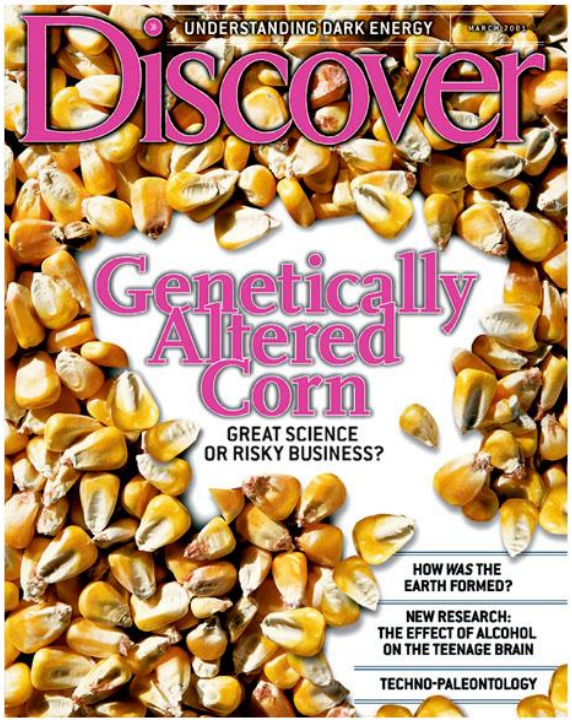
Inquiry into Life

Eleventh Edition

Sylvia S. Mader

Chapter 24
Lecture Outline

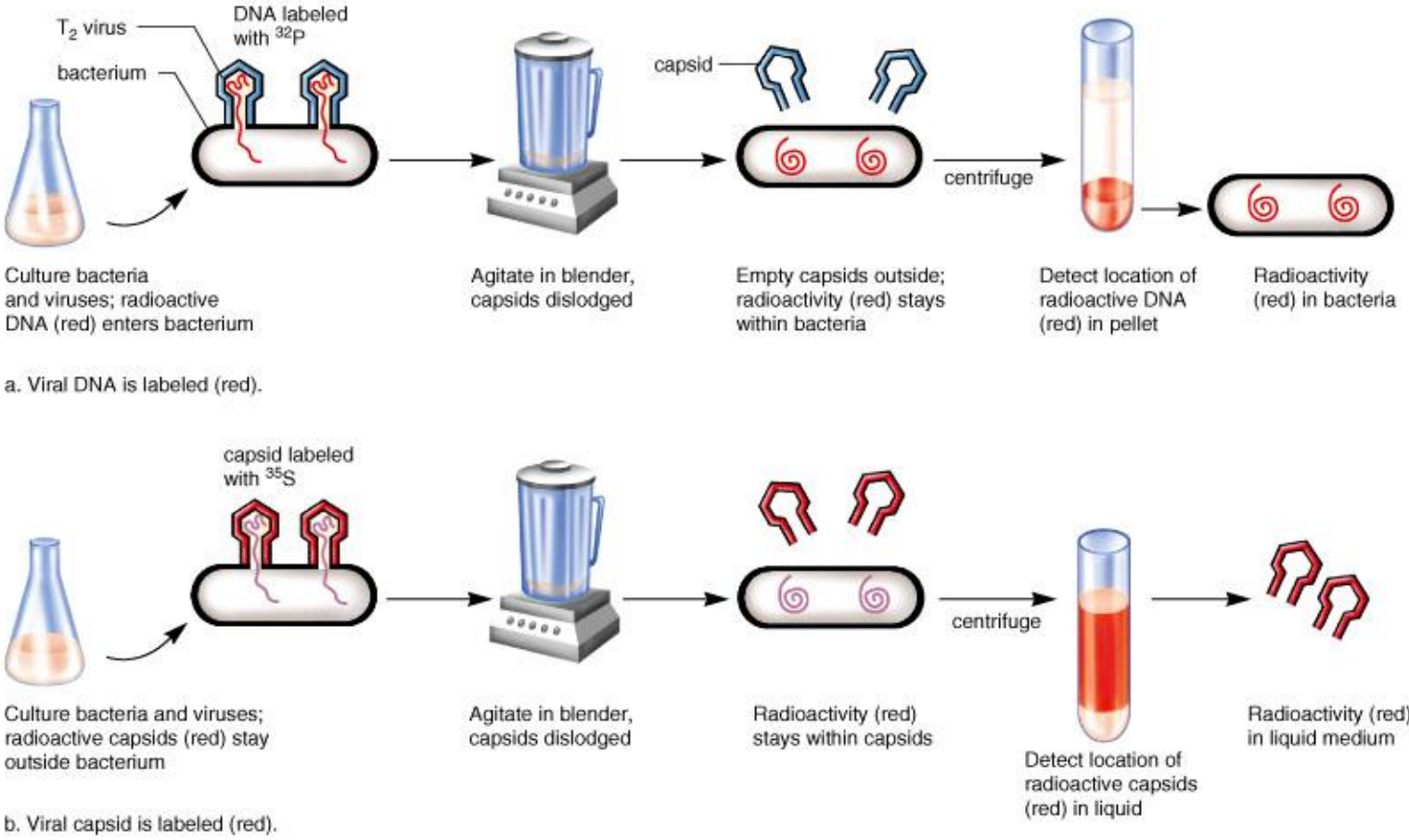
Prepared by: Wendy Vermillion
Columbus State Community College



24.1 DNA structure and replication

- Hershey and Chase experiments
  - Determined that DNA is the genetic material
  - Experiment 1
    - Viruses with DNA labeled with 32P were incubated with *E.coli*
      - Mixed in a blender to remove virus particles attached to cells
      - Centrifuged so bacteria formed a pellet
    - Results- viral DNA was inside the bacteria
  - Experiment 2
    - Viral proteins in capsids were labeled with 35S and viruses were incubated with *E.coli*
      - Mixed in blender and centrifuged
    - Results- labeled proteins were washed off with the capsids and were not inside the bacteria

Discovering that DNA is the genetic material



- Fig. 24.1

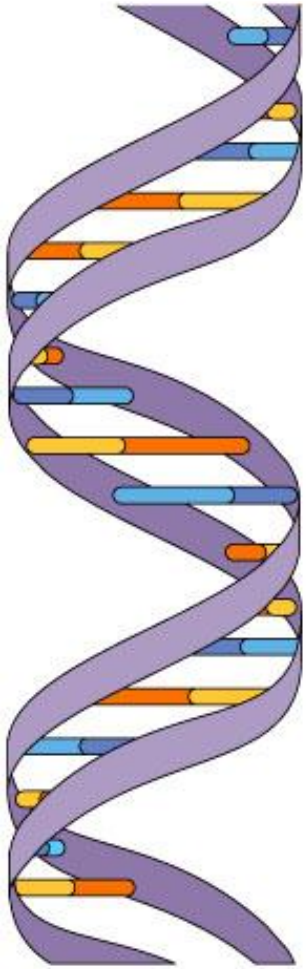
DNA structure and replication cont'd.

- Structure of DNA
  - Determined by Watson and Crick
    - Double helix
    - Composed of monomers called nucleotides
    - Each nucleotide has 3 parts
      - Phosphoric acid (phosphate)
      - deoxyribose sugar
      - Nitrogen base- 4 possible
        - » Adenine and guanine- purine bases- double ring structure
        - » Cytosine and thymine- pyrimidine bases-single ring structure

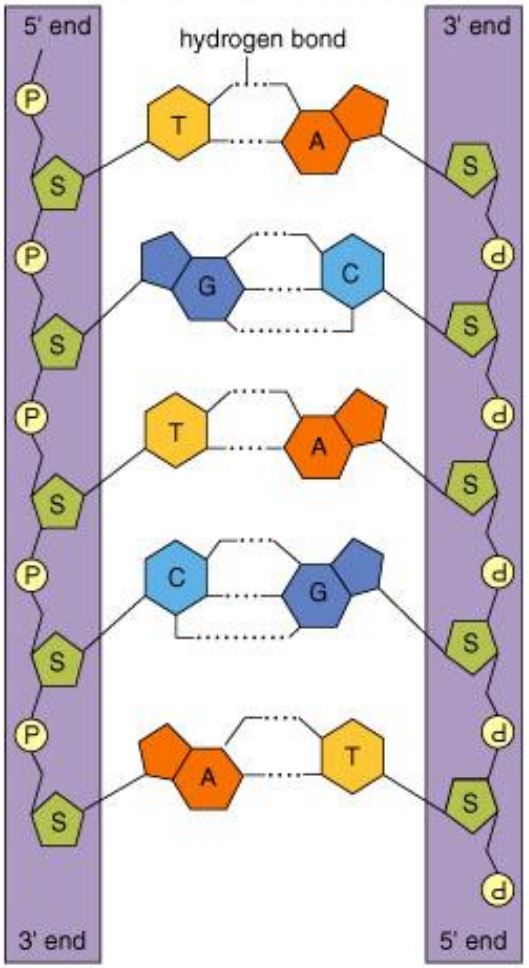
DNA structure and replication cont'd.

