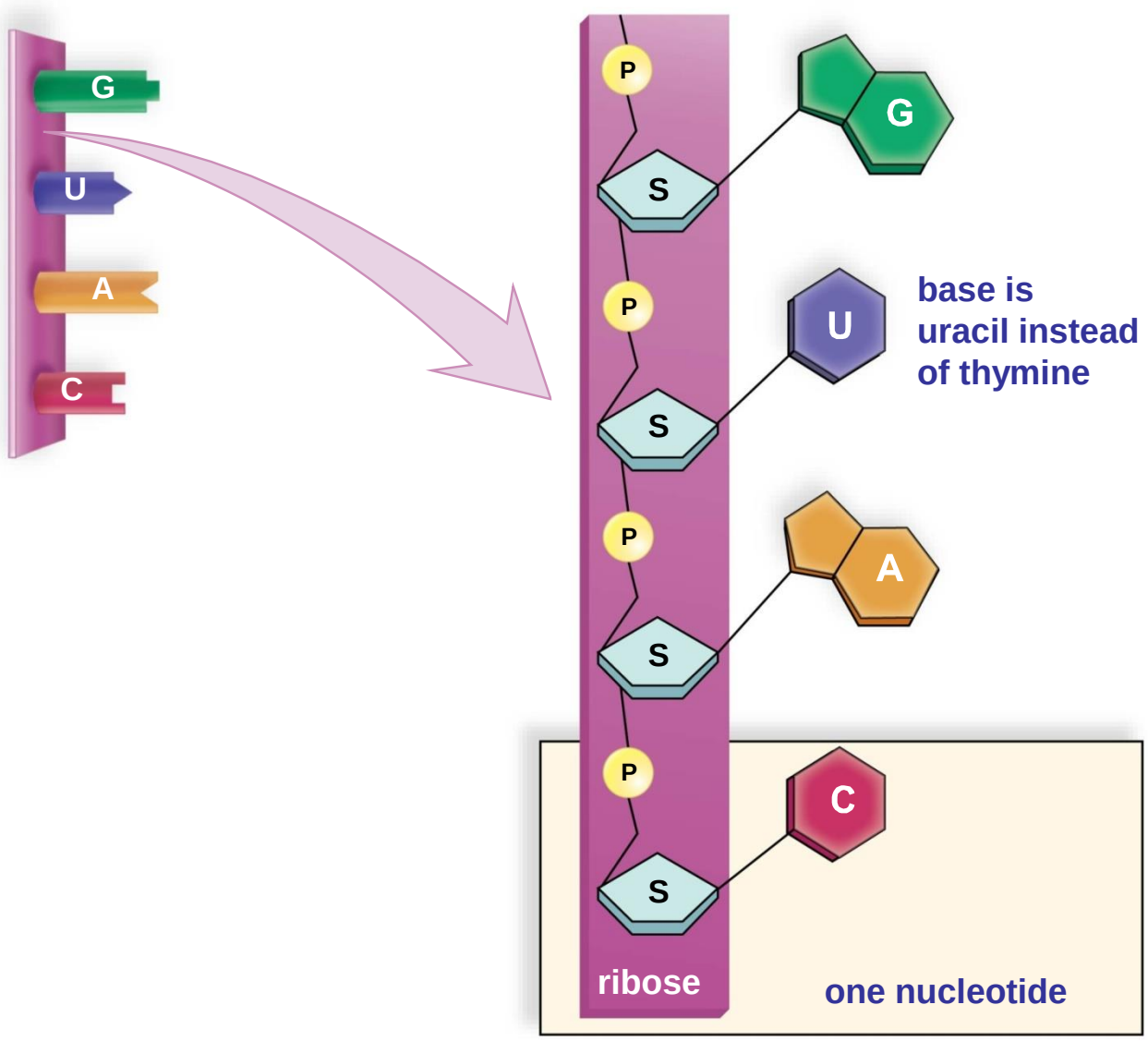
DNA Structure & Function

Chapter 25

25.2 RNA Structure and Function

- RNA (ribonucleic acid)
  - Uracil (U) used instead of thymine (T)
  - Helper to DNA
  - Three major types

Structure of RNA



Comparison of DNA and RNA

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TABLE 25.1 Comparison of DNA and RNA

	DNA	RNA
Sugar	Deoxyribose	Ribose
Bases	Adenine, guanine, thymine, cytosine	Adenine, guanine, uracil, cytosine
Strands	Double stranded	Single stranded
Helix	Yes	No

25.2 RNA Structure and Function

- **Three Classes of RNA**
  - Messenger RNA (mRNA)
    - Produced in nucleus during transcription
    - Takes a message from DNA to the ribosomes
  - Transfer RNA (tRNA)
    - Produced in nucleus
    - Transfers amino acids to ribosomes
    - Each tRNA carries only one type of amino acid
  - Ribosomal RNA (rRNA)
    - Produced in nucleus
    - Makes up ribosomes (along with proteins)

Questions

25.2 p505-506

Questions CYP → p506

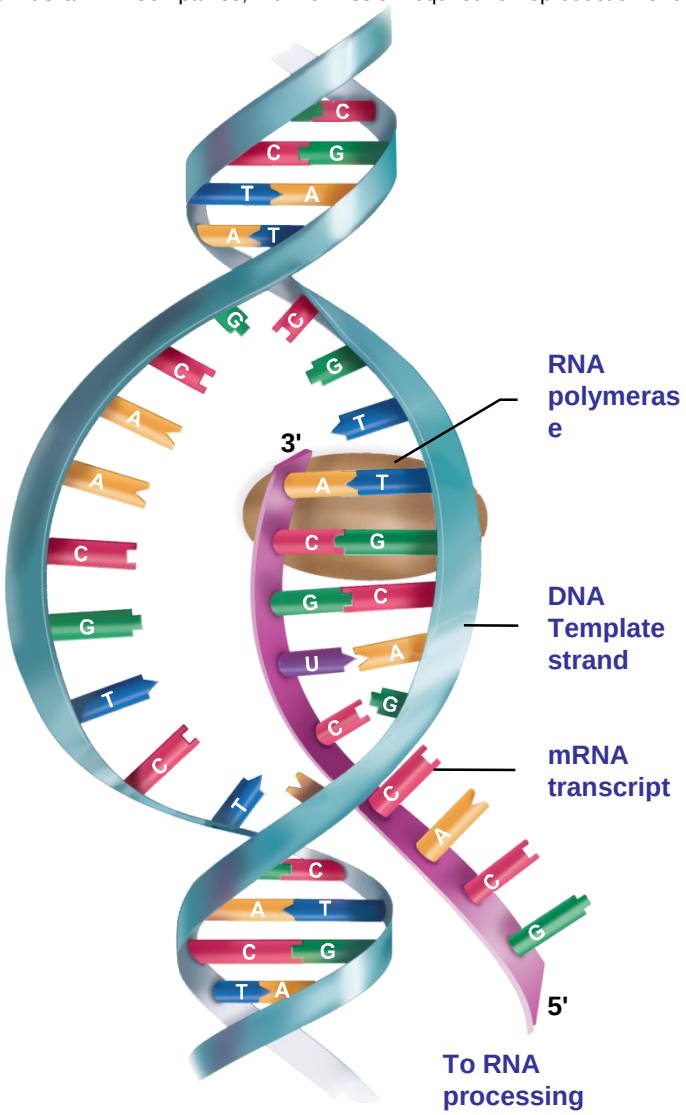
25.3 Gene Expression

- Gene Expression Requires Two Steps
  1. **Transcription**
     - Takes place in the nucleus
     - Portion of DNA serves as a template for mRNA formation
  2. **Translation**
     - Takes place in the cytoplasm
     - Sequence of mRNA bases (which are complementary to those in the template DNA) determines the sequence of amino acids in a polypeptide

25.3 Gene Expression

- **Transcription**
  - During transcription, a gene (segment of the DNA) serves as a template for the production of an RNA molecule
    - All three classes of RNA
  - Messenger RNA (mRNA)
    - RNA polymerase binds to a promoter (in DNA)
    - DNA helix is opened so complementary base pairing can occur
    - RNA polymerase joins new RNA nucleotides in a sequence complementary to that on the DNA

