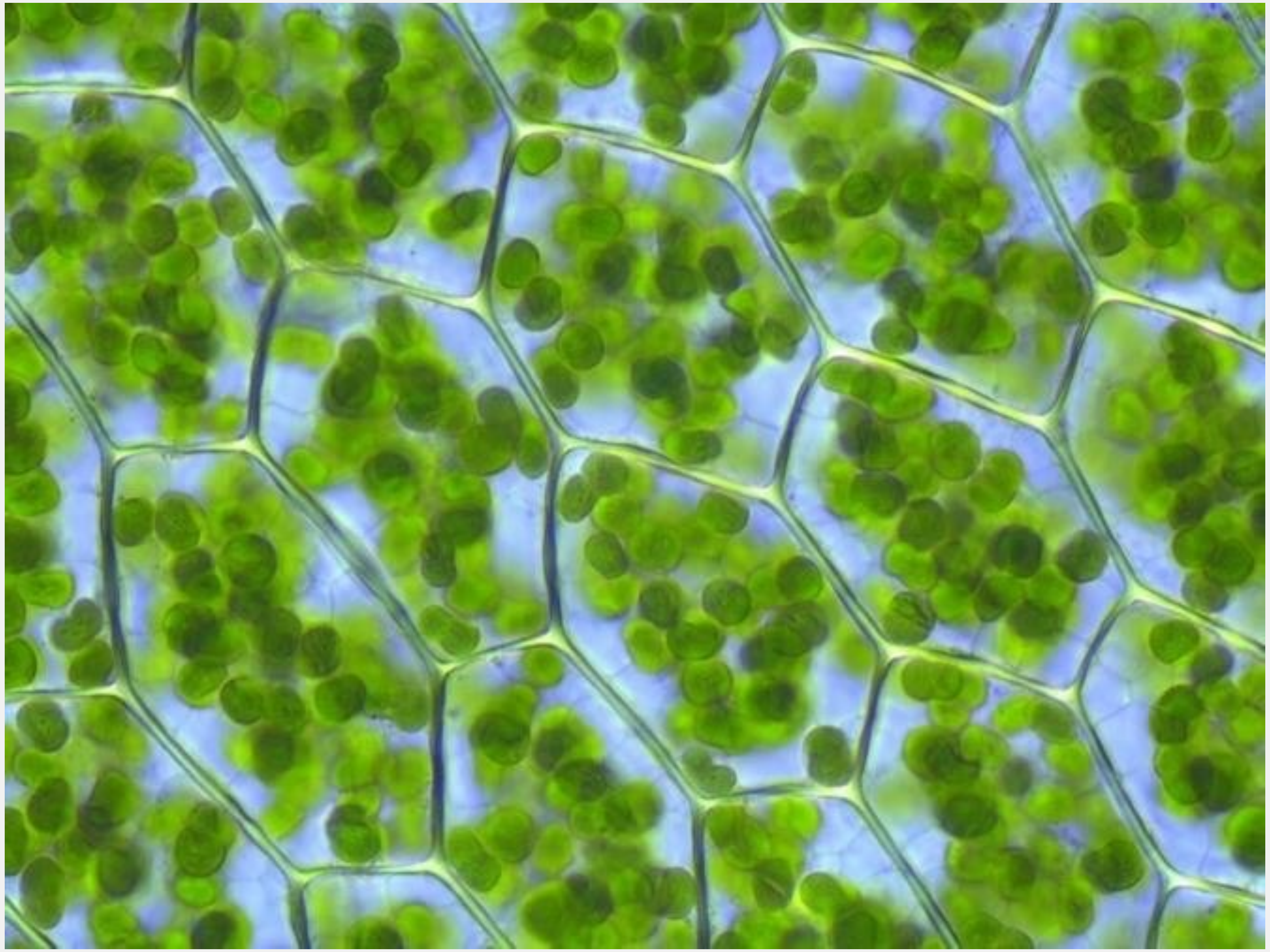
$$\text{Light Energy} + 6CO_2 + 6H_2O \rightarrow C_6H_{12}O_6 + 6O_2$$

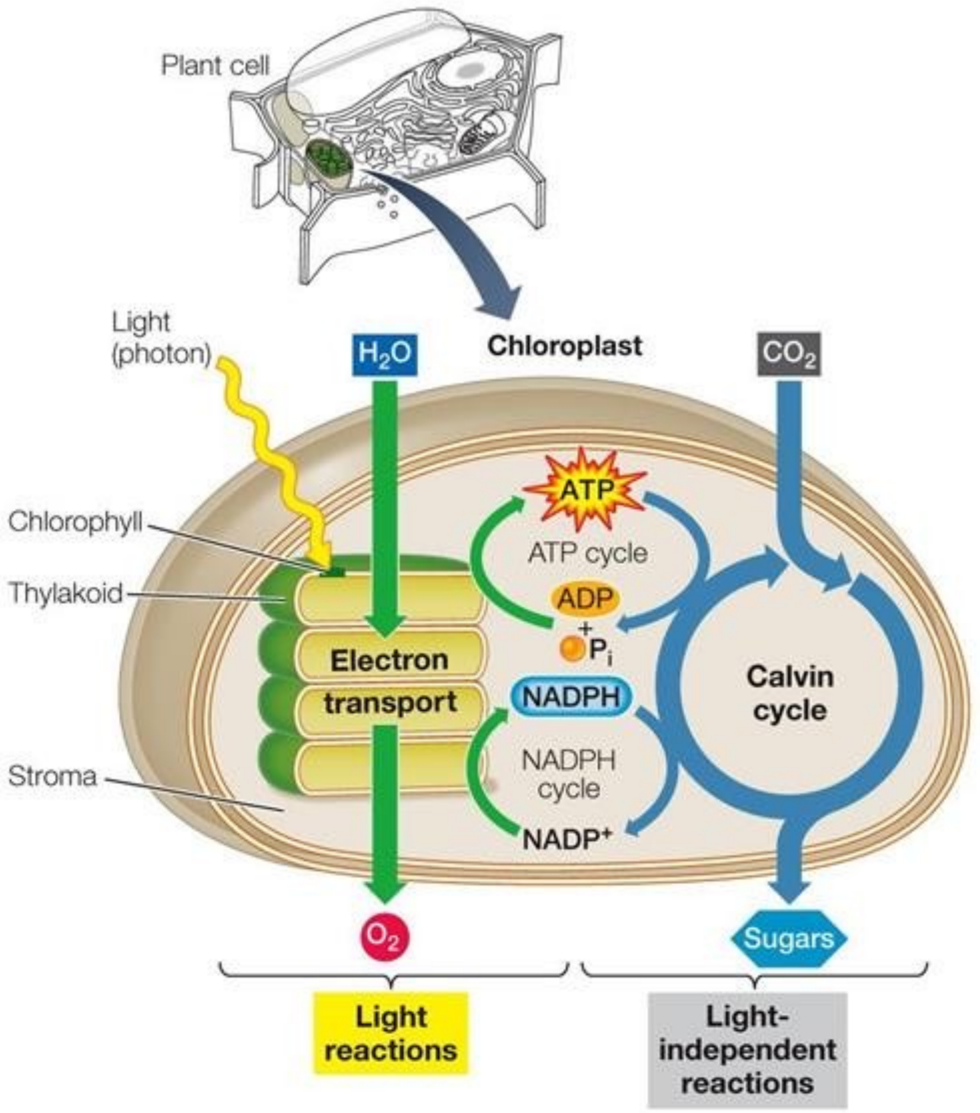
Oxidized

# THE PLANT CELL



# CHLOROPLAST



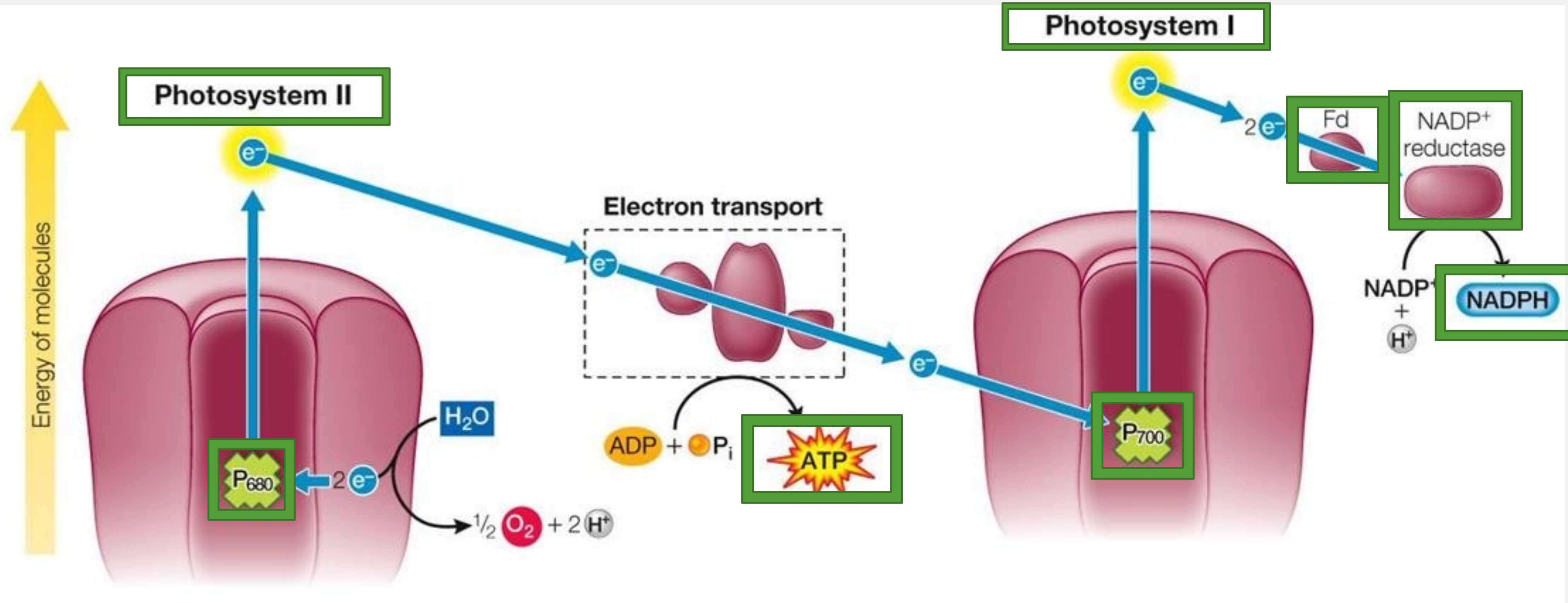



*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 10.2

# THE LIGHT REACTION

A look within chloroplasts

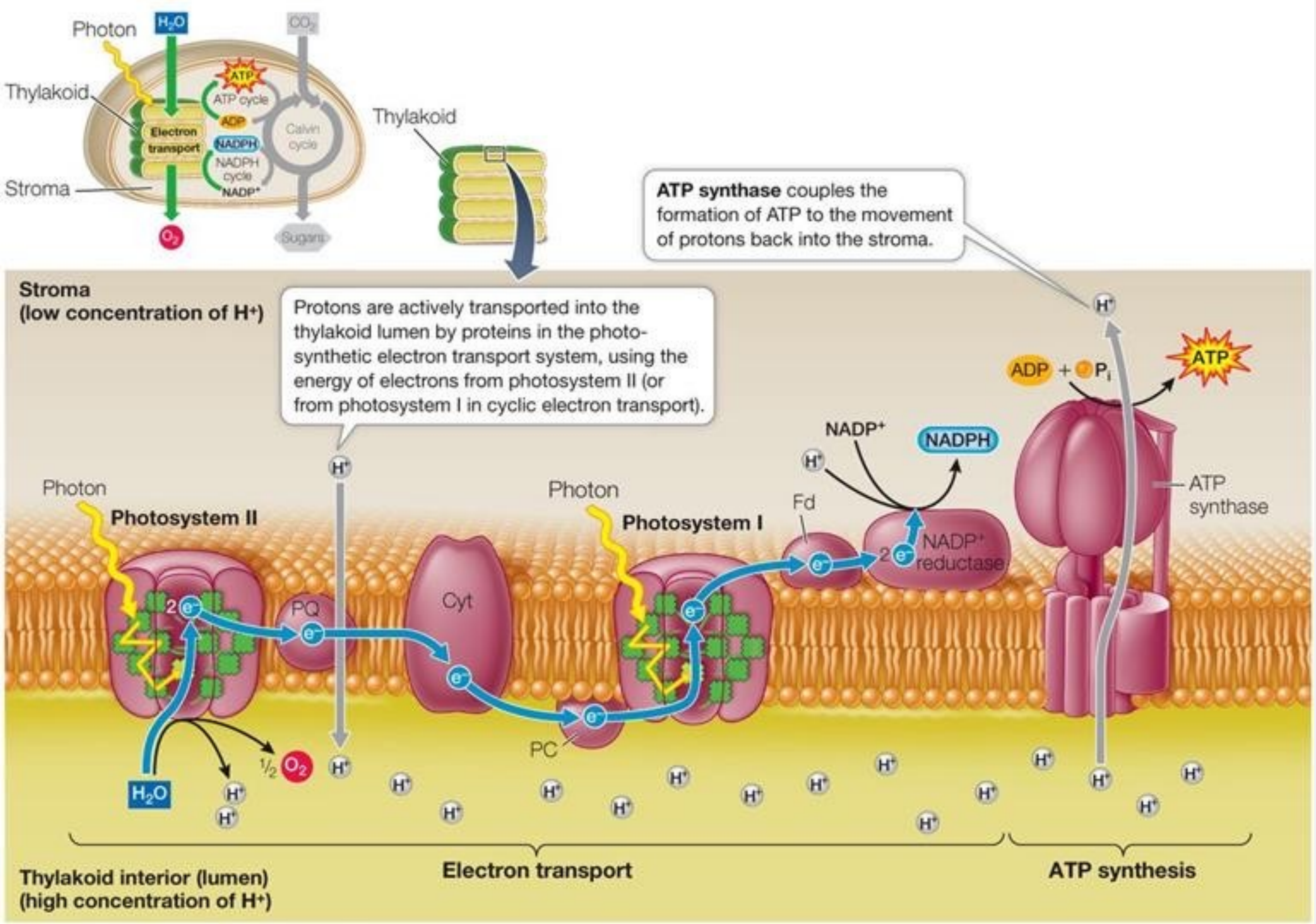
# NONCYCLIC (LINEAR) ELECTRON TRANSPORT




LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 10.7


Consumed: $H_2O$ Transformed: ADP + $NADP^+$ Products: ½ $O_2$ + ATP + NADPH

# CHEMIOSMOSTIC ATP PRODUCTION — PHOTOPHOSPHORYLATION




*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 10.9

# KNOWLEDGE CHECK

**Which sequence gives a correct order of steps taking place during the light reactions?**

a. Light energy → excited electron → pH gradient → ATP synthesis → electron transport

b. Excited electron → light energy → ATP synthesis → electron transport → pH gradient

c. pH gradient → light energy → excited electron → electron transport → ATP synthesis

d. Light energy → excited electron → electron transport → pH gradient → ATP synthesis

e. ATP synthesis → light energy → excited electron → electron transport → pH gradient

# KNOWLEDGE CHECK

**Electron transport and photophosphorylation provide the Calvin cycle with**

a. protons and electrons.

b. ATP and NADPH.

c. water and photons.

d. light and chlorophyll.

e. $CO_2$ and sugars.

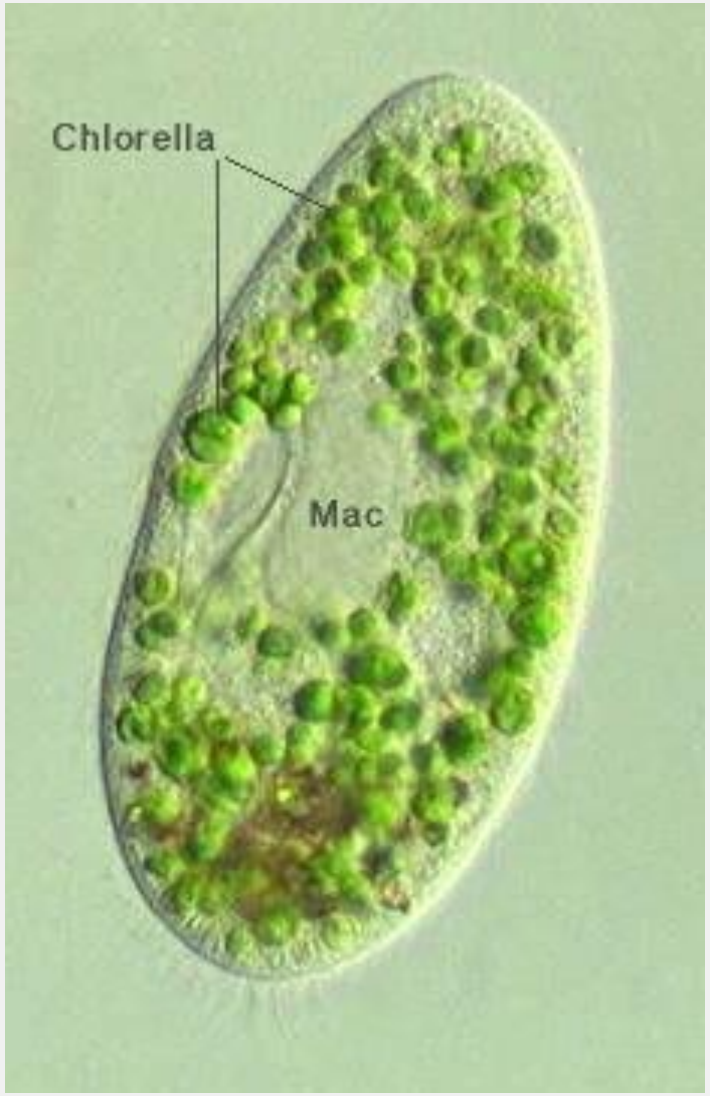
# CALVIN-BENSON CYCLE:
## THE LIGHT-INDEPENDENT REACTION

$$6CO_2 + 12H_2O \rightarrow C_6H_{12}O_6 + 6O_2 + 6H_2O$$

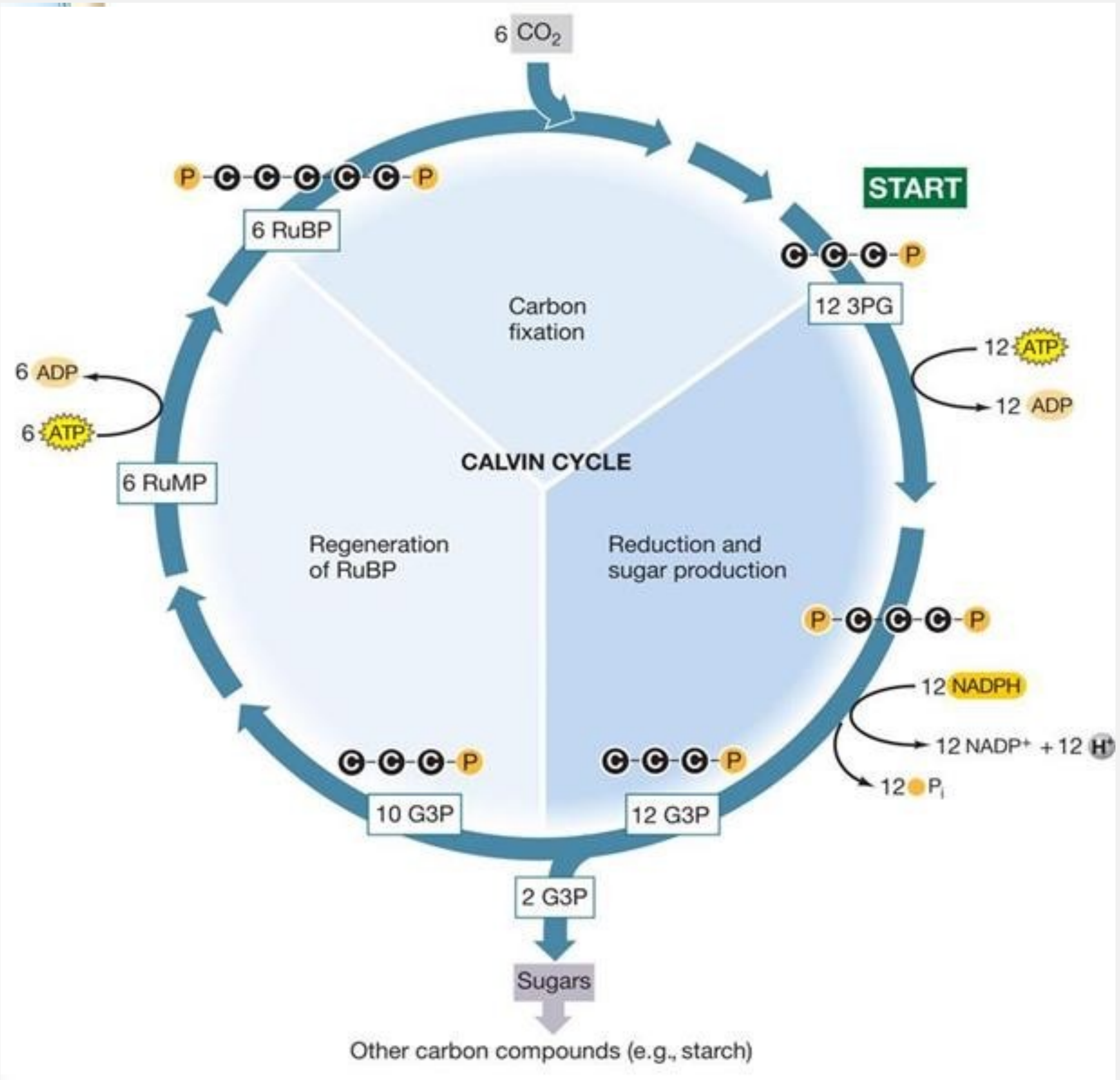
# THE CALVIN BENSON EXPERIMENTS

- Exposure of *Chlorella* cells to $^{14}CO_2$ for various durations resulted in compounds labeled with $^{14}C$.

- The first stable compound: **3-phosphoglycerate** (3PG), a 3-carbon sugar, appeared after a few seconds' exposure.



# THE CALVIN-BENSON CYCLE




Products: 2 G3P + 18 ADP + 12 NADP$^+$

Recycled: ADP and NADP$^+$

# KNOWLEDGE CHECK

**Which of the following occurs during the light-independent reactions of photosynthesis?**

a. Water is converted into hydrogen and oxygen.

b. $CO_2$ is converted into sugars.

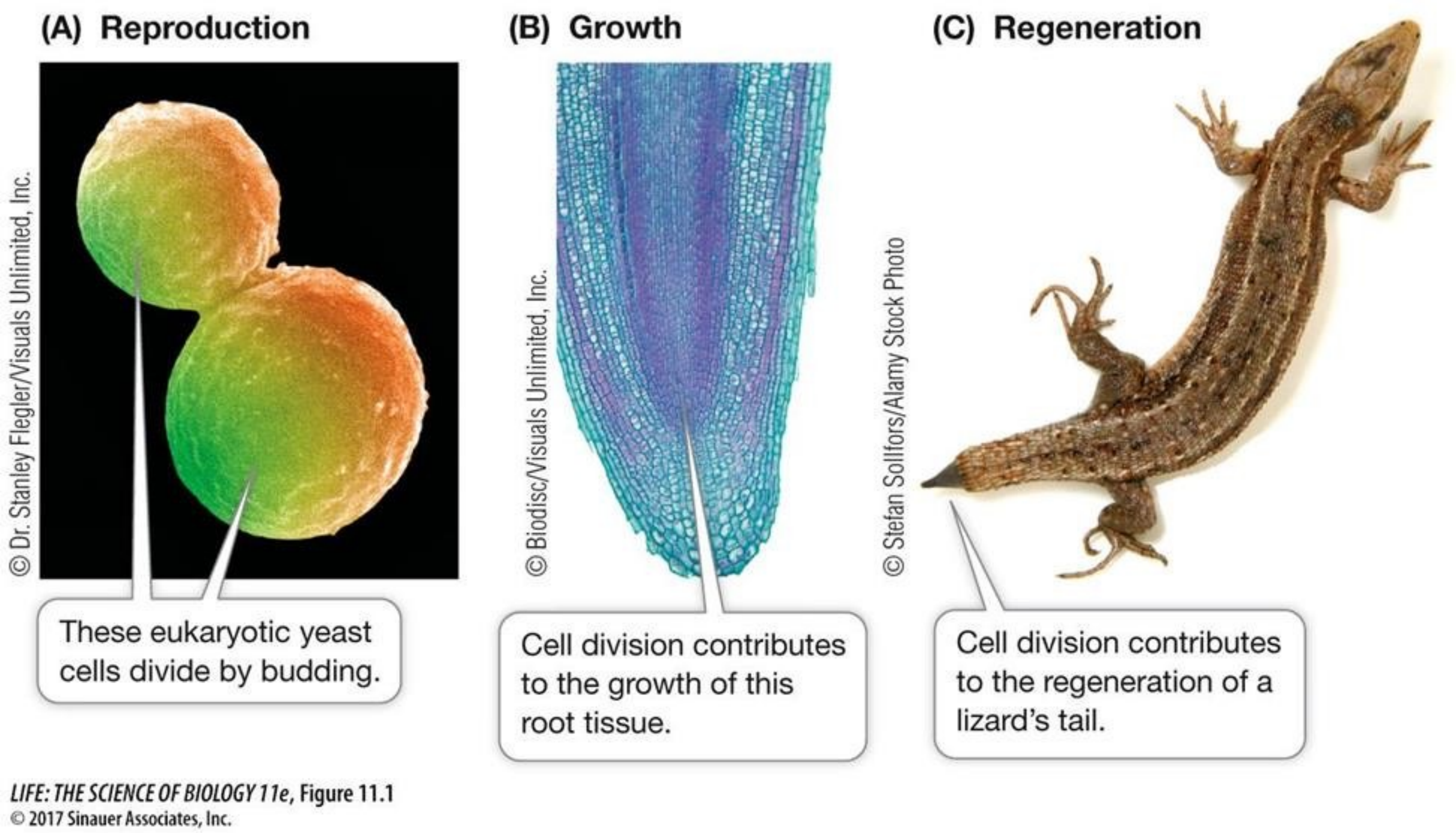
c. Chlorophyll acts as an enzyme.

d. Nothing occurs; the plant rests in the dark.

e. $CO_2$ is split into carbon and oxygen.

# CHAPTER 11: THE CELL CYCLE AND CELL DIVISION

# THREE MAIN REASONS FOR CELL DIVISION

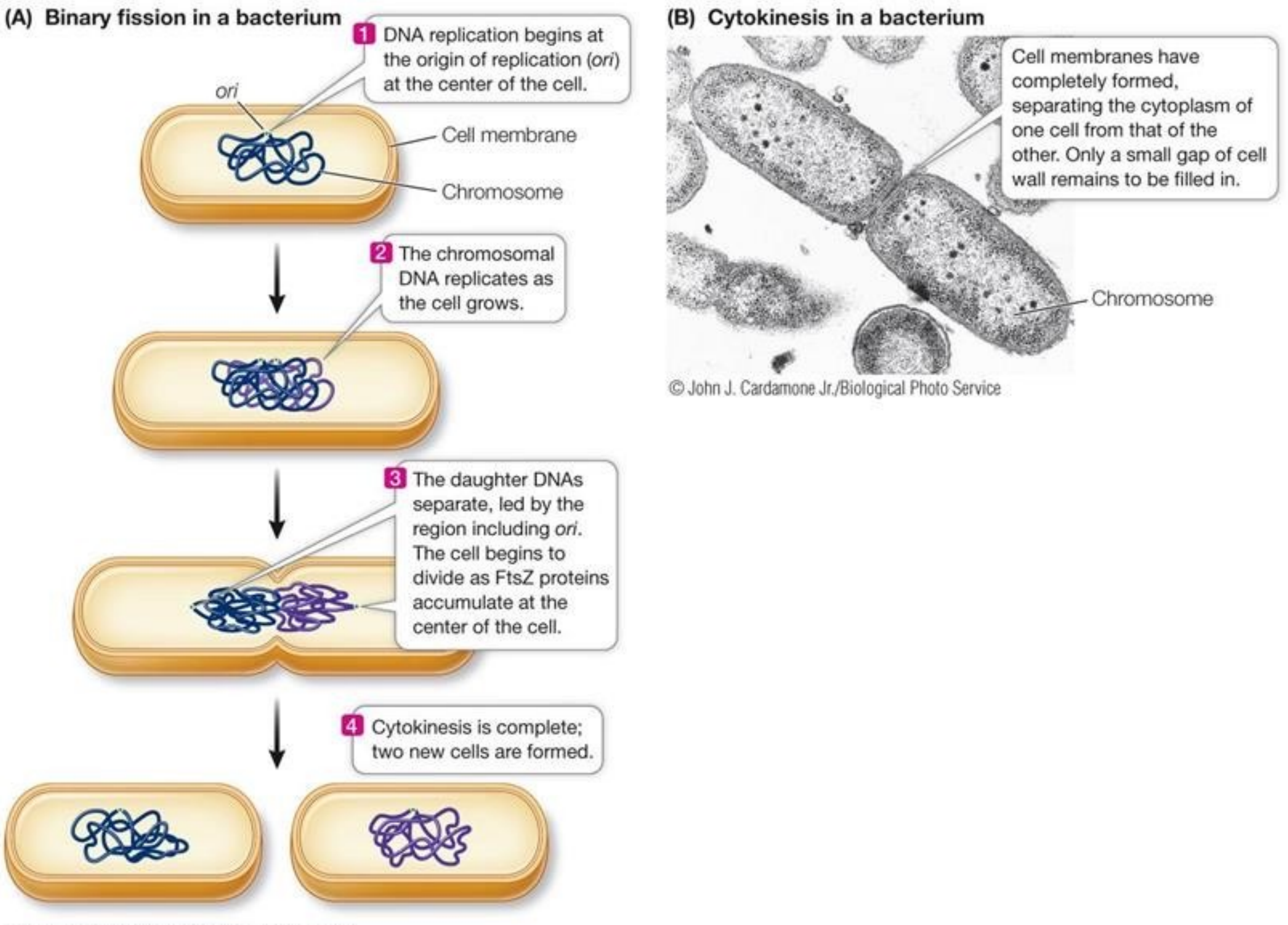


# THE GENERAL STEPS FOR CELL DIVISION

1. **Reproductive Signal**: to initiate cell division
2. **Replication**: of DNA
3. **Segregation**: distribution of the DNA into the two new cells
4. **Cytokinesis**: separation of the two new cells

# PROKARYOTIC CELL DIVISION

# PROKARYOTIC CELL DIVISION




*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 11.2

# KNOWLEDGE CHECK

**A bacterial cell gives rise to two genetically identical daughter cells by a process known as**

a. nondisjunction.

b. mitosis.

c. meiosis.

d. binary fission.

e. fertilization.

# KNOWLEDGE CHECK

**Bacteria typically have _______, whereas eukaryotes have _______.**

a. one chromosome that is circular; many chromosomes that are linear.

b. several chromosomes that are circular; many chromosomes that are linear.

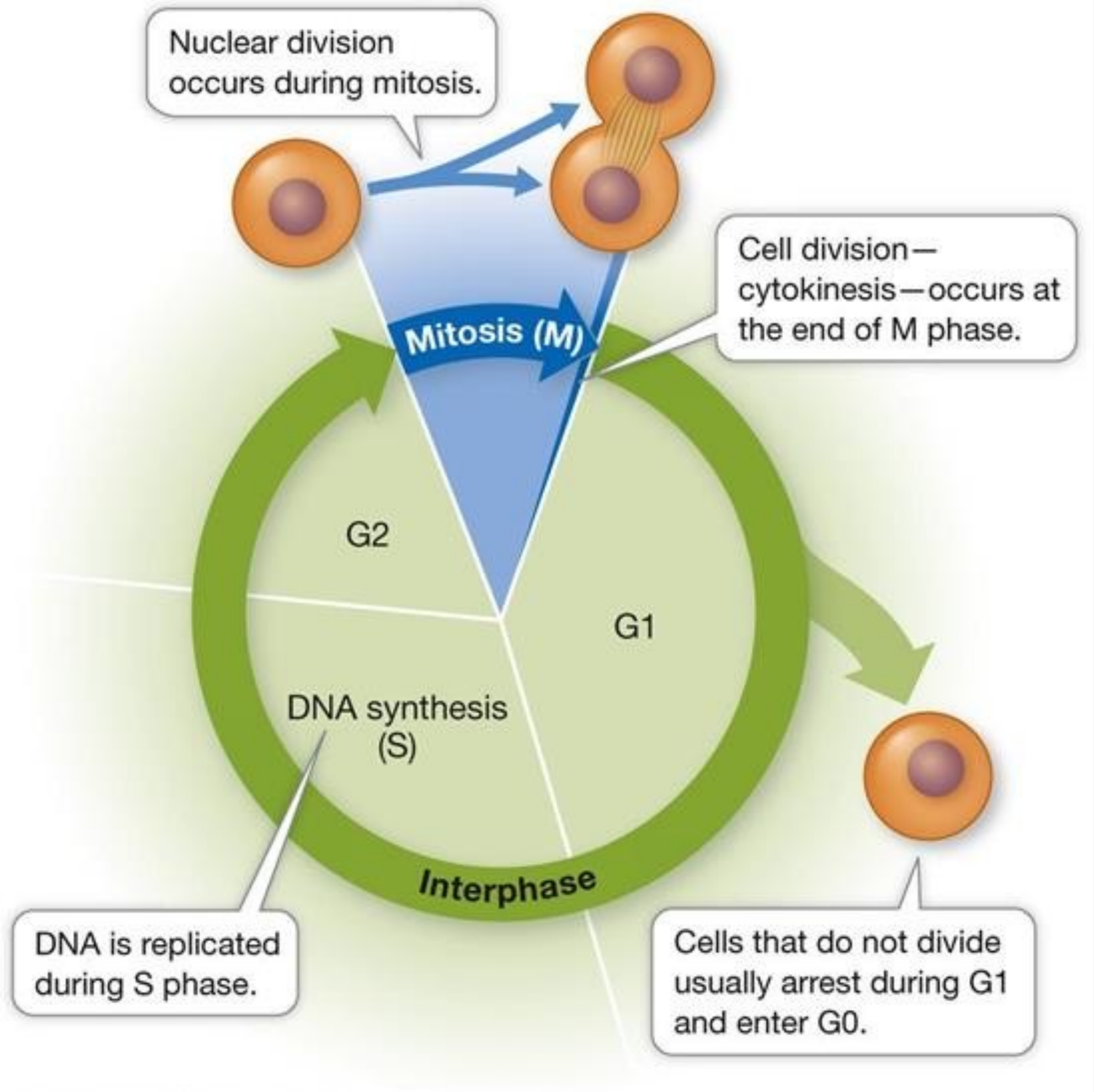
c. one chromosome that is linear; many chromosomes that are circular.

d. two chromosomes that are circular; eight chromosomes that are linear.

e. None of the above.

# EUKARYOTIC CELL DIVISION

# THE EUKARYOTIC CELL CYCLE




LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 11.3

# KNOWLEDGE CHECK

**How does a nucleus in the G2 differ from a nucleus in G1?**

a. the G2 nucleus has double the amount of DNA as a G1 nucleus.

b. DNA synthesis occurs only in the G1 phase.