- DNA structure- ladder analogy
  - DNA molecule consists of 2 chains of nucleotides
  - Arranged in a "ladder" configuration
    - Alternating phosphate and sugar groups form sides of ladder
    - Rungs are composed of paired nitrogen bases
      - Complementary base pairing-purine with pyrimidine
        - » Adenine pairs with thymine
        - » Guanine pairs with cytosine
      - The "ladder" then coils to form a helix

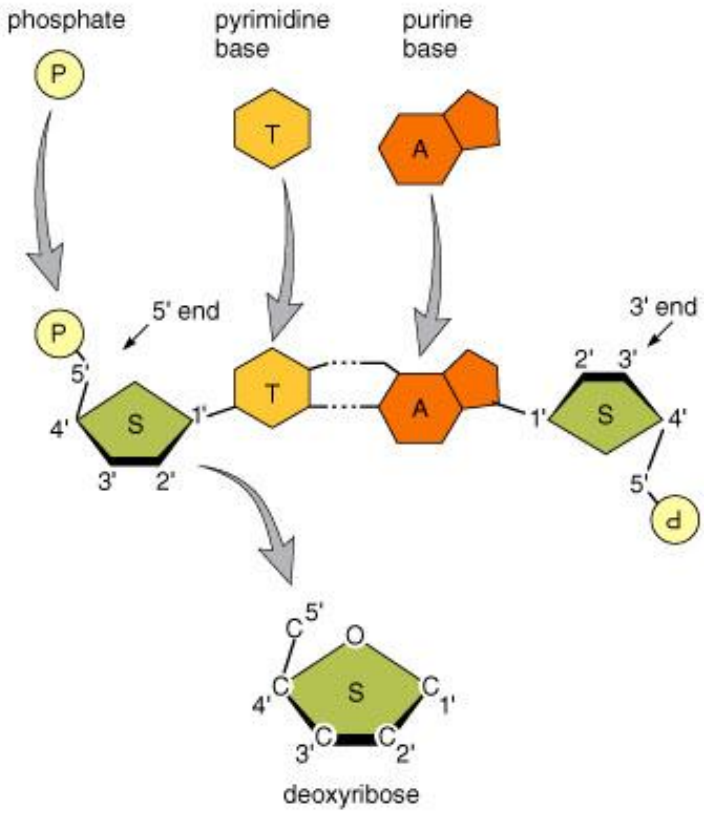
Overview of DNA structure



a. Double helix



b. Ladder structure



c. One pair of bases

- Fig. 24.2

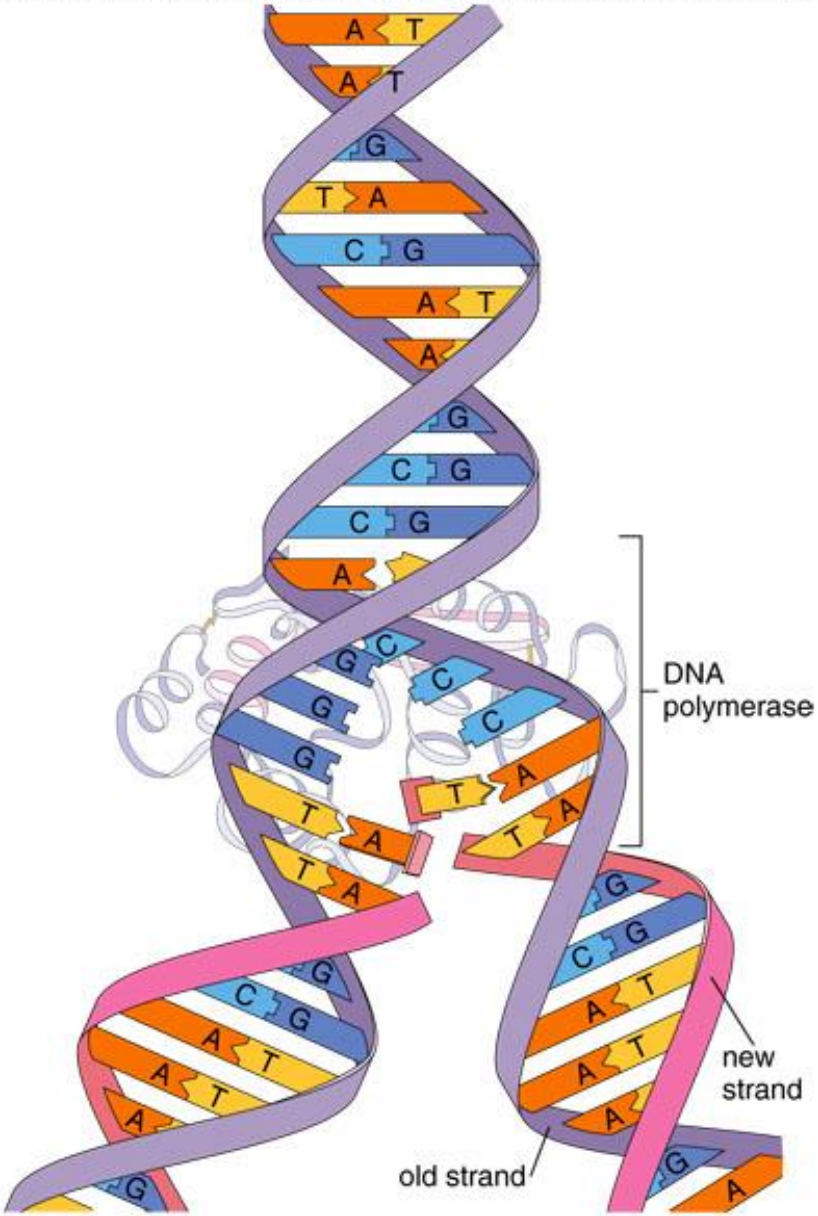
DNA structure and replication cont'd.

- Replication of DNA
  - Occurs during S phase of the cell cycle
  - Semi-conservative replication
    - Each daughter DNA molecule consists of one new chain of nucleotides and one from the parent DNA molecule
  - The 2 daughter DNA molecules will be identical to the parent molecule

DNA structure and replication cont'd.

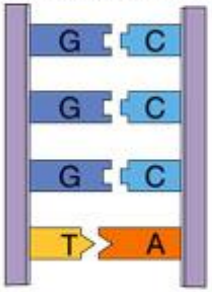
- DNA replication cont'd.
  - Before replication begins, the 2 strands of the parent molecule are hydrogen-bonded together
  - Enzyme helicase unwinds and "unzips" the double-stranded DNA
  - New DNA nucleotides fit into place along divided strands by complementary base pairing
  - New nucleotides form bonds with the existing ones- DNA polymerase
  - DNA ligase repairs any breaks in the sugar-phosphate backbone
  - Two daughter DNA molecules have now formed that are identical to the original

Overview of DNA replication

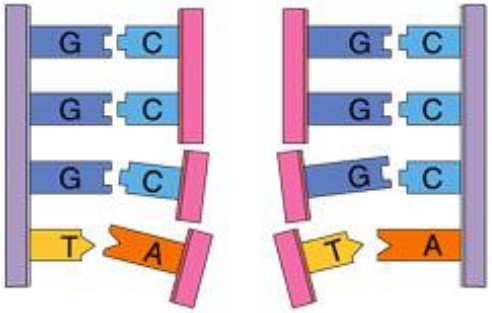


- Fig. 24.3

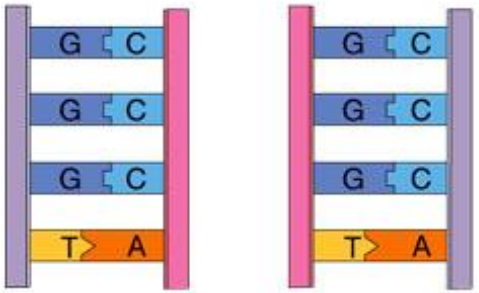
Ladder configuration and DNA replication



Parental DNA molecule contains so-called old strands hydrogen-bonded by complementary base pairing.



Region of replication. Parental DNA is unwound and unzipped. New nucleotides are pairing with those in old strands.



Replication is complete. Each double helix is composed of an old (parental) strand and a new (daughter) strand.