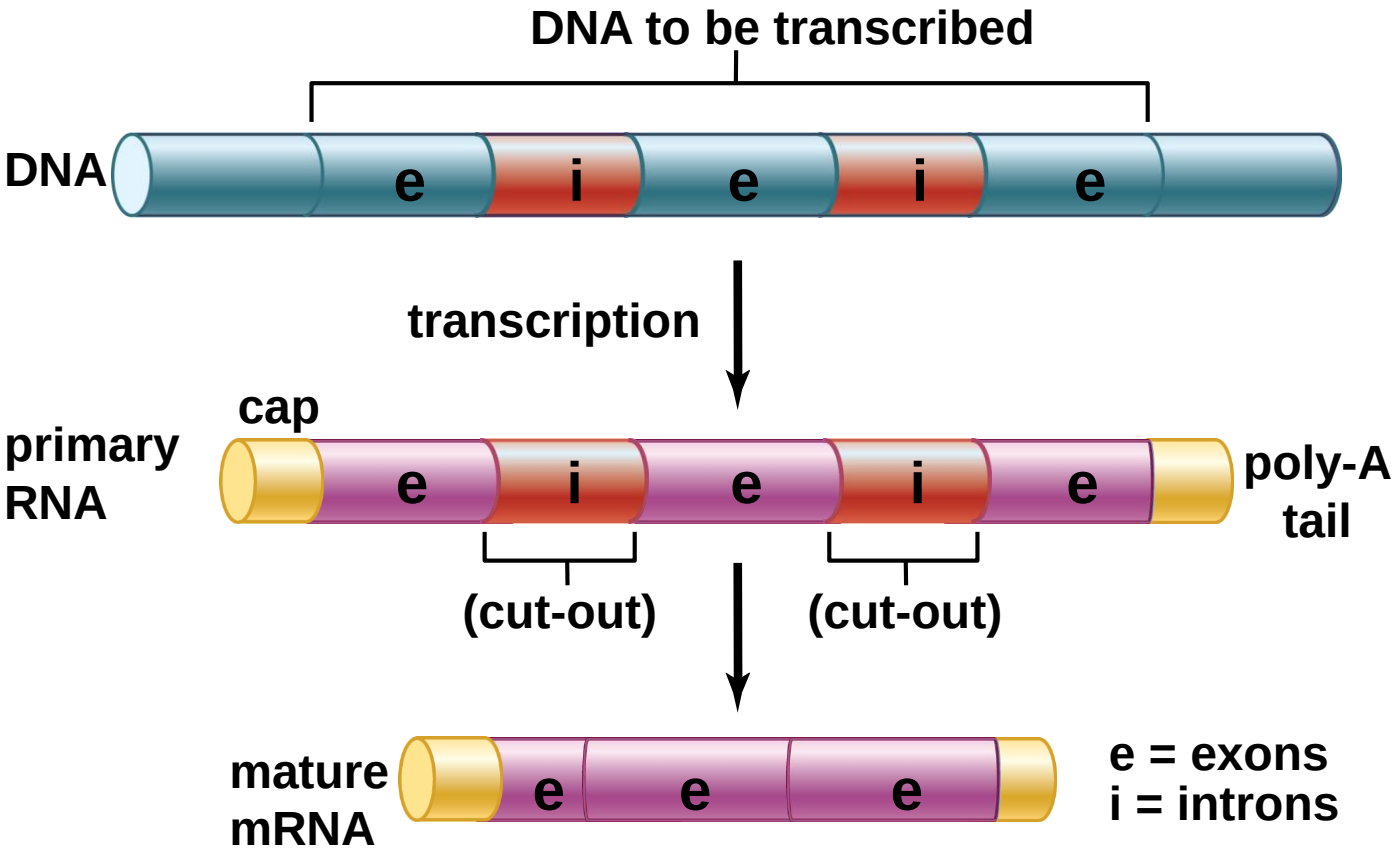
Transcription of DNA to Form mRNA



25.3 Gene Expression

- Transcription
  - Processing of mRNA
    - Primary mRNA contains bases complementary to both **intron** and **exon** segments of DNA
      - **Introns** are intragene segments – will be removed
      - **Exons** are the portion of a gene that is expressed
    - Intron sequences are removed
    - Guanine cap and poly-A tail added
    - Mature mRNA transcript ready

mRNA Processing



25.3 Gene Expression

- Translation
  - Gene expression leads to protein synthesis
  - The Genetic Code
    - Triplet code - each three-nucleotide unit of a mRNA molecule is called a codon
    - There are 64 different mRNA codons
      - 61 code for particular amino acids
        - Redundant code - some amino acids have numerous code words
        - Provides some protection against mutations
      - three are stop codons that signal polypeptide termination

Messenger RNA Codons

See Ch 25 Page 508

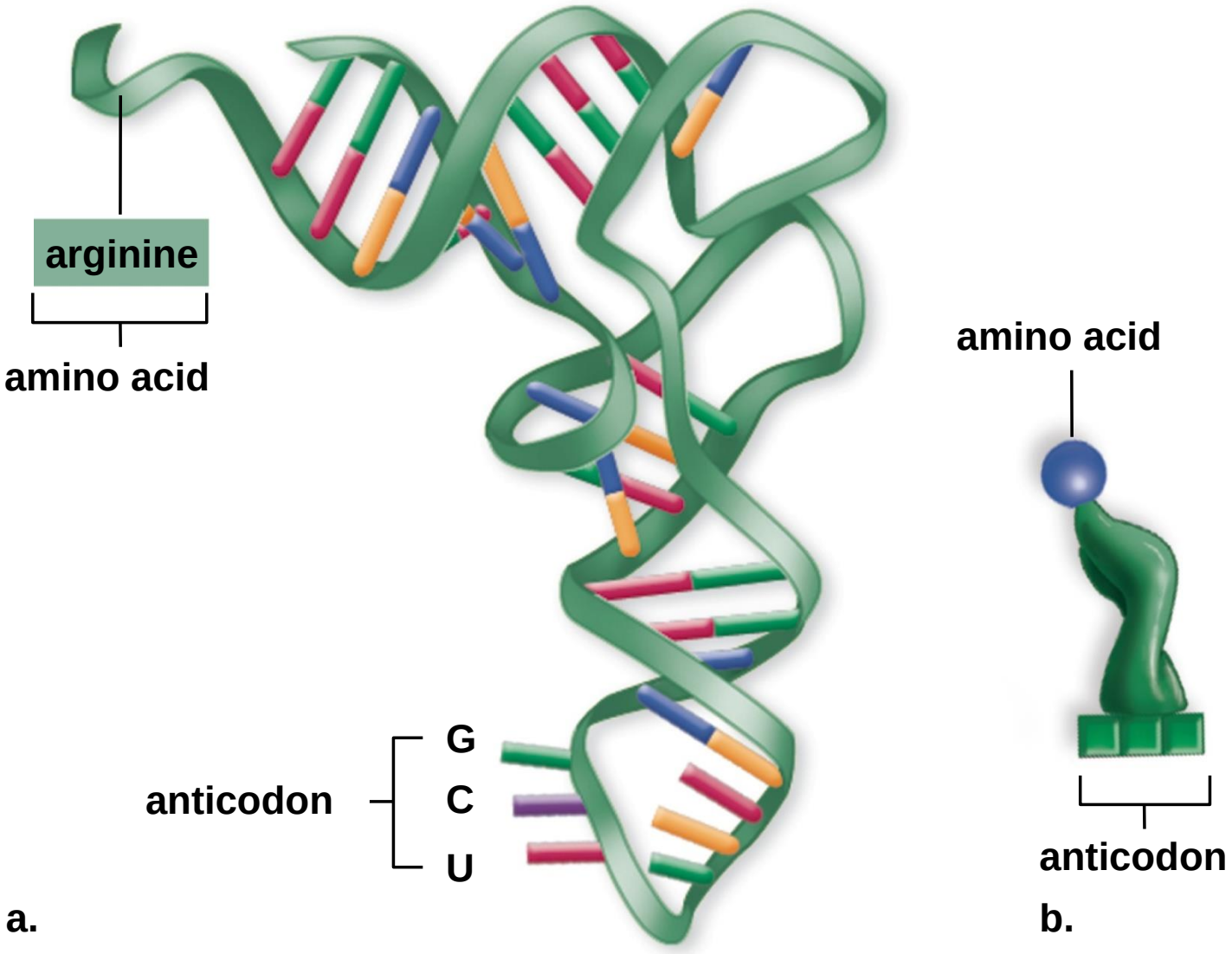
First Base	Second Base				Third Base
	U	C	A	G	
U	UUU phenylalanine	UCU serine	UAU tyrosine	UGU cysteine	U
	UUC phenylalanine	UCC serine	UAC tyrosine	UGC cysteine	C
	UUA leucine	UCA serine	UAA stop	UGA stop	A
	UUG leucine	UCG serine	UAG stop	UGG tryptophan	G
C	CUU leucine	CCU proline	CAU histidine	CGU arginine	U
	CUC leucine	CCC proline	CAC histidine	CGC arginine	C
	CUA leucine	CCA proline	CAA glutamine	CGA arginine	A
	CUG leucine	CCG proline	CAG glutamine	CGG arginine	G
A	AUU isoleucine	ACU threonine	AAU asparagine	AGU serine	U
	AUC isoleucine	ACC threonine	AAC asparagine	AGC serine	C
	AUA isoleucine	ACA threonine	AAA lysine	AGA arginine	A
	AUG (start) methionine	ACG threonine	AAG lysine	AGG arginine	G
G	GUU valine	GCU alanine	GAU aspartate	GGU glycine	U
	GUC valine	GCC alanine	GAC aspartate	GGC glycine	C
	GUA valine	GCA alanine	GAA glutamate	GGA glycine	A
	GUG valine	GCG alanine	GAG glutamate	GGG glycine	G

25.3 Gene Expression

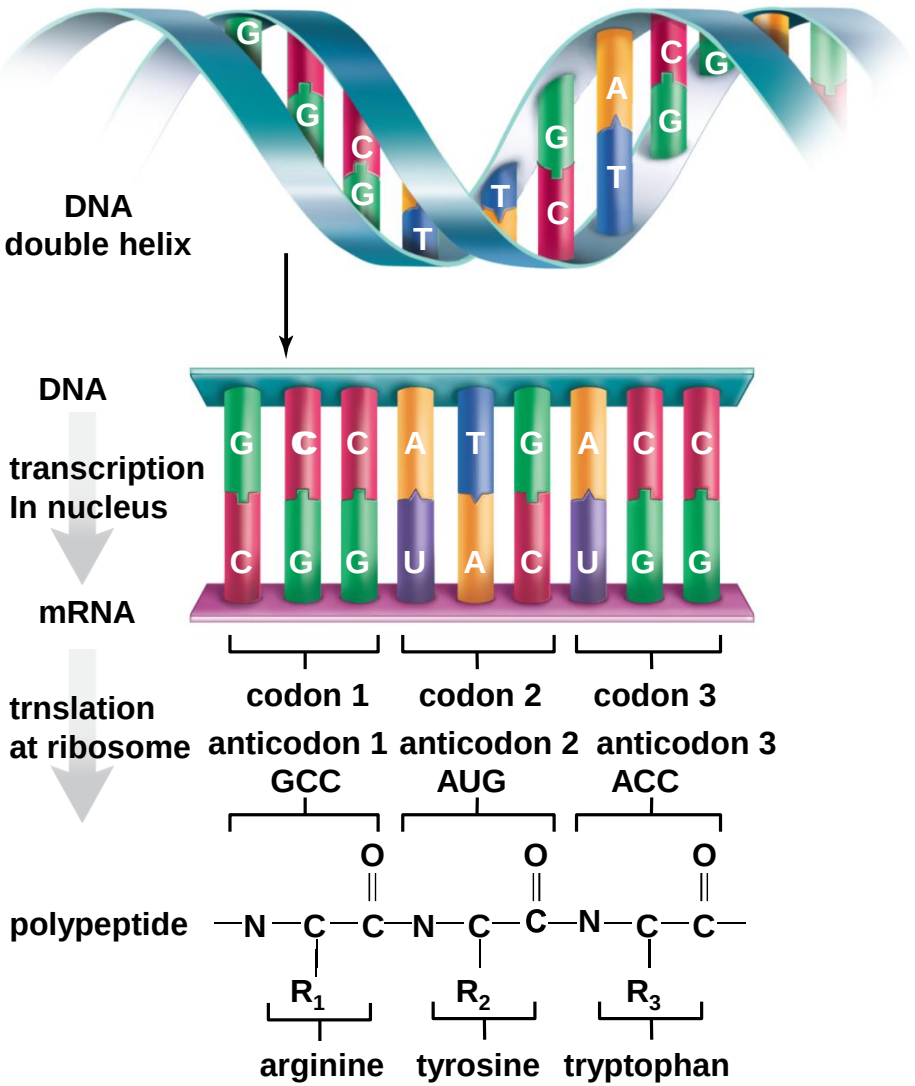
- Transfer RNA
  - tRNA transports amino acids to the ribosomes
  - Boot-like shape
  - Amino acid binds to one end, the opposite end has an anticodon
    - Triplet of three bases complementary to a specific codon of mRNA
  - Order of mRNA codons determines the order in which tRNA brings in amino acids

