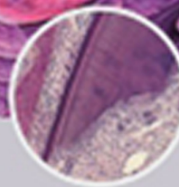
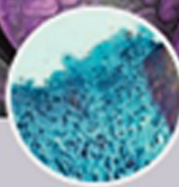


Daniel J. Chiego, Jr.

Essentials of



Oral Histology and Embryology

A Clinical Approach

EDITION

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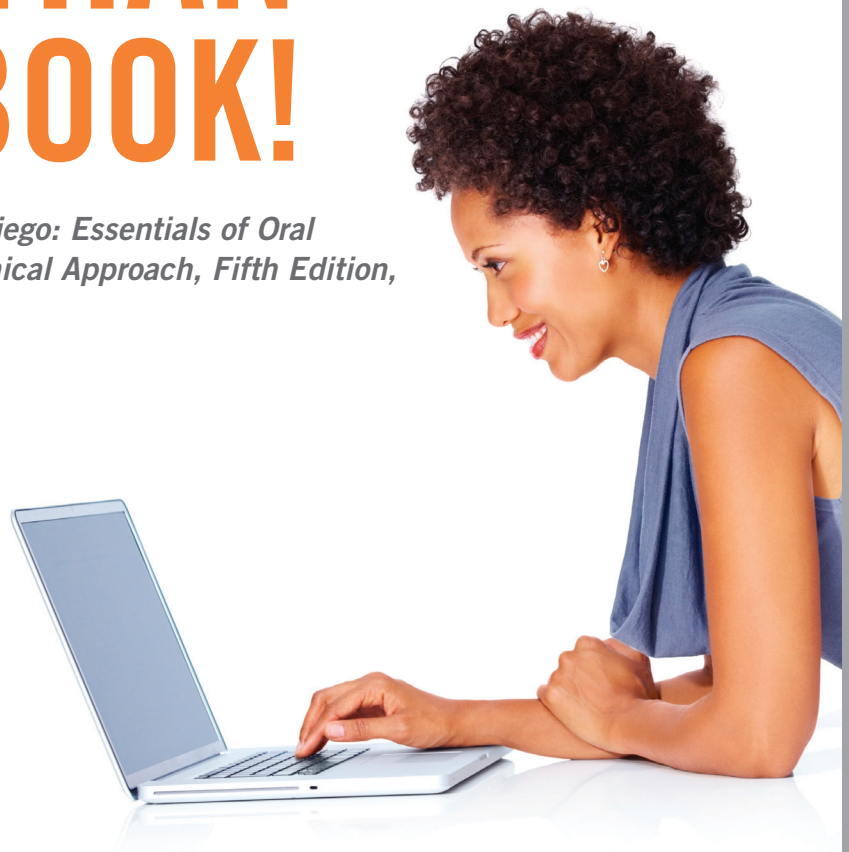
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Essentials of Oral Histology and Embryology: A Clinical Approach

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Essentials of Oral Histology and Embryology: A Clinical Approach

FIFTH EDITION

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The fifth edition of *Essentials of Oral Histology and Embryology: A Clinical Approach* has been enhanced with additional photomicrographs and text, which are associated with a translational approach to clinical dentistry. Each chapter has a new clinical comments section that poses a question and provides the interpretation based on current literature. The chapters have had numerous updates and information added to further add to the students' understanding of the anatomy, embryology, and histology necessary for the complete understanding of the patient's chief complaint and possible systemic sequelae not normally associated with dental procedures. Modern dental education is rapidly becoming interdisciplinary, encompassing other clinical and auxiliary professionals in a holistic approach to patient wellness. The clinical comments in each chapter address this interdisciplinary approach by associating, integrating, and correlating the basic science with the clinical component and therefore providing the reader with an evidence-based answer and treatment plan. References have also been updated for every chapter and include seminal papers when possible. My personal teaching philosophy has always been one of including as much information as I possibly can associated with a specific topic so that students will have a vast armamentarium of information to help in their decision-making processes associated with diagnosis and treatment planning.

With the vast amount of information available to students and health care providers, it is a prodigious task to filter and apply the pertinent evidence-based treatment to each individual case. One of the purposes of this textbook is to make it easier for the user to be able to make the correct decisions based partly on the information provided by this updated edition.

Daniel J. Chiego, Jr.

