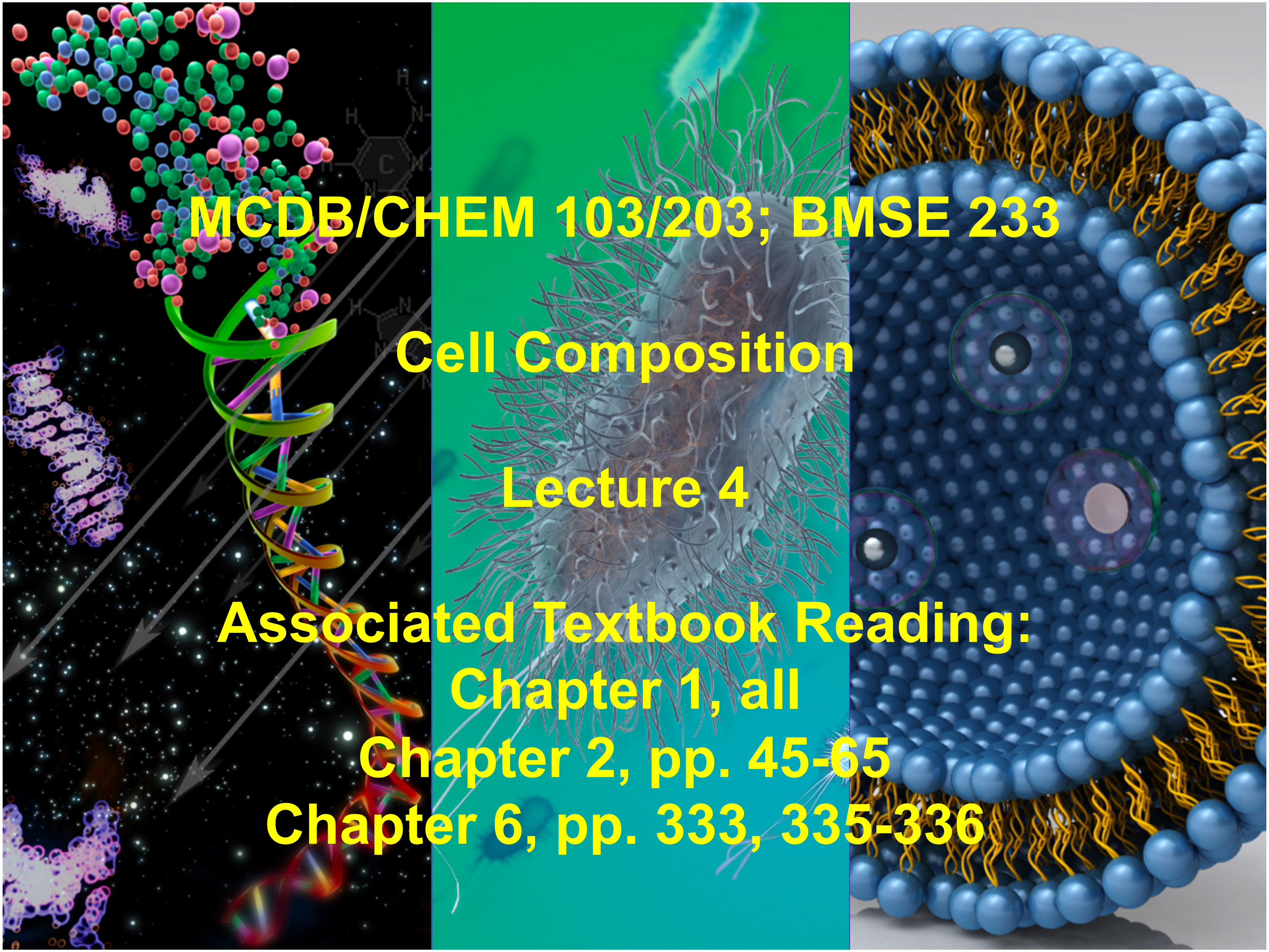


MCDB/CHEM 103/203; BMSE 233

Cell Composition

Lecture 4

Associated Textbook Reading:
Chapter 1, all
Chapter 2, pp. 45-65
Chapter 6, pp. 333, 335-336

Table 2–2 The Approximate Chemical Composition of a Bacterial Cell

	PERCENT OF TOTAL CELL WEIGHT	NUMBER OF TYPES OF EACH MOLECULE
Water	70	1
Inorganic ions	1	20
Sugars and precursors	1	250
Amino acids and precursors	0.4	100
Nucleotides and precursors	0.4	100
Fatty acids and precursors	1	50
Other small molecules	0.2	~300
Macromolecules (proteins, nucleic acids, and polysaccharides)	26	~3000

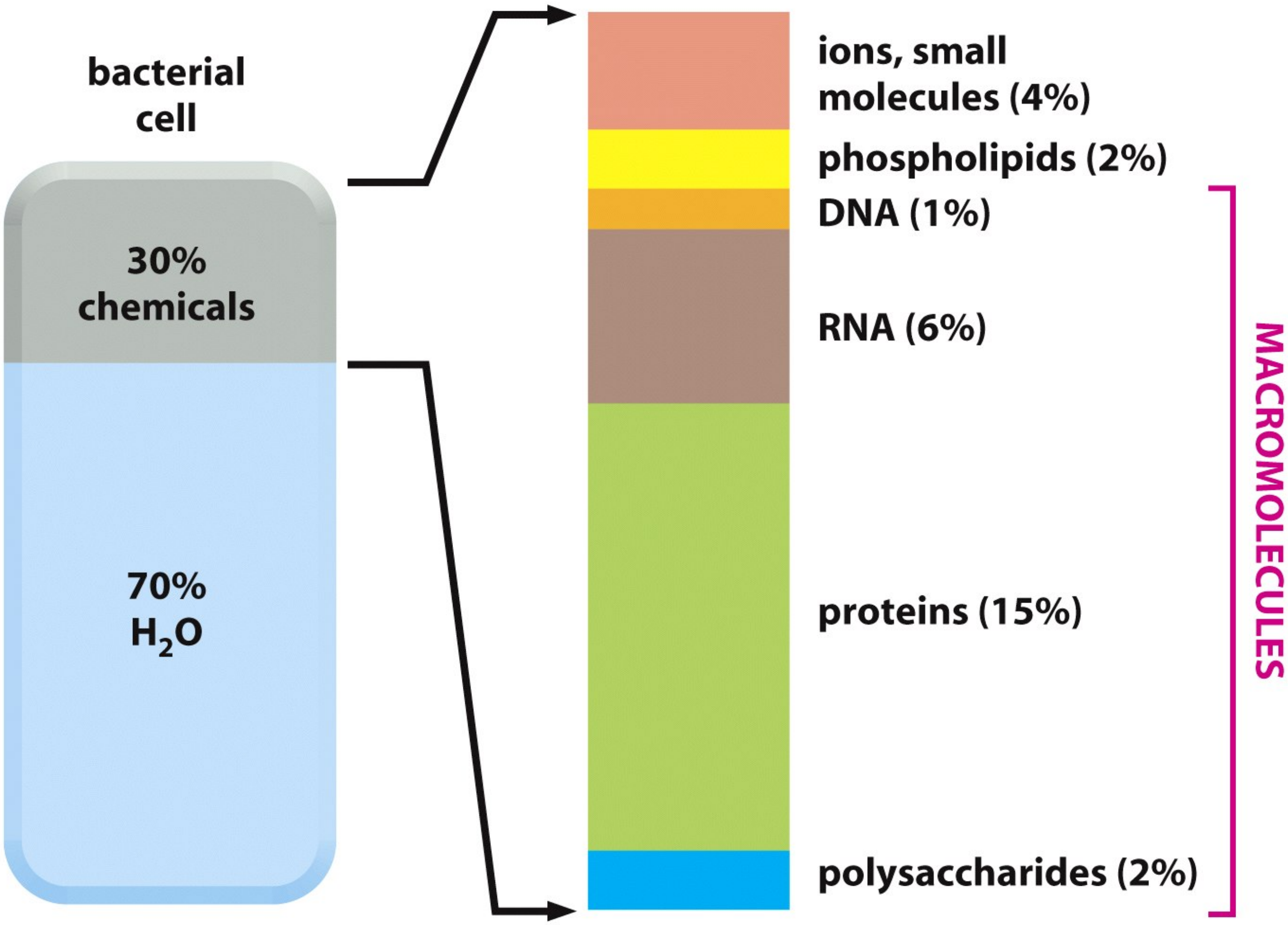


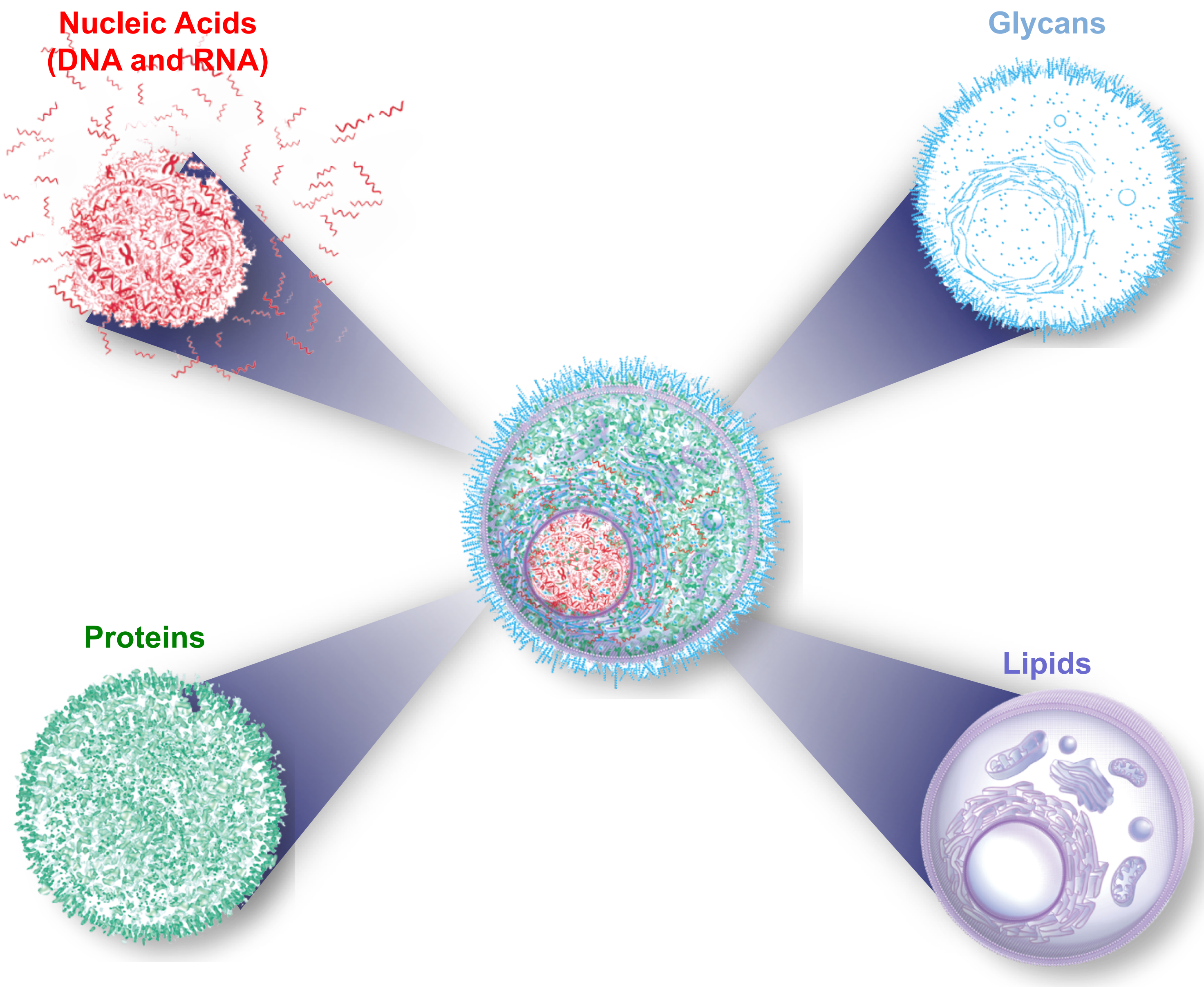
Figure 2-29 *Molecular Biology of the Cell* (© Garland Science 2008)

Table 2–3 Approximate Chemical Compositions of a Typical Bacterium and a Typical Mammalian Cell

COMPONENT	PERCENT OF TOTAL CELL WEIGHT *E. COLI* BACTERIUM	MAMMALIAN CELL
H_2O	70	70
Inorganic ions (Na^+, K^+, Mg^{2+}, Ca^{2+}, Cl^-, etc.)	1	1
Miscellaneous small metabolites	3	3
Proteins	15	18
RNA	6	1.1
DNA	1	0.25
Phospholipids	2	3
Other lipids	–	2
Polysaccharides	2	2
Total cell volume	2×10^{-12} cm^3	4×10^{-9} cm^3
Relative cell volume	1	2000

Proteins, polysaccharides, DNA, and RNA are macromolecules. Lipids are not generally classed as macromolecules even though they share some of their features; for example, most are synthesized as linear polymers of a smaller molecule (the acetyl group on acetyl CoA), and they self-assemble into larger structures (membranes). Note that water and protein comprise most of the mass of both mammalian and bacterial cells.

