HISTOLOGY PRACTICAL MANUAL

FOR

Second Year Health Science Students

PART 2: Organ Systems

SCHOOL OF ANATOMICAL SCIENCES
UNIVERSITY OF THE WITWATERSRAND

PRACTICAL HISTOLOGY FOR SECOND YEAR HEALTH SCIENCE STUDENTS

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Adapted and revised in 2012, 2014 from the original work of

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SCHOOL OF ANATOMICAL SCIENCES

FACULTY OF HEALTH SCIENCES

UNIVERSITY OF THE

WITWATERSRAND JOHANNESBURG,

SOUTH AFRICA

PART 2: THE ORGAN SYSTEMS

PART 2: The Organ Systems

Consist of:

1. Skin
2. Cardiovascular System
3. Lymphatic System
4. Respiratory System
5. Central Nervous System
6. Digestive System
7. Urinary System
8. Reproductive Systems
9. Endocrine System

These organ systems are made up of different combinations of primary tissues.

A NOTE ON STAINING TECHNIQUES

1. The most common dyes used for staining tissue sections are haematoxylin (blue) and eosin (pink). Haematoxylin acts as a basic dye and reacts with cell components that are acidic (e.g. DNA, thus staining the chromatin blue); structures that stain with basic dyes are said to be basophilic. Eosin is an acidic dye and is therefore bound by basic structures (e.g. cytoplasm of many cells), which stain pink and are said to be acidophilic or eosinophilic. Please do not refer to structures as staining "blue" or "pink" with H & E.

2. In order to demonstrate specific structures other stains may be used for the demonstration slides e.g. the Periodic Acid-Schiff technique (PAS) is used to demonstrate acid mucopolysaccharides. Structures that stain magenta with this stain are referred to as Pas +ve. Osmium Tetroxide, which is a fixative, will stain lipid black and is often used to demonstrate myelin. It is also used in electron microscopy.

The Skin

OBJECTIVES

- To understand and describe the overall structure of Skin
- To list the basic tissues that make up the skin
- To understand and be able to describe the differences between thin and thick skin
- To be able to draw the structure of thick and thin skin
- To know the main functions of thick and thin skin
- To understand the concept of and to describe the structure and function of the main epidermal derivatives
- To be able to describe the process of keratinisation

NOTES

Notes from Ross and Paulina, Histology a Text and Atlas 5th addition, 2005

The skin and its derivatives constitute the integumentary system. The skin is the first organ system that you will study. It is also the largest organ in the human body constituting 15 to 20 % of the body mass.
Skin derivatives or epidermal derivatives or epidermal appendages and their products include hair follicles, hair, sweat glands, sebaceous glands, nails, claws, mammary glands and some other more specialised features (eyelashes; tear ducts).

The skin itself consists of two layers, the epidermis (from ectoderm) composed of a **keratinised stratified squamous epithelium** and the dermis (from mesoderm) consisting mainly of **dense irregular connective tissue.** The underlying hypodermis is not strictly part of the skin and consists of variable amounts of lobulated adipose tissue (=adipose with connective tissue septa). So the skin consists essentially of two basic tissues: epithelium and dense irregular connective tissue.

The skin and its derivatives constitute a complex organ composed of many different cell types. The diversity of these cells and their ability to work together provide a way for the individual to cope with the external environment.

So just to summarise, the functions of skin include:
- Barrier
- Homeostasis
- Sensory
- Endocrine
- Excretion

Note that skin is permeable to some lipid rich substances and although this is not a function of skin as such, we tend to use this property to deliver pharmaceutical preparations, for example steroid hormones.

The topography of skin is more or less uniform, but different regions are characterised by certain features. For example, most of the body is covered with thin skin; "**thin" refers to the thickness of the epidermis;**

thick skin is found in the palms of the hands and on the soles of the feet this skin is also hairless. Note that the thickest thin skin is found on the upper part of the back.

PRACTICAL WORK

I. THIN SKIN

Skin of scalp
Slide: 36
Stain: H & E

Macroscopic and L.P.

Note:

- The thin epidermis with rete pegs
- The dermis with the papillary and reticular layers
- The hypodermis (tela subcutanea) mostly adipose tissue
- Hair follicles and sebaceous glands in the reticular layer of the dermis
- The many cross sections of the coiled end-pieces of the eccrine sweat glands in the dermis and hypodermis
- Blood vessels, nerves and muscle

Draw a map diagram of thin skin. Label with the features listed above.

(a) The epidermis of thin skin

Under H.P. study and draw a few cells of each of the layers of the epidermis.

- The stratum basale (the basal layer). What shape are the cells?
  - Note the melanin granules within the cells of the stratum basale and the "clear" cells without melanin interspersed between the basal cells.
  - What are the "clear" cells and what is their function?

- The stratum spinosum - "prickle cells" - how many rows of cells?
- The stratum granulosum - basophilic granules in the cytoplasm (1-2 rows)
- The stratum corneum - several rows of eosinophilic flattened cells without nuclei.

Note: You may see the spiral course of the duct of an eccrine sweat gland passing through the epidermis. What type of secretion occurs in these glands?

The cells on the surface of the epidermis are continually being worn away. What mechanism compensates for the loss of cells and where does it occur?

(b) Epidermal derivatives

Skin of scalp
Slide: 36
Stain: H&E

Sebaceous glands

Under L.P. find a sebaceous gland opening into a hair follicle

Study and draw:

- The flattened cells of the basal layer of the gland

- The change in shape of the secretory cells from the base of the gland to the duct region.
- The frothy appearance of the cells
- The debris in the lumen of the duct

Classify the sebaceous gland.
What is the composition of the secretion produced and what is its function?

What is the mode of secretion of the sebaceous gland?

Eccrine sweat glands

Under L.P. locate the duct and secretory endpiece of an eccrine sweat gland in the dermis and study and draw them under H.P.

In the secretory end piece note the:
- Small lumen
- Secretory cells - what shape?
- Myoepithelial cells - location?

In the duct note the:
- Narrow lumen
- Two layers of cells lining the lumen

What type of epithelium lines the duct?
What type of epithelium lines the secretory end piece?

Classify the sweat gland.
What is the chemical nature of sweat and what is its function?

Hair follicles

Under L.P. locate a hair follicle in transverse section in the dermis.

Identify the:

- Outer connective tissue sheath
- Outer root sheath - 2-3 layers of vacuolated cells
- Inner root sheath which stains eosinophilically
- Hair shaft which is pigmented (they have often fallen out in the sections)

In L.S. identify the same structures as in T.S. and also note the:

- Bulb of the hair
- Dermal papillae
- Arrector pili muscle (what type of muscle is it and what other epidermal derivative is it associated with?)

Apocrine sweat glands (M)

Skin of axilla
Slide: 29
Stain: H&E

Apocrine sweat glands are found only in a few areas of the body, namely the axilla, the anal and genital regions.

Under L.P. and H.P. draw:

- The large lumen of the secretory portion
- The epithelial cells lining the lumen of these glands (what type?)

Classify these glands with respect to morphology, type/mode of secretion and nature of secretion.

Skin of palm or fingertip
Slide: 35/42
Stain: H&E

Study the epidermis under L.P. and H.P. and use the scheme outlined for the study of thin skin.

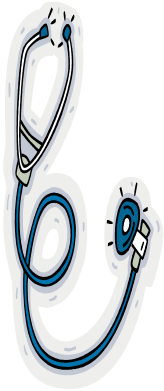
Note that there are 5 layers in the epidermis of thick skin.
How does the epidermis of thick skin differ from that of thin skin?

How does the dermis and hypodermis of thick skin differ from that of thin skin?

GLANDS OF THICK SKIN

Eccrine sweat glands

L.P. Identify an eccrine sweat gland and a duct.
Note the position of the secretory end piece and the duct in relation to the surrounding tissue.



Clinical Correlation

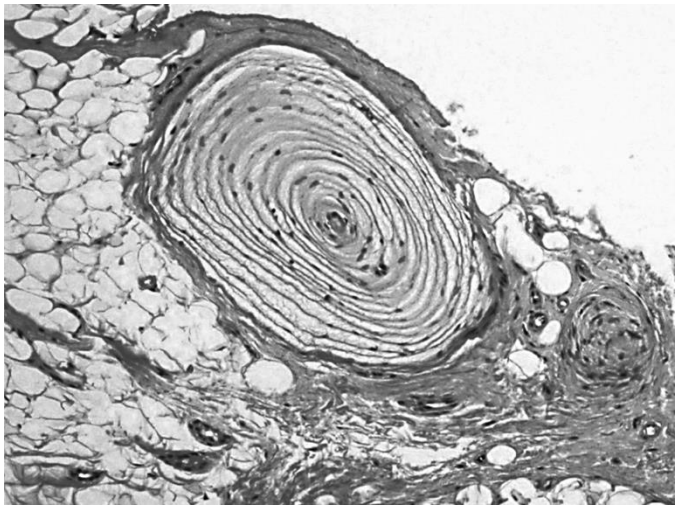
Many systemic diseases have cutaneous manifestations often presenting as skin lesions. The skin lesion may be the first manifestation of the disease. These diseases include the systemic auto-immune diseases such as lupus erythematosus, rheumatoid disease and progressive systemic sclerosis where soft tissue is replaced by collagen. In diabetes mellitus, patients may develop shiny or yellowish depressed plaques on their legs owing to degeneration of dermal collagen known as necrobioses lipoidica.

Stevens et al. (2009). Core Pathology. Third edition. Mosby, Elsevier.

III. NERVE ENDINGS (ENCAPSULATED) IN THE SKIN
Skin of palm or fingertip
Slide: 35/42
Stain: H&E

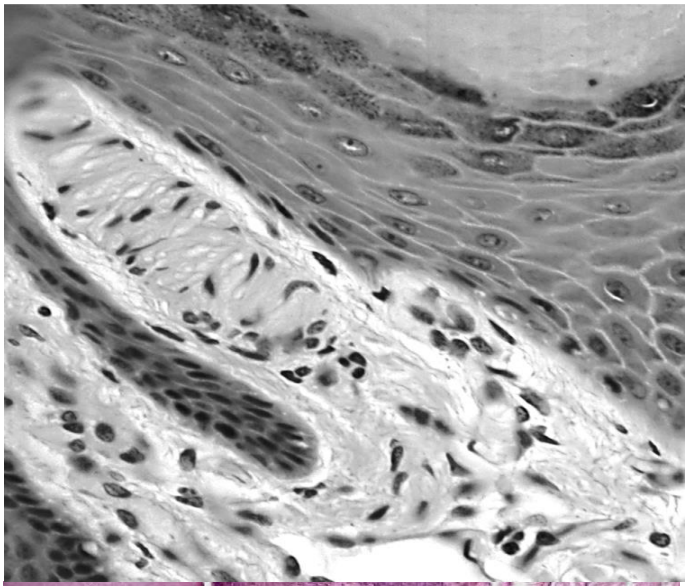
See demonstration: also look at your section:

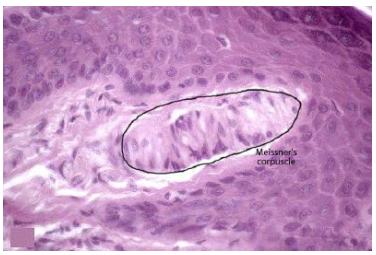
- Tactile (Meissner's) corpuscles
- Lamellated (Pacinian) corpuscles

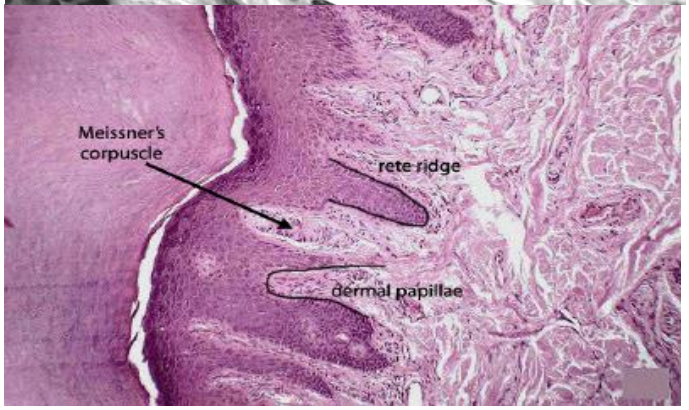


Pacinian corpuscle: A type of deep pressure receptor seen in the hypodermis. These are for the detection of vibration and pressure.

Note *the dense irregular connective tissue and lobulated adipose tissue.*

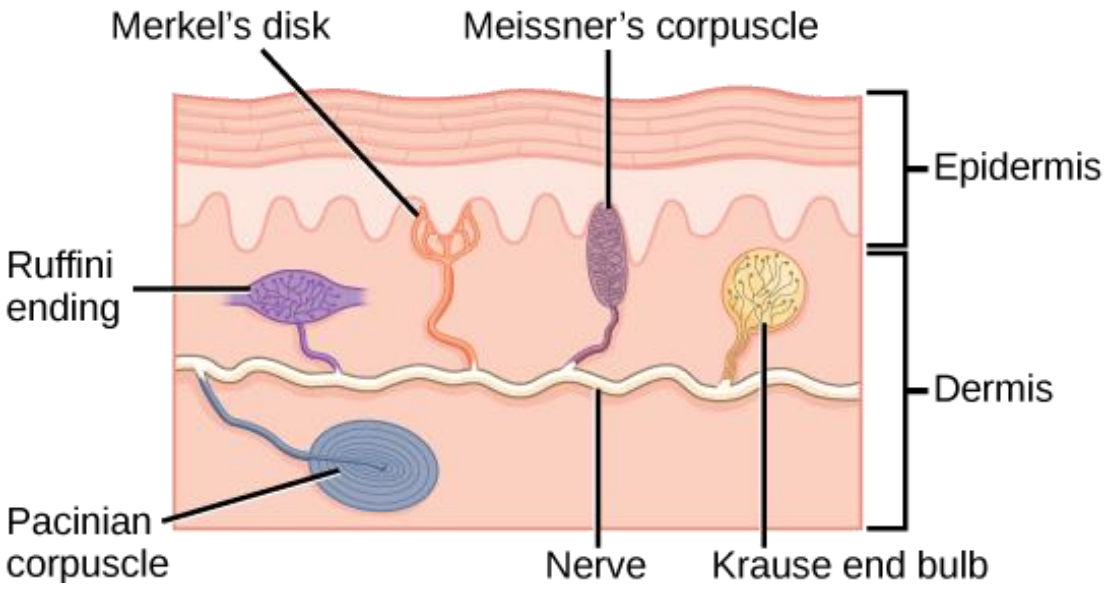


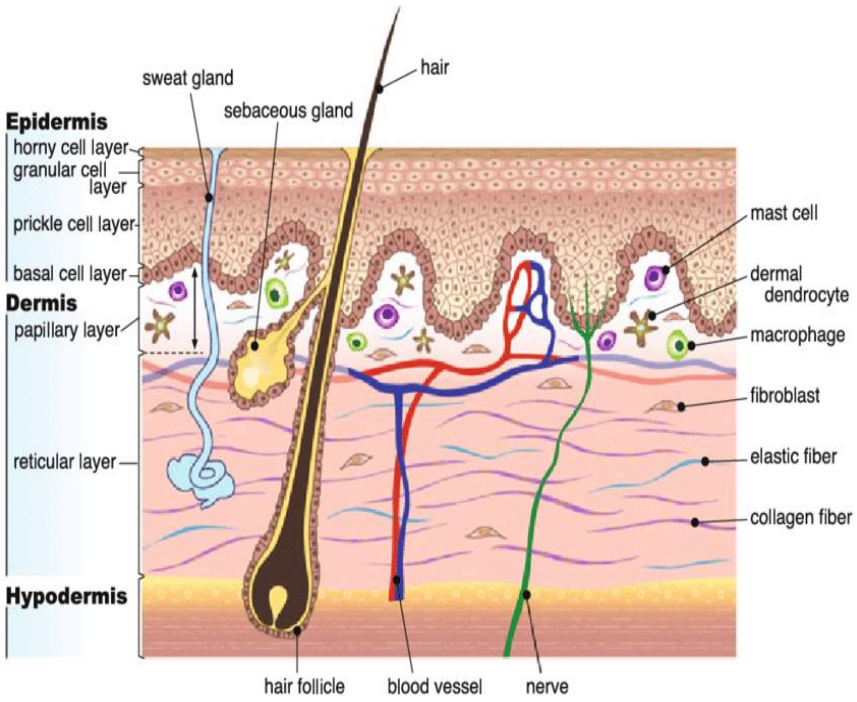




Three classes of mechanoreceptors: tactile, proprioceptors, and baroreceptors. Mechanoreceptors- stimulated due to physical deformation of their plasma membranes. They contain mechanically-gated ion channels whose gates open or close in response to pressure, touch, stretching, and sound. Four primary tactile mechanoreceptors in human skin: Merkel's disks, Meissner's corpuscles, Ruffini endings, and Pacinian corpuscle.Two located→ surface of the skin and two are located deeper.

A fifth type of mechanoreceptor, Krause end bulbs, are found only in specialized regions.





RECAPITULATION
SKIN

1. List the distinguishing features of thin skin and thick skin

2. From which part of the skin are the hair follicles and sebaceous glands derived?
3. From which part of the skin are the eccrine sweat glands derived?
4. What type of connective tissue predominates in the reticular layer of the dermis?
5. What are the functions of skin?

6. From which germ layer are each of the following layers derived?
    a. epidermis
    b. dermis

The Cardiovascular System

OBJECTIVES

To identify, and describe the histological structure and function of blood vessels.
To understand the number of layers and components of each layer
To know the differences between the layers in different types of vessels
To link the histological structure of the layers of each vessel type to its function

NOTES

The cardio-vascular system is a transport system that carries blood and lymph to and from the tissues of the body. It is a closed system of vessels which includes the heart, arteries, arterioles, capillaries, venules and veins. Differences in content and thickness of the wall can be directly related to differences in function.
Follow the scheme outlined below when studying the blood vessels.

TAKE NOTE OF THE FOLLOWING:

- The overall diameter of the vessel
- The shape and size of the lumen
- The coats in the wall - relative thickness and tissue components
- The presence of an endothelium
- The presence or absence of internal and/or external elastic laminae

PRACTICAL WORK

1. Medium-sized (muscular) artery

Neuro-vascular bundle
Slide: 26
Stain: H&E, elastic

Macroscopic: Identify the blood vessels with their open lumina.

Under L.P. identify the medium sized (muscular) artery by its size, and its thick wall. Use the scheme outlined above and draw a topographical diagram to illustrate the characteristic features of this vessel.

Under H.P. make a detailed histological drawing of part of the wall of the artery from the lumen to the adventitia.

2. Medium-sized vein

Neuro-vascular bundle
Slide: 26
Stain: H&E, elastic

L.P. and H.P. Study and illustrate the structure of a medium-sized vein in the same way as outlined for the medium-sized artery. Also look for valves in this vessel.

Tabulate the similarities and differences in structure between the medium-sized artery and vein

What are the functions of medium-sized arteries and veins?

3. Elastic (large) artery

Aorta
Slide: 28
Stain: Stained for elastic only

Note the many discontinuous elastic laminae in the wall of the aorta.
What is the function of elastic arteries?

4. Arterioles, Venules and Capillaries

Jejunum
Slide 85
Stain: H&E

Macroscopic and L.P. Look for blood vessels in the broad layer of connective tissue in the middle of the section (of this slide of jejunum)

Using the same scheme study and draw the smaller vessels under H.P.

Distinguish between small arteries, arterioles and venules.

Look for capillaries under H.P. These vessels have a very narrow lumen only slightly wider than the diameter of the red blood corpuscle ie 7.5μm. (Any RBCs present will thus be in single file). Study and draw a capillary under H.P.

Lymphatics may be confused with veins and venules. They are thin walled, may contain lymph but no RBCs. Valves may be seen in both veins and lymphatic vessels.

Tabulate the similarities and differences in structure between:

- small arteries and arterioles
- arterioles and venules
- veins and lymphatic vessels

What are the distinguishing features of capillaries?

What is the function of each of the vessels listed above?

THE HEART

Section of left ventricle and atrium
Slide: 83
Stain: H&E, elastic

Macroscopic and L.P: Identify

- The broad muscular wall of the ventricle and the thinner wall of the atrium
- The atrio-ventricular (in this case, mitral) valve projecting from the endocardial surface
- The groove between the atrium and the ventricle, containing adipose tissue and a coronary artery.

(a) The ventricle wall

L.P. Study and draw the layers of the ventricle wall. Remember to look for the mesothelium of the epicardium.

It is said that the heart is a "modified blood vessel". What is implied by this statement?

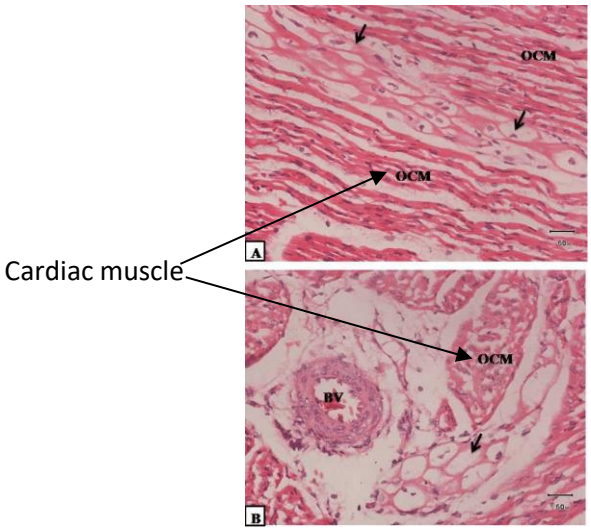
(b) Interventricular septum

Slide: 57
Stain: Iron haematoxylin

Under L.P. and H.P. look for a region where "ordinary" cardiac muscle fibres are cut longitudinally and banding is evident and revise the structure of

- The "ordinary" cardiac muscle fibres in transverse section;
- Purkinje fibres in L.S. and T.S. (these are larger and paler than "ordinary" cardiac muscle fibres
- The blood vessels in the endomysium.

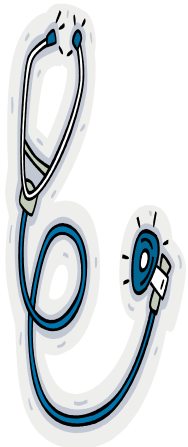
Revise the differences in structure between Purkinje fibres and "ordinary" cardiac muscle fibres (see Muscle)



A: Photomicrograph showing Purkinje Fibres (arrows) in camel foetus of 131 cm CVRL. Purkinje fibers parallel to the ordinary cardiac muscle (OCM). B: PF (arrow) near the blood vessel in the same heart in A. H&E (X40).

What is the function of the Purkinje fibres?

Clinical Correlation



Accelerated or malignant hypertension refers to a situation where the increase in blood pressure is of rapid onset and marked degree i.e. systolic and diastolic blood pressures are greater than 220 and 120mmHg respectively. Under these circumstances, muscular arteries develop severe thickening of the tunica intima by proliferation of intimal cells. In moderate hypertension the tunica media and the internal elastic lamina remain unchanged. In severe hypertension the intimal cells undergo rapid proliferation which is often complicated by disruption of the vessel wall, with leakage of plasma proteins, including fibrinogen, into and beyond the arteriolar wall

Young, B., Stewart, W., O'Dowd, G. (2011). Wheater's basic pathology. Fifth edition, Churchill, Livingstone

RECAPITULATION
CARDIOVASCULAR SYSTEM

QUESTIONS.

1. Name the three layers forming the wall of blood vessels and briefly describe the general structure of each.
   A

   B

   C

2. Name the three types of capillaries and explain the structural and functional differences between them.

3. What are vasa vasorum and where are they found?

4. Relate the structure of the ventricular wall of the heart to the typical pattern of blood vessels.

5. Complete the following table. Use the notes in your practical manual to decide on appropriate features for comparison.

FEATURE	LARGE ELASTIC ARTERY	MEDIUM MUSCULAR ARTERY	SMALL ARTERY	ARTERIOLE	CAPILLARY	VENULE	VEIN

The Lymphatic System

OBJECTIVES

To identify and understand the histological structure and function of:

Cell types of the lymphatic system:

- Lymphocytes (effector cells of the immune system)
- Granulocytes (neutrophils, eosinophils, basophils)
- Antigen-presenting cells (dendritic cells, follicular dendritic cells, macrophages)
- Reticular cells and epithelioreticular cells

Distributions of lymphatic tissue

- Diffuse lymphatic tissue
- Nodular lymphatic tissue
- Partially encapsulated lymphatic organs
- Encapsulated lymphatic organs

NOTES

Ross & Pawlina, (2011). Histology A Text and Atlas 6th Edition.

The lymphatic system includes lymphatic vessels and all organs and parts of organs within the body made up of lymphoid tissue.

Lymphatic capillaries begin as blind-ended tubes in many tissues. These vessels are lined by endothelium, and contain one-way valves. At strategic points they pass through *lymph nodes* where the lymph, consisting of predominantly water and dissolved substances like electrolytes and proteins, is scanned for *antigens* and thereafter returned to the venous system. Any substance that can induce an immune response is commonly referred to as an antigen. Before an immune response can be mounted, the antigen must first be processed.
While lymphatic vessels are found in most tissues and organs, they are absent from the CNS, the eyeball, internal ear, the epidermis, cartilage and bone.

Lymphoid tissue is an accumulation of the cell types of the lymphatic system (see objectives). Nodular and diffuse lymphoid tissue will be encountered in all the organ systems, but particularly in the respiratory and digestive tracts (consider the exposure of these systems to pathogens).

Macrophages are the first line of defence against bacteria for example. They recognise bacteria through receptors that bind to the components found on bacterial surfaces. Neutrophils are also phagocytic and play a key role in innate immunity.

Two types of adaptive immune responses are noted:

1) The humoral response

- This response is associated with B lymphocytes which when activated differentiate into antibody-producing plasma cells

2) The cell-mediated response
    - This response is associated with specific T lymphocytes that destroy foreign cells, infected cells, and even tumour cells.

T and B lymphocytes of the adaptive immune system first undergo antigen-independent activation in the primary lymphatic organs, with the T lymphocytes becoming *immunocompetent* in the thymus and B lymphocytes achieving the same in the bone marrow. Gut-associated lymphatic tissue (GALT) is also regarded as a primary lymphatic organ. This type of activation allows lymphocytes to distinguish between self and non-self antigens. These *immunocompetent* lymphocytes then undergo antigen-dependant activation in the secondary lymphatic organs which include: lymphatic nodules, lymph nodes, tonsils and spleen. Antigen-presenting cells (see objectives) are required to process encountered antigens and help initiate the immune response.

PRACTICAL WORK

When studying any part of the lymphatic system,

Note:

- Whether the lymphoid tissue is nodular (arranged as a discrete concentration of cells) or diffuse
- The cell types present ie. reticular cells (produce the reticular fibre framework), medium-sized and small lymphocytes, plasma cells, fixed macrophages lining the sinusoids (pale-staining, sausage-shaped nuclei and ingested particles), fixed or free macrophages in the stroma.

I. THE LYMPH NODE

Slide: 45
Stain: H&E

Lymph nodes are encapsulated lymphatic organs interposed along lymphatic vessels. They filter lymph and trap particulate matter for subsequent processing and presentation to lymphocytes.

Macroscopic and L.P.:

Study and draw a segment across the lymph node from capsule to hilum to illustrate in detail the structure of:

- The capsule with afferent lymphatic vessels entering the lymph node.
- Trabeculae of connective tissue continuous with the capsule and extending through the cortex and into the medulla.
- The superficial cortex with primary and/or secondary lymphatic nodules and deep cortex with diffuse lymphoid tissue
- The medulla with medullary cords continuous with the cortical areas
- The subcapsular sinus and paratrabecular sinuses of the cortex, and the medullary sinuses.
- The efferent lymphatic vessels (with valves) and blood vessels at the hilum.

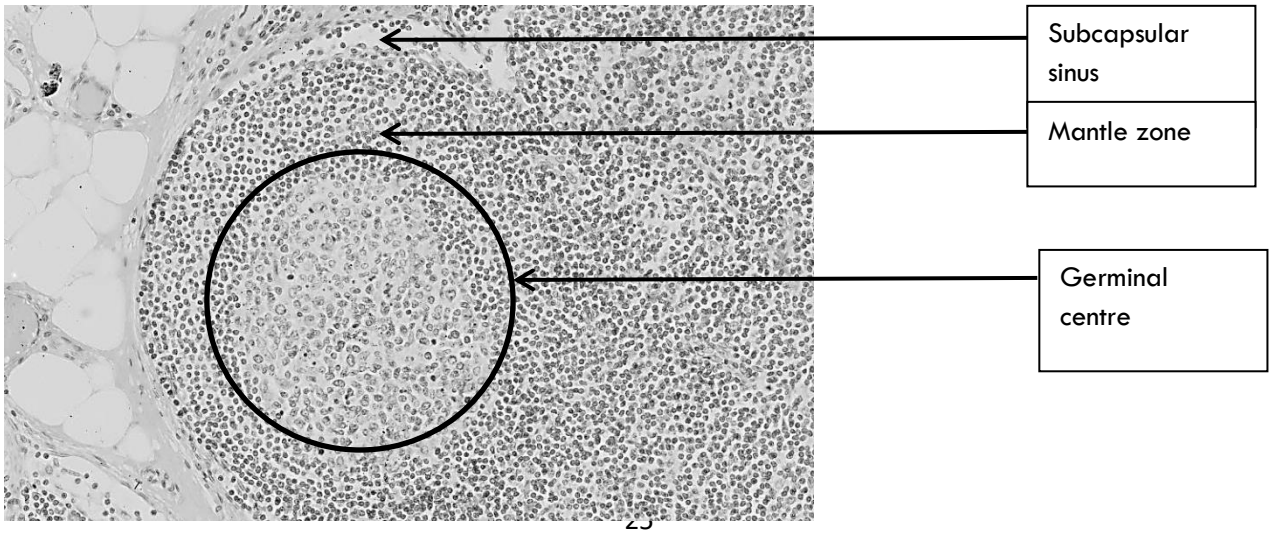
By means of arrows indicate in your diagram the course of lymph flow through the lymph node.

H.P.:

Study the finer detail of the cortex, medulla and associated lymphatic sinuses:

- The endothelial lining of the lymphatic sinuses and cell types found within the sinuses
- The specialised high endothelial venules found in the deep cortex
- The medulla with medullary cords continuous with the cortical areas
- The subcapsular sinus and paratrabecular sinuses of the cortex, and the medullary sinuses.
- The efferent lymphatic vessels (with valves) and blood vessels at the hilum.

The Lymph Node – Cortex showing Secondary Lymphatic Nodule



QUESTIONS.
Which cell types form the parenchyma of this organ?

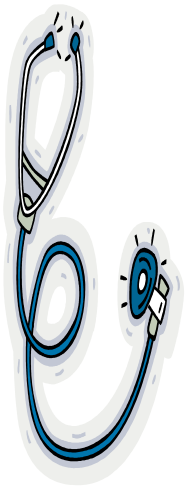
Can you identify the capsule and adipose tissue?

Give a possible reason as to why a secondary lymphatic nodule has developed in this organ and comment on its function.

What is the function of a lymph node?

Relate the functions of the cell types present to the function of the lymph node as a whole.

Clinical Correlation



Lymphadenopathy

Lymph nodes draining sites of infection respond to antigenic stimuli by cell proliferation leading to lymph node enlargement (lymphadenopathy). Depending on the antigenic stimulus, a lymph node may exhibit a B-cell response with proliferation of cells in the germinal centre (and at times the marginal zone).

Underwood and Cross, (2009). General and Systemic Pathology 5th Edition.

Ross & Pawlina, (2011). Histology A Text and Atlas 6th Edition.

II. THE SPLEEN **(M)**

The spleen performs both immunologic and haemopoietic functions. Immunologic functions would include, as indicated in the notes section – antigen-presentation by specific cells to B and T lymphocytes and their resulting activation and proliferation. Haemopoietic functions include the destruction of senescent or damaged erythrocytes (which cell type would assist in the removal of these obsolete erythrocytes?) and recycling of haemoglobin. The spleen is also responsible for the formation of erythrocytes during early foetal stages.

(a) The Spleen

Slide: 47
Stain: H&E

Macroscopic and L.P.:

Identify and draw:

- The connective tissue capsule covered by a mesothelium (the mesothelium is part of the peritoneum)
- Trabeculae containing blood vessels
- The basophilic white pulp within which is the 'central artery' surrounded by lymphocytes constituting the periarterial lymphatic sheath (PALS)
- Expansions of PALS within the white pulp (germinal centres) which displace the central artery to an eccentric position
- The red pulp with splenic sinuses and splenic cords (of Billroth)
- The hilum on the medial surface of the spleen (note the passage of nerves, blood and lymphatic vessels)

Under H.P.:

QUESTIONS.

Identify and draw:

- Splenic sinuses (describe the lining endothelium) and splenic cords

Why are the splenic corpuscles called "white pulp"?

Why are the splenic sinuses and splenic cords called "red pulp"?

Why is the spleen considered to be part of the lymphatic system?

Describe or illustrate the route of the blood as it circulates through the spleen.

Account for the presence of extravascular red blood corpuscles in the splenic cords (of Billroth).

What is haemosiderin and where is it formed?

What are the functions of the spleen? Relate the functions of the cell types present to the functions of the spleen as a whole.