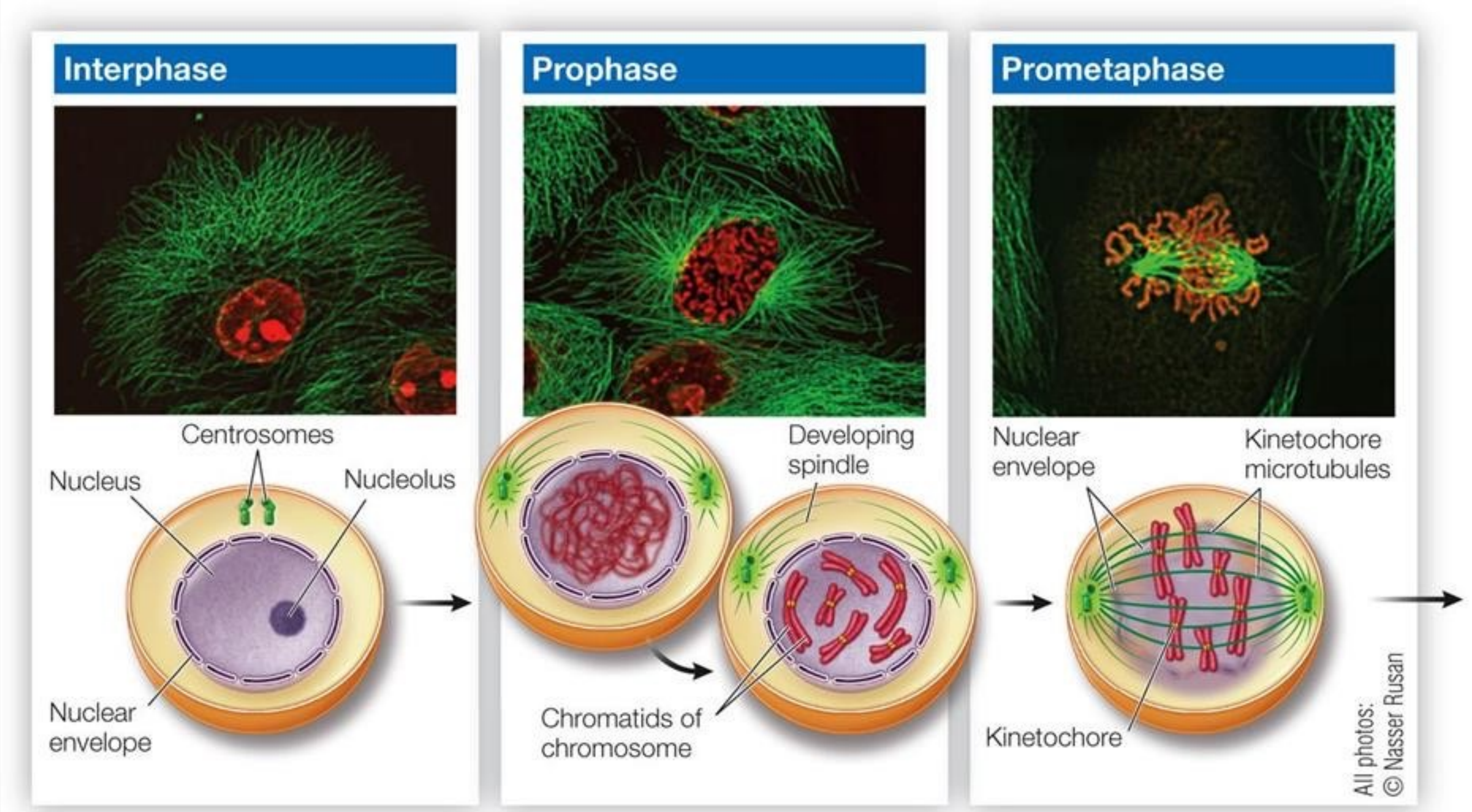
c. inactive cells are arrested only in the G2 phase.

d. during G2, the cell prepares for S phase.

e. all of the above

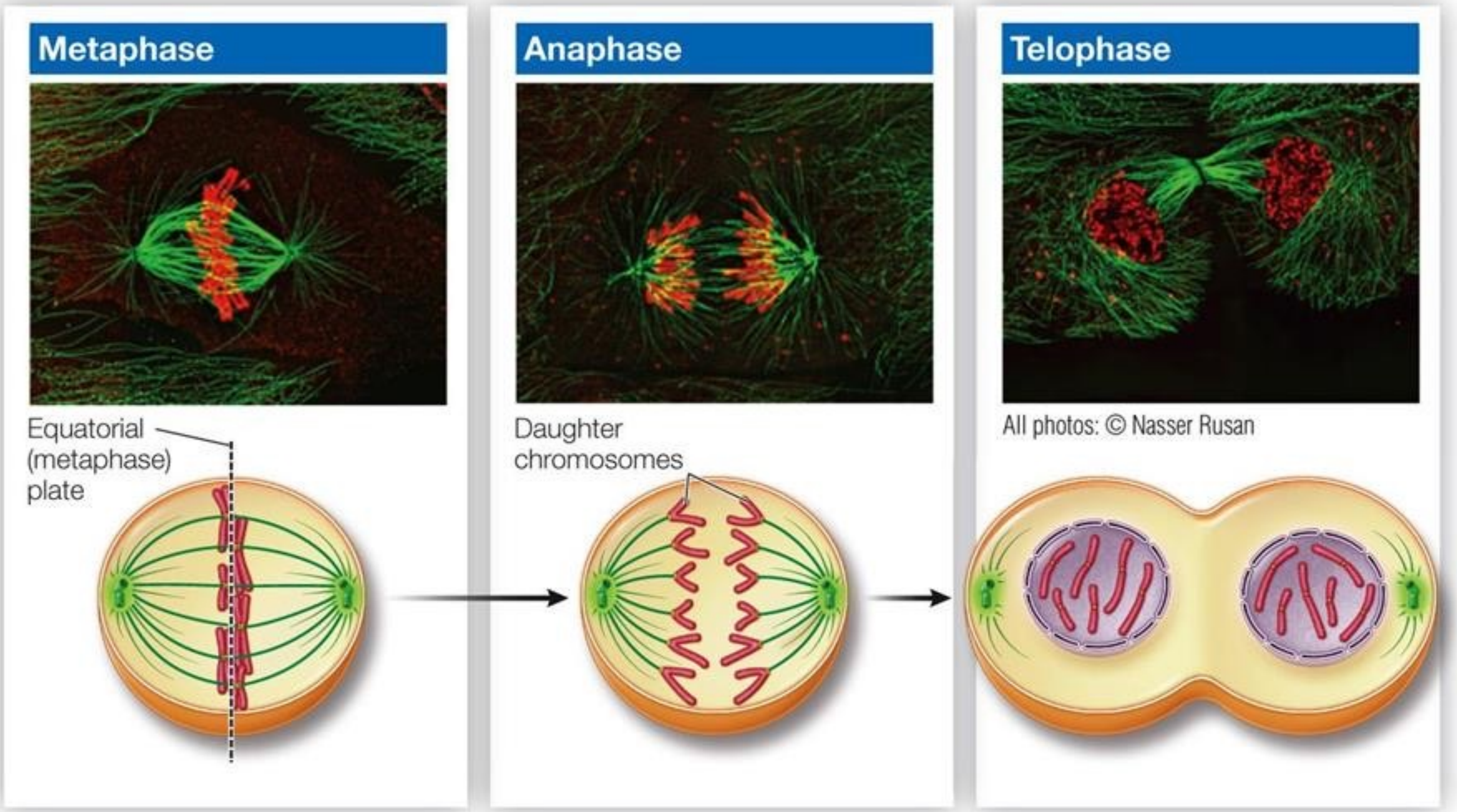
# PHASES OF MITOSIS

# PHASES OF MITOSIS




*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 11.9 (Part 1)

# PHASES OF MITOSIS




*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 11.9 (Part 2)

# KNOWLEDGE CHECK

**Which statement about mitosis is true?**

a. Two genetically identical daughter cells are formed.

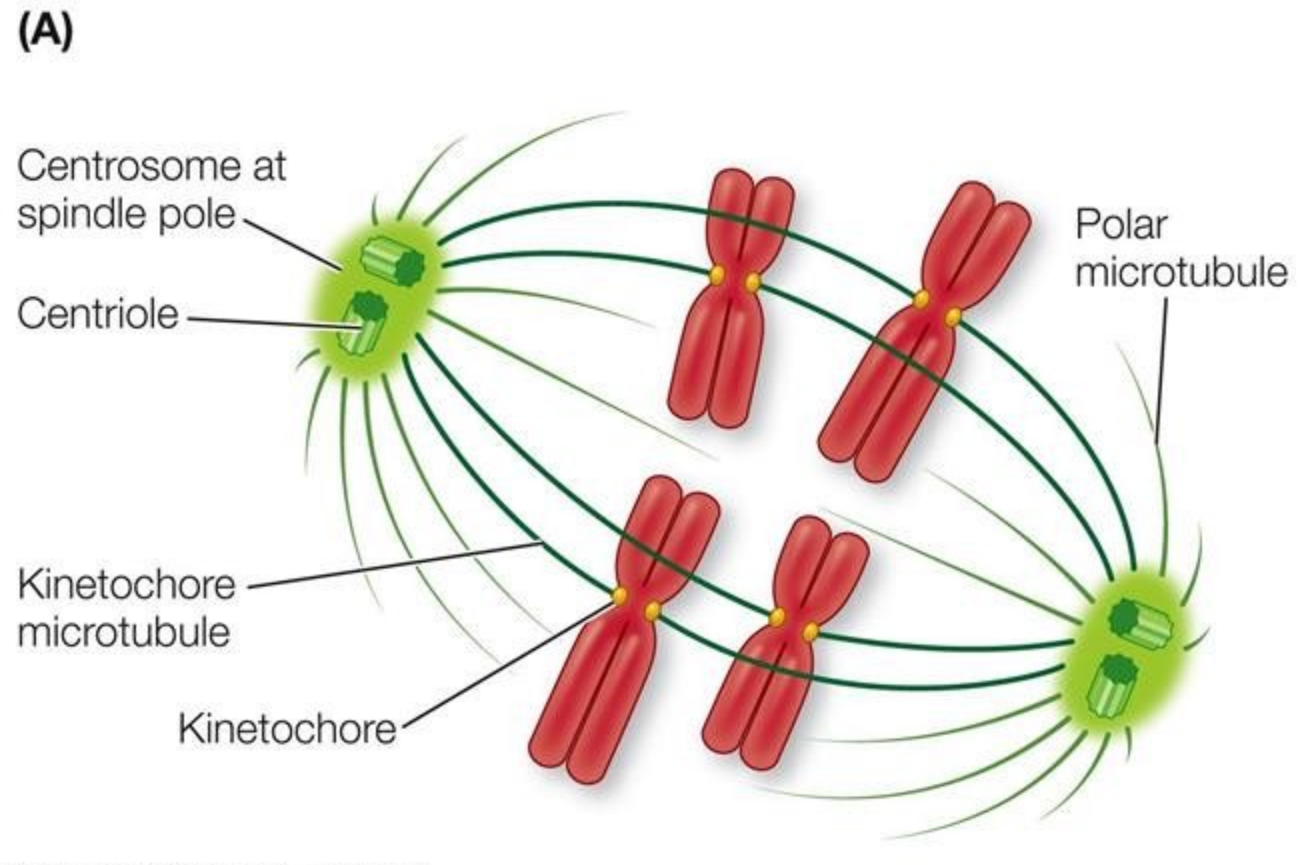
b. The chromosome number in the resulting cells is halved.

c. DNA replication is completed in prophase.

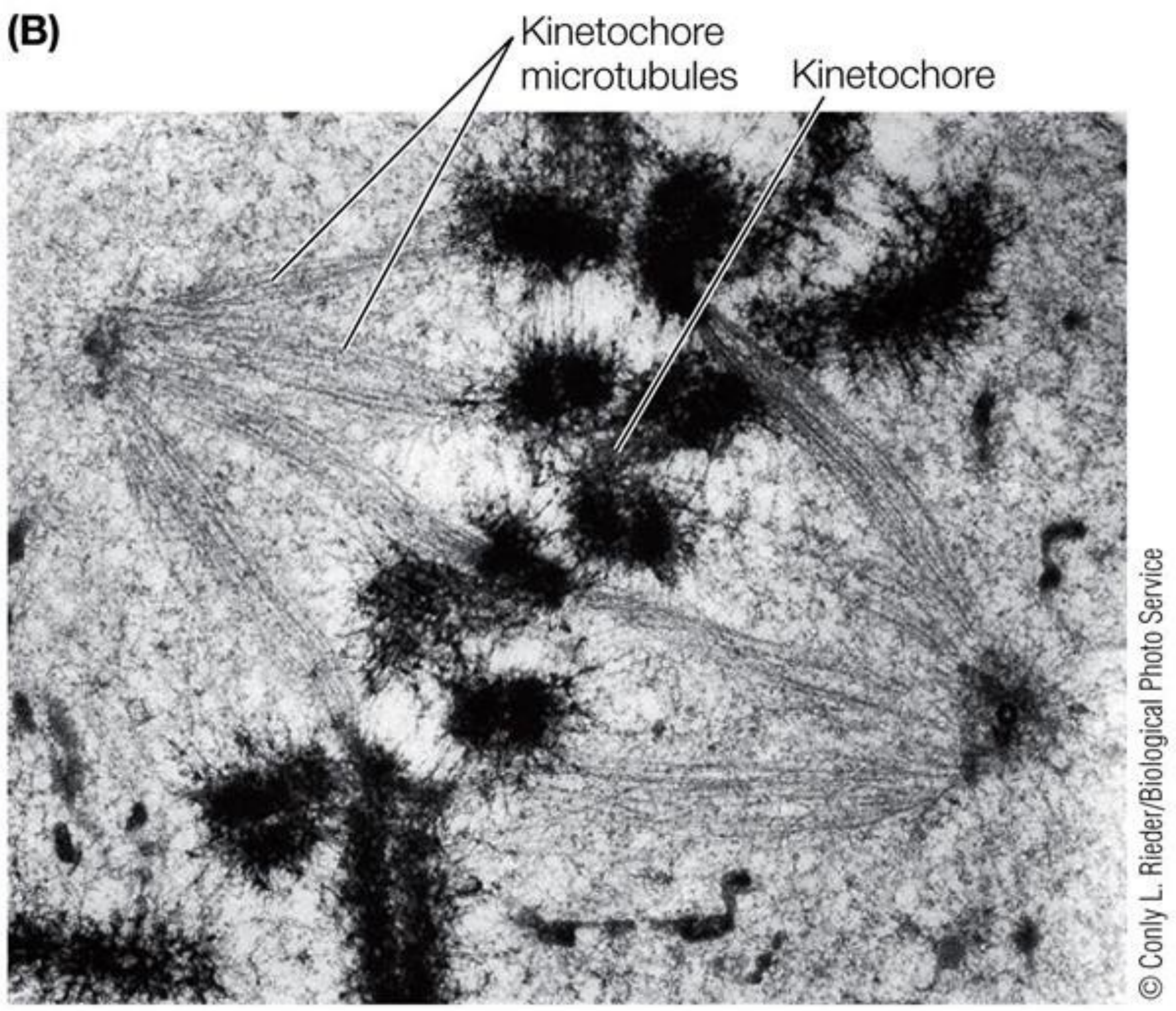
d. Crossing over occurs during prophase.

e. It consists of two nuclear divisions.

# MITOTIC SPINDLE

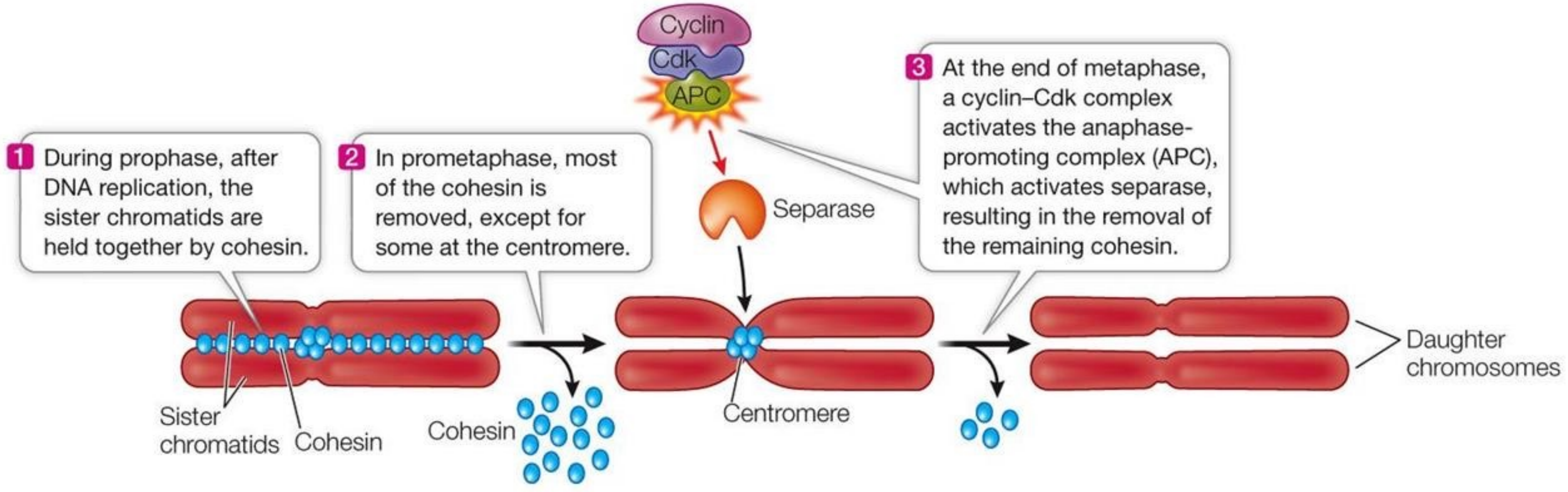



LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 11.10 (Part 1)


LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 11.10 (Part 2)

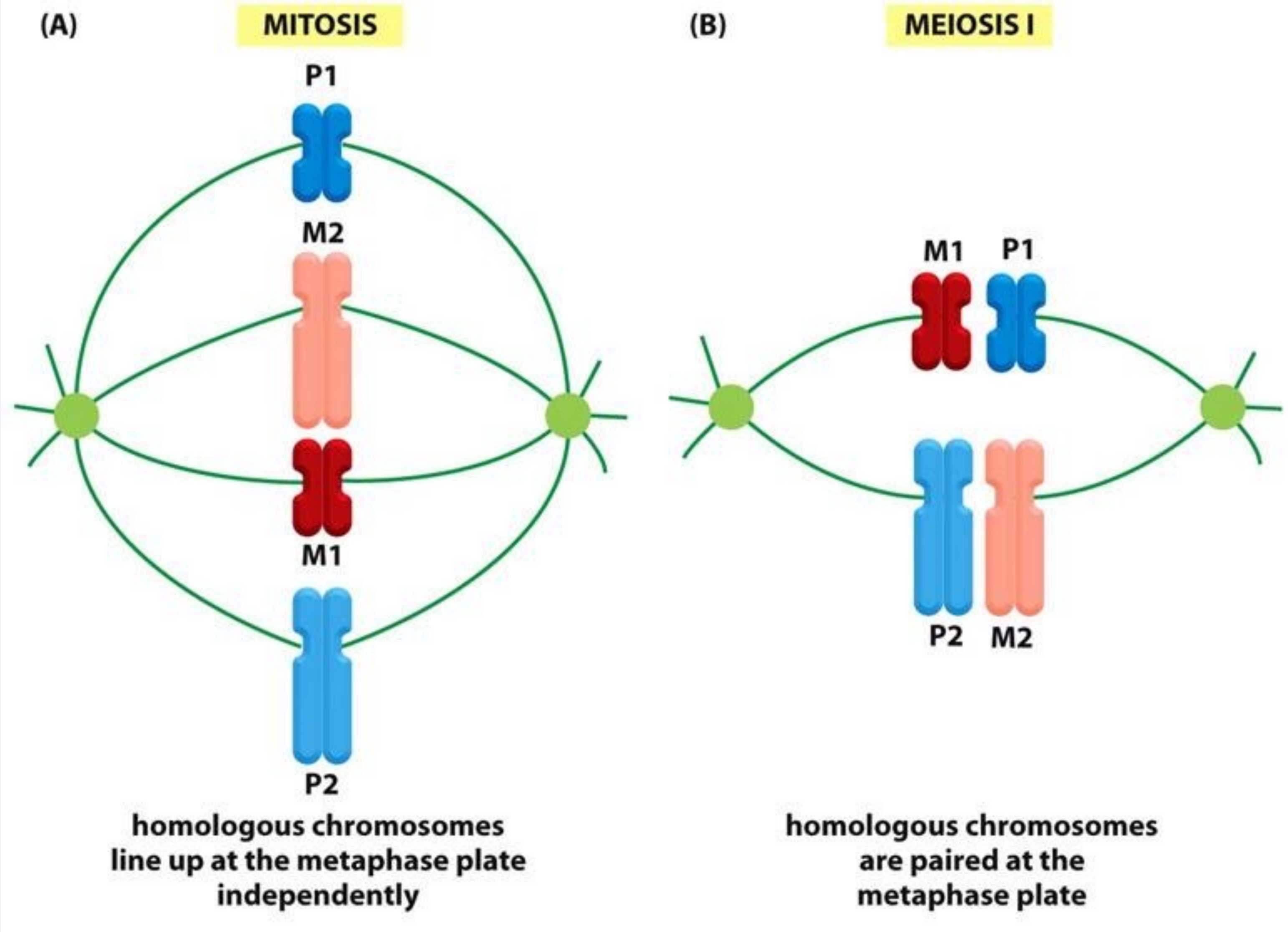
# CHROMATID ATTACHMENT AND SEPARATION




LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 11.11

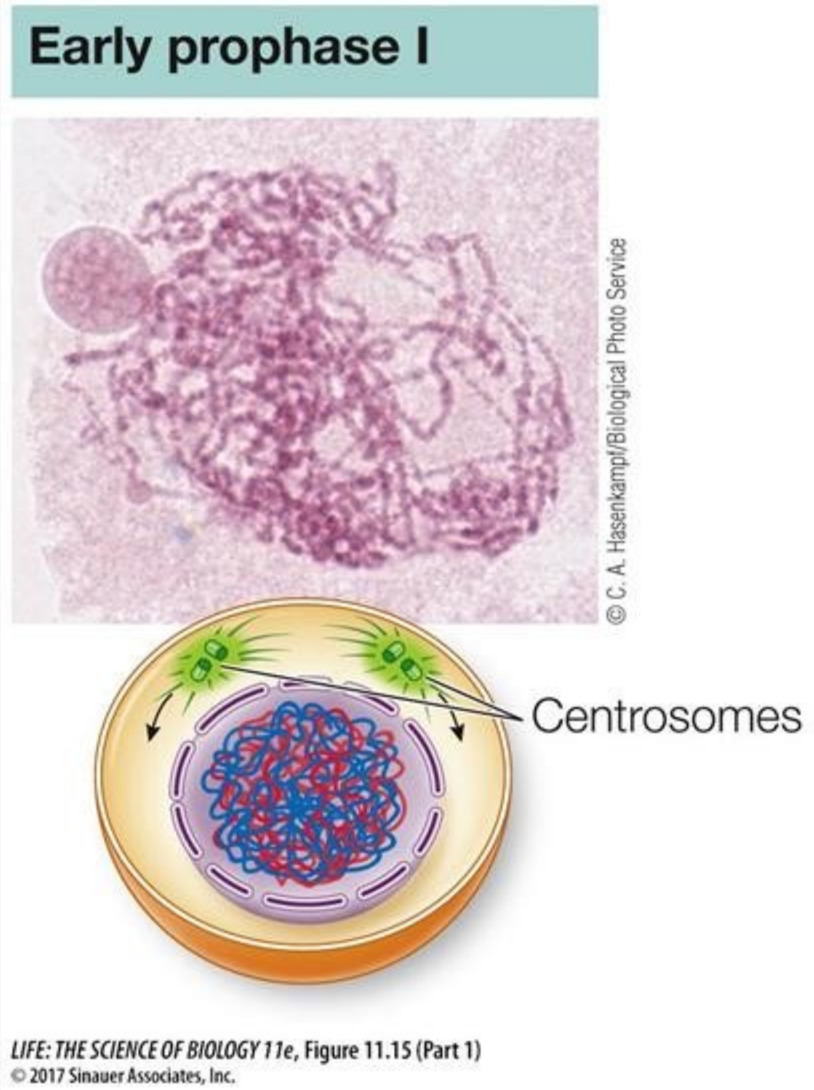
# MEIOSIS

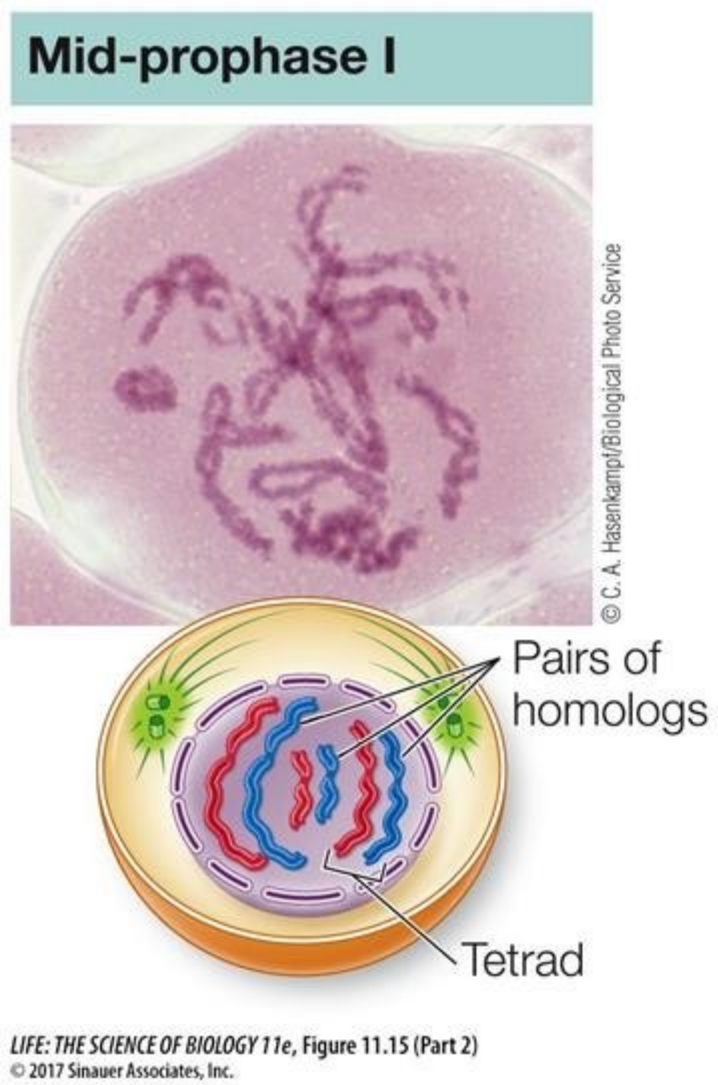
# DIFFERENCE IN MEIOSIS AND MITOSIS

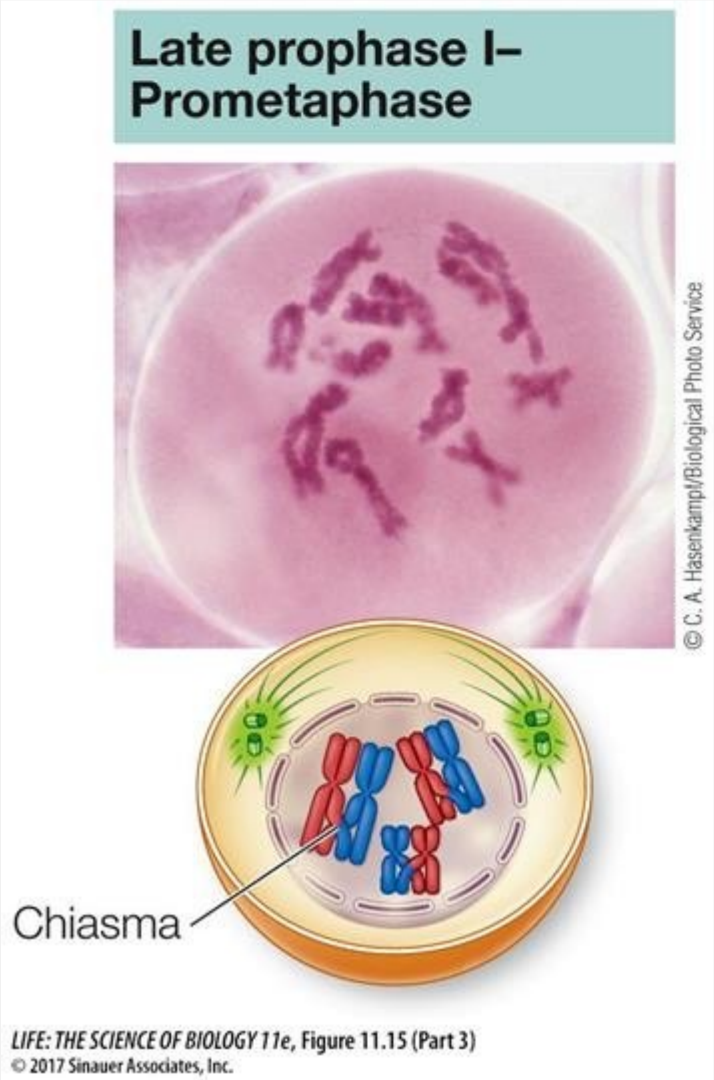



$M_{1,2}$ – maternal
$P_{1,2}$ - paternal

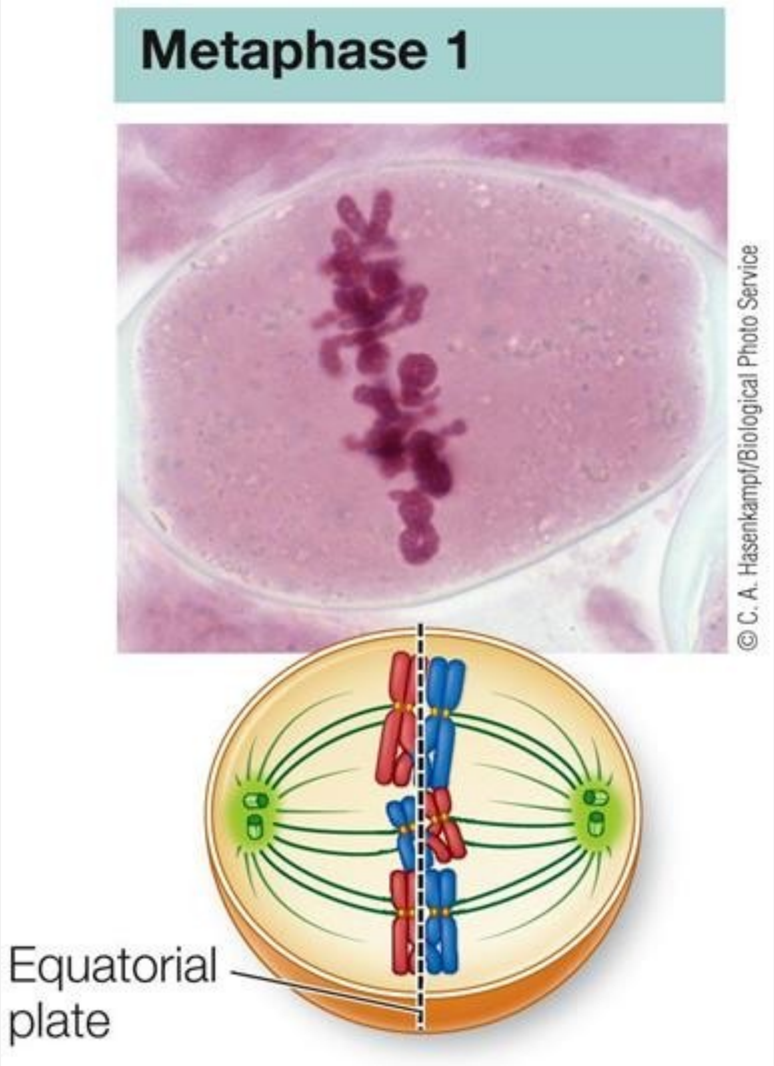
# PHASES OF MEIOSIS



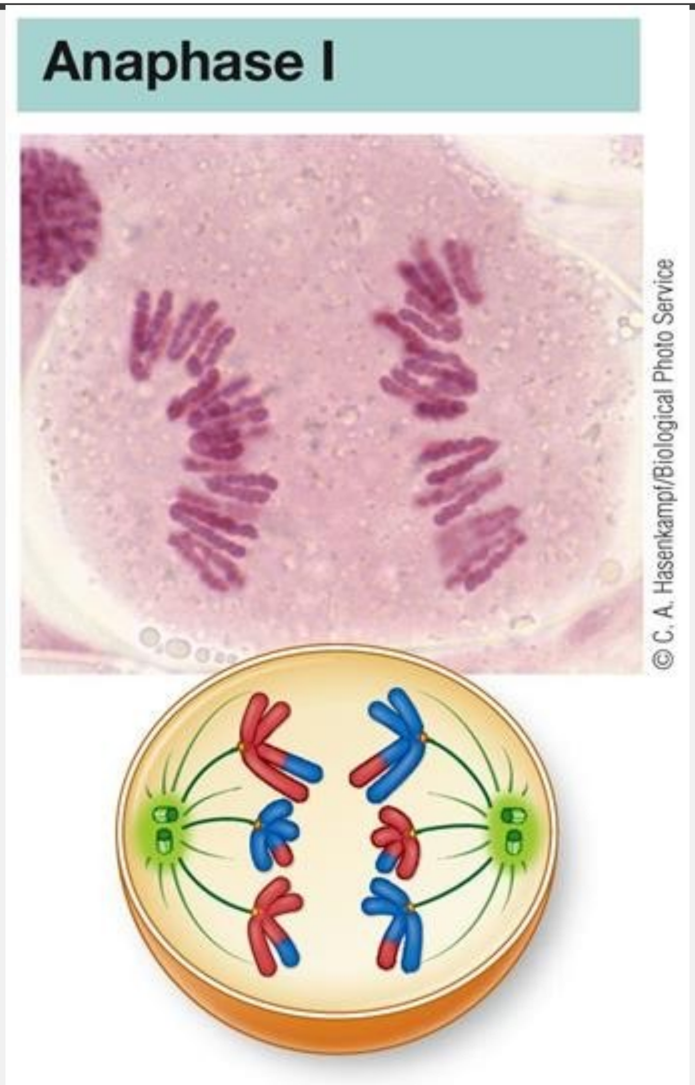



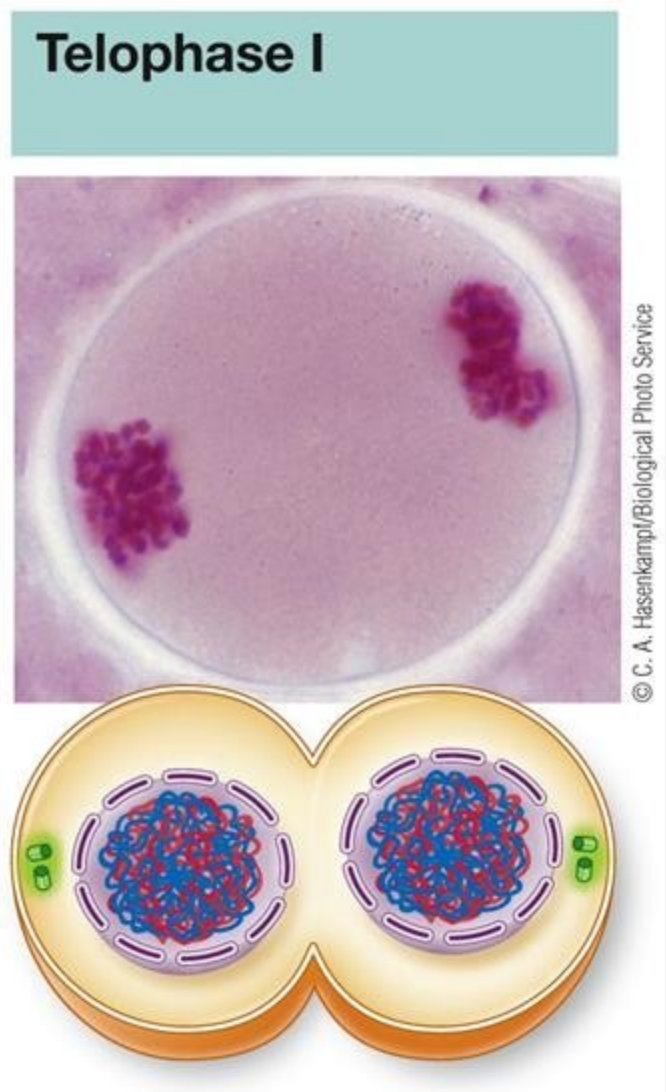
# PHASES OF MEIOSIS




LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 11.15 (Part 4)