Cells are Composed of Four Types of Molecular Components



FROM THE TEXTBOOK:

THE FOUR FUNDAMENTAL CELLULAR MACROMOLEULES AND STRUCTURAL COMPONENTS

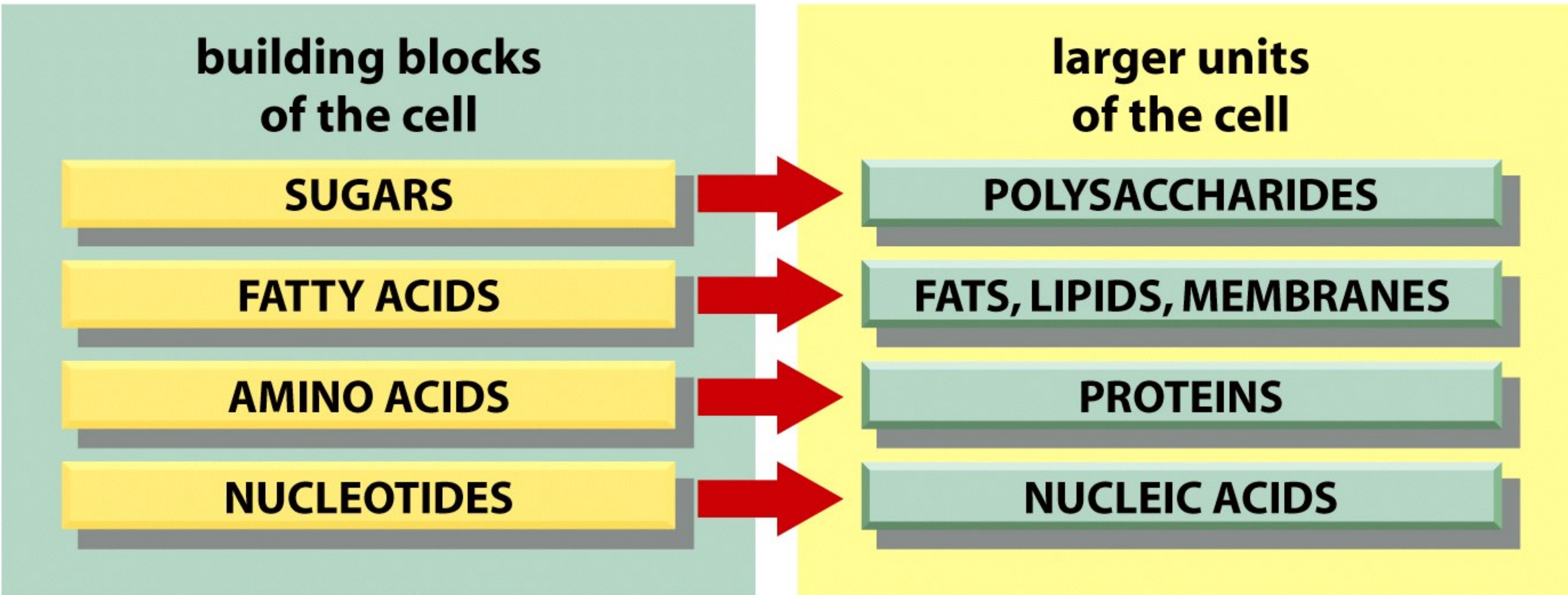
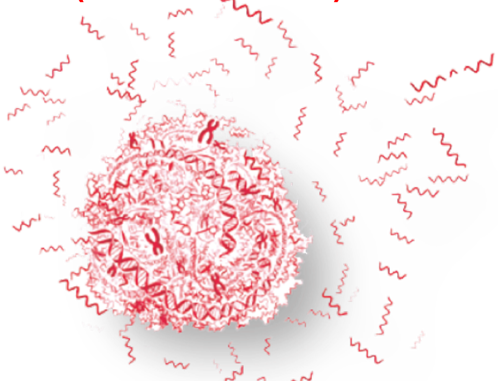


Figure 2-17 ***Molecular Biology of the Cell*** **(© Garland Science 2008)**

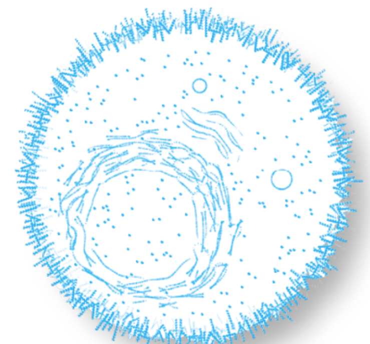
Cells are Composed of Four Types of Molecular Components: Comprised of 70 Building Blocks

Nucleic Acids (DNA and RNA)

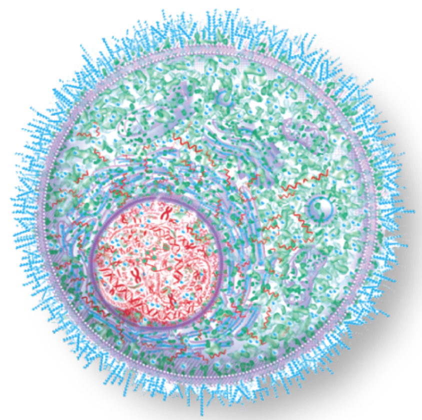


Deoxyadenosine, Deoxycytidine, Deoxyguanosine, Deoxythymidine, Adenosine, Cytidine, Guanosine, Uridine

Glycans



Fucose, Galactose, Glucose, Glucuronic Acid, Mannose, N-Acetylgalactosamine, N-Acetylglucosamine, Neuraminic Acid, Xylose, Nononic Acid, Octulosonic Acid, Arabinose, Arabinofuranose, Bacillosamine, Colitose, Fructose, Galactofuranose, Galacturonic Acid, Glucolactillic Acid, Heptose,Legionaminic Acid, Mannuronic Acid, N-Acetylfucosamine, N-Acetylgalacturonic Acid, N Acetylmannosamine, N-Acetylmannosaminuronic Acid, N-Acetylmuramic Acid, N-Acetylperosamine, N Acetylquinovosamine, Perosamine, Pseudaminic Acid, Rhamnose, Talose



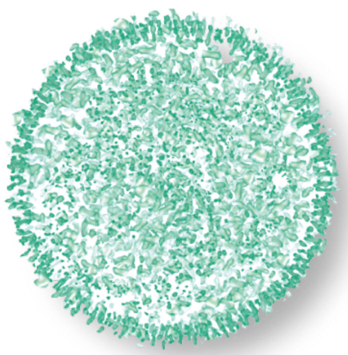
dA, dC, dG, dT, rA, rC, rG, rU

A, R, D, N, C, E, Q, G, H, I, L, K, M, F, P, S, T, W, Y, V

Fuc, Gal, Glc, GlcA, Man, GalNAc, GlcNAc, NeuAc, Xyl, Kdn, Kdo, Ara, Araf, Bac, Col, Frc, Galf, GalA, GlcLA, Hep, Leg, ManUA, FucNAc, GalNAcUA, ManNAc, ManNAcUA, MurNAc, PerNAc, QuiNAc, Per, Pse, Rha, Tal

Fa, Gl, Glpl, Pk, Pl, Scl, Sphl, Stl

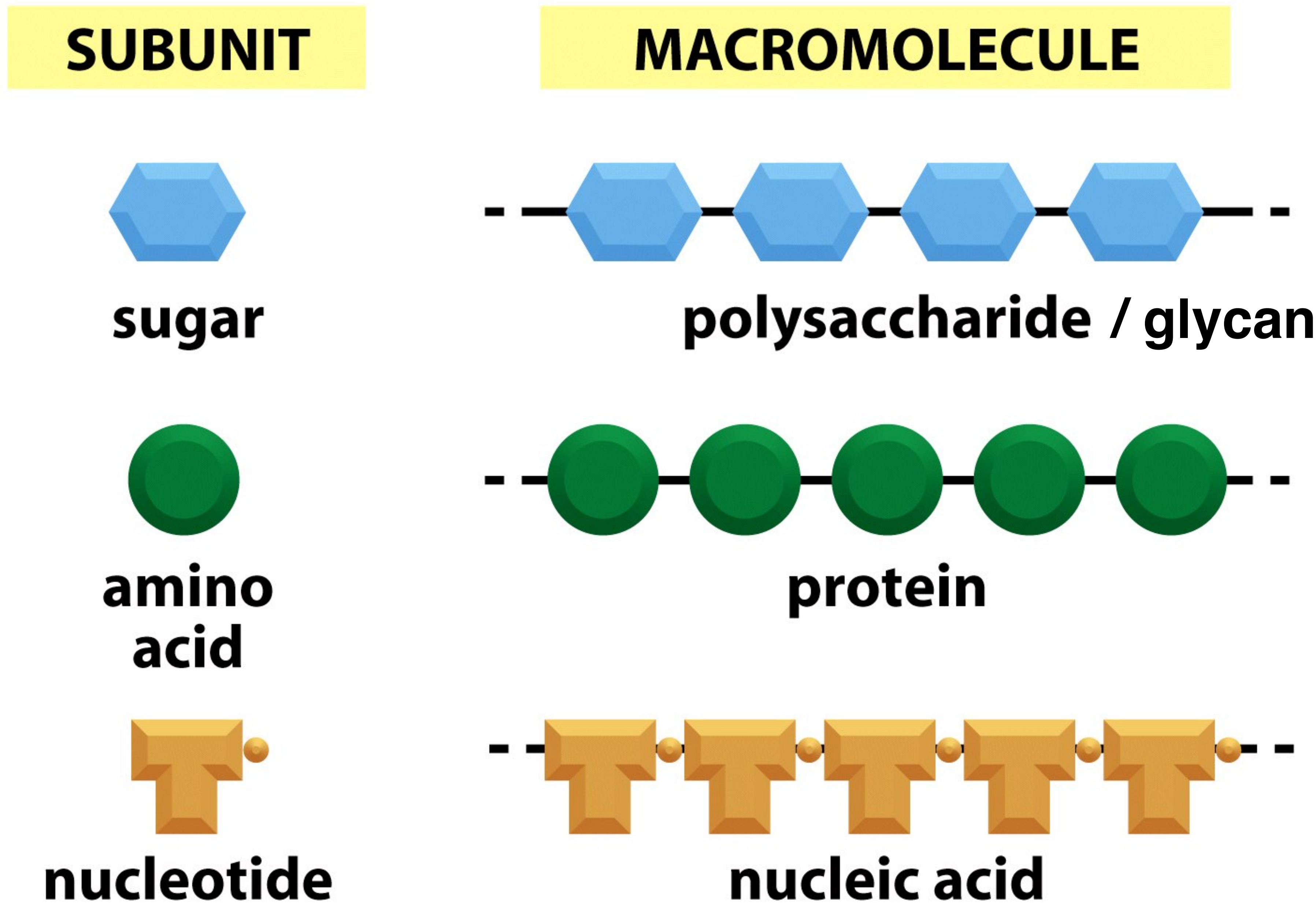
Proteins



Alanine, Arginine, Aspartic Acid, Asparagine, Cysteine, Glutamic Acid, Glutamine, Glycine, Histidine, Isoleucine, Leucine, Lysine, Methionine, Phenylalanine, Proline, Serine, Threonine, Tryptophan, Tyrosine, Valine

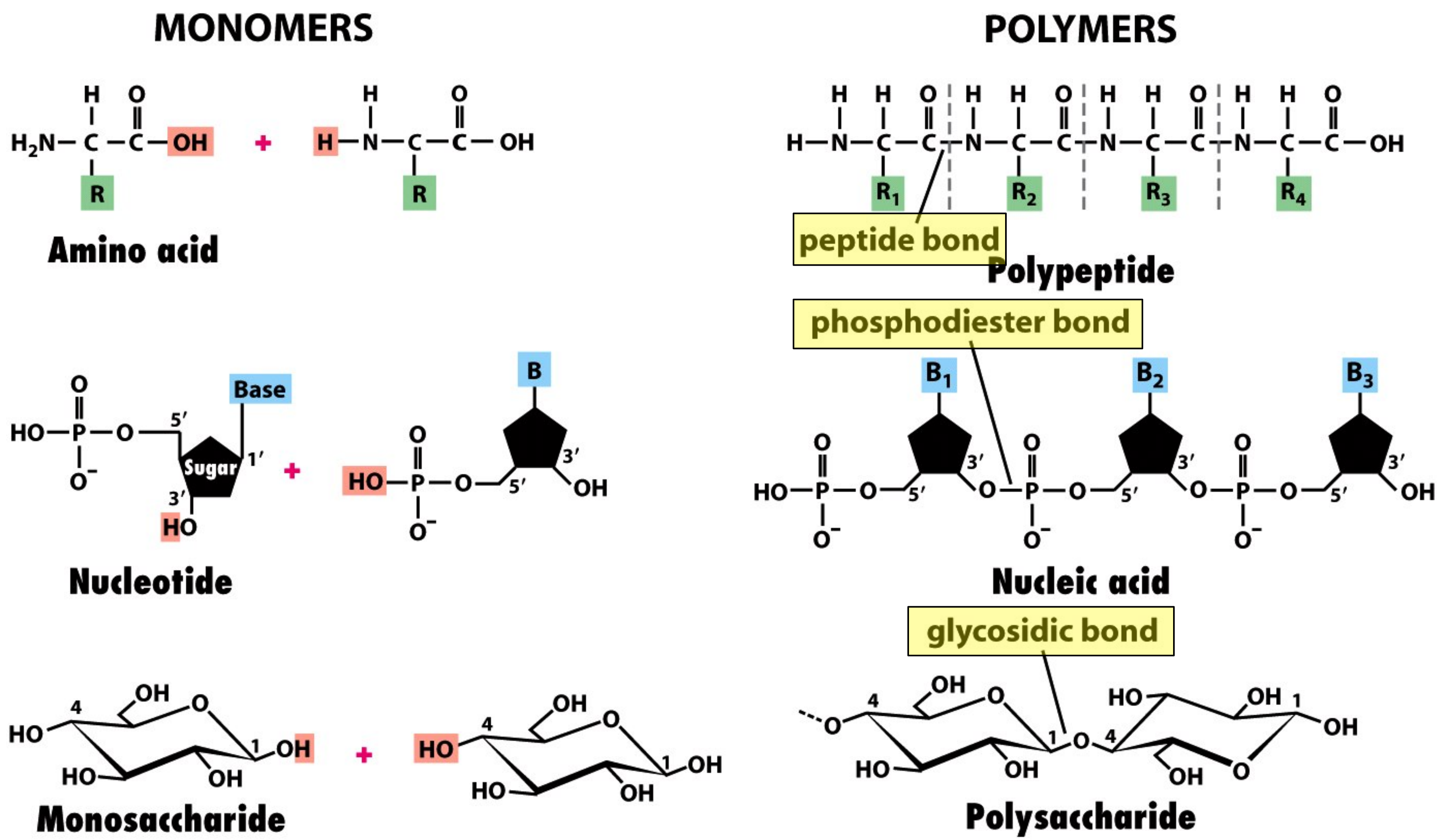
Lipids

Fatty Acyls, Glycerolipids, Glycerophospholipids, Polyketides, Prenol Lipids, Saccharolipids, Sphingolipids, Sterol Lipids



Modified version of Figure 2-30 *Molecular Biology of the Cell* (© Garland Science 2008)

KEY MOLECULAR BONDS OF LIFE



LIPIDS

Carbon-carbon and hydrocarbon repeats of lipids are also sometimes called fatty acids.