- Fig. 24.4

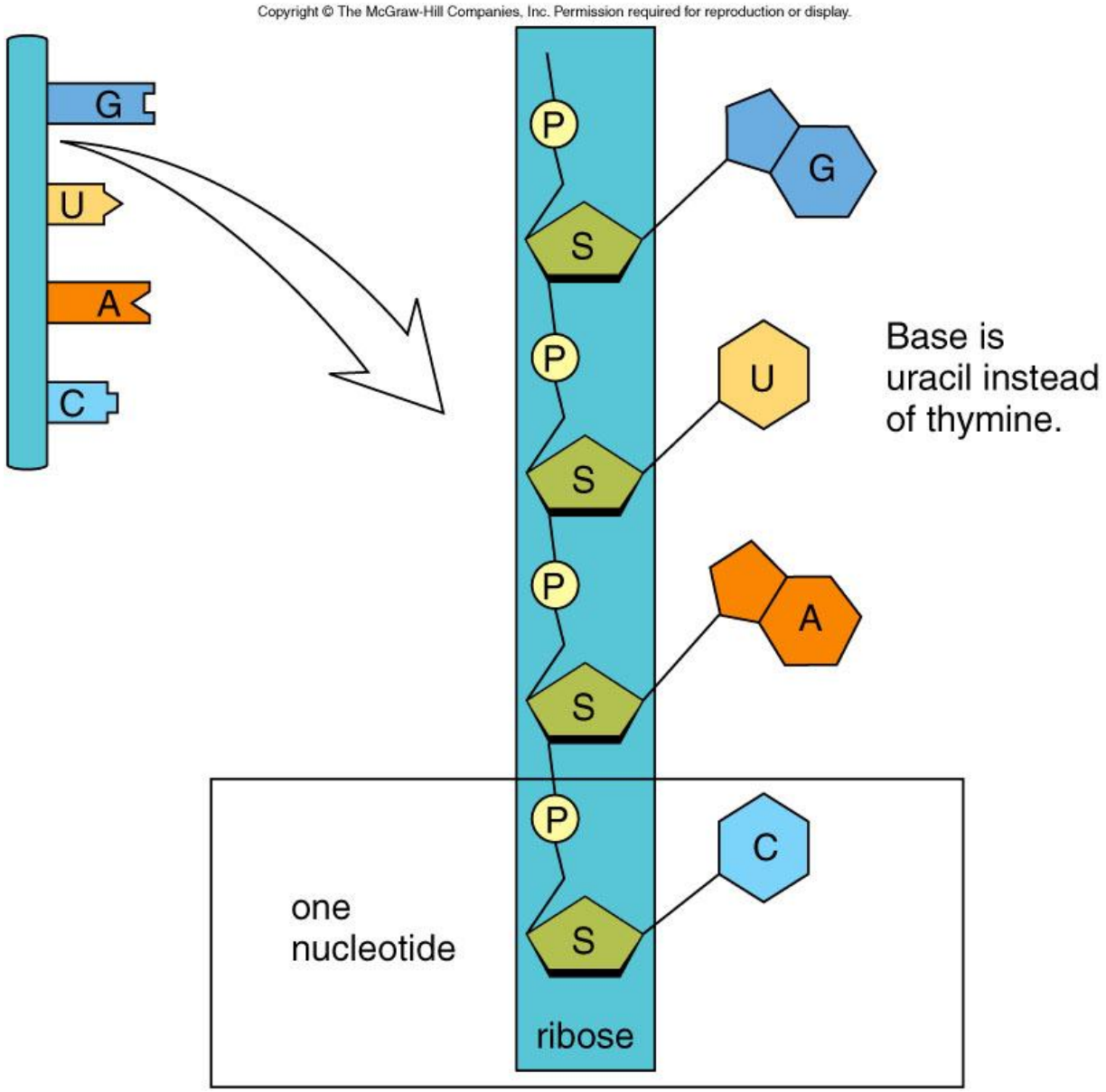
24.2 Gene expression

- Gene- segment of DNA that specifies the amino acid sequence of a protein
  - Stored in the form of a nucleotide code
  - A difference in base sequence causes a difference in protein structure
  - A gene does not directly control protein synthesis
    - First passes genetic information on to RNA
    - 3 types of RNA are involved in protein synthesis

Gene expression cont'd.

- RNA
  - Composed of nucleotides
  - Each nucleotide has 3 parts
    - Phosphate
    - Sugar- ribose
    - 4 possible nitrogen bases
      - Adenine and guanine
      - Cytosine and uracil
        - » Note that uracil replaces thymine
  - 3 major classes of RNA
    - mRNA- carries genetic information from the DNA out to ribosomes
    - rRNA- composes ribosomes, site of protein assembly
    - tRNA- brings in amino acids to the ribosomes

Structure of RNA



- Fig. 24.5

DNA structure compared to RNA structure

TABLE 24.1 DNA STRUCTURE COMPARED TO RNA STRUCTURE

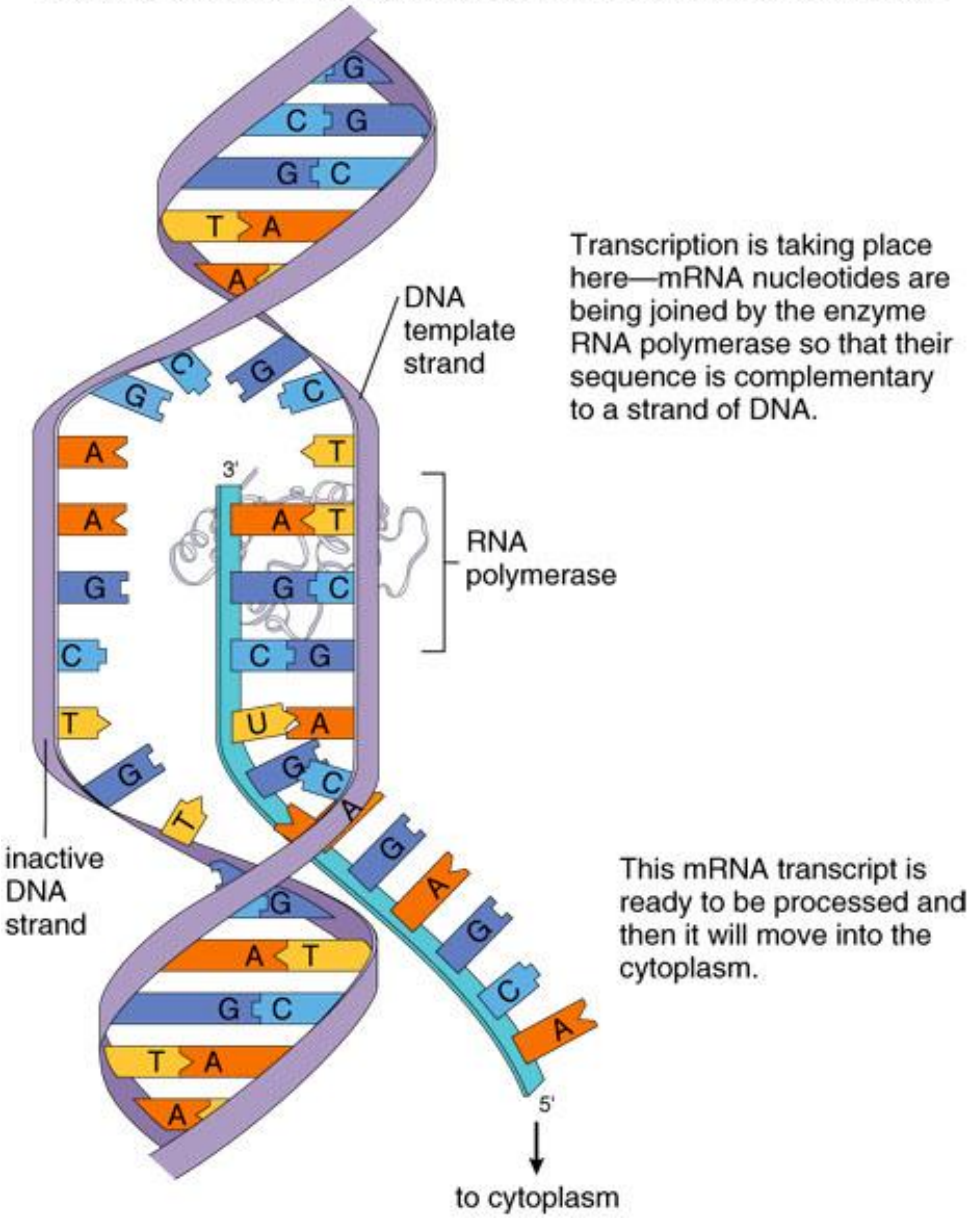
	DNA	RNA
Sugar	Deoxyribose	Ribose
Bases	Adenine, guanine, thymine, cytosine	Adenine, guanine, uracil, cytosine
Strands	Double stranded with base pairing	Single stranded
Helix	Yes	No

- Table 24.1

Gene expression cont'd.

