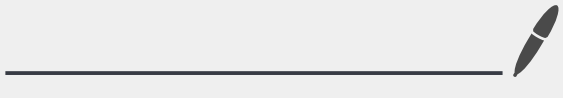


Chapter 3

whole chapter

Cytology - the scientific study of cells
↳ born in 1666 w/ Robert Hooke

cell = simple structural and functional unit of life

Cell Shapes + Sizes

Squamous - thin, flat, scaly shape, often w/ bulge where nucleus is
↳ they line the esophagus + form the epidermis

Cuboidal - squarish (liver cell

Columnar - rectangular (lines stomach + intestines)

Polygonal - irregular shape

Stellate - starlike shape (nerve cells

Spheroidal / ovoid - round

discoidal - disc shaped (red blood cells)

fusiform - spindle shaped (smooth muscle cells)

fibrous - threadlike (skeletal muscle cells and axons)

* μm
↳ micrometer used for measuring cell size

cell size is limited to volume and surface area

Basic Component of a cell

cytoplasm - fluid b/w cell's nucleus and membrane

Ultrastructure = fine detail on molecular level

cell membrane - surrounds cell

ICF = cytosol ↙ ↘ organelles

Plasma Membrane

- defines boundaries of the cell
- governs interactions w/ other cells
- controls passage of materials into/out of cell

intracellular = side that faces cytoplasm
extracellular face = side that faces outward

98% of pm –
- *phospholipids – fluidity
- glycolipids – contributes to glycocalyx
- cholesterol – holds phospholipids still

transmembrane proteins - glycoproteins that pass completely through phospholipid bilayer.

peripheral proteins – adhere to either inner or outer face of membrane, typically anchored to a transmembrane protein and/or cytoskeleton.

Functions of membrane proteins:

- Receptor: needed for chemical communication, specific like enzymes.
  ↳ interact with messenger
- Second-messenger systems: when messenger binds to surface receptor, it may trigger changes that produces a second messenger in the cytoplasm
- Enzymes: carry out final stages of starch and protein digestion in the small intestine, help produce second messengers, break down hormones + other signaling molecules
- Channel proteins: allow hydrophillic substances + water through membrane
  - ligand-gated – responds to chemical signals
  - voltage-gated – changes in electrical potential
  - mechanically gated – stress/pressure

defect in channel proteins = channelopathies

- Carriers: bind to glucose, electrolytes, other solutes + transfer them to the other side of membrane.
  * pumps = carriers that consume ATP
- Cell identity marker: glycoproteins that contribute to the glycocalyx
- Cell adhesion molecules

Composed of carbohydrate moiety of membrane glycoproteins and glycolipids.
- Chemically unique in everyone but identical twins
* Acts like ID tag that enables the body to recognize its own cells from transplanted cells, invading organisms,
  ↳ transplant / transfusion compatibility is determined by glycocalyx

functions of glycocalyx: protection from injury, immunity, defense against cancer, cell adhesion, fertilization (enables sperm to recognize + bind to eggs), embryonic development (guides cells to where they're supposed to go)

Extensions of cell surface

* microvilli = extensions of the plasma membrane that primarily increase a cell's surface area.
  * epithelial cells of kidneys + small intestines

brush border = a fringe of microvilli on the apical surface of an epithelial cell, promotes absorption + increases surface area
apical = outer surface / side facing lumen

made of actin filaments

Cilia - hairlike processes, sensory * defects = ciliopathies
  ↳ occurs in fallopian tubes, respiratory tract, testes, brain
they beat in saline layer at cell surface made by chloride pumps

axoneme = core of cilia made of microtubules

Dynein = motor proteins, using ATP to crawl up pair of microtubules

flagellum - whip like tail or sperm

psydopods - cytoplasm-filled extensions of the cell that continually change

Membrane Transport

plasma membrane is selectively permeable
- ↳ passive - does not need ATP (osmosis, filtration, diffusion)
- ↳ active - needs ATP
  - carrier-mediated transport
  - active transport
  - vesicular transport

filtration (think coffee through filter)

Simple diffusion - net particle movement down concentration gradient (high to low)

rate of diffusion depends on:
- temperature
- molecular weight ← easier for small molecules
- steepness of concentration gradient
- membrane surface area
- membrane permiability
  - ↳ hydrophobic + nonpolar, lipid-soluable substances (oxygen, nitrous oxide, alcohol, steroids) diffuse through membrane.

hydrophillic & olar molecules need channel proteins

Osmosis - flow of water
- ↳ occurs through plasma membrane + non living things

water accumulates to the side with most solute.

aquaporins - channel proteins specialized for water

hydrostatic pressure = force water puts on cell membrane

osmotic pressure = solute concentration that pulls water in osmosis

Reverse osmosis = mechanical pressure overrides osmotic pressure, forces water to move against concentration gradient.
↳ capilary filtration

osmolarity = osmotic concentration milliosmoles / liter mOsm/L
↳ measure of osmotic pressure in a solution

tonicity = ability of a solution to affect the fluid volume and pressure inside a cell
↳ measure of osmotic pressure gradient b/w two solutions separated by plasma membrane

hypotonic solution – cells absorb too much water / may swell
↳ lower concentration of solute than ICF

hypertonic solution – cells may shrivel, lost too much water
↳ higher concentration of solute to ICF

Isotonic solution = equal solute concentration to ICF

hypotonic solution.
too little solute
→ water moves into cell, may burst

* normal saline = 0.9% solution NaCl (isotonic to blood cells)

hypertonic solution
too much solute
→ water moves out of cells, causing them to shrink

Carrier-mediated transport – cell membrane is necessary

carriers act like enzymes
↳ but don't chemically change their ligand

carrier: ligand/messenger
enzyme: substrate

uniport → one type of solute
symport (cotransport) → two/more, same direction
antiport (countertransport) → two/more, opposite directions

facilitated diffusion = carrier-mediated down concentration gradient
* does not use ATP

Primary active transport - carrier mediated transport UP concentration gradient

Secondary active transport - but indirectly depends on ATP

*Sodium - potassium pump $Na^+ K^+$ ATPase
↳ functions:
- secondary active transport (potential energy)
- regulation of cell volume
- maintenance of membrane potential
- heat production

Vesicular transport → endocytosis - materials in to cells
takes away pieces of plasma membrane

exocytosis - materials out of cells
replaces plasma membrane lost by endocytosis

phagocytosis - (cell eating) - engulfing large particles
↳ dust, bacteria, cellular debris

Vesicle = phagosome

pinocytosis - (cell drinking) taking in droplets of ECF

receptor-mediated endocytosis → specific receptors that allow specific pinocytosis or phagocytosis

transcytosis - capture on one side, release to other

Examples of exocytosis - endothelial cells release insulin to the tissue fluid, sperm cells release enzymes when penetrating an egg, mammary gland cells secrete milk sugar, gland cells release hormones.

the cell interior

cytoskeleton = network of protein filaments and cylinders that structurally support a cell, determine its shape, organize its contents, direct movements of materials within a cell, and contribute to cell movements as a whole.

they are connected to transmembrane proteins, creating a strong structural continuity from extracellular material to the cytoplasm.

- microfilaments = thin filaments made of actin. Holds phospholipids together, forms the supportive cores of microvilli, cell movement.
  - * actin plays role in embryonic development, muscle contraction, immune function, wound healing, cancer metastasis
- intermediate filaments → give cell its shape, reduces stress, participates in junctions that attaches cell to its neighbors
  - ↳ made of keratin in epidermal cells
- microtubules = 13 strands of protofilaments. each protofilament is made of globular proteins (tubulin). They radiate from an area of the cell called the centrosome.
  - ↳ they hold organelles in place, form bundles that maintain cell shape + rigidity. Not permanent structures.
  - * form axonemes of cilia + flagella (responsible for beating movements) they also form the mitotic spindle that guide chromosome movement.

organelle = internal structures of a cell that carry out specialized metabolic tasks.

↳ organelles surrounded by membranes = membranous organelle

nucleus → contains the cell's chromosomes, the center for cellular activity.

mature red blood cells are anuclear.

enclosed in nuclear envelope

↳ envelope has nuclear pores →

→ formed by a ring of proteins called nuclear pore complex.
↳ regulates traffic through the envelope, holds two layers of envelope together.
going into nucleus = hormones, materials for DNA + RNA synthesis, enzymes, and other chemical messengers.
going out of nucleus = RNA

nuclear lamina: supports nuclear envelope + pores, provides point of attachment + organization for the chromosomes inside the nucleus, and plays a role in regulating DNA replication + cell life cycle.
↳ just inside the nuclear envelope.
abnormalities = genetic diseases + premature cell death.

nucleoplasm = material in b/w nuclear lamina + nucleolis
↳ contains chromatin, fine threadlike matter composed of DNA + protein
↳ nucleoli → RNA production

Endoplasmic Reticulum "little network within the cytoplasm"
system of interconnected channels → cisterns

- Rough Endoplasmic Reticulum = studded with ribosomes, protein synthesis + makes phospholipids
↳ found in RER nucleoli, cytosol, mitochondria, nuclear envelope — they read coded genetic messages from mRNA + assemble amino acid proteins & enzymes.

- Smooth Endoplasmic Reticulum = no ribosomes, synthesizes steroids + lipids, detoxifies alcohol + other drugs, manufactures nearly all membranes of the cell, stores calcium + releases it to trigger muscle contraction.

Golgi Complex - small system of cisterns that synthesize carbohydrates + put finishing touches on protein + glycoprotein synthesis. Receives, cut/splice + adds carb moieties to proteins from RER.

↳ mature cistern w/ finished cell products break up into membrane bound Golgi vesicles. Some become lysosomes, some become secretory vesicles (breast milk or digestive enzymes)

a package of enzymes bound by a membrane. Function to hydrolize proteins, nucleic acids, complex carbohydrates, phospholipids, other substrates, and digest/dispose of surplus or nonvital organelles to recycle + be used for cell needs, aid in process of cell suicide

↳ autophagy

autolysis = digestion of surplus cells by their own lysosomal enzymes.

Peroxisomes - like lysosomes but contain different enzymes. Uses molecular oxygen to oxidize organic molecules. Their reactions produce hydrogen peroxide, which is used to break down other molecules.

↳ catalase = enzyme used to break down excess molecules into water and oxygen.

Proteasome = responsible for protein disposal (80%) located in nucleus + cytoplasm, enzymes break down + unfold into short peptides and free amino acids.

