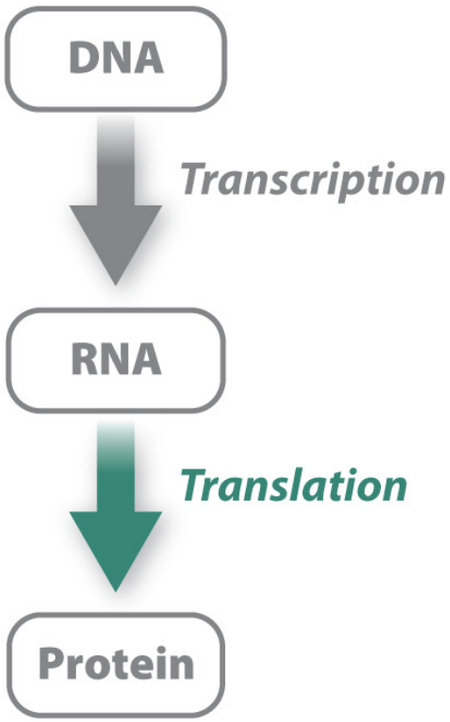


BIOL2107, Fall '23

Lecture 26

Gene Regulation: Only the Beginning

DNA

rRNA

tRNA

mRNA

RNA

µRNA

Catalytic

Structural

Regulatory

Protein

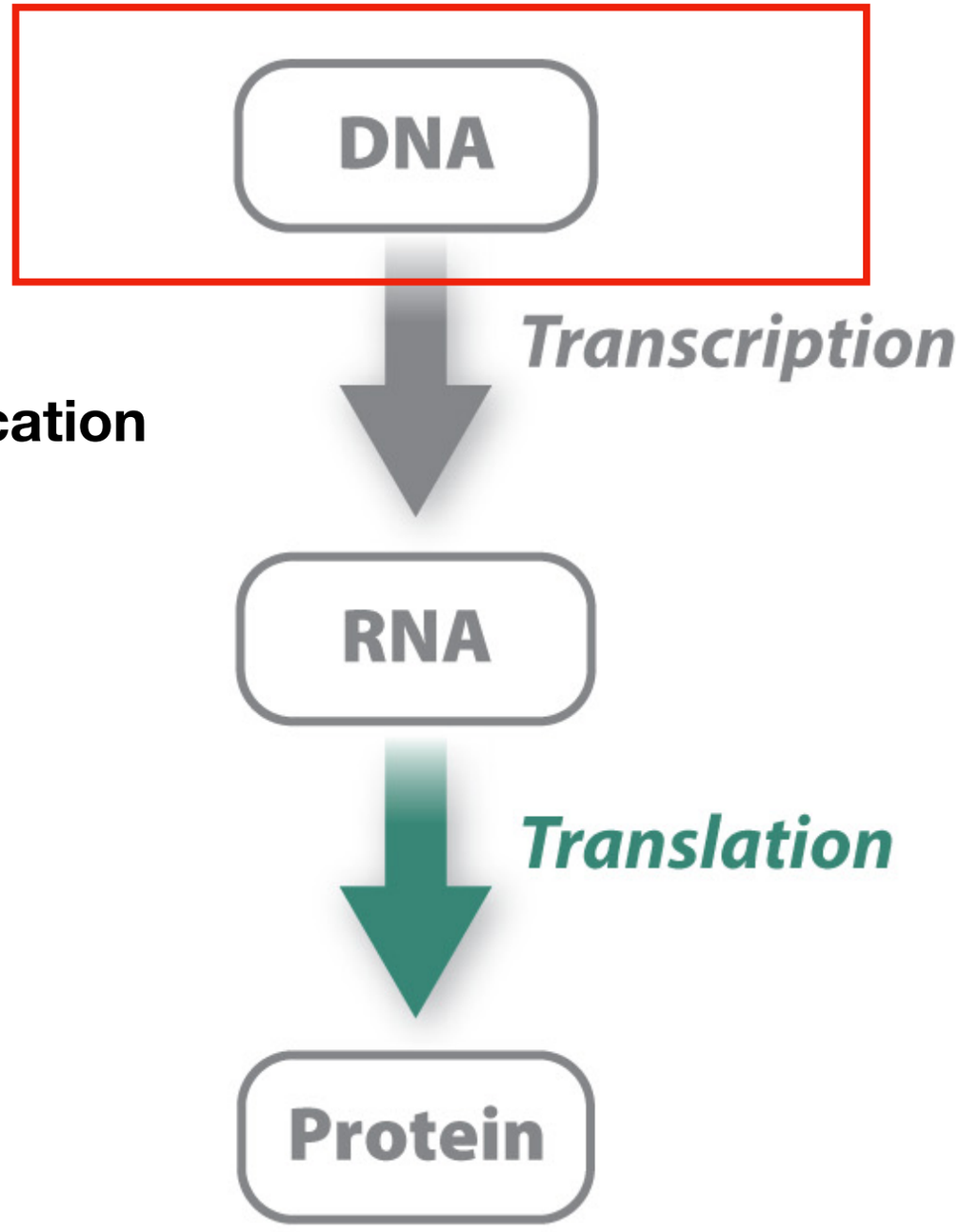
Circular vs Linear chromosomes

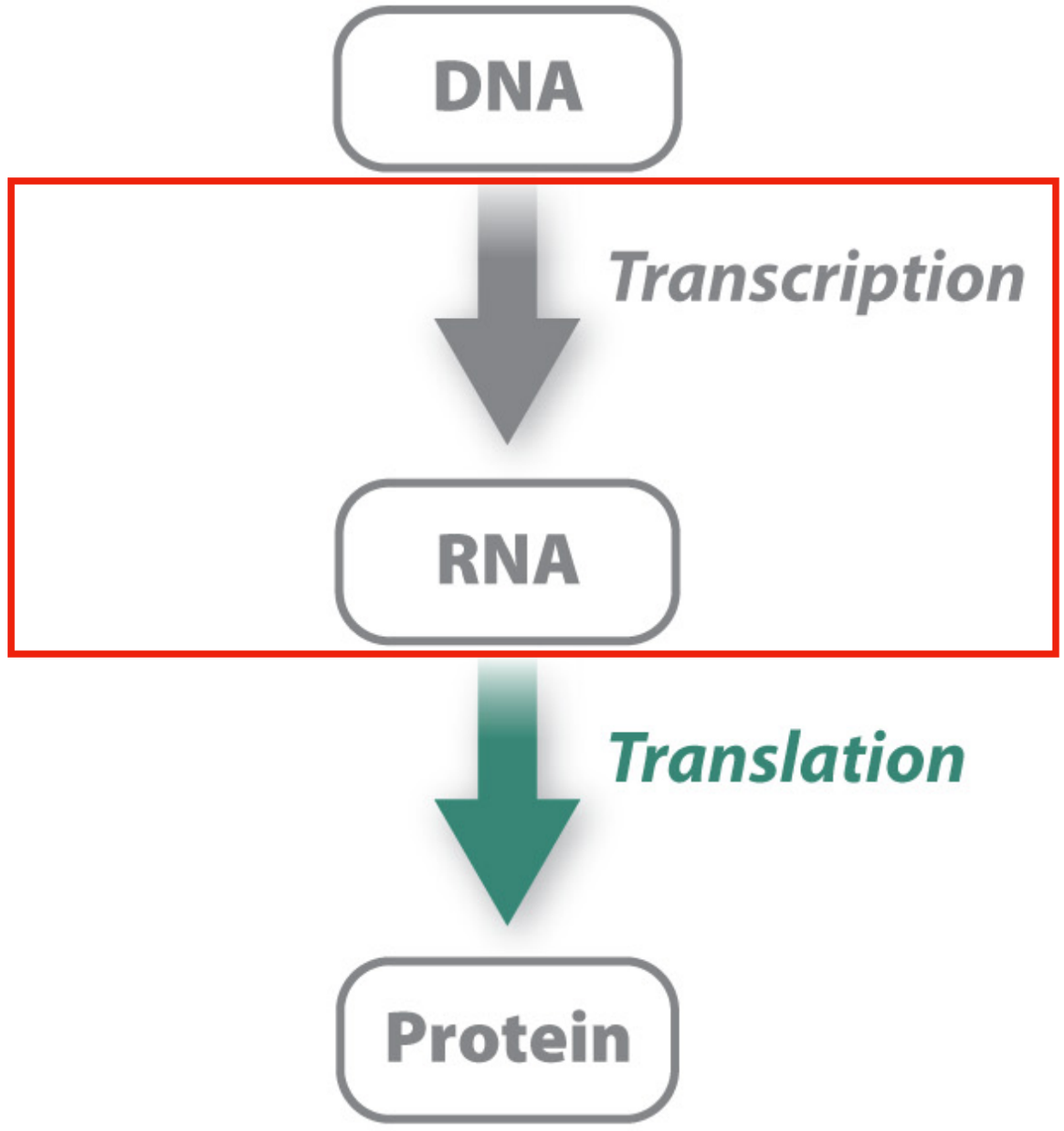
Single vs multiple "Replication origins.."

Cell Cycle control of Replication

S- phase

Gene organization…




DNA
Transcription
RNA
Translation
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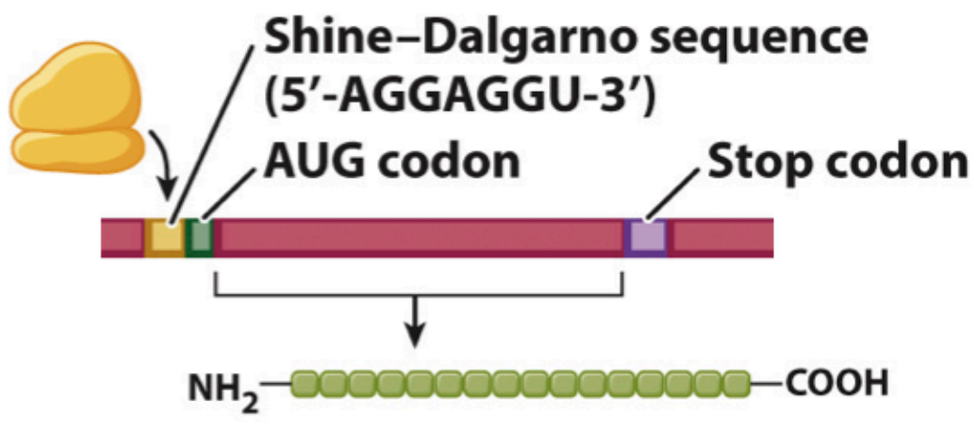
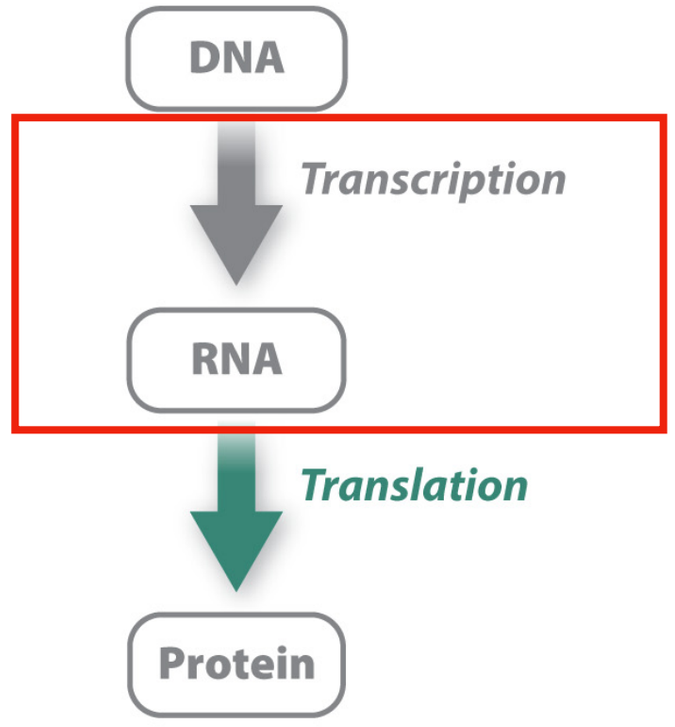
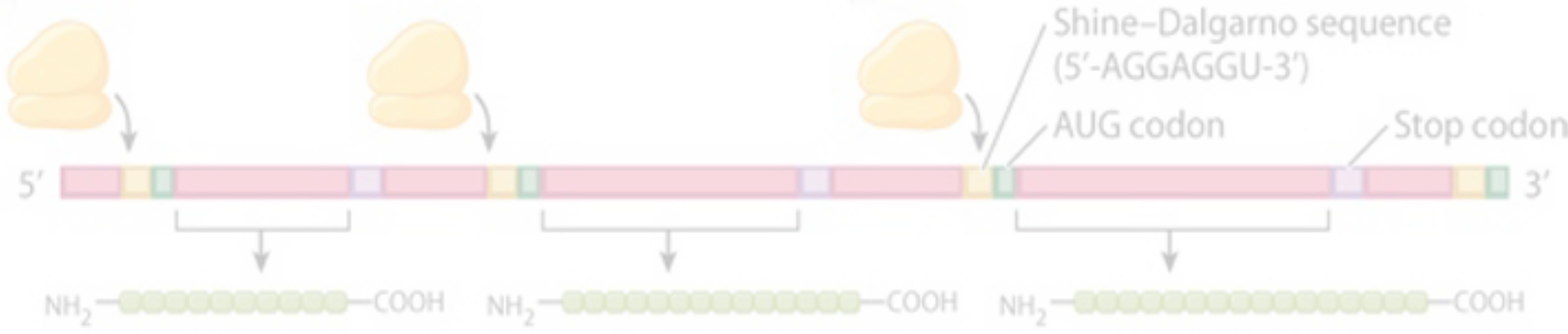
a. Monocistronic mRNA





b. Polycistronic mRNA

Initiation in prokaryotes is at any Shine–Dalgarno sequence; the mRNA can therefore be a polycistronic mRNA that codes for several polypeptides.



DNA

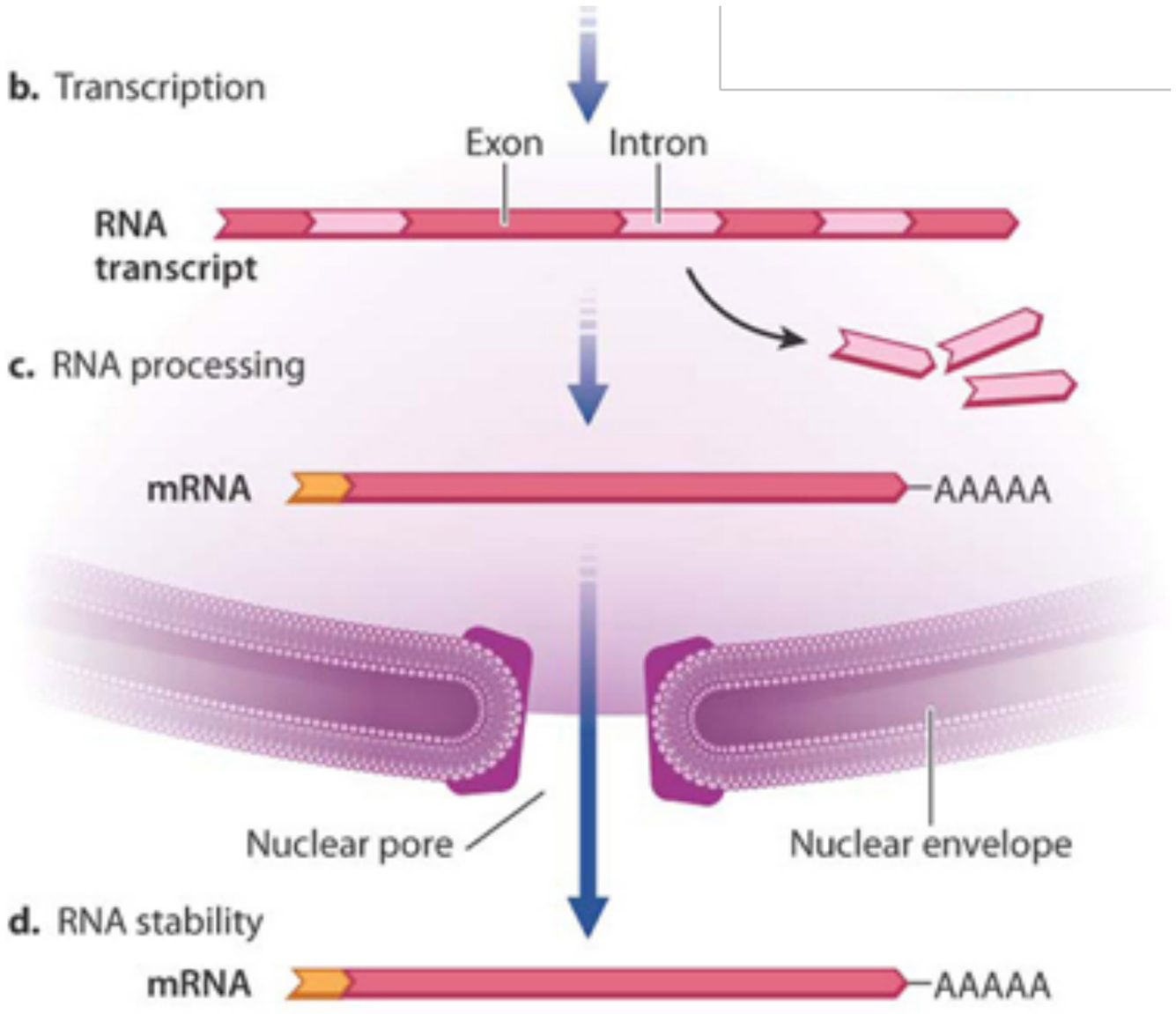
Transcription

RNA

Translation

Protein

Messenger RNA (mRNA)



DNA

Transcription

RNA

Translation

Protein

Messenger RNA (mRNA)

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Transcription

RNA

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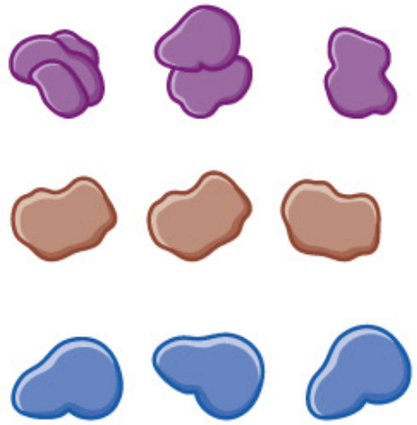
Messenger RNA (mRNA)

Initiation factors

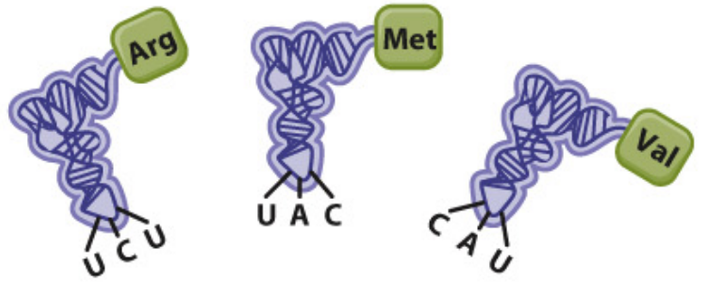
Elongation factors

Release factors



Aminoacyl tRNA synthetases

Transfer RNA (tRNA)



Ribosome (ribosomal RNA + ribosomal proteins)

DNA

Transcription

RNA

Translation

Protein

Messenger RNA (mRNA)

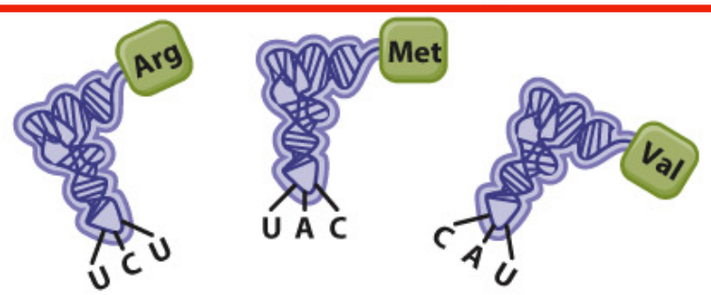
Initiation factors

Elongation factors

Release factors

Aminoacyl tRNA synthetases

Transfer RNA (tRNA)



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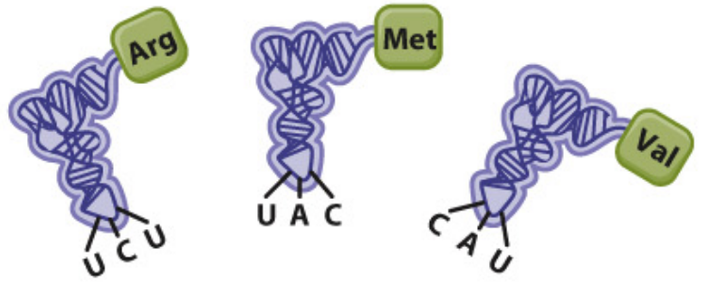

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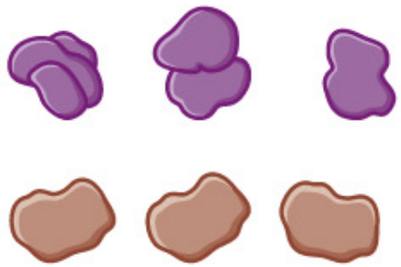

Release factors

Aminoacyl tRNA synthetases

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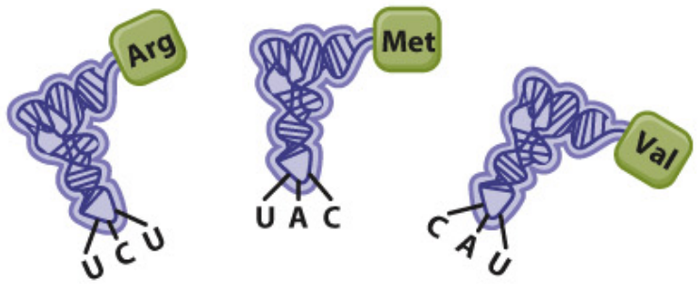

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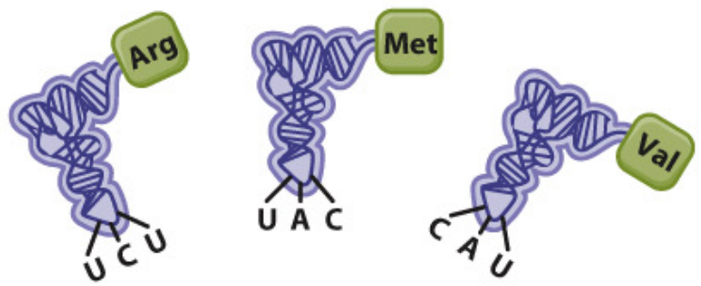

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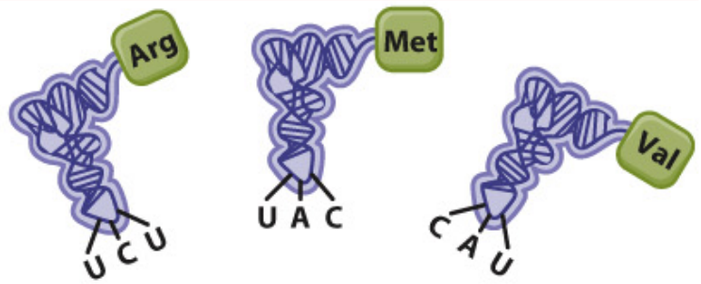

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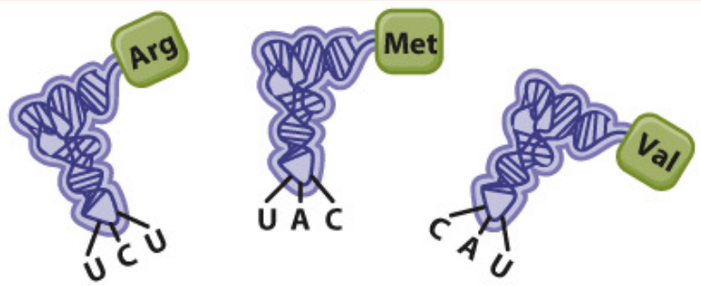

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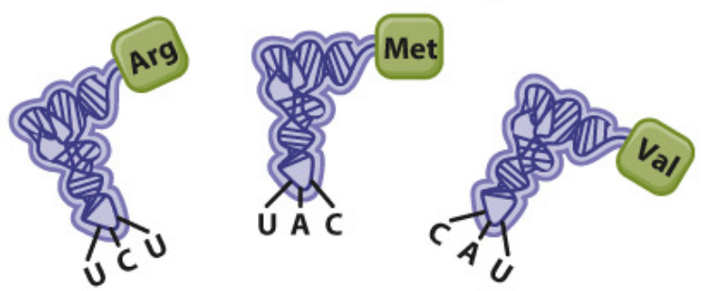


Ribosome (ribosomal RNA + ribosomal proteins)

“Universal” Genetic Code

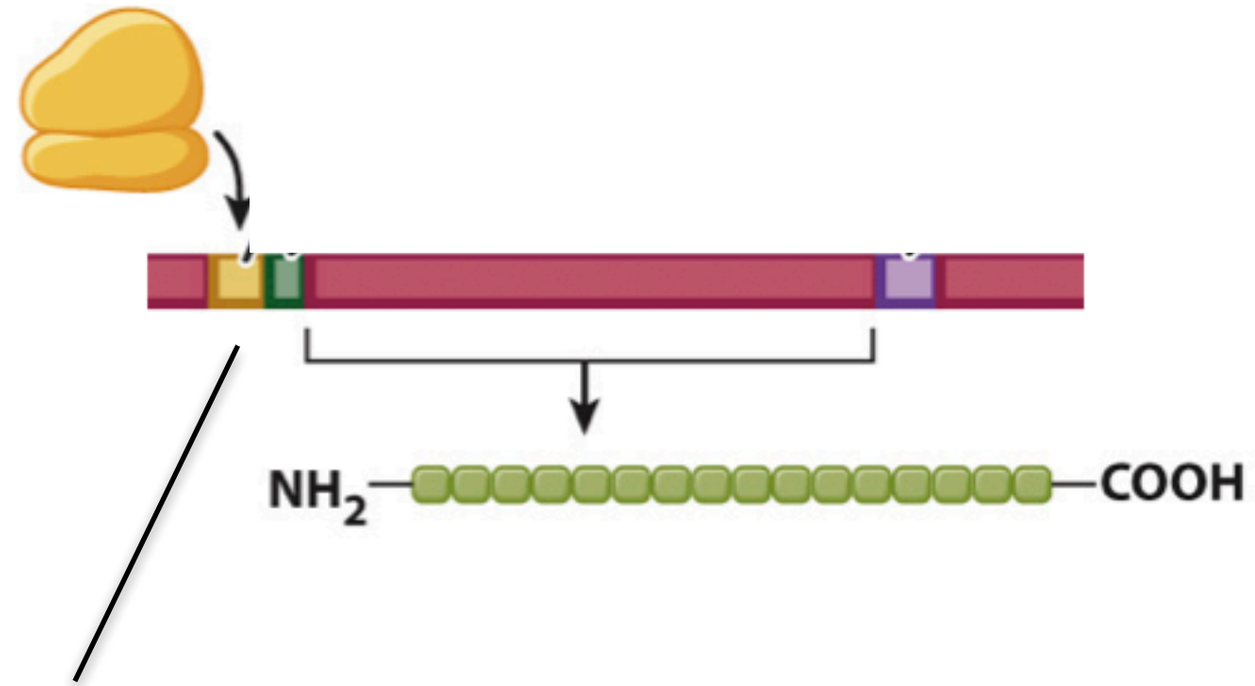
First letter	Second letter: U	Second letter: C	Second letter: A	Second letter: G	Third letter
U	UUU, UUC: Phenylalanine	UCU, UCC, UCA, UCG: Serine	UAU, UAC: Tyrosine	UGU, UGC: Cysteine	U, C
	UUA, UUG: Leucine		UAA: Stop codon; UAG: Stop codon	UGA: Stop codon; UGG: Tryptophan	A, G
C	CUU, CUC, CUA, CUG: 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	ACU, ACC, ACA, ACG: Threonine	AAU, AAC: Asparagine; AAA, AAG: Lysine	AGU, AGC: Serine; AGA, AGG: Arginine	U, C, A, G
	AUG: Methionine; start codon				
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

AUG, which codes for the amino acid **methionine**, is called the ***start* codon**, which initiates the translational process.

Three of the possible codons are *stop* codons (**UAA**, **UAG**, and **UGA**), which direct the ribosomes to STOP reading the mRNA; that is, they end translation.

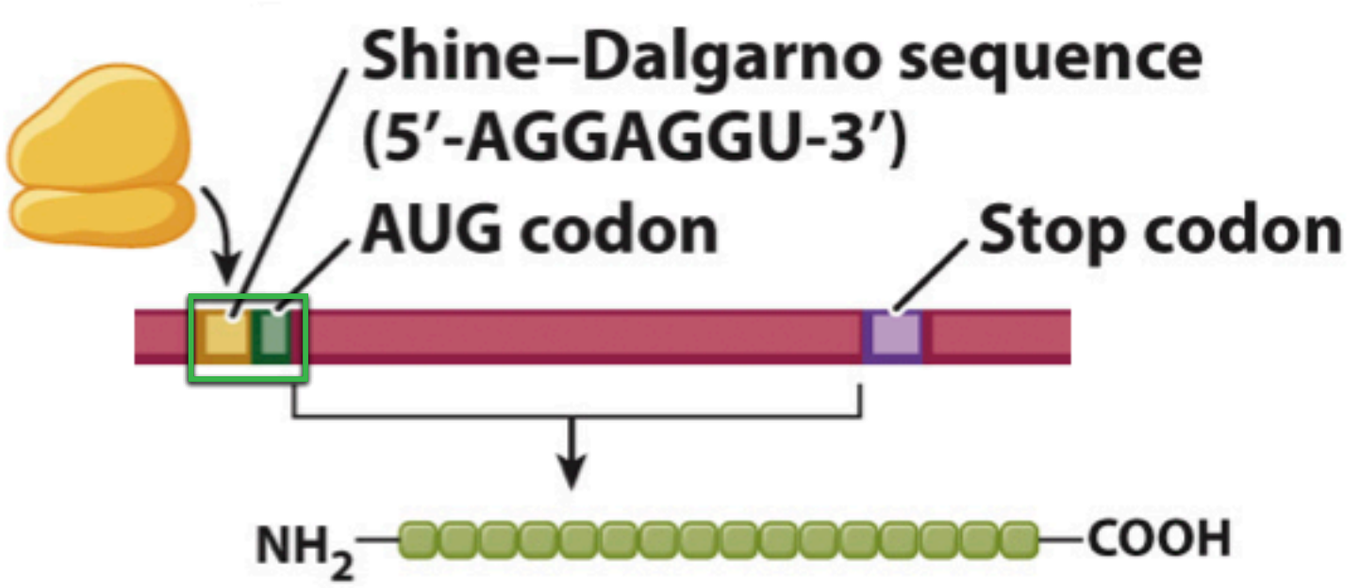
Initiation in prokaryotes is at any Shine–Dalgarno sequence; the mRNA can therefore be a polycistronic mRNA that codes for several polypeptides.