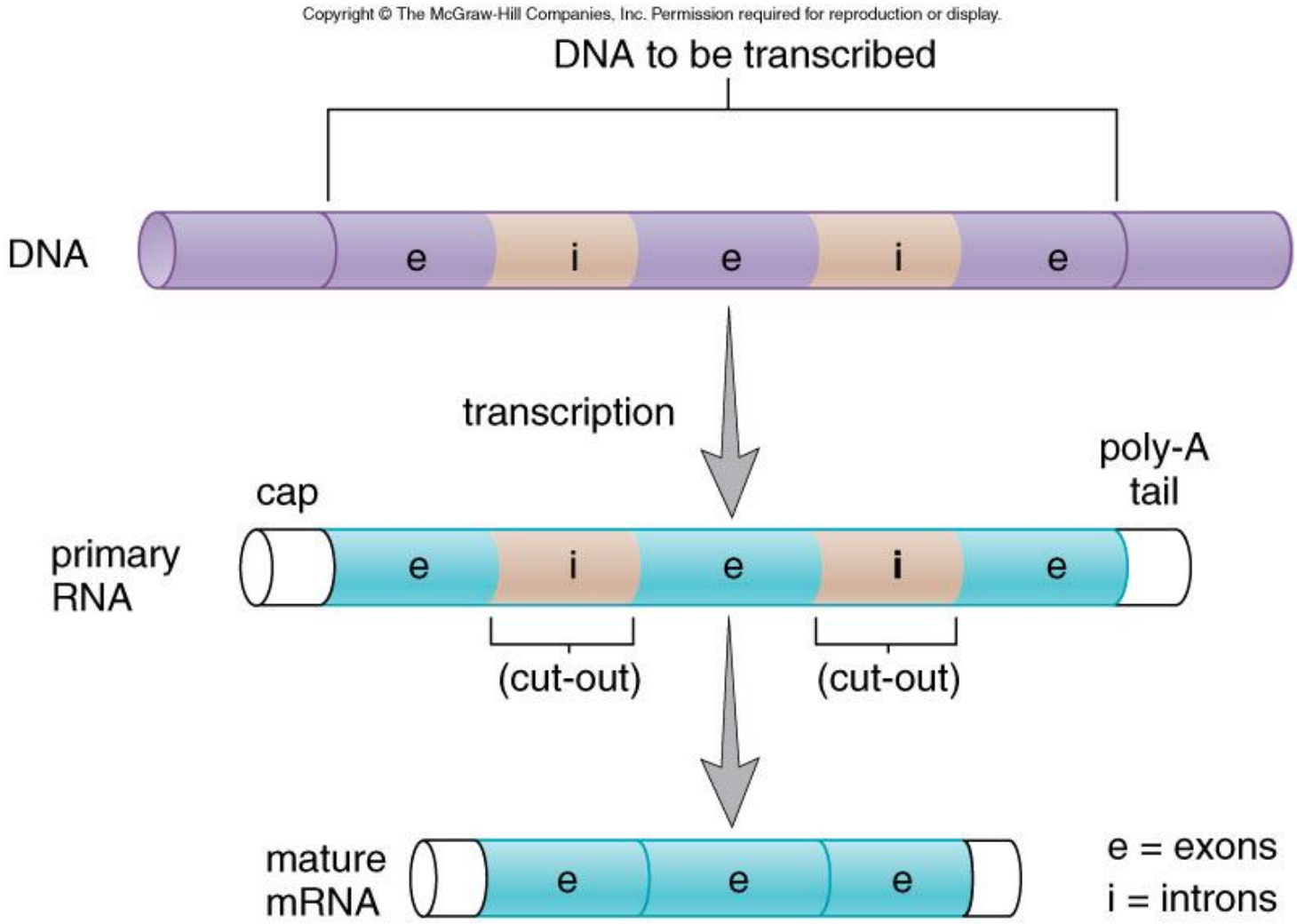
- Transcription
  - Segment of DNA serves as a template for production of mRNA
  - Messenger RNA (mRNA)
    - RNA polymerase binds to a promoter
    - DNA helix is opened so complementary base pairing can occur
    - RNA polymerase joins new RNA nucleotides in a sequence complementary to that on the DNA
  - Processing of mRNA
    - Primary mRNA becomes mature mRNA
    - Contains bases complementary to both intron and exon segments of DNA
    - Intron sequences are removed, and a poly-A tail is added
      - Ribozyme splices exon segments together

Transcription to form mRNA



- Fig. 24.6

mRNA processing



- Fig. 24.7

Gene expression cont'd.

- Translation
  - The genetic code
    - Triplet code- each 3-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
      - 3 are stop codons signal polypeptide termination
      - One codon stands for methionine-signals polypeptide initiation

Messenger RNA codons

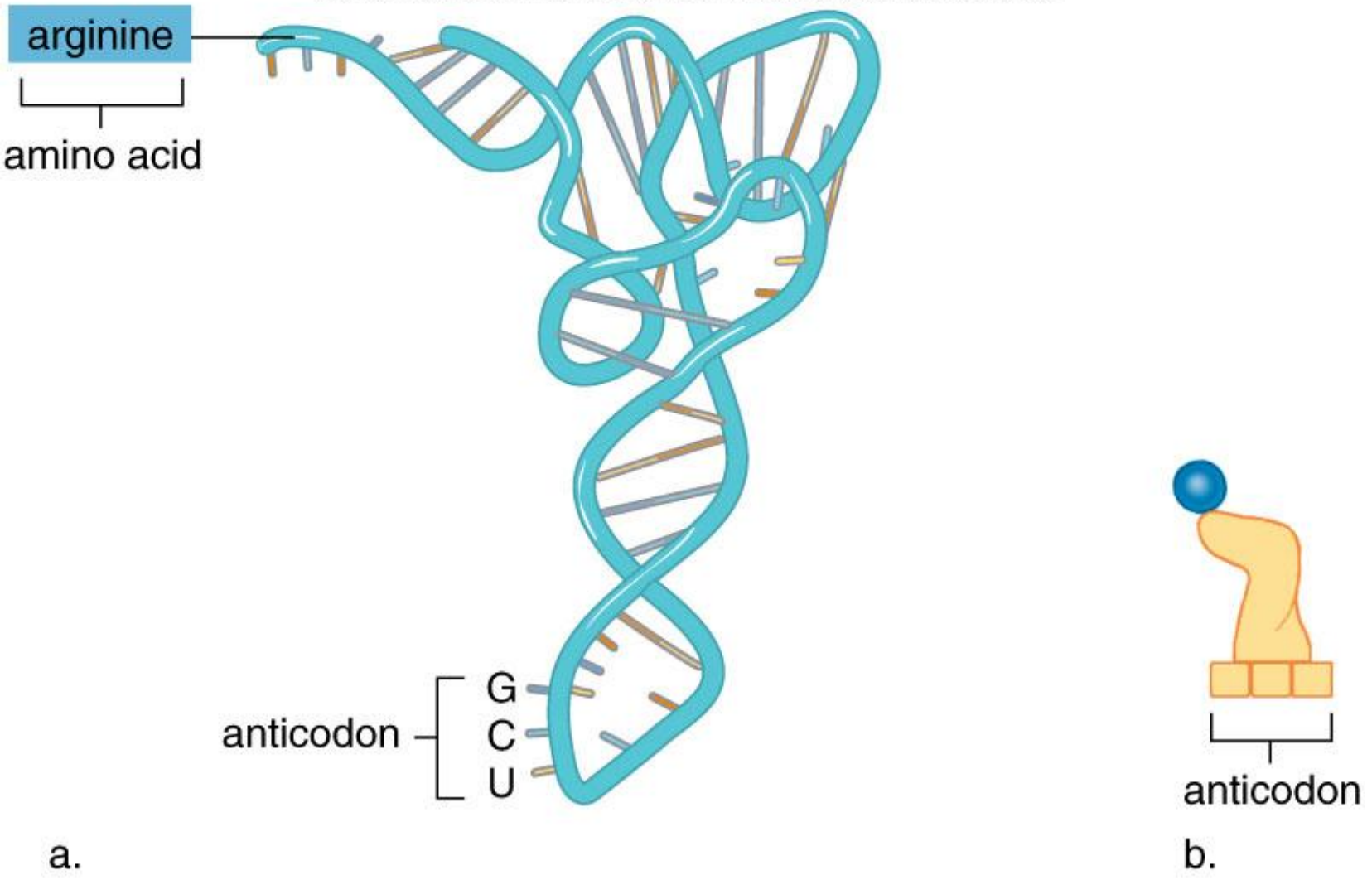
First Base	Second Base				Third Base
	U	C	A	G	
U	UUU phenylalanine	UCU serine	UAU tyrosine	UGU cysteine	U
	UUC phenylalanine	UCC serine	UAC tyrosine	UGC cysteine	C
	UUA leucine	UCA serine	UAA *stop*	UGA *stop*	A
	UUG leucine	UCG serine	UAG *stop*	UGG tryptophan	G
C	CUU leucine	CCU proline	CAU histidine	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

- Fig. 24.8

Gene expression cont'd.