Mitochondria - ATP synthesis, surrounded by double-membrane.

cristae - inner folds of mitochondria

matrix = space b/w cristae, contains ribosomes, mitochondrial DNA

Centrioles - short cylindrical assembly of microtubules, arranged in 9 groups of 3 microtubules per group

centrosome = clear patch of cytoplasm near the nucleus containing a pair of perpendicular centrioles

inclusions
- accumulated cell products (glycogen granules, pigments, oil droplets)
- foreign bodies (viruses, bacteria, dust particles, and other debris phagocytized by a cell

→ never enclosed in a membrane, not essential for cell survival

Chapter 3 Diagrams & images

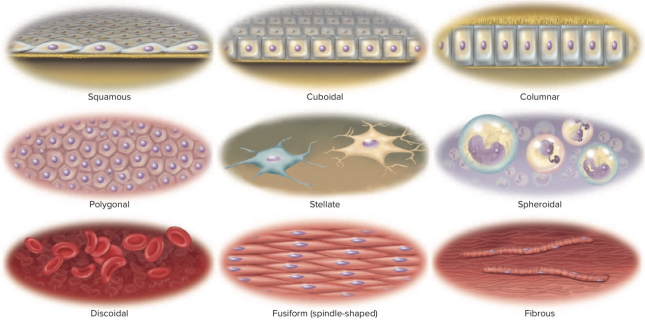


FIGURE 3.1 Common Cell Shapes. APR

TABLE 3.1 Sizes of Biological Structures in Relation to the Resolution of the Eye, Light Microscope, and Transmission Electron Microscope

Object	Size
Visible to the Naked Eye (Resolution 70–100 µm)	
Human egg, diameter	100 µm
Visible with the Light Microscope (Resolution 200 nm)	
Most human cells, diameter	10–15 µm
Cilia, length	7–10 µm
Mitochondria, width × length	0.2 × 4 µm
Bacteria *(Escherichia coli)*, length	1–3 µm
Microvilli, length	1–2 µm
Lysosomes, diameter	0.5 µm = 500 nm
Visible with the Transmission Electron Microscope (Resolution 0.5 nm)	
Nuclear pores, diameter	30–100 nm
Centriole, diameter × length	20 × 50 nm
Poliovirus, diameter	30 nm
Ribosomes, diameter	15 nm
Globular proteins, diameter	5–10 nm
Plasma membrane, thickness	7.5 nm
DNA molecule, diameter	2.0 nm
Plasma membrane channels, diameter	0.8 nm

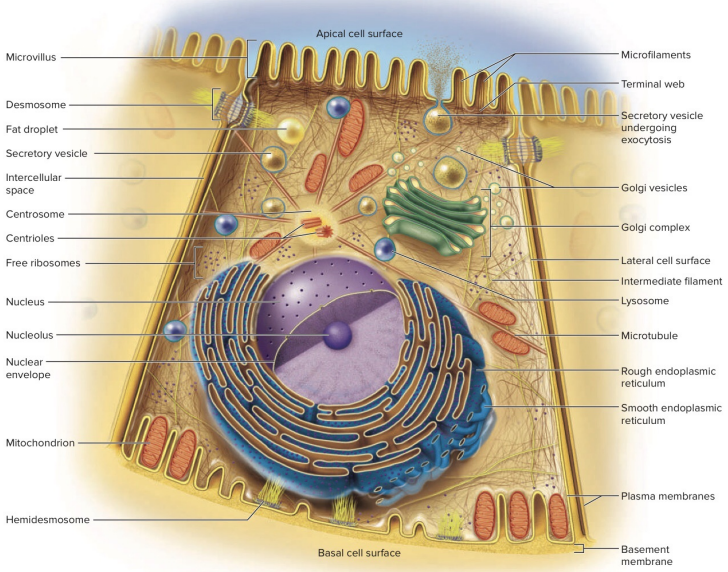


FIGURE 3.4 Structure of a Representative Cell.

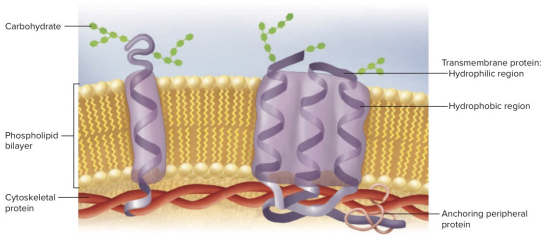
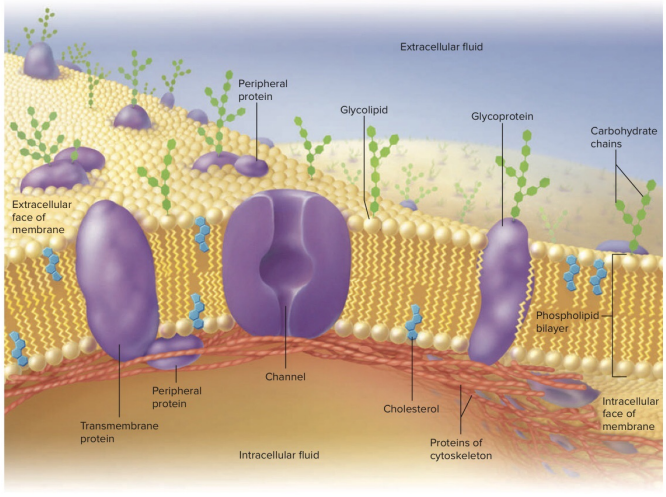


FIGURE 3.6 Transmembrane Proteins. A transmembrane protein has hydrophobic regions embedded in the phospholipid bilayer a hydrophilic regions projecting into the intracellular and extracellular fluids. The protein may cross the membrane once (left) or multiple (right). The intracellular regions are often anchored to the cytoskeleton by peripheral proteins.



(b)

FIGURE 3.5 The Plasma Membrane. (a) Plasma membranes of two adjacent cells (TEM). (b) Molecular structure of the plasma membrane.

a: Dr. Donald Fawcett/Science Source

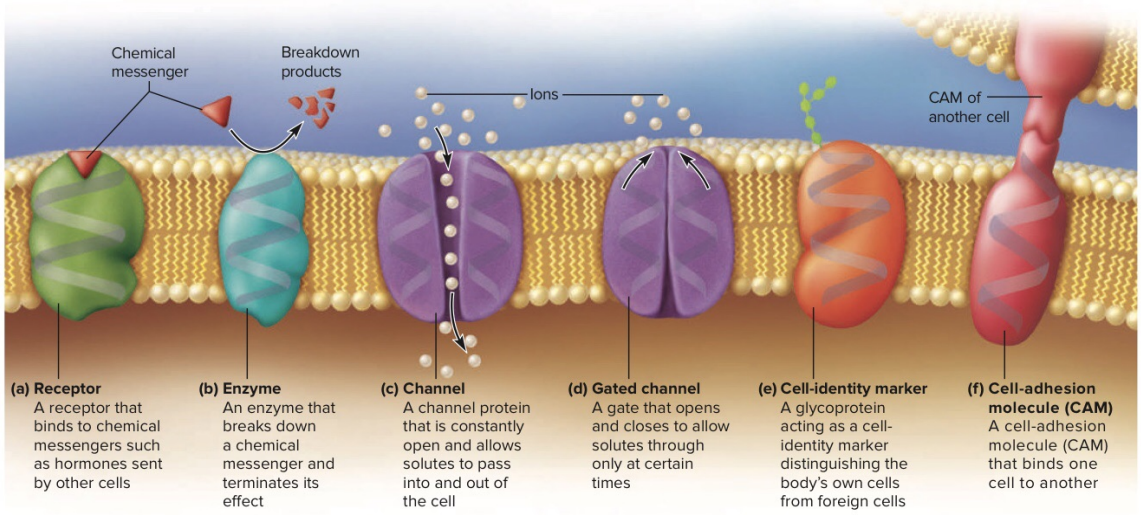
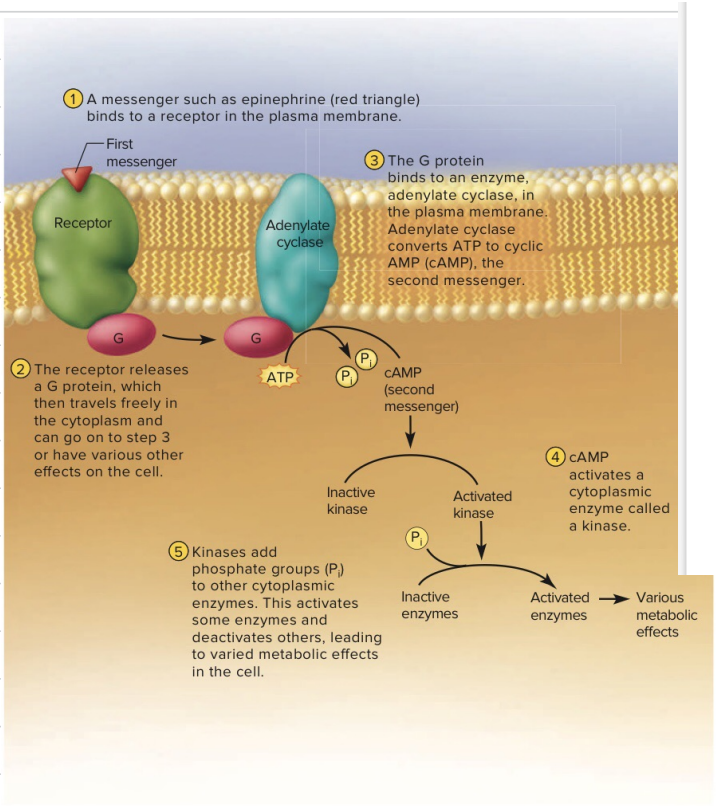


FIGURE 3.7 Some Functions of Membrane Proteins.