(b) The Spleen **(M)**

Slide: 48
Stain: Wilder's silver impregnation method

Examine this slide

Note *that the structural elements stained with silver consist of reticular fibres. The basement membrane of the endothelial cells lining blood vessels are also evident.*

III. THE TONSIL **(M)**

Slide: 34
Stain: H&E

Examine the slide.

IV. THE THYMUS **(M)**

Slide: 71
Stain: H&E

The thymus is a lymphoepithelial organ derived from the third and sometimes from the fourth pharyngeal pouches. It is a bilobed organ located in the superior mediastinum anterior to the heart. Recall that the thymus is a *primary lymphatic organ.* T lymphocytes are *primed* i.e. undergo *antigen-independent differentiation* in this organ. The epithelioreticular cells that form the meshwork of the organ also form functional barriers that allows for compartmentalisation for T lymphocyte education. Importantly they also form part of the blood-thymic barrier that is essential to preventing developing T lymphocytes from contact with blood-borne antigens (consider which other cells types would form part of this barrier).

The thymus is fully formed and functional by birth but begins to regress, or *involute* with most of the tissue being replaced by adipose tissue after the onset of puberty. If circumstances are such that rapid T cell proliferation is required, the thymus can be restimulated.

Macroscopic and L.P.:

Identify and draw:

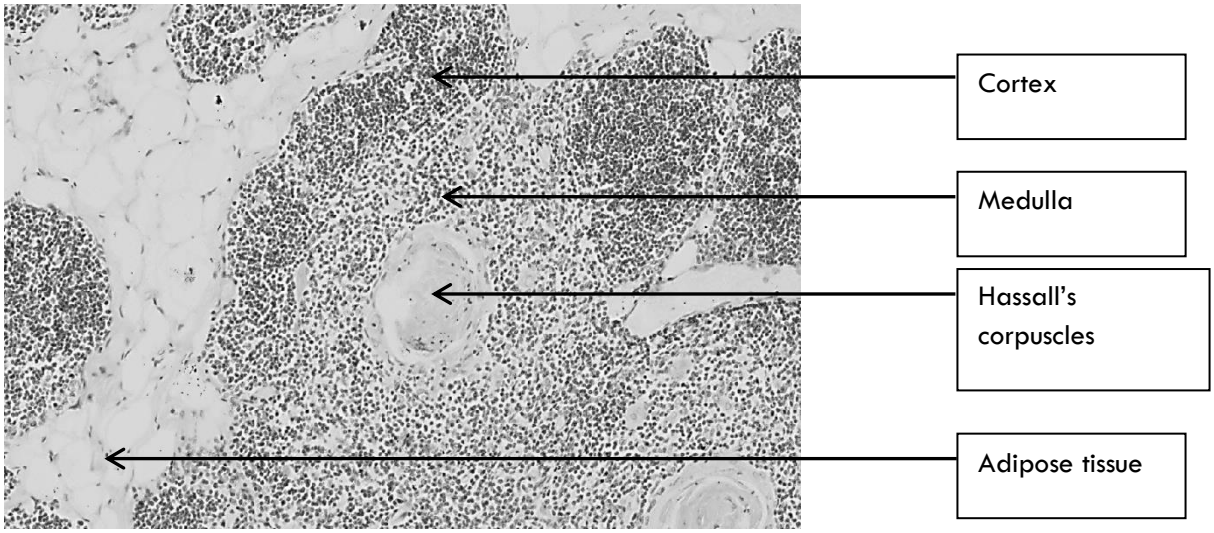
- The eosinophilic capsule and trabeculae
- The thymic lobules with a darkly basophilic cortex and a central, light-stained medulla with Hassall's (thymic) corpuscles

H.P.:

Identify and draw:

- Hassall's (thymic) corpuscles composed of concentrically arranged, flattened type VI epithelioreticular cells with a keratinised core
- The developing T lymphocytes (thymocytes)
- The meshwork of epithelioreticular cells

Thymus



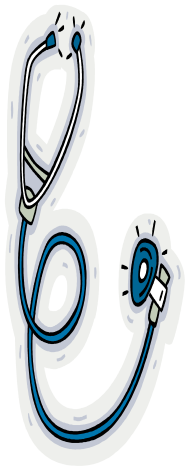
Is the lymphoid tissue of the thymus nodular of diffuse?
Why is the medulla more lightly stained than the cortex?

Account for the abundance of adipose tissue in this section of thymus.

Describe the structure and function of the blood-thymus barrier.

What type of epithelioreticular cell forms the Hassall's corpuscle?

Clinical Correlation



Myasthenia gravis is an autoimmune disease in which antibodies are produced against the acetylcholine receptors. These antibodies block the ability of the receptor to bind to acetylcholine, hindering normal nerve-muscle interaction and thus leading to progressive muscle weakness. The thymus, in patients presenting with this disease, exhibits lymphoid hyperplasia – similar to spleen and lymphoid nodules when undergoing an immune response. This leads to autoimmunity by affecting a particular subset of T lymphocytes (regulatory T lymphocytes) which control antibody production by differentiated B lymphocytes (plasma cells).

Underwood and Cross, (2009). General and Systemic Pathology 5th Edition.

1. What is the overall path a T cell takes in the body?

a. T cells start in the bone marrowand then are released to continue gene rearrangement
b. From the bone marrow, T cells travel to the thymus to develop
c. Mature T cells then travel to secondary lymphoid tissuesand then to the site of infection or to macrophages.

2. What are the main structural features of the thymus?

a. Cortex
i. Outer part of the thymus that is tightly packed and consists of ectodermal cells
ii. Has thymocytes and macrophages
b. Medulla
i. Inner part of the thymus that is less dense and consists of endodermal cells
ii. Has thymocytes, dendritic cells, and macrophages
c. Thymic anlage (skeleton of the thymus)
i. Combination of the ectodermal and endodermal cells that are early in development and is later colonized in the bone marrow

3. What is the thymic anlage?

a. The early thymus that acts as the skeleton of the thymus

4. Why is it okay, although not desirable, to get a thymectomy?

a. T cell repertoireis long-lived and self-renewing so by getting rid of your thymus, you'll still have enough T cells to self renew
b. The older you get, the less action the thymus takes in developing T cellsi.Thymus starts degrading after puberty

5. What kind of cells enter the thymus?

a. Progenitor stem cells enter the thymus and do not have T cell markers

RECAPITULATION
THE LYMPHATIC SYSTEM

QUESTIONS.

1. Distinguish between nodular and diffuse lymphatic tissue.

2. Which lymphatic tissues have you studied that are 'encapsulated'?

3. Which lymphocytes are responsible for the "humoral immune response"? Where are such lymphocytes found in the lymphoid organs that you have studied? How are they derived?

4. What are plasma cells and where are they found? What is their function? How are they derived?

5. Which lymphocytes are responsible for the "cellular immune response"? Where are such lymphocytes found in the lymphoid organs that you have studied? How are they derived?

6. Give three distinguishing characteristics of the lymph node cortex.

7. Give three distinguishing characteristics of the lymph node medulla.

8. Give three distinguishing characteristics of the white pulp of the spleen. **(M)**

9. Give three distinguishing characteristics of the red pulp of the spleen. **(M)**

10. What is the function of the thymus? **(M)**

11. Explain how the cortex and medulla of the thymus differs from the cortex and medulla of the lymph node histologically. **(M)**

12. What are Hassall's corpuscles? **(M)**

13. Why are there no germinal centres seen in the normal thymus? **(M)**

The Respiratory System

OBJECTIVES

- To identify the histological structure and function of respiratory and olfactory mucosa and relevant epithelia
- To identify the histological structure (cells, fibres, muscles, layers etc) and function of:
    - Trachea
    - Bronchus
    - Bronchiole
    - Terminal bronchiole
    - Respiratory bronchiole
    - Alveolar Ducts
    - Alveolar Sacs
    - Alveoli
- To understand the histological structure and function of interalveolar septum and blood-air barrier and differences between the two

NOTES

The respiratory system consists of the paired lungs and a series of air passages leading to and from the lungs. The main function of the respiratory system is uptake of oxygen from the inhaled air and elimination of carbon dioxide from the body. The respiratory system is divided into:

(a) **Conducting portion** - a series of patent passages which start from the nasal cavities (and during forced breathing the oral cavity) continuing with nasopharynx, oropharynx, larynx, trachea, bronchii, bronchioles and finally finish with the terminal bronchioles, all of which have a function in conducting the air to the respiratory tissue.

(b) **Respiratory portion** - where the gaseous exchange (respiration), between the air and the blood, is taking place. This unit includes respiratory bronchioles, alveolar ducts, alveolar sacs and alveoli.

Study the examples of different parts of the respiratory tract, noting the layers in their wall outlined under the general topography below. With progression along the respiratory passages in a distal direction, some tissues are absent (e.g. cartilage and glands), some become reduced (e.g. connective tissue) and some show a relative increase (e.g. smooth muscle and elastic). In the alveoli, where gaseous exchange takes place, the layers are reduced to a minimum. To understand this fully, refer to the diagram below, which explains divisions of the bronchial tree and gives a summary of its histologic features. Also, refer to the pattern within the wall of the respiratory system structures, covered in the respiratory system lecture.

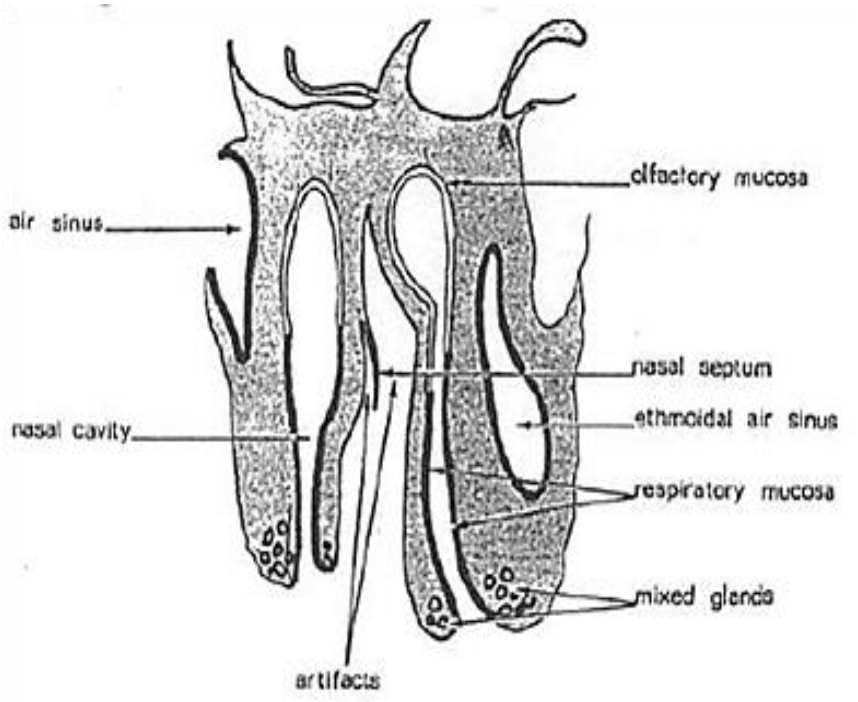
PRACTICAL WORK

THE CONDUCTING PORTION

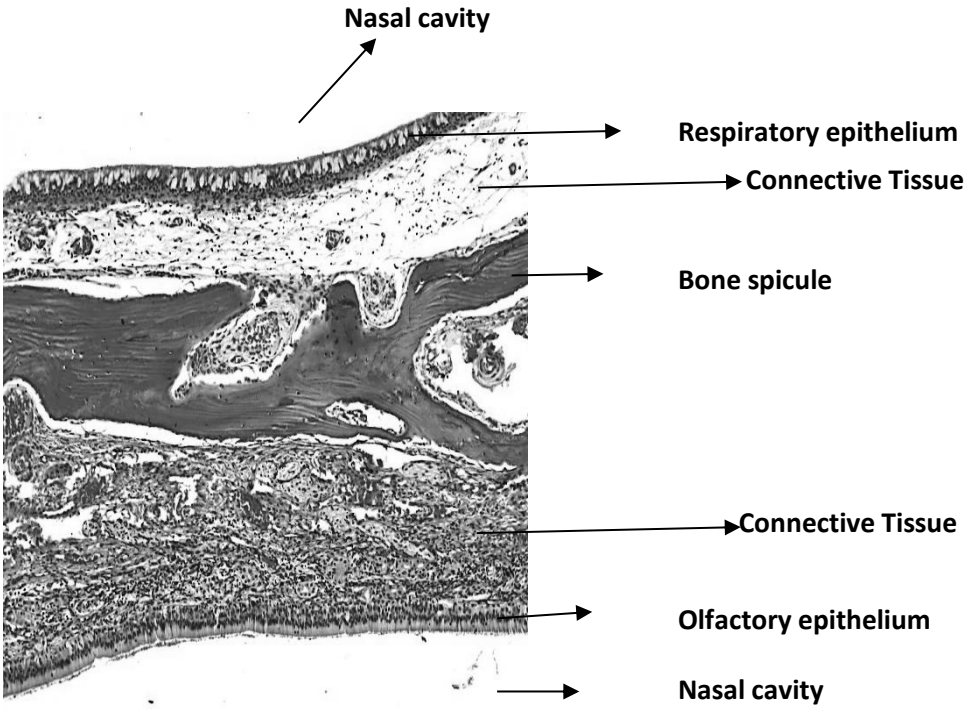
I. THE NASAL CAVITIES AND AIR SINUSES

Slide 67
Stain: H&E

This section includes the nasal cavities and the ethmoidal air sinuses. The supporting bone has been decalcified and stains eosinophilically. During preparation of the tissue, the mucoperiosteum was pulled away from the nasal septum - the space around the nasal septum, in most sections, is therefore an artefact. In the photomicrograph of nasal cavities you will study respiratory and olfactory mucosa. In order to orientate yourself use the diagram below.



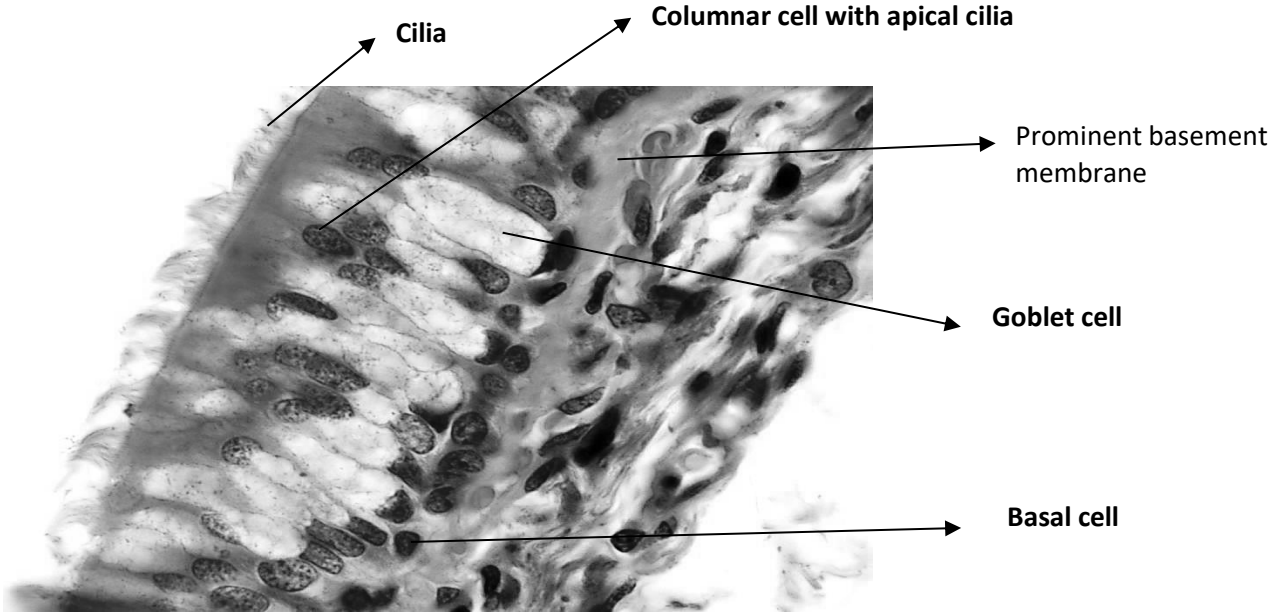
Coronal section through nasal cavities and air sinuses

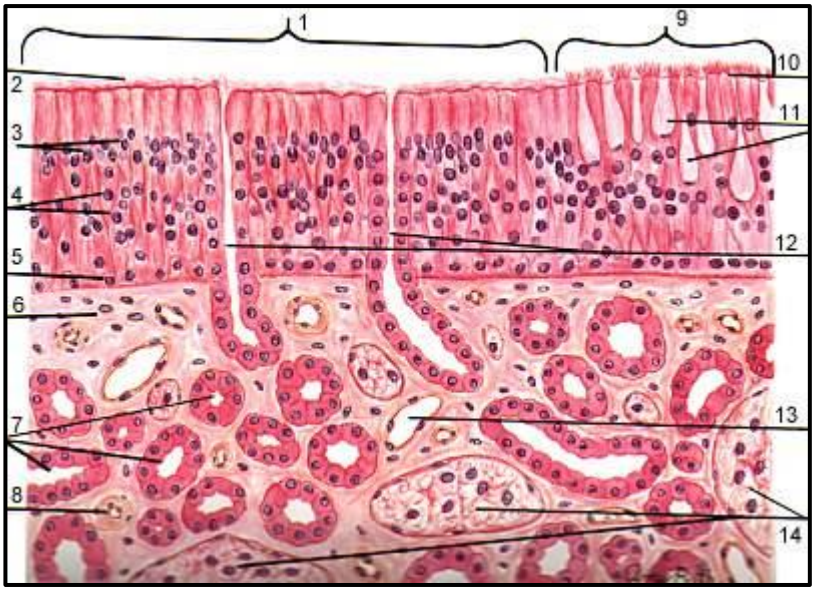


The above photomicrograph shows both respiratory and olfactory mucosa with their respective epithelia, underlying connective tissue and spongy-cancellous bone spicule (Revise the histological structure of the cancellous bone).

The "respiratory" mucosa

Under L.P (see the photomicrograph below) this region is identified by the prominent basement membrane. Typically, goblet cells and mucus-secreting glands (not shown) should be abundant in this region.





Olfactory mucosa (transition area) H&E. 500x

1=olfactory epithelium	2=surface mucus
3=nuclei of supportive cells	4=nuclei of olfactory cells
5=nuclei of basal cells	6=lamina propria
7=olfactory (Bowman's) glands	8=arteriole
9=respiratory epithelium	10=cilia
11=goblet cells	12=ducts of olfactory (Bowman's) glands
13=venule	14=olfactory nerves

Eroschenko (1993) *di Fiore's Atlas of Histology 7th Ed.* **Plate 81, Fig. 2, p. 213**

Note:

- The lining epithelium (what type?)
- The connective tissue (lamina propria) underlying the epithelium (what type?)
- The glands (mucous, serous or mixed?) and their ducts within the lamina propria
- The many large thin-walled veins and venous sinuses within the lamina propria
- The regular fibres of the periosteum that have been pulled away from the nasal septum but are continuous with those of the lamina propria

Under H.P. make a detailed drawing of a segment of the epithelium with goblet cells and cilia (See the above photomicrograph)

In your drawing illustrate:

- The small, spherical darkly stained nuclei of the basal cells (What is their function?)
- The oval, most superficial nuclei of ciliated columnar cells
- Flattened and very darkly staining nuclei of goblet cells (What is the function of these cells?)
- Columnar cells with short, blunt microvilli (difficult to distinguish between columnar ciliated cells)
- Small granule cells (difficult to distinguish at the LM level)

List the unique features of the respiratory mucosa.

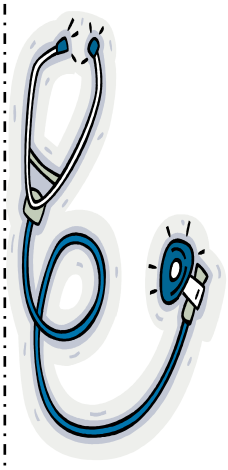
QUESTIONS.

Are the glands seen in this region simple or compound? Give a reason for your answer

What is meant by the term "mixed" gland?

What are the functions of:

- The cilia?
- The mucus?
- The abundant blood supply to the "respiratory" mucosa?



Clinical Correlation

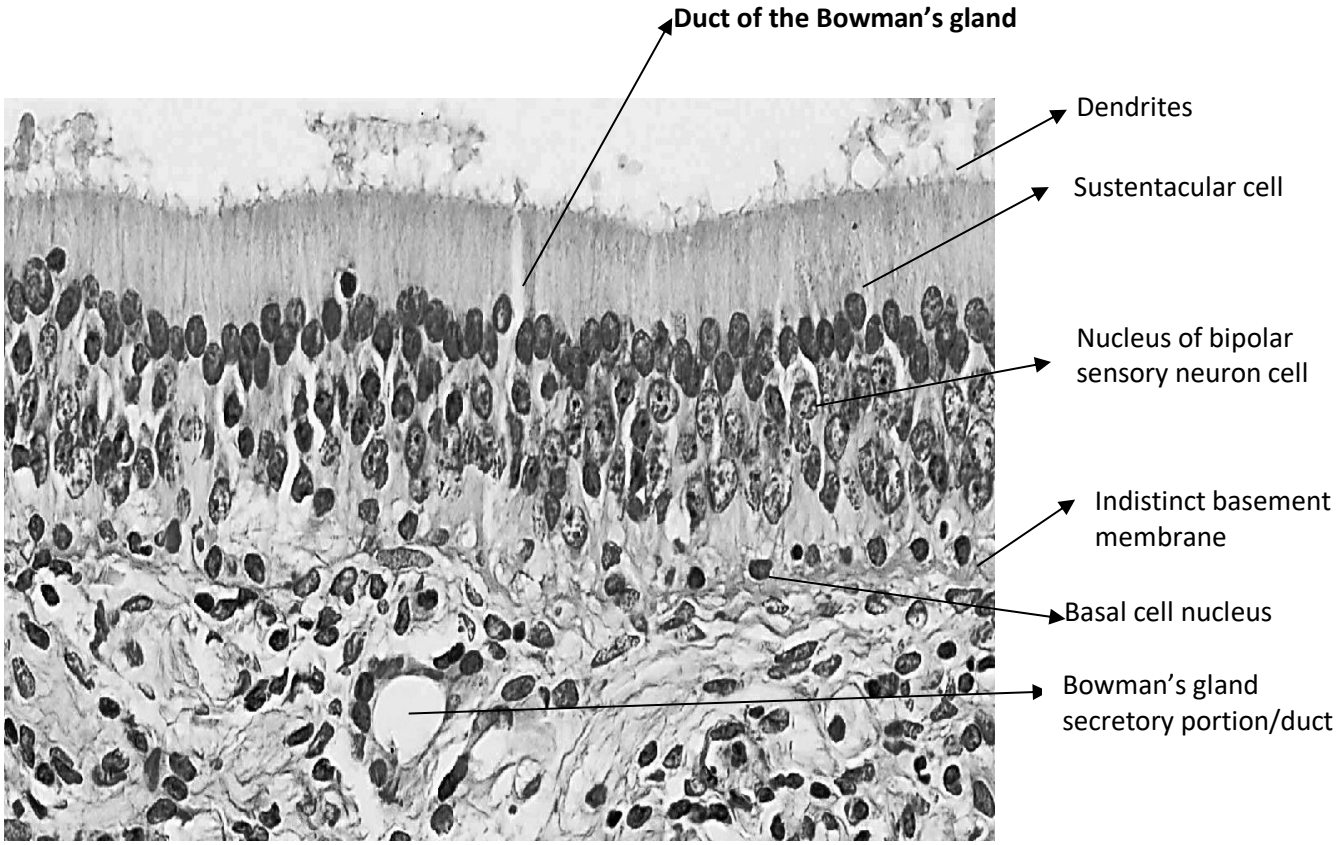
Primary ciliary dyskinesia also known as immotile cilia syndrome includes several hereditary disorders all affecting the function of cilia. These diseases are affecting 1 in 20 000 individuals at birth. Motile cilia covering the apical domain of the cells of respiratory tract epithelia are responsible for clearing the passageways from invading bacteria and other pathogens or mucous produced by the glands. Failure of this mucociliary transport occurs in Kartagener's syndrome which is caused by the structural abnormality which results in the absence of dynein arms. The similar problem occurs in Young's syndrome characterised by defect of radial spokes as well as dynein arms structure. The most prominent symptoms of these disorders are chronic respiratory distress which includes bronchitis and sinusitis, otitis media (inflammation of the middle ear), persistent cough and asthma

Netter's Essential Histology, W.K. Ovalle and P.C. Nahirney, Saunders, Elsevier

Histology A text and Atlas, 5th Edition, M.H. Ross and W. Pawlina, Lippincot Williams and Wilkins

The olfactory mucosa

The olfactory mucosa is situated in the roof of each nasal cavity. It may also extend down the sides for a short distance (Refer to the above diagram)



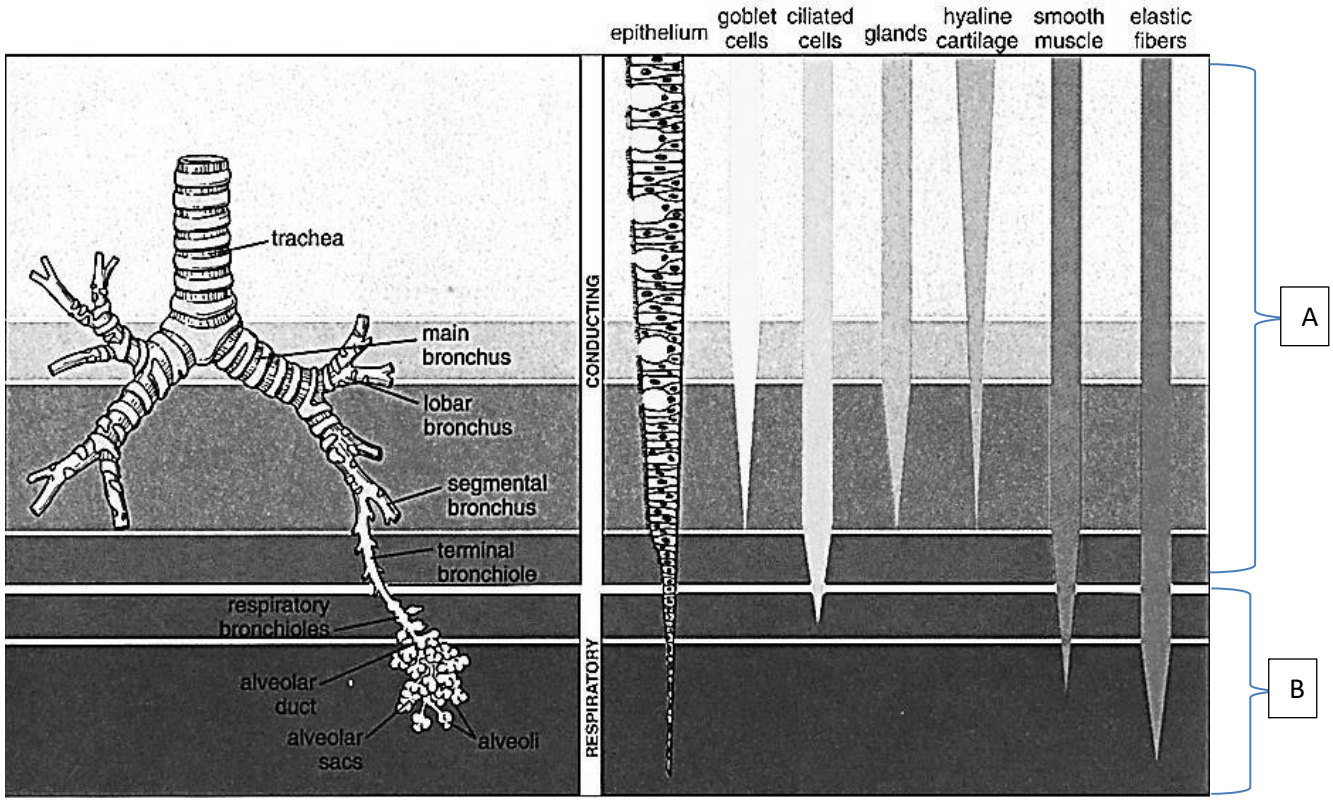
Under L.P. identify the epithelium (refer to the first photomicrograph of the nasal septum) by the lack of a visible basement membrane, the arrangement of the nuclei in three layers (the middle layer consisting of one to three rows of large spherical and vesicular nuclei) and the absence of goblet cells. How is this epithelium classified?

Under H.P. note and draw a small area to illustrate:

- The small, spherical darkly stained nuclei of the basal cells (distinguish carefully between these nuclei and those of lymphocytes wandering through the epithelium)
- The oval nuclei nearest the free surface - these belong to the columnar, supporting (sustentacular) cells
- The middle layer of large, spherical and vesicular nuclei of the bipolar sensory cells
- The peripheral processes (dendrites) of the bipolar sensory cells, between the supporting cells. What kind of neuron is a bipolar sensory neuron? Classify this type of a neuron?
- The lack of a visible basement membrane
- The serous glands (of Bowman)
- What is the function of the serous glands of Bowman?
- The bundles of nerve fibres, some of which convey impulses from the bipolar sensory cells
- The blood vessels. Note particularly, the large venous sinuses.
- List the distinguishing features of the olfactory mucosa

II. THE TRACHEA

Slide 32
Stain: H&E



Study the following structures (labelled 1 to 7) from both respiratory (B) and conducting (A) portions of the respiratory system, according to the following method:

OBJECTIVES

1. Know the basic components of the conducting and respiratory portions of the system and describe distinctive structural features of each component related to particular functions in respiration.
2. Know the types of cells present in the respiratory epithelium and their functions in respiration.
3. Be able to identify the trachea, bronchi, terminal bronchioles, respiratory bronchioles, alveolar ducts and alveoli of the respiratory tract on the basis of:

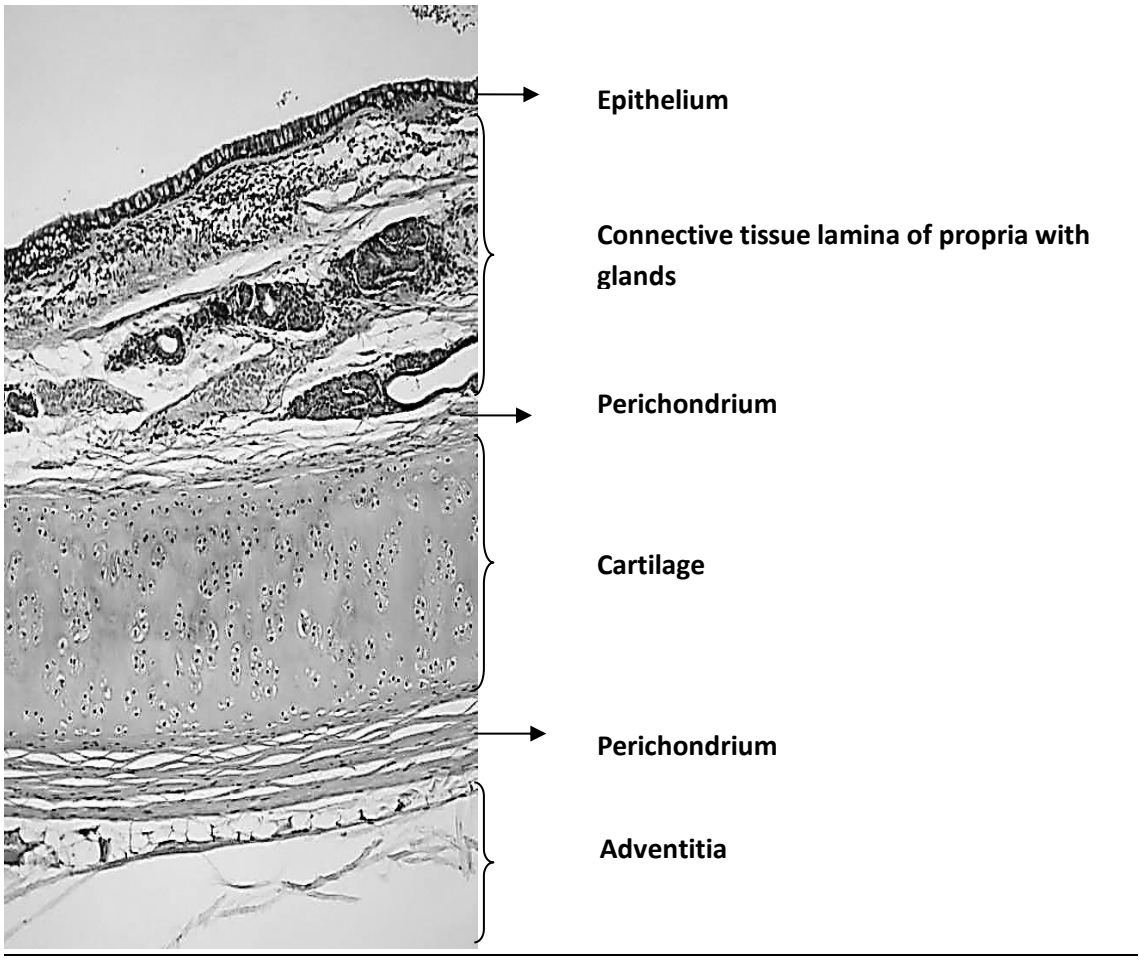
a. Epithelial cell types present, and relative amounts of glands, cartilage, smooth muscles and connective tissue fibers present in the wall of the tubes.

