A Photographic Atlas for the ZOOLOGY LABORATORY

THIRD EDITION 3RD FULL COLOR

Kent M. Van De Graaff & John L. Crawley

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To the naturalists, environmentalists, and conservation biologists who are dedicated to the preservation of animal species from extinction.

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Preface

Zoology is an exciting, dynamic, and challenging science. It is the study of organisms within the kingdom Animalia, and it is a fascinating discipline within the broader science of biology. Students are fortunate to be living at a time when insights and discoveries in almost all aspects of zoology are occurring at a very rapid pace. Much of the knowledge learned in a zoology course has application in improving humanity and the quality of life. An understanding of zoology is essential in establishing a secure foundation for more advanced courses in the biological sciences or health sciences.

Zoology is a visually oriented science. *A Photographic Atlas for the Zoology Laboratory* is intended to provide you with quality photographs of animals, similar to those you may have the opportunity to observe in a zoology laboratory. It is designed to accompany any zoology text or laboratory manual you may be using in the classroom. In certain courses *A Photographic Atlas for the Zoology Laboratory* could serve as the laboratory manual.

An objective of this atlas is to provide you with a balanced visual representation of the major phyla of zoological organisms. Great care has been taken to construct completely labeled, informative figures that are depicted clearly and accurately. The terms used in this atlas are in agreement with those appearing in the more commonly used college zoology texts.

Animals inhabit nearly all aquatic and terrestrial habitats of the biosphere. The greatest number of animals are marine, where the first animals probably evolved. Depending on the classification scheme, animals may be grouped into as many as 35 phyla (see the table on the next page). The most commonly known phylum is *Chordata* that includes the subphylum *Vertebrata*, or the backboned animals. Chordates, however, comprise only about 5% of all the animal species. All other animals are frequently referred to as *invertebrates*, and account for 95% of the animal species.

Several dissections of invertebrate and vertebrate animals were completed and photographed in the preparation of this atlas. An understanding of the structure of an animal is requisite to learning about physiological mechanisms, and even how the animal functions in its environment. The selective pressures that determine evolutionary changes frequently have an influence on anatomical structures. Studying dissected specimens, therefore, provides phylogenetic information, or how one group of organisms is related to another.

Some zoology laboratories have the resources to provide students with opportunities for doing selected invertebrate and vertebrate dissections. For these students, the photographs contained in this atlas will be a valuable source for identification of structures on your specimens as they are dissected and studied. If dissection specimens are not available, the excellent photographs of carefully dissected prepared specimens presented throughout this atlas will be an adequate substitute. Care has gone into the preparation of these specimens to depict and identify the principal body structures from representative specimens of each of the major animal phyla. As the anatomy of the various animal specimens are studied in this atlas, note the similarities of body structure from one group to another. Even the anatomy of the human organism is similar to other animals, particularly to those of other mammals.

The information contained in Chapters 1 and 2 is intended to provide you with an orientation as to the basic structure of an animal and an understanding of how cells divide. The animal phyla are presented in Chapters 3 through 16. Chapter 17 of this atlas is devoted to the biology of the human animal, which is presented in many zoology textbooks and courses. In this chapter, you are provided with a complete set of photographs for each of the human body systems. Human cadavers have been carefully dissected and photographs taken to clearly depict each of the principal organs from each of the body systems. Selected radiographs (X-rays), CT scans, and MR images depict structures from living persons and thus provide an applied dimension to this portion of the atlas.

Some Representative of the Kingdom Animalia

Phyla and Representative Kinds	*Characteristics*
Porifera: sponges,	Multicellular, aquatic animals, with stiff skeletons and bodies perforated by pores
Cnidaria: corals, hydra, and jellyfish	Aquatic animals, radially symmetrical, mouth surrounded by tentacles bearing cnidocytes (stinging cells); body composed of epidermis and gastrodermis, separated by mesoglia
Platyhelminthes: flatworms	Elongated, flattened, and bilaterally symmetrical; distinct head containing ganglia; nerve cords; protonephrida or flame cells
Nematoda: roundworms and nematodes	Mostly microscopic, unsegmented wormlike; body enclosed in cuticle; whip like body movement
Mollusca: mollusks; clams, snails, and squids	Bilaterally symmetrical with true coelom containing mantle; many have muscular foot and protective shell
Annelida: segmented worms	Body segmented by septa; a series of hearts; hydrostatic skeleton and circular and longitudinal muscles
Arthropoda: crustaceans and insects	Body segmented; paired and jointed appendages; chitinous exoskeleton; hemocoel for blood flow
Echinodermata: echinoderms; sea stars, sand dollars, sea cucumbers, and sea urchins	Larvae have bilateral symmetry; adults have pentaradial symmetry; coelom with complete digestive tract; regeneration of body parts
Chordata: amphioxus, amphibians, fishes, reptiles, birds, and mammals	Fibrous notochord, pharyngeal gill pouches, dorsal hollow nerve cord, and postanal tail present at some stage in their life cycle.

Acknowledgments

Many professionals have assisted in the preparation of *A Photographic Atlas for the Zoology Laboratory, third edition*, and have shared our enthusiasm of its value for students of zoology. We are especially appreciative of Drs. Wilford M. Hess, Ferron L. Andersen, and William B. Winborn for their help in obtaining photographs and photomicrographs. Drs. Dwayne Meadows and Samuel I. Zeveloff of the Department of Zoology at Weber State University were especially helpful and supportive of this project. The radiographs, CT scans, and MR images have been made possible through the generosity of Gary M. Watts, MD and the Department of Radiology at Utah Valley Regional Medical Center. Ryan L. Van De Graaff spent many hours in assisting us with dissections, photography, and labeling. Several other students were very helpful in performing dissections. We gratefully acknowledge the assistance of Nathan A. Jacobson, Scott R. Gunn, Sandra E. Sephton, Michelle Kidder, and Michael K. Visick. Thanks is extended to Christopher H. Creek for his line art throughout the book. We also appreciate Focus Design and the employees, Stacy Wilcken, Coriantumr Jones, Michael Hancock, Julie Hancock and James Jensen for the layout and organization of this atlas. We are indebted to Douglas Morton and the personnel at Morton Publishing Company for the opportunity, encouragement, and support to prepare this atlas.

Many of the photographs of living animals were made possible because of the cooperation and generosity of the San Diego Zoo, San Diego Wild Animal Park, Sea World (San Diego), and Hogle Zoo (Salt Lake City). We are especially appreciative to the professional zoologists at these fine institutions.

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Cells and Tissues

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Animals are heterotrophic organisms that ingest food materials and store carbohydrate reserves as glycogen or fat. The cells of animals lack cell walls, but do contain intercellular connections including desmosomes, gap junctions, and tight junctions. Animal cells are also highly specialized into the specific kinds of tissues depicted in this chapter. Most animals are motile through the contraction of muscle fibers containing actin and myosin proteins. The complex body systems of animals include elaborate sensory and neuromotor specializations that accommodate dynamic behavioral mechanisms.