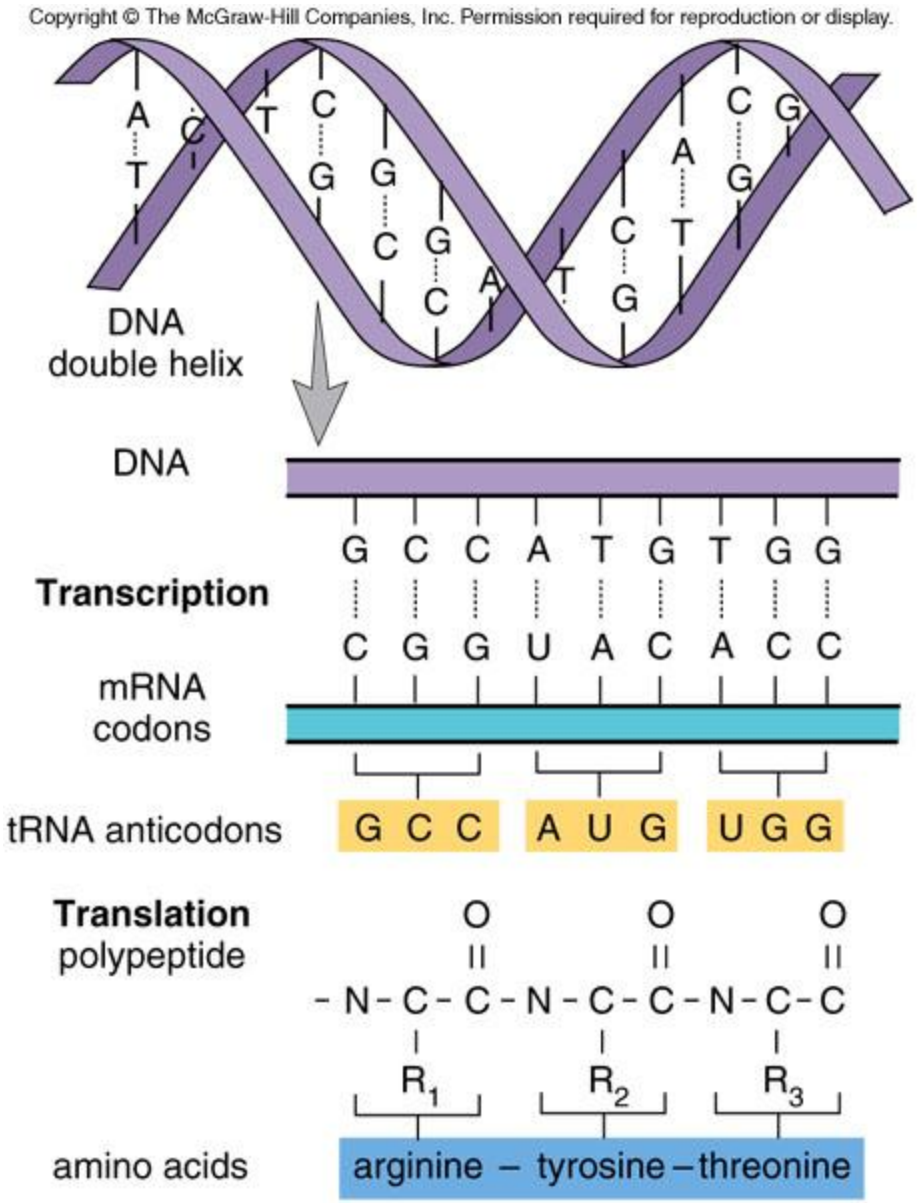
- Translation cont'd.
  - Transfer RNA (tRNA)
    - tRNA transports amino acids to the ribosomes
    - Single stranded nucleic acid that correlates a specific nucleotide sequence with a specific amino acid
    - Amino acid binds to one end, the opposite end has an anticodon
  - the order of mRNA codons determines the order in which tRNA brings in amino acids

Transfer RNA; amino acid carrier



- Fig. 24.9

Role of DNA, mRNA, and tRNA

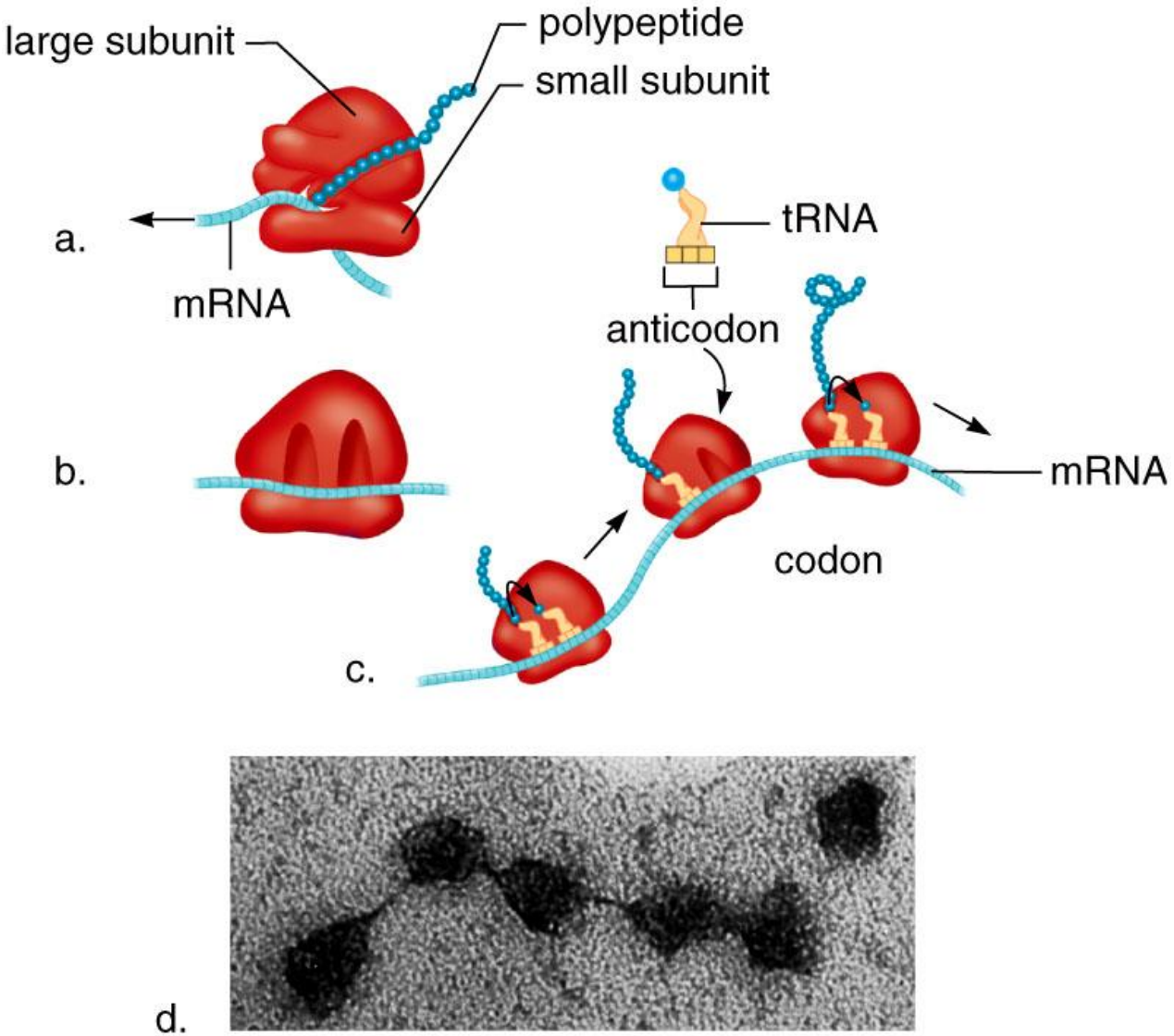


- Fig. 24.10

Gene expression cont'd.

- Translation cont'd.
  - Ribosomes and ribosomal RNA
    - Ribosome has a binding site for mRNA and for 2 tRNAs
    - Facilitate complementary base pairing
    - Ribosome moves along mRNA and new tRNAs come in and line up in order
    - This 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