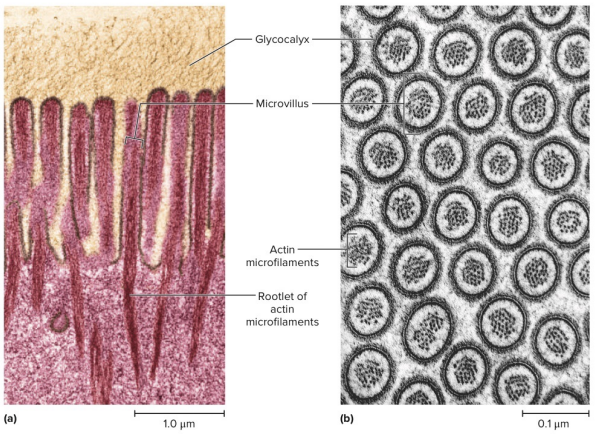


FIGURE 3.9 Microvilli and the Glycocalyx (TEM). The microvilli are anchored by microfilaments of actin, which occupy the core of each microvillus and project into the cytoplasm. (a) Longitudinal section, perpendicular to the cell surface. (b) Cross section.

a: Don W. Fawcett/Science Source; b: Biophoto Associates/Science Source

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urface

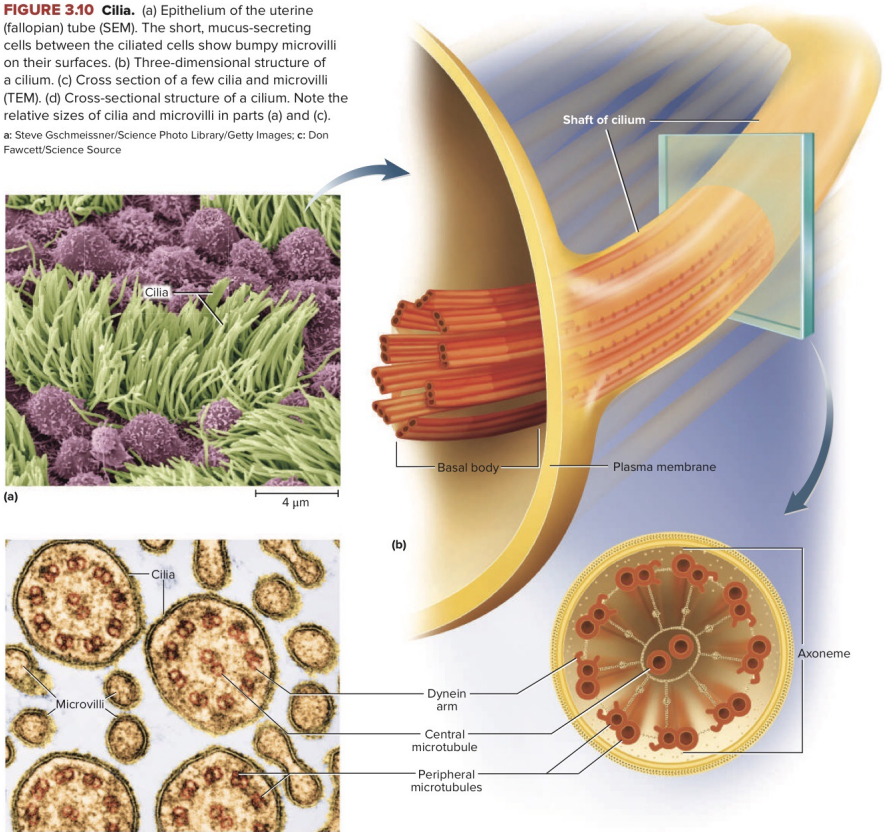
lled *microvilli, cilia,*
rption, movement, and

TABLE 3.2 Functions of the Glycocalyx

Protection	Cushions the plasma membrane and protects it from physical and chemical injury
Immunity to infection	Enables the immune system to recognize and selectively attack foreign organisms
Defense against cancer	Changes in the glycocalyx of cancerous cells enable the immune system to recognize and destroy them
Transplant compatibility	Forms the basis for compatibility of blood transfusions, tissue grafts, and organ transplants
Cell adhesion	Binds cells together so tissues do not fall apart
Fertilization	Enables sperm to recognize and bind to eggs
Embryonic development	Guides embryonic cells to their destinations in the body

FIGURE 3.10 Cilia. (a) Epithelium of the uterine (fallopian) tube (SEM). The short, mucus-secreting cells between the ciliated cells show bumpy microvilli on their surfaces. (b) Three-dimensional structure of a cilium. (c) Cross section of a few cilia and microvilli (TEM). (d) Cross-sectional structure of a cilium. Note the relative sizes of cilia and microvilli in parts (a) and (c).

a: Steve Gschmeissner/Science Photo Library/Getty Images; c: Don Fawcett/Science Source



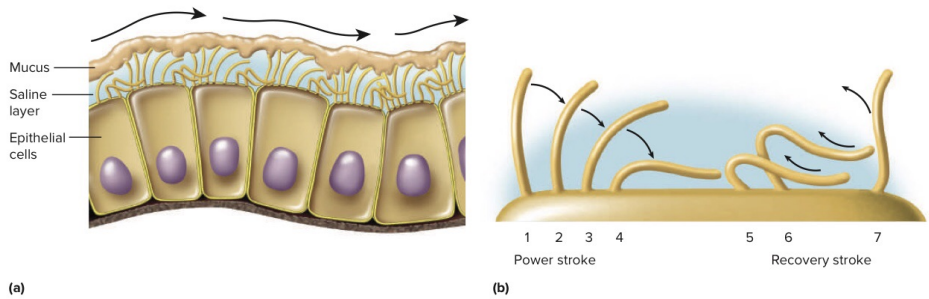


FIGURE 3.11 Ciliary Action. (a) Cilia of an epithelium moving mucus along a surface layer of saline. (b) Power and recovery strokes of an individual cilium. The cilium goes limp on the recovery stroke to return to its original position without touching the mucus above.

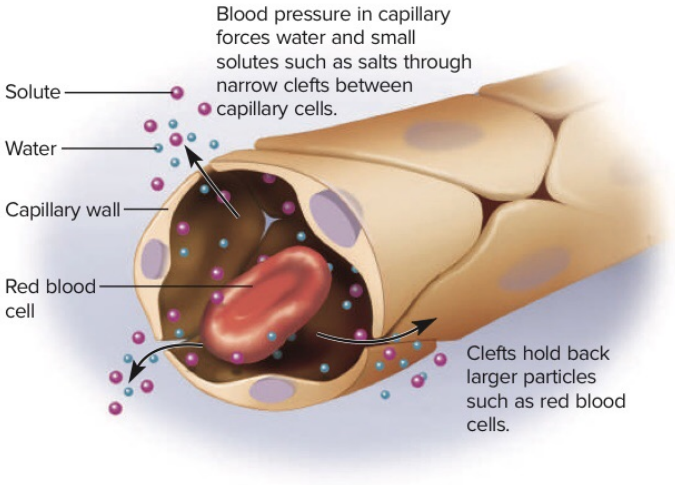
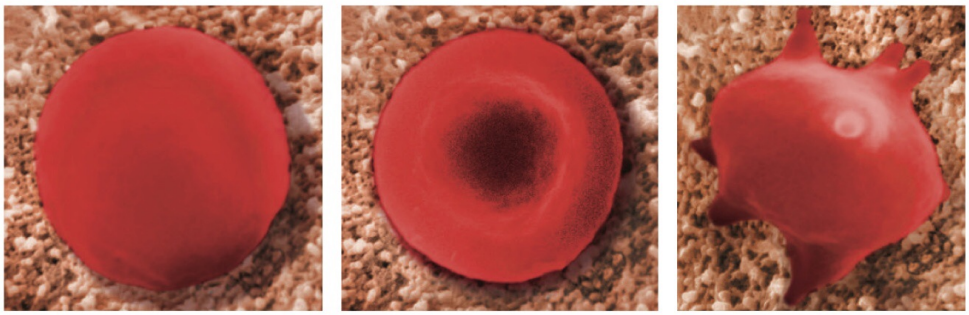


FIGURE 3.13 Filtration Through the Wall of a Blood Capillary. Water and small solutes pass through gaps between cells, while blood cells and other large particles are held back.



(a) Hypotonic (b) Isotonic (c) Hypertonic

FIGURE 3.15 Effects of Tonicity on Red Blood Cells (RBCs). (a) RBC swelling in a hypotonic medium such as distilled water. (b) Normal RBC size and shape in an isotonic medium such as 0.9% NaCl. (c) RBC shriveling in a hypertonic medium such as 2% NaCl.

a–c: David M. Phillips/Science Source

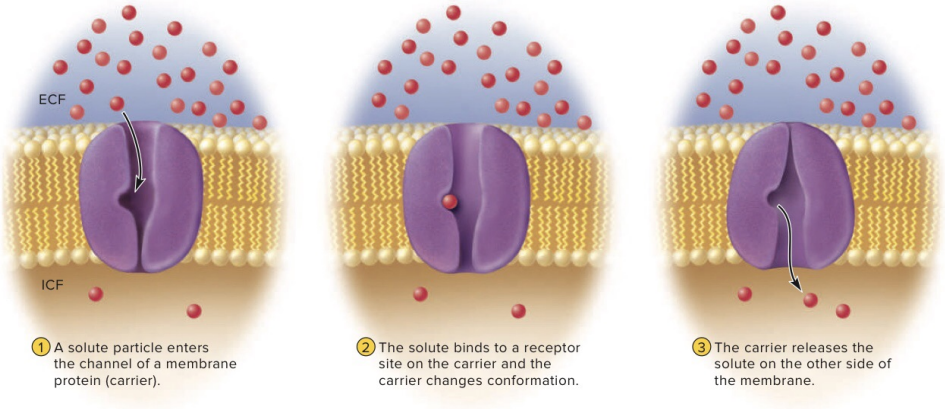


FIGURE 3.17 Facilitated Diffusion. Note that the solute moves down its concentration gradient.