Cells are the basic structural and functional units of organization within living organisms. A cell is a minute, membrane enclosed, protoplasmic mass consisting of chromosomes surrounded by cytoplasm containing the specific organelles which function independently but in coordination one with another. Based on structure, there are prokaryotic cells and eukaryotic cells.

Prokaryotic cells lack a membrane-bound nucleus, contain a single *chromosome* composed of a single strand of *nucleic acid*, contain few organelles, and have a rigid or semirigid *cell wall* outside the *cell (plasma) membrane* that provides shape to the cell. The bacteria, within the kingdom Monera, are examples of prokaryotic, single-celled, organisms.

Eukaryotic cells contain a nucleus with multiple chromosomes, have numerous specialized *organelles*, and have a differentially permeable *cell (plasma) membrane*. Examples of eukaryotic organisms include protozoa, fungi, algae, plants, and invertebrate and vertebrate animals.

The *nucleus* is the large spheroid body within the eukaryotic cell that contains the *nucleolus*, *nucleoplasm*, and *chromatin* — the genetic material of the cell. The nucleus is enclosed by a double membrane called the *nuclear membrane*, or *nuclear envelope*. The nucleolus is a dense, nonmembranous body composed of protein and RNA molecules. The chromatin consists of fibers of protein and DNA molecules. Prior to cellular division, the chromatin shortens and coils into rod-shaped *chromosomes*. Chromosomes consist of DNA and proteins called *histones*.

The *cytoplasm* of the eukaryotic cell is the medium of support between the nuclear membrane and the cell membrane. *Organelles* are minute membrane-bound structures within the cytoplasm of a cell that are concerned with specific functions. The cellular functions carried out by the organelles are referred to as *metabolism*. The functions of the principal organelles are listed in Table 1.1. In order for cells to remain alive, metabolize and maintain *homeostasis*, certain requirements must be met that include having access to nutrients and oxygen, being able to eliminate wastes, and being maintained in a constant, protective environment.

The *cell membrane* is composed of carbohydrate (phospholipid) and protein molecules, which gives form to a cell and controls the passage of material into and out of a cell. More specifically, the proteins in the cell membrane provide:

1. structural support;
2. a mechanism of molecule transport across the membrane;
3. enzymatic control of chemical reactions;
4. receptors for hormones and other regulatory molecules;
5. cellular markers (antigens), which identify the blood and tissue type.

The carbohydrate molecules:

1. repel negative objects due to their negative charge;
2. act as receptors for hormones and other regulatory molecules;
3. form specific cell markers which enable like cells to attach and aggregate into tissues;
4. enter into immune reactions.

Tissues are aggregations of similar cells that perform specific functions. The tissues of the body of a multicellular animal are classified into four principal types, determined by structure and function:

1. *epithelial tissues* cover body and organ surfaces, line body cavities and lumen (hollow portion of a body tube), and form various glands;
2. *connective tissues* bind, support, and protect body parts;
3. *muscle tissues* contract to produce movements;
4. *nervous tissues* initiate and transmit nerve impulses from one body part to another.

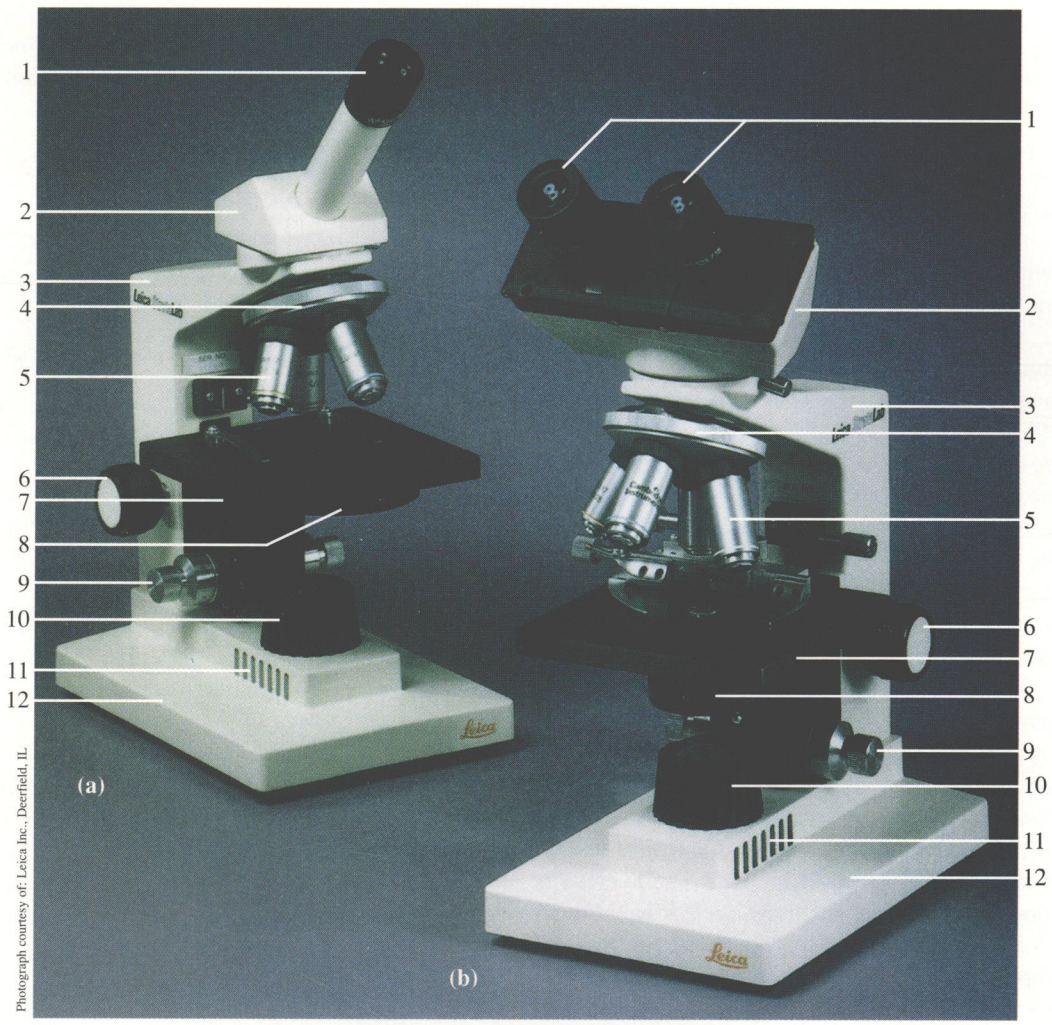


Figure 1.1 (a) A compound monocular microscope and (b) a compound binocular microscope.

1. Eyepiece(s)
2. Body
3. Arm
4. Nosepiece
5. Objective
6. Focus adjustment knob
7. Fixed stage
8. Condenser
9. Stage adjustment knob
10. Collector lens with field diaphragm
11. Illuminator (inside)
12. Base

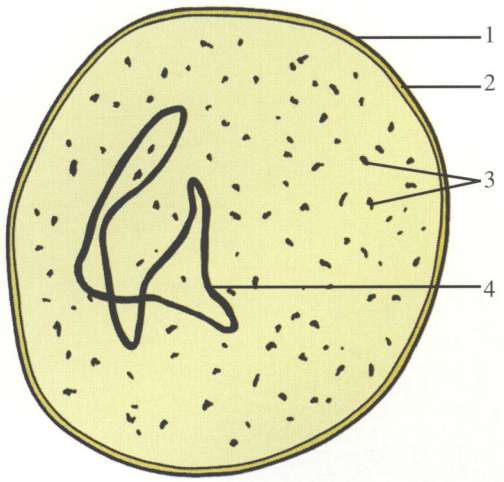


Figure 1.2 A prokaryotic cell.

