Biology for non-biologists

MINES
Saint-Étienne

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“The biologist and the engineer should be friends”

Outline

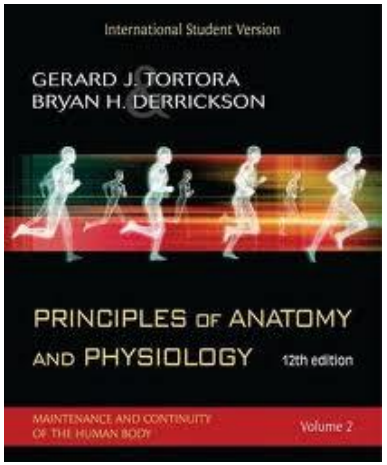
- Basics: individual molecules: DNA, RNA, proteins, lipids, sugars, proteins
- Elements of the cell; plasma membrane, nucleus (transcription), ribosome (translation),
- Elements of the cell contd.; cytoskeleton, mitochondria (energy) transport, cell division
- Cell types and function; neurons, epithelial cells, muscle cells, blood cells,

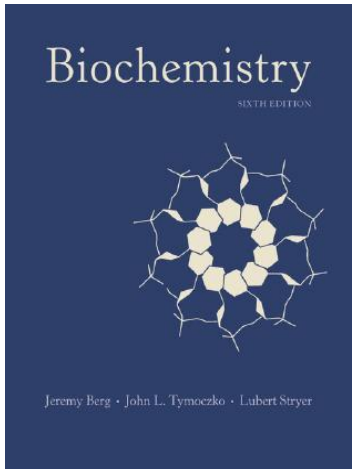
Questionnaire

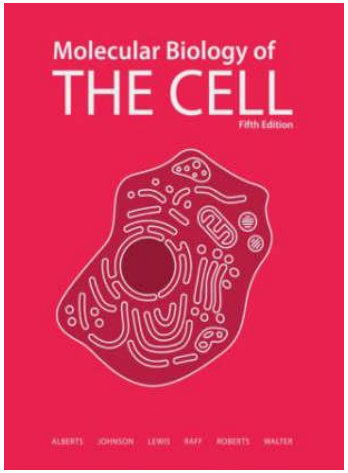
- What do you know about biology?
- What is DNA – where is it found?
- What is a protein? Give an example
- What is a tissue
- What is the difference between a eukaryote and a prokaryote
- Name 3 cell types
- What is a key property of a neuron?

Bibliography

- **Biochemistry by *Jeremy M. Berg***
  - ISBN 10 1429276355
- **Molecular Biology of the Cell 5^{E} by *Bruce Alberts***
  - ISBN10 0815341067
- **Principles of Anatomy and Physiology by *Gerard J. Tortura***
  - ISBN 10 0470233478

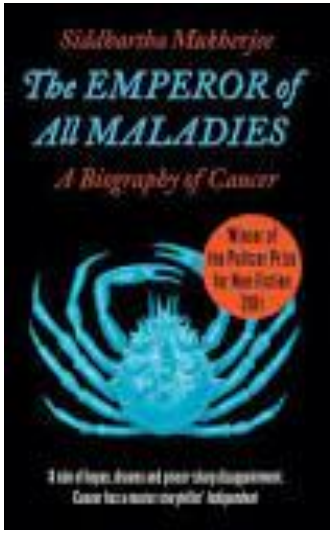


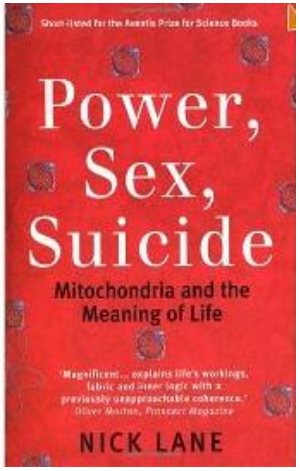


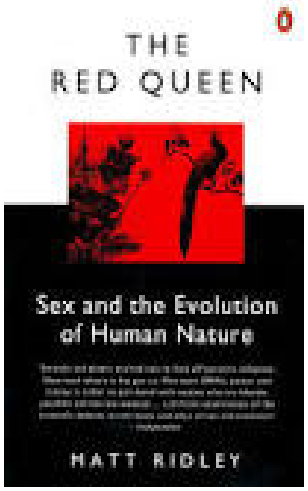


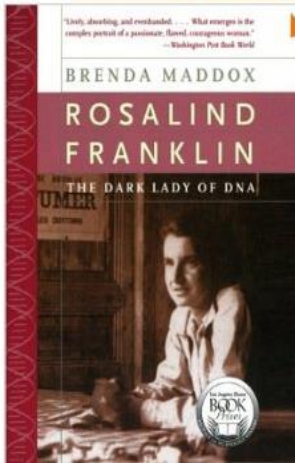
Some light reading

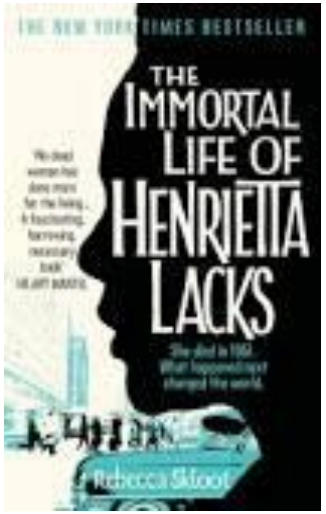
- The emperor of all maladies, *Siddhartha Mukherjee*
- The immortal life of Henrietta Lacks, *Rebecca Skloot*
- The dark lady of DNA, *Brenda Maddox*
- The red queen, *Matt Ridley*
- Power, Sex, Suicide, *Nick Lane*
- The Spark of Life, *Frances Ashcroft*



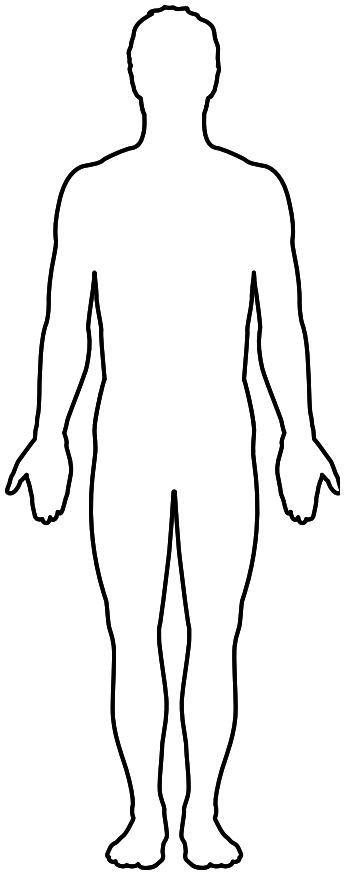


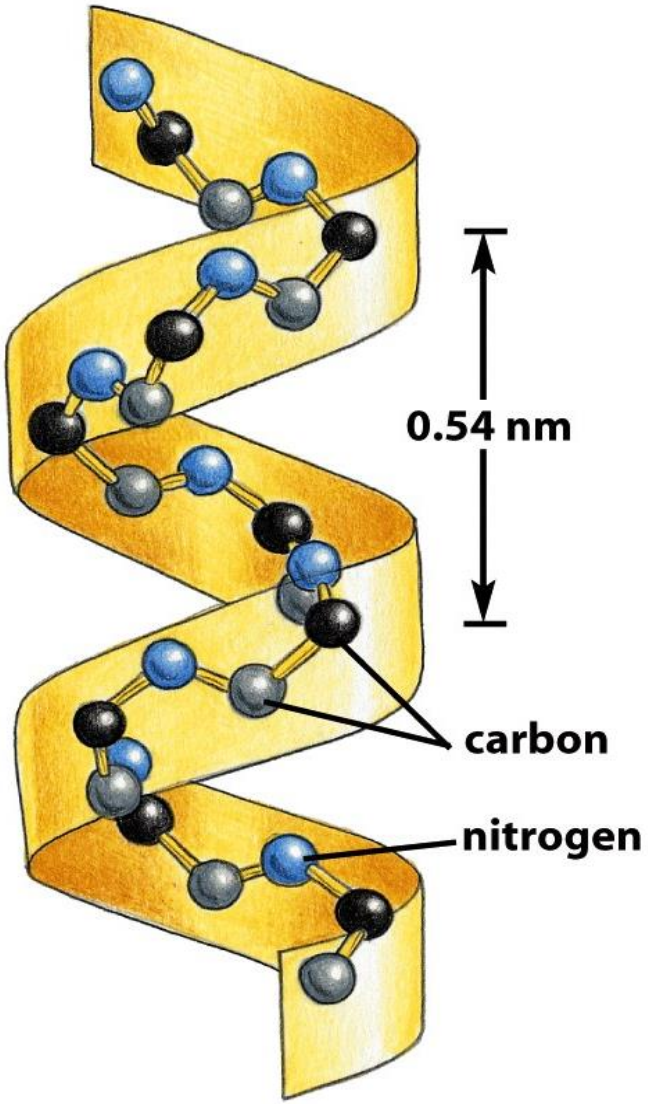






Levels of organisation in animal physiology





Comparison of Eukaryotic and Prokaryotic Cells

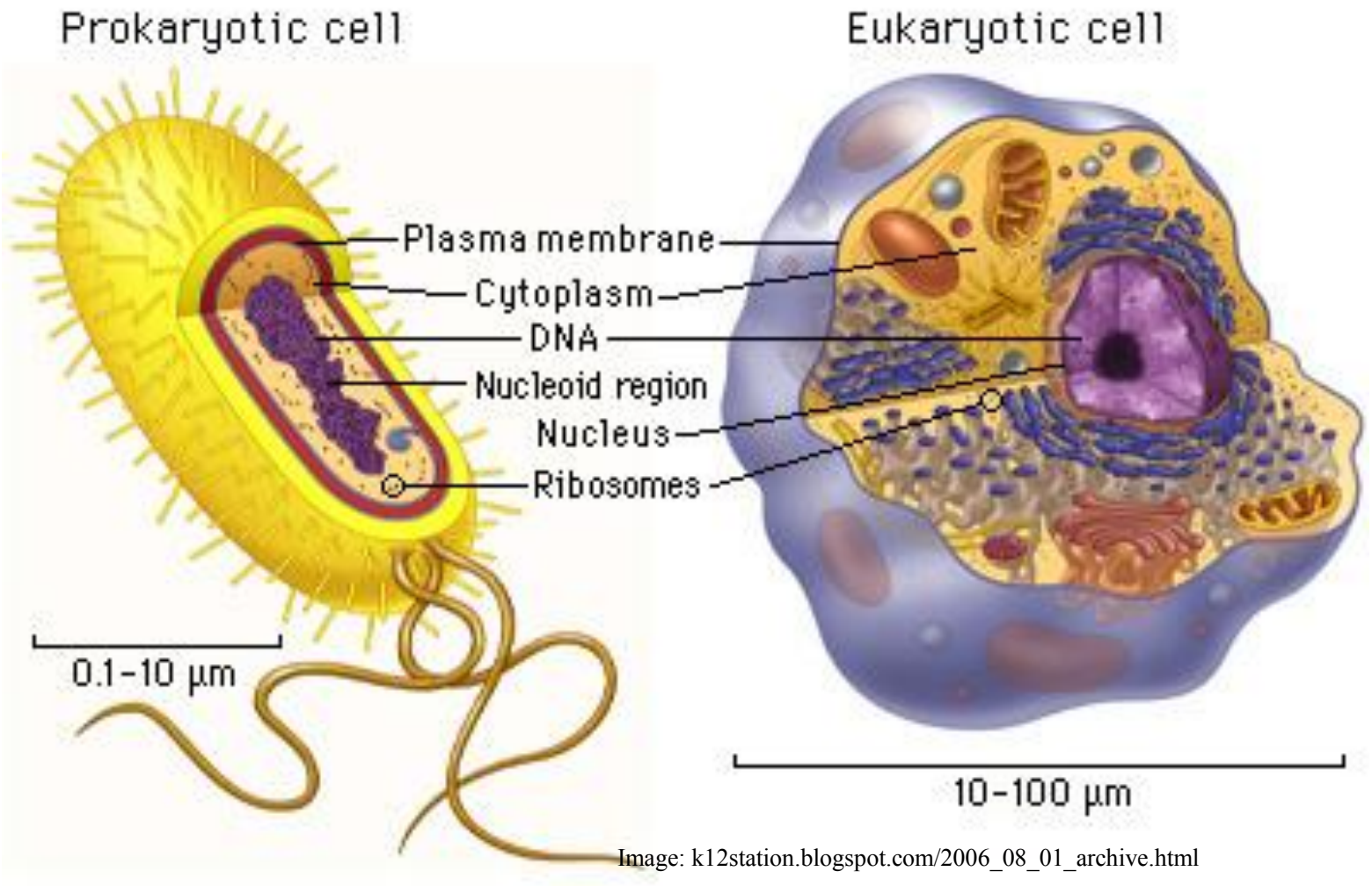
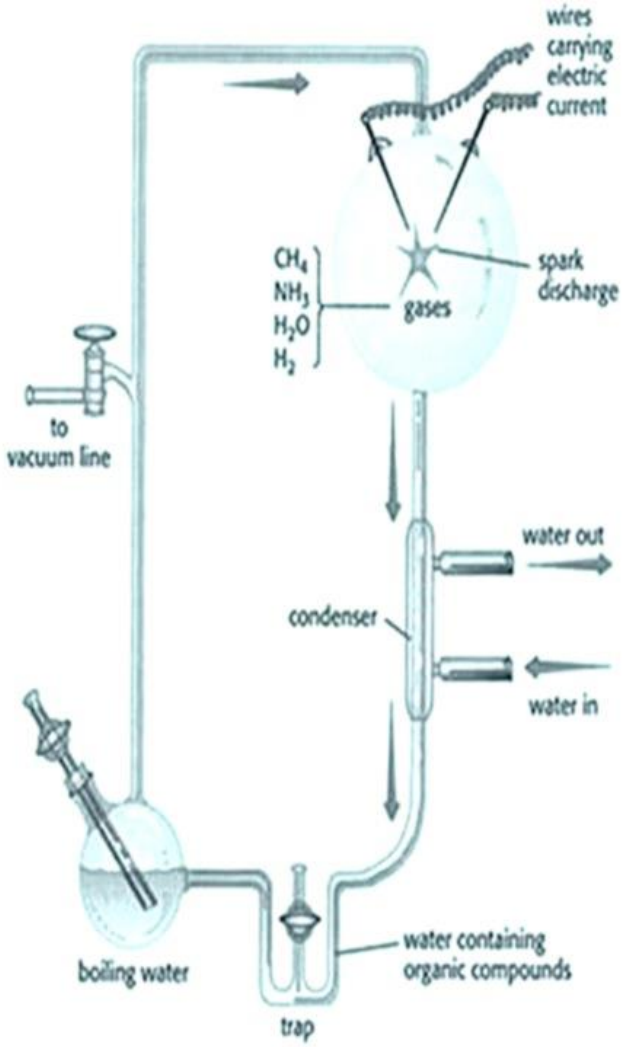


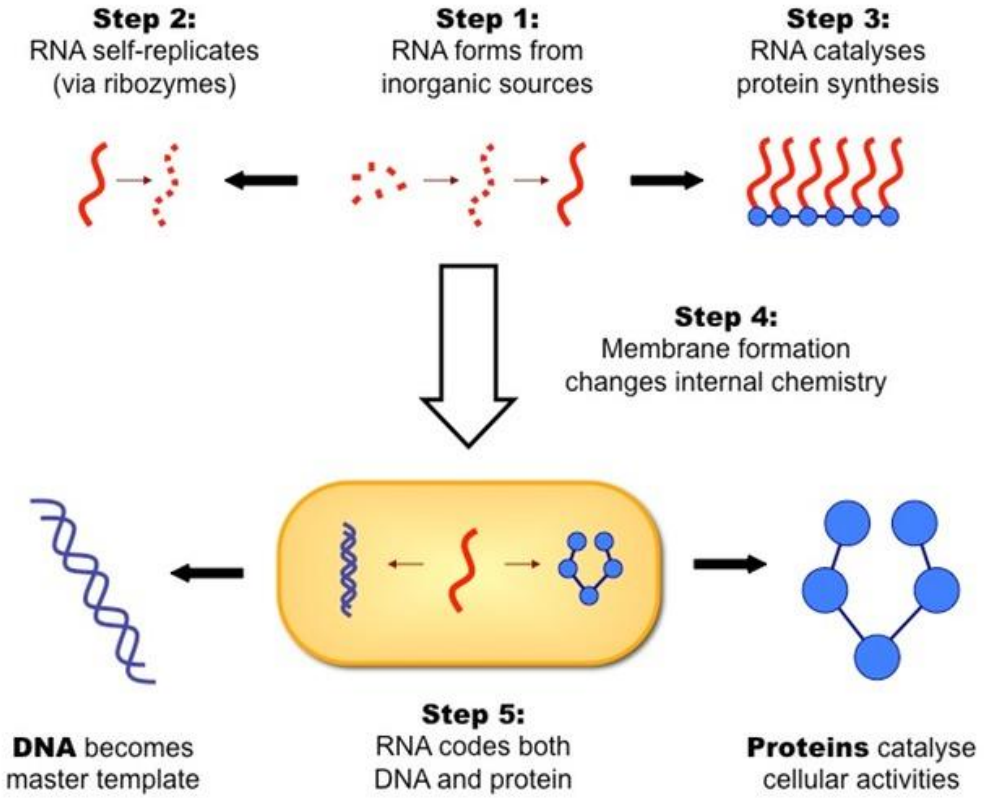
Image: k12station.blogspot.com/2006_08_01_archive.html

How did it all begin?

Miller and Urey (1953)



RNA world



Simple Chemistry

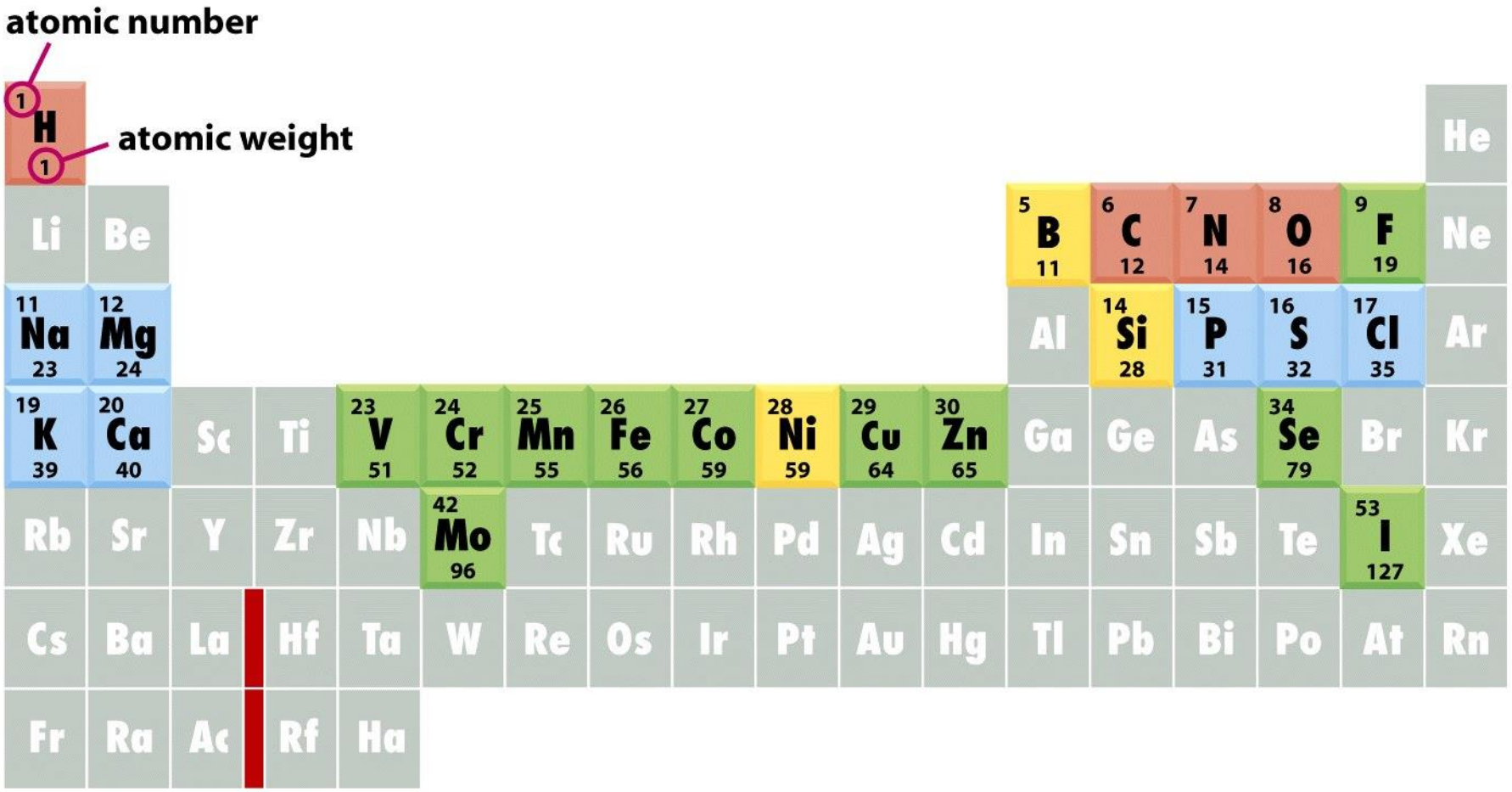


Figure 2-6 *Molecular Biology of the Cell* (© Garland Science 2008)

Simple Chemistry

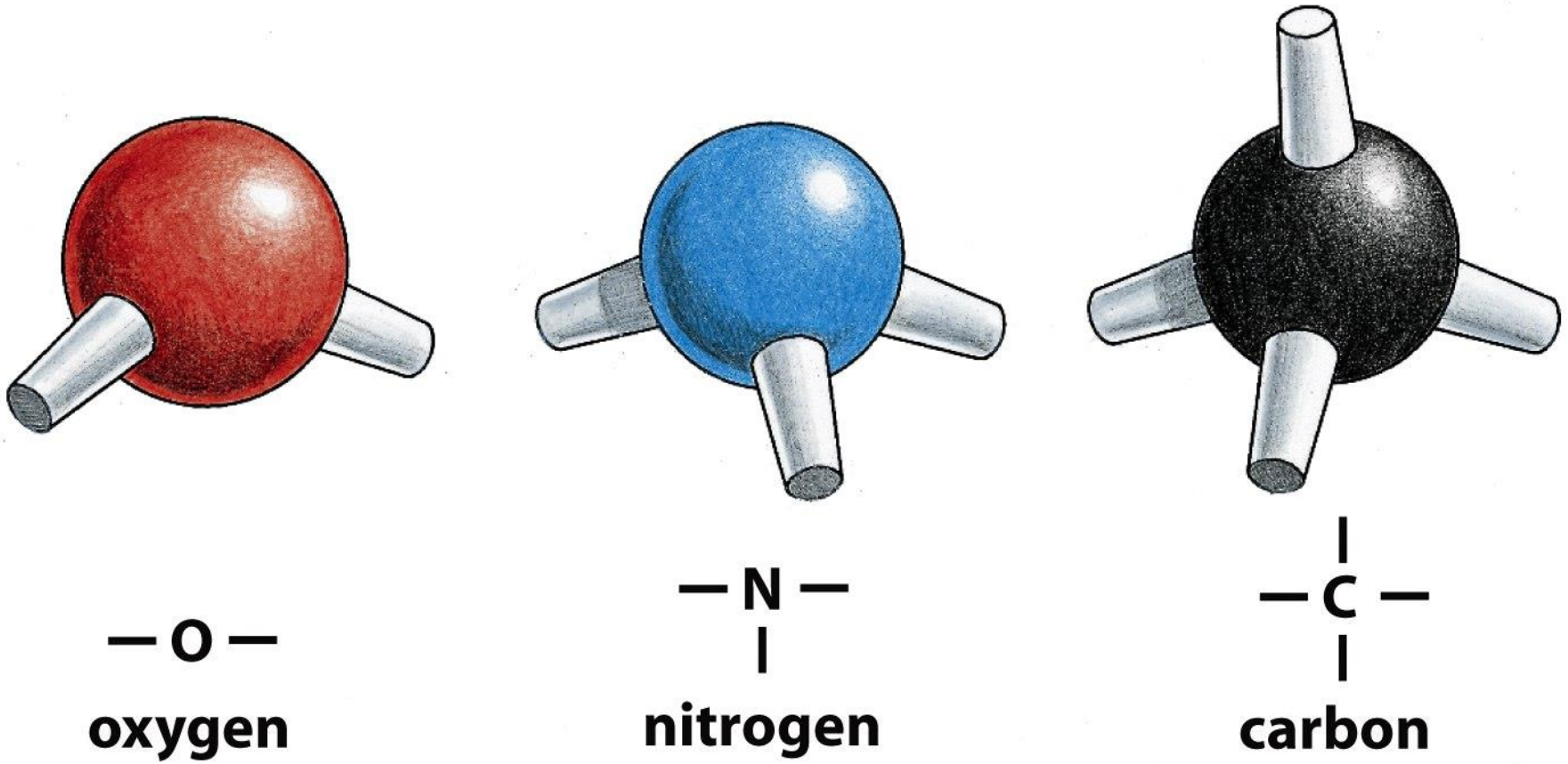


Figure 2-8a *Molecular Biology of the Cell* (© Garland Science 2008)

Macromolecules

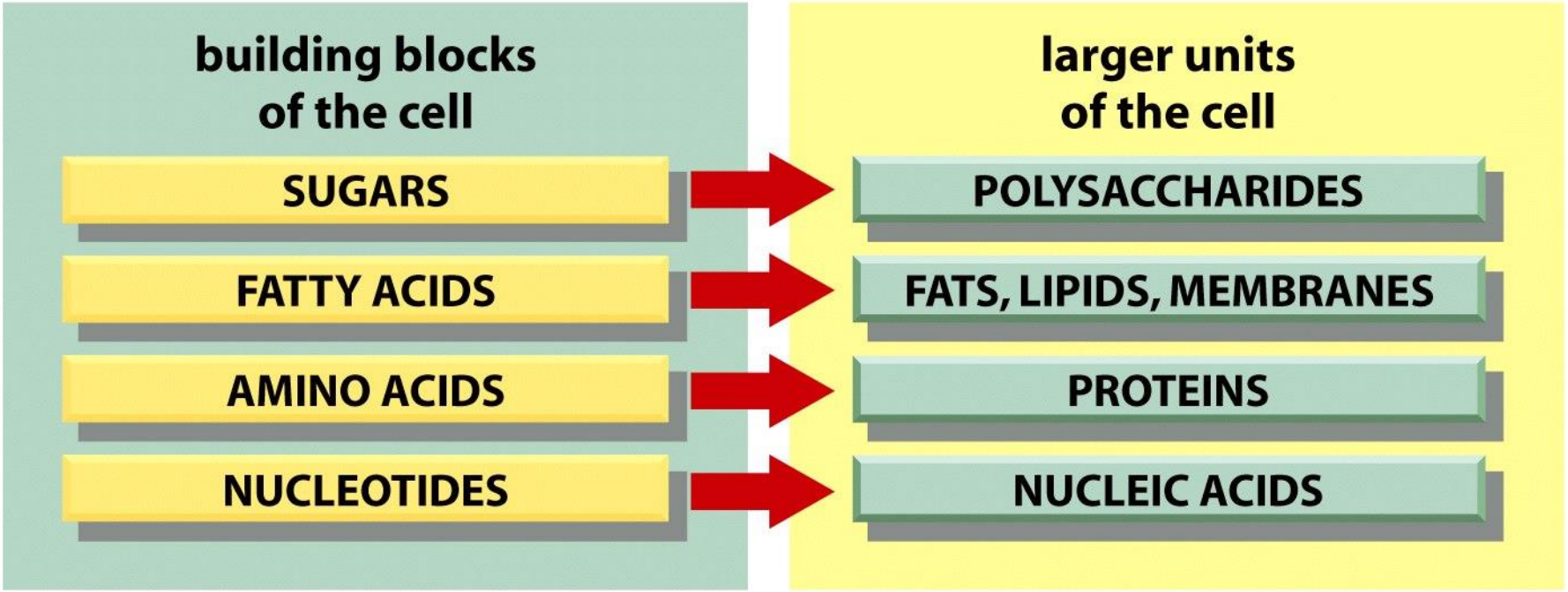


Figure 2-17 *Molecular* 2008)

Macromolecules

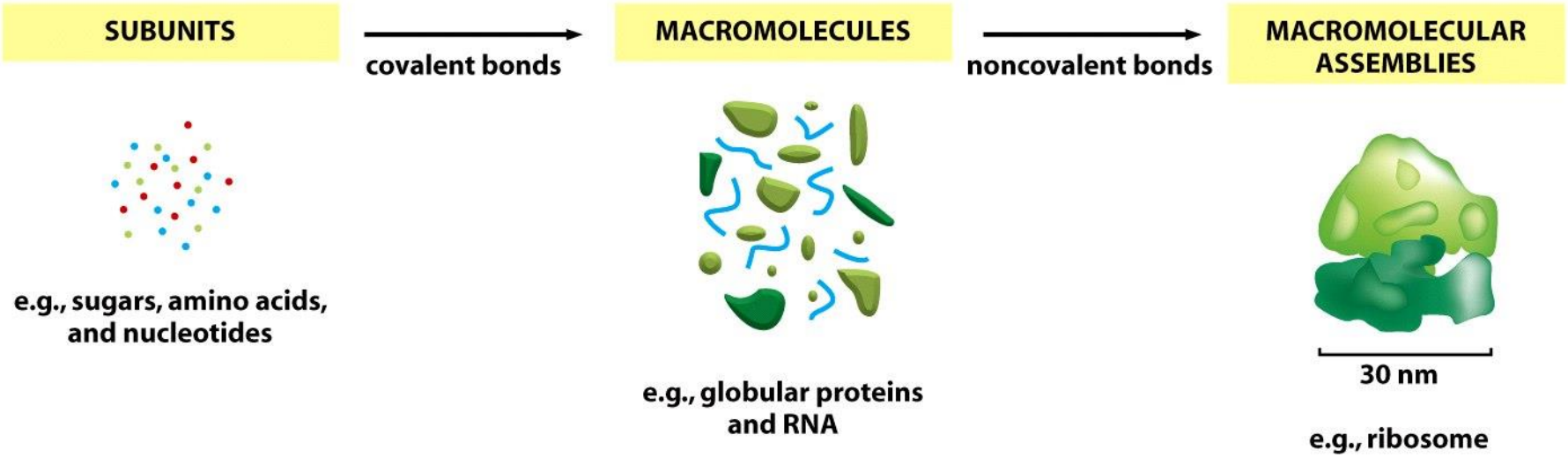


Figure 2-32 *Molecular* ... 2008)

Sugars

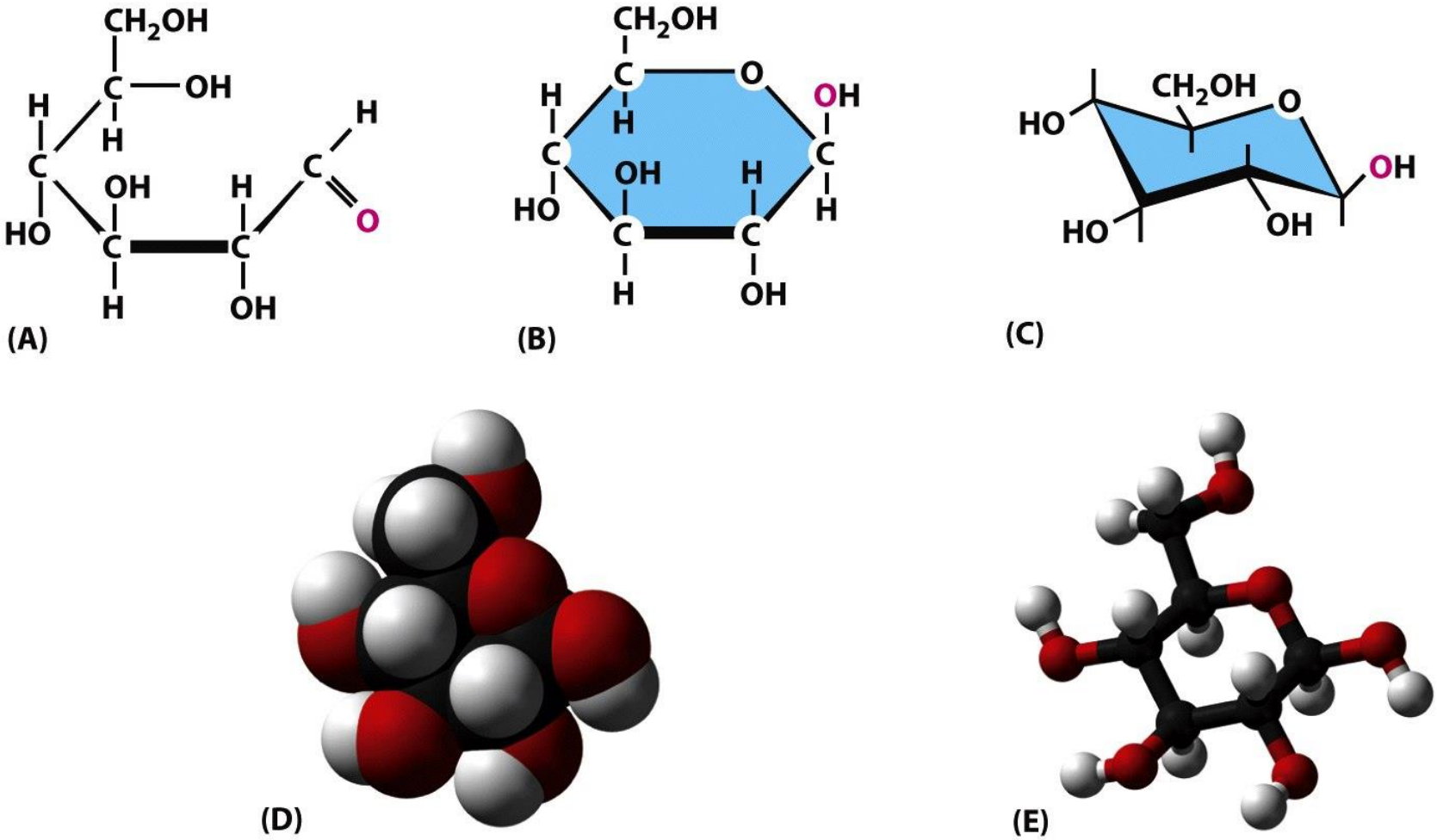


Figure 2-18 *Molecular Biology of the Cell* (© Garland Science 2008)

Lipids

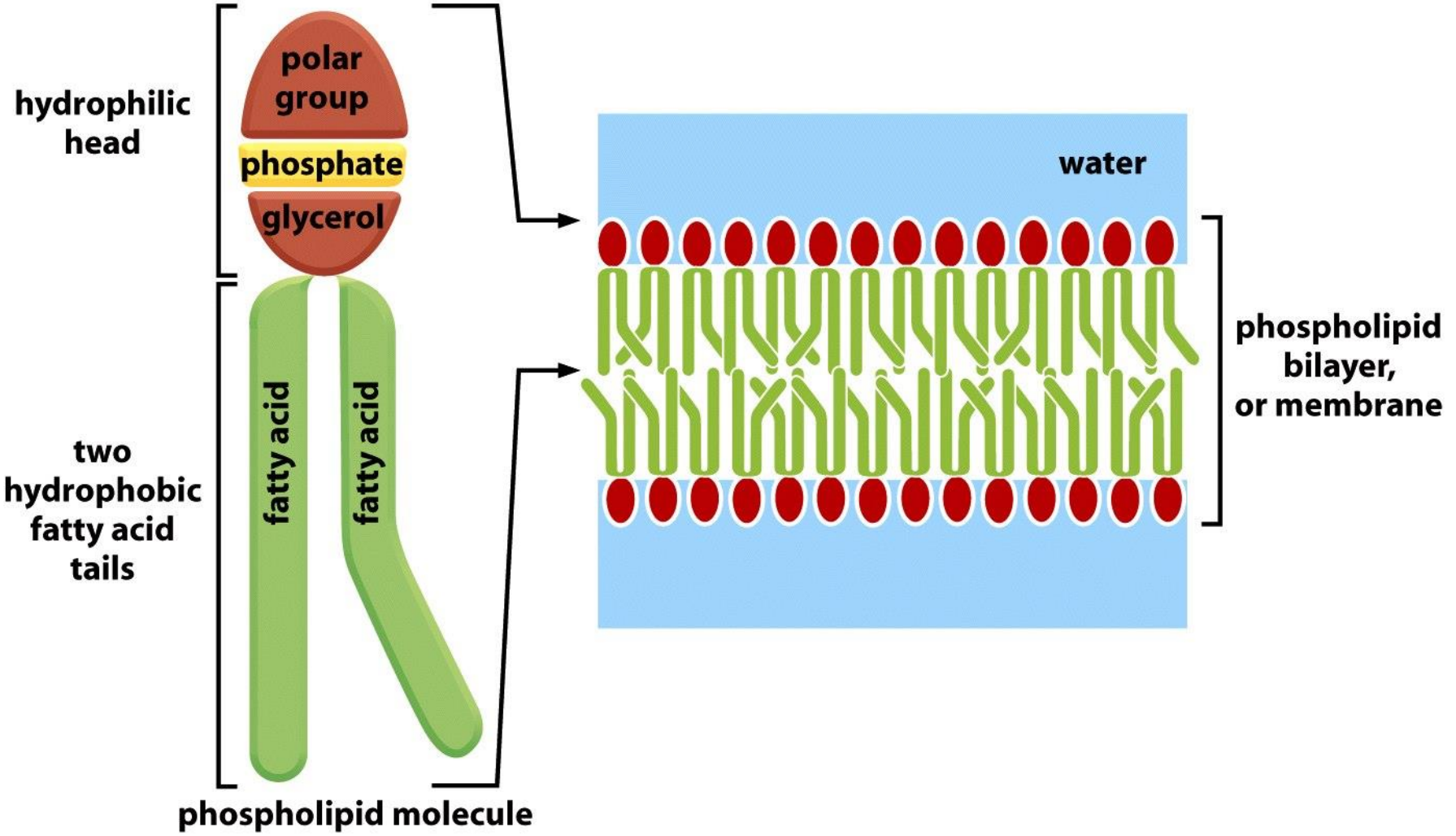
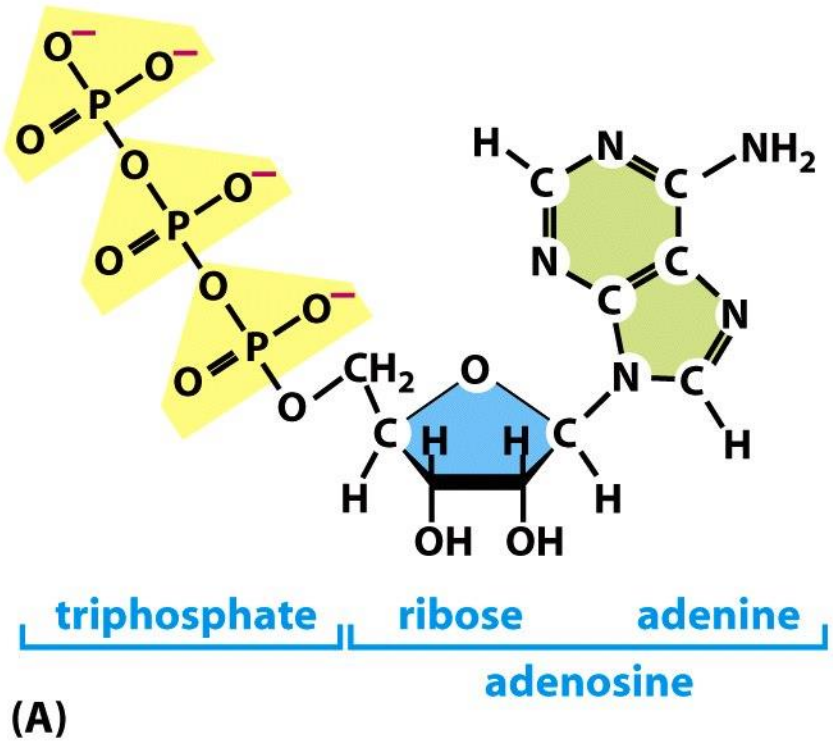


Figure 2-22 *Molecular Biology of the Cell* (© Garland Science 2008)

Nucleotides



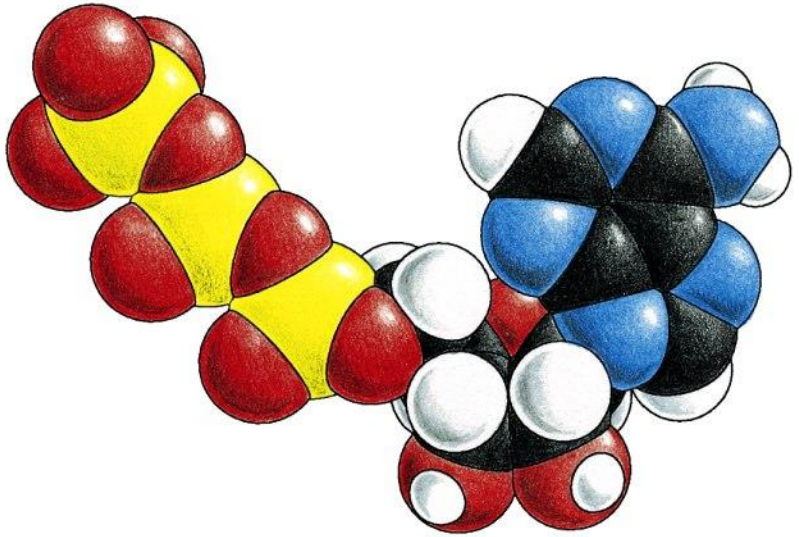


Figure 2-26 *Molecular Biology of the Cell* (© Garland Science 2008)

Amino acids

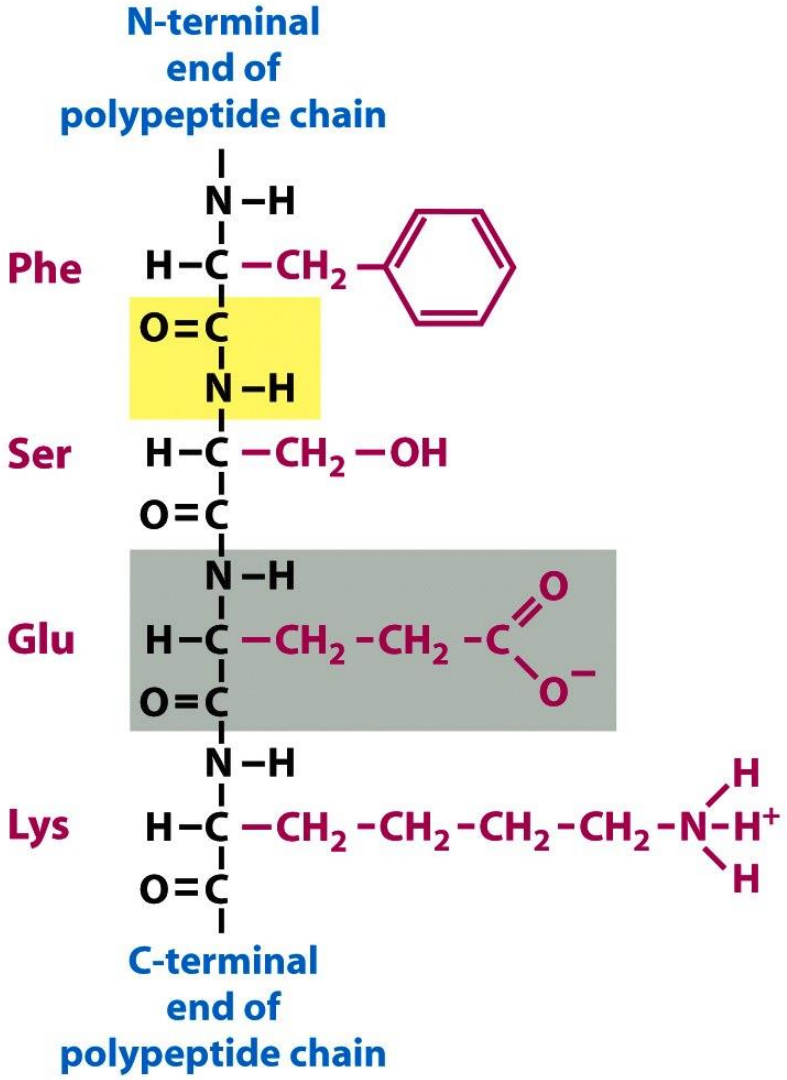


Figure 2-24 *Molecular Biology of the Cell* (© Garland Science 2008)

Information flows from DNA to RNA to proteins.

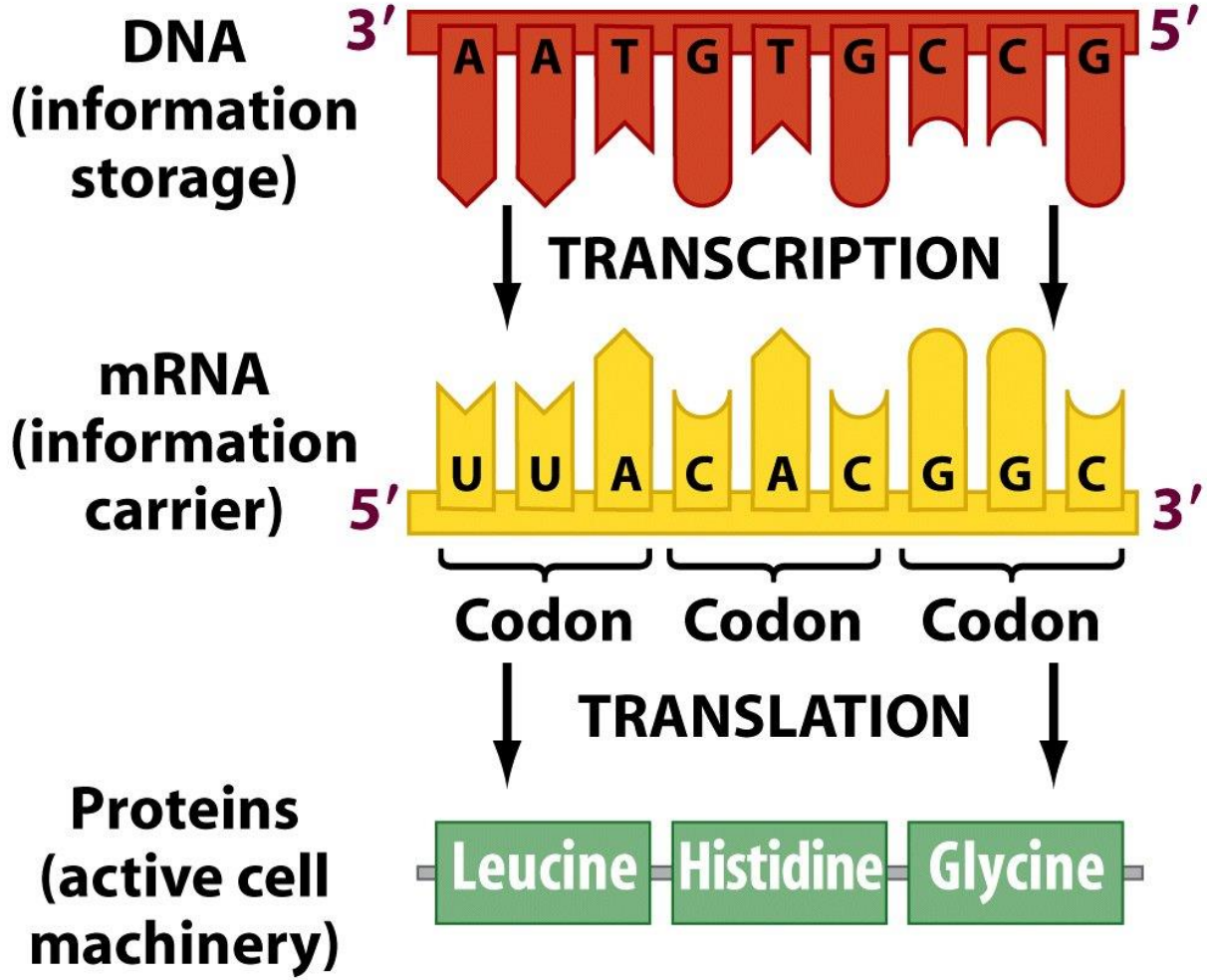
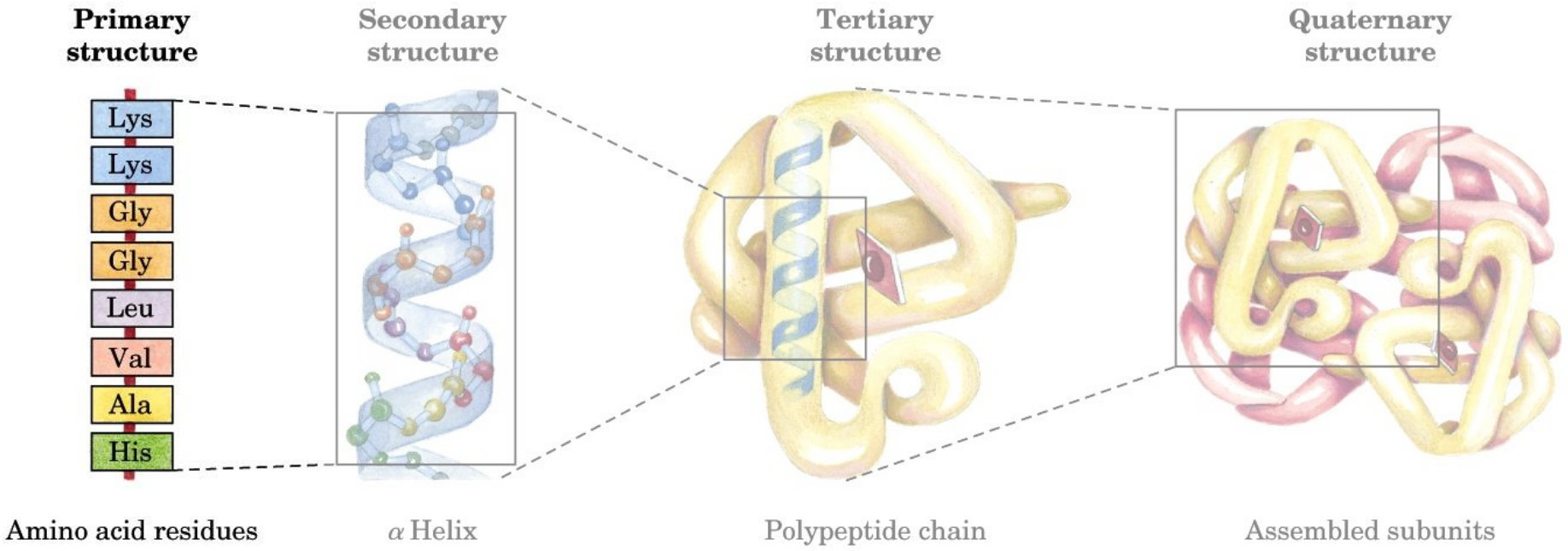


Figure 15-10a Biological Science, 2/e

Proteins

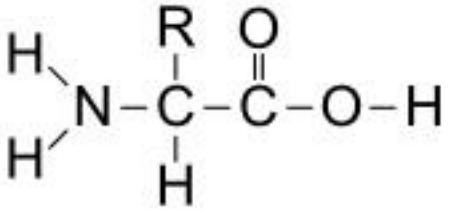
Primary structure = order of amino acids in the protein chain



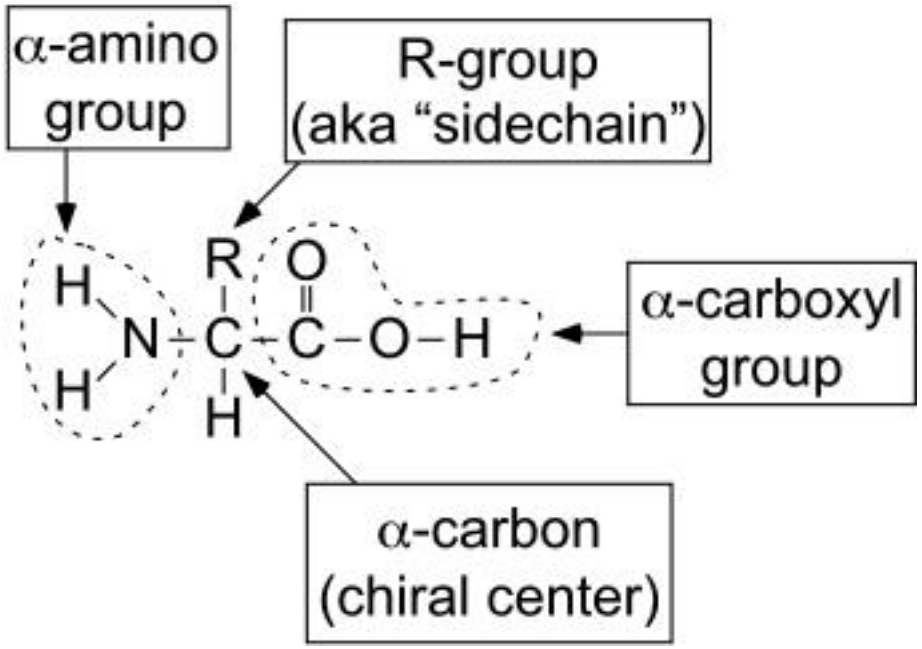
Proteins

Anatomy of an amino acid

General amino acid structure



Chemical anatomy of an amino acid



Proteins

How to remember the 1 letter code

- A: alanine
- C: cysteine
- D: aspartate
- E: glutamate
- F: phenylalanine
- G: glycine
- H: histidine
- I: isoleucine
- K: lysine
- L: leucine
- M:methionine
- N: Asparagine
- P: Proline
- Q: Glutamine
- R: Arginine
- S: Serine
- T: Threonine
- W: Tryptophan

Proteins

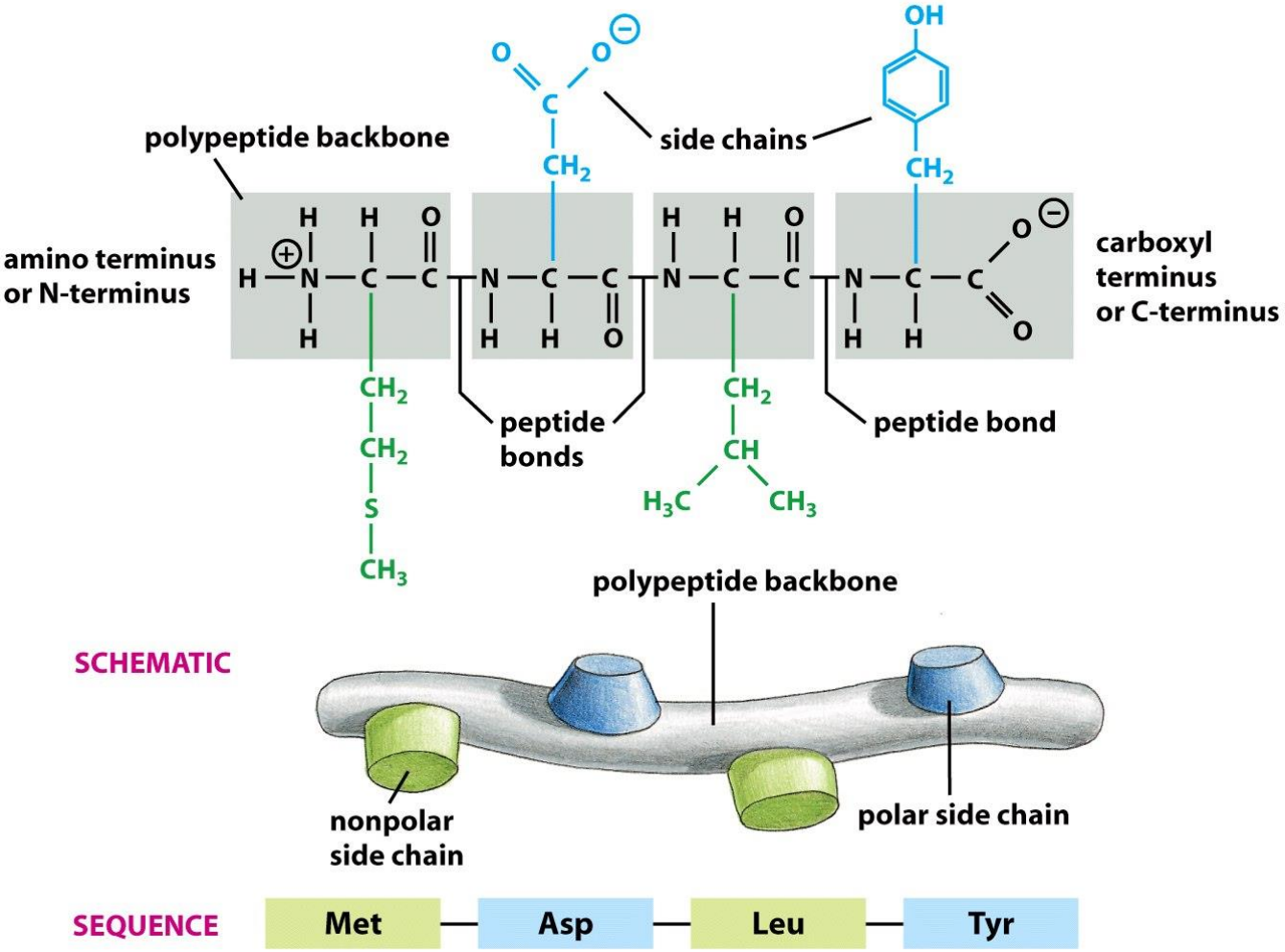
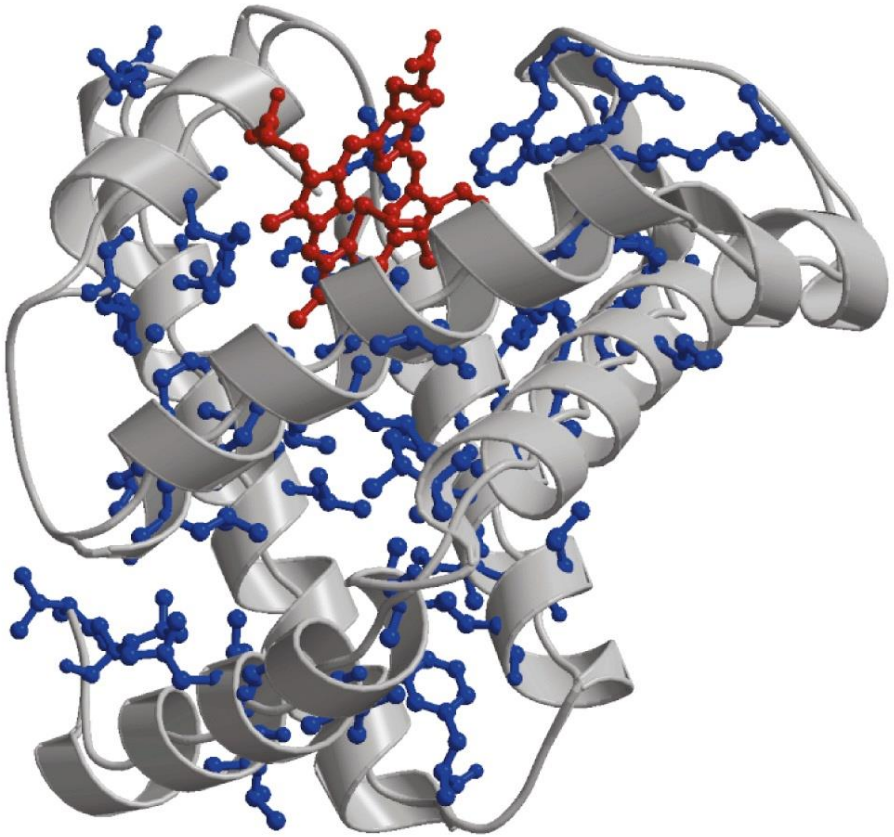


Figure 3-1 (part 2 of 2) *Molecular Biology of the Cell* (© Garland Science 2008)

Proteins

Non-polar R-groups tend to be buried in the cores of proteins



(d)

Myoglobin
Blue = non-polar R-group

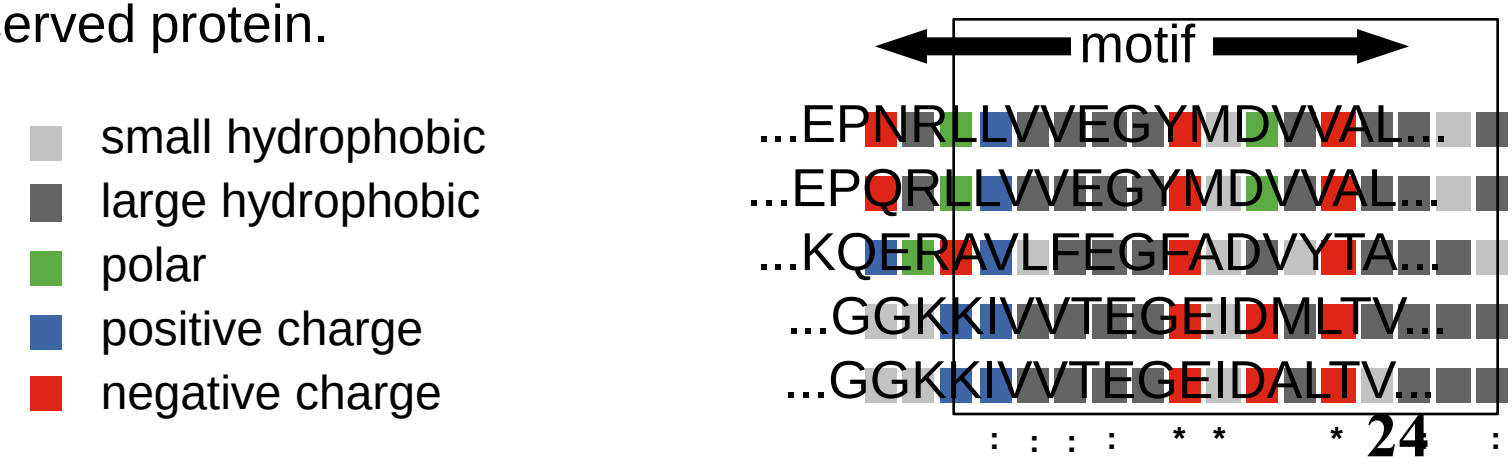
Red = Heme

Proteins

Primary sequence reveals important clues about a protein

- Evolution conserves amino acids that are important to protein structure and function across species. Sequence comparison of multiple “homologs” of a particular protein reveals highly conserved regions that are important for function.