Codon (mRNA)	Anticodon (tRNA)	Amino Acid (protein)
CGG	GCC	Arginine

Transfer RNA: Amino Acid Carrier

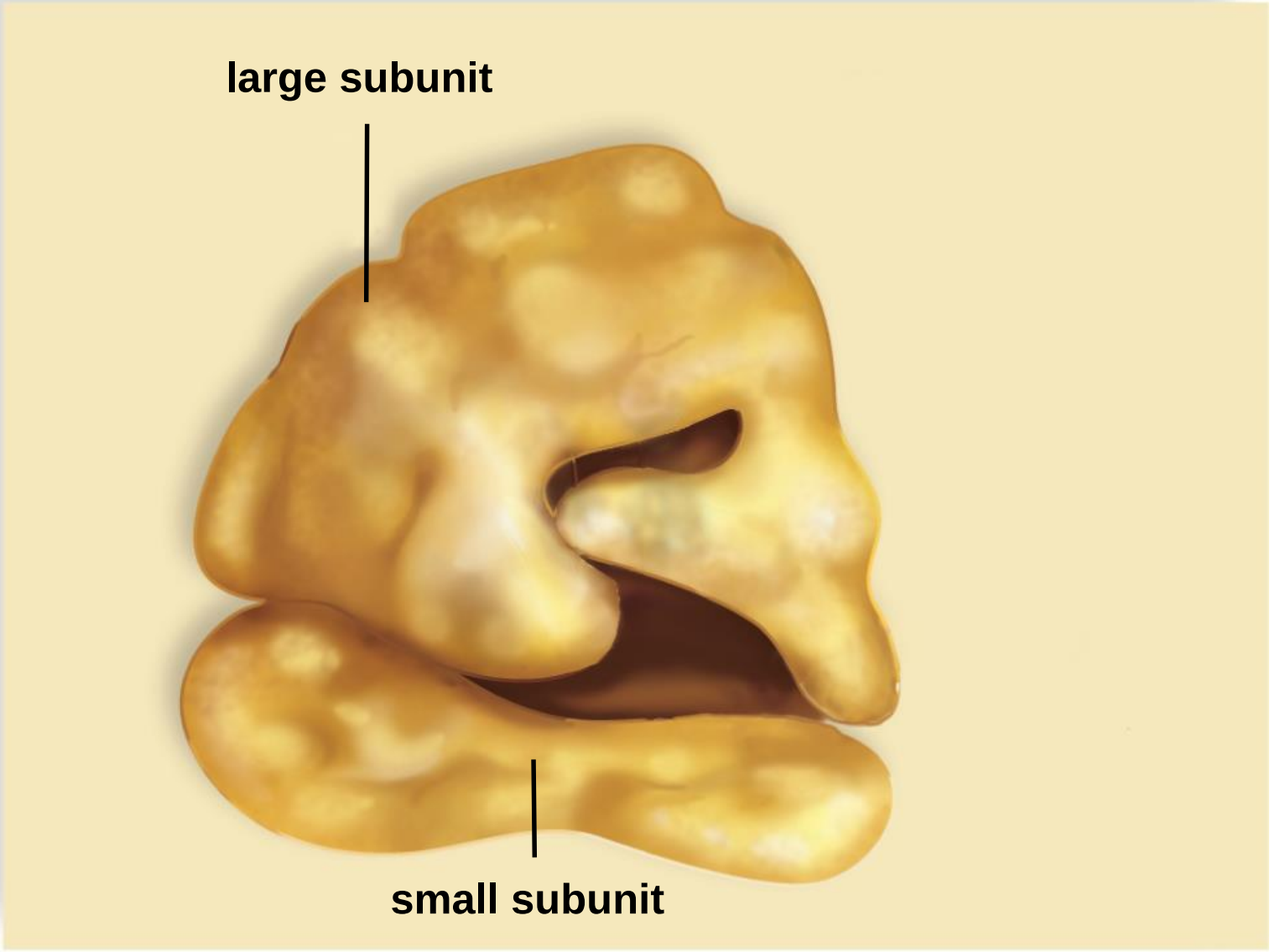


Overview of Gene Expression

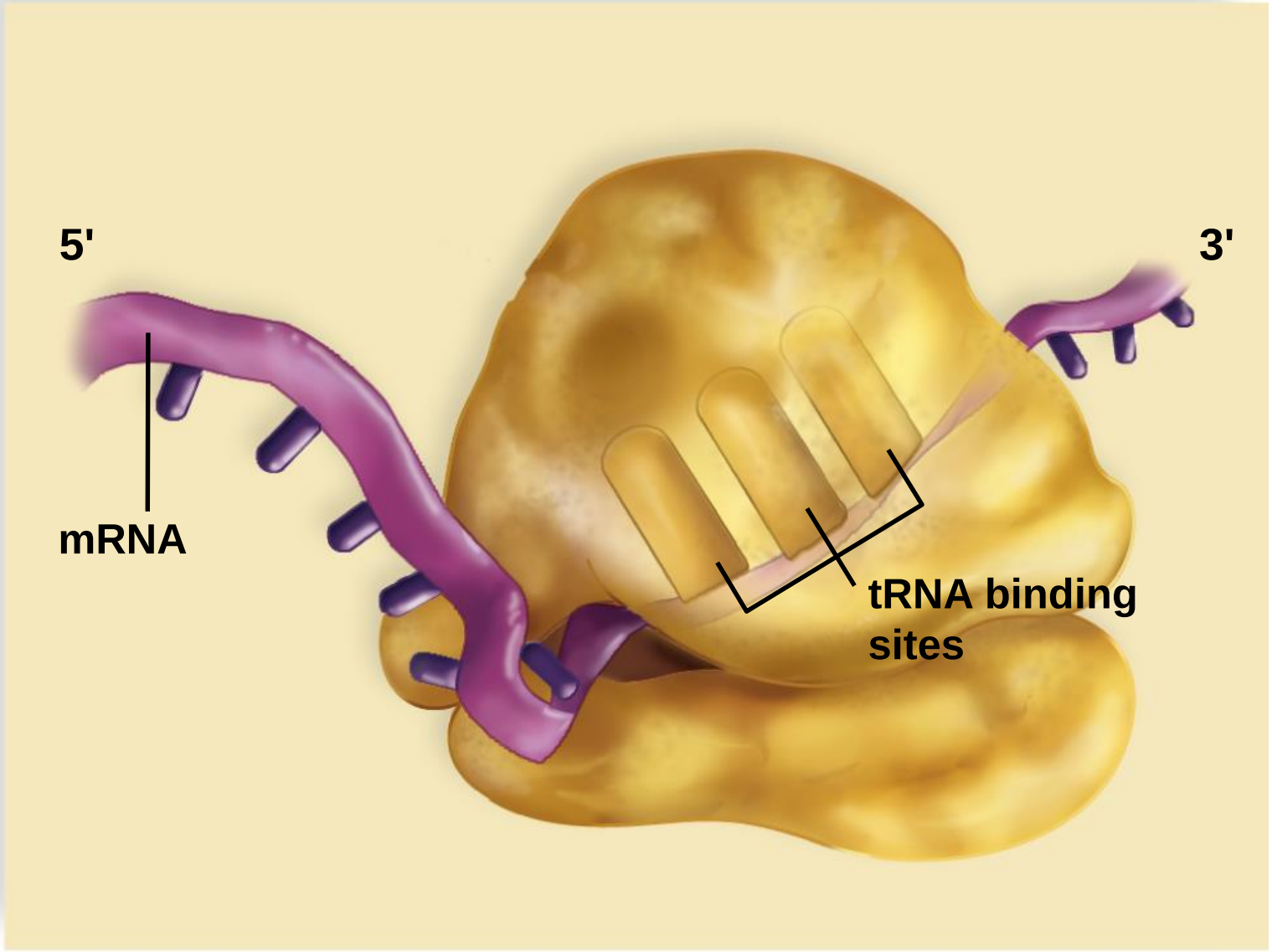


25.3 Gene Expression

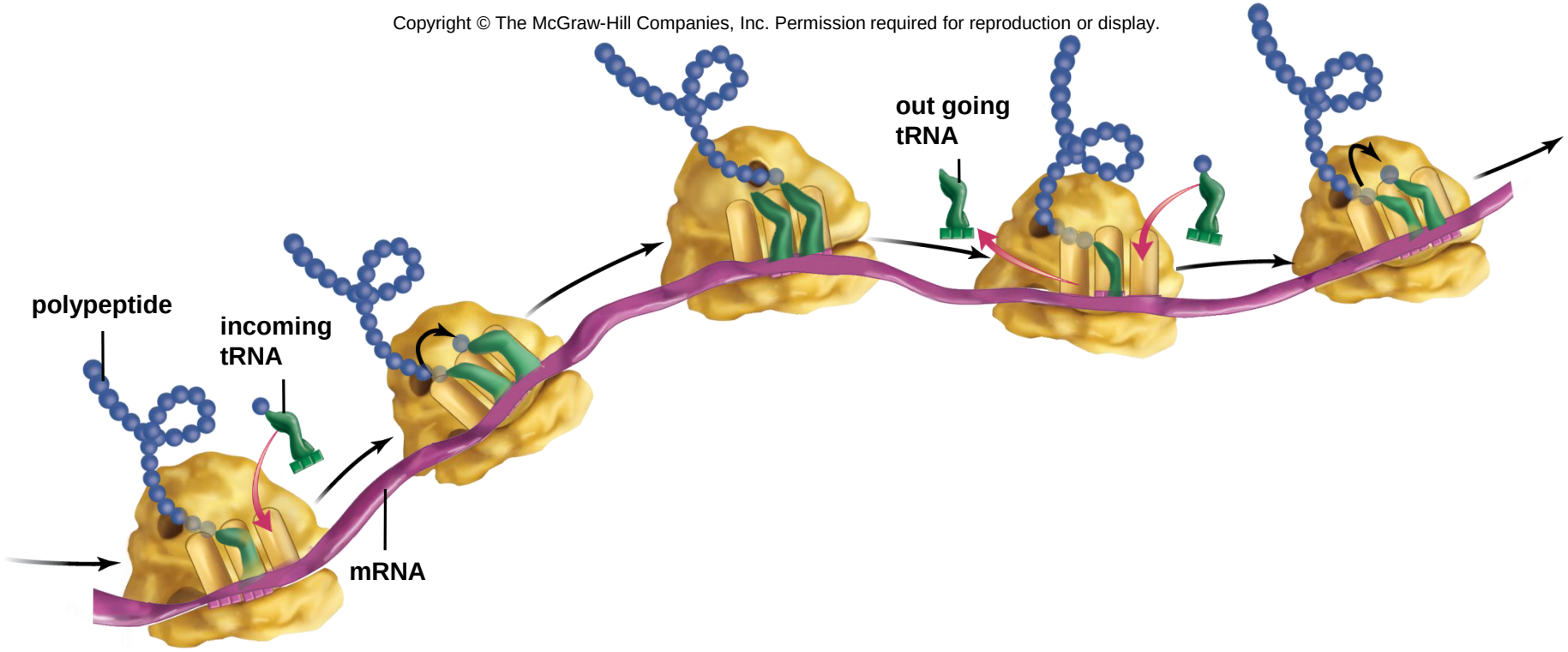
- Ribosome and Ribosomal RNA
  - Free or attached to endoplasmic reticulum
  - Two subunits – one large and one small
  - Binding site for mRNA and three tRNAs
  - Binding sites facilitate complementary base pairing between tRNA anticodons and mRNA codons
  - Brings amino acids in line in a specific order to form a polypeptide
  - Several ribosomes may move along the same mRNA
    - Multiple copies of a polypeptide may be made
    - The entire complex is called a polyribosome