NEW TO THIS EDITION

The fifth edition of *Essentials of Oral Histology and Embryology: A Clinical Approach* contains new content on biofilm and its association with systemic disease, the causes of temporomandibular joint dysfunction, clinical applications with dental pulp, new enamel proteins, synthetic oral mucosa, and more. New illustrations, micrographs, and histograms add to the already robust art program. Case studies have been included in each chapter to help students connect content to real-world situations.

ABOUT THE EVOLVE SITE

The accompanying Evolve site includes instructor and student resources. Material found on Evolve includes:

For the instructor:

- A **500-Question Test Bank** with accompanying rationales, chapter objective mapping, and page number references for remediation
- **PowerPoint Presentations** separated by chapter and designed to guide lectures
- **Image Collection** in downloadable formats

For the student:

- **Practice Quizzes** organized by chapter and provided in assessment format with answers, rationales, and page number references

These updated ancillaries make the fifth edition of *Essentials of Oral Histology and Embryology* an invaluable asset to classroom learning and individual study alike.

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ACKNOWLEDGMENTS

When Kristin Wilhelm called and suggested that it was time for the fifth edition of *Essentials of Oral Histology and Embryology: A Clinical Approach* I thought a fifth edition would be good because of scientific advances and some additional concepts I had been thinking of introducing into the next edition. At many professional meetings around the world, colleagues and students would discuss what they liked in the text and changes that would enhance the current edition. When I was introduced to Erin Garner, who was my development editor during the course of all the steps that it takes to publish a textbook, my writing life became easier. Erin was extremely helpful and always kept me calm when I was stressing just before a deadline. I couldn't have asked for a better Development Editor. I would like to thank all members of the development team:

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Daniel J. Chiego, Jr.

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Development and Structure of Cells and Tissues

LEARNING OBJECTIVES

- Describe the cell and how it divides.
- Discuss how cells change from a stem cell to a terminally differentiated state.
- Discuss the origin of tissue and the ovarian cycle and the development of the embryonic disk.
- Describe the various tissues of the human body and some of the adverse factors such as environmental stress, hereditary, and dietary factors that may affect development of these tissues.

OVERVIEW

The smallest unit of structure in the human body is the cell, composed of a nucleus and cytoplasm. The nucleus contains **deoxyribonucleic acid (DNA)** and **ribonucleic acid (RNA)**, the fundamental structures of life. The cytoplasm functions in absorption and cell duplication, in which organelles perform specific actions. The cell cycle is the time required for the DNA to duplicate before mitosis. This chapter discusses the four stages of mitosis: prophase, metaphase, anaphase, and telophase. Also described are the three periods of prenatal development: proliferative, embryonic, and fetal. The fertilization of the ovum in the distal uterine tube, zygote migration, and the zygote's implantation in the uterine wall are discussed. In addition, the origin of human tissues—ectoderm, mesoderm, and endoderm—is presented, followed by the differentiation of tissue types, such as those of ectodermal origin, epithelium and skin with its derivatives, and the central and peripheral nervous systems. This chapter also delineates development of the mesodermal components involving connective tissues of the body, such as fibrous tissue, three types of cartilage, two types of bone, three kinds of muscles, and the cardiovascular system. The reader will better comprehend the origin, development, organization, and structure of the various cells and tissues of the human body.

CELL STRUCTURE AND FUNCTION

The human body is composed of cells, intercellular substance (the products of these cells), and fluid that bathes these tissues. Cells are the smallest living units capable of independent existence. They carry out the vital processes of **absorption, assimilation, respiration, irritability, conductivity, growth, reproduction, and excretion**. Cells vary in size, shape, structure, and function. Regardless of function, each cell has a number of characteristics in common with other cells, such as **cytoplasm** and a **nucleus**, which contains a **nucleolus**.

However, some cell characteristics are related to function. A cell on the surface of the skin, for example, serves best as a thin, flattened disk, whereas a respiratory cell functions best as a cuboidal or columnar cell to facilitate adsorption with mobile cilia to move fluid from the lung to the oropharynx. Surrounding each cell is the **intercellular material** that provides the cell with nutrition, takes up waste products, and provides the body with form. It may be as soft as loose connective tissue or as hard as bone, cartilage, or teeth. **Fluid**, the third component of the body, is the blood and lymph that travel throughout the body in vessels or the tissue fluid that bathes each cell and fiber of the body.