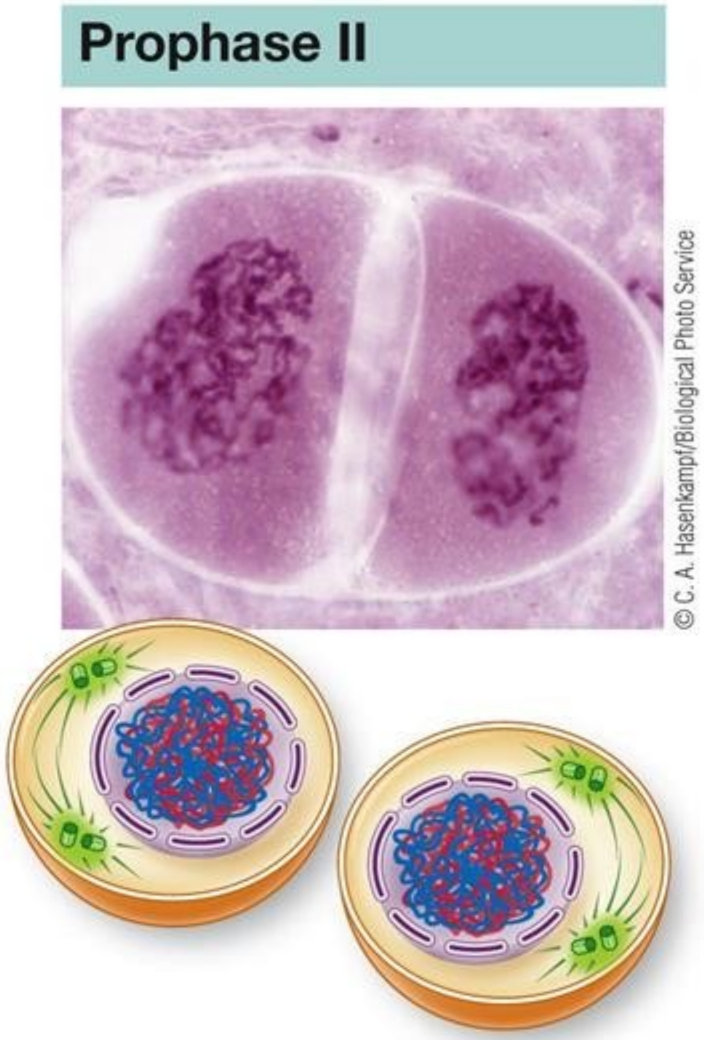




LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 11.15 (Part 5)

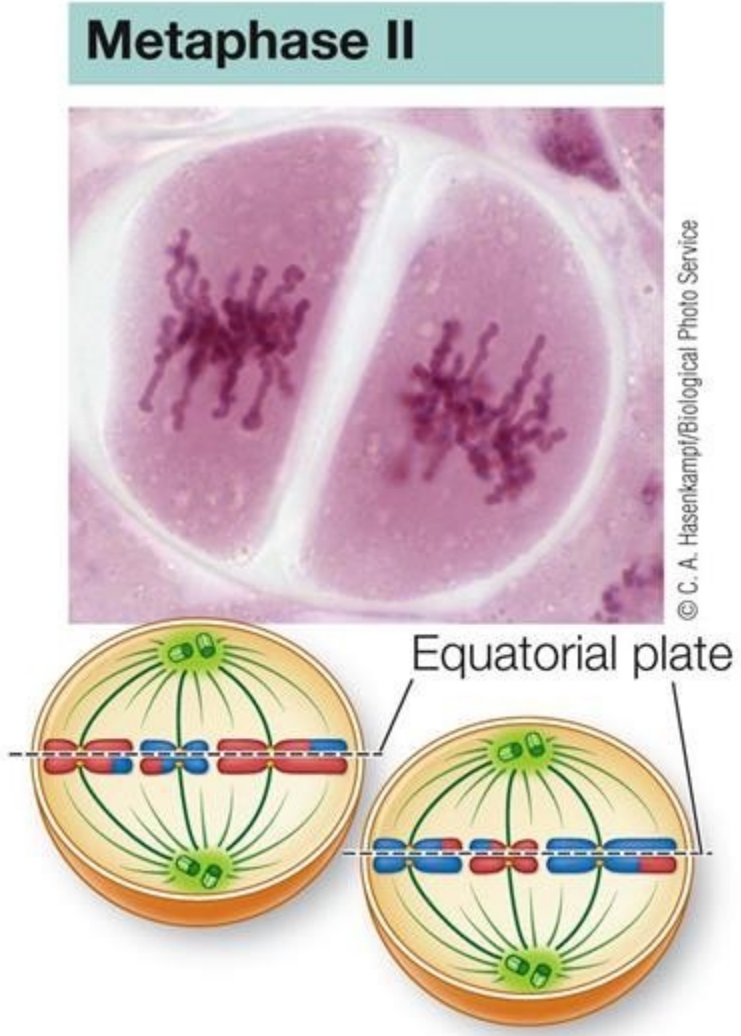




LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 11.15 (Part 6)

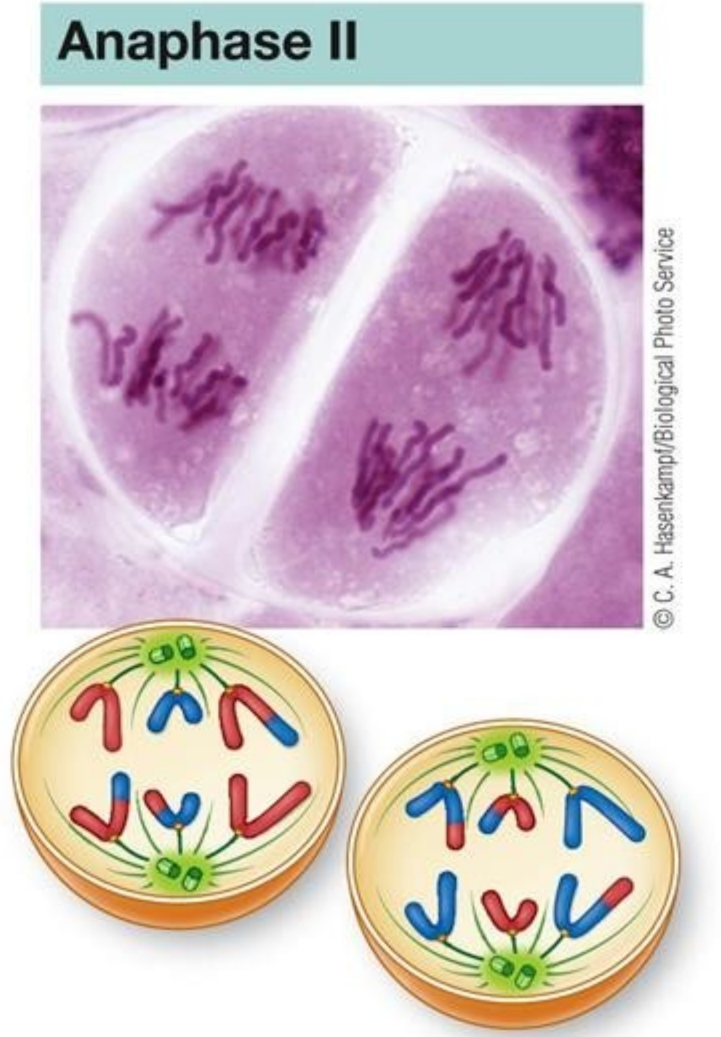
# PHASES OF MEIOSIS




LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 11.15 (Part 7)

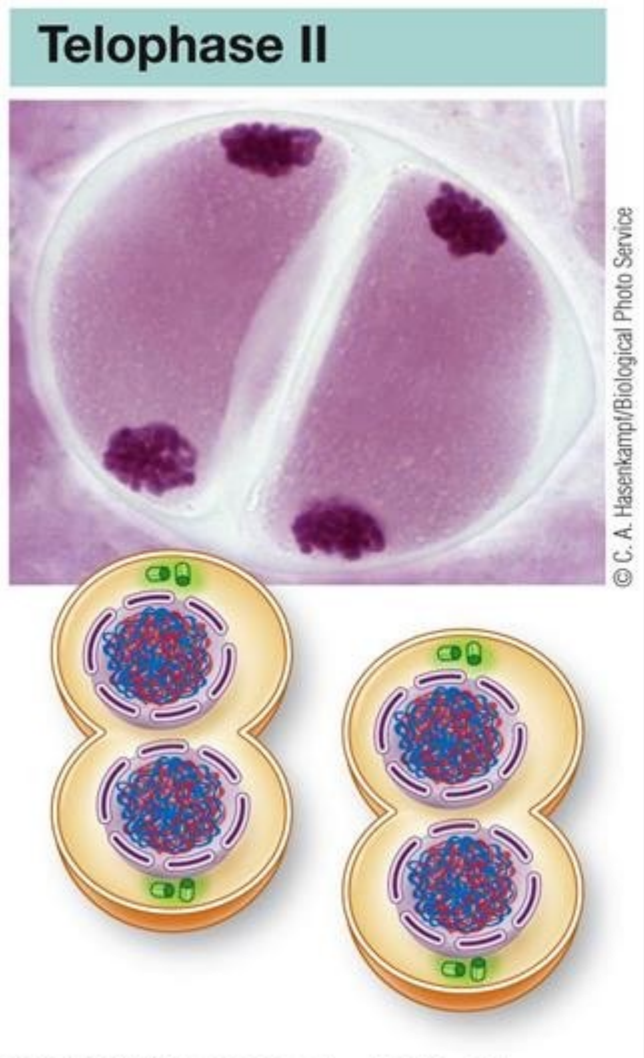




LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 11.15 (Part 8)

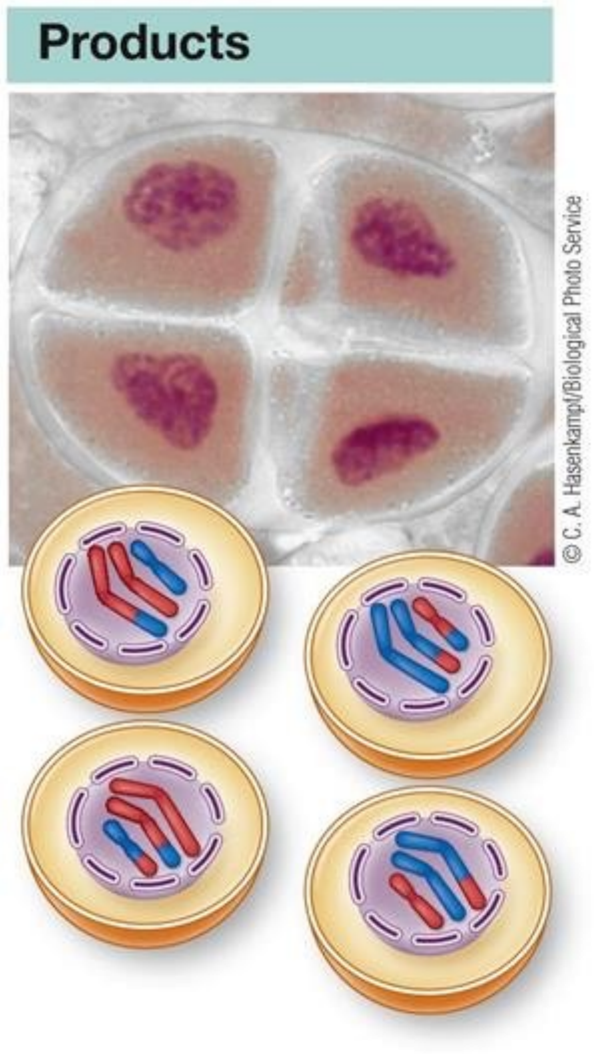




LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 11.15 (Part 9)

# PHASES OF MEIOSIS



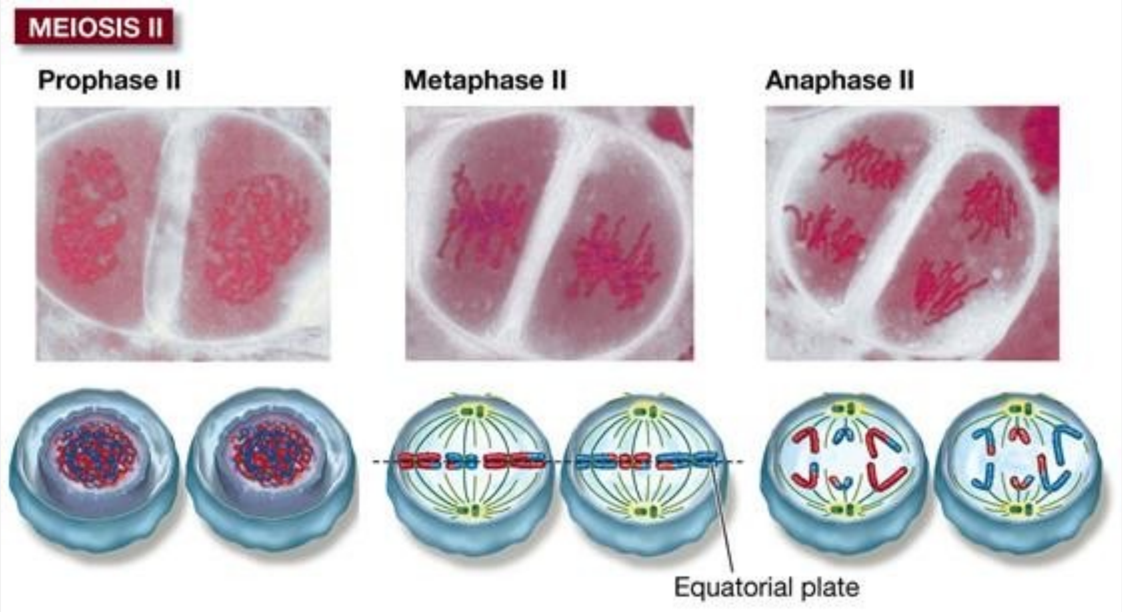

LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 11.15 (Part 10)

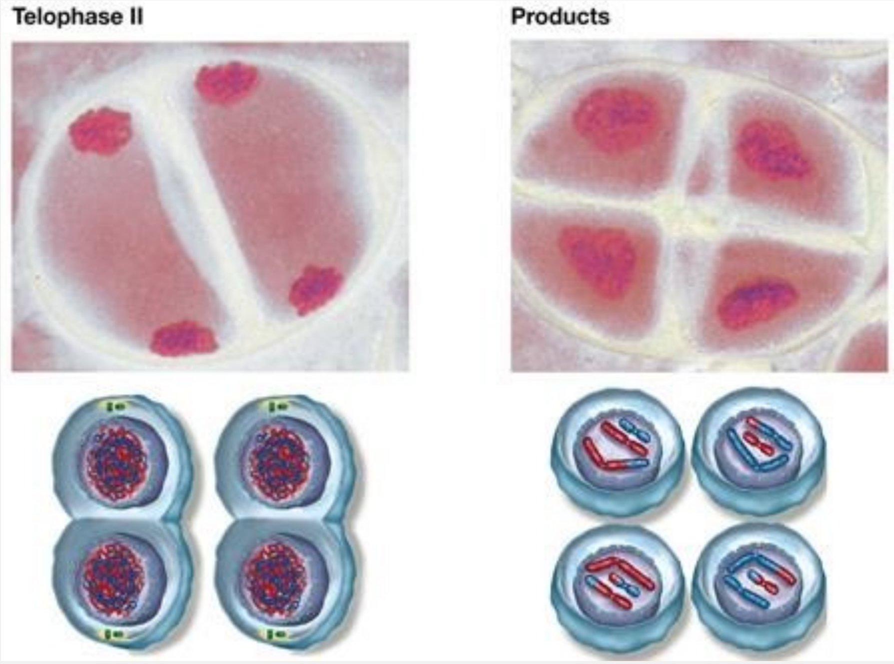




LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 11.15 (Part 11)

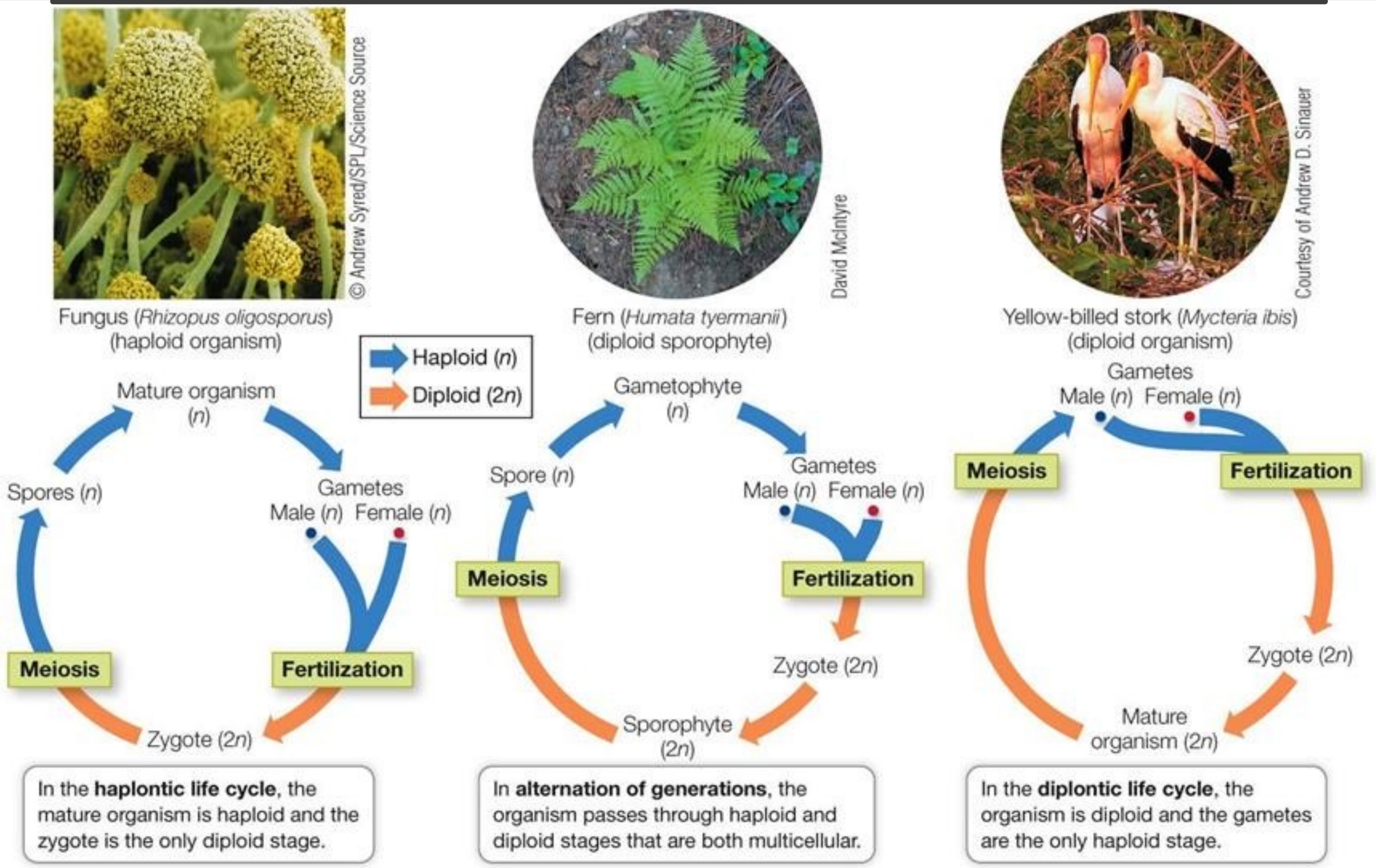
# DIFFERENCES BETWEEN MEIOSIS II AND MITOSIS

- DNA does not replicate before meiosis II
- In meiosis II, the sister chromatids will not be identical because of crossing over



# FERTILIZATION AND MEIOSIS ALTERNATE IN SEXUAL REPRODUCTION




*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 11.14

# KNOWLEDGE CHECK

**The major drawback of asexual reproduction, as compared to sexual reproduction, is that it**

a. takes a great deal of time.

b. generates variation.

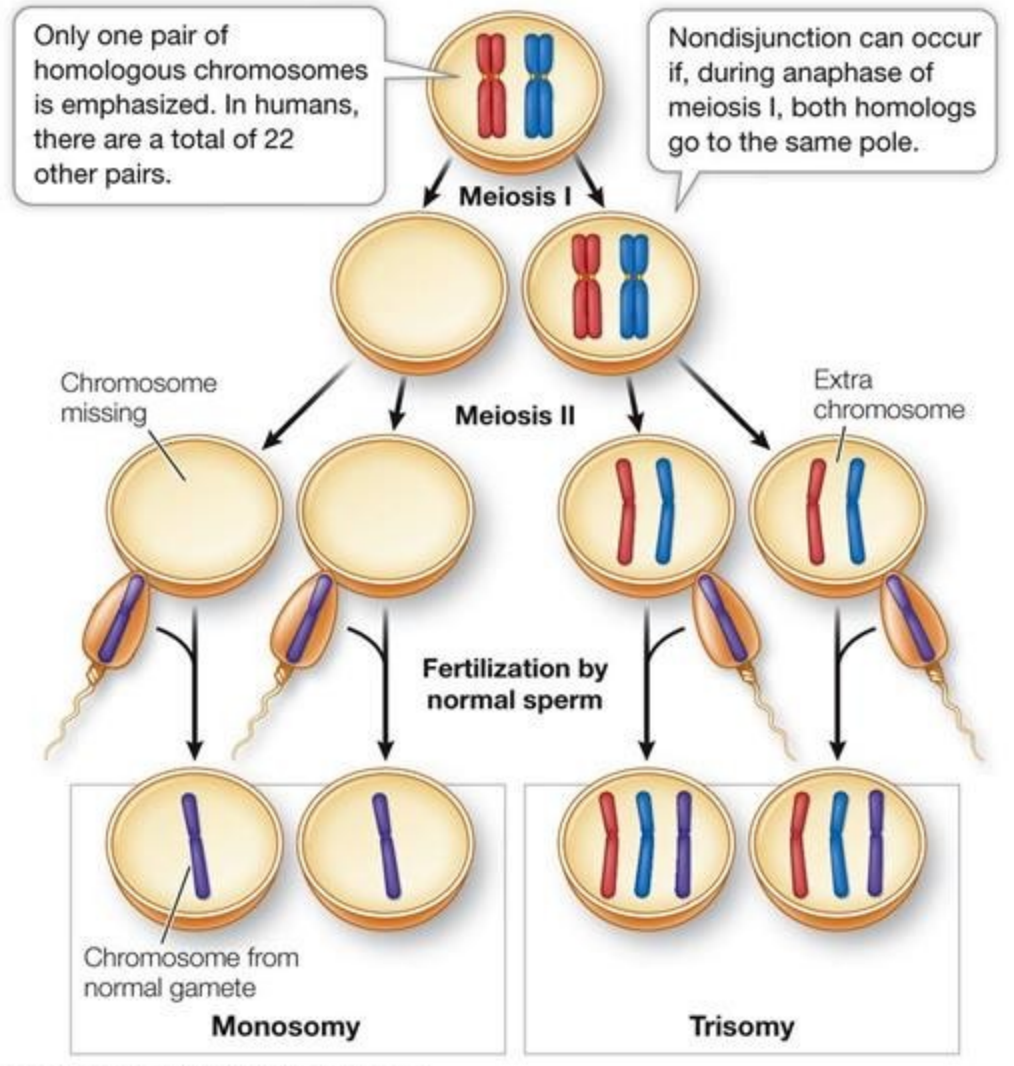
c. requires cytokinesis.

d. produces less variation among offspring.

e. None of the above; there are no major drawbacks associated with asexual reproduction.

# MEIOTIC ERRORS

# NONDISJUNCTION




*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 11.19

# KNOWLEDGE CHECK

**Many chromosome abnormalities (trisomies and monosomies) are not observed in the human population because:**

a. they are lethal and cause spontaneous abortion of the embryo early in development.

b. all trisomies and monosomies are lethal early in childhood.

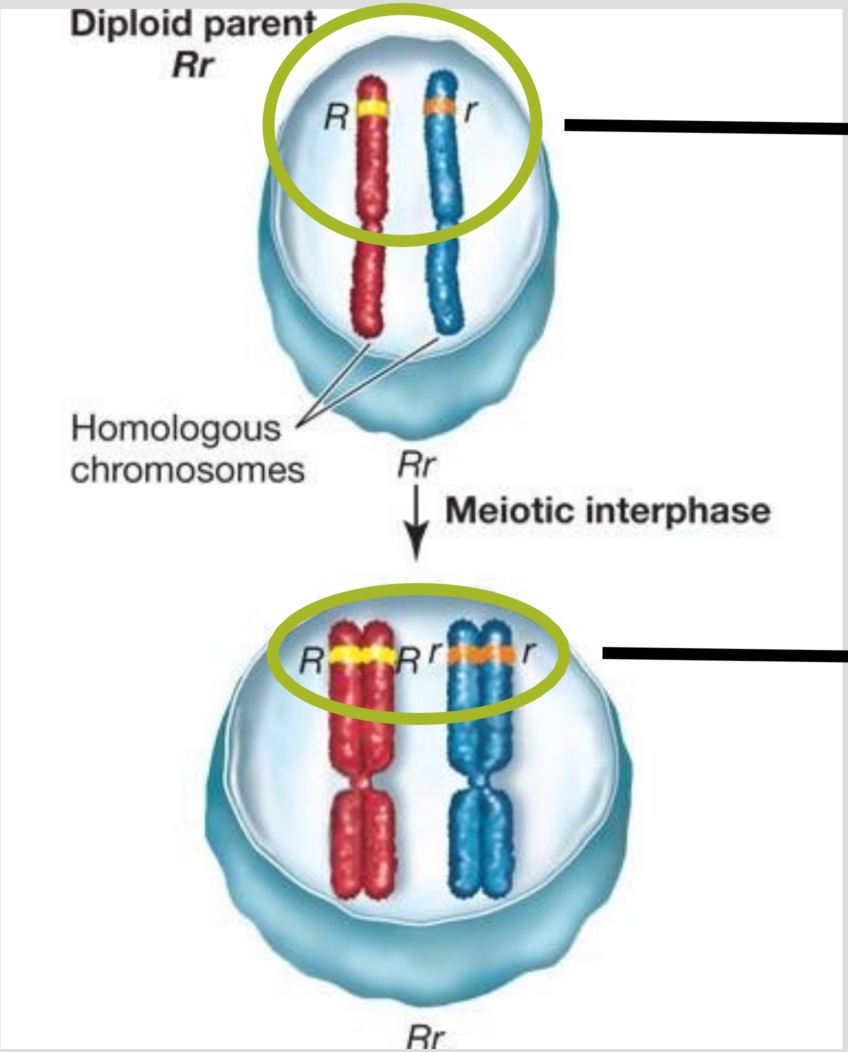
c. meiosis distributes chromosomes to daughter cells with great precision.

d. they are so difficult to count.

e. the human meiotic spindle is self-correcting.

# CHAPTER 12: INHERITANCE (MENDELIAN GENETICS)

# TERMINOLOGY BY APPLICATION




**Heterozygous** Alleles: same gene at same locus carries different alleles, Rr or rR

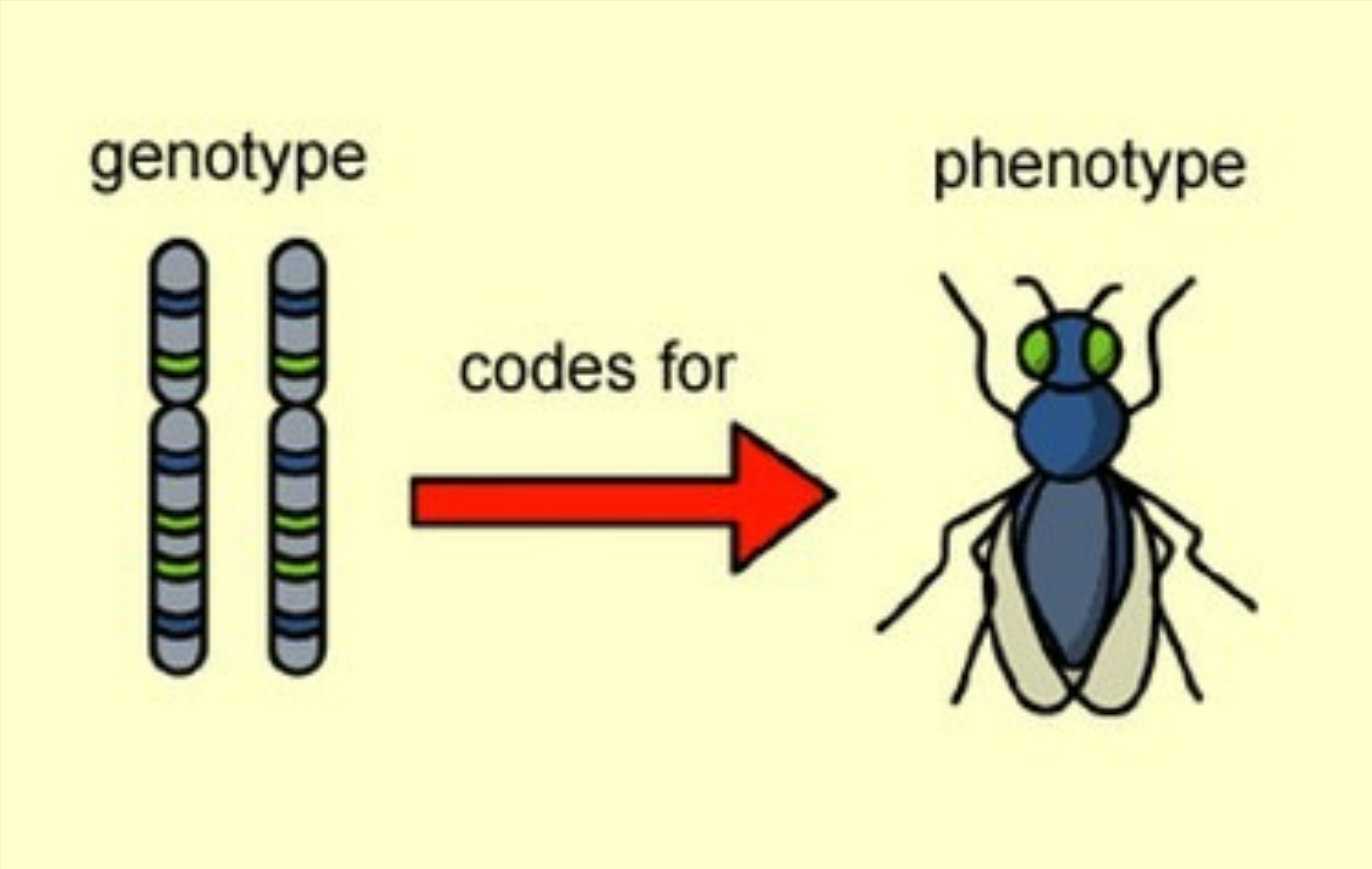
**Homozygous** Alleles: same gene at same locus carries the same alleles, RR or rr

# TERMINOLOGY BY APPLICATION

| Dominant Gene | Recessive Gene |
|---|---|
| Cleft Chin | No Cleft |
| Widow's Peak | No Widow's Peak |
| Dimples | No Dimples |
| Brown/Black Hair | Blonde Hair |
| Freckles | No Freckles |
| Brown Eyes | Gray/Blue Eyes |
| Free Earlobe | Attached Earlobe |

**Dominant VS. Recessive**

# TERMINOLOGY BY APPLICATION




**Genotype VS. Phenotype**

# TERMINOLOGY BY APPLICATION

Punnett Square for a true-breeding, cross in Parental Generation

| | A | A |
|---|---|---|
| a | Aa | Aa |
| a | Aa | Aa |

Homozygous **Dominant**

**AA x aa**

Homozygous **Recessive**

**True breeding, Parental (*P*) Generation**

First Filial (***F1***) Generation

**Aa**

**Heterozygous**

Self-pollination (**Aa x Aa**)

# TERMINOLOGY BY APPLICATION

**Genotypic Ratio:**(1)**AA :** (2)**Aa :** (1)**aa**

**Phenotypic Ratio:**(3)**Dominant :** (1)**Recessive**

**Second Filial (*F2*) Generation**

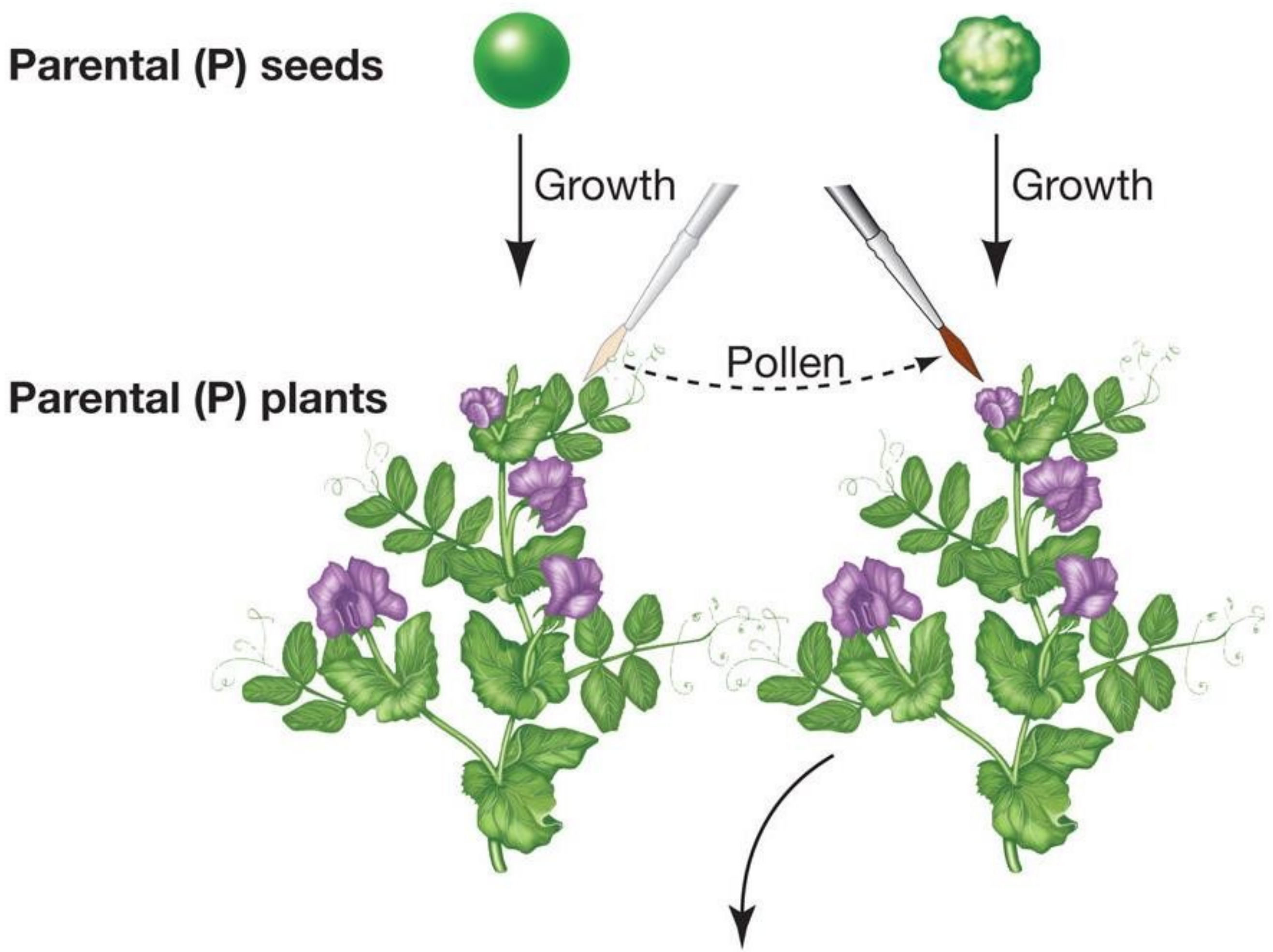
| | A | a |
|---|---|---|
| A | AA | Aa |
| a | aA | aa |

# MENDEL'S MONOHYBRID CROSS

## INVESTIGATING**LIFE**

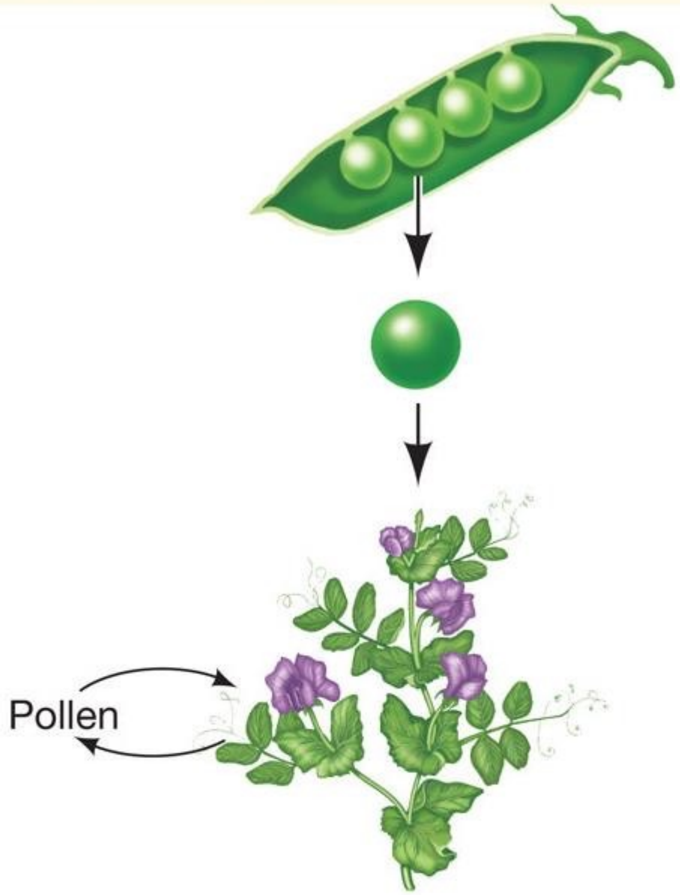
**HYPOTHESIS** When two strains of peas with contrasting traits are bred, their characteristics are irreversibly blended in succeeding generations.