4. Be able to name the cellular and structural elements that form the blood-air barrier.

General topography:

1) Observe the layers of the structure wall, starting from the epithelium which surrounds its lumen (Again refer to the diagram above to fully understand the structural change in the epithelium from pseudostratified columnar to simple squamous epithelium)
2) Observe the increase/decrease in goblet cells and cilia at the epithelial apical surface
3) Look out for any specific structures in the connective tissue lamina propria (E.G. glands or accumulations of the lymphatic nodules)
4) Observe the increase in the elastic fibres. What is their function?

5) Observe variations in the presence and thickness of the muscularis mucosae. What is its function?
6) Observe the presence/absence of cartilage ring/plates in the submucosa
7) Briefly study the layer of the muscle called muscularis externa. What type of muscle is it?
8) Study the components of the last connective tissue layer – adventitia. What type of connective tissue is it?



Under L.P. and H.P. identify the trachea by the blue-stained plate of cartilage (C-shaped in entire section).

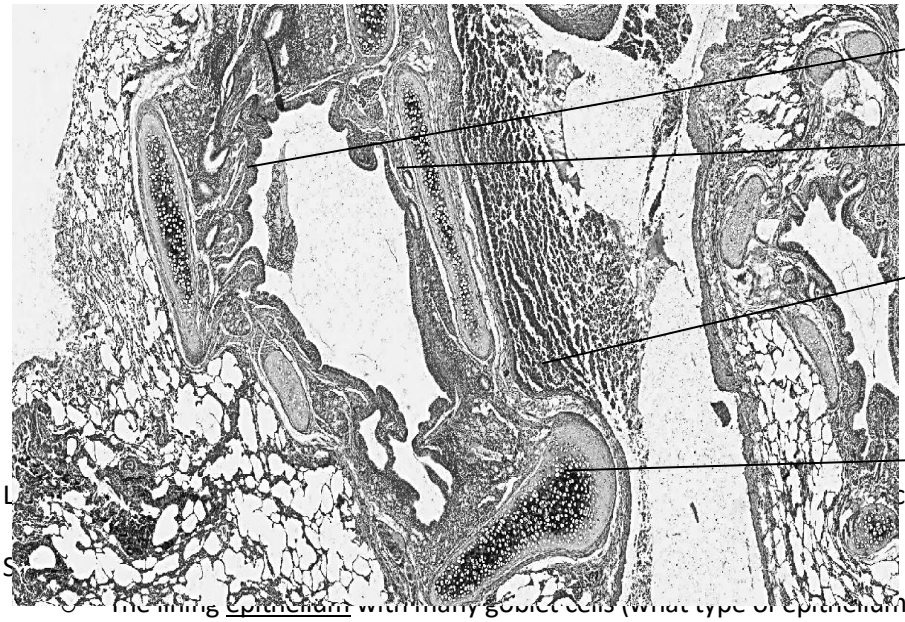
Study and draw:

- The lining epithelium (in some sections, goblet cells may be lacking; in others, the epithelium has been damaged). Revise and classify this type of epithelium?
- The plate of cartilage (what type?)
- The connective tissue (lamina propria) between the epithelium and the plate of cartilage (note particularly the elastic fibres)
- The glands within the lamina propria. What type? Revise: What kind of secretory end pieces are present in these glands? How do you distinguish between "duct" and "secretory end piece"
- The adventitia with blood vessels and nerves

- Also note, posteriorly, where the two end pieces of the C shape ring meet, the bundles of fibres of the trachealis muscle (what type?) and the position of the glands and elastic fibres in this region.

III. THE INTRAPULMONARY BRONCHUS

Hilus of lung
Slide 97
Stain: H&E and elastic stain



L… …t plates c… …walls.

S…

- The lining epithelium with many goblet cells (What type of epithelium is this? - check under H.P.)
- The plate of cartilage (what type?)
- The connective tissues lamina propria and submucosa between the epithelium and the plate of cartilage (note the abundance of elastic fibres)
- The band of smooth muscle fibres of the muscularis mucosa
- Within the connective tissue of submucosa, locate the secretory end-pieces of the glands (which type(s)?)

Also, include in your diagram any other structural features e.g. lymphoid tissue, blood vessels and nerves, and indicate their relationship to the other parts of the wall.

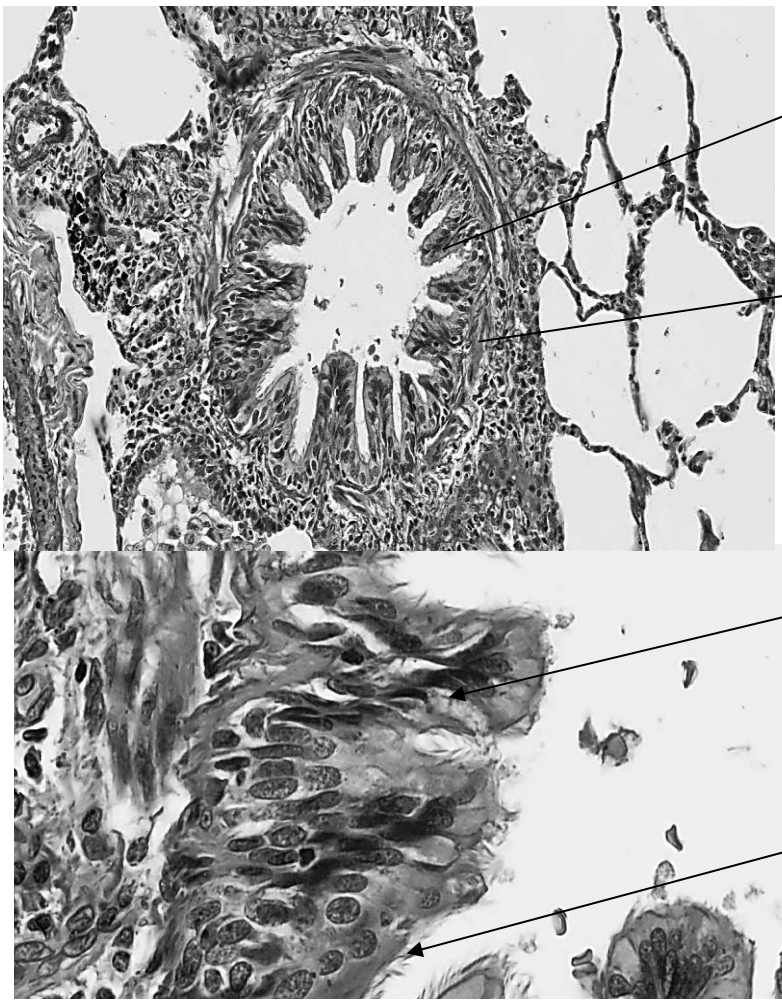
Tabulate the similarities and differences in structure between the trachea and the intrapulmonary bronchus.

IV. THE BRONCHIOLES

Lung

Slide: 97 & 98

Stain: H&E and elastic stain



Under L.P. and H.P. note and draw the following

- The epithelial lining of the bronchiole lumen (What type?)
- The scattered goblet cells within the epithelium
- The lack of glands and cartilage in the mucosa
- The presence of a thick smooth muscle band. What is its function?

V. THE TERMINAL BRONCHIOLE

Lung
Slide: 97 & 98
Stain: H&E and elastic stain

Terminal bronchiole is the last structure in the conducting portion of the respiratory system. Under L.P. identify a terminal bronchiole - smaller than the bronchiole and also completely surrounded by respiratory tissue. A simple, ciliated cuboidal epithelium without goblet cells lines the lumen.

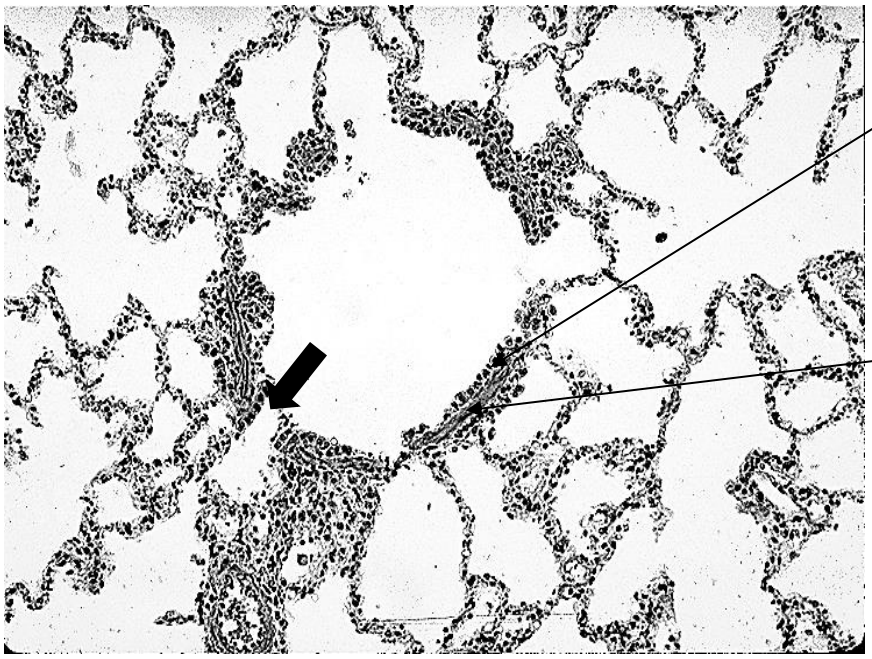
Draw and label a terminal bronchiole to illustrate the distinguishing features using the general topography outline.

THE RESPIRATORY PORTION

The respiratory units of the lung are made up of respiratory bronchioles, alveolar ducts, alveolar sacks and alveoli.

I. THE RESPIRATORY BRONCHIOLE **(M)**

Lung
Slides: 97 and 98
Stain: H&E and elastic stain



The respiratory portion starts with the respiratory bronchiole. Under L.P. identify a respiratory bronchiole. Proximally, simple ciliated cuboidal epithelial cells interspersed with Clara cells line the respiratory bronchioles, while distally, Clara cells predominate.
Note and tabulate the presence/absence of goblet cells/cartilage/glands/smooth muscle. The epithelium of the respiratory bronchiole becomes continuous with the simple squamous lining of the alveolar duct (see where the thick arrow is pointing in the above photomicrograph).

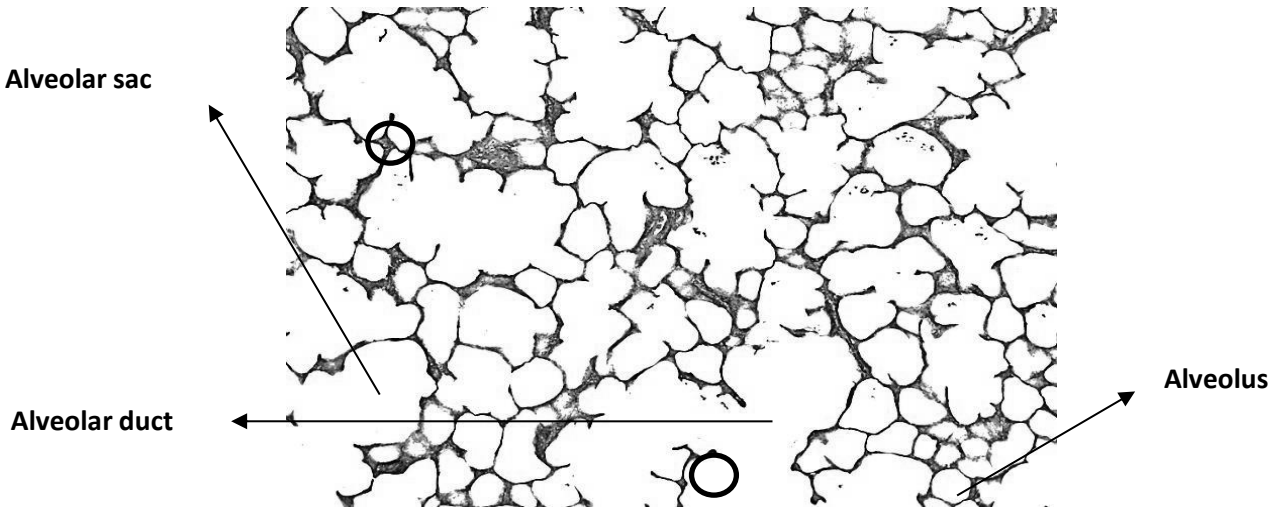
Draw and label the distinguishing features of a respiratory bronchiole.

II. THE ALVEOLAR DUCT **(M)**

Lung
Slides: 97 and 98
Stain: H&E and elastic stain

Under L.P identify an alveolar duct (See labels below). These are elongated structures which may be interrupted by the openings of the alveolar sacs.

Under H.P. note: The alveolar ducts are airways with alveolar outpockets. The alveolar ducts are lined by simple squamous cells. Protrusions of smooth muscle cells cause knob-like bulges (encircled in black in the photomicrograph below) between the openings of the alveolar sacs. Alveolar sacs are spaces surrounded by clusters of alveoli.



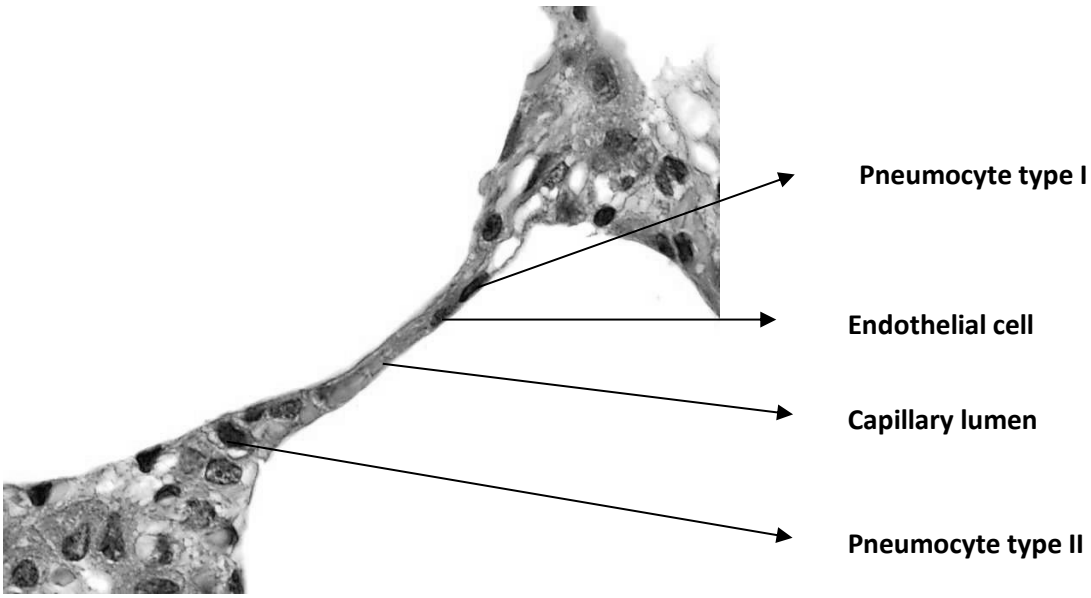
III. THE ALVEOLI

Lung
Slides: 97 and 98
Stain: H&E and elastic stain

The openings to the alveoli from the alveolar duct are numerous. The small portions of the wall of the alveolar duct that remain are reduced to knob-like thickenings which contain eosinophilic smooth muscle (encircled in black in the above photomicrograph).

Under L.P. and H.P. the entrances to the alveoli can be identified by these eosinophilic knob-like thickenings. Adjacent alveoli are separated from one another by interalveolar septa i.e. they are so closely applied to one another that each alveolus does not have a separate wall of its own.

Under L.P. and H.P., note the structure and arrangement of the alveolar ducts and the alveoli.
Under **oil immersion** study and draw an interalveolar septum (see next page) noting the:

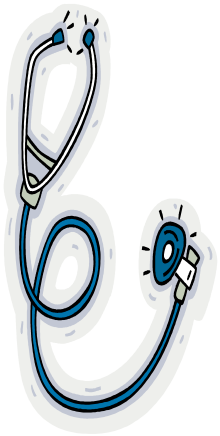


- Pneumocytes type I cells - Attenuated simple squamous cells lining the alveolus on each side with flattened nuclei. What is their function?

- Pneumocytes type II cells - Cuboidal septal cells, occur in groups of 3 -4 and have spherical, pale-staining nuclei. What is their function?

- The fibro-elastic connective tissue between the two epithelial layers which contains a rich capillary plexus.
- "Dust cells" or alveolar macrophages identified by ingested foreign particles.

Clinical Correlation



Infant respiratory distress syndrome is a common disorder affecting 10% of premature infants. Due to premature birth, pneumocyte type II cells fail to develop and mature properly which causes inadequate surfactant production. The premature babies have difficulties with breathing caused by inability of pulmonary alveoli to enlarge and remain patent after inspiration. Treatments include oxygen supply to assist respiration, mechanical ventilation, corticosteroid therapy or artificial surfactant supply of the lungs.

Netter's Essential Histology, W.K. Ovalle and P.C. Nahirney, Saunders, Elsevier

RECAPITULATION
RESPIRATORY SYSTEM

QUESTIONS

1. What is the function of a) goblet cells and b) cilia in the respiratory tract? How far down the tract does each of these extend?

2. Where are Clara cells found? Describe their structure and function

3. Compare the histological structure and function of the respiratory mucosa and olfactory mucosa of the nasal cavities

4. What are the distinguishing characteristics, classification and function of the glands of Bowman?

5. Name four cell types found in the interalveolar septum. Give the distinguishing characteristics and function of each.

   a)

   b)

   c)

   d)

6. What is the difference between the interalveolar septum and the blood-air barrier?

7. Illustrate by means of a fully labeled diagram the histological structure of a blood-air barrier

8. Complete the following table to compare the structures of the respiratory tract.

	EPITHELIUM	LAMINA PROPRIA	GLANDS	BONE AND CARTILAGE	MUSCLE
TRACHEA					
IP BRONCHUS					
BRONCHIOLE					
TERMINAL BRONCHIOLE					
RESPIRATORY BRONCHIOLE					
ALVEOLAR DUCT					

The Central Nervous System

OBJECTIVES

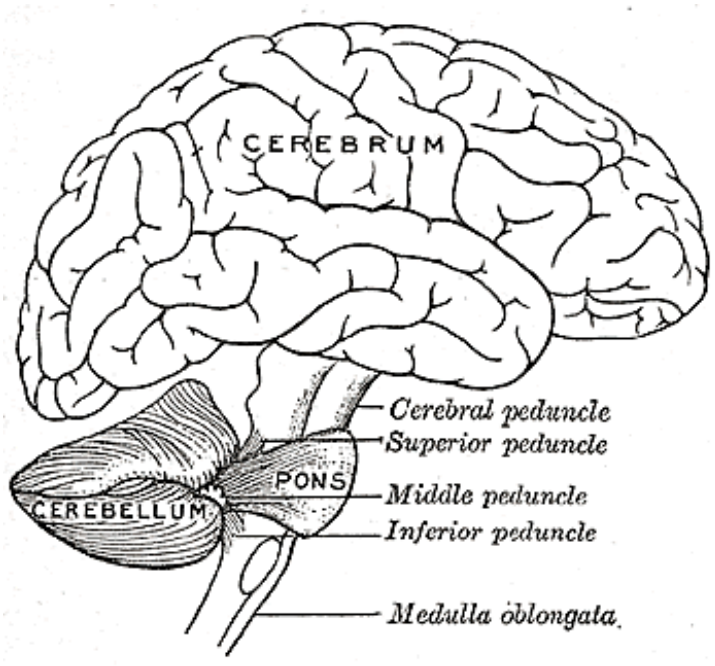
- Identify white and grey matter and know the components of both
- Be able to identify and describe the structural organization of the cerebrum and cerebellum – in other words, identify, describe and recognize the different layers
- Identify and describe the pyramidal cells of the cerebral cortex and the Purkinje cells of the cerebellum
- Identify, describe and relate the structure to the function of the cells of the choroid plexus

NOTES

The Central Nervous System (CNS) includes all the nervous tissue found in the brain and spinal cord. Use the nervous tissue practical to revise the spinal cord. For the brain we will focus on the two regions, namely the cerebrum and cerebellum.

The cerebrum processes information controlling conscious movements, communication and memory, whereas the cerebellum processes involuntary movements and functions, such as balance and coordination.

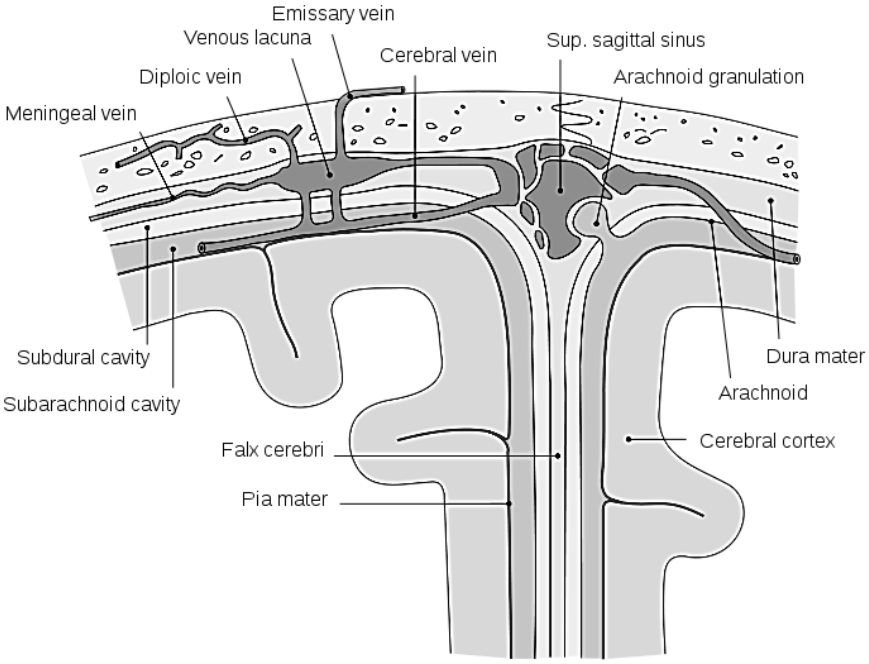
Cortex is grey matter found on the surface of the brain. Other deeper areas of the brain containing grey matter also occur, these grey matter areas are called nuclei, not to be confused with nuclei within individual cells. Grey matter is where the synapses occur; hence we will study the cerebral and cerebellar cortices in detail.



From Gray's Anatomy (public domain)

Surrounding both the cerebrum and cerebellum are the meninges. The meninges are the connective tissue elements of the CNS. There are three layers of connective tissue surrounding the brain:

- The *dura mater* a thick outer dense connective tissue
- The *arachnoid* a loose connective tissue
- The *pia mater*, a delicate layer of collagen and fibroblast like cells that lies immediately adjacent to the brain tissue



http://commons.wikimedia.org/wiki/File:Gray769-en.svg

The arachnoid has a web like appearance, and between the thin threads of the arachnoid are the subarachnoid spaces, which are filled with cerebrospinal fluid. Since the pia mater and arachnoid layer arise from the same mesenchymal layer during embryonic development, they are often collectively called the pia-arachnoid or leptomeninges. The pia-arachnoid also dips down into the sulci of the cerebrum and between the folia of the cerebellum. Other than the meninges, the rest of the brain has no connective tissue, which is why fresh brain tissue is extremely soft (http://www.slideshare.net/ananthatiger/histology-of-nerve-system; www.siumed.edu/~dking2/ssb/ neuron.htm)

Nervous tissue, particularly the fine processes of the neurons and neuroglial cells, cannot be clearly visualized by light microscopy without the use of special stains.

PRACTICAL WORK

I. THE CEREBRUM

Slide: 63
Stain: Kluver and Barrera technique

In this section, myelin sheaths stain blue, nuclei and basophilic substances (Nissl bodies) stain purple.

The cerebrum consists of a core of white matter surrounded by grey matter. The grey matter (cerebral cortex) is loosely organized into 6 layers. Cells of the cerebral cortex belong to neurons and neuroglial cells of different sizes and shapes. The most notable are the pyramidal cells.

The thickness of each layer is not uniform throughout the cerebral cortex of the brain. In other words the different regions of the cerebrum will show differences in the thickness of the different layers and in the size and type of the pyramidal cells. For example in the motor cortex, very large pyramidal cells are observed that belong to upper motor neurons and are called giant Betz cells.

Both afferent and efferent neurons are found in the cerebral cortex. Some detect sensory impulses, whilst others control voluntary movements. The cell bodies of these neurons are found in different regions of the cortex. However, most of the neurons found in the cerebral cortex are interneurons that interconnect neurons to each other and integrate the sensory input and motor responses. (http://www.slideshare.net/ananthatiger/histology-of-nerve-system; http://histology.med.umich.edu/medical/central-nervous-system; www.siumed.edu/~dking2/ssb/neuron.htm).

The pyramidal cells are the efferent neurons of the cerebrum. Their large cell body is attributed to the very long distances that its axon has to travel and thus it has to be able to support the cytoplasmic components within that axon throughout its long distance. The dendrites tend to extend from the three points of the pyramidal cell body. One large dendrite travels upward towards the surface of the cerebrum, whilst several others extend from the sides. The stellate and granule cells, which are not as easily identified, are short axon interneurons and thus have small cell bodies and their processes will synapse onto the cell bodies of other neurons within the grey matter of the cerebral cortex. Some granule cells are also sensory neurons. The name "stellate" and "granule" cells, is purely descriptive, referring to shape of their cell body being either star-shaped, or small and rounded. Therefore not all stellate cells are the same, and will be involved in different functions of the cerebral cortex. (www.siumed.edu/~dking2/ssb/neuron.htm)

Macroscopic and L.P: Identify, write notes on and draw:

- The connective tissue and blue-stained blood vessels of the pia-arachnoid (leptomeninges).

  NOTE: *The dura mater was removed prior to sectioning this tissue, so it will not be present in your slide*

- Folds of cerebral tissue called gyri
- The depressions between the gyri, called sulci, containing the connective tissue pia-arachnoid
- The light blue-stained grey matter (cerebral cortex), on the outer surface of the brain. It consists of a loose weave of pale blue-stained nerve fibres and scattered purple-stained nuclei. To which cells do the purple-stained nuclei belong?
- The intensely blue-stained white matter forming the internal core of the cerebrum, consisting of a dense collection of blue stained nerve fibres (axons), and a few purple stained nuclei of neuroglia. These nerve fibres transmit signals to other parts of the cortex and CNS
  - Are the fibres in the white matter myelinated or unmyelinated?
  - Which cell is responsible for CNS myelination
- The blood vessels in both the grey and the white matter
  - Brain tissue is highly vascular, and therefore a significant feature in any light microscopic section of CNS. The blood vessels are often cut obliquely and may appear to be torn; they are identified by the blue-stained erythrocytes and the flattened, purple-stained endothelial cell nuclei (check under H.P.)

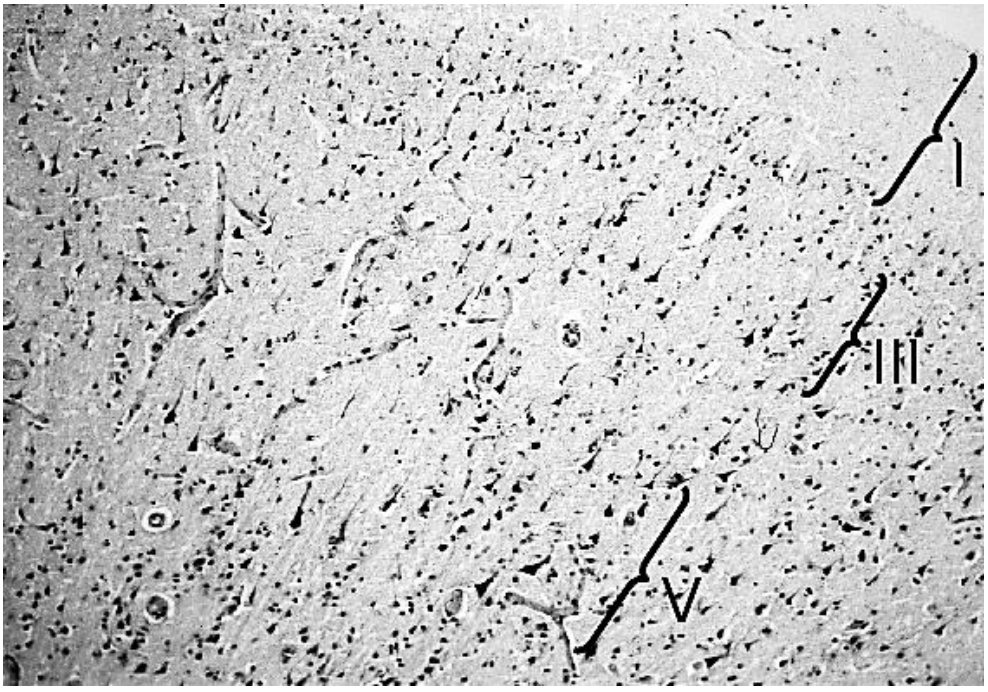
***NOTE**: Any spaces observed in CNS tissue, are usually artefacts due to the shrinkage that occurs of this very soft tissue during fixation, the spaces are most obviously seen around the neuron cell bodies and blood vessels*

Under L.P.: Look for evidence of the layered arrangement of the cells in the cerebral cortex.

***NOTE:** The identity and positioning of all the layers of the cerebral cortex are based on the presence of the two layers of pyramidal cells, namely layer III called the external pyramidal cell layer and layer V, called the ganglionic layer or internal pyramidal layer.*

- **Layer I** (molecular layer) is found directly underneath the pia-arachnoid. It is mostly acellular so easily identified. The cells present in this layer mostly belong to neuroglial cells and a few horizontal cells of Cajal, although a different staining technique is required to identify them.
- **Layer II** (external/outer granular layer), contains very small granule cells and numerous neuroglial cells. It is found between the acellular molecular layer (layer I) and layer III, which is the first layer of moderately sized pyramidal cells.
- **Layer III** (external/outer pyramidal layer) consists of small pyramidal cells
- **Layer IV** (internal/inner granular layer), consists of a large collection of small stellate cells. It will be found between layer III and the a layer containing larger pyramidal cells
- **Layer V** (internal/inner pyramidal layer), consists of larger pyramidal cells than those in layer III, if section has been taken from motor cortex (Betz cells). If section has not been taken from motor cortex then the pyramidal cells in this layer would be slightly smaller than those seen in the previous layer (i.e. layer III)
- **Layer VI** (multiform/polymorphic layer), contains cells of many shapes, and will be found between layer V and the intensely blue stained white matter.
  (http://histology.med.umich.edu/medical/central-nervous-system)

The typical 6-layered pattern of the cortex, however, may not be clearly evident, in your section. Should you struggle to locate them, look at the following micrograph or the demonstration as a guideline.



Draw a schematic diagram of the cerebrum at low power

H.P. Study an area containing some large pyramidal cells. Identify, write notes on and draw:

- The shape of the pyramidal cells in relation to the adjacent cells
- Classify the pyramidal cells (structural and functional classification)

- The size of the pyramidal cells in relation to the adjacent cells and anterior horn cells in the spinal cord
- The structural features of the nuclei of the pyramidal cells
- The purple-stained Nissl bodies in their cytoplasm
- In which direction does the axon of the pyramidal cell leave the cell body? (Towards, away from, or within the grey matter?)
- The spherical purple-stained nuclei of the neuroglial cells surrounded by unstained cytoplasm – do not confuse them with small neurons.
    - How would you distinguish between the nuclei of neuroglia and small neurons?

    - Name the types of neuroglial cells found in the cerebrum and their functions.

- The fine blue-stained fibres in the neuropil. To what do these fibres belong?

- The presence of blood vessels throughout the cerebrum

How is the surface area of the cerebral cortex increased?

List the structural features that identify the pyramidal cells as neurones. Are they sensory or motor neurones?

Clinical Correlation

Alzheimer's Disease is a progressive disease whereby patients have increasing memory loss and eventually can no longer perform basic activities of daily living. Confirmation of the disease only comes from histological examination of the cerebral cortex at autopsy. Histological sections show an increase of senile and neuritic plaques. The senile plaques contain deposition of a misfolded protein (Aβ), whereas neuritic plaques consist of of fragmenting neuronal processes resulting in degenerative presynaptic endings. Astrocytes and microglia are also often found in association within these plaques. Neurofibrillary tangles are also seen in the pyramidal cells caused by the tangling of proteins (neurofilaments) that are involved in transporting molecules to and from the cell body in the axon. Ultimately there is significant atropy (wasting away) of the cerebral cortex in the patient.

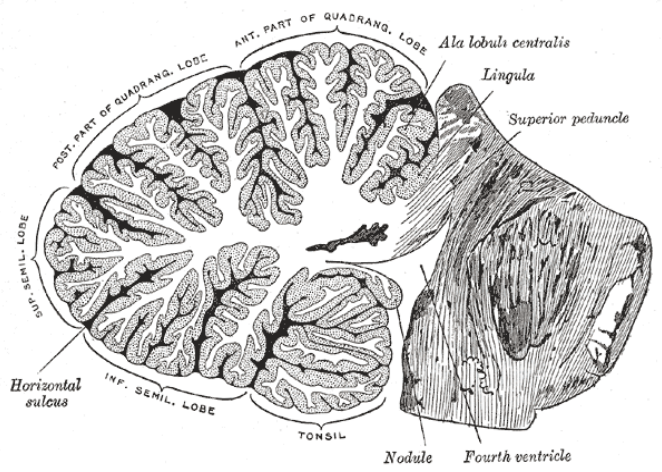
http://library.med.utah.edu/WebPath/TUTORIAL/CNS/CNSDG.html
http://en.wikipedia.org/wiki/Alzheimer%27s_disease.