1. Cell wall
2. Cell (plasma) membrane
3. Ribosomes
4. Circular molecule of DNA

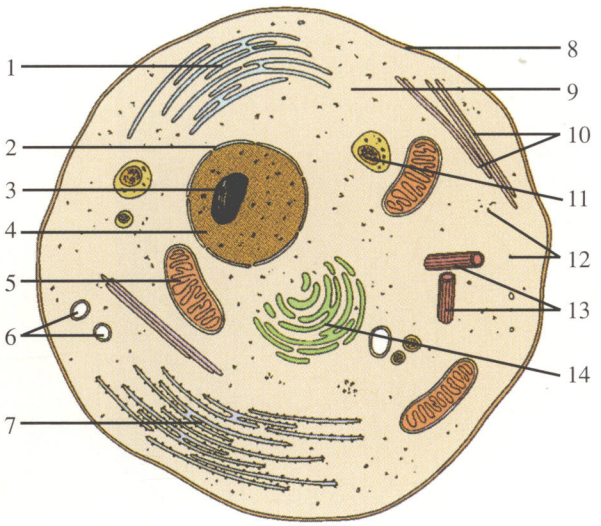


Figure 1.3 A typical animal cell.

1. Smooth endoplasmic reticulum
2. Nuclear membrane
3. Nucleolus
4. Nucleoplasm
5. Mitochondrion
6. Vesicles
7. Rough endoplasmic reticulum
8. Cell membrane
9. Cytoplasm
10. Microtubules
11. Lysosome
12. Ribosomes
13. Centrioles
14. Golgi complex

Table 1.1 Structure and Function of Cellular Components

Component	*Structure*	*Function*
Cell (plasma) membrane	Composed of protein and phospholipid molecules	Provides form to cell; controls passage of materials into and out of cell
Cytoplasm	Fluid to jelly-like substance	Serves as suspending medium for organelles
Endoplasmic reticulum	Interconnecting membrane-lined channels	Provides supporting framework of cell; enables cell transport
Ribosomes	Granules of nucleic acid	Synthesize protein
Mitochondria	Double-layered sacs with cristae	Produce ATP (cellular respiration)
Golgi complex	Flattened membrane-lined chambers	Synthesize carbohydrates and packages molecules for secretion
Lysosomes	Membrane-surrounded sacs of enzymes	Digest foreign molecules and worn cells
Centrosome	Mass of two rodlike centrioles	Organizes spindle fibers and assists mitosis
Vacuoles	Membranous sacs	Store and secrete substances within the cytoplasm
Fibrils and microtubules	Protein strands	Support cytoplasm and transport materials
Cilia and flagella	Cytoplasmic extensions from cells	Move particles along cell surface, or move cell
Nucleus	Nuclear membrane, nucleolus, and chromatin (DNA)	Directs cell activity; forms ribosomes

Figure 1.4. An electron micrograph of a freeze-fractured nuclear membrane (nuclear envelope), showing the nuclear pores. 1000X

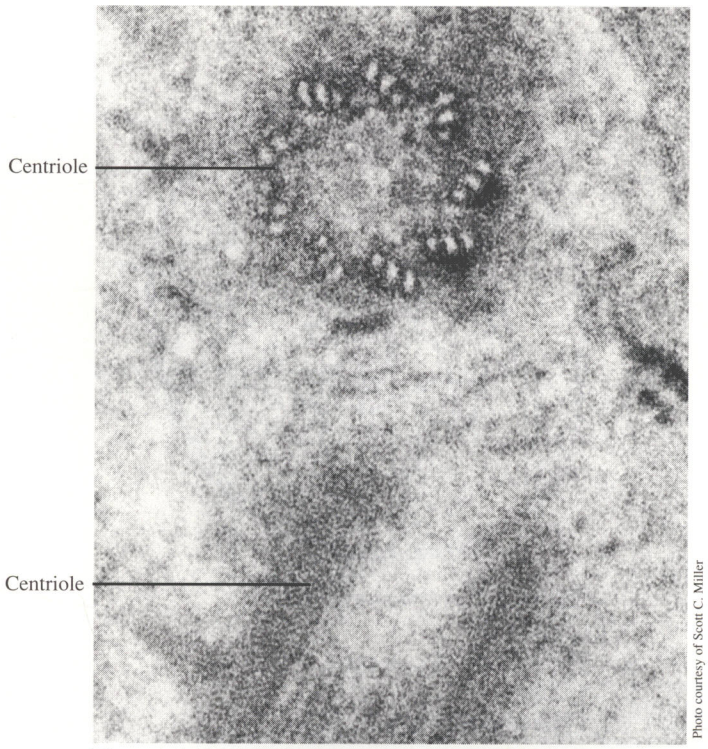


Figure 1.5. An electron micrograph of centrioles. The centrioles are positioned at right angles to one another.