Monocistronic mRNA

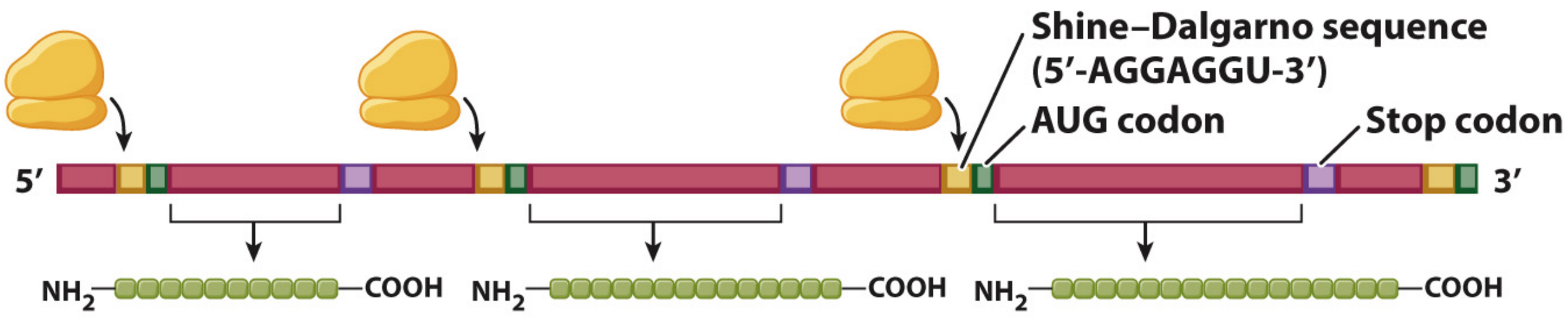


5’- AACGC**AGGAGG** -7 bases- **AUG**/CAG/GGA/…. **UGA** -3’

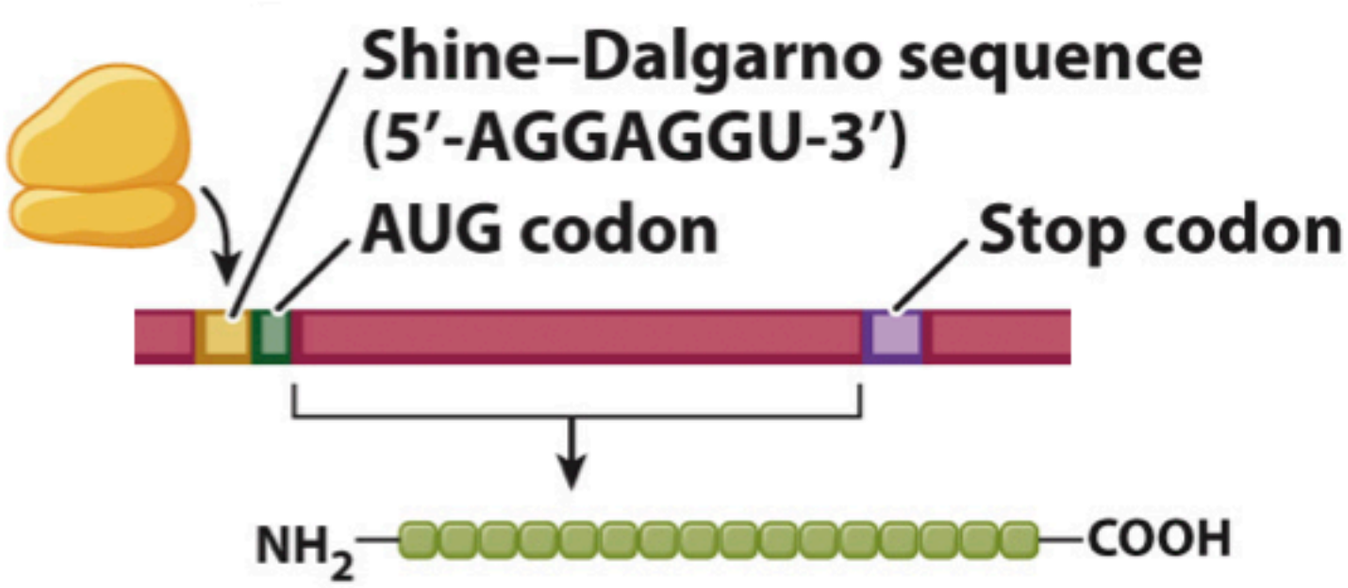
Monocistronic mRNA



Polycistronic mRNA



Monocistronic mRNA



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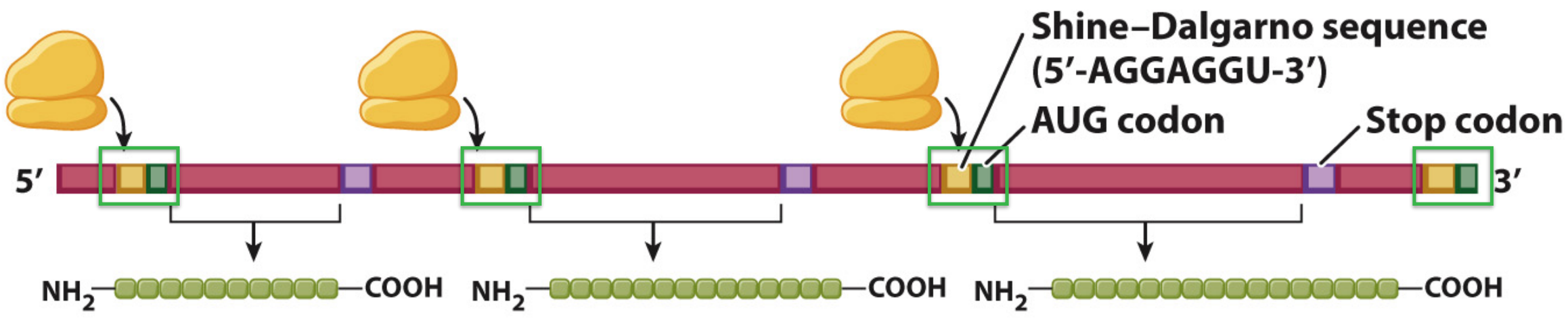
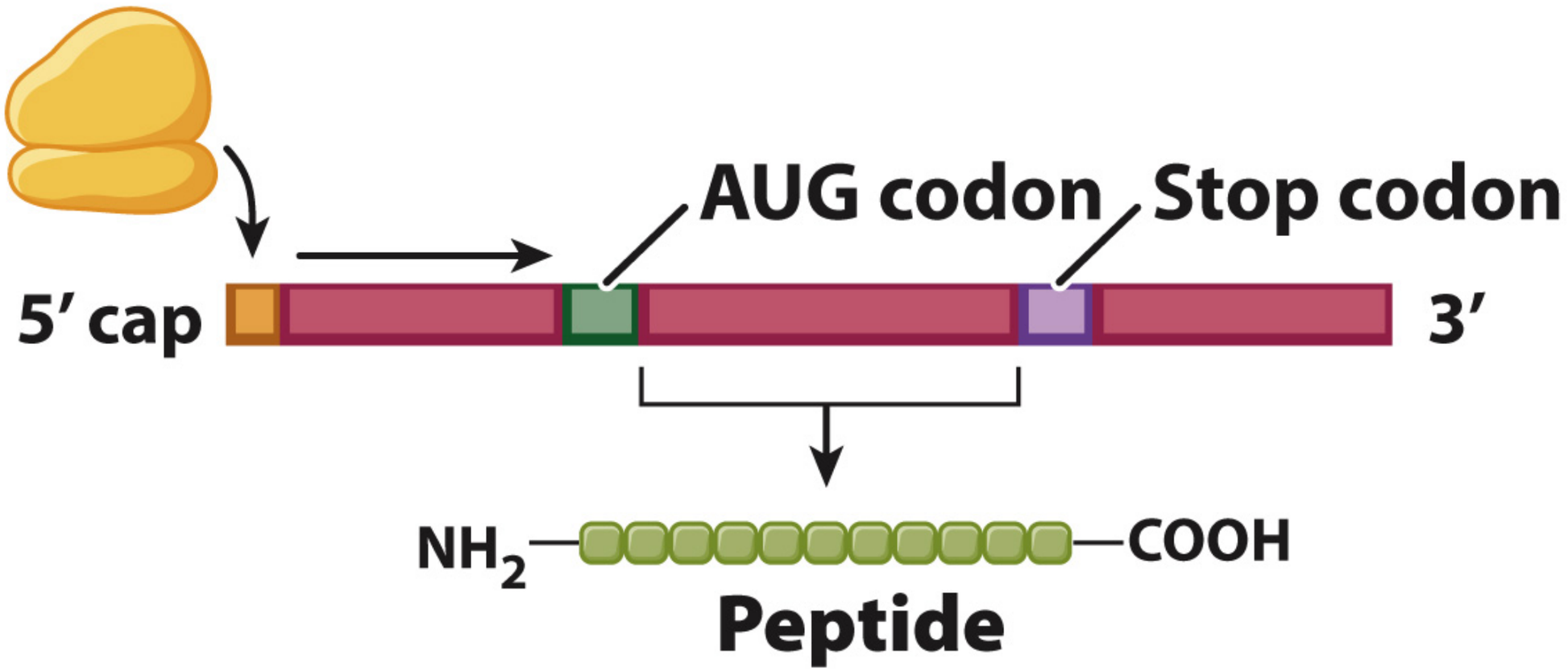


Monocistronic mRNA

Initiation in eukaryotes is at the 5′ cap, and the first AUG is the start codon.



Transcription
During transcription, RNA polymerase reads a DNA sequence and produces a complementary, antiparallel strand of RNA.

RNA processing
In eukaryotes, the primary RNA transcript is modified in the nucleus, creating mature mRNA and noncoding RNA.

Transport
mRNA travels through nuclear pores into the cytoplasm.

Translation
Ribosomes translate mRNA in the cytosol, producing polypeptide chains. The resulting proteins carry out vital cellular functions.

DNA → RNA → mRNA → mRNA → Protein

Noncoding RNAs do not encode proteins and include tRNA and rRNA. These RNAs are transcribed from DNA found in the nucleolus.

Nucleolus

tRNA

DNA

Gene

RNA polymerase

Primary transcript (RNA)

During mRNA processing, introns are excised from the strand while exons are spliced together. The mRNA receives a 5′ cap and a poly(A) tail, then travels out of the nucleus.

5′ cap

Exon

Intron

AAAAA

Spliceosome

Intron lariat

RNA transcription begins at a promoter region and continues until a terminator sequence is encountered.

RNA transcript

RNA–DNA duplex

Template DNA

Promoter region

Terminator sequence

5′

3′

Gene

Polymerase movement

Nucleus

Growing polypeptide chain

Met Leu Arg Thr Ser Pro Glu Glu Asp Val Phe Ala Met Gly Val Arg

During elongation, the appropriate tRNA anticodon matches with the available codon on the mRNA, bringing the next amino acid to the polypeptide chain.

tRNA

E site

P site

A site

Incoming tRNA charged with amino acid

Anticodon

Ribosome

A G A A C C G A A

U G G

C U U

5′

3′

Codon

mRNA

Ribosome moves along mRNA in a 5′ to 3′ direction.

Proteins have many different roles in the cell. They provide structural support, act as enzymes that facilitate chemical reactions, and are involved in cell signaling and communication.

Growing actin filament

Actin protein

A ribosome attaches to the mRNA and scans the transcript for an AUG start codon. The ribosome initiates translation at that point and synthesizes a polypeptide chain based on the sequence of the mRNA until it reaches a stop codon.

Ribosomes

Cytosol

Extracellular fluid

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3′

Gene

Polymerase movement

Nucleus

During elongation, the appropriate tRNA anticodon matches with the available codon on the mRNA, bringing the next amino acid to the polypeptide chain.

Phe Ala Met Gly Val Arg Thr

tRNA

E site

P site

A site

Glu

Incoming tRNA charged with amino acid

Anticodon

Ribosome

A G A A C C G A A

U U C U U G

5′ 3′

Codon

mRNA

Ribosome moves along mRNA in a 5′ to 3′ direction.

…oteins have many …ferent roles in the cell. …ey provide structural …pport, act as enzymes …at facilitate chemical reactions, and are involved in cell signaling and communication.

Growing actin filament

Actin protein

A ribosome attaches to the mRNA and scans the transcript for an AUG start codon. The ribosome initiates translation at that point and synthesizes a polypeptide chain based on the sequence of the mRNA until it reaches a stop codon.

Ribosomes

Cytosol

Extracellular fluid

Transcription
During transcription, RNA polymerase reads a DNA sequence and produces a complementary, antiparallel strand of RNA.

RNA processing
In eukaryotes, the primary RNA transcript is modified in the nucleus, creating mature mRNA and noncoding RNA.

Transport
mRNA travels through nuclear pores into the cytoplasm.

Translation
Ribosomes translate mRNA in the cytosol, producing polypeptide chains. The resulting proteins carry out vital cellular functions.

DNA → RNA → mRNA → mRNA → Protein

Noncoding RNAs do not encode proteins and include tRNA and rRNA. These RNAs are transcribed from DNA found in the nucleolus.

Nucleolus

tRNA

DNA

Gene

RNA polymerase

Primary transcript (RNA)

During mRNA processing, introns are excised from the strand while exons are spliced together. The mRNA receives a 5′ cap and a poly(A) tail, then travels out of the nucleus.

5′ cap

Exon

Intron

AAAAA

Spliceosome

Intron lariat

RNA transcription begins at a promoter region and continues until a terminator sequence is encountered.

RNA transcript

RNA–DNA duplex

Template DNA

Promoter region

Terminator sequence

5′

3′

Gene

Polymerase movement

Nucleus

Growing polypeptide chain

Met Leu Arg Thr Ser Pro Glu Glu Asp Val Phe Ala Met Gly Val Arg

During elongation, the appropriate tRNA anticodon matches with the available codon on the mRNA, bringing the next amino acid to the polypeptide chain.

tRNA

E site

P site

A site

Incoming tRNA charged with amino acid

Anticodon

Ribosome

A G A A C C G A A

U G G

C U U

5′

3′

Codon

mRNA

Ribosome moves along mRNA in a 5′ to 3′ direction.

Proteins have many different roles in the cell. They provide structural support, act as enzymes that facilitate chemical reactions, and are involved in cell signaling and communication.

Growing actin filament

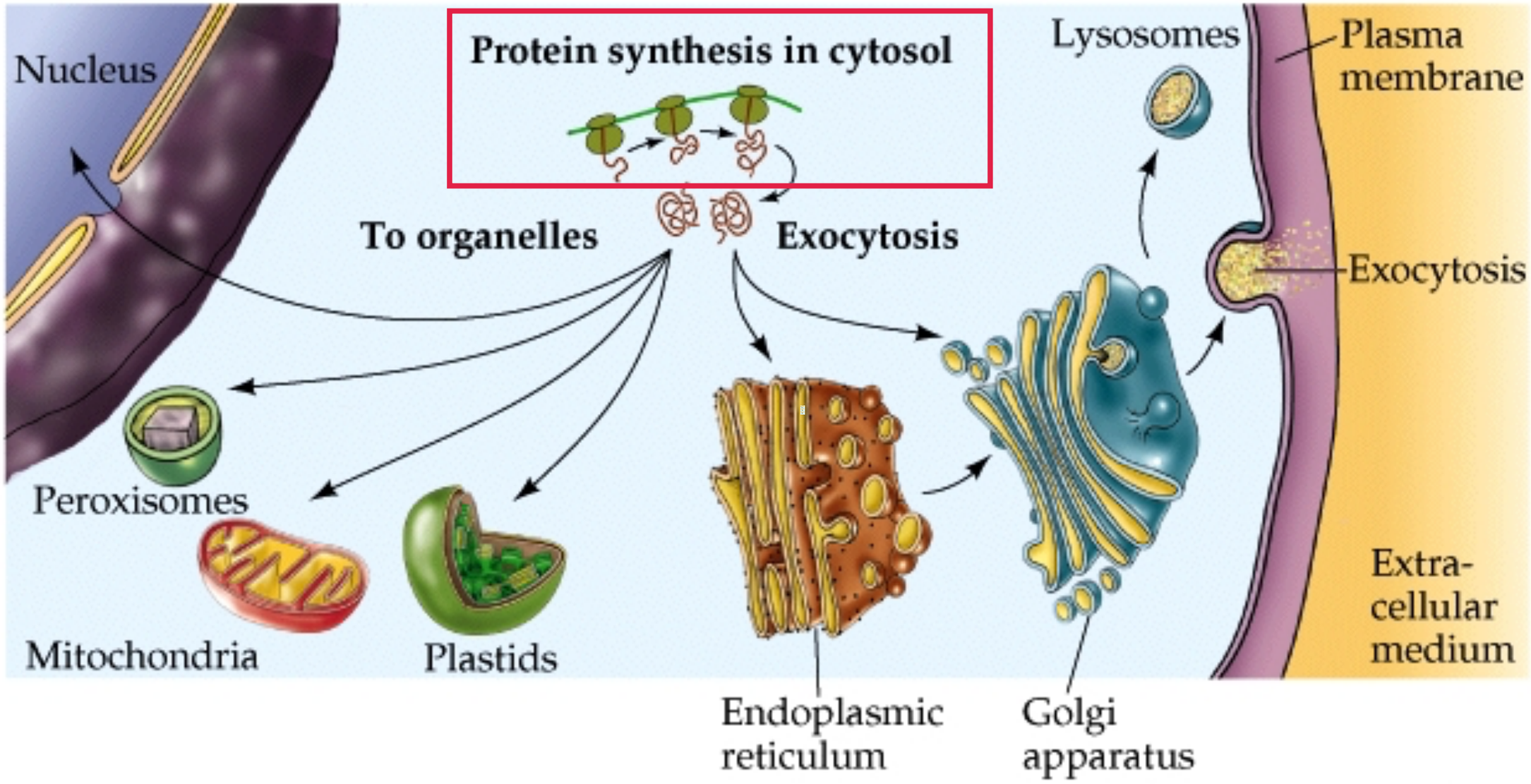
Actin protein

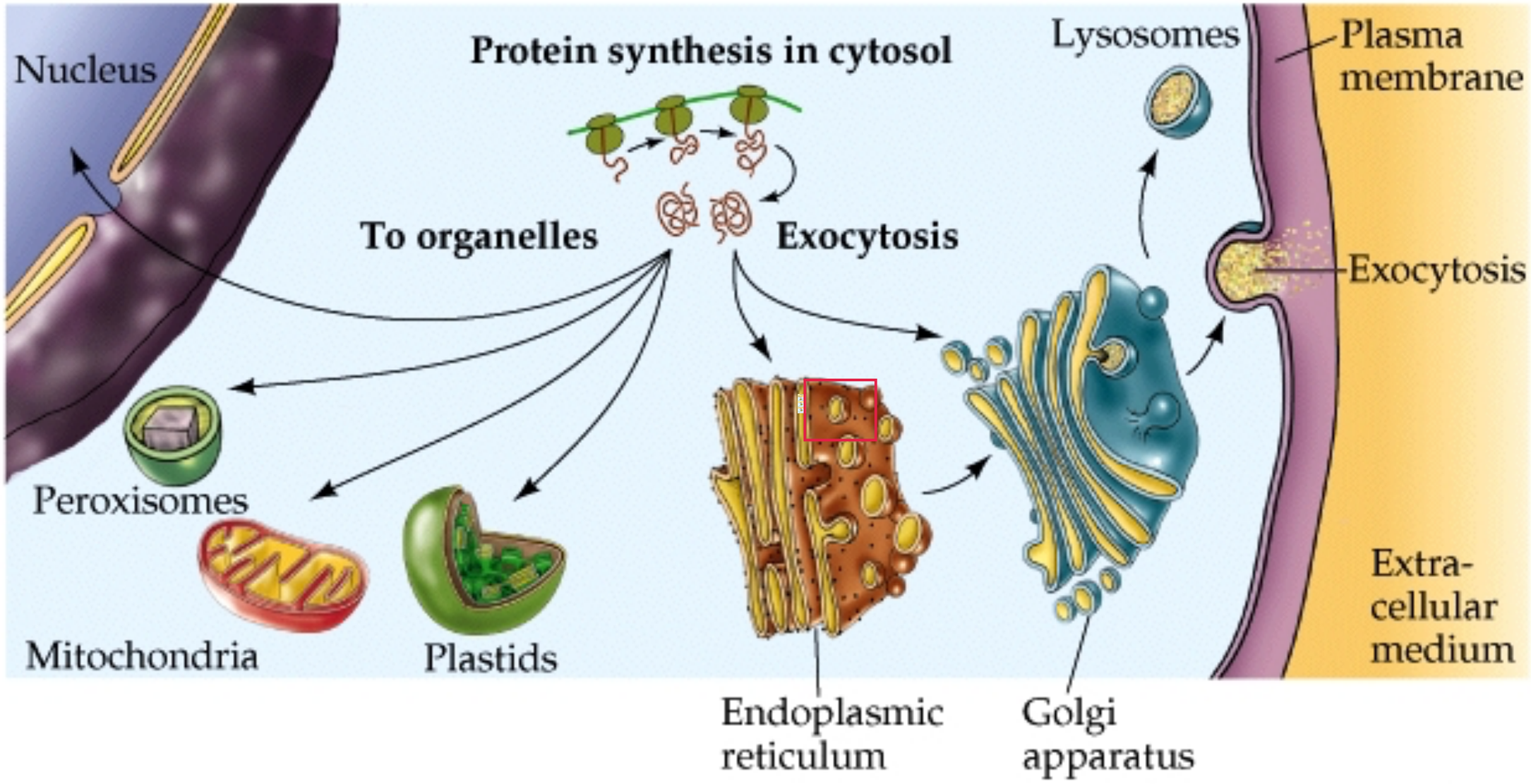
A ribosome attaches to the mRNA and scans the transcript for an AUG start codon. The ribosome initiates translation at that point and synthesizes a polypeptide chain based on the sequence of the mRNA until it reaches a stop codon.

Ribosomes

Cytosol

Extracellular fluid


Protein synthesis in cytosol
Nucleus
To organelles
Exocytosis
Lysosomes
Plasma membrane
Exocytosis
Peroxisomes
Mitochondria
Plastids
Endoplasmic reticulum
Golgi apparatus
Extra-cellular medium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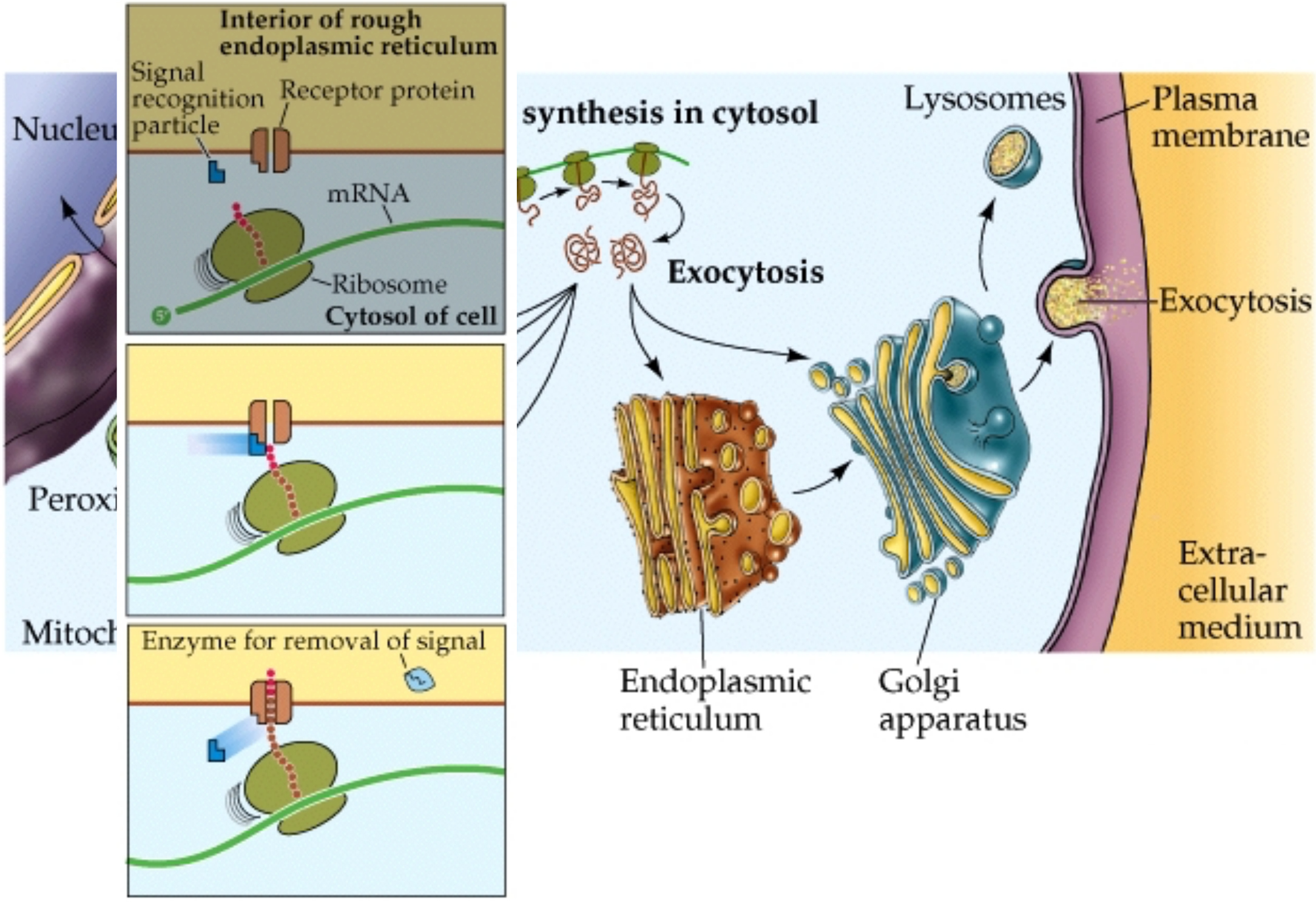
Nucleu
Peroxi
Mitoch
Interior of rough endoplasmic reticulum
Signal recognition particle
Receptor protein
mRNA
Ribosome
Cytosol of cell
Enzyme for removal of signal
synthesis in cytosol
Exocytosis
Lysosomes
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Interior of rough endoplasmic reticulum

Signal recognition particle

Receptor protein

mRNA

Ribosome

5'

Cytosol of cell

Enzyme for removal of signal

synthesis in cytosol

Excised signal

3'

Completed protein

Ribosome released

3'

