Asterion

The Practical Handbook of

ANATOMY

Asterion

The Practical Handbook of

ANATOMY

Second Edition

Editors

Harishanker JS
Ajai Sasi
Avinash N

2011-2012 Batch MBBS
Malabar Medical College
Kerala University of Health Sciences
Calicut, Kerala, India

The Health Sciences Publisher

New Delhi | London | Philadelphia | Panama

Jaypee Brothers Medical Publishers (P) Ltd.

Headquarters

Jaypee Brothers Medical Publishers (P) Ltd.
4838/24, Ansari Road, Daryaganj
New Delhi 110 002, India
Phone: +91-11-43574357
Fax: +91-11-43574314
E-mail: jaypee@jaypeebrothers.com

Overseas Offices

J.P. Medical Ltd.
83, Victoria Street, London
SW1H 0HW (UK)
Phone: +44-20 3170 8910
Fax: +44(0)20 3008 6180
E-mail: info@jpmedpub.com

Jaypee-Highlights Medical Publishers Inc.
City of Knowledge, Bld. 237, Clayton
Panama City, Panama
Phone: +1 507-301-0496
Fax: +1 507-301-0499
E-mail: cservice@jphmedical.com

Jaypee Medical Inc.
The Bourse
111, South Independence Mall East
Suite 835, Philadelphia, PA 19106, USA
Phone: +1 267-519-9789
E-mail: jpmed.us@gmail.com

Jaypee Brothers Medical Publishers (P) Ltd.
17/1-B, Babar Road, Block-B
Shaymali, Mohammadpur
Dhaka-1207, Bangladesh
Mobile: +08801912003485
E-mail: jaypeedhaka@gmail.com

Jaypee Brothers Medical Publishers (P) Ltd.
Bhotahity
Kathmandu, Nepal
Phone: +977-9741283608
E-mail: kathmandu@jaypeebrothers.com

Website: www.jaypeebrothers.com
Website: www.jaypeedigital.com

Asterion—The Practical Handbook of Anatomy

First Edition: 2013
Second Edition: **2015**

ISBN 978-93-5152-396-3

Printed at

Dedicated to
Our family and friends
for continuous suppport at all times

"Learn to see, learn to hear, learn to feel, learn to smell, and know that by practice alone can you become expert"
—*Sir William Osler*

Foreword

I am very happy to know that the students of Malabar Medical College, Calicut, Kerala, India, are coming out with a handbook on anatomy. When they approached me with a different idea, *Asterion—The Practical Handbook of Anatomy*, I readily welcomed that idea. The editors have seen that the book is brief and student-friendly. This handbook covering Histology, Osteology, Embryology, Radiology and Surface Marking will make a quick reference for the examination going students. It will also help them save a lot of time to concentrate on gross and applied anatomy.

I am using this opportunity to congratulate Harishanker JS, Ajai Sasi and Avinash N of 2nd batch, all staff members of Department of Anatomy and all those students of Malabar Medical College, Calicut, Kerala, India, who helped them to see that the book is through. I wish all the success for this venture.

VS Akbar Sherif MBBS MS MCh
Pediatric Surgeon
Principal, Malabar Medical College
Calicut, Kerala, India

Preface to the Second Edition

It gives us immense pleasure to present before you once again the revised second edition of Asterion. The first handout was indeed a success, which made many of the 1st MB's to walk through their practicals with a light heart. The response of Asterion was the biggest encouragement for the upcoming of its modified version.

Many more modifications have been brought into this book. We have included the finer most images. Every chapter of anatomy has been incorporated with fine details and its clinical aspects dealt in detail. The first edition was made with a solo motto of getting every student through the practical. But now the focus of Asterion is not just cracking the examinations, but it will help you get into the subject. All the most probable questions have been included in the chapter Red Alert so that you do not even miss the toughest of the questions.

Altogether Asterion is a definite solution for every examination preparing student which can surely promise them an upper hand in their examination.

Harishanker JS
Ajai Sasi
Avinash N

Preface to the First Edition

Every tributary of anatomy confluent to form "Asterion". It is the right solution for all the last minute queries of every student just before the examination. It is an exclusive handout focusing mainly on practical anatomy.

A need of such a book will be felt maximum as we approach our university examination, a point of time when we get lost completely but keep staring at Histology, Radiology, Osteology, etc with a heavy heart full of fear and anxiety. Such a fear was there indeed in our heart too, which gave us the spark of compiling all these together, and this gave birth to our Asterion.

Asterion covers all practical aspects of anatomy comprising Histology, Embryology, Osteology, Radiology and Surface Marking. It is only a preparatory manual for undergraduates (UG), not a complete textbook. It is a very student-friendly concise book which will make you so confident that you can spot the toughest of spotters with no time. It gives you the exact idea for facing every exam—be it viva or theory at most precision, thus helping you to leave the exam hall with a smile.

One of the marking features of Asterion is that it presents you "The Red Alert" section which gives you the most probable theory questions from the gross anatomy section, thereby clearing away your vague minds and promising you a sure shot at the exam.

Now everything is set. Here we present you so gladly and proudly the magical wand of anatomy "Asterion". So take away the wand and cast your spell on the examiner, so that everyone of you have a magical result.

Harishanker JS
Ajai Sasi
Avinash N

Acknowledgments

We would take this opportunity to express our profound gratitude and deep regards to our principal Dr VS Akbar Sherif for his exemplary guidance, monitoring and constant encouragement throughout the course.

We also extend our sincere thanks to the Dr BS Ratna (Head, Department of Anatomy) and all the teachers and staff of the Department of Anatomy. We are also grateful to Dr Major Hari Bhaskar S and to all the other staff of the Department of Radiology, Malabar Medical College, Calicut, Kerala, India.

We are heartily thankful to Shri Jitendar P Vij (Group Chairman), Mr Ankit Vij (Group President), Mr Tarun Duneja (Director-Publishing), Mr Sunil Kumar Dogra (Production Executive), Mr Neelambar Pant (Production Coordinator) Mr Bharat Bhushan (Typesetter), Mr Manoj Pahuja (Graphic Designer), M/s Jaypee Brothers Medical Publishers (P) Ltd., New Delhi, India, for their valuable guidance and support. We also note the help and continued support of Mr PM Sebastian (Jose) Branch Manager and Mr Diffin Robin, M/s Jaypee Brothers Medical Publishers (P) Ltd., Kochi, Kerala, India

We would like to thank Shabeeb PK, Rarimol, Midhun NL, Mekha Premachandran, Hemanth Raj and the first batch of Malabar Medical College for their help and support. We are also thank Mohamed Abshad for the assistance with photographs.

We are indebted to Fathima Farsana Pulikkal, Sreekiran PR, Fathima Bathool (IInd batch, Malabar Medical College), Kavya P Valsaraj (Government Dental College, Calicut, Kerala, India), Ashwin Ramesh, Aswin KR (KMCT Medical College, Calicut, Kerala, India) for the immense help with illustrations.

We also thank Abhijith Varma, Aswathy BI, Shreelakshmi Pradeep, Ambili Pillai (IInd batch, Malabar Medical College) for their help in the initial editing and valuable suggestions.

We are also grateful to Team MASK, Sonu P Alex, Aishwarya A, Anagha Manoj (IInd batch, Malabar Medical College), Aparna J and Karthika J (IIIrd batch, Malabar Medical College) for providing us the right resources at the right time.

We also take this opportunity to thank the all students of Malabar Medical College, Calicut, Kerala, India, especially second batch without their support this would not have been a complete one.

We would also like to express our deep gratitude to our parents, who has helped and supported us throughout the entire making process. And above all without the blessing of God Almighty this book would not have been a complete one.

Contents

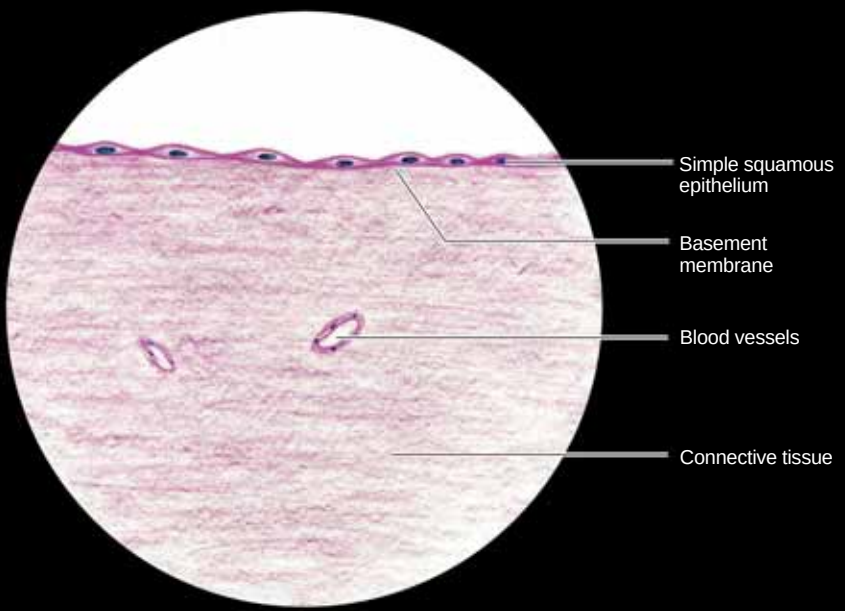
CHAPTER

1

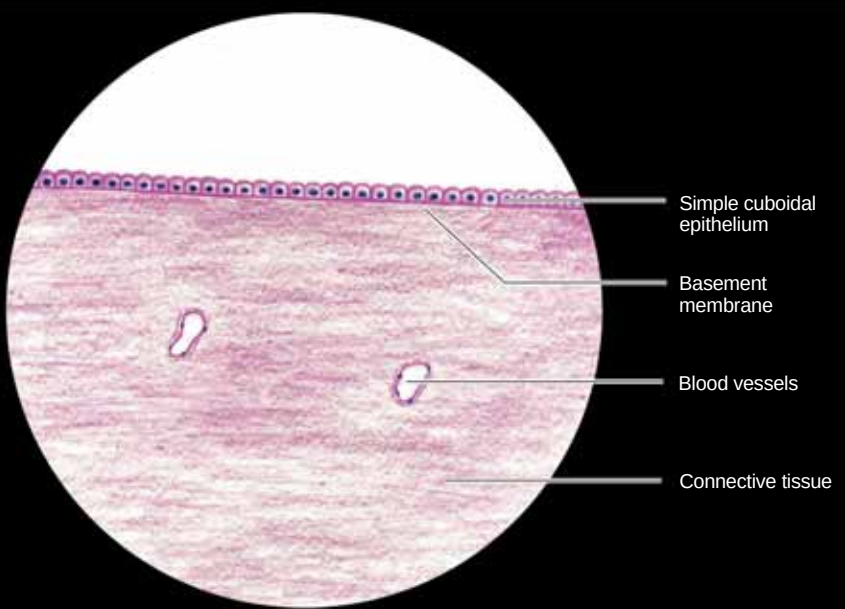
Histology

Epithelia

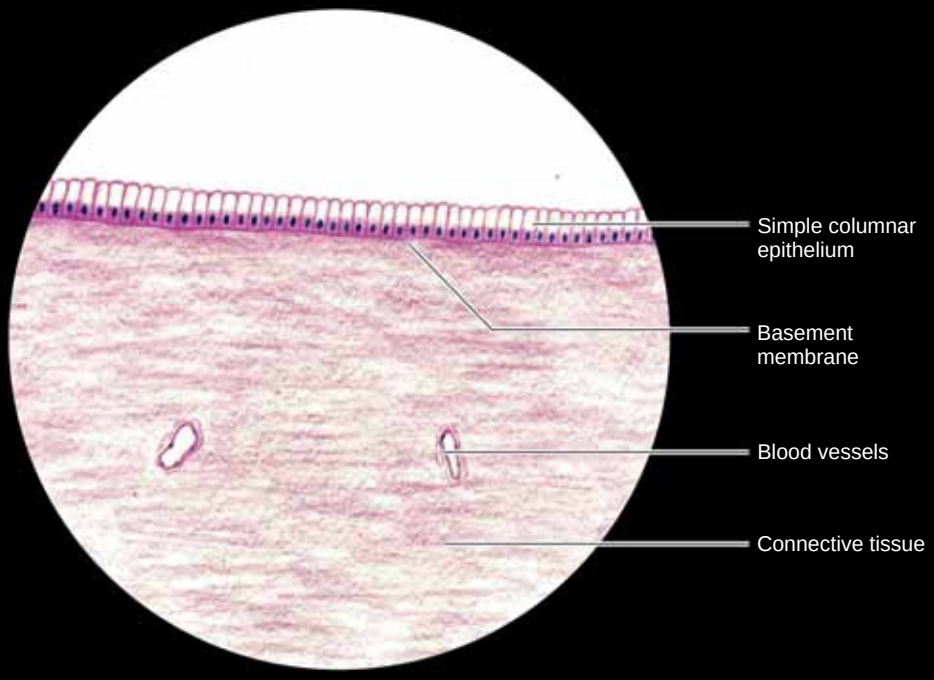
SIMPLE SQUAMOUS EPITHELIUM



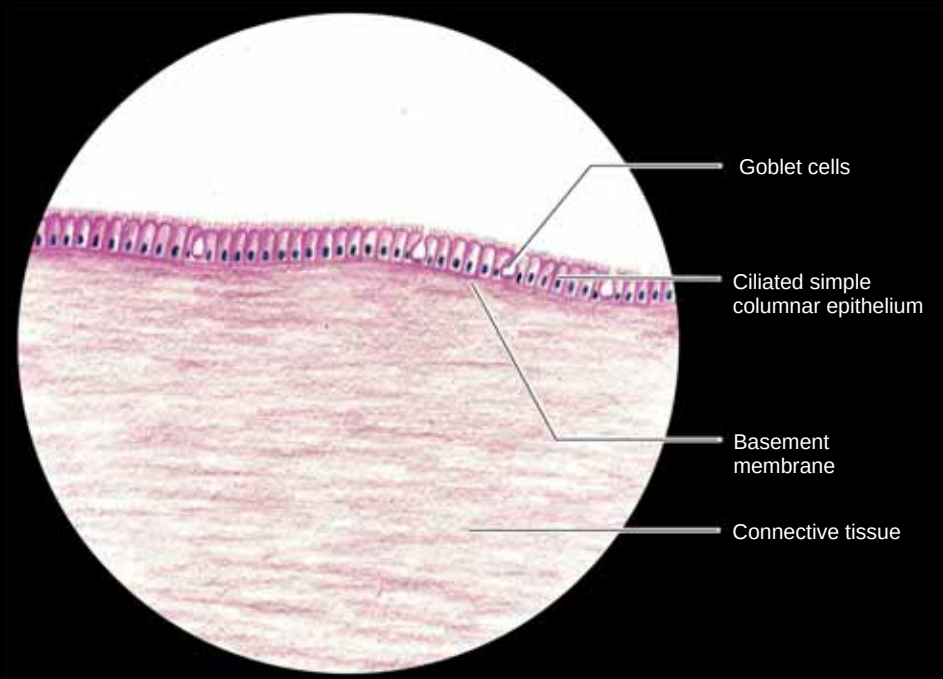
SIMPLE CUBOIDAL EPITHELIUM



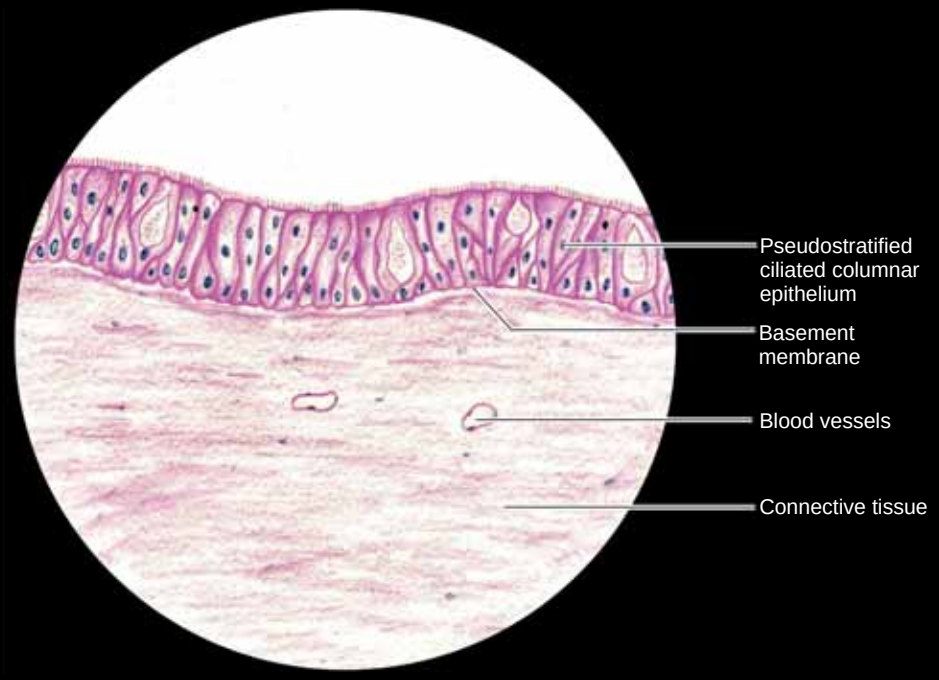
SIMPLE COLUMNAR EPITHELIUM



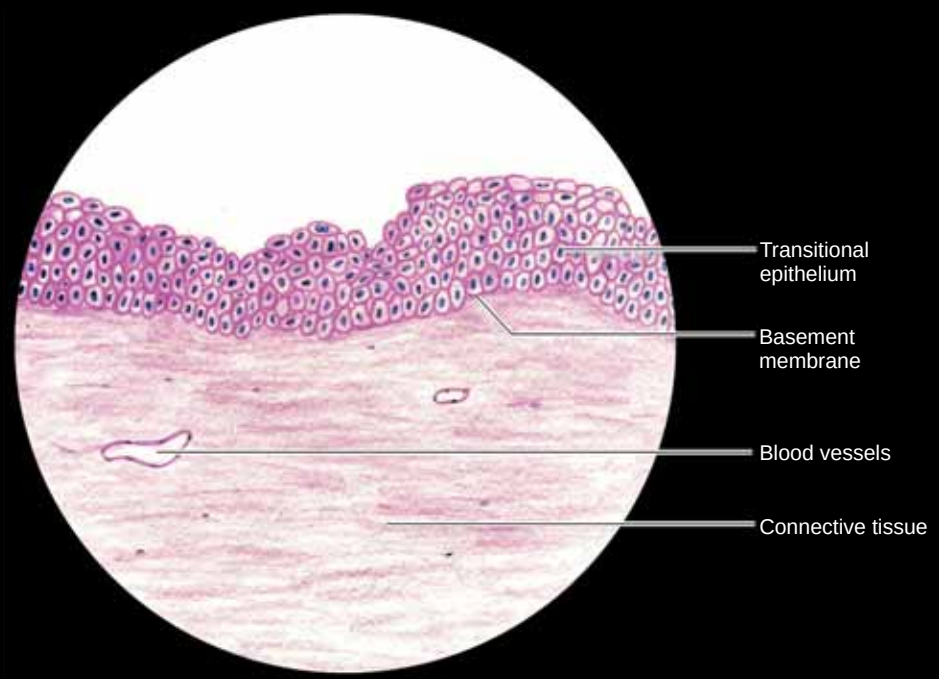
CILIATED COLUMNAR EPITHELIUM WITH GOBLET CELLS



PSEUDOSTRATIFIED COLUMNAR EPITHELIUM



TRANSITIONAL EPITHELIUM



Cartilage

General Aspects

- Develops from **primitive mesenchyme**.
- Three types:
  1. **Hyaline**
  2. **Elastic**, and
  3. **Fibrocartilage**
- It consists of cells viz. **chondrocytes, chondroblasts, fibroblasts, connective tissue fibers and ground substance**.
- The **ground substance** of cartilage is made of proteins and carbohydrates, they form a meshwork which is filled by water and dissolved salts.
- **Nonvascular**, nutrition via diffusion. However researches have shown the presence of cartilage canals through which blood vessesls may enter the cartilage.
- The highly hydrated nature of ground substances is responsible for diffusion.

Structure

- **Matrix** with chondrocytes surrounded by perichondrium (except in **fibrocartilage**, and **hyaline cartilage at articular surfaces**).
- Matrix consist of connective tissue fibers.
- Cells in the matrix exist in **lacunae** (singly or in isogenous groups).
- The nucleus of cartilage cells are initially euchromatic, as cells starts to mature the nuclei become heterochromatic.
- **Perichondrium** consists of two layers:
  i. **Outer fibrous layer** made of type 1 collagen fibers.
  ii. **Inner cellular/chondrogenic layer** contains chondroblast cells.
- Growing pattern are by two different ways:
  i. **Interstitial growth:** Newly formed cartilage grows by proliferation of cells throughout its substance.
  ii. **Appositional growth:** It occurs in mature cartilage. Growth of cartilage takes place by addition of new cartilage over the surface of existing cartilage.

HYALINE CARTILAGE

- **Perichondrium** is present.
- **Chondrocytes** are present inside the **lacunae** and are arranged homogenously in the matrix.
- In hematoxylin and eosin staining, the matrix is basophilic (i.e. stained blue in color).
- **Chondrocytes** in the center are larger than those at periphery.
- **Matrix** can be differentiated into two types:
  1. **Territorial matrix:** Darker matrix adjacent to chondrocytes.
  2. **Interterritorial matrix:** Lightly stained matrix between chondrocytes.
- Ground substance consists of **type 2 collagen** fibers.
- For example, *costal cartilage, trachea, thyroid cartilage.*

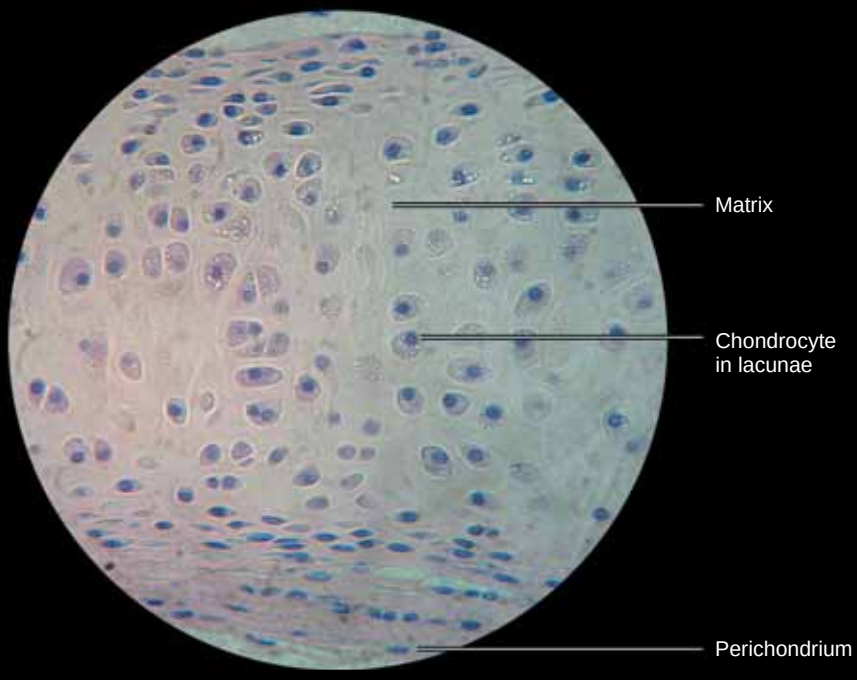
Applied Anatomy

- Hyaline cartilage forms the skeleton of the fetus. The cartilage forms a framework of the bones and later endochondral ossification occurs and is replaced by bone.
- Hyaline cartilage calcifies on ageing whereas elastic cartilage does not.
- Chondromas are benign tumors of cartilage, in which the chondrocytes are arranged in clusters with abundant intercellular stroma.

Viva-voce

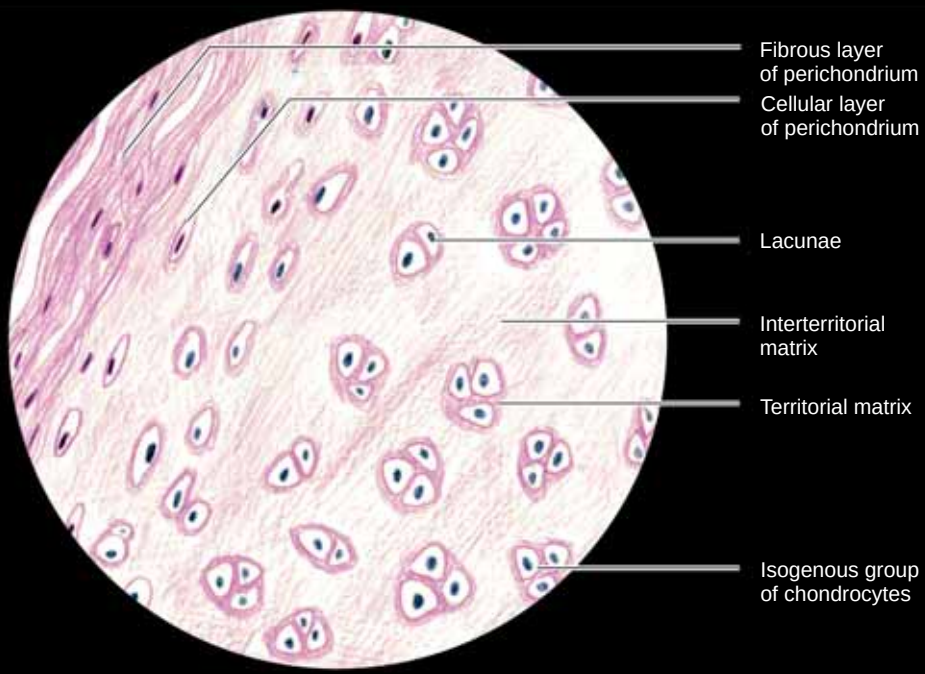
Q. Costal cartilage is composed of what type of cartilage?
Ans. Hyaline cartilage.
Q. Which is the most abundant type of cartilage in the body?
Ans. Hyaline cartilage.
Q. Which type of cartilage forms the articular surface on bones?
Ans. Hyaline cartilage.

HYALINE CARTILAGE

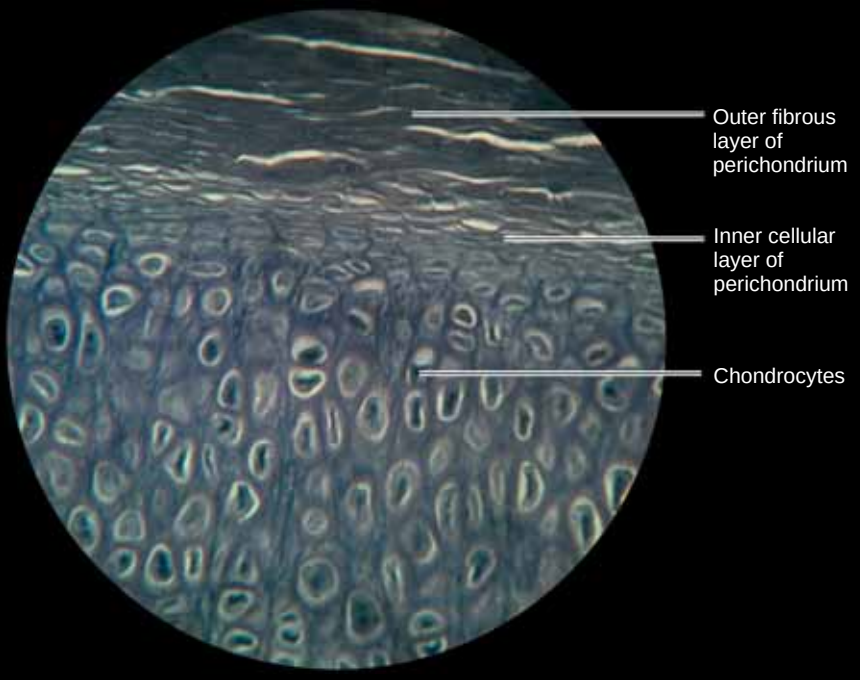


SP:

- Cell nests of chondrocytes present.
- Territorial and interterritorial matrix present, perichondrium present.

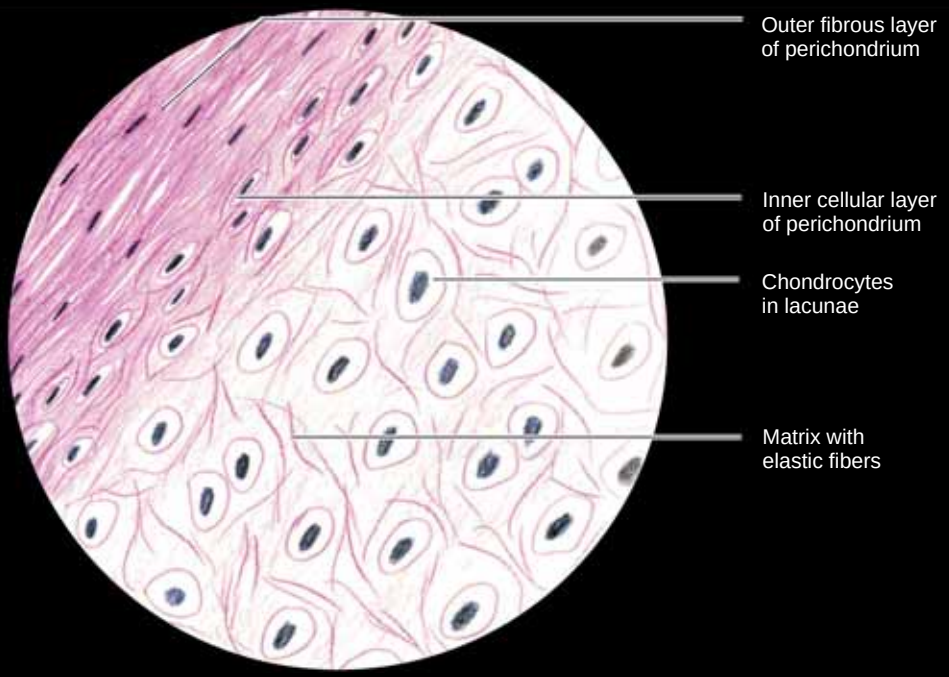


ELASTIC CARTILAGE



SP:

- Large singly arranged chondrocytes in lacunae.
- Perichondrium present.



ELASTIC CARTILAGE

- It is also known as **yellow fibrocartilage**.
- **Perichondrium** is present.
- Highly flexible.
- **Matrix** contains numerous **elastic fibers** instead of collagen fibers.
- **Chondrocytes** are larger, **singly arranged** and are present in lacunae.
- In H and E staining the fibers are not clearly visualized, it is better seen in special staining methods like Verhoeff's method.
- Density of fibers vary according to the site where it is present.
- For example, *external ear, epiglottis, auditory tube,* etc.

Applied Anatomy

- Elastic cartilage does not calcify on aging.
- Due to its high flexibility it regains its shape quickly after being deformed.

Viva-voce

Q. What stain would be best to demonstrate the elastic fibers in elastic cartilage?
Ans. Resorcin-fuchsin and orcein would best show the elastic fibers in elastic cartilage.
Q. If you bend your ear forward, it bounces back into its proper position. Why is it so?
Ans. If you bend your ear forward, it bounces back into its proper position. This is due to the elastic cartilage present in the external ear. Due to its high flexibility it regains its shape quickly after being deformed.

FIBROCARTILAGE

- It is also known as **white fibrocartilage**.
- It consists of alternating layers of cartilage matrix and thick dense layers of **type 1 collagen fibers**.
- Collagen fibers are arranged as **wavy bundles**.
- **Chondrocytes** in lacunae distributed **in rows**.
- Chondrocytes are of similar size.
- **Perichondrium absent**, since fibrocartilage form a transitional area between hyaline cartilage and tendon/ligament.
- For example, *intervertebral discs, glenoid labrum, symphysis pubis*.

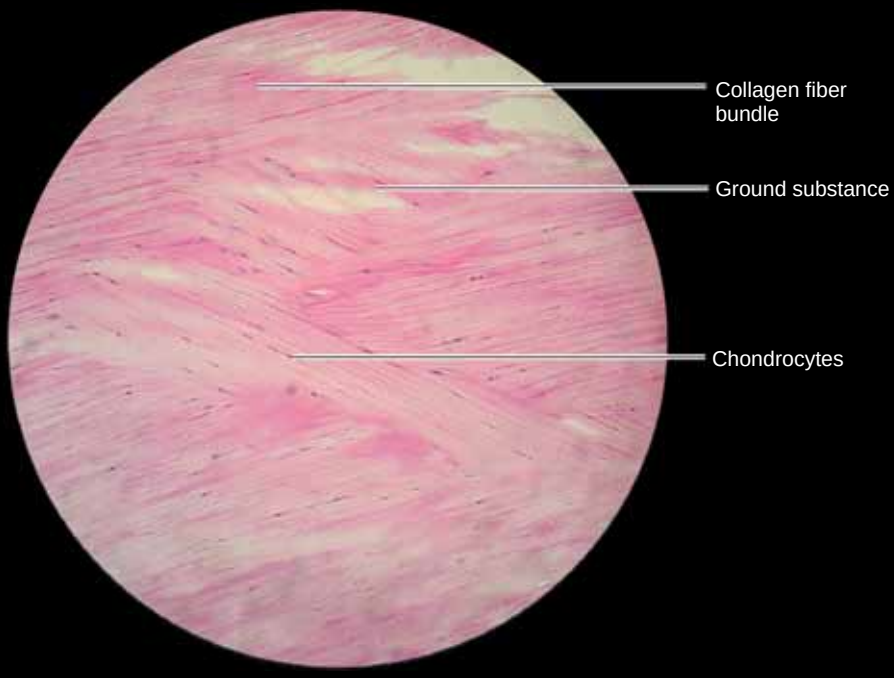
Applied Anatomy

It possess great tensile strength and considerable amount of elasticity.

Viva-voce

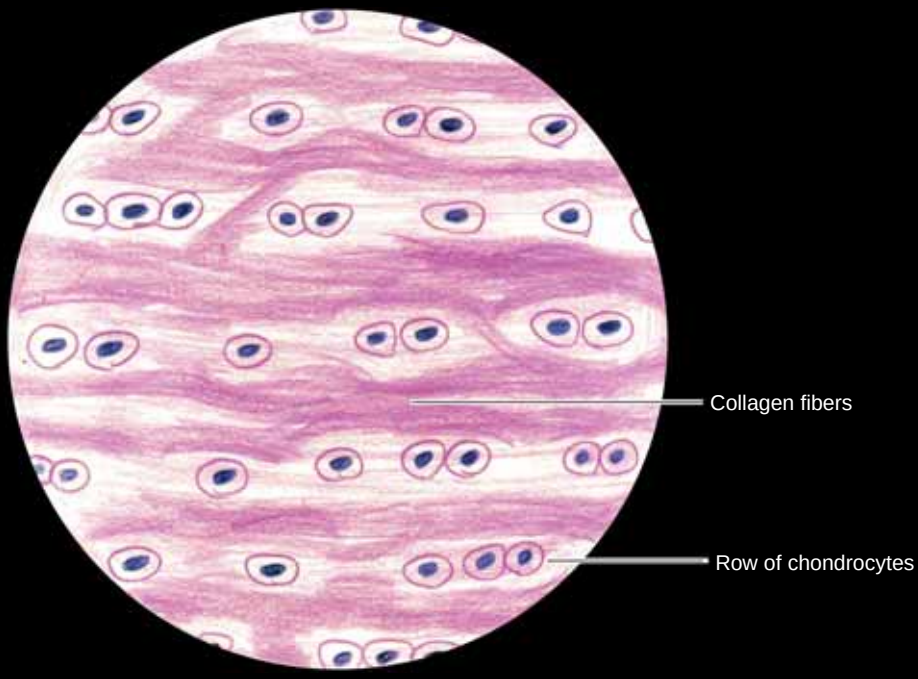
Q. Which type of cartilage forms the intervertebral disc?
Ans. Fibrocartilage forms the intervertebral disc.
Q. How is collagen fibers arranged?
Ans. Collagen fibers are arranged as wavy bundles.
Q. Which type of collagen fibers make up the fibrocartilage?
Ans. Type 1 collagen fibers.

FIBROCARTILAGE

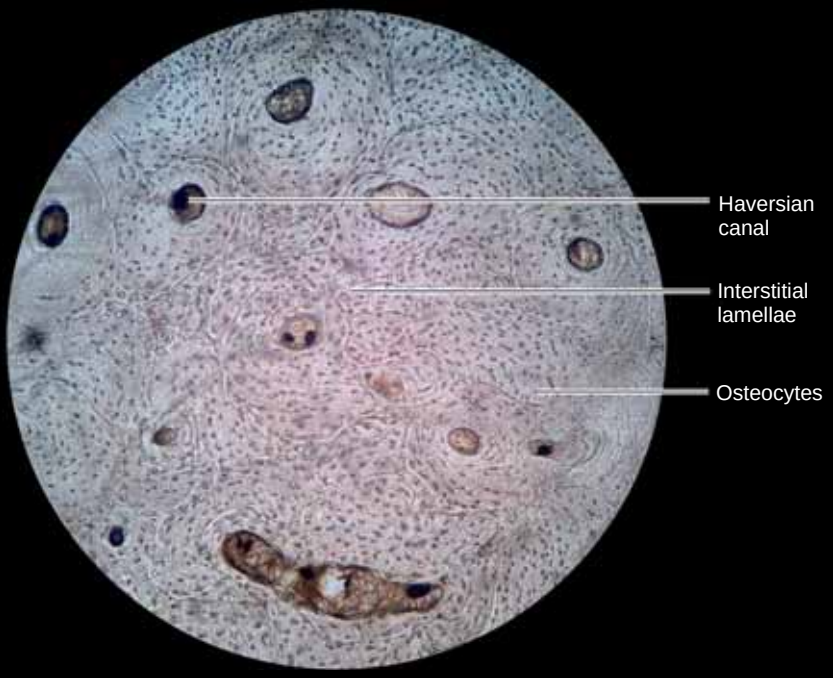


SP:

- Chondrocytes of similar size present between collagen bundles.
- Perichondrium absent.

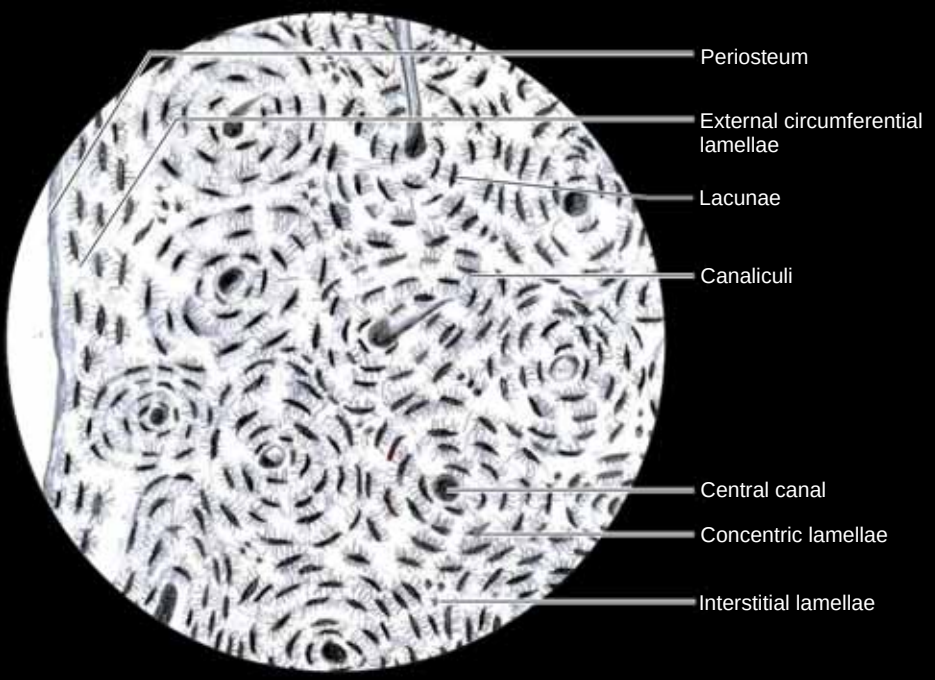


COMPACT BONE : TRANSVERSE SECTION



SP:

- Presence of osteocytes in lacunae.
- Haversian system present with concentric lamellae.



Bone

General Aspects

- Special form of **connective tissue**.
- Bone formation occur by two processes.
  1. **Endochondral ossification:** Bone development is preceded by **cartilage model**.
  2. **Intramembranous ossification:** Bone develops from a **connective tissue mesenchyme**.
- Bone types—**compact** and **Spongy** bone.
- Bone contains cells, fibers (**type 1 collagen fibers**) and extracellular matrix.
- There are four types of bone cells—**osteoprogenitor** cells, **osteoblasts, osteocytes,** and **osteoclasts**.
- Bone matrix is calcified, and is harder than cartilage but contains living cells and extracellular materials.
- Highly **vascularized**.

BONE TRANSVERSE SECTION

- **Haversian systems** or **osteons** are the structural units of bone matrix.
- Each osteon is outlined by a **cement line**.
- **Osteons** are located between internal and external **circumferential lamellae**.
- It consists layers of **concentric lamellae** arranged around a central canal.
- **Central canal** consists of blood vessels, nerves and reticular connective tissue.
- **Lamellae** contains osteocytes in spaces called **lacunae** and tiny canals radiate from lacunae known as **canaliculi**.
- Small irregular areas of bone are present between osteons, known as **interstitial lamellae** and represents remnants of eroded osteons.
- External wall is formed by **external circumferential lamellae** and internal wall by **internal circumferential lamellae**.

BONE LONGITUDINAL SECTION

- **Osteocytes** present.
- **Central canal** is surrounded by lamellae with **lacunae** and **canaliculi**.
- **Volkmann's canal (perforating canal)** is visible in longitudinal section (LS).
- Volkmann's canal is formed by anastomoses between central canals.
- Volkmann's canal joins the central canal with marrow cavity.
- **Concentric lamellae is absent** in Volkmann's canal since they directly penetrate via lamellae.
- Throughout life there is continuous destruction and rebuilding of haversian system.

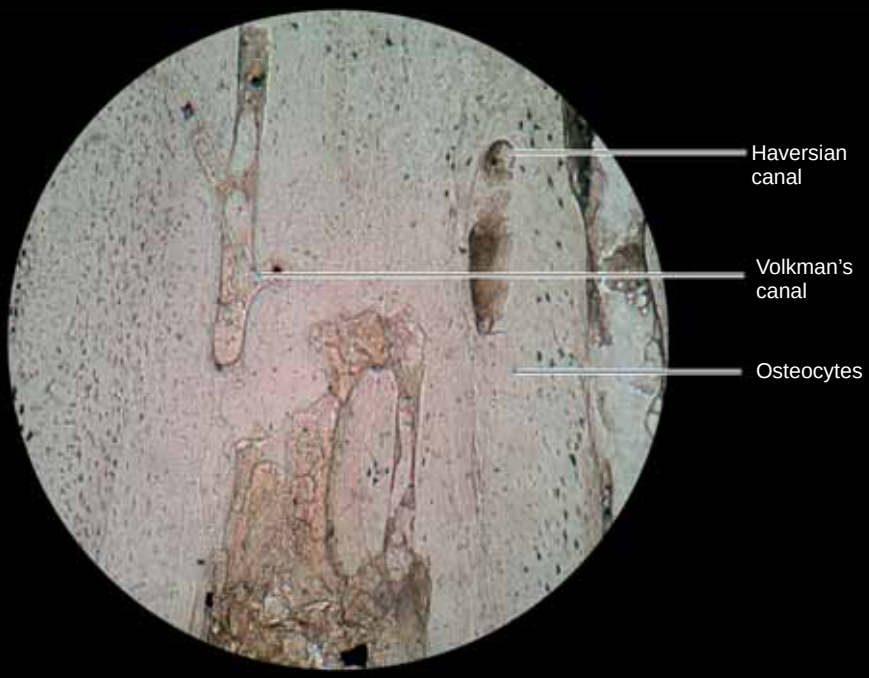
Applied Anatomy

- Inflammation of bone marrow is known as osteomyelitis.
- Ischemia results in avascular necrosis of bones which is mainly caused by fracture or dislocation.
- Osteoporosis is a condition resulted from the quantitative reduction of the normal bone.
- Osteomalacia and rickets are conditions occurring in adults and children respectively characterized by qualitative abnormality as impaired bone mineralization due to deficiency of vitamin D.
- Aneurysmal bone cyst is a expanding osteolytic lesion filled with blood.
- Osteoarthritis is a chronic disorder of synovial joints characterized by progressive degenerative changes in articular cartilage over years.

Viva-voce

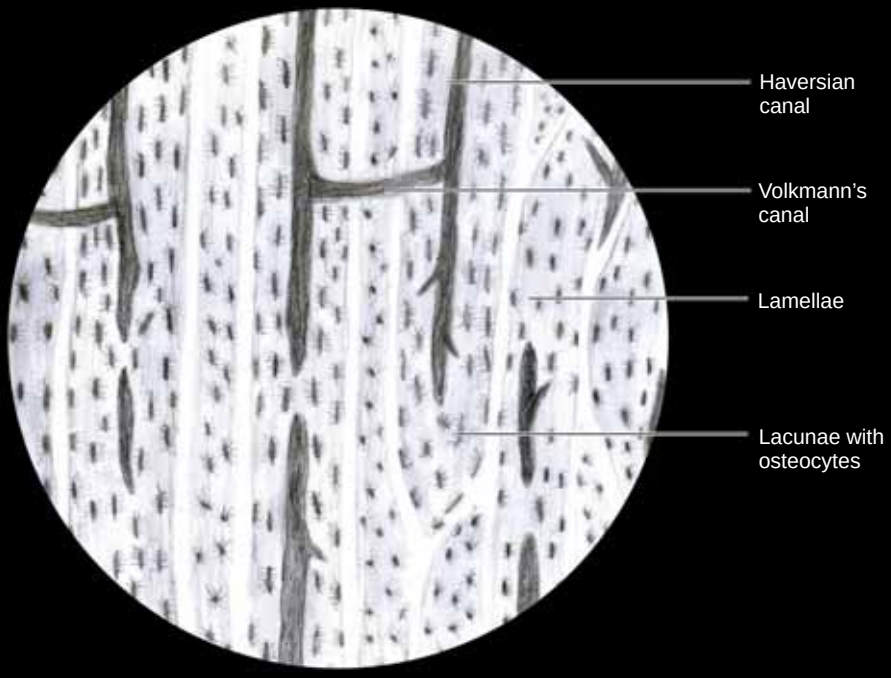
Q. What structures are found within haversian canals?
Ans. Capillaries and nerves.
Q. Is the osseous lamella adjacent to the haversian canal the youngest or the oldest lamella of a particular osteon?
Ans. The youngest.
Q. What structure in mature bone is created by the zone of resorption?
Ans. The marrow canal.
Q. What are the differences between intramembranous ossification and endochondral ossification?
Ans. *Intramembranous ossification:* Does not use a cartilage framework, bone develops directly on or within mesenchyme. Bone growth is appositional. Found in irregular bones such as the bones of the skull.
Endochondral ossification: Replaces a pre-existing cartilage framework. The bone lengthens through interstitial growth and changes diameter through appositional growth. Found in long bones.

COMPACT BONE : LONGITUDINAL SECTION

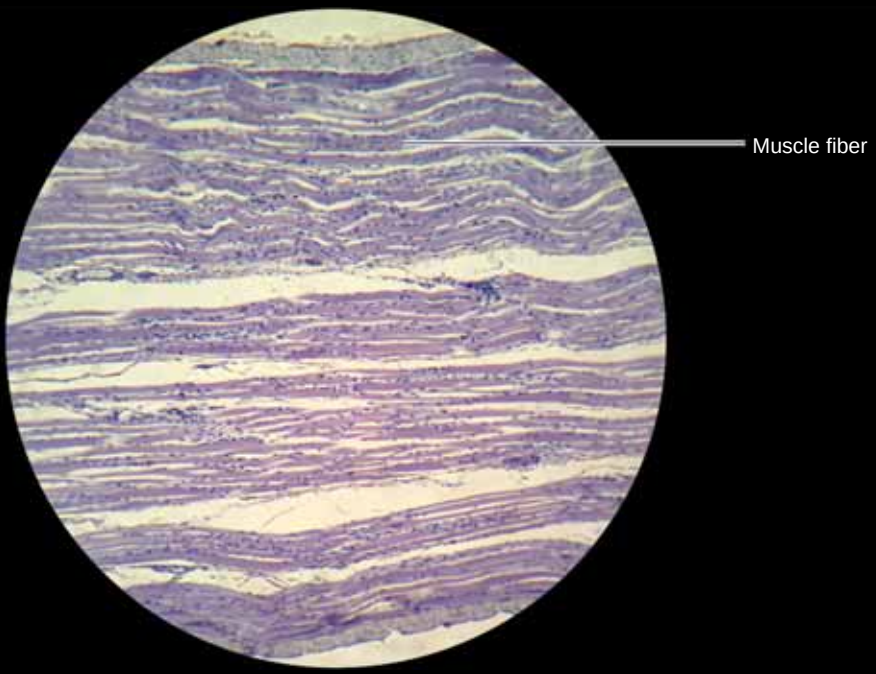


SP:

- Osteocytes present.
- Longitudinal section of haversian system and Volkmann's canal seen.

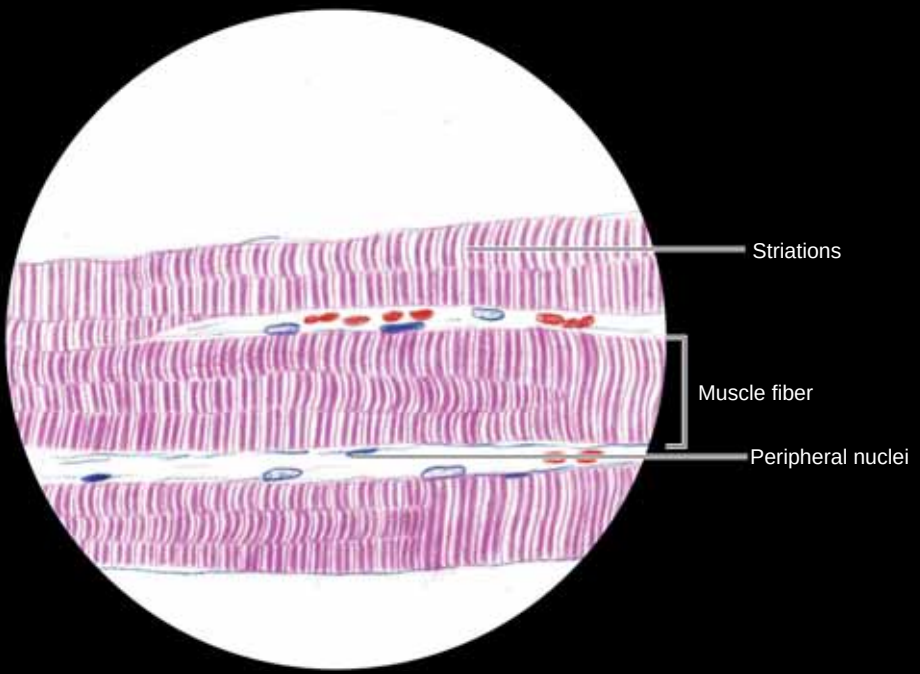


SKELETAL MUSCLE



SP:

- Cylindrical muscle fibers with prominent striations.
- Presence of peripherally arranged flattened multinuclei.



Muscle

General Aspects

- Types:
  - **Skeletal muscle**
  - **Smooth muscle**
  - **Cardiac muscle**
- Muscle tissue consists of elongated cells called **myocytes**.
- Muscle cytoplasm—**sarcoplasm**.
- Cell membrane—**sarcolemma**.
- Muscle fibers contains **myofibrils**.
- Myofibrils made of contractile proteins called **actin** and **myosin**.

SKELETAL MUSCLE

- Also known as **voluntary** muscle.
- Muscle fibers are **long, cylindrical** and **multi-nucleated**.
- Nuclei arranged at **periphery** and are **elongated**.
- **Striated**, since regular arrangement of actin and myosin filaments form cross striation patterns.
- Interior of muscle is divided into **fascicles**.
- Individual muscle fibers are surrounded by connective tissue called **endomysium**.
- Fascicles are surrounded by a stronger connective tissue **perimysium**.
- A connective tissue covers the entire muscle known as **epimysium**.
- For example, *biceps brachii*.

Applied Anatomy

- Heat rigor occurs above 43°C where the muscle protein gets denatured, as a result muscle remains in a contracted state.
- Skeletal muscle is capable of limited regeneration. If large regions are damaged, regeneration does not occur and the missing muscle is replaced by connective tissue.
- Polymyositis is a disease of muscle characterized by inflammation of the muscle fibers.

SMOOTH MUSCLE

- **Involuntary** muscle.
- Present in walls of hollow viscera and blood vessels.
- **Uninucleated, spindle** shaped myocytes.
- **Centrally** placed single nucleus.
- **Nonstriated**, since actin and myosin filaments are arranged randomly and are without cross striation patterns.
- Present in walls of organs like esophagus, stomach, small intestine, arteries and veins.

Applied Anatomy

- Smooth muscle has got the most good regeneration capacity than any other type of muscle tissue.
- Leiomyosarcomas are malignant tumors of smooth muscle. The tumor consists of spindle cells with large hyperchromatic nuclei.
- Hyperplasia means increase in muscle mass. The most common cause is the increase in number of smooth muscle fibers.
- The contraction of smooth muscle cells is slow, but they can remain contracted for long periods.
- Smooth muscle cells form the extracellular fibrous tissue components in the tunica media of blood vessels.
- Smooth muscle cells in the walls of elastic arteries regulate the blood supply to their target tissues.

Viva-voce

Q. When the muscle cells are cut in cross section, there are interruptions in the basal laminae. What is responsible for these discontinuities?

Ans. Gap junctions.

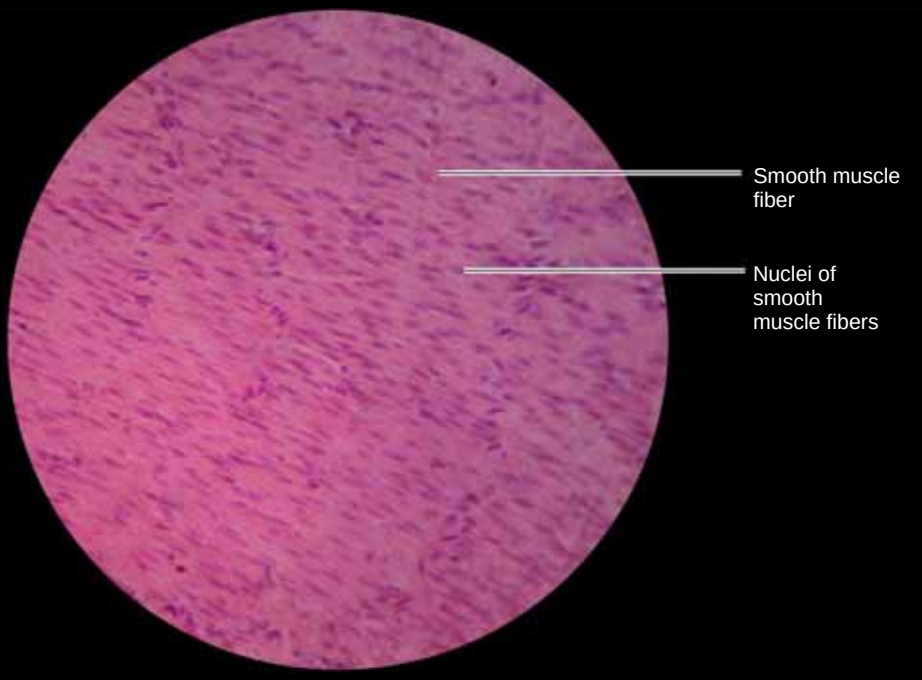
Q. Why do smooth muscle fibers in cross section have different diameters and why do some of these fail to show nuclei?

Ans. Smooth muscle cells have tapered ends. Since the cells interdigitate different diameters would be revealed in a particular plane of section and the plane of section does not always go through the nucleus.

