Edition 01

HISTOLOGY
Practical workbook

HISTOLOGY

PRACTICAL WORK BOOK

For

MBBS UNDERGRADUATES

1st EDITION - 2022

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Wayamba University of Sri Lanka

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PREFACE

The human body is made up of four fundamental tissues namely epithelial tissue, connective tissue, muscle tissue, and nerve tissues. Each of the four fundamental tissues consists of cells and extracellular matrix, and all organs and organ systems in the body are made up of variable proportions of them. This simple notion is crucial to understanding the histology of the body organs and organ systems.

Students are taught about the basic components of cells and their matrices from the beginning of the MBBS preclinical histology course. Students can explore the organization of these two components into the basic tissues of the body once they grasp the nature of the link between cells and their matrices.

This practical workbook is intended to help MBBS students with their studies in the histology lab. The book includes twenty practical sessions organized into ten modules of the preclinical course. Each practical session begins with a set of learning objectives that students must achieve effectively in each practical session. Following that, a list of practical tasks along with questions based on the students' observations of the accompanying histology slides/images assigned to respective practical sessions.

The key answers for the exercises and questions from the first and second practical sessions have been included in the appendix of the book: microscope, cell and cell organelles, and epithelial tissues.

CONTENTS

1. FOUNDATION

1.1 Microscope, cell and cell organelles

Objectives

At the end of the practical session, the student should be able to

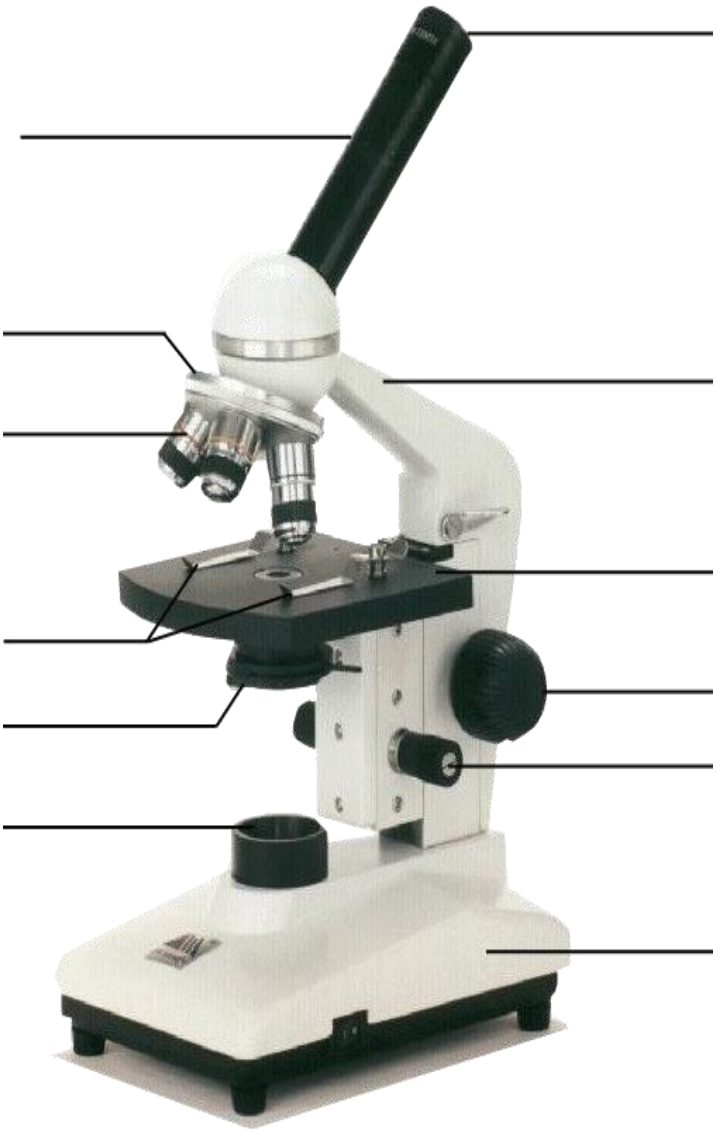
1. Identify the different parts of light microscope
2. List important functions of each part
3. Outline principle behind light microscope and electron microscope
4. Identify the size of a cell under the low power, mid power and high power of the light microscope
5. Identify different cell shapes found in the tissues provided
6. Identify cell membrane, nucleus and other cell organelles through the light microscope

Introduction

Humans are multicellular organisms with a variety of specialized cells grouped into tissues that perform numerous functions. The invention of the light microscope allows us to observe and study cells. Scanning electron microscopy now allows us to study cells down to the nanoscale.

This practical session covers a brief overview of correct light microscope handling and the special care needed for microscope handling and storage in the laboratory, as well as the ultrastructure of prokaryotic and eukaryotic cells and cell organelles, and various cell morphologies such as size, shape, and so on.

1.1.1 Label each part of light microscope



1.1.2 List the functions of each part of light microscope

	Part of the microscope	Functions
1.	Ocular lens	
2.	Body tube	
3.	Revolving nosepiece	
4.	Objective lens	
6.	Arm	
7.	Stage	
8.	Stage clips	
9.	Diaphragm	
10.	Coarse adjustment knob	
11.	Fine adjustment knob	
12.	Bulb	
13.	Base	

1.1.3 List the steps in preparation of light microscope to observe blood cells under 100X

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1.1.4 Outline the principles behind light microscope and electron microscope

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1.1.5 List five advantages of compound light microscope than the scanning electron microscope

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1.1.6 State special care needed for handling light microscope in the histology lab

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1.1.7 Outline the ultrastructure of a prokaryotic cell

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1.1.8 Draw and label the ultrastructure of a prokaryotic cell

1.1.9 Outline the ultrastructure of an eukaryotic cell

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1.1.10 Draw and label the ultrastructure of an eukaryotic cell

1.1.11 List the structural differences between eukaryotic cell and prokaryotic cell

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1.1.12 Identify and draw microscopic appearance of a liver cell in 4X,10X,40X and 100X

4X

10X

40X

100X

1.1.13 Identify and draw microscopic appearance of different cell shapes found in different tissues provided

Tissue A

Medium size artery

Tissue B

Thyroid follicles

Tissue C

Colon

Tissue D

Principle bronchus

1.1.14 Identify and draw cell organelles under 100X

1.1.15 Identify and draw cell organelles in electron micrographs provided and outline the structure of each cell organelle.

Mitochondria

Structure

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Nucleus

Structure

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Endoplasmic reticulum

Structure

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Golgi apparatus

Structure

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Ribosome

Structure

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Lysosome

Structure

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Peroxisome

Structure

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Cytoplasmic inclusions

Structure

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Cell membrane

Structure

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1.1.16 Outline the structural adaptations of mitochondria and cell membrane

Mitochondria

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Cell membrane

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1.1.17 Review of cell structure and functions

Organelle	Key feature	Functions
Nucleus		
Nuclear membrane		
Nucleolus		
Ribosomes		
Endoplasmic reticulum		
Golgi apparatus		
Mitochondria		
Plasma membrane		
Cytoskeleton		
Peroxisomes		

2. BODY TISSUES AND LOCOMOTOR SYSTEM

2.1 Epithelial tissues

Objectives

At the end of the practical session, the student should be able to

1. Identify different types of epithelia under the light microscope
2. Outline the structure of each epithelium
3. List sites in which each type of epithelium is found
4. Relate the structural characteristics of each epithelium to its functions

Introduction

A layer or sheet of cells that covers a surface or lines a cavity is known of an epithelium. The creation of a protective layer, absorption of water and solutes, secretion and excretion are some of the functions of epithelia. Epithelia is classified using two criteria in most cases. They are the cell shapes and cell layers that are accommodated.

Epithelial cells can be squamous, cuboidal, or columnar in form. A single cell layer thickness characterizes simple epithelium, while two or more cell layer thickness characterizes stratified epithelium. Pseudostratified epithelium is a form of epithelium that looks to be stratified but is actually one cell layer epithelium. The form of the cells on the free surface of stratified epithelia determines whether they are squamous or cuboidal. Transitional epithelium is a sort of stratified epithelium that is distinct from the rest.

2.1.1 Classify epithelial tissues according to cell shapes and number of cell layers by using a flowchart

2.1.2 Outline the microscopic view of simple squamous epithelium

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2.1.3 Draw a labeled line diagram of the microscopic view of simple squamous epithelium provided

2.1.4 Give four sites in which simple squamous epithelium is found

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2.1.5 Correlate the structure with the function of simple squamous epithelium

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2.1.6 Outline the microscopic view of simple cuboidal epithelium

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2.1.7 Draw a labeled line diagram of the microscopic view of simple cuboidal epithelium provided

2.1.8 Give four sites in which simple cuboidal epithelium is found

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2.1.9 Correlate the structure with the function of simple cuboidal epithelium

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2.1.10 Outline the microscopic view of simple columnar epithelium

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2.1.11 Draw a labeled line drawing of the microscopic view of simple columnar epithelium provided

2.1.12 Give four sites in which simple columnar epithelium is found

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2.1.13 Correlate the structure with the function of simple columnar epithelium

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2.1.14 Outline the microscopic view of simple ciliated columnar epithelium

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2.1.15 Draw a labeled line diagram of the microscopic view of simple ciliated columnar epithelium provided

2.1.16 Give three sites in which simple ciliated columnar epithelium is found

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2.1.17 Correlate the structure with the function of simple ciliated columnar epithelium

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2.1.18 Outline the microscopic view of pseudostratified ciliated columnar epithelium

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2.1.19 Draw a labeled line diagram of the microscopic view of pseudostratified ciliated columnar epithelium provided

2.1.20 Give four sites in which pseudostratified ciliated columnar epithelium is found

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2.1.21 Correlate the structure with the function of pseudostratified ciliated columnar epithelium

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2.1.22 Outline the microscopic view of stratified squamous epithelium (keratinized/non keratinized)

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2.1.23 Draw a labeled line diagram of the microscopic view of stratified squamous epithelium (keratinized/non keratinized) provided

2.1.24 Give four sites in which stratified squamous epithelium (keratinized/non keratinized) is found

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2.1.25 Correlate the structure with the function of stratified squamous epithelium (keratinized/non keratinized)

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2.1.26 Outline the microscopic view of stratified cuboidal epithelium

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2.1.27 Draw a labeled line diagram of the microscopic view of stratified cuboidal epithelium provided

2.1.28 Give two sites in which the stratified cuboidal epithelium is found

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2.1.29 Correlate the structure with the function of stratified cuboidal epithelium

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2.1.30 Outline the microscopic view of transitional epithelium

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2.1.31 Draw a labeled line diagram of the microscopic view of transitional epithelium provided

2.1.32 Give three sites in which transitional epithelium is found

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2.1.33 Correlate the structure with the function of transitional epithelium

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2.1.34 Review of epithelium: major types and locations

Type of epithelium	Sub-classification	Sites	Functions
Squamous	Simple		
	Stratified keratinized		
	Stratified non-keratinized		
Cuboidal	Simple		
	Stratified		
Columnar	Simple		
	Simple ciliated		
	Pseudostratified ciliated		
Transitional			

2. BODY TISSUES AND LOCOMOTOR SYSTEM

2.2 Glandular tissues

Objectives

At the end of the practical session, the student should be able to

1. State the histological differences of endocrine and exocrine glands
2. Identify and describe the structural characteristics of unicellular glands
3. Identify different types of exocrine glands under light microscope
4. Classify exocrine glands with reference to shape of secretory units and nature of the duct system

Introduction

Glandular tissue is a type of epithelium that creates glands by folding epithelium and growing into the connective tissue beneath it. Glands are divided into two major categories. They are exocrine and endocrine glands. The product of endocrine glands is secreted into the extracellular area, where it quickly transports into circulatory system. There is no excretory duct system. Exocrine glands discharge their contents into a duct, which subsequently transports them to lumen of a organ or the epithelial free surface.

The secretory component of an exocrine gland is separated from the duct system. It is possible for the duct system to be branched or unbranched. Secretory components can be tubular or acinar types. Coiled or branching secretory components are also possible. This practical session discusses the detailed histology of glandular tissues.

2.2.1 State the structural differences between exocrine glands and endocrine glands

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2.2.2 Using a flow chart classify exocrine glands based on the shape of secretory units and pattern of duct system (branching/ non-branching)

2.2.3 Outline the structure of a unicellular gland

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2.2.4 Draw a labeled line diagram of the microscopic view of an unicellular gland provided

2.2.5 Give four sites in which unicellular glands are found

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2.2.6 Correlate the structure of the unicellular gland with its function

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2.2.7 Outline the microscopic view of a simple alveolar gland

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2.2.8 Draw a labeled line diagram of the microscopic view of simple alveolar gland (mucus glands of the penile urethra) provided

2.2.9 Give a site in which simple alveolar glands are found

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2.2.10 Outline the microscopic view of simple tubular gland

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2.2.11 Draw a labeled line diagram of the microscopic view of simple tubular glands (large intestine) provided

2.2.12 Give two sites in which simple tubular glands are found

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2.2.13 Outline the microscopic view of simple coiled gland

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2.2.14 Draw a labeled line diagram of the microscopic view of simple coiled gland (sweat glands of skin) provided

2.2.15 Give two body sites in which sweat glands are predominantly found

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2.2.16 Outline the microscopic view of simple branched alveolar glands

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2.2.17 Draw a labeled line diagram of the microscopic view of simple branched alveolar gland (sebaceous glands) provided

2.218 Give two places in which simple branched alveolar glands are predominantly found.

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2.2.19 Outline the microscopic view of simple branched tubular gland

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2.2.20 Draw a labeled line diagram of the microscopic view of simple branched tubular glands (gastric glands) provided

2.2.21 Give two sites in which simple branched tubular glands are found

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2.2.22 Outline the microscopic view of compound branched alveolar glands

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2.2.23 Draw a labeled line diagram of the microscopic view of compound branched alveolar glands (pancreas) provided

2.2.24 Give a site in which compound branched alveolar glands are found

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2.2.25 Outline the microscopic view of compound branched tubular glands

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2.2.26 Draw a labeled line diagram of the microscopic view of compound branched tubular glands (Burner's glands) provided

2.2.27 Give a site in which compound branched tubular glands are found

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2.2.28 Outline the microscopic view of compound branched tubular alveolar glands

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2.2.29 Draw a labeled line diagram of the microscopic view of compound branched tubular alveolar glands (submandibular salivary gland) provided

2.2.30 Give a site in which compound branched tubular alveolar glands are found

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2.2.31 Review of exocrine glands: major types and locations

Type of exocrine glands	**Sub-classification**	**Sites**	**Functions**
Unicellular			
Tubular	Simple		
	Simple branched		
	Compound branched		
Coiled			
Acinar	Simple		
	Simple branched		
	Compound branched		
Tubular Acinar	Compound		

2. BODY TISSUES AND LOCOMOTOR SYSTEM

2.3 Connective tissues

Objectives

At the end of the practical session, the student should be able to

1. Identify and describe different cells and fibers found in the connective tissues
2. Identify different types of connective tissues under light microscope
3. List the places in which each type of connective tissue is found in human body
4. State the structural adaptations of each connective tissue

Introduction

Connective and supportive tissues have evolved to provide structural and functional support to other functional tissues and are organized as adjacent to them. The morphogenesis of structures, organs, and organ systems is aided by these tissues. Connective tissues have three general characteristics. They are highly vascularized. They recover quickly from damage and they contain more non-cellular material. The extracellular matrix is the non-cellular component of connective tissue and it is made up of matrix fibers and ground substances.

Collagen and elastin are extracellular matrix fibers that give the tissue to its tensile strength and elasticity respectively. Fibroblasts, myofibroblasts, adipocytes, defense cells such as macrophages, mast cells, and various lymphocytes are the main types of cells present in the connective tissue. Fibroblasts create matrix chemicals and fibers, macrophages scavenge the tissue as an immune cell, and mast cells release heparin and histamine in response to stress. This practical session discusses the detailed histology of connective tissues.

2.3.1 Outline the microscopic view of loose connective tissue

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2.3.3 Draw a labelled line diagram of the microscopic view of loose connective tissue provided

2.3.4 Give two sites in which loose connective tissues are found

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2.3.5 Correlate the structure of loose connective tissue with its function

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2.3.6 Outline the microscopic view of dense regular connective tissue

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2.3.7 Draw a labelled line diagram of the microscopic view of dense regular connective tissue (capsule of the testis) provided

2.3.8 Give three sites in which dense regular connective tissues are found

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2.3.9 Correlate the structure of dense regular connective tissue with its function

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2.3.10 Outline the microscopic view of dense irregular connective tissue

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2.3.11 Draw a labelled line diagram of the microscopic view of dense irregular connective tissue (dermis of the skin) provided

2.3.12 Give two sites in which dense irregular connective tissues are found

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2.3.13 Correlate the structure of dense irregular connective tissue with its function

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2.3.14 Outline the microscopic view of white adipose tissue

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2.3.15 Draw a labelled line diagram of the microscopic view of white adipose tissue (hypodermis) provided

2.3.16 Give four sites in which white adipose tissues are found

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2.3.17 Correlate the structure of white adipose tissue with its function

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2.3.18 Outline the microscopic view of brown adipose tissue

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2.3.19 Draw a labelled line diagram of the microscopic view of brown adipose tissue provided

2.3.20 Give two sites in which brown adipose tissues are found

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2.3.21 Outline the structures of different fiber types found in connective tissue

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2.3.22 Draw labelled line diagrams of different fiber types found in connective tissues provided

2.3.23 Outline the structures of different cells found in the connective tissue and their structural adaptations

2.3.24 Draw labelled line diagrams of different cell types found in connective tissues provided

2.3.25 Review of connective tissues

Category	Component/nature	Different types	Characteristics features	Functions
Matrix fibres	Collagen fibres			
	Elastin fibres			
Ground substances	Glycosaminoglycans (GAGs)	Hyaluronte; proteoglycan		
	Structural glycoproteins	Fibronectin		
Basement membrane	Interface of cells with connective tissue	.		
Cells	Mesenchyme	Mesenchymal cells		
	Fibroblasts	Fibroblast		
		Myofibroblast		
	Adipocytes	White adipose		
		Brown adipose		
	Haematopoietic stem cell–derived	Mast cells		
		Tissue macrophages		
		Lymphocytes, eosinophils, neutrophils, plasma cells		

2. BODY TISSUES AND LOCOMOTOR SYSTEM

2.4 Skeletal tissues

Objectives

At the end of the practical session, the student should be able to

1. Outline the microscopic structure of hyaline cartilage, fibrocartilage and elastic cartilage
2. List the places where each type of cartilage is found in human body
3. Identify different types of cartilages over the light microscope
4. Identify different types of bone (woven bone, lamellar bone, cortical bone and cancellous bone etc.) under the light microscope
5. Outline the microscopic structure of different types of bone provided

Introduction

Cartilage

Cartilage is a type of tough, flexible connective tissue that provides support. Cartilage is avascular, unlike bone and all other types of connective tissue. Chondroitin sulfate is a gelatinous ground substance found in the cartilage. Collagen and elastin fibers are embedded into the ground substance. These elements work together to create a matrix that is both flexible and resistant to compression pressures. As a result, cartilage can be found in a various location in the body where support, flexibility, and compression resistance are required. Hyaline, elastic, and fibrocartilage are the three types of cartilage.