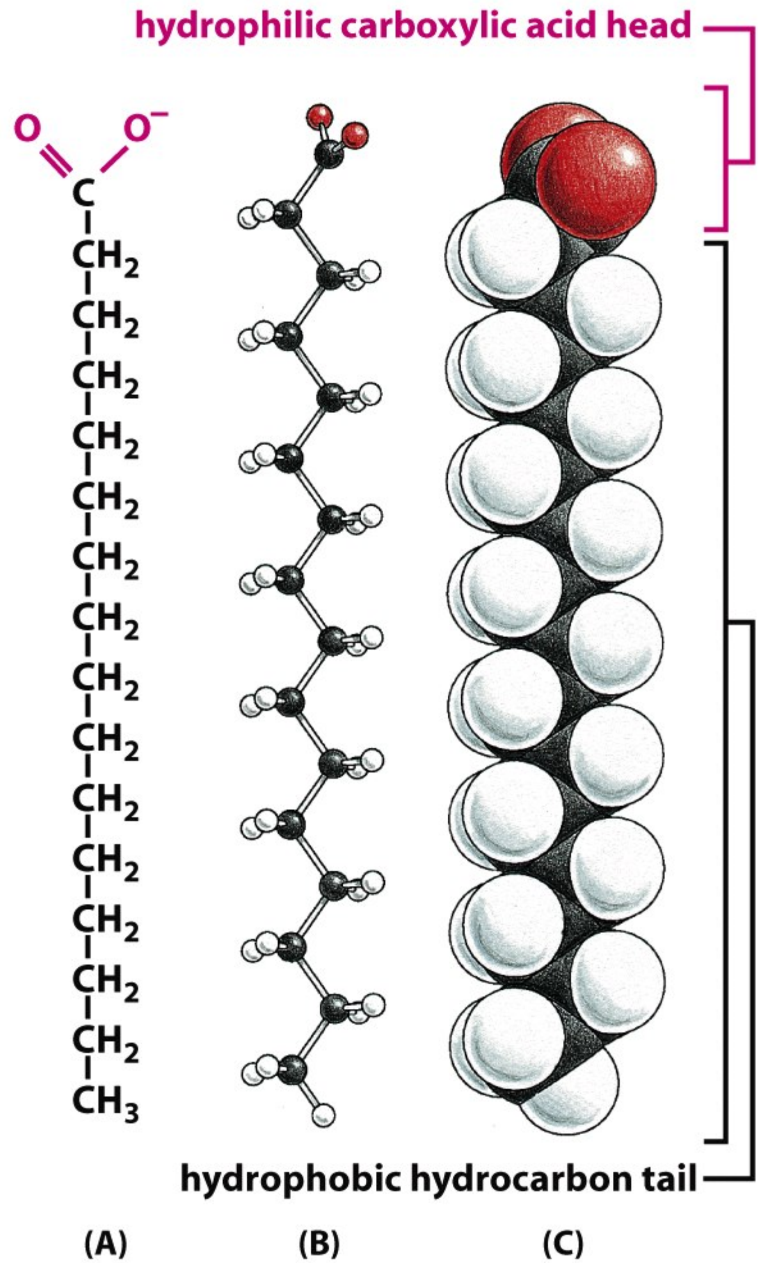
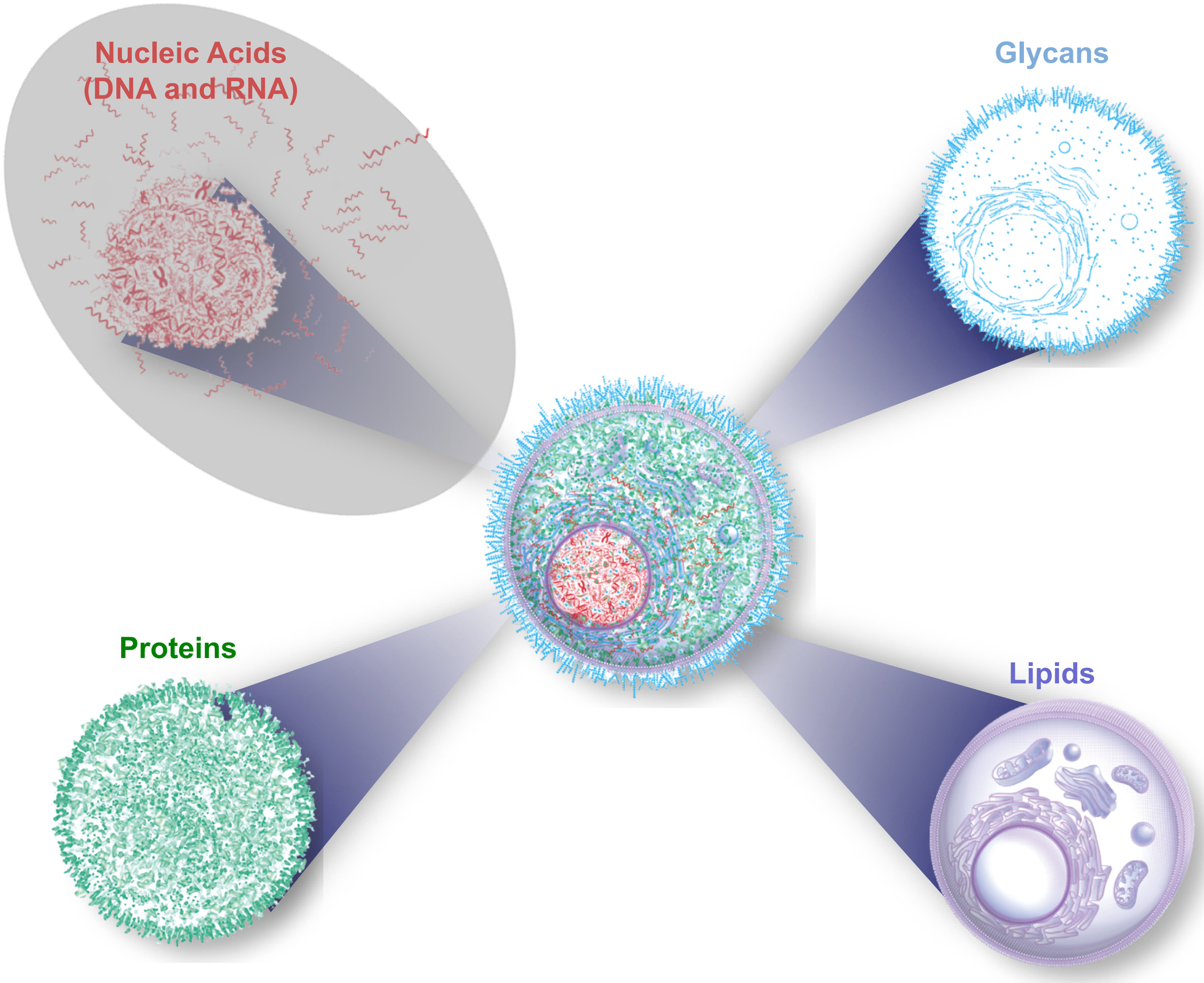


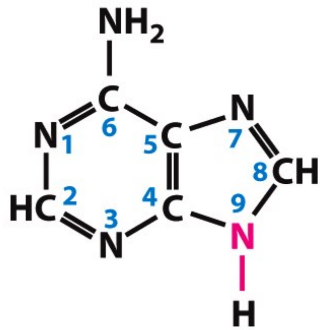
Figure 2-21 Molecular Biology of the Cell 5/e (© Garland Science 2008)

Cells are Composed of Four Types of Molecular Components

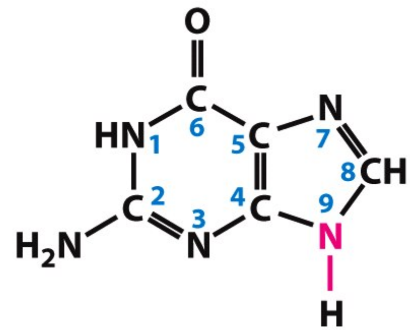


STRUCTURE OF THE PRINCIPAL BASES OF NUCLEOSIDES / NUCLEOTIDES

PURINES

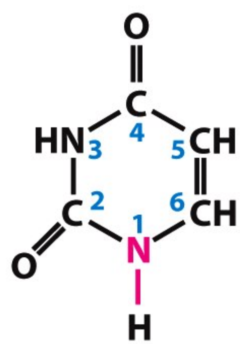


Adenine (A)

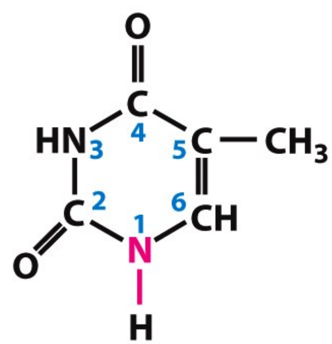


Guanine (G)

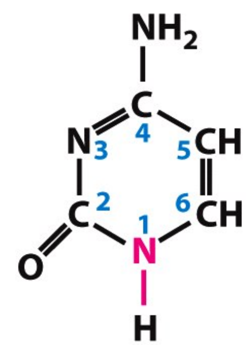
PYRIMIDINES



Uracil (U)

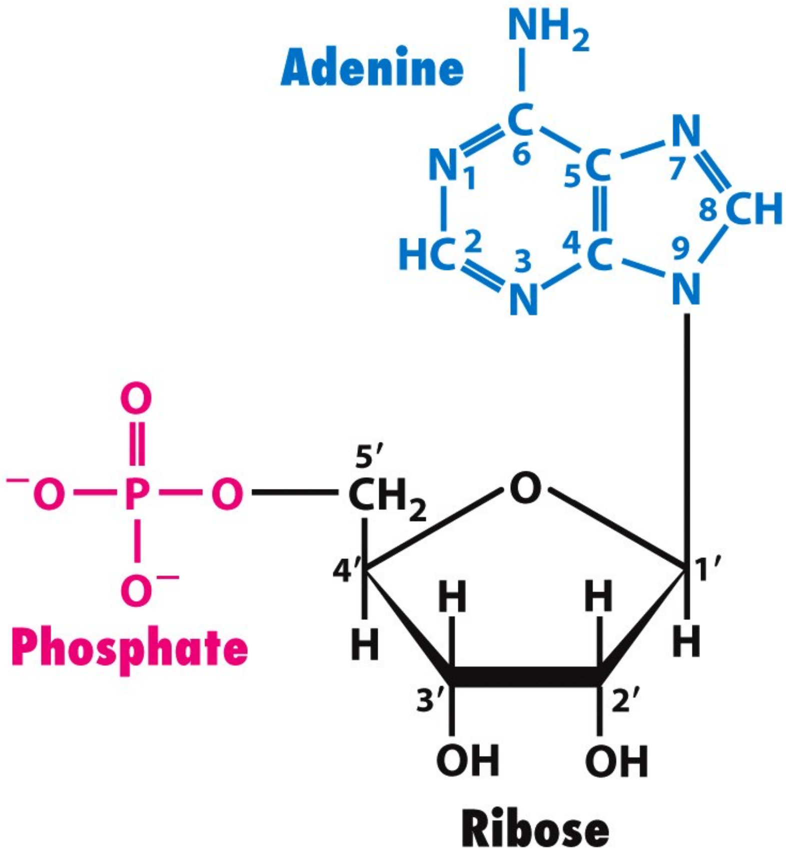


Thymine (T)

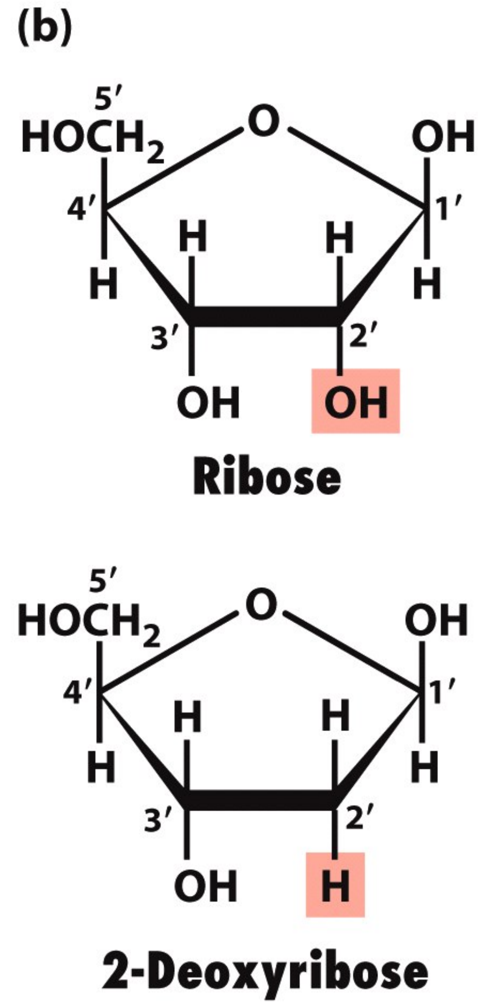


Cytosine (C)

STRUCTURE OF NUCLEOTIDES /NUCLEOSIDES



Adenosine 5′-monophosphate (AMP)



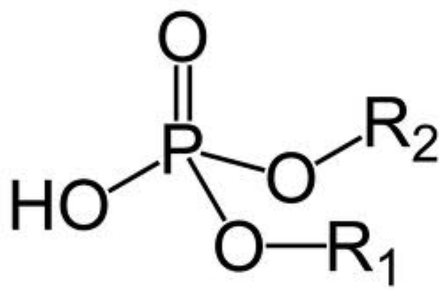
NUCLEOTIDES / NUCLEOSIDES

TABLE 2-3 Terminology of Nucleosides and Nucleotides

BASES		PURINES		PYRIMIDINES	
		ADENINE(A)	GUANINE(G)	CYTOSINE(C)	URACIL(U) THYMINE(T)
Nucleosides	in RNA	Adenosine	Guanosine	Cytidine	Uridine
	in DNA	Deoxyadenosine	Deoxyguanosine	Deoxycytidine	Deoxythymidine
Nucleotides	in RNA	Adenylate	Guanylate	Cytidylate	Uridylate
	in DNA	Deoxyadenylate	Deoxyguanylate	Deoxycytidylate	Deoxythymidylate
Nucleoside monophosphates		AMP	GMP	CMP	UMP
Nucleoside diphosphates		ADP	GDP	CDP	UDP
Nucleoside triphosphates		ATP	GTP	CTP	UTP
Deoxynucleoside mono-, di-, and triphosphates		dAMP, etc.	dGMP, etc.	dCMP, etc	dTMP, etc.

NUCLEIC ACIDS: DNA

Phosphodiester bond



DNA

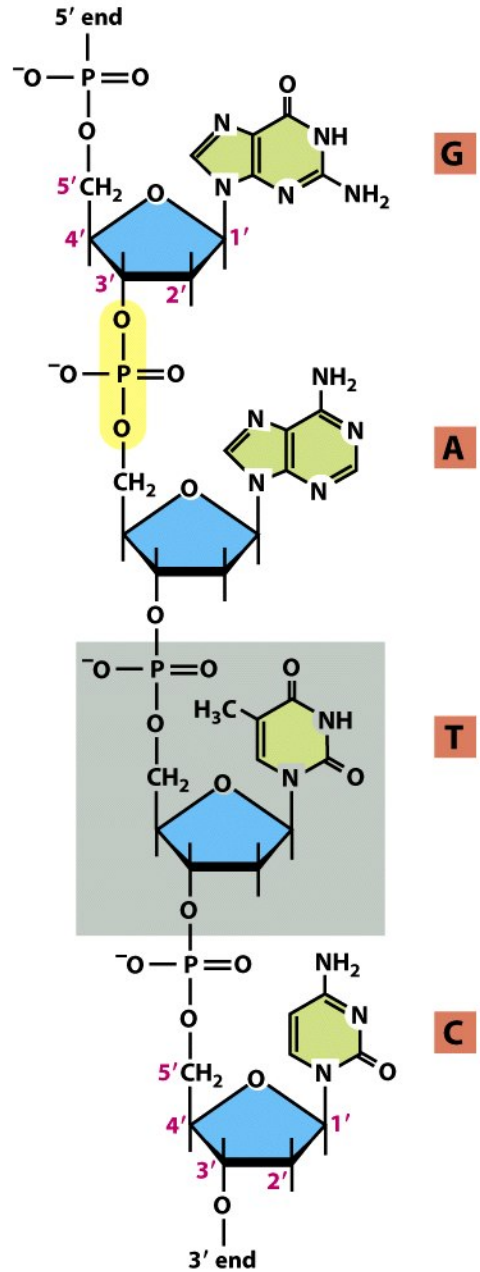


Figure 2-28 *Molecular Biology of the Cell* (© Garland Science 2008)

One DNA Strand, a Complement of the Other DNA Strand…..