Q. Are myofibrils or sarcomeres present in smooth muscle fibers?

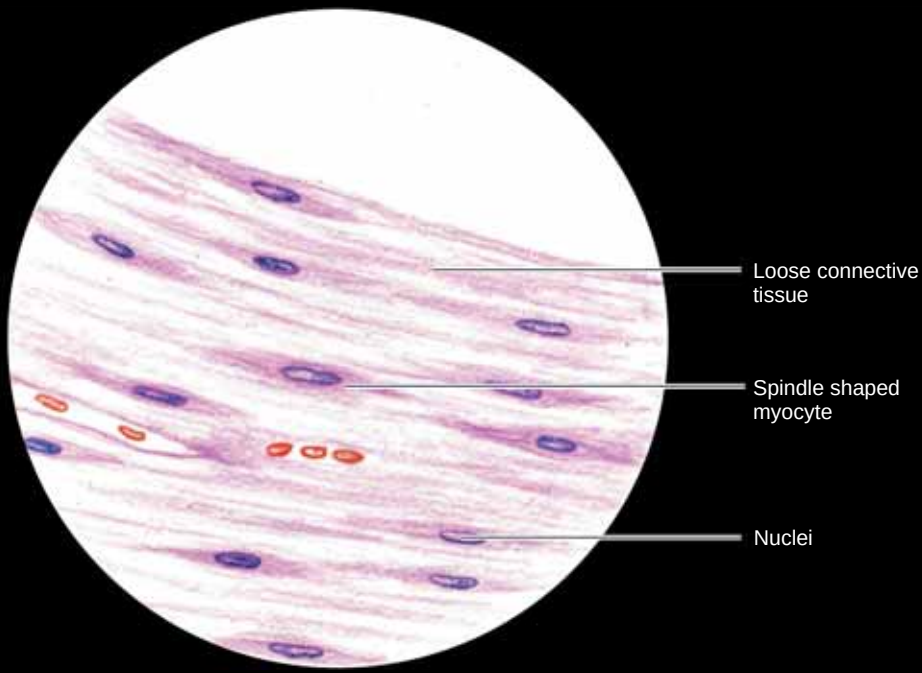
Ans. No.

SMOOTH MUSCLE

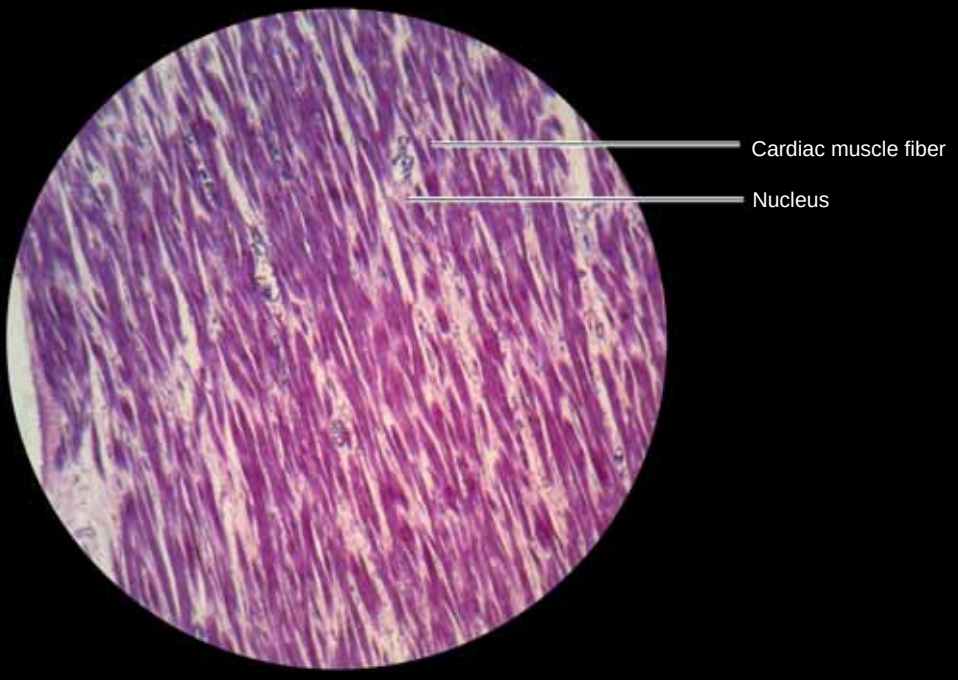


SP:

- Presence of single, uninucleated, spindle shaped fibers
- Presence of centrally placed nucleus.

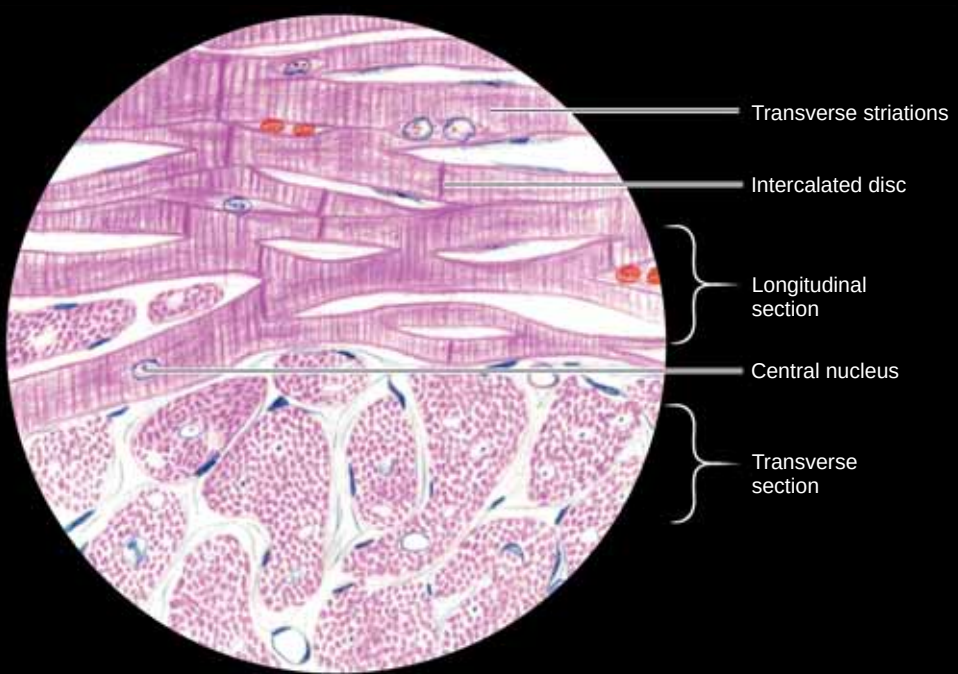


CARDIAC MUSCLE



SP:

- Branching fibers with striations present.
- Intercalated discs and centrally placed nucleus present.



CARDIAC MUSCLE

- **Involuntary** muscle.
- It is made up of **cylindrical fibers** with **striations**.
- Cardiac muscle fibers are **shorter** than skeletal muscle fibers.
- Contains **single central** nucleus.
- Binucleate muscle fibers are occasionally seen.
- It is present in branching anastomosis.
- **Intercalated discs (gap junction complex)** are present at regular intervals.
- These gap junctions couples all fibers for rhythmic contraction.
- Cardiac muscle fibers exhibit **autorhythmicity**.
- For example, *walls of heart, aorta, pulmonary trunk.*

Applied Anatomy

- Fibrillation is the abnormal contraction of cardiac muscle.
- Angina pectoris is episode of chest pain due to temporary ischemia of cardiac muscle.
- Persistent ischemia due to blockage of coronary arteries results in necrosis (death) of the cardiac muscle.
- In brown atrophy of heart there will be accumulation of yellowish brown lipid pigment called lipofuscin in the myocardial fibers (Lipofuscin—wear and tear pigment).

Viva-voce

Q. What is the position of the nuclei in cardiac muscle cell?
Ans. Central.
Q. Do the myofibrils pass through intercalated discs?
Ans. No.
Q. How can you distinguish cross sections of cardiac muscle fibers from those of skeletal muscle fibers?
Ans. Central nuclei, intercalated discs, branching fibers.

Blood Vessels

General Aspects

Artery Structure

Arterial wall composed of three concentric layers.

1. **Tunica intima**
   - Innermost layer.
   - Lined by endothelium with underlying subendothelial connective tissue.
2. **Tunica media**
   - Middle layer.
   - Contains smooth muscle, elastic and reticular fibers.
   - Thickest layer of the artery.
3. **Tunica adventitia**
   - Outermost layer
   - Contains collagen fibers (type 1) and elastic fibers.
   - Vasovasorum (vessels that supply the vessels) is present which helps in nutrition.

Veins Structure

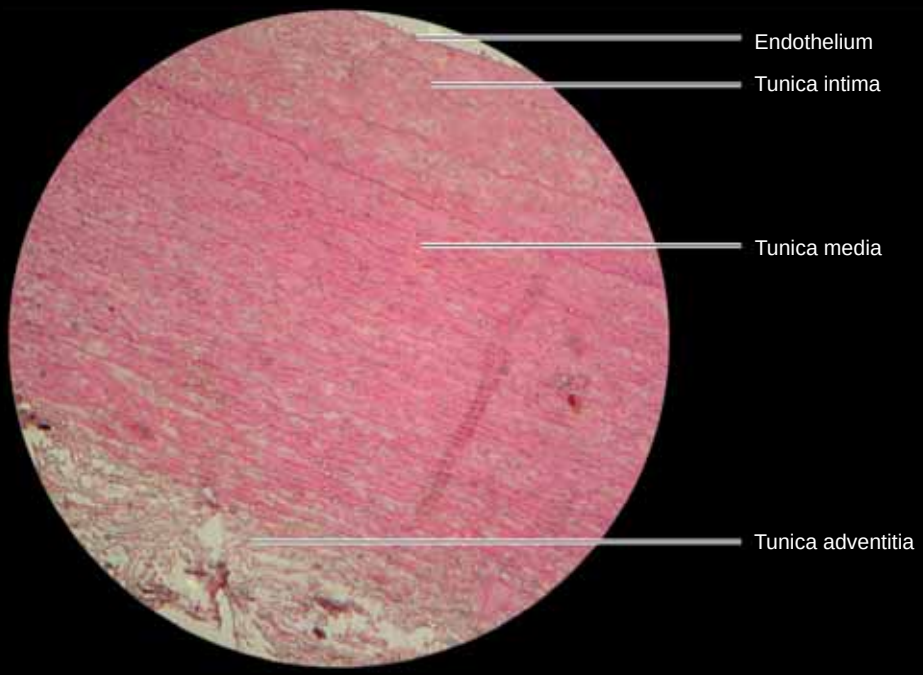
Walls are made up of three layers.

1. **Tunica intima**
   - Innermost layer.
   - Lined by endothelium with underlying subendothelial connective tissue.
2. **Tunica media**
   - Middle layer
   - Contains smooth muscle, elastic and reticular fibers.
3. **Tunica adventitia**
   - Thickest and best developed layer (most contrasting feature of vein with artery).
   - Longitudinal muscle bundles are seen in this layer.
   - Vasovasorum present.

LARGE ARTERY OR ELASTIC ARTERY

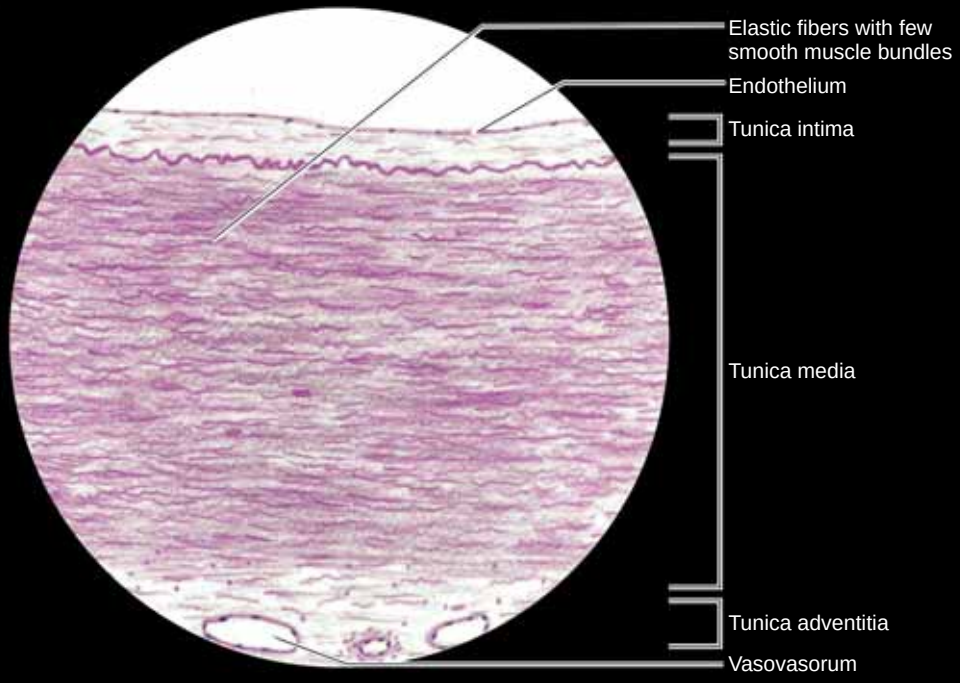
- Arterial wall made of three layers, i.e. tunica intima, tunica media and tunica adventitia.
- **Tunica intima** consisting of the endothelium and subendothelial connective tissue.
- **Tunica media** is the thickest layer.
- Tunica media made of mainly **elastic fibers** with few smooth muscle fibers.
- This feature of elastic artery responsible for Windkessel effect.
- Vasovasorum present in **tunica adventitia**.
  "Example: *Aorta, common carotid artery, etc.*"

LARGE ARTERY

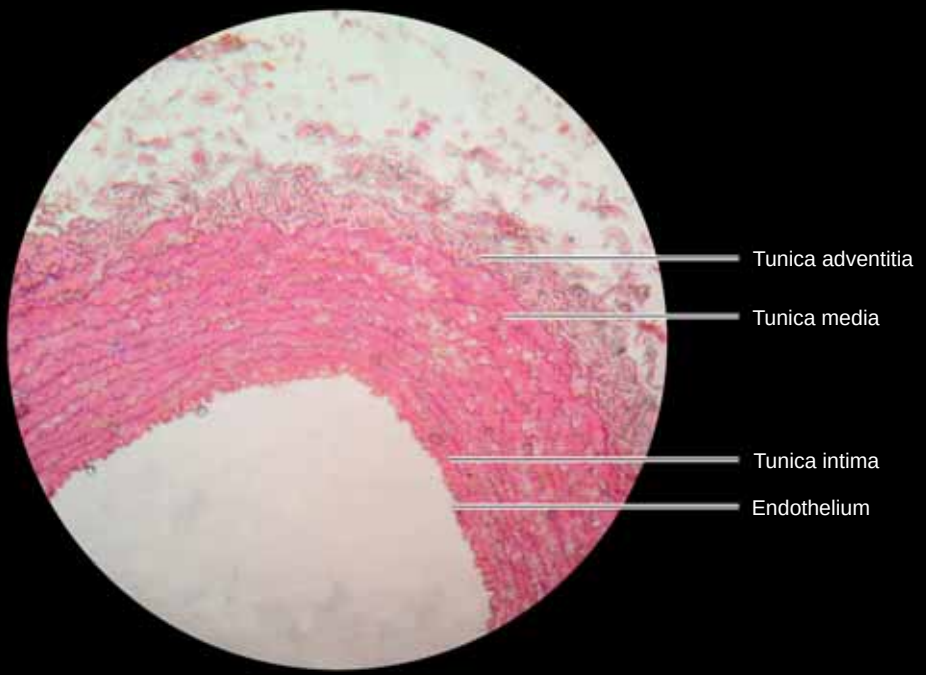


SP:

- Presence of three layers tunica intima, tunica media and tunica adventitia.
- Tunica media more prominent with more elastic fiber and few smooth muscle fibers.

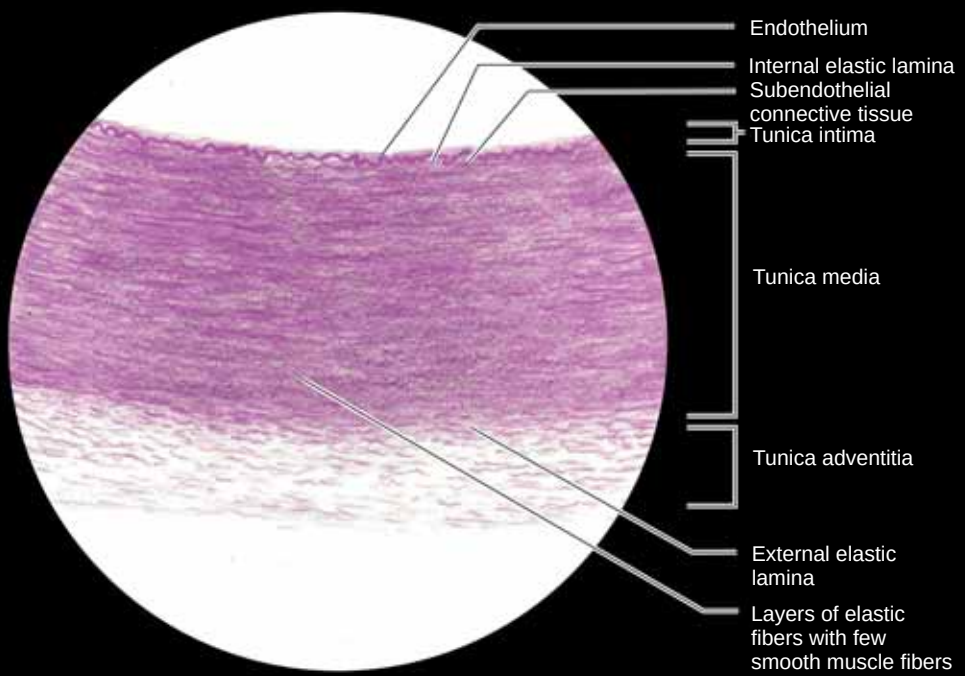


MEDIUM SIZED ARTERY



SP:

- Thick tunica media with numerous smooth muscle fibers.
- Presence of internal elastic lamina thrown into folds.



MEDIUM SIZED ARTERY

- Also known as **muscular artery**.
- Arterial wall made up of three layers.
- Tunica media thicker than adventitia.
- **Tunica intima** consisting of the endothelium and subendothelial connective tissue.
- **Tunica media** consists of **mainly smooth muscle fibers** and few elastic fibers.
- **Internal elastic lamina** (elastic fibers) is present between tunica intima and tunica media.
- **External elastic lamina** separates tunica media and adventitia.
- **Vasovasorum** present in tunica adventitia.
- For example, *radial artery, ulnar artery, brachial artery.*

Applied Anatomy

- In old age the arteries become stiff. This phenomenon it called arteriosclerosis.
- In atherosclerosis usually large and medium sized arteries are affected, where smooth muscles and macrophages within the tunica intima are filled with lipid vacoules with cholesterol esters which crystallise to form needle like structures and produce clefts in intimal tissue.
- Inflammation of an artery is known as arteritis.
- Thromboangitis obliterans is inflammation of peripheral arteries of the legs, seen in smokers.
- The ability of medium sized arteries to decrease their diameter (to vasoconstrict) regulates the flow of blood to different parts of the body as required.
- The maintenance of blood pressure in the arterial system between contractions of the heart results from the elasticity of large arteries. This quality allows them to expand when the heart contracts and to return to normal between cardiac contractions.

Viva-voce

Q. What is pulse?

Ans. Pulse is a pressure wave transmitted along the artery as a result of the ejection of the blood by the ventricles.

Q. What is blood pressure?

Ans. Blood pressure is the measure of the force that the circulating blood exerts against the artery wall.

LARGE VEIN

- Tubular organ having relatively thin wall and bigger lumen.
- Thin wall comprises of following: tunica intima, tunica media, tunica adventitia.
- **Tunica intima—**consisting of **endothelium**, small amount of **subendothelial connective tissue**, and **internal elastic lamina**.
- **Tunica media**—thin circular arrangement of smooth muscle fibers.
- **Tunica adventitia**—largely developed, smooth muscles in longitudinal arrangement as bundles, surrounded by connective tissue containing **vasovasorum**.
- In large vein tunica media and intima is distinguished by the presence of **internal elastic lamina**.
- Longitudinal bundles of smooth muscles are seen as **muscular patches** in cross section.
- For example, *superior and inferior vena cava*.

Applied Anatomy

- Inflammation of an vein is known as phlebitis.
- Valves are present in veins to prevent the backflow of blood. But in cases of large veins like superior vena cava and inferior vena cava, the valves are absent.

Viva-voce

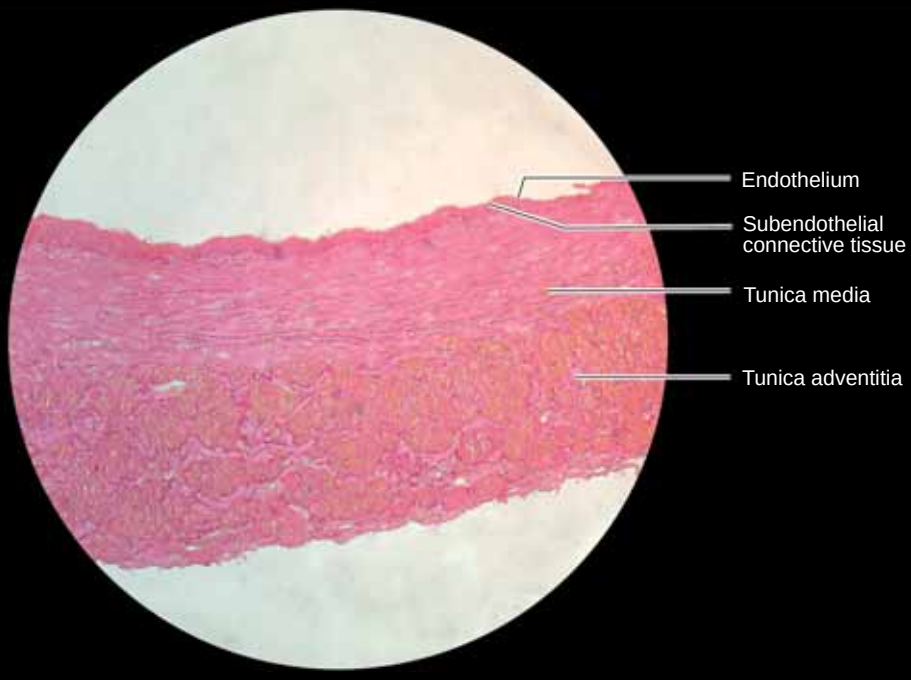
Q. How will you identify longitudinal smooth muscle bundles in a histology slide under microscope?

Ans. The longitudinal smooth muscle fibers bundle are seen as muscular patches on cross section when viewed under microscope.

Q. What is aortocaval compression syndrome?

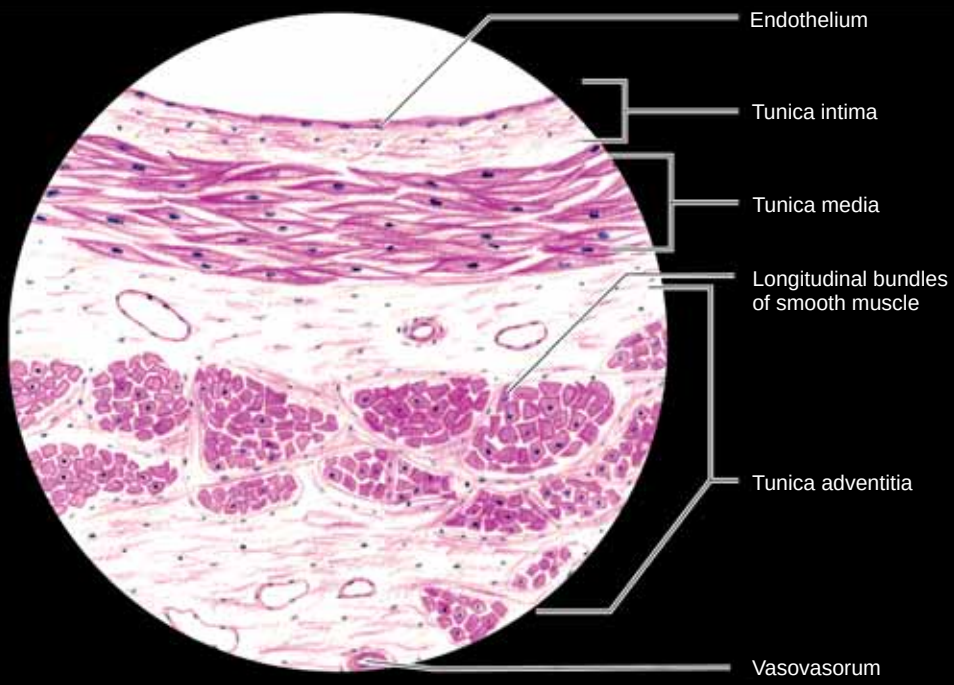
Ans. Aortocaval compression syndrome, is compression of the abdominal aorta and inferior vena cava by the gravid uterus when a pregnant woman lies on her back, and is a frequent cause of maternal hypotension, which can in result in loss of consciousness.

LARGE VEIN



SP:

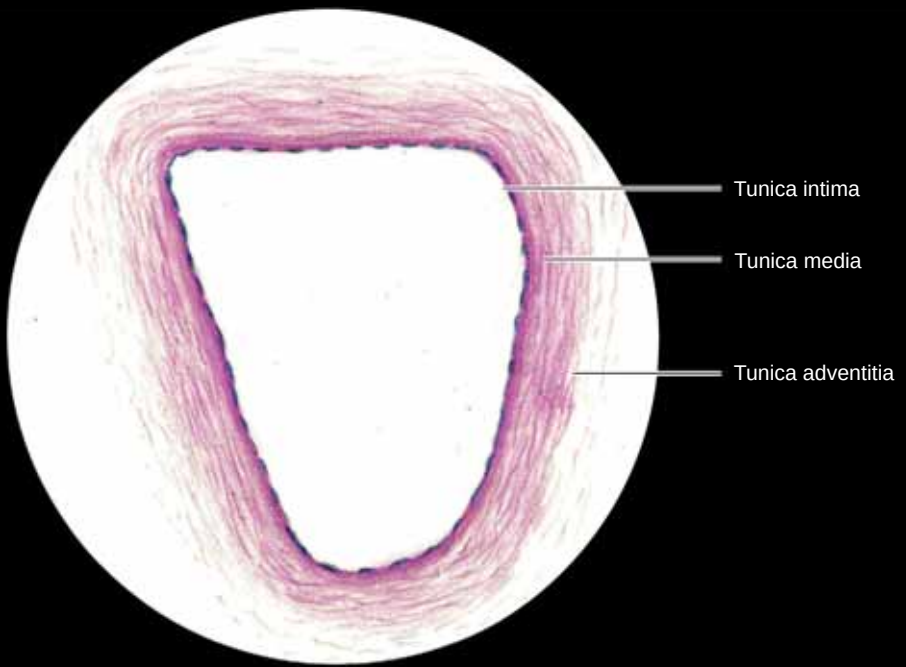
- Presence of 3 layers tunica intima, tunica media and tunica adventitia.
- Tunica adventitia more prominent with muscular patches seen.



MEDIUM SIZED VEIN

SP:

- Presence of three layers tunica intima, tunica media and tunica adventitia.
- Thin tunica intima with collapsed lumen.



MEDIUM SIZED VEIN

- It is made up of 3 layers.
- Tunica intima, tunica media, tunica adventitia.
- Internal and external elastic lamina is **absent**.
- **Tunica media** consists of few smooth muscle fibers and elastic fibers, in collagen fibers.
- **Tunica adventitia** consists of loose connective tissue.
- **Vasovasorum** and nerve fibers are also present in this layer.
- **Lumen** is collapsed.
- For example, *saphenous vein, median cubital vein, cephalic vein.*

Applied Anatomy

- Endothelial cells and the basal lamina can act as selective filters between the blood and the tissue surrounding the blood vessel.
- Venous insufficiency is the most common disorder of the venous system, and is usually manifested as spider veins or varicose veins.
- Deep-vein thrombosis is a condition in which a blood clot forms in a deep vein, which can lead to pulmonary embolism and chronic venous insufficiency.
- Communicating veins (or perforator veins) are veins that directly connect superficial veins to deep veins which are usually medium sized veins.
- In neurogenic and hypovolemic shock the smooth muscles surrounding the veins become slack and the veins fill with the majority of the blood in the body, keeping blood away from the brain and cause unconsciousness.

Viva-voce

Q. Is there medium sized veins without valves? If so name any one vein.

Ans. Yes, emissary veins present in the head and neck region and the besian veins within the myocardium of heart.

Q. How will you distinguish a medium sized artery and vein of same size lying close to each other?

Ans. The medium sized vein on compression will collapse easily due to less number of smooth muscle fibers, but a medium sized artery due to its thick muscle coat is difficult to compress.

Lymphoreticular System

LYMPH NODE

- It is an oval shaped discrete structure.
- Consist of **capsule, cortex, para cortex** and **medulla**.
- **Capsule:** Consisting of connective tissue with arteriole and venule, afferent lymphatic vessel. It sends the **trabeculae** to interior. It is separated from cortex by subcapsular sinus or marginal sinus to which the afferent lymph vessels empty its contents.
- **Cortex:** Consisting of **lymphatic nodules** with **germinal center**, are incompletely separated by trabeculae.
- **Lymphatic follicles** are made by B lymphocytes.
- There is a dark zone surrounding the germinal center, which is made up of smaller mature B lymphocytes known as **mantle zone**.
- The deeper part of cortex or the **para cortex** is occupied by T cells.
- **Medulla:** Consisting of **medullary cords** (Anastomosing cords of lymphatic tissues with plasma cells, macrophages and lymphocytes) and **medullary sinus** (capillary channels that drains lymph through different lymph vessels).
- Main framework by reticular connective tissues.

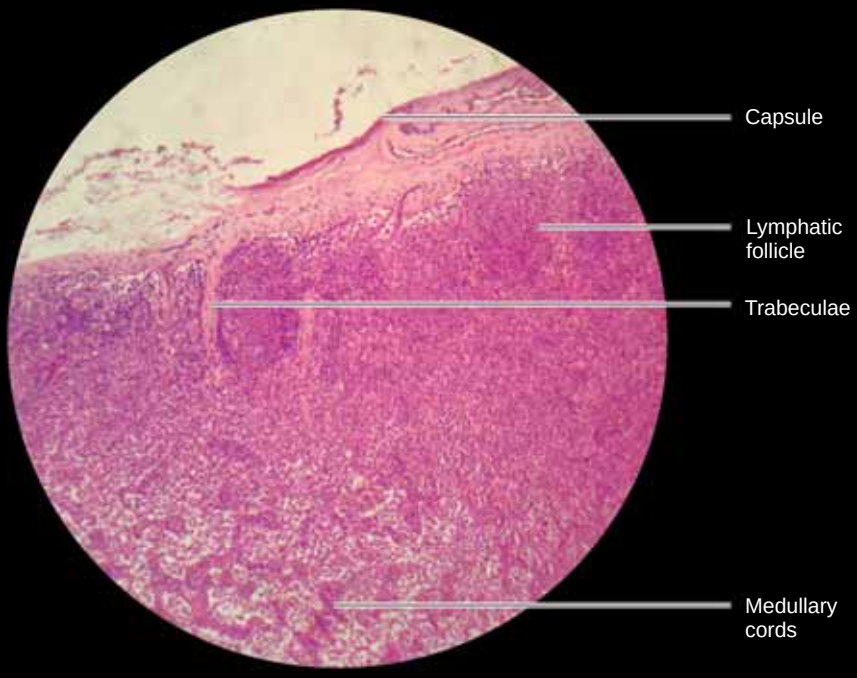
Applied Anatomy

- In chronic lymphocytic lymphoma the lymph node architecture is diffusely effaced by tumor cells.
- Sites of antigenic recognition and antigenic activation.
- During antigenic activity B cells are converted to centroblasts then into centrocytes.
- Lymphocytes are relatively small in the medullary sinus than in lymphatic nodules helping to distinguish each other.
- Lymphadenitis is the inflammation of the lymph nodes and is due to the infection of the body part drained by it.
- From the primary cancer sites, cancer cells metastases through the lymphatics and get lodged at the lymph nodes draining the corresponding primary site.

Viva-voce

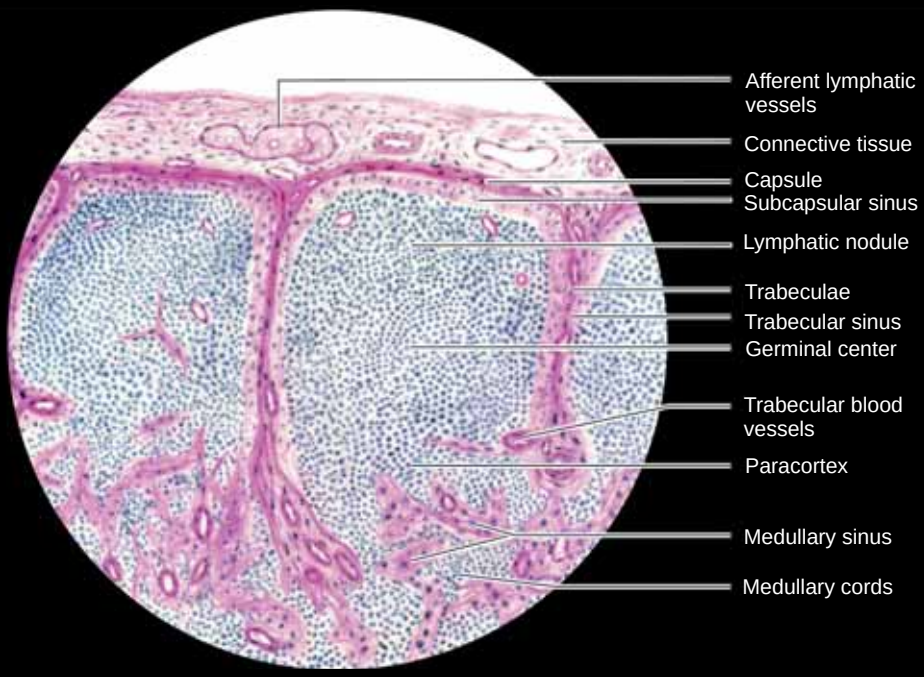
Q. What are medullary cords?
Ans. These are anastomosing cords of lymphatic tissues present in the medulla.

LYMPH NODE

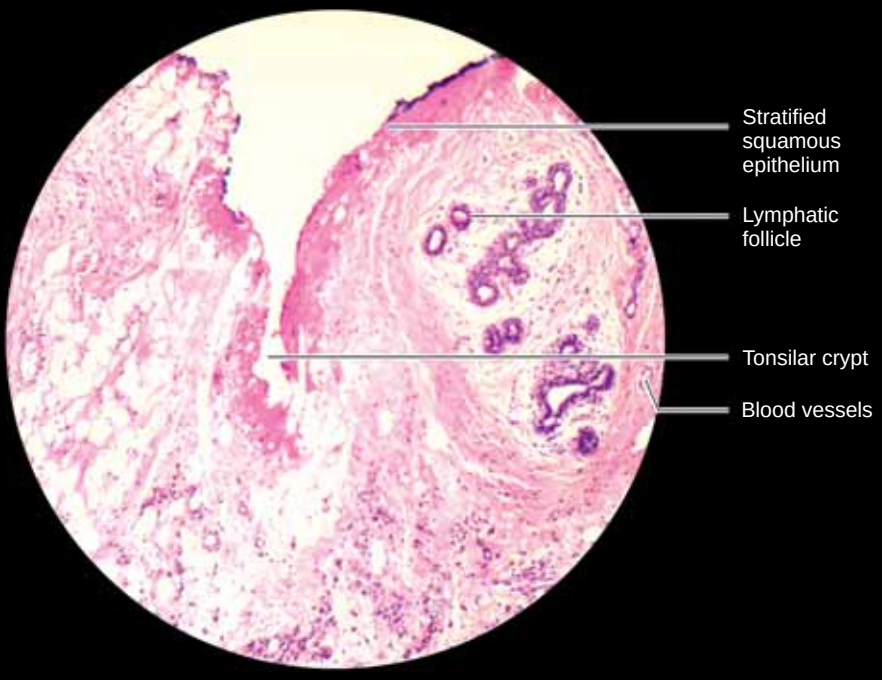


SP:

- Presence of lymphatic nodules in cortex
- Presence of medullary cords and sinuses in the medullary.

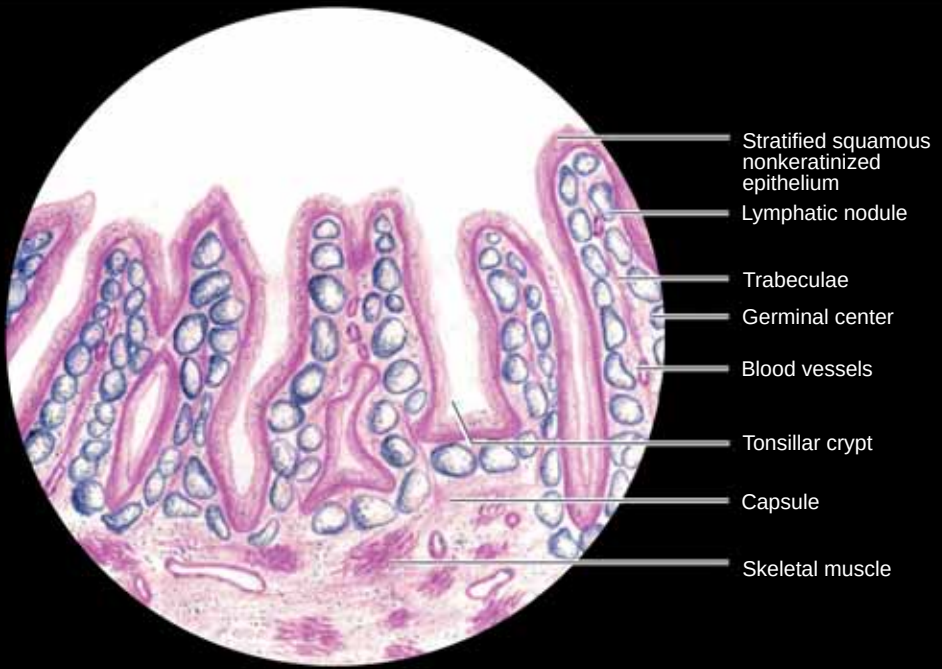


PALATINE TONSIL



SP:

- Presence of crypts
- Presence of subepithelial lymphoid nodule



PALATINE TONSIL

- Consists of a protective layer of **stratified squamous nonkeratinized epithelium.**
- Invaginated by deep grooves called **crypts**.
- A dense connective tissue underlies the tonsil and forms its **capsule** consisting of some blood vessels.
- Below the epithelium, numerous **lymphatic nodules** are distributed and they merge frequently with each other and exhibit lighter staining **germinal center**.
- The tonsilar crypts usually contain the dead antigen, broken debris, disarmed bacteria, etc.

Applied Anatomy

- In case of secondary infections, the tonsil is one the lymphoid organ where inflammation is distinctly visible.
- Mouth of crypts appear as purulent spots in tonsillitis due to infection and pus formation.

Viva-voce

Q. What kind of epithelium lines the tonsil?
Ans. Tonsil is lined by stratified squamous nonkeratinized epithelium.
Q. What are crypts?
Ans. The surface of the tonsil is invaginated by deep grooves. These grooves are known as tonsilar crypts.
Q. What does tonsilar crypts contain?
Ans. The tonsilar crypts usually consists of dead antigen, broken debris, disarmed bacteria, etc.
Q. What does germinal center contain?
Ans. Germinal center consist of new and mature lymphocytes. The former is present in the inner aspect and the latter is present in the outer aspect of the germinal center.

SPLEEN

- Consists of a dense connective tissue capsule from which **trabeculae** arise and contains trabecular arteries and veins.
- Does not exhibit cortex and medulla but the capsule divides into compartments called **splenic pulps**.
- **White pulp** is made up of numerous lymphatic follicles which has a **germinal center** and peripherally located **central artery**.
- **Red pulp** is formed by the diffuse cellular meshwork around the white pulp and act as a single unit. It contains venous **sinuses** and **splenic cords**.
- White pulp is the site of immune response to blood borne antigens, T cells and B cells are present within the nodules.
- Spleen consists of **venous sinuses** in contrast to the lymphatic sinuses in lymph nodes.
- Splenic cords contain macrophages, lymphocytes, plasma cells and different blood cells.

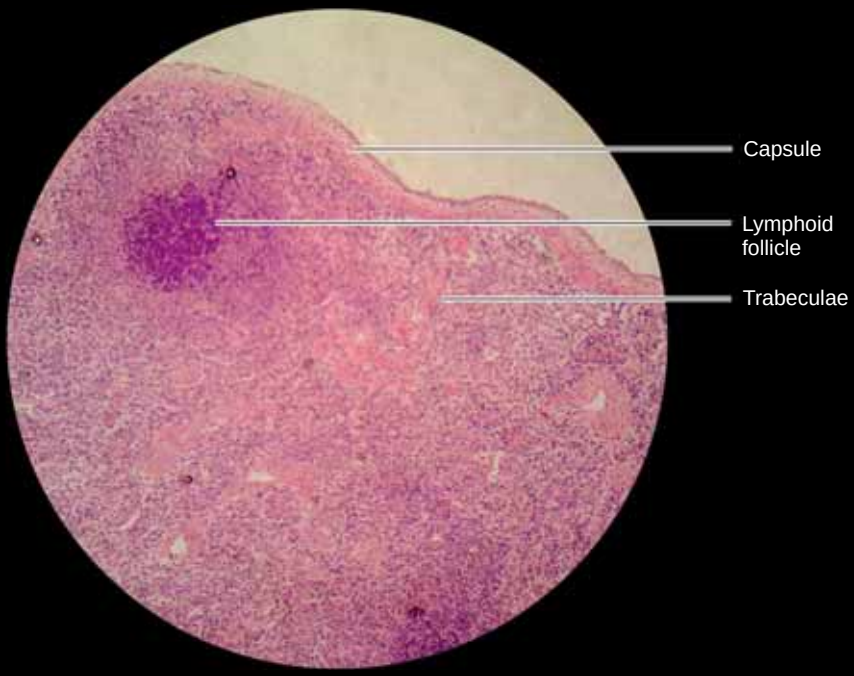
Applied Anatomy

- In spleen lymphatic nodules are found throughout the structure.
- Spleen does not exhibit subcapsular or subtrabecular sinuses.
- The capsule and trabeculae in spleen are thicker than those in lymph node.
- In congestive splenomegaly, there is splenic obstruction due to chronic venous obstruction. Here red pulp is congested early and cirrhosis of the liver is the main cause.

Viva-voce

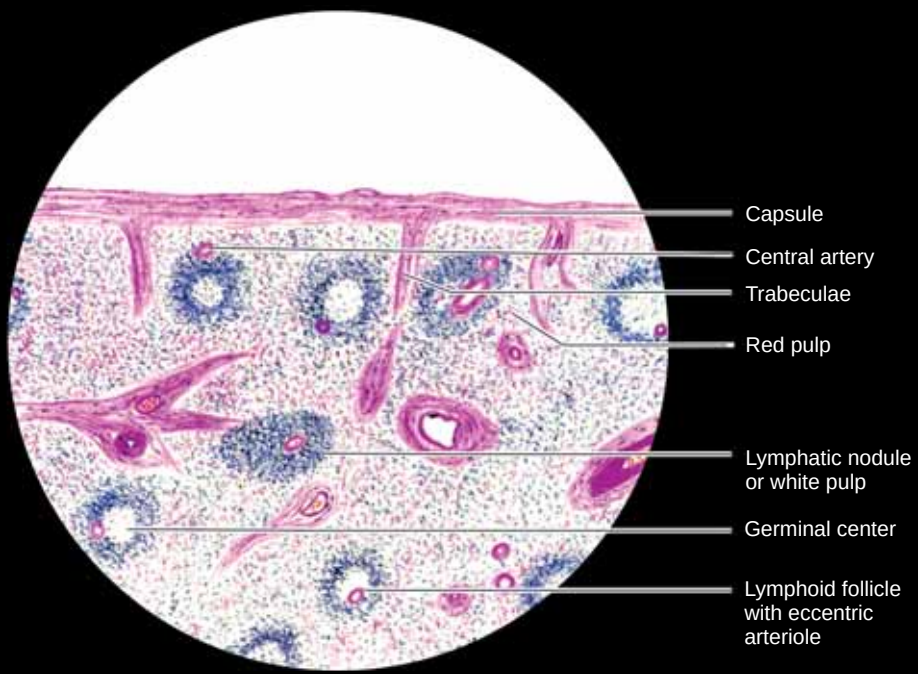
Q. Where do the blood vessels directly open in spleen?
Ans. The blood vessels open into the red pulp giving the characteristic red color.
Q. What are the contents of splenic cords?
Ans. Splenic cords consist of macrophages, lymphocytes, plasma cells and different blood cells.
Q. What are splenic pulps?
Ans. Splenic pulps are the different compartments of the spleen formed by the passage of capsule into the organ.

SPLEEN

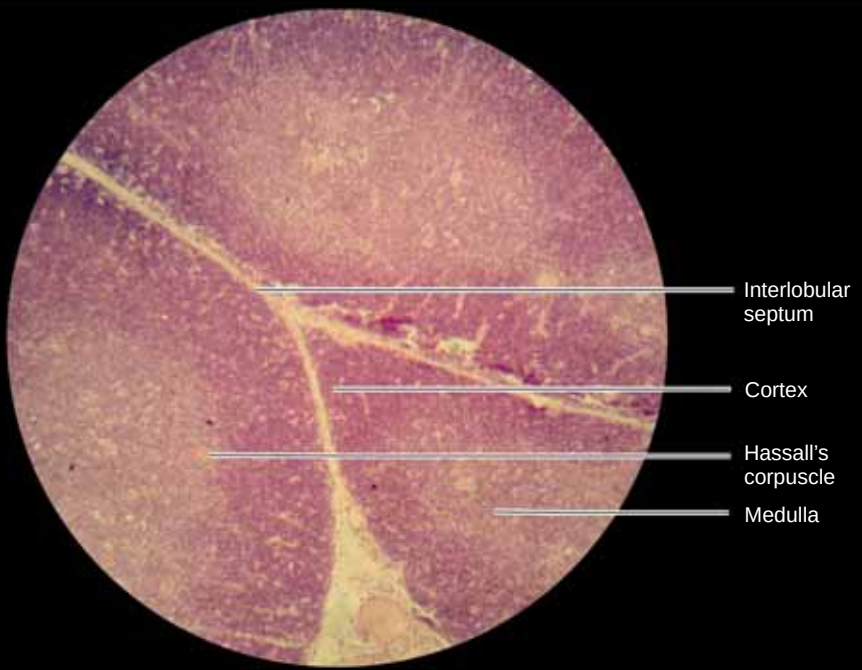


SP:

- Presence of thick capsule and trabeculae.
- Red pulp containing splenic cords and sinusoids and white pulp present.

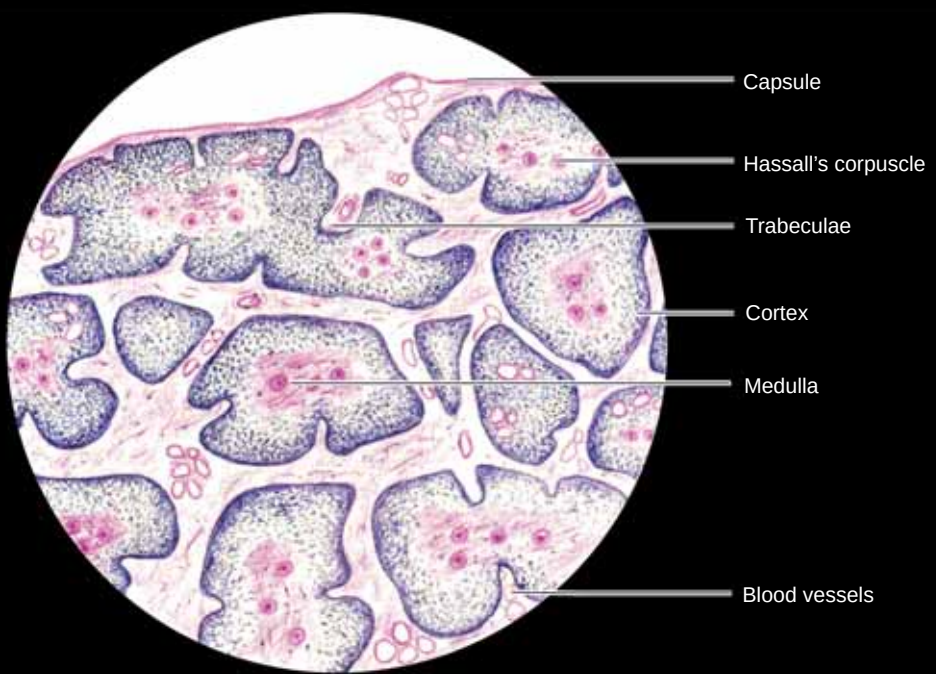


THYMUS



SP:

- Presence of lobules with lymphoid tissue.
- Presence of Hassall's corpuscles in the medulla.



THYMUS

- Consist of connective tissue **capsule** from which **trabeculae** arise and extend into interior dividing the gland into numerous incomplete lobules, blood vessels pass to gland via this.
- Each lobule consists of dark staining outer **cortex** and light staining inner **medulla**.
- As lobules are incomplete medulla shows continuity between neighboring lobules.
- **Cortex** consists of densely packed lymphocytes whereas medulla contains few lymphocytes and more **epithelial reticular cells** which form **Hassall's corpuscle** or **thymic corpuscle**.
- **Hassall's corpuscles** are oval structures consisting of aggregations or whorls of flattened epithelial cells and exhibit degeneration.

Applied Anatomy

In thymic follicular hyperplasia, there is appearance of numerous B cell germinal centers with in the thymus. Usually this is seen in myasthenia gravis and rheumatoid arthritis.

Viva-voce

Q. What are Hassall's corpuscles?
Ans. These are whorls or aggregations of flattened epithelial reticular cells which later undergo degeneration.
Q. Why there is a medullary continuity?
Ans. Since the lobules are incompletely seperated there is medullary continuity between the adjacent lobules.
Q. How do blood vessels and other lymphatic vessels enter the organ?
Ans. The blood vessels and lymphatics enters the capsule and then pass through the trabeculae to enter the thymus.

Nervous Tissue

NERVE FIBER

- Consist of **central axon** appearing as slender thread which stains lightly.
- Surrounded by **myelin sheath** which is not continuous throughout the length of axon, forming interruption called **nodes of Ranvier** and occurs between adjacent **Schwann cells**.
- At the node of Ranvier, the Schwann cell membrane is seen as a thin peripheral boundary that descend towards axon.
- Around some of the axons a **connective tissue** layer is also present.
- A possible **Schwann cell nucleus** and a **fibrocyte** is usually associated with it.
- Outside the axons a capillary with blood cells is also found.
- **Nodes of Ranvier** are responsible for saltatory conduction in large myelinated neurons resulting in more efficient and faster conduction.
- Usually the surrounding myelin sheath will be dissolved by chemicals during preparation and are seen as empty spaces.

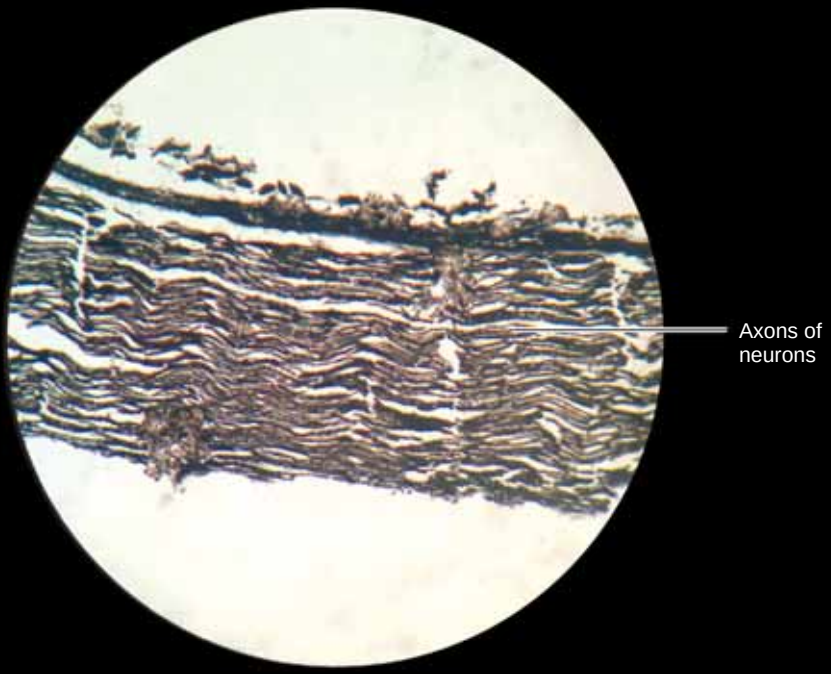
Applied Anatomy

- Inflammation of the nerve is known as neuritis.
- Neuropathy is damage or disease of nerves which may affect sensation, movement, gland or organ function or other health aspects depending on the nerve involved.
- Neuropraxia is a temporary interruption or physiological block of conduction without loss of axon continuity.
- Axonotmesis is the loss of relative continuity of the axon and its myelin, but connective tissue framework is preserved.
- Neurotmesis is the total destruction of the entire nerve fiber.

Viva-voce

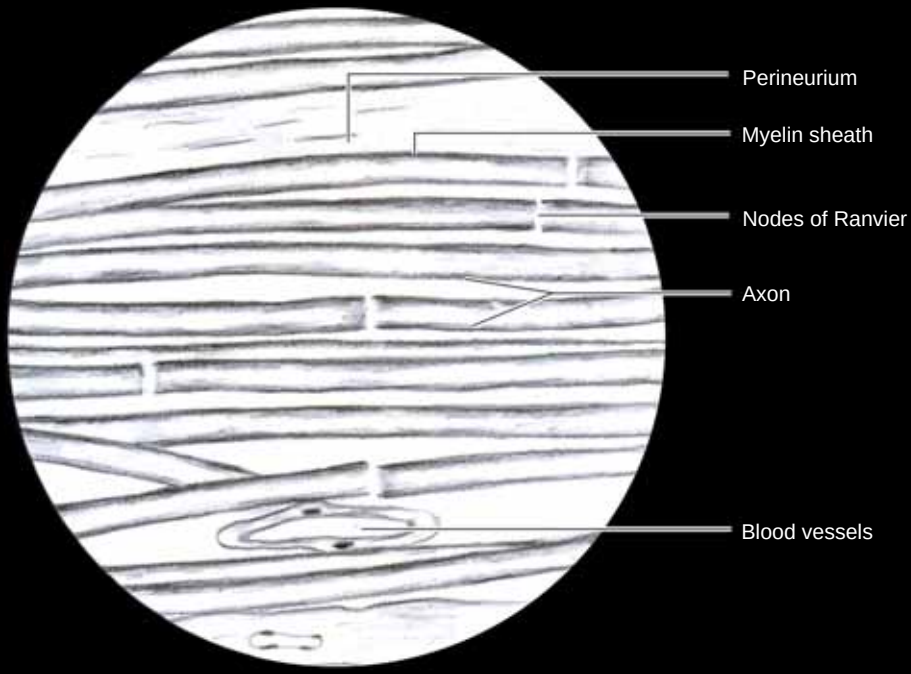
Q. What are nodes of Ranvier?
Ans. These are interruptions or discontinuities in the myelin sheath surrounding the axon.
Q. Which structure helps to maintain the appropriate microenvironment for peripheral nerve fibers?
Ans. Perineurium.
Q. Which cell type forms the myelin sheath around myelinated axons in the central nervous system?
Ans. Oligodendrocyte.

NERVE FIBER

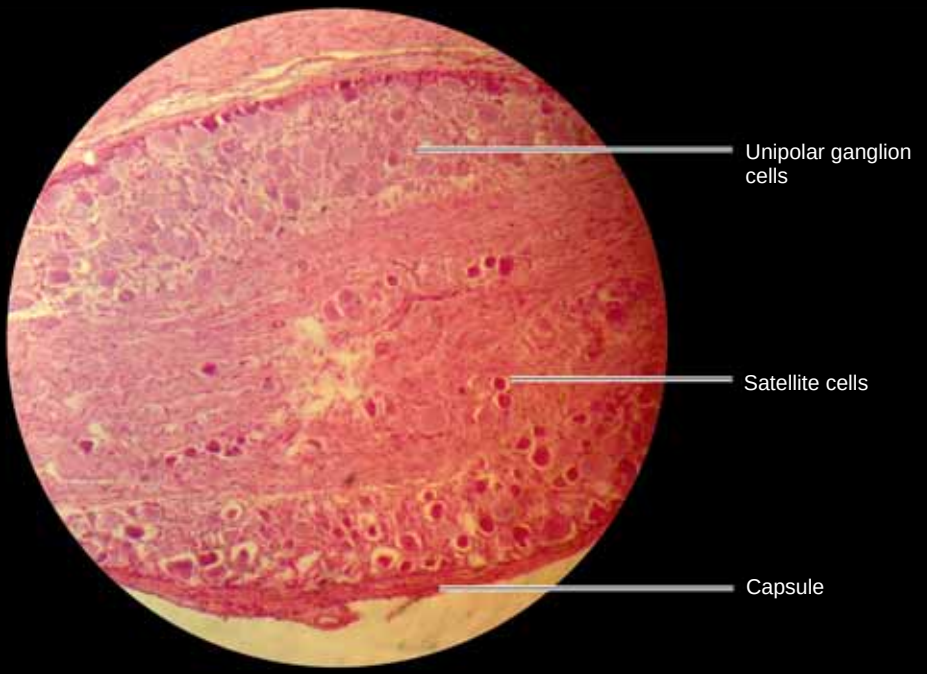


SP:

- Axon cylinder seen at the center.
- Nodes of Ranvier present.