II. THE CEREBELLUM

Slide: 61
Stain: Kluver and Barrera technique

The cerebellum lies beneath the cerebrum within the posterior cranial fossa. It lies inferior to the cerebrum and although it only makes up about 10% of the volume of the brain it contains 50% of the brains neurons. It functions in fine motor control by maintaining balance and equilibrium. It also refines learned movement patterns by making fine adjustments such that movement is smooth and coordinated. It does this by coordinating the motor commands and sensory information received and regulates the responses of the neurons in the cerebral cortex. Damage to the cerebellum therefore does not cause paralysis, but affects fine movements, posture, motor learning and sense of balance.

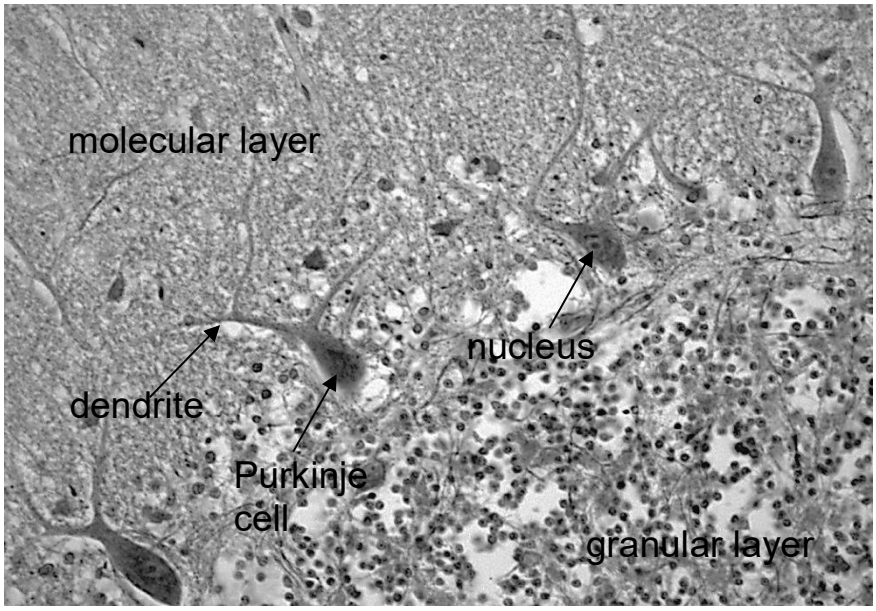
The cerebellum consists of a core of white matter surrounded by grey matter (cerebellar cortex). The folded nature of the cerebellar cortex resembles a tree, with the folds being called folia (Latin for leaves). An ancient name for the cerebellum was thus the "arbor vitae" or "tree of life", suggesting that without it a person would die both physically and spiritually.



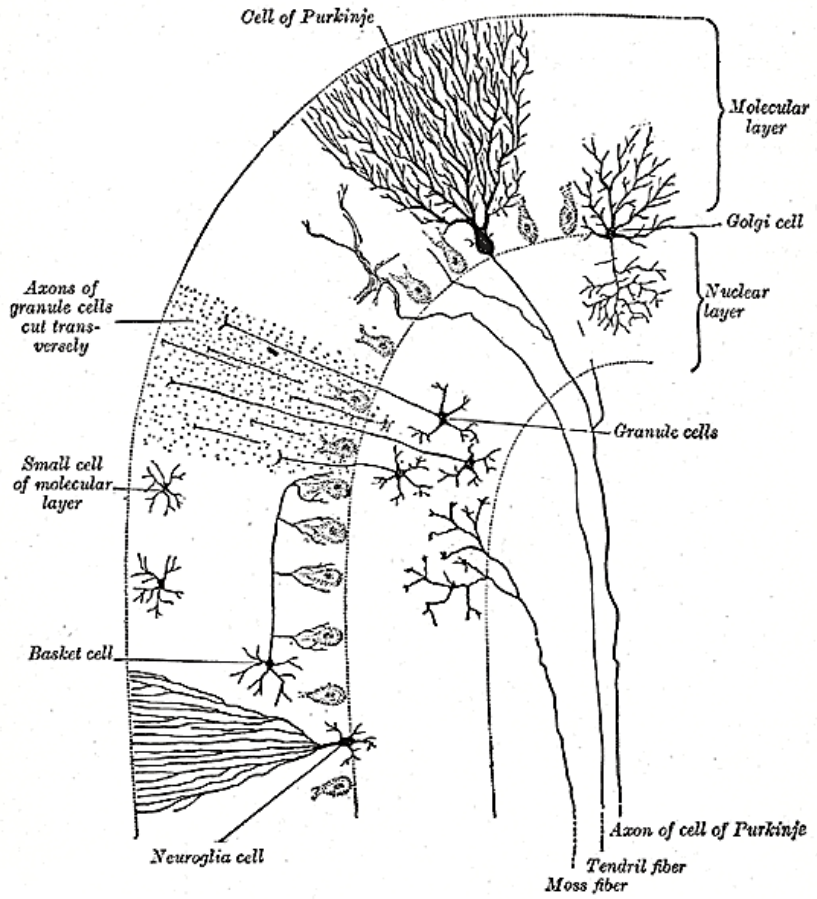
From Gray's Anatomy (public domain)

The cerebellar cortex consists of three layers: molecular layer, Purkinje cell layer and granular layer. Purkinje cells are the efferent (output) cells of the cerebellar cortex. They have a large flask shaped cell body and, as with all neurons, a large vesicular nucleus and prominent nucleolus. Purkinje cells have one long axon that extends deep into the white matter of the cerebellum and an extensive dendritic arborization (tree-like branching) extending into the molecular layer. Purkinje cells receive information from interneurons and granule cells in the cerebellum. They also receive input from afferent neurons named climbing fibres. The axons of the climbing fibres extend from the underlying white matter to synapse onto Purkinje cells. Mossy fibres are another type of afferent fibre that extend from the white matter into the grey matter of the cerebellum, but these fibres synapse with the granules cells in the granular layer. Other neuron cell bodies found in the cerebellar cortex include stellate, basket and Golgi cells found in the molecular and granular layers. Note that the stellate and granule cells of the cerebellum are completely different cells to the stellate and granule cells of the cerebral cortex. You will not be able to distinguish between these other neurons and fibres as special stains are required to identify the specific neurons. The Purkinje cells are constantly fed information form proprioreceptors and input from senses such as vision and hearing. They integrate all the information and "make decisions" regarding the appropriate response to the sensory information. The coordinated information is then sent out as nerve impulses to the appropriate parts of the central nervous system that control the effector organs/tissues and further "decisions" are made as to the appropriate motor responses.

(www.siumed.edu/~dking2/ssb/neuron.htm; http://www.slideshare.net/ananthatiger/histology-of-nerve-system; http://en.wikipedia.org/wiki/Cerebellum; http://www.vetmed.vt.edu/education/Curriculum/VM8054/Labs/Lab9/lab9.htm)



Transverse section of a cerebellar folium, showing principal cell types and connections



From Gray's Anatomy (public domain)

Macroscopic and L.P: Note and draw:

- The intensely blue-stained white matter with a central main stem and many branches (the "arbor vitae")
- The folia (leaf like folds) of the cerebellum. Each folium is made up of blue staining grey matter covering a branch of the intensely blue staining white matter (a tangential section through a folium may not pass through the white matter)
- The layers in the **grey matter** of a folium:
    - The few scattered cells in the outer palely stained molecular layer
        - The molecular layer mostly consists of dendrites of the Purkinje cells and axons of the granule cells, the few nuclei found in this layer belong to basket cells and neuroglial cells
    - The many closely packed granule cells in the inner darkly stained granular layer
        - The granule cells receive stimuli from other parts of the CNS, their axons extend into the molecular layer of the cerebellum where they branch and synapse on Purkinje cells and basket cells
        - Golgi cells are another class of neurons found in the granular layer, however special stains are needed to visualize them

- The single layer of large Purkinje cells on the boundary between the molecular and the granular layers
- The connective tissue and blue-stained blood vessels of the pia-arachnoid (leptomeninges)
- The presence of blood vessels throughout the cerebellum

Note: *The fibres from the white matter can be traced into the granular and the molecular layers of the cerebellar cortex. These are mossy and/or climbing fibres.*

H.P. Study and draw the Purkinje cells.

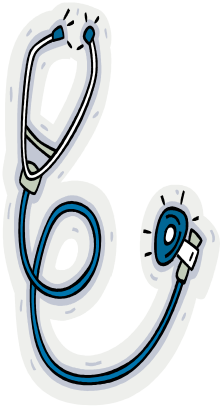
Note:

- The shape of the cell body and its size
  - Compare these in relation to that of the adjacent cells, to the pyramidal cells of the cerebrum and to anterior horn cells of the spinal cord
- The distribution of the purple-stained basophilic substance (Nissl bodies)
- The structural features of the nucleus
- The dendrites penetrating into the molecular layer
  - How are the dendrites identified?
  - What is the pattern of their branching; in which plane do they branch?
- The proximal part of the single axon at the opposite pole of the cell body

Note: *You may battle to find this, as not every cell will be sectioned through its axon where it leaves the cell body*

Compare the histological structure of the Purkinje cells with the pyramidal cells.

What are Purkinje **fibres** and where are they found?



Clinical Correlation

Multiple Sclerosis is an autoimmune disease that destroys the oligodendrocytes and the myelin sheath. This causes demyelination of CNS neurons and since myelinated axons only have voltage gated sodium channels at nodes of Ranvier, it prevents propagation of nerve impulses. Biochemical changes in the myelin also result in many irregular shaped plaques occurring in the white matter of these patients, which is where the name of the disease comes from (sclerosis = scars / plaques). Communication between the brain and spinal cord is lost and a number of neurological deficit symptoms arise, although they may vary between patients, depending on the areas of white matter affected. Some common symptoms include loss of vision, sensation, muscle coordination, movement, bladder control and bowel control. Although the disease is thought to be an immune mediated disorder, the initial cause for the immunological attack on the myelin is not known.

(www.siumed.edu/~dking2/ssb/neuron.htm; Ross and Pawlina, 2006; http://en.wikipedia.org/wiki/Multiple_sclerosis)

Slide: 105
Stain: Silver impregnation technique

This technique blackens the neurofibrils in nerve cells. The neurofibrils in the perikaryon of the Purkinje cells have not taken up the silver well and appear brown-stained in this preparation. Since the neurofibrils lie within the axons, the white matter is clearly recognized with this stain as being composed of many nerve fibres (axons)

Macroscopic and L.P.: Scan the section and identify the white matter and the three layers of the cerebellar cortex. Also note that this technique demonstrates the extent of the nerve cell processes:

- In the white matter
- Extending from the white matter into the grey matter
- Extending from the Purkinje cells into the molecular layer
- Extending from the smaller neurons in the molecular and the granular layers

H.P.: Study and draw an area that includes one or two Purkinje cells. Focus carefully, and note that fine brown-stained neurofibrils can be seen:

- In the dendrites of the Purkinje cells; and
- In the processes (axons) of the "basket cells" which are synapsing on the perikaryon of the Purkinje cells

"Basket cells" are neurons in the inner part of the molecular layer.

List the structural features that identify the Purkinje cells as neurons.

What evidence is there in slide 105 that "basket cells" are neurons and not neuroglial cells?

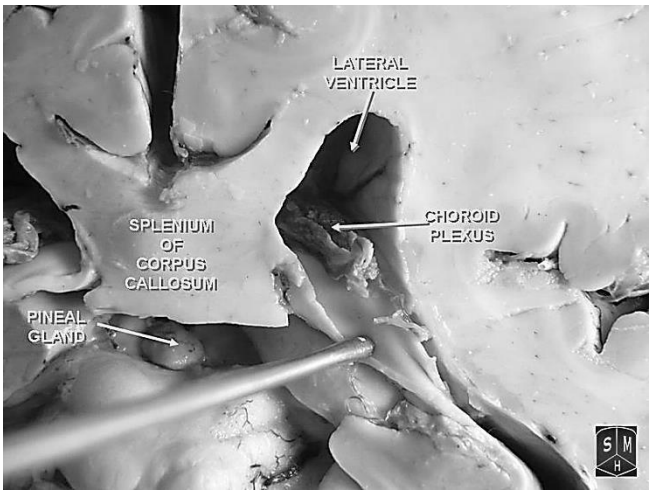
What is the function of the cerebellum?

III. THE CHOROID PLEXUS

Slide 66
Stain: H&E

A single layer of cuboidal cells lines the choroid plexus. These cells are called ependymal cells and they are modified to produce and secrete cerebrospinal fluid into the ventricles of the brain and have characteristics of fluid transporting cells. Like epithelial cells the ependymal cells have tight junctions between the cells, to prevent non-specific fluid movement between cells, and like typical epithelial cells they have basement membrane. Their apical membrane contains both cilia and microvilli which are not easily visible in your sections. Materials are transported from the capillaries in the underlying connective tissue, into the ependymal cells. These molecules together with additional molecules synthesized by the ependymal cells form cerebrospinal fluid, which is then secreted into the ventricles.

Macroscopic and L.P:



Note:

- The solid mass of brain tissue
- The more delicate, very vascular choroid plexus. This is a contorted membrane, therefore "islands" of choroid plexus may appear in a section

H.P. Draw a small area of the choroid plexus and note:

- The lining epithelium (what type is this?)
- The brush border (this may not be visible under light microscopy)
- The underlying connective tissue (what type?)
- The numerous blood vessels of varying size

What is the function of the choroid plexus?

Clinical Correlation

Anoxia of the Cerebellum. Anoxia is the extreme form of hypoxia or decrease in oxygen levels. Purkinje cells have been found to be extremely sensitive to oxygen deprivation, due to the high oxygen demands of the cerebellum, as shown by their large size, as compared to other parts of the brain. Anoxia may occur as a result of events such as cardiac arrest or CO poisoning. Anaerobic glycolysis is unable to occur, in the brain, as fatty acids are unable to cross the blood brain barrier. The loss of energy, as a result of oxygen deprivation, causes depolarization of the neuronal membrane resulting in a loss of electrical conduction and hence a loss of consciousness. Neurons and glial cells will remain viable if circulation is restored, however if the hypoxia persists, (longer than 4-5 minutes) the cell membrane integrity breaks down, normal cellular functions cease and toxins start to accumulate resulting in cell death. Histologically, if the patient died shortly after the initial insult e.g. cardiac arrest, the cerebellum looks normal. However if the patient survived the initial insult and circulation was restored, the affected Purkinje cells are observed to be shrunken and intensely eosinophilic due to damaged mitochondria. Macrophages eventually remove the damaged cells leading to cortical atrophy and gliosis (increase in glial cells). Loss of vital brain functions results, with the most common symptom being ataxia - an inability of the brain to regulate the body's posture and inability to regulate the strength and direction of limb movements.

(http://neuropathology-web.org/chapter2/chapter2aHIE.html; Dow RS & Moruzzi G (1958) *The Physiology and Pathology of the Cerebellum* (University Of Minnesota Press).

RECAPITULATION
THE CENTRAL NERVOUS SYSTEM

QUESTIONS.

1. Name the two divisions of the central nervous system.

2. Explain the difference between them with regard to the arrangement of grey and white matter.

3. Name the layers of the cerebral cortex and explain how the layers may be identified.

4. What is the function of each of the different components of the meninges?

5. Draw a diagram to show the structure of the cerebellar cortex.

6. What structural features do all neurons have in common with one another?

7. Complete the following table to compare the neuroglia of the central nervous system.

Cell type					
Location					
Structure					
Function					

12. How does myelination differ in the central and peripheral nervous systems?

13. Which of the elements of nervous tissue constitute the neuropil?

14. Describe the elements making up the blood brain barrier

The Digestive System

OBJECTIVES

After studying the histological structure and ultrastructure of selected regions of the digestive system, you should be able to Identify and describe the structure and function of:

- The digestive tract
- The oesophagus
- The stomach (fundus)
- The small intestine (e.g. the duodenum)
- The large intestine (e.g. the colon)
- The glands associated with the oesophagus, stomach, small and large intestine

NOTES

The digestive system extends from the lips to the anal canal and includes all those organs concerned with:

- The breakdown and ultimate absorption of food and water into the blood stream
- The elimination of waste to the exterior by defecation

When studying any part of the digestive tract, note the basic pattern in construction of the wall i.e. the wall of all parts of the digestive tract is made up of four layers of tissues, concentrically arranged.

These four layers are (from the lumen to external surface):

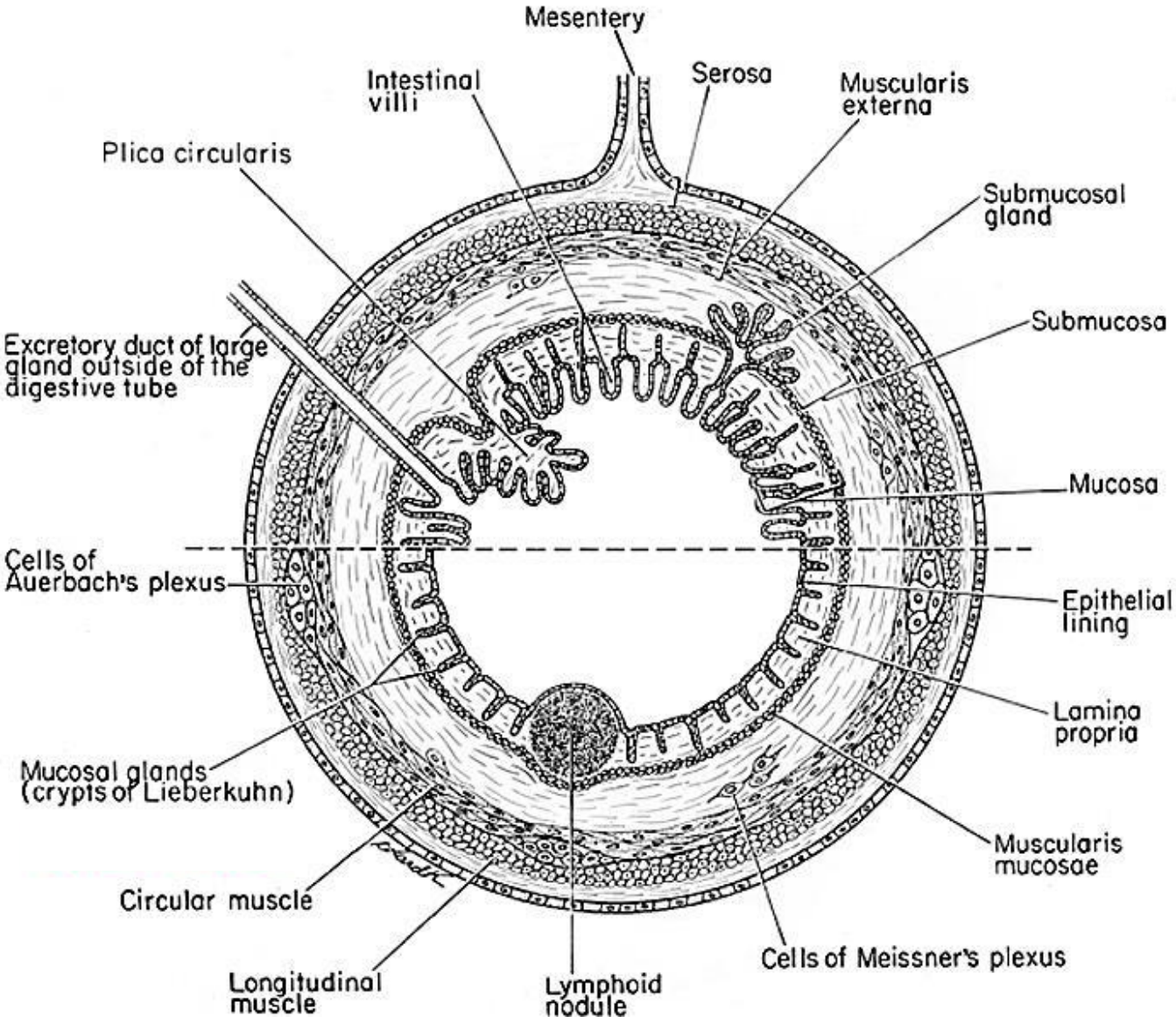
1. The **mucosa** made up of:
   - A *surface epithelium* (from which glands are derived)
   - The *lamina propria* (a cellular connective tissue)
   - The *muscularis mucosae* (thin inner circular and outer longitudinal layers of smooth muscle. Exception: oesophagus thick single layer of longitudinally arranged smooth muscle.)
2. The **submucosa** (fibrous connective tissue layer with large blood and lymphatic vessels, submucosal (Meissner's plexus and glands)
3. The thick **muscularis externa** consisting of an inner circular and an outer longitudinal layer of smooth muscle (**exception:** in upper and middle region of oesophagus also skeletal muscle)
4. An outermost connective tissue layer (**adventitia** or **serosa**).

Note: The autonomic ganglia and nerves in the submucosal (Meissner's) plexus and a myenteric (Auerbach's) plexus, between the layers of muscle in the muscularis externa. Also note the relative abundance of lymphoid tissue throughout the digestive tract.

Of these layers, the mucosa shows the greatest degree of variation from one part of the tract to another.

In this practical you will study part of the digestive tract (oesophagus, stomach (fundus), duodenum and colon) as well as the glands associated with the digestive system (the submandibular salivary gland, the liver and the exocrine pancreas)

Pattern of the GIT

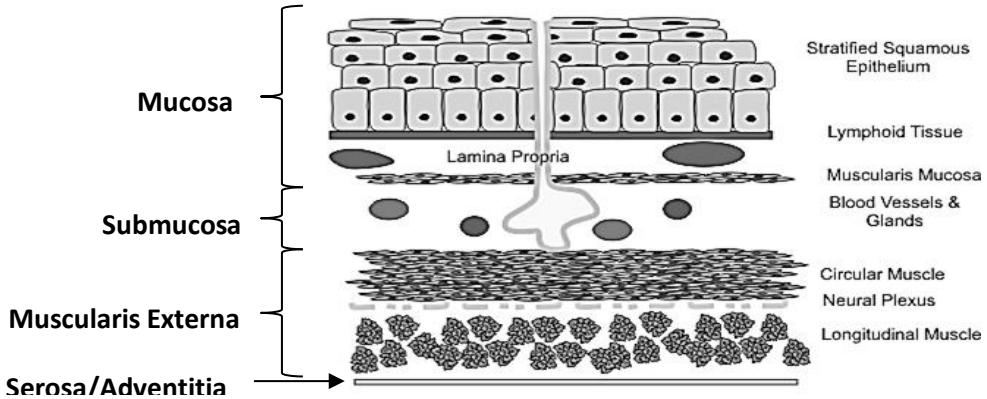


http://medcell.med.yale.edu/histology/gi1/images/gi_tract_cartoon.jpg

PRACTICAL WORK

I. THE OESOPHAGUS

Slide: 32
Stain: H&E



http://commons.wikimedia.org/wiki/File:Oesophageal_layers.png

Macroscopic and L.P. Locate the oesophagus with the thick wall.

Study and note:

- The shape of the lumen
- The type of epithelium (keratinized or non-keratinized?)
- The bundles of fibres in the muscularis mucosae. Identify the type and orientation of the fibres
- The basophilic lymphoid tissue in the submucosa. Look for "deep" oesophageal glands. What type are they and what do they secrete? This gland often has a cystic (dilated) duct
- The two layers of the muscularis externa. Identify the type of muscle and its orientation. Is this the same throughout the length of the oesophagus?
- The absence of a mesothelium on the outer connective tissue layer. Is this outermost layer an adventitia or a serosa?

What division of the nervous system controls the muscle in the wall of the digestive tract?

List the distinguishing features of the oesophagus with particular reference to this section.

From which level of the oesophagus was this section taken? Give reasons for your answer.

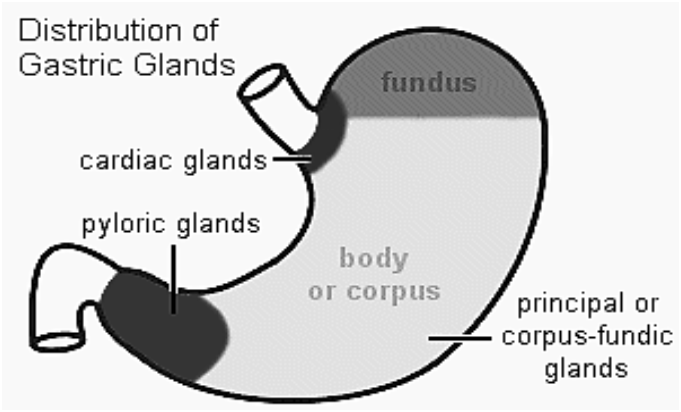
Clinical Correlation

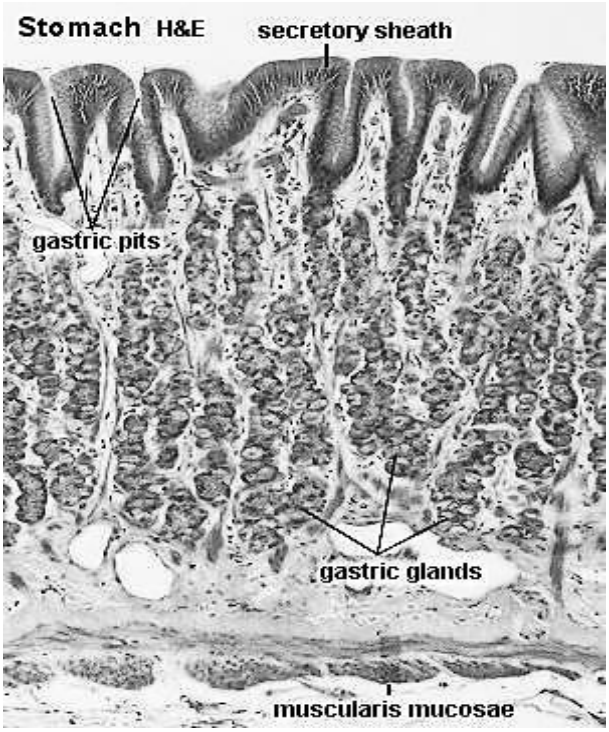
Barrett's Oespohagus is a condition where the stratified squamous epithelium of the distal part of the organ is transformed to a simple columnar epithelium due to extensive gastric reflux. Patients that suffer from this condition are at a high risk of developing adenocarcinomas

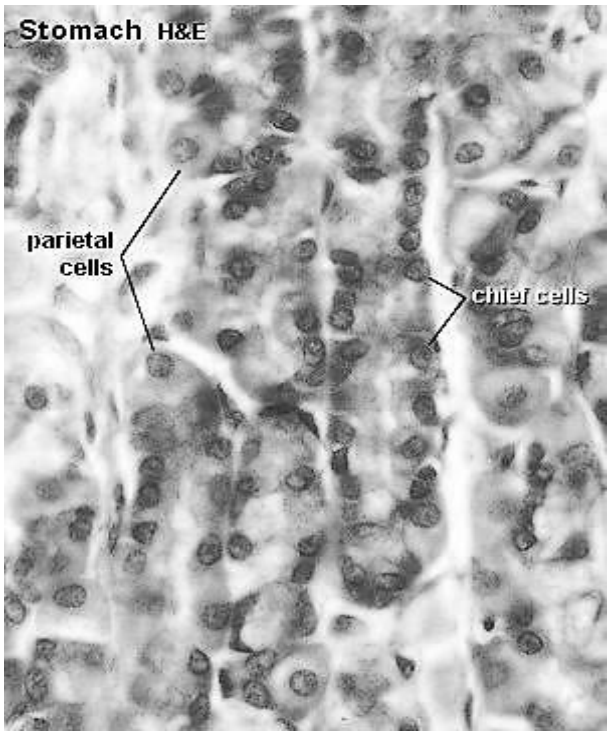
Harhold Sheedlo (2005). USMLE Road Map: Histology.

II. THE STOMACH

The stomach (fundus)
Slide: 81
Stain: H&E







http://www.lab.anhb.uwa.edu.au/mb140/

With the naked eye note:

- The basophilic mucosa
- The very thick muscularis externa
- The intervening connective tissue layer (submucosa)

Macroscopic and L.P. Draw a topographical diagram to illustrate the arrangement of the layers (refer to the plan of the four layers outlined above)

Also note:

- The pitted inner surface of the stomach
- The mucosa, (upper half is eosinophilic, the lower half basophilic)
- The eosinophilic smooth muscle of the muscularis mucosae

- The vascular submucosa
- The layers of muscle in the muscularis externa (not clearly distinguishable). Check orientation and number of layers
- The outermost connective tissue layer (adventitia or serosa?)

Has this section been cut longitudinally or transversely?

Under L.P. find an area where the gastric glands and pits are cut in longitudinal section. Try to trace the outline of a gland and note that the lumen opens into a gastric pit. Note that the bases of the glands extend as far as the muscularis mucosae.

Under H.P. note and draw:

- The surface epithelium and the epithelium lining a gastric pit (What type of epithelium is this and what do the cells secrete?)
- The large, eosinophilic parietal (oxyntic) cells in the upper part of the gastric (fundic) gland
- The basophilic chief (zymogenic) cells and a few scattered parietal cells in the lower part of the gland

What other cell types occur in the gastric glands?

What is the function of all the cell types found in the glands?

How would you classify the gastric (fundic) glands?

What is the function of the muscularis mucosae?

Between which layers of muscularis externa did you find the myenteric (Auerbach's) plexus?

A bundle of smooth muscle fibres can easily be confused with a nerve in the wall of an organ. Find a nerve in this section and compare it with the smooth muscle noting:

- the presence or absence of a connective tissue sheath
- the thickness of the fibres and the shape
- staining reaction and position of the nuclei in relation to the fibres

Clinical Correlation

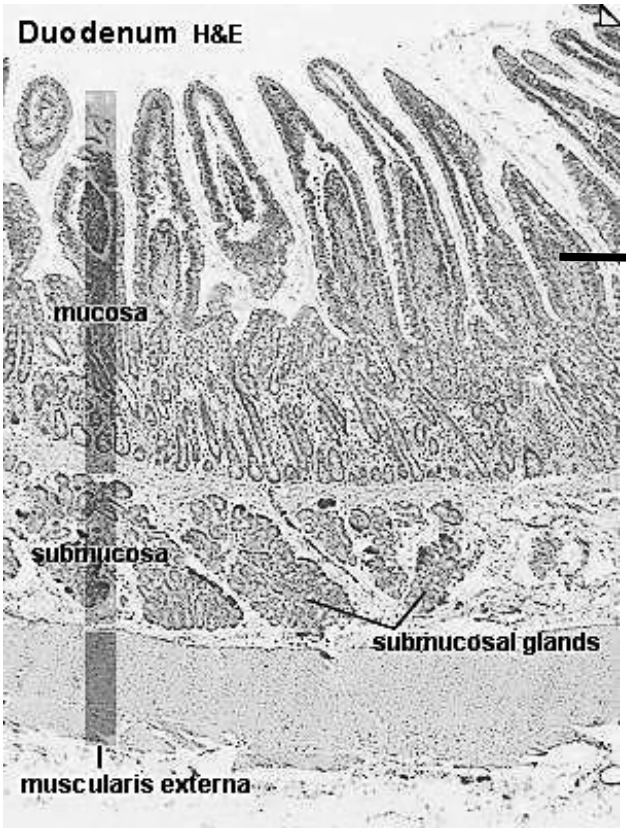
Peptic Ulcers, or chronic lesions, results from constant exposure of the gastric mucosa to an acidic environment. These ulcers are just restricted to the stomach but can also occur in other regions of the gastrointestinal tract. The first and second most common sites for peptic ulcers are the first part of duodenum and the stomach respectively.

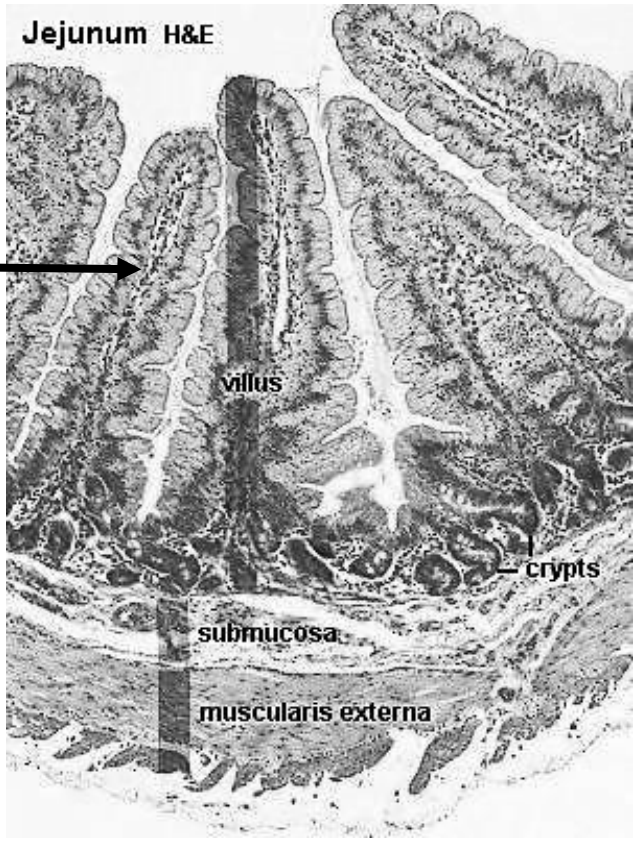
Harhold Sheedlo (2005). USMLE Road Map: Histology.