Figure 1-2b Molecular Biology of the Cell 5/e (© Garland Science 2008)

The Structure of DNA

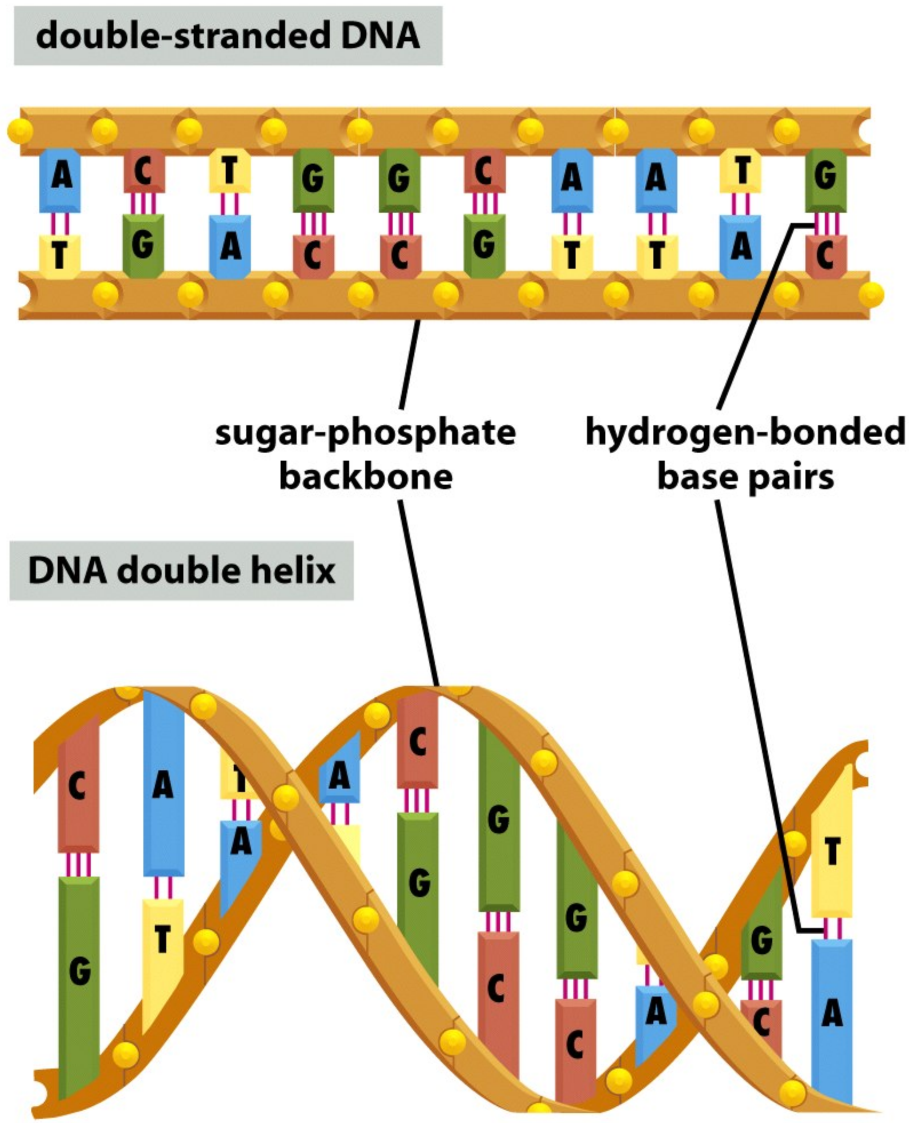
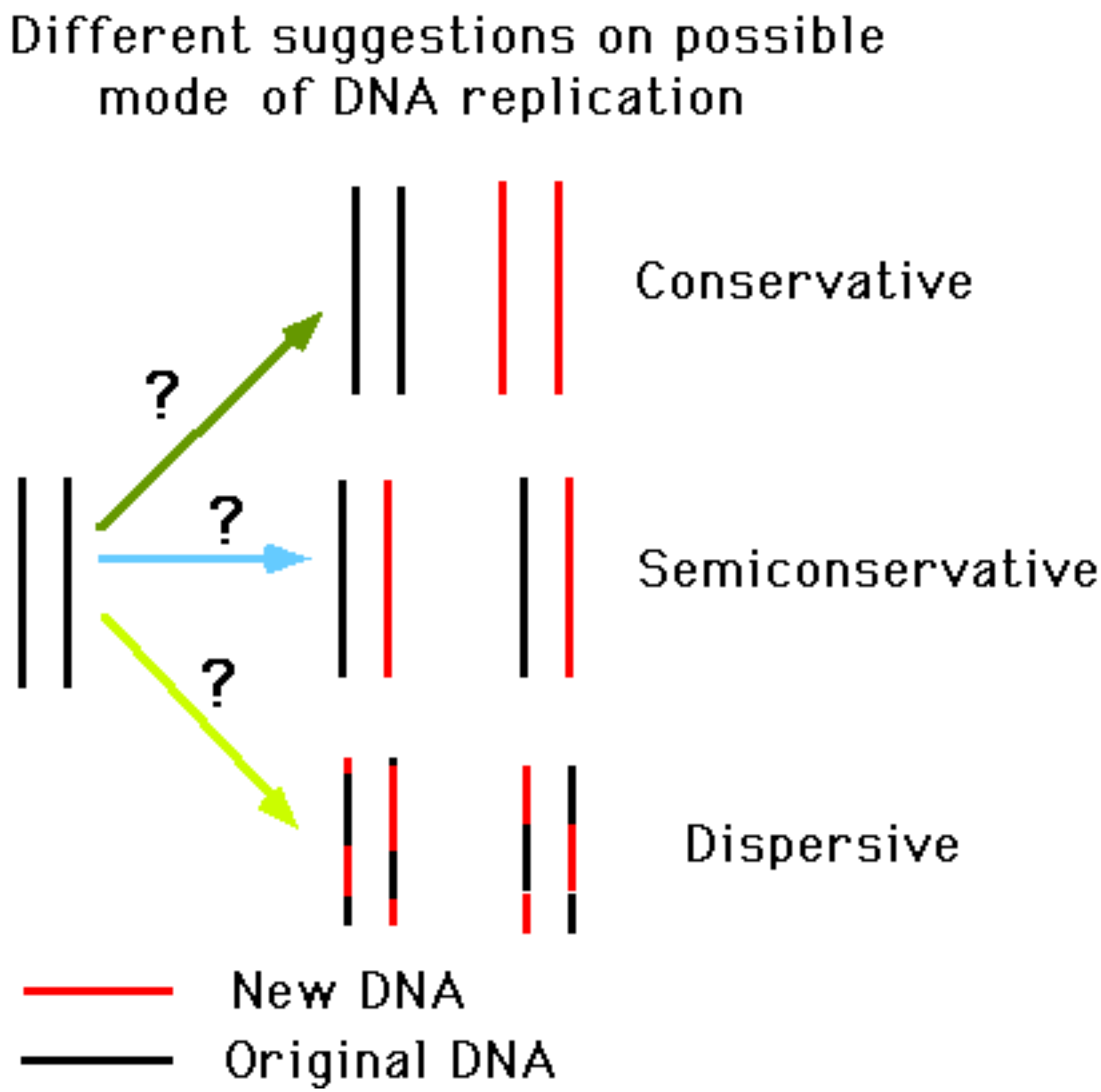


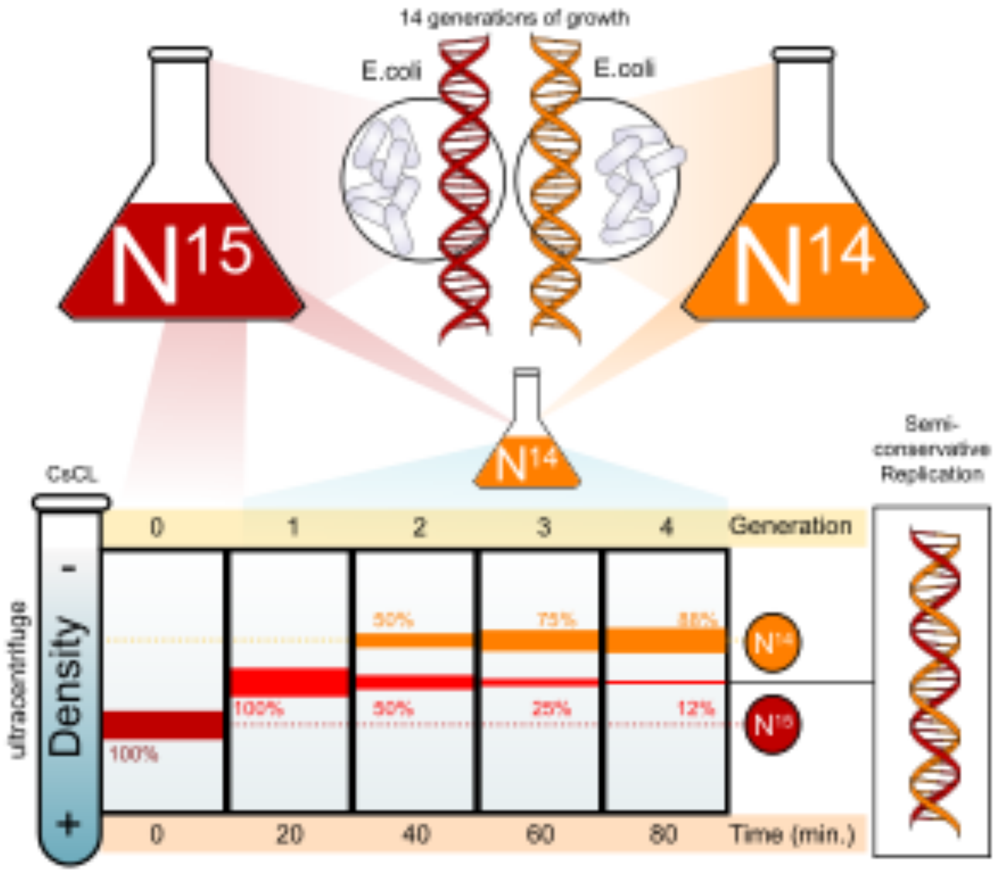
Figure 1-2de Molecular Biology of the Cell 5/e (© Garland Science 2008)

James Watson
Francis Crick
Nobel Prize, 1962

How does DNA Replicate?



The Meselson-Stahl Experiment



Frank Stahl

Matthew Meselson

DNA Replication is Semi-Conservative!

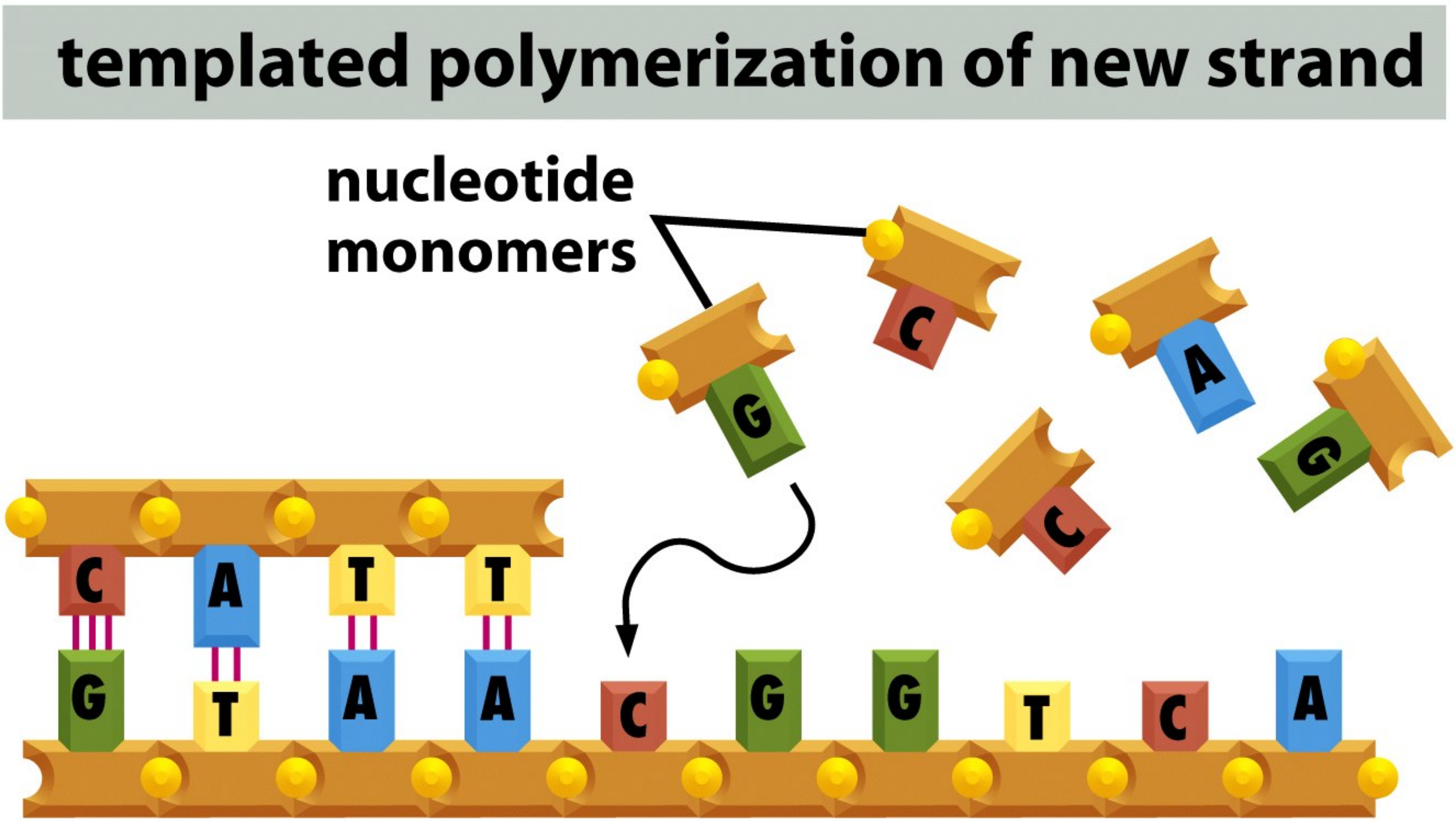


Figure 1-2c Molecular Biology of the Cell 5/e (© Garland Science 2008)