TABLE 3.3 Methods of Membrane Transport

Transport Without Carriers	**Movement of Material Without the Aid of Carrier Proteins**
Filtration	Movement of water and solutes through a selectively permeable membrane as a result of hydrostatic pressure
Simple diffusion	Diffusion of particles through water or air or through a living or artificial membrane, down their concentration gradient, without the aid of membrane carriers
Osmosis	Net flow of water through a selectively permeable membrane, driven by either a difference in solute concentration or a mechanical force
Carrier-Mediated Transport	**Movement of Material Through a Cell Membrane by Carrier Proteins**
Facilitated diffusion	Transport of particles through a selectively permeable membrane, down their concentration gradient, by a carrier that does not directly consume ATP
Primary active transport	Transport of solute particles through a selectively permeable membrane, up their concentration gradient, by a carrier that consumes ATP
Secondary active transport	Transport of solute particles through a selectively permeable membrane, up their concentration gradient, by a carrier that doesn't use ATP itself but depends on concentration gradients produced by primary active transport elsewhere in the membrane
Cotransport	Simultaneous transport of two or more solutes in the same direction through a membrane by a carrier protein called a *symport,* using either facilitated diffusion or active transport
Countertransport	Transport of two or more solutes in opposite directions through a membrane by a carrier protein called an *antiport,* using either facilitated diffusion or active transport
Vesicular (Bulk) Transport	**Movement of Fluid and Particles Through a Plasma Membrane by Way of Membrane Vesicles; Consumes ATP**
Endocytosis	Vesicular transport of particles into a cell
Phagocytosis	Process of engulfing large particles by means of pseudopods; "cell eating"
Pinocytosis	Process of imbibing extracellular fluid in which the plasma membrane sinks in and pinches off small vesicles containing droplets of fluid; "cell drinking"
Receptor-mediated endocytosis	Phagocytosis or pinocytosis in which specific solute particles bind to receptors on the plasma membrane, and are then taken into the cell in clathrin-coated vesicles with a minimal amount of extraneous matter
Exocytosis	Process of eliminating material from a cell by means of a vesicle approaching the cell surface, fusing with the plasma membrane, and expelling its contents; used to release cell secretions, replace worn-out plasma membrane, and replace membrane that has been internalized by endocytosis

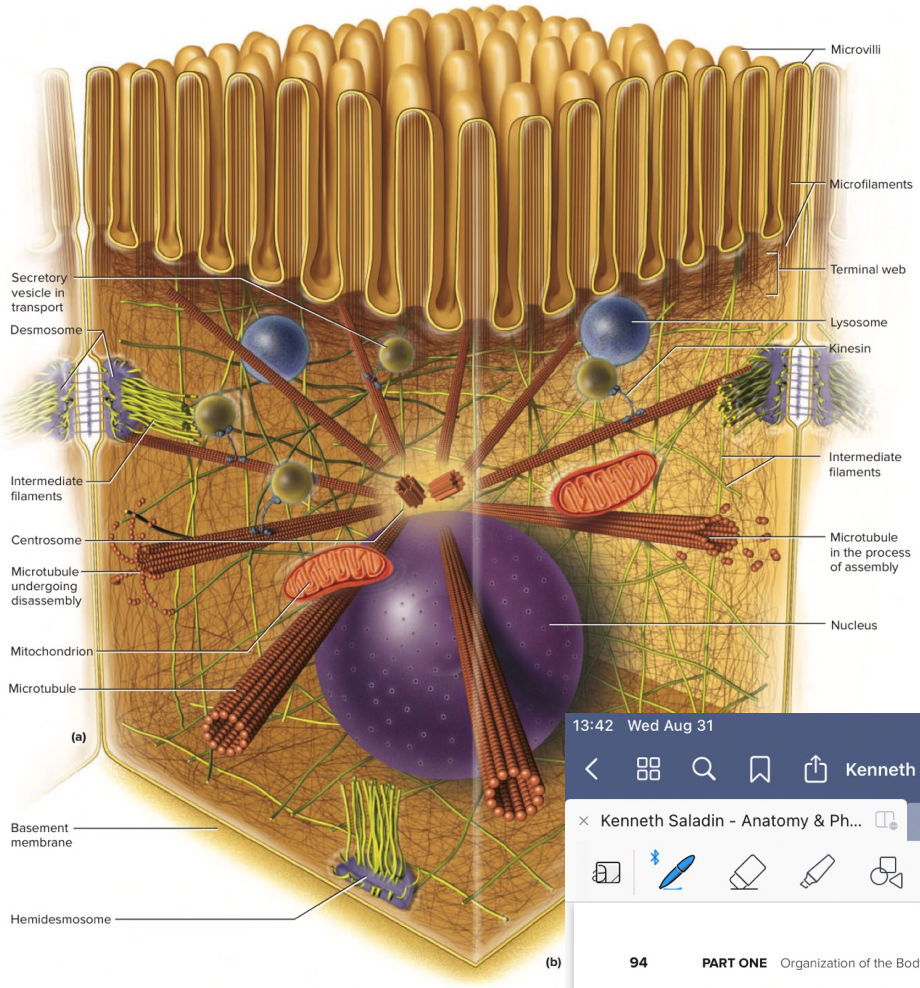


FIGURE 3.24 The Cytoskeleton. (a) Components of the cytoskeleton. Few organelles are shown in order to emphasize the cytoskeleton. (b) Cells with their cytoskeletons labeled with fluorescent antibodies, photographed through a fluorescence microscope. The density of a typical cytoskeleton far exceeds even that shown in part (a). The pink bodies are the cell nuclei.

b: Dr. Torsten Wittmann/Science Source

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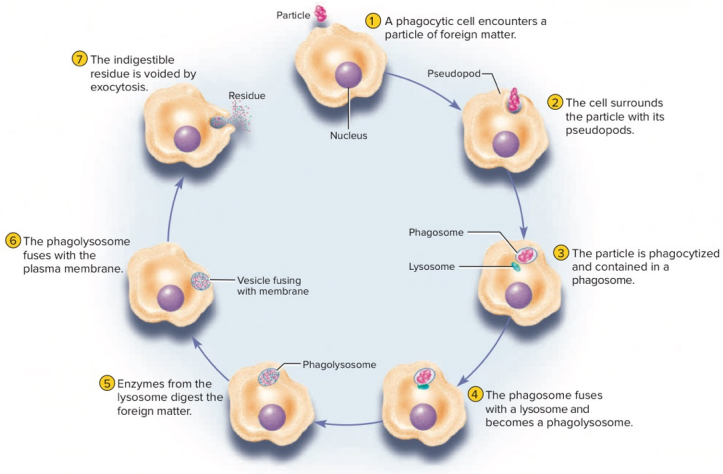


FIGURE 3.20 Phagocytosis, Intracellular Digestion, and Exocytosis.

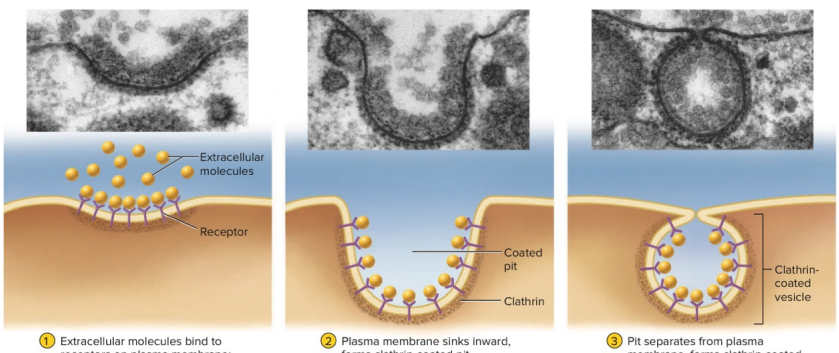


FIGURE 3.21 Receptor-Mediated Endocytosis.

1–3: Courtesy of The Company of Biologists, Ltd.

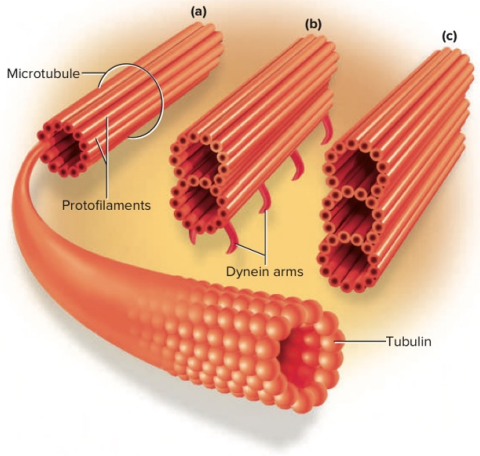


FIGURE 3.25 Microtubules. (a) A microtubule is composed of 13 protofilaments. Each protofilament is a helical array of globular proteins called tubulin. (b) One of the nine microtubule pairs that form the axonemes of cilia and flagella, with the motor protein dynein attached. (c) One of the nine microtubule triplets that form a centriole.

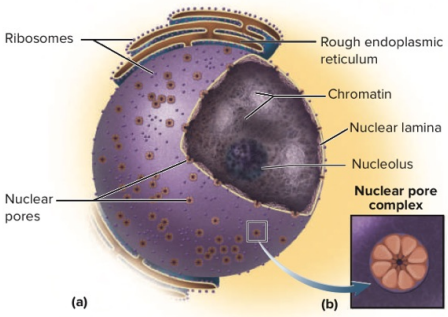


FIGURE 3.27 Structure of the Nucleus. (a) Cutaway view showing the nuclear surface and contents of the nucleoplasm. (b) Detail of a nuclear pore complex.

Why do these nuclear pores have to be larger in diameter than the channels in the cell's plasma membrane? (See table 3.1.)

masses called **nucleoli** (singular, *nucleolus*), where ribosomes are produced. The genetic function of the nucleus is described in section 4.2.

Endoplasmic Reticulum

Endoplasmic reticulum (ER) literally means "little network within the cytoplasm." It is a system of interconnected channels

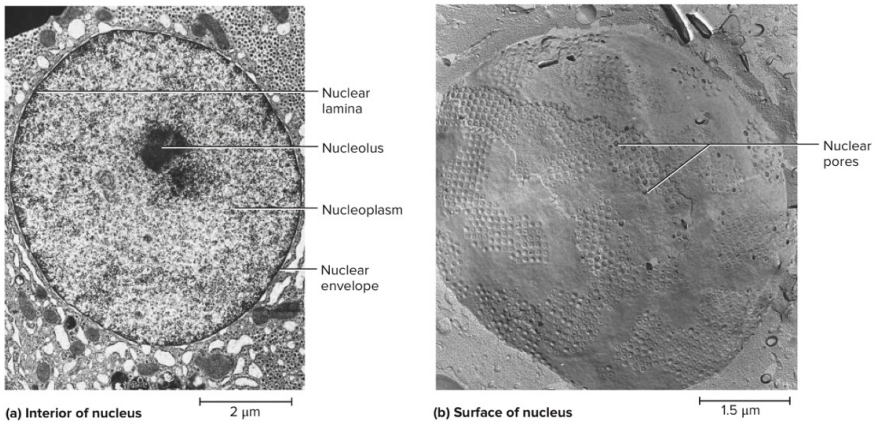


FIGURE 3.26 The Nucleus as Seen by Electron Microscopy. These photomicrographs were made by different TEM methods to show the internal structure of the nucleus and surface of the nuclear envelope. (a) Interior of the nucleus. (b) Surface of the nucleus, showing clusters of nuclear pores.