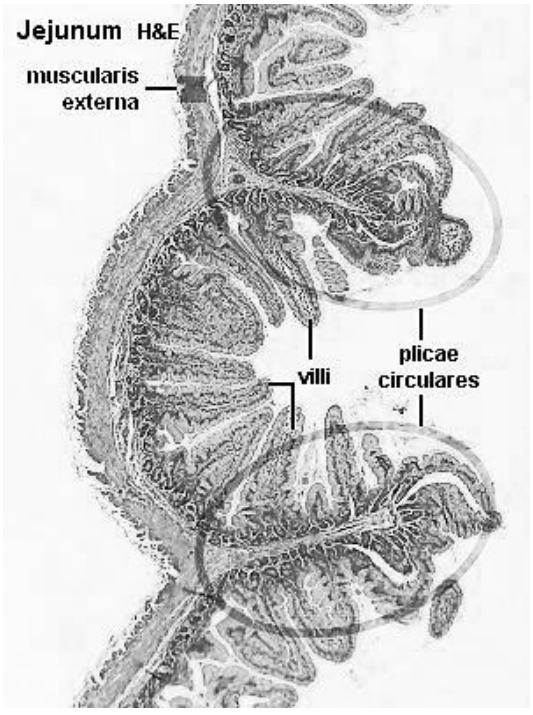
III. THE SMALL INTESTINE

The duodenum
Slide: 84
Stain: H&E

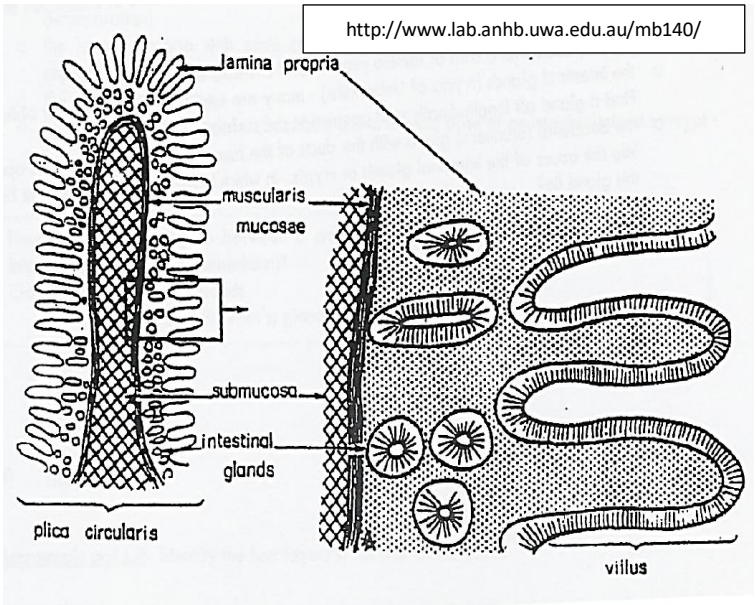
Macroscopic and L.P. Refer to the plan of the four layers of the GIT above and identify the four layers. (Note that with contraction of the smooth muscle, the section appears to be inside out). Relate the appearance of your section to the diagram below and note:







http://www.lab.anhb.uwa.edu.au/mb140/



Note:

- The large folds (plicae circulares or valves of Kerckring have a core of submucosa and are covered by numerous villi)
- The muscularis mucosae
- The villi, each with a core of lamina propria and covered with an epithelium
- The intestinal glands (crypts of Lieberkuhn) - many are sectioned transversely or obliquely. Find a gland cut longitudinally and opening to the surface between two villi
- The duodenal (Brunner's) gland with the ducts of the mucous secretory end-pieces opening into the bases of the intestinal glands or crypts. In which layer of the wall does the bulk of this gland lie?

Under H.P. study and draw a portion of a villus and an adjoining intestinal gland in L.S. Indicate the continuity of the epithelium in your drawing.

Note:

- The epithelium of the villus (what type of epithelium?) and the many goblet cells interspersed between the columnar cells

- The Paneth cells at the base of the gland (may have red stained secretory granules). Enterochromaffin cells also occur in intestinal glands but require special fixation
- The lamina propria with some connective tissue cell types and fibres and containing capillaries and lymphatics
- The muscularis mucosae
- An opening of the duodenal (Brunner's) gland into the base of an intestinal gland or crypt

How would you distinguish between a cross-section of a villus and a cross-section of an intestinal gland (crypt of Lieberkuhn)?

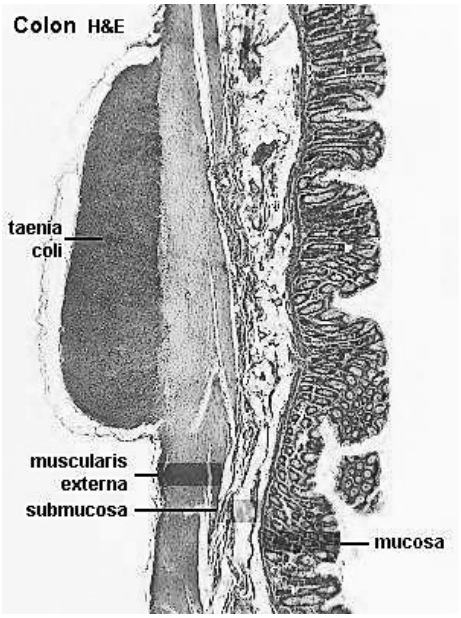
Classify:

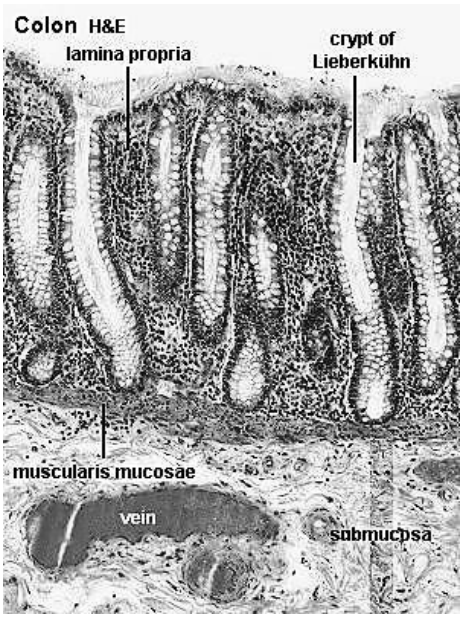
a. The intestinal glands

b. The duodenal (Brunner's) gland

IV.THE COLON

Slide: 91
Stain: H&E





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Macroscopic and L.P. Identify the four layers in the wall of the colon.

Draw and note:

- The presence or absence of villi
- The abundance of goblet cells in the surface epithelium and intestinal glands (compare this with the duodenum)

- The presence or absence of one of the taeniae coli in the muscularis externa
- The adventitia or serosa (may have attached appendices epiploicae).

Classify the intestinal glands

RECAPITULATION
THE DIGESTIVE SYSTEM

QUESTIONS.

1. In the diagram below identify the different layers in a transverse section through the GIT

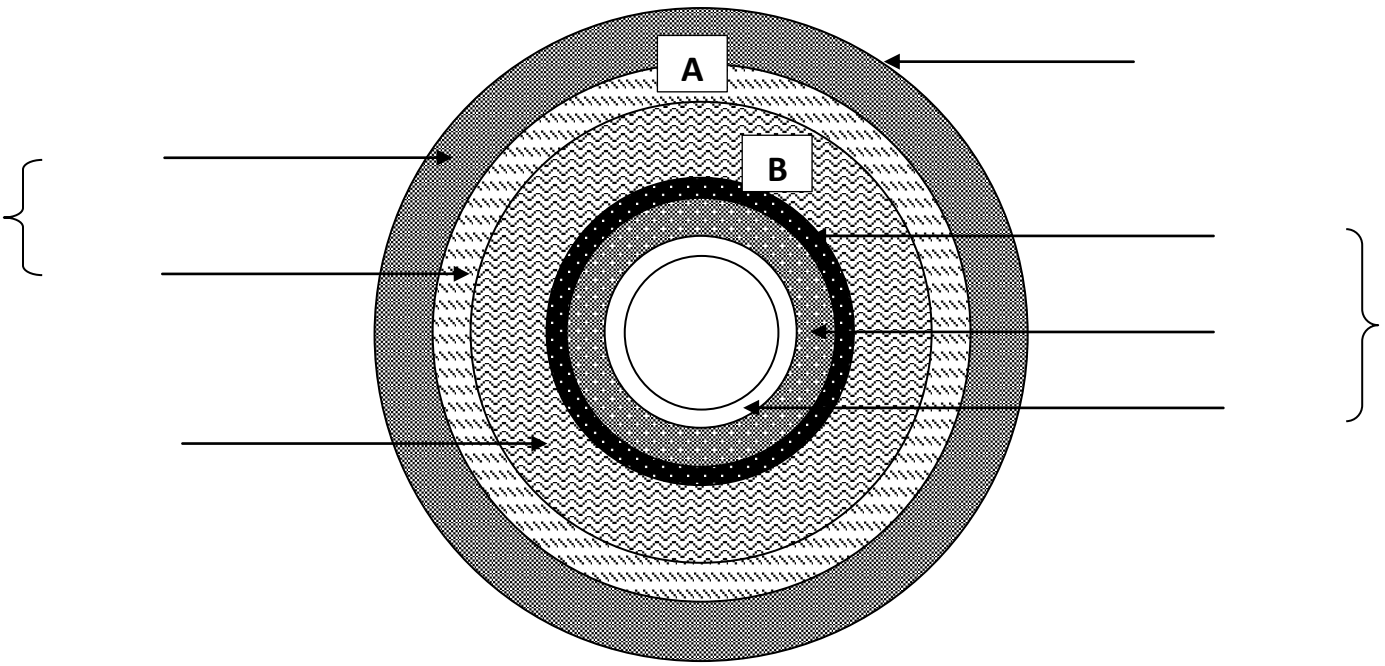
2. Which of these layers shows the greatest variability between the different regions of the tract?
   Explain your answer

3. Name the nerve plexuses found in regions A and B and give the function of the nerves in these regions
   A

   B

4. Name the two regions of the GIT which have glands in region B.

5. In which region/s is lymphoid tissue found? Explain your answer.



6. Complete the following table comparing the structure and function of different regions of the gastrointestinal tract.

FEATURE	OESOPHAGUS	STOMACH (Fundic region)	DUODENUM	COLON

7. Compare the four cell types found in the fundic glands of the stomach:

CELL TYPE				
FEATURES				
FUNCTION/S				

The Digestive Glands

*** ANAT 2020 ONLY ***

OBJECTIVES

After studying the histological and ultrastructure of certain glands associated with the digestive tract you should be able to identify and describe the histological structure and function of:

- The digestive glands
- The salivary glands (e.g. the submandibular gland)
- The liver
- The pancreas

In addition to the above you should also be able to classify each of the above named digestive glands

NOTES

The glands that are associated with the digestive system include:

- The salivary glands
- The liver
- The pancreas
- The gallbladder

The three major salivary glands include:

- The parotid gland
    - Largest of the three major salivary glands
    - Classified as a compound alveolar gland
    - Composed almost exclusively of serous acini
    - Adipose tissue also seen
- The sublingual gland
    - Classified as a compound tubulo-alveolar gland
    - Contain both mucous and serous secretory units
    - Majority of secretory units are mucous
- The submandibular gland
    - Classified as a compound tubulo-alveolar gland
    - Contain both mucous and serous secretory units
    - Majority of secretory units are serous

Duct system of these salivary glands consists of:

- Intercalated ducts
    - Intralobular ducts
    - Lined by cuboidal epithelium
- Striated ducts
    - Intralobular ducts
    - Lined by columnar epithelium
    - Have basal membrane invaginations and numerous mitochondria which give these ducts a striated appearance when viewed under a light microscope
- Excretory ducts

- Interlobular ducts
- Usually lined by a stratified squamous to columnar epithelium and surrounded by connective tissue

The liver is the largest mass of glandular tissue in the human body. It has both an exocrine (synthesis and secretion of bile) and endocrine (synthesis and secretion of plasma protein, cholesterol, lipoproteins and glucose) functions. Apart from these functions the liver is also involved in detoxification of lipid-soluble drugs, steroid hormone breakdown, glycogen storage, and the production of urea.

The pancreas is a lobulated compound alveolar gland and like the liver has both exocrine and endocrine functions. The exocrine component of the pancreas is found throughout the organ and synthesizes and secretes digestive enzyme precursors. The duct system of the exocrine pancreas consists of centro-acinar cells, intercalated ducts, intralobular ducts, interlobular ducts, the main pancreatic duct and the accessory pancreatic duct. There are no striated ducts in the pancreas. The endocrine component of the pancreas is dispersed throughout the exocrine component as pale staining, distinct cell masses, the Islets of Langerhans. The endocrine component of the pancreas is responsible for the secretion of insulin, glucagon and somatostatin. You will only be studying the exocrine component of the pancreas in this practical.

PRACTICAL WORK

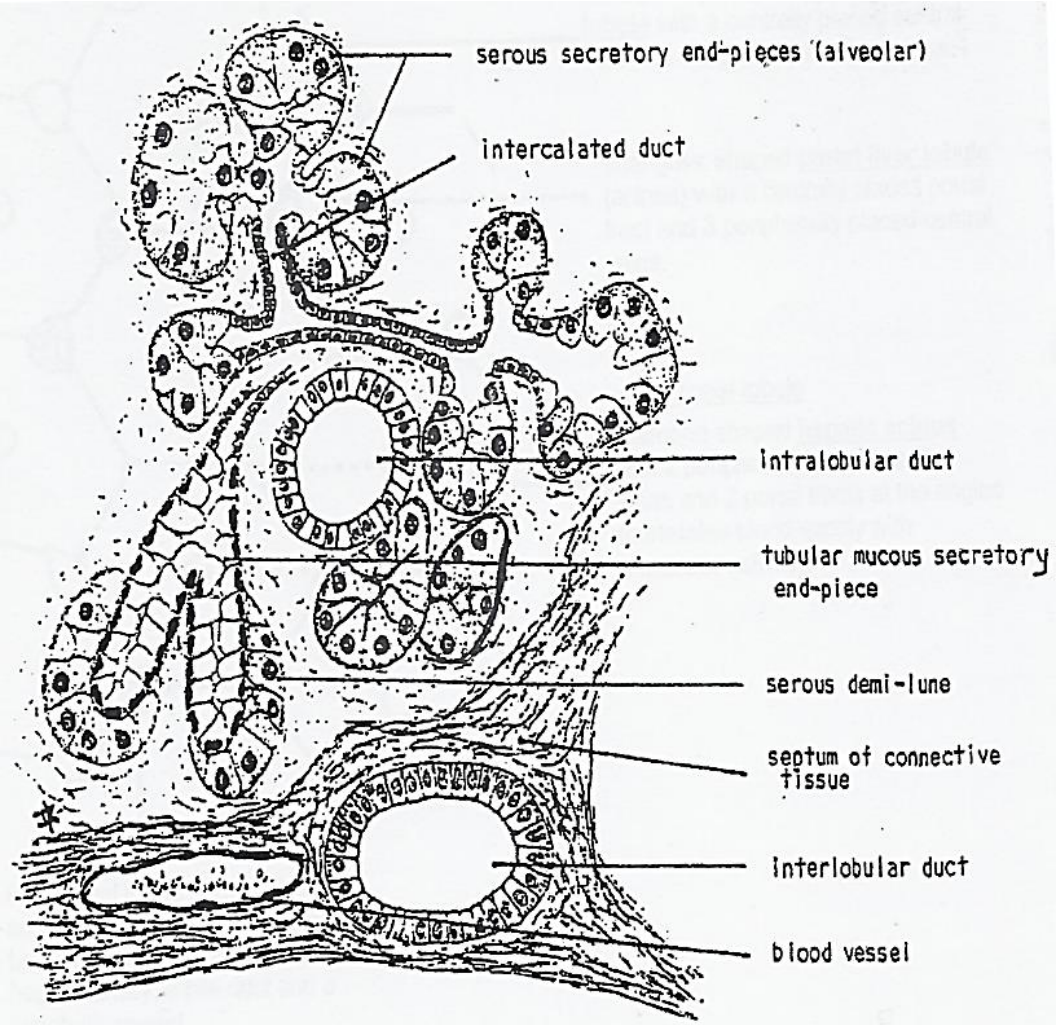
I. THE SALIVARY GLANDS

The submandibular gland
Slide: 2
Stain: H&E

Macroscopic and L.P. Portions of two or more lobes are included in this section of the gland.

Note and draw a topographical diagram to illustrate:

- The eosinophilic capsule and septa dividing up the gland into lobes and lobules
- The ducts and blood vessels lying in the septa
- The parenchyma of the gland



Secretory end-pieces and ducts in submandibular gland

Under L.P. scan the section. Are the secretory end-pieces mostly mucous or mostly serous?

Under L.P. and H.P. note and draw:

- A tubular mucous secretory end-piece
- A serous secretory end-piece
- A mucous secretory end-piece with a serous demi-lune
- Myoepithelial cells in the secretory end-pieces (these are not often seen so do not spend time looking for them)
- A striated intralobular duct
- An intercalated intralobular duct (The latter are difficult to find. They have a diameter approximately half that of the striated duct and is lined by an eosinophilic, simple low cuboidal epithelium

Note the capillaries in the fine connective tissue framework of the parenchyma.
What is the function of the striated intralobular duct?

What type of epithelium lines the interlobular ducts?

Name the enzymes secreted by the salivary glands. Give their functions.

Classify the submandibular salivary gland.

II. THE LIVER

Slide: 23
Stain: H&E

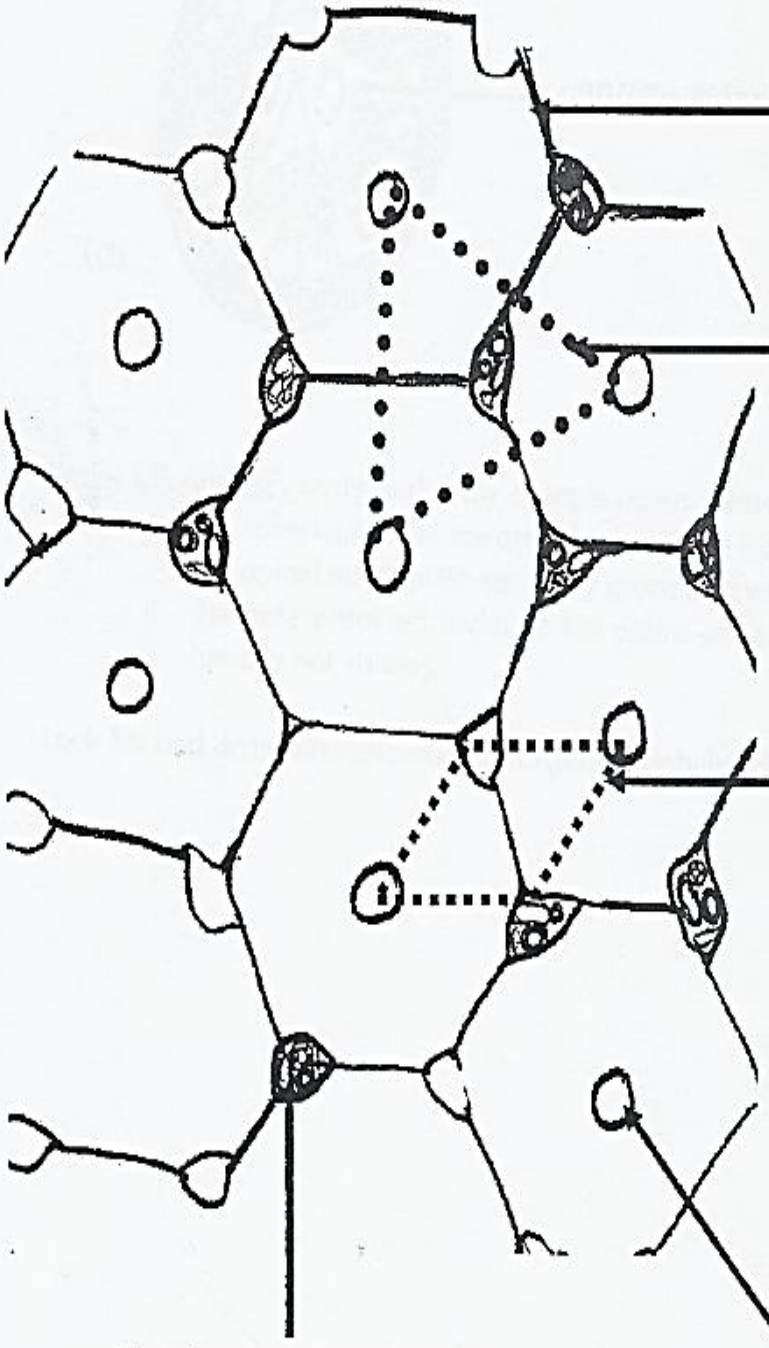
Macroscopic: This section is of a small part of a lobe of the liver. Scan the edge of the section to find the capsule.

Under L.P. note the capsule and connective tissue septa, the liver parenchyma made up of cords of cells (separated by sinusoids) draining into central veins and portal tracts surrounded by connective tissue.

Under L.P. and H.P. draw the components of a portal tract noting:

- A branch of the bile duct lined by a simple cuboidal epithelium
- One or more branches of the hepatic artery
- One or more branches of the portal vein
- Lymphatic vessels are sometimes seen in the portal tracts

Hepatic Lobules



Morphological lobules

Hexagonally shaped **classical liver lobule** with a centrally placed central vein and 4-6 peripheral portal tracts.

Triangular shaped **portal liver lobule** (acinus) with a centrally placed portal tract and 3 peripherally placed central veins.

Functional lobule

Diamond shaped **hepatic acinus** with 2 peripherally placed central veins and 2 portal tracts at the angles (correlates blood supply with metabolic activity).

Portal tract in the angle between adjacent classical lobules, contain branches of the hepatic portal vein, hepatic artery, a bile duct and a lymphatic vessel

Central vein

Trace the boundary of a "classical" liver lobule which is centred around a central vein. Note that the cords of liver cells and the sinusoids radiate towards the central vein.

Study the liver parenchyma under H.P. Note and draw:

- The arrangement, size and shape of the liver cells and the position, shape, size and number of nuclei per cell
- The staining reaction of the cytoplasm - the yellow or brownish-yellow particles of haemosiderin within the cytoplasm of some of the cells
- The sinusoids lined by endothelial cells between the cords of liver cells
- The phagocytic (Kupffer) cells with palely stained nuclei and stellate eosinophilic cytoplasm often spanning the lumen of the sinusoids

Bile canaliculi occur between adjacent liver cells. Illustrate their position in your drawing.

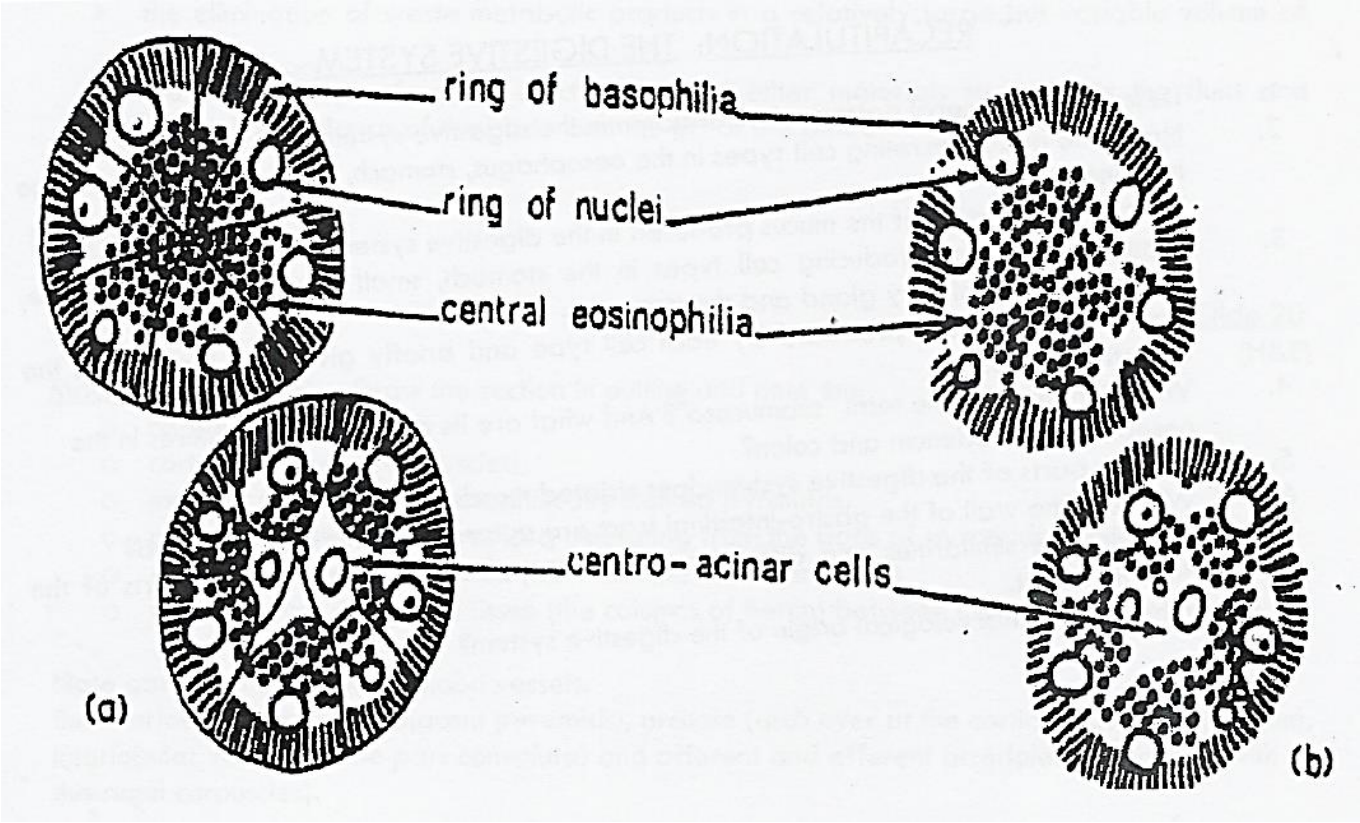
What are the functions of the liver cells? Relate the structure of these cells as seen by light microscopy (and from electron micrographs) to their functions.

What is the function of the phagocytic (Kupffer) cells?

III. THE PANCREAS

Slide: 17
Stain: H&E

Macroscopic and L.P. Identify the connective tissue capsule and septa, the latter with ducts and blood vessels, the parenchyma of the exocrine pancreas and the small, pale-stained islets of Langerhans, (the endocrine components to be studied later in the year).



The borders of the acini are at first difficult to distinguish.

Under L.P. and H.P. study and draw a single acinus.

Note:

- The spherical nuclei towards the base, the basophilic basal chromidial substance and the apical eosinophilic secretory granules (zymogen granules)
- The palely-stained nuclei of the centro-acinar cells surrounding the very small lumen (usually not visible)
- Look for and draw intercalated and larger intralobular ducts

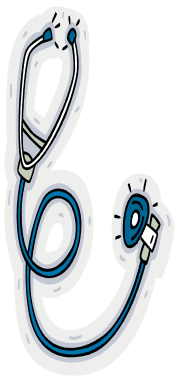
What is the function of the pancreatic acinar cells?

Name the enzymes secreted by the pancreatic acinar cells. Give their functions.

Explain the structural and functional relationship between the centro-acinar cells and the acinar cells.

What are the distinguishing features of the pancreas?

Clinical Correlation



Acute Pancreatitis, results from the activation of pro enzymes such as trypsin, chemotrypsin and other proeolytic enzymes by viruses, drugs or alcohol. The patient usually shows symptoms such as abdominal pain and nausea due to the active digestion of the cellular components of the pancreas by the activated enzymes.

RECAPITULATION
THE DIGESTIVE GLANDS

QUESTIONS.

1. Summarise all the glands you have studied in the gastrointestinal tract by completing the following table:

ORGAN	GLANDS	**CLASSIFICATION (Shape of secretory units and duct system)**	**SECRETION/S**	
ORAL CAVITY				
OESOPHAGUS				
STOMACH			CELL	Secretion/s
DUODENUM				
COLON				
PANCREAS	EXOCRINE			
	ENDOCRINE			
LIVER			Exocrine:	
			Endocrine:	

2. Compare the histological structure and function of the submandibular gland and the exocrine pancreas.

FEATURE	**SUBMANDIBULAR**	**PANCREAS**
Secretory end-pieces		
Ducts		
Functions		

3. List the functions of mucus in the gastrointestinal tract:

   a)

   b)

   c)

4. Draw a fully labelled diagram of a classical liver lobule and explain the flow of blood and bile in the lobule in relation to the functions of the liver.
   Indicate the position and constituents of the portal tracts.

The Urinary System

*** ANAT 2020 AND P/N ONLY ***

OBJECTIVES

- To identify and describe the histological structure of the kidneys and the urinary bladder.
- Understand the organization of the renal corpuscle and the cells present within it.
- Describe the filtration barrier between blood and urine in the renal corpuscle.
- Name the divisions of the nephron, and specify their locations (pars convoluta or medullary ray of cortex, or medulla).
- Relate the histological specializations found in specific divisions of the nephron to the functions of that division.
- Describe the blood supply of the kidney.
- Describe what structures are involved in regulation of blood pressure.

NOTES

The urinary system consists of the paired kidneys and the excretory passages (the ureters, the urinary bladder, and the urethra).

The kidneys are involved in:

- The elimination of waste metabolic products in a relatively large but variable volume of water
- The conservation of water, electrolytes and other materials to maintain the fluid and electrolyte balance of the body and the pH of the blood.

The kidneys produce urine, initially an ultrafiltrate of the blood, which is then modified by selective reabsorption and specific secretion by the cells of the kidney. The urine is conveyed by the ureters to the urinary bladder, where it is stored until discharged via the urethra.

PRACTICAL WORK

I.THE KIDNEY

Slide: 20
Stain: H&E

Macroscopic and L.P.: Draw the section in outline and note the:

- Capsule
- Cortex (with renal corpuscles)
- Medulla (one or more basophilically stained pyramids)
- Medullary rays or pars radiata (radiating from the base of pyramids into the cortex)
- Pars convoluta of the cortex (between the medullary rays)

Note parts of the following blood vessels:

- The interlobar, (between adjacent pyramids), arcuate (arch over at the cortico-medullary junction), interlobular vessels (in the pars convoluta) and afferent and efferent arterioles (associated with the renal corpuscles).

Study the nephron, collecting tubules and ducts and associated blood vessels under the following headings:

A. The pars convoluta of the cortex

Under L.P. and then H.P. look for a renal corpuscle with arteriole(s).

Note:

- The shape of the renal corpuscle and locate a vascular and urinary pole (the latter seldom seen).
- The thin parietal epithelium and the urinary space
- The capillaries of the glomerulus with flattened endothelial cell nuclei and the larger, palely stained nuclei of the visceral cells (podocytes)
- Relate the structure of the filtration barrier seen with the light microscope to that seen with an electron microscope.

- A macula densa (a dense packing of nuclei immediately adjacent to the vascular pole of the renal corpuscle (is the macula densa part of a proximal or of a distal tubule ?)

- A small cluster of darkly stained nuclei may be seen between the macula densa and the vascular pole. These are the "lacis" cells.

What is the function of the renal corpuscle?

What are the three components of the juxta-glomerular complex?

What are the functions of each component of the juxta-glomerular complex?

The proximal and distal convoluted tubules

Note:

- The many sections of proximal convoluted tubules with brightly eosinophilic cytoplasm and few palely stained nuclei
- A few sections of distal convoluted tubules with a lower epithelium and several darkly stained nuclei

Compare the proximal and distal convoluted tubules noting the type of epithelium, shape and spacing of the nuclei, size and staining reaction of the epithelial cells, visibility of the cell borders, presence (or absence) of a brush (striated) border and the shape and size of the lumen in relation to the overall size of the tubule in cross-section.

Also note the many capillaries and scanty connective tissue between the tubules.

Tabulate the similarities and differences in structure between the proximal and distal convoluted tubules.

Relate the function of the proximal and distal convoluted tubules to their structure.

B. The pars radiata (medullary rays) of the cortex

In a medullary ray note and draw under L.P. and H.P.

- The straight parts of the proximal and distal tubules (which are "descending", which "ascending"?)

- The collecting ducts with palely stained cytoplasm and prominent cell borders
- Capillaries running between the tubules.

Do the straight parts of the proximal and distal tubules differ in structure from the convoluted parts?

What is the function of the collecting duct?

a. The medulla

Under L.P. trace a medullary ray from the cortex into the medulla. (How do you identify the medulla?)

Study and draw under H.P.

- Straight parts of the distal tubules (in which limb of the loops of Henle are these?)
- The collecting ducts
- The straight vessels (vasa recta) running parallel to the tubules
- The thin limbs of the loops of Henle (how do you distinguish these from the vasa recta?)

What is the function of the thin part of the loop of Henle?

Tabulate the similarities and differences between the tubules and blood vessels found in the medulla.