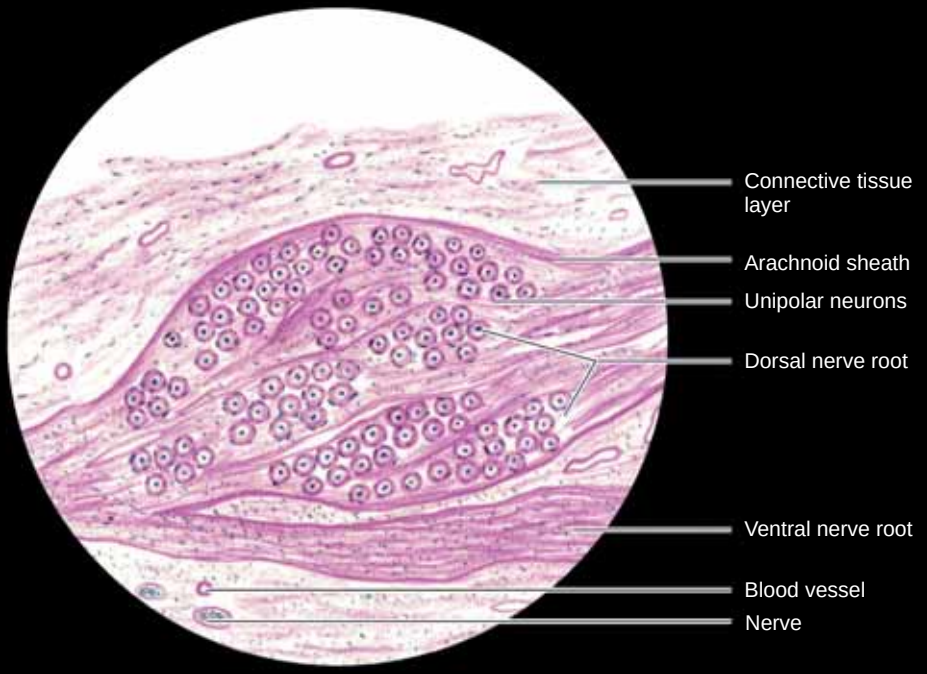


SPINAL GANGLION



SP:

- Presence of round pseudounipolar neurons in groups.
- Presence of nerve fibers in the form of bundles in between ganglion cells.



SPINAL GANGLION

- Each ganglion is enclosed by a **irregular connective tissue** layer that contain **adipose cells, nerves** and **blood vessels**.
- Consists of mainly numerous round **pseudounipolar neurons** in groups with **central nucleus**.
- Numerous **fascicles** of nerve fibers pass between the neurons. These nerve fibers represent the nerve process formed by bifurcation of a single axon.
- Regularly arranged nerve fibers enter and leave the ganglion.
- Contain well-defined **satellite cells** which are small flat cells that surround the neurons of ganglia of peripheral nervous system and provide structural support for **neuronal bodies**, insulate them and regulate exchange of different metabolic substances.
- They are enclosed in a well-defined **connective tissue capsule** and capsular cells.

Applied Anatomy

- Develops from the neural crest cells and not from the neural tube.
- The nerve endings of dorsal root ganglion neurons have a variety of sensory receptors that are activated by mechanical, thermal, chemical, and noxious stimuli.
- Unlike the majority of neurons found in the central nervous system, an action potential in dorsal root ganglion neuron may initiate in the distal process in the periphery, bypass the cell body, and continue to propagate along the proximal process until reaching the synaptic terminal in the dorsal horn of the spinal cord.

Viva-voce

Q. What kind of neurons are mainly present in spinal ganglion?
Ans. Pseudounipolar neurons.
Q. What are the suppportive cells present in spinal ganglion?
Ans. Satellite cells which are small flat cells that surround the neurons of ganglia.
Q. Does spinal ganglion have a capsule?
Ans. Yes, spinal ganglion consist of a well-defined connective tissue capsule.

SYMPATHETIC GANGLION

- Neurons are **multipolar** and more uniform in size due to which their outlines and their dendritic process appear irregular.
- Neurons contain **eccentric nuclei** and may be **binucleate** and in older individuals a brownish lipofuscin pigment accumulates in cytoplasm.
- **Satellite cells** surround multipolar neurons but are less in number compared to spinal ganglion and the **connective tissue capsule** and cells are not well-defined around the neurons but fibrocytes and venule are usually present.
- Nerve fibers are not arranged in groups and the nerve fibers are seen irregularly or scattered.
- The flattened nuclei on the periphery are the **Schwann cells**.
- These nerve fibers represent both preganglionic and post-ganglionic axons.

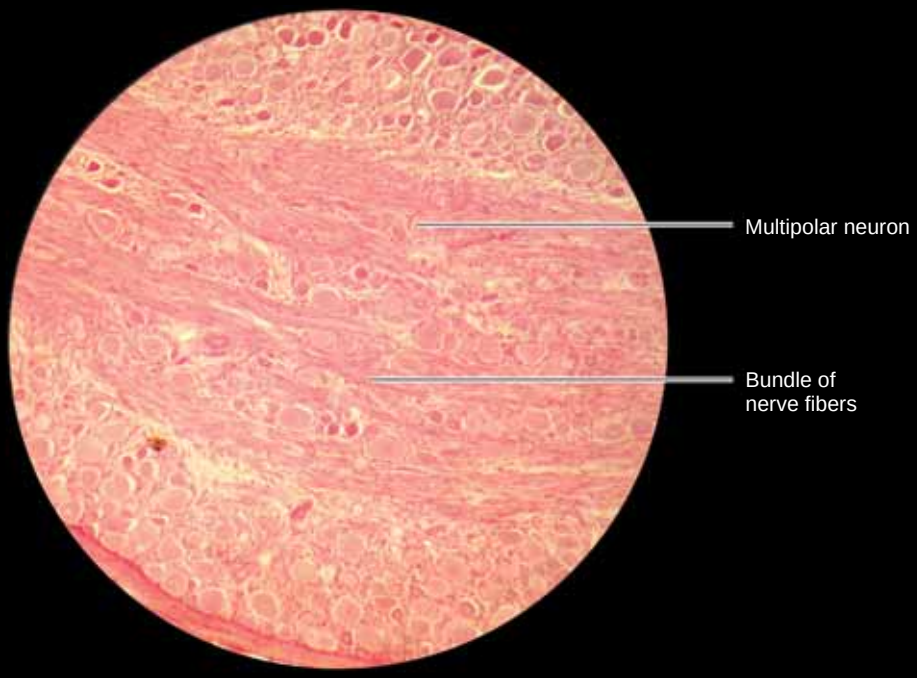
Applied Anatomy

- Responsible for fight or flight response in stress and in impending danger.
- Neuroblastoma tumor arises from the sympathetic ganglial tissue.
- If sympathetic nervous system takes control for long durations, it may release the cortisol hormone instead of the adrenaline, which can harm the brain and can cause anxiety, mood swings, hypertension and palpitation of the heart.

Viva-voce

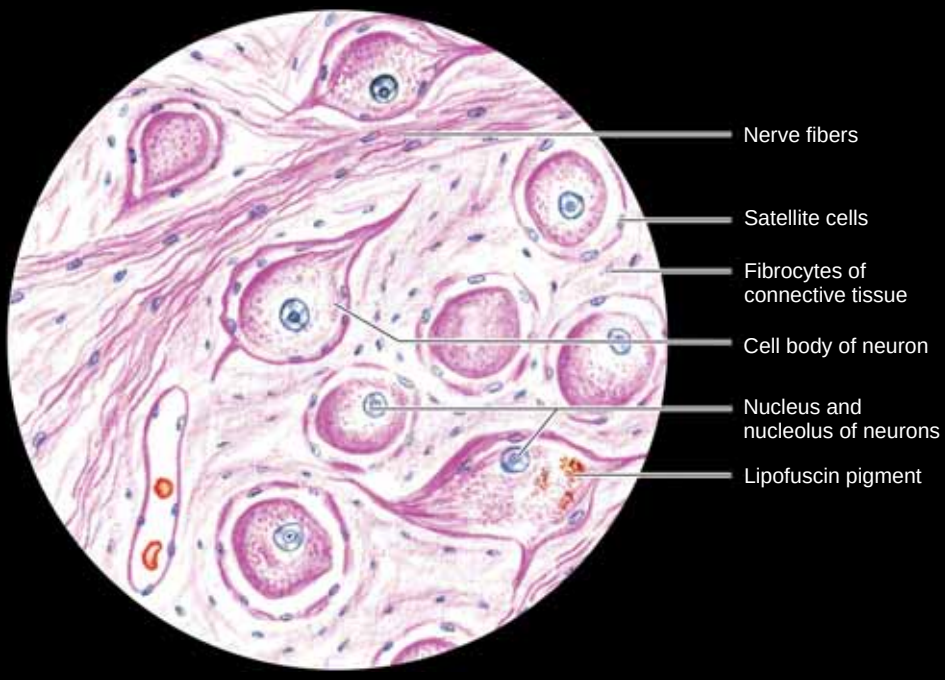
Q. What kind of neurons are mainly present in sympathetic ganglion?
Ans. Multipolar neurons.
Q. What are the suppportive cells present in sympathetic ganglion?
Ans. Satellite cells which are small flat cells that surround the neurons of ganglia and fibrocytes.
Q. Does spinal ganglion have a capsule?
Ans. Yes, spinal ganglion consist of a connective tissue capsule which is not so well-defined when compared to that of the spinal ganglion.

SYMPATHETIC GANGLION

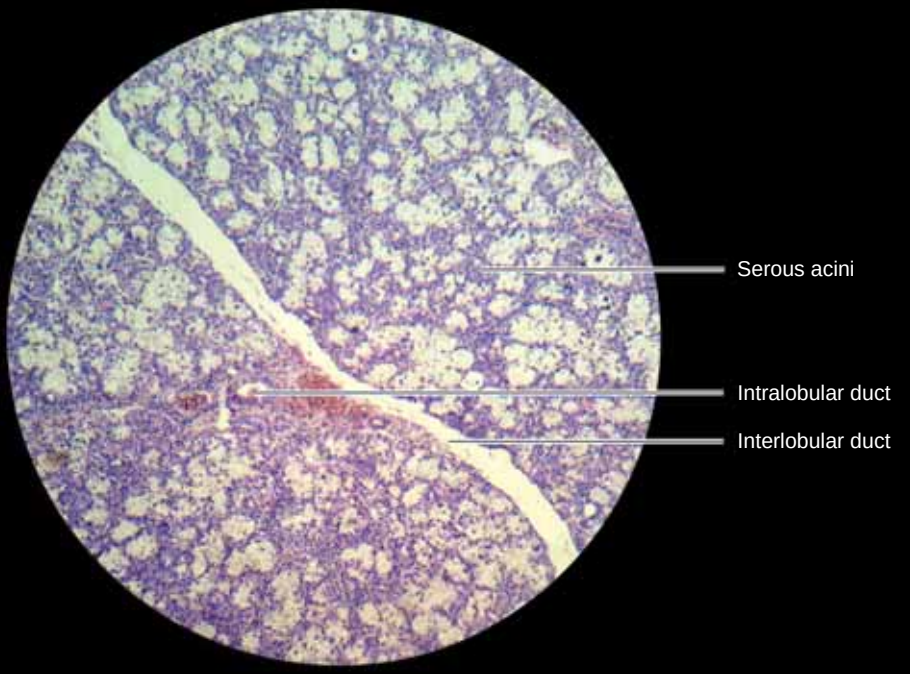


SP:

- Presence of small and scattered multipolar neurons with eccentric nucleus.
- Presence of satellite cells.

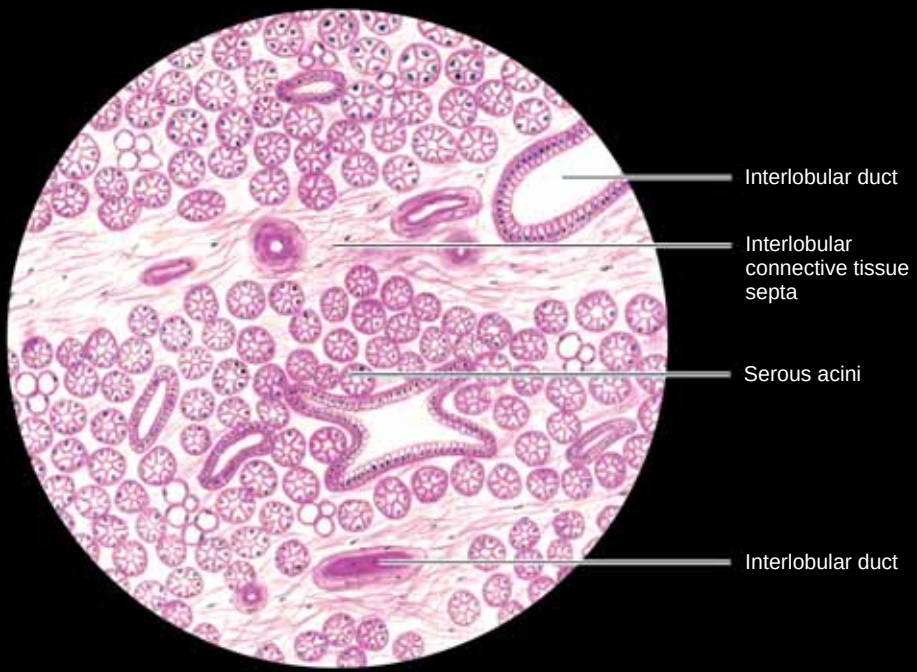


SEROUS SALIVARY GLAND



SP:

- Presence of serous acini with round basal nuclei and small lumen.
- Presence of lobar and interlobular ducts.



Oral Cavity and Structures

SEROUS SALIVARY GLAND

- Example: **Parotid gland**.
- The gland is surrounded by **dense connective tissue capsule** from which **septa** arise and subdivide gland into lobes and lobules.
- Each lobule consists of pyramidal shaped serous cells (secretory cells) with round basal nuclei that forms the **serous acini**.
- Serous acini are surrounded by thin **contractile myoepithelial** cells.
- Small secretory granules are visible in the cell apices of serous cells (at high power).
- In between the lobules, in the connective tissue septa arterioles, venules, and **interlobular excretory ducts** are located.
- Some lobules may also contain numerous **adipose cells**.
- Secretory acini empty their product into narrow channels, the **intercalated ducts** the secretory product from intracalated ducts drains into **striated ducts** and then to **intralobular ducts**.

Applied Anatomy

- Lymphoid infiltrates of the salivary glands are common to a variety of pathologic conditions including autoimmune disorders, malignant lymphomas, and immunoregulatory responses to parenchymal neoplasms.
- Mumps affects the parotid gland.
- Adenoma is one of the benign epithelial tumor that affect the parotid gland.
- Sialadenitis is the inflammation of the salivary gland.
- A sialocele is a localized, subcutaneous cavity containing saliva. It is caused by trauma (e.g. surgical trauma) or infection. They are relatively common complication following surgery to the salivary glands, commonly the parotid gland.

Viva-voce

Q. What is Frey syndrome?

Ans. After parotidectomy, at times there may be regeneration of secretomotor fibers of auriculotemporal nerve which joins the great auricular nerve. This causes stimulation of sweat glands and hyperaemia in the area of its distribution, thus producing redness and sweating in the area of skin supplied by the nerve.

MUCOUS SALIVARY GLAND

- Example: **Sublingual gland**.
- It contains **mucous acini** formed by mucous cells with cytoplasm filled with mucous and flat, single, basally located nuclei.
- **Contractile myoepithelial cells** are seen around individual mucous acini.
- Duct system is different, intercalated ducts are short or absent, in contrast, the nonstriated **intralobular excretory ducts** are more prevalent in the sublingual glands.
- More abundant interlobular connective tissue septa.
- Arteriole, venule, nerve fibers and interlobular excretory ducts are seen in the septa.
- Oval shaped **adipose tissues** are found scattered in connective tissue of the gland.
- **Saliva** is produced after autonomic stimulation.

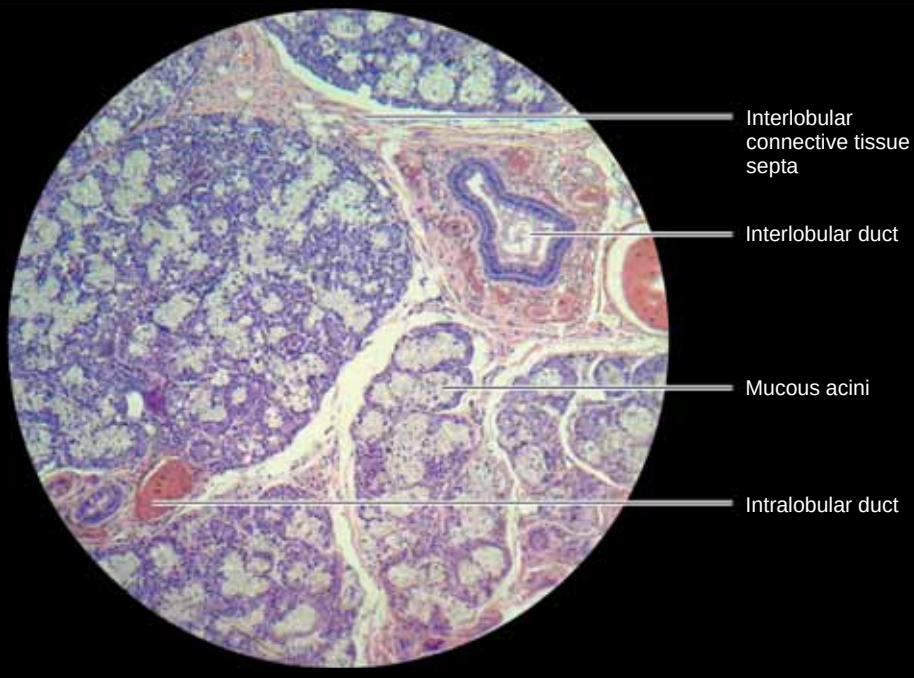
Applied Anatomy

- Salivary duct calculus may cause blockage of the ducts, causing pain and swelling of the gland because of cysts.
- Ranula is the name used when a mucocele occurs in the floor of the mouth (underneath the tongue) and may grow to a larger size than mucoceles at other sites, and they are usually associated with the sublingual gland.
- Sialadenosis (sialosis) is an uncommon, non-inflammatory, non-neoplas tic, recurrent swelling of the salivary glands. The cause is hypothesized to be abnormalities of neurosecretory control and may be associated with alcoholism.

Viva-voce

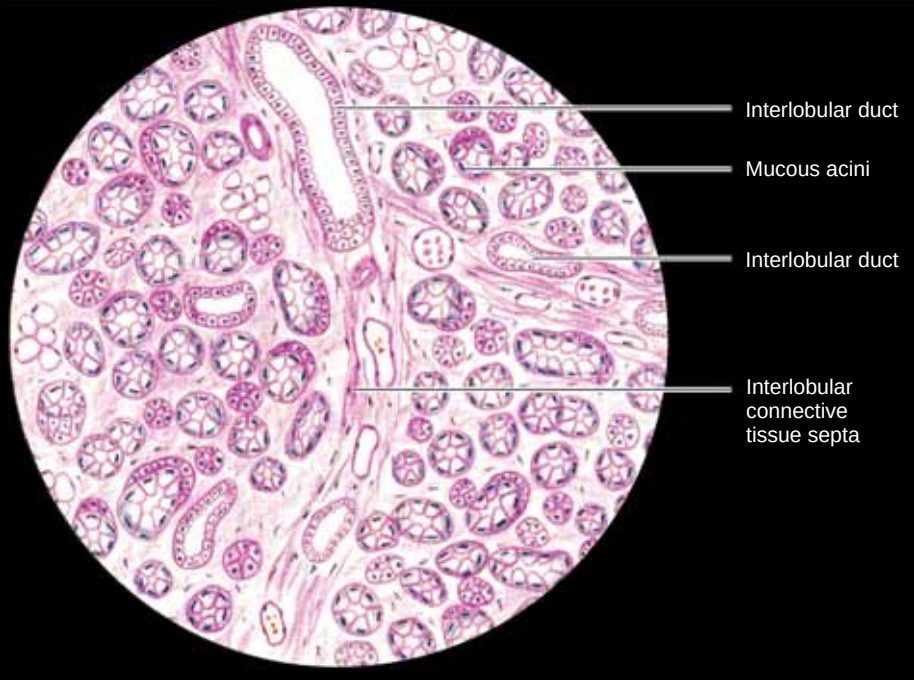
Q. What percentage of the total salivary volime does sublingual gland contribute?
Ans. Only 10% of total salivary volume.
Q. From what structure does sublingual gland develop from?
Ans. They develop from epithelial buds in the sulcus surrounding the sublingual folds on the floor of the mouth, lateral to the developing submandibular gland.

MUCOUS SALIVARY GLAND

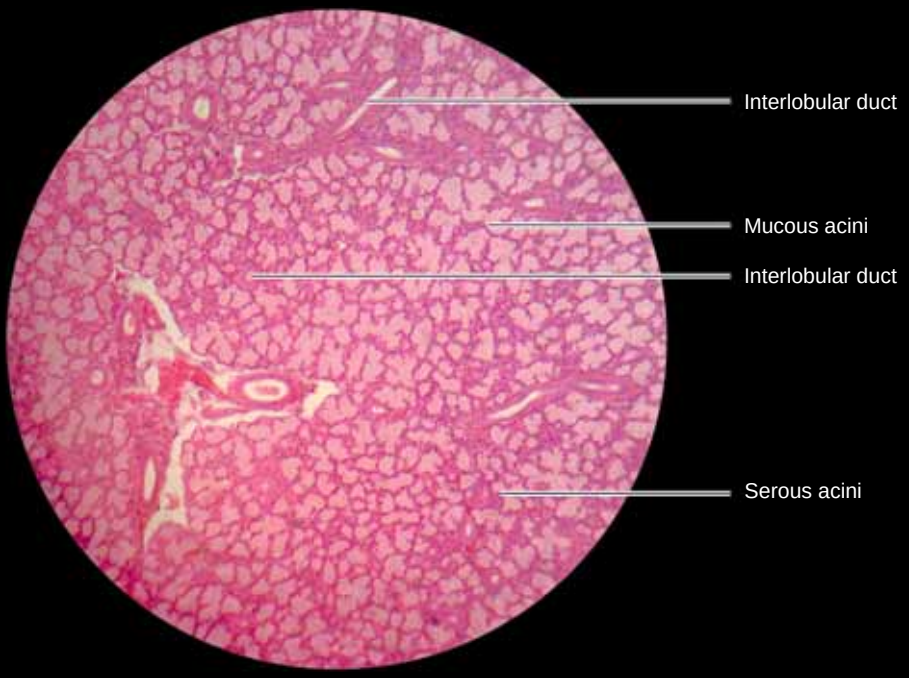


SP:

- Presence of mucous acini with flattened basal nucleus
- Presence of interlobular and intralobular ducts.

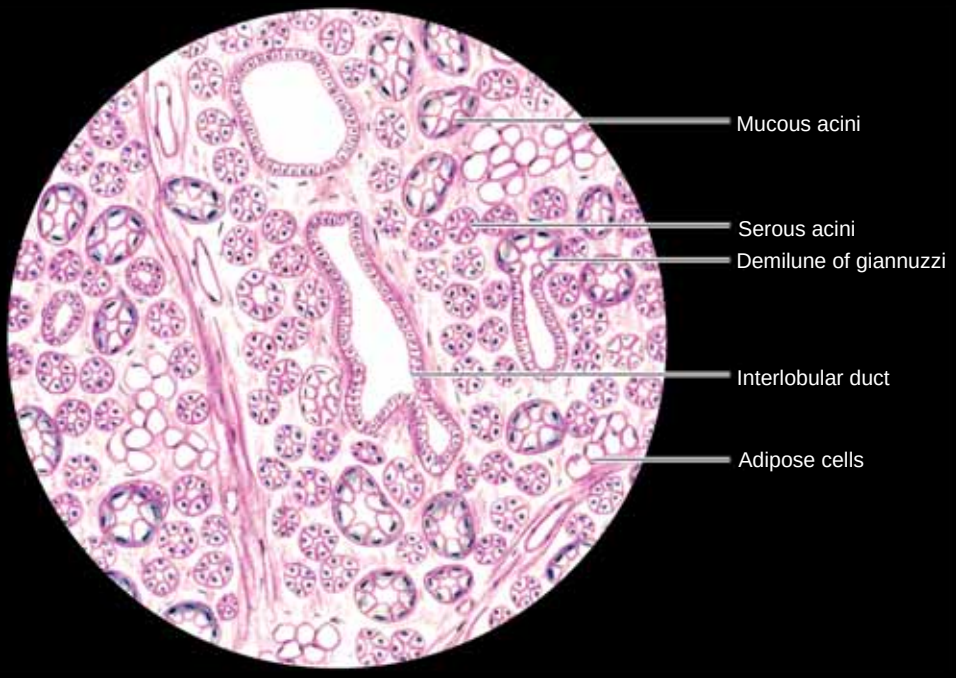


MIXED SALIVARY GLAND



SP:

- Presence of mucous and serous acini with serous demilunes.
- Presence of lobar and interlobar ducts.



MIXED SALIVARY GLAND

- Example: **Submandibular gland**.
- It consist of both **serous** and **mucous acini** but mucous acini predominating.
- Serous cells form cresent shaped cap over the mucous acini and are known as serous demilunes or demilunes of Gianuzzi.
- Both the serous and mucous acini are covered by the contractile myoepithelial cells along with **intercalated ducts**.
- **Interlobular connective tissue septa** divides the glands into lobules.
- Located in the connective tissue septa are nerves, arteriole, venule and adipose cells.
- The duct system of submandibular gland is similar to that of parotid gland.

Applied Anatomy

- Sialolithiasis is a condition where a calcified mass forms within a salivary gland, usually in the duct of the submandibular gland.
- Sialolithiasis can result in chronic obstructive type of sialadenitis (inflammation).
- Chronic sclerosing sialadenitis is a chronic (long-lasting) inflammatory condition affecting the salivary gland. It is benign, but presents as hard, indurated and enlarged masses that are clinically indistinguishable from salivary gland neoplasms or tumors.
- The chorda tympani nerve supplying the secretomotor fibers to subman dibular gland lies medial to spine of sphenoid. Any injury to the spine may involve the nerve and can result in loss of secretion of saliva.

Viva-voce

Q. Which muscle divides the submandibular gland?
Ans. Mylohyoid muscle.
Q. Why the submandibular gland have greater chance of getting calculi or small stones?
Ans. Due to the presence of both serous and mucous acini, the secretions from the gland is more viscous as a result there are more chances of getting calculi.

TONGUE

- Consists of **intercalated skeletal muscle fibers**.
- Surface covered by surface elevations called **filiform, fungiform and circumvallate papillae**.
- **Filiform papillae** are the most numerous and smallest that cover tongue, lack tastebuds.
- **Circumvallate papillae** are the largest, are in the back of tongue and have furrows, underlying serous glands and tastebuds.
- **Foliate papillae** are rudimentary in human.
- **Posterior lingual glands** in the connective tissue open onto dorsal surface of tongue.
- **Skeletal muscle fibers** are arranged both in longitudinally and transversely.

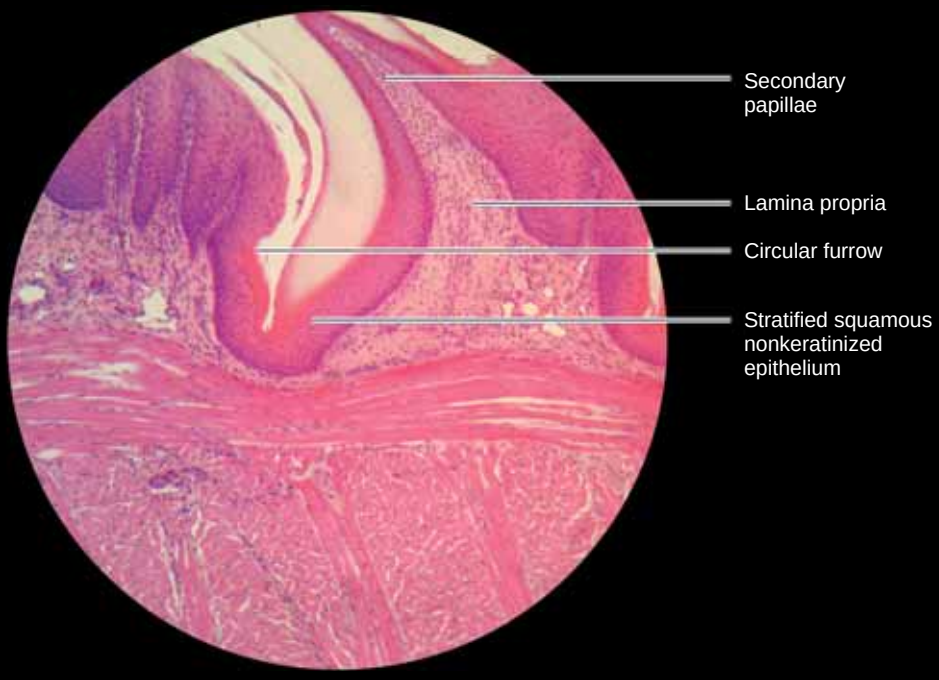
Applied Anatomy

- The loss of taste sensations in the anterior 2/3rd of the dorsum is mainly due to lesions in facial nerve.
- The loss of taste from vallate papillae is seen most likely due to lesion of glossopharyngeal nerve or its nucleus.
- Inspection of tongue helps in diagnosis of various diseases like:
  1. Reddish tongue in glossitis.
  2. Excessive furrowing in prolonged fever.
  3. Black hairy tongue in AIDS.

Viva-voce

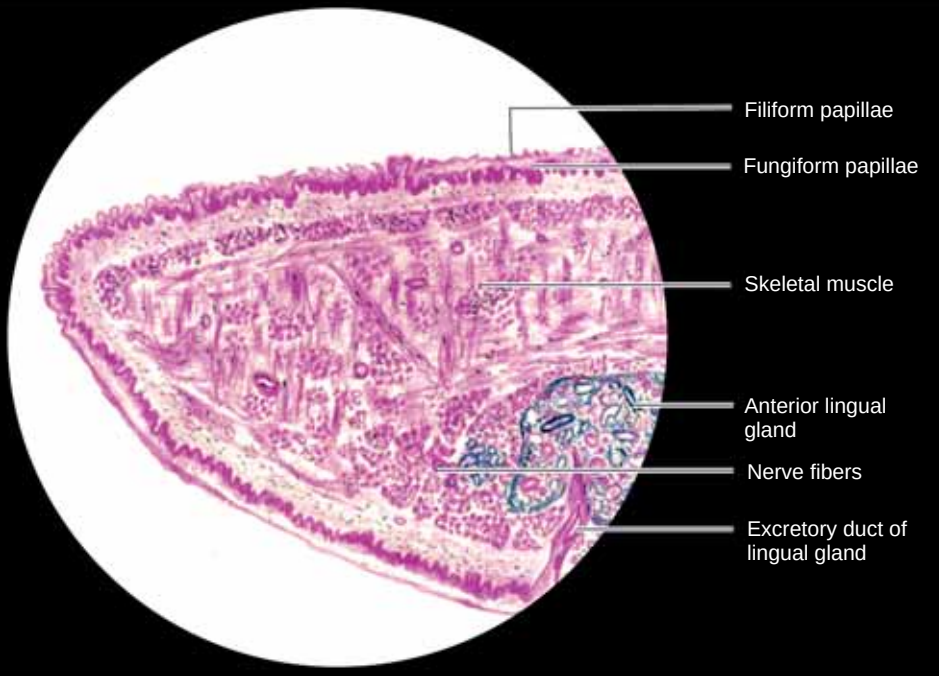
Q. What are papillae?
Ans. These are surface elevations present on the surface of tongue.
Q. What are the types of papillae present on tongue?
Ans. Filiform, fungiform and circumvallate papillae.
Q. Which papillae contain tastebuds?
Ans. Circumvallate papillae.
Q. Which papillae lack taste buds?
Ans. Filiform papillae.
Q. Where do the posterior lingual glands open into?
Ans. The posterior lingual glands open into the dorsal surface of the tongue.

TONGUE

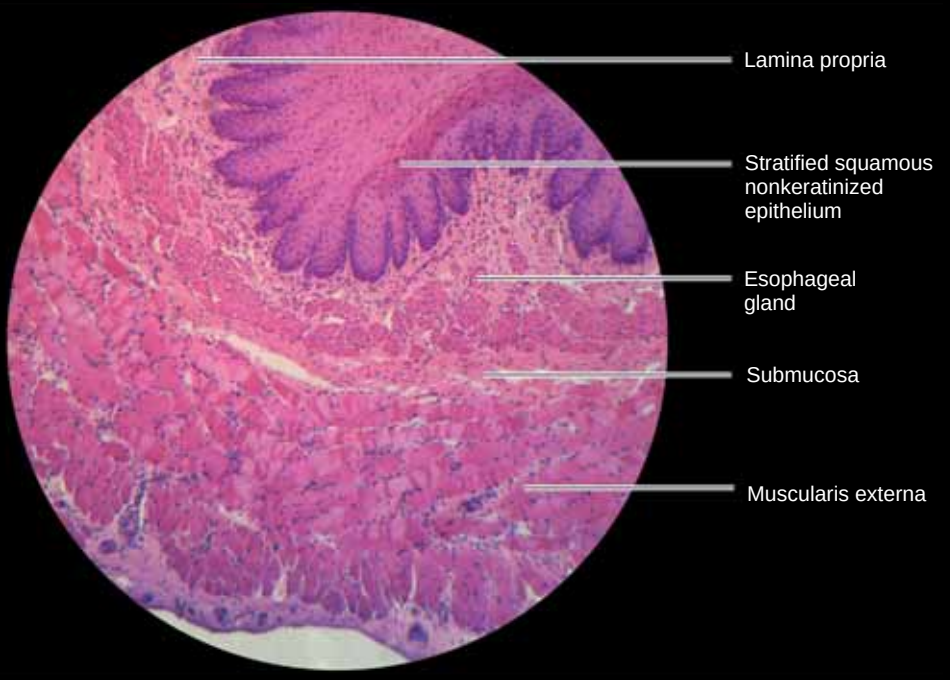


SP:

- Presence of different kinds of papillae with skeletal muscle fibers.
- Presence of glands and stratified nonkeratinized squamous cell lining.

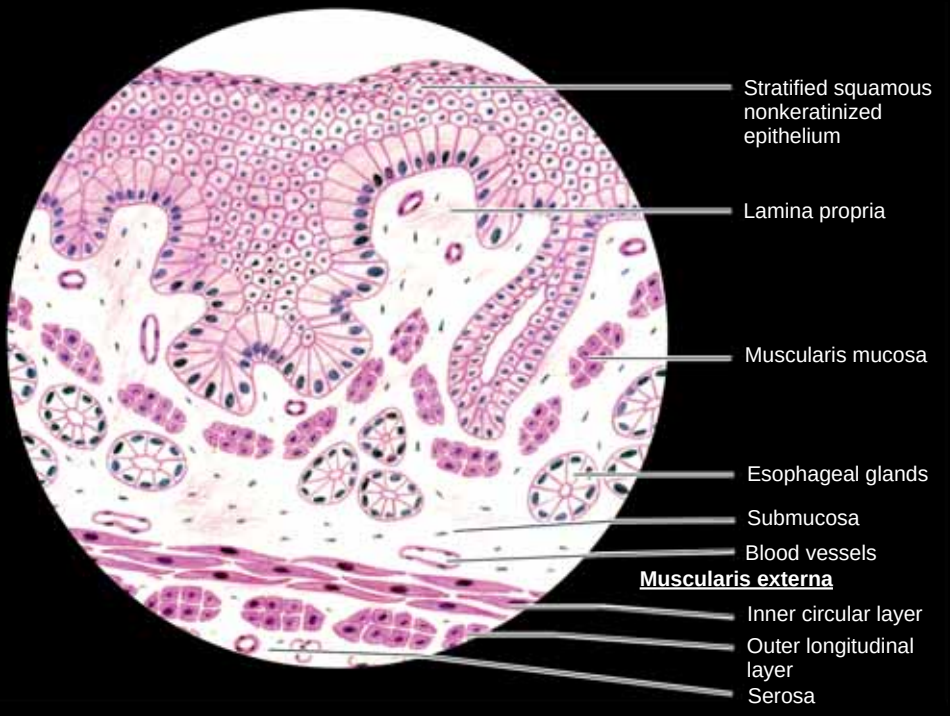


ESOPHAGUS



SP:

- Presence of 4 layers of GIT.
- Presence of esophageal glands in submucosa.



Alimentary System

General Aspects

- Wall of gastrointestinal tract or the GIT has 4 basic layers:
  1. **Mucosa**
  2. **Submucosa**
  3. **Muscularis externa**
  4. **Serosa or adventitia**
- These layers exhibit variations at different sites due to the functional differences of these sites.
  1. **Mucosa** consists of:
     a. **Lining epithelium**
     b. **Lamina propria**
     c. **Muscularis mucosa** with **inner circular** and **outer longitudinal** smooth muscle layers.
  2. **Submucosa**
     - Located below mucosa
     - Made up of dense irregular connective tissue with numerous blood vessels and lymphatic vessels.
     - Consists of submucosal or **Meissner's nerve plexus** containing postganglionic parasympathetic neurons controlling the motility of the mucosa as well as secretory activities of associated mucosal glands.
     - In the duodenal region, numerous branched mucous glands are present.
  3. **Muscularis externa**
     - Thick smooth muscle layer situated inferior to the submucosa.
     - Consists of **inner circular** and **outer longitudinal** layers of smooth muscle except at the site of large intestine.
     - **Myentric nerve plexus or Auerbach's plexus** is located in between these two smooth muscle layers.
     - This plexus contains some **postganglionic parasympathetic neurons** and controls the motility of intestine.
  4. **Serosa and adventitia**
     - The visceral organs may or may not be covered by a thin outer layer of squamous epithelium called **mesothelium**.
     - If the mesothelium covers the visceral organs, the organs will be within the abdominal or pelvic cavity (intraperitonial) and now the outer layer is called **serosa**.
     - When the visceral organs are not covered by mesothelium, then they will lie outside the visceral cavity (retroperitoneal) and now, outer layer is called **adventitia**.

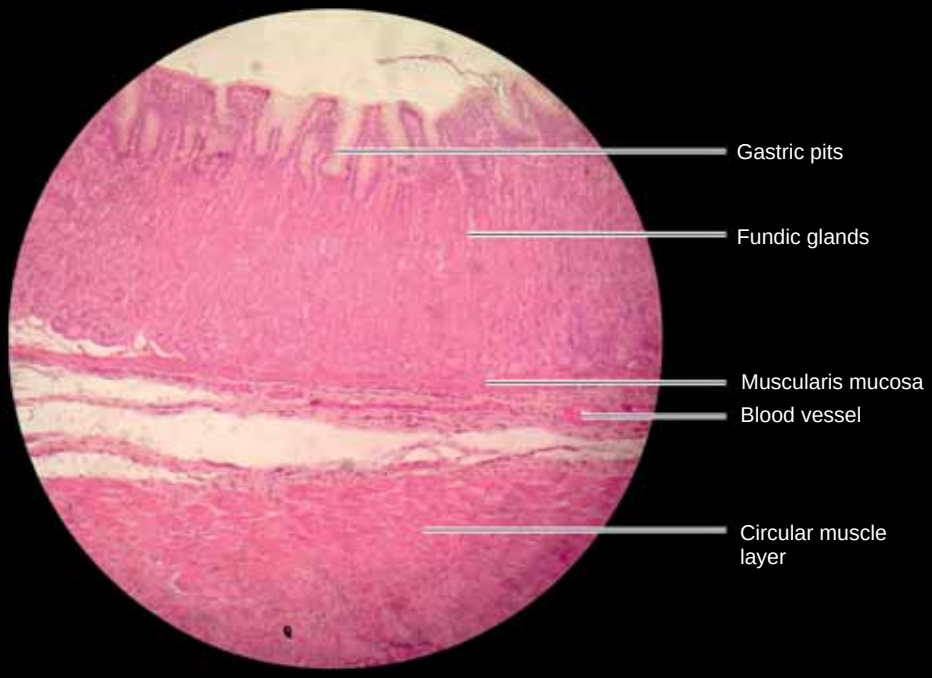
ESOPHAGUS

- Inner lining mucosa made up of **stratified nonkeratinized squamous epithelium**.
- Underlying thin layer of connective tissue—**lamina propria** and layer of longitudinal smooth muscle fiber—**muscularis mucosae**.
- **Submucosa** is wider and consists of adipose tissue, mucous acini of esophageal glands proper and numerous blood vessels such as veins, arteries, etc.
- The **muscularis externa** consists of inner circular and outer longitudinal muscle layer separated by thin layer of connective tissue.
- The **adventitia** consists of loose connective tissue layer that blends with adventitia of trachea and surrounding structures.
- Adipose tissue, large blood vessels, artery and vein and nerve fibers are numerous in adventitia.
- In the upper 1/3, muscularis externa contains skeletal muscle fibers. Middle 1/3 consist of both skeletal and smooth muscle and the lower 1/3 entirely of smooth muscle fibers.

STOMACH FUNDUS

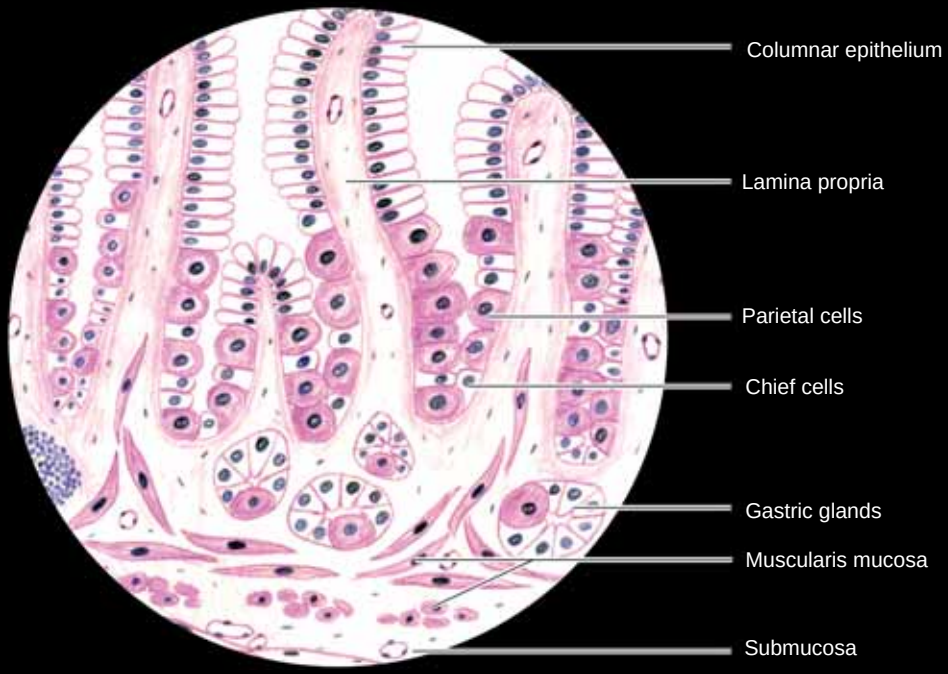
- Posess four layers.
- **Mucosa** consists of:
  - **Surface epithelium** formed by the simple columnar epithelial cells extends into the gastric pits, and lines it.
  - **Lamina propria** containing gastric glands.
  - **Muscularis mucosa** extending into lamina propria.
- **Gastric glands** consists of five types of cells mainly—**parietal (oxyntic)** cells producing HCl, **chief (zymogenic)** cells producing pepsinogen and other digestive enzymes, **mucous neck cells** producing mucous, **endocrine cells—**secrete gastrin and serotonin, and **undifferentiated (Stem) cells**– replace other cells when there is a damage.
- The subglandular region of lamina propria consists of either lymphatic tissue or small lymphatic nodules.
- **Submucosa** forms rugae and consists of capillaries, arterioles, venules and **Meissner's nerve plexus**.
- **Muscularis externa** consists of inner oblique, middle circular and outer longitudinal layers of smoth muscle along with **myenteric nerve plexus**.
- **Serosa** is covered by simple squamous mesothelium of the visceral peritonium and may contain adipose cells.

STOMACH FUNDUS

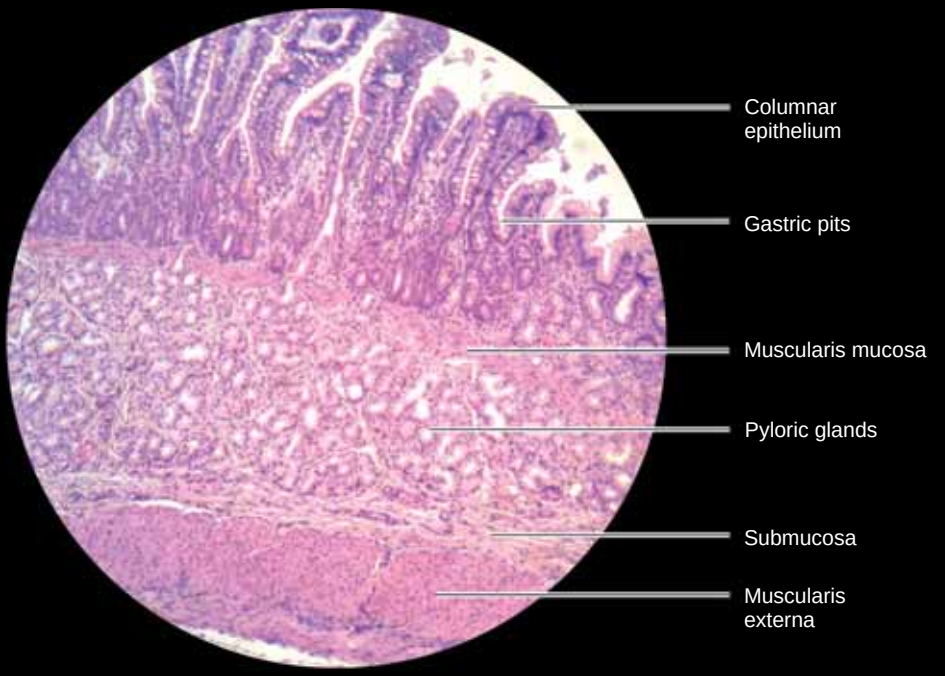


SP:

- Presence of 4 layers of GIT
- Presence of fundic glands, gastric pits and mucosal folds.

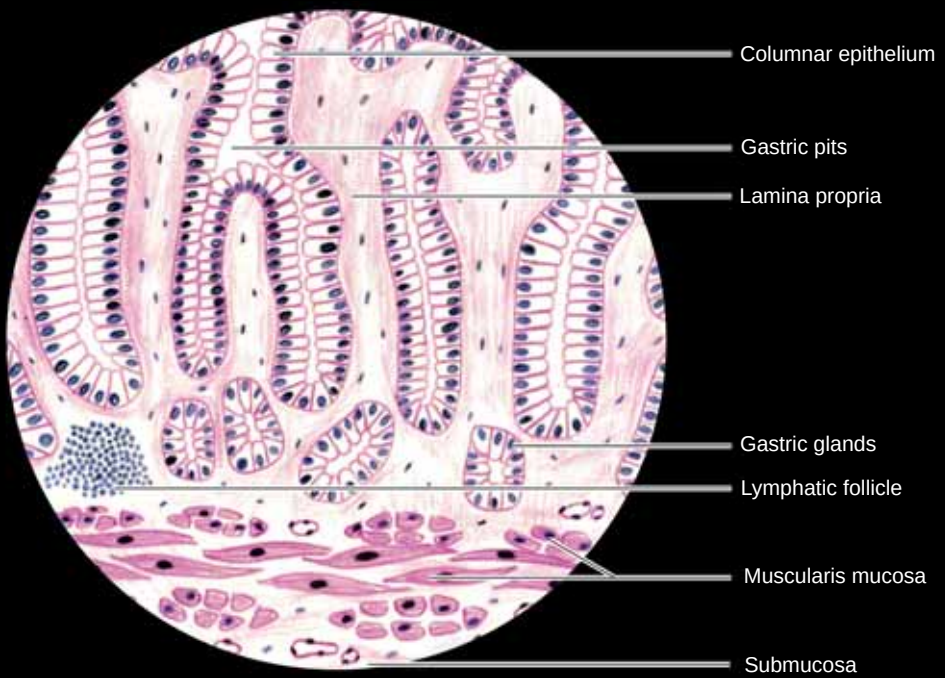


STOMACH PYLORUS



SP:

- Presence of four layers of GIT
- Presence of pyloric glands, and abundant mucous neck cells.



STOMACH PYLORUS

Stomach pylorus consist of four layers.

1. **Mucosa**
   - The surface is lined by **simple columnar epithelium** which extends into and lines all the deeply located gastric pits.
   - **Gastric glands** are opened into the gastric pits and they produces mucous as well as lysozymes.
   - **Lamina propria** containing diffuse lymphatic tissue and an occasional lymphatic nodule.
   - Individual smooth muscle fibers from the circular layer of muscularis mucosa pass upwards into lamina propria.
2. **Submucosa** contain blood vessels (arteriole and venule) of different size.
3. **Muscularis externa** consists of **inner oblique, middel circular** and **outer longitudinal layers** of smooth muscles of which the middle layer is more thickened to form the **pyloric sphincter**.
4. **Serosa** is covered by simple squamous mesothelium of the visceral peritoneum and may contain adipose cells.

Applied Anatomy

- In achalasia cardia, the tone of lower esophageal sphincter is increased due to impaired smooth muscle relaxation, causing esophageal obstruction.
- GERD (gastroesophageal reflux disease) and Barret esophagus:
  - Reflux of gastric contents into the lower part of the esophagus leads to esophagitis.
  - Long standing gastroesophageal reflex may cause replacement of distal squamous mucosa by metaplastic columnar epithelium known as Barret esophagus and esophageal adenocarcinoma.
- *Peptic ulcer:* It is chronic, most often solitary lesion that occur in any part of the GI tract exposed to aggressive action of acid/peptic juices.
- Gastric leiomyosarcoma is rare among gastric malignancies, and only 20% of the cases are located in the gastric cardia or fundus.
- In pyloric stenosis, there is narrowing of the opening from the stomach to the first part of the small intestine known as the duodenum, due to enlargement (hypertrophy) of the muscle surrounding this opening, which spasms when the stomach empties.

SMALL INTESTINE

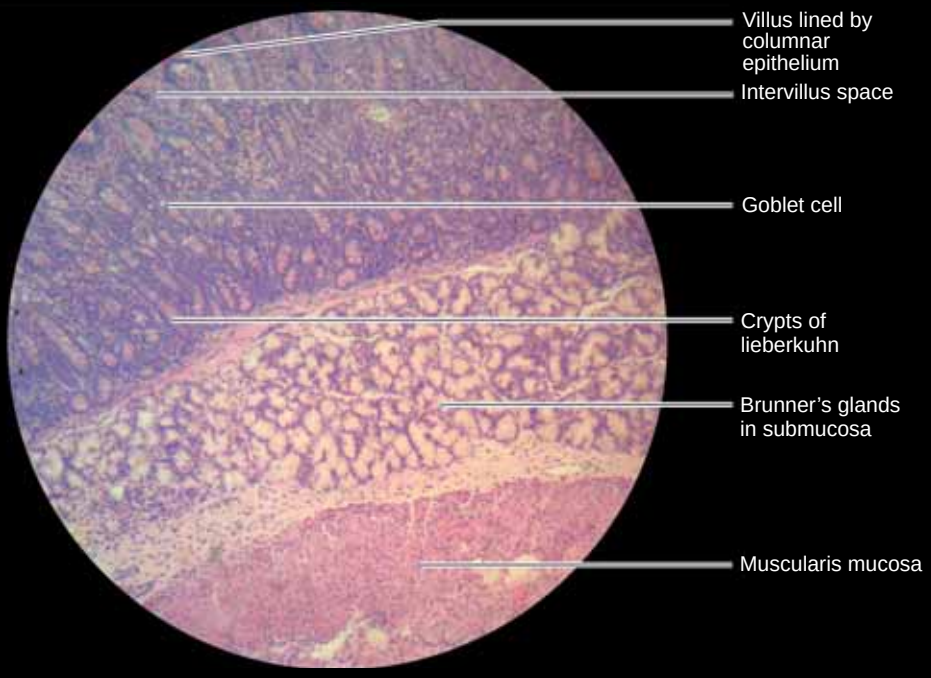
General Aspects

- Extends from junction with stomach to join with large intestine or colon.
- Divided into:
  - **Duodenum**
  - **Jejunum**
  - **Ileum**
- **Mucosa shows plica circularis:** The permanent spiral folds, villi—permanent fingerlike projections of lamina propria that extend into intestinal lumen, microvilli—the cytoplasmic extensions that cover the apices of intestinal absorptive cells—all these aids the absorption better.
- **Intestinal glands (crypts of lieberkuhn)** are located between the villi at the base throughout the small intestine. **Stem cells, absorptive cells, goblet cells, paneth cells** and some **enteroendocrine cells** are also present.
  - **Enterocytes (absorptive cells)** are involved in the absorption process.
  - **Goblet cells** are present in between enterocytes and produces mucous secretions.
  - **Paneth (zymogen)** cells produce lysozymes and other enzymes.
  - **Enteroendocrine (enterochromaffin)** cells are associated with endocrine function.
- Besides these, **duodenal (Brunner's) glands, Peyer's patches, M-cells,** etc. are also seen.
  - **Brunner's gland** are present in duodenal submucosa .
  - **Peyer's patches** are present in lamina propria of ileum.
  - **M-cells** are present along the epithelium above lymphatic follicles.

DUODENUM

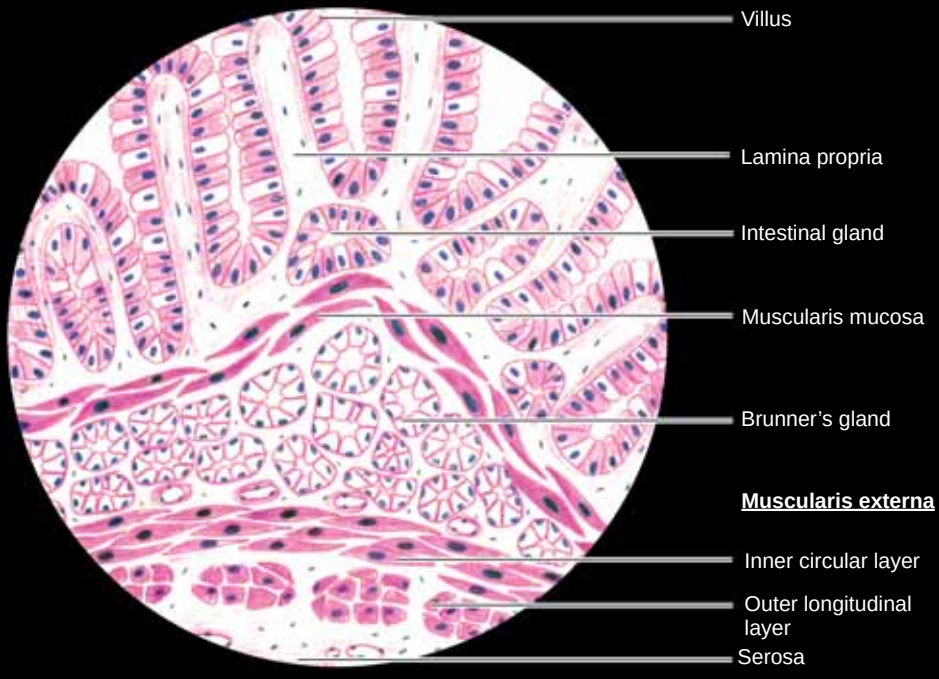
- Shortest segment of the small intestine and consist of 4 layers.
- **Mucosa** lined by **simple columnar epithelium, lamina propria**, and **muscularis mucosae** with connective tissue cells, lymphatic cells, plasma cells, macrophages, smooth muscle cells, etc.
- **Villi** in these region are **leaf** like, tall and numerous with fewer goblet cells in the epithelium.
- **Submucosa** consist of mucous duodenal (Brunner's) glands.
- **Muscularis externa** consist of two **smooth muscle layers, inner circular and outer longitudinal layers**.
- Some parts consist of visceral peritoneum or serosa which is incomplete.