Bone

Bone is a supporting tissue that is strong, flexible, and semi-rigid. It has the ability to tolerate compression forces and bend. Bone is made up of cells and extracellular matrix, just like cartilage and other types of connective tissue. Osteoblasts, osteocytes, osteo-progenitor cells, and osteoclasts are the cells that make up the bone.

Proteoglycans, glycosaminoglycans, glycoproteins, osteonectin, and osteocalcin are all found in the extracellular matrix, which is made up of 30% organic matter. Collagen fibres are primarily type I (90 percent), with certain other forms like type V. Only 25% of bone is made up of water. Hydroxyapatite, a bone mineral, accounts for over 70% of bone mass. This session discusses the histology of bone and cartilage in detail.

2.4.1 Outline the microscopic view of hyaline cartilage and correlate its structure with the function

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2.4.2 Draw a labelled line diagram of the microscopic view of hyaline cartilage provided

2.4.3 Give three sites in which hyaline cartilage is found in the human body

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2.4.4 Outline the microscopic view of elastic cartilage and correlate its structure with the function

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2.4.5 Draw a labelled line diagram of the microscopic view of elastic cartilage provided

2.4.6 Give three sites in which elastic cartilage is found in the human body

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2.4.7 Outline the microscopic view of fibrous cartilage and correlate its structure with the function

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2.4.8 Draw a labelled line diagram of the microscopic view of fibrous cartilage provided

2.4.9 Give three sites in which fibrous cartilage is found in the human body

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2.4.10 Outline the microscopic structure of intervertebral disc

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2.4.11 Draw a labelled line diagram of the microscopic view (CS) of intervertebral disc

2.4.12 Outline the microscopic view of compact bone and correlate its structure with the function

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2.4.13 Draw a labelled line diagram of the microscopic view of compact bone (LS and TS)

2.4.14 Give three sites in which compact bones are found in the human body

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2.4.15 Outline the microscopic view of spongy bone

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2.4.16 Draw a labelled line diagram of the microscopic view of spongy bone provided

2.4.17 Give three sites in which the spongy bones are found in the human body

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2.4.18 Outline the microscopic view of woven bone

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2.4.19 Draw a labelled line diagram of the microscopic view of woven bone provided

2.4.20 Outline the microscopic structure of epiphyseal plate

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2.4.21 Draw a labelled line diagram of the microscopic view of epiphyseal plate provided

2.4.22 Compare and contrast the histology of hyaline cartilage, elastic cartilage and fibrous cartilage.

Type of cartilage	Components	Distinctive structural feature	Functions
Hyaline cartilage	Ground substances		
	Fibers		
	Cellular component		
Elastic cartilage	Ground substances		
	Fibers		
	Cellular component		
Fibrous cartilage	Ground substances		
	Fibers		
	Cellular component		

2.4.23 Compare and contrast the microscopic structure of compact and spongy bone

Key features	Compact bone	Spongy bone

2. BODY TISSUES AND LOCOMOTOR SYSTEM

2.5 Muscular tissues

Objectives

At the end of the practical session, the student should be able to

1. Identify the structural characteristics of skeletal, cardiac and smooth muscles under the light microscope
2. Outline the microscopic structure of each type.
3. Identify the motor end plate under the light microscope
4. Outline the molecular arrangement of sarcomere

Introduction

Muscle tissue is adapted for contractions. They are made up of elongated muscle cells that are organized parallel to the contraction direction. A cell, often known as a muscle fiber, is the basic unit of muscular tissue. In contrast to a connective tissue fiber, which is non-cellular, and a nerve fiber, which is a cell process, the term "fiber" is employed here. The endomysium is a basal lamina that surrounds every muscle fiber. The sarcolemma is the name given to the plasma membrane of a muscle fiber and sarcoplasm is the name given to its cytoplasm. The myofilaments are cytoplasmic contractile components found within the sarcoplasm.

Smooth, skeletal, and cardiac muscles are characterized structurally and functionally. Because of the organization of myofilaments, skeletal and cardiac muscle fibers exhibit a distinctive striated appearance. Smooth muscle fibers have non-striated cells because the myofilaments are not aligned in a regular pattern. This practical session discusses the detailed histology of skeletal, cardiac and smooth muscles.

2.5.1 Outline the microscopic view of a skeletal muscle tissue and correlate its structure with the function

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2.5.2 Draw a labelled line diagram of the microscopic view of skeletal muscle tissue (LS) provided

2.5.3 Outline the microscopic structure of cardiac muscle tissue and correlate its structure with the function

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2.5.4 Draw a labelled line diagram of the microscopic view of cardiac muscle tissue (LS)

2.5.5 Outline the microscopic structure of smooth muscle tissue

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2.5.6 Draw a labelled line diagram of the microscopic view of smooth muscle tissue (LS)

2.5.7 Outline the microscopic structure of a skeletal muscle (TS)

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2.5.8 Draw a labelled line diagram of the microscopic view of a skeletal muscle (TS)

2.5.9 Draw a labelled line diagram of the microscopic view of a skeletal muscle fiber (LS)

2.5.10 Outline the structural organization of a sarcomere

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2.5.11 Draw a labelled line diagram of the microscopic view of a sarcomere (LS)

2.5.12 Outline the structural arrangement of a motor end plate

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2.5.13 Draw a labeled line diagram of the microscopic view of a motor end plate

2.5.13 Review of muscles

Type	Key features	Functions	Locations
Skeletal muscle			
Cardiac muscle			
Smooth muscle			

2.5.13 Outline the structural changes of muscles in following pathological conditions

Muscle atrophy

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Muscle dystrophy

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Muscle hypertrophy

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Muscle hyperplasia

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2. BODY TISSUES AND LOCOMOTOR SYSTEM

2.6 Nervous tissues

Objectives

At the end of the practical session, the student should be able to

1. Describe the ultra-structure of a neuron.
2. Identify different types of neurons present in nervous tissues.
3. Identify different types of supportive cells present in nervous tissues.
4. Identify synapse and motor end plate under low power, mid power and high power.
5. Outline the structure of a peripheral nerve.

Introduction

Nervous tissue is one of four major tissues and it makes up the central nervous system and the peripheral nervous system. The two main roles of nerve tissue are integration and communication. Neurons and neuroglia are the two main types of cells found in nervous tissue. Neurons are specialized cells that generate and conduct nerve impulses. Neuroglia are supporting cells that help with physical activity, debris removal, and electrical insulation. This practical session discusses the detailed histology of nervous tissues.

2.6.1 Outline the ultrastructure of a nerve cell and correlate its structure with the function

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2.6.2 Draw a labelled line diagram of the microscopic view of a nerve cell

2.6.3 Outline the structure of a myelinated nerve fiber

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2.6.4 Draw a labelled line diagram of the microscopic view of a myelinated nerve fiber (CS and LS)

2.6.5 Outline the ultrastructure of a synapse

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2.6.6 Draw a labelled line diagram of the microscopic view of a synapse (LS)

2.6.7 Outline the structure of a peripheral nerve

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2.6.8 Draw a labelled line diagram of the microscopic view of a peripheral nerve (TS)

2.6.9 Outline the structure of following glial cell types found in the central nervous system and peripheral nervous system

Astrocytes

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Oligodendrocytes

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Ependymal cells

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Microglia

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Satellite cells

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Schwann cells

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2.6.10 Draw labelled line diagrams of the microscopic view of each glial cell type found in the central nervous system and the peripheral nervous system

Astrocytes

Oligodendrocytes

Ependymal cells

Microglia

Satellite cells

Schwann cells

2.6.9 Outline the microscopic structure of following sensory receptors

Neuromuscular spindle

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Meissner corpuscle

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Merkel cells

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Ruffini corpuscles

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Pacinian corpuscles

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Free nerve endings

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2.6.10 Draw labelled line diagrams of the microscopic view of the following sensory receptors

Neuromuscular spindle

Meissner corpuscle

Merkel cells

Pacinian corpuscles

Free nerve endings

2.6.11 Review of nervous tissues

Category/item	**Sub category**	**Structural features**	**Functions**
Neuron	Cell body		
	Dendrites		
	Axons		
Schwann cells and oligodendrocyte	Myelination		
	Non-myelinated		
	Synapses		
Peripheral nerves	Neuronal processes		
Sensory receptors	Free nerve endings		
	Meissner corpuscles		
	Merkel cell		
	Neuromuscular spindles		
	Pacinian corpuscles		
Neuroglia cells	Astrocytes		
	Oligodendrocytes		
	Microglia		
	Ependymal cells		
	Satellite cells		
	Schwann cells		

2. BODY TISSUES AND LOCOMOTOR SYSTEM

2.7 Integumentary system

Objectives

At the end of the practical session, the student should be able to

1. Outline the microscopic structure of skin.
2. Identify different regions of skin and specific structures in each region under light microscope
3. Identify skin appendages under light microscope
4. Identify differences of skin tissues in different regions of human body under light microscope

Introduction

The skin is made up of three layers of tissue, the epidermis, dermis, and hypodermis. The epidermis is a constantly proliferating stratified squamous epithelium that creates a non-living keratin surface layer with accompanying lipid that is in direct contact with the external environment and is constantly lost. The dermis is made up of fibrous and fibro-adipose tissue that physically and metabolically supports the epidermis. It also consists of blood vessels, nerves, and sensory receptors. The subcutis, also known as the hypodermis, is the layer beneath the dermis and is made up mostly of adipose tissue with fibrous septa for support. The larger blood vessels that supply and drain the dermal blood vasculature are found in this stratum. This practical session discusses the detailed histology of skin.

2.7.1 Outline the microscopic structure of epidermis and correlate its structure with the function

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2.7.2 Draw a labelled line diagram of the microscopic view of epidermis

2.7.3 Outline the structure of following epidermal appendages and correlate the structure with the function.

Hair follicle and hair

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Sweat glands

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Sebaceous glands

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Nails

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2.7.4 Draw labelled line diagrams of the microscopic view of following epidermal appendages.

Hair follicle and hair

Sweat glands

Sebaceous glands

2.7.5 Outline the microscopic structure of dermis and sub-cutis of the skin

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2.7.6 Draw labelled line diagrams of the microscopic view of dermis and sub-cutis of the skin

2.7.7 Outline the microscopic structure of thin skin

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2.7.8 Draw a labelled line diagram of the microscopic view of thin skin

2.7.9 Outline the microscopic structure of thick skin

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2.7.10 Draw a labeled line diagram of microscopic view of thick skin

2.7.11 Outline the microscopic structure of skin of scalp, sole, palm, labia majora and vulva

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Skin of sole

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Skin of palm

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Skin of labia majora and vulva

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2.7.12 Draw labelled line diagrams of the microscopic view of skin of scalp, sole, palm, labia majora and vulva provided

Skin of scalp

Skin of sole

Skin of palm

Skin of labia majora and vulva

2.7.13 Review of skin

Major structures	**Main structures**	**Distinct structural features**	**Functions**
Epidermis	Keratin layer		
	Granular cell layer		
	Prickle cell layer		
	Basal cell layer		
Dermis	Papillary dermis		
	Reticular dermis		
Adnexae	Pilosebaceous units Hair follicle Sebaceous gland Arrector pili muscles		
	Eccrine glands		
	Apocrine glands		
	Nails		
Subcutis	Adipose tissue		
	Fibrous tissue septae		

3. BLOOD AND IMMUNE SYSTEM

3.1 Red blood cells, white blood cells and platelets

Objectives

At the end of the practical session, the student should be able to

1. Illustrate the procedure in preparation of thick and thin blood film
2. Identify different blood cells present in thin and thick blood films
3. Outline the normal morphology of each blood cell
4. Identify different cell morphologies found in different stages of erythropoiesis
5. Describe abnormal morphologies of red blood cells found in selected pathological conditions

Introduction

Blood is regarded as a type of connective tissue. Red blood cells (RBCs), white blood cells (WBCs), and platelets make up the cellular element of blood. The most abundant cells in the blood are RBCs, commonly known as erythrocytes. RBCs are responsible for the red color of blood. RBCs make up about 40 to 45 percent of blood volume.

WBCs, also known as leukocytes, are immune cells that aid in the protection against infection. WBCs are divided into five categories namely neutrophils, eosinophils, basophils, lymphocytes, and monocytes. Granulocytes include neutrophils, eosinophils, and basophils, which include granules in their cells that contain digesting enzymes. Agranulocytes are lymphocytes and monocytes that lack granules in their cytoplasm.

Megakaryocytes, which are very massive cells that break up into fragments, produce platelets in the bone marrow. They lack a nucleus and have a large number of granules. This practical session discusses the detailed histology of blood cells.

3.1.1 Illustrate the procedure in preparation of a thin blood film by using a flow chart and give its uses

3.1.2 Illustrate the procedure in preparation of a thick blood film by using a flow chart and give its uses

3.1.3 Draw labelled line diagrams of different cells present in a thin blood film

3.1.4 Outline the structure of each immature erythrocyte present in the different stages of erythropoiesis

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3.1.5 Draw labelled line diagrams of immature erythrocyte present in the different stages erythropoiesis

3.1.6 Outline the structure of a reticulocyte

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3.1.7 Draw a line diagram of a reticulocyte

3.1.8 Outline the structure of a RBC and relate its structure to its function

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3.1.9 Draw a line diagram of a RBC

3.1.10 Outline different cell morphologies of RBCs found in the pathological slides provided

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3.1.11 Draw line diagrams of the morphologies of different sized RBCs found in the pathological slides provided

3.1.12 Draw line diagrams of the morphologies of different shapes of RBCs found in pathological slides provided

3.1.13 Outline the structural characteristics of granulocytes

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3.1.14 Outline the structural characteristics of agranulocytes

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3.1.15 Outline the structure of a neutrophil

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3.1.16 Draw a line diagram of a neutrophil

3.1.17 Outline the structure of an eosinophil

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3.1.18 Draw a line diagram of an eosinophil

3.1.19 Outline the structure of a basophil

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3.1.20 Draw a line diagram of a basophil

3.1.21 Outline the structure of a lymphocyte

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3.1.22 Draw a line diagram of a lymphocyte

3.1.23 Outline the structure of monocytes

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3.1.24 Draw a line diagram of a monocyte

3.1.25 Outline the structure of a platelet

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3.1.26 Draw a line diagram of a platelet (EM view)

3.1.27 Review of blood cell structure and functions

Cell type	**Distinctive structural features**	**Functions**
Red blood cells		
Neutrophils		
Eosinophils		
Basophils		
Monocytes		
Lymphocytes		
Platelets		

3. BLOOD AND IMMUNE SYSTEM

3.2 Lymphoid organs

Objectives

At the end of the practical session, the student should be able to

1. List primary and secondary lymphoid tissues
2. Identify different lymphoid tissues under light microscope
3. Outline the microscopic structure of primary lymphoid tissue: - thymus
4. Outline the microscopic structure of secondary lymphoid tissues:- lymph nodes, palatine tonsils, payer's patches and spleen

Introduction

Lymphoid tissue contains a variety of structural arrangements that are connected to its role in the immune response. Lymphoid organs are divided into two major categories. Primary lymphoid organs where the lymphocytes are formed and matured. The red bone marrow and the thymus are the two primary lymphoid organs. Lymphocytes are stimulated in secondary lymphoid tissues. Lymph nodes, tonsils, spleen, payer's patches, and mucosa associated lymphoid tissue are among them (MALT) are the secondary lymphoid organs.

The most highly organized lymphoid tissues are the thymus and lymph nodes, which are well-defined encapsulated organs with easily identifiable architectures. The bone marrow is not an organized lymphoid tissue and its stroma is filled with the blood-forming cells. The most diffuse lymphoid tissue is found in the loose connective-tissue spaces beneath most wet epithelial membranes, such as those that line the gastrointestinal tract and the respiratory system.

The lymphoid system has a variety of cell types. Reticulocytes and white blood cells like macrophages and lymphocytes are among them. Reticular cells provide structural support, since they produce and maintain the thin networks of fibres that are a framework for most lymphoid organs. Macrophages help eliminate invaders by engulfing foreign materials and initiating the immune response. This practical session discusses the detailed histology of lymphoid organs.

3.2.1 Outline the microscopic structure of thymus

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3.2.2 Draw a labelled line diagram of the microscopic view of thymus

3.2.3 Outline the microscopic structure of a lymph node

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3.2.4 Draw a line diagram of the microscopic view of a lymph node

3.2.5 Outline the microscopic structure of spleen

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3.2.6 Draw a labelled line diagram of the microscopic view of spleen

3.2.7 Outline the microscopic structure of mucosa associated lymphoid tissue (MALT)

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3.2.8 Draw labelled line diagrams of the microscopic view of MALT provided

3.2.9 Outline the microscopic structure of a palatine tonsil

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3.2.10 Draw a labelled line diagram of the microscopic view of a palatine tonsil

3.2.11 Review of the immune system

Organ/tissue	**Basic structural components**	**Component functions**
Bone marrow	Red marrow	
	Yellow marrow	
Thymus	Cortex	
	Medulla	
Lymph node	Cortex	
	Para cortex	
	Medulla	
Mucosal associated lymphoid tissue (MALT)	Bronchial-associated lymphoid tissue (BALT)	
	Gut-associated lymphoid tissue (GALT)	
	Tonsils	
Spleen	White pulp	
	Red pulp	

4. CARDIOVASCULAR SYSTEM

4.1 Heart and blood vessels

Objectives

At the end of the practical session, the student should be able to

1. Identify tissue layers in cardiac wall under the light microscope
2. Outline the organization of tissue layers in cardiac wall
3. Outline the organization of tissue layers in a typical blood vessel wall
4. Identify large arteries, muscular arteries, arterioles, capillaries, venules, small to medium veins and large veins under the light microscope
5. Outline the microscopic anatomy of each blood vessel

Introduction

Cardiac muscles, specialized conducting tissues, valves, blood vessels, and connective tissue make up the heart. Endocardium, myocardium, and epicardium are the three sublayers of the cardiac wall. Simple squamous epithelium lines the endocardium, which is the innermost layer of the heart. The cardiac muscle makes up the myocardium. The epicardium is the heart's outermost layer.

