

Chapter 14: From DNA to Protein

Steps from DNA to Proteins

Same two steps produce all proteins:

1) DNA is transcribed to form RNA

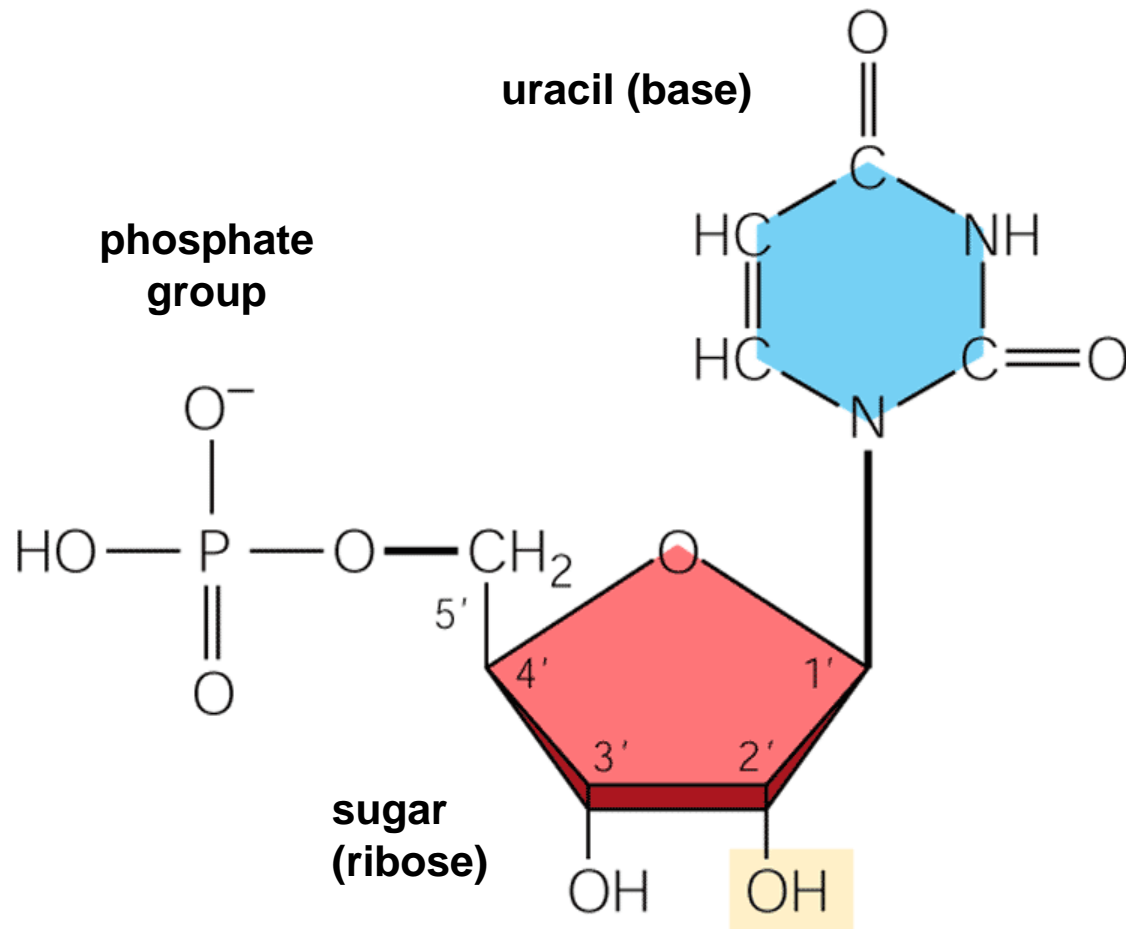
- Occurs in the nucleus
- RNA moves into cytoplasm

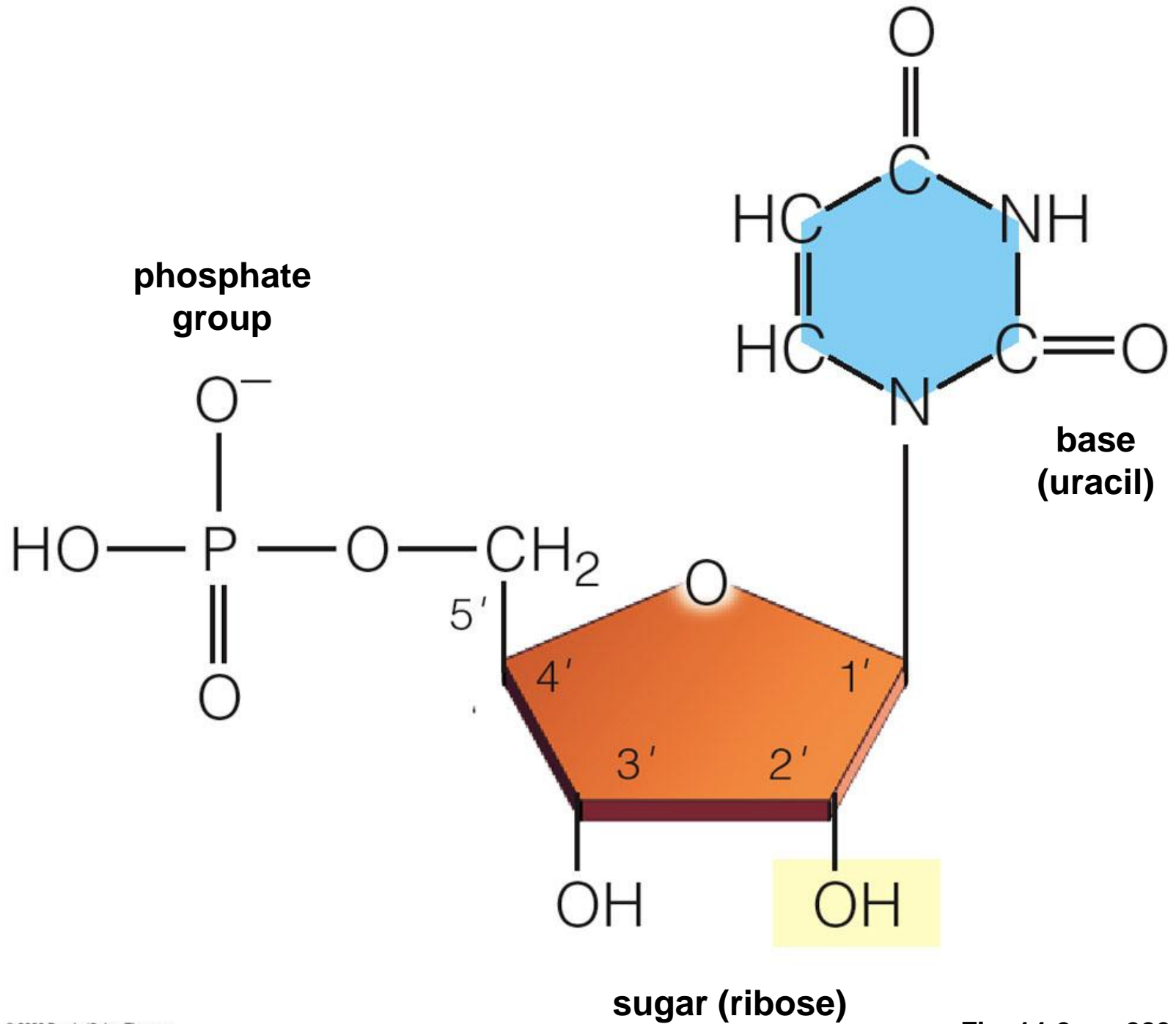
2) RNA is translated in ribosomes to form polypeptide chains, which fold to form proteins

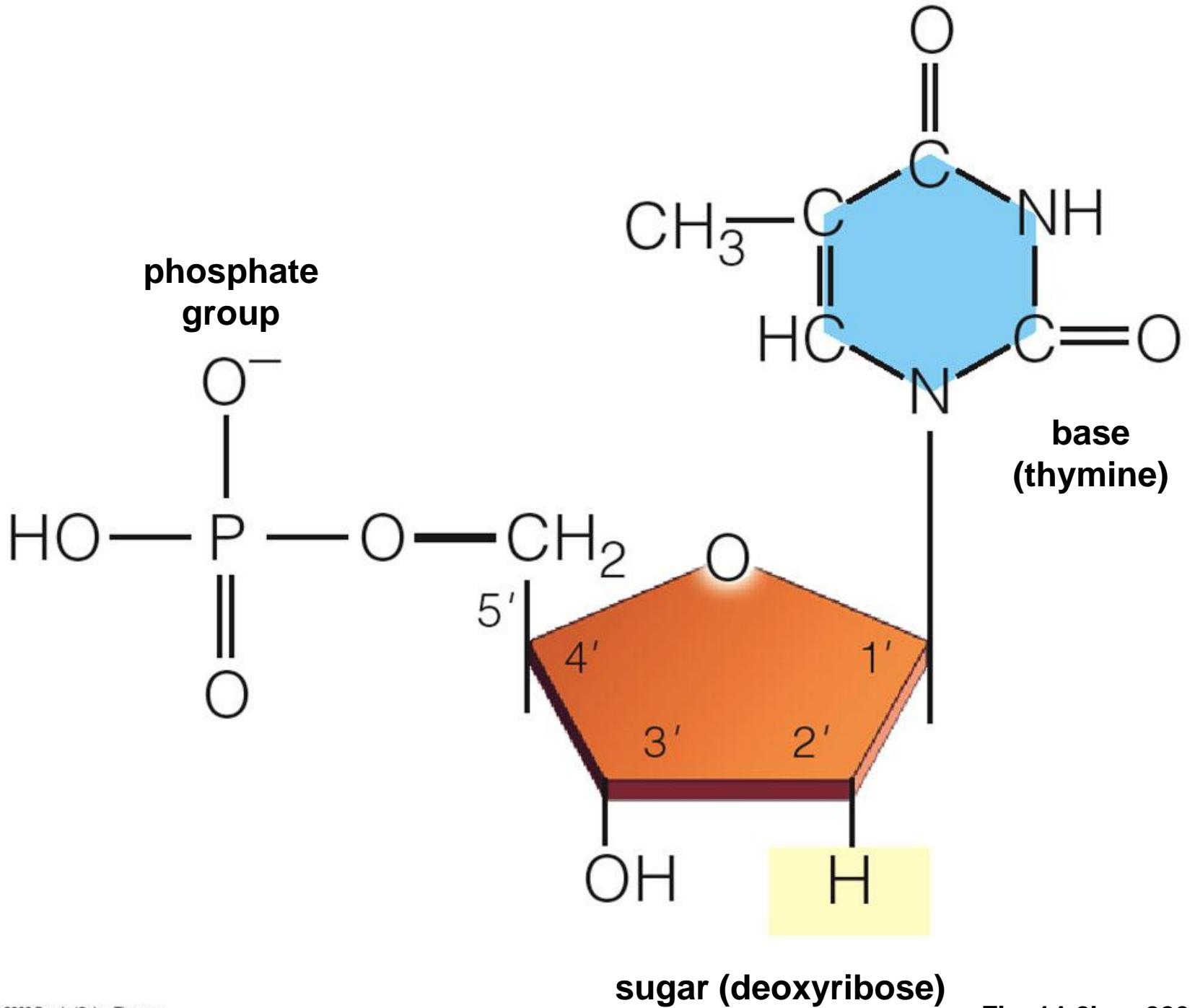
Three Classes of RNAs

- **Messenger RNA (mRNA)**
 - Carries protein-building instruction
- **Ribosomal RNA (rRNA)**
 - Major component of ribosomes
- **Transfer RNA (tRNA)**
 - Delivers amino acids to ribosomes