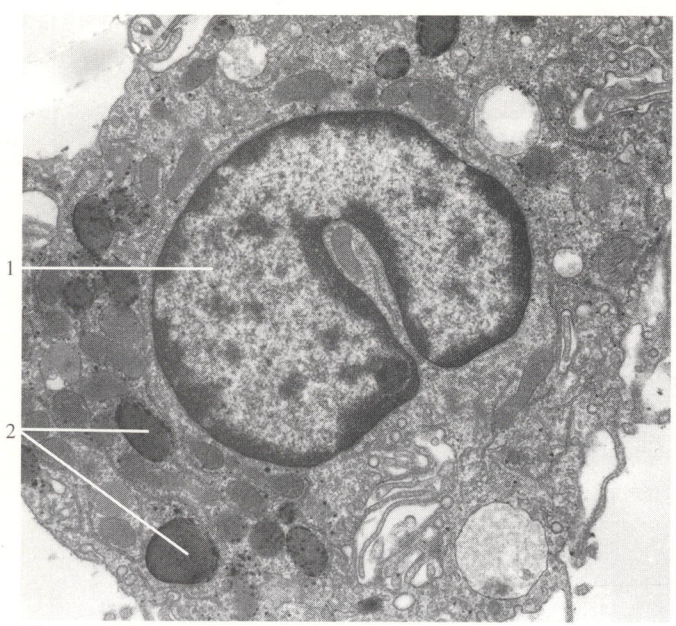


Figure 1.6 An electron micrograph of lysosomes.
1. Nucleus 2. Lysosomes

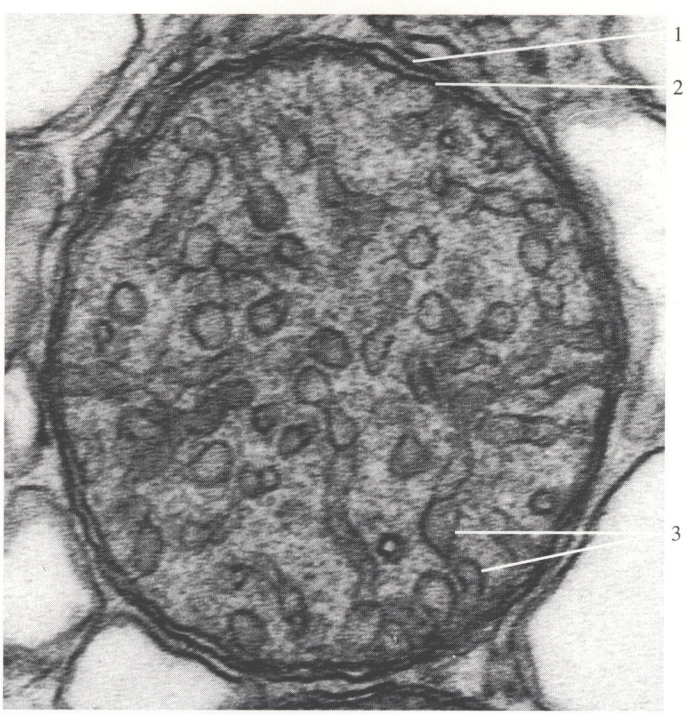


Figure 1.7 An electron micrograph of a mitochondrion.
1. Outer membrane 3. Crista
2. Inner membranes

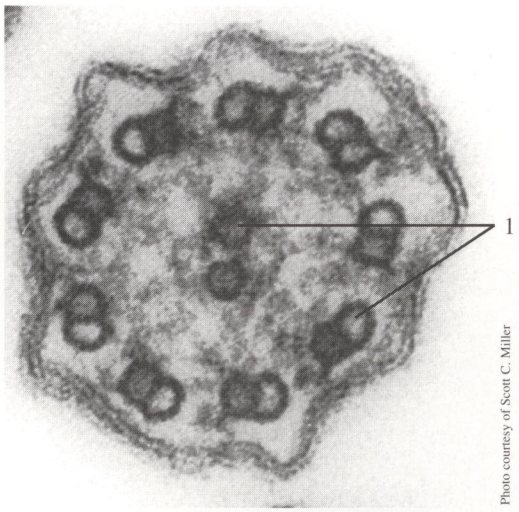


Figure 1.8 An electron micrograph of cilia showing the characteristic "9 + 2" arrangement of microtubules in cross sections.

1. Microtubules

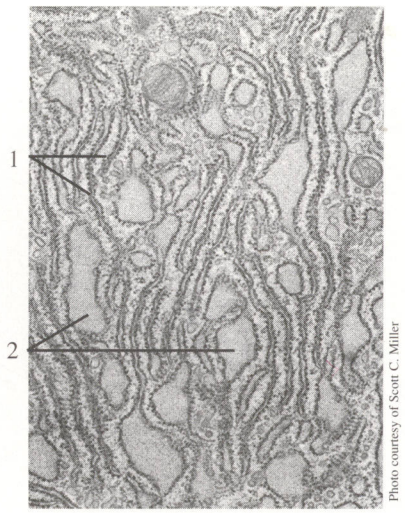


Figure 1.9 An electron micrograph of rough endoplasmic reticulum.

1. Ribosomes 2. Cisternae

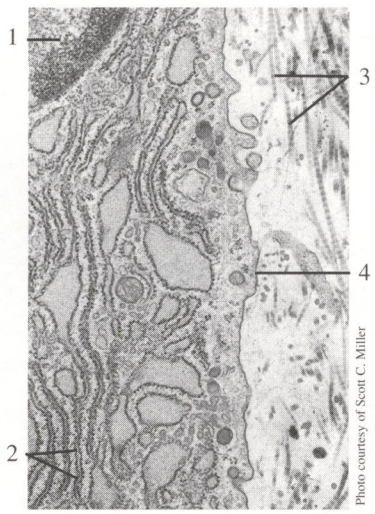


Figure 1.10 Rough endoplasmic reticulum secreting collagenous filaments to the outside of the cell.

1. Nucleus
2. Rough endoplasmic reticulum
3. Collagenous filaments
4. Cell membrane

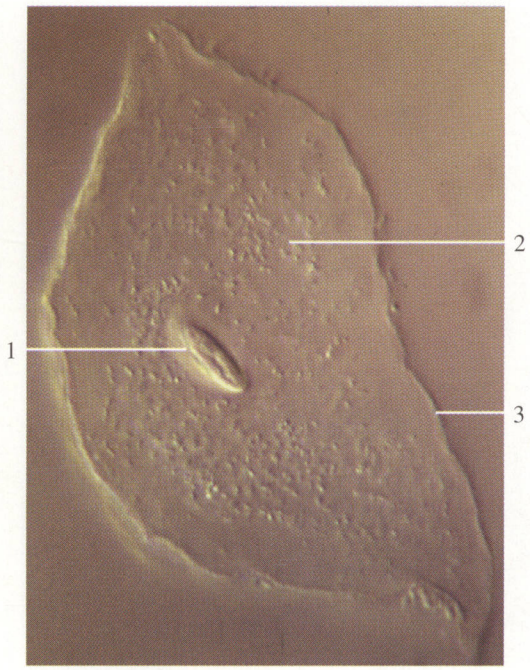


Figure 1.11 An epithelial cell from a cheek scraping.

1. Nucleus
2. Cytoplasm
3. Cell membrane

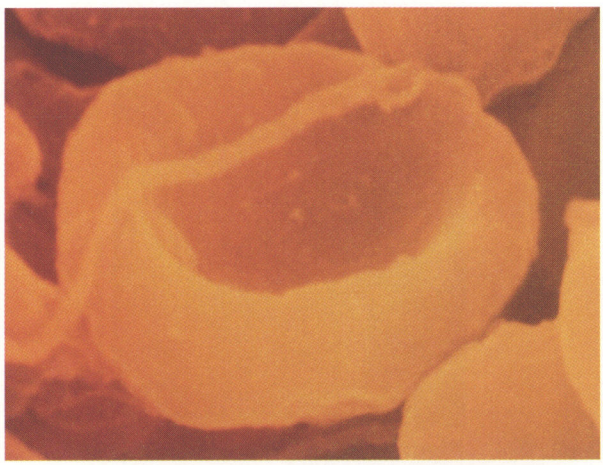


Figure 1.12 An electron micrograph of an erythrocyte (red blood cell).