Blood vessels are composed of endothelial cells, smooth muscle cells and extracellular matrix composed of collagen and elastin. These are organized into three tunicae which are organized as concentric layers. From the lumen to the edge of the vessel, they are tunica intima, tunica media, and tunica adventitia. The intima is the thinnest and innermost layer that abuts the vascular lumen. A single layer of endothelial cells and a little quantity of sub-endothelial connective tissue make up this layer. The media is the thickest layer, sandwiched between the intima and adventitia. Smooth muscle cells and connective tissue make up this layer which varies in quantity according to the type of vessel.

4.1.1 Outline the microscopic structure of cardiac wall

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4.1.2 Draw a labelled line diagram of the microscopic view of cardiac wall (CS)

4.1.3 Outline the microscopic view of myocardium and relate its structure to function

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4.1.4 Draw a labelled line diagram of the microscopic view of myocardium

4.1.5 Outline the structure of cardiac muscles found in the conducting system and correlate its structure to function

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4.1.6 Draw a labelled line diagram of the microscopic view of cardiac muscles found in the conducting system

4.1.6 Outline the microscopic structure of aorta and correlate its structure to the function

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4.1.7 Draw a labelled line diagram of the microscopic view of the wall of aorta (CS)

4.1.8 Outline the microscopic structure of a muscular artery and correlate its structure to function

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4.1.9 Draw a labelled line diagram of the microscopic view of a muscular artery (CS)

4.1.10 Outline the microscopic structure of an arteriole and correlate its structure to the function

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4.1.11 Draw a labelled line diagram of the microscopic view of an arteriole (CS)

4.1.12 Outline the microscopic structure of a capillary and correlate its structure to the function

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4.1.13 Draw a labelled line diagram of the microscopic view of a capillary (CS/LS)

4.1.14 Identify the different types of capillaries found in the human body and correlate its structure to the function

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4.1.15 Draw a labelled line diagrams of the microscopic view of different types of capillaries found in the microscopic slides provided.

4.1.16 Outline the microscopic structure of post-capillary, collecting and muscular venules and correlate its structure to the function

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4.1.17 Draw a labelled line diagrams of the microscopic view of a post-capillary, a collecting and muscular venules (CS)

4.1.18 Outline the microscopic structure of a medium-sized vein

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4.1.19 Draw a labeled line diagram of the microscopic view of a medium-sized vein (CS)

4.1.20 Outline the microscopic structure of a large muscular vein and correlate its structure to the function

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4.1.21 Draw a labelled line diagram of the microscopic view of a large muscular vein (CS)

4.1.22 Outline the microscopic view of inferior vena cava and correlate its structure to the function

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4.1.23 Draw a labeled line diagram of the microscopic view of inferior vena cava (CS)

4.1.24 Review of the circulatory system

Structure	Key components	Key features	Functions
Heart	Endocardium		
	Myocardium		
	Epicardium		
Blood vessels	Aorta		
	Muscular artery		
	Arterioles		
	Capillaries		
	Post-capillary venules		
	Muscular venules		
	Medium size vein		
	Muscular vein		
	Vena cava		

5. RESPIRATORY SYSTEM

5.1 Airway and lungs

Objectives

At the end of the practical session, the student should be able to

1. Identify the lining epithelial of different parts of the airway under light microscope
2. Identify the structural characteristics of muco-cilliary escalator under light microscope
3. Identify the organ tissues of different parts of upper and lower airway under light microscope
4. Outline the ultrastructure of alveolar capillary membrane

Introduction

The respiratory system comprises of a series of specific organs involving in air conduction and gaseous exchange. The nasal cavity, pharynx, larynx, principal bronchi, secondary bronchi, tertiary bronchi, segmental bronchi, bronchioles are in the conducting zone of the airway. The respiratory bronchioles, alveolar ducts and alveoli are in the respiratory zone. The primary organs of the respiratory system are lungs, which are responsible for inhaling oxygen and expelling carbon dioxide. This system also involves in some other functions like olfaction, phonation and defense. The respiratory epithelium changes in the bronchial tree and lung parenchyma in relation to its function. The muco-cilliary escalator also serves as a major component of body's innate immunity system. Alveolar capillary membrane is structurally adapted to gaseous exchange. This practical session discusses the detailed histology of organ tissues in the airway.

5.1.1 Outline the structure of the typical respiratory epithelium and correlate its structure with the function

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5.1.2 Draw a labelled line diagram of the typical respiratory epithelium

5.1.3 Outline the microscopic structure of nasal cavity and naso-pharynx

Nasal cavity

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Naso-pharynx

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5.1.4 Draw labelled line diagrams of the microscopic view of nasal cavity and naso-pharynx

5.1.5 Outline the microscopic structure of larynx

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5.1.6 Draw a labelled line diagram of the microscopic view of larynx provided

5.1.7 Outline the microscopic view of a trachea

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5.1.8 Draw a labelled line diagram of the microscopic view of trachea (CS)

5.1.9 Outline the components of muco-cilliary escalator and correlate the structure with the function

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5.1.10 Outline the microscopic structure of primary bronchi, secondary brochi and tertiary bronchi

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5.1.11 Draw labelled line diagrams of the microscopic view of primary bronchi, secondary bronchi and tertiary bronchi (LS/CS)

5.1.12 Outline the microscopic structure of terminal bronchioles and respiratory bronchioles

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5.1.13 Draw labelled line diagrams of the microscopic view of terminal bronchioles and respiratory bronchioles (LS/CS)

5.1.14 Outline the microscopic structure of alveoli

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5.1.15 Draw a labelled line diagram of the microscopic view of the alveoli

5.1.16 Outline the ultrastructure of alveolar capillary membrane and correlate its structure with the function

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5.1.17 Draw a labelled line diagram of the alveolar capillary membrane

5.1.15 Review of the respiratory system

Structure	Key features	Functions
Nasal cavity		
Naso-pharynx		
Larynx		
Trachea		
Primary bronchus		
Lobar bronchus		
Terminal bronchioles		
Respiratory bronchioles		
Lung parenchyma		
Alveolar capillary membrane		
Pleura		

6. GASTROINTESTINAL SYSTEM AND HEPATOBILLIARY SYSTEM

6.1 Digestive tract

Objectives

At the end of the practical session, the student should be able to

1. Outline the typical organization of four concentric tissue layers in the digestive tract
2. Identify different organ tissues of the digestive tract under the light microscope
3. Identify the differences in lining epithelium of the different part of the digestive tract
4. Identify transition of lining epithelium at cardio-oesophageal junction, gastro-duodenal junction, ileo-ceacal junction and recto-anal junction under light microscope

Introduction

The digestive system consists of oral cavity, pharynx, oesophagus, stomach, small intestine, large intestine, anal canal and anus. Organs of the digestive tract typically have four concentric tissue layers. Proceeding outward from the lumen these are: the mucosa (mucous membrane), the submucosa, the muscularis propria (muscularis externa), and the adventitia or serosa. The mucosa has three components: the epithelium and its underlying basement membrane, a thin underlying layer of loose connective tissue, the lamina propria, and a relatively thin layer of smooth muscle called the muscularis mucosae. The muscularis mucosa consists of both circular and longitudinally arranged layers. The submucosa is composed of a layer of dense, irregularly arranged connective tissue that contains nervous tissue (the submucosal plexus of Meissner) as well as blood vessels. The muscularis externa consists of at least two layers of smooth muscle, an inner circular and outer longitudinal layers of smooth muscles. Connective tissue separating the muscle layers contains nerves (myenteric plexus of Auerbach) and blood vessels. The outermost layer or adventitia consists of a thin layer of loose connective tissue. Where the digestive system is covered by peritoneum the adventitial layer is called the serosa. This practical session discusses in detail about the histology of organs/tissues in the gastrointestinal tract.

6.1.1 Outline the microscopic structure of different areas of the oral cavity

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6.1.2 Draw labelled line diagrams of the microscopic view of different areas of the oral cavity (LS)

6.1.3 Outline the microscopic structure of tongue

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6.1.4 Draw a labelled line diagram of the microscopic view of tongue (LS)

6.1.5 Outline the microscopic structure of oropharynx

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6.1.6 Draw a labelled line diagram of the microscopic view of oropharynx (LS)

6.1.7 Outline the microscopic structure of oesophagus

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6.1.8 Draw a labelled line diagram of the microscopic view of oesophagus: upper, middle and lower parts (LS)

6.1.9 Outline the microscopic structure of cardio-oesophageal junction

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6.1.10 Draw a labelled line diagram of the microscopic view of a cardio-oesophageal junction (LS)

6.1.11 Outline the microscopic structure of stomach

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6.1.12 Draw a labelled line diagram of the microscopic view of stomach: cardiac, fundus, body and pyloric (LS)

6.1.13 Compare and contrast the microscopic structure of mucosa of cardia / fundus and body /pyloric part

Mucosa	cardiac part	fundus and body	pyloric part

6.1.14 Outline the microscopic structure of gastro-duodenal junction

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6.1.15 Draw a labelled line diagram of the microscopic view of gastro-duodenal junction (LS)

6.1.16 Outline the microscopic structure of duodenum

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6.1.17 Draw a labelled line diagram of the microscopic view of a duodenum (LS)

6.1.18 Outline the microscopic structure of jejunum

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6.1.19 Draw a labelled line diagram of the microscopic view of jejunum (LS)

6.1.20 Outline the microscopic structure of ilium

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6.1.21 Draw a labelled line diagram of the microscopic view of ilium (LS)

6.1.22 Outline the microscopic structure of ileo- ceacal junction

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6.1.23 Draw a labelled line diagram of the microscopic view of ileo- caecal junction (LS)

6.1.24 Outline the microscopic structure of appendix

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6.1.25 Draw a labelled line diagram of the microscopic view of appendix (LS/CS)

6.1.26 Outline the microscopic structure of colon

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6.1.27 Draw a labelled line diagram of the microscopic view of colon (LS)

6.1.28 Outline the microscopic structure of ano-rectal junction

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6.1.29 Draw a labelled line diagram of the microscopic view of ano-rectal junction (LS)

6.1.30 Outline the microscopic structure of anal canal

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6.1.31 Draw a labelled line diagram of the microscopic view of anal canal (LS)

6.1.34 Review of gastrointestinal tract

Part of the GIT	Type of epithelium	Main cell type of epithelium	Other distinctive features	Functions
Oesophagus				
Body/fundus of stomach				
Pylorus and cardia of stomach				
Duodenum				
Jejunum and ileum				
Large intestine				
Appendix				
Anus				

6. GASTROINTESTINAL SYSTEM AND HEPATOBILLIARY SYSTEM

6.2 Accessory organs in the digestive system

Objectives

At the end of the practical session, the student should be able to

1. Identify salivary glands under light microscope
2. Outline the microscopic structure of parotid, submandibular and sub lingual salivary glands
3. Identify organ tissues of liver, extra-hepatic biliary apparatus and pancreas under light microscope
4. Outline the microscopic structure of liver, extra-hepatic biliary apparatus and pancreas

Introduction

The main digestive tract is in charge for ingestion, digestion and absorbing nutrients from ingested foods. Its operations are aided by accessory digestive organs, which offer additional enzymes and lubricants to aid in further digestion of food and transport down the gastrointestinal tract. The salivary glands, liver, gallbladder, and extra-biliary system, as well as the pancreas, are accessory digestive organs that aid and support the digestive system.

Salivary glands are a type of compound glands. Acinar and tubules are the secretory units that they have. The majority of the duct system is branched. Liver is a large accessory organ in the gastrointestinal tract surrounded by a connective tissue capsule. The stroma is made up of reticulin fibers and liver parenchyma. Similar to the gastrointestinal tract, the gallbladder has four concentric tissue coatings. A simple columnar epithelium lines the innermost layer, which has a mucosal fold. Next layer is muscular coat comprising several layers of smooth muscles and serosa contains connective tissues along with lymphatics, blood vessels and nerve fibers. Pancreas contains of both exocrine and endocrine tissues. The secretory units and their duct systems are represented by the exocrine portion of the pancreas. This practical session discusses the detailed histology of accessary glands of the gastrointestinal tract.

6.2.1 Outline the microscopic structure of parotid salivary gland

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6.2.2 Draw a labelled line diagram of the microscopic view of parotid salivary gland

6.2.3 Outline the microscopic structure of sub-mandibular salivary gland

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6.2.4 Draw a labelled line diagram of the microscopic view of sub-mandibular salivary gland

6.2.5 Outline the microscopic structure of sub-lingual salivary gland

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6.2.6 Draw a labelled line diagram of the microscopic view of sub-lingual salivary gland

6.2.7 Outline the microscopic structure of a liver lobule

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6.2.8 Draw a labelled line diagram of the microscopic view of a liver lobule

6.2.9 Outline the microscopic structure of gall bladder and extra biliary system

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6.2.10 Draw labelled line diagrams of the histological view of gall bladder (LS) and a bile duct (CS)

6.2.11 Outline the microscopic structure of exocrine portion of pancreas

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6.2.12 Draw a labelled line diagram of the histological view of exocrine portion of the pancreas

6.2.13 Review of accessary glands in digestive tract

Structure	Key components and features	Functions
Liver lobule	Hepatocytes -	
	Portal triad -	
	Kupffer cells -	
	Bile canaliculi -	
	Architecture -	
Gall bladder and bile duct	Gall bladder -	
	Common bile duct -	
Pancreas	Exocrine component -	
Parotid gland		
Submandibular gland		
Sublingual gland		

7. RENAL AND URINARY SYSTEM

7.1 Kidney, ureter, urinary bladder and urethra

Objectives

At the end of the practical session, the student should be able to

1. Outline the ultrastructure of urothelium
2. Outline the histology of kidney, ureter and urinary bladder
3. Identify kidney, ureter, urinary bladder and urethra under light microscope
4. Identify each part of the nephron under light microscope
5. Outline the ultrastructure of a nephron

Introduction

The kidneys, ureters, urinary bladder, and urethra make up the urinary system. Urine generation, storage, and excretion are its primary functions. A renal corpuscle and a long folded renal tubule make up the functional and structural unit of the kidney, the nephron. Kidney architecture has a complicated histology. The kidney has a variety of functions and histological modifications.

The ureters are two muscular tubes that transport urine from the kidneys to the bladder via a small lumen. There are three layers in the wall of ureter. The fibrous coat, also known as the outer layer, is a connective tissue supporting layer made up of fibrous connective tissue. The inner circular and outer longitudinal smooth muscles make up the muscular coat, which makes up the intermediate layer. The mucosa, the inner layer, is a transitional epithelium.

The urinary bladder is a hollow muscular structure at the base of the pelvis that stores urine. Its wall is made up of three separate tissue layers. When the bladder is empty, the mucosa lined by the transitional epithelium displays mucosal folds. Detrusor muscles make up the middle layer, which is made up of smooth muscles. The bladder's outer covering is known as serosa. The urethra is a muscular tube that transports urine from the bladder to the urethral aperture on the outside. This practical session will go cover the histology of the renal and urinary systems in depth.

7.1.1 Outline the microscopic structure of kidney

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7.1.2 Draw a labelled line diagram of the histological view of a kidney (LS)

7.1.3 Outline the microscopic structure of renal cortex

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7.1.4 Draw a labelled line diagram of the histological view of renal cortex (LS)

7.1.5 Outline the ultra-structure of a nephron

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7.1.6 Draw a labelled line diagram of a nephron

7.1.7 Outline the microscopic structure of a renal corpuscle

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7.1.8 Draw a labelled line diagram of the microscopic view of a renal corpuscle

7.1.9 Outline the ultrastructure of glomerular capillary membrane and correlate its structure to the function

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7.1.10 Draw a labelled line diagram of the ultrastructure of glomerular capillary membrane

7.1.11 Outline the microscopic structure of proximal convoluted tubule and distal convoluted tubule and correlate their structure with function

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7.1.12 Draw labelled line diagrams of the microscopic view of proximal convoluted tubule and distal convoluted tubule (CS)/ (LS)

7.1.13 Outline the microscopic view of loop of Henley and collecting duct and correlate their structure with function

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7.1.14 Draw labelled line diagrams of the microscopic view of loop of Henley and collecting duct (CS)/ (LS)

7.1.15 Outline the structure of juxtaglomerular apparatus and correlate its structure with function

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7.1.16 Draw a labelled line diagram of the microscopic view of juxtaglomerular apparatus

7.1.17 Outline the microscopic structure of ureter

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7.1.18 Draw a labelled line diagram of the microscopic view of ureter (CS)

7.1.19 Outline the microscopic structure of urinary bladder

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7.1.20 Draw a labelled line diagram of the microscopic view of urinary bladder (LS)

7.1.21 Outline the microscopic view of urethra

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7.1.22 Draw a labelled line diagram of the microscopic view of urethra (CS)

7.1.23 Review of the urinary system

Kidney

Part of nephron	**Important structural components/lining epithelium**	**Special features**	**Functional significance**
Glomerulus			
Bowman's capsule			
Proximal convoluted tubule (PCT)			
Thin descending/ ascending limbs			
Thick ascending limb			
Distal convoluted tubule (DCT)			
Collecting tubule			
Cortical collecting duct			
Medullary collecting duct of Bellini			

Lower urinary tract

Component	**Lining epithelium**	**Arrangement of muscular layer**	**Functional significance**
Pelvicalyceal system			
Ureter			
Bladder			
Urethra			

8. ENDOCRINE SYSTEM

8.1 Endocrine organs

Objectives

At the end of the practical session, the student should be able to

1. Identify endocrine organ tissues under the light microscope
2. Outline the microscopic structure of pituitary, thyroid, parathyroid, adrenal, pancreatic and pineal glands.

