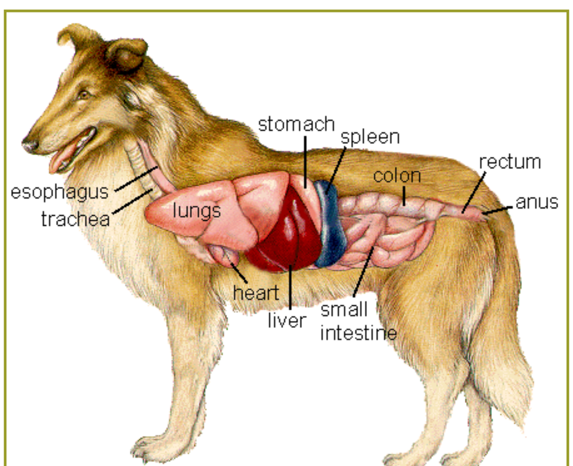
Animal Anatomy and Physiology 1

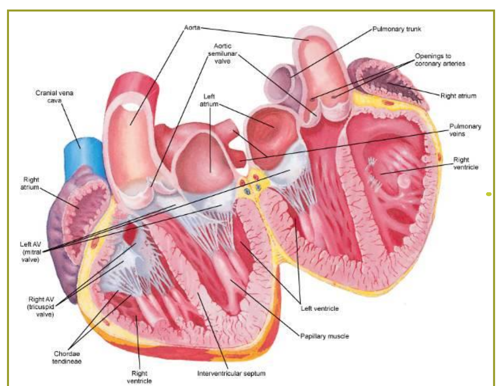
Lesson 1

Introduction to Anatomy and Physiology

Chapters 1, 2, 3, 4, 5

Introduction to Anatomy and Physiology Chapter 1





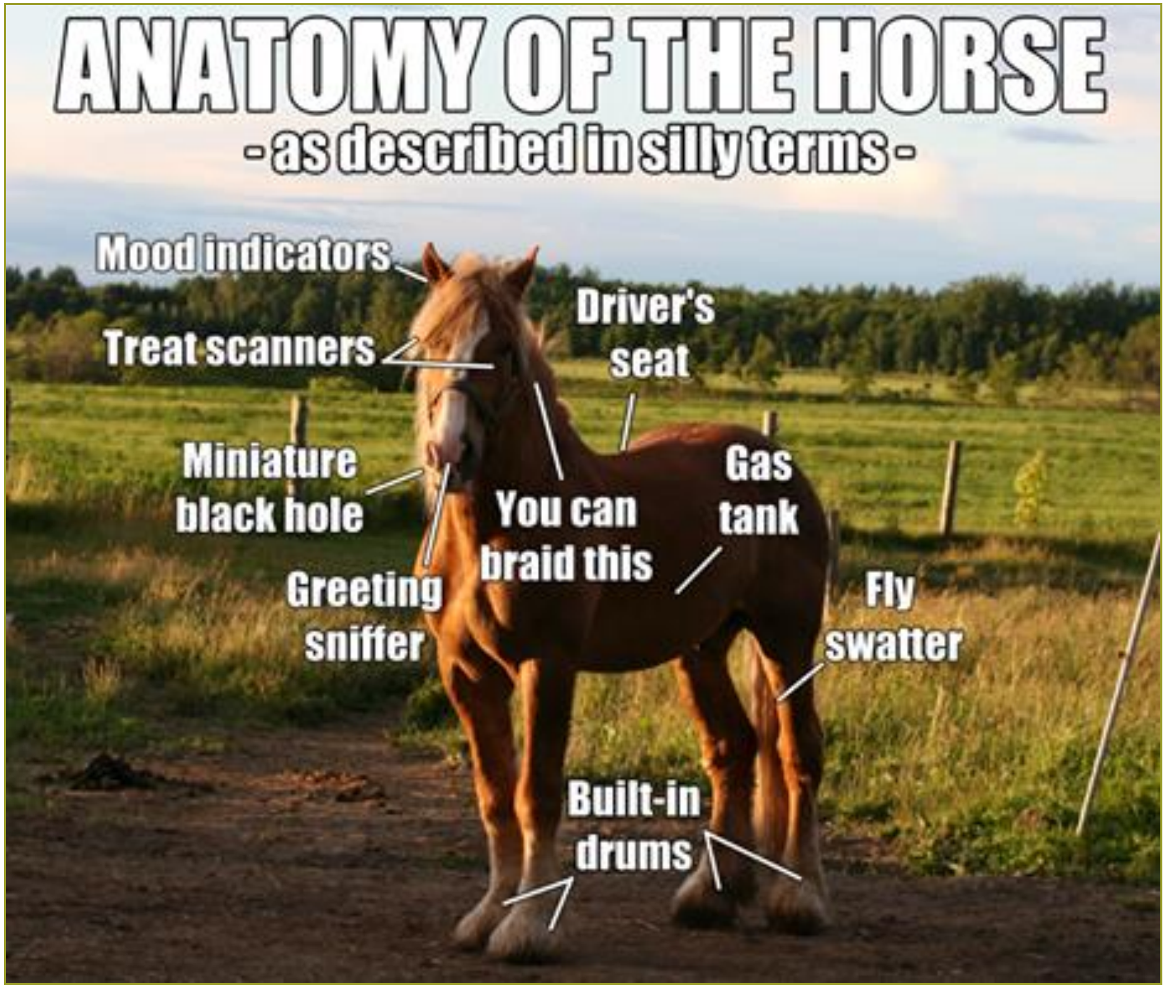
Pages 1-8

Textbook Learning Objectives

Chapter 1 – Page 1

- Define the terms *anatomy and physiology*
- Differentiate between microscopic and macroscopic anatomy
- Differentiate between the study of regional anatomy and the study of systemic anatomy
- Describe the four anatomical planes of reference
- List and describe the anatomical terms of direction
- List the components of the dorsal body cavity
- List the components of the ventral body cavity
- List the four basic types of body tissues
- Define *homeostasis*

Will We Be Covering the Anatomy of the Horse? YES! ☺



Topic 1

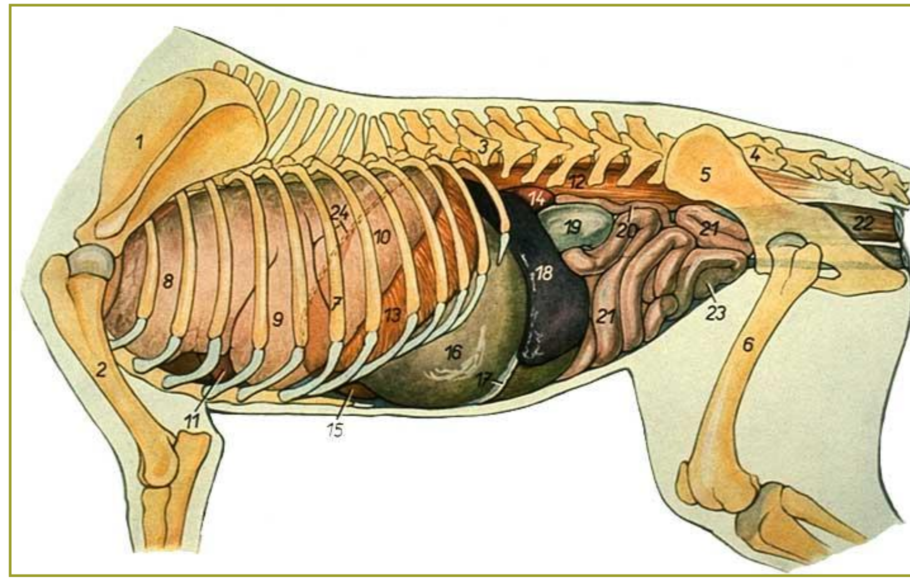
Define the terms *anatomy* and *physiology*

8 Secrets of Life

- Balance is the key!
- We are all walking saltwater aquariums!
- The solution to pollution is dilution!
- Use it or lose it!
- Get tough or die!
- It’s not polite to fool Mother Nature!
- Recycle resources!
- Thoughts are things!

A&P Terms

- Anatomy
  - Gross Anatomy
  - Microscopic anatomy
- Physiology

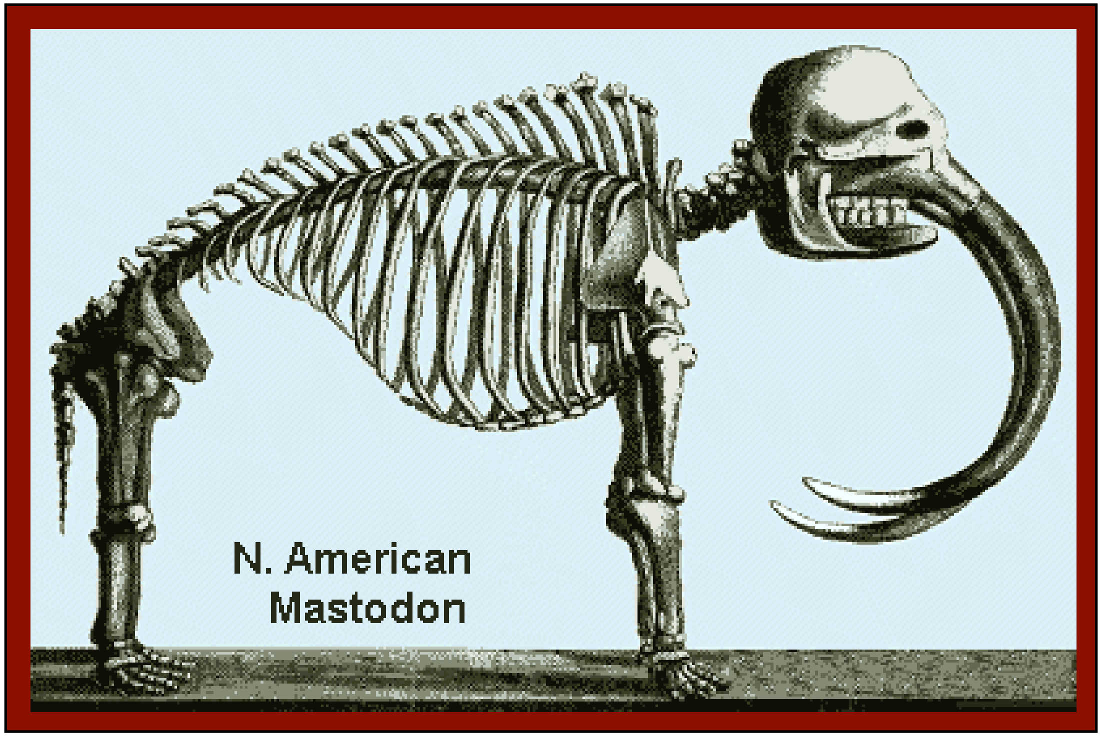


A&P Terms

- Pathology
  - Gross pathology
  - Histopathology
- Comparative anatomy & physiology

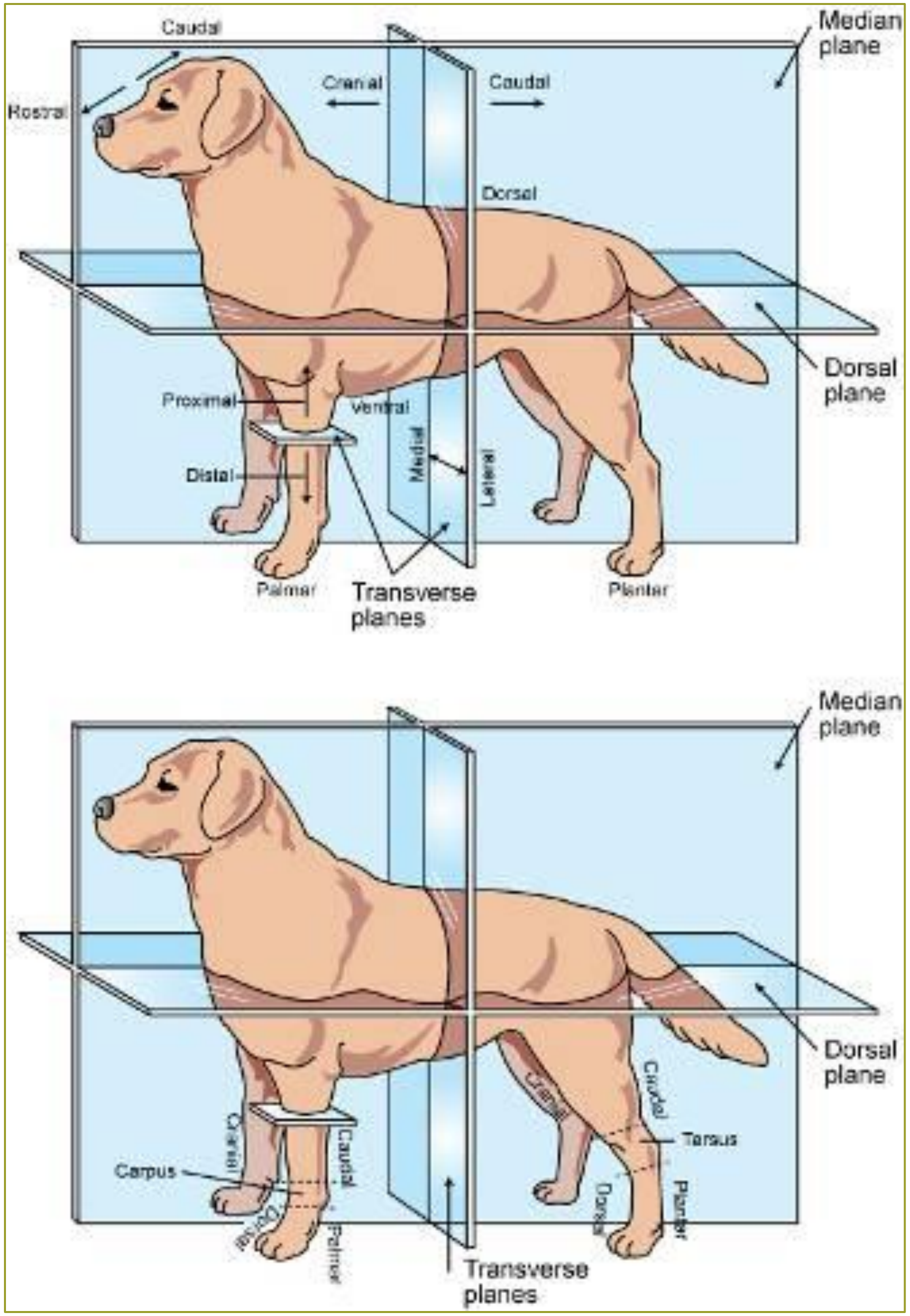
Topic 2

Use anatomical terms for describing body orientation and body parts



Anatomic Planes of Reference

Figure 1-1, Page 3



Planes

Figure 1-1, Page 3

- Medial plane (sagittal plane)
- Transverse plane (cross section)
- Dorsal plane (top to bottom)

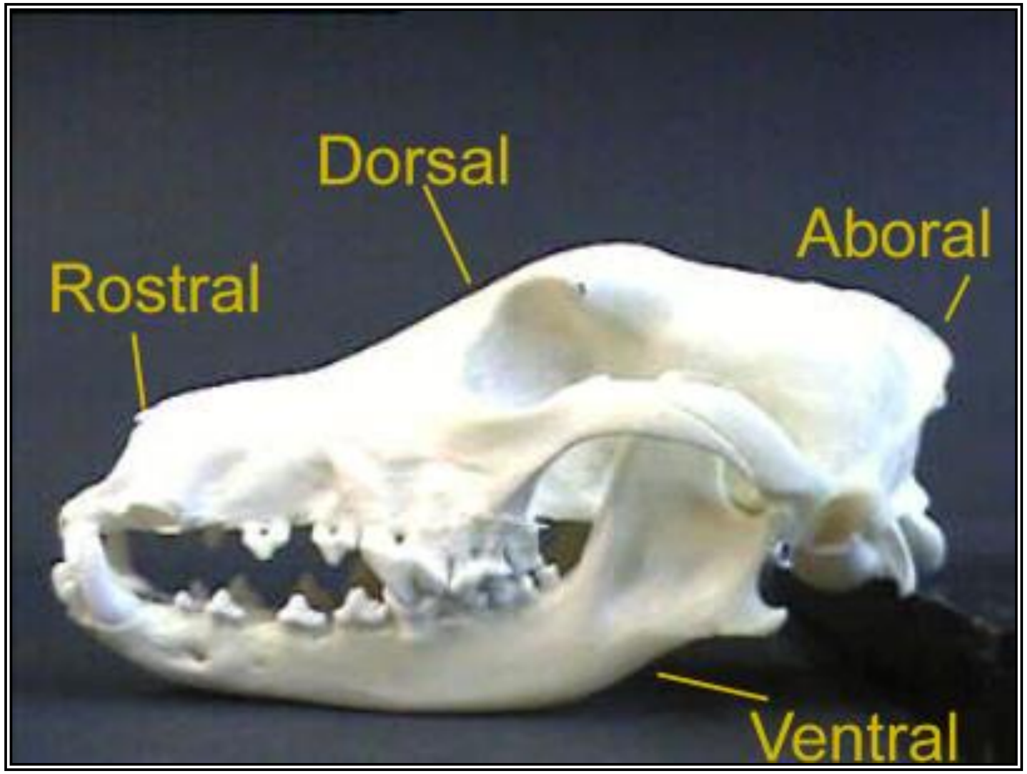
Directional Terms – Human vs. Animal

Table 1-2, Page 5

Direction	Domestic Animal	Human
Individual's left	Left	Left
Individual's right	Right	Right
Toward the head end of the body	Cranial	Superior
Toward the tip of the nose (head only)	Rostral	Nasal
Toward the tail end of the body	Caudal	Inferior
Toward the back	Dorsal	Posterior
Toward the belly	Ventral	Anterior
Toward the median plane	Medial	Medial
Away from the median plane	Lateral	Lateral
Toward the center (whole body or part)	Deep (internal)	Deep (internal)
Toward the surface (whole body or part)	Superficial (external)	Superficial (external)
Toward the body (extremity)	Proximal	Proximal
Away from the body (extremity)	Distal	Distal
"Back" of forelimb distal to carpus	Palmar	Palmar
"Back" of hindlimb distal to tarsus	Plantar	Plantar
"Front" of forelimb and hindlimb distal to carpus and tarsus	Dorsal	Anterior

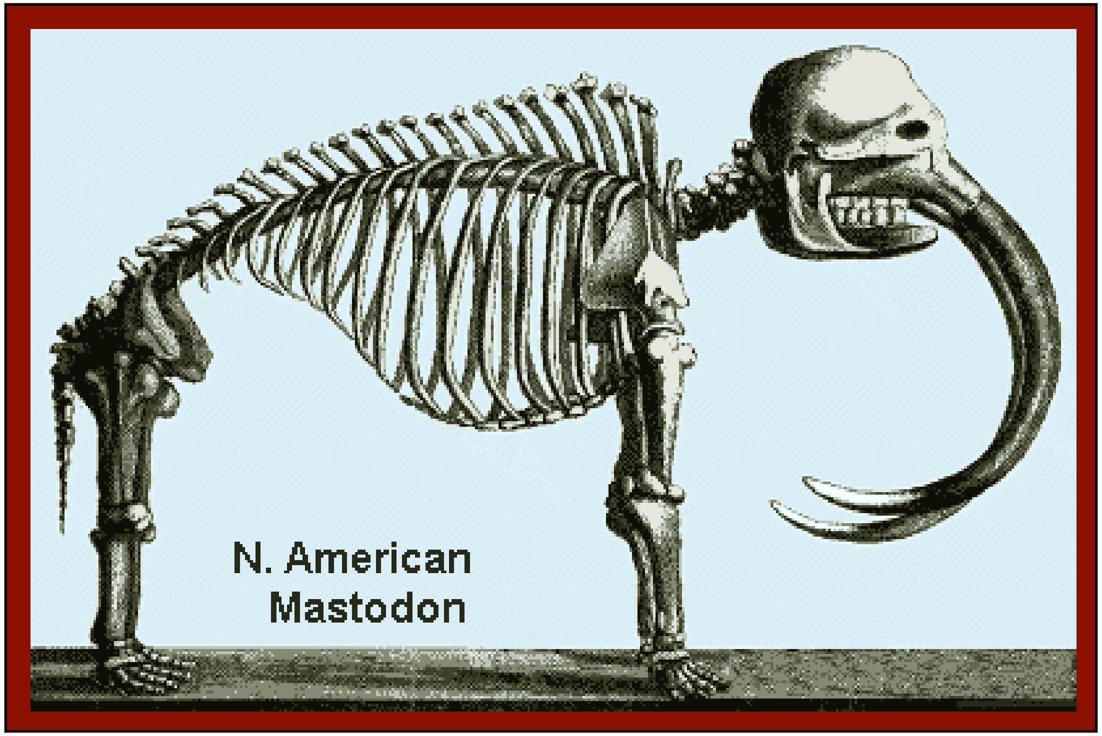
Paired Opposites

- Dorsal/ventral
- Medial/lateral
- Cranial/caudal (anterior/posterior)
- Rostral
- Superficial/deep
- Proximal/distal
- Palmar/plantar



Limbs (Extremities)

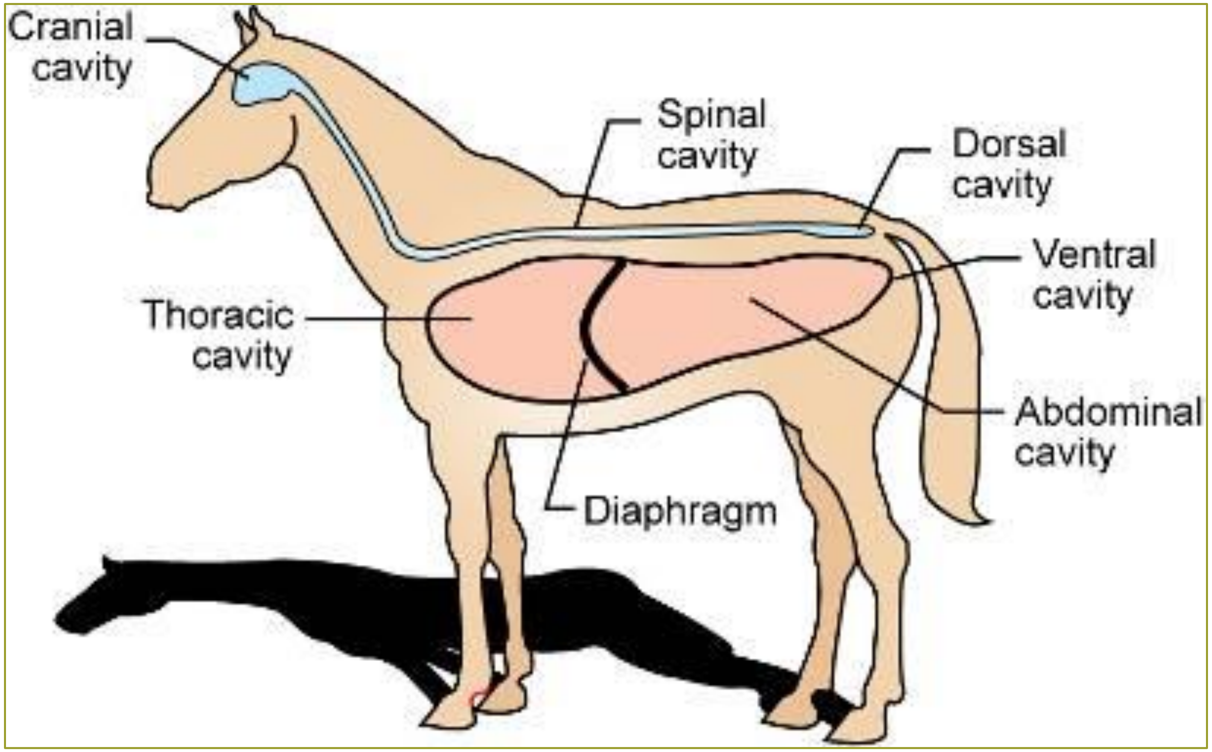
- Thoracic limb (forelimb)
- Pelvic limb (hind limb)

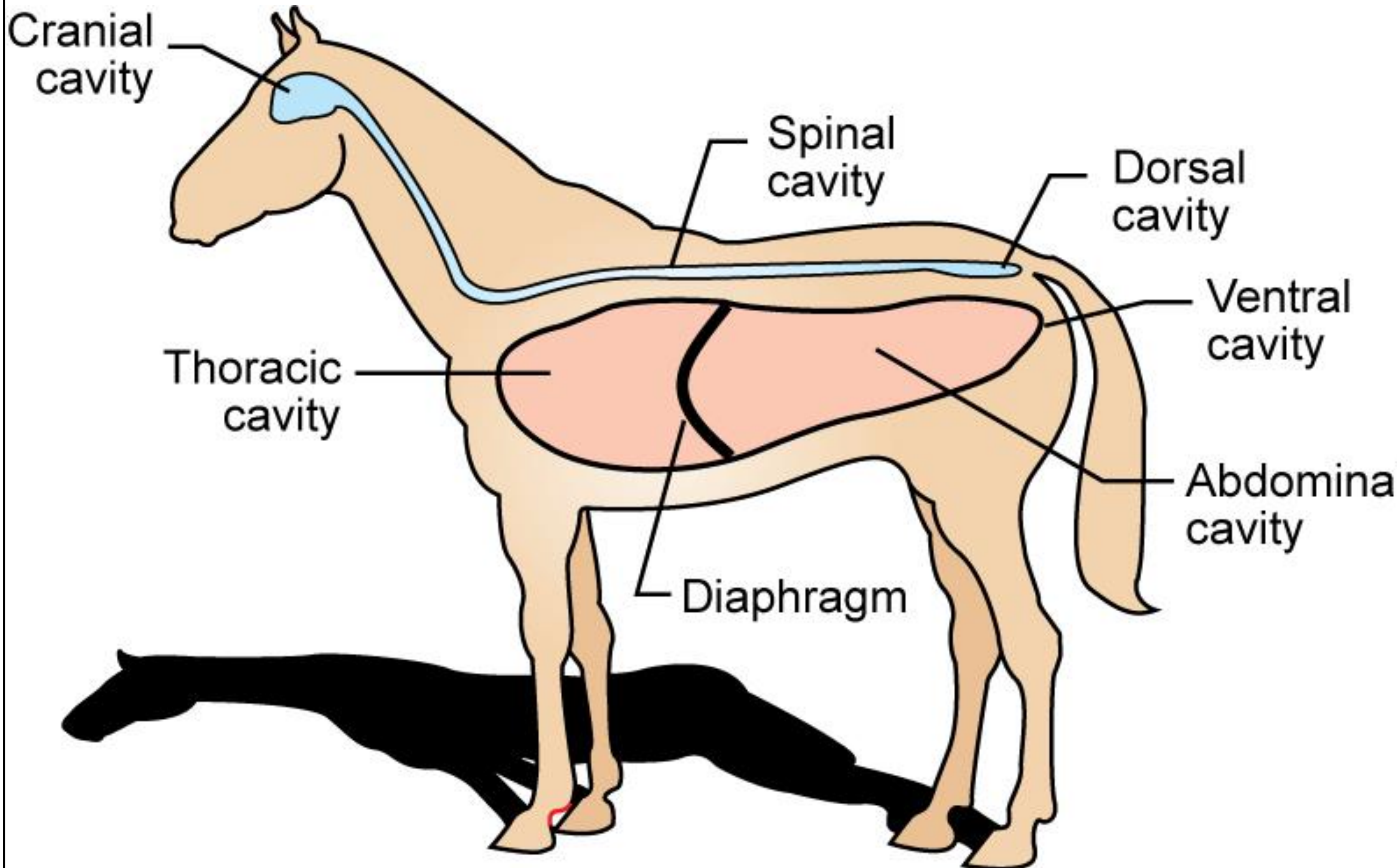


Animal Body Cavities

Figure 1-3, Page 6

- Dorsal body cavity contains the central nervous system
- Ventral body cavity contains most of the viscera of the body



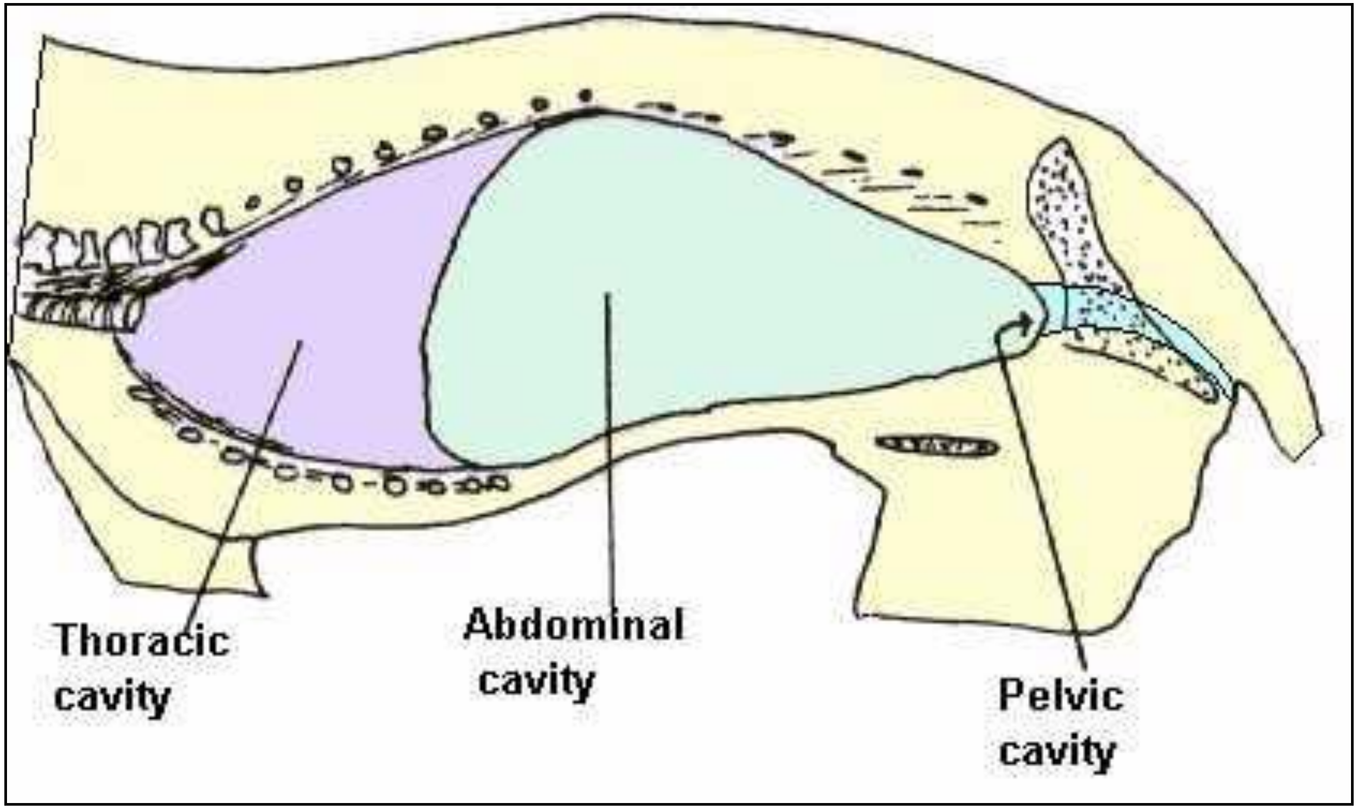

Cranial cavity
Spinal cavity
Dorsal cavity
Ventral cavity
Thoracic cavity
Abdominal cavity
Diaphragm

Dorsal Body Cavity

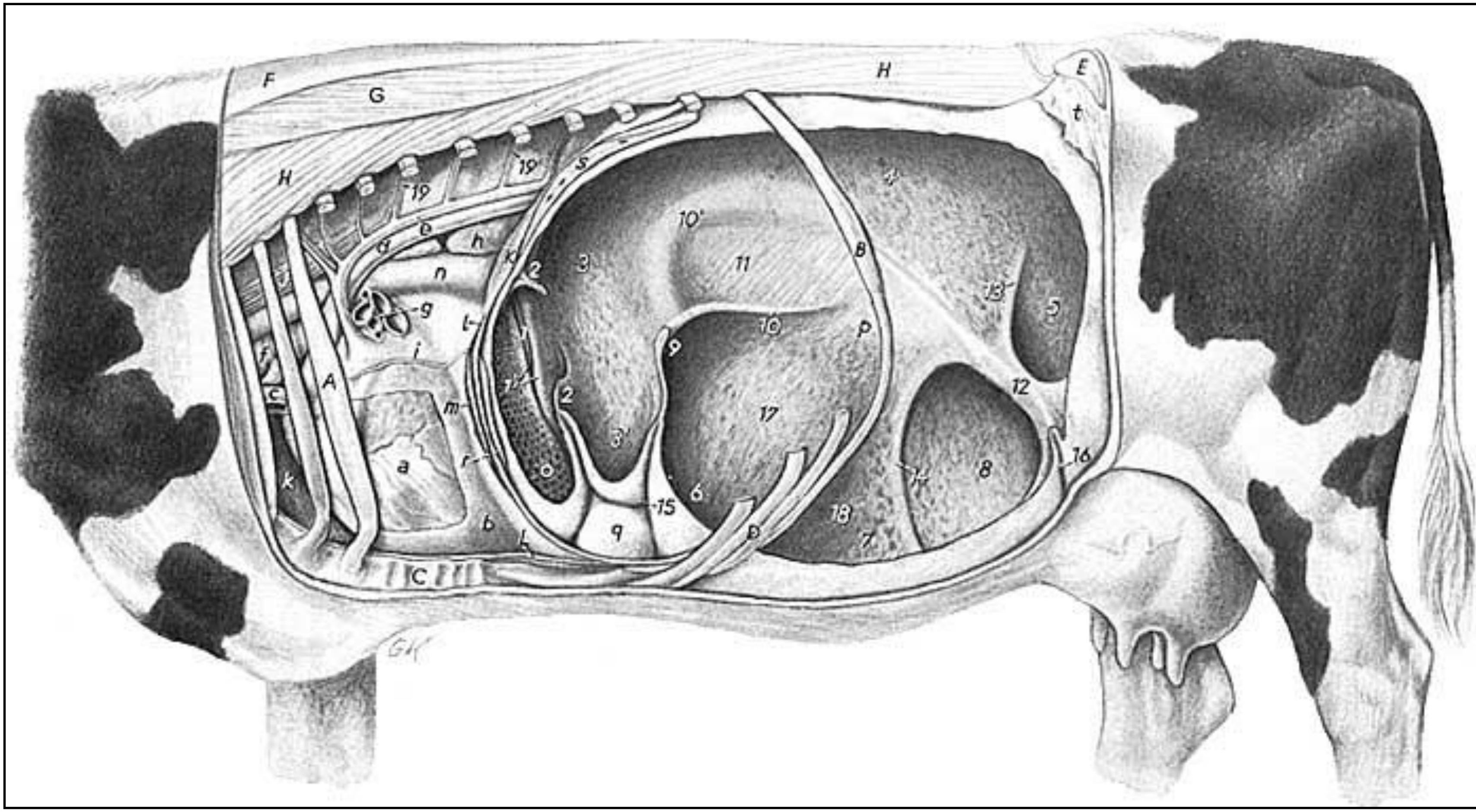
- Cranial cavity (brain)
- Spinal cavity (spinal cord)

Ventral Body Cavity (Viscera)

- Thoracic cavity (thorax)
- Abdominal cavity (abdomen)



Bovine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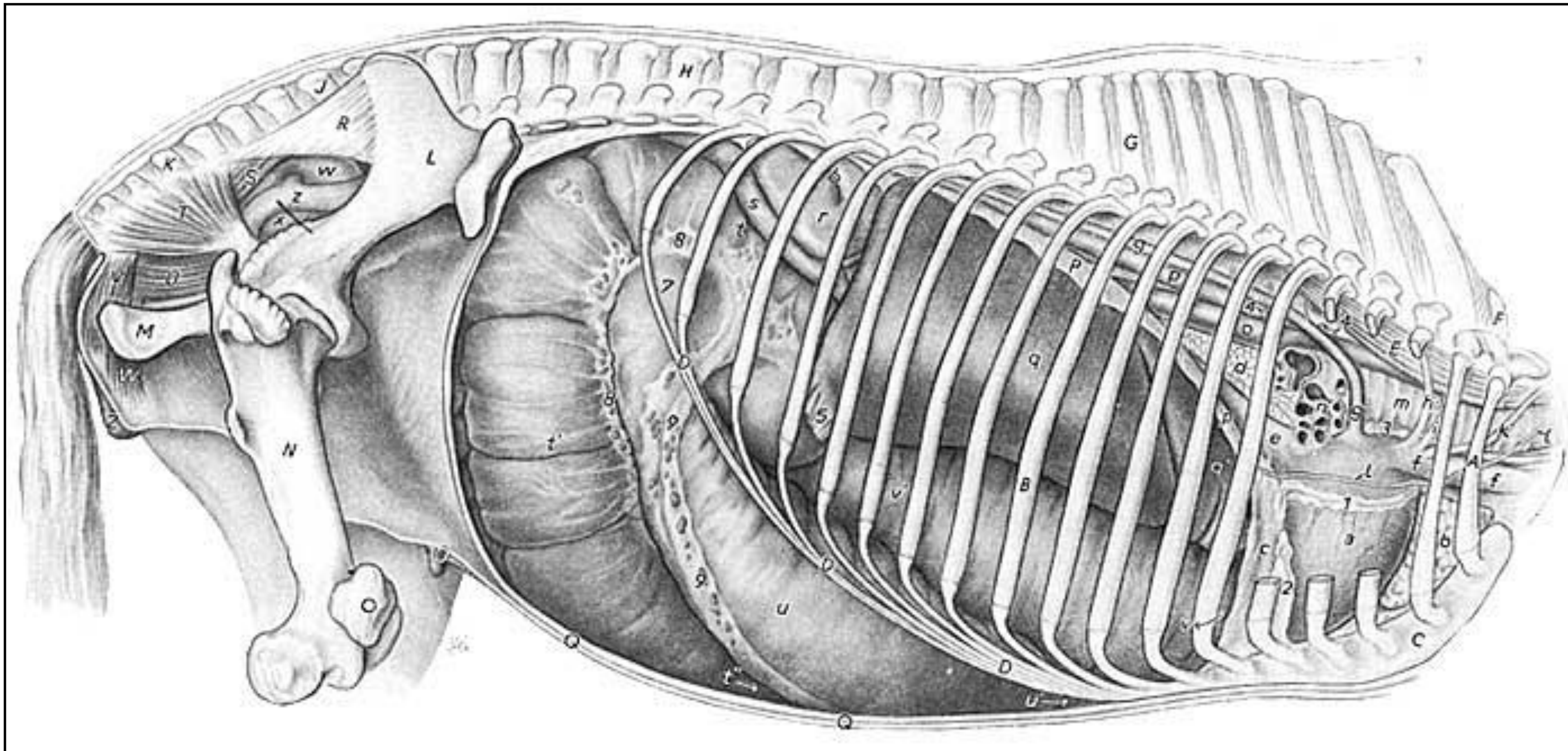
Equine



Test Yourself – Do These! ☺

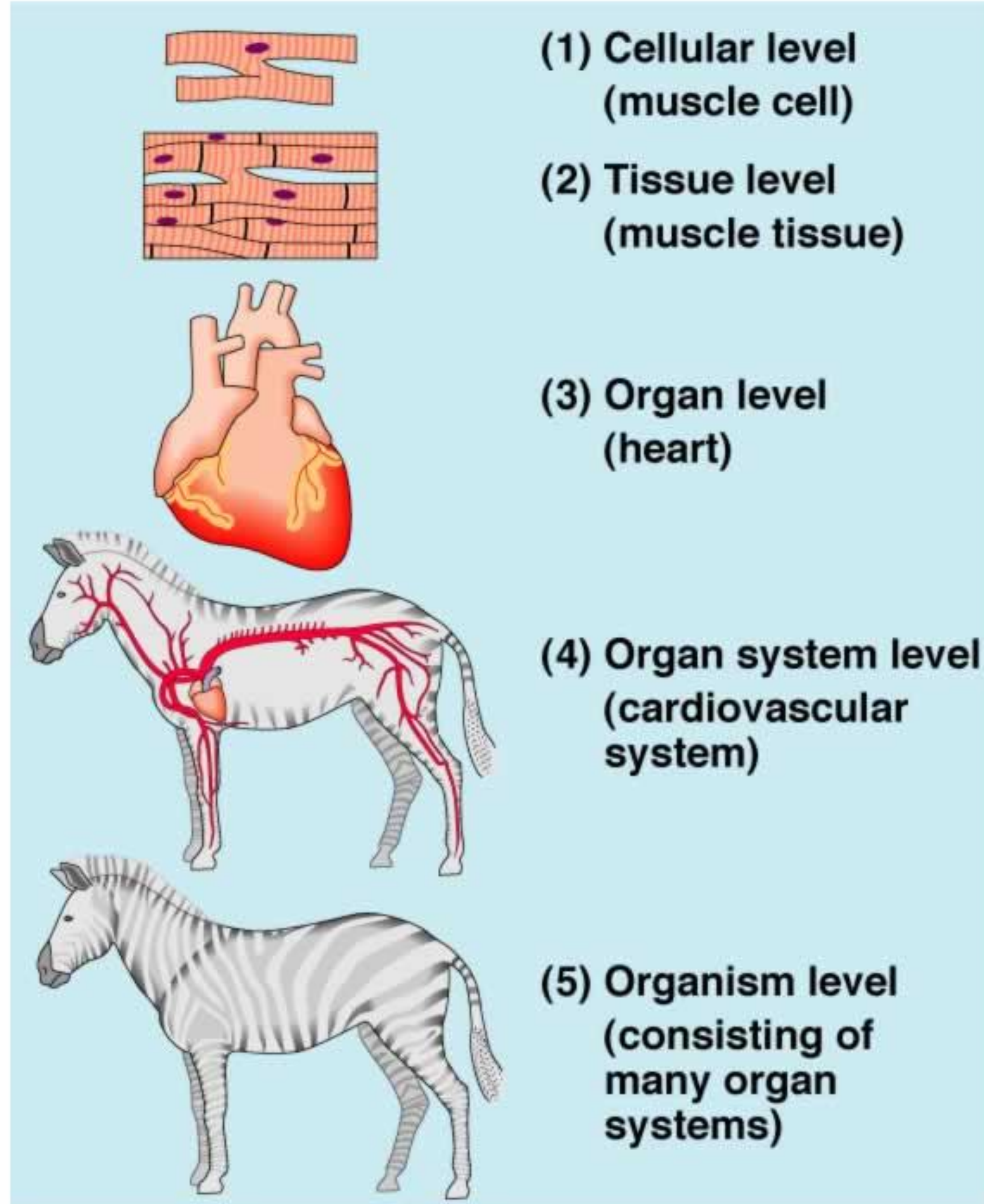
Page 6

TEST YOURSELF

1. How does each of the anatomical planes of reference (sagittal, median, transverse, and dorsal) divide a cow's body?
2. If you are facing a cat head-on, is its left ear on your left or right side?
3. Why must the term *rostral* be used instead of *cranial* to describe structures on a hedgehog's head, but the term *caudal* works just fine?
4. If your left hand is on a goat's belly and your right hand is on its back, which hand is on the animal's dorsal surface and which is on its ventral surface?
5. The next time you see a dog, differentiate between the medial and lateral surfaces of one of its elbows and the proximal and distal ends of one of its legs.
6. If you insert a hypodermic needle into a horse's muscle to give it an injection, which end of the needle—the tip or the hub—is located deep in the muscle, and which end is located superficially?
7. What surface of a hamster's front leg is in contact with the ground when it is walking normally? What surface of the hind leg?

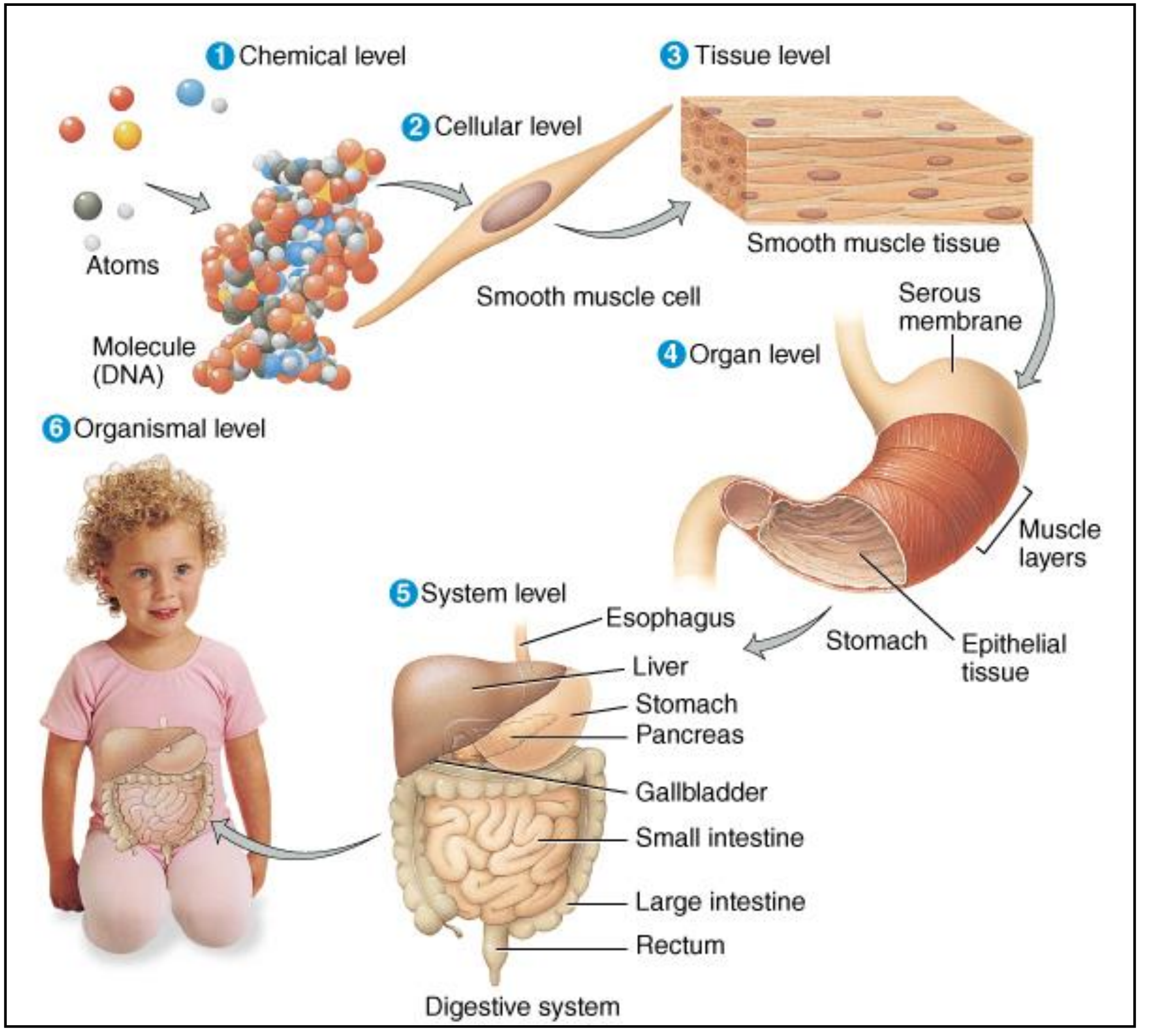
Topic 3

Distinguish between cells, tissues, organs, organ systems both structurally and functionally



Levels of Organization

- Chemical level
- Cellular level
- Tissue level
- Organ level
- Organ system
- Animal itself



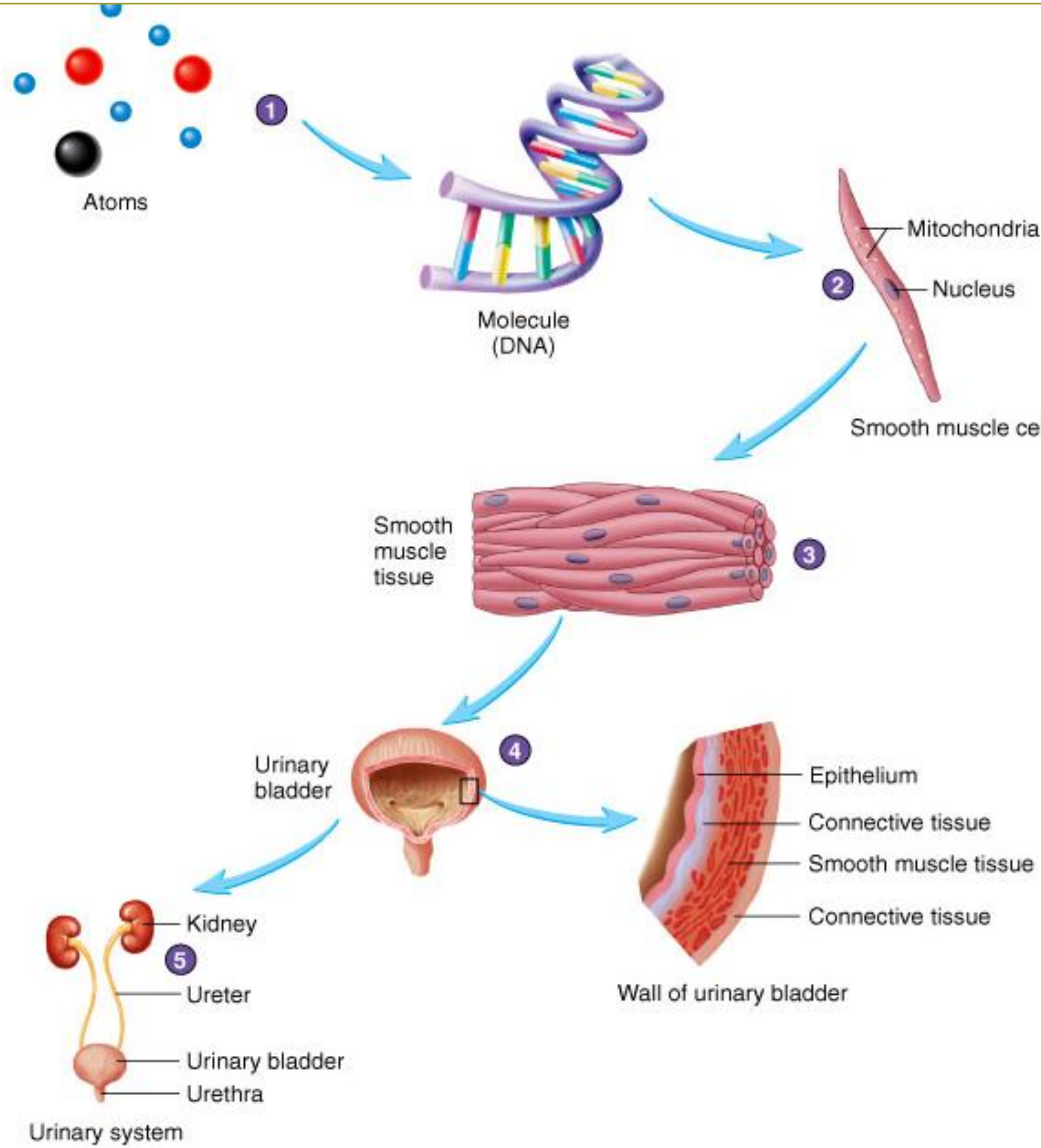
1. **Chemical level.** Atoms (*colored balls*) combine to form molecules.

2. **Cell level.** Molecules form organelles, such as the nucleus and mitochondria, which make up cells.

3. **Tissue level.** Similar cells and surrounding materials make up tissues.

4. **Organ level.** Different tissues combine to form organs, such as the urinary bladder.

5. **Organ system level.** Organs such as the urinary bladder and kidneys make up an organ system.



Homeostasis

- Definition
- The maintenance of a dynamic equilibrium in the body
- All the physiological processes that actively maintain balance in the various structures, functions, and properties of the body

Homeostasis

- **1st Secret of Life!!! – Balance Is the Key!!!**
- Health = "normal anatomy & physiology" **(Page 7)**
- Disease
  - **Healthy cells = healthy animal**
  - Diseased cells = diseased animal
  - Too many diseased cells = DEAD animal

Balance is the Key!   ☺

How Does It Work?

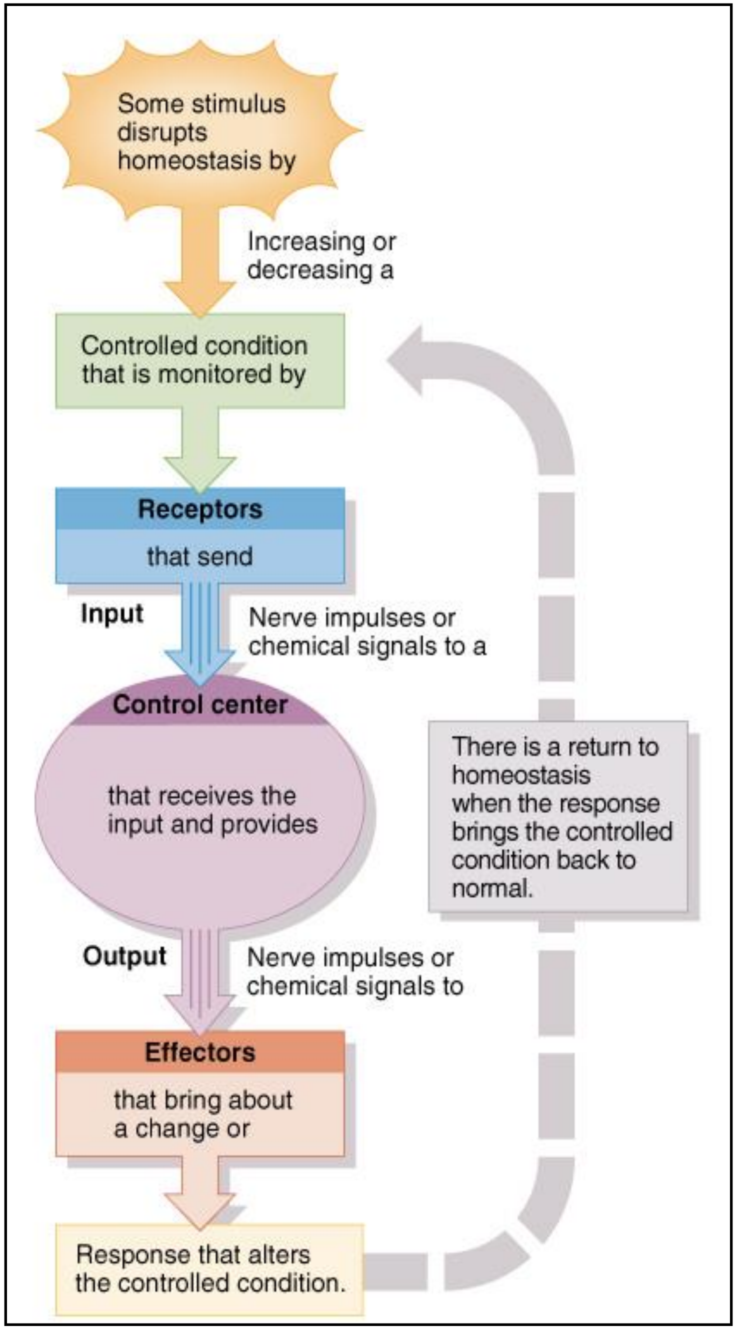
- Negative Feedback Systems
- Example – thermostat, furnace, air conditioner

Feedback System “Parts”

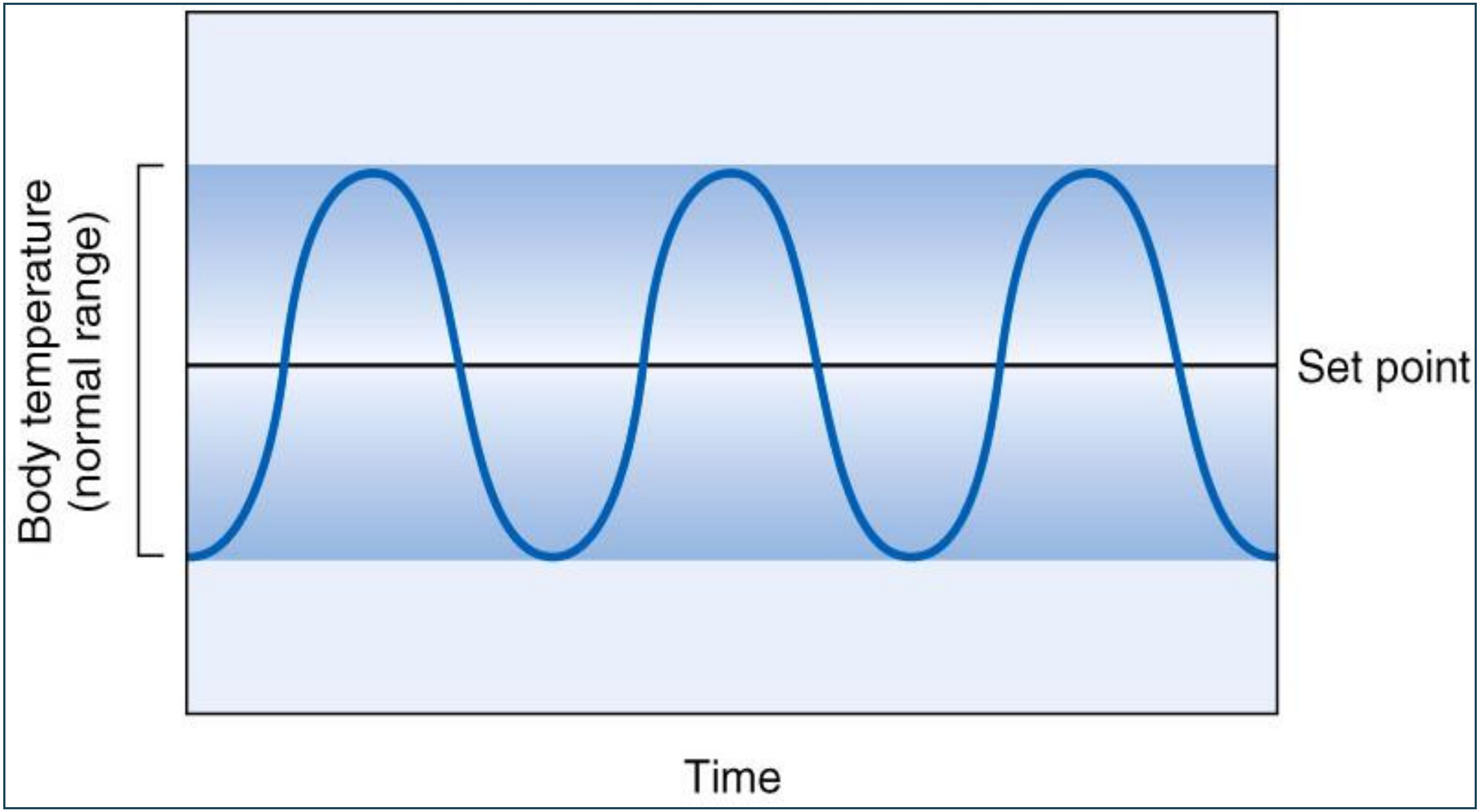
- Thermostat – receptor & control center
- Furnace – effector
- Air conditioner – effector

Components of Feedback Loop

- **Receptor**
  - monitors a controlled condition
- **Control center**
  - determines next action
- **Effector**
  - receives directions from the control center
  - produces a response that changes the controlled condition

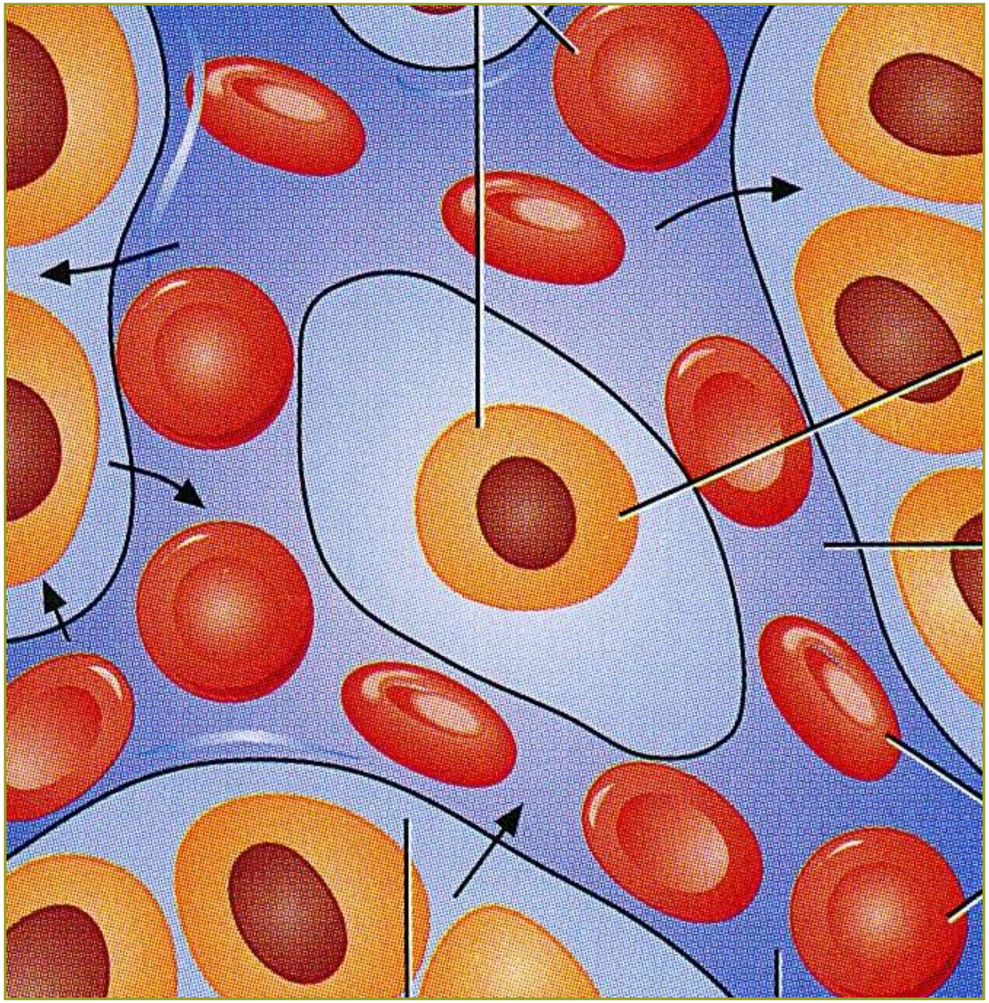


Body Temperature Homeostasis



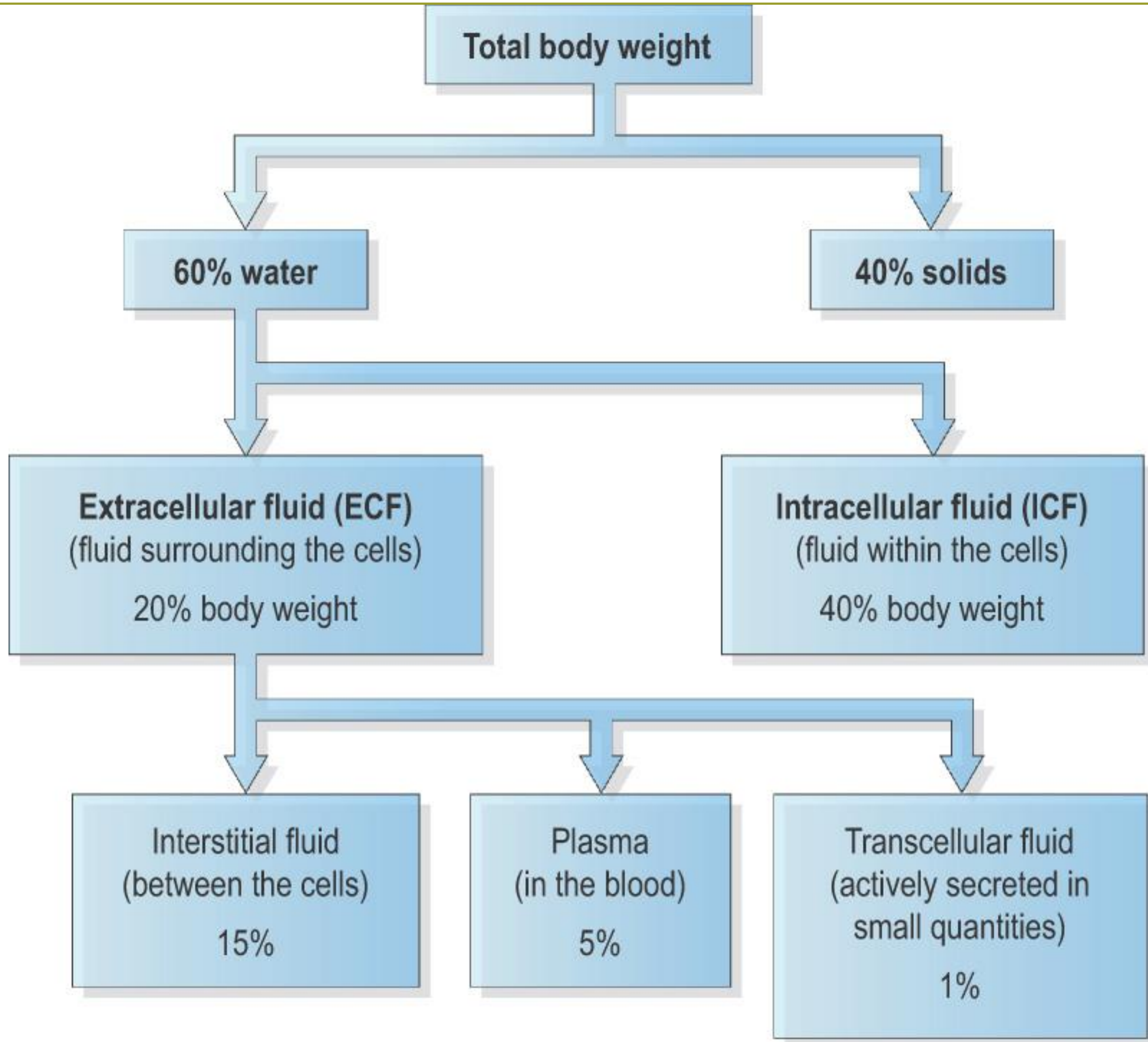
Homeostasis of Body Fluids

- Fluid compartments
  - [Intracellular fluid (ICF, cytosol)]
  - Extracellular fluid (ECF)
    - Interstitial fluid
    - Plasma



2nd Secret of Life

- We are all walking saltwater aquariums!

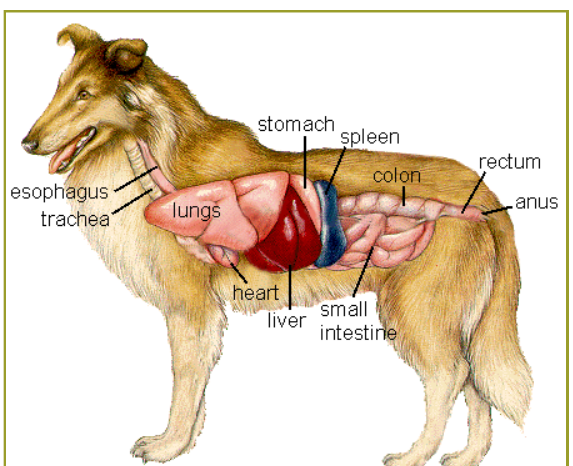

Total body weight
60% water
40% solids
Extracellular fluid (ECF)
(fluid surrounding the cells)
20% body weight
Intracellular fluid (ICF)
(fluid within the cells)
40% body weight
Interstitial fluid
(between the cells)
15%
Plasma
(in the blood)
5%
Transcellular fluid
(actively secreted in
small quantities)
1%

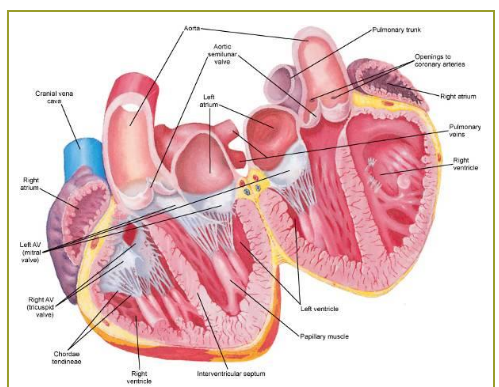
Common Name	Scientific Name	Speed in kmph	Speed in Mph
Cheetah	*Acinonyx jubatus*	96+	60
Pronghorn Antelope	*Antilocarpa americana*	88.5	55
Wildebeest	*Connochaetes taurinus*	80	50
Thomson's Gazelle	*Gazella thomsoni*	80	50
Grant's Gazelle	*Gazella granti*	80	50
European Hare	*Lepus europeaus*	72	45
Domestic Horse	*Equus ferus*	69.6	43.3
Grizzly Bear	*Ursus arctos*	64	40
Coyote	*Canis latrans*	64	40
Mountain Zebra	*Equus zebra*	64	40
Lion	*Panthera leo*	58	36
Polar Bear	*Ursus maritimus*	56	35
Giraffe	*Giraffa camelopardalis*	56	35
Grey Kangaroo	*Macropus giganteus*	56	35
Cape Buffaloe	*Synceros caffer caffer*	56	35
Black Rhinoceros	*Diceros bicornis*	45	28
Grey Wolf	*Canis lupus*	45	28
Wild Rabbit	*Onyctolagus cuniculus*	40	25
African Elephant	*Loxodonta africana*	40	25
Camel	*Camel bactrianus*	16	10

Clinical Applications

Pages 4, 8

Chemical Basis of Life
Chapter 2





Pages 9-38

Textbook Learning Objectives

Chapter 2 – Page 9

- List the characteristics of each of the subatomic particles.
- Differentiate between a molecule and a compound.
- List and describe the types of chemical bonds that may form between elements.
- Give the general equations for synthesis, decomposition, and exchange reactions.
- Differentiate between organic and inorganic compounds; hydrophobic and hydrophilic molecules; acids and bases.
- List the unique properties of the water molecule.
- Describe the actions of a buffer system.
- List the components of carbohydrates, lipids, proteins, and nucleic acids.
- List the functions of body proteins.
- Describe the actions of enzymes.

Topic 4

Describe the chemical elements found in an animal's body

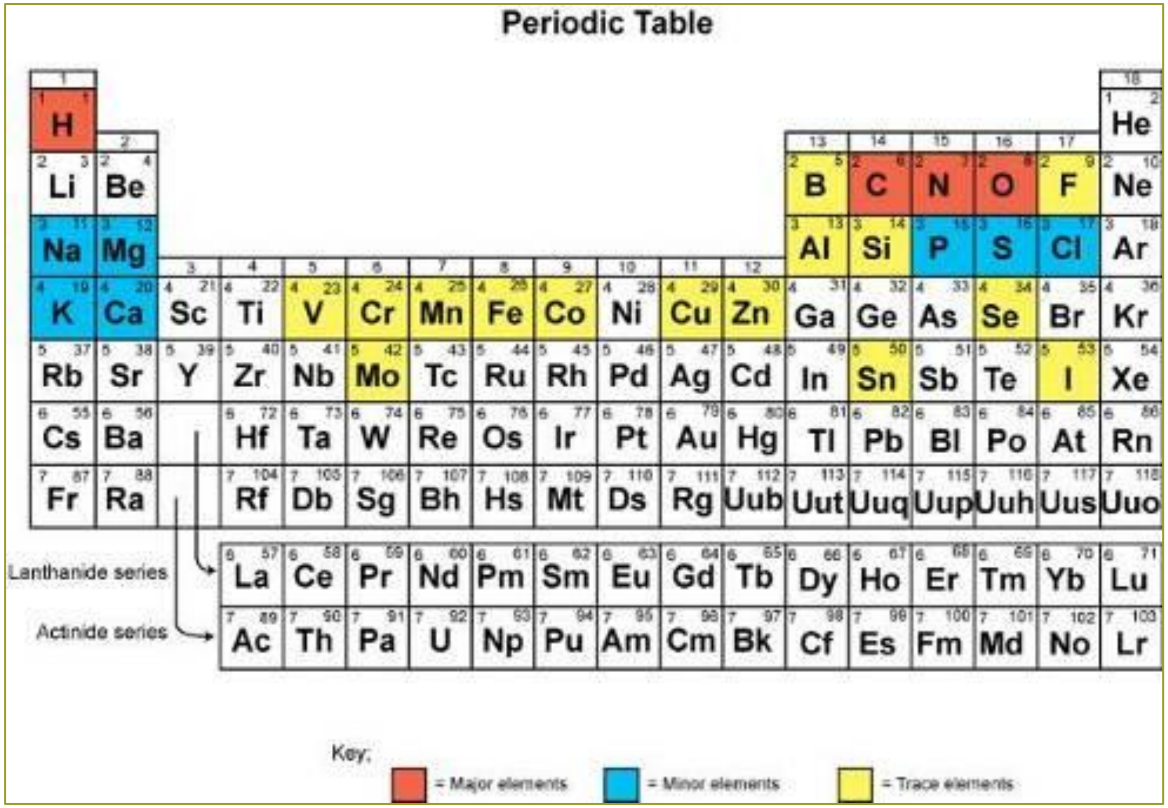
Matter

Figure 2-3, Page 10

- Anything that occupies space and has mass
- Matter can exist as a gas, liquid, or solid
- Matter is composed of 92 elements

Elements – The "Big 4"

- Nitrogen, oxygen, hydrogen, and carbon make up 96% of all matter found in living organisms



Periodic Table of the Elements

Figure 2-5, Page 11

- The Periodic Table of the Elements gives us important information about each element: the **chemical symbol**, **atomic number**, and **atomic weight**. The Table groups elements with similar properties. The elements shaded in **red** are the **major elements** that make up 96% of the matter in the animal body. The elements shaded in **blue** are the **minor elements**, and those shaded in yellow are **trace elements**.

Periodic Table

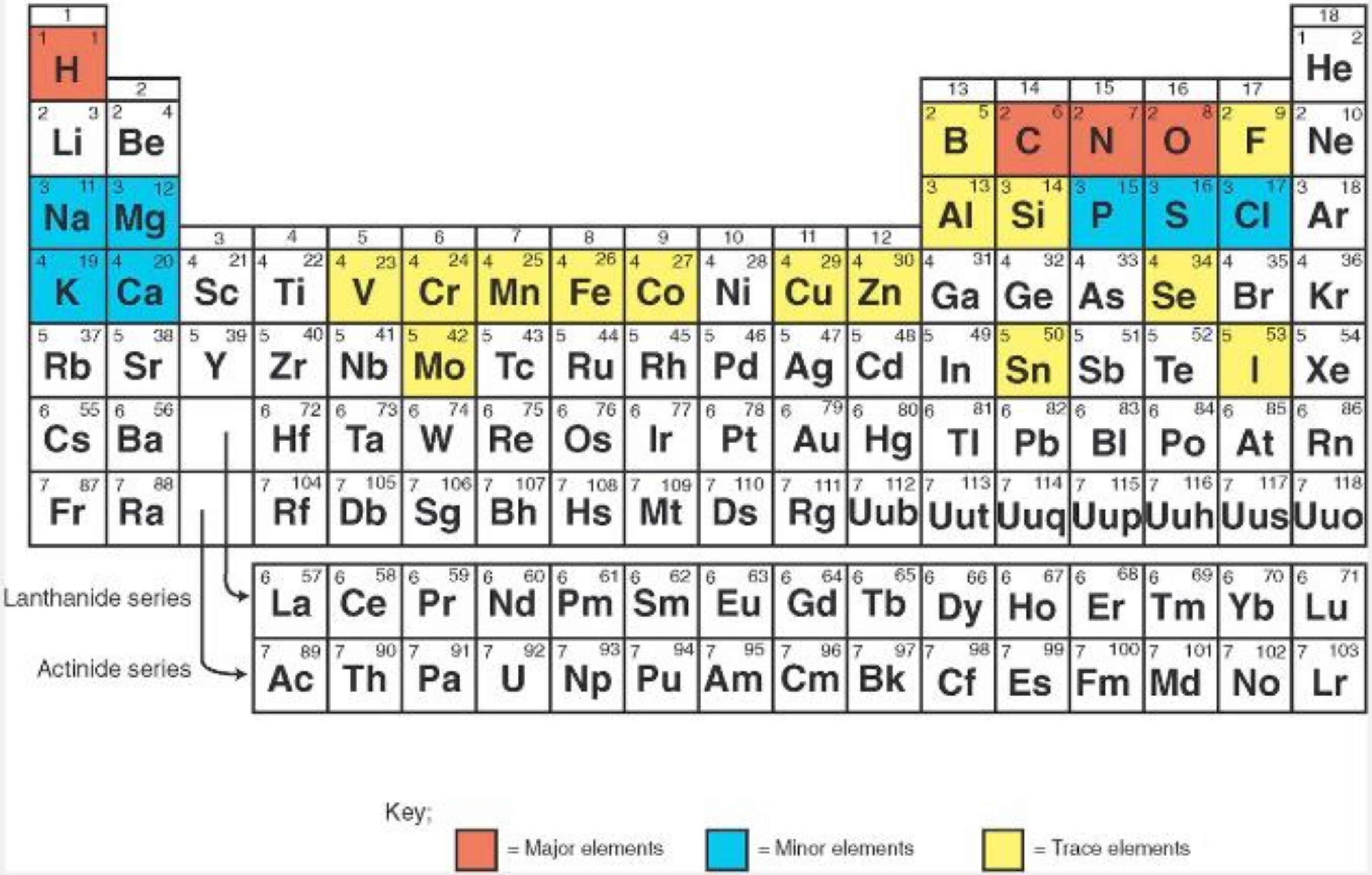
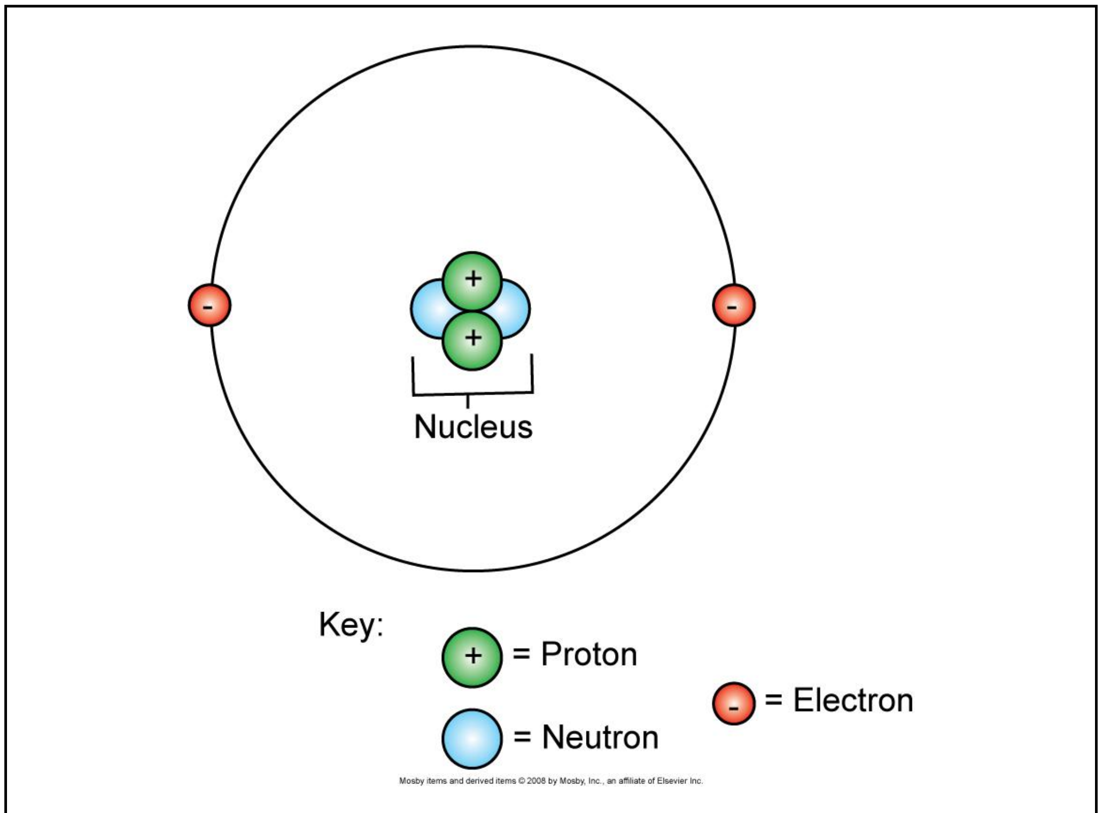


Table 2.1 Some Common Elements

Element	Symbol	Atomic Number	Mass Number	Percent in Human Body by Weight	Percent in Human Body by Number of Atoms
Hydrogen	H	1	1	9.5	63.0
Carbon	C	6	12	18.5	9.5
Nitrogen	N	7	14	3.3	1.4
Oxygen	O	8	16	65.0	25.5
Sodium	Na	11	23	0.2	0.3
Phosphorus	P	15	31	1.0	0.22
Sulfur	S	16	32	0.3	0.05
Chlorine	Cl	17	35	0.2	0.03
Potassium	K	19	39	0.4	0.06
Calcium	Ca	20	40	1.5	0.31
Iron	Fe	26	56	Trace	Trace
Iodine	I	53	127	Trace	Trace

Topic 5

Compare and contrast the structures found in atoms



Atoms
Figure 2-7A, Page 13

- The <u>smallest unit of an element</u> which retains the unique properties of the element
- Composed of smaller subatomic particles
  - Protons
  - Neutrons
  - Electrons

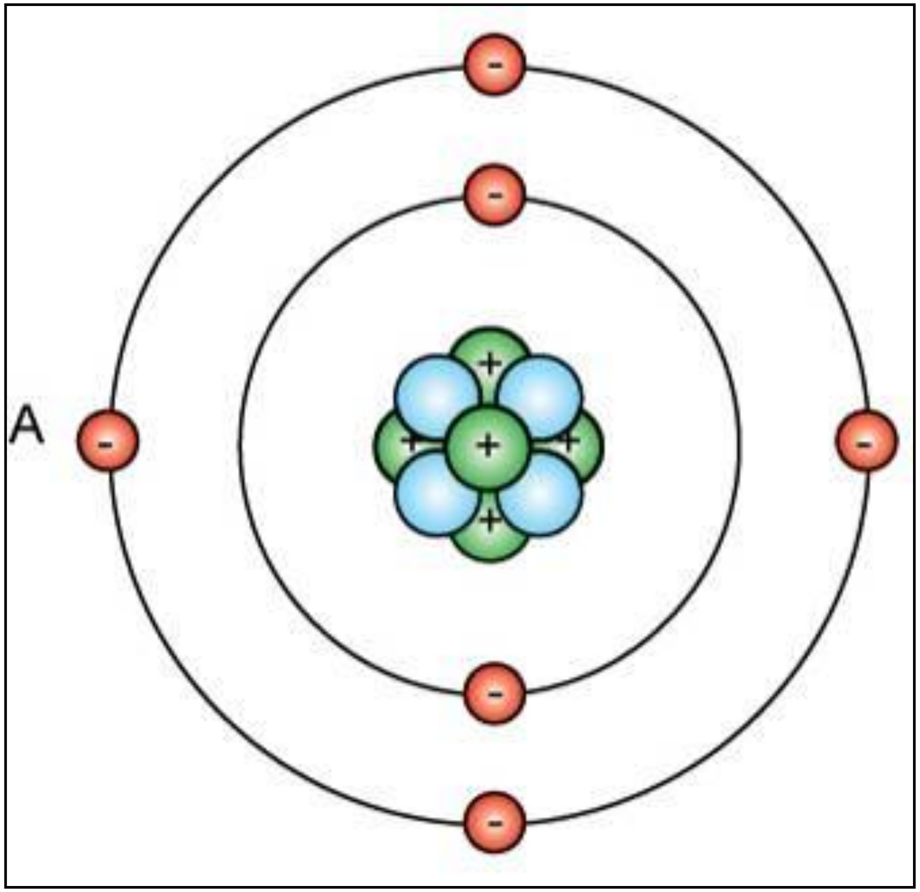
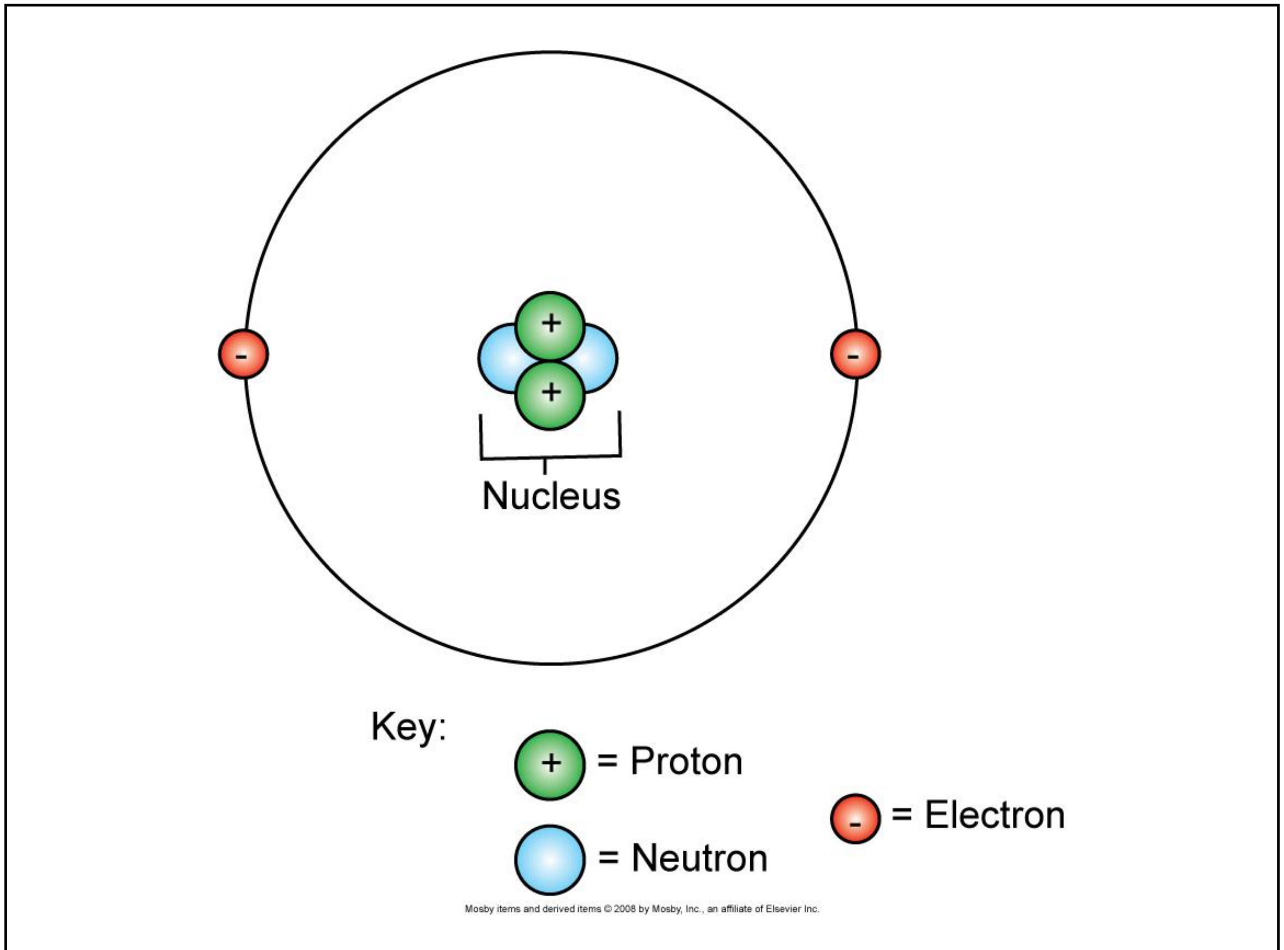


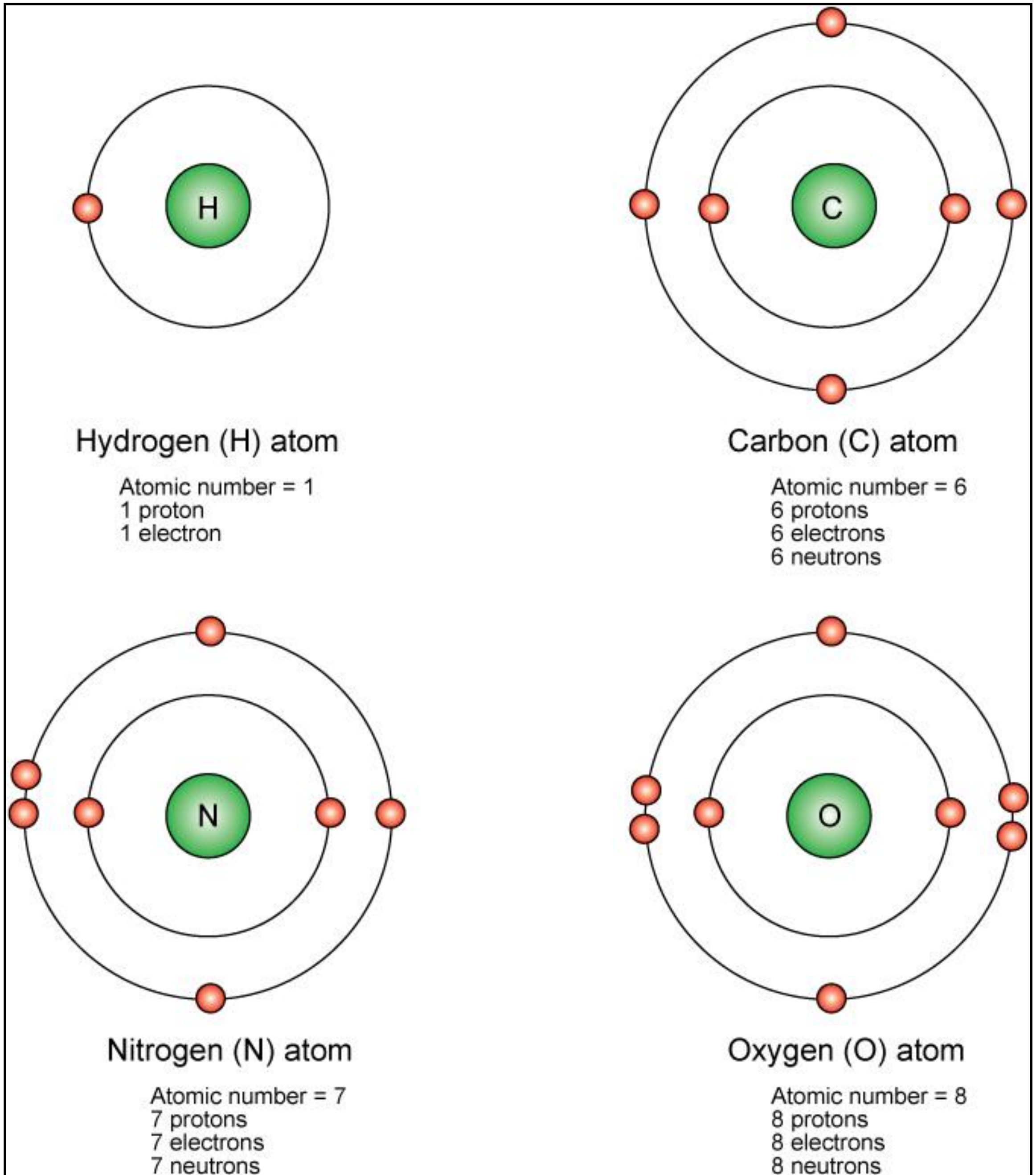
Diagram of an Atom

Figure 2-6, Page 13



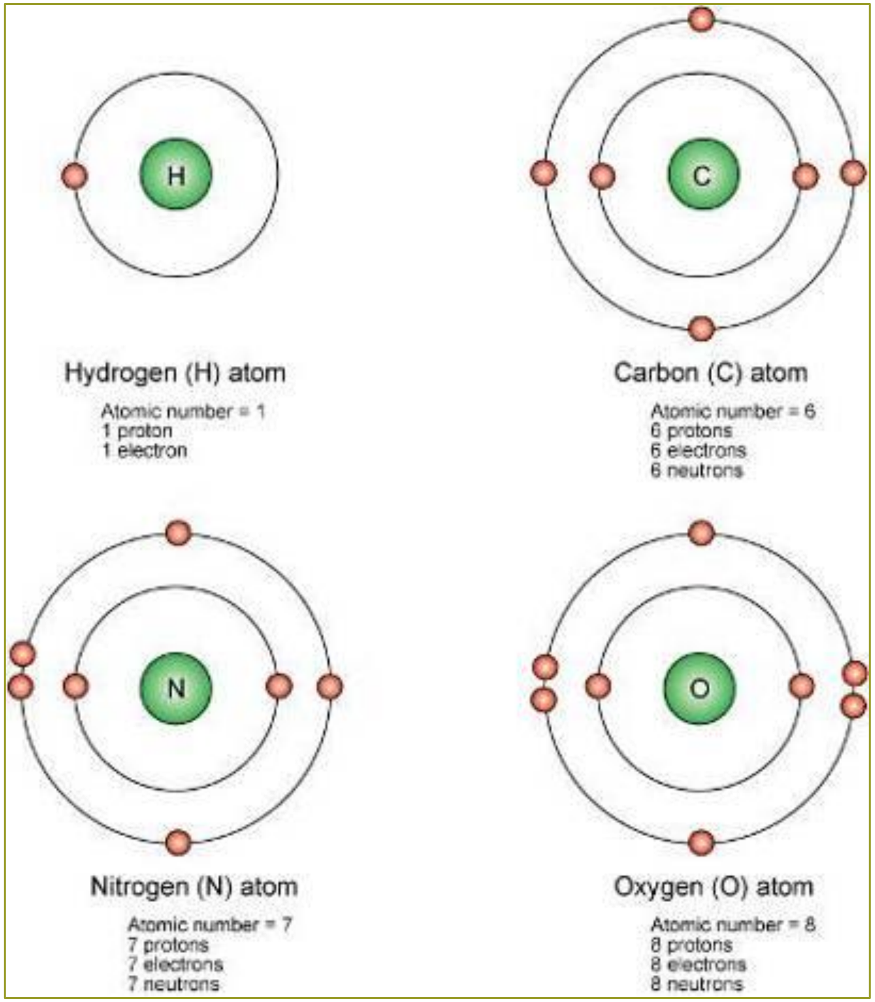
Examples of Atoms

Figure 2-8, Page 14



Atoms; Ions; Isotopes

- Ion: an atom that has lost or gained an electron, giving it a positive or negative charge.
- Isotopes: atoms that contain a different number of neutrons.

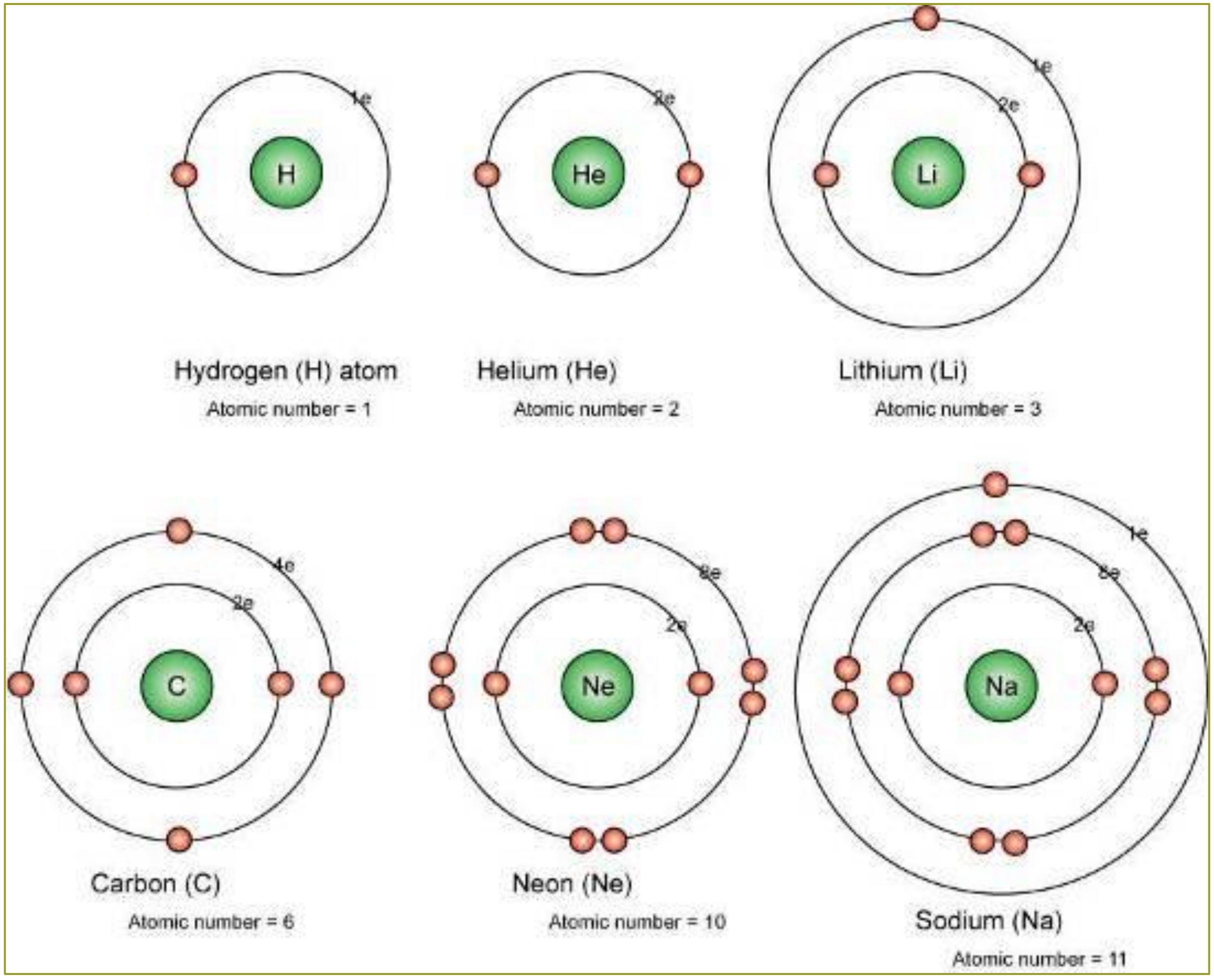


Electron Shell

- The area around the nucleus where electrons have their most likely position.
- Electrons of lower energy exist in the first electron shell closest to the nucleus; electrons of higher energy are in the second electron shell.

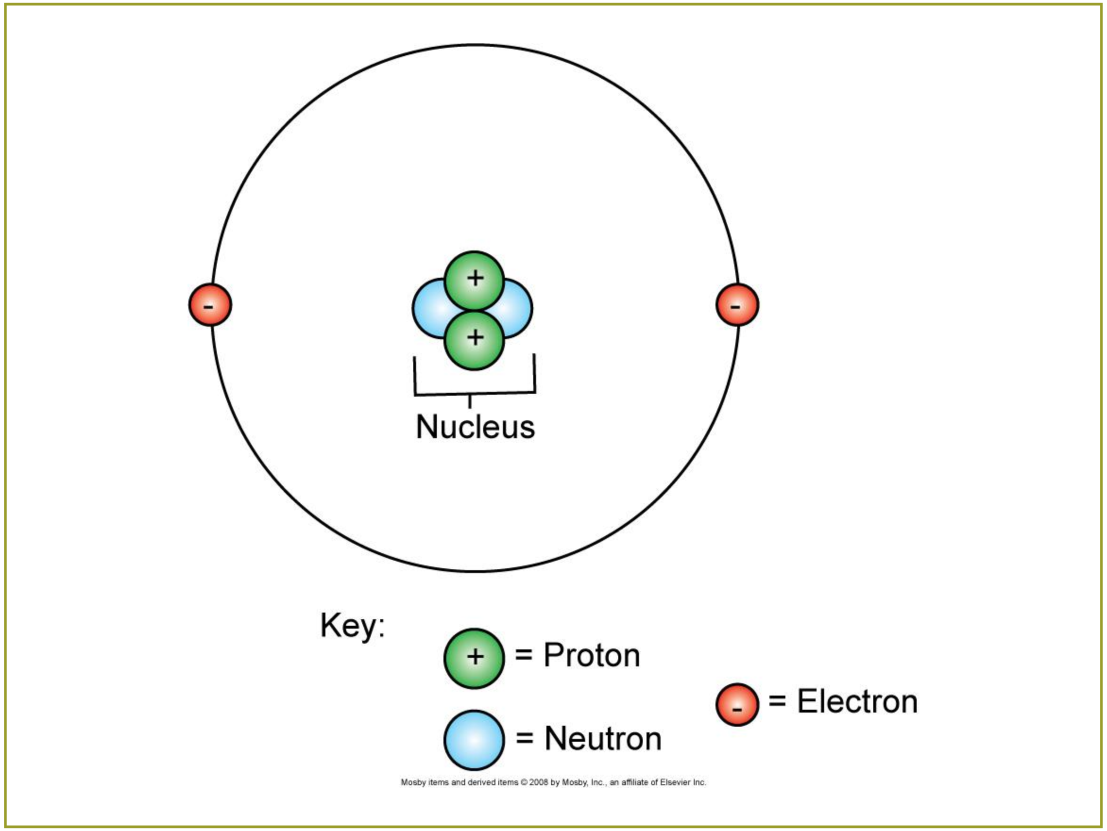
Electron Shell

Figure 2-19, Page 15

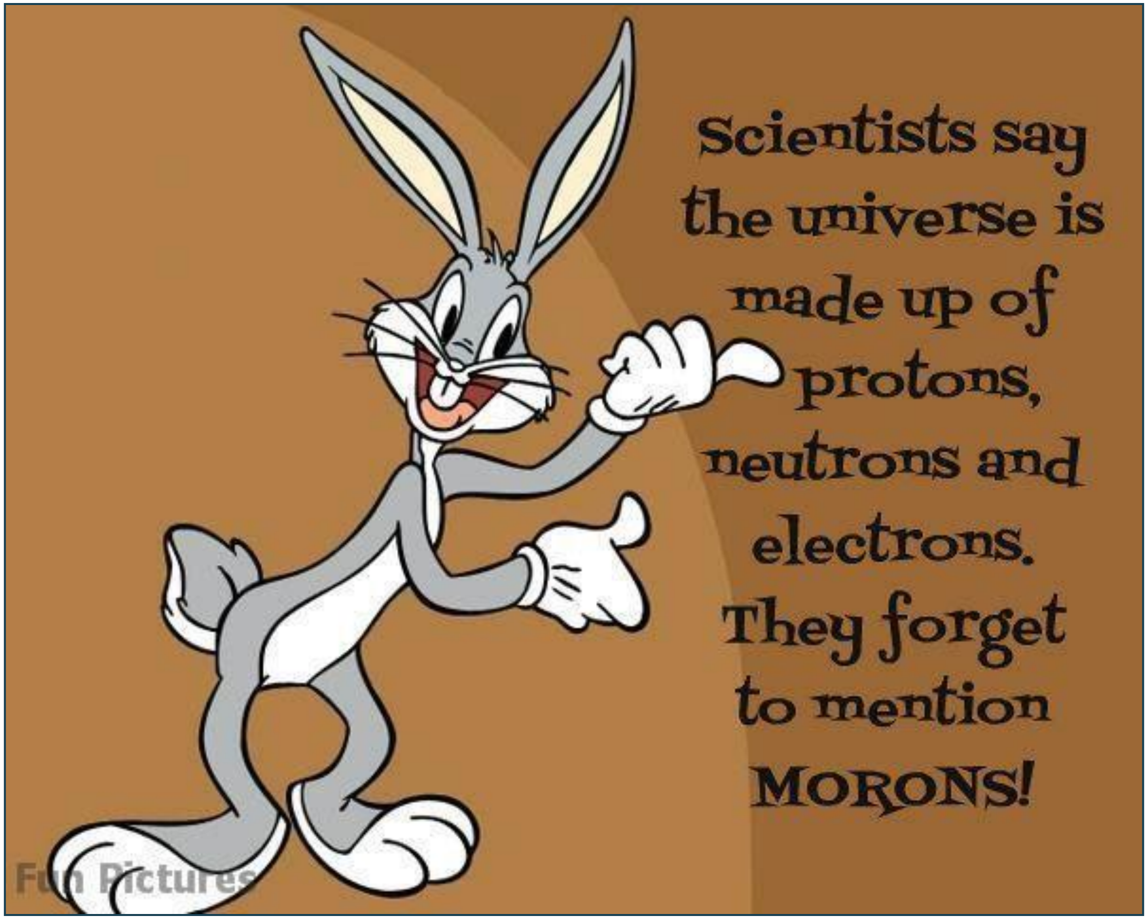


Topic 6

Describe the types of bonds used to form molecules



Thought You Might Like This! ☺



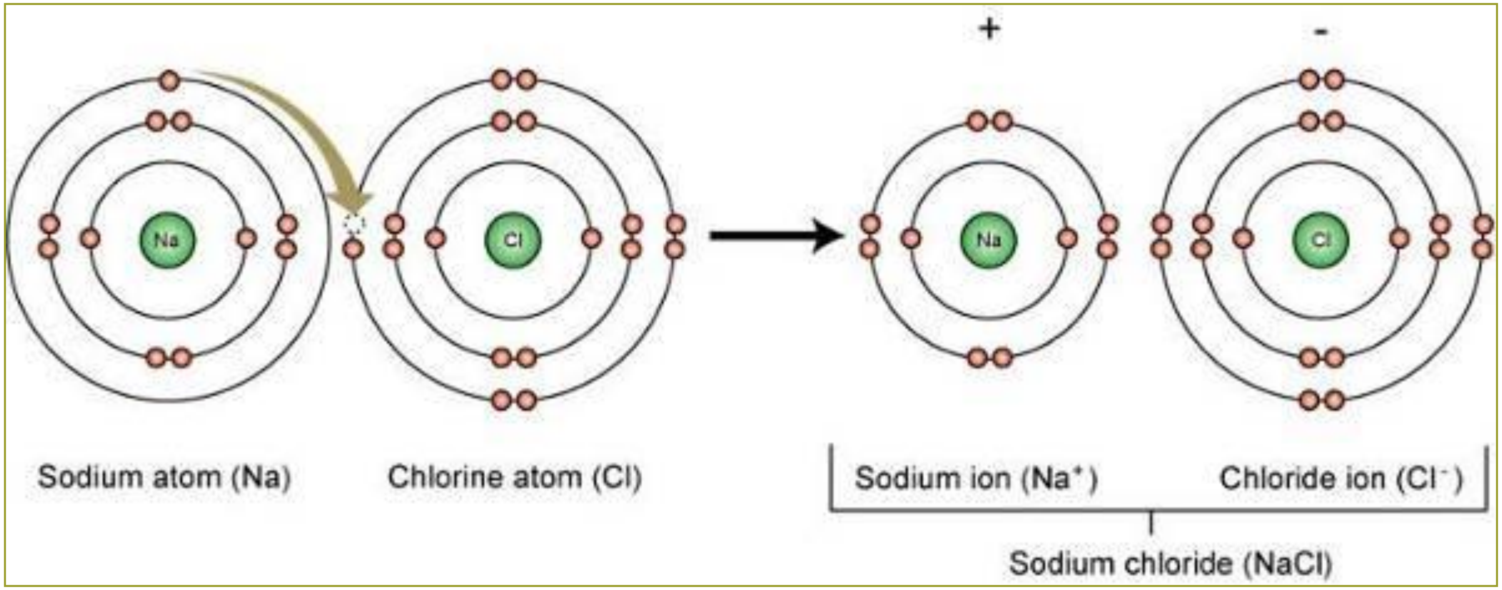
Atomic Bonding

Ionic, Covalent, and Hydrogen Bonds

Molecules and Compounds

Figure 2-12, Page 17

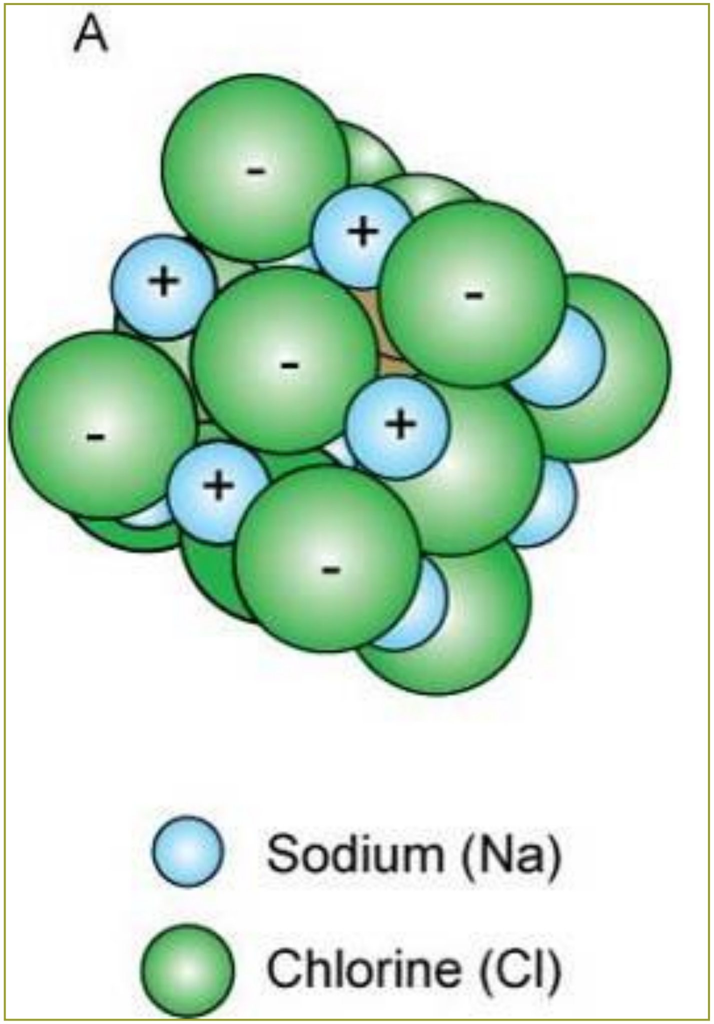
- If two or more atoms of different elements are joined, the result is a **molecule**
- A molecule is the smallest unit of a **compound** that retains the properties of that compound



Ionic Bond

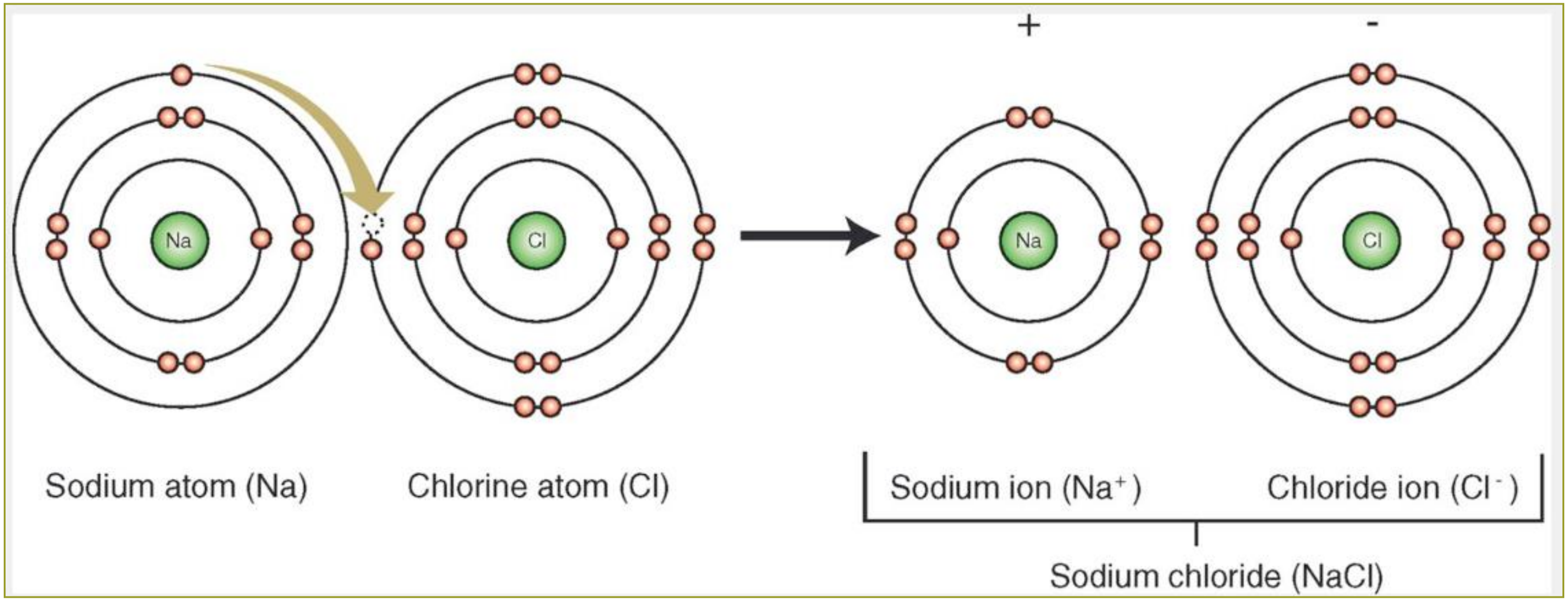
Figure 2-16A, Page 20

- Charged atoms
- Formed when electrons are [transferred]() from one atom to another
- Creates [electrolytes]()



Sodium Chloride – Ionic Bonding

Figure 2-12, Page 17



Ions (Electrolytes) in the Animal Body

Table 2.2 Important Ions

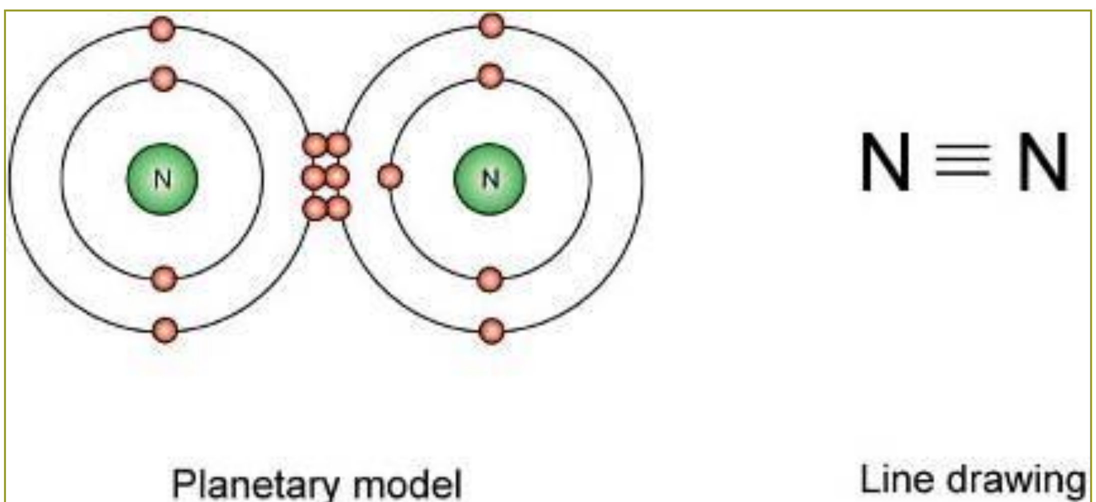
Common Ions	Symbols	Significance
Calcium	Ca^{2+}	Part of bones and teeth, blood clotting, muscle contraction, release of neurotransmitters
Sodium	Na^{+}	Membrane potentials, water balance
Potassium	K^{+}	Membrane potentials
Hydrogen	H^{+}	Acid–base balance
Hydroxide	OH^{-}	Acid–base balance
Chloride	Cl^{-}	Water balance
Bicarbonate	HCO_3^{-}	Acid–base balance
Ammonium	NH_4^{+}	Acid–base balance
Phosphate	PO_4^{3-}	Part of bones and teeth, energy exchange, acid–base balance
Iron	Fe^{2+}	Red blood cell formation
Magnesium	Mg^{2+}	Necessary for enzymes
Iodide	I^{-}	Present in thyroid hormones

The ions are part of the structures or play important roles in the processes listed.