Polyribosome structure and function

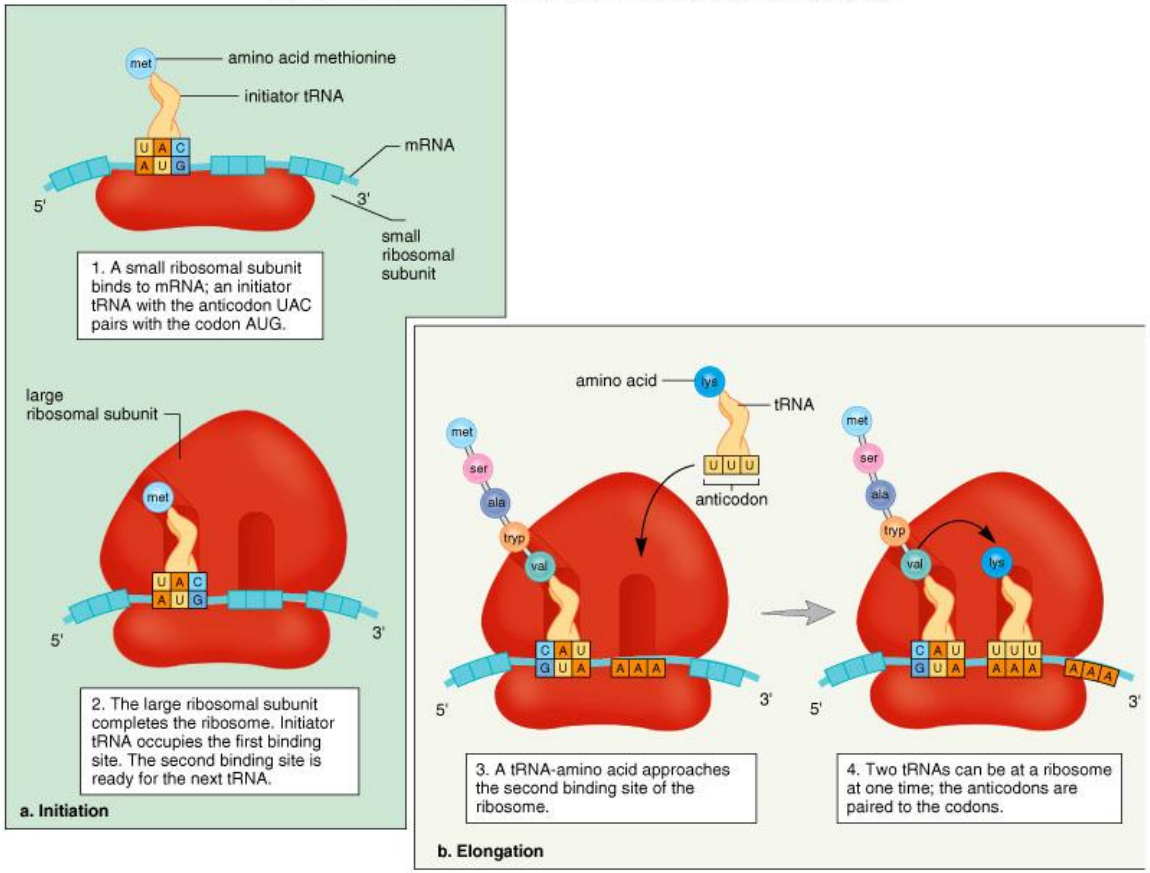


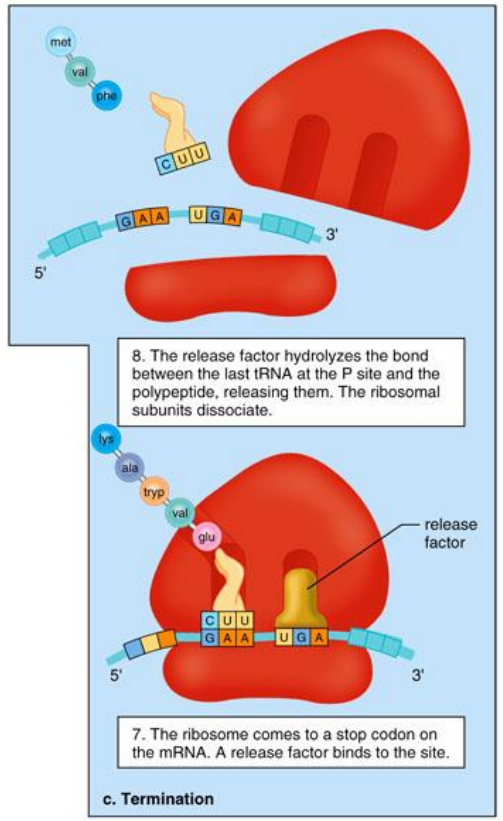
- Fig. 24.11

Gene expression cont'd.

- Translation requires 3 steps
  - Chain initiation
    - Small ribosomal subunit attaches to mRNA at start codon
    - Anticodon of the initiator tRNA-methionine complex binds to start codon
    - Large ribosomal subunit joins to the small subunit
  - Chain elongation
    - Amino acids are added one at a time
    - Each new tRNA-amino acid complex at the second binding site receives a peptide from a tRNA at the first binding site
    - This tRNA breaks away, and the ribosome moves forward one codon
    - The tRNA at the second binging site now occupies the first site
    - Movement of the ribosome is called translocation

Protein synthesis





- Fig. 24.12

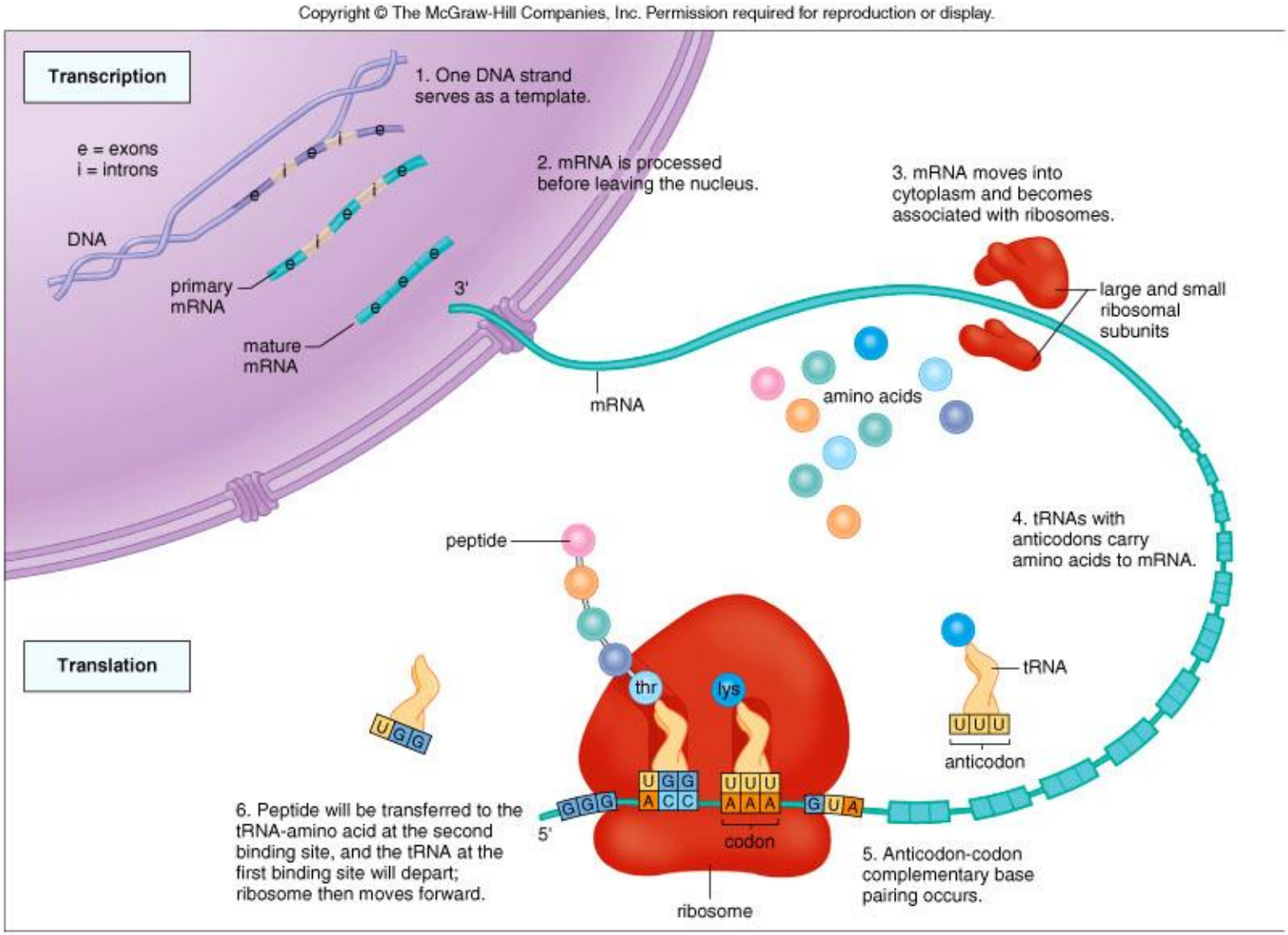
Gene expression cont'd.

- Three steps of translation cont'd.
  - Chain termination
    - Occurs at a stop codon
    - Polypeptide is cleaved by an enzyme from the last tRNA
    - Ribosome dissociates into 2 subunits

Gene expression cont'd.

- Review of gene expression
  - DNA in nucleus contains a triplet base code
    - Each group of 3 bases stands for a specific amino acid
  - Transcription- complementary mRNA is made from the template strand of DNA
    - Every 3 bases along mRNA is called a codon
    - mRNA is processed before it leaves the nucleus to go out to ribosomes
  - Translation
    - Initiation- initiator codon, 2 ribosomal subunits, and tRNA-methionine
    - Chain elongation- anticodons of tRNA line up along mRNA codons
    - Chain termination- at the termination codon polypeptide is released