Lysosomes

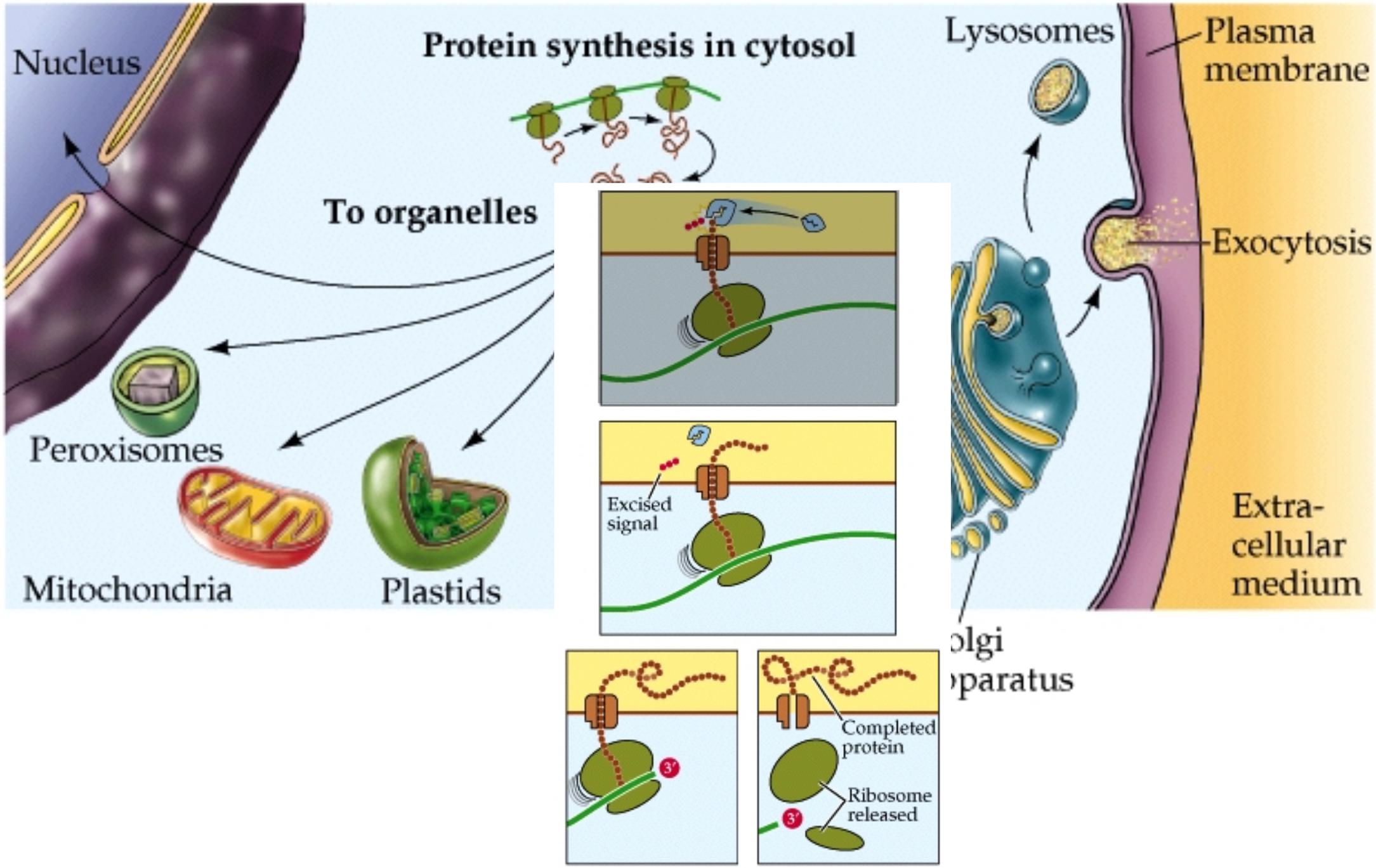
Plasma membrane

Exocytosis

Extra-cellular medium

olgi

paratus


Protein synthesis in cytosol
Nucleus
To organelles
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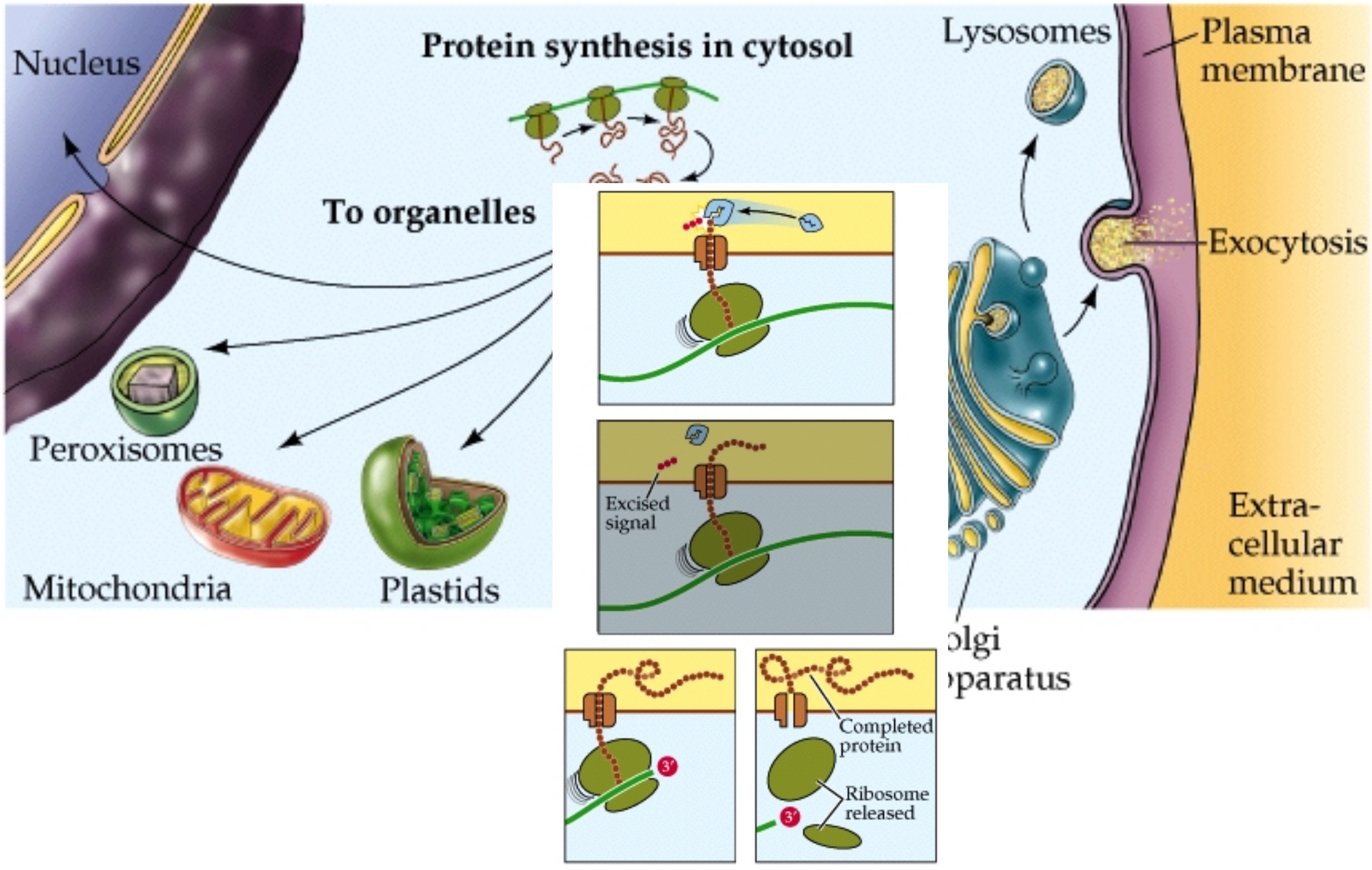
Mitochondria
Plastids
Excised signal
3′
Completed protein
Ribosome released
3′
Lysosomes
Plasma membrane
Exocytosis
Extra-cellular medium
olgi
paratus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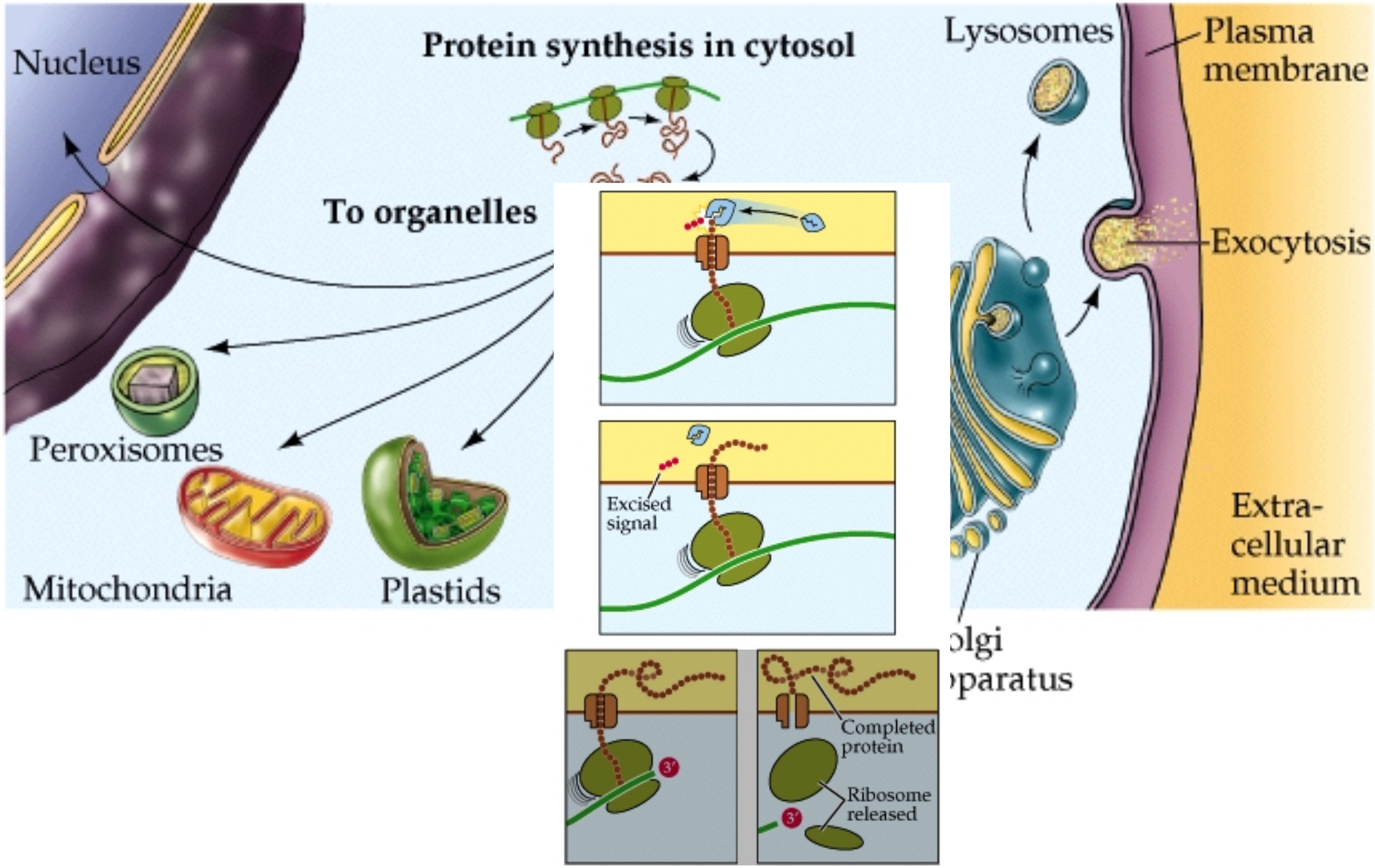
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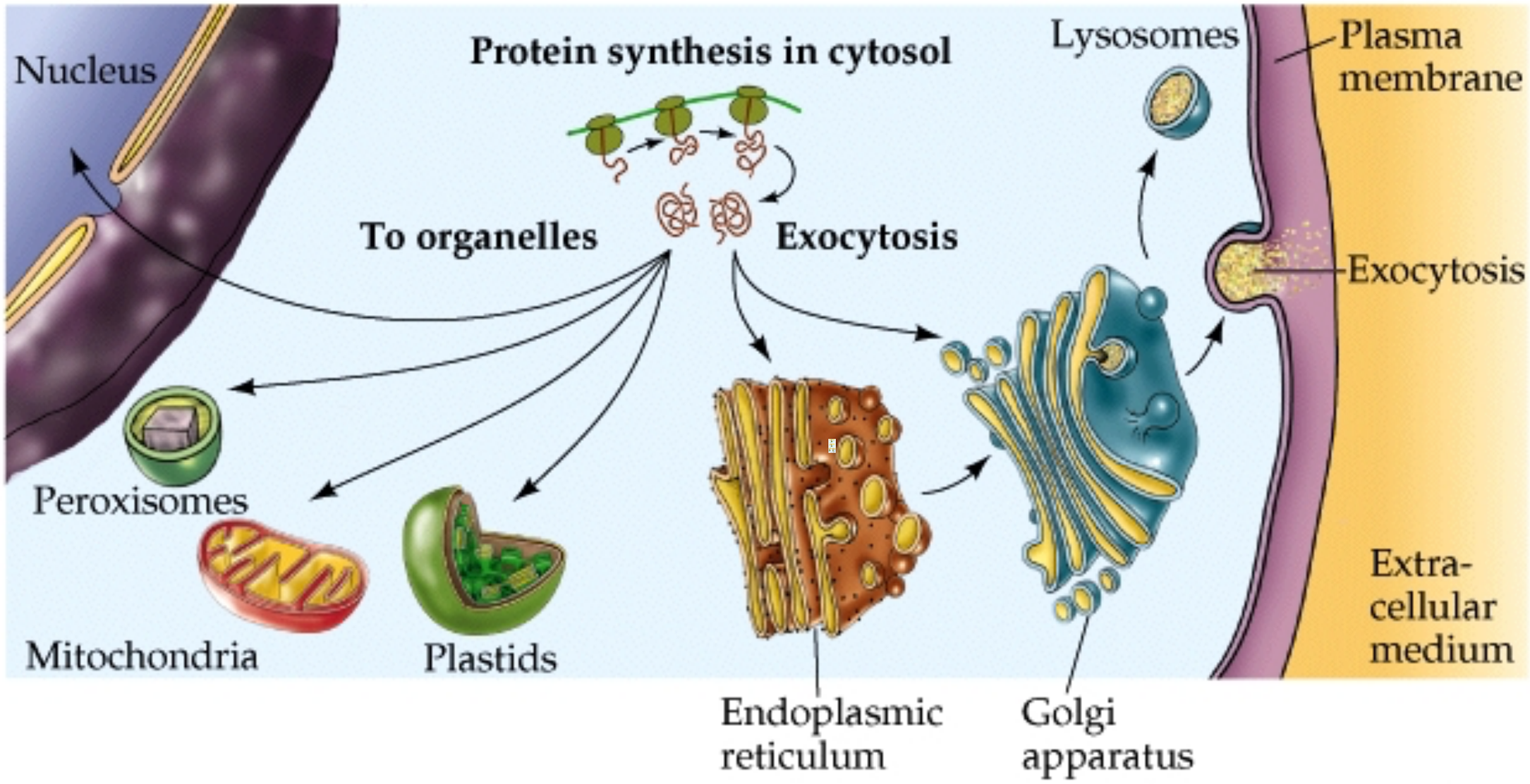
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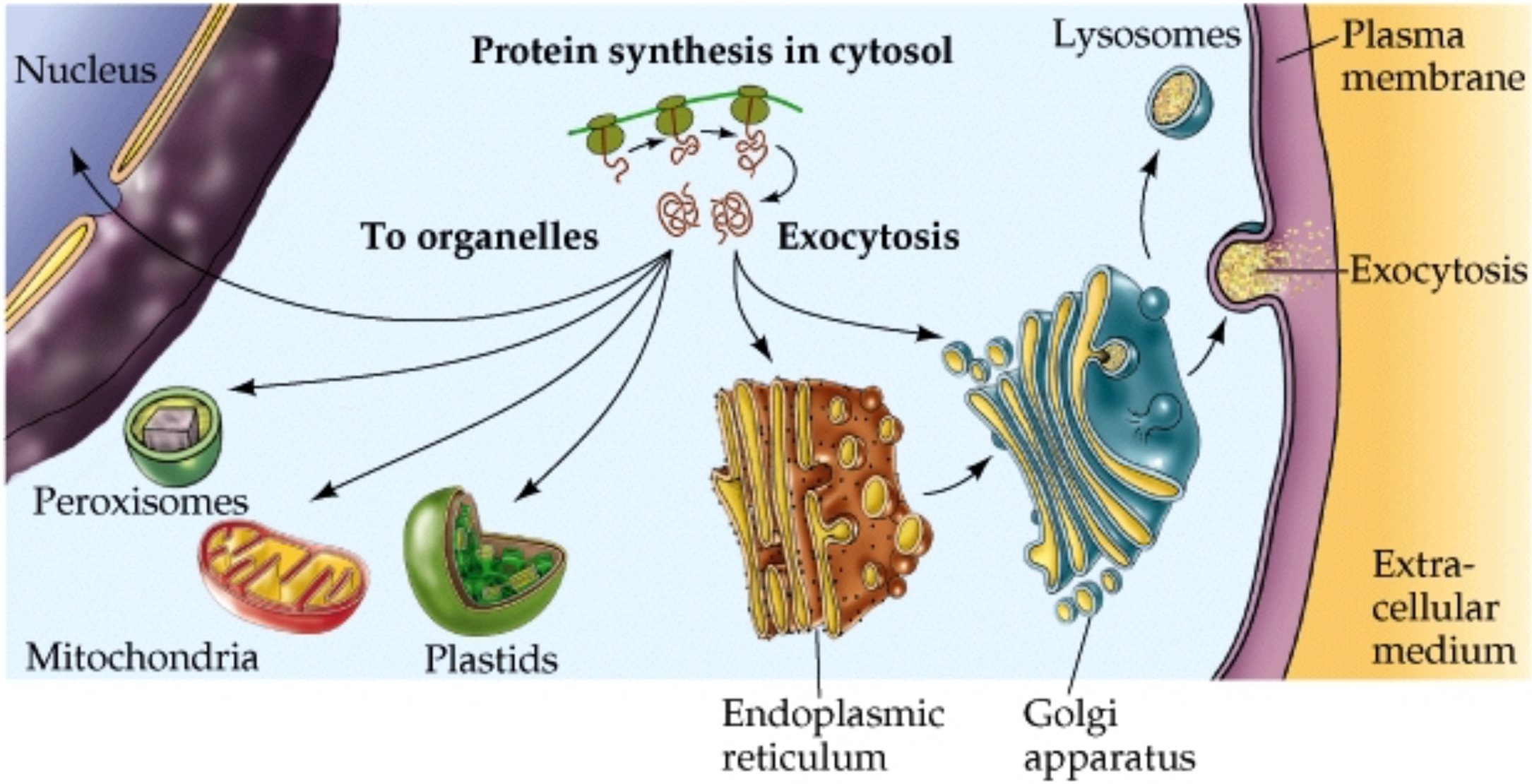
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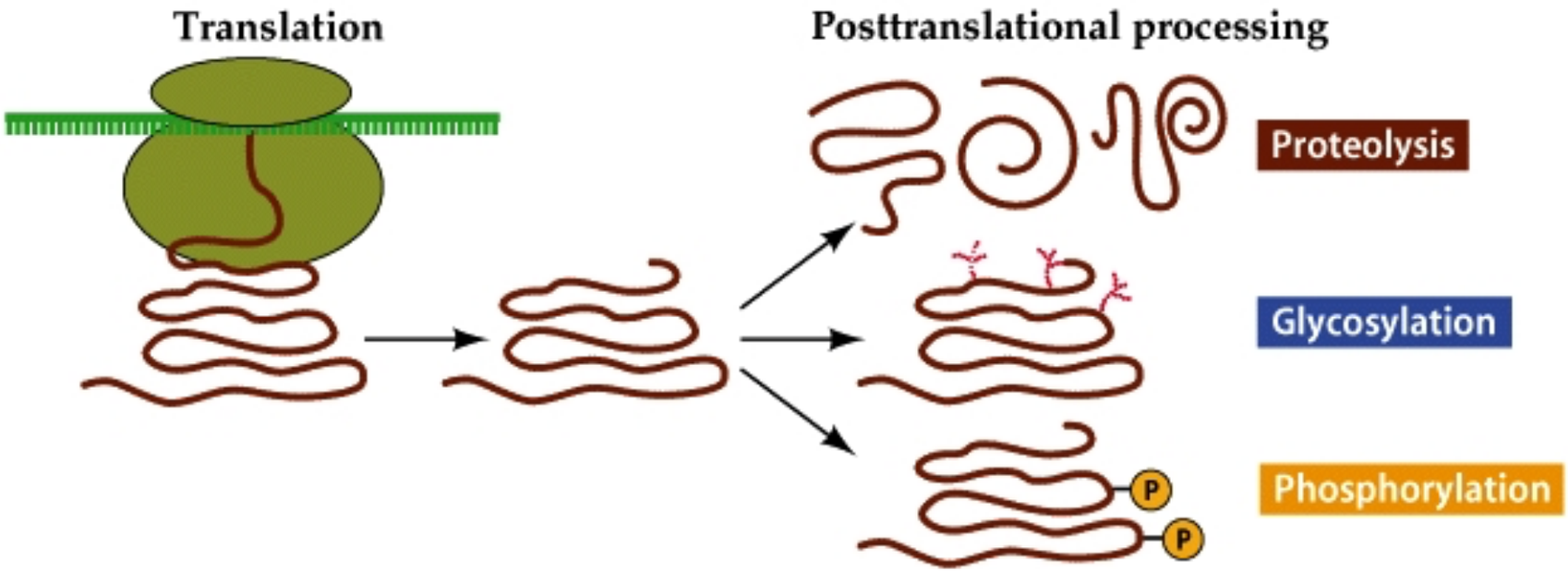
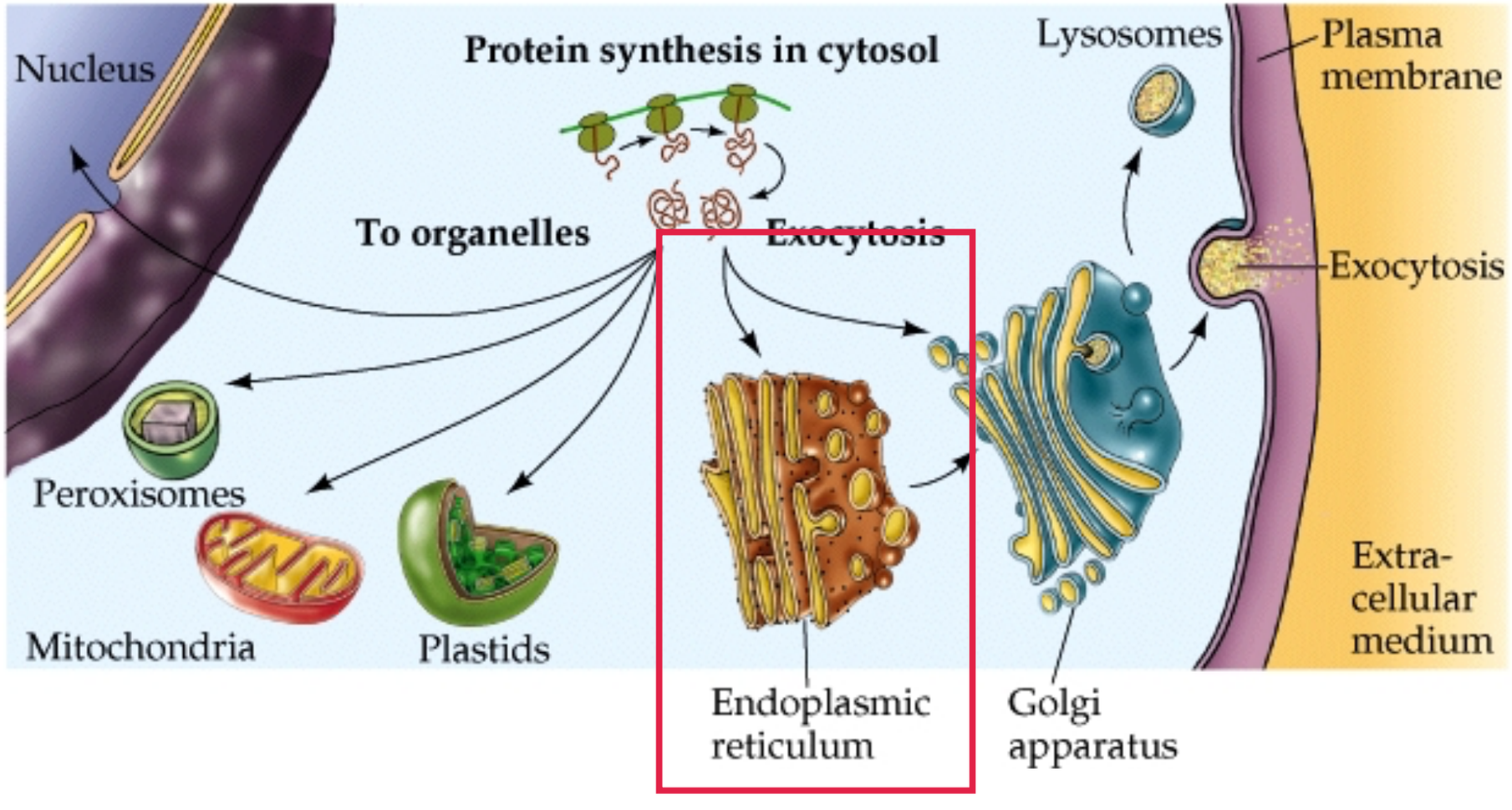

Translation
Posttranslational processing
Proteolysis
Glycosylation
Phosphorylation
P
P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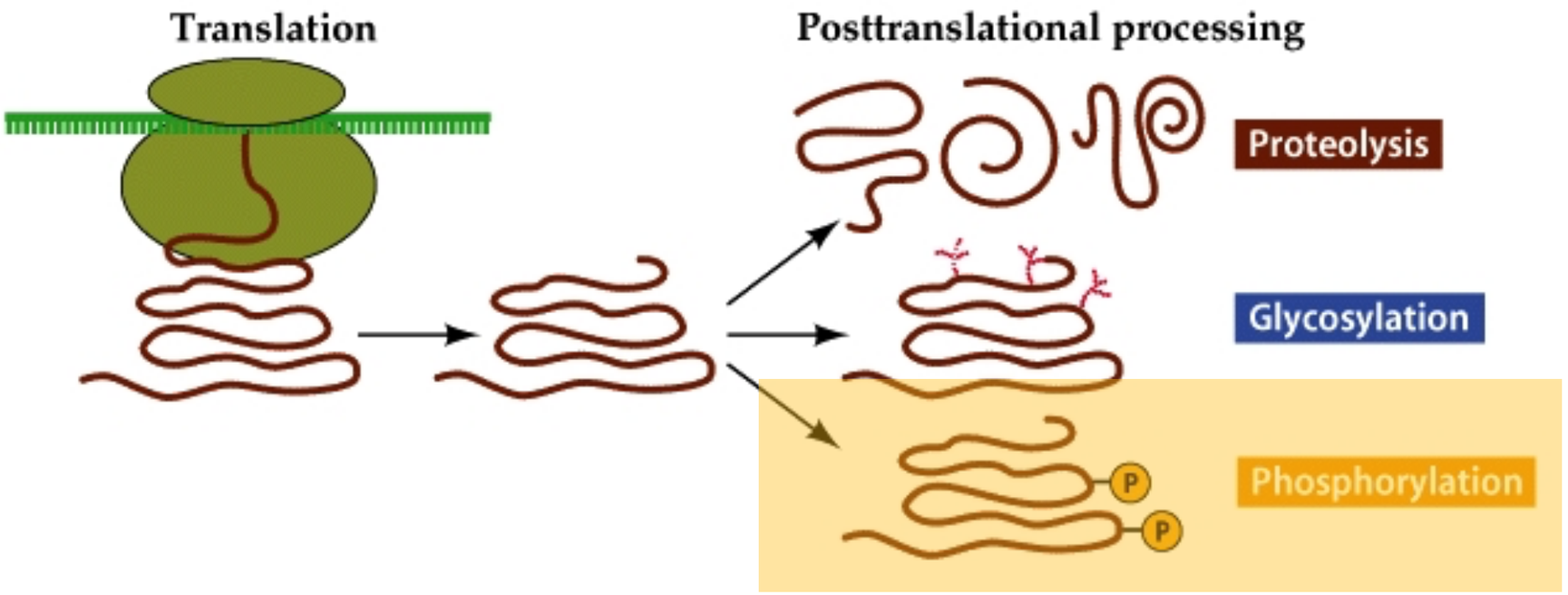