ard Chao; **b:** ©E.G. Pollock

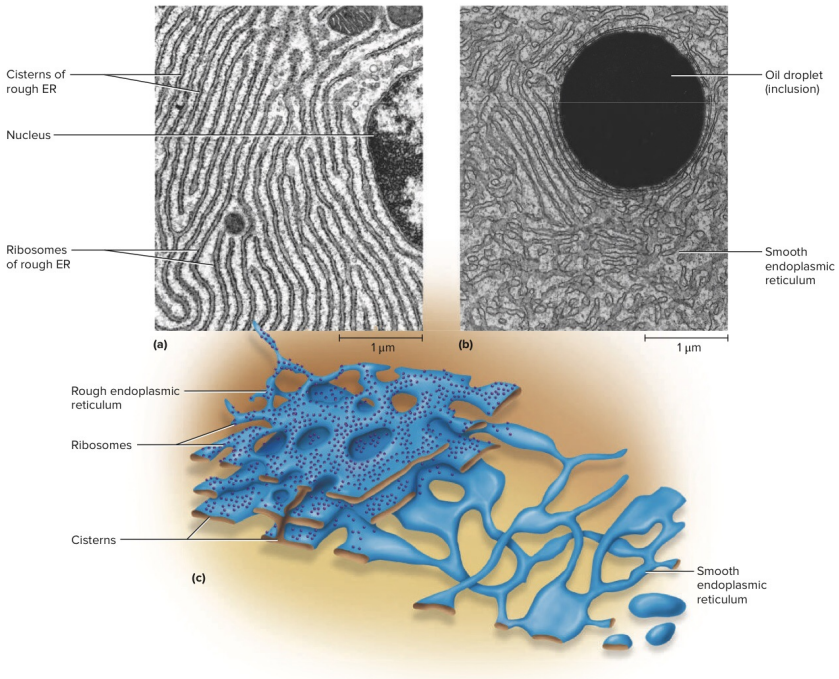


FIGURE 3.28 Endoplasmic Reticulum (ER). (a) Rough ER. (b) Smooth ER and an inclusion (oil droplet). (c) Structure of the endoplasmic reticulum, with rough and smooth regions.

a-b: Don Fawcett/Science Source

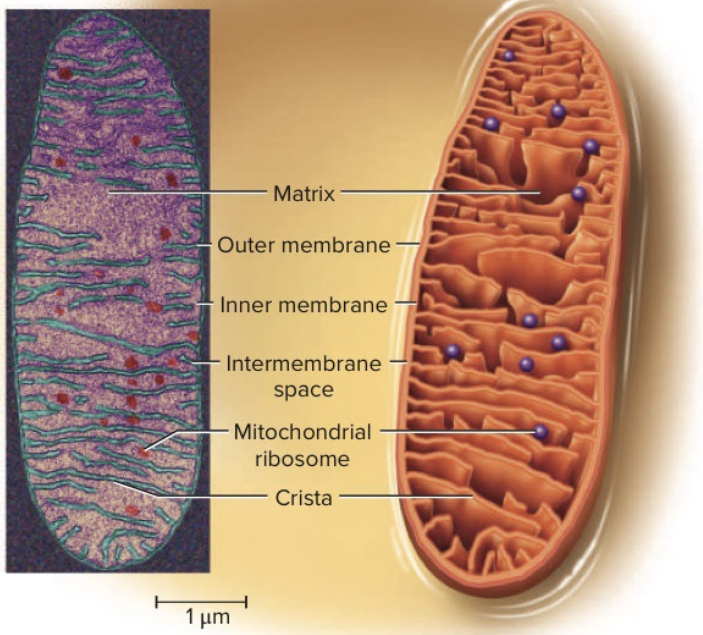


FIGURE 3.32 A Mitochondrion.
Keith R. Porter/Science Source

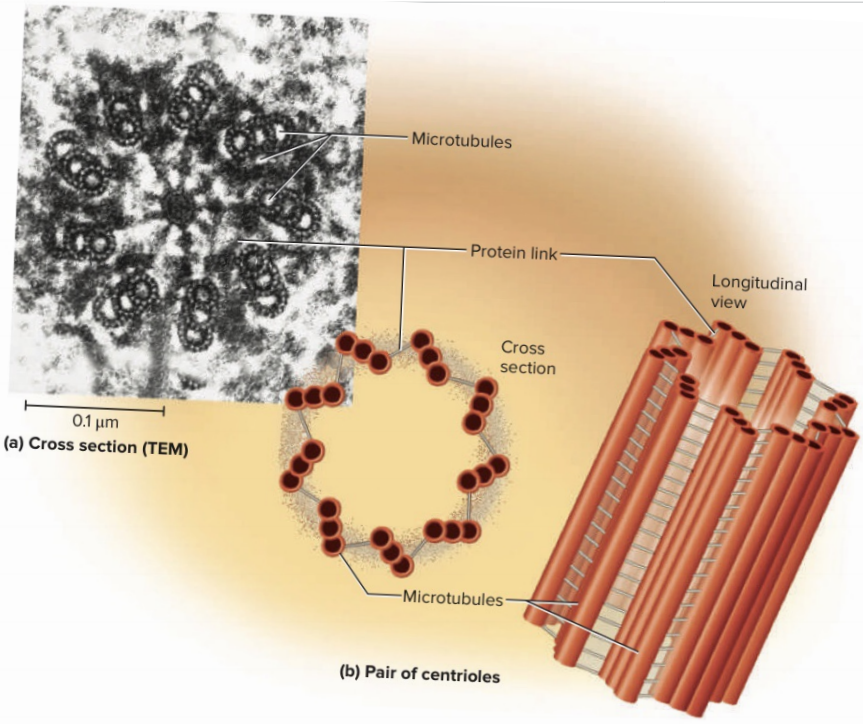


FIGURE 3.33 Centrioles. (a) Electron micrograph of a centriole as seen in cross section. (b) A pair of perpendicular centrioles.
a: Don W Fawcett/Getty Images

How does a centriole resemble the axoneme of a cilium? How does it differ?

TABLE 3.4 Summary of Organelles and Other Cellular Structures

Structure	Appearance to TEM	Function
Plasma membrane (fig. 3.5)	Two dark lines at cell surface, separated by a narrow light space	Prevents escape of cell contents; regulates exchange of materials between cytoplasm and extracellular fluid; involved in intercellular communication
Microvilli (fig. 3.9)	Short, densely spaced, hairlike processes or scattered bumps on cell surface; interior featureless or with bundle of microfilaments	Increase absorptive surface area; widespread sensory roles (hearing, equilibrium, taste)
Cilia (fig. 3.10)	Long hairlike projections of apical cell surface; axoneme with usually a 9 + 2 array of microtubules	Move substances along cell surface; widespread sensory roles (equilibrium, smell, vision)
Flagellum	Long, single, whiplike process with axoneme	Sperm motility
Microfilaments (figs. 3.9 and 3.24)	Thin protein filaments (6 nm diameter), often in parallel bundles or dense networks in cytoplasm	Support microvilli and plasma membrane; involved in muscle contraction and other cell motility, endocytosis, and cell division
Intermediate filaments (fig. 3.24)	Thicker protein filaments (8–10 nm diameter) extending throughout cytoplasm or concentrated at cell-to-cell junctions	Give shape and physical support to cell; anchor cells to each other and to extracellular material; compartmentalize cell contents
Microtubules (figs. 3.24 and 3.25)	Hollow protein cylinders (25 nm diameter) radiating from centrosome	Form axonemes of cilia and flagella, centrioles, basal bodies, and mitotic spindles; enable motility of cell parts; form trackways that direct organelles and macromolecules to their destinations within a cell
Nucleus (figs. 3.4, 3.26, and 3.27)	Largest organelle in most cells, surrounded by double membrane with nuclear pores	Genetic control center of cell; directs protein synthesis; shelters the DNA
Rough ER (fig. 3.28a)	Extensive sheets of parallel membranes with ribosomes on outer surface	Protein synthesis and manufacture of cellular membranes
Smooth ER (fig. 3.28b)	Branching network of tubules with smooth surface (no ribosomes); usually broken into numerous small segments in TEM photos	Lipid synthesis, detoxification, calcium storage
Ribosomes (fig. 3.28c)	Small dark granules free in cytosol, on surface of rough ER and nuclear envelope, and inside nucleus and mitochondria	Interpret the genetic code and synthesize polypeptides
Golgi complex (fig. 3.29)	Several closely spaced, parallel cisterns with thick edges, usually near nucleus, often with many Golgi vesicles nearby	Receives and modifies newly synthesized polypeptides; synthesizes carbohydrates; adds carbohydrates to glycoproteins; packages cell products into Golgi vesicles
Golgi vesicles (fig. 3.29)	Round to irregular sacs near Golgi complex, usually with light, featureless contents	Become secretory vesicles and carry cell products to apical surface for exocytosis, or become lysosomes
Lysosomes (fig. 3.30a)	Round to oval sacs with single enclosing membrane, often a dark featureless interior but sometimes with protein layers or crystals	Contain enzymes for intracellular digestion, autophagy, programmed cell death, and glucose mobilization
Peroxisomes (fig. 3.30b)	Similar to lysosomes; often lighter in color	Contain enzymes for detoxification of free radicals, alcohol, and other drugs; oxidize fatty acids
Proteasomes (fig. 3.31)	Small cytoplasmic granules composed of a cylindrical array of proteins	Degrade proteins that are undesirable or no longer needed by a cell
Mitochondria (fig. 3.32)	Round, rod-shaped, bean-shaped, or threadlike structures with double enclosing membrane and shelflike infoldings called cristae	ATP synthesis
Centrioles (fig. 3.33)	Short cylindrical bodies, each composed of a circle of nine triplets of microtubules	Form mitotic spindle during cell division; unpaired centrioles form basal bodies of cilia and flagella
Centrosome (fig. 3.24)	Clear area near nucleus containing a pair of centrioles	Organizing center for formation of microtubules of cytoskeleton and mitotic spindle
Basal body (fig. 3.10b)	Unpaired centriole at the base of a cilium or flagellum	Point of origin, growth, and anchorage of a cilium or flagellum; produces axoneme
Inclusions (fig. 3.28b)	Highly variable—fat droplets, glycogen granules, protein crystals, dust, bacteria, viruses; never enclosed in membranes	Storage products or other products of cellular metabolism, or foreign matter retained in cytoplasm

(random information I got wrong on worksheets)