DUODENUM

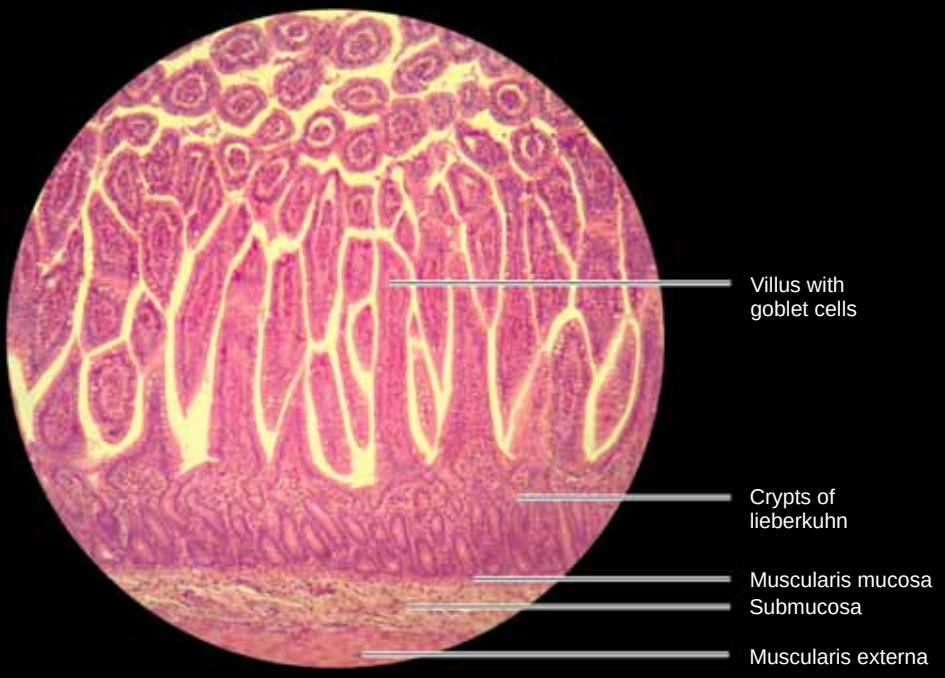


SP:

- Presence of 4 layers of GIT
- Presence of Brunner's glands in submucosa and villi on mucous membrane.

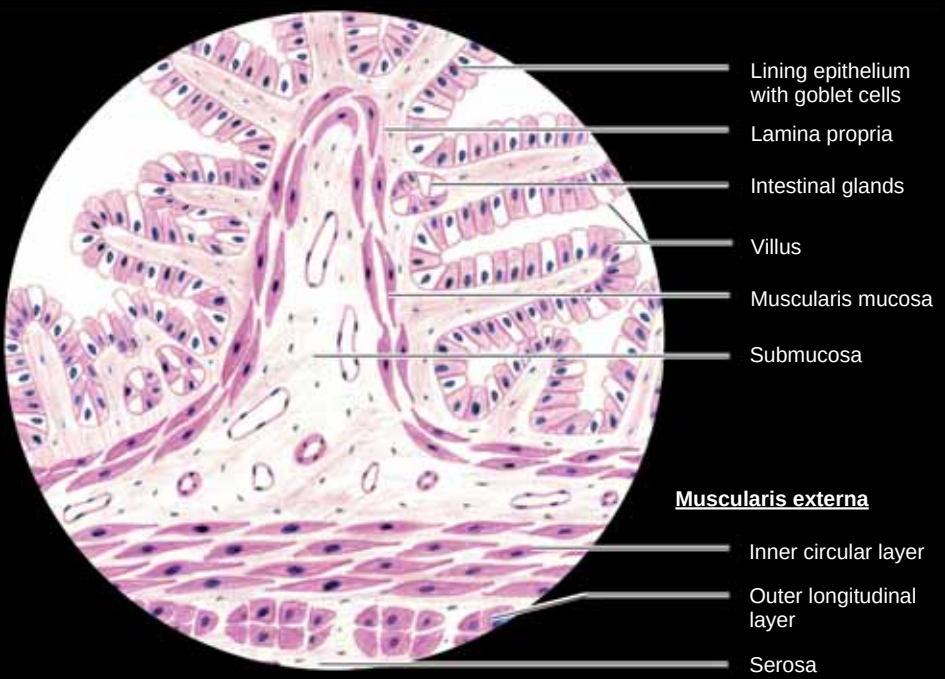


JEJUNUM



SP:

- Presence of 4 layers of GIT
- Presence of intestinal crypts and tongue shaped villi.



JEJUNUM

- Consists of four layers.
- **Mucosa** is lined by **simple columnar epithelium with brush border**.
- The **goblet cells** lies in between columnar cells and is more in number when compared to duodenum.
- **Shorter, narrower** and fewer villi than the duodenum with **tongue shape**.
- **Lamina propria** consists of lymphatic cells, macrophages, smooth muscle cells, blood vessels, etc.
- Intestinal gland ends at muscularis mucosae.
- **Submucosa** lacks Brunner's gland and Peyers patches.
- **Muscularis externa** has inner circular and outer longitudinal smooth muscle layers with **myenteric plexus** present in between them.
- Visceral peritoneum or **serosa** surrounds the small intestine.

Applied Anatomy (Duodenum and Jejunum)

- The first part of duodenum is overlapped by liver and gallbladder, either of these structures can adhere to the duodenum, and may be eroded by the duodenal ulcer, if present.
- It is in the first part of duodenum where majority of ulcers are present.
- Even gallstones can be extruded from the fundus of a inflammed gallbladder to duodenum and from duodenum to jejunum as well as ileum.
- In a barium meal procedure, after intake of contrast, the first part of duodenum becomes visible in the radiograph as a triangular shadow called duodenal cap and is emptied to the jejunum every one minute.
- Intestinal atresia (congenital absence of lumen) and stenosis (narrowing of lumen) is most commonly seen in duodenum and jejunum.

Viva-voce

Q. Where are myenteric plexus present?
Ans. Myenteric plexus is present in between the inner circular and outer longitudinal smooth muscle layers.
Q. What kind of epithelium lines the mucosa?
Ans. Simple columnar epithelium with brush border.

ILEUM

- Consists of four layers.
- **Mucosa** is lined by **simple columnar epithelium** with **goblet cells**.
- **Villi are thin and slender** having lacteals.
- **Lamina propria** contains intestinal glands and aggregation of lymphatic nodules called **Peyers patches**.
- Usually the lymphatic nodules are seen in close association to each other with indistinct boundaries.
- **Muscularis mucosa** is disrupted by Peyer's patches by extending into the submucosa.
- **Muscularis externa** having inner circular and outer longitudinal layer of smooth muscle fibers.
- **Serosa** having blood vessels and connective tissue.

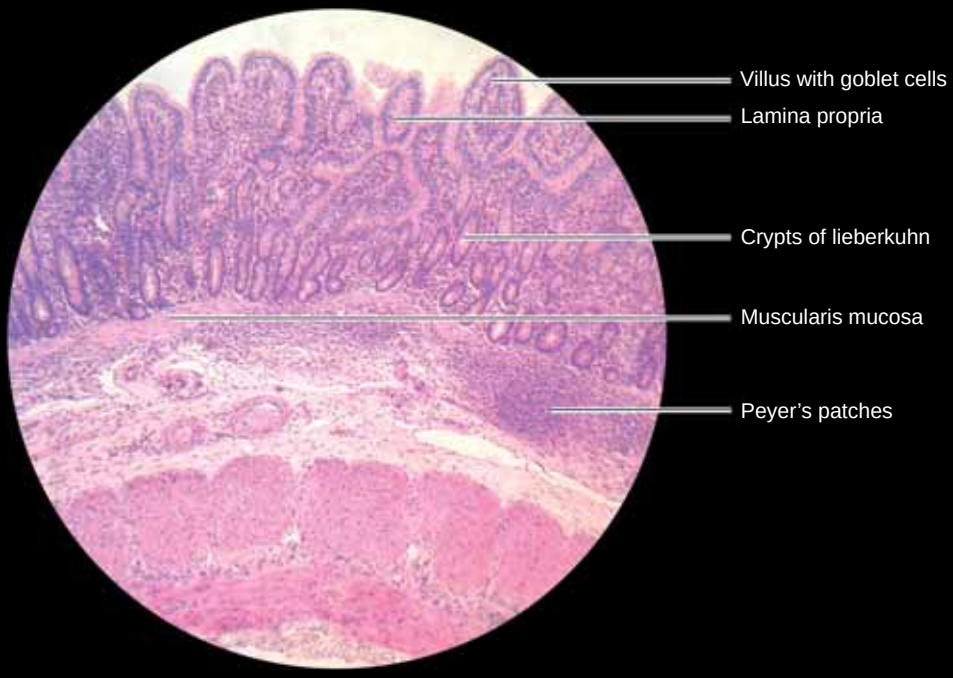
Applied Anatomy

- Pathogenic microorganisms and other antigens entering the intestinal tract encounter macrophages, dendritic cells, B-lymphocytes and T-lymphocytes found in Peyer's patches and aids immunity.
- Peyer's patches are present only in ileum throughout the GIT, Brunner's gland is absent in ileum, the villi present are finger shaped.

Viva-voce

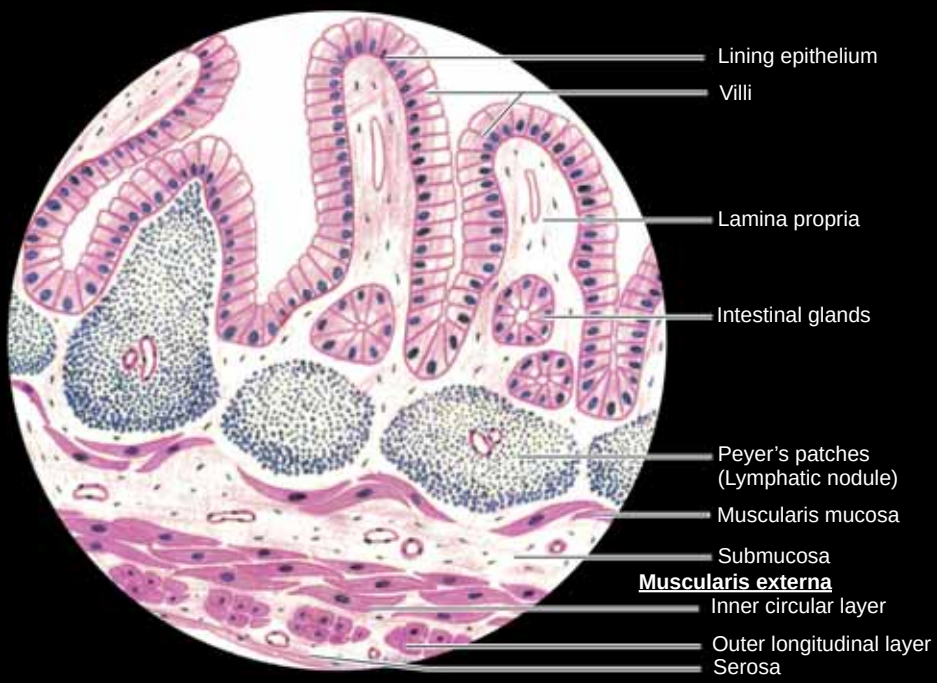
Q. What are Peyer's patches?
Ans. Lamina propria contains aggregation of lymphatic nodules called Peyers patches.
Q. What type of epithelium lines the ileal mucosa?
Ans. Mucosa is lined by simple columnar epithelium with goblet cells. Specialized epithelilal cells called M-cells are present over Peyer's patches.

ILEUM

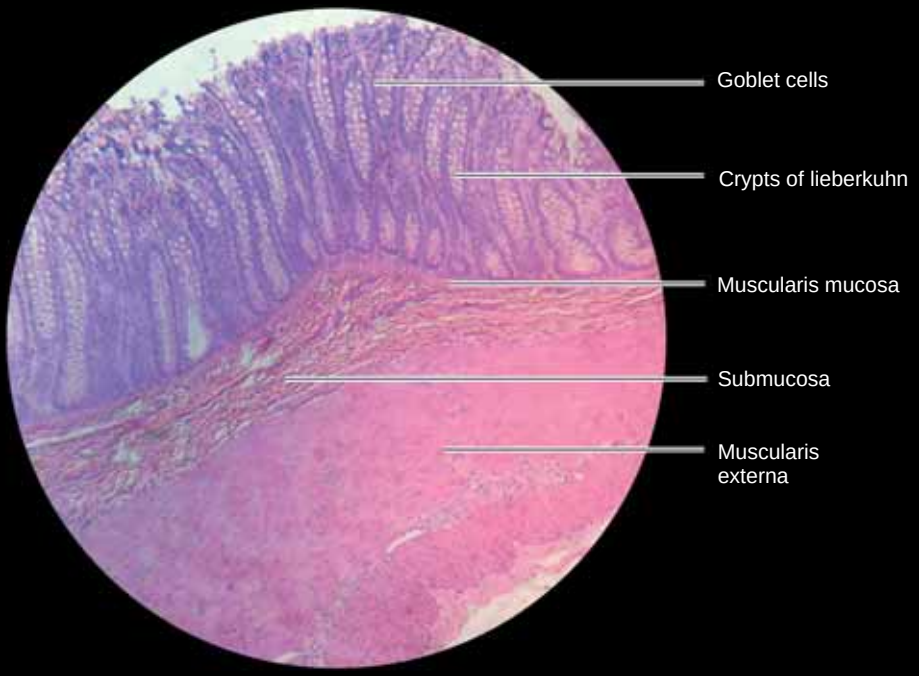


SP:

- Presence of 4 layers of GIT
- Presence of Peyer's patches and finger shaped villi.

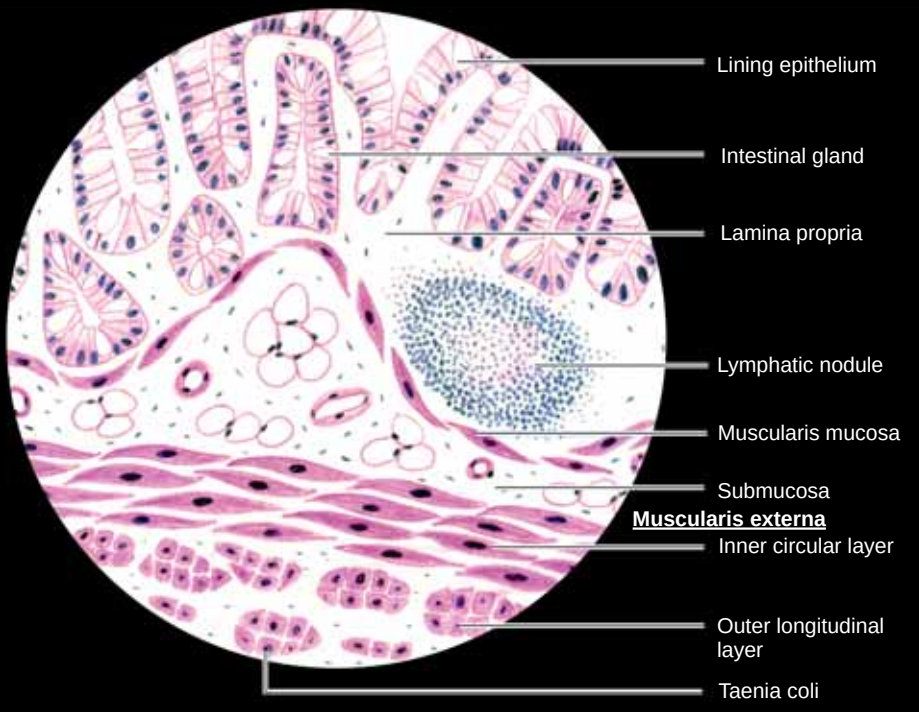


COLON



SP:

- Presence of 4 layers of GIT
- Presence of taenia coli and tubular glands in folds with goblet cells



COLON

- Consists of four basic layers.
- **Mucosa** is lined by **absorptive simple columnar epithelial cells** and larger number of mucous filled goblet cells.
- **Lamina propria** contains intestinal glands.
- **Muscularis mucosae** is well-defined.
- **Submucosa and lamina propria** are filled with aggregations of lymphatic cells and lymphatic nodules.
- **Submucosa** also contains connective tissue cells and fibers, various blood vessels and nerves.
- **Muscularis externa** consists of:
  - **Inner circular** layer throughout the length of colon.
  - **Outer longitudinal** layer is condensed into 3 broad longitudinal bands called **taeniae coli** whose contraction causes **sacculations** or **haustra**.
  - **Parasympathetic ganglion cells** of the myentric nerve plexus are found between the circular and longitudinal muscle layers.
- **Serosa** covers transverse colon and sigmoid colon.
- Serosa shows fat filled peritoneal pockets called **appendices epiploicae**.

Applied Anatomy

Ulcerative colitis is a recurrent ulceroinflammatory lesion of the colon characterized by diffuse inflammation ulcerations, crypt abscess formation, goblet cell depletion and paneth cell metaplasia.

Viva-voce

Q. What is taenia coli?

Ans. Outer longitudinal layer of muscularis externa is condensed into 3 broad longitudinal bands called taeniae coli and they extend from base of appendix to caecum.

Q. What are the characteristic features of submucosa of large intestine?

Ans. Submucosa and lamina propria are filled with aggregations of lymphatic cells and lymphatic nodules. It also contains connective tissue cells and fibers, various blood vessels and nerves.

APPENDIX

- Consist of four basic layers.
- **Mucosa** having epithelium containing numerous goblet cells.
- **Lamina propria** shows intestinal glands (crypts of Lieberkühn).
- In appendix villi are absent and it has small angular lumen compared to the thick wall.
- **Lymphatic nodules** with germinal center originate in lamina propria and may extend from the surface epithelium to submucosa.
- **Muscularis mucosae** is disrupted by lymphatic nodules.
- **Submucosa** having numerous blood vessels.
- **Muscularis externa** with inner circular and outer longitudinal layer.
- Para sympathetic ganglia of **Myenteric plexus** are located in between the smooth muscle layers.
- Outermost layer is **serosa** under which adipose cells are seen.

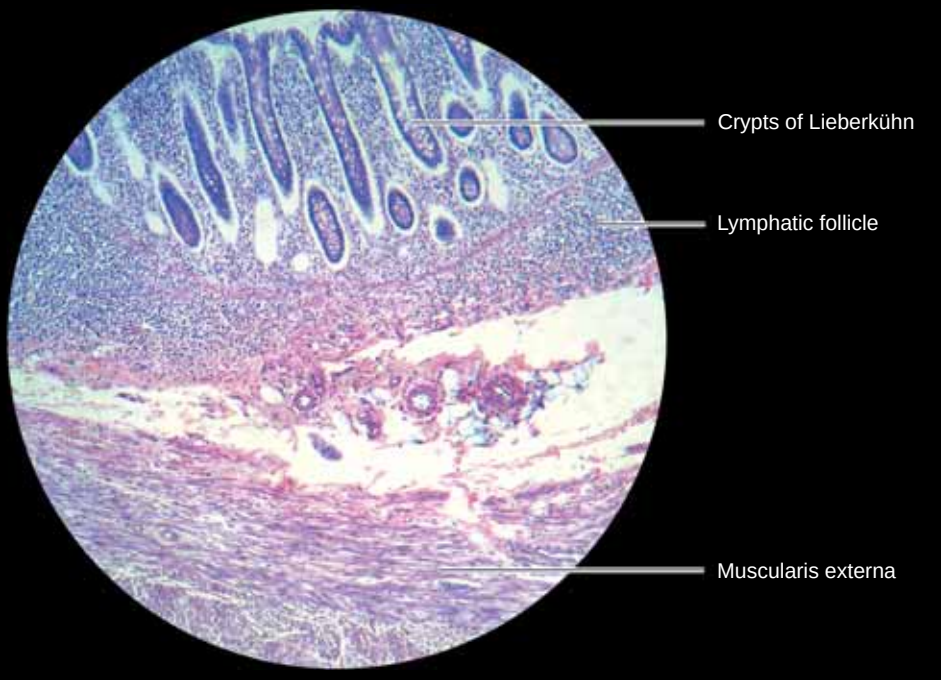
Applied Anatomy

- Appendicitis is the inflammation of the appendix and is a medical emergency.
- The lymphoid tissue in the mucosa and submucosa is similar to the Peyer's patches in small intestine.

Viva-voce

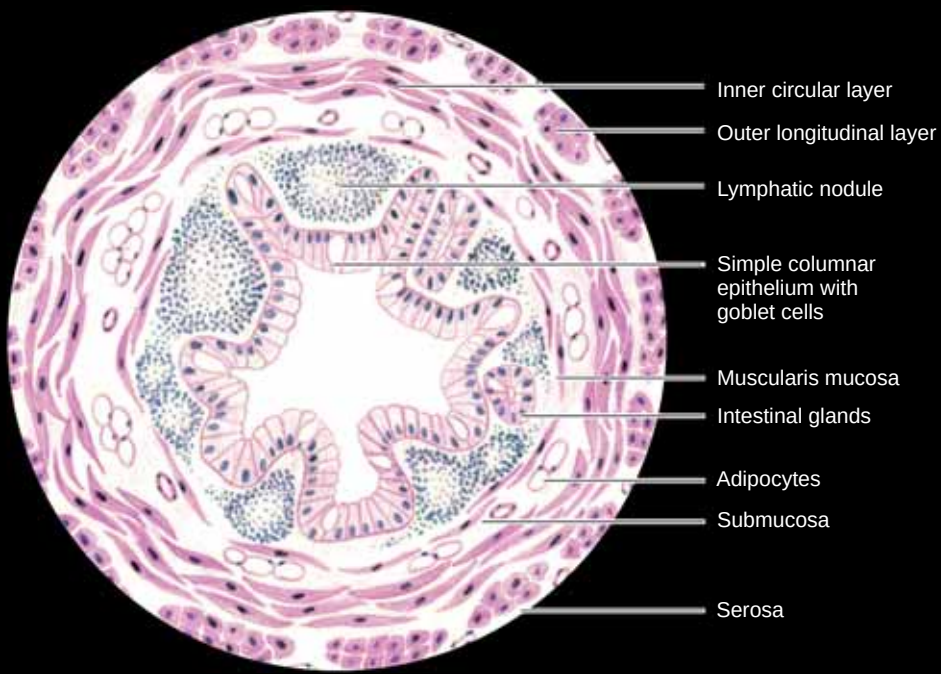
Q. Where are the parasympathetic ganglia of myenteric plexus present?
Ans. Parasympathetic ganglia of myenteric plexus are located in between the smooth muscle layers.
Q. What are the characteristic features of lamina propria of appendix?
Ans. Lamina propria shows intestinal glands (crypts of Lieberkühn) and lymphatic nodules with germinal center originate in lamina propria and may extend from the surface epithelium to submucosa.

APPENDIX



SP:

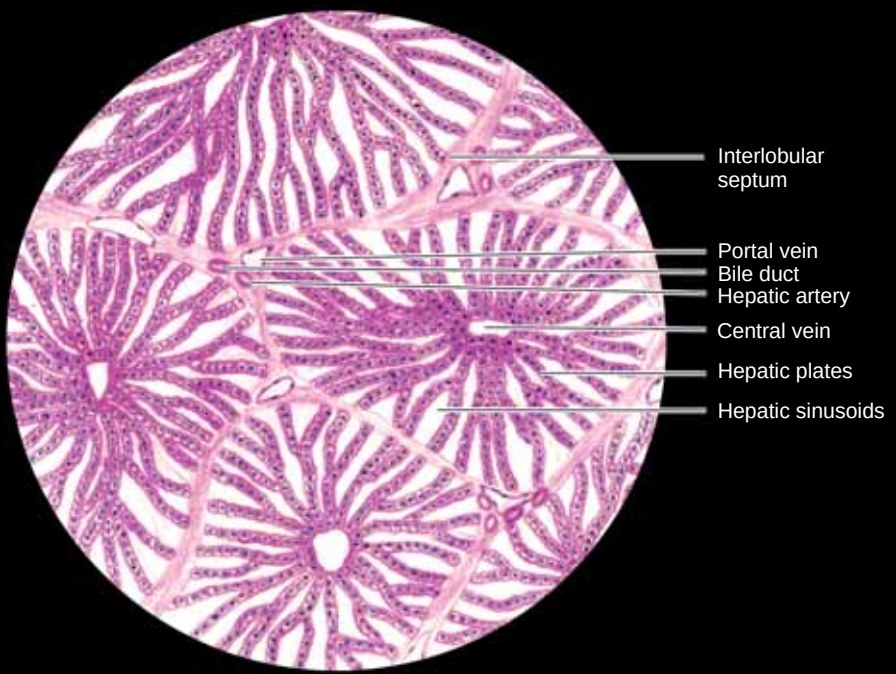
- Presence of 4 layers of GIT
- Lymphatic nodules present in submucosa.



LIVER

SP:

- Hexagonally arranged hepatocytes with portal triad.
- Presence of central vein.



Liver and Pancreas

LIVER

- Accessory digestive organ.
- Microscopic structure consists of hexagonal units called **hepatic lobules**.
- A **central vein** is present in the center of each lobule.
- From central vein radiating plates of **hepatocytes and sinusoids** are present towards the periphery.
- **Sinusoids** are located in between plates of hepatocytes and posses **Kupffer cells (macrophagic cells)**.
- **Hepatic sinusoids** are dilated blood channels lined by discontinuous fenestrated endothelial cells.
- Sinusoids and hepatocytes are separated by a subendothelial **peri-sinusoidal space (Space of Disse)**.
- At the periphery of each lobule 3-6 portal area/canals are present.
- **Portal canal** contains portal triad viz. **hepatic artery, portal vein, bile duct** and also lymph vessels.
- Hepatic artery, portal vein and bile duct are covered by fibrocollagenous tissue.
- Portal area is bounded by a layer of hepatocytes called as the limiting plate.
- Arterial and venous blood mix at liver sinusoids and open into central vein.
- **Bile canaliculi** (tiny channels) are present between hepatocytes which recieve the bile secreted by the liver cells, they converge and open into the bile duct.

Applied Anatomy

- In hepatitis, the limiting plate gets destroyed and is known as Piece meal necrosis.
- The structural feature of sinusoids help in efficient exchange of substances between hepatocytes and blood.
- Since bile flow in canaliculi towards bile duct and blood in sinusoids towards central vein, i.e. in opposite direction, the blood and bile does not mix.

GALLBLADDER

- It is a muscular sac.
- Its walls consists **mucosa, muscularis and serosa**.
- **Muscularis mucosa** or muscularis interna and submucosa are absent.
- **Mucosa** lined by **simple columnar epithelium** with underlying lamina propria.
- Lymphatics, blood vessels, loose connective tissue, etc. are present in lamina propria.
- **Mucosal folds** are seen in nondistended states.
- **Crypts** are seen between mucosal folds and resembles glands.
- But glands are only present in neck region of the organ.
- **Muscularis layer** consists of randomly placed bundles of smooth muscles with interlacing elastic fibers.
- This layer also contains lymphatics, nerves and blood vessels.
- **Serosa** contains connective tissue.

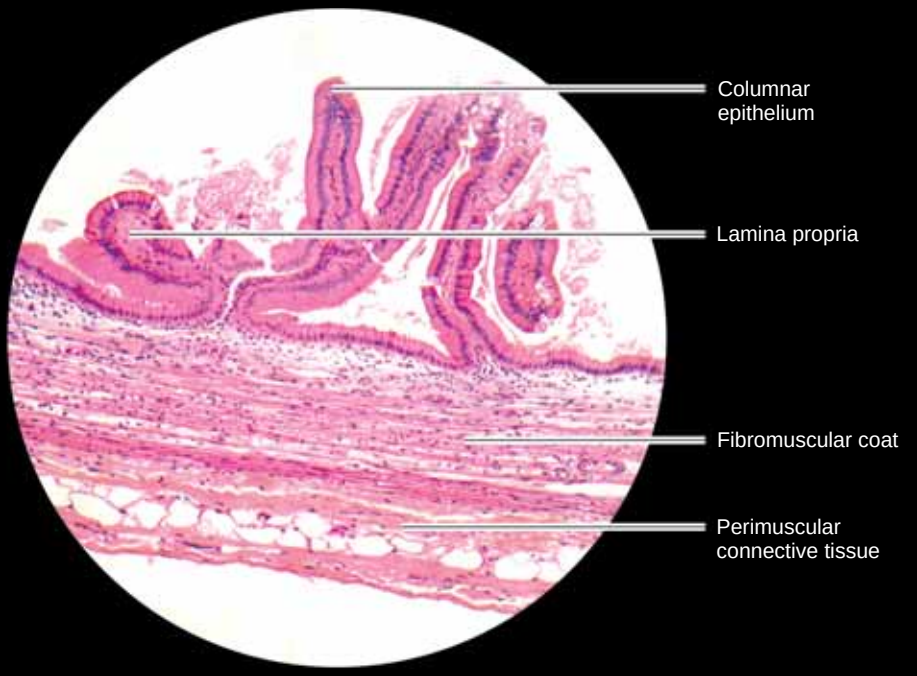
Applied Anatomy

- Usually gallbladder is nonpalpable during clinical examination, but it becomes palpable in cases of jaundice, mucocele and empyema.
- In cholelithiasis, stones may be present in gallbladder or in biliary passages and can cause obstructive jaundice and obstructive cholecystitis.
- In cholecystitis the mucosa is ulcerated with areas of necrosis.

Viva-voce

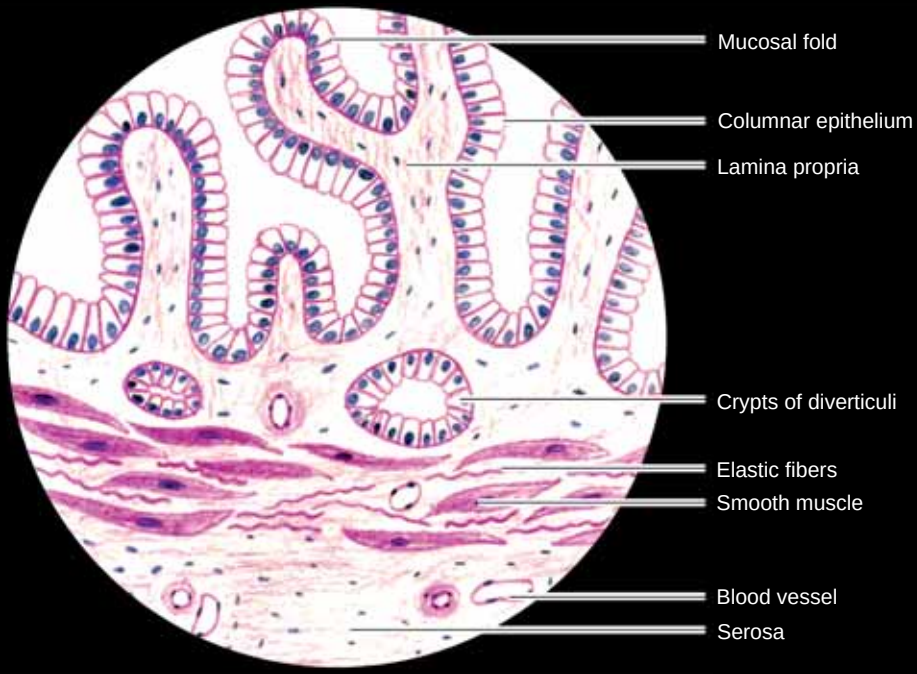
Q. What is the distinguishing feature of gallbladder from other part of the gastrointestinal system?
Ans. Submucosa is absent in gallbladder, whereas present in almost all parts of GIT.
Q. What is the characteristic feature of muscularis layer?
Ans. Muscularis layer consists of randomly placed bundles of smooth muscles with interlacing elastic fibers.
Q. What is the characteristic feature of lamina propria of gallbladder?
Ans. Lymphatics, blood vessels, loose connective tissue, etc. are present in lamina propria.

GALLBLADDER

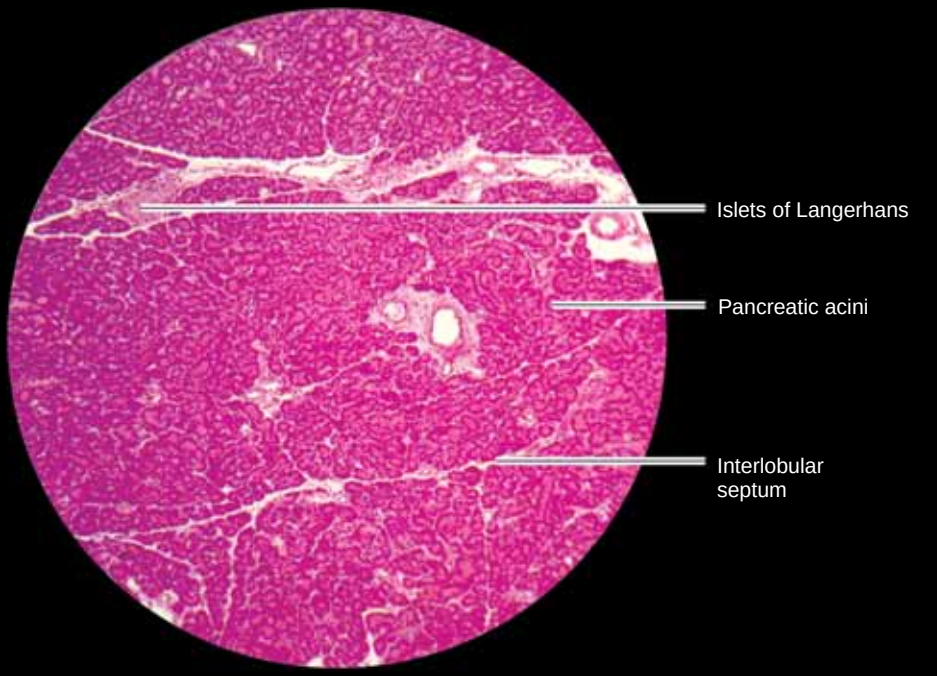


SP:

- Presence of 3 layers of GIT
- Absence of submucosa.

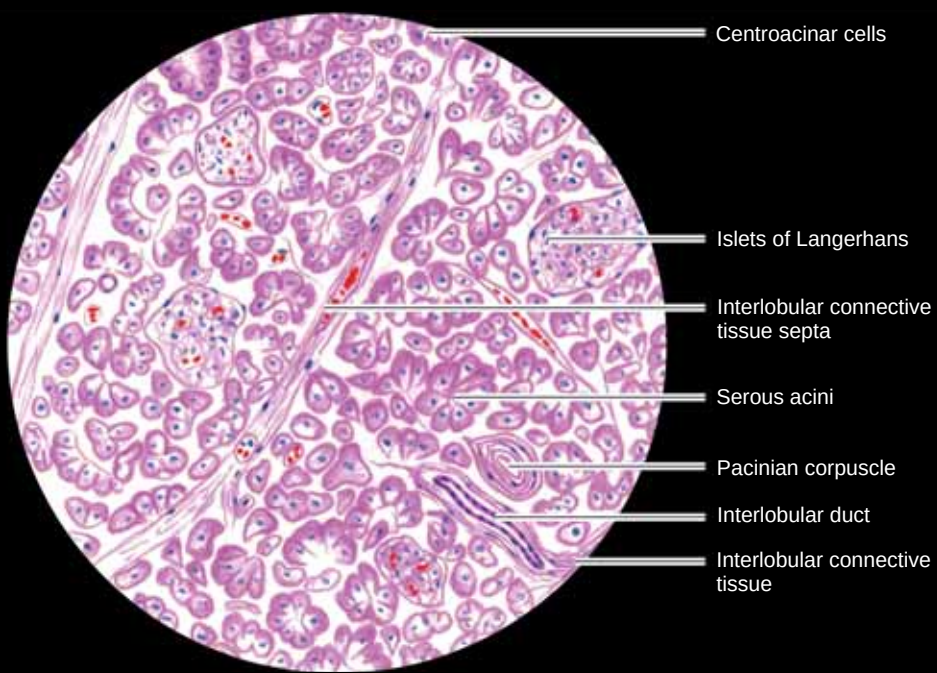


PANCREAS



SP:

- Presence of pancreatic acini.
- Presence of islets of Langerhans.



PANCREAS

- Consists of endocrine and exocrine part.
- **Exocrine part** forms the major portion and consist of **secretory serous acini and zymogenic cells**.
- These are arranged into small lobules bounded by **thin intralobular** and **interlobular connective tissue septa** having **interlobular ducts** and blood vessels.
- **Endocrine part** is represented by the isolated **pancreatic islets or islets of Langerhans** present between serous acini.
- Each **acinus** consists of pyramidal shaped protein secreting cells that surround a small lumen. Their ducts are visible as centroacinar cells and the secretions leave via intralobular ducts to interlobular ducts.
- Islets are separated from acini by a thin layer of reticular fibers and are actually compact clusters of epithelial cells permeated by capillaries and have alpha, beta, delta and F-cells.

Applied Anatomy

- The exocrine part of pancreas is responsible for the production of digestive enzymes like pancreatic amylase, lipase, etc.
- The pancreas secretes digestive enzymes in the form of inactive precursors called zymogens.
- Hormones produces by the islets are as follows:
  - *Alpha cells:* Glucagon
  - *Beta cells:* Insulin
  - *Delta cells:* Somatostatin
  - *F-cells:* Pancreatic polypeptide

Viva-voce

Q. What is the characteristic feature of an acini?

Ans. Each acinus consist of pyramidal shaped protein secreting cells that surround a small lumen. Their ducts are visible as centroacinar cells and the secretions leave via intralobular ducts to interlobular ducts.

Q. What is the endocrine part of the pancreas represented by?

Ans. The endocrine part is represented as pancreatic islets or islets of Langerhans.

Q. What is the exocrine part of pancreas formed from?

Ans. Exocrine part consists of secretory serous acini and zymogenic cells.

Respiratory System

TRACHEA

- **Tracheal** wall consists of **mucosa, submucosa, hyaline cartilage and adventitia**.
- Tracheal lumen is lined by **pseudostratified ciliated columnar epithelium** with **goblet cells**.
- The underlying **lamina propria** contain fine connective tissue fibers and lymphatic tissue.
- In the deeper part **longitudinal elastic membrane** is present that divides lamina propria from submucosa.
- **Submucosa** consists of connective tissue fibers, tubuloacinar seromucous tracheal gland and ducts opening to tracheal lumen.
- The **'C' shaped hyaline cartilage** is present in incomplete ring which form the frame work and is surrounded by connective tissue perichondrium.
- The **chondrocytes** in the lacunae are larger and become flatter towards perichondrium.
- The gap between the posterior ends of cartilage is filled by **trachealis muscle**.

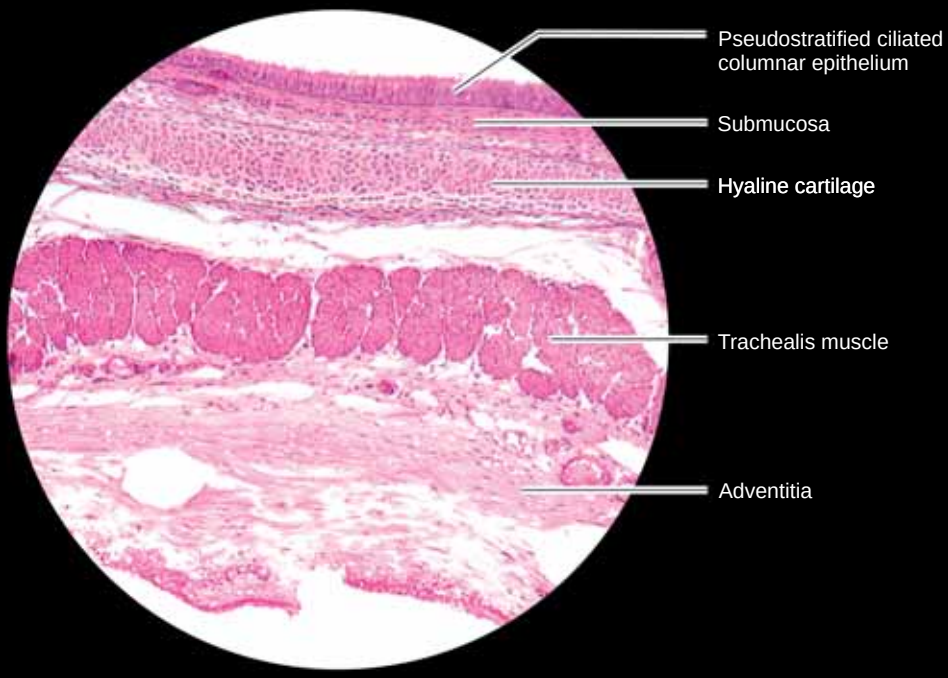
Applied Anatomy

- Cilia filters out all foreign particles that enter the body during inhalation.
- Smoking destroys cilia allowing bacteria, viruses, etc. to enter the body and produces diseases like pneumonia.
- Tracheostomy consists of making an incision on the anterior aspect of neck and opening a direct airway through a direct incision in the trachea.

Viva-voce

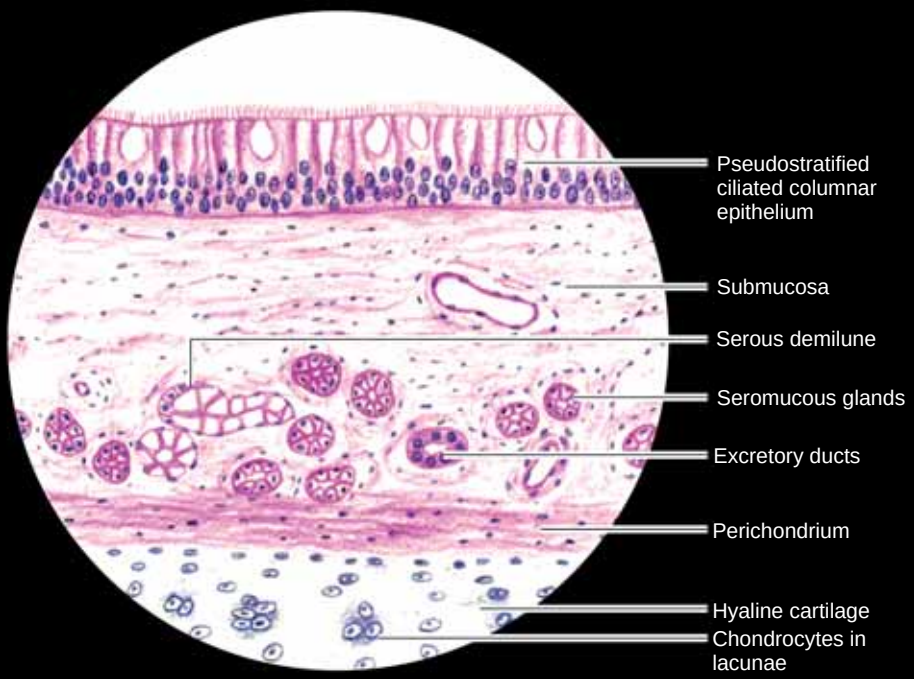
Q. What is the distinctive structural component wall of the trachea?
Ans. Cartilage rings.
Q. What type of epithelium lines the tracheal lumen?
Ans. Tracheal lumen is lined by pseudostratified ciliated columnar epithelium with goblet cells.
Q. What is the characteristic feature of submucosa layer in trachea?
Ans. Submucosa consists of connective tissue fibers, tubuloacinar seromucous tracheal gland and ducts opening to tracheal lumen.

TRACHEA

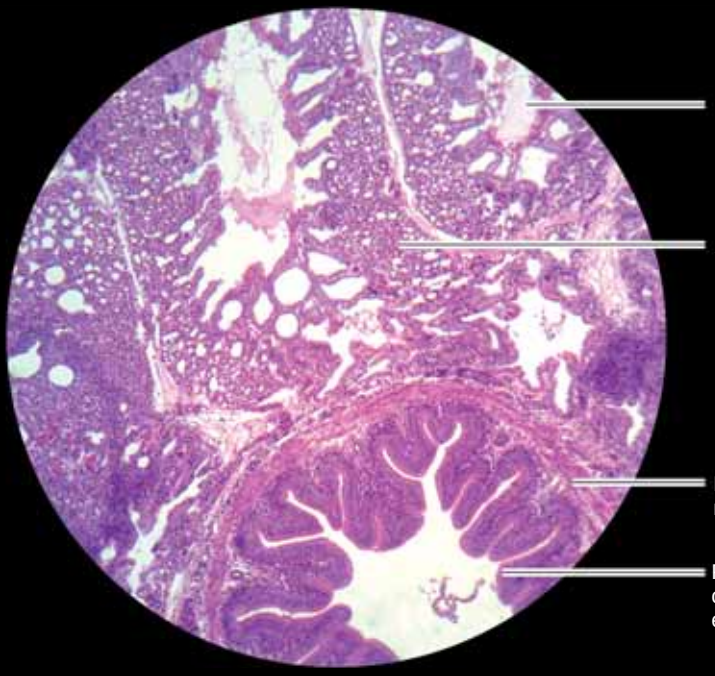


SP:

- Presence of hyaline cartilaginous plates.
- Presence of mucous and serous glands in lamina propria.

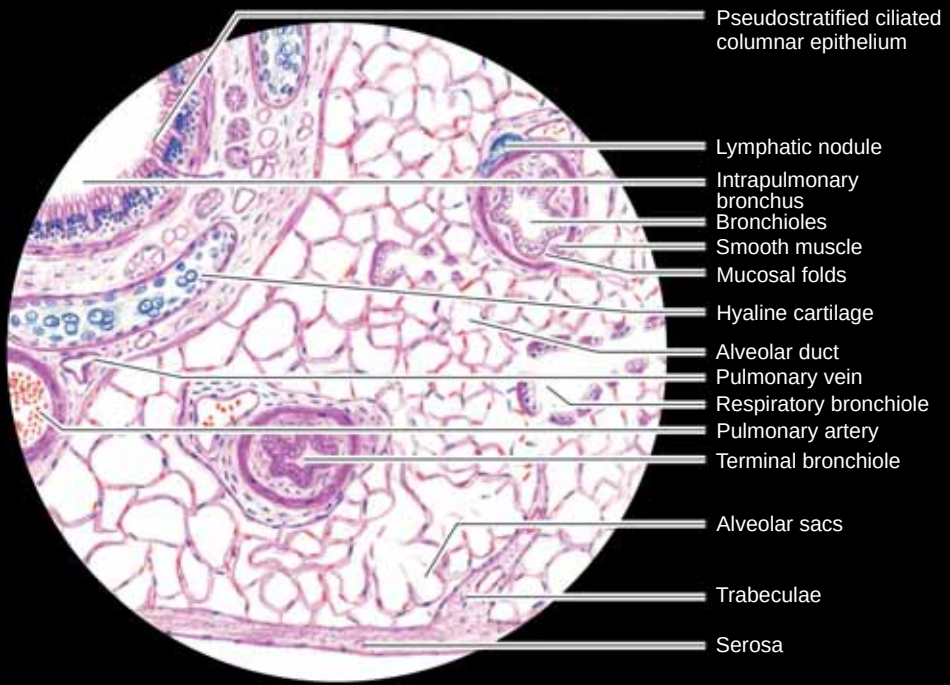


LUNG



SP:

- Presence of various bronchioles.
- Presence of alveoli lined by simple squamous epithelium.



LUNG

- Consists of intrapulmonary bronchus (2º or 3º bronchi), bronchiole, terminal bronchiole, respiratory bronchiole and parenchyma.
- **Parenchyma** is composed of alveolar duct and alveoli.
- **Intrapulmonary bronchus** is identified by surrounding hyaline cartilage plates, lined by **pseudostratified ciliated epithelium**.
- Consists of thin **lamina propria**, small layer of **smooth muscle, submucosa with bronchial glands, hyaline cartilage and adventitia**.
- **Bronchiole** lined by **pseudostratified columnar ciliated epithelium**, lumen shows mucosal folds, smooth muscle present, adventitia present, glands and cartilage are absent.
- **Terminal bronchiole** is lined by **ciliated low columnar epithelium**, characterized by irregular lumen, smooth muscle layer and adventitia present.
- **Respiratory bronchiole** is lined by columnar or cuboidal cells with cilia, thin connective tissue cells with smooth muscle and elastic fibers seen in association with alveoli.
- **Alveolar duct** formed from respiratory bronchiole, smooth muscle bundles are present in the rim of the duct.
- **Alveoli** lined by thin simple squamous cells, share a common interalveolar septum numerous capillaries are present in these septa, at the free ends of the septa and open end of alveoli narrow band of smooth muscle is present.

Applied Anatomy

- In interstitial lung disease like pulmonary eosinophilia, there will be thickening of alveolar septa with infiltration of eosinophils.
- In bronchioalveolar carcinoma, the tumor cells lines the alveolar septa and thus giving an alveolar appearance to the tumor.

Viva-voce

Q. What is the importance of elastin in the respiratory system?
Ans. Allows for expandability and return to original volume during expiration.
Q. Which cells are responsible from keeping the lungs free from obstructing particulate matter? How do they carry out this function?
Ans. Macrophages (dust cells). By means of phagocytosis.

Renal System

KIDNEY

- Consists of an outermost capsule, i.e. the renal capsule. Beneath it is the outer dark cortex and inner lighter medulla.
- **Cortex** consists of both **proximal convoluted tubule (PCT)** and **distal convoluted tubule (DCT)**, renal corpuscle, interlobular arteries and veins, and medullary rays (formed by straight portions of nephrons blood vessels, and collecting tubules that join in medulla to form collecting ducts) and these do not extend to capsule.
- **Medulla** consists of **renal pyramids** and base of each pyramid is adjacent to cortex and apex forms the renal papilla which projects to minor calyx which is the dilated portion of ureter and they joins to form major calyx which then join to form the renal pelvis.
- The renal **corpuscle** consists of **Bowman's capsule and glomerulus**. Bowman's capsule is made of an outer parietal layer and inner visceral layer. Outer layer is made by simple squamous epithelium and inner layer by specialized cells called **podocytes**.
- **Glomerulus** is made of tuft of anastomosing capillaries lined by fenestrated epithelium.
- **PCT** is lined by simple cuboidal epithelium with microvilli giving brush bordered appearance.
- The thin segment of **Loop of Henle** is lined by simple squamous epithelium and is permeable to water and sodium whereas thick segment is lined by cuboidal epithelium and is impermeable to water.
- **DCT** is lined by simple cuboidal epithelium and is not brush bordered.
- The **collecting tubules** are lined by simple cuboidal epithelium whereas collecting ducts are by simple columnar epithelium.

Applied Anatomy

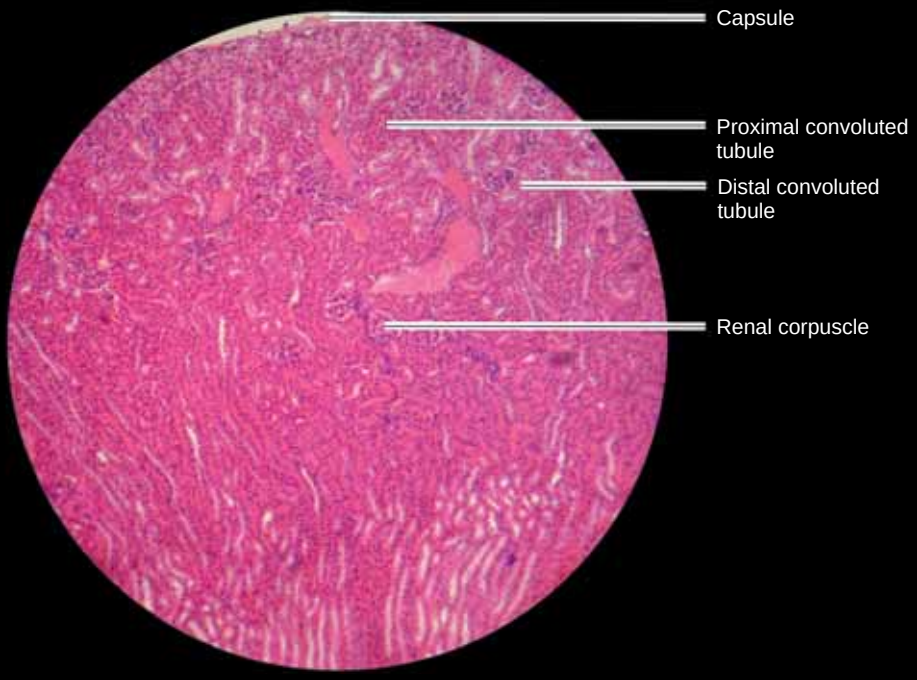
In membranous glomerulonephritis there is diffuse thickening of glomerular basement membrane with subepithelial deposit of immunoglobulins.

Viva-voce

Q. What is the functional significance of the occurrence of a brush border in the proximal tubule?

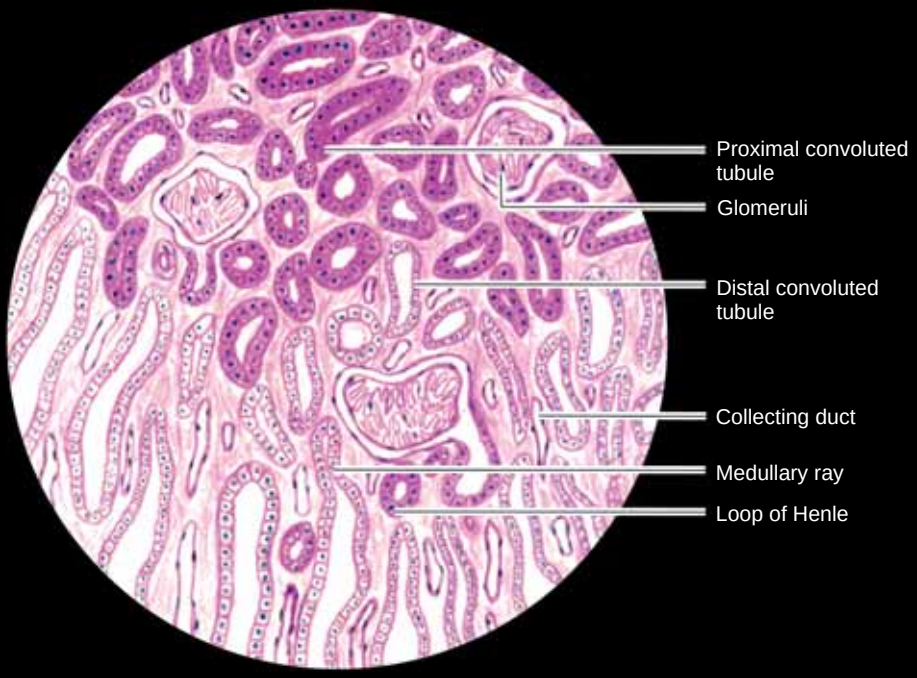
Ans. The brush border increases the surface area, facilitating the reabsorption that occurs in the proximal tubule.

KIDNEY

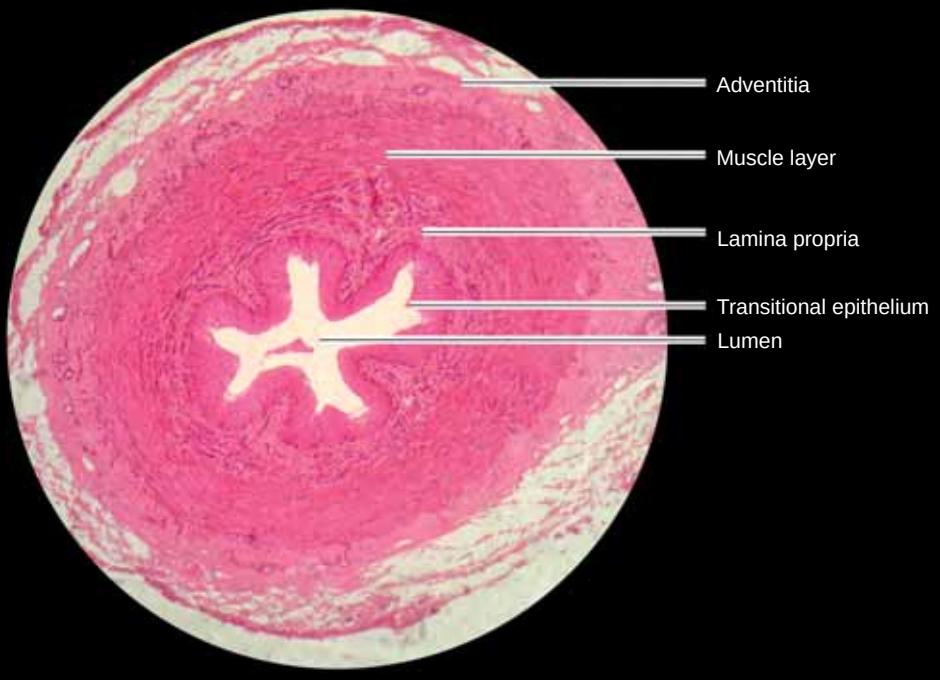


SP:

- Presence of cortex and medulla with cut sections of PCT, DCT, etc.
- Presence of medullary rays and renal corpuscles.

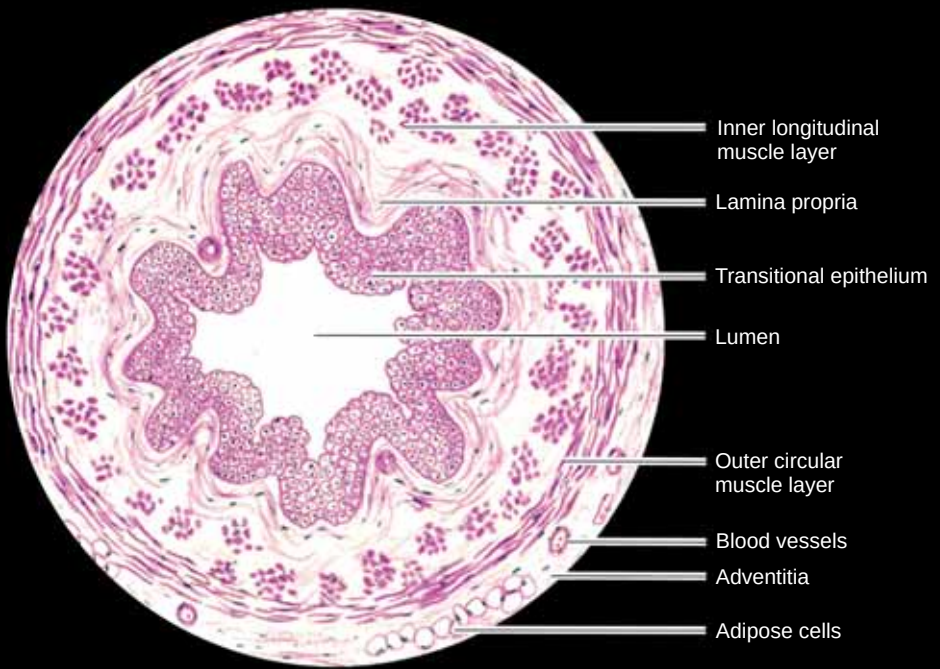


URETER



SP:

- Presence of star shaped lumen lined by transitional epithelium.
- Presence of 3 muscle coats.