A Nucleotide Subunit of RNA







Base Pairing during Transcription

DNA

A

C

T

C

RNA

U

G

A

G

base pairing
during
transcription

DNA

A

C

T

C

DNA

T

G

A

G

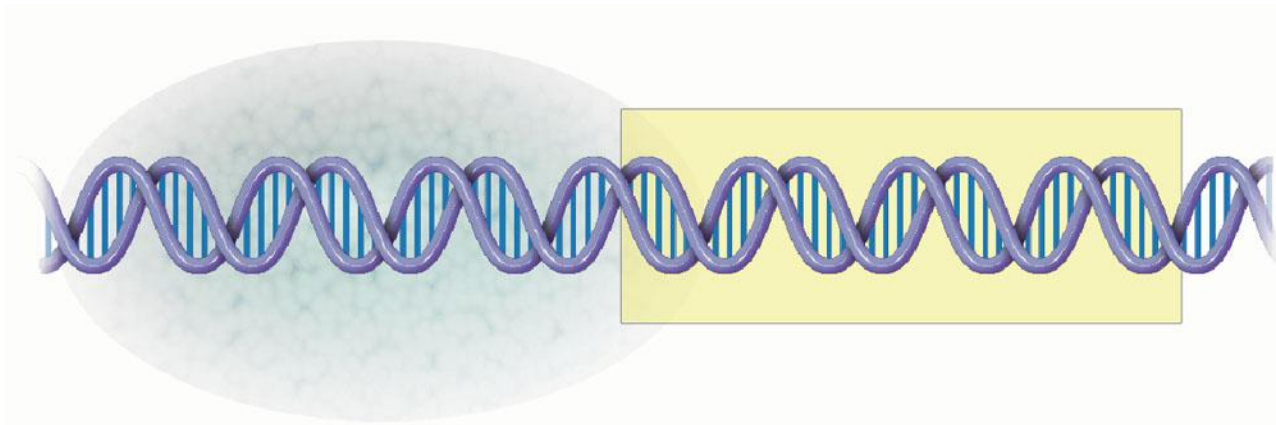
base pairing
during DNA
replication

Transcription & DNA Replication

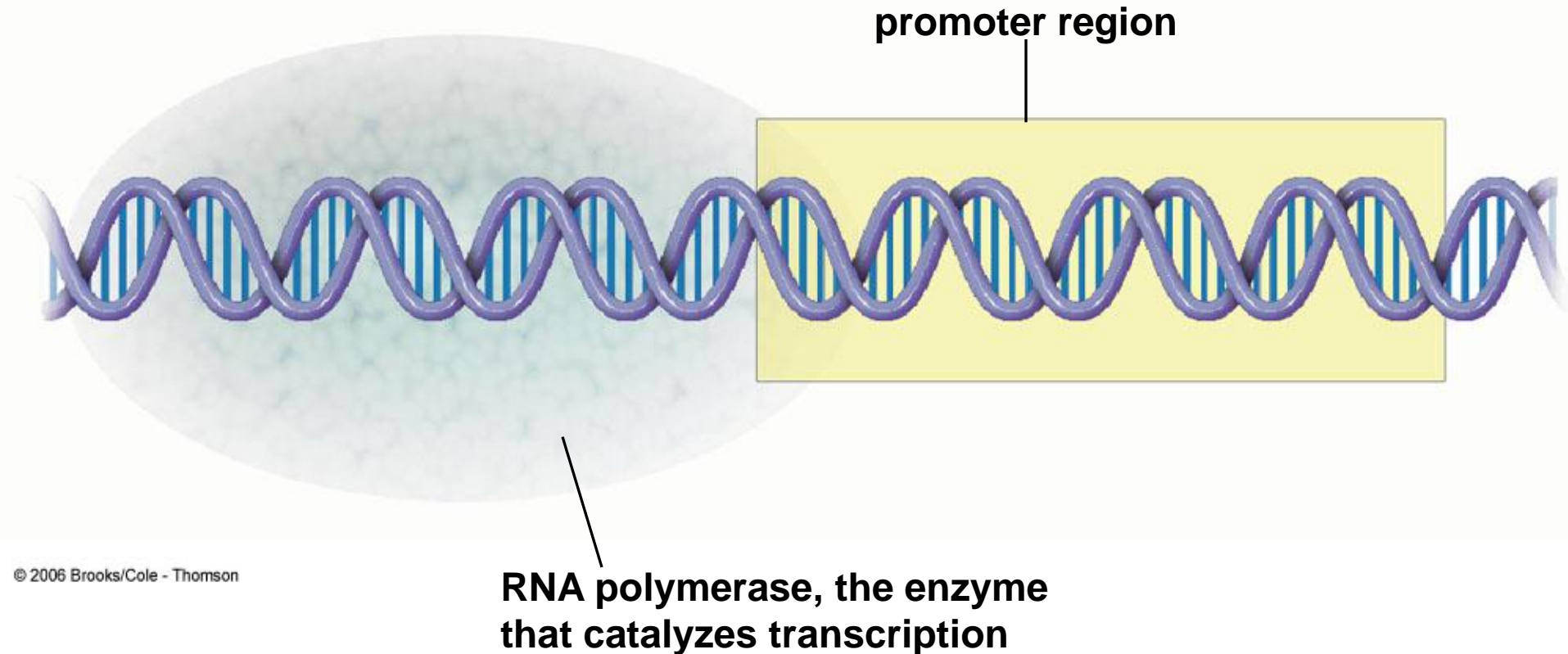
- Like DNA replication
 - Nucleotides added in 5' to 3' direction
- Unlike DNA replication
 - Only small stretch is template
 - Product is a single strand of RNA
 - RNA polymerase catalyzes nucleotide addition

Promoter

- A base sequence in the DNA that signals the start of a gene
- For transcription to occur, RNA polymerase must first bind to a promoter

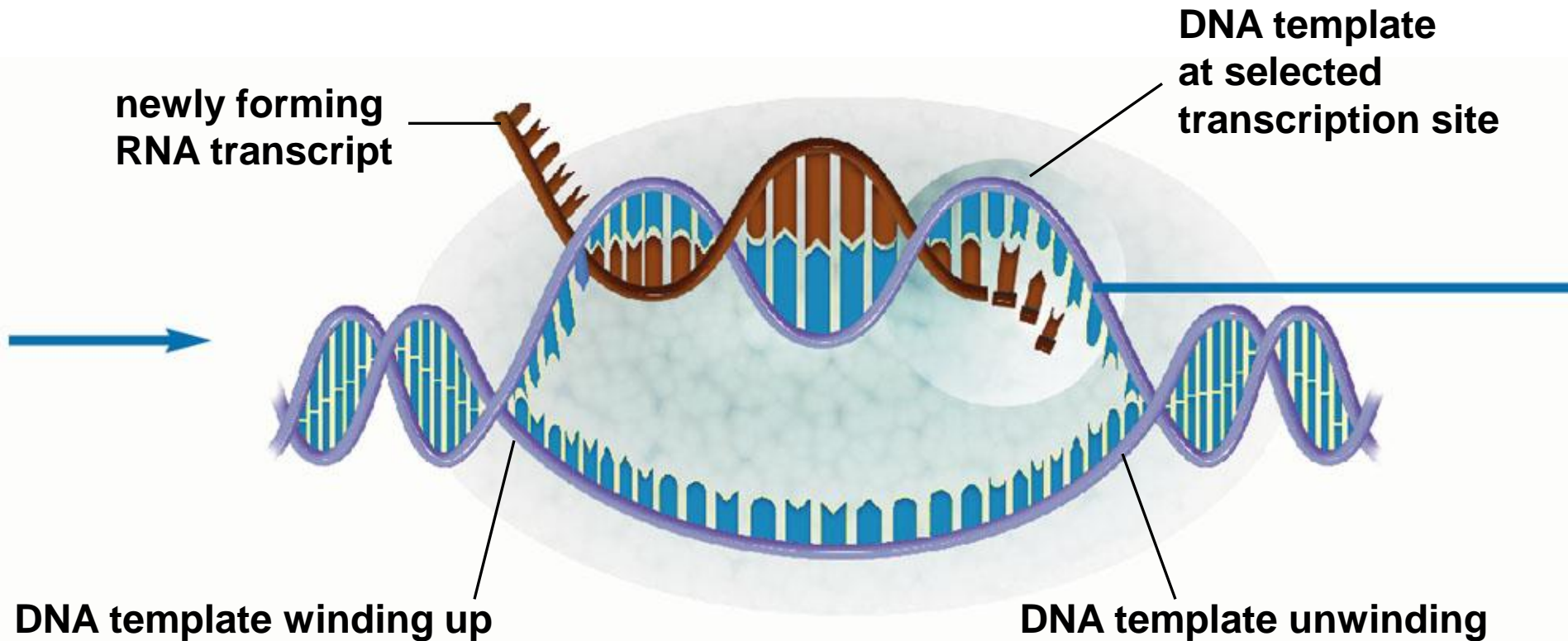


Promoter



a RNA polymerase initiates transcription at a promoter region in DNA. It recognizes a base sequence located next to the promoter as a template. It will link the nucleotides adenine, cytosine, guanine, and uracil into a strand of RNA, in the order specified by DNA.