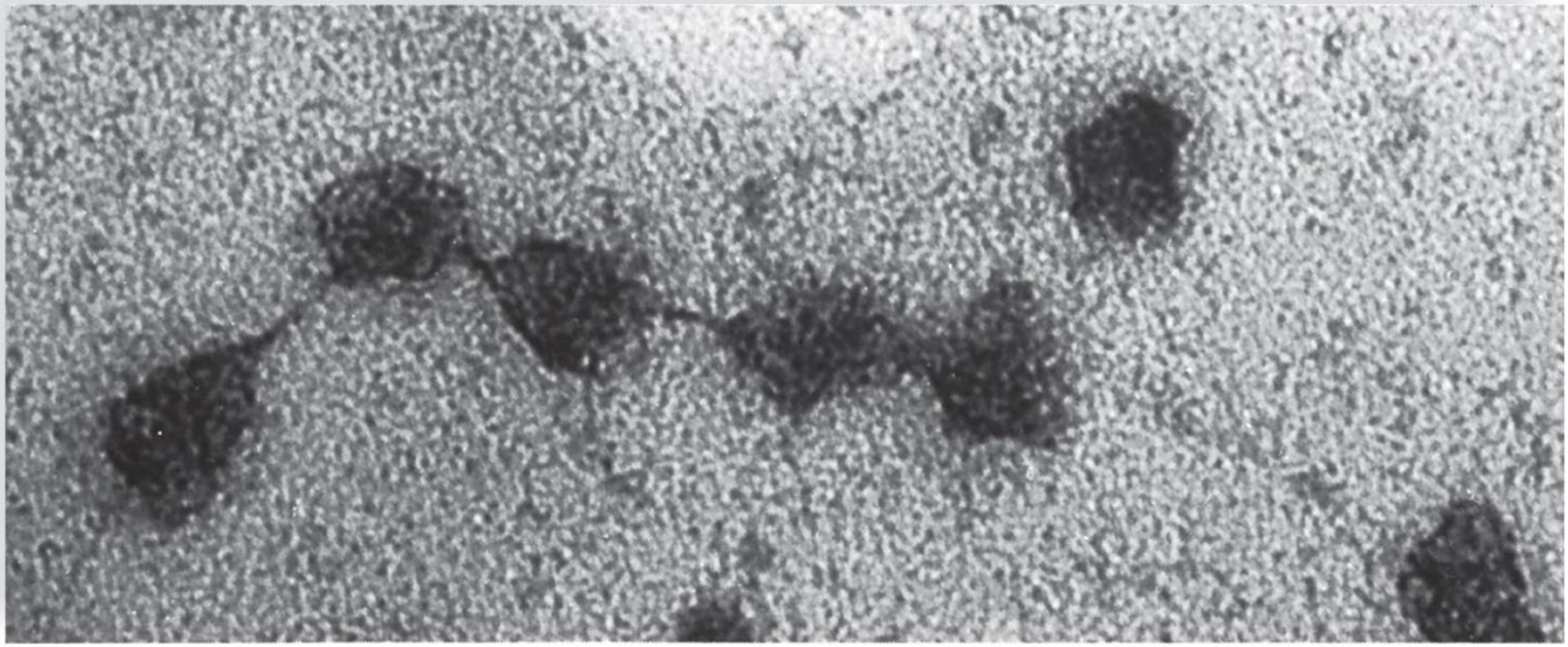
a. Structure of a ribosome



b . Binding sites of ribosome



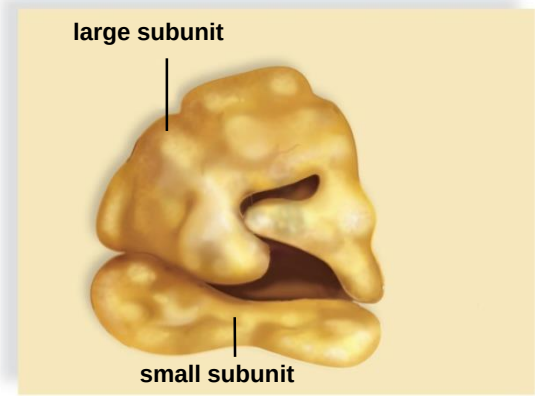
c. Function of ribosomes



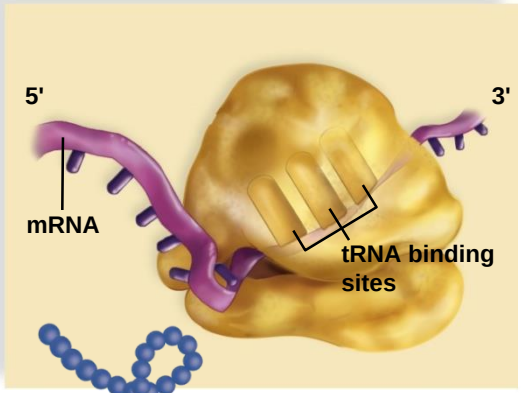
Courtesy Alexander Rich;