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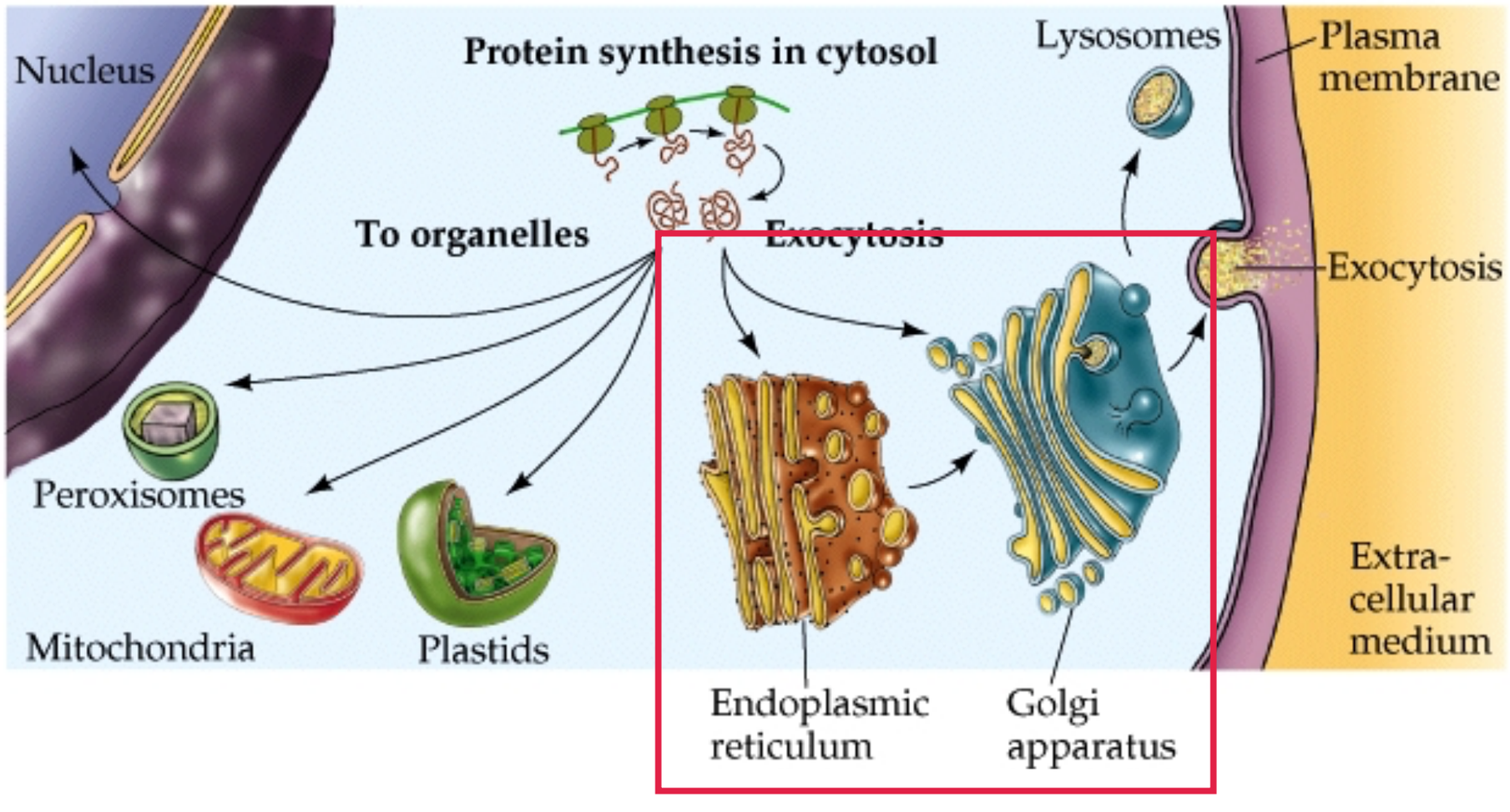
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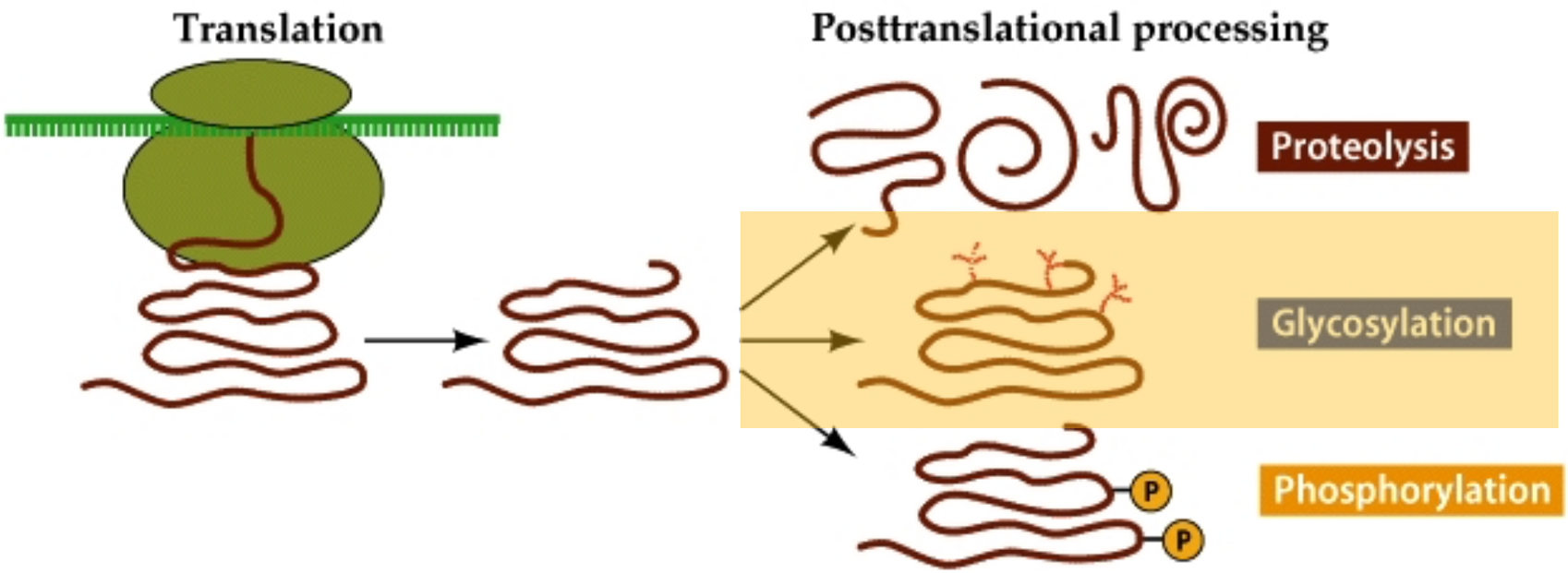
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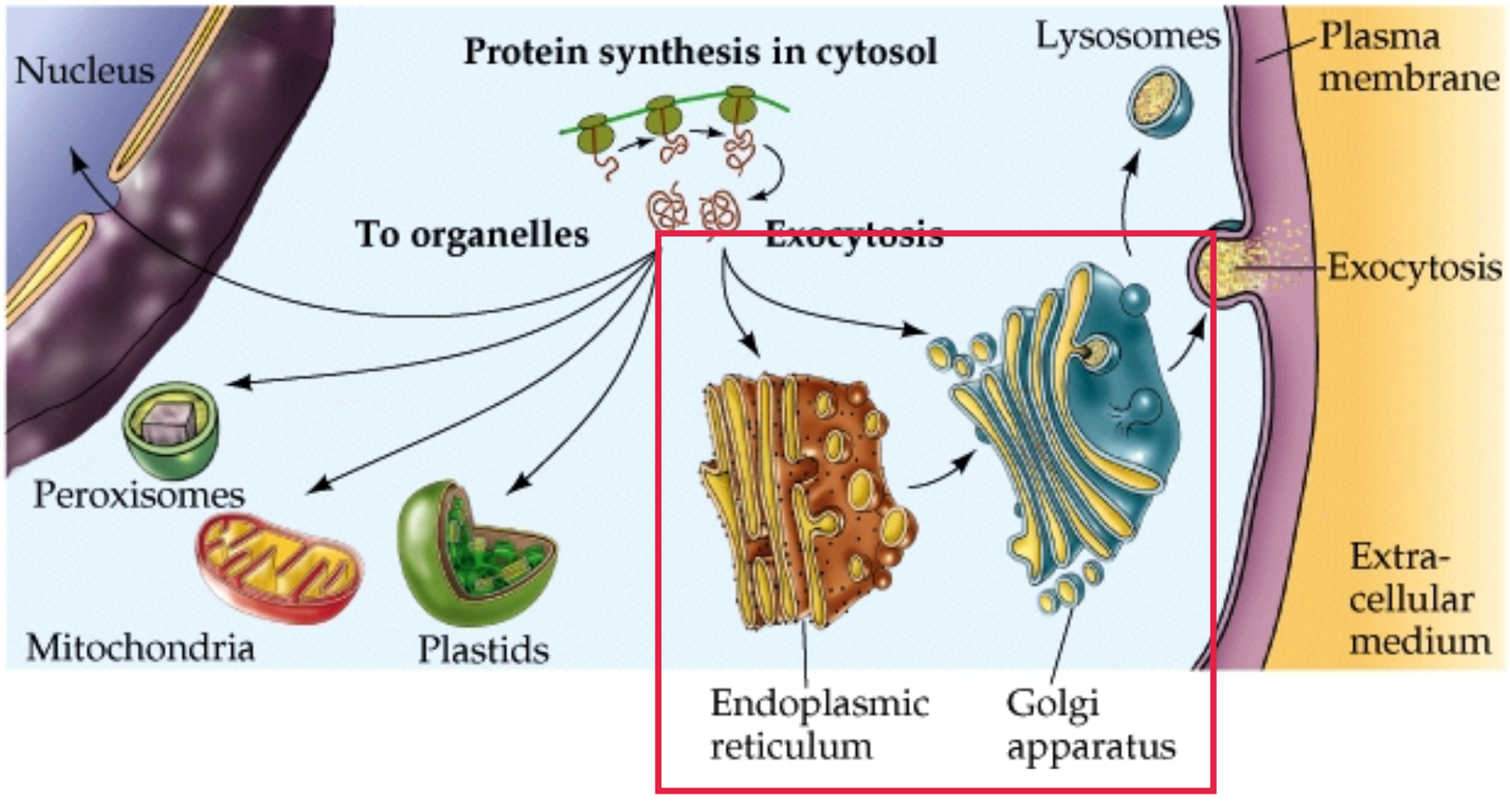
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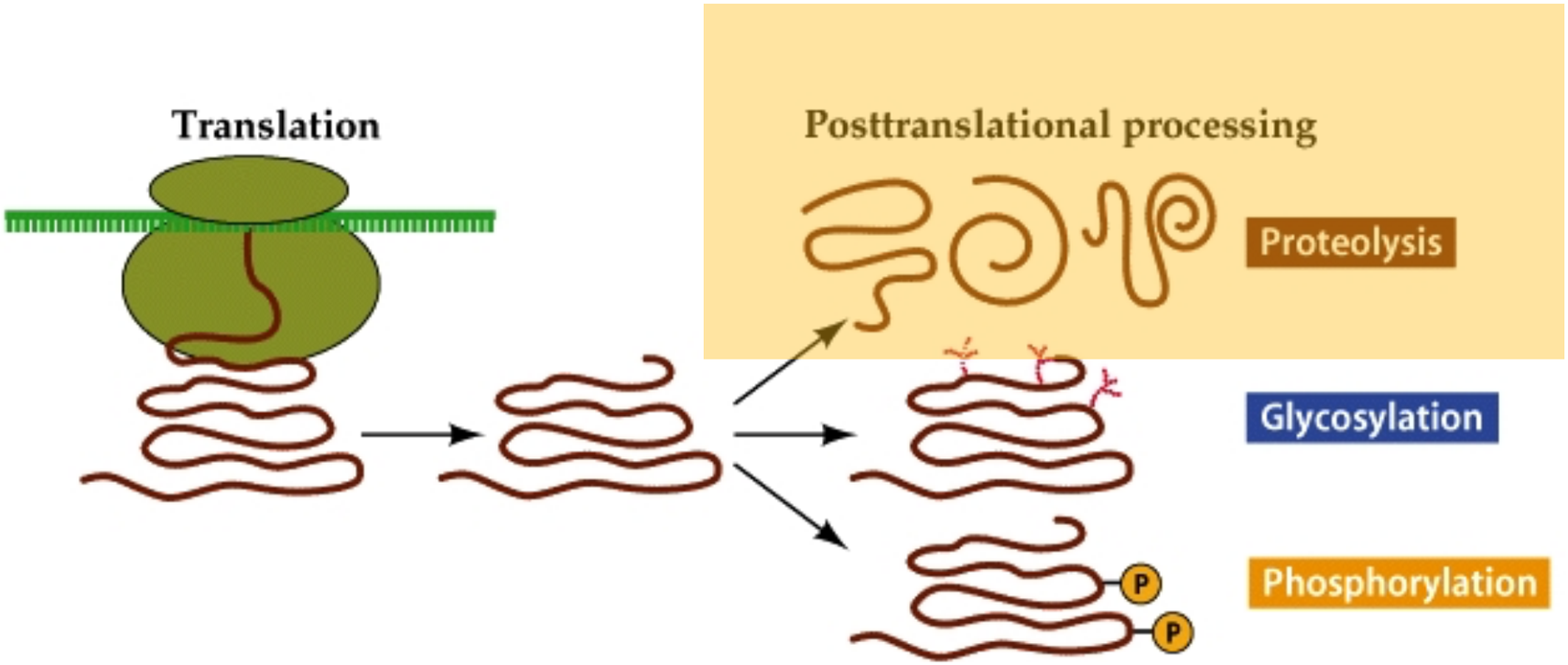
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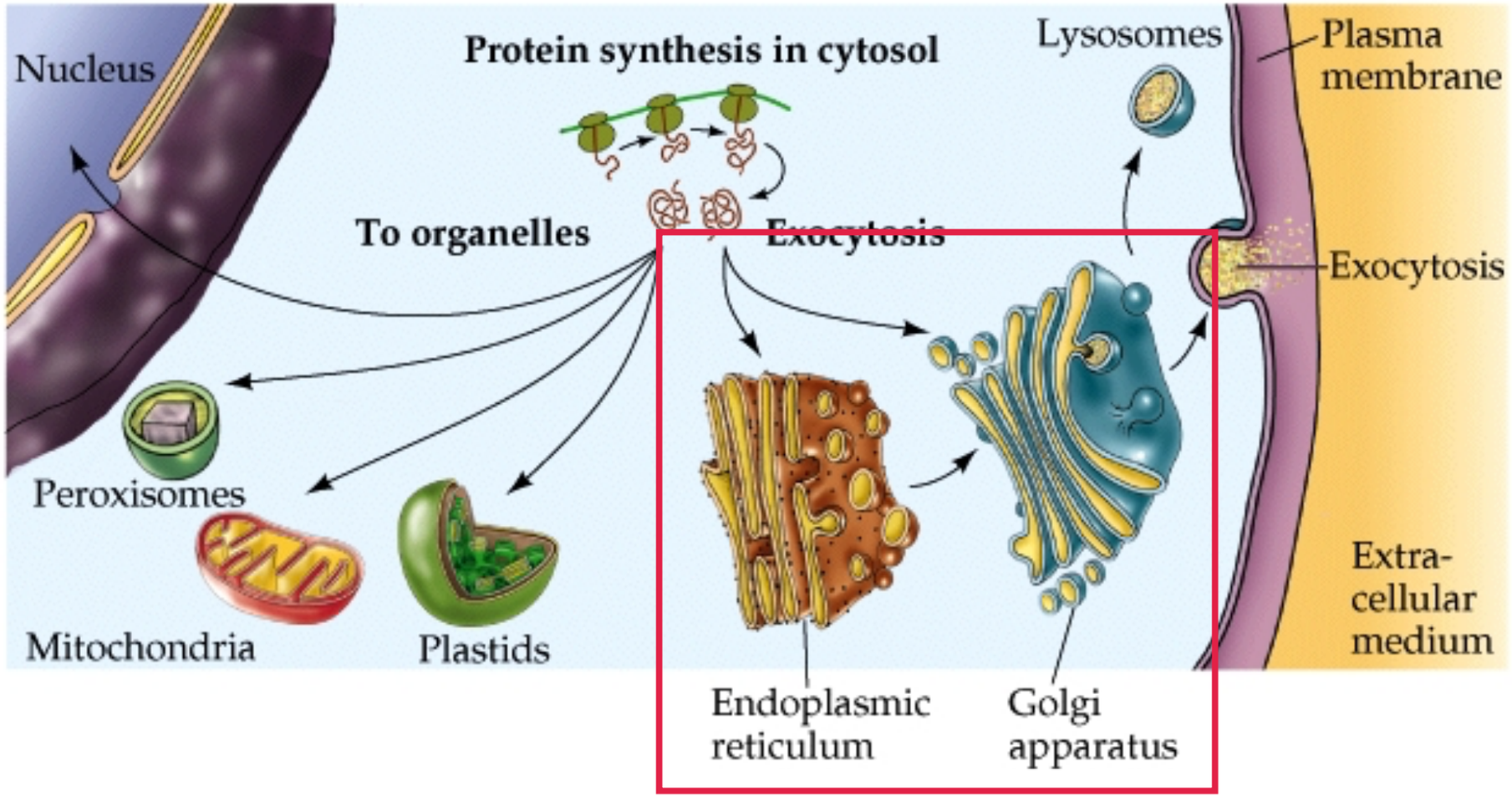
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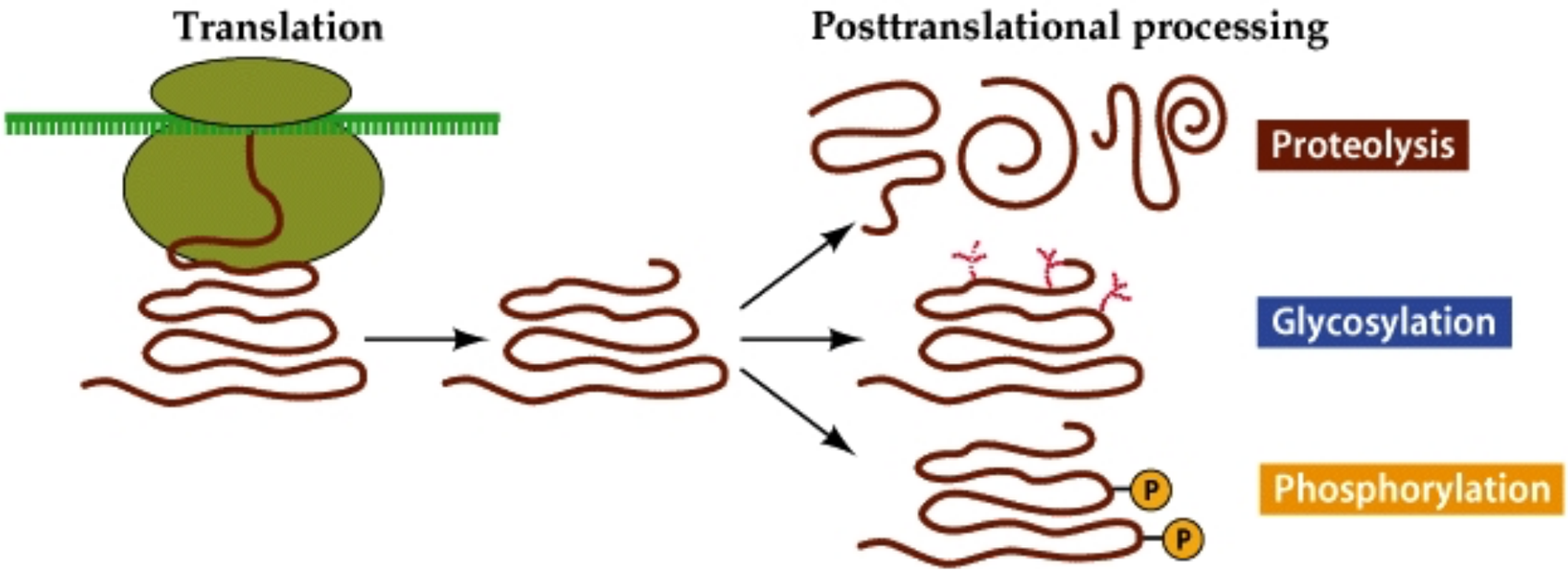
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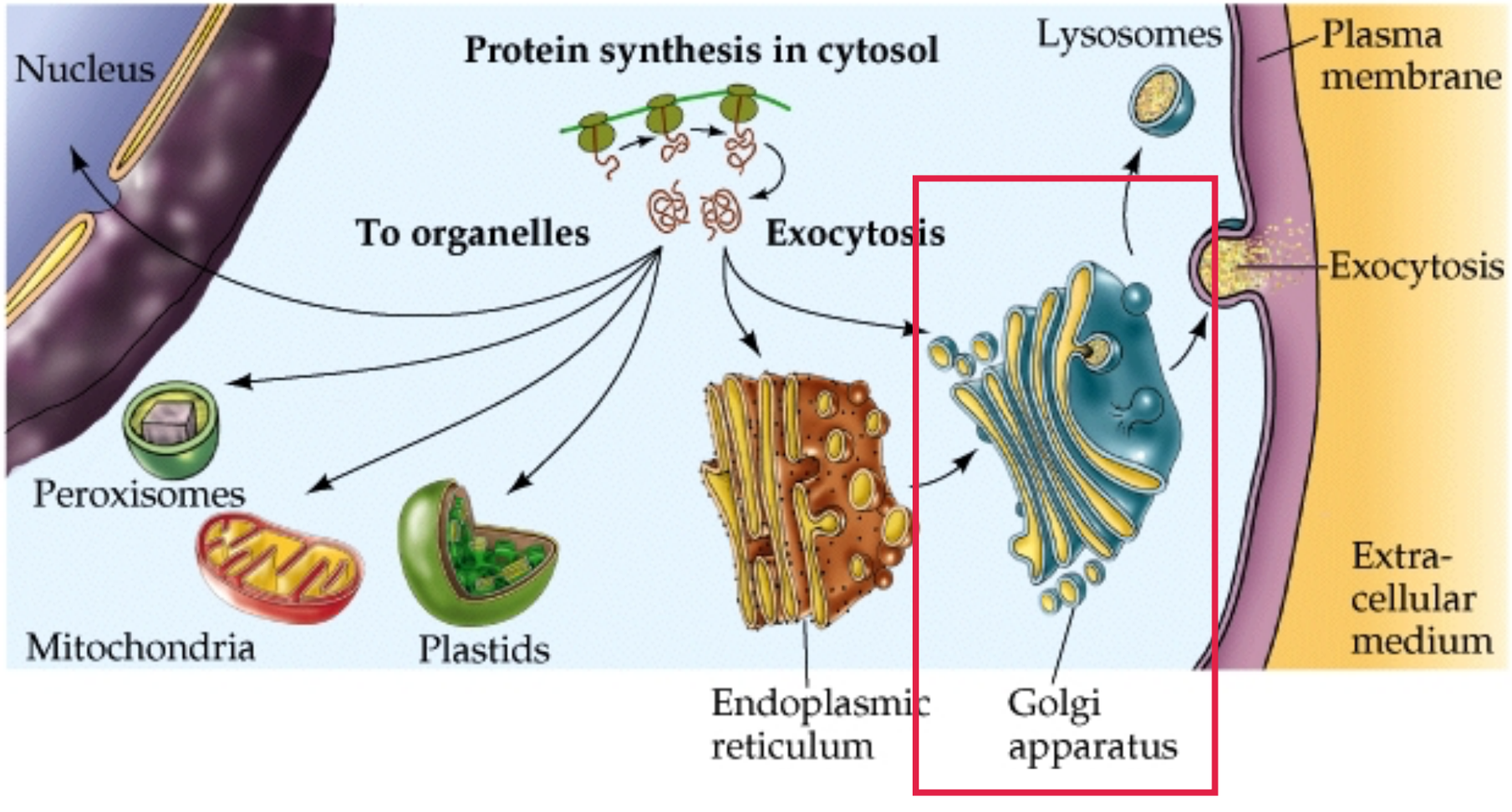
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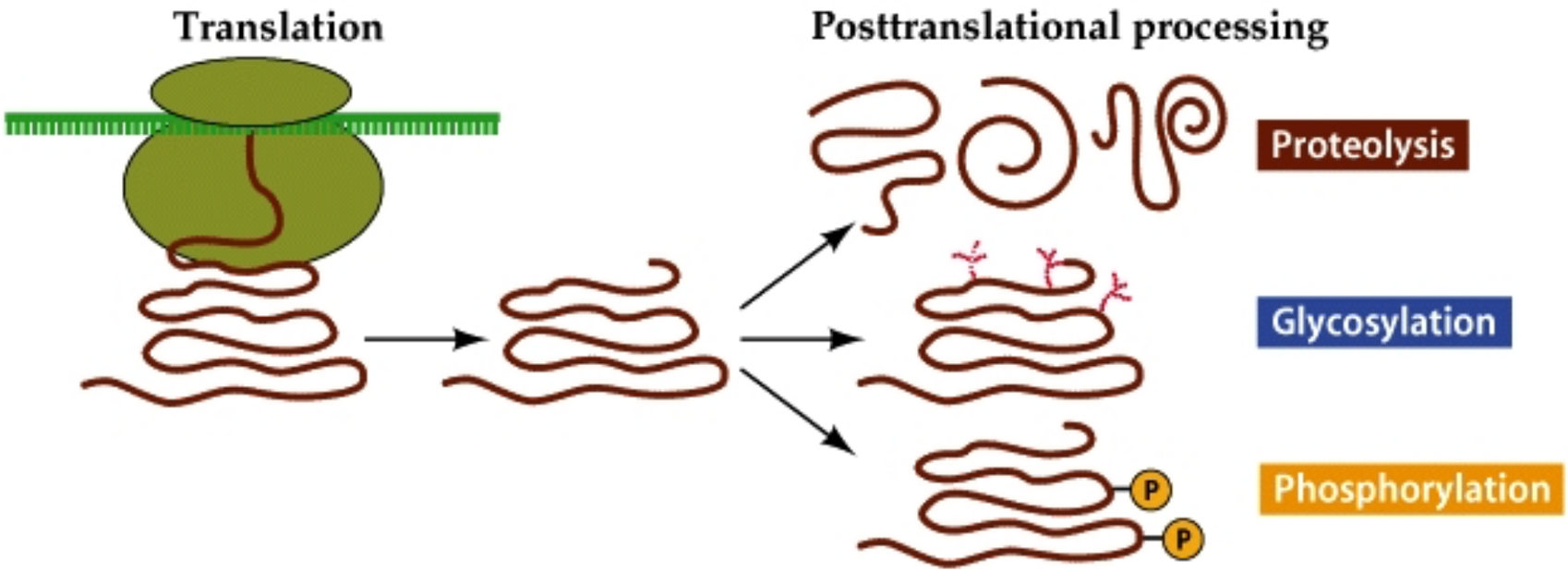
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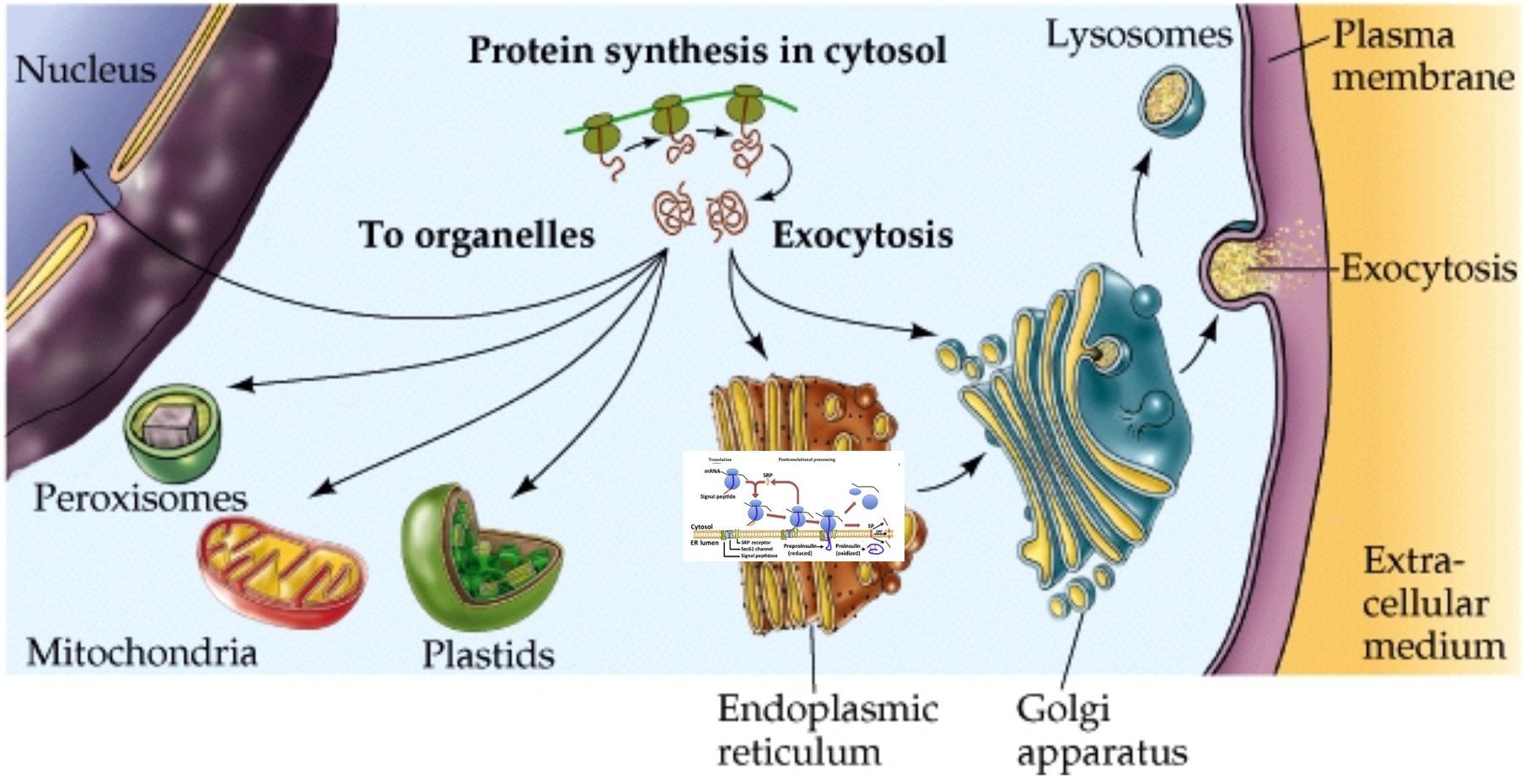
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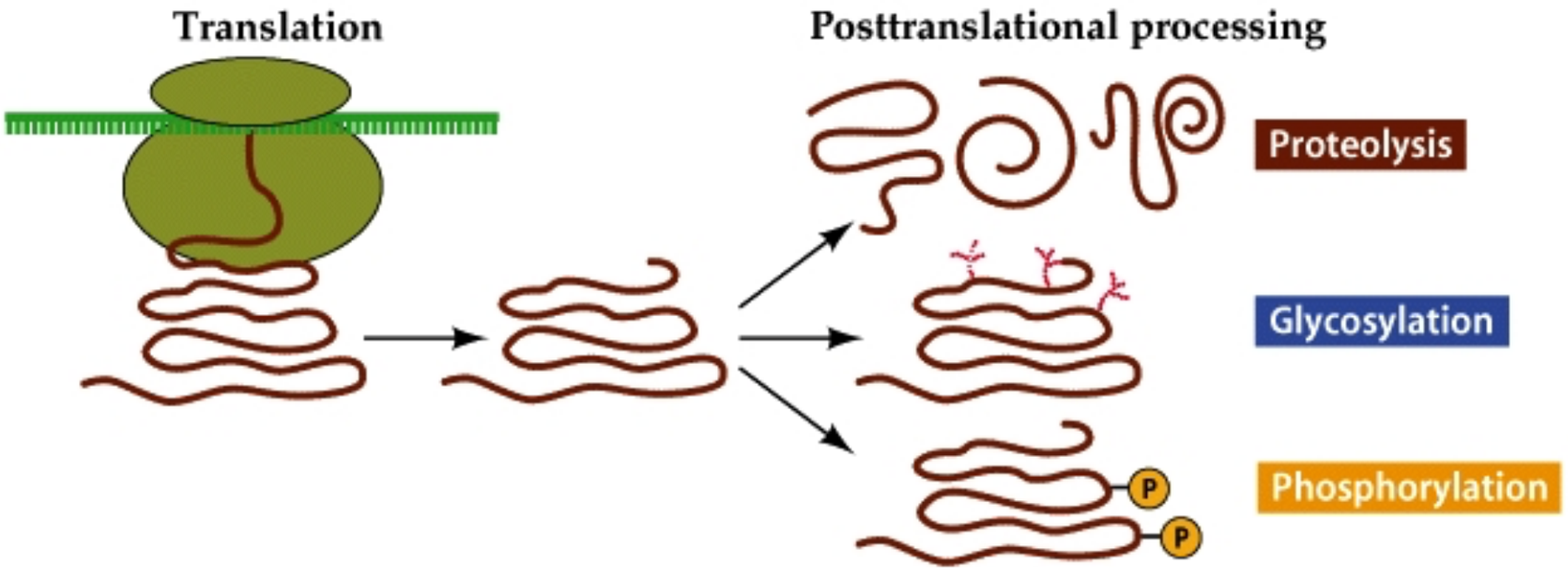
Translation
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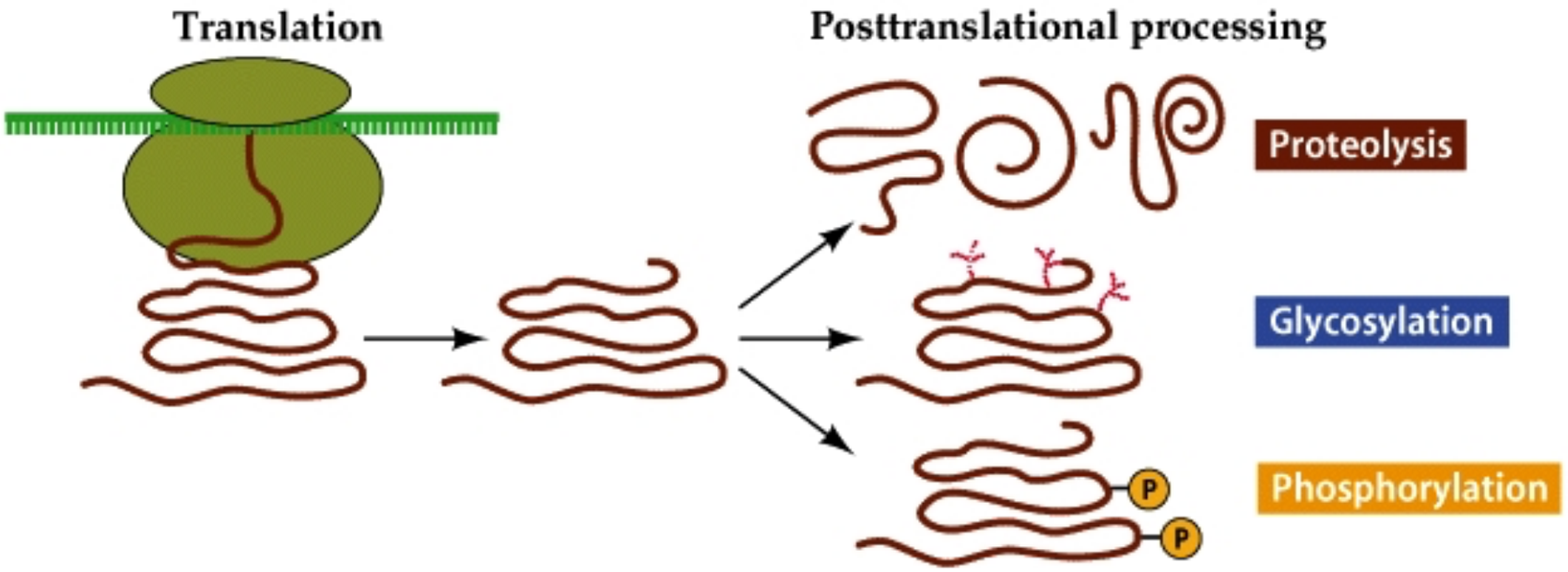
Glycosylation
Phosphorylation
P
P