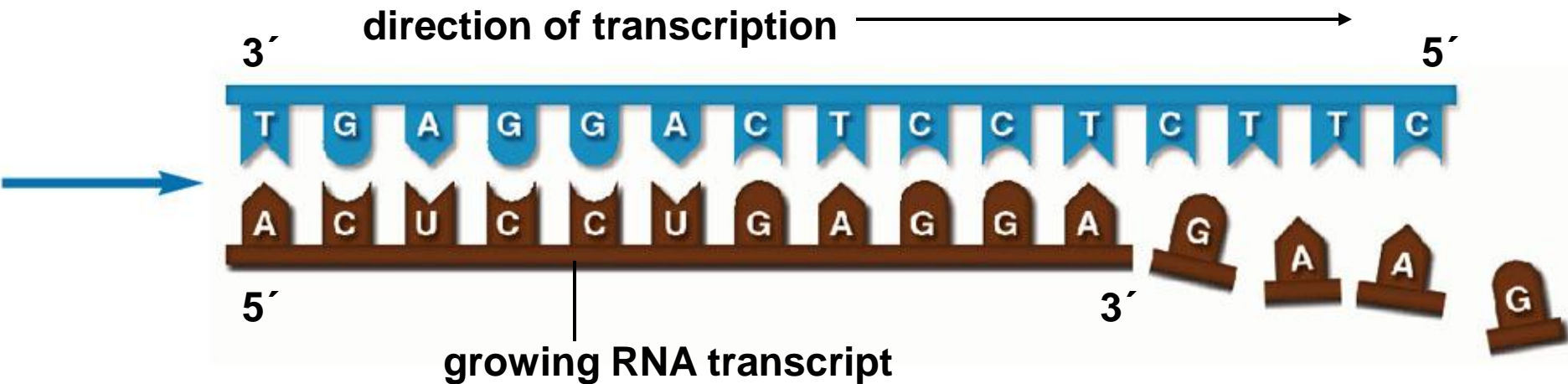
Gene Transcription



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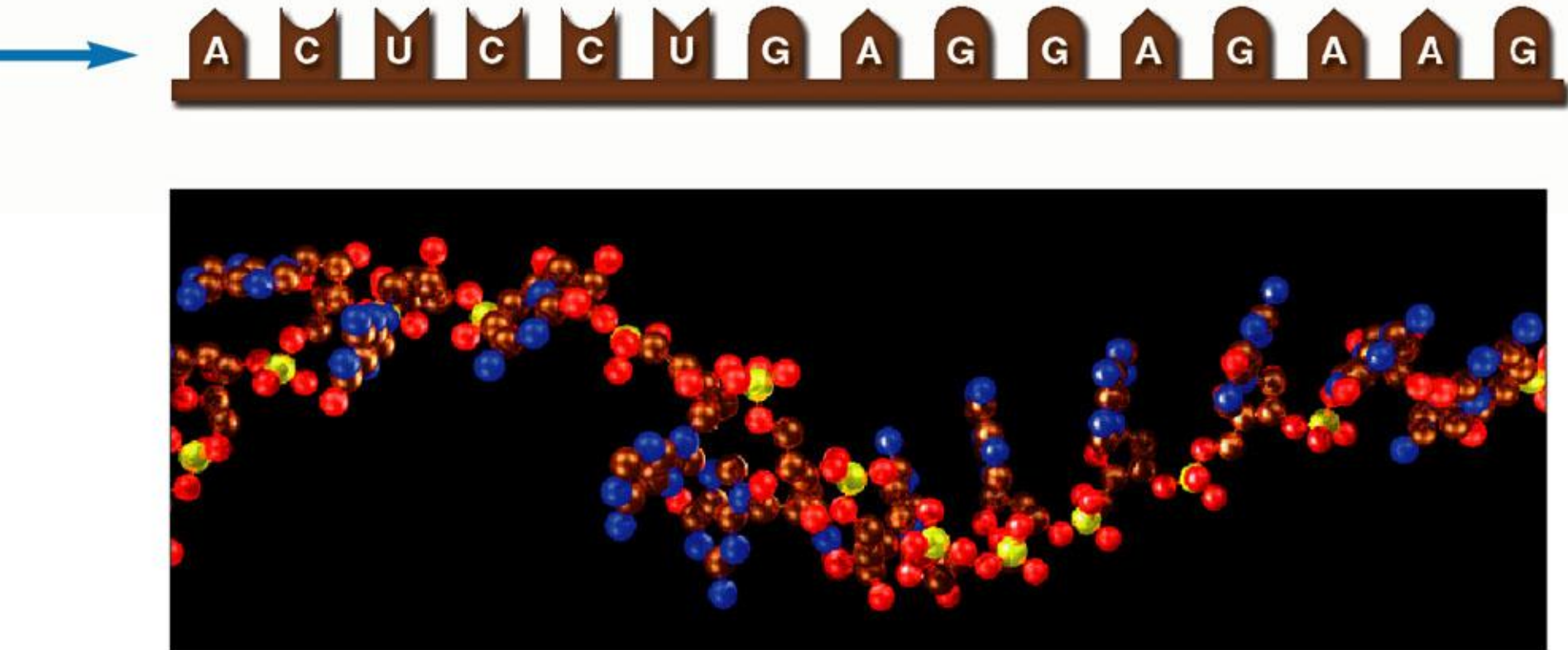
b All through transcription, the DNA double helix becomes unwound in front of the RNA polymerase. Short lengths of the newly forming RNA strand briefly wind up with its DNA template strand. New stretches of RNA unwind from the template (and the two DNA strands wind up again).

Adding Nucleotides



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c What happened at the assembly site? RNA polymerase catalyzed the assembly of ribonucleotides, one after another, into an RNA strand, using exposed bases on the DNA as a template. Many other proteins assist this process.



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d At the end of the gene region, the last stretch of the new transcript is unwound and released from the DNA template. Shown below is a model for a transcribed strand of RNA.

<http://www.stolaf.edu/people/giannini/fla-shanimat/molgenetics/transcription.swf>

http://highered.mcgraw-hill.com/sites/dl/free/0072995246/291136/mRNA_synthesis.swf

Transcript Modification

unit of transcription in a DNA strand

exon

intron

exon

intron

exon



transcription into pre-mRNA

cap

poly-A tail



snipped out

snipped out



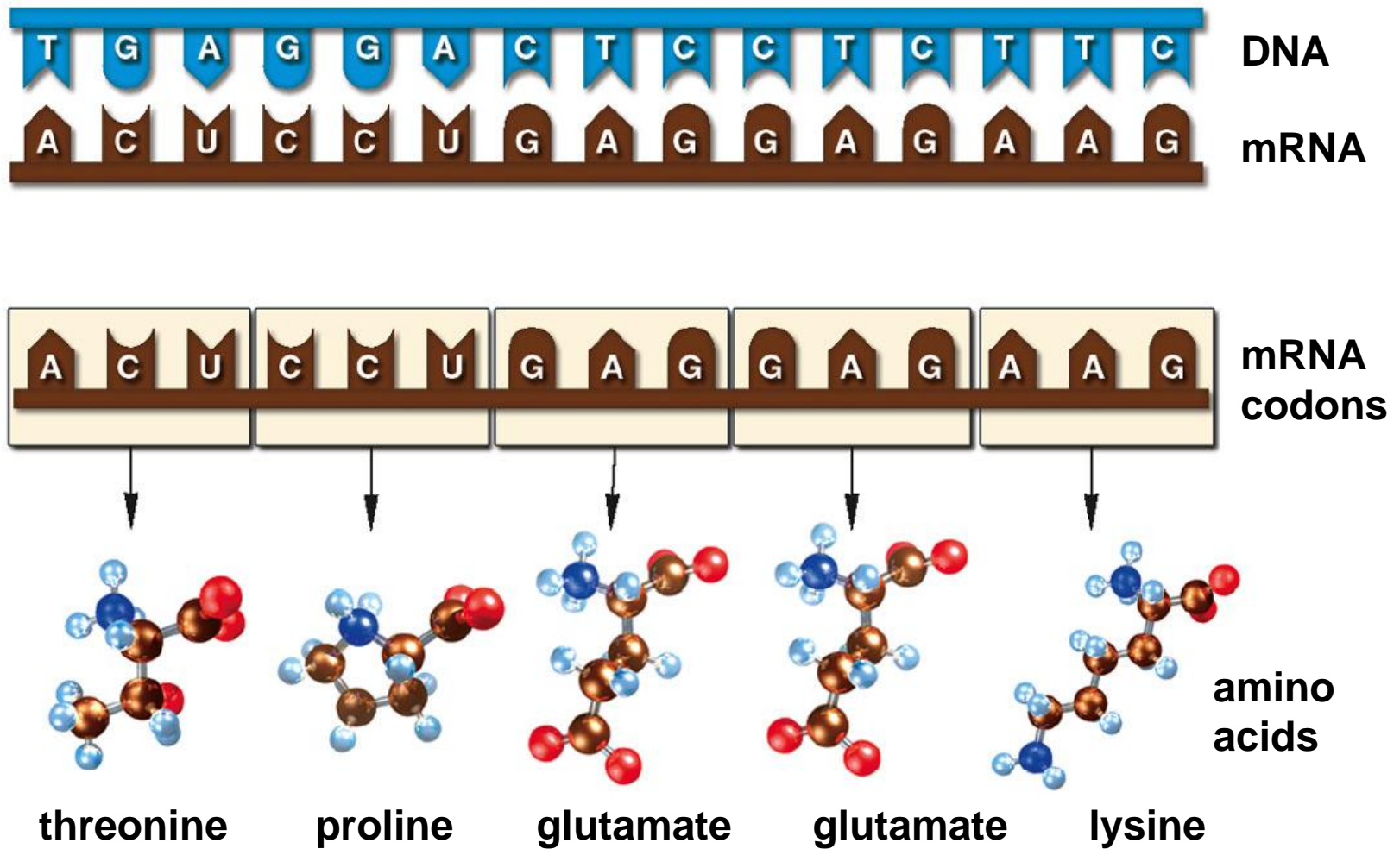
mature mRNA transcript

Genetic Code

- Set of 64 base triplets
- Codons
- 61 specify amino acids
- 3 stop translation

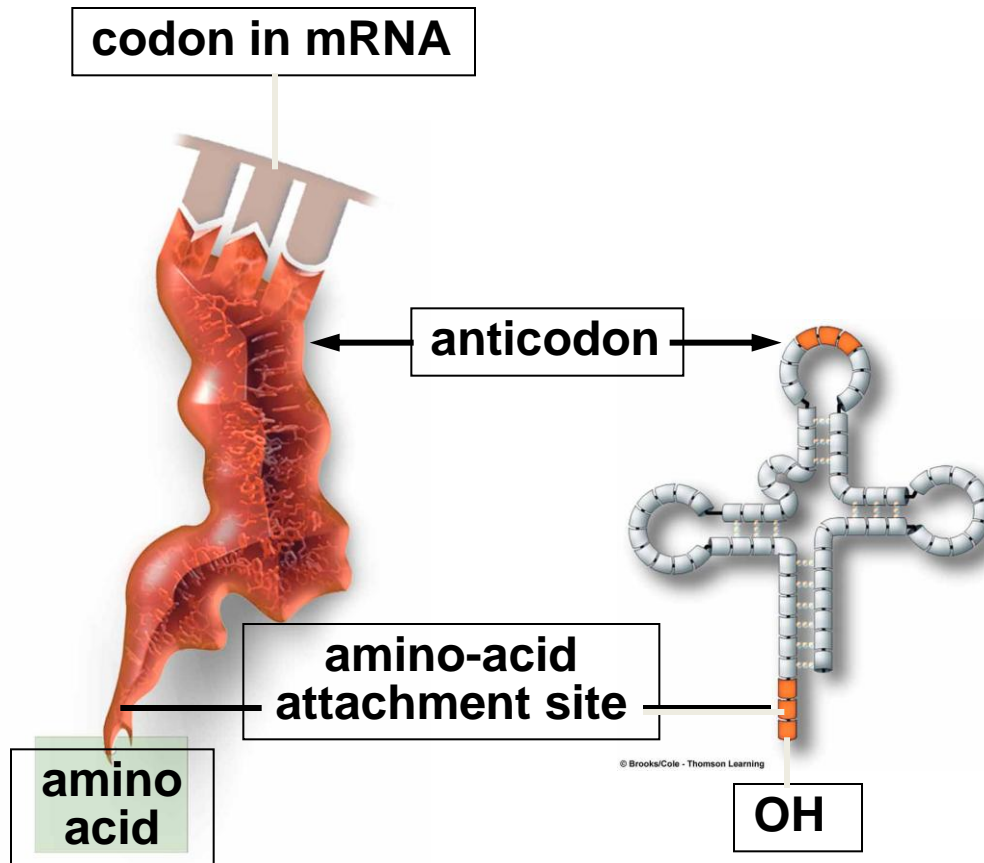
first base	second base				third base
	U	C	A	G	
U	phenylalanine	serine	tyrosine	cysteine	U
	phenylalanine	serine	tyrosine	cysteine	C
	leucine	serine	STOP	STOP	A
	leucine	serine	STOP	tryptophan	G
C	leucine	proline	histidine	arginine	U
	leucine	proline	histidine	arginine	C
	leucine	proline	glutamine	arginine	A
	leucine	proline	glutamine	arginine	G
A	isoleucine	threonine	asparagine	serine	U
	isoleucine	threonine	asparagine	serine	C
	isoleucine	threonine	lysine	arginine	A
	methionine (or START)	threonine	lysine	arginine	G
G	valine	alanine	aspartate	glycine	U
	valine	alanine	aspartate	glycine	C
	valine	alanine	glutamate	glycine	A
	valine	alanine	glutamate	glycine	G