Semi-Conservative DNA Replication

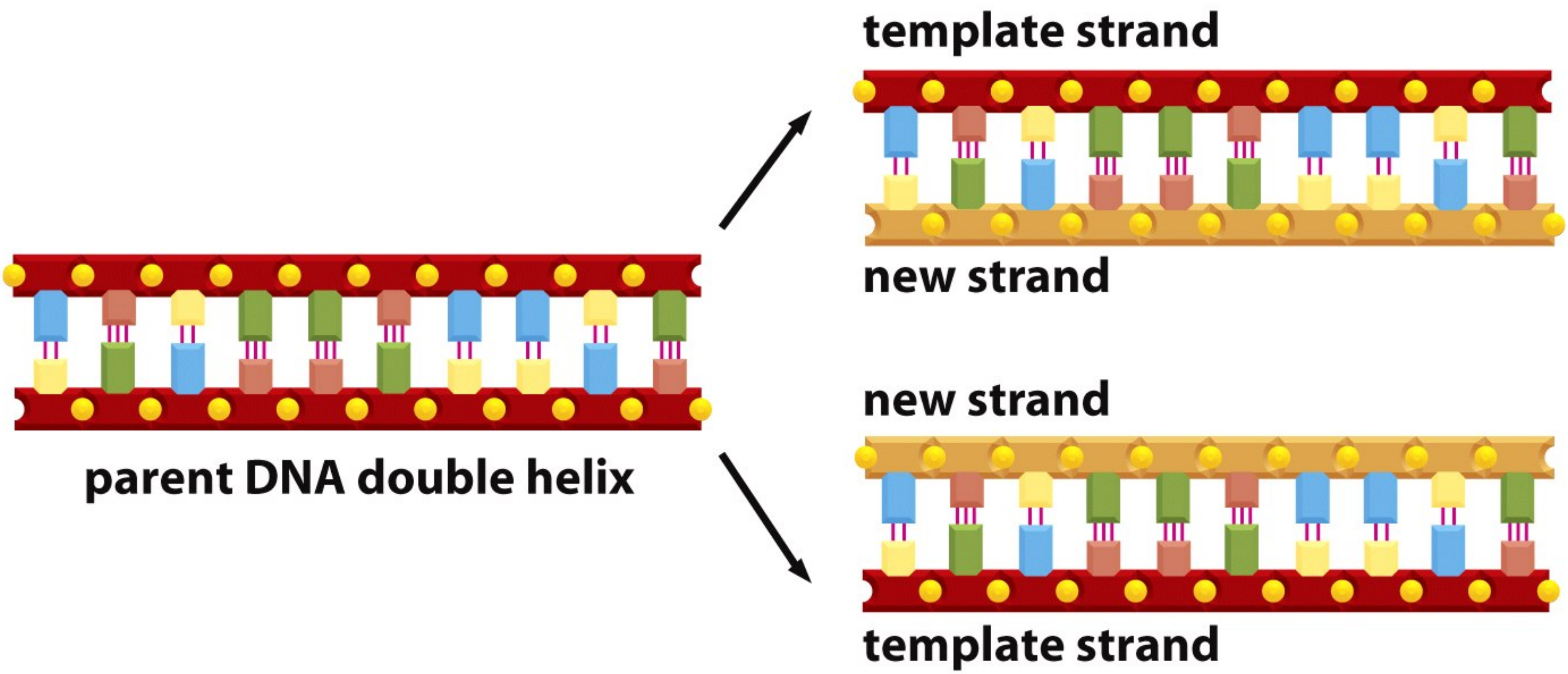
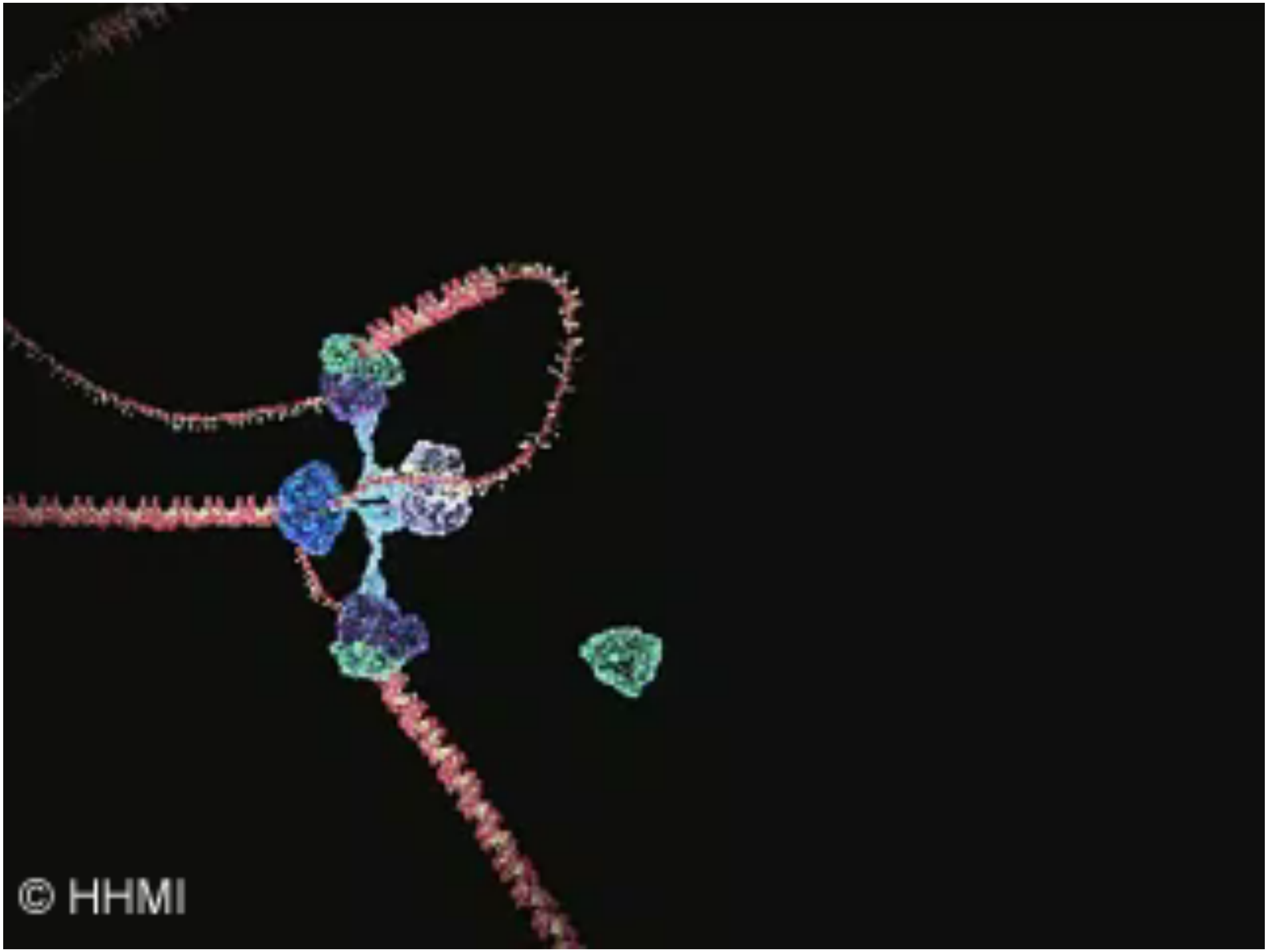
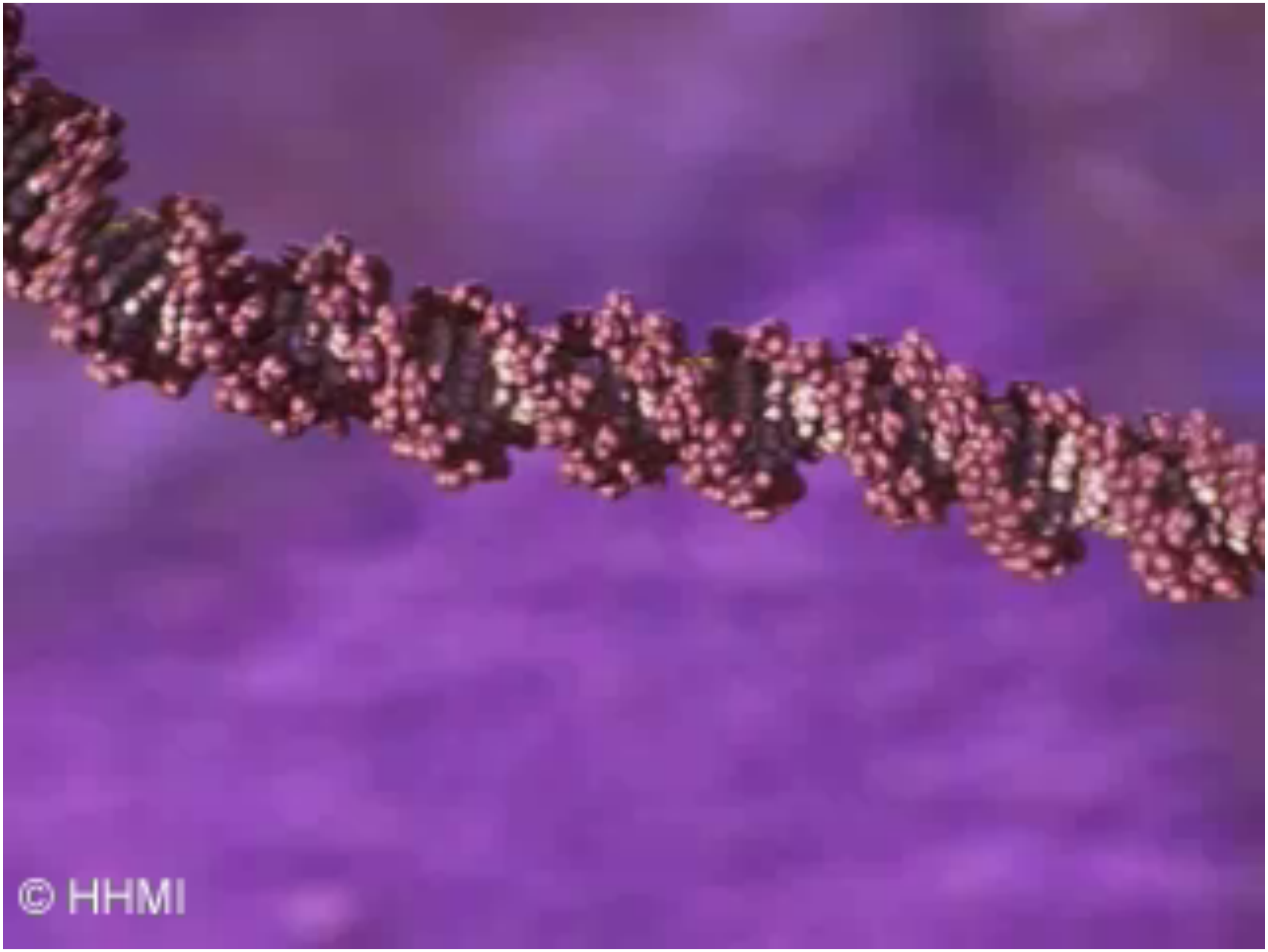


Figure 1-3 Molecular Biology of the Cell 5/e (© Garland Science 2008)

DNA Replication
Movie 5.4



In the Cell, DNA is packaged as Chromatin
Movie 4.2



Inheritable and Somatic Changes to the Genomes of Organisms

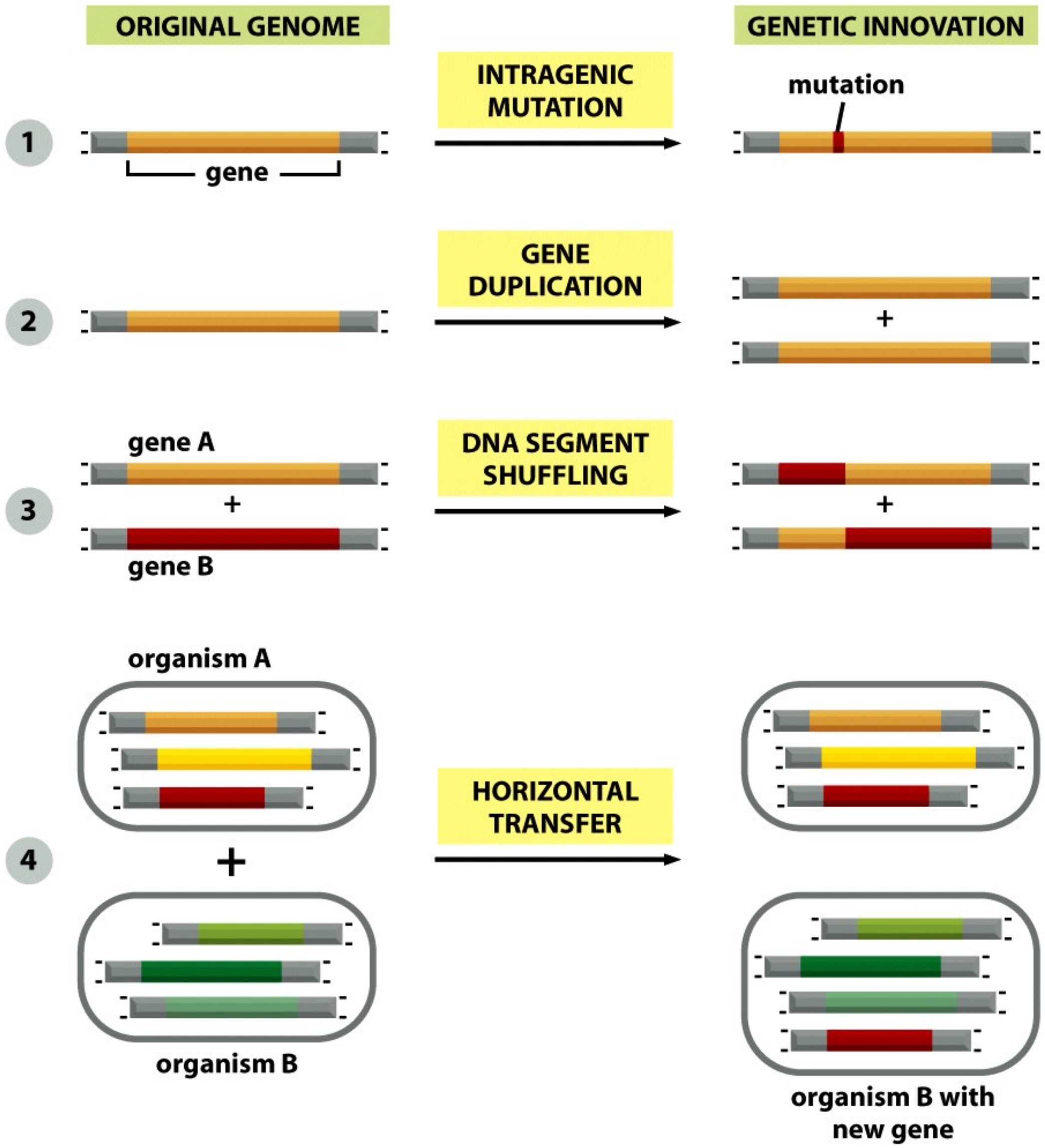


Figure 1-23 Molecular Biology of the Cell 5/e (© Garland Science 2008)

What is a Gene Ortholog?

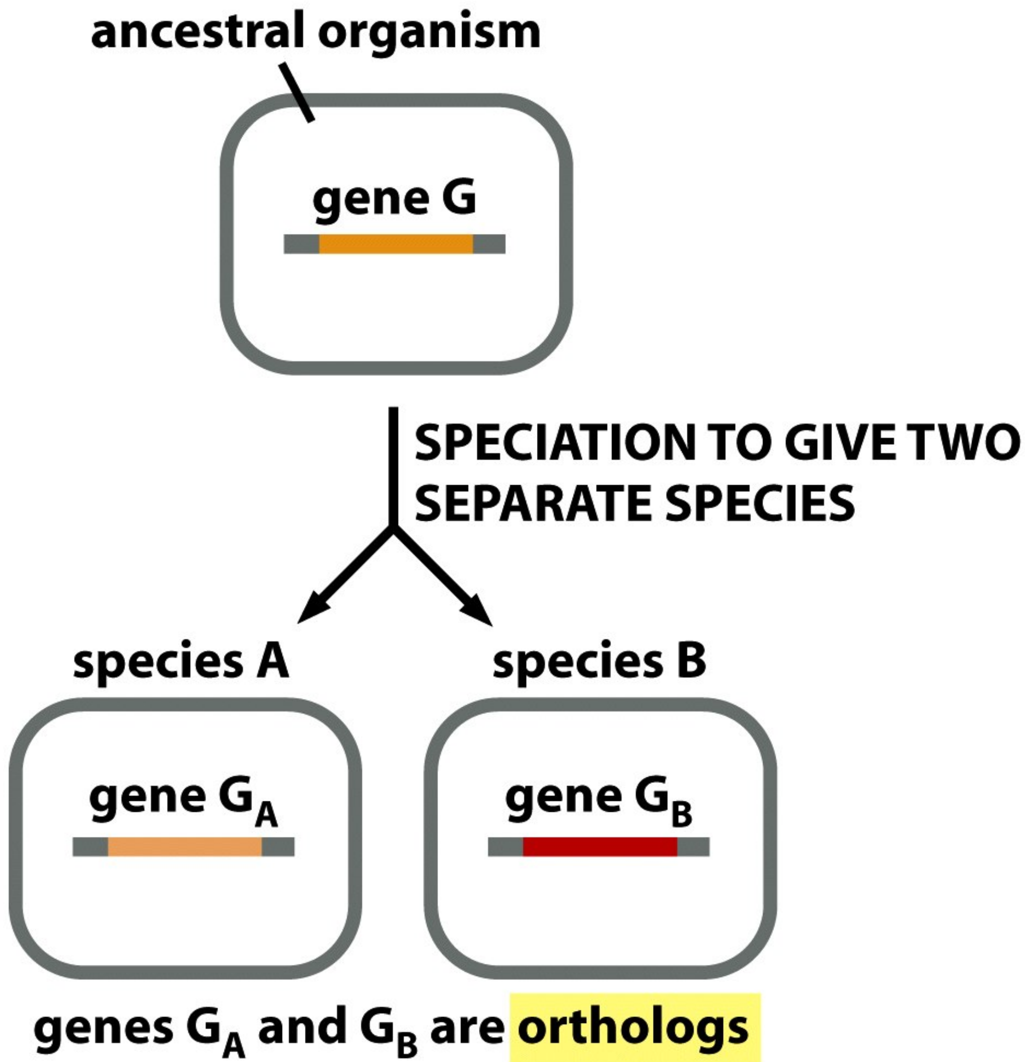


Figure 1-25a Molecular Biology of the Cell 5/e (© Garland Science 2008)

What is a Gene Paralog?