URETER

- Made of three layers:
  1. **Mucosa**
  2. **Muscle coat**
  3. **Adventitia**.
- **Mucosa** consisting of **transitional epithelium** and lamina propria.
- **Lamina propria** consists of supporting connective tissue rich in elastic fibers.
- **Mucosa** is thrown into folds giving **star shaped** appearance.
- **Muscle coat**—consisting of smooth muscle fibers arranged in 2 layers.
  - **Inner longitudinal** layer.
  - **Outer circular** layer.
  - Additional **outer longitudinal** layer is present in lower 1/3 of ureter located near the bladder.
- **Adventitia** is made up of loose connective tissue with blood vessels, lymphatics, nerves and adipose tissue.

Applied Anatomy

- A descending ureteric calculus produces loin to groin pain and is colicky type of pain.
- A ureteric calculus is often associated with hematuria.
- When the stone is imapcted, the colic goes off and causes a dull ache.
- Stone in the ureter is visualized using intravenous pyelography or cystoscopy.
- Transitional cell carcinoma is a common cause of ureteric cancer and other urinary tract cancers.

Viva-voce

Q. What is the functional importance of thick muscular coat?
Ans. Urine is squeezed into the urinary bladder by means of peristalsis.
Q. What is functional importance of folded mucosa?
Ans. The folded mucosa protects against the reflux of urine when the bladder is full.

URINARY BLADDER

- Consists of three layers:
  1. **Mucosal** layer
  2. **Muscle coat**
  3. **Adventitia**
- **Mucosa—**Made of **transitional epithelium** and lamina propria.
- **Transitional epithelium** or **urothelium** is binucleate and when the bladder is empty it exhibits five to six layers and folds.
- But when the bladder is distended, the epithelium is thin, consists of 3-4 layers and the superficial cells are flattened.
- **Muscle coat** is made up of 3 loosely arranged indistinctive layers of smooth muscle fibers:
  1. **Inner longitudinally** arranged layer
  2. **Middle circularly** arranged layer
  3. **Outer longitudinally** arranged layer
- Adventitia is made of fibroelastic connective tissue with blood vessels, nerves and lymphatics.

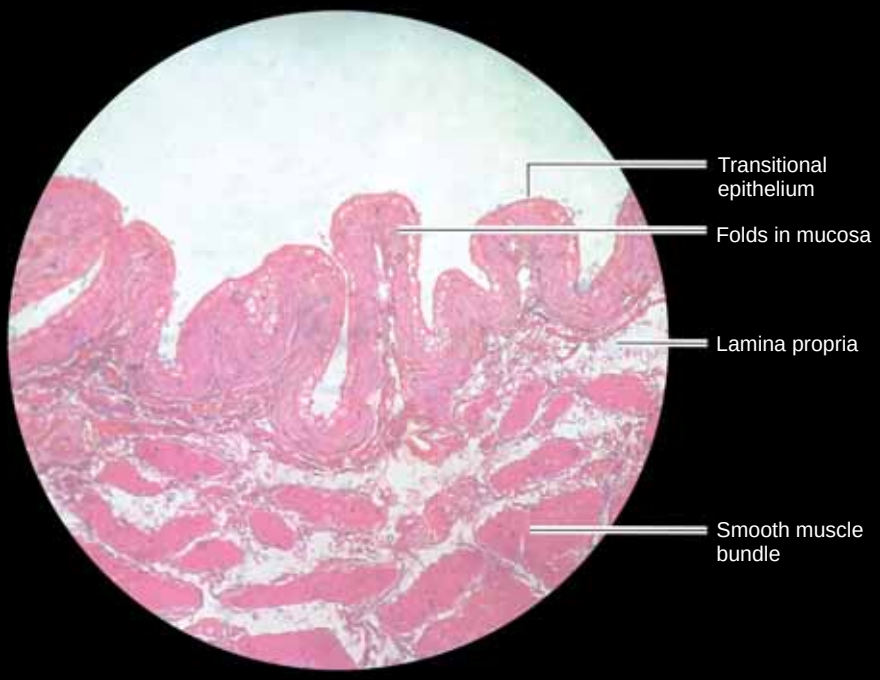
Applied Anatomy

- Transitional epithelium has the following function here:
  - Protects mucosa from being corroded by acidic pH of urine.
  - Acts as an osmotic barrier.
  - They are nonabsorptive in function.
- Detrusor muscle is layer of urinary bladder wall and problems with this muscle layer can lead to incontinence.

Viva-voce

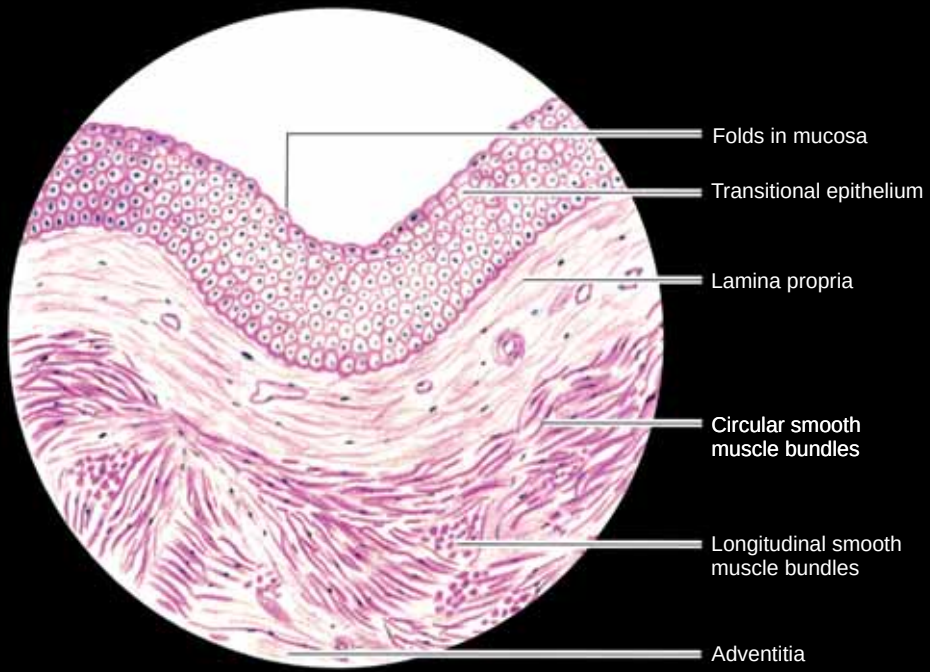
Q. Which part of the urinary bladder can undergo malignant changes?
Ans. Urothelium.
Q. What is the typical feature of transitional epithelium?
Ans. Transitional epithelium is binucleate and when the bladder is empty it exhibits five to six layers and folds and when the bladder is distended, the epithelium is thin, consists of 3-4 layers and the superficial cells are flattened.

URINARY BLADDER

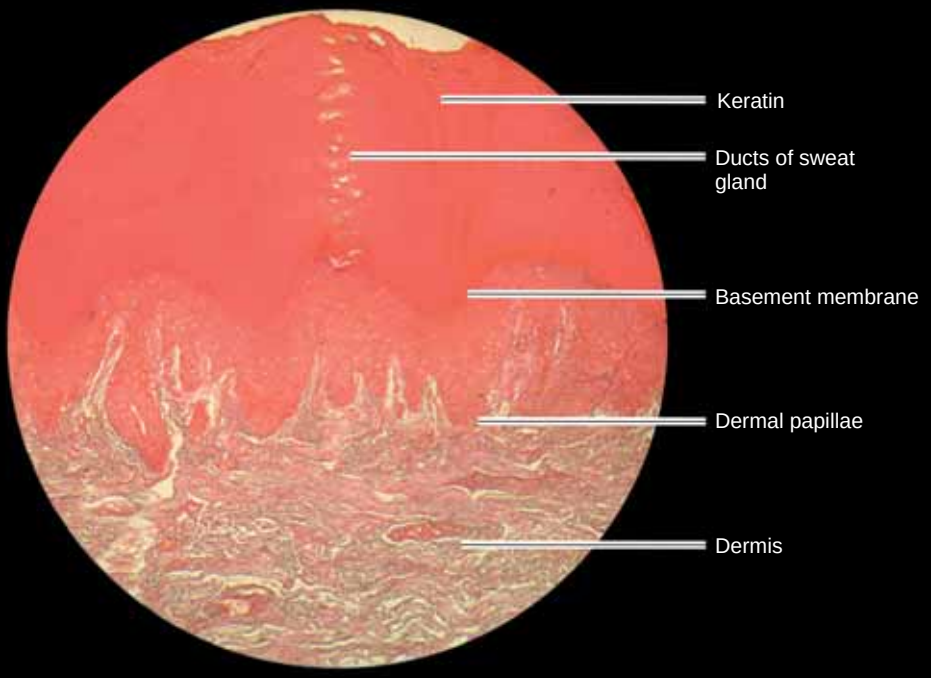


SP:

- Presence of transitional epithelial lining.
- Presence of ill-defined muscle coat.

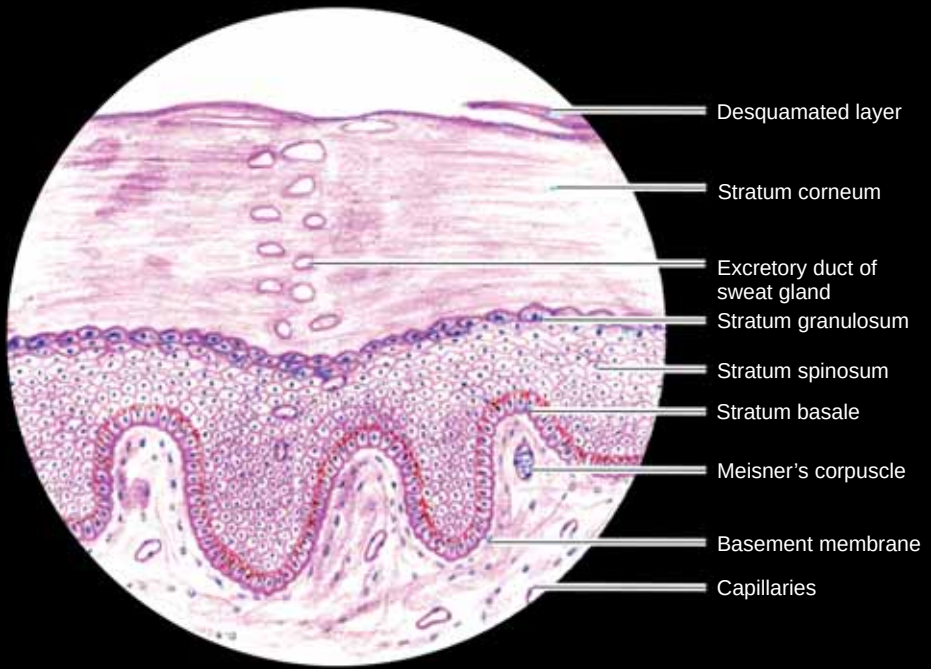


THICK SKIN



SP:

- Presence of dermis and thick epidermis.
- Presence of dermis with sweat glands.



Skin

General Aspect

- Skin, its derivatives and appendages constitute the integument system.
- Skin consists of two distinct regions viz. **epidermis and dermis**.
- These two layers are separated by a basement membrane.

Epidermis

- Superficial region.
- Lined by **keratinized stratified squamous epithelium**.
- Nonvascular.
- Five layers are seen in this region (from deep to superficial).
  - I. **Stratum basale**
    - Deepest layer of epidermis.
    - Consists of simple columnar cells.
    - Contains specialized sensory cells called as **cells of Merkel**.
  - II. **Stratum spinosum**
    - Consists of several layers of polyhedral cells.
    - Cells are held together by desmosomes.
  - III. **Stratum granulosum**
    - Made up of 3-5 layers of flattened fusiform shaped cells.
    - Cells contain keratohyaline granules (basophilic) and membrane coating granules.
  - IV. **Stratum lucidum**
    - Homogenous glassy layer of flattened dead cells (eosinophillic).
    - Cytoplasm contains keratin.
    - Nuclei and organelles not evident.
  - V. **Stratum corneum**
    - Superficial layer of epidermis.
    - Made up of flattened, nonnucleated, dead, scaly keratinized cells.
    - Cytoplasm filled with keratin.

Dermis

- This region is present inferior to epidermis.
- It is homologous to lamina propria of mucous membrane.
- Vascular in nature.
- Contains dense irregular connective tissue fibers.
- Dermis can be subdivided into two layers:
  1. **Superficial papillary layer**
     - Contains sweat glands, loose CT, fibroblasts mast cells, etc.
     - Meissner's corpuscle (sensory receptor) present in this layer.
  2. **Deep reticular layer**
     - Contains irregular collagenous connective tissue (Type I).
     - **Pacinian corpuscle (sensory receptor)** present in this layer.

THICK SKIN

- **Epidermis** is very thick due to thick stratum corneum layer.
- Hair follicles and sebaceous glands are **absent**.
- **Sweat glands** are present in dermis.

THIN SKIN

- **Epidermis** is very thin due to thin stratum corneum.
- **Contains** hair follicle and sebaceous glands.
- Sweat glands present in dermis.

Applied Anatomy

- In squamous cell carcinoma cells of stratum spinosum layer are affected.
- In psoriasis cells of stratum basale layer proliferate very rapidly and undergo keratinization very early, it leads to increased thickness of skin and raised red patches under white scale.
- Membrane coating granules present in the cells discharge their contents into granular layer providing the epidermis a sealing effect against foreign materials.

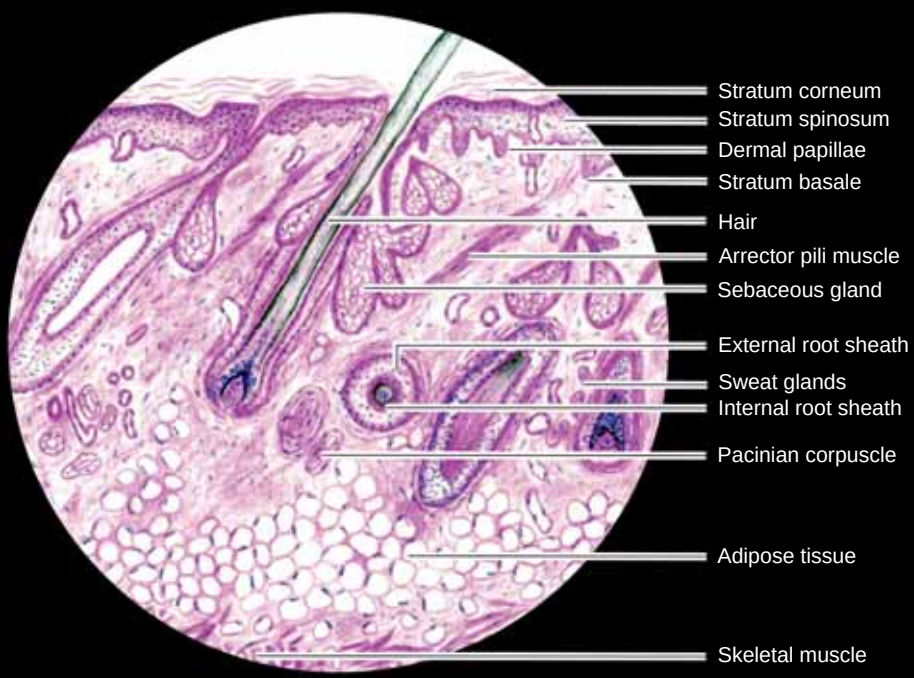
Viva-voce

Q. What are the cell junctions in the stratum spinosum?
Ans. Desmosomes
Q. Where are the melanocytes located?
Ans. Stratum basale
Q. Where are cells of Merkel present?
Ans. Stratum basale
Q. Where are Meissner's corpuscles present?
Ans. Superficial papillary layer of dermis
Q. Where are Pacinian corpuscles present?
Ans. Deep reticular layer of dermis.
Q. What are the characteristic features of stratum lucidum layer?
Ans. Homogenous glassy layer of flattened dead cells, cytoplasm contains keratin, and nucleus and organelles are not evident.

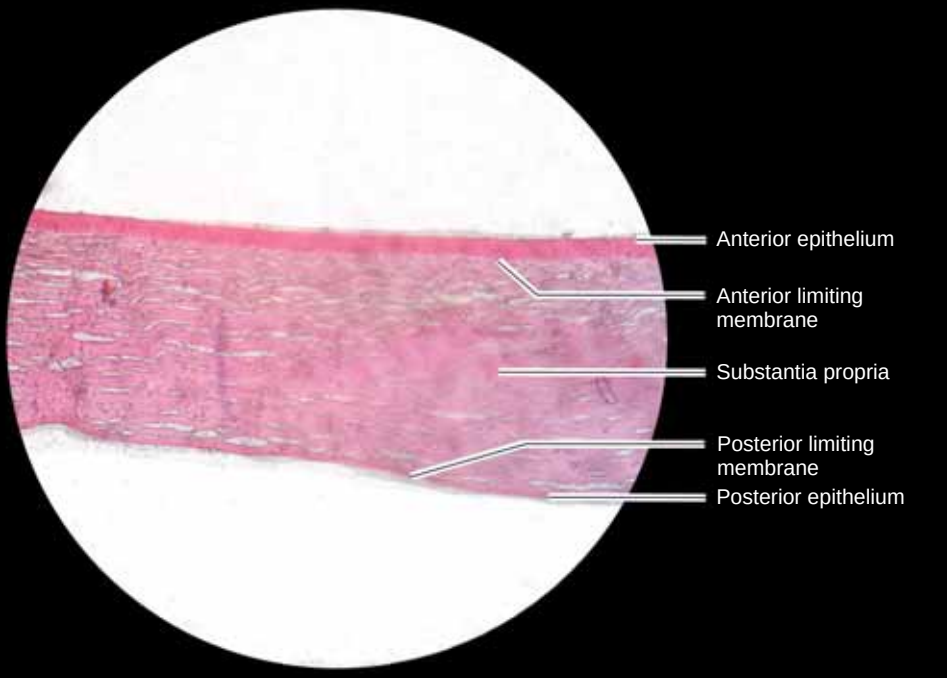
THIN SKIN

SP:

- Presence of dermis and epidermis
- Presence of dermis with hair follicles and sebaceous glands.

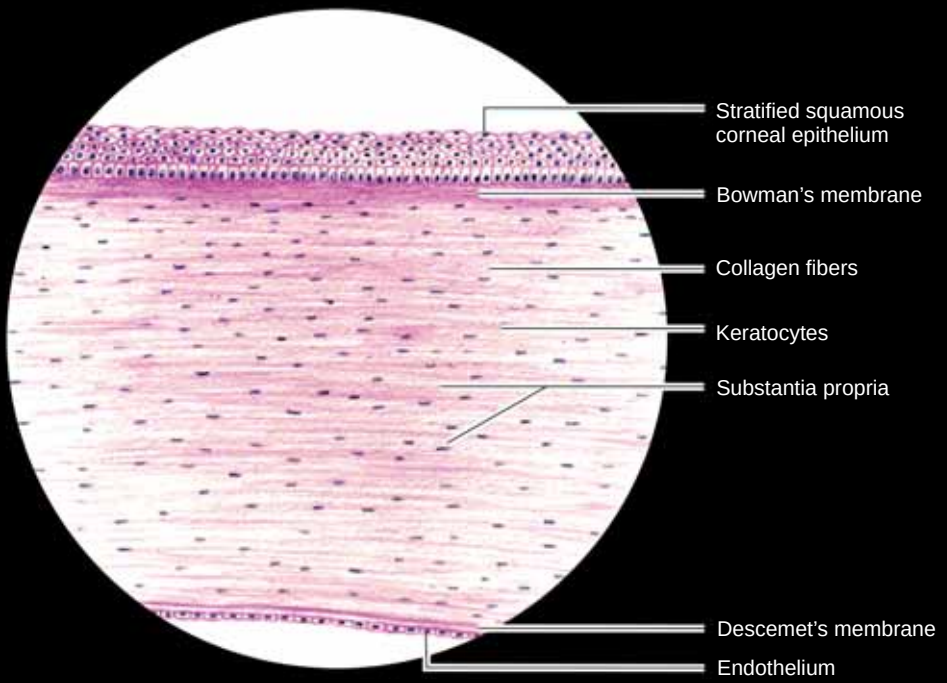


CORNEA



SP:

- Presence of anterior limiting lamina.
- Presence of thick substantia propria with keratocytes.



Special Senses

CORNEA

- It is a **thick, transparent, and a nonvascular** structure.
- It is composed of 5 layers.
- **Anterior (corneal) epithelium** made up of **nonkeratinized stratified squamous epithelium**.
- **Bowman's membrane (anterior limiting membrane)**: Acellular layer made up of compactly packed collagen fibers.
- **Corneal stroma (Substantia propria)** consists of bundles of collagen fibers arranged in layers, parallel to surface of cornea.
- **Descemet's membrane (posterior limiting membrane)**: Made up of collagen fibers, seperates substantia propria from endothelium.
- **Corneal endothelium** is lined by a single layer of squamous epithelium, it forms the posterior surface of cornea.

Applied Anatomy

- Due to its avascular nature:
  1. Transparency of cornea is maintained.
  2. Chances of endogenous infections are rare.
  3. Corneal transplants are not immunologically rejected.
- Corneal abrasion involves loss of surface epithelial layer due to trauma.
- In corneal dystrophy one or more parts loses its normal clarity.
- Corneal neovascularization is due to excessive ingrowth of blood vessels from limbal vascular plexus into the cornea caused by lack of oxygen from air.

Viva-voce

Q. What is Descemet's membrane made up of?
Ans. It is made up of collagen fibers, seperates substantia propria from endothelium.
Q. What is the other name of anterior limiting membrane?
Ans. Bowman's membrane.
Q. What kind of epithelium line the corneal endothelium?
Ans. Corneal endothelium is lined by a single layer of squamous epithelium.

RETINA

- **Innermost coat** of the eyeball.
- In total, retina is made up of **10 layers**.
- **Pigment layer** made of pigmented cuboidal cells.
- **Nervous layer** is a layer made by **outer and inner segments of rods and cones** whose tips are surrounded by processes of pigment cells.
- **External limiting membrane** separates rods and cones from the dense outer nuclear layer.
- **Outer nuclear layer** contains the nuclei of rods and cones and outer processes of **Müller's cells**.
- **Outer plexiform layer**, where the axons of rods and cones synapses with dendrites of horizontal cells.
- **Inner nuclear layer** is a dense layer of cell bodies of bipolar neurons.
- **Inner plexiform layer** where the axons of bipolar cells synapses with dendrites of ganglion and amacrine cells.
- **Ganglion cell layer** contains cell bodies of ganglion cells and neuroglial cells.
- **Optic nerve fiber layer** is made up of bundles of unmyelinated axons of ganglion cells and inner fibers of Müller's cells.
- **Internal limiting membrane—**formed by expanded basal ends of Müller's cells with there basement membrane.

Applied Anatomy

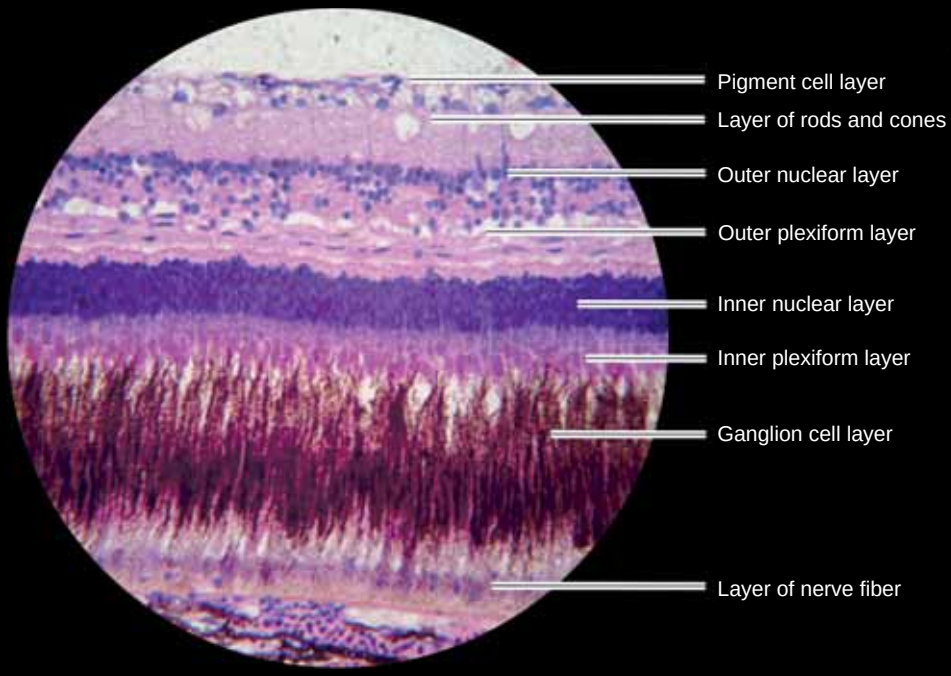
- In nonproliferative type of diabetic retinopathy, there will be thickening of capillary basement membrane. Whereas in case of proliferative type of diabetic retinopathy there will be neovascularization of retina.
- *Retinoblastoma:* Most common tumor of childhood. It arises from retinal neurons.
- Since pigment cell layer more firmly attached to choroid than to nervous layer, in myopies retinal detachment usually occurs, leading to blindness.
- Posterior (¾) part of retina is called as optic part since photosensitive and derived from the walls of optic cup.

Viva-voce

Q. What are Müller's cells?

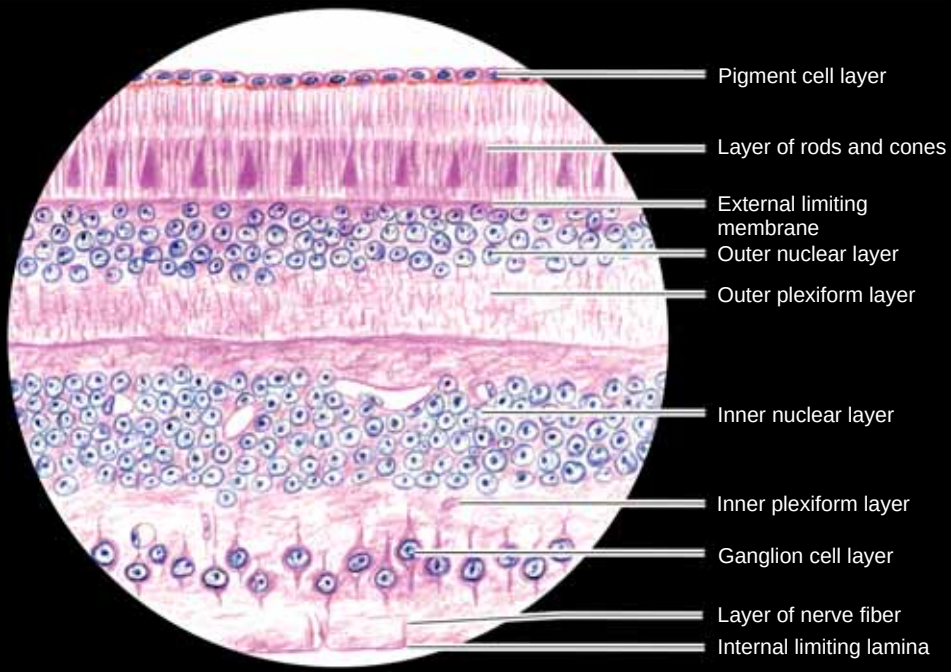
Ans. These are supportive cells for the neurons of retina and have the ability of dedifferentiation to form particular cells when there is injury.

RETINA

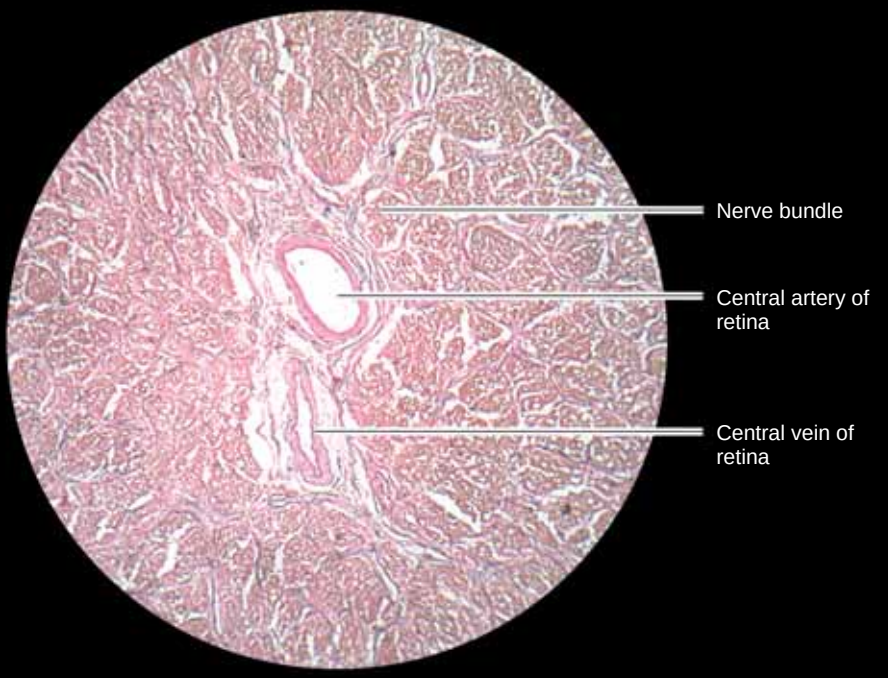


SP:

- Presence of 10 layers.
- Presence of external and internal limiting lamina.

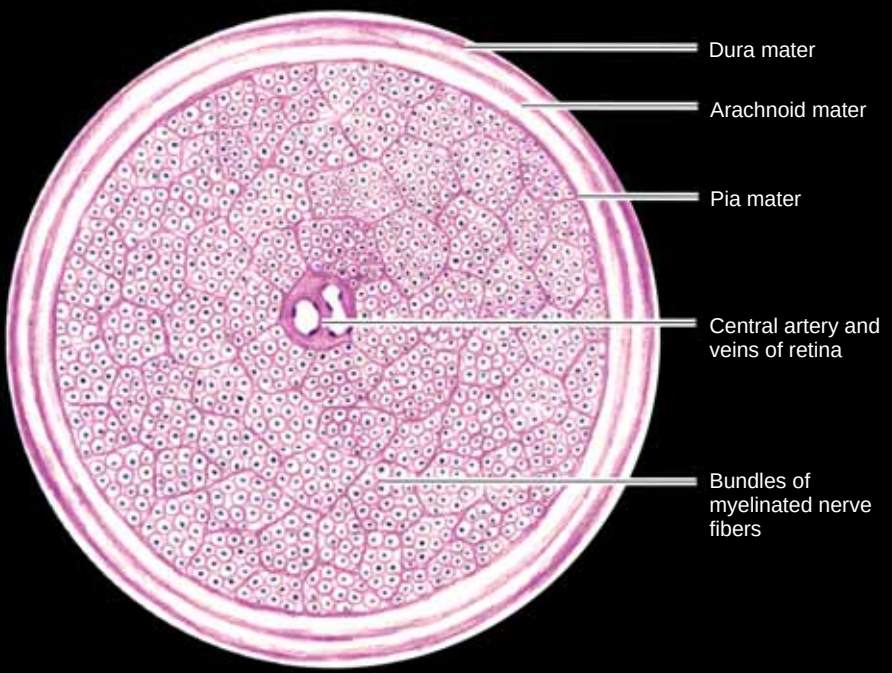


OPTIC NERVE



SP:

- Presence of 3 layers of meninges.
- Presence of central artery and vein along with nerve fiber bundles.



OPTIC NERVE

- It is covered by **dura mater, arachnoid mater and pia mater**.
- Within the covering bundles of nerve fibers surrounded by **astrocytes** are seen.
- Each bundle contains many **myelinated nerve fiber axons** of varying caliber.
- **Nerve fibers** are derived from the ganglion cells of retina.
- These bundles also contains small number of **pupilomotor fibers** and some **centrifugal fibers**.
- **A central artery and vein** are present at the center.

Applied Anatomy

- Optic nerve is not covered by neurilemma, which is present in other peripheral nerves, as a result optic nerve can not regenerate when it is cut.
- The optic nerve fibers develops from the nerve fiber layer of retina which grow into optic stalk by passing through choroidal fissure and pass posteriorly into brain.
- Lesions of the optic nerve is characterized by marked loss of vision or complete blindness on the affected side and associated with loss of direct light reflex in the ipsilateral side.
- Common lesions of optic nerve include optic atrophy, trauma, avulsion, indirect optic neuropathy, acute optic neuritis, etc.
- Congenital anomalies of optic nerve include medullated or opaque nerve fibers and result in enlargement of blind spot.

Viva-voce

Q. What are the supportive cells present in optic nerve?
Ans. Astrocytes
Q. From which structure does nerve fibers of optic nerve develop from?
Ans. Nerve fibers are derived from the ganglion cells of retina.

Female Reproductive System

MAMMARY GLAND

- Consists of mainly parenchyma and stroma.
- Both of these components differ in case of lactating gland as well as a nonlactating one.

In **nonlactating gland:**

- **Parenchyma** consists of **less glandular tissue, poorly developed alveoli** having solid cord of cells, extensive branching of duct system, duct lumen poorly visible, tubules and ducts are lined by **cuboidal epithelium**.
- **Stroma** contains more connective tissue and adipose tissue, interlobular connective tissue septum is **thick**, abundant intralobular loose connective tissue with numerous **fibroblasts**.

In **lactating gland:**

- **Parenchyma** having **more glandular tissue** with **proliferated tubules** enlarged to alveoli which is highly developed, external branching of alveolar ducts and large ducts being lined by **stratified epithelium**.
- **Lumen** filled with milk and contain fat droplets.
- **Stroma: Less connective tissue** and adipose tissue, interlobular connective tissue septum is **thin**, intralobular connective tissue is less and contain **lymphocytes and plasma cells**.

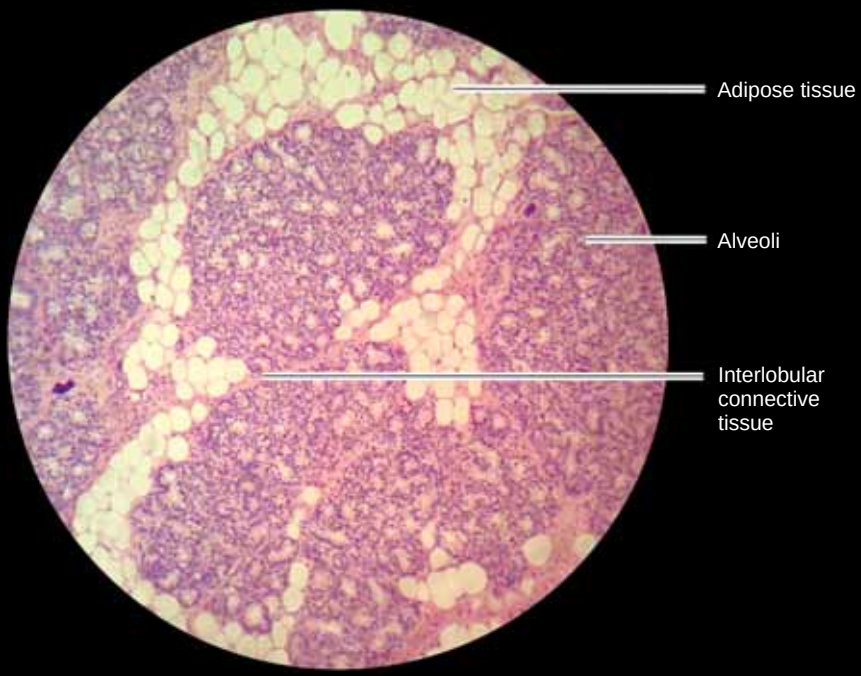
Applied Anatomy

- In normal mammary gland alveoli are small and few in number whereas in lactating one alveoli are enlarged and distended and number of ducts also increase.
- The cancers arising from the ductal portion of breast is called ductal carcinomas and cancers arising from the lobules is called lobular carcinoma.
- Metastasis from one breast to another or to other sites can occur.

Viva-voce

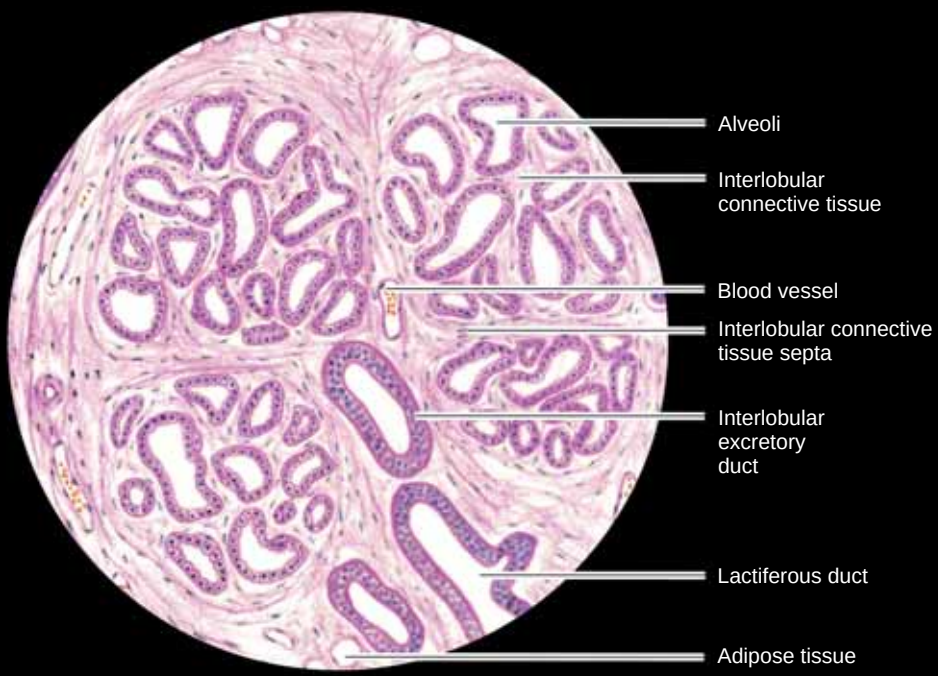
Q. What are the major hormones responsible for the cyclic changes in the mammary gland?
Ans. Estrogen and progesterone.

MAMMARY GLAND

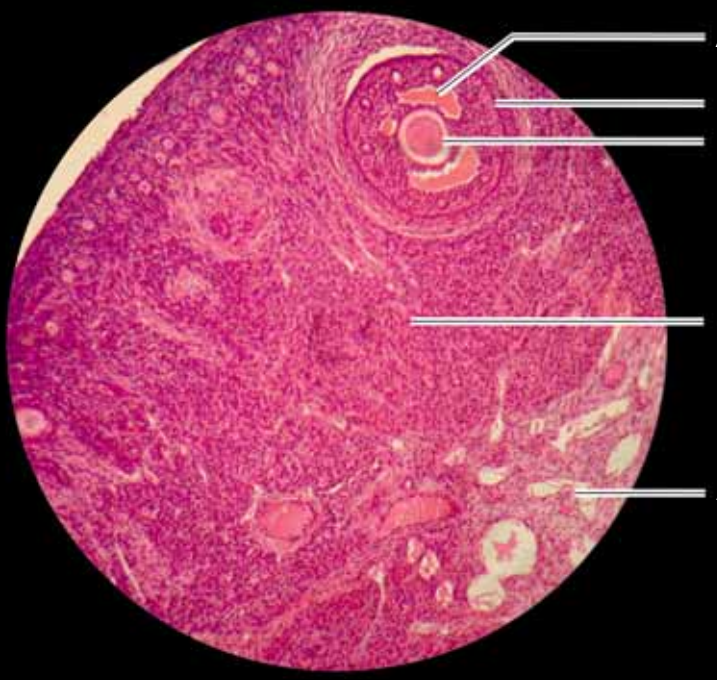


SP:

- Presence of secretory acinar tissue.
- Presence of intralobular CT, interlobular CT and their ducts.

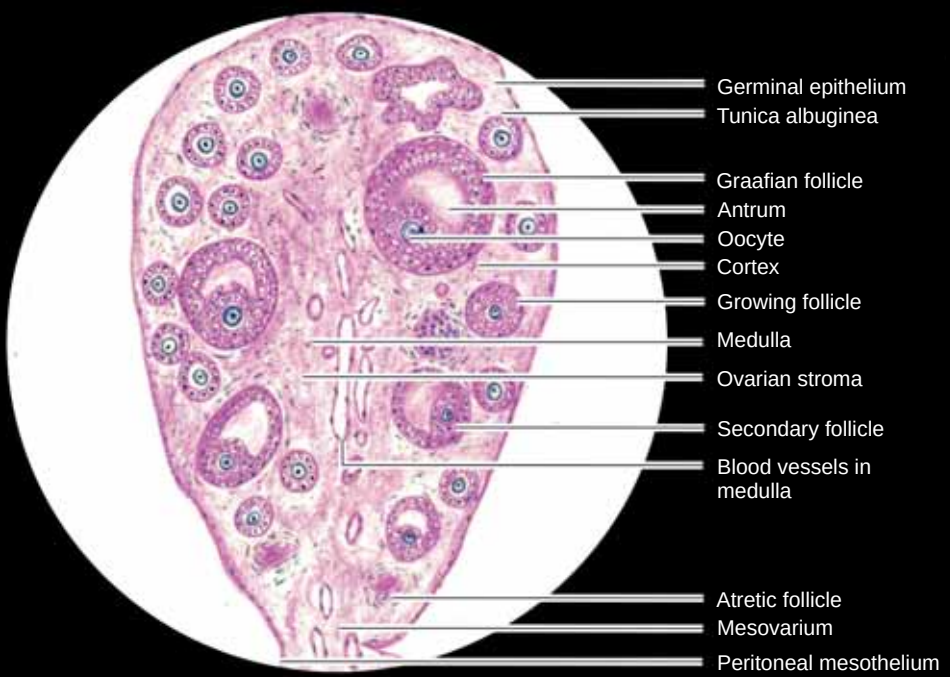


OVARY



SP:

- Presence of follicles with oocytes in different stages of maturity.
- Presence of germinal epithelium.



OVARY

- Lined by **simple cuboidal epithelium called as germinal epithelium** which is continuous with mesothelium of peritoneum.
- Beneath the epithelium a layer of dense connective tissue is present called **tunica albuginea**.
- Exhibits cortex and medulla arrangement.
- **Cortex** occupies the most part and contains **stroma** (dense reticular fibers and spindle shaped cells with no fibrils) and **ovarian follicles** of different stages (also **atretic follicles, corpus luteum, corpus albicans**).
- **Medulla** is made of loose fibroelastic connective tissue and contains blood vessels, lymphatics and nerves and is continuous with the mesovarium of peritoneum.
- **The primary ovarian follicles** and corpus luteum follicles posses a large central cell and a surrounding flattened cell layer whereas secondary follicle is multilayered.
- And the largest of all the **graafian follicle** is seen with varying sizes and lines near surface and consists of:
  1. **Oocyte** surrounded by **ooplasm** or yolk.
  2. **Ovum** covered by **zona pellucida**.
  3. Surrounded by **membrana granulosa** having **cumulus oophorus** and **discus proligerus** and a follicular cavity embedded in it called **antrum folliculi**.
  4. **Theca folliculi** comprising of theca externa and theca interna.

Applied Anatomy

- *Polycystic ovary:* It is a condition characterized by presence of numerous cysts in the ovary. The cysts are lined by granulosa cells.
- *Mucinous tumor of ovary:* Also cystic tumors, it composes of hundreds of cysts which are filled with mucin.

Viva-voce

Q. What is the lining epithelium of ovary?
Ans. Lined by simple cuboidal epithelium called as germinal epithelium.
Q. What is the primary ovarian source of estrogenic hormones?
Ans. Granulosa cells.

FALLOPIAN TUBE

- Also known as uterine tubes.
- Made up of three layers:
  1. **Mucosa**
  2. **Muscle coat**
  3. **Serosa**
- **Mucosa** includes lining epithelium and lamina propria.
- Lined by **simple ciliated columnar epithelium**.
- Apart from **ciliated columnar cells**, it also contains some **nonciliated secretory peg cells**.
- **Ciliated columnar cells** are short and is more prominent in the proliferative phase.
- **Nonciliated peg cells** are longer than ciliated columnar cells.
- **Mucosa** consists of extensive folds, as a result the lumen becomes highly irregular which help in providing nutrition to fertilized ovum from all sides.
- **Muscle coat** is made of two layers smooth muscles:
  1. **Inner circularly** arranged layer.
  2. **Outer longitudinally** arranged layer.
- **Serosa** consisting of mesothelium (peritoneum of broad ligament) and supported by connective tissue.

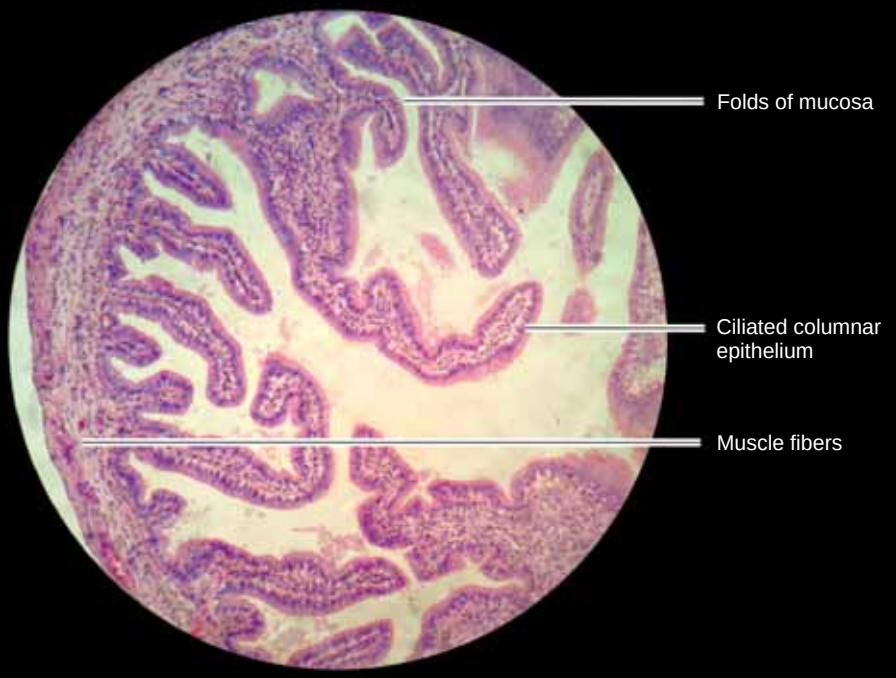
Applied Anatomy

- Tubal obstruction forms one of the major causes of infertility in females.
- Tubal patency is assesed by using procedures like hysterosalpingography, laproscopy.
- Surgical removal of fallopian tubes is called as salpingectomy.
- Propulsion of gametes and embryos is achieved by complex interaction between muscle contractions, ciliary activity and the flow of tubal secretions.

Viva-voce

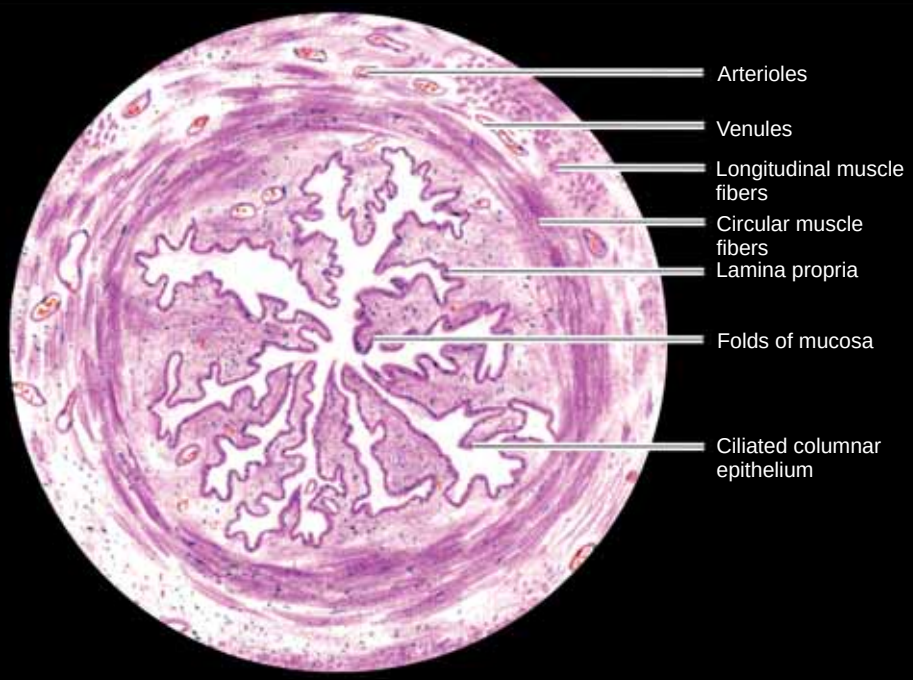
Q. What is the lining epithelium of mucosa of fallopian tube?
Ans. Lined by simple ciliated columnar epithelium and nonciliated secretory peg cells.
Q. What are the characteristics of columnar cells in proliferative phase?
Ans. The columnar cells are prominent and short in the proliferative phase.

FALLOPIAN TUBE

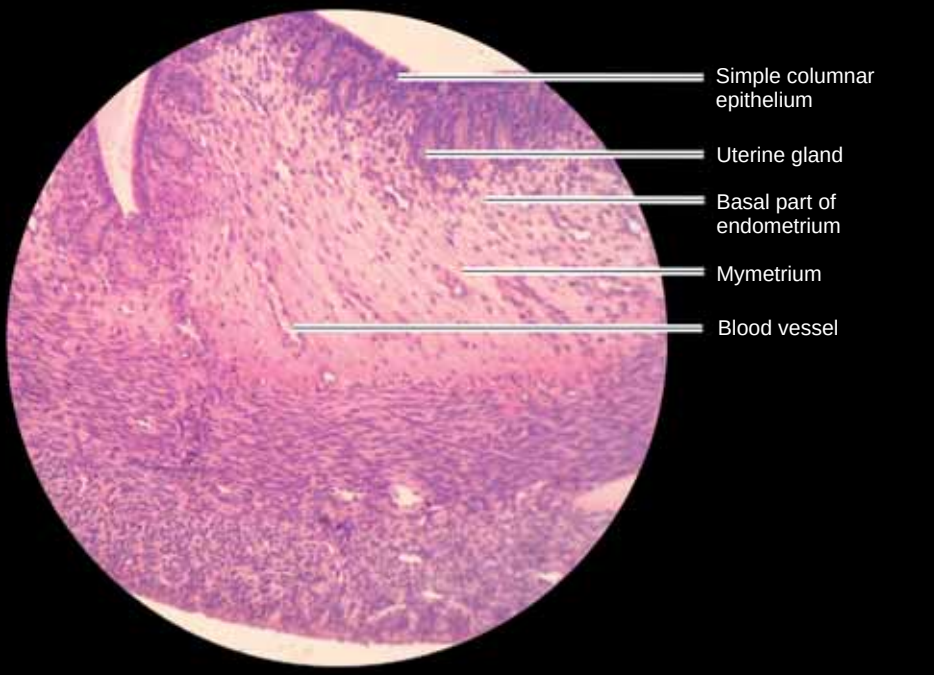


SP:

- Presence of 1º, 2º, 3º mucosal folds and its lumen.
- Presence of circular muscle coat.

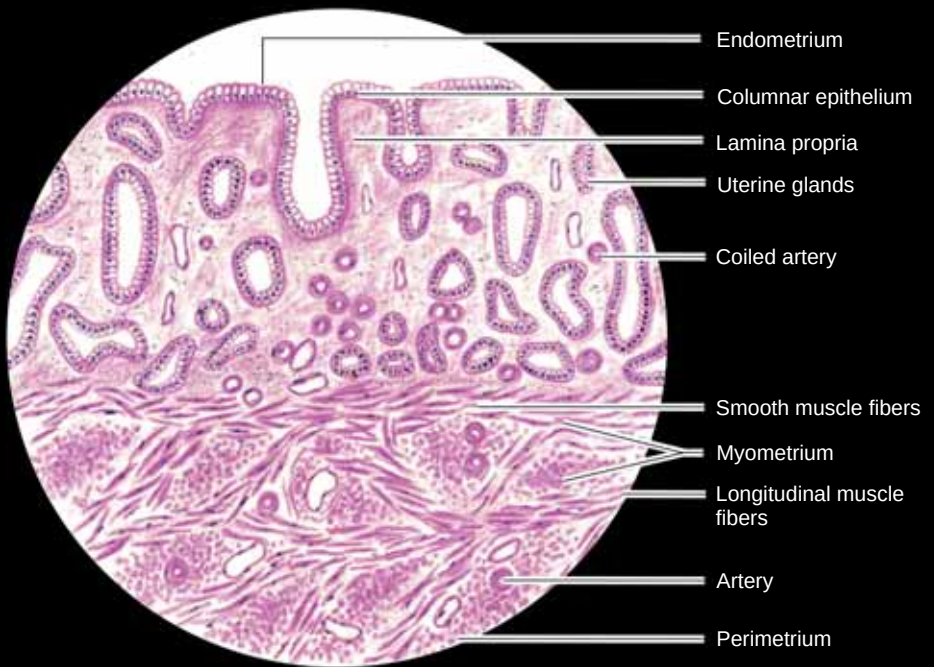


UTERUS



SP:

- Presence of thick myometrium with smooth muscle.
- Presence of uterine glands in endometrium.



UTERUS

Proliferative Phase

- Made up of three layers (outer to inner):
  1. **Perimetrium (serosa)**
  2. **Myometrium (Muscle coat)**
  3. **Endometrium (mucosa)**
- **Perimetrium** is lined by simple squamous epithelium, supported by connective tissue and contains numerous blood vessels and elastic fibers.
- **Myometrium** is a thick muscular layer, composed of smooth muscle fibers arranged in three indistinctive layers:
  1. **Outer longitudinal layer**.
  2. **Middle circular layer (Thickest of the three)**.
  3. **Inner longitudinal layer**.
- **Myometrium** is highly vascular having areolar tissue, blood vessels and lymphatics.
- **Endometrium** lined by simple columnar epithelium. Beneath it, a layer called **lamina propria** is present which is highly cellular.
- Lining epithelium extends down into the lamina propria and forms long tubular uterine glands.
- Uterine endometrium is divided into **superficial stratum functionalis** and **deep stratum basalis**.

Applied Anatomy

- *Leiomyoma:* Benign tumor of smooth muscle affecting the uterus.
- *It is seen in uterus mainly at 3 sites:* Submucosa, intramural and subserosa.
- *Adenomyosis:* Islands of endometrial tissue found deep in the myometrium.
- It is mainly the stratum functionalis where the changes occur in response to hormones and is usually shed when fertilization do not occur.

Viva-voce

Q. What are the layers of uterine endometrium?

Ans. Uterine endometrium is divided into superficial stratum functionalis and deep stratum basalis.

PLACENTA

- Consists of fetal portion and as well as maternal portion.
- **Fetal portion** is formed by **chorionic plate** and its villi.
- **Maternal portion** is formed by the **decidua basalis of endometrium**.
- **The chorionic plate** is formed by:
  - **Trophoblast cells** are present just below the connective tissue layer, which is located below the lining of amniotic surface.
  - Section shows cross sections of **chorionic villi** of different sizes and shapes scattered in intervillous spaces filled with maternal blood.
- **In early stages of pregnancy**
  - The **chorionic villi form chorionic plate** which contain
    1. Connective tissue core.
    2. Fetal blood vessels (including branches of umbilical arteries and vein).
    3. Mesenchyme cells.
    4. Macrophages.
  - The villi are separated by **intervillous space**.
  - Maternal blood reaches the intervillous space through spiral arteries of decidua and baths the villi containing fetal blood cells.
- In **full term of pregnancy**
  - The **chorionic villi** shows:
    - Chorionic epithelium reduced to **syncytiotrophoblast**.
    - Connective tissue having more fibers and fibroblasts.
    - Fetal blood vessels of increased complexity.
    - The intervillous space surrounded by maternal blood cells.