Genetic Code



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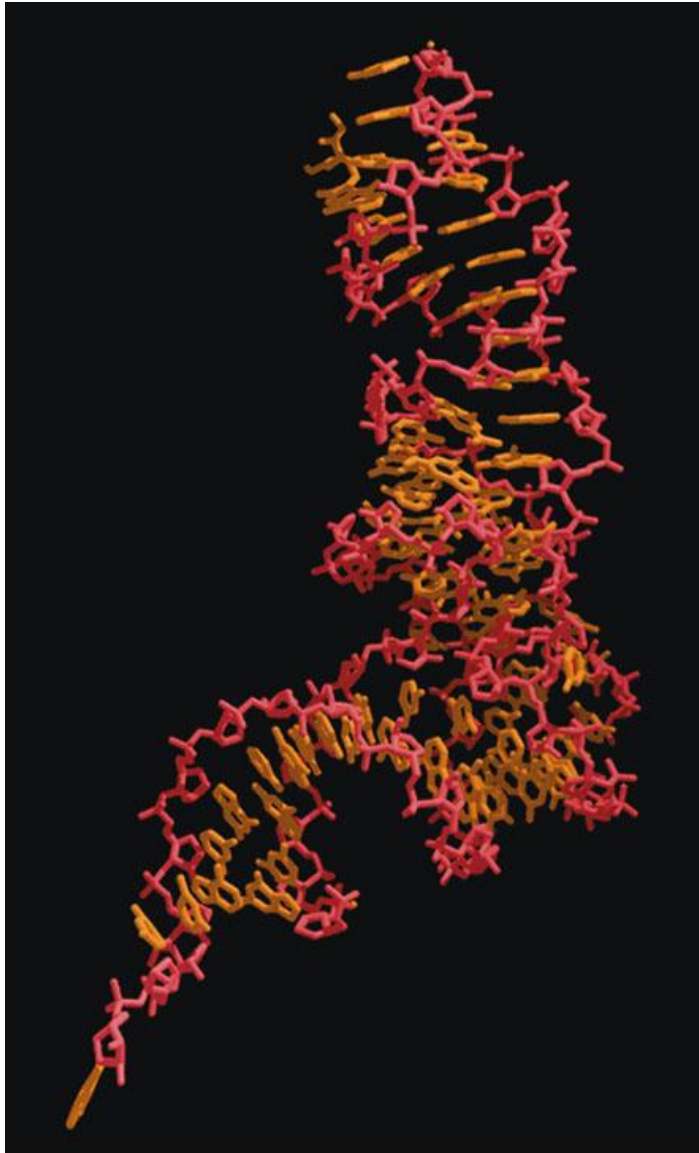
tRNA Structure



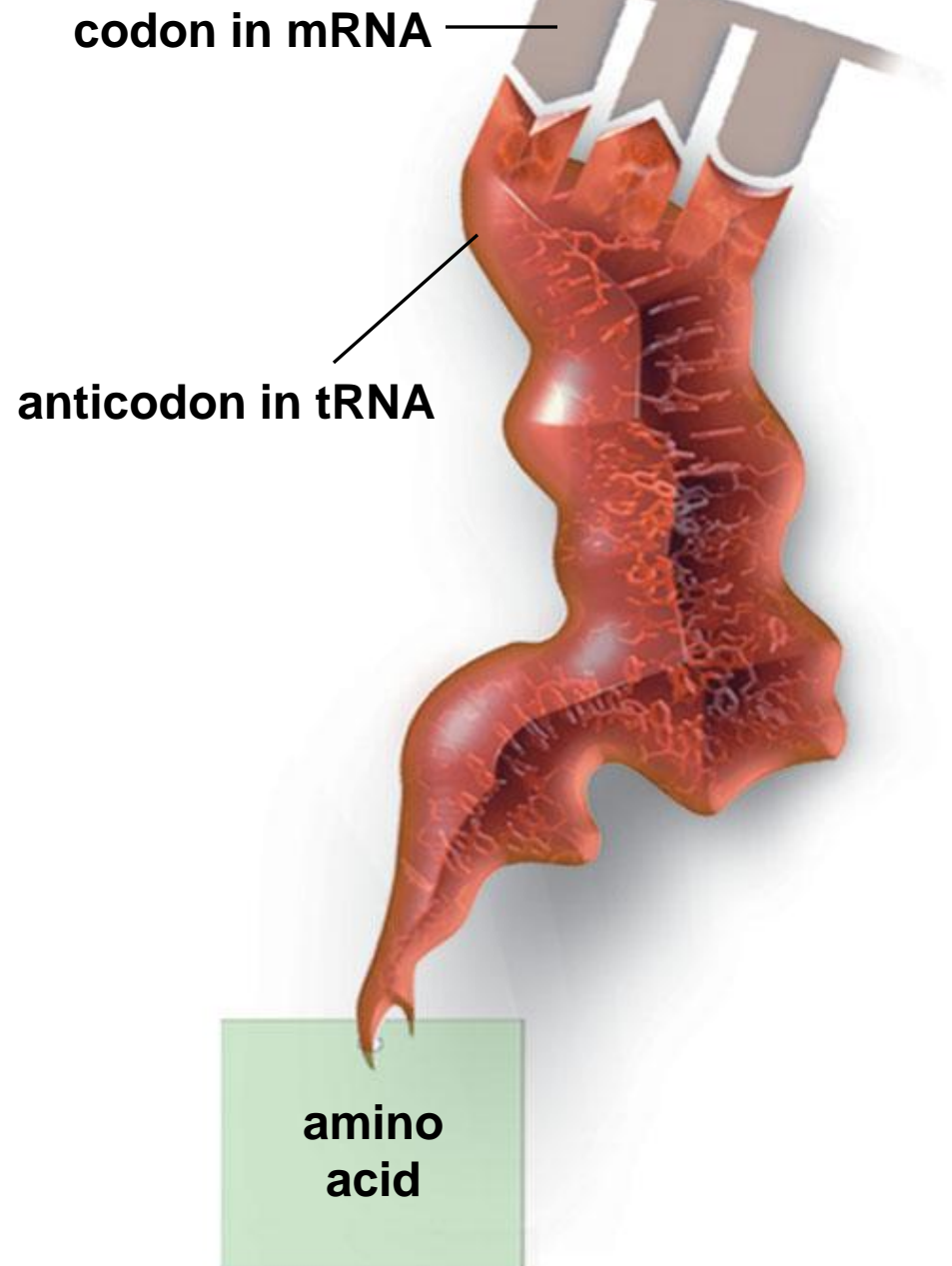
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Figure 14.7
Page 223

tRNA Structure



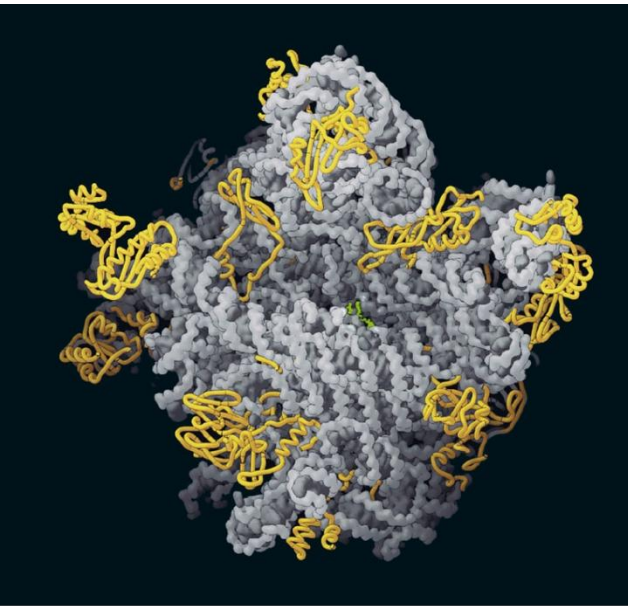
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Fig. 14-7, p.223