- Clusters of conserved residues are called “motifs” -- motifs carry out a particular function or form a particular structure that is important for the conserved protein.



Proteins

Getting amino acid sequence

collagen [Homo sapiens]

GenBank: BAA04809.1

FASTA Graphics

Go to:

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DEFINITION  collagen [Homo sapiens].
ACCESSION   BAA04809
VERSION     BAA04809.1  GI:466538
DBSOURCE    locus HUMCO accession D21337.1
KEYWORDS    .
SOURCE      Homo sapiens (human)
  ORGANISM  Homo sapiens
            Eukaryota; Metazoa; Chordata; Craniata; Vertebrata; Eut
            Mammalia; Eutheria; Euarchontoglires; Primates; Haplorr
            Catarrhini; Hominidae; Homo.
REFERENCE   1  (residues 1 to 1678)
  AUTHORS   Oohashi,T., Sugimoto,M., Mattei,M.G. and Ninomiya,Y.
  TITLE     Identification of a new collagen IV chain, alpha 6(IV),
            isolation and assignment of the gene to chromosome Xq22
            the same locus for COL4A5
  JOURNAL   J. Biol. Chem. 269 (10), 7520-7526 (1994)
   PUBMED   8125972
REFERENCE   2  (residues 1 to 1678)
  AUTHORS   Oohashi,T.
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Display Settings: FASTA

collagen, partial [Homo sapiens]

GenBank: AAA36358.1

GenPept Graphics

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>gi|292352|gb|AAA36358.1| collagen, partial [Homo sapiens]
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RDGKPGLPGPPGDPIALPLLGDIGALLKNFCGNCQASVPGLKSNKGEEGGAGEPGKYDSMARKGDIGPRG
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Proteins: techniques

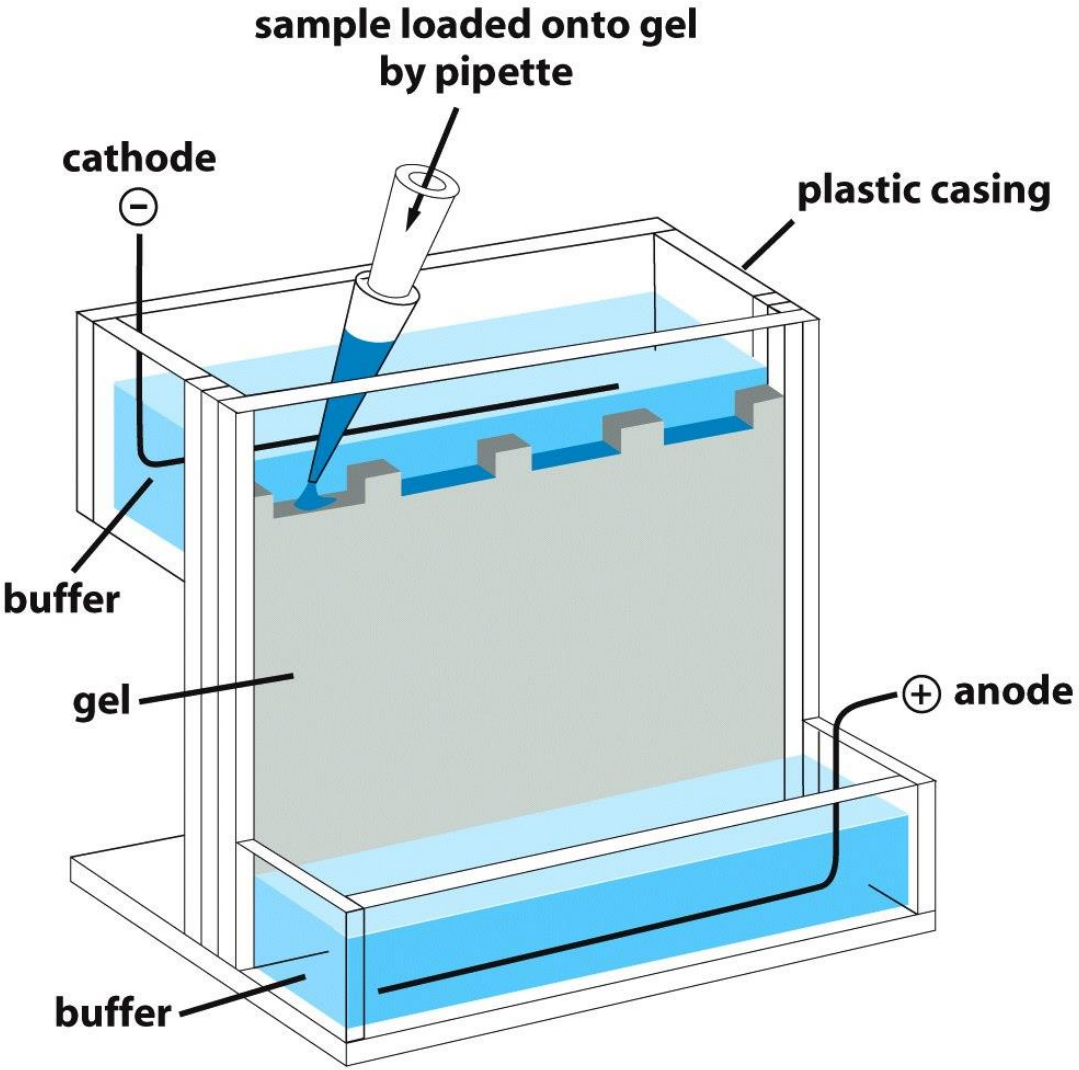
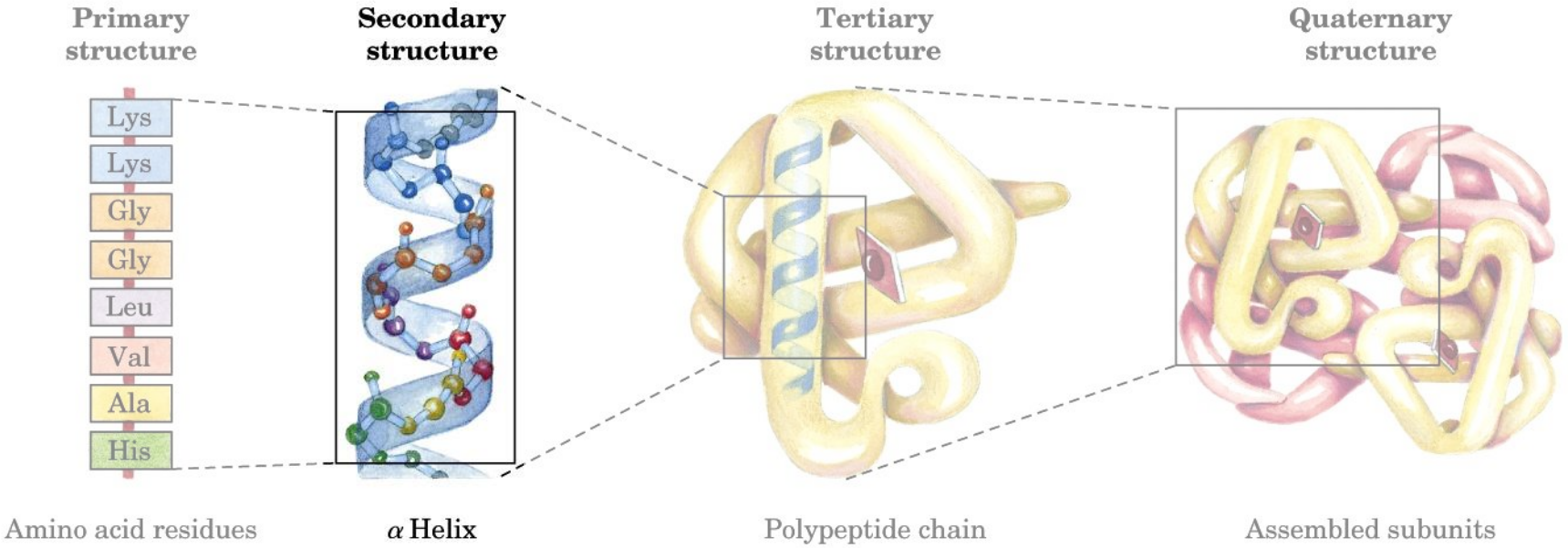


Figure 8-18a *Molecular Biology of the Cell* (© Garland Science 2008)

Proteins

Secondary structure = local folding of residues into regular patterns



Proteins

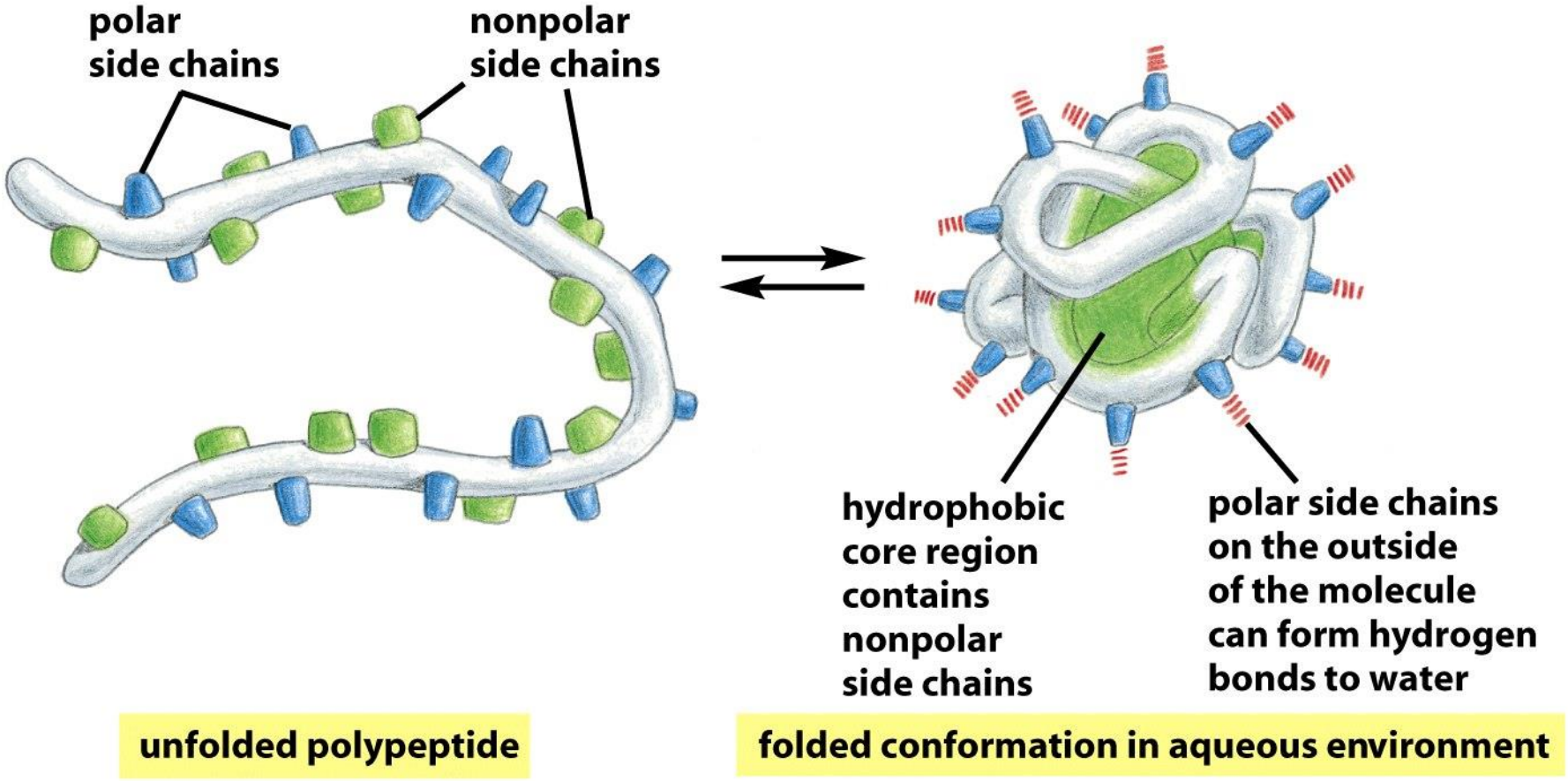


Figure 3-5 *Molecular Biology of the Cell* (© Garland Science 2008)

Proteins

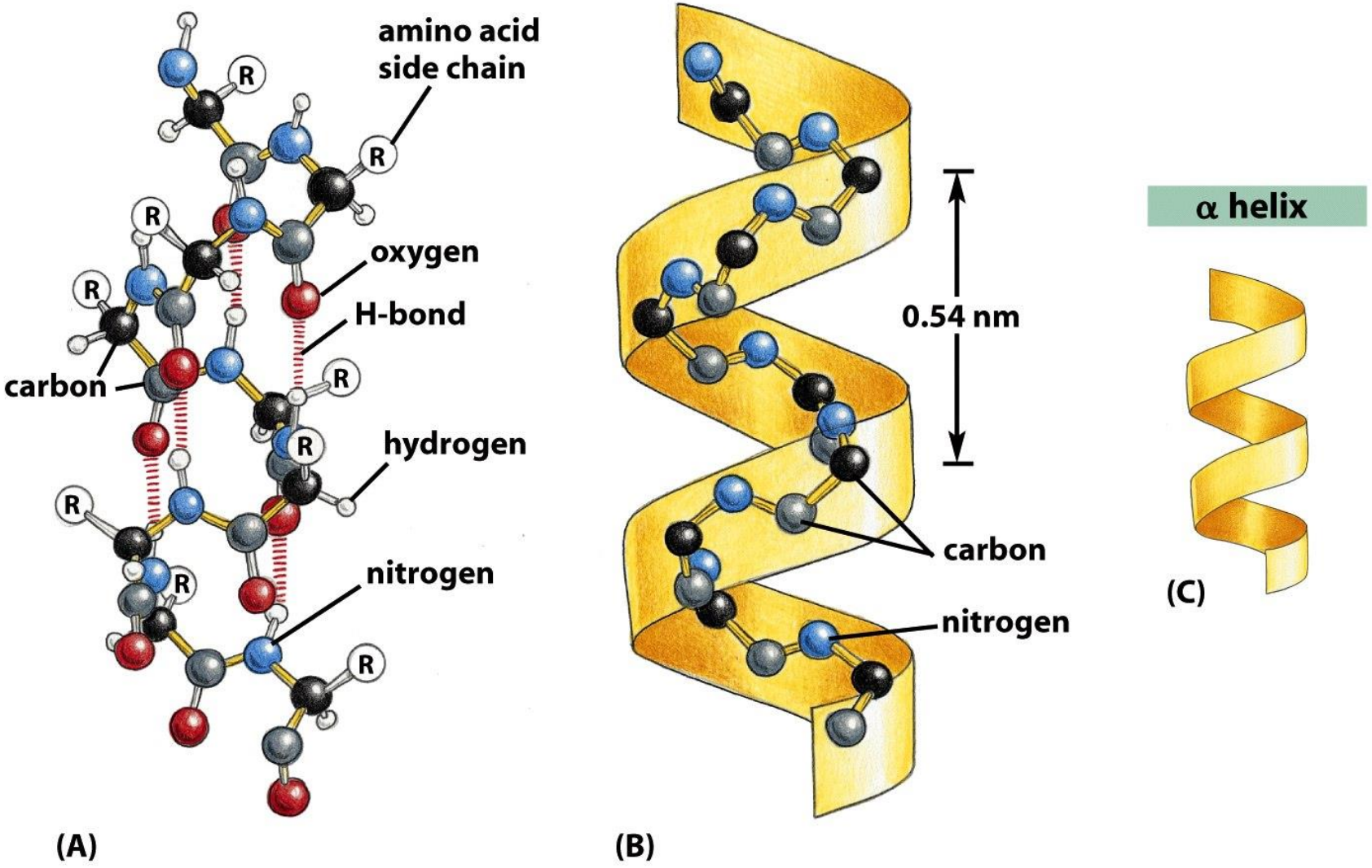


Figure 3-7a,b,c *Molecular Biology of the Cell* (© Garland Science 2008)

Proteins

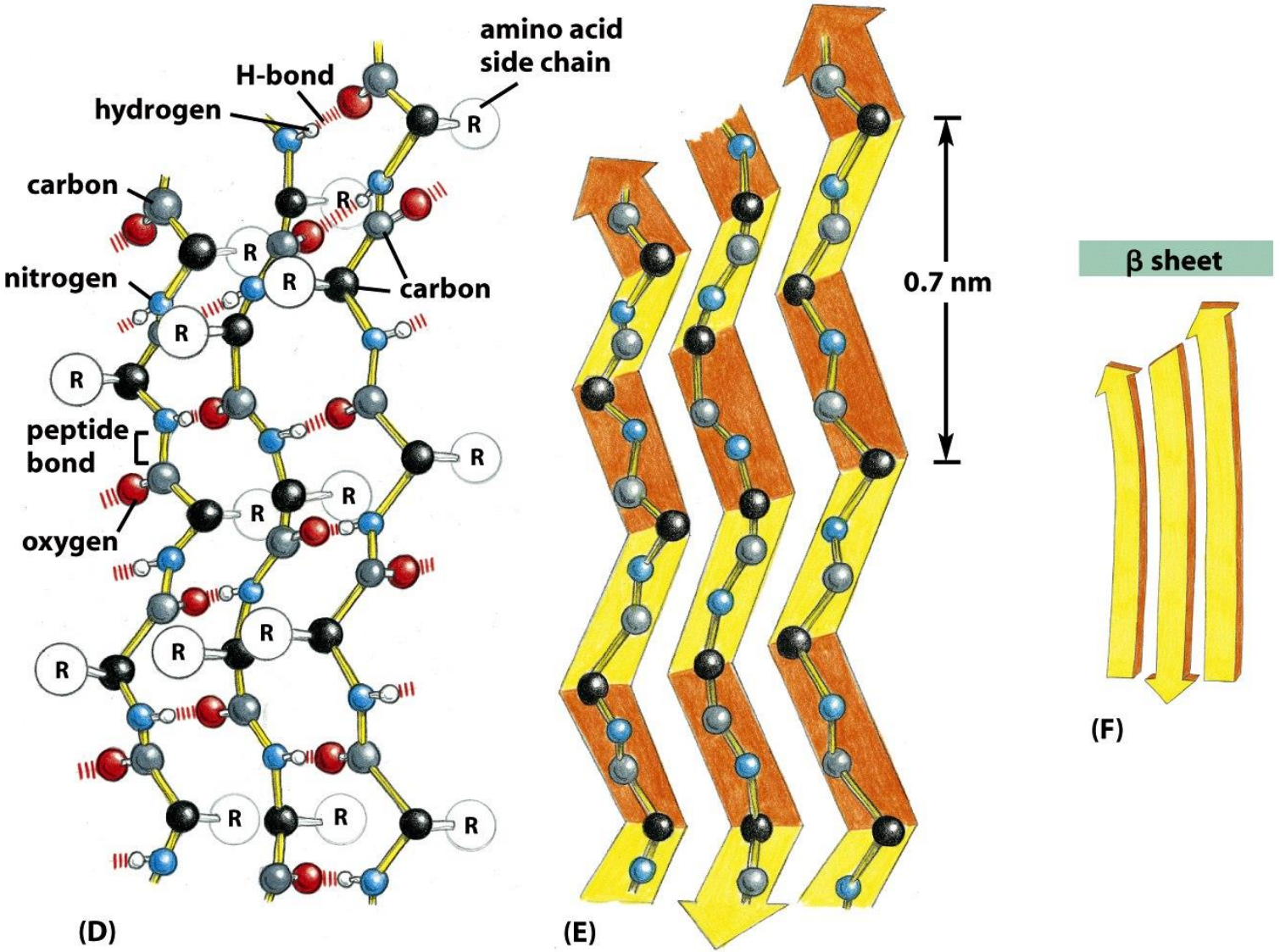
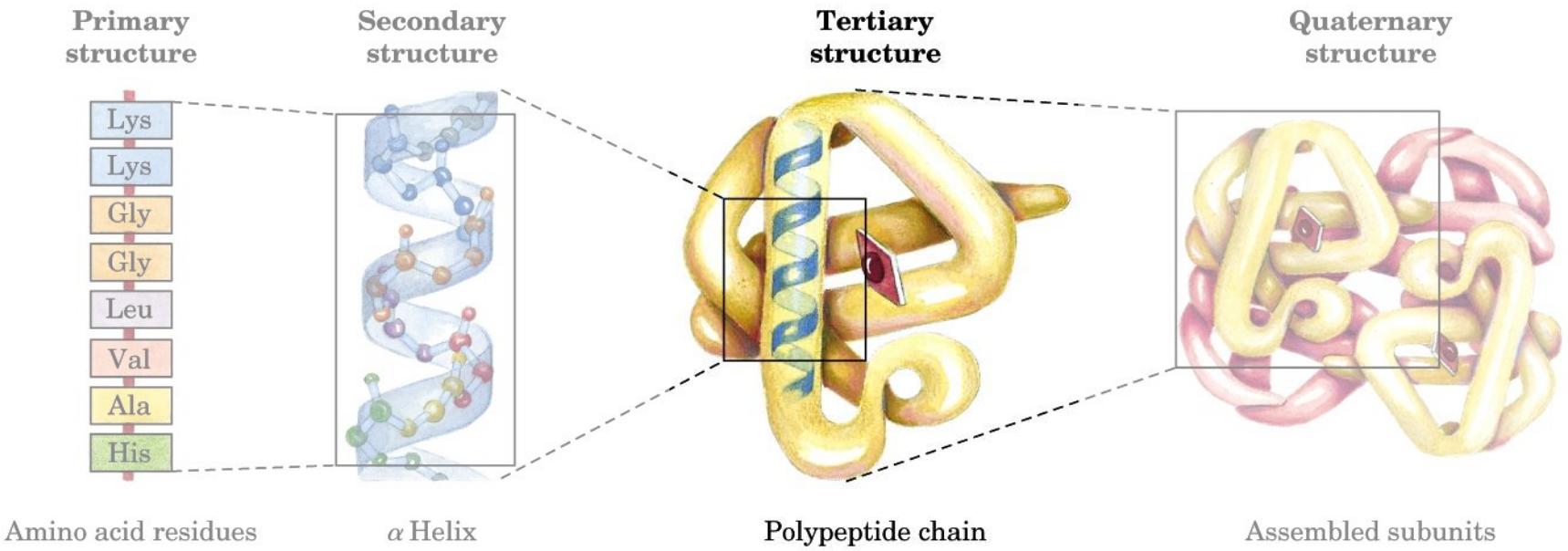


Figure 3-7d,e,f *Molecular Biology of the Cell* (© Garland Science 2008)

Proteins

Tertiary structure = global folding of a protein chain



Proteins

Protein stability

- **Electrostatic forces**
  - Interactions of positive and negative charges
- **Ionic interactions (ion pair/salt bridge)**
- **Dipole-dipole interactions e.g Van der Waals**
  - Very weak, but very numerous
- **Hydrogen bonding**
  - 12-30 kJ/mol
- **Hydrophobic forces**
  - Hydrophobic go in, hydrophillic out
- **Disulfide bonds**
  - Between 2 SH groups (251kJ/mol)

Proteins

Protein denaturation

- **Low conformation stability => highly susceptible to denaturation**
  - Changes in temperature (Tm less than 1OO°C) but small changes in folding result in almost total loss of 3D structure
  - pH changes: Ionisation of side groups change – changes H-bonding, charge distrib.
  - Detergents: change hydrophobic interactions
  - Organic substances: interfere with hydrophobic interactions (have their own interaction with water)
  - Salts: can stabilise (raise Tm) Ils can be good
  - Chaotropic agents: urea, Guanidinium – increase solubility of nonpolar substances in water – disrupt hydrobphobic interactions (expel water)

Proteins: motifs reused

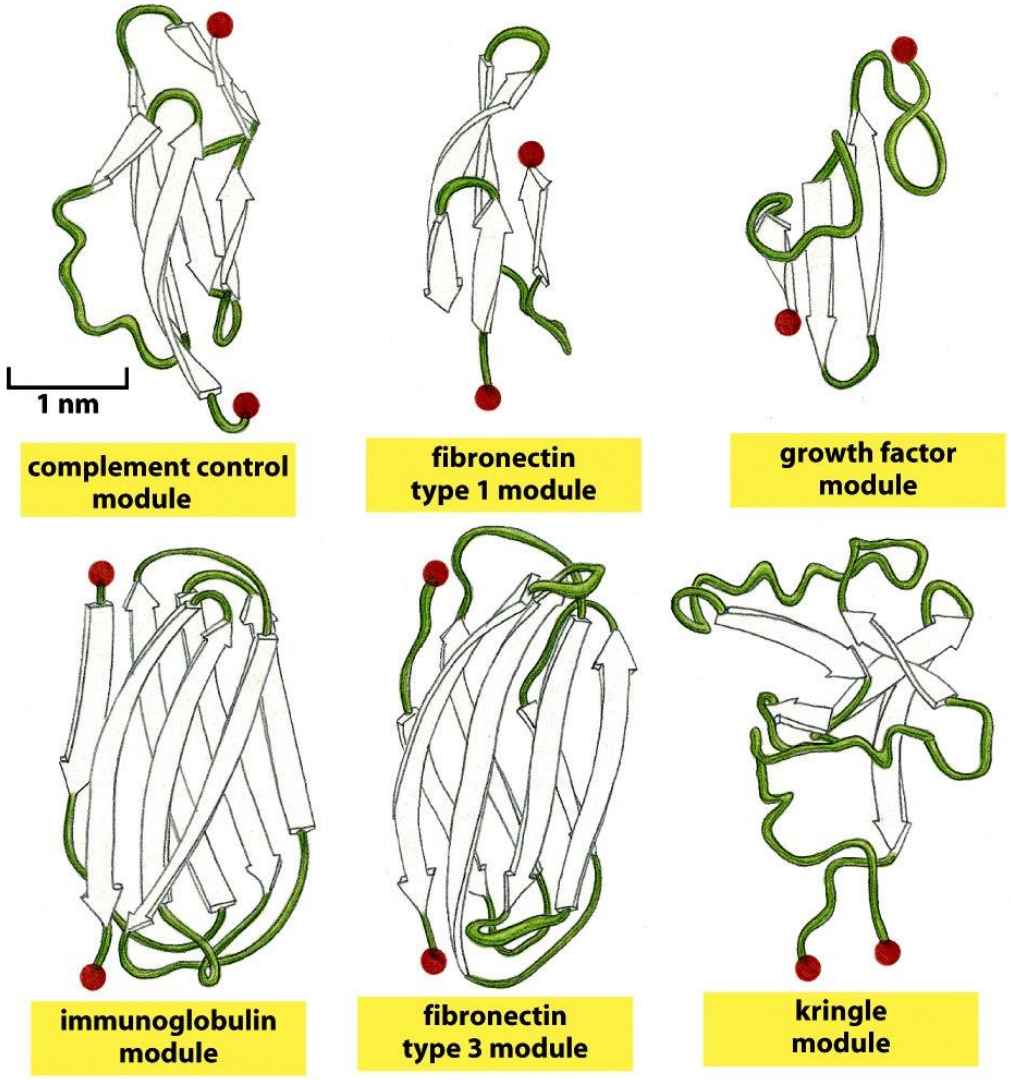


Figure 3-16 *Molecular Biology of the Cell* (© Garland Science 2008)

Proteins

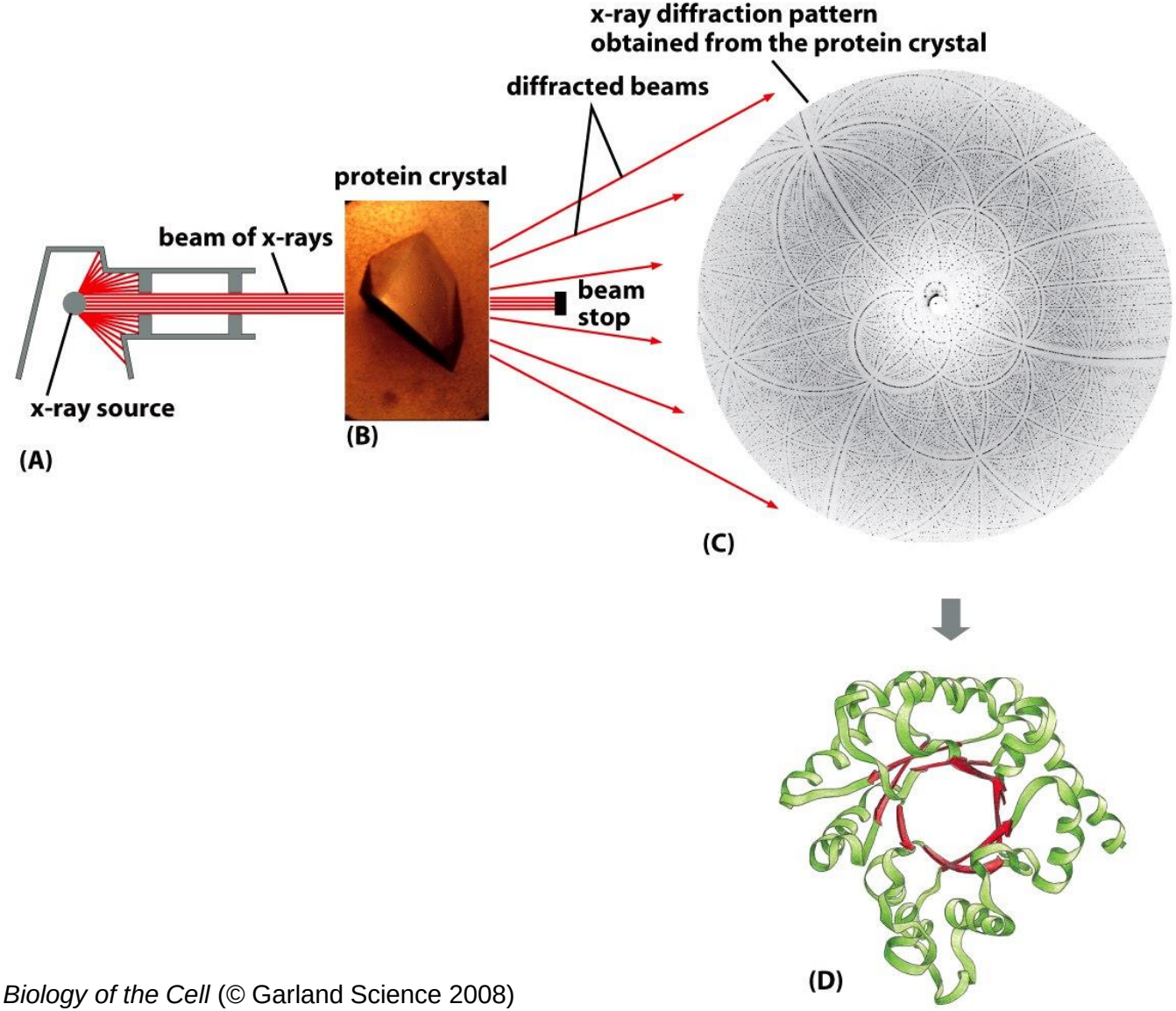
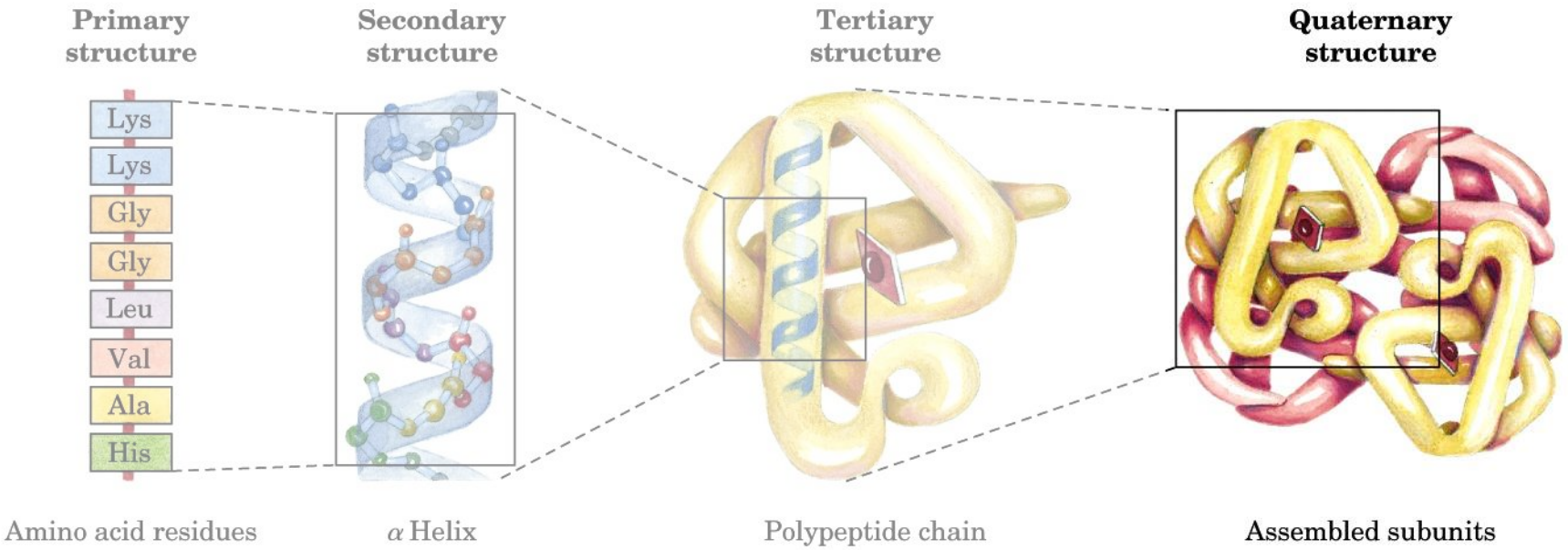


Figure 8-28 *Molecular Biology of the Cell* (© Garland Science 2008)

Proteins

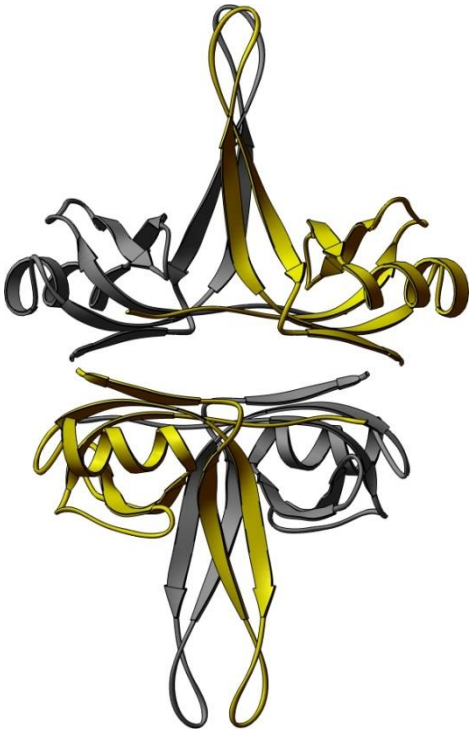
Quaternary structure = Higher-order assembly of proteins



Proteins

Examples of other quaternary structures

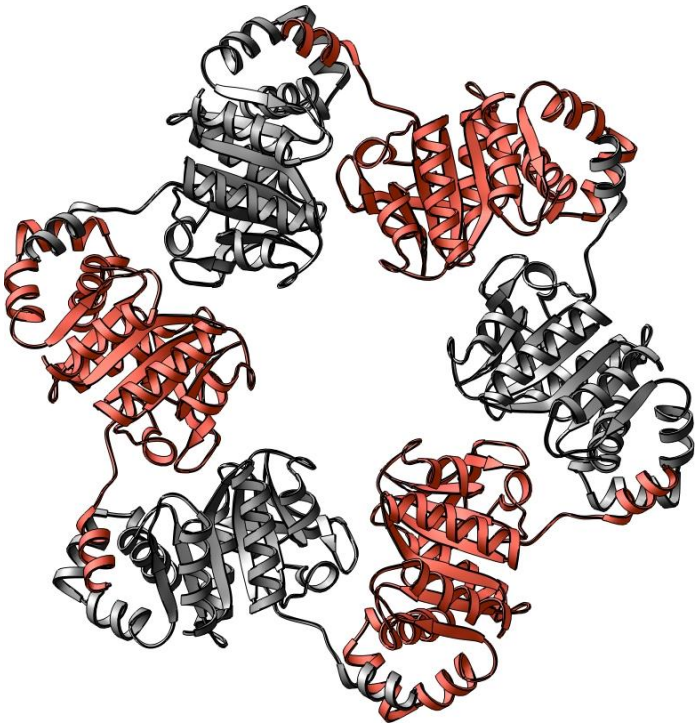
Tetramer



SSB

Allows coordinated DNA binding

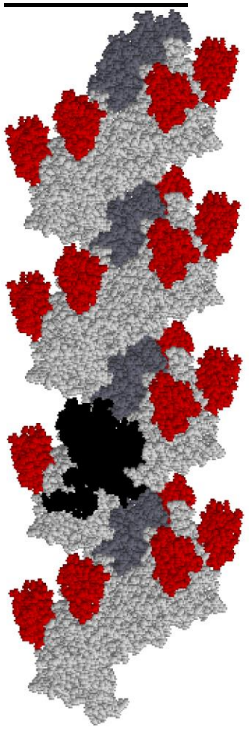
Hexamer



DNA helicase

Allows coordinated DNA binding and ATP hydrolysis

Filament



Recombinase

Allows complete coverage of an extended molecule

Protein types

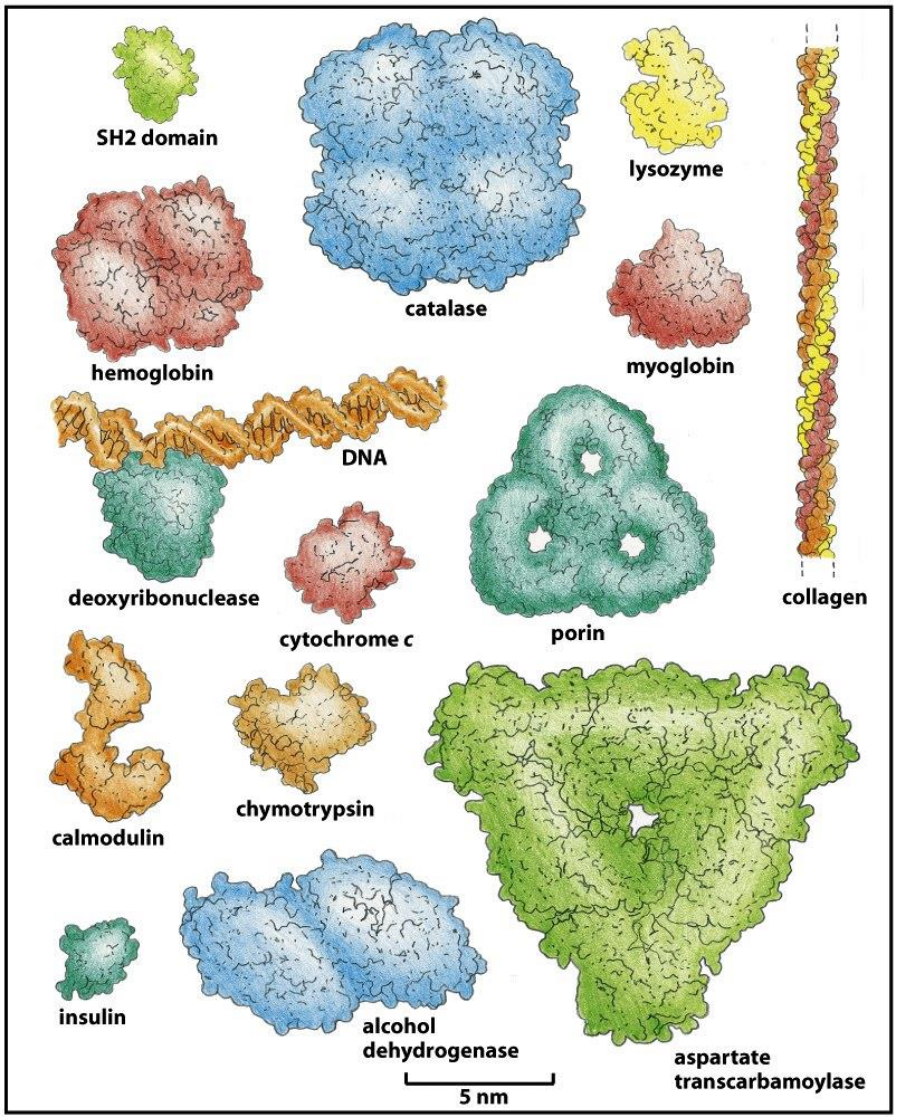


Figure 3-23 *Molecular Biology of the Cell* (© Garland Science 2008)

Protein types: enzymes

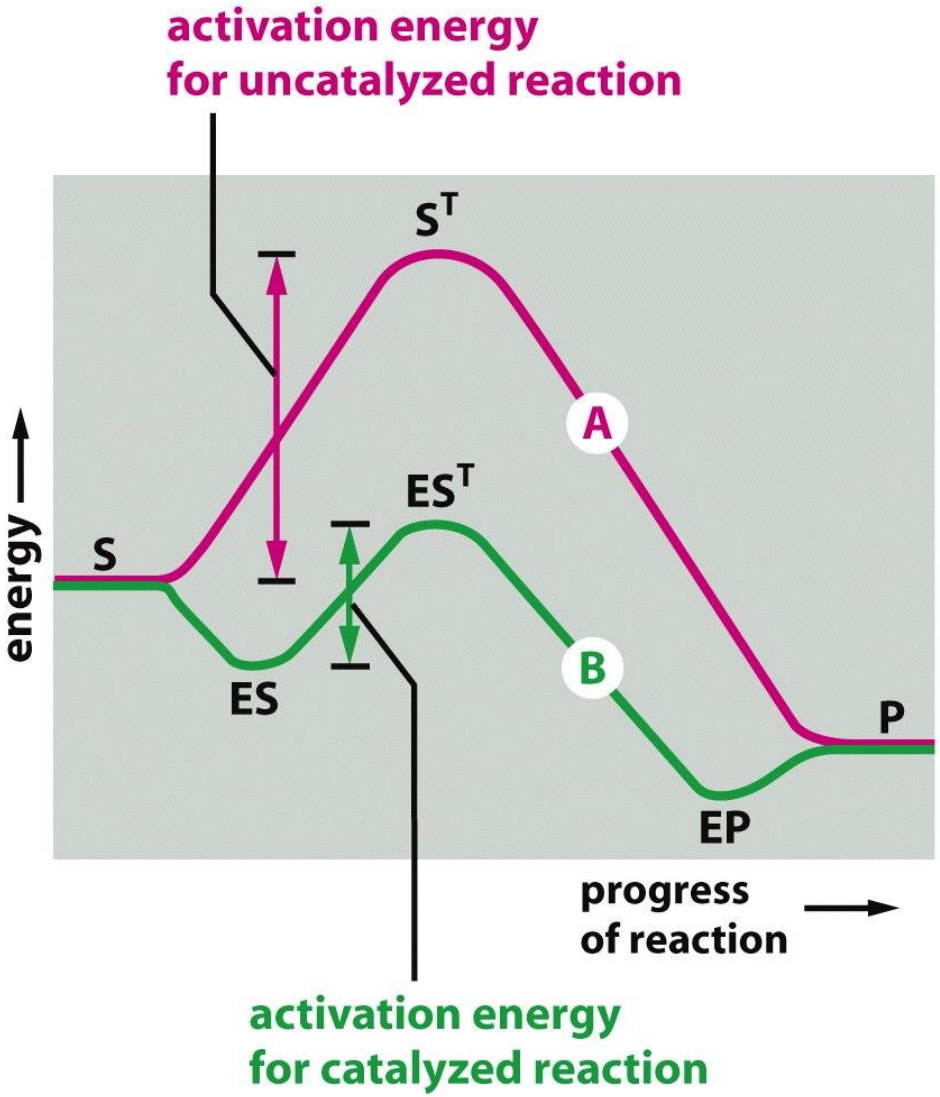


Figure 3-46 *Molecular Biology of the Cell* (© Garland Science 2008)

Protein types: enzymes

Table 3–2 Many Vitamins Provide Critical Coenzymes for Human Cells

VITAMIN	COENZYME	ENZYME-CATALYZED REACTIONS REQUIRING THESE COENZYMES
Thiamine (vitamin B_1)	thiamine pyrophosphate	activation and transfer of aldehydes
Riboflavin (vitamin B_2)	FADH	oxidation–reduction
Niacin	NADH, NADPH	oxidation–reduction
Pantothenic acid	coenzyme A	acyl group activation and transfer
Pyridoxine	pyridoxal phosphate	amino acid activation; also glycogen phosphorylase
Biotin	biotin	CO_2 activation and transfer
Lipoic acid	lipoamide	acyl group activation; oxidation–reduction
Folic acid	tetrahydrofolate	activation and transfer of single carbon groups
Vitamin B_{12}	cobalamin coenzymes	isomerization and methyl group transfers

Table 3-2 *Molecular Biology of the Cell* (© Garland Science 2008)

DNA

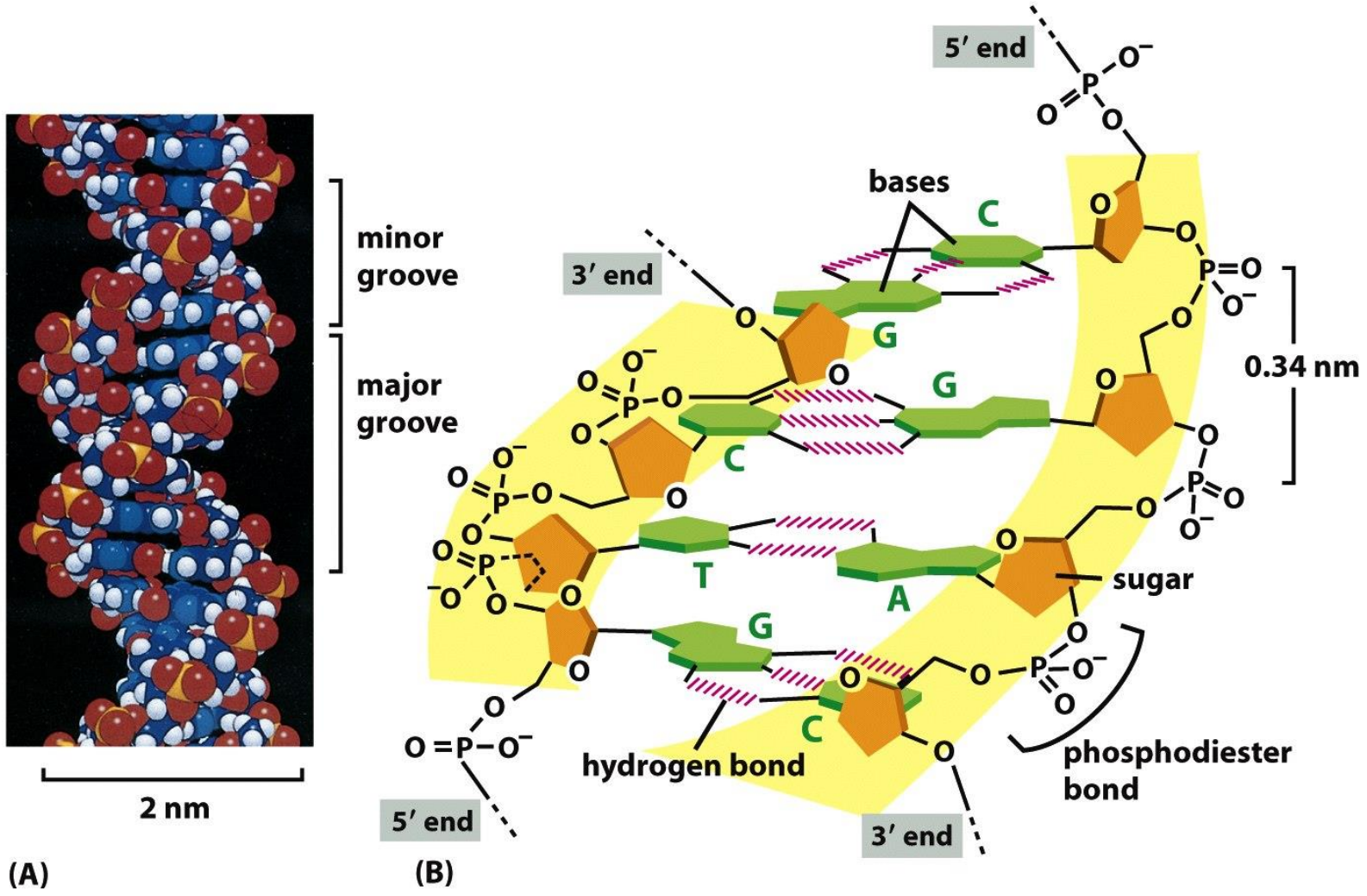


Figure 4-5 *Molecular Biology of the Cell* (© Garland Science 2008)

DNA synthesis: 5’ -> 3’

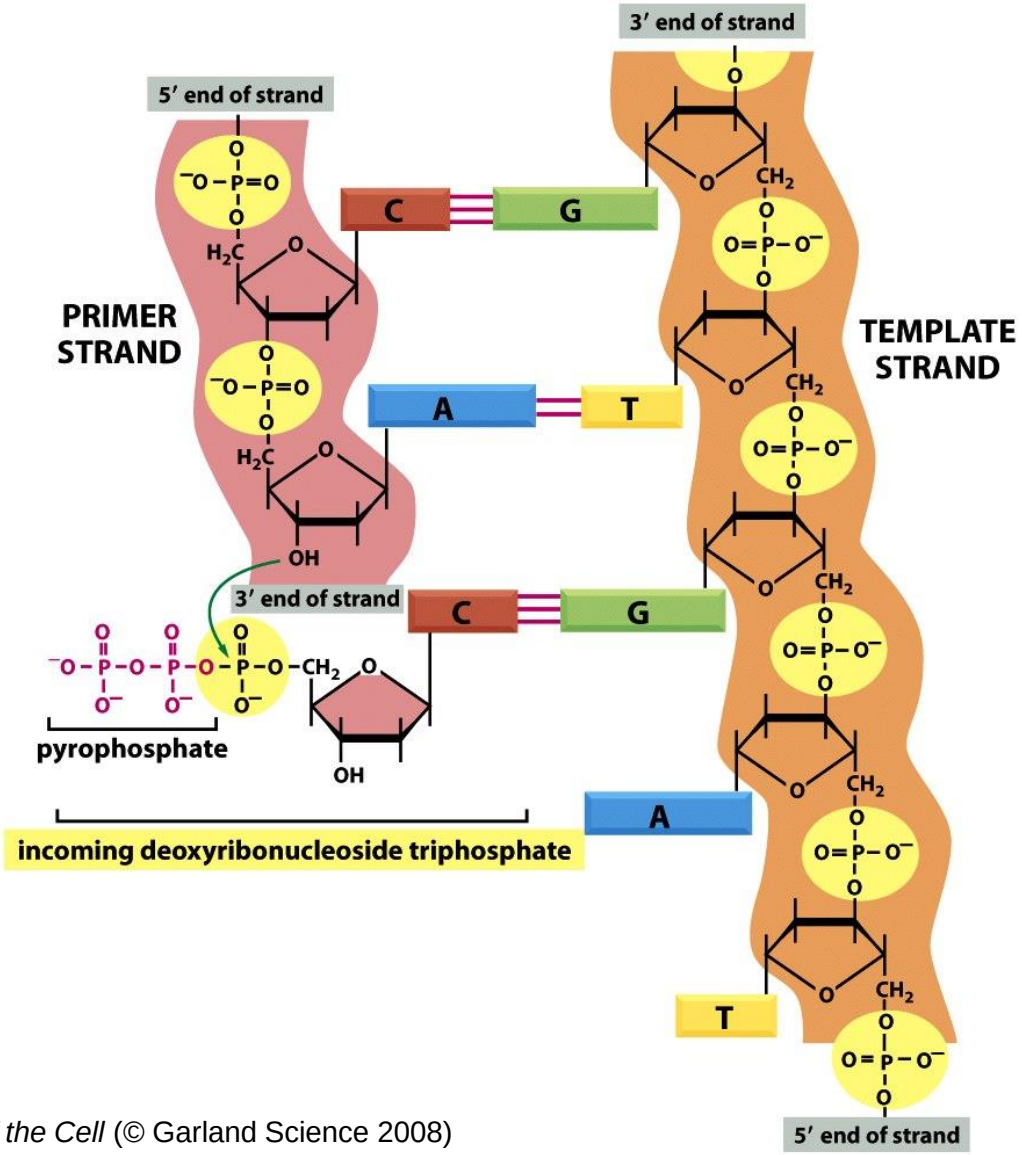


Figure 5-3 *Molecular Biology of the Cell* (© Garland Science 2008)

DNA polymerase

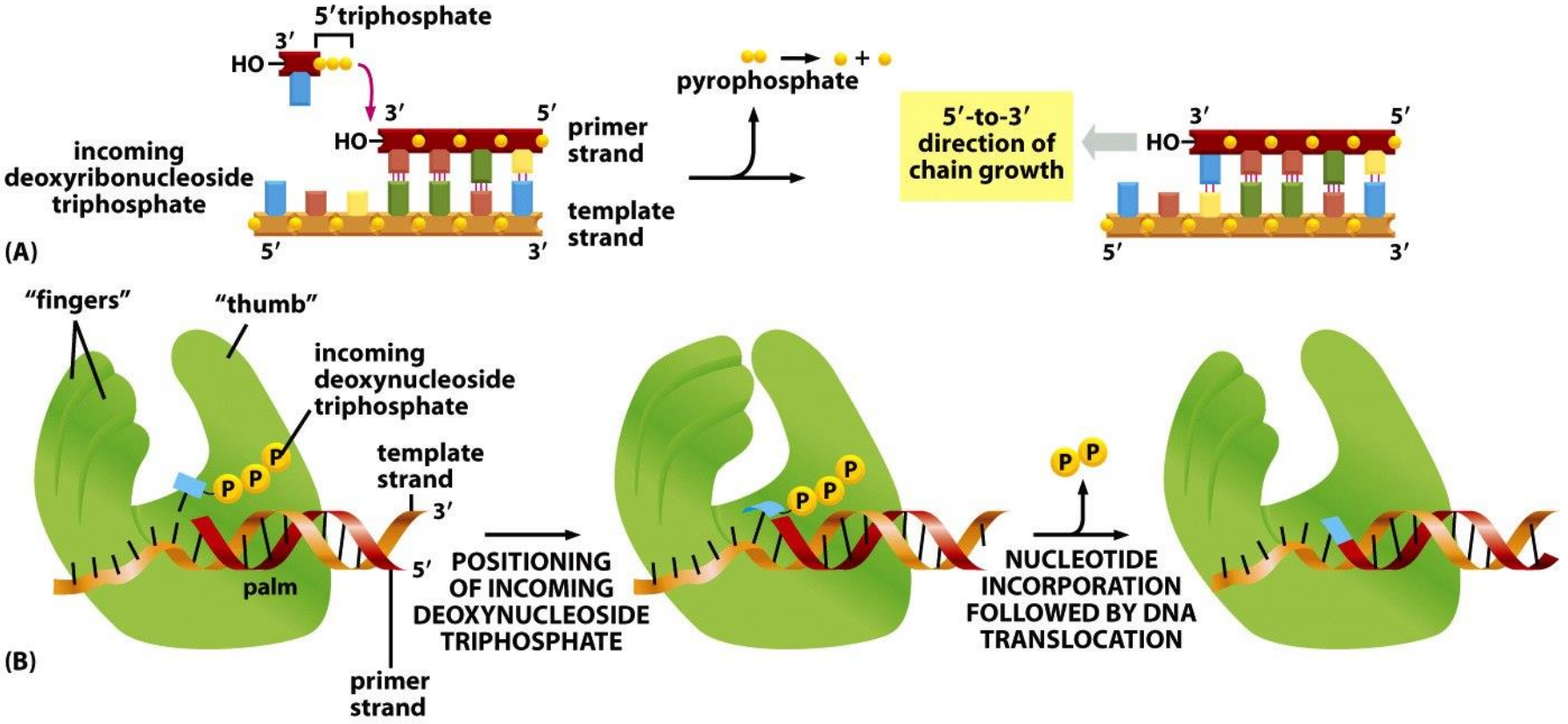


Figure 5-4 *Molecular Biology of the Cell* (© Garland Science 2008)

High fidelity DNA synthesis

Table 5–1 The Three Steps That Give Rise to High-Fidelity DNA Synthesis

REPLICATION STEP	ERRORS PER NUCLEOTIDE
5′ → 3′ polymerization	1 in 10^5
3′ → 5′ exonucleolytic proofreading	1 in 10^2
Strand-directed mismatch repair	1 in 10^2
Combined	1 in 10^9

The third step, strand-directed mismatch repair, is described later in this chapter.