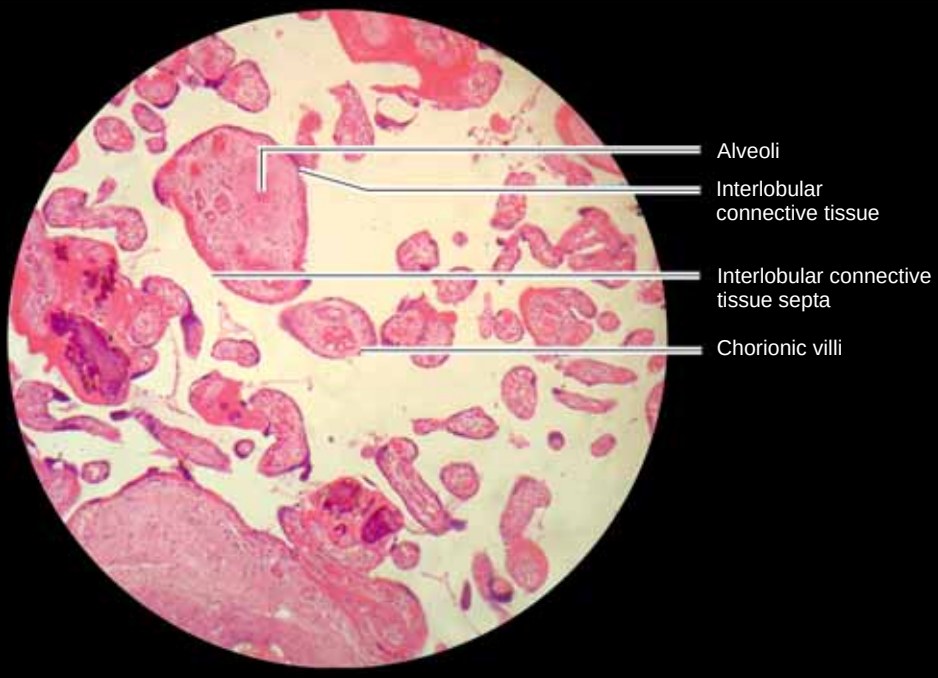
Applied Anatomy

- *Placental site trophoblastic tumor:* It is a trophoblastic tumor mainly composed of monomorphic population of intermediate trophoblasts. The tumor cells are irregular, large polyhedral cells with hyperchromatic nuclei.
- *Choriocarcinoma:* This is also a carcinoma affecting placenta arising from the trophoblast.

Viva-voce

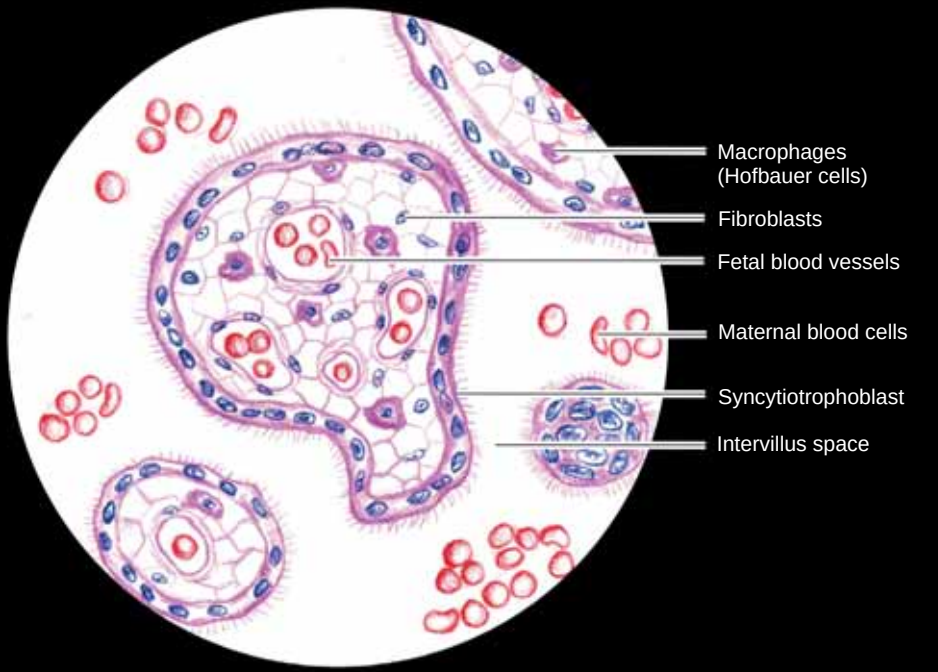
Q. What are the parts of placenta?
Ans. Fetal part formed by chorionic plate and villi and maternal portion by decidua basalis.

PLACENTA

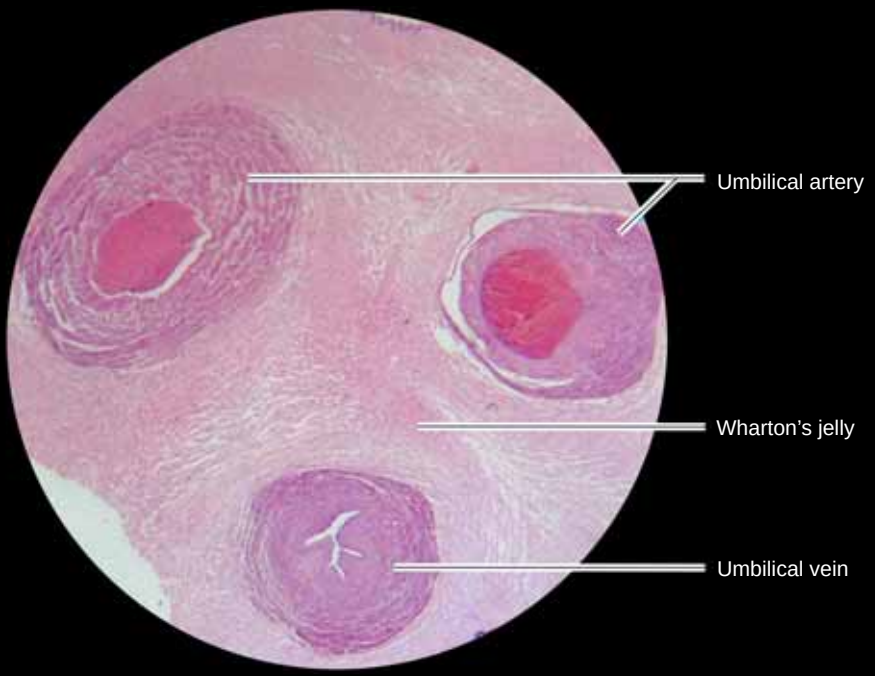


SP:

- Chorionic villi of different stages seen.
- Intervillous space filled with maternal blood and RBCs.

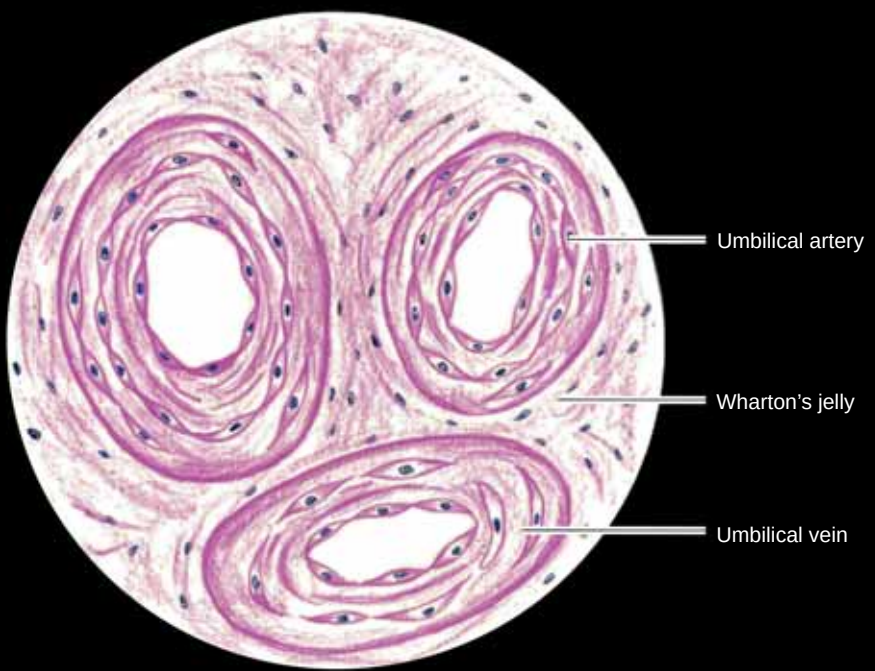


UMBILICAL CORD



SP:

- Presence of 2 umbilical arteries and 1 umbilical vein.
- Presence of Wharton's jelly.



UMBILICAL CORD

- Consists of **single umbilical vein, 2 umbilical arteries, Wharton's jelly, and a layer of amnion**.
- **Umbilical vein** is a thin walled structure with wider lumen and bring oxygenated blood from placenta to fetus.
- **Umbilical artery** is thick walled in nature and has a narrow lumen and takes deoxygenated blood from fetus to placenta.
- **Wharton's jelly** is a mass of gelatinous mucoid connective tissue which hold together the umbilical vessels.
- A thin single layered amnion covers all the above structures.
- **Amnion** is made up of single layer of cuboidal epithelium.

Applied Anatomy

- The nonpatent obliterated part of umbilical artery is the medial umbilical ligament.
- The umbilical vein of the newborn baby is used as a site for regular transfusion in case of hemolytic disease of newborn since umbilical vein remains patent for atleast a week after birth.
- After a week since birth the umbilical vein is completely obliterated and is replaced by a fibrous cord called ligamentum teres of liver.

Viva-voce

Q. What is Wharton's jelly?
Ans. Wharton's jelly is a mass of gelatinous mucoid connective tissue which hold together the umbilical vessels.
Q. What is the function of umbilical artery?
Ans. Umbilical artery is thick walled in nature and has a narrow lumen and takes deoxygenated blood from fetus to placenta.
Q. What is the function of umbilical vein?
Ans. Umbilical vein is a thin walled structure with wider lumen and bring oxygenated blood from placenta to fetus.
Q. What is the lining epithelium of amnion?
Ans. Single layer of cuboidal epithelium.

Male Reproductive System

TESTIS

- Each testis is enclosed within an outer thick connective tissue capsule called **tunica albuginea** and inner vascular layer of loose connective tissue called the **tunica vasculosa**.
- **Connective tissue** that extend inward into the testes and surrounds, binds, supports the seminiferous tubules is called **interstitial connective tissue**.
- Thin fibrous septa divides the testes into compartments called **lobules**.
- Within each lobule one to four seminiferous tubules are present.
- **Seminiferous tubules** are lined with stratified epithelium called germinal epithelium containing **spermatogenic cells** producing sperms.
- **Germinal epithelium** roots on basement membrane.
- Supportive **Sertoli cells** in the seminiferous tubules nourishes the developing sperm and produces hormones like **inhibin, anti-Müllarian hormone, etc**.
- **Leydig cells (interstitial cells)** situated in the interstitial connective tissue produces testosterone.
- Alongwith the Leydig cells, clusters of epithelial cells, blood vessels, loose connective tissue cells are also present in the interstitial connective tissue.

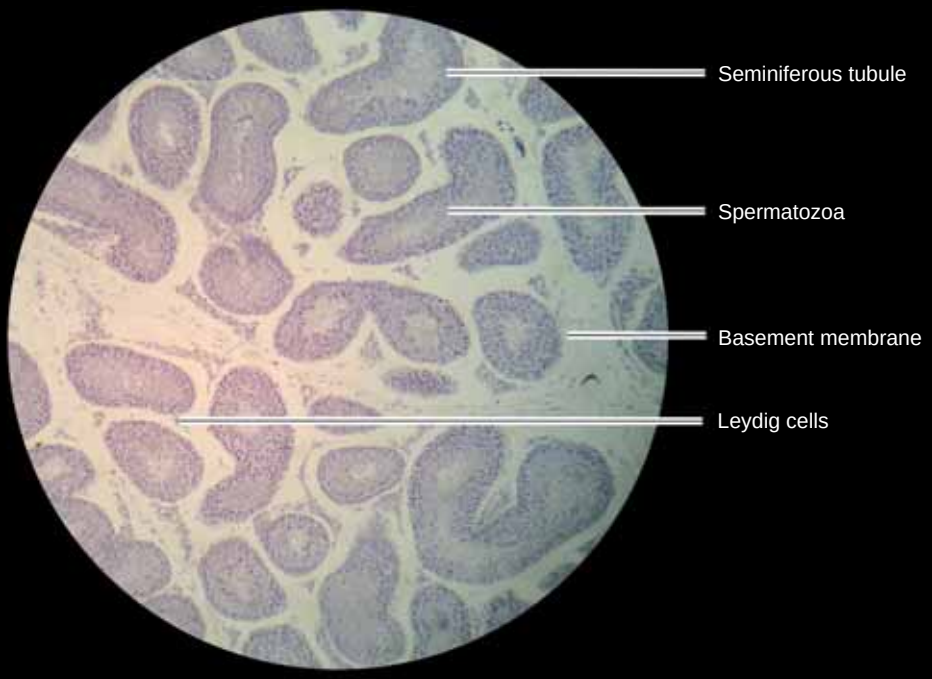
Applied Anatomy

- Seminoma is the most common testicular tumor arising from germ cells.
- Cryptorchidism is undescent of testis which can predispose to testicular tumors.
- Leydig cell tumors are functional tumors (hormone producing) arising from the interstitial cells of Leydig.

Viva-voce

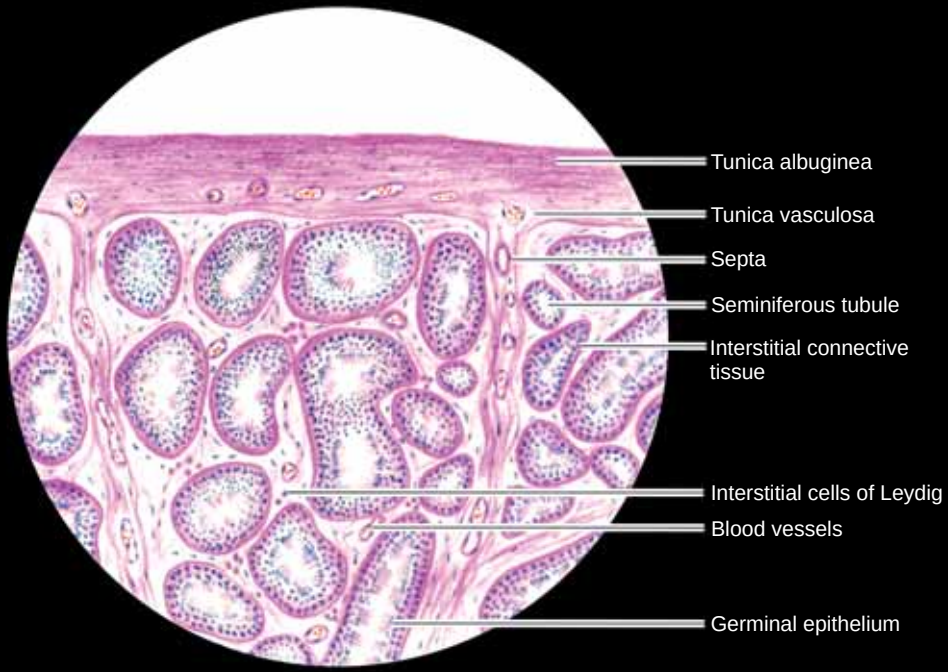
Q. What is the difference between spermatogenesis and spermiogenesis?
Ans. Spermatogenesis is entire the process of formation of sperm from stem cell to spermatozoon. Spermiogenesis is the maturation process from spermatid to spermatozoon.
Q. What are the components of the blood-testis barrier and what is its significance?
Ans. Tight junctions between Sertoli cells isolate developing sperm from the vasculature (prevent their immunological rejection).
Q. What is the primary source of testosterone?
Ans. The Leydig cells.

TESTIS

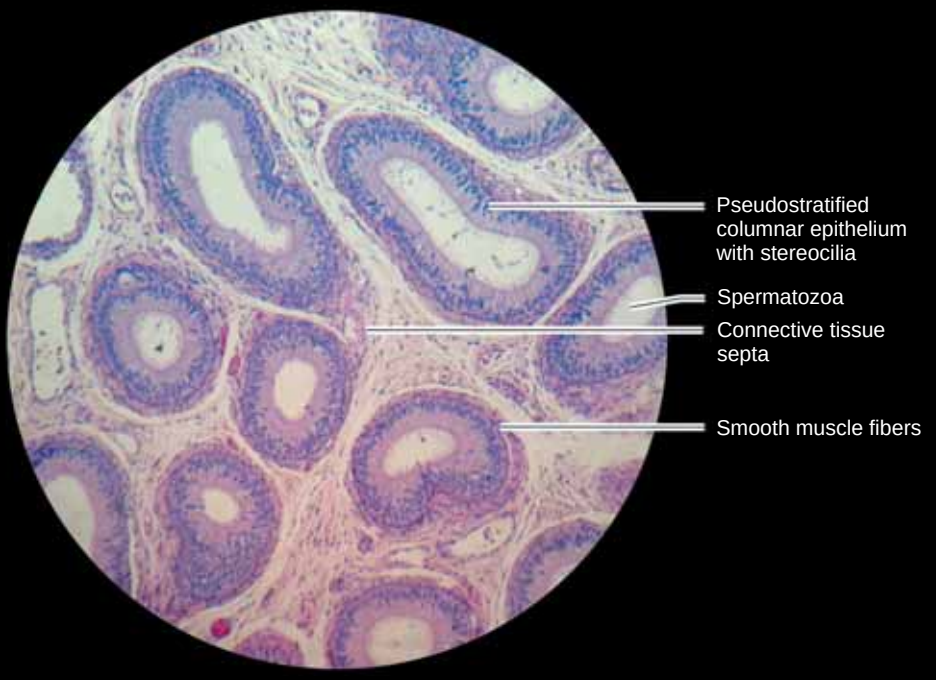


SP:

- Presence of seminiferous tubules with spermatozoa.
- Presence of interstitial cells between the tubules.

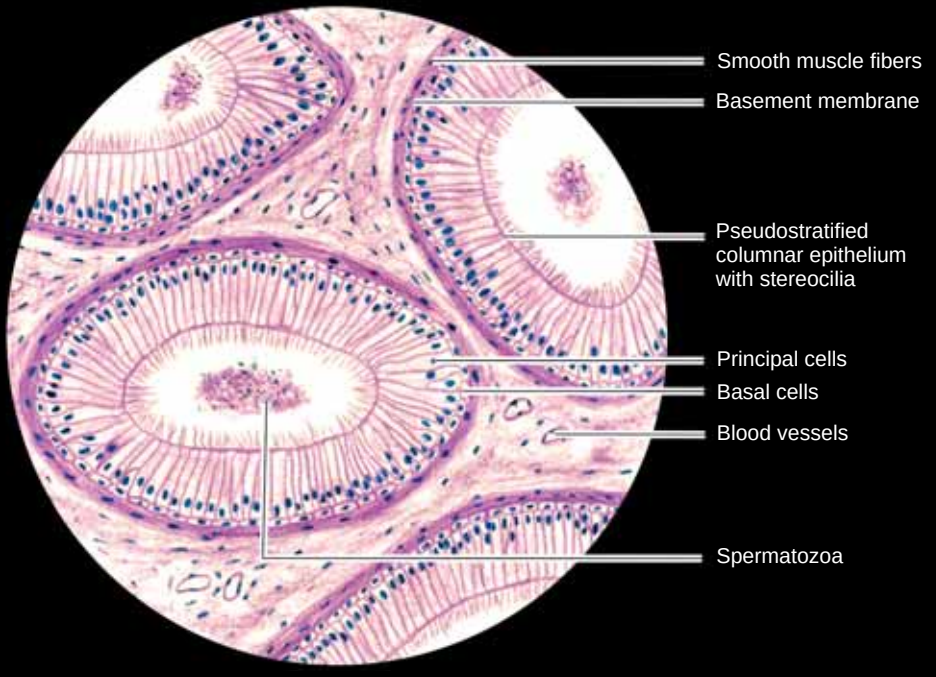


EPIDIDYMIS



SP:

- Presence of highly convoluted efferent ductules with stereocilia.
- Presence of smooth muscle around the ductules.



EPIDIDYMIS

- Contains highly convoluted efferent ductules called **ductus epididymis**
- These are surrounded by connective tissue and thin smooth muscle layer.
- Lumen of ductus epididymis is lined by **pseudostratified columnar epithelium** with 2 types of cells:
  1. **Tall columnar principal cells.**
  2. **Small basal cells.**
- The **tall columnar cells** bear microvilli called stereocilia.
- Some parts of the ductus contain mature sperm.

Applied Anatomy

- The stereocilia present in the epididymis are responsible for the absorption and removal of the sperm which fails to leave the epididymis.
- The name stereocilia is a misonomer as it does not move like the other cilia, and it is moreover like the villi of gut.

Viva-voce

Q. Where is the principal site of storage and mobility acquisition of spermatozoa in the male reproductive system?
Ans. Epididymis.
Q. What are the two types of cells present in the lining of lumen of epididymis?
Ans. Tall columnar cells and small basal cells.

VAS DEFERENS

- Consists of mainly three layers.
- **Mucosa** is lined by **pseudostratified columnar epithelium** and provided with stereocilia in extra-abdominal part of the duct.
- The mucosa is thrown into longitudinal folds which permit expansion of the duct during ejaculation.
- Underlying **lamina propria** consists of compact collagen fibers and a fine network of elastic fibers.
- **Muscular layer** consists of three smooth muscle layers an layer:
  - **Thin inner longitudinal** layer
  - **Thick middle circular** layer, and
  - **Thinner outer longitudinal** layer.
- **Adventitia** is made up of fibroelastic connective tissue having abundant blood vessels, venules, arterioles and nerves.
- The lumen may carry sperms.

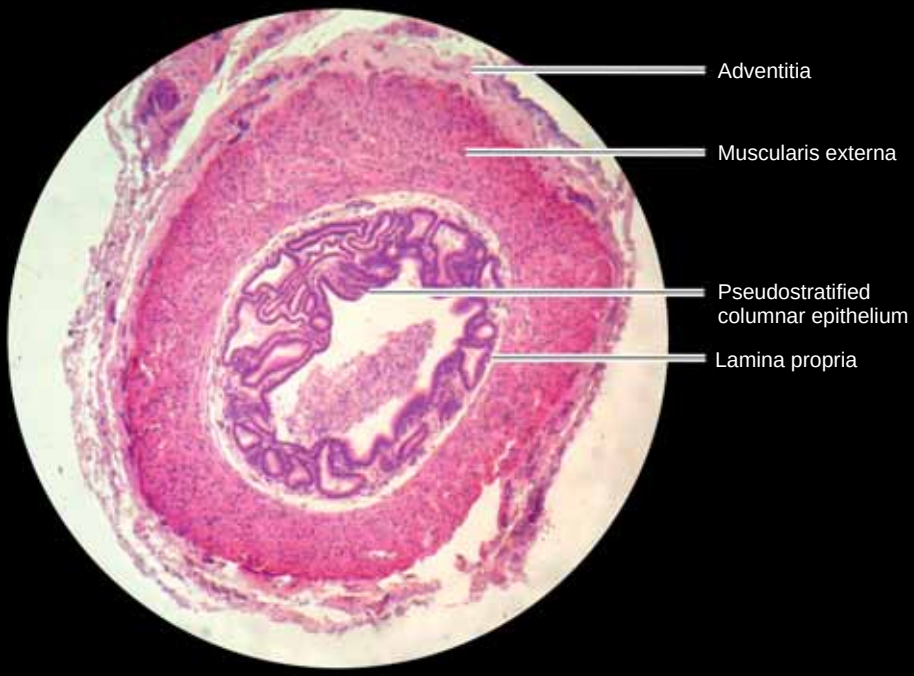
Applied Anatomy

- The unexpelled sperms produced daily are mainly absorbed by the pseudostratified columnar epithelium of vas deferens. And the absorbed sperms are engulfed and lysed by the macrophages.
- The same thing happens in men who has undergone vasectomy procedure.

Viva-voce

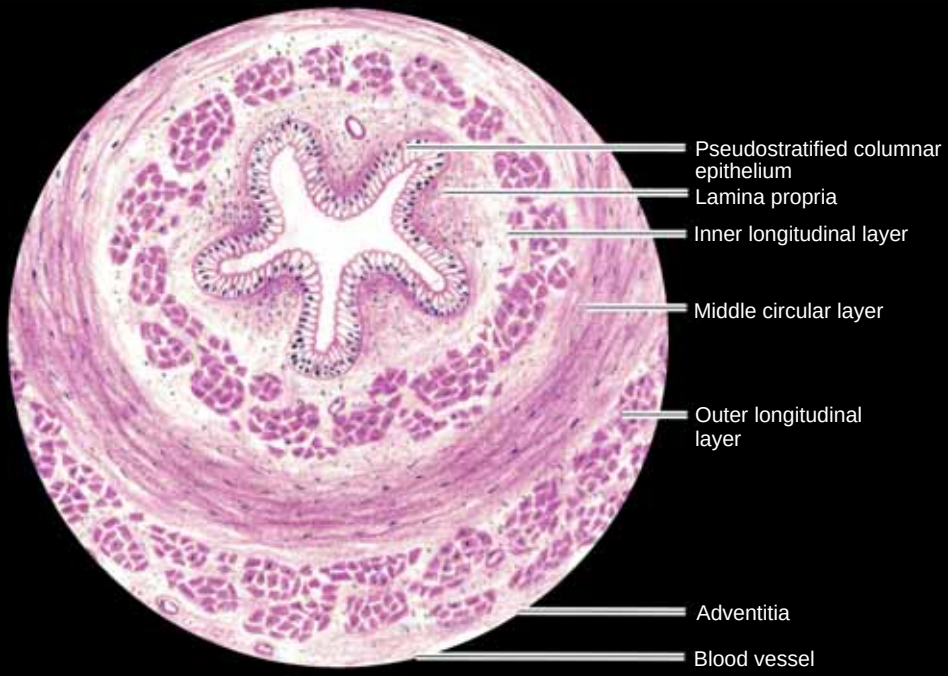
Q. What type of epithelium lines the mucosa of vas deferens?
Ans. Mucosa is lined by pseudostratified columnar epithelium and has stereocilia in extra-abdominal part of the duct.
Q. What does lamina propria of vas deferens contain?
Ans. Lamina propria consists of compact collagen fibers and a fine network of elastic fibers.

VAS DEFERENS

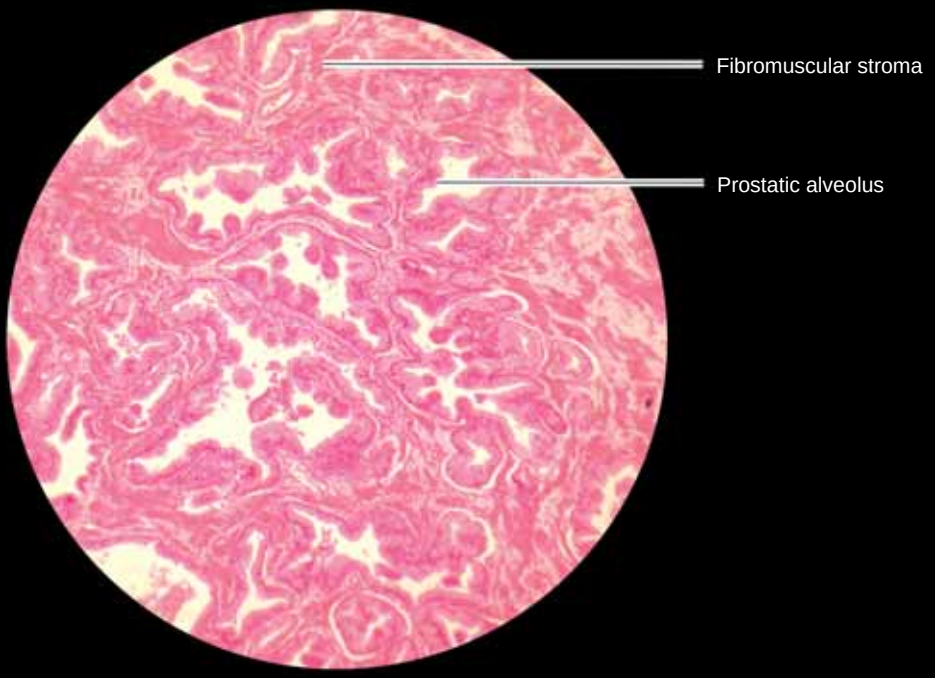


SP:

- Presence of narrow irregular lumen with mucosal folds.
- Presence of thick circularly arranged muscle coat.

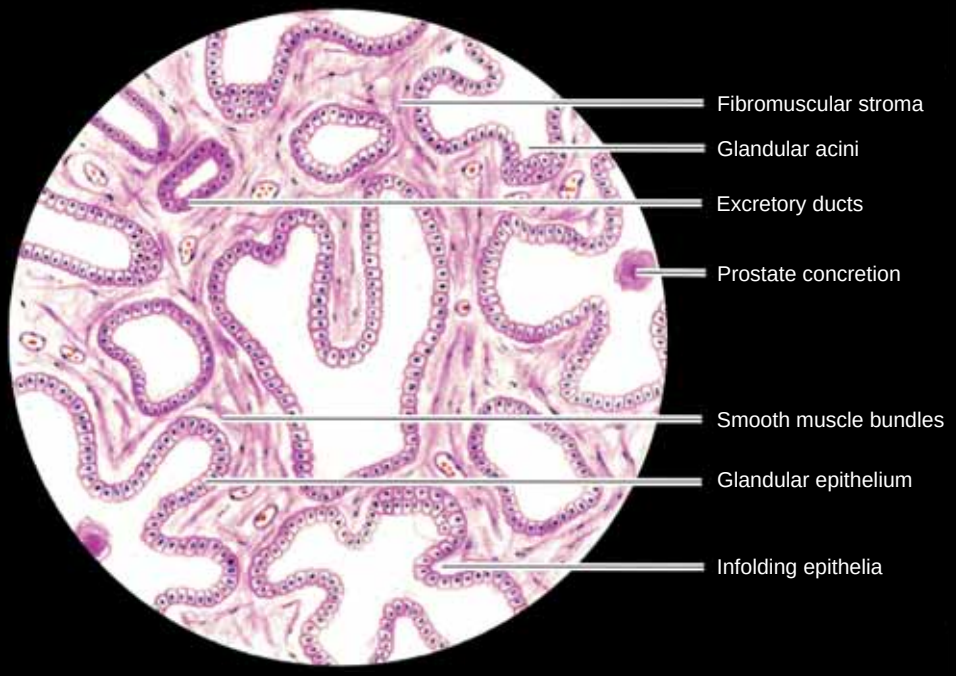


PROSTATE GLAND



SP:

- Presence of prostatic acini separated by fibromuscular tissue.
- Presence of amyloid body.



PROSTATE GLAND

- **Prostate** is covered by
  - **Inner capsule—**formed by condensation of fibromuscular stroma.
  - **False capsule—**formed by pelvic fascia.
- It is composed of 30-50 branched tubuloalveolar glands embedded in **fibromuscular stroma**.
- The ducts of the gland opens into prostatic urethra which is lined by **transitional epithelium**.
- The **parenchyma** is made up of large irregular prostatic alveoli with wide lumen which is lined by epithelium varying from **cuboidal to columnar** depending on its activity.
- The lumen of prostatic alveoli contain condensed prostatic secretions called **prostatic concretion or amyloid bodies**.
- The **fibromuscular stroma** supports the parenchyma and is made of smooth muscle fibers with connective tissue fibers.
- Stroma also contain blood vessels, lymphatics and nerves.

Applied Anatomy

- In nodular hyperplasia of prostate, there will be hyperplasia of all 3 tissue elements—glandular, fibrous and muscular, in which glandular hyperplasia predominates.
- In adenocarcinoma of prostate, malignant acini have little or no stroma between them.
- Prostatic secretions along with the secretions from seminal vesicles from major part of semen.

Viva-voce

Q. What are prostatic concretions?
Ans. The lumen of prostatic alveoli contain condensed prostatic secretions called prostatic concretion or amyloid bodies.
Q. What is the type of epithelium lining the prostatic alveoli?
Ans. The prostatic alveoli is lined by cuboidal to columnar type of epithelium depending on its activity.
Q. What is fibromuscular stroma of prostate made of?
Ans. The fibromuscular stroma is made of smooth muscle fibers and connective tissue fibers.

Endocrine System

ADRENAL GLAND

- Consist of capsule, cortex, medulla.
- **Cortex—**Consists of the following layers from outer to inner.
  - **Zona glomerulosa—**Cells arranged in clumps (inverted 'U' shape), cytoplasm stains pink.
  - This layer produces **mineralocorticoids**.
  - **Zona fasciculata—**Widest layer, cells arranged in vertical columns or radial plates, lightly stained due to the presence of numerous lipid droplets.
  - This layer produces **glucocorticoids**.
  - **Zona reticularis—**Close to medulla, cells form anastomosing cords.
  - This layer produces **sexcorticoids**.
- **Medulla**—Not sharply demarcated from cortex.
  - Consists of polyhedral cells which modified sympathetic neurons and are seen singly or in groups.
  - The cell groups are separated by wide sinusoidal capillaries.
  - Adrenal medullary cells produces **adrenaline and noradrenaline**.
  - After tissue fixation fine brown granules become visible in cells called **chromaffin cells** indicating presence of medullary hormones.
  - The hormones produced by cortex are:
    1. **Zona glomerulosa—Mineralocorticoid.**
    2. **Zona fasciculata—Glucocorticoid.**
    3. **Zona reticularis—Sex corticoids.**
  - The hormones synthesized by **medulla** include:
    1. **Epinephrine.**
    2. **Norepinephrine.**

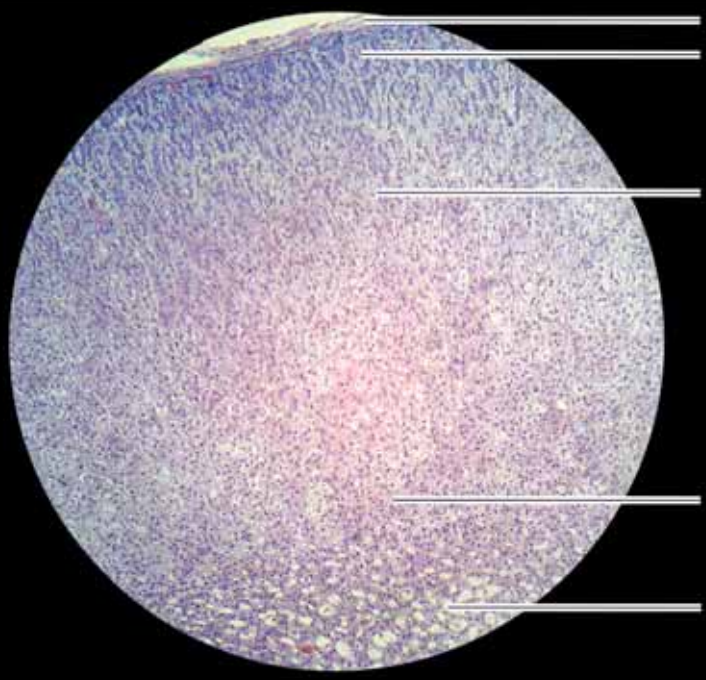
Applied Anatomy

Pheochromocytoma: They are tumors arising from chromaffin cells of the adrenal medulla. The tumor cells are polygonal in shape and are arranged in groups surrounded by a fibrovascular septa.

Viva-voce

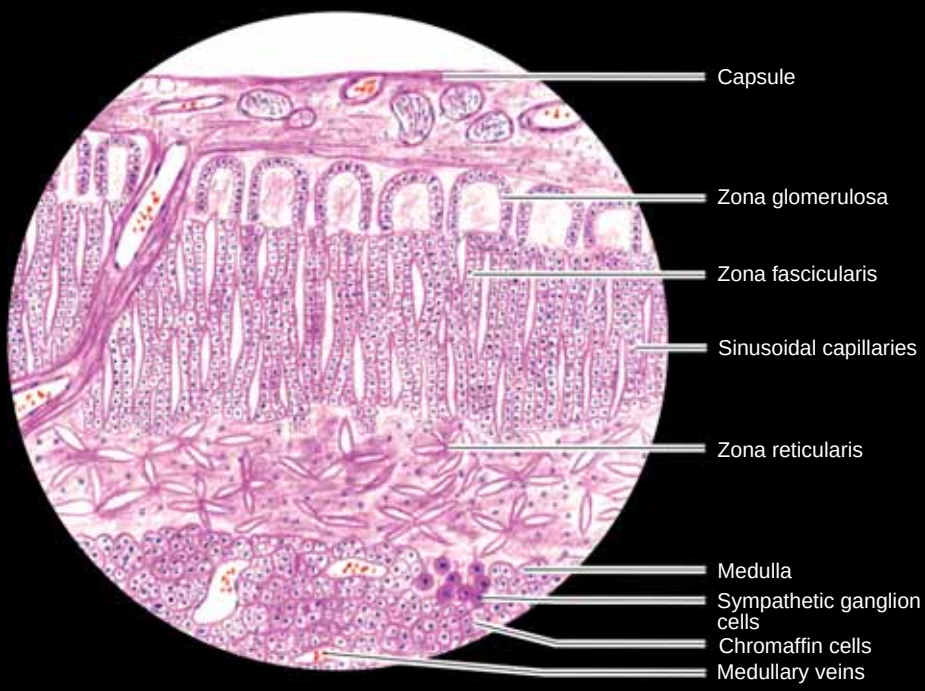
Q. How is medullary function regulated?
Ans. Through presynaptic nerves and glucocorticoids.

ADRENAL GLAND

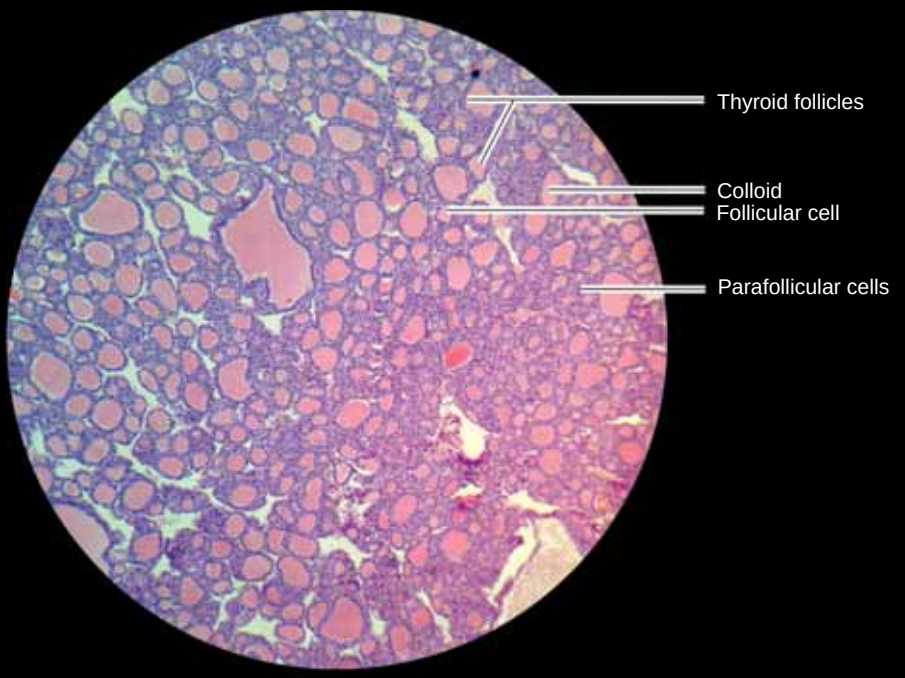


SP:-

- Presence of cortex and medulla.
- Presence of secretory cells and sympathetic neurons.

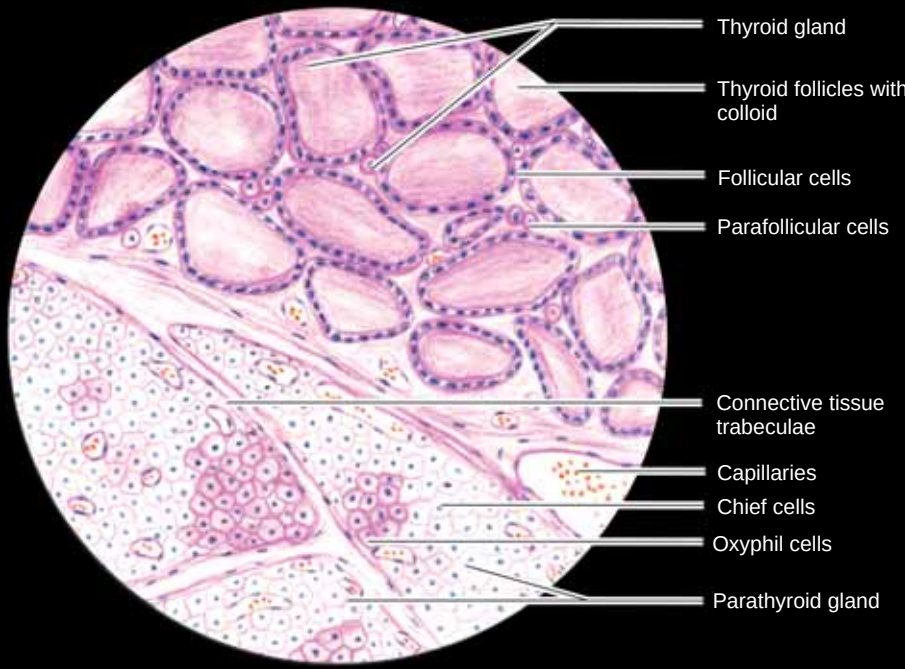


THYROID GLAND



SP:

- Presence of thyroid follicles filled with colloid.
- Presence of parafollicular cells.



THYROID GLAND

- Consists of mainly follicular cells.
- **Follicular cells** are arranged spherically into follicles.
- These **follicles** are the structural and functional units of thryoid gland.
- In highly **active follicles**, epithelium is **cuboidal** whereas in **less active ones** the epithelium is **flat**.
- All follicles are filled with colloid but some of them may show retraction due to preparation.
- **Parafollicular cells** are seen within follicular epithelium or in between follicles.
- Surrounding the thyroid follicles and follicular cells, thin interfollicular connective tissue is present containing blood vessels and capillaries.
- The follicular cells are responsible for the production of thyroid hormones.
- Parafollicular cells secrete **calcitonin**.

PARATHYROID GLAND

- They lie in close relation to thyroid gland.
- **Glands** are covered by a connective tissue capsule from which septa extend into the substance of the gland.
- The **stroma** is formed by a network of reticular fibers and adipocytes.
- The **parenchyma** consist of mainly two types of cells viz. **chief cells and oxyphil cells** which are arranged in a cord like manner.
- The **chief cells** are small round cells with vesicular nuclei.
- The **oxyphil cells** are larger cells with granules.
- The chief cells produce parathormone.
- The oxyphil cells have the ability to produce autocrine/paracrine factors (Parathyroid hormone-related protein and calcitriol).

Applied Anatomy

- In Graves disease, the follicular epithelial cells are tall and thrown into as small papillae. The papillae project into lumen of the follicle.
- In Hashimoto thyroiditis, the thyroid tissue shows dense infiltration lymphocytes and plasma cells. The lymphocytes form lymphoid follicles with germinal centers.

PITUITARY GLAND

- Mainly divided into **adenohypophysis and neurohypophysis**.
- **Adenohypophysis** consisting of **pars distalis (anterior lobe), pars tuberalis, pars intermedia**.
- **Neurohypophysis** consisting of **pars nervosa, infundibulum, and median eminence**.
- **Pars nervosa** forms the largest portion of neurohypophysis.
- **Pars distalis** consists of **chromophobe cells** (cells that do not take stain), and **chromophil cells** (cells that take stain—acidophils, basophils).
- **Pars intermedia** contains **colloid filled cystic follicles**.
- **Pars nervosa** consists of axons and supporting pituicytes with oval nuclei. It also contain accumulation of neurosecretory material called **herring bodies**.

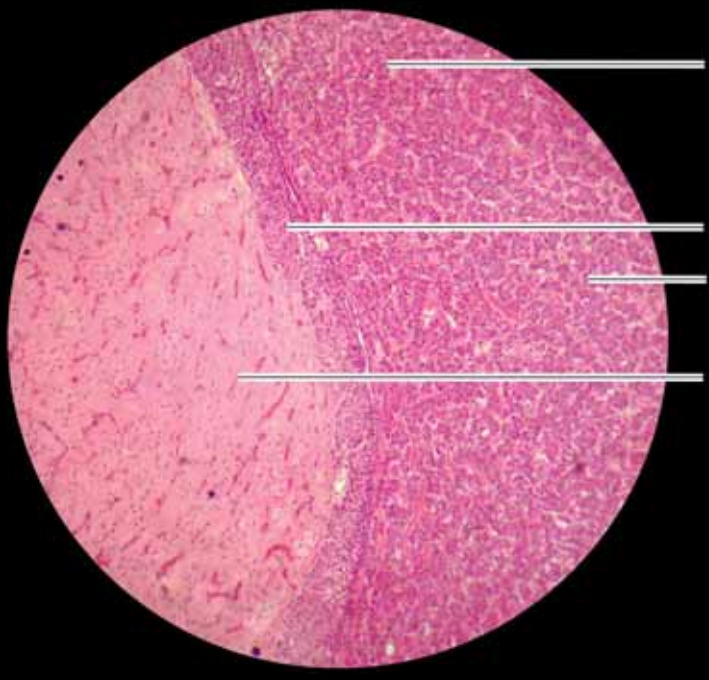
Applied Anatomy

- *Pituitary adenomas:* In this condition there will be presence of tumor cells arranged in nests surrounded by thin connective tissue. Cells can also be arranged in cord like manner.
- Damage to hypothalamus which stores antidiuretic hormone produced by neurohypophysis, causes deficiency of ADH and leads to diabetes insipidus.

Viva-voce

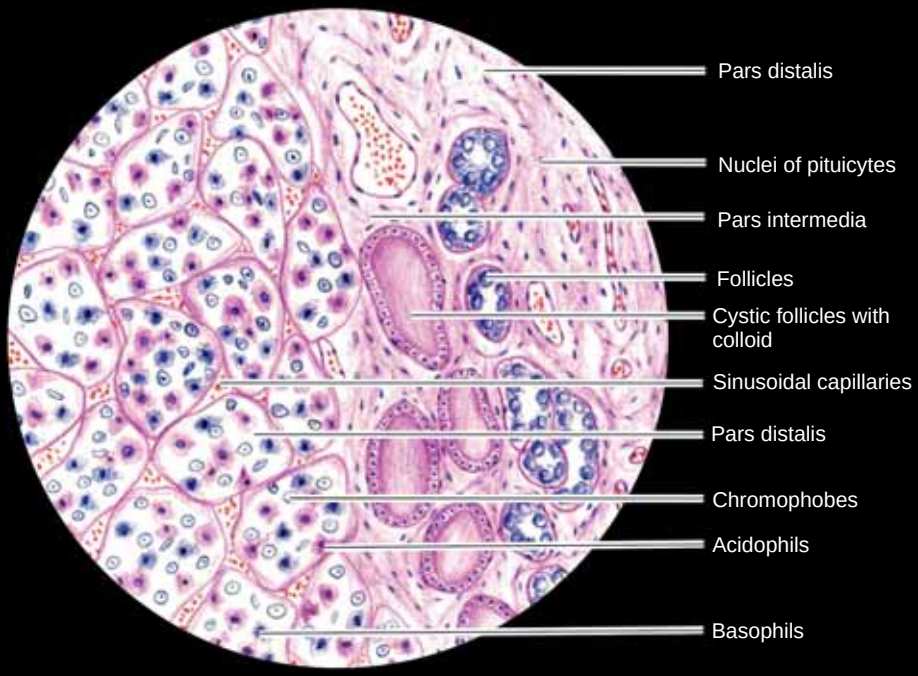
Q. What kinds of cells are in the neurohypophysis?
Ans. Pituicytes (glia), endothelial cells.
Q. What do Herring bodies represent?
Ans. Sites for storage or degradation of neurotransmitters.
Q. What hormones might you expect to find in Herring bodies?
Ans. Vasopressin (antidiuretic hormone) and oxytocin.
Q. Where are the hormones of the neurohypophysis synthesized?
Ans. Hypothalamus.
Q. What are chromophil and chromophobe cells?
Ans. Chromaphobe cells are cells that do not take stain, and chromophil cells are cells that take stain and includes acidophils, basophils.
Q. What is the functional significance of the hypothalamohypophyseal system?
Ans. It allows for rapid and direct delivery of hypothalamic products with releasing and inhibiting effects on anterior pituitary cells.

PITUITARY GLAND

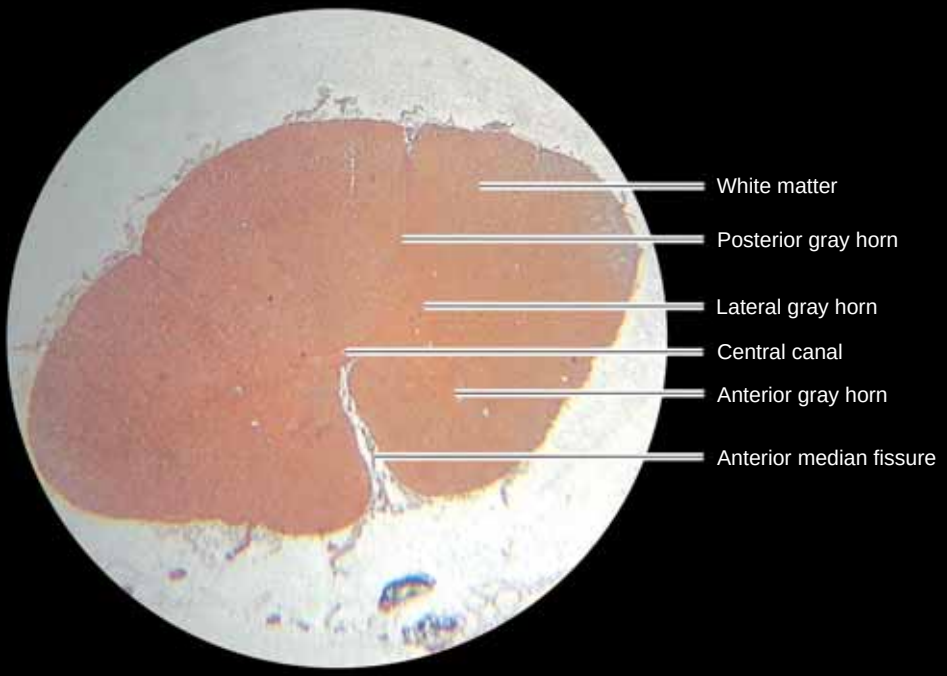


SP:

- Presence of pars anterior with acidophils and basophils
- Presence of pars nervosa with pituicytes and pars intermedius with colloid.

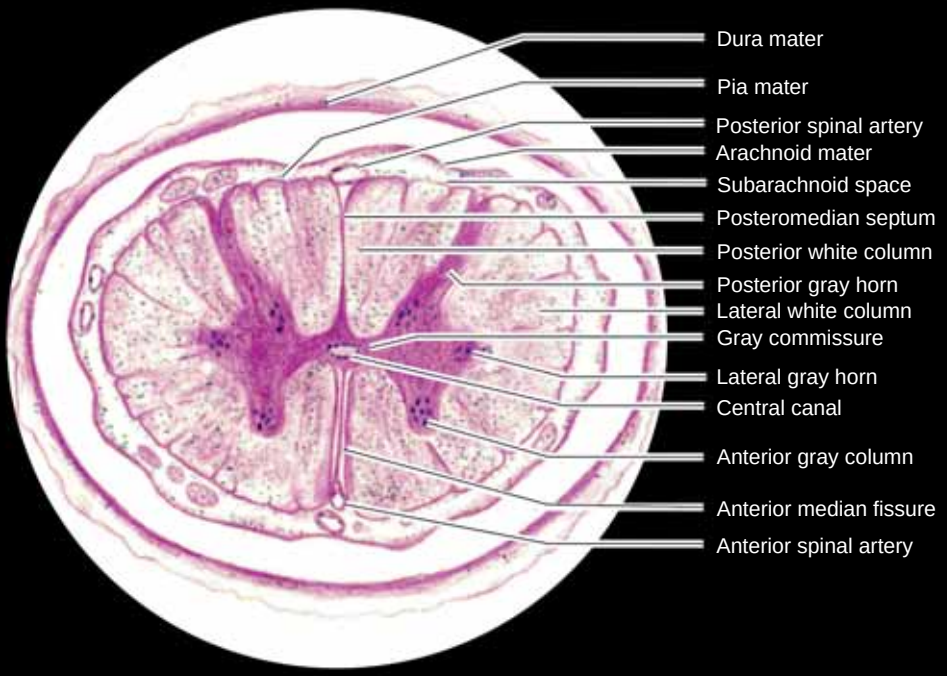


SPINAL CORD



SP:

- Presence of H shaped gray mater.
- Presence of central canal.



Central Nervous System

SPINAL CORD

- In the TS of thoracic segment of spinal cord, we can see gray matter inside and white matter on the periphery.
- **Gray matter** is almost an H shaped or butterfly shaped structure.
- Each half of the gray matter can be divided into three portions namely:
  1. **Anterior gray horn:** Large anterior mass, this region consists of multipolar motor neurons.
  2. **Posterior gray horn:** Narrow and elongated part, which is located posteriorly, **Clark's column or dorsal nucleus** is present in the medial part of the base of the posterior horn.
  3. **Lateral gray horn:** It is a wedge shaped lateral projection of gray matter between anterior and posterior gray horns. This region consists of sympathetic preganglionic visceral motor neurons.
- **Lateral gray horn** is limited to the thoracic and upper two lumbar segments of spinal cord.
- Two half's of gray matter is connected by the gray commissure at the midline.
- **A central canal** is present at the midpoint of horizontal limb of H.
- Central canal is lined by **ependymal cells** and it represents the lumen of neural tube.
- **White matter** which lies in the periphery is divided into two half's: Right and left
  1. **Anteriorly by anterior median fissure.**
  2. **Posteriorly by posterior median septum.**
- **Anterior spinal artery** is present in the anterior median fissure.
- Similar to gray matter, the white matter of each half can be divided into three portions:
  1. **Anterior white column**: White matter anterior and medial to anterior gray horn.
  2. **Posterior white column**: White matter medial to posterior gray horn.
  3. **Lateral white column**: White matter lateral to anterior and posterior gray horns.
- White matter of each half is connected to each other anteriorly by the **anterior white commissure**.
- A sulcus is present just behind the posterior most end of posterior median septum called as **posterior median sulcus**.

Applied Anatomy

- Damage to lateral horn can lead to Horner's syndrome.
- *Poliomyelitis:* Inflammation of gray matter of spinal cord.

CEREBELLUM

- **Cortex** is highly folded.
- These folds are called **cerebellar folia**.
- Folds are separated by transverse fissures called **sulci**.
- **Folium** contains an inner core of white matter and an outer cortex of gray matter covered by the thin connective tissue called **pia mater**.
- **Cortex** consists of 3 layers:
  - **External molecular layer:** Superficial layer, thick, and made of nerve fibers and cells: **stellate cells** above and basket cells below.
  - **Purkinje cell layer:** Made up of **Purkinje cells** (Large sized, flask shaped neurons arranged between molecular and granular layer in single row).
  - Dendrite of Purkinje cells synapses with axons of granular cells.
  - **Granular layer:** Densely packed with very small granule neurons (smallest cells in the body), they exhibit intensly stained nuclei, few Golgi cells are also present.
  - Dendrite of granule cells and axons of Golgi cells synapses with mossy fibers to form glomeruli (lightly stained).
  - **Mossy fibers** are afferent fibers ending in granular layer.
  - **White matter** consists of myelinated nerve fibers.

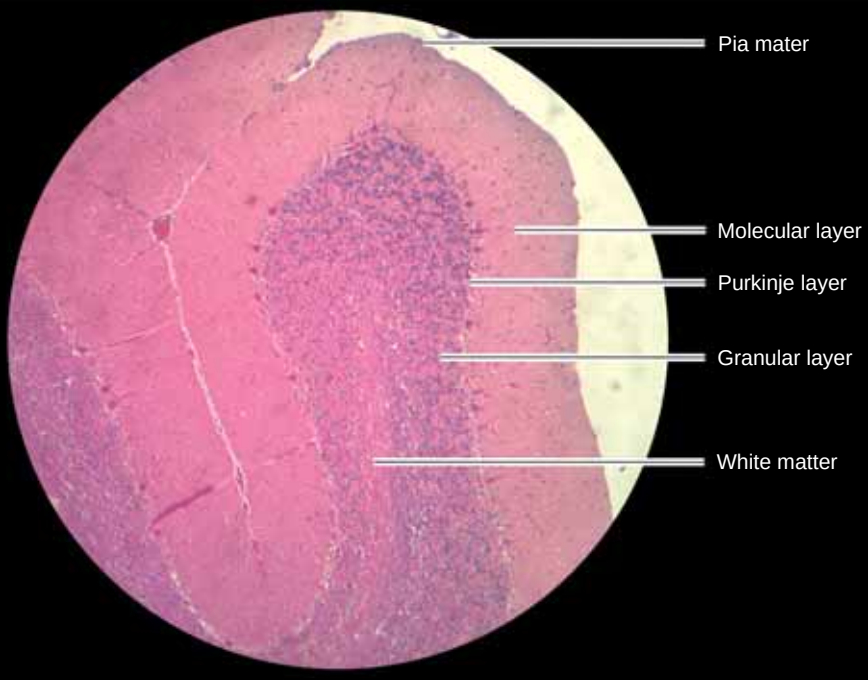
Applied Anatomy

- Rett syndrome is a cerebellar pathology characterized by loss of Purkinje cells, atrophy, astrocytic gliosis of the molecular and granular layers.
- Cerebellar diseases result in lack of coordination and disturbances of accuracy movements causing a constellation of symptoms and motor signs.