Cuboidal cells line the liver

Squamous cells line the esophagus

tissue fluid = interstitial fluid

75% of plasma membrane = phospholipids

transmembrane proteins are amphipatic

↳ glycolipids form the glycocalyx

physical pressure drives filtration through a membrane

filtration/capillary filtration (blood pressure) forces fluid through gaps in the capillary wall

physical force generated by a liquid = hydrostatic pressure

tonicity = the ability of a solution to cause osmosis, affects volume + pressure

enzymes to be secreted by the cell are produced on the RER

lysosomes arise from Golgi apparatus

microvilli and cilia differ in function and structure

Chapter 4 insight 4.3

DEEPER INSIGHT 4.3
CLINICAL APPLICATION

Cancer

Anyone awaiting the results of a tumor biopsy hopes for the good news: benign! This means the tumor is slow-growing and contained in a fibrous capsule so it will not metastasize, and in most cases it is relatively easy to treat. The dreaded news is that it's malignant, meaning that it tends to grow rapidly and to *metastasize*—to give off cells that seed the growth of multiple tumors elsewhere, such as colon cancer metastasizing to the lungs and brain **(fig. 4.22).**

Oncology is a medical specialty that deals with both benign and malignant tumors, but only malignancies are called *cancer.* The word *cancer* literally means "crab." Hippocrates was the first to use the word this way, upon seeing a breast tumor with a tangle of blood vessels that reminded him of a crab's outstretched legs. Energy-hungry tumors often stimulate such ingrowth of blood vessels—a phenomenon called *tumor angiogenesis.*

Cancers are named for the tissue of origin: *carcinomas* originate in epithelial tissue; *lymphomas* in the lymph nodes; *melanomas* in pigment cells (melanocytes) of the epidermis; *leukemias* in blood-forming tissues such as bone marrow; and *sarcomas* in bone, other connective tissue, or muscle. About 90% of malignancies are carcinomas.

Only 5% to 10% of cancers are hereditary, but cancer is always a genetic disease. This is not as contradictory as it may seem. Most cases are due to mutations arising anew in the affected individual, not to genes inherited from a parent. Mutations can arise through errors in DNA replication or from exposure to carcinogens—radiation such as ultraviolet rays and X-rays; chemicals such as cigarette tar; and viruses such as human papillomavirus (HPV), hepatitis C, and type 2 herpes simplex.

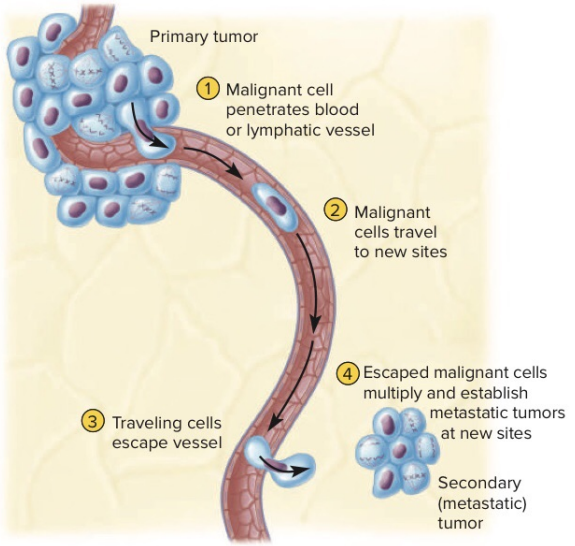


FIGURE 4.22 Metastasis. The process by which malignant cells escape from a primary tumor, travel in the blood or lymph, and seed the growth of new (metastatic) tumors in other localities. Colon cancer, for example, can metastasize to the liver or brain by this method.

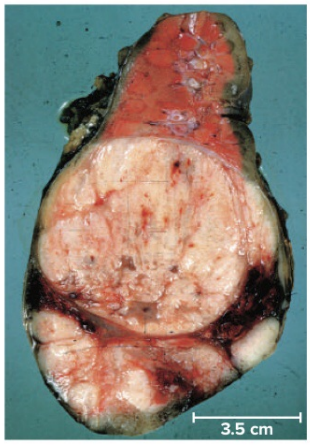


FIGURE 4.23 Wilms Tumor. A malignant tumor of the kidney occurring especially in children.

Source: From the University of Alabama at Birmingham, Department of Pathology PEIR Digital Library © http://peir.net

Oncologists are especially interested in two families of cancer genes called oncogenes and tumor suppressor genes. An *oncogene* is analogous to a stuck accelerator on a car—it causes cell division to accelerate out of control, sometimes by inducing the excessive secretion of growth factors that stimulate mitosis, or the production of excessive growth-factor receptors. An oncogene called *ras* underlies about one-quarter of human cancers, and *erbB2* is a common factor in breast and ovarian cancer. *Tumor suppressor (TS) genes* inhibit cancer by opposing oncogene action, coding for DNA-repair enzymes, and other means. Consequently, mutations that destroy their protective "braking" function can lead to cancer. Mutation of a TS gene called *p53,* for example, is involved in about 50% of cases of leukemia and colon, lung, breast, liver, brain, and esophageal tumors. Many human cancers are associated, however, not with mutation but with aberrant DNA methylation, which can, for example, silence one's TS genes and thus turn off their protective function.

Cancer seldom results from just one mutation. It usually requires 5 to 10 mutations at different gene loci. It takes time for so many mutations to accumulate, which is why cancer is more common in the elderly than in the young. In addition, as we age, we accrue more lifetime exposure to carcinogens, our DNA- and tissue-repair mechanisms become less efficient, and our immune system grows weaker and less able to detect and destroy malignant cells.

About one in every five of us in America will die of cancer. Cancer is almost always fatal if not treated. Malignant tumors replace functional tissue in vital organs **(fig. 4.23);** they steal nutrients from the rest of the body, sometimes causing a severe wasting away called *cachexia* (ka-KEX-ee-ah); they weaken one's immunity, opening the door to *opportunistic infections* that a healthier person could ward off; and they often invade blood vessels, lung tissue, or brain tissue, with such consequences as hemorrhage, pulmonary collapse, seizures, or coma. Mortality usually results not from the original (primary) tumor, but from metastasis.

Cancer is usually treated with surgery, chemotherapy, or radiation therapy. Two lively areas of cancer research today are the development of drugs to starve tumors by blocking tumor angiogenesis, and *cancer immunotherapy,* programming one's own immune cells (T cells) to selectively recognize and attack tumor cells.

Chapter 5

tissue = cells + matrix

tissue = group of similar cells and cell products that arise from the same region of the embryo and work together to perform a specific structural or physiological role in an organ.

1. Connective
2. Epithelial
3. Nervous
4. Muscular

*matrix = extracellular material

Epithelial - Tissue composed of closely spaced cells that cover organ surfaces, form glands, serve for protection, secretion, and absorption
ex: epidermis, inner lining of digestive tract, liver + other glands

Connective - Tissue usually with more matrix than cell volume, often specialized to support and to protect organs and bind tissues + organs to each other
ex: tendons, ligaments, cartilage, bones, blood

Nervous - Tissue containing excitable cells specialized for rapid transmission of coded information to other cells
ex: brain, spinal cord, nerves

Muscular - Tissue composed of elongated, excitable muscle cells specialized for contraction
ex: skeletal muscles, cardiac muscle, walls of viscera (smooth muscle)

matrix is composed of fibrous proteins + clear gel → (ground substance, tissue fluid, extracellular fluid [ECF], or interstitial fluid)
* ground substance contains water, minerals, gases, wastes, hormones, nutrients, etc.

Embryonic Tissues → development of 3 primary tissues in the embryo = embryogenesis

1st tissues when fertilized egg divides itself into cells & cells organize themselves into layers.

first 3 layers = primary germ layers
↳ eventually becomes all of the body's mature tissues

ectoderm → outer layer (epidermis + nervous system)
mesoderm → middle layer, turns into mesenchyme (cardiac muscle, bones + blood)
endoderm → inner layer (digestive tract, respiratory tract & digestive glands)

most tissues come from 2 or more primary germ layers

Interpreting Tissue Sections

histological sections = thin slices of a tissue on a microscope slide
* tissue sections are prepared in a fixative
* stains enhance detail on slide

smear = liquid tissue is rubbed/spread across slide (instead of sliced)

Epithelial Tissue (brick and mortar) * AVASCULAR *

↳ consists of a sheet of closely adhering cells, one or more cells thick, with the upper surface usually exposed to the environment or to an internal space in the body
* covers body surface, lines body cavities, forms the external and internal linings of many organs, and constitutes most gland tissue.

Functions:
1. protection against injury or infection
2. secretions (glands)
3. excretions (CO_2, bile, wastes, etc)
4. Absorption
5. Filtration (blood vessels + kidneys)
6. Sensation (touch of skin or irritation of stomach)

Epithelial cells usually lie on vessel-rich layer of connective tissue, which gives them nutrients and waste removal (through diffusion?)

* basement membrane = between epithelium and connective tissue
  1. anchors epithelial to connective tissue
  2. binds growth factors to regulate epithelial growth
  3. controls exchange of materials b/w connective tissue and epithelium

epithelial tissue closest to connective tissue have a higher rate of mitosis, they are able to repair themselves faster

basal surface = part of epithelial cell that faces basement membrane

apical surface = surface of epithelial cell that faces towards body surface or internal cavity (lumen) of an organ

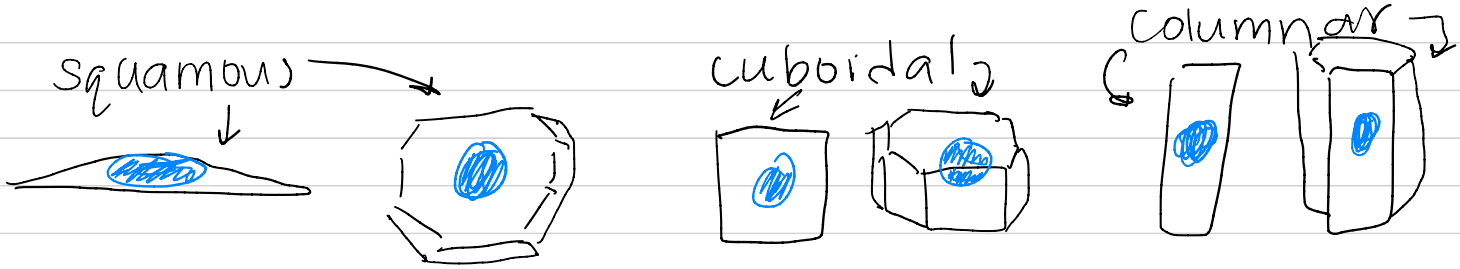
sidewall (between basal and apical surface) = lateral surface