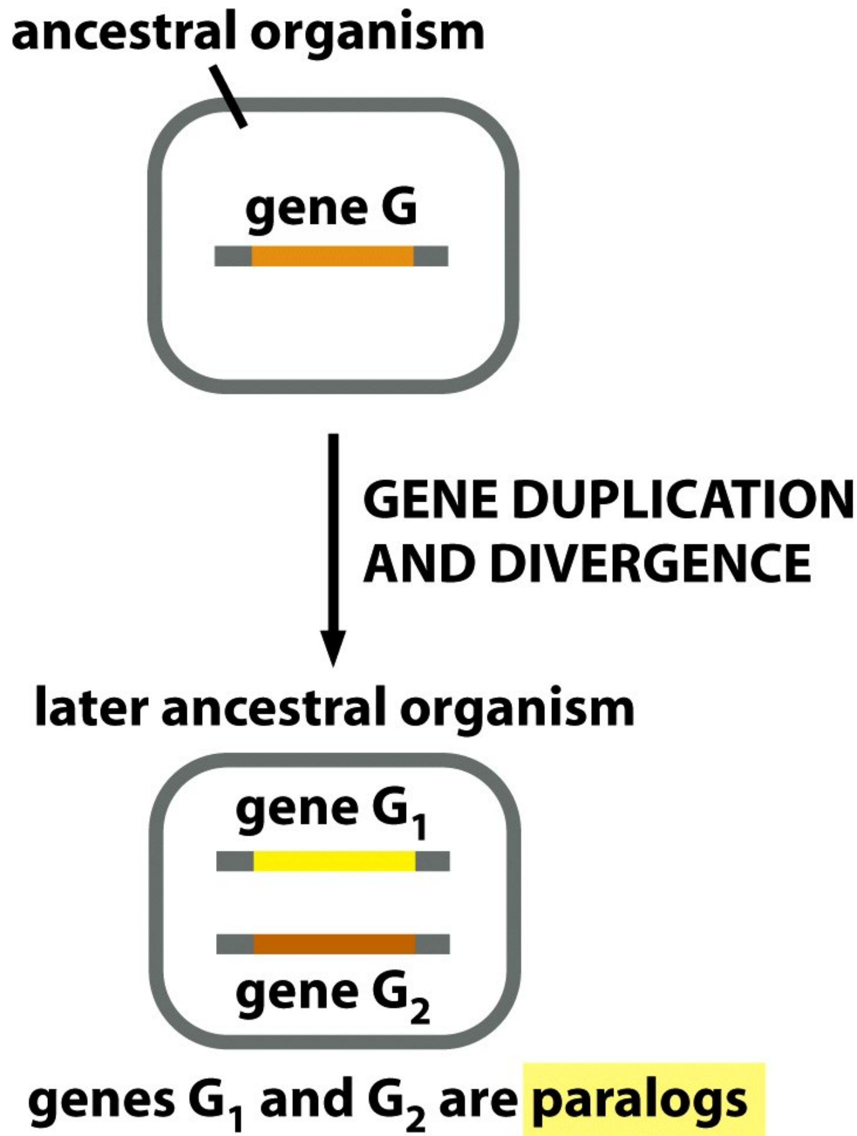


Figure 1-25b Molecular Biology of the Cell 5/e (© Garland Science 2008)

It Can Be More Complicated

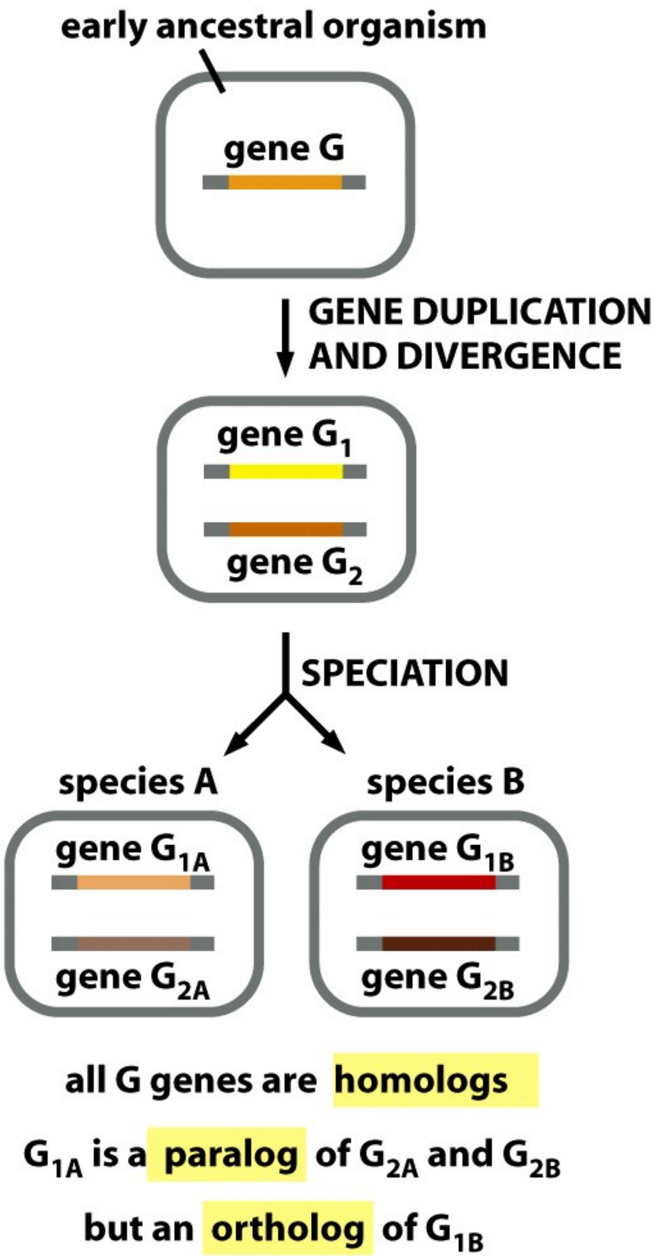


Figure 1-25c Molecular Biology of the Cell 5/e (© Garland Science 2008)

Genes related by descent in either way are homologs

Gene Evolution: The Globins

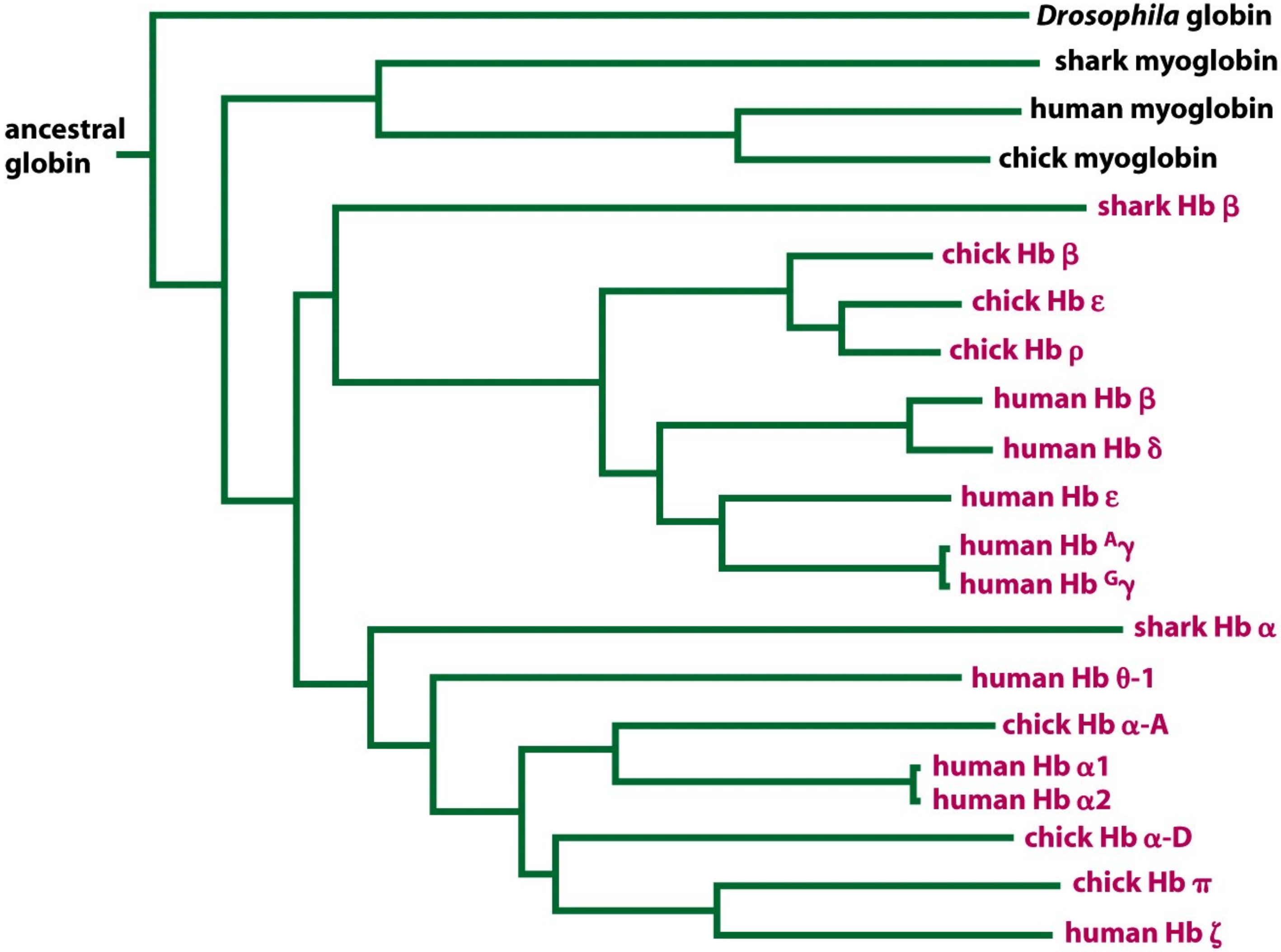
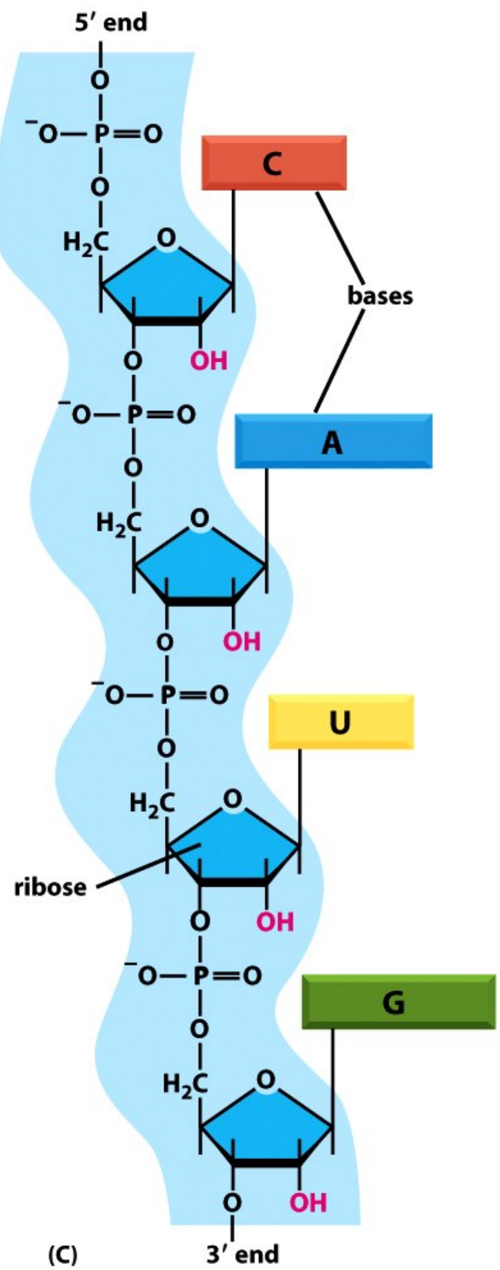


Figure 1-26 Molecular Biology of the Cell 5/e (© Garland Science 2008)