Introduction

Metabolism, growth and development, tissue function, sexual function, reproduction, and many other processes are all controlled by the endocrine system. The hypothalamus, pituitary, thyroid, parathyroid, adrenal, pancreas, and pineal glands are among the organs that make up this system. Secondary endocrine functions are performed by the kidney, liver, heart, and gonads. Specific tissue and cell types have been modified to secrete specific hormones by different endocrine organs. The thyroid gland, for example, has follicular cells that emit the hormone thyroxine, whereas the anterior pituitary contains corticotrophs, thyrotrophs, gonadotrophs, lactotrophs, and somatotrophs that secrete ACTH, TSH, FSH, and LH, prolactin, and growth hormone, respectively. The comprehensive histology of endocrine organs is discussed in this practical session.

8.1.1 Outline the microscopic structure of anterior pituitary

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8.1.2 Draw a labelled line diagram of the microscopic view of anterior pituitary gland

8.1.3 Outline the microscopic structure of posterior pituitary

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8.1.4 Draw a labelled line diagram of the microscopic view of posterior pituitary

8.1.5 Outline the microscopic structure of thyroid gland

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8.1.6 Draw a labelled line diagram of the microscopic view of thyroid gland

8.1.7 Outline the microscopic structure of parathyroid gland

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8.1.8 Draw a labelled line diagram of the microscopic view of parathyroid gland

8.1.9 Outline the microscopic structure of adrenal gland

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8.1.10 Draw a labelled line diagram of the microscopic view of adrenal gland

8.1.11 Outline the microscopic view of adrenal cortex and correlate its structure with the function

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8.1.12 Draw a labelled line diagram of the microscopic view of adrenal cortex

8.1.13 Outline the microscopic structure of adrenal medulla

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8.1.14 Draw a labelled line diagram of the microscopic view of adrenal medulla

8.1.15 Outline the microscopic structure of endocrine pancreas

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8.1.15 Draw a labelled line diagram of the microscopic view of endocrine pancreas

8.1.16 Review of endocrine system

Organ	Component	Major cell types	Key features	Major products
Pituitary	Anterior pituitary			
	Pars intermedia			
	Posterior pituitary			
Thyroid				
Parathyroid				
Adrenal cortex	Zona glomerulosa			
	Zona fasciculata			
	Zona reticularis			
Adrenal medulla				
Pancreas	Islets of Langerhans			
Pineal gland				
Diffuse neuroendocrine system	Widespread in gastrointestinal and respiratory tracts			

9. REPRODUCTIVE SYSTEM

9.1 Male reproductive organs

Objectives

At the end of the practical session, the student should be able to

1. Identify male reproductive organ tissues under light microscope
2. Outline the microscopic structure of epididymis, vas deferens and ejaculatory ducts
3. Identify different spermatogonia and spermatocytes present in seminiferous tubules
4. Outline the ultrastructure of a Sertoli cell and the blood testis barrier
5. Identify organ tissues of the prostate gland, seminal vesicles and bulbourethral glands

Introduction

The testes, conducting tubules and ducts (epididymis, vas deferens, ejaculatory ducts), accessory sex glands (seminal vesicles, prostate, and bulbourethral glands), and the penis make up the male reproductive system.

Tunica vaginalis, tunica albuginea, and tunica vasculosa are connective tissue capsules that cover the testis. Seminiferous tubules are extremely convoluted tubules that produce spermatozoa within testicular lobules. Seminiferous tubules converge on the rete mediastinum testis.

The ductuli efferentes empty the rete testis into the epididymis' head. The epididymis is a long, convoluted duct that runs from the posterior side of the testis to the lower pole, where it merges to form the ductus deferens. The epididymis is made up of three parts: a head, a body, and a tail. It aids in the accumulation, storage, and maturation of spermatozoa. The spermatozoa are transported from the epididymis to the ejaculatory ducts through the ductus deferens. Seminal vesicles, which are lined by pseudostratified tall columnar epithelium, secrete up to 85% of the entire amount of seminal fluid. It has a honeycomb-shaped lumen that is uneven. The prostate gland is made up of tubuloacinar glands that are branching and embedded in a fibromuscular stroma. This practical session discusses the detailed histology of male reproductive organs.

9.1.1 Outline the microscopic structure of testis

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9.1.2 Draw a labelled line diagram of the microscopic view of testis (LS)

9.1.3 Outline the microscopic structure of seminiferous tubules

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9.1.4 Draw a labelled line diagram of the microscopic view of seminiferous tubules (CS)

9.1.5 Outline the microscopic structure of epididymis

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9.1.6 Draw a labelled line diagram of the microscopic view of epididymis (CS)

9.1.7 Outline the microscopic structure of ductus deferens

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9.1.8 Draw a labelled line diagram of the microscopic view of ductus deferens (CS)

9.1.9 Outline the microscopic structure of seminal vesicle

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9.1.10 Draw a labelled line diagram of the microscopic view of seminal vesicle (LS/ CS)

9.1.11 Outline the microscopic structure of prostate gland

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9.1.12 Draw a labelled line diagram of the microscopic view of prostate gland (CS/ LS)

9.1.13 Outline the microscopic structure of bulbo-urethral gland

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9.1.14 Draw a labelled line diagram of microscopic view of bulbo-urethral gland

9.1.15 Review of male genital tract

Organ	Main components	Cell types	Functions
Testis	Seminiferous tubules		
	Interstitium		
	Rete testis		
Epididymis			
Vas deferens			
Prostate	Central, transition and peripheral zones and anterior fibromuscular stroma		
Seminal vesicle			
Bulbourethral gland			

9. REPRODUCTIVE SYSTEM

9.2 Female reproductive organs

Objectives

At the end of the practical session, the student should be able to

1. Identify the female reproductive organ tissues under light microscope
2. Outline the histology of female reproductive organs
3. Identify different ovarian follicles present in the ovarian cortex
4. Outline the microscopic structure of corpus luteum and corpus albicans

Introduction

The female reproductive system includes the ovaries, oviducts, uterus, vagina, placenta, and mammary glands. They work together on the production of female gametes (oocytes), fertilization, fetal development, delivery to the outside world, and infant feeding. Fallopian tube is a smooth muscular tube that connects the uterus to the ovary. Three layers of tissue make up the uterine wall. Perimetrium, myometrium, and endometrium are the three layers of uterine wall. The stratum compactum, stratum spongiosum, and stratum basalis are the three layers of endometrium. The uterine cervix is the lower section of the uterus. The vaginal tissue is made up of three layers. The mucosa, which is bordered by non-keratinized stratified squamous epithelium, is the innermost layer. Elastin fibers can be seen in the lamina propria. Inner circular and outer longitudinal smooth muscle layers are found in the middle layer. The connective tissue layer that connects the rectum and bladder is known as adventitia. This practical lesson focuses into the histology of female reproductive organs in depth.

9.2.1 Outline the microscopic structure of an ovary

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9.2.2 Draw a labelled line diagram of the microscopic view of an ovary (LS)

9.2.3 Outline the structure of different ovarian follicles found in ovarian cortex: primordial follicle, primary follicle, secondary follicle and Graafian follicle

Primordial follicle

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Primary follicle

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Secondary follicle

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Graafian follicle

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9.2.4 Draw labelled line diagrams of the microscopic view of different ovarian follicles: primordial follicle, primary follicle, secondary follicle and Graafian follicle

Primordial follicle

Primary follicle

Secondary follicle

Graafian follicle

9.2.5 Outline the microscopic structure of corpus luteum and corpus albicans

Corpus luteum

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Corpus albicans

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9.2.6 Draw labelled line diagrams of the microscopic view of the corpus luteum and corpus albicans

Corpus luteum

Corpus albicans

9.2.7 Outline the microscopic structure of fallopian tube (CS)

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9.2.8 Draw a labelled line diagram of the microscopic view of fallopian tube (LS/CS)

9.2.9 Outline the microscopic structure of the uterus and uterine cervix

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9.2.10 Draw labelled line diagrams of the microscopic view of uterus and uterine cervix (LS/CS)

9.2.11 Outline the uterine changes seen in proliferative and secretory phase of the menstrual cycle

Proliferative phase

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Secretory phase

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9.2.12 Draw labelled line diagrams of the microscopic view of uterus in proliferative and secretory phase of the menstrual cycle

Proliferative phase

Secretory phase

9.2.13 Outline the microscopic structure of vagina

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9.2.14 Draw a labelled line diagram of the microscopic view of vagina (LS/CS)

9.2.15 Outline the microscopic structure of umbilical cord

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9.2.16 Draw a labelled line diagram of the microscopic view of umbilical cord (CS)

9.2.17 Outline the microscopic structure of the non-pregnant, pregnant and lactating breast

Non-pregnant

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Pregnant state

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Lactating

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9.2.18 Draw labelled line diagrams of the microscopic view of non-pregnant, pregnant and lactating breast

Non-pregnant

Pregnant state

Lactating state

9.2.19 Review of the female reproductive system

Part of the female genital tract	**Key features**	**Functions**
Ovary		
Fallopian tube		
Uterus		
Endocervix		
Ectocervix		
Vagina		
Vulva		
Placenta		
Breast		

10. NERVOUS SYSTEM

10.1 Brain, spinal cord and peripheral nerves

Objectives

At the end of the practical session, the student should be able to

1. Identify different types of glial cells under the light microscope
2. Identify different nerve cells present in the cerebral cortex and cerebellar cortex
3. Outline the microscopic structure of cerebral cortex and cerebellar cortex
4. Outline the microscopic structure of spinal cord

Introduction

The human nervous system is made up of a network of over 100 million nerve cells (neurons) and many more glial cells. It is by far the most complicated system in the human body. Each neuron contains at least 1000 synapses with other neurons, resulting in a very complex communication system. Circuits are made up of neurons. Neural circuits, like electronic circuits, are highly specialized combinations of parts that form systems of varying sizes and complexities. As an integrated communications network, nerve tissue is dispersed throughout the body. The nervous system is divided into two parts: the central nervous system, which includes the brain and spinal cord, and the peripheral nervous system, which includes nerves fibers and small clusters of neuron cells bodies known as ganglions. This practical lesson focuses into the histology of nervous system in depth.

10.1.1 Outline the microscopic structure of cerebral cortex

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10.1.2 Draw a labelled line diagram of the microscopic view of cerebral cortex (LS)

10.1.3 Outline the microscopic view of cerebellar cortex

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10.1.4 Draw a labelled line diagram of the microscopic view of cerebellar cortex (LS)

10.1.5 Outline the cross sections of spinal cord at following levels

Cervical

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Thoracic

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Lumbar

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Sacral

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10.1.6 Draw labelled line diagrams of the microscopic view of spinal cord (CS) at following levels

Cervical

Thoracic

Lumbar

Sacral

10.1.7 Outline the microscopic structure of a peripheral nerve (CS)

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10.1.8 Draw a labelled line diagram of the microscopic view of a peripheral nerve (CS)

10.1.9 Outline the microscopic structure of cross sections of pons and medulla oblongata

Pons

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Medulla oblongata

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10.1.10 Draw labelled line diagrams of the microscopic view of pons and medulla oblongata (CS)

10.1.10 Review of the central nervous system

Main structures	**Sub-structures**	**Key features and functions**
Cerebral cortex		
Cerebella cortex		
Spinal cord	White columns	
	Anterior horns	
	Spinal canal	
	Commissure	
Brain stem	Pons	
	Medulla	
Glial cells		

10. NERVOUS SYSTEM

10.2 Sensory organs

Objectives

At the end of the practical session, the student should be able to

1. Identify the tissues of special sensory organs under the light microscope
2. Identify types of cells found in the olfactory epithelium under light microscope
3. Identify the different types of papillae present in the tongue under light microscope
4. Identify and outline the ultrastructure of a taste bud
5. Identify the tissue layers in the cornea and retina under light microscope
6. Outline the microscopic structure of inner ear

Introduction

Organs of special sense are complex sensory structures in which specialized sensory receptors are embedded in a non-neural structure that improves and refines incoming stimuli reception. The main special sense organs are the eye and the audio-vestibular apparatus of the ear, although gustatory (taste) and olfactory (smell) receptors are usually included as well. Sight and hearing sensory receptors are found in big, sophisticated sensory organs such as the eyes and ears. Those for smell and taste are found in organs that serve other systems, such as nose and mouth. This practical lesson focuses into the histology of special sensory organs in detail.

10.2.1 Outline the microscopic structure of a taste bud

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10.2.2 Draw a labelled line diagram of the microscopic view of a taste bud

10.2.3 Outline the microscopic structure of following tissue layers in the wall of eye

Corneo-scleral layer

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Uveal layer

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Retinal layer

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10.2.4 Draw labelled line diagrams of the microscopic view of tissue layers in the wall of eye

10.2.5 Outline the microscopic view of tissue layers of retina

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10.2.6 Draw a labelled line diagram of the microscopic view of retina

10.2.7 Outline the microscopic structure of fovea

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10.2.8 Draw a labelled line diagram of the microscopic view of fovea

10.2.9 Outline the microscopic structure of ciliary body

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10.2.10 Draw a labelled line diagram of the microscopic view of ciliary body

10.2.11 Outline the microscopic structure of iris

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10.2.12 Draw a labelled line diagram of the microscopic view of iris

10.2.13 Outline the microscopic structure of cornea

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10.2.14 Draw a labelled line diagram of the microscopic view of cornea

10.2.15 Outline the microscopic structure of conjunctiva

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10.2.16 Draw a labelled line diagram of the microscopic view of conjunctiva

10.2.17 Outline the microscopic structure of lacrimal gland

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10.2.18 Draw a labelled line diagram of the microscopic view of lacrimal gland

10.2.19 Outline the microscopic structure of eyelid

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10.2.20 Draw a labelled line diagram of the microscopic view of eyelid

10.2.21 Outline the microscopic structure of external auditory meatus

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10.2.22 Draw a labealled line diagram of the microscopic view of external auditory meatus

10.2.23 Outline the microscopic structure of tympanic membrane

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10.2.24 Draw a labelled line diagram of the microscopic view of tympanic membrane

10.2.25 Outline the microscopic structure of Eustachian canal

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10.2.26 Draw a labelled line diagram of the microscopic view of Eustachian canal

10.2.27 Outline the microscopic structure of organ of Corti

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10.2.28 Draw a labelled line diagram of the microscopic view of organ of Corti

10.2.31 Review of special sense organs

Sensory organ	**Main /subsidiary structures and key features**			**Functions**
Tongue	Taste buds -			
Nose	Olfactory receptors -			
Eye	Retina	Rods		
		Cones		
		Fovea		
		Macula lutea		
		Optic disc		
	Cornea	Epithelium		
		Stroma		
	Sclera	Fibrous layer forming the eye globe; continuous with corneal stroma		
	Uvea	Choroid		
		Ciliary body		
		Iris		
		Canal of Schlemm		
	Lens			
Ear (hearing)	External	Pinna and canal		
	Middle	Middle ear space and Eustachian tub		
		Tympanic membrane		
		Ossicles		
	Inner			
		Cochlea		
Ear (balance)	Inner ear	Semicircular canals		
		Vestibule		

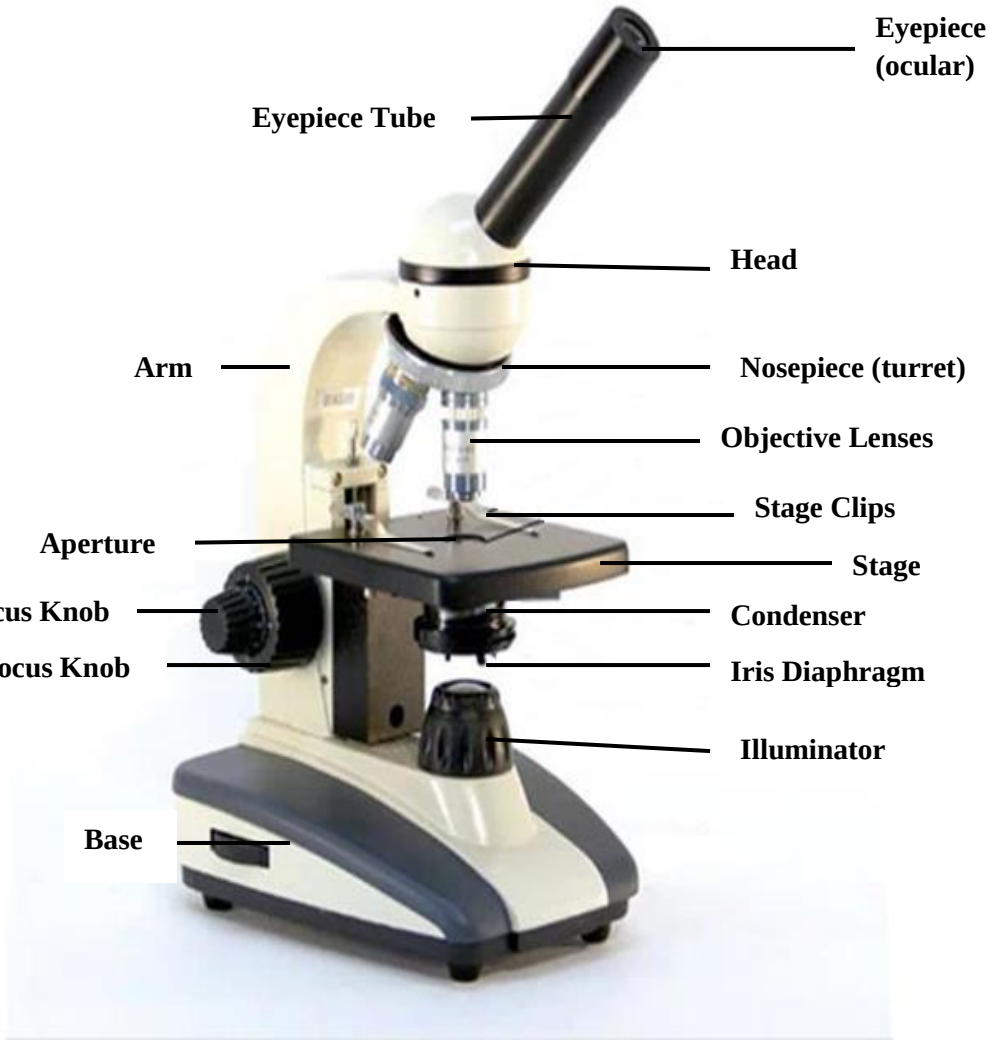
Appendix

Key Answers

1. Foundation

1.1 Microscope, cell and cell organelles

1.1.1



1.1.2

	Parts of the microscope	**Functions**
1.	Ocular lens	It holds the eye at the top of the microscope to look through it
2.	Body tube	It keeps the eyepieces above the objective lens in place.
3.	Revolving nosepiece	It's where the objectives are attached. The objectives are exposed and set on a rotating turret, allowing for easy selection of different targets.
4.	Objective lens	On a microscope, these are the primary optical lenses. They enlarge the object and range in size from 4x to 100x.
6.	Arm	It connects the base to the head and provides a manual lift.
7.	Stage	Stage is where the specimen to be viewed is placed. A mechanical stage is used when working at higher magnifications where delicate movements of the specimen slide are required.
8.	Stage clips	Stage clips are used to fasten the slide over the stage. The viewer is required to move the slide manually to view different sections of the specimen by releasing the clips.
9.	Diaphragm	Diaphragm controls the amount of light reaching the specimen
10.	Coarse adjustment knob	It is used to focus the microscope with large scale steps.
11.	Fine adjustment knob	It is used to focus the microscope with minute scale steps.
12.	Illuminator	Light source provides adequate visibility of the specimen.
13.	Base	It provides a wide support for the microscope by touching ground.