Simple epithelium = one layer, all connected to basement membrane

Stratified = more than one layer, one layer rests on top of the other

↳ urothelium = unique to the urinary tract aka transitional epithelium

pseudostratified = looks like more than one layer, but at least a little bit of each cell makes contact with basement membrane



Simple squamous epithelium - single thin layer of cells (shaped like fried eggs)

↳ alveoli of lungs, glomerular capsules of kidneys, kidney tubules, endothelium of heart + blood vessels, serous membranes of stomach, intestines + other viscera, surface mesothelium of pleura, pericardium, peritoneum, mesenteries

functions: Allows rapid diffusion or transport of substances through membrane, secretes lubricating serous fluid

Simple cuboidal epithelium - single layer of square/round cells

↳ *glands

Liver, thyroid, mammary, salivary, and other glands, most kidney tubules, bronchioles

functions: Absorption and secretion, production of protective mucus coat, movement of respiratory mucus

Simple columnar epithelium - Single layer of tall, narrow cells

↳ inner lining of stomach, intestines, gallbladder, uterus, uterine tubes, some kidney tubules

function: Absorption + secretion of mucus and other products, movement of egg and embryo in uterine tube

Pseudostratified Columnar epithelium - looks multilayered (some cells do not reach cell surface) but all cells reach basement membrane)

↳ respiratory tract from nasal cavity to bronchi, some portions of male urethra

functions: Secretes and propels mucus

Goblet cells: produce protective mucus coatings over cell membrane (usually wine-glass shaped)

* Simple columnar + pseudostratified cells usually have this.

most widespread epithelium in body. deepest cell layers are cuboidal or columnar, include mitotically active stem cells.
(exfoliation = desquamation)

Stratified squamous epithelium (keratinized) - multiple cell layers becoming increasingly flat towards surface w/ a layer of dead compact cells w/o nuclei. Basal cells may be cuboidal or columnar
↳ keratinocytes
↳ epidermis (palms + soles are heavily keratinized)
Stratified squamous epithelium (non-keratinized) - just like keratinized but without the layer of dead cells
↳ tongue, oral mucosa, esophagus, anal canal, vagina
function: resists abrasion and penetration by pathogenic organisms
(keratinized also inhibits water loss through skin)

Stratified Cuboidal Epithelium - two or more layrs, surface cells are square or round
↳ sweat gland ducts, egg-producing vesicles (follicles) of ovaries, sperm-producing ducts (seminiferous tubules) of testis
functions: contributes to sweat secretion, secretes ovarian hormones, sperm production

Urothelium - resembles stratified squamous epithelium but surface cells are round instead of flat
↳ urinary tract (kidney, bladder, ureter, part of urethra)
function: stretches to allow filling of urinary tract, protects underlying tissues from osmotic damage by urine
* umbrella cells = protect urothelium
Uroplakins are impermeable to urine + protect urothelium

Connective Tissue

↳ most abundant, widely distributed and histologically variable of the primary tissues. Includes fibrous and adipose tissue, blood, bones, ligaments, and cartilage. Usually, cells occupy less space than extracellular matrix.

functions of connective tissue:

1. Binding of organs (tendons, ligaments, fat, fibrous tissue)
2. Support - bones + cartilage
3. physical protection - bones + fat
4. immune protection = blood
5. movement - bones + cartilage
6. storage } fat
7. heat production }
8. transport (blood)

Fibrous Connective Tissue

Cell Types

Fibroblasts - large, fusiform or stellate cells that often have thin, whispy branches. They produce ground substance and fibers that form the matrix of the tissue.

Macrophages - large phagocytic cells that engulf + destroy bacteria, dead/dying cells, or other foreign particles. They arise from monocytes (WBCs)

Leukocytes (WBCs) - White Blood Cells (immune system)
- neutrophils → attack bacteria
- lymphocytes → forms dense patches in mucous membranes + react against toxins, bacteria, or other foreign agents.

Plasma Cells - Certain lymphocytes turn into plasma cells when they detect foreign agents. They make antibodies. seen in wall of intestines + inflamed tissue

Mast Cells - secrete heparin (anti-blood clotting) and histamine (increases localized blood flow) in blood vessels

adipocytes - fat cells

Fiber Types

Collagenous Fibers - fibers (made of collagen) that are tough and flexible and resist stretching.
Body's most abundant protein (25% total)
* tendons, ligaments, and dermis mainly made of collagen

Reticular Fibers - thin collagen fibers coated with glycoprotein. they form a spongelike framework for organs like the spleen and lymph nodes, constitute part of basement membrane for epithelia

Elastic Fibers - thinner than collagenous fibers, made of elastin coated with fibrillin (glycoprotein)
Stretches under tension and returns to its original length when release, responsible for resilience of organs like lungs and skin

*elasticity is the tendency to recoil when stretched, NOT the ability to stretch

glycosaminoglycan = a polysaccharide composed of modified sugars with amino groups - the major component of a proteoglycan. (GAGs) are responsible for the viscous consistency of tissue gel and stiffness of cartilage.

proteoglycan = a large molecule composed of a bristlelike arrangement of glycosaminoglycans surrounding a protein core in a shape resembling a bottle brush. Binds cells to extracellular materials and gives the tissue fluid a gelatinous consistency

adhesive glycoproteins = protein-carbohydrate complexes that bind plasma membrane proteins to extracellular collagen and proteoglycans. They bind the components of a tissue together and mark paths that guide migratic embryonic cells to their destinations in a tissue.

Types of fibrous connective tissue

Loose = areolar, reticular tissues

dense = dense regular, dense irregular connective tissues

↙ possesses all 6 cell types

Areolar Tissue - loose arrangement of collagenous and elastic fibers; scattered cells of various types, lots of ground substance, numerous blood vessels
↳ Underlying most epithelia, surrounding blood vessels, nerves, trachea, esophagus; fascia b/w muscles; mesenteries; visceral layers of pericardium and pleura
function: loosely binds epithelia to deeper tissues, allows passage of nerves and blood vessels through other tissues, provides arena for immune defense, blood vessels provide nutrients and waste removal for overlying epithelia

Reticular Tissue - loose network of reticular fibers and cells, infiltrated with numerous leukocytes, especially lymphocytes
↳ lymph nodes, spleen, thymus, bone marrow
function: forms supportive framework for lymphatic organs

↙ only cells are fibroblasts

Dense Regular Connective Tissue - densely packed, wavy, parallel collagen fibers, scarcity of blood vessels
↳ tendons and ligaments
functions: ligaments tightly bind bones together and resist stress; tendons attach muscles to bones and transfer muscular tension to bones *vocal cords + spinal ligaments are made of elastic tissue

Dense Irregular Connective Tissue - Densely packed collagen fibers running in random directions, scarcity of blood vessels
↳ deeper part of dermis, capsules around viscera such as liver, kidney, spleen; fibrous sheaths around cartilage and bones
functions: withstand stress in unpredictable directions; imparts durability to tissues

↑ also forms fibrous sheath surrounding nerves, bones, cartilages.

Adipose tissue = fat (made of adipocytes). Space b/w adipocytes is occupied by areolar, reticular, and blood capillary tissues. Large, empty-looking cells with thin margins. Blood vessels present

↳ subcutaneous skin layer, breasts, heart surface, mesenteries, surrounding organs (kidneys and eyes)

function: energy storage, heat insulation, heat production (brown fat) protective cushion for organs, filling space, shaping body

Fat = body's primary energy reservoir.

white/yellow fat = provides thermal insulation, shapes body, cushions organs

brown fat (found in infants, children, fetuses, and adults [small deposits in adults]) - heat generating

Cartilage - relatively stiff connective tissue with a rubbery matrix

↳ produced by cells called chondroblasts.
* cells in lacunae (cavities) are called chondrocytes.
no blood capillaries ←

(I gave up writing out the table lol)

hyaline cartilage - named for its clear, glassy appearance

fibrocartilage - named for its coarse bundles of collagen

perichondrium - sheath of dense irregular connective tissue that surrounds elastic and hyaline cartilage

TABLE 5.7 Cartilage

Hyaline Cartilage

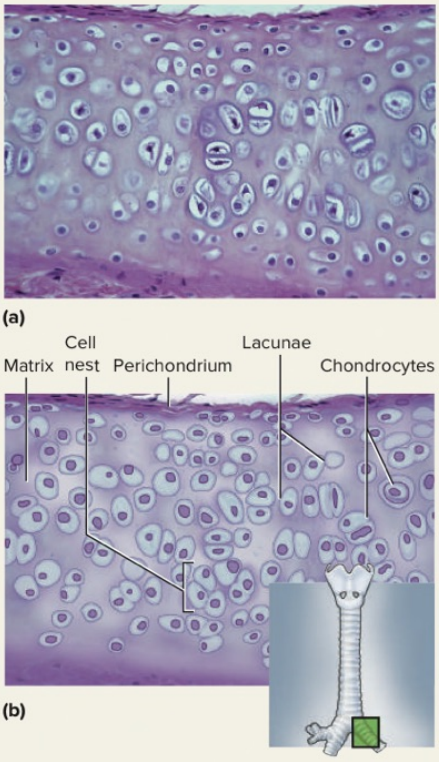


FIGURE 5.19 Hyaline Cartilage. Bronchus (×400). (a) Light micrograph. (b) Labeled drawing. A&PR

a: ©Ed Reschke

Microscopic appearance: Clear, glassy matrix, often stained light blue or pink in tissue sections; fine, dispersed collagen fibers, not usually visible; chondrocytes enclosed in lacunae, often in small clusters of three or four cells *(cell nests);* usually covered by perichondrium

Representative locations: A thin *articular cartilage*, lacking perichondrium, over the ends of bones at movable joints; supportive rings and plates around trachea and bronchi; a boxlike enclosure around the larynx; much of the fetal skeleton; and a *costal cartilage* attaches the end of a rib to the breastbone

Functions: Eases joint movements; holds airway open during respiration; moves vocal cords during speech; a precursor of bone in the fetal skeleton and the growth zones of long bones of children