Ribosomes



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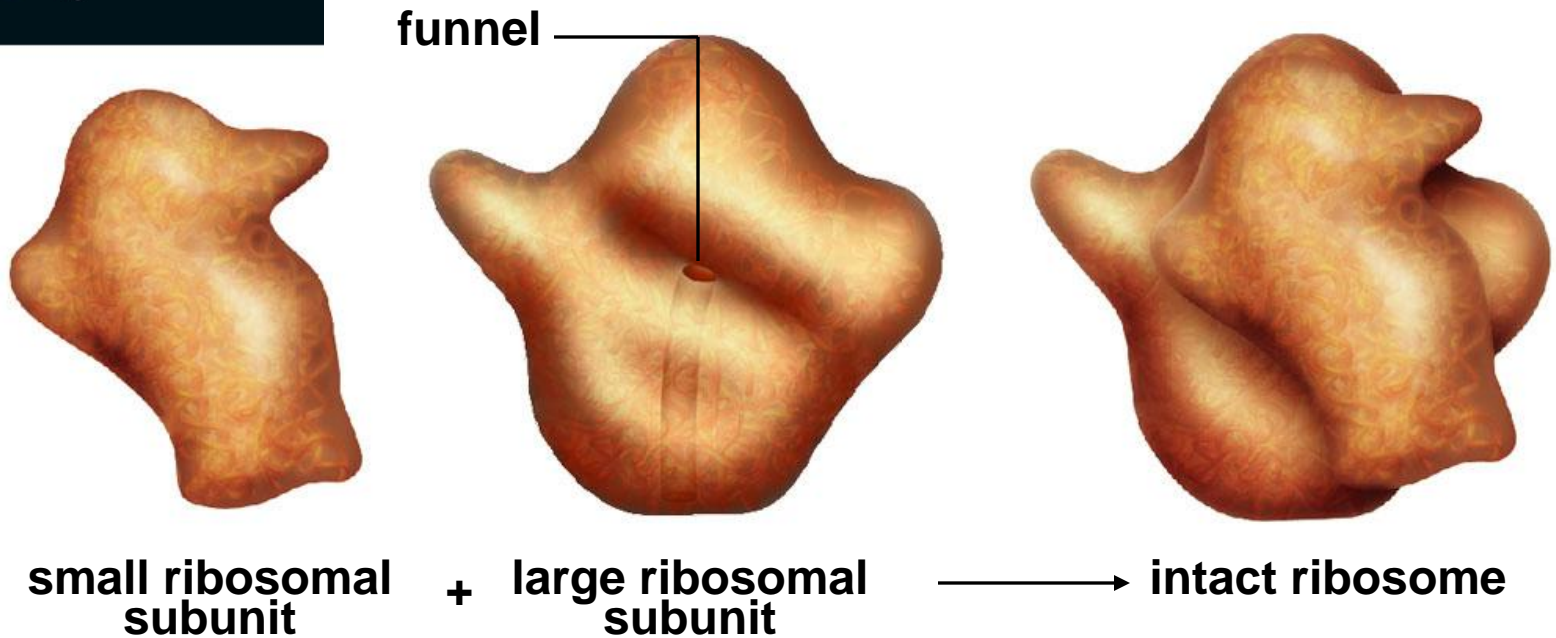


Fig. 14-8, p.223

Three Stages of Translation

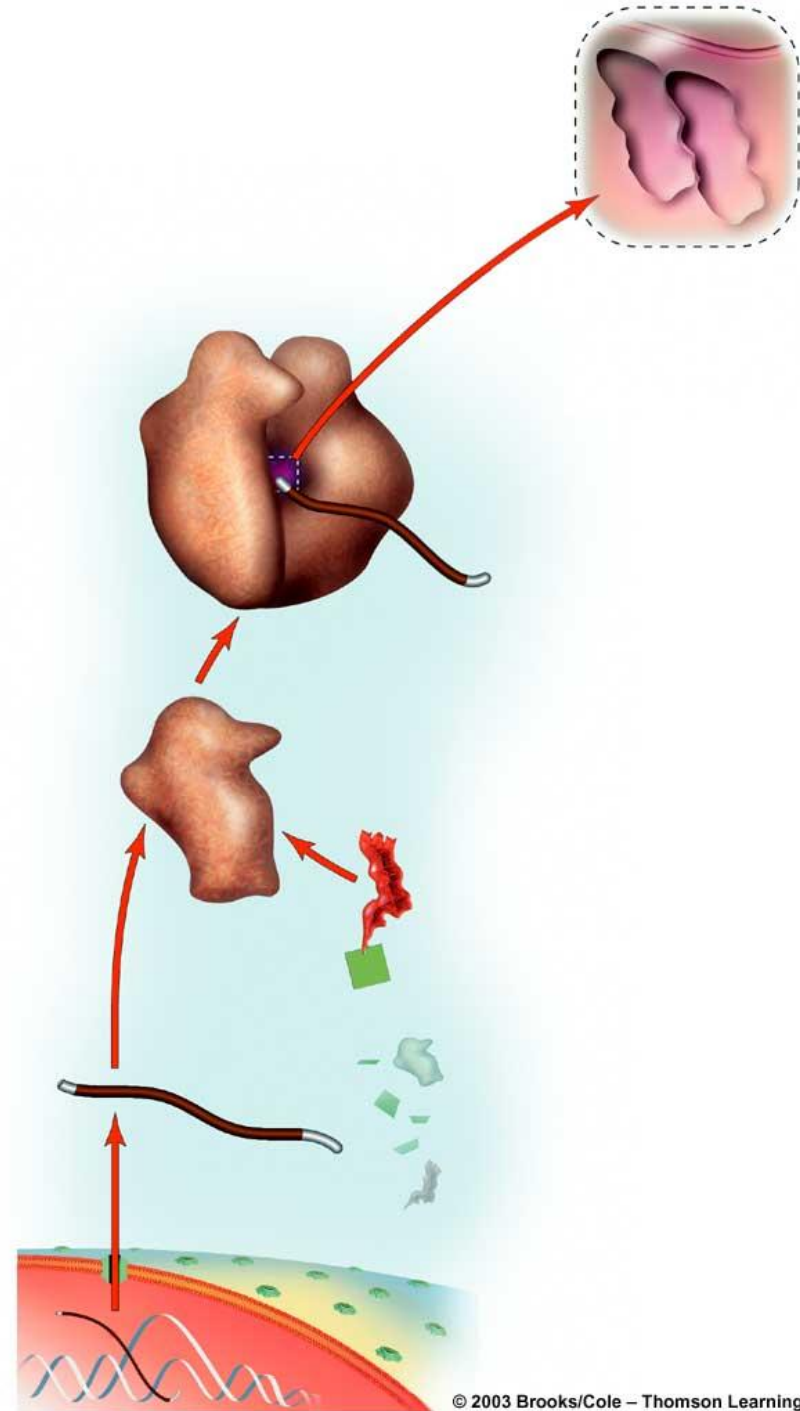
Initiation

Elongation

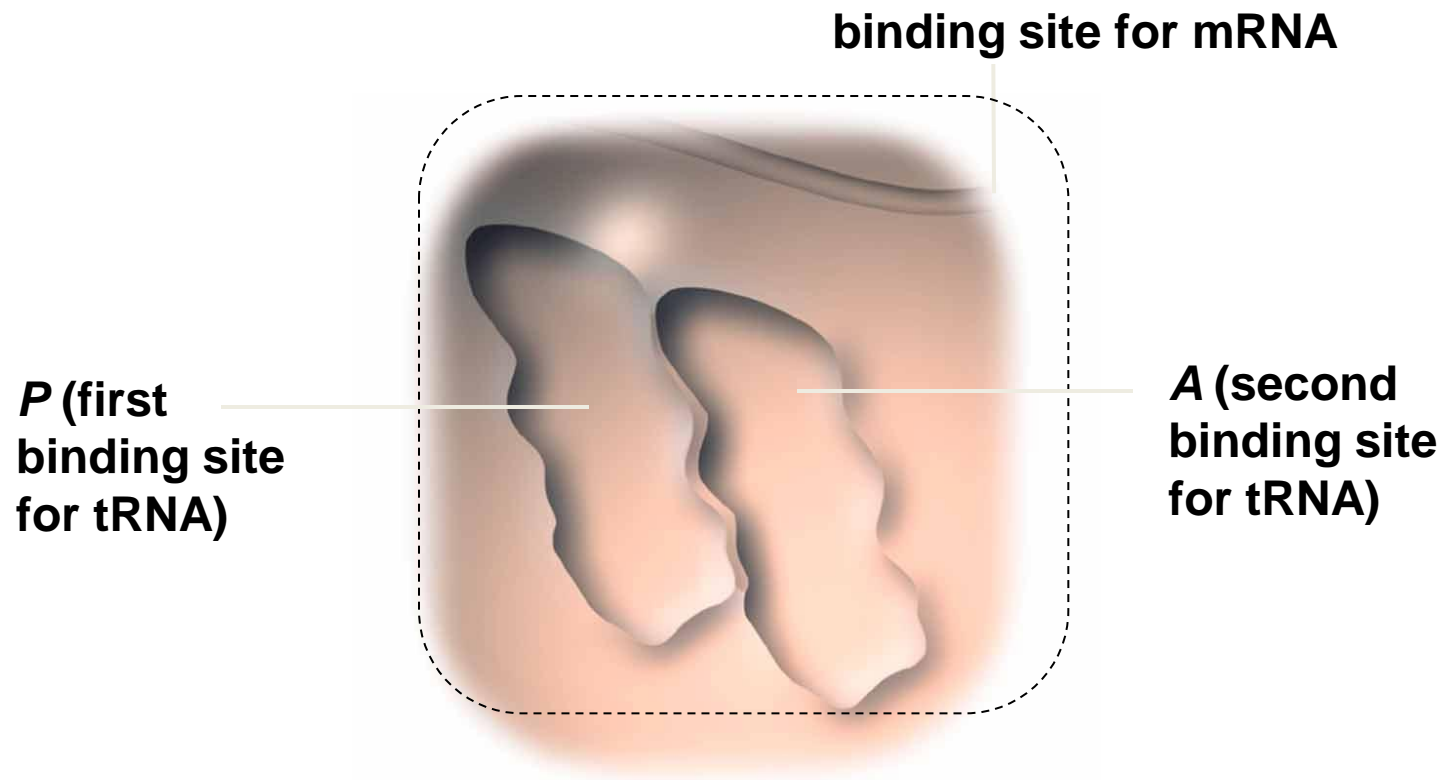
Termination

Initiation

- **Initiator tRNA binds to small ribosomal subunit**
- Small subunit/tRNA complex attaches to mRNA and moves along it to an AUG “start” codon
- Large ribosomal subunit joins complex