1.1.3

Turn on the illuminator. Because the bulb heats up quickly, it's preferable to gradually increase the light intensity when using the dimmer.

Place a blood smear on the stage, with the sample just above the aperture, and use the stage clips to secure it.

Make sure the iris diaphragm is fully open, letting as much light as possible to reach the slide and lenses.

Rotate the nosepiece so that the lowest magnification objective lens is exactly above the sample. Lower magnifications, such as 4X or 10X, can be used to pick the part of the specimen that is of interest before adjusting to the higher magnification.

Examine the iris diaphragm through the binocular eyepieces until the amount of light is satisfactory.

To bring the blood smear into broad focus, turn the coarse adjustment knob.

Adjust the fine adjustment knob until the sharp focus.

Then, with minimal focusing, move the nosepiece to higher settings and bring the sample into greater and more resolution.

Transfer the focus to 100X and fine-tune the focus once blood cells are clearly visible at mid magnifications.

1.1.4

A light microscope is designed to emit light onto or through objects and magnify the transmitted or reflected light with the objective and ocular lenses.

To gain information about structure, morphology, and composition, electron microscopes employ signals generated by the interaction of an electron beam with the material. Electrons behave like waves. A beam of electrons travels through the specimen before being magnified by a series of lenses. The picture is caused by electron scattering by atoms in the specimen.

1.1.5

There is no requirement of cooling system.

Living, as well as the dead sample, can be viewed.

Studying the detailed structure of an organism is difficult.

The natural color of specimen is obtained.

The image can be seen directly.

Preparation of sample is quick and simple.

No radiation risks.

Easily available and cheaper in rate.

1.1.6

Move safely

Carry the microscope from the base to the support arm, grip the arm with one hand and place the other hand on the base's bottom. It can become misaligned if it is picked up by the stage or eyepiece holder.

Keep covered

Cover the microscope kit whenever you use or clean it to prevent dust and other pollutants from entering the equipment. If you can't find your cover, either contact the laboratory in charge for a replacement or find an appropriate substitute, such as a large plastic bag.

Store safely

Keep the microscope in a dry, draft-free location where it will not be bumped, pushed, or wet, and where nothing will fall on it. For long-term storage, the microscope should be stored in a humidifying cabinet.

Keep area clean

Keep the place clean, organized, and ready to use for the next person. Discard used lens paper/wipes, cover any bottles, clean the counter, and keep important objects within easy reach of the user.

Clean the stage with lens paper to remove dust and particles. if necessary, a little alcohol can be used to remove oil and other filth. To dust off the microscope, use a little soft brush or canned air.

Keep the lenses clean

After each use, wipe the oil immersion lenses using lens paper. Because oil becomes sticky and attracts dust and dirt, this should be done on a regular basis after each use. To remove oil, use little amount of alcohol but always follow the manufacturer's instructions. Use only lens wipes or lens paper. The lens will be scratched if you use a tissue, paper towel, or any other sort of wipe. Clean the ocular lens in the eyepiece; eyelashes, cosmetics, and fingers can all cause it to become dirty. The objective lenses will also need to be cleaned on a regular basis; follow the microscope manual's instructions or get a professional to do it for you.

Take care of bulbs

After you've finished using the microscope, turn it off. The bulb's life will be shortened if the light is left on all day. Always keep a couple of additional bulbs on hand, not just one.

Refer to the user manual

Have the manual next to the microscope: hang it on the wall, put it in a drawer, whatever it takes to keep it close at hand.

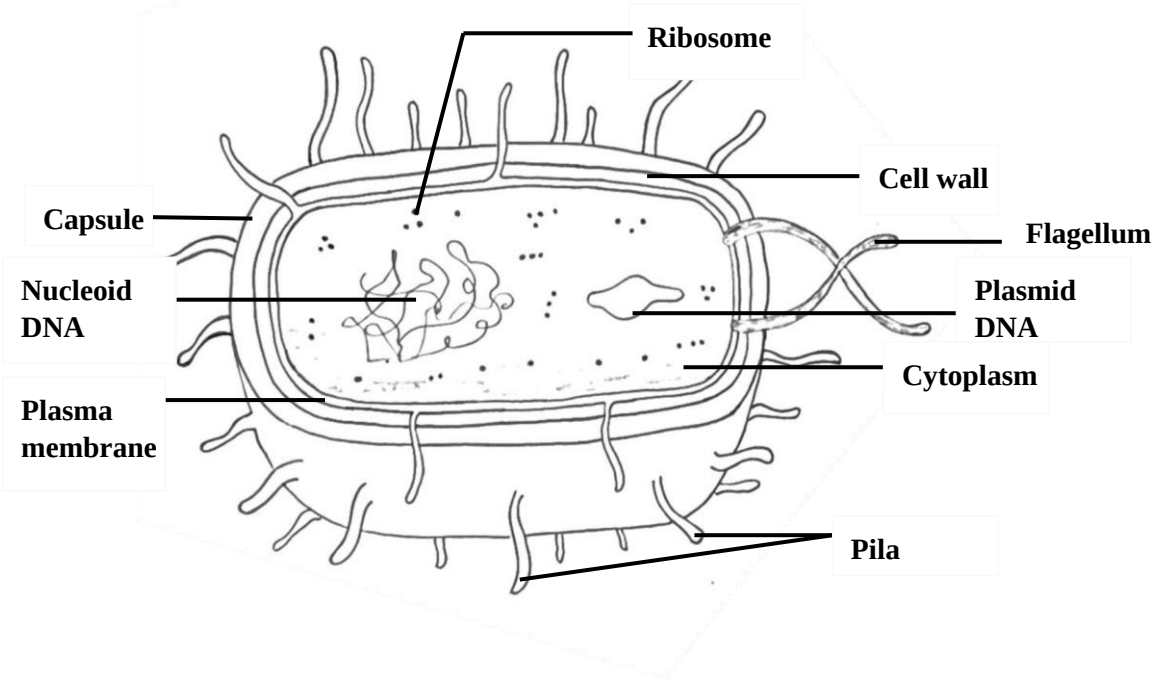
If you are new to the lab, go over the manual at least once. This is especially important if you are not going to rely solely on oral history.

1.1.7

Prokaryotes are single-celled organisms that fall into the bacteria and archaea domains. Prokaryotic cells are evolutionally primitive than the eukaryotic cells. They lack a nucleus as well as cytoplasmic organelles. A single circular chromosome is seen in most prokaryotic cells. They may also contain plasmids, which are tiny circular DNA

fragments. A cell wall surrounds all prokaryotic cells. A cell wall and a capsule are seen in many prokaryotes. The cell wall provides an additional layer of protection, aids in cell shape maintenance, and prevents dehydration. The cell can adhere to surfaces in its environment thanks to the capsule. Appendages are common on the surface of prokaryotes. Fimbriae help the cell cling to a surface, and sex pili are used for DNA exchange.

1.1.8



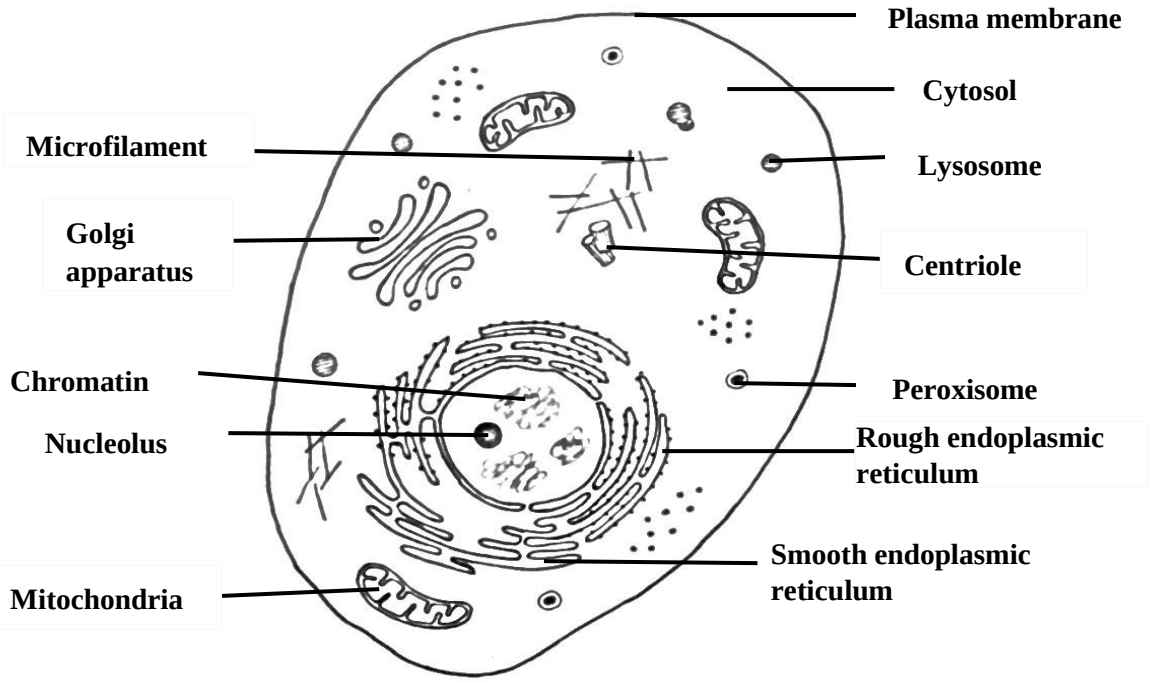
1.1.9

Eukaryotes have well-organized cells with a nuclear membrane enclosing the nucleus. The plasma membrane, also known as the plasmalemma, is an exterior lipid membrane that surrounds cells. The nucleus is the biggest organelle, and its material is enclosed by the nuclear envelope or membrane, which is a membrane system. The nucleus houses the cell's genetic material in the form of DNA. A number of membrane-bound organelles can be found in the

cytoplasm. The endoplasmic reticulum, which is made up of flattened membrane-bound tubules, saccules, and flattened cisterns, is widely dispersed throughout the cytoplasm. Golgi apparatus is located close to the nucleus.

A number of relatively big, elongated organelles called mitochondria, with a smooth outer membrane and a convoluted inner membrane system, are scattered freely in the cytoplasm. Other membrane-bound structures seen in the cell include intracellular transport vesicles and lysosomes. The cytoplasmic organelles are floating in the cytosol, a gel-like substance. The cytoskeleton is a network of minute tubules and filaments that runs throughout the cytoplasm.

1.1.10

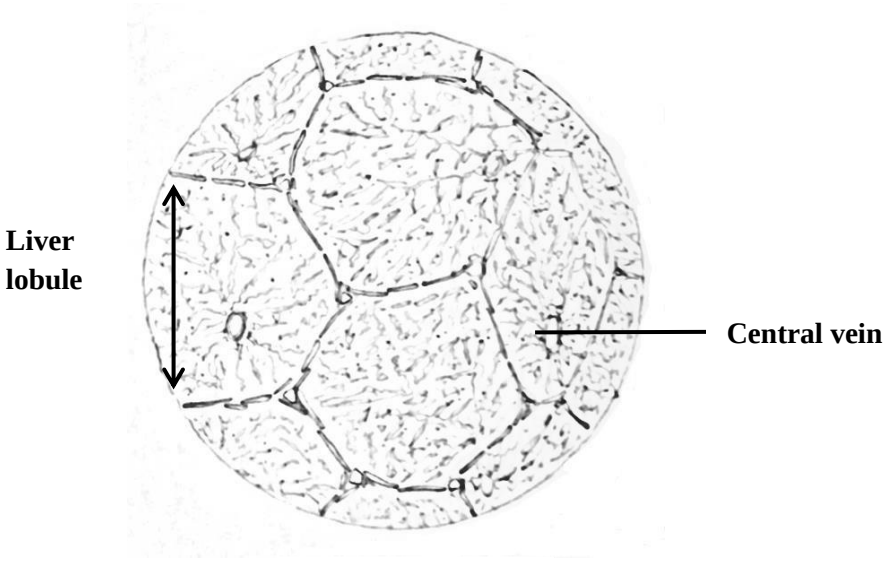


1.1.11

	Prokaryote	**Eukaryotic**
Cell size	Smaller (0.1-5 μm)	Larger (10-100 μm)
Nucleus	Absent	Present
Membrane-bound organelles	Absent	Present
DNA form	Circular	Linear
Complexity	Simpler	More complex

1.1.12

4X



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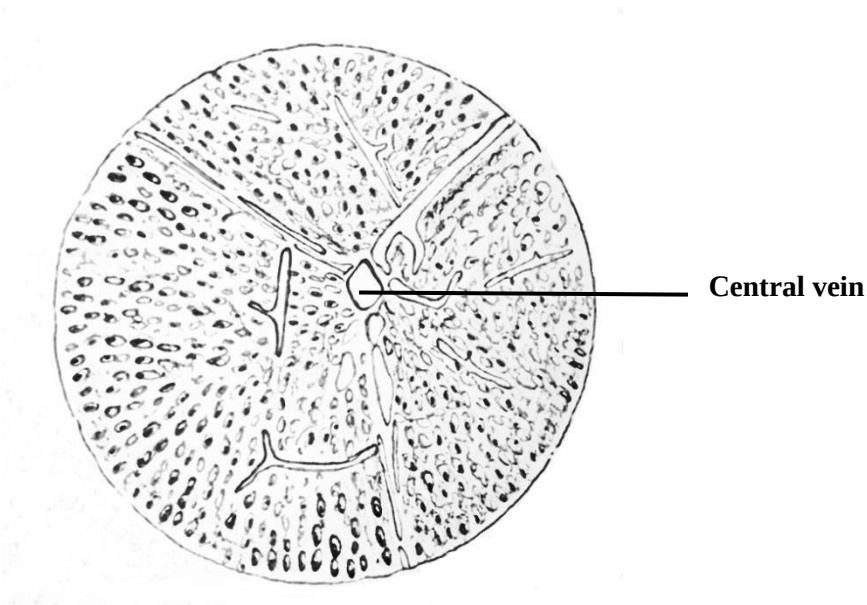
10X



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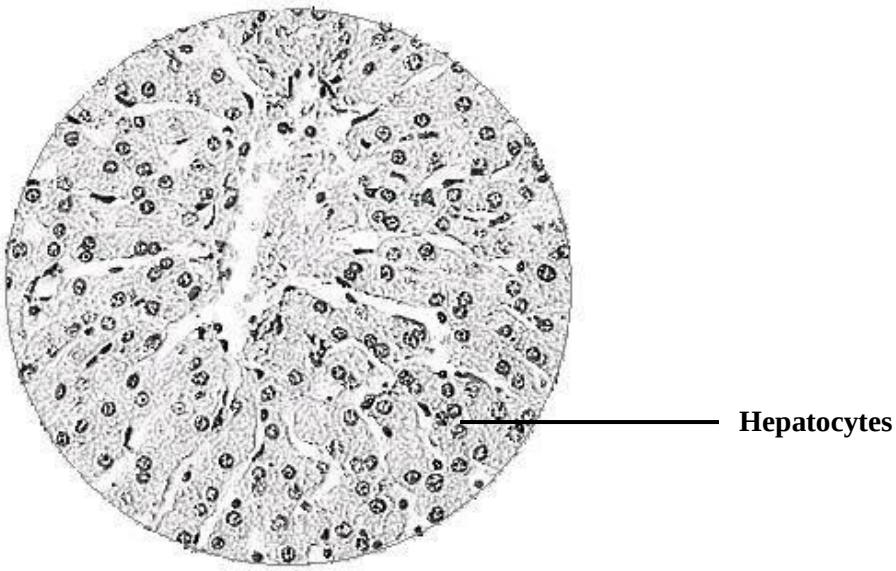
40X



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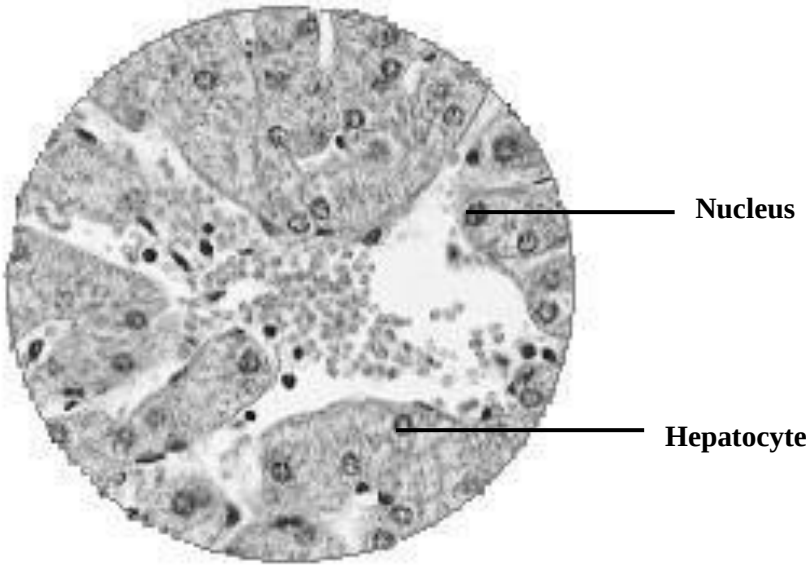
100X