Translation
Posttranslational processing
mRNA
Signal peptide
SRP
Cytosol
ER lumen
SRP receptor
Sec61 channel
Signal peptidase
Preproinsulin
(reduced)
Proinsulin
(oxidized)
SP
SPP


Translation
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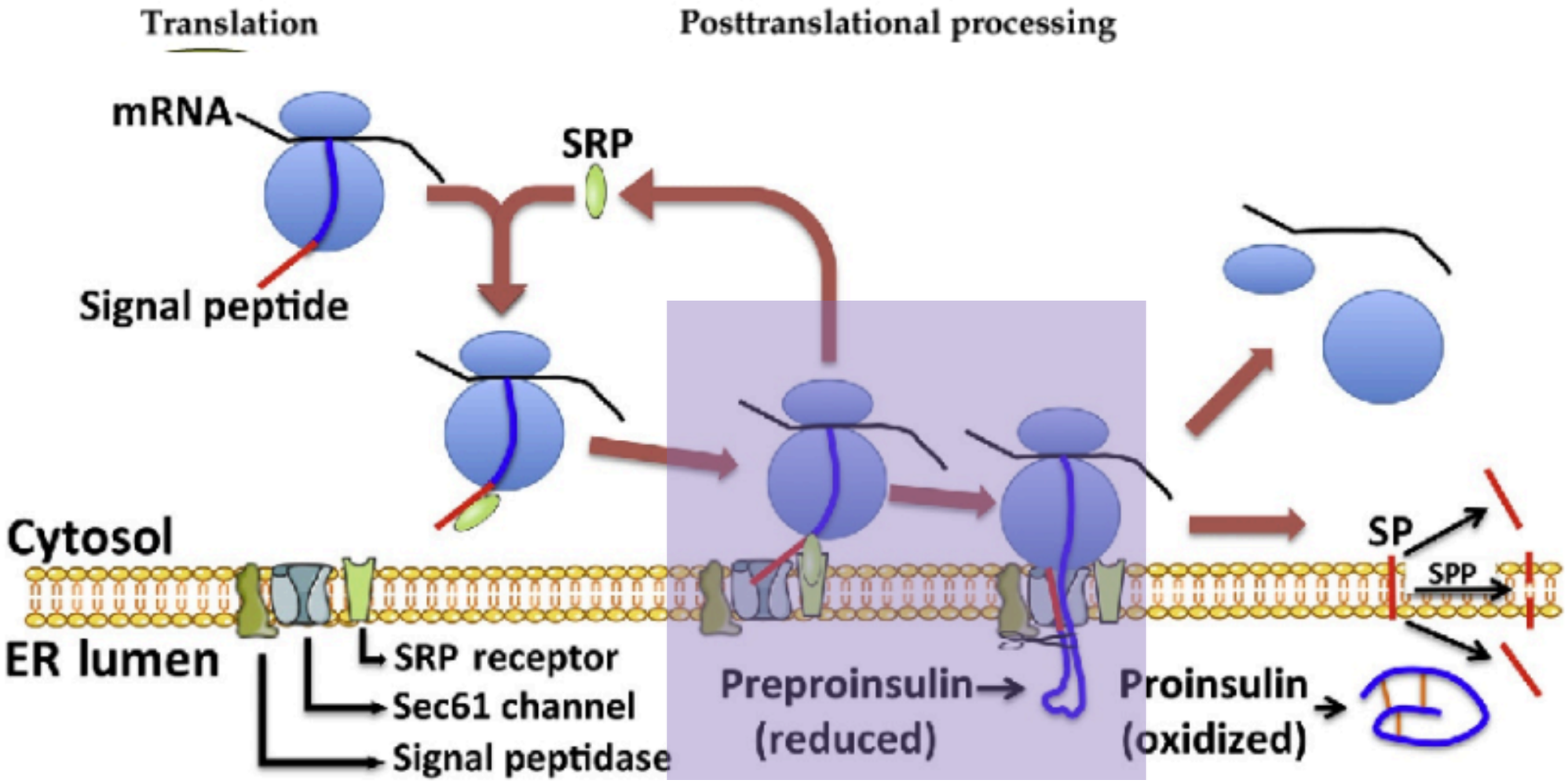
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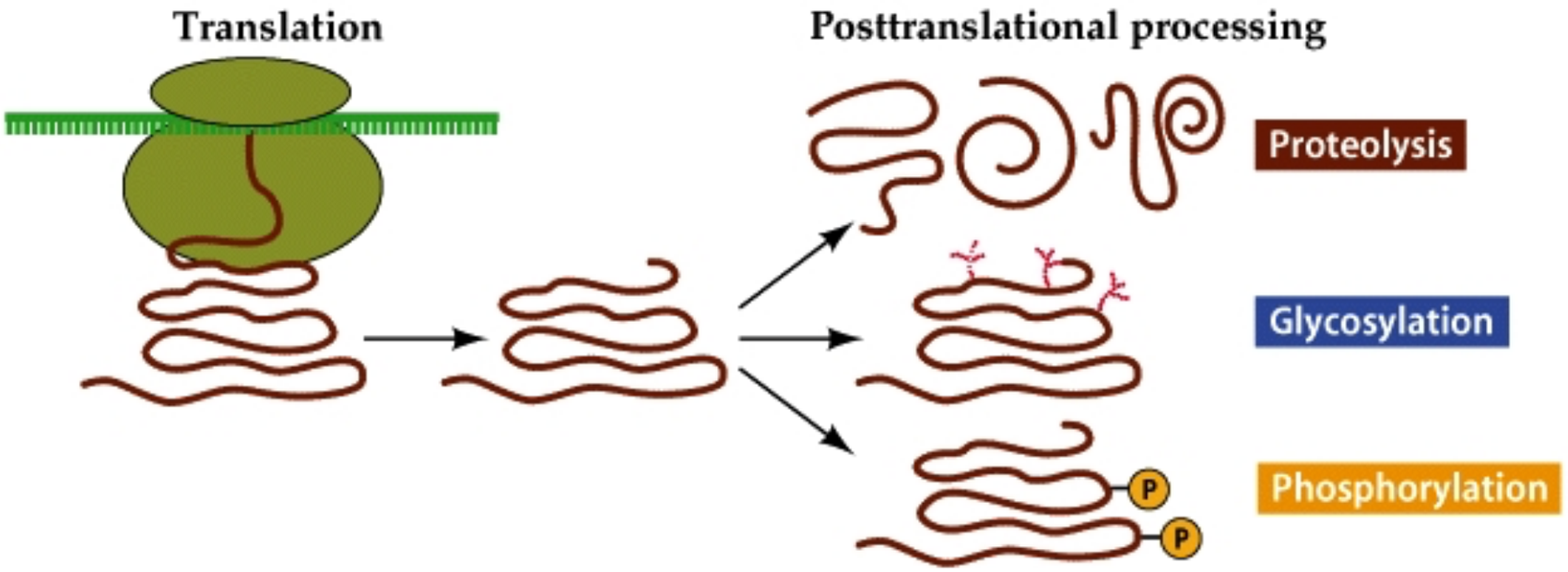
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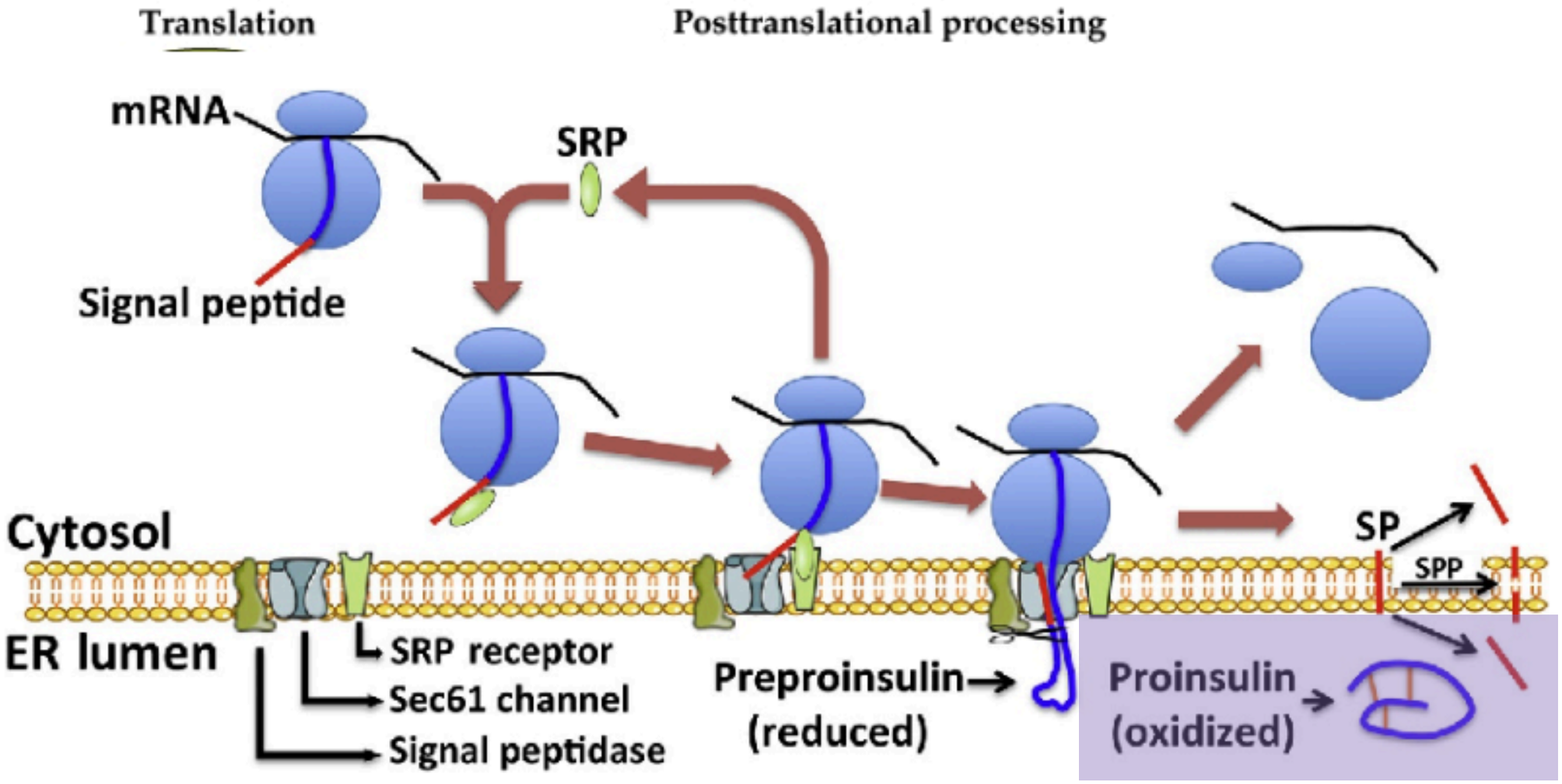
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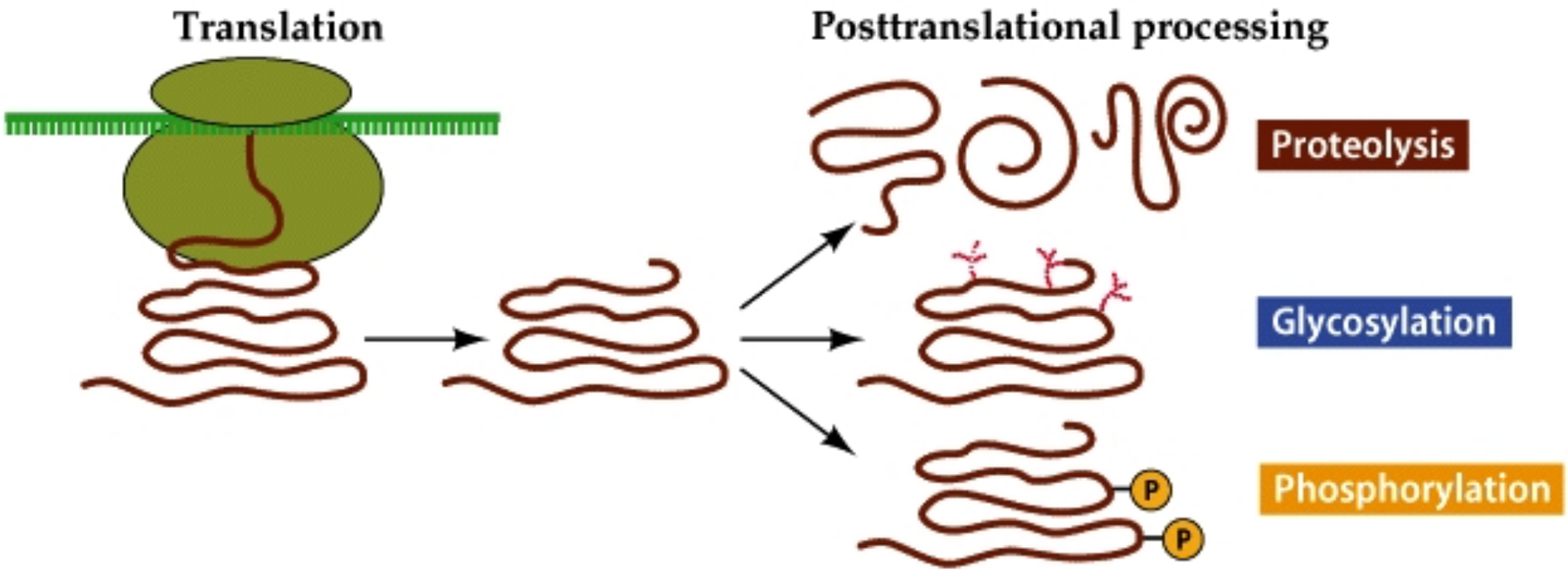
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Glycosylation
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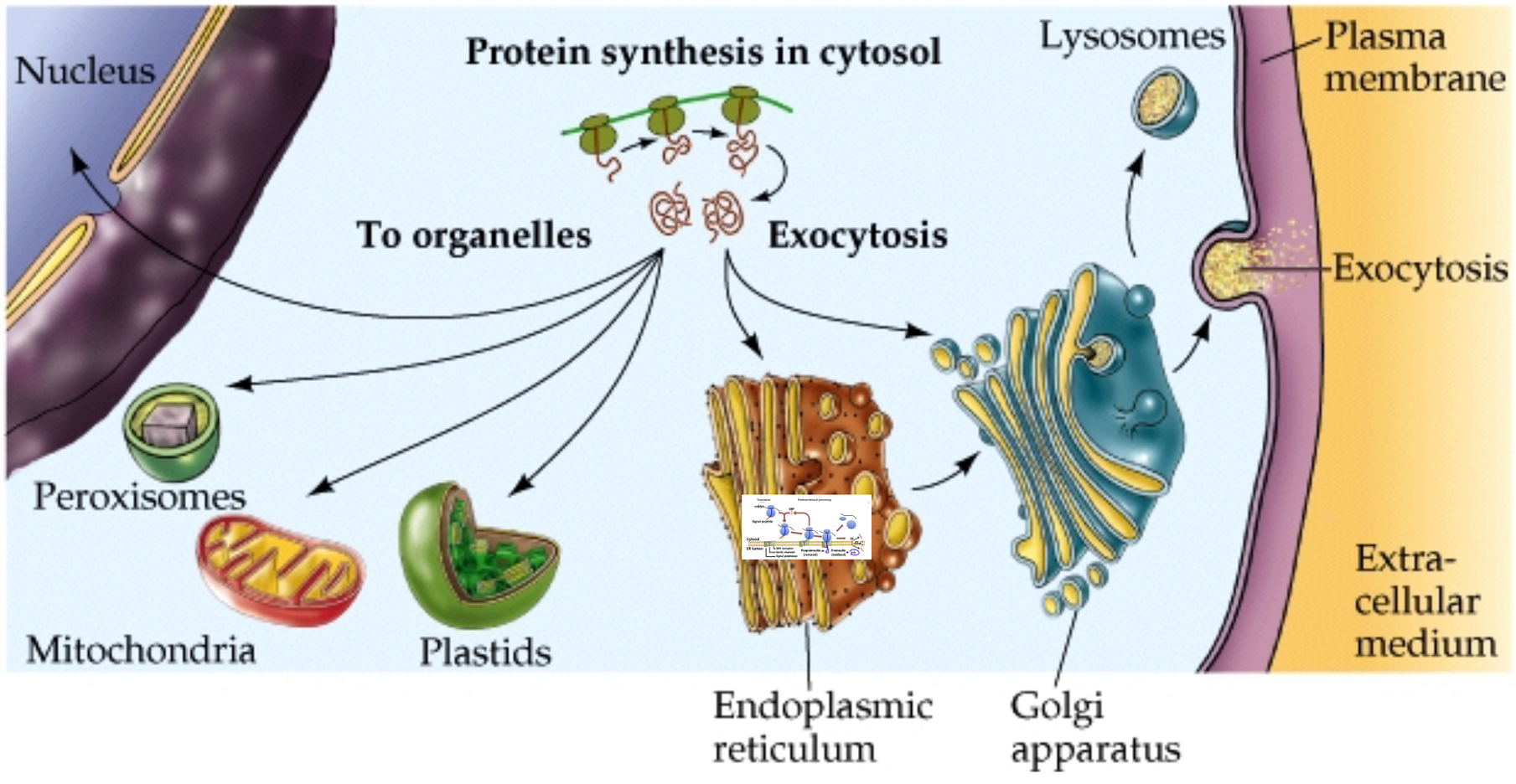
Nucleus
Protein synthesis in cytosol
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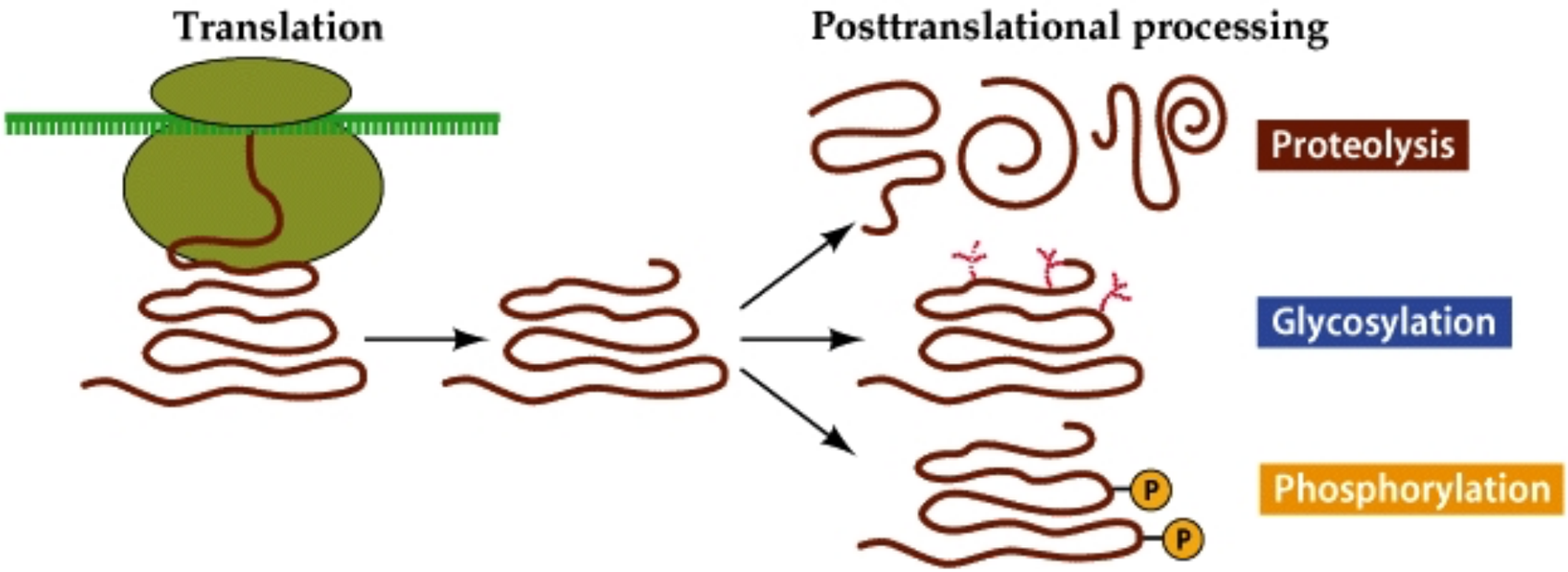
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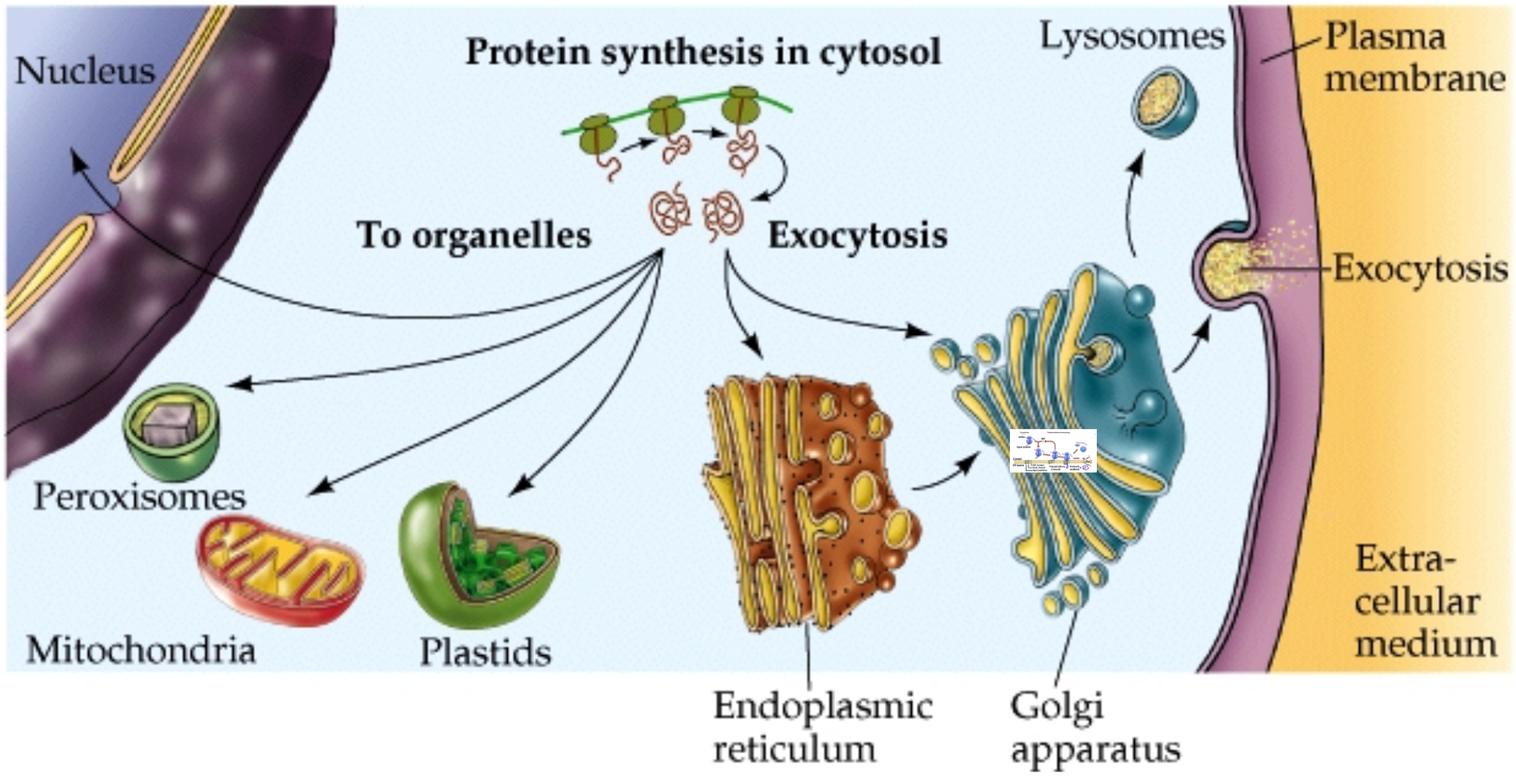
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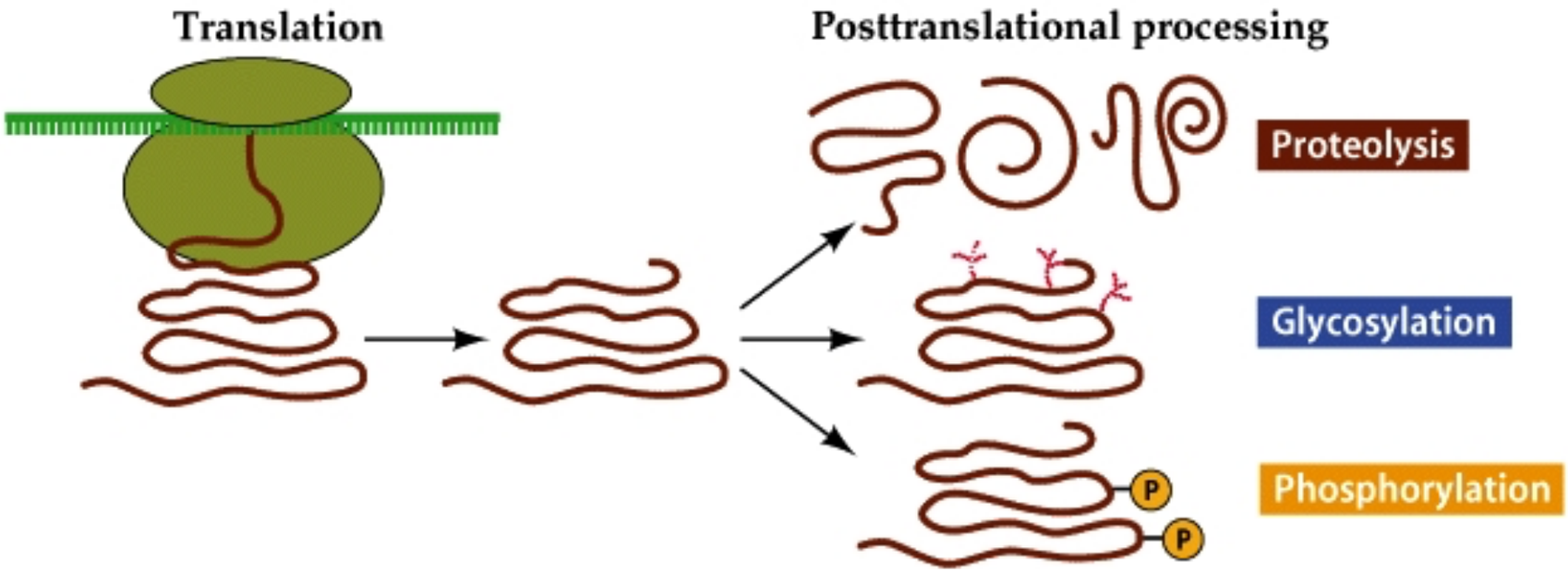
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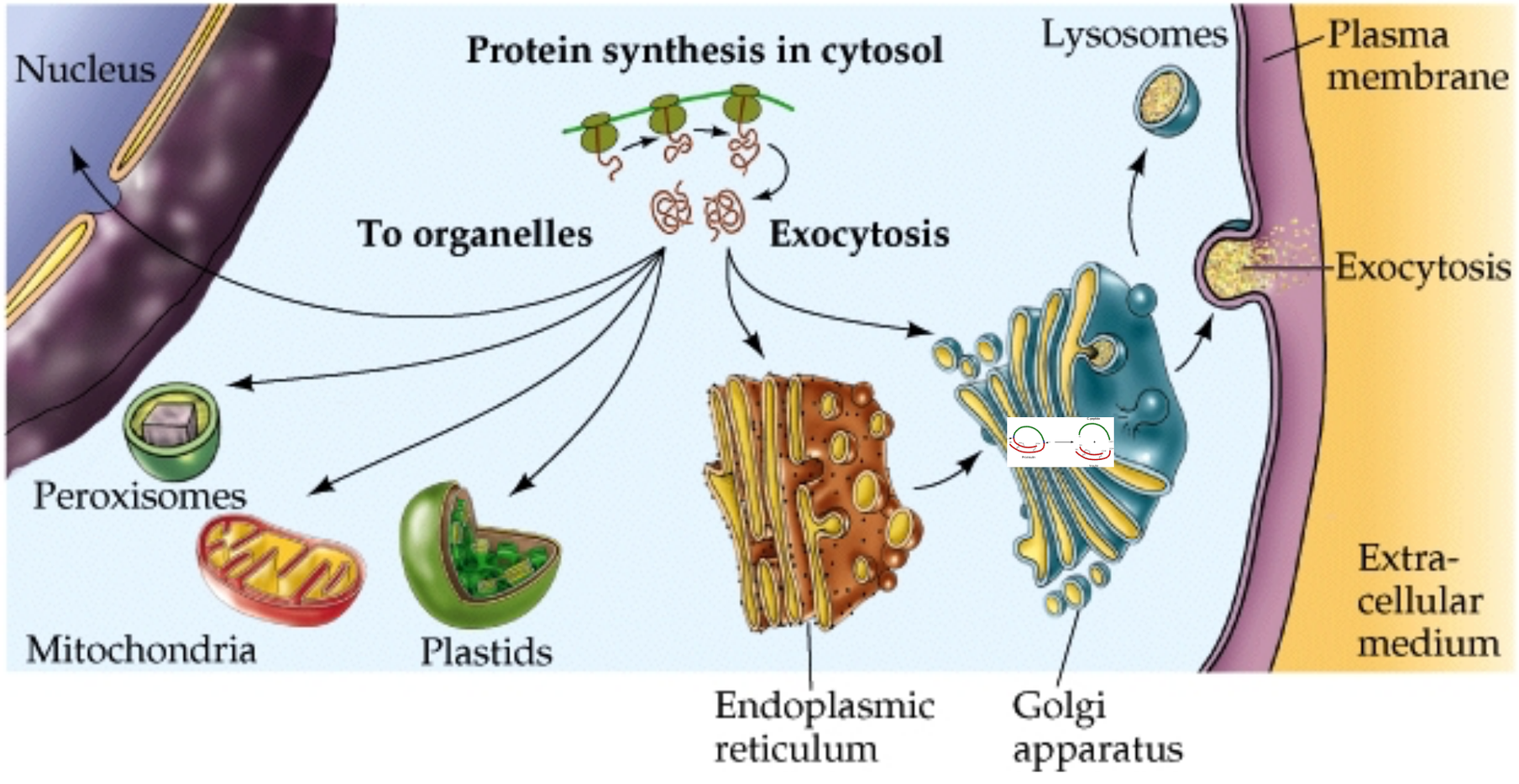
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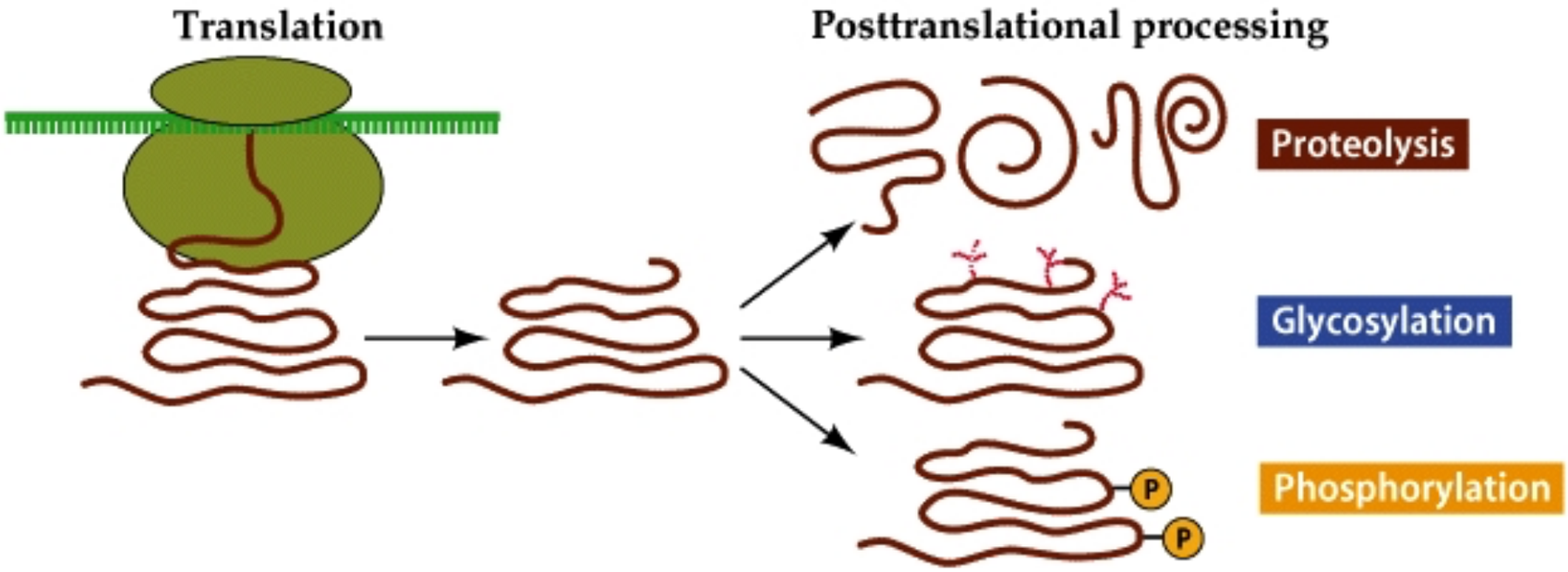
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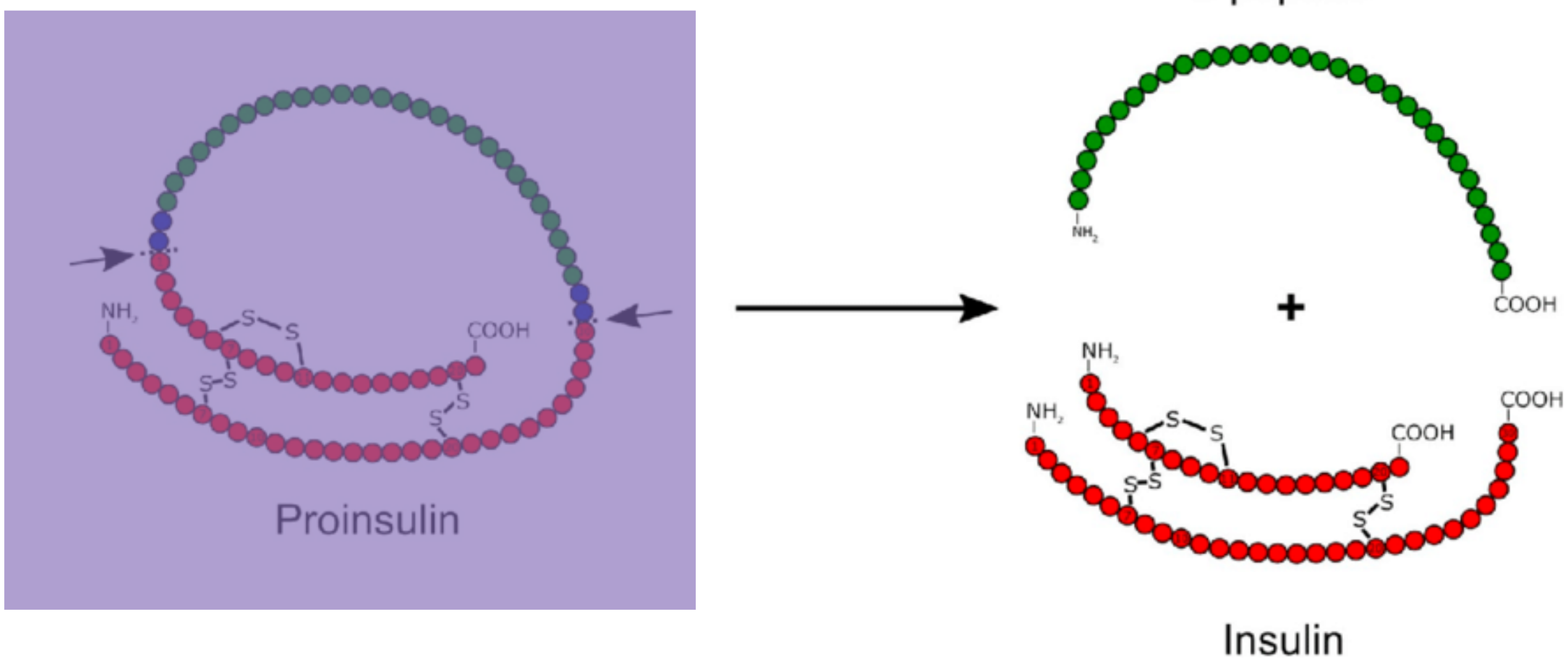
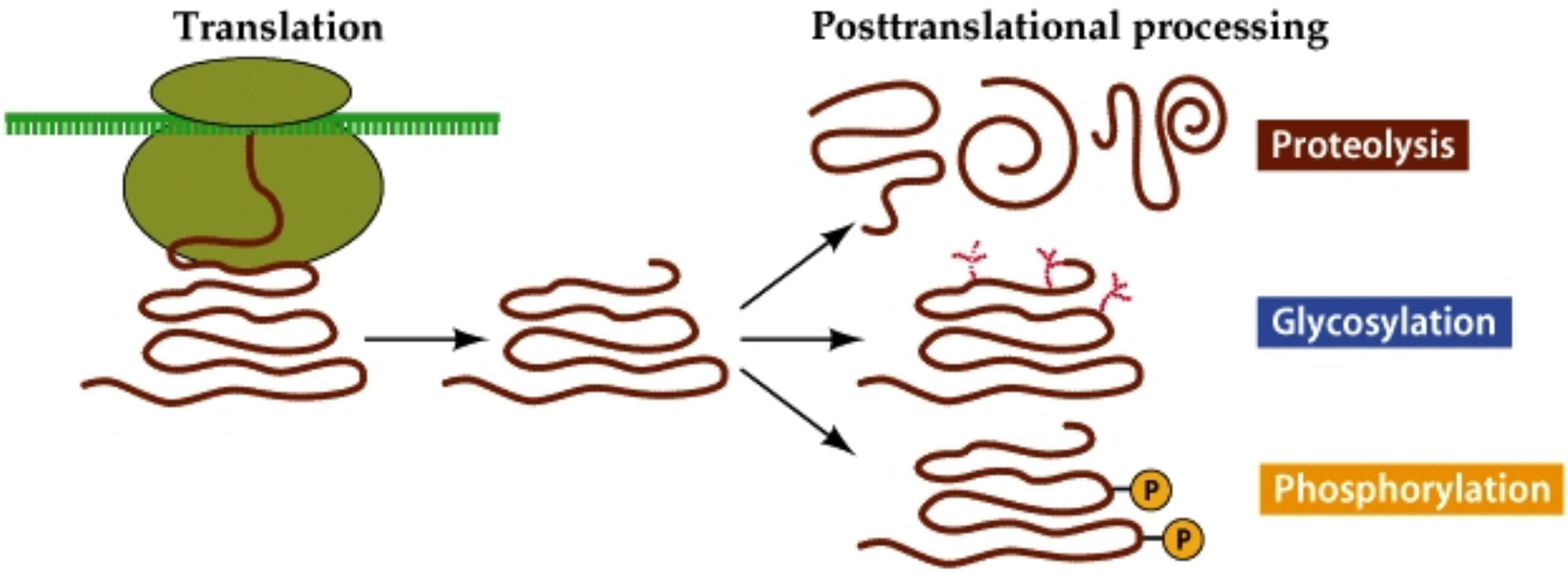

C-peptide
NH2
S
S
S
S
S
S
COOH
Proinsulin
NH2
COOH
+
NH2
NH2
S
S
S
S
S
S
COOH
COOH
Insulin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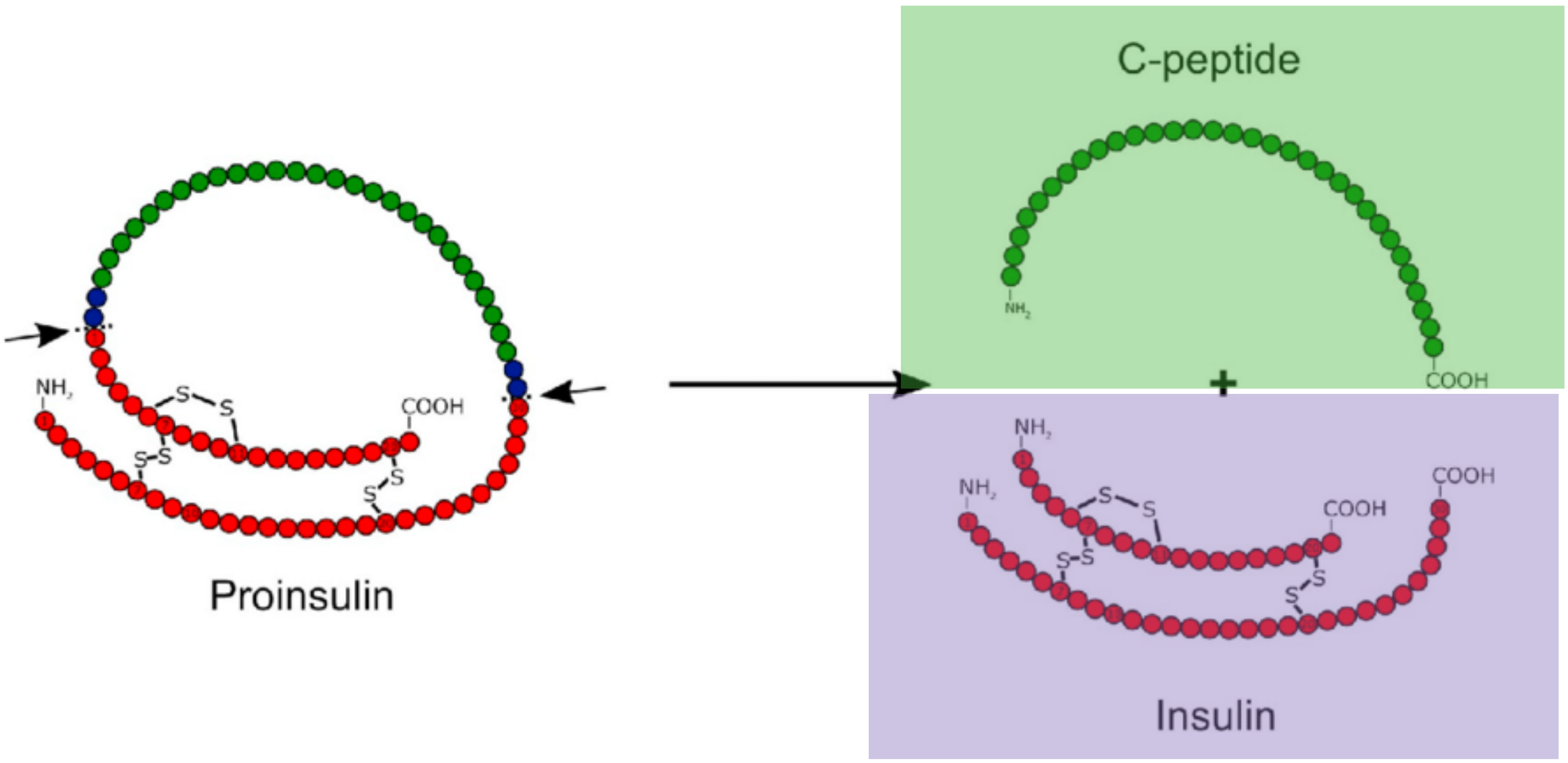
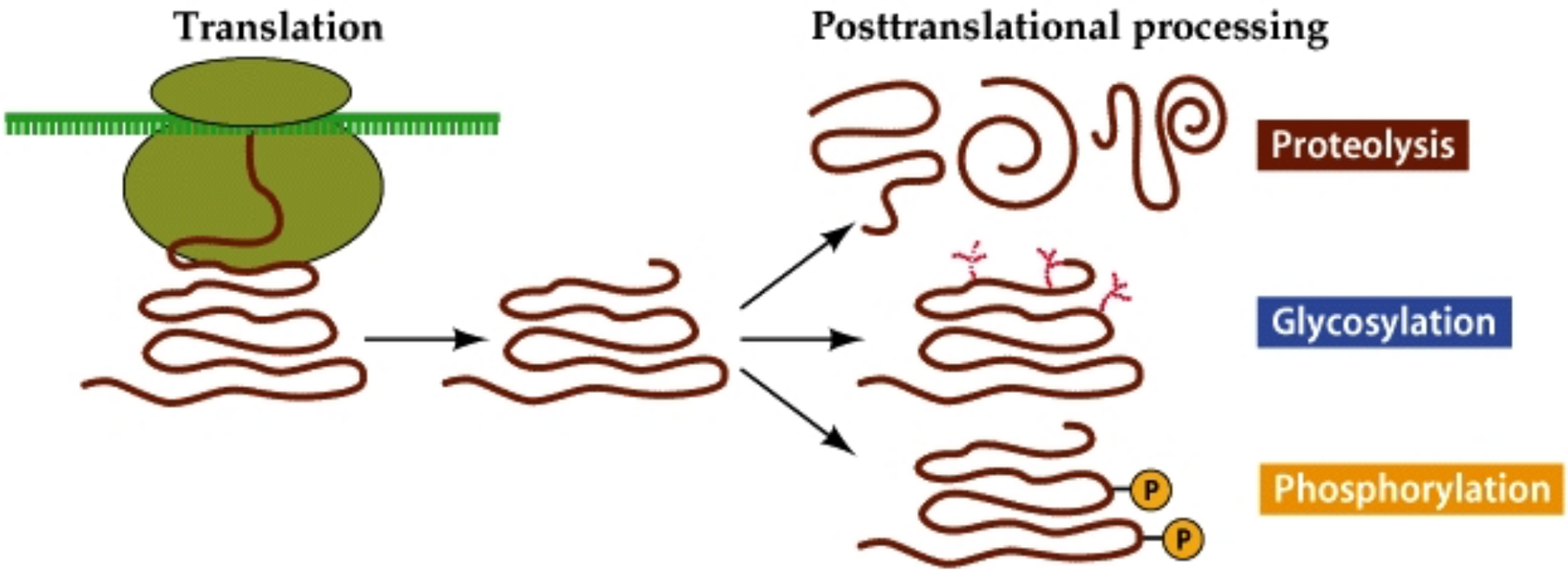
Proteolysis
Glycosylation
Phosphorylation
P
P