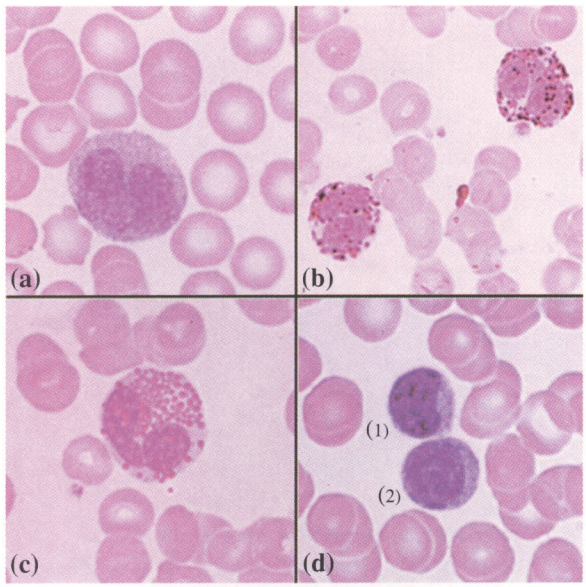


Figure 1.13 Types of leukocytes. 200X

(a) Neutrophil
(b) Basophils
(c) Eosinophil
(d) Monocyte (1); lymphocyte (2)

Figure 1.14 An electron micrograph of a capillary containing an erythrocyte.

1. Lumen of capillary
2. Nucleus of endothelial cell
3. Erythrocyte
4. Endothelial cell

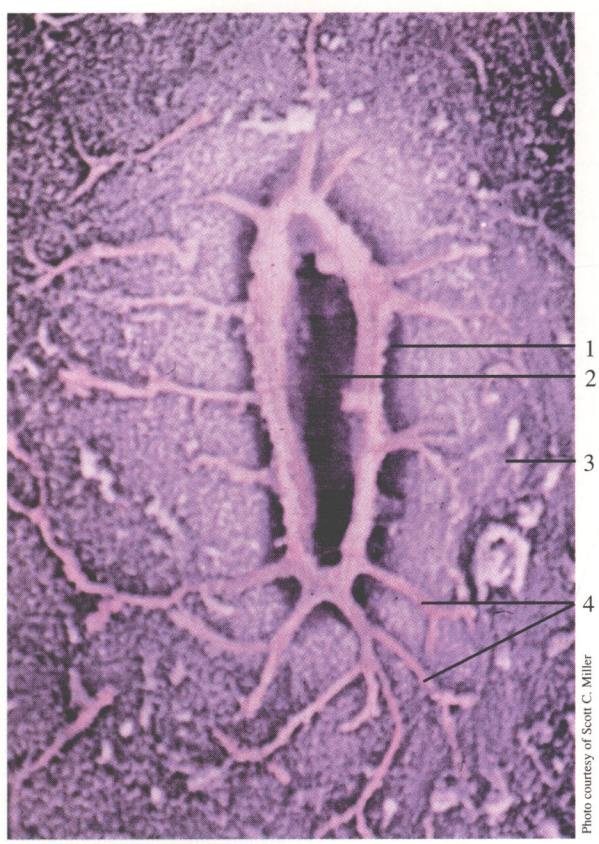


Figure 1.15 An electron micrograph of an osteocyte in cortical bone matrix.

1. Lacuna
2. Osteocyte
3. Bone matrix
4. Canaliculi

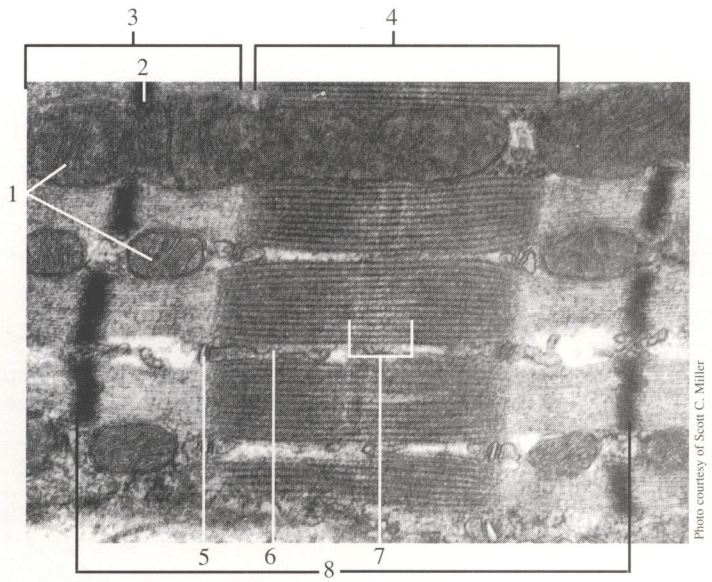


Figure 1.16 An electron micrograph of a skeletal muscle myofibril, showing the striations.