d. Polyribosome

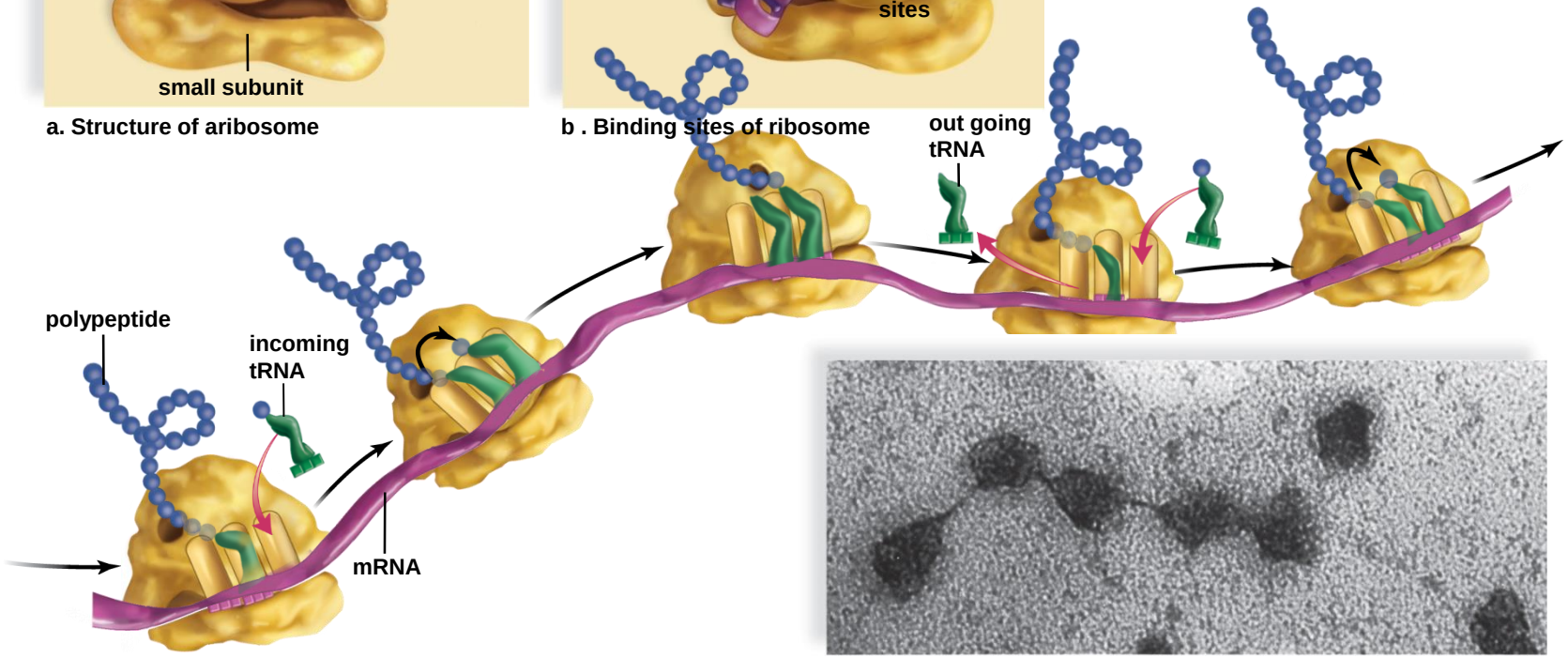
Polyribosome Structure and Function



a. Structure of aribosome



b . Binding sites of ribosome



c. Function of ribosomes

d. Polyribosome

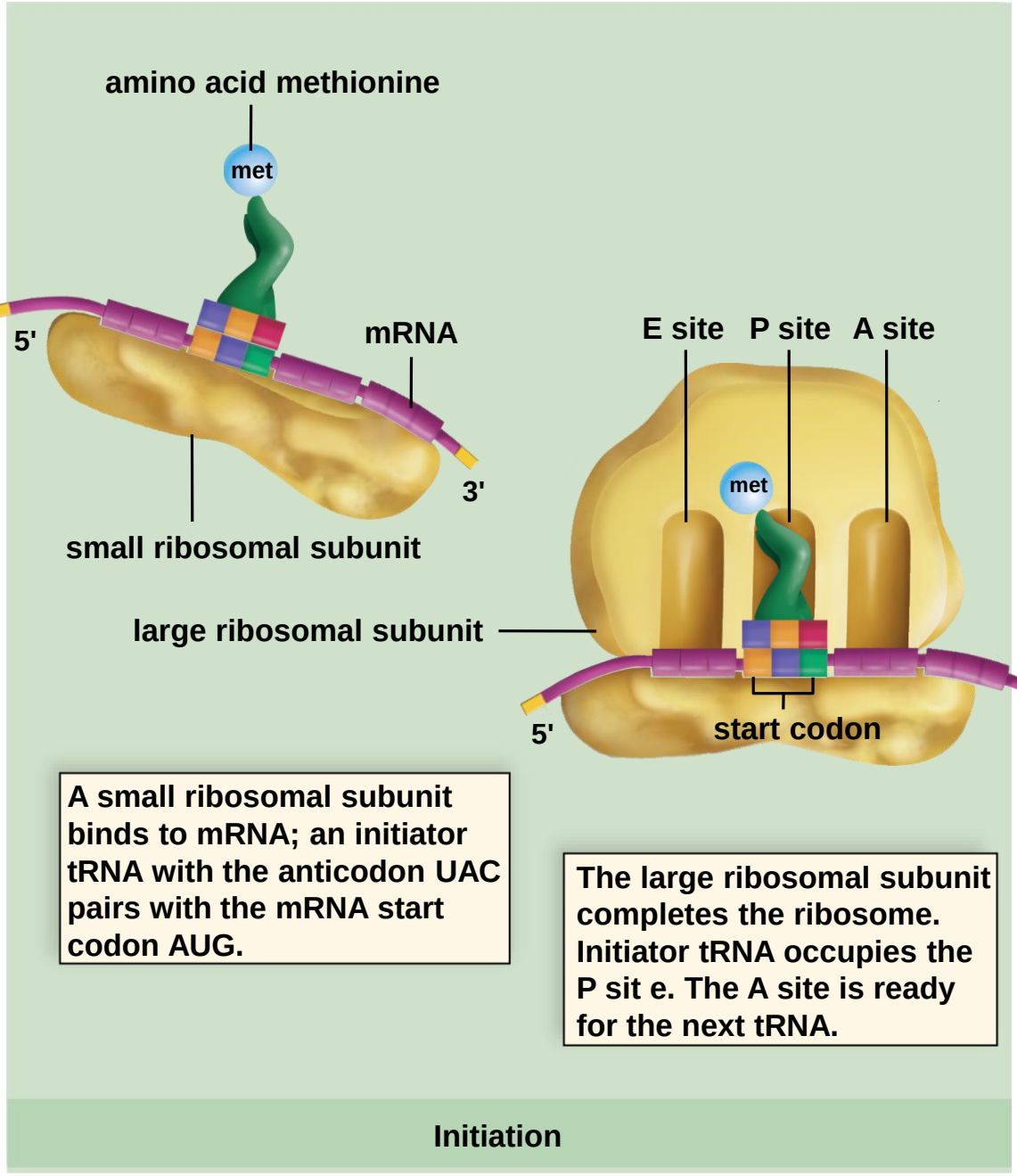
D: Courtesy Alexander Rich;

25.3 Gene Expression

- Translation Requires Three Steps
  - Initiation (requires energy)
    - Initiation factors assemble components
    - Start codon (AUG)
    - P (peptide) site, A (amino acid) site, and E (exit) site
  - Elongation (requires energy)
  - Termination
    - Stop codon
    - Requires release factor

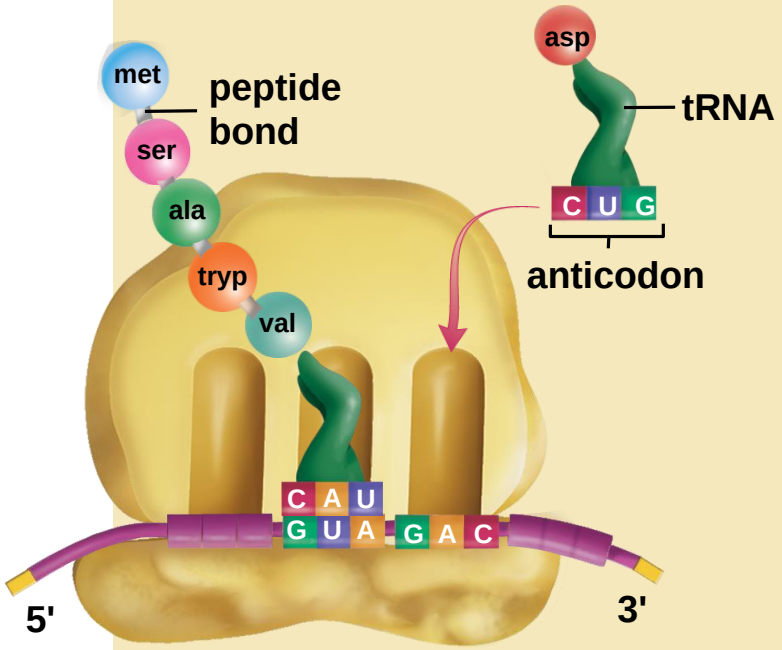
    - On the following slides please write in your notes the steps for Initiation, Elongation, and Termination.