Cell Nucleus

A nucleus is found in all cells except mature red blood cells and blood platelets. The nucleus is usually round to ovoid, depending on the cell's shape. Ordinarily a cell has a single nucleus; however, it may be binucleate, as are cardiac muscle cells or parenchymal liver cells, or multinucleate, as are osteoclasts and skeletal muscle cells. The nucleus is important in the production of DNA and RNA. DNA contains the genetic information in the cell, and RNA carries information from the DNA to sites of actual protein synthesis, which are located in the cell cytoplasm. The nucleus is bound by a membrane, the **nuclear envelope**, which has openings at the **nuclear pores**. This envelope is composed of two phospholipid layers similar to the plasma membrane of the cell. The pores are associated with the **endoplasmic reticulum (ER)** that forms at the end of each cell division. The nucleus contains from one to four nucleoli, which are round, dense bodies constituting the RNA contained in the nucleus. Nucleoli have no limiting membrane (Fig. 1-1).

Cell Cytoplasm

Cytoplasm contains structures necessary for adsorption and for creation of cell products. The **cytosol** is the part of the

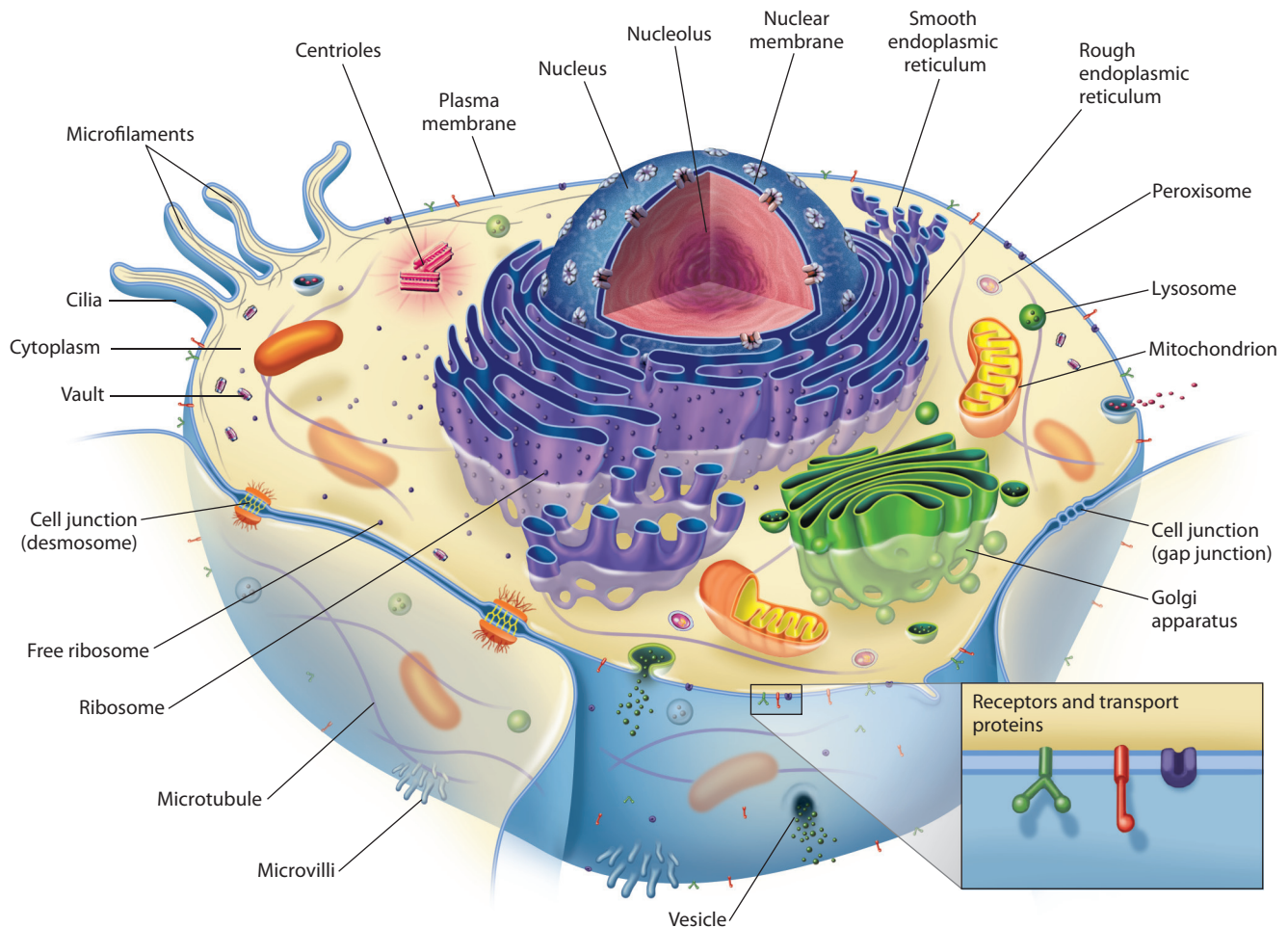


FIG. 1-1 Nucleus, rough surface endoplasmic reticulum (ER), mitochondria, Golgi apparatus, centrioles, and gap junctions as viewed by electron microscopy (artist's rendition). Cells communicate with each other to regulate organization, growth, and development.

cytoplasm that contains the organelles and solutes. The cytosol uses the raw materials brought into the cell to produce energy. It also functions in the excretion of waste products. These functions are carried out by the ER-parallel membrane-bound cavities in the cytoplasm that contain newly acquired and synthesized protein. Two types of ER, smooth surfaced and granular or rough surfaced, can be found in the same cell. Rough-surfaced ER is caused by ribosomes on the surface of the reticulum and is the site at which protein production is initiated. Proteins are vital to the cell's metabolic processes, and each type of protein is composed of a number of different amino acids linked in a specific sequence. Amino acids form protein-containing groups, which, in turn, form acids or bases.

Ribosomes are particles that translate genetic codes for proteins and activate mechanisms for their production. They can be found as separate particles in the cytoplasm, clustered as polyribosomes, or attached to the ER membranes. Ribosomes are nonspecific as to what type of protein they synthesize. The type is dependent on the **messenger RNA (mRNA)**, which carries the message directly from the DNA of the nucleus to the RNA in the ER. This molecule attaches to the ribosomes and