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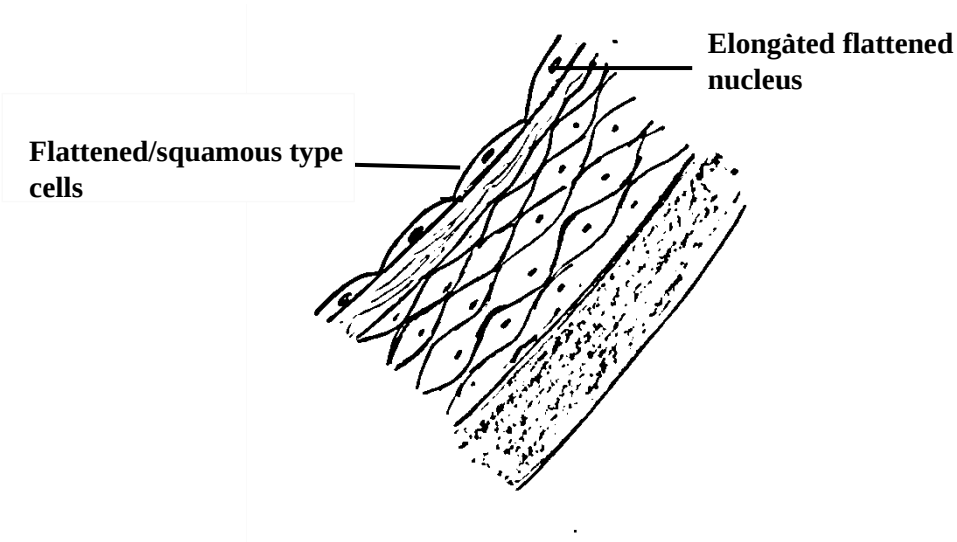
1.1.13

Tissue A

Medium size artery



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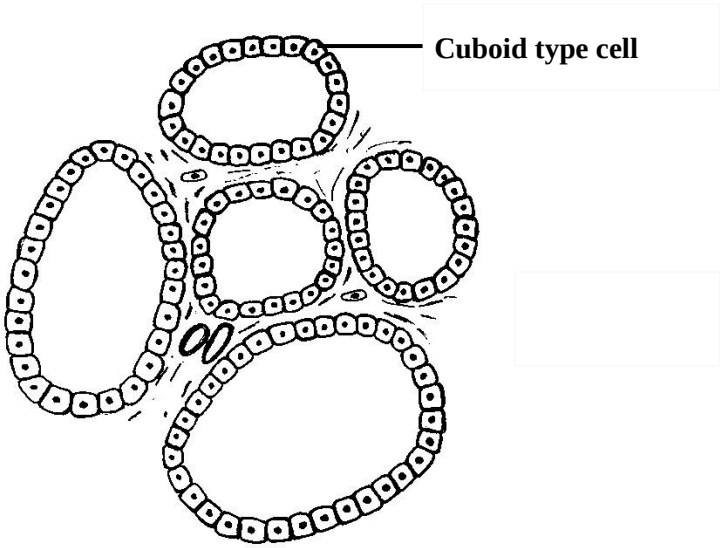
Tissue B

Thyroid follicles



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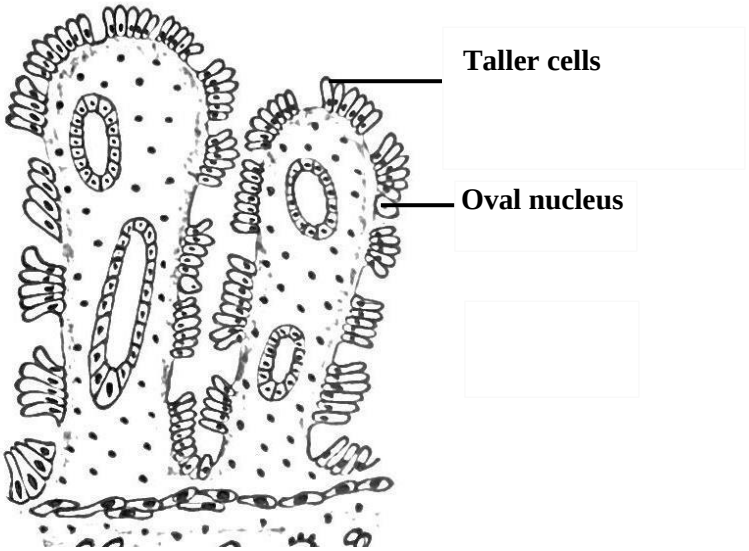
Tissue C

Enterocytes of the colon



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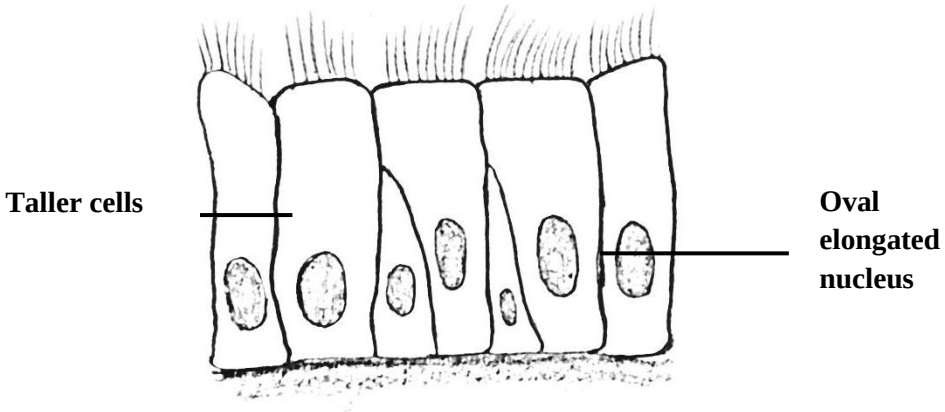
Tissue D

Principle bronchus



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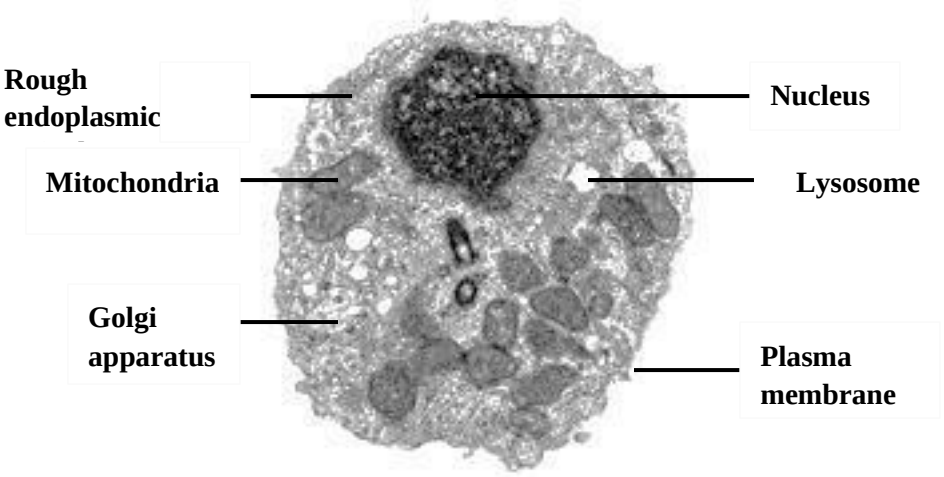
1.1.14



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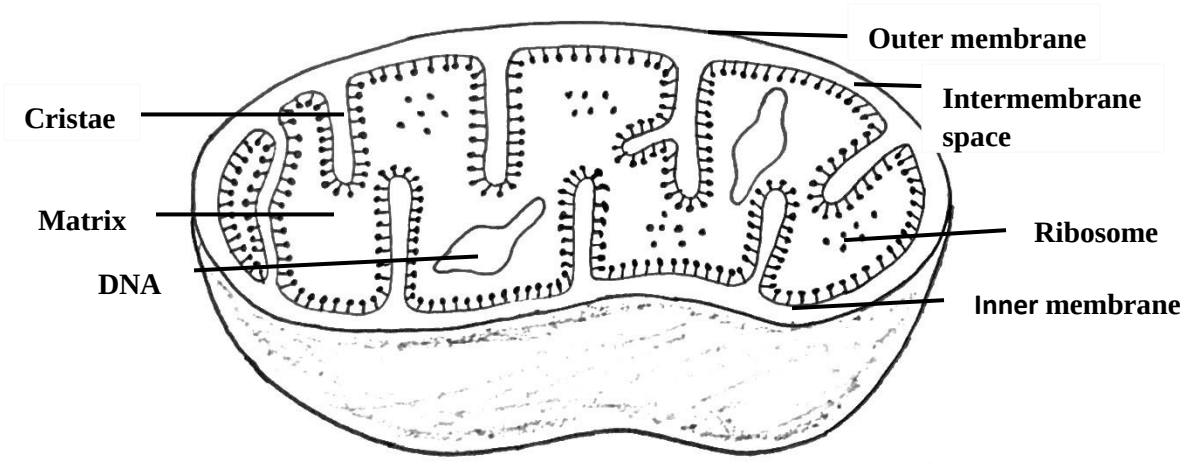
1.1.15

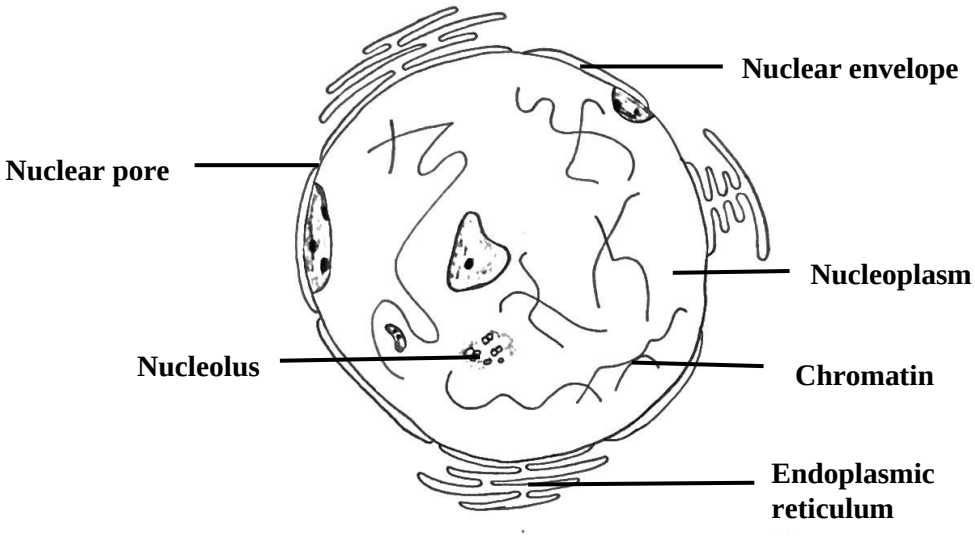
Mitochondria



Structure

Mitochondria are made up of two membranes. The outer membrane, inner membrane, intermembrane space, and matrix are the four different domains. Two membranes enclose the organelle: a smooth outer membrane and a folded or tubular inner mitochondrial membrane with a substantial surface area that encloses the matrix region. Proteins abound in both mitochondrial membranes. Between the inner and outer membranes is the intermembrane gap. The number and structure of mitochondria, as well as the amount of cristae on them, varies greatly between cell types. Tissues with a high rate of oxidative metabolism, such as heart muscle, have mitochondria with a high number of cristae. The morphology of mitochondria can vary even within one type of tissue, depending on their functional condition.

Nucleus



Structure

The nucleus is a membrane-bound organelle that houses genetic material (DNA). The nuclear envelope, a double membrane that encloses the entire organelle and isolates its contents from the cellular cytoplasm, and the nuclear matrix (which includes the nuclear lamina), a network

within the nucleus that adds mechanical support, similar to how the cytoskeleton supports the cell as a whole, are the two main structures that make up the nucleus.

Nuclear envelope and nuclear pores

A double membrane nuclear envelope surrounds the cell nucleus. The nucleus' contents are separated from the cytoplasm, a gel-like fluid that contains all other organelles, by the membrane. Phospholipids create a lipid bilayer similar to that of the cell membrane in the nuclear envelope. Nuclear pores in this lipid bilayer allow molecules to enter and exit the nucleus, as well as transfer from the cytoplasm to the nucleoplasm.

The nuclear envelope aids in the maintenance of the nucleus' shape. It is attached to the endoplasmic reticulum (ER) in such a way that the nuclear envelope's internal chamber is continuous with the ER's lumen (or inside).

Chromatin

Chromosomes, which contain DNA, are housed in the nucleus. DNA holds heredity information and instructions for cell growth, development, and reproduction. When a cell is "resting," or not dividing, its chromosomes are arranged into chromatin, which are lengthy entangled structures.

Nucleoplasm

The gelatinous substance within the nuclear membrane is called nucleoplasm. This semi-aqueous substance, like cytoplasm, is mostly made up of water with dissolved salts, enzymes, and organic molecules suspended inside. Nucleoplasm surrounds the nucleolus and chromosomes, cushioning and protecting nuclear contents.

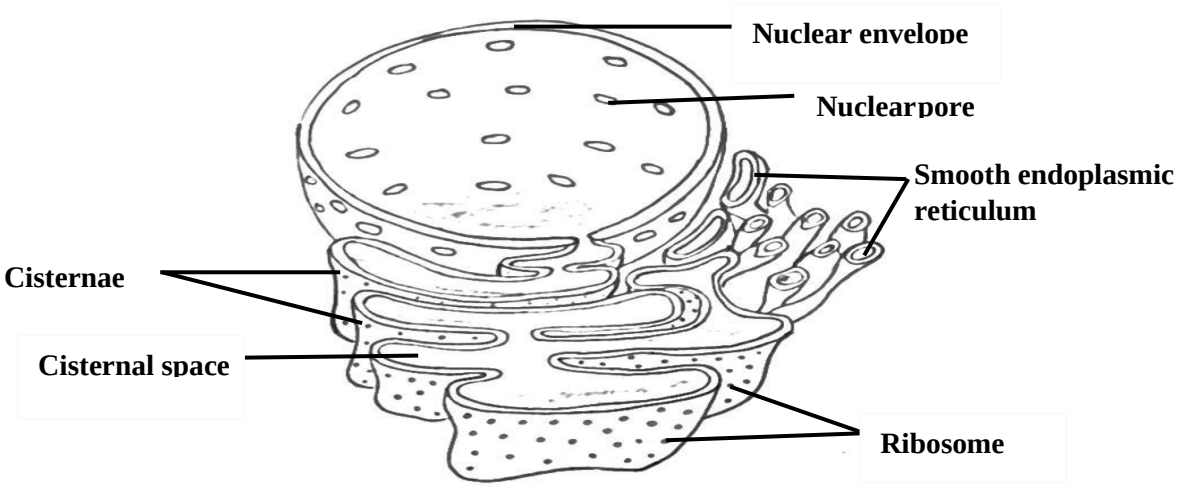
The nucleoplasm, like the nuclear membrane, helps the nucleus maintain its shape. It also serves as a conduit for the movement of components such as enzymes and nucleotides (DNA and RNA subunits) throughout the nucleus to its various regions.

Nucleolus

The nucleolus is a dense, membrane-less structure made up of RNA and proteins. Nucleolar organizers, which are portions of chromosomes that carry the genes for ribosome synthesis, are found in the nucleolus. By transcribing and assembling ribosomal RNA subunits, the nucleolus

aids in the formation of ribosomes. During protein synthesis, these components come together to form ribosomes.

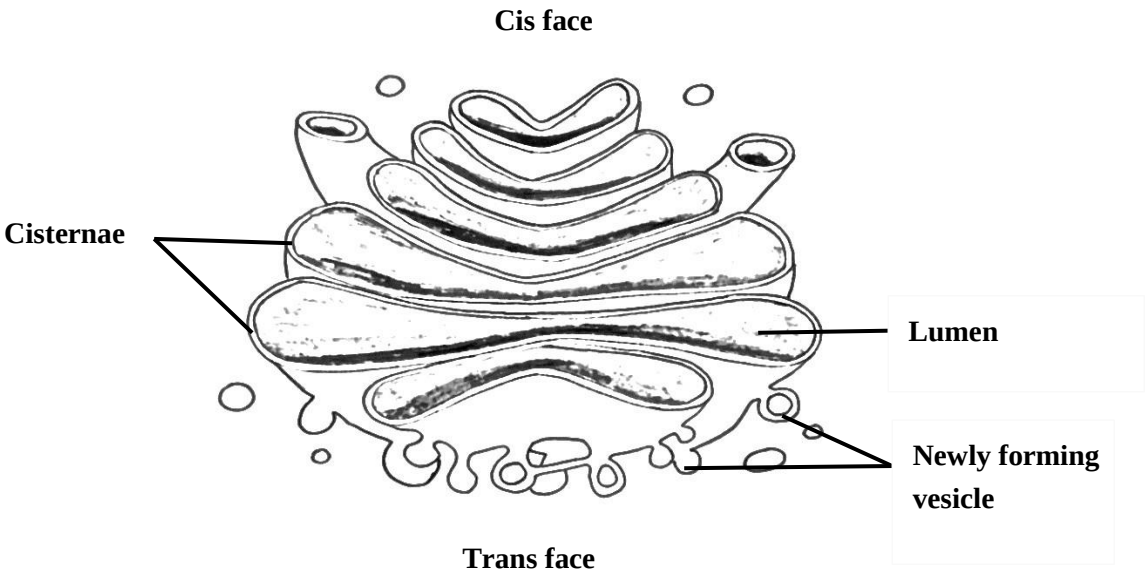
Endoplasmic reticulum



Structure

The endoplasmic reticulum (ER) is a large, dynamic continuous membrane system that creates a series of flattened sacs within eukaryotic cells' cytoplasm and serves various activities, including protein production, folding, modification, and transport. Smooth endoplasmic reticulum and rough endoplasmic reticulum are the two types of the endoplasmic reticulum. Smooth ER does not have connected ribosomes, but rough ER does. The protein-making ribosome is studded on the rough endoplasmic reticulum's surface, giving it a rough appearance. The smooth endoplasmic reticulum consists of tubules, which are located near the cell periphery. This network increases the surface area for the storage of key enzymes and the products of these enzymes.