Gene expression



- Fig. 24.13

Participants in gene expression

TABLE 24.2 PARTICIPANTS IN GENE EXPRESSION

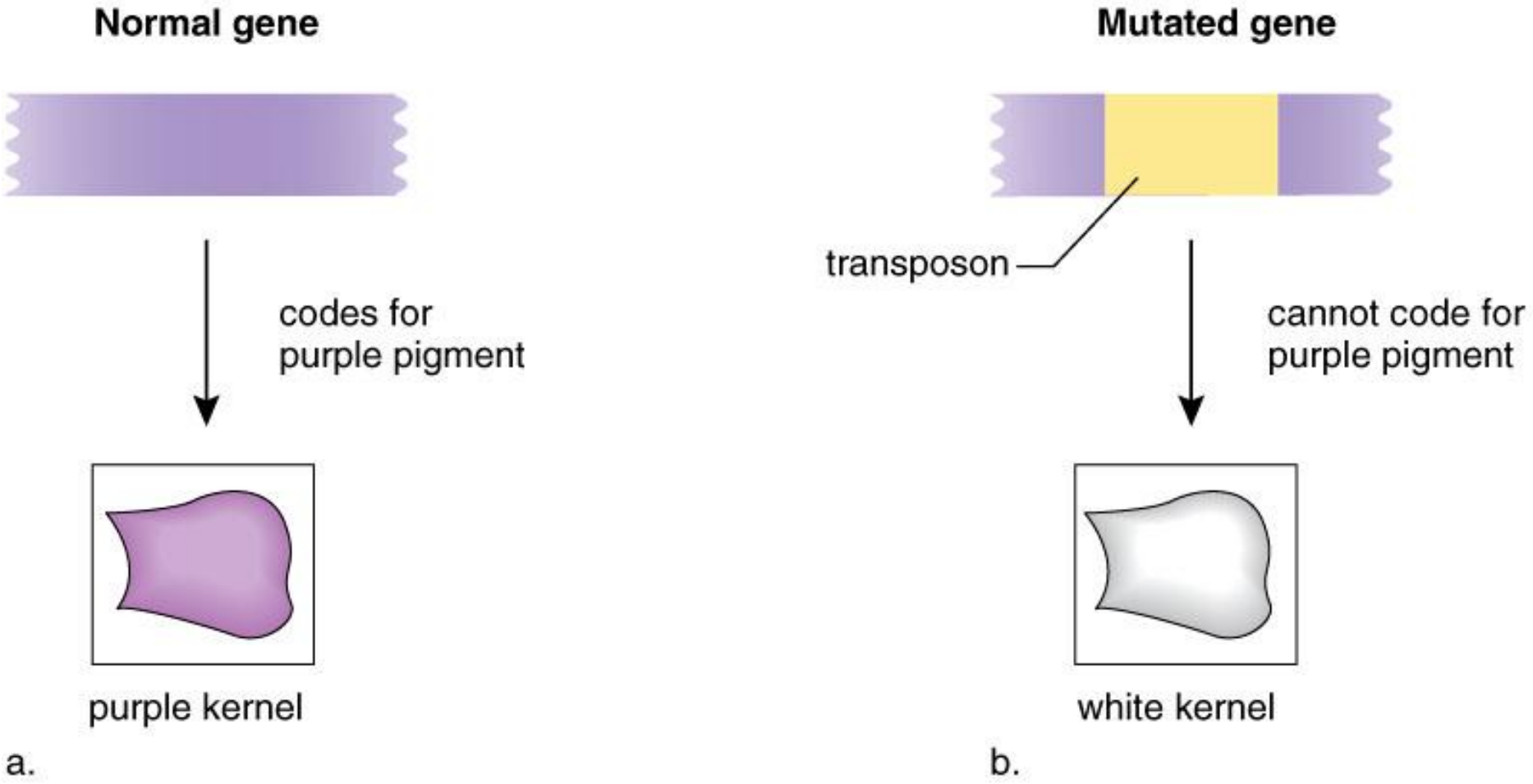
Name of Molecule	Special Significance	Definition
DNA	Genetic information	Sequence of DNA bases
mRNA	Codons	Sequence of three RNA bases complementary to DNA
tRNA	Anticodon	Sequence of three RNA bases complementary to codon
rRNA	Ribosome	Site of protein synthesis
Amino acid	Building block for protein	Transported to ribosome by tRNA
Protein	Enzyme, structural protein, or secretory product	Amino acids joined in a predetermined order

- Table 24.2

Gene expression cont'd.

- Genes and gene mutations
  - Causes of gene mutations
    - Gene mutation is a change in base code sequence
    - Errors in replication
      - Rare
      - DNA polymerase "proof reads" new strands and errors are cleaved out
    - Mutagens
      - Environmental influences
      - Radiation, UV light, chemicals
      - Rate is low because DNA repair enzymes monitor and repair DNA
    - Transposons
      - "jumping genes"
      - Can move to new locations and disrupt sequences

Transposon

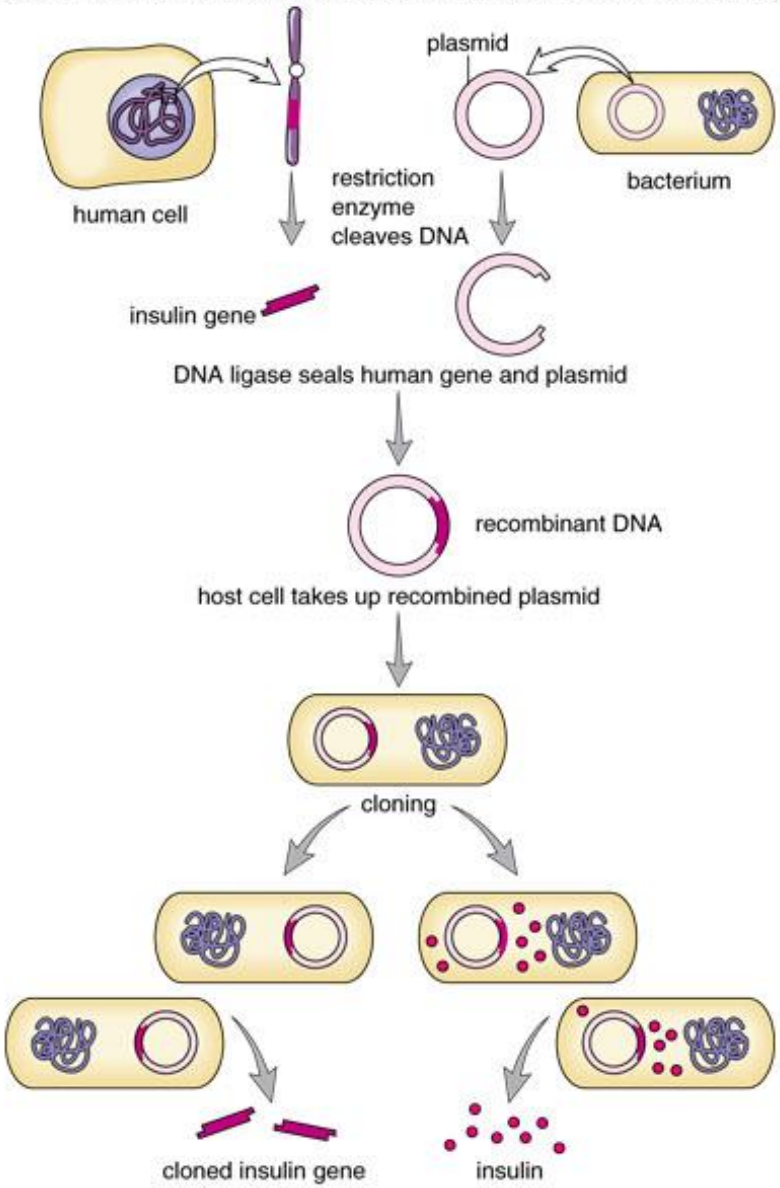


- Fig. 24.14

24.3 DNA technology

- The cloning of a gene
  - Production of identical copies by asexual means
    - Gene cloning-many copies of a gene
  - Gene cloning by recombinant DNA technology
    - rDNA-contains DNA from 2 or more sources
    - Restriction enzyme- breaks open vector DNA
      - Vector is a plasmid-when plasmid replicates, inserted genes will be cloned
      - Restriction enzyme breaks it open at specific sequence of bases-"sticky ends"
      - Foreign DNA to be inserted also cleaved with same restriction enzyme so ends match
    - Foreign DNA is inserted into plasmid DNA and "sticky ends" pair up
    - DNA ligase seals them together

Cloning of a human gene

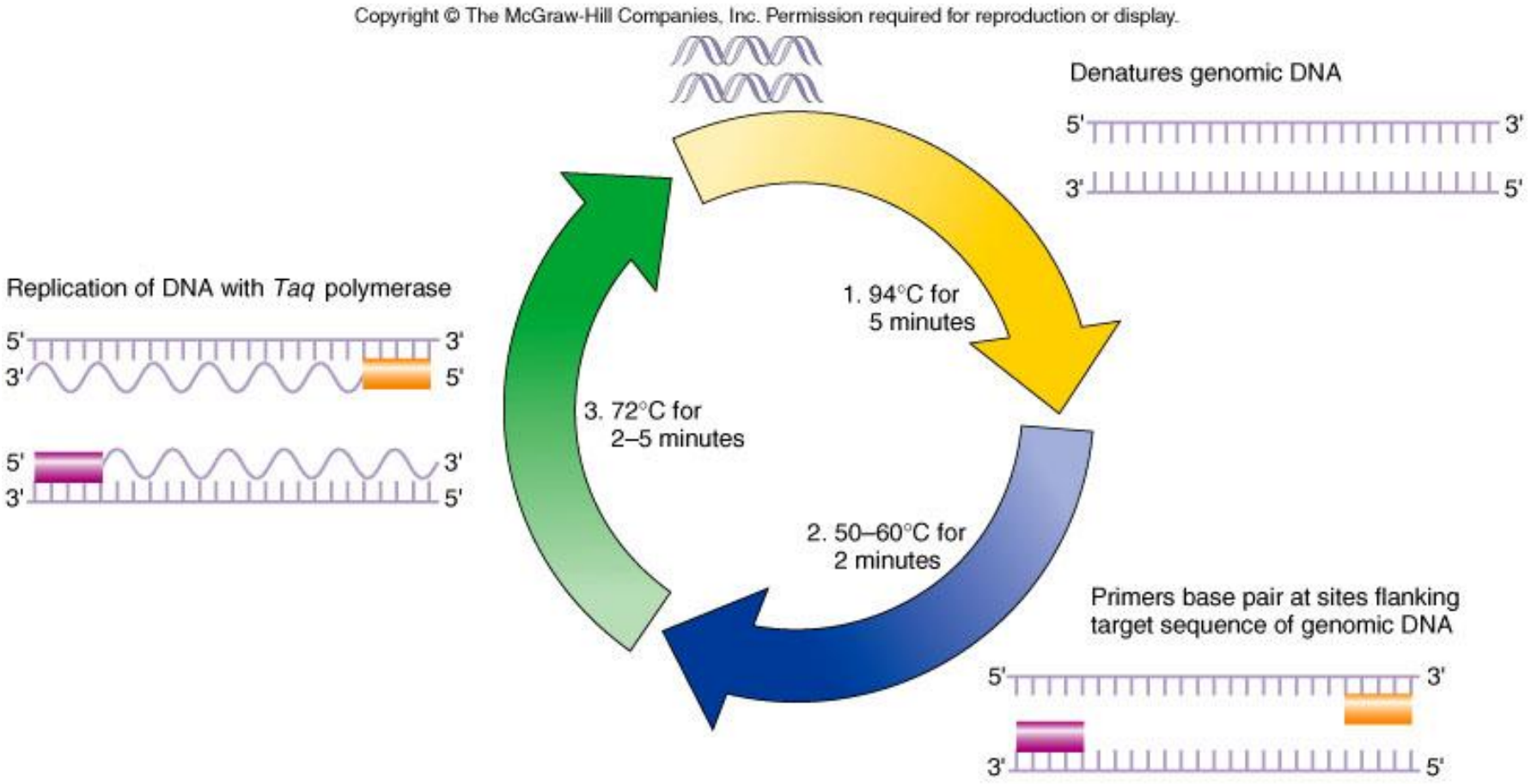


- Fig. 24.15

DNA technology cont'd.