gives orders about the formation of the amino acids. **tRNA** is another type of RNA that acts at the level of the ribosome by carrying amino acids for the synthesis of proteins.

The ER transports substances in the cytoplasm. The ER is connected to the Golgi apparatus via small vesicles. The **Golgi apparatus** or **complex** is critical for posttranslational modifications which help sort, condense, package, and deliver proteins arriving from the ER. The Golgi apparatus is composed of cisternae (flat plates) or saccules, small vesicles, and large vacuoles. From here the secretory vesicles move or flow to the cell surface, where they fuse with the cell membrane and the plasmalemma and release their contents by exocytosis.

Lysosomes are small, membrane-bound organelles that contain a variety of acid hydrolases, hydrogen peroxide, and digestive enzymes to help break down substances both inside and outside the cell. They are in all cells except red blood cells but are prominent in macrophages and leukocytes. Peroxisomes, another intracellular organelle, are also important for breaking down fatty acids.

Mitochondria are membrane-bound organelles that lie free in the cytoplasm and are present in all cells. They are important in generating energy, are a major source of adenosine

triphosphate (ATP), and therefore are the site of many metabolic reactions. These organelles appear as spheres, rods, ovoid, or threadlike bodies. Usually the inner layer of their trilaminar bounding membrane inflects to form transverse-appearing plates, the cristae (see Fig. 1-1). Mitochondria lie adjacent to areas that require their energy production. They also have the ability to store ionic calcium and to release it when needed by the cell for various reactions, including signal transduction. They are self-replicating and contain maternal DNA.

Intermediate are a family of proteins that function as cytoskeletal elements and are categorized as VI types including acid and basic keratins, desmin, glial fibrillary acidic protein (GFAP), vimentin, neurofilaments, laminins, and nestin.

Microtubules are small tubular structures in the cytoplasm that are composed of the protein tubulin. These structures may appear as singles, doublets, or triplets. They function as structural and force-generating elements and relate to cilia (motile cell processes) and to **centrioles** in relation to mitosis. They have cytoskeletal functions in maintaining cell shape. Centrioles are short cylinders appearing near the nucleus. Their walls are composed of nine triplets of microtubules. Centrioles are microtubule-generating centers and are important in mitosis, self-replicating before mitosis begins.