Table 5-1 *Molecular Biology of the Cell* (© Garland Science 2008)

DNA mutations

Table 5–2 Some Inherited Syndromes with Defects in DNA Repair

NAME	PHENOTYPE	ENZYME OR PROCESS AFFECTED
MSH2, 3, 6, MLH1, PMS2	colon cancer	mismatch repair
Xeroderma pigmentosum (XP) groups A–G	skin cancer, UV sensitivity, neurological abnormalities	nucleotide excision–repair
XP variant	UV sensitivity, skin cancer	translesion synthesis by DNA polymerase η
Ataxia telangiectasia (AT)	leukemia, lymphoma, γ-ray sensitivity, genome instability	ATM protein, a protein kinase activated by double-strand breaks
BRCA2	breast, ovarian, and prostate cancer	repair by homologous recombination
Werner syndrome	premature aging, cancer at several sites, genome instability	accessory 3′-exonuclease and DNA helicase
Bloom syndrome	cancer at several sites, stunted growth, genome instability	accessory DNA helicase for replication
Fanconi anemia groups A–G	congenital abnormalities, leukemia, genome instability	DNA interstrand cross-link repair
46 BR patient	hypersensitivity to DNA-damaging agents, genome instability	DNA ligase I

Table 5-2 *Molecular Biology of the Cell* (© Garland Science 2008)

DNA amplification: PCR

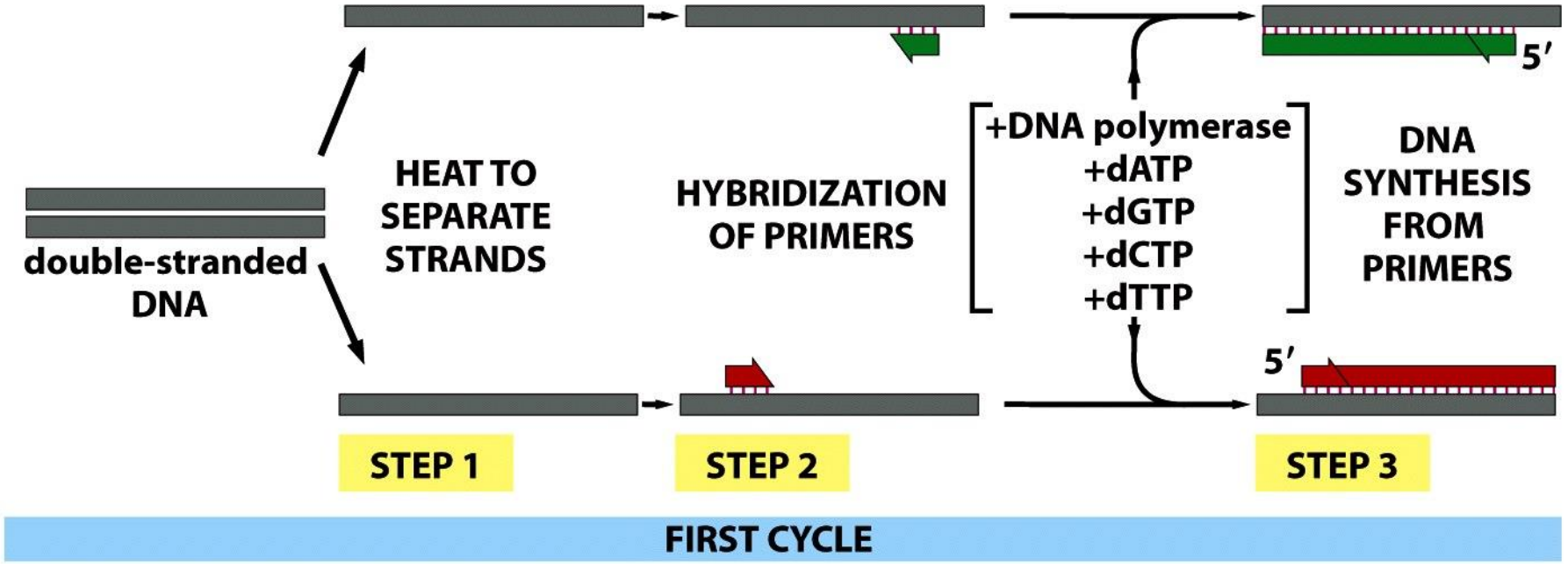


Figure 8-45a *Molecular Biology of the Cell* (© Garland Science 2008)

DNA to RNA

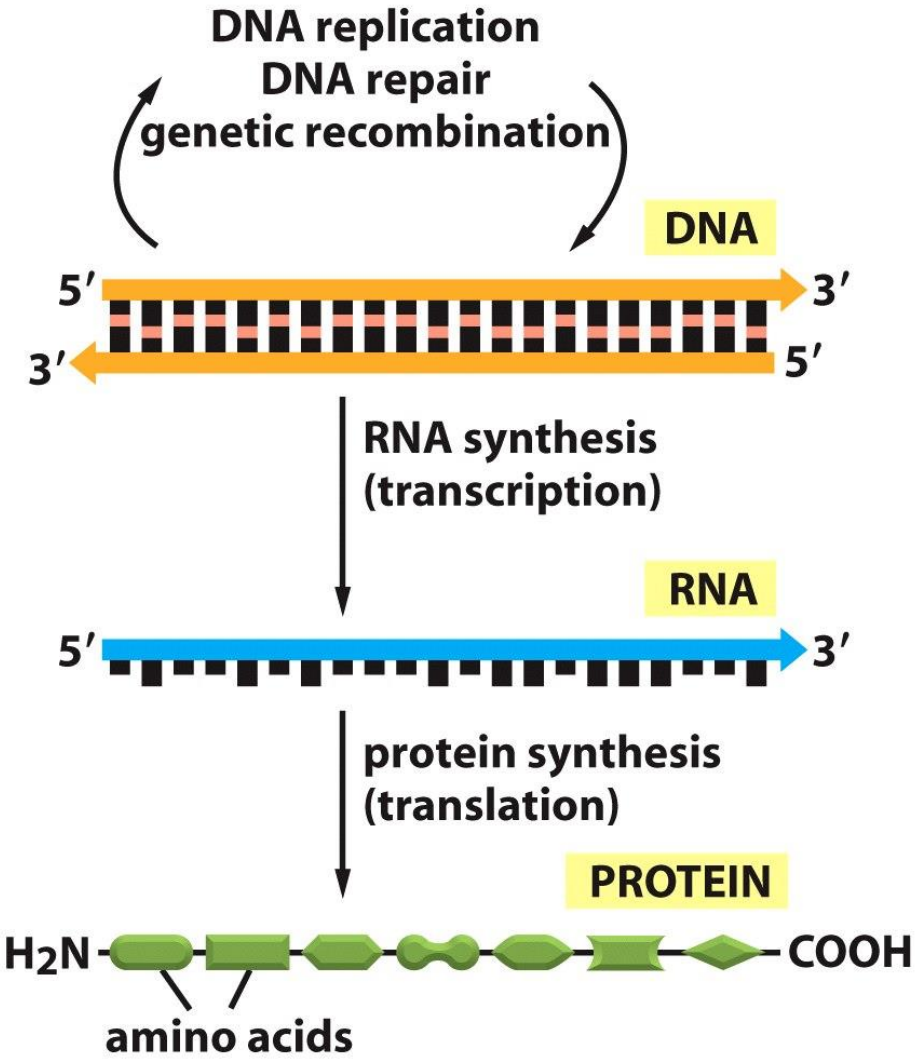


Figure 6-2 *Molecular Biology of the Cell* (© Garland Science 2008)

RNA: ribonucleic acid

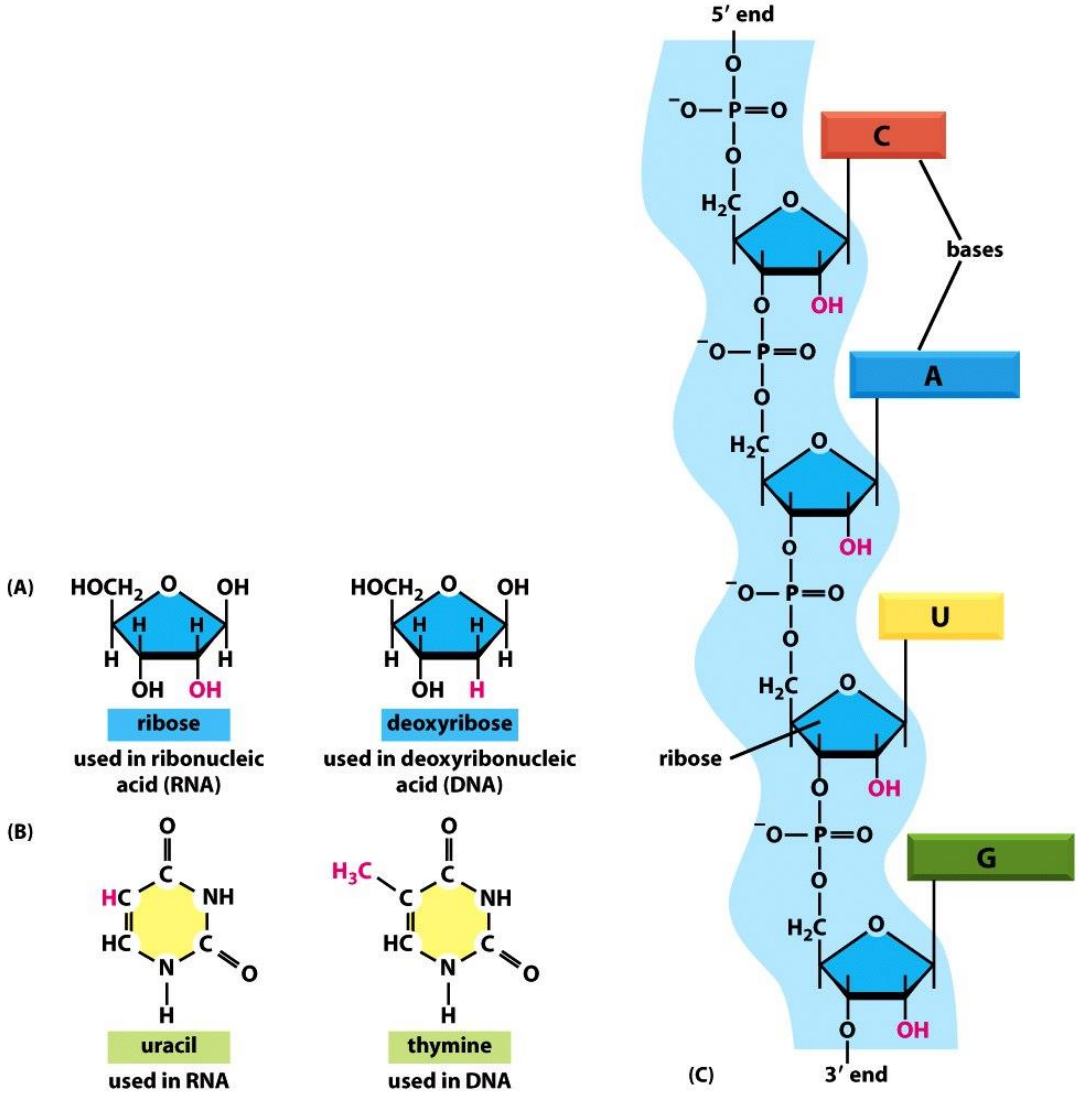
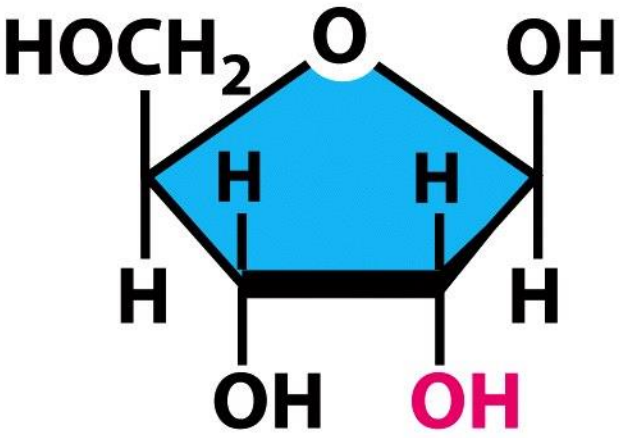


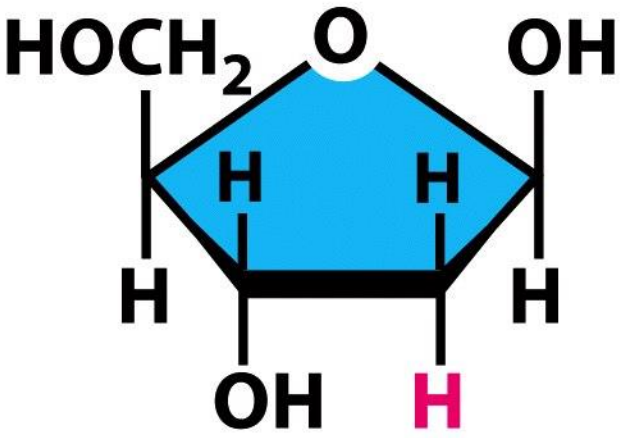
Figure 6-4 *Molecular Biology of the Cell* (© Garland Science 2008)

RNA: ribonucleic acid



ribose

used in ribonucleic acid (RNA)

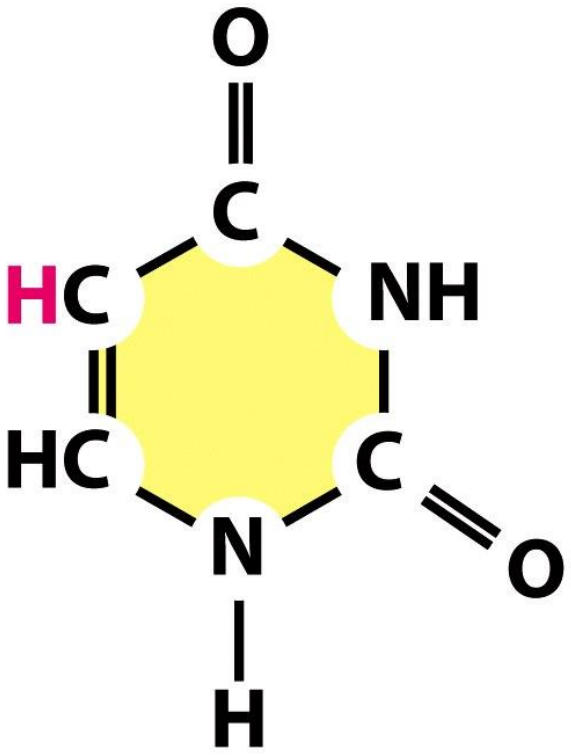


deoxyribose

used in deoxyribonucleic acid (DNA)

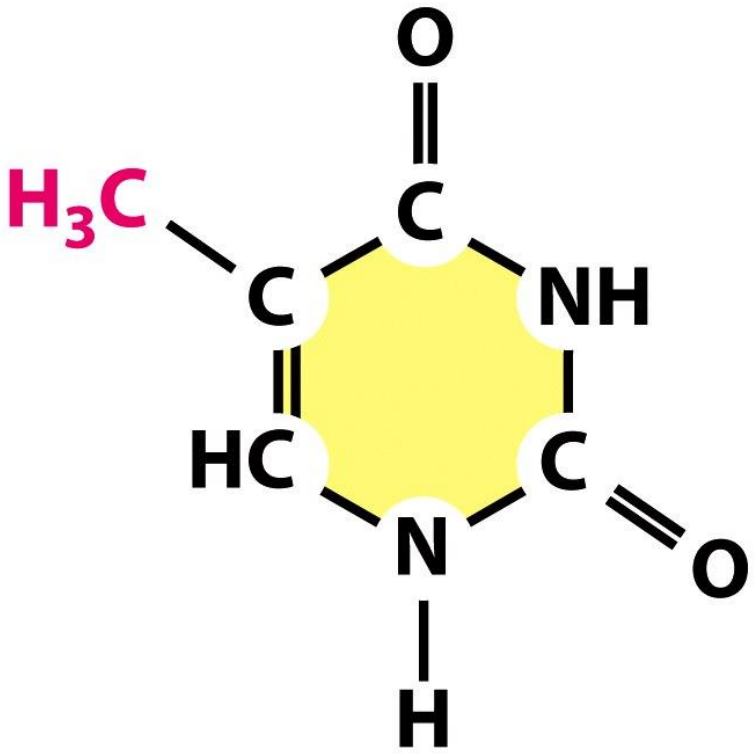
Figure 6-4a *Molecular Biology of the Cell* (© Garland Science 2008)

RNA: ribonucleic acid



uracil

used in RNA



thymine

used in DNA

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

RNA structures

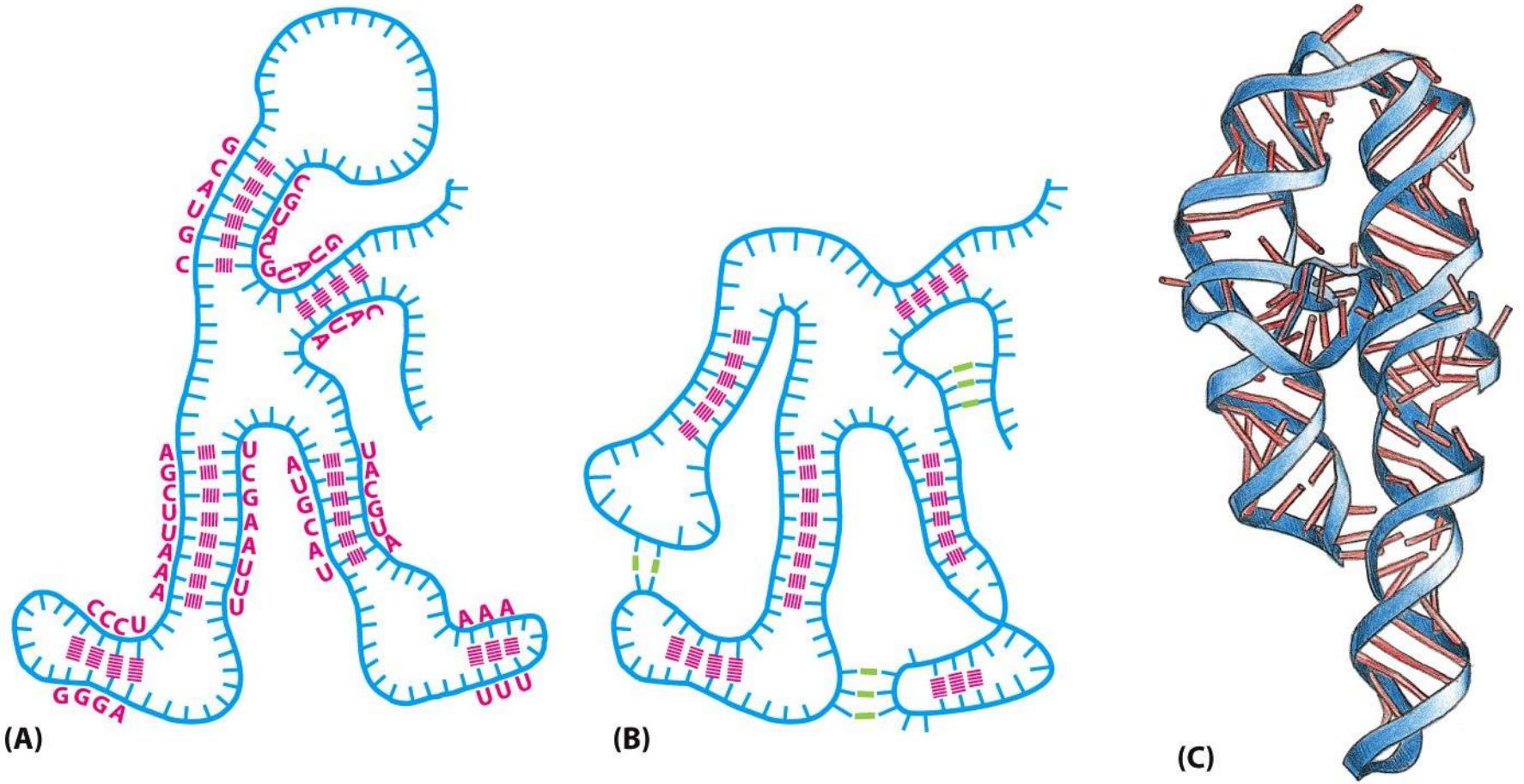


Figure 6-6 *Molecular Biology of the Cell* (© Garland Science 2008)

Transcription results in ss RNA

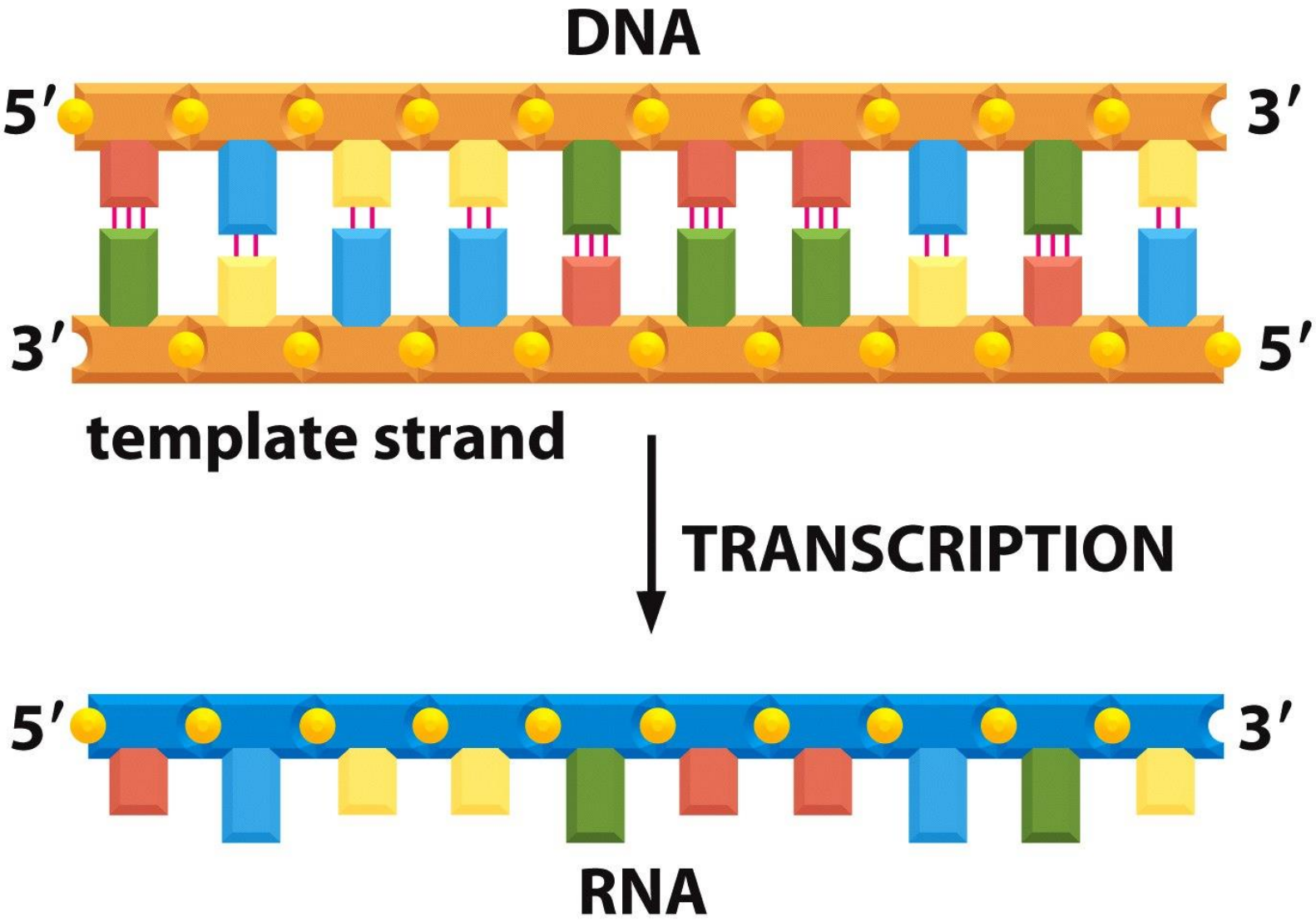


Figure 6-7 *Molecular Biology of the Cell* (© Garland Science 2008)

Multiple types of RNA

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* (© Garland Science 2008)

RNA polymerase

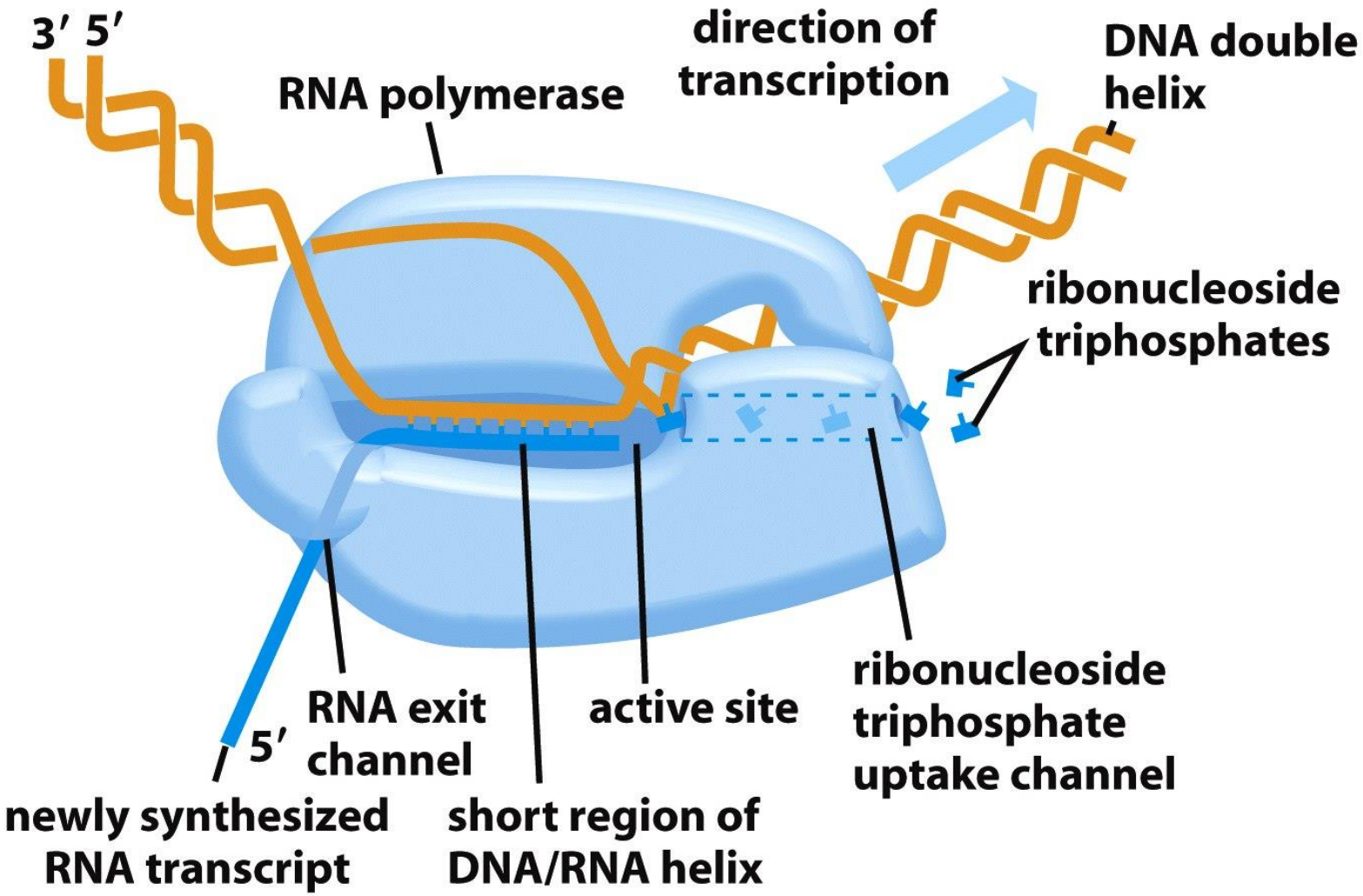
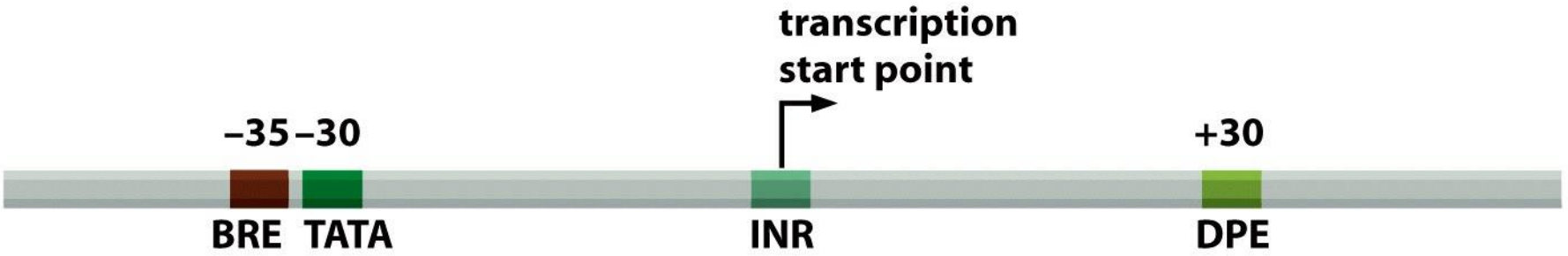


Figure 6-8a *Molecular Biology of the Cell* (© Garland Science 2008)

RNA synthesis



element	consensus sequence	general transcription factor
BRE	G/C G/C G/A C G C C	TFIIB
TATA	T A T A A/T A A/T	TBP
INR	C/T C/T A N T/A C/T C/T	TFIID
DPE	A/G G A/T C G T G	TFIID

Figure 6-17 *Molecular Biology of the Cell* (© Garland Science 2008)

RNA is exported

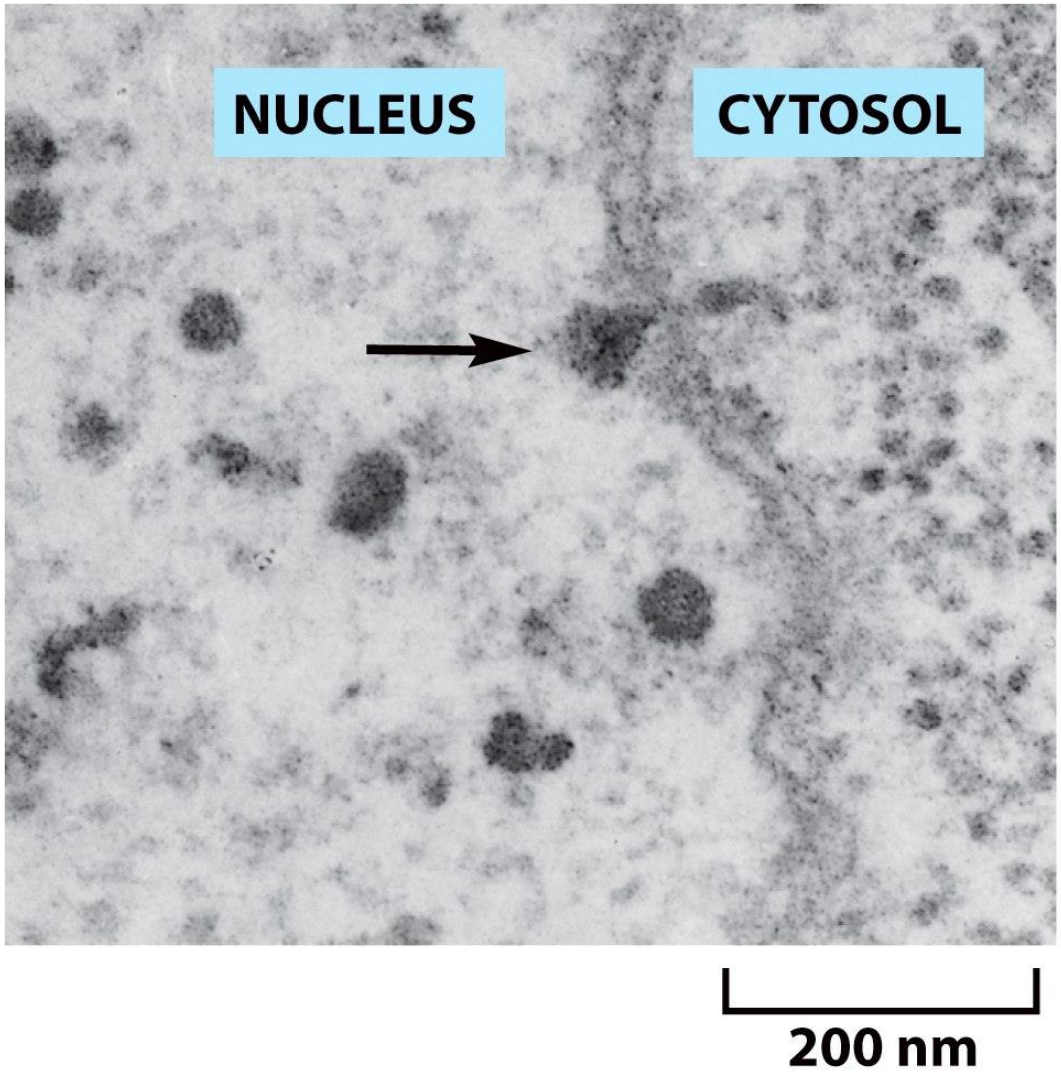


Figure 6-39b *Molecular Biology of the Cell* (© Garland Science 2008)

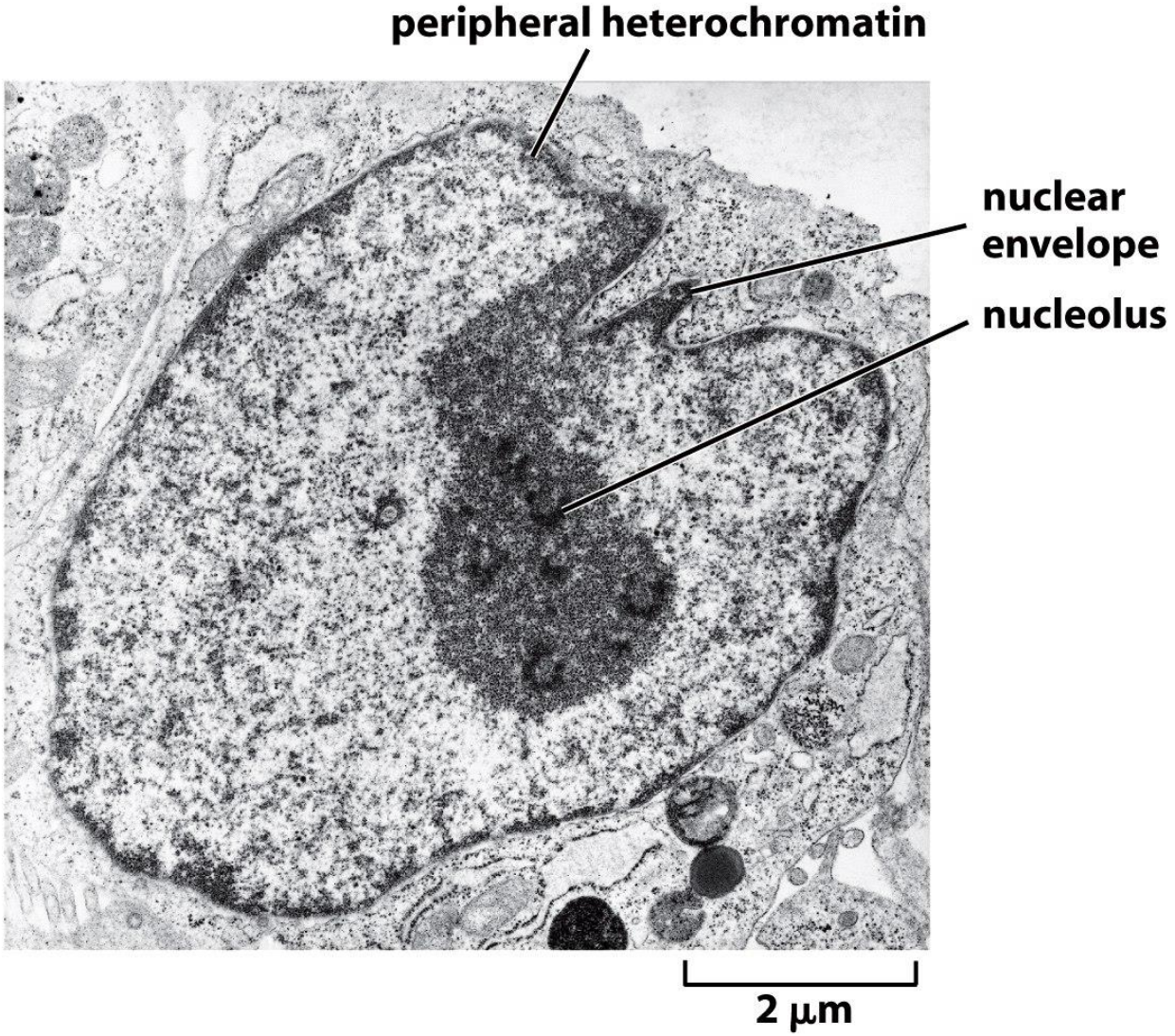


Figure 6-44a *Molecula* 2008)

The genetic code

GCA GCC GCG GCU	AGA AGG CGA CGC CGG CGU	GAC GAU	AAC AAU	UGC UGU	GAA GAG	CAA CAG	GGA GGC GGG GGU	CAC CAU	AUA AUC AUU	UUA UUG CUA CUC CUG CUU	AAA AAG	AUG	UUC UUU	CCA CCC CCG CCU	AGC AGU UCA UCC UCG UCU	ACA ACC ACG ACU	UGG	UAC UAU	GUA GUC GUG GUU	UAA UAG UGA
Ala	Arg	Asp	Asn	Cys	Glu	Gln	Gly	His	Ile	Leu	Lys	Met	Phe	Pro	Ser	Thr	Trp	Tyr	Val	stop
A	R	D	N	C	E	Q	G	H	I	L	K	M	F	P	S	T	W	Y	V	

Figure 6-50 *Molecular Biology of the Cell* (© Garland Science 2008)

Three reading frames

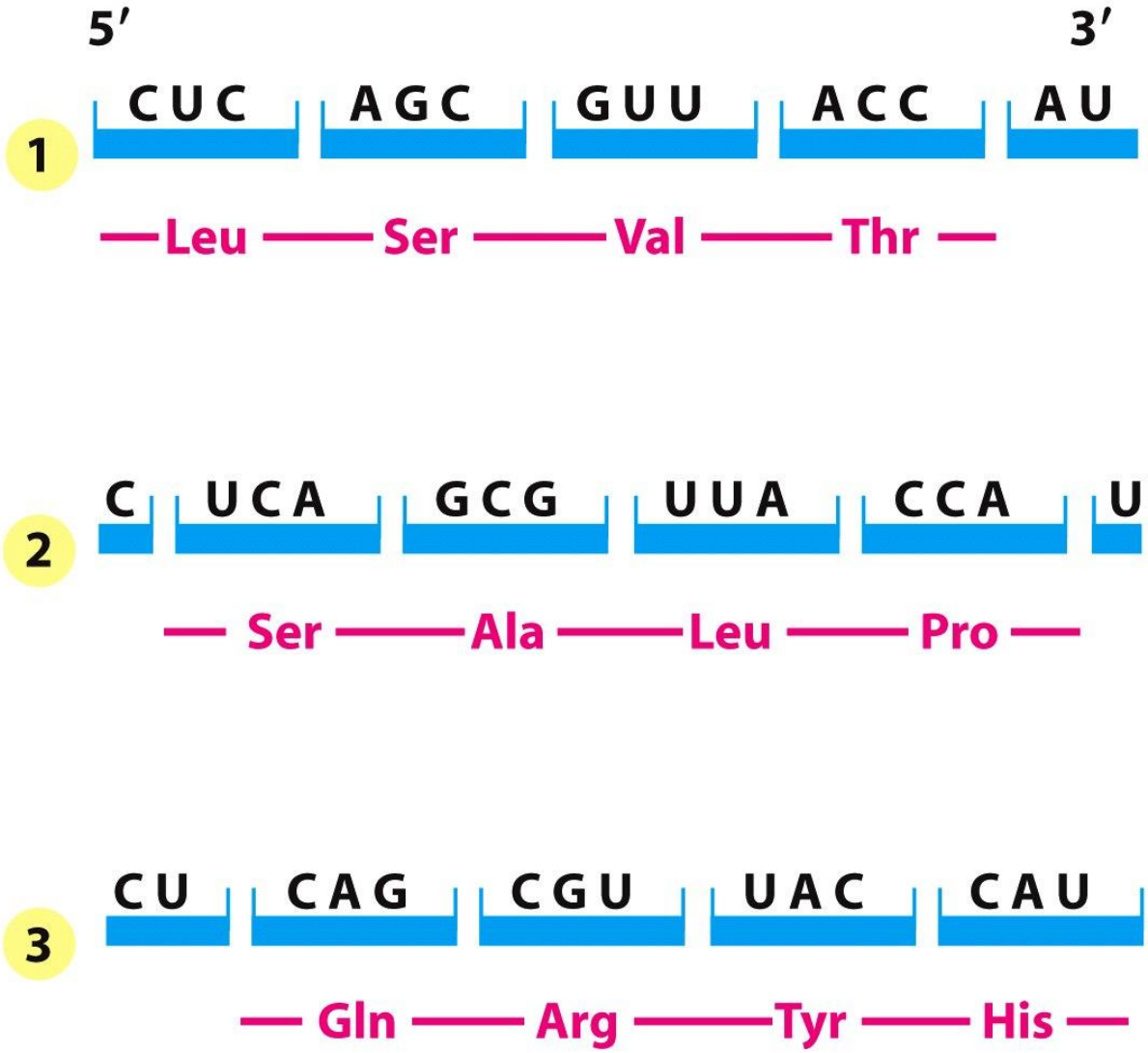


Figure 6-51 *Molecular Biology of the Cell* (© Garland Science 2008)

The ribosome

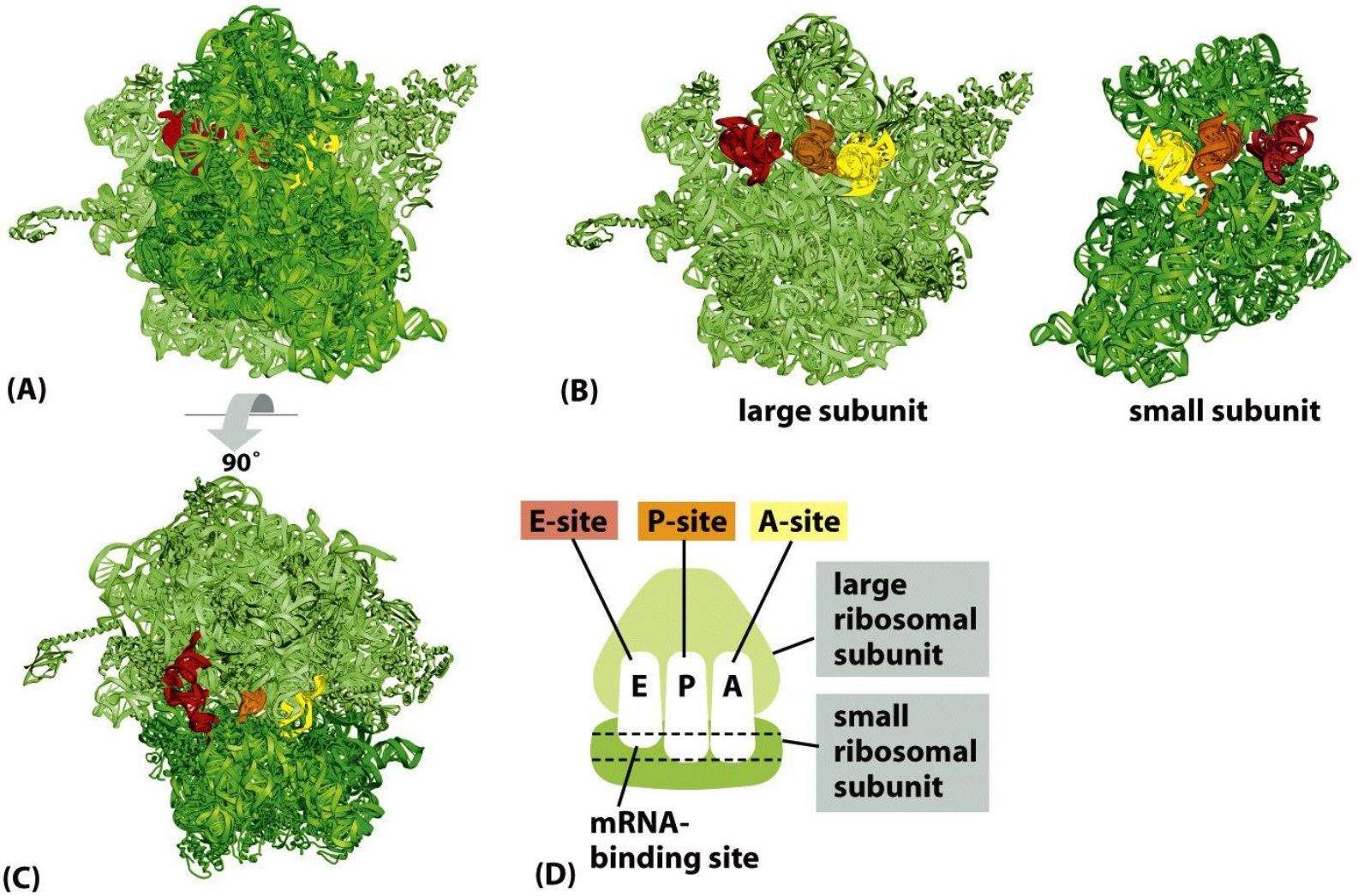


Figure 6-64 *Molecular Biology of the Cell* (© Garland Science 2008)

Translation: polyribosomes

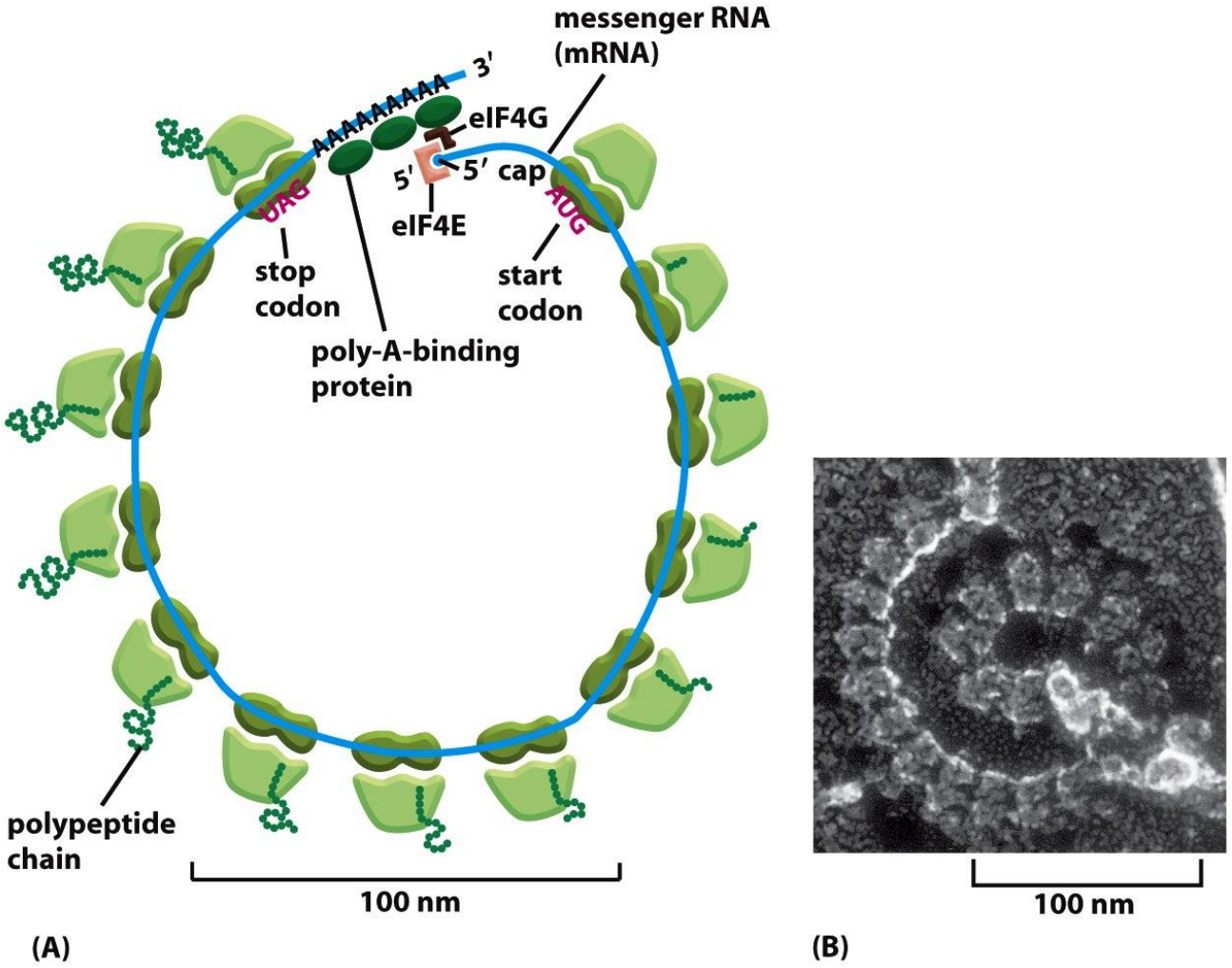


Figure 6-76 *Molecular Biology of the Cell* (© Garland Science 2008)

Ribosomes: targets for antibiotics

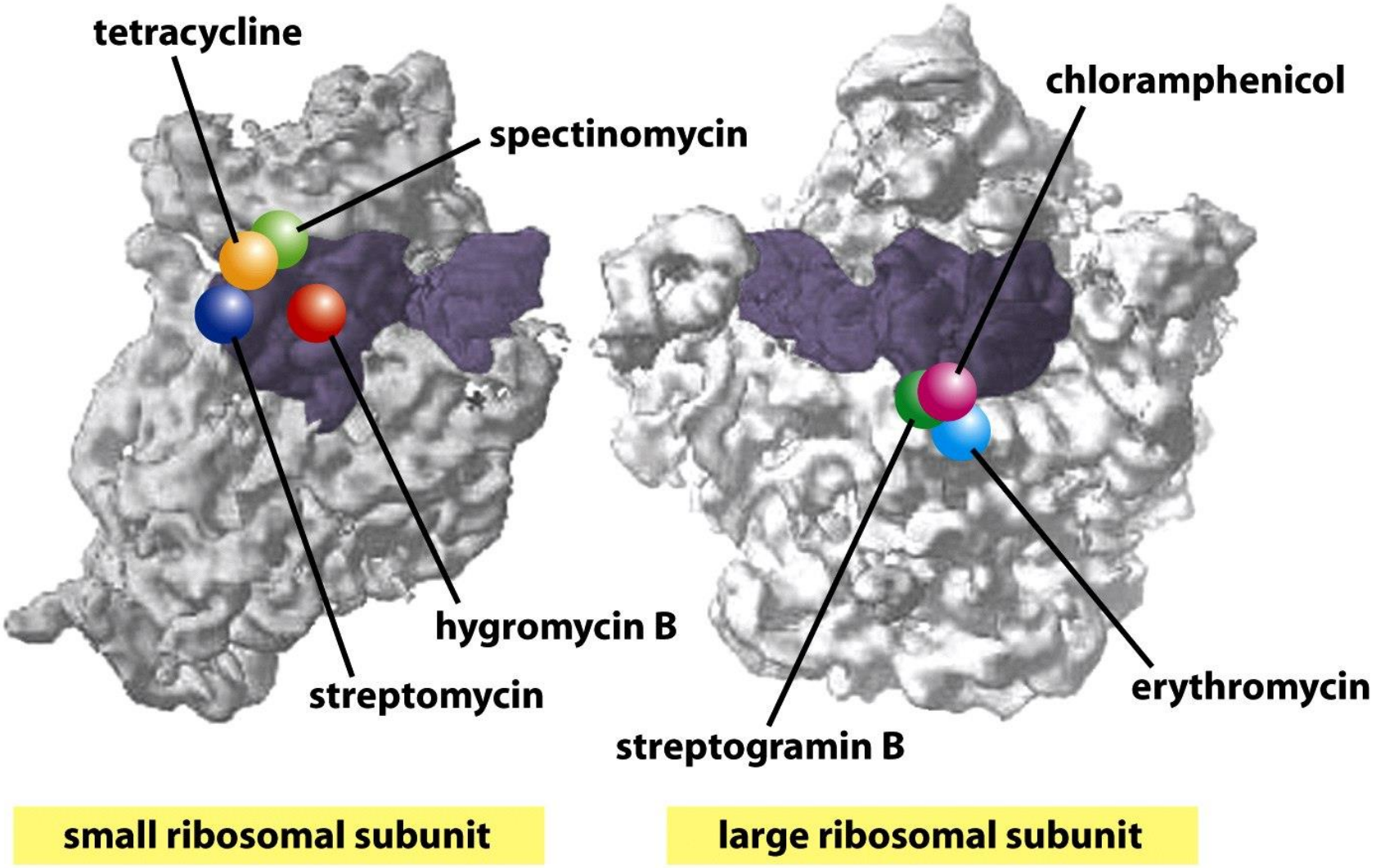


Figure 6-79 *Molecular Biology of the Cell* (© Garland Science 2008)

Ribosomes: targets for antibiotics

Table 6–4 Inhibitors of Protein or RNA Synthesis

INHIBITOR	SPECIFIC EFFECT
Acting only on bacteria	
Tetracycline	blocks binding of aminoacyl-tRNA to A-site of ribosome
Streptomycin	prevents the transition from translation initiation to chain elongation and also causes miscoding
Chloramphenicol	blocks the peptidyl transferase reaction on ribosomes (step 2 in Figure 6–66)
Erythromycin	binds in the exit channel of the ribosome and thereby inhibits elongation of the peptide chain
Rifamycin	blocks initiation of RNA chains by binding to RNA polymerase (prevents RNA synthesis)
Acting on bacteria and eucaryotes	
Puromycin	causes the premature release of nascent polypeptide chains by its addition to the growing chain end
Actinomycin D	binds to DNA and blocks the movement of RNA polymerase (prevents RNA synthesis)
Acting on eucaryotes but not bacteria	
Cycloheximide	blocks the translocation reaction on ribosomes (step 3 in Figure 6–66)
Anisomycin	blocks the peptidyl transferase reaction on ribosomes (step 2 in Figure 6–66)
α-Amanitin	blocks mRNA synthesis by binding preferentially to RNA polymerase II

The ribosomes of eucaryotic mitochondria (and chloroplasts) often resemble those of bacteria in their sensitivity to inhibitors. Therefore, some of these antibiotics can have a deleterious effect on human mitochondria.

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

The Cell Membrane

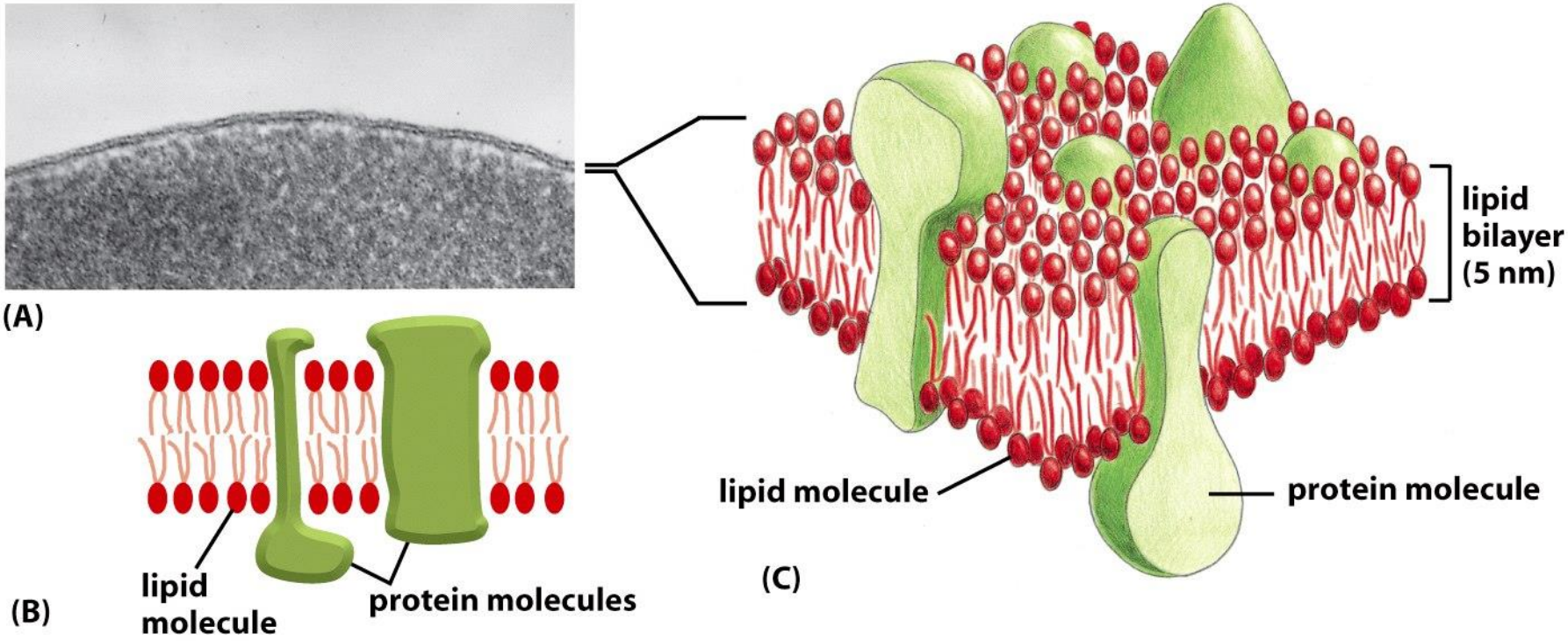


Figure 10-1 *Molecular Biology of the Cell* (© Garland Science 2008)

Membrane proteins

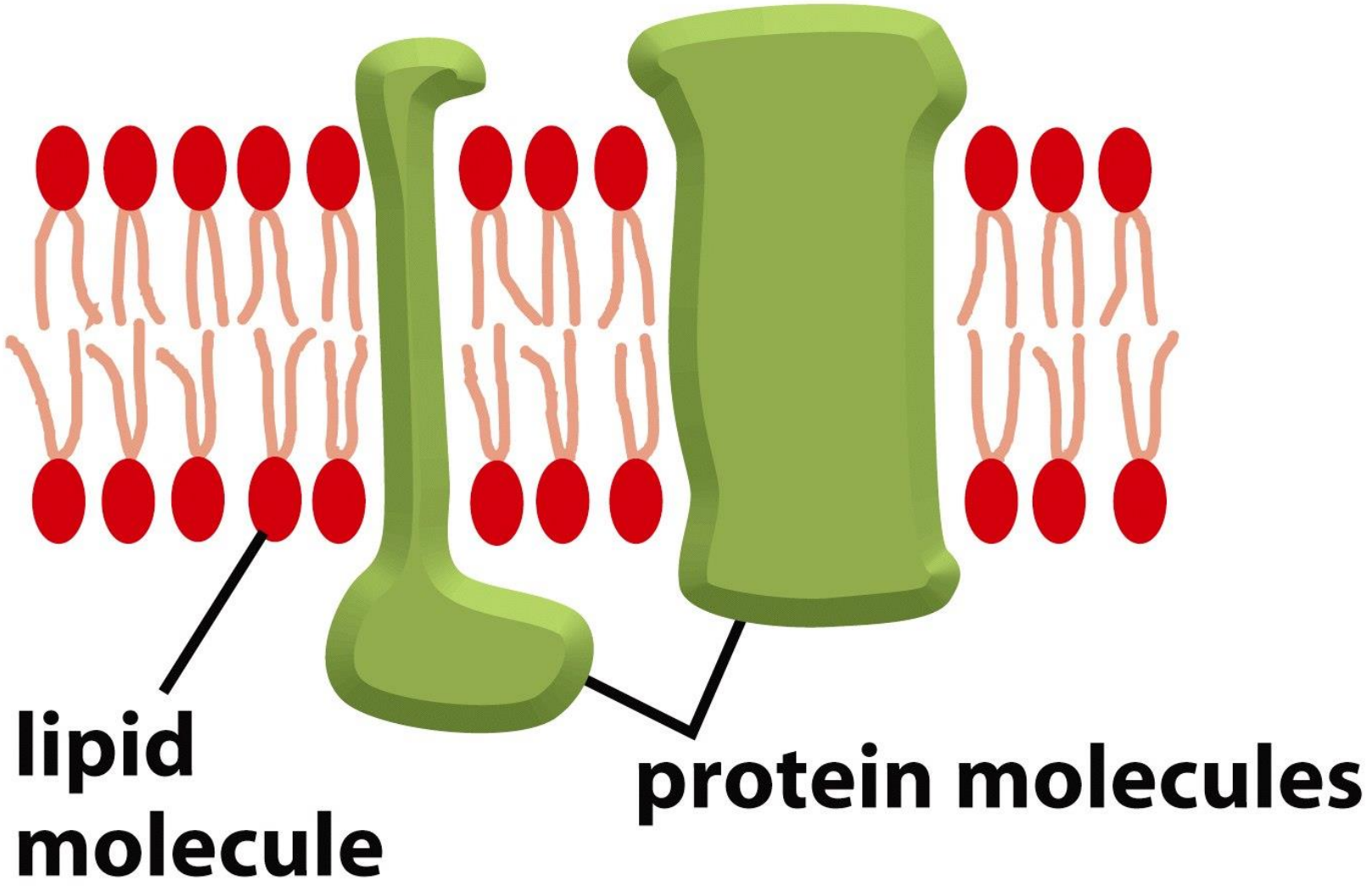
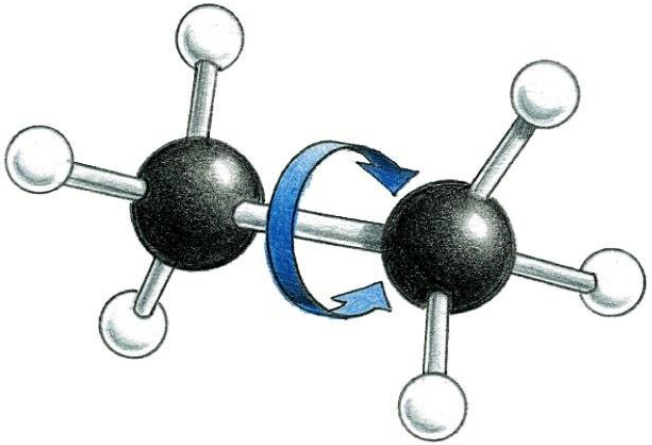


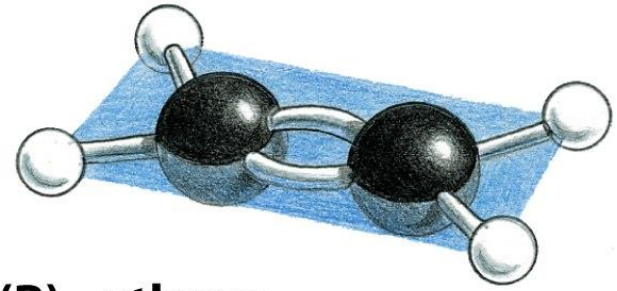
Figure 10-1b *Molecular Biology of the Cell* (© Garland Science 2008)

Single vs Double bonds



(A) ethane

saturated

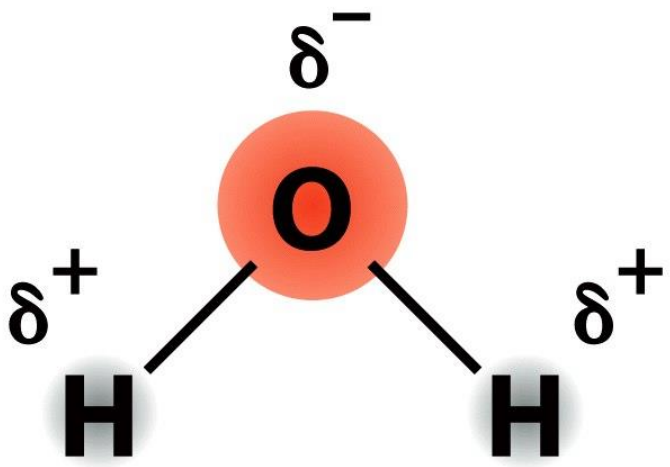


(B) ethene

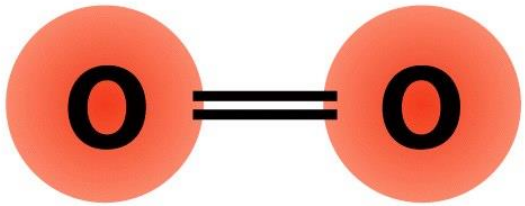
unsaturated

Figure 2-9 *Molecular Biology of the Cell* (© Garland Science 2008)

Polar vs non-polar



water



oxygen

Figure 2-10 *Molecular Biology of the Cell* (©

Hydrophobic vs hydrophillic

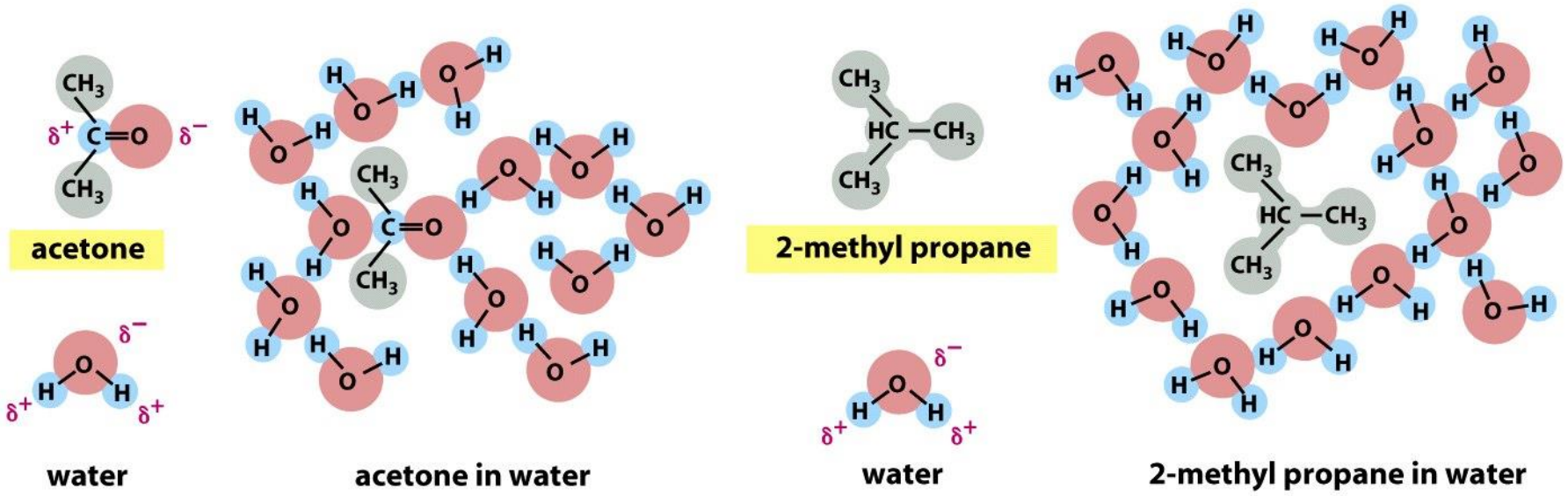


Figure 10-6 *Molecular Biology of the Cell* (© Garland Science 2008)