1. Mitochondria
2. Z line
3. I band
4. A band
5. T-tubule
6. Sarcoplasmic reticulum
7. H band
8. Sacromere

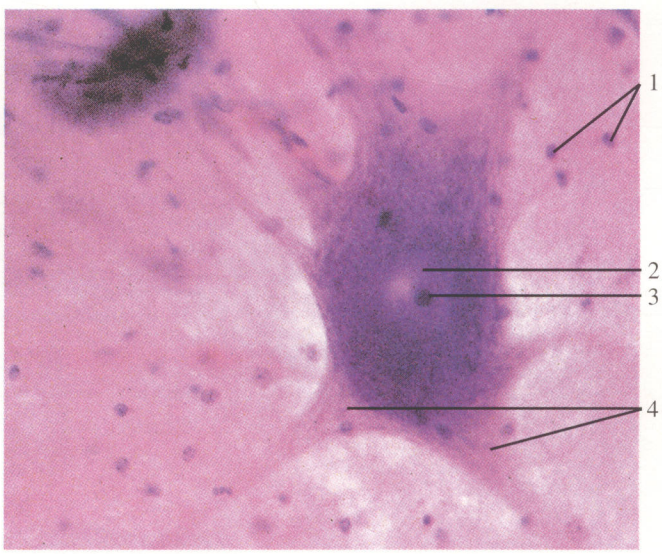


Figure 1.17 The histology of a neuron. 400X

1. Nuclei of surrounding neuroglial cells
2. Nucleus of neuron
3. Nucleolus of neuron
4. Dendrites of neuron

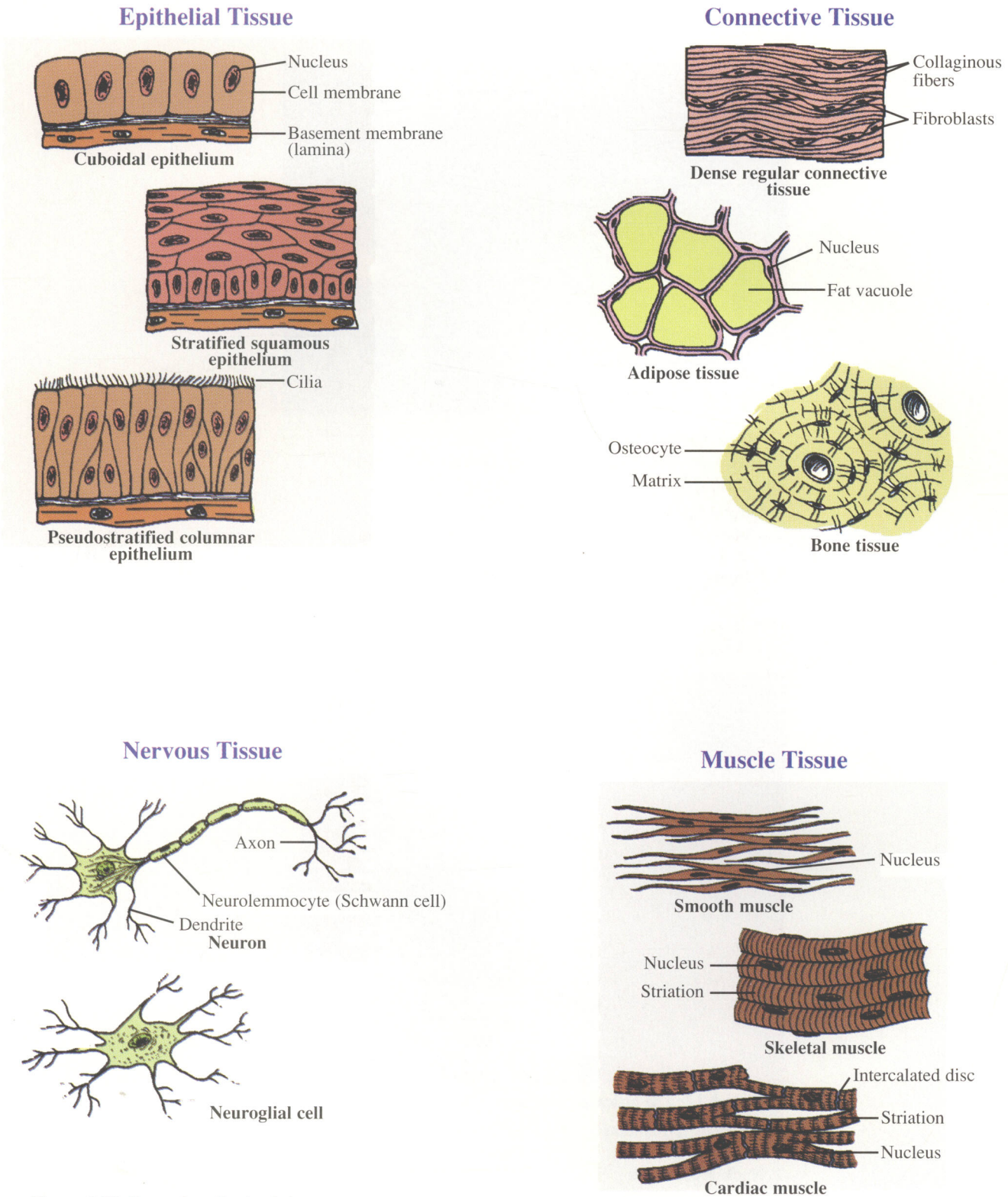


Figure 1.18 Examples of animal tissues.