Covalent Bonds

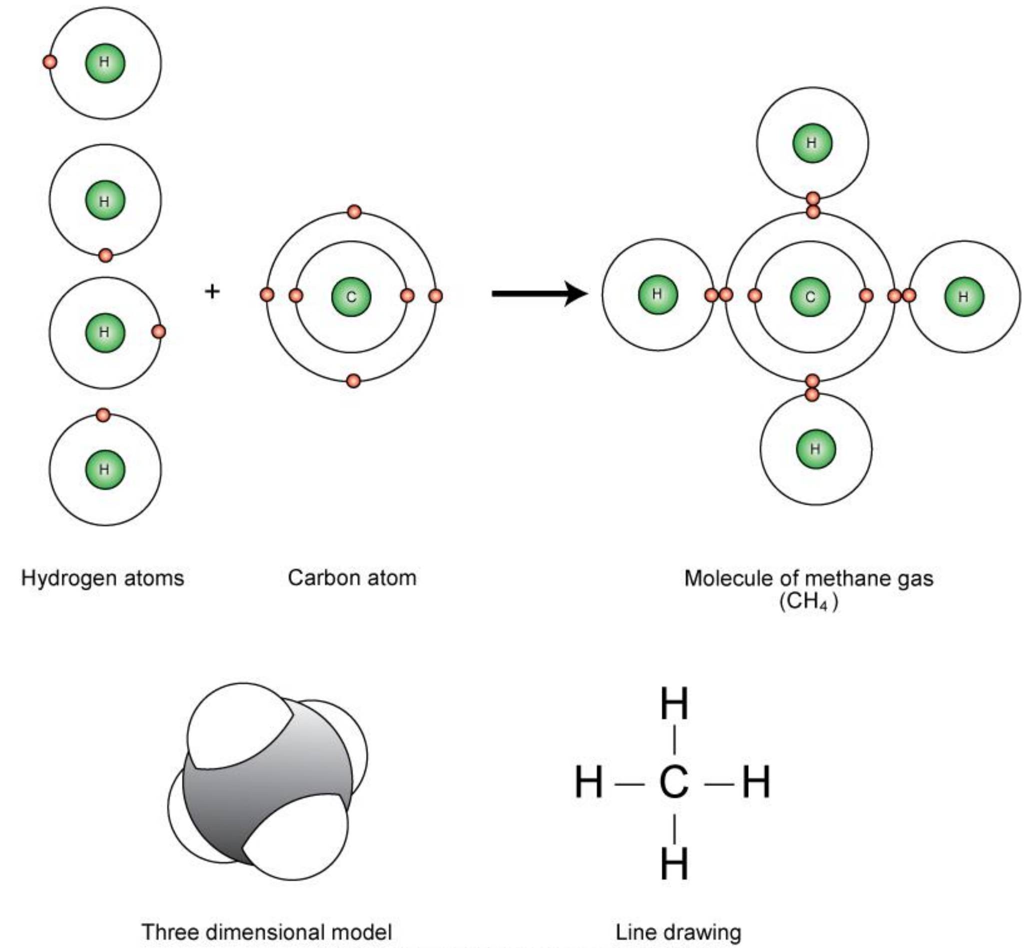
Figure 2-14, Page 19

- A **covalent bond** is formed when atoms **share** electrons.
  - ***single*** *covalent bond* — one electron is shared
  - ***double*** *covalent bond* — two electrons are shared
  - ***triple*** *covalent bond* — three electrons are shared



Covalent Bonding to Form Organic Molecules

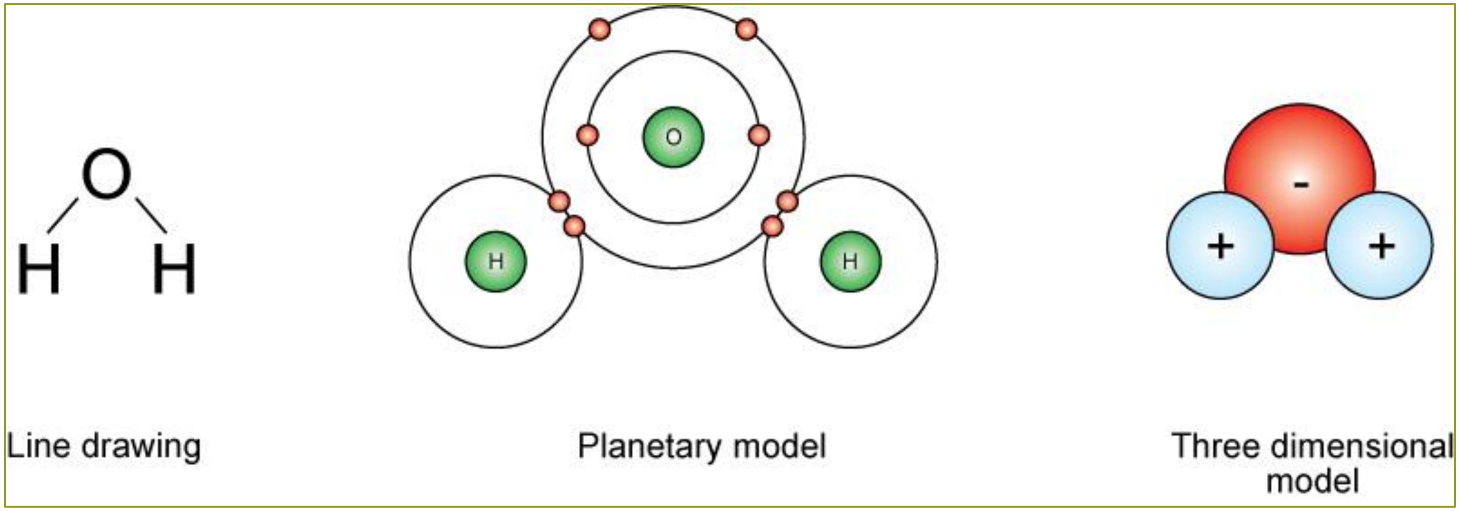
Figure 2-13, Page 18



Polar Water Molecule

Figure 2-15, Page 19

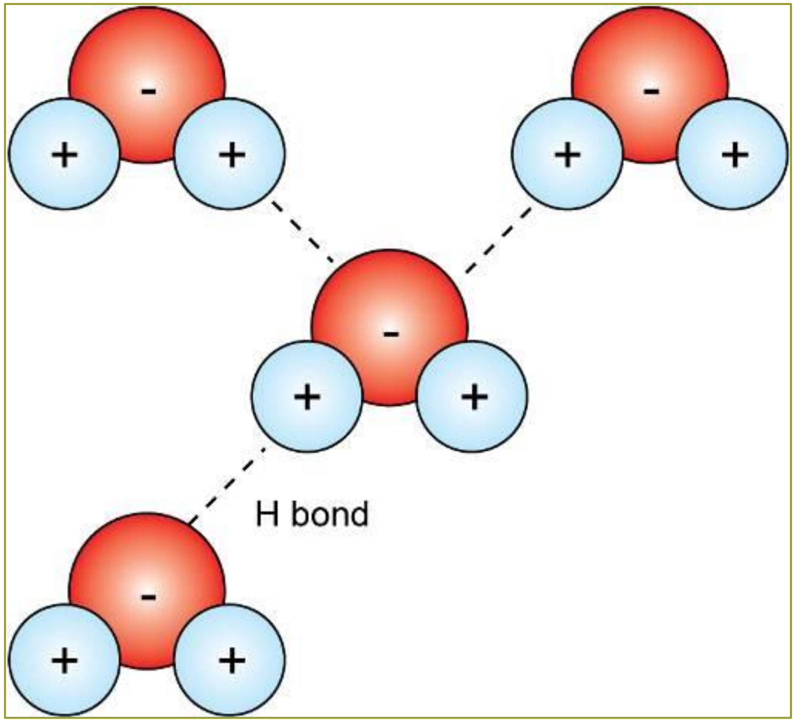
- The shared electrons in a covalently bonded molecule may spend more time near one atom than the other
- The shared electrons in a water molecule spend more time near oxygen than hydrogen atoms



Hydrogen Bond

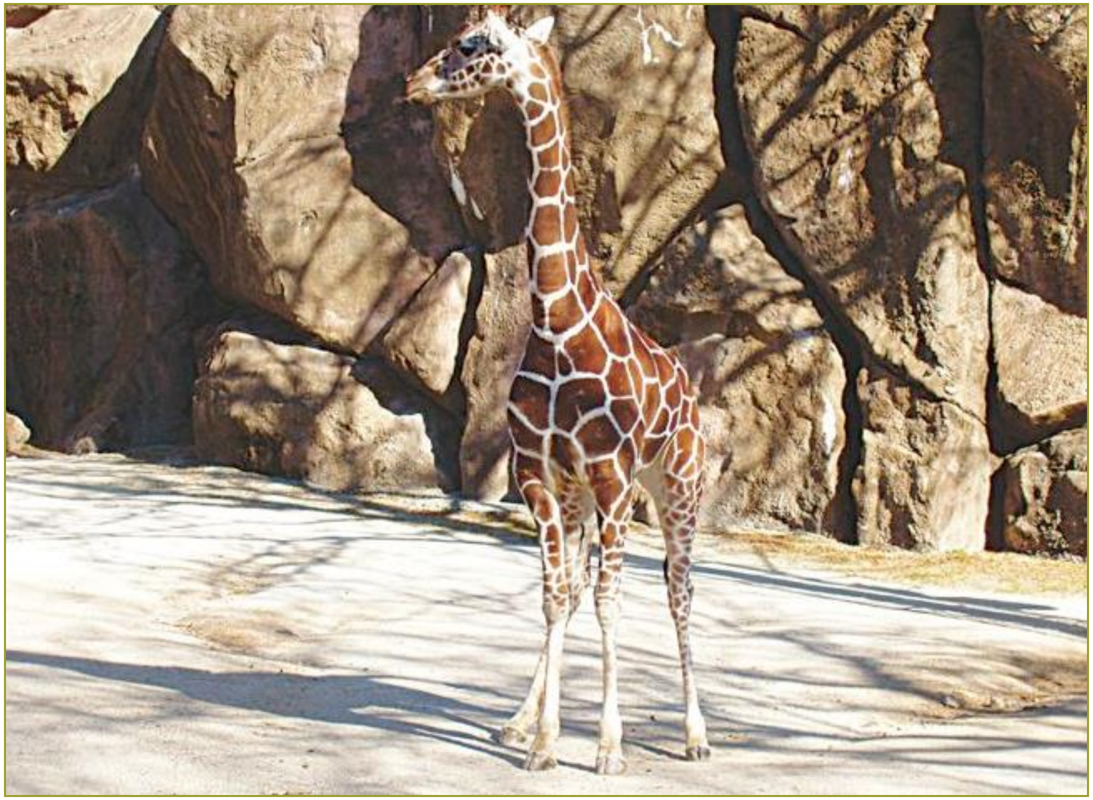
Figure 2-17, Page 20

- A bond between hydrogen atoms already covalently bonded in a molecule to oppositely charged particles
- Hydrogen bonds are weaker than ionic or covalent bonds
- Formed mostly ***between*** *molecules*



Topic 7

Distinguish between inorganic and organic molecules



Organic and Inorganic Molecules

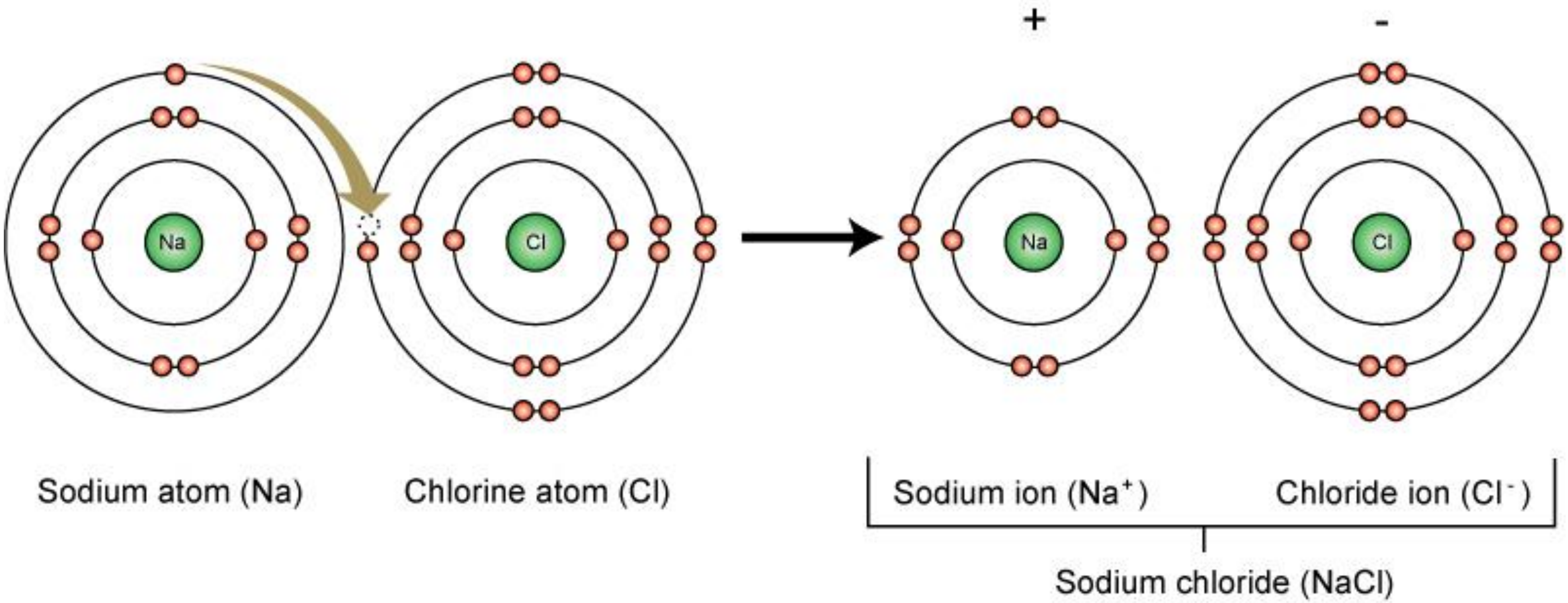
With or without Carbon Atoms

Organic & Inorganic Molecules

- **Organic molecules**
  - Contain hydrocarbon groups
  - Usually are **covalently bonded**
  - Examples: carbohydrates, lipids, proteins, and nucleic acids
  - Many of the organic molecules used in the body are **macromolecules.**
- **Inorganic molecules**
  - Do not contain hydrocarbon groups
  - Often have **ionic bonding**
  - Examples: water, salts, acids, and bases.

Inorganic Compounds
Figure 2-12, Page 17

- 1 or no carbon atoms
- Examples: water (H_2O), CO_2, sodium chloride (table salt)



Role of Water

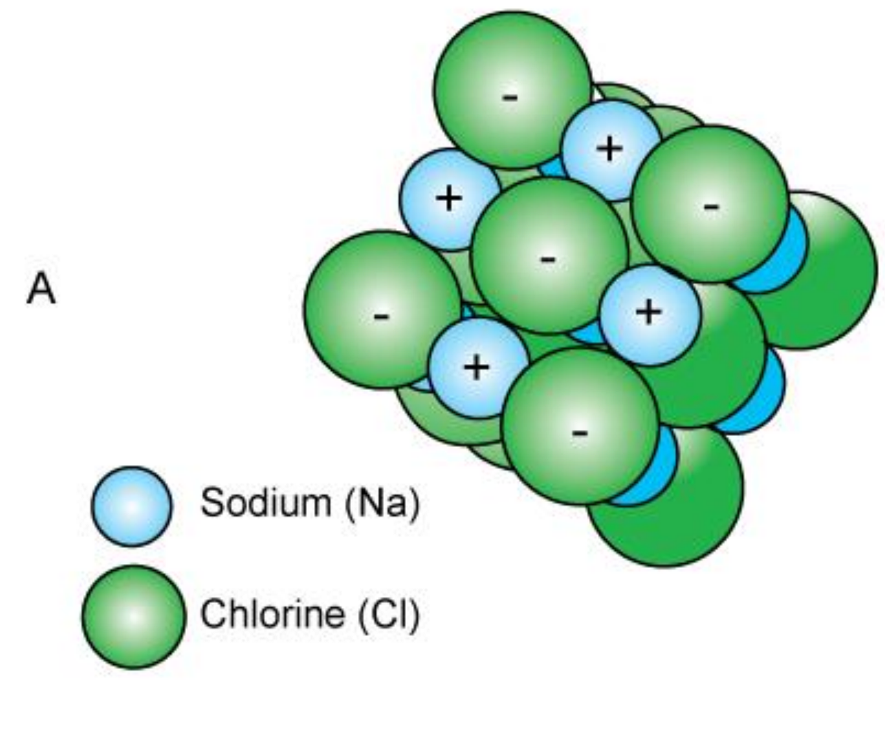
- Water is the universal solvent
- Water is an ideal transport medium
- Water has a high heat capacity and a high heat of vaporization
- Water is used for lubrication

2nd Secret of Life!!!

Salts

Figure 2-22A, Page 23

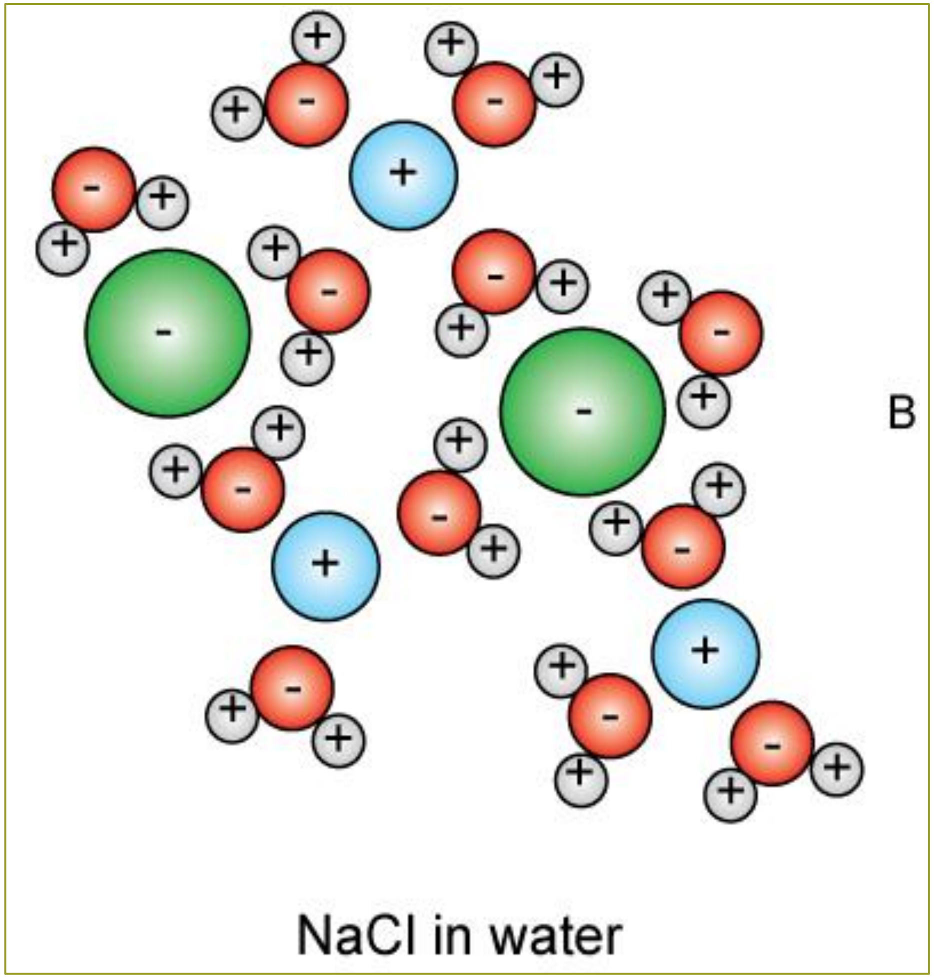
- Salts are mineral compounds that have ionic bonds
- Salts are the principle form of **minerals** that enter and are stored in the body



NaCl crystal structure

Salts
Figure 2-22B, Page 23

- When salts are added to water they immediately **ionize**
  - Salts in their ionic form are known as electrolytes.
  - **Electrolytes (ions)** are substances that have the ability to transmit an electrical charge.



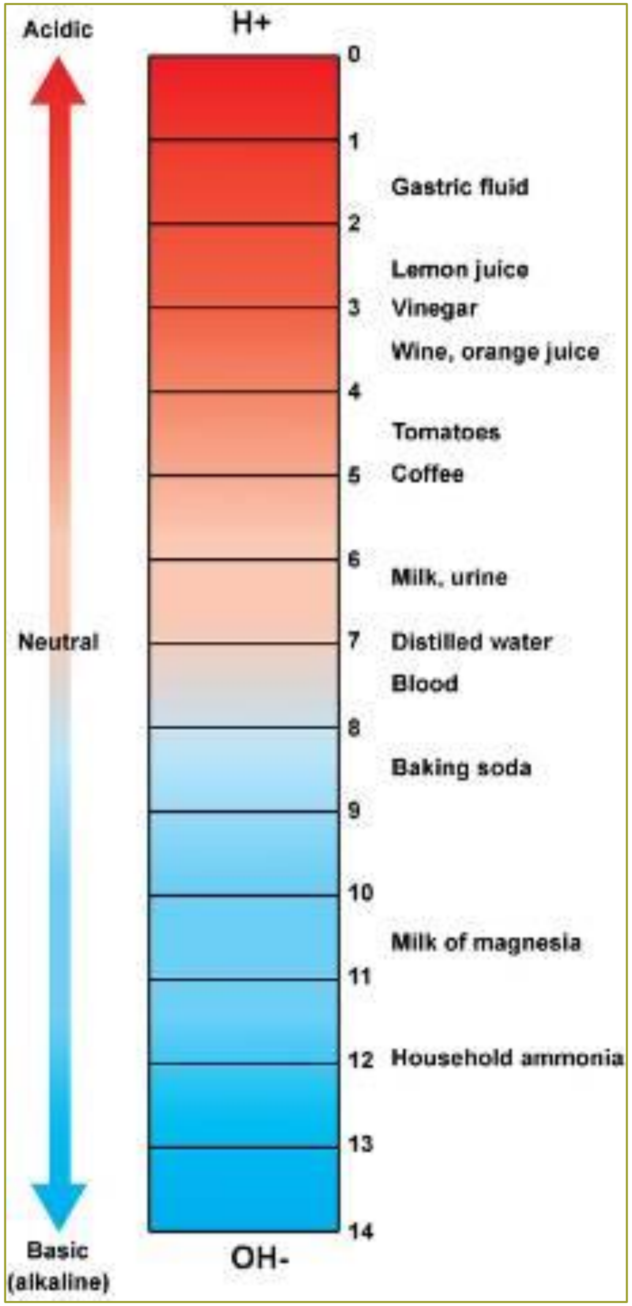
Acids and Bases

- **Acids**
  - Example: hydrochloric acid (HCl) dissociates into H^+ and Cl^- ions
  - **pH < 7.0**
- **Bases**
  - Example: sodium hydroxide (NaOH) dissociates into Na^+ and OH^- ions
  - **pH > 7.0**
- Acids and bases are also **electrolytes** – when they ionize in water, they can transmit electricity

pH Scale

Figure 2-23, Page 24

- **Acidity** and **alkalinity** are measured on a pH scale
- The scale ranges from 1 (the most acidity) to 14 (the most alkaline, or basic)
- A pH of 7 in the middle of the scale is **neutral**

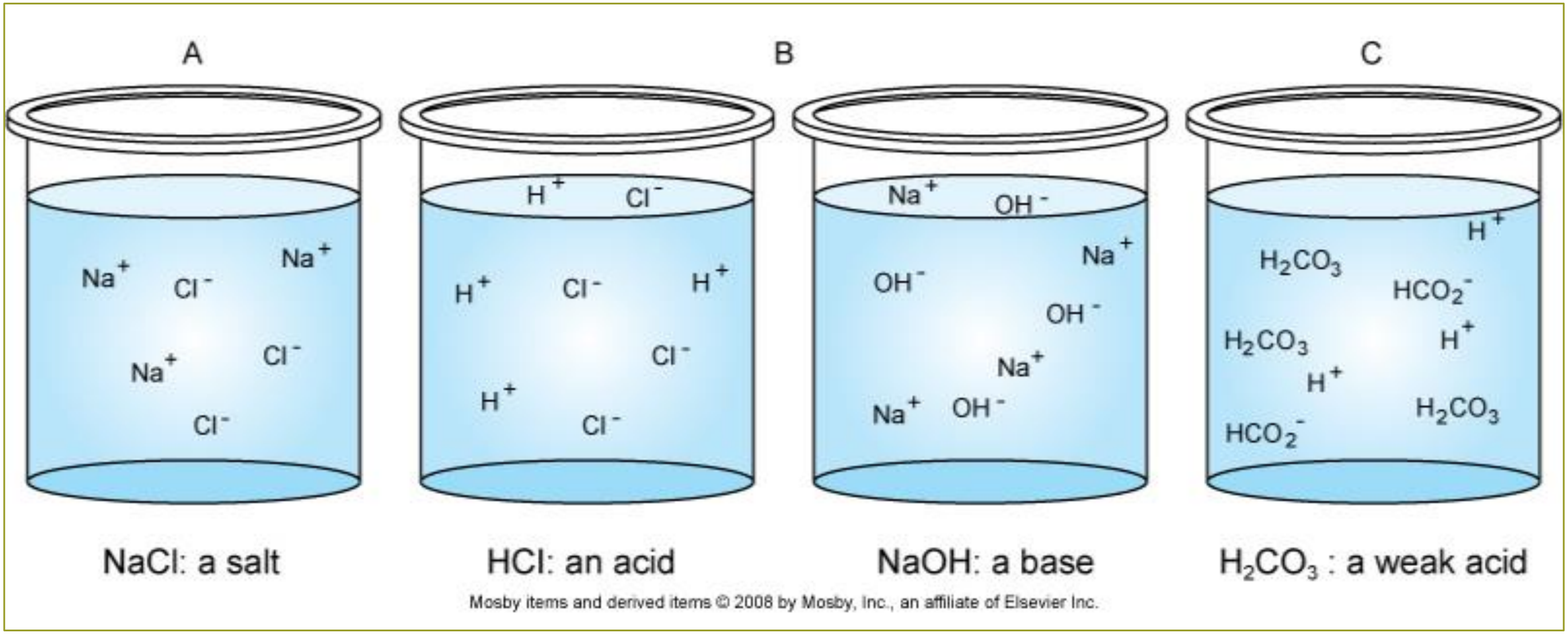


Buffers

- **Buffers** are weak acids and bases that do not completely ionize in water.
- Buffers help the cell maintain a neutral pH.
- Buffer system example: carbonic acid and **bicarbonate**
  - $H_2CO_3 \Leftrightarrow H^+ + HCO_3^- \Leftrightarrow 2H^+ + CO_3^{-2}$
  - **Lactated Ringers Solution (LR)**

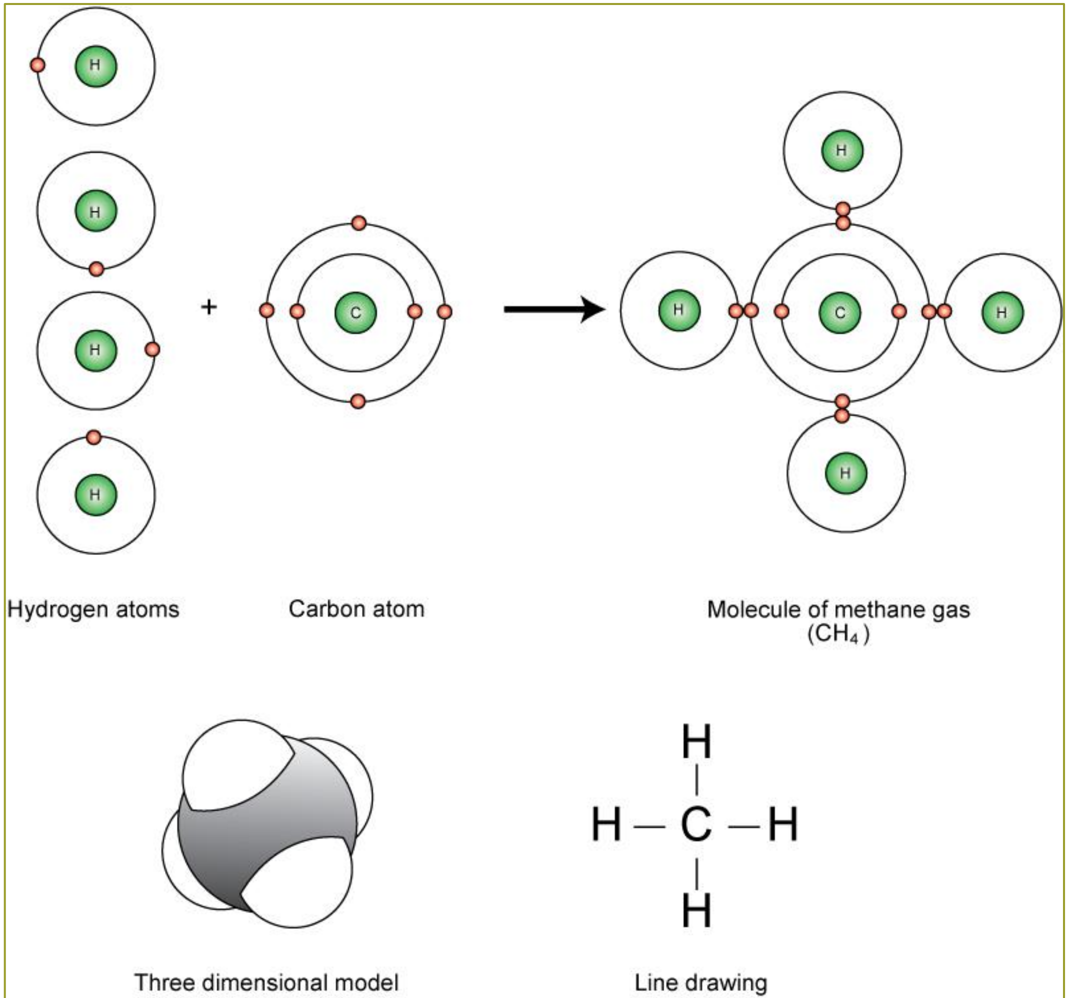
Walking Salt Water Aquariums!

Figure 2-24, Page 25

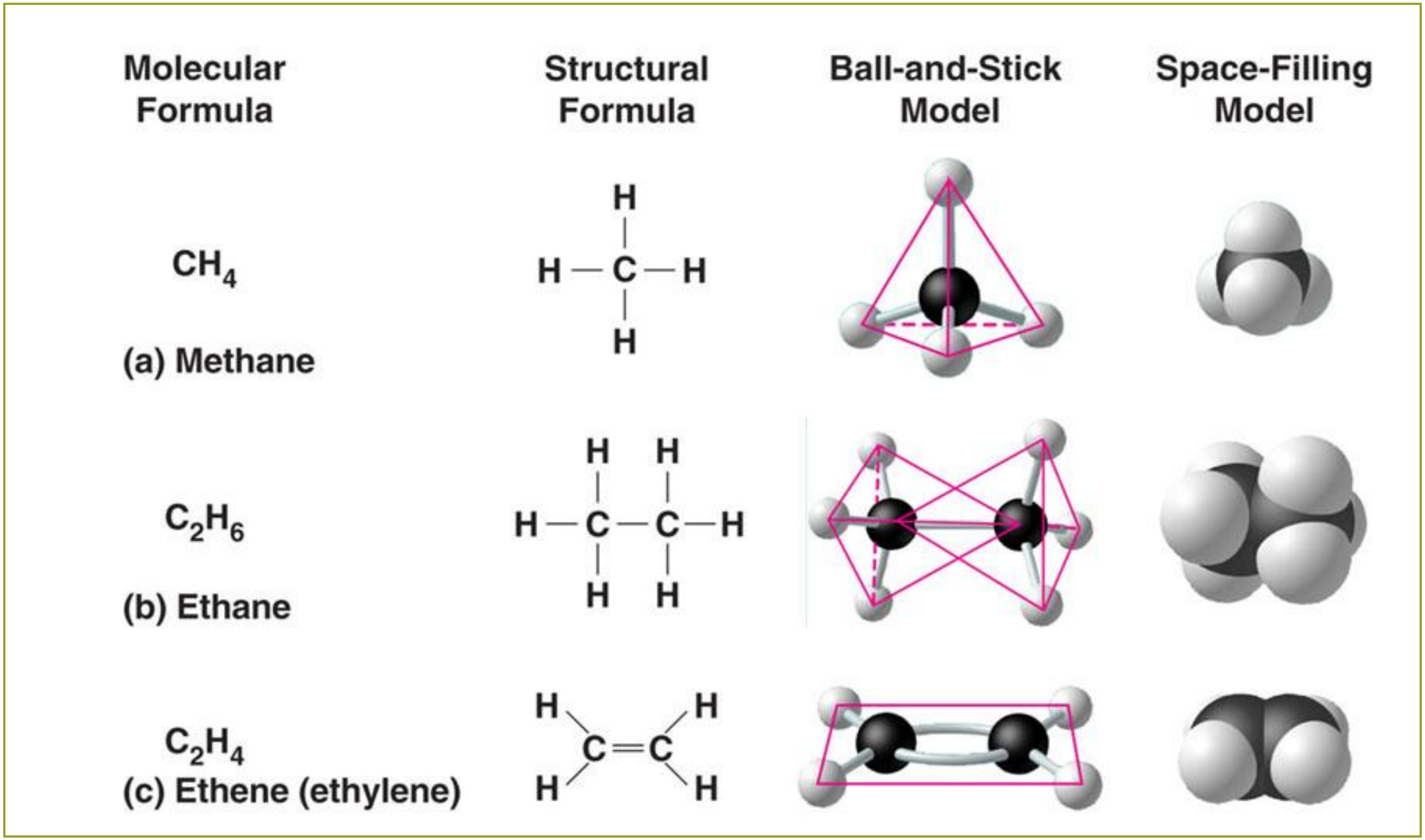


Organic Compounds – Usually 2 or More Carbon Atoms

Figure 2-13, Page 18



Organic Compounds



Topic 8

Describe the important life molecules (macromolecules) found in an animal's body

Molecule	Unit	Function
Carbohydrates		
Glycogen	Glucose	Stores energy as liver glycogen
Ribose	Pentose sugars	Backbone of DNA and RNA
Lipids		
Triglycerides	Glycerol and three fatty acids	Stores energy (eg., in body fat)
Phospholipids	Glycerol, three fatty acids, and phosphate	Primary cell membrane molecules
Steroids	Four rings of carbon	Cell membrane, hormone synthesis
Prostaglandins	20-carbon unsaturated fatty acids with a 5-carbon ring	Regulate hormone synthesis, enhance immune system, inflammatory response
Proteins		
Globular	Amino acids	Regulate chemical reactions, enzymes
Fibrous	Amino acids	Body support tissues: muscle, cartilage, tendons (collagen), skin, hair (keratin)
Nucleic Acids		
DNA	Nucleotides	Chromosomes
RNA	Nucleotides	Messenger, transfer
Adenosine triphosphate (ATP)	Adenine nucleotide and two phosphate groups	Stored energy in phosphate bonds

The "Big 4" Macromolecules

- Carbohydrates
  - C, H, O
- Lipids
  - C, H, O
- Proteins
  - C, H, O, N
- Nucleic Acids
  - C, H, O, N, P

Table 2.3 Important Organic Molecules and Their Functions

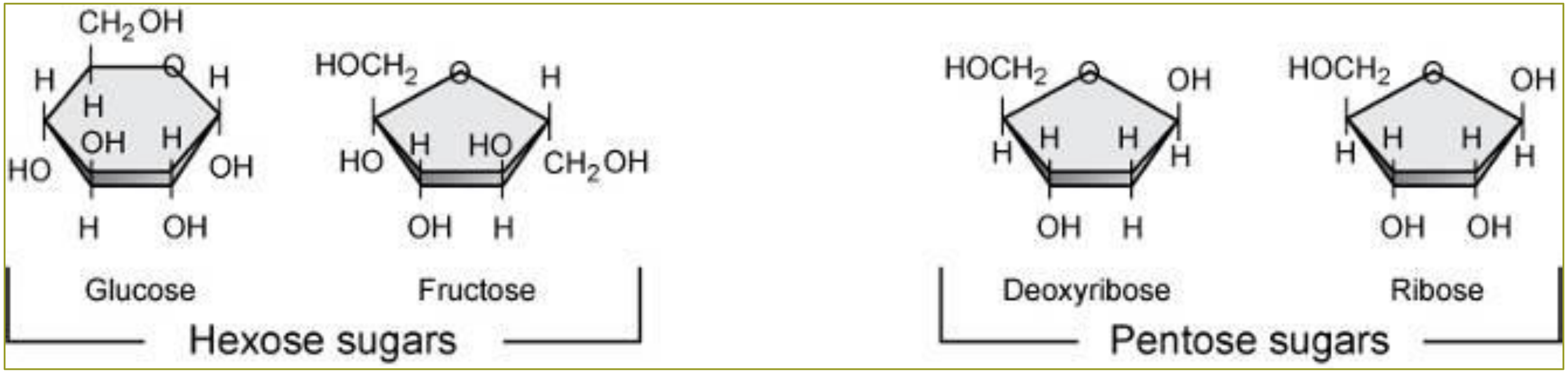
Molecule	Elements	Building Blocks	Function	Examples
Carbohydrate	C, H, O	Monosaccharides	Energy	Monosaccharides can be used as energy sources. Glycogen (polysaccharide) is an energy-storage molecule.
Lipid	C, H, O (P, N in some)	Glycerol and fatty acids (for fats)	Energy	Fats can be stored and broken down later for energy; per unit of weight fats yield twice as much energy as carbohydrates.
			Structure	Phospholipids and cholesterol are important components of cell membranes.
			Regulation	Steroid hormones regulate many physiological processes (e.g., estrogen and testosterone are responsible for many of the differences between males and females).
Protein	C, H, O, N (S in most)	Amino acids	Regulation	Enzymes control the rate of chemical reactions. Hormones regulate many physiological processes (e.g., insulin affects glucose transport into cells).
			Structure	Collagen fibers form a structural framework in many parts of the body.
			Energy	Proteins can be broken down for energy; per unit of weight they yield the same energy as carbohydrates.
			Contraction	Actin and myosin in muscle are responsible for muscle contraction.
			Transport	Hemoglobin transports oxygen in the blood.
			Protection	Antibodies and complement protect against microorganisms and other foreign substances.
Nucleic acid	C, H, O, N, P	Nucleotides	Regulation	DNA directs the activities of the cell.
			Heredity	Genes are pieces of DNA that can be passed from one generation to the next generation.
			Protein synthesis	RNA is involved in protein synthesis.

The "Big 4"
Table 2-2, Page 26

Molecule	Unit	Function
Carbohydrates		
Glycogen	Glucose	Stores energy as liver glycogen
Ribose	Pentose sugars	Backbone of DNA and RNA
Lipids		
Triglycerides	Glycerol and three fatty acids	Stores energy (eg., in body fat)
Phospholipids	Glycerol, three fatty acids, and phosphate	Primary cell membrane molecules
Steroids	Four rings of carbon	Cell membrane, hormone synthesis
Prostaglandins	20-carbon unsaturated fatty acids with a 5-carbon ring	Regulate hormone synthesis, enhance immune system, inflammatory response
Proteins		
Globular	Amino acids	Regulate chemical reactions, enzymes
Fibrous	Amino acids	Body support tissues: muscle, cartilage, tendons (collagen), skin, hair (keratin)
Nucleic Acids		
DNA	Nucleotides	Chromosomes
RNA	Nucleotides	Messenger, transfer
Adenosine triphosphate (ATP)	Adenine nucleotide and two phosphate groups	Stored energy in phosphate bonds

Carbohydrates
Figure 2-26, Page 27

- The sugar unit is the building block for carbohydrates
- “Good Carbs” & “Bad Carbs”

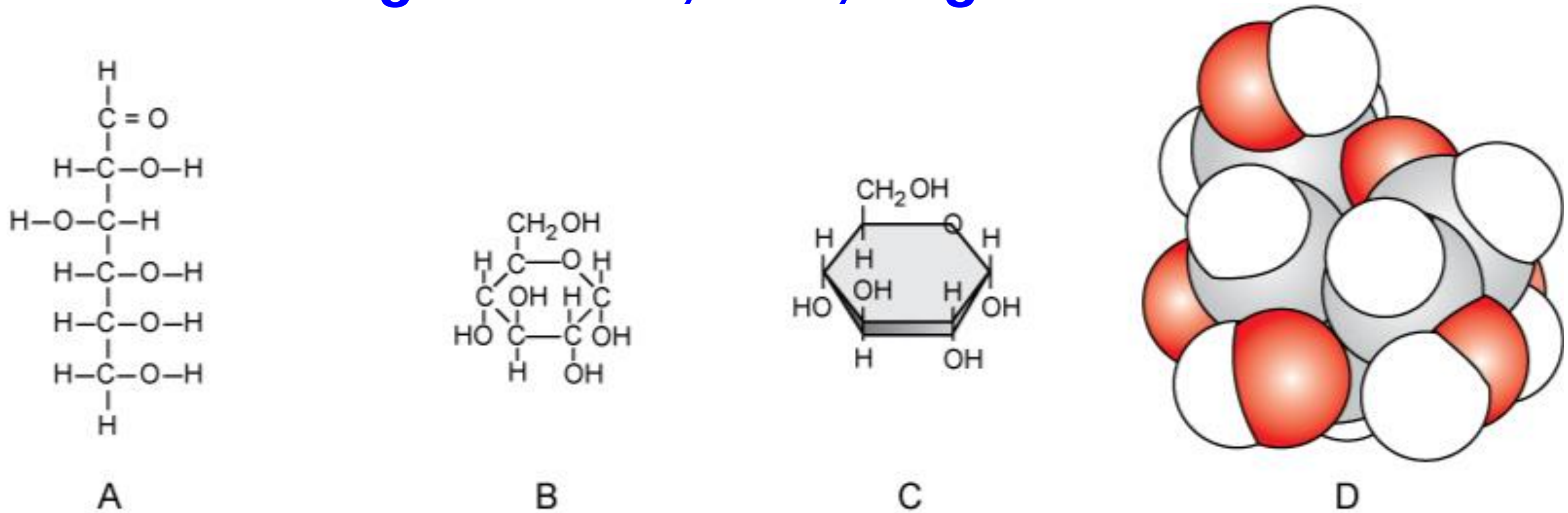


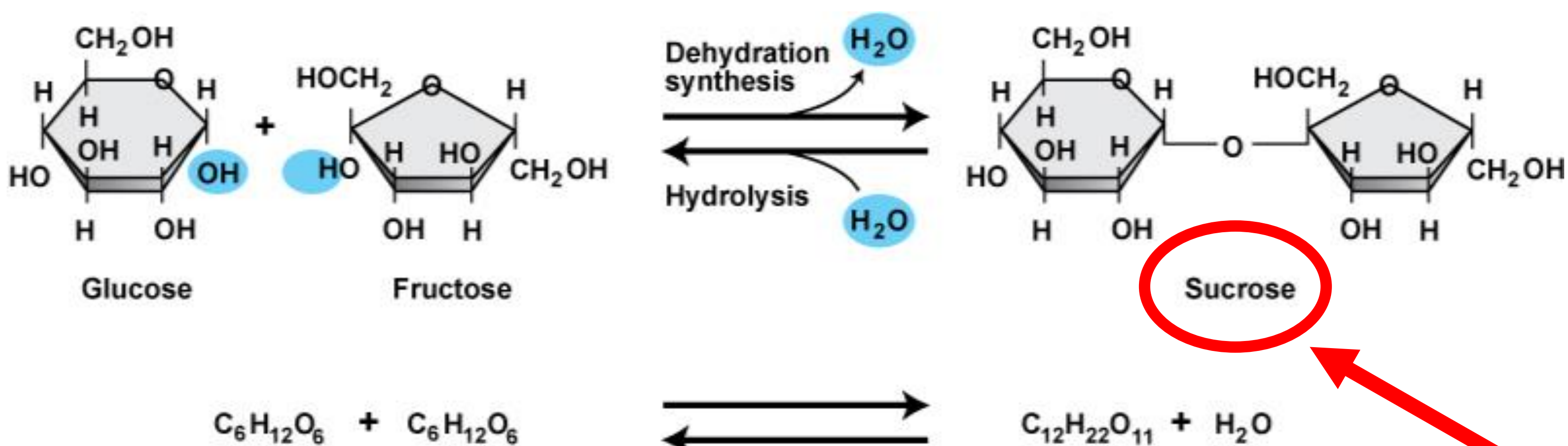
Carbohydrates

- Functions: used for energy, storage of energy, and cellular structures
- Monosaccharides: contain three to seven carbon atoms in a chain or ring
  - Example: glucose, chemical formula $C_6H_{12}O_6$
- Disaccharides: two monosaccharides joined together
  - Example: glucose + fructose = **sucrose**
- Polysaccharides: combinations of many monosaccharides
  - Examples: glycogen, starch, and cellulose

Monosaccharides

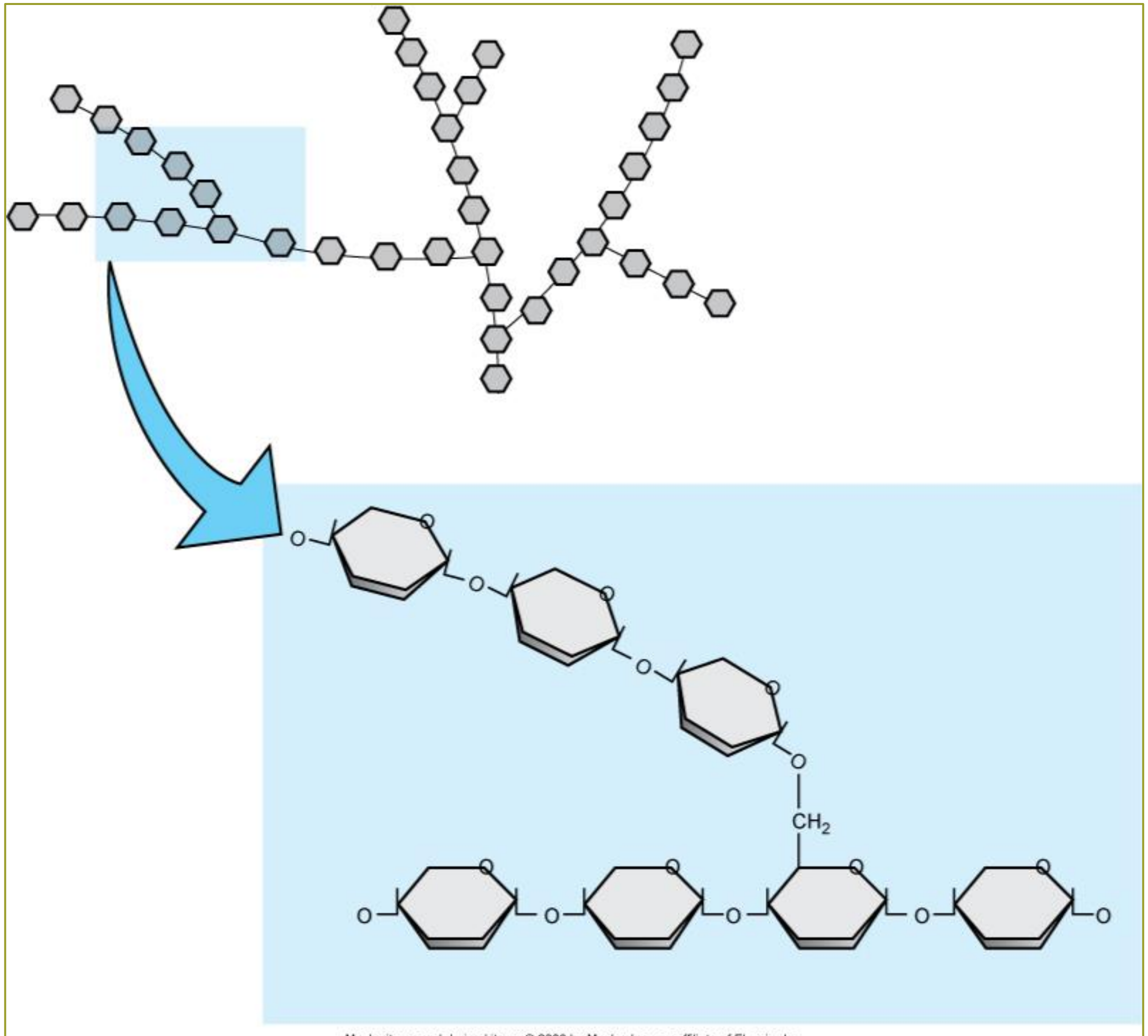
Figures 2-25, 2-27, Pages 26-27





Polysaccharides

Figure 2-28, Page 28



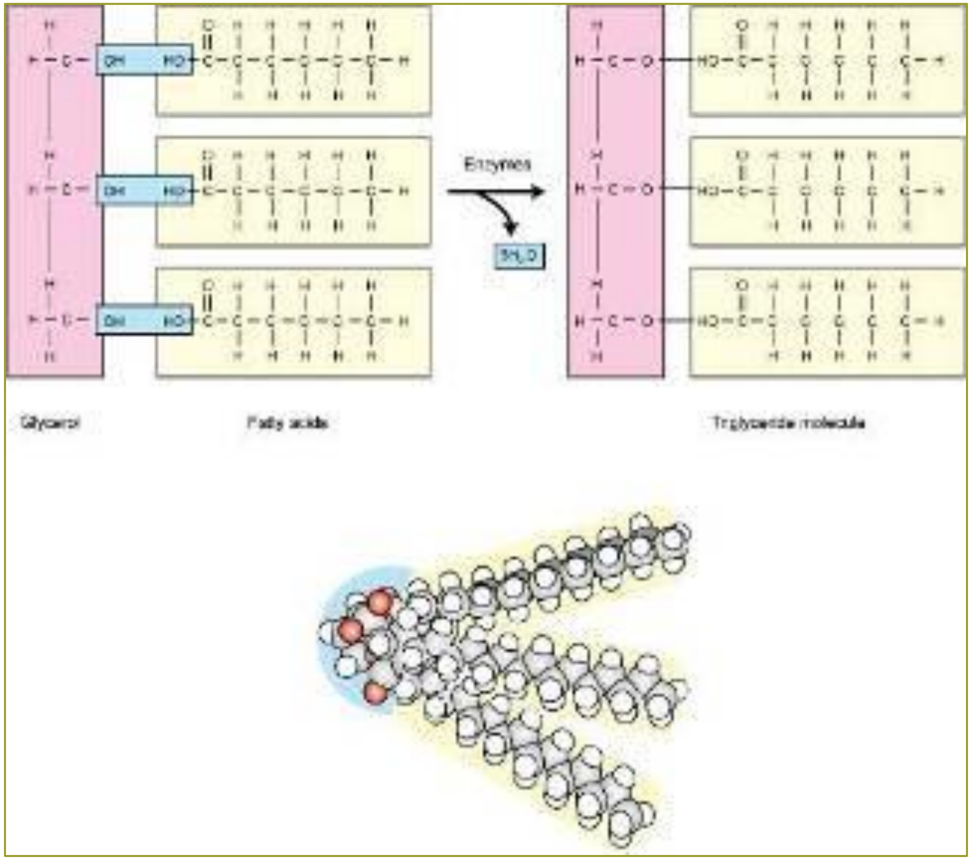
Lipids

- Functions: used in the body for energy and stored in fat for future energy needs
- Four classes of lipids:
  - Neutral fats
    - “Good fats”
  - Phospholipids
  - Steroids
  - Eicosanoids

Neutral Fats (Triglycerides)

Figure 2-30, Page 29

- Contain three fatty acids and a glycerol molecule
- A **glycerol** molecule is a modified three-carbon simple sugar
- A **fatty acid** is a chain of carbon atoms with one or two hydrogen atoms attached to each carbon by single or double bonds



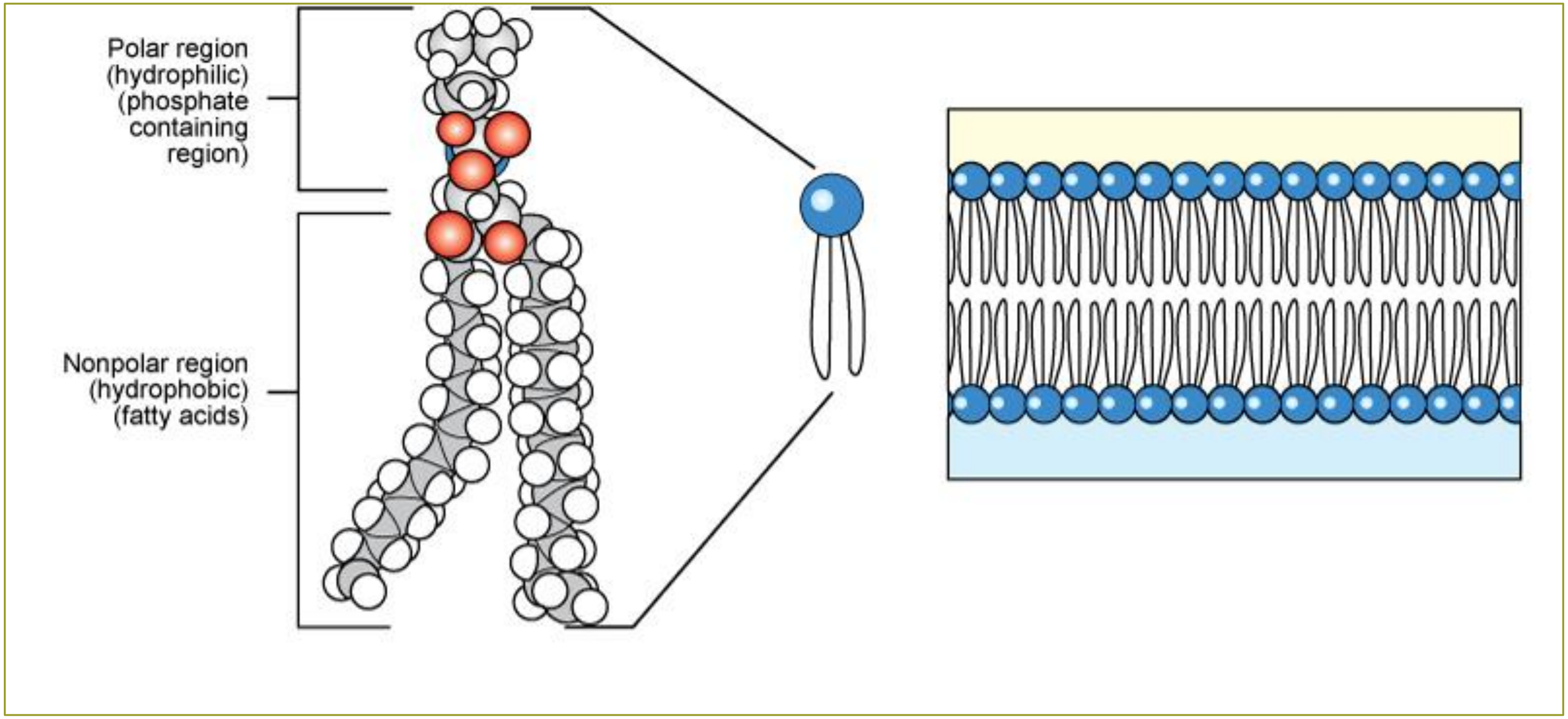
Saturated & Unsaturated Fats

- A fatty acid is called **saturated** when all the bonds in the hydrocarbon chain are single bonds and as many hydrogen atoms as possible are attached to carbon
- A fatty acid is called **unsaturated** when there are some double bonds between the carbon and hydrogen atoms

Phospholipids

Figure 2-31, Page 30

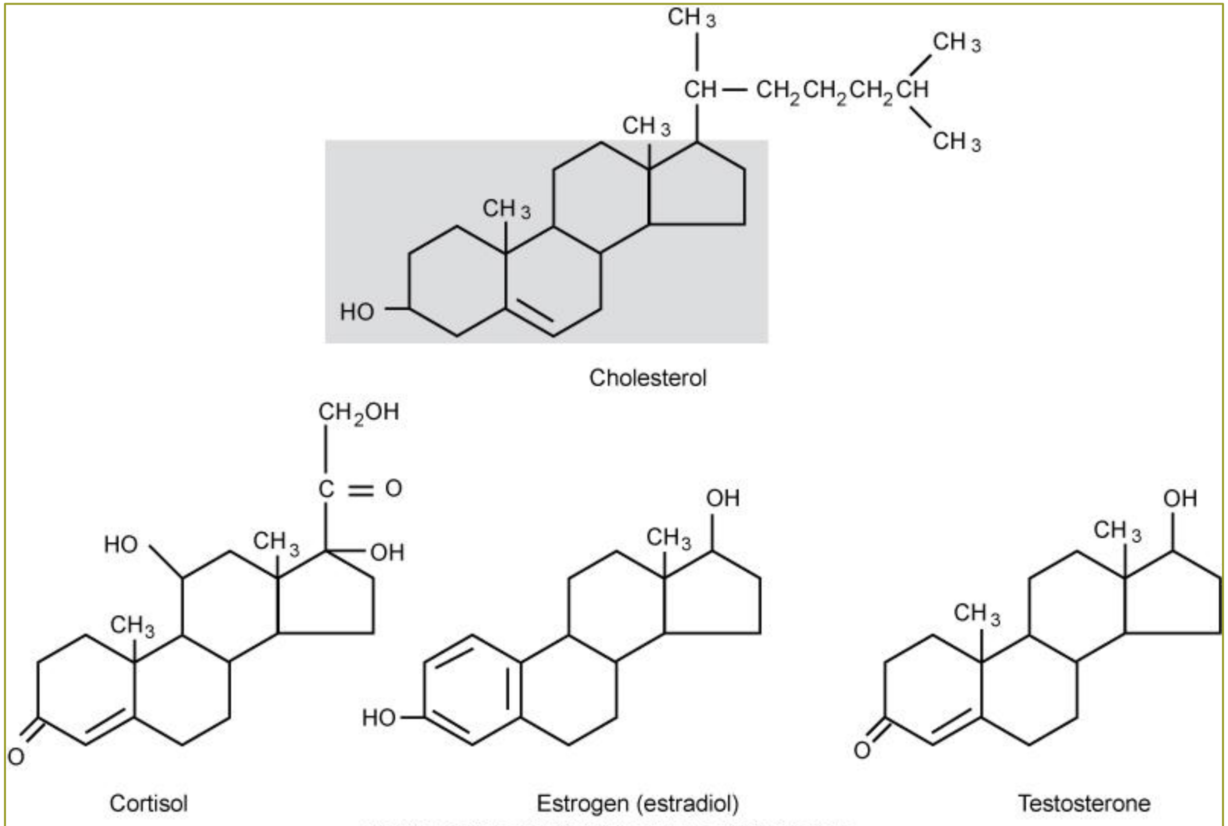
- Contain two fatty acids attached to glycerol extending in one direction
- **ALL cell membranes**



Steroids

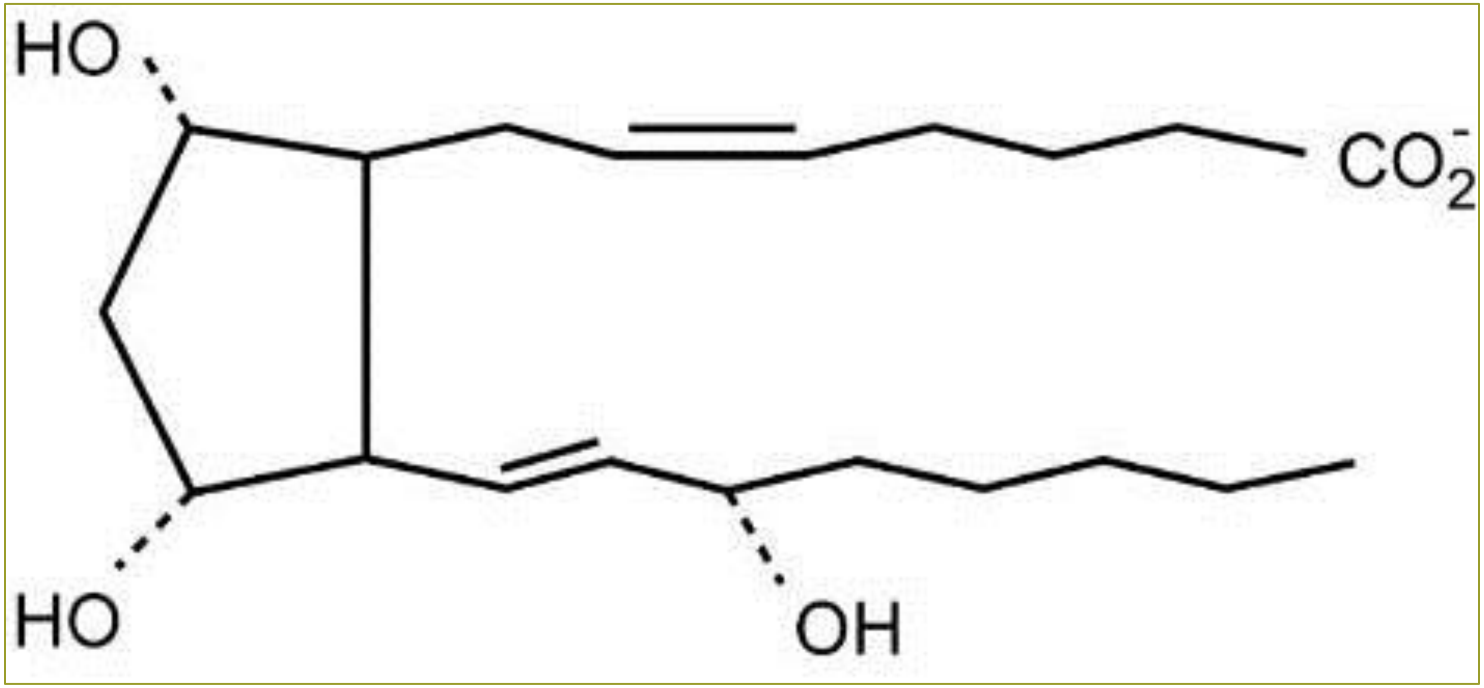
Figure 2-32, Page 31

- Lipids that take the form of four interlocking hydrocarbon rings



Eicosanoids
Figure 2-33, Page 31

- Lipids formed from a 20-carbon fatty acid and a ring structure
  - **Prostaglandins:** mediate inflammation

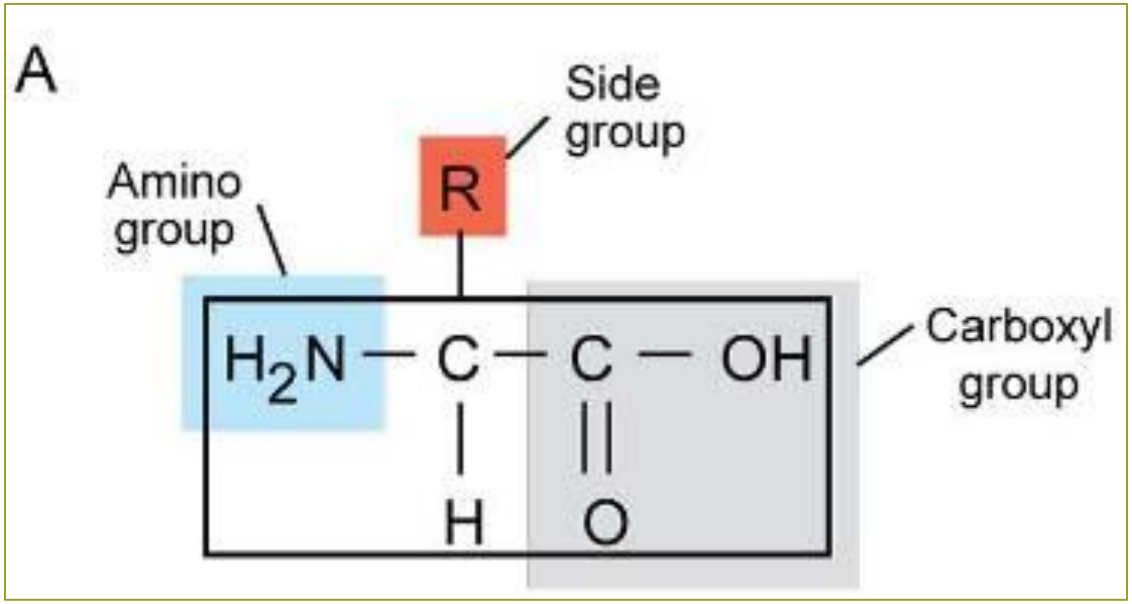


Proteins

- **Proteins** are the most abundant organic molecules in the body
- Composed primarily of **C, O, H, and N**
- Made of amino acids
- **Functions**: used for cell structures and structural body tissues, for controlling chemical reactions, for regulating growth, for transporting molecules, for defending the body against invaders, for catalyzing all reactions occurring in the body

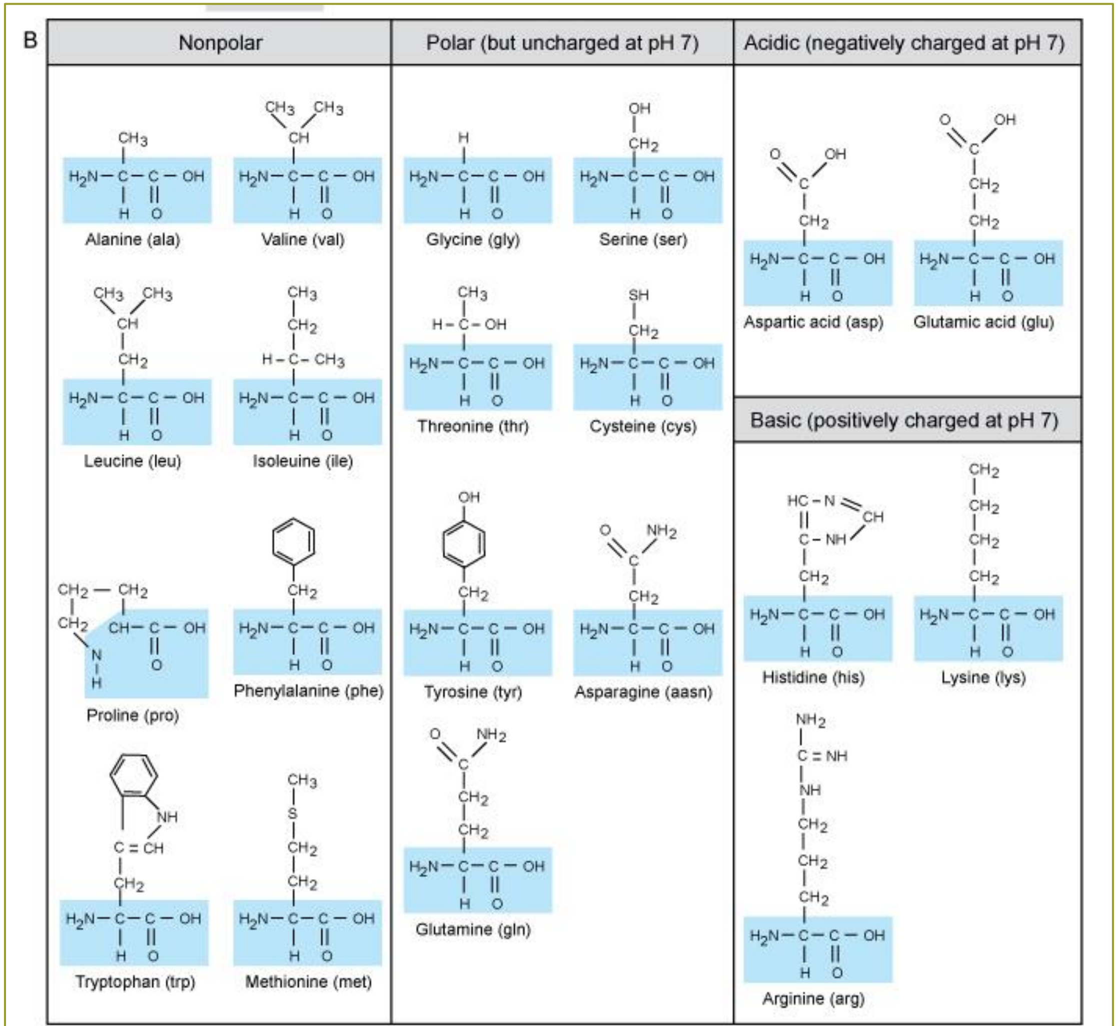
Amino Acids
Figure 2-34A, Page 32

- 20 different amino acids used by the animal's body
- Contains a central carbon atom attached to a hydrogen atom, an *amino group* (NH_2), a *carboxyl group* (COOH) and a side chain (designated by the letter "R")
- The R group defines each amino acid.



Amino Acid Structure

Figure 2-34B, Page 32



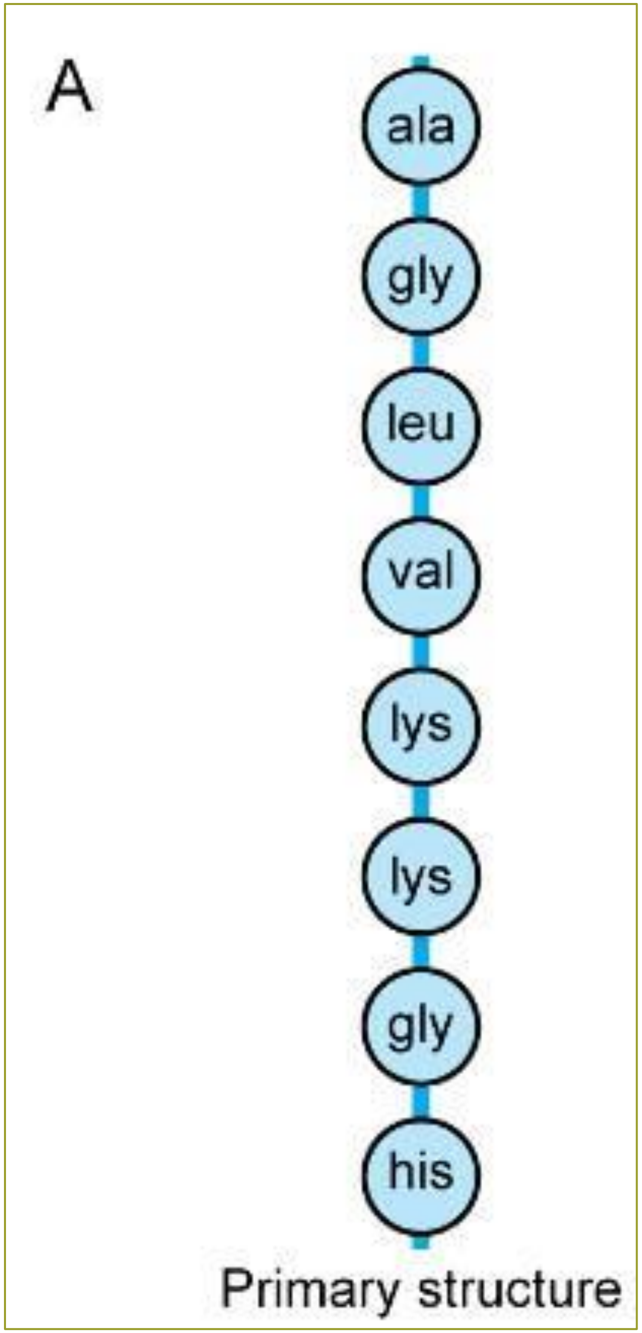
Amino Acids

- The specific combination of amino acids is determined by the cell's DNA
- Two amino acids are linked together by a peptide bond
- A polypeptide is a chain of ten or more amino acids linked together
- Essential amino acids
  - Definition

Structure of Proteins

Figure 2-36A, Page 34

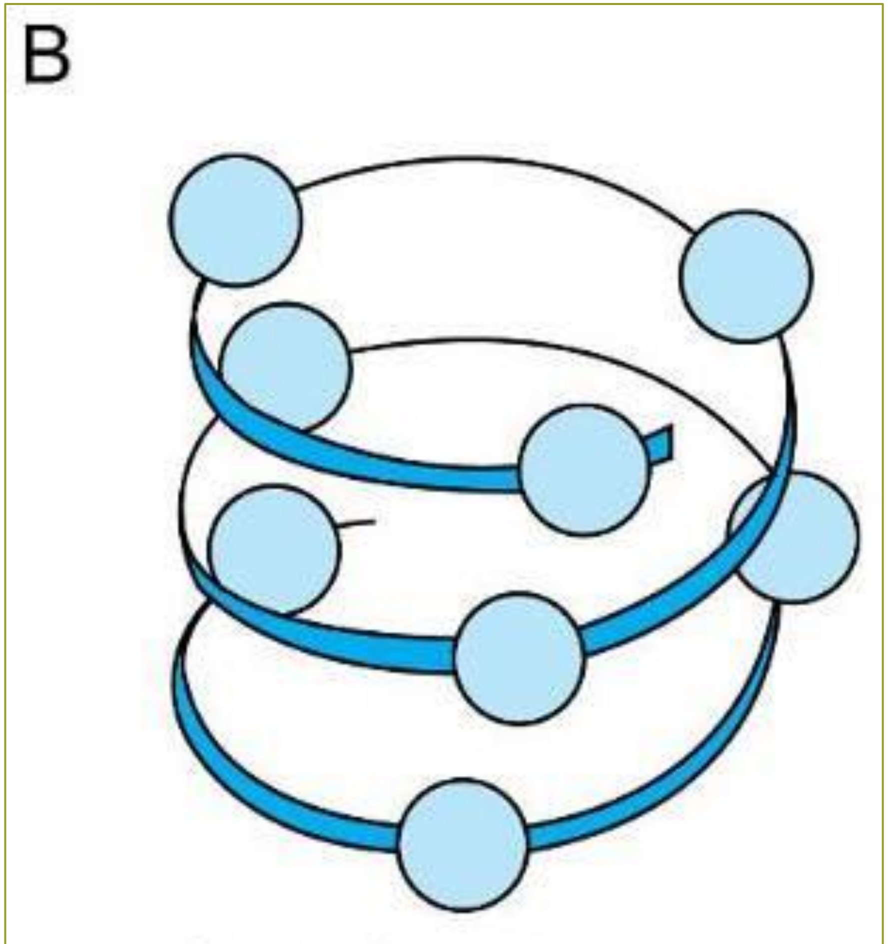
- Primary structure: the sequence and number of amino acids that link together to form the peptide chain



Structure of Proteins

Figure 2-36B, Page 34

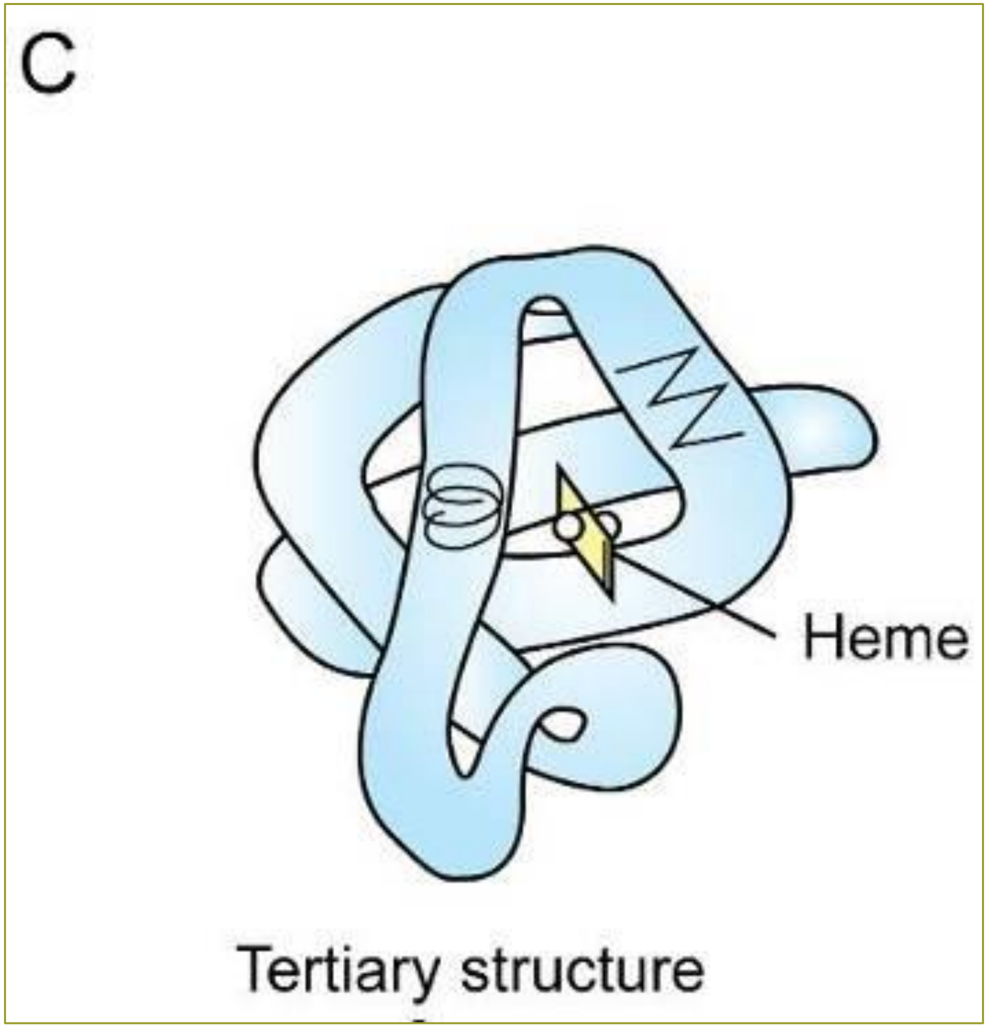
- Secondary structure: the natural bend of parts of the peptide chain as it is formed in three dimensions



Secondary structure

Structure of Proteins
Figure 2-36C, Page 34

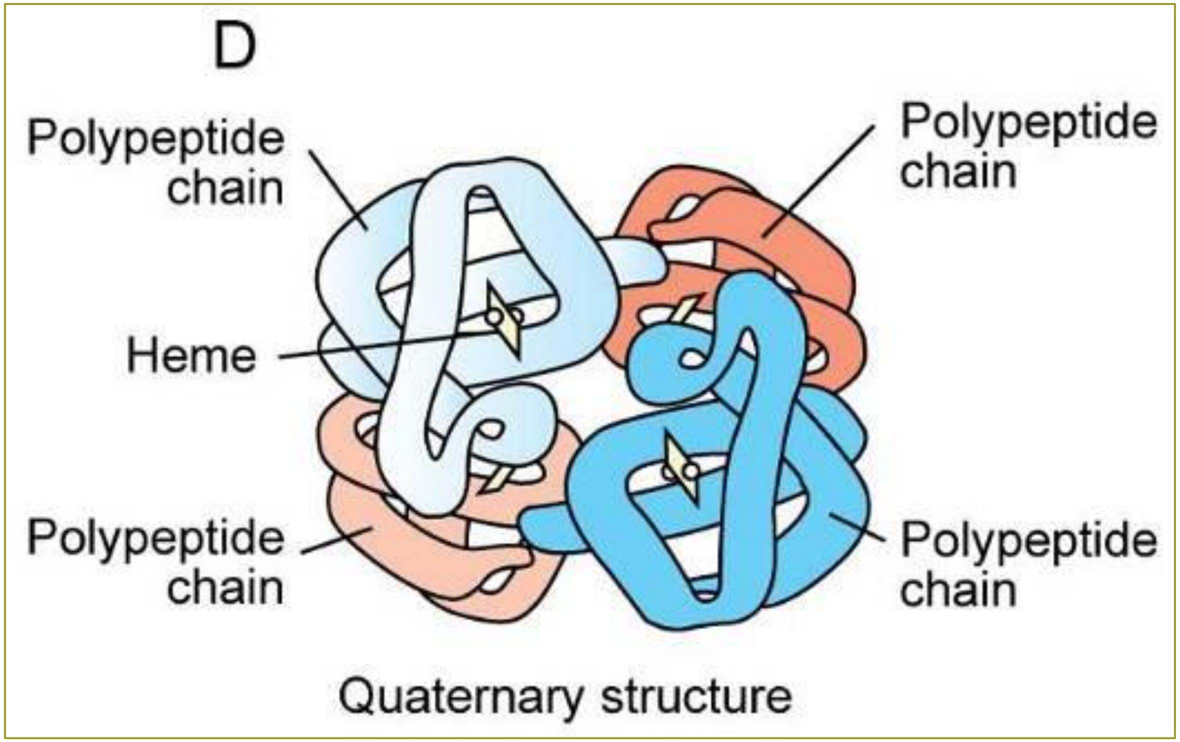
- Tertiary structure: the overall shape of a single protein molecule



Structure of Proteins

Figure 2-36D, Page 34

- Quaternary structure: two or more protein chains join to form a complex macromolecule



Types of Proteins

Table 2-3, Page 33

- **Structural proteins** are stable, **rigid**, **water-insoluble** proteins that are used for adding strength to tissues or cells
  - Examples: collagen, fibrin, and keratin
- **Functional proteins** are generally **water-soluble** and have a flexible, three-dimensional shape that can change under different circumstances
  - Examples: hemoglobin, antibodies, **enzymes**, and protein-based hormones

TABLE 2-3 Functions of Proteins

Protein Structure	Function	Example
Functional (globular)	Chemical reactions	Protein enzymes: essential to almost every biochemical reaction in the body
	Transport of molecules	Hemoglobin transports oxygen in the blood
	Regulation of metabolism	Peptide hormones: regulate metabolic activity, growth, and development. For example, thyroid hormone regulates metabolic rate and insulin regulates blood sugar levels
	Immune system	Antibodies (immunoglobulins) are proteins created by immune cells that recognize foreign substances such as viruses
Structural (fibrous)	Structural framework	Collagen: gives strength to bones, tendons, ligaments
		Keratin: hair, nails, waterproofing of skin
	Physical movement	Actin and myosin: contractile proteins found in muscle; actin also used for intracellular transport

Enzymes

- **Enzymes** are proteins that act as catalysts to speed up a chemical reaction without themselves being altered or destroyed

Nucleic Acids

- **Nucleic acids** are the largest molecules in the body
- Composed of C, O, H, N, and P
- Two classes of nucleic acids:
  - **DNA (deoxyribonucleic acid)** – exists mainly in the nucleus (but also in mitochondria) and is the molecule that contains all the instructions needed by the cell to build protein
  - **RNA (ribonucleic acid)** – transfers instructions out of the nucleus and into the cytoplasm of the cell; builds proteins

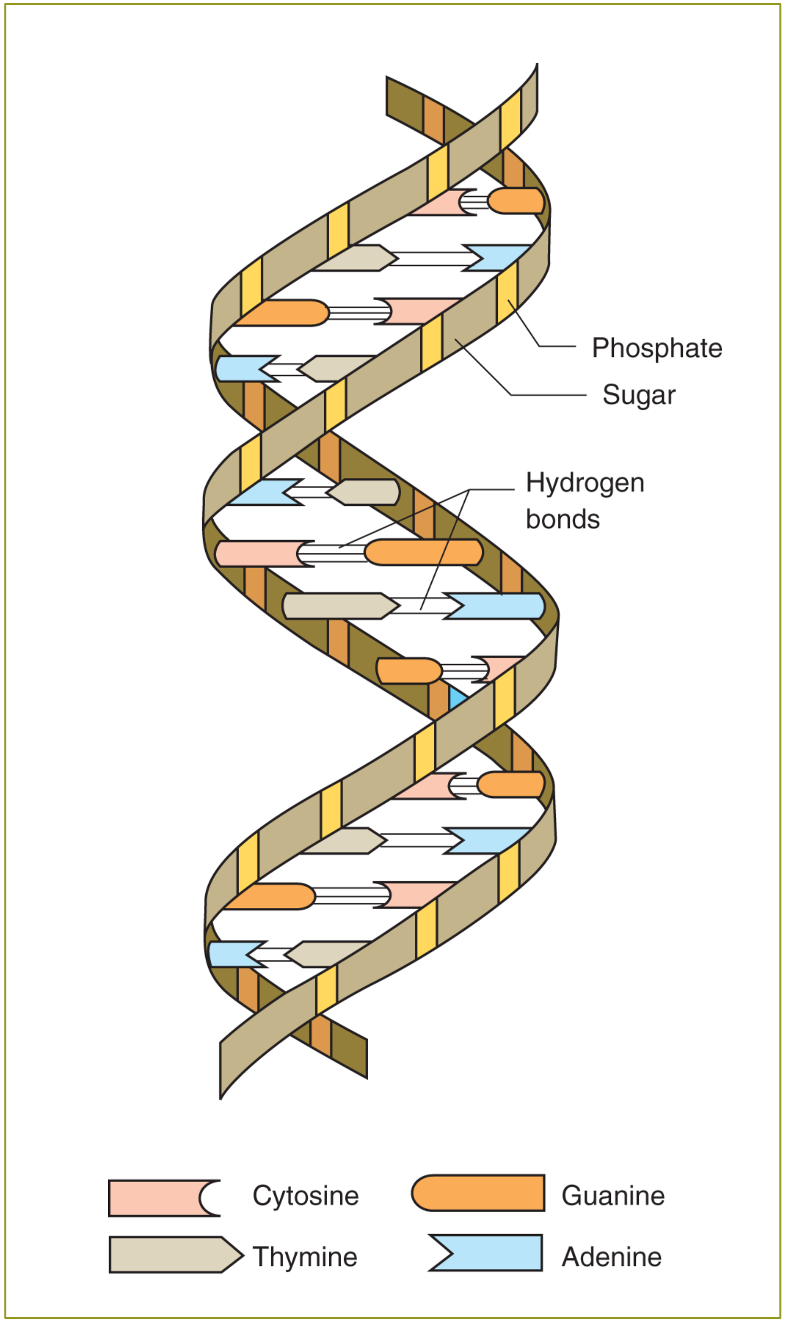
Nucleotides

- Molecular building blocks of nucleic acids
- Consist of a nitrogenous base plus a 5-carbon (pentose) sugar plus a phosphate group
- The sugar in DNA is deoyxribose and in RNA, ribose

DNA

Figure 2-41, Page 37

- DNA is constructed of two parallel strands of the nucleotides A, G, C, and T
- The two strands of bonded nucleic acid twist around each other in a spiral called a ***double helix***



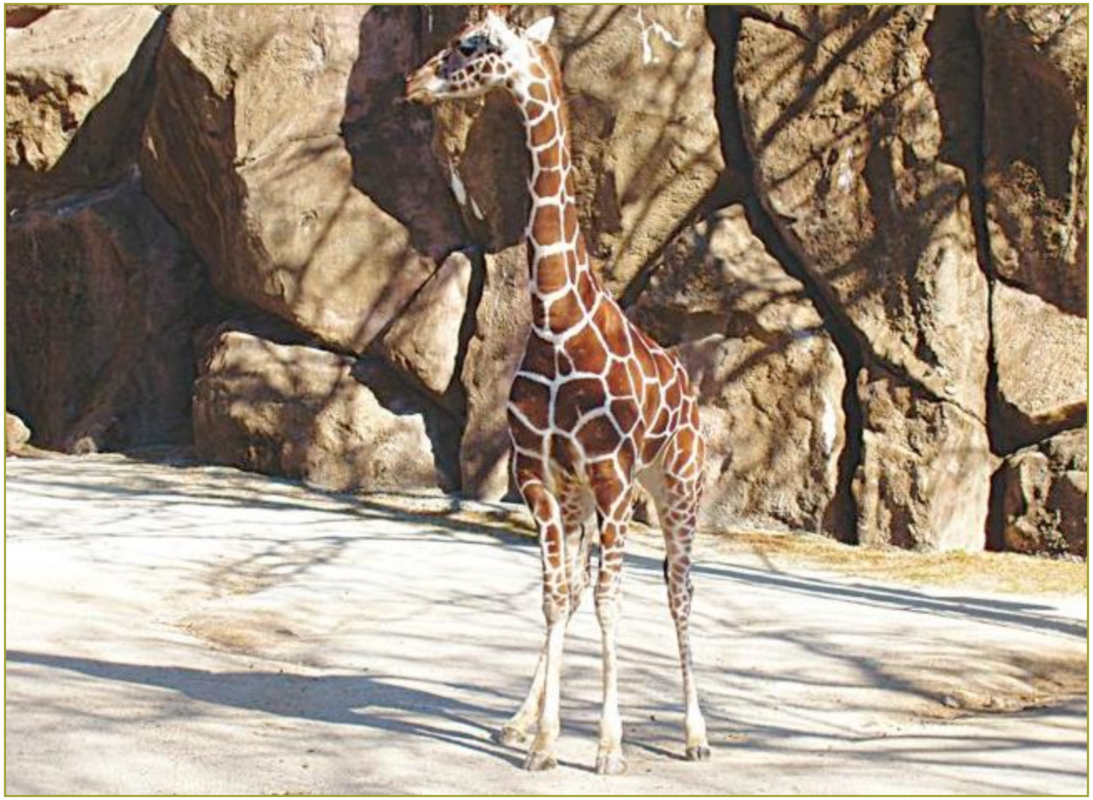
RNA

- RNA consists of a single strand of the nucleotides

  A, G, C, and U
- Three types of RNA
  - Transfer
  - **Messenger**
  - Ribosomal RNA

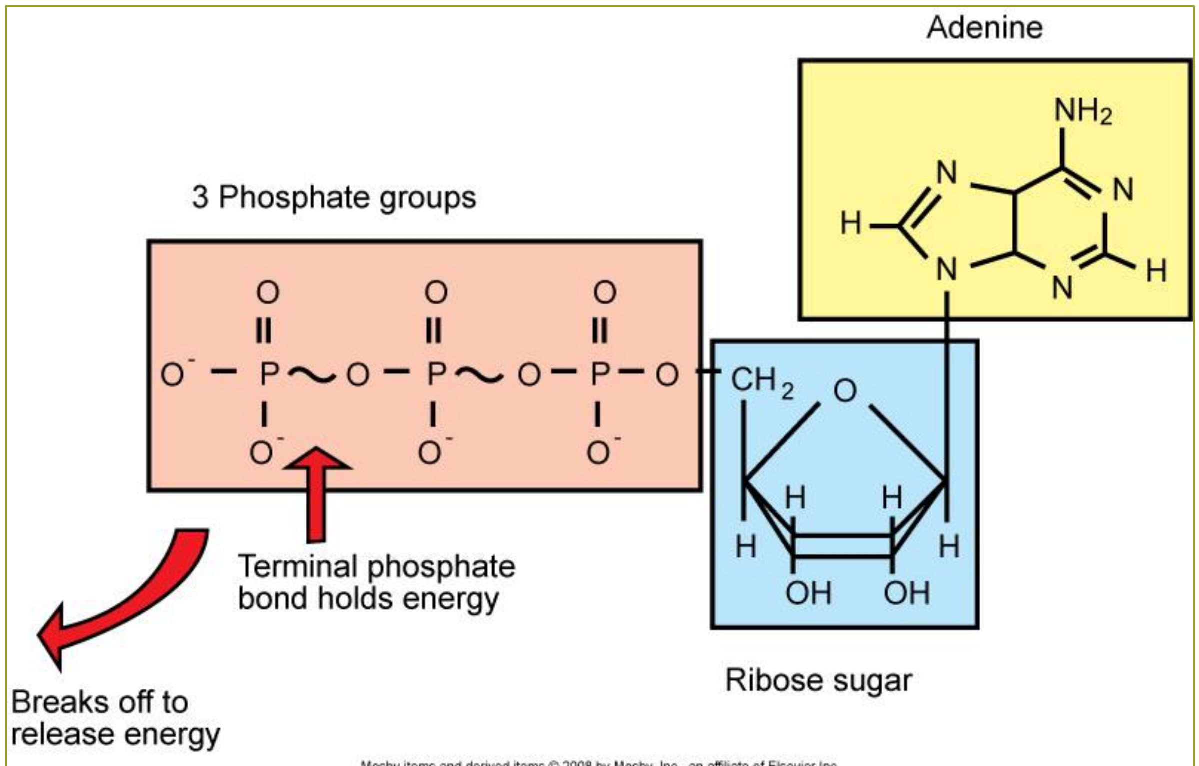
Topic 9

Compare and contrast the types of metabolism seen in animals



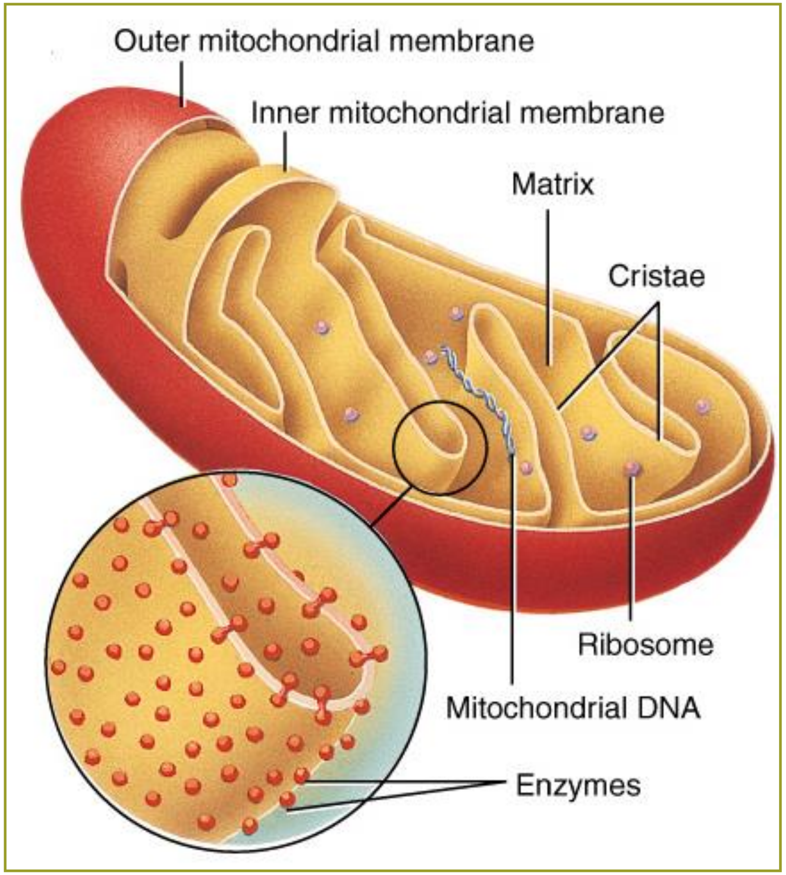
ATP
Figure 2-42, Page 38

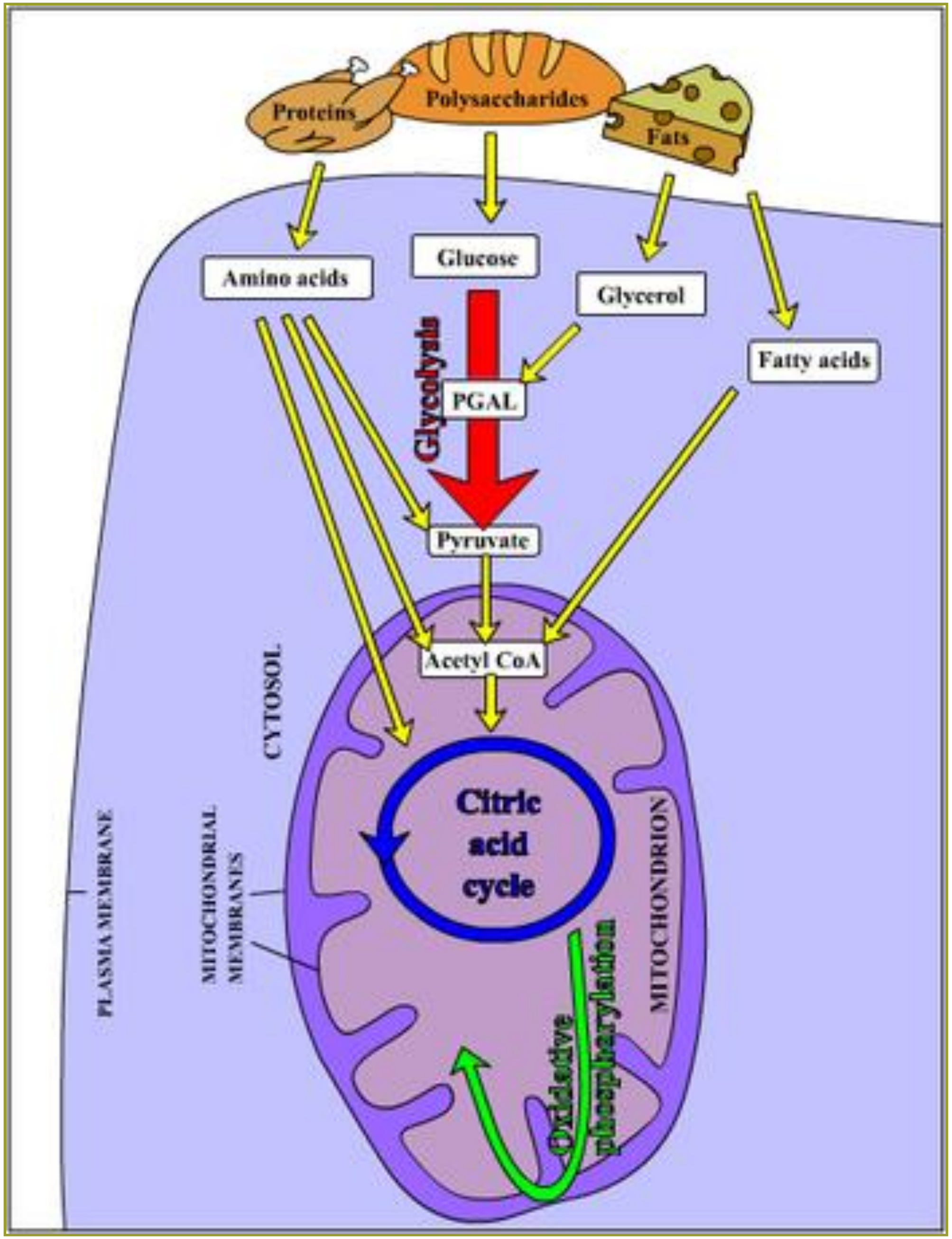
- The **energy needed by the animal's body** is stored in the **phosphate** bonds of the ATP molecule



Cell Metabolism

- Definition





2 Parts to Metabolism

Catabolism

Anabolism

Catabolism

- Definition – **breakdown of molecules** in animal's body
- Releases energy (ATP)
- Examples
  - Digestion
  - Cellular respiration

Anabolism

- Definition – **Building of molecules** in animal's body
- Requires energy (ATP)
- Formation of macromolecules
  - Protein
  - Glycogen
  - Fat
- Anabolic steroids (Winstrol-V)

Control of Metabolic Reactions

- Enzymes
  - Definition – protein molecules that act as catalysts
  - End in …….**ase**
- Coenzymes
  - Definition – substances needed to form enzymes
  - Some minerals, vitamins (B vitamins)