Cell membrane lipids

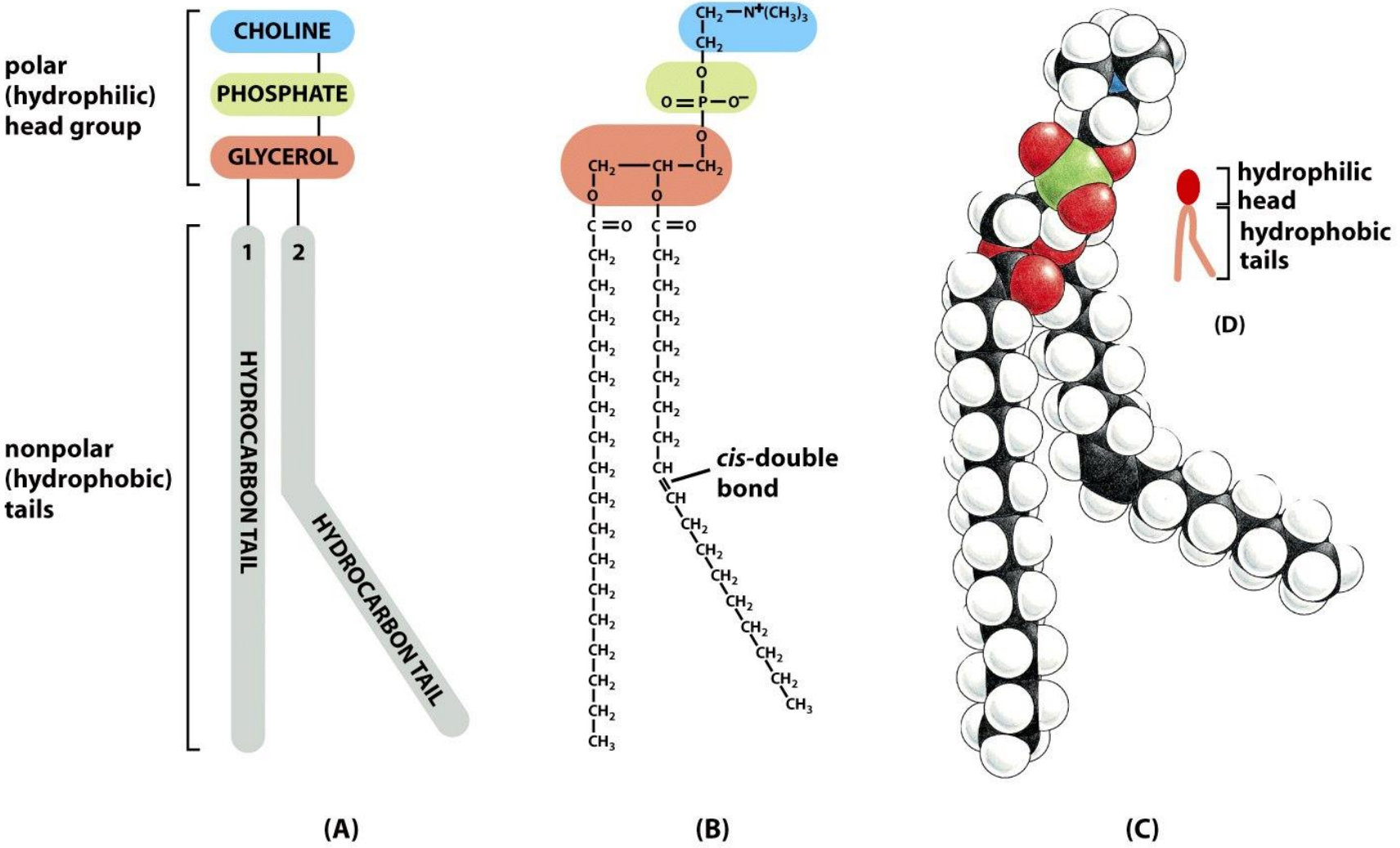


Figure 10-2 *Molecular Biology of the Cell* (© Garland Science 2008)

Membrane structure

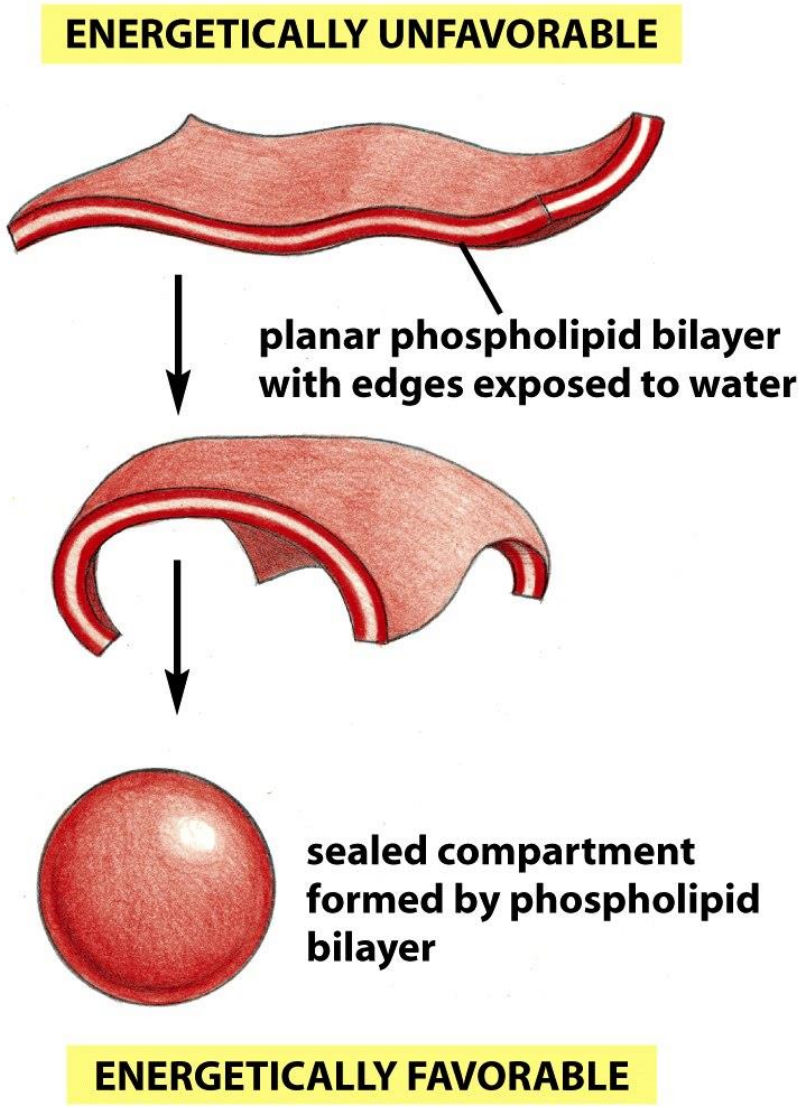


Figure 10-8 *Molecular Biology of the Cell* (© Garland Science 2008)

Membrane composition

Table 10–1 Approximate Lipid Compositions of Different Cell Membranes

LIPID	PERCENTAGE OF TOTAL LIPID BY WEIGHT					
	LIVER CELL PLASMA MEMBRANE	RED BLOOD CELL PLASMA MEMBRANE	MYELIN	MITOCHONDRION (INNER AND OUTER MEMBRANES)	ENDOPLASMIC RETICULUM	*E. COLI* BACTERIUM
Cholesterol	17	23	22	3	6	0
Phosphatidylethanolamine	7	18	15	28	17	70
Phosphatidylserine	4	7	9	2	5	trace
Phosphatidylcholine	24	17	10	44	40	0
Sphingomyelin	19	18	8	0	5	0
Glycolipids	7	3	28	trace	trace	0
Others	22	13	8	23	27	30

Table 10-1 *Molecular Biology of the Cell* (© Garland Science 2008)

Membrane asymmetry

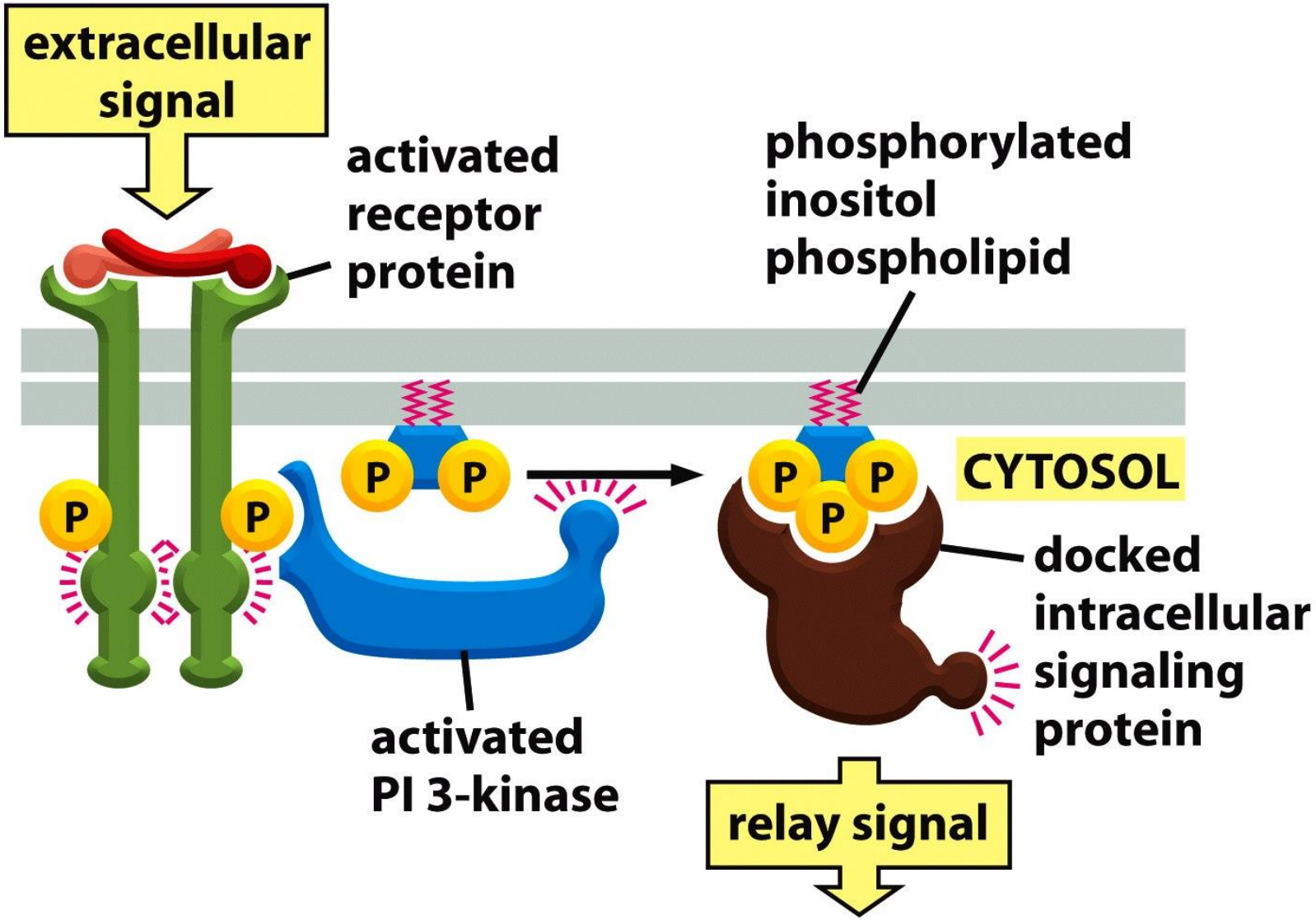


Figure 10-17a *Molecular Biology of the Cell* (© Garland Science 2008)

Membrane proteins

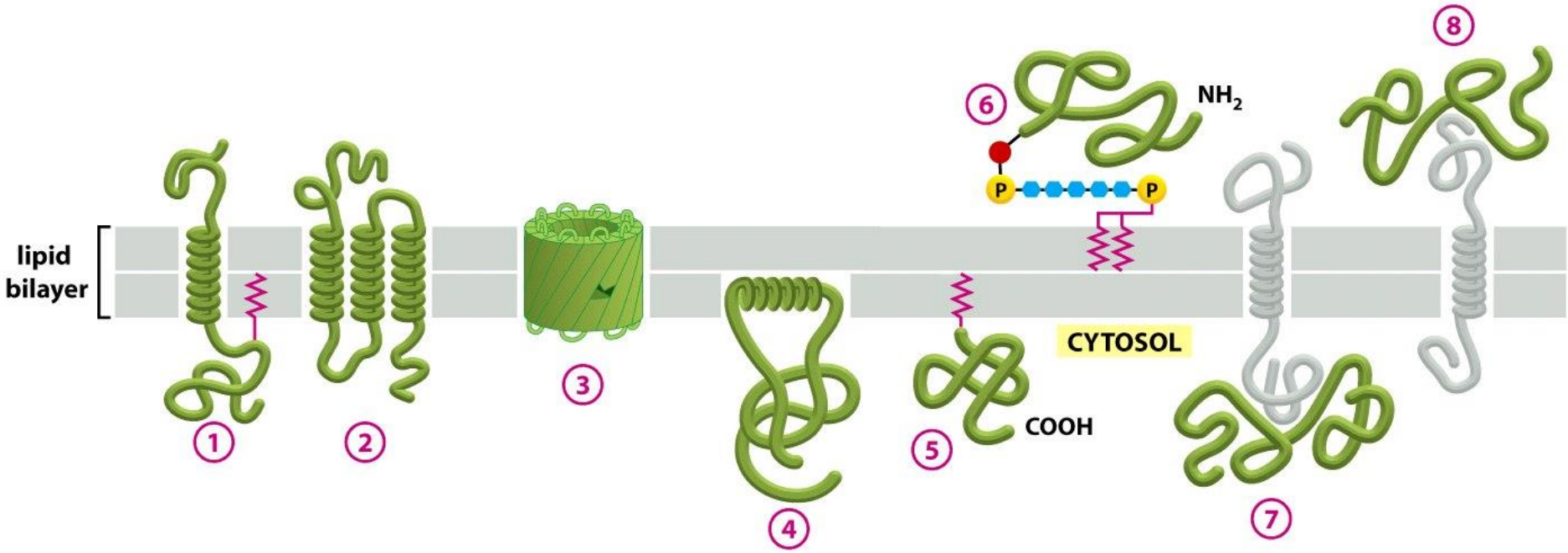


Figure 10-19 *Molecular Biology of the Cell* (© Garland Science 2008)

Membrane proteins

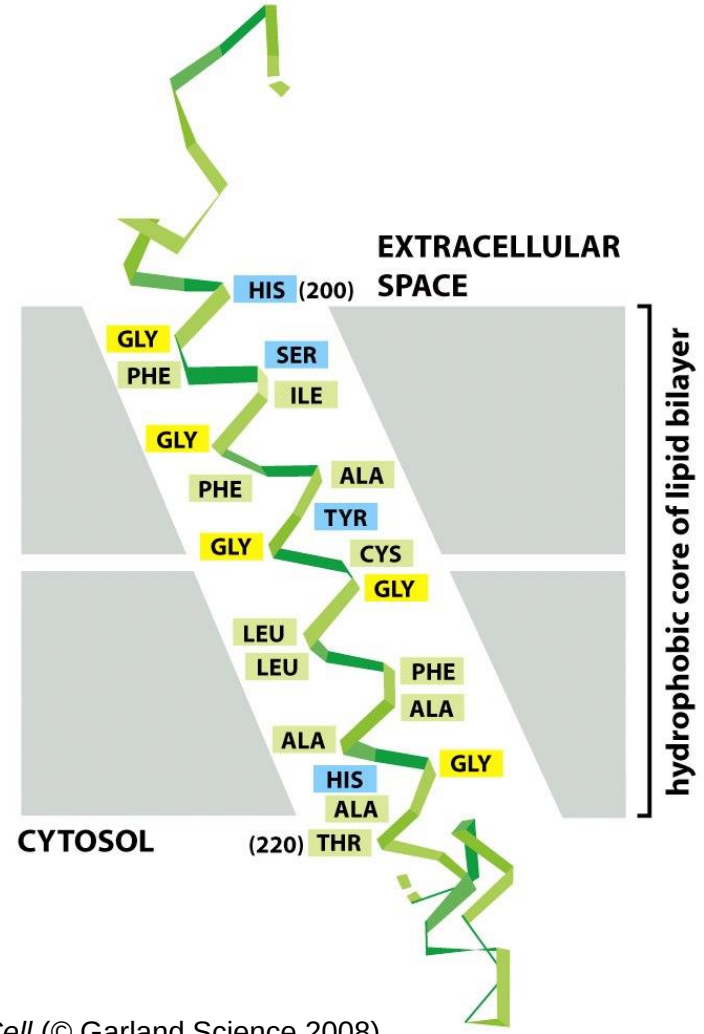
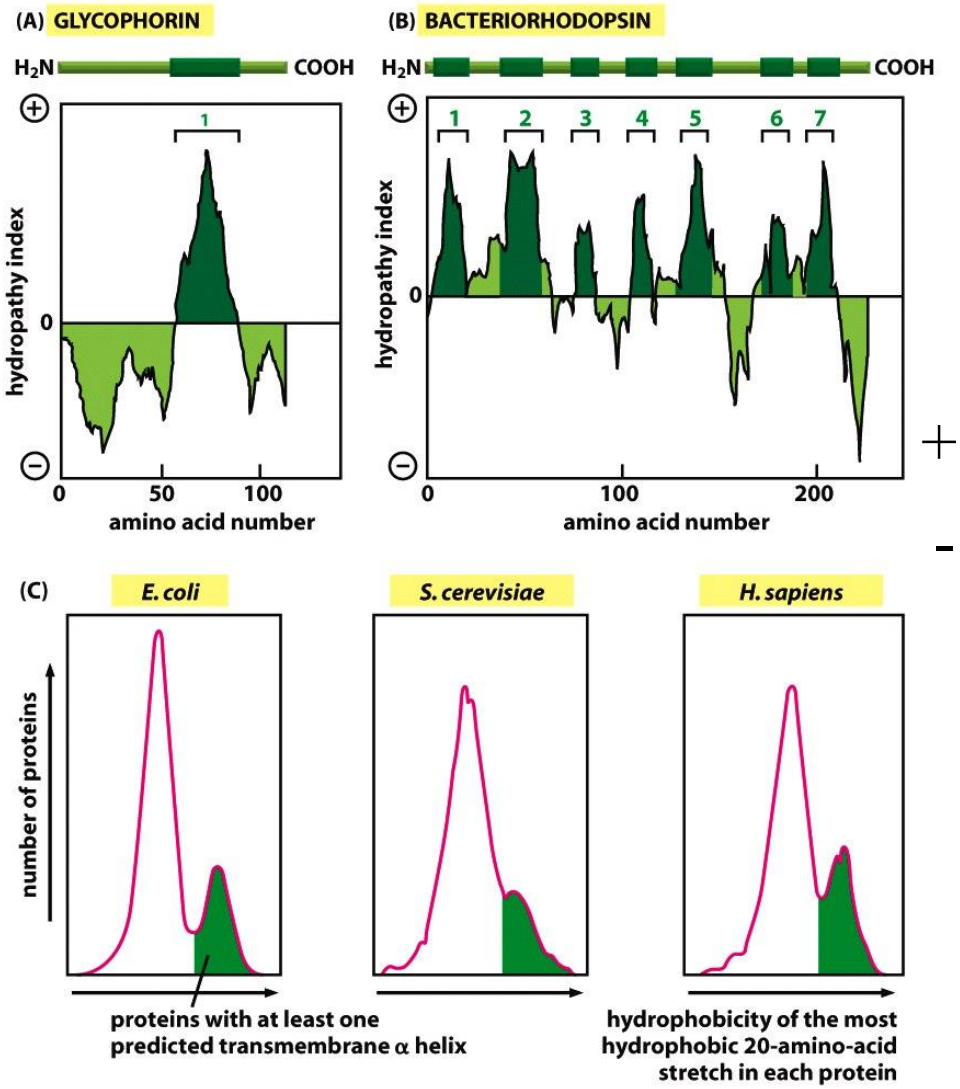


Figure 10-21 *Molecular Biology of the Cell* (© Garland Science 2008)

Membrane proteins



\+ = hydrophobic

\- = hydrophillic

Figure 10-22 *Molecular Biology of the Cell* (© Garland Science 2008)

Membrane transport

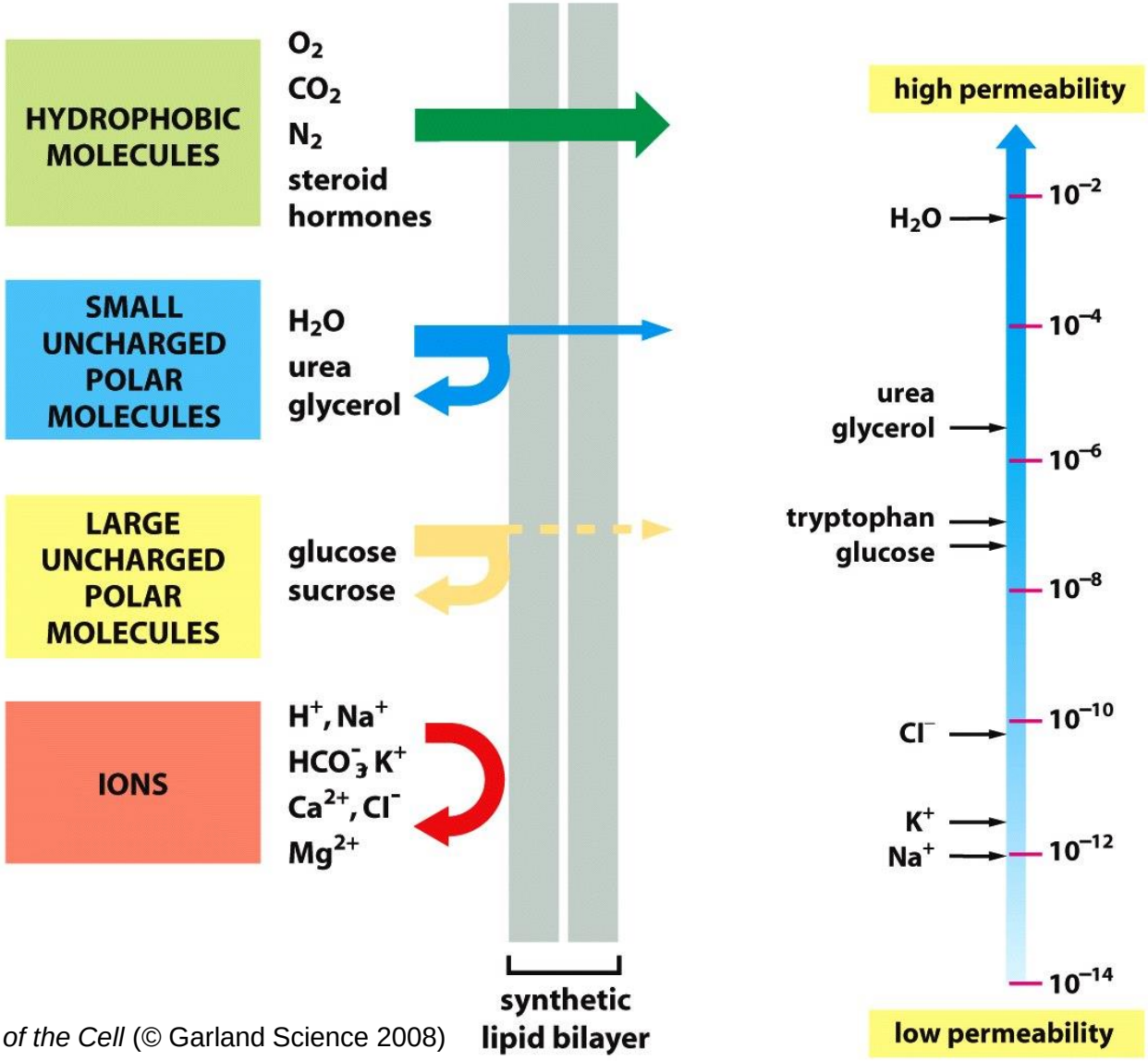


Figure 11-1 *Molecular Biology of the Cell* (© Garland Science 2008)

Membrane transport: transporters/channels

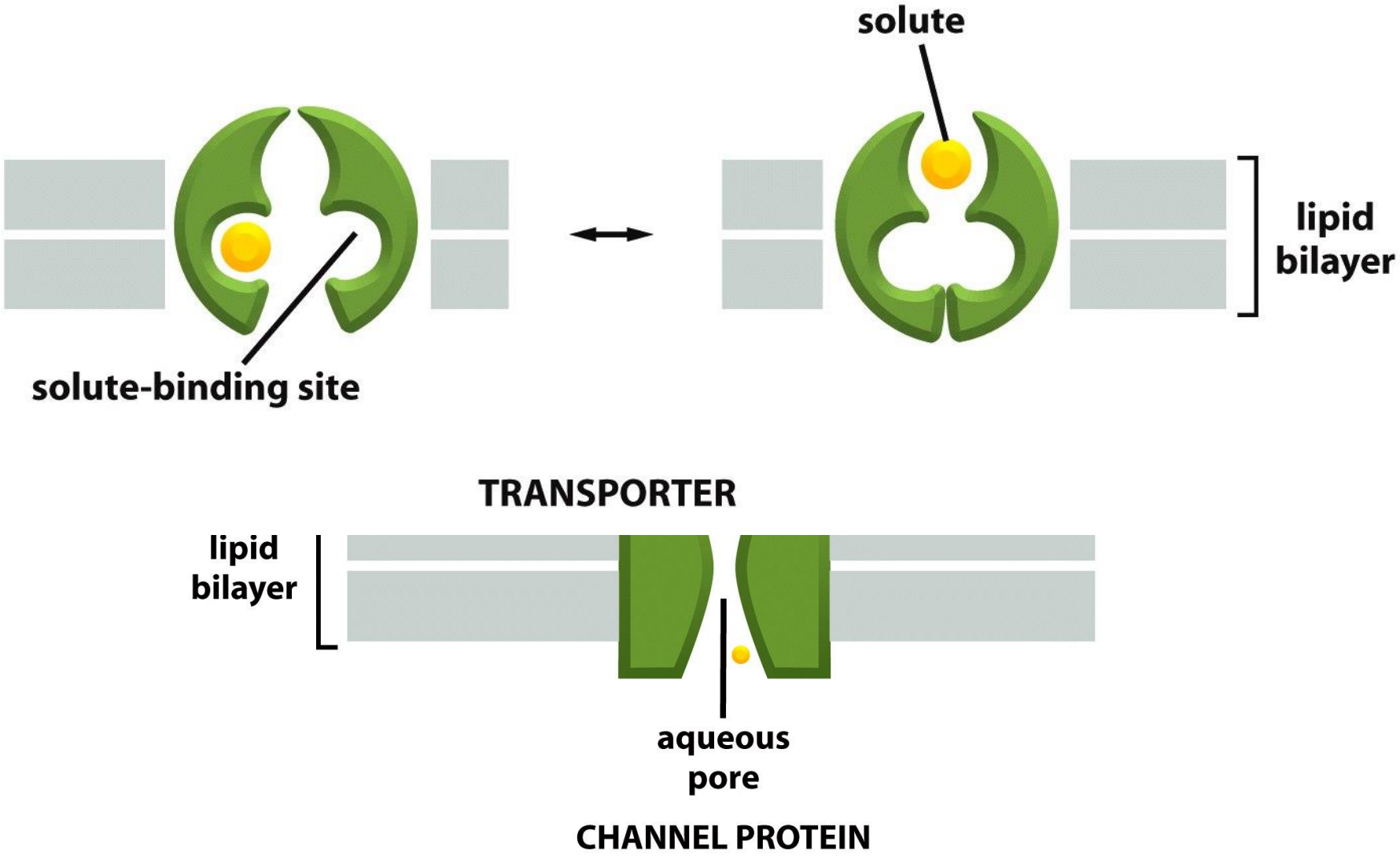


Figure 11-3a *Molecular Biology of the Cell* (© Garland Science 2008)

Membrane transport

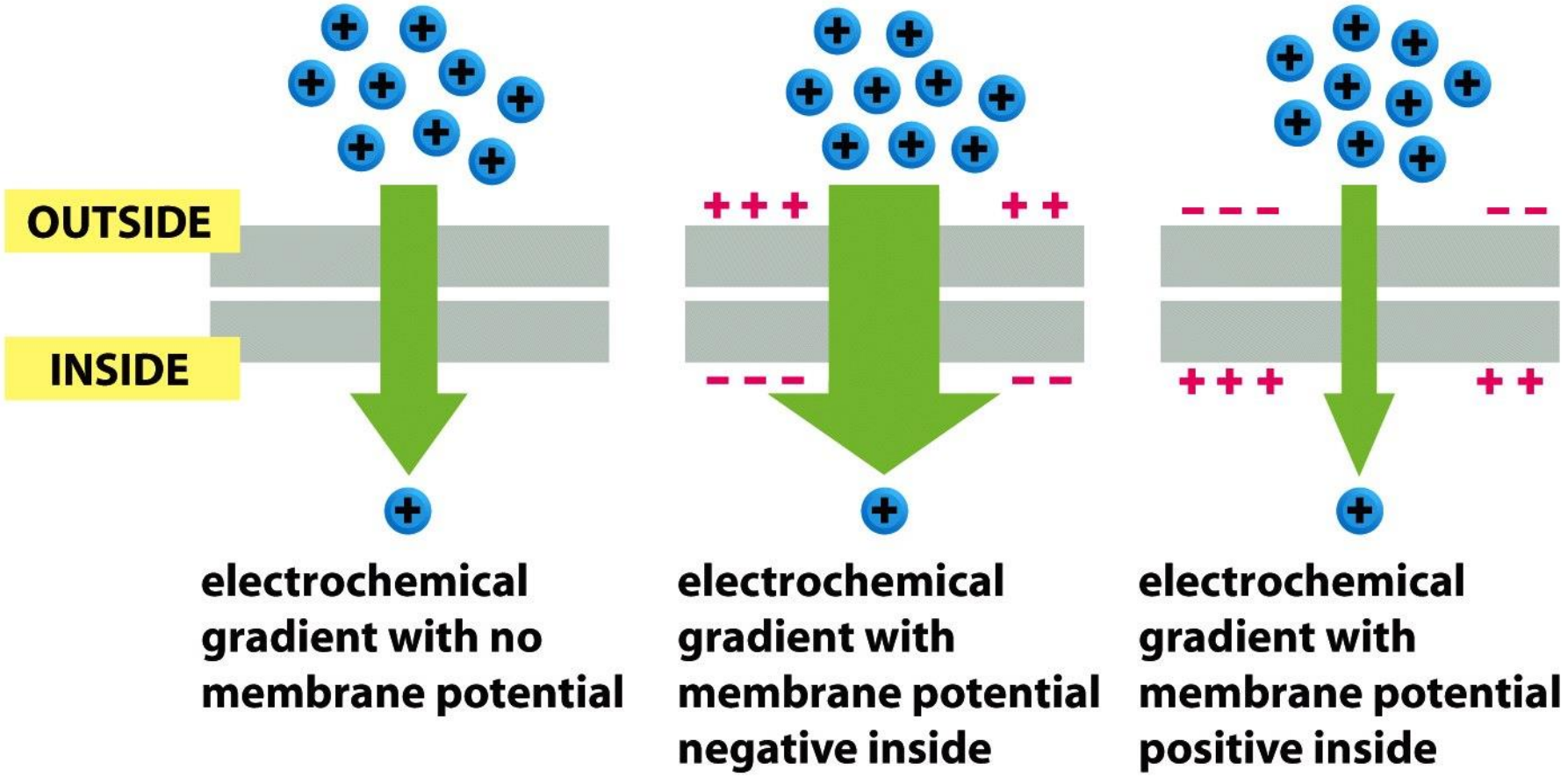


Figure 11-4b *Molecular Biology of the Cell* (© Garland Science 2008)

Active transport

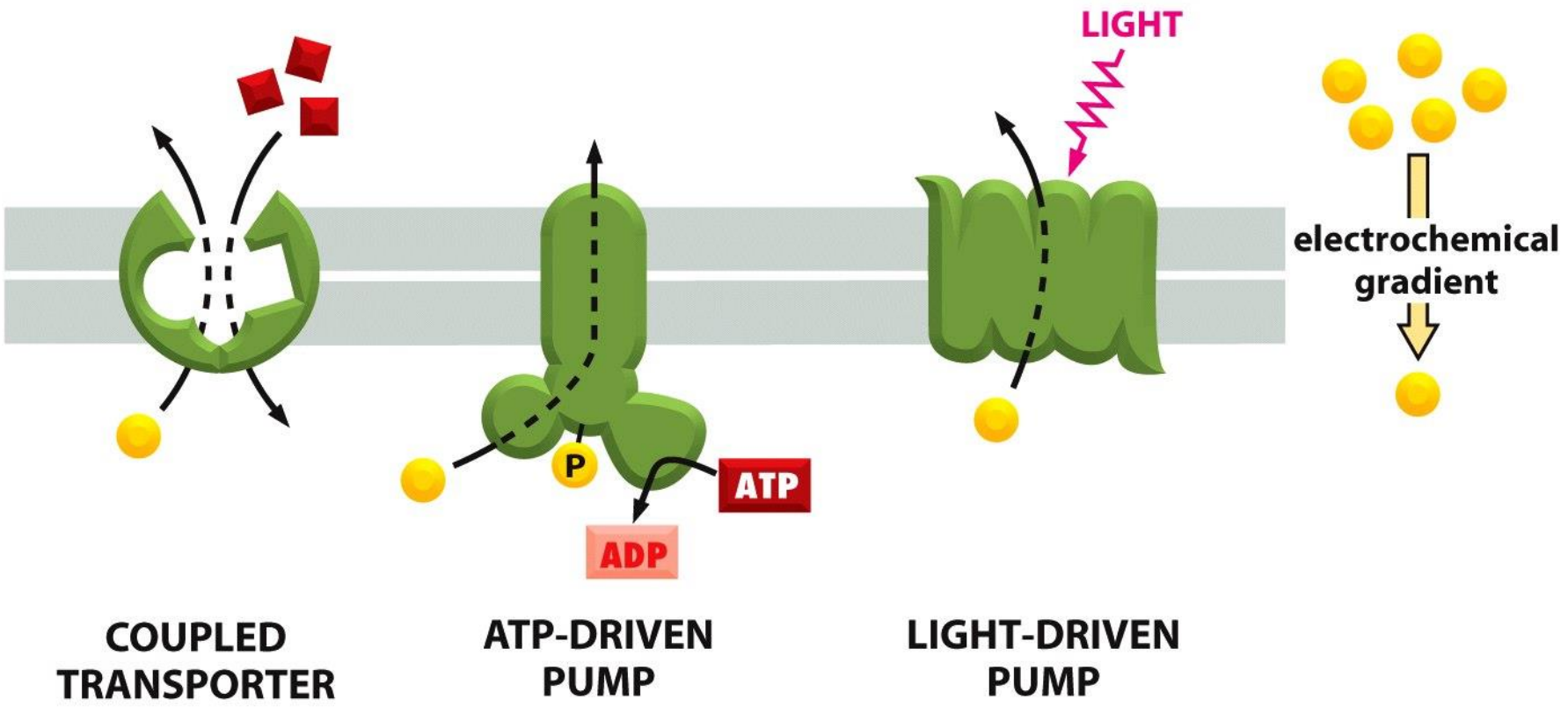


Figure 11-7 *Molecular Biology of the Cell* (© Garland Science 2008)

Na^+/K^+ pumps: for maintaining osmolarity

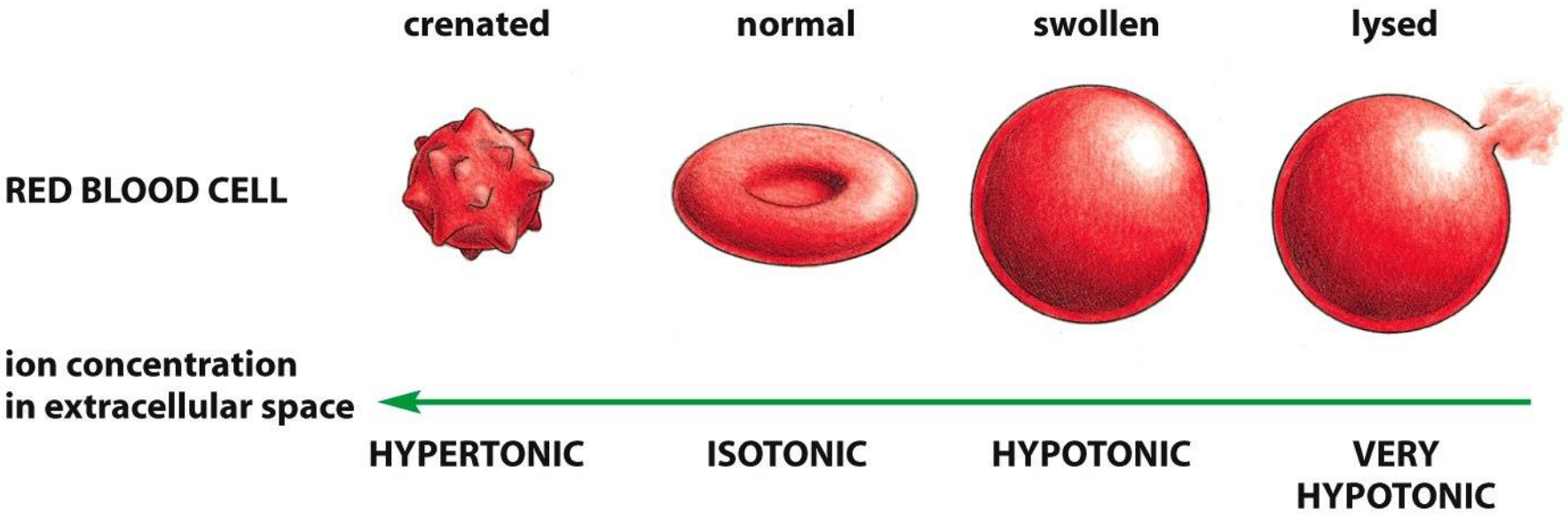
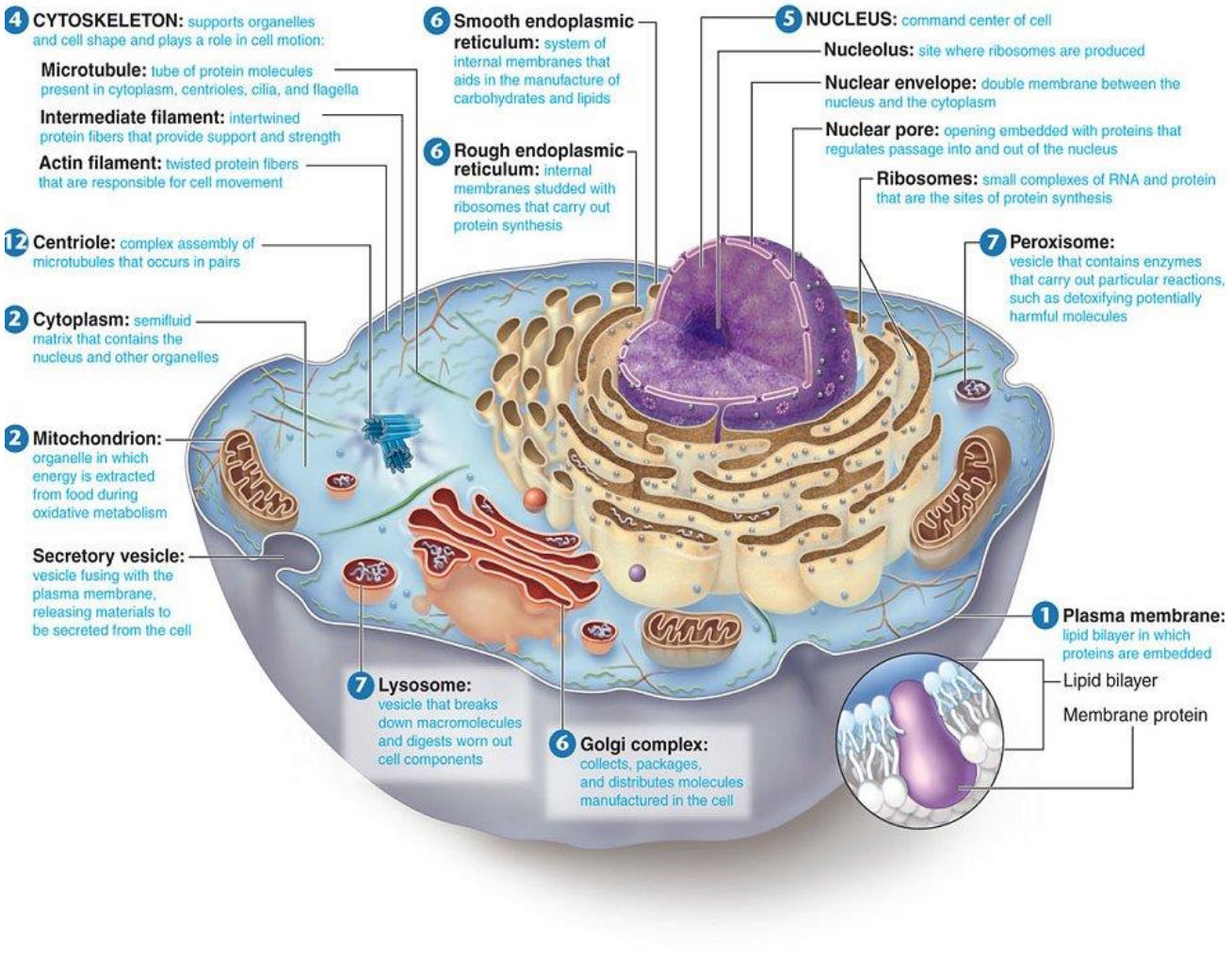


Figure 11-16 *Molecular Biology of the Cell* (© Garland Science 2008)

Eukaryotic cell structure



stephenyardleybrendan.blogspot.com

Visualising cells

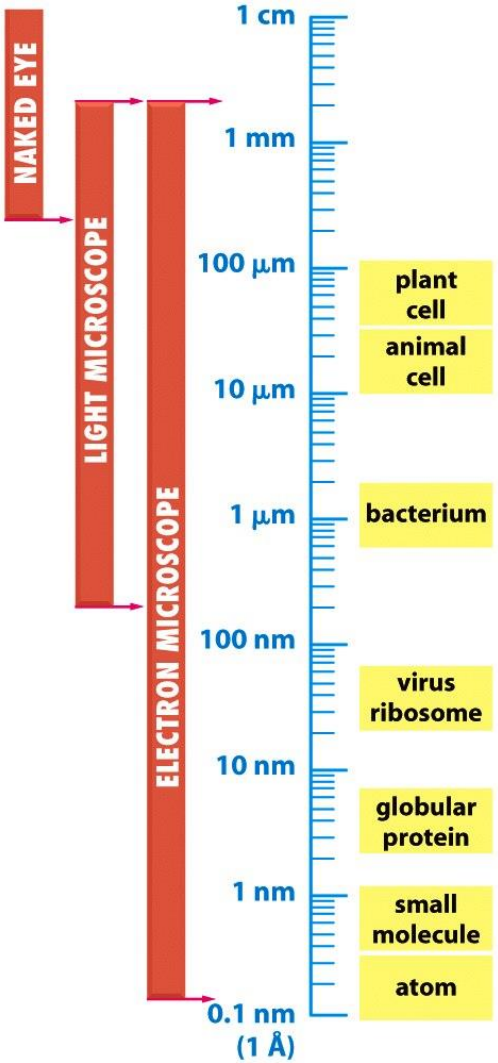


Figure 9-2 *Molecular Biology of the Cell* (© Garland S

Visualising cells: immunofluorescence

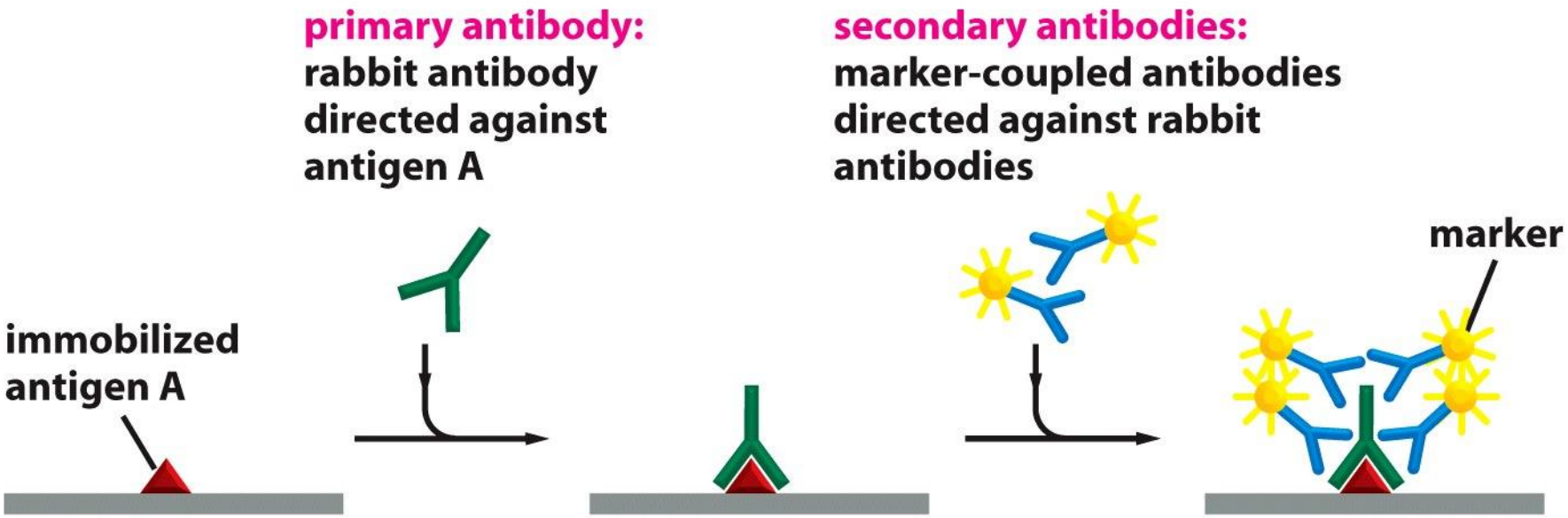


Figure 9-18 *Molecular Biology of the Cell* (© Garland Science 2008)

Visualising cells: EM

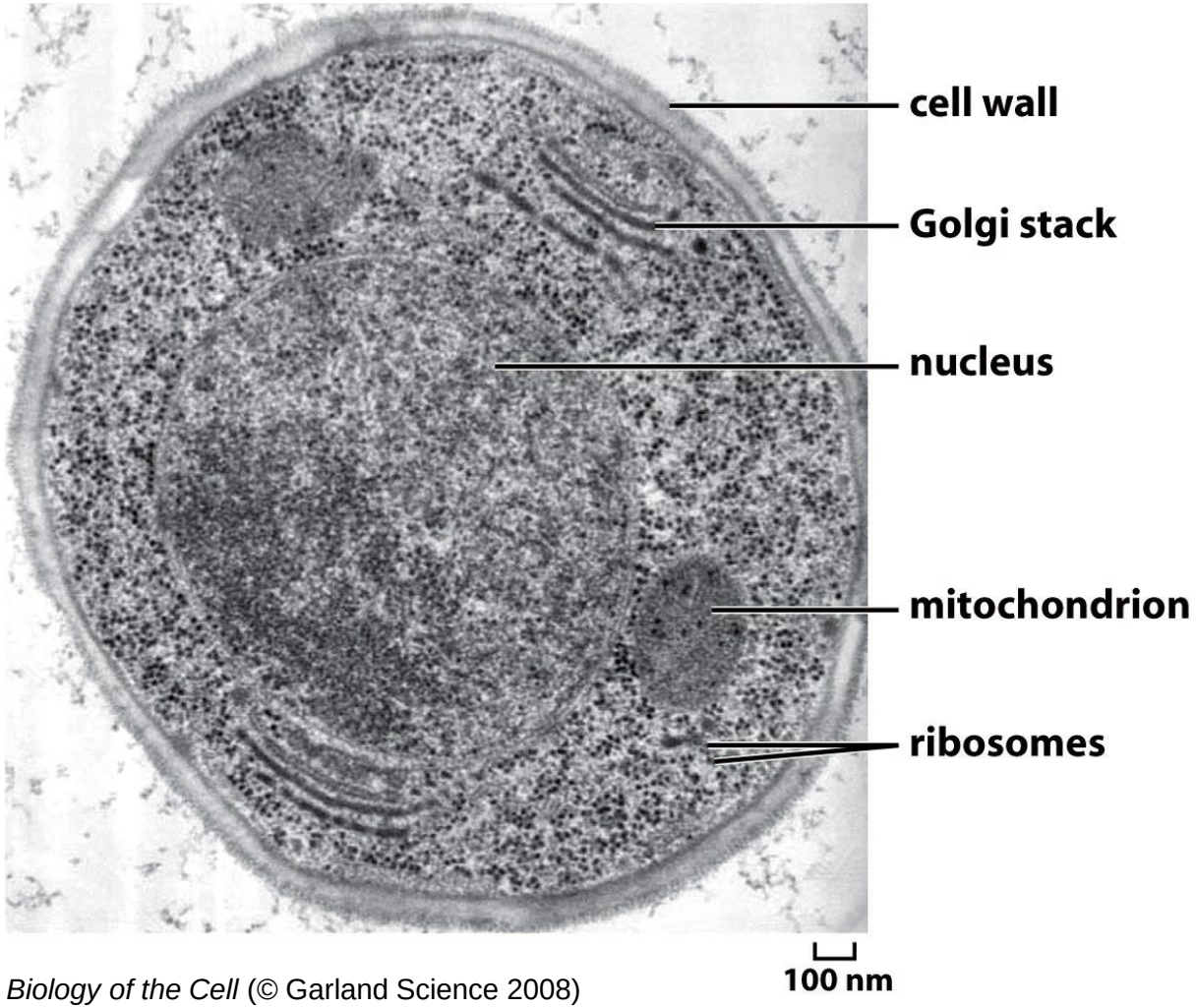


Figure 9-45 *Molecular Biology of the Cell* (© Garland Science 2008)

The cytoskeleton: organisation

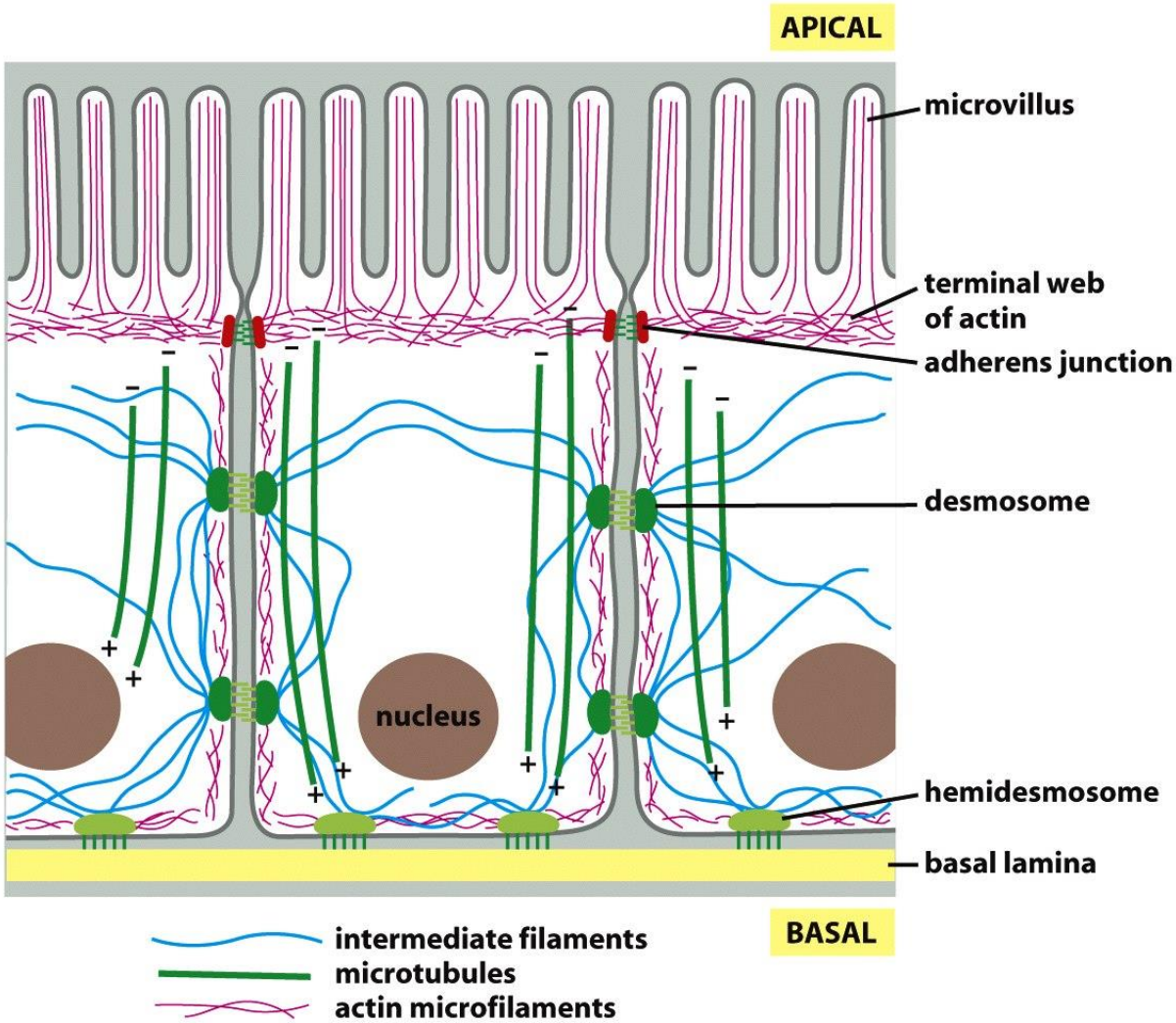


Figure 16-5 *Molecular Biology of the Cell* (© Garland Science 2008)

The cytoskeleton: rapid diss/assembly

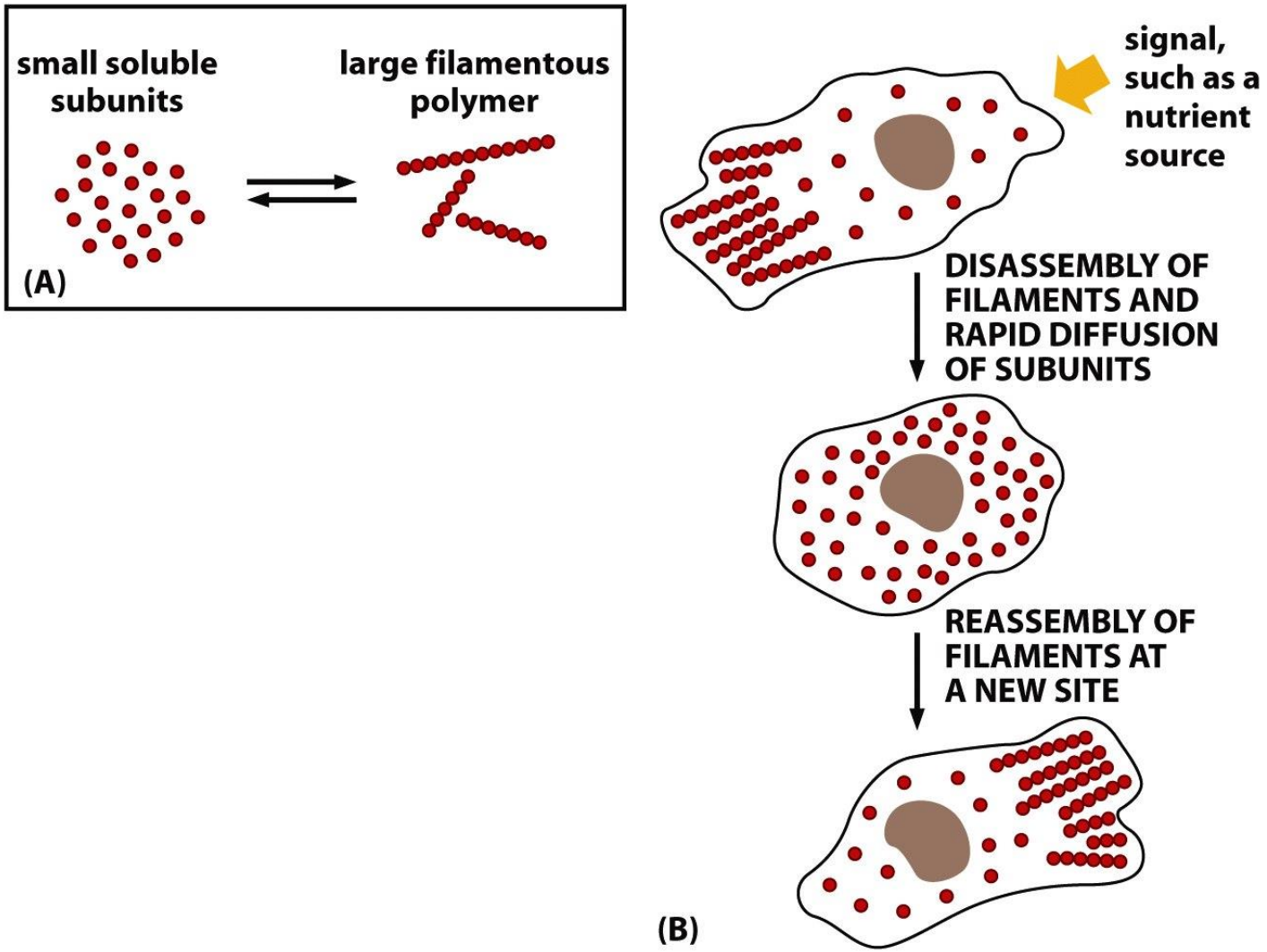


Figure 16-7 *Molecular Biology of the Cell* (© Garland Science 2008)

The cytoskeleton: filaments

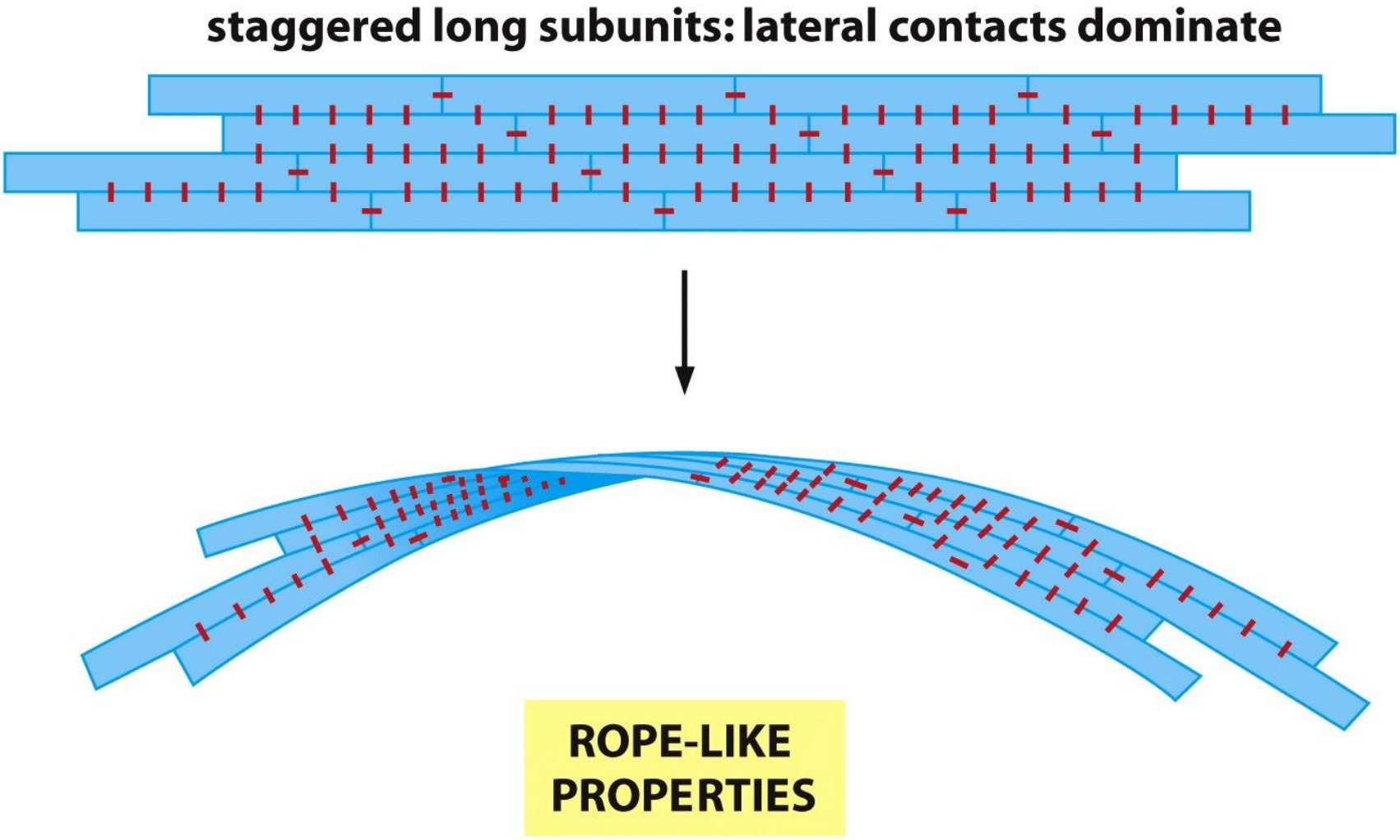


Figure 16-9 *Molecular Biology of the Cell* (© Garland Science 2008)