***Method*** Plant a true-breeding round seed — Plant a true-breeding wrinkled seed



$F_1$ seeds

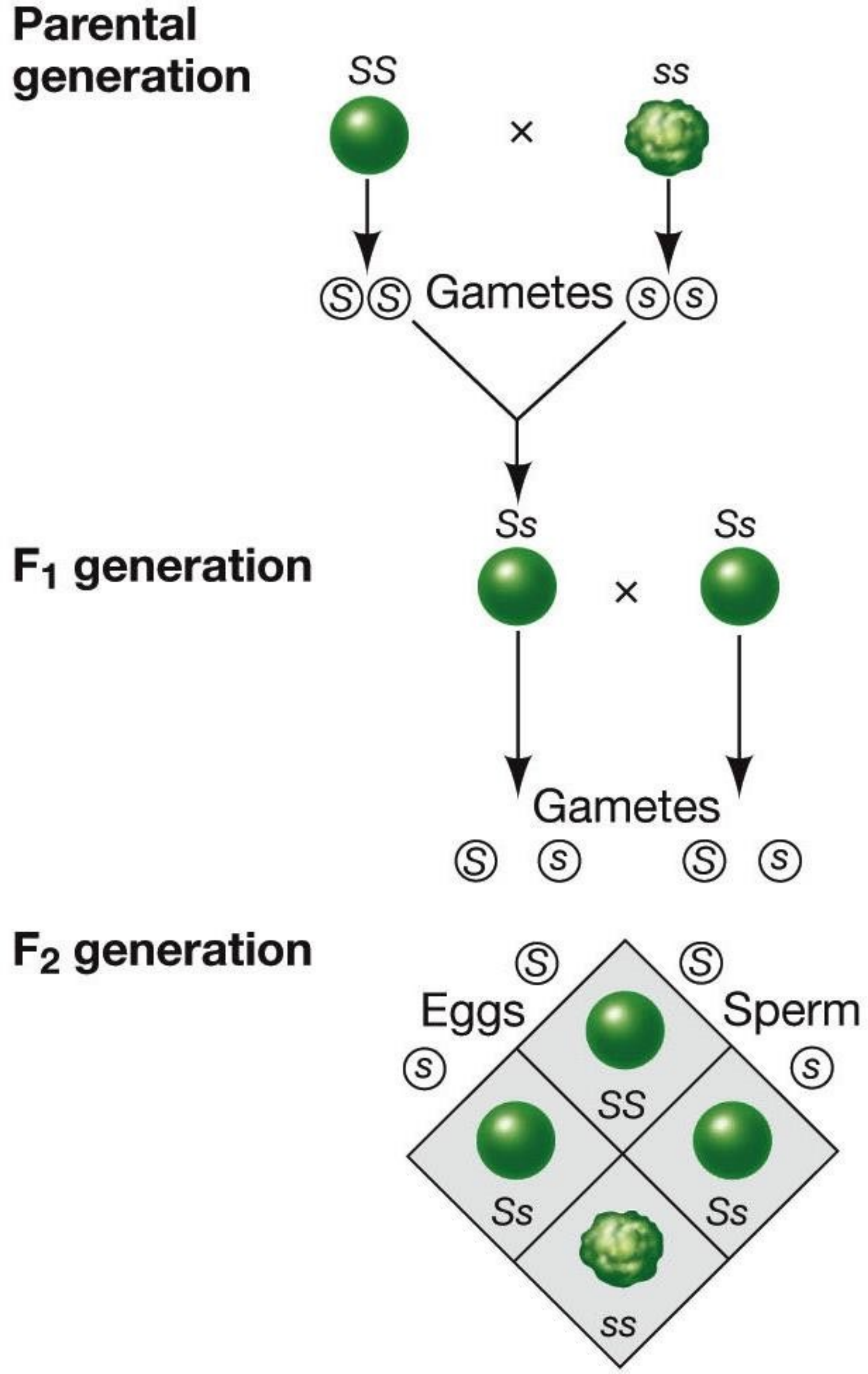
$F_1$ plant




*Results*

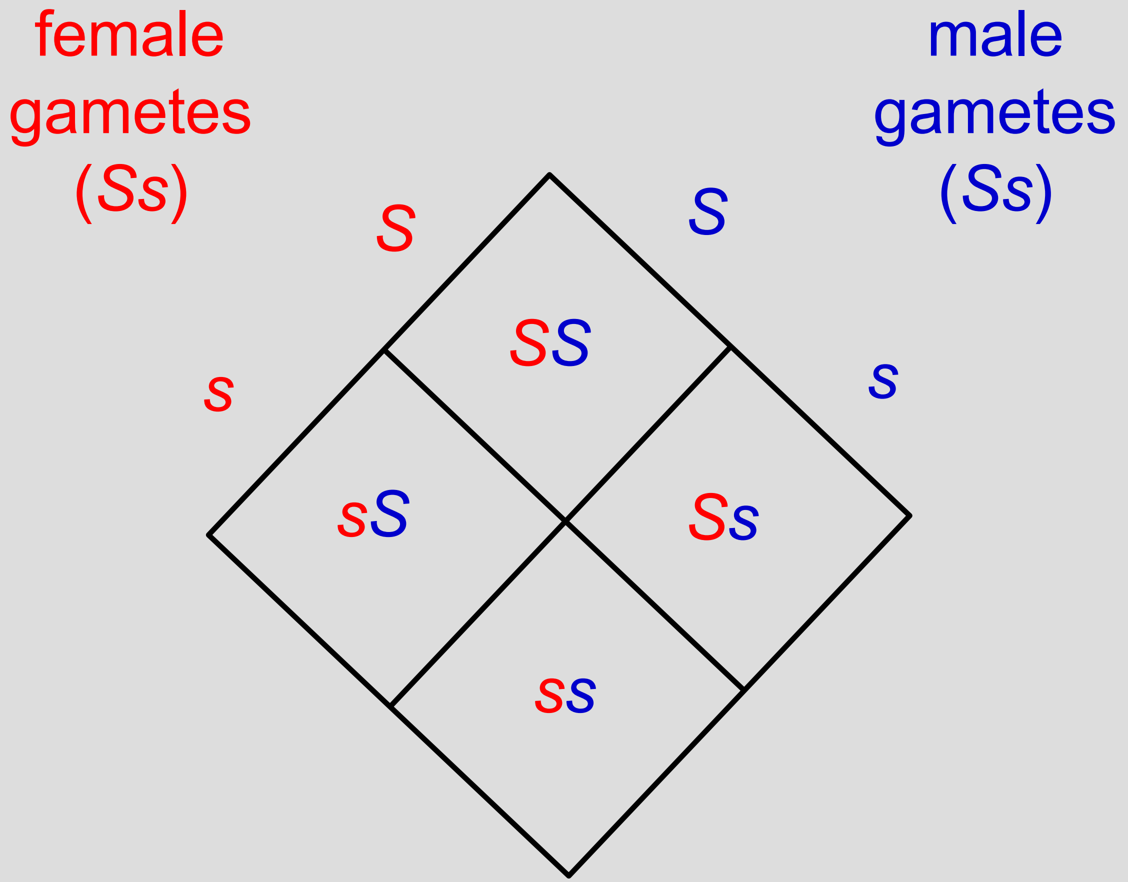
$F_2$ seeds from $F_1$ plant

**CONCLUSION** The hypothesis is rejected. There is no irreversible blending of characteristics, and a recessive trait can reappear in succeeding generations.

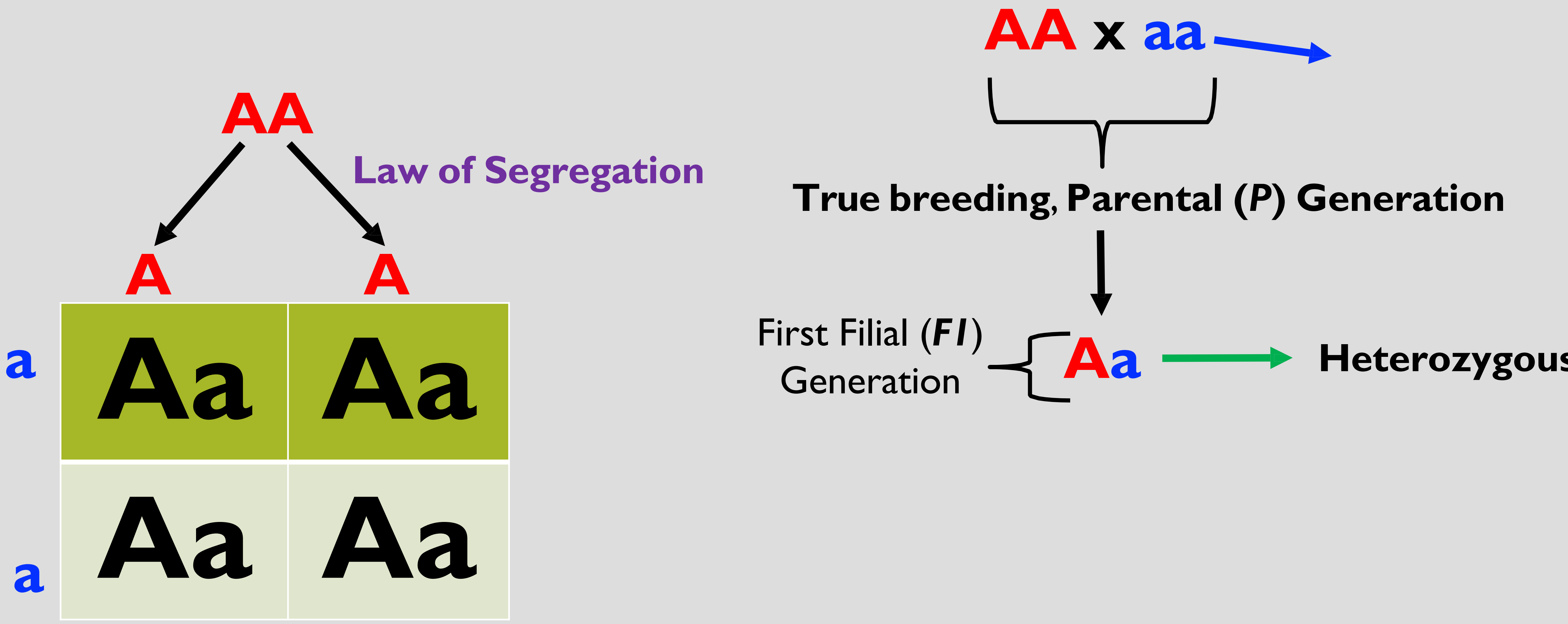



# What Mendelian Law can be applied here?

## Law of Independent Assortment



# LAW OF SEGREGATION



# MENDEL'S DIHYBRID CROSS

Two Traits

# MENDELIAN LAWS OF INHERITANCE

**SSYY—spherical yellow seeds**

**ssyy—wrinkled green seeds**

| | SY | SY | SY | SY |
|---|---|---|---|---|
| sy | SsYy | SsYy | SsYy | SsYy |
| sy | SsYy | SsYy | SsYy | SsYy |
| sy | SsYy | SsYy | SsYy | SsYy |
| sy | SsYy | SsYy | SsYy | SsYy |

Homozygous **Dominant** for 2 traits

**SSYY x ssyy**

Homozygous **Recessive** for 2 traits

**True breeding, Parental (*P*) Generation**

First Filial (***F1***) Generation

**SsYy Heterozygous**

Self-pollination (**SsYy x SsYy**)

# CONTINUATION

**Second Filial (*F2*) Generation**

***Phenotypic Ratio***

| | |
|---|---|
| ***S_Y_*** **— spherical yellow seeds** | 9 |
| ***S_yy*** **— spherical green seeds** | 3 |
| ***ssY_*** **— wrinkled yellow seeds** | 3 |
| ***ssyy*** **—wrinkled green seeds** | 1 |

**Law of Independent Assortment**

| | SY | Sy | sY | sy |
|---|---|---|---|---|
| SY | SSYY | SSYy | SsYY | SsYy |
| Sy | SSYy | SSyy | SsYy | Ssyy |
| sY | SsYY | SsYy | ssYY | ssYy |
| sy | SsYy | Ssyy | ssYy | ssyy |

# A FEW QUESTIONS:

**Different Alleles/Variation in Alleles arise because of __Mutations__.**

**Random mutations can cause more than two (2) alleles to be present in a population, however, any one individual can carry __2__ alleles.**

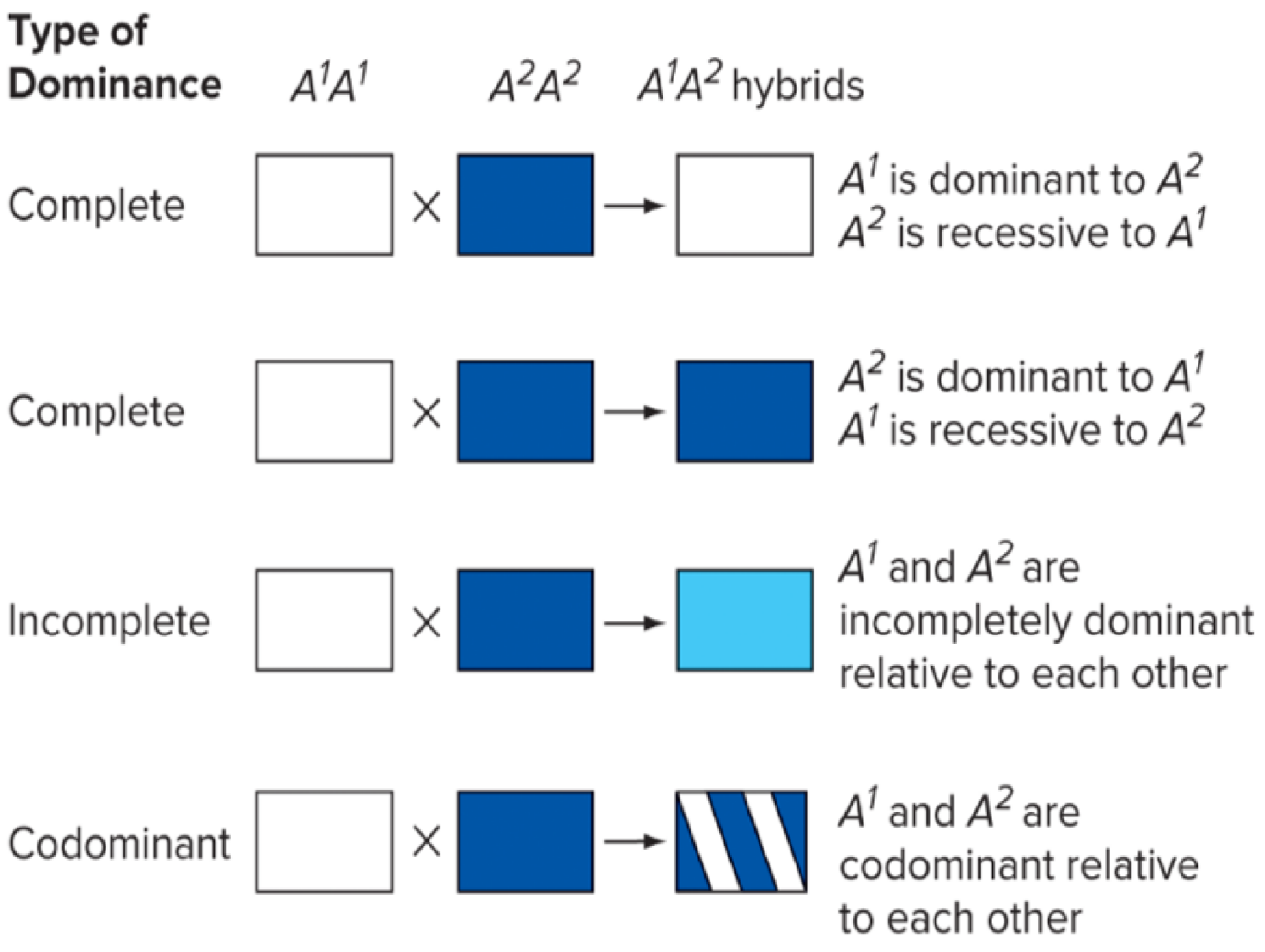
**Multiple alleles increase the number (#) of possible __Phenotypes__.**

**A __Wild-type__ allele is present the most in a population.**

**__Mutant__ alleles are present the least in a population.**

# GENES DO INTERACT WITH EACH OTHER

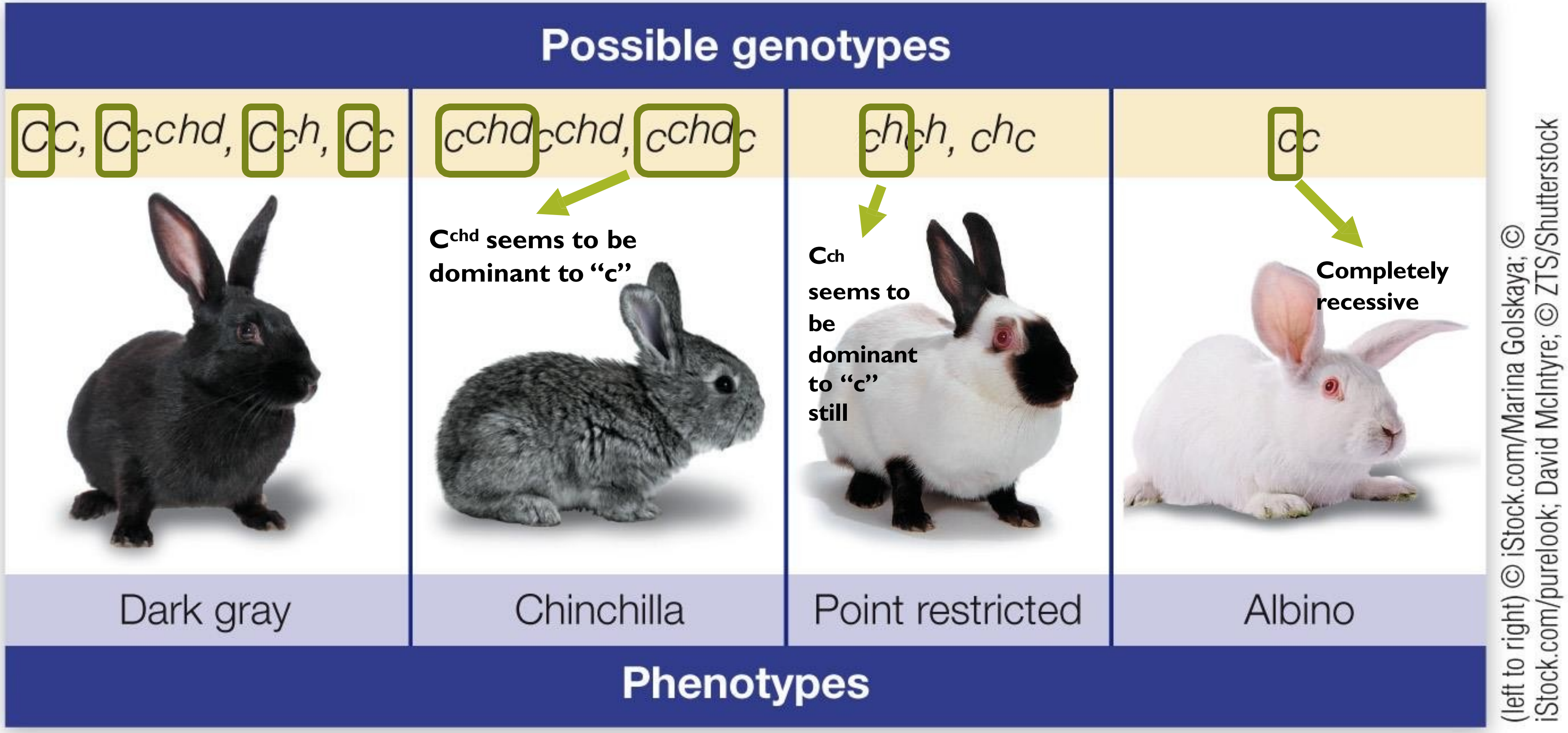
# TAKE ALL


Type of Dominance
A1A1
A2A2
A1A2 hybrids
Complete
A1 is dominant to A2
A2 is recessive to A1
Complete
A2 is dominant to A1
A1 is recessive to A2
Incomplete
A1 and A2 are incompletely dominant relative to each other
Codominant
A1 and A2 are codominant relative to each other

# POLYMORPHISM

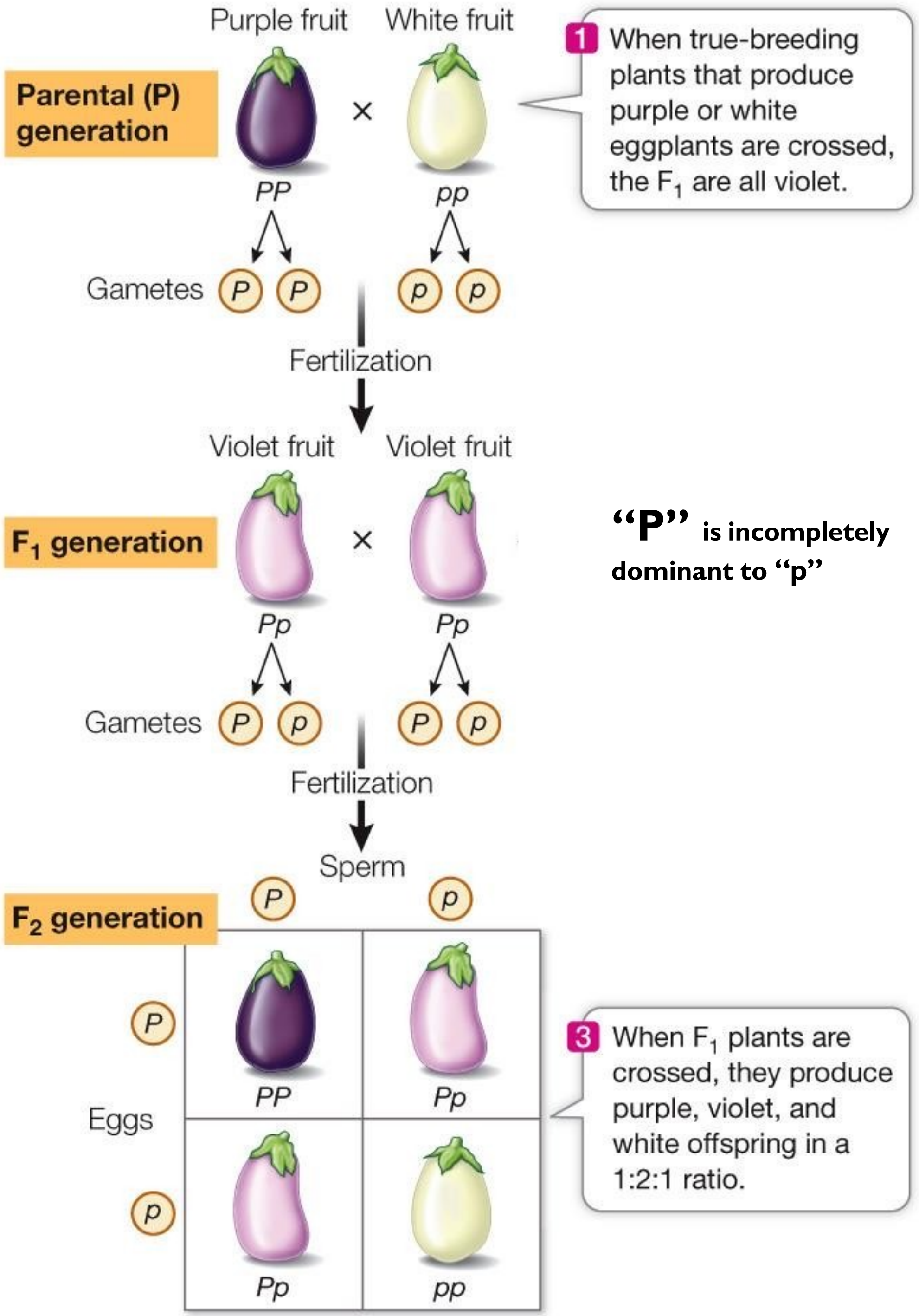
**Dark Gray is Dominant over White**

**All these genotypes have a "C"**




*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 12.8

# INCOMPLETE DOMINANCE

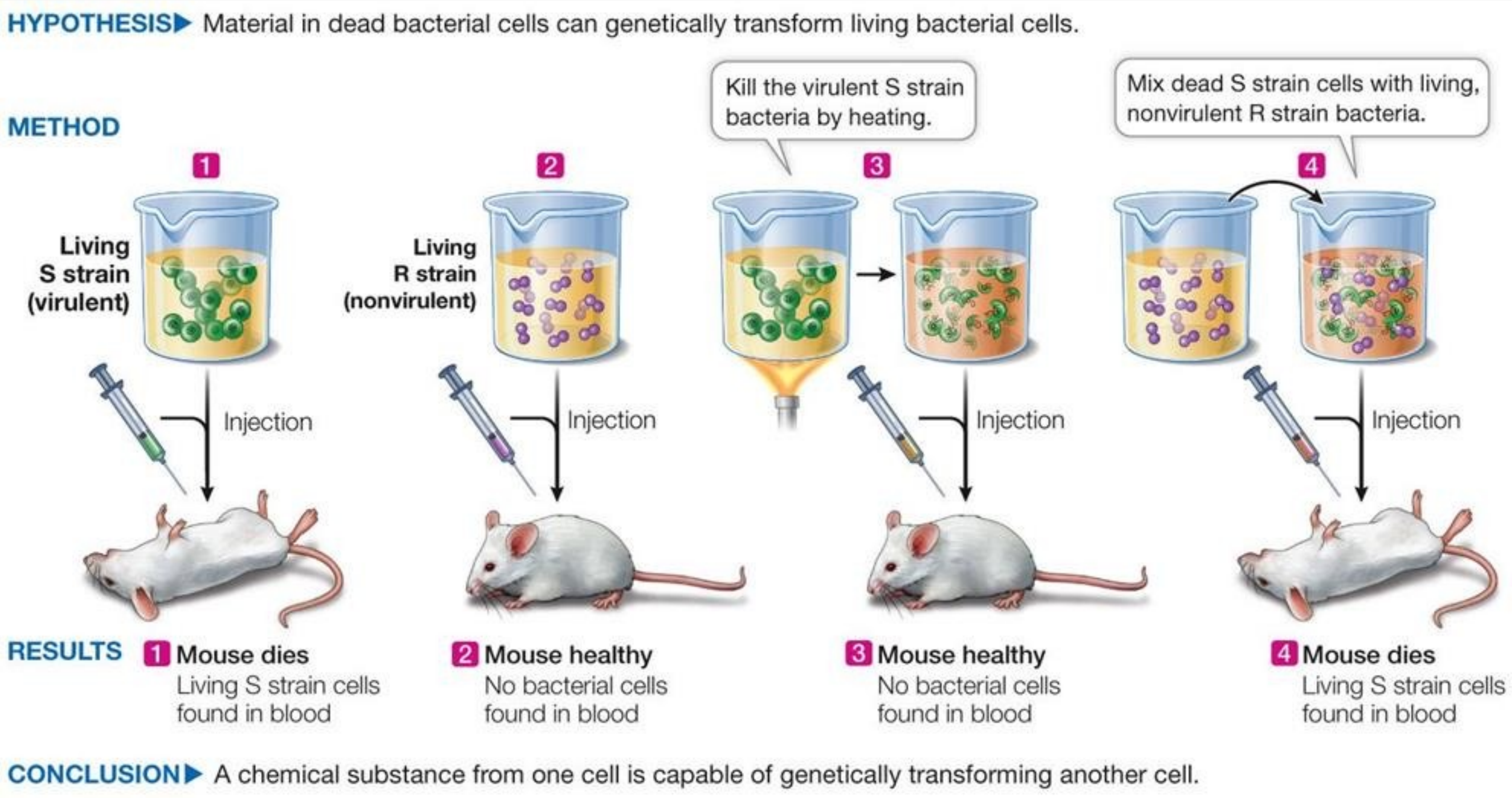



**"P" is incompletely dominant to "p"**

# CHAPTER 13: DNA AND ITS ROLE IN HEREDITY

# FREDRICK GRIFFITH’S EXPERIMENTS: GENETIC TRANSFORMATION

# TRANSFORMING PRINCIPLE

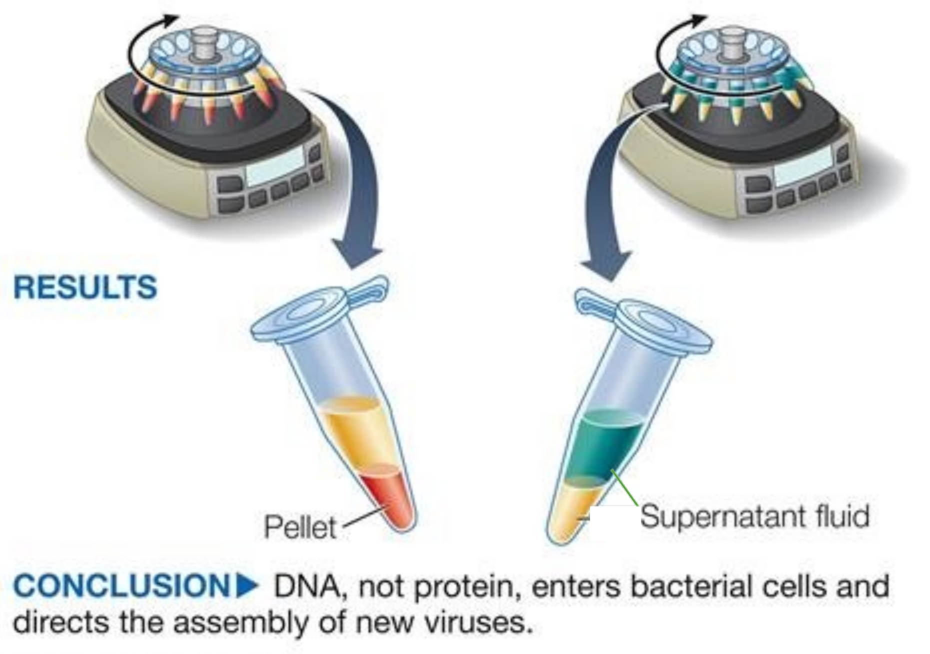



*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 13.1

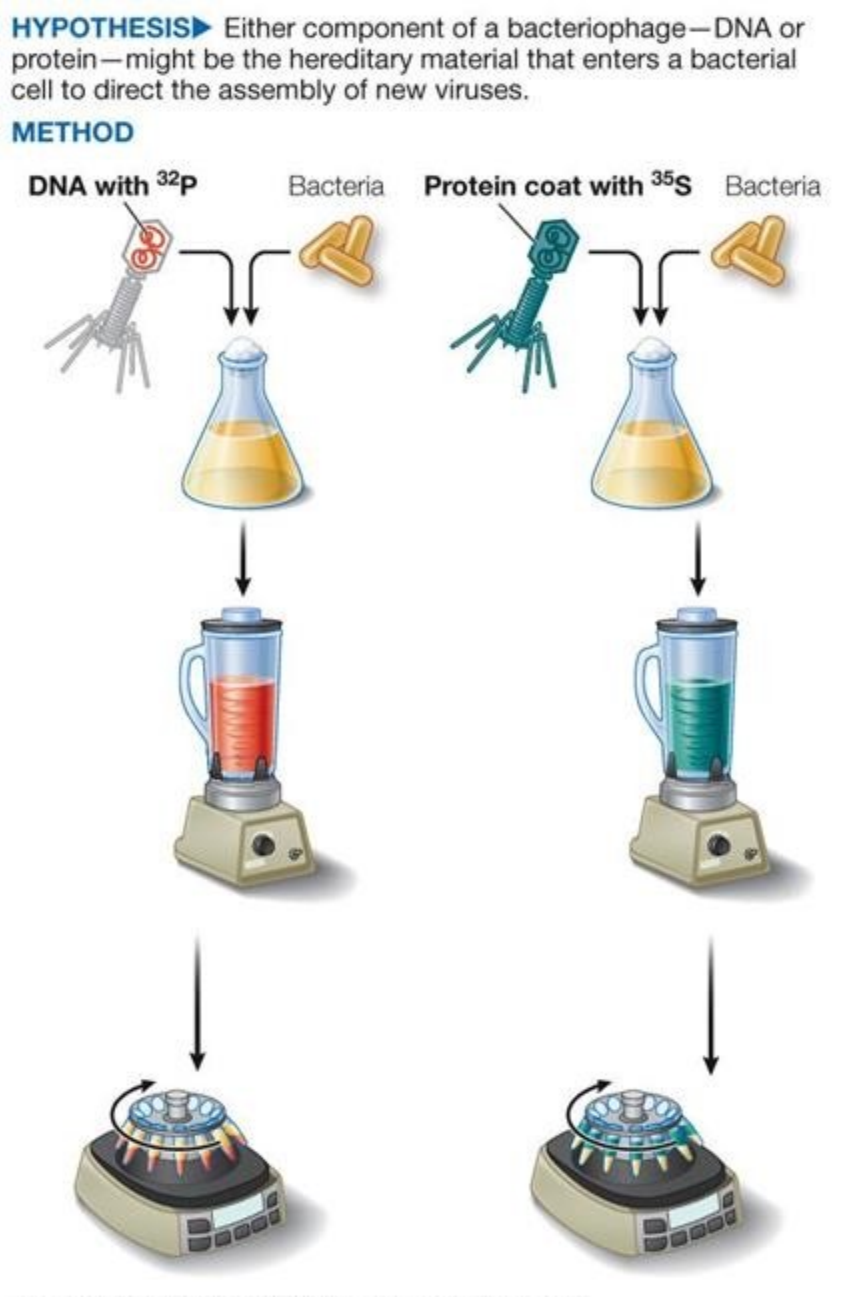
# THE HERSHEY-CHASE EXPERIMENTS

# THE HERSHEY-CHASE EXPERIMENTS

- They used bacteriophage T2 virus to determine whether DNA, or protein, is the genetic material
- Bacteriophage proteins were labeled with $^{35}S$; the DNA was labeled with $^{32}P$