- Cloning of a gene cont'd.
  - Cloning of a gene using the polymerase chain reaction
    - Amplifies a targeted DNA sequence
    - Requires DNA polymerase, a set of primers, and a supply of nucleotides
      - Primers- single stranded DNA sequences that start replication process
      - Amount of DNA doubles with each replication cycle
    - Process is now automated

Polymerase chain reaction

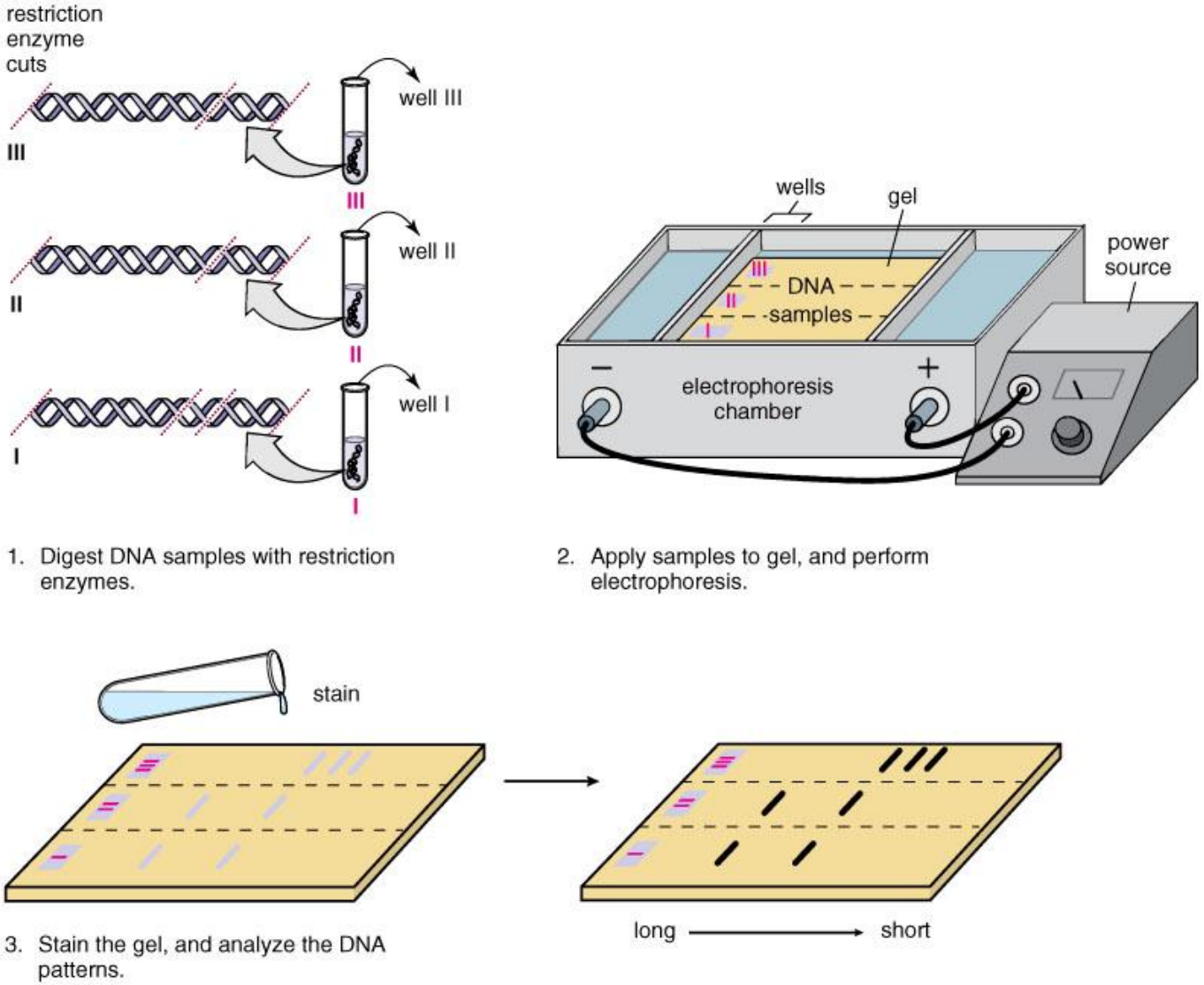


- Fig. 24.16

DNA technology cont'd.

- DNA fingerprinting
  - Permits identification of individuals and their relatives
  - Based on differences between sequences in nucleotides between individuals
  - Detection of the number of repeating segments (called repeats) are present at specific locations in DNA
    - Different numbers in different people
    - PCR amplifies only particular portions of the DNA
    - The greater the number of repeats, the greater the amount of DNA that is amplified
    - The quantity of DNA that results at completion of PCR tells the number of repeats

DNA fingerprints



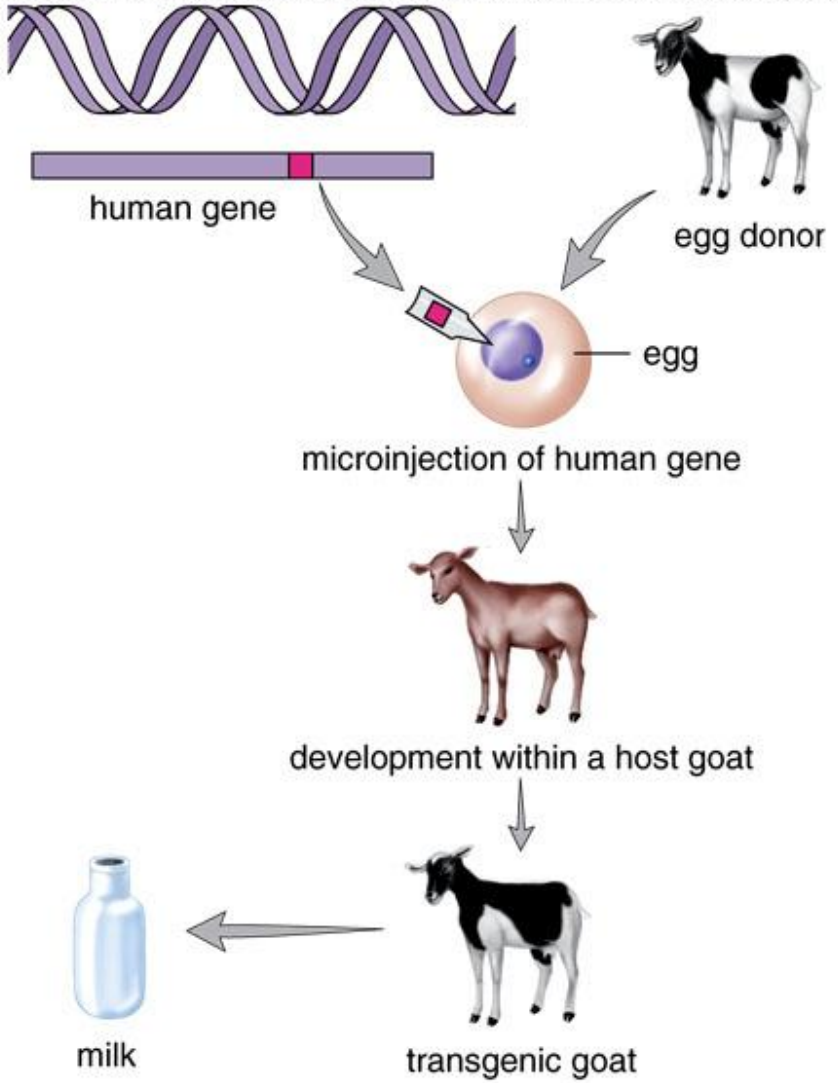
- Fig. 24.17

DNA technology cont'd.

- Biotechnology
  - Transgenic bacteria
    - Contain a recombinant gene which is then cloned and expressed
    - Product can be collected from medium the bacteria are grown in
    - Transgenic bacteria have been developed for many uses
  - Transgenic plants
    - Insert new genes into protoplasts-plant cells with cell walls removed
    - Can make plants insect-resistant, disease-resistant, etc.
    - Can "pharm" plants to produce human proteins
  - Transgenic animals
    - Genes inserted into animal eggs
    - Can increase size of animals
    - Can "pharm" animals to produce drugs in milk

Transgenic animals

a.



b.

- Fig. 24.20