Microtubules

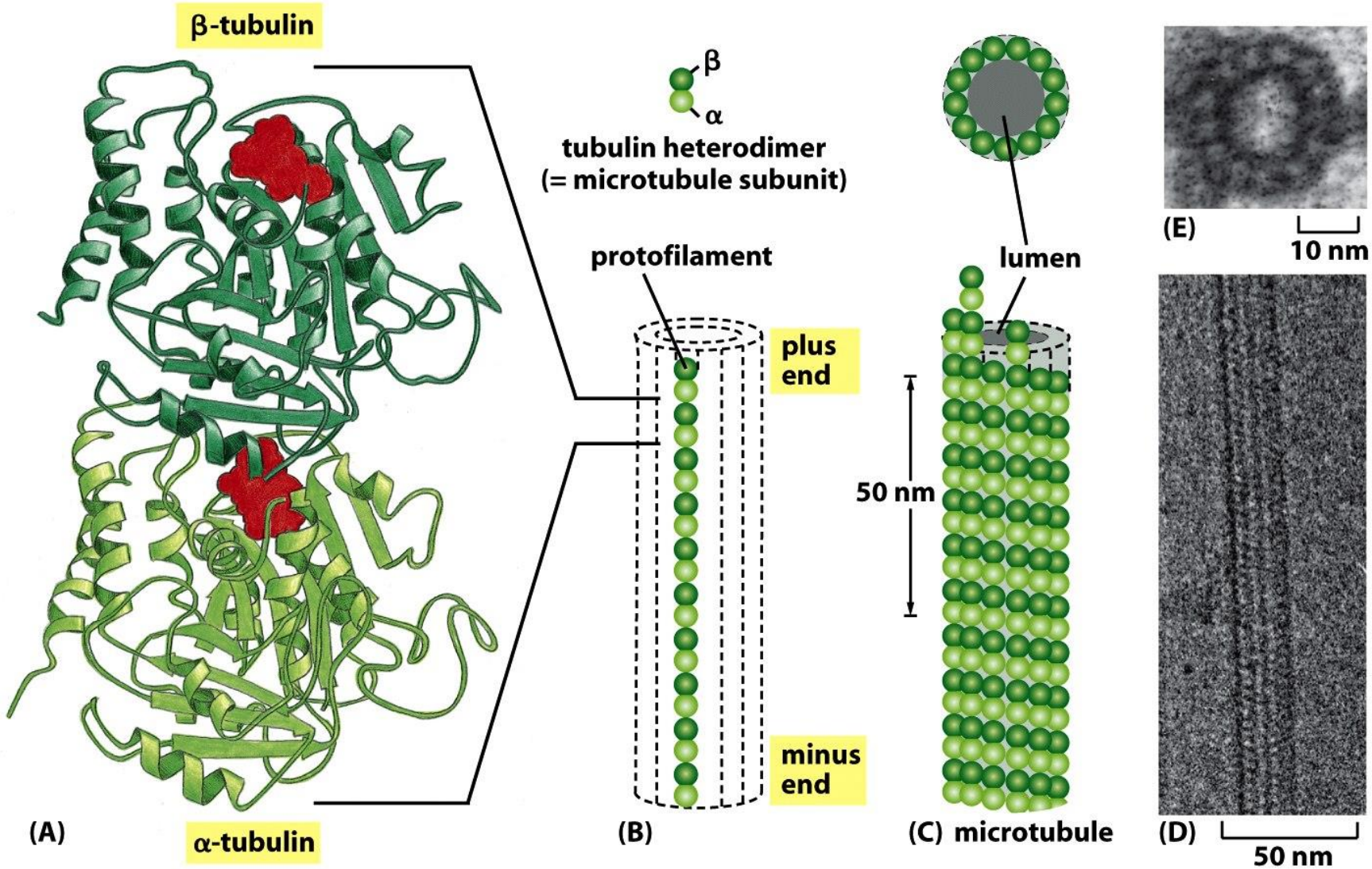


Figure 16-11 *Molecular Biology of the Cell* (© Garland Science 2008)

Actin

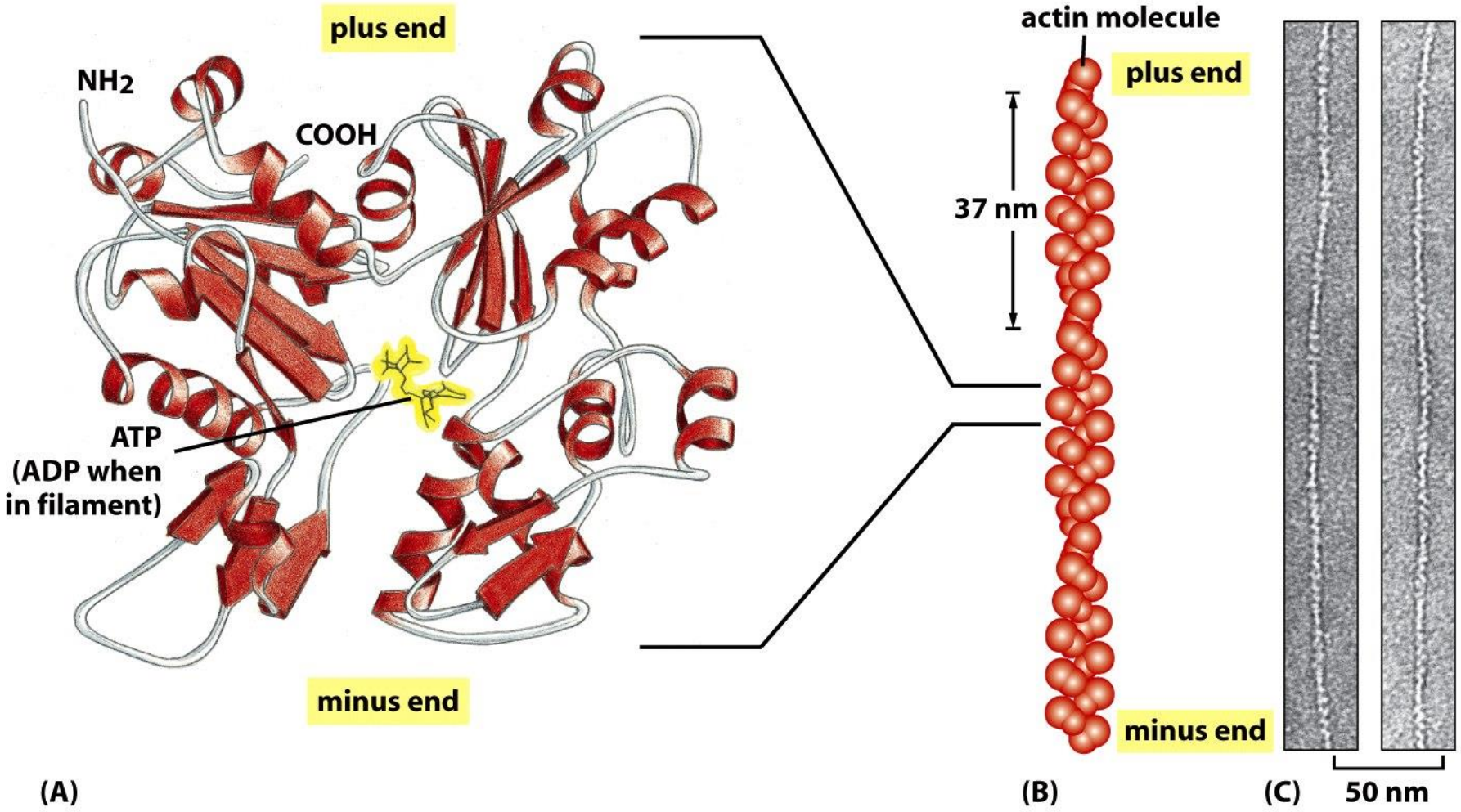


Figure 16-12 *Molecular Biology of the Cell* (© Garland Science 2008)

Other filaments

Table 16–1 Major Types of Intermediate Filament Proteins in Vertebrate Cells

TYPES OF IF	COMPONENT POLYPEPTIDES	LOCATION
Nuclear	lamins A, B, and C	nuclear lamina (inner lining of nuclear envelope)
Vimentin-like	vimentin	many cells of mesenchymal origin
	desmin	muscle
	glial fibrillary acidic protein	glial cells (astrocytes and some Schwann cells)
	peripherin	some neurons
Epithelial	type I keratins (acidic)	epithelial cells and their derivatives (e.g., hair and nails)
	type II keratins (basic)	
Axonal	neurofilament proteins (NF-L, NF-M, and NF-H)	neurons

Table 16-1 *Molecular Biology of the Cell* (© Garland Science 2008)

Actin arrays

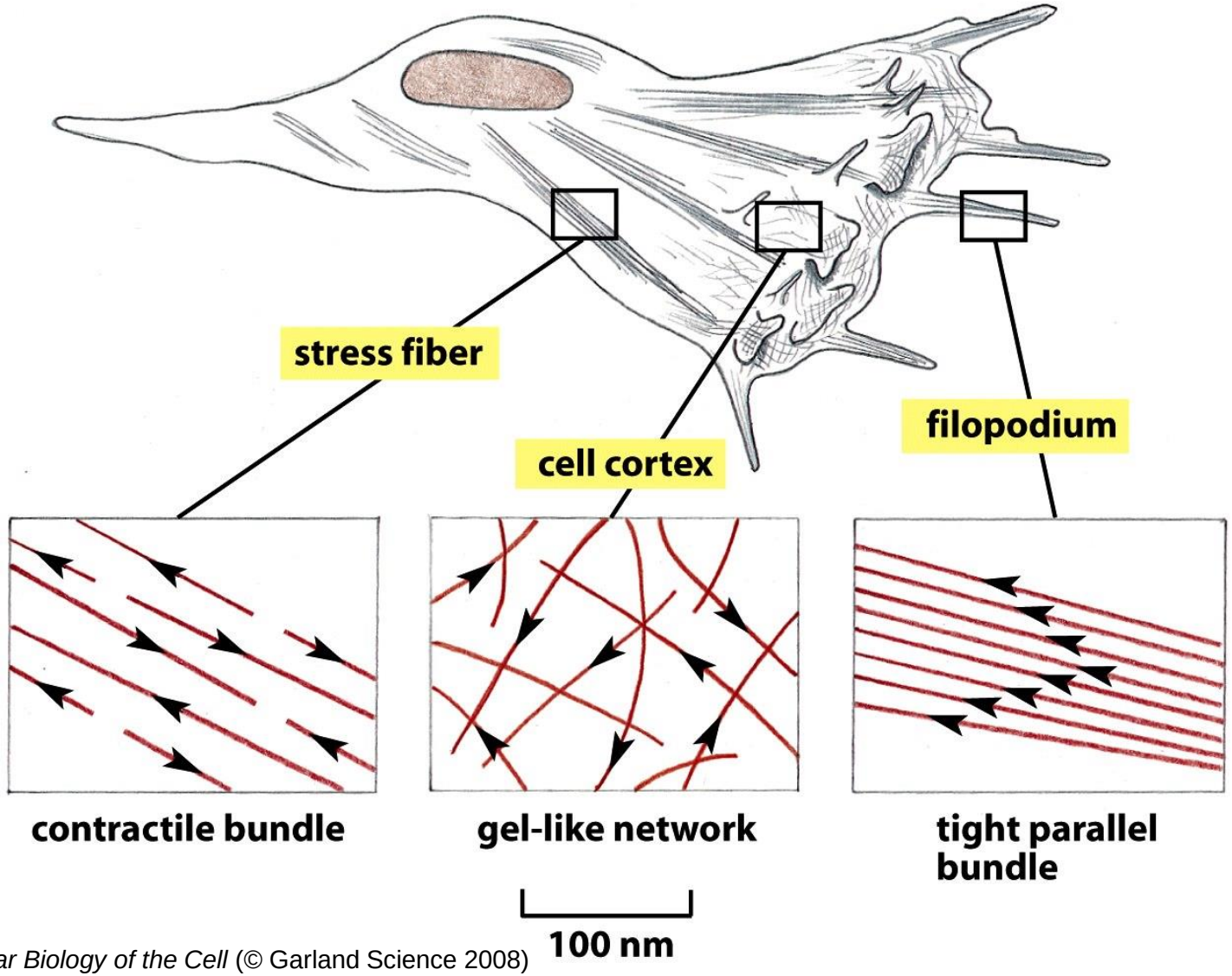
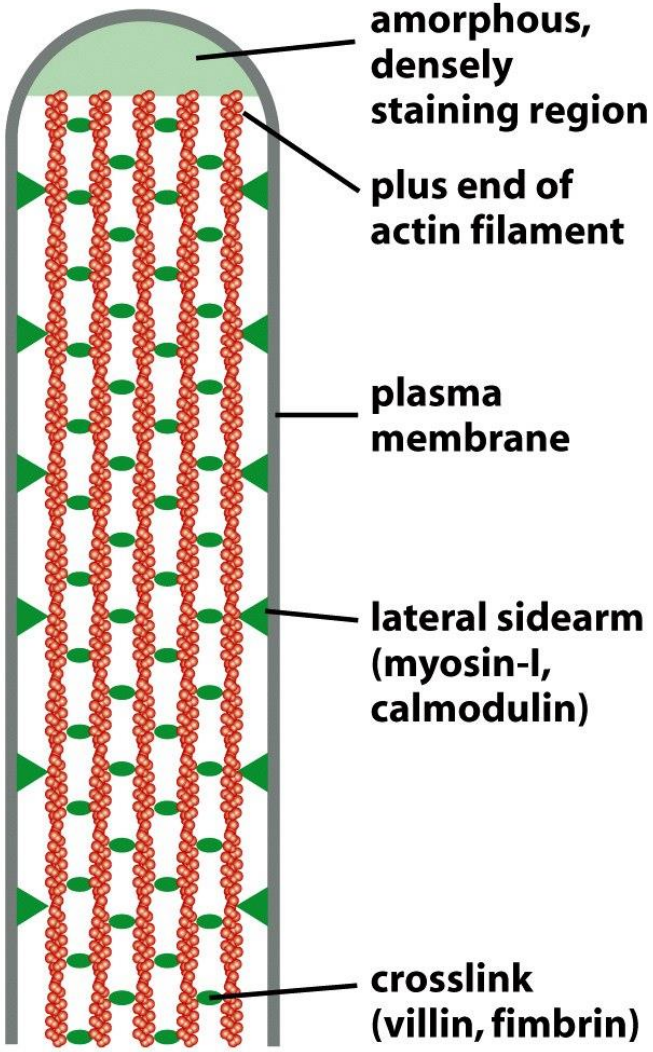
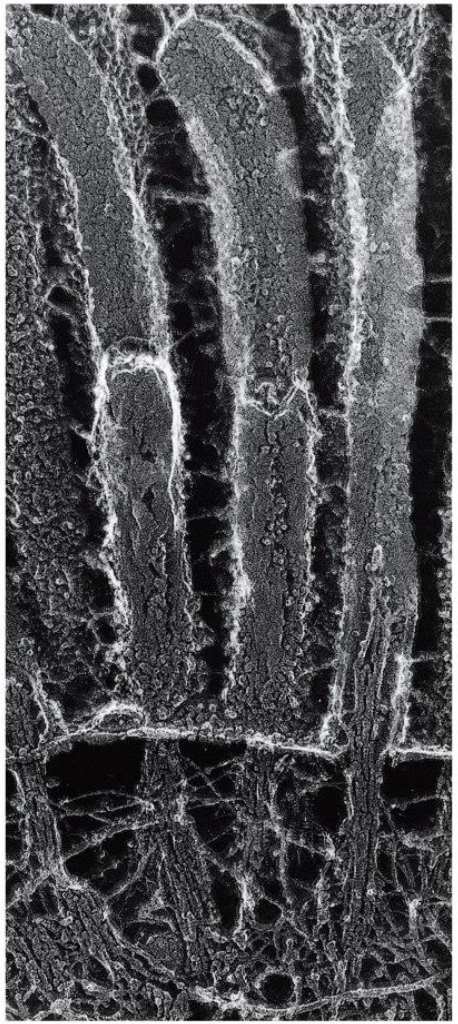


Figure 16-47 *Molecular Biology of the Cell* (© Garland Science 2008)

Microvilli: actin bundle structure





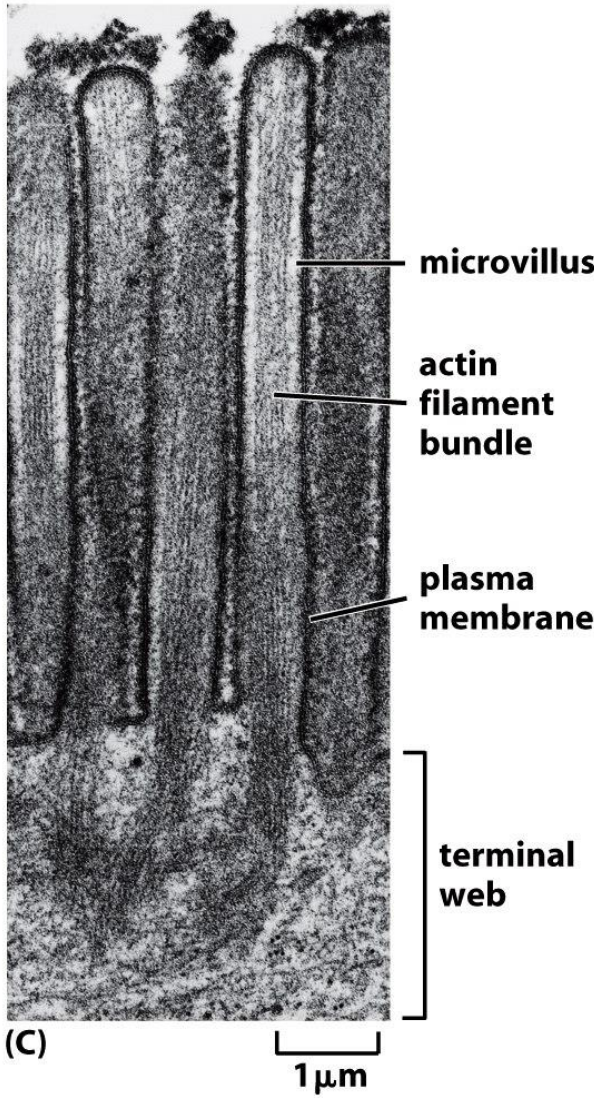
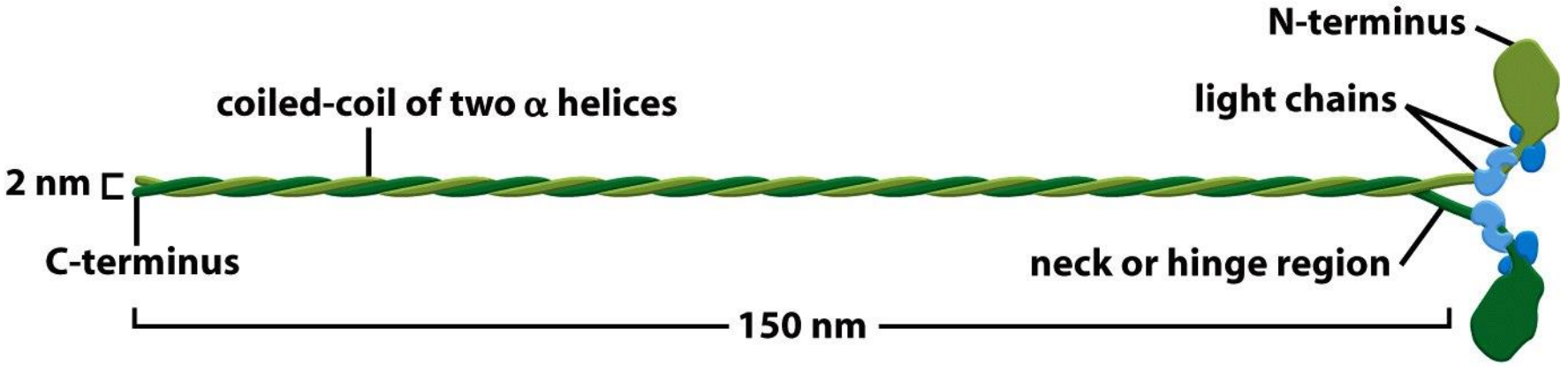


Figure 16-50a *Molecular Biology of the Cell* (© Garland Science

Molecular motors: actin based (myosin)



Motor proteins can bind to polarised filaments (actin or MT) and use Energy to move along it

Figure 16-54a *Molecular Biology of the Cell* (© Garland Science 2008)

Myosin in muscle

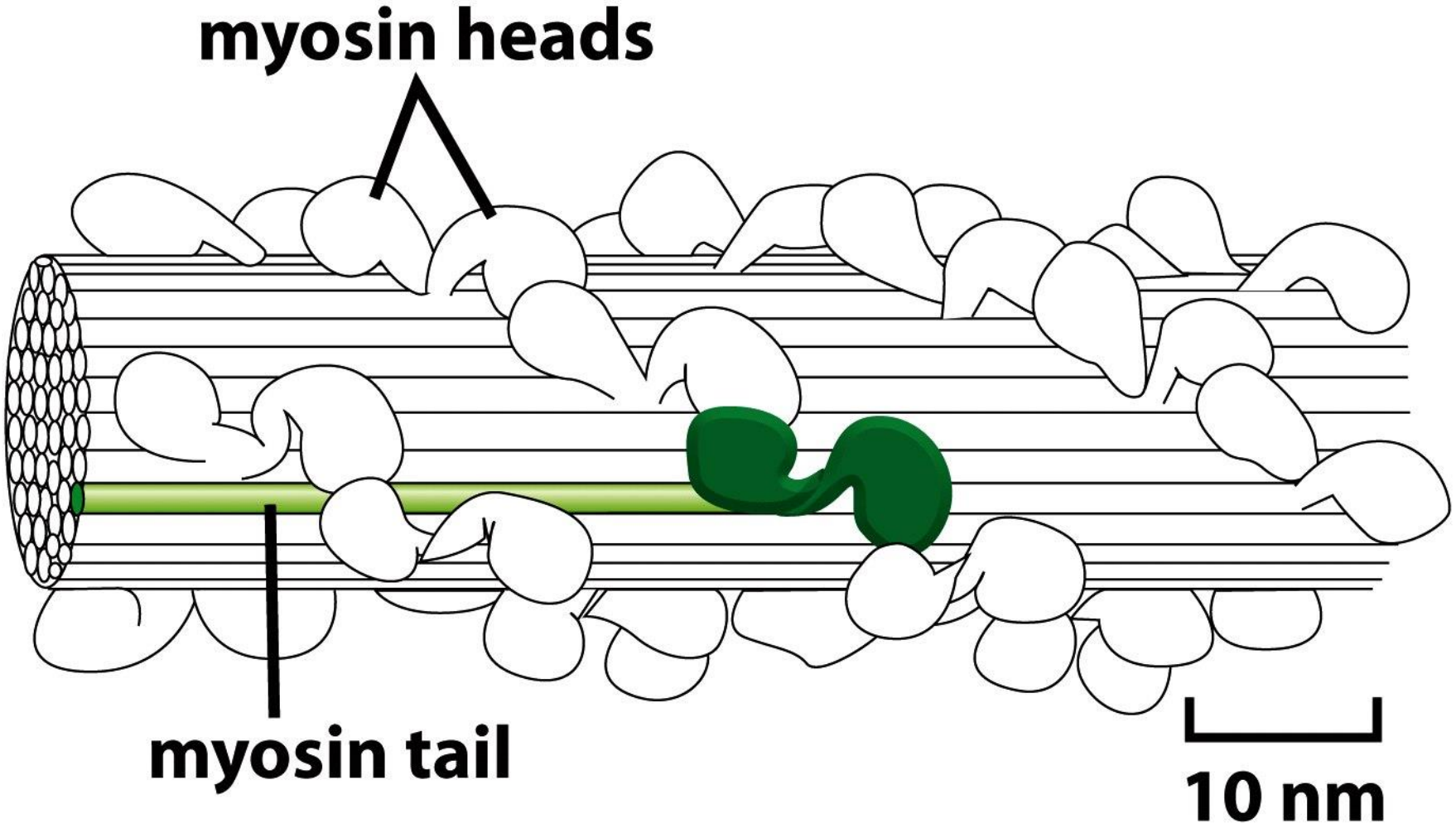


Figure 16-55c *Molecular Biology of the Cell* (© Garland Science 2008)

Actin polymerisation dependent movement

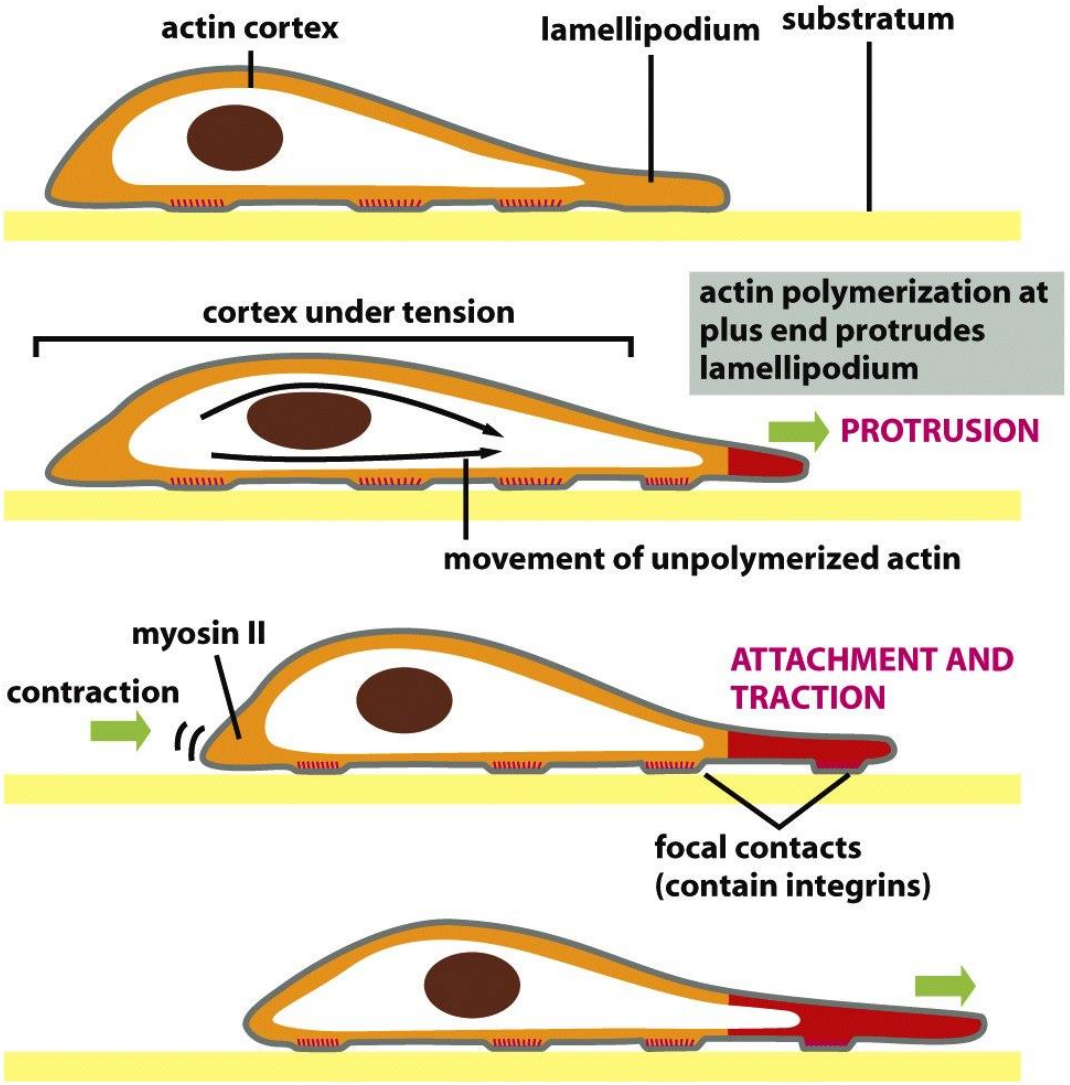


Figure 16-86 *Molecular Biology of the Cell* (© Garland Science 2008)

Intracellular compartments

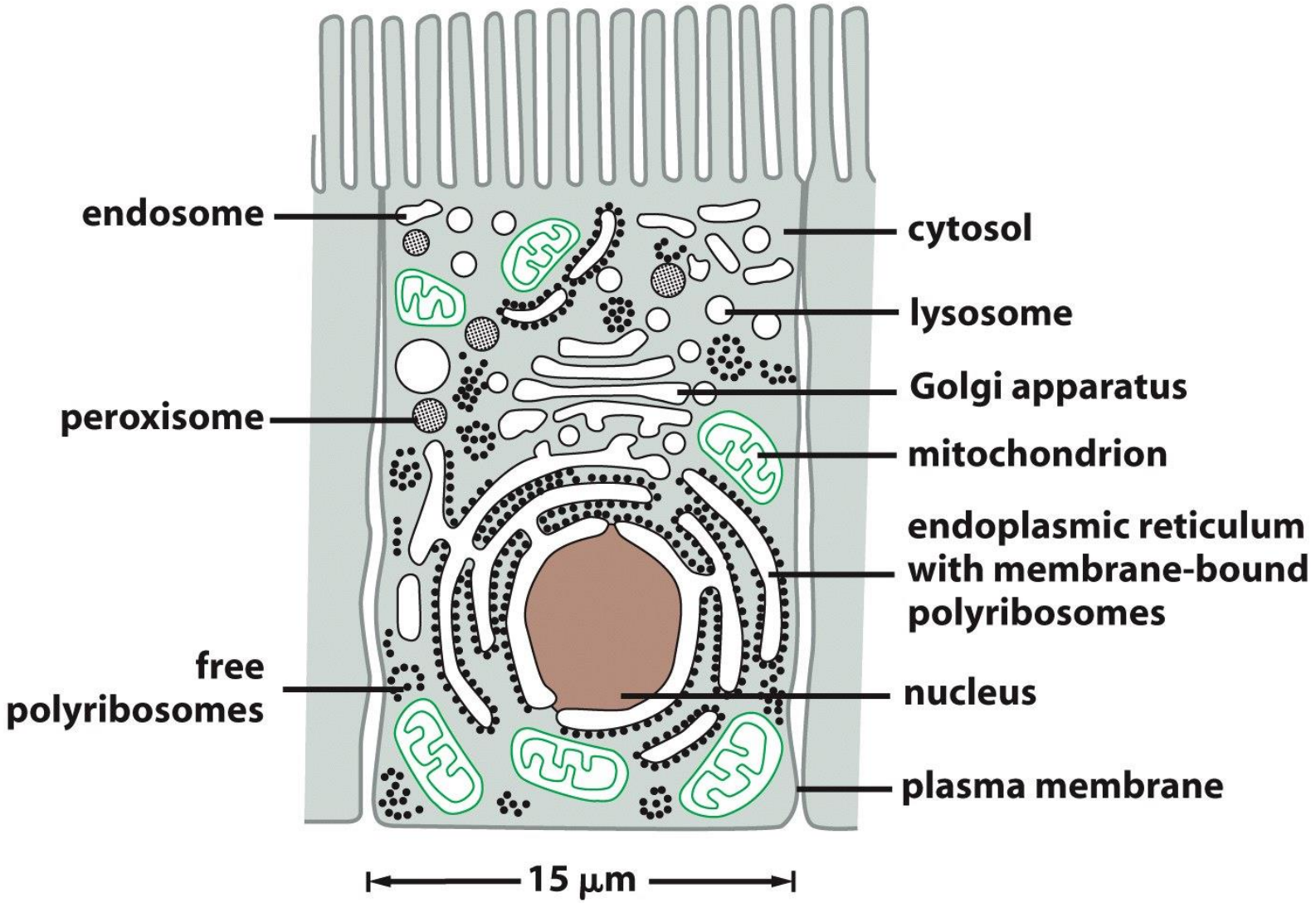


Figure 12-1 *Molecular Biology of the Cell* (© Garland Science 2008)

Protein traffic: 3 types

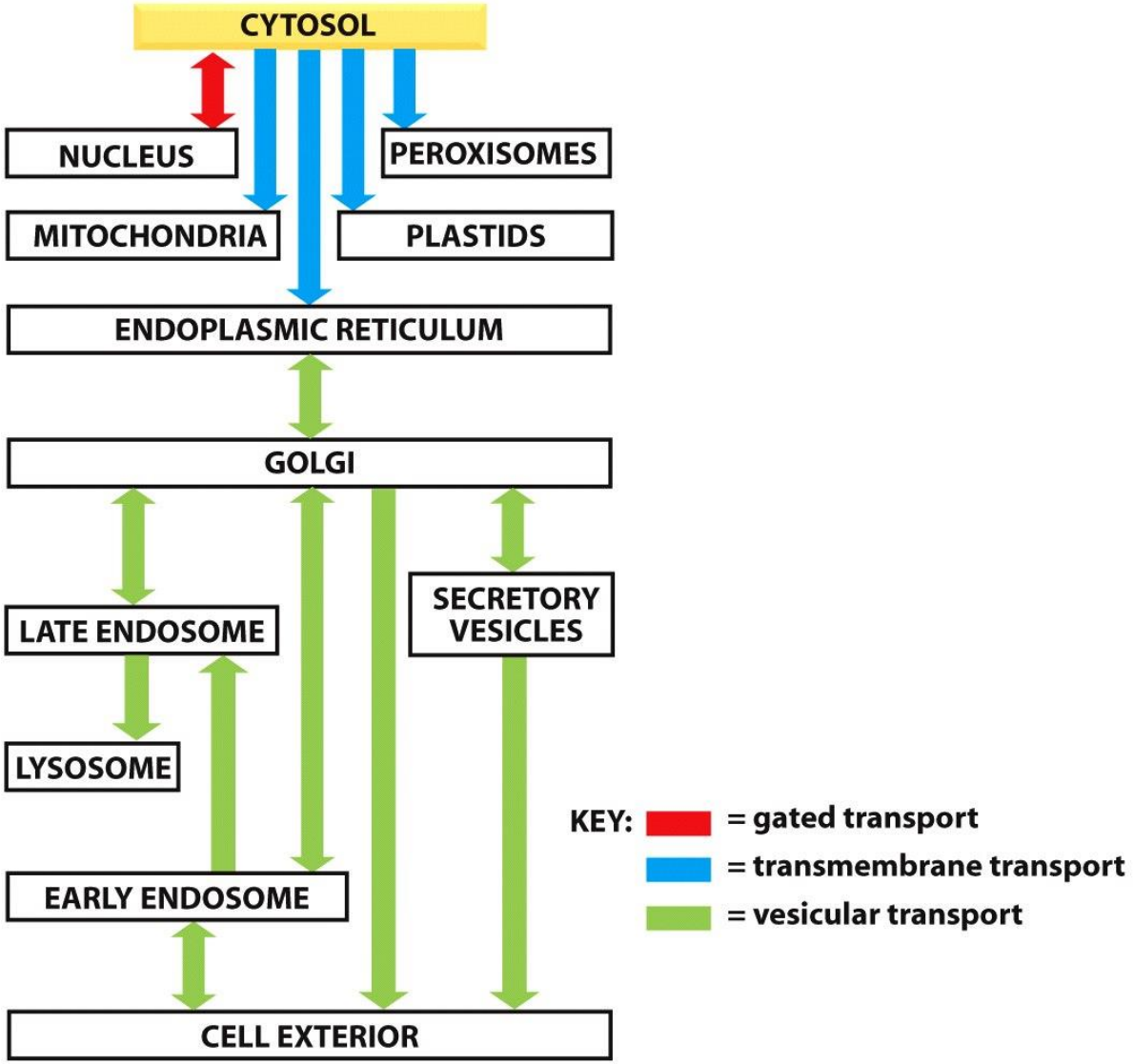


Figure 12-6 *Molecular Biology of the Cell* (© Garland Science 2008)

Vesicular traffic

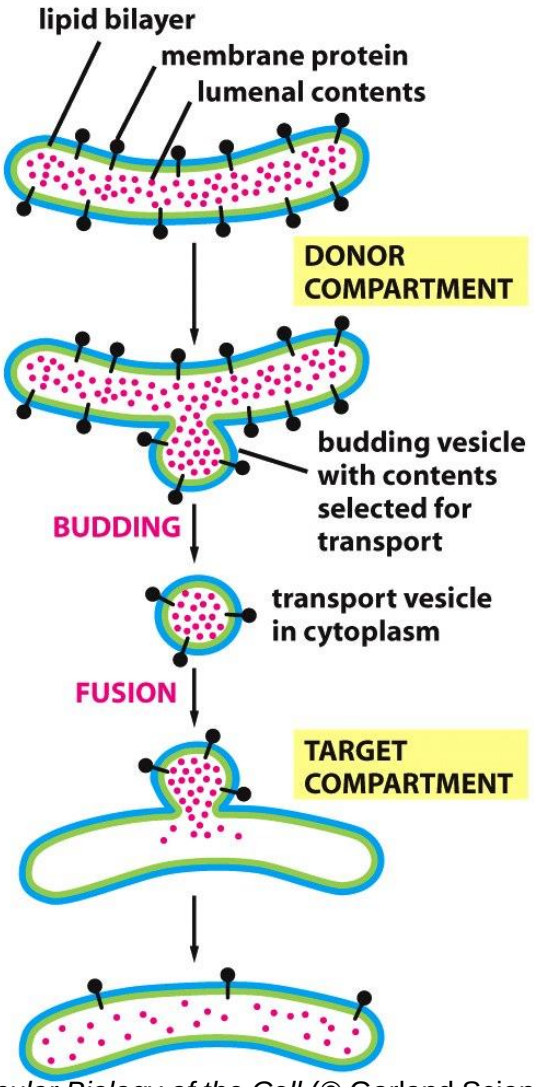


Figure 12-7 *Molecular Biology of the Cell* (© Garland Science 2008)

Signal sequences

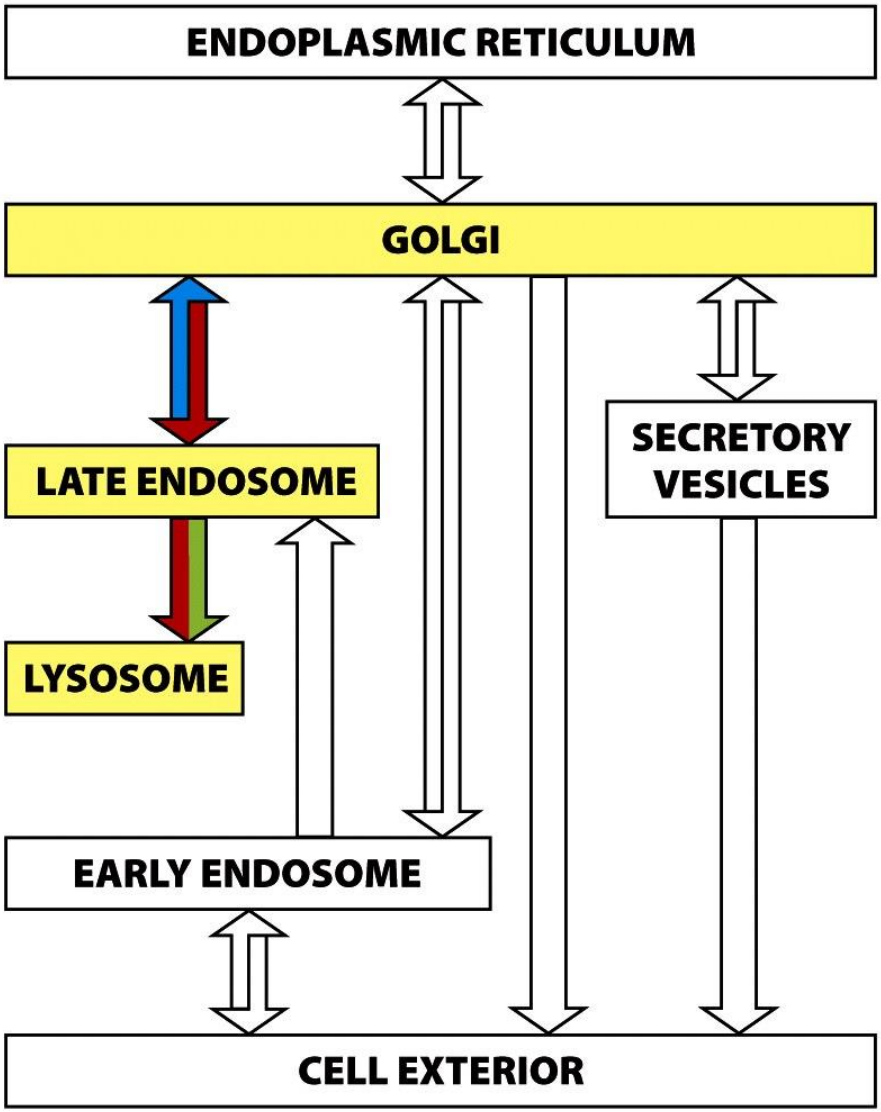
Table 12–3 Some Typical Signal Sequences

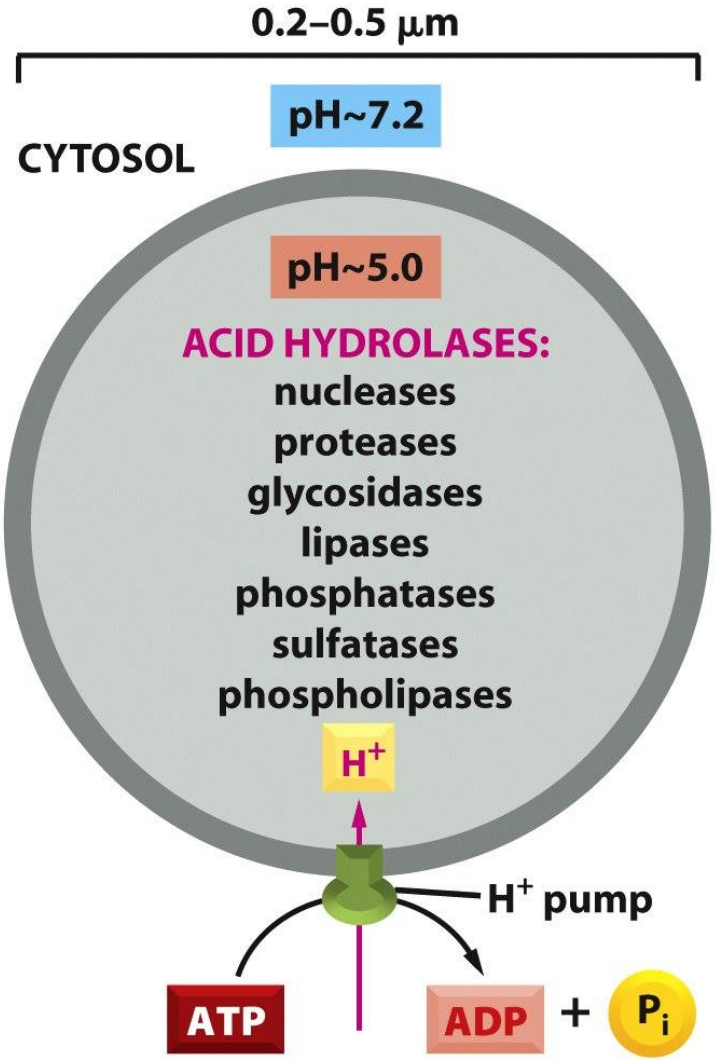
FUNCTION OF SIGNAL SEQUENCE	EXAMPLE OF SIGNAL SEQUENCE
Import into nucleus	-Pro-Pro-Lys-Lys-Lys-Arg-Lys-Val-
Export from nucleus	-Leu-Ala-Leu-Lys-Leu-Ala-Gly-Leu-Asp-Ile-
Import into mitochondria	$^{+}H_3N$-Met-Leu-Ser-Leu-Arg-Gln-Ser-Ile-Arg-Phe-Phe-Lys-Pro-Ala-Thr-Arg-Thr-Leu-Cys-Ser-Ser-Arg-Tyr-Leu-Leu-
Import into plastid	$^{+}H_3N$-Met-Val-Ala-Met-Ala-Met-Ala-Ser-Leu-Gln-Ser-Ser-Met-Ser-Ser-Leu-Ser-Leu-Ser-Ser-Asn-Ser-Phe-Leu-Gly-Gln-Pro-Leu-Ser-Pro-Ile-Thr-Leu-Ser-Pro-Phe-Leu-Gln-Gly-
Import into peroxisomes	-Ser-Lys-Leu-COO^{-}
Import into ER	$^{+}H_3N$-Met-Met-Ser-Phe-Val-Ser-Leu-Leu-Leu-Val-Gly-Ile-Leu-Phe-Trp-Ala-Thr-Glu-Ala-Glu-Gln-Leu-Thr-Lys-Cys-Glu-Val-Phe-Gln-
Return to ER	-Lys-Asp-Glu-Leu-COO^{-}

Some characteristic features of the different classes of signal sequences are highlighted in color. Where they are known to be important for the function of the signal sequence, positively charged amino acids are shown in *red* and negatively charged amino acids are shown in *green*. Similarly, important hydrophobic amino acids are shown in *white* and hydroxylated amino acids are shown in *blue*. $^{+}H_3N$ indicates the N-terminus of a protein; COO^{-} indicates the C-terminus.

Table 12-3 *Molecular Biology of the Cell* (© Garland Science 2008)

Transport to the lysosome





Page 779 *Molecular Biology of the Cell* (© Garland Science 2008)

Transport to the lysosome

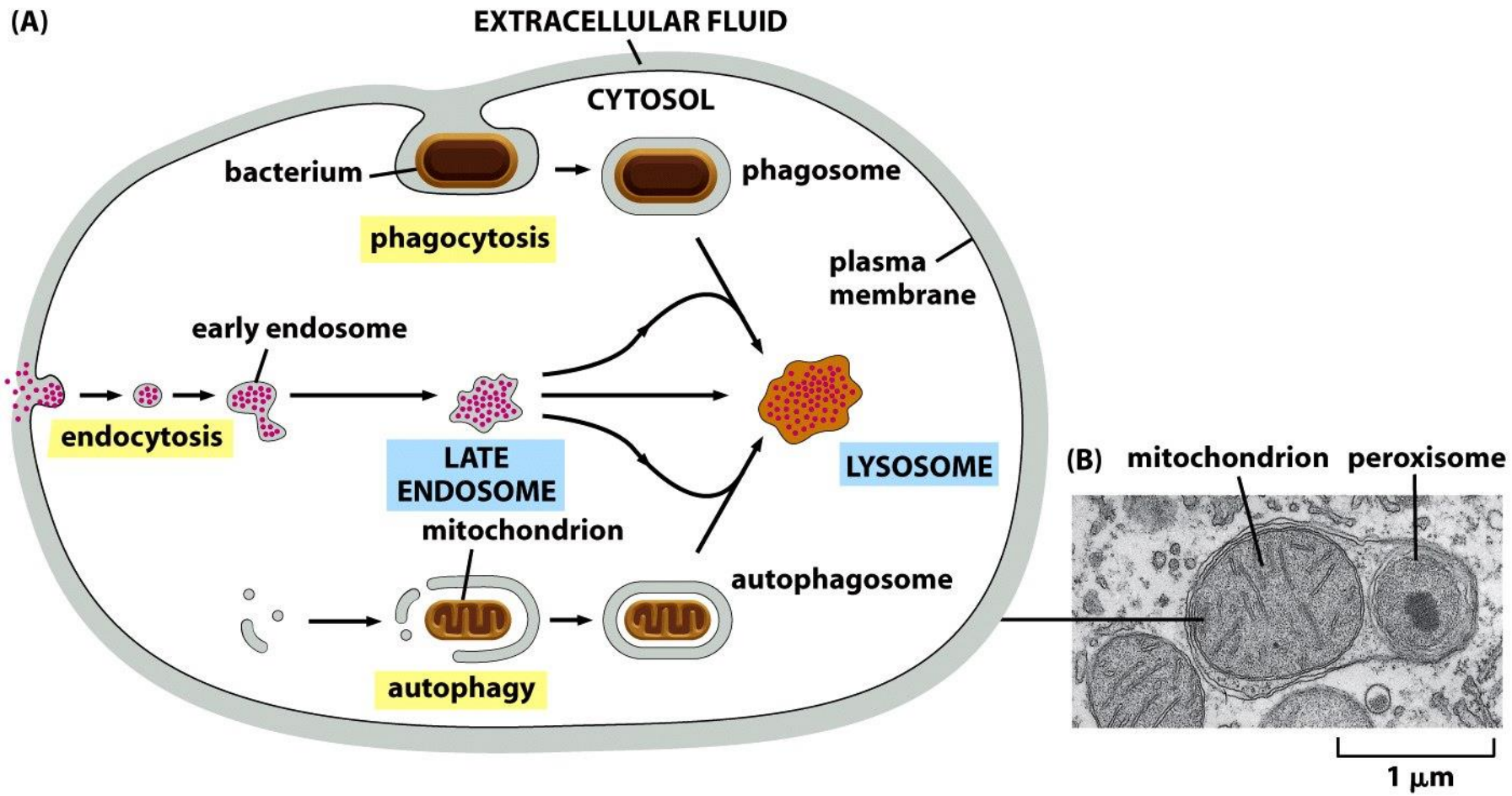


Figure 13-42 *Molecular Biology of the Cell* (© Garland Science 2008)

Transport into the cell

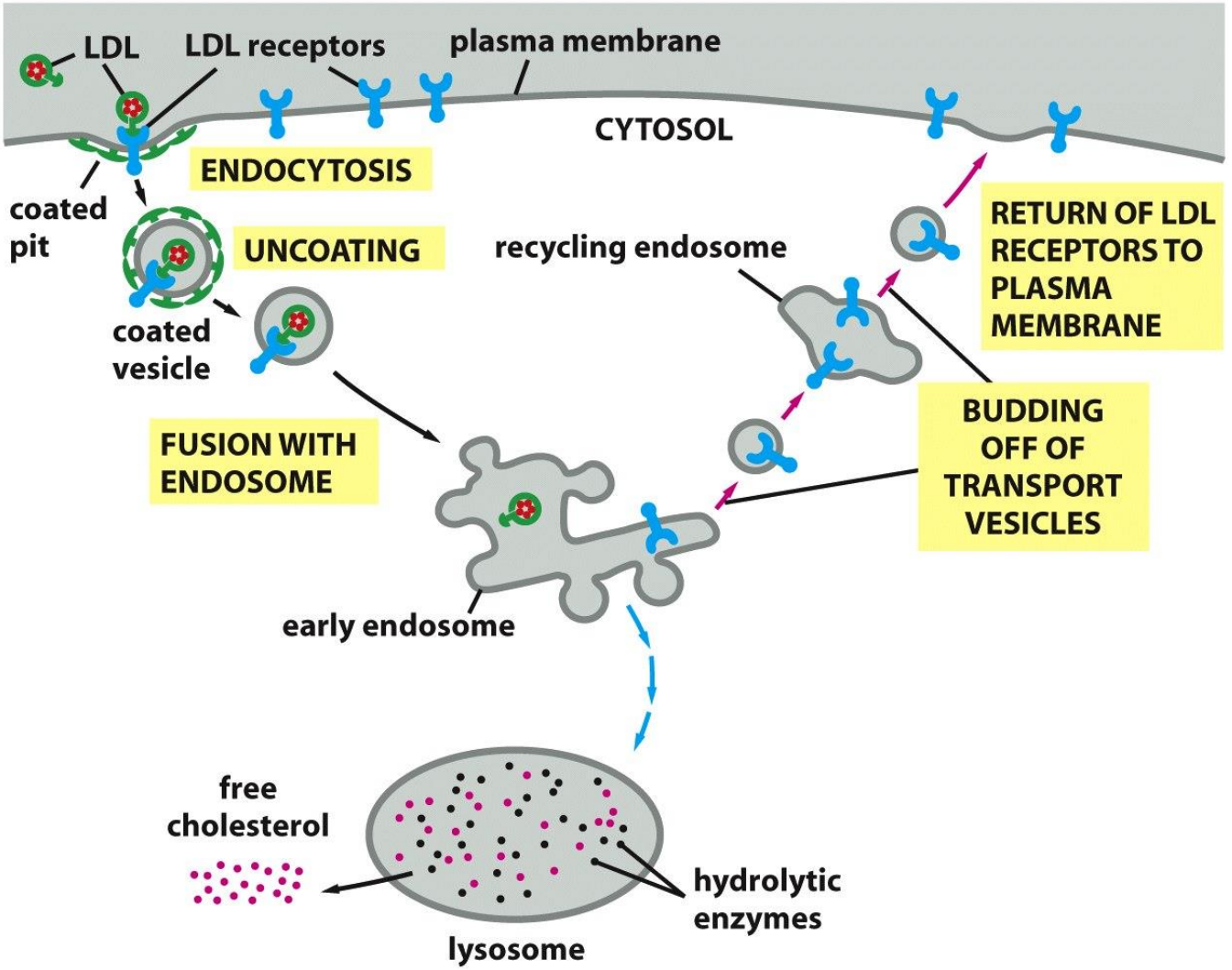
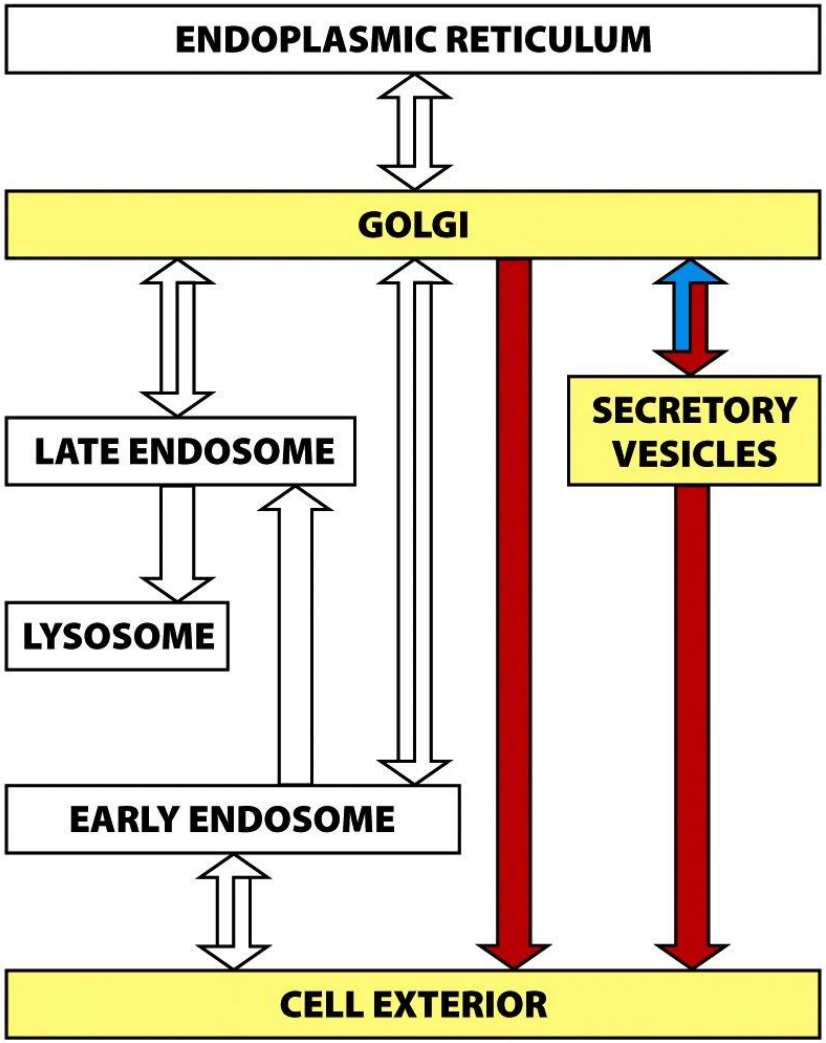


Figure 13-53 *Molecular Biology of the Cell* (© Garland Science 2008)

Transport out of the cell



Page 799 *Molecular Biology of the Cell* (© Garland Science 2008)

The Mitochondrion

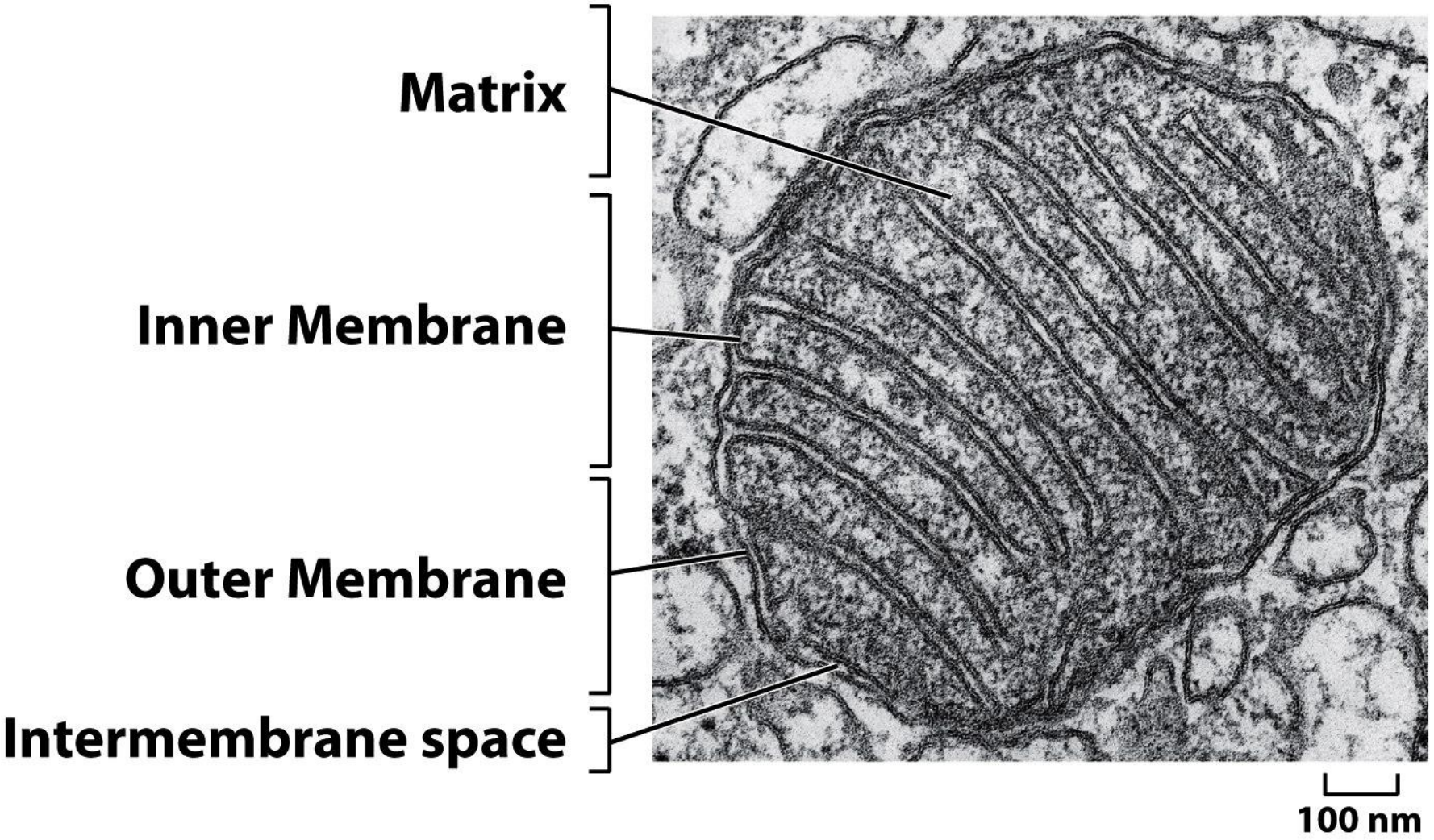


Figure 14-8 (part 1 of 2) *Molecular Biology of the Cell* (© Garland Science 2008)

Chemiosmotic coupling

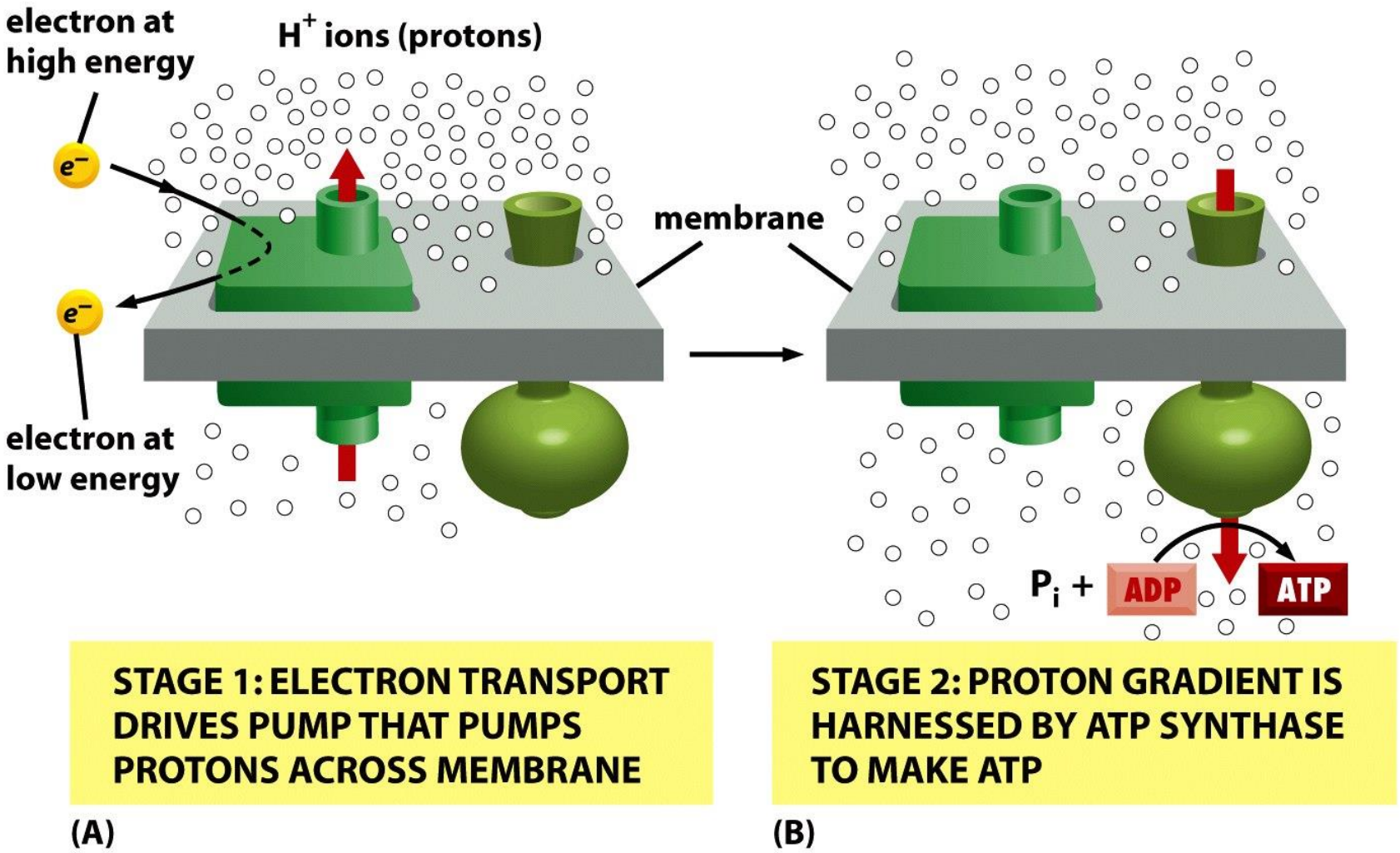


Figure 14-1 *Molecular Biology of the Cell* (© Garland Science 2008)