Metabolic Pathways

Carbohydrate Metabolism

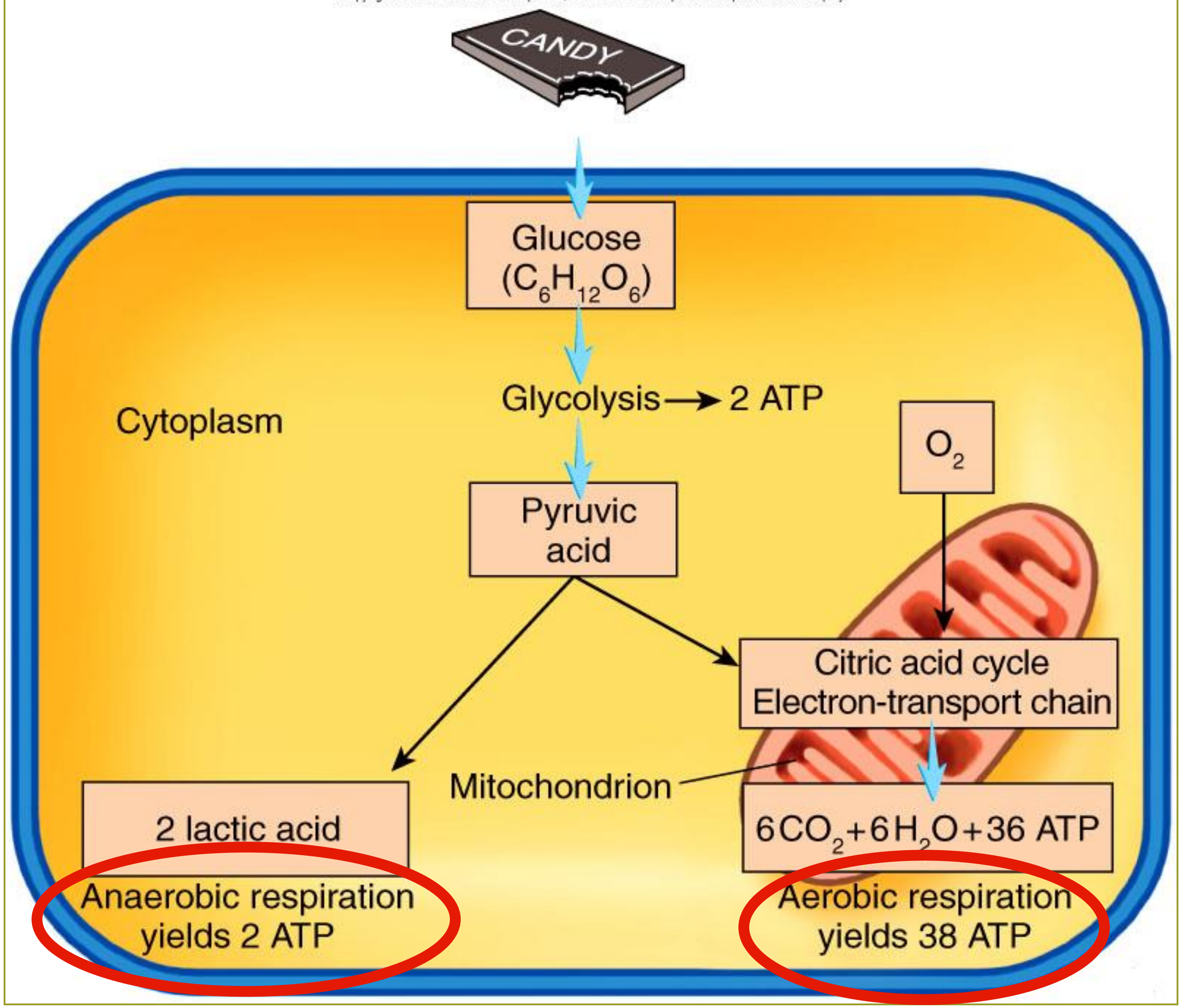
Lipid (Fat) Metabolism

Protein Metabolism

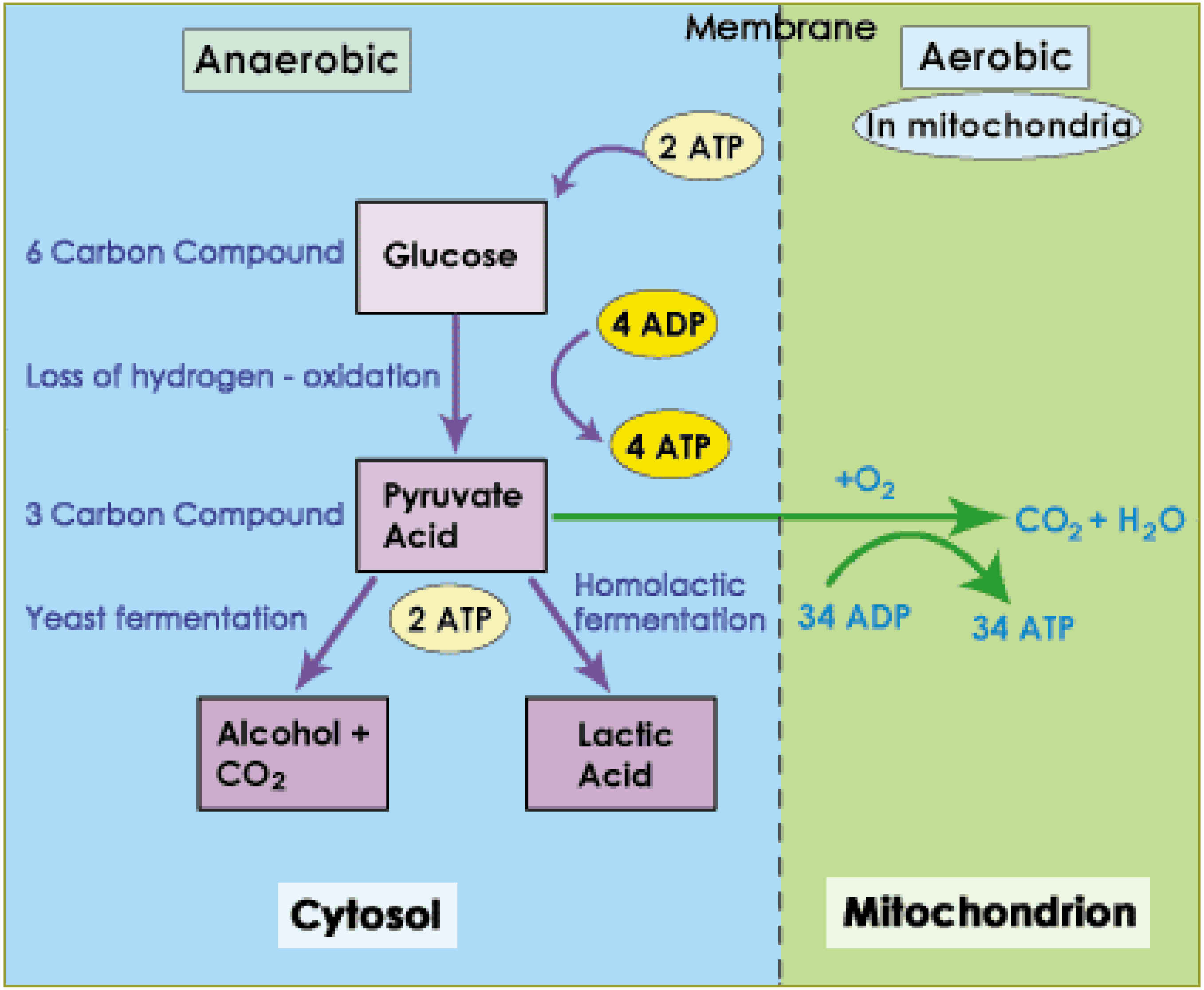
Carbohydrate Metabolism

- Aerobic cellular respiration
  - Glucose burned with oxygen
  - How many ATP?
  - Where?
- Anaerobic cellular respiration
  - Glucose burned without oxygen
  - How many ATP?
  - Lactic Acid production

Cellular Respiration



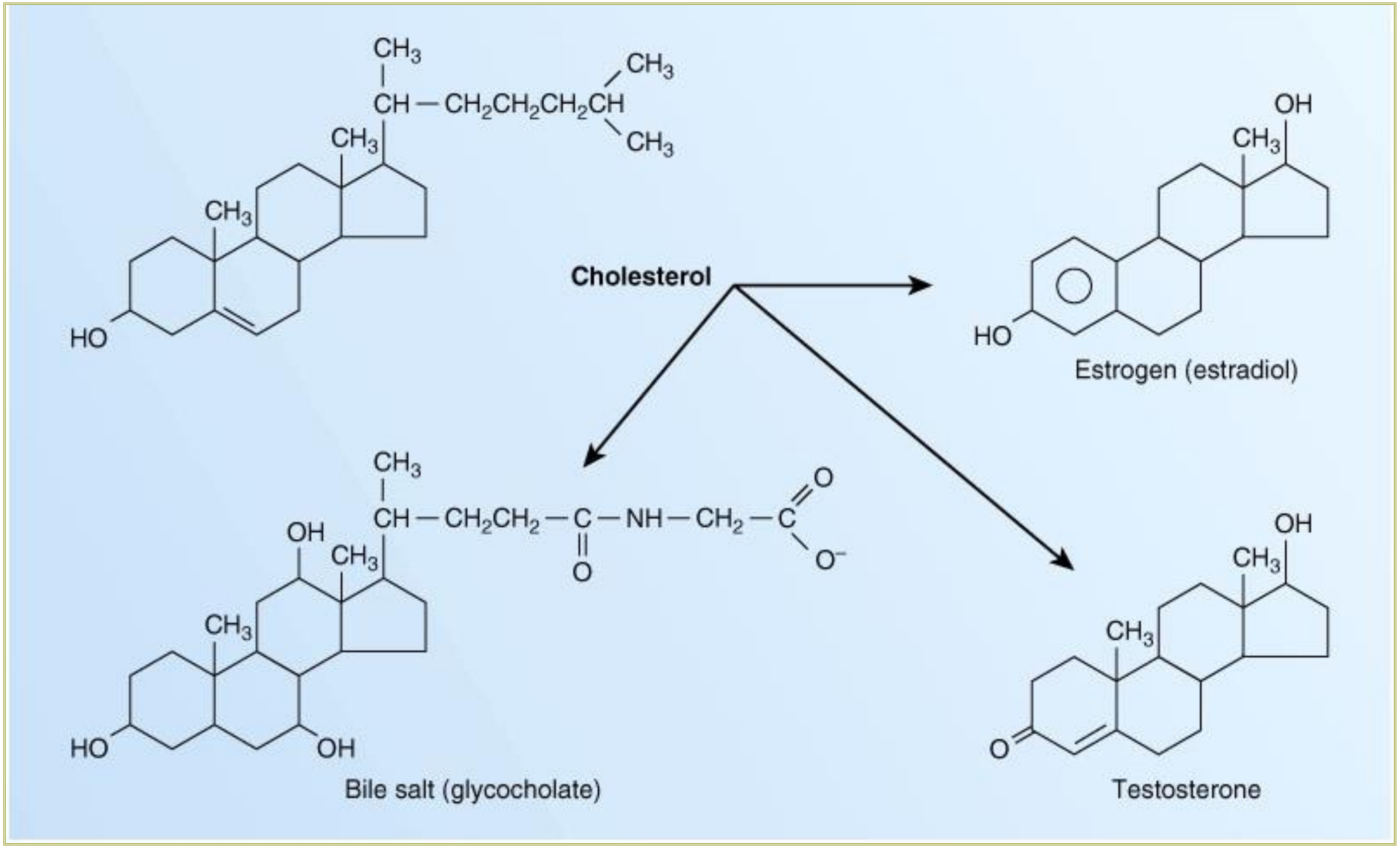
Another Look



Lipid Metabolism

- Liver controls this
- Ketone bodies
  - **Ketosis**

Cholesterol Metabolism

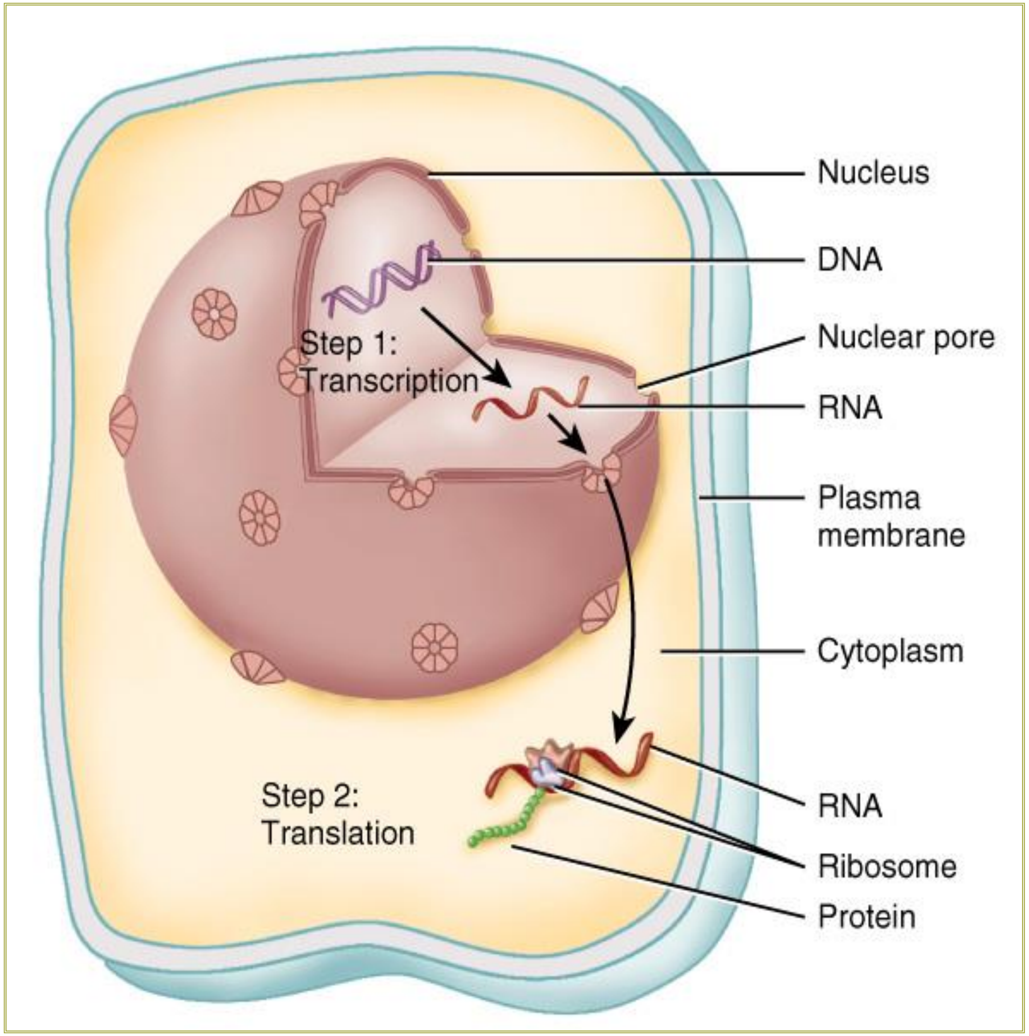


Protein Metabolism

- Amino acids
- Essential amino acids

Building Proteins

- Each cell makes a few hundred kinds of protein
- DNA
- RNA
- [Ribosomes]

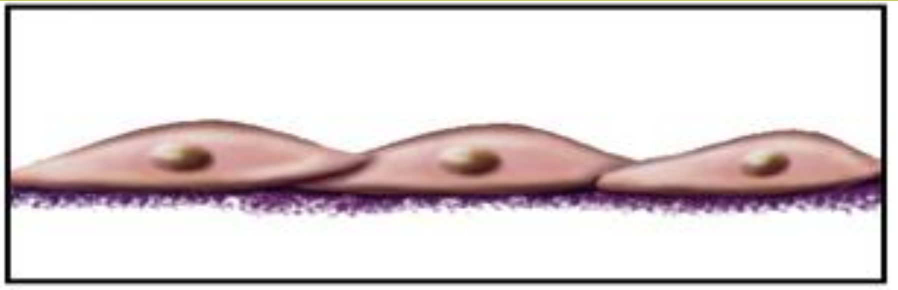


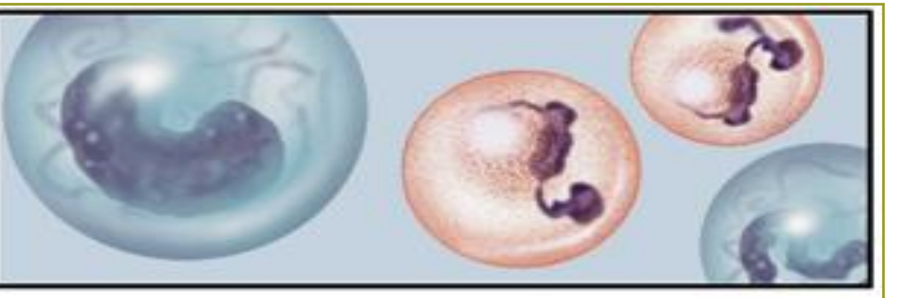
Genetic Mutations

- Definition – **a genetic mistake** that occasionally occurs in replication of DNA (genes/chromosomes)
- **Mutagens** – causes of mutations
  - Viruses
  - Radiation
  - Chemicals (cigarette smoke)

Clinical Applications

Pages 12, 23, 25, 35, 37



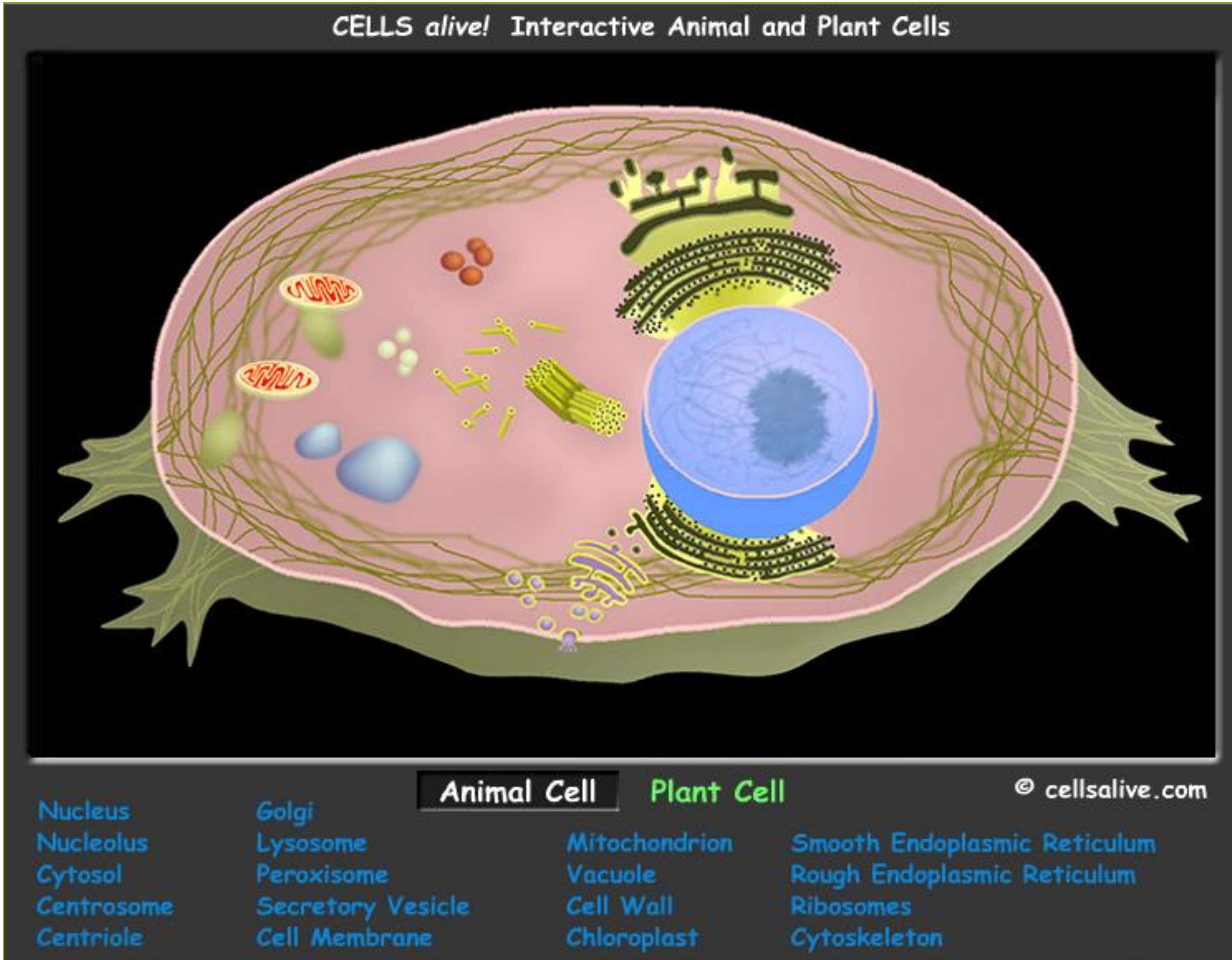


The Amazing Cell
Chapter 3

Pages 39-89

“Cells Alive!” Website

http://cellsalive.com/cells/cell_model.htm


CELLS alive! Interactive Animal and Plant Cells
Animal Cell
Plant Cell
© cellsalive.com
Nucleus
Nucleolus
Cytosol
Centrosome
Centriole
Golgi
Lysosome
Peroxisome
Secretory Vesicle
Cell Membrane
Mitochondrion
Vacuole
Cell Wall
Chloroplast
Smooth Endoplasmic Reticulum
Rough Endoplasmic Reticulum
Ribosomes
Cytoskeleton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Animal Cell
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Nucleus
Nucleolus
Cytosol
Centrosome
Centriole
Golgi
Lysosome
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Secretory Vesicle
Cell Membrane
Mitochondrion
Vacuole
Cell Wall
Chloroplast
Smooth Endoplasmic Reticulum
Rough Endoplasmic Reticulum
Ribosomes
Cytoskeleton

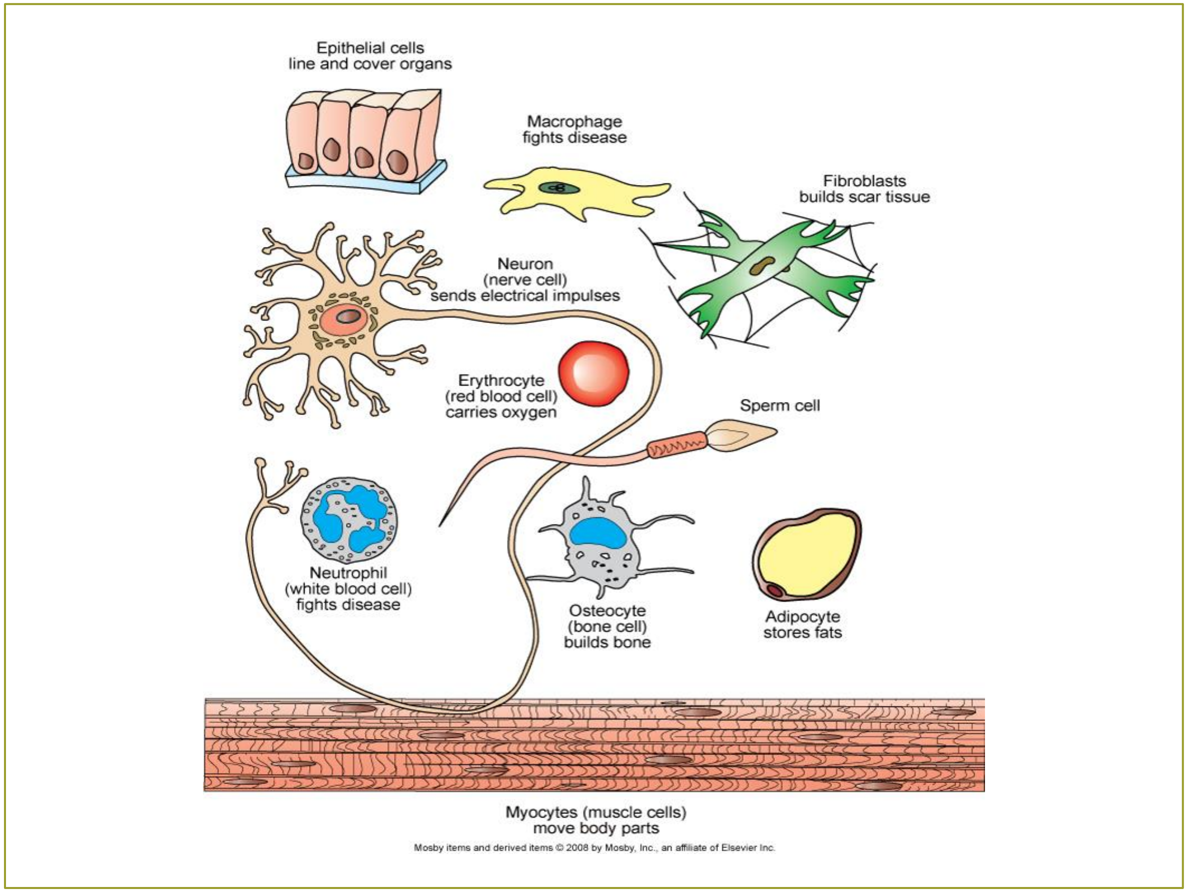
Textbook Learning Objectives

Chapter 3 – Page 39

- Differentiate between prokaryotic and eukaryotic cells.
- Describe the structure of the plasma membrane.
- List and describe the components of the cytoskeleton.
- Describe the structure and functions of each of the cellular organelles.
- Differentiate between active and passive transport processes.
- Describe the factors that determine whether a molecule can pass through a plasma membrane by passive diffusion.
- Differentiate between diffusion and facilitated diffusion.
- Describe the processes of osmosis, active transport, endocytosis and exocytosis.
- Describe the role of ions in maintaining a cell's resting membrane potential.
- List the phases of mitosis and describe the events that occur in each phase.
- List the steps in replication of DNA and the synthesis of proteins.

Topic 10

Discuss the history and diversity of cells

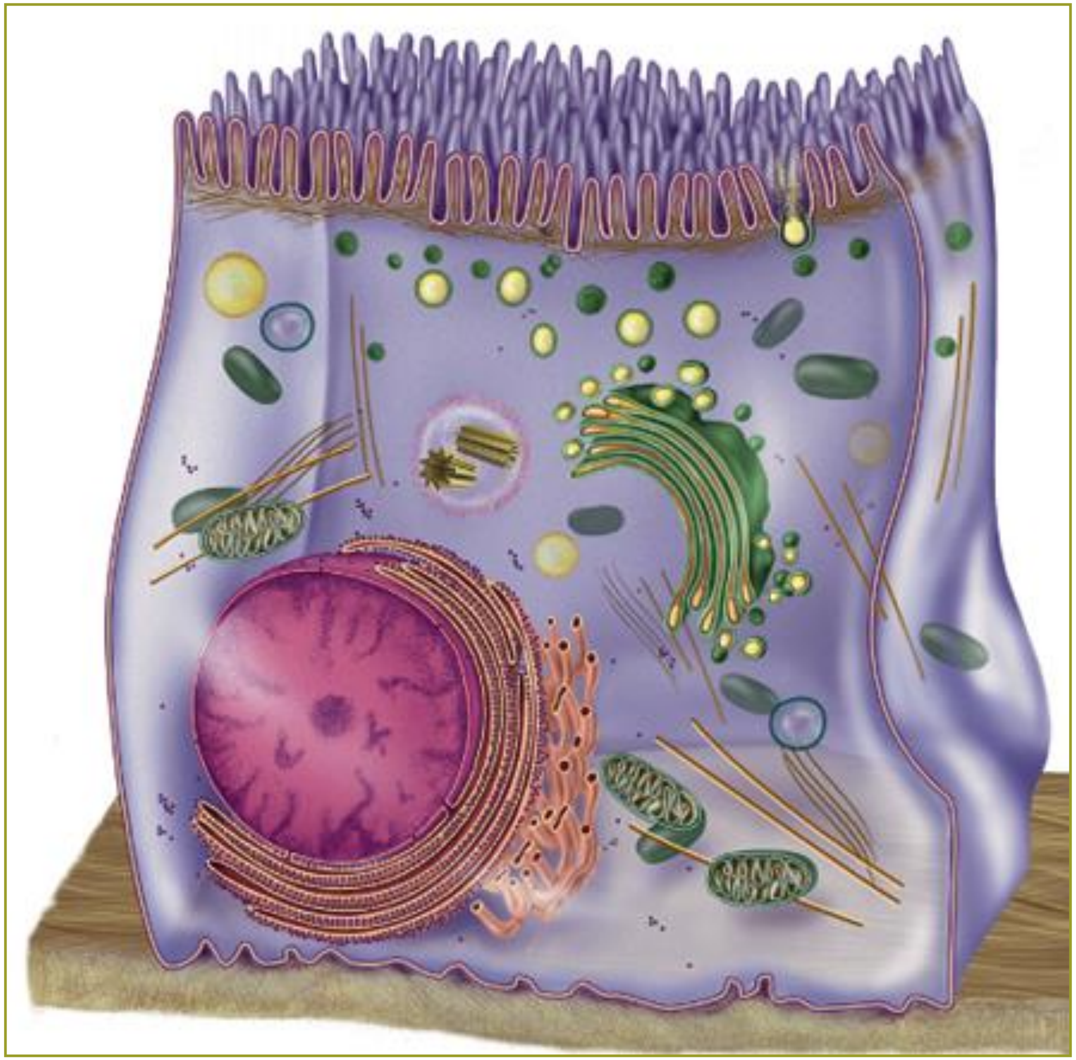


Prokaryotic and Eukaryotic Cells

- **Prokaryotes**: cells which do not possess a nucleus
  - Bacteria
- **Eukaryotes**: found in all multi-cellular organisms today
  - Characterized by having a distinct nucleus in which the DNA has combined with protein to form chromosomes surrounded by a protective nuclear envelope
  - **All multi-cellular plants & animals; protozoa**

History of the Cell

- Robert Hooke
  - First saw cells under microscope
- Cell theory
  - Schleiden – plant cells
  - Schwann – animal cells



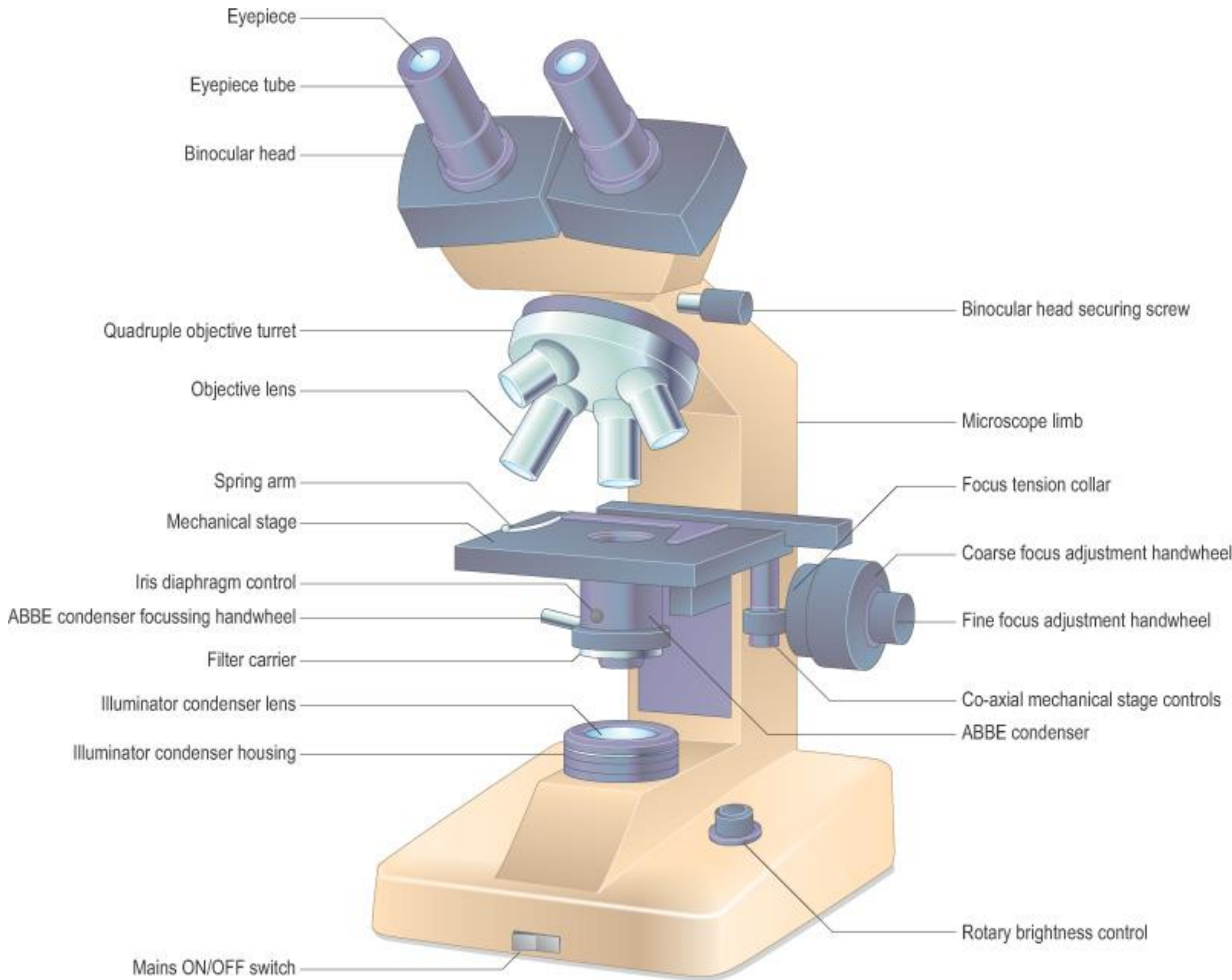
Cell Theory

- All living things are composed of cells (except viruses)
- Modern cells can arise only from pre-existing cells

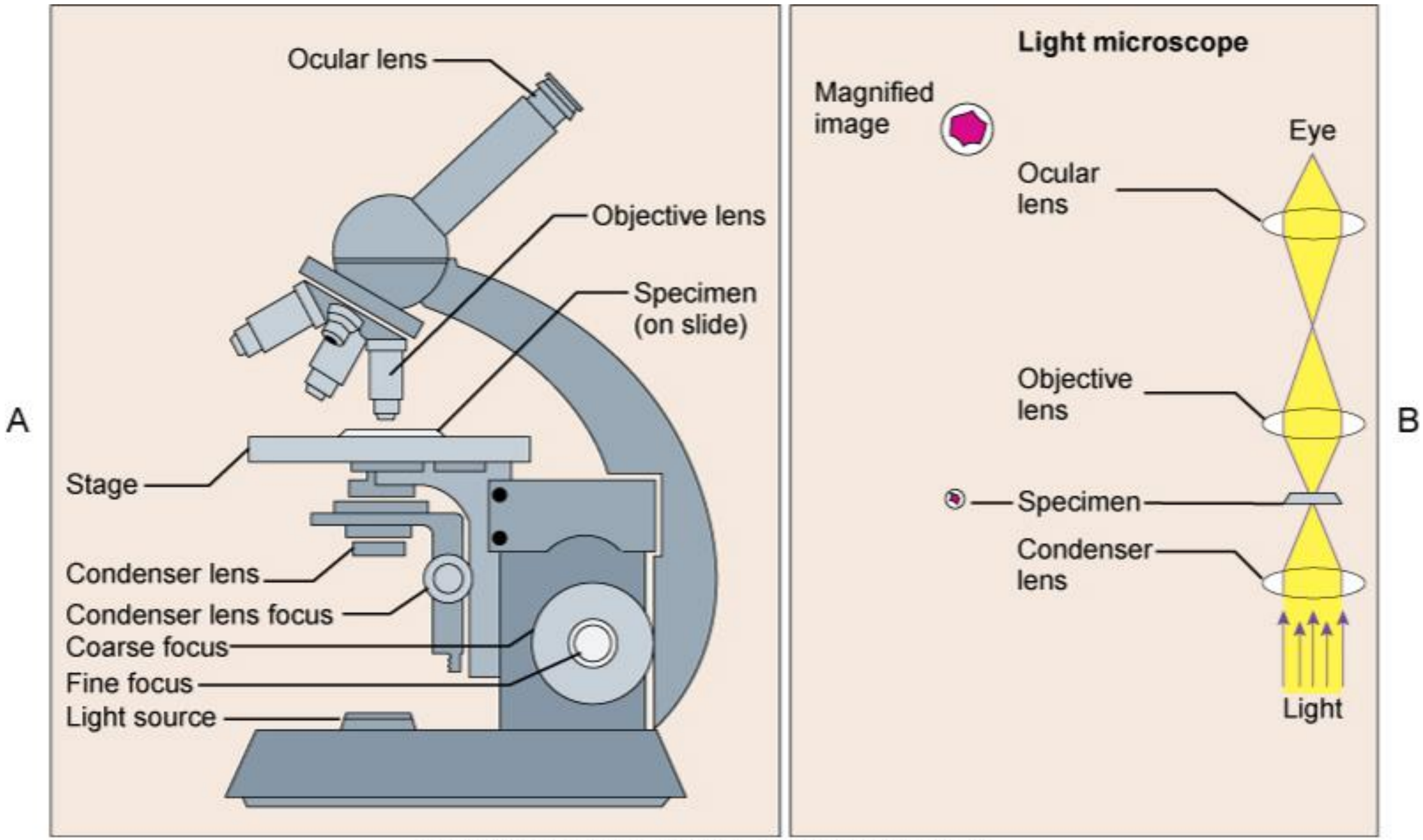
How to Use a Microscope

http://www.wisc-online.com/objects/ViewObject.aspx?ID=BIO905

http://www.wisc-online.com/objects/ViewObject.aspx?ID=BIO905

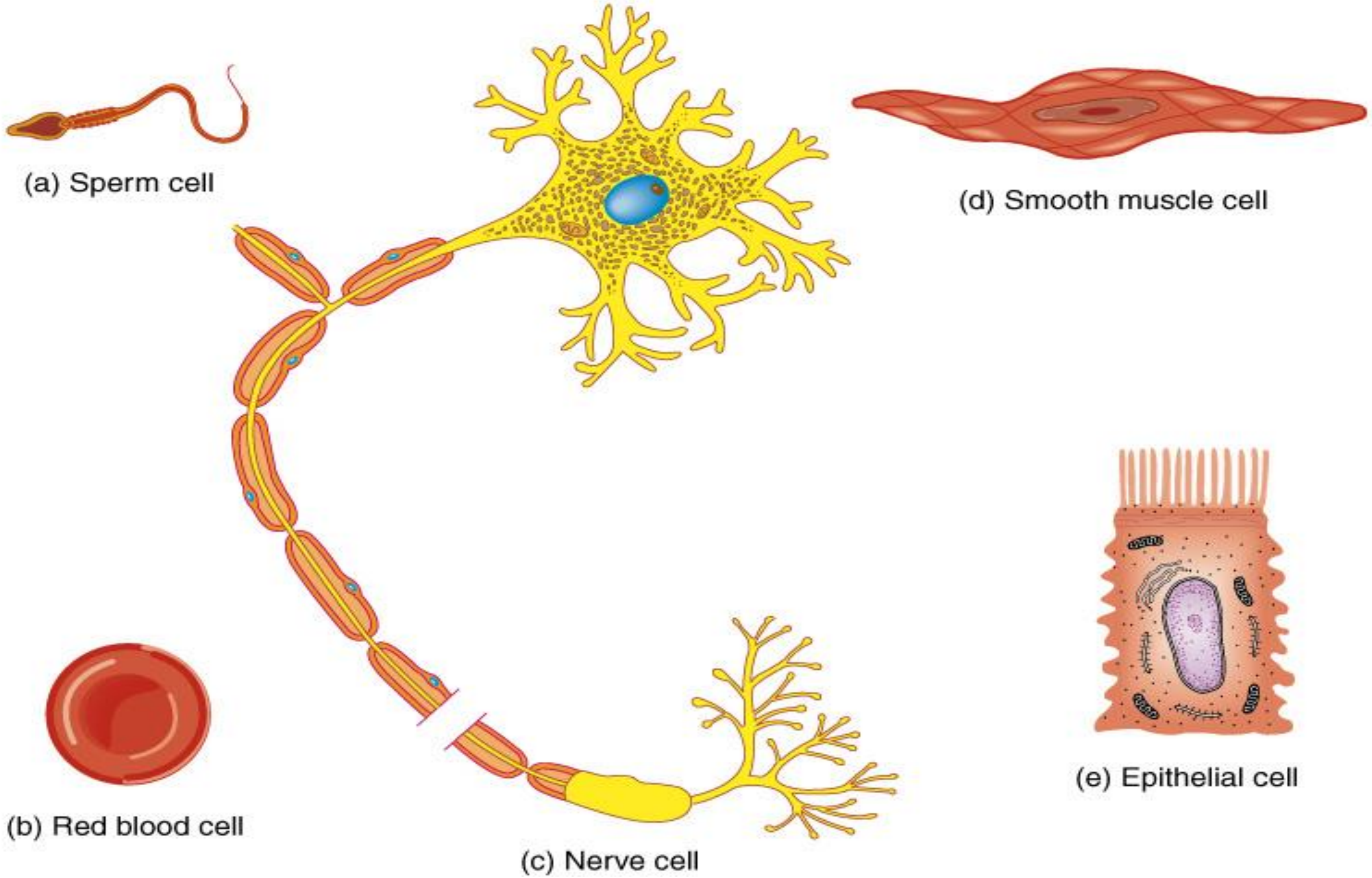

Eyepiece
Eyepiece tube
Binocular head
Quadruple objective turret
Objective lens
Spring arm
Mechanical stage
Iris diaphragm control
ABBE condenser focussing handwheel
Filter carrier
Illuminator condenser lens
Illuminator condenser housing
Mains ON/OFF switch
Binocular head securing screw
Microscope limb
Focus tension collar
Coarse focus adjustment handwheel
Fine focus adjustment handwheel
Co-axial mechanical stage controls
ABBE condenser
Rotary brightness control

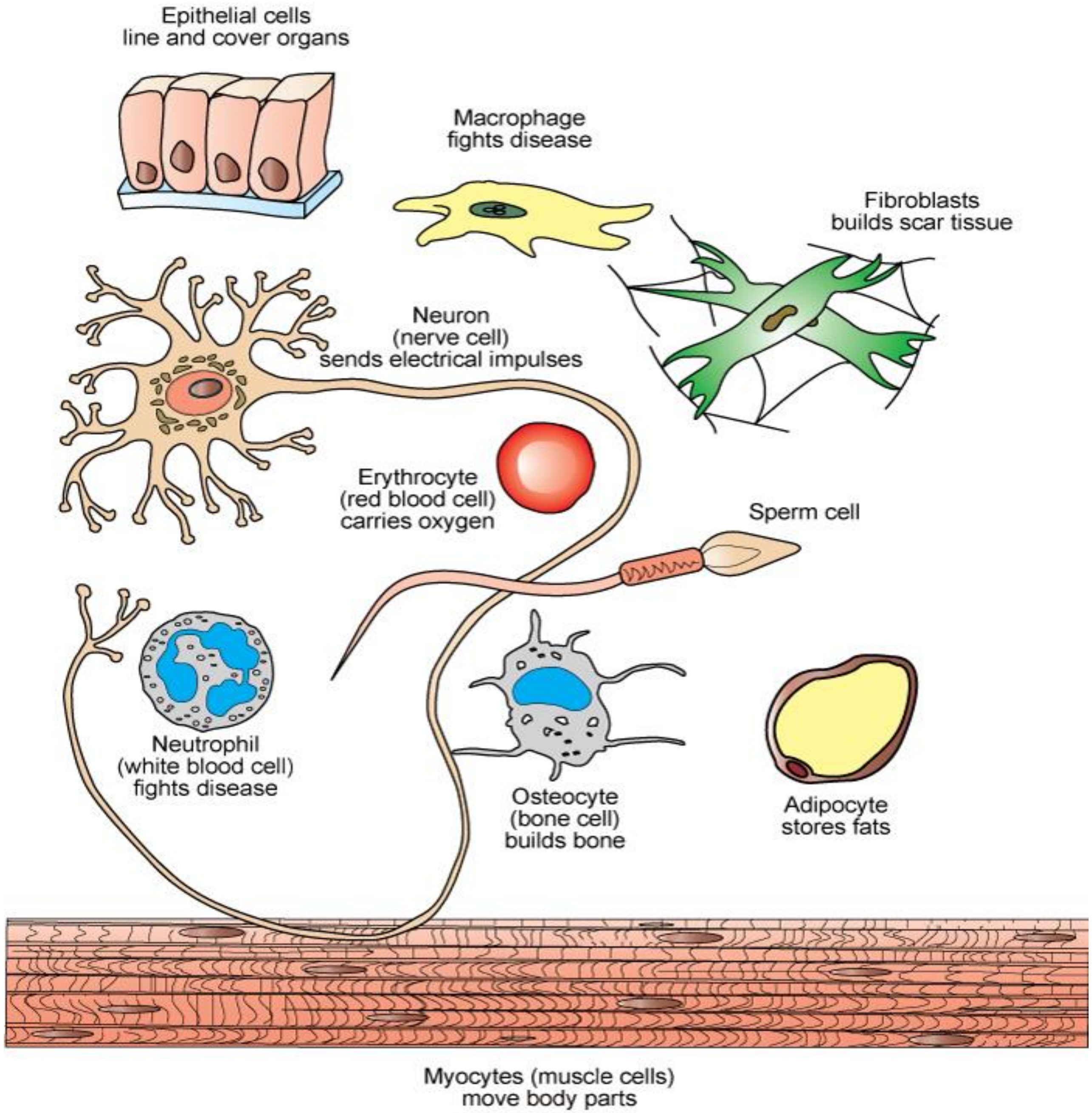
Box 3-1, Page 42



Cell Diversity

Figure 3-1, Page 40




Epithelial cells
line and cover organs
Macrophage
fights disease
Fibroblasts
builds scar tissue
Neuron
(nerve cell)
sends electrical impulses
Erythrocyte
(red blood cell)
carries oxygen
Sperm cell
Neutrophil
(white blood cell)
fights disease
Osteocyte
(bone cell)
builds bone
Adipocyte
stores fats
Myocytes (muscle cells)
move body parts

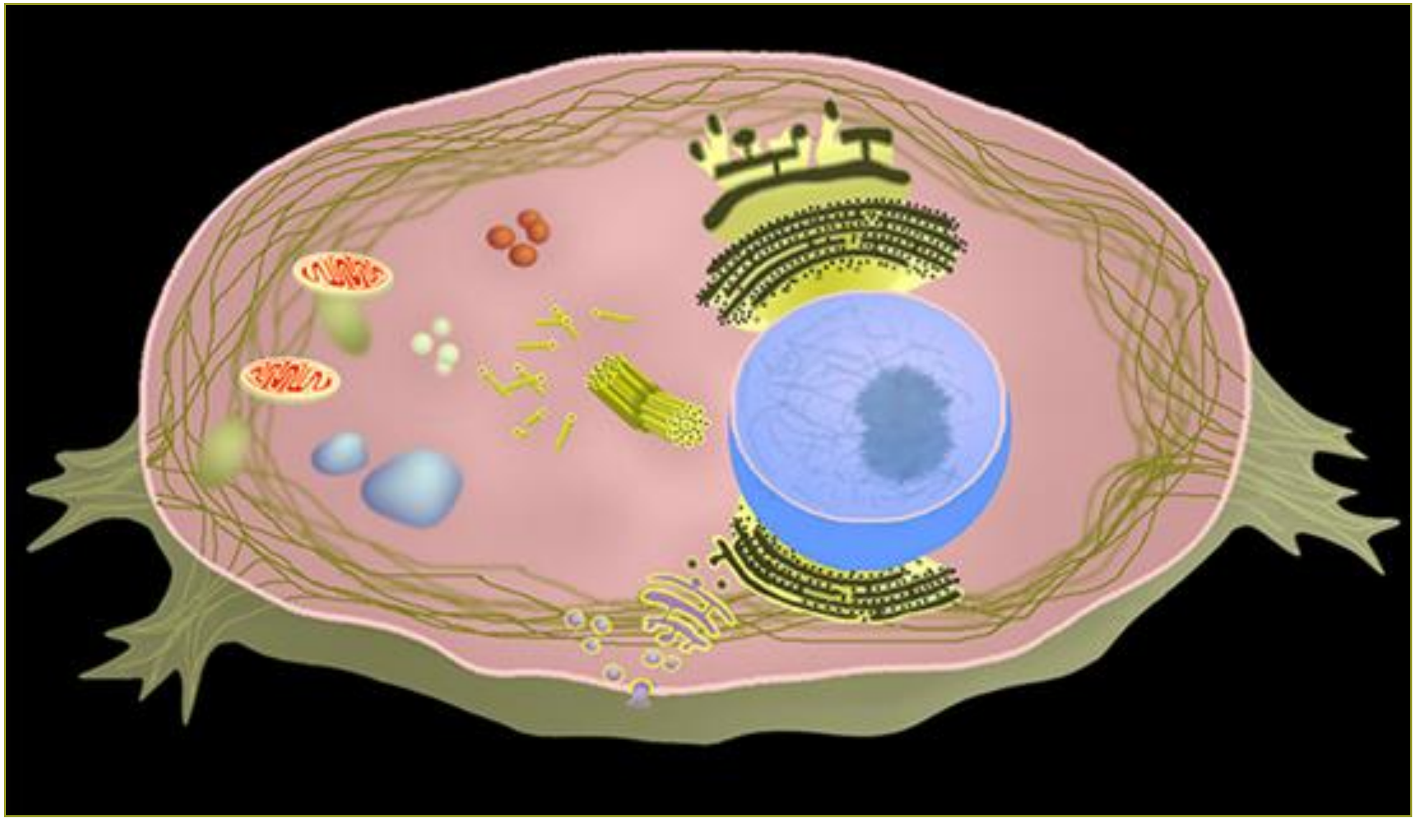
Important Concepts!

Healthy Cells = Healthy Animal

Diseased Cells = Diseased Animal

Topic 11

Describe the three major components of animal cells



Cell Anatomy (Morphology)

Cell Membrane

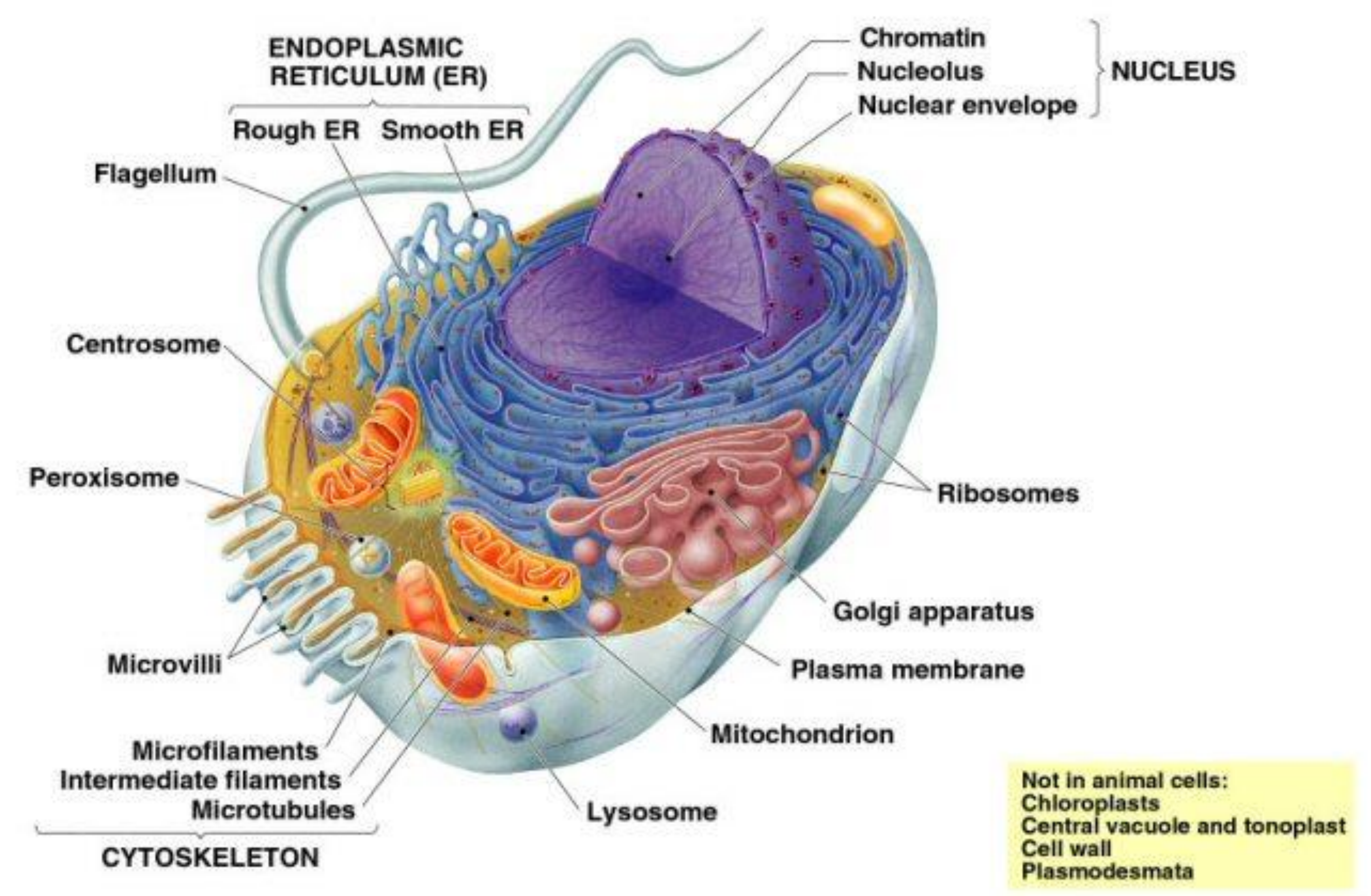
Nucleus

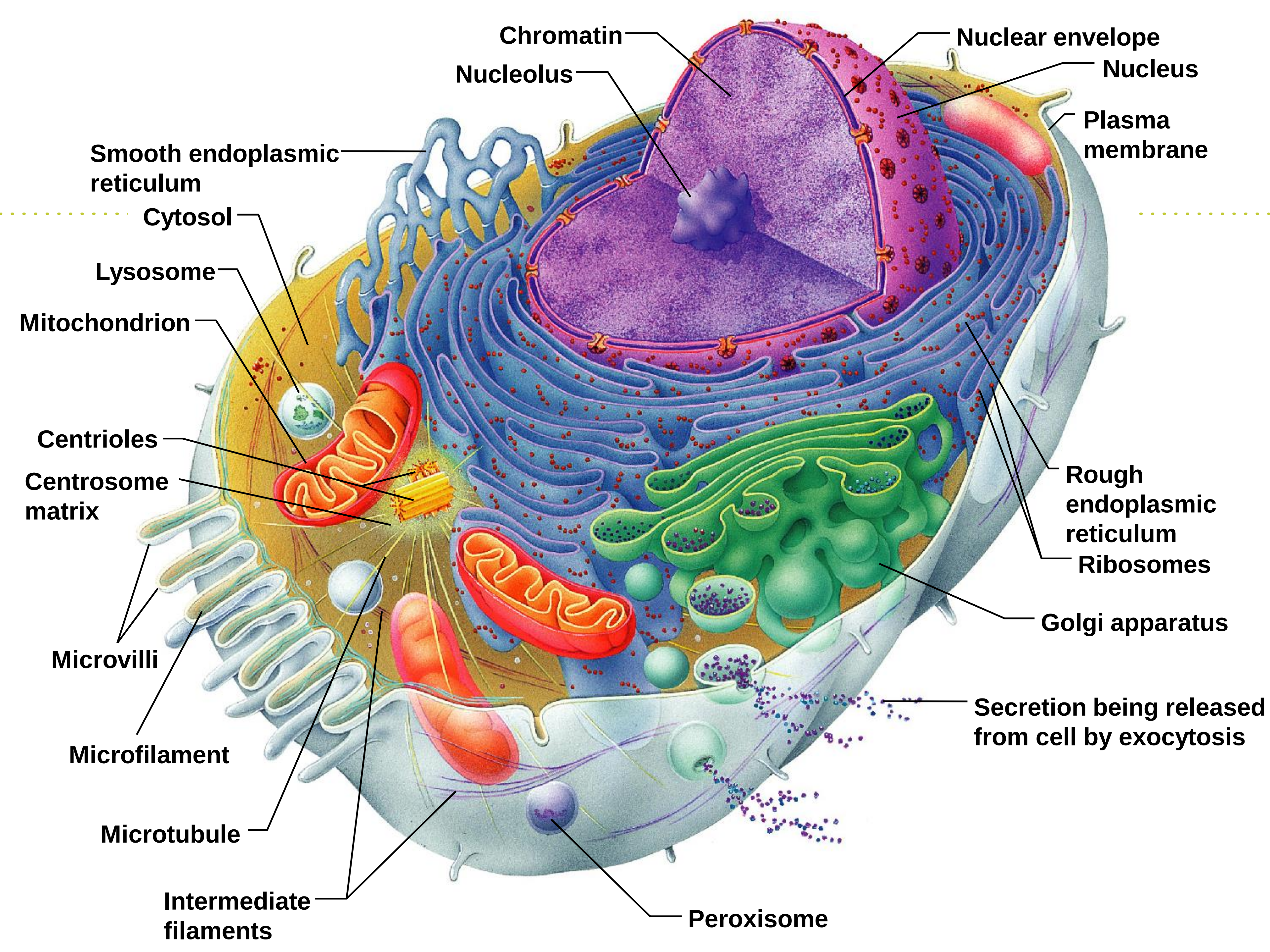
Cytoplasm

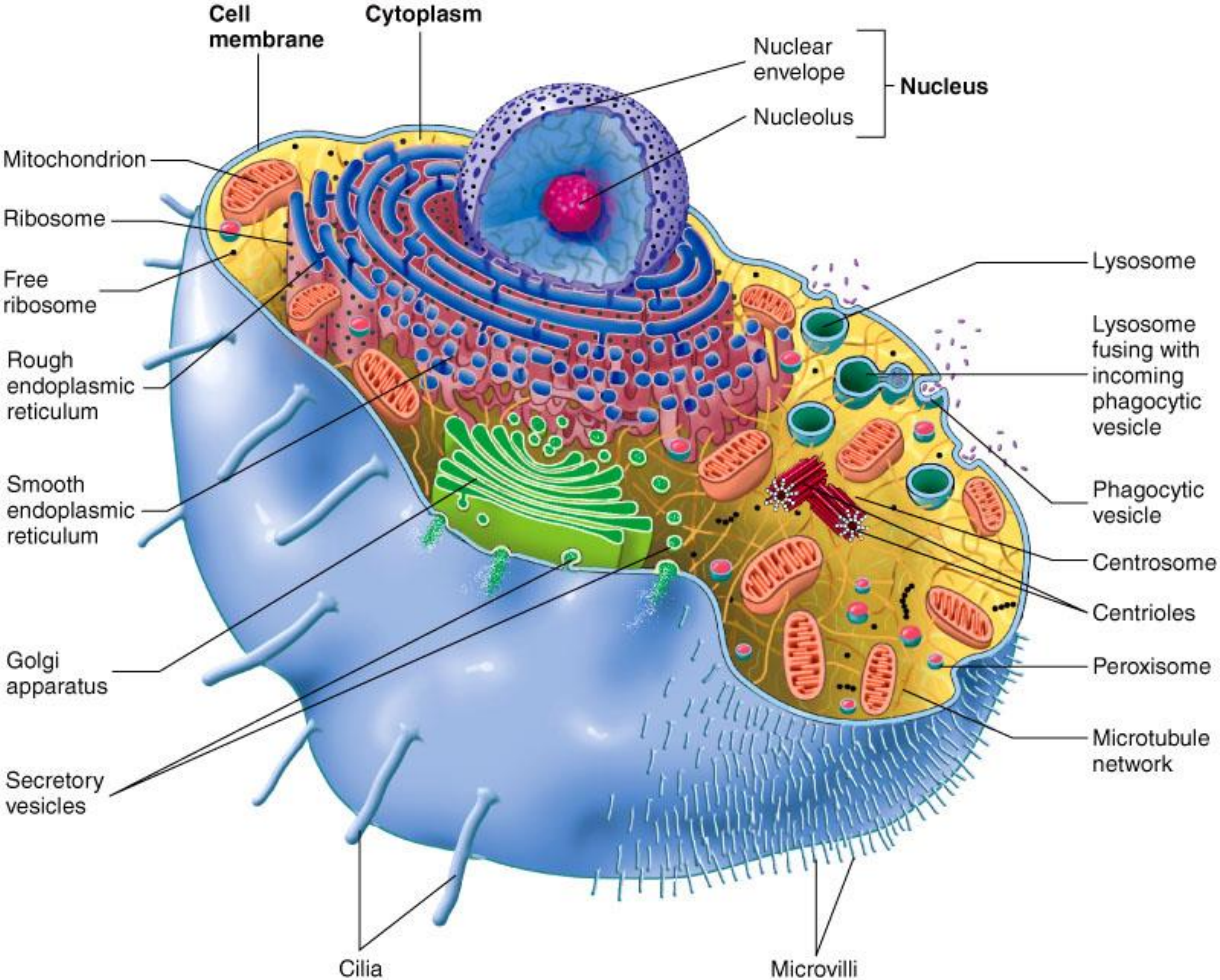
Mammalian Cell Anatomy

- Structures found in all mammalian cells include the **cell membrane**, the **cytoplasm**, and the **nucleus**
- Everything inside the cell membrane other than the nucleus and genetic material is known as the ***cytoplasm***
- Cytoplasm is composed of proteins, electrolytes, metabolites, a flexible cytoskeleton, and organelles

Mammalian Cell Anatomy
Figure 3-2; Table 3-1 – Pages 46-48

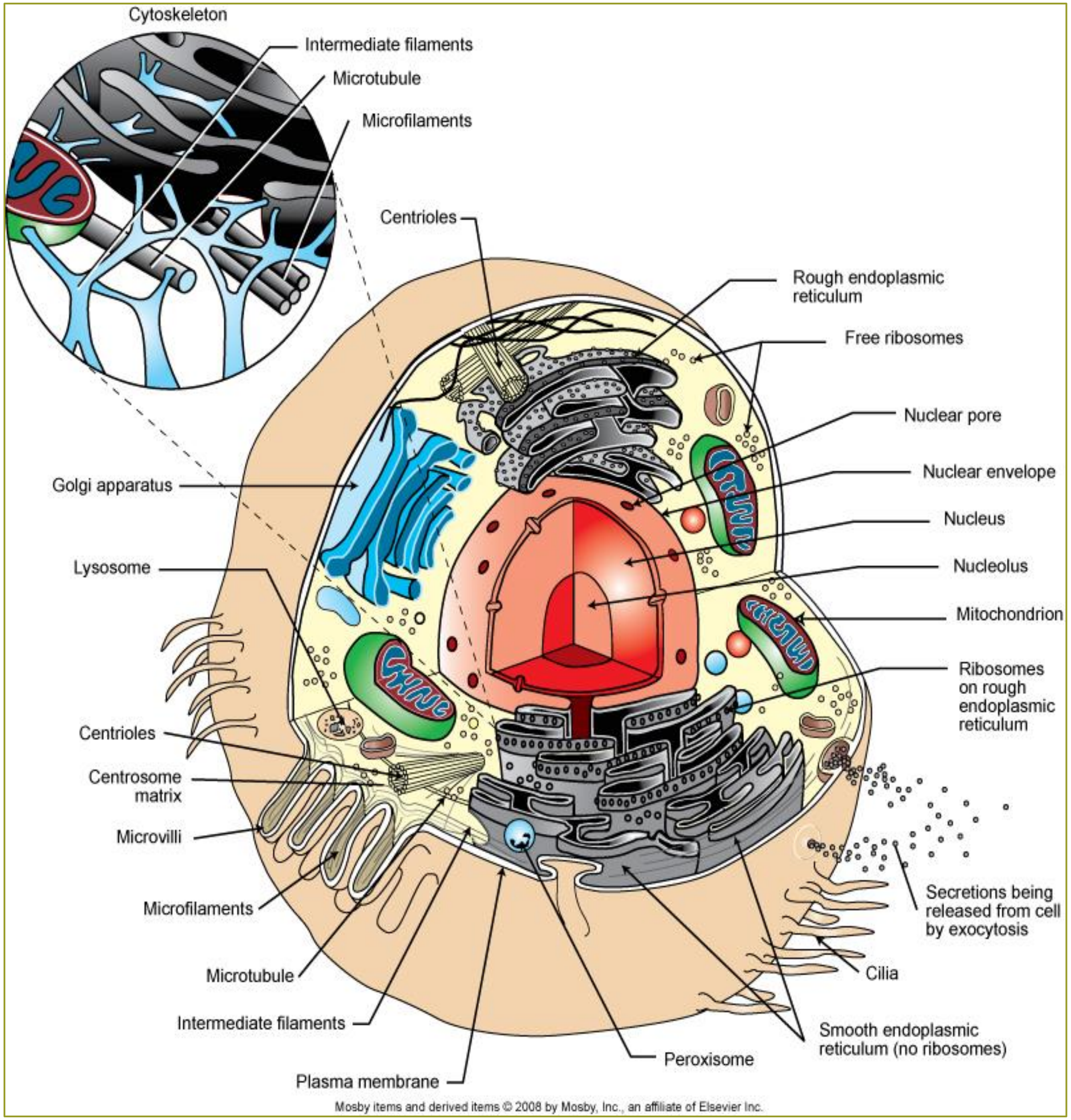



Chromatin
Nucleolus
Nuclear envelope
Nucleus
Plasma membrane
Smooth endoplasmic reticulum
Cytosol
Lysosome
Mitochondrion
Centrioles
Centrosome matrix
Microvilli
Microfilament
Microtubule
Intermediate filaments
Peroxisome
Rough endoplasmic reticulum
Ribosomes
Golgi apparatus
Secretion being released from cell by exocytosis


Cell membrane
Cytoplasm
Nuclear envelope
Nucleolus
Nucleus
Mitochondrion
Ribosome
Free ribosome
Rough endoplasmic reticulum
Smooth endoplasmic reticulum
Golgi apparatus
Secretory vesicles
Cilia
Microvilli
Lysosome
Lysosome fusing with incoming phagocytic vesicle
Phagocytic vesicle
Centrosome
Centrioles
Peroxisome
Microtubule network

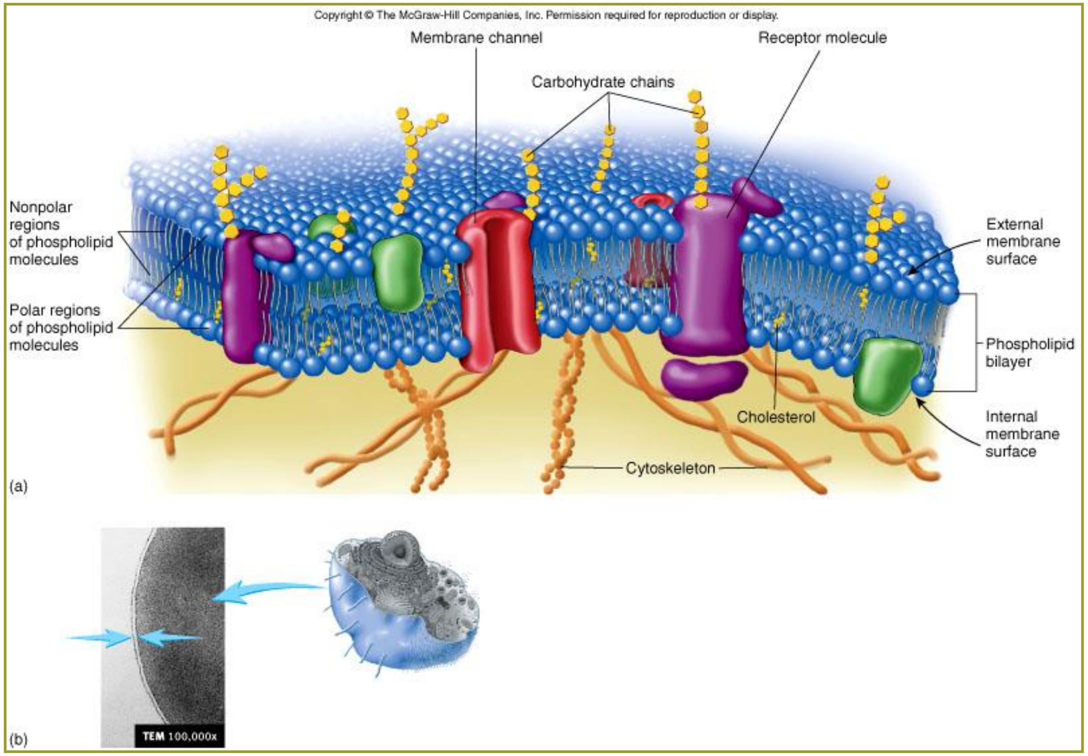
Mammalian Cell

Figure 3-2, Page 46

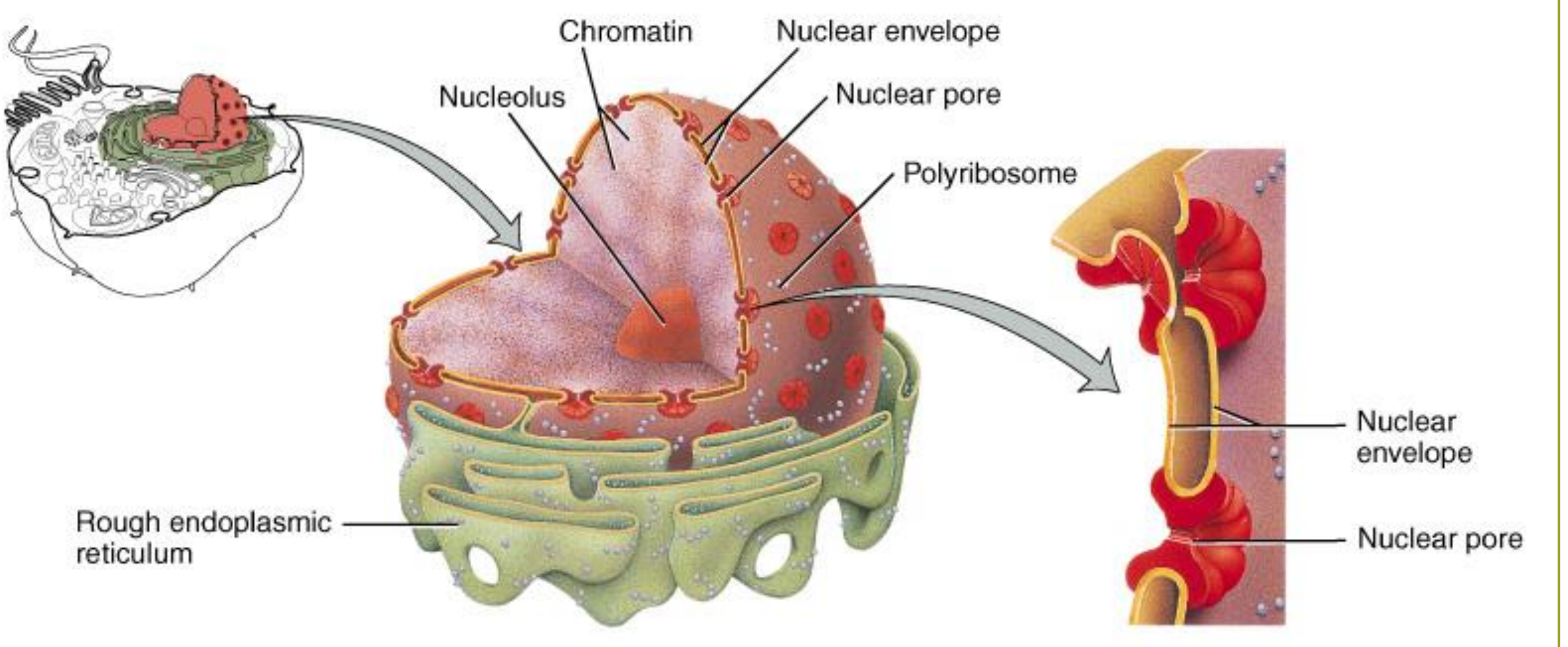


Cell Membrane
Figure 3-3, Page 49

- Phospholipid bilayer
- Protein “iceburgs” ☺



The Nucleus

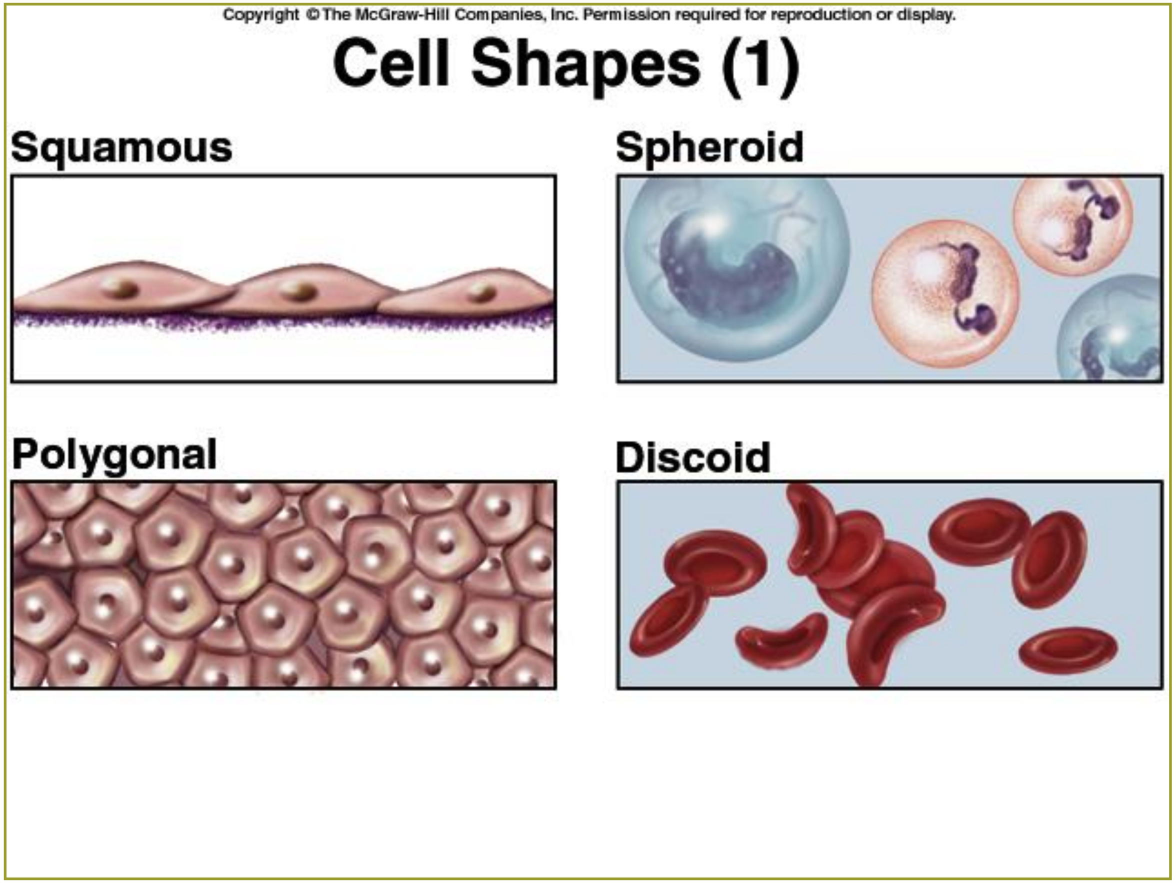


(a) Details of nucleus

(b) Details of nuclear envelope

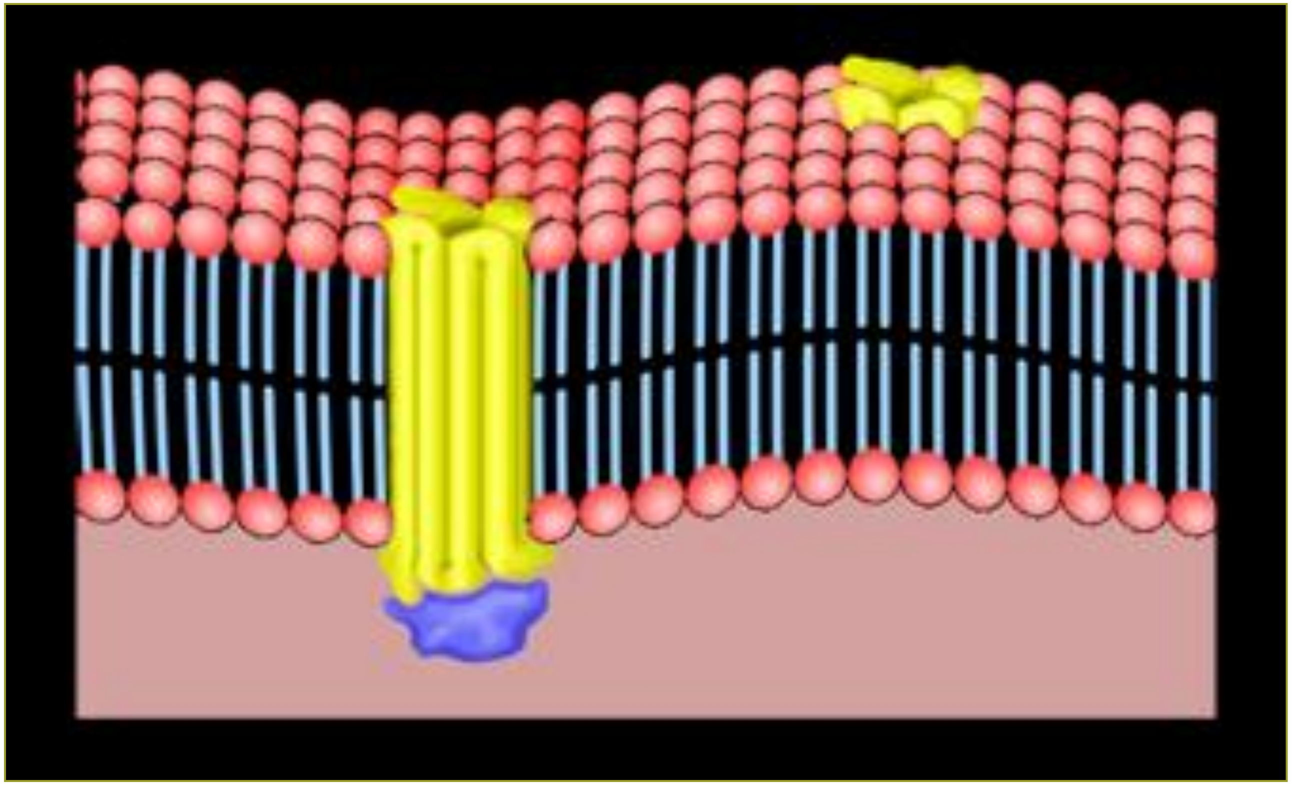
Cytoplasm

- Cytosol (ICF)
- Cytoskeleton
- Organelles in cytoplasm



Topic 12

Discuss the structure and function of the cell (plasma) membrane



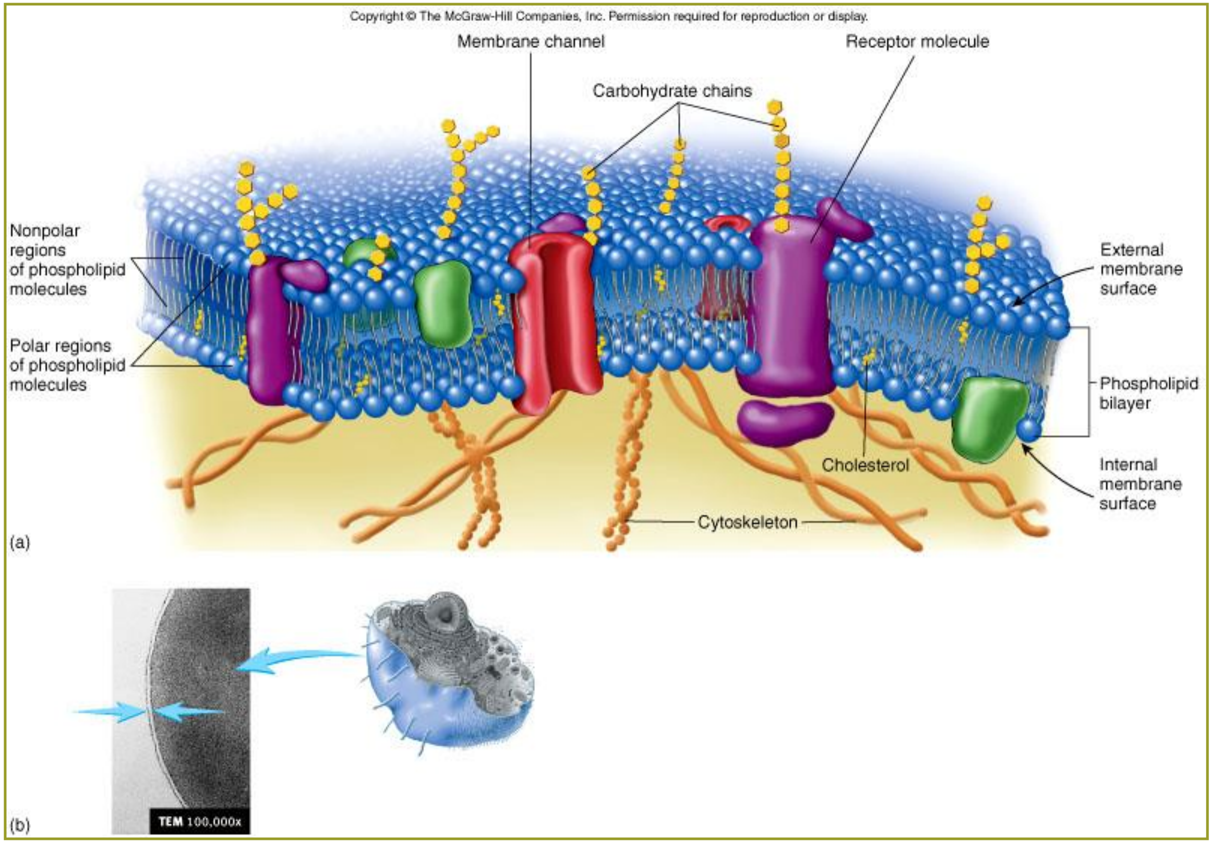
1. Cell Membrane

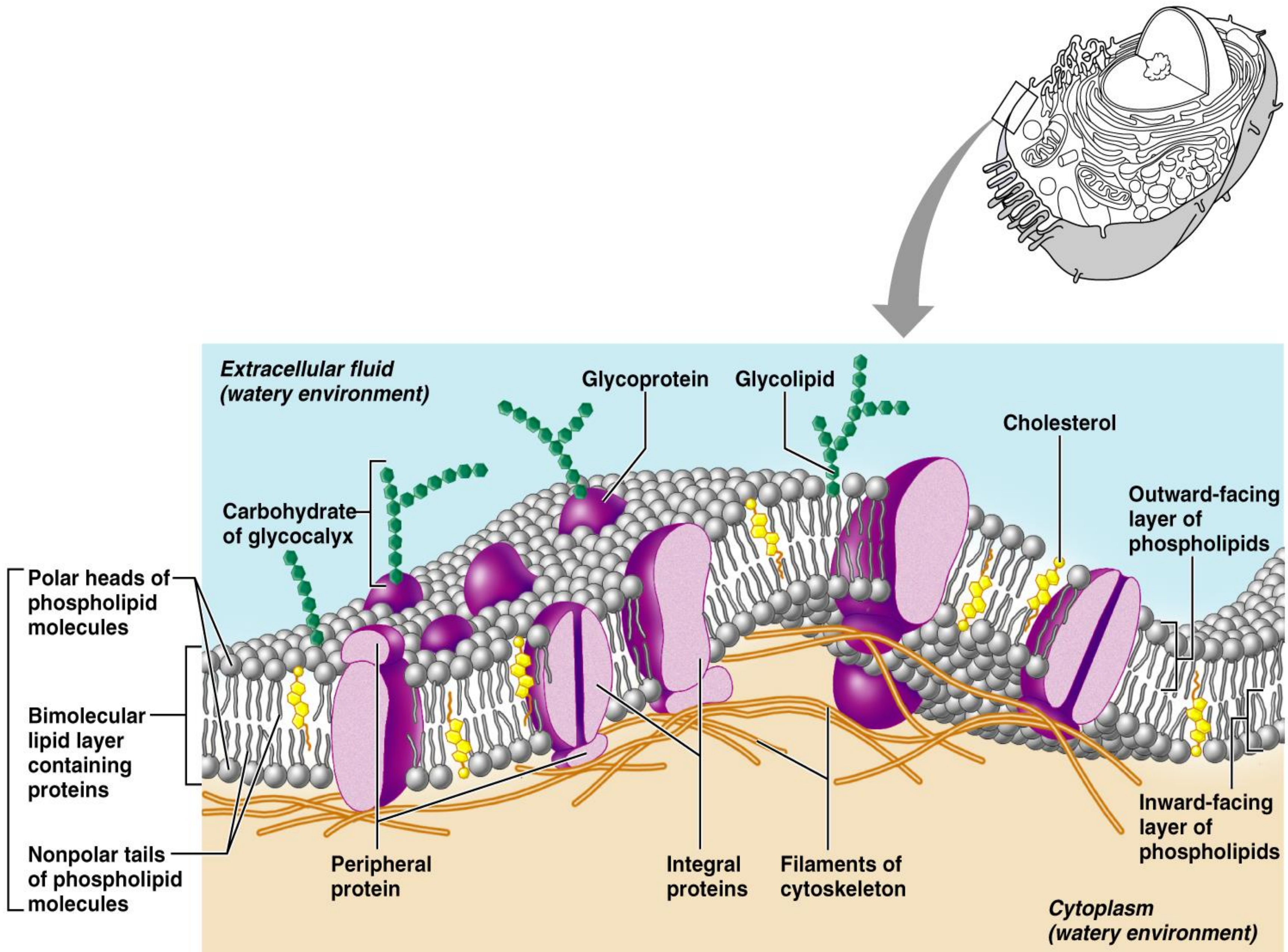
Phospholipid Bilayer

“Floating” Proteins

Cell Membrane
Figure 3-3, Page 49

- Phospholipid bilayer
- Protein "iceburgs" ☺





Extracellular fluid
(watery environment)
Glycoprotein
Glycolipid
Cholesterol
Carbohydrate of glycocalyx
Outward-facing layer of phospholipids
Polar heads of phospholipid molecules
Bimolecular lipid layer containing proteins
Nonpolar tails of phospholipid molecules
Peripheral protein
Integral proteins
Filaments of cytoskeleton
Inward-facing layer of phospholipids
Cytoplasm
(watery environment)

Cell Membrane

- Functions: acts as a flexible, elastic barrier between the inner cytoplasm and the outside environment
  - Governs the movement of atoms and molecules in and out of the cell
- Consists primarily of protein and phospholipids
  - Also includes cholesterol, other lipids, and carbohydrates

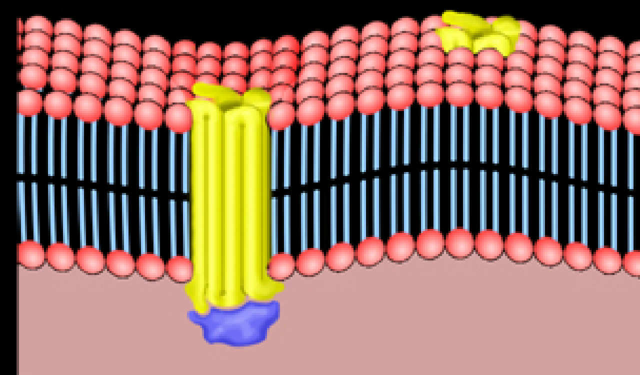
Membrane Structure

- **Lipid bilayer**: composed of two layers of phospholipid molecules arranged so that the hydrophilic “heads” are on the outside and the hydrophobic fatty acid “tails” are on the inside
- **Fluid mosaic**: Proteins are suspended in the bilayer and move easily throughout the membrane to create a constantly changing pattern

Cells Alive! –
Their Take on the Cell Membrane

CELLS *alive!* Interactive Animal and Plant Cells

CELL MEMBRANE



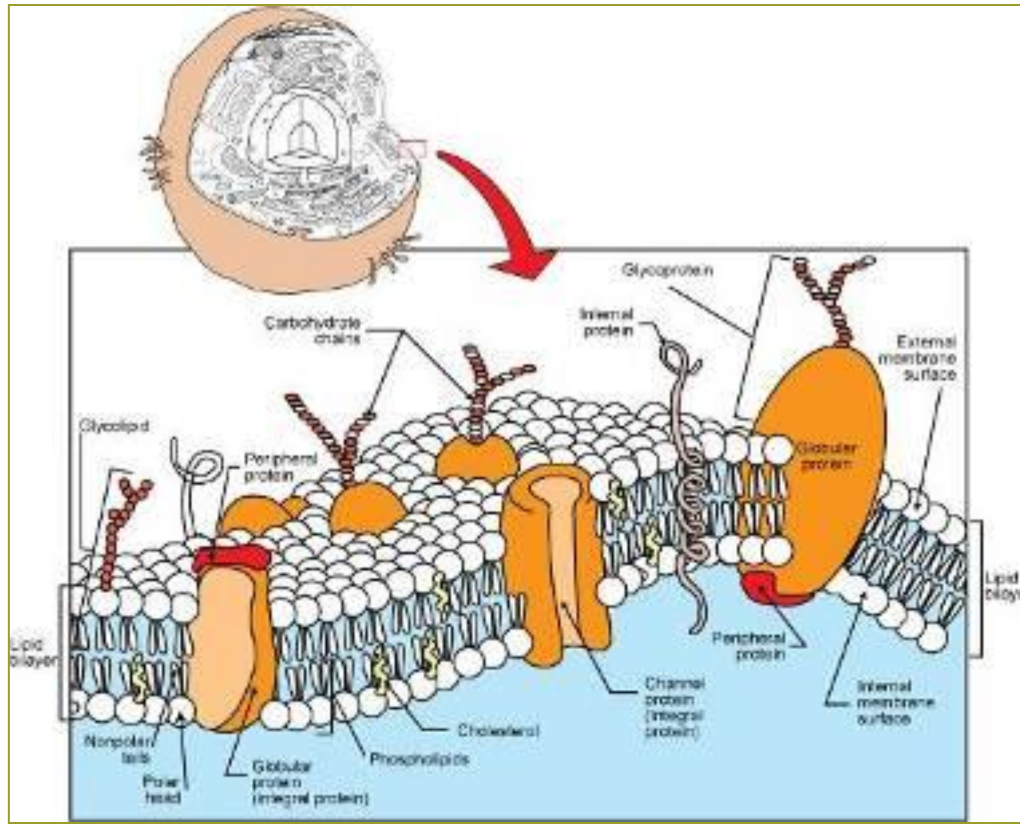
Every cell is enclosed in a membrane, a double layer of phospholipids (lipid bilayer). The exposed heads of the bilayer are "hydrophilic" (water loving), meaning that they are compatible with water both within the cytosol and outside of the cell. However, the hidden tails of the phospholipids are "hydrophobic" (water fearing), so the cell membrane acts as a protective barrier to the uncontrolled flow of water. The membrane is made more complex by the presence of numerous proteins that are crucial to cell activity. These proteins include receptors for odors, tastes and hormones, as well as pores responsible for the controlled entry and exit of ions like sodium (Na+) potassium (K+), calcium (Ca++) and chloride (Cl-).

RETURN to CELL DIAGRAM

Membrane Structure

Figure 3-3, Page 49

- Most lipid-soluble materials easily pass through the membrane
- Water-soluble molecules do not readily pass through
- Remember this for [Pharmacology](#)!



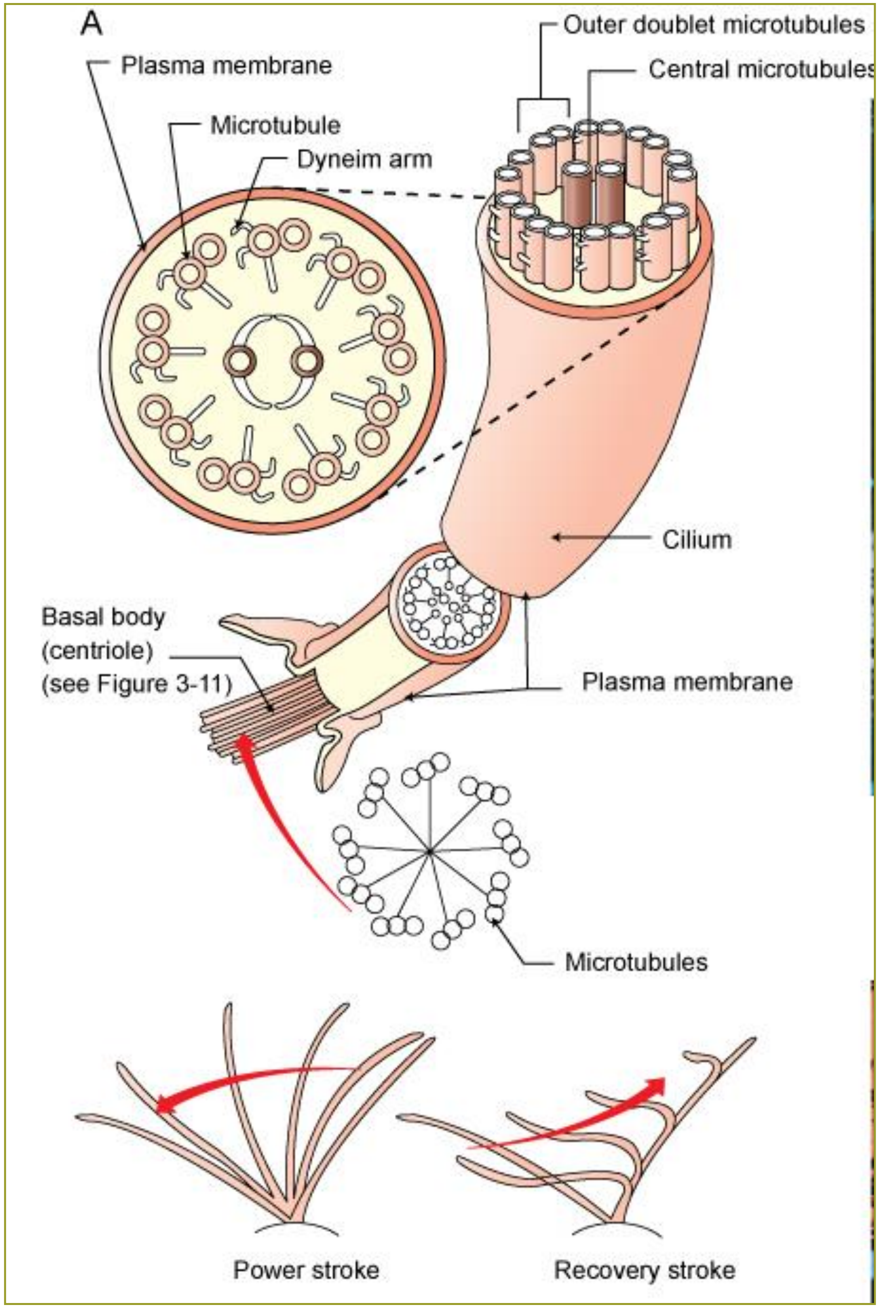
What about Drugs?