II.THE URINARY BLADDER

Slide: 43
Stain: H&E

Macroscopic, L.P. and H.P.

Note and draw:

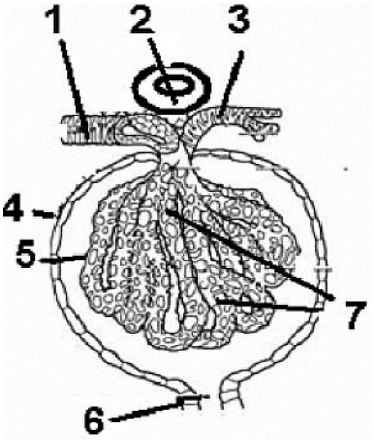
- The epithelium (what type is this)
- The lamina propria with blood vessels of different sizes
- The many bundles of interlacing layers of muscle fibres (what type?)

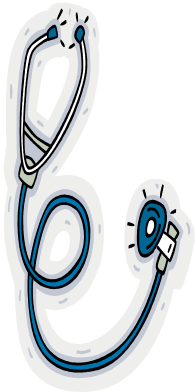
Which anatomical muscles control the outflow of urine from the urinary bladder? Are these muscles made up of smooth or striated fibres? Are these muscles under voluntary or involuntary control?

What type of epithelium is characteristic of the excretory passages of the urinary system?

What structural features of the epithelium allow for the distension of the excretory passages, the urinary bladder in particular?

Provide labels 1-7 for the diagram below (showing the structure of the renal corpuscle)





Clinical Correlation

Disorders of the kidney arise from a wide range of pathological causes, many of which are common in other organ systems. However, the kidney is unusual in that it is much more prone to immunological disorders than most other organs. Vascular diseases such as hypertension and vasculitis, and the common metabolic disease, diabetes mellitus, may also have profound effects on renal function. Disorders of the kidney can be divided into categories according to which structural component of the kidney is primarily affected; as an example, **glomerulonephritis** (deposition of immune complexes within the glomerulus), **vasculitis** (vascular disorder), and **diabetes mellitus.**

Young, B., Stewart, W., O'Dowd, G. (2011). Wheater's basic pathology. Fifth edition, Churchill, Livingstone

RECAPITULATION
URINARY SYSTEM

QUESTIONS.

1. Draw a diagram of a typical nephron showing its orientation within the cortex and medulla of the kidney. Include the arrangement of the blood vessels supplying the nephron.

2. Name the components of the filtration barrier and explain the role of each in the filtration process.

3. Describe the structure of the components of the juxtaglomerular apparatus. Explain the presumed function of the different components and how the position of each is related to its function.

4. Explain how the epithelial and muscle layers of the urinary bladder function together as the bladder fills and empties. Refer to the specialisations of the epithelium in your answer.

The Female Reproductive System

*** ANAT 2020 AND P/N ONLY ***

OBJECTIVES

- To understand, be able to draw and describe the histological structure and function of the female reproductive organs including ovaries and uterus at different stages of the menstrual cycle.
- To be able to draw and describe the structure and function of the developing ovarian follicles
- To be able to correlate the hormonal functions of the ovaries with uterine structure during the ovarian/menstrual cycle.
- To understand and describe the hormonal control of ovulation and implantation
- To be able to describe and draw the placenta at various stages of pregnancy and to correlate the structure and functions of the placenta at different stages of pregnancy

NOTES

The female reproductive system includes the internal pelvic organs, the paired ovaries and uterine tubes, the uterus and vagina; the external genitalia and the mammary glands because their development and function are related to the steroid hormones. Also included is the transient placenta only present during pregnancy.

From infancy to puberty, the ovaries, uterus, uterine tubes, vagina and mammary glands change in the normal course of growth. From menarche (marking the end of puberty) to menopause these organs then undergo rhythmic monthly changes in their structural and functional activities - referred to as the menstrual cycle. The menstrual cycle is concerned with the production of ova and the preparation for pregnancy. To complicate matters pregnancy and its hormonal control and changes both physical (development of active breast tissue and placenta) and hormonal, seen during its course are also considered. A further change occurs at menopause when ovulation ceases and oestrogen and progesterone secretion cease. Most of the oestrogen produced after menopause comes from the adipose tissue in the body.

PRACTICAL WORK

I. THE OVARY

Ovary (baboon)
Slide: 9 and 9.2
Stain: H& E

Macroscopic: Identify the ovary. Identify the basophilic outer edge of the ovary and the eosinophilic tunica albuginea. Note the cortex with many follicles.

Under L.P. note:

- The coelomic ("germinal") epithelium on the outer surface of the ovary and the fibrous tunica albuginea and cellular stroma
- The numerous primordial follicles (each surrounded by a single layer of flattened (squamous) granulosa (follicular) cells
- Unilaminar/primary follicles (each with a single layer of cuboidal/columnar granulosa (follicular) cells). Note the immature ovum (primary oocyte) in the follicle
- "growing follicles" - early stage (2 - 5 layers of granulosa cells, an eosinophilic zona pellucida surrounding the "ovum" and theca forming)
- "growing follicles" - later stage (fluid begins to accumulate between the granulosa cells forming a crescent-shaped cavity)
- More mature (Graafian) follicles (large cavity and eccentric cumulus oophorus)
- Atretic follicles (loose granulosa cells and degenerate, darkly stained (pyknotic) nuclear fragments lying in the antrum)

Under L.P. and H.P. draw and note the stages in the formation of the mature (Graafian) follicle.

- The central immature ovum surrounded by the the zona pellucida (eosinophilic membrane around the immature ovum)
- The corona radiata, (a ring of granulosa cells). This may be separated from the zona pellucida by a shrinkage space in more mature follicles
- The granulosa cells, cumulus oophorus and large follicular antrum
- The theca interna, (cells have oval to round nuclei with capillaries between them) and the more flattened darker nuclei of the theca externa formed from the stromal cells

The coelomic epithelium of the ovary is called "germinal" epithelium in the older textbooks. To what does this term refer? What is now known to be the origin of the primordial sex cells?

At what stage in the menstrual cycle was this ovary released? Give reasons for your answer.

What are the functions of:

- The follicular (granulosa) cells
- The theca interna
- The theca externa

How many ova as a rule, are produced at each ovulation?

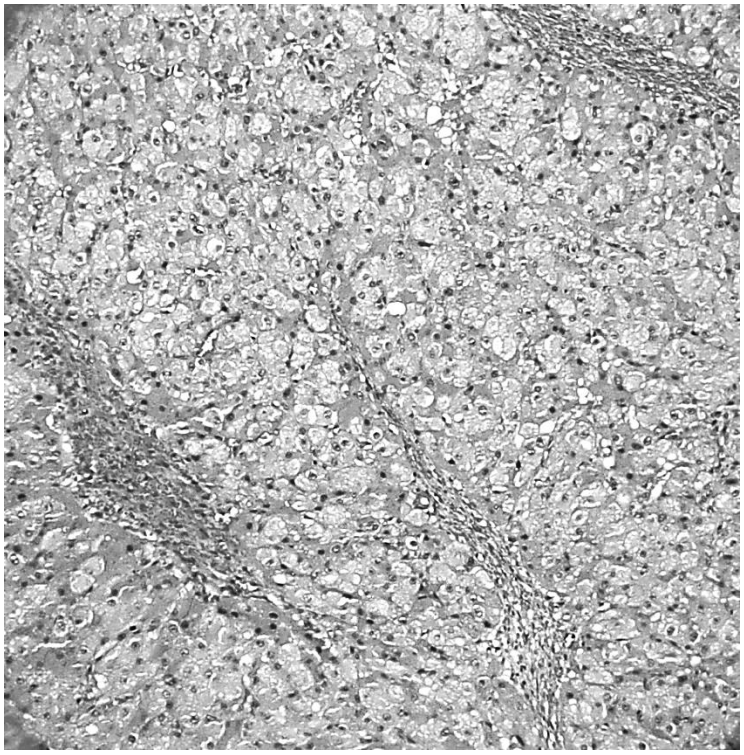
Please note that the slides have no medulla – so you need to look in your textbook or atlas.

II. THE CORPUS LUTEUM

Slide 56
Stain: H&E

You can also look at the slide in Olyvia.

See demonstration



The corpus luteum is formed from the remains of the tertiary follicle after ovulation. The three cell types seen in the tertiary follicle are seen in the corpus luteum. These in order of abundance are the granulosa lutein cells, the theca lutein cells and the connective tissue septa originating from the theca externa.

Clinical Correlation

Polycystic ovary syndrome (Stein-Leventhal syndrome) is a common cause of infertility. Patients with this syndrome are often obese, hirsute and have acne and menstrual abnormalities including amenorrhea. The ovaries themselves have a thickened capsule and many follicular cysts with stromal hyperplasia evident. The pathogenesis is uncertain but may be caused by the following situations that always result in overproduction of androgens by the ovary.

1. Defects in the hypothalomopituitary-gonadal axis causing abnormalities in the secretion of GnRH and/or LH resulting in over production of ovarian androgens.
2. A defect in ovarian steroidogenesis may favour androgen production
3. Insulin resistance in peripheral tissue may divert metabolic pathways towards androgen production.

IVF procedures for these patients can be problematic as ovarian hyperstimulation (which usually is part of an IVF treatment) can occur.

Core Pathology 3rd Edition. Editors: Stevens A, Lowe J, Scott I and Damjamov I.Mosby, Elsevier Ltd., 2009

III.THE UTERUS

The uterus (with pre-ovulatory endometrium) (baboon)
Slide: 10 and 10-2
Stain: H&E

Macroscopic:
Identify the lumen surrounded by the thick basophilic endometrium, below that the eosinophilic myometrium and the outer perimetrium (serosa or adventitia?)

Under L.P. and H.P. note and draw:

- The lining epithelium and the glands in the endometrium (what type?)
  Note the size and shape of the lumina of the glands and the type of epithelium lining the surface and glands.
- The stroma of the endometrium and observe the relative density of cells and fibres.
- Coiled arteries within the stroma.
- Note the arrangement of muscle fibres in the myometrium (what type?) and the arteries and sinusoidal veins (what are sinusoidal veins?) in the myometrium.
- At what stage in the menstrual cycle was this uterus (endometrium) desquamate?
- What is the function of the coiled arteries within the wall of the uterus?

Endometrium (post-ovulatory)
Slide: 58
Stain: H&E

These are sections of scraps of endometrium curetted on the 25th day of the menstrual cycle. Study the sections under L.P. and H.P. and draw labelled drawings to illustrate the distinguishing features.

Compare the following features with those in slide 10:

- The size and shape of the glands and their lumina
- The glandular epithelial cells: their size, presence of mitotic figures and secretion
- The density of cells and fibres and presence of oedema in the stroma

Tabulate the similarities and differences in structure between pre- and postovulatory endometrium.

Which hormones stimulate the development of the following structures? Indicate too, which glandular cells secrete each hormone.

- The follicles of the ovary
- The corpus luteum
- The preovulatory glands of the endometrium
- The postovulatory glands of the endometrium

What do the postovulatory glands secrete? What is the possible function of this secretion?

Which parts of the endometrium are shed during menstruation?

Which part of the endometrium is responsible for its regeneration after menstruation?

If fertilization should occur after ovulation, into which part of the endometrium does the young embryo implant?

IV. THE CERVICO VAGINAL CANAL

Slide: 123
Stain: H&E

Examine this slide

V. THE PLACENTA

Slide: 60
Stain: H&E

Macroscopic and L.P.:

Note and draw:

- The eosinophilic myometrium
- The fused amnion and chorion at the opposite edge of the section
- The numerous sections of slightly basophilic chorionic (placental) villi in the intervillous space
- The spongy endometrium (decidua basalis)
- The anchoring villi, i.e. those chorionic villi attaching on to the surface of the decidua basalis
- The placental surface of the decidua basalis covered by cytotrophoblast and attenuated syntrophoblast (latter towards blood space)
- Nitabuch's membrane (eosinophilic)
- The blood in the intervillous space (maternal or foetal?)
- The basophilic "giant cells" (syncytial knots - maternal or foetal?) seen in the intervillous space

Which parts of the placenta are maternal, which are foetal in origin?

H.P. Study part of a villus.

Note:

- The syntrophoblast
- The scattered cell bodies of the cytotrophoblast cells
- The mesenchymal core containing capillaries
- The large Hofbauer cells with eosinophilic cytoplasm

In an anchoring villus, also note the many cells forming a "foot plate".
(See the demonstration if an anchoring villus is not well shown in your slide.)
Name the components of the "placental barrier" between foetal and maternal blood.

Are the chorionic villi seen in this section, primary, secondary or tertiary? Give reasons for your answer.

What is the possible function of the Hofbauer cells?

What is a possible function of the "giant cells" (syncytial knots)?

VI. THE MAMMARY GLAND **(M)**

(a) The non-lactating mammary gland
Slide: 122
Stain: H&E

Examine this slide

(b) The lactating mammary gland
Slide: 55
Stain: H&E

Examine this slide

RECAPITULATION
FEMALE REPRODUCTIVE SYSTEM

QUESTIONS.

1. What is the “germinal epithelium” of the ovary? Why is this an inappropriate name?

2. Name the different stages of ovarian follicular development and compare the distinguishing criteria for each stage.

FOLLICLE	FEATURES

3. During which stages of development of the ovum do meiosis I and meiosis II occur?

4. What is the difference between an oocyte and an ovum?

5. List five important differences between oogenesis and spermatogenesis.

6. Explain the endocrine function of the ovary and its regulation.

7. Complete the following table comparing the pre- and post-ovulatory endometrium:

FEATURE	PRE-OVULATORY	POST- OVULATORY

8. Name the components of the maternal–foetal blood barrier and explain how it changes during pregnancy.

9. Name the substances which are able to cross the maternal–foetal barrier. (You should be able to list at least 12).

10. Describe the endocrine function of the placenta.

11. Can you suggest any possible explanation for the fact that the maternal immune system does not reject the foetus and placenta?

The Male Reproductive System

*** ANAT 2020 AND P/N ONLY ***

OBJECTIVES

After studying the male reproductive system you should be able to identify and describe histological structure and function of:

- The testis **(M/P/N)**
- The genital excurrent ducts (i.e. efferent tubules, epididymis and vas deferens) **(M)**
- The prostate gland **(M)**
- The penis **(M)**

NOTES

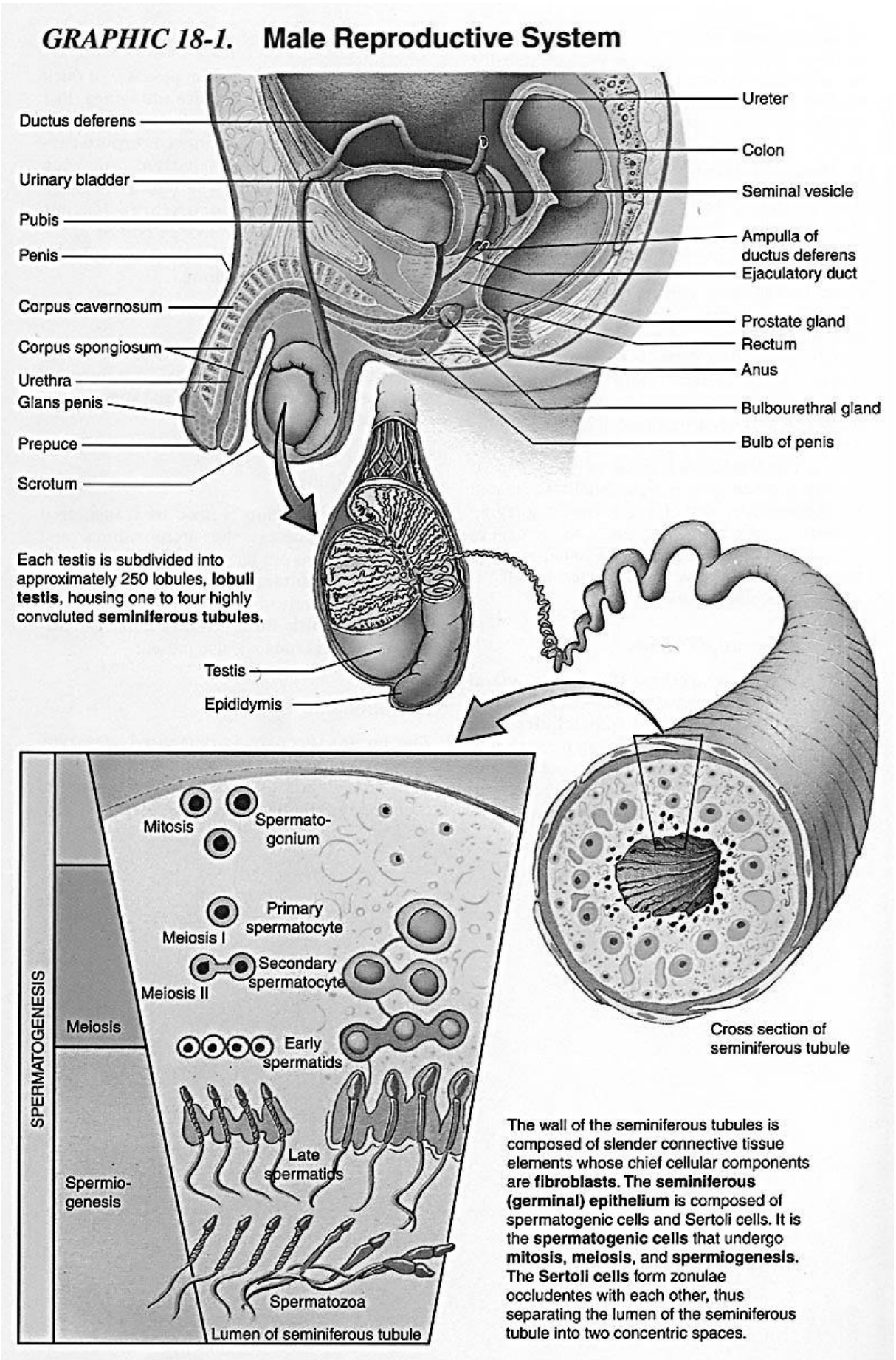
The male reproductive system is concerned with the formation of spermatozoa and the transport of spermatozoa in the seminal fluid to the exterior. It is composed of the testis, the genital excurrent ducts (the efferent ductules, the epididymis and the vas deferens), the accessory sex glands (seminal vesicles, bulbourethral glands and the prostate gland) and the penis.

Each testis is covered by a thick connective tissue capsule, the tunica albuginea. Incomplete connective tissue septa will divide each testis into lobes. Each lobe contains one to four highly coiled seminiferous tubules. The seminiferous tubules are lined by a complex stratified epithelium consisting of two basic cell populations: 1) Sertoli cells and 2) Spermatogenic cells (these include spermatogonia, spermatocytes and spermatids). The interstitial cells, Leydig cells, are located in the connective tissue outside the seminiferous tubules and are responsible for the production and secretion of testosterone. The testis functions in the production of male gametes/sperm (spermatogenesis) and the synthesis of androgens/sex hormones (steroidogenesis). The androgens produces by the testes, primarily testosterone, play an important role in the embryonic development of the male fetus and sexual dimorphism.

Pathway of sperm from the seminiferous tubules to the exterior:

Seminiferous tubules → Tubuli Recti → Rete Testis → Efferent Ductules → Epididymis → Vas Deferens → Ejaculatory Duct → Prostatic Urethra → Membranous Urethra → Penile Urethra

In this practical you will be studying the histological structure of the testis, the genital excurrent ducts, the prostate gland and the penis.



http://medcell.med.yale.edu/histology/gi1/images/gi_tract_cartoon.jpg

PRACTICAL WORK

I. THE TESTIS

(a) The testis **(M/P/N)**

Slide: 7
Stain: Iron haematoxylin

Note: *Iron haematoxylin, a blue-black stain demonstrates the chromosomes in the dividing cells of the testis.*

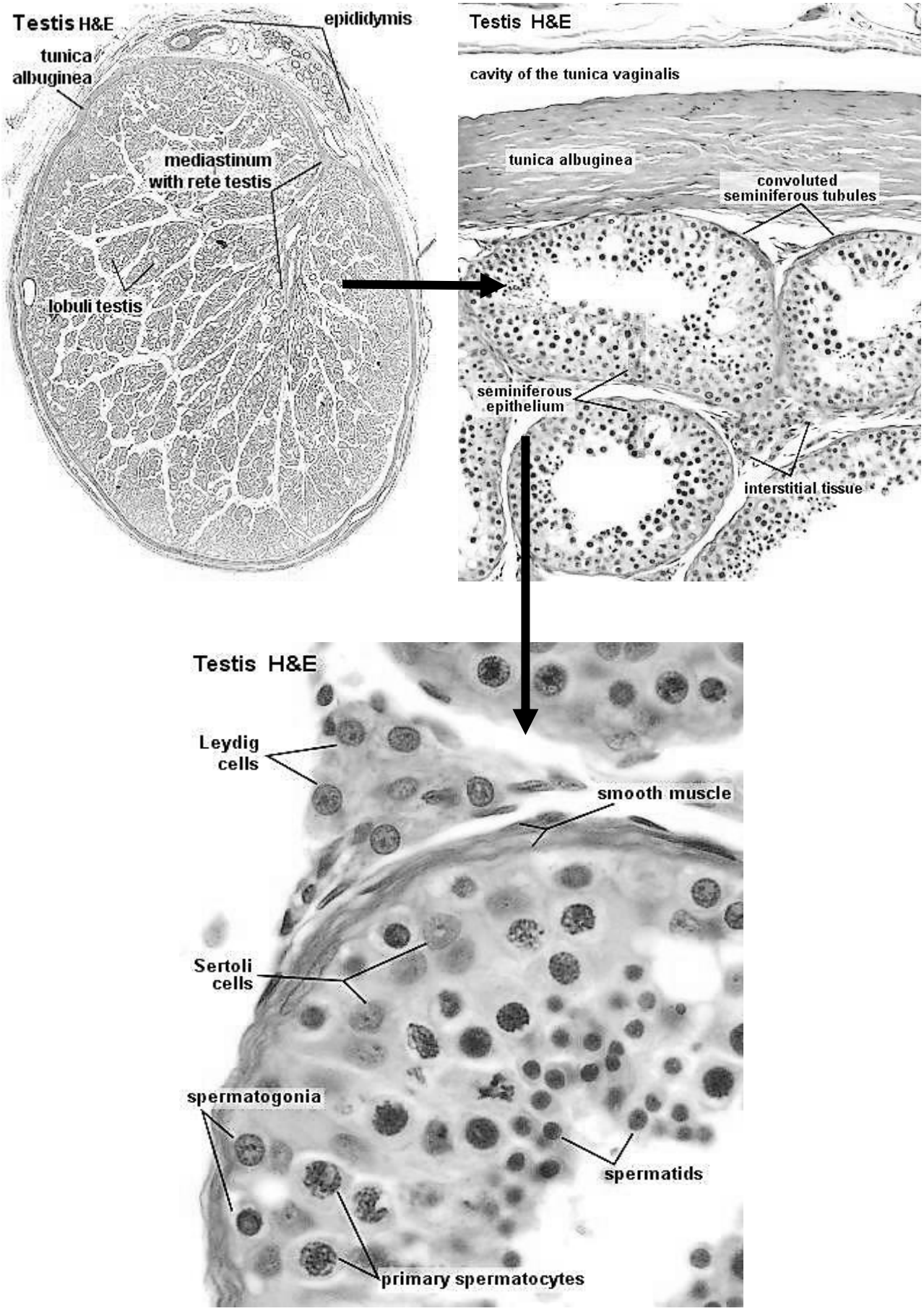
Macroscopic and L.P.

Note and draw:

- The thick capsule (tunica albuginea) and the many seminiferous tubules
- The loose connective tissue stroma between the tubules containing clumps of large interstitial cells (of Leydig), blood vessels and nerves

Note: *The size and shape of the interstitial cells and their position relative to the vessels in the surrounding stroma*

What is the function of the interstitial cells (of Leydig)?



ttp://www.lab.anhb.uwa.edu.au/mb140/

Under H.P. study and draw seminiferous tubules.

Note:

- The layered sheath around the tubule and the thin basement membrane internal to the sheath
- The supporting (Sertoli) cells, (large pale nuclei with prominent nucleoli) located at some distance from the basement membrane
    - What are the distinguishing features of the supporting (Sertoli) cells? What is their function?

- The sex or germ cells which make up a layer of 4 to 8 cells deep
    - What type of epithelium do these cells constitute? In which direction within this layer are the cells progressively differentiating?

Now study some of the phases in the meiotic division of the germ cells. Note the size and shape of the cells and the arrangement of the chromatin or chromosomes:

- The spermatogonia, (adjacent to the basement membrane - do these cells divide mitotically or meiotically?)
- The primary spermatocytes, (large and very numerous in the middle zone with a very distinctive chromatin pattern)
- The early spermatids (often in groups of four close to the lumen)
- The late spermatids (very condensed, tightly coiled chromatin, their "heads" are embedded in the apical portion of the Sertoli cells and their "tails" project into the lumen)
- The spermatozoa (inside the lumen of the seminiferous tubule)

Do not attempt to identify secondary spermatocytes; this is a transitory stage.

List the two epithelial cell types found in the lining of the seminiferous tubules.

What do you understand by the term "spermatogenesis"?

What is the significance of a reduction division (meiosis) in the formation of the gametes?

(b) The testis and epididymis **(M)**

Slide: 11
Stain: H&E

Macroscopic and L.P.

Note and draw in outline the extent and position of the following:

- The seminferous tubules
- The mediastinum testis with numerous large blood vessels
- The many sections of the highly tortuous epididymal duct (ductus epididymidis). These are larger than the sections of the seminiferous tubules
- The tubuli recti among the seminiferous tubules near the mediastinum
- The rete testis and its lining epithelium (what type?)
- The ductuli efferentes (if present) forming the head of the epididymis and connecting the rete testis with the ductus epididymidis - identified by the irregular luminal outline of the epithelium

Under H.P. Draw a few cells from each type of tubule to show the epithelium and supporting layers.

In the ductus epididymidis, note particularly:

- The type of epithelium
- The presence of stereocilia at the luminal surface (how do these differ in structure from microvilli and from cilia, and what is their function?)
- The surrounding layer of smooth muscle fibres (what is the possible function of this muscle layer?)
- The presence of spermatozoa in the lumen

What is the function of the epididymis?

Account for the presence of a mesothelium covering the tunica albuginea of the testis.

(c) The vas deferens **(M)**
Spermatic cord
Slide: 116
Stain: H&E

Examine the slide.
Compare the histological structure and function of the efferent ductules, the epididymis and the vas deferens.

Clinical Correlation

Failure of the abdominal testes to descend into the scrotum results in a condition known as **chrytorchidism,** or undescended testes. This particular abnormality is usually unilateral. If the condition is bilateral normal body temperature will inhibit normal spermatogenesis, which results in sterility.

Harhold Sheedlo (2005). USMLE Road Map: Histology.

II. THE PROSTATE GLAND **(M)**

Slide: 77
Stain: H& E

Macroscopic:

Note and draw:

- The shape of the lumen of the urethra
- The colliculus seminalis, a part of the wall of the urethra bulging into the lumen
- The utriculus prostaticus, with a star-shaped lumen and situated within the colliculus seminalis
- Two darkly stained ejaculatory ducts which run parallel to one another and are directed towards the urethra through the colliculus seminalis
- The many secretory alveoli
- The ducts of the latter identified solely by the fact that they open into the urethra
- The dense, fibrous and eosinophilic stroma
- The capsule of the gland, with numerous blood vessels

L.P. and H.P.

Note and draw:

- The epithelium lining the urethra with its many folds (the epithelium is variable in our sections and what you see may not agree with the description in your textbook)
- The variable epithelium (what types?) lining the secretory alveoli and the ducts (indistinguishable from each other)
- The concretions within some of the secretory alveoli
- The connective tissue and muscle fibre types within the stroma

What are the distinguishing features of:

a. The prostate?

b. The prostatic urethra?

What is the function of the prostate gland?

III. THE PENIS **(M)**

Slide: 37
Stain: H&E and elastic

Macroscopic: Draw a diagram to illustrate the following:

- The three masses of erectile tissue: the paired corpora cavernosa (dorsal) and the unpaired corpus spongiosum (corpus cavernosum urethrae)
- The urethra within the corpus spongiosum
- The thick eosinophilic tunica albuginea around the corpora cavernosa
- The thinner tunica albuginea around the corpus spongiosum
- The wrinkled skin
- The numerous blood vessels in the connective tissue between the skin and the masses of erectile tissue

Under L.P. and H.P. note and draw:

- The erectile tissue made up of irregular cavernous (venous) spaces (some containing blood) separated by thick partitions
- The endothelium lining the cavernous spaces
- The bundles of muscle fibres (what type?), connective tissue fibres (what type(s)?) and nerves within the partitions
- The helicine arteries in the partitions of the erectile tissue - the larger arteries have a thick media and may have an irregular lumen
- The shape of the lumen of the urethra
- The epithelium lining the urethra (what type?)
- The palely stained secretory cells (what do they secrete?) within the folds or crypts of the epithelium
- The paraurethral glands (of Littre) which may be deep within the lamina propria (what do they secrete?).

What are the distinguishing features of

(a) The penile urethra?

(b) The erectile tissue?

Explain the mechanism of erection

RECAPITULATION
MALE REPRODUCTIVE SYSTEM

QUESTIONS

1. What do you understand by:
   Spermiogenesis

   Spermatogenesis

2. Explain the formation and function of the A and B spermatogonia

3. Complete the following table. Indicate the cells which are part of the spermatogenic series and the points at which meiosis I and meiosis II take place.

CELL TYPE	CHROMOSOME NUMBER	DNA CONTENT (N, 2N, 4N)
Interstitial cell		
Sertoli cell		
Spermatogonium		
Primary spermatocyte		
Secondary spermatocyte		
Spermatid		
Spermatozoon		

4. Describe the structure of the "blood -testis barrier" and explain its importance.

5. What do you think is the functional advantage of the interstitial cells lying outside the seminiferous tubules? Explain their function and relate this to their histological structure.

6. Complete the following table:

TUBULE	LOCATION	EPITHELIUM	SURROUNDING TISSUE	FUNCTION
Tubuli recti				
Rete testis				
Ductuli efferentes				
Ductus epididymidis				
Ductus deferens				
Ejaculatory duct				
Prostatic urethra				
Penile urethra				

6. Classify the prostate gland according to its structure

What is the function of the prostate gland?

What are prostatic concretions?

7. The drug Viagra is a muscle relaxant. With reference to the structure of the erectile tissue of the penis, explain the mechanism of erection and how Viagra could aid in this process.

Joints

*** PT/OT and D ONLY ***

OBJECTIVES

- To understand the relationship between the studied primary tissues and their interaction to form morphological joints.
- To understand the gross and histological structure and function of the structures that form synovial joints.
- To understand the relationship between muscle, tendons and ligaments and bone.

NOTES

Joints, articulations or arthroses are regions where bones meet one another. Joints vary considerably in form depending on the degree or type of movement required between the bones. Joints are classified according to their degree of mobility as well as the types of connective tissues involved.

There are three major categories.

1. **Synarthroses**, (temporary growth) zones which include for example:
   - The sutures (syndesmoses) of the cranium, containing fibrous connective tissue (the closure of a suture occurs when opposing periostia grow together).
   - Synchondroses are the epiphyseal discs of the limb bones. In this context the diaphysis and epiphyses of each bone may be considered separate bones because they each develop from separate centres of ossification.

2. **Amphiarthroses**, these types of joints permit limited movement and are not responsible for growth as seen in synarthroses and are permanent joints. Almost all amphiarthroses in the body are symphyses. In symphyses the adjacent joints are covered by articular (hyaline) cartilage and the two layers of cartilage are joined by fibrous connective tissue or fibro-cartilage. Examples include intervertebral discs and the joint between the two pubic bones.

3. **Diarthroses** or **synovial joints** are freely movable. The articulating bones in this case are held together by a fibrous capsule enclosing a fluid-filled space. Synovial joints vary widely in shape and therefore in the types of movement possible (e.g. hinge, ball and socket) they all conform to the same basic pattern and all develop within a continuous sheath of poorly defined connective tissue.

The fact that limb bones develop within a continuous sheath of connective tissue (mesenchyme first) explains why there is no perichondrium found on the articular surfaces of hyaline cartilage.