NH2
S
S
S
S
S
S
COOH
Proinsulin
C-peptide
NH2
COOH
+
NH2
NH2
S
S
S
S
S
S
COOH
COOH
Insulin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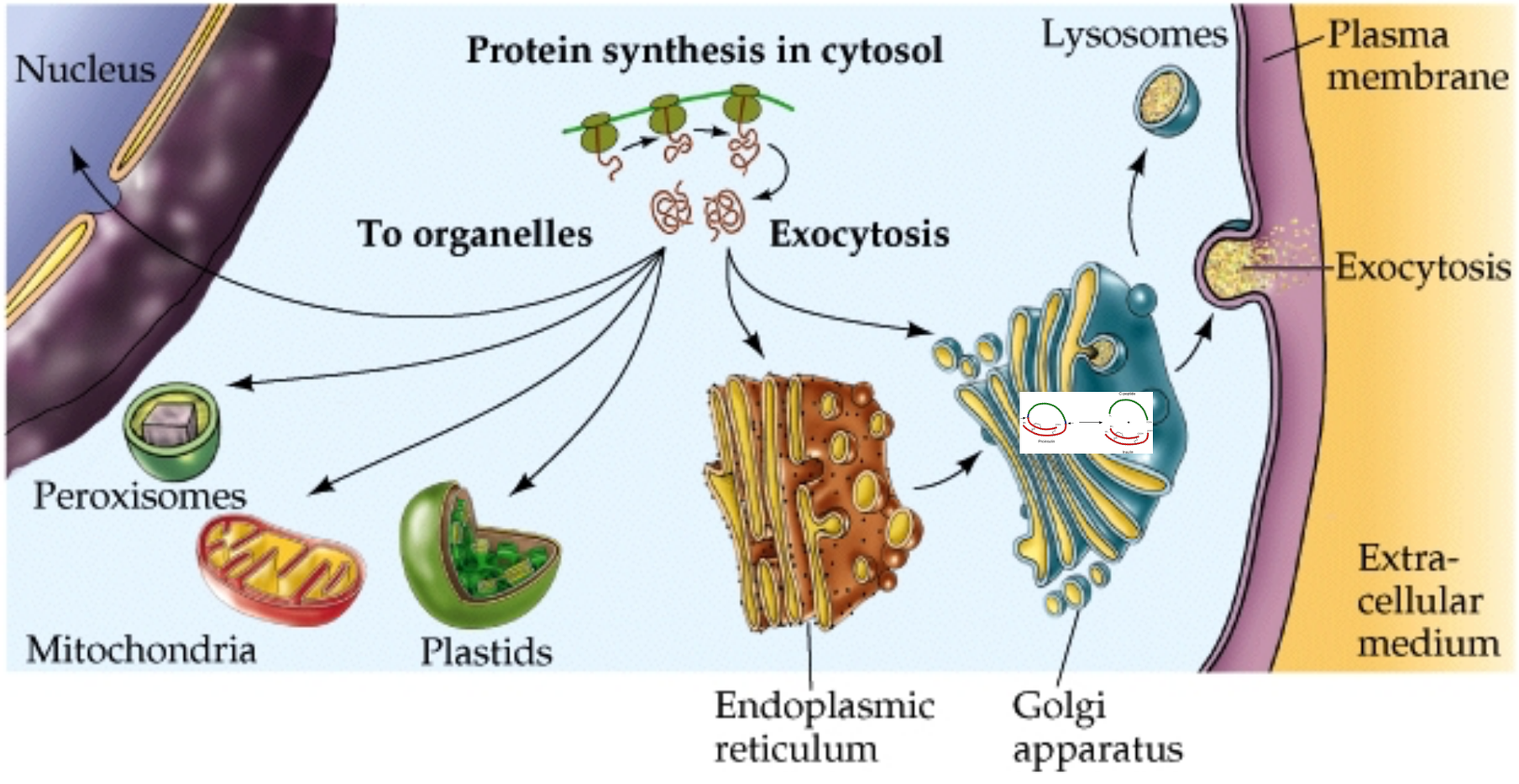
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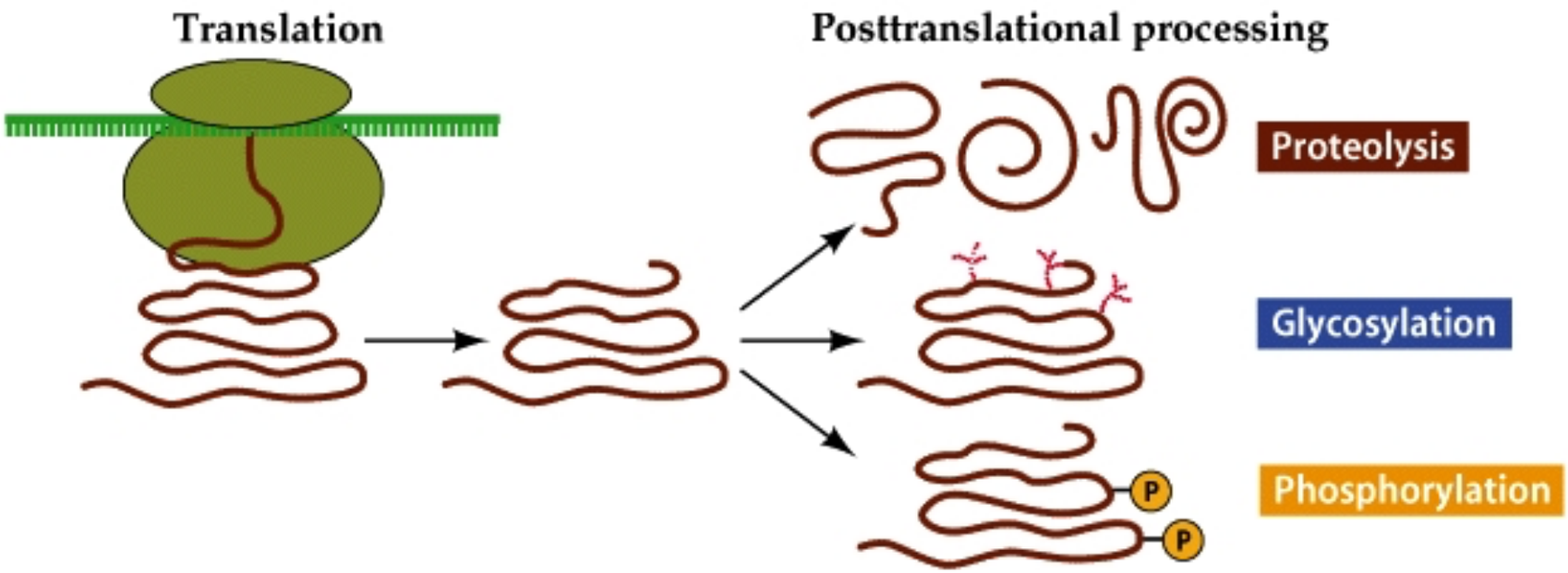
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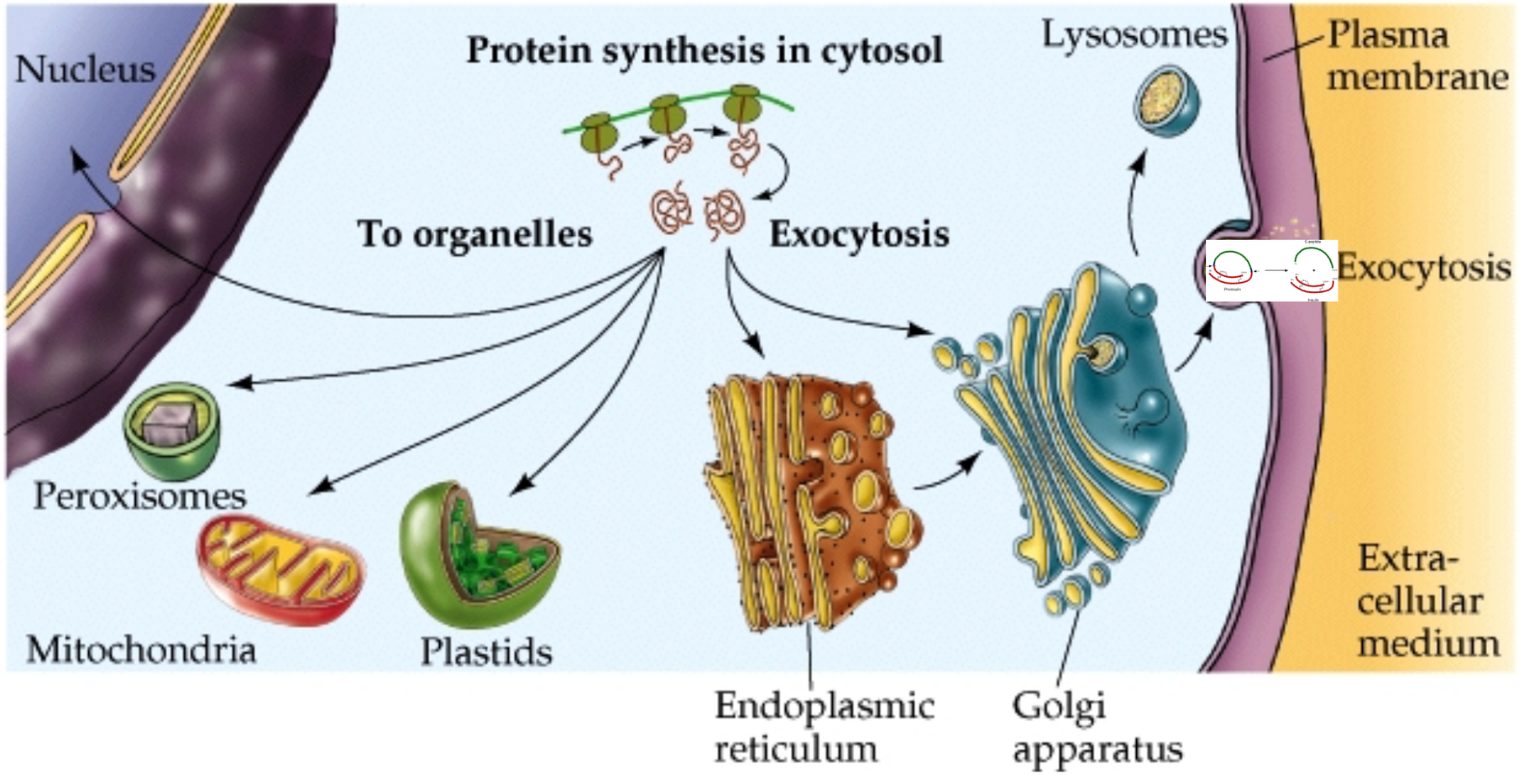
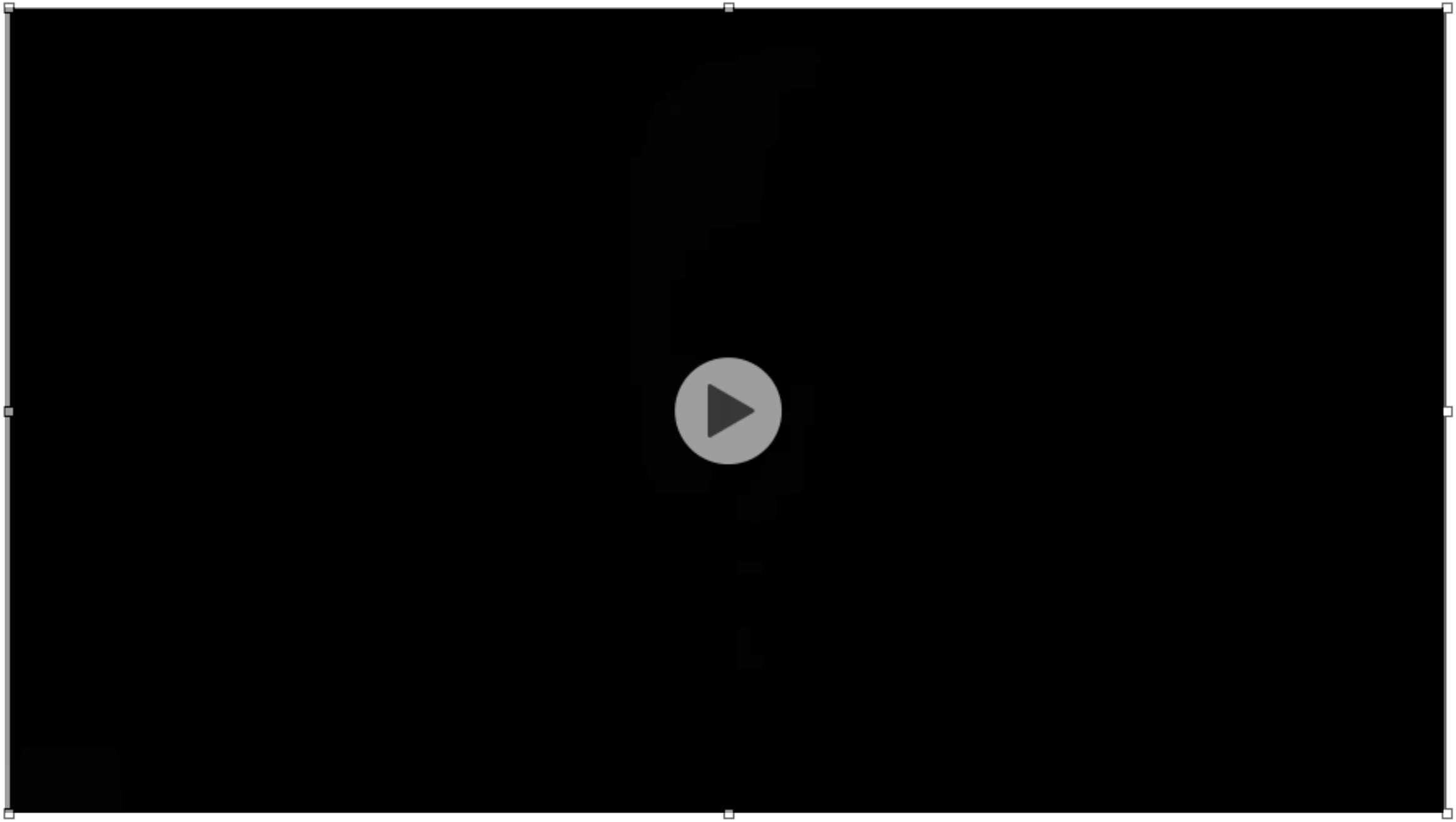
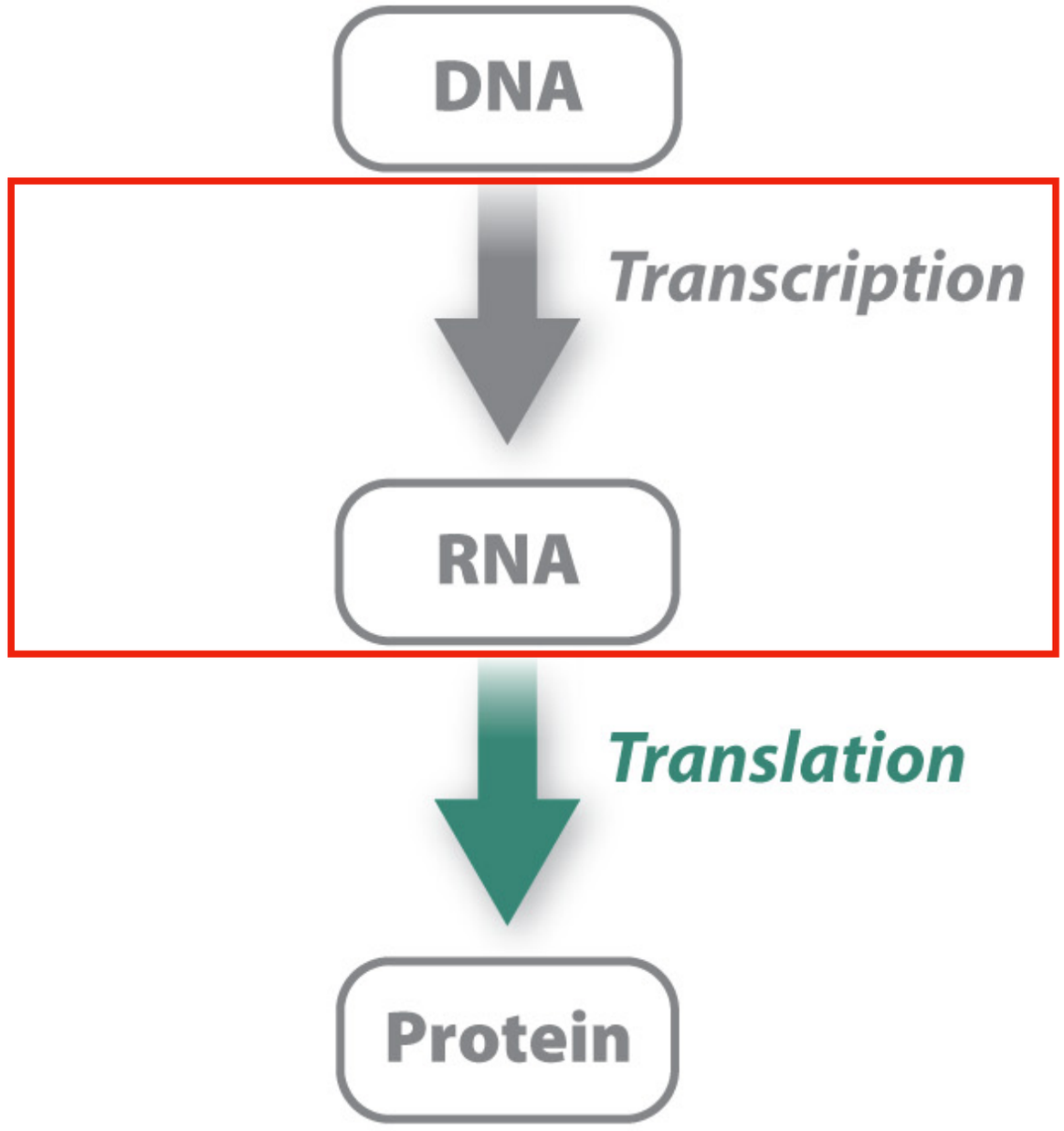
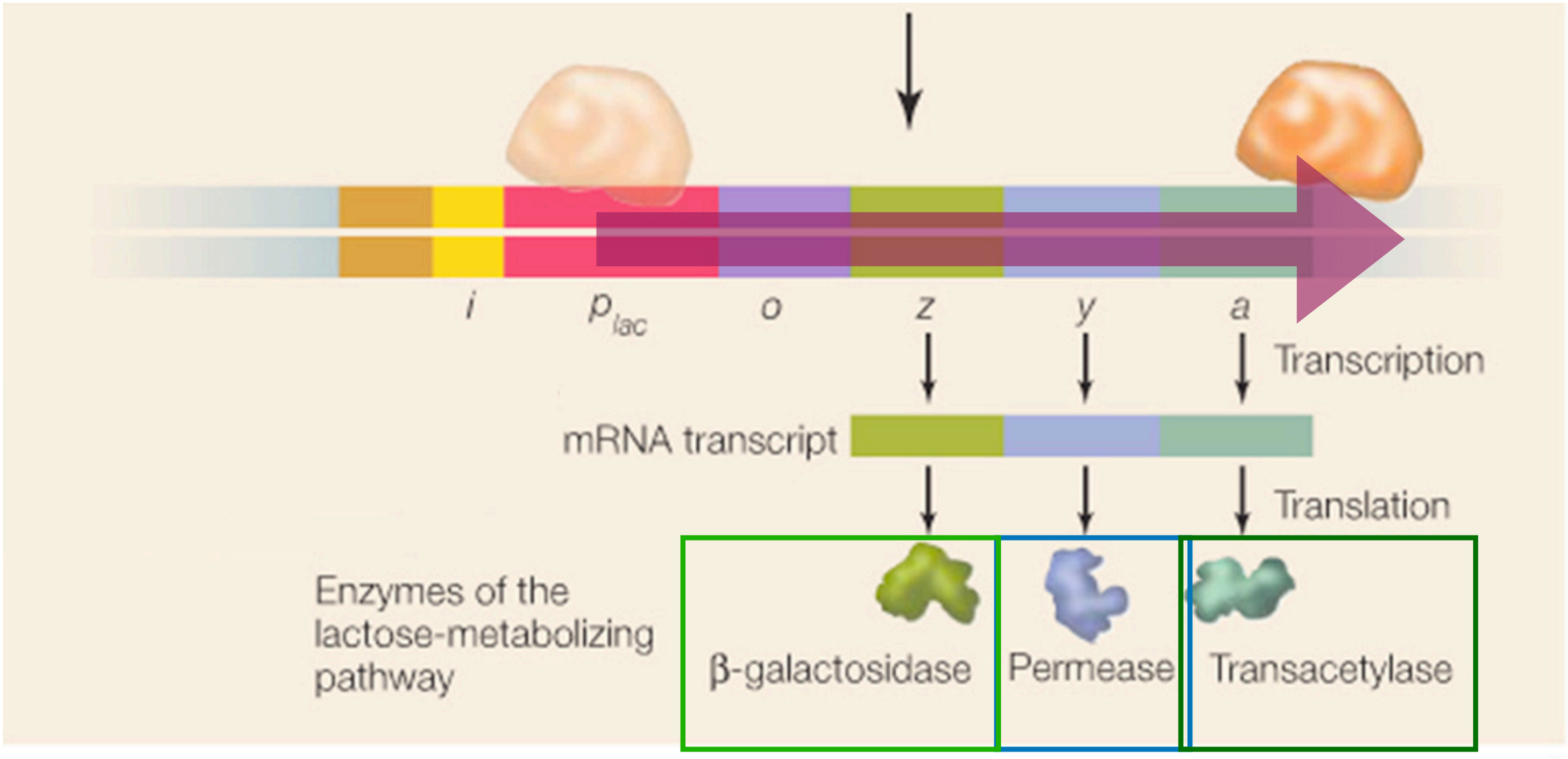
P
P


Nucleus
Protein synthesis in cytosol
Lysosomes
Plasma membrane
To organelles
Exocytosis
Exocytosis
Peroxisomes
Mitochondria
Plastids
Endoplasmic reticulum
Golgi apparatus
Extra-cellular medium

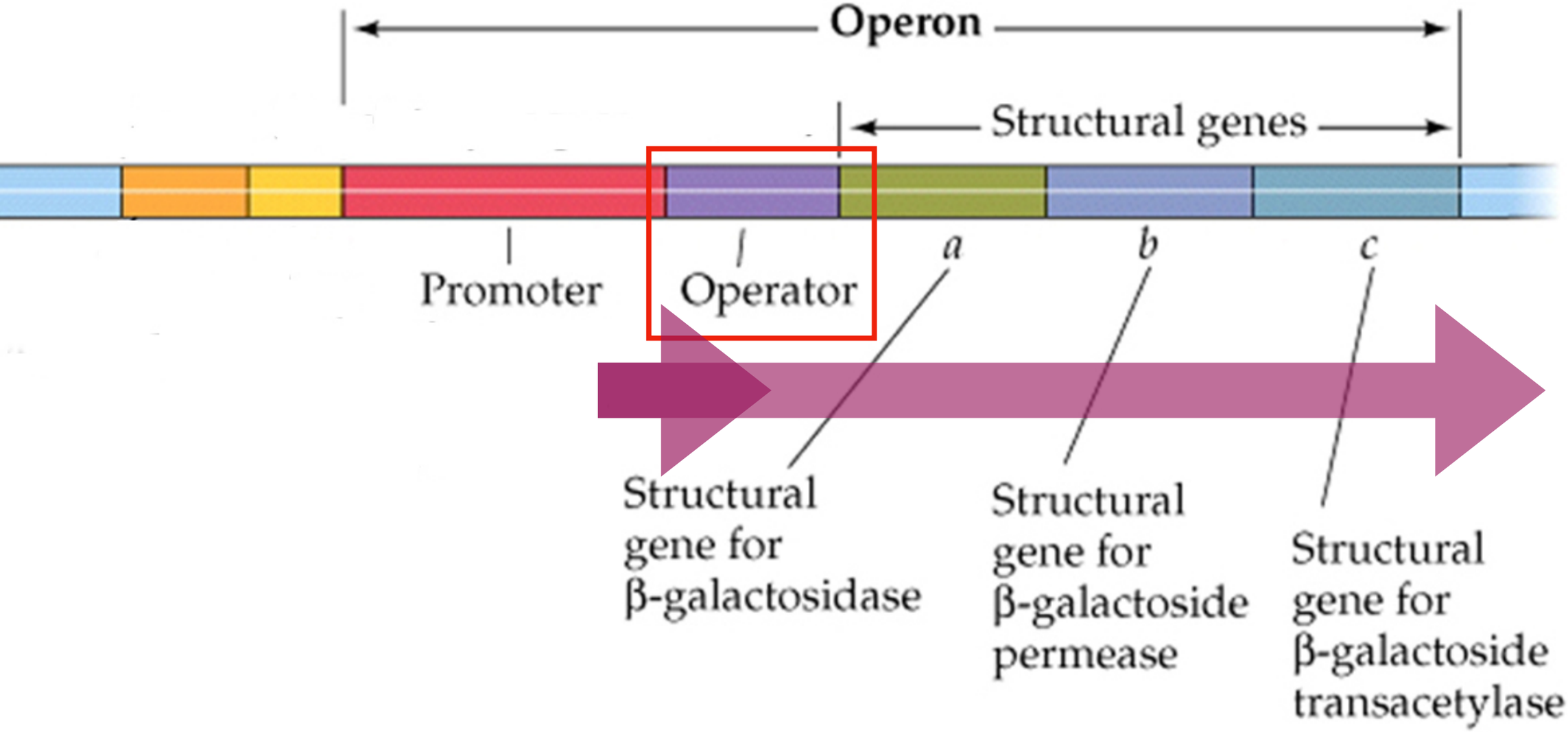


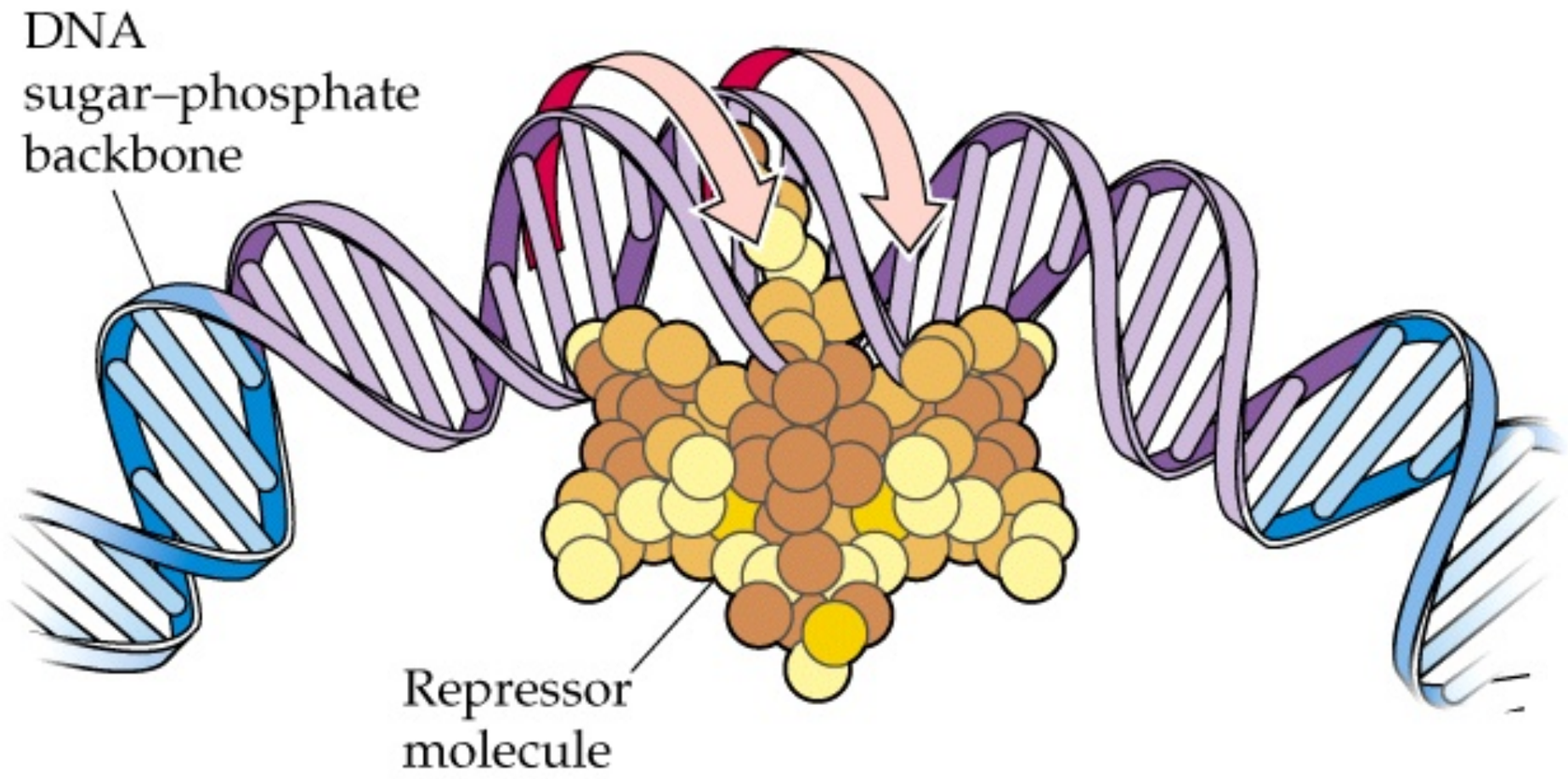
WHERE and **HOW** do you regulate the whole process?????


DNA
Transcription
RNA
Translation
Protein



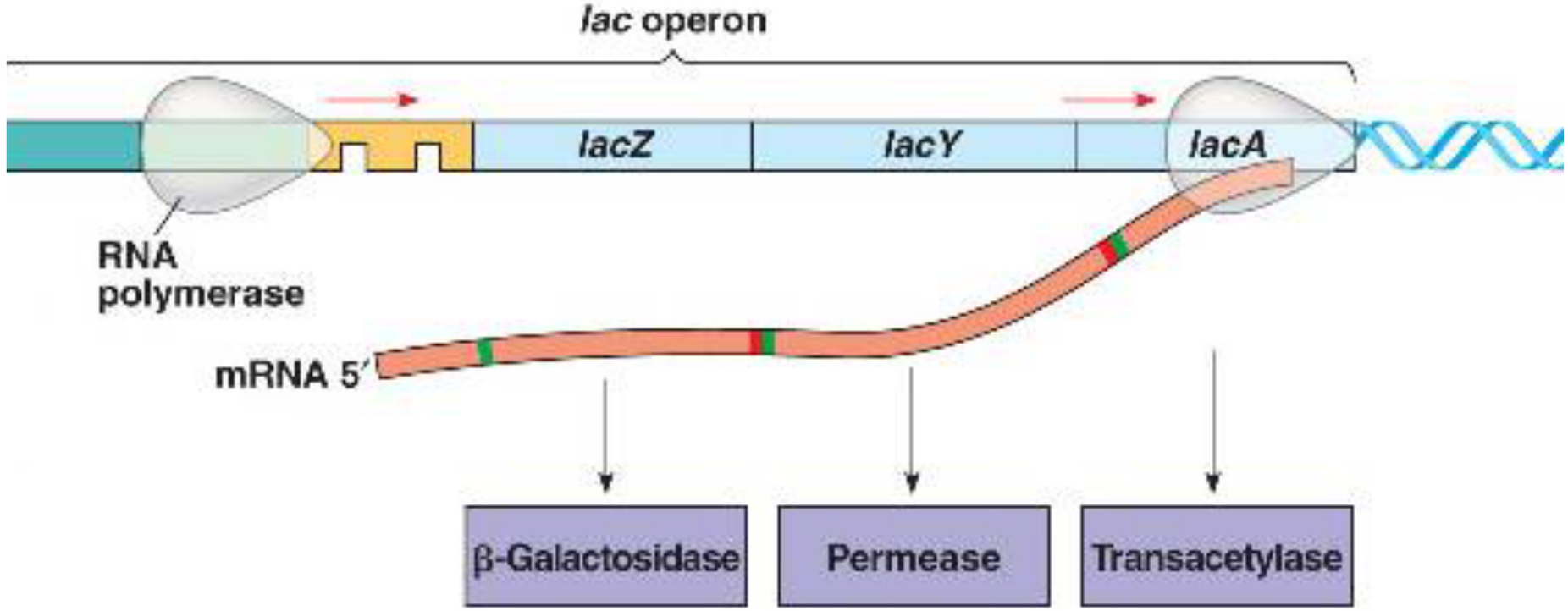
Pokaryotic Regulatory gene organization…. uses “OPERONS”


Operon
Structural genes
Promoter
Operator
a
b
c
Structural gene for β-galactosidase
Structural gene for β-galactoside permease
Structural gene for β-galactoside transacetylase


DNA
sugar–phosphate
backbone
Repressor
molecule

Regulation of Transcription in prokaryotes is a complex and multi-tiered phenomenon.

- Organization of **gene Clusters….** relative to the origin of replication… **and to each other.**
- **example, the lac operon.**



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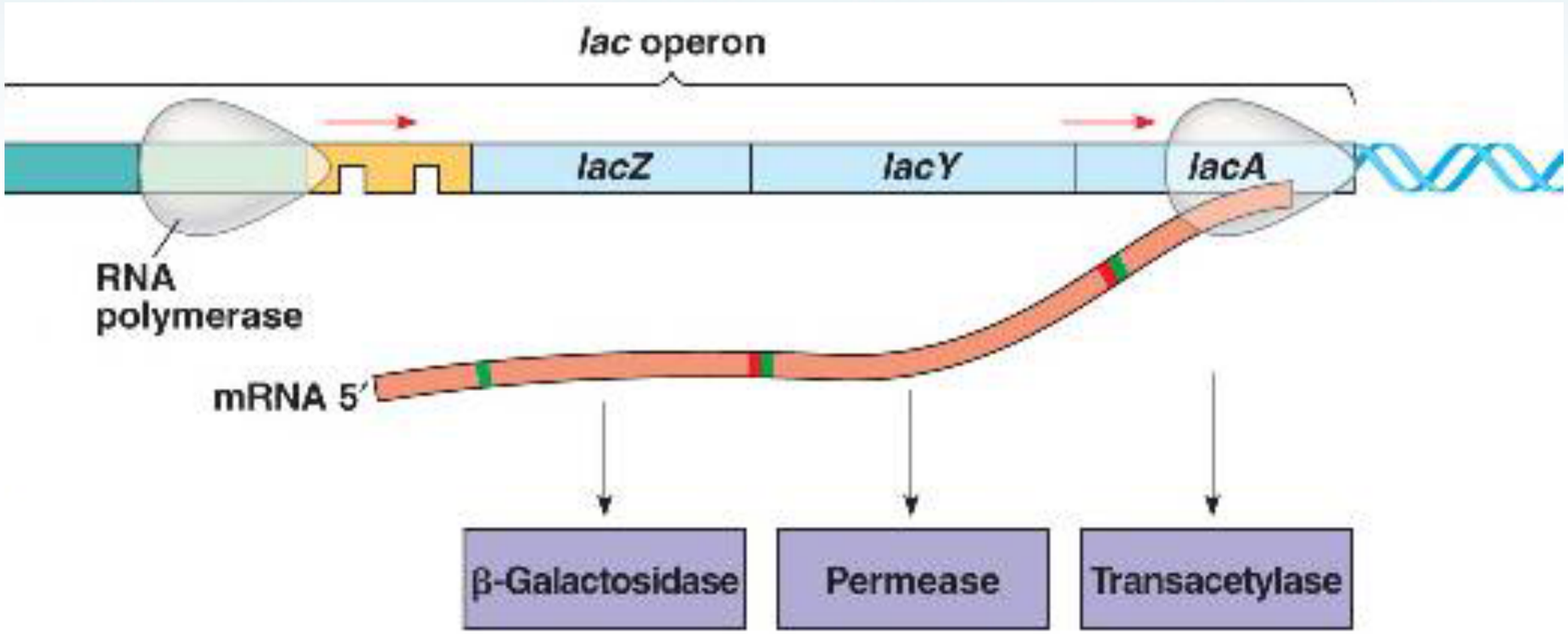
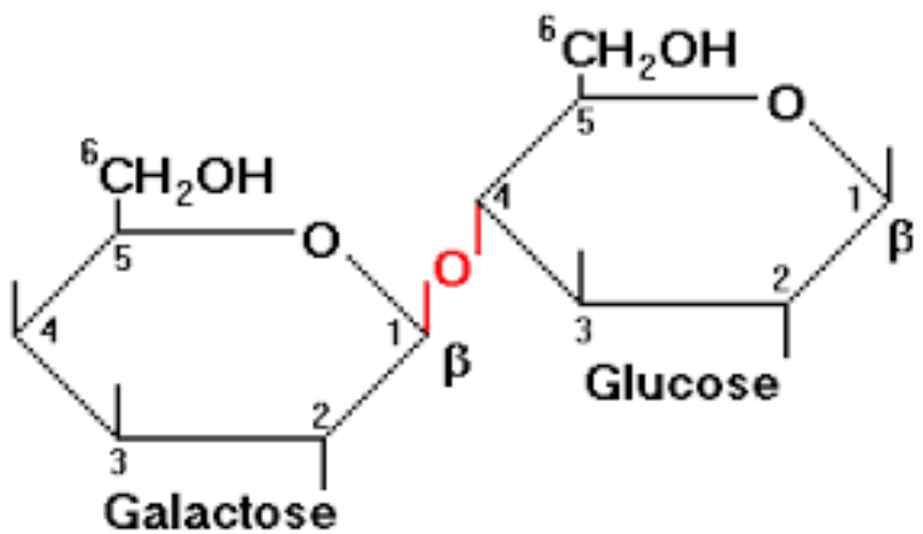
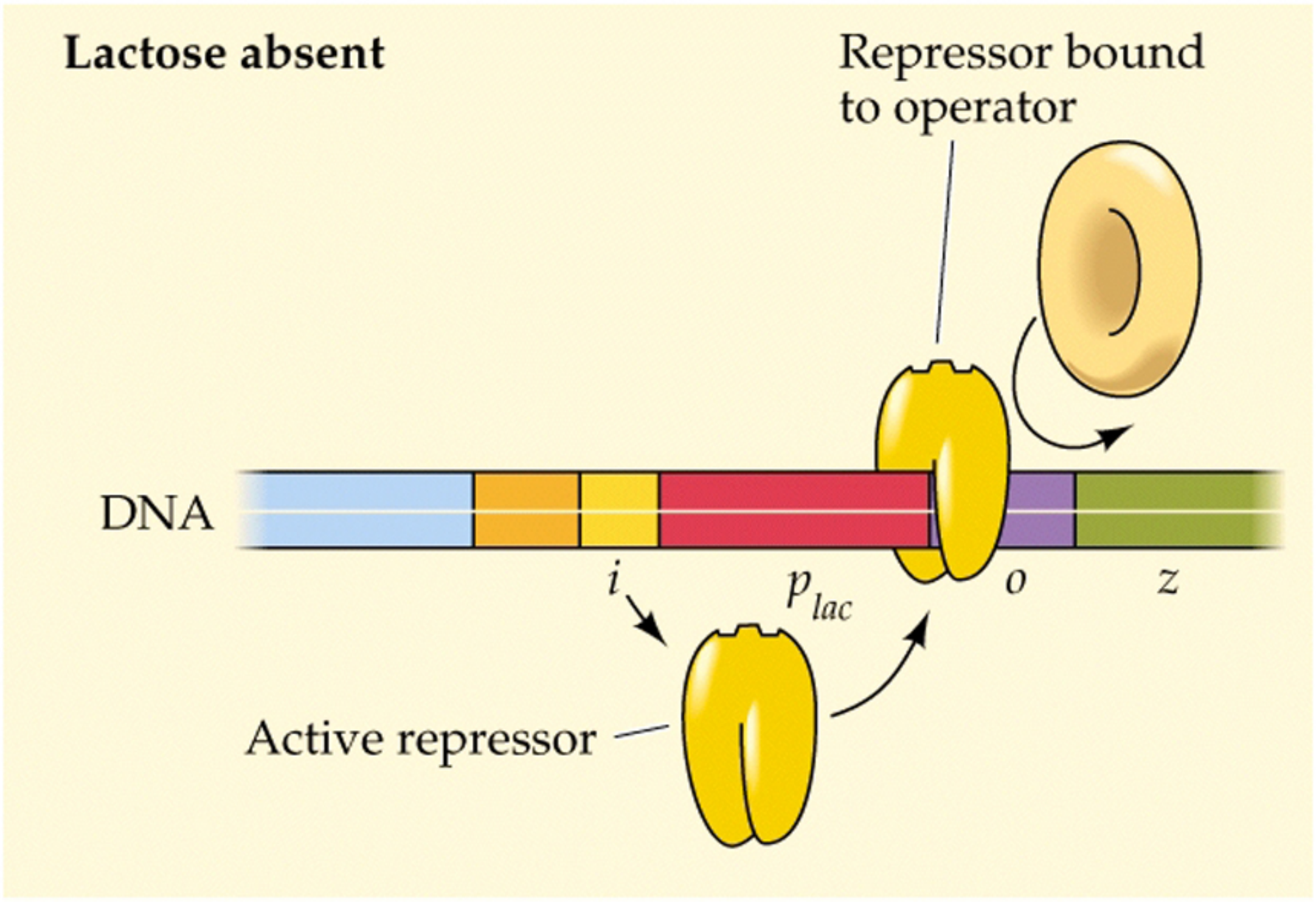


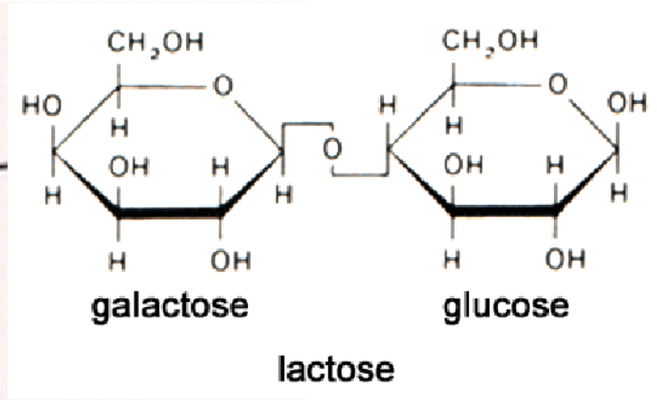


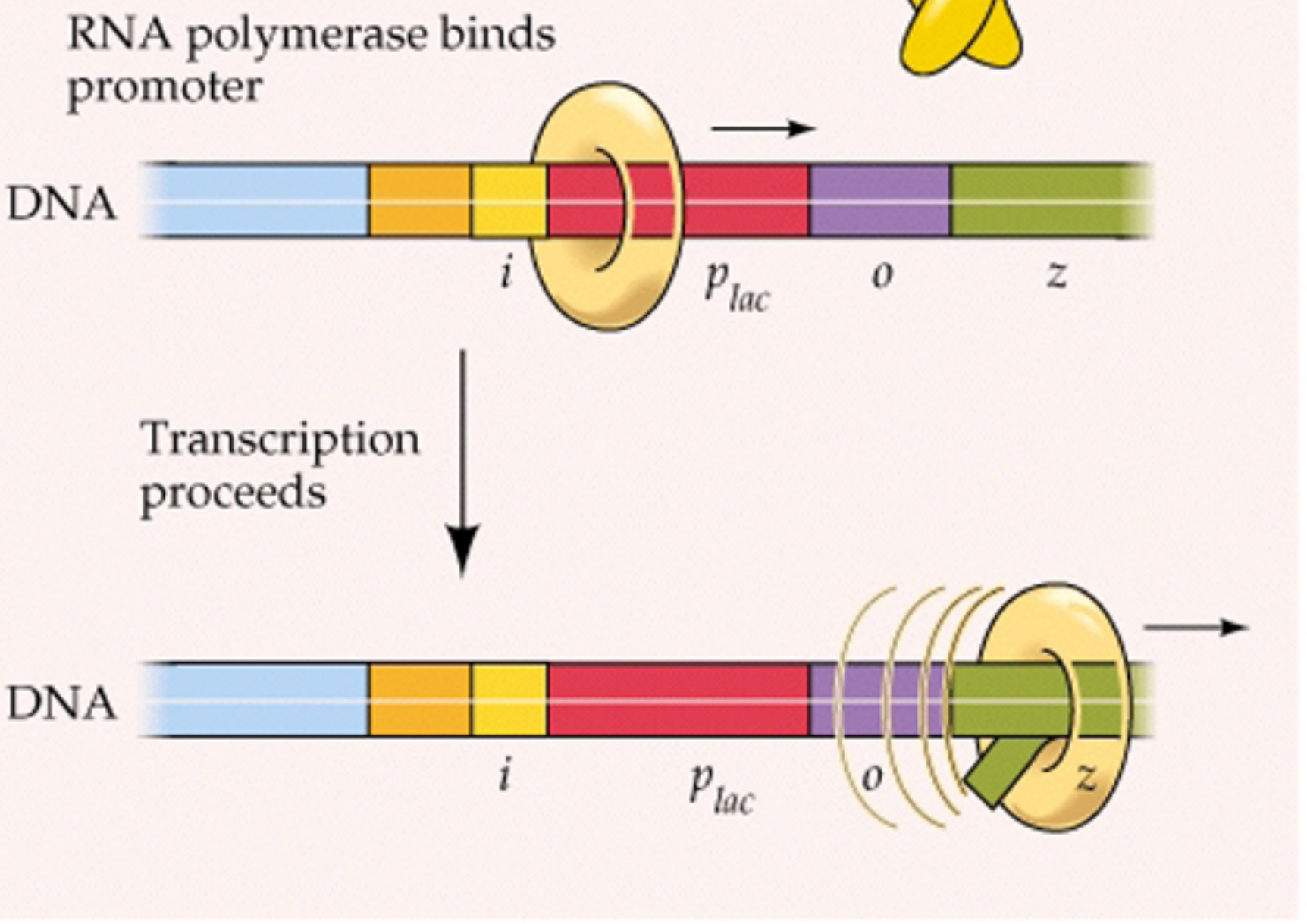
Lactose:
Result:

REWIND | STOP | PLAY | << | >>

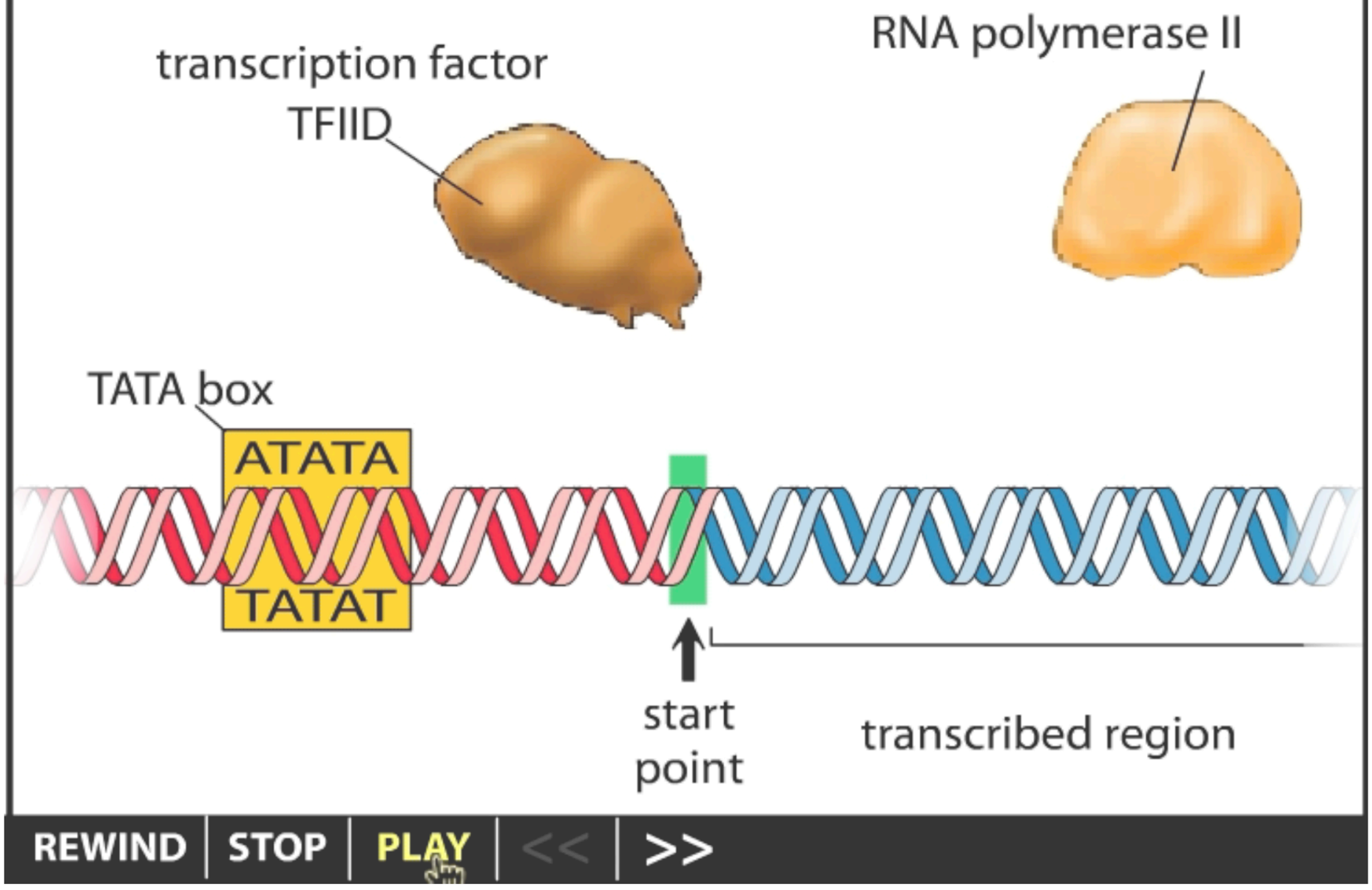


Lactose present

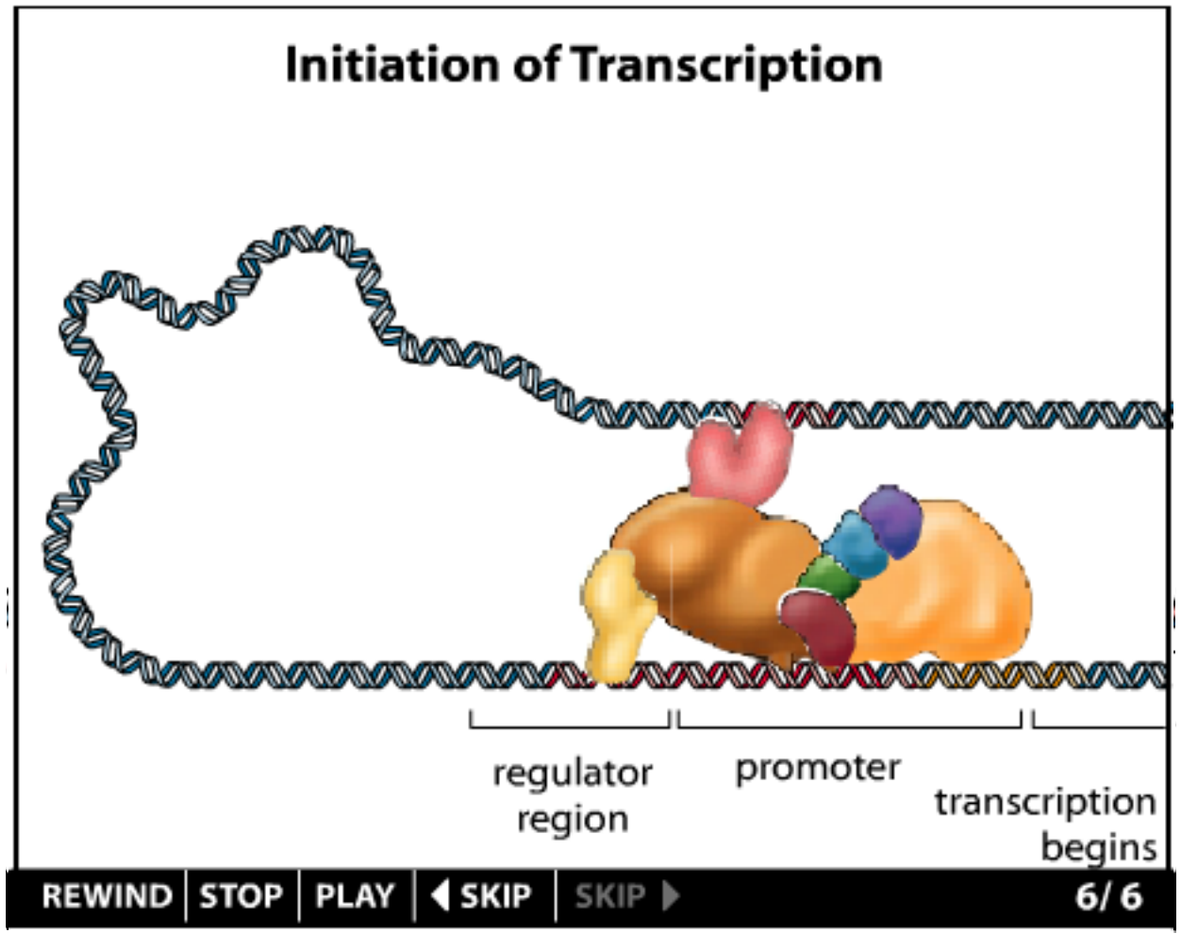




Initiation of Transcription



REWIND | STOP | PLAY | << | >>


Initiation of Transcription
regulator region
promoter
transcription begins
REWIND
STOP
PLAY
SKIP
SKIP
6/ 6

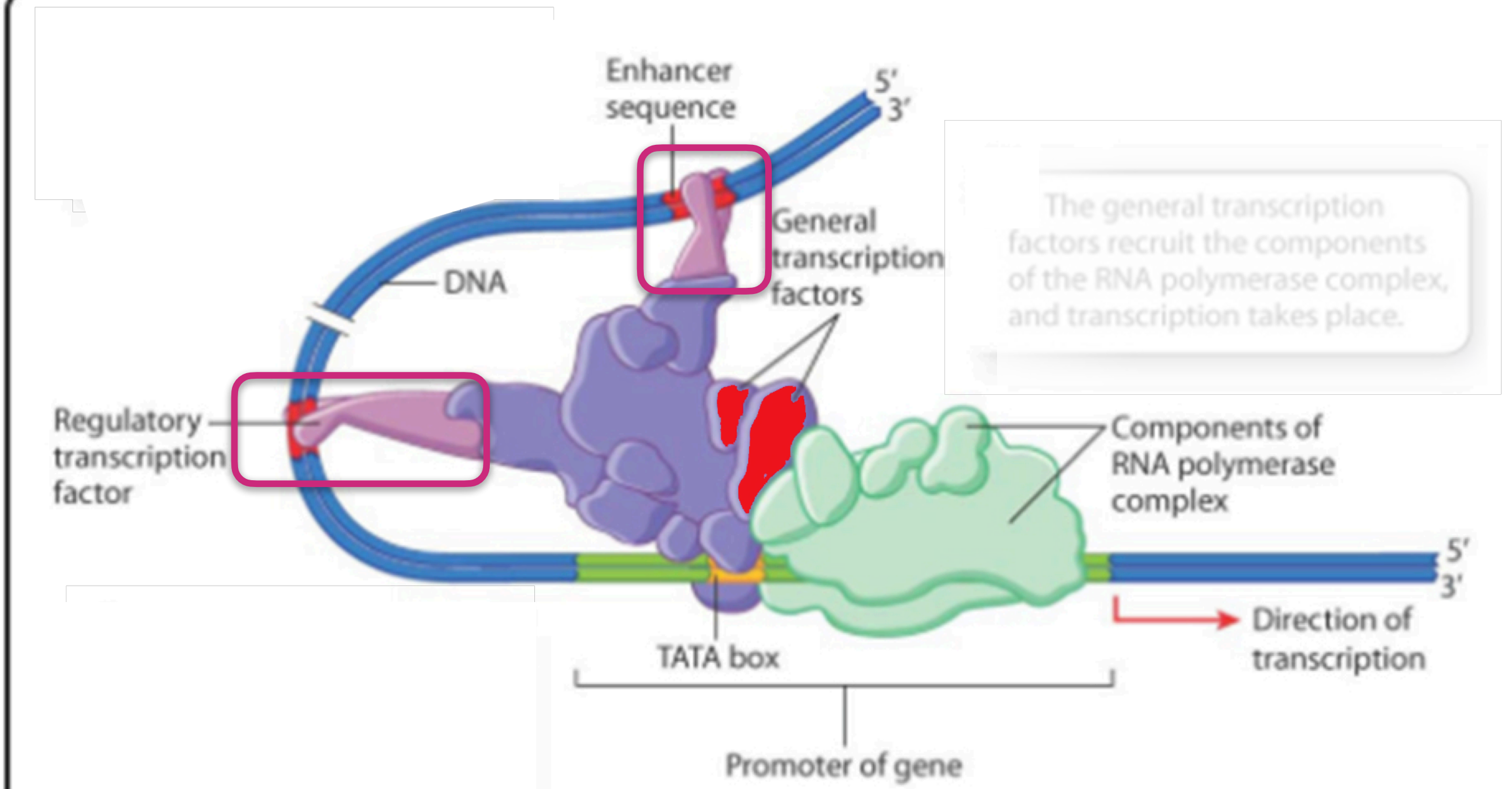


Figure 19.6: Protein–DNA and protein–protein interactions in the eukaryotic transcription complex.

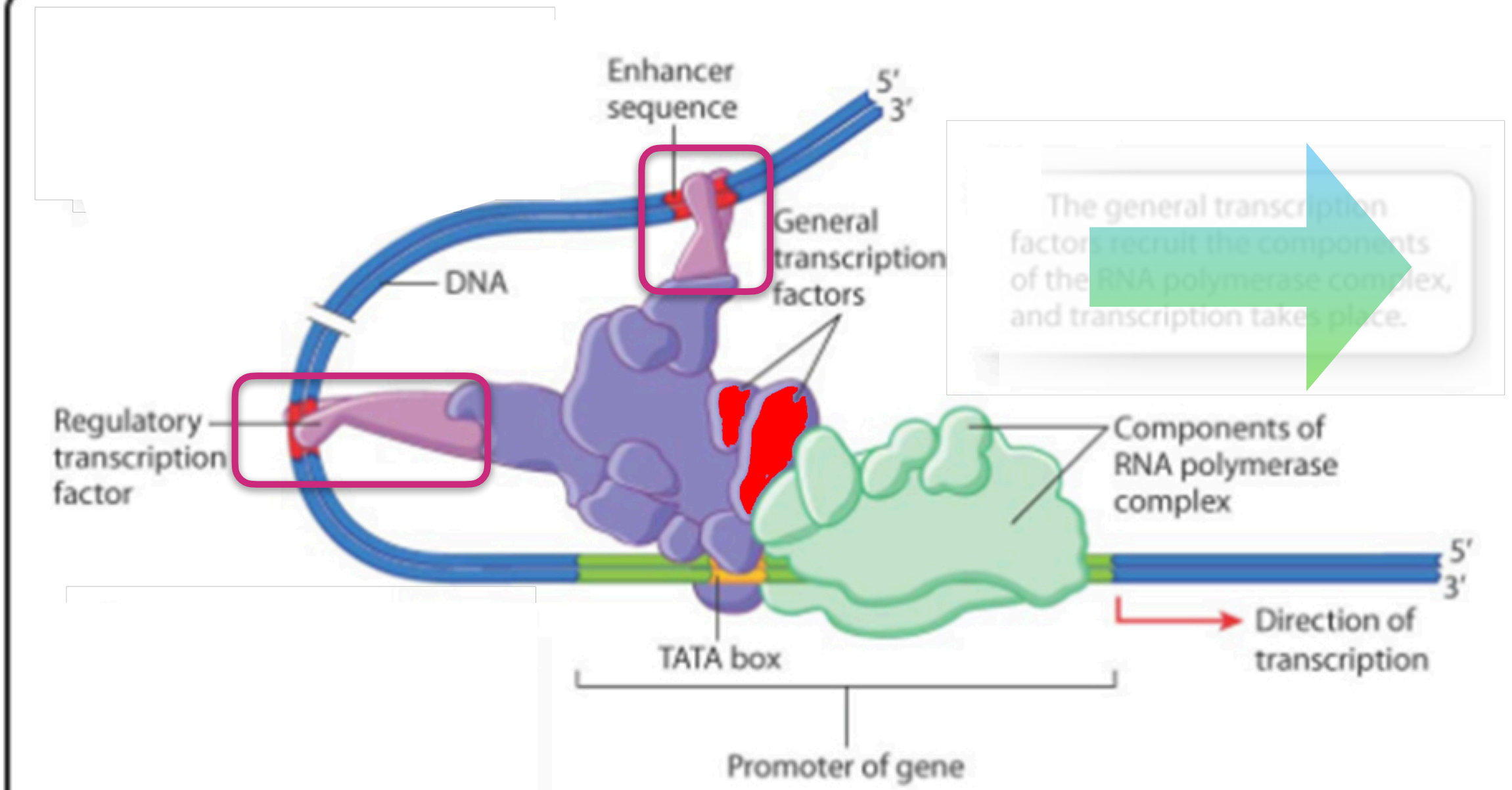
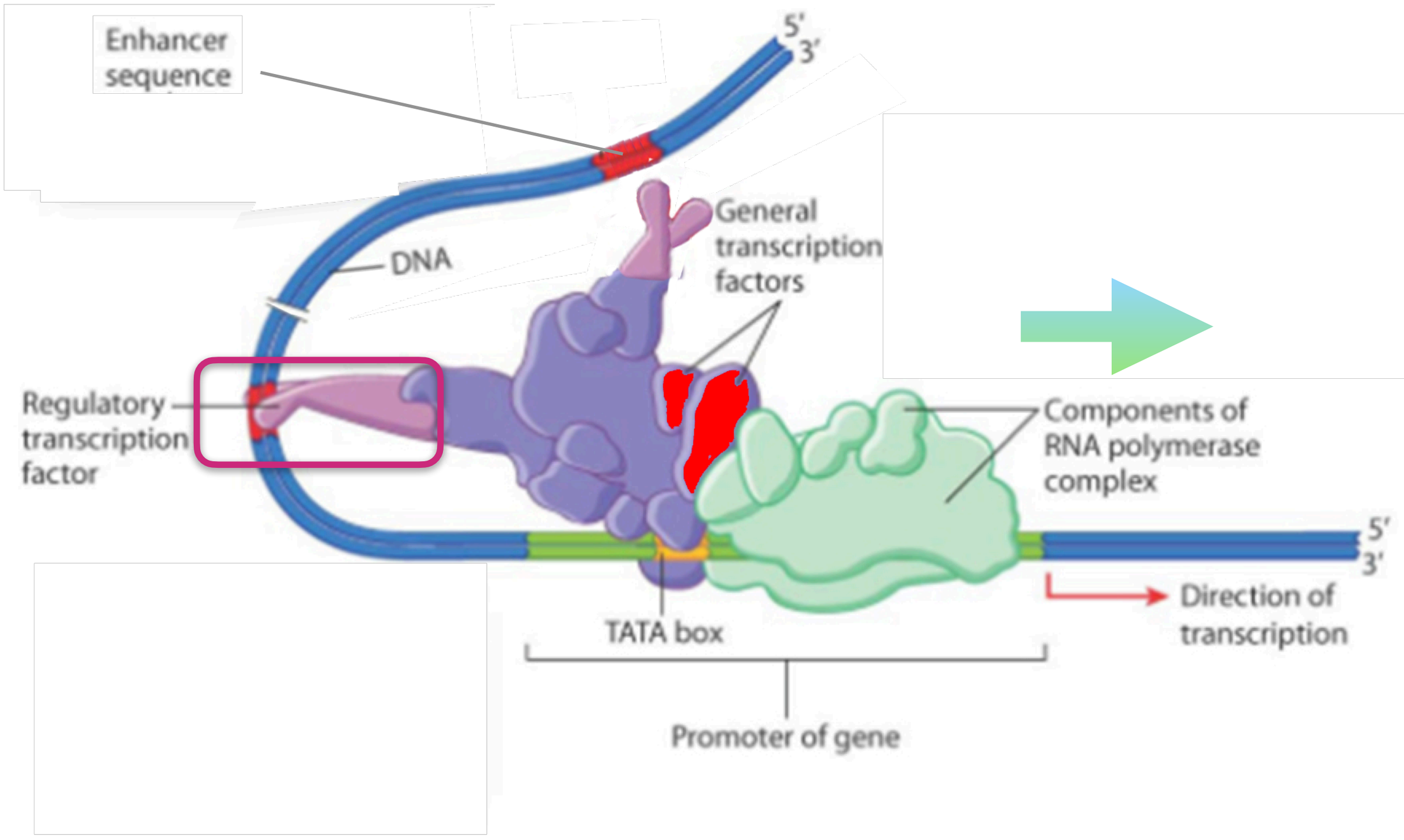


Figure 19.6: Protein–DNA and protein–protein interactions in the eukaryotic transcription complex.



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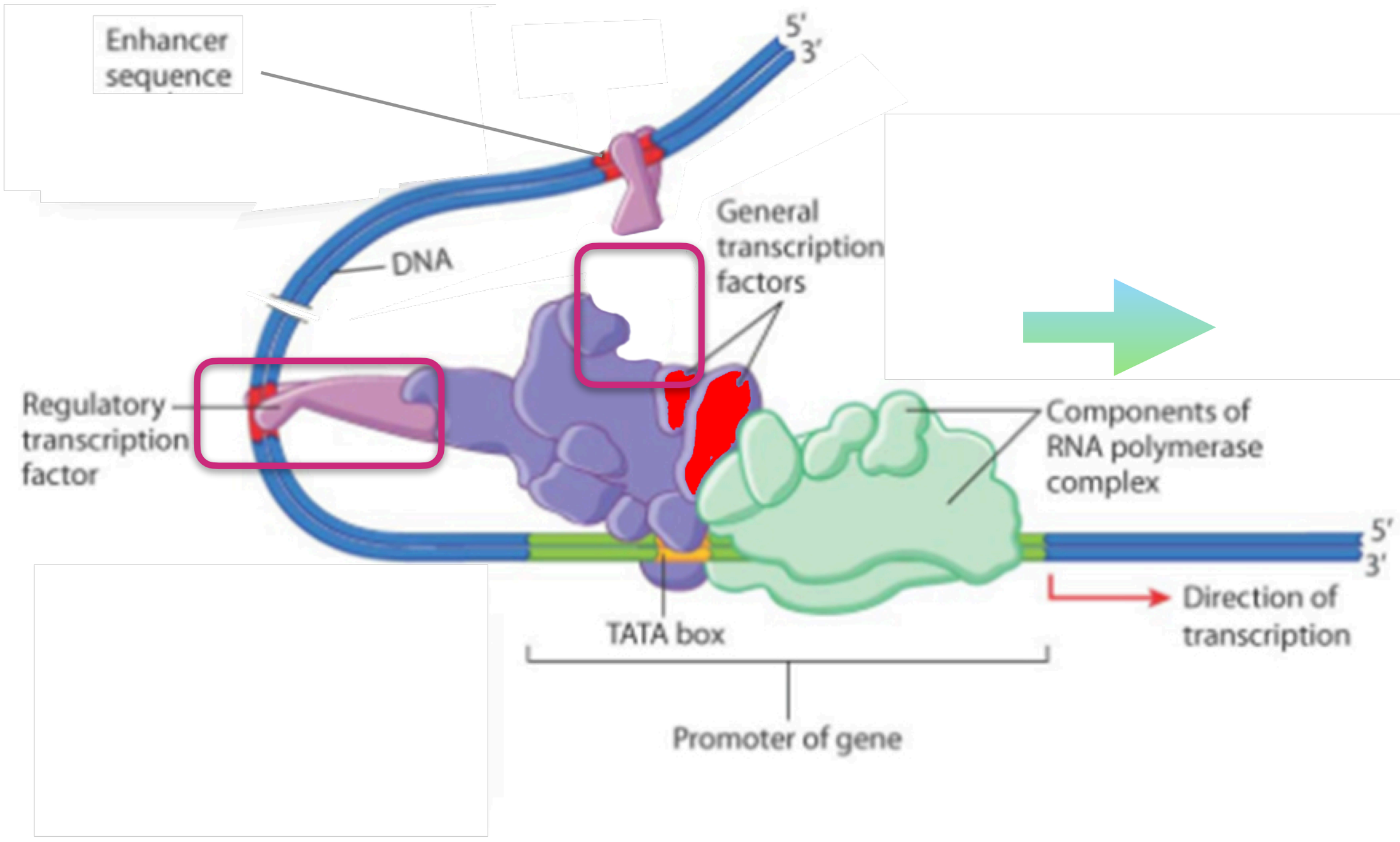

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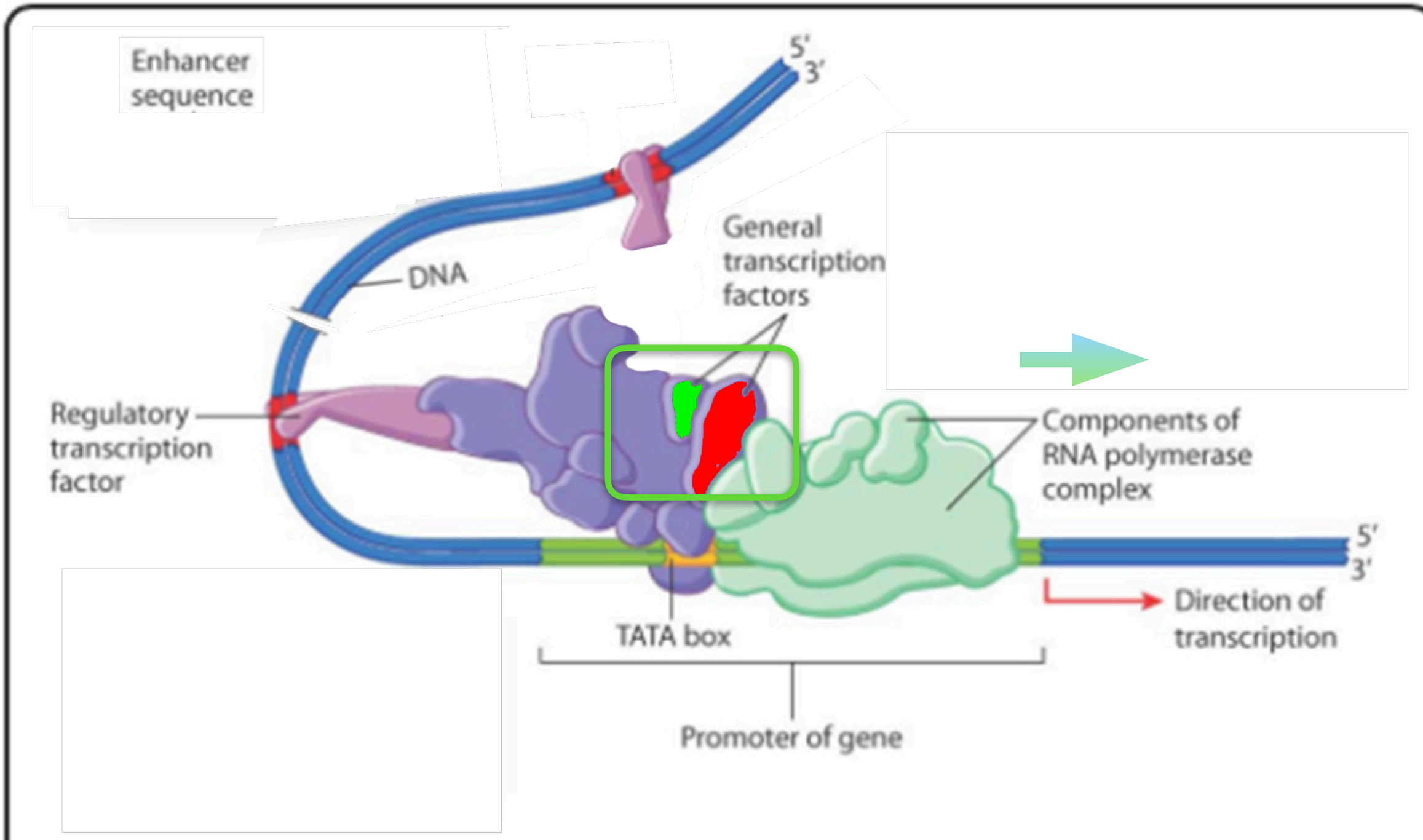

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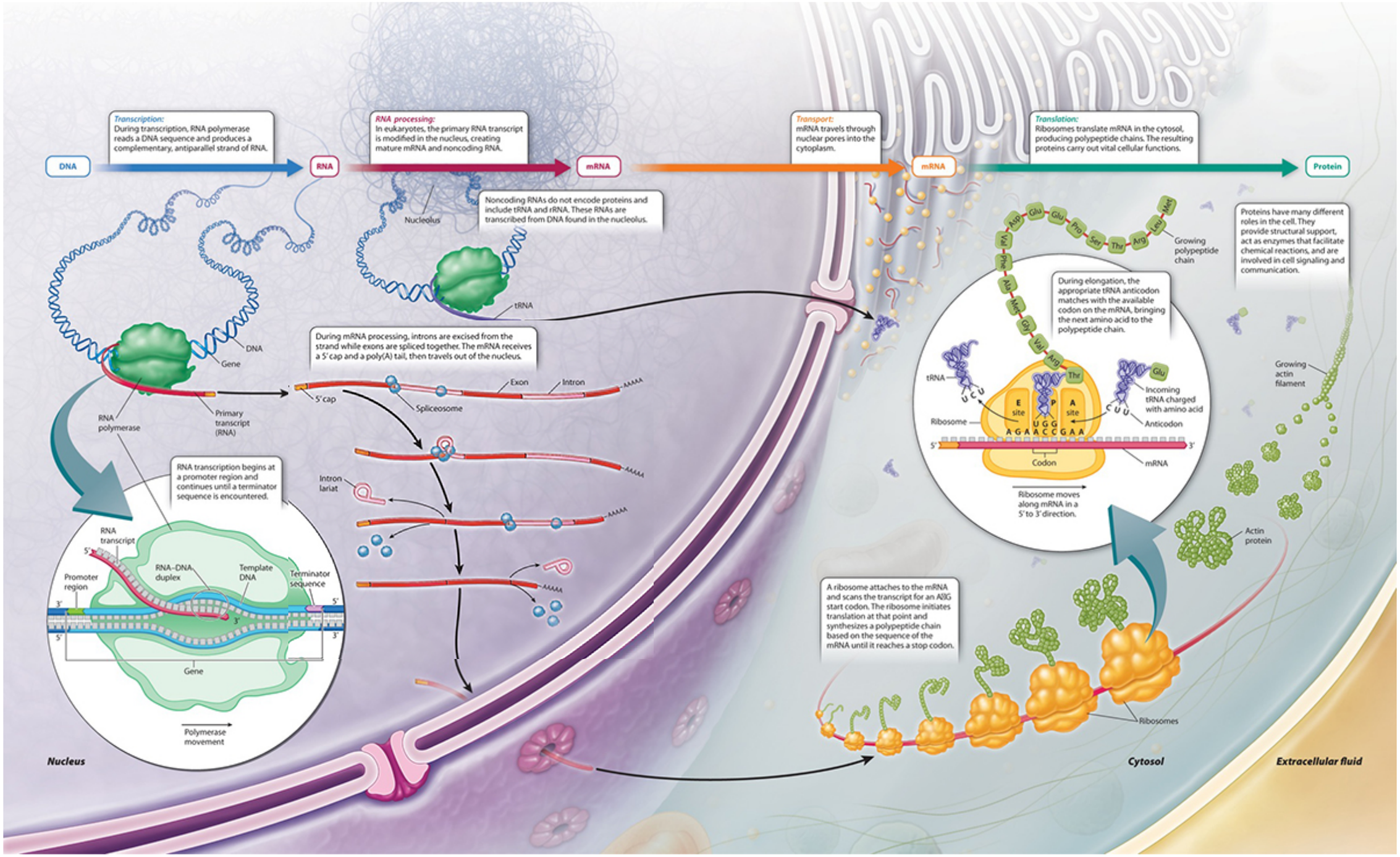
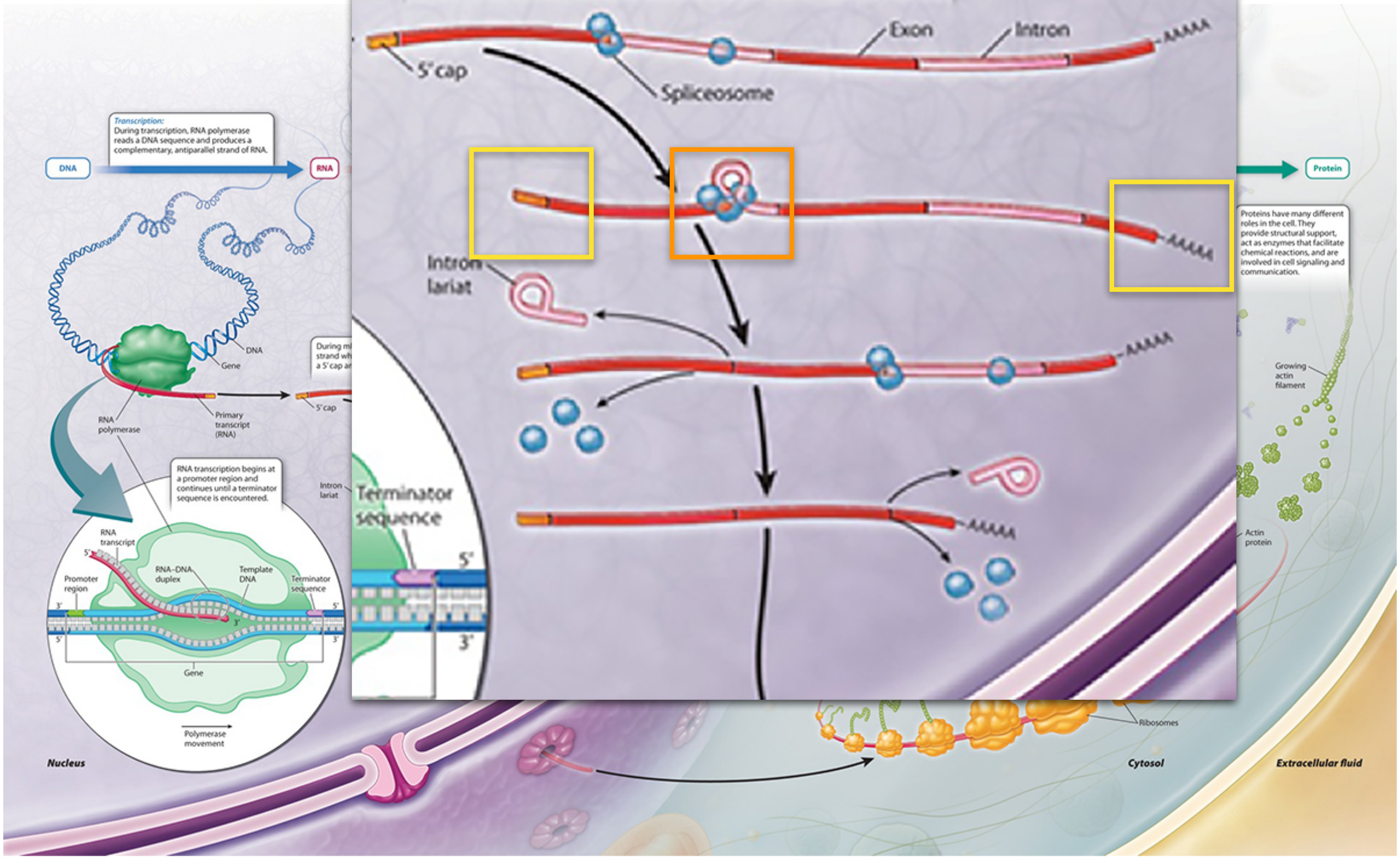