CLINICAL COMMENT

Drugs that can adversely affect microtubule formation by binding tubulin, a major component of microtubules, include colchicine, vinblastine, and vincristine. Inhibiting microtubule formation prevents cells from being able to undergo mitosis. Vinblastine and vincristine are commonly used antimitotic drugs in the treatment of cancer. They are not specific for cancer cells, but since certain kinds of cancer cells divide more often than normal cells, the cancer cells are affected more.

Surrounding the cell is the **plasma membrane** or plasmalemma, which envelops the cell and provides a selective barrier that regulates transport of substances into and out of the cell. All membranes are composed mainly of lipids and proteins with a small amount of carbohydrates. The plasma membrane receives signals from hormones, growth factors, and neurotransmitters by having them bind to receptors located on the surface and within the plasma membrane, eventually activating a second messenger (e.g., cyclic adenosine monophosphate [cAMP]) that signals intracellular organelles or the nucleus/nucleolus to modify cell activity, such as increasing the production of a protein. Also included in the plasma membrane are many kinds of ion channels that can activate many different cell functions. In addition, cells contain proteins, lipids, or fatty substances that provide energy in the cell and are important components of cell membranes and permeability. Carbohydrates are also important in cells as the most available energy component in the body. These carbohydrates may exist as polysaccharide-protein complexes, glycoprotein complexes, glycoproteins, and glycolipids. Carbohydrate compounds are important in cell function and for development of cell products, such as supportive tissues and body lubricants.

Genetic mechanisms help a cell to develop and maintain a high degree of order. This ability is dependent on the genetic information that is expressed within the cell. The basic genetic processes in the cell are RNA and protein synthesis, DNA repair, and replication and genetic recombination. These processes produce the proteins and nucleic acids of a cell. These genetic events are relatively simple compared with other cell processes.

CELL DIVISION

Cell Cycle

Cell division is a continuous series of discrete steps by which the cell component divides. This function is related to the need for growth or replacement of tissues and is partly dependent on the length of the cell's life. Continually renewing cells line the gastrointestinal tract and compose the epidermis and the bone marrow. A second type of cell is part of an expanding population—the cells of the kidney, liver, and some glands. The third type of cell does not undergo cell division or DNA synthesis. An example is the neurons of the adult nervous system. For a somatic cell to undergo cell division, it must pass through a **cell cycle**, which ensures time for DNA genetic material in the daughter cells to duplicate that of the parent cell. However, in a sex cell, an ovum or spermatozoon, the process of meiosis occurs, in which a reduction division of chromosomes in the daughter cell takes place. The result is that half as many chromosomes are in the daughter cell as are in the parent cell. Through meiosis, after fertilization of the ovum by the male sperm, the original (diploid) number of chromosomes is regained. The duration of the cell cycle in somatic cells is now known (Fig. 1-2). After mitosis, the cells enter the reduplication

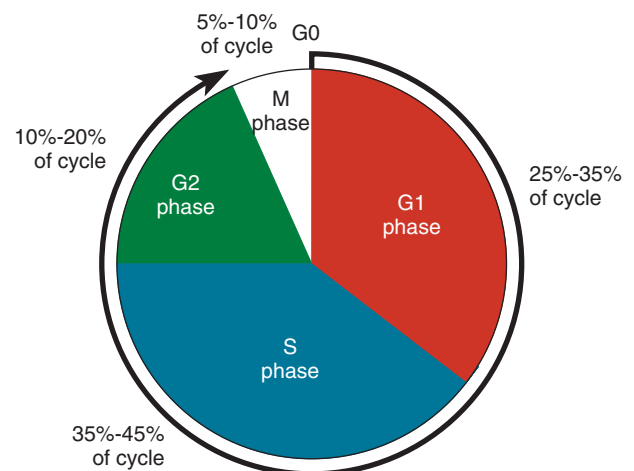


FIG. 1-2 Periods of cell cycle indicate relative time needed for each phase. G1 is the reduplication phase, or resting phase, which takes about 6 to 8 hours. In the S phase, DNA duplication takes place in 8 to 10 hours. The G2 phase is the postduplication phase, which takes about 4 to 6 hours. In the M phase, mitosis takes about 35 to 40 minutes. These figures are for cultured mammalian cells. The total is 18 to 24 hours for these four stages of cytokinesis. Other types of cells can have a longer or shorter cell cycle.