The development of synovial joints and symphyses is similar in that both are formed by the differentiation of connective tissue within a continuous fibrous tube. A better understanding of the

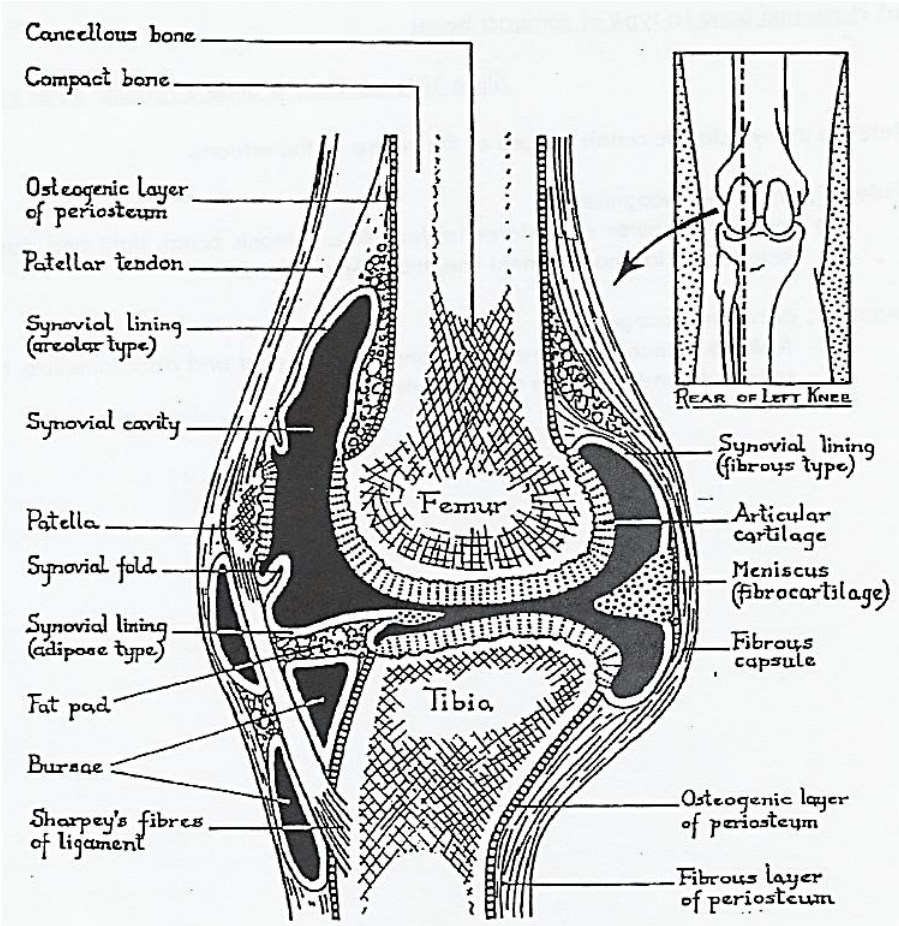
relationship between bones and joints is gained by knowing something of the development of the bones.

Synovial joint capsule

The capsule of a synovial joint includes an outer layer of dense irregular connective tissue which is continuous with *periosteum.* The inner layer of the capsule is the *synovium* which is composed of 1-4 layers of synovial cells. This layer does not cover the articular cartilage, but rather extends into the cavity as a fold. There are two types of synovial cells, Type A cells and Type B cells. *Synovial fluid* is a combined product of the synovial cells and ultrafiltrate of the capillaries. It is rich in hyaluronic acid, glycoproteins and lymphocytes and functions in lubrication, nutrition and immune defence. The capsule also contains encapsulated nerve endings: Ruffini's corpuscles, Pacinian corpuscles and Google organs as well as free nerve endings.

Articular cartilage within the synovial joint

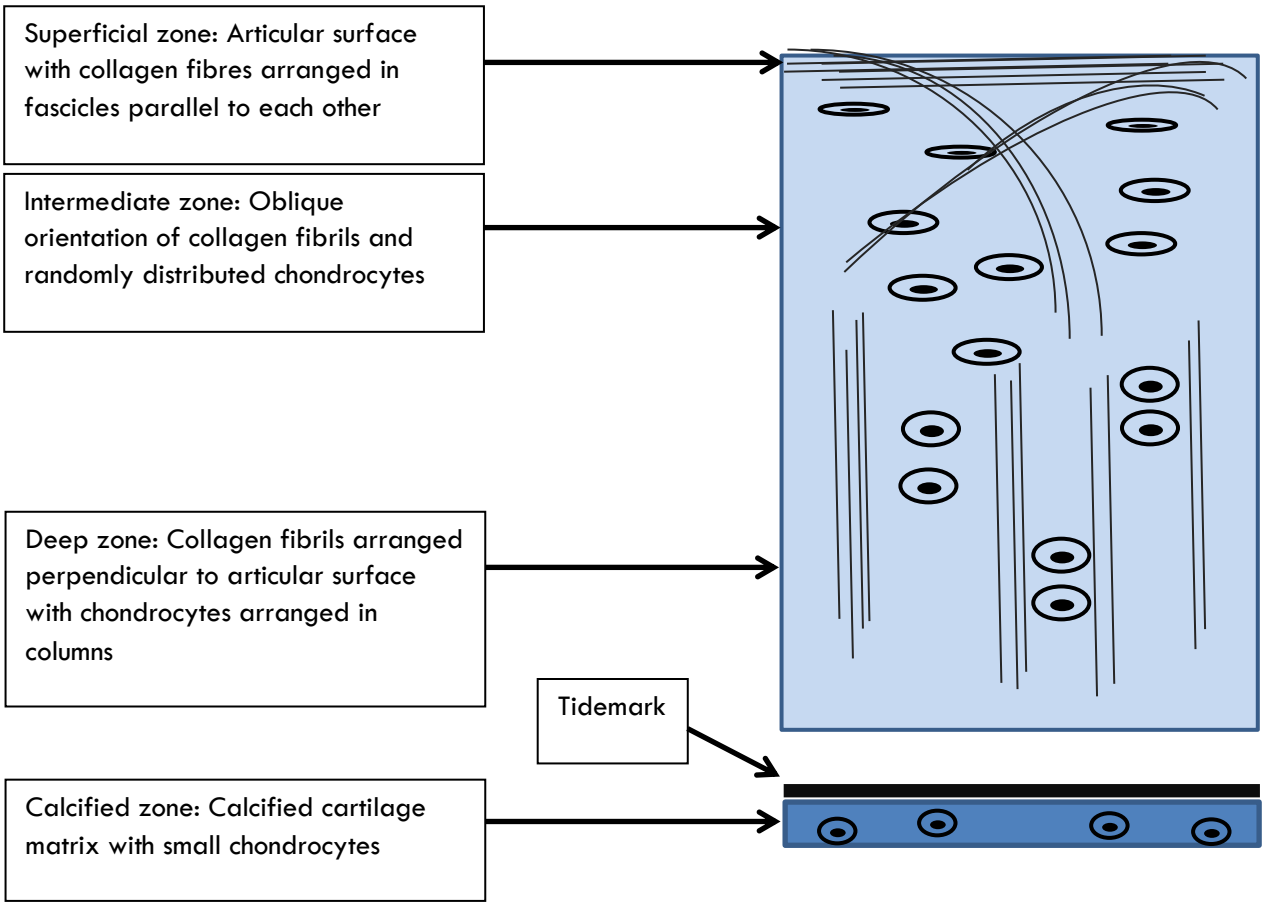
Articular cartilage is composed of hyaline cartilage which lacks a perichondrium at the site of articulation. Both the cellular (chondrocytes) and extracellular components of articular cartilage exhibit specific arrangements. Consider the function of articular cartilage! Articular cartilage is thus divided into zones:



HUMAN KNEE JOINT, L.S. — EXAMPLE OF A DIARTHROSIS. (After Ham & Cormack, 1979)

Note that the size of the synovial cavity and the thickness of the synovial lining, articular cartilage and periosteum have been exaggerated for clarity.

Articular cartilage in a synovial joint



Insertions to bone

Insertions to bone allow for transmission of force from a flexible, tension-bearing structure (joint capsules, tendons and ligaments) to a rigid structure. Collagen fibres from these connective tissue structures insert into bone as Sharpey's fibres. Recall that tendons are composed of dense regular connective tissue (consider the connective tissue sheaths that surround fibrils and fascicles of collagen fibres. Both tendons and ligaments exhibit an enthesis – an attachment site for these connective tissue elements into bone.

PRACTICAL WORK

(a) Haversion bone (a type of compact bone)

Slide: 1
Stain: Decalcified

And

Slide: 3
Stain: Ground silver impregnated

Note the many osteonic canals placed at the centre of the osteons**.**

Under LP, draw and recognise:

- Periosteum, outer circumferential lamellae, osteonic canal, light and dark lamellae, osteocytes, lacunae, cement line, transverse canals.

Under HP, draw and recognise:

- A single osteon and show the arrangement of light and dark lamellae, the lacunae, canaliculi, and remnants of osteocytes.

Why is the cement line colourless?

Where are perforating collagen fibre bundles (Sharpey's fibres) found and what is their function?

What is osteoid and where is it generally found?

Where are osteoblasts, osteocytes and osteoclasts generally located?

Do canaliculi pass between osteons? What is their function?

**How would you determine if the osteon (with a large space) was being destroyed or reconstructed?

(b) Spongy or cancellous bone (Nasal cavity and air sinuses)

Slide: 67
Stain: H&E, decalcified

The bone has been decalcified and so the trabeculae or spicules stain eosinophilically.

Under LP and HP recognise:

- Periosteum, endosteum, arrangement of lamellae, marrow spaces, lacunae, canaliculi, osteoprogenitor cells, osteoblasts, osteocytes, osteoclasts.

What ultrastructural characteristic of active osteoblasts and osteocytes explains their cytoplasmic basophilia?

What is the function of each of the bone cells?

JOINTS

(a) Foetal knee (developing joint)

Slide: 52
Stain: (H&E, decalcified)

What types of joints are present?

Classify these joints.

What is the main difference between articular cartilage and hyaline cartilage?

Revise the structure of fibrocartilage.

Under LP:

Draw a diagram showing the different parts of the joint. Show the positions of: developing articular cartilage, the synovial cavity, synovial fluid, joint capsule (outer fibrous layer and synovial lining), adipose tissue, areolar connective tissue, blood vessels, ligaments, bursae and menisci.

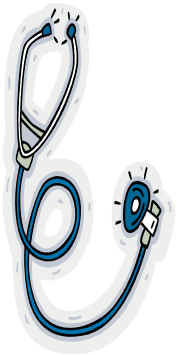
Under HP:

- Examine the structure of the synovial membrane, which consists of connective tissue cells (not epithelium).

Describe the relationship between the synovial membrane and synovial fluid.

Give the main function for each of the components of a synovial joint.

Clinical Correlation



Osteoarthritis is a degenerative joint disease related to aging and injury of articular cartilage. Patients present with chronic joint pain and destruction of the articular cartilage associated with weight-bearing joints. The production of IL-1 & TNF-α induces the production of metalloproteinases which break down extracellular matrix components, and inhibits the synthesis of collagen type II and proteoglycans. This decrease in proteoglycan content adversely affects hydration thereby hindering the ability of articular cartilage to respond to pressure loads. The articular cartilage surface is gradually eroded, increasing pain and reducing mobility.

Ross & Pawlina, (2011). Histology A Text and Atlas 6th Edition.

RECAPITULATION
JOINTS

QUESTIONS

1. Describe the structure and function of a synovial joint e.g. the knee joint.

2. What is the function of synovial fluid?

3. Describe the arrangement of collagen fibrils and chondrocytes in articular cartilage in relation to its function.

4. Describe the insertion of tendon into bone (enthesis).

5. How do tendons and ligaments differ from each other, both in histological structure and function?

Special Nerve Endings

*** PT/OT ONLY ***

OBJECTIVES

- To identify and know the function of the encapsulated nerve endings in the skin, namely the Meissner's and Pacinian corpuscles
- **To identify and understand the function of the neuromuscular junction (motor end plate) as seen in the light microscope.**
- To understand the components making up a **muscle spindle**

NOTES

CLASSIFICATION
NOTE: Broad categories

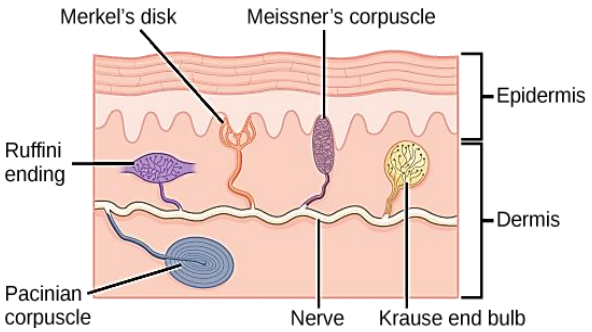
-Sensory receptors of the skin
Encapsulated nerve endings
Unencapsulated nerve endings
-Neuromuscular Junction
-Muscle spindles
-Golgi tendon organ

Sensory receptors

3 methods of classification:
►By receptor complexity
Free nerve endings, Encapsulated nerve endings and Sense organs
►By location
Exteroceptors, Interoceptors, Proprioceptors
►Type of stimulus detected
Mechanoreceptors, Photoreceptors, Thermoreceptors, Chemoreceptors, Nociceptors

Encapsulated Nerve Endings:
These are nerve ending that are covered by connective tissue sheath. Examples include: Pacinian corpuscles, Meissner's corpuscles, Ruffini's corpuscles, Krause's end bulb, Muscle spindles and Golgi tendon organs.

Pacinian corpuscles



Large ovoid structure, located in reticular dermis and hypodermis and asociated with joints, periosteum and internal organs. Size: >1mm along long axis.

Structure:

♦Myelinated nerve ending surrounded and the corpuscle is invested by strong C.T capsule.

♦Nerve enters capsule at one pole with myelin intact

♦Myelin is retained for one or two nodes and is then lost

♦Unmyelinated portion of axon extends to opposite pole

♦Length of this axon covered by tightly packed, flattened Schwann cell lamellae that form inner core of corpuscle

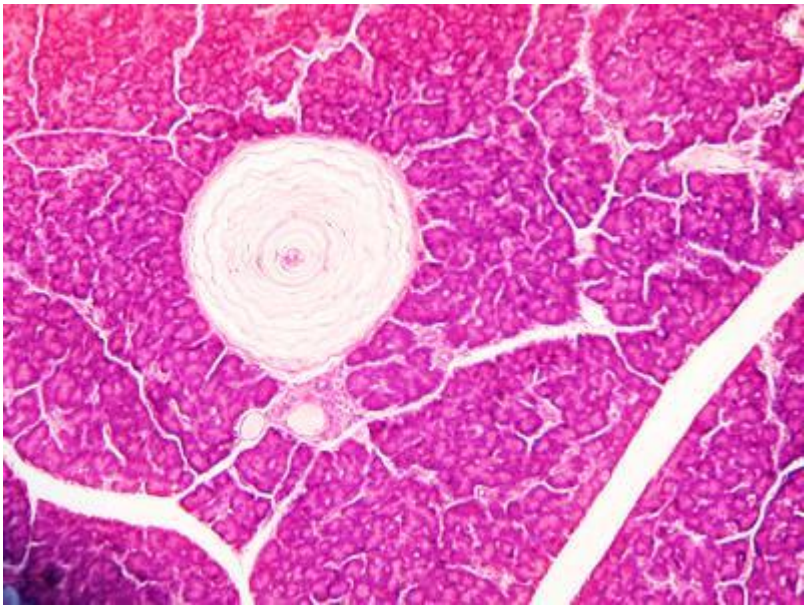
♦Outer core formed by series of concentric lamellae separated from one another by a narrow fluid filled space

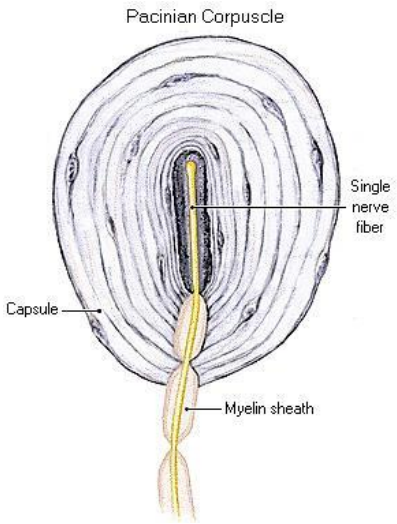
♦Collagen fibres and capillaries found between lamellae

Function:

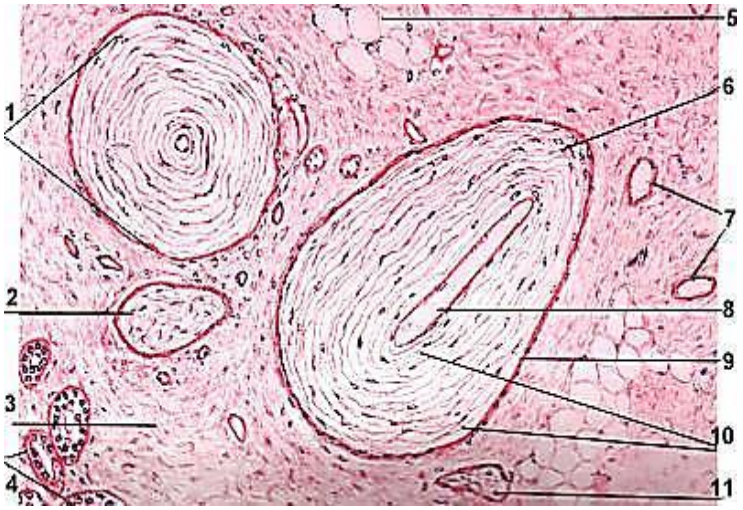
♦Respond to pressure and vibration through displacement of the corpuscle lamellae

♦Displacement of lamellae results in depolarization of the axon





This histology slide of the pancreas shows a pacinian corpuscle within the pancreas.

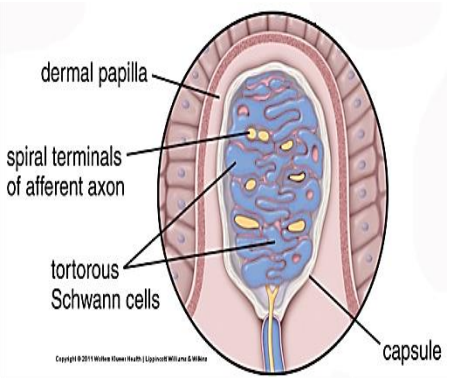


Pacinian corpuscles (dermis of thick skin) PASH. 350x

Eroschenko (1993) *di Fiore's Atlas of Histology 7th Ed.* Plate 49, Fig. 2, p. 133

Meissner's Corpuscles

Located in papillary layer of hairless skin within the dermal papillae. A tapered cylindrical structure about 150µm along long axis and orientated perpendicular to skin surface

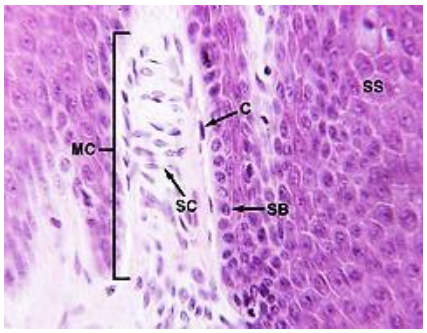


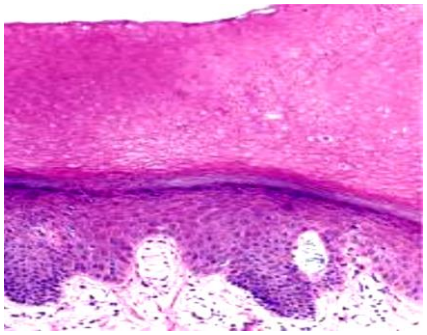
Structure:

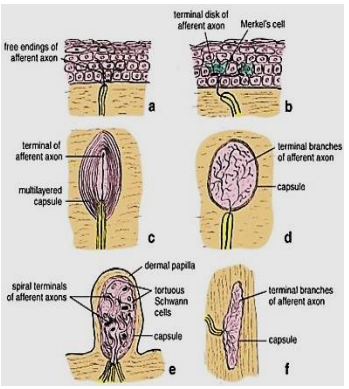
Consists of 1 or 2 unmyelinated endings of myelinated nerve fibres that spirals within the corpuscle with flattened Schwann cells forming several irregular lamellae through which axons course to pole of corpuscle. A CT capsule invest the whole corpuscle.

Function:

♦Touch receptors particularly responsive to low frequency stimuli







A dermal papilla containing a specialized sensory nerve ending - Meissner's Corpuscle (MC). Seen are the following: a capsular layer of connective tissue (C), neurolemmal or Schwann cells (SC), the stratum basalis (SB) and stratum spinosum (SS) of the

Ruffini's Corpuscles

♦Elongated, fusiform shape

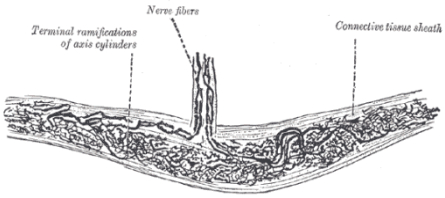
♦Located in deeper layers of the dermis

♦Size: 1 – 2□m in length

Structure:

♦Thin CT capsule enclosing a fluid filled space

♦Collagen fibres pass though capsule



♦Single myelinated fibre that enters capsule and then loose myelin sheath and branch

♦Branches form dense arborisation of fine axonal endings, each terminating in small knob-like bulb

♦Axonal endings are dispersed and intertwined within the capsule

♦Axonal endings respond to displacement of collagen fibres induced by sustained/continuous mechanical stress

Mesher, A.L. Junqueira's Basic Histology. Text and Atlas, 12th edt
http://en.wikipedia.org/wiki/Bulbous_corpuscle
http://en.wikipedia.org/wiki/Bulbous_corpuscle

Function:

♦Respond to stretch and torque

♦Rapid adapting (phasic) receptors

Krause End Bulbs

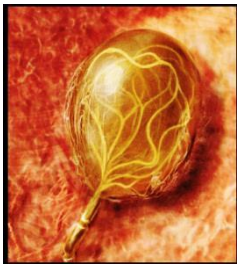
Krause's are rapidly adapting sensory nerve ending (receptors) found in the superficial layers of the dermis, they are

♦Ovoid structures

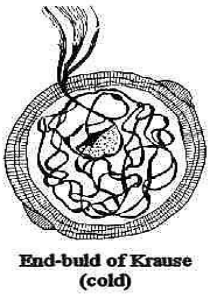
♦Extremely thin, collagenous CT capsule

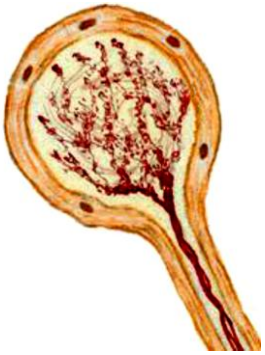
♦Sensory nerve fibre penetrate capsule

♦Found primarily in skin of penis and clitoris



www.starsandseas.com





www.virtualworldlets.netquizlet.com

Function:

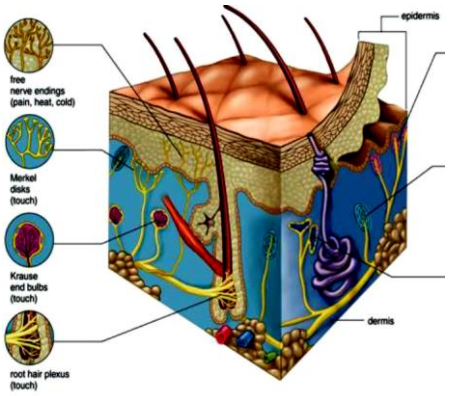
♦Sense low frequency vibrations

The end-bulbs of Krause were named after German anatomist Wilhelm Krause (1833-1910).

Unencapsulated Nerve Endings

Merkel's disc:

Merkel's cells (stratum basale) associated with expanded terminal bulb of afferent myelinated nerve fibres. Neuron terminal loses Schwann cell covering and penetrates basal lamina and then expands into a disc/plate-like ending that lies in close apposition to the base of the Merkel's cell. Function as tonic receptors for sustained light touch and sensing and object's texture



classes.midlandstech.edu

Free nerve endings:

♦Extend from papillary dermis and terminate in stratum granulosum

♦No connective tissue or Schwann cell investment

♦Respond to high and low temperatures, pain and itching, also functions as tactile receptors

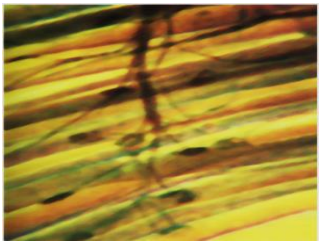
Root hair plexus:

♦Web of sensory fibres surrounding the bases of hair follicles in reticular dermis and detects hair movement.

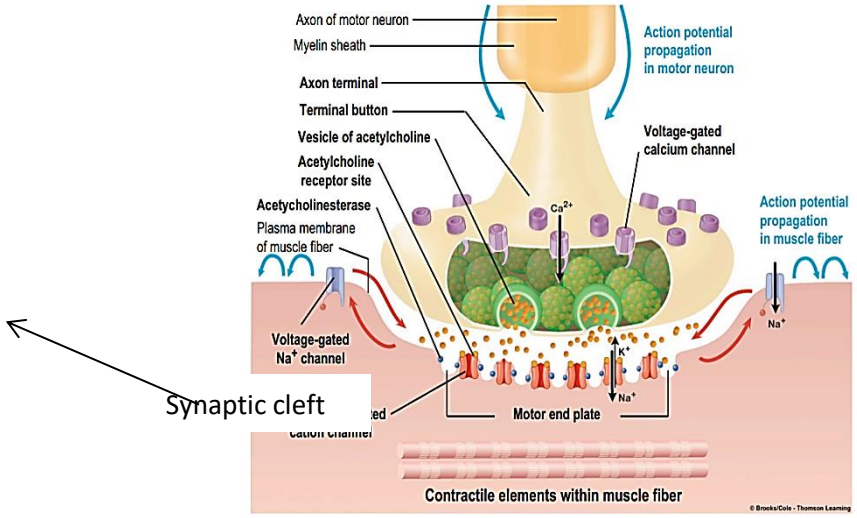
Neuromuscular Junctions

Are chemical synapses between branch of motor nerve axon and skeletal muscle fibre, also known as motor end plate or myoneural junction.

Motor end plate



Neuromuscular junctions are the last synaptic outpost in the "final common path" that leads, via the axons of motor neurones, out of the central nervous system and these axons terminate (**axon terminal, presynaptic membrane**) in skeletal muscle (postsynaptic membrane). The space between presynaptic (axon terminal) and postsynaptic (muscle sarcolemma) membranes is the synaptic cleft – neurotransmitters are released into this junctional cleft. Each branch of a motoneuron forms a single junction with a muscle fiber. The myelin sheath surrounding the motor axon ends near the surface of the muscle fiber and the axon divides into a number of short processes that lie embedded in grooves on the muscle-fiber surface (increased surface area). This region of the sarcolemma (muscle membrane) is known as the motor end plate. Acetylcholine is the neurotransmitter in these synapses**.**



Steps in neuromuscular transmission:
1) nerve action potential.
2) calcium entry into the presynaptic terminus.
3) release of Ach quanta.
4) diffusion of Ach across cleft.
5) combination of Ach with post-synaptic receptors and Ach breakdown via esterase.
6) opening of Na+/K+
channels (cation channels).
7) postsynaptic membrane depolarization (EPP).
8) muscle action potential.

Proprioceptors

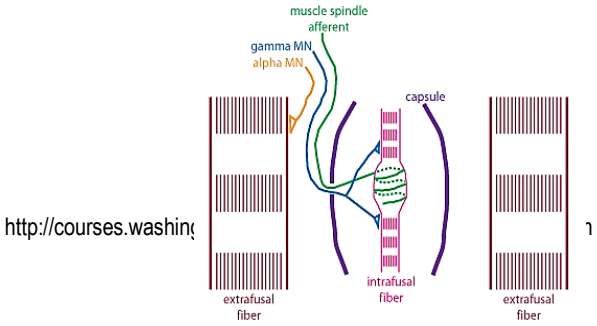
Proprioception means "sense of self". In the limbs, the proprioceptors are sensors that provide information about joint angle, muscle length, and muscle tension, which is integrated to give information to CNS about the position of the limb in space.

Two types
1. The muscle spindle provides information about changes in muscle length.
2. The Golgi tendon organ provides information about changes in muscle tension.

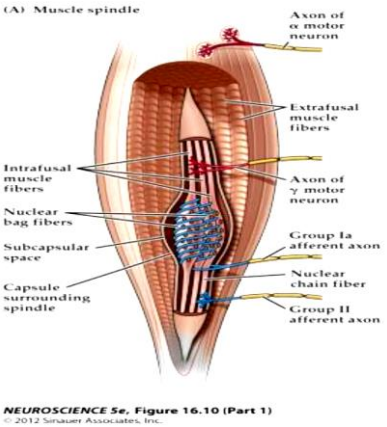
Muscle Spindle (Neuromuscular Spindle)
Are elongated, fusiform sensory organ within skeletal muscle, ~2mm long and 0.1mm wide and function primarily as stretch receptor enclosed within a **capsule (**modified perimysium with concentric layers of flattened cells). Below the capsule is fluid filled subcapsular space. They are found throughout the body

of a muscle, in parallel with **extrafusal fibers** (typical muscle fibers, surrounds connective tissue capsule and innervated by large diameter alpha motor neurons).

Within a muscle spindle, are several small about 8-10, specialized/modified skeletal muscle fibers known as **intrafusal fibers (surrounded by CT capsule) which** have **contractile proteins** (thick and thin filaments) at either end, with a central region that is devoid of contractile proteins (not striated). The central region is wrapped by the **sensory dendrites** of the **muscle spindle afferent**. There two types: (1).Nuclear Bag fibres (2 -3 fibres, either dynamic or static fibers) with aggregation of nuclei in expanded mid-region and (2), Nuclear Chain fibres (variable in number, usually 5 fibres) with many nuclei arranged in chain. The intrafusal fibers are innervated by an efferent neuron -**gamma motor neuron (MN).** The role of the gamma MN is to **maintain muscle spindle sensitivity**, regardless of muscle length. When the extrafusal fibers have been stimulated to contract by alpha MN activation, the gamma MN is simultaneously excited. This is known as **alpha-gamma coactivation**. The gamma MN stimulates contraction in the two ends of the intrafusal fiber, readjusting its length and keeping the central region of the intrafusal fiber taut, thereby keep the muscle spindle afferent responsive.



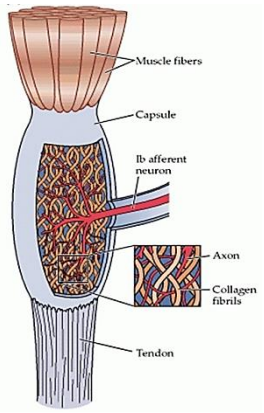
http://courses.washing ı



Golgi Tendon Organ

Unlike muscle spindles (which are located **in parallel** with muscle fibers), the Golgi tendon organs are **in series** with muscle fibers, located in the tendons that attach muscle to bone. The sensory dendrites of the Golgi tendon organ afferent are interwoven with collagen fibrils in the tendon. They are about ~ 1mm long and 0.1mm in diameter, and are encapsulated collagen fibres surrounded by terminal branches of group Ib sensory nerves. Axons of these nerves loose myelin after entering the capsule and branch into many fine nerve endings, each of which intertwines among the braided collagen fascicle. When the muscle contracts, the collagen fibrils are pulled tight, and this activates the Golgi tendon organ afferent. Because changes in muscle tension will provide different degrees of pull on the tendon, the Golgi tendon organ provides information about muscle tension.

In summary
Stretching of tendon → straightening of collagen fibres → compression of free nerve endings between collagen fibres → firing of AP from nerve endings → inhibition of alpha efferent (motor) neurons preventing further contraction.



References

Kandel, E.R., Schwartz, J.H., Jessel, T.M. Principles of Neural Science, 4th Edition
Mesher, A.L. Junqueira's Basic Histology. Text and Atlas, 12th and 13th Editions
Gartner, L.P., Hiatt, J.L., and Strum, J.M. BRS Cell Biology and Histology, 6th Edition
Ross. M.H. and Pawlina, W. Histology a Text and Atlas, 6th Edition
Neuroscience, 2nd edition, by Purves D, Augustine GJ, Fitzpatrick D, et al., editors. Sunderland (MA): Sinauer Associates; 2001.
Mesher, A.L. Junqueira's Basic Histology. Text and Atlas, 12th edt;
http://cmdi.medicine.dal.ca/Anat5217/Lab9/26lhmc.html

PRACTICAL WORK

I. NERVE ENDINGS ENCAPSULATED IN SKIN

Skin
Slide: 35/42
Stain: H&E

Identify and draw:

- Lamellar (pacinian) corpuscles
  - Situated deep in the skin, between the dermis and hypodermis
  - Note the shape and size of the pacinian corpuscle
  - Note the arrangement of the lamellae or connective tissue surrounding the axon, including fibres and nuclei
- Tactile (Meissner's) corpuscles
  - Situated within the dermal papillae underlying the epidermis
  - Note the shape and size of the Meissner's corpuscles
  - Note the connective tissue (fibres & nuclei) arrangement, how does it differ from that of the Pacinian

Describe the structure of these corpuscles and list their functions.

Clinical Correlation

Pacinian Neuroma is a benign but very painful and very rare lesion of pacinian corpuscles. They usually occur in the fingers (digits), although in very rare cases they occur in the feet. At the microscopic level the neuroma shows either an increase in the size (hypertrophy) and / or number (hyperplasia) of mature pacinian corpuscles. It is also often associated with an increase in the connective tissue elements (fibrosis) of the pacinian corpuscle's capsule as well as its adjacent nerve (endoneural and perineural fibrosis). They seem to occur subsequently to some sort of local trauma to the area, although some patients present without such history of trauma. In most cases surgical removal of the neuroma relieves the pain, however in more severe cases digital neurectomy (complete surgical removal of the nerve) or ray amputation (surgical removal of the affected digit) is required.

Kumar et al., (2003) Pacinian Corpuscles Hyperplasia – An Uncommon Cause of Digital Pain. *Acta Orthopaedica Belgica*, 69(1):74-76

II. NEUROMUSCULAR (MYONEURAL) JUNCTION

Striated (skeletal) muscle (snake)
Slide: 4
Stain: H&E and gold impregnation

This is a whole mount of striated skeletal muscle of the snake impregnated with gold to demonstrate nerve fibres.