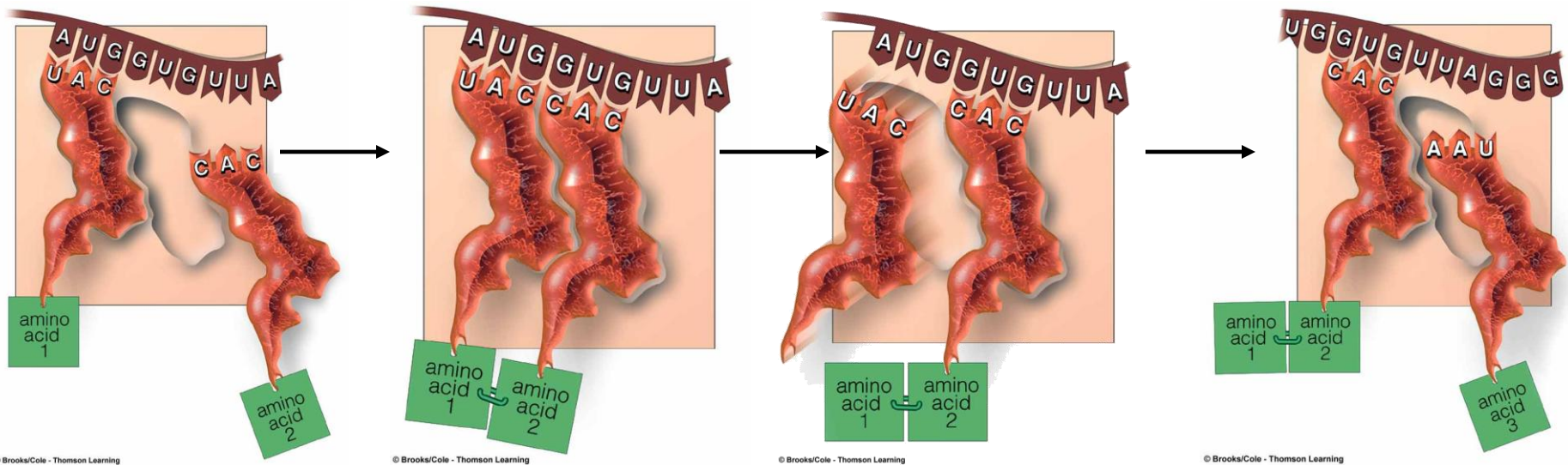
Binding Sites



Elongation

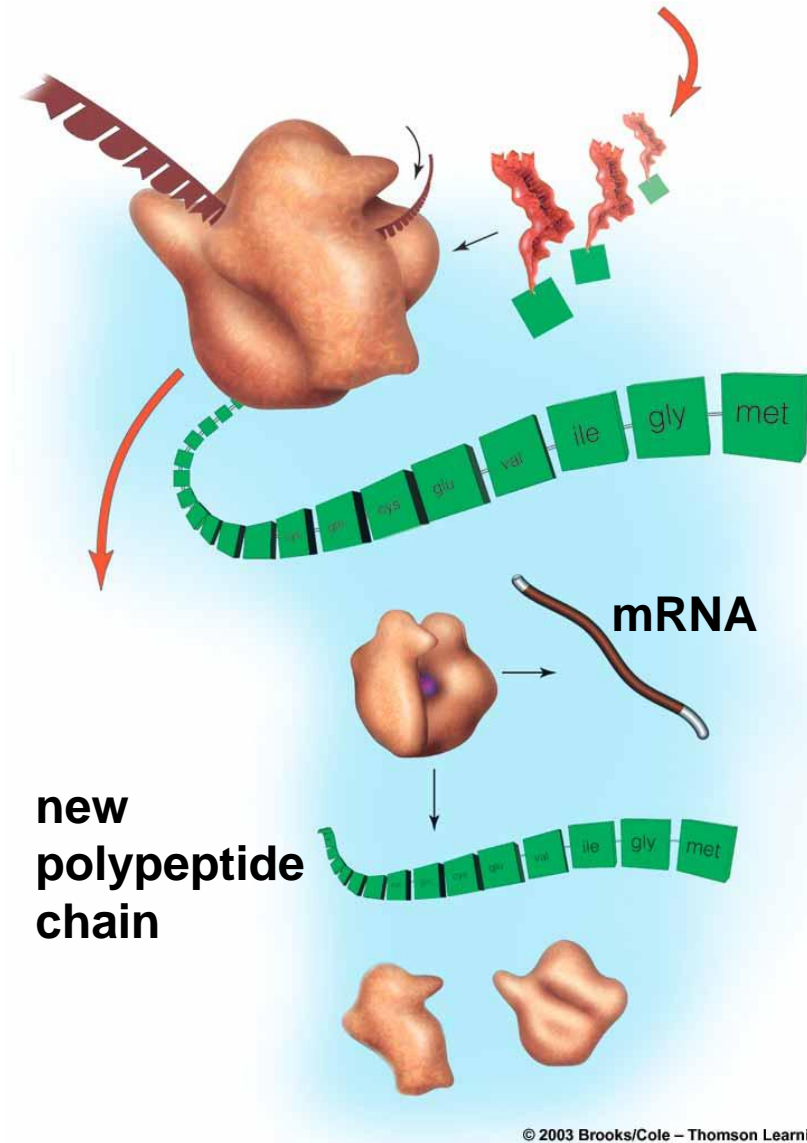
- mRNA passes through ribosomal subunits
- **tRNAs deliver amino acids to the ribosomal binding site in the order specified by the mRNA**
- **Peptide bonds form between the amino acids and the polypeptide chain grows**

Elongation



Termination

- **Stop codon into place**
- No tRNA with anticodon
- Release factors bind to the ribosome
- **mRNA and polypeptide are released**

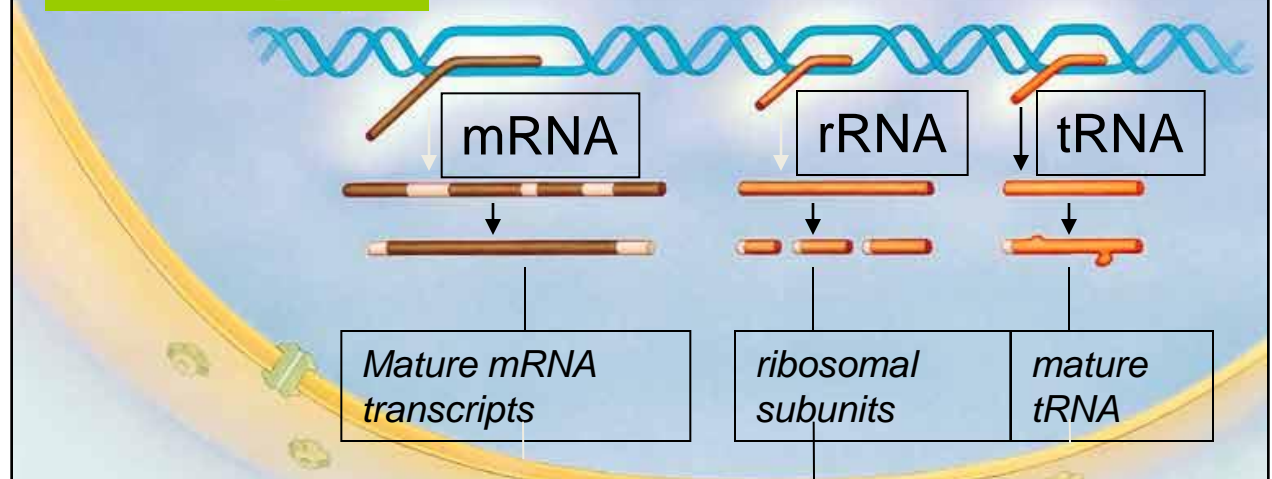


What Happens to the New Polypeptides?

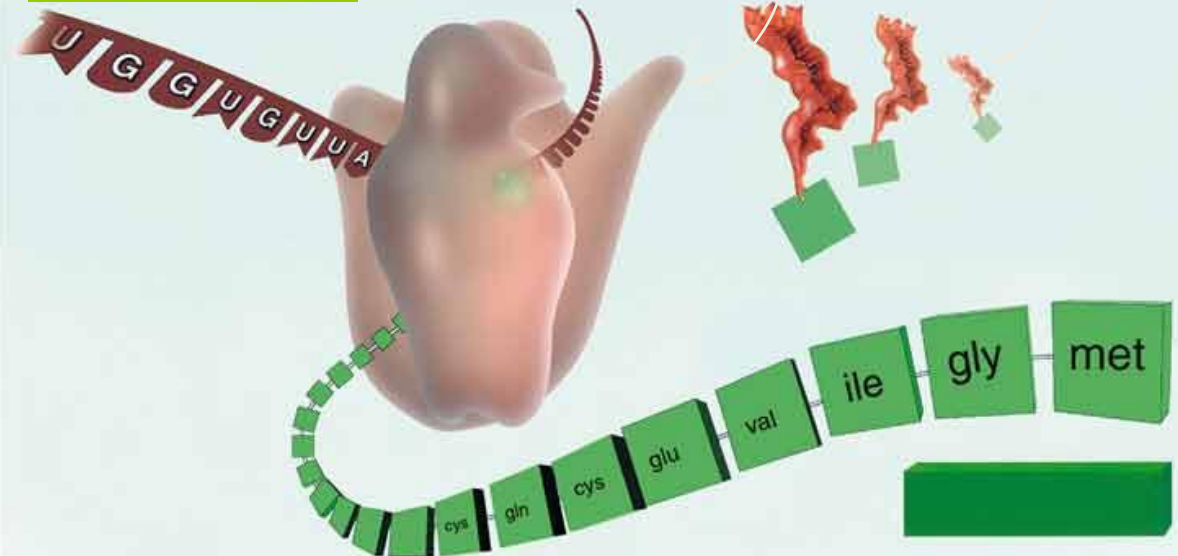
- **Some just enter the cytoplasm**
- **Many enter the endoplasmic reticulum**