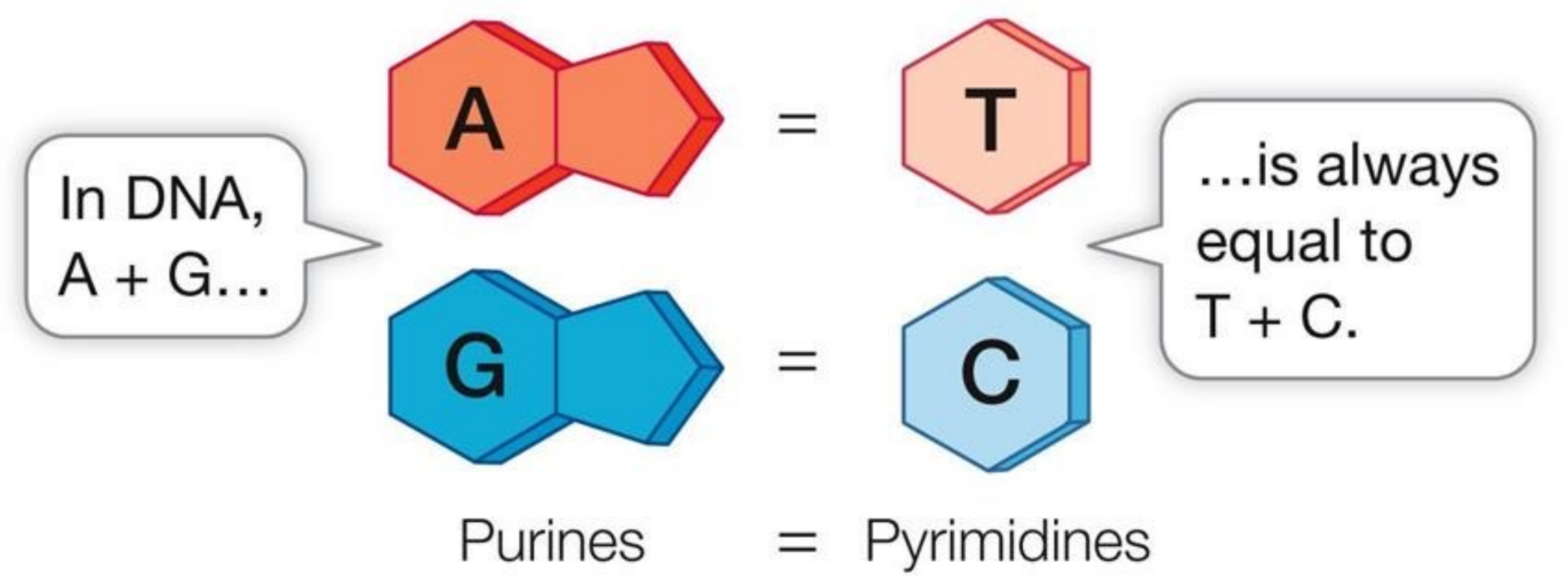

LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 13.4 (Part 2)


LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 13.4 (Part 1)

# THE STRUCTURE OF DNA

# ERWIN CHARAGAFF: THE BASES OF DNA




*LIFE: THE SCIENCE OF BIOLOGY 11e*, In-Text Art, Ch. 13, p. 271 (1)

# KNOWLEDGE CHECK

**If a sequence in one strand of DNA is 5′-AGCTGCTGA-3′, what is the sequence in the complementary strand?**

a. 5′-AGCTGCTGA-3′

b. 3′-AGCTGCTGA-5′

c. 5′-TCGACGACT-3′

d. 3′-TCGACGACT-5′

e. 3′-TCGATGACT-5′

# KNOWLEDGE CHECK

**Thirty percent of the bases in a sample of DNA extracted from eukaryotic cells are adenine. What percentage of cytosine is present in this DNA?**

a. 10 percent

b. 20 percent

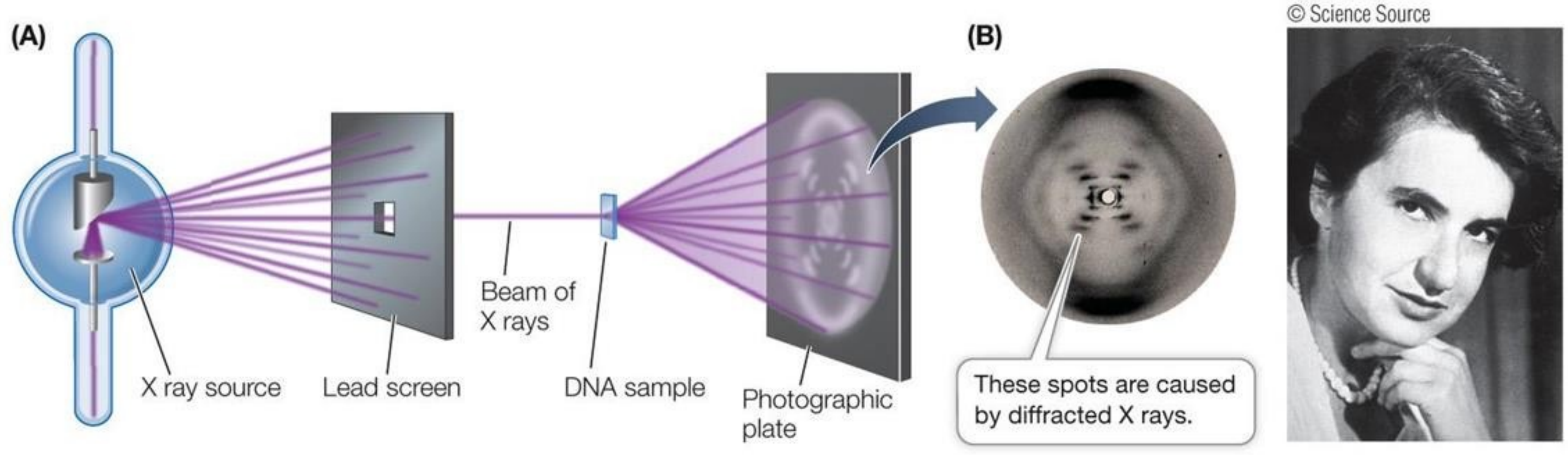
c. 30 percent

d. 40 percent

e. 50 percent

# STRUCTURE OF DNA: ROSALIND FRANKLIN

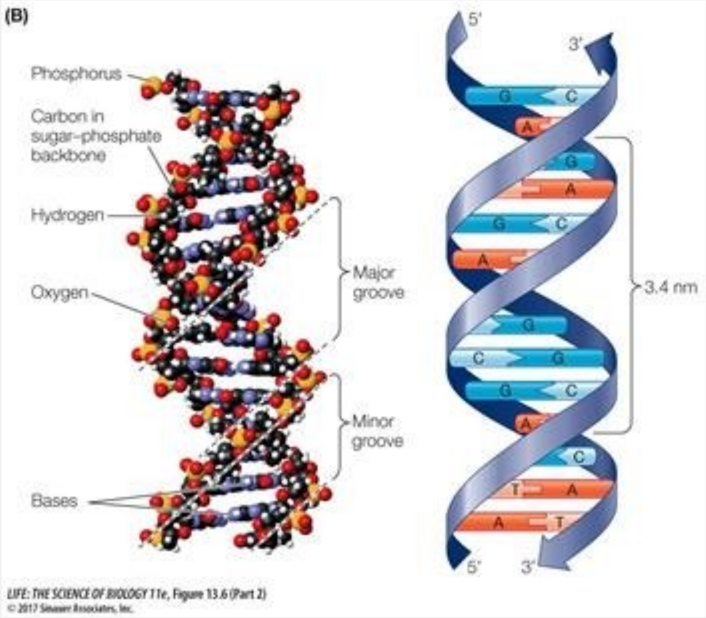
- The structure of DNA was determined by many different sources of evidence, however crucial piece came from X-ray crystallography.
- Crystallography suggested: double helix with sugar-phosphate backbone of each strand on outside.

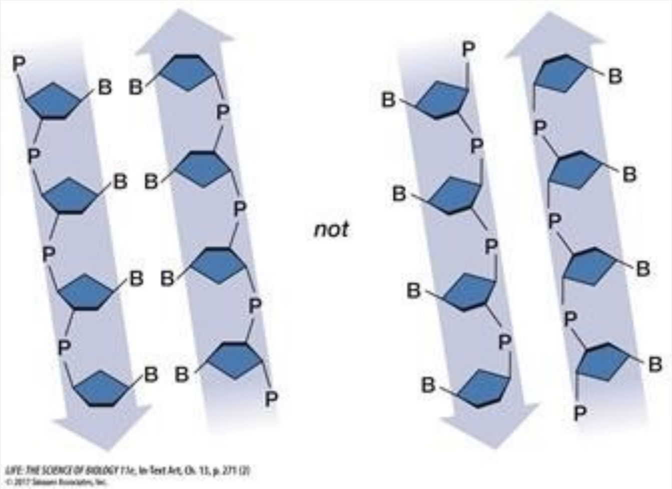



LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 13.5

# JAMES WATSON AND FRANCIS CRICK

- They used model building and combined all prior knowledge of DNA to determine its structure.
- Four key features of DNA structure:
  - It is a *double-stranded*
  - It is *right-handed… for the most part*
  - It is *antiparallel*
  - Outer edges of nitrogenous bases are *exposed* in the major and minor grooves



# KNOWLEDGE CHECK

**Which of the following molecular models describes the structure of the DNA molecule?**

a. Single-stranded and antiparallel

b. Single-stranded and parallel

c. Double-stranded and antiparallel

d. Double-stranded and parallel

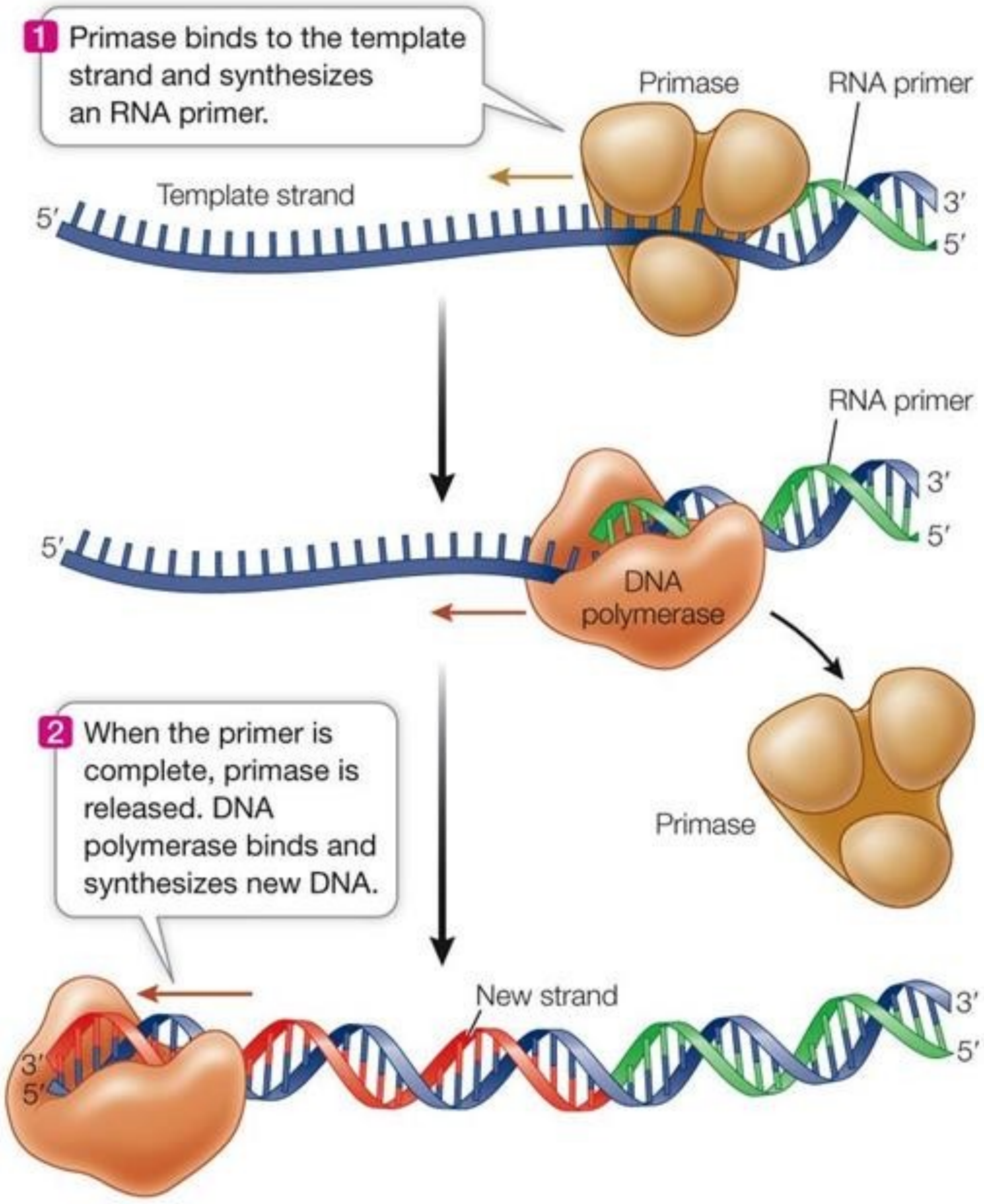
e. Triple-stranded and parallel

# FUNCTION OF GENETIC MATERIAL

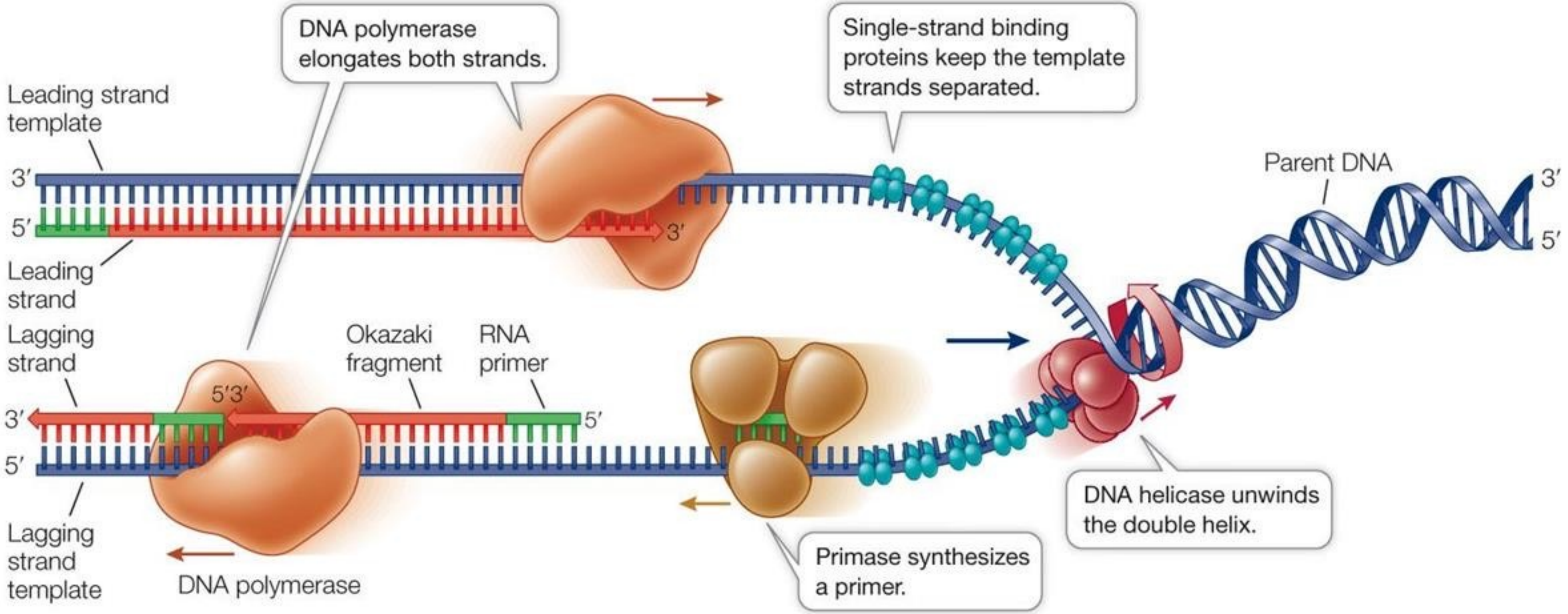
Four important functions of genetic material…

1) *Stores genetic information*
2) *Susceptible to mutation*
3) *Is precisely replicated* in cell division
4) *Expressed as the phenotype*

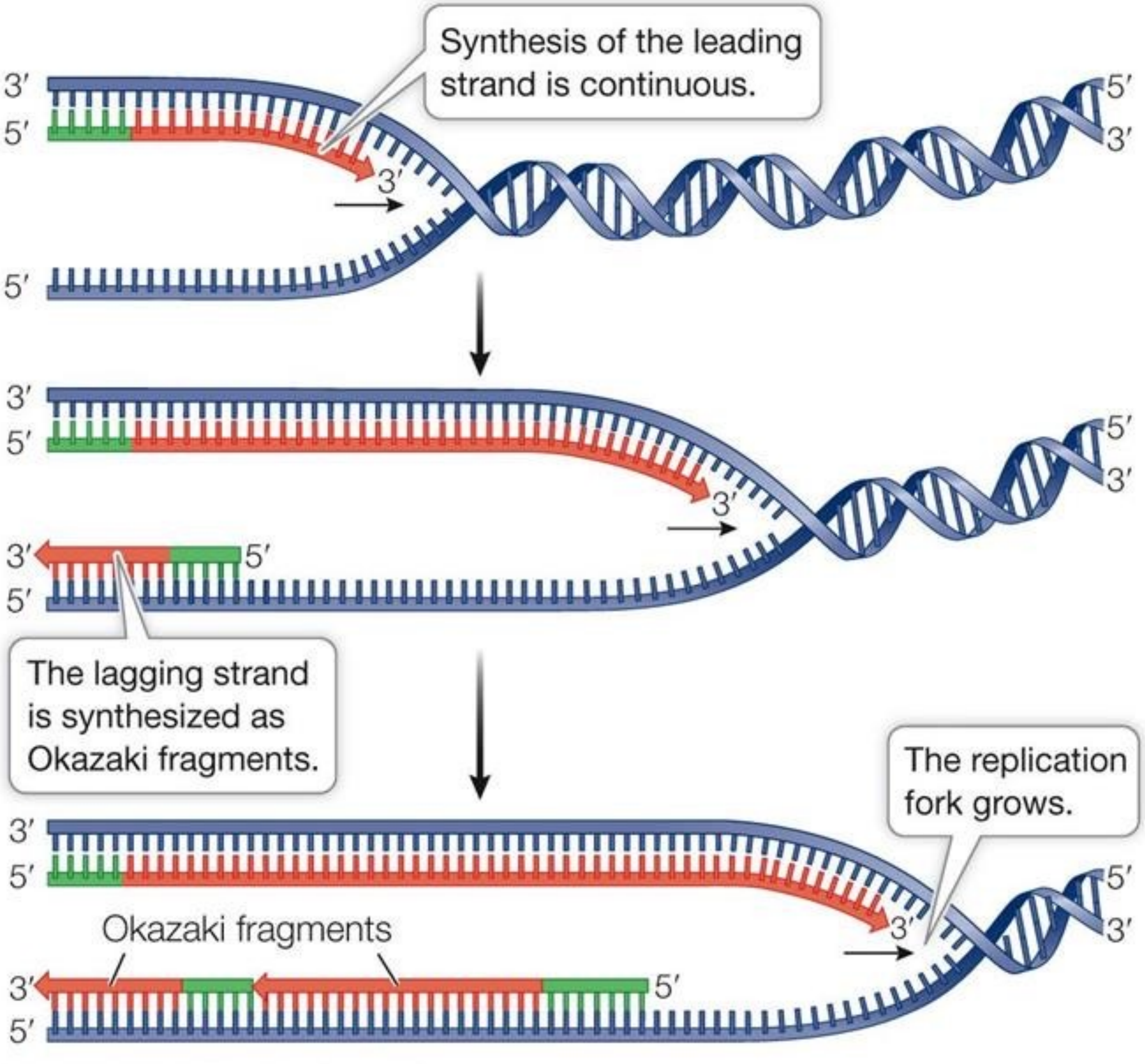
# DNA REPLICATION



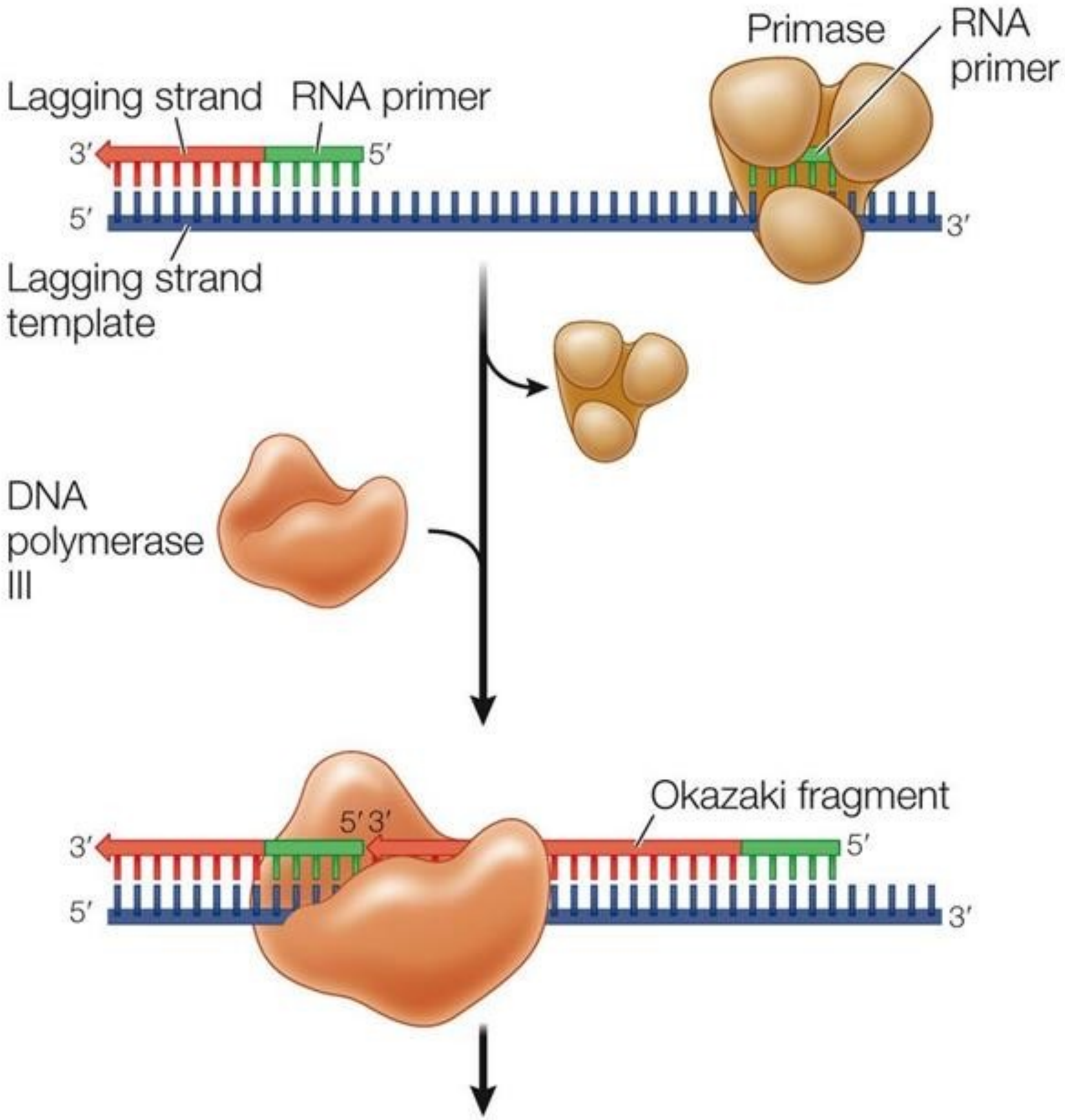

*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 13.11



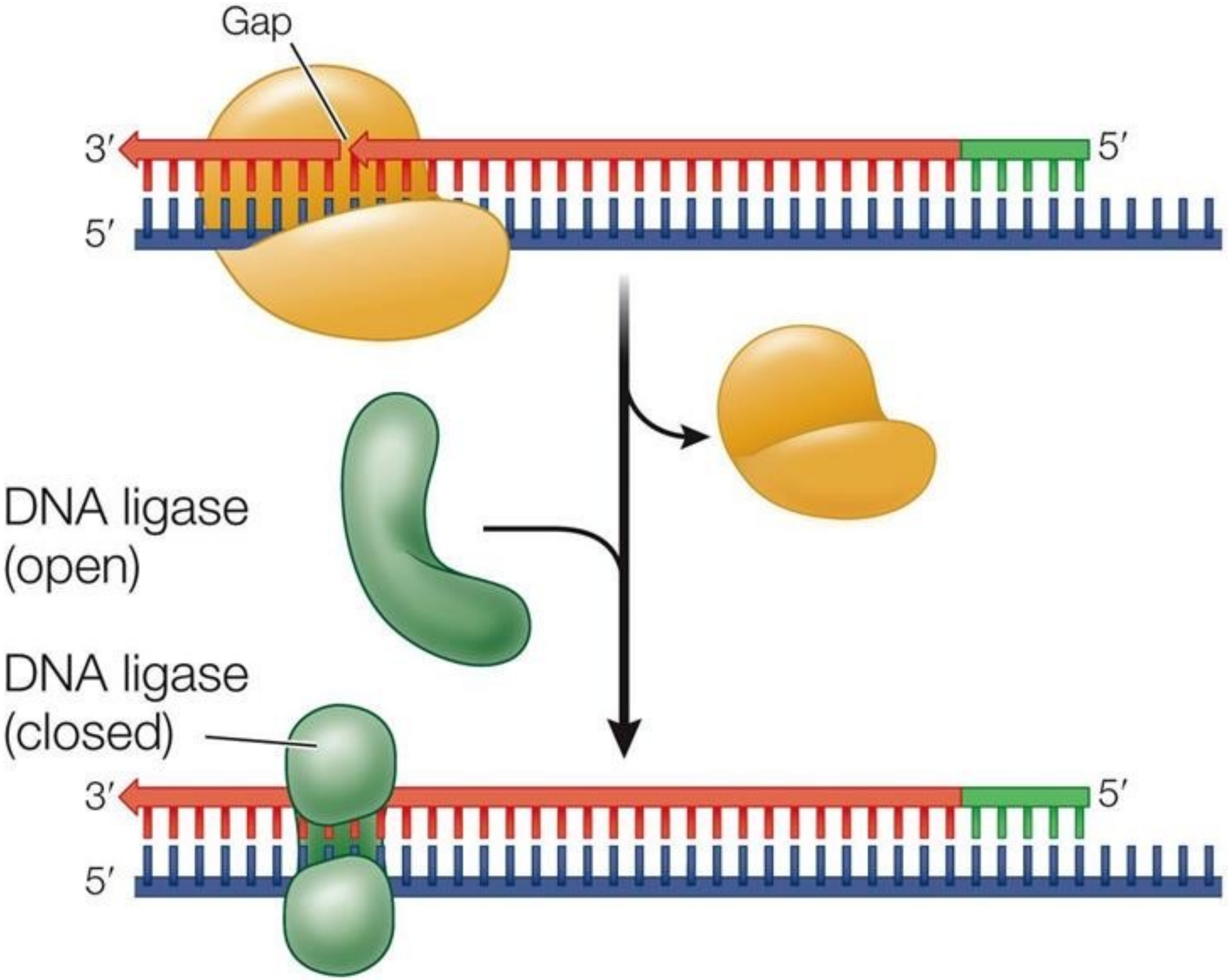

*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 13.13




*LIFE: THE SCIENCE OF BIOLOGY 11e*, **Figure 13.14**




*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 13.15 (Part 1)




*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 13.15 (Part 2)

# DNA REPLICATION

- DNA polymerases III make mistakes in replication, and DNA can be damaged in living cells.

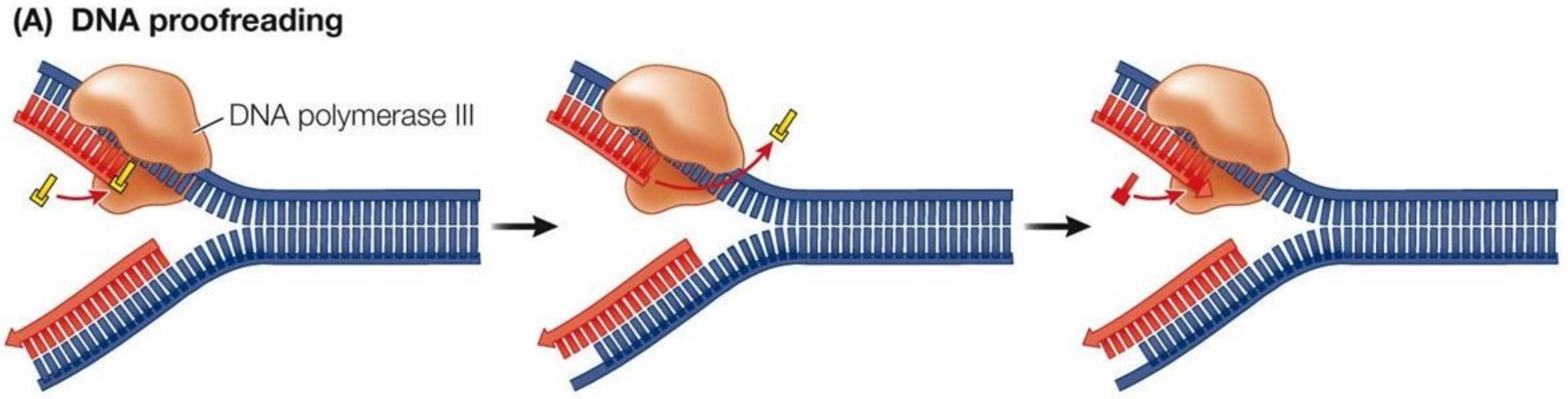
- Cells have several repair mechanisms:

1.) Proofreading

2.)Mismatch repair

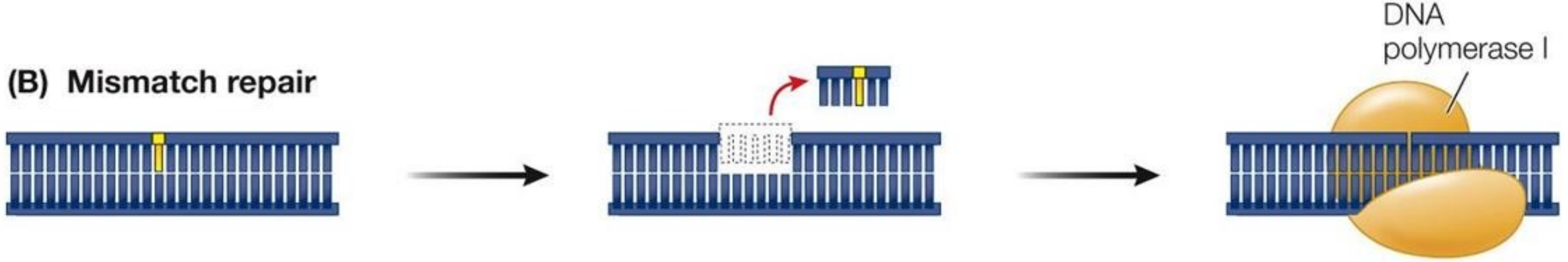
3.)Excision repair

# DNA PROOFREADING




*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 13.18 (Part 1)

# MISMATCH REPAIR




LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 13.18 (Part 2)

# EXCISION REPAIR

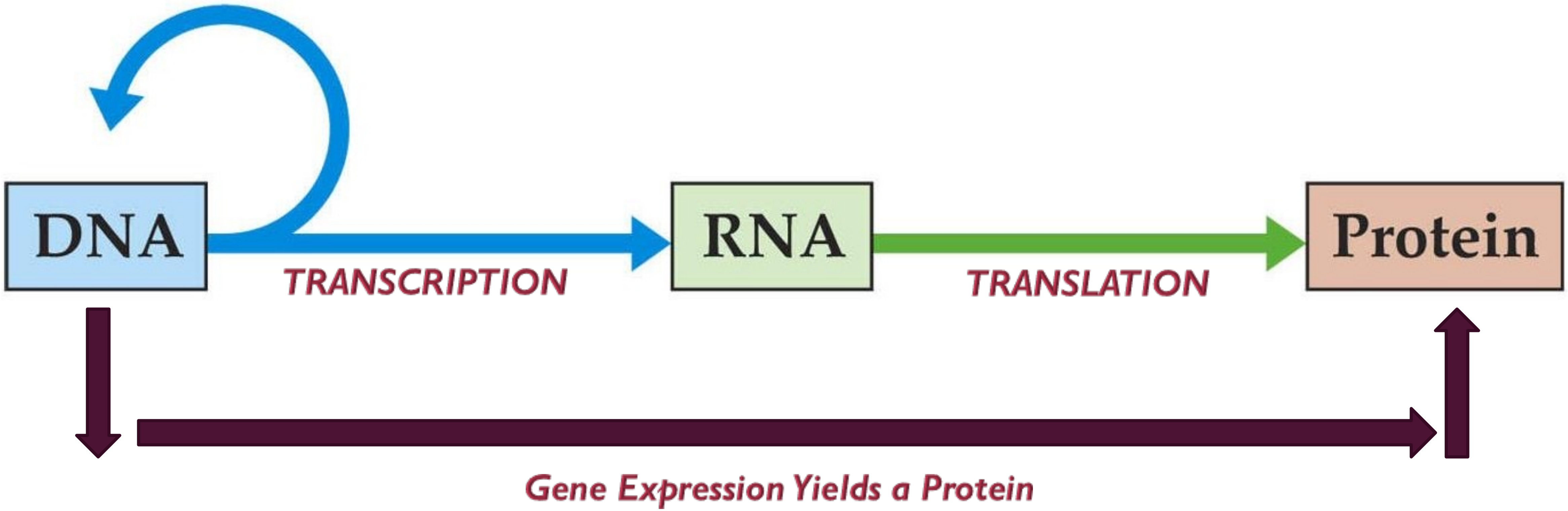
(C) Excision repair

*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 13.18 (Part 3)