- Draw and fully label a neuromuscular junction at the light microscopy level.
- You are also expected to know and understand the ultrastructure of the neuromuscular junction. For this reason, look at the electron micrographs of neuromuscular junctions in the EMG folder on your computer.

Clinical Correlation

Neurogenic Atrophy. A muscle requires neural innervation to function correctly. If a nerve is damaged through disease or it is cut during surgery, the muscle cells undergo neurogenic atrophy. This means that the muscle fibres decrease in size and their contractile units (sarcomeres) break down. Although the muscle fibres are no longer functional, they do not die as they retain their nuclei and are able to maintain their metabolic activity. Instead they lie in "suspended animation" waiting for nerve impulses that never come. Atrophy of the muscle can also occur when the muscle has not been used, for example when somebody breaks their leg and it lies in a cast for several weeks. This kind of atrophy is however reversible with exercise, that rebuilds the lost contractile units.

www.vetmed.vt.edu/education/curriculum/vm8054/Labs/Lab10/lab10.htm

Describe how a neuromuscular junction functions

III. MUSCLE SPINDLE

See Fig. 11.12 on page 326 in Ross and Paulina.

Draw a schematic diagram of a neuromuscular spindle.

A 'dynamic response' is one of two ways in which neuromuscular spindles can respond to changes in length. Describe this response using the clinical 'knee jerk test' as an example.

Clinical Correlation

Cerebral palsy (CP) is characterized by abnormal muscle tone. It is caused by damage to the developing CNS, particularly in the motor control centres of the brain. It therefore occurs either in utero or in early childhood up to the age of three. It results in limited movement and posture that limits normal activities. As a result of abnormal neuromuscular activities, secondary musculoskeletal problems can also occur, such as disturbances in sensation, depth perception, other sight based perceptual problems, communication and even epilepsy.

Spastic cerebral palsy is the most common type of CP, whereby patients are hypertonic, meaning that their muscles are very tight and do not stretch, hence the effected limbs, joints and sides of the body become very stiff and straighten out. Patients often walk abnormally and have muscle weakness or complete paralysis of a group of muscles. Additional uncontrollable muscle spasms, and shock like contractions of all or part of a group muscles also occur. This is as a result of the loss of control of motor neurons which causes disordered spinal reflexes, an increased excitability of muscle spindles and decreased synaptic inhibition. Physical and Occupational therapy are used to manage the disease thus assisting the patient in static stretching, strengthening and functional tasks, which reduce motor neuron excitability.

www.ncbi.nlm.nih.gov/pubmedhealth/PMH0001734/
http://en.wikipeida.org/wiki/Cerebral_palsy

The Endocrine System

*** ANAT 2020 ONLY ***

OBJECTIVES

- To identify, and describe the histological structure and function of different types endocrine glands
- Describe the organization and function of endocrine tissues, including the key endocrine organs as well as diffuse endocrine cells.
- Distinguish the different types of pituitary cells using the light microscope and electron microscope.
- Name and describe the different layers of the adrenal gland, as well as the blood supply to this gland.
- Explain what is unique about the structure of the thyroid gland.
- Contrast the structure of the thyroid with that of the parathyroid.
- Identify islets of Langerhans within pancreatic tissue and explain the relative positions of alpha and beta cells.
- Recognize the differences between normal and pathological specimens of thyroid, adrenal gland, parathyroid, and pancreas.

NOTES

The endocrine glands are ductless glands which pass their secretions directly into the blood stream. Many endocrine glands are encapsulated and are separate entities, e.g. hypophysis, suprarenal, parathyroid and thyroid; others are scattered masses of cells within another organ, e.g. the islets of Langerhan in the Pancreas, the endrocrine cells of the gastro-intestinal glands, the corpus luteum and thecal cells of the ovary, the interstitial cells (Leydig) in the testis.

The hypophysis, thyroid, suprarenal, and the islets of Langerhans will be studied

PRACTICAL WORK

I. THE HYPOPHYSIS

The hypophysis cerebri
Slide 94
Stain: Mallory

This section has been stained with three acid dyes viz. Acid fuchsin (red), aniline blue and Orange G. Collagen and reticular fibers are stained blue and colloid blue or orange. The secretory cells of the pars distalis are identified by their staining reaction with red and blue dyes. Nuclei stain red and erythrocytes orange.

Macroscopic and L.P.

Study and draw:

- The blue-stained capsule surrounding the gland
- The red- and blue-stained pars distalis and the palely stained and smaller pars nervosa
- The blue- and orange-stained colloid in the cleft (or cysts) in the blue-stained pars intermedia

Identify the palely stained infundibular stem and the blue-stained pars tuberalis

List the parts of the hypophysis which are included in:

- The adenohypophysis
- The neurohypophysis

Under H.P. study and draw:

a. The pars distalis

Note the clusters of epithelial cells of three types and the network of fine, blue-stained connective tissue fibres (what type are these fibres and what is their function?) containing dilated capillaries.

Now study and draw in detail, examples of each of the epithelial cell types, viz. "acidophils", "basophils", and chromophobes. Note : the staining reaction of the cytoplasm or secretory granules.

- Why are the granular epithelial cell types referred to as "chromophils"?
- Why are the grey-stained epithelial cells referred to as "chromophobes"?
- What is the possible relationship between the chromophobes and the chromophils?

List the pituitary hormones which are secreted by the "acidophils" and the "basophils" of the pars distalis?

b. <u>The pars nervosa</u>

Note:

- The many fine, non-myelinated nerve fibres and the blue-stained connective tissue fibres supporting thin-walled capillaries
- The "basophils" wandering in from the pars intermedia
- The spherical and finely-granular "Herring bodies" frequently stained a brownish-orange or mauve (found close to the blood vessels)
- Identify the oval, palely or orange-stained and somewhat granular nuclei of "pituicytes" (neuroglial-like cells)

Where are the hormones of the neurohypophysis secreted and how do they reach the blood stream?

Name the hormones of the neuropypophysis and give their functions.

What is the function of the "pituicytes"?

What are the distinguishing features of the pars distalis and the pars nervosa?

What is the embryological origin of the:

- adenohypophysis
- neurohypophysis

II.THE THYROID GLAND

Slide 44
Stain: H&E

Macroscopic and L.P.: Note the capsule and connective tissue septa (continuous with the capsule) forming distinct lobules.

Note the many follicles of various shapes and sizes within the lobules and the homogeneous and eosinophilic colloid within the follicles. Connective tissue and blood vessels lie between the follicles (what type of blood vessels are these?).

Study and draw the follicles under H.P.

Note:

- The variation in the height of the epithelium lining the follicles (what type of epithelium is this?)
- The staining reaction of the epithelial cells lining the follicles
- The small clumps of cells, without colloid and between the follicles - some of these are cells of follicles cut tangentially; others are "C cells".
- The capillaries in the connective tissue surrounding the follicles.

What is the chemical composition of the colloid in the thyroid?

What hormones are secreted by the thyroid gland?

What is the function of calcitonin?

Which cells secrete calcitonin?

Explain briefly the interrelationships between thyroxine and the thyroid stimulating hormone secreted by the pars distalis of the pituitary.

What are the distinguishing features of the thyroid gland?

III. THE PARATHYROID GLAND

Slide 21
Stain: H&E

Examine this slide

What hormone is secreted by the parathyroid gland?

What is the function of the hormone secreted by the parathyroid gland?

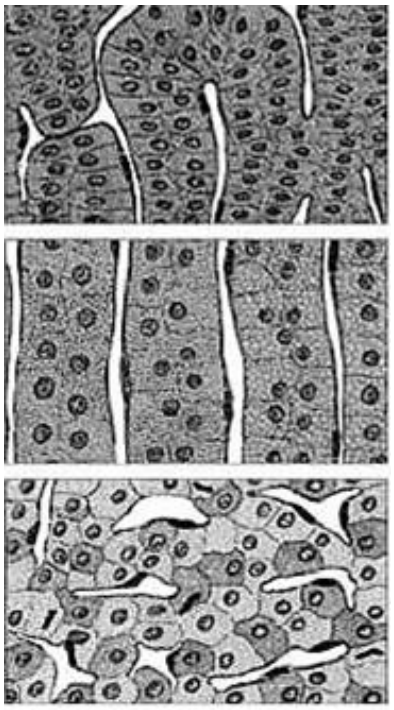
V. THE SUPRARENAL GLAND

Slide 92
Stain: H&E
Macroscopic : Note the eosinophilic fibrous capsule of the gland and the cortex - (the outermost region palely stained, the inner region more eosinophillically stained). Identify the palely stained medulla with large veins.

Under L.P. and H.P. draw and label a small segment of the section.

Note:

- The vascular capsule with fine trabeculae penetrating into the gland continuous with the fine connective tissue fibre framework.
- Identify the three zones of the cortex noting the staining reaction of the cells:
    a) The zona glomerulosa, the narrow outermost zone, the cells arranged in ovoid groups (why is this layer referred to as "glomerulosa"?)
    b) The zona fasciculata with similar cells arranged in long radial cords (why is this layer referred to as "fasciculata"?)
    c) The zona reticularis - note the arrangement of the cells (why is this layer referred to as "reticularis"?)
- The medulla arranged in groups of palely stained cells (do not confuse these with occasional patches of fasiculata cells deep to the reticularis).



Z. Glomerulosa

Z. Fasciculata

Z. Reticularis

Account for the vacuolated appearance of the cells in the zona glomerulosa and zona fasciculata of the suprarenal cortex.

- What is the chemical nature of the hormones secreted by these two zones of the suprarenal cortex?

- Name the three main groups of hormones produced by the suprarenal cortex and give their functions. Also indicate which cells are thought to be responsible for the secretion of each group of hormones.

- What is the chemical nature of the hormones secreted by the suprarenal medulla?

- Name the hormones secreted by the suprarenal medulla and give their functions.

- Which cells of the suprarenal medulla are responsible for the secretion of these hormones?

- A specific hormone of the pituitary gland controls the secretion of a suprarenal cortical hormone. Which hormones are referred to in this statement?

- What is the embryological origin of the secretory cells of:
  a) the cortex
  b) the medulla of the suprarenal gland?

VI. THE PANCREATIC ISLETS (Islets of Langerhans)

Slide 17
Stain: H&E

Macroscopic and L.P:

Note the palely stained islets among the darker stained exocrine acini.

H.P Note and draw:

- The arrangement of the cells in cords
- The numerous capillaries
- The fine connective tissue framework

It is not possible to distinguish the different types of endocrine cells with H and E.

- Name the hormones secreted by the pancreatic islet cell types.

- What is the chemical nature of these hormones?

- State briefly the function of each of these hormones.

- What are the distinguishing features of the pancreatic islets?

Clinical Correlation

Structural defects of the pituitary gland are few, although functional abnormalities are potentially numerous, leading to under-or overproduction of one more of the many hormones produced by the pituitary and its target endocrine glands. The most important histopathological lesions of the pituitary gland are **benign adenomas** derived from the anterior pituitary. These commonly secrete anterior pituitary hormones and result in the development of **endocrine syndromes**. Adenomas may be derived from any of the normal anterior pituitary cell types and can be classified by the hormones they secrete.

Prolactinomas secrete prolactin and may lead to infertility and inappropriate breast milk production

Somatotroph adenomas secrete excess growth hormone and lead to gigantism or acromegaly

Young, B., Stewart, W., O'Dowd, G. (2011). Wheater's basic pathology. Fifth edition, Churchill, Livingstone

RECAPITULATION
THE ENDOCRINE SYSTEM

QUESTIONS

1. List the characteristics common to all endocrine tissues

2. Give examples of endocrine glands which secrete:

   Peptides: 1 2 3

   Steroids: 1 2 3

   Catecholamines Neuropeptides Didpeptides

3. Name the cell types (according to staining reaction) found in the pars distalis of the hypophysis and give the secretion/s of each.

   Name the secretions of the pars nervosa. Give the site of synthesis of these secretions.

   What are Herring bodies? Explain their function.

   Explain the importance of the hypothalamo-hypophyseal portal system

4. Name the cell types of the pancreatic islets and the hormone produced by each.

   Name two methods by which these cells may be distinguished from one another.

   What is the embryonic origin of the exocrine and the endocrine cells of the pancreas.

5. Describe the distinguishing characteristics of the thyroid gland.

Give two reasons why the thyroid follicles may appear to be different sizes in a section.

Where are the C- cells of the thyroid found? What do they secrete?

Give the embryonic origin of the follicular and the C-cells of the thyroid.

Use the regulation of thyroid hormone secretion to explain what is meant by negative feedback.

6. Complete the following table relating to the suprarenal cortex

ZONE			
POSITION & THICKNESS			
ARRANGEMENT OF CELLS			
STAINING REACTION			
SECRETIONS			

7. Give the distinguishing characteristics of the suprarenal medulla and relate to its embryonic origin and function

Glands Affecting Lifestyle

*** TSDs ONLY ***

OBJECTIVES

After studying the histological and ultrastructure of certain glands affecting lifestyle you should be able to identify and describe the histological structure and function of:

- The liver
- The pancreas
- Hypophysis
- Thyroid gland
- Suprarenal (adrenal) gland

In addition to the above you should also be able to classify each of the named glands.

NOTES

The liver is the largest mass of glandular tissue in the human body. It has both an exocrine (synthesis and secretion of bile) and endocrine (synthesis and secretion of plasma protein, cholesterol, lipoproteins and glucose) functions. Apart from these functions the liver is also involved in detoxification of lipid-soluble drugs, steroid hormone breakdown, glycogen storage, and the production of urea.

The pancreas is a lobulated compound alveolar gland and like the liver has both exocrine and endocrine functions. The exocrine component of the pancreas is found throughout the organ and synthesizes and secretes digestive enzyme precursors. The duct system of the exocrine pancreas consists of centro-acinar cells, intercalated ducts, intralobular ducts, interlobular ducts, the main pancreatic duct and the accessory pancreatic duct. There are no striated ducts in the pancreas. The endocrine component of the pancreas is dispersed throughout the exocrine component as pale staining, distinct cell masses, the Islets of Langerhans. The endocrine component of the pancreas is responsible for the secretion of insulin, glucagon and somatostatin.

The endocrine glands are ductless glands which pass their secretions directly into the blood stream. Many endocrine glands are encapsulated and are separate entities, e.g. hypophysis, suprarenal, parathyroid and thyroid; others are scattered masses of cells within another organ, e.g. the islets of Langerhans in the Pancreas, the endrocrine cells of the gastro-intestinal glands, the corpus luteum and thecal cells of the ovary, the interstitial cells (Leydig) in the testis.

PRACTICAL WORK

I. THE LIVER

Slide: 23
Stain: H&E

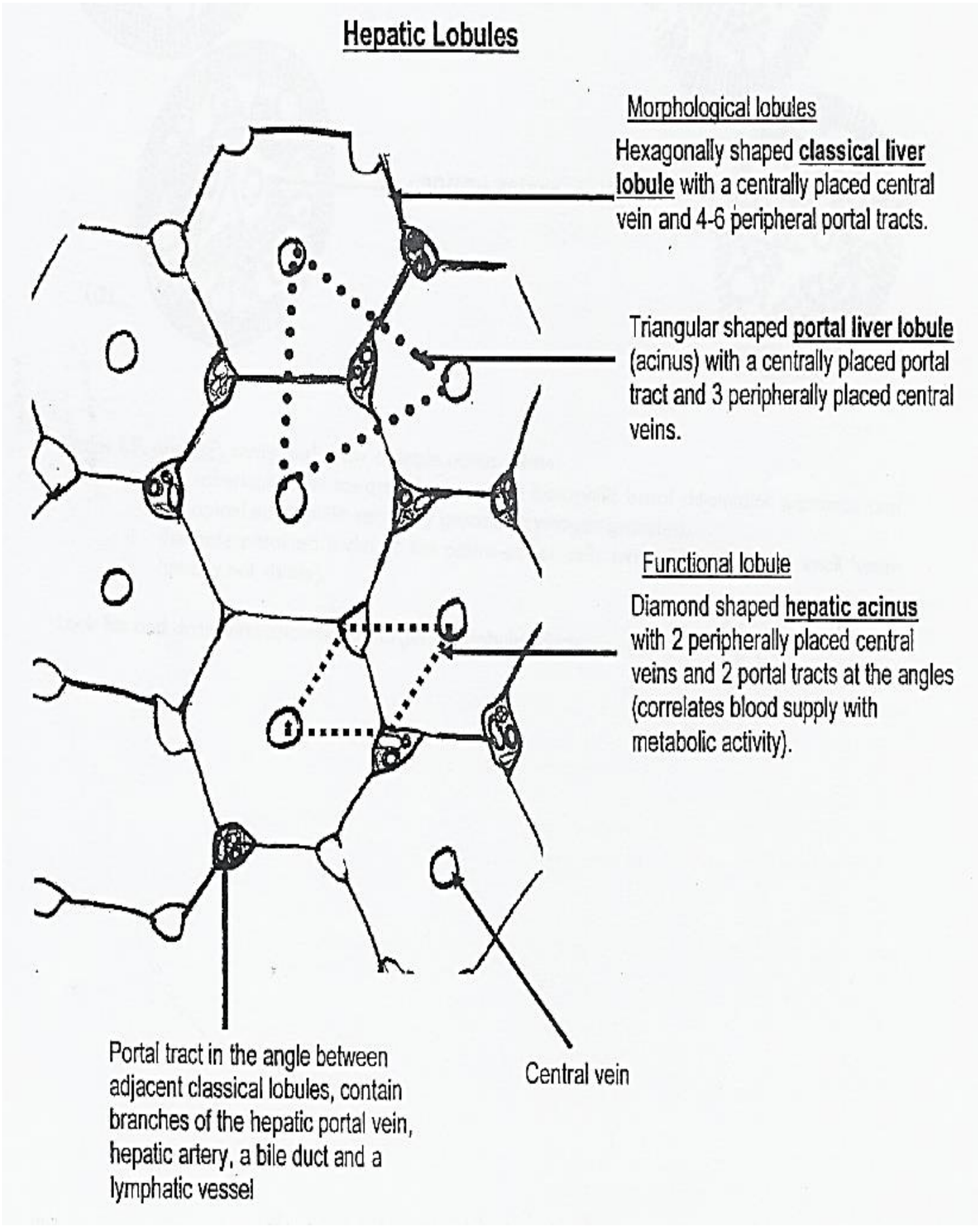
Macroscopic: This section is of a small part of a lobe of the liver. Scan the edge of the section to find the capsule.

Under L.P. note the capsule and connective tissue septa, the liver parenchyma made up of cords of cells (separated by sinusoids) draining into central veins and portal tracts surrounded by connective tissue.

Under L.P. and H.P. draw the components of a portal tract noting:

- The bile duct lined by a simple cuboidal epithelium
- One or more branches of the hepatic artery
- One or more branches of the portal vein

Lymphatic vessels are sometimes seen in the portal tracts.



Trace the boundary of a "classical" liver lobule which is centred around a central vein. Note that the cords of liver cells and the sinusoids radiate towards the central vein.

Study the liver parenchyma under H.P. Note and draw:

- The arrangement, size and shape of the liver cells and the position, shape, size and number of nuclei per cell
- The staining reaction of the cytoplasm - the yellow or brownish-yellow particles of haemosiderin within the cytoplasm of some of the cells
- The sinusoids lined by endothelial cells between the cords of liver cells
- The phagocytic (Kupffer) cells with palely stained nuclei and stellate eosinophilic cytoplsm often spanning the lumen of the sinusoids

Bile canaliculi occur between adjacent liver cells. Illustrate their position in your drawing.

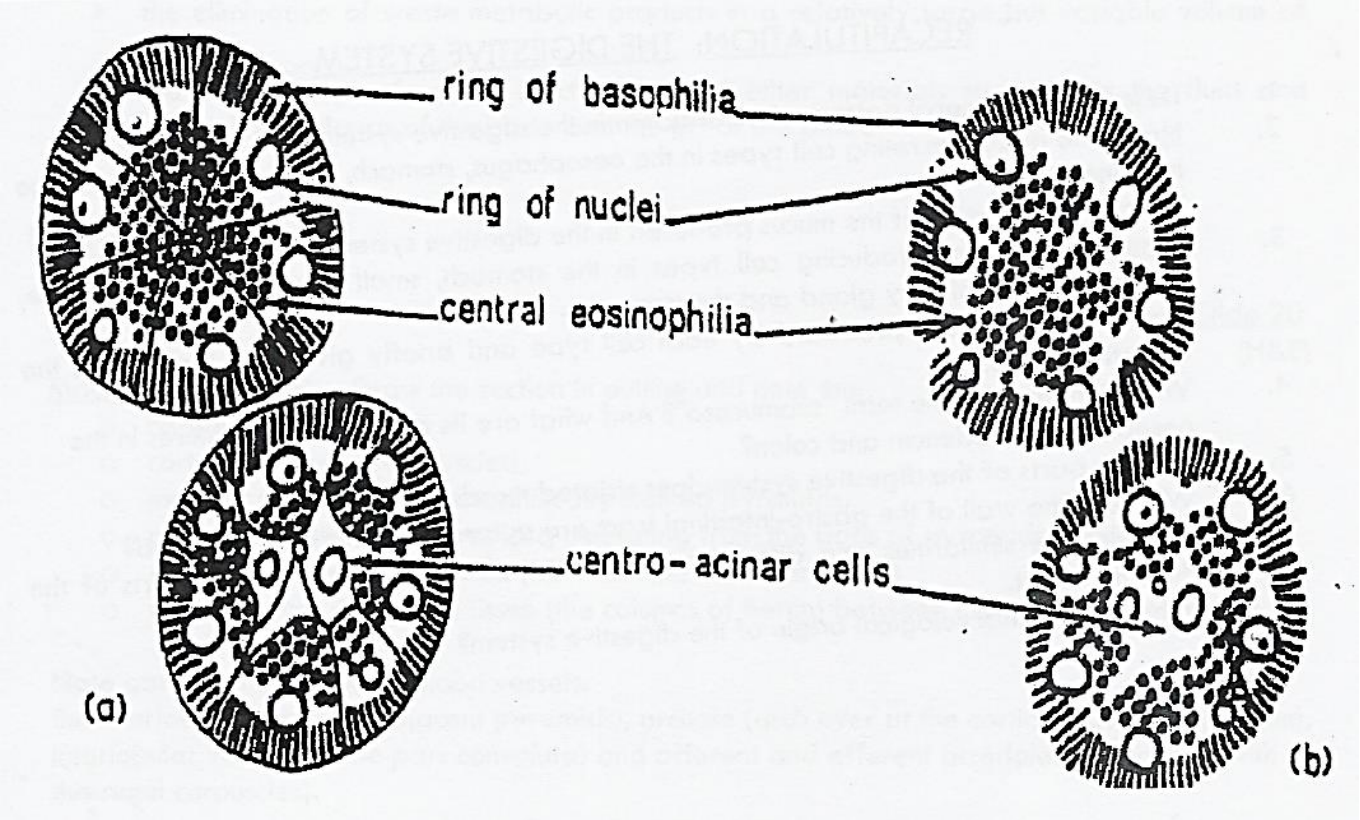
What are the functions of the liver cells? Relate the structure of these cells as seen by light microscopy (and from electron micrographs) to their functions.

What is the function of the phagocytic (Kupffer) cells?

II. THE PANCREAS

Slide: 17
Stain: H&E

Macroscopic and L.P. Identify the connective tissue capsule and septa, the latter with ducts and blood vessels, the parenchyma of the exocrine pancreas and the small, pale-stained Islets of Langerhans, (the endocrine components to be studied later in the year).



The borders of the acini are at first difficult to distinguish.

Under L.P. and H.P. study and draw a single acinus.

Note:

- The spherical nuclei towards the base, the basophilic basal chromidial substance and the apical eosinophilic secretory granules (zymogen granules).
- The palely-stained nuclei of the centro-acinar cells surrounding the very small lumen (usually not visible).
- Look for and draw intercalated and larger intralobular ducts.

What is the function of the pancreatic acinar cells?

Name the enzymes secreted by the pancreatic acinar cells. Give their functions.

Explain the relationship between the centro-acinar cells and the acinar cells.

What are the distinguishing features of the pancreas?

Clinical Correlation

Acute Pancreatitis, results from the activation of pro enzymes such as trypsin, chemotrypsin and other proeolytic enzymes by viruses, drugs or alcohol. The patient usually shows symptoms such as abdominal pain and nausea due to the active digestion of the cellular components of the pancreas by the activated enzymes.

Harhold Sheedlo (2005). USMLE Road Map: Histology.

III. THE HYPOPHYSIS

The hypophysis cerebri
Slide 94
Stain: Mallory

This section has been stained with three acid dyes viz. Acid fuchsin (red), aniline blue and Orange G. Collagen and reticular fibers are stained blue and colloid blue or orange. The secretory cells of the pars distalis are identified by their staining reaction with red and blue dyes. Nucleoli stain orange and erythrocytes, orange or red.

Macroscopic and L.P.

Study and draw:

- The blue-stained capsule surrounding the gland
- The red- and blue-stained pars distalis and the palely stained and smaller pars nervosa
- The blue- and orange-stained colloid in the clefts (or cysts) in the blue-stained pars intermedia

Identify the palely stained infundibular stem and the blue-stained pars tuberalis.

Name the parts of the hypophysis which are included in:

- The adenohypophysis
- The neurohypophysis

Under H.P. study and draw:

a. The pars distalis

Note the clusters of epithelial cells of three types and the network of fine, blue-stained connective tissue fibres (what type of fibres are these and what is their function?) containing dilated capillaries.

Now study and draw in detail, examples of each of the epithelial cell types, viz. "acidophils", "basophils", and chromophobes. Note: the staining reaction of the cytoplasm or secretory granules.

- Why are the granular epithelial cell types referred to as "chromophils"?
- Why are the grey-stained epithelial cells referred to as "chromophobes"?
- What is the possible relationship between the chromophobes and the chromophils?

List the pituitary hormones which are secreted by the "acidophils" and the "basophils" of the pars distalis.

b. The pars nervosa

Note:

- The many fine, non-myelinated nerve fibres and the blue-stained connective tissue fibres supporting thin-walled capillaries
- The "basophils" wandering in from the pars intermedia
- The spherical and finely-granular "Herring bodies" frequently stained a brownish-orange or mauve (found close to the blood vessels)
- Identify the oval, palely or orange-stained and somewhat granular nuclei of "pituicytes" (neuroglial-like cells)

Where are the hormones of the neurohypophysis secreted and how do they reach the blood stream?

Name the hormones of the neuropypophysis and give their functions.

What is the function of the "pituicytes"?

What are the distinguishing features of the pars distalis and the pars nervosa?

What is the embryological origin of the:

- Adenohypophysis
- Neurohypophysis

IV.THE THYROID GLAND

Slide 44
Stain: H&E

Macroscopic and L.P.: Note the capsule and connective tissue septa (continuous with the capsule) forming distinct lobules.

Note the many follicles of various shapes and sizes within the lobules and the homogeneous and eosinophilic colloid within the follicles. Connective tissue and blood vessels lie between the follicles (what type of blood vessels are these?).

Study and draw the follicles under H.P.

Note:

- The variation in the height of the epithelium lining the follicles (what type of epithelium is this?)
- The staining reaction of the epithelial cells lining the follicles
- The small clumps of cells, without colloid and between the follicles - some of these are cells of follicles cut tangentially; others are "C cells"
- The capillaries in the connective tissue surrounding the follicles

What is the chemical composition of the colloid in the thyroid?

What hormones are secreted by the thyroid gland?

Describe briefly the secretory process of the follicular cells of the thyroid in the formation of thyroxine.

Which cells secrete calcitonin?

What is the effect of the secretion of calcitonin?

Explain briefly the interrelationships between thyroxine and the thyroid stimulating hormone secreted by the pars distalis of the pituitary.

What are the distinguishing features of the thyroid gland?

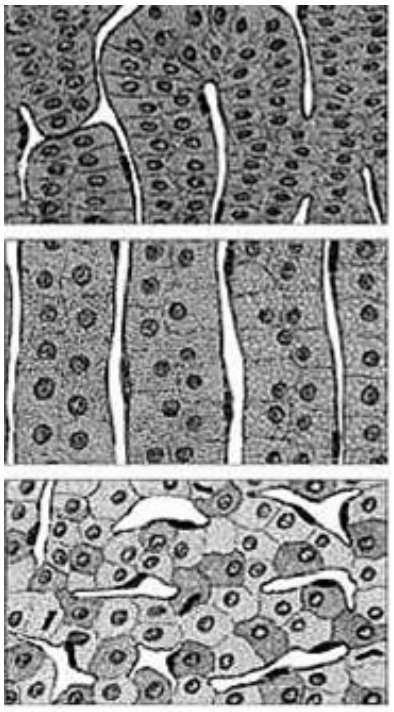
V.THE SUPRARENAL GLAND

Slide 92
Stain: H&E

Macroscopic : Note the eosinophilic fibrous capsule of the gland and the cortex - (the outermost region palely stained, the inner region more eosinophillically stained). Identify the palely stained medulla with large veins.

Under L.P. and H.P. draw and label a small segment of the section.
Note:

- The vascular capsule with fine trabeculae penetrating into the gland continuous with the fine connective tissue fibre framework
- Identify the three zones of the cortex noting the staining reaction of the cells:
    a) The zona glomerulosa, the narrow outermost zone, the cells arranged in ovoid groups (why is this layer referred to as "glomerulosa"?)
    b) The zona fasciculata with similar cells arranged in long radial cords (why is this layer referred to as "fasciculata"?)
    c) The zona reticularis - note the arrangement of the cells (why is this layer referred to as "reticularis"?)
- The medulla arranged in groups of palely stained cells (do not confuse these with occasional patches of fasiculata cells deep to the reticularis)



Zona Glomerulosa

Zona Fasciculata

Zona Reticularis

Account for the vacuolated appearance of the cells in the zona glomerulosa and zona fasciculata of the suprarenal cortex.

- What is the chemical nature of the hormones secreted by these two zones of the suprarenal cortex?

- Name the three main groups of hormones produced by the suprarenal cortex and give their functions. Also indicate which cells are thought to be responsible for the secretion of each group of hormones.

- What is the chemical nature of the hormones secreted by the suprarenal medulla?

- Name the hormones secreted by the suprarenal medulla and give their functions.

- Which cells of the suprarenal medulla are responsible for the secretion of these hormones?

- A specific hormone of the pituitary gland controls the secretion of a suprarenal cortical hormone. Which hormones are referred to in this statement?

- What is the embryological origin of the secretory cells of the suprarenal gland in:
  a) The cortex
  b) The medulla

Clinical Correlation

Structural defects of the pituitary gland are few, although functional abnormalities are potentially numerous, leading to under-or overproduction of one more of the many hormones produced by the pituitary and its target endocrine glands. The most important histopathological lesions of the pituitary gland are **benign adenomas** derived from the anterior pituitary. These commonly secrete anterior pituitary hormones and result in the development of **endocrine syndromes**. Adenomas may be derived from any of the normal anterior pituitary cell types and can be classified by the hormones they secrete.

Prolactinomas secrete prolactin and may lead to infertility and inappropriate breast milk production

Somatotroph adenomas secrete excess growth hormone and lead to gigantism or acromegaly

Young, B., Stewart, W., O'Dowd, G. (2011). Wheater's basic pathology. Fifth edition, Churchill, Livingstone

RECAPITULATION
GLANDS AFFECTING LIFESTYLE

QUESTIONS

1. Summarise the all the glands you have studied in the gastrointestinal tract by completing the following table:

ORGAN	GLANDS	**CLASSIFICATION (Shape of secretory units and duct system)**	**SECRETION/S**
PANCREAS	Exocrine		
	Endocrine		
LIVER			Exocrine:
			Endocrine:

2. Compare the histological structure and function of the submandibular gland and the exocrine pancreas.

FEATURE	**SUBMANDIBULAR**	**PANCREAS**
Secretory end-pieces		
Ducts		
Functions		

3. Draw a fully labelled diagram of a classical liver lobule and explain the flow of blood and bile in the lobule in relation to the functions of the liver.
   Indicate the position and constituents of the portal tracts.

4. List the characteristics common to all endocrine tissues

5. Give examples of endocrine glands which secrete:

   Peptides: 1 2 3

   Steroids: 1 2 3

   Catecholamines:

   Neuropeptides:
   Dipeptides:

6. Name the cell types (according to staining reaction) found in the pars distalis of the hypophysis and give the secretion/s of each.

Name the secretions of the pars nervosa. Give the site of synthesis of these secretions.

What are Herring bodies? Explain their function.

Explain the importance of the hypothalamo-hypophyseal portal system.

7. Name the cell types of the pancreatic islets and the hormone produce by each.

Name two methods by which these cells may be distinguished from one another.

What is the embryonic origin of the exocrine and the endocrine cells of the pancreas?

8. Describe the distinguishing characteristics of the thyroid gland.

Give two reasons why the thyroid follicles may appear to be different sizes in a section.

Where are the C-cells of the thyroid found? What do they secrete?

Give the embryonic origin of the follicular and the C-cells of the thyroid.

Use the regulation of thyroid hormone secretion to explain what is meant by negative feedback.

9. Complete the following table relating to the suprarenal cortex

ZONE			
POSITION & THICKNESS			
ARRANGEMENT OF CELLS			
STAINING REACTION			
SECRETIONS			

10. Give the distinguishing characteristics of the suprarenal medulla and relate to its embryonic origin and function.