- High lipid solubility
- Low lipid solubility

Cilia and Flagella

Figure 3-5A, Page 52

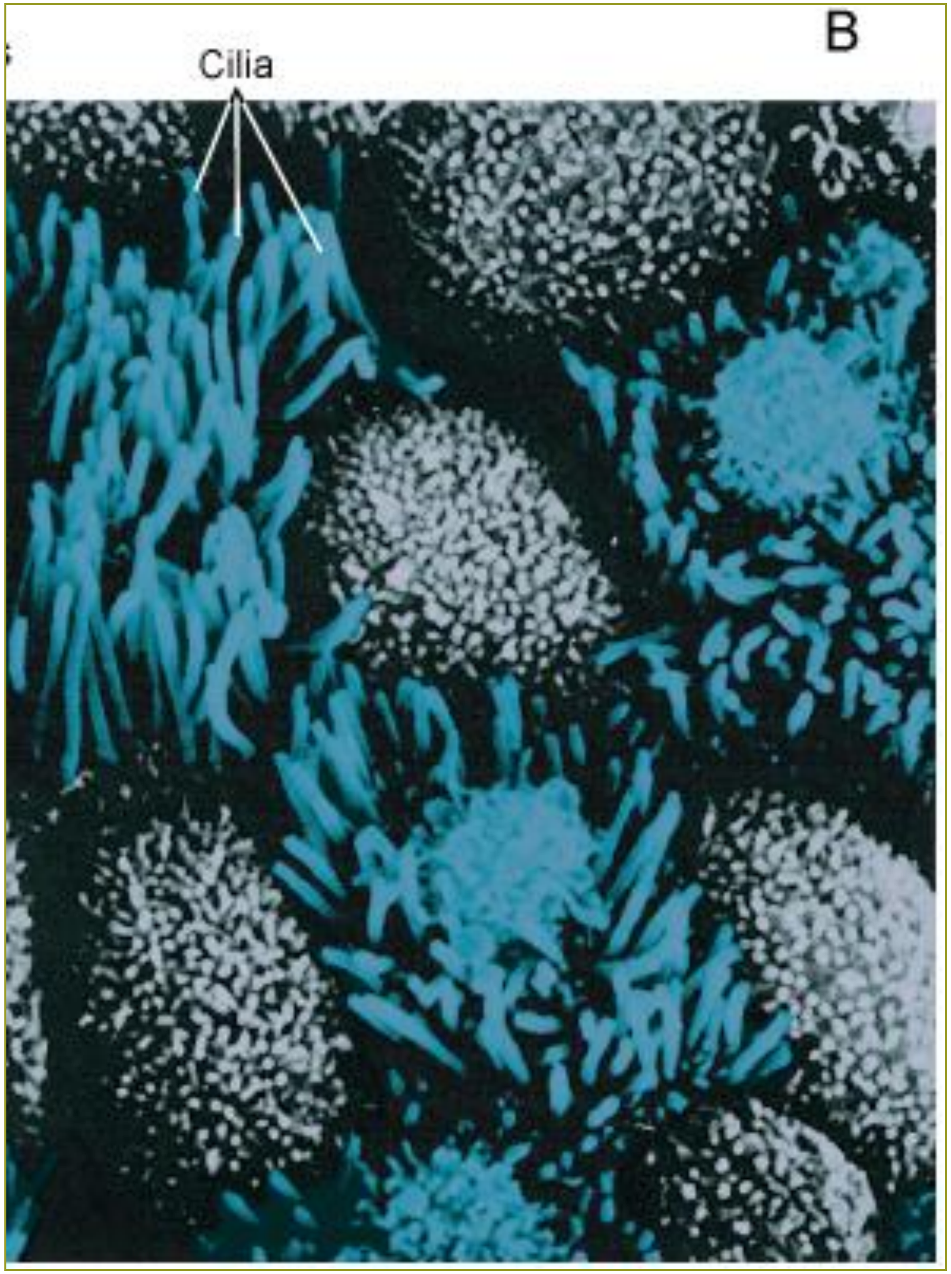
- Extensions of the plasma membrane that extend into the extracellular space
- Composed of nine pairs of microtubules that encircle a central pair of microtubules
- "9 + 2" arrangement



Cilia

Figure 3-5B, Page 52

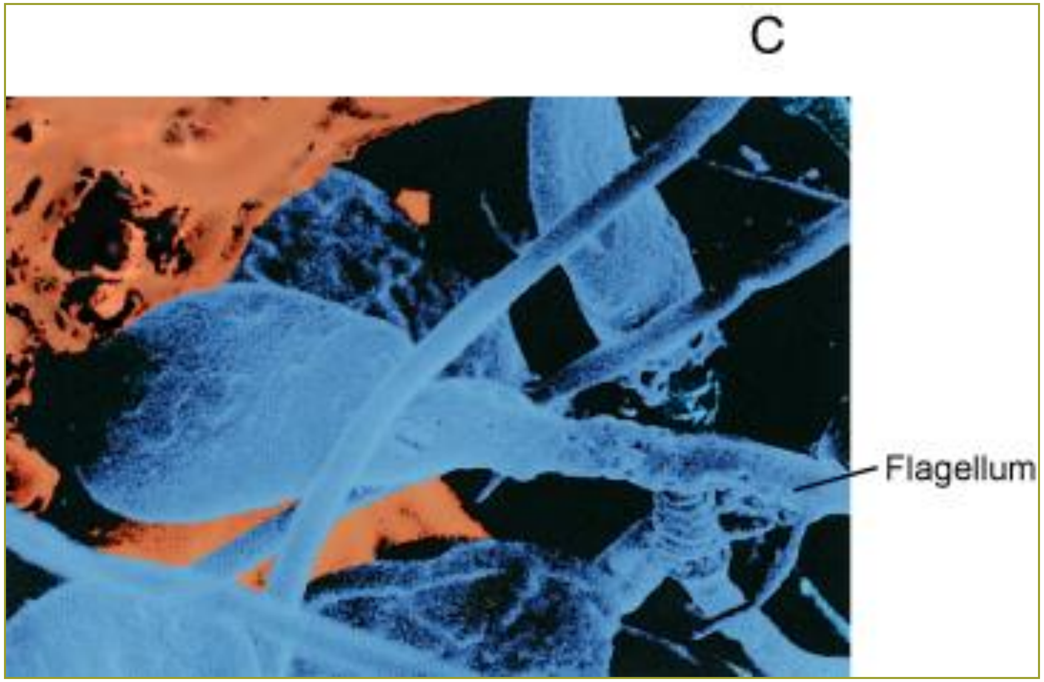
- Cilia occur in large numbers on the exposed surface of some cells
  - Move synchronously creating waves of motion that propel fluid, mucus, and debris across the cellular surface



Flagella

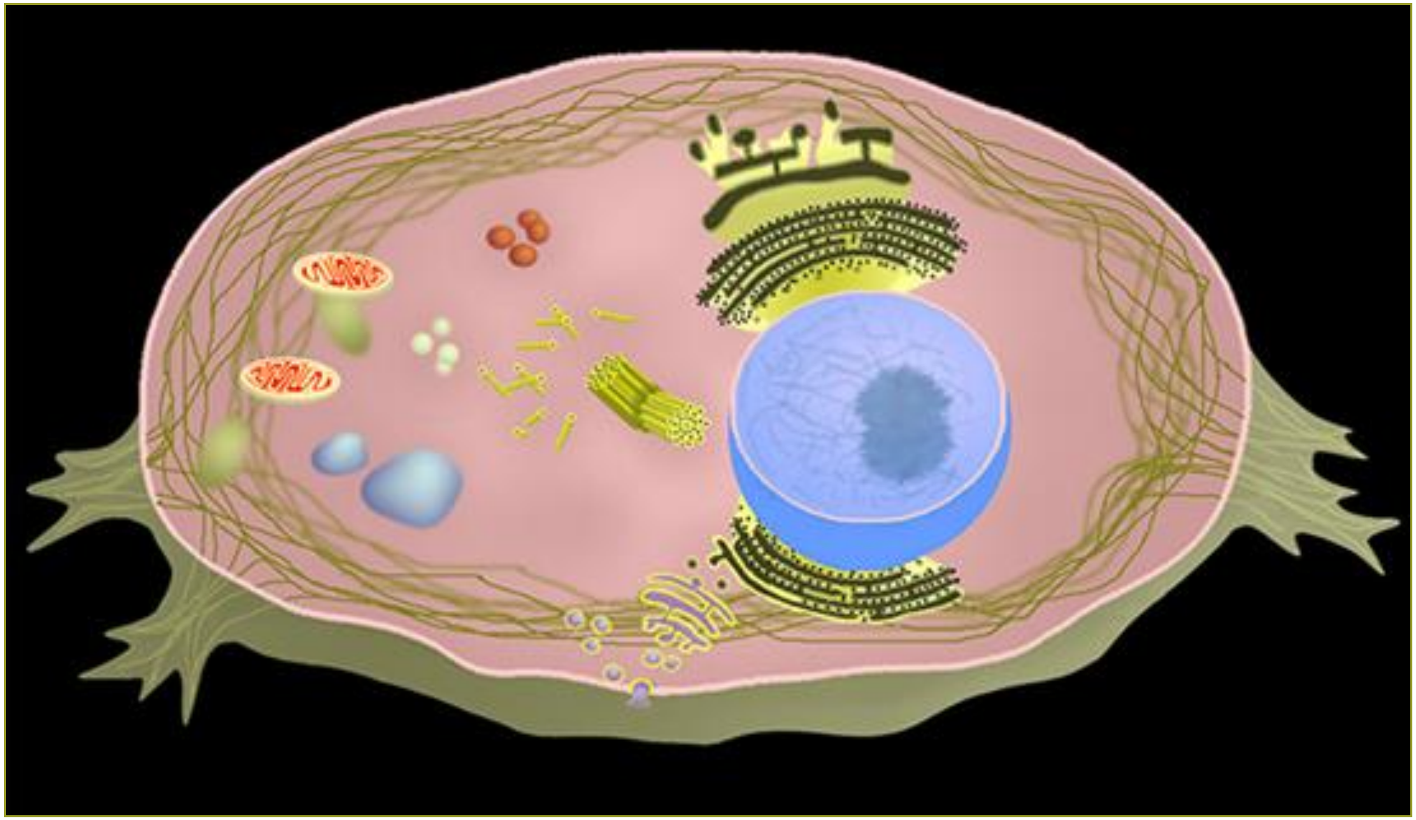
Figure 3-5C, Page 52

- Usually **occur singly** and are significantly **longer than cilia**
- Attached to individual cells and propel the cell forward by undulating



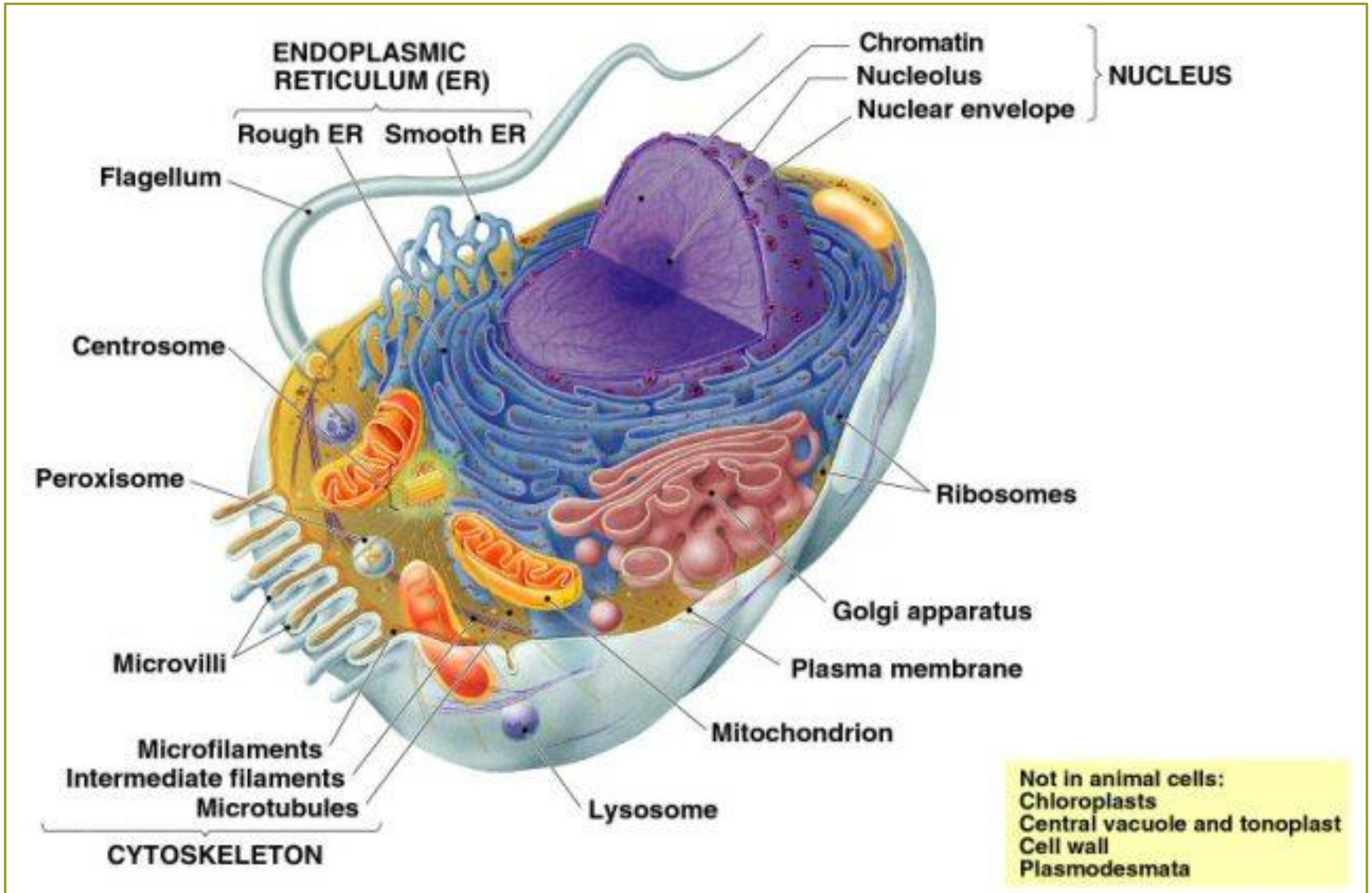
Topic 13

Discuss the structure and function of organelles found in the cytoplasm



Mammalian Cell Anatomy

Figure 3-2; Table 3-1 – Pages 46-48



2. Cytoplasm

Mitochondria

Ribosomes

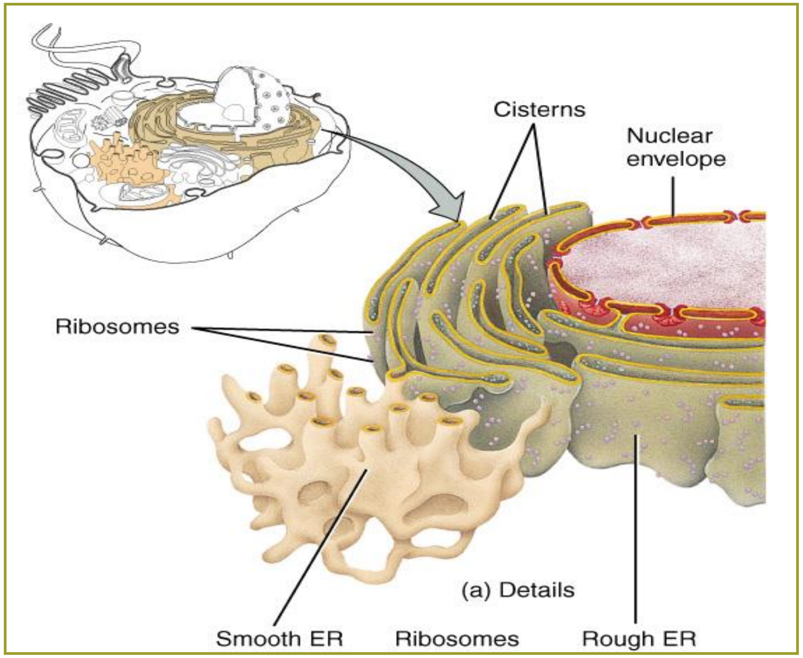
Endoplasmic Reticulum (ER)

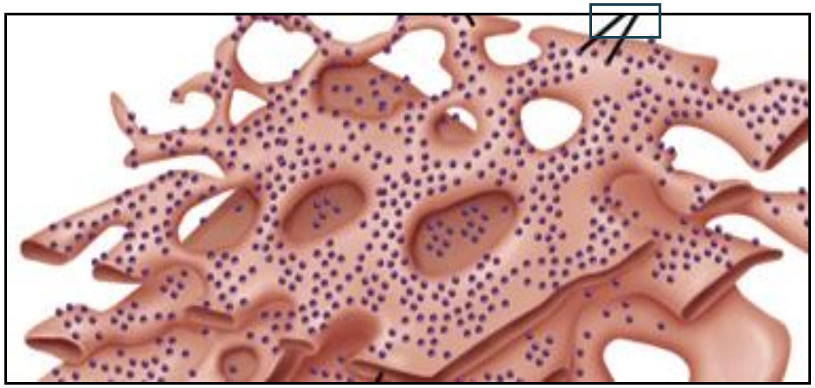
Golgi Apparatus

Lysosomes

Cytoplasmic Organelles

- Mitochondria
- Ribosomes
- Endoplasmic reticulum (ER)
  - Smooth ER
  - Rough ER

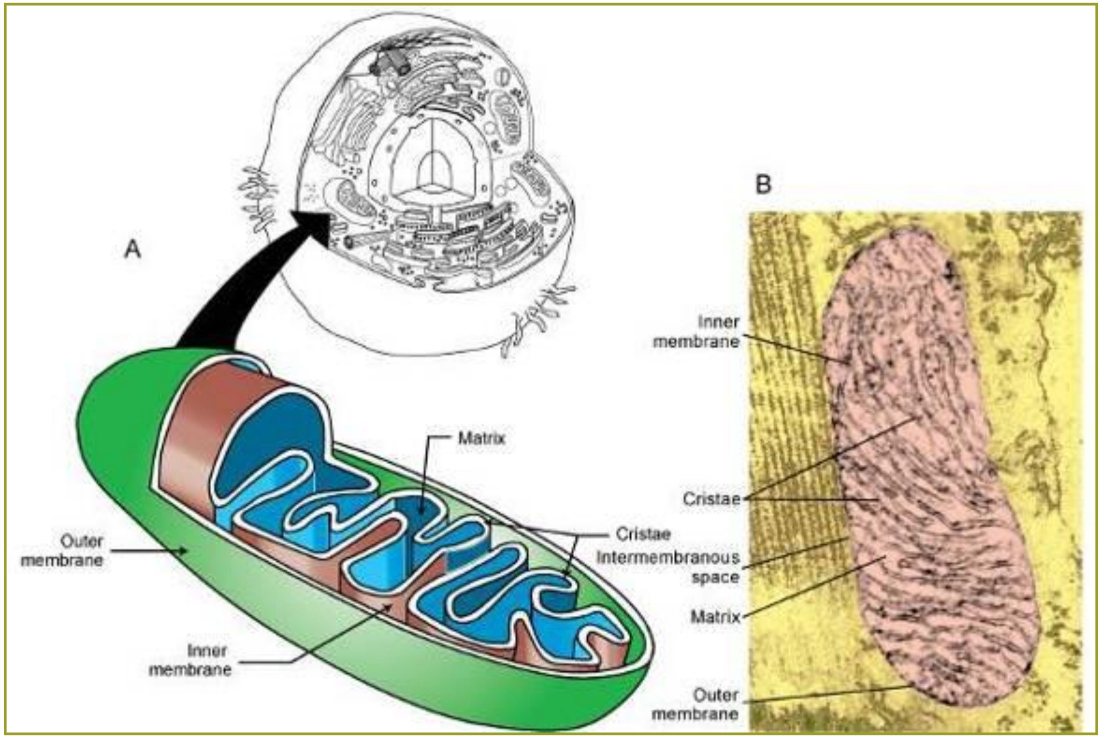




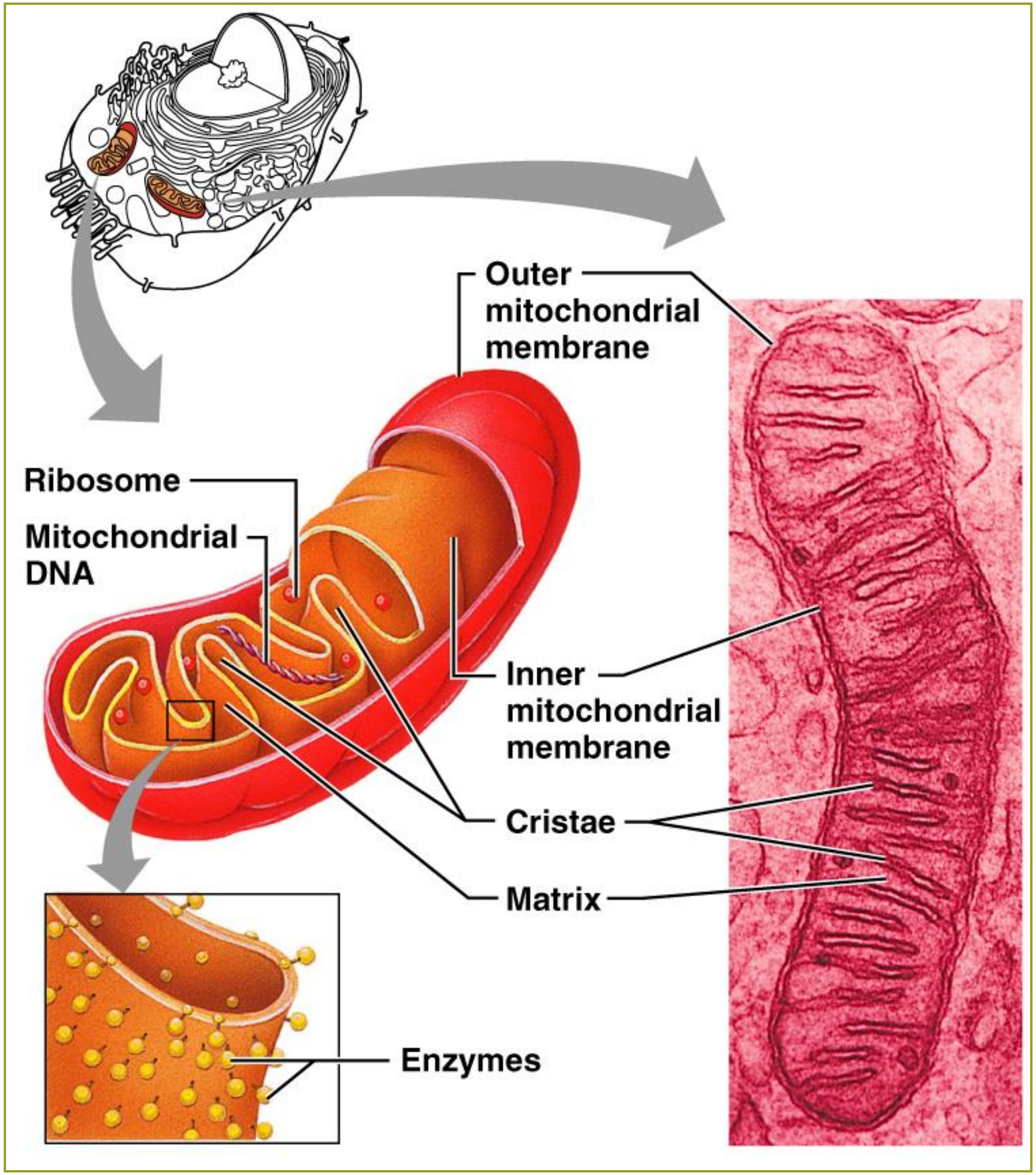
Mitochondria

Figure 3-7, Page 54

- Produces most of the energy that fuels the cell
- Site of aerobic cellular respiration

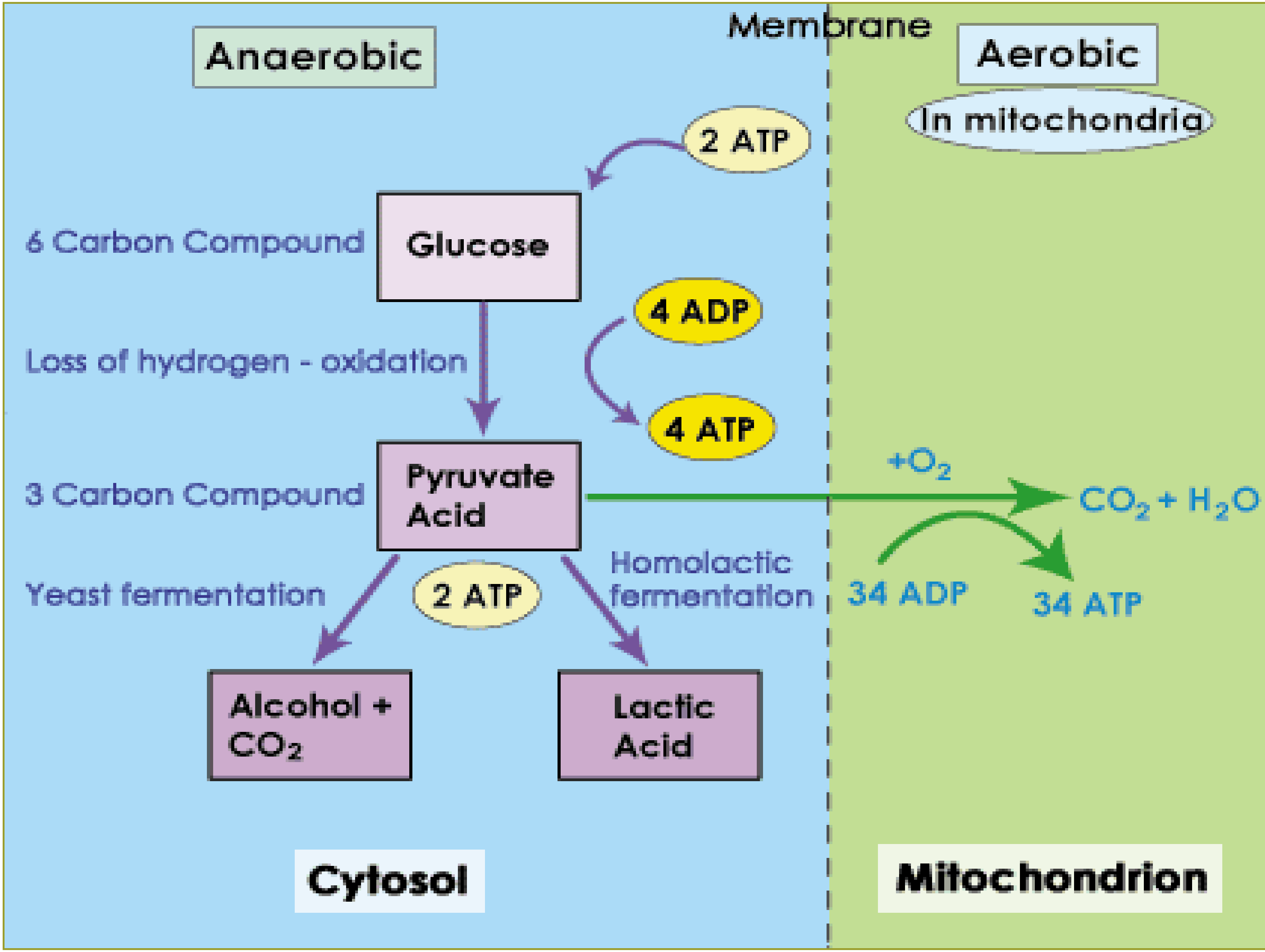


Mitochondria



Aerobic Cellular Respiration

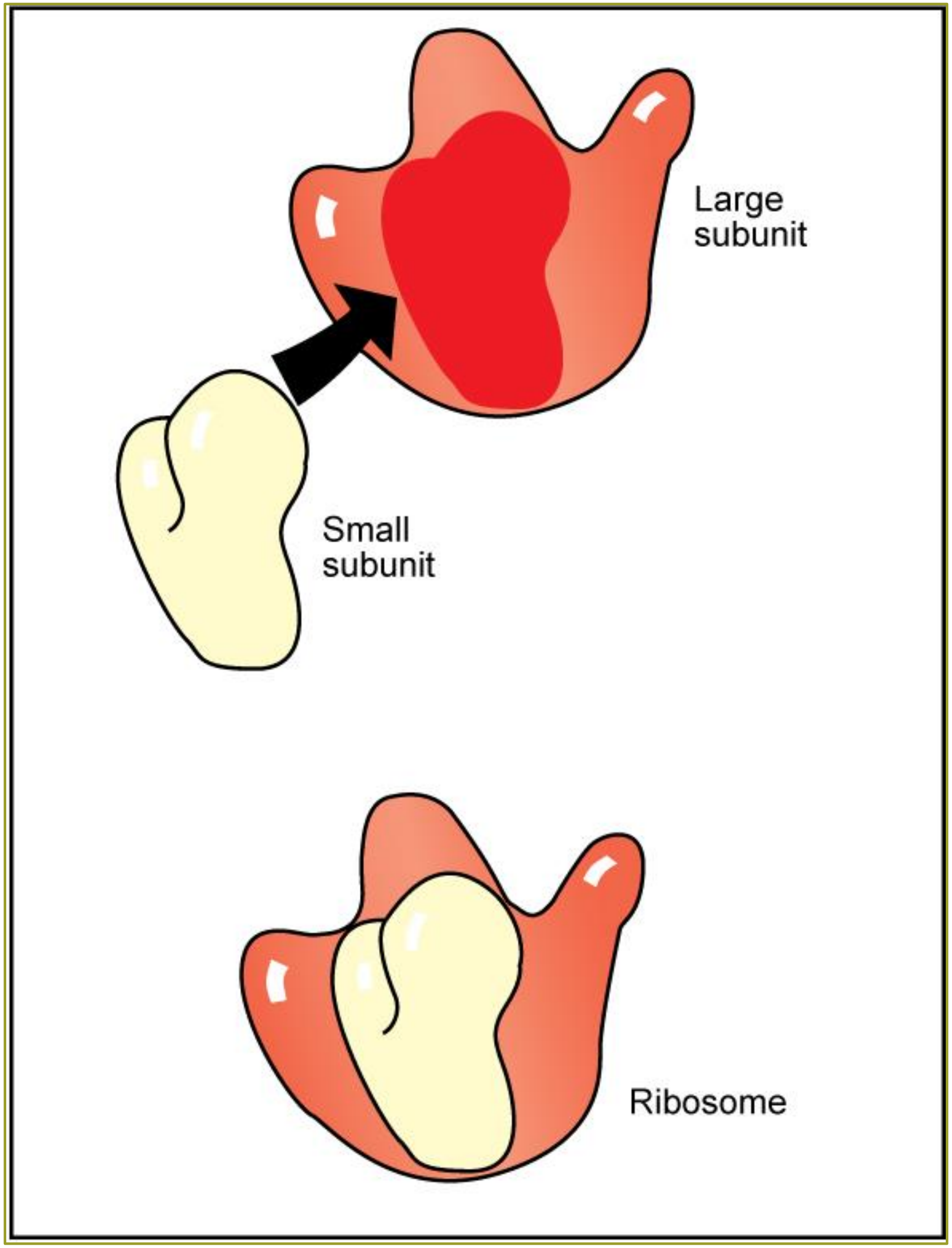
- In mitochondria
- Formula – **Glucose + Oxygen → Water + Carbon Dioxide + 36-38 ATP**


Membrane
Anaerobic
Aerobic
In mitochondria
2 ATP
6 Carbon Compound
Glucose
4 ADP
Loss of hydrogen - oxidation
4 ATP
$+O_2$
3 Carbon Compound
Pyruvate Acid
$CO_2 + H_2O$
Homolactic fermentation
Yeast fermentation
2 ATP
34 ADP
34 ATP
Alcohol + CO_2
Lactic Acid
Cytosol
Mitochondrion

Ribosomes

Figure 3-8, Page 55

- Important site for protein synthesis
- Individuals in cytoplasm
- Attached to **endoplasmic reticulum (rough ER)**

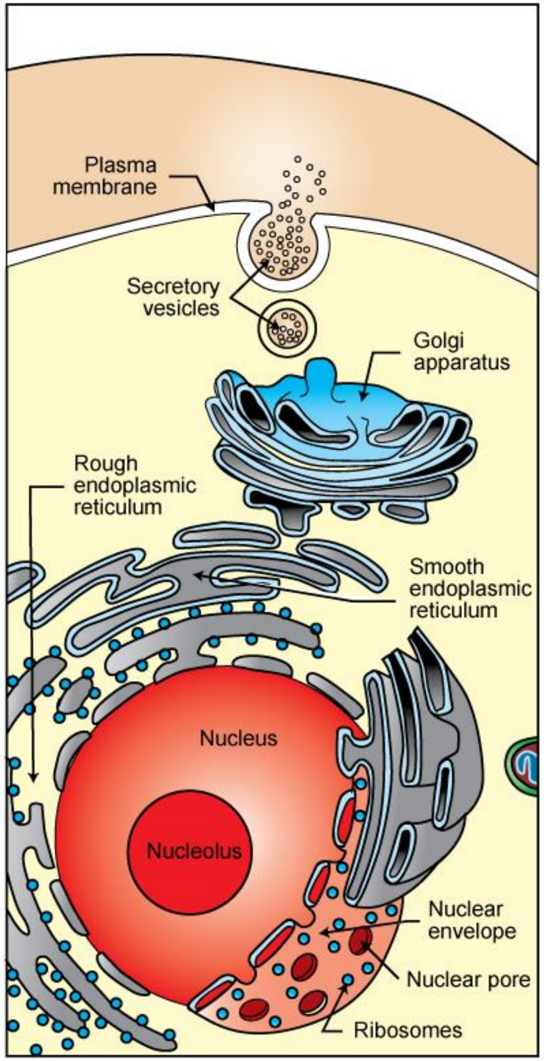


Endoplasmic Reticulum (ER)

Figure 3-9A, Page 56

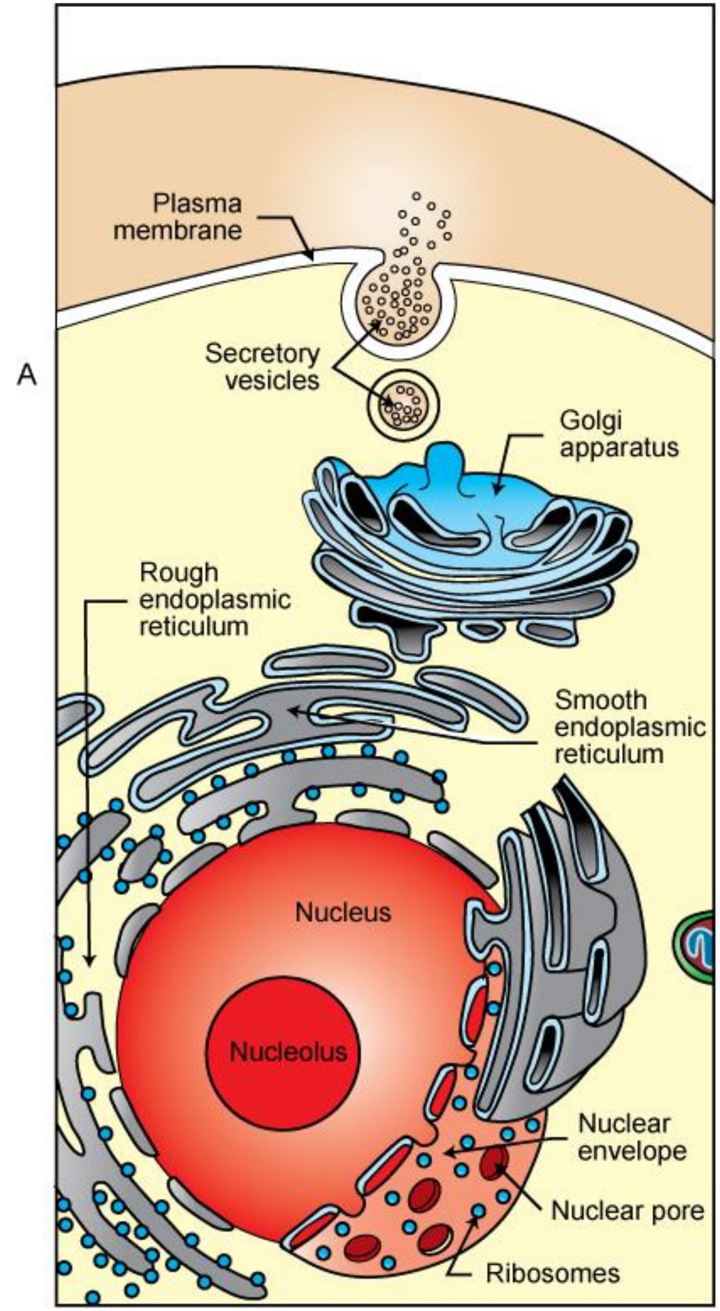
- Series of flattened tubes stacked on one another and bent into a crescent shape
- The walls of the ER are composed of a single lipid bilayer and are <u>continuous with the membranes of the nucleus and Golgi apparatus</u>

A



ER

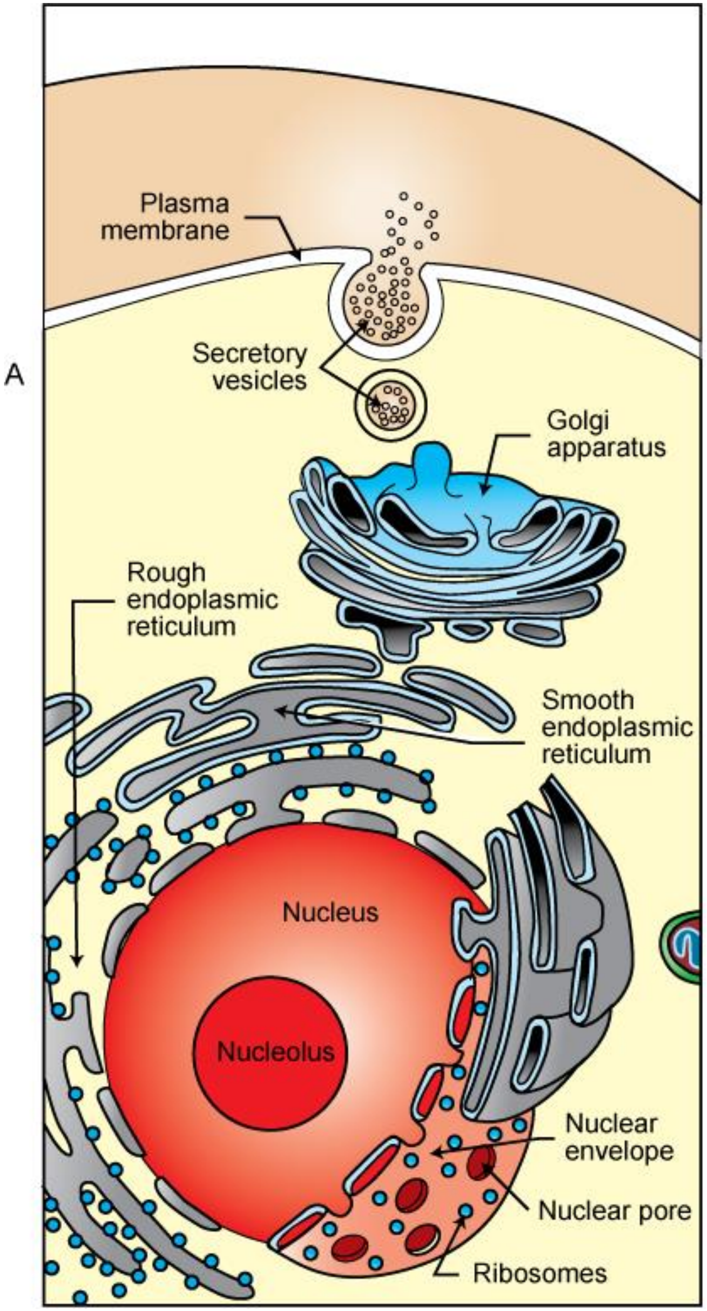
- **Rough ER** – ribosomes on its surface and is involved in production of **protein**
- **Smooth ER** – involved in the synthesis and storage of **lipids**



Golgi Apparatus

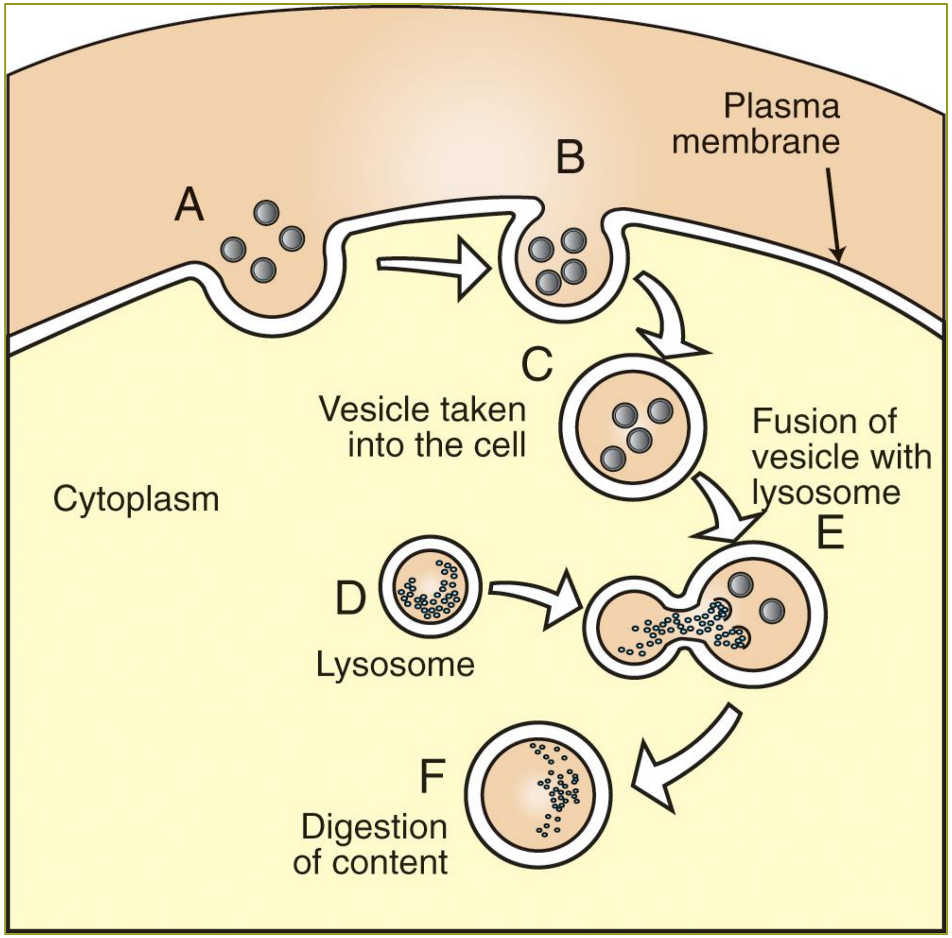
Figure 3-9, Page 56

- Composed of stacks of flattened, crescent-shaped tubes called *cisternae*
- Acts as a modification, packaging, and distribution center for molecules

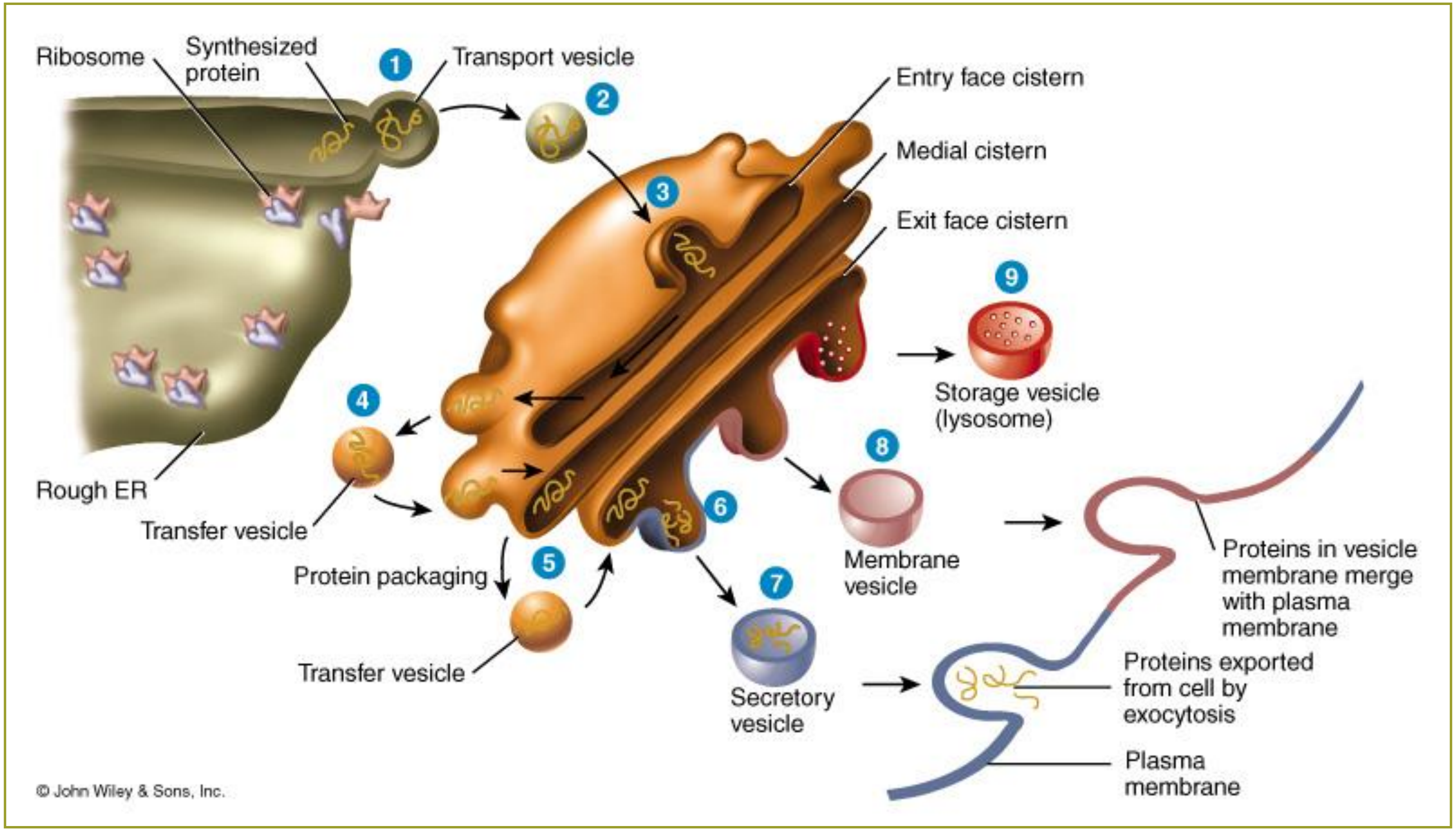


Lysosomes
Figure 3-10, Page 57

- Specialized vesicle formed by the Golgi apparatus
- Contains hydrolytic enzymes enclosed in a single protective membrane
- **Function**: to breakdown nutrient molecules into usable smaller units and to digest intracellular debris



Golgi Apparatus; Lysosomes

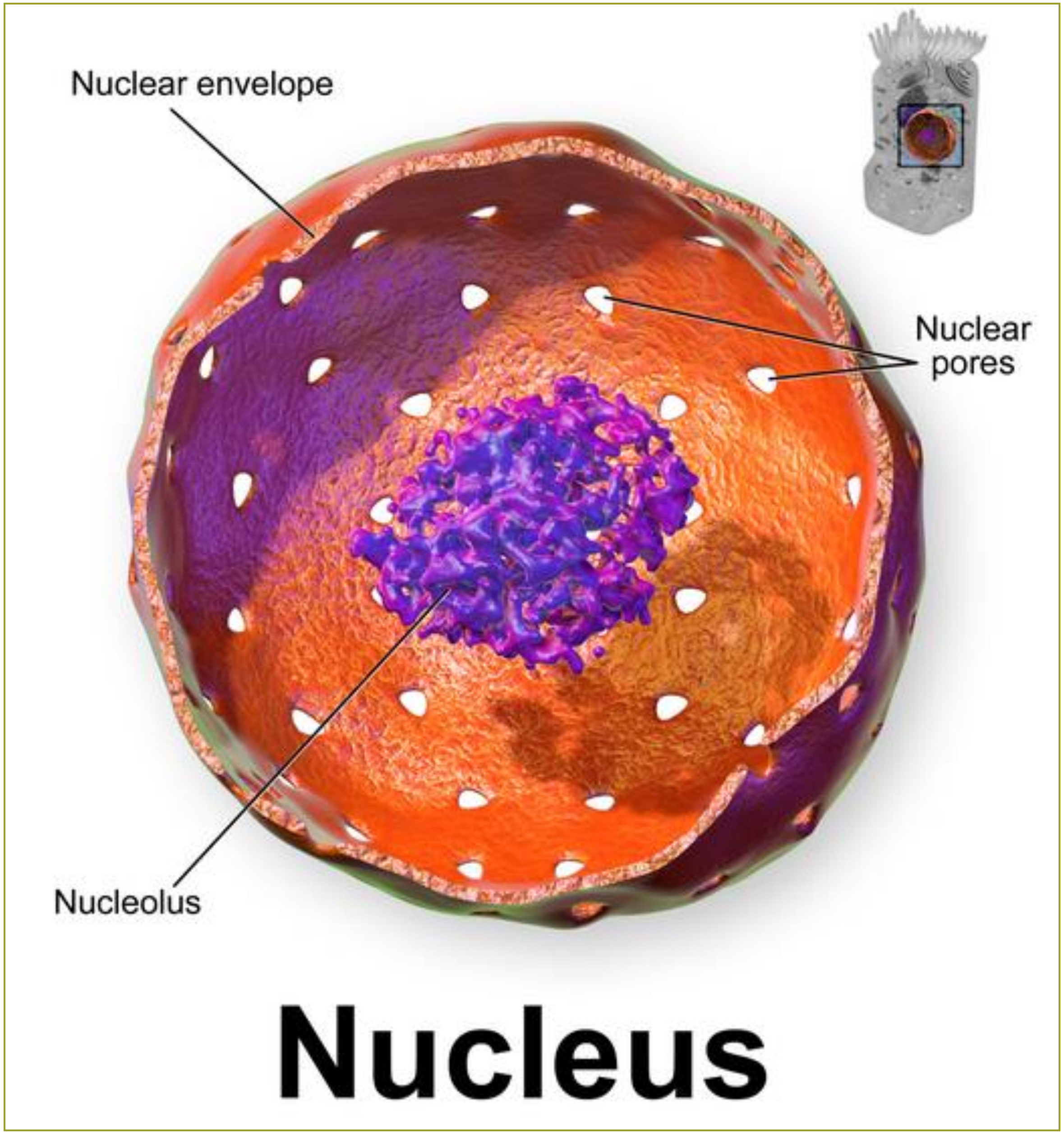


Inclusions

- **Metabolic products or substances that the cell has engulfed**
- May have a single-layer membrane (e.g., secretory granules, vacuoles, and vesicles)
- May be non-membrane-bound (e.g., lipid droplets and fat globules)

Topic 14

Discuss the structure and function of the nucleus



3. The Nucleus

Nuclear Envelope

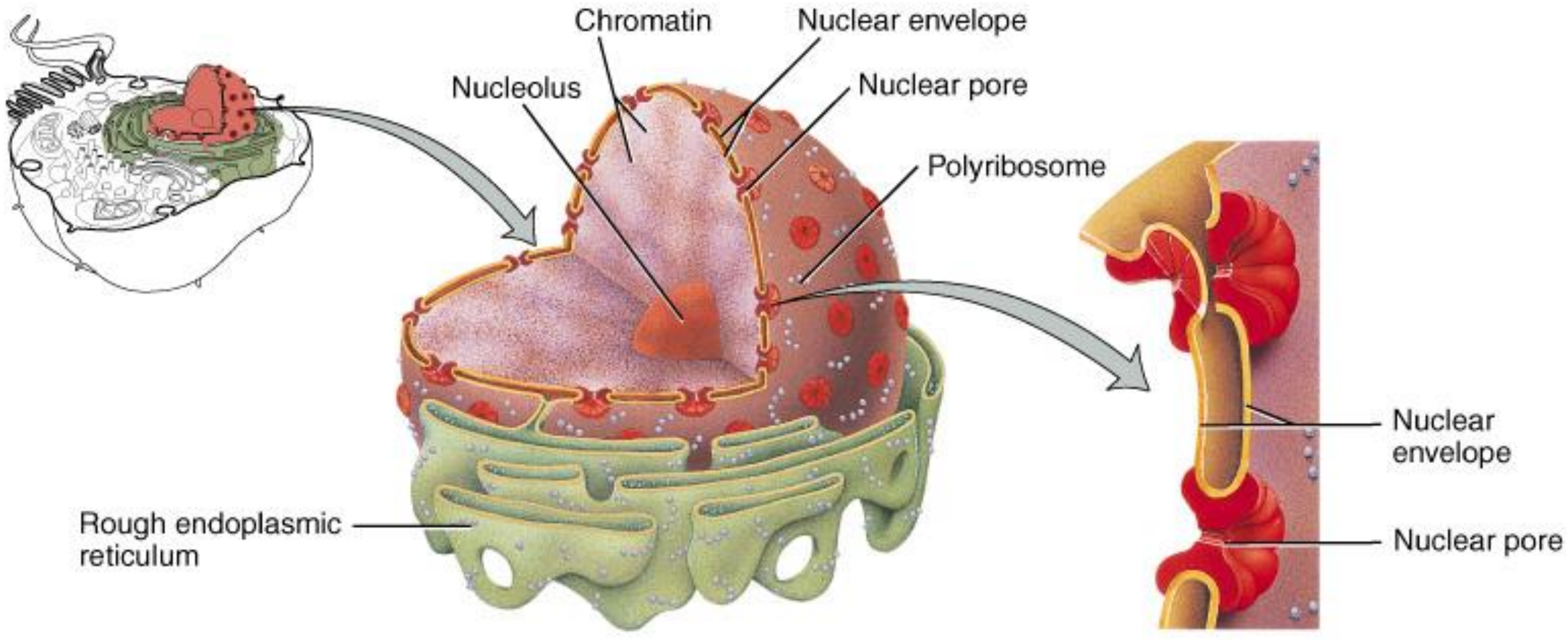
Chromatin (Chromosomes)

DNA (Genes)

Protein

Nucleolus

The Nucleus



(a) Details of nucleus

(b) Details of nuclear envelope

Nucleus

- Dark-staining, spherical or multi-segmented body
- Primary functions: maintain the **hereditary information** of the species and control cellular activities through **protein synthesis**
- Large cells are multinucleated
- Mature mammalian red blood cells (RBC's) are non-nucleated

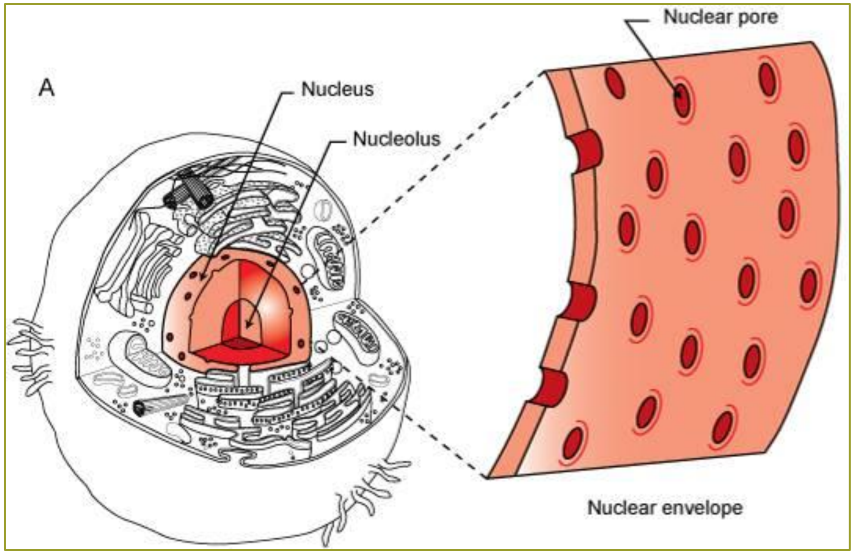
Nucleus

- The anatomy (morphology) of the nucleus is divided into the following four parts:

1. **Nuclear envelope** or membrane
2. **Nucleoplasm**: gel-like substance similar to cytoplasm
3. **Chromatin**
4. **Nucleolus**

Nuclear Envelope
Figure 3-12A, Page 58

- Composed of two lipid bilayers
- Outer layer is continuous with the **ER** and is studded with ribosomes
- Also consists of **nuclear pores** where the two layers of the nuclear envelope have fused to form a channel



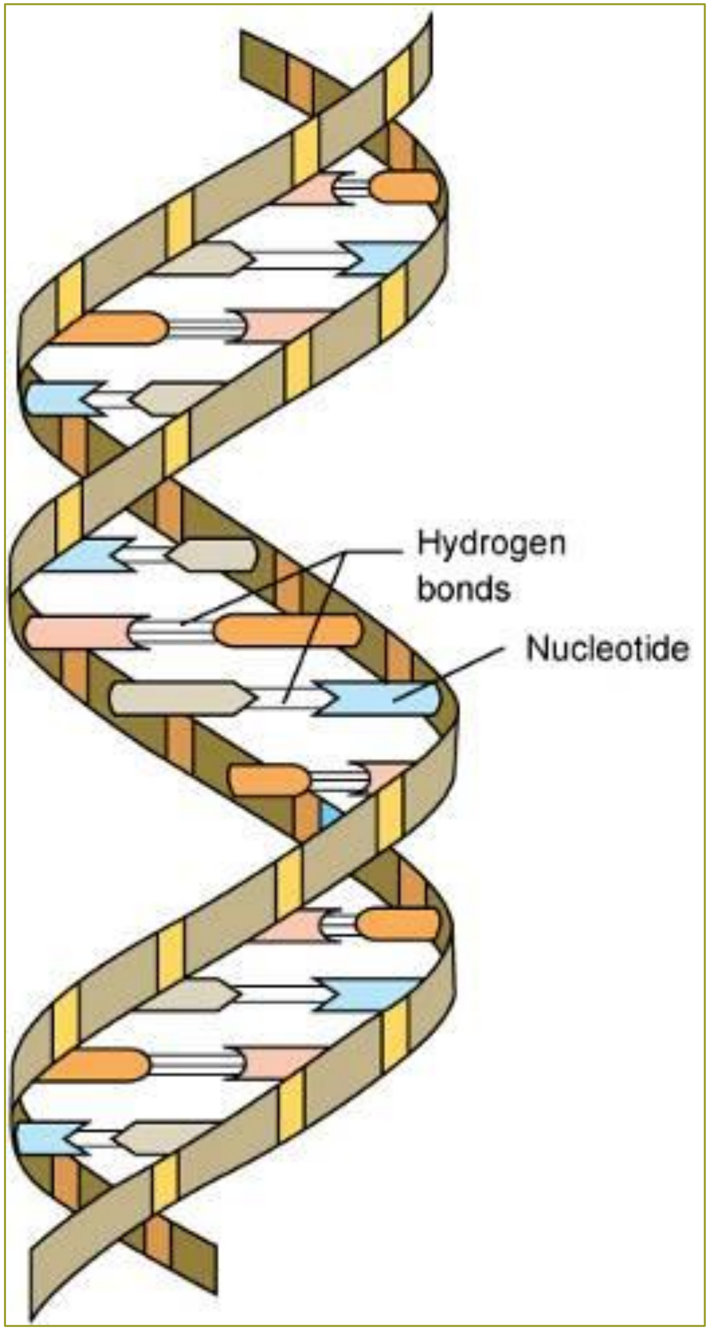
DNA and RNA

- DNA and RNA are made up of chains of nucleotides.
- Composed of three subunits: a nitrogenous base, a five-carbon sugar, and a phosphate group
- DNA and RNA nucleotides are linked to form a “backbone” of alternating sugar and phosphate groups.

DNA and RNA

Figure 3-13, Page 61

- DNA forms a <u>double stranded</u> molecule called the [*double helix*]
- RNA is a single-stranded molecule that has no opposing strand
- The single strand of RNA is similar in structure to each of the strands found in DNA



Chromatin

- Light or dark fibers in the nucleoplasm
- Made up of DNA and histones
  - Histones play an important role gene regulation
- A single strand of DNA winds around eight (8) histone molecules forming a granule called a nucleosome
- The nucleosomes are held together by short strands of DNA called *linker DNA*

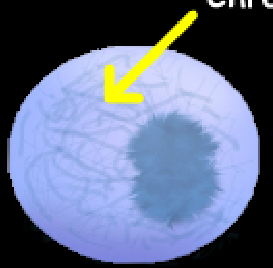
Nucleolus

- Small, dark-staining spherical patches in the nucleus
- Not membrane bound
- Located **where ribosomal subunits are made**
  - These subunits are exported from the nucleus and are assembled in the cytoplasm to form functional ribosomes
- Nucleoli also contain the DNA that governs the synthesis of ribosomal RNA (rRNA)

How Cells Alive! Sees the Nucleus

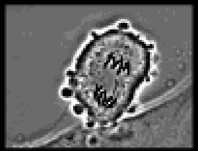
CELLS *alive!* Interactive Animal and Plant Cells

The NUCLEUS



The nucleus is the most obvious organelle in any eukaryotic cell. It is enclosed in a double membrane and communicates with the surrounding cytosol via numerous nuclear pores.

Within the nucleus is the DNA responsible for providing the cell with its unique characteristics. The DNA is similar in every cell of the body, but depending on the specific cell type, some genes may be turned on or off - that's why a liver cell is different from a muscle cell, and a muscle cell is different from a fat cell.



When a cell is dividing (left), the nuclear chromatin (DNA and surrounding protein) condenses into chromosomes that are easily seen by microscopy.

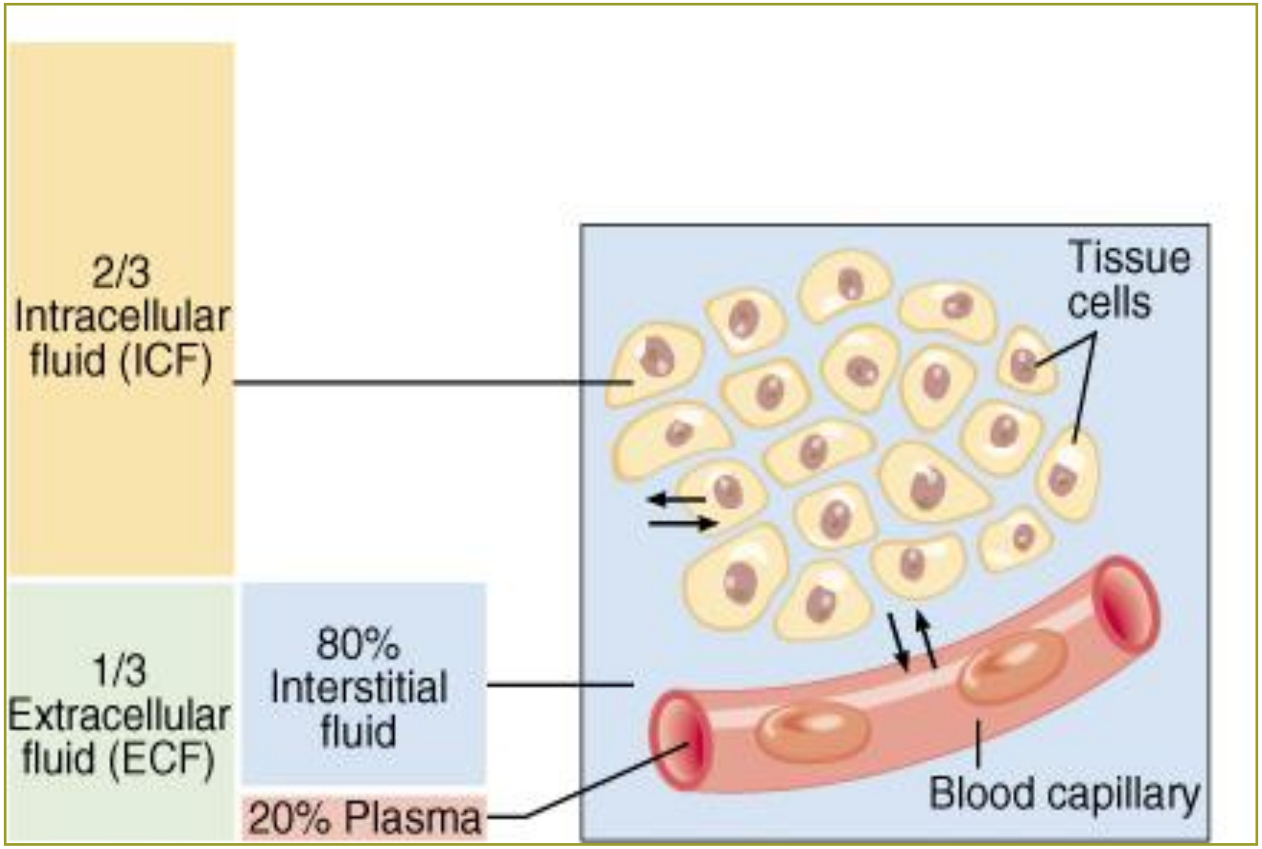
RETURN to CELL DIAGRAM

Table 3.1 Organelles and Their Locations and Functions

Organelles	Location	Function(s)
Nucleus	Often near center of the cell	Contains genetic material of cell (DNA) and nucleoli; site of ribosome and messenger RNA synthesis
Nucleolus	In the nucleus	Site of ribosomal RNA synthesis and ribosomal subunit assembly
Rough endoplasmic reticulum (rough ER)	In cytoplasm	Many ribosomes attached to rough ER; site of protein synthesis
Smooth endoplasmic reticulum (smooth ER)	In cytoplasm	Site of lipid synthesis; detoxification
Golgi apparatus	In cytoplasm	Modifies protein structure and packages proteins in secretory vesicles
Secretory vesicle	In cytoplasm	Contains materials produced in the cell; formed by the Golgi apparatus; secreted by exocytosis
Lysosome	In cytoplasm	Contains enzymes that digest material taken into the cell
Mitochondrion	In cytoplasm	Site of aerobic respiration and the major site of ATP synthesis
Microtubule	In cytoplasm	Supports cytoplasm; assists in cell division and forms components of cilia and flagella
Cilia	On cell surface with many on each cell	Cilia move substances over surfaces of certain cells
Flagella	On sperm cell surface with one per cell	Propels sperm cells
Microvilli	Extensions of cell surface with many on each cell	Increase surface area of certain cells

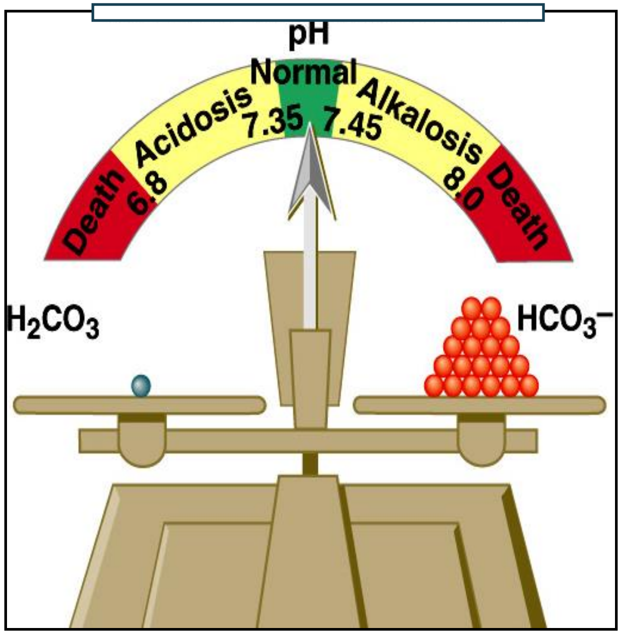
Topic 15

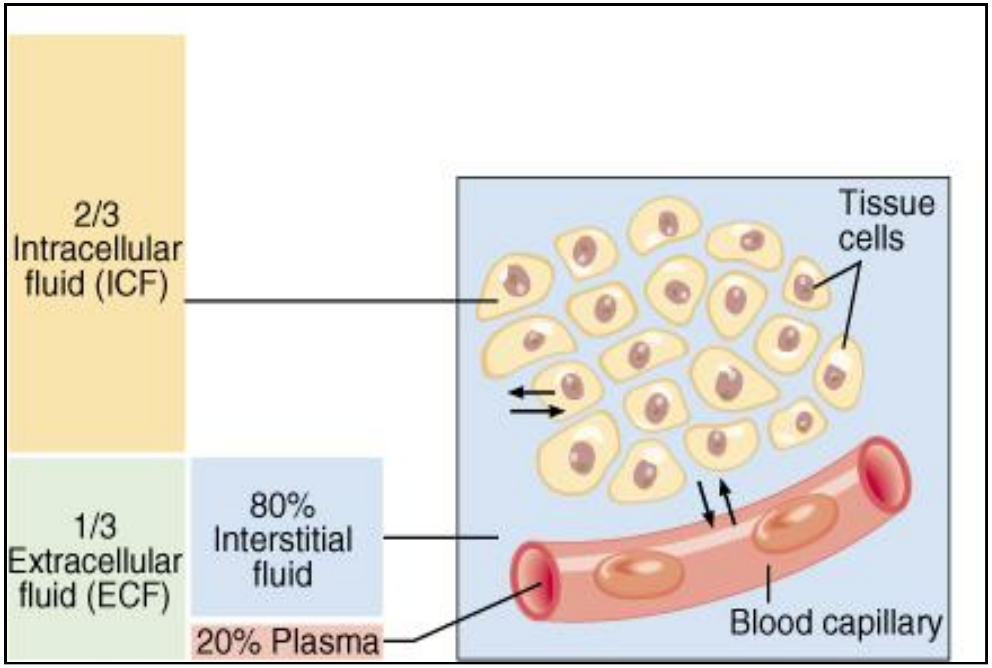
Describe cellular physiology



Cellular Physiology

- **Secrets of Life!!! ☺**
- Body fluid compartments
  - ECF
    - Plasma
    - Interstitial fluid
  - ICF (cytosol)
- Ions (electrolytes)
- pH



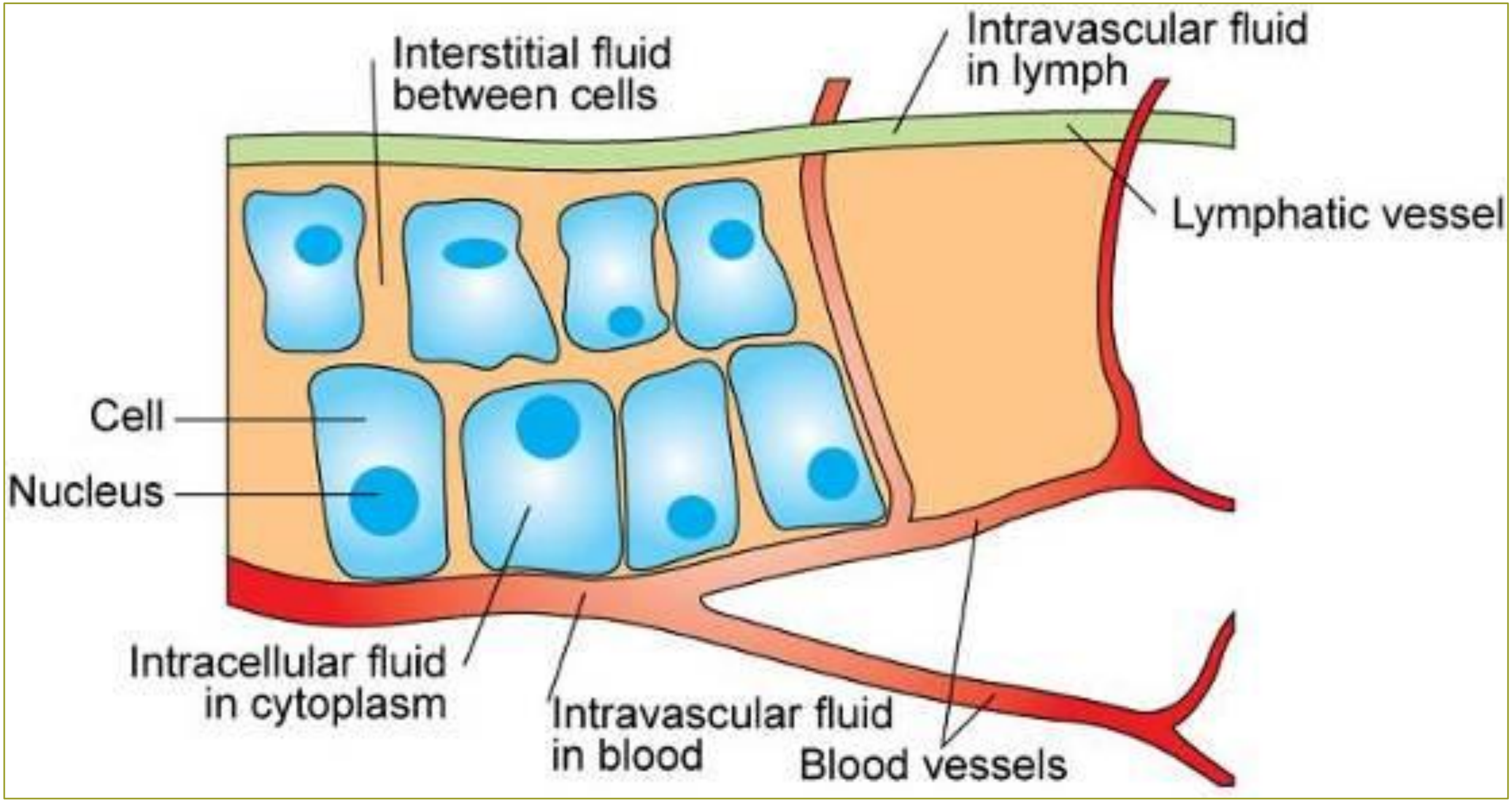


Body Fluids

- **Intracellular fluid (ICF)**: inside the cell
  - Cytosol
- **Extracellular fluid (ECF)**: outside the cell
  - **Interstitial fluid**: extracellular fluid specifically found in tissues
  - Plasma: extracellular fluid surrounding blood cells in the blood

Fluid Spaces

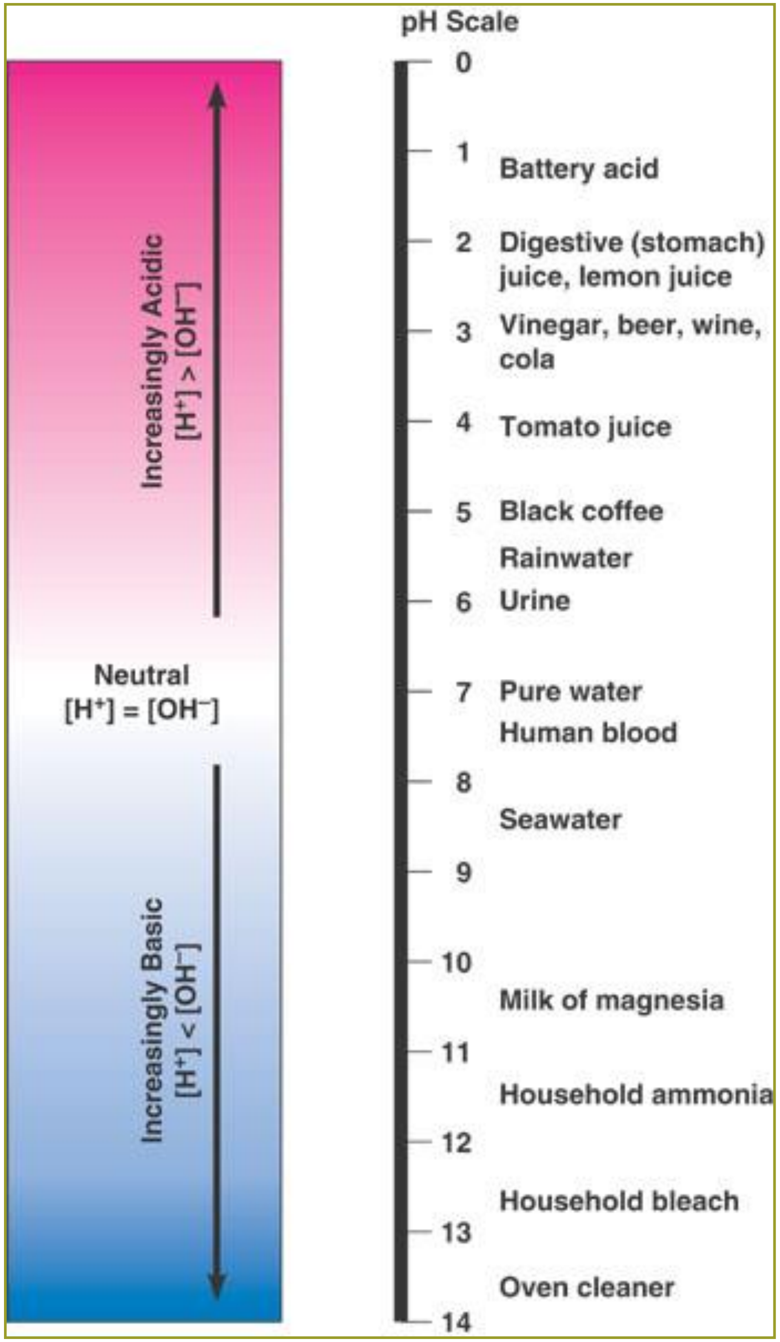
Figure 3-16, Page 63



Ions, Electrolytes, and pH

- Extracellular and intracellular fluid contains cations and anions
- These ions are electrolytes
- Acids and bases are also electrolytes
- In sick or injured animals, the electrolyte concentrations and pH of intracellular and extracellular fluid can become abnormally high or low. **(Walking Salt Water Aquariums!)**

pH

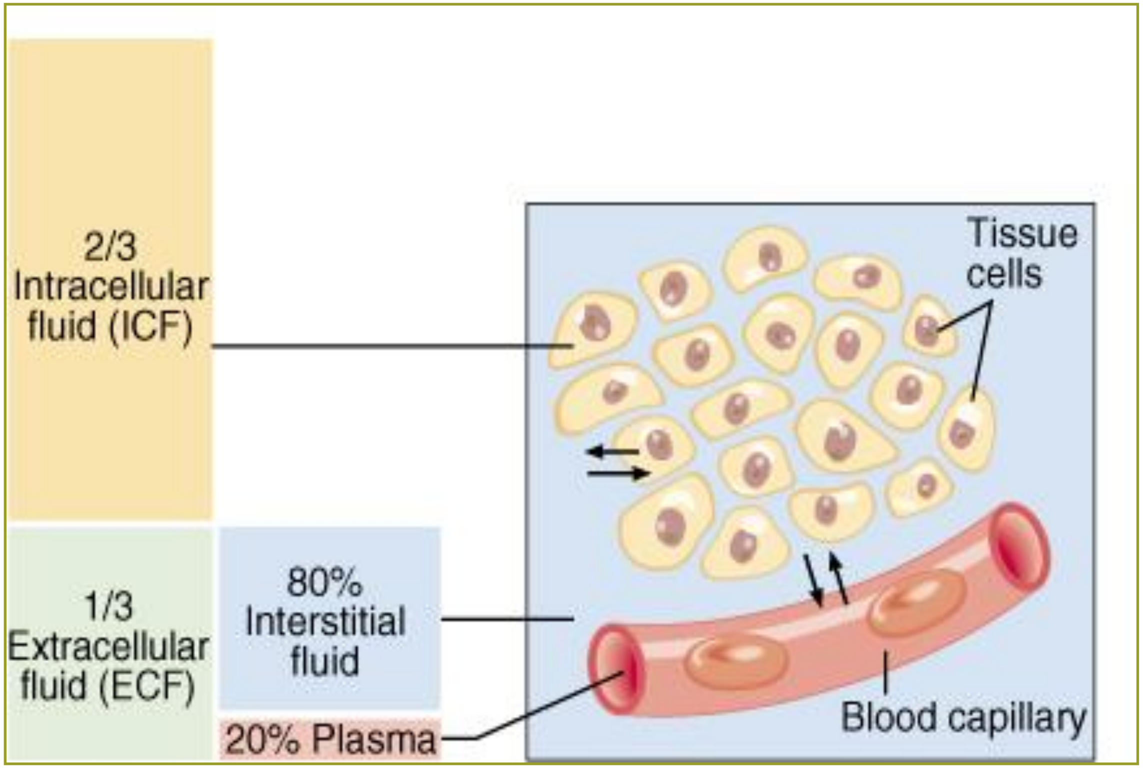

pH Scale
Increasingly Acidic
[H+] > [OH−]
Neutral
[H+] = [OH−]
Increasingly Basic
[H+] < [OH−]
0
1 Battery acid
2 Digestive (stomach) juice, lemon juice
3 Vinegar, beer, wine, cola
4 Tomato juice
5 Black coffee
Rainwater
6 Urine
7 Pure water
Human blood
8
Seawater
9
10
Milk of magnesia
11
Household ammonia
12
Household bleach
13
Oven cleaner
14

Membrane Processes

- The absorption of nutrients or excretion of waste may occur with or without the expenditure of energy by the cell
- Absorptive or excretory processes that require energy are considered active, whereas those that do not require energy are passive

Topic 16

Compare and contrast the various types of cell membrane transportation that occurs in an animal cell



Cell Membrane Transportation

Passive Processes

Active Processes

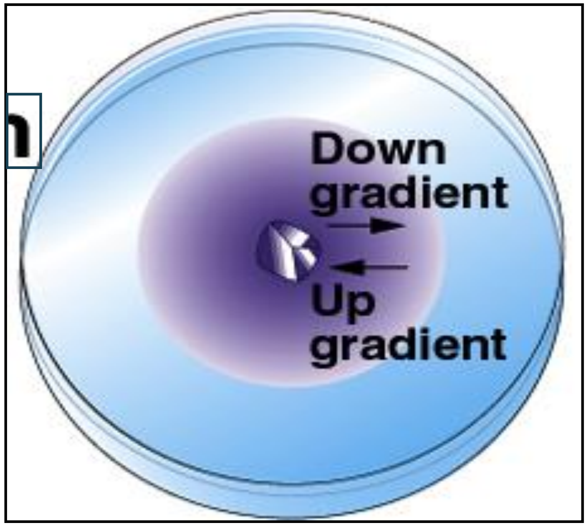
Membrane Processes

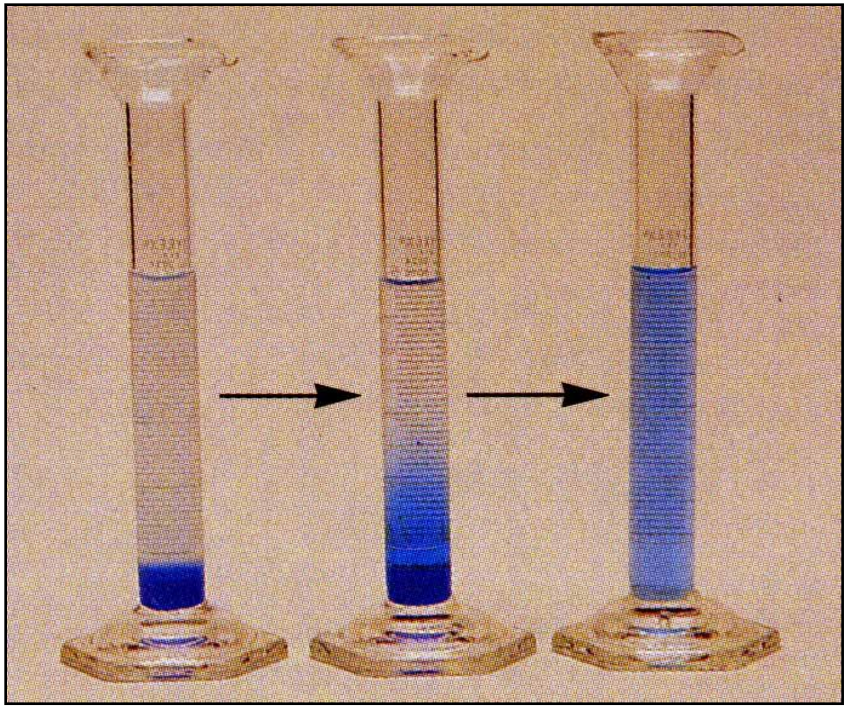
Table 3-2, Pages 64-65

- **Passive** Transport **(No ATP Needed)**
  1. Diffusion
  2. Facilitated Diffusion
  3. Osmosis (Tonicity)
  4. Filtration
- **Active** Transport **(ATP Needed)**
  1. Sodium/Potassium pump
  2. Endocytosis
  3. Exocytosis

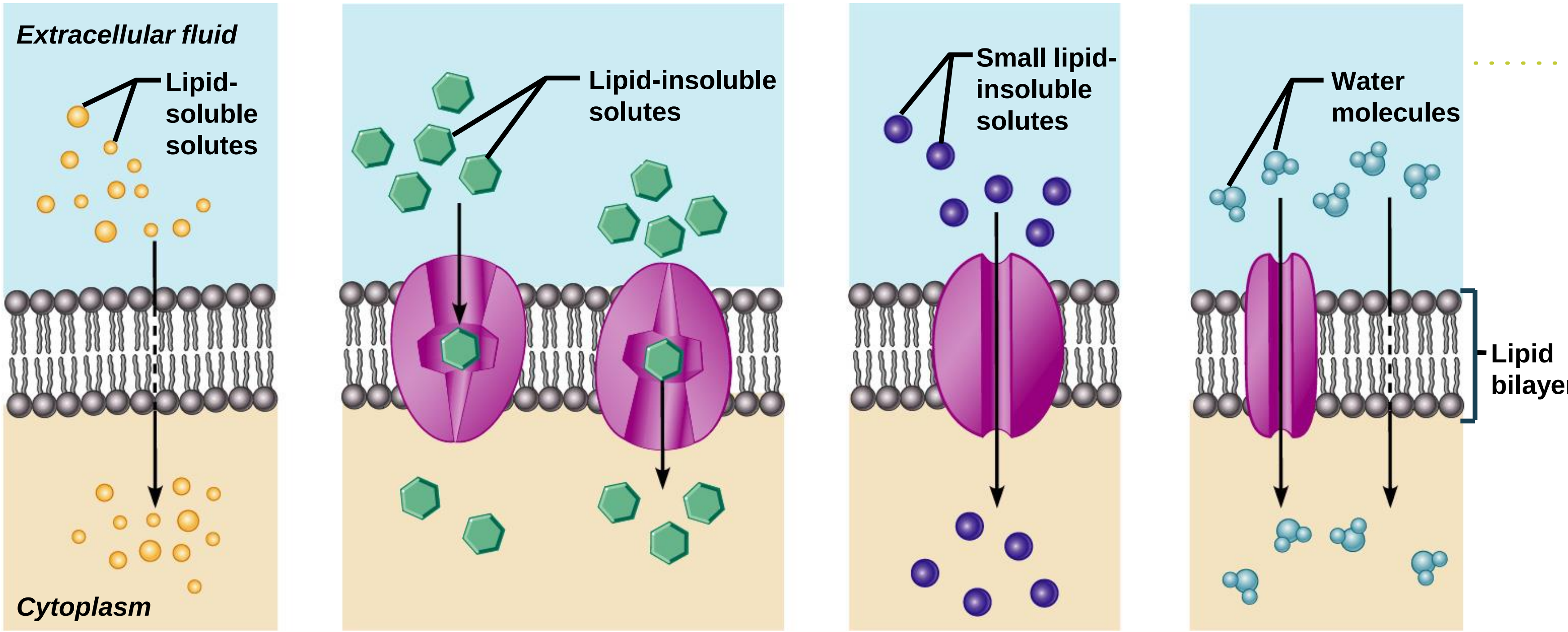
Passive Processes

- [No ATP needed]
- Diffusion
- Osmosis
- Facilitated diffusion
- Filtration (kidneys)





Diffusion through the Plasma Membrane



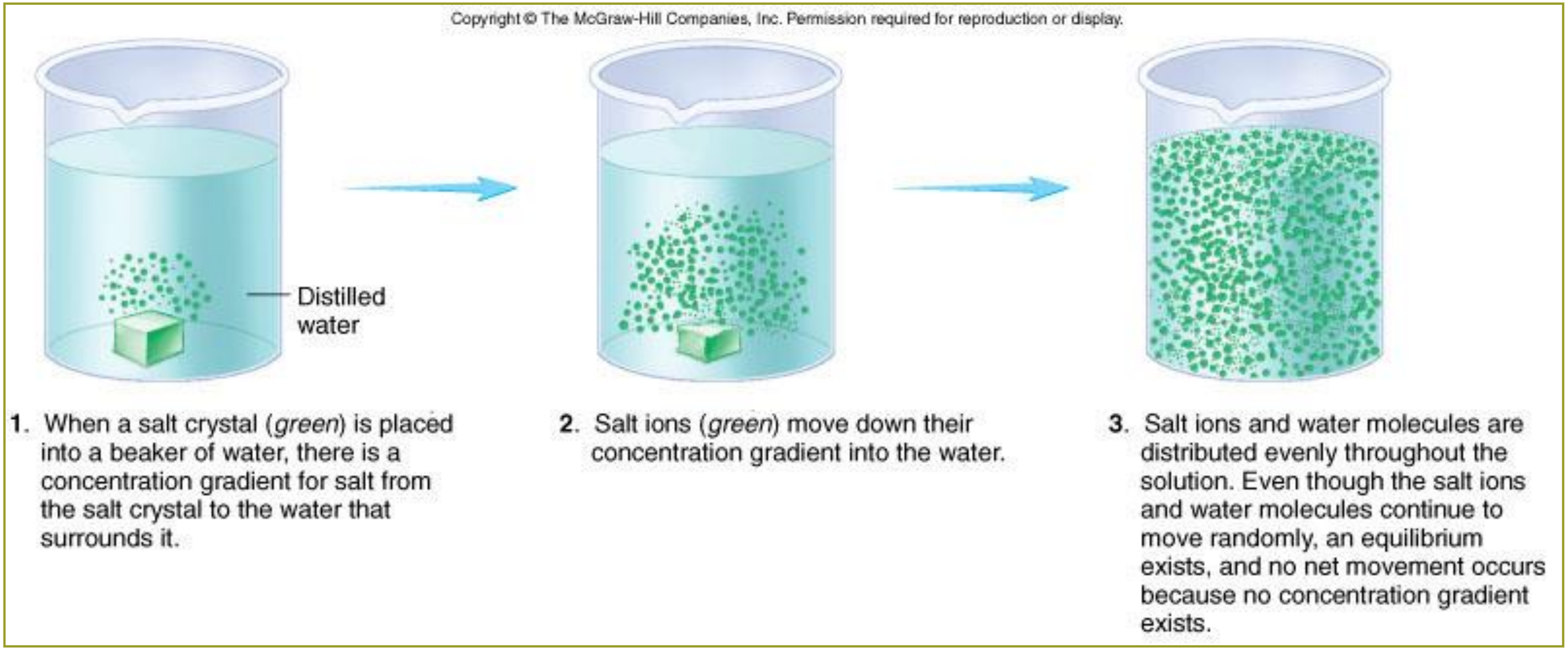
(a) Simple diffusion directly through the phospholipid bilayer

(b) Carrier-mediated facilitated diffusion via protein carrier specific for one chemical; binding of substrate causes shape change in transport protein

(c) Channel-mediated facilitated diffusion through a channel protein; mostly ions selected on basis of size and charge

(d) Osmosis, diffusion through a specific channel protein (aquaporin) or through the lipid bilayer

Diffusion



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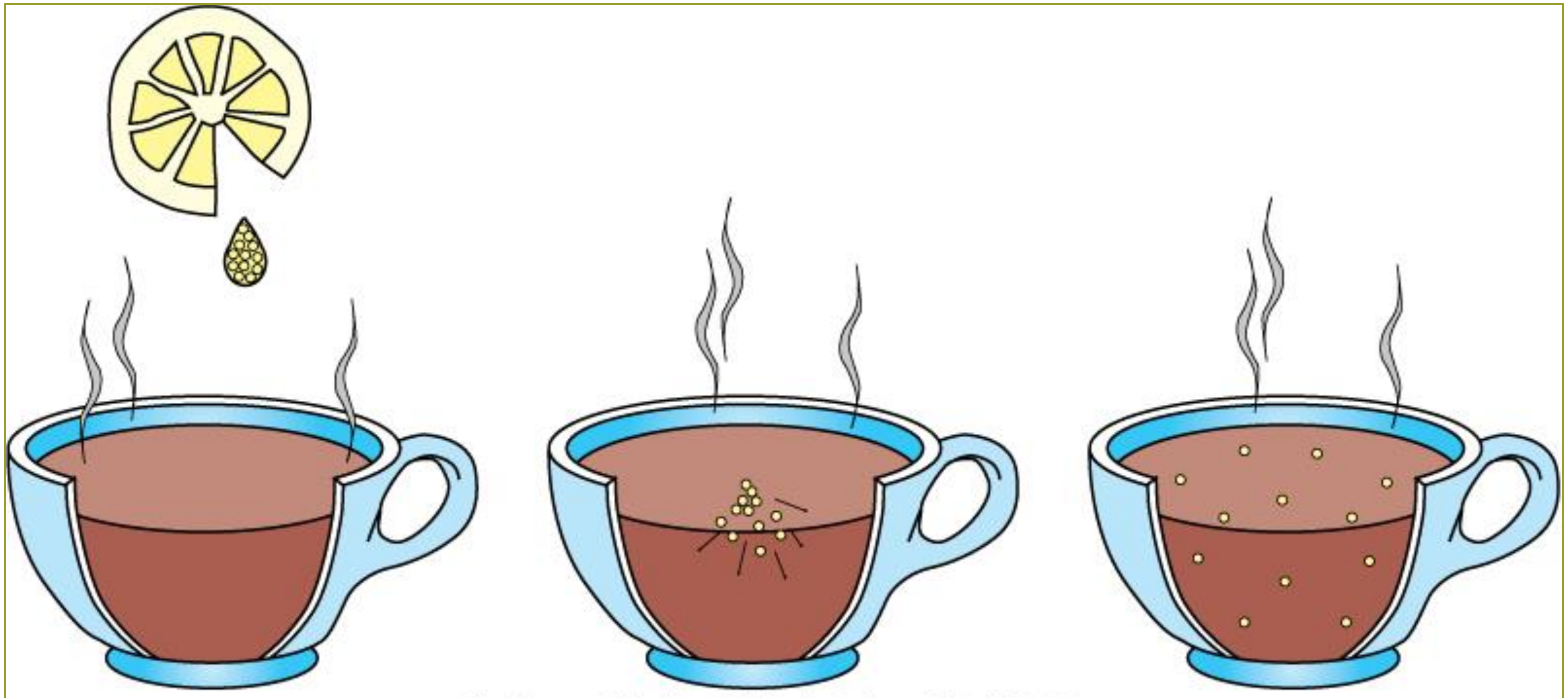
Distilled water
1. When a salt crystal (*green*) is placed into a beaker of water, there is a concentration gradient for salt from the salt crystal to the water that surrounds it.
2. Salt ions (*green*) move down their concentration gradient into the water.
3. Salt ions and water molecules are distributed evenly throughout the solution. Even though the salt ions and water molecules continue to move randomly, an equilibrium exists, and no net movement occurs because no concentration gradient exists.

Diffusion

- Movement of molecules from an area of higher concentration to an area of lower concentration
- Various factors determine whether a molecule may pass through the cell membrane by passive diffusion:

  1. *Molecular size*
  2. *Lipid solubility*
  3. *Molecular charge*

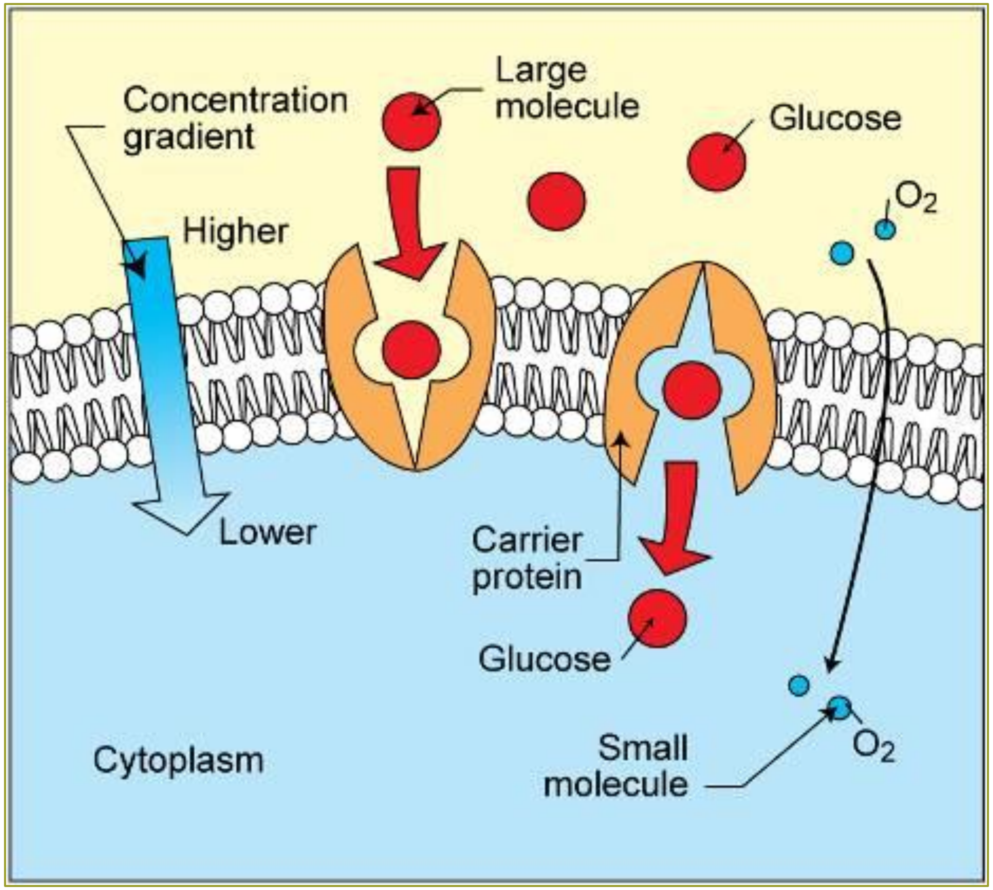
Diffusion
Figure 3-17, Page 66



Facilitated Diffusion

Figure 3-18, Page 66

- Movement of molecules through the cell membrane with the assistance of an integral protein or carrier protein located in the bilayer
- **Requires no energy from the cell**



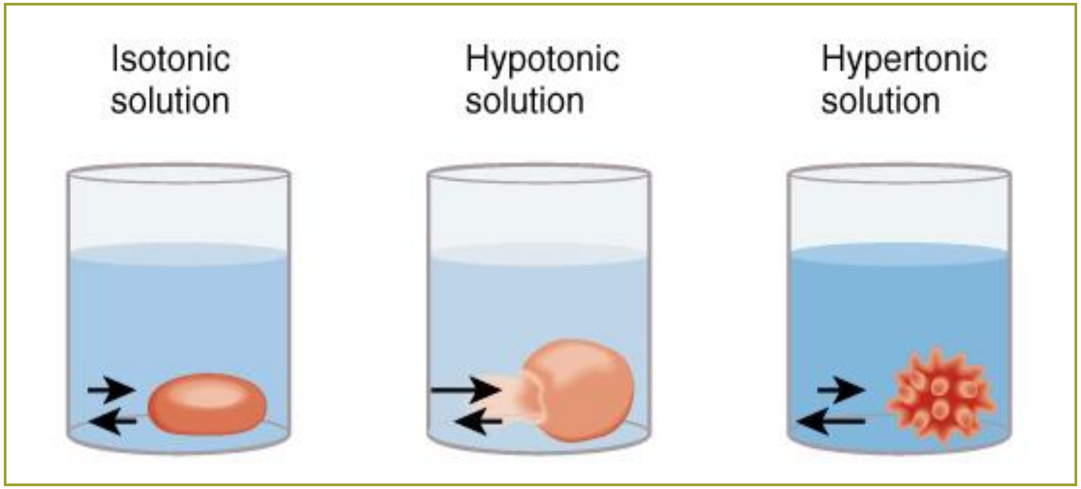
Osmosis

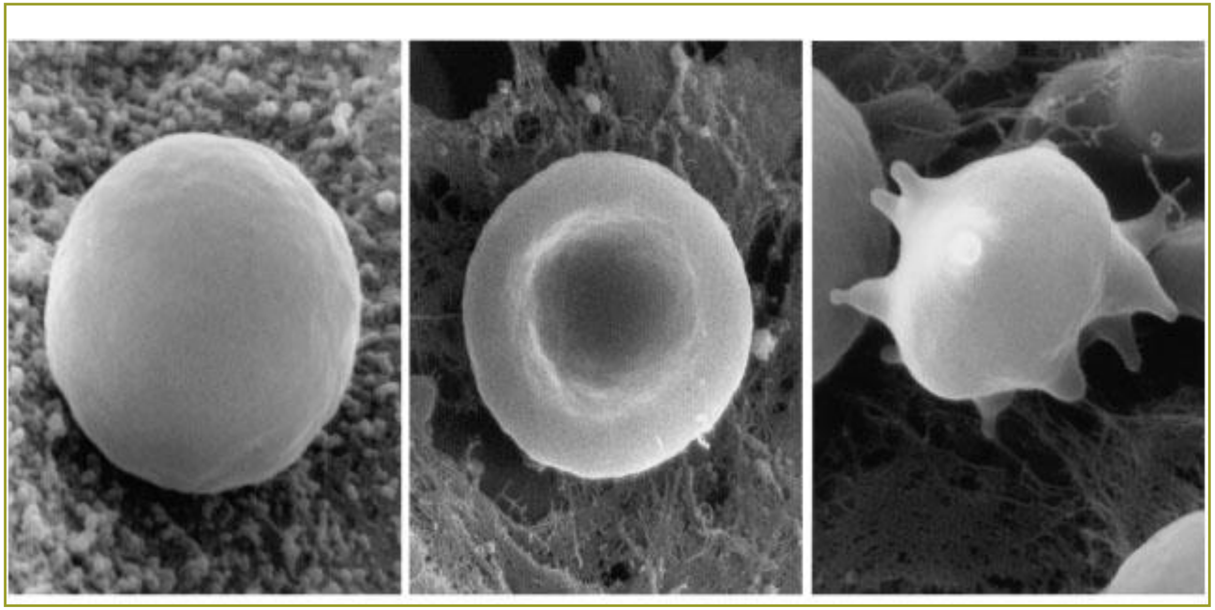
- Passive diffusion of water through a semipermeable membrane into a solution where the water concentration is lower
- The force of water moving from one side of the membrane to the other is called the osmotic pressure

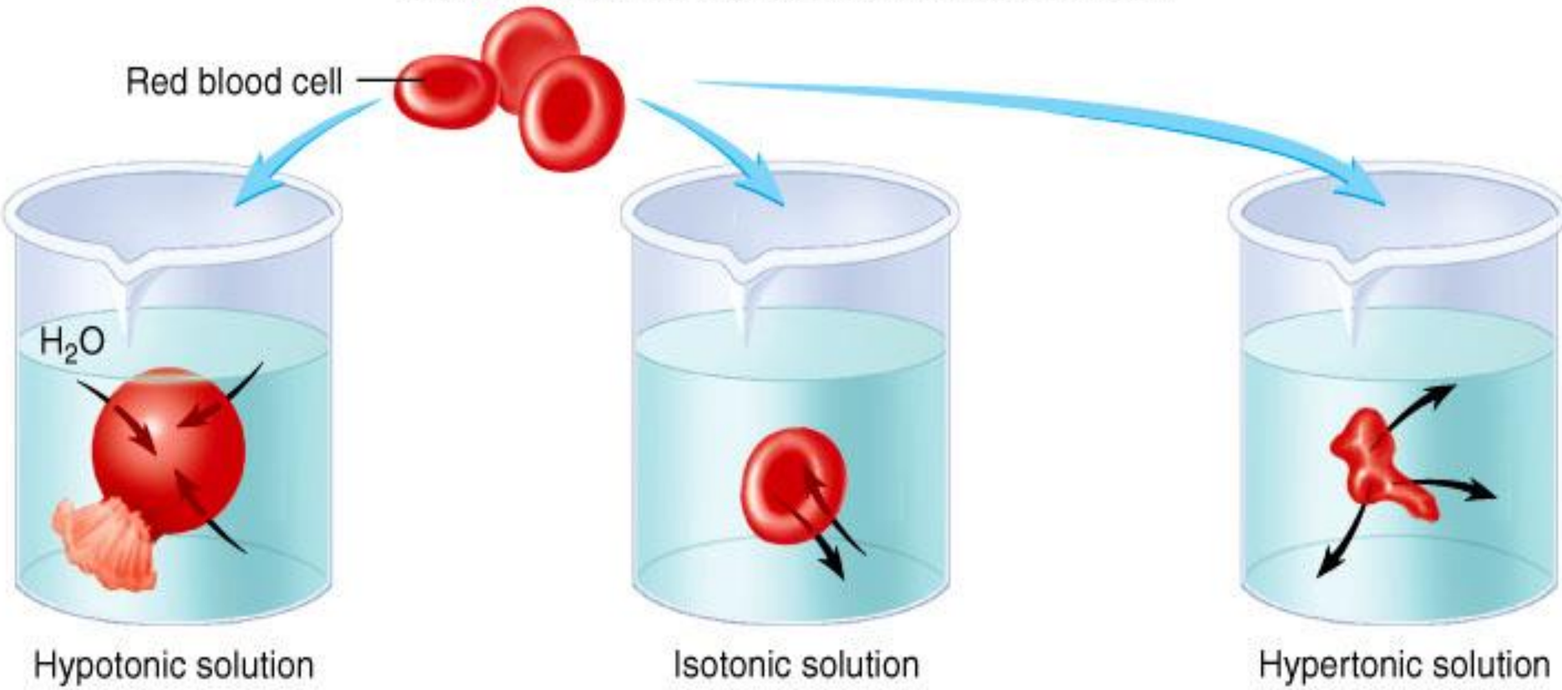
Solutions

Figure 3-20, Page 68

- Definition
- Tonicity
  - Isotonic
  - Hypertonic
  - Hypotonic







(a) A hypotonic solution with a low solute concentration results in swelling of the red blood cell placed into the solution. Water enters the cell by osmosis (*black arrows*), and the red blood cell lyses (*bursts; puff of red in the lower part of the cell*).

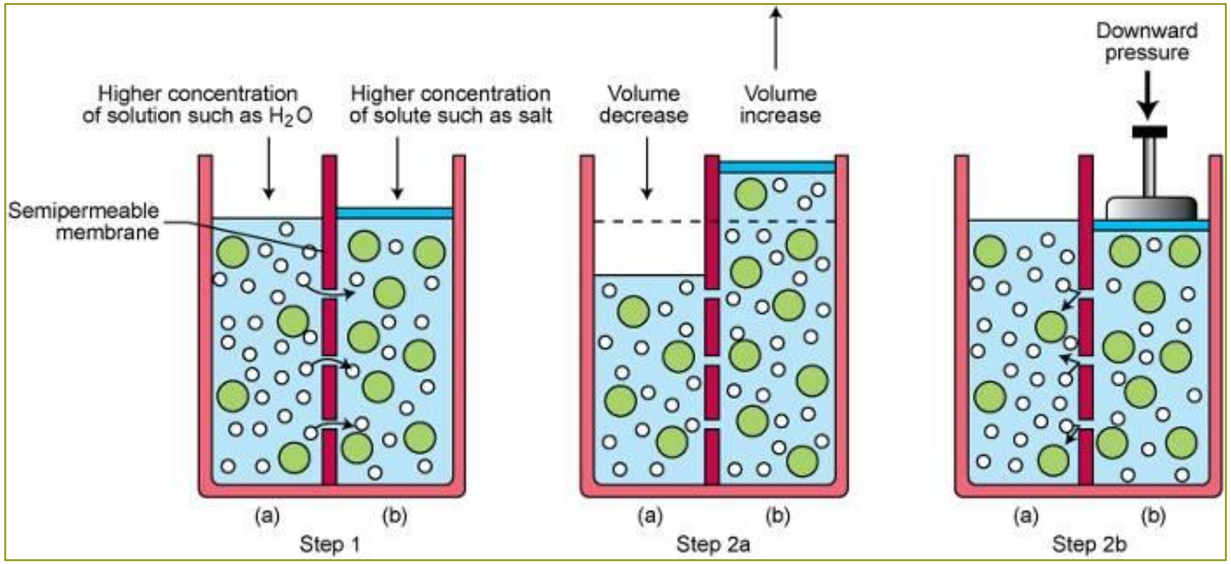
(b) An isotonic solution with a concentration of solutes equal to that inside the cell results in a normally shaped red blood cell. Water moves into and out of the cell at the same rate (*black arrows*), but there is no net water movement.

(c) A hypertonic solution, with a high solute concentration, causes shrinkage (crenation) of the red blood cell as water moves by osmosis out of the cell and into the hypertonic solution (*black arrows*).

Osmosis

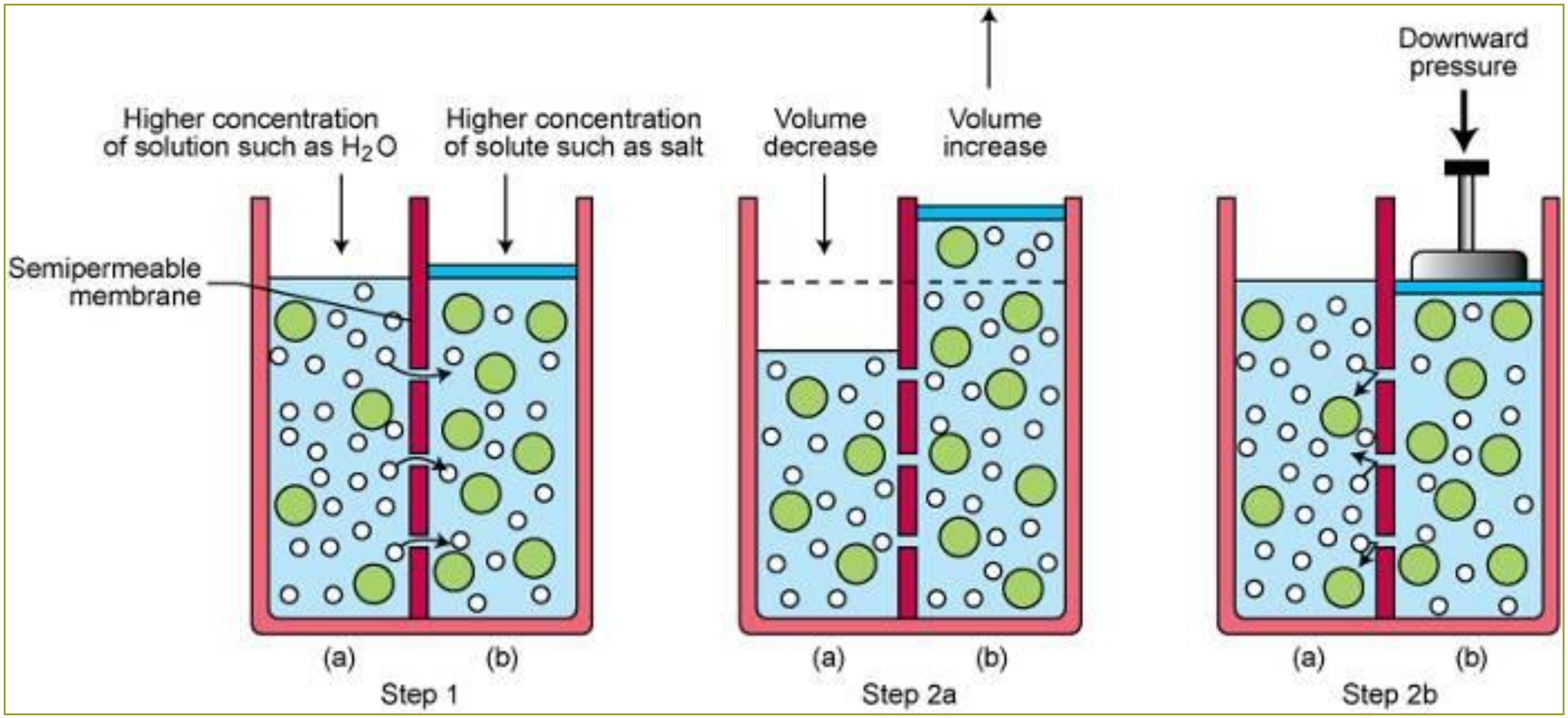
Figure 3-19, Page 67

- Osmosis occurs in the opposite direction of diffusion
  - Unlike diffusion, the **water**, not solute, is moving
  - Osmosis requires a selective membrane, whereas diffusion does not



Osmosis

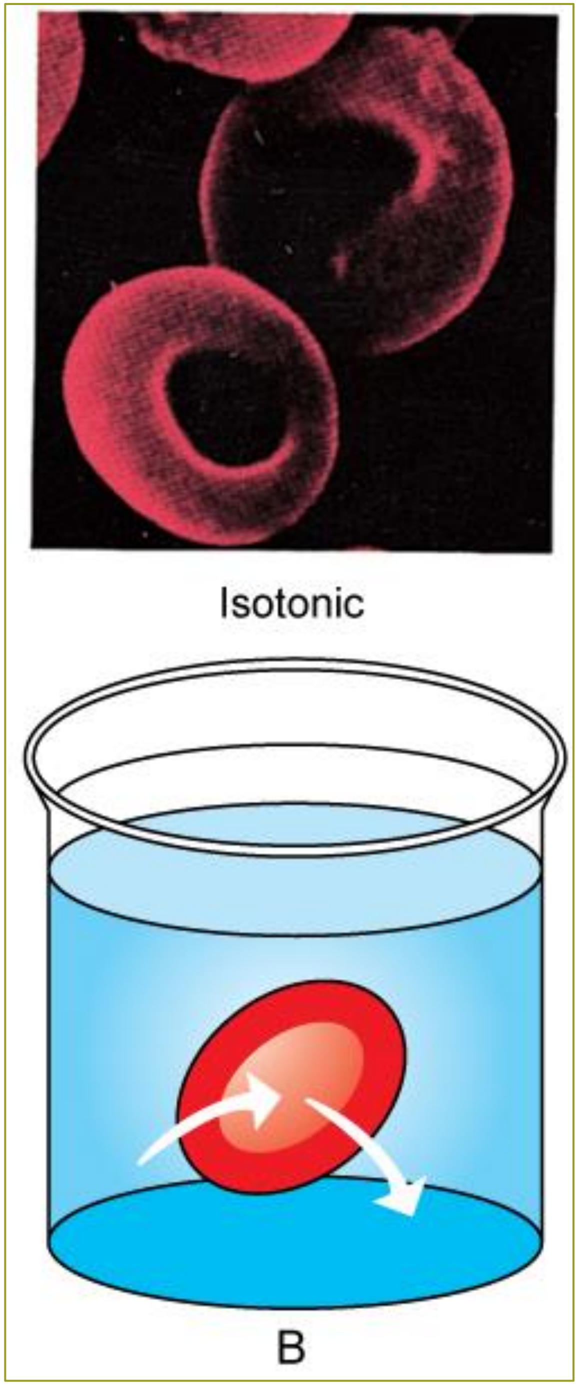
Figure 3-19, Page 67



Tonicity

Figure 3-20B, Page 68

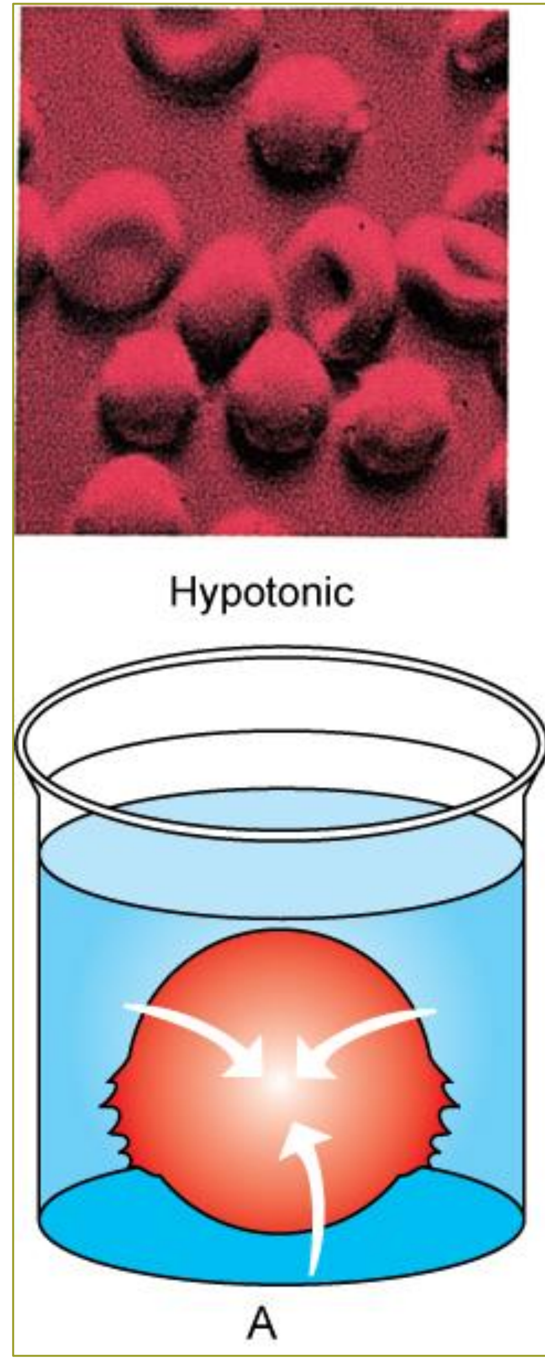
- **Isotonic** : Extracellular fluid has the same concentration of dissolved substances as intracellular fluid



Tonicity

Figure 3-20A, Page 68

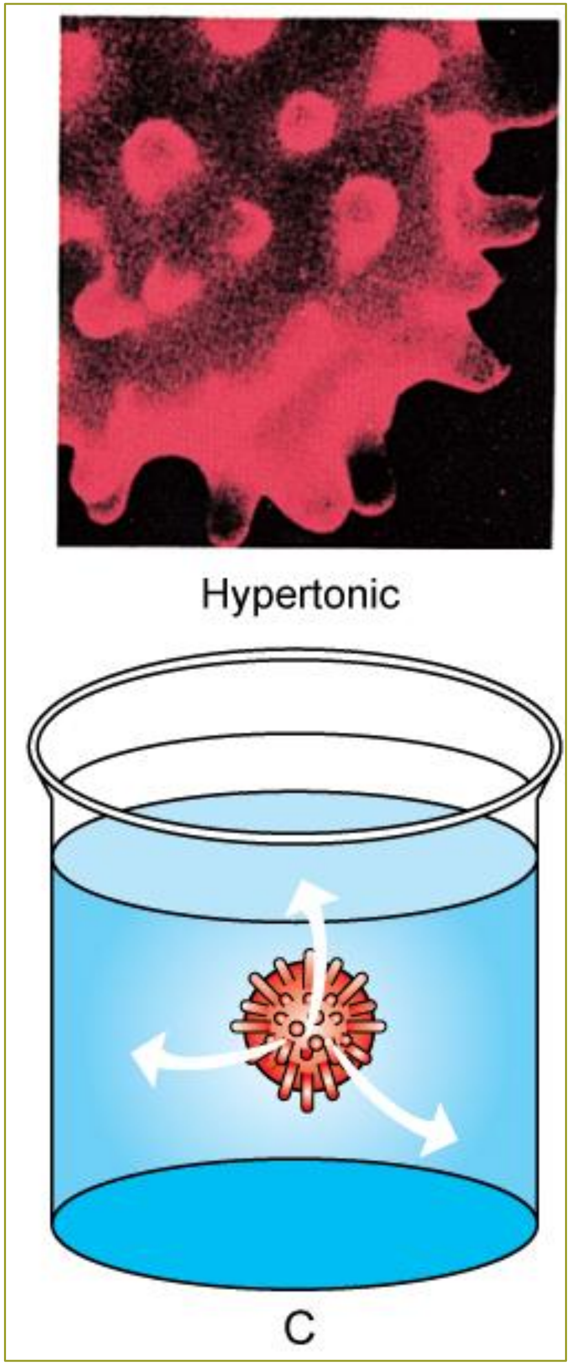
- Hypotonic: The cytoplasm of the cell is more concentrated than the extracellular fluid
  - Water flows into the cell and causes it to swell and possibly **burst**



Tonicity

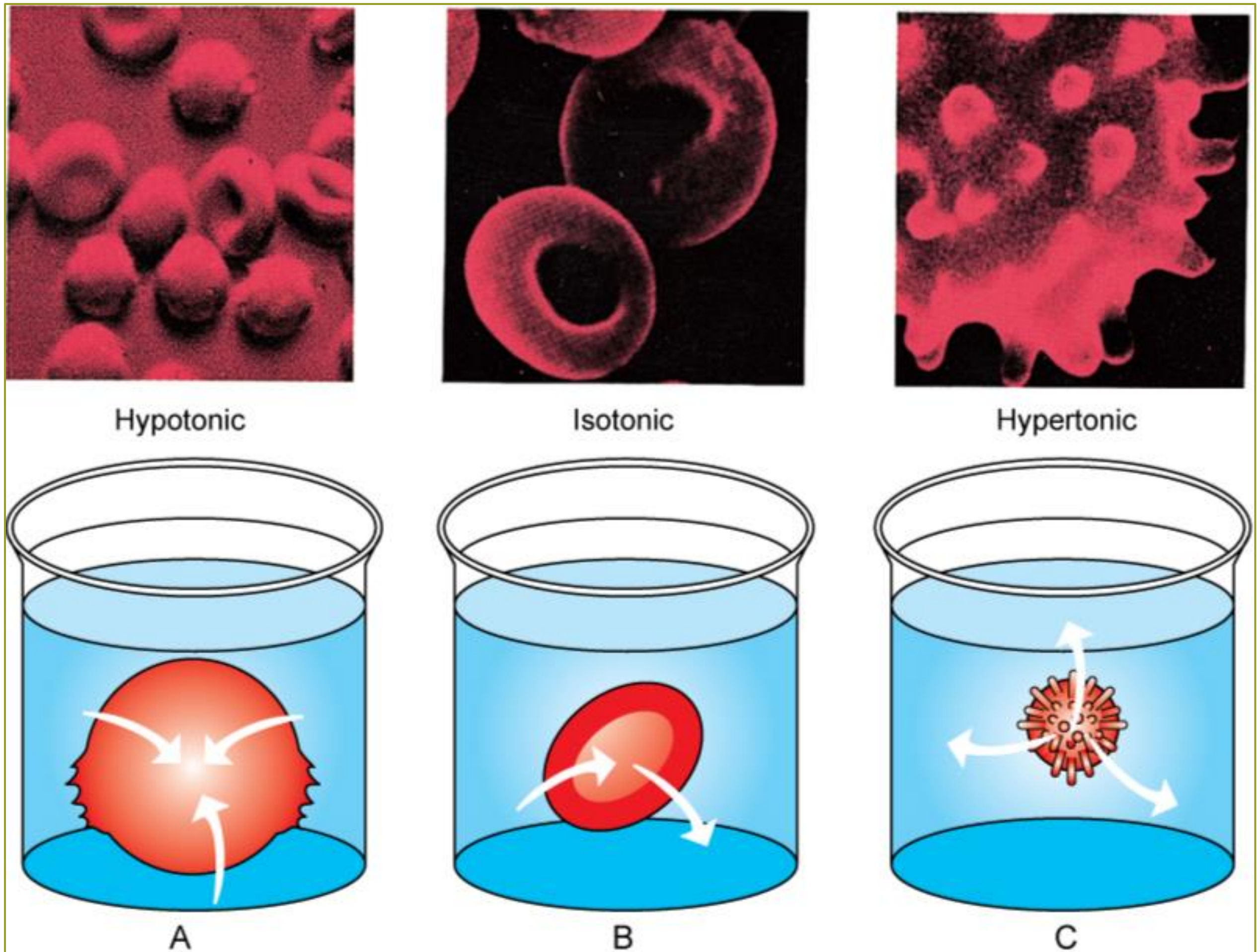
Figure 3-20C, Page 68

- **Hypertonic**: The extracellular fluid is more concentrated than the cytoplasm
  - Water shifts into the extracellular space, causing the cell to shrink and become shriveled



Osmosis (Tonicity) Summary

Figure 3-20, Page 68



(Photomicrographs from Thibodeau GA, Patton KT: *Anatomy & physiology*, ed 5, St Louis, 2003, Mosby.)