# From Gene to Protein

DY

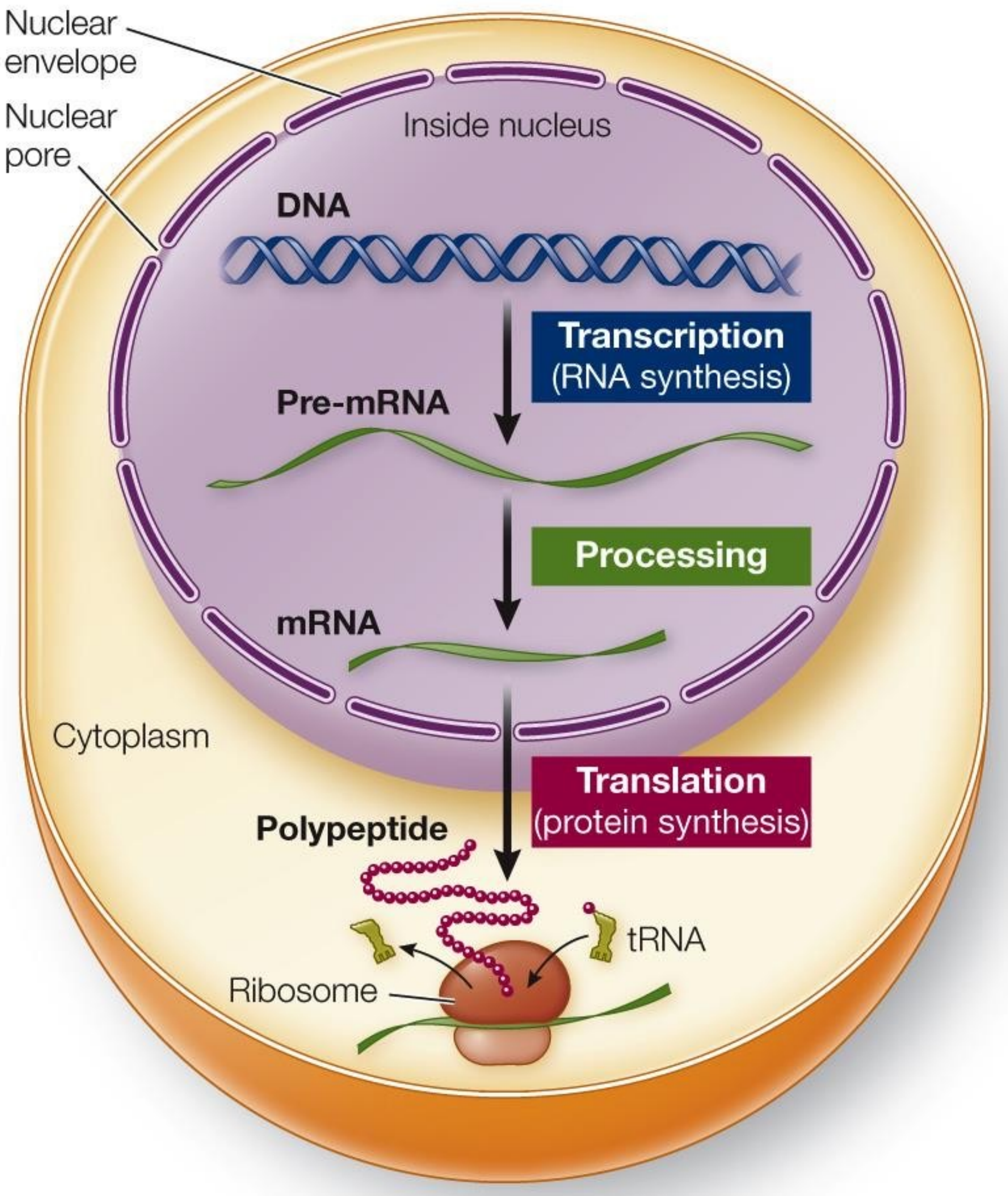
# THE CENTRAL DOGMA OF GENE EXPRESSION



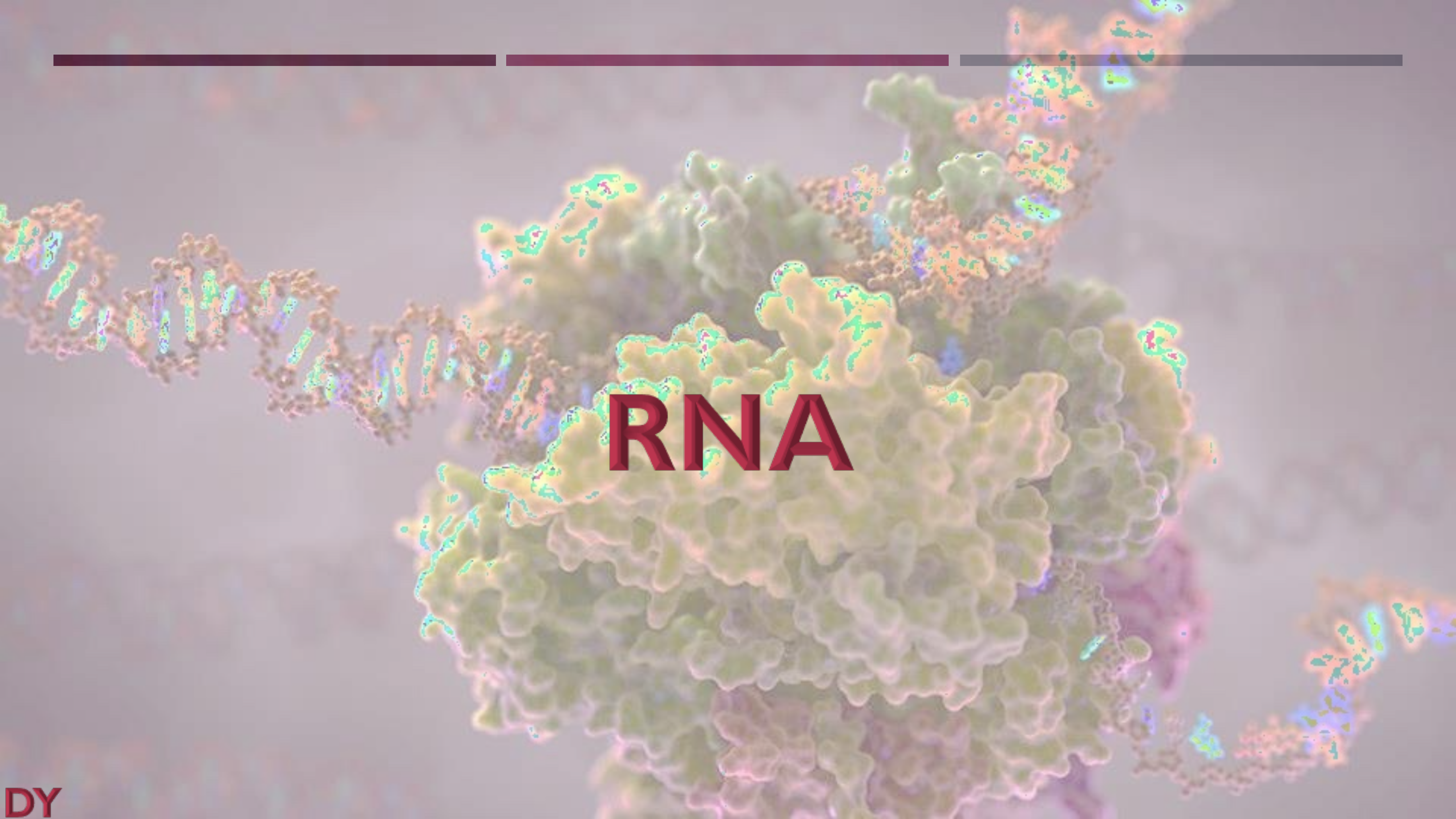
# SOME EXCEPTIONS

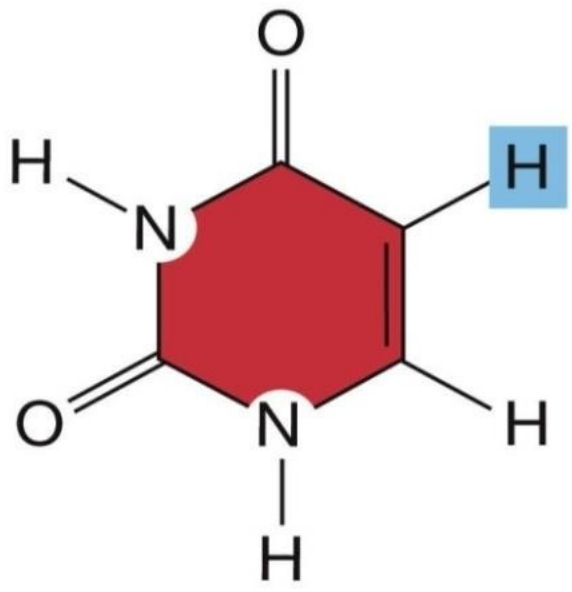
## Viruses (can use RNA to encode information)


## Viruses (can also convert RNA to DNA)

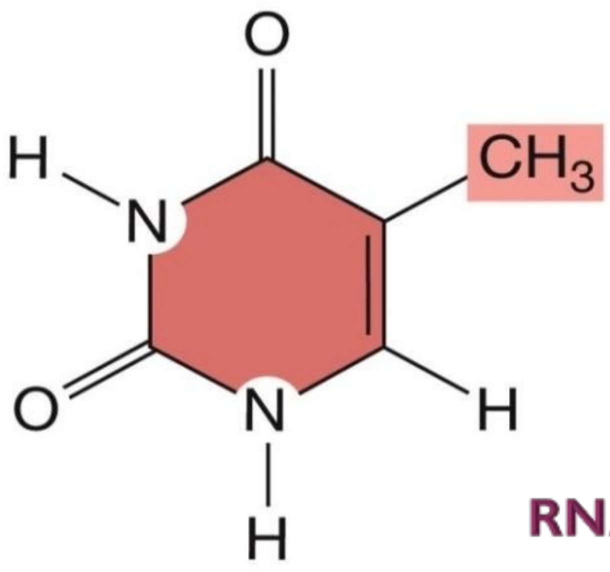



*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 14.2


RNA
DY




Uracil



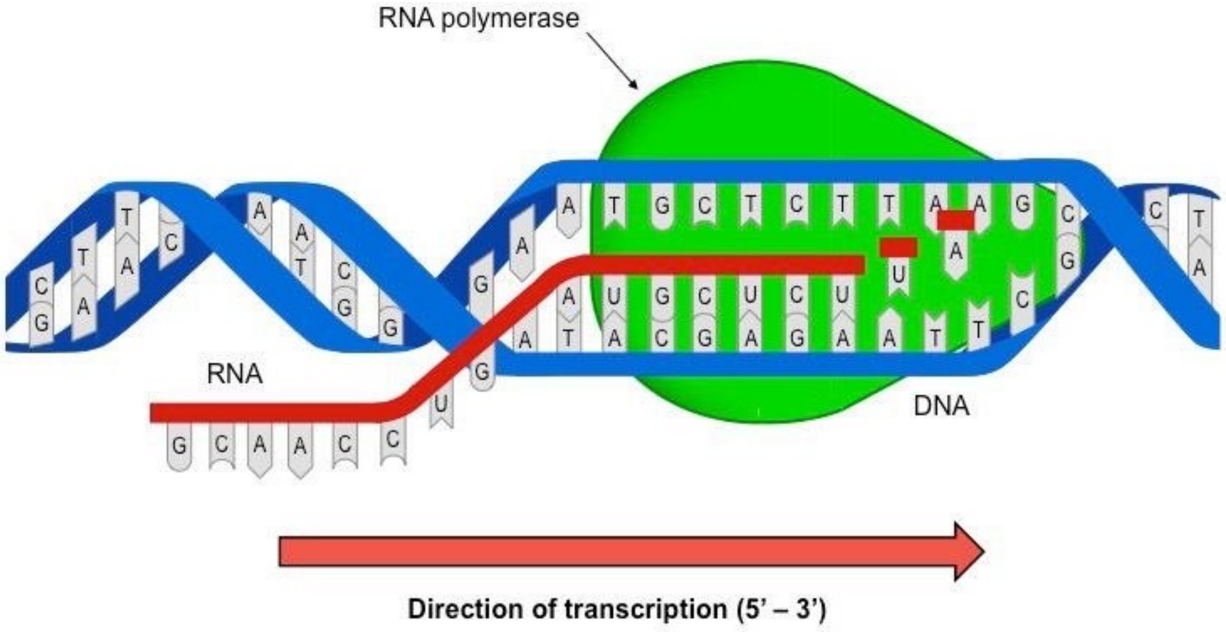

Thymine

**RNA (ribonucleic acid)** differs from DNA:

- One polynucleotide strand
- Sugar = **Ribose** (DNA = Deoxyribose)
- **Uracil** instead of thymine.
- Base Pairing: **A-U** and **C-G**
- **3-types of RNAs** used in Protein Synthesis
  - mRNA
  - tRNA
  - rRNA

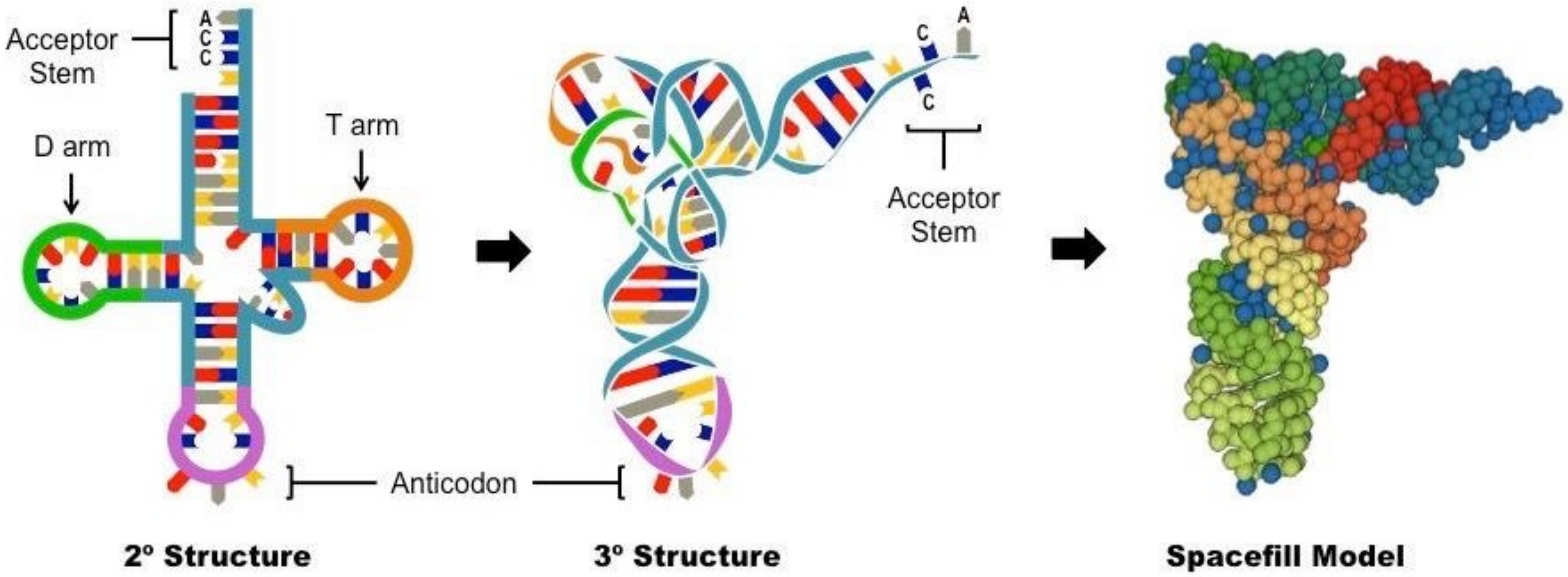
# MESSENGER RNA (M-RNA)

- Carries transcript of DNA sequence to the site of protein synthesis at the ribosome
- Similar to the coding strand of the DNA
- Complementary to the template strand of the DNA
- Undergoes **post-transcriptional modification** before translation



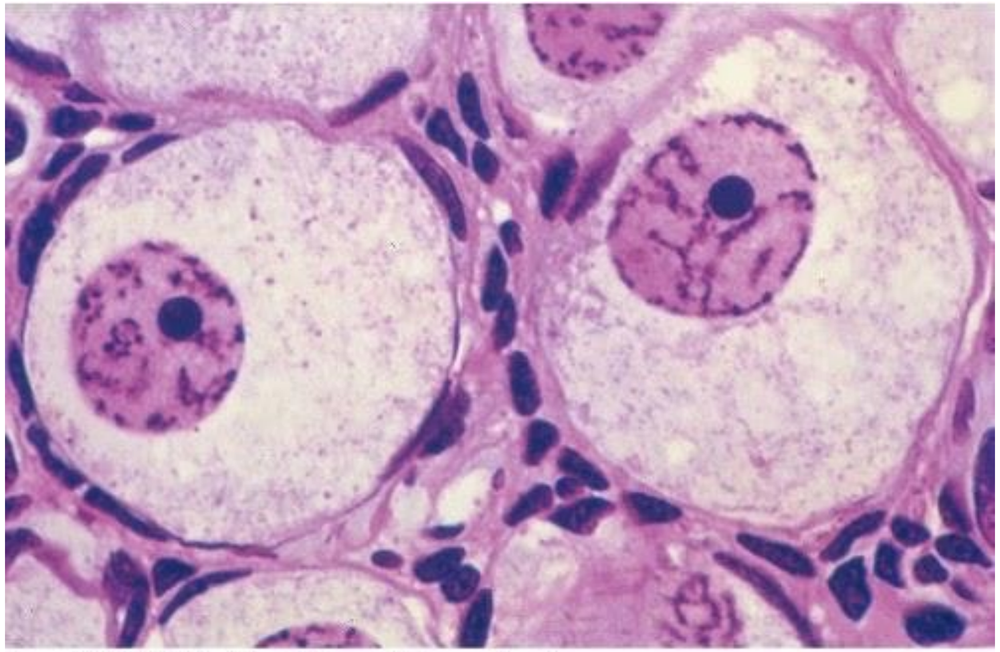
# TRANSFER RNA (T-RNA)

- Translator: nucleic acid sequence on mRNA → polypeptide
- 20 tRNAs (1 for each amino acid)
- tRNA has an anticodon that is complementary to the codon sequence on the mRNA.
- Interact with the mRNA and rRNA during protein synthesis.

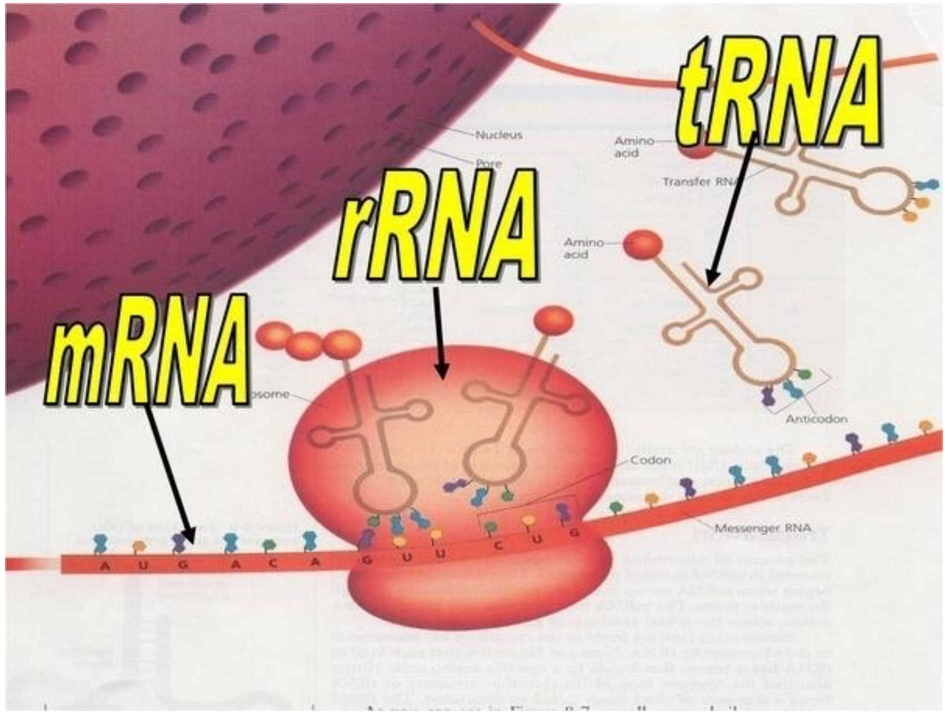


# RIBOSOMAL RNA (R-RNA)

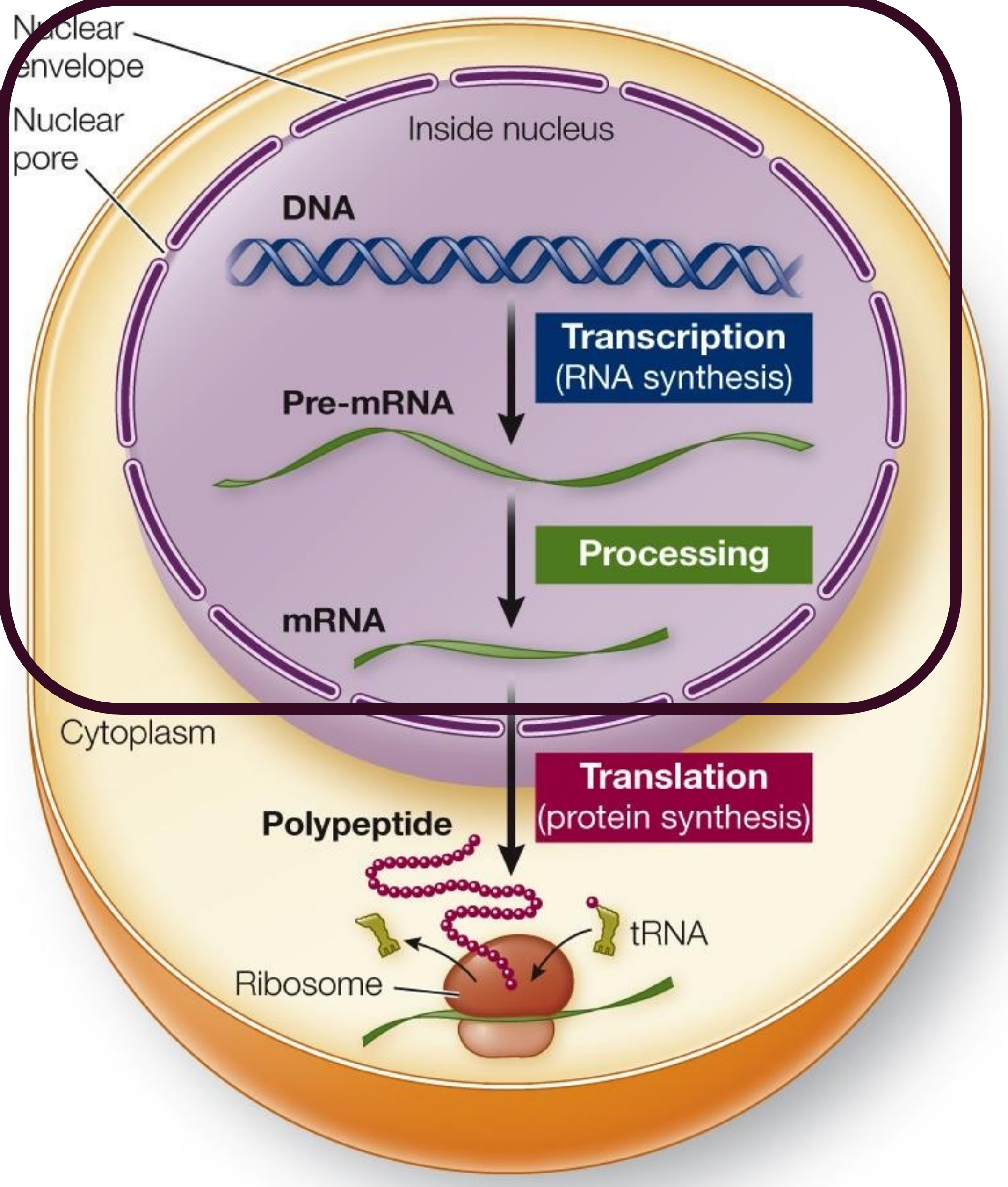
- Transcribed constantly in **nucleoli**
- Form the bulk of ribosomes in cytoplasm.
- Provide structural support and act as enzyme (**ribozyme**) - used to catalyze the peptide bond formation during translation








Transcription
DNA → mRNA
DY

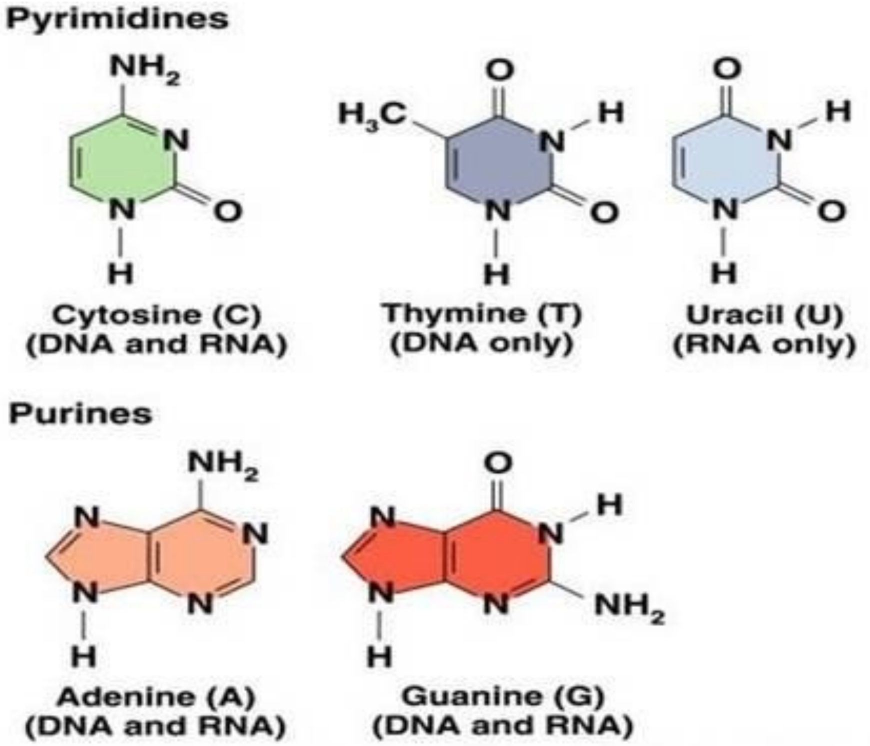


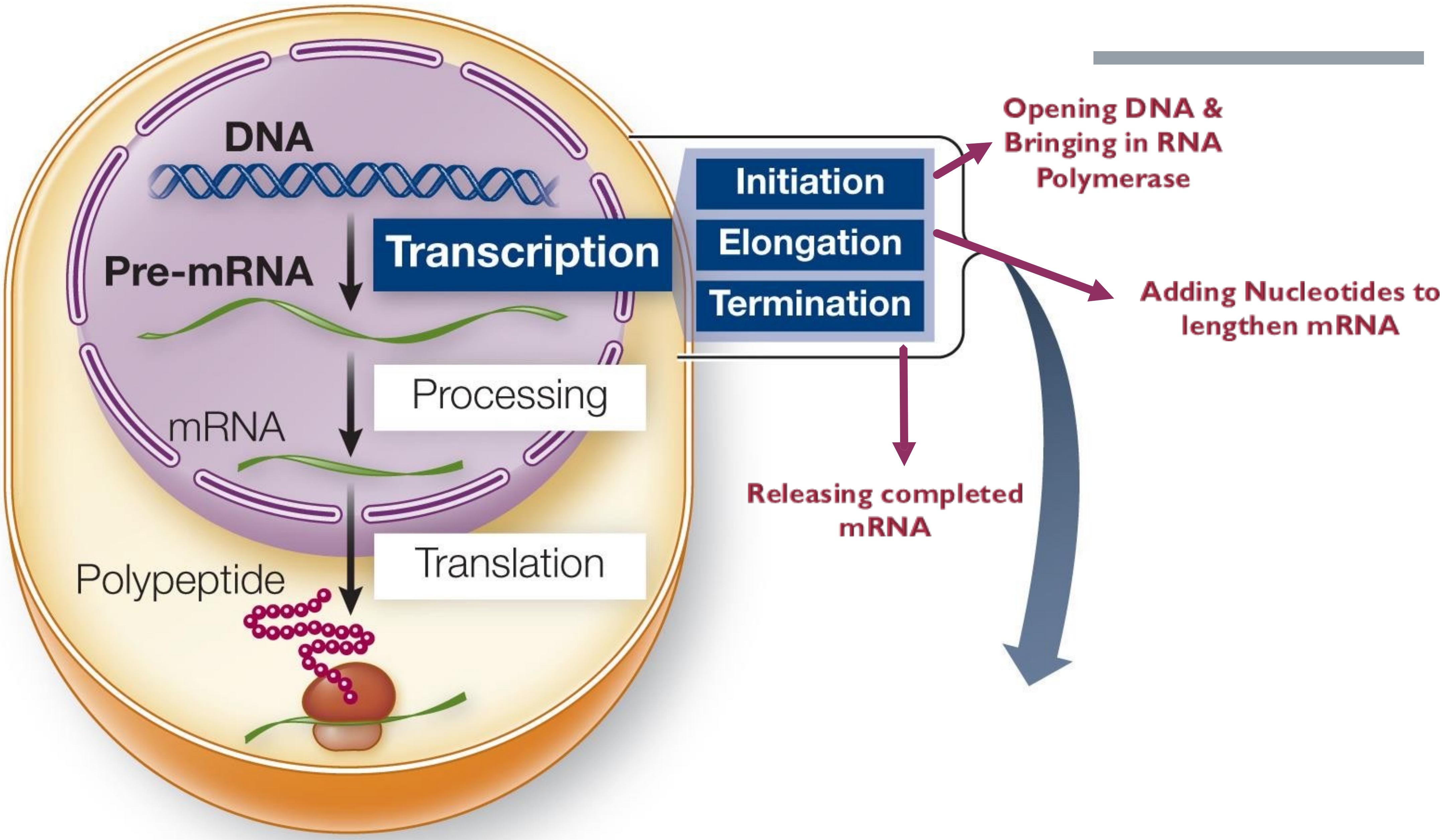

*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 14.2



## Transcription Materials:

1. DNA Template (for base pairing)
2. Nucleotides (ATP, GTP, CTP, UTP)
3. RNA Polymerase Enzyme



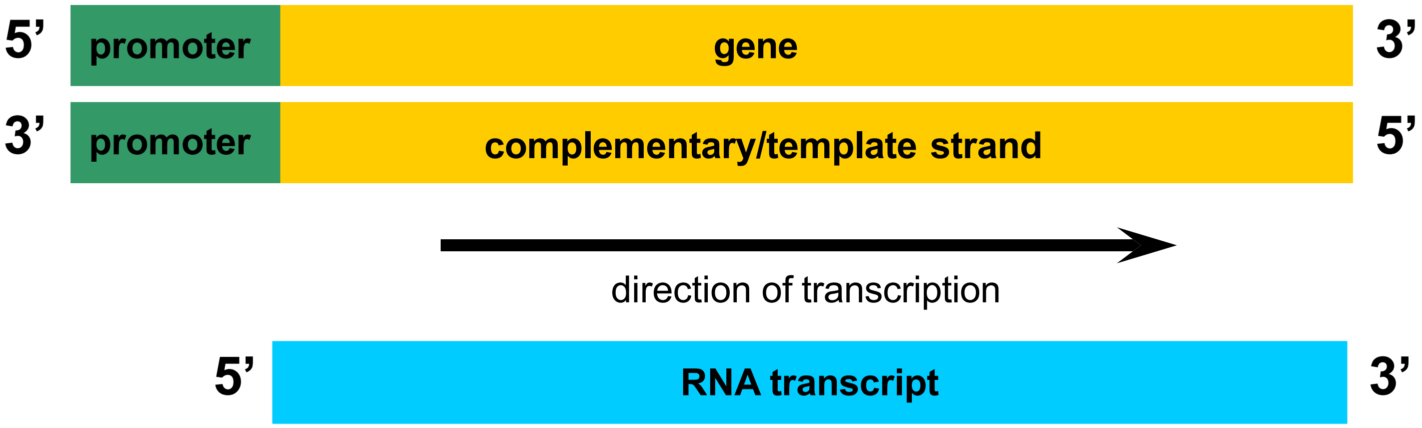



*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 14.4 (Part 1)

# THE PROMOTER REGION

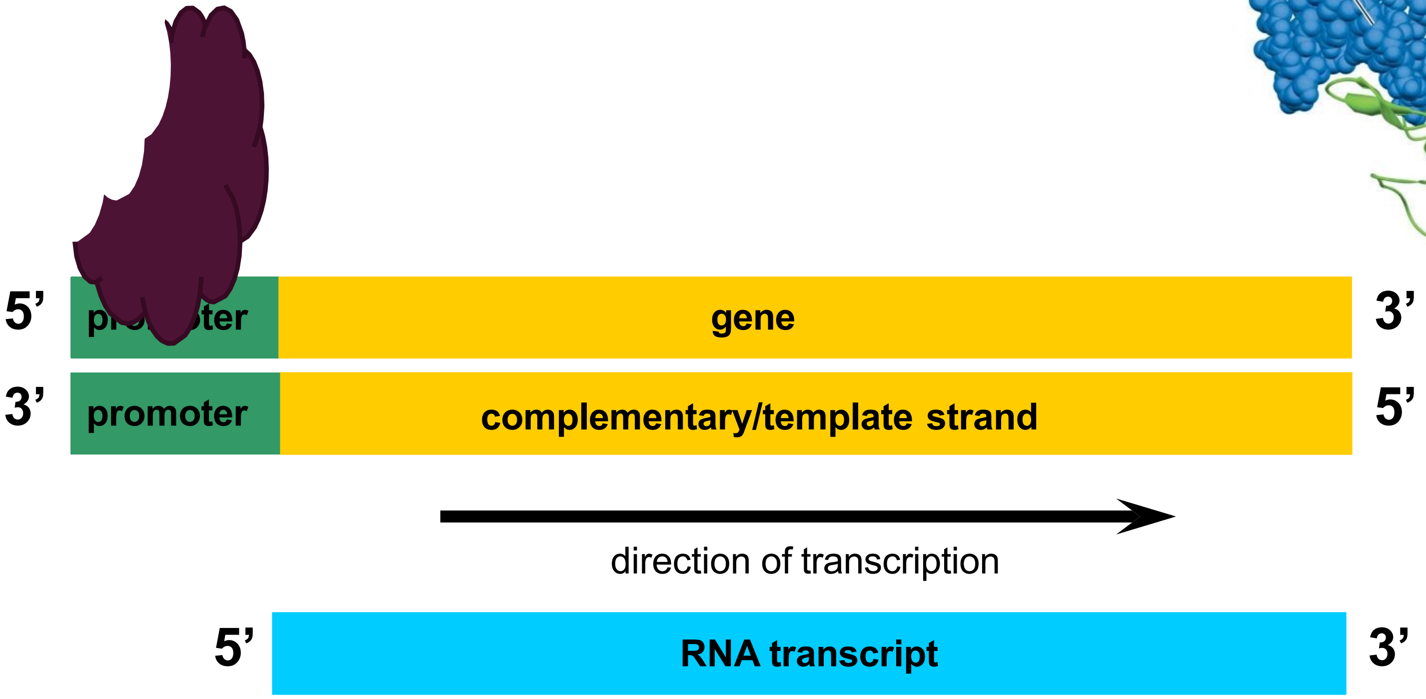
**What is the promoter?** Sequence of DNA nucleotides that tells the RNA polymerase

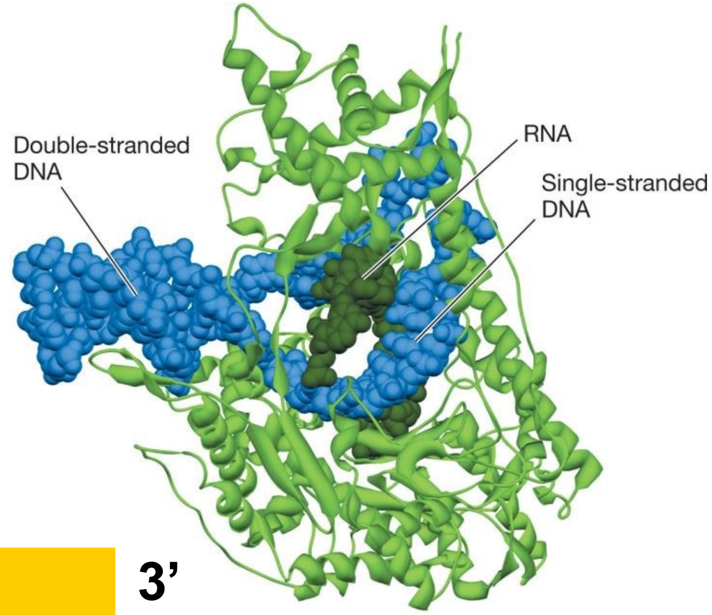
1. Where the gene begins
2. Which strand is to be the template for transcription
3. Which direction the RNA polymerase should move



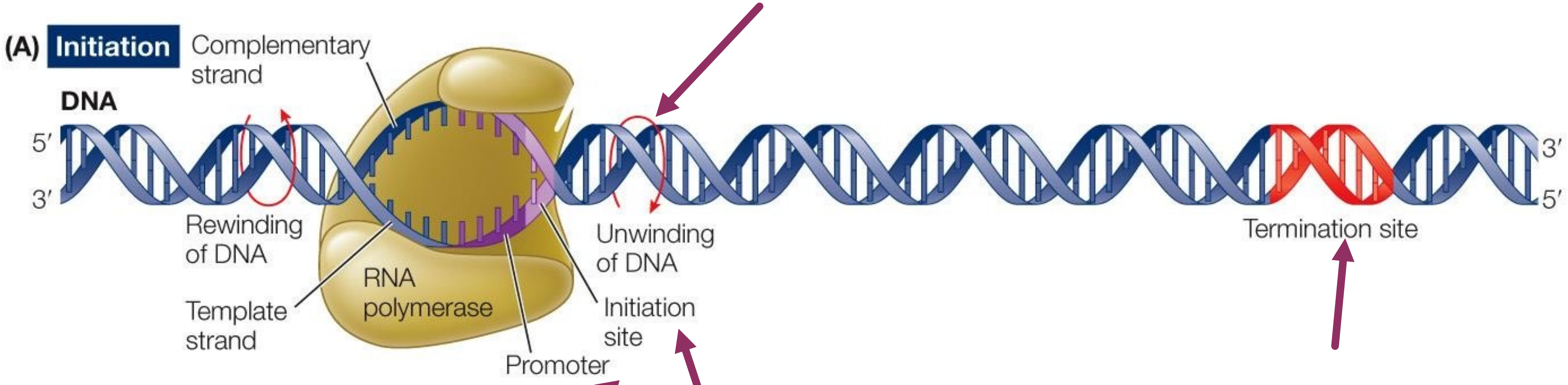
# INITIATION

RNA Polymerase binds to the promotor region of a gene



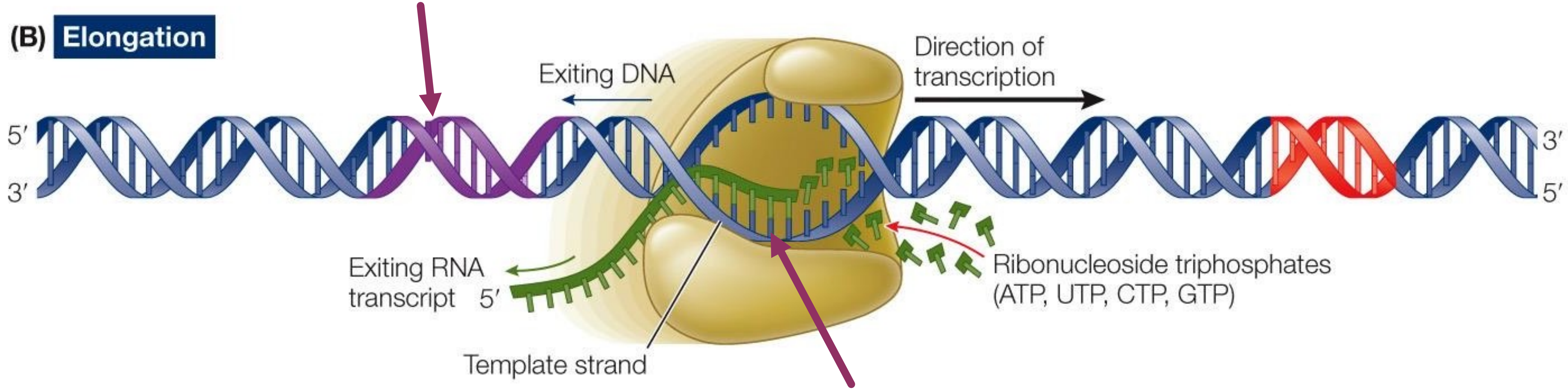
# INITIATION




*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 14.4 (Part 2)

# ELONGATION

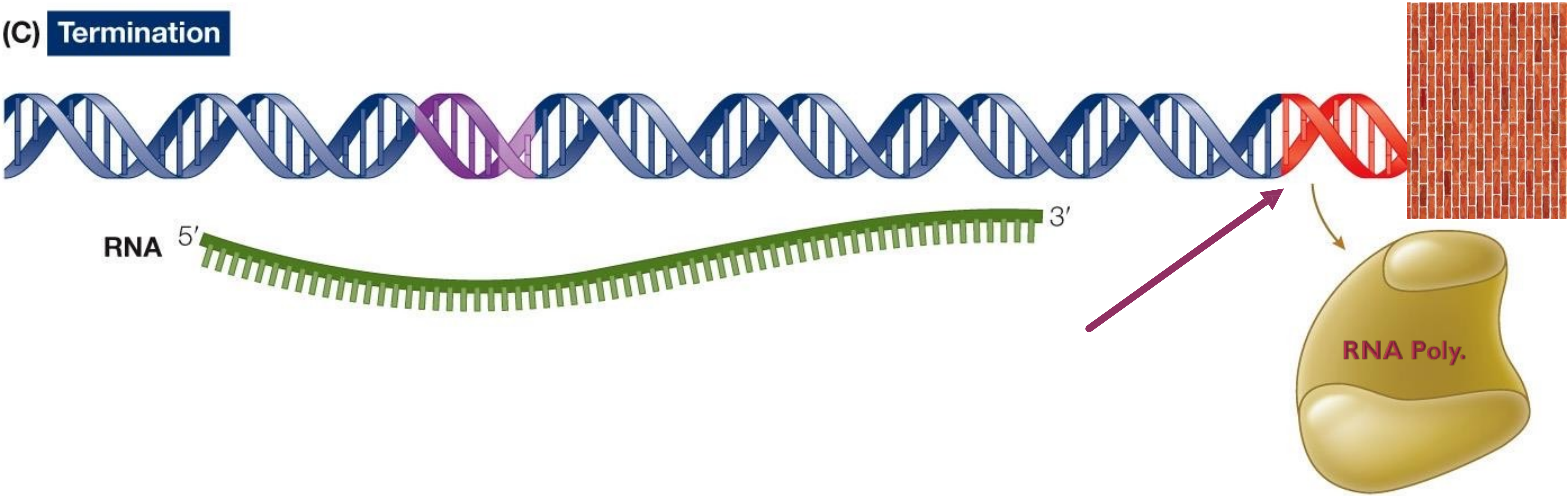
This is the site of the
_Promoter_




*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 14.4 (Part 3)


We are reading the template strand in the __3'__' to __5'__' direction. The RNA transcript is being synthesized in the __5'__' to __3'__' direction. Therefore the RNA transcript is __Anti-parallel__ (directionality) to the template strand.