Viva-voce

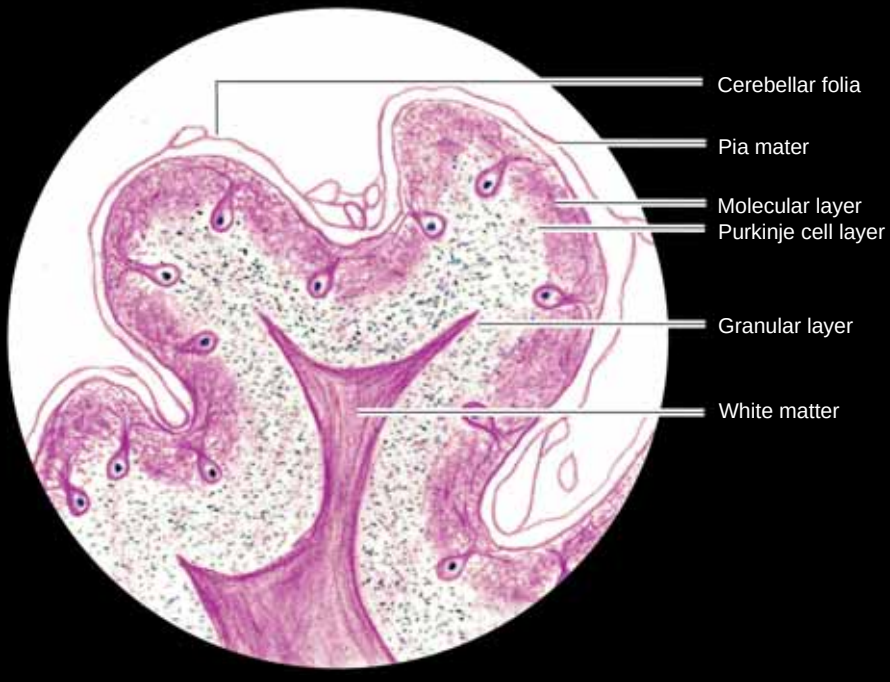
Q. What are Purkinje cells?
Ans. These are large sized, flask shaped neurons arranged between molecular and granular layer in single row.
Q. What are the characteristics of granular layer?
Ans. The layer is densely packed with very small granule neurons (smallest cells in the body), they exhibit intensly stained nuclei, and few Golgi cells are also present.
Q. What are mossy fibers?
Ans. These are afferent fibers ending in granular layer.

CEREBELLUM

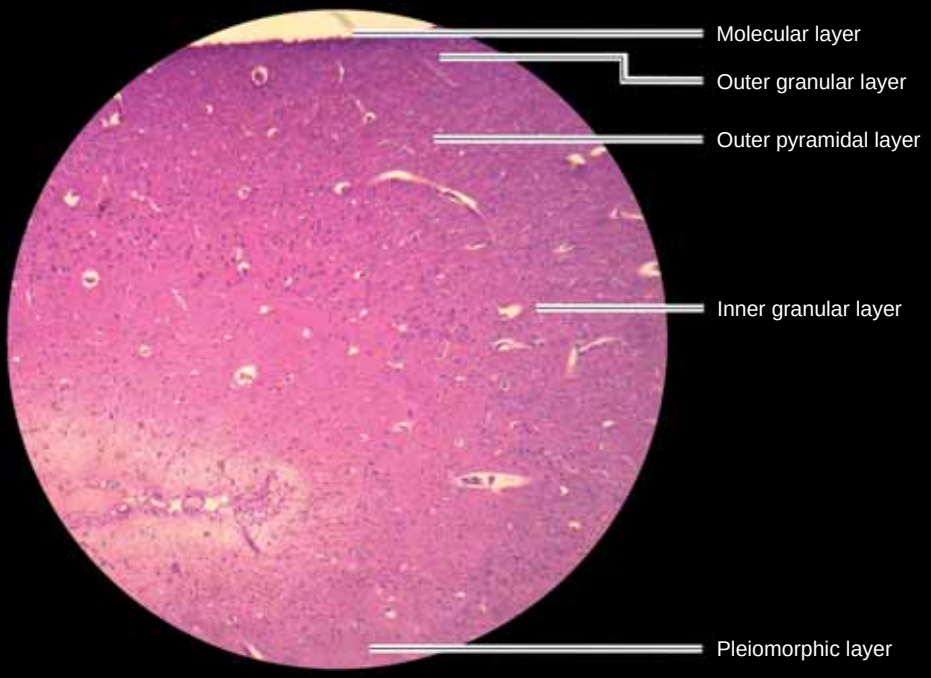


SP:

- Presence of molecular layer and granular layer and white mater.
- Presence of Purkinje cells in Purkinje cell layer.

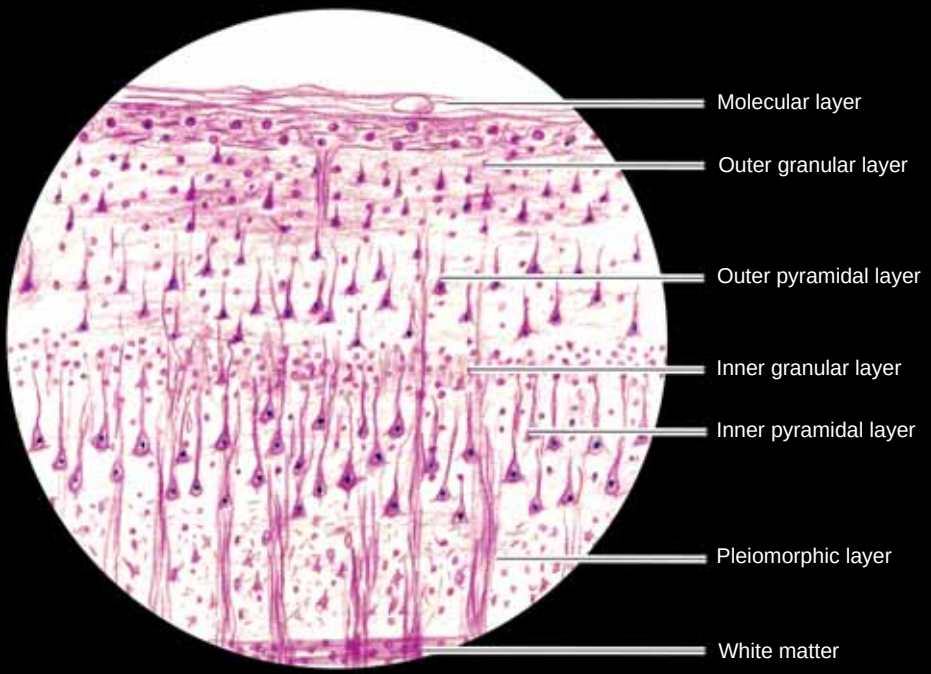


CEREBRUM



SP:

- Presence of superficial pia mater and inner white matter.
- Presence of stellate cells and giant pyramidal cells.



CEREBRUM

- Cortex is made up of gray matter.
- Cortex consists of nerve fibers, nerve cells, neuroglia and blood vessels.
- **Neuroglia** are highly branched cells that support neurons.
- Made up of six layers of nerve cells and associated fibers.
- A layer called **superficial pia mater** also present, it is a layer of pia mater overlying and covering the molecuar layer.
- Layers from above to below.
  - **Molecular layer/plexiform layer**—superficial layer, well defined, mainly consists of **neuroglial cells** and **horizontal cells of Cajal**.
  - **External granular layer**—it consists of **stellate cells** and **small pyramidal cells**.
  - **External pyramidal layer**—made up of mainly medium sized pyramidal cells, few stellate cells and **cells of Martinotti** (small multipolar cells).
  - Internal granular layer it is a thin layer containing stellate cells which are closely packed and nerve fibers which are arranged horizontally called as outer band of Baillarger.
  - **Internal pyramidal layer/ganglionic layer**—consists of numerous **large pyramidal cells (Betz cells)** located mainly on the motor area, also contains few stellate cells and cells of Martinotti. The nerve fibers are arranged horizontally called as **inner band of Baillarger**.
  - **Multiform layer**—polymorphic cell layer, deepest layer, contains mainly **fusiform cells**, few **stellate cells** and also **cells of Martinotti** are present. They are mixed with nerve fiber which runs from and to the white matter beneath.

Applied Anatomy

- In Huntington disease (autosomal dominant), striatal neurons are lost from cerebral cortex and putamen.
- *Ganglioglioma:* Tumor affecting temporal lobe. There will be presence of a mixed population of neoplastic astrocytes and abnormal ganglion cells.

Viva-voce

Q. What is inner band of Baillarger?
Ans. The nerve fibers of the pyramidal layer are arranged horizontally. And this is known as inner band of Baillarger.
Q. Where are horizontal cells of Cajal present?
Ans. They are present in the molecular or plexiform layer.

CHAPTER

2

Embryology

General Embryology

EMBRYOGENESIS (FIG. 1)

- Sperm + oocyte → Zygote → Cleavage → Morula → Differntiate → Inner cell mass (embryoblast) + trophoblast → Blastocyst → Embryonic Disc
- Inner cell mass (Embryoblast) has two parts:
  1. Epiblast (Ectoderm) → Embryo, amnion
  2. Hypoblast (Endoderm) → Yolk sac
- Trophoblast → Syncytiotrophoblast + Cytotrophoblast → Placenta (fetal part).

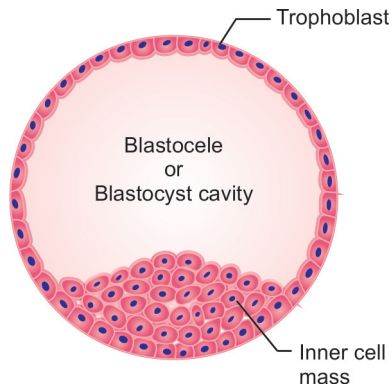


Fig. 1: Blastocyst

IMPLANTATION (FIG. 2)

- Post shedding of the ovum, it reaches uterus via uterine tubes and undergoes fertilization.
- A fertilized ovum as it reaches uterus, it would have become a morula.
- Trophoblast cells of embryo have a property to stick to any tissue which it comes in contact with.
- Morula covered by zona pellucida prevent morula from sticking to the walls of uterine tube.
- After zona pellucida disappears the trophoblast cells become exposed and gets sticked to uterine endometrium. This is known as implantation.

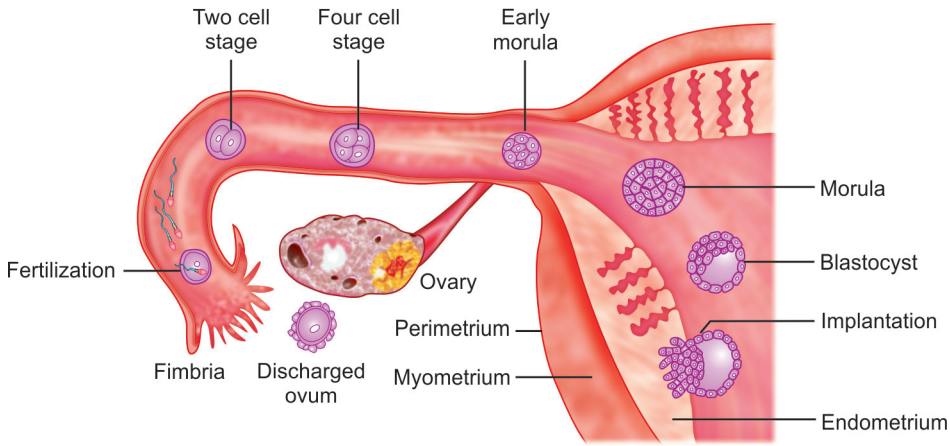


Fig. 2: Implantation

Interstitial Implantation

In humans, the trophoblast of blastocyst after sticking to the uterine endometrium burrow and grow deep into it and finally whole of embryo comes under the substance of endometrium.

Applied Anatomy

Abnormal Implantation

- *Extra uterine implantation/Ectopic pregnancy*: Sites include ovary, uterine tubes, abdominal cavity (common), very rarely in caesarian scar.
- *Abnormal intrauterine implantation*: Placenta previa, it occurs in the lower part of uterine cavity.

DECIDUA (FIG. 3)

- Uterine endometrium after implantation is known as decidua.
- Stromal cells become enlarged and vacuolated and stores glycogen and lipids, also nuclei become rounded, volume of cell increases, etc. this change in stromal cells is termed as decidual reaction.
- Decidua consists of three parts:
  1. *Decidua basalis:* Maternal source of placenta, firmly attached to chorion, present at embryonic pole and also called decidual plate and contain large cells with high lipid content.
  2. *Decidua capsularis:* Separates embryo from uterine lumen.
  3. *Decidua parietalis:* It lines the uterine cavity.

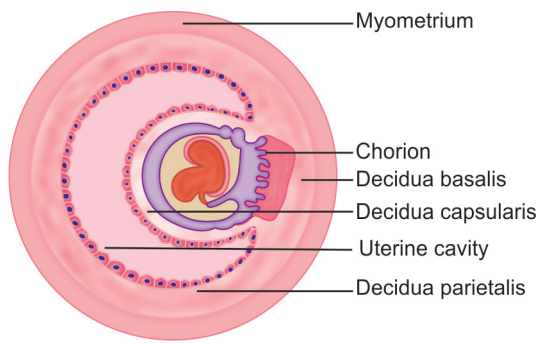


Fig. 3: Decidua

EMBRYONIC DISC AND GERM LAYERS (FIG. 4)

- Some cells of the inner cell mass differentiate into flat cells and come to lower end and form endoderm, remaining cells become columnar and form ectoderm.
- A space arises between trophoblast and ectoderm called amniotic cavity.
- Some cells of trophoblast gets seperated and forms the roof of amniotic cavity. These cells are called amniogenic cells.
- Flat cells from endoderm cover blastocystic cavity and the newly formed cavity is called primary yolk sac.
- The cells of trophoblast form a mass called extra embryonic mesoderm. Gradually small spaces form inside these mass of cells and form a cavity called extraembryonic celom.

- As a result extraembryonic mesoderm is split into 2 layers—the outermost part called somatopleuric or parietal extraembryonic mesoderm and innermost, i.e. just outside the yolk sac called the splanchnopleuric or visceral extraembryonic mesoderm.
- But the extraembryonic celom is not continuous where extraembryonic mesoderm attaches the amniotic cavity to trophoblast. And this unsplit part of extraembryonic mesoderm forms the **connecting stalk**.
- **Chorion** is formed by parietal extraembryonic mesoderm and overlying trophoblast.
- **Amnion** is formed by amniogenic cells derived from trophoblast.
- The primary yolk sac undergoes reduction in size and cells become cubical forming **secondary yolk sac**.
- In the disc formed, in an area near the margin, the cubical cells of endoderm becomes columnar and this area is called **prochordal plate**.
- Soon some of the cells lying along the central axis of prochordal plate proliferate and bulge and form elevation called **primitive streak**.

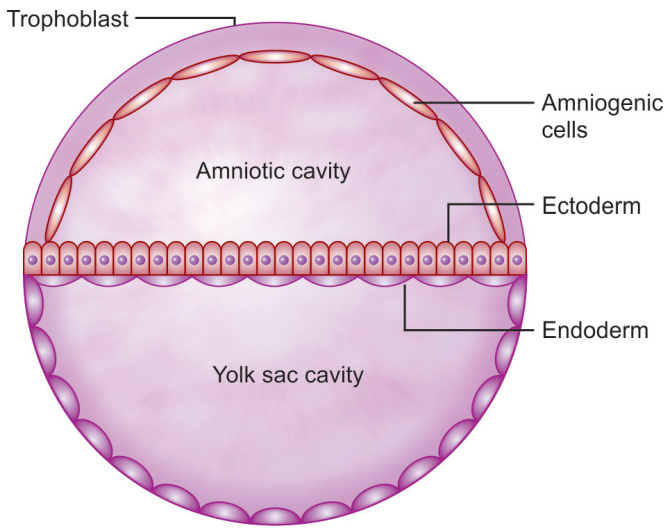


Fig. 4: Embryonic germ layers

INTRAEMBRYONIC MESODERM

- Cells present on both sides of primitive streak proliferates, these cells migrate craniolateraly between endoderm and ectoderm layers and forms the intraembryonic mesoderm. It get's divided into four parts:
  1. **Paraxial mesoderm** → somites, neuromers.
  2. **Intermediate cell mass** → nephrons, smooth muscles and connective tissue of respiratory system.
  3. **Lateral plate mesoderm** → somatopleuric mesoderm, splanchnopleuric mesoderm and septum transversum.
  4. **Endothelium** of vessels and endocardium of heart.

SOMITES

- Paraxial mesoderm on either side of notochord differentiates, which gives rise to cuboidal paired bodies, known as somitomeres which further differentiates into somites.
- It extends from cranial end of notochord to coccygeal end, somites contains a slit like cavity called **myocele**.
- Each somite is subdivided in to three parts, each part give rise to specialized structure they are:
  1. **Sclerotome** (ventromedial part)—gives rise to vertebral column and ribs.
  2. **Dermatome** (lateral part)—gives rise to dermis of skin and subcutaneous tissue.
  3. **Myotome** (intermediate part)—gives rise to striated muscles.

NOTOCHORD (FIG. 5)

- The cranial end of primitive streak gets thickened and this part is known as **primitive knot**.
- A depression appears in the center of primitive knot called as **blastopore**. Cells in the primitive knot multiply and pass cranially in between ectoderm and endoderm and reaches the caudal margin of prochordal plate resulting in formation of a solid cord known as **notochordal process**.
- The cells of notochordal process undergoes various degree of rearrangements and finally forms a solid rod called **notochord**.
- Notochord mostly disappears after development but small portion of it persist as **nucleus pulposes** in intervertebral discs.

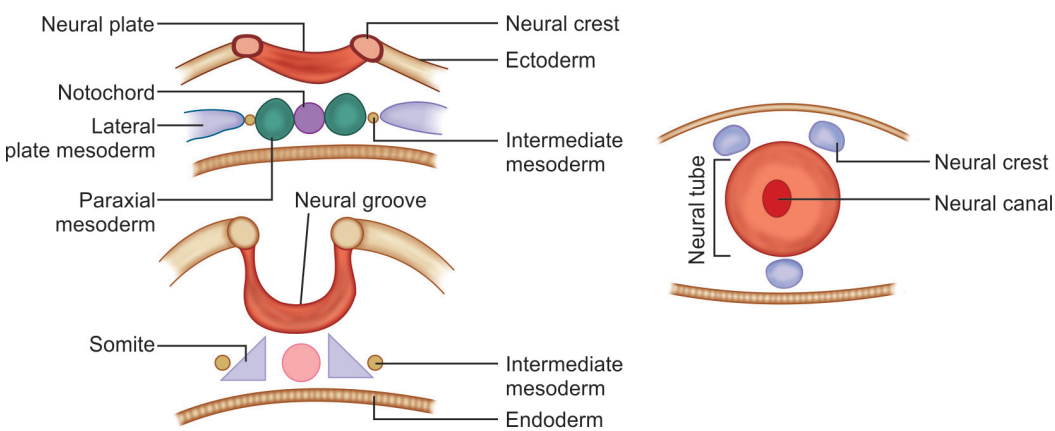


Fig. 5: Notochord and neural tube formation

NEURULATION

- It is the process of formation of neural tube from the precursor neural plate and neural folds. Ectoderm overlying the notochord undergoes thickening.
- This thickened plate is known as **neural plate**.
- Notochord induces the formation of neural plate.
- Neural plate gets depressed in the midline to form **neural groove**.
- Neural groove has raised lateral edges known as the **neural folds**.
- Neural folds begins fusing at the middle and the fusion extends cranially and caudally.
- Since initially the middle part is becoming tubular, the neural tube opens cranially and caudally, forming the **anterior neuropore** and **posterior neuropore** respectively.
- Anterior neuropore closes 2-3 days before the the closure of posterior neuropore.
- Neurulation is completed by the complete closure of the neuropores, resulting in formation of **neural tube**.
- Neural tube can be divided into:

1. Enlarged cranial part → Brain
   - Prosencephalon
   - Mesencephalon
   - Rhombencephalon
2. Tubular caudal part → Spinal cord.

NEURAL CREST

- During the formation of neural plate few cells located between neural plate and rest of ectoderm undergo differentiation and become specialized.
- These specialized neuroectodermal cells are called **neural crest** cells.
- At the point of separation of neural tube from ectoderm surface, the neural crest cells lies on the dorsolateral aspect of neural tube.
- Later, the neural crest cells becomes free and migrate to distant sites, they mainly forms the peripheral nervous system.
- Structures derived from neural crest include arachnoid and piamater, neurons of dorsal root ganglion, Schwann cells, melanoblasts, chromaffin tissue, cardiac semilunar valves, tooth enamel, thyroid parafollicular cells, derivatives of pharyngeal arches, etc.

LAMINA TERMINALIS

- Derived from wall of neural tube.
- Closes cranial end of **prosencephalon**.

PLACENTA (FIG. 6)

- Formed from two sources:
  1. Fetal source — **chorion frondosum**
  2. Maternal source — **decidua basalis**
- The essential part of placenta is chorionic villi surrounded by maternal blood and fetal blood circulates through capillaries in villi.
- Syncytiotrophoblast part of trophoblast proliferates and grow towards the decidua basalis and capsularis.
- Trophoblast proper with primary mesoderm forms chorion.
- Lacunar spaces appear within the syncytiotrophoblast and decidua basalis.
- Trabeculae containing cords of syncytial cells are present between these lacunar spaces.
- Lacunae enlarge and contain uterine vessels.
- Then the cytotrophoblast extends in to the core of trabeculae, converts them in to **primary chorionic villi**.
- Now lacunar spaces are called **intervillous spaces**.
- In the development of chorionic villi it undergoes 3 stages:
  1. **Primary villi** consisting of a central core of cytotrophoblast covered by syncytiotrophoblast.
  2. **Secondary villi** having layers extraembryonic mesoderm, cytotrophoblast and syncytiotrophoblast.
  3. **Tertiary villi** having blood capillaries in extraembryonic mesoderm.
- Cytotrophoblast spreads outwards at tips of primary villi, resulting in outer cytotrophoblastic shell.
- Primary mesodermal cells invade central core of primary villi to form secondary villi.
- Fetal vessels derived from umbilical vessels appear within primary mesoderm, forming the tertiary villi.
- Tertiary chorionic villi attached to decidua basalis forms the chorion frondosum. Rest of the villi attached to the embryonic pole degenerates. This results in the formation of placenta from chorion frondosum and decidua basalis.

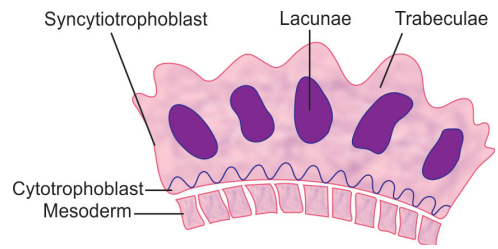


Fig. 6: Chorionic villi formation

Anomalies

- **Chorion epithelioma:** It is a malignant tumor, results when endometrium is too resistant to blastocyst.

Systemic Embryology

PHARYNGEAL ARCHES (FIG. 7)

- Series of mesodermal thickenings appear in the wall of cranial part of primitive foregut, known as **pharyngeal arches**.
- Each arch contains an outer lining of **ectoderm**, inner core of **mesoderm**, and an inner lining of **endoderm**.
- At first there will be **six arches**, later the **fifth arch disappears**.
- Each arch extends in to the floor of primitive pharynx and meet's its corresponding arch at the midline.
- At this stage the cranial end of pharynx is separated from stomatodeum by **buccopharyngeal membrane**.
- Buccopharyngeal membrane ruptures soon.
- In the gap between successive arches the endoderm is pushed outside and ectoderm is pushed inside, giving rise to endodermal pouches and ectodermal clefts respectively.
- Each pharyngeal arch consists of 3 elements:
  1. **Skeletal element:** It is cartilaginous in beginning, it remains as such or form bone or disappears.
  2. **Striated muscle:** Supplied by special nerve of the arch, first attached with skeletal elements, may retain or not retain these attachments in future. May subdivide to give distinct muscles. Sometimes these muscles moves away from arch but takes it's nerve with it.
  3. **Arterial arch (aortic arch):** Arteries develop ventral and dorsal to foregut, known as ventral and dorsal aortae respectively. Two arteries of a pharyngeal arch are connected by an aortic arch of its own. Artery gets modified during the course of time.
- Important derivatives of pharyngeal arches:
  - **First arch (mandibular arch):** Meckel's cartilage, maleus, incus, muscles of mastication, etc.
  - **Second arch (hyoid arch)** → Superior part of hyoid, stapes, styloid process, muscles of face, etc.
  - **Third arch** → Greater part of hyoid, stylopharyngeus, etc.
  - **Fourth arch and sixth arch** → Larynx (cartilaginous part), muscles of larynx and pharynx, etc.

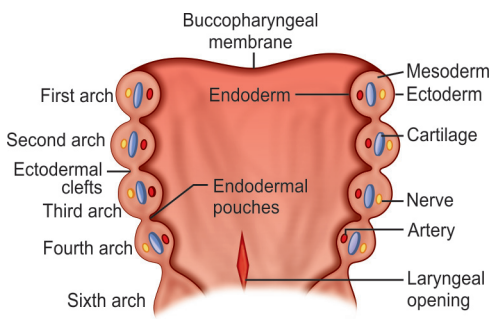


Fig. 7: Pharyngeal arches

PALATE (FIG. 8)

Palate is developed from:
- **Maxillary process**, which is two in number.
- **Frontonasal process**

Steps of Fusion

- From each maxillary process, a plate like shelf grows medially known as **palatal process**.
- Primitive palate is formed by the fusion of medial nasal folds.
- Medial nasal folds are folds of frontonasal process.
- Now palate proper is formed by the fusion of these three components, i.e. two palatal processes and one primitive palate.
- Each palatal process fuses with posterior margin of primitive palate.
- Each palatal processes fuses with each other at midline.
- Also palatal process fuses with lower free edge of nasal septum separating nasal cavity into two.
- Most of palate gets ossified to form **hard palate** and unossified posterior part forms **soft palate**.

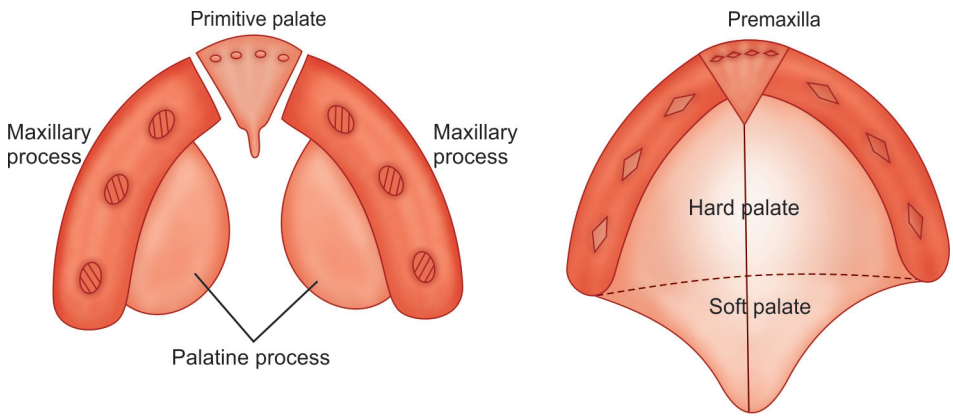


Fig. 8: Development of palate

Cleft Palate

It is a developmental anomaly (Fig. 9) due to defective fusion of various components of palate.

1. Bilateral complete cleft palate
   - Occurs due to complete non-fusion.
   - Give rise to Y-shaped cleft.
   - Associated with bilateral cleft lip.
2. Unilateral complete cleft palate
   - Due to complete arrest of fusion of palatine process of one side with primitive palate and nasal septum.
   - Associated with unilateral hair lip.

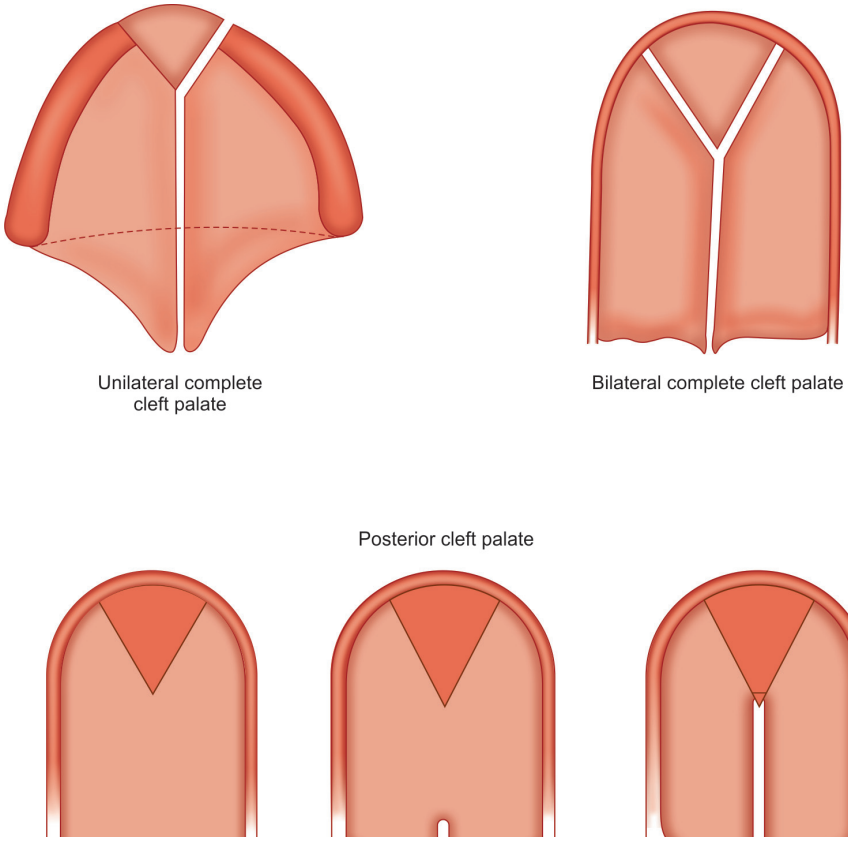


Fig. 9: Anomalies of palate

3. Partial midline cleft
   - Due to complete failure of fusion of palatine process with each other.
4. Cleft of soft palate
   - Due to complete failure of fusion of palatine process with each other in the dorsal ¼ part.

FACE (FIG. 10)

- Face develops from various processes (eminences), that develop around the stomatodeum, due to proliferation of underlying mesoderm.
- The neural crest cells that migrate into the head and neck region are responsible for the differentiation of mesoderm.
- The various processes are:
  1. Frontonasal process
  2. A pair of mandibular and maxillary processes
  3. A pair of lateral and medial nasal processes
- Mesoderm infront of the prosencephalon proliferates and forms the frontonasal process.

- **Mandibular process** (formed from mandibular arch) develops dorsolaterally to stomatodeum and it is directed medially.
- **Maxillary process** is formed as a branch from the dorsolateral part of mandibular process.
- On each side of frontonasal process, an ectodermal elevation occurs called as **nasal placodes or olfactory placodes**.
- Mesoderm surrounding the margins of nasal placodes starts to proliferate and gets raised.
- As a result the nasal placodes sinks and this give rise to **nasal pits or olfactory pits**.
- The raised margins are divided in to two:
  1. **Medial nasal process**, present medially
  2. **Lateral nasal process**, present laterally
- Frontonasal process gives rise to forearm, dorsum of nose and nasal septum.
- Mandibular process grows medially and fuses with each other, resulting in formation of lower jaw, lower lip, etc.
- Mandibular and maxillary processes combinedly gives rise to cheeks, in addition maxillary process forms the lateral part of upper lip.
- Medial nasal process fuses with each other and forms the **philtrum**.
- Lateral nasal process gives rise to lateral wall of nose.

Anomalies

Macrostomia: Due to incomplete fusion of mandibular and maxillary processes leading to large mouth.

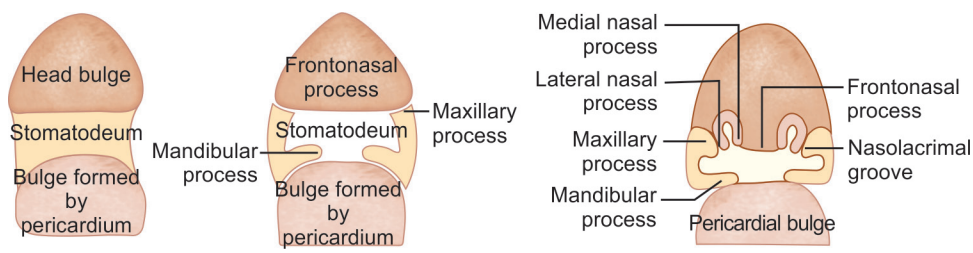


Fig. 10: Development of face

UPPER LIP

Developed principally from fusion **lateral and medial nasal process** with **right and left maxillary process**.

Steps of Fusion

- **Maxillary and lateral nasal process** are initially separated by a **nasolacrimal groove**.
- Both maxillary process grows medially.

- Maxillary process first fuses with lateral nasal process.
- Secondly fuses with medial nasal process.
- Medial and lateral nasal process also then fuses with each other.
- Median part of upper lip or philtrum is derived from **frontonasal process**.
- By the formation of upper lip, nasal pits are cut off from the stomatodeum.

TONGUE (FIG. 11)

- Medial most part of first pharyngeal arches proliferates and forms two **lingual swellings**.
- Lingual swellings are partially separated by a median swelling called **tuberculum impar**.
- Another midline swelling called **hypobranchial eminence** is also formed from mesoderm of 2nd, 3rd, and 4th arches.
- Anterior 2/3rd of tongue is formed by the fusion of two lingual swellings with tuberculum impar.
- The cranial part of hypobranchial eminence (3rd arch) give rise to posterior one third of tongue.
- Posterior most part is formed from fourth arch.
- Connective tissue is derived from mesenchyme.
- Tongue muscles are derived from **occipital myotomes**.

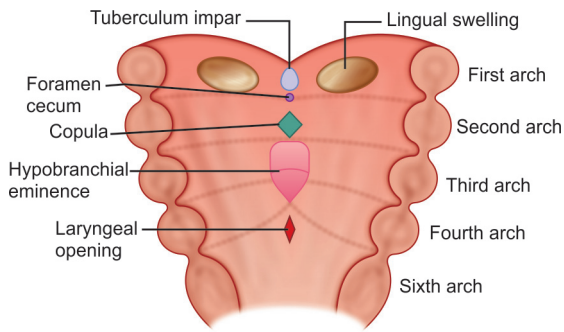


Fig. 11: Tongue

Anomalies

Ankyloglossia (Tongue tie): Here frenulum extends to tip of tongue as a result tongue become anchored to floor of mouth.

THYROID GLAND (FIG. 12)

- Thyroid gland develops from an endodermal **thyroid diverticulum** arising from the floor of pharynx.

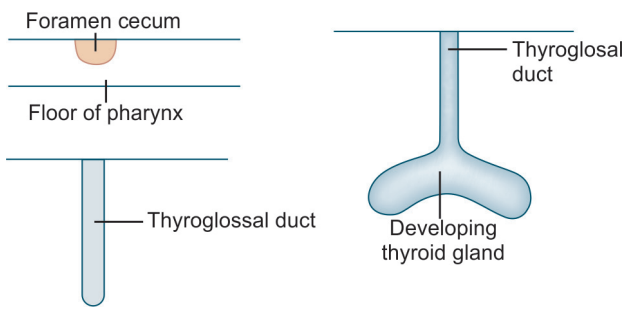


Fig. 12: Thyroid gland

- At the floor of pharynx, medial ends of two mandibular arches are separated by a midline swelling called **tuberculum impar**.
- Endodermal cells dorsal to tuberculum impar proliferate to cause a surface elevation at the midline (at the junction of anterior one-third and posterior two-thirds of tongue).
- Later, this elevation get depressed and cells get evaginated caudally, and forms a narrow thyroid diverticulum.
- It grows downwards into the neck. As the lower end of diverticulum reaches ventral to the proximal part of trachea, it bifurcates and forms a bilobed mass. This bilobed mass develops into thyroid gland.
- Rest of diverticulum remains narrow and is known as thyroglossal duct (usually disappears).
- The cranial end of disappeared thyroglossal duct persist as foramen cecum.
- Lower end of thyroglossal duct may persist as pyramidal lobe.
- Parafollicular cells are derived from caudal pharyngeal complex called ultimobranchial body.
- Remnants of thyroglossal ducts may sometimes results in thyroglossal fistula.

LUNGS

- Lungs developed from lung buds which develops at the caudal end of laryngotracheal tube.
- It divides into two knob like bronchial buds, which grows into celomic ducts, the primordia of pleural cavities.
- They are surrounded by splanchnic mesenchyme.
- Each bronchial bud enlarges to form primary bronchus.
- Primary bronchus on right side forms superior and inferior secondary bronchi, on the left side forms two secondary bronchus for superior and inferior lobes.
- Secondary bronchus forms tertiary bronchus. Ten on right and nine on left side each.
- And surrounding mesenchyme gives rise to a bronchopulmonary segment.
- Cartilage, smooth muscles, connective tissue, and capillaries are derived from surrounding splanchnic mesenchyme.
- Visceral pleura from splanchnic mesoderm and parietal pleura from somatopleuric mesoderm.

HEART TUBE (FIG. 13)

- Mesodermal in origin.
- During 3rd week angioblastic cords are formed from intraembryonic mesoderm.
- Angioblastic cords are paired endothelial strands formed in cardiogenic area.
- Cords undergo canalization and forms heart tubes.
- Firstly heart is right and left endothelial tubes which fuse together to form single tube.
- Single tube undergo dilatation separated by constrictions from top to bottom.

- These dilatations from above to below are later identified as:
  1. Bulbus cordis has three parts:
     i. *Truncus arteriosus*: Distal 1/3rd part, forms ascending aorta and pulmonary trunk, truncus arteriosus continuous distally with aortic sac.
     ii. *Conus*: Middle 1/3rd, forms outflow tracts of ventricles.
     iii. *Proximal* 1/3rd part, forms primitive right ventricle
  2. Primitive ventricle, form trabeculated part of left ventricle.
  3. Primitive atrium
  4. Sinus venosus
- Sinus venosus has prolongations at caudal end called right and left horns.
- Each horn is joined by a vitelline vein,umbilical vein and common cardinal vein.

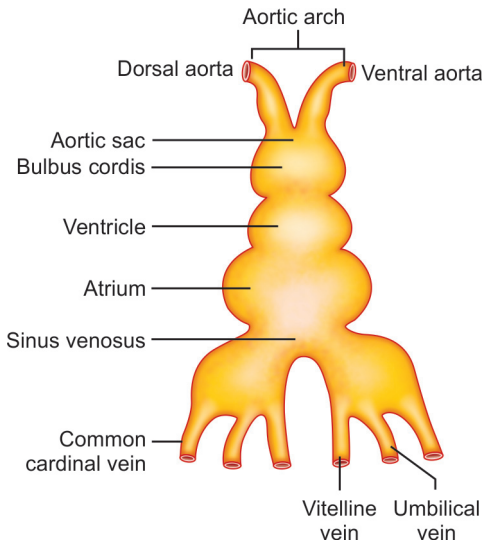


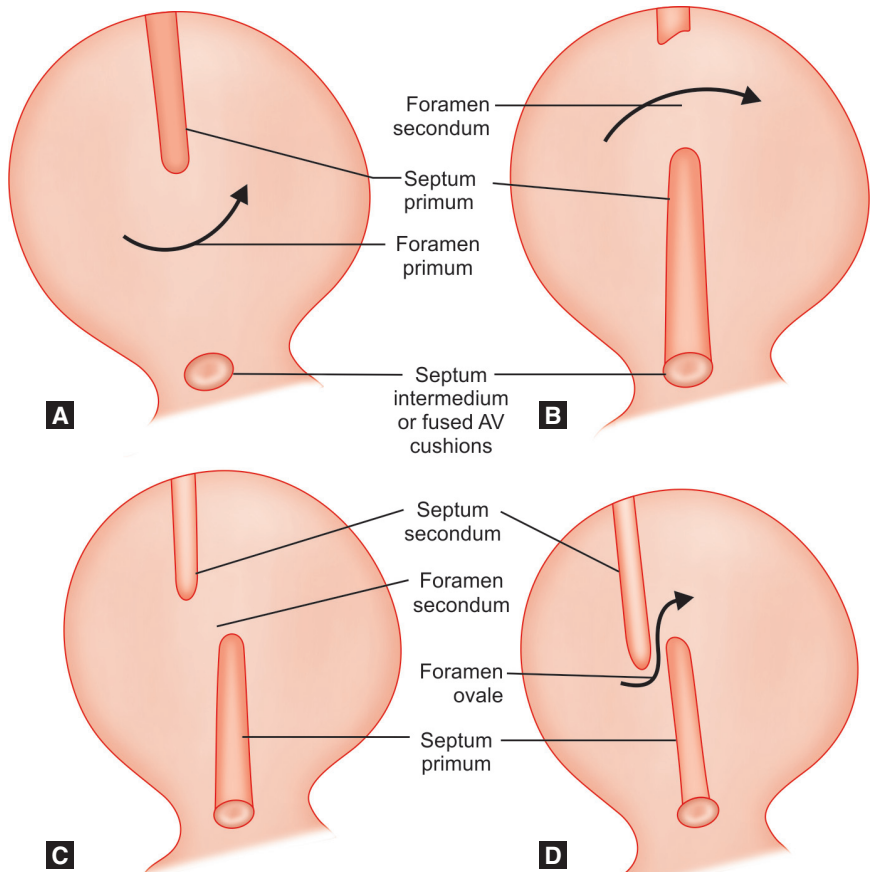
Fig. 13: Heart tube

RIGHT ATRIUM

- Mainly formed from the right half of primitive atrium.
- Rough anterior part develops from right horn of sinus venosus.
- Sinus venosus and right half of atrioventricular canal get absorbed into right atrium.
- Smooth posterior part along with right auricle develops from primitive atrium.

INTERATRIAL SEPTUM (FIGS 14A TO D)

- It develops from two septa (septum primum and septum secondum) arising from the roof of atrial chamber.
- Septum primum arise from roof of atrial chamber and grows downwards towards septum intermedium.
- Initially there will be a gap between septum primum and septum intermedium known as foramen primum.
- Finally septum primum fuses with septum intermedium.
- Before the fusion, the upper part of septum primum breaks down leaving a free upper edge.
- And a new foramen is created known as foramen secondum.
- Another septum called as septum secondum start to grow from the right of the septum primum, towards septum intermedium.
- Another septum called as septum secondum start to grow from the right of the septum primum, towards septum intermedium.
- Septum secondum overlaps the upper margin of septum primum, creating an oblique passage between septum primum and secondum called as foramen ovale.
- In fetal life, foramen ovale allows the blood to flow from right to left atrium.



Figs 14A to D: Development of interatrial septum

- Finally by the fusion of septum secondum and septum primum, the foramen ovale is obliterated.
- Thus upper and lower half of interatrial septum is formed by septum secondum and primum respectively.

FALLOT'S TETRALOGY

Congenital condition characterized by:

- Stenosis of pulmonary trunk.
- Large ventricular septal defect.
- Overriding of aortic orifice above VSD
- Right ventricular hypertrophy due to high BP in RV.
- Results in severe cyanosis.

DIAPHRAGM

- Central tendon from septum transversum.
- Dorsal paired portion of diaphragm from pleuroperitonial membrane. Circumferential portion from lateral thoracic wall.
- Dorsal unpaired portion from dorsal mesentery of esophagus.

Gut

Endoderm differentiates into foregut, midgut and hindgut.

FOREGUT DERIVATIVES

Epithelium of pharynx, esophagus, stomach, duodenum till ampulla of Vater, respiratory system auditory tube and mucous membrane of tongue, parenchyma of liver, pancreas, thyroid, parathyroid, etc.

MIDGUT DERIVATIVES

Epithelium of duodenum from ampulla of Vater to junction of right 2/3rd and left 1/3rd of transverse colon.

HINDGUT DERIVATIVES

Mucous membrane of large intestine from left 1/3rd of transverse colon to mucocutaneous junction of anal canal, parenchyma of prostate, epithelium of urinary bladder, urethra, etc.

ESOPHAGUS

- Developed from posterior most part of foregut.
- It is short in the beginning but it lengthens quickly due to descend of heart and lungs.
- Musculature is derived from the splanchnic mesenchyme surrounding the foregut.

STOMACH (FIG. 15)

- Distal part of foregut shows a fusiform dilatation.
- This dilatation represents the primitive stomach.
- Primitive stomach has anterior and posterior borders, right and left surfaces. The posterior border grows faster than anterior border.
- It undergoes 90 degrees clockwise rotation along vertical axis.
- As a result left and right surfaces becomes anterior and posterior surfaces, posterior and anterior borders give rise to greater (left border) and lesser (right border) curvatures respectively.

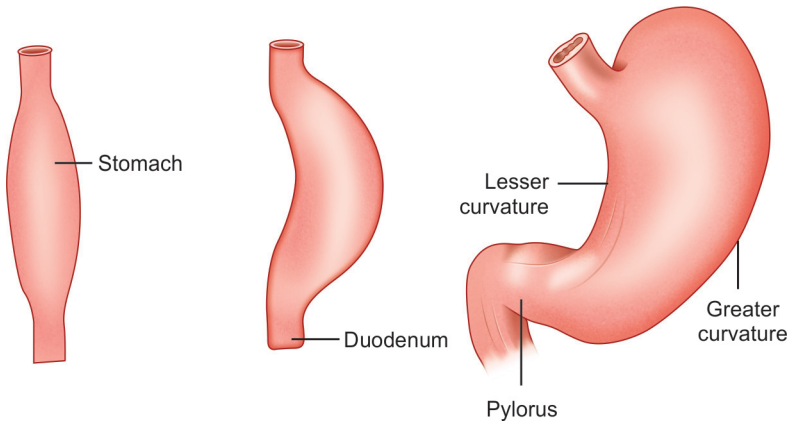


Fig. 15: Development of stomach

MECKEL'S DIVERTICULUM (FIG. 16)

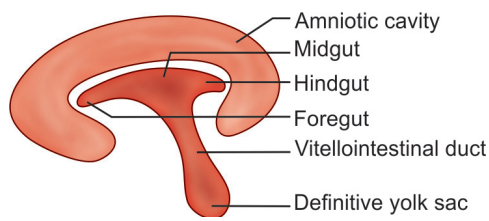


Fig. 16: Meckel's diverticulum

- Midgut communicate with yolk sac at embryological stage through vitellointestinal duct.
- Normally vitellointestinal duct involutes and disappears, occasionally the duct closes at umbilical end but remain patent at intestinal end.
- Patent vitellointestinal duct gives rise to Meckel's diverticulum.
- This patent part appears as out pocketing of ileum.
- Occurs in 2% subjects, 2 inches long and situated 2 ft proximal to ileocecal valve, occurs most commonly in children under 2, and is symptomatic in 2% of patients.

PANCREAS (FIG. 17)

- Pancreas is developed from two endodermal buds (ventral and dorsal buds), formed at the junction of foregut and midgut.
- Dorsal bud lies at dorsal aspect of gut. Ventral bud lies below hepatic bud.
- Large part of pancreas develops from dorsal bud.
- Ventral bud gives rise to inferior part of head of pancreas and uncinate process.
- Dorsal bud gives rise to upper part of head of pancreas, body and tail of pancreas.
- Dorsal and ventral buds give rise to primitive ducts.
- Proximal part of the duct of dorsal bud form accessory pancreatic duct.
- Distal part of duct of dorsal bud and duct of ventral bud, together forms main pancreatic duct.

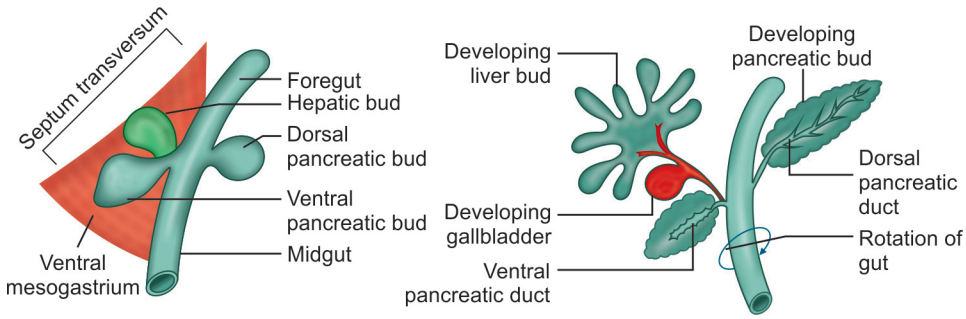


Fig. 17: Development of liver and pancreas

Anomalies

Annular pancreas: Pancreatic tissue surrounds the duodenum and obstructs it.

LIVER AND GALLBLADDER (FIG. 17)

- Liver is derived from an endodermal bud known as hepatic bud.
- Hepatic bud is formed at the junction between foregut and midgut.
- It grows into the septum transversum via ventral mesogastrium.
- The bud enlarges and divides into:
  - Large cranial part called **pars hepatica**.
  - Small caudal part called **pars cystica**.
- Pars hepatica divides into two parts, that later forms the parenchyma of right and left lobes, Kupffer's cells and blood cells are formed from mesoderm of septum transversum.
- Pars cystica forms the gallbladder and cystic duct.

KIDNEY (FIG. 18)

- Kidney develops from the intermediate cell mass.
- Intermediate cell mass lies between paraxial mesoderm and lateral plate mesoderm.
- Paraxial mesoderm gives rise to somites.
- Intermediate cell masses extends craniocaudally on both sides of primitive dorsal aorta.
- In cervical and upper thoracic region it shows segmentation called nephrotomes.
- Remaining unsegmented portion below give rise to nephrogenic cord.
- Nephrogenic cord later divides into 3 parts, from above to below pronephros, mesonephros, metanephros.
- Excretory tubules of kidney are formed from metanephros.
- Collecting part of kidney is formed from a diverticulum called ureteric bud.
- Ureteric bud is derived from lower part of mesonephric duct.
- Horse-shoe kidney—lower pole of two kidneys fuse together to form an isthmus.

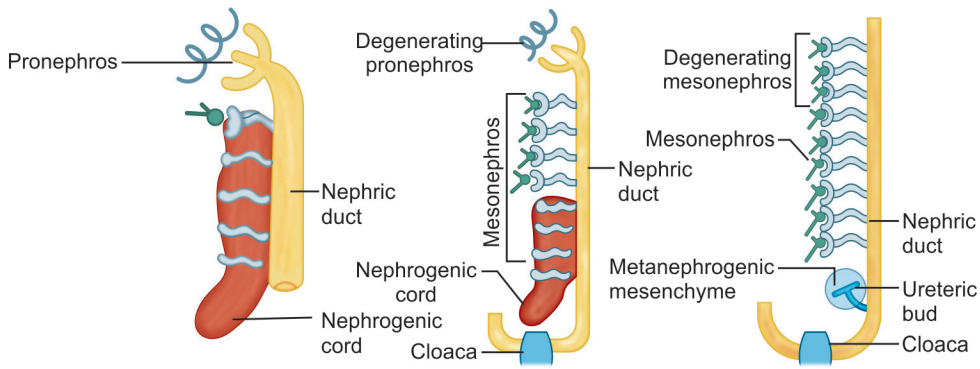


Fig. 18: Development of kidney

URINARY BLADDER

- Cloaca is subdivided by urorectal septum into:
  - Anterior primitive urogenital sinus
  - Posterior anorectal canal
- Cranial and largest part of urogenital sinus is called vesicourethral canal.
- Vesicourethral canal forms most of the urinary bladder.
- Trigone of bladder is formed by absorption of mesonephric duct.
- Apex of bladder is derived from urachus.
- Splanchnopleuric mesoderm gives rise to muscular and serous walls of the bladder.
- *Ectopia vesicae*: Congenital anomaly in which posterior wall of bladder is exposed to outside, anterior wall of bladder is missing.
- *Hour glass bladder*: Urinary bladder become divided into upper and lower part by a middle constriction, thus giving an appearance of a hour glass.

UTERUS (FIG. 19)

- Paramesonephric ducts (Müllerian ducts) gets fused to form uterovaginal canal.
- Epithelium of uterus is developed from uterovaginal canal.
- Myometrium is formed from surrounding mesoderm.
- Unfused horizontal parts of two paramesonephric ducts partially get embedded in substance of myometrium to form "fundus of uterus".
- Soon after, cervix is also recognized as a separate region.
- *Didelphys uterus*: Complete duplication of uterus.
- *Unicornuate uterus*: One-half of uterus absent.

UTERINE TUBE (FIG. 19)

Derived from unfused parts of paramesonephric ducts.

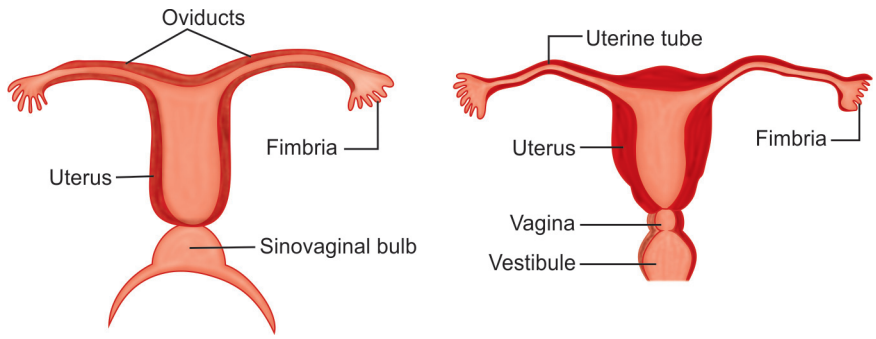


Fig. 19: Development of uterus and uterine tubes

DEVELOPMENT OF GONADS (TESTIS AND OVARIES) (FIG. 20)

- The development of testis and ovaries begins in a similar manner but parts way at a particular point.
- Gonads develop from three sources:
  1. **Intermediate mesoderm—**which is present medial to middle part of mesonephros.
  2. **Coelomic epithelium—**which covers the intermediate mesoderm.
  3. **Primordial germ cells** from the wall of yolk sac near the allantois.
- Coelomic epithelium begins to proliferate and it gets thickened.
- Mesoderm below the coelomic epithelium condenses due to thickening of coelomic epithelium.
- Both these process lead to formation of genital ridge.
- Coelomic epithelial cells continue to proliferate and they invade the condensed mesoderm in the form of solid cords, known as the **"sex cords"**.
- Primordial germ cells from the wall of yolk sac migrate along the dorsal mesentery of hindgut towards the developing gonad.
- Sex cords and primordial germ cells get intermixed.
- Till this point the development of testis and ovaries are the same.

Testis

- Sex cords increase in length and extend into the medulla of developing gonad. Sex cords are now called as **medullary cords**.
- The sex cords anastomoses with each other and canalize resulting in formation of seminiferous tubules.
- The ends of seminiferous tubules anastomoses with one another giving rise to rete testis.
- Two types of cells lines the seminiferous tubules:
  1. *Spermatogenic cells:* Formed from primordial germ cells.
  2. *Sertoli cells:* Formed from coelomic epithelium.
- A dense fibrous layer is formed by mesoderm which separates the sex cords from coelomic epithelium, known as **tunica albuginea**. Mesoderm also gives rise to:
  1. Leydig cells.
  2. Connective tissue around seminiferous tubules.
  3. Mediastinum testis.
- The canal of epididymis and vas deferens develop from mesonephric duct.

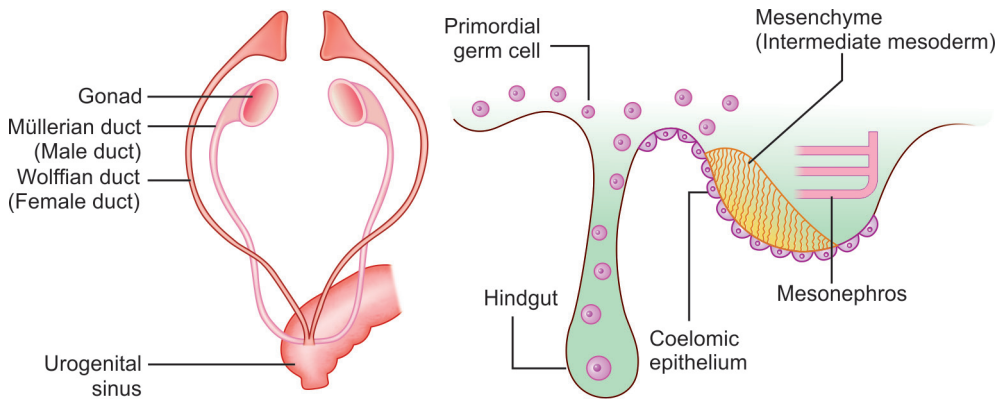


Fig. 20: Development of gonads

Descend of Testis

- Testis which develops in relation to lumbar region of the posterior abdominal wall starts to descend.
- It gradually descend to the scrotum through iliac fossa (3rd month) and inguinal canal (7th month), finally reaching scrotum by the end of 8th month. It is a mandatory developmental process to ensure that the mature testis promotes normal spermatogenesis.
- Some factors responsible for descend of testis are:
  - Increased intra-abdominal pressure.
  - *Gubernaculum:* Guiding force for descent.
  - Differential growth of body wall.