Filtration

- Based on pressure, not concentration
- Example – **blood pressure causes filtration through kidneys**

Active Processes

- **ATP needed**
- Active transport
  - Sodium-potassium pump (neurons)
- Endocytosis
  - Phagocytosis
- Exocytosis

Types of Active Transport

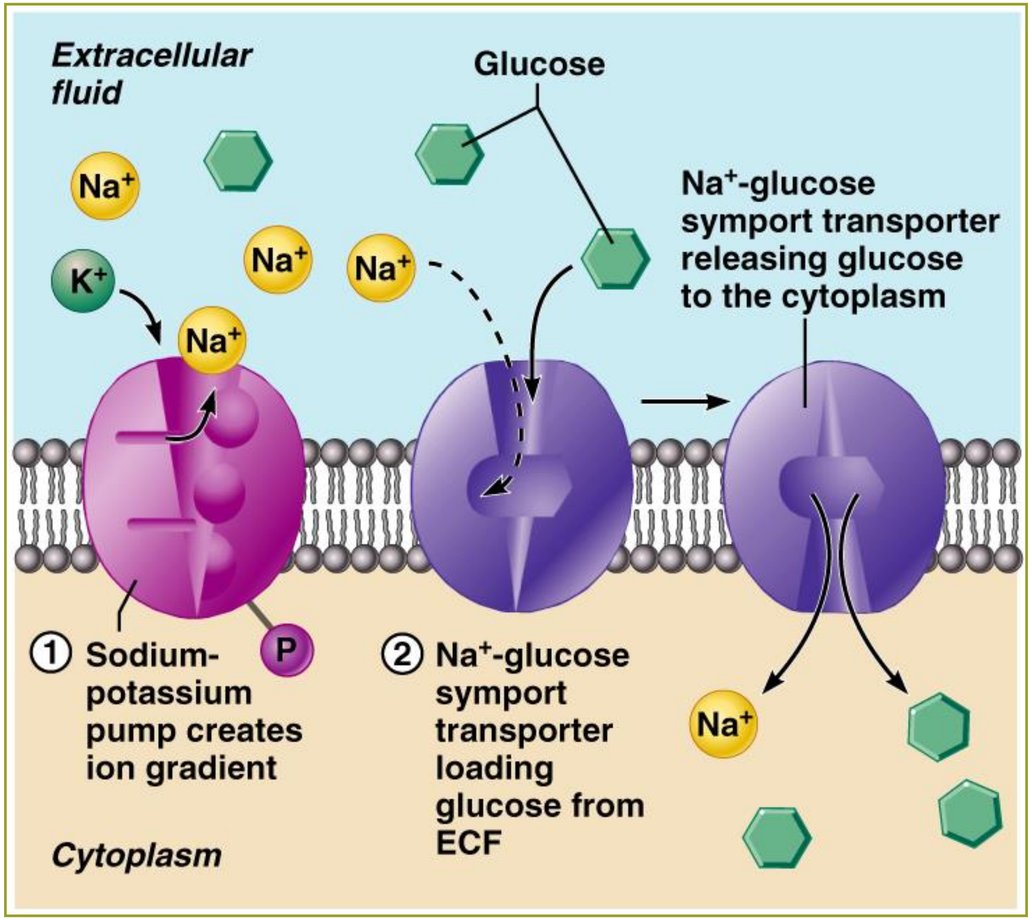
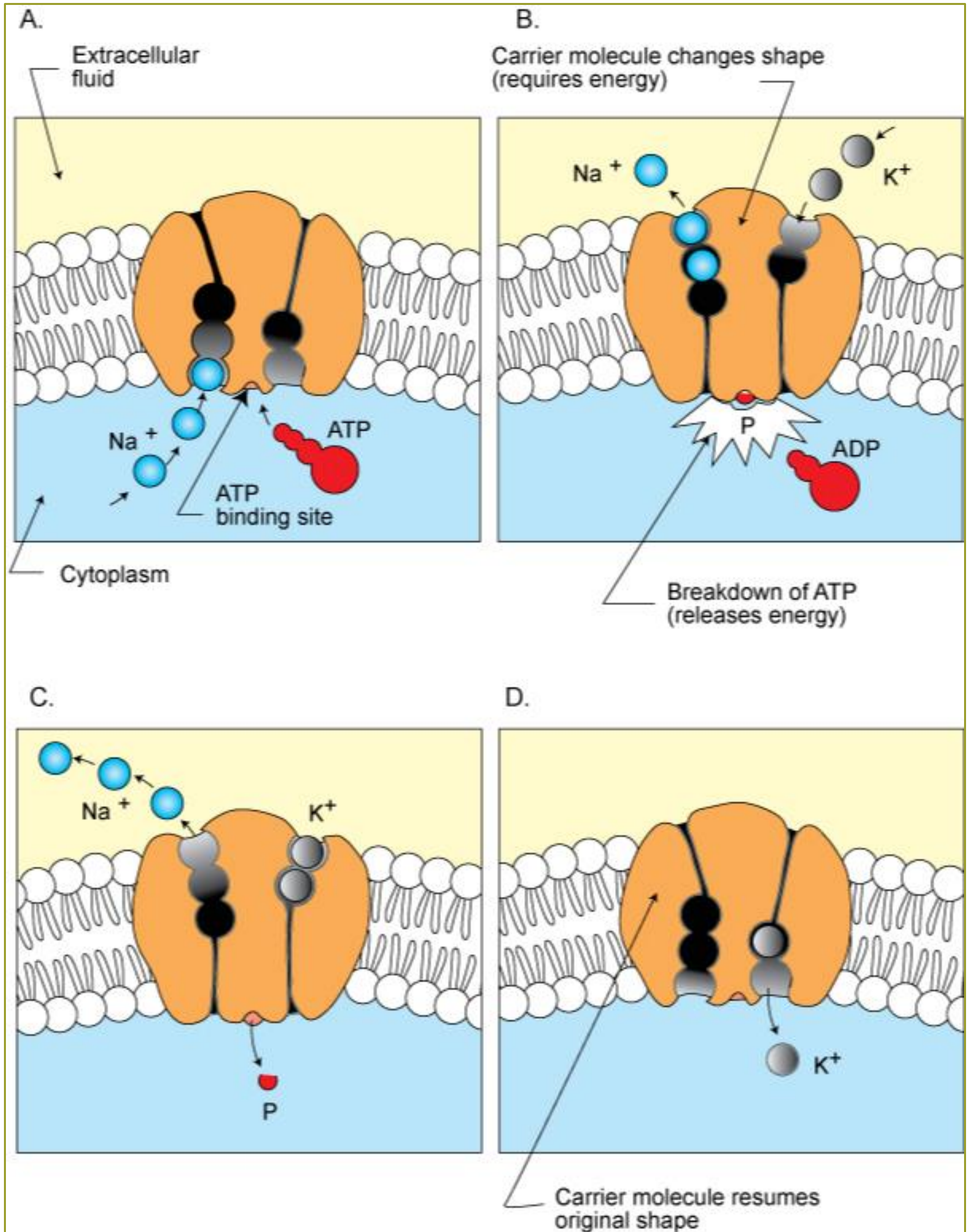


Figure 3.11

Active Transport – Sodium/Potassium Pump

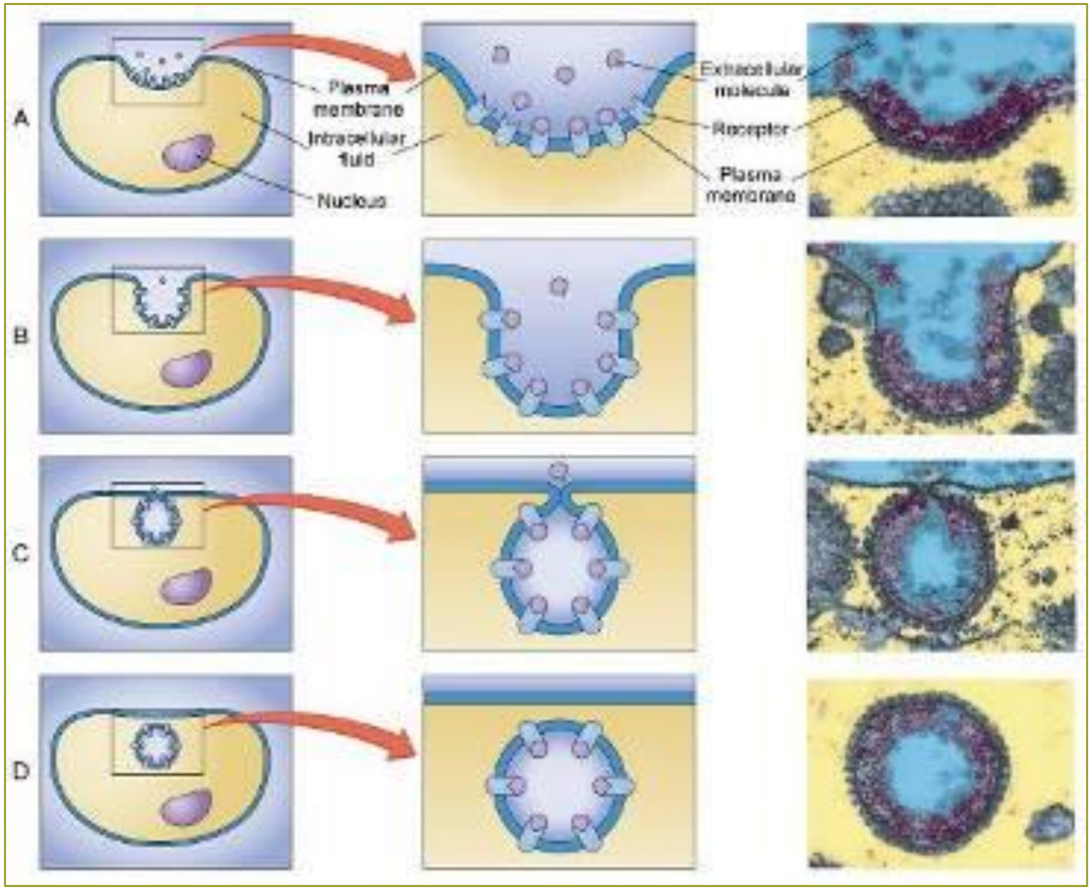
Figure 3-21, Page 71



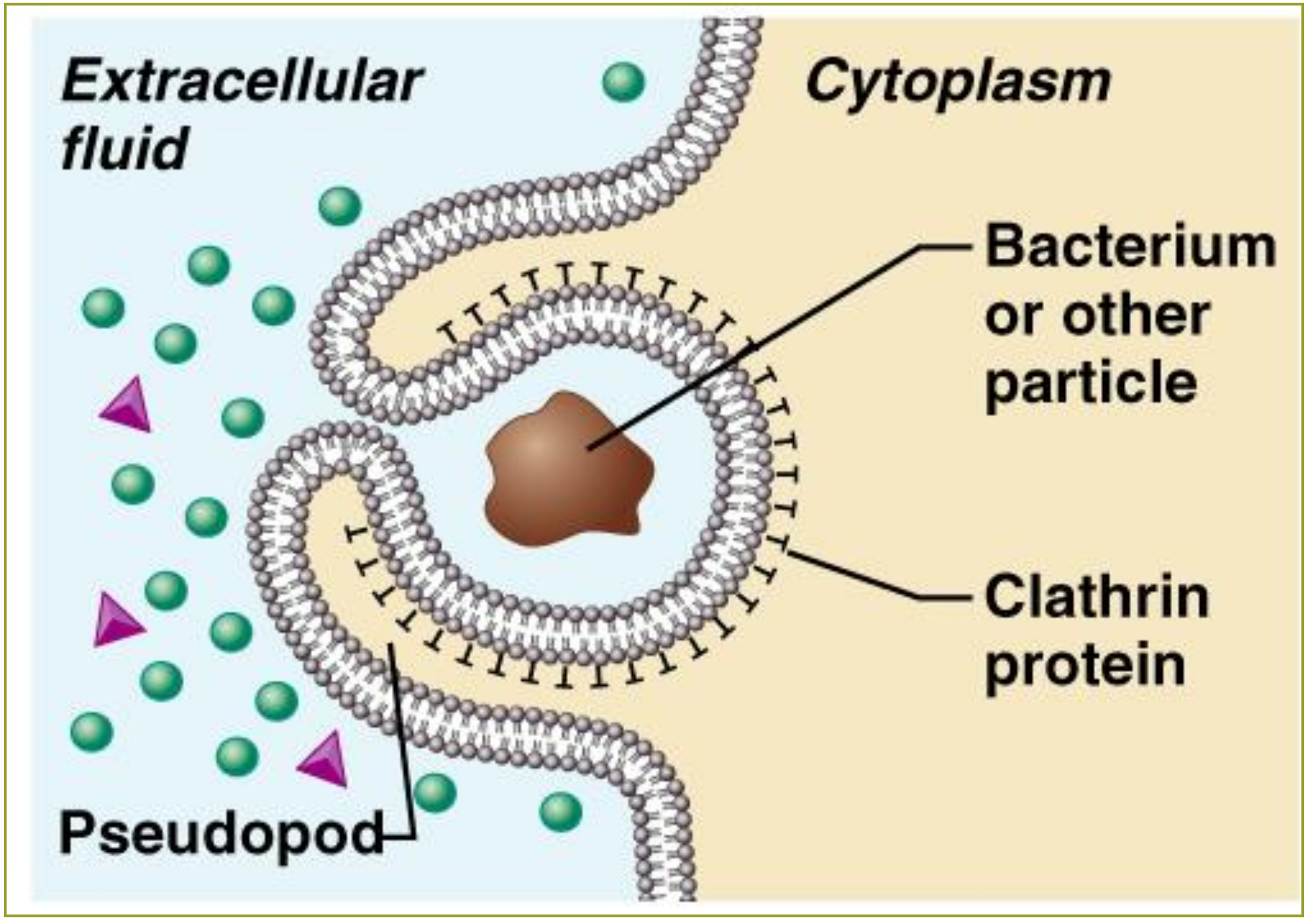
Endocytosis – "Receptors"

Figure 3-22, Page 72

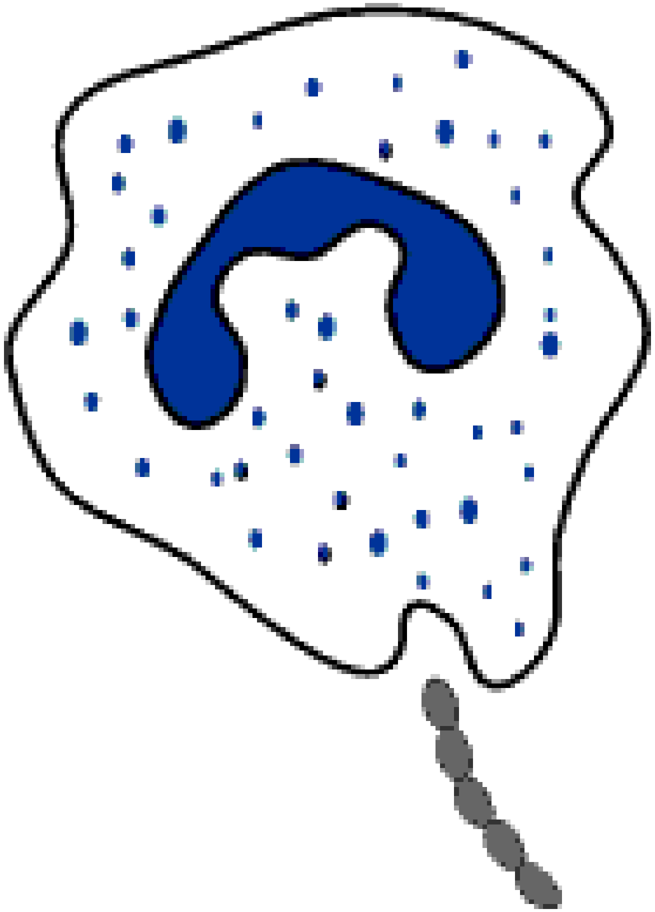
- Transports large particles or liquids into the cell by engulfing them
  - Solid material: *phagocytosis*
  - Liquid: *pinocytosis*



Phagocytosis (WBC's)



Neutrophil Engulfing Bacteria



Exocytosis

- Excretion
  - Waste products
- Secretion
  - Cell manufactures molecules, such as sebum, hormones, etc.

Exocytosis

- Neurotransmitter into synapse
- Secretion of hormones into blood

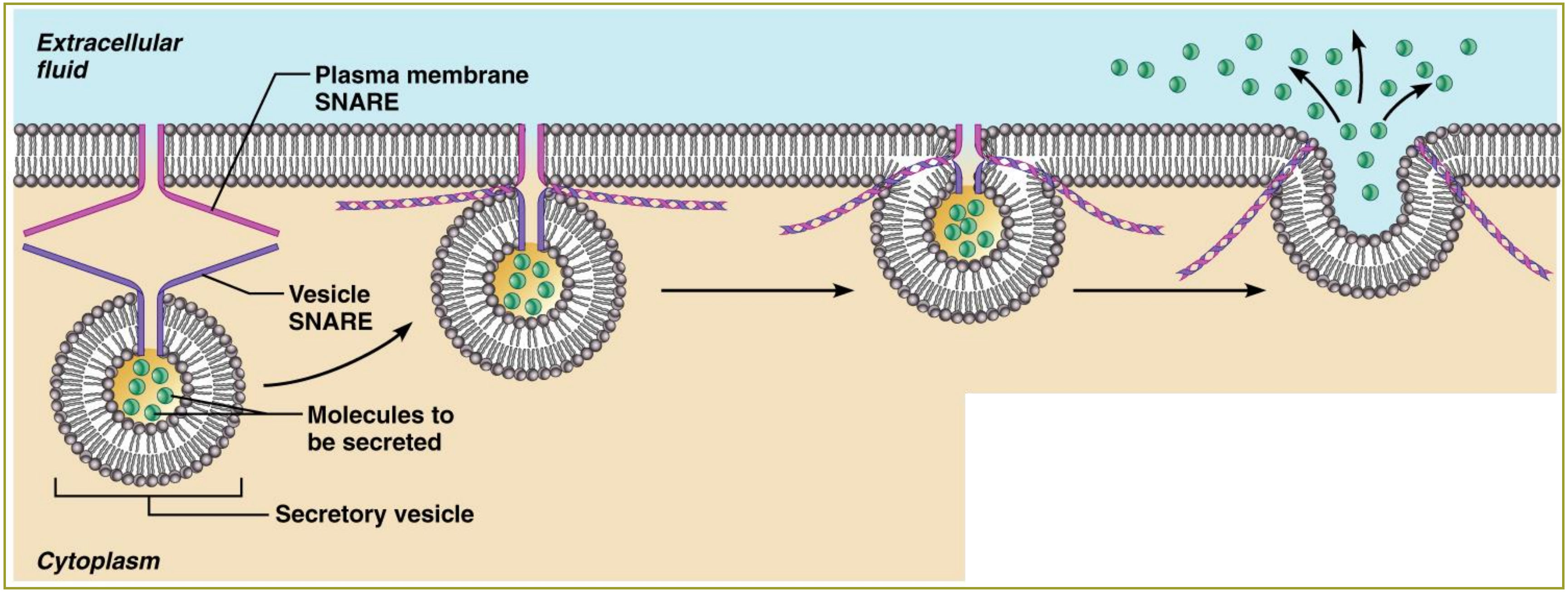
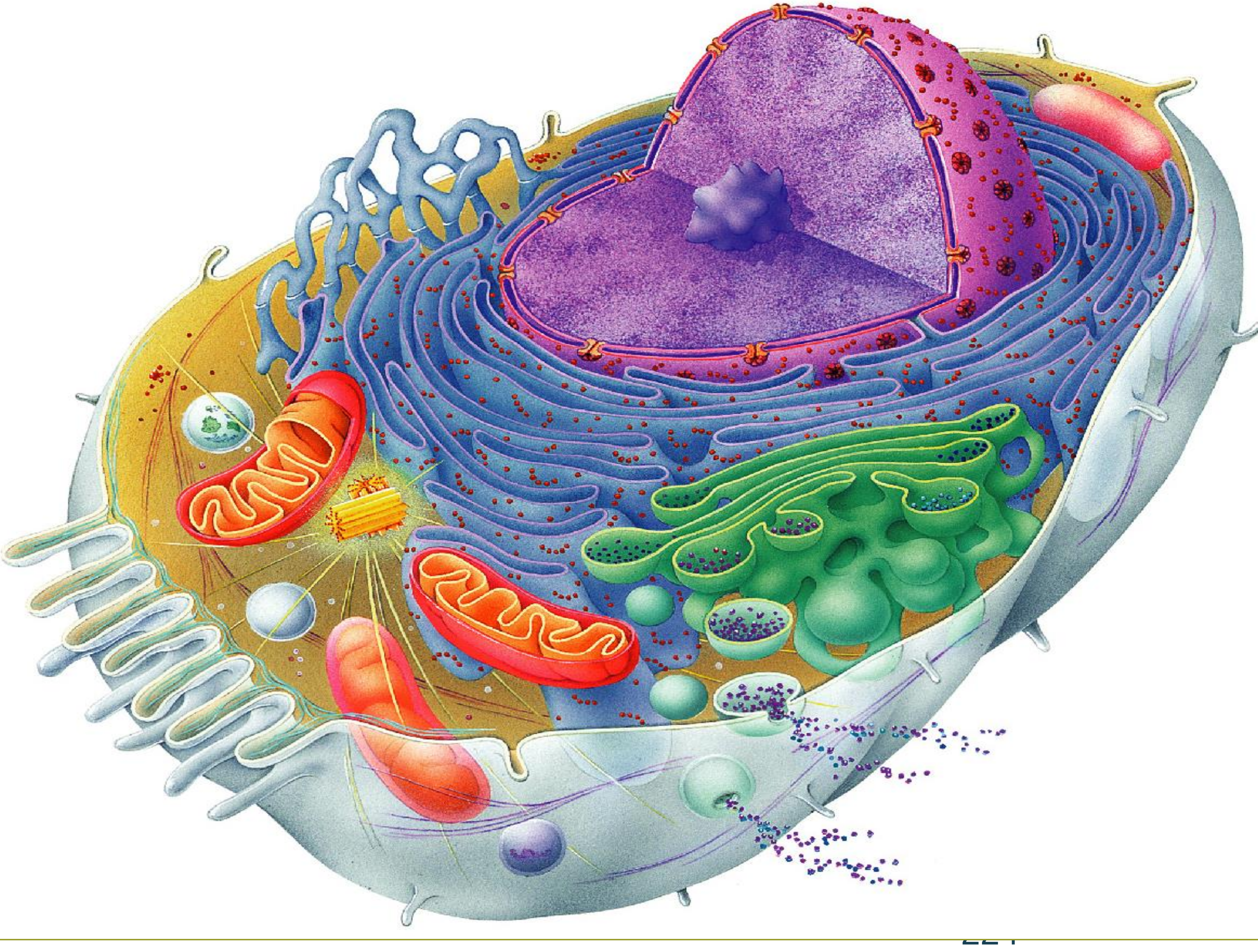


Figure 3.12a



Cell Membrane Transportation

Process	**Energy Source**	**Example**
Simple diffusion	No ATP needed	Movement of O_2 through membrane
Facilitated diffusion	No ATP needed	Movement of glucose into cells
Osmosis	No ATP needed	Movement of H_2O in & out of cells
Filtration	Hydrostatic pressure	Formation of kidney filtrate
Active Transport	ATP	Movement of ions across membranes
Endocytosis	ATP	WBC phagocytosis
Exocytosis	ATP	Neurotransmitter release

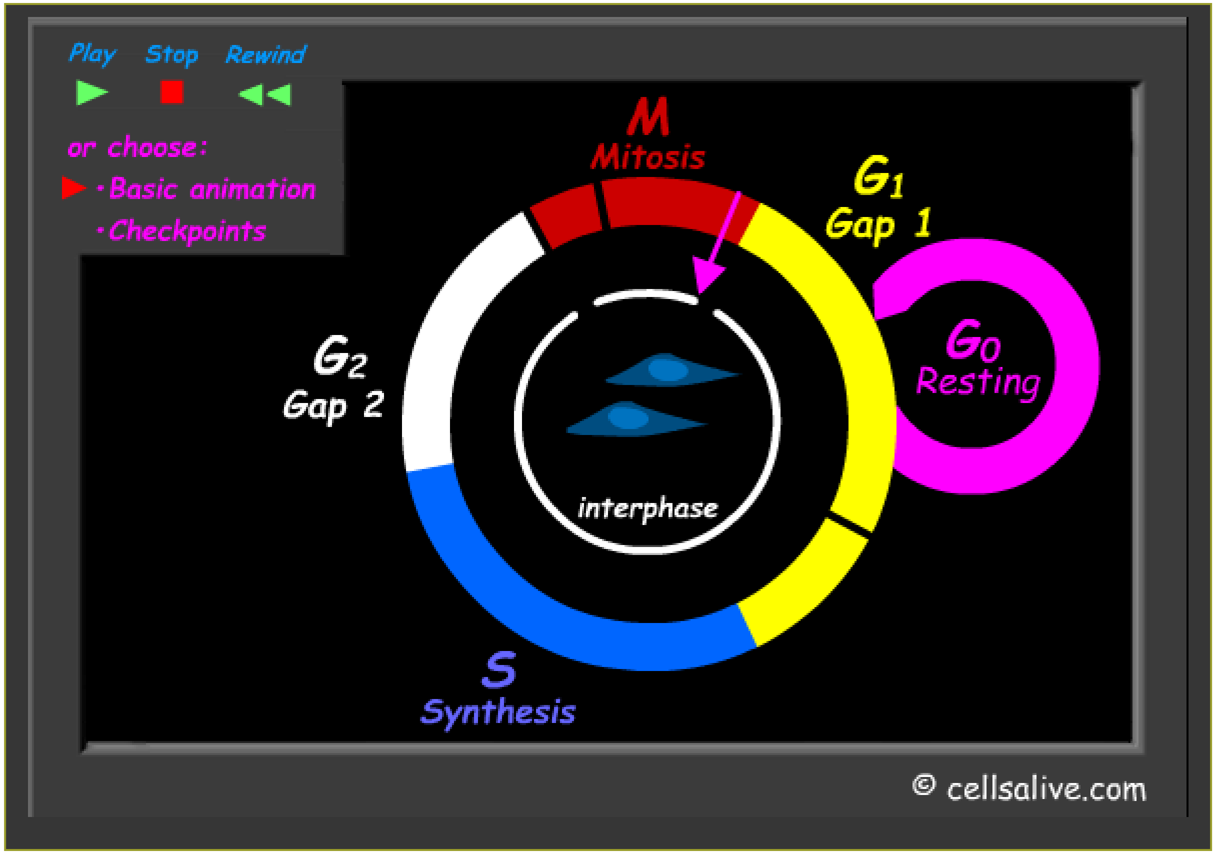
Table 3.2 Types and Characteristics of Movement Across Membranes

Type	Transport	Requires ATP	Examples
Diffusion	With the concentration gradient through the lipid portion of the cell membrane or through membrane channels	No	Oxygen, carbon dioxide, chloride ions, and urea
Osmosis	With the concentration gradient (for water) through the lipid portion of the cell membrane or through membrane channels	No	Water
Filtration	Movement of liquid and substances by pressure through a partition containing holes	No	In the kidneys, filtration of everything in blood smaller than proteins and blood cells
Facilitated diffusion	With the concentration gradient by carrier molecules	No	Glucose in most cells
Active transport	Against the concentration gradient* by carrier molecules	Yes	Na^+, K^+, Ca^{2+}, and H^+; amino acids
Secondary active transport	Against the concentration gradient by carrier molecules; the energy for secondary active transport of one substance comes from the concentration gradient of another	Yes	Glucose, amino acids
Endocytosis	Movement into cells by vesicles	Yes	Ingestion of particles by phagocytosis or receptor-mediated endocytosis and liquids by pinocytosis
Exocytosis	Movement out of cells by vesicles	Yes	Secretion of proteins

*Active transport normally moves substances against their concentration gradient, but it can also move substances with their concentration gradient.

Topic 17

Describe the processes of cell division



Mammalian Cell Division

Mitosis

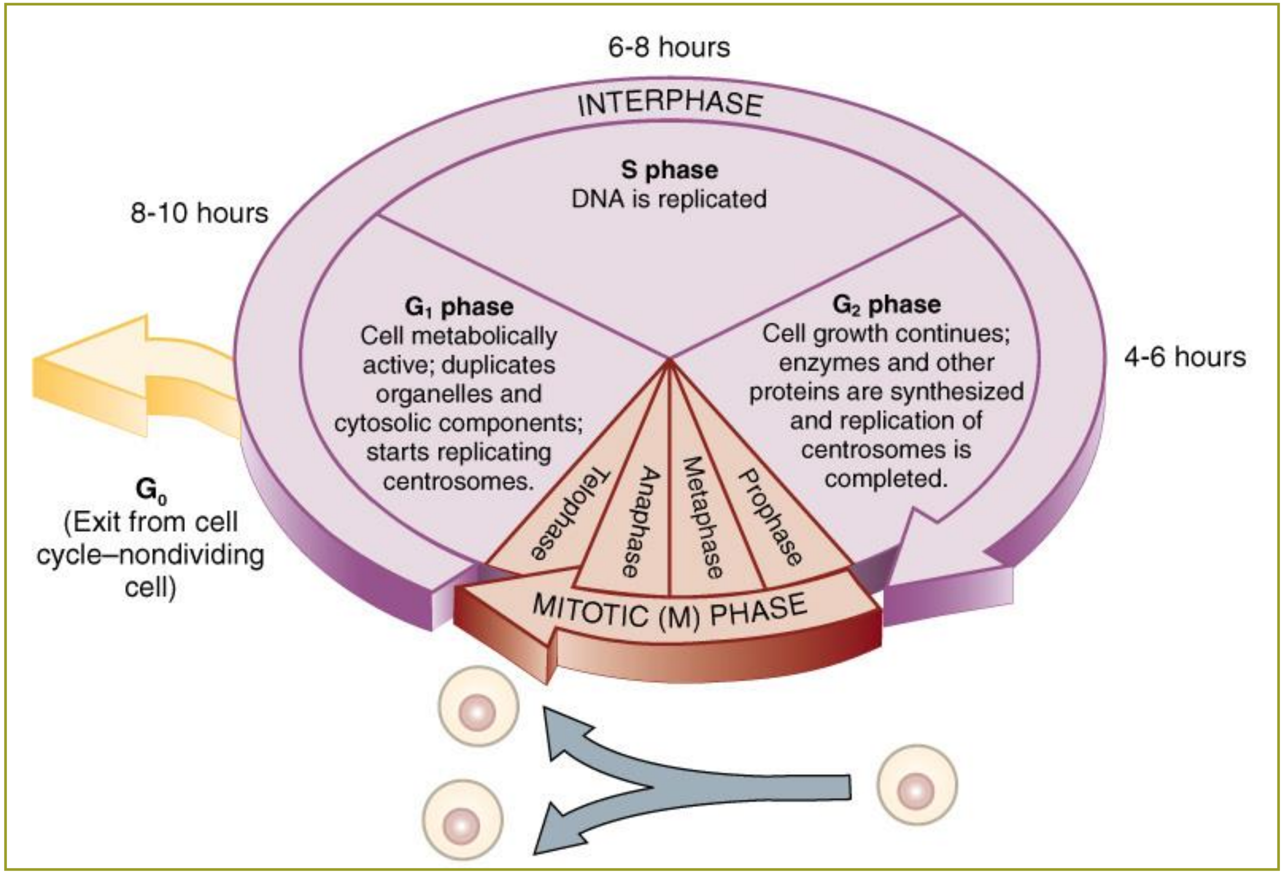
Meiosis

Mitosis (Cell Cycle)

- The life cycle of the cell has been divided into two major periods:
  - **Interphase**: The cell is growing, maturing, and differentiating
  - **Mitotic phase**: The cell is actively dividing

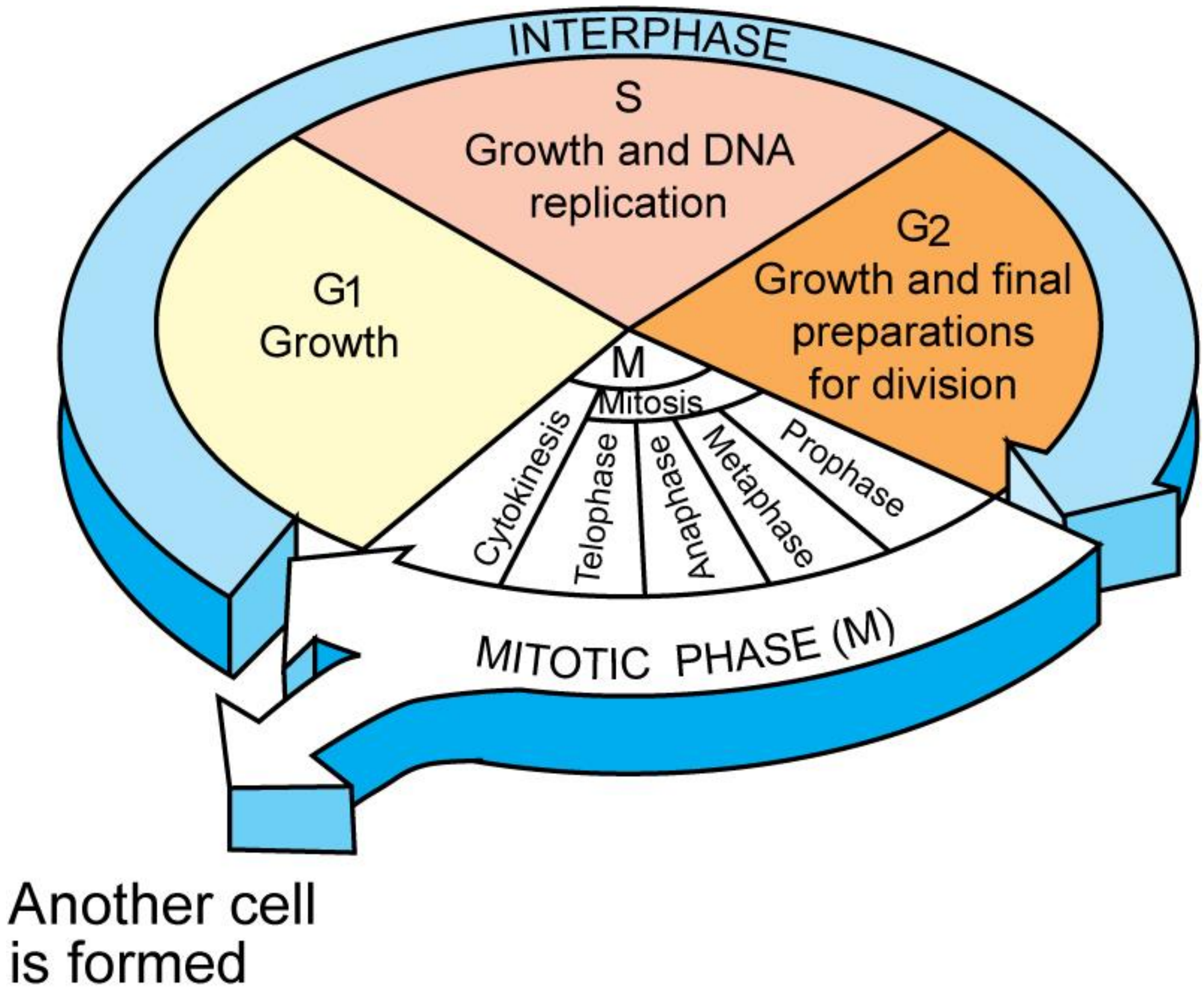
The Cell Cycle

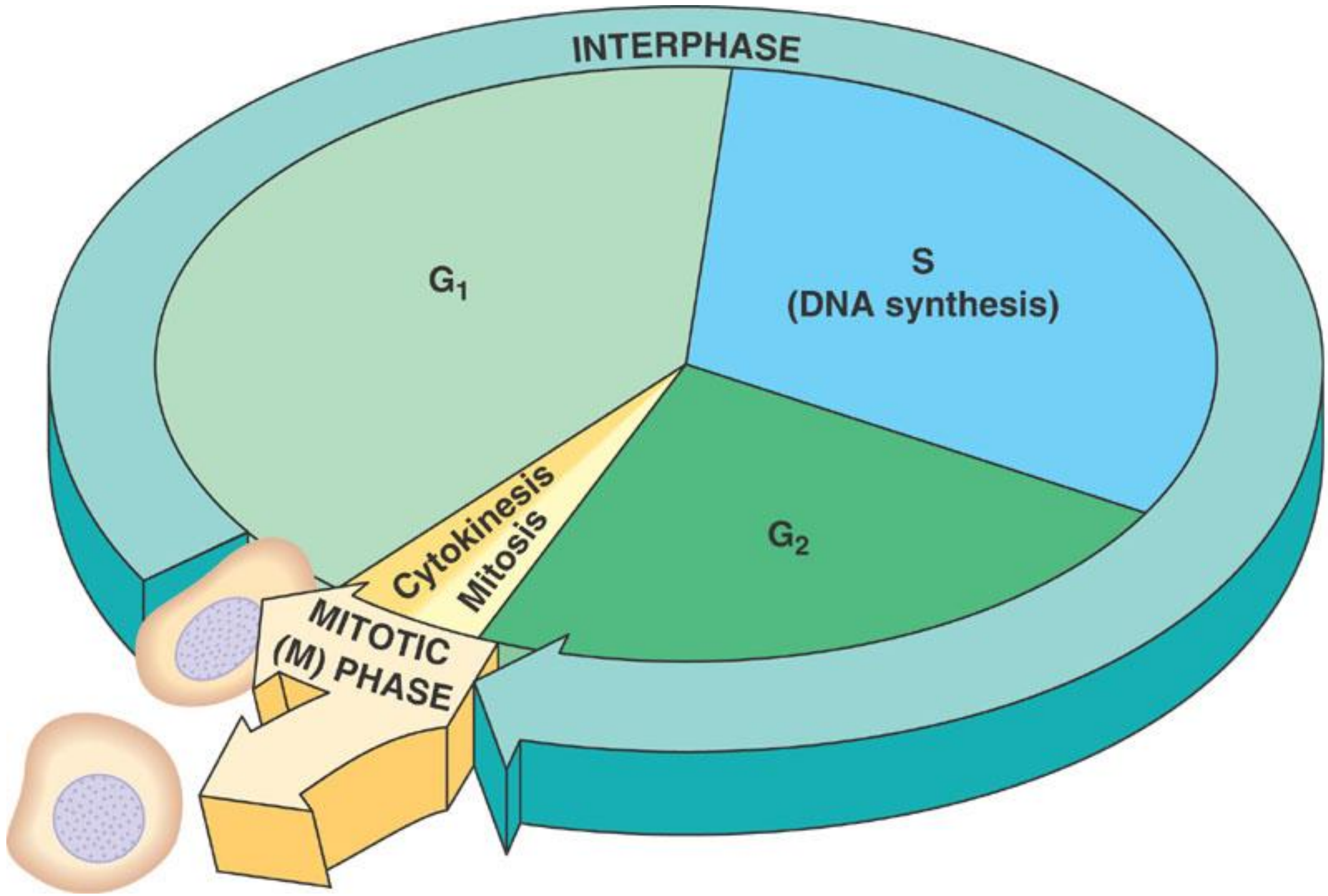
- Interphase
- Prophase
- Metaphase
- Anaphase
- Telophase



Cell Cycle

Figure 3-24, Page 74





INTERPHASE
G_1
S
(DNA synthesis)
G_2
Cytokinesis
Mitosis
MITOTIC
(M) PHASE

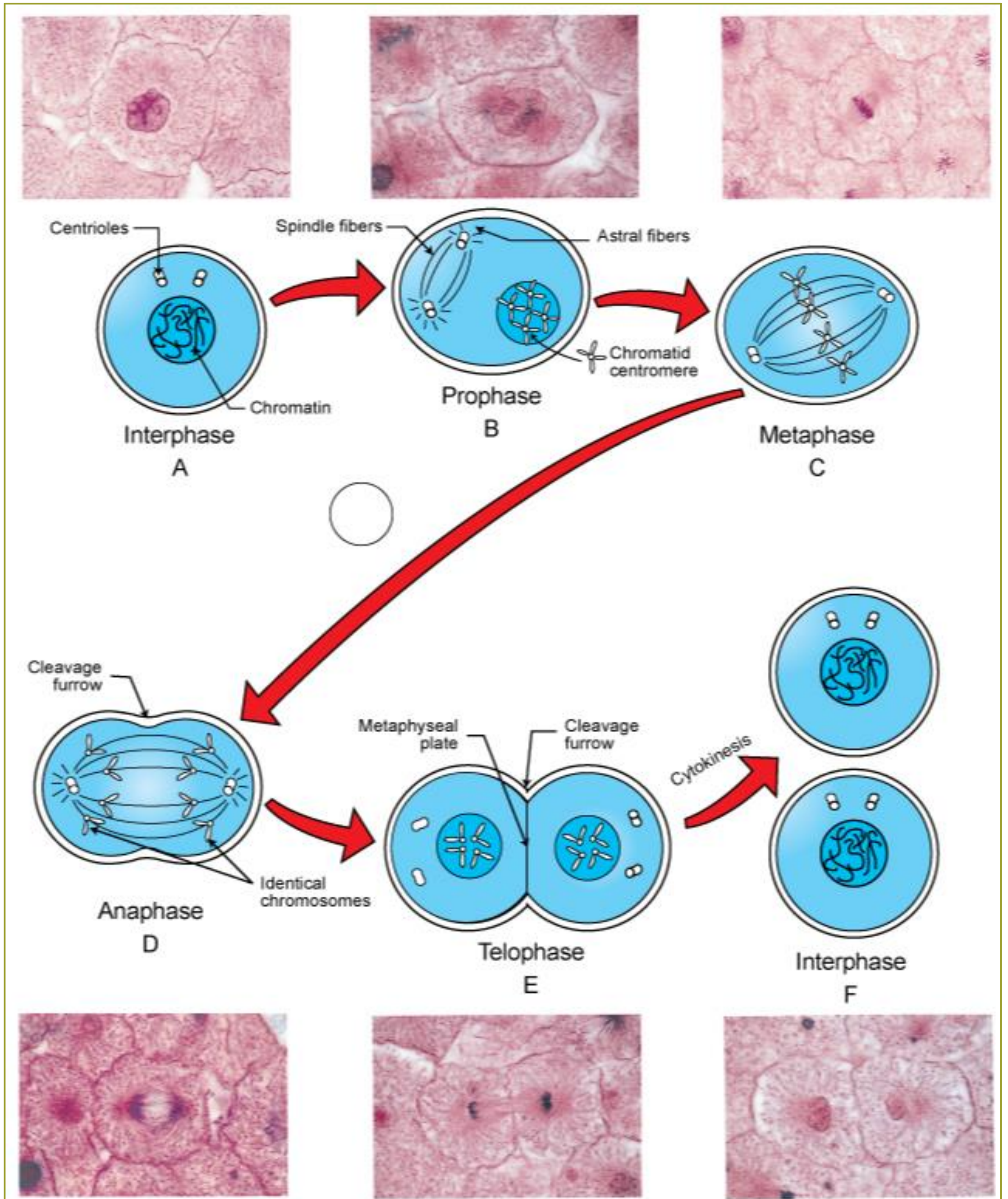
Mitosis

Figure 3-26, Page 77

- Prophase
- Metaphase
- Anaphase
- Telophase

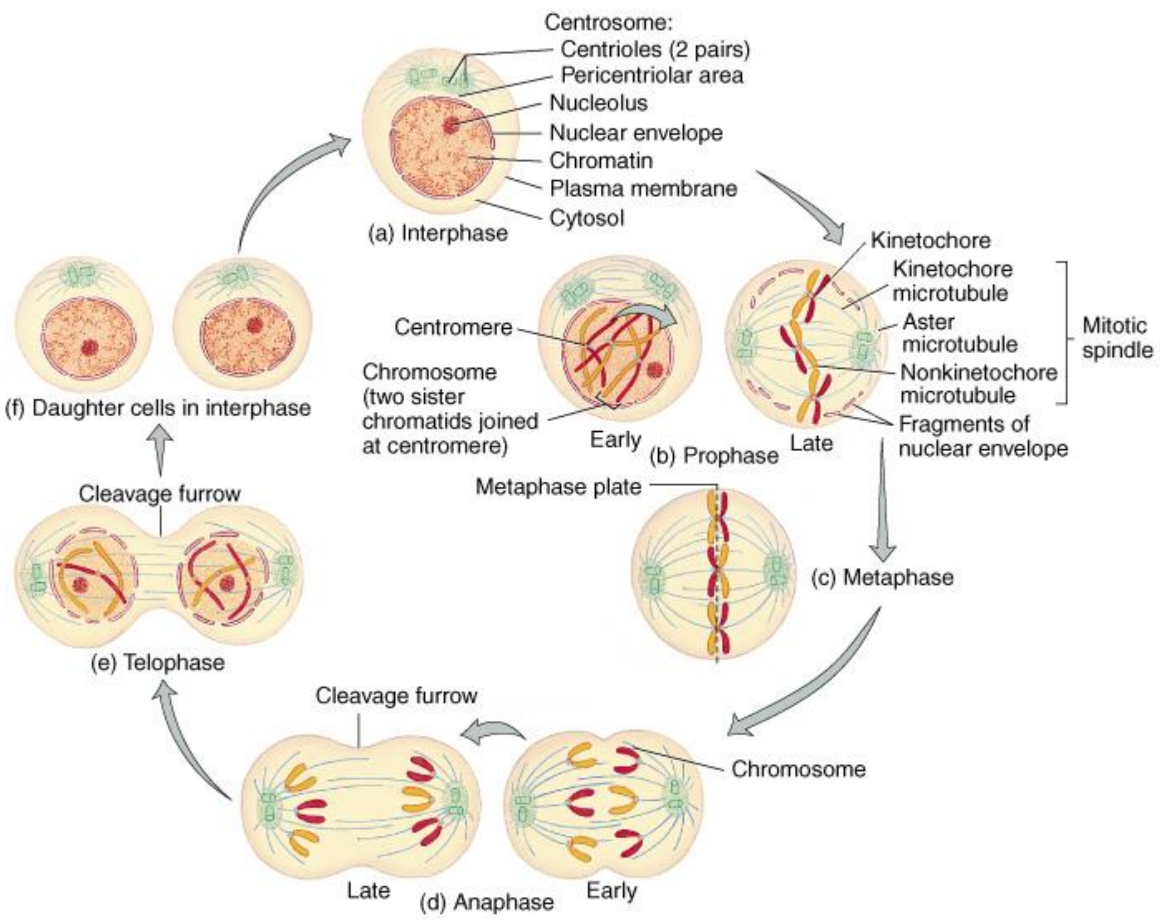
Mitosis

Figure 3-26, Page 77

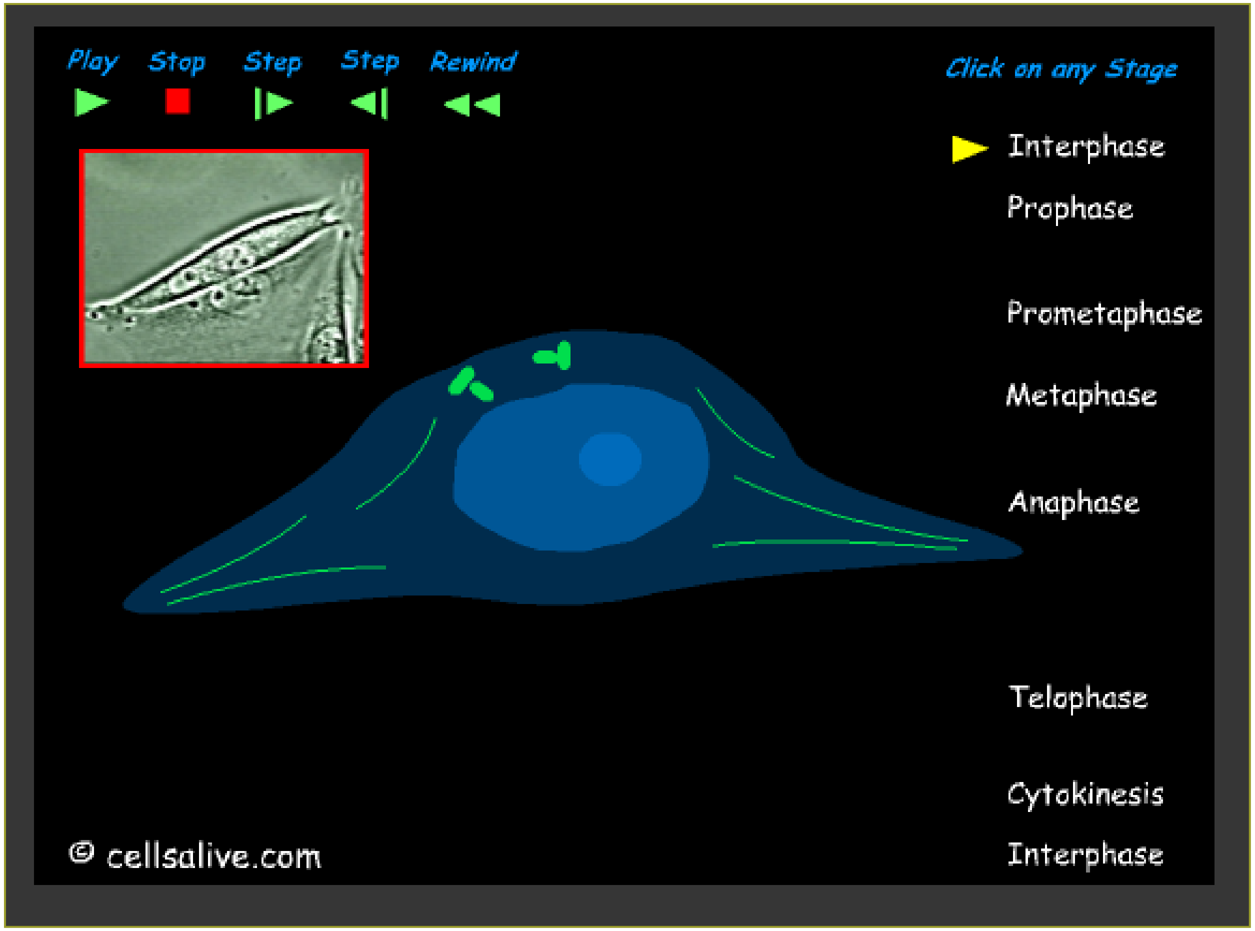


(Photomicrographs from Thibodeau GA, Patton KT: *Anatomy & physiology*, ed 5, St Louis, 2003, Mosby.)

Mitosis Summary



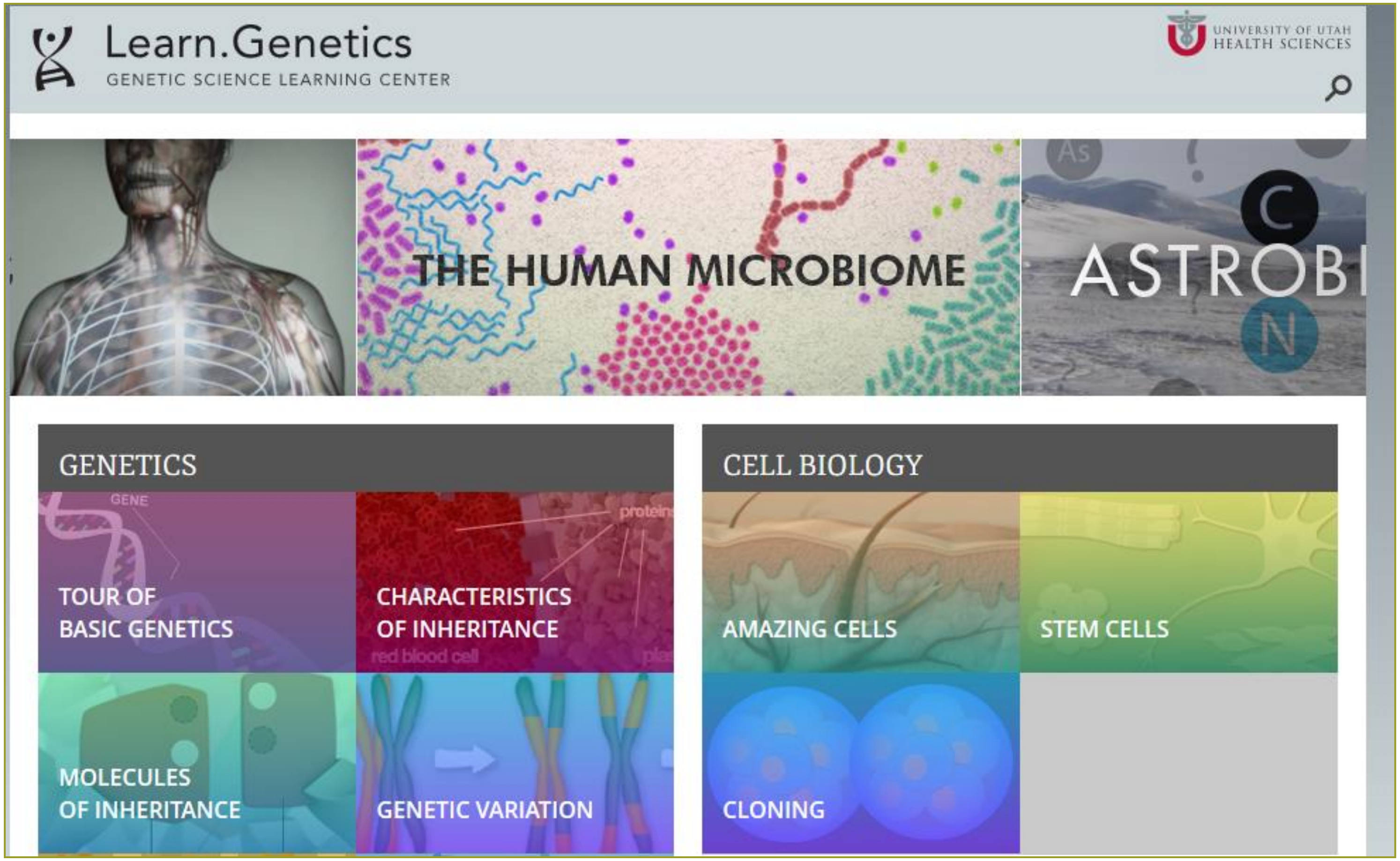
Cells Alive! Mitosis
http://cellsalive.com/mitosis.htm



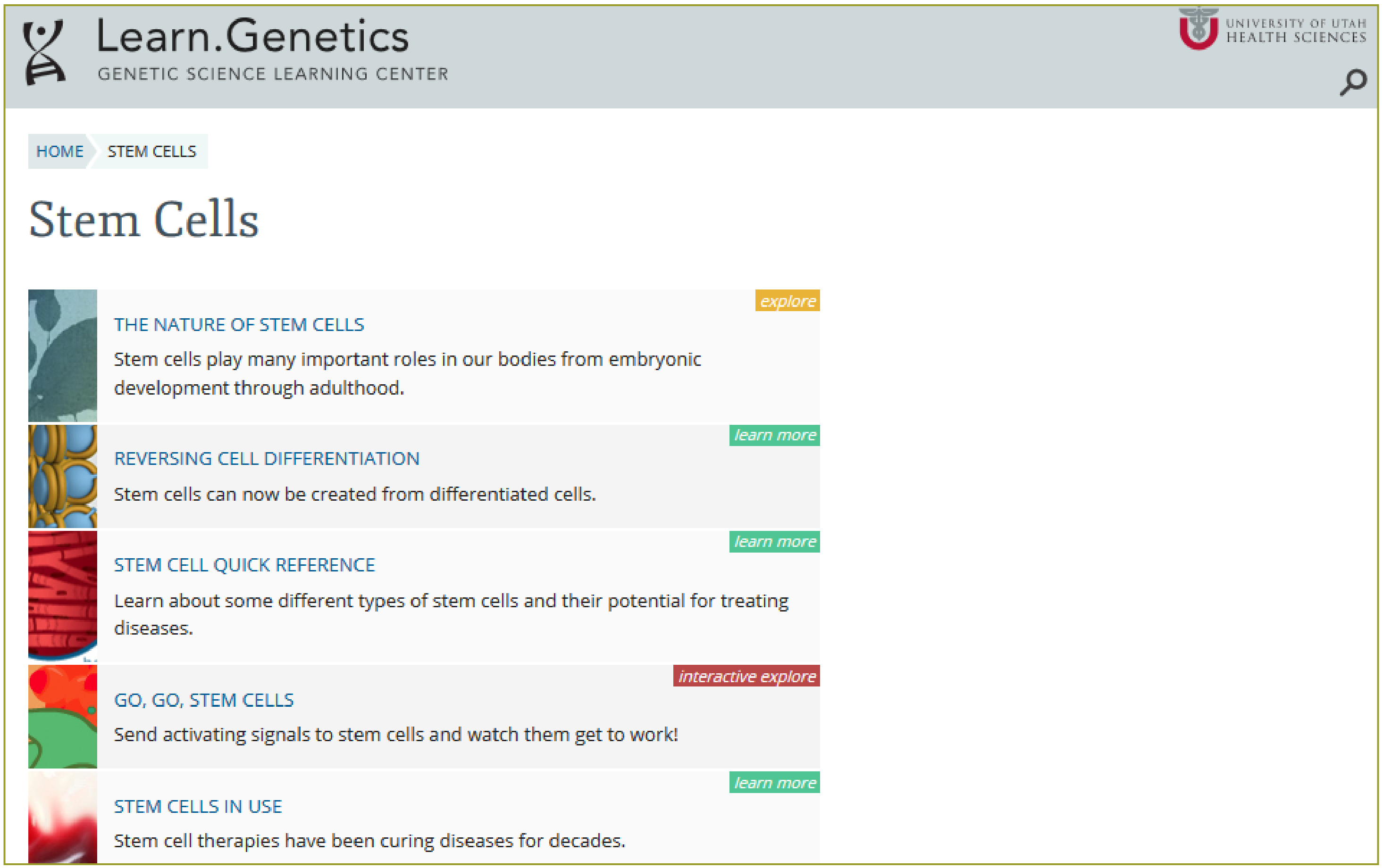
Stem Cells?
http://learn.genetics.utah.edu/

- **KOOOOOL Genetics Website, with info on Stem Cells, Cloning, and more!!!!**
- Stem cells – what are they?
- Stem cell research
- The future in veterinary medicine?

Learn.Genetics website



Stem Cells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Stem Cells
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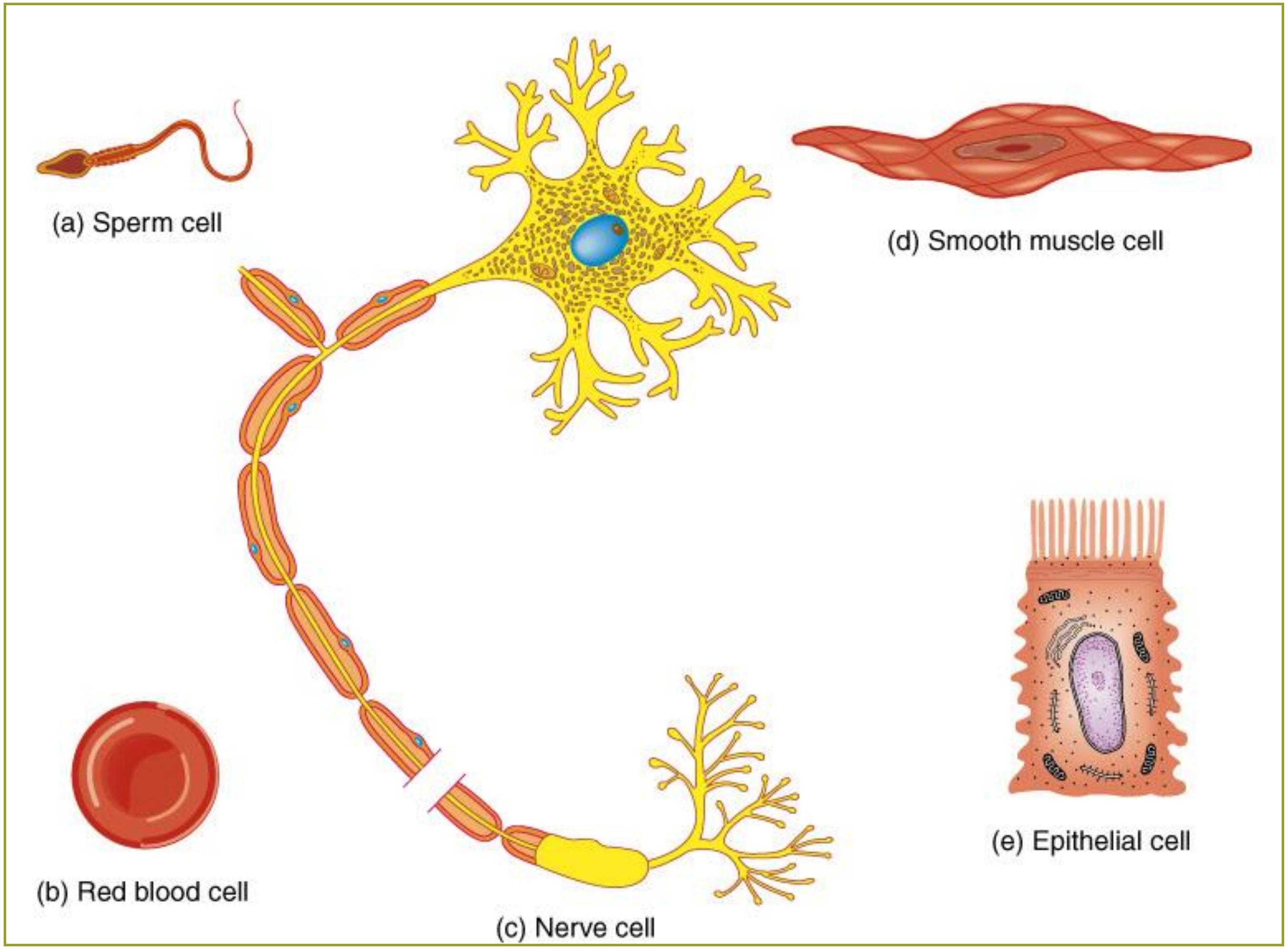
THE NATURE OF STEM CELLS
Stem cells play many important roles in our bodies from embryonic development through adulthood.
learn more
REVERSING CELL DIFFERENTIATION
Stem cells can now be created from differentiated cells.
learn more
STEM CELL QUICK REFERENCE
Learn about some different types of stem cells and their potential for treating diseases.
interactive explore
GO, GO, STEM CELLS
Send activating signals to stem cells and watch them get to work!
learn more
STEM CELLS IN USE
Stem cell therapies have been curing diseases for decades.

Cell Differentiation

- Involves the temporary or permanent inhibition of genes that may be active in other cells

Cell Diversity – Deja Vu



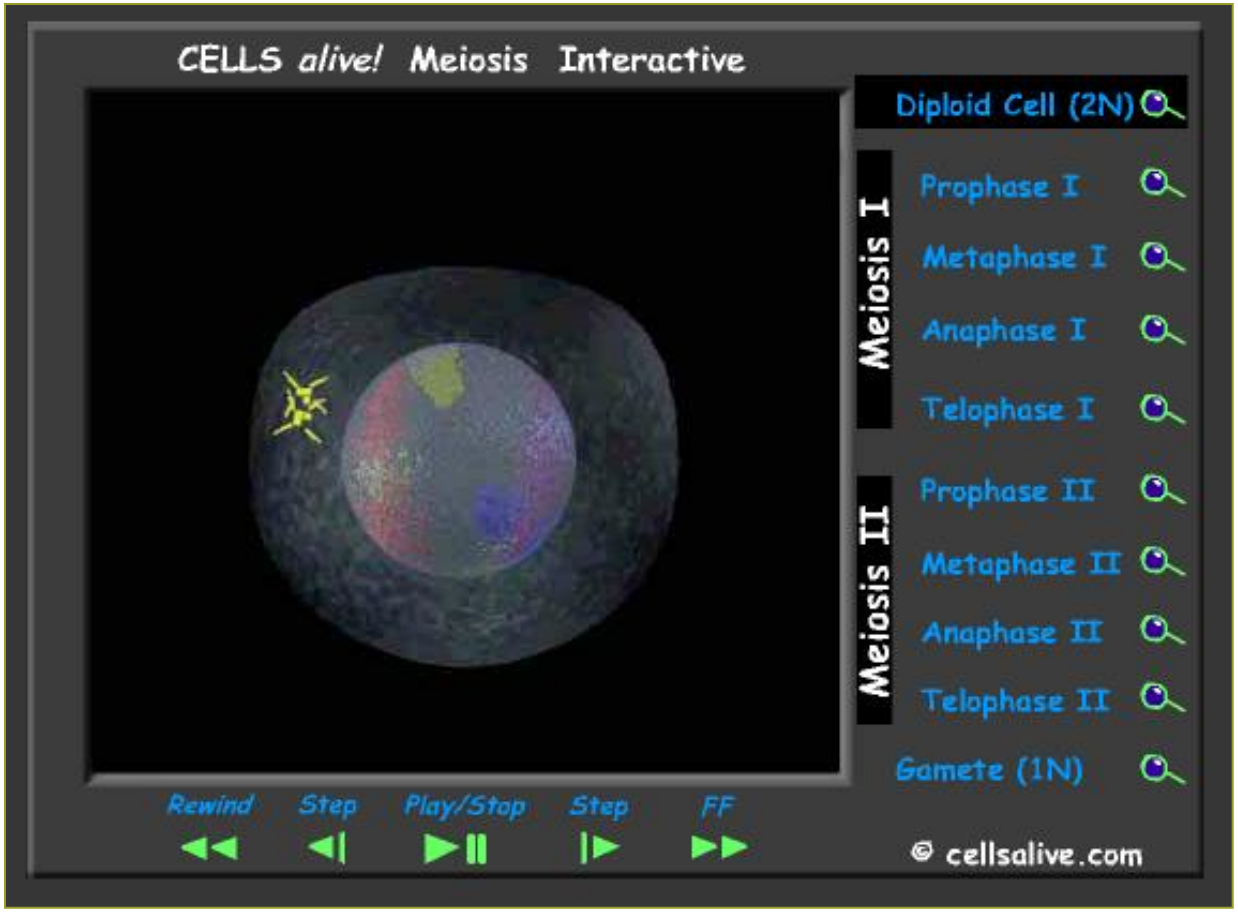
Genetic Mutations

- Errors in DNA replication
- **Mutagen**: anything that causes genetic mutation
  - **Viruses**, ionizing radiation, and certain chemicals
  - Spontaneous mutation

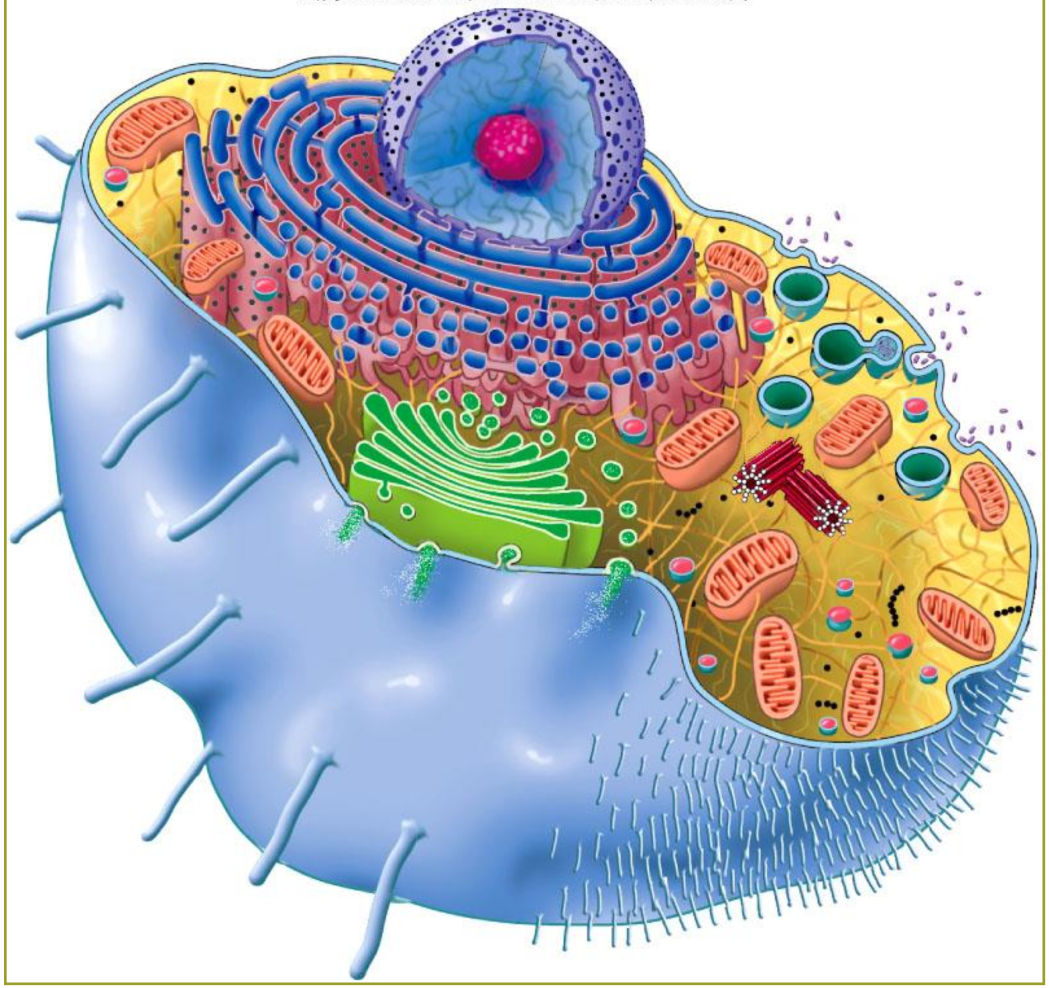
Meiosis

- Creation of gametes
  - Sperm & egg
- Diploid number → haploid number
- Meiosis I
  - Tetrads
  - Crossing over
- Meiosis II
  - Like mitosis

Cells Alive! Meiosis
http://cellsalive.com/meiosis.htm

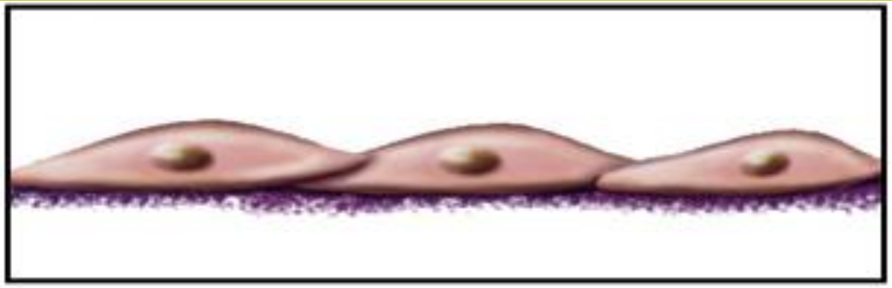


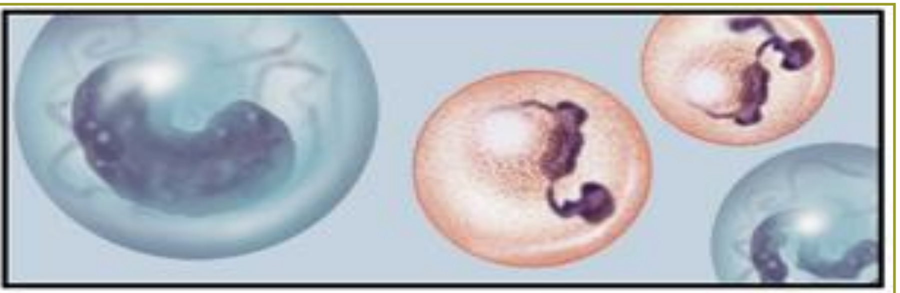
Review



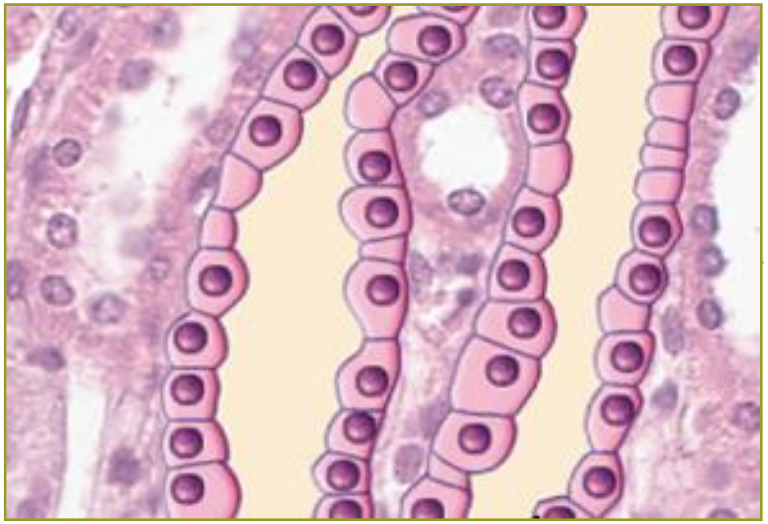
Clinical Applications

Pages 45, 69, 84-87, 88, 89





Tissues: Living Communities
Chapter 4



Pages 90-130

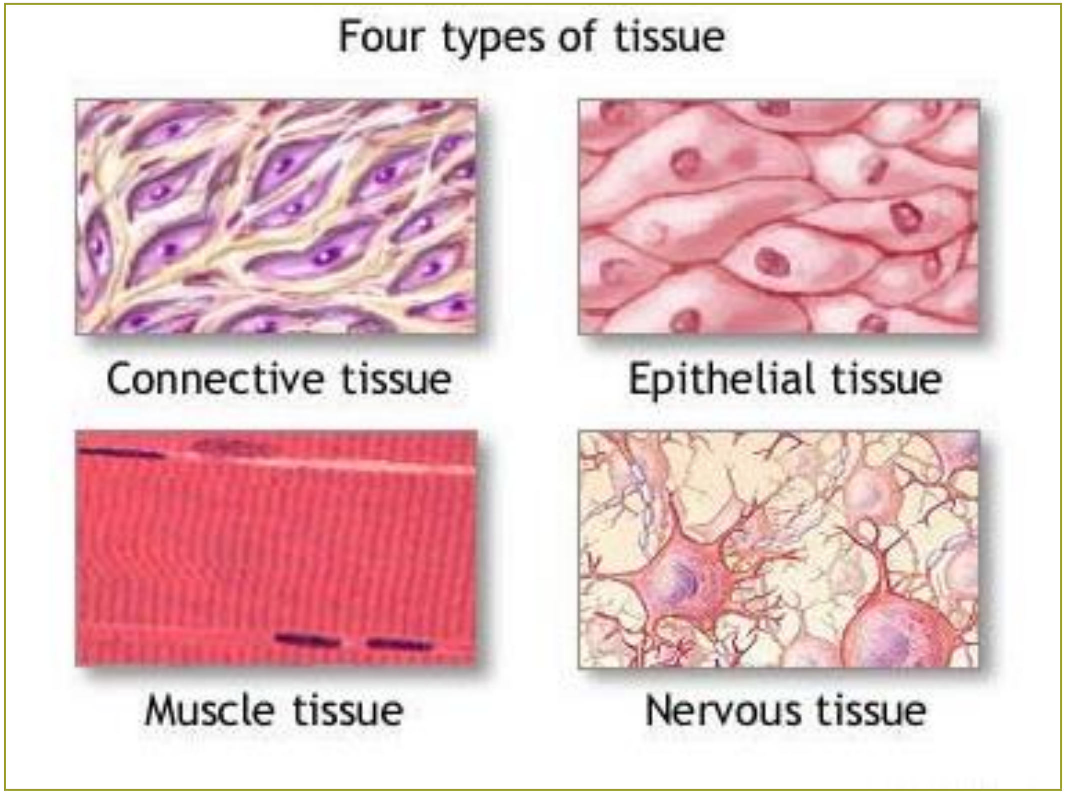
Textbook Learning Objectives

Chapter 4 – Page 90

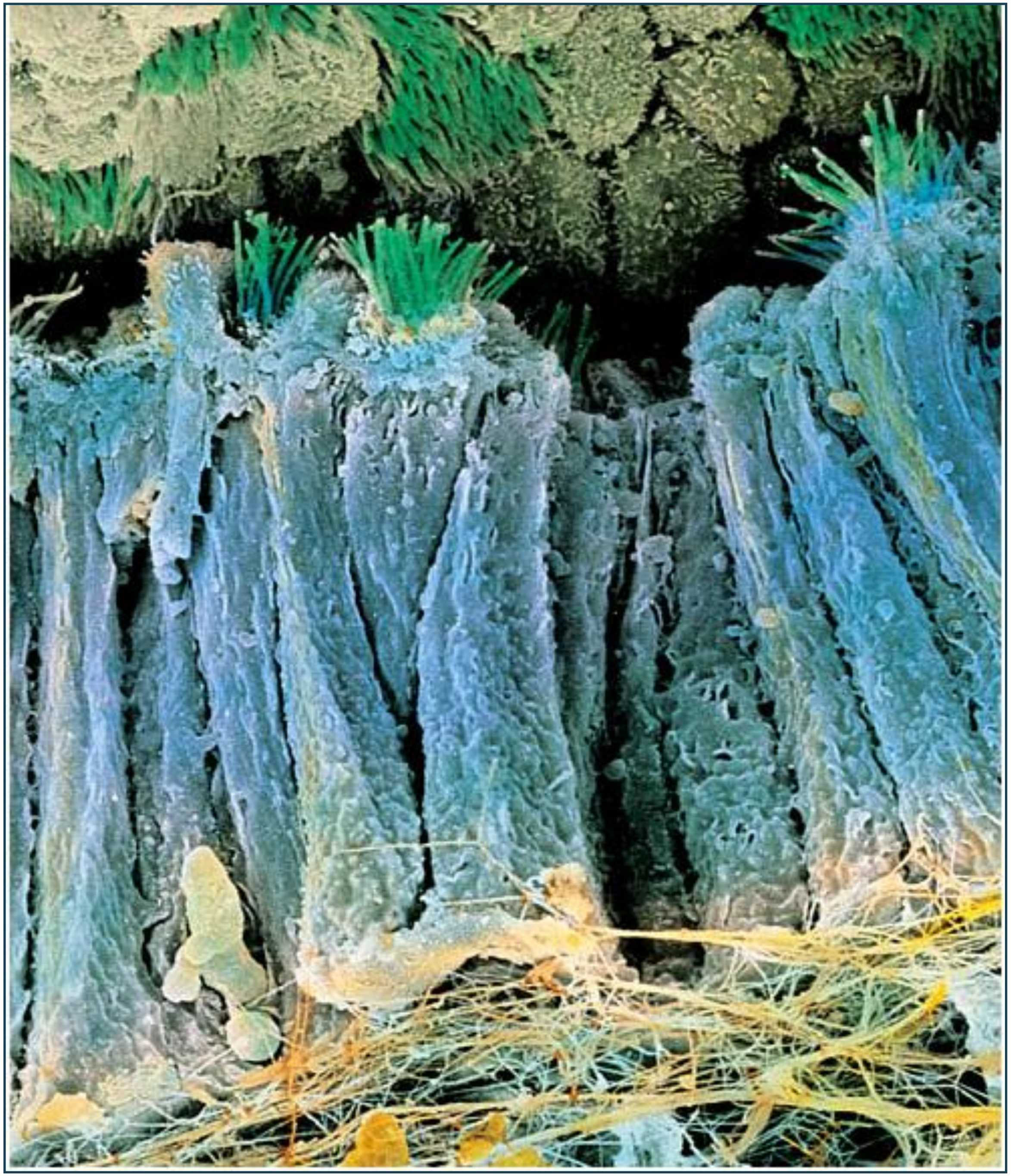
- Describe the functions of epithelial tissues.
- Differentiate between the three major types of cellular junctions found between epithelial cells.
- Describe the structure of the basement membrane.
- List and describe the characteristics used to classify different epithelial tissues.
- List and describe the characteristics used to classify different glands.
- List and describe the components that make up connective tissues.
- Differentiate between areolar, adipose, and reticular connective tissues.
- Differentiate between dense regular, dense irregular, and elastic connective tissues.
- Differentiate between hyaline cartilage, elastic cartilage, and fibrocartilage.
- List and describe the components of bone.

Topic 18

Compare and contrast the four tissue types found in animals' bodies



What Tissue?



Types of Tissues

- Tissues are classified into the following four primary types:
    1. Epithelial tissue
    2. Connective tissue
    3. Muscle tissue
    4. Nervous tissue

1. Epithelial Tissue

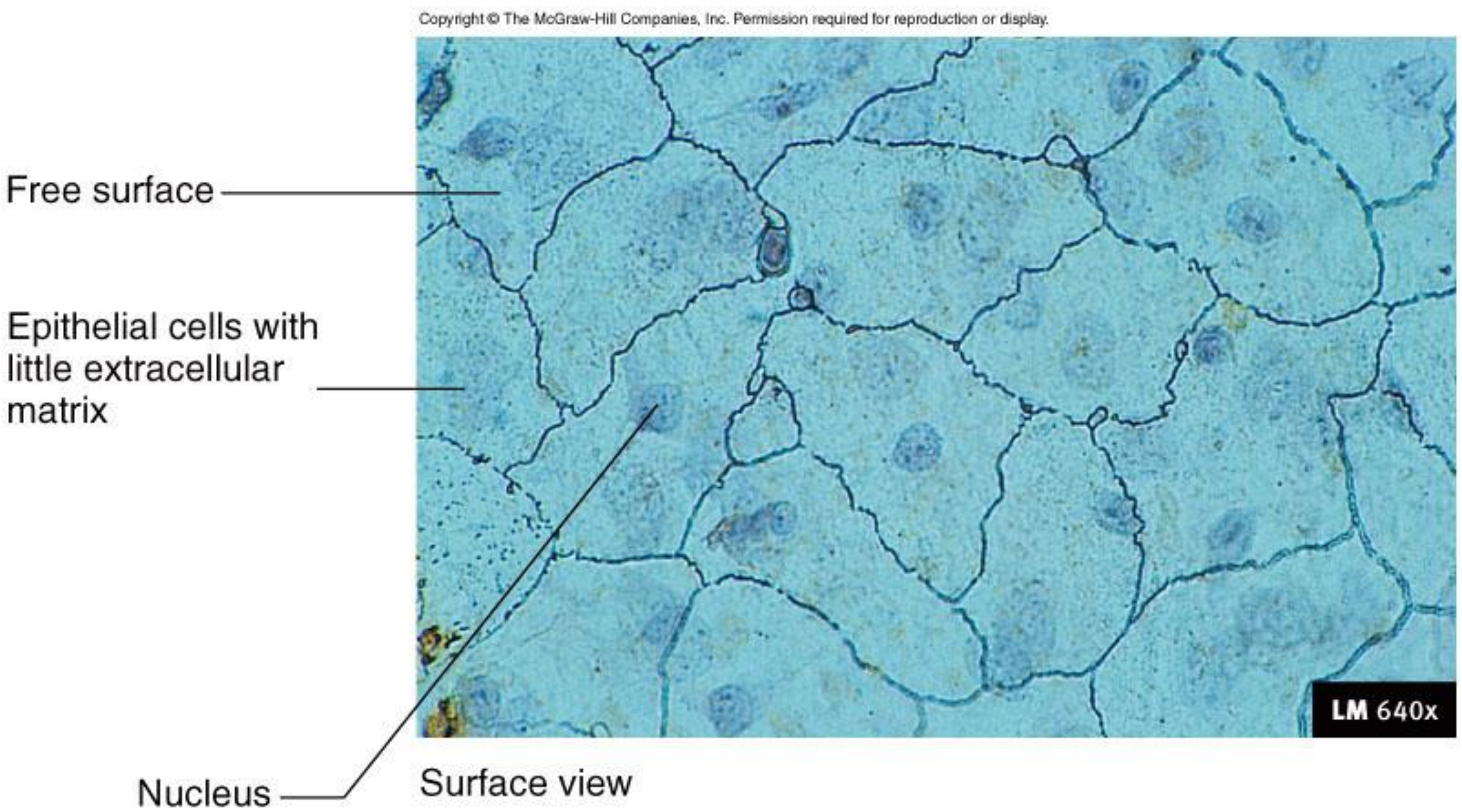
Sheetlike

Glandular

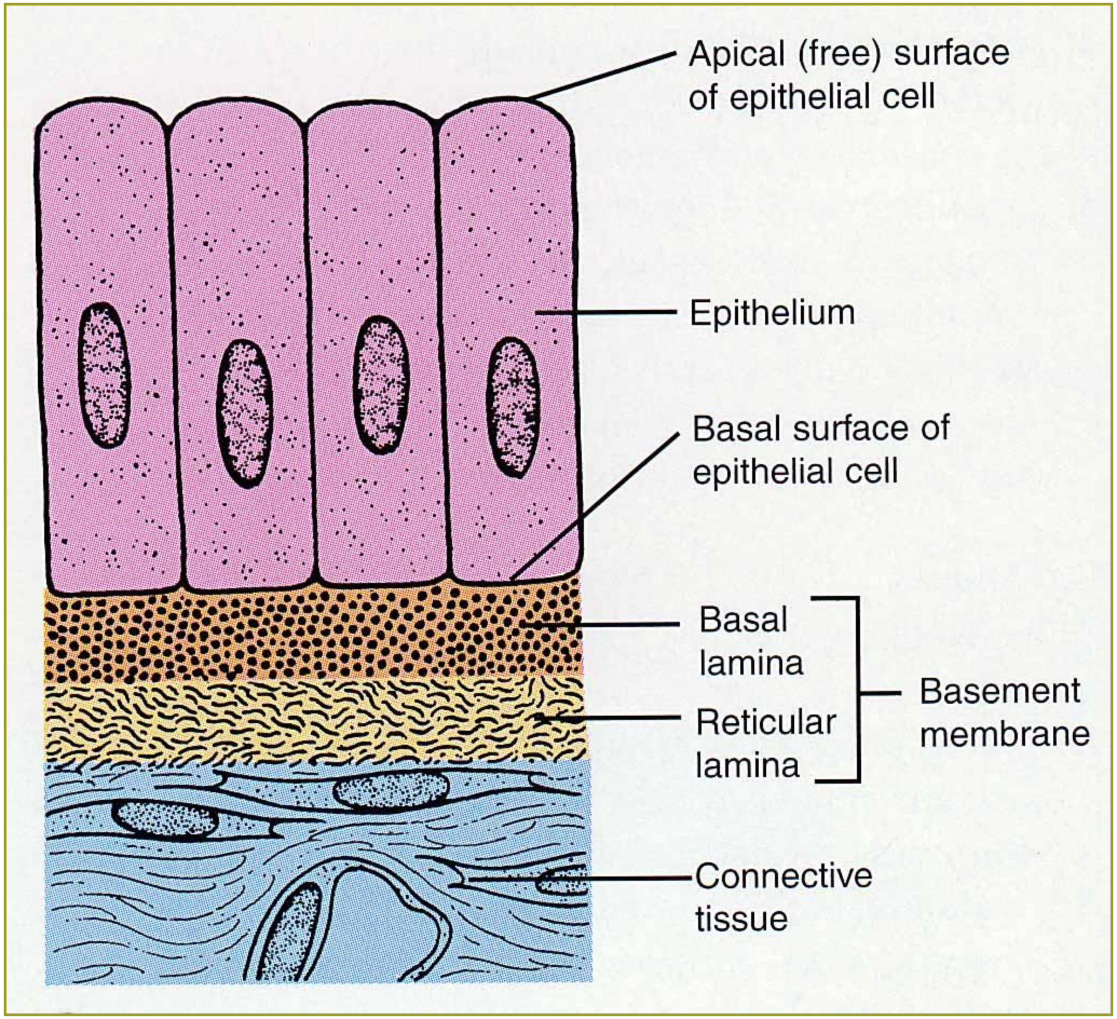
Epithelial Tissues

- Sheets of cells that cover and line other tissues
- Protect underlying tissues and may act to filter biochemical substances
- May absorb, secrete, or excrete biochemical substances
- May play a role in the reception of sensory input

Epithelial Tissue



Anatomy of Epithelial Tissue



Characteristics of Epithelia

- Each epithelial cell has an **apical surface** and a **basal surface**
  - Apical surface faces the **lumen** or outside of the organ
  - Basal surface faces the basal lamina and blood vessels
- Lateral surfaces are connected to neighboring cells by junctional complexes.
- Epithelial cells are **avascular**
- Most epithelial cells are **innervated**

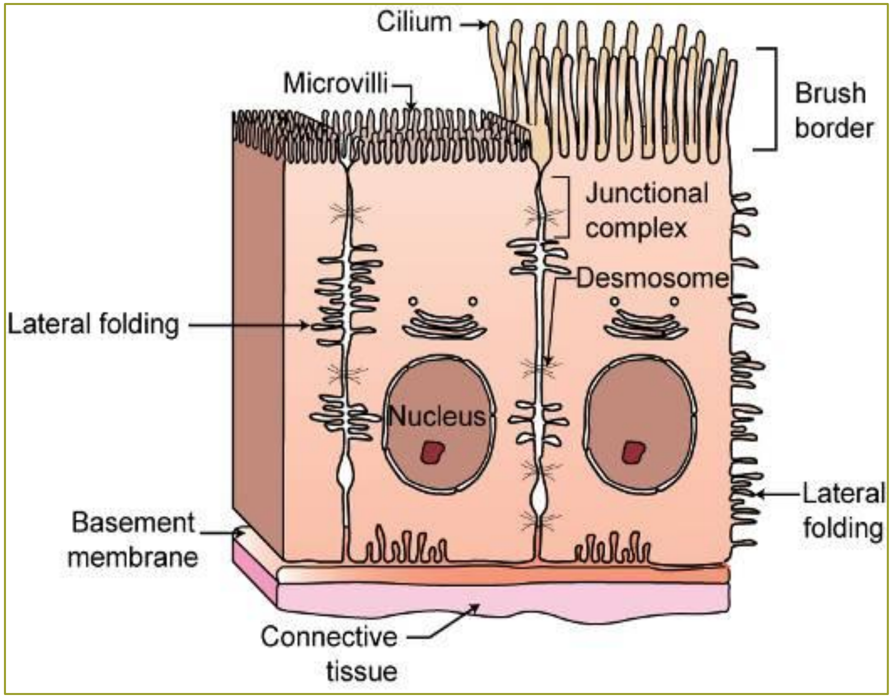
Basement Membrane

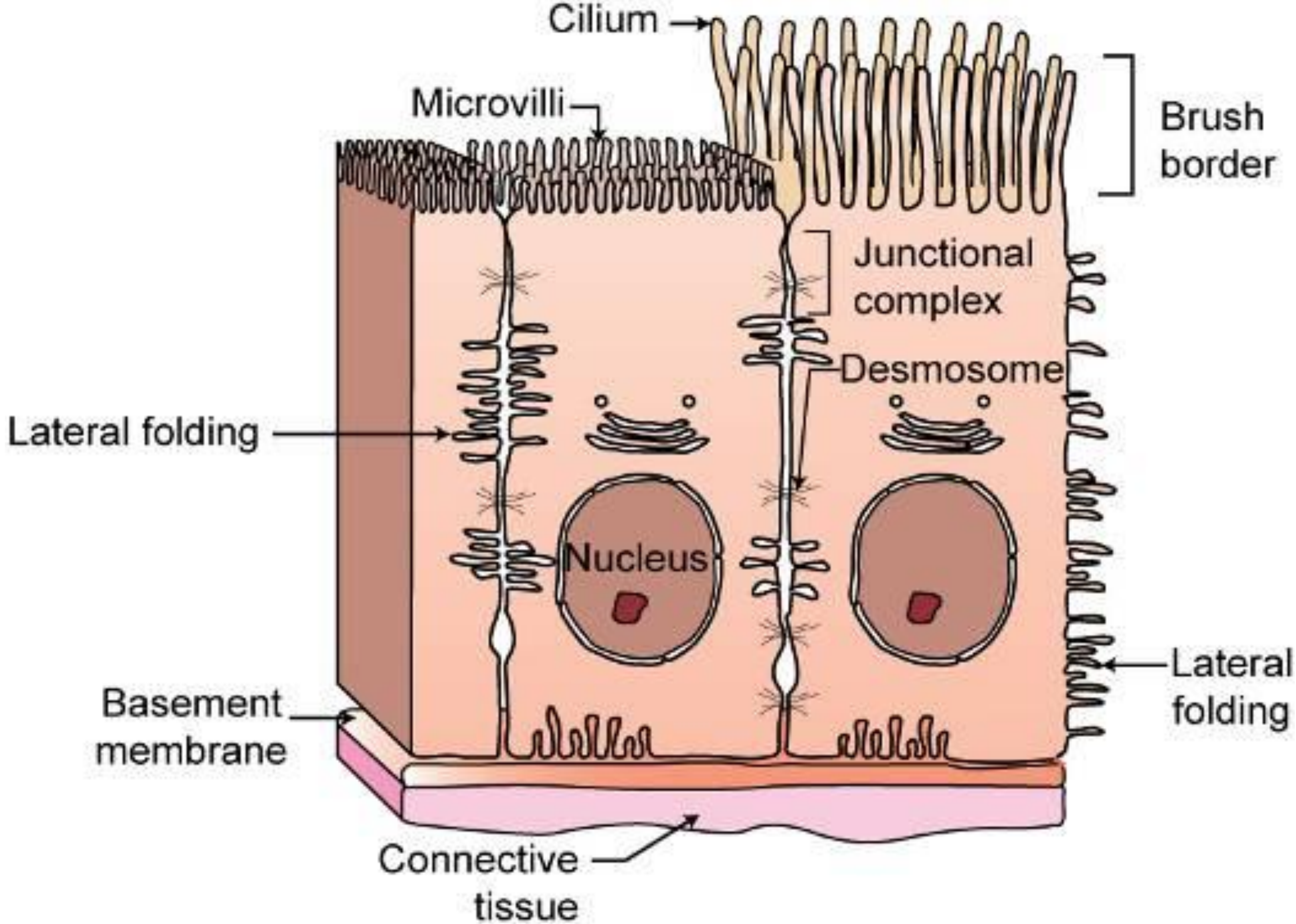
- Meshwork of fibers that cements the epithelial cell to the underlying connective tissue
- Also called *basal lamina*
- Varies in thickness
- Helps prevent the cell from being torn off by intraluminal pressures
- Acts as a partial barrier between the epithelial cell and the underlying connective tissue

Surface Specialization

Figure 4-2, Page 93

- Surfaces of epithelial cells vary depending on where they are located and what role they play in the function of the tissue
  - Smooth
  - Microvilli (brush border)
  - Cilia
  - Keratin

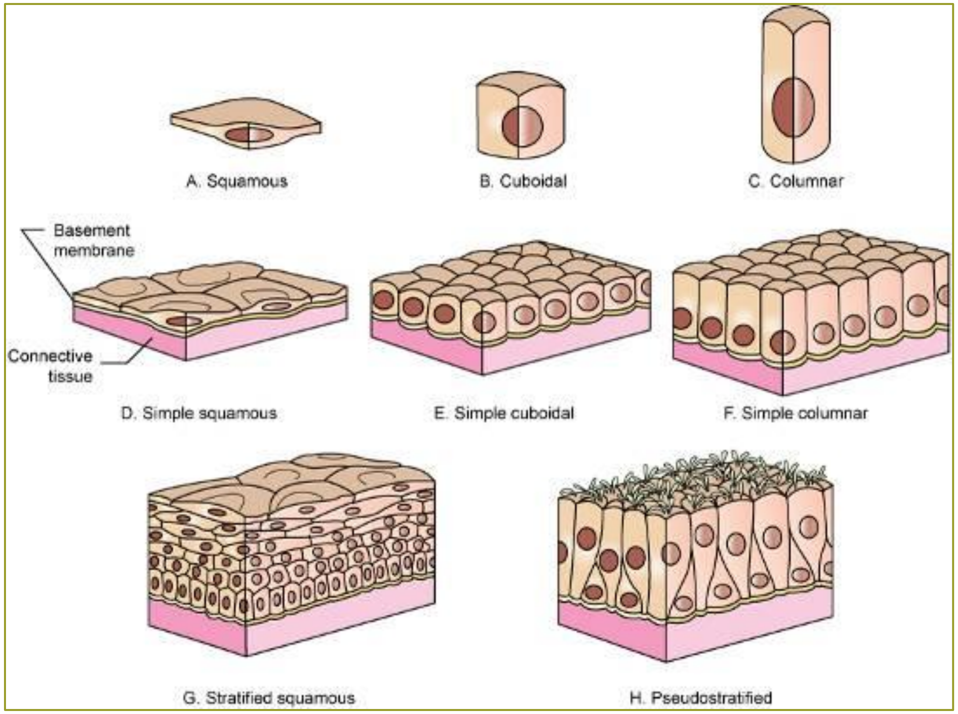


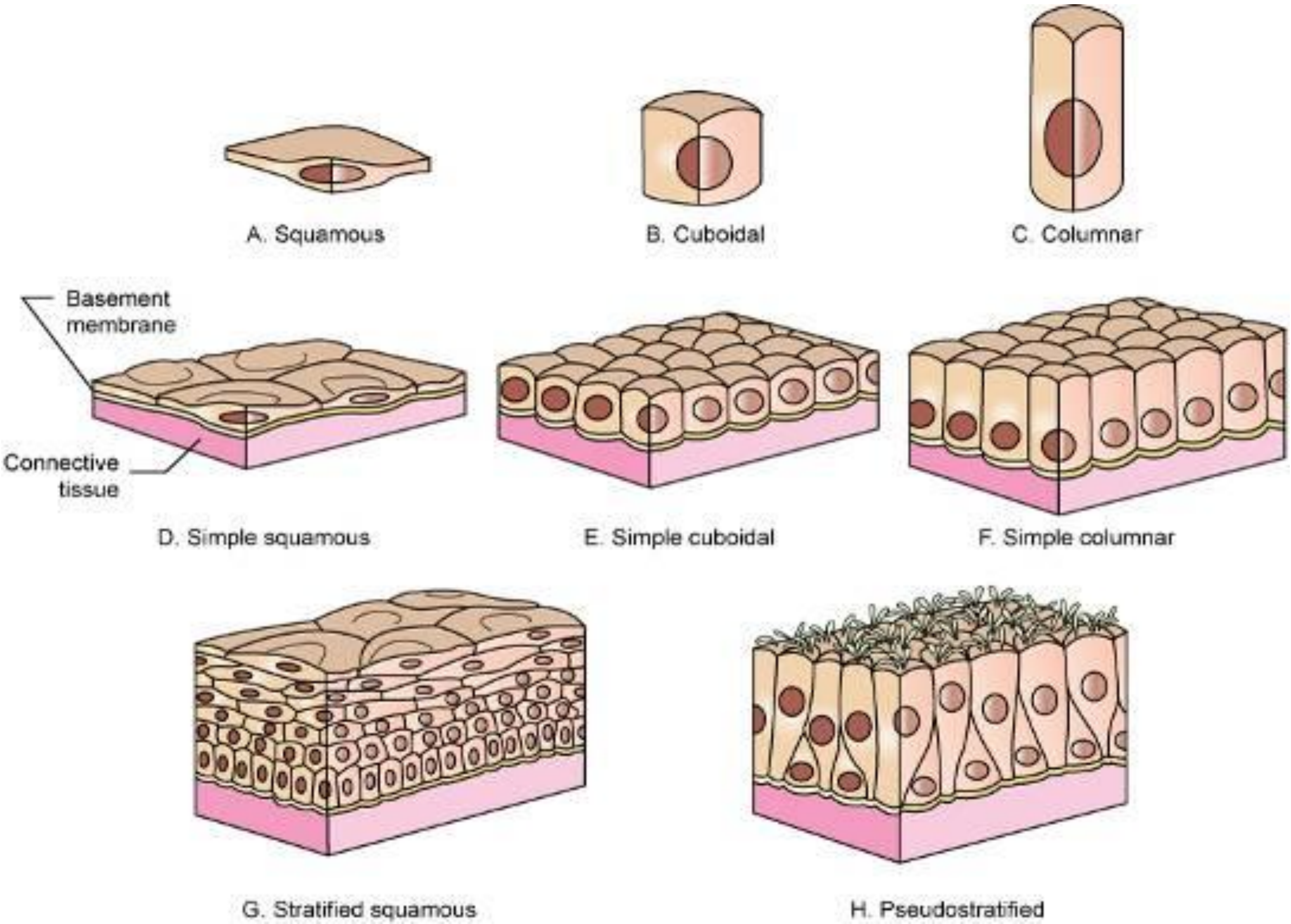

Cilium
Microvilli
Brush border
Junctional complex
Desmosome
Lateral folding
Nucleus
Lateral folding
Basement membrane
Connective tissue

Classification of Epithelial Tissue

Figure 4-3, Page 95

- Number of layers of cells: Simple or stratified
- Shape of the cells: Squamous, cuboidal, and columnar
- Presence of surface specializations: Cilia, keratin, etc.