Time / nucleotide changes →

NUCLEIC ACIDS: RNA

Phosphodiester bond



RNA

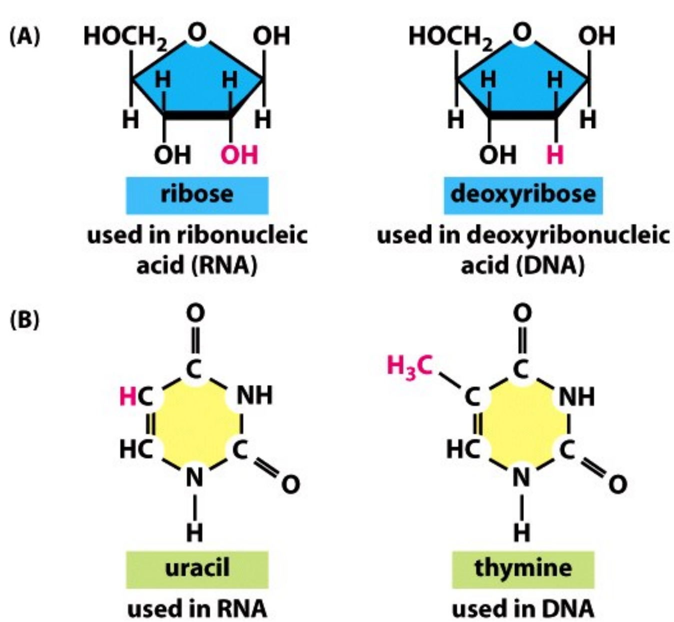
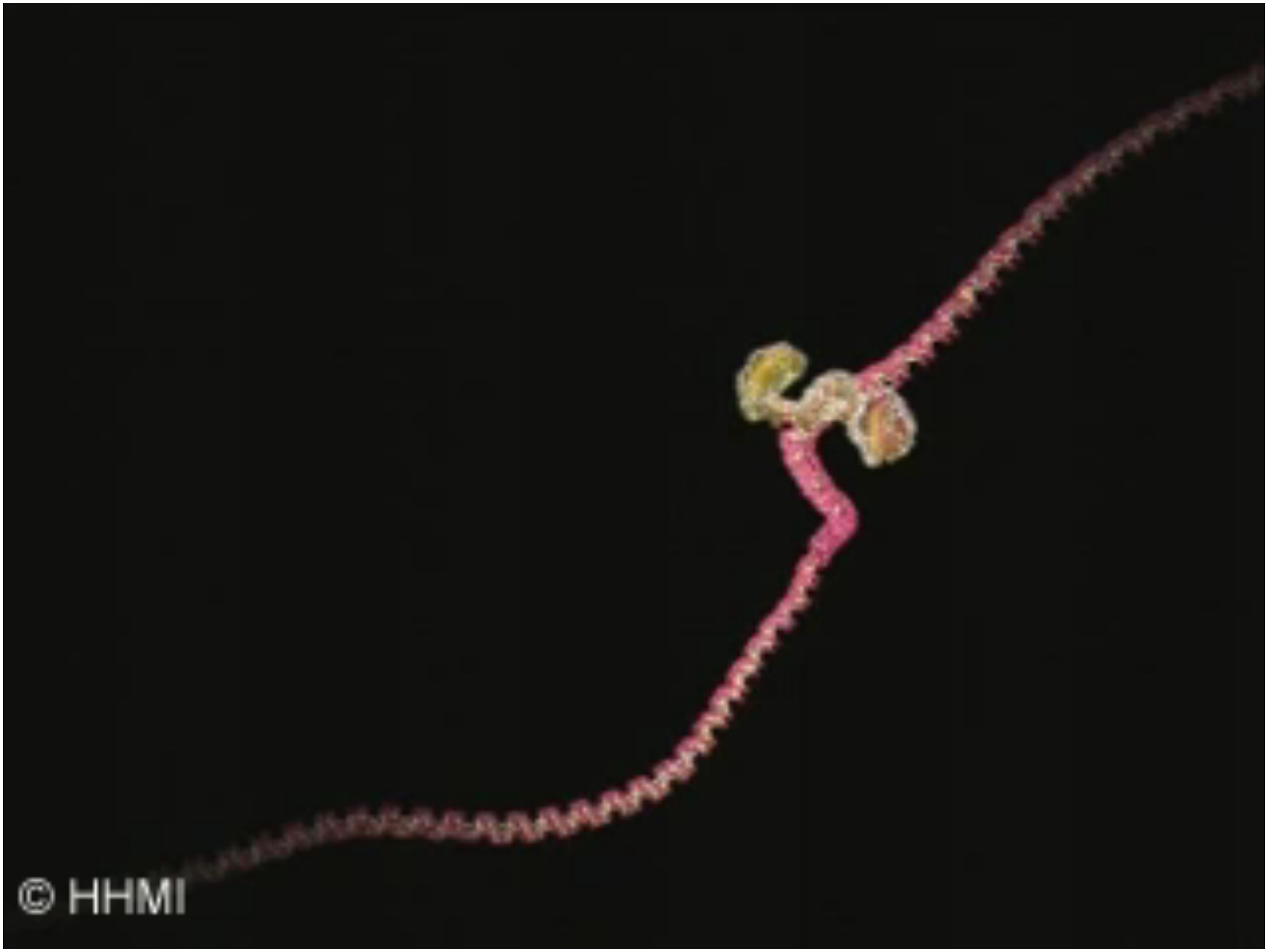
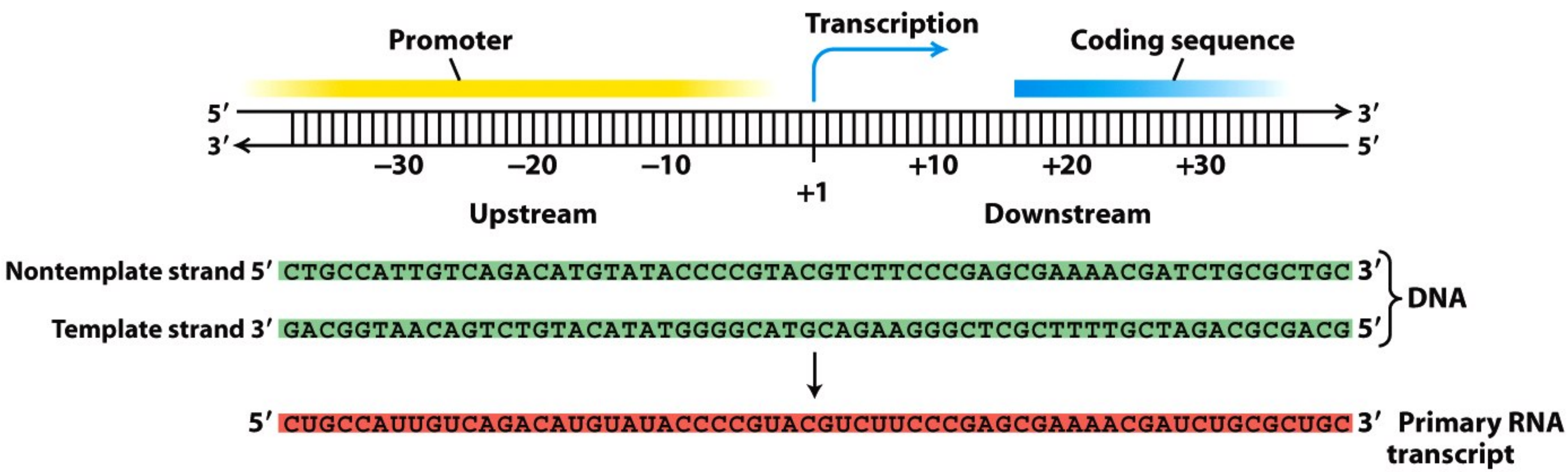


Figure 6-4 ***Molecular Biology of the Cell*** **(© Garland Science 2008)**

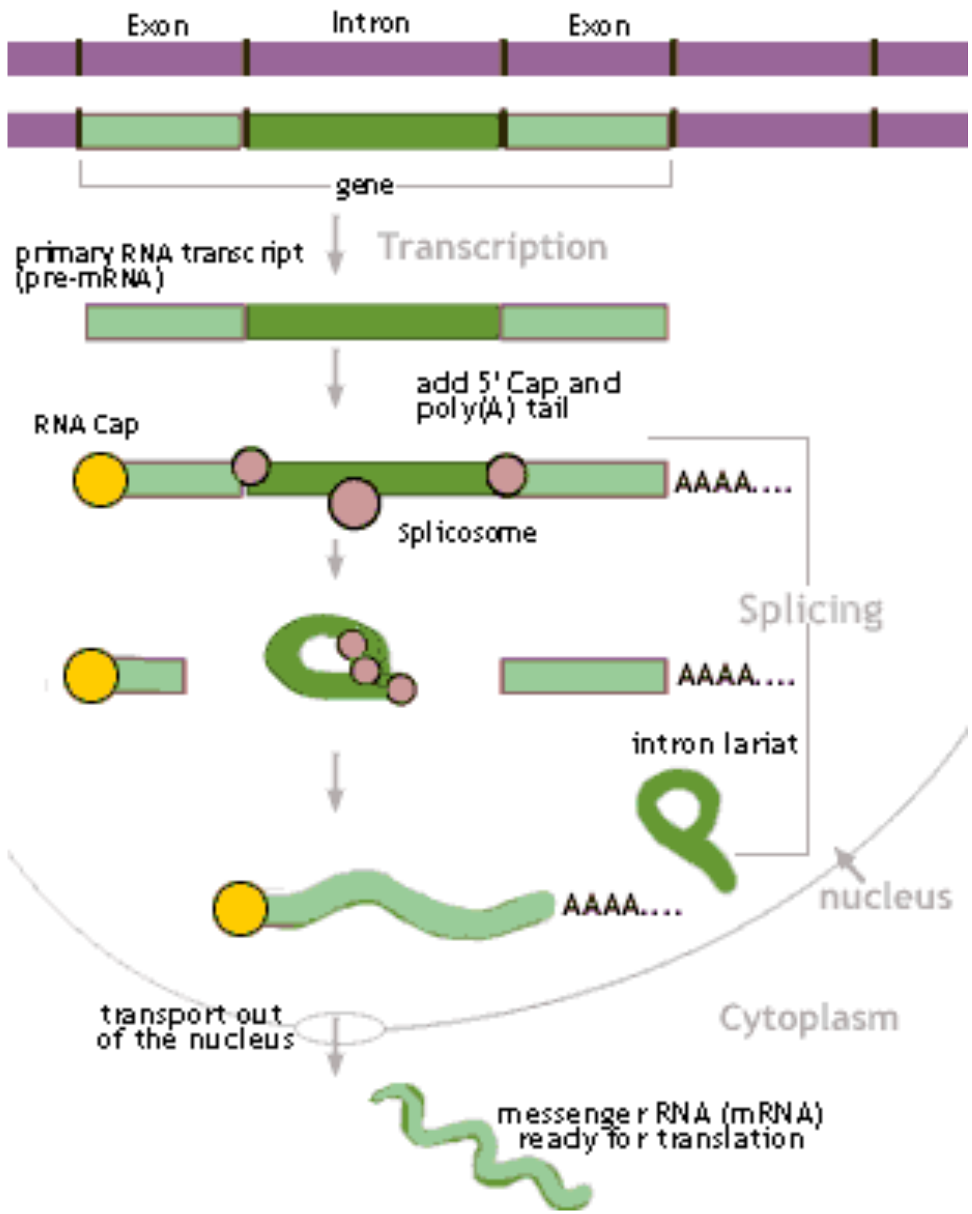
RNA Transcription
Movie 6.2



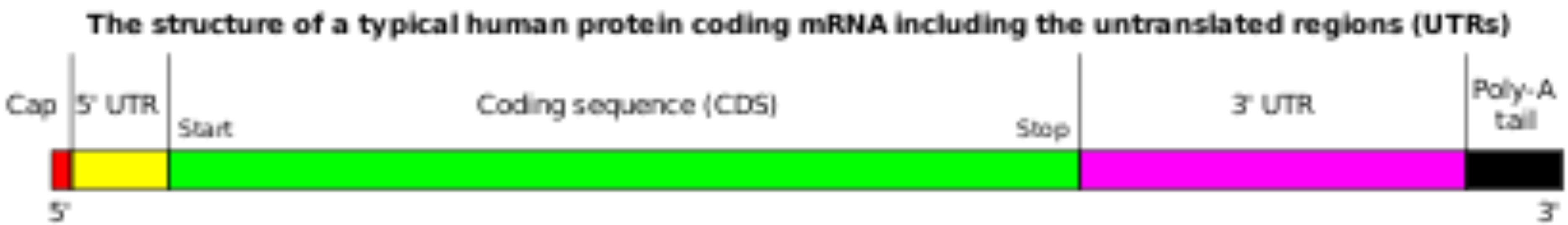
Major Features of the Gene and its encoded mRNA



DNA to RNA (for Protein Encoding Genes: 5% of genome)

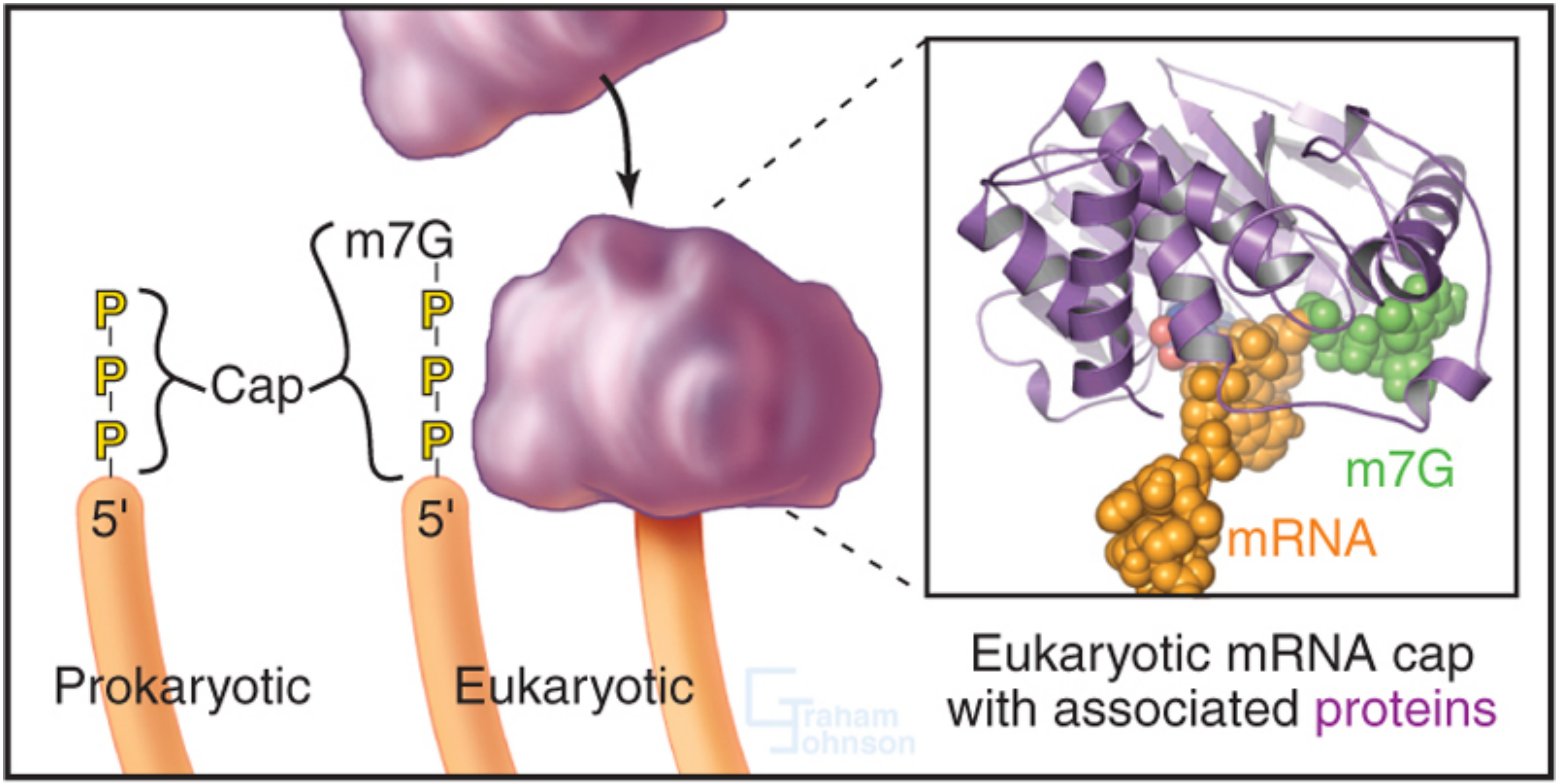


mRNA Structural Features

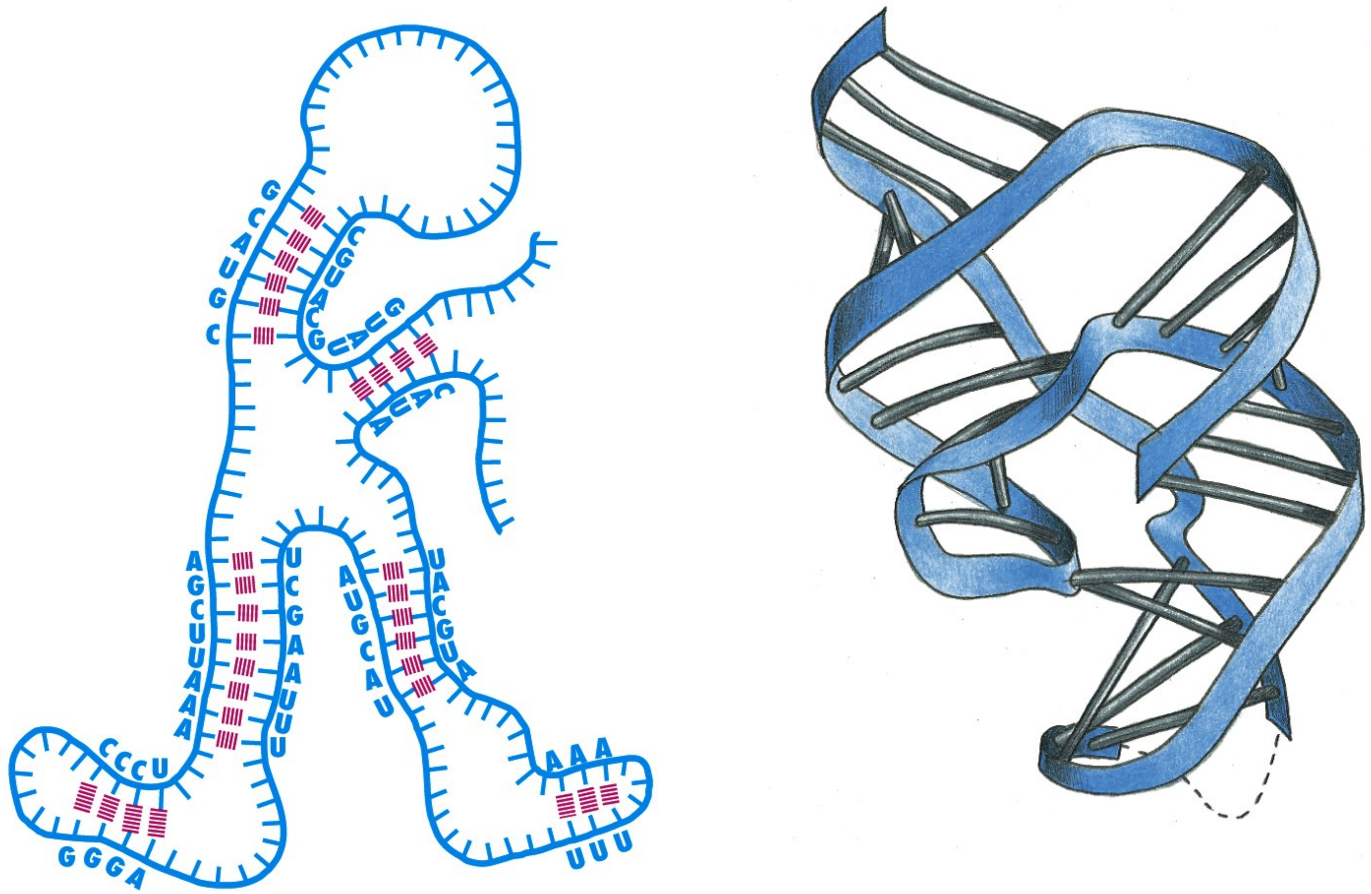


The 5' CAP and 3' polyA tail help protect eukaryotic mRNAs from premature degradation