# TERMINATION




LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 14.4 (Part 4)

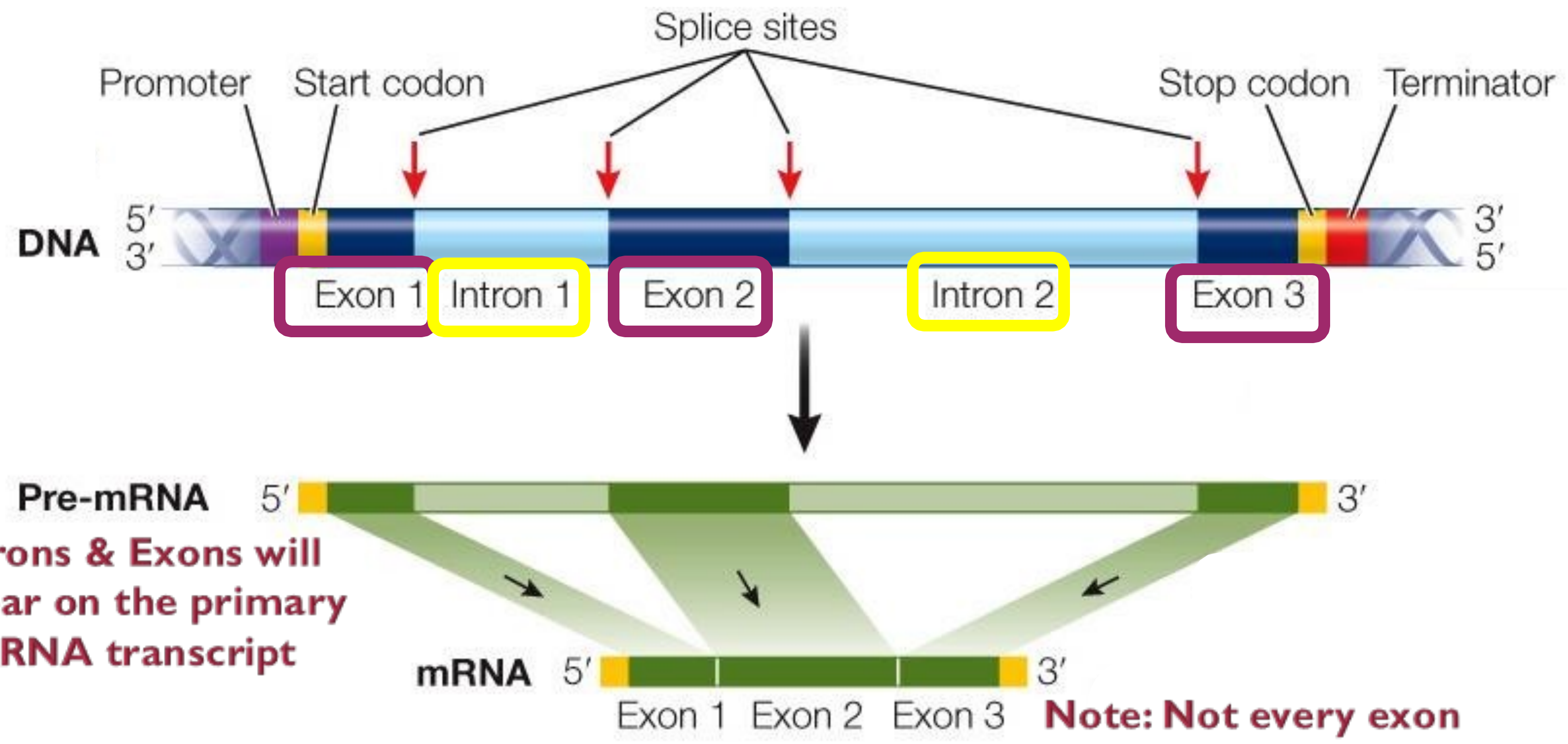

Sometimes RNA Polymerase just falls off & sometimes another protein comes and pushes it off.

# Post-Transcriptional Processing & Modification

Processed before leaving nucleus

DY

# STRUCTURE OF THE EUKARYOTIC GENE



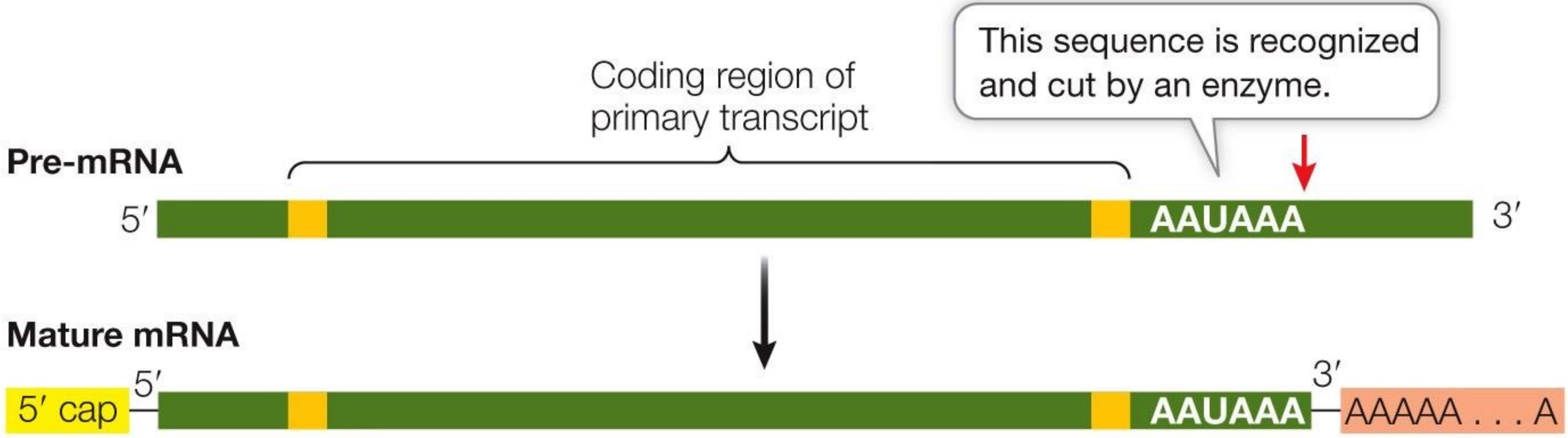

**Introns & Exons will appear on the primary mRNA transcript**

**Note: Not every exon codes for a different protein; exons may code for different domains of one protein.**

**EXONS (Expressed Regions) = Protein Coding regions/sequences**

**INTRONS (Intervening Regions) = non-coding regions/sequences**

# POST-TRANSCRIPTIONAL MODIFICATIONS TO RNA




Why is a 5' GTP cap added to mature mRNA?

A. Allows for mRNA binding to ribosome
B. Protects from being digested by ribonucleases

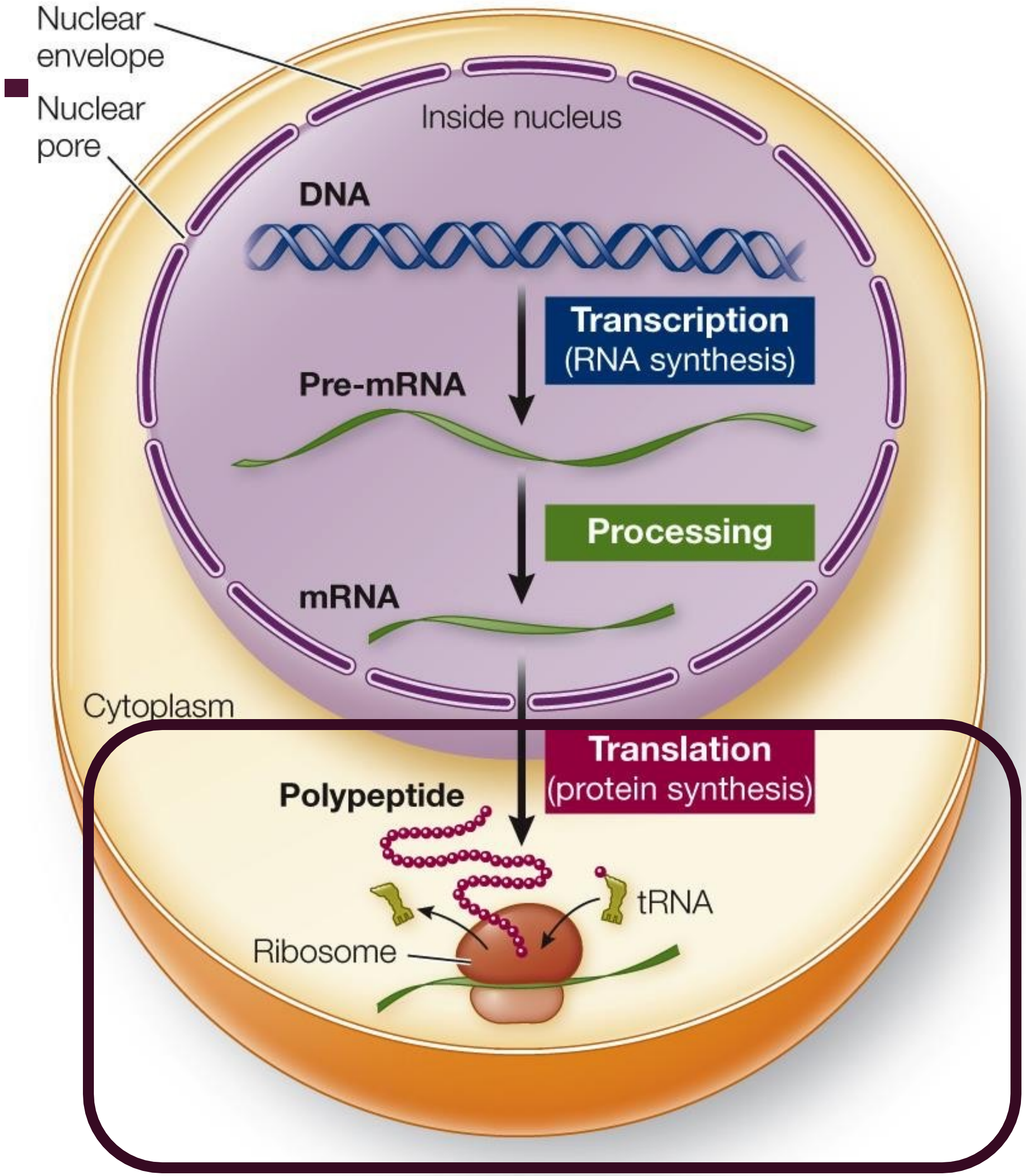
Why is the poly-A tail added to mature mRNA?

A. Stabilizes mRNA

# Translation

**RNA → Protein**

DY




LIFE: THE SCIENCE OF BIOLOGY 11e, Figure 14.2



Mature RNA travels from the nucleus to the __Cytoplasm__.

A cap-binding protein complex binds to the __5__' end of the __mRNA__ in the nucleus.

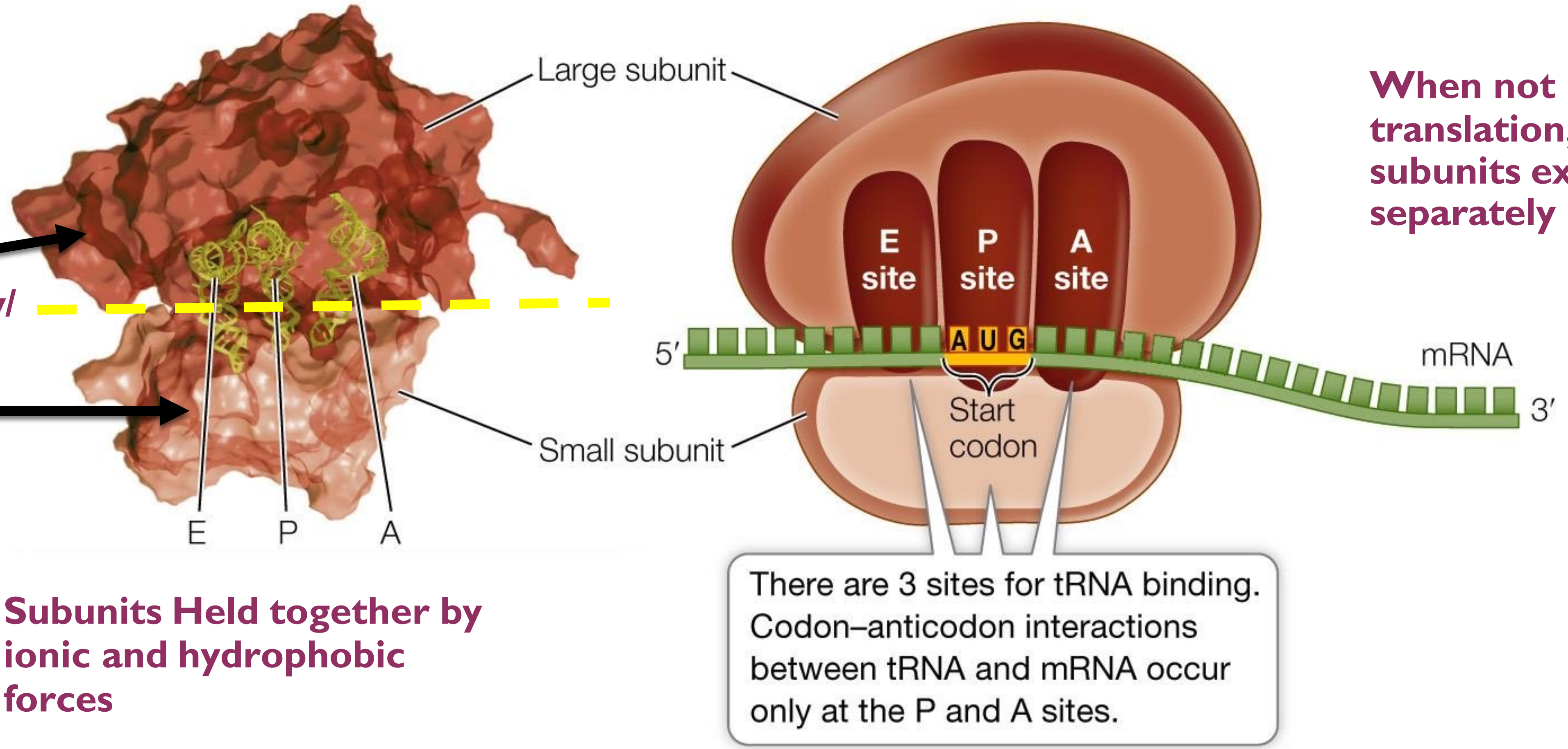
These cap-binding proteins lead the mRNA through the __pores__ of the nucleus. The unprocessed pre-mRNA remain in the __nucleus__.

Two Key Events must happen during Translation to ensure protein synthesis:

1. Codons have to be read correctly by tRNA anticodon
2. tRNA has to bring over the correct amino acid for protein sequence

# RIBOSOME STRUCUTRE

2 subunits w/ rRNA and many proteins




When not in translation, subunits exist separately

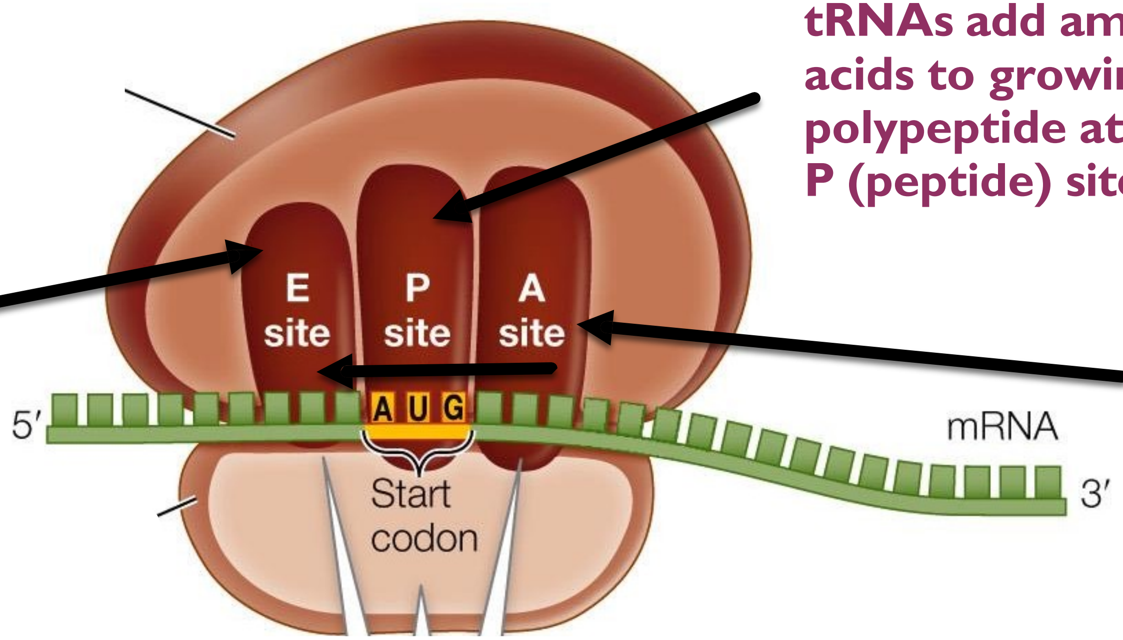
Subunits Held together by ionic and hydrophobic forces

*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 14.12

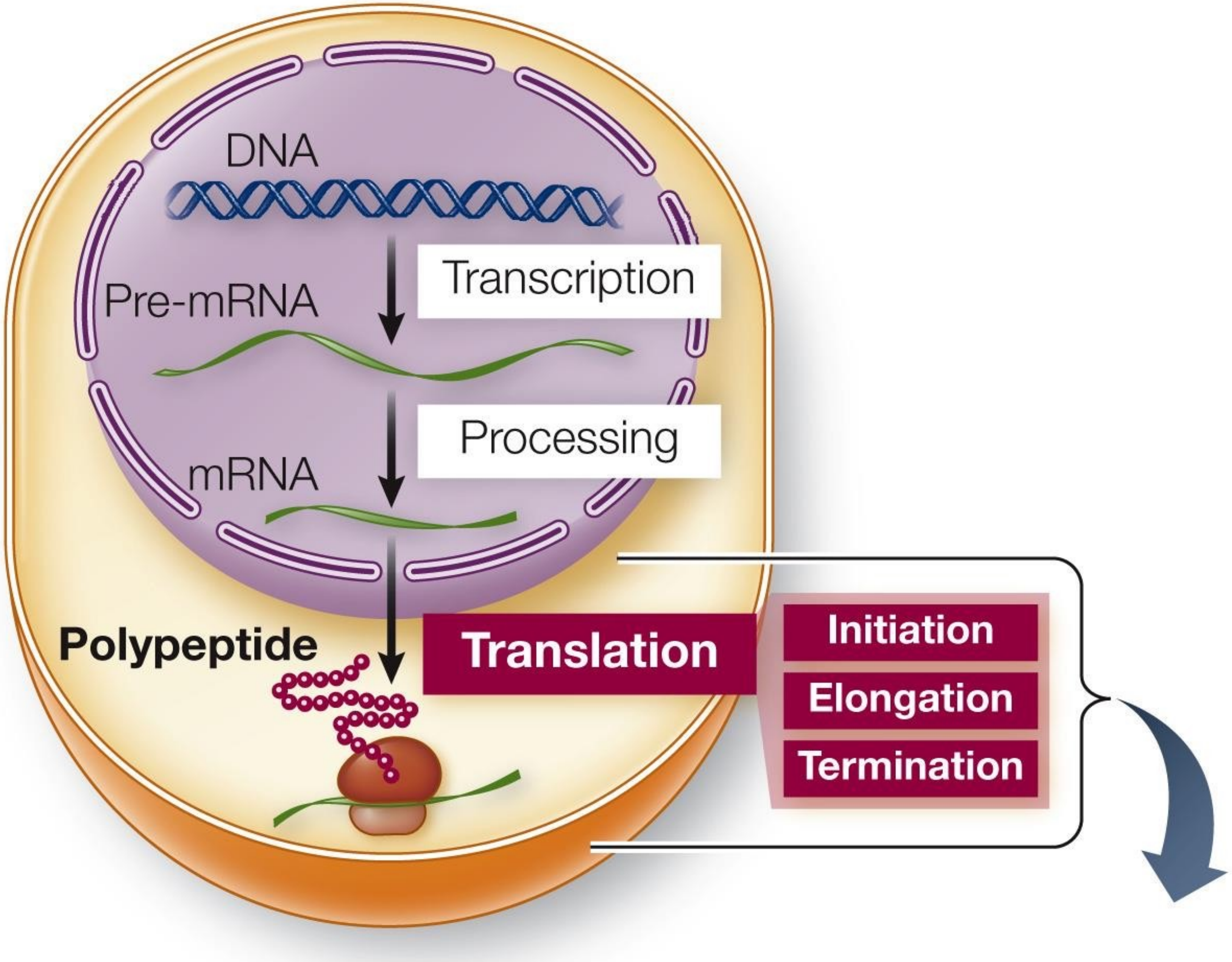
# RIBOSOME STRUCUTRE

tRNAs add amino acids to growing polypeptide at the P (peptide) site

Exit Site



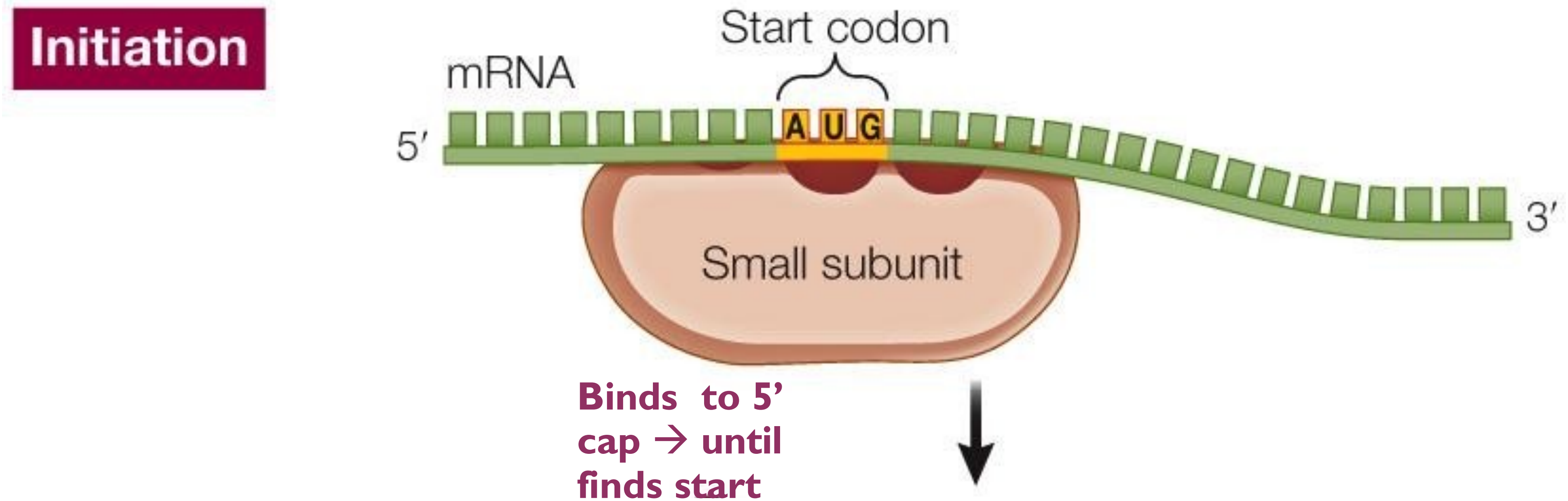

A (amino site) presents the next codon;  binds to anticodon of the charged tRNA.




*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 14.13 (Part 1)

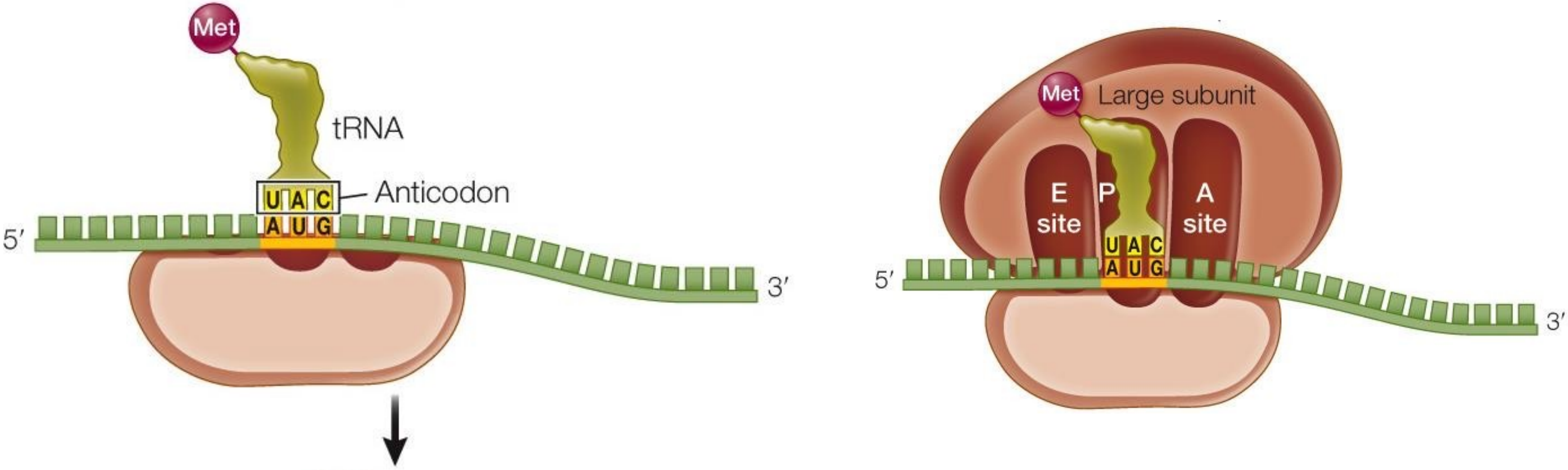
# INITIATION

Everything in this mechanism is put together using a group of proteins called <u>initiation factors</u>



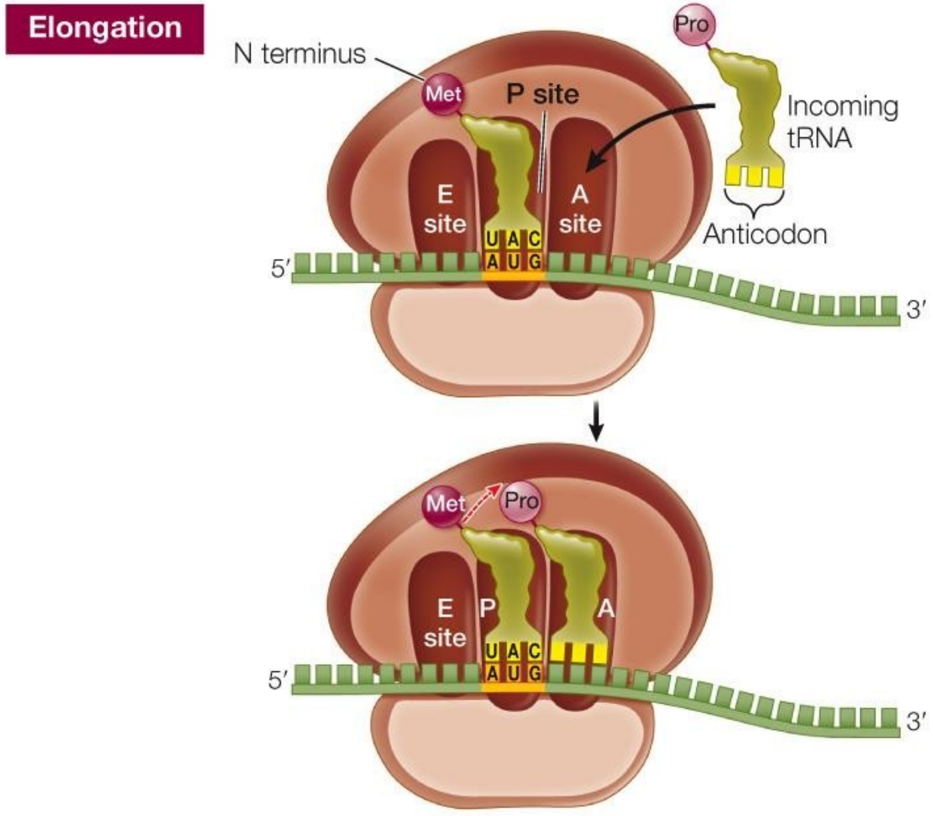

Binds to 5' cap → until finds start codon

# INITIATION



Met
tRNA
U A C
Anticodon
A U G
5′
3′
Met
Large subunit
E
site
P
A
site
U A C
A U G
5′
3′

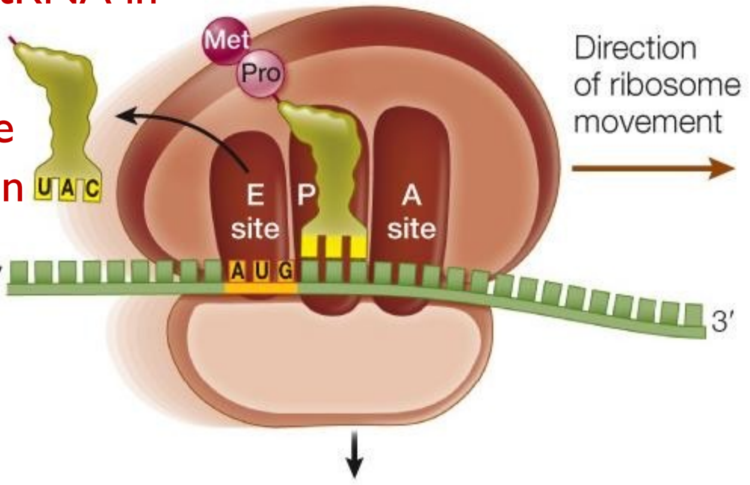
# PEPTIDE ELONGATION




The large subunit catalyzes two reactions:

A. Breaks bond between tRNA in the P site and its amino acid.
B. It catalyzes the formation of peptide bond between that amino acid and the amino acid on tRNA in the A site