A. Squamous
B. Cuboidal
C. Columnar
Basement membrane
Connective tissue
D. Simple squamous
E. Simple cuboidal
F. Simple columnar
G. Stratified squamous
H. Pseudostratified

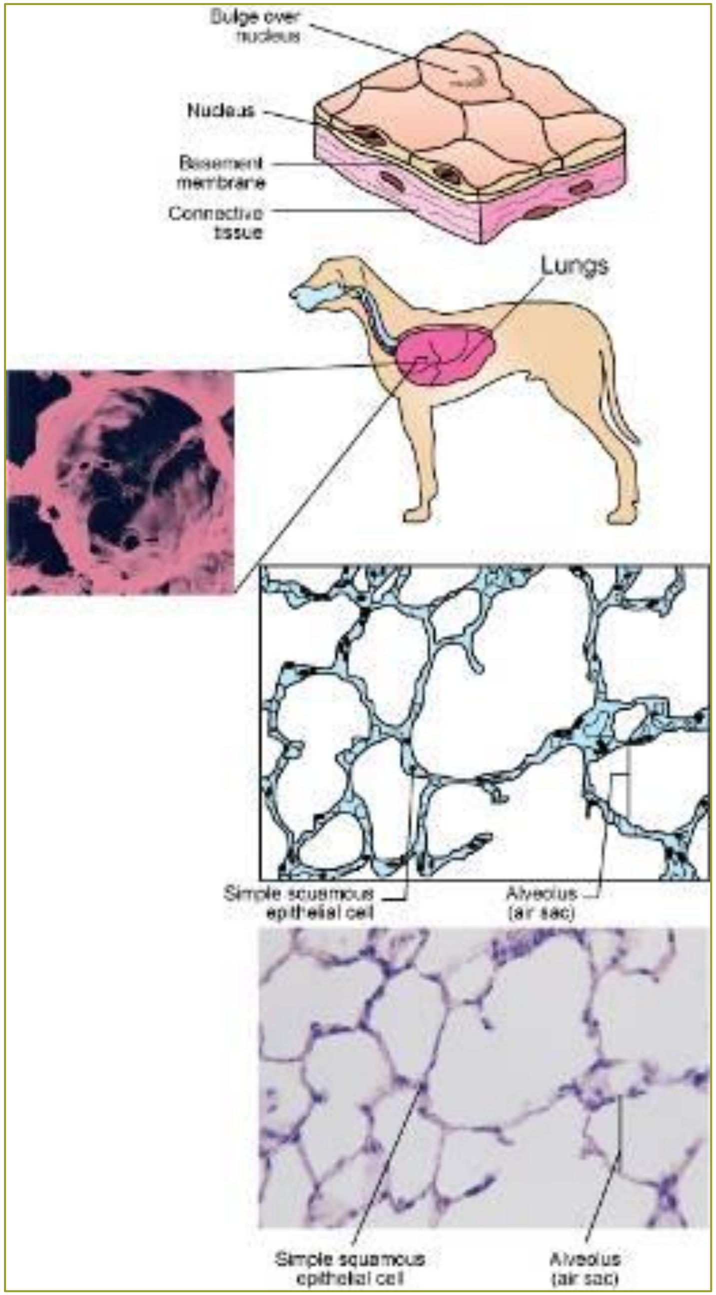
Table 4.1 Classification of Epithelia

Number of Layers	Cell Shape
Simple (one layer)	Squamous Cuboidal Columnar
Pseudostratified (a modified form of simple epithelium)	Columnar
Stratified (more than one layer)	Squamous Keratinized Nonkeratinized (moist)
Transitional (a type of stratified epithelium)	Roughly cuboidal to columnar when not stretched and squamouslike when stretched

Simple Squamous Epithelium

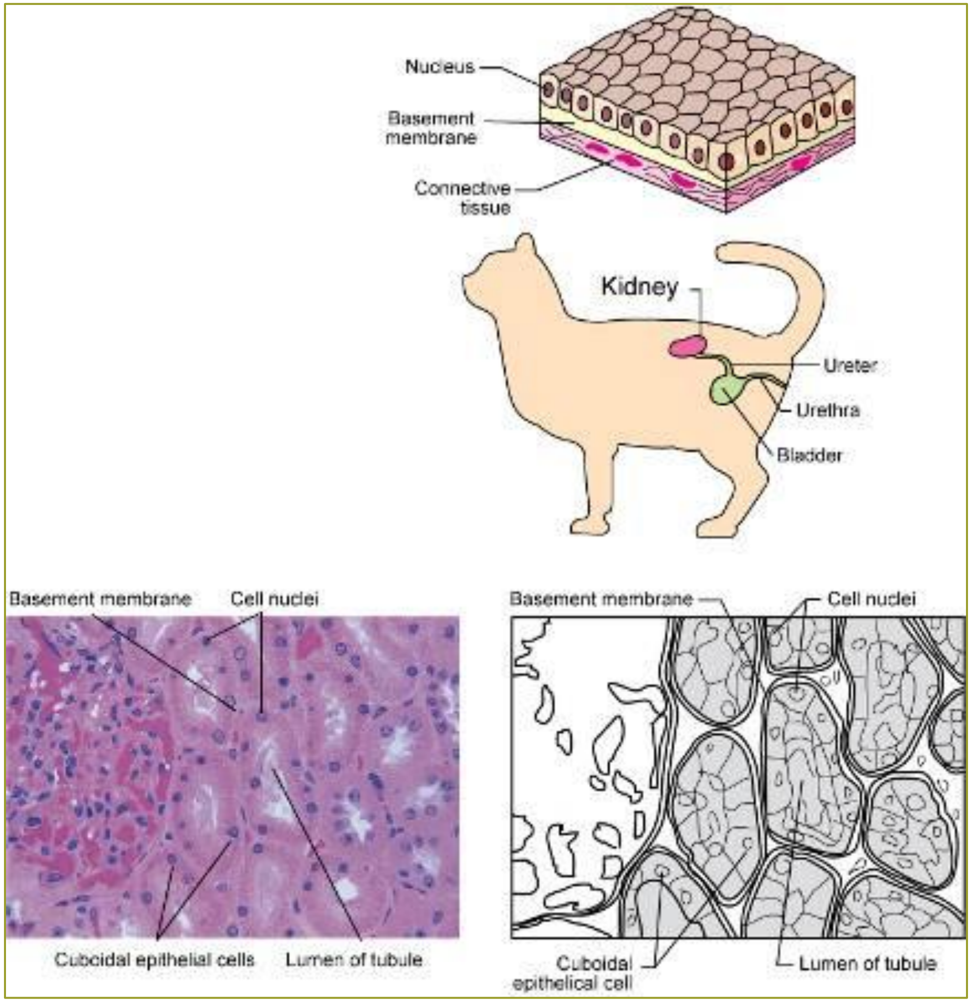
Figure 4-4, Page 96

- Fragile and thin
- Found lining surfaces involved in the passage of either [gas]() or [liquid]()
- Flat and smooth



Simple Cuboidal Epithelium
Figure 4-5, Page 97

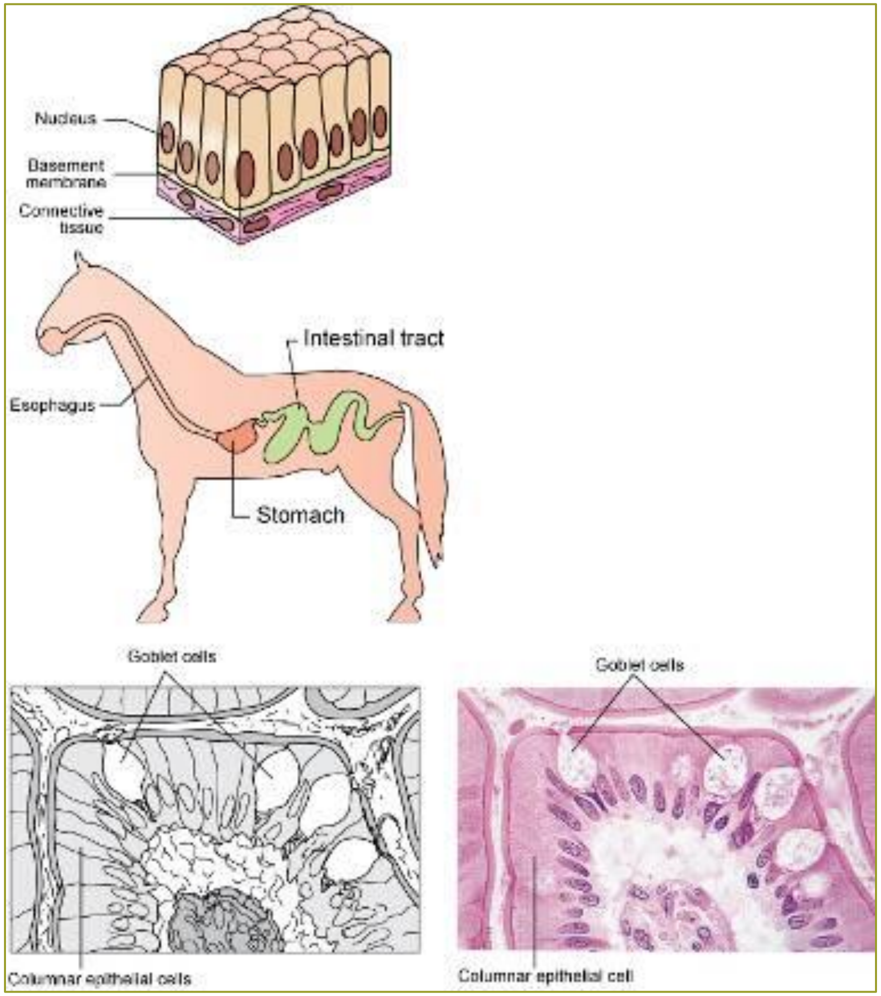
- Single layer of cube-shaped cells
- Round, dark-staining nuclei aligned in a single row
- Occurs in areas of the body where secretion and absorption take place



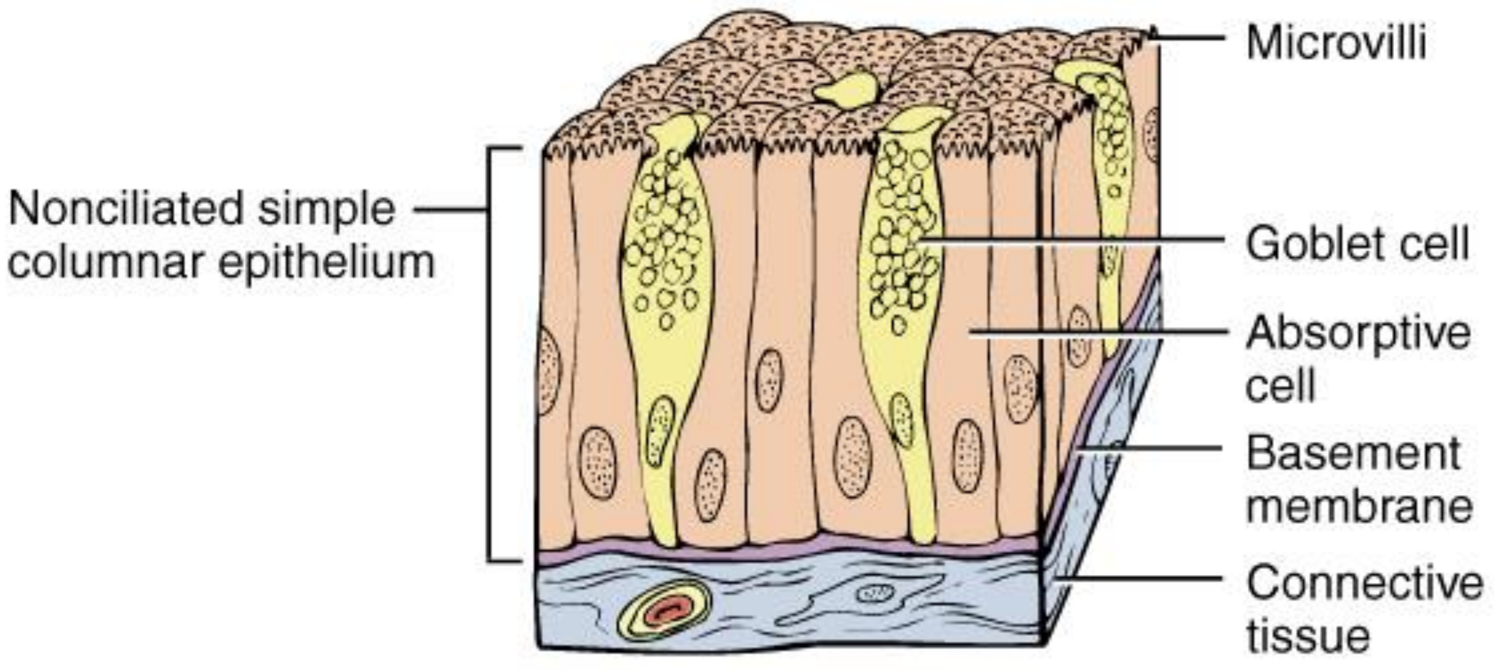
Simple Columnar Epithelium

Figure 4-6, Page 98

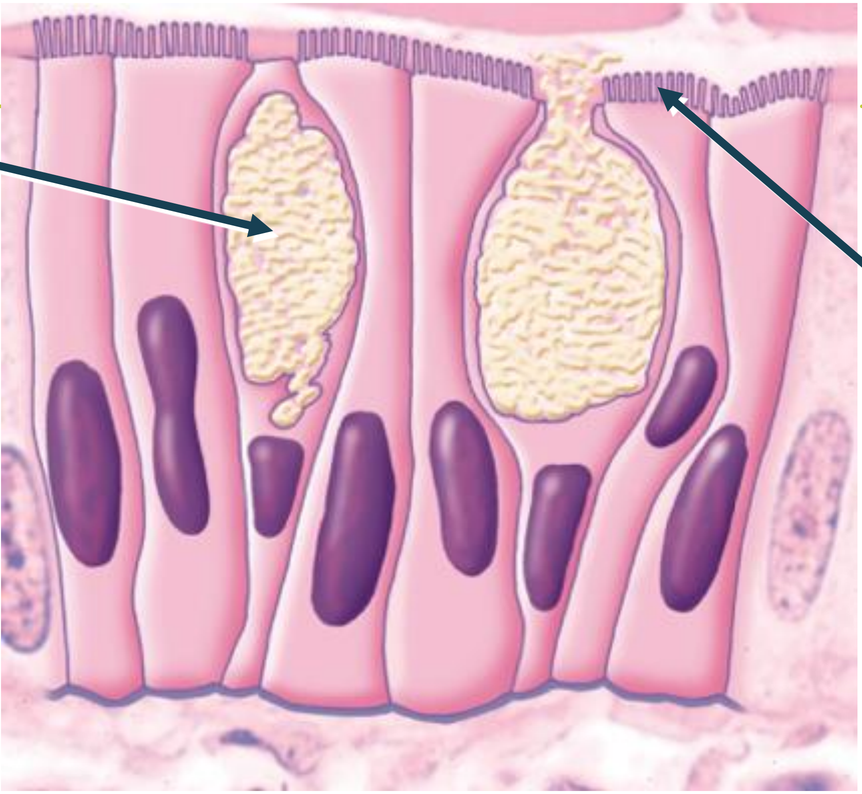
- Elongated and closely packed together
- Nuclei aligned in a row at the base of the cell near the basement membrane
- Found in many excretory ducts as well as in the digestive tract



Simple Columnar Epithelium

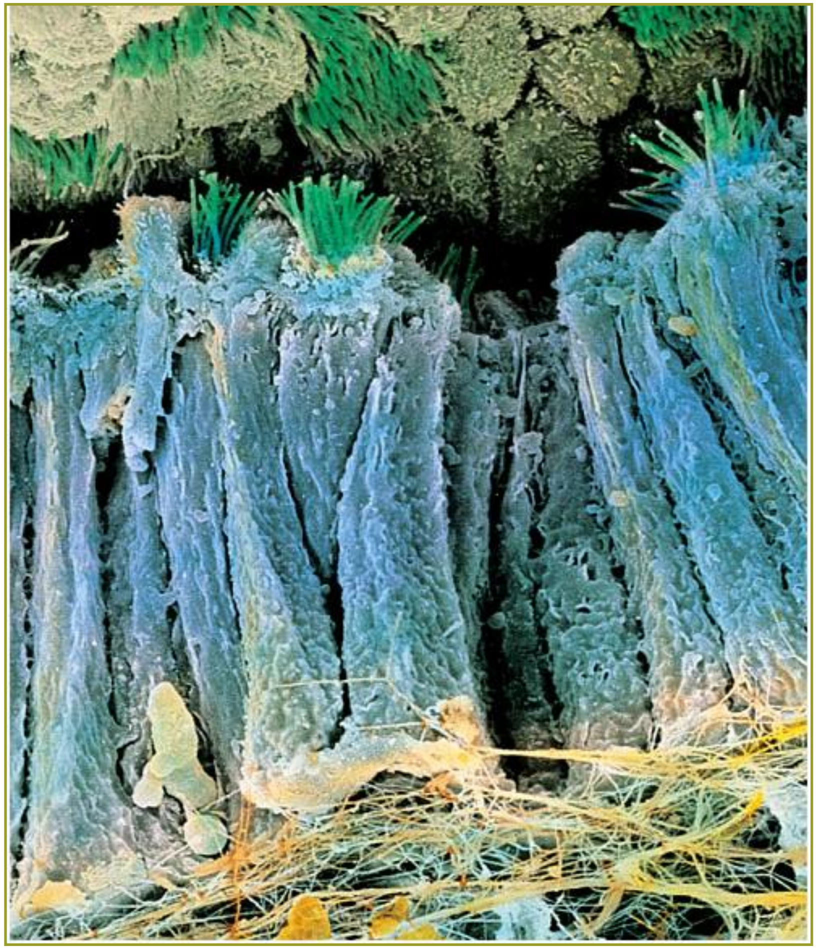


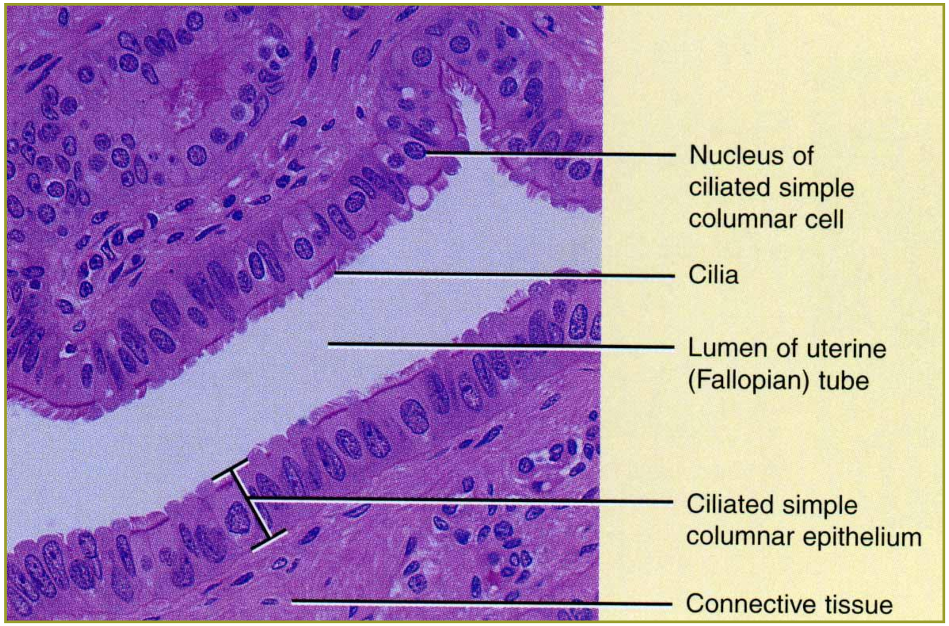
Simple Columnar Epithelium



- Digestive System

Oviduct (Uterine Tube)

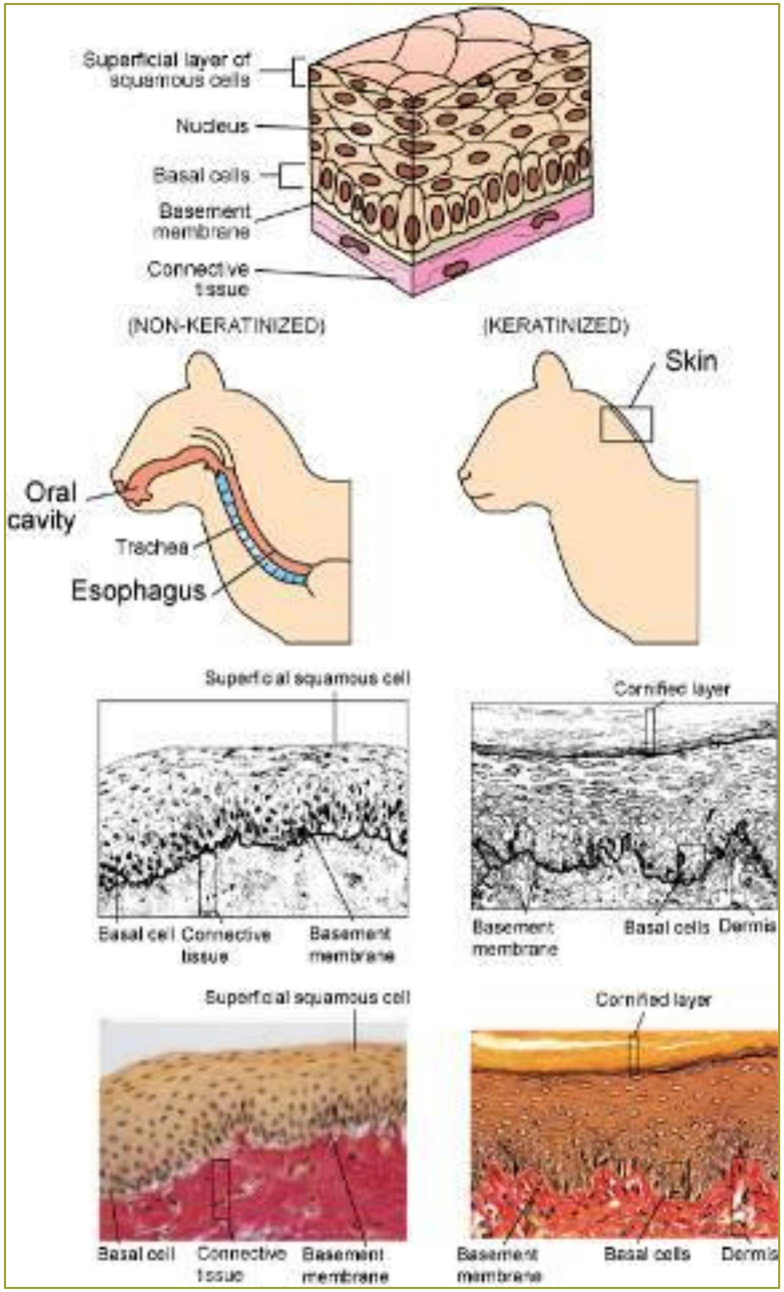




Stratified Squamous Epithelium

Figure 4-7, Page 99

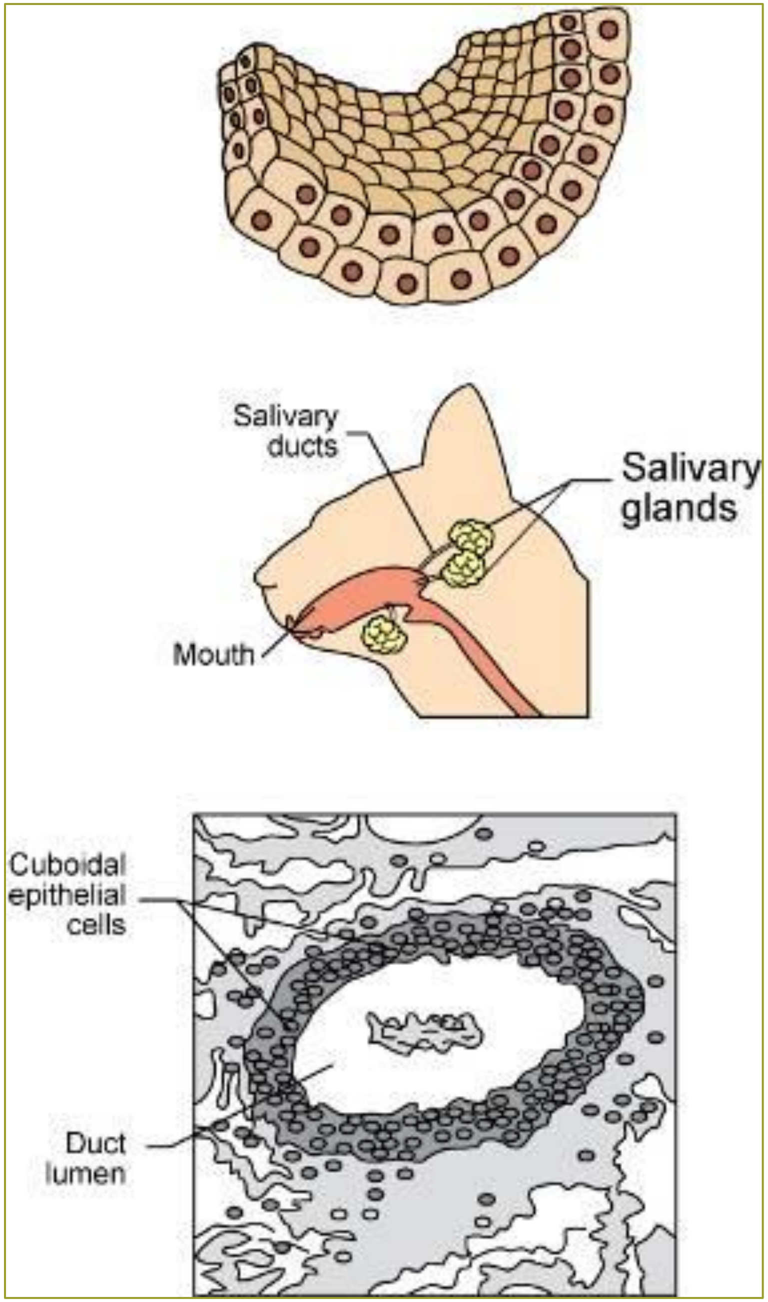
- Multilayered
- Occur in areas of the body subject to mechanical and chemical stresses
- Protect underlying tissues



Stratified Cuboidal Epithelium

Figure 4-8, Page 100

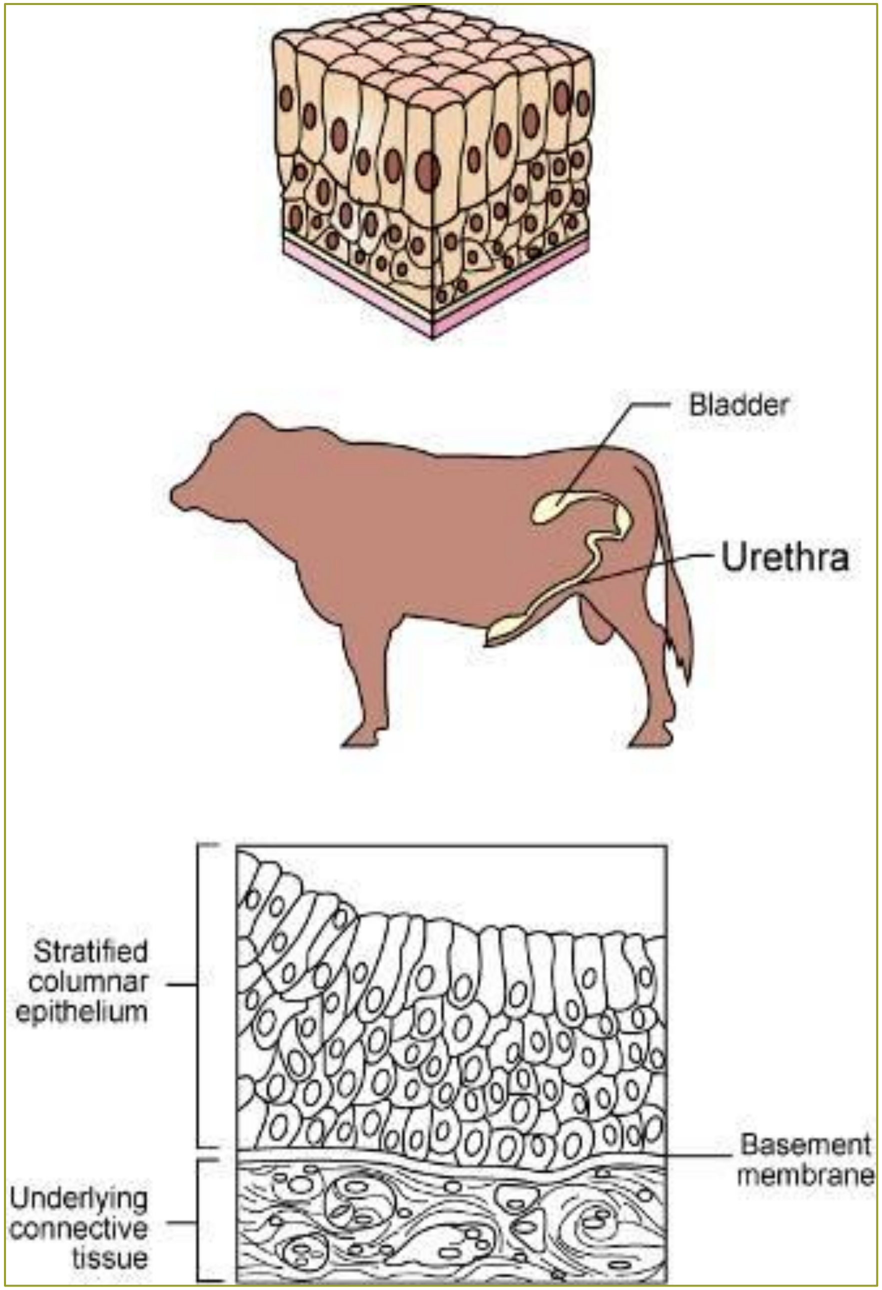
- Usually two layers of cuboidal cells
- Found primarily along large excretory ducts
- Protects underlying tissues



Stratified Columnar Epithelium

Figure 4-9, Page 100

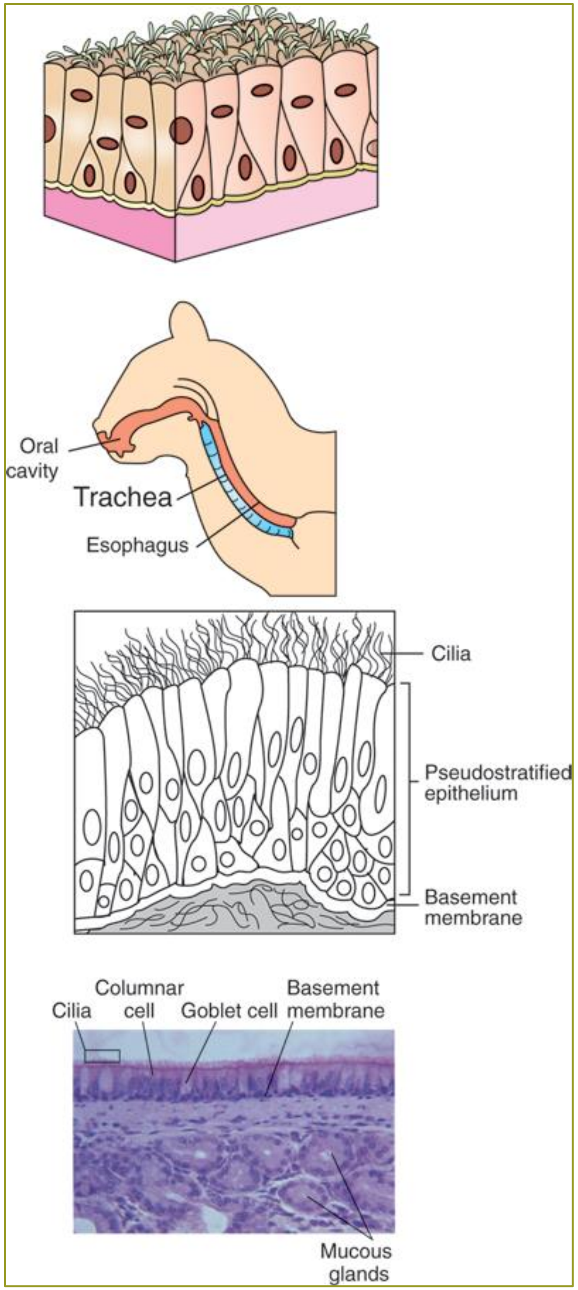
- Found only in select parts of the respiratory, digestive, reproductive systems and along some excretory ducts
- Function in secretion and protection



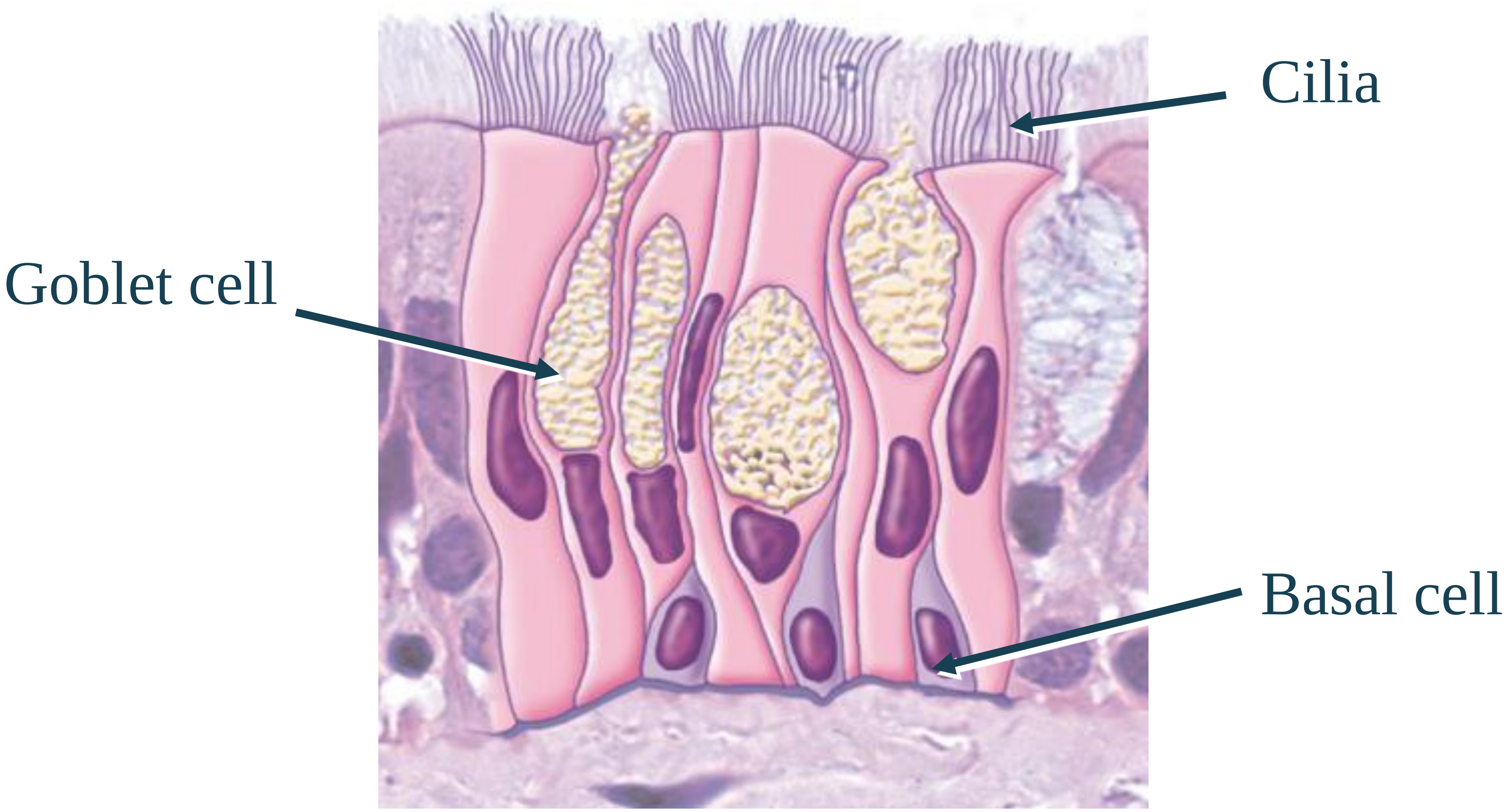
Pseudostratified Columnar Epithelium

Figure 4-10, Page 101

- Cell nuclei are found at different levels across the length of the tissue
- Some cells do not reach the luminal surface
- Found in [respiratory tract]() and in portions of the male reproductive tract



Pseudostratified Epithelium

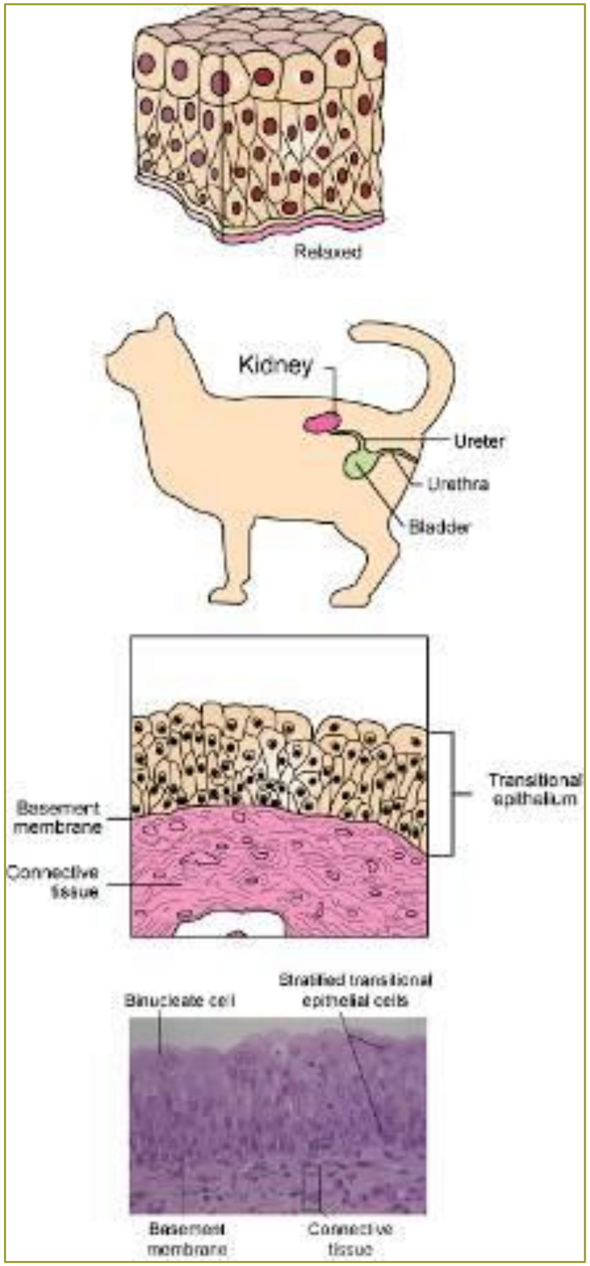


- **Respiratory System**

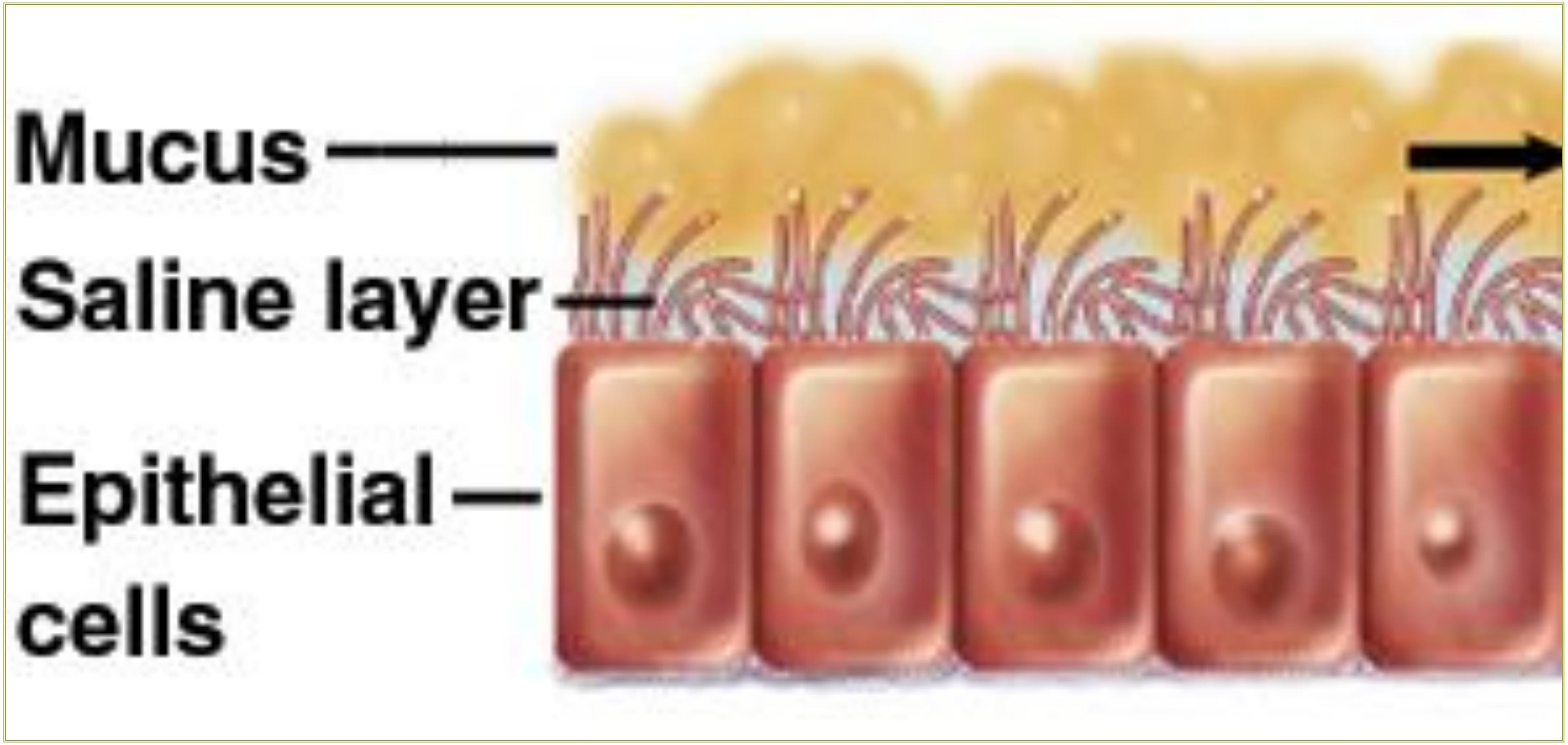
Transitional Epithelium

Figure 4-11, Page 102

- Stratified epithelium with a basal layer of cuboidal or columnar cells and a superficial layer of cuboidal or squamous cells
- Found in areas of the body required to expand and contract as part of their normal function – [urinary tract]()



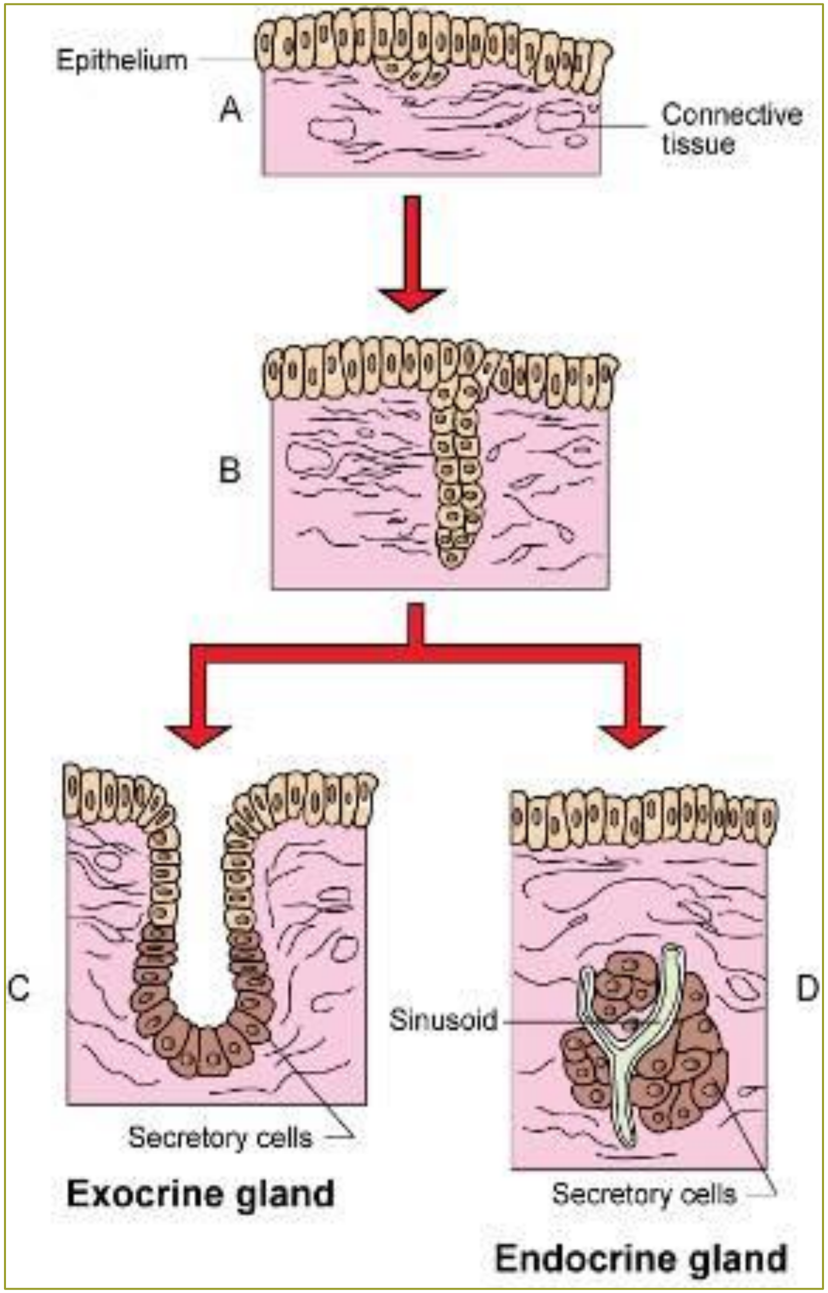
Mucosal Layer of Tracts



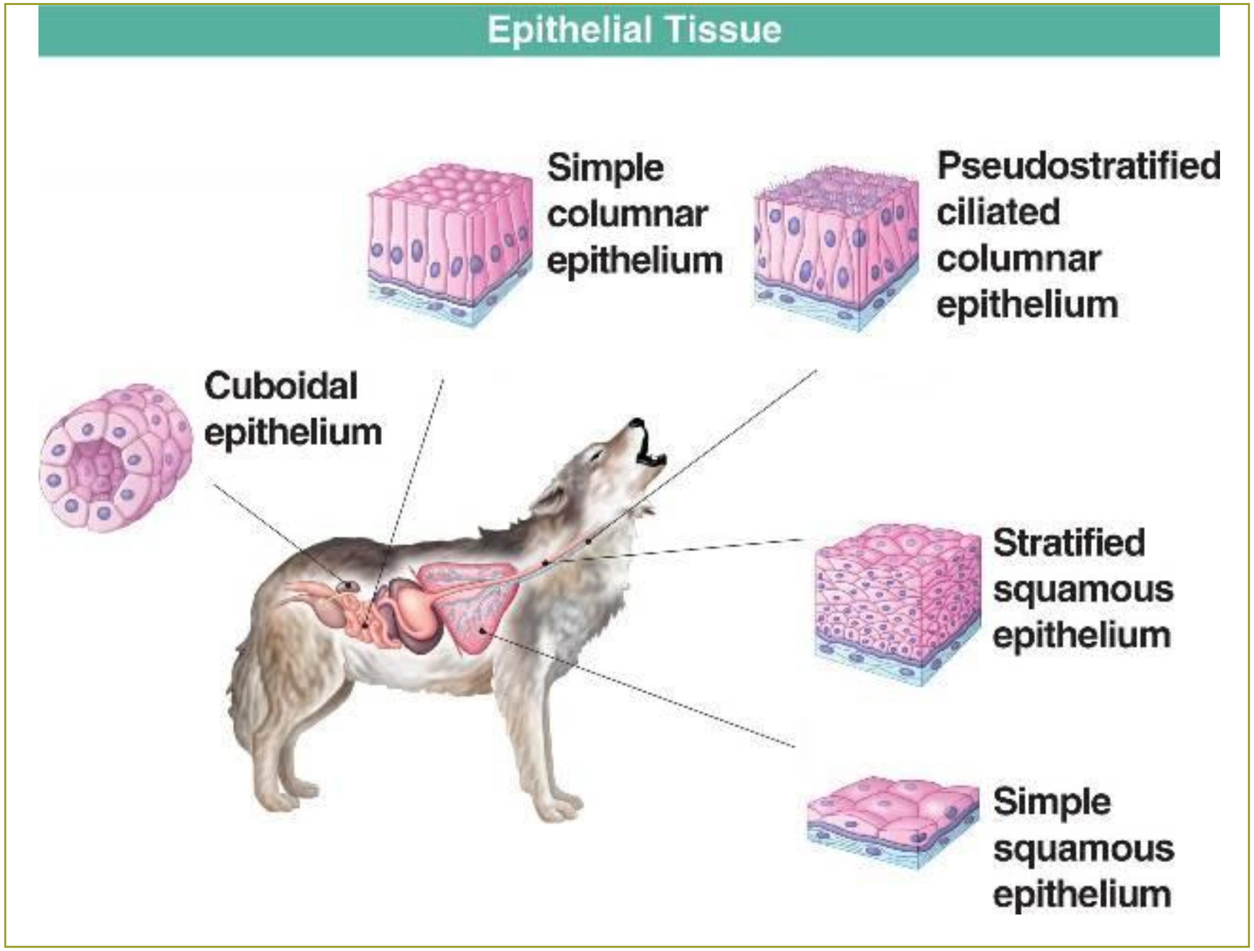
Glandular Epithelium

Figure 4-12, Page 103

- Groups of cells that manufacture and discharge a secretion
- Classification of glands
  1. Presence or absence of ducts
  2. Number of cells that compose them
  3. Shape of the secreting ducts
  4. Complexity of the glandular structure
  5. Type of secretion they produce
  6. Manner in which the secretion is stored and discharged



Epithelial Tissue Summary ☺



Endocrine Glands

- Glands that do not have ducts or tubules and whose secretions are distributed throughout the body
- Produce and secrete hormones into the bloodstream or the lymphatic system
- Part of a complex, biochemical network known as the endocrine system

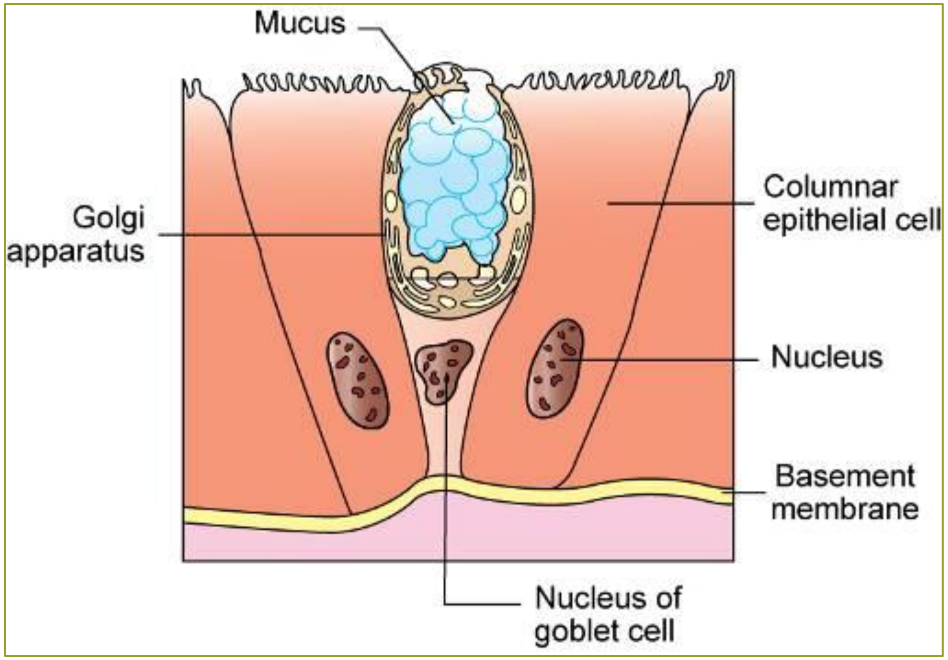
Exocrine Glands

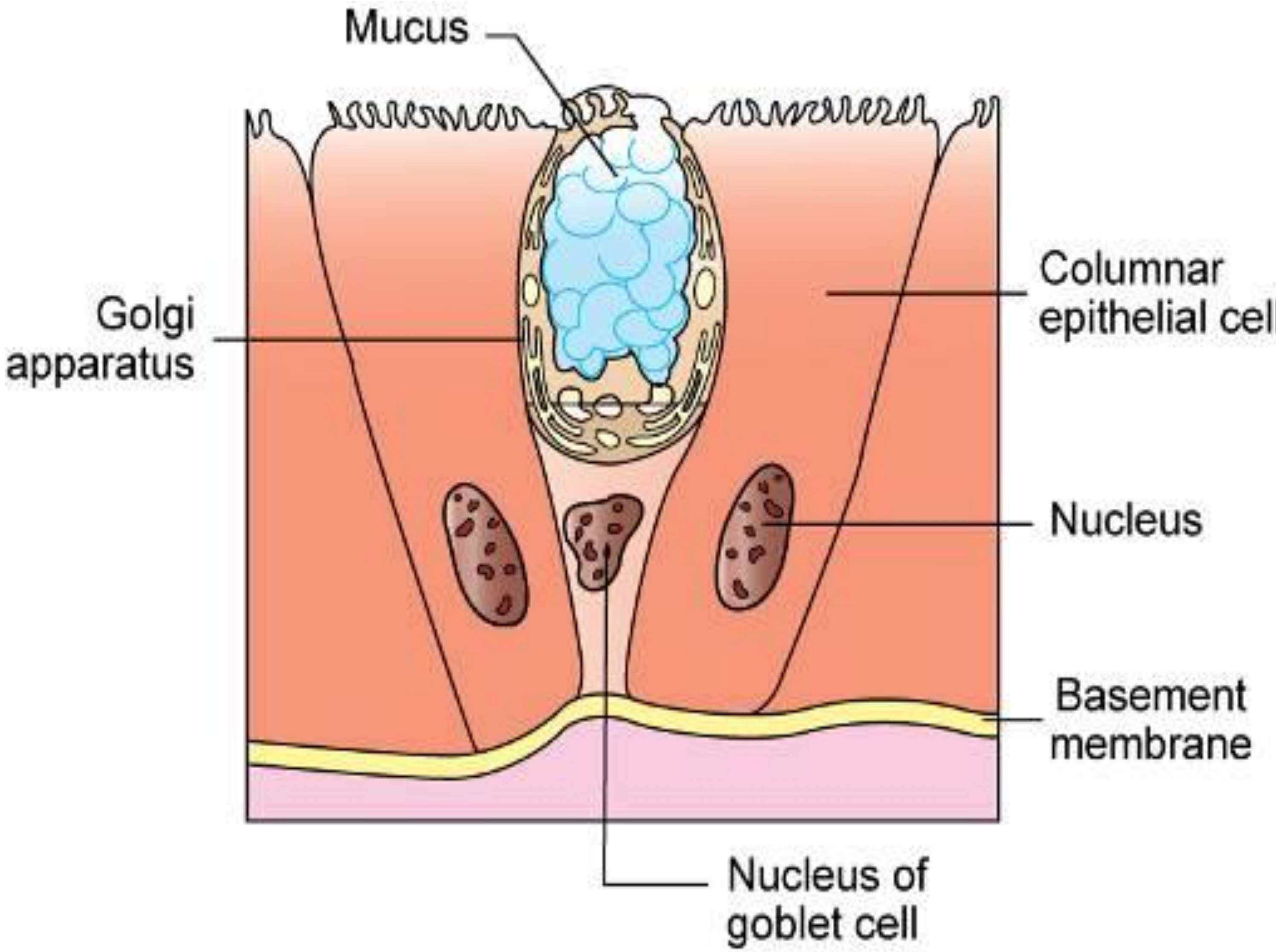
- Discharge secretions via ducts directly into local areas (except for goblet cell)
- Unicellular or multicellular

Goblet Cell

Figure 4-13, Page 104

- Unicellular exocrine gland
- Ductless and composed of modified columnar epithelial cell
- Found among columnar cells of the respiratory and digestive tracts and the conjunctiva of the eye
- Secretes mucin




Mucus
Golgi apparatus
Columnar epithelial cell
Nucleus
Basement membrane
Nucleus of goblet cell

Multicellular Exocrine Glands

Table 4-1, Page 105

- Composed of a secretory unit and a duct
- Secretory unit is usually surrounded by connective tissue rich in blood vessels and nerve fibers
- May be surrounded by myoepithelial cells that assist with the discharge of secretions into the glandular duct

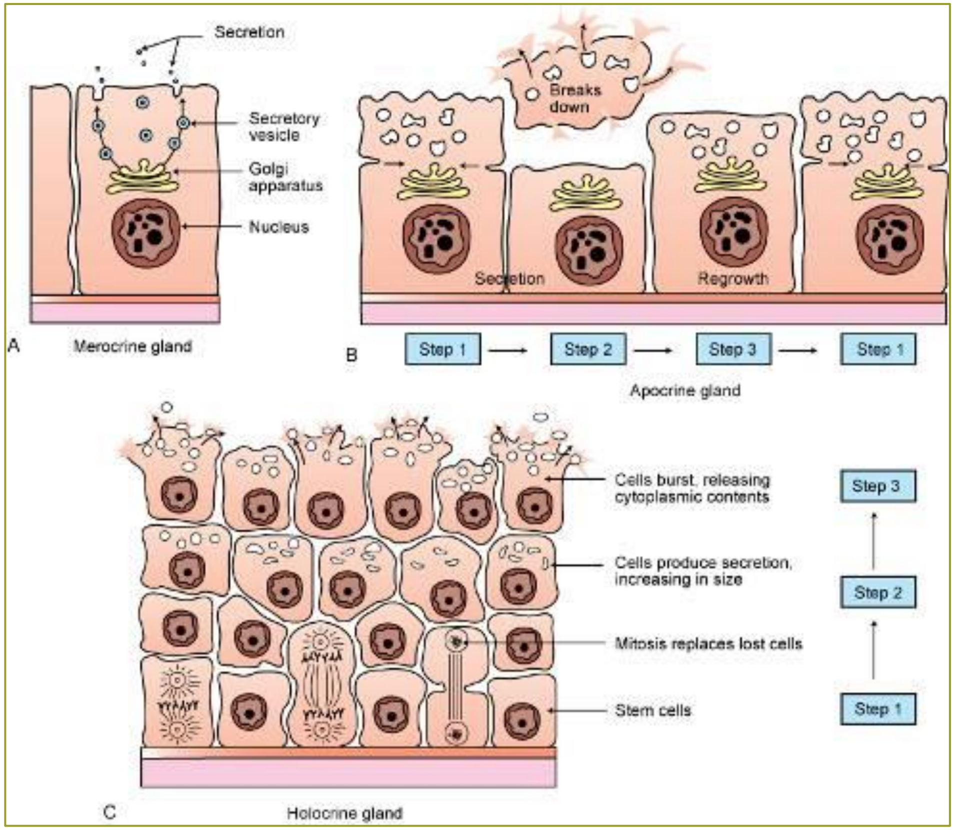
Classification of Exocrine Glands

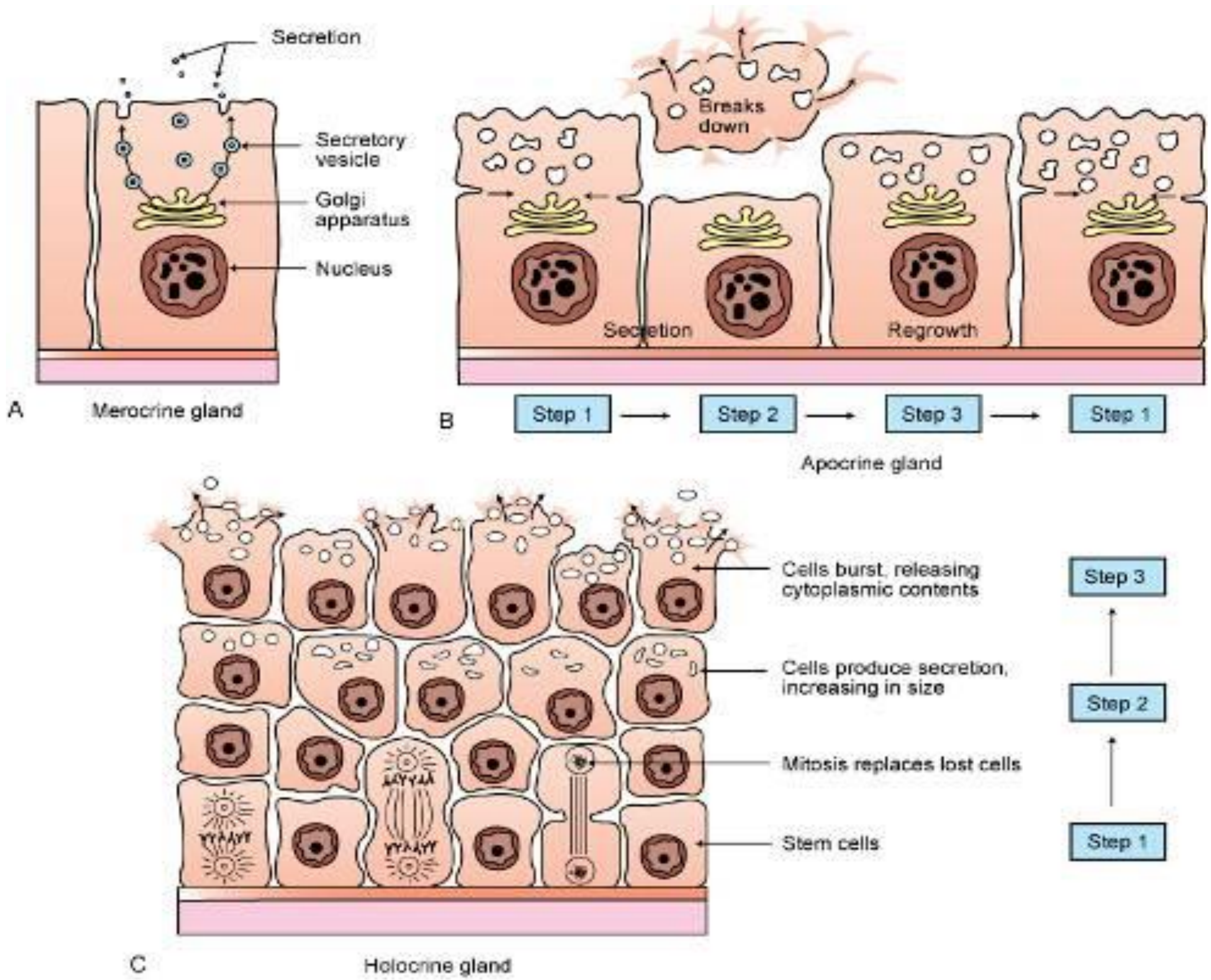
- Ducts:
  - Simple: main duct is unbranched
  - Compound: main duct is branched
- Shape of secretory portions
  - Tubular: secretory cells form a long channel of even width
  - Alveolar or acinar: secretory unit forms a rounded sac
  - Tubuloalveolar, or tubuloacinar: secretory units possess both tubular and alveolar qualities

Classification of Exocrine Glands

Figure 4-15, Page 106

- Merocrine glands package their secretions and release them via exocytosis as they are manufactured
- Apocrine glands store their secretions and then release the top part of the cell into the duct system
- Holocrine glands store their secretions and then release the entire contents of the cell





Secretion
Secretory vesicle
Golgi apparatus
Nucleus
A
Merocrine gland
Breaks down
Secretion
Regrowth
B
Step 1
Step 2
Step 3
Step 1
Apocrine gland
Cells burst, releasing cytoplasmic contents
Cells produce secretion, increasing in size
Mitosis replaces lost cells
Stem cells
Step 3
Step 2
Step 1
C
Holocrine gland

Classification of Exocrine Glands

Type of secretion produced

- **Serous** secretions
  - Watery
  - Contain a high concentration of enzymes
- **Mucous** secretions
  - Thick, viscous
  - Composed of glycoproteins
- Mixed exocrine glands contain both mucous and serous components

2. Connective Tissue

Few Cells

Matrix in between

Connective Tissue Functions

- Forms metabolic and structural connections between other tissues
- Forms a protective sheath around organs and helps insulate the body
- Acts as a reserve for energy
- Provides the frame that supports the body
- Composes the medium that transports substances from one region of the body to another
- Plays a role in the healing process and in the control of invading microorganisms

Connective Tissue Components

- Extracellular matrix
  - Extracellular fibers
  - Ground substance
- Cells

Ground Substance

- Medium through which cells exchange nutrients and waste with the bloodstream
- Amorphous, homogeneous material
- Ranges in texture from a liquid or gel to a calcified solid
- Acts to protect the more delicate cells it envelopes
- Serves as an effective obstacle for invading microorganisms

Extracellular Fibers

- Collagenous fibers
  - Strong, thick strands of collagen
  - Found in **tendons** and **ligaments**
- Reticular fibers
  - Thin, delicate, branched networks of collagen
  - Found around blood vessels, nerves, muscle fibers, and capillaries
- Elastic fibers
  - Branched networks composed primarily of the protein elastin
  - Occur in tissues commonly subjected to stretching (vocal cords, lungs, skin, and walls of blood vessels)

Cell Types

- **Fixed Cells**: involved in production and maintenance of the matrix
  - Fibro**blasts**, chondroblasts, osteoblasts, adipocytes, reticular cells
- **Transient Cells**: involved in the repair and protection of tissues
  - Leukocytes, mast cells, macrophages **(the army, police!)**

Table 4.4 Classification of Connective Tissues

Loose (areolar) connective tissue
Adipose tissue

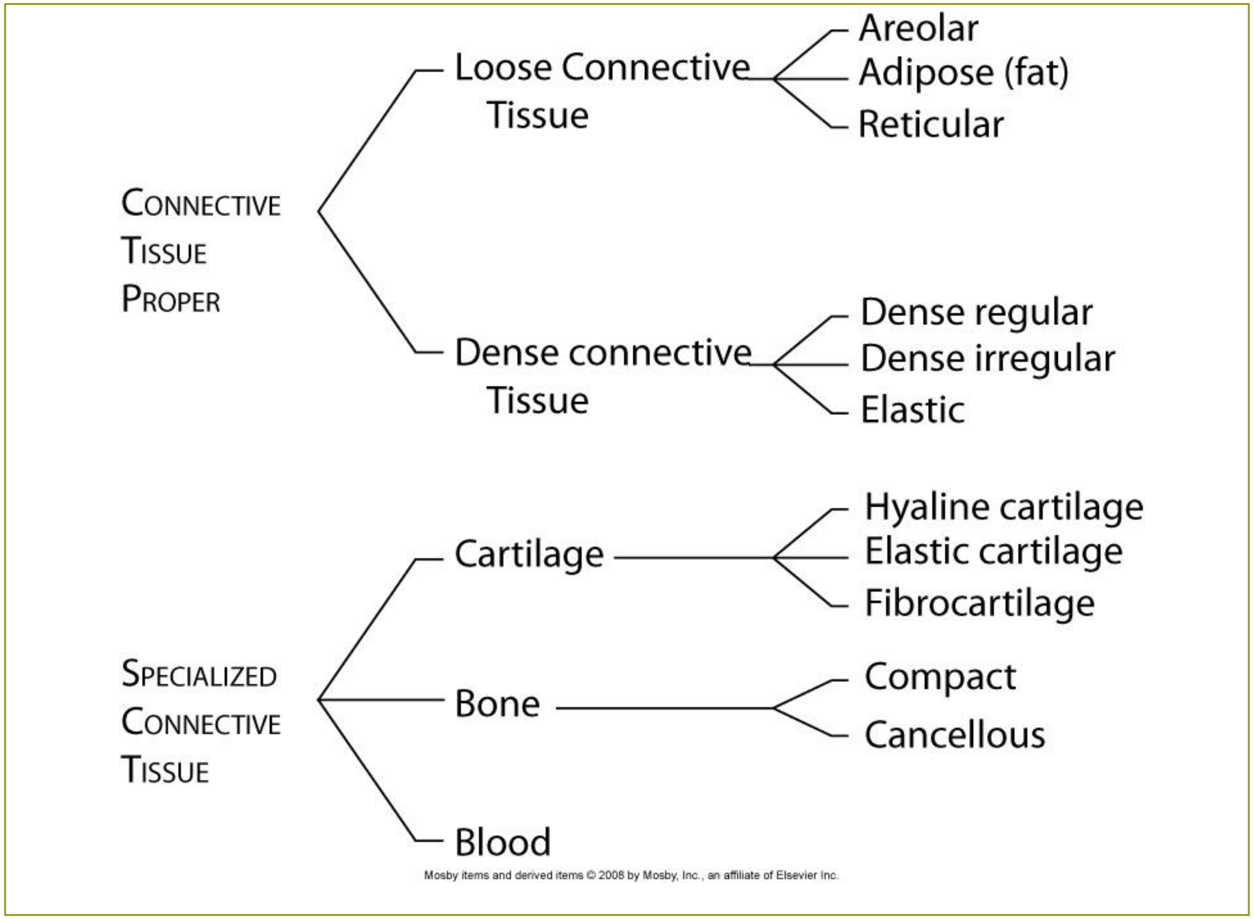
Dense connective tissue
  Dense collagenous connective tissue
    Collagen fibers arranged in the same direction
    Collagen fibers arranged in many directions
  Dense elastic connective tissue
    Elastic fibers arranged in the same direction
    Elastic fibers arranged in many directions

Cartilage
  Hyaline cartilage
  Fibrocartilage
  Elastic cartilage

Bone
Blood

Connective Tissue Types

Box 4-2, Page 117



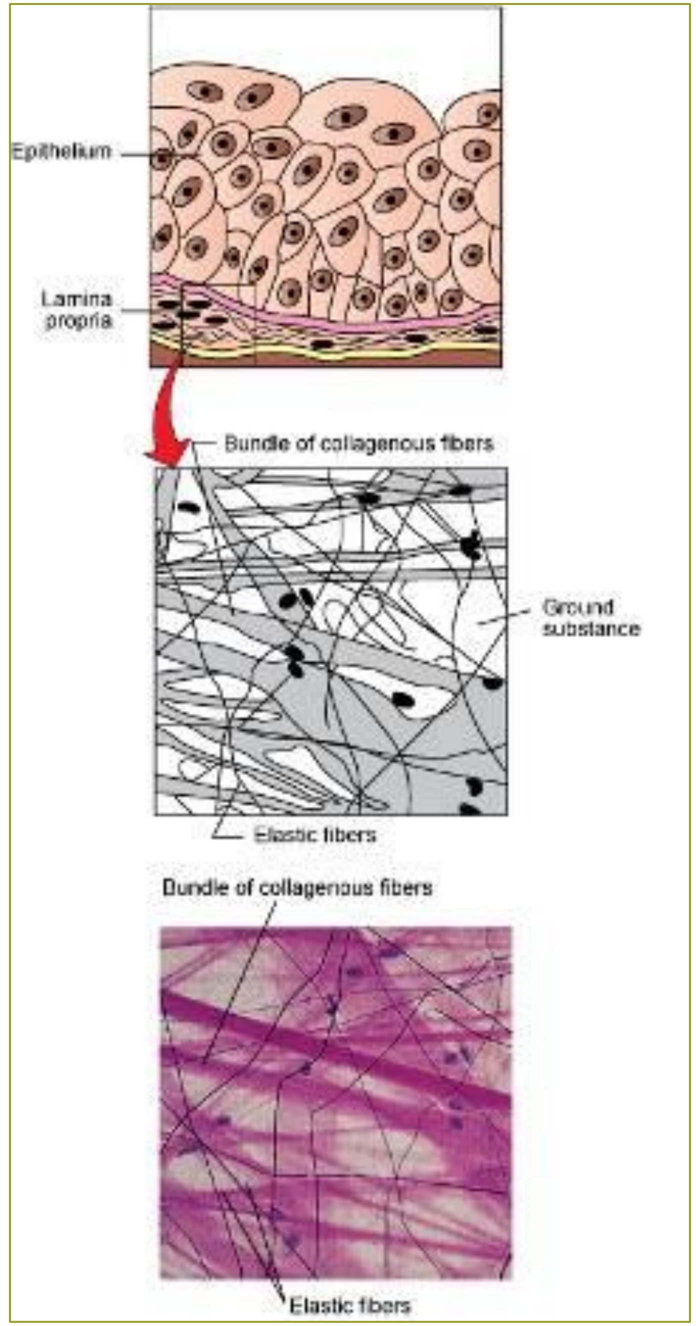
Connective Tissue Proper

- Loose connective tissue
  - Areolar
  - Adipose
  - Reticular
- Dense connective tissue
  - Dense regular
  - Dense irregular
  - Elastic

Areolar Connective Tissue

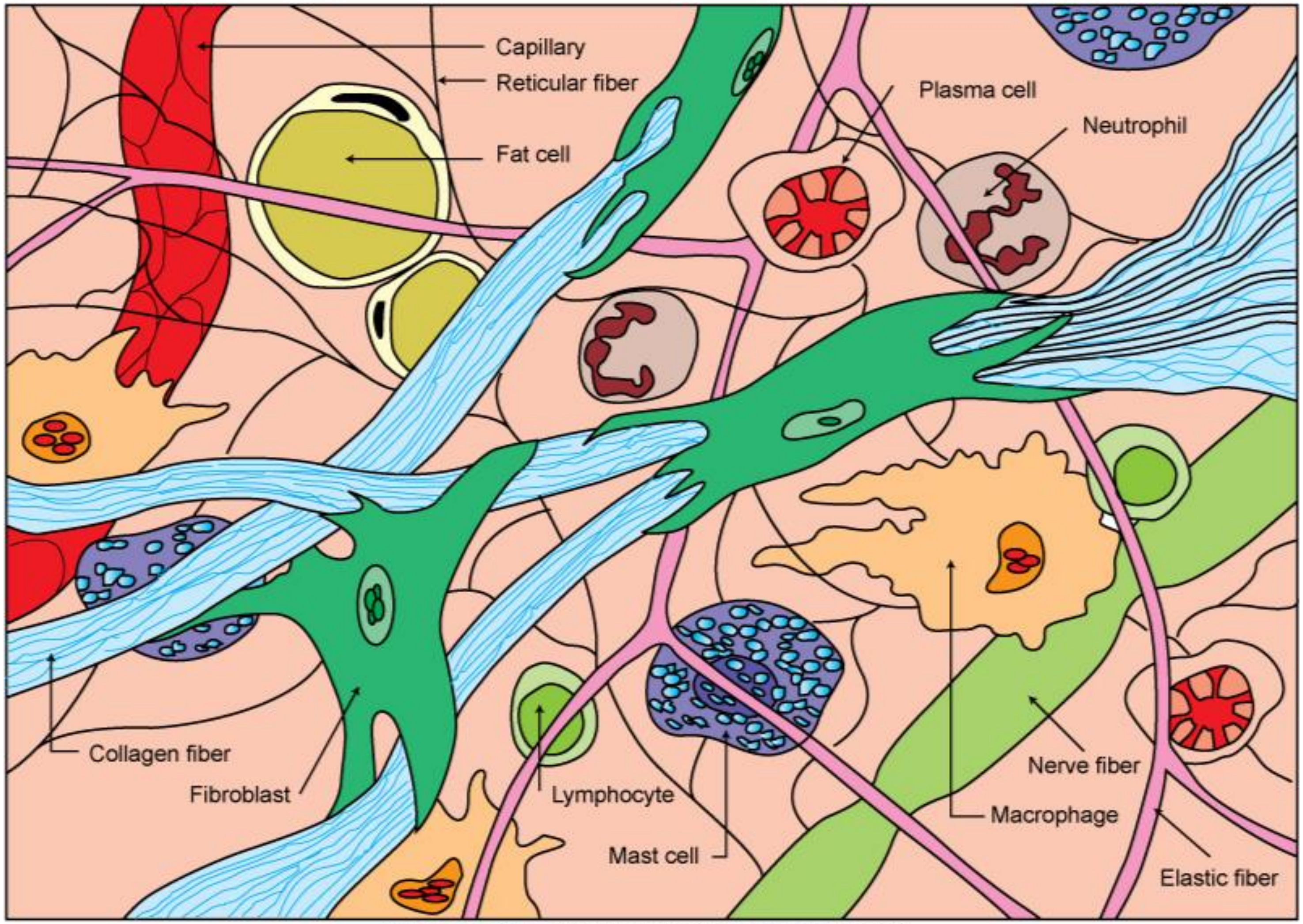
Figure 4-17, Page 110

- Loose connective tissue
- Fibers and cells suspended in a thick, translucent ground substance
- Predominant cell is the fibroblast
  - Manufactures the elastic, reticular, and collagenous fibers
- Surrounds every organ; forms the SQ layer that connects skin to muscle; envelopes blood vessels, nerves, and lymph nodes; present in all mucous membranes



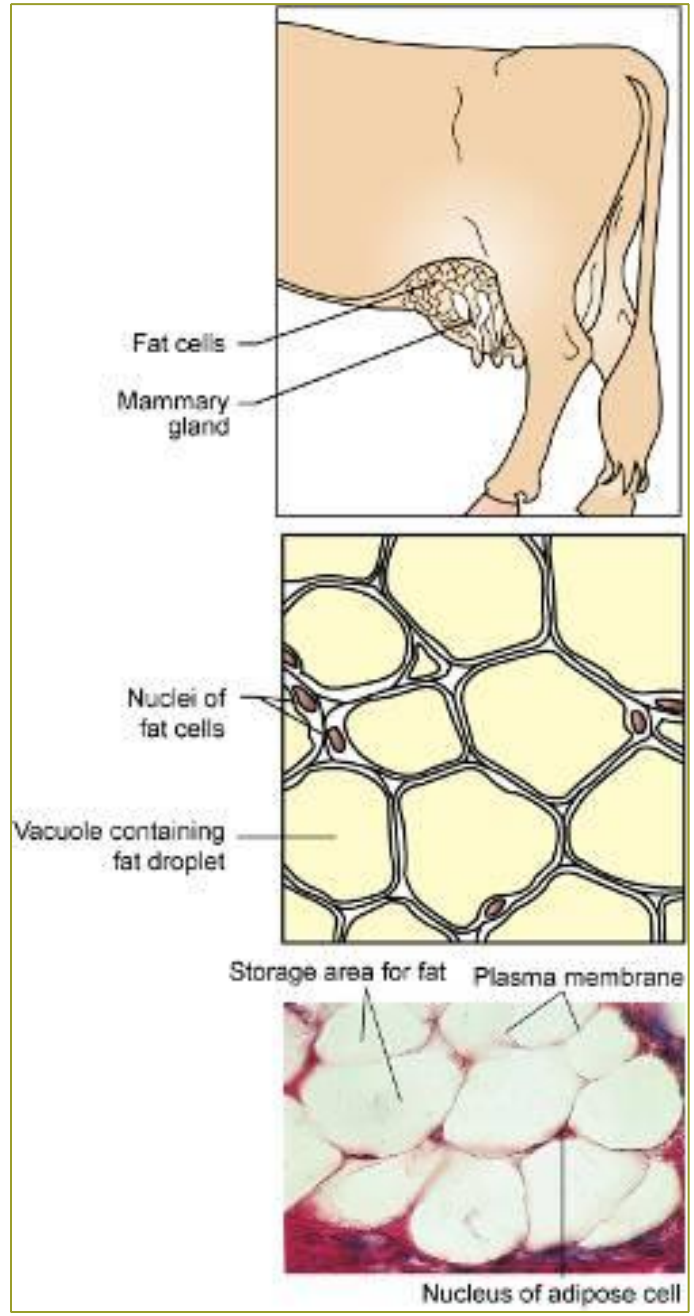
Areolar Connective Tissue

Figure 4-16, Page 107



Adipose Tissue
Figure 4-18, Page 111

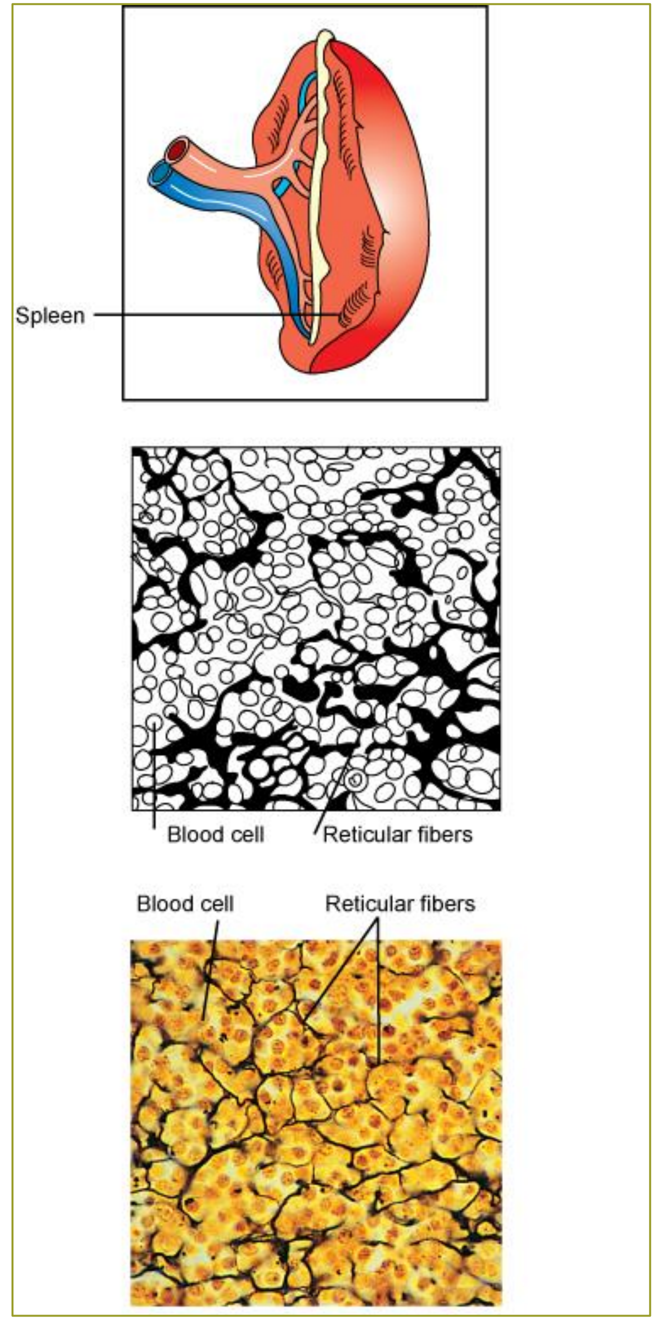
- Loose connective tissue
- Areolar tissue in which adipocytes predominate
- **Highly vascular**
- Acts as an energy storehouse and a thermal insulator



Reticular Connective Tissue

Figure 4-19, Page 112

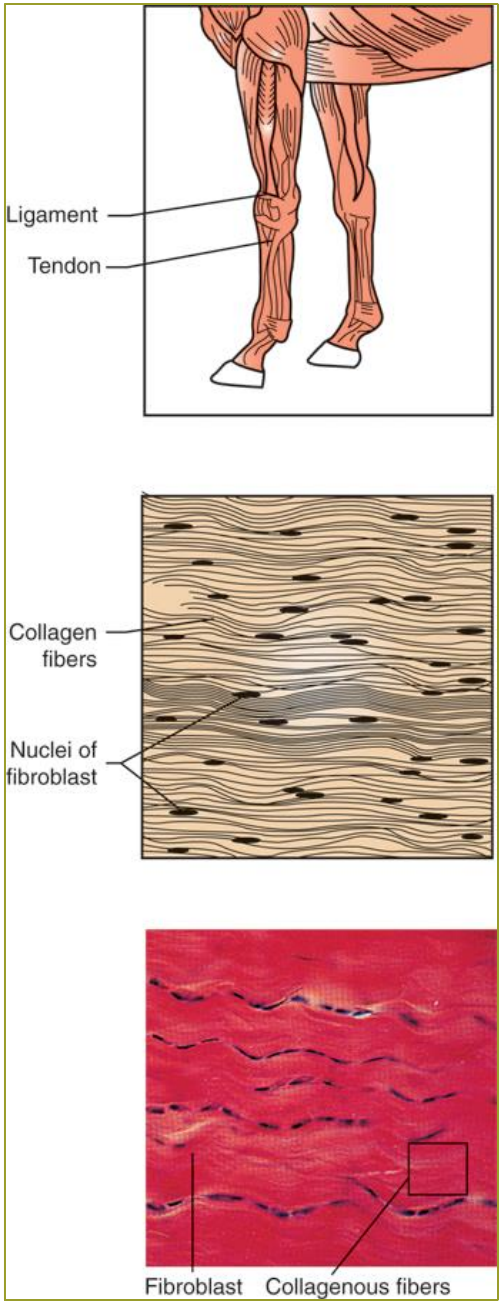
- Loose connective tissue
- Network of thin reticular fibers.
- Contains loosely arranged fibers and many fibroblasts suspended in a supportive ground substance
- Forms the stroma (framework of several organs)



Dense Regular Connective Tissue

Figure 4-20, Page 113

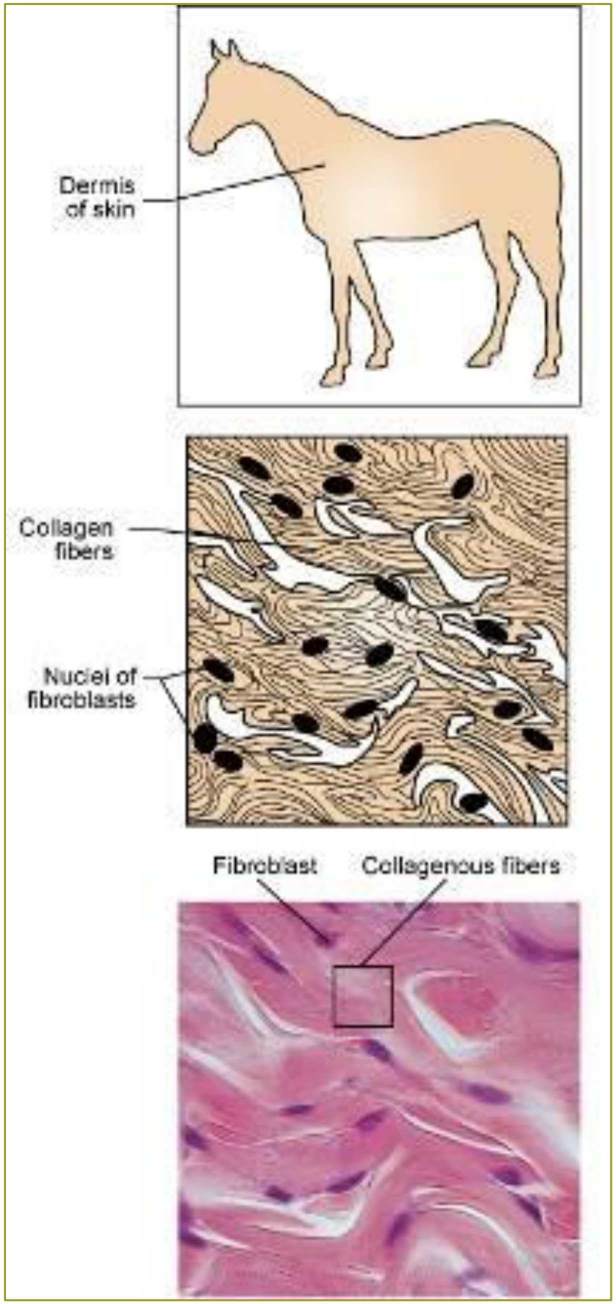
- Composed of tightly packed, parallel collagen fibers
- Relatively avascular
- Makes up the tendons and ligaments
- Can be found in fascial sheets that cover muscles



Dense Irregular Connective Tissue

Figure 4-21, Page 113

- Composed primarily of collagen fibers arranged in thick bundles
- Fibers are interwoven to form a single sheet
- Found in the dermis of the skin and in the fibrous coverings of many organs
- Forms the tough capsule of joints



Elastic Connective Tissue

- Primarily composed of **elastic** fibers
- Fibers may be arranged parallel or in interwoven patterns with fibroblasts and collagenous fibers interspersed
- Found in spaces between vertebrae and in areas of the body that require stretching (walls of arteries, stomach, bronchi, bladder, etc.)

Specialized Connective Tissues

- Cartilage
  - Hyaline cartilage
  - Elastic cartilage
  - Fibrocartilage
- Bone
- Blood

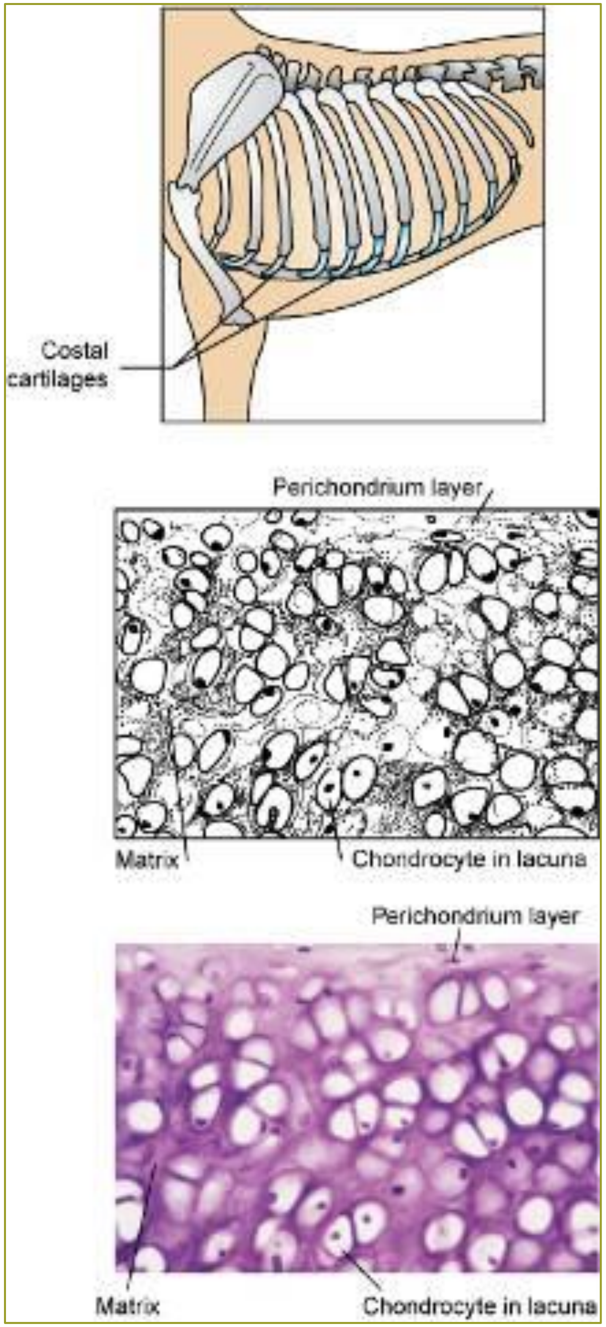
Cartilage

- Found in joints and in the ear, nose, and vocal cords
- Forms a framework on which bone is formed
- No innervation; avascular
- Cells:
  - Chondrocytes: live in hollowed-out pockets in the matrix called *lacunae*
- Matrix:
  - Ground substance: gel of chondroitin sulfate, hyaluronic acid, and chondronectin
  - Collagen fibers are most commonly found in the matrix, but elastic fibers are also present in varying amounts

Hyaline (Smooth) Cartilage

Figure 4-22, Page 114

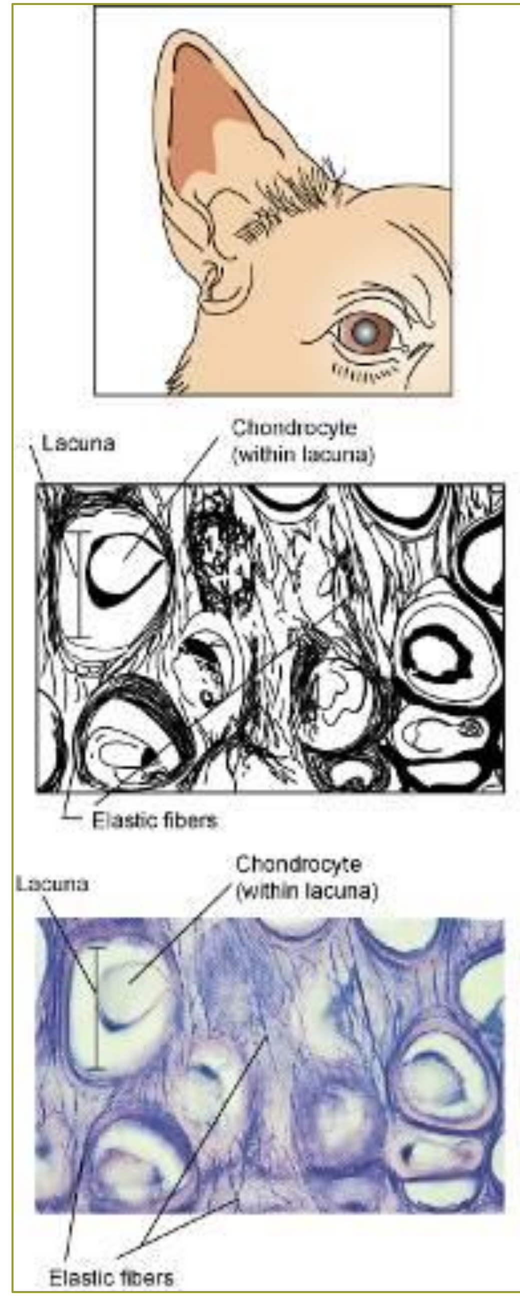
- **Most common type of cartilage found in the animal body**
- Composed of closely packed collagen
- Found in joints at the ends of long bones, growth plates of long bones, tracheal rings, and connections of the ribs to the sternum
- **Composes most of the embryonic skeleton**



Elastic Cartilage

Figure 4-23, Page 115

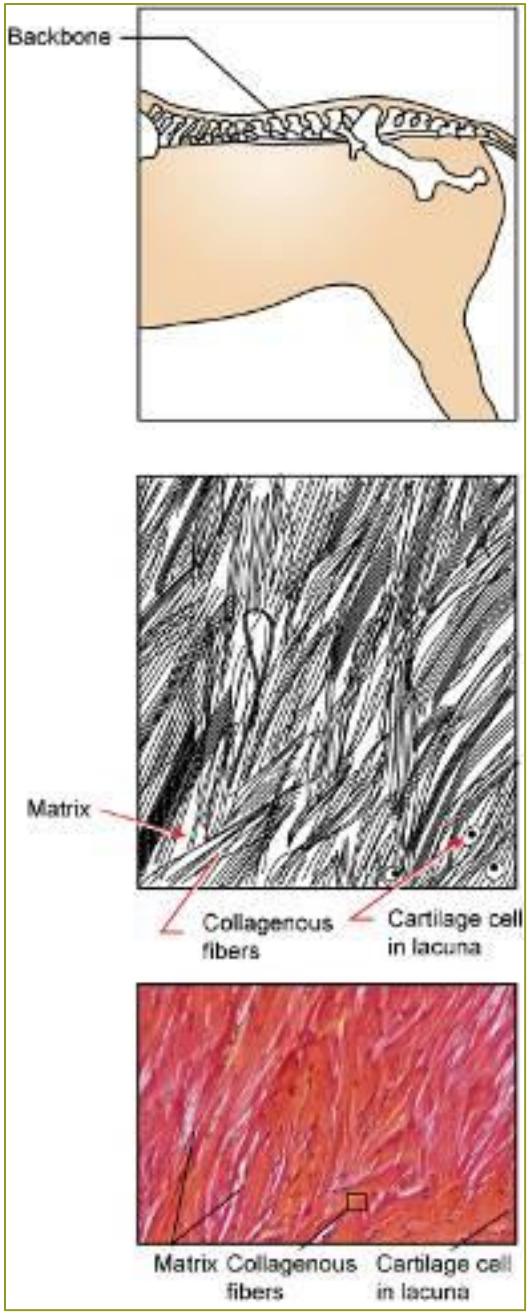
- Contains elastic fibers in dense branching bundles
- Flexible: can withstand repeated bending
- Found in the epiglottis of the larynx and in pinnae of ears of animals



Fibrocartilage

Figure 4-24, Page 116

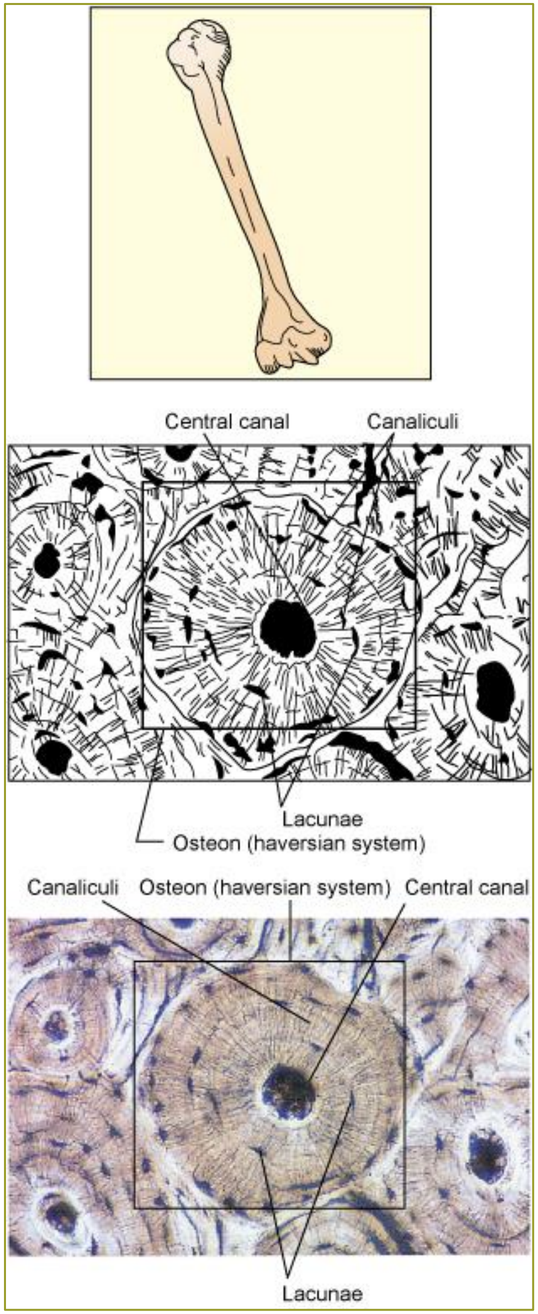
- Usually found merged with hyaline cartilage and dense connective tissue
- Contains thick bundles of collagen fibers with fewer chondrocytes than hyaline cartilage
- Lacks a perichondrium
- Found in spaces between vertebrae of the spine, between bones in the pelvic girdle, and in the knee joint



Bone

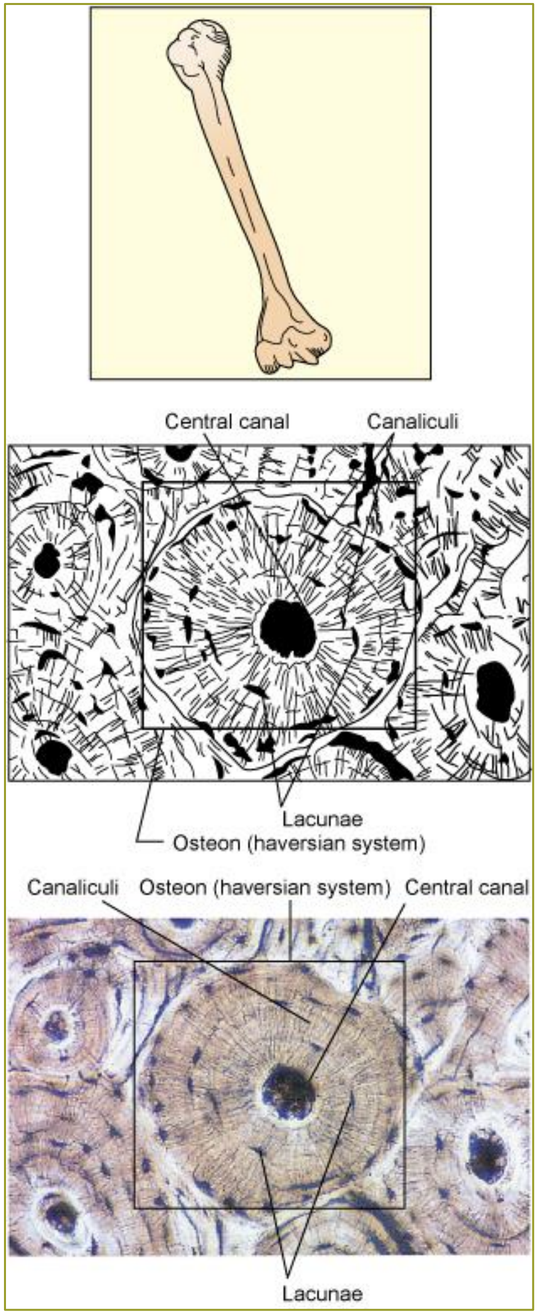
Figure 4-25, Page 116

- Matrix is a combination of organic collagen fibers and inorganic calcium salts
- **Well vascularized**
- Haversian canal contains both a vascular and a nerve supply
- Canaliculi: channels within the matrix support passage of blood vessels into deeper portions of tissue



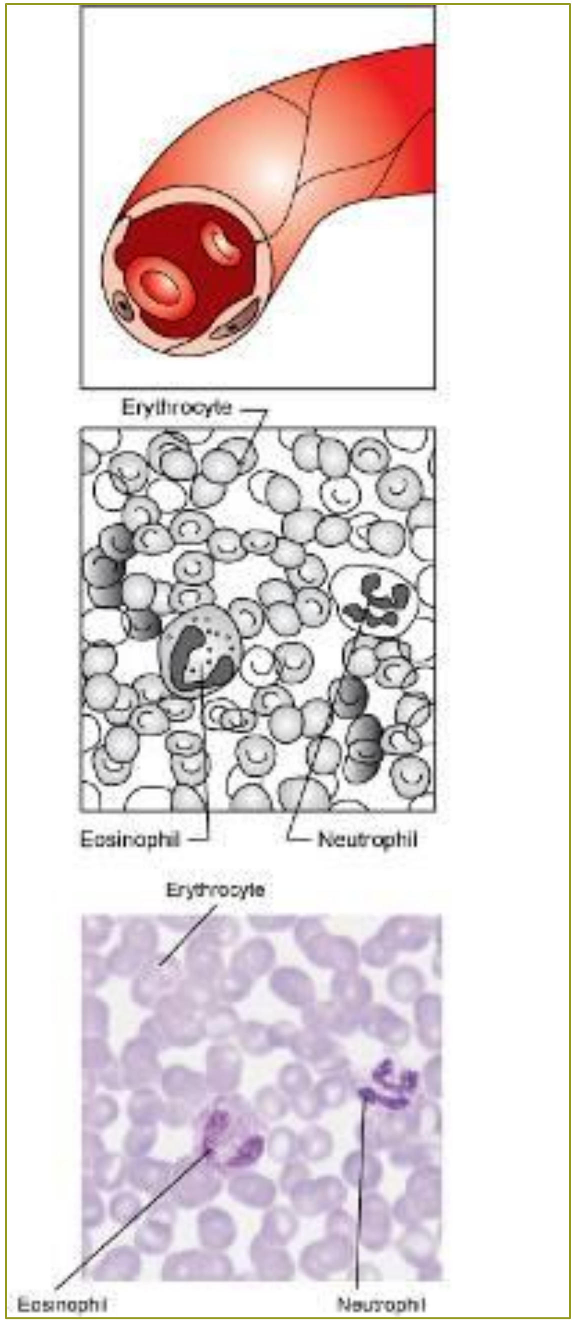
Bone Cells

- Osteo**blasts**: manufacture the fibers that are part of the matrix
  - Lacunae and canaliculi are created as the osteoblasts manufacture the bony matrix
- **Osteocytes** reside in lacunae
  - Cellular extensions pass through the canaliculi

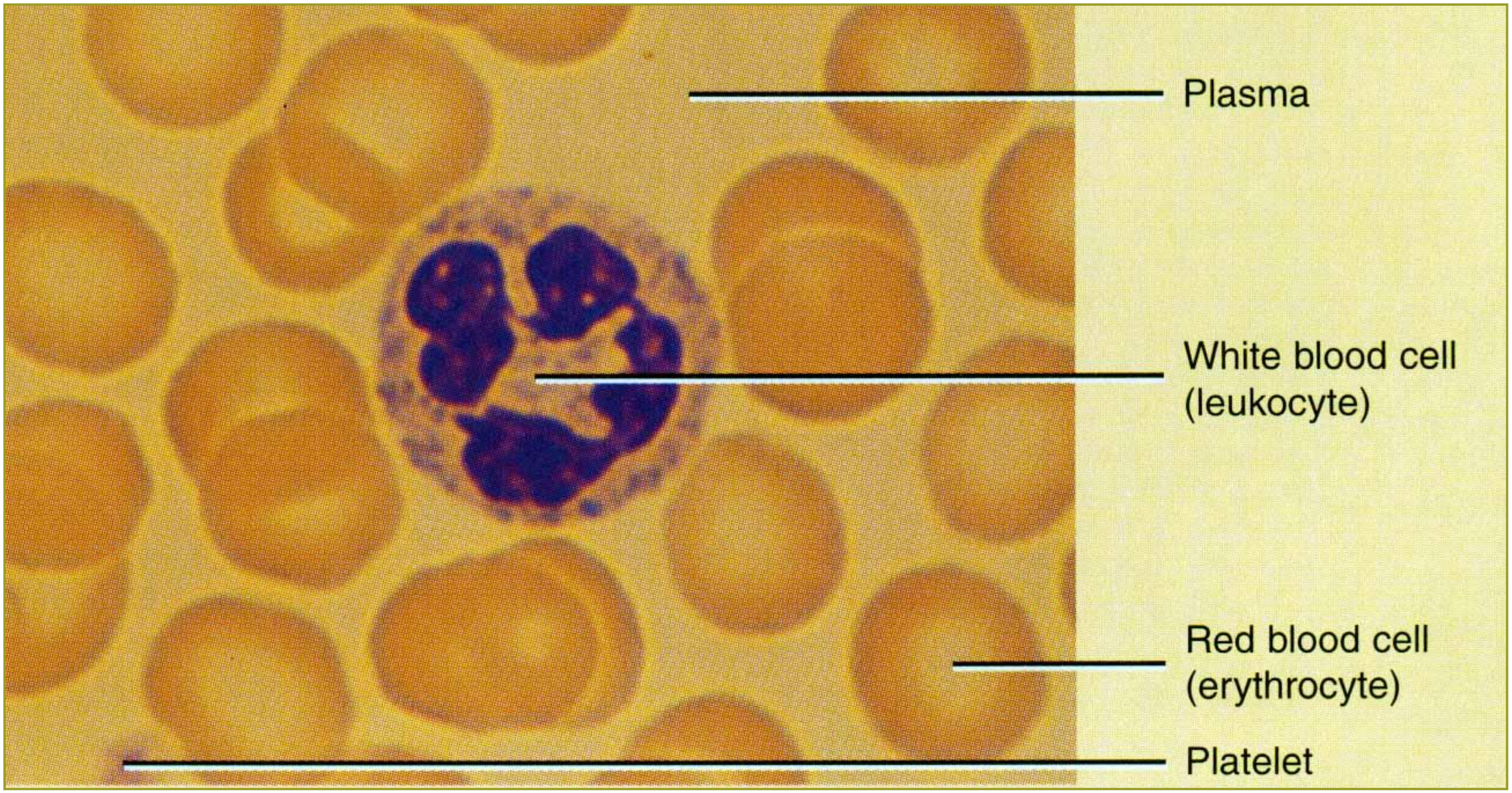


Blood
Figure 4-26, Page 117

- **Matrix**:
  - Ground substance: **plasma**
  - fibrous component: protein
- **Cells**
  - Erythrocytes
  - Leukocytes
  - Thrombocytes



Blood Tissue



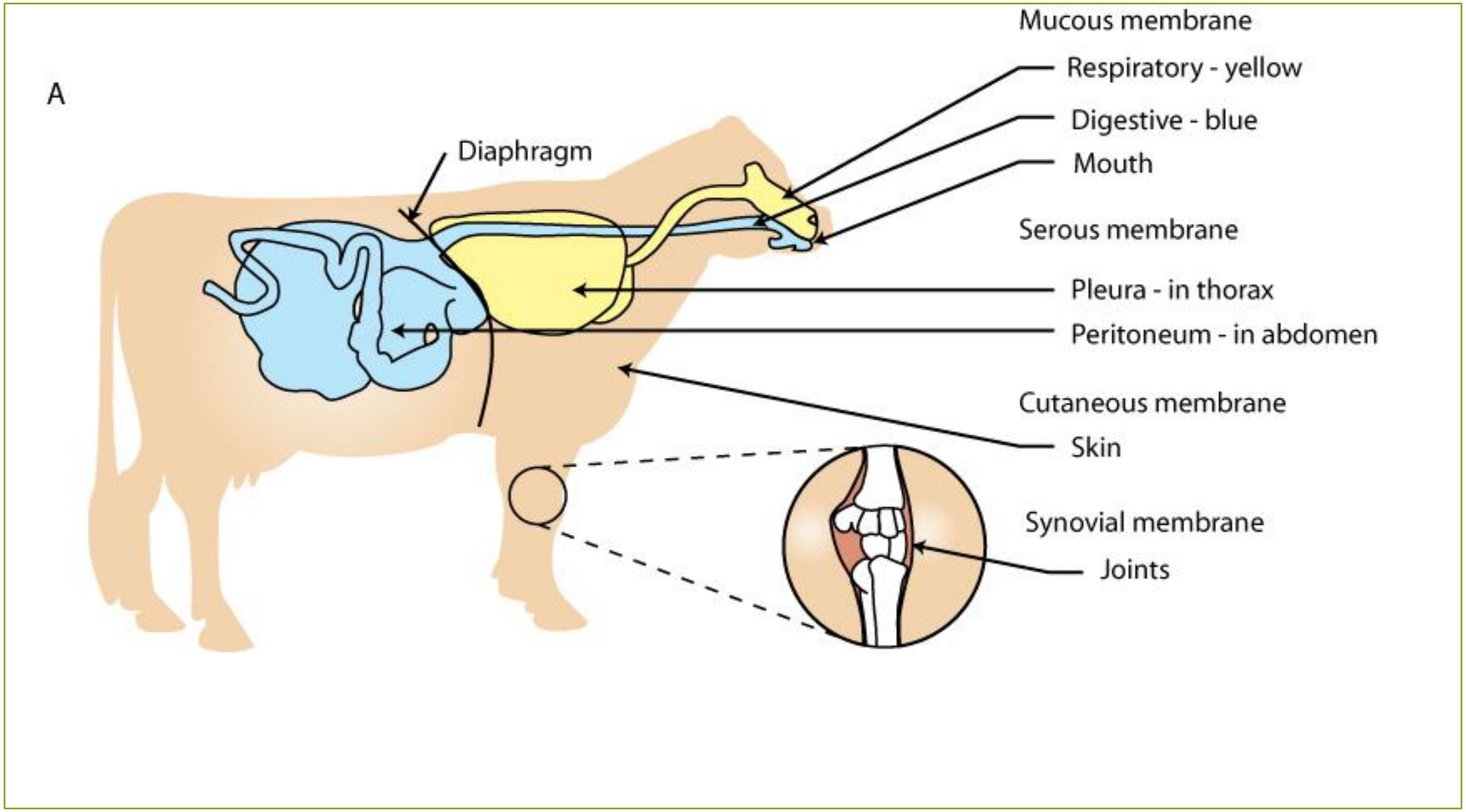
Membranes

Epithelial Tissue

Connective Tissue

Mucous Membranes

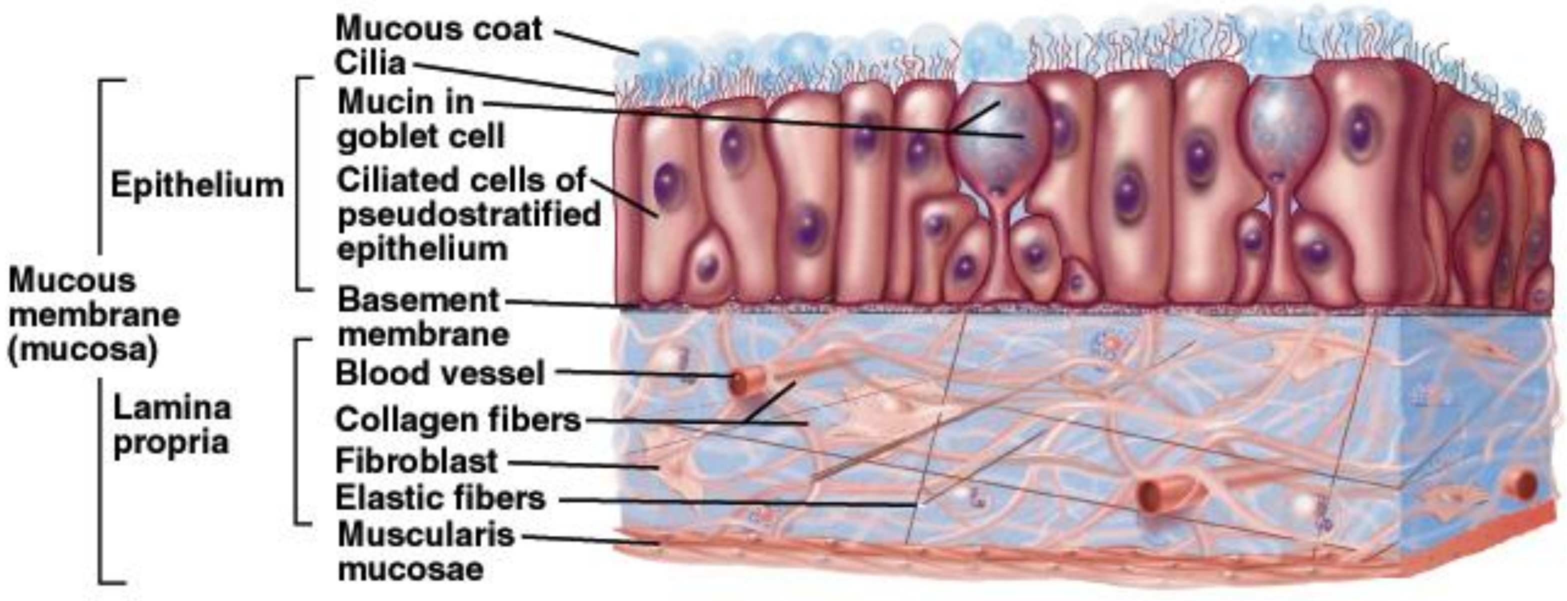
Figure 4-27A, Page 118



Mucous Membranes (Mucosae)

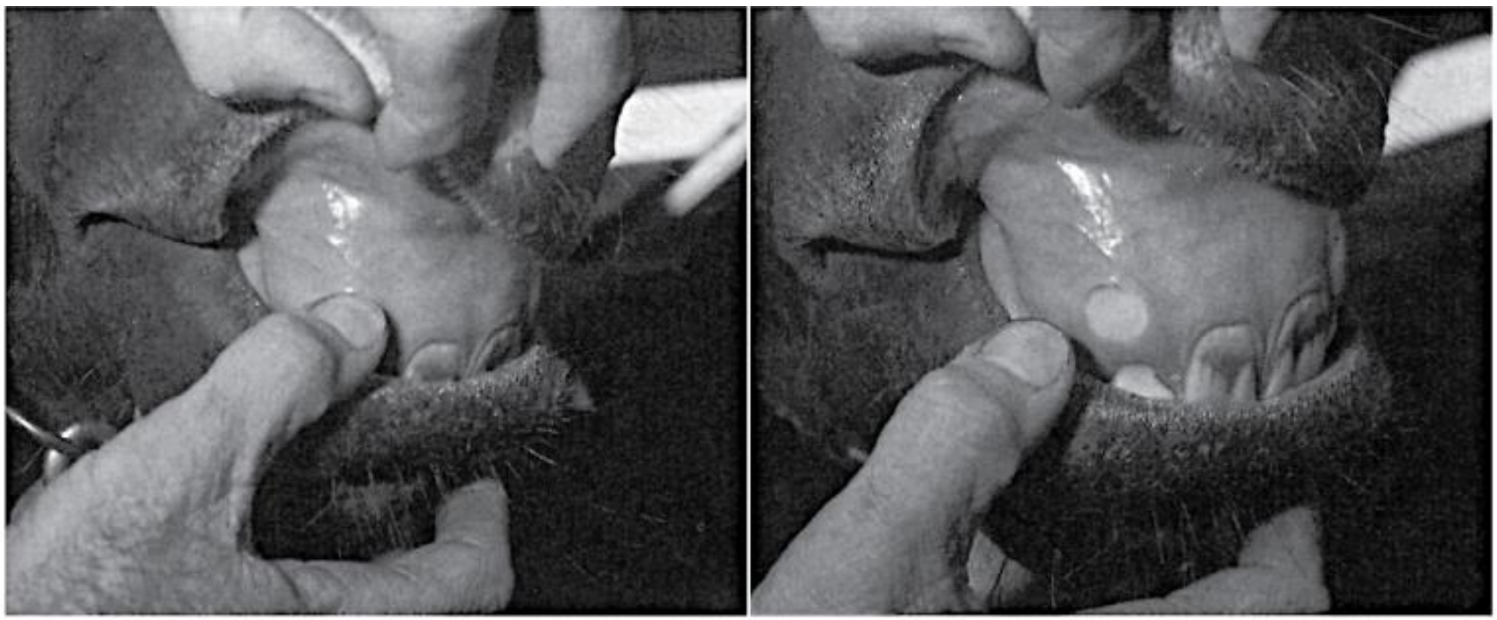
- Line organs with connections to the outside environment (mouth, intestines, nasal passages, etc.)
- Usually composed of either stratified squamous or simple columnar epithelium covering a layer of loose connective tissue
- May contain goblet cells or multicellular glands
  - Can produce large quantities of mucus
- Some mucosae also can absorb (e.g., the epithelial layer in the intestine)

Mucous Membranes (Mucosa)



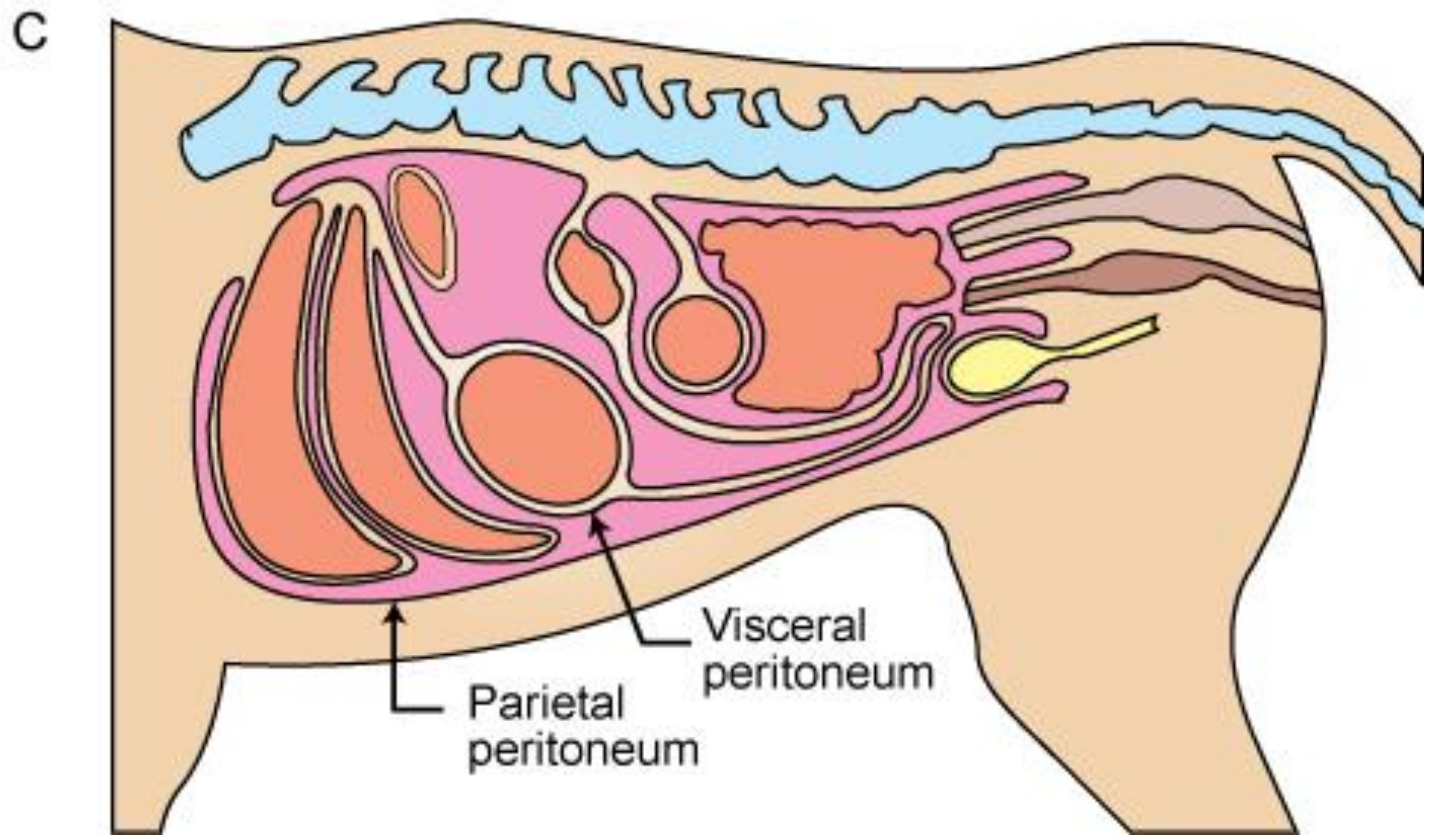
Mucous Membrane Color & Capillary Refill Time (CRT)

Clinical Application, Page 119

A  B

Serous Membranes

Figure 4-27C, Page 118



Serous Membranes (Serosae)

- Line walls and cover organs of body cavities (e.g., thorax and abdominopelvic cavities)
- Consist of a continuous sheet **doubled over** on itself to form **two layers**
- The portion of the membrane that lines the cavity wall is called the **parietal layer**
- The portion of the membrane that covers the outer surface of organs is called the **visceral layer**
- In abdominopelvic cavity, visceral layers of serosa merge to form **mesenteries**

Cutaneous Membrane (Skin)

- Also called **integument** (or, more simply, **skin**)
- Composed of an outer keratinized stratified squamous epithelium, or **epidermis**
- Epidermis is attached to an underlying layer of dense irregular connective tissue called the **dermis**
- Dermis contains collagenous, reticular, and elastic fibers which enable skin to be both strong and elastic

Synovial Membranes

- Line the cavities of joints
- Composed of loose connective tissue and adipose tissue covered by a layer of collagen fibers and fibroblasts
- Manufacture the **synovial fluid** that fills the joint spaces

3. Muscle Tissue

Skeletal

Smooth

Cardiac

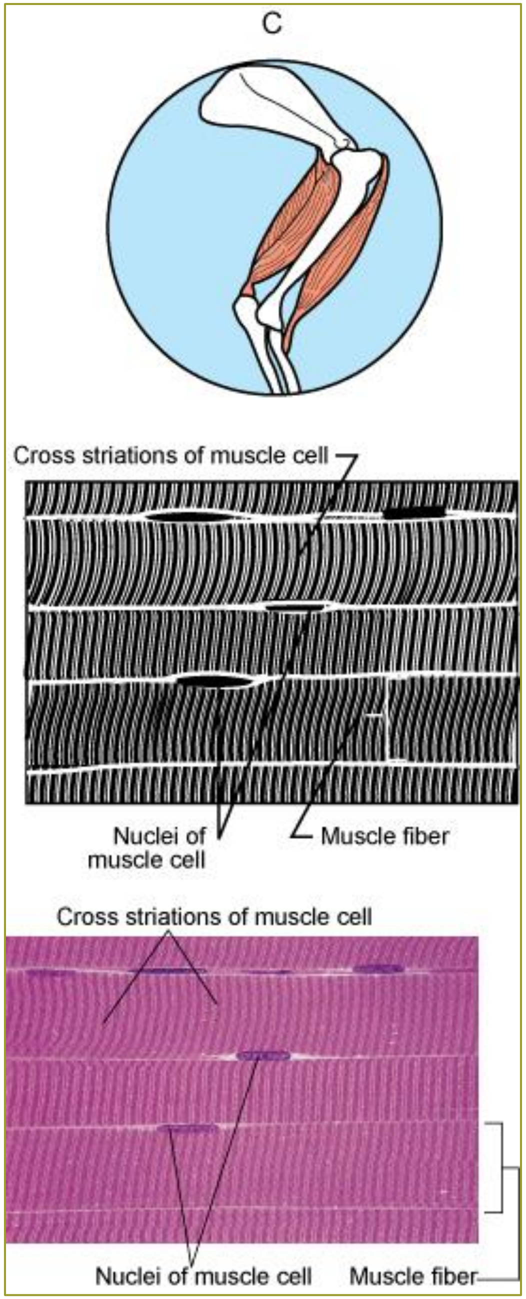
Table 7.2 Comparison of Muscle Types

Feature	Skeletal Muscle	Cardiac Muscle	Smooth Muscle
			
Location	Attached to bone	Heart	Wall of hollow organs, blood vessels, and glands
Appearance			
Cell shape	Long, cylindrical	Branched	Spindle-shaped
Nucleus	Multiple, peripheral	Usually single, central	Single, central
Special features		Intercalated disks	Cell–cell attachments
Striations	Yes	Yes	No
Autorhythmic	No	Yes	Yes
Control	Voluntary	Involuntary	Involuntary
Function	Move the whole body	Heart contraction to propel blood through the body	Compression of organs, ducts, tubes, etc.