Initiation



Add to your notes what is in the 2 boxes →

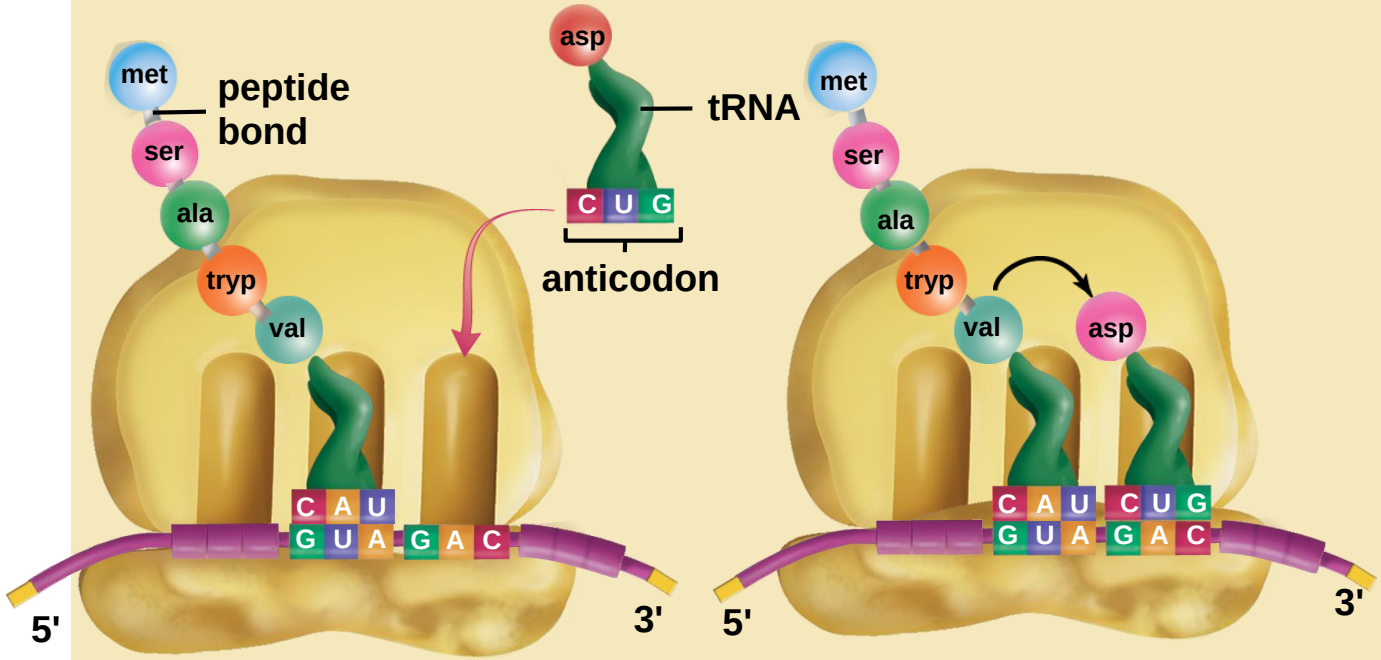
Elongation



Add to your notes the next 4 boxes for Elongation Steps →

1. A tRNA–amino acid approaches the ribosome and binds at the A site.

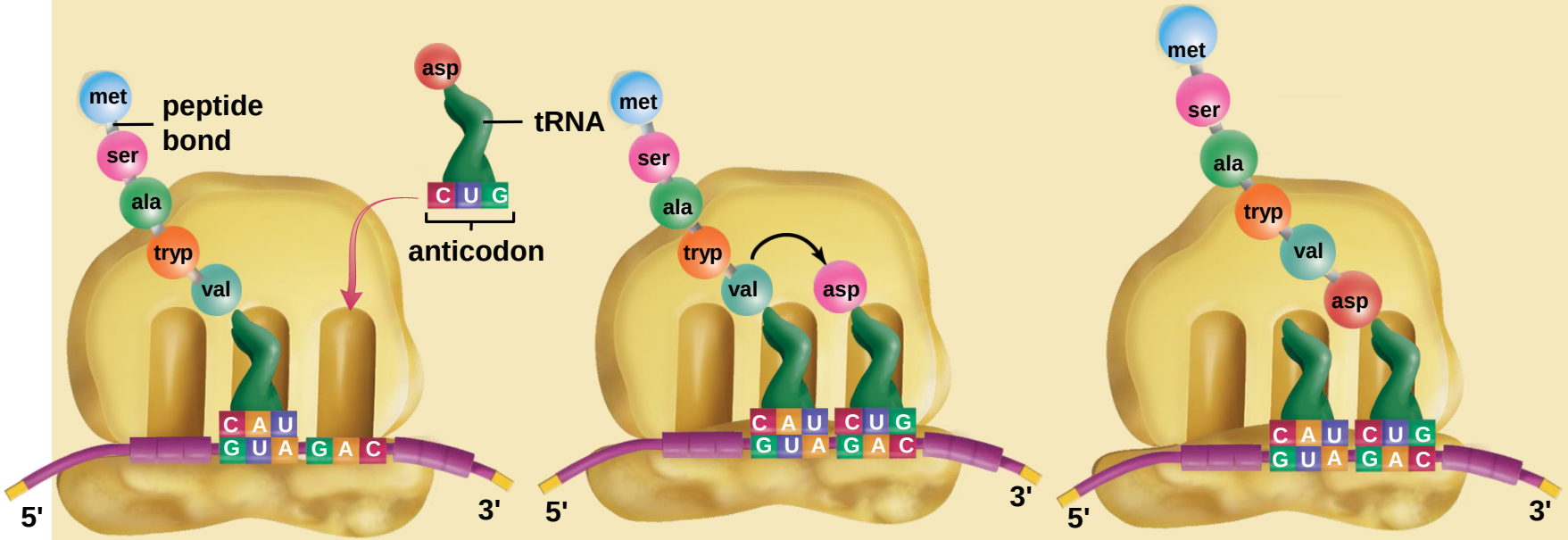
Elongation



1. A tRNA–amino acid approaches the ribosome and binds at the A site.

2. Two tRNAs can be at a ribosome at one time; the anticodons are paired to the codons.

Elongation



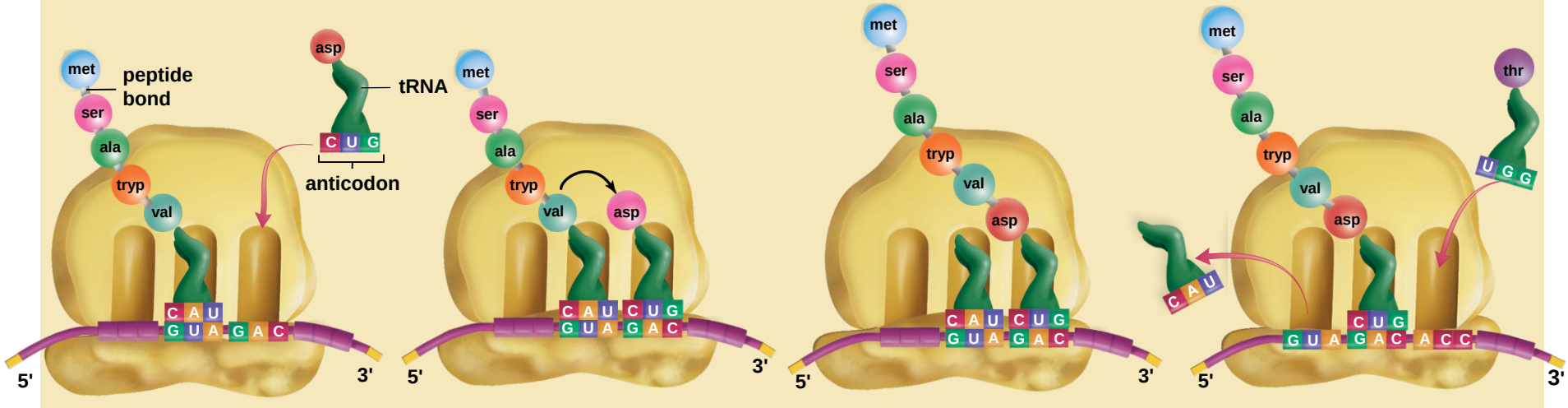
1. A tRNA–amino acid approaches the ribosome and binds at the A site.

2. Two tRNAs can be ta a ribosome at one time; the anticodons are paired to the codons.

3. Peptide bond formation attaches the peptide chain to the newly arrived amino acid.

Elongation

Elongation



1. A tRNA–amino acid approaches the ribosome and binds at the A site.

2. Two tRNAs can be ta a ribosome at one time; the anticodons are paired to the codons.

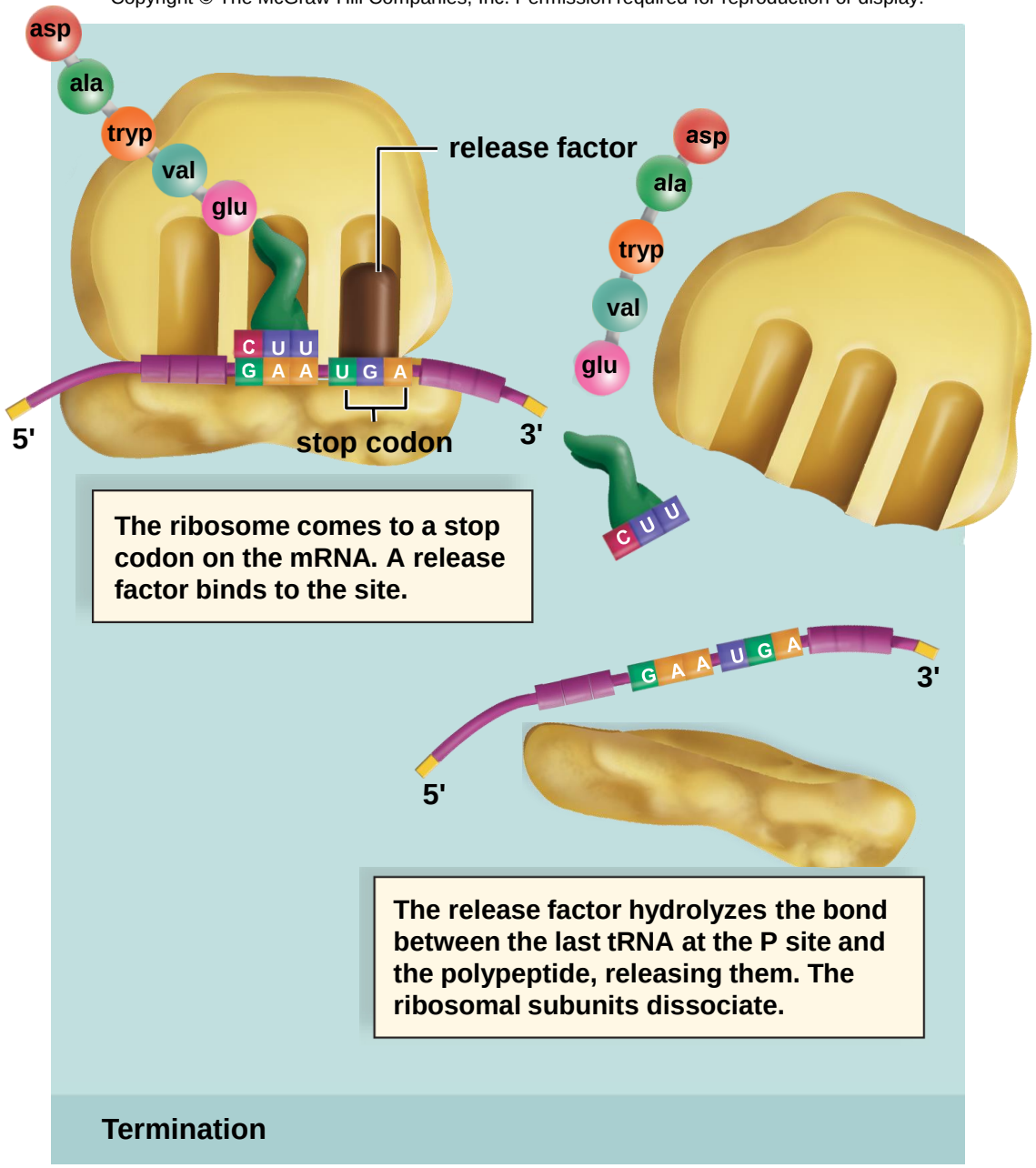
3. Peptide bond formation attaches the peptide chain to the newly arrived amino acid.

4. The ribosome moves for ward; the “empty” tRNA exits from the E site; the next amino acid–tRNA complex is approaching the ribosome.

Elongation

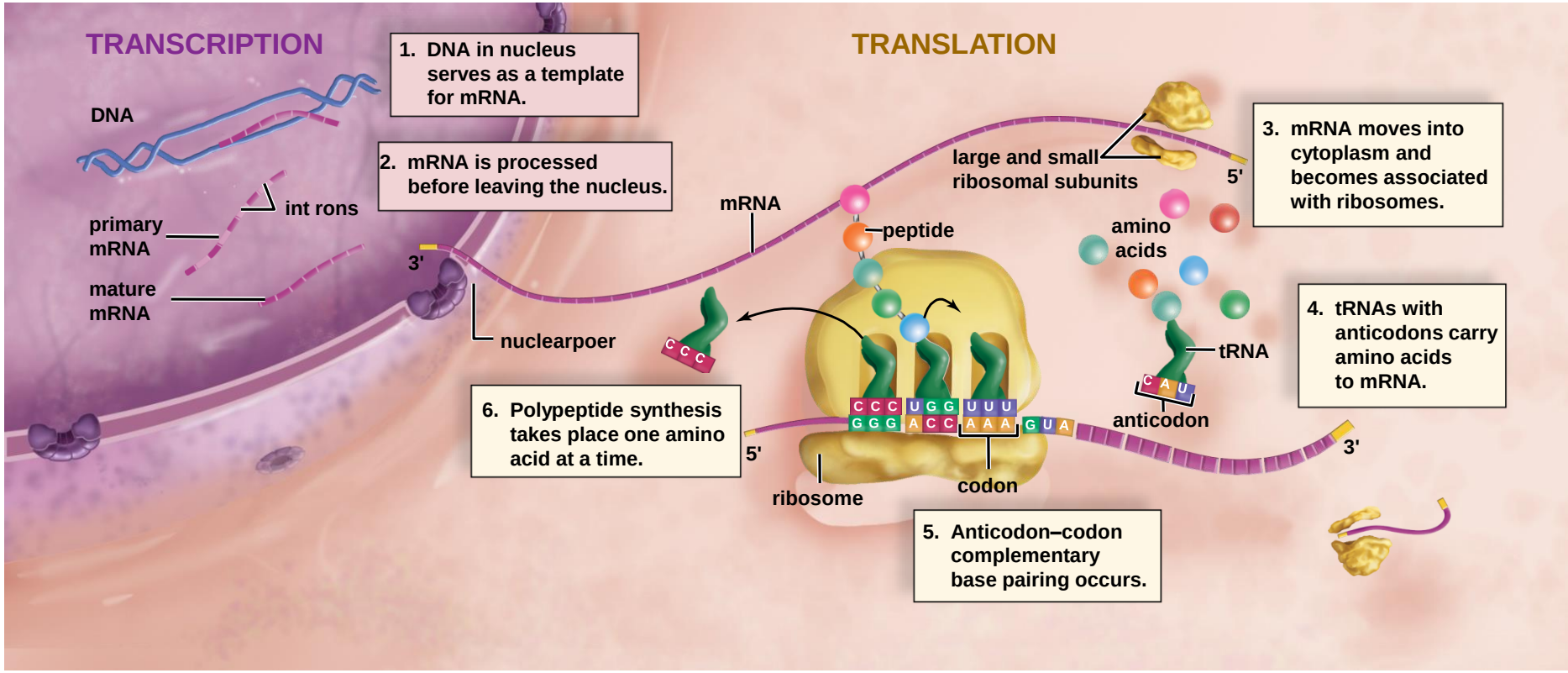
Termination

Add to your notes the 2 boxes for Termination Steps→



Review of Gene Expression

This can be found in Chapter 25 on page 512



25.2 & 25.3 Questions

- Question: A DNA sequence of nitrogenous bases is TACTTTCCCCAAATC. What would the sequence of nitrogenous bases be on the corresponding mRNA? What would be the resulting amino acid chain? What would the corresponding bases be on the tRNA that brought the amino acids to the ribosome?