Electron transport chain

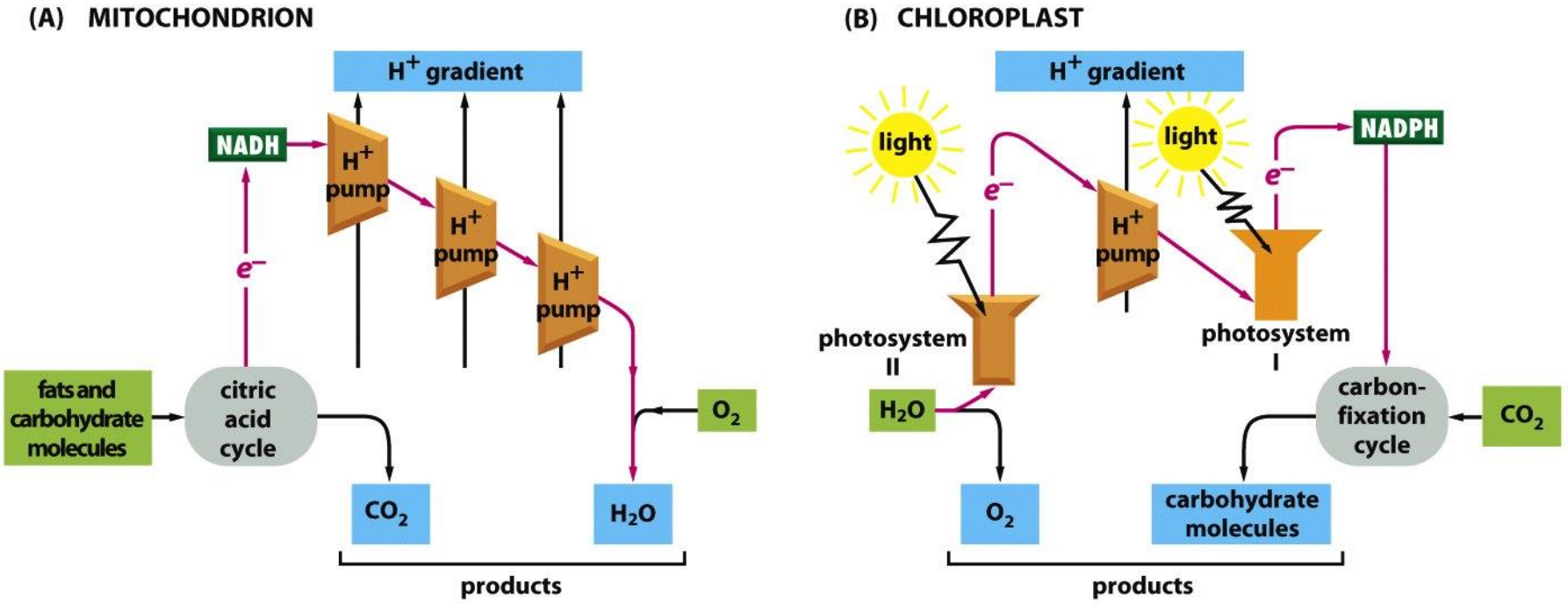


Figure 14-3 *Molecular Biology of the Cell* (© Garland Science 2008)

Energy from food generates NADH

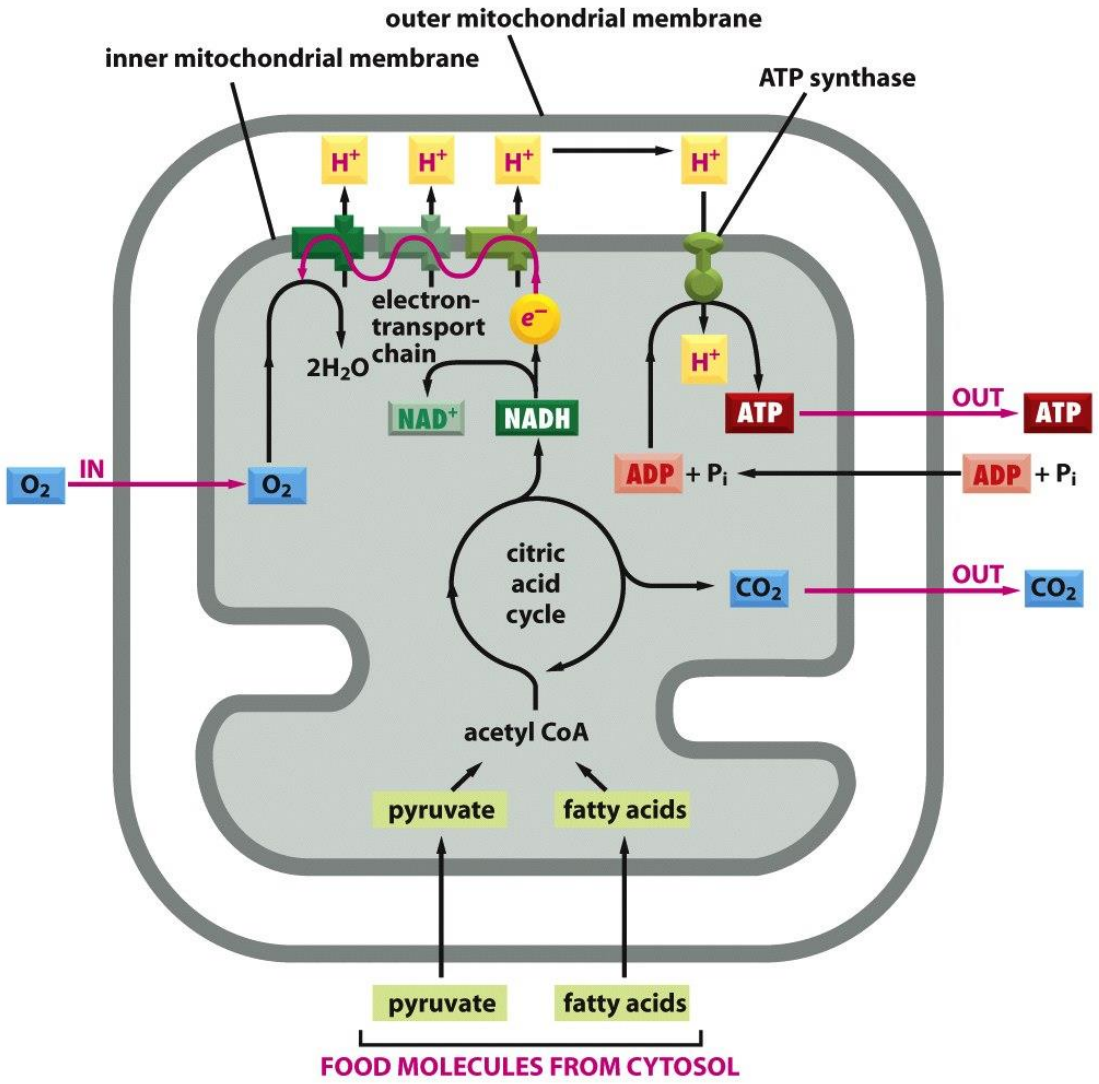


Figure 14-10 *Molecular Biology of the Cell* (© Garland Science 2008)

Biological systems store energy

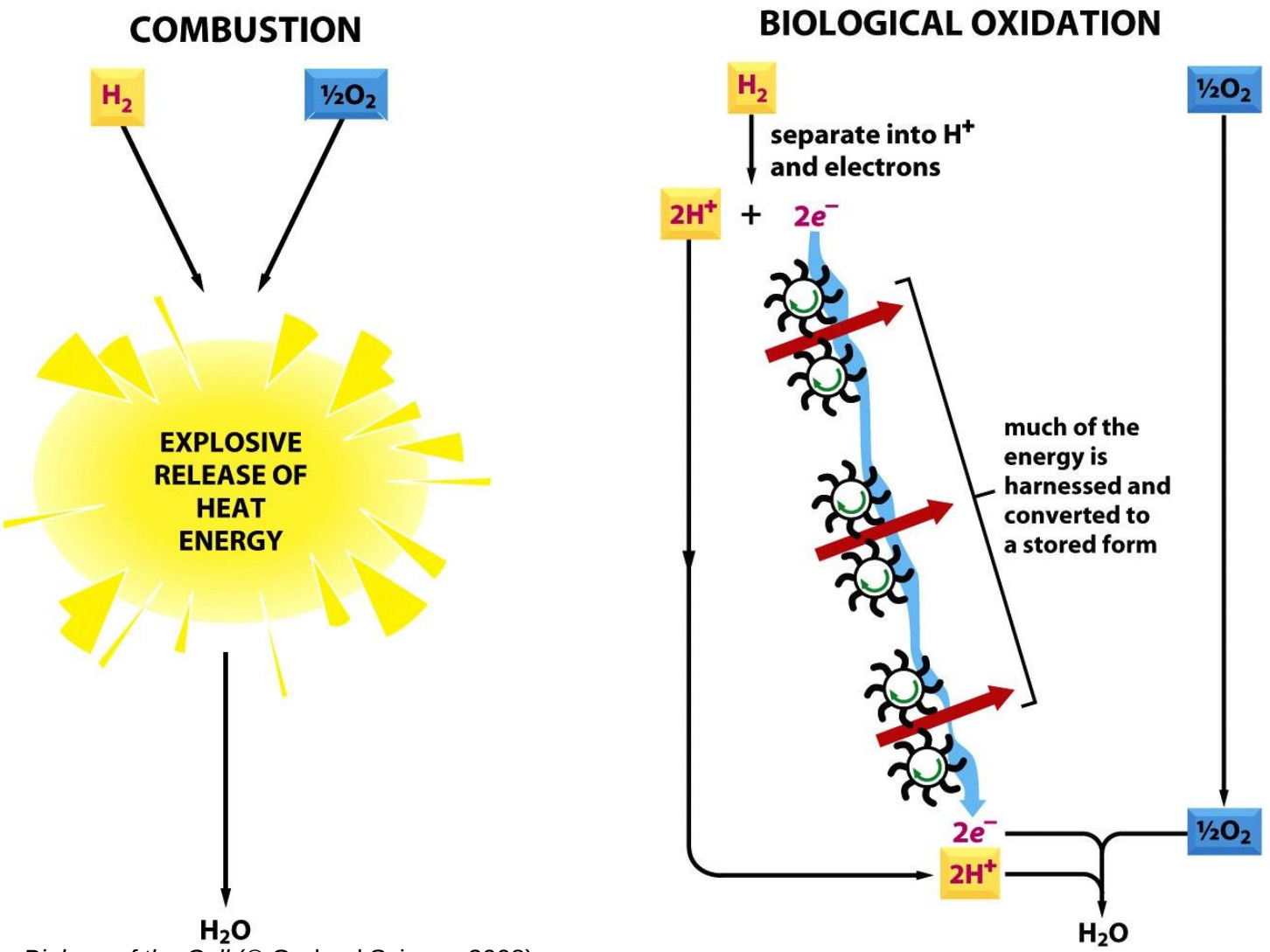


Figure 14-12a *Molecular Biology of the Cell* (© Garland Science 2008)

Oxidative phosphorylation

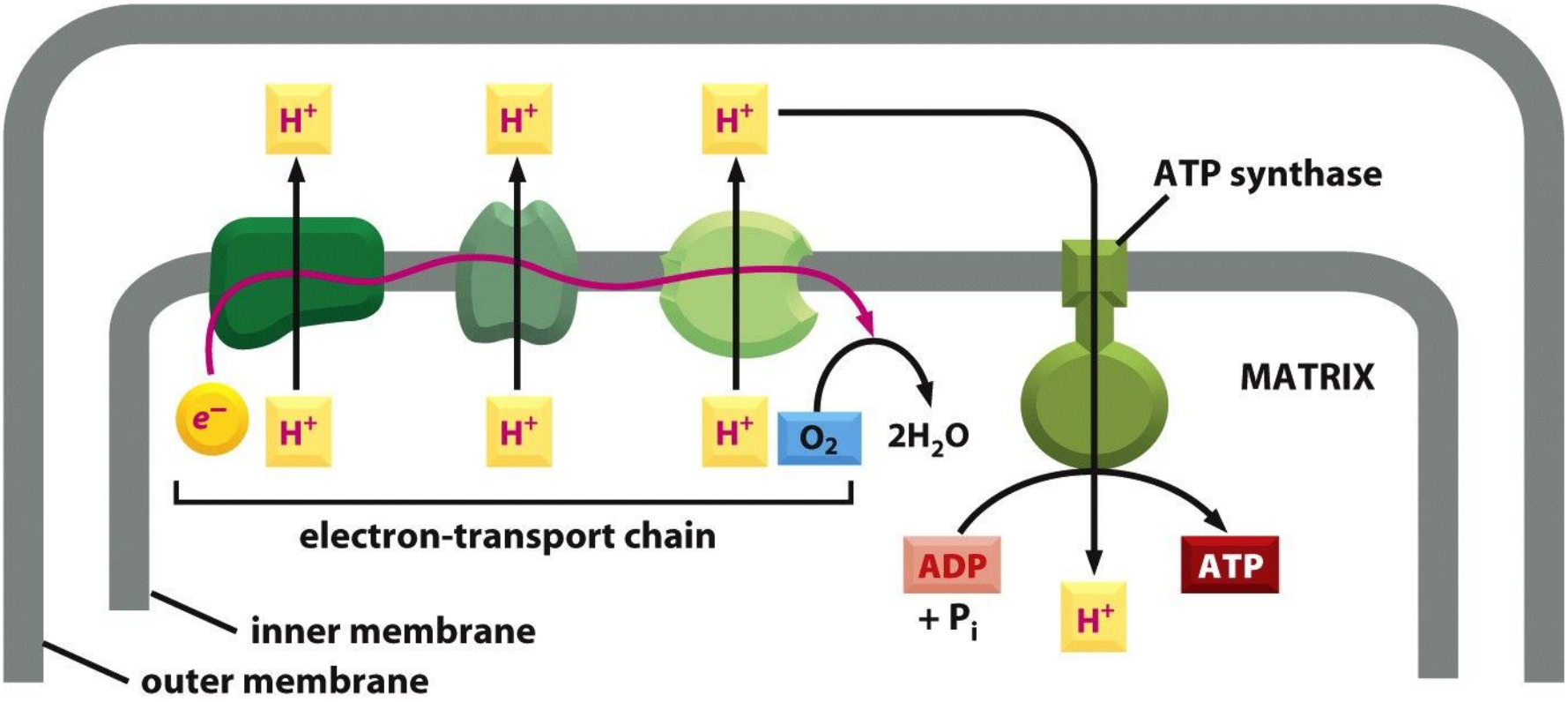


Figure 14-14 *Molecular Biology of the Cell* (© Garland Science 2008)

Generation of membrane potential

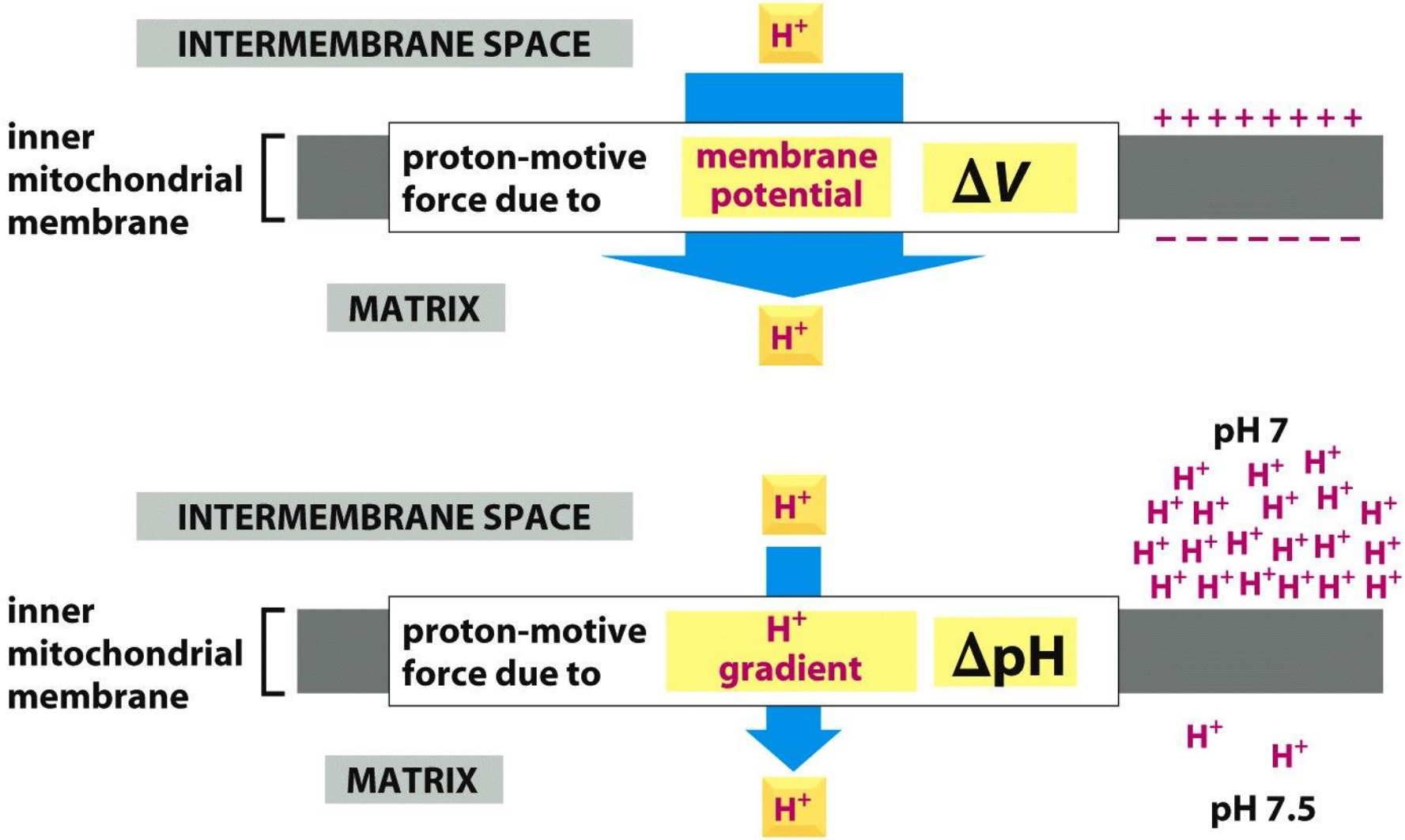


Figure 14-13 *Molecular Biology of the Cell* (© Garland Science 2008)

ATP synthase

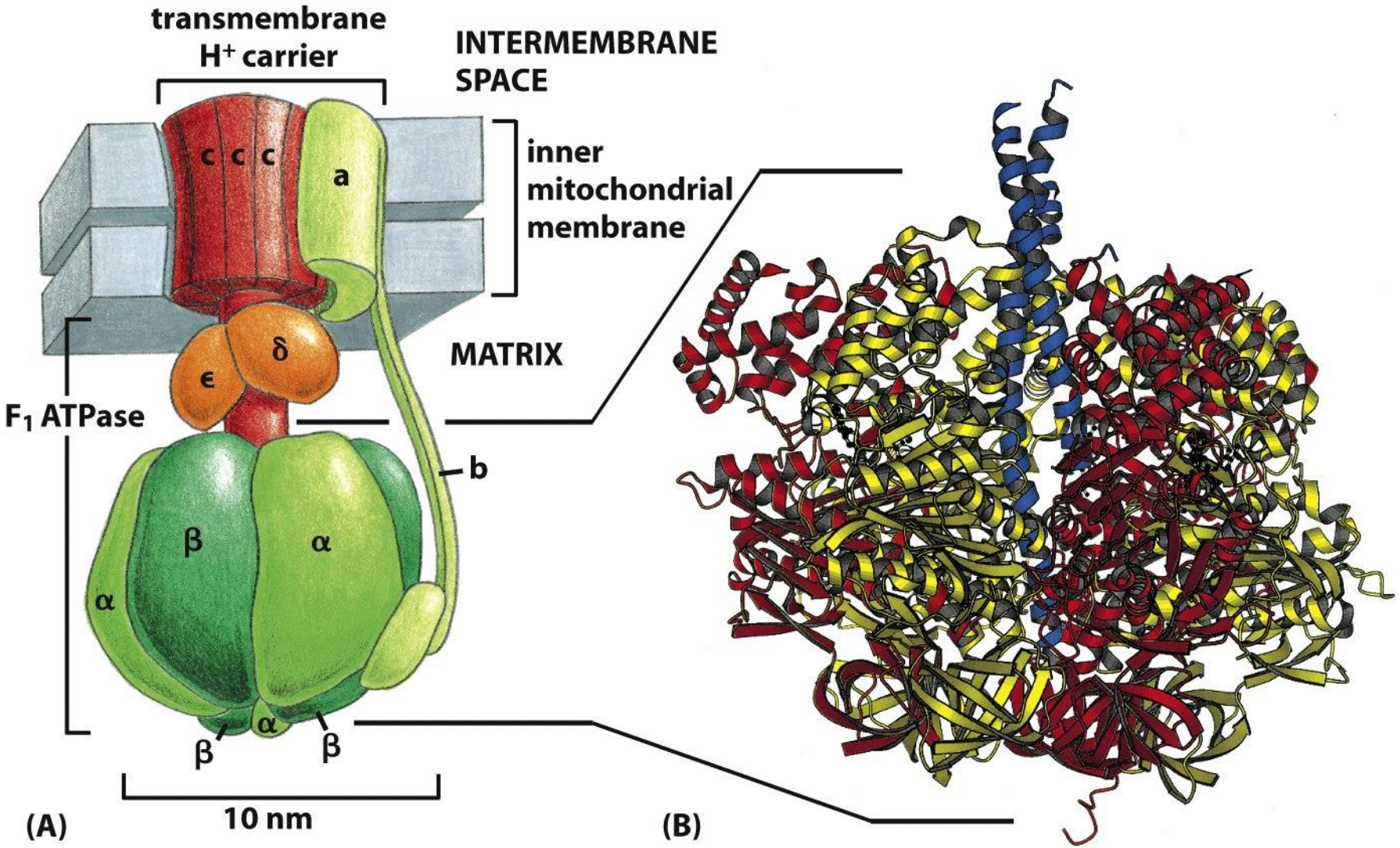


Figure 14-15 *Molecular Biology of the Cell* (© Garland Science 2008)

ATP:ADP ratio is high

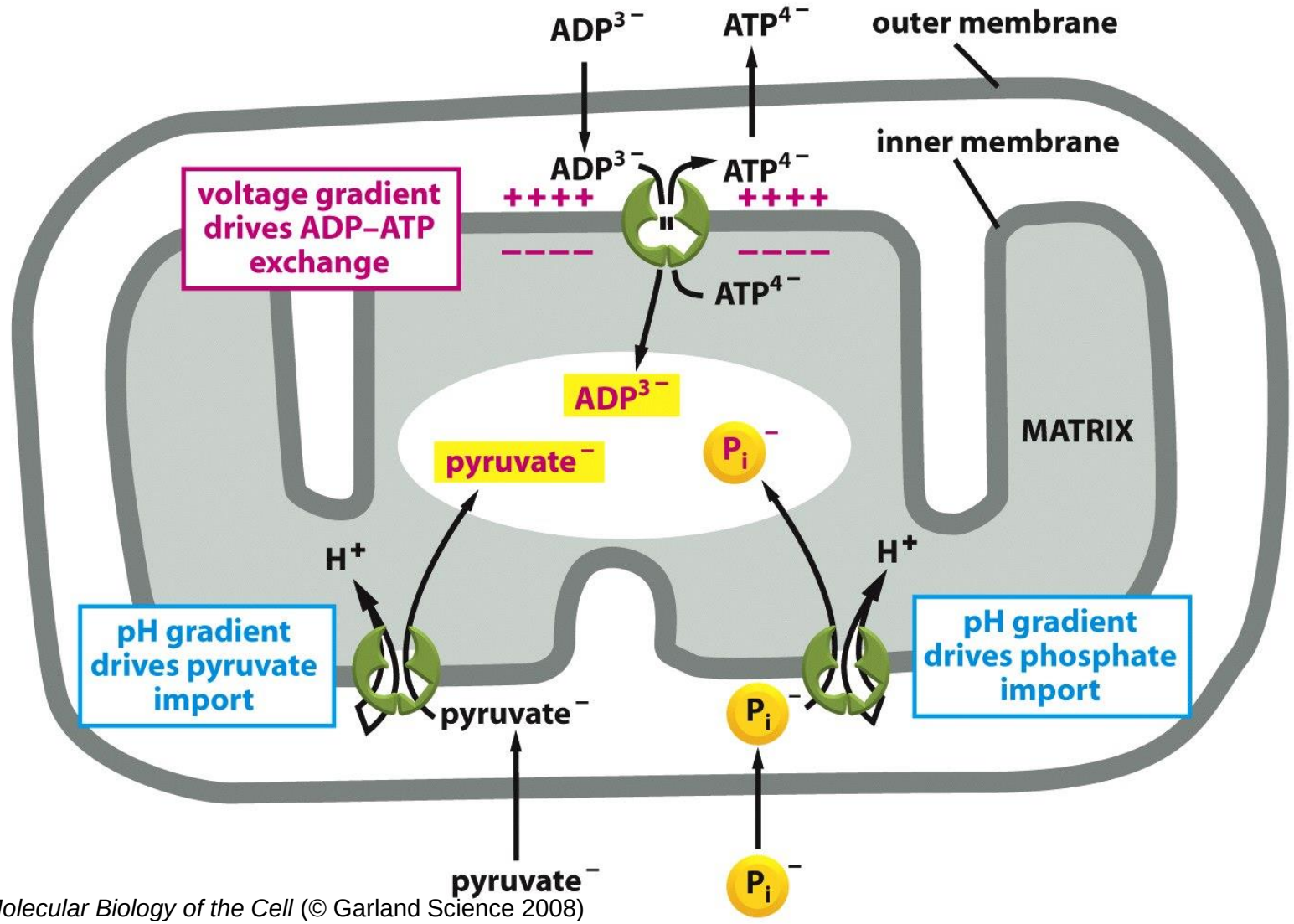


Figure 14-16 *Molecular Biology of the Cell* (© Garland Science 2008)

Energy yields

Table 14–1 Product Yields from the Oxidation of Sugars and Fats

A. NET PRODUCTS FROM OXIDATION OF ONE MOLECULE OF GLUCOSE
In cytosol (glycolysis) 1 glucose → 2 pyruvate + 2 NADH + 2 ATP In mitochondrion (pyruvate dehydrogenase and citric acid cycle) 2 pyruvate → 2 acetyl CoA + 2 NADH 2 acetyl CoA → 6 NADH + 2 $FADH_2$ + 2 GTP
Net result in mitochondrion 2 pyruvate → 8 NADH + 2 $FADH_2$ + 2 GTP
B. NET PRODUCTS FROM OXIDATION OF ONE MOLECULE OF PALMITOYL COA (ACTIVATED FORM OF PALMITATE, A FATTY ACID)
In mitochondrion (fatty acid oxidation and citric acid cycle) 1 palmitoyl CoA → 8 acetyl CoA + 7 NADH + 7 $FADH_2$ 8 acetyl CoA → 24 NADH + 8 $FADH_2$ + 8 GTP
Net result in mitochondrion 1 palmitoyl CoA → 31 NADH + 15 $FADH_2$ + 8 GTP

Table 14-1 *Molecular Biology of the Cell* (© Garland Science 2008)

Mitochondria: key role in cell metabolism

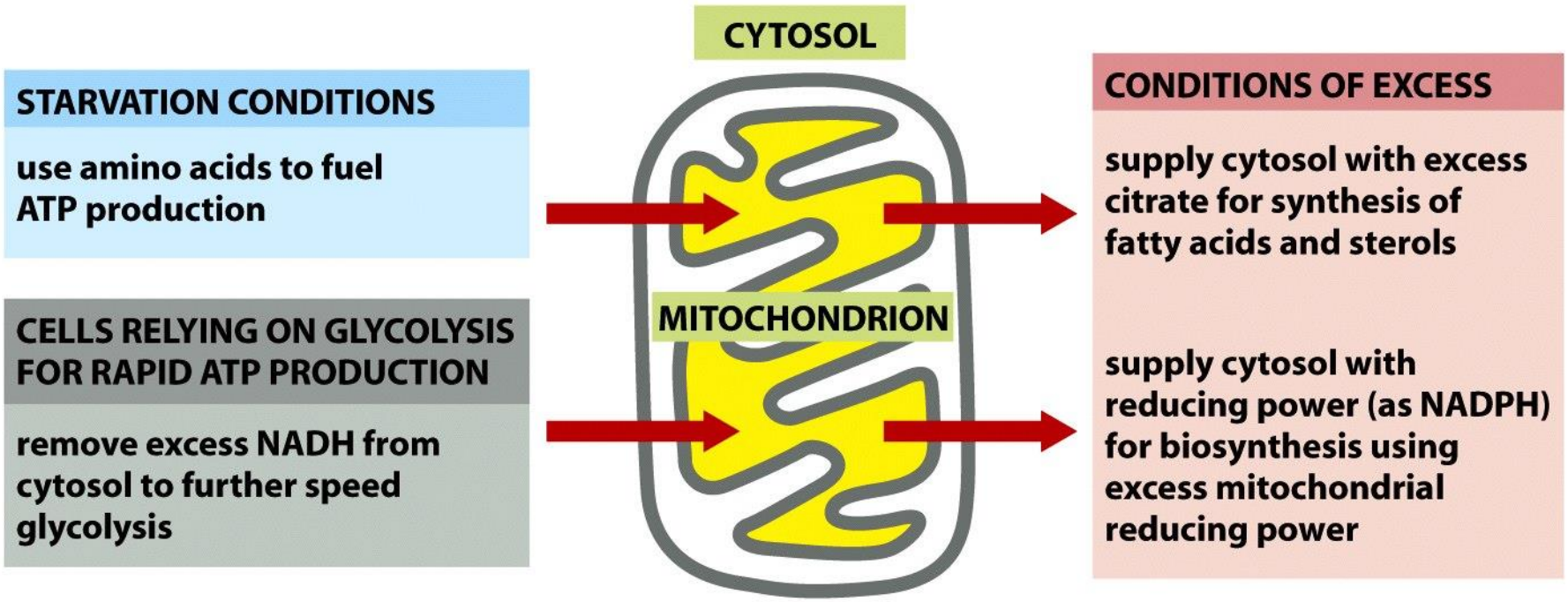


Figure 14-32 *Molecula* 2008)

The cell cycle

Meiosis and Mitosis

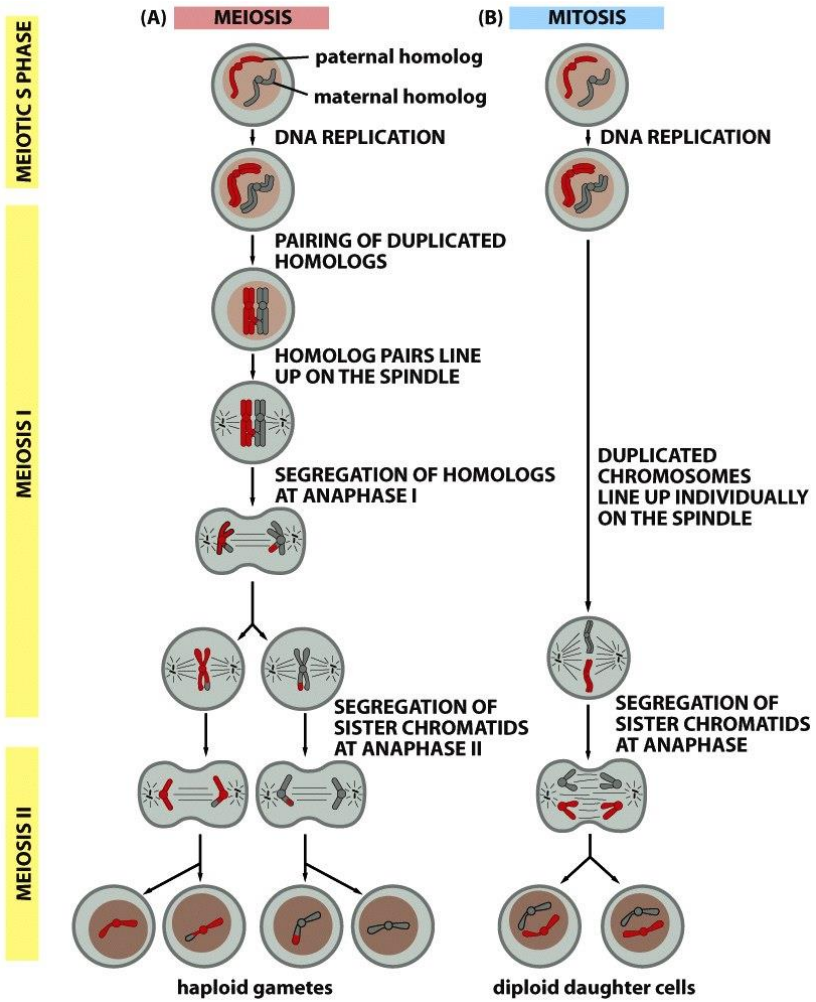


Figure 17-47 *Molecular Biology of the Cell* (© Garland Science 2008)

The cell cycle

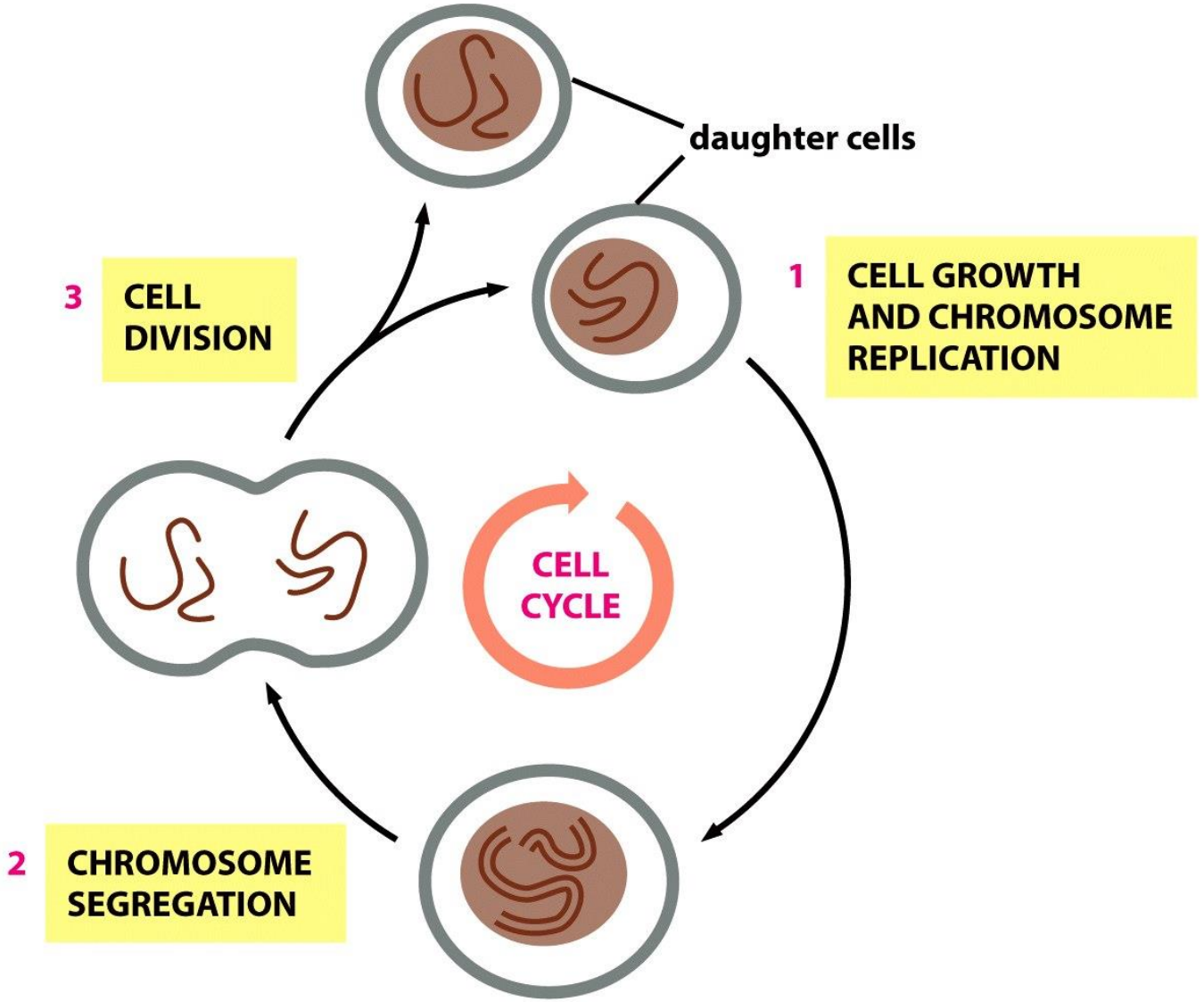


Figure 17-1 *Molecular Biology of the Cell* (© Garland Science 2008)

The cell cycle

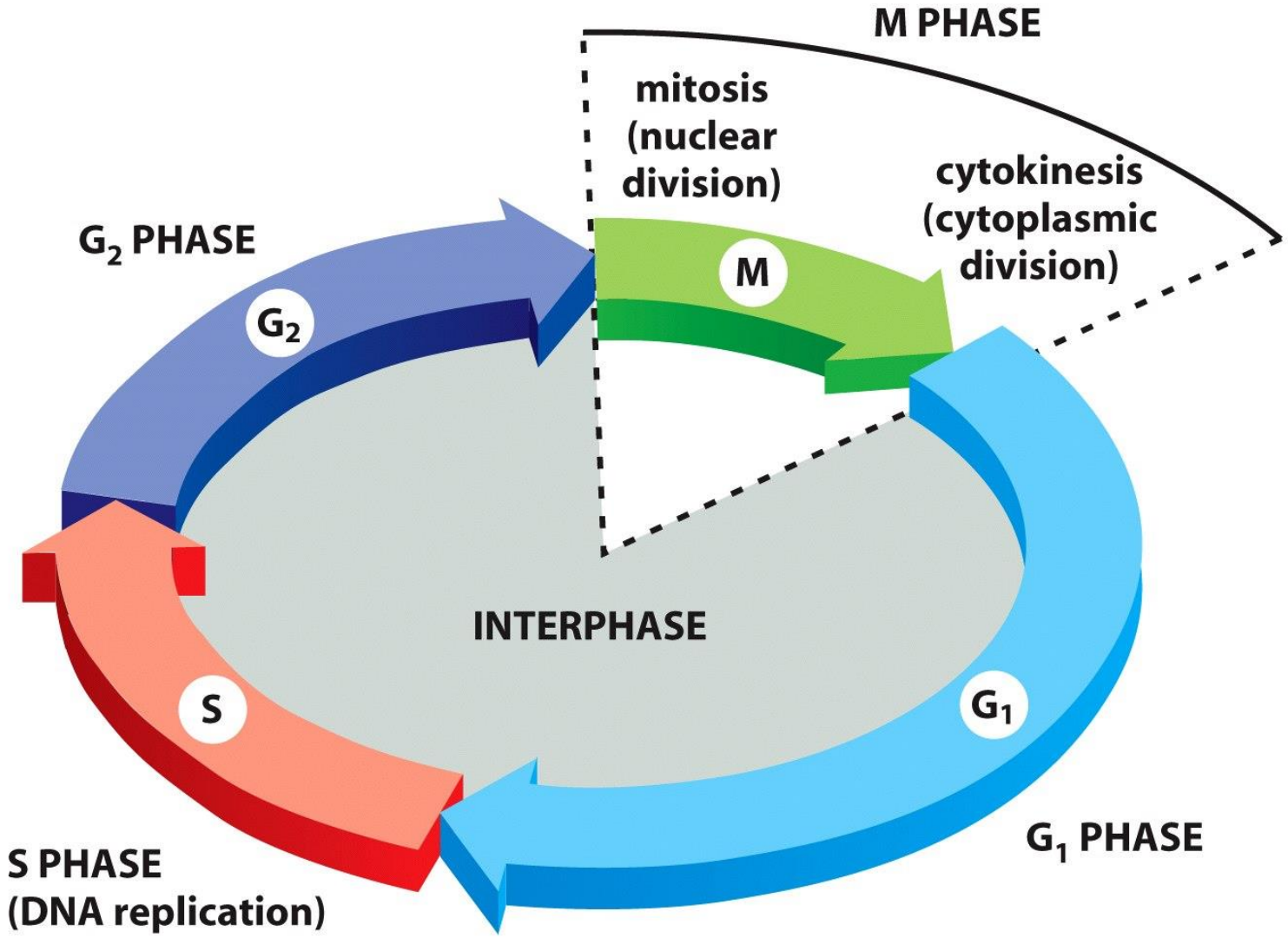


Figure 17-4 *Molecular Biology of the Cell* (© Garland Science 2008)

The cell cycle: cyclins control checkpoints

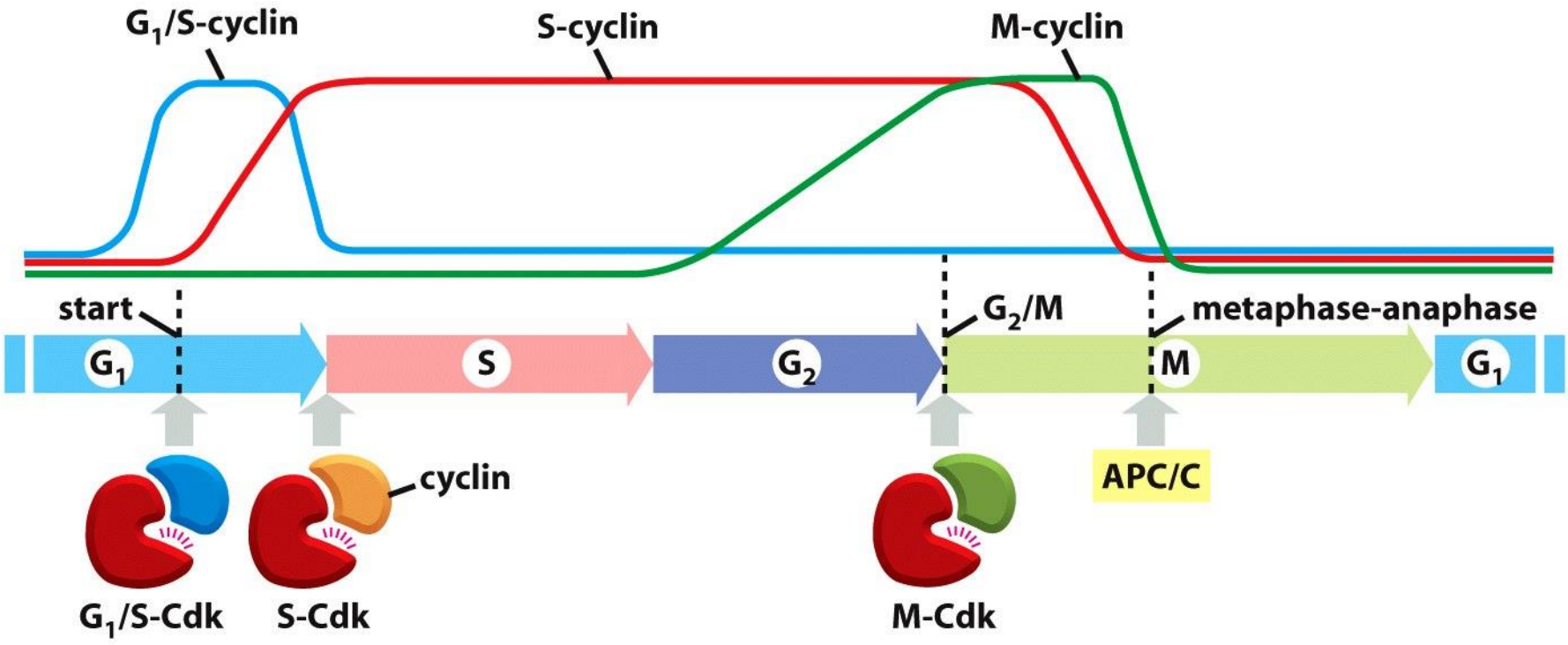


Figure 17-16 *Molecular Biology of the Cell* (© Garland Science 2008)

Apoptosis: programmed cell death

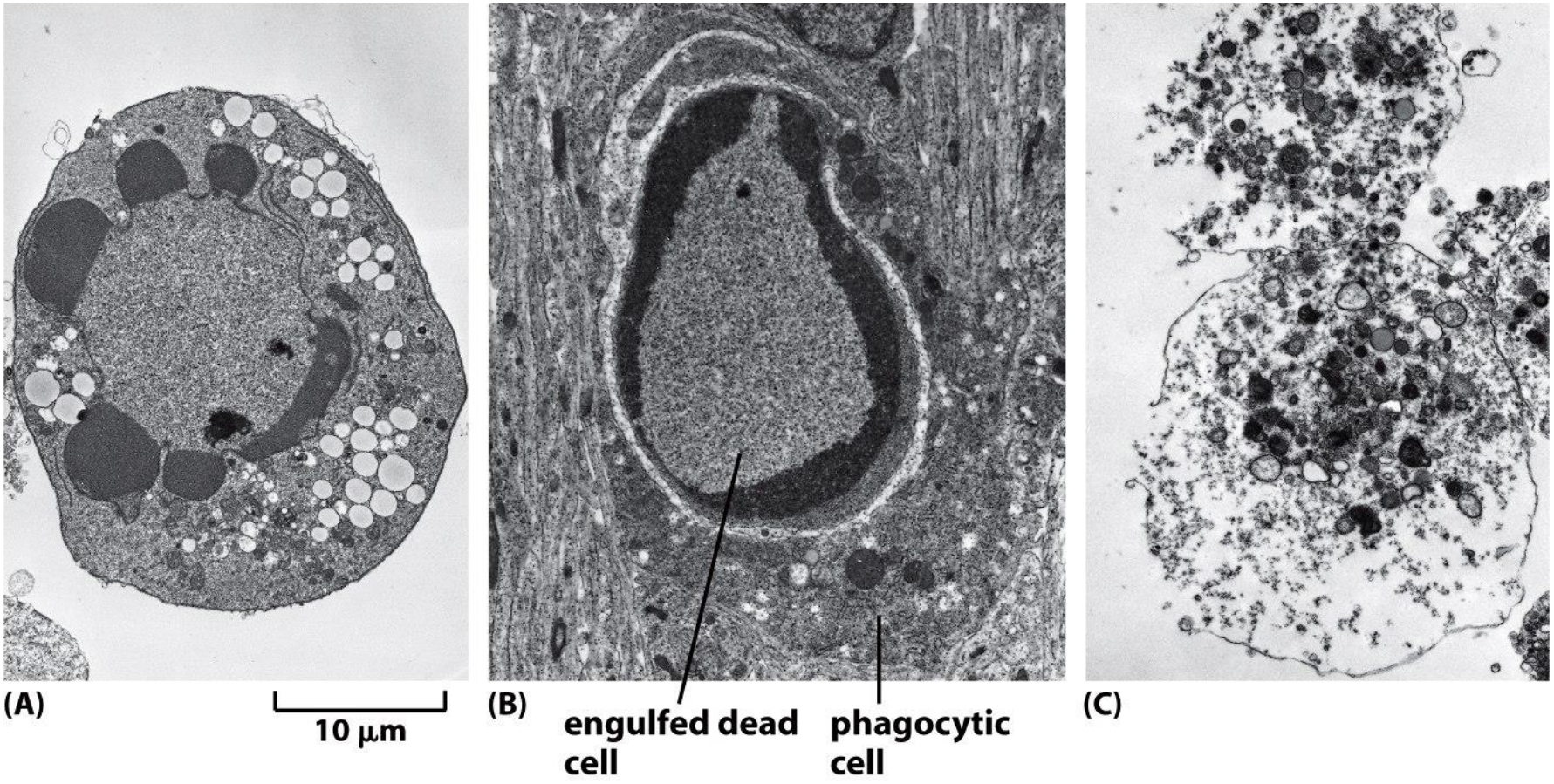


Figure 18-1 *Molecular Biology of the Cell* (© Garland Science 2008)

Apoptosis: during embryonic develop.

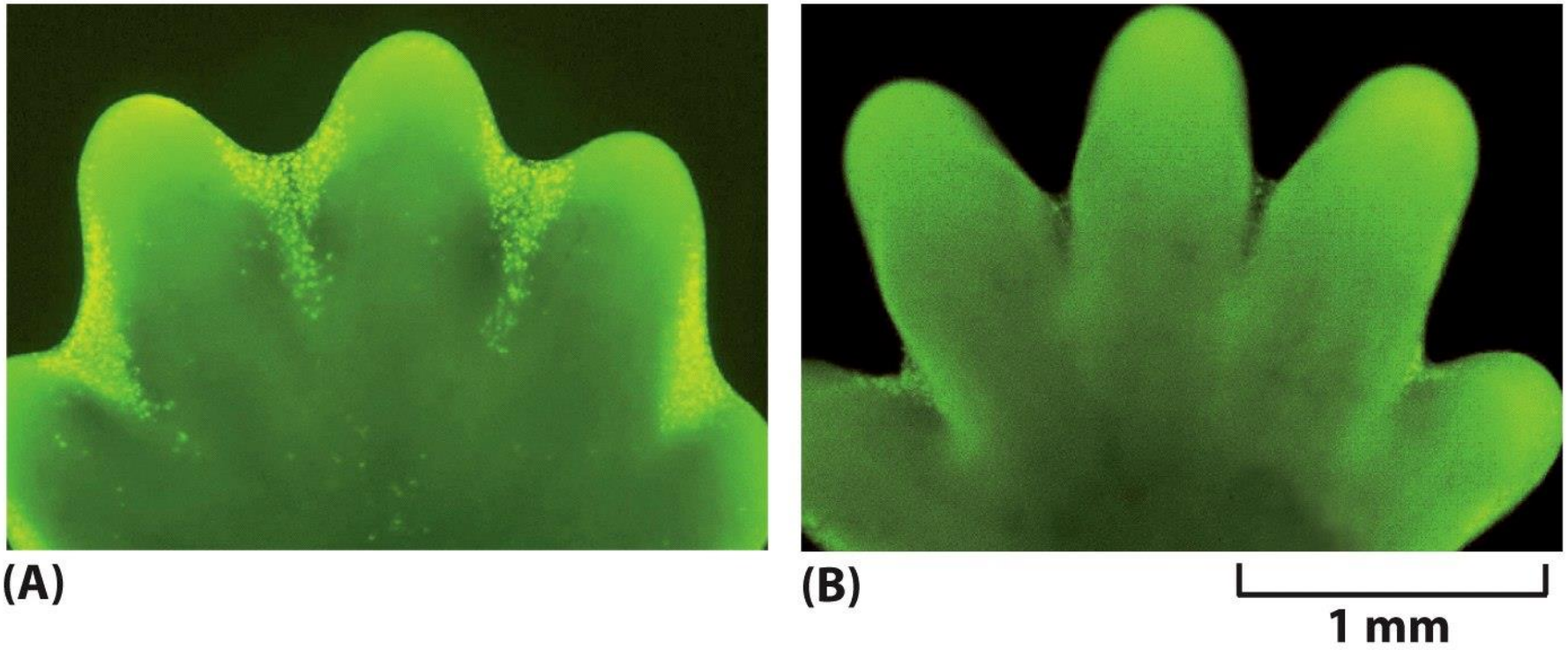


Figure 18-2 *Molecular Biology of the Cell* (© Garland Science 2008)

Apoptosis: mediated by caspases

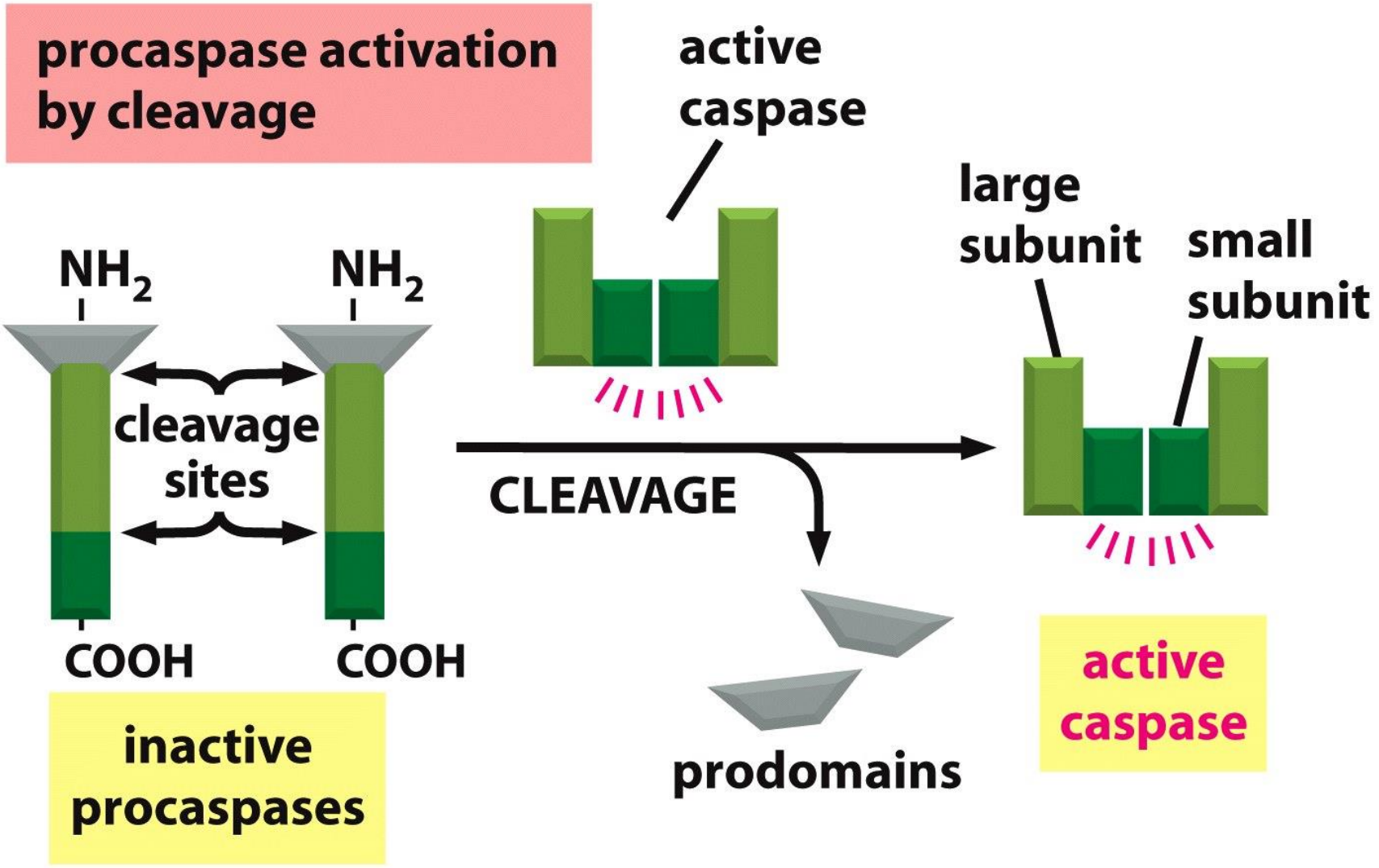


Figure 18-5a *Molecular Biology of the Cell* (© Garland Science 2008)

Apoptosis: can be signalled from outside

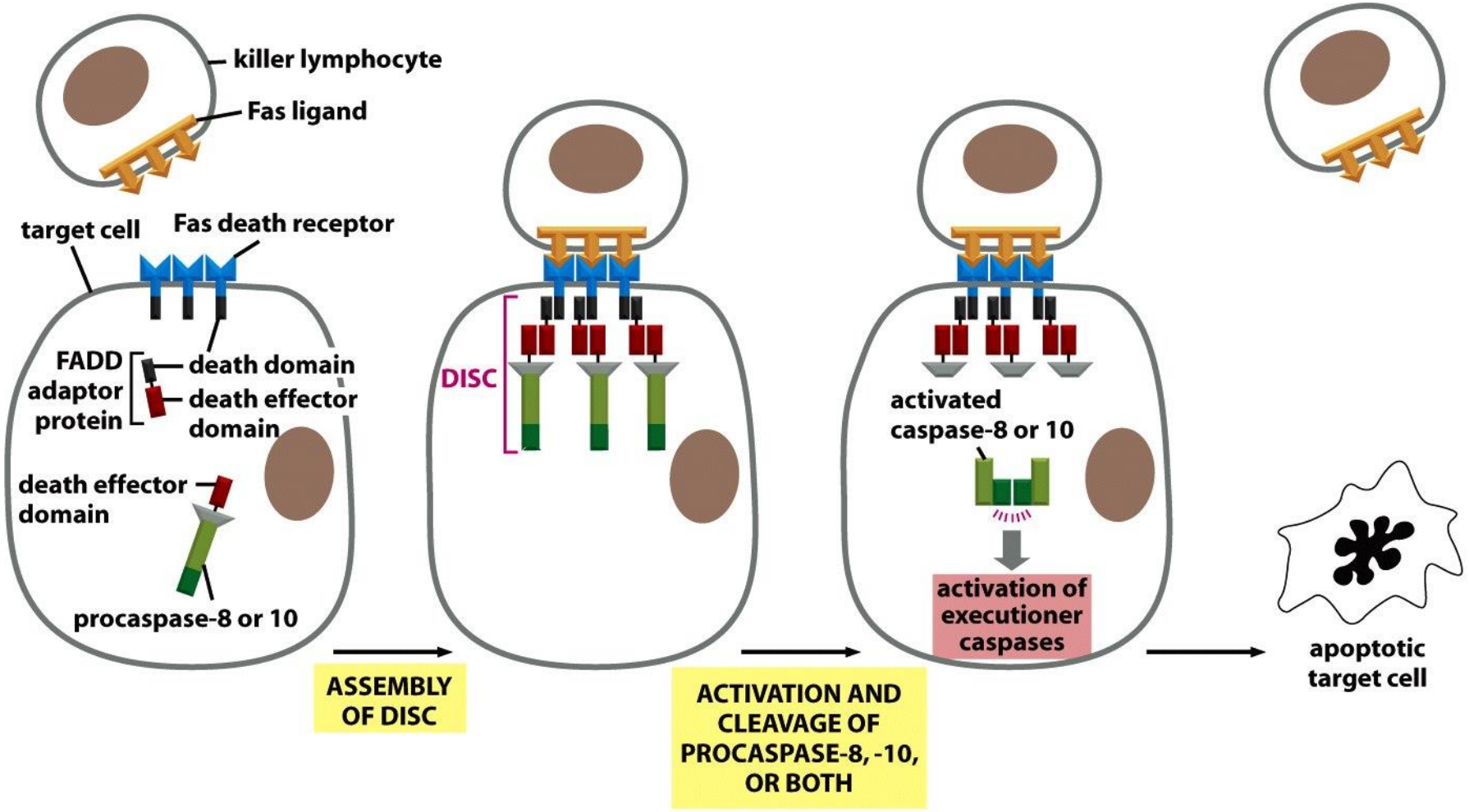


Figure 18-6 *Molecular Biology of the Cell* (© Garland Science 2008)

Apoptosis: can be signalled from mito.