Skeletal Muscle

Figure 4-28-C, Page 126

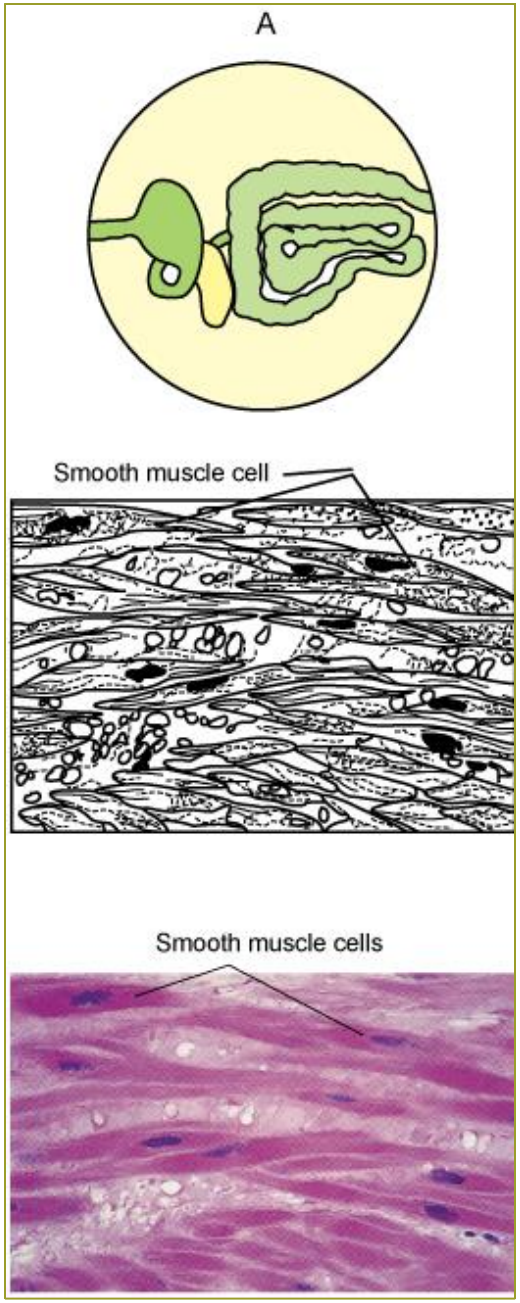
- Large cells that contain **hundreds of nuclei and mitochondria**
- Usually controlled through conscious efforts (**voluntary** muscle)
- Skeletal muscle cells are **striated**
- The collagen fibers that surround the cells merge with the collagen fibers in tendons



Smooth Muscle

Figure 4-28-A, Page 126

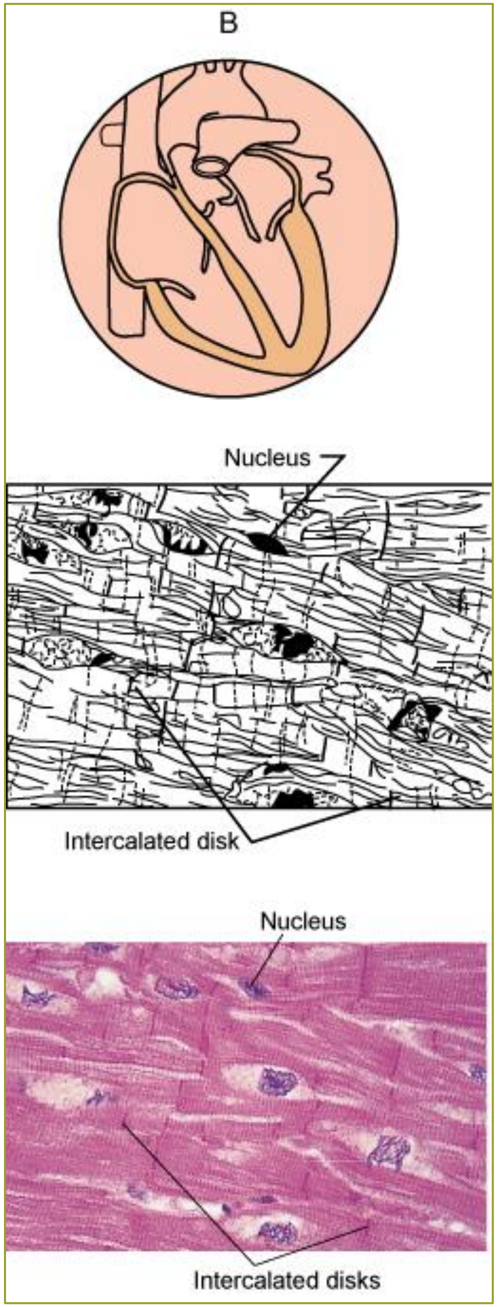
- Small cells that lack striations
- Muscle contractions cannot be consciously controlled (non-striated involuntary muscle)
- Found in the walls of hollow organs, in exocrine glands, and along the respiratory tract
  - Responsible for peristalsis in gastrointestinal tract, constriction of blood vessels, and emptying of urinary bladder



Cardiac Muscle

Figure 4-28-B, Page 126

- Found **only in the heart**
- Contains **specialized pacemaker cells** that supply signal for heart to contract at regular intervals
- Entirely **involuntary** and **striated**
- Cardiac muscle cells connected to one another via **intercalated disks**



4. Nervous Tissue

Neurons

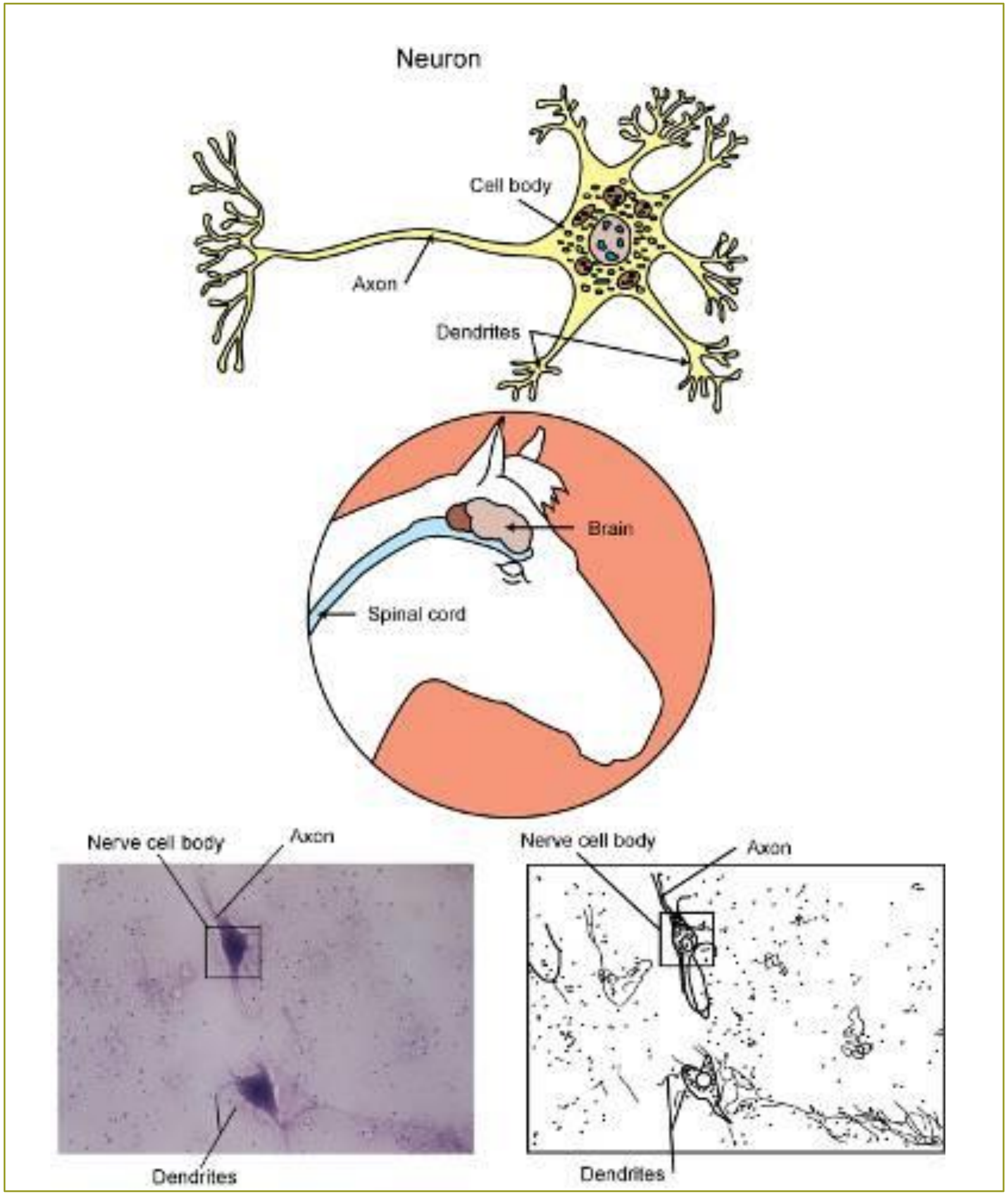
Neuroglial Cells

Nervous Tissue

- Designed to receive and transmit electrical and chemical signals throughout the body
  - **Most specialized cells in animal's body**
  - Longest cells in animal's body
- Found in the brain, spinal cord, and peripheral nerves
- Composed of two general cell types:
  - **Neurons**
  - **Supporting neuroglial cells**

Nervous Tissue

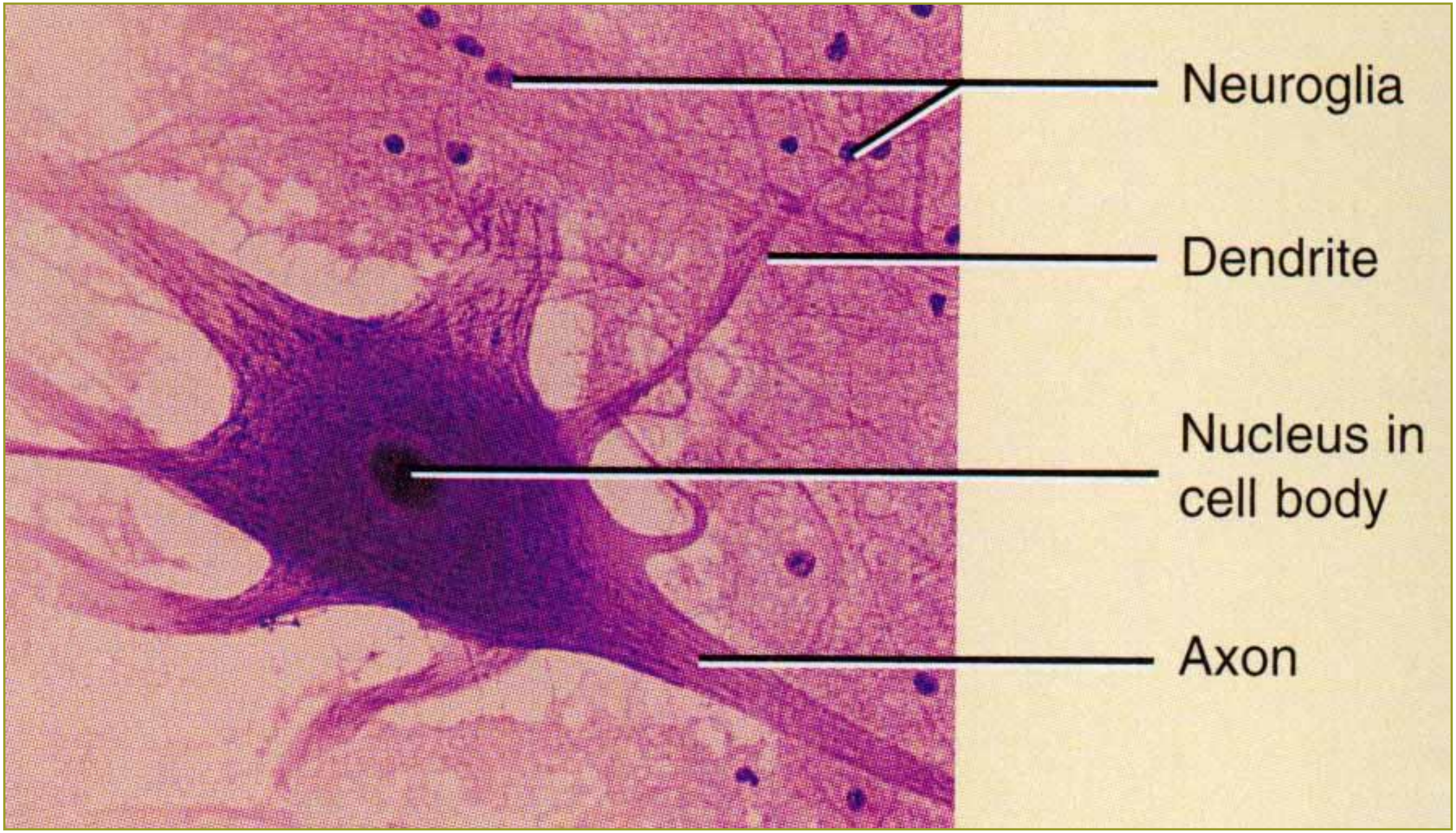
Figure 4-29, Page 127



Nervous Tissue Cells

- **Neurons – longest cells** in the animal body; three primary parts:
  - **Perikaryon** – the **cell body**; contains the nucleus
  - **Dendrites** – short cytoplasmic extensions; receives impulses
  - **Axons** – long, single extension; conducts impulses away from the cell body
- **Neuroglial cells**
  - Support the neurons

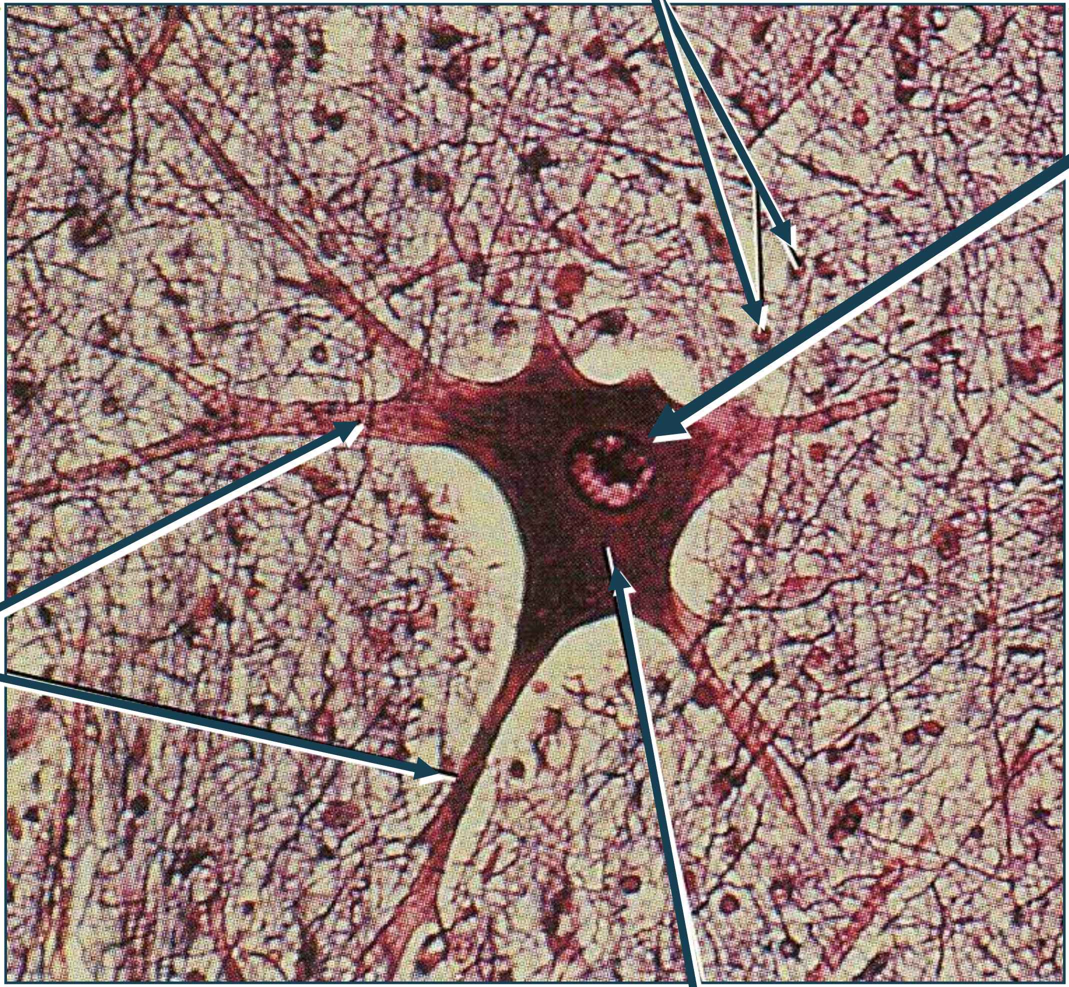
Parts of a Neuron



Parts of a Neuron

Neuroglial cells

Nucleus with Nucleolus

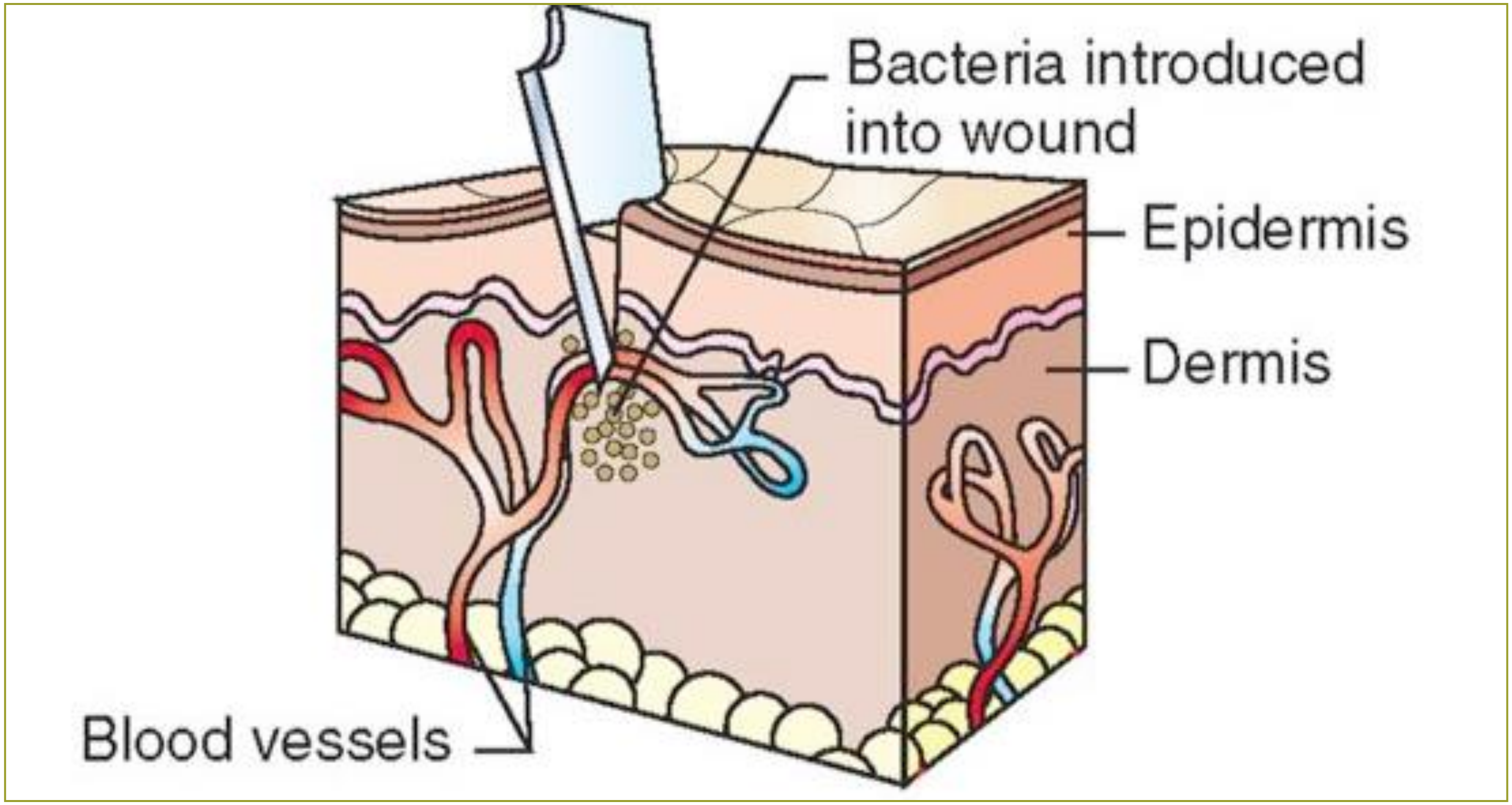


Axons or Dendrites

Cell body

Topic 19

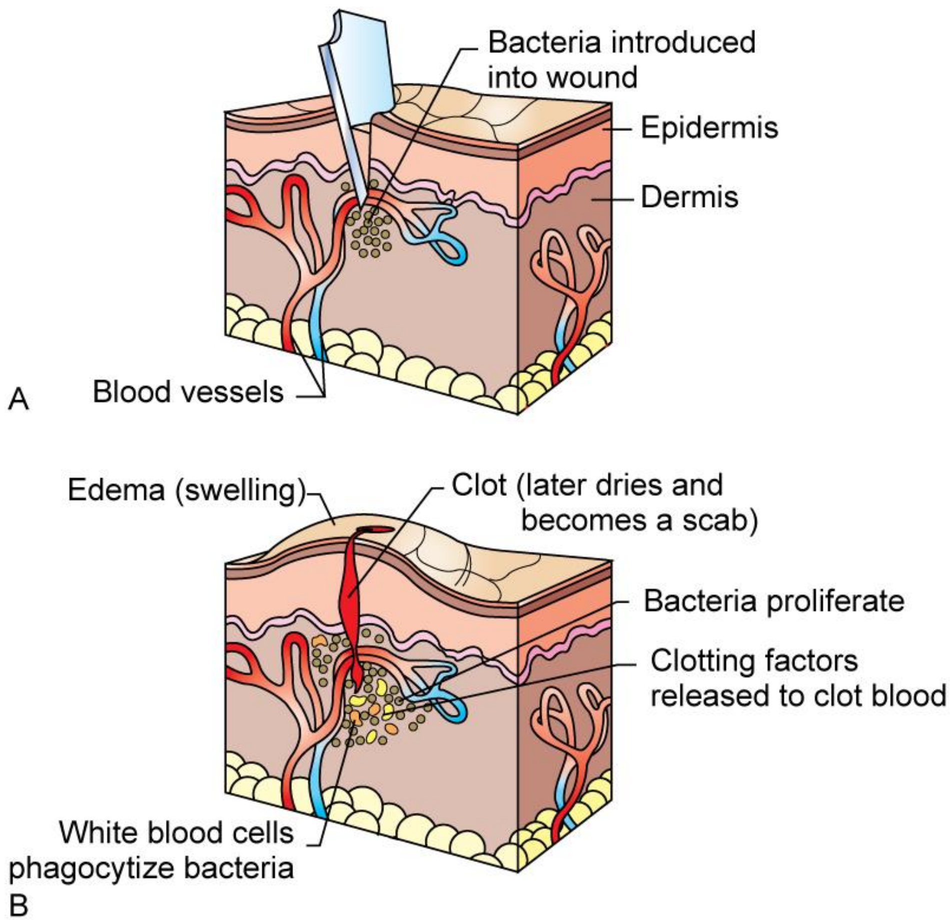
Describe the steps of wound healing in an animal body



Tissue Healing and Repair

- **Inflammation**: initial response to injuries
  - Goal: limit further damage and eliminate any harmful agents
- **Repair**: involves organization of granulation tissue and regeneration of lost tissue or formation of scar tissue

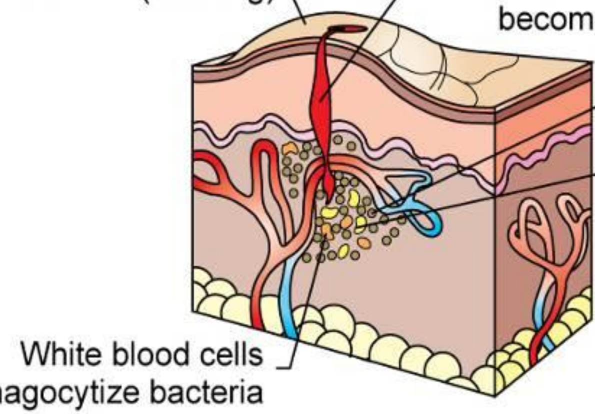
Tissue Repair
Figure 4-30A&B, Page 128



Inflammation

Figure 4-30B, Page 128

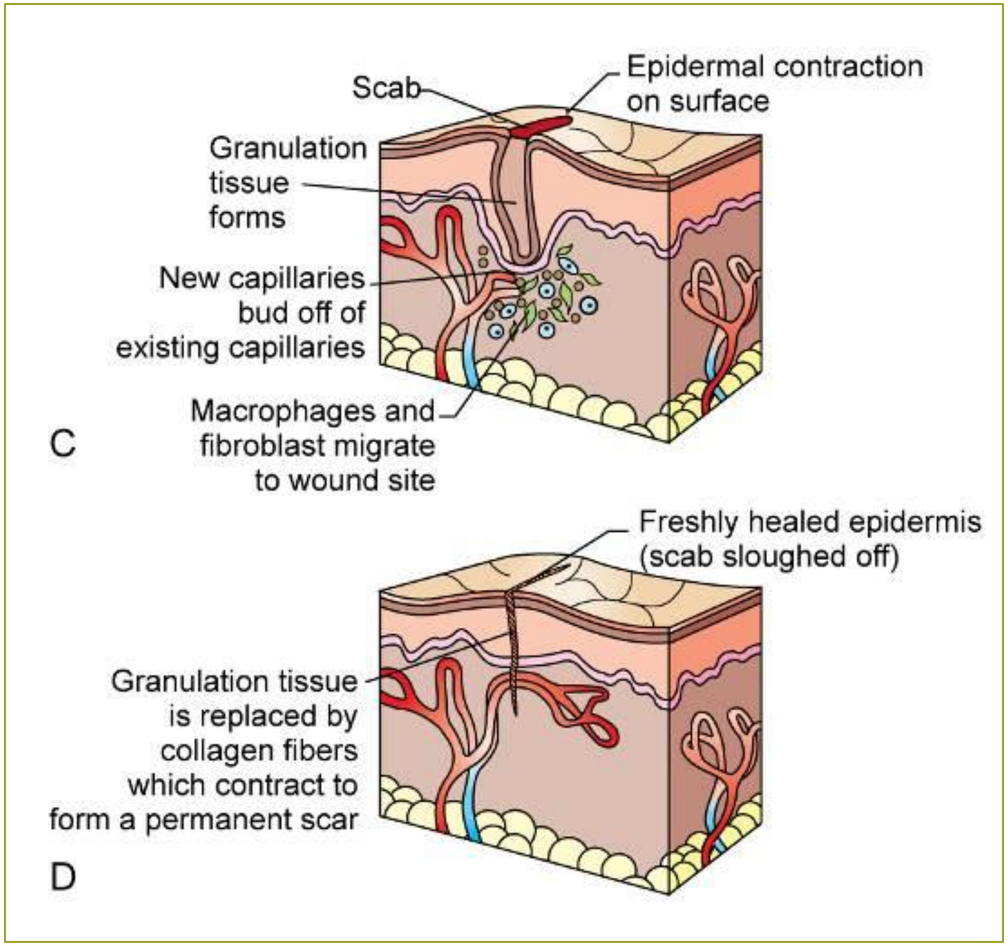
- **Nonspecific reaction** to injury or disease
- Steps
  1. Vasodilation
  2. Swelling
  3. Clot formation
  4. Phagocytosis
  5. Capillaries return to normal size, blood flow and fluid leakage into the affected area abate



Formation of Granulation Tissue and Epithelialization

Figure 4-28-C & D, Page 128

- Tissue that forms beneath the overlying blood clot or scab
- Composed of a layer of collagen fibers infiltrated with capillaries (that have branched off existing capillaries in deeper layers of damaged tissue)
- Granulation tissue is slowly replaced by fibrous scar tissue

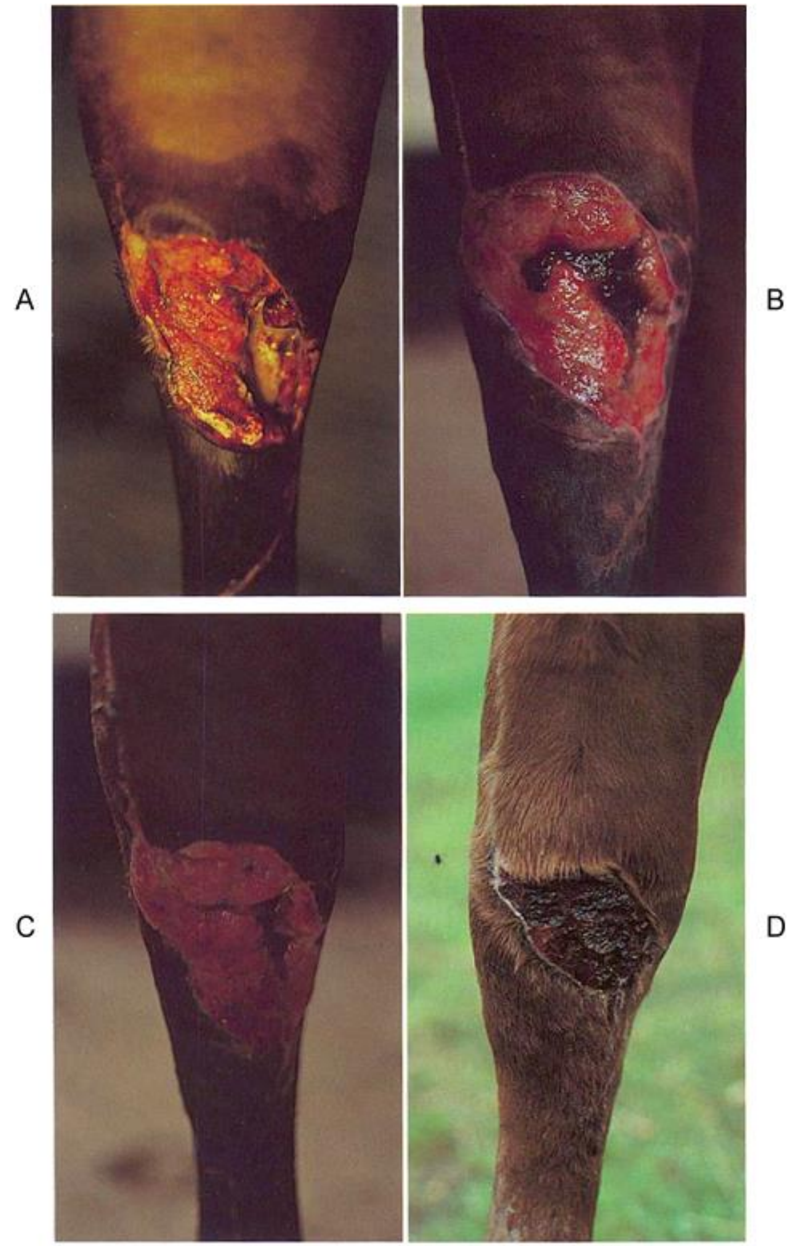


Classification of Wound Healing

- First intention:
  - Edges of wound held in close apposition
  - Skin forms a primary union without formation of granulation tissue or significant scarring
- Second intention:
  - Edges of wound separated from each another
  - Granulation tissue forms to close gap; scarring results
- Third intention:
  - Contaminated wound left open until contamination is reduced and inflammation subsides; later closed by first intention; also called *delayed primary closure*

Second Intention Wound Healing

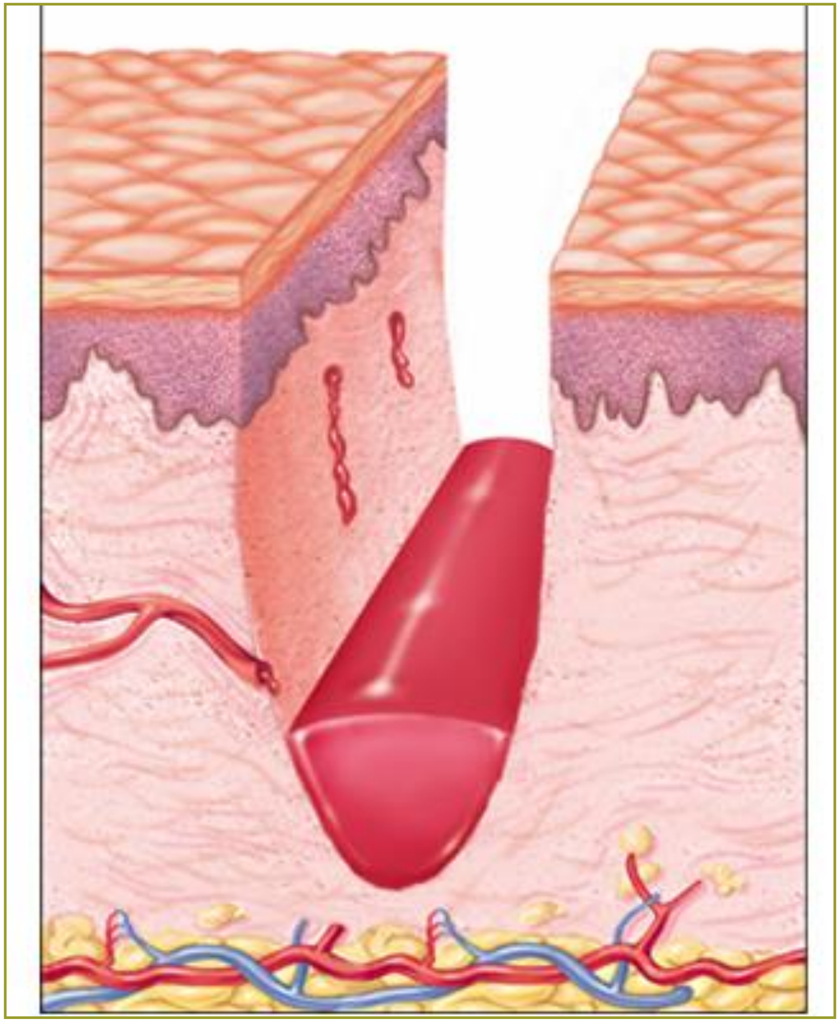
Figure 4-31, Page 130



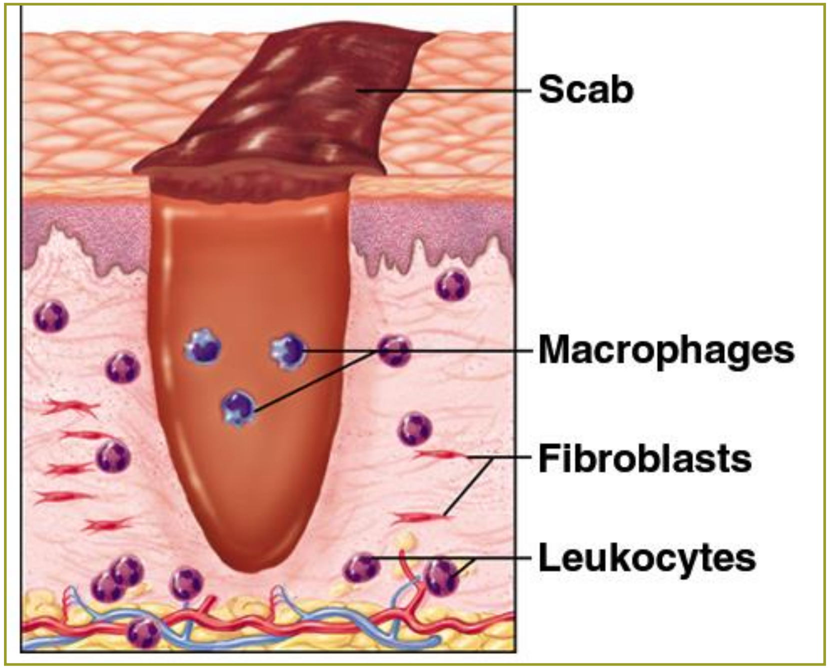
(From Melling M, Alder M: *Equine practice*, ed 3, Philadelphia, 1998, Saunders.)

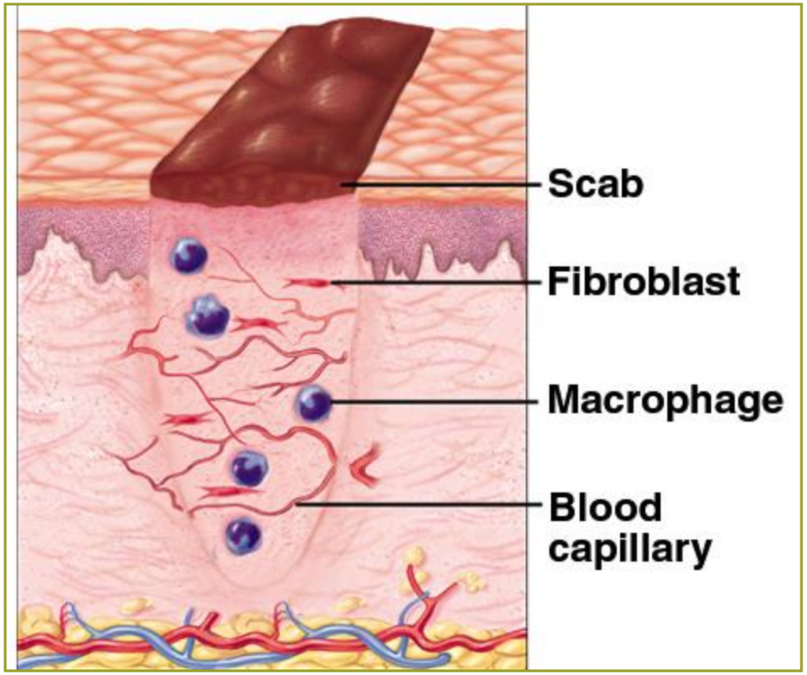
Review – Tissue Healing & Repair

- Injury to tissue
- Inflammation
- Formation of granulation tissue
- Regeneration (new tissue) or fibrosis (scar tissue)



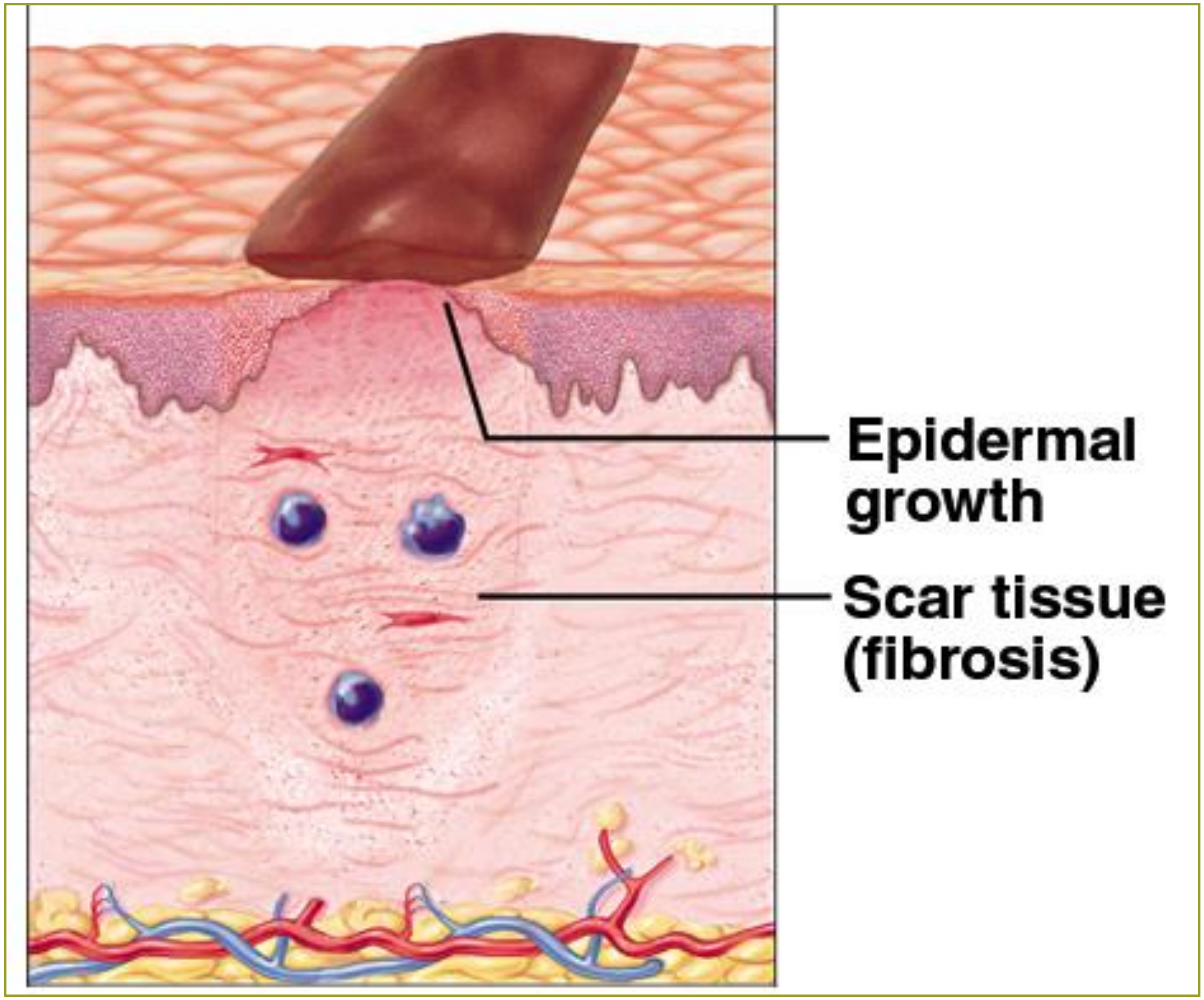
Steps of Wound Healing



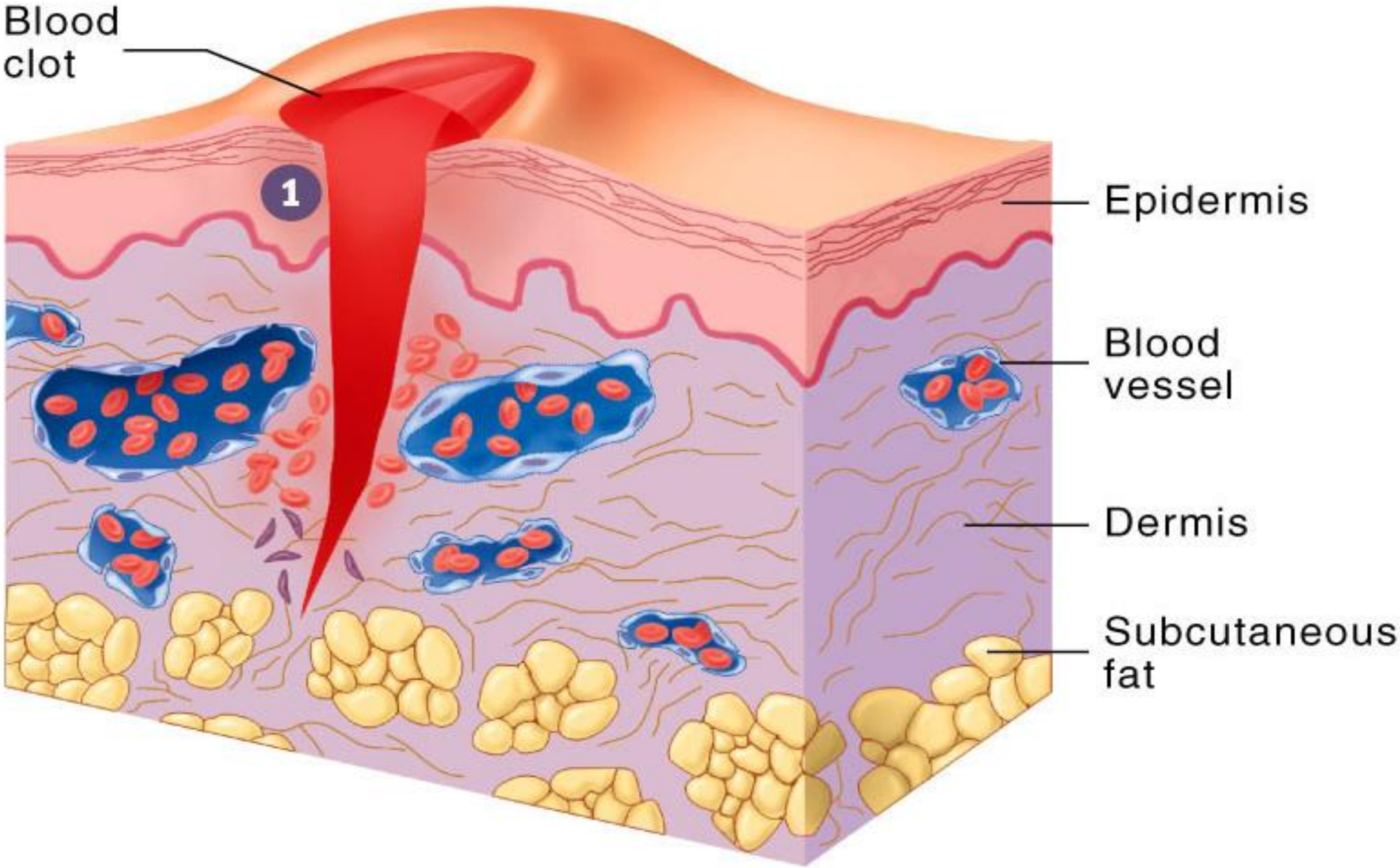


Scab formation

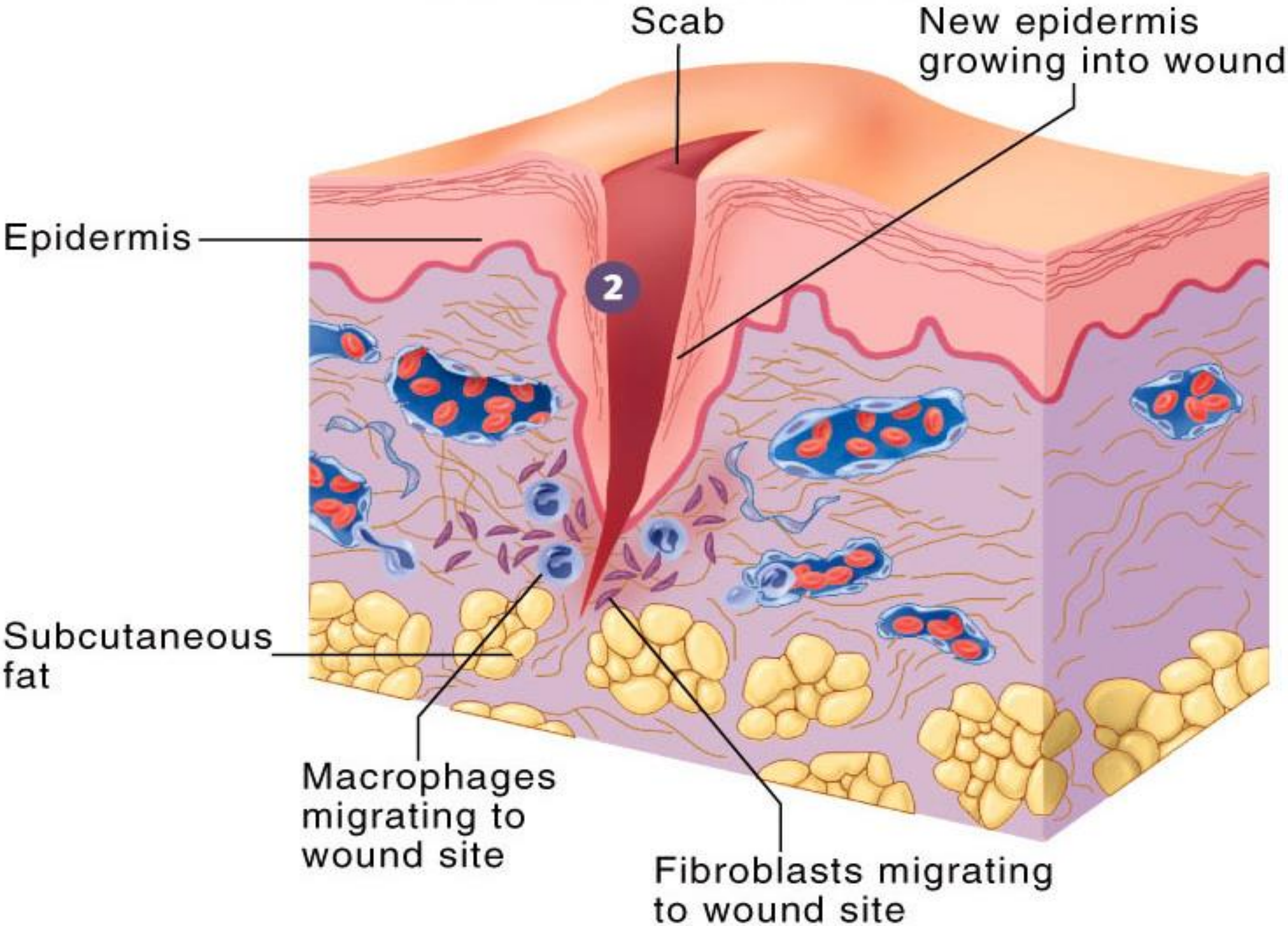
Formation of granulation tissue



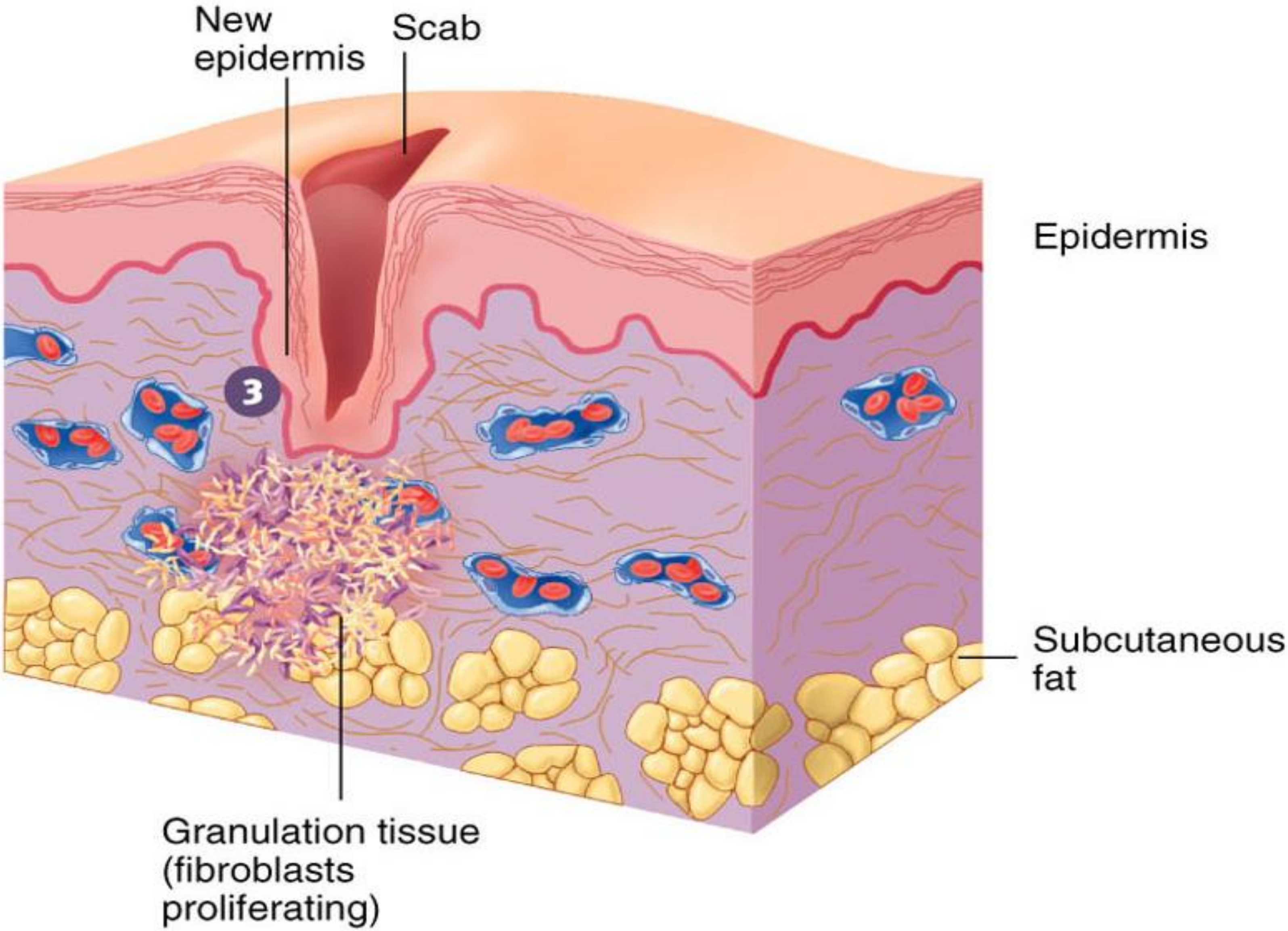
Epithelial regeneration & connective tissue fibrosis



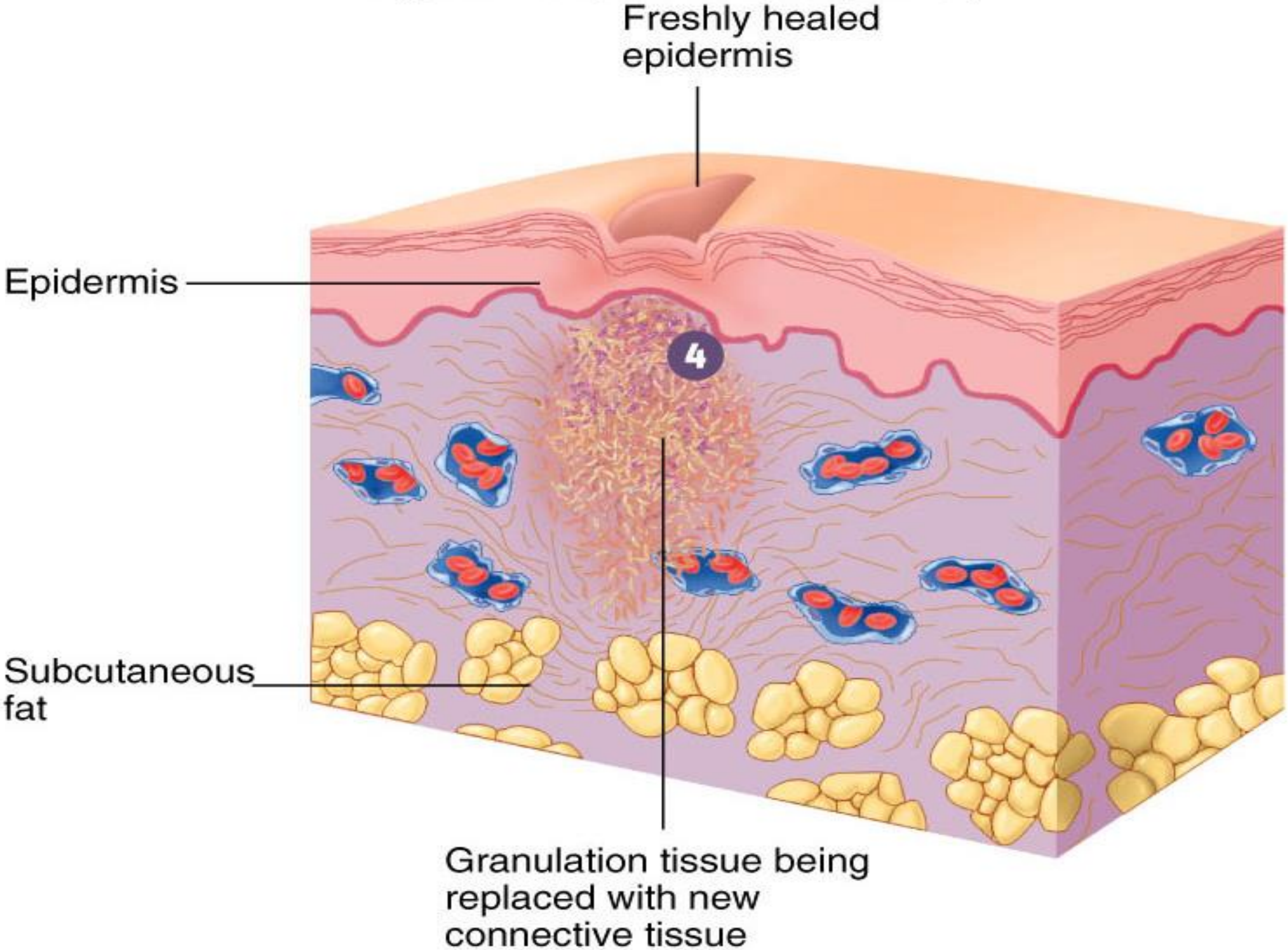
1. Fresh wound cuts through the epithelium (epidermis) and underlying connective tissue (dermis), and a clot forms.



2. Approximately 1 week after the injury, a scab is present, and epithelium (new epidermis) is growing into the wound.



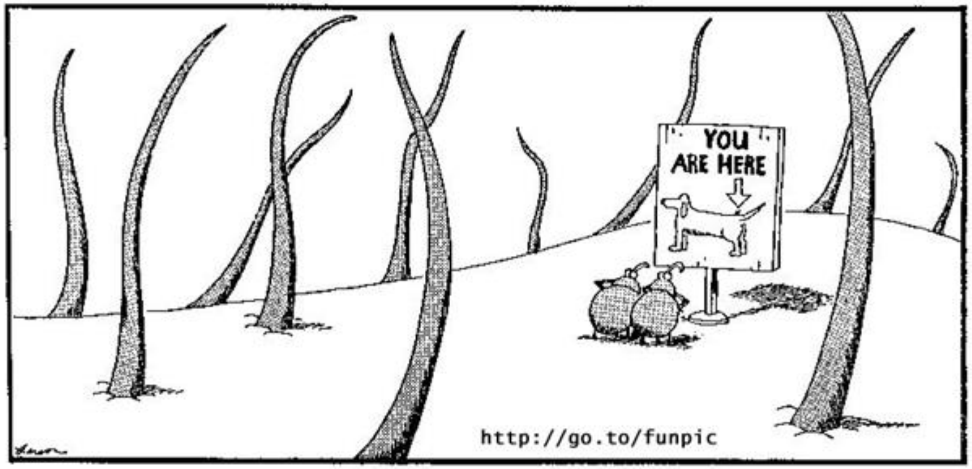
3. Approximately 2 weeks after the injury, the epithelium has grown completely into the wound, and fibroblasts have formed granulation tissue.



4. Approximately 1 month after the injury, the wound has completely closed, the scab has been sloughed, and the granulation tissue is being replaced by new connective tissue.

Clinical Applications

Pages 94, 119, 121-124, 130



The Integument and Related Structures
Chapter 5

Pages 131-152

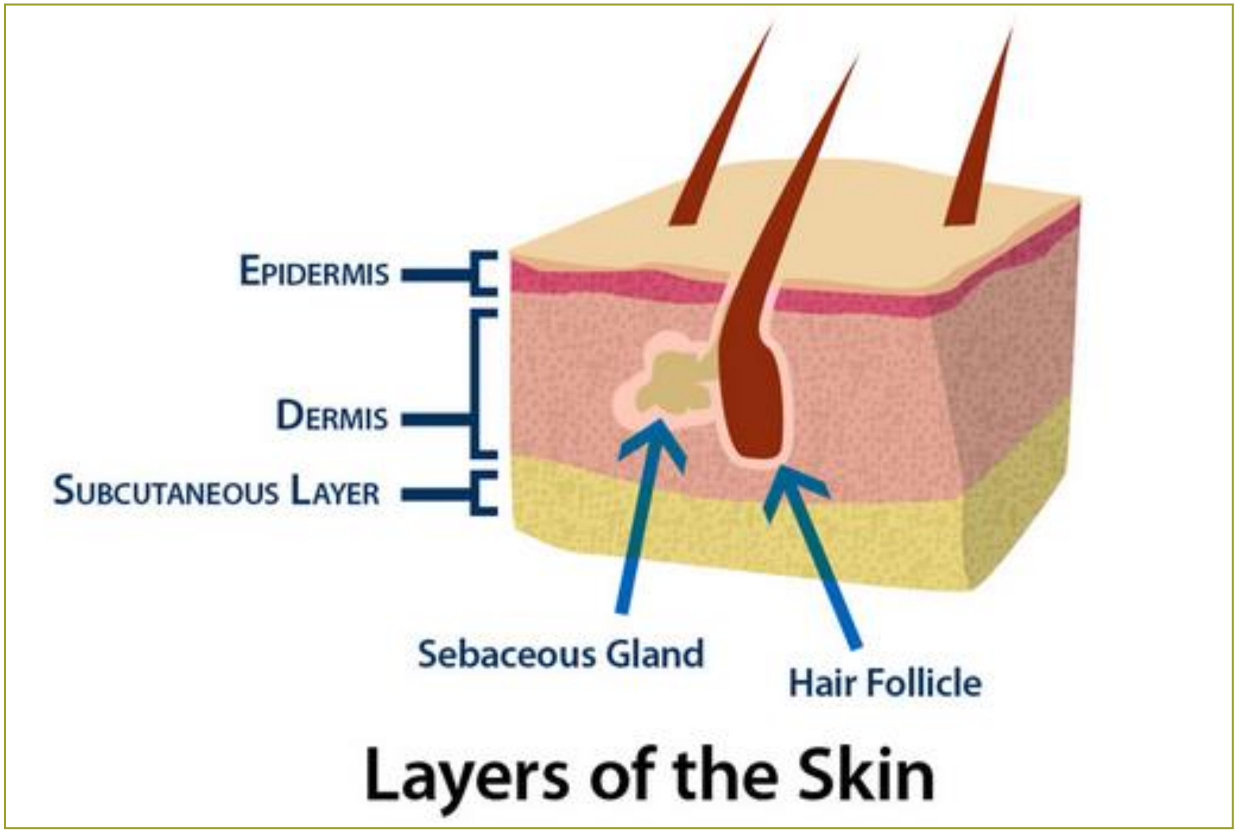
Textbook Learning Objectives

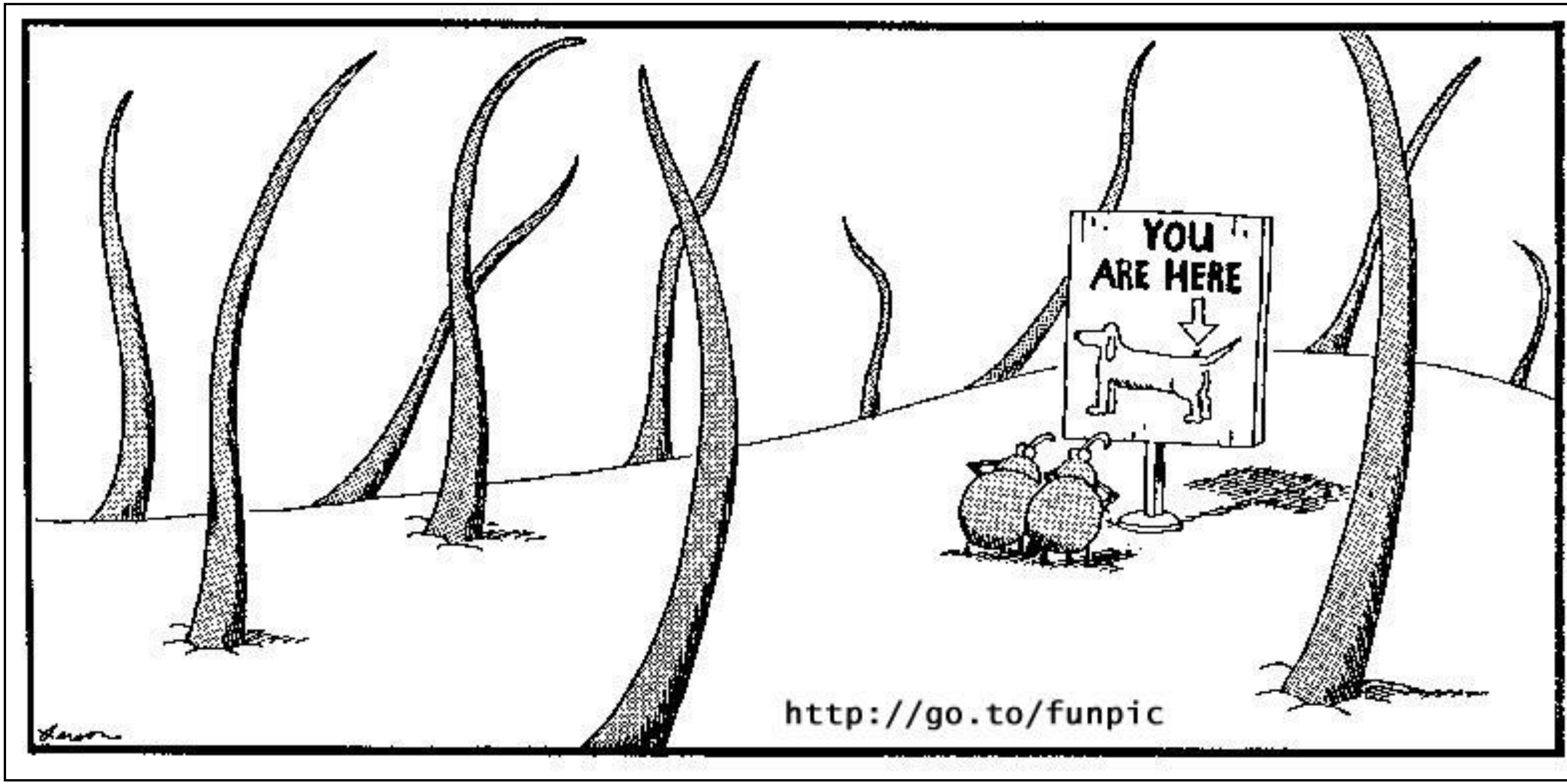
Chapter 5 – Page 131

- List the cell types that make up the epidermis and describe the function of each cell type.
- List the five layers of the epidermis.
- Describe the process of keratinization.
- List the structures that constitute the dermis and describe the function of each.
- List the structures of the hypodermis.
- Describe the unique features of the paw pads and planum nasale.
- Describe the parts of the hair follicle and explain how hair grows.
- List and describe the three types of hair.
- Describe the structure and location of sebaceous glands.
- Differentiate between eccrine and apocrine sweat glands.

Topic 20

Describe the structures and functions of the three layers of skin

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Overview

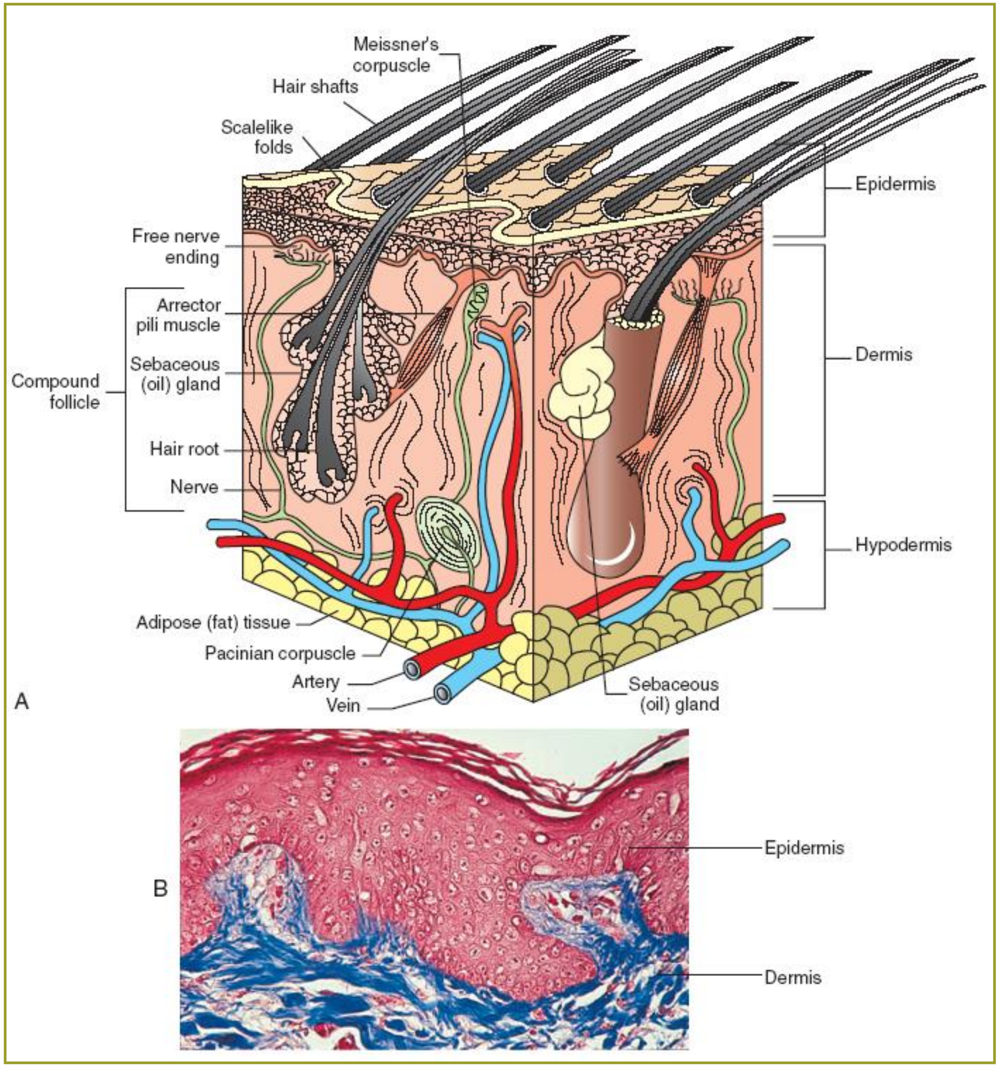
- Dermatology
- Integumentary System
  - Skin
  - Adnexa (related structures)
    - Hair, hooves, horns, claws, skin-related glands
- Skin continous with mucous membranes that line body openings
- Remarkable ability to regenerate & heal

Functions of Skin

- Covering (waterproofing) for animal body
  - Part of animal body's **first line of defense**
- Protection from trauma, temperature change, entrance of pathogens
- Makes vitamin D
- Sensory organ
- Heat-regulating organ in cats, horses
- Excretes water & salt

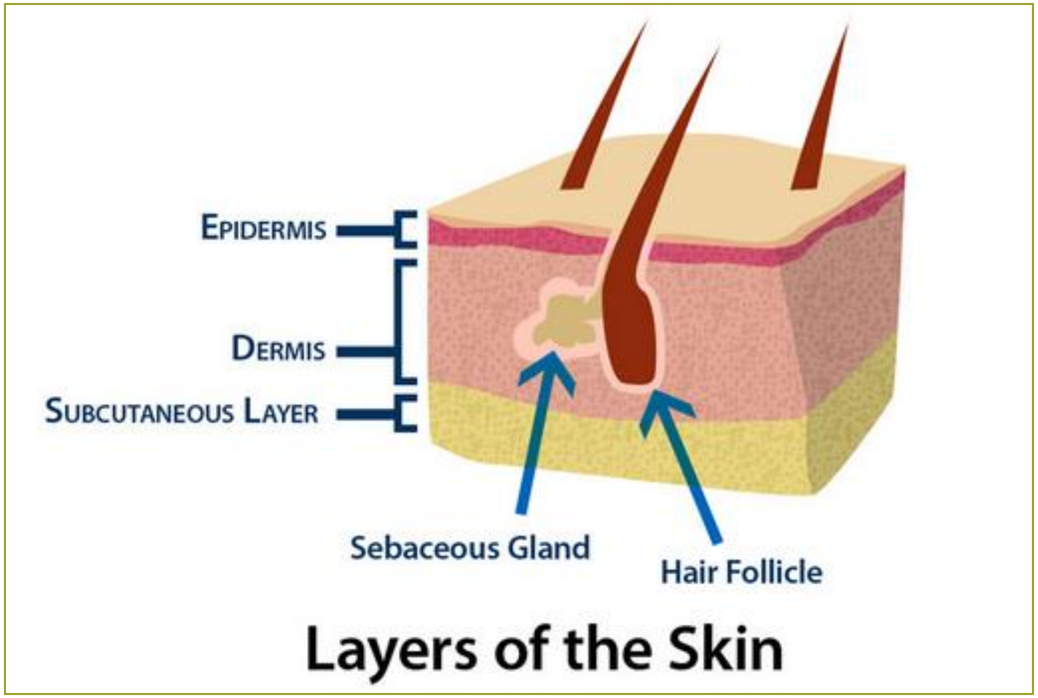
Integumentary System
Figure 5-1, Page 132

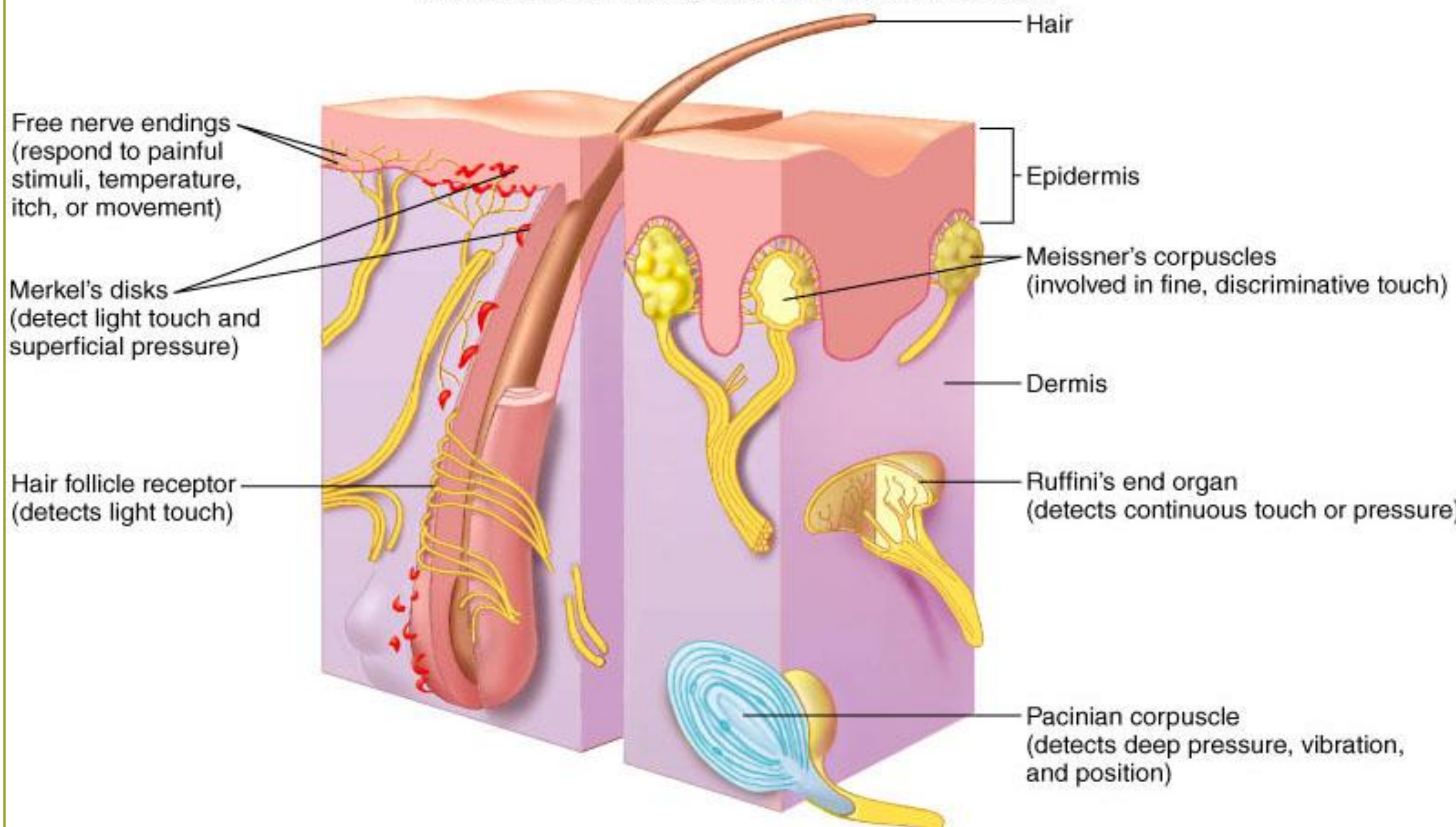
- Consists of three layers:
  - Epidermis
  - Dermis
  - Hypodermis

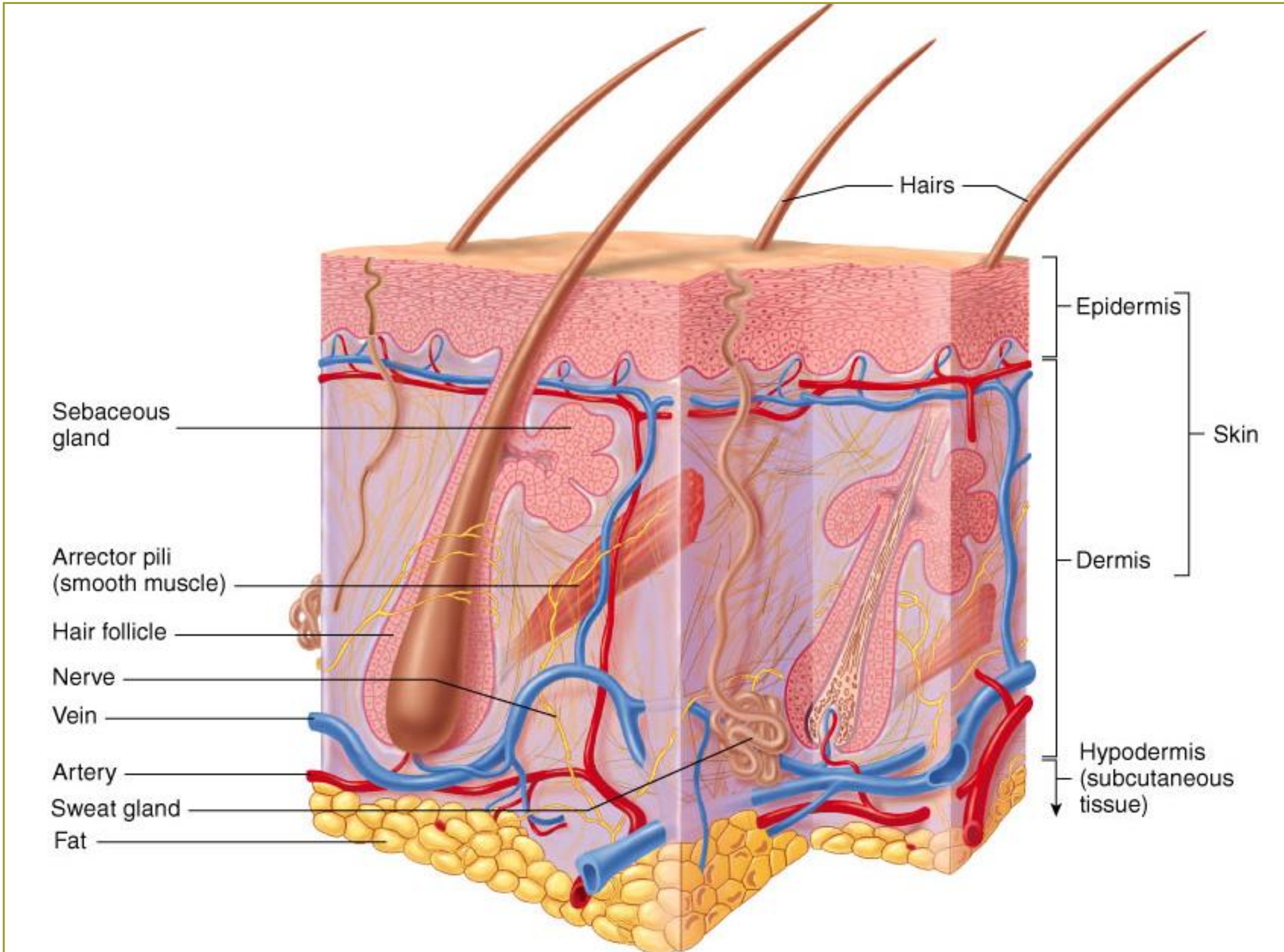


Anatomy of Canine Skin

- 3 distinct layers
  - Epidermis
  - Dermis
  - Hypodermis (subcutaneous)
    - Adipose tissue
- Related structures

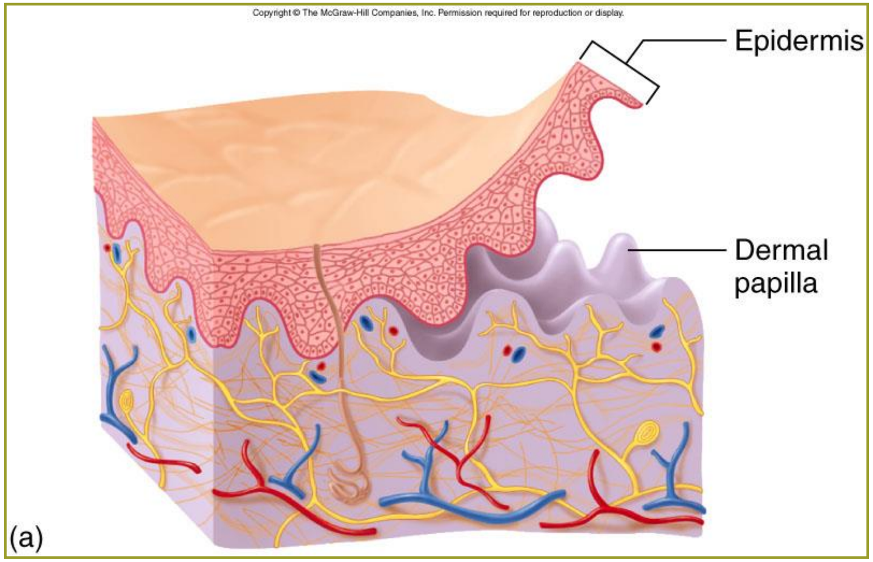


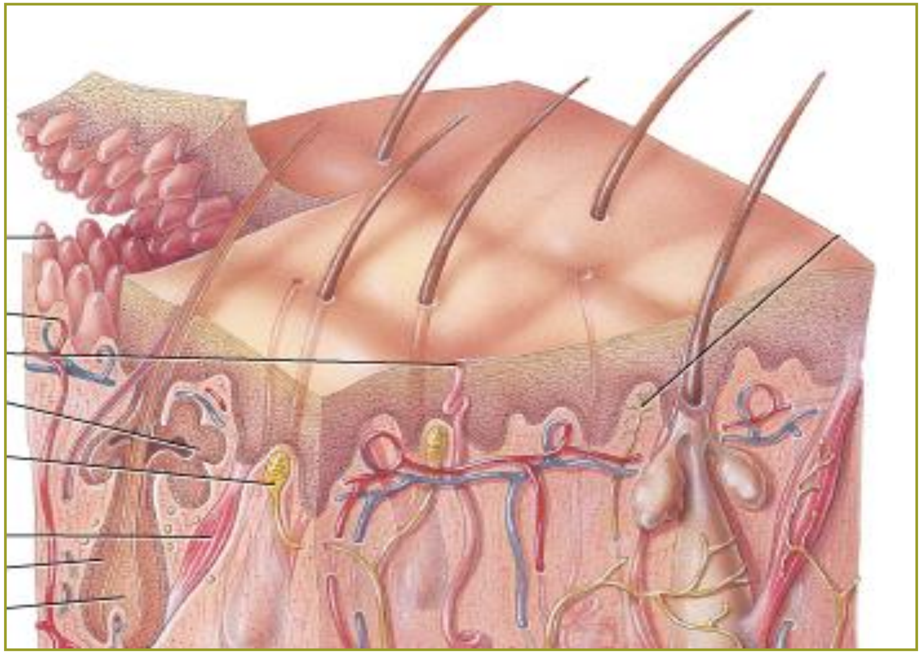

Hair
Free nerve endings (respond to painful stimuli, temperature, itch, or movement)
Epidermis
Merkel's disks (detect light touch and superficial pressure)
Meissner's corpuscles (involved in fine, discriminative touch)
Dermis
Hair follicle receptor (detects light touch)
Ruffini's end organ (detects continuous touch or pressure)
Pacinian corpuscle (detects deep pressure, vibration, and position)


Hairs
Epidermis
Skin
Dermis
Hypodermis
(subcutaneous
tissue)
Sebaceous
gland
Arrector pili
(smooth muscle)
Hair follicle
Nerve
Vein
Artery
Sweat gland
Fat

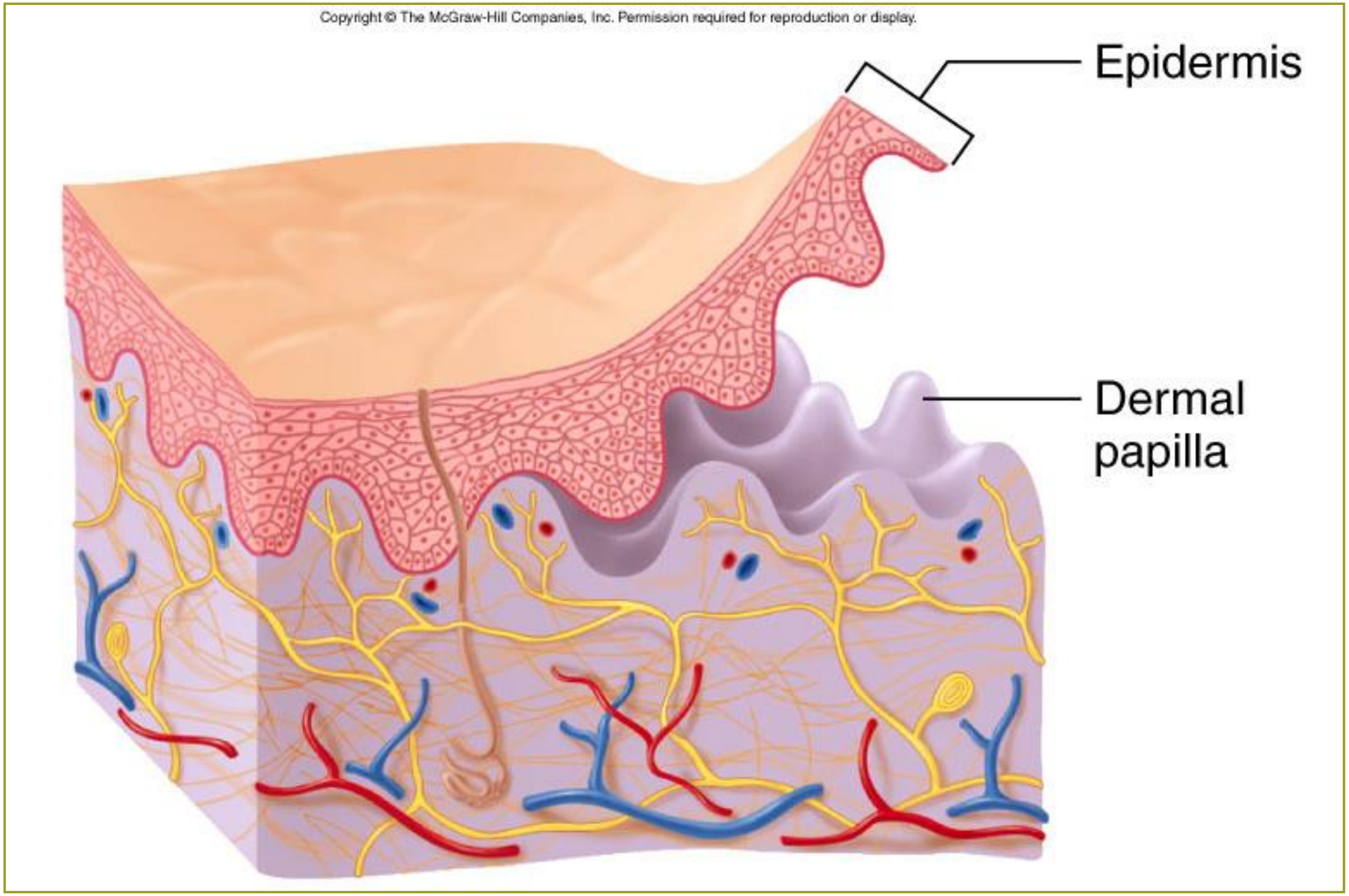
Epidermis

- Most superficial layer
  - Thin, cellular
  - Nerve supply, no blood supply
  - Constantly growing, constant mitosis





Epidermis



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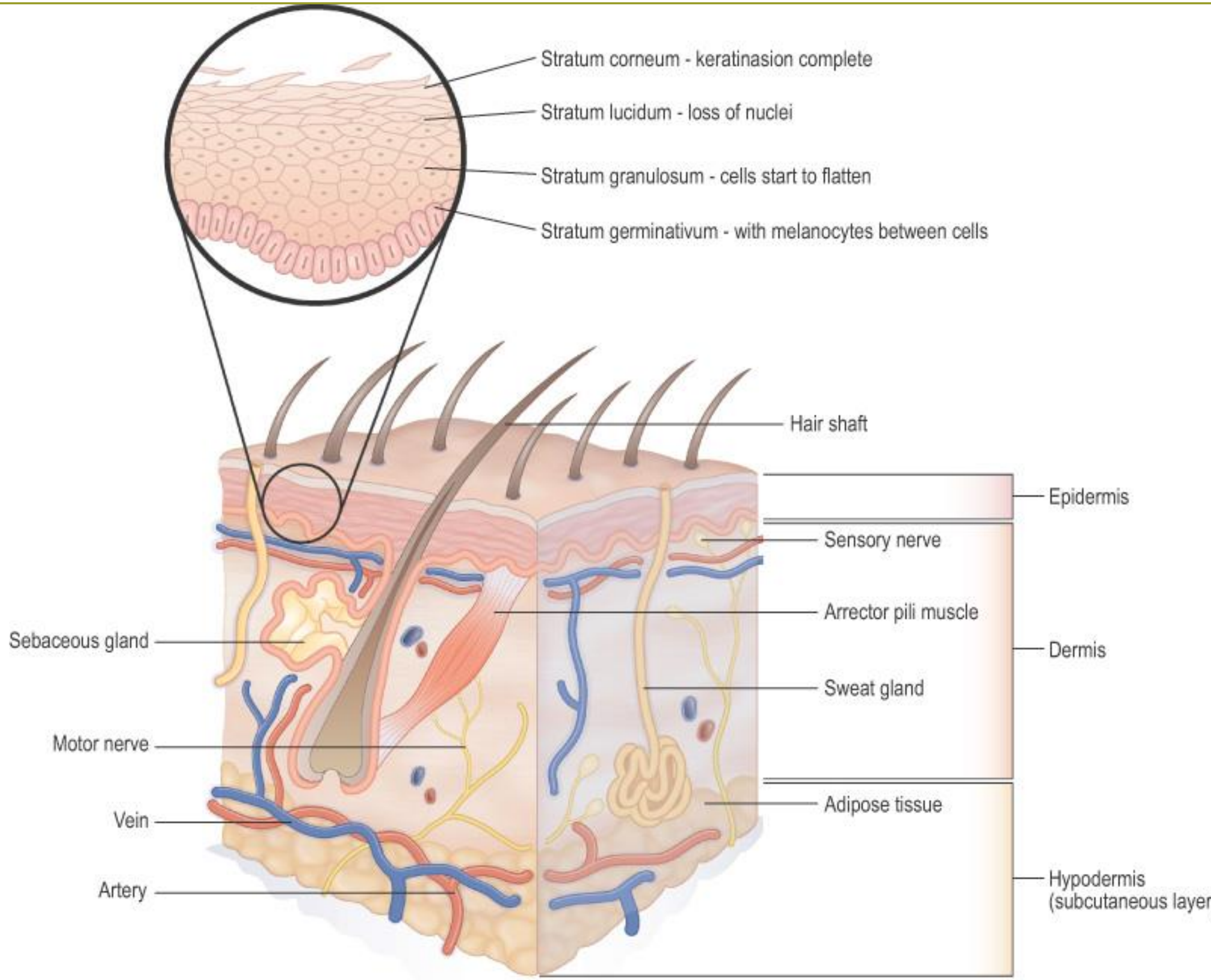
Epidermis
Dermal
papilla