Will become charged again




THE SCIENCE OF BIOLOGY 11e, Figure 14.14 (Part 1)
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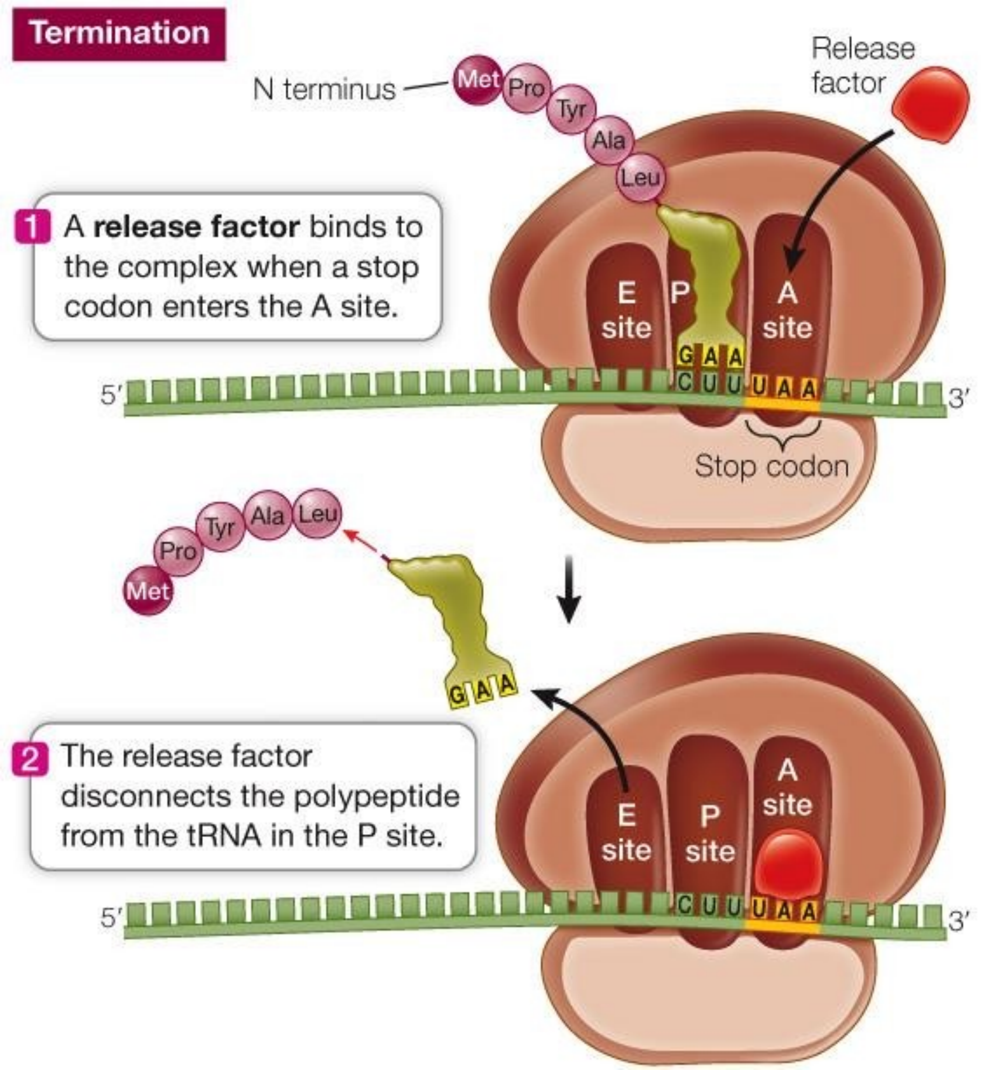
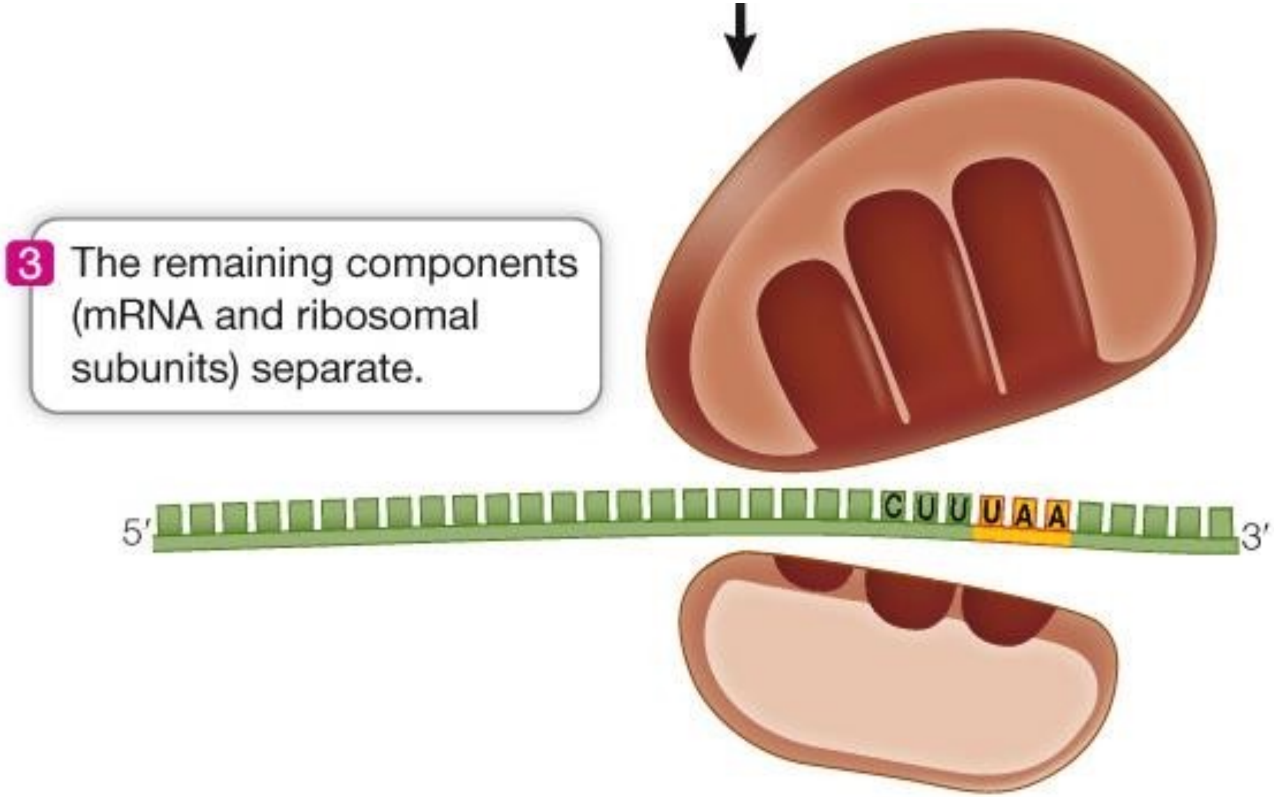
[Elongation Factors]

# TERMINATION



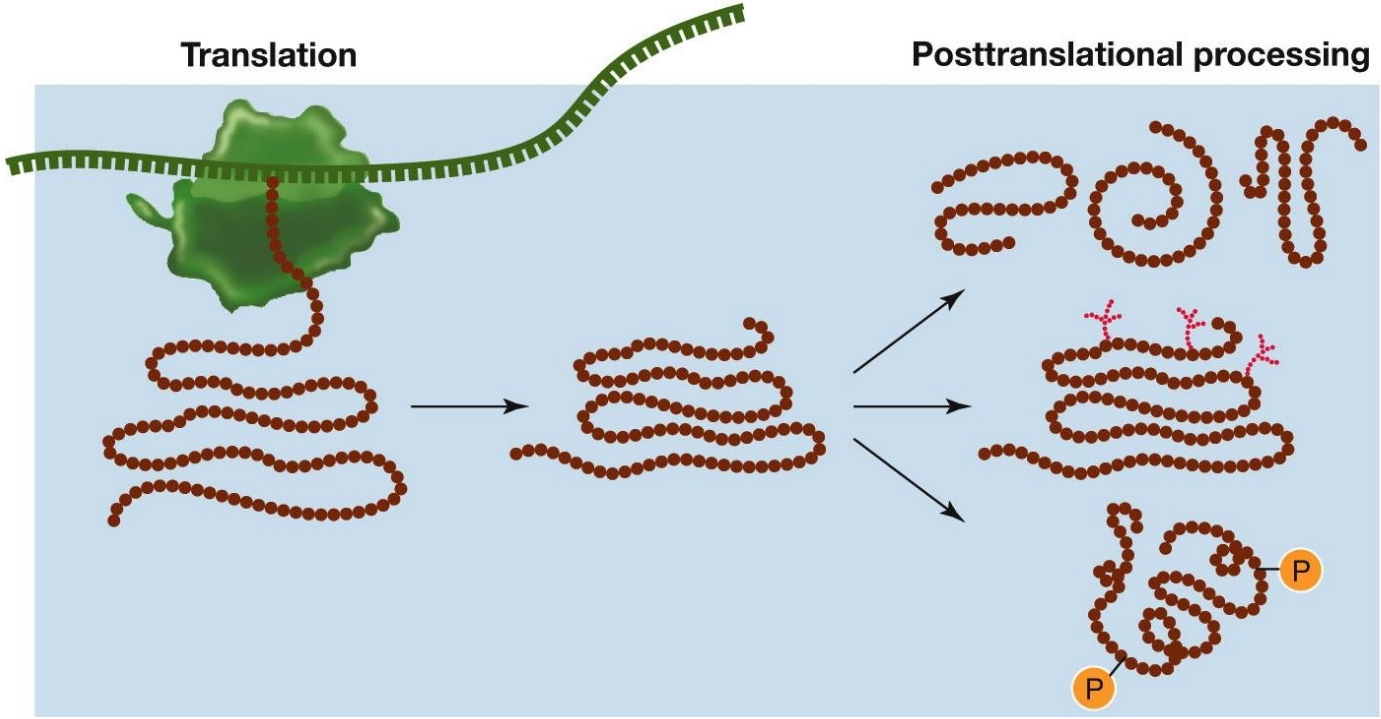
# TERMINATION

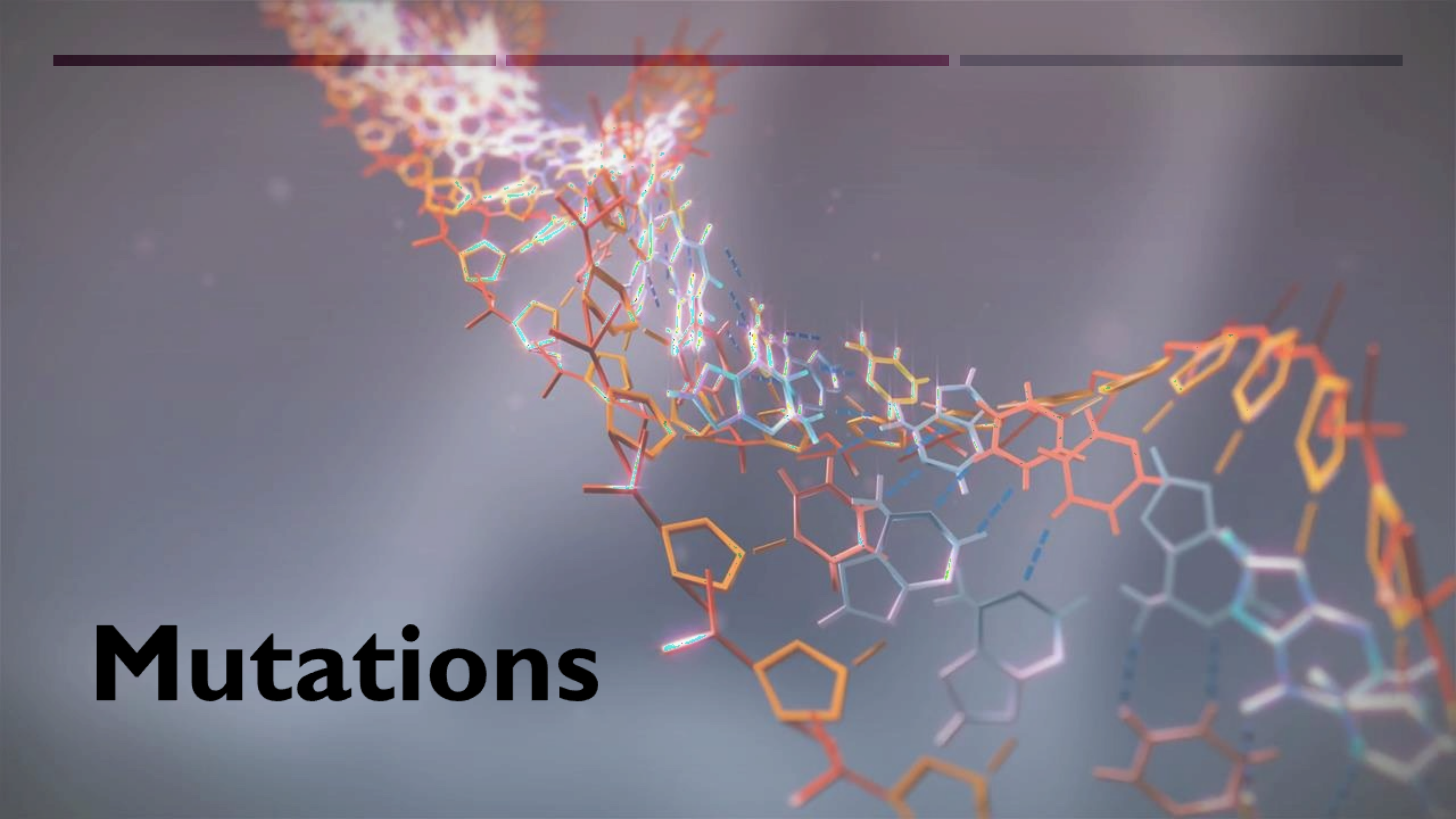



*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 14.15

# Post-Translational Modifications

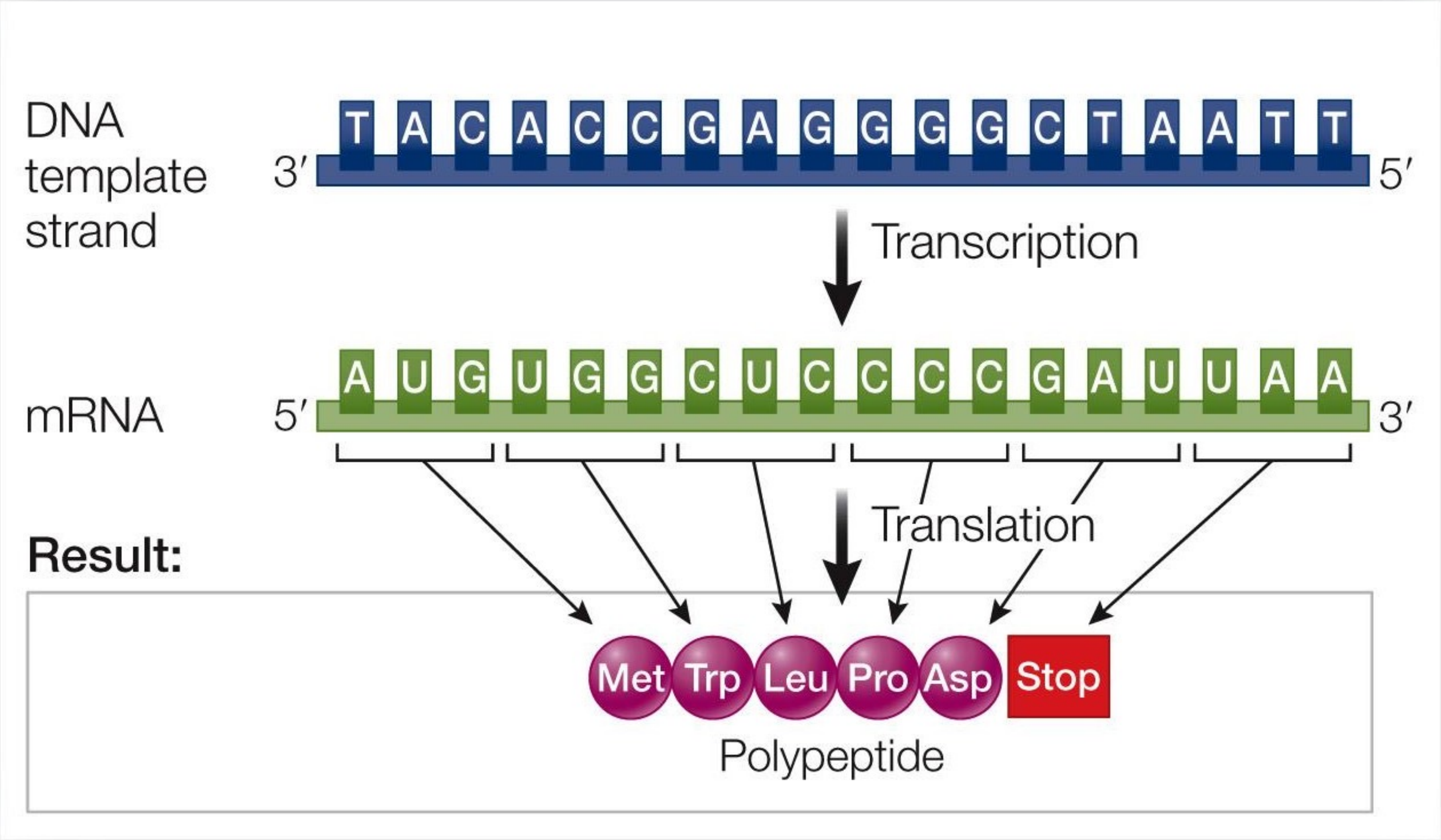
- **Proteolysis**: Cutting of a long polypeptide chain into final products, by **proteases** – one gene may produce multiple peptides.
- **Glycosylation**: Addition of sugars to form glycoproteins.
- **Phosphorylation**: Addition of phosphate groups catalyzed by **protein kinases** – charged phosphate groups change the protein conformation.





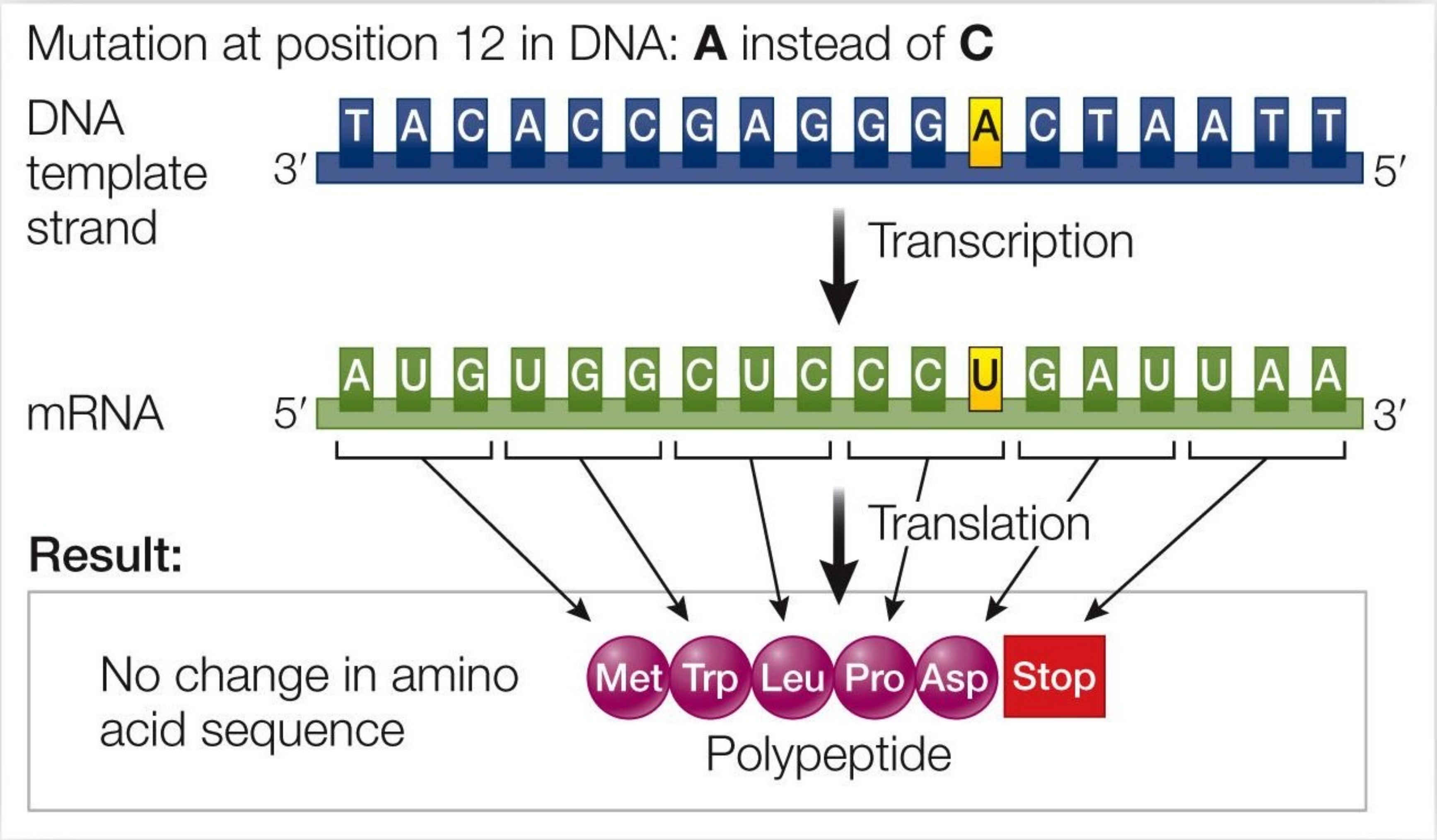
# Mutations

(A) Wild type (normal)




*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 15.2 (Part 1)

## (B) Silent mutation

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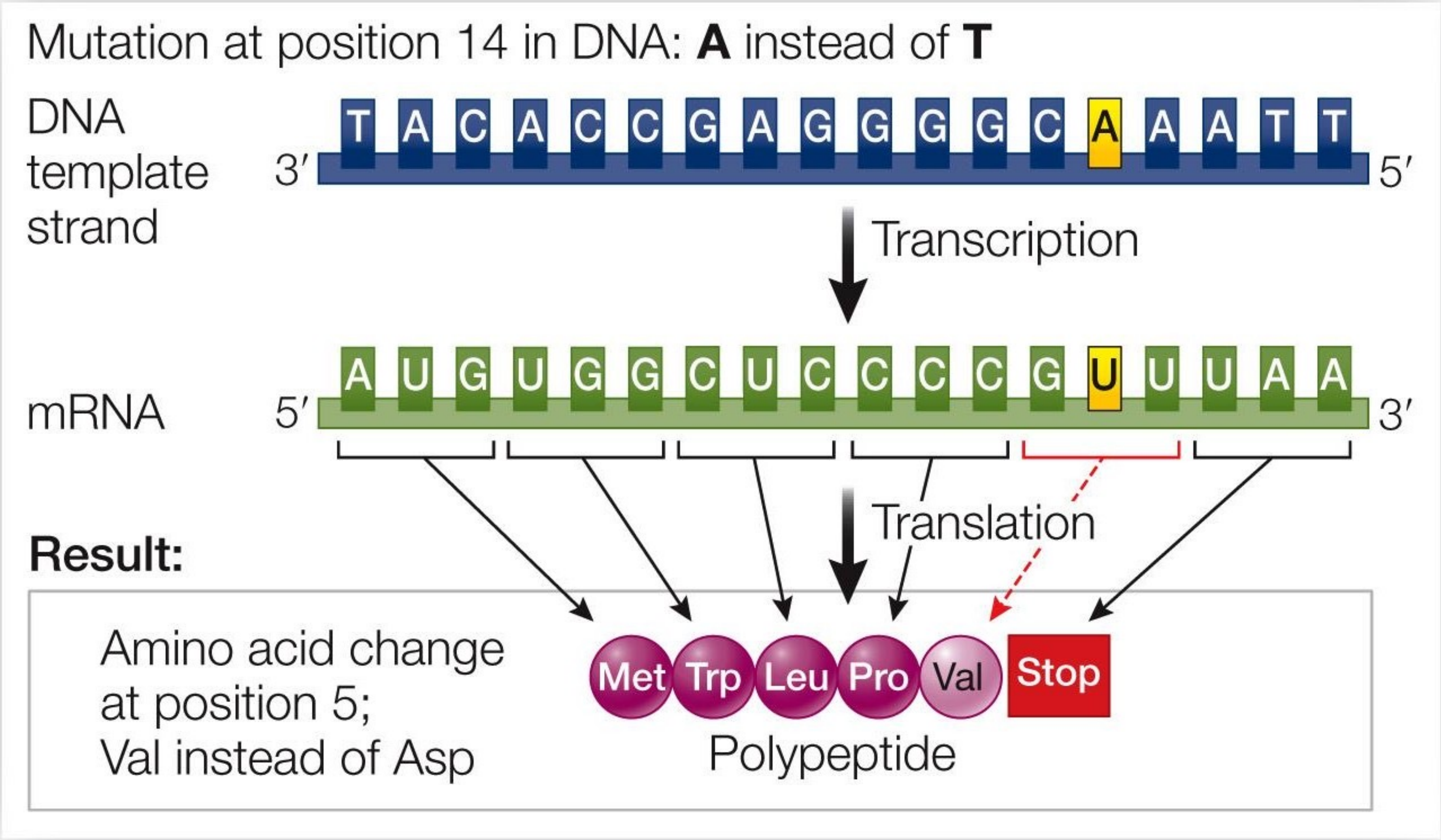
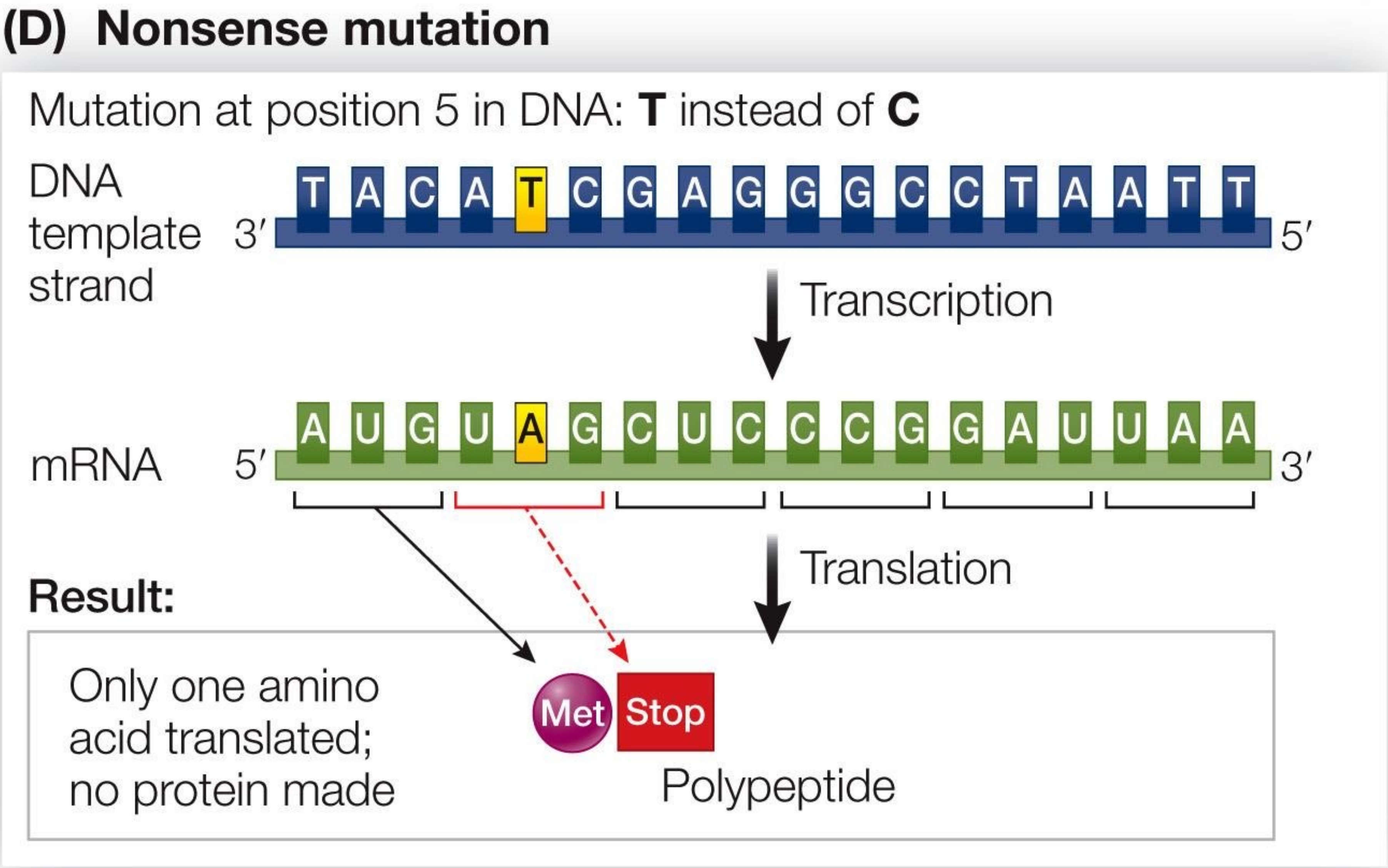
## (C) Missense mutation

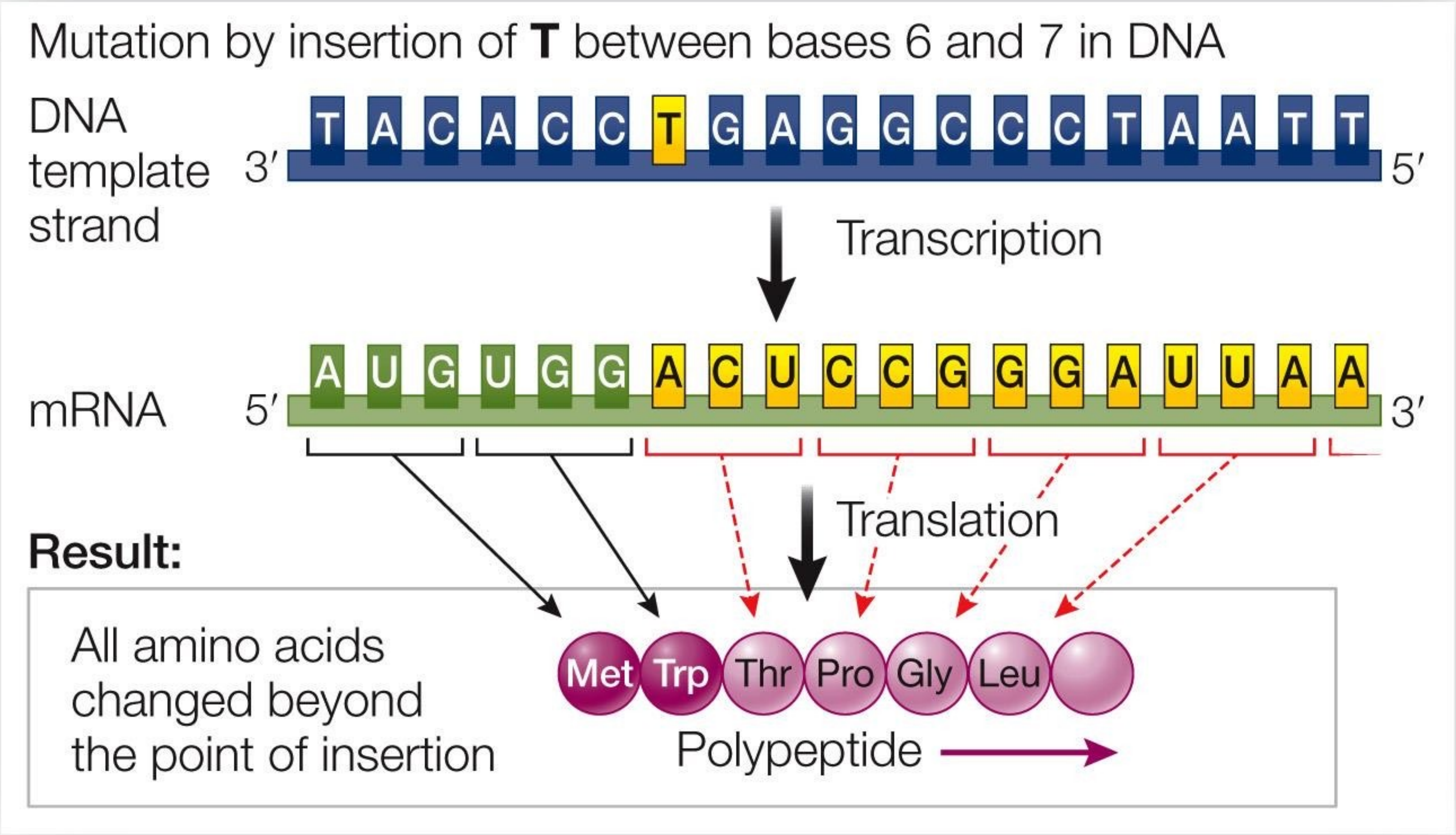



*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 15.2 (Part 3)

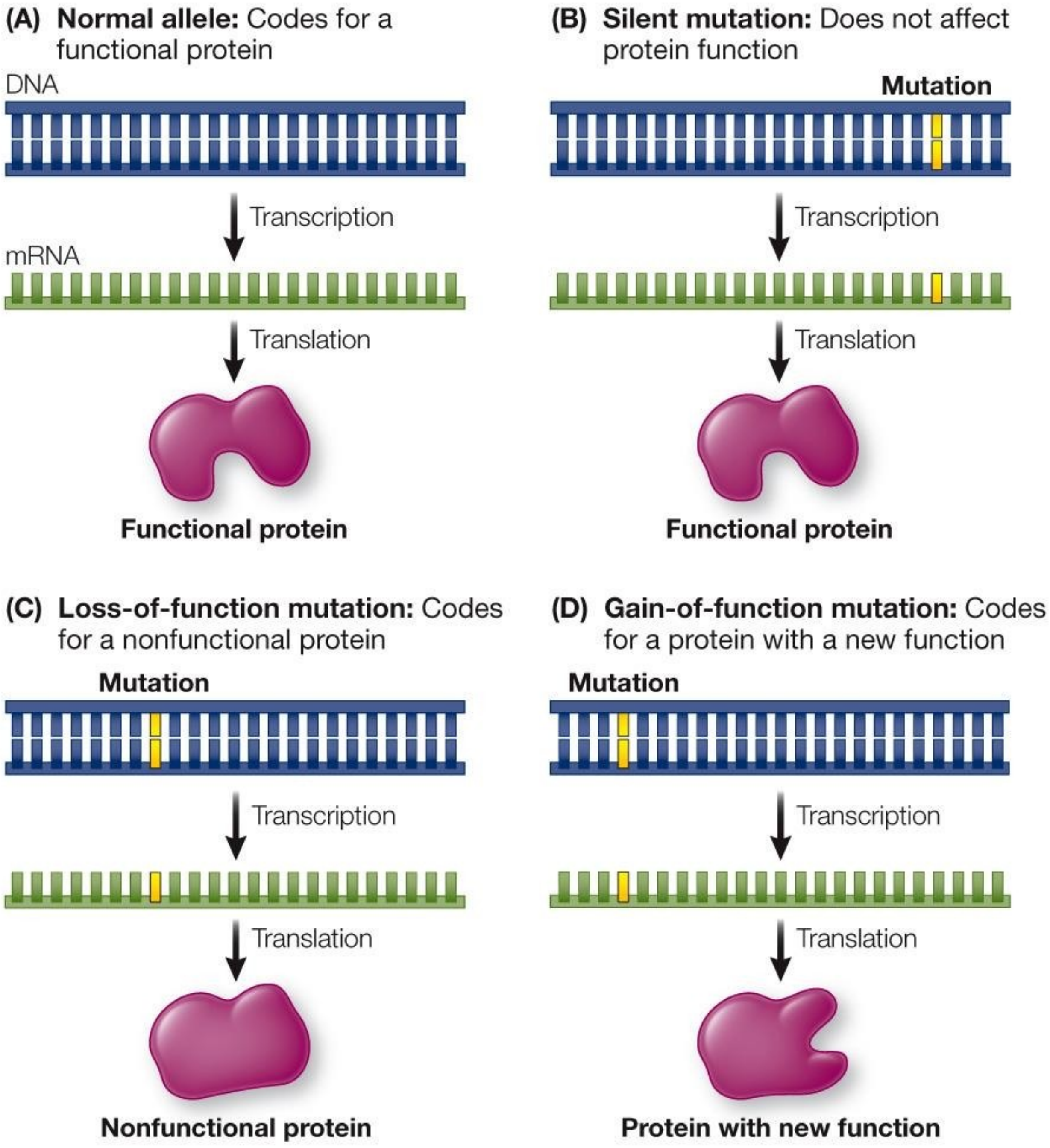



*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 15.2 (Part 4)

## (E) Frame-shift mutation




*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 15.2 (Part 5)




*LIFE: THE SCIENCE OF BIOLOGY 11e*, Figure 15.1