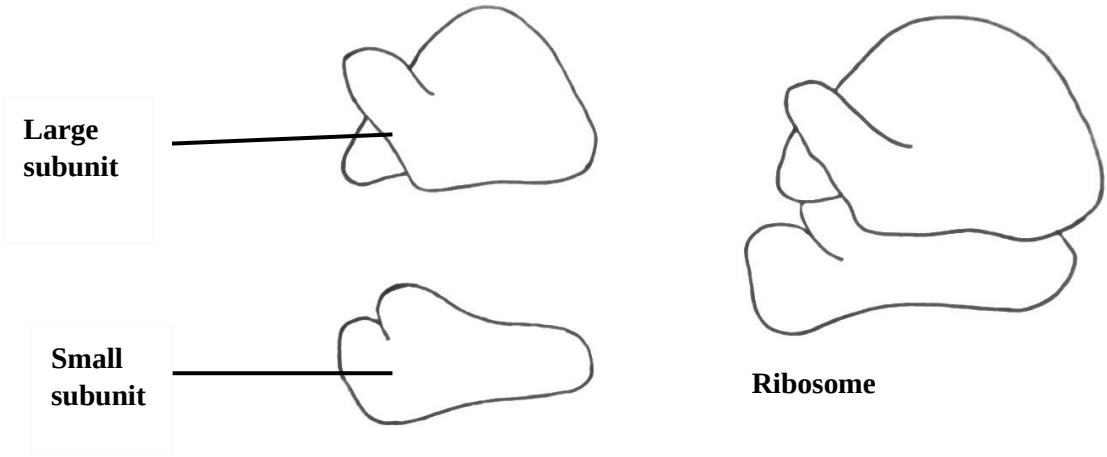
Golgi apparatus



Structure

The Golgi apparatus is made up of 4 to 6 membrane-bound saucer-shaped cisternae. The cis and trans Golgi networks are a network of tubules that make up the outermost cisternae. It is found in the cytoplasm, close to the cell nucleus and next to the endoplasmic reticulum. While many types of cells have only one or a few Golgi apparatuses, the Golgi apparatus is usually made up of four to eight cisternae, while it can be as many as 60 cisternae in some single-celled organisms. The cisternae are held together by matrix proteins, while cytoplasmic microtubules sustain the entire Golgi apparatus. The apparatus is divided into three compartments: cis (cisternae closest to the endoplasmic reticulum), medial (cisternae central layers), and trans (cisternae farthest from the endoplasmic reticulum). The cis Golgi network and the trans Golgi network, which are made up of the outermost cisternae at the cis and trans faces, respectively, are in charge of sorting proteins and lipids that the organelle receives (at the cis face) or releases (at the trans face).

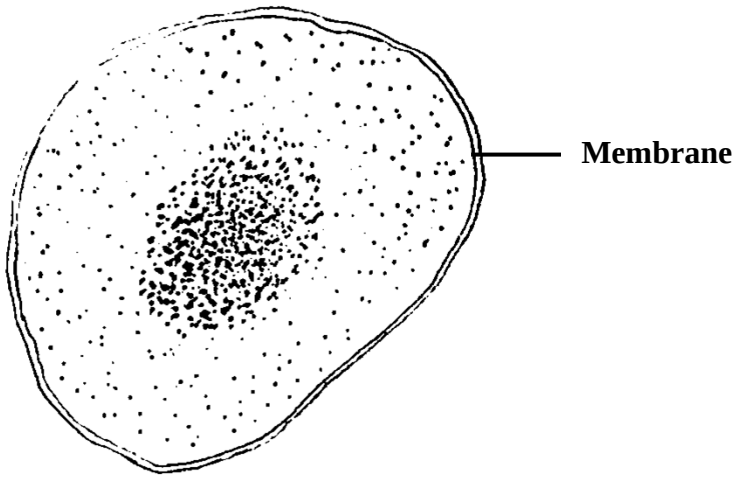
Ribosome



Structure

Ribosomes are made up of two subunits of different sizes. A strand of RNA, ribosomal RNA (rRNA) molecules, and related ribosomal proteins form a globular structure in each subunit. Ribosomes are frequently seen coupled to mRNA molecules in polyribosomes or polysomes PR, which are small circular aggregations formed by a single strand of mRNA with ribosomes attached along its length. Each ribosome in a polyribosome produces a distinct protein molecule. Endoplasmic reticulum can also have ribosomes and polyribosomes connected to its surface.

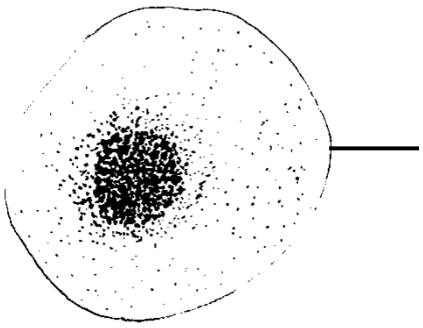
Lysosome



Structure

Electron-dense particulate materials and amorphous granular materials are found in lysosomes, which are membrane-bound organelles containing an amorphous granular substance. They're spherical vesicles with hydrolytic enzymes that can break down a wide range of biomolecules. The membrane proteins and luminal proteins of a lysosome have an unique makeup.

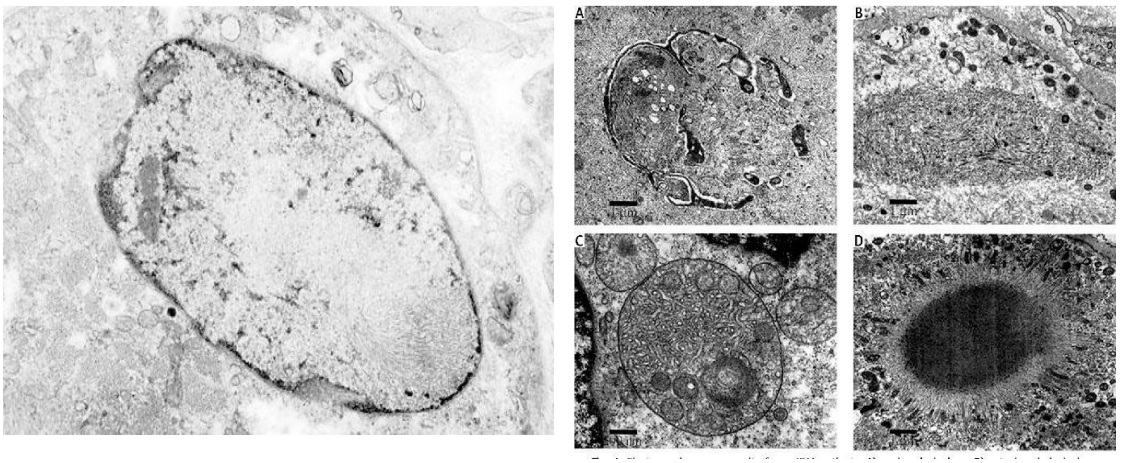
Peroxisome



Structure

Peroxisomes are organelles that look similar to lysosomes but are smaller. A phospholipid bilayer with numerous membrane-bound proteins makes up these organelles. Peroxisomes selectively import enzymes involved in detoxification and lipid metabolism.

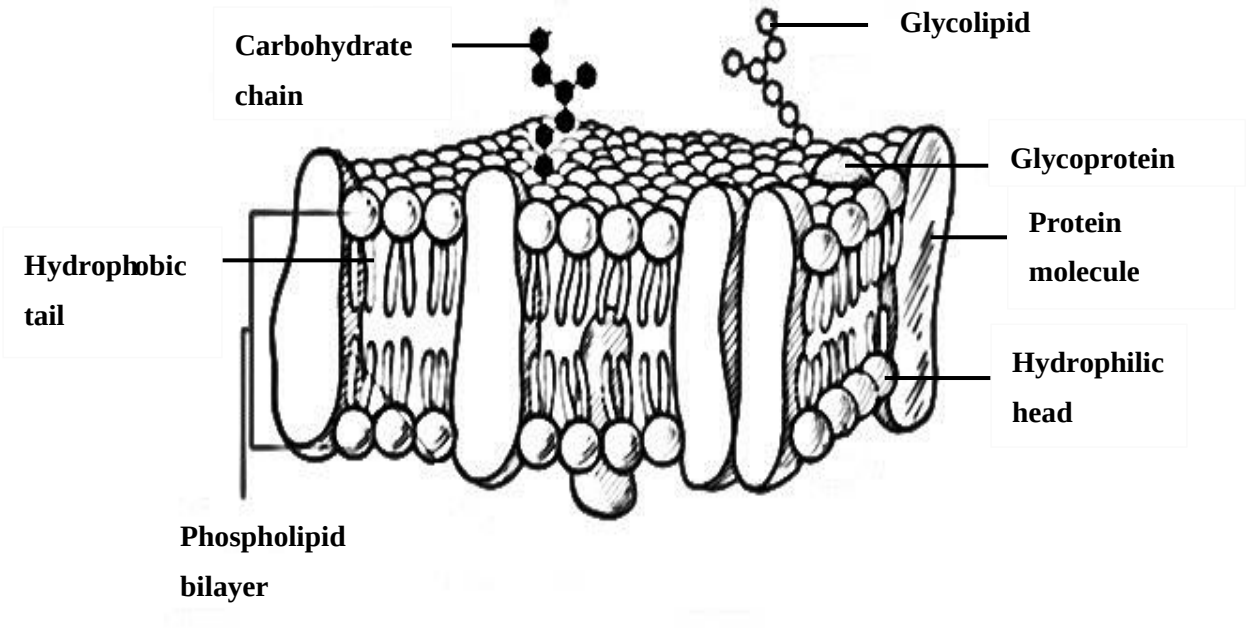
Cytoplasmic inclusions



Structure

Inclusions are cytoplasmic molecular aggregates that are not restricted by membranes and include pigments, organic polymers, and crystal. Cell inclusions include fat droplets and glycogen granules, for example.

Cell membrane



Structure

It is made up of a bilayer of phospholipids. The amphiphilic phospholipid molecules that make up the lipid bilayers. They are made up of polar, hydrophilic heads pointing outwards from the lipid bilayer and non-polar, hydrophobic tails pointing inwards. Cholesterol molecules coexist with phospholipids in a about 1:1 ratio in the bilayer.

Cholesterol molecules are amphiphilic and have a kinked conformation, which prevents the phospholipid fatty acid tails from being unduly densely packed while also filling the gaps between the unsaturated fatty acid tails' kinks.

Peripheral membrane proteins are attached to the inner or outer membrane leaflet. Protein molecules are embedded within the lipid bilayer. They are intrinsic or integral proteins. Some

of these proteins span the entire thickness of the membrane known as transmembrane proteins to be exposed to each surface, while others are embedded within the inner or outer lipid leaflet.

Most membrane proteins and some membrane lipids are coupled with short polysaccharide chains on the exterior surface of animal cell plasma membranes. These glycoproteins and glycolipids protrude from the bilayer's surface, generating the glycocalyx, an outer covering that aids in cell identification.

1.1.16

Structural adaptations of mitochondria

Outer membrane – the outer membrane contains transport proteins that enable the shuttling of pyruvate from the cytosol
Inner membrane – contains the electron transport chain and ATP synthase (used for oxidative phosphorylation)
Cristae – the inner membrane is arranged into folds (cristae) that increase the surface area: volume ratio (more available surface)
Inter membrane space – small space between membranes maximizes hydrogen gradient upon proton accumulation
Matrix – central cavity that contains appropriate enzymes and a suitable pH for the Krebs cycle to occur. It contains its own DNA when contain genetic blueprint for its own enzymes.

Structural adaptations of cell membrane

The immiscibility of lipids with water leads them to form lipid bilayers, which effectively prevent passage of polarized ions and molecules; thus, the contents of different compartments are kept separate and ion gradients between different compartments are maintained.

Proteins embedded within the lipid bilayer act as channels to allow selective passage of particular ions and molecules. Some types of cell signaling are also mediated by membrane proteins.

The glycocalyx is involved in cell recognition phenomena, in the formation of intercellular adhesions and in the adsorption of molecules to the cell surface; the glycocalyx also provides mechanical and chemical protection for the plasma membrane

1.1.17

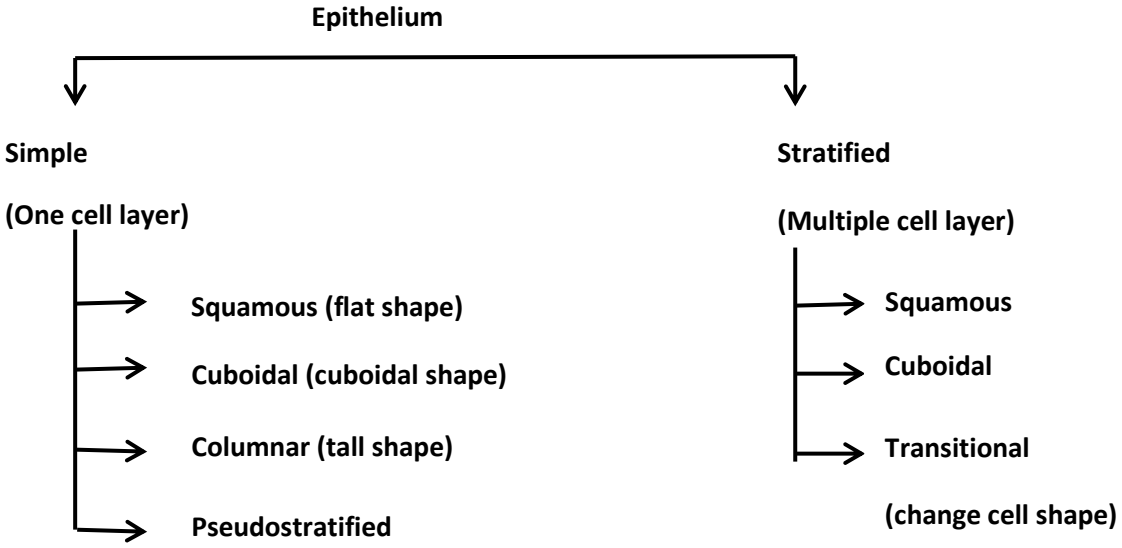
Organelle	**Key structural feature**	**Functions**
Nucleus	Double membrane-bound large structure containing chromatin	Chromosomes (DNA) contain the genetic blueprint for every protein in the body
Nuclear envelope/ membrane	Double lipid bilayer with nuclear pore complexes	Separates and mediates transport between nucleus and cytoplasm
Nucleolus	Dense non-membrane bound structure in nucleus	Ribosomal RNA synthesis and ribosome assembly
Ribosomes	Small structures free in cytoplasm or bound to endoplasmic reticulum. Consist of two subunits of ribosomal RNA	Protein synthesis— formation of peptide bonds between amino acids to make polypeptide chains using messenger RNA as templates
Endoplasmic reticulum	Extensive membrane system within the cell; may be rough endoplasmic reticulum with associated ribosomes, or smooth endoplasmic reticulum without associated ribosomes	Modification and folding of proteins synthesized on ribosomes (rER), synthesis of some lipids (sER)
Golgi apparatus/stack	Stacks of flattened membrane-bound cisternae	Final assembly and glycosylation of proteins and dispatch to their ultimate destination
Mitochondria	Double membrane-bound organelles with folded inner membrane	Energy production, mainly in the form of ATP

Plasma membrane	Lipid bilayer containing intrinsic proteins and with an external coat of carbohydrate	Divides cell from external environment and mediates interactions with external environment
Cytoskeleton	Microfilaments, intermediate filaments and microtubules	Maintain cell shape and orientation, cell movement, movement of organelles around the cell, movement of chromosomes during cell division
Lysosomes	Membrane-bound vesicles contain mostly hydrolytic enzymes	Phagocytosis or endocytosis and of old or unnecessary cellular constituents and intracellular digestion of foreign matter
Peroxisomes	Membrane-bound vesicles often with a protein coat	Transport materials between different cell compartments and to plasma membrane for export

2. Body Tissues and Locomotor System

2.1 Epithelial tissues

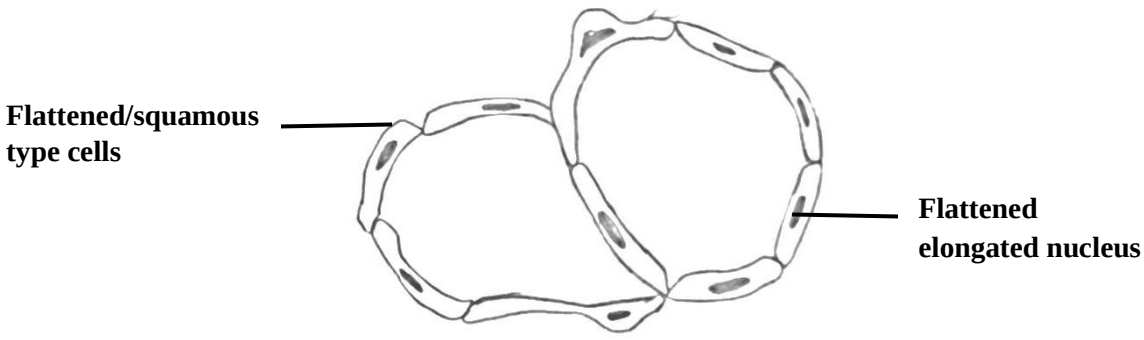
2.1.1



2.1.2

A simple squamous epithelium is a single layer of flat cells in contact with the basal lamina or basement membrane. Simple squamous epithelium is composed of flattened, irregularly shaped cells forming a continuous surface. As the cells are flattened, they can only be recognized by their flattened and oblong nuclei, which bulge on the surface.

2.1.3



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2.1.4

Vascular endothelium, mesothelium of peritoneal lining, alveolar lining, Bowman's capsule

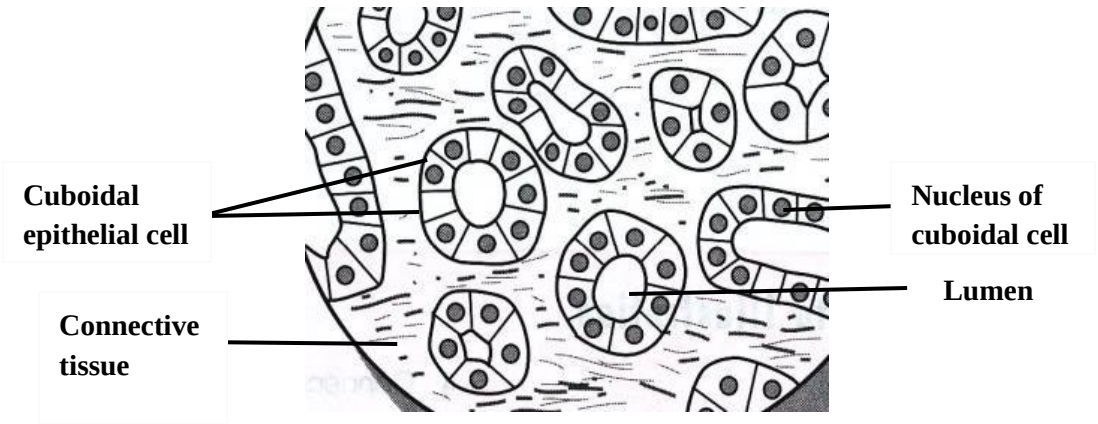
2.1.5

A simple squamous epithelium is a single layer of flat cells in contact with the basal lamina (one of the two layers of the basement membrane) of the epithelium. This is permeable and occurs where small molecules need to pass quickly through membranes via filtration or diffusion. Simple squamous epithelia are found in tissues where rapid diffusion is required. Cells are flat with flattened and oblong nuclei. This epithelium is associated with filtration and diffusion. This tissue is extremely thin, and forms a delicate lining. It offers very little protection.