Anomalies

- *Cryptorchidism:* Descend of one or both testis may fail to occur or is arrested somewhere in the pathway.
- *Ectopic testis:* Testis may lie in abnormal positions like in the femoral canal, under the skin of penis or on the front of thigh, behind the scrotum in perineum.

Ovary

- Unlike the development of testis where the sex cords increase in length and extend into the medulla, the sex cords of female do not extend into medulla.
- Instead they get fragmented into small mass of cells.
- Each mass of cells surround a primordial germ cell, forming a primordial follicle.

RECTUM AND ANAL CANAL

- Upper part of rectum develops from endoderm of hind gut. Lower part of rectum and upper part of anal canal are developed from the anorectal canal.
- Lower part of anal canal developed from proctodeum.

PROSTATE

- Prostate develops from a large number of buds arising from the prostatic urethra.
- Buds arising from the endodermal part of prostatic urethra forms the glandular part of prostate.
- Buds arising from mesodermal part of prostatic urethra forms the stroma of prostate.

AMNIOCENTESIS

- Amniocentesis is a medical procedure used to obtain a sample of the amniotic fluid.
- Amniotic fluid contains cells shed by the fetus along with various enzymes, proteins, hormones, and other substances.
- These cells possess genetic information of the fetus and can be used to diagnose genetic abnormalities like chromosomal disorders and open neural tube defects (ONTDs).
- Amniocentesis can be performed in late pregnancy to check fetal well-being, such as lung maturity, infections, etc.
- Amniocentesis is generally done in women who are at high risk for chromosome abnormalities. Commonly between 15th to 20th weeks of pregnancy.
- Sex of fetus can also be determined by this procedure.

Genetics

BARR BODY (SEX CHROMATIN)

- Found by Barr and Bertram.
- This is seen in those species whose sex is determined by the presence of Y-chromosome.
- It is a densely stained, inactivated and condensed X-chromosome in a female somatic cell.
- It is found attached to the nuclear membrane.
- They are inactivated by a process known as lyonization. In lyonization the chromosome is inactivated by packing it in a way such that it has a transcriptionally inactive structure.
- Lyon's hypothesis (N-1 Rule)
- N = No of X chromosomes
- It states that in cells with multiple X chromosomes, all the X chromosomes except one are inactivated.
- So in human female, XX, no of Barr body: 2 – 1 = 1

  Male, XY, no of Barr body : 1 – 1 = 0

CHROMOSOME BANDING

- It is also known as G-banding or Giemsa banding. Since Giemsa staining is most commonly used.
- It is a technique used in cytogenetics for precise identification of individual chromosomes or its parts.

- Method
  1. Cells are treated with tubulin inhibitors (colchicine's) which depolymerize the spindle and arrest the cells in metaphase.
  2. Cells are spread on glass slide.
  3. Chromosomes are then treated with trypsin and stained with Giemsa stain.
  4. This will give rise to dark regions (bands) and light regions (bands) in all the chromosomes.
  5. Each chromosome has a unique alternating dark and light staining pattern.
- Banding techniques used are:
  1. G-Banding (Giemsa stain)
  2. Q-Banding (quinacrine fluorescence stain)
  3. R-Banding (reverse Giemsa staining)
  4. C-Banding (constitutive heterochromatin demonstration)
- *Applications:* Chromosome mapping, to check for chromosomal rearrangements in malignancies, look for deletion and inversion in case of mutations.

KARYOTYPING

- Karyotype is the photographic representation of the stained preparation of chromosomes.
- Karyotyping is the classification of chromosomes based on their:
  1. Banding pattern.
  2. Length.
  3. Position of centromere.
- Chromosomes are arranged in the descending order of their length
- Identical chromosomes are paired and numbered from 1 to 22 (1 is the longest chromosome).
- These chromosomes are divided in to 7 groups (Fig. 21):
  1. Group A (CHR 1-3)
  2. Group B (CHR 4-5)
  3. Group C (CHR 6-12)
  4. Group D (CHR 13-15)
  5. Group E (CHR 16-18)
  6. Group F (CHR 19-20)
  7. Group G (CHR 21-22)
- *Applications:* To study chromosomal aberrations, to identify abnormal chromosome, to gather information about past evolutionary events, etc.

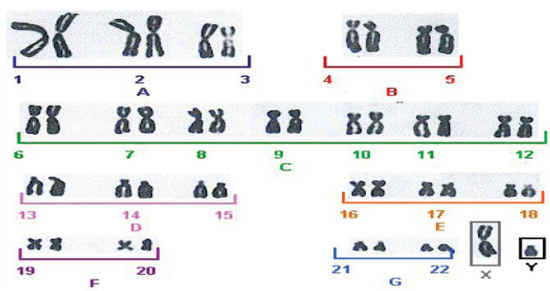


Fig. 21: Groups of chromosome

NONDISJUNCTION

- It is the failure of chromosomes to separate from each other during anaphase of meiosis one.
- It occurs due to faulty spindle formation, slow chromatid movement, viruses, etc.

KLINEFELTER SYNDROME

- Male hypogonadism or testicular dysgenesis due to two or more X and one or more Y chromosomes respectively (trisomy).
- Incidence is 1 in 100 males
- Occurs due to nondisjunction of sex chromosomes during meiosis.
- Extra X chromosome could be of maternal or paternal origin.
- Risk of recurrence increases with maternal age.
- Clinical features:
  - Testicular dysgenesis—small testis and penis.
  - Increased length between soles and pubic bones.
  - Poorly developed secondary sexual characters.
  - High pitched voice.
  - Gynecomastia.
  - Osteoporosis, due to deficient testosterone production.
  - Mild mental retardation.

TURNER'S SYNDROME

- Hypogonadism.
- Due to complete or partial loss of one X chromosome (monosomy).
- Incidence is 1 in 500 females.
- Monosomy occurs due to nondisjunction.
- Clinical features:
  - Short stature.
  - Webbing of neck.
  - Broad chest.
  - Low hairline.
  - Cubitus valgus (increased carrying angle).
  - Atrial septal defect.
  - Low hair line.

DOWN SYNDROME

- Trisomy in chromosome 21.
- Incidence 1/700 live birth.
- Risk of incidence more in elderly gravida (pregnancy at age 45 years or more).
- Causes are nondisjunction, translocation, and mosaicism.
- Clinical features:
  - Mental retardation.
  - Flat face.
  - Small, low bridged nose.
  - Mongoloid appearance due to epicanthal folds of eye.
  - Hypotonia.
  - Atrial and ventricular septal defect and cataract.

CHAPTER

3

Radiology

Basics

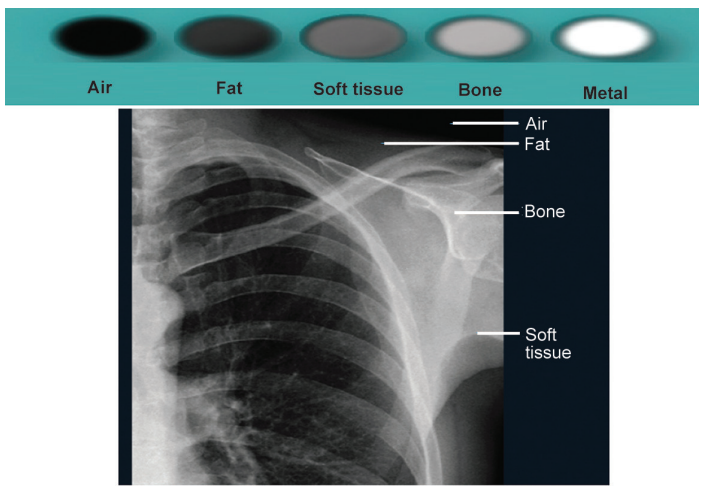
IMAGING MODALITIES

The principal imaging modalities used today are:

1. Using ionizing radiations like X-rays, gamma rays
   a. Plane radiographs
   b. Contrast radiographs
   c. Computated tomography (CT), PET
2. Using non ionizing radiations
   a. Ultrasonography, Doppler, etc
   b. Magnetic resonance imaging (MRI)

RADIO-OPACITIES

The fundamental principle of all radiographic tests that employ X-rays is that different body tissues have a different capacity to block or absorb X-rays. The tissue densities (in order of increasing radio-opacity, i.e. whiteness on conventional radiographic film or computerized tomograms) which are usually seen on a radiograph are:



1. **Air**, as found, for example, in the trachea and lungs, the stomach and intestine, and the paranasal sinuses.
2. **Fat**.
3. **Soft tissues**, e.g. heart, kidney, muscles (these are all approximately the density of water).
4. **Calcific** (due to the presence of calcium and phosphorus), for example, in the skeleton.

5. **Enamel** of the teeth.
6. **Dense foreign bodies**, for example, metallic fillings in the teeth. Also radio-opaque contrast media, such as a barium meal in the stomach or intravascular contrast.

PLANE RADIOGRAPHS

- Here no contrast media is used.
- Produced by passage of X-rays through subject and exposing a radiographic film.
- Here bone absorbs most radiation causing least film exposure, thus developed film appears white at such regions.
- On the other hand air absorbs least radiation causing maximum exposure, so film appears black on such areas.
- Between these extremes, large differential tissues absorb radiation producing grey scale image.

Types of Views

- Posteroanterior view (PA view)
  - Here the beam of rays enters from back to front of the subject.
  - Here the structures visible are mostly the anterior most structures.
- Anteroposterior view (AP view)
  - Here the beam enters from front to the back of the subject.
  - Here the structures visible are mostly the posterior most structures.
- Lateral view
  - Here the beam passes through the lateral part of the body or it passes through sideways of the body.
- Oblique view
  - Here the beam enters any part at a particular angle so that the structures which are not seen in the all other 3 views can be visualized.

CONTRAST RADIOGRAPHS

- When the density of a structure is too similar to that of adjacent structures, it is more preferable to use a contrast media to enhance or outline its contours.
- Used to obtain more information about various soft tissues components and also various body cavities.
- Contrast media are classified as radiolucent (e.g. air) and radio-opaque (e.g. barium or iodinated contrast media).
- A contrast agent is being used here mainly consisting of salts of barium and iodine.
- These by utilization of photoelectric effect absorb X-rays completely resulting in white film where the beam has met contrast agent.

I. Barium Studies

- Used in mainly GI tract evaluation.

Advantages	*Disadvantages*
• Inert, safe and no drug interaction	• Time consuming.
• Coats the mucosal lining so allow detection of various disease process of mucosa from ulcers to cancers.	• Difficulty of preparation of subject for study.

Types

Barium Swallow
- To visualize region from hypopharynx to gastroesophageal junction.
- $BaSO_4$ suspension taken orally.

Barium Meal
- To visualize gastroesophageal junction to duodenojejunal flexure.
- Taken orally.

Barium Meal Follow Through
- To visualize from gastroesophageal junction to ileocecal junction.
- Taken orally.

Barium Follow Through
- To visualize from duodenojejunal flexure to ileocecal junction.
- Taken orally.

Small Bowel Enema
- To visualize from duodenojejunal junction to ileocecal junction.
- Done by using a tube placed at a duodenojejunal junction and barium given through it.

Barium Enema
- To visualize from rectum to ileocecal junction.
- Barium instilled through catheter inserted per rectally.

II. Iodine Studies

Used for both intravenous injection, intraluminal injection, etc.

Advantages	*Disadvantages*
• Bear no drug interaction • Pharmacologically inert • Cause adequate contrast	• Nausea* • Vomiting* * Low risk

Types

- For urinary system studies
  - Intravenous pyelography (IVP)
  - Retrograde pyelography (RGP)
  - Cystogram
- For biliary tree studies
  - Endoscopic retrograde cholangiopancreatogram (ERCP)

A. *Intravenous pyelography (IVP):* Visualization of urinary tract and functions though injection of contrast through peripheral vein.
B. *Retrograde pyelography (RGP):* Contrast instilled through a tube placed in ureter for delineation of the ureteric abnormalities in a nonexcreting kidney.
C. *Cystogram:* Intracavity instillation of contrast into urinary bladder enables morphological visualization.
D. *Endoscopic retrograde cholangiopancretogram (ERCP):* Used in case of obstructive jaundice.

III. Water-soluble Contrast Study

Water-soluble contrast media used.

A. Hysterosalpingography:
   - Use of water-soluble iodinated contrast.
   - To delineate the uterus and fallopian tubes and assess tubal patency.
B. Myelography:
   - Injection of contrast medium to subarachnoid space via lumbar puncture for evaluating abnormalities of spinal cord and nerves which is not visible in plane X-ray.

SOME TERMS

Shenton's line: The line of the upper margin of the obturator foramen follows the same curve as that of the under surface of the neck and medial side of the shaft of the femur.

Nelaton's line: The line between anterior superior iliac spine and ischial tuberosity with subject in supine position. Normally, the greater trochanter lies on or below this line, so if it is above this line the femur has been displaced upwards.

Shoemaker's line: A line projected on each side of the body from the greater trochanter beyond the anterior superior iliac spine. The two lines meet in the midline or above the umbilicus. If one femur is displaced upwards, the lines meet away from the midline and if both are displaced upwards then the lines meet below the umbilicus.

Contrast Studies

- Barium studies are radiographic procedures used for visualization of alimentary canal.
- **Principle:** Barium is a white, 'radio-opaque' powder (due to high molecular weight) that is not transparent to X-rays. The alimentary canal, like other soft-tissue structures, does not show clearly enough for diagnostic purposes on plain radiographs. But if radiograph is taken after drinking a white liquid that consisting of suspension of 5% barium sulfate in water, the outline of the upper parts of the gut (esophagus, stomach and small intestines) shows up clearly on radiographs. This is because X-rays do not pass through barium.

BARIUM SWALLOW

- The subject is restricted from eating or drinking for 6 hours prior to the examination.
- Subject is made to drink 5% barium sulfate solution.
- Subject should stand in front of an X-ray machine and X-ray pictures are taken as he swallows the solution.
- This test helps to check for problems in the esophagus, such as narrowing (stricture), hiatus hernias, tumors, reflux from the stomach, disorders of swallowing, etc.

BARIUM MEAL

- Similar to barium swallow.
- Help to check for problems in the stomach and duodenum.
- Subject is made to drink 5% barium sulfate solution (subject ingests gas pellets and citric acid to expand the stomach and duodenum and also pushes the barium to coat the lining of the stomach and duodenum, which makes the radiographs clearer).
- Subject is made to lie on a couch while radiograph is being taken over the abdomen.
- Stomach and duodenum can be visualized immediately after barium drink.
- Barium is normally excreted within 24 hours.
- Barium meal mainly helps to detect problems like ulcers, polyps, tumors of stomach and duodenum.

BARIUM ENEMA

- This test helps to diagnose diseases and other problems that affect the large intestine.
- Subject is given mild laxative two nights before the examination to clean up the large intestine.
- 2 liters of barium sulfate poured into the large intestine through a tube inserted into the anus.
- Enema is stopped when barium starts flowing into the terminal ileum through ileocecal valve and a radiograph is taken.

- Rectum and sigmoid colon appear much dilated and the colon also shows haustrations.
- There are two types of barium enemas:
  1. **Single-contrast study:** Barium outlines the intestine and reveals large abnormalities.
  2. **Double-contrast or air-contrast study:** The colon is first filled with barium and then the barium is evacuated, leaving only a thin layer of barium on the wall of the colon and air is injected through anus to distend the colon. This gives a detailed view of the inner surface of the colon, making it easy to point out narrowed areas (strictures), diverticula, or inflammation.
- Barium enema helps to find out intussusception, identify inflammation of the intestinal wall (inflammatory bowel diseases—ulcerative colitis or Crohn's disease) and its progress.

INTRAVENOUS PYELOGRAPHY (IVP)

- The IVP consists of a series of abdominal radiographs taken sequentially at 1, 5 and 15 minutes after injection of contrast (urograffin, Conray 420).
- First a normal abdominal radiograph is taken, called as the scout film. On scout film, kidney and bladder contours are normally visualized. Kidney stones are seen as white calcification over the kidney shadow and ureteric stone are seen as white calcification along the course of the ureters.
- In the contrast injected radiograph the urinary system becomes outlined by the white contrast material. The whitened kidney seen on radiograph is known as nephrogram.
- In addition we can also see renal calyces, renal pelvis, ureteropelvic junctions (UPJ), the ureters, and the ureterovesicular junctions (UVJ).
- The scout film is compared with the contrast radiographs to check for abnormalities.
- No nephrogram means, kidney not functioning or absent.
- Dilated ureter indicates ureteric stone or a tumor encasing the ureter.

HYSTEROSALPINGOGRAPHY (HSG)

- The radiograph obtained is called as hysterosalpingogram.
- Investigations are done preferably in first 5-10 days of menstrual cycle.
- **Procedure:** A cannula is inserted into the internal os and is connected with a syringe. A dye (Iodized oil, Lipiodol) is passed through it into the uterus.
- Due to the anatomical continuation uterus with fallopian tube, the dye will flow into the fallopian tubes.
- Radiograph taken at this point shows uterus and fallopian tube clearly.

Uses

- Determine the patency of uterus and fallopian tube.
- To check presence polyps, fibroids, adhesions, or a foreign object in the uterus.
- To check presence of an abnormal passage or fistula in the region.
- To check success of tubal ligation post-surgery.

How to Read a Chest Radiograph (PA View) ?

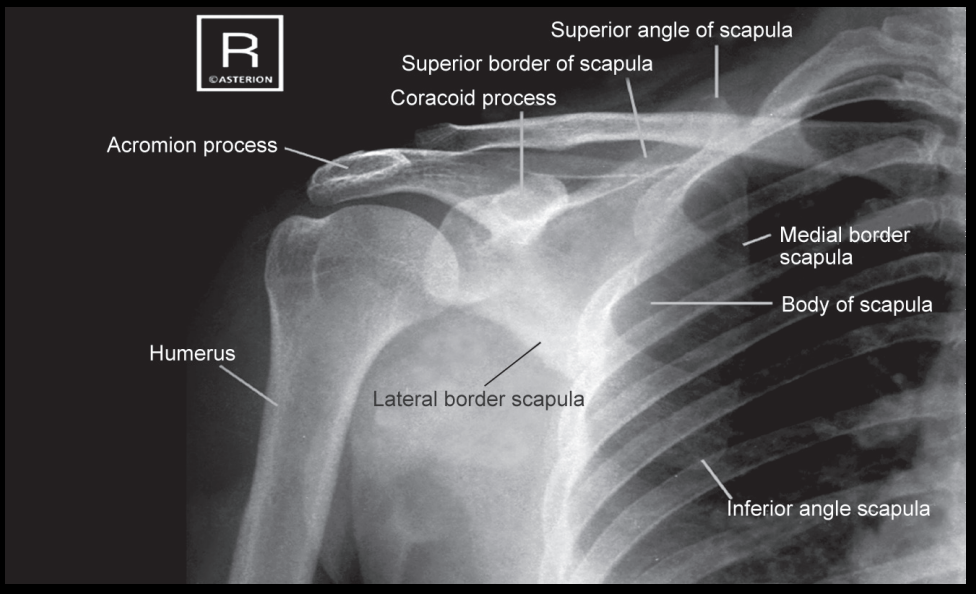
- **Check the patient's name and age**. First make sure that you are looking at the correct chest X-ray.
- **Read the date of the chest radiograph**. The date of radiograph provides important context for interpreting any findings. For example, a mass that has become bigger over 3 months is more significant than one that has become bigger over 3 years.
- **Identify the type of film and view**. The standard view of the chest is the posteroanterior radiograph, or "PA chest." Posteroanterior refers to the direction of the X-ray passing the patient from posterior to anterior. This film is taken with the patient upright, in full inspiration. Other types of chest radiographs include:
  - The **anteroposterior (AP) chest radiograph** is obtained with the X-ray passing the patient from anterior to posterior, usually obtained with a portable X-ray machine from very sick patients, those unable to stand, and infants.
  - The **lateral chest radiograph** is taken with the patient's left side of chest held against the X-ray cassette (left instead of right to make the heart appear sharper and less magnified, since the heart is closer to the left side).
  - A **lateral decubitus view** is taken by making the patient lying down on the side. It helps to determine whether suspected fluid (pleural effusion) will layer out to the bottom, or suspected air (pneumothorax) will rise to the top.
- **Look for markers:** 'L' for Left, 'R' for Right, 'PA' for posteroanterior, 'AP' for anteroposterior, etc. Note the position of the patient: supine (lying flat), upright, lateral decubitus.
- **Note the technical quality of film.**
  - **Exposure (Penetration):** Overexposed films look darker than normal, making fine details harder to see; underexposed films look whiter than normal, and cause appearance of areas of opacification. Look for barely visible intervertebral bodies behind the heart in a properly penetrated chest X-ray. If detailed spine and pulmonary vessels are seen behind the heart, the exposure is correct. An under-penetrated chest X-ray cannot differentiate the vertebral bodies from the intervertebral spaces, while an over-penetrated film shows the intervertebral spaces very distinctly, but not the pulmonary vessels.
  - **Rotation:** Rotation means that the patient was not positioned flat on the X-ray film, with one plane of the chest rotated compared to the plane of the film. To assess rotation see if the medial ends of both clavicle are equidistant from the spinous process of the vertebrae.
  - **Inhalation:** Check for 9-10 posterior ribs or 6-7 anterior ribs in a properly inhalated radiograph.

- **External soft tissues:** Look at the soft tissues of neck, shoulders and axilla for any abnormalities, for example, enlarged lymph nodes, subcutaneous emphysema (air density below the skin), and other lesions.
- **Diaphragms:** Look for a flat or raised diaphragm. A flattened diaphragm may indicate emphysema. A raised diaphragm may indicate area of airspace consolidation (as in pneumonia). The right diaphragm is normally 2 cm higher than the left, due to the presence of the liver below the right diaphragm. Also look at the costophrenic angle for any blunting (normally sharp), which may indicate effusion.
- **Gas bubble:** Look for the presence of a gastric bubble, just below the left hemidiaphragm.
- **Free air:** Look for free air just beneath the diaphragm.
- **Bones:** Check the bones for any fractures, lesions and joint disease. Note the overall size, shape, and contour of each bone, cortical thickness in comparison to medullary cavity. At joints, look for joint spaces narrowing, widening, calcification in the cartilages, air in the joint space, abnormal fat pads, etc.
  - **Spine:** Examine the spinous process, each vertebra and inter vertebral spaces.
  - **Clavicle:** Examine the both ends of clavicle and the shaft.
  - **Scapula:** Examine the coracoid process, acromioclavicular joint and glenoid fossa.
  - **Humerus:** Examine the visible portion of humerus.
  - **Ribs:** Examine each and every visible rib.
- **Fields of the lungs:** Look for symmetry, vascularity, presence of any mass, nodules, infiltration, fluid, etc. in the upper, middle and lower zones of each lung.
- **Hila:** Look for nodes and masses in the hila of both lungs. On the frontal view, most of the hilar shadows represent the left and right pulmonary arteries. The left pulmonary artery is always more superior than the right, making the left hilum higher.
- **Airway:** Examine the trachea, carina (point of bifurcation of trachea) and main stem bronchi. Check to see if the airway is patent and midline. For example, in a tension pneumothorax, the airway is deviated away from the affected side.
- **Cardiac silhouette:** Look at the size of the cardiac silhouette (the bright white space between the lungs representing the outline of heart). A normal cardiac silhouette occupies less than half the chest width. Look for abnormal shapes of heart on PA plain film, like water bottle shaped heart in pericardial effusion.
- **Edges of heart:** Look the edges of the heart for the silhouette sign (the loss of normal borders between thoracic structures, usually caused by intrathoracic masses).
- **Instrumentation:** Look for any tubes (e.g. tracheal, nasogastric), IV lines, ECG leads, pacemaker, surgical clips, drains, etc.

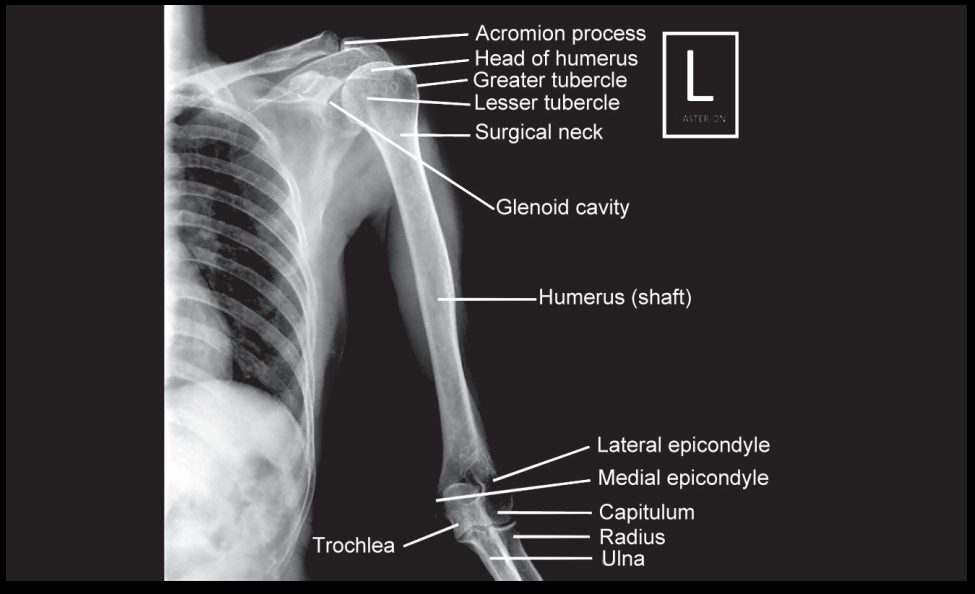
Plane Radiographs

A. UPPER LIMB

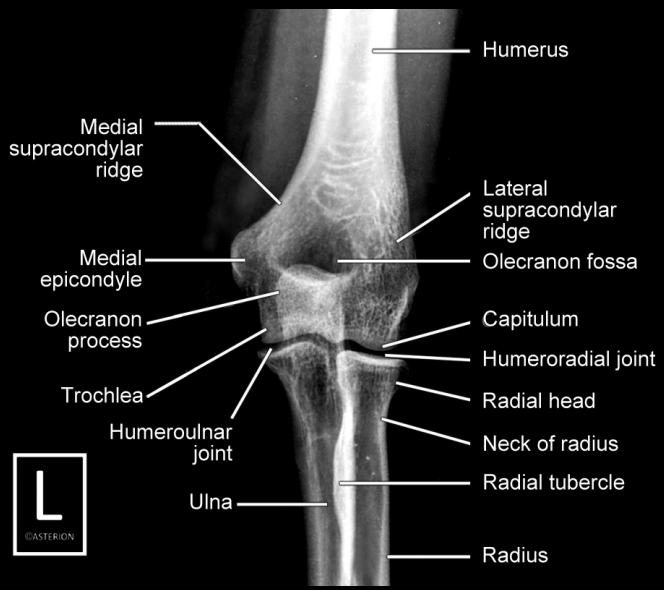
SHOULDER: AP VIEW



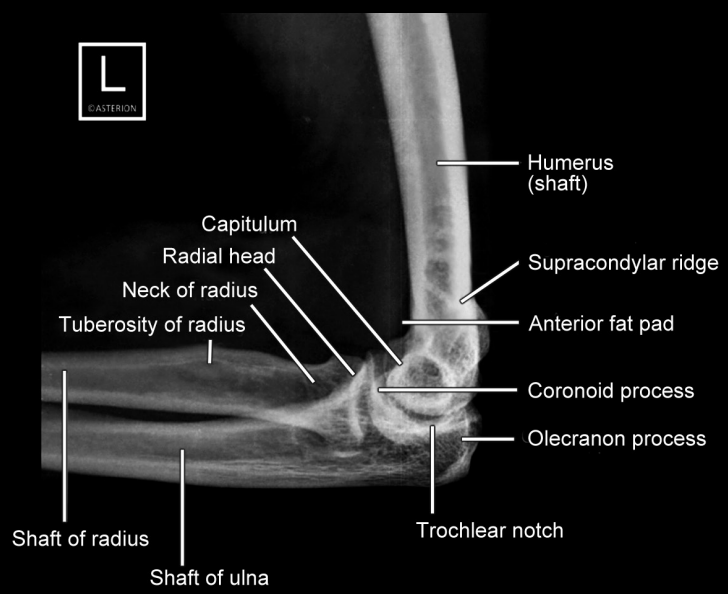
ARM: AP VIEW



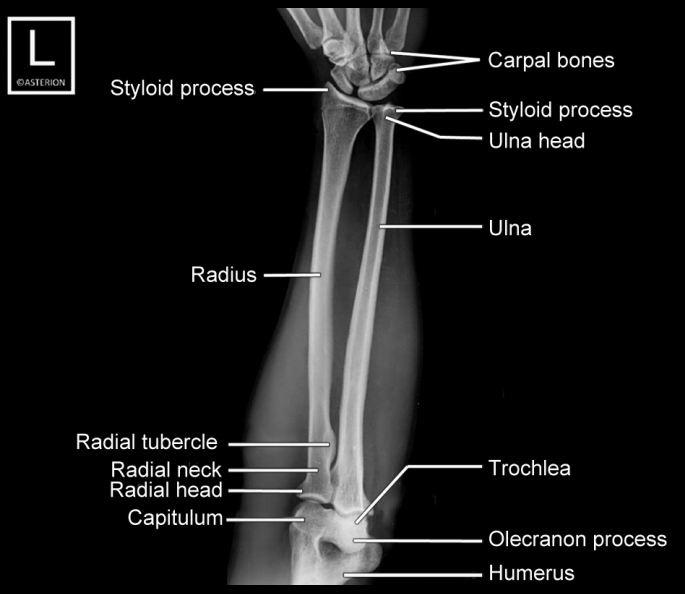
ELBOW: AP VIEW



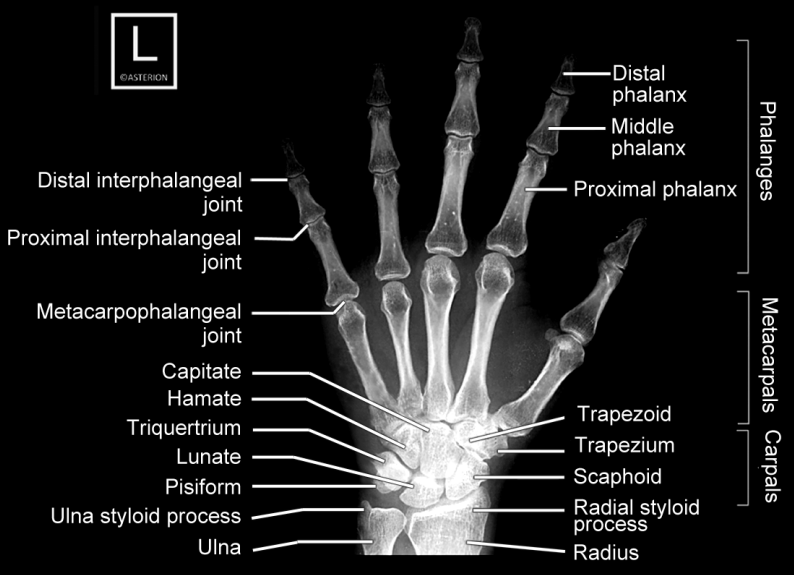
ELBOW: LATERAL VIEW



FOREARM : AP VIEW

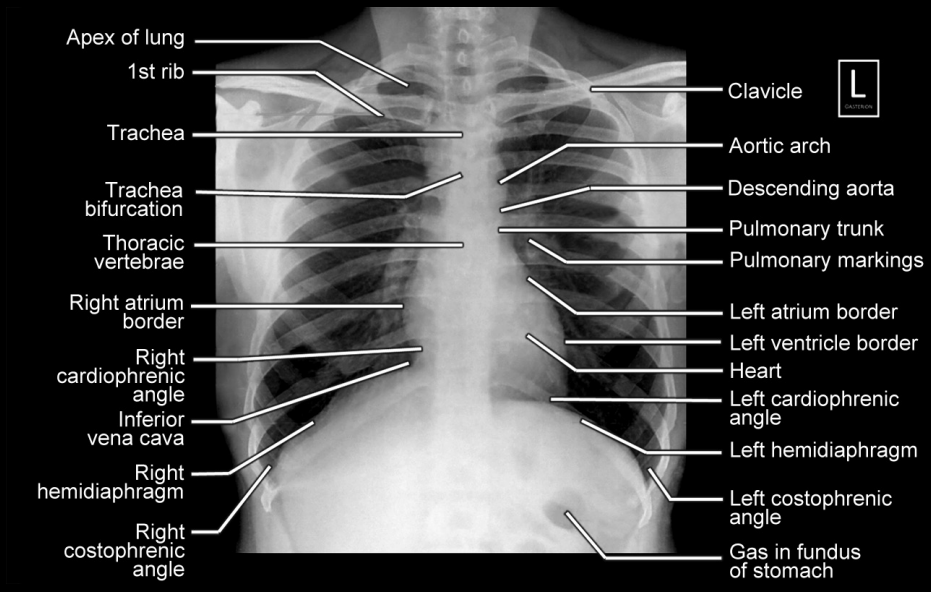


WRIST AND HAND : AP VIEW

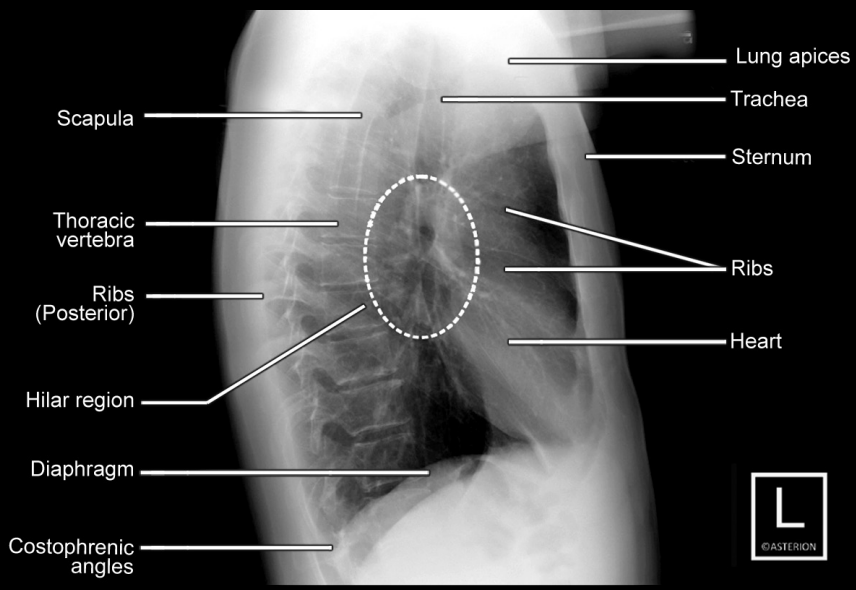


B. THORAX AND ABDOMEN

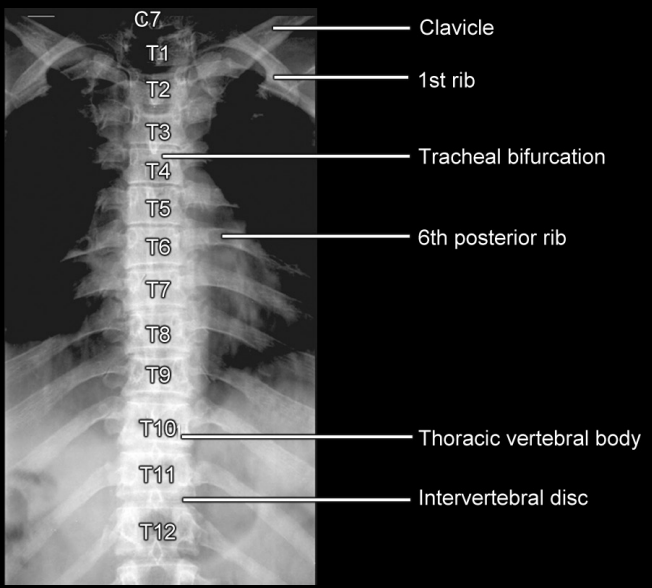
CHEST : PA VIEW



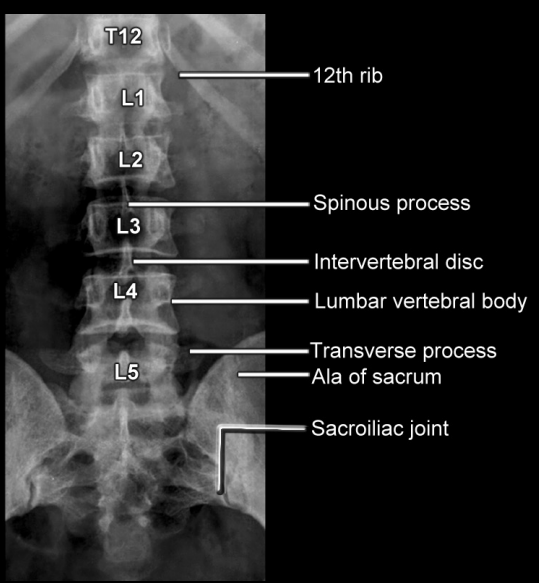
CHEST : LATERAL VIEW



THORACIC VERTEBRAE : AP VIEW

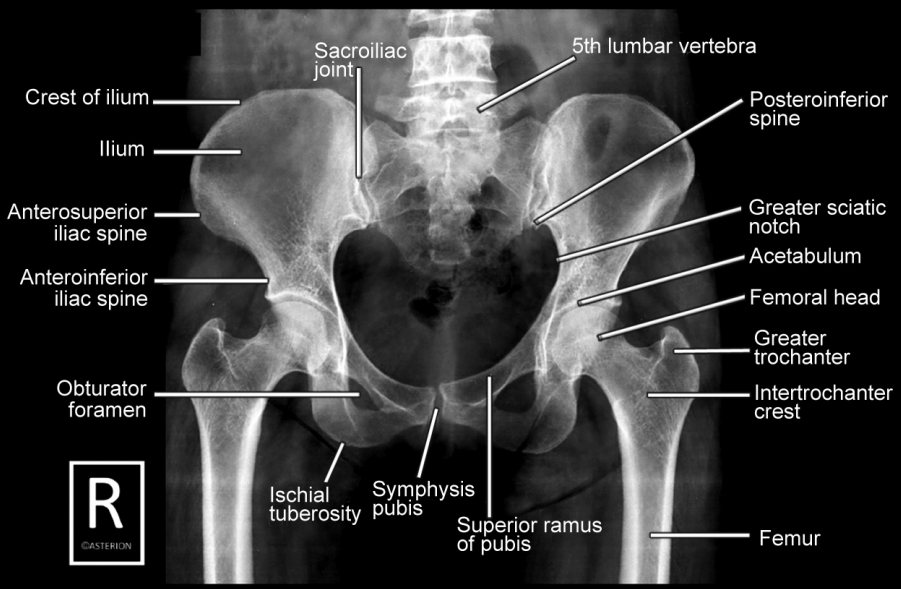


LUMBAR VERTEBRAE : AP VIEW

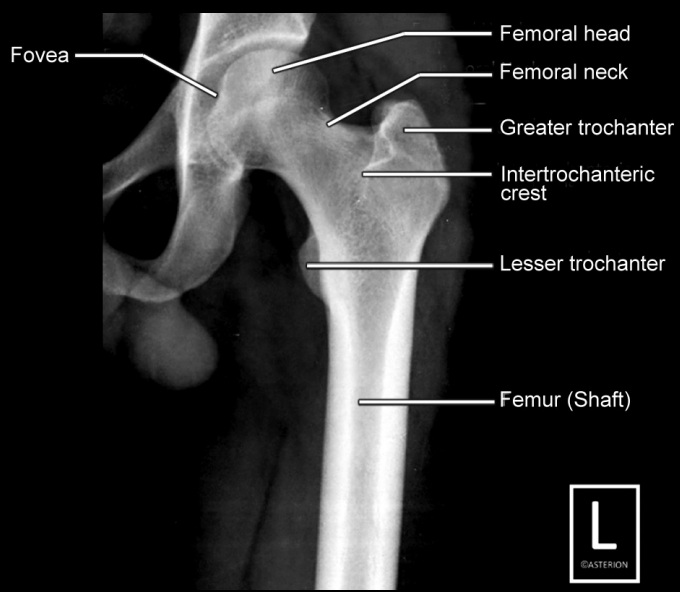


C. LOWER LIMB

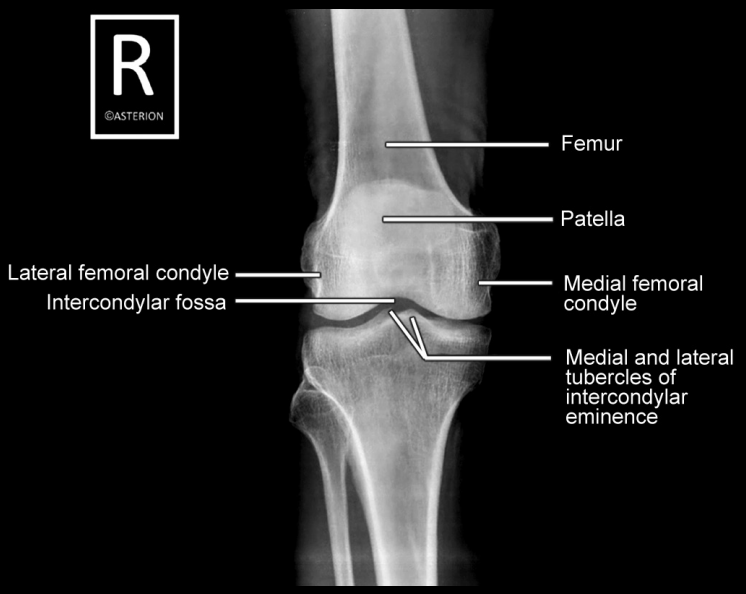
PELVIS : AP VIEW



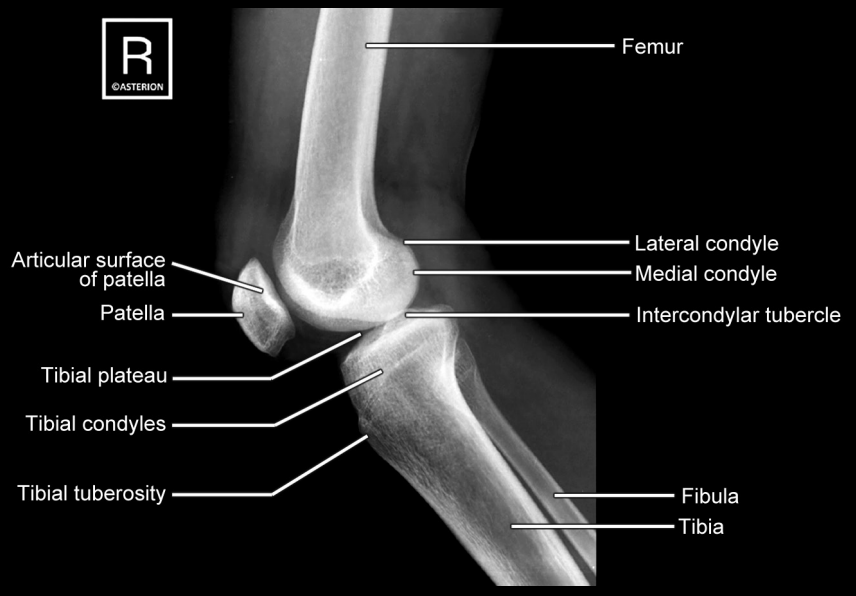
THIGH : AP VIEW



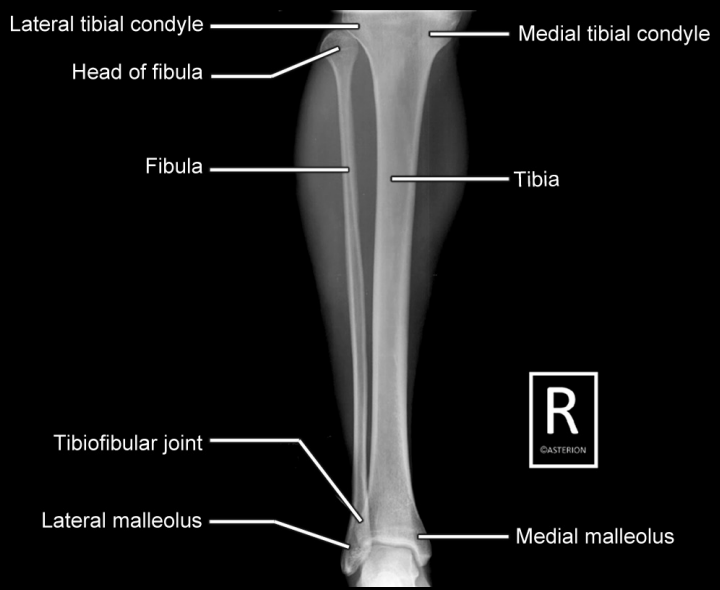
KNEE : AP VIEW



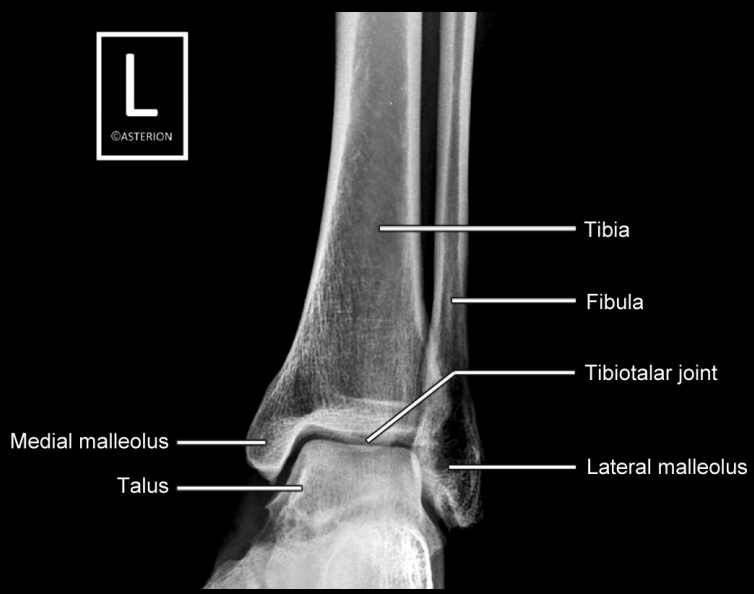
KNEE : LATERAL VIEW



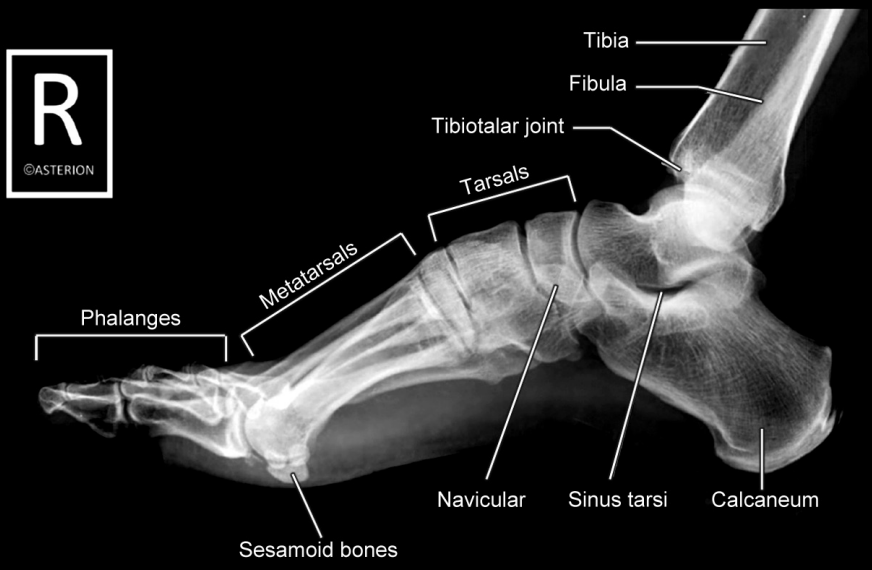
LEG : AP VIEW



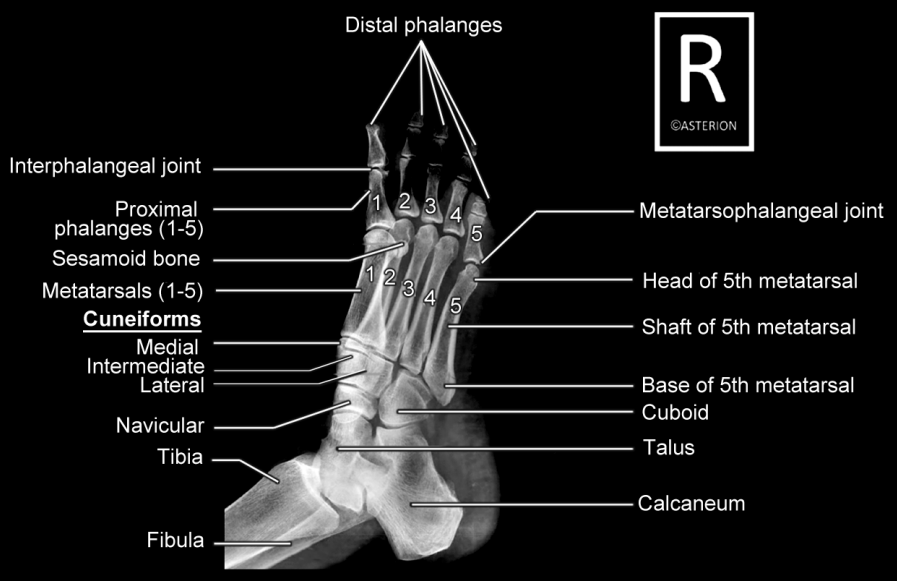
ANKLE : AP VIEW



FOOT : LATERAL VIEW

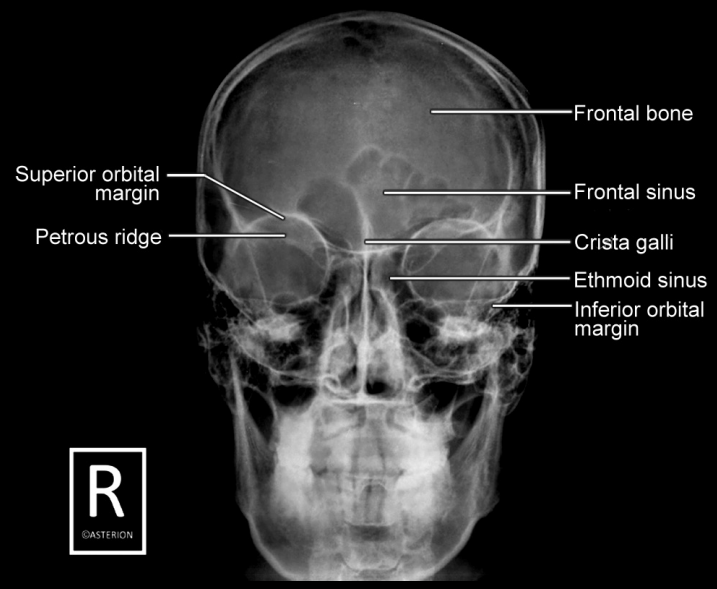


FOOT : OBLIQUE VIEW

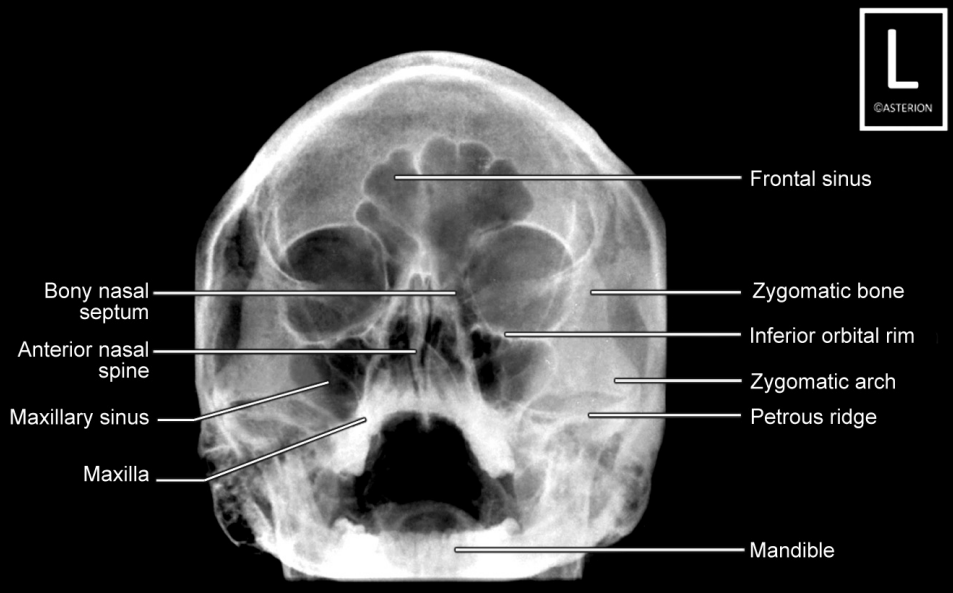


D. HEAD AND NECK

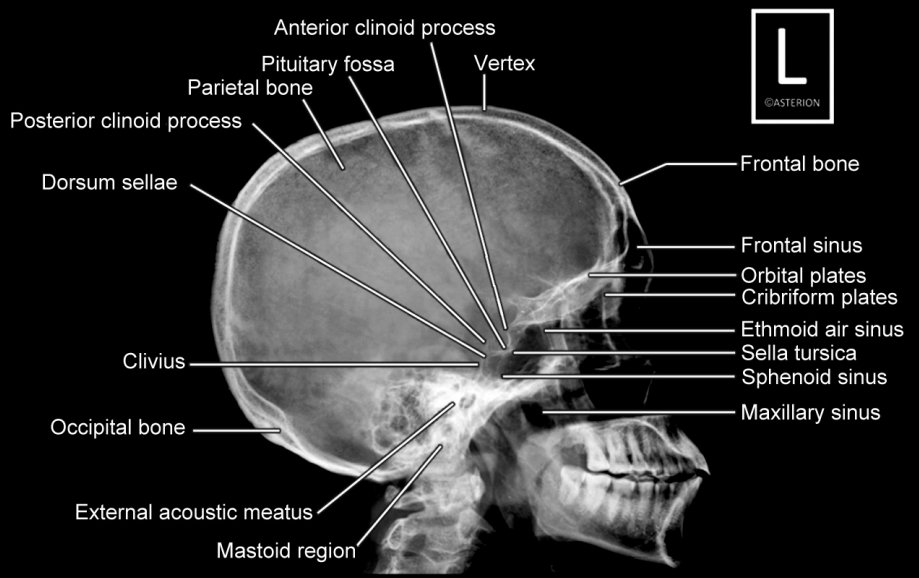
SKULL : AP VIEW



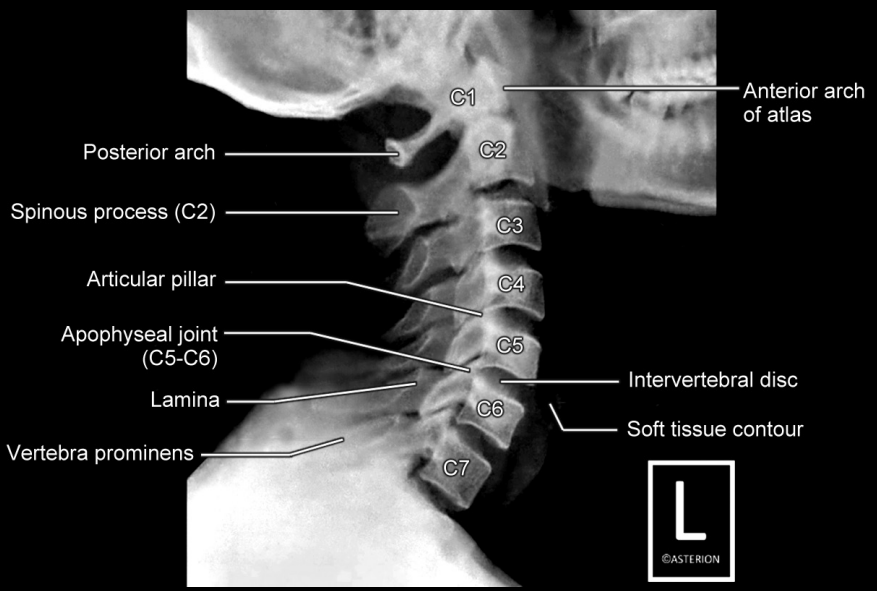
SKULL : OCCIPITOMENTAL VIEW



SKULL : LATERAL VIEW