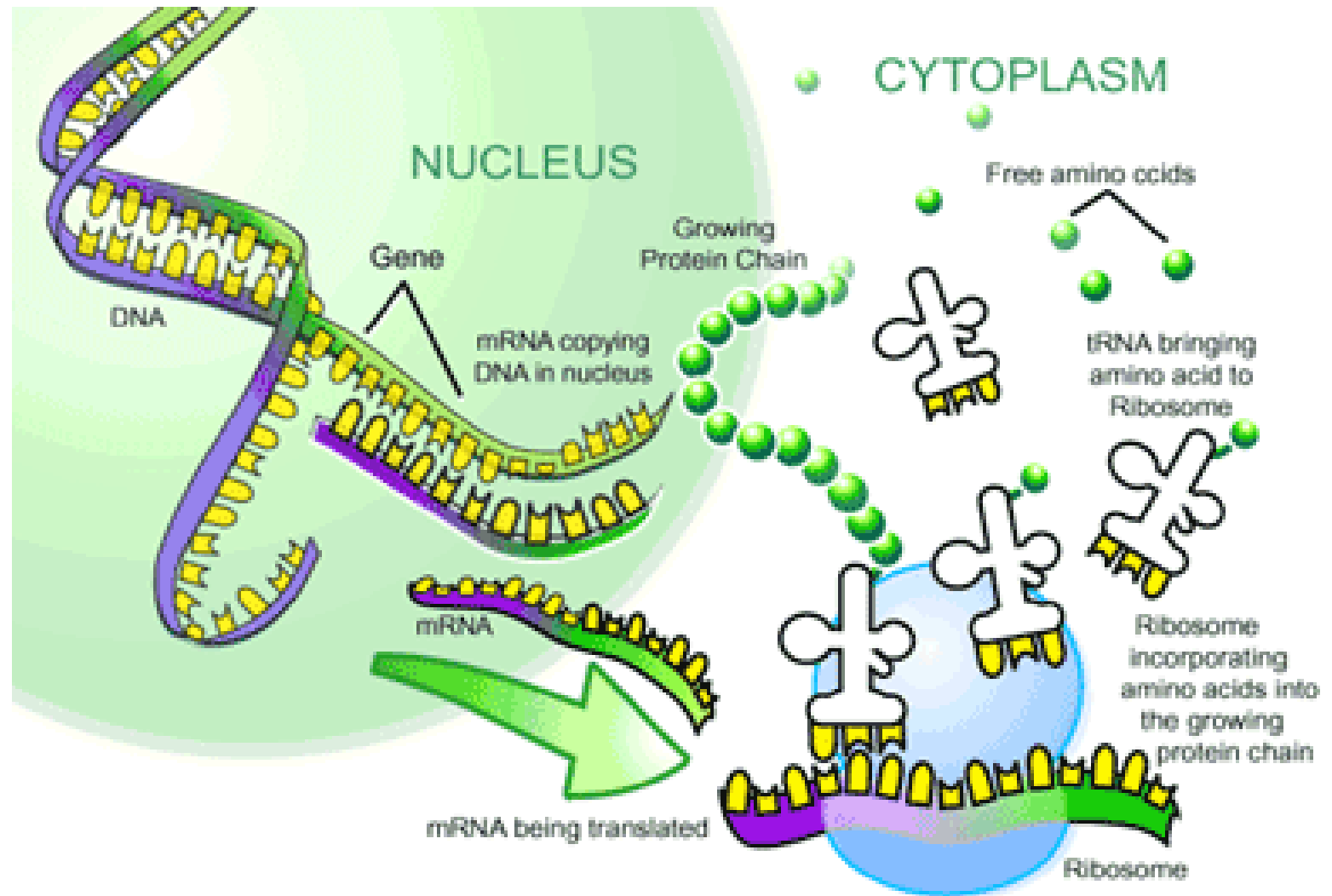
Overview

Transcription



Translation





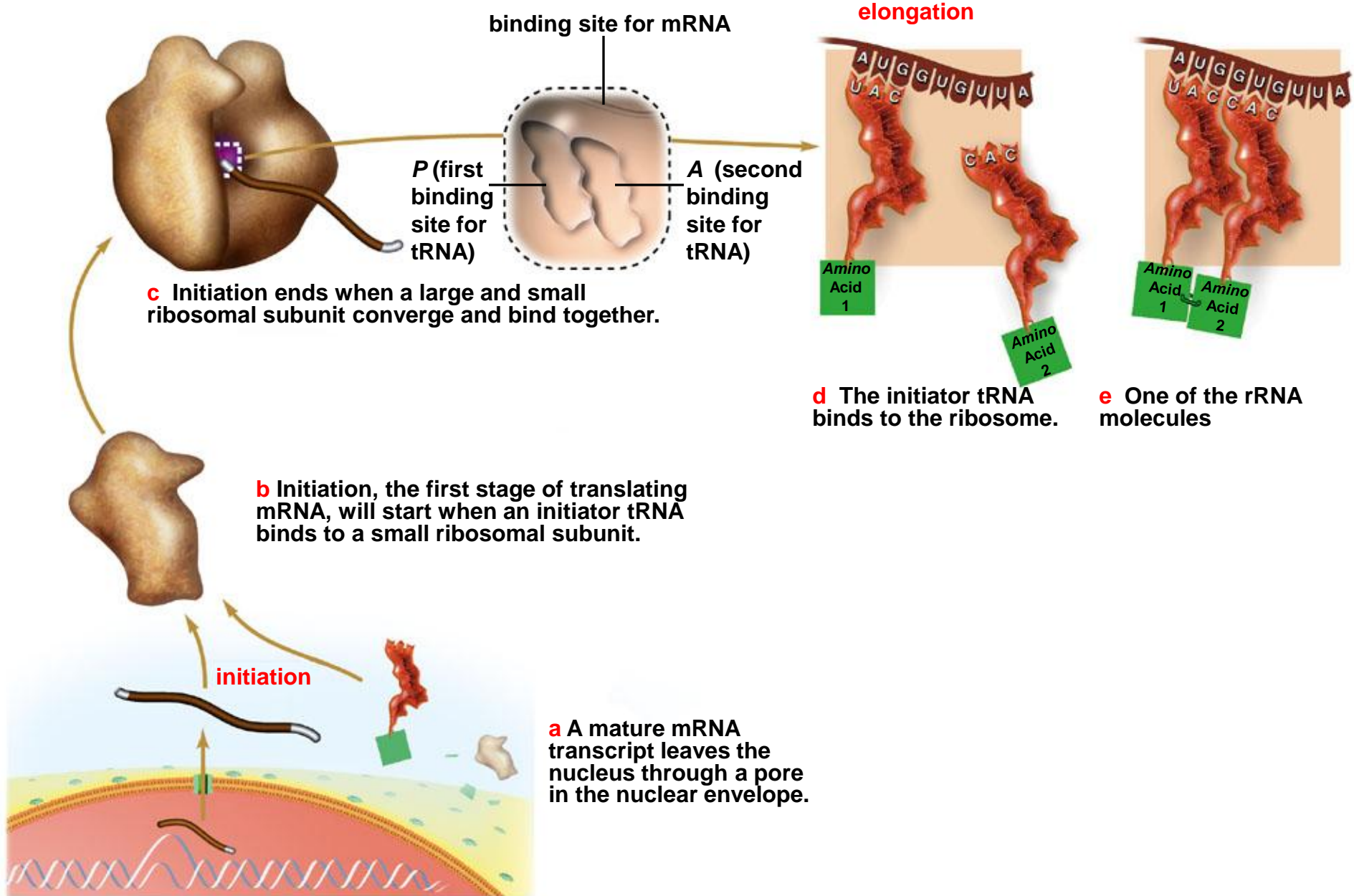
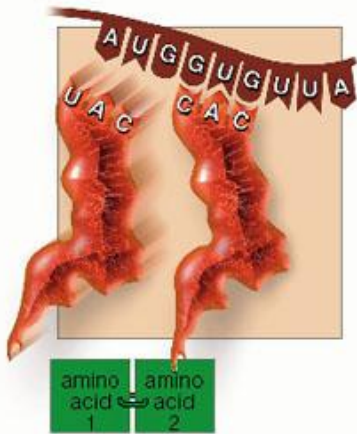
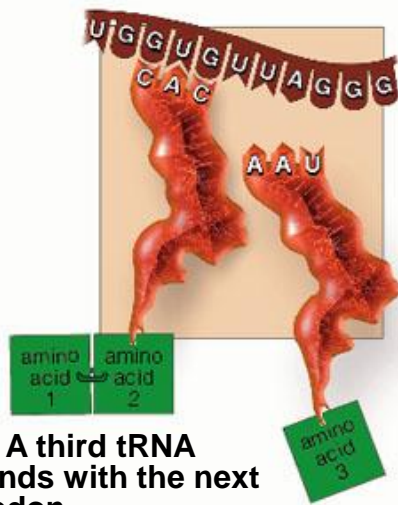


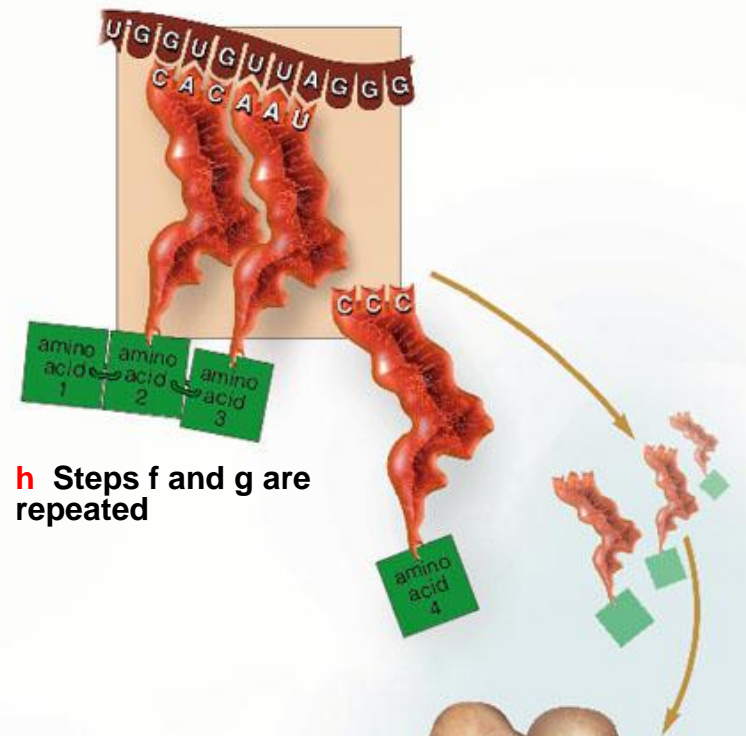
Fig. 14-9a-e, p.224



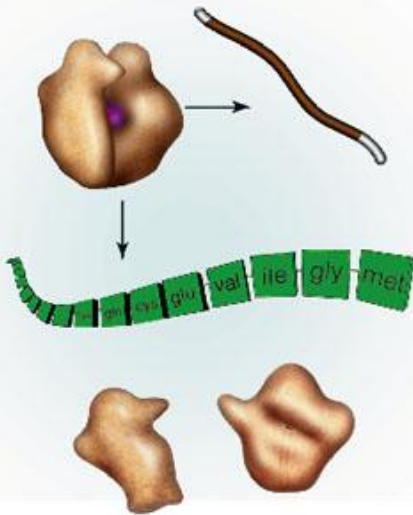
f The first tRNA is released



g A third tRNA binds with the next codon



h Steps f and g are repeated



termination

i A STOP codon moves into the area where the chain is being built.

j The new polypeptide chain is released from the ribosome.



k The two ribosomal subunits now separate, also.

<http://www.stolaf.edu/people/giannini/flashanimat/molgenetics/translation.swf>

<http://www.youtube.com/watch?v=5bLEDd-PSTQ>

<http://learn.genetics.utah.edu/content/begin/dna/transcribe/>

Gene Mutations

Base-Pair Substitutions

Insertions

Deletions

Frameshift Mutations

- **Insertion**
 - Extra base added into gene region
- **Deletion**
 - Base removed from gene region
- **Both shift the reading frame**
- **Result in many wrong amino acids**

Base-Pair Substitution

original base triplet
in a DNA strand



a base substitution
within the triplet (red)

During replication, proofreading
enzymes make a substitution

possible outcomes:



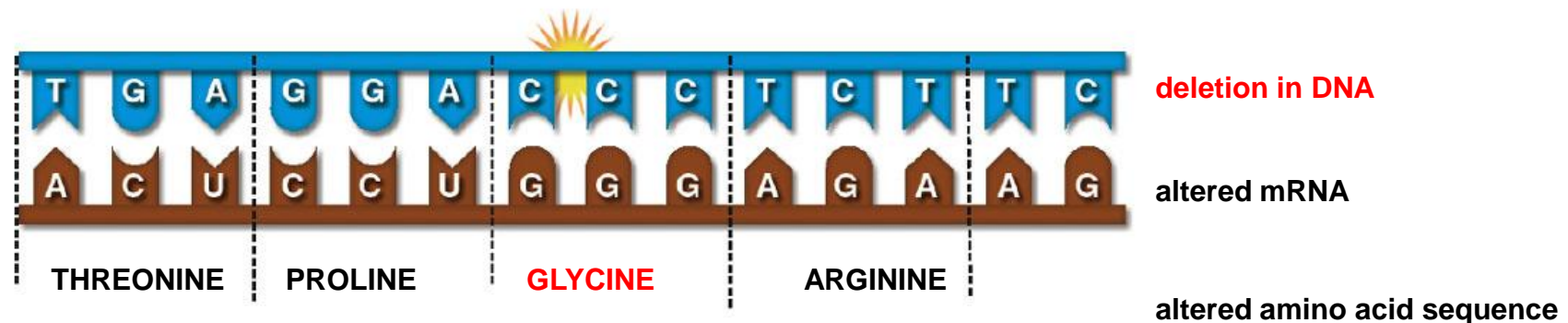
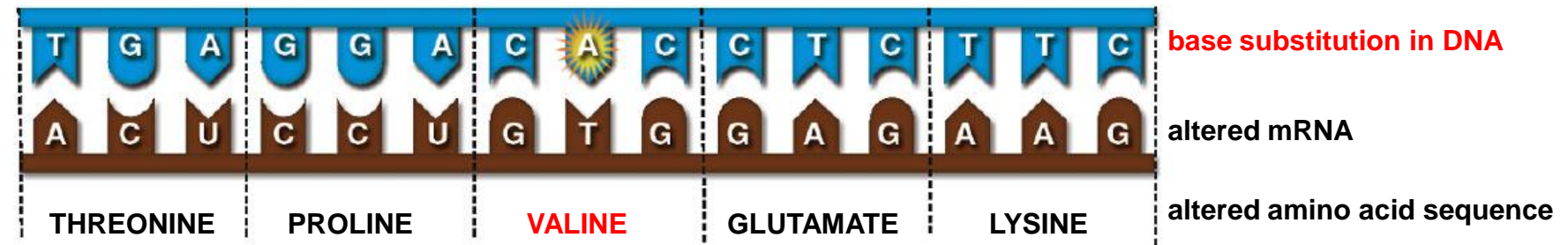
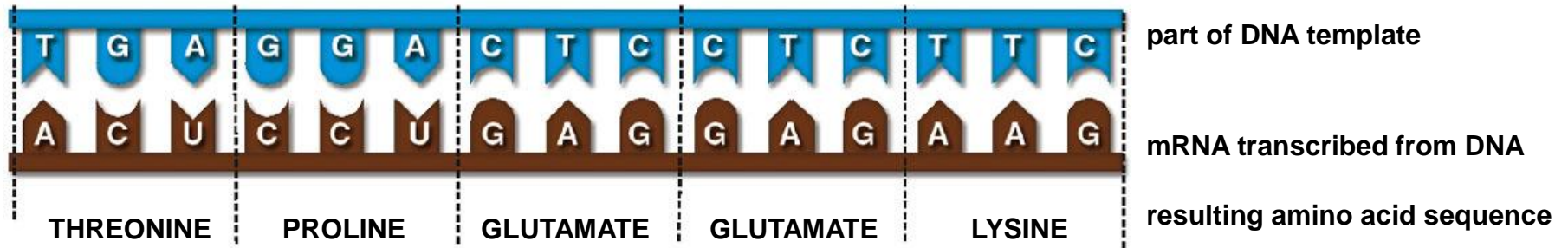
original, unmutated
sequence

or



a gene mutation

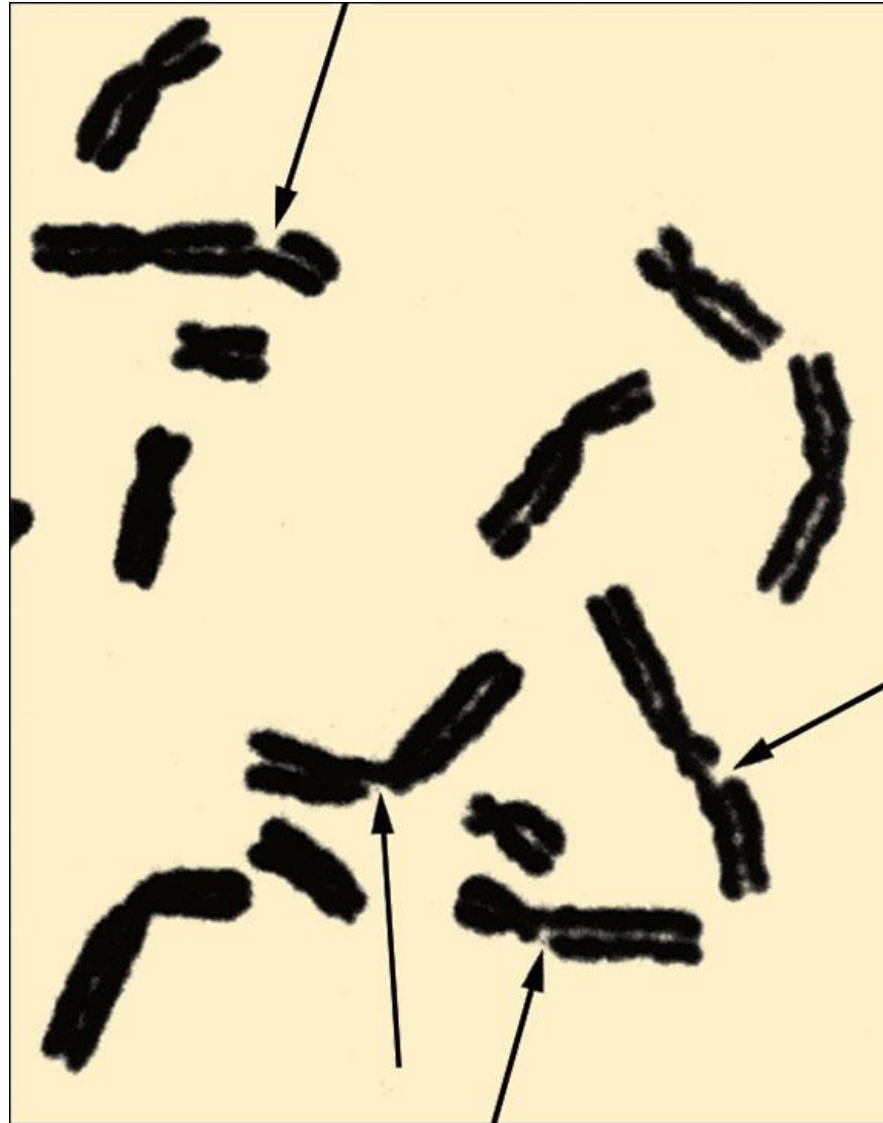
Frameshift Mutation

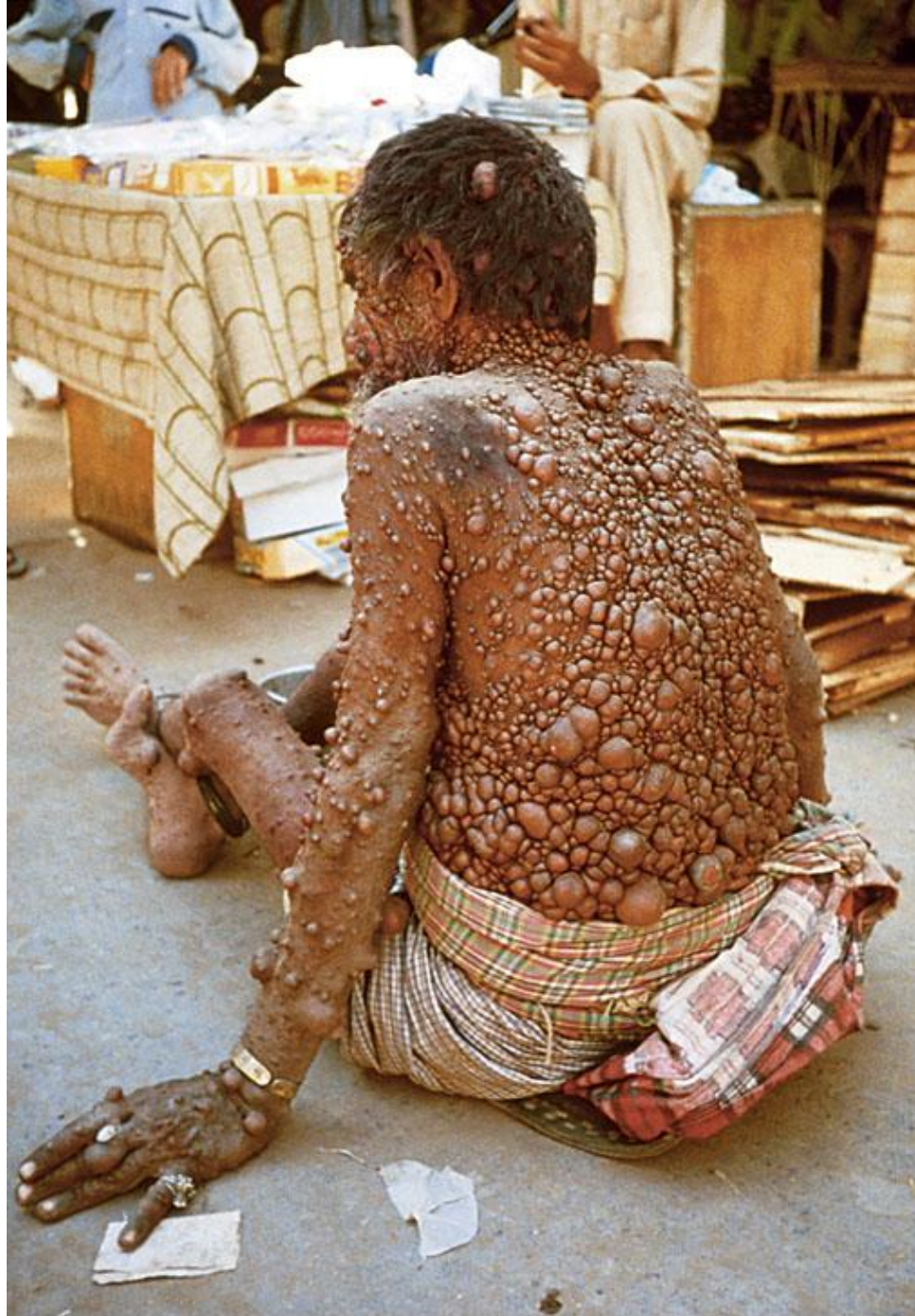


Mutagens

- Ionizing radiation (X rays)
- Nonionizing radiation (UV)
- Natural and synthetic chemicals

Ionizing Radiation





first base	second base				third base
	U	C	A	G	
U	phenylalanine	serine	tyrosine	cysteine	U
	phenylalanine	serine	tyrosine	cysteine	C
	leucine	serine	STOP	STOP	A
	leucine	serine	STOP	tryptophan	G
C	leucine	proline	histidine	arginine	U
	leucine	proline	histidine	arginine	C
	leucine	proline	glutamine	arginine	A
	leucine	proline	glutamine	arginine	G
A	isoleucine	threonine	asparagine	serine	U
	isoleucine	threonine	asparagine	serine	C
	isoleucine	threonine	lysine	arginine	A
	methionine (or START)	threonine	lysine	arginine	G
G	valine	alanine	aspartate	glycine	U
	valine	alanine	aspartate	glycine	C
	valine	alanine	glutamate	glycine	A
	valine	alanine	glutamate	glycine	G