- Questions p509 answer Check Your Progress #1-3
- Questions p511 answer Check your Progress #1-3

25.5 Gene Mutations

- A gene is a section of DNA that codes for a specific polypeptide.
- A mutation is a change in the sequence of nitrogenous bases within a gene.
- Usually the rate is low because DNA repair enzymes fix problems as they occur.

25.5 Gene Mutations

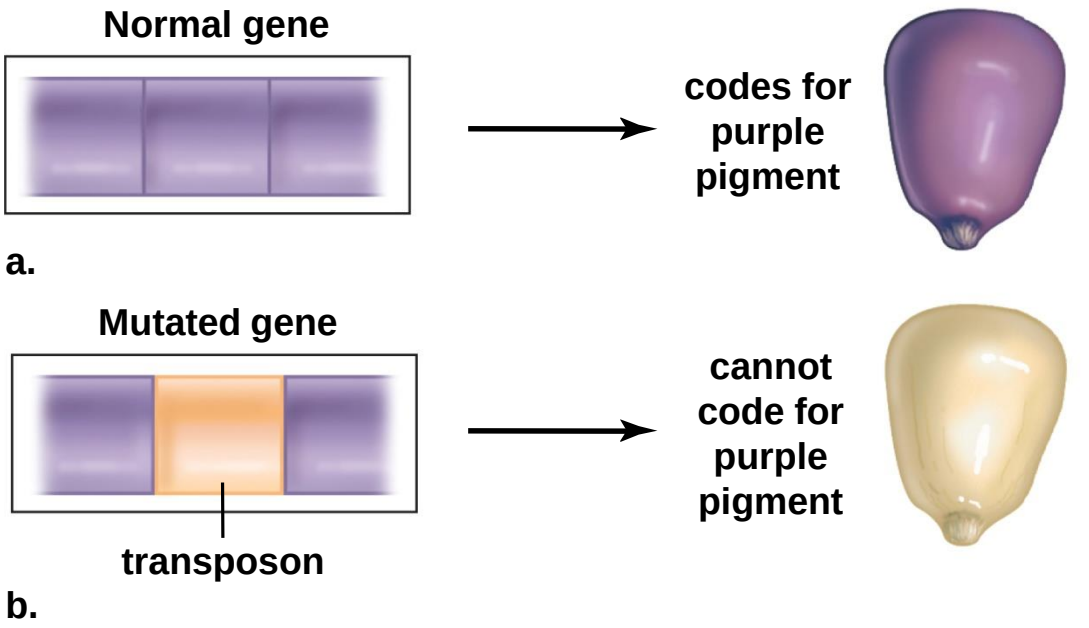
- There are basically three types of mutations:
- **Additions**→ Somehow an extra nucleotide is added. Any time this gene undergoes transcription, the set of triplet codons is incorrect from this point on.

25.5 Gene Mutations

- **<u>Deletions</u>**→ A single nucleotide is left out. Again the set of codons is incorrect from this point on.

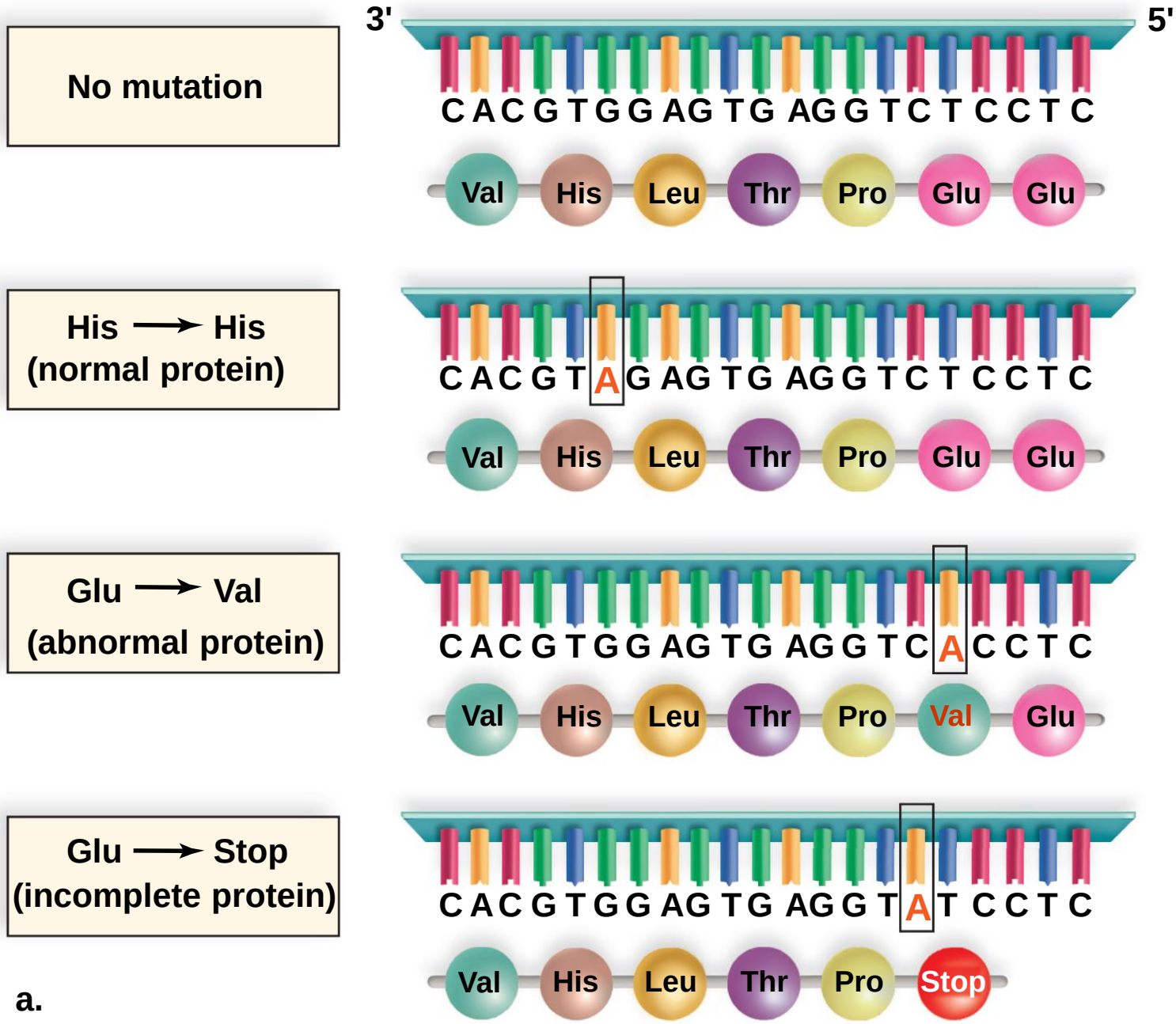
25.5 Gene Mutations

- **<u>Substitutions</u>**→ Here everything is correct except in one location where one nucleotide replaces another.
- The mRNA strand produced will contain all the right codons, except that one codon contains the substituted nucleotide.
- This change *<u>may</u>* affect the incorporation of the correct amino acid into the protein.



c.

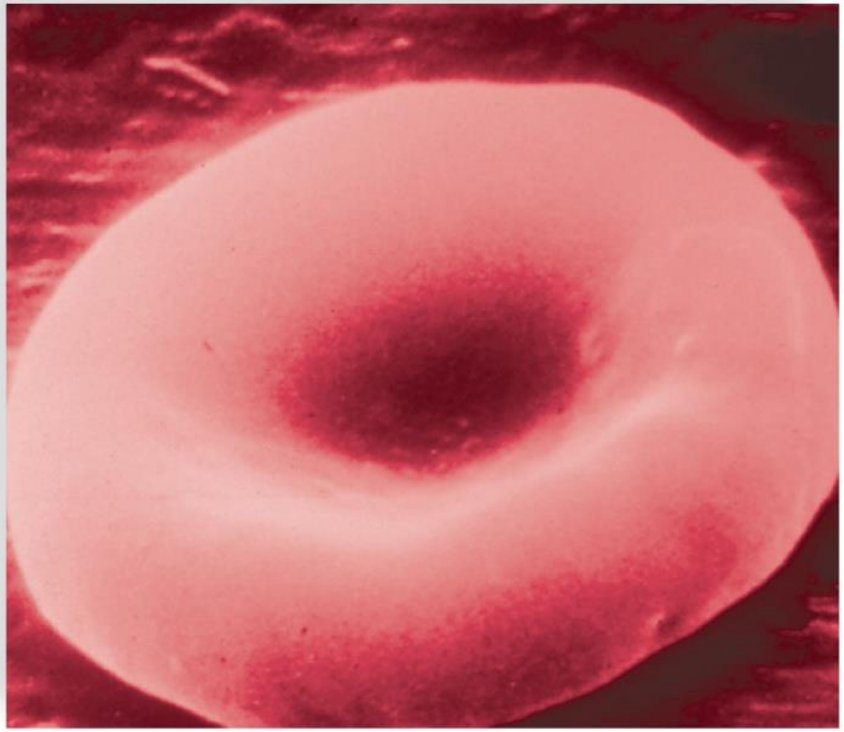
C: © Mondae Leigh Baker;



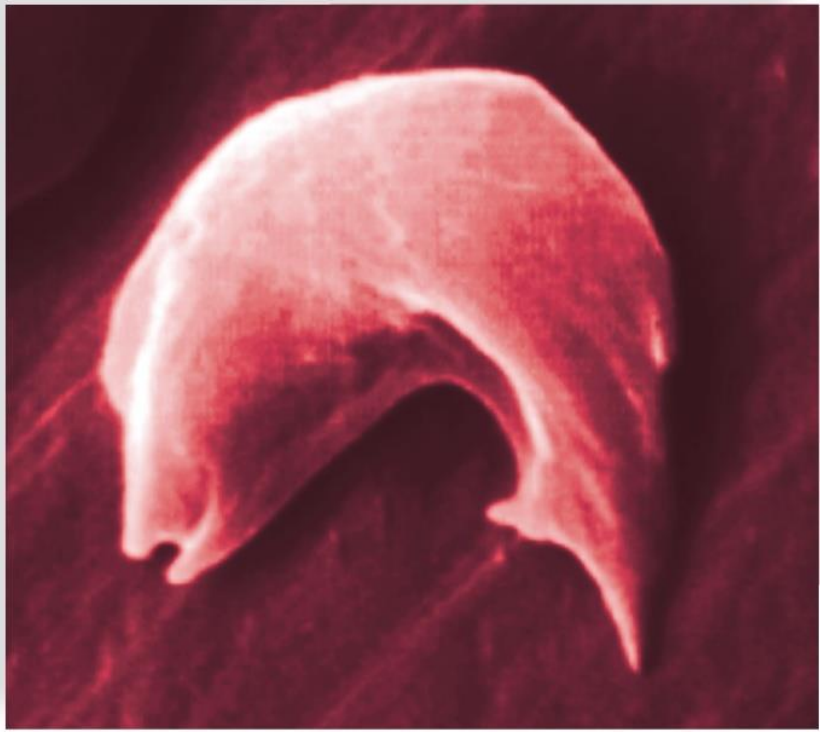
25.5 Gene Mutations

Assignment:

- Identify which type of mutation causes sickle cell anaemia and explain why it has such a profound effect on humans.
- Add this to your notes.
- (page 479-480 & 516-517)



b. Normal red blood cell



c. Sickled red blood cell

25.5 Gene Mutations

Environmental Mutagens Causing Mutations in Humans

1. **<u>Radiation</u>** – radioactive elements, X-rays, UV radiation

25.5 Gene Mutations

2. **Organic chemicals** – e.g. chemicals in cigarette smoke, certain pesticides

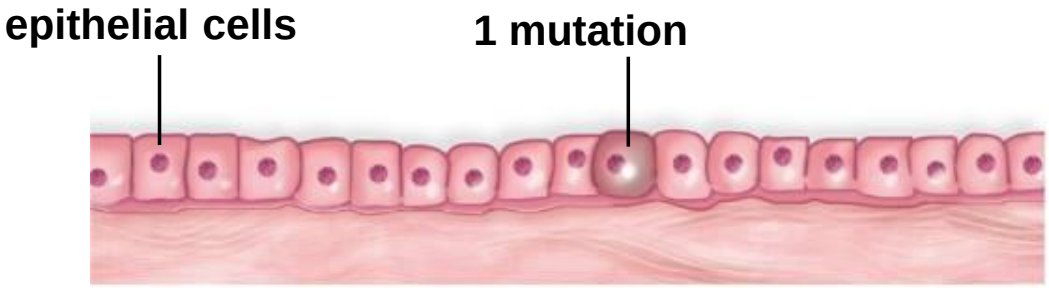
- if mutation occurs in the gametes then the offspring is affected
- if mutation occurs in body cells then tumour or deformity may result

25.5 Gene Mutations

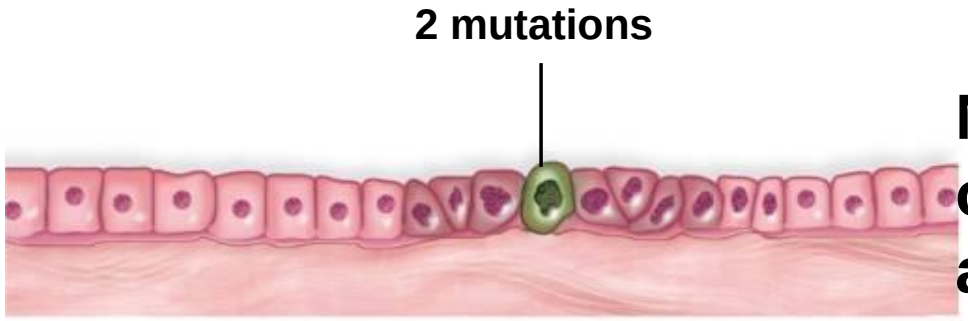
- Mutations can cause cancer
  - Some forms of cancer are lung, prostate, and breast cancer
- Although cancers vary greatly, they usually follow a common multistep progression

25.5 Gene Mutations

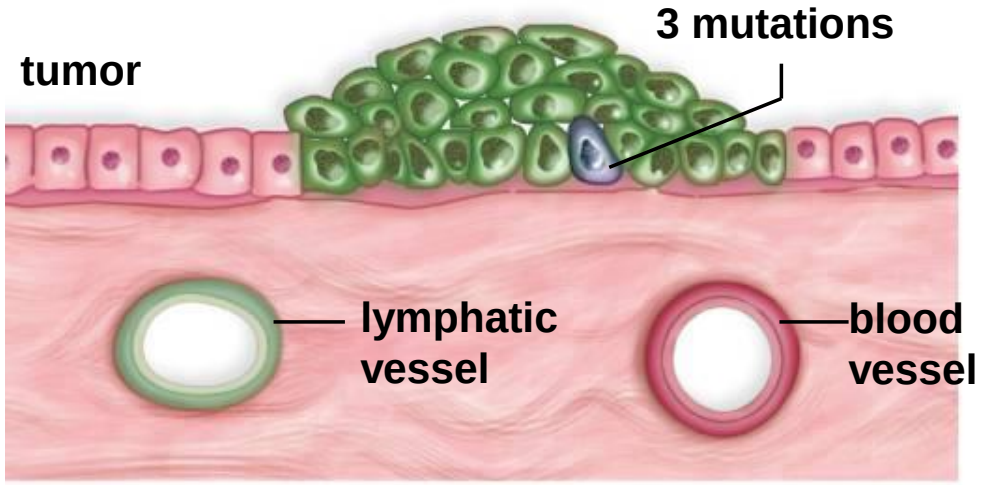
- Most cancers begin as an abnormal cell growth that is benign (not cancerous), and usually does not grow larger.
- Growth may become malignant, meaning that it is cancerous and possesses the ability to spread.



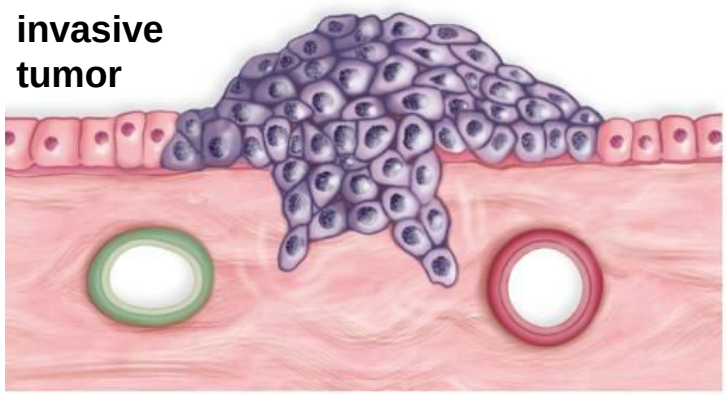
Cell (dark pink) acquires a mutation for repeated cell division.



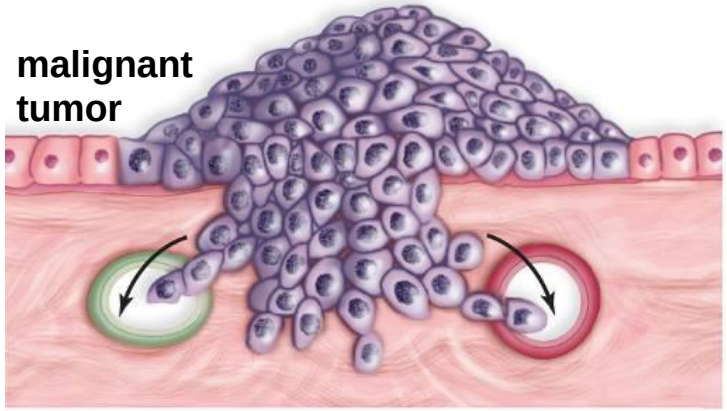
New mutations arise, and one cell (green) has the ability to start a tumor.



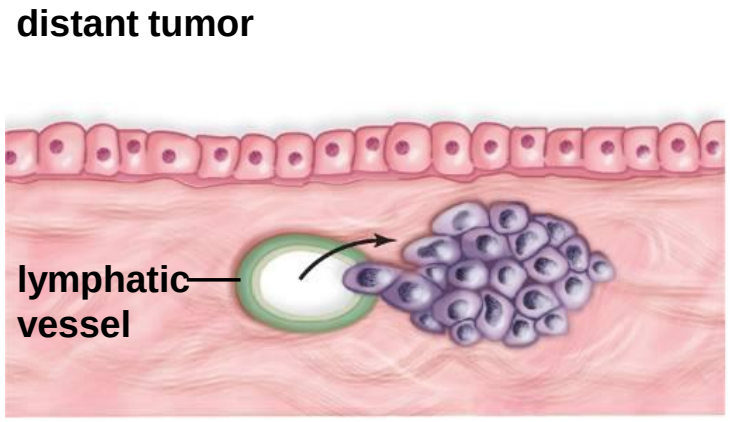
The tumor is at its place of origin. One cell (purple) mutates further.



Cells have gained the ability to invade underlying tissues by producing a proteinase enzyme.



Cancer cells now have the ability to invade lymphatic and blood vessels.



New metastatic tumors are found some distance from the tumor.

25.5 Gene Mutations

- Characteristics of Cancer Cells
  - Cancer cells are genetically unstable
  - Cancer cells do not correctly regulate the cell cycle
  - Cancer cells escape the signals for cell death
  - Cancer cells can survive and proliferate elsewhere in the body

Questions

25.5 p515-520

Questions CYP → p520 #1-3

26 Recombinant DNA

Recombinant DNA

- contains DNA from 2 or more different sources (a vector or carrier is used to introduce DNA into cells)
- portions of DNA can be inserted into bacterial plasmids (small rings of non-functional DNA) or into viruses
- they then replicate as part of the bacteria or virus

26 Recombinant DNA

Uses of recombinant DNA

- **<u>From bacteria</u>**

1. mass-production of hormones and similar proteins
- e.g. growth hormone to treat growth abnormalities
- insulin for diabetes

26 Recombinant DNA

2. bioengineered bacteria released into environment to clean up pollutants, increase fertility of soil or kill insect pests
3. bacteria that are especially good at making phenylalanine – NutraSweet
4. a bacteria has been developed that will live on the roots of corn plants and produce an insect toxin

26 Recombinant DNA

- **From plants**

1. used to make agricultural crops resistant to pests and herbicide

- **From animals**

1. inserting growth hormone into farm animals
2. developed mice that will produce human growth hormone in their urine

26 Recombinant DNA

3. growing pigs that will be used for organ donors for humans (inserting DNA that will make rejection by receiving body less likely)
4. cloning of genetically engineered individual animals

- Read 526-531
- Answer Progress Questions p528 & p531