mRNA 5’ Structural Features



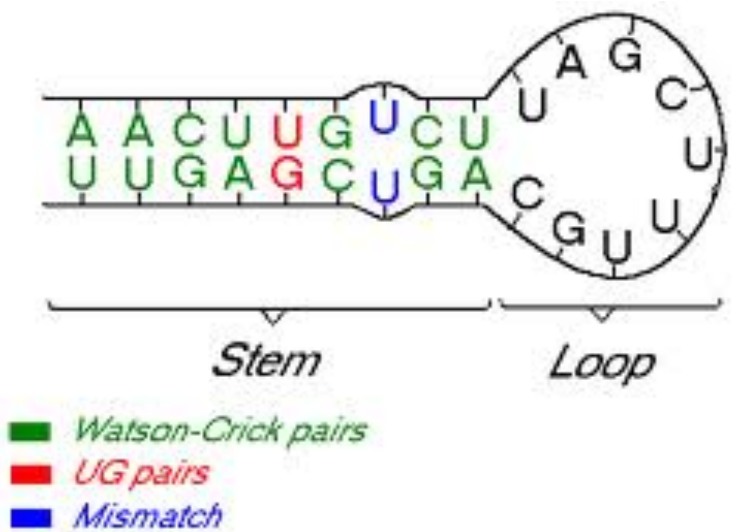
RNA has Tremendous Structural Diversity mostly through nucleotide base pairing

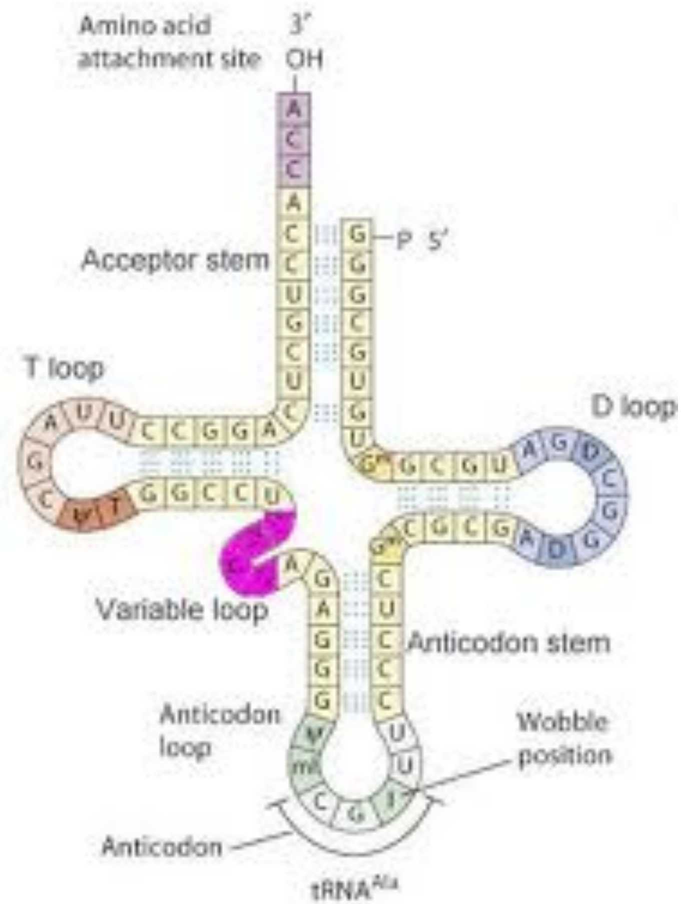


(A) (B)

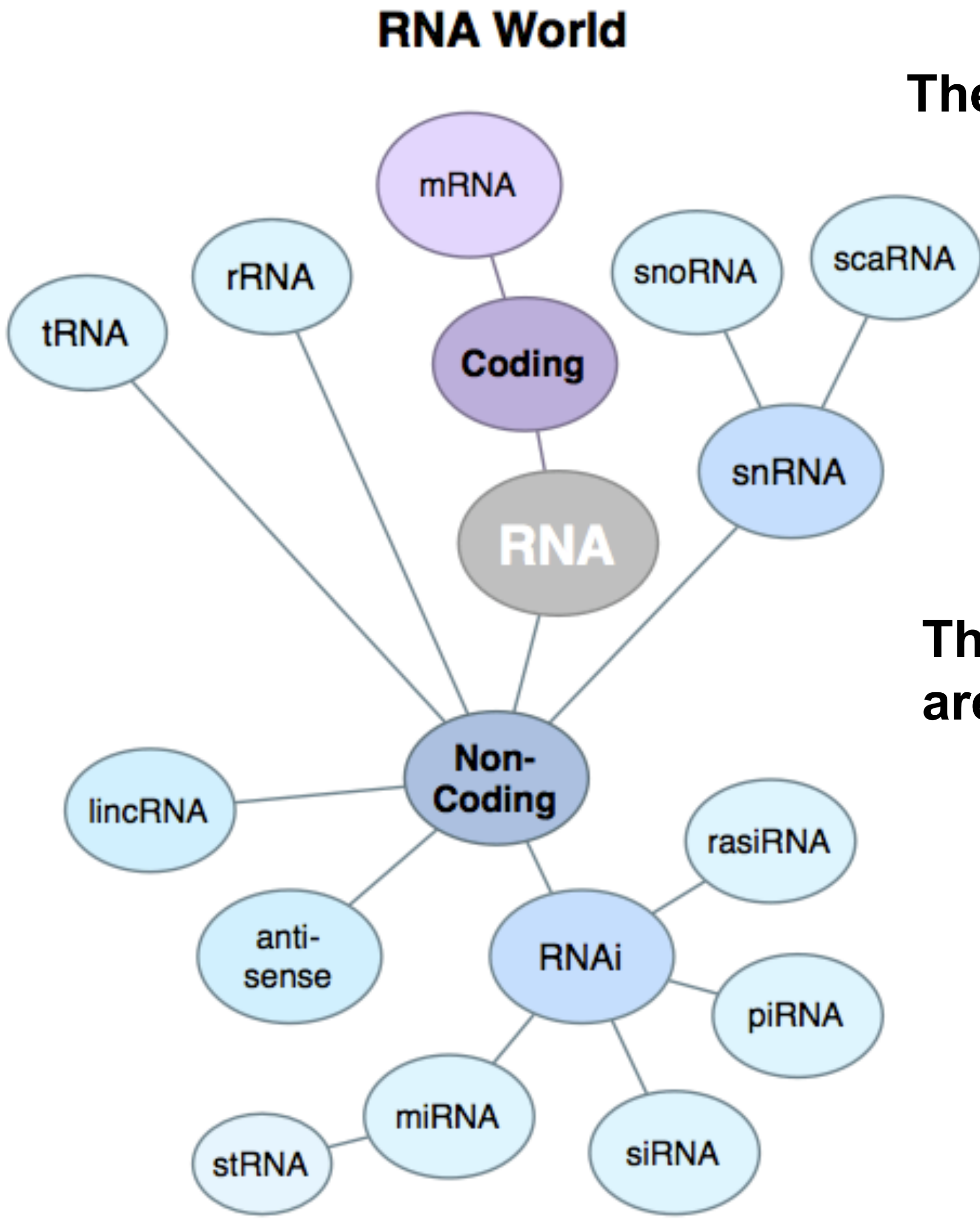
Figure 1-6 Molecular Biology of the Cell 5/e (© Garland Science 2008)

RNA has Tremendous Structural Diversity mostly through base pairing





tRNA



There are Many Types of RNAs

The majority of RNA species are non-coding RNAs (ncRNA)

Many Types of RNAs are Made: Each Has a Different Function

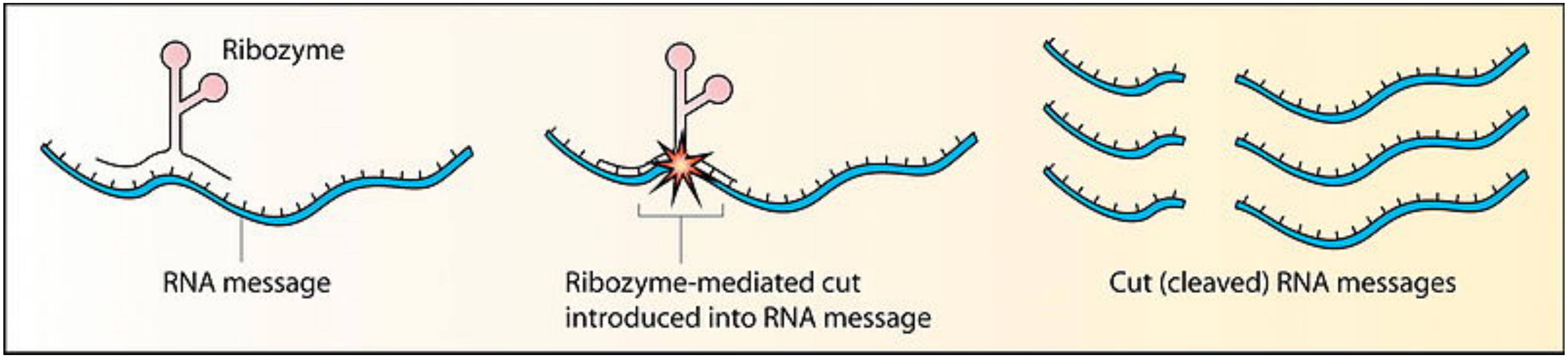
Table 6–1 Principal Types of RNAs Produced in Cells

TYPE OF RNA	FUNCTION
mRNAs	messenger RNAs, code for proteins
rRNAs	ribosomal RNAs, form the basic structure of the ribosome and catalyze protein synthesis
tRNAs	transfer RNAs, central to protein synthesis as adaptors between mRNA and amino acids
snRNAs	small nuclear RNAs, function in a variety of nuclear processes, including the splicing of pre-mRNA
snoRNAs	small nucleolar RNAs, used to process and chemically modify rRNAs
scaRNAs	small cajal RNAs, used to modify snoRNAs and snRNAs
miRNAs	microRNAs, regulate gene expression typically by blocking translation of selective mRNAs
siRNAs	small interfering RNAs, turn off gene expression by directing degradation of selective mRNAs and the establishment of compact chromatin structures
Other noncoding RNAs	function in diverse cell processes, including telomere synthesis, X-chromosome inactivation, and the transport of proteins into the ER

Table 6-1 Molecular Biology of the Cell 5/e (© Garland Science 2008)

The functions of some RNAs are still unknown

RNA can be an Enzyme!

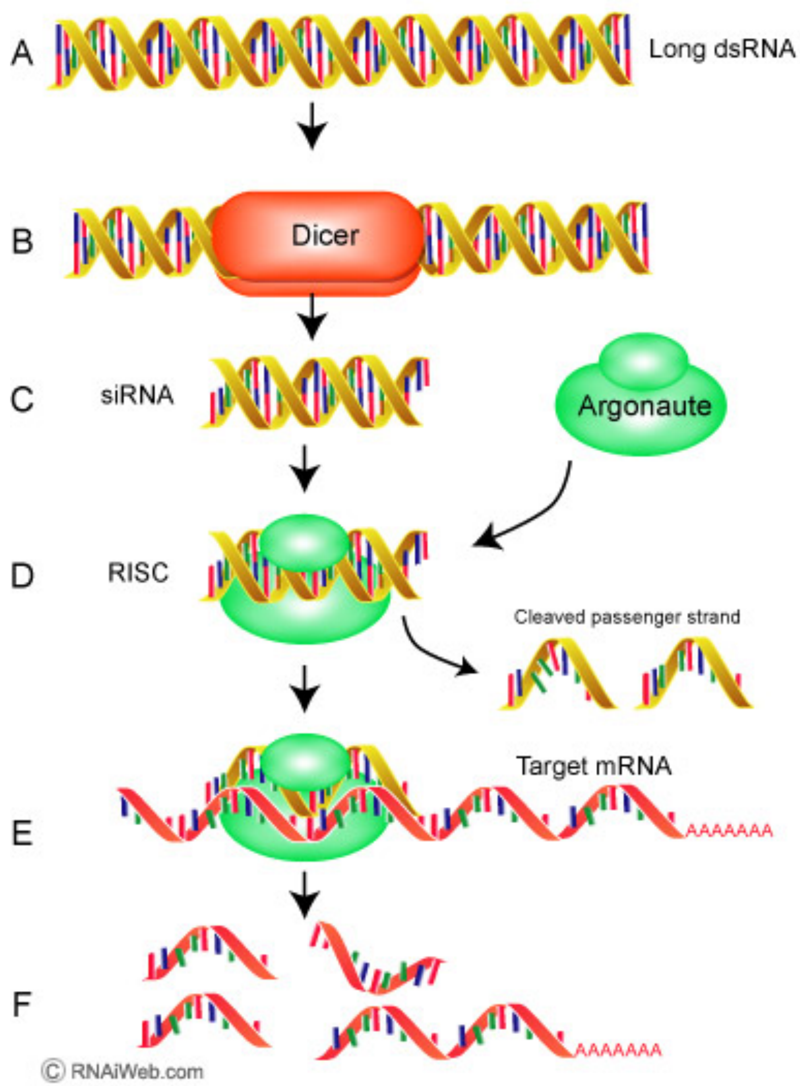


Ribozymes cleave RNA


Courtesy of Paul Fetters,
Howard Hughes Medical Institute.
Noncommercial, educational use only.

Tom Cech
Nobel Prize 1989

RNA interference (RNAi) of translation/protein synthesis



Andrew Fire

Craig Mello

Nobel Prize 2006