DNA
Transcription:
During transcription, RNA polymerase reads a DNA sequence and produces a complementary, antiparallel strand of RNA.
RNA
RNA processing:
In eukaryotes, the primary RNA transcript is modified in the nucleus, creating mature mRNA and noncoding RNA.
mRNA
Transport:
mRNA travels through nuclear pores into the cytoplasm.
mRNA
Translation:
Ribosomes translate mRNA in the cytosol, producing polypeptide chains. The resulting proteins carry out vital cellular functions.
Protein
Nucleolus
Noncoding RNAs do not encode proteins and include tRNA and rRNA. These RNAs are transcribed from DNA found in the nucleolus.
tRNA
DNA
Gene
RNA polymerase
Primary transcript (RNA)
During mRNA processing, introns are excised from the strand while exons are spliced together. The mRNA receives a 5′ cap and a poly(A) tail, then travels out of the nucleus.
5′ cap
Exon
Intron
AAAAA
Spliceosome
Intron lariat
RNA transcription begins at a promoter region and continues until a terminator sequence is encountered.
RNA transcript
5′
Promoter region
3′
RNA–DNA duplex
Template DNA
3′
Terminator sequence
5′
3′
5′
Gene
Polymerase movement
Nucleus
Growing polypeptide chain
Met
Leu
Arg
Thr
Ser
Pro
Glu
Glu
Asp
Val
Phe
Ala
Met
Gly
Val
Arg
During elongation, the appropriate tRNA anticodon matches with the available codon on the mRNA, bringing the next amino acid to the polypeptide chain.
tRNA
U C U
E site
P site
A site
Thr
Glu
Incoming tRNA charged with amino acid
Ribosome
U G G
A G A A C C G A A
Anticodon
5′
3′
mRNA
Codon
Ribosome moves along mRNA in a 5′ to 3′ direction.
Proteins have many different roles in the cell. They provide structural support, act as enzymes that facilitate chemical reactions, and are involved in cell signaling and communication.
Growing actin filament
Actin protein
A ribosome attaches to the mRNA and scans the transcript for an AUG start codon. The ribosome initiates translation at that point and synthesizes a polypeptide chain based on the sequence of the mRNA until it reaches a stop codon.
Ribosomes
Cytosol
Extracellular fluid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RNA
DNA
Gene
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5′ cap
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RNA transcript
5′
Promoter region
RNA–DNA duplex
Template DNA
Terminator sequence
3′
5′
Gene
Polymerase movement
Intron lariat
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Intron
Spliceosome
AAAAA
Intron lariat
Terminator sequence
5′
3′
Protein
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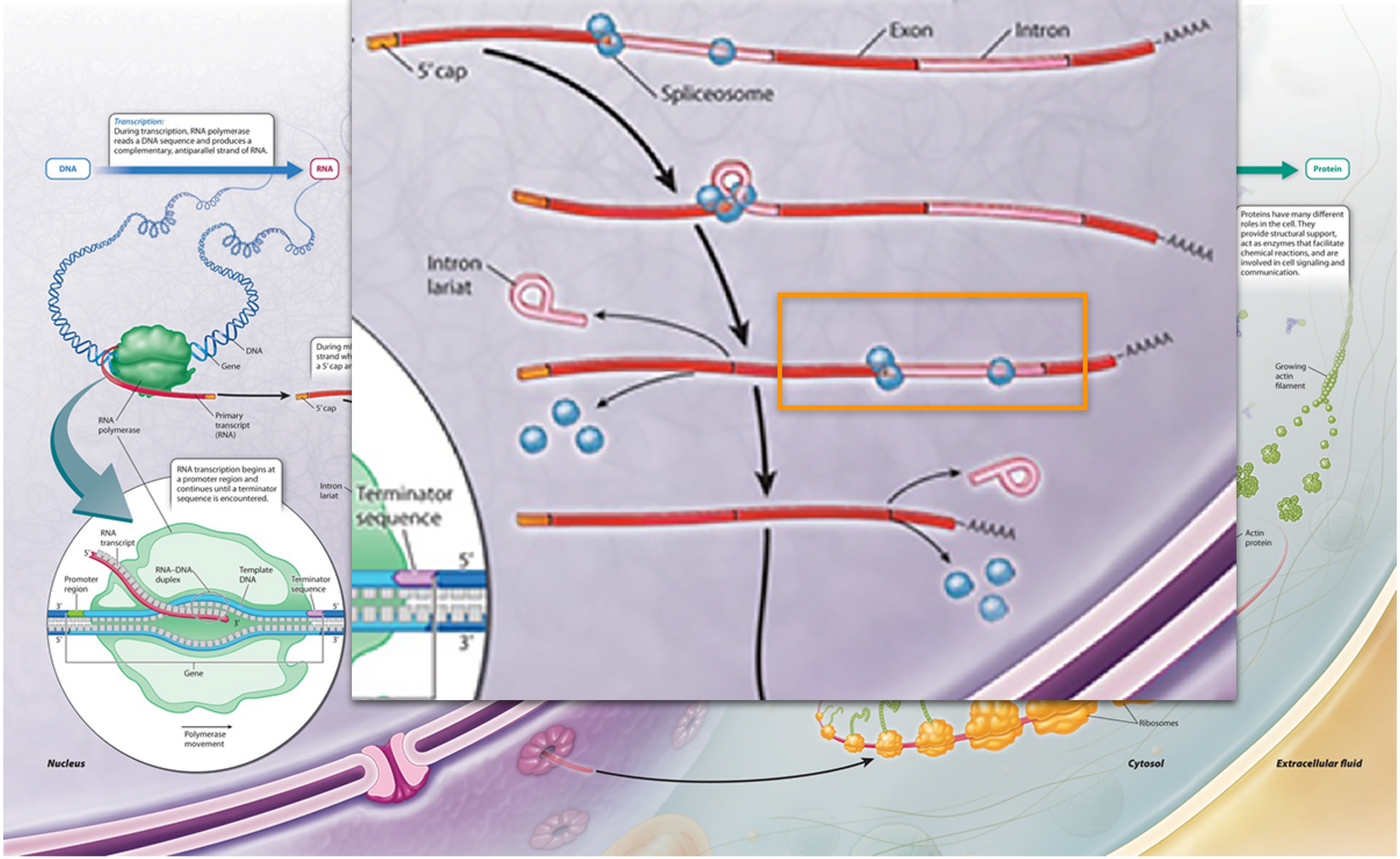
Growing actin filament
Actin protein
Ribosomes
Nucleus
Cytosol
Extracellular fluid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Polymerase movement
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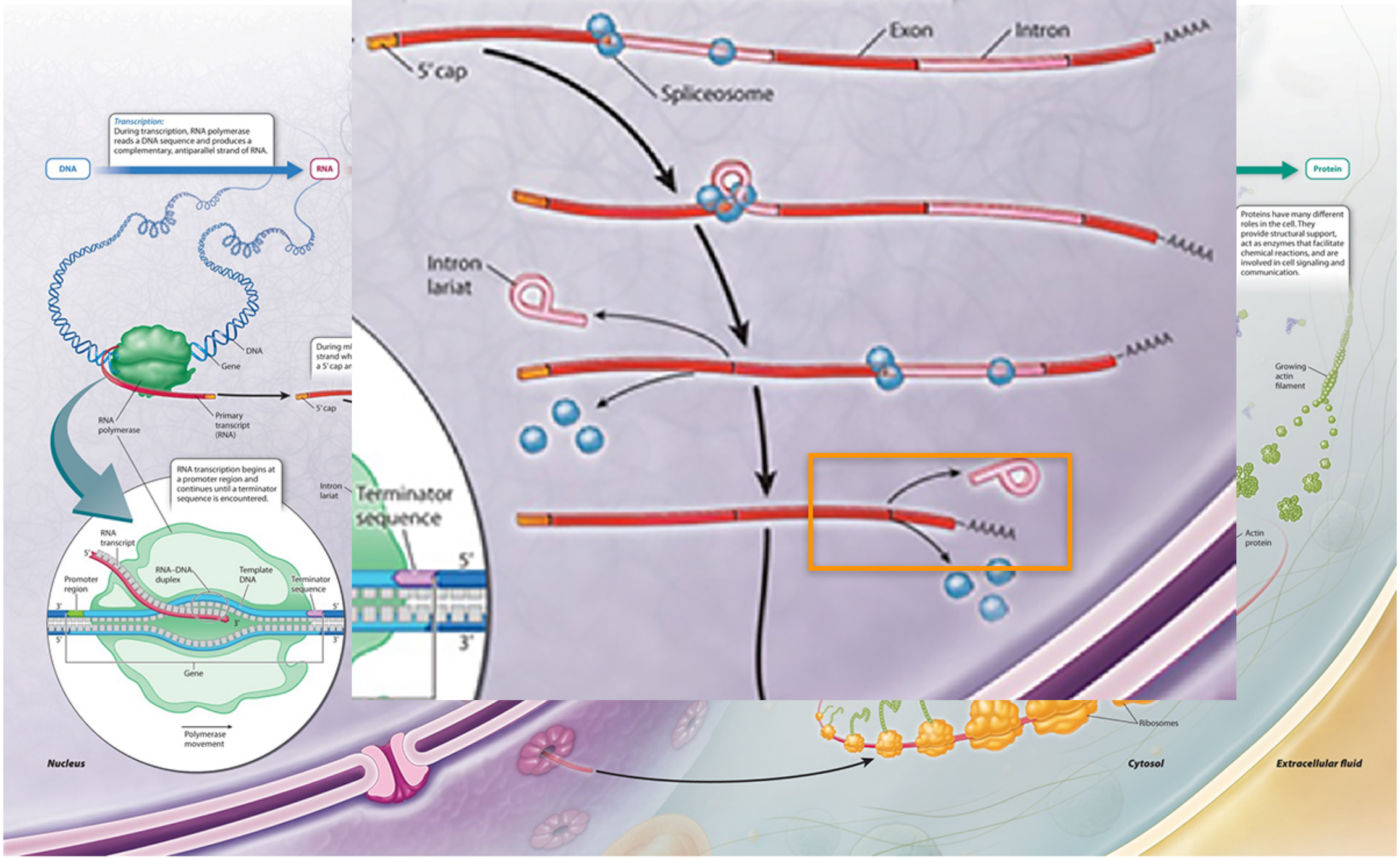
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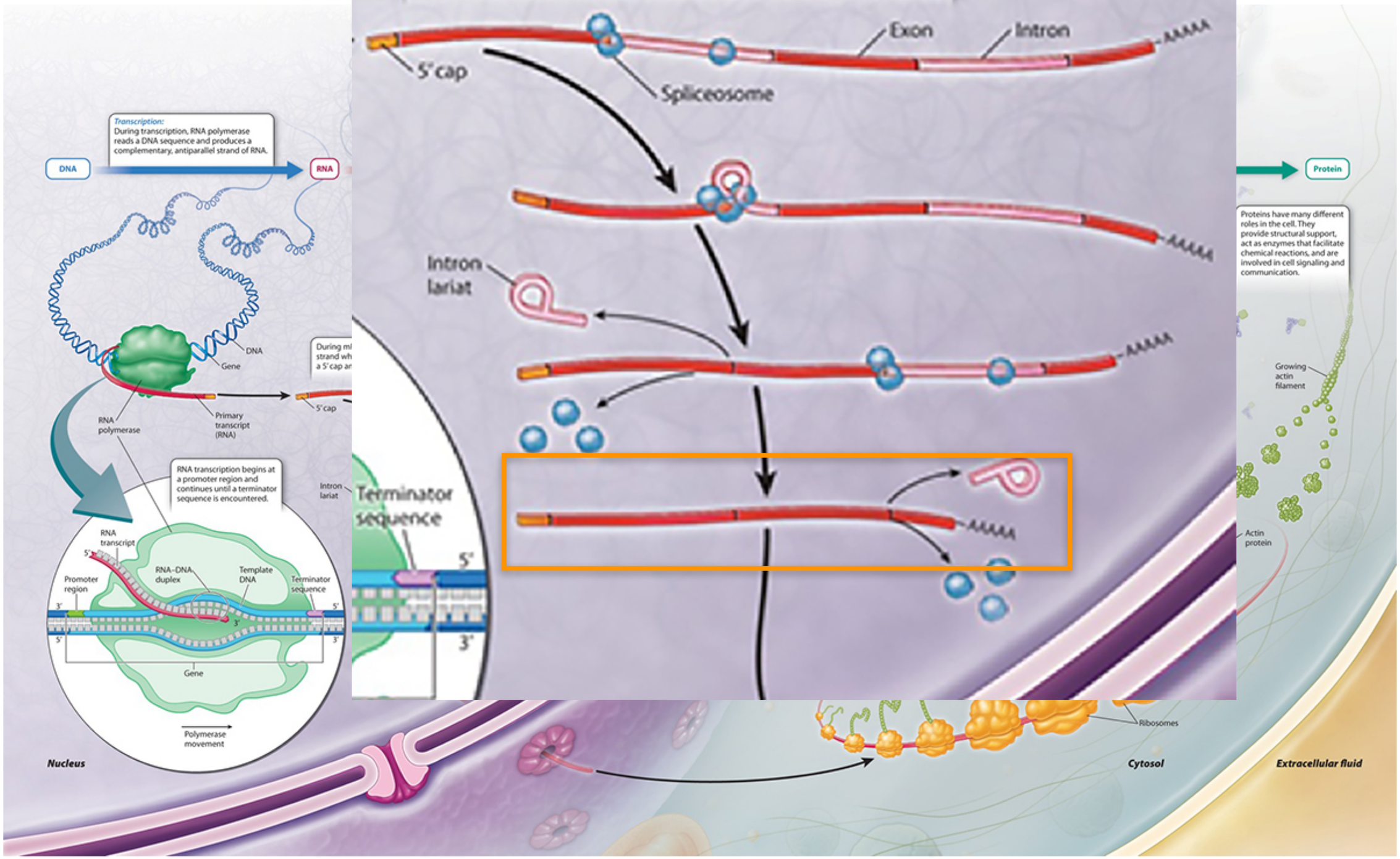
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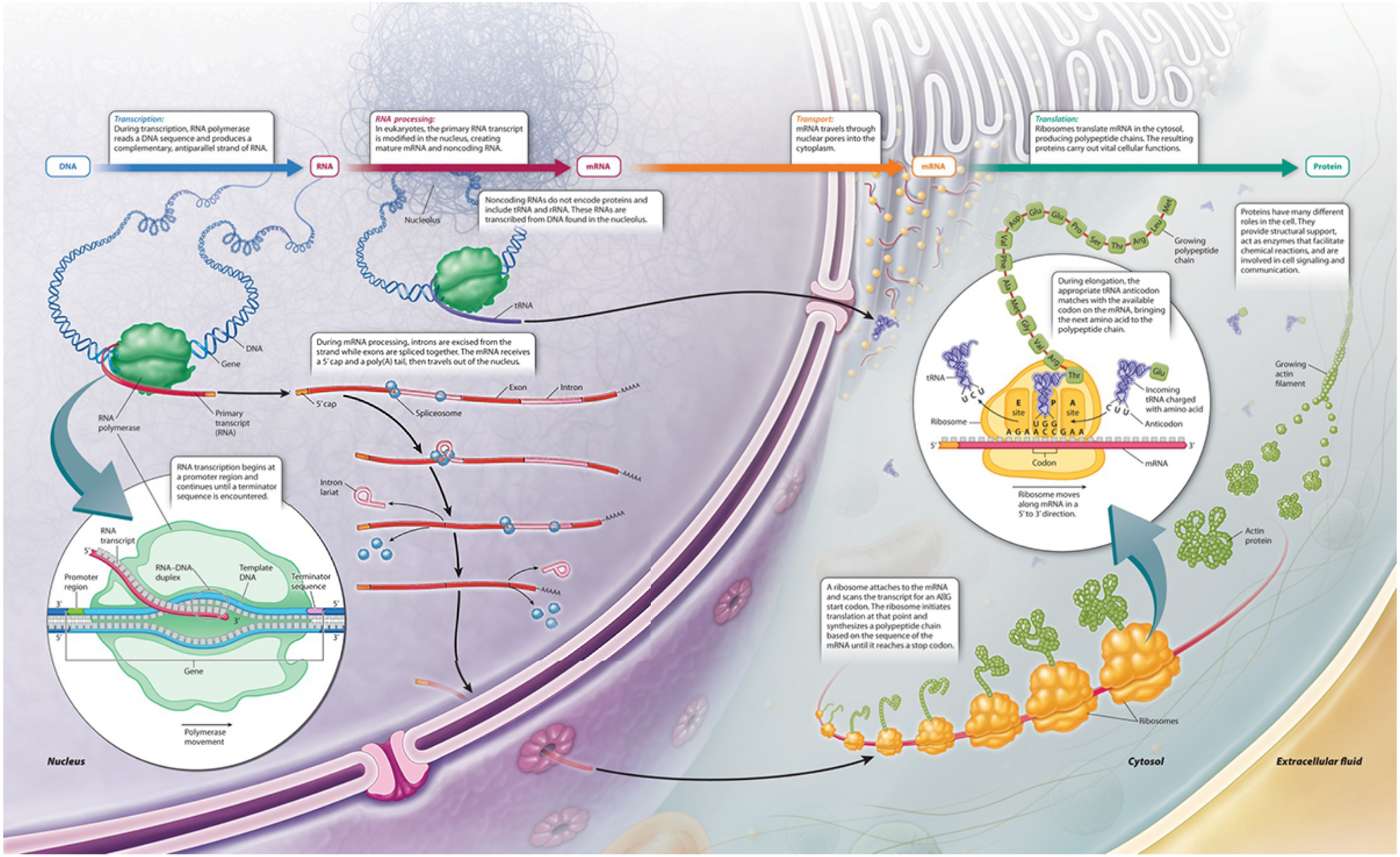
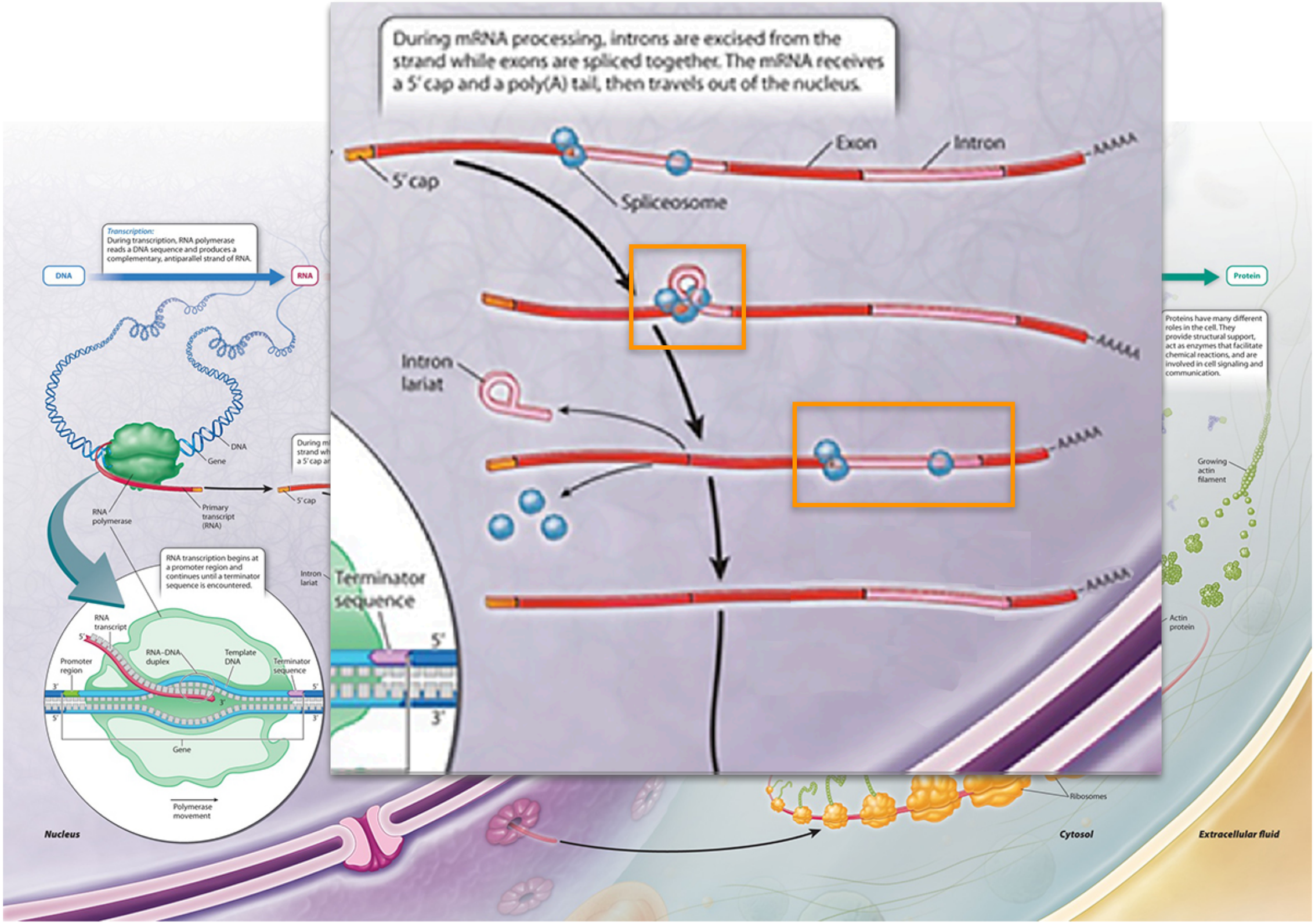
DNA ⟶ **RNA** maturation

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Growing actin filament
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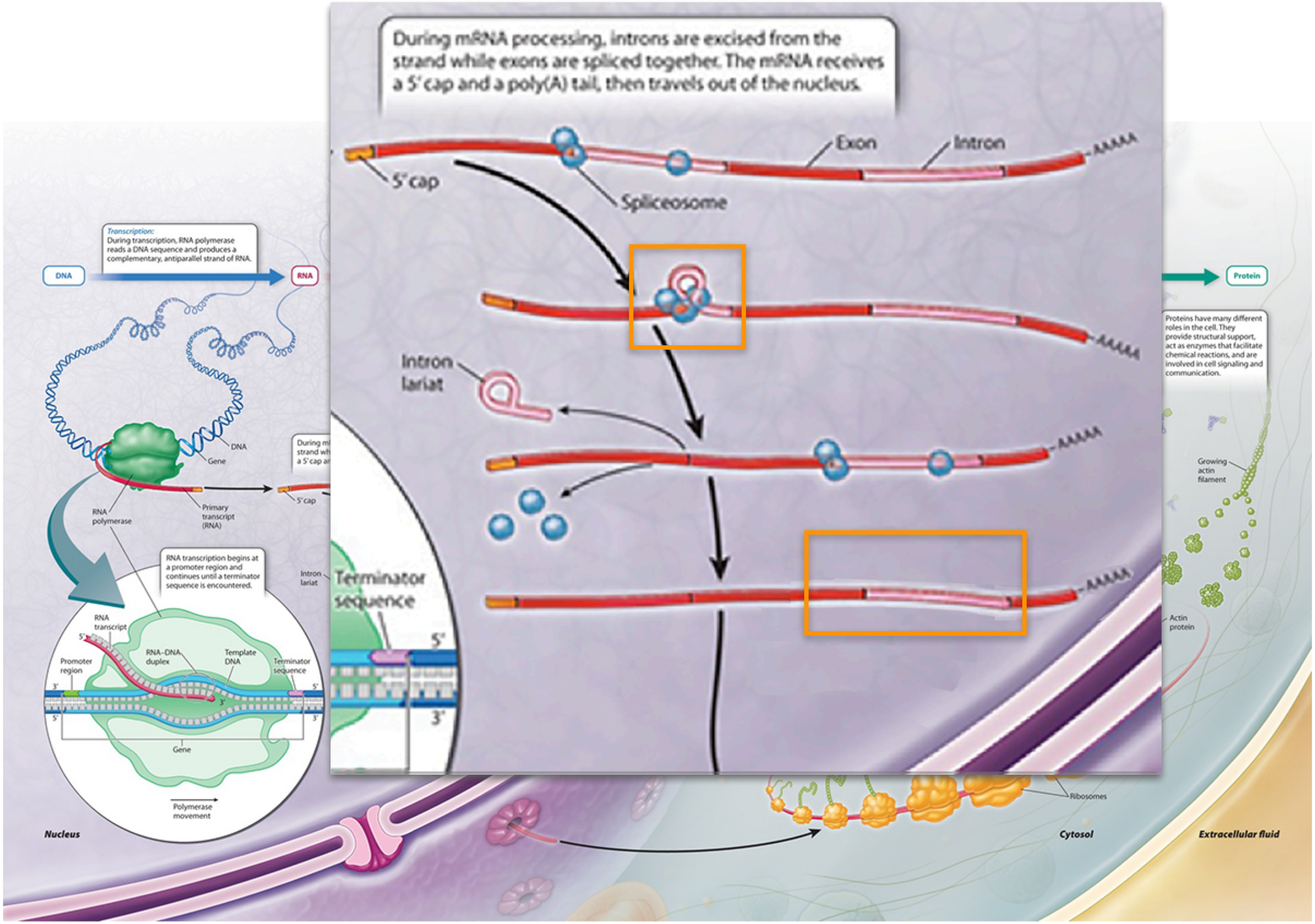
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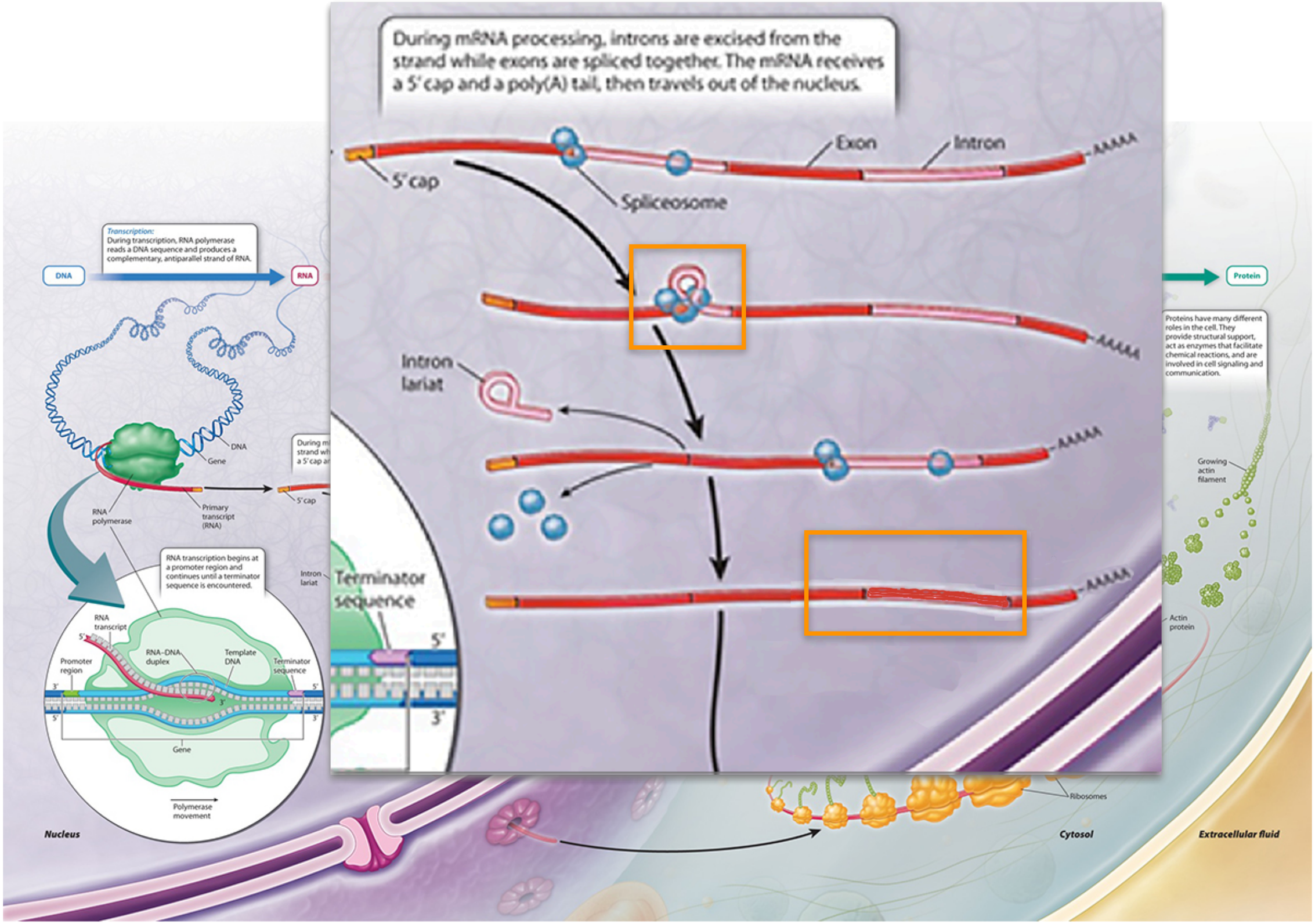
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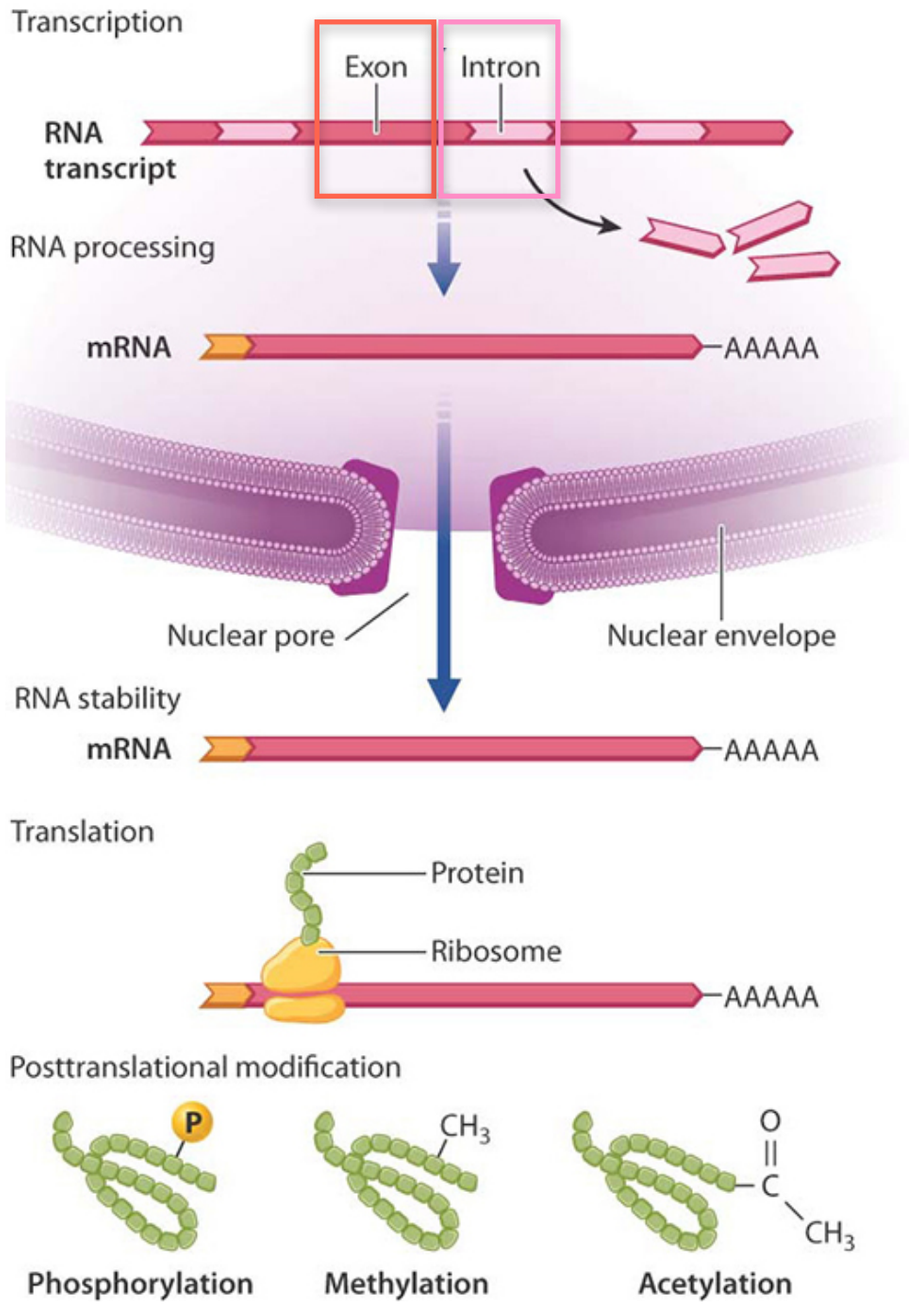
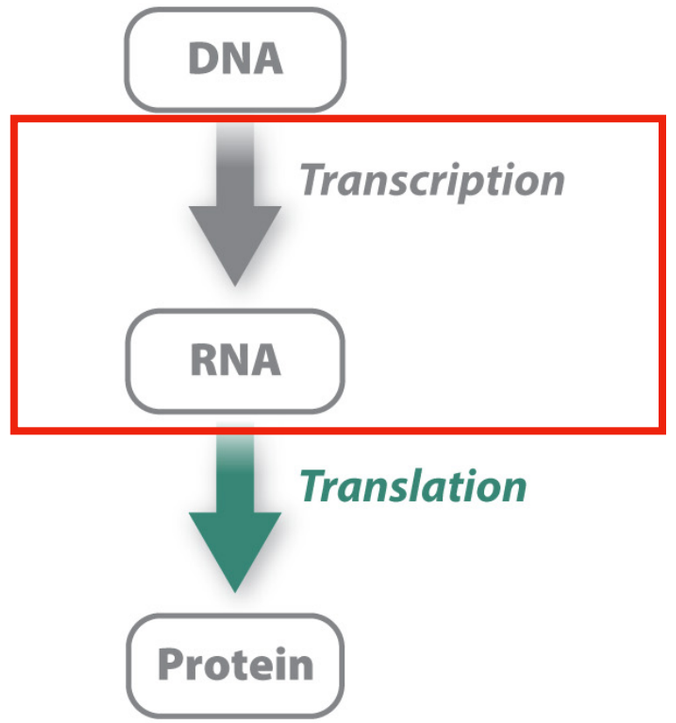
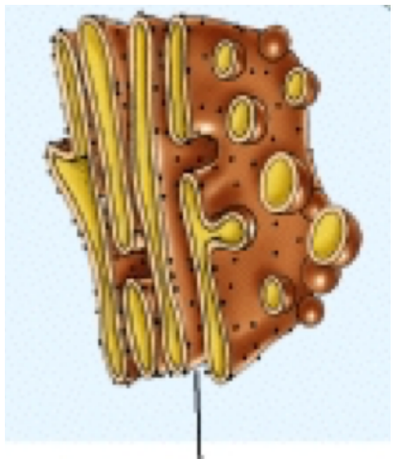
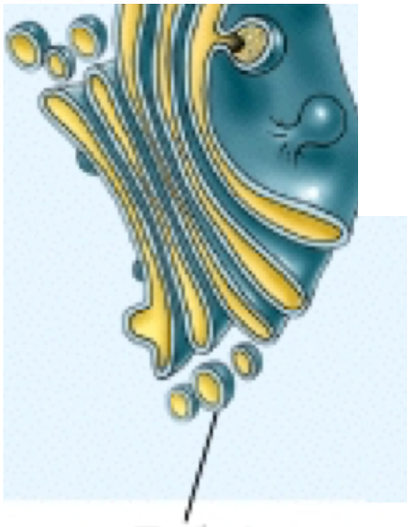






Endoplasmic reticulum



Golgi apparatus