Elastic Cartilage

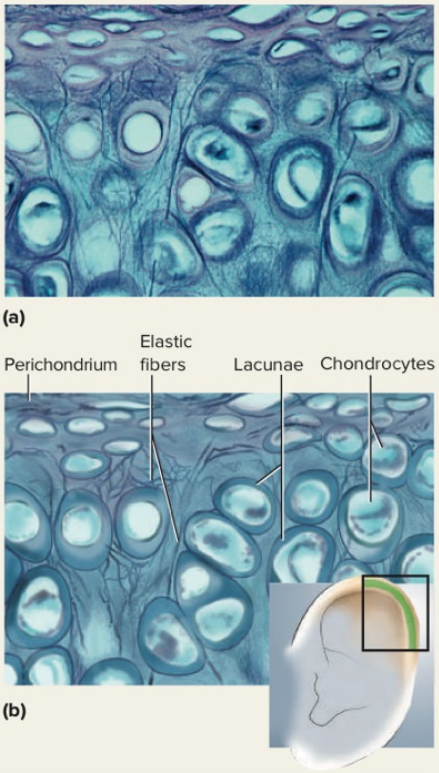


FIGURE 5.20 Elastic Cartilage. External ear (×1,000). (a) Light micrograph. (b) Labeled drawing. A&PR

a: ©Ed Reschke

Microscopic appearance: Elastic fibers form weblike mesh amid lacunae; always covered by perichondrium

Representative locations: External ear; epiglottis

Functions: Provides flexible, elastic support

Fibrocartilage

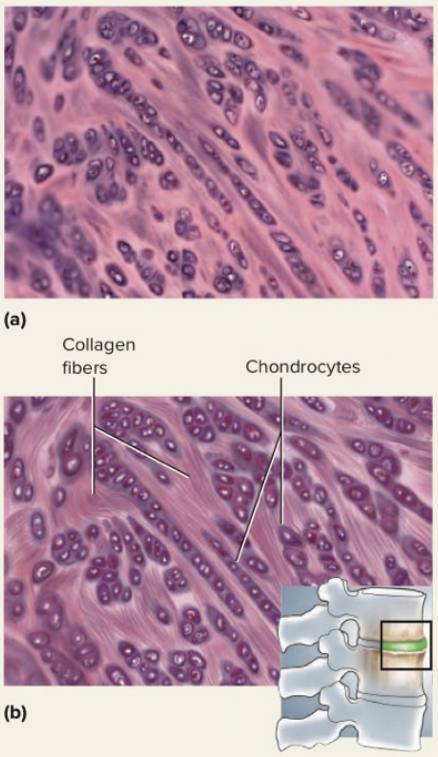


FIGURE 5.21 Fibrocartilage. Intervertebral disc (×400). (a) Light micrograph. (b) Labeled drawing. A&PR

a: Dr. Alvin Telser

Microscopic appearance: Parallel collagen fibers similar to those of tendon; rows of chondrocytes in lacunae between collagen fibers; never has a perichondrium

Representative locations: Pubic symphysis (anterior joint between two halves of pelvic girdle); intervertebral discs, which separate bones of vertebral column; menisci, or pads of shock-absorbing cartilage, in knee joint; at points where tendons insert on bones near articular hyaline cartilage

Functions: Resists compression and absorbs shock in some joints; often a transitional tissue between dense connective tissue and hyaline cartilage (for example, at some tendon–bone junctions)

Bone (osseous tissue) - hard, calcified connective tissue that composes the skeleton.
* bone is also composed of cartilage, bone marrow, dense irregular connective tissue, etc

Calcified matrix arranged in concentric lamellae around central canals, osteocytes in lacunae b/w adjacent lamellae, lacunae interconnected by delicate canaliculi
↳ skeleton
function: physical support of the body, leverage for muscle action, protective enclosure of viscera, reservoir of calcium and phosphorus

spongy bone = inside, fills heads of long bones and forms middle layer of flat bones
compact (dense) bone = outer shell + external surfaces of bones
* most compact bone is arranged in cylinders of tissues that surround central (osteonic) canals, which run longitudinally. Blood vessels + nerves go through these canals

Concentric lamellae - onionlike layers around each canal that bone matrix is deposited in

osteon - central canal surrounding lamellae

osteocytes = mature bone cells (occupy tiny lacunae between lamellae)

periosteum - covering of the bone → tough + fibrous

Blood - fluid connective tissue. Primary function = transport cells + dissolved matter
ground substance = blood plasma
formed elements = cellular components
RBCs
↓
* blood does not exhibit fibers except when it clots
Erythrocytes, WBCs, platelets
↳ contained in heart + blood vessels
functions: transports gases, waste, chemical signals, heat, WBCs, clotting agents, tissue maintenance + repair

Nervous and Muscular Tissue

membrane potential - basis for excitation = electrical charge difference (voltage)

Nervous tissue - tissue composed of neuroglia and neurons, specialized for electrical communication + chemical signal communication. Neuroglia (glial cells) protect and assist neurons. Neurons detect stimuli, respond, transmit encoded info to other cells.

neurosoma = cell body (nerve cell) → center of genetic control + protein synthesis (houses nucleus)

dendrites = short, branched processes that receive signals from other cells and conduct messages to the neurosoma

axon (nerve fiber) - sends message out to other cells

* glial cells constitute for the most volume of the nervous tissue, much smaller than neurons.
  ↳ supportive, protective, "housekeping functions"
  they communicate w/ neurons + each other but do NOT send long-distance signals.

Muscle Tissue - specialized to contract when stimulated exert physical force on tissues, organs, fluids. Also important source of body heat.

Skeletal muscle tissue - long, threadlike, unbranched fibers, striated, multinucleate
  ↳ skeletal muscles, tongue, esophagus, lips, eyelids, urethra, anus
functions: body movements, facial expressions, posture, breathing, speech, swallowing, urinating + defecating, childbirth, VOLUNTARY CONTROL

↙ cells of cardiac muscle = cardiomyocytes

Cardiac muscle - short, branched cells (striated?)
↳ heart
functions: pumping blood, INVOLUNTARY CONTROL

Smooth muscle - short, fusiform cells overlapping each other, non-striated
↳ sheets of tissue in walls of blood vessels and viscera (digestive tract, iris, hair follicles, sphincters of urethra + anus) INVOLUNTARY CONTROL
functions: swallowing, contraction of stomach and intestines, expulsion of feces and urine, labor contractions, control of blood pressure + flow, control of respiratory airflow, control of pupillary diameter, erection of hairs

Cellular Junctions, Glands, membranes

cell junction = connection b/w one cell and another
↳ enable cells to resist stress, communicate, and control movement of substances b/w tissues.

tight junction - plastic 6-pack can harness
↳ plasma membranes are linked by transmembrane cell-adhesion proteins @ apical surface
* substances can't pass b/w cells, but some things can pass through them

Desmosome - button on jeans
↳ keeps cells from pulling apart, enables tissue to resist mechanical stress.
*common in epidermis, cervix, cardiac muscle
connects cytoskeleton to cell membrane, links to transmembrane protein of next cell

hemidesmosome = half-desmosome (each cell contributes half a desmosome)

Gap Junctions - (communication formed by connexon) consists of 6 TMPs arranged in a ring
* allows thing to pass through cells

Glands - cell/organ that secretes substances, composed mostly of epithelial tissue

exocrine glands - ducts → secreting something to body surface (sweat, tears, etc) or into cavity of another organ (salivary glands, liver, pancreas)

endocrine glands - no ducts → secrete products into blood (hormones)

Unicellular glands = secretory cells predominantly nonsecretory

Exocrine Gland Structure - multicellular Ex. glands enclosed in a capsule

Capsule = fibrous covering of a structure

connective tissue framework of gland = stroma

→ gives off extensions (septum or trabeculae)

divisions of the interior of gland = lobes

cells that perform synthesis and secretion = parenchyma

simple structure = unbranched duct,

compound structure = branched duct

tubular = gland with uniform duct + secretory diameter

Types of secretions

Serous = thin + watery (milk, tears, sweat)

mucous = secretes mucin (oral + nasal cavities)

mixed = serous + mucous

Modes of secretion

eccrine glands (merocrine) - release products via exocytosis
↳ tear glands, salivary glands, lactose + milk protein (casein, lactalbumin)

apocrine glands - lipids coalesce from cytosol into a droplet that buds from cell surface, covered by a layer of plasma membrane + thin film of cytoplasm (sweat)

holocrine glands - cells accumulate a product and then disintegrates, becoming the secretion instead of releasing one.
*thick + oily (oil-producing glands on scalp + skin)

Membranes - covering of viscera + organ linings
connective, epithelial, or epithelial + connective + muscular
cutaneous membrane = skin (dry)

mucous membrane → lines passages that open up to environment (digestive, respiratory, urinary, reproductive tracts)
3 layers
1. an epithelium
2. areolar connective tissue (lamina propria)
3. smooth muscle (muscularis mucosae)

secretory, protective, and absorptive functions.

Serous membrane - produce watery serous fluid, composed of simple squamous epithelium resting on thin layer of areolar connective tissue.
ex: pleura, pericardium, peritoneum
arises from blood serum

lines inside of body cavities + forms a smooth outer surface on viscera (digestive tract)

endothelium = inner lining (blood vessels) - derived from mesoderm

connective tissue membranes = dura mater, periosteum, synovial membranes

Tissue Growth, Development, Repair, Degeneration

hyperplasia = most embryonic + childhood growth (tissue growth through cell multiplication)

hypertrophy = enlargement of preexisting cells (adipose tissue + skeletal muscle)

Neoplasia = development of tumor

differentiation = development of specialized form + function

metaplasia = change of one mature tissue type to another

Stem cells = undifferentiated cells

developmental plasticity = diversity of mature cell types they can become

* embryonic stem cells compose the human embryo

unlimited developmental plasticity = totipotency

pluripotent = embryonic cells that can't develop into accessory organs of pregnancy

multipotent = able to develop into two or more mature cells → blood cells

unipotent = able to differentiate into one type of mature cell → reproductive cells

Tissue Repair

regeneration - replacement of dead/damaged cells with the same cell types as before → liver & skin injuries

Fibrosis - replacement of damaged tissue w/ scar tissue
* doesn't restore normal organ function

Tissue Degeneration + Death

Atrophy = shrinkage of tissue through a loss in cell size & number
↳ results from normal aging (senile atrophy) + lack of use of an organ (disuse atrophy)

Necrosis = premature, pathological tissue death due to trauma, toxins, infection, etc
↳ infarction = sudden tissue death, occurs from cut off blood supply
Gangrene = tissue necrosis resulting from infection or obstructed blood supply.

Apoptosis = programmed cell death