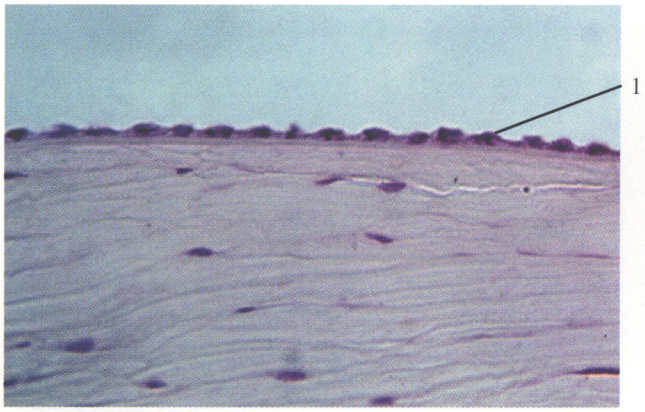


Figure 1.19 Simple squamous epithelium. 300X

1. Single layer of flattened cells

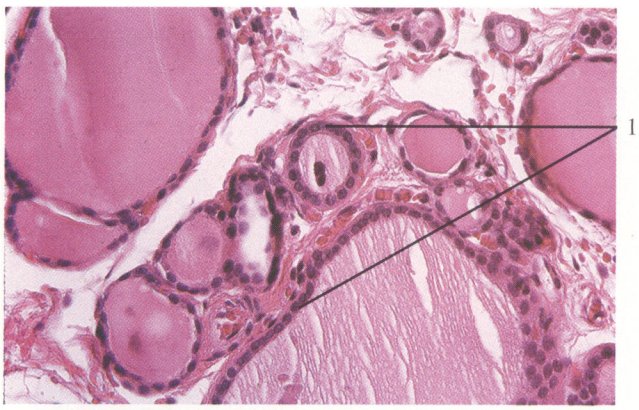


Figure 1.20 Simple cuboidal epithelium. 300X

1. Single layer of cells with round nuclei

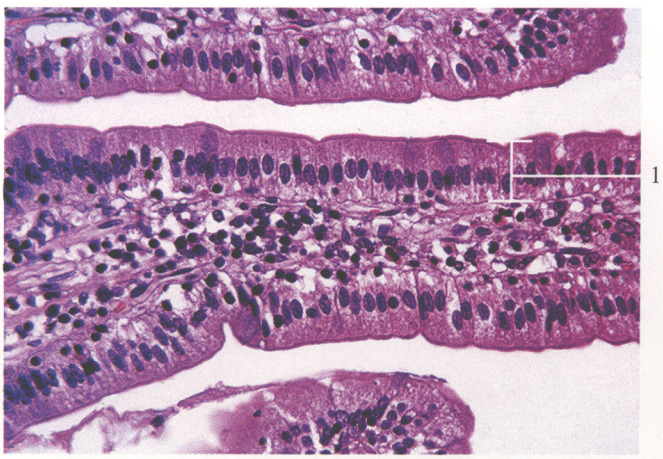


Figure 1.21 Simple columnar epithelium. 300X

1. Single layer of cells with oval nuclei

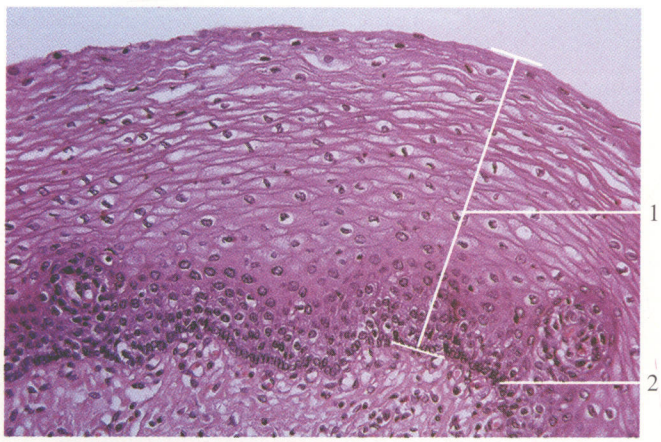


Figure 1.22 Stratified squamous epithelium. 200X

1. Multiple layers of cells, which are flattened at the surface
2. Basal (germinal) layer

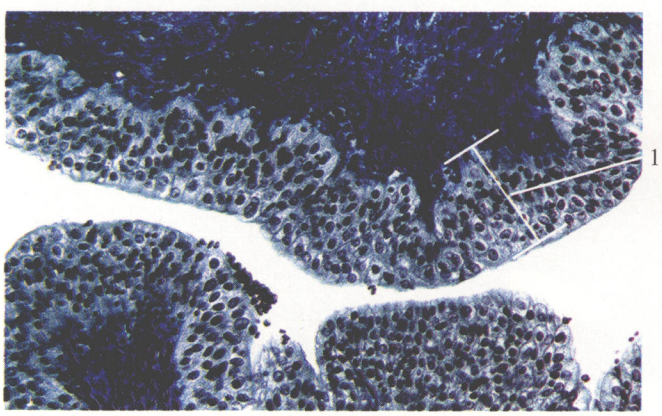


Figure 1.23 Stratified columnar epithelium. 200X

1. Cells are balloon-like at surface

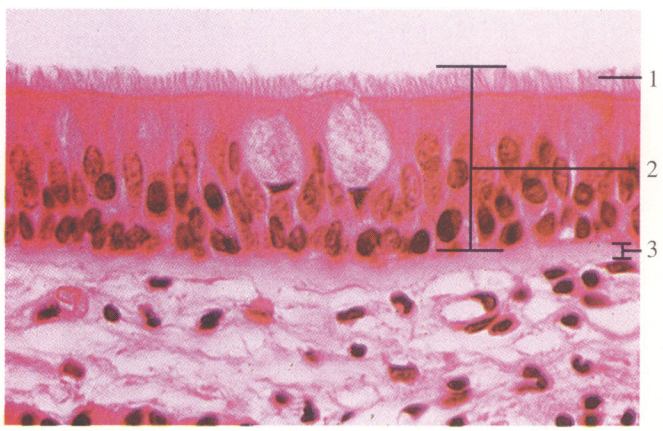


Figure 1.24 Pseudostratified columnar epithelium. 600X

1. Cilia
2. Pseudostratified columnar epithelium
3. Basement membrane

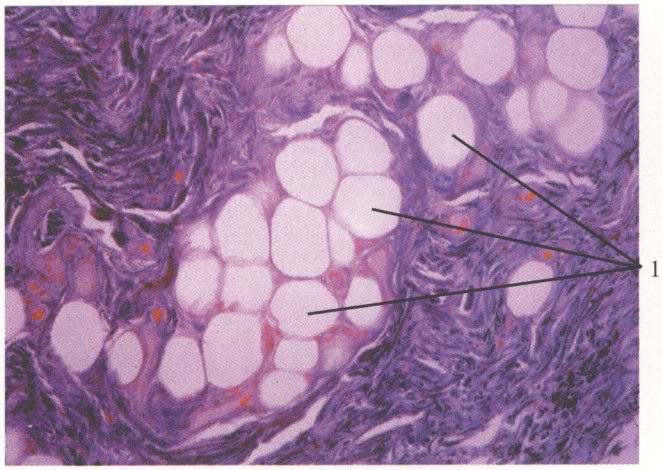


Figure 1.25 Adipose connective tissue. 200X

1. Adipocytes (adipose cells)

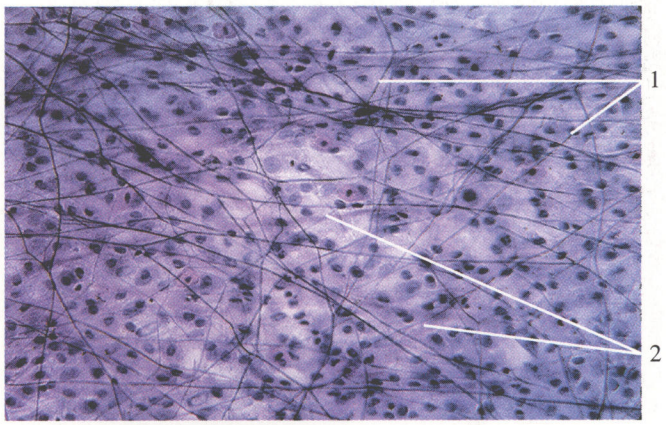


Figure 1.26 Loose connective tissue stained for elastic and collagen fibers. 200X