2.1.6

The epithelial cells appear square, leading to its traditional description as cuboidal epithelium; on surface view, however, the cells are actually polygonal in shape. They lie on the basement membrane. The nucleus is centrally located and is usually rounded.

2.1.7



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2.1.8

surface of ovaries, renal tubule walls (proximal convoluted tubules), pancreatic acini cells, the salivary acini cells, thyroid follicles

2.1.9

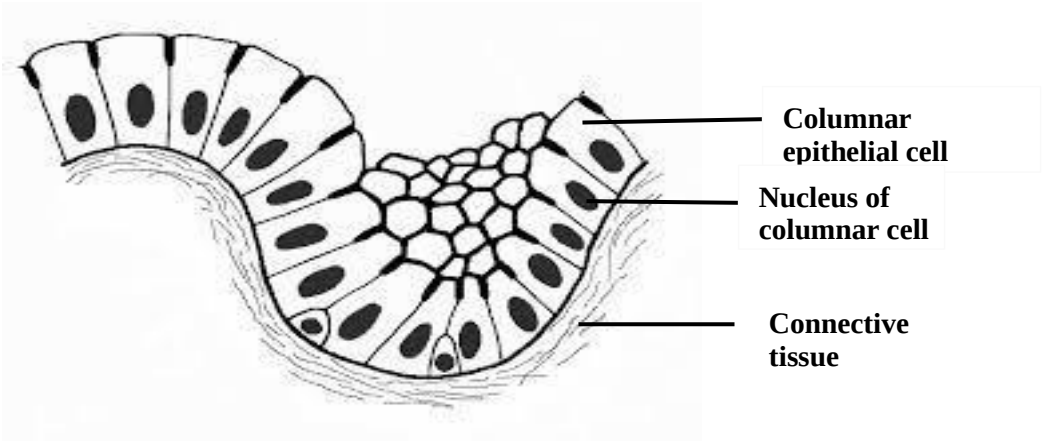
These cells offer secretory, absorptive, or excretory functions and therefore often provide protection via active (pumping material into or out of the lumen) or passive mechanisms depending on the physiological location and cellular specialization. The cytoplasm has more organelles like endoplasmic reticulum and mitochondria compared to simple squamous, which are responsible for several metabolic and functional activities that facilitate secretions. There are few cases in which microvilli are found on the free surface of the cuboidal cells facilitate absorptions.

2.1.10

Simple columnar epithelium is similar to simple cuboidal epithelium except that the cells are taller and appear columnar in sections perpendicular to the basement membrane.

The height of the cells may vary from low to tall columnar, depending on the site and/or degree of functional activity. The nuclei are elongated and may be located towards the base, the center or occasionally the apex of the cytoplasm; this is known as the polarity of the nucleus.

2.1.11



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2.1.12

Lining epithelium of stomach, small intestine, colon, gallbladder

2.1.13

This type of epithelium is commonly adapted for secretion, absorption and protection. The striated border of the cells is the surface modification of absorptive columnar cells and consist of numerous non-motile minute microvilli which give the striated or brush border appearance and increase the surface area for absorption.

Glandular goblet cells are a type of simple columnar cell that functions to secrete mucins. The nucleus of a goblet cell is found polarized at the base of the cell, as well as the other cellular organelles. The rest of this elongated cell type is composed of cytoplasm occupied by membrane-bound secretory granules that serve to secrete mucin, and are polarized towards the apical surface. Goblet cells help to protect the membrane through formation of a protective mucinous layer that provides lubrication and protects the organ lining from foreign irritants.

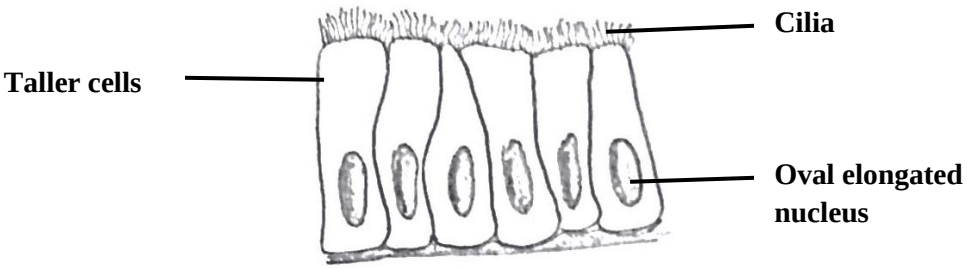
2.1.14

Some simple columnar epithelia have surface cilia on the majority of the cells. Among the ciliated cells are scattered non-ciliated cells that usually have a secretory function.

Cilia are much larger than microvilli and are readily visible with the light microscope. Each cilium consists of a finger-like projection of the plasma membrane, its cytoplasm containing modified microtubule.

The predominant cell type in this epithelium is tall columnar and ciliated, the nuclei being located towards the mid zone of the cells.

2.1.15



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2.1.16

Lining epithelium of fallopian tube, uterus, endo-cervix

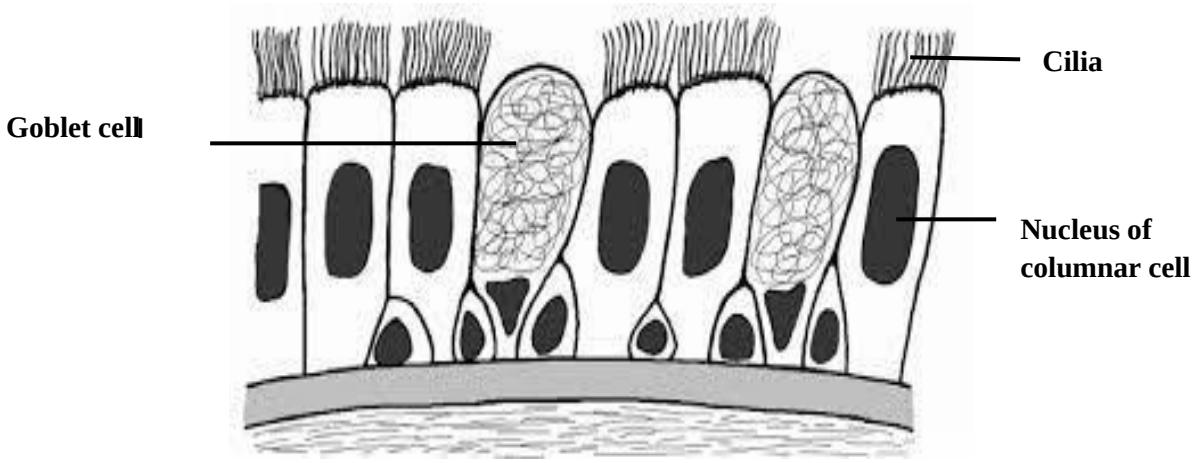
2.1.17

The waving motion of the cilia propels fluid or minute particles over the epithelial surface and they facilitate the movement of substances in the lumen. Due to the movement of the cilia in ciliated columnar epithelium, this type generally plays a role of clearing or moving substances or very small foreign bodies. In the female reproductive system, the ciliated columnar epithelium lines the lumen of the uterine tube and the movements generated by the cilia propel the egg towards the uterus. In male reproductive tubes, epithelium facilitates propel of spermatozoon.

2.1.18

This is a true simple epithelium, since all the cells rest on the basement membrane. The nuclei of these cells, however, are disposed at different levels, thus creating the illusion of cellular stratification. Scattered stem cells are found throughout the epithelium. These cells generally are devoid of cilia and are less differentiated cells. They do not extend to the luminal surface. The individual cells of the pseudostratified epithelium exhibit polarity, with nuclei being mainly confined to the basal two-thirds of the epithelium. Cilia are present on these cells. Flask shaped goblet cells are present along the epithelium.

2.1.19



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2.1.20

Lining epithelium of nasal cavity, trachea, bronchi, bronchioles, vas deferens and epididymis

2.1.21

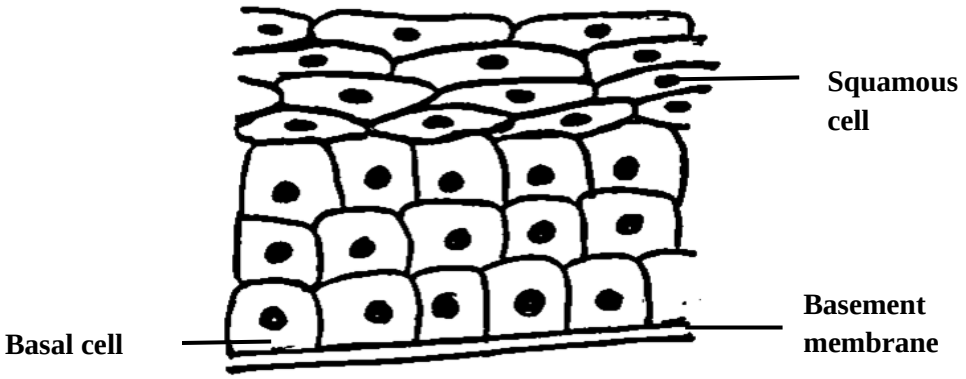
This type of epithelium is found in regions where there is a need to secrete mucus to trap foreign bodies and sweep those particles away through the coordinated action of cilia. Additionally, they are also seen in locations where the epithelia have a combined secretory and absorptive function, such as in the vas deferens and epididymis. Such tissues usually contain stereocilia, which are cytoplasmic projections made of actin microfibrils those facilitate the absorptive and secretory functions.

The presence of pseudostratified columnar epithelium in the upper respiratory tract (composed of the nose, trachea and bronchi) protects the lungs from these irritants. Goblet cells of the epithelium secrete mucus to trap particles and prevent them from traveling further down respiratory passages. The coordinated action of cilia on longer columnar cells facing the lumen moves the mucus along with the particulate matter away from the lung. While smaller particles are removed as a part of the normal drainage of the nose, larger or heavier particulate loads are sneezed or coughed out.

2.1.22

Stratified squamous epithelium consists of a variable number of cell layers that exhibit maturation from a cuboidal basal layer to a flattened surface layer. The basal cells which are adherent to the underlying basement membrane include continuously dividing stem cells, their offspring migrating towards the surface and cell become flat cells or squamous cells. Keratinizing stratified squamous epithelium constitutes the epithelial surface layers containing keratin and is adapted to withstand the constant abrasion and desiccation to which the body surface is exposed

2.1.23



2.1.24

Non-keratinized stratified squamous epithelium - oral cavity, tongue, oesophagus, rectum and vagina

Keratinized stratified squamous epithelium - skin, lips and hard palate

2.1.25

Stratified squamous epithelium consists of multiple layers of squamous epithelial cells arranged in layers upon a basal membrane. Only one layer is in contact with the basement membrane; the other layers adhere to one another to maintain structural integrity and this structural arrangement facilitates the protection of the tissue by mechanical and chemical pressure.

Stratified squamous epithelium is adapted to withstand abrasion, with plentiful cell junctions and a prominent intermediate filament (keratin) cytoskeleton. The cells of the basal layer are mitotically active and renew the epithelium continuously.

Non-keratinized surfaces must be kept moist by bodily secretions to prevent them from drying out.

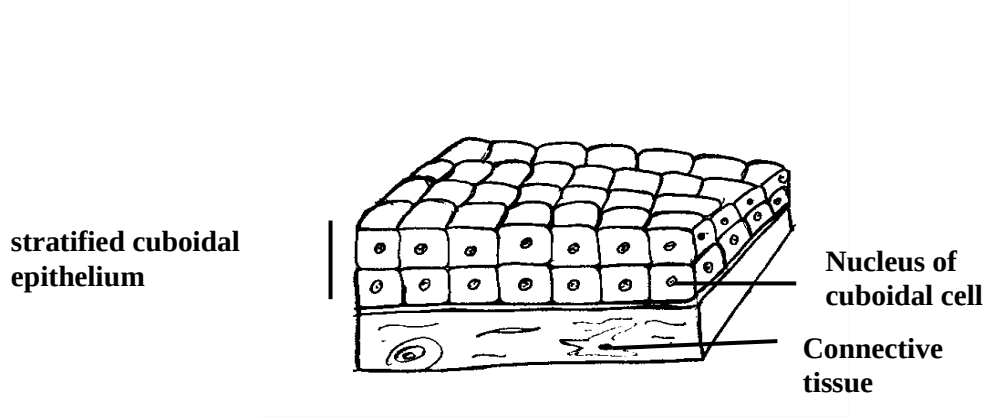
Even non-keratinized surfaces, consisting as they do of keratinocytes, have a minor superficial keratinized layer of varying thickness, depending on the age of the epithelium and the damage it has experienced.

Keratinized surfaces are protected from abrasion by keratin and kept hydrated and protected from dehydration by glycolipids produced in the stratum granulosum.

2.1.26

Stratified cuboidal epithelium is a thin, stratified epithelium that usually consists of only two or three layers of cuboidal cells.

2.1.27



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2.1.28

Lining of the larger excretory ducts of exocrine glands such as the salivary glands, pancreas

2.1.29

Stratified cuboidal epithelium is a type of epithelial tissue found mainly in glands, which specialize in selective absorption and secretion by the gland into blood or lymph vessels.

Wherever it is found, stratified cuboidal epithelium serves two general purposes: secretion and protection. Stratified cuboidal epithelium typically makes multiple membrane junctions between adjacent cells. In effect, this creates an impermeable barrier between two distinct surfaces in the body. This barrier acts like a filter, forcing nutrients and water to pass through the cells.

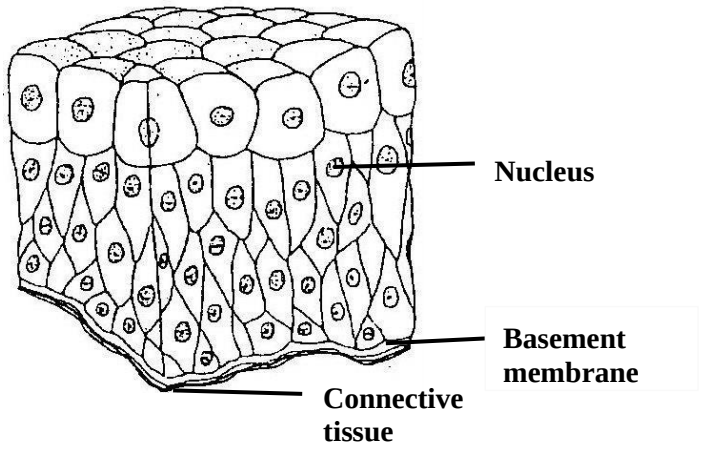
Stratified cuboidal epithelium provides a more robust lining than would be afforded by a simple epithelium.

2.1.30

Transitional epithelium (or urothelium) is a form of stratified epithelium. This epithelial type has some features intermediate (transitional) between stratified cuboidal and stratified squamous epithelia. In the non-distended state, transitional epithelium appears to be about four to five cell layers thick.

The basal cells are roughly cuboidal, the intermediate cells are polygonal and the surface cells known as umbrella or dome cells are large and rounded and may contain two nuclei. In the stretched state, transitional epithelium often appears only two or three cells thick and the intermediate and surface layers are extremely flattened

2.1.31



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2.1.32

Lining of urinary bladder, ureters and pre-prostatic urethra

2.1.33

The appearance of transitional epithelium depends on the layers in which it resides. Cells of the basal layer are cuboidal, or cube-shaped, and columnar, or column-shaped, while the cells of the superficial layer vary in appearance depending on the degree of distension. These cells appear to be cuboidal with a domed apex when the organ or the tube in which they reside is not stretched. When the organ or tube is stretched the tissue compresses and the cells become stretched. When this happens, the cells flatten, and they appear to be squamous and irregular.

The transitional epithelium cells stretch readily in order to accommodate fluctuation of volume of the liquid in an organ. Transitional epithelium also functions as a barrier between the lumen, or inside hollow space of the tract that it lines and the bloodstream. To help achieve this, the cells of transitional epithelium are connected by tight junctions, or virtually impenetrable junctions that seal together to the cellular membranes of neighboring cells. This barrier prevents re-absorption of toxic wastes and pathogens by the bloodstream

2.1.34

Type of epithelium	**Sub-classification**	**Sites**	**Functions**
Squamous	Simple	Lining of blood vessels (endothelium), lining body cavities (mesothelium), alveoli of lungs, Bowman ‘s capsule and loop of Henle of kidney	Diffusion, Filtration, Absorption
	Stratified non-keratinized	Lining oral cavity, epiglottis, oesophagus, anus, cervix, vagina, vulva, glans penis, cornea	Protection
	Stratified keratinized	Skin (epidermis) /hard palate, lip	Protection
Cuboidal	Simple	Renal tubules, small ducts of exocrine glands, exocrine acini surface of ovary	Absorption, Secretion
	Stratified	Larger ducts of exocrine glands	Absorption Protection
Columnar	Simple	Stomach, small intestine, large intestine, gallbladder, collecting ducts of kidney,	Secretion, Absorption
	Pseudostratified ciliated	Respiratory tract lining epithelium: nose, trachea, bronchi and bronchiole	Secretion, Protection, Transportation
	Simple ciliated	Fallopian tubes, uterus	Transportation
Transitional		Lower urinary tract (renal pelvis, ureters, bladder and urethra)	Allows expansion / stretch Protection

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The book is an excellent resource for medical students interested in learning about the ultrastructure of cells, tissues, organs, and organ systems in the human body. In each practical session designed for MBBS Degree programme, preclinical medical students can make use of the histology notebook to record their observations/microscopic images of cells, tissues, and organ systems. Students can obtain the skills needed to answer histology questions in MBBS Degree examinations by answering the questions in each practical session.