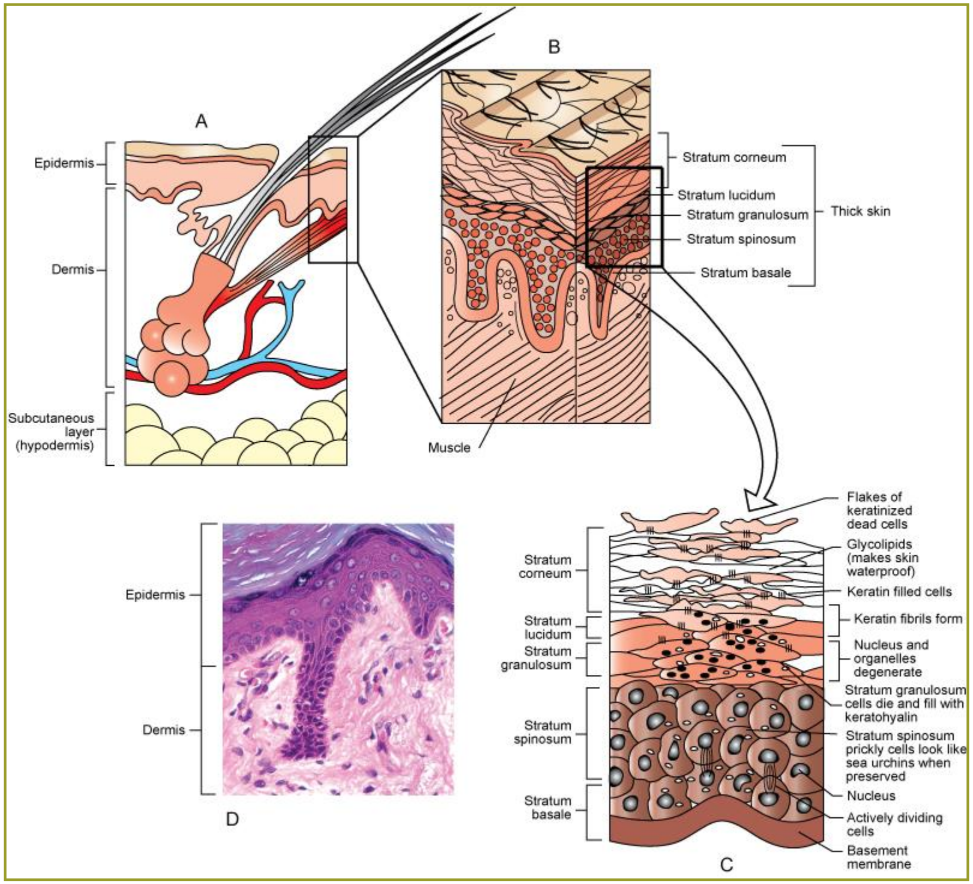
Stratum corneum - keratinasion complete
Stratum lucidum - loss of nuclei
Stratum granulosum - cells start to flatten
Stratum germinativum - with melanocytes between cells
Hair shaft
Epidermis
Sensory nerve
Arrector pili muscle
Dermis
Sebaceous gland
Sweat gland
Motor nerve
Adipose tissue
Vein
Hypodermis
(subcutaneous layer)
Artery

5 Layers of Epidermis

1. Stratum Germinativum

Figure 5-2, Page 134

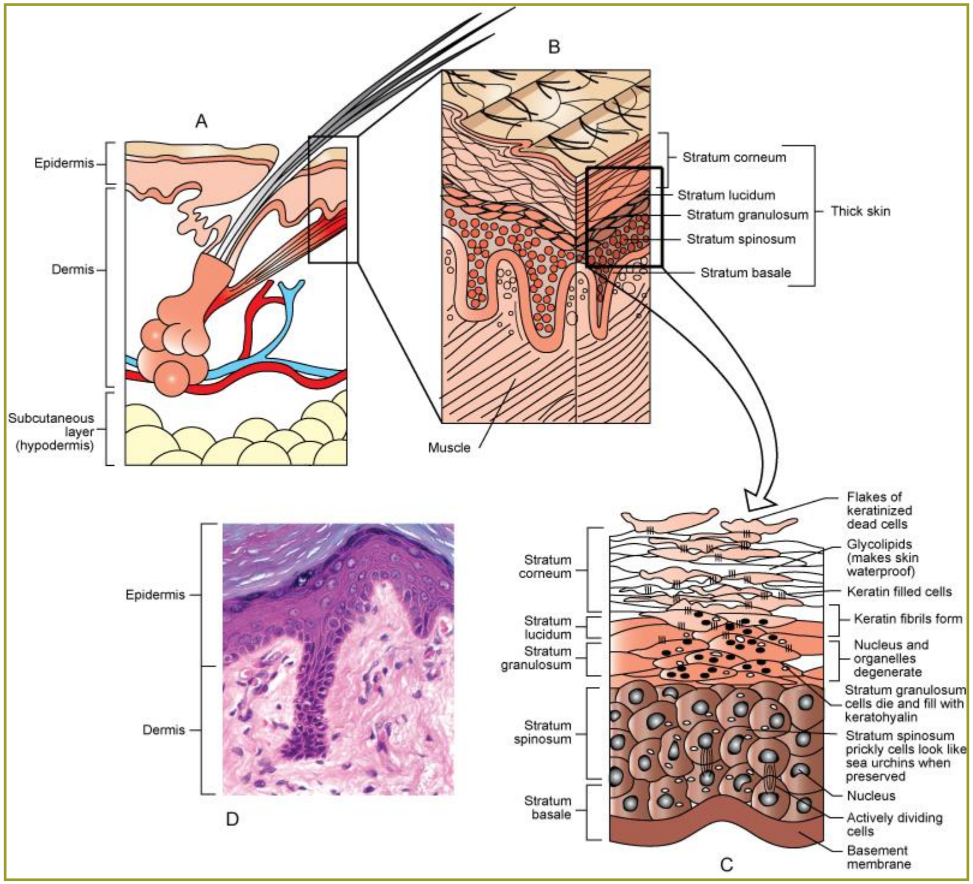
- Deepest layer
- Consists of a single row of keratocytes attached to epithelial basement membrane
- Merkel cells, melanocytes, keratocytes, found in this layer



2. Stratum Spinosum

Figure 5-2, Page 134

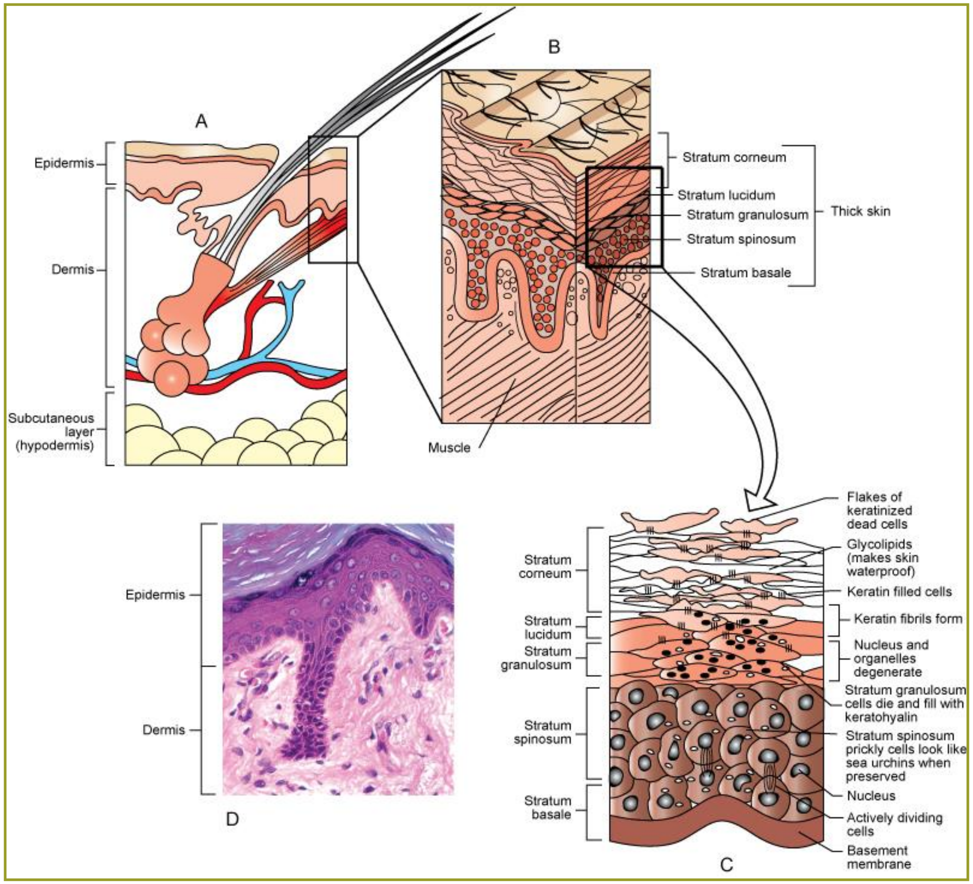
- Contains several layers of cells held together by desmosomes
- Langerhans cells found in this layer



3. Stratum Granulosum

Figure 5-2, Page 134

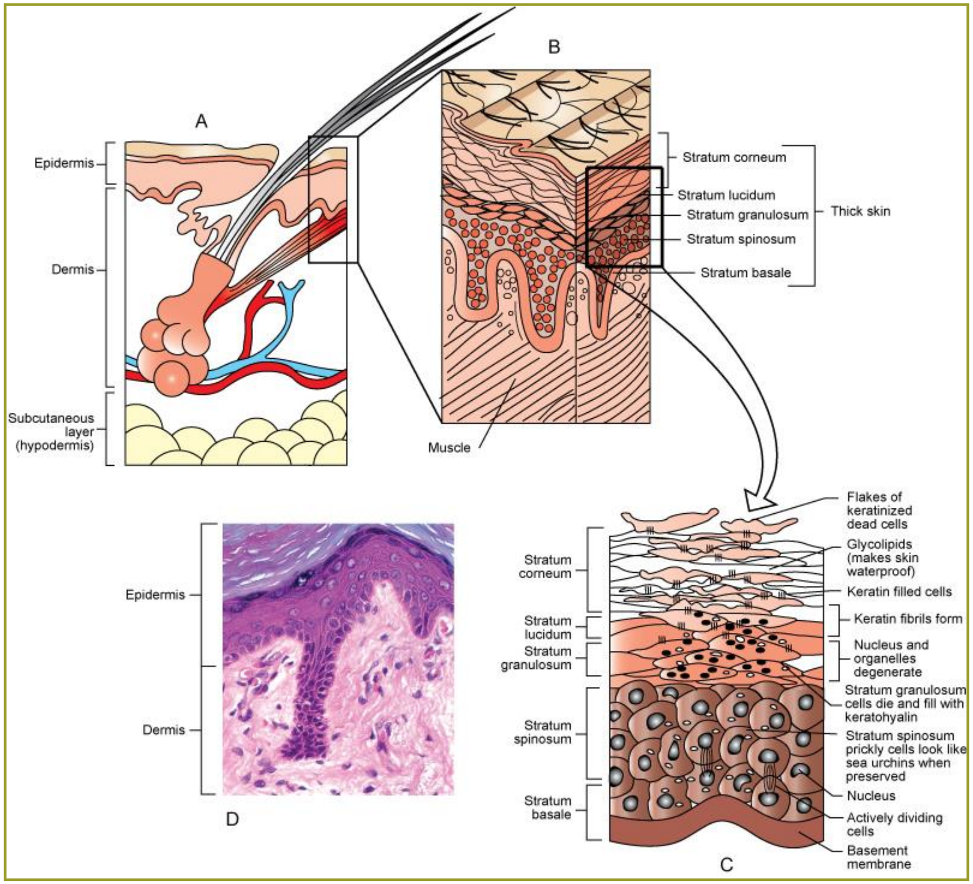
- Composed of two to four layers of flattened, diamond-shaped keratocytes that contain lamellated granules of glycolipids
- These glycolipids play a role in helping waterproof the skin and slowing water loss across the epidermis



4. Stratum Lucidum

Figure 5-2, Page 134

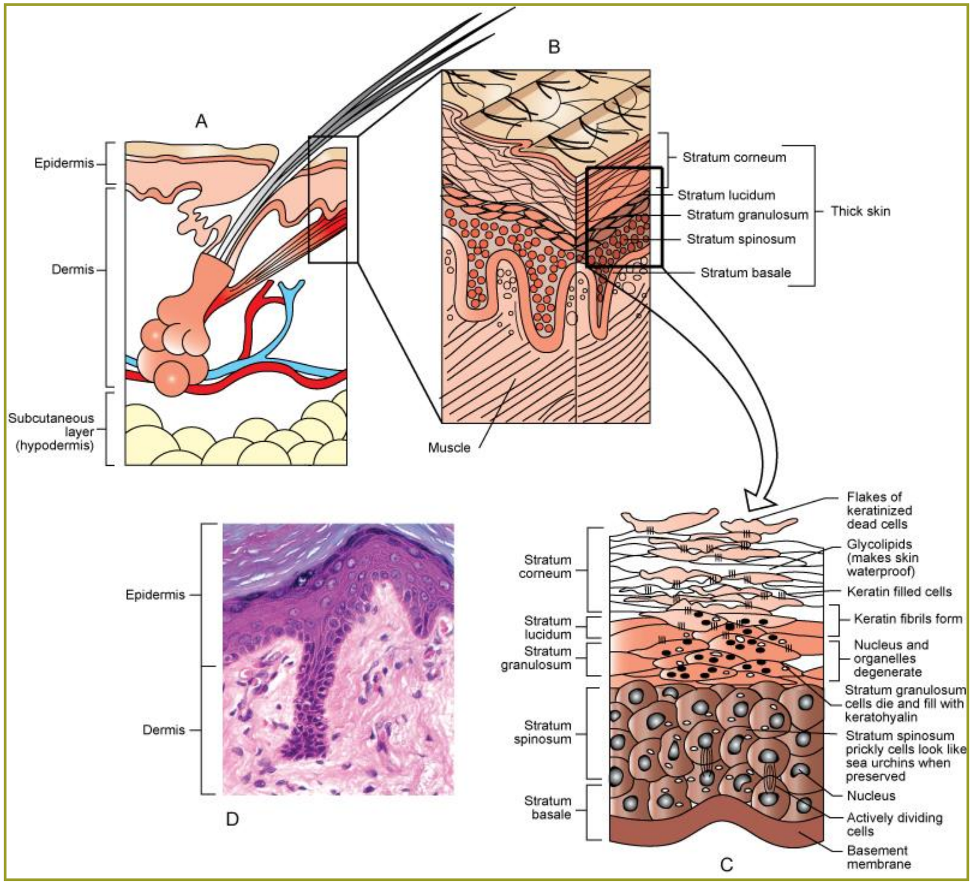
- Found in very thick skin
- Composed of a few rows of flattened dead cells
- Contents of the keratogranules combine with intracellular tonofilaments to form keratin fibrils



5. Stratum Corneum

Figure 5-2, Page 134

- Horny outermost layer
- Composed of 20 to 30 rows of keratocyte “remnants”
  - Sometimes called *horny* or *cornified cells*



Epidermis of Hairy Skin

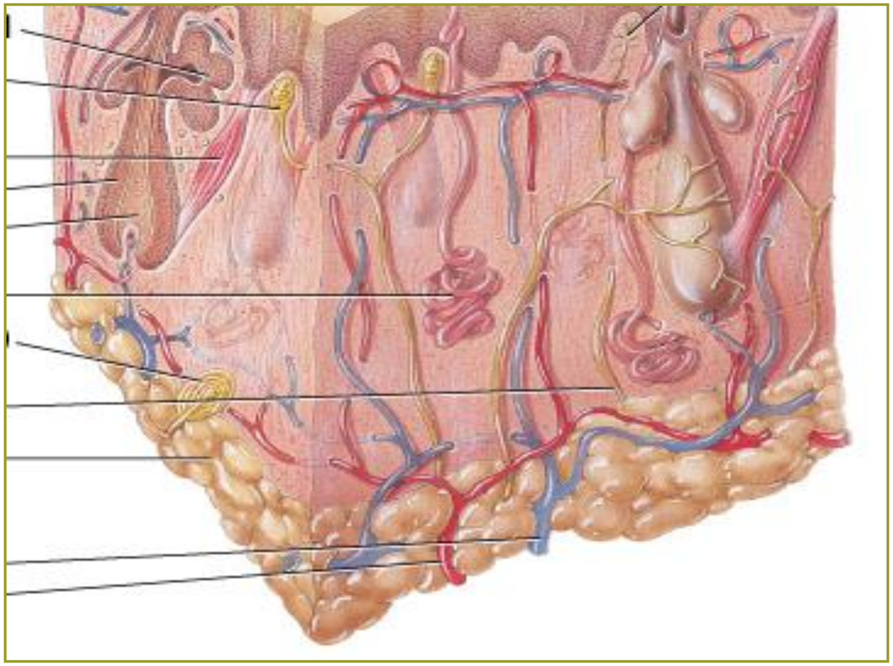
- Hairy skin usually consists of three epidermal layers rather than five (stratum basale, stratum spinosum, and stratum corneum)
- The surface of hairy skin is covered in scalelike folds
- A knoblike elevation can be seen periodically
  - Tactile elevation or epidermal papilla
  - Usually associated with a tactile hair (tylotrich hairs)

Epidermis Gives Rise To Following Structures

- Hair
- Feathers
- Glands
- Paw pads
- Nails, horns, beaks

Dermis

- [Greatest portion of integument]
- Much fibrous connective tissue
  - Few cells, lots of matrix
  - Gives strength to skin
- Good nerve & blood supply
- Used to make leather (the “**hide**”)

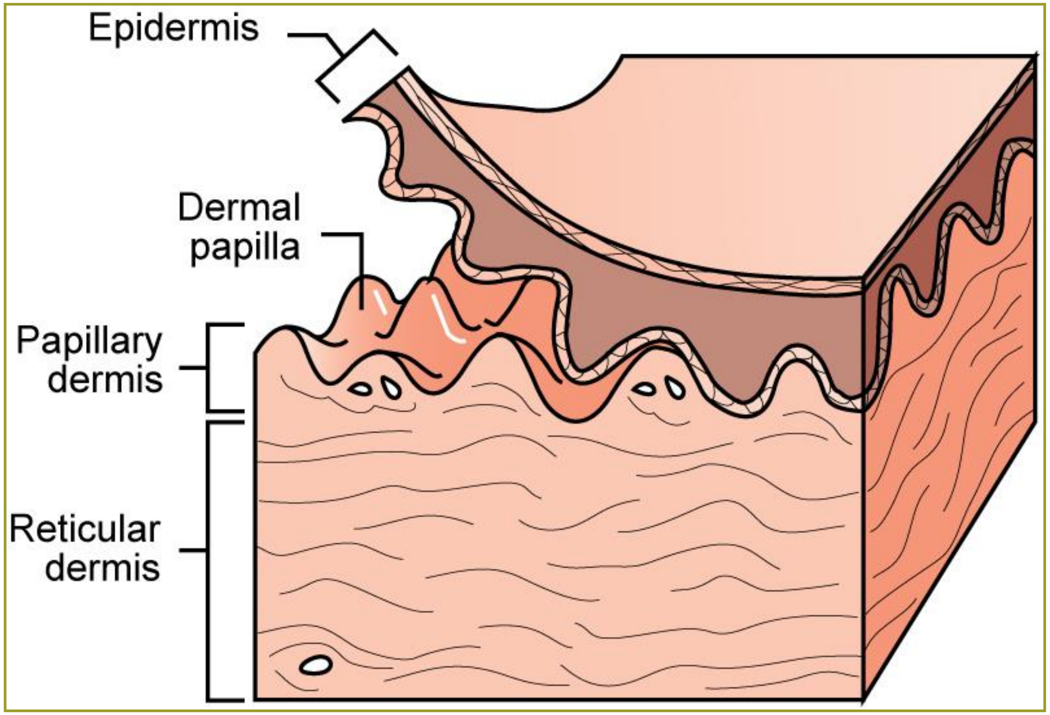


Dermis

- Also includes hair follicles, nerve endings, glands, smooth muscle, blood vessels, and lymphatics
- Two layers:
  - **Papillary layer**
  - **Reticular layer**

Papillary Layer
Figure 5-4, Page 138

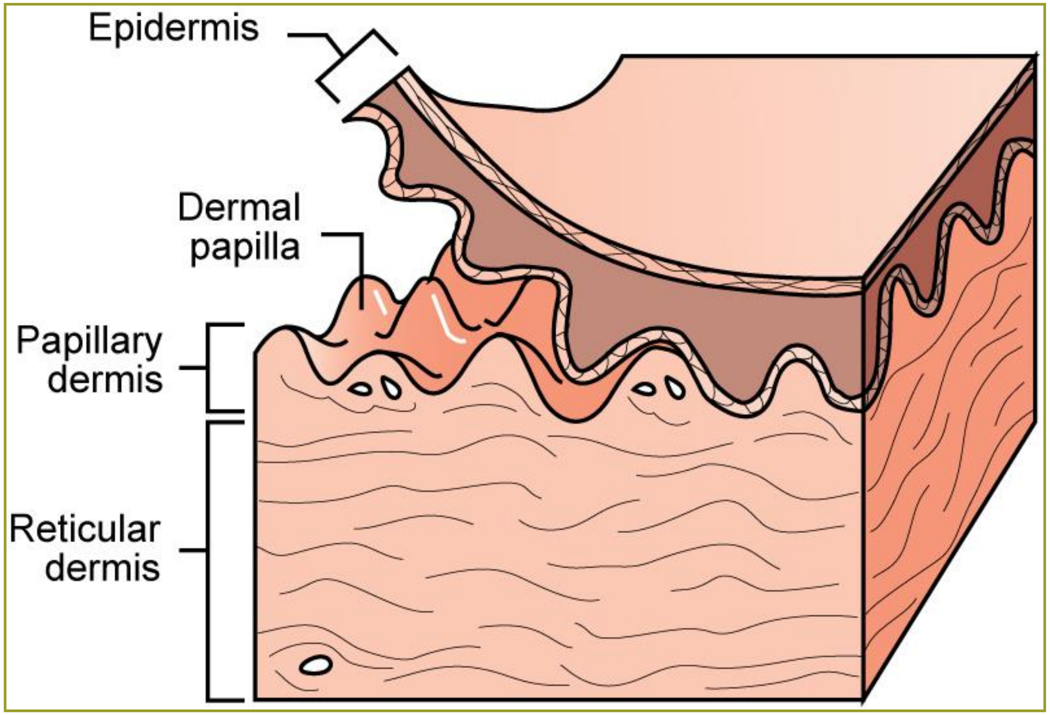
- Underneath the epithelial layer of the epidermis
- Dermal papillae help cement the epidermis and the dermis together
- Blood vessels, pain, temperature, and touch receptors also present



Reticular Layer

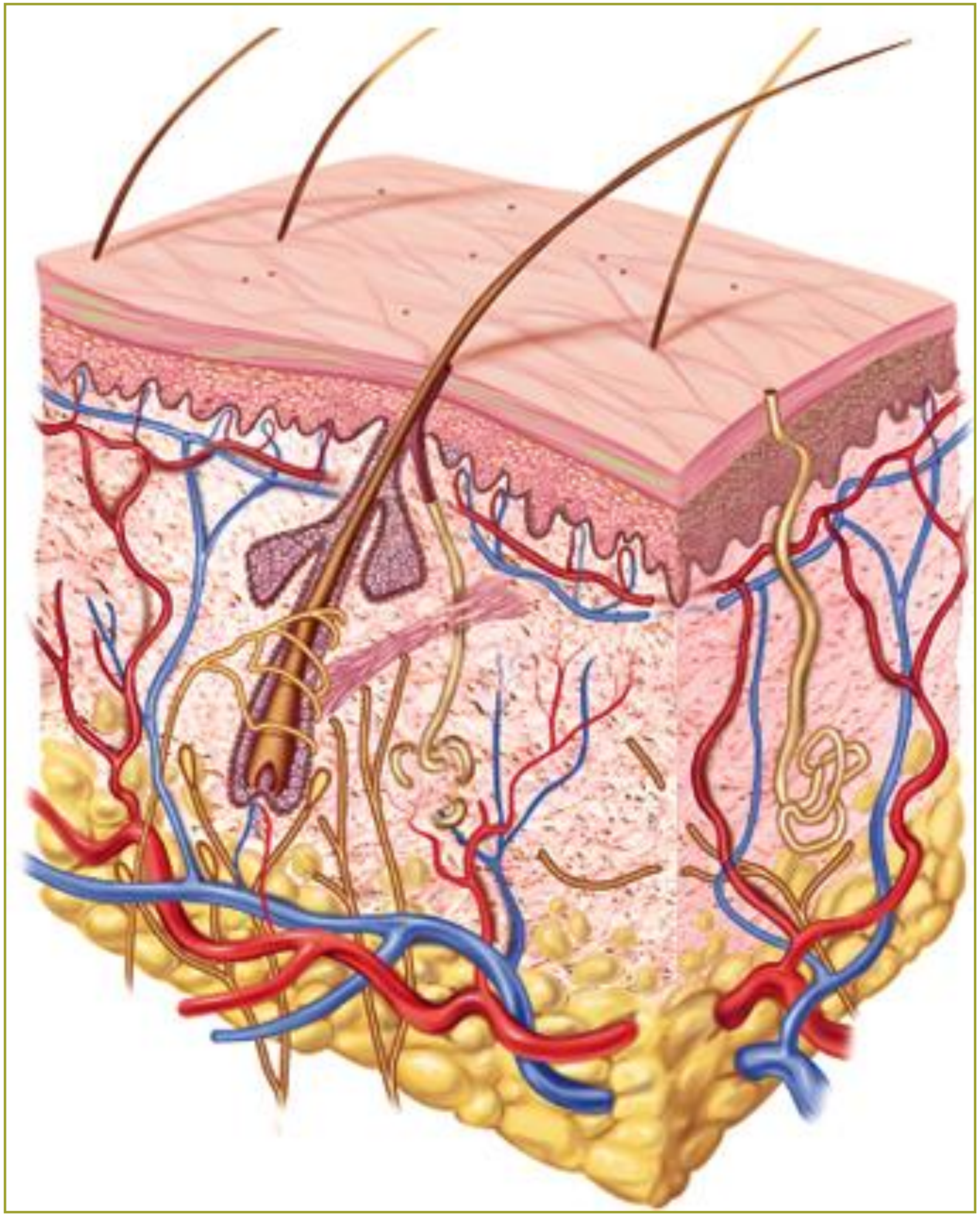
Figure 5-4, Page 138

- Consists of dense irregular connective tissue



Hypodermis

- Subcutaneous layer
- [Thick](#) layer
- Permits free movement of skin
- 24% of body weight of newborn puppy
- 12% of adult body weight



Hypodermis

- Composed of areolar tissue containing adipose, blood and lymphatic vessels, and nerves
- Contains special touch receptor – the *pacinian corpuscle (*sensitive to heavier pressure than Meissner's corpuscle)
- Fibers of hypodermis are continuous with those of dermis
- Hypodermal layer permits skin to move freely over underlying bone and muscle without putting tension on skin

Clinical Application!
What Is Mange Anyway?

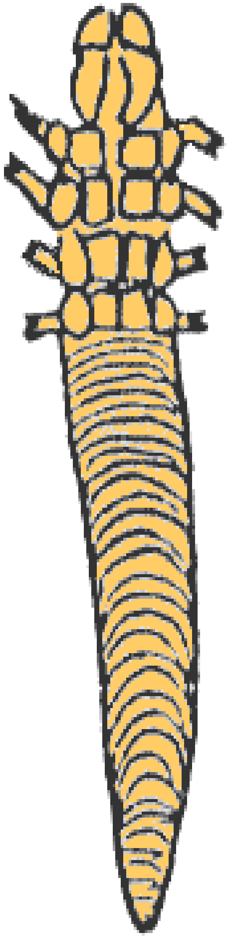
Pages 136-137

Sarcoptic Mange

- Burrows through epidermis
- Zoonosis
  - [“Scabies”]

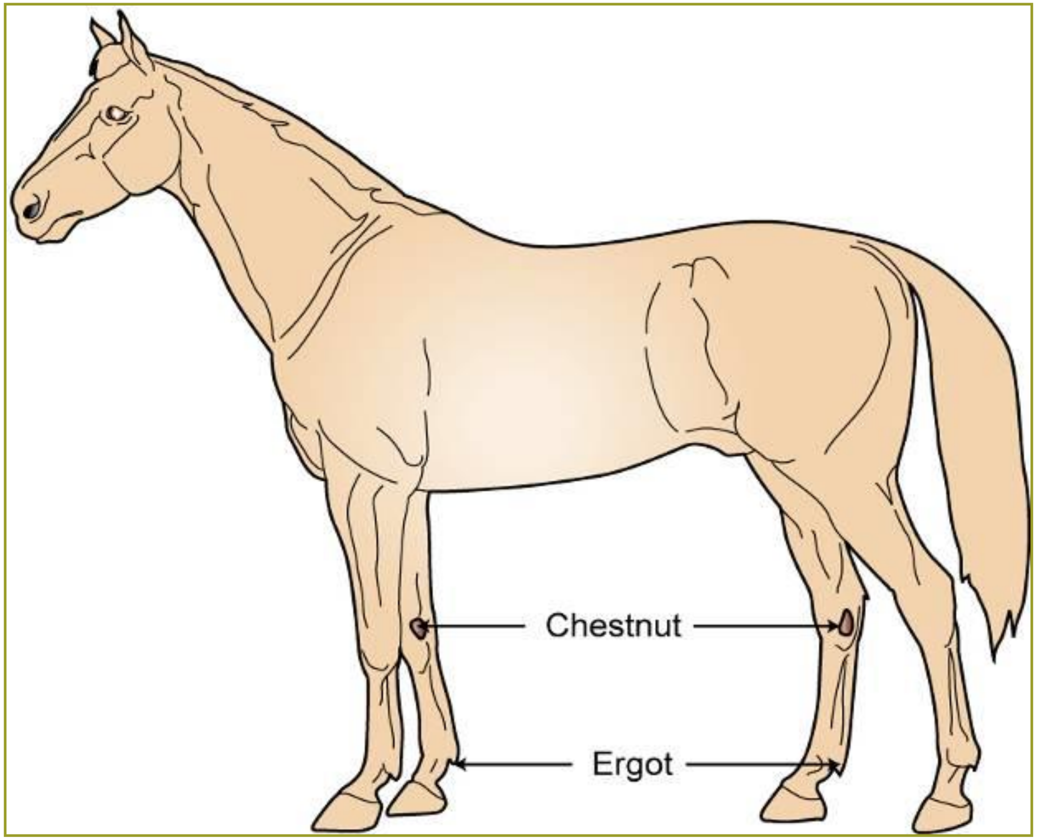
Demodectic Mange

- Lives at base of hair follicles
- Not a zoonosis



Topic 21

Discuss the special features found in the integument



Special Features of the Integument

- Pigmentation
- Paw Pads
- Planum Nasale
- **Ergots and Chestnuts**
- Cutaneous Pouches in Sheep

Pigmentation

- Result of presence or absence of **melanin** granules in the extensions of melanocytes
  - No pigmentation if granules are concentrated around nucleus of the melanocyte
  - As granules move into the cellular extensions and into surrounding tissue, pigmentation becomes macroscopically apparent
- The more granules present, the darker the pigmentation

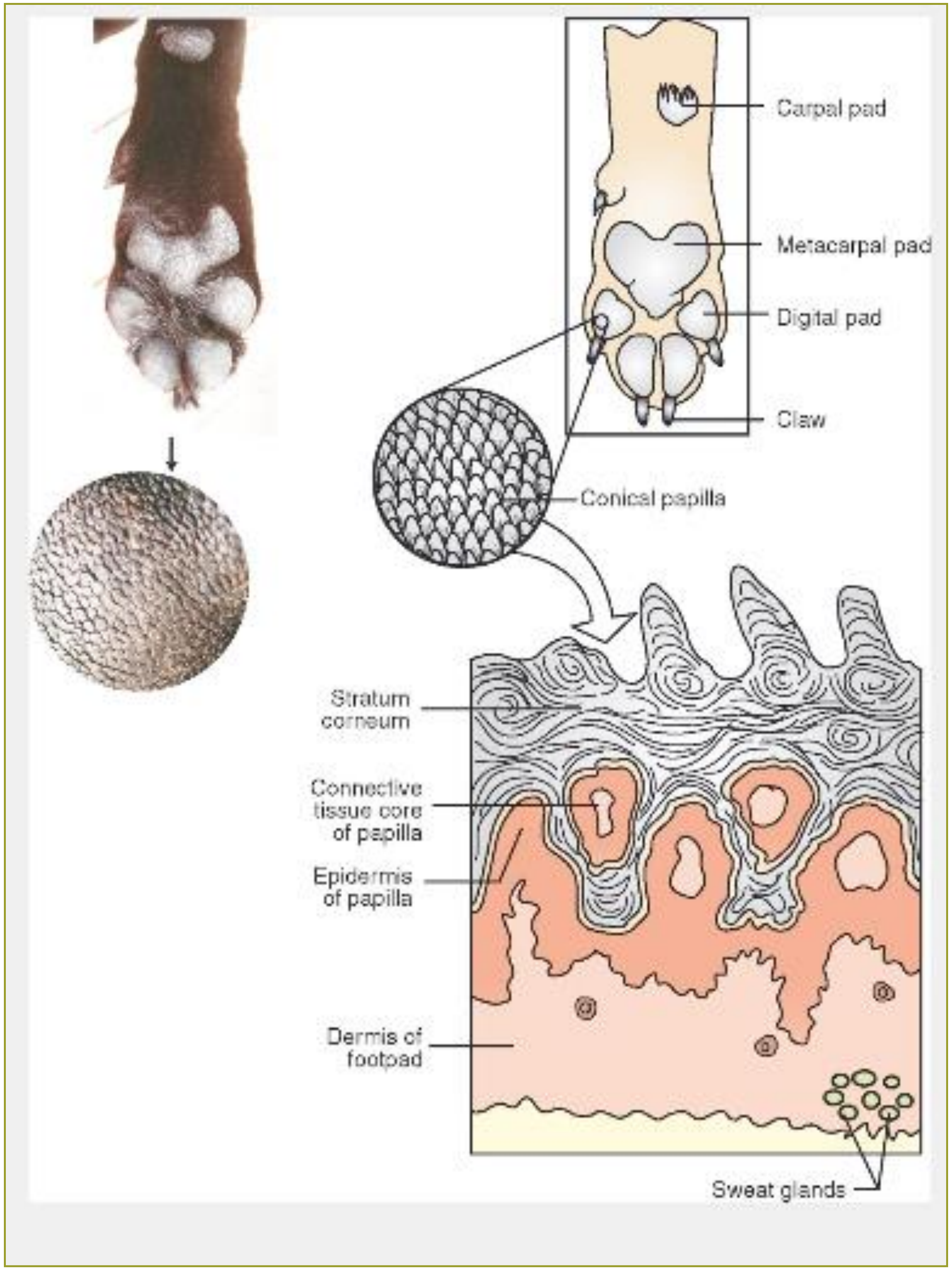
Paw Pads

Figure 5-5, Page 140

- Thick layers of fat & connective tissue
- Outer surface is toughest & thickest skin in animal's body
- Often pigmented; composed of all five epidermal layers
  - **Stratum corneum** is thicker than all other layers combined
- Exocrine & sweat glands

Paw Pads

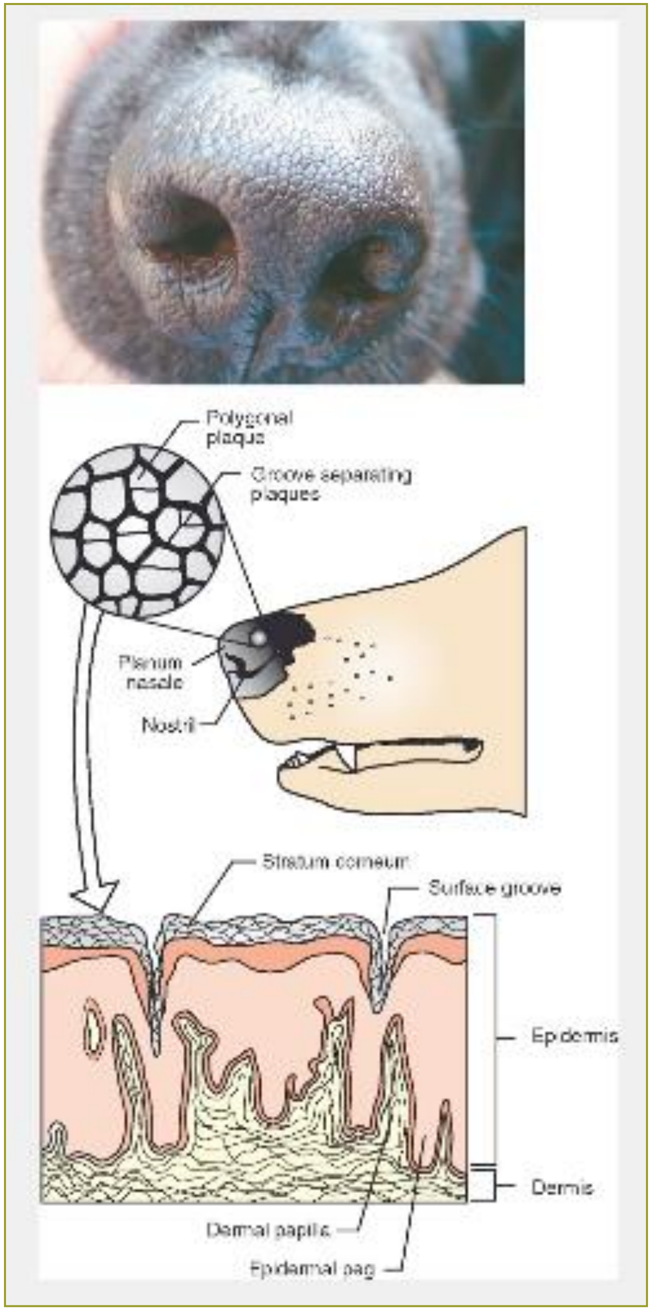
Figure 5-5, Page 140



Planum Nasale

Figure 5-6, Page 141

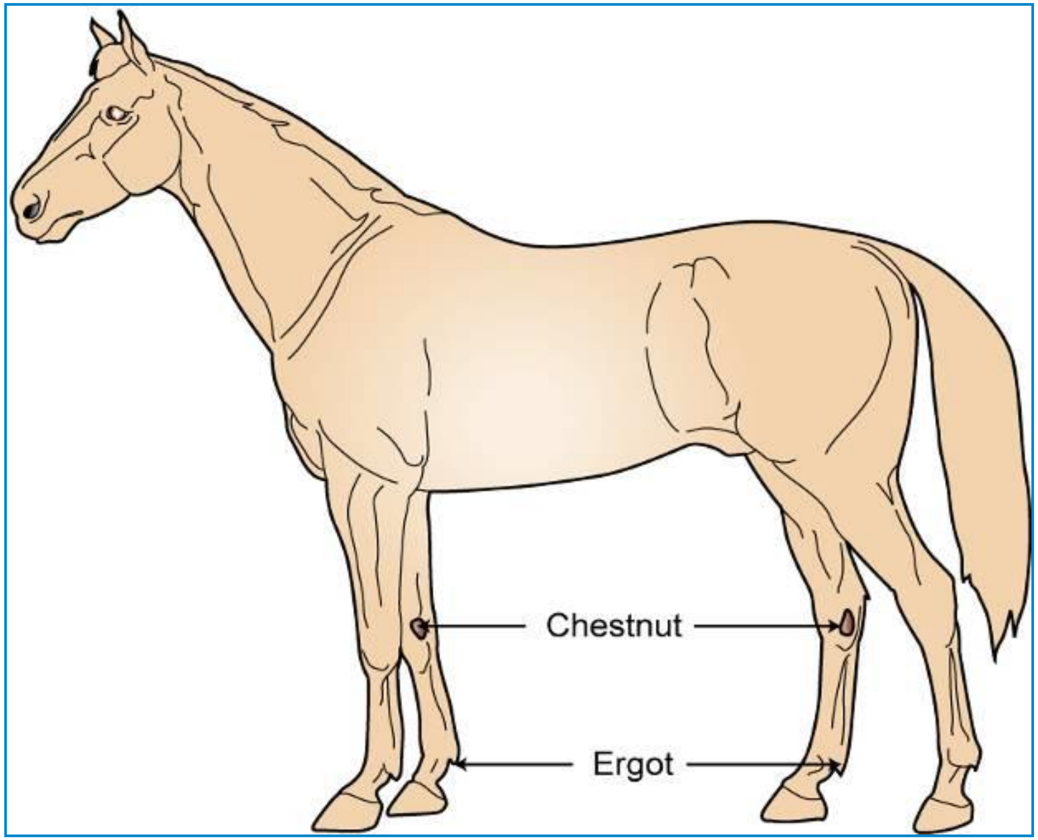
- Top of the nose in cats, pigs, sheep, and dogs
- Wet or dry not a health indicator
- Usually pigmented
  - ("Collie Nose")



Ergots and Chestnuts

Figure 5-7, Page 141

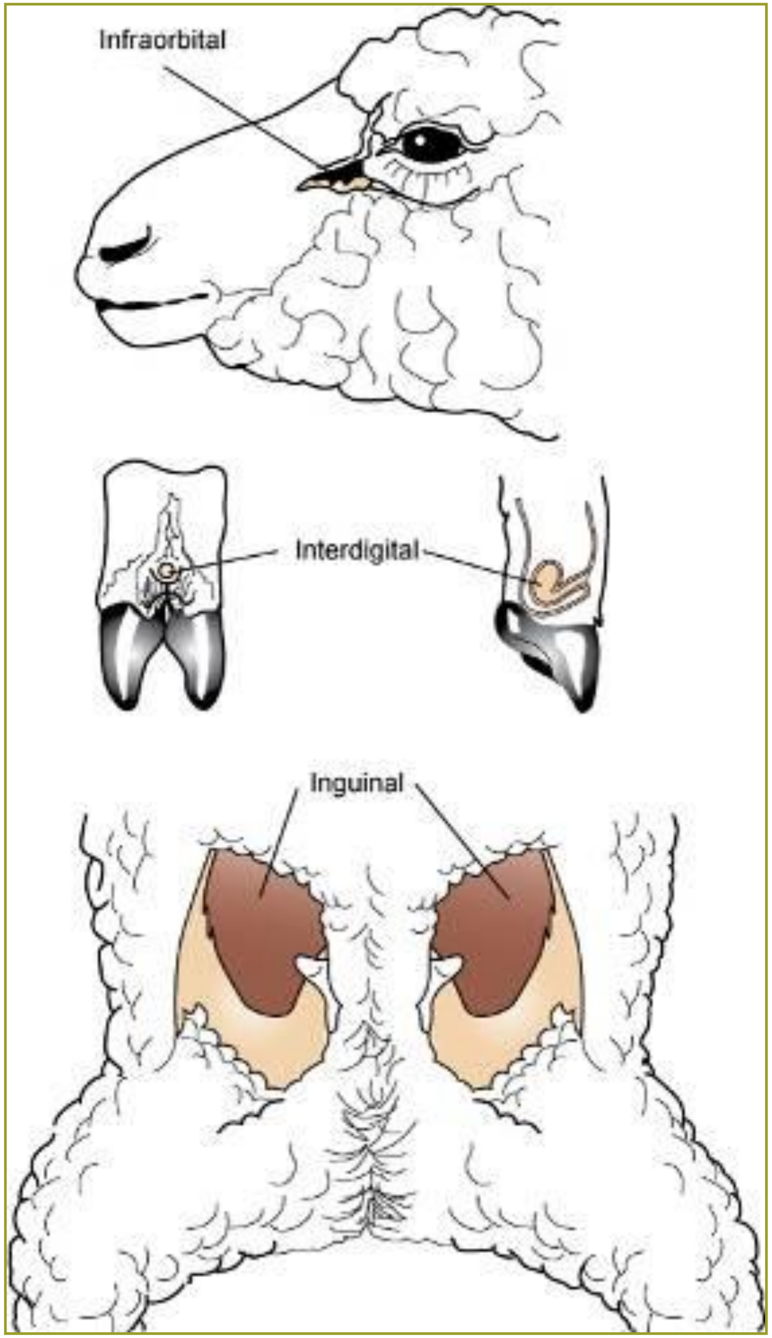
- Dark horny structures found on inside legs of horses, ponies, and other [equidae]
- Thought to be vestiges of carpal and tarsal pads of second and fourth digits
  - ("[splint bones]")



Cutaneous Pouches in Sheep

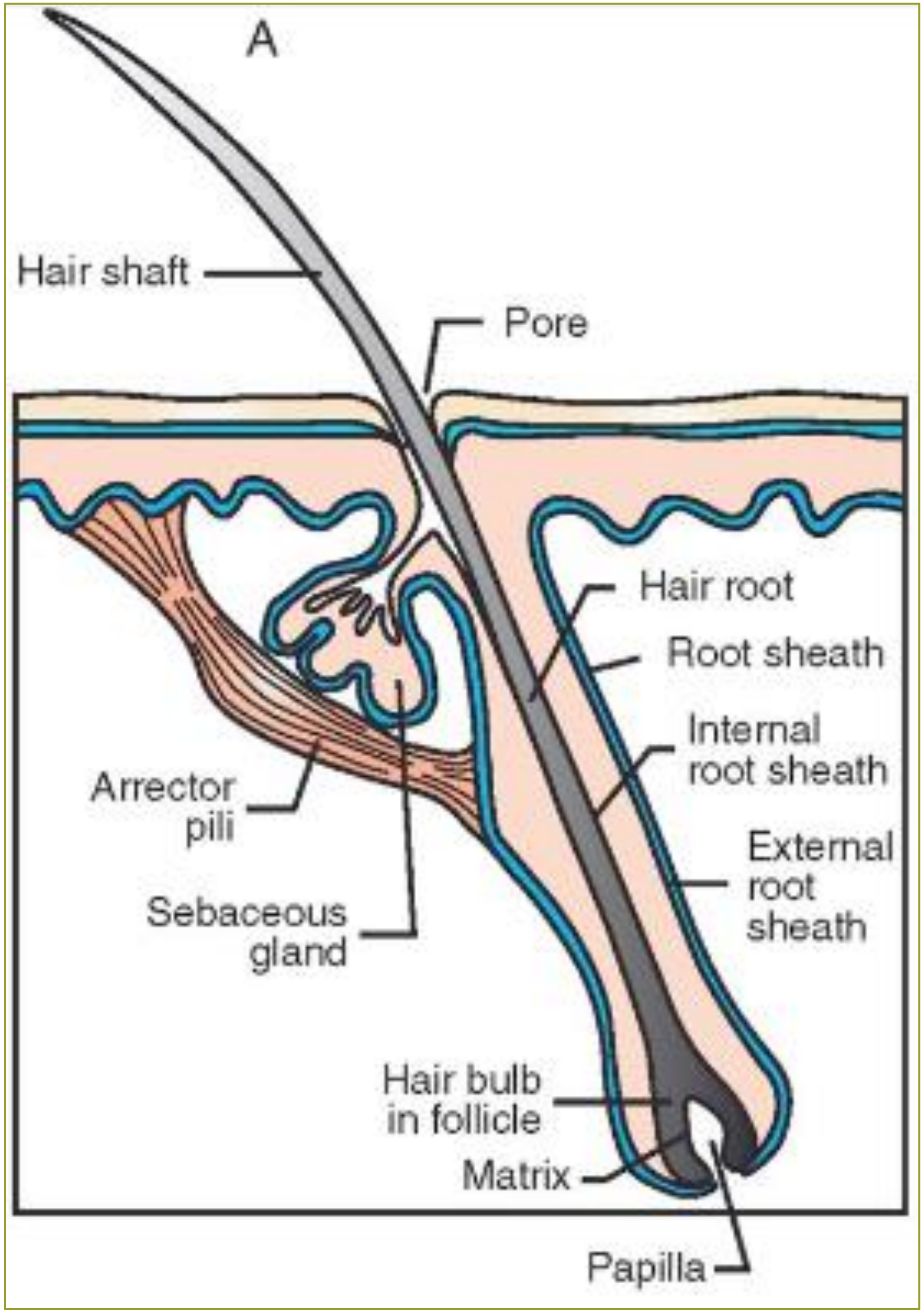
Figure 5-8, Page 141

- Infoldings of skin
- Infraorbital, interdigital, and inguinal pouches
- Contain fine hairs and numerous sebaceous and oil glands
- Secrete a fatty yellow substance which covers and sticks to the skin when dry



Topic 22

Discuss the adnexa (related structures) found in the integument



Related Structures of Integument

- Hair
  - Hair strands and follicles
  - Types of hair
- Glands of the skin
  - Sebaceous and sweat glands
  - Tail glands
  - Anal glands
- Claws and dewclaws
- Hoof
- Horns

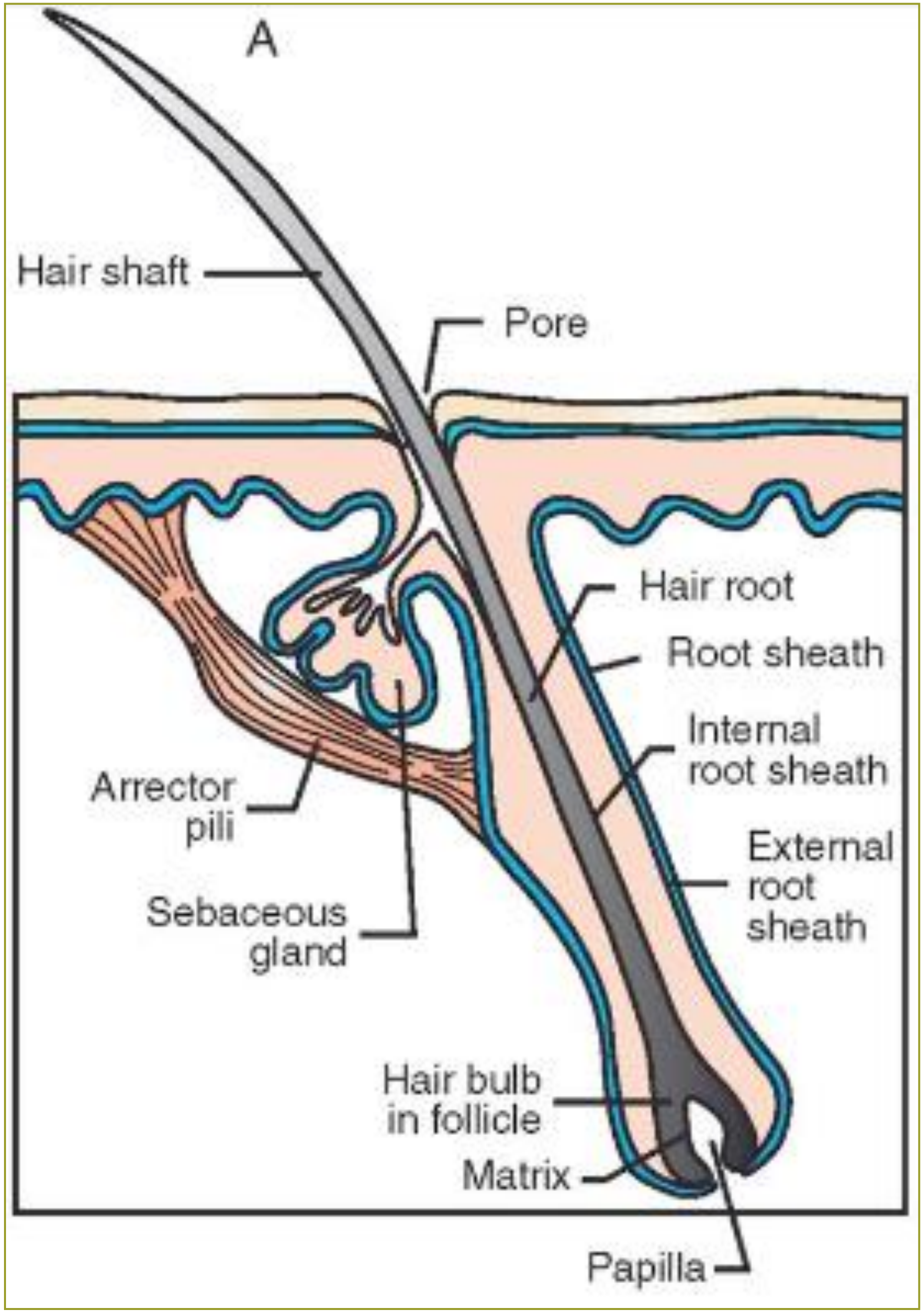
Hair

- Functions in maintaining body temperature; camouflage
- Thickens in cooler weather
  - More hair shafts per hair follicle

Hair

Figure 5-9A, Page 143

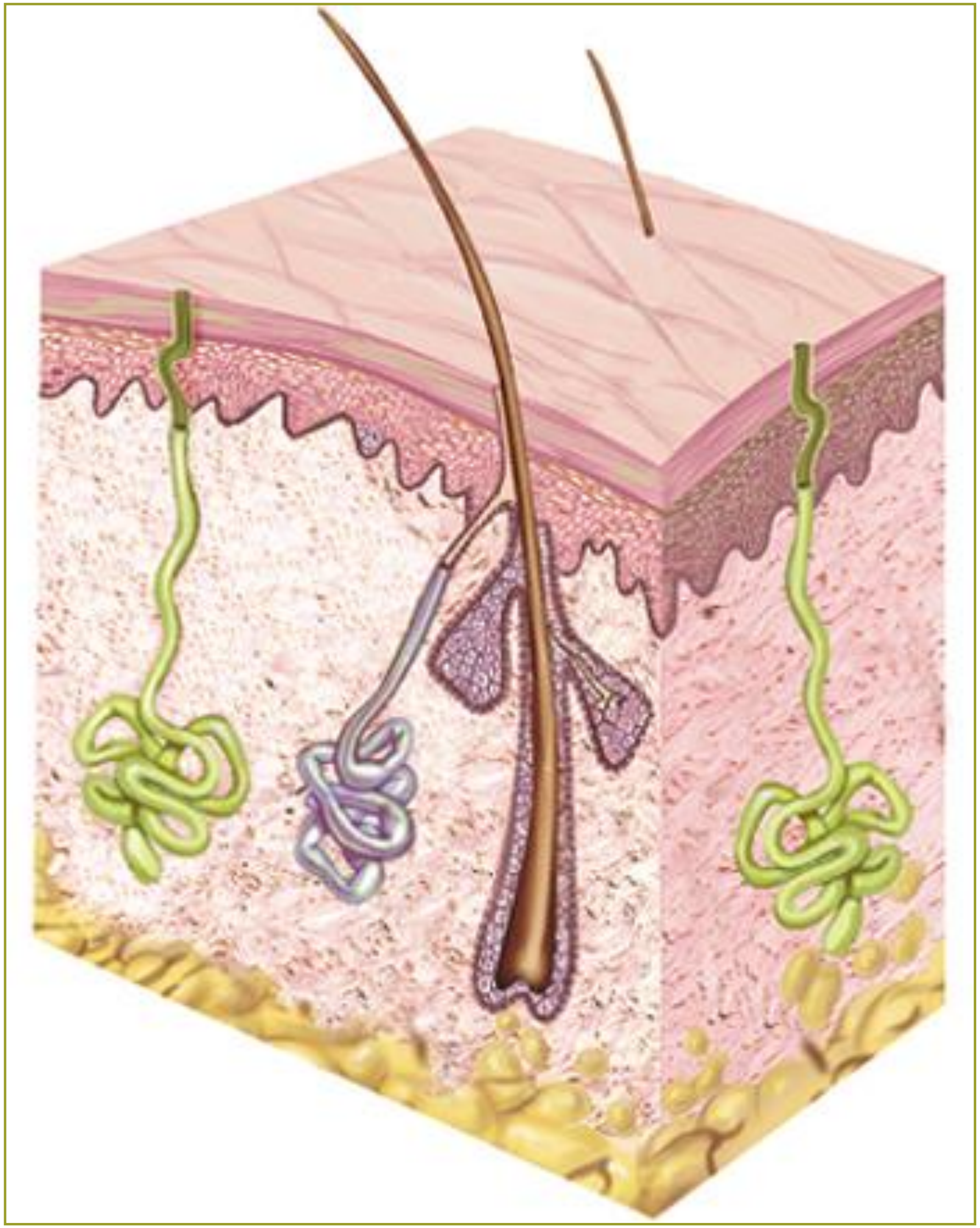
- Occurs as fur in most mammals
- Thickest on most exposed areas
- Hair follicle
  - Shaft
  - Pore
  - Root
  - Hair bulb
  - Dermal papilla
- Vibrissae

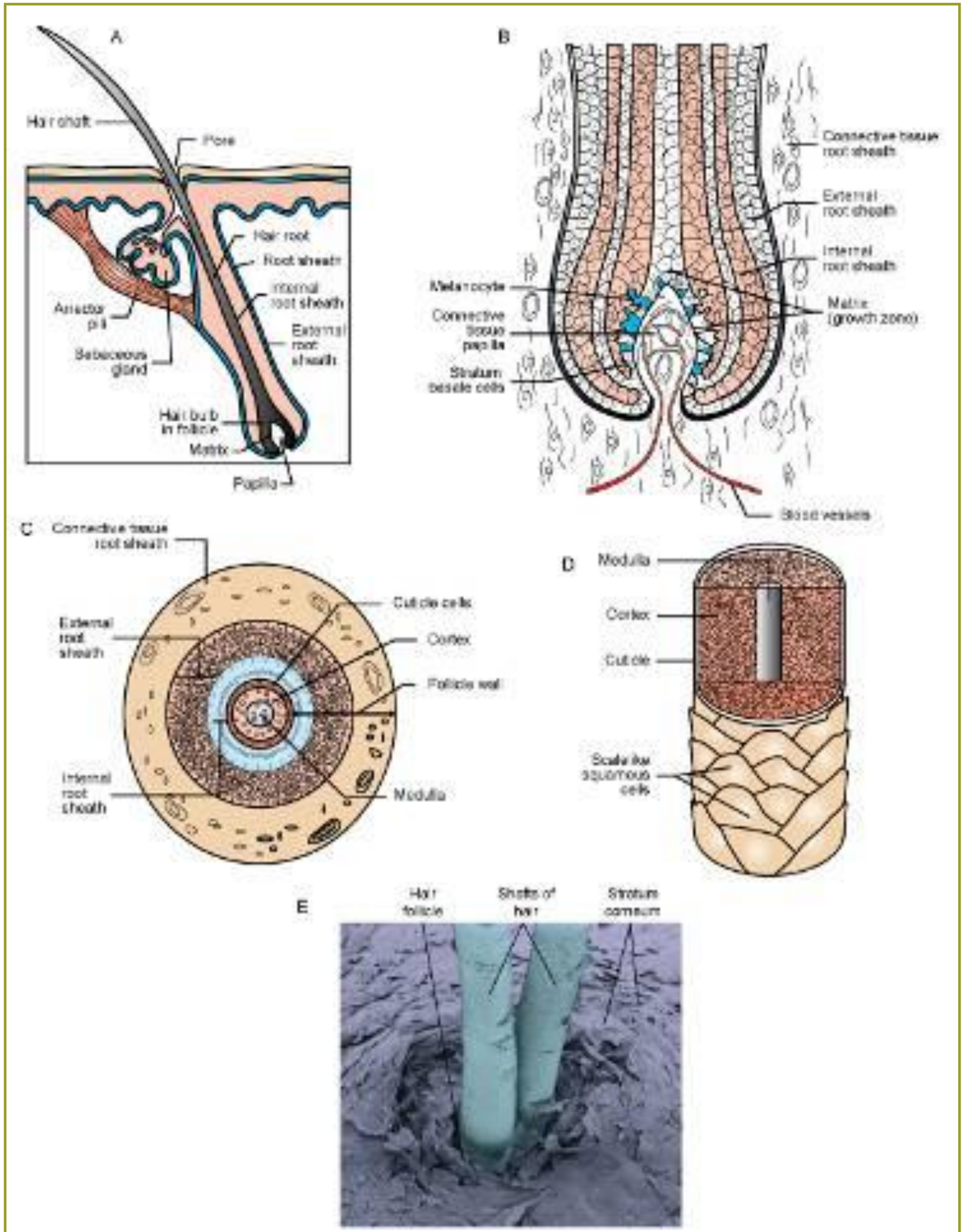


Hair Follicle Anatomy

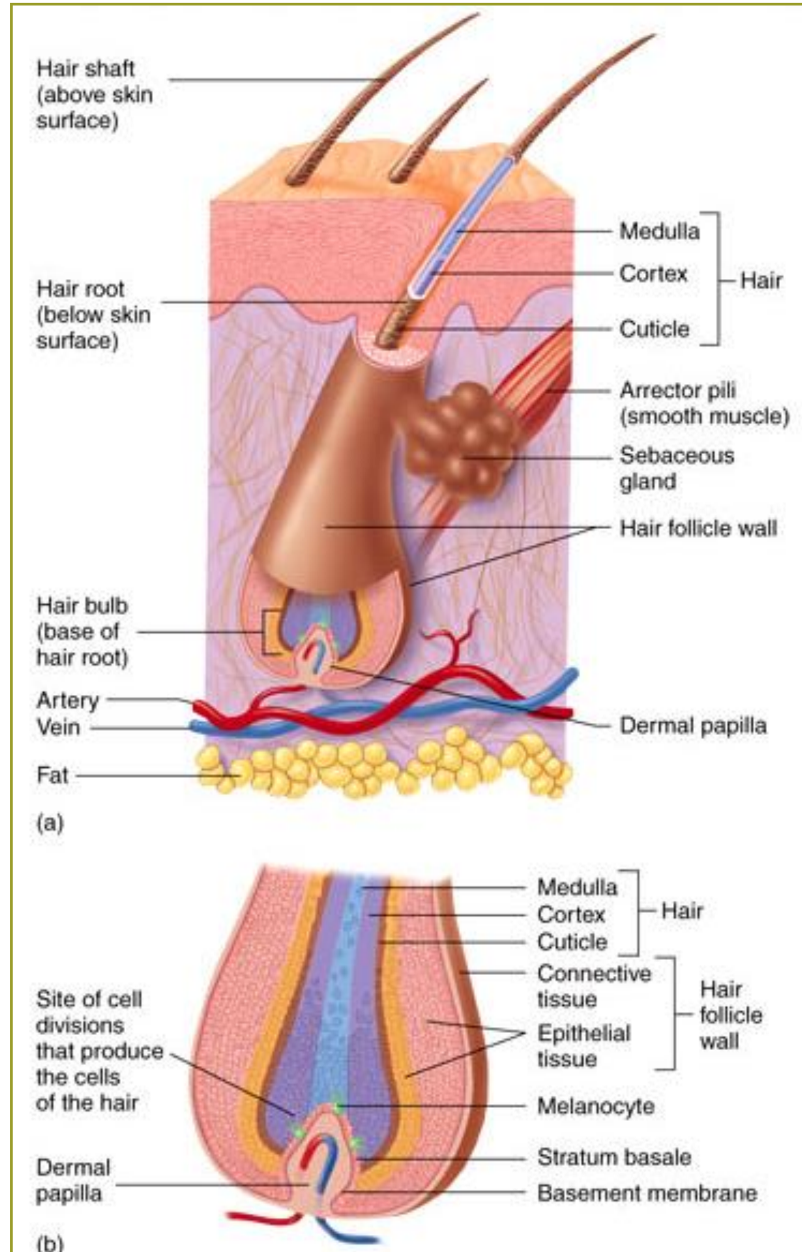
Figure 5-9, Page 143

- Hair shaft: visible above the skin
- Hair root: buried within the skin
- Hair follicle: anchors the hair
  - Deepest part of hair follicle expands to form a hair bulb
  - At base of hair bulb is mound of dermal cells called papilla
  - Hair strands are formed as epithelial cells mature, fill with keratin, and move away from papilla
  - Root hair plexus: web of sensory nerve endings
    - Touch receptor





A
Hair shaft
Pore
Hair root
Root sheath
Internal root sheath
External root sheath
Arrector pili
Sebaceous gland
Hair bulb in follicle
Matrix
Papilla
B
Connective tissue root sheath
External root sheath
Internal root sheath
Melanocyte
Connective tissue papilla
Matrix (growth zone)
Stratum basale cells
Blood vessels
C
Connective tissue root sheath
Cuticle cells
External root sheath
Cortex
Follicle wall
Internal root sheath
Medulla
D
Medulla
Cortex
Cuticle
Scale-like squamous cells
E
Hair follicle
Shafts of hair
Stratum corneum



Hair shaft (above skin surface)
Hair root (below skin surface)
Medulla
Cortex
Cuticle
Hair
Arrector pili (smooth muscle)
Sebaceous gland
Hair follicle wall
Hair bulb (base of hair root)
Artery
Vein
Dermal papilla
Fat
(a)
Medulla
Cortex
Cuticle
Hair
Connective tissue
Epithelial tissue
Hair follicle wall
Site of cell divisions that produce the cells of the hair
Melanocyte
Stratum basale
Dermal papilla
Basement membrane
(b)

Hair Color

- Melanocytes at base of hair follicle
- Less melanin in older dogs (gray hair)
- White hair is formed when the cortex loses its pigment entirely and the medulla becomes completely filled with air

Hair Growth

- Hair growth – 0.18 mm per day
- Shedding
  - Genetics
    - “Groomer” dogs
  - Environment
    - Season change
    - Bitch after whelping

Hair Coat Length

- **Secret of Life!**
- Normal
  - Same as wild **Canidae** (German Shepard)
- Short
  - Boxers, Chihuahuas, Doberman Pinschers
- Long (often an “undercoat”)
  - Chow Chow, Malemute, Husky
- Seasonal changes – **more hairs per follicle**

Arrector Pili Muscles

- Small, smooth muscle attached to each hair follicle
- Innervated by sympathetic nervous system
  - "Fight or flight"
- Best erected on dorsal neck, back, & tail
- Not on vibrissae
- "Goosebumps" in people

Glands of the Skin

Sebaceous Glands

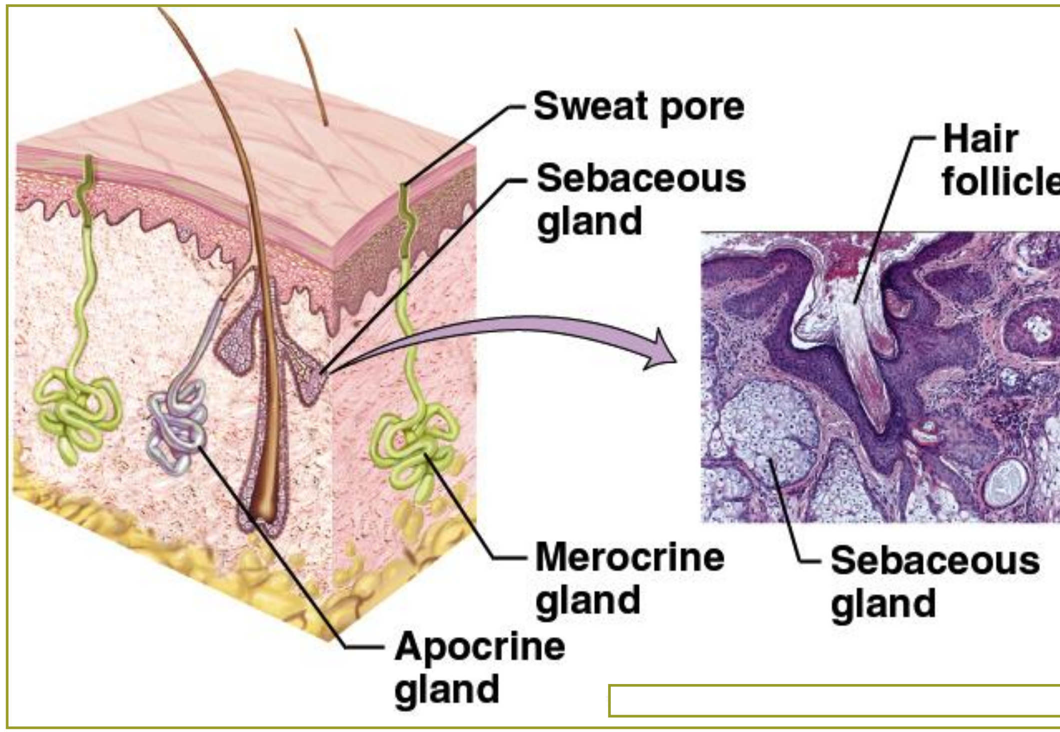
Sweat Glands (Sudoriferous Glands)

Tail Glands

Anal Sacs

Sebaceous Glands

- All over body in dermis except paw pads & planum nasale
- Duct empties into hair follicle
- Sebum – oily, lipid substance
  - Lanolin in sheep
- Sebaceous cysts
  - What dog breed?



Sebum

- Arrector pili muscle contracts and compresses sebaceous gland, forcing sebum through the duct into the hair follicle
- Coats the base of the hair and surrounding skin
  - Helps trap moisture, keeps hair soft, pliant, and somewhat waterproof
  - Sebum also helps reduce the skin's risk of infection

Sweat Glands

Figure 5-11, Page 146

- AKA "Sudoriferous Glands"
- Found over entire body of most domestic species
- Sweat helps cool animal body through evaporation
- 2 type of sweat glands
  - Eccrine – watery, found in footpads
  - Apocrine – thicker, smellier secretion
    - Found only with hairs

Sweat Glands

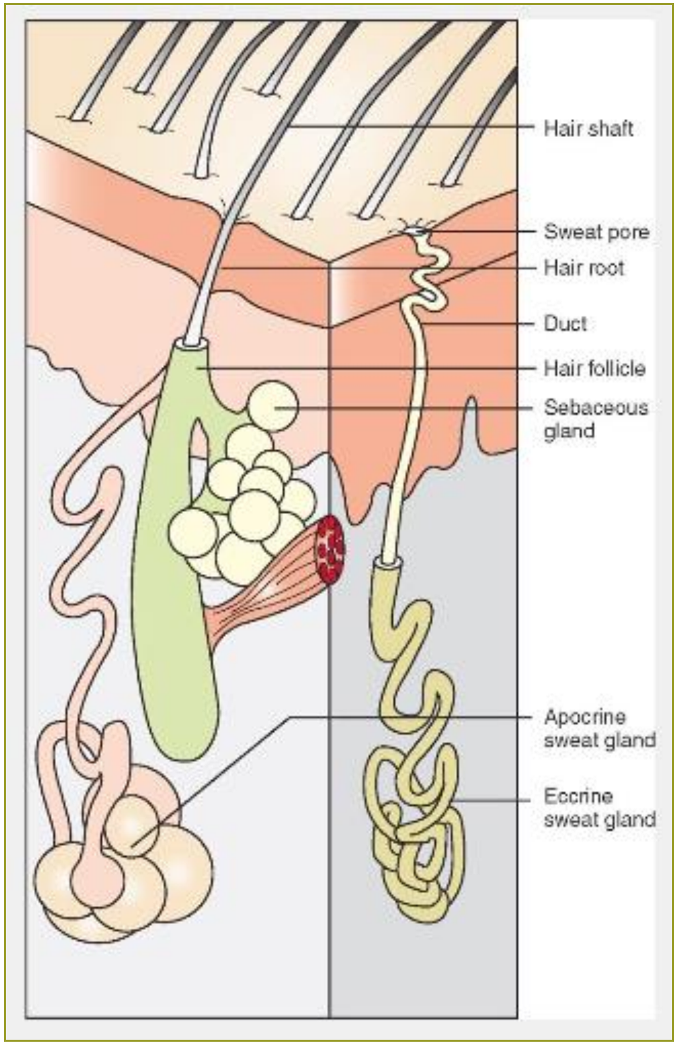
Figure 5-11, Page 146

Eccrine Sweat Glands:

- Excretory portion consists of a simple coiled tube located in the dermis or hypodermis
- Empty onto surface of skin through a long duct

Apocrine Sweat Glands:

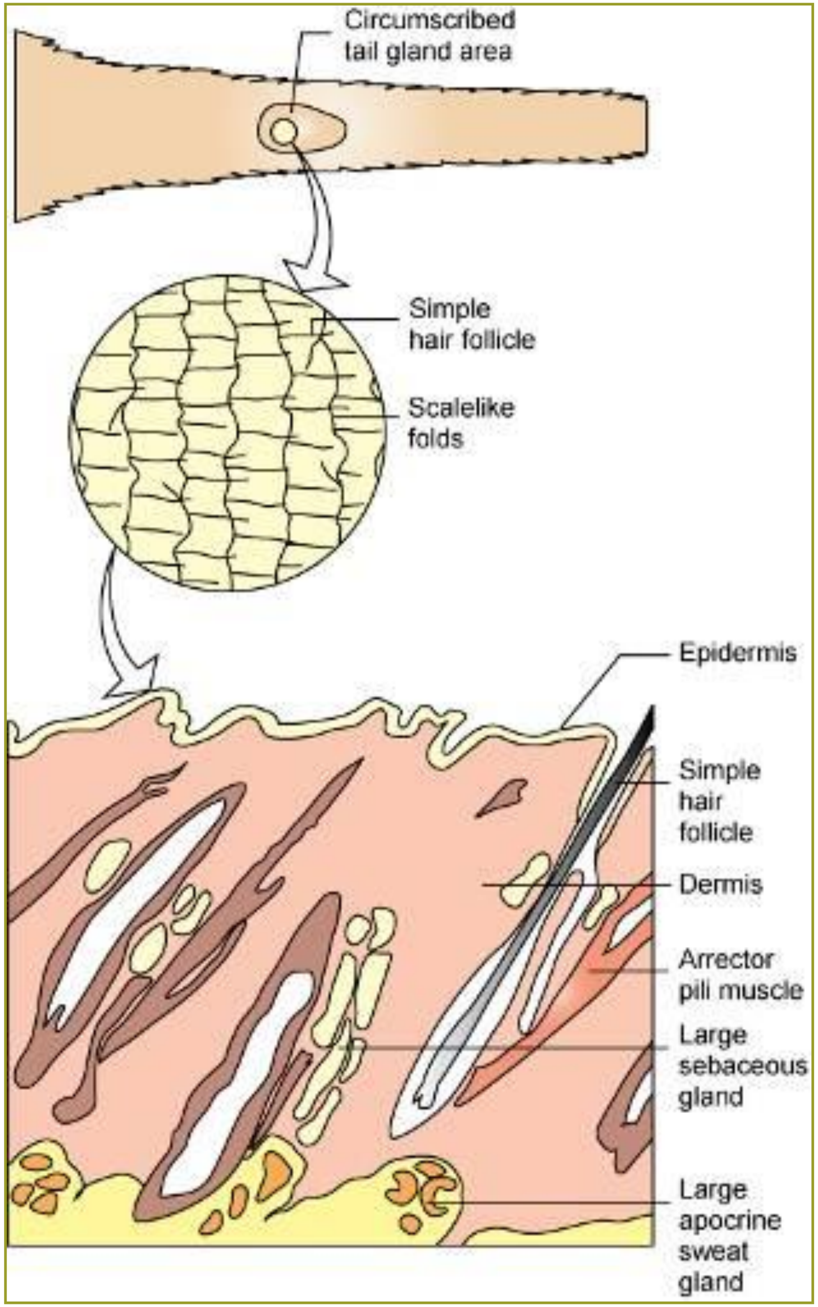
- Coiled excretory portion buried in the dermis or hypodermis; single excretory duct
- Empty into hair follicles



Tail Glands

Figure 5-12, Page 147

- Oval region at the dorsal base of the tails of most dogs and cats
- Contains coarse, oily hairs
- Very large apocrine and sebaceous glands present
- Thought to assist with recognition and identification of individual animals



Tail Glands

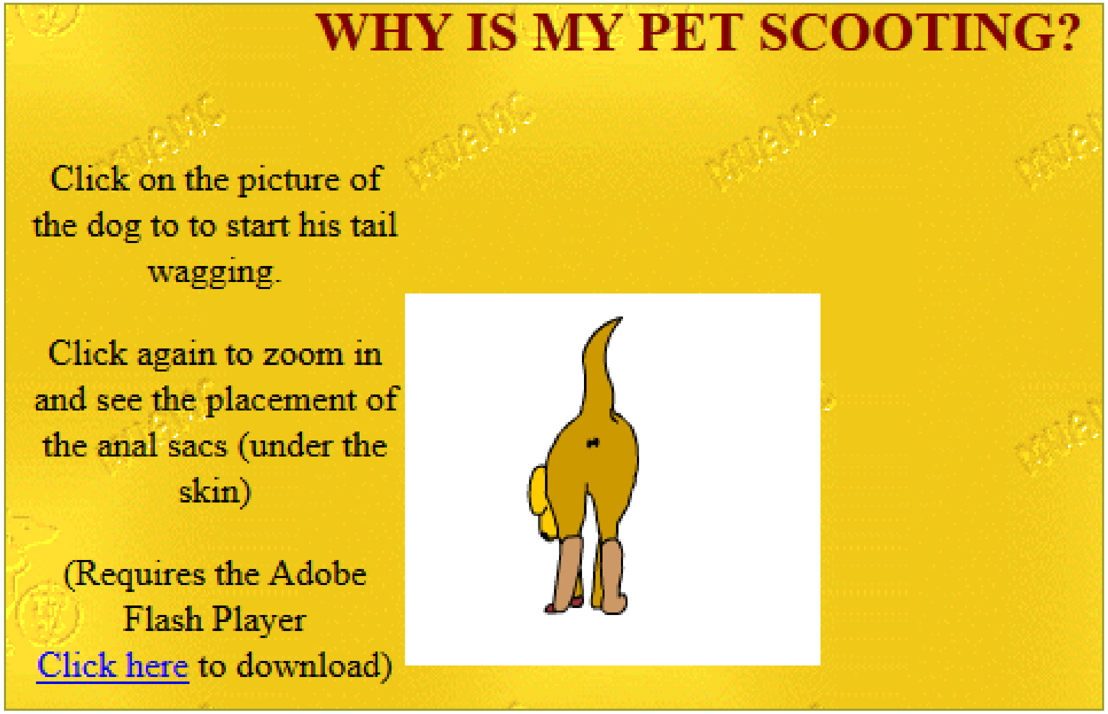
- Sex hormone influence?
- Wild Canidae a lot

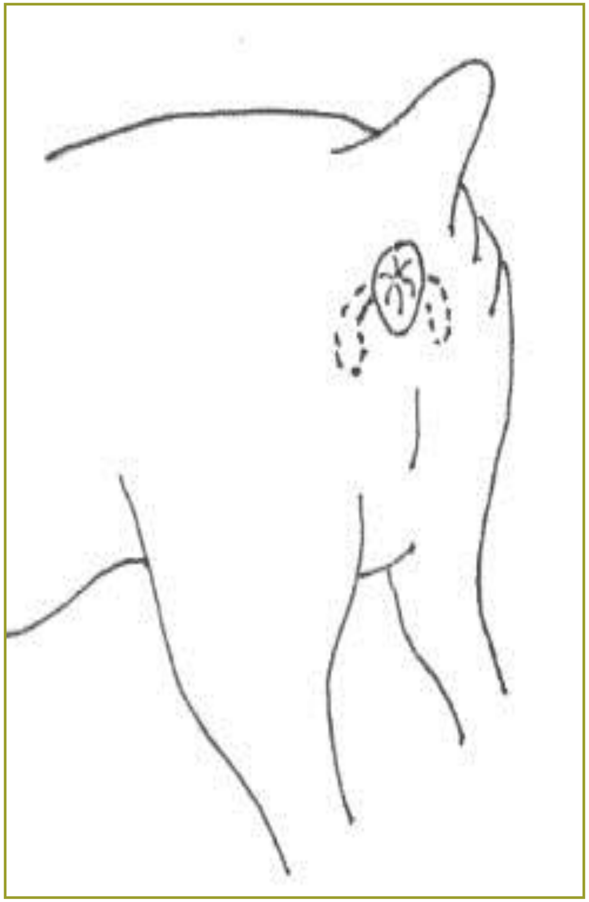
Anal Glands (Sacs)

- Cats and dogs have anal sacs similar to musk glands of skunks
- Located at 4 and 8 o'clock positions relative to anus
- Connected to lateral margin of the anus by a small single duct
- When an animal defecates or becomes frightened, some or all of the anal sac contents are expressed

Anal Glands (Anal Sacs)
http://www.marvistavet.com/html/body_anal_sacs.html

- 4 & 8 o'clock





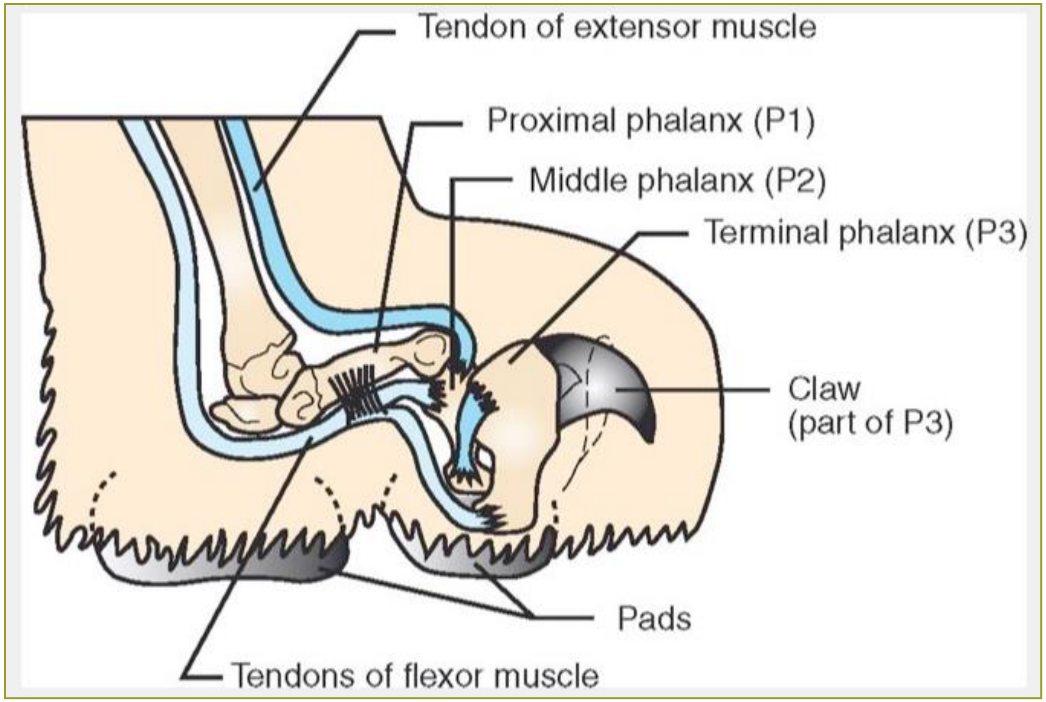
Claws, Nails, Hooves, Horns

From the Epidermis

Claws

Figure 5-13, Page 147

- Retractable or non-retractable
- Anatomy
  - Nail bed attached to distal phalanx (P3)



Claws and Dewclaws

Claws

- Hard outer coverings of the distal digits
- Usually pigmented
- Function in maintaining traction and serve as tools for defense and catching prey
- Claws are non-retractable except in most cat species

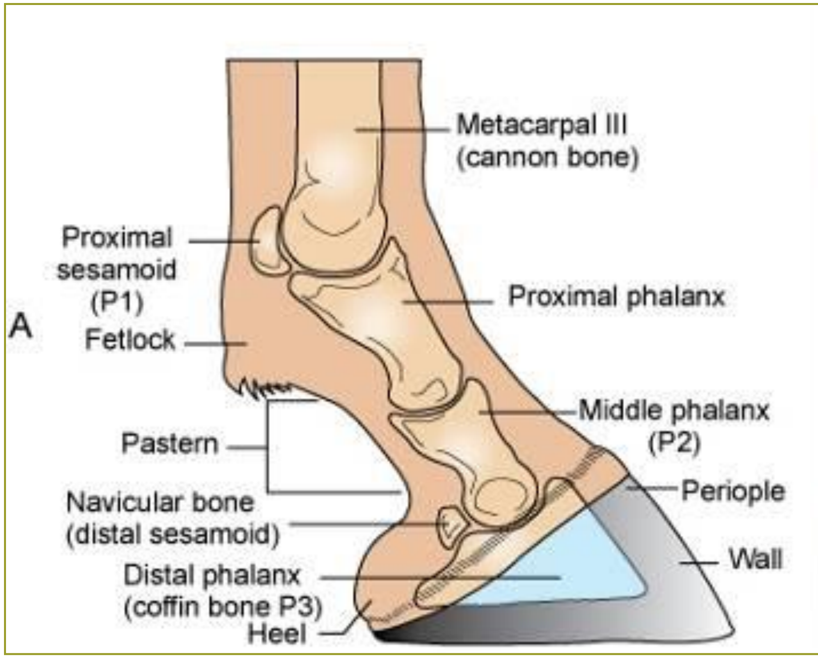
Dewclaws

- Evolutionary remnants of digits
- In the dog, the dewclaw is the first digit
- In the cow, pig, and sheep, the medial and lateral dewclaws are the second and fifth digits, respectively

Hoof

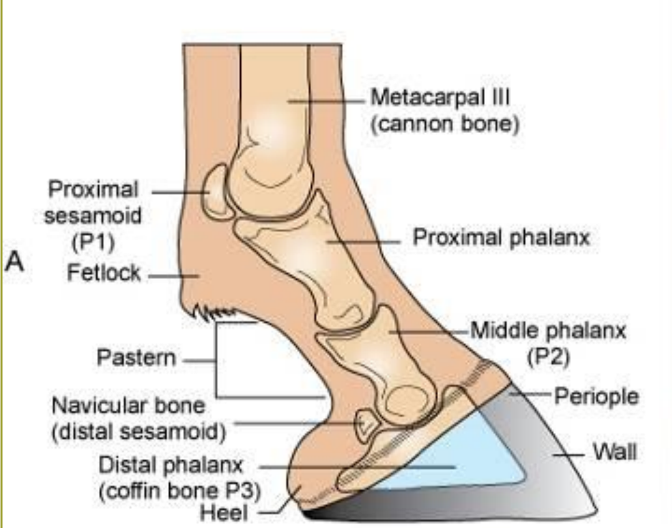
Figure 5-14, Page 148

- Horny outer covering of digits of some animals
- Another name for “hoof” is *ungula*
  - Hoofed animals are called *ungulates*



Hoof

- The skeletal foot of horse includes
  - Distal part of the second phalanx
  - Distal sesamoid bone (navicular bone)
  - Entire third phalanx (coffin bone).
- The equine hoof is generally divided into three parts: the wall, the sole, and the frog



Hoof

The wall:

- External portion of the hoof

The sole:

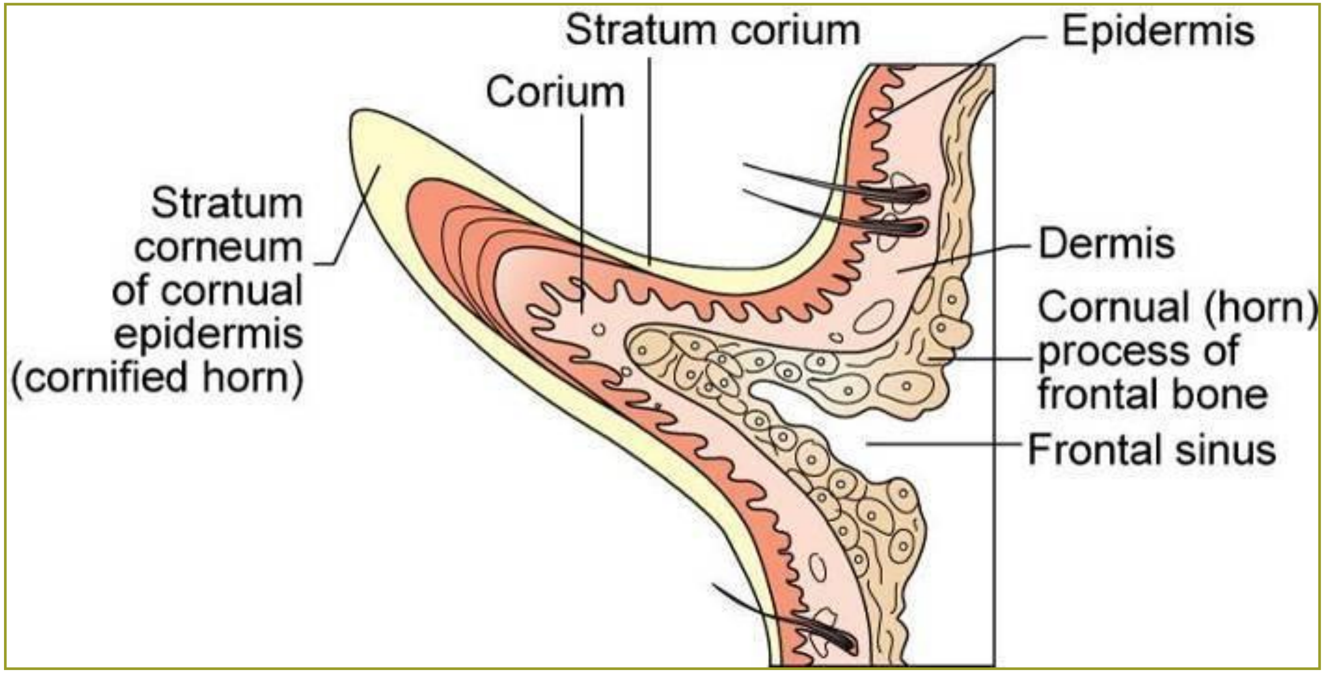
- Plantar, or palmar, surface of the hoof; outer layers are avascular and lack innervation

The frog:

- Triangular horny structure located between the heels on the underside of the hoof

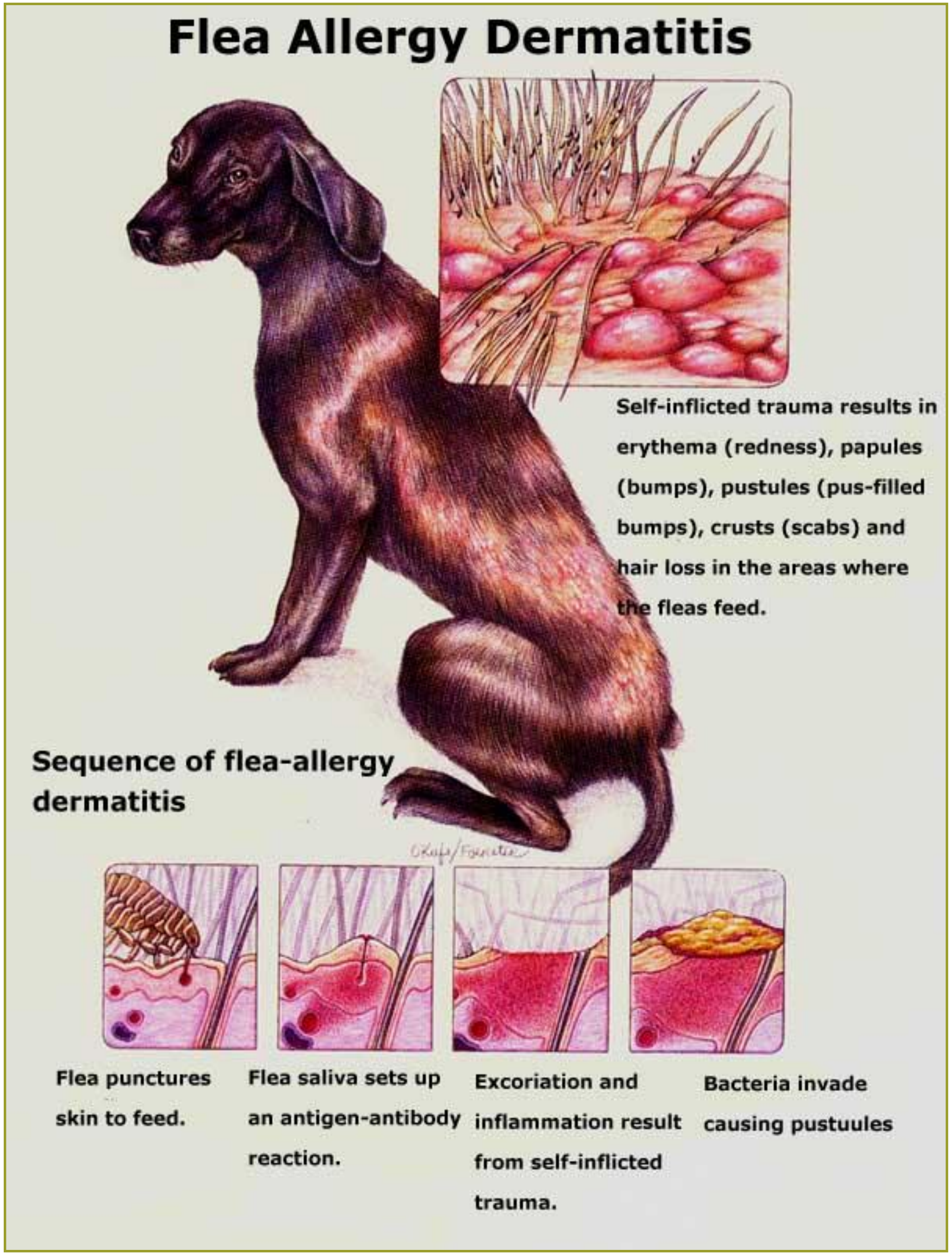
Horns
Figure 5-19, Page 150

- Epidermal in origin
- Structurally similar to hair
- Composed of keratin



Topic 23

Discuss some of the skin pathology commonly seen in veterinary practice

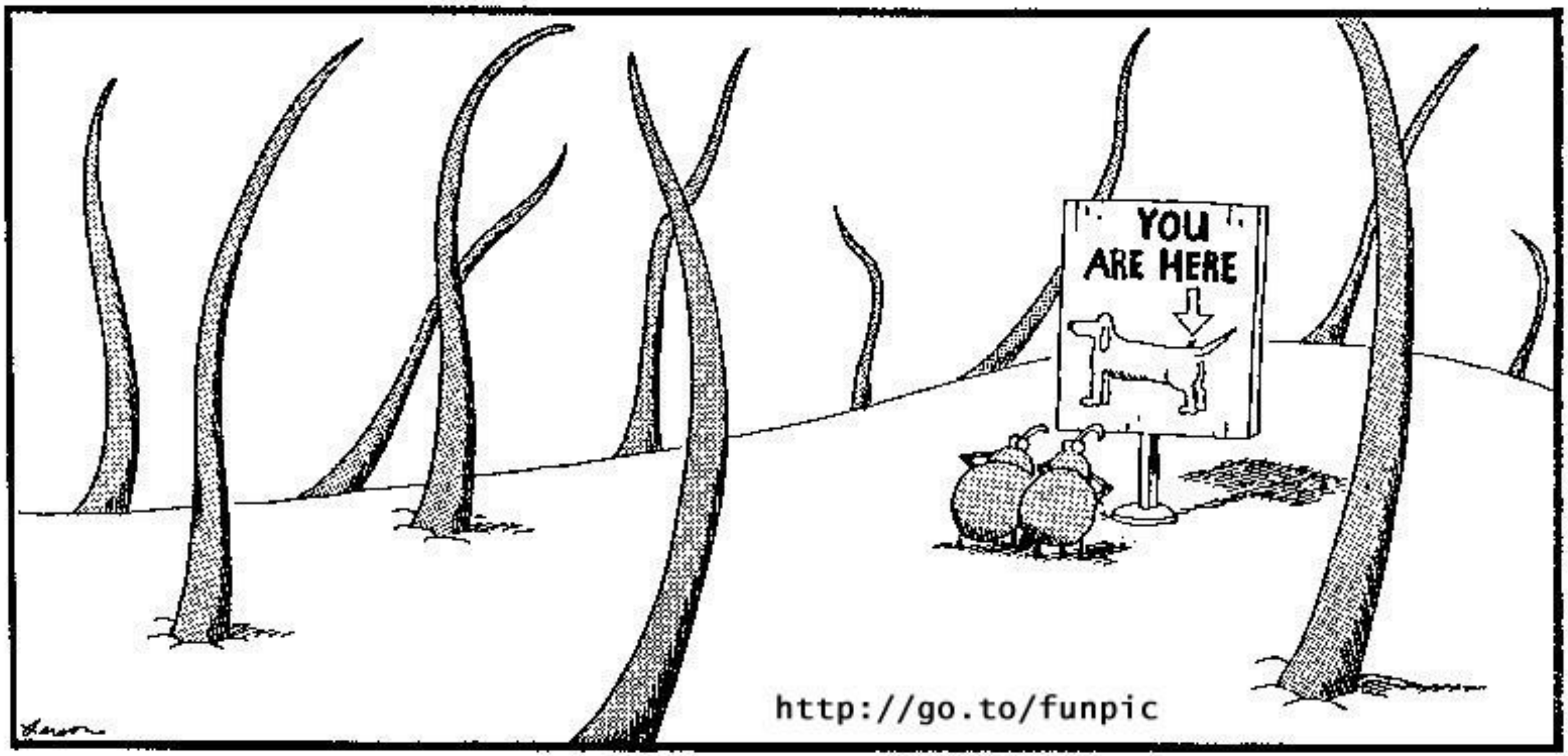


Common Skin Pathology

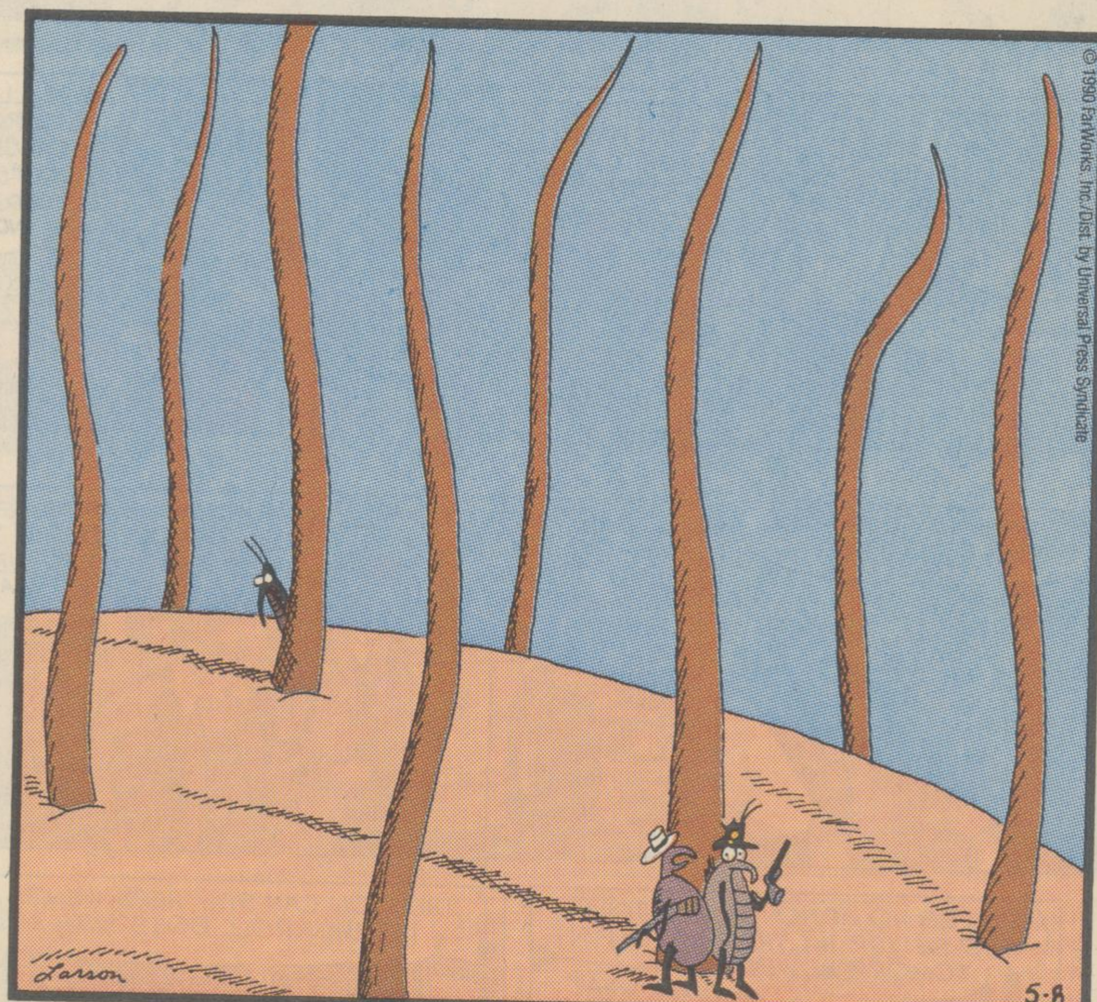
- Dermatitis
- Alopecia
- Pruritis
- "Hot spots"
- Seborrhea
- Ectoparasites
  - Fleas
  - Mites

Alopecia? ☺

Fleas!

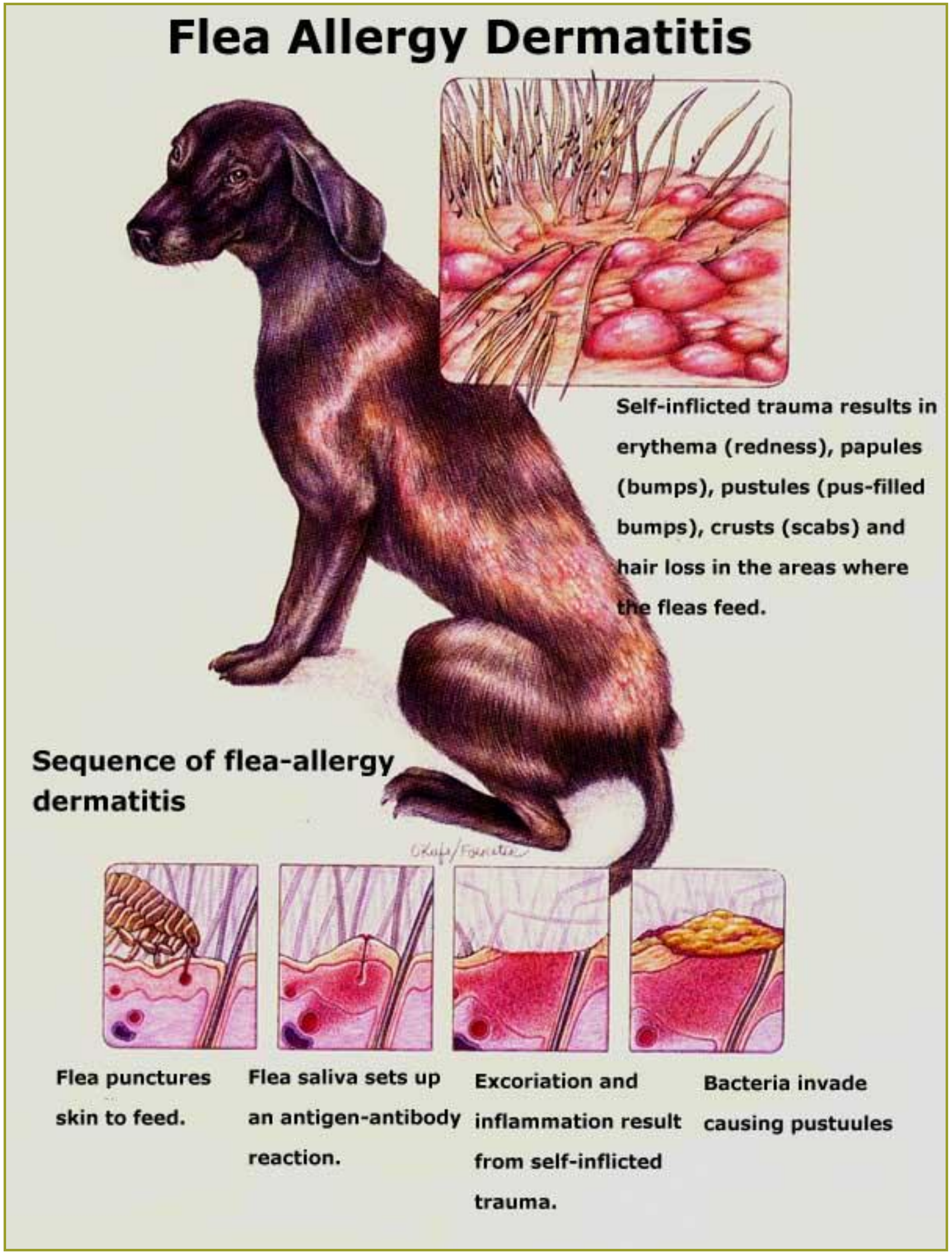


THE FAR SIDE BY GARY LARSON



"Listen, before we take this guy, let me ask you this:
You ever kill a flea before, Dawkins? It ain't easy."

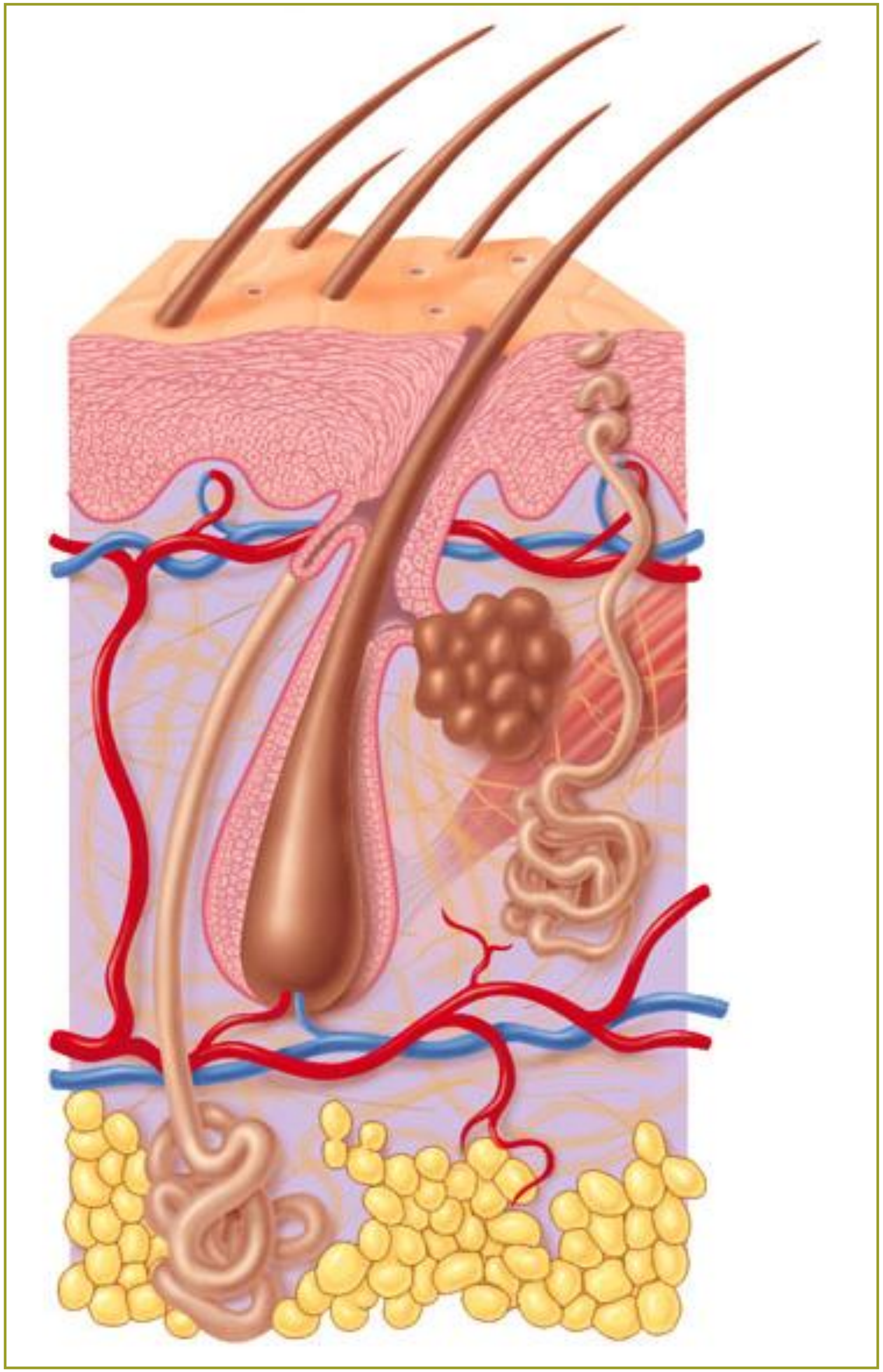
Flea Allergy Dermatitis (FAD)



Clinical Applications

- Skin Cancer (Page 133)
- Allergies: Itchy Business (Page 145)
- Laminitis: A Painful Health Risk to Horses (Page 152)

Review of the Skin



Clinical Applications

Pages 133, 136-137, 138, 145, 152