1. Elastic fibers (black)
2. Collagenous fibers (pink)

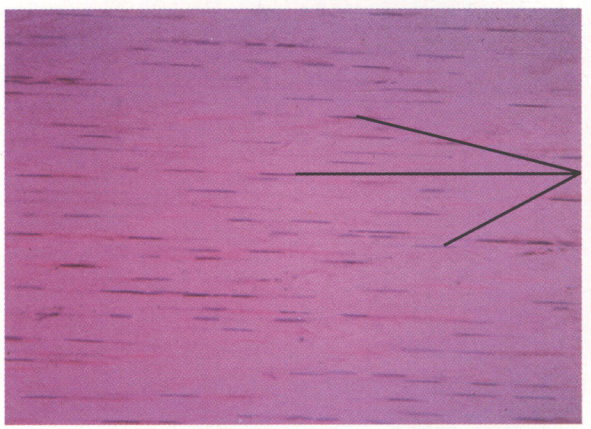


Figure 1.27 Dense regular connective tissue. 200X

1. Nuclei of fibroblasts arranged in parallel rows

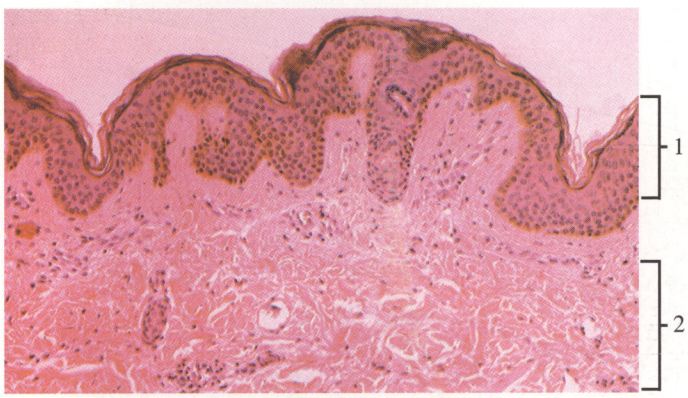


Figure 1.28 Dense irregular connective tissue. 200X

1. Epidermis
2. Dense irregular connective tissue (reticular layer of dermis)

Figure 1.29 An electron micrograph of dense irregular connective tissue. 200X

1. Collagenous fibers

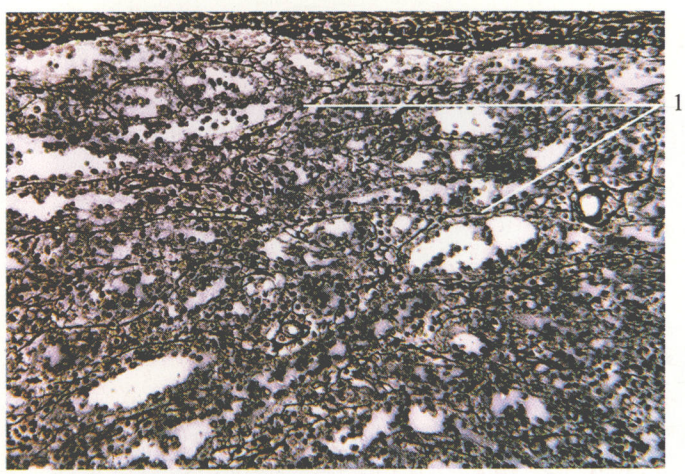


Figure 1.30 Reticular connective tissue. 200X

1. Reticular fibers

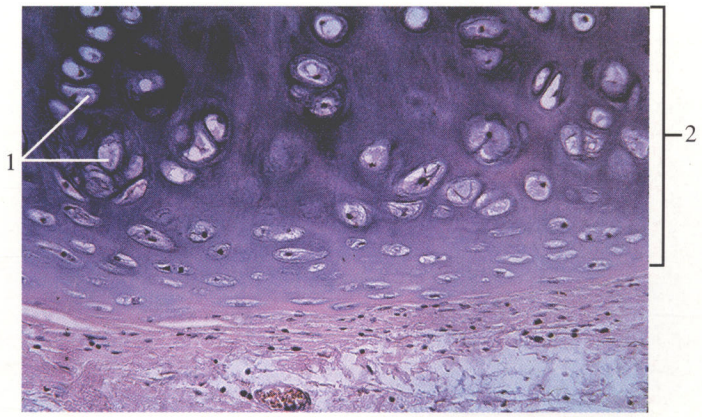


Figure 1.31 Hyaline cartilage. 200X

1. Chondrocytes within lacunae
2. Hyaline cartilage

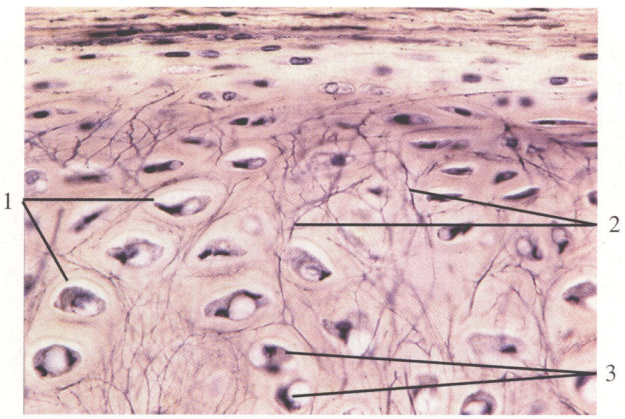


Figure 1.32 Elastic cartilage. 150X

1. Lacunae
2. Elastic fibers
3. Chondrocytes

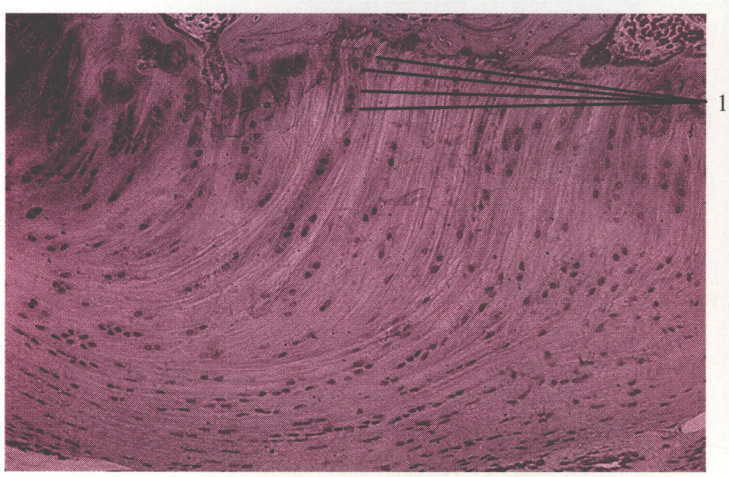


Figure 1.33 Fibrocartilage. 150X

1. Chondrocytes arranged in a row

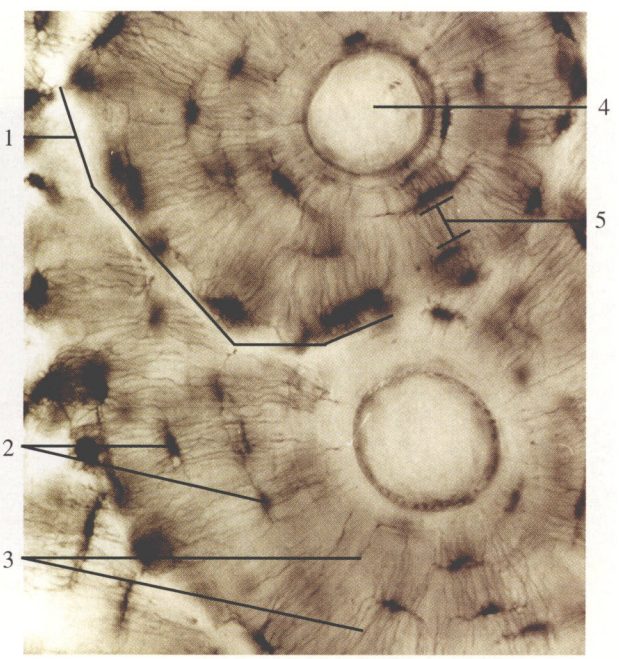
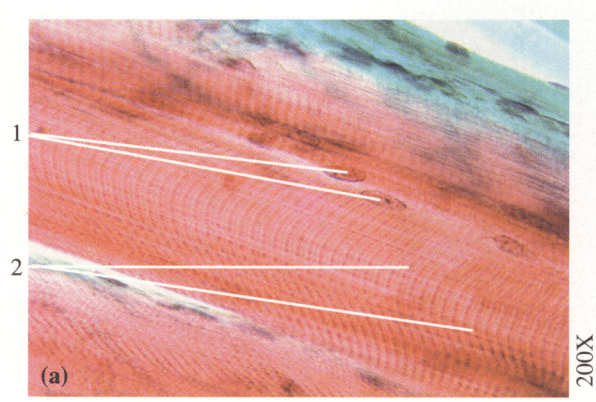


Figure 1.34 Bone tissue. 55X

1. Osteon (Haversian system)
2. Osteocytes in lacunae
3. Canaliculi
4. Central canal (Haversian canal)
5. Lamella of osteon



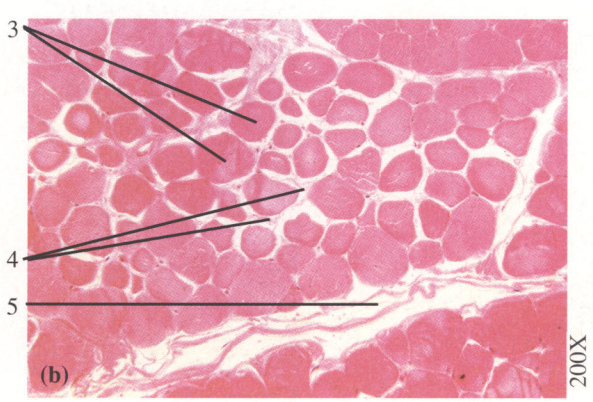


Figure 1.35 Skeletal muscle tissue. (a) A longitudinal section and (b) a cross section.

1. Nuclei
2. Striations of skeletal muscle fibers
3. Skeletal muscle fibers
4. Endomysium
5. Perimysium