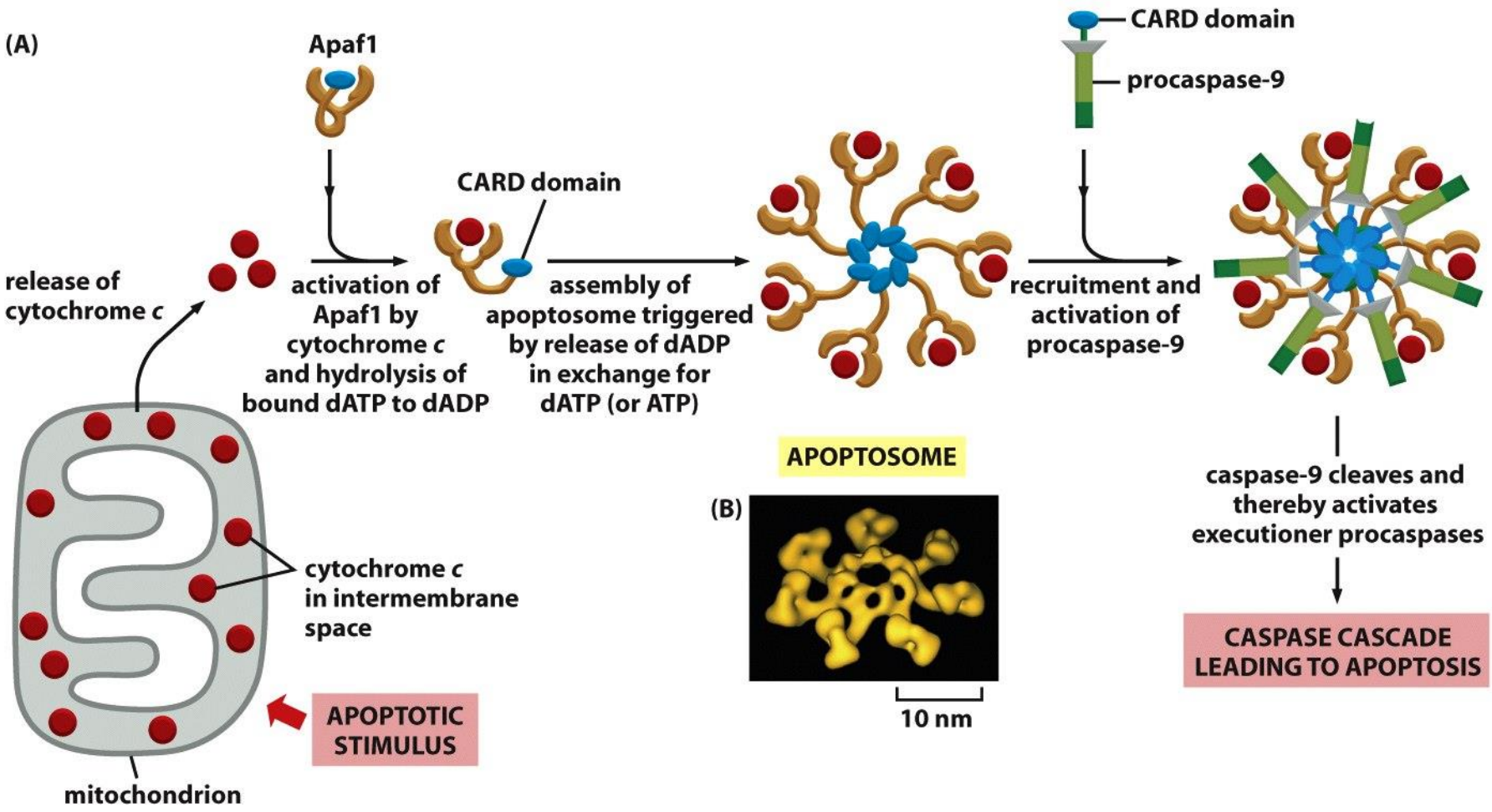
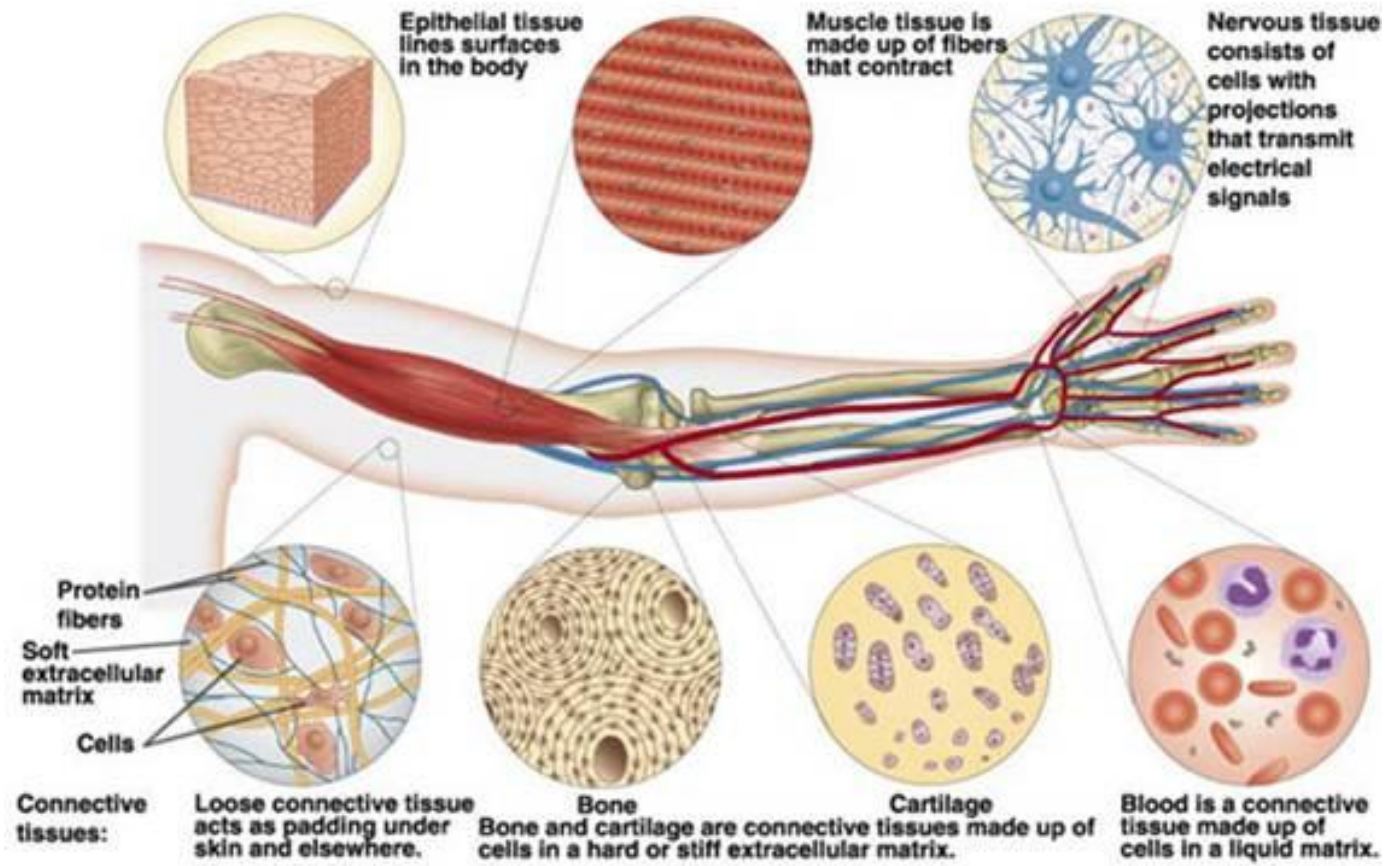


Figure 18-8 *Molecular Biology of the Cell* (© Garland Science 2008)

Cell types


Epithelial tissue lines surfaces in the body
Muscle tissue is made up of fibers that contract
Nervous tissue consists of cells with projections that transmit electrical signals
Protein fibers
Soft extracellular matrix
Cells
Connective tissues:
Loose connective tissue acts as padding under skin and elsewhere.
Bone
Cartilage
Bone and cartilage are connective tissues made up of cells in a hard or stiff extracellular matrix.
Blood is a connective tissue made up of cells in a liquid matrix.

Cell types

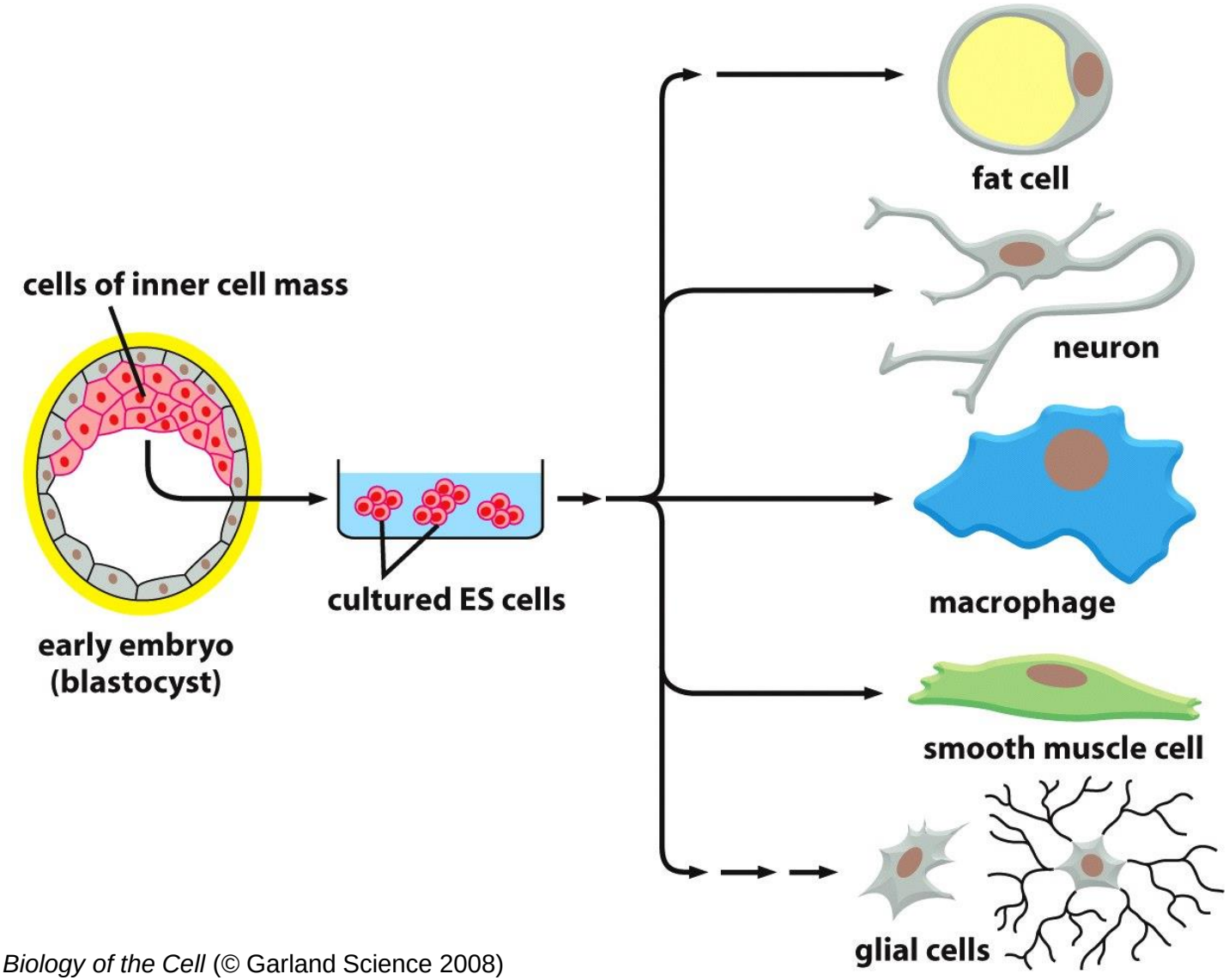
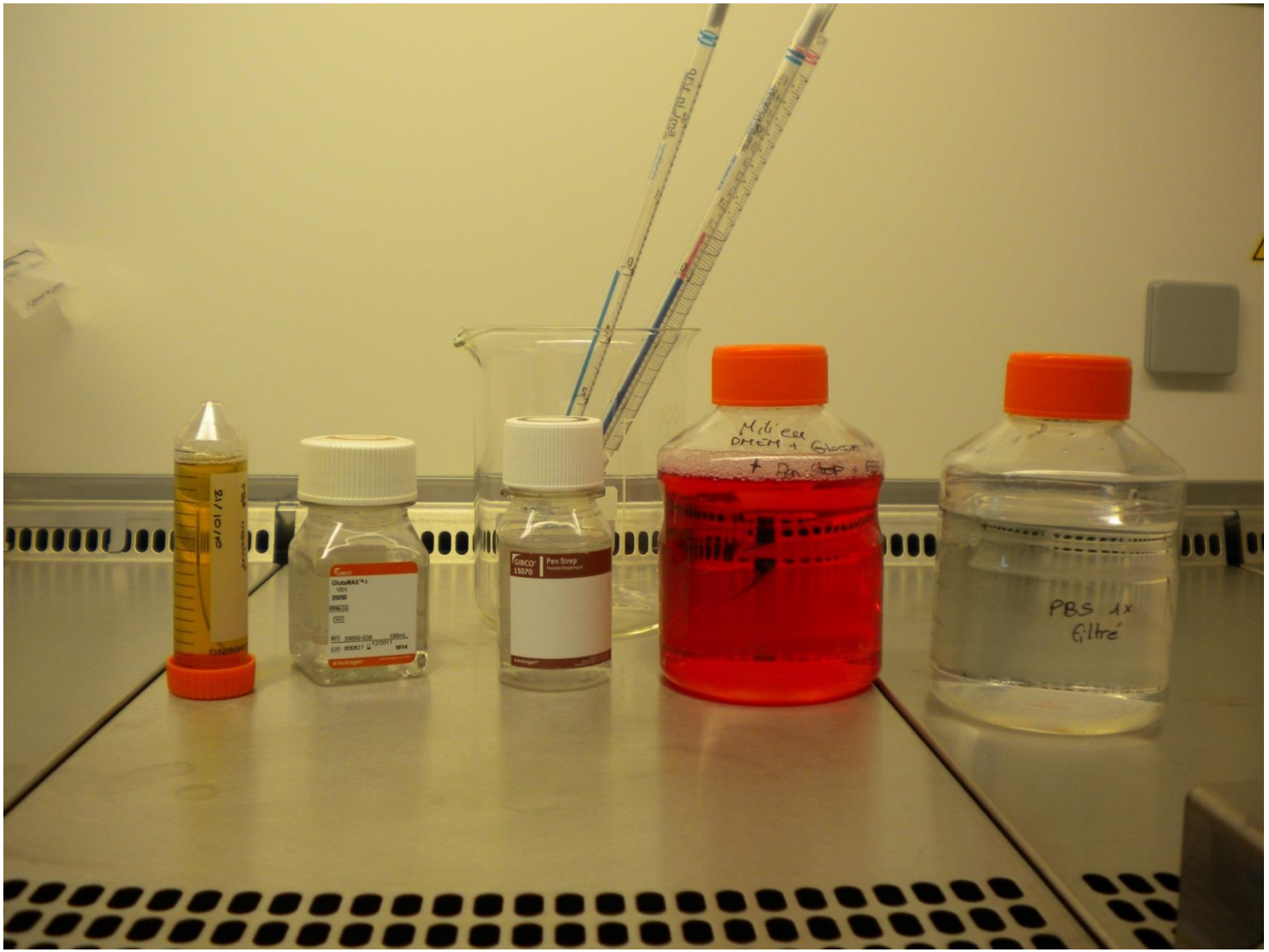


Figure 8-5 *Molecular Biology of the Cell* (© Garland Science 2008)

Tissue culture



MINES Saint-Étienne

Cell Communication

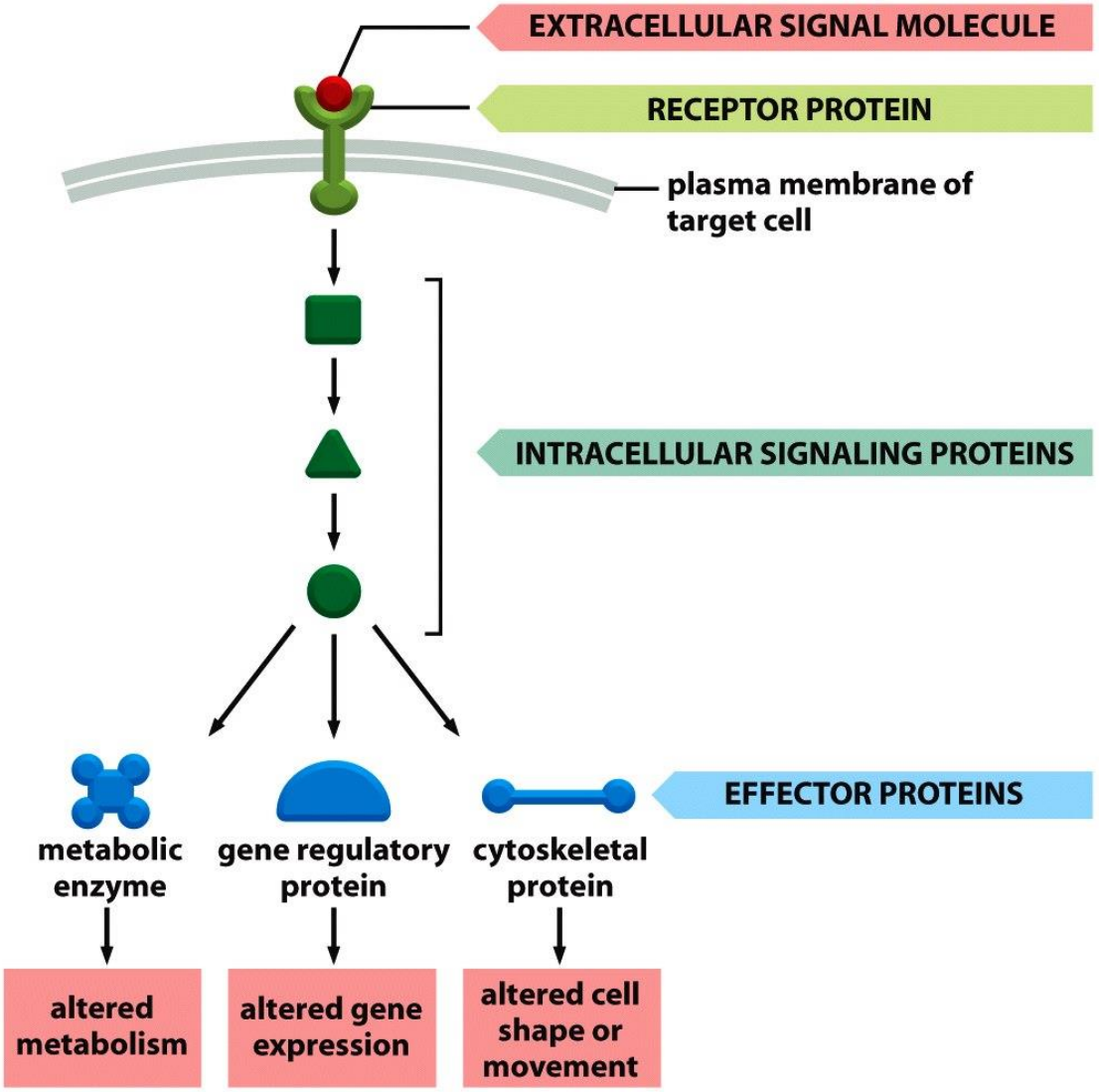


Figure 15-1 *Molecular Biology of the Cell* (© Garland Science 2008)

Extracellular receptors

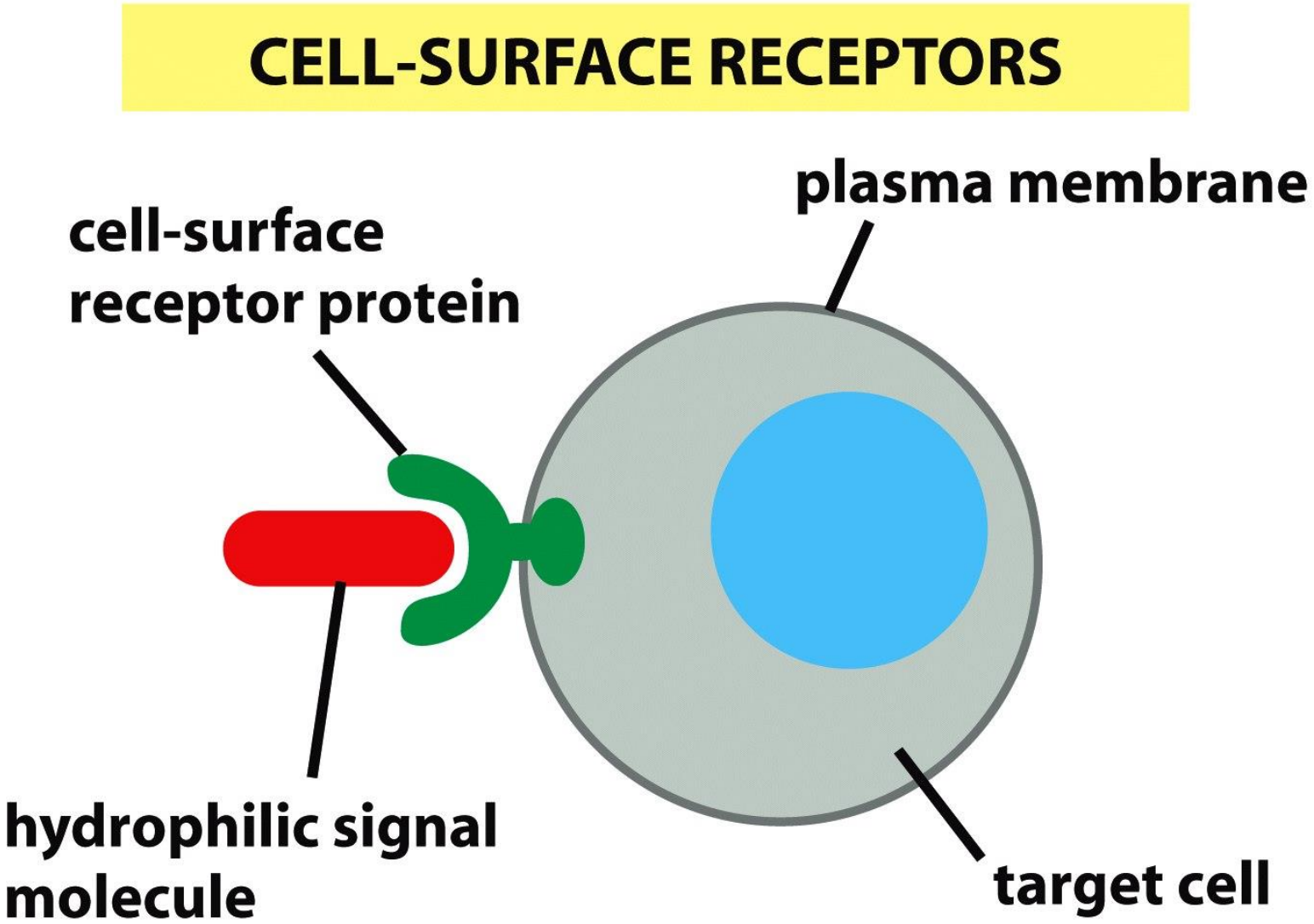


Figure 15-3a *Molecular Biology of the Cell* (© Garland Science 2008)

Intracellular receptors

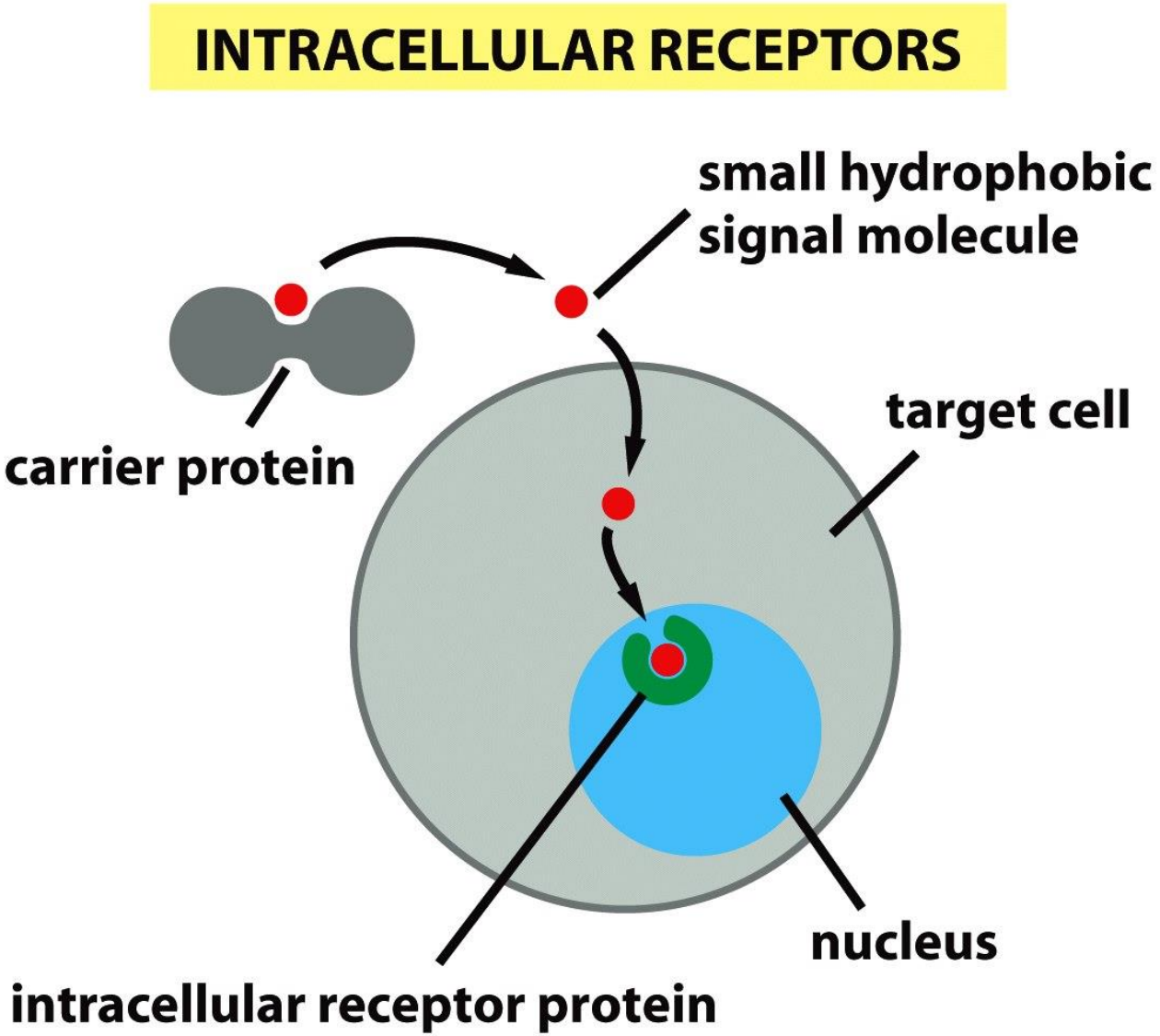


Figure 15-3b *Molecular Biology of the Cell* (© Garland Science 2008)

Types of signalling molecules

- Proteins
- Small peptides
- Amino acids
- Nucleotides
- Steroids
- Retinoids
- Fatty acid derivatives
- Dissolved gases (NO, CO)

Intercellular signalling

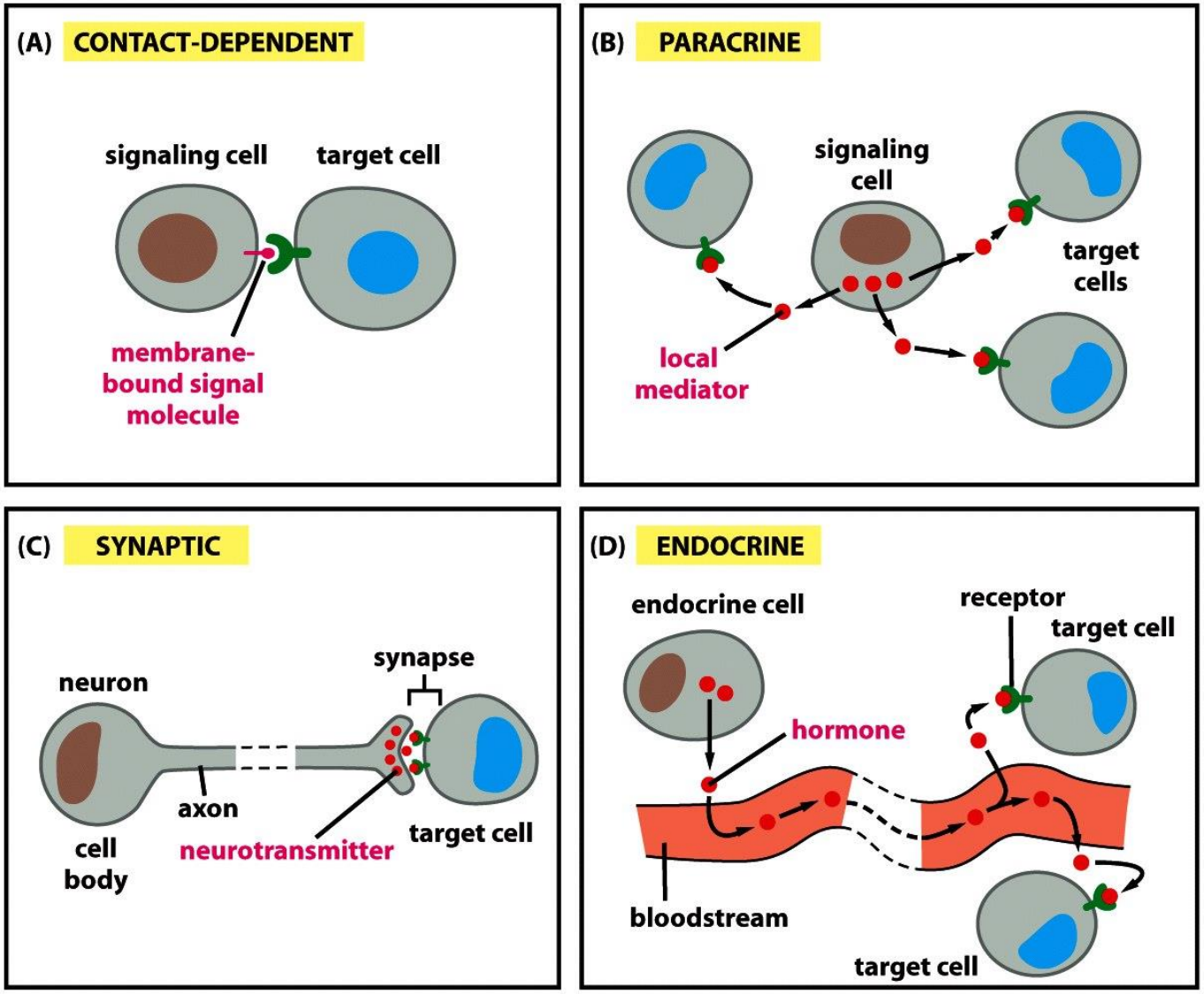


Figure 15-4 *Molecular Biology of the Cell* (© Garland Science 2008)

Signalling can be slow or fast

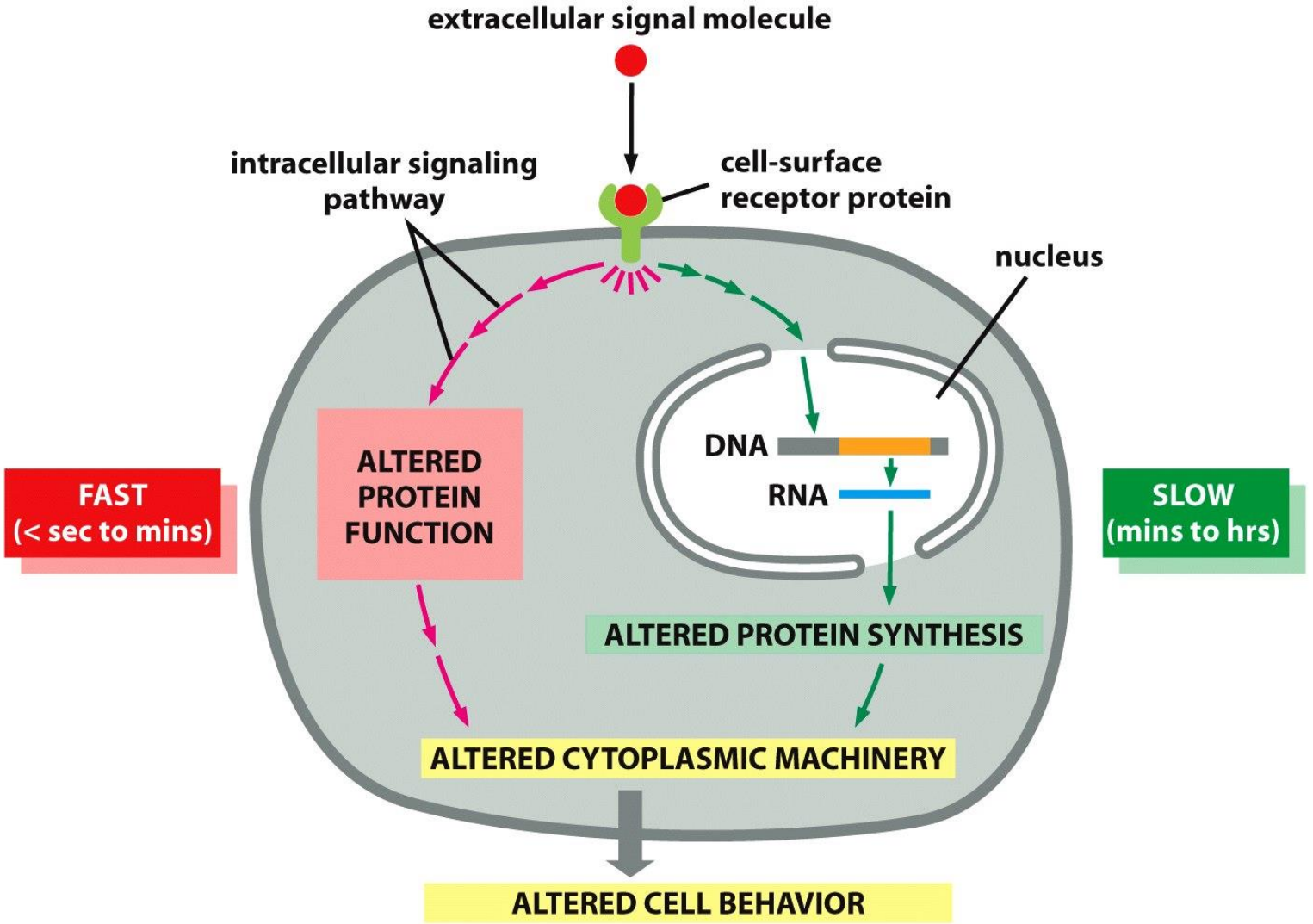


Figure 15-6 *Molecular Biology of the Cell* (© Garland Science 2008)

Cells selectively respond to signals

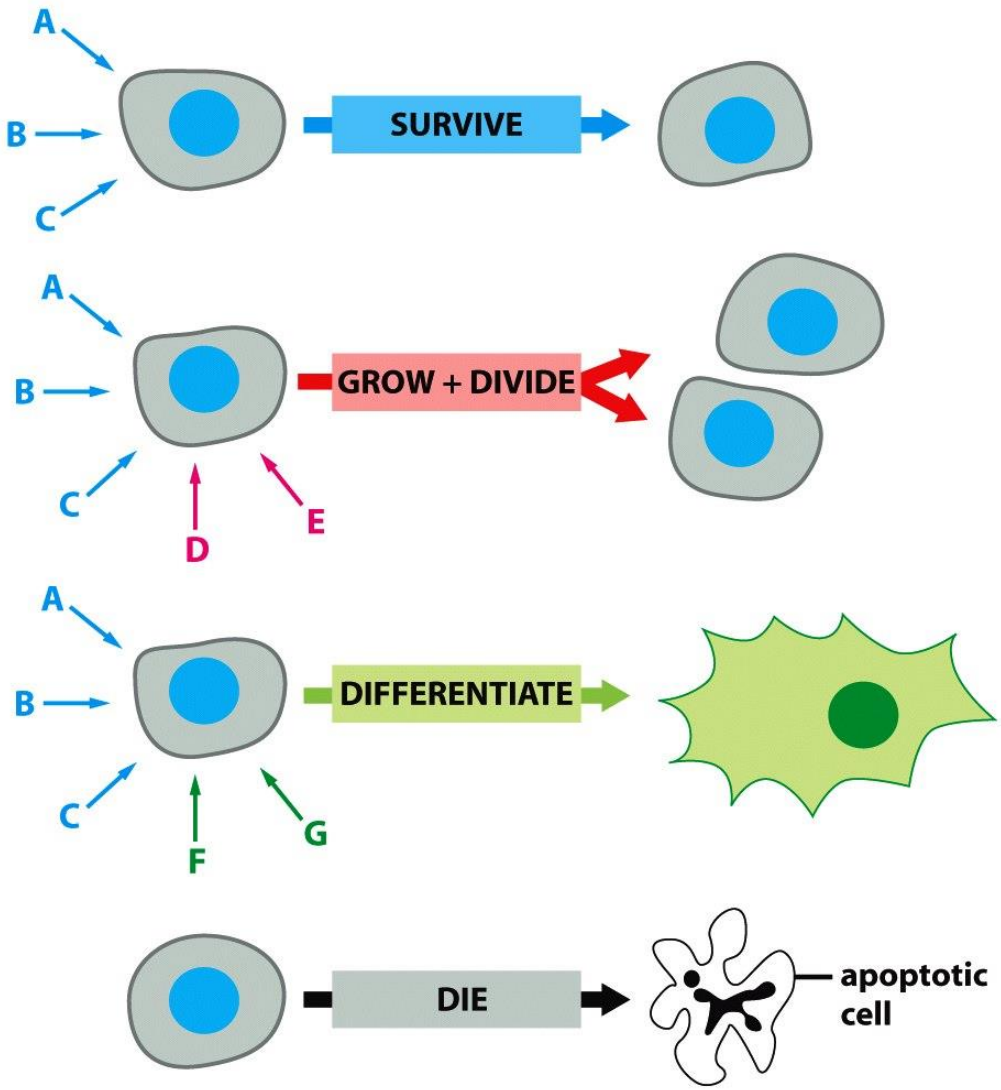


Figure 15-8 *Molecular Biology of the Cell* (© Garland Science 2008)

A sample signalling pathway

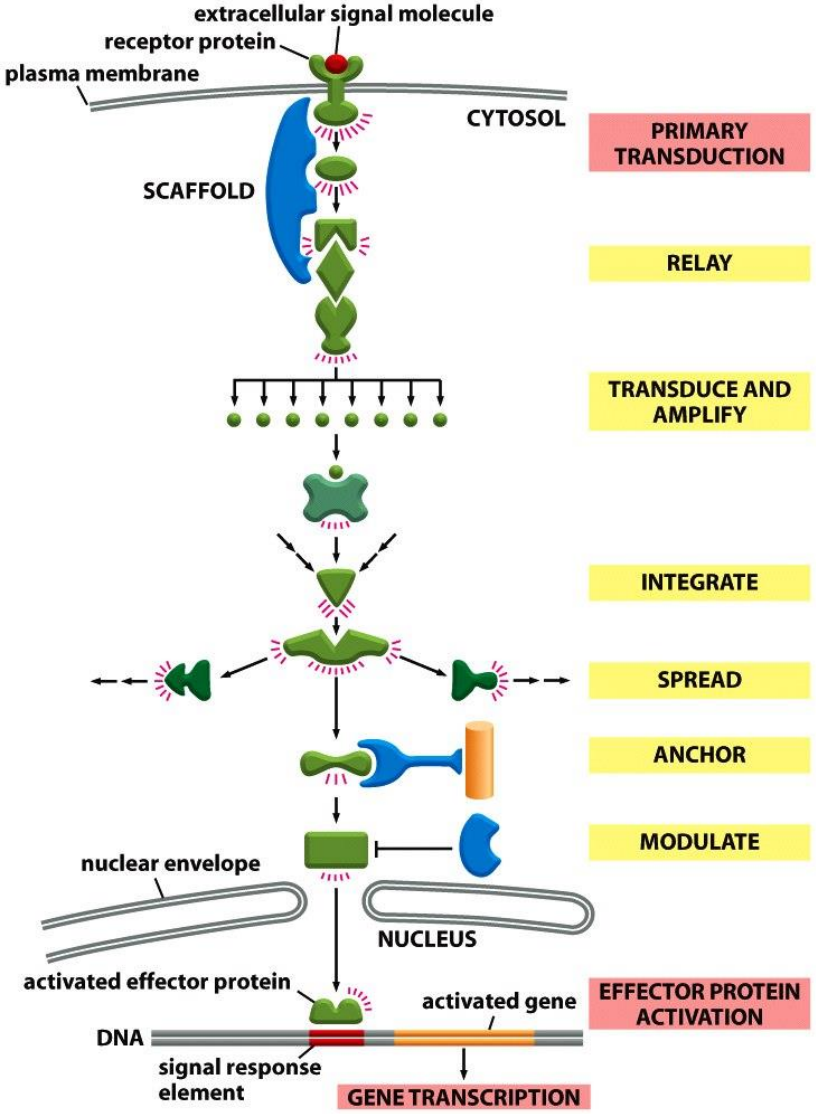


Figure 15-17 *Molecular Biology of the Cell* (© Garland Science 2008)

Ca^{2+} is a ubiquitous mediator

Location	Ca^{2+} concentration
Cytosol	10^{-7} M
Extracellular fluid	10^{-3} M
ER	10^{-4} M

Egg fertilisation triggers Ca^{2+}

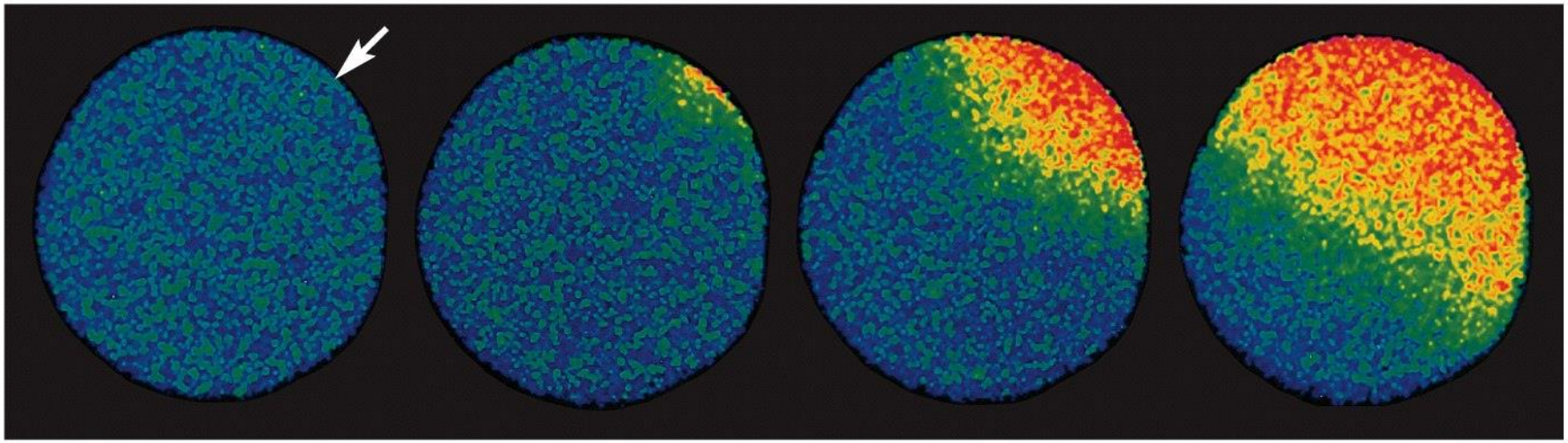
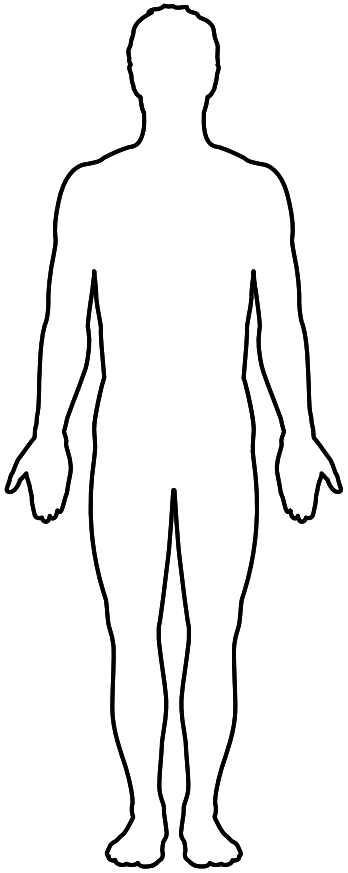


Figure 15-40 *Molecula* 2008)

MINES Saint-Étienne

Tissue types



Four Types of Animal Tissue:

1. *Epithelial/Barrier Tissue*
   - *Covers body surfaces and lines organs, cavities and ducts, glands too*
2. *Connective Tissue*
   - *Protects and supports. Bind organs, stores energy as fat, helps provide immunity*
3. *Muscle Tissue*
   - *Generates physical force to make body move and generates body heat*
4. *Nervous Tissue*
   - *Detects changes in environment inside and out and responds by generating action potentials that activate muscle contractions and secretions*

Cell junctions, adhesions and ECM

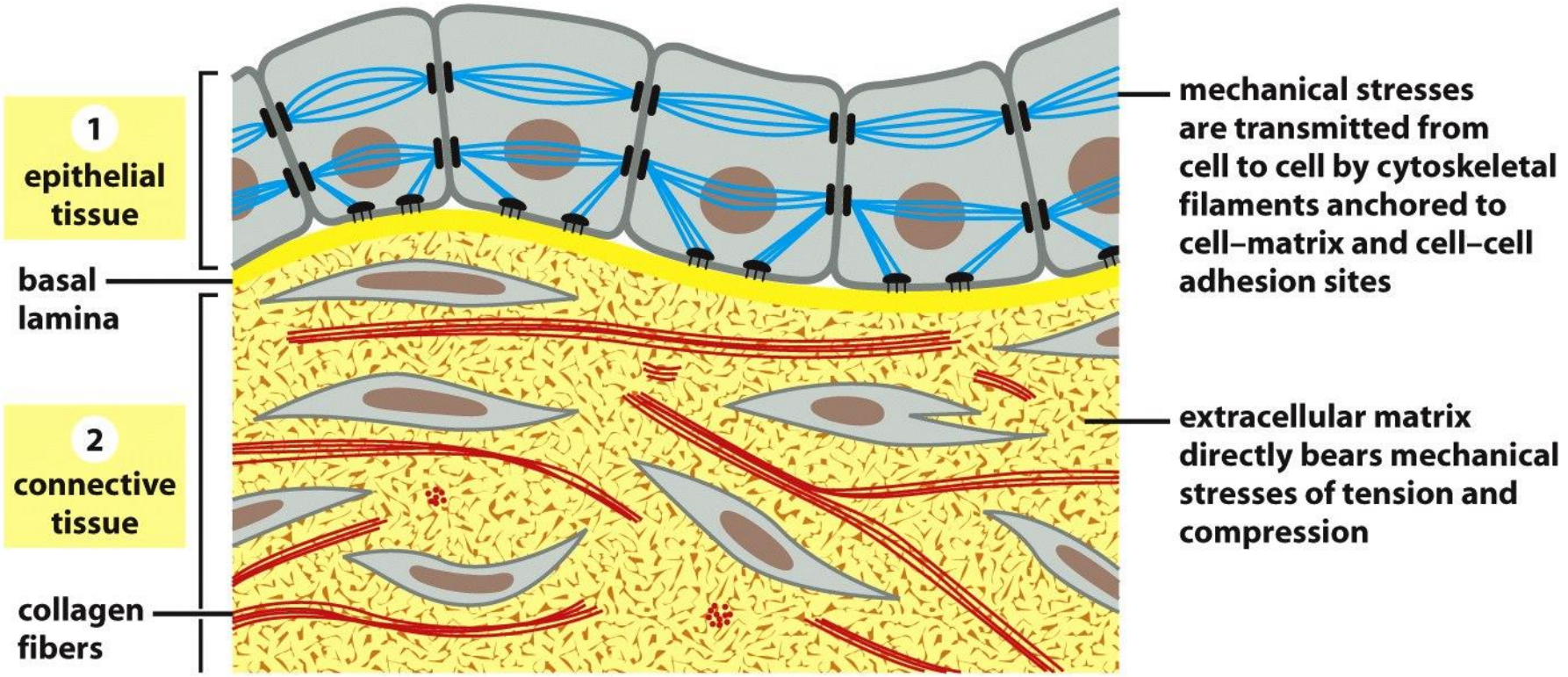


Figure 19-1 *Molecular Biology of the Cell* (© Garland Science 2008)

Cell junctions

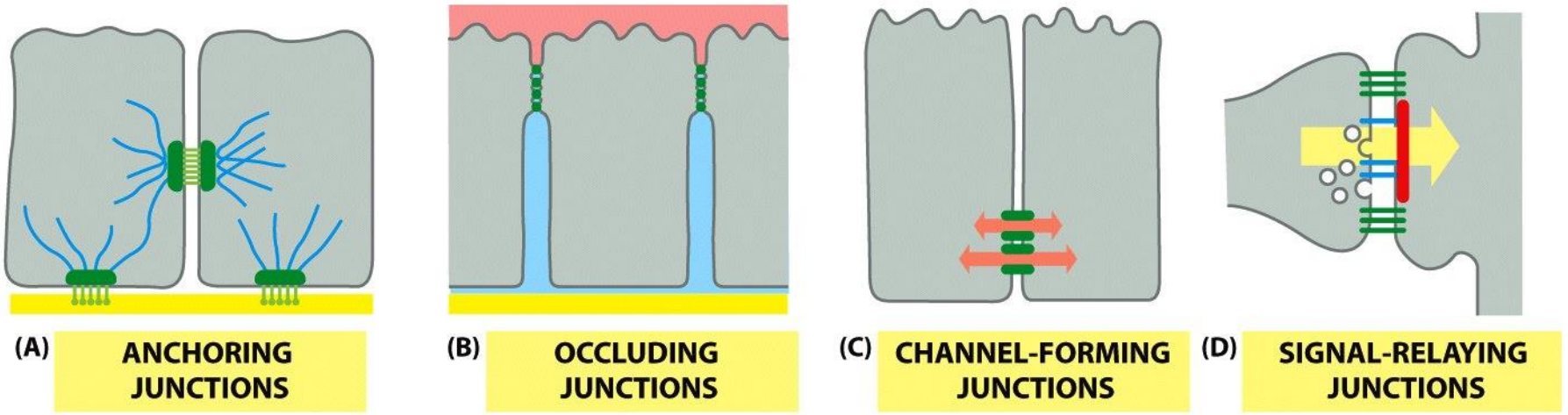


Figure 19-2 *Molecular Biology of the Cell* (© Garland Science 2008)

Cell junctions

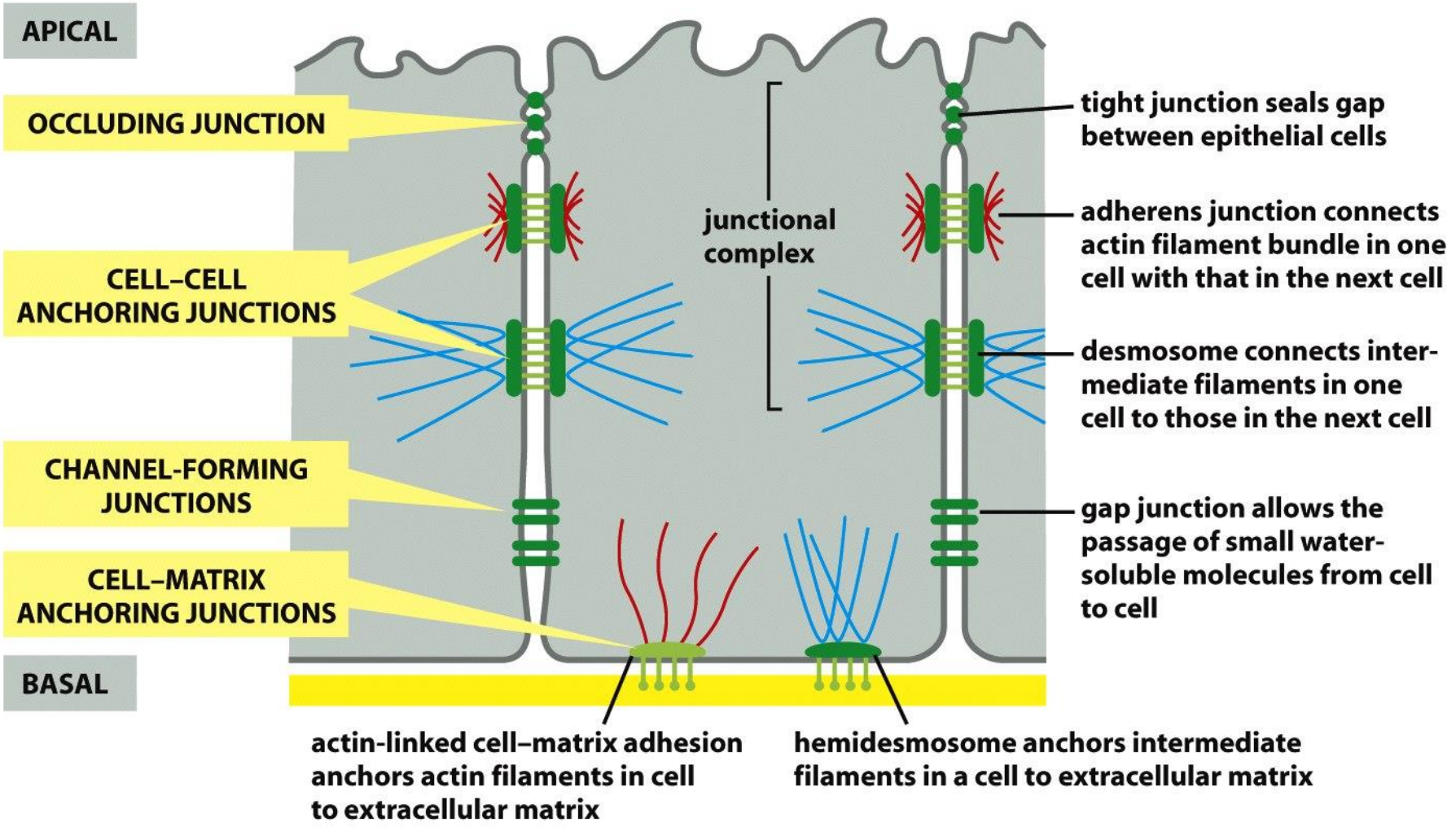


Figure 19-3 *Molecular Biology of the Cell* (© Garland Science 2008)

Basal lamina /basement membrane

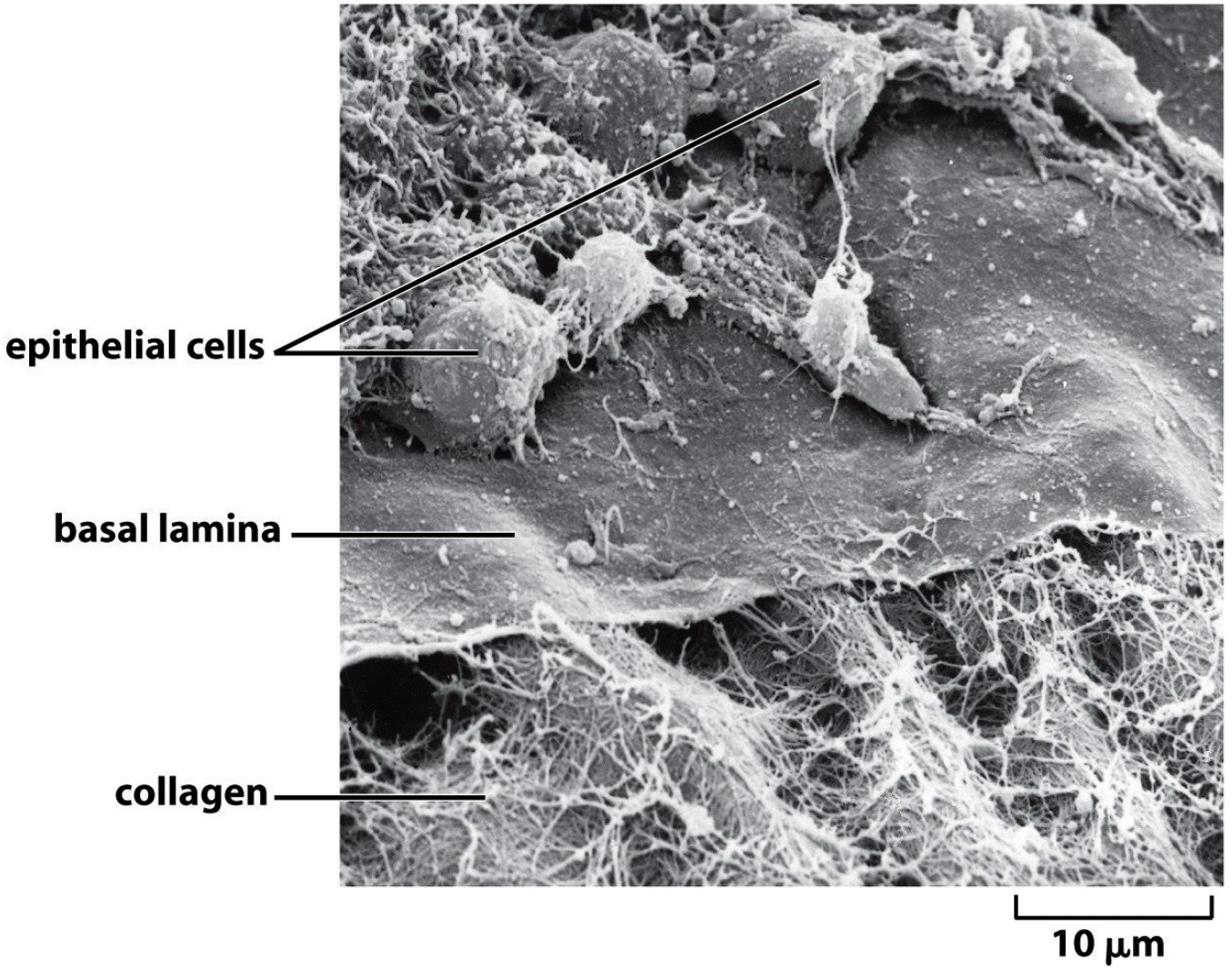


Figure 19-40 *Molecular Biology of the Cell* (© Garland Science 2008)

ECM molecules

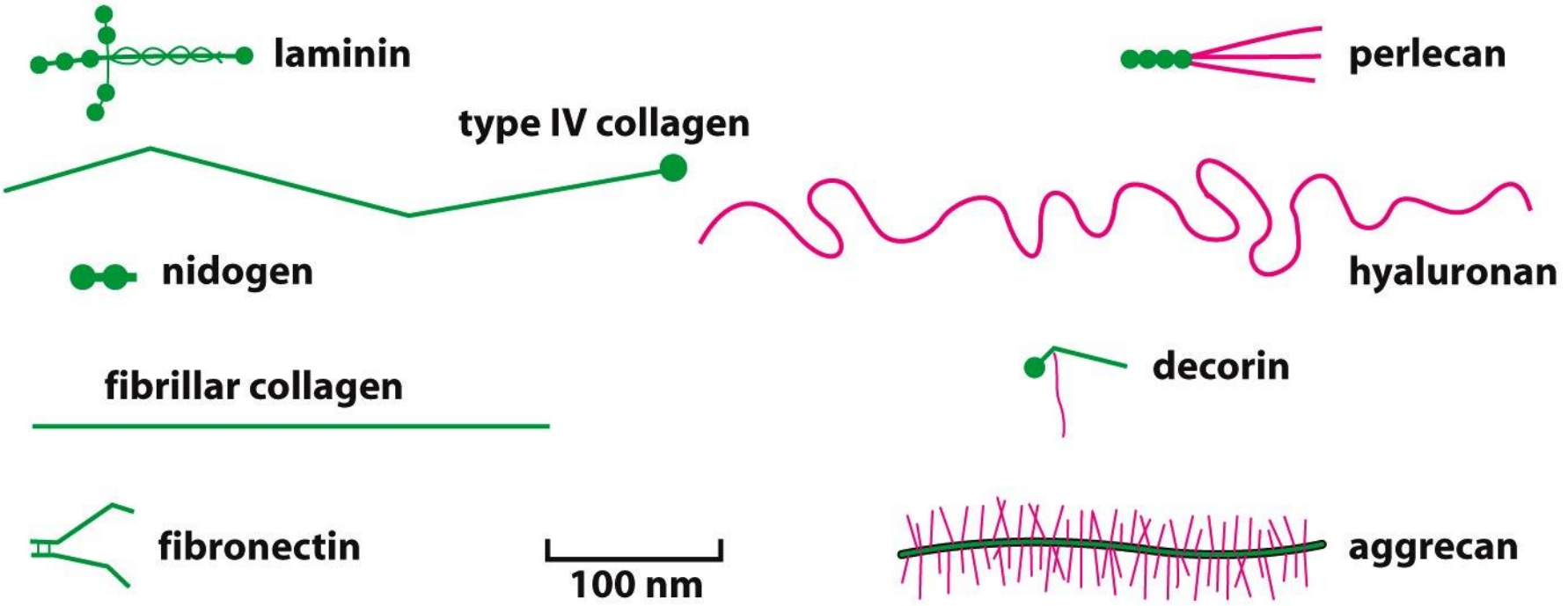


Figure 19-41 *Molecular Biology of the Cell* (© Garland Science 2008)

Model of basal lamina

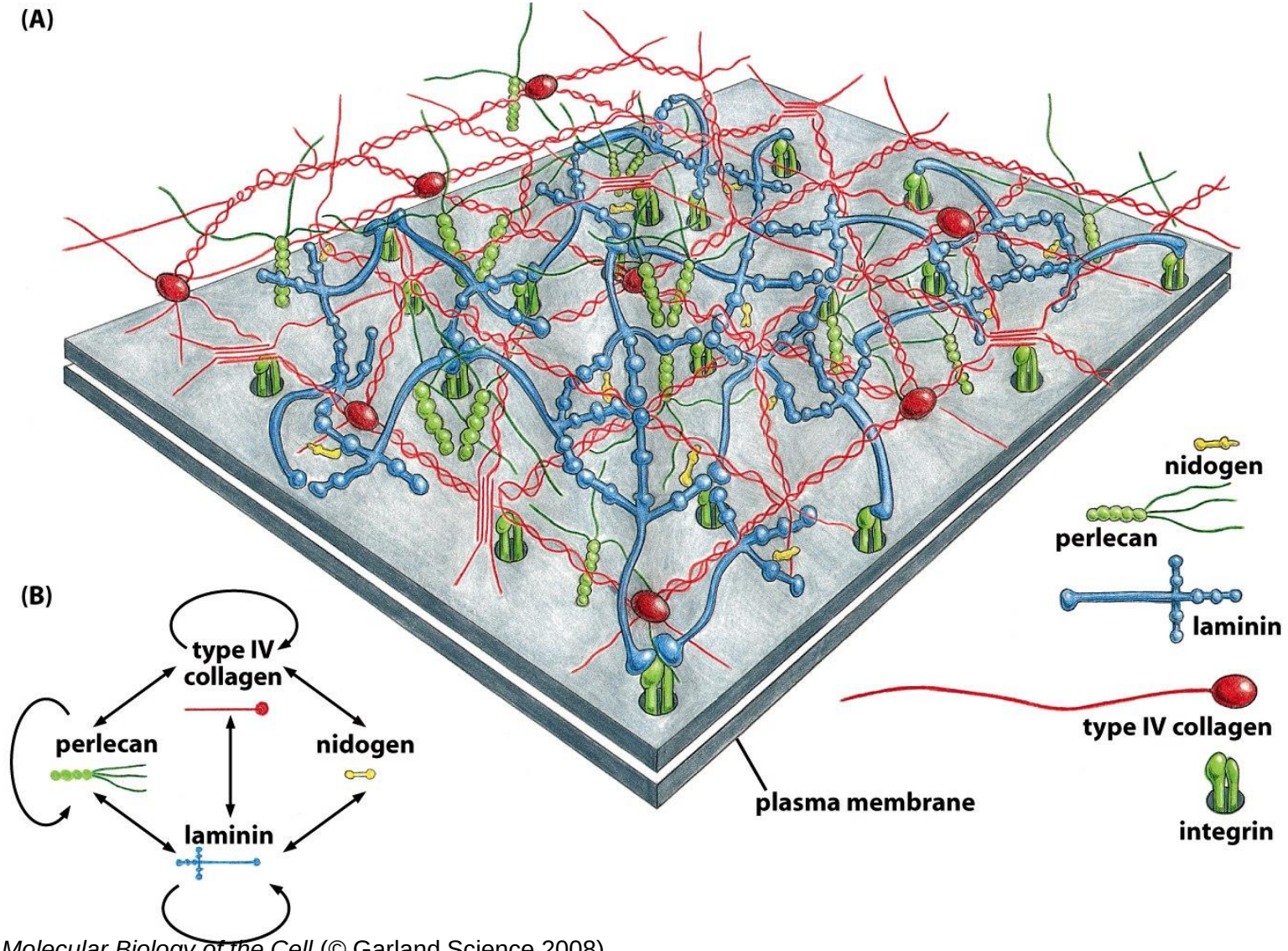


Figure 19-43 *Molecular Biology of the Cell* (© Garland Science 2008)

ECM molecules: integrins

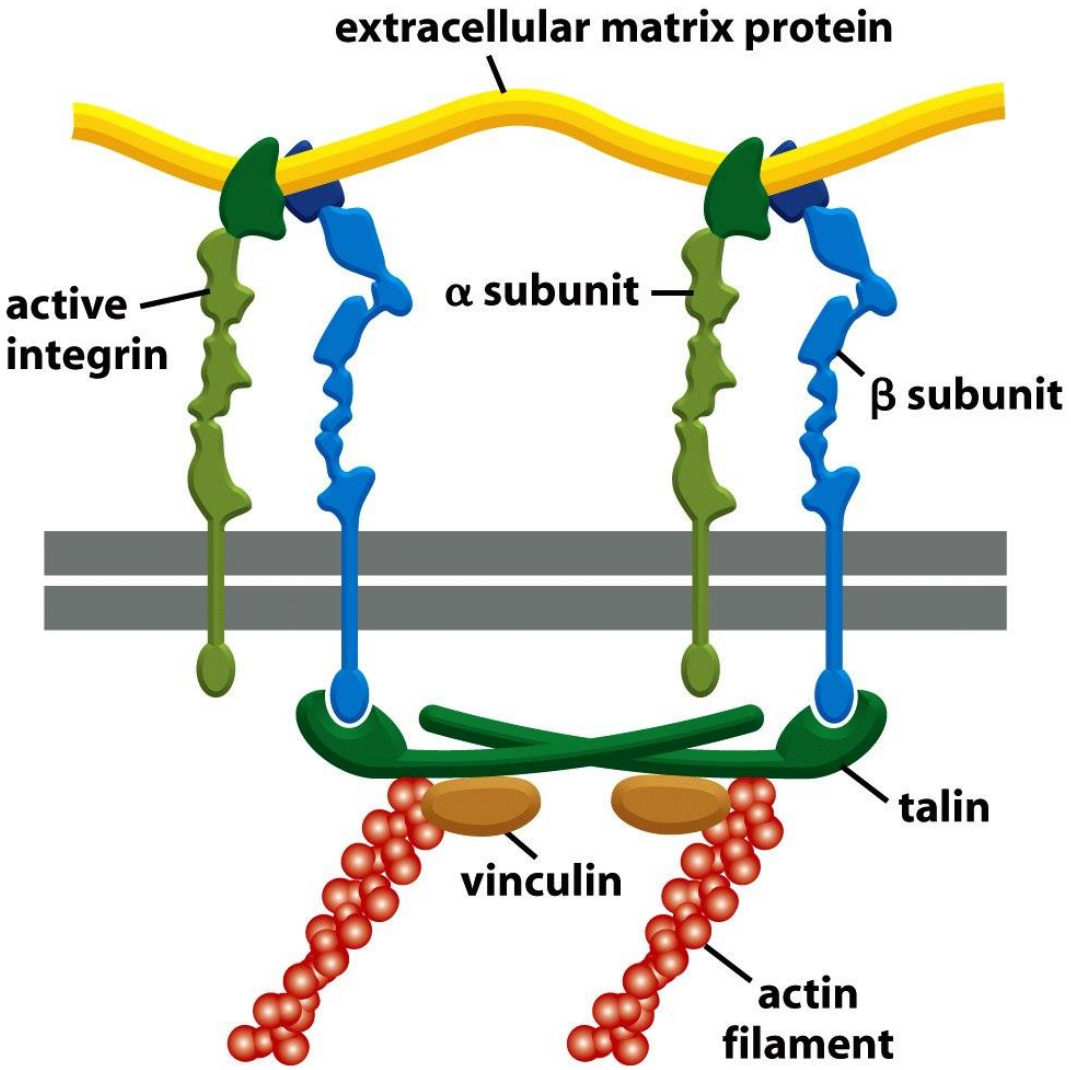


Figure 19-45 *Molecular Biology of the Cell* (© Garland Science 2008)

Integrin mediated T cell activation

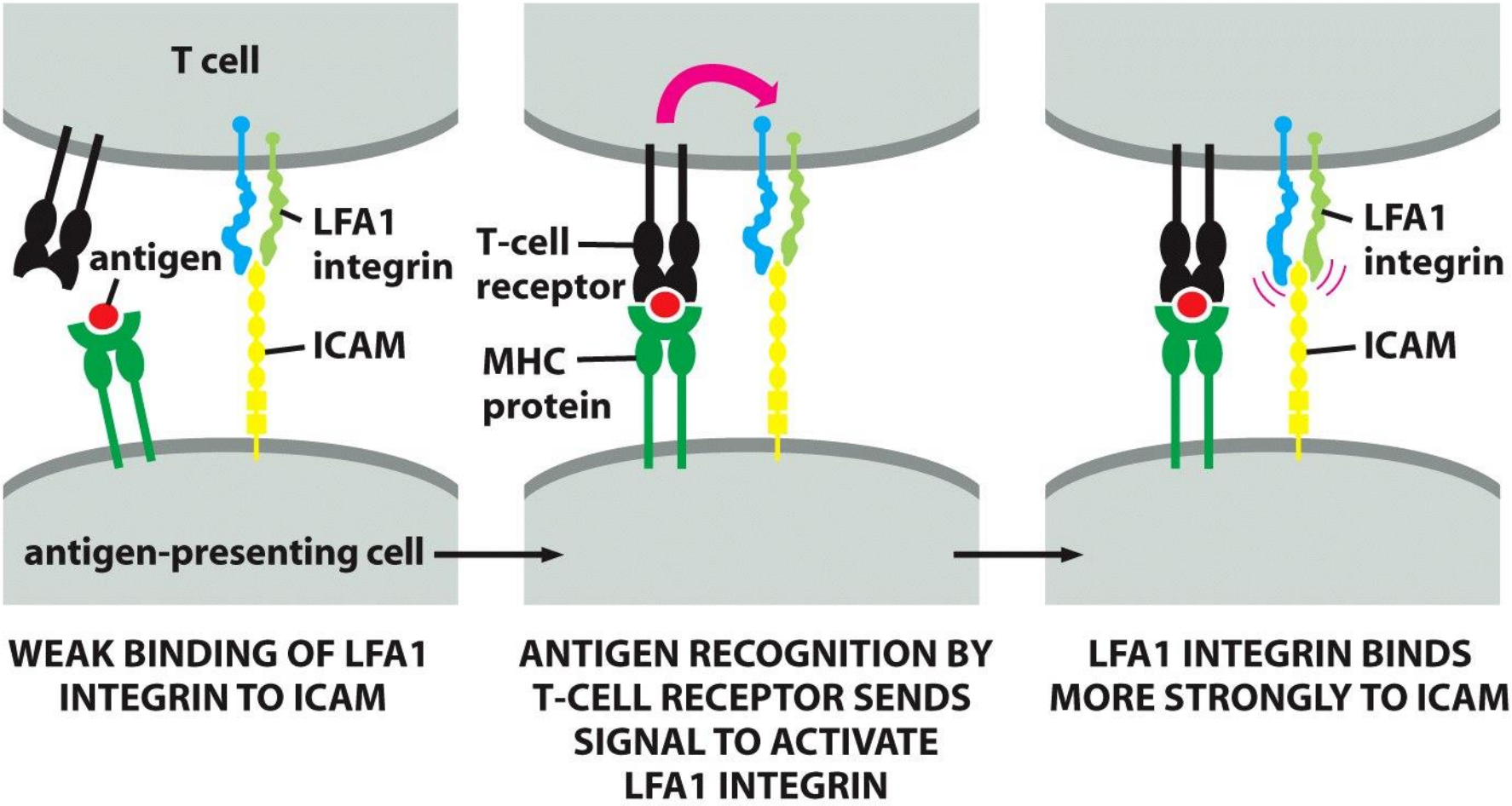


Figure 19-50 *Molecular Biology of the Cell* (© Garland Science 2008)

Adhesion molecule summary

Table 19–5 Cell Adhesion Molecule Families

	SOME FAMILY MEMBERS	Ca^{2+} OR Mg^{2+} DEPENDENCE	HOMOPHILIC OR HETEROPHILIC	CYTOSKELETON ASSOCIATIONS	CELL JUNCTION ASSOCIATIONS
Cell–Cell Adhesion					
Classical cadherins	E, N, P, VE	yes	homophilic	actin filaments (via catenins)	adherens junctions, synapses
Desmosomal cadherins	desmoglein, desmocollin	yes	homophilic	intermediate filaments (via desmoplakin, plakoglobin, and plakophilin)	desmosomes
Ig family members	N-CAM, ICAM	no	both	unknown	neuronal and immunological synapses
Selectins (blood cells and endothelial cells only)	L-, E-, and P-selectins	yes	heterophilic	actin filaments	(no prominent junctional structure)
Integrins on blood cells	αLβ2 (LFA1)	yes	heterophilic	actin filaments	immunological synapses
Cell–Matrix Adhesion					
Integrins	many types	yes	heterophilic	actin filaments (via talin, paxillin, filamin, α-actinin, and vinculin)	focal adhesions
	α6β4	yes	heterophilic	intermediate filaments (via plectin and dystonin)	hemidesmosomes
Transmembrane proteoglycans	syndecans	no	heterophilic	actin filaments	(no prominent junctional structure)

Table 19-5 *Molecular Biology of the Cell* (© Garland Science 2008)

Connective tissue

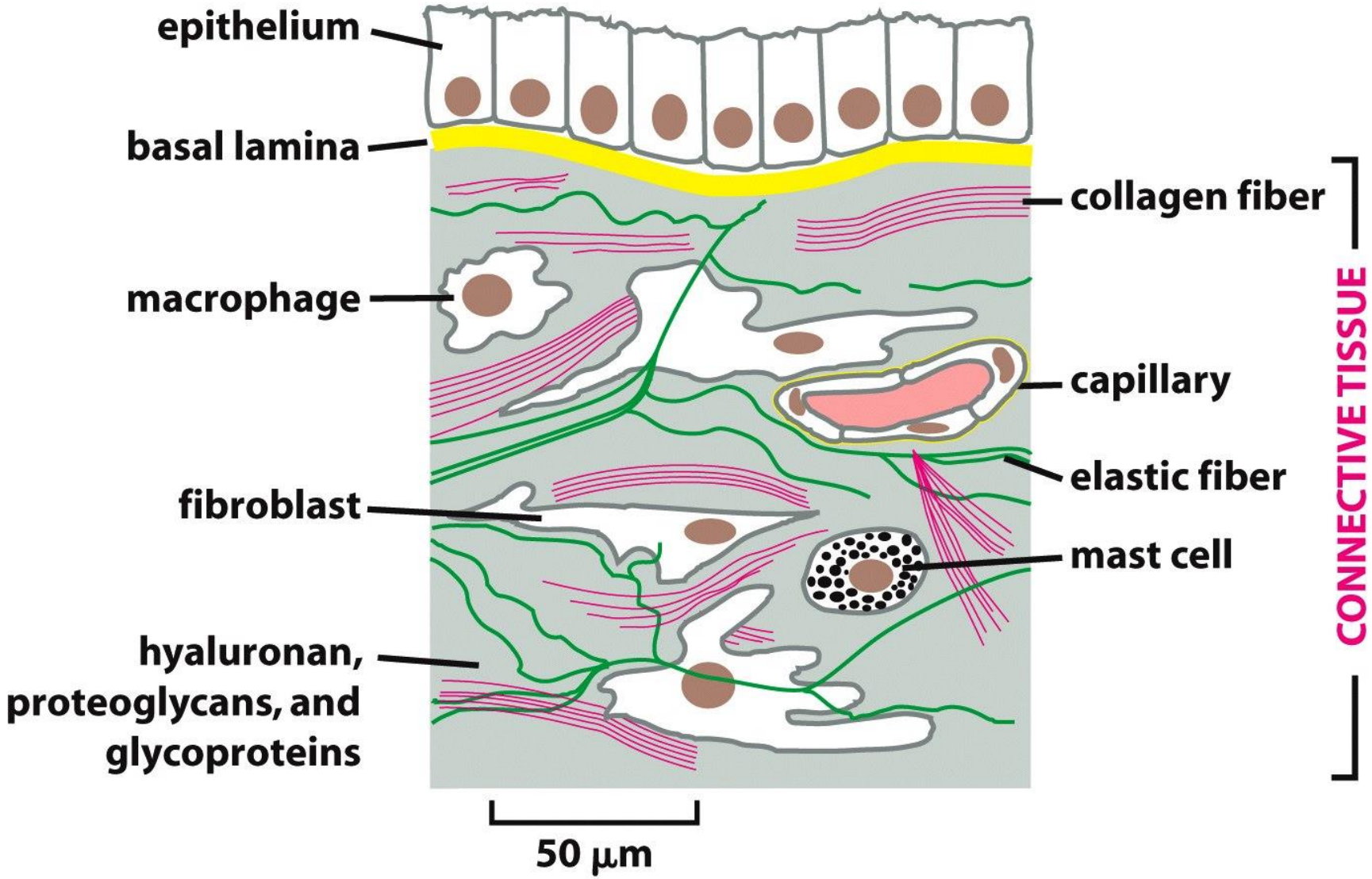
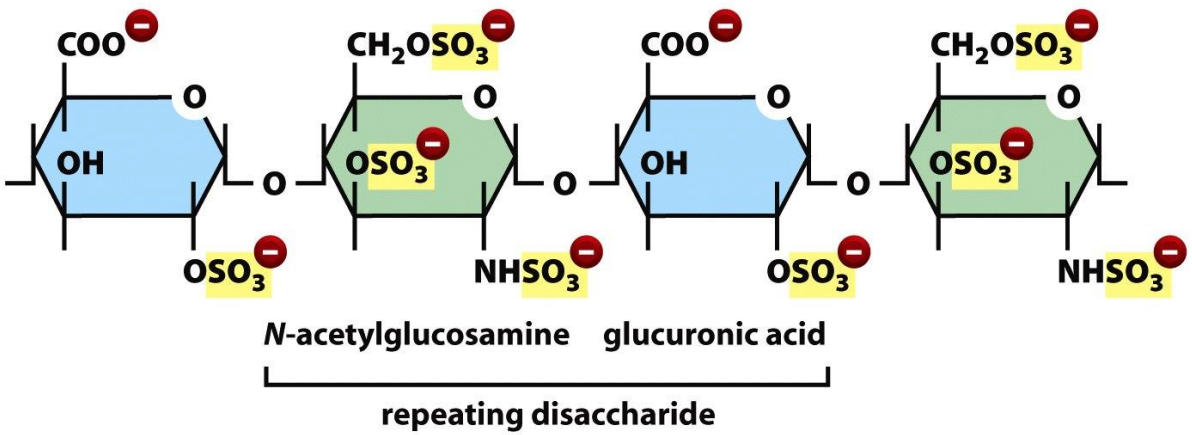
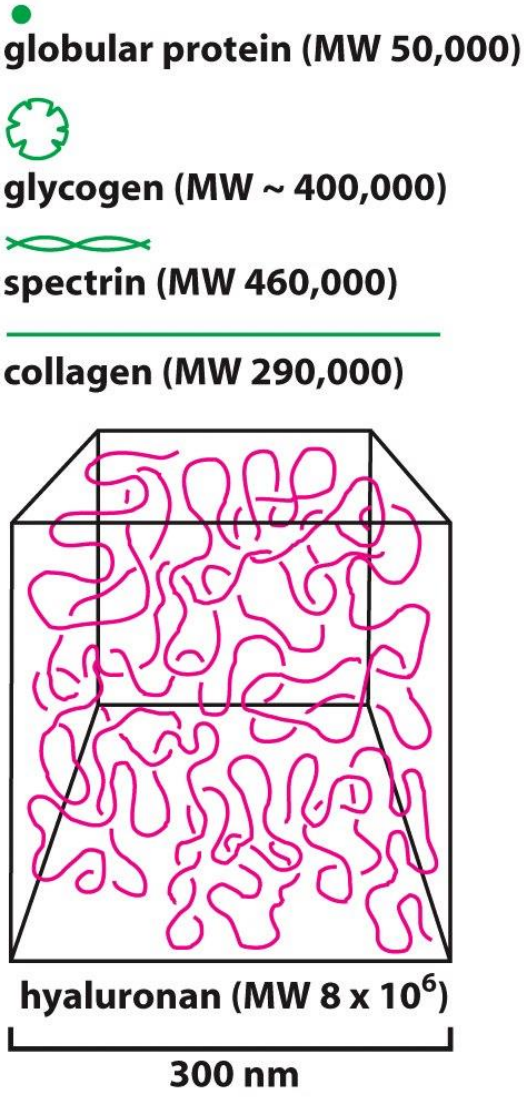


Figure 19-53 *Molecular Biology of the Cell* (© Garland Science 2008)

Connective tissue: hydrogels





Glycosaminoglycans:

- Hyaluronic acid
- Chondroitin sulfate
- Dermatan sulfate
- Heparan sulfate
- Keratan sulfate

Figure 19-55 *Molecular Biology of the Cell* (© Garland Science 2008)

Neurons

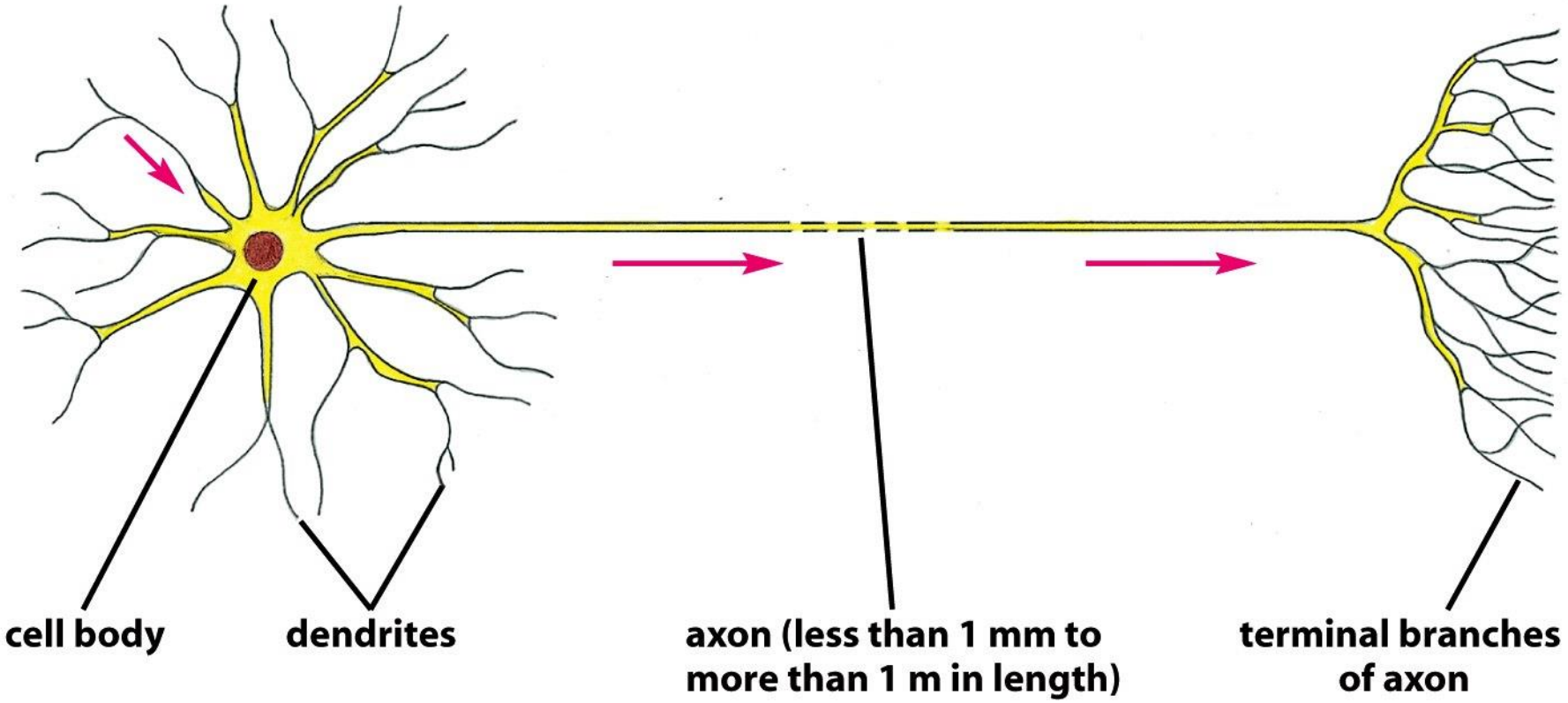


Figure 11-28 *Molecular Biology of the Cell* (© Garland Science 2008)

Neurons

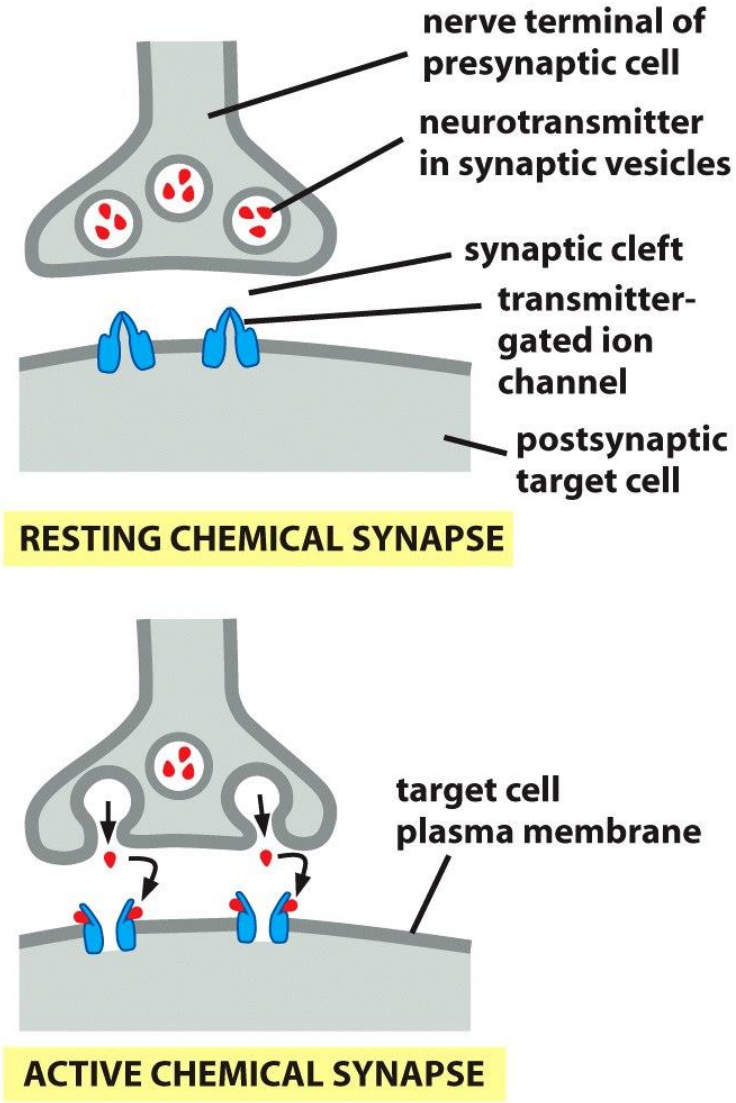


Figure 11-35a *Molecular Biology of the Cell* (© Garland Science 2008)

Neuromuscular junction

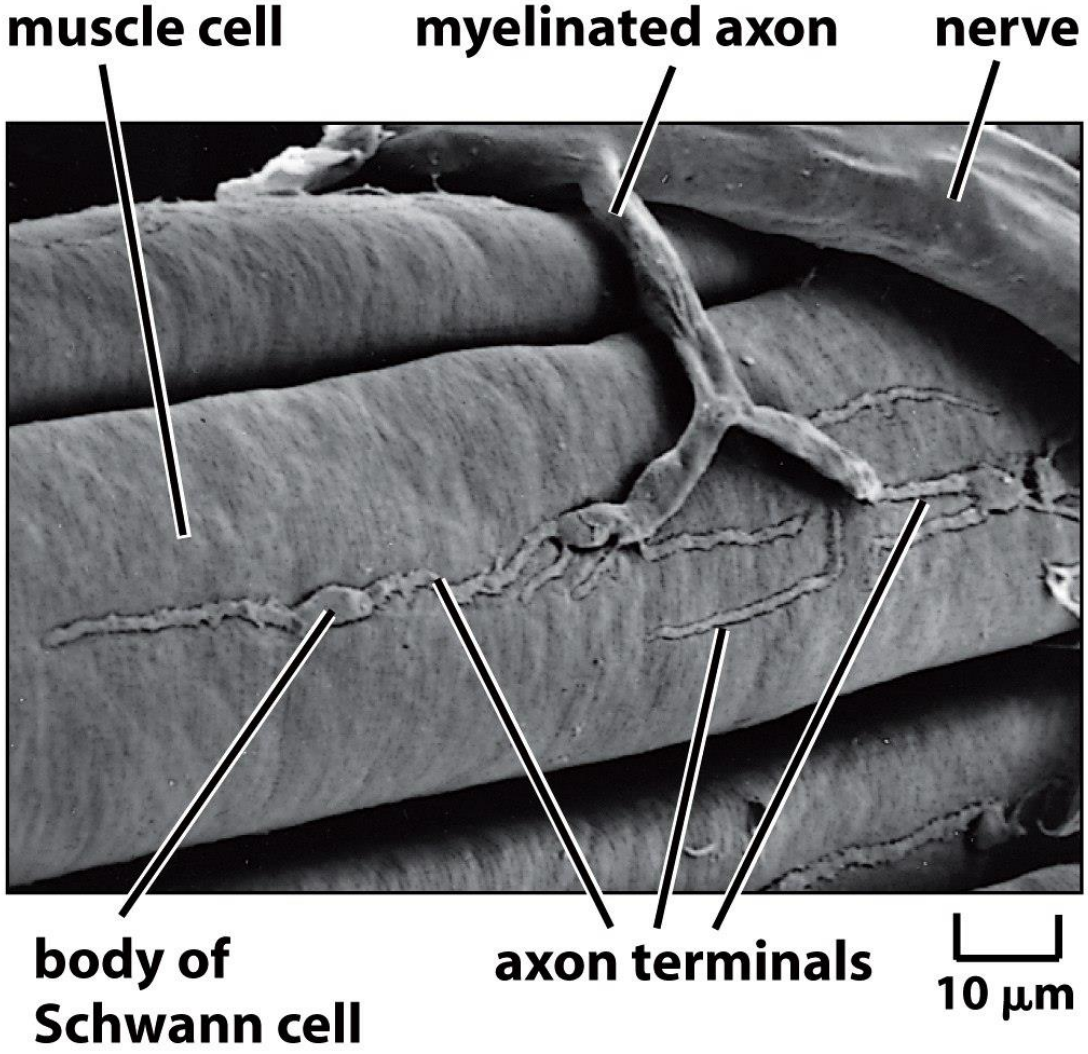


Figure 11-36 *Molecular Biology of the Cell* (© Garland Science 2008)

Synapses require complex adhesion

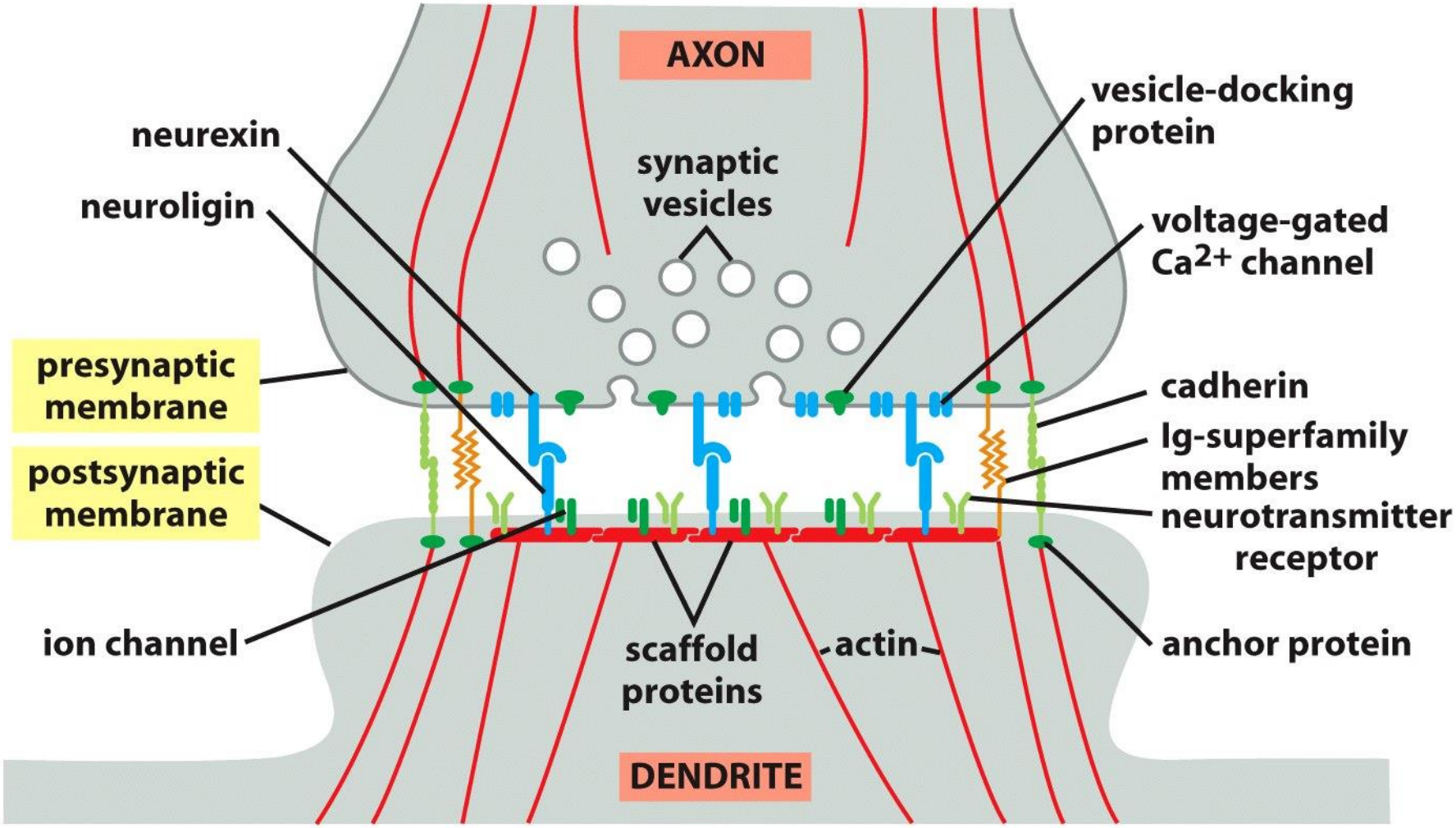


Figure 19-22c *Molecular Biology of the Cell* (© Garland Science 2008)

Cellular Diversity

- The average adult has nearly 100 trillion cells
- There are about 200 different types of cells
- Cells come in a variety of shapes and sizes
- Cellular diversity permits organization of cells into more complex tissues and organs

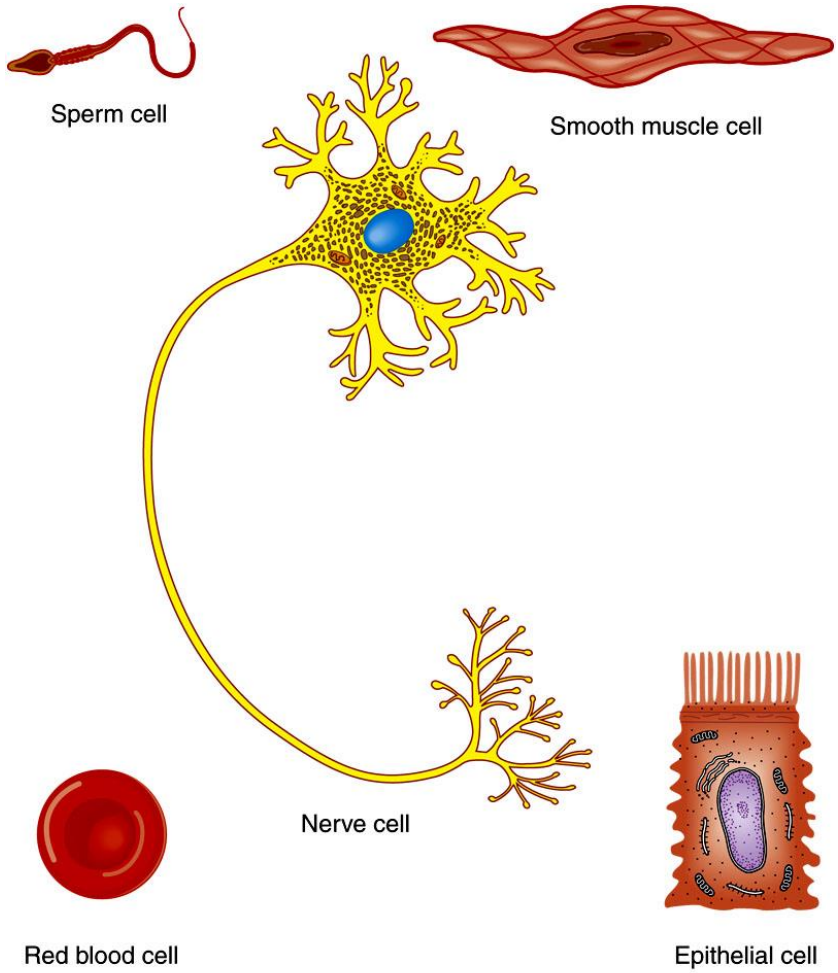
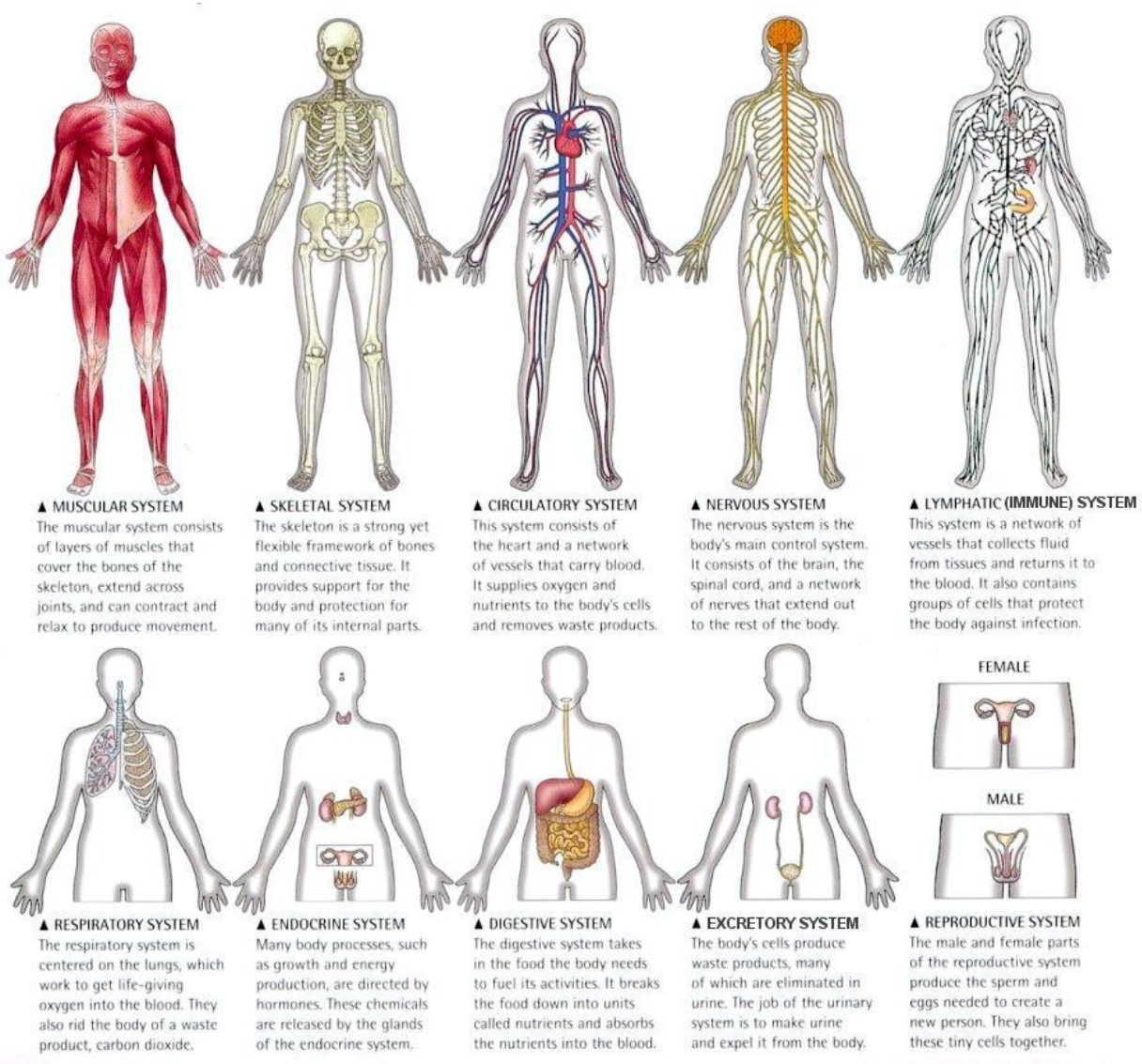


Figure 03.35 Tortora - PAP 12/e

What is a Tissue?

- **A tissue is a group of cells**
  - Common embryonic origin
  - Function together to carry out specialized activities
- **Hard (bone), semisolid (fat), or liquid (blood)**
- **Histology is the science that deals with the study of tissues.**
- **Pathologist specialized in laboratory studies of cells and tissue for diagnoses**

Tissues as building blocks of organ systems



▲ MUSCULAR SYSTEM
The muscular system consists of layers of muscles that cover the bones of the skeleton, extend across joints, and can contract and relax to produce movement.

▲ SKELETAL SYSTEM
The skeleton is a strong yet flexible framework of bones and connective tissue. It provides support for the body and protection for many of its internal parts.

▲ CIRCULATORY SYSTEM
This system consists of the heart and a network of vessels that carry blood. It supplies oxygen and nutrients to the body's cells and removes waste products.

▲ NERVOUS SYSTEM
The nervous system is the body's main control system. It consists of the brain, the spinal cord, and a network of nerves that extend out to the rest of the body.

▲ LYMPHATIC (IMMUNE) SYSTEM
This system is a network of vessels that collects fluid from tissues and returns it to the blood. It also contains groups of cells that protect the body against infection.

▲ RESPIRATORY SYSTEM
The respiratory system is centered on the lungs, which work to get life-giving oxygen into the blood. They also rid the body of a waste product, carbon dioxide.

▲ ENDOCRINE SYSTEM
Many body processes, such as growth and energy production, are directed by hormones. These chemicals are released by the glands of the endocrine system.

▲ DIGESTIVE SYSTEM
The digestive system takes in the food the body needs to fuel its activities. It breaks the food down into units called nutrients and absorbs the nutrients into the blood.

▲ EXCRETORY SYSTEM
The body's cells produce waste products, many of which are eliminated in urine. The job of the urinary system is to make urine and expel it from the body.

FEMALE

MALE

▲ REPRODUCTIVE SYSTEM
The male and female parts of the reproductive system produce the sperm and eggs needed to create a new person. They also bring these tiny cells together.

Human body

↓

10 major organ systems

↓

Each organ (e.g., lung)

↓

Functional units (e.g., alveoli)

↓

Tissues

Epithelial Tissues

- **Epithelial tissue consists of cells arranged in continuous sheets, in either single or multiple layers**
  - Closely packed and held tightly together
  - Covering and lining of the body
  - Free surface
- **3 major functions:**
  - Selective barrier that regulates the movement of materials in and out of the body
  - Secretory surfaces that release products onto the free surface
  - Protective surfaces against the environment

General Features of Epithelial Cells

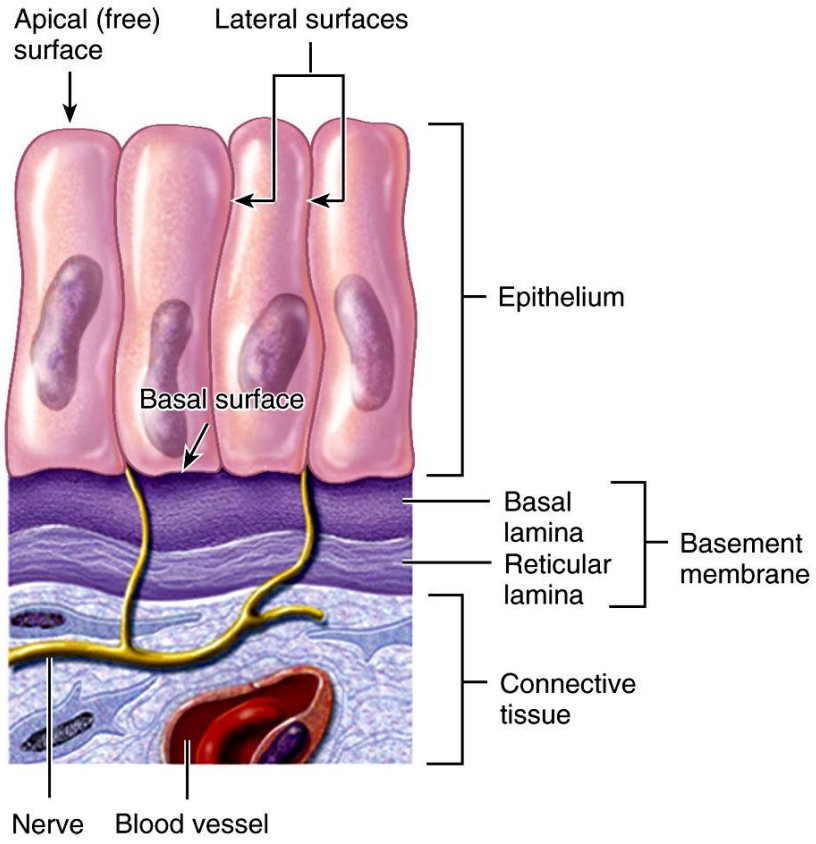


Figure 04.02 Tortora - PAP 12/e

Basement membrane

- Thin double extracellular layer that serves as the point of attachment and support for overlying epithelial tissue

Basal lamina

- Closer to and secreted by the epithelial cells
- Contains laminin, collagen, glycoproteins, and proteoglycans

Reticular lamina

- Closer to the underlying connective tissue
- Contains collagen secreted by the connective tissue cells

Connective tissue

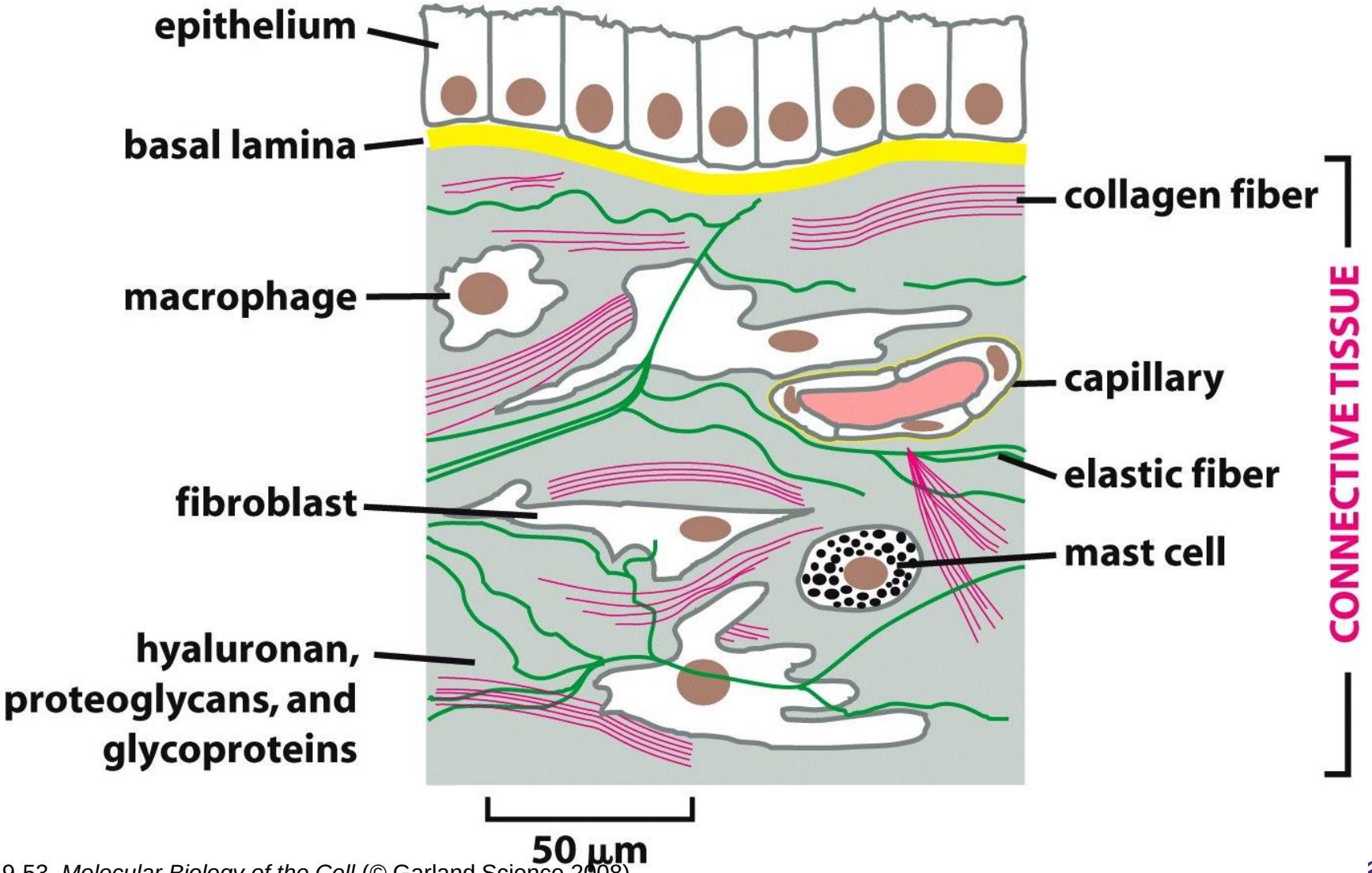


Figure 19-53 *Molecular Biology of the Cell* (© Garland Science 2008)

Connective Tissue

Most abundant and widely distributed tissues in the body

Numerous functions

- Binds tissues together
- Supports and strengthen tissue
- Protects and insulates internal organs
- Compartmentalize and transport
- Energy reserves and immune responses

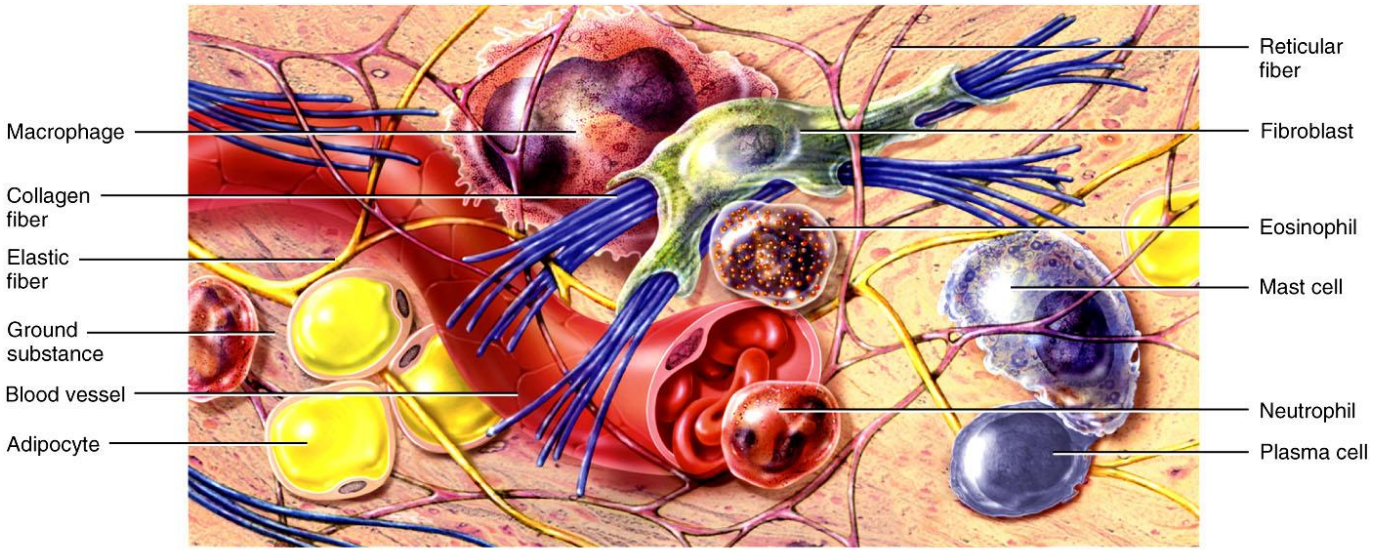


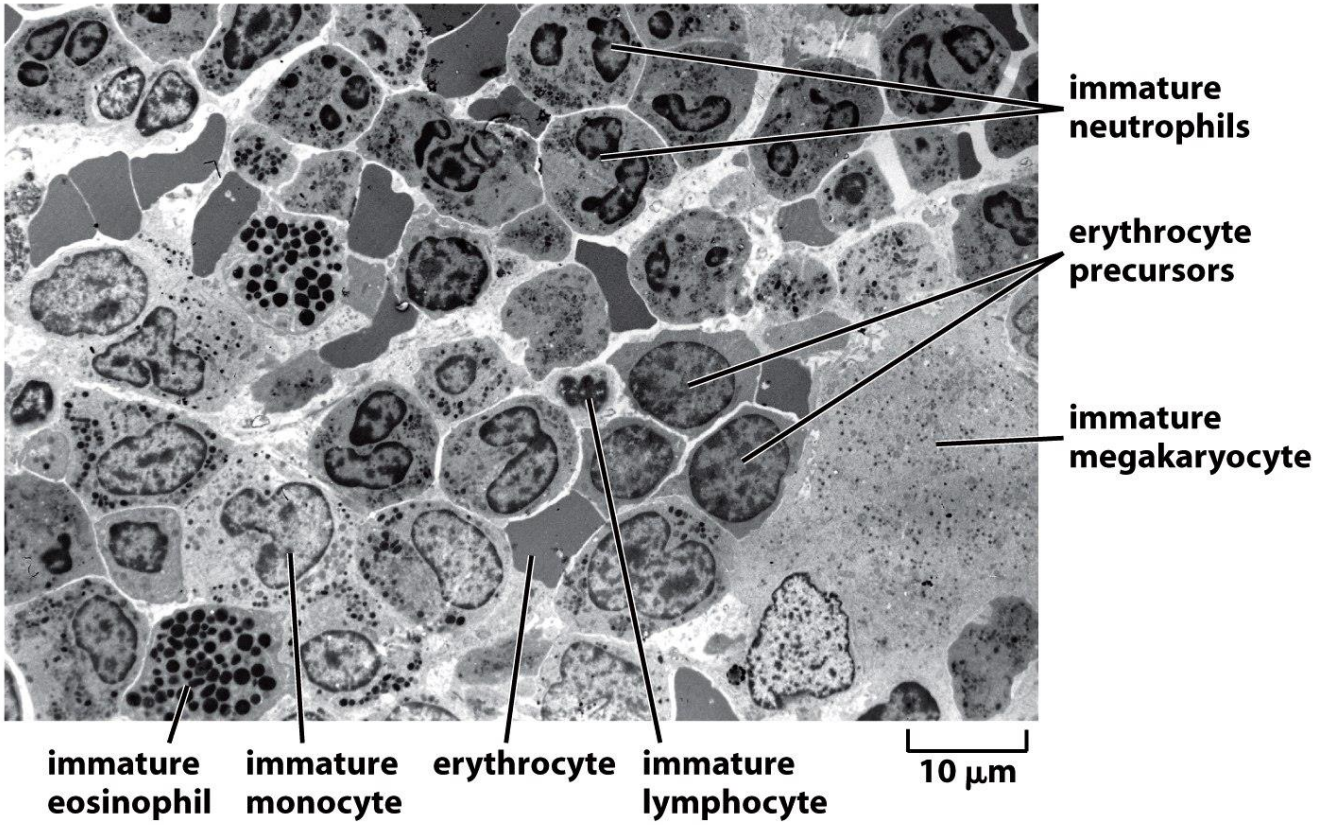
Figure 04.06 Tortora - PAP 12/e

Liquid Connective Tissue

Blood tissue

- Connective tissue with liquid extracellular matrix called blood plasma

Lymph



Blood cells

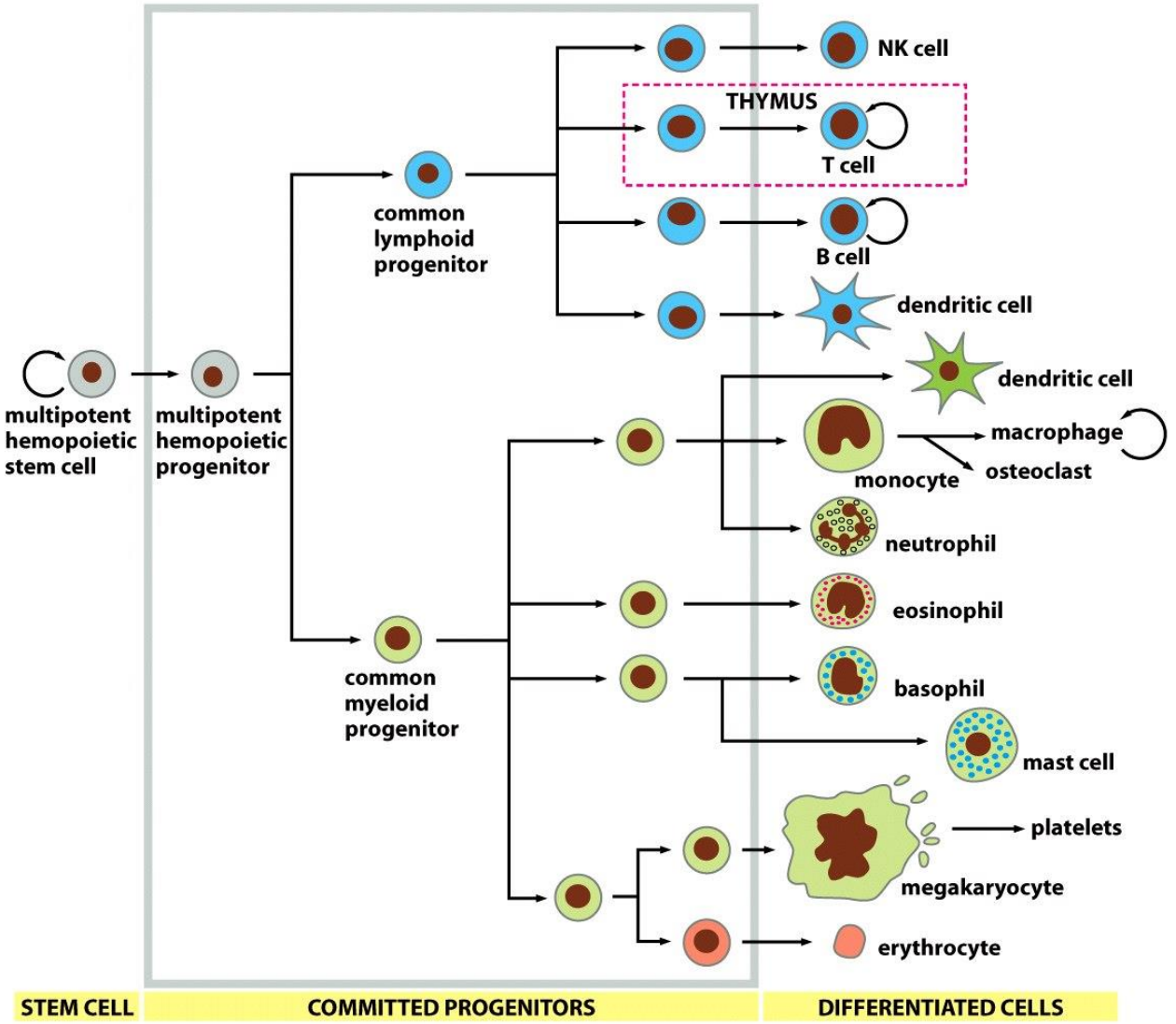
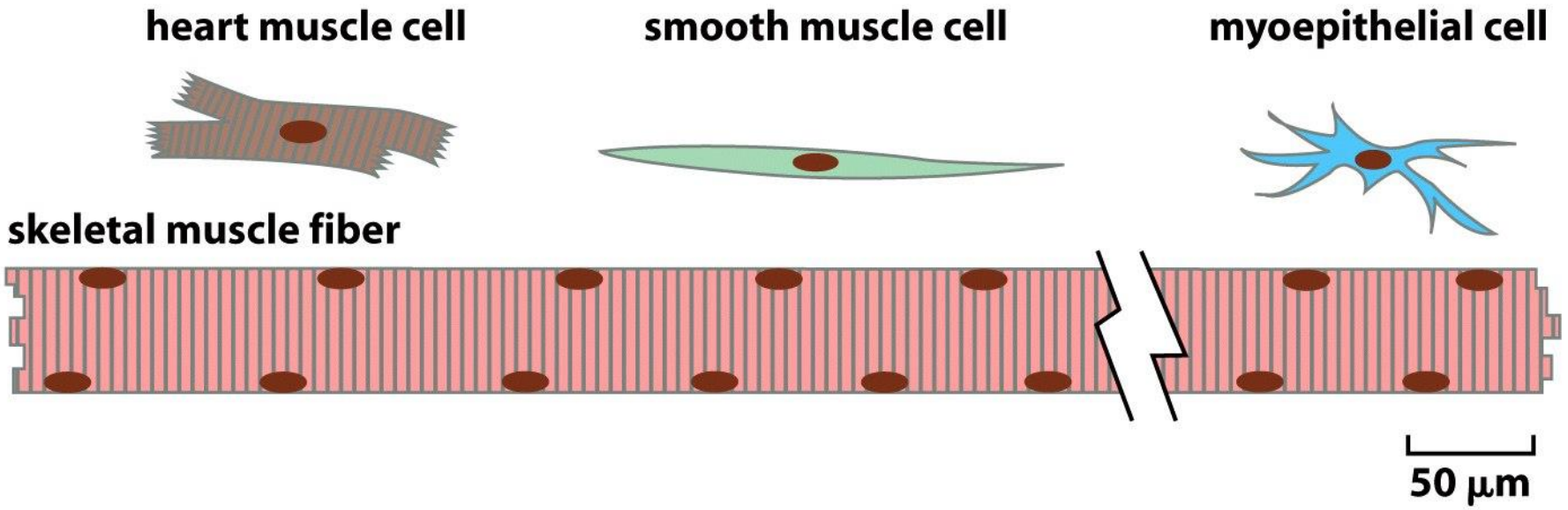


Figure 23-42 *Molecular Biology of the Cell* (© Garland Science 2008)

Muscular Tissue

Consists of elongated cells called muscle fibers or myocytes

- Cells use ATP to generate force
- Several functions of muscle tissue
- Classified into 3 types: **skeletal, cardiac,** and **smooth muscular tissue**



Nervous Tissue

- **Consists of two principle types of cells**
  - Neurons or nerve cells
  - Neuroglia

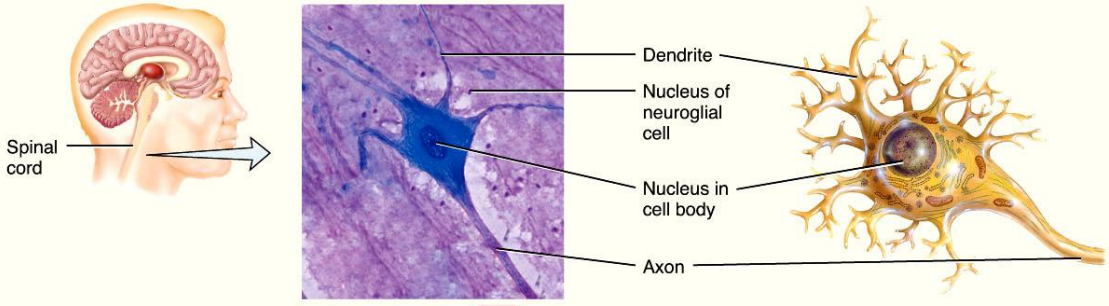
TABLE 4.6

Nervous Tissue

Description: Consists of neurons (nerve cells) and neuroglia. Neurons consist of a cell body and processes extending from the cell body (multiple dendrites and a single axon). Neuroglia do not generate or conduct nerve impulses but have other important supporting functions.

Location: Nervous system.

Function: Exhibits sensitivity to various types of stimuli, converts stimuli into nerve impulses (action potentials), and conducts nerve impulses to other neurons, muscle fibers, or glands.



Neuron of spinal cord

Table 04.06 Tortora - PAP 12/e

Excitable Cells

- **Neurons and muscle fibers**
- **Exhibit electrical excitability**
  - The ability to respond to certain stimuli by producing electrical signals such as action potentials
  - Actions potentials propagate along a nerve or muscle plasma membrane to cause a response
    - Release of neurotransmitters
    - Muscle contraction

Outline

- Basics: individual molecules: DNA, RNA, proteins, lipids, sugars, proteins
- Elements of the cell; plasma membrane, nucleus (transcription), ribosome (translation),
- Elements of the cell contd.; cytoskeleton, mitochondria (energy) transport, cell division
- Cell types and function; neurons, epithelial cells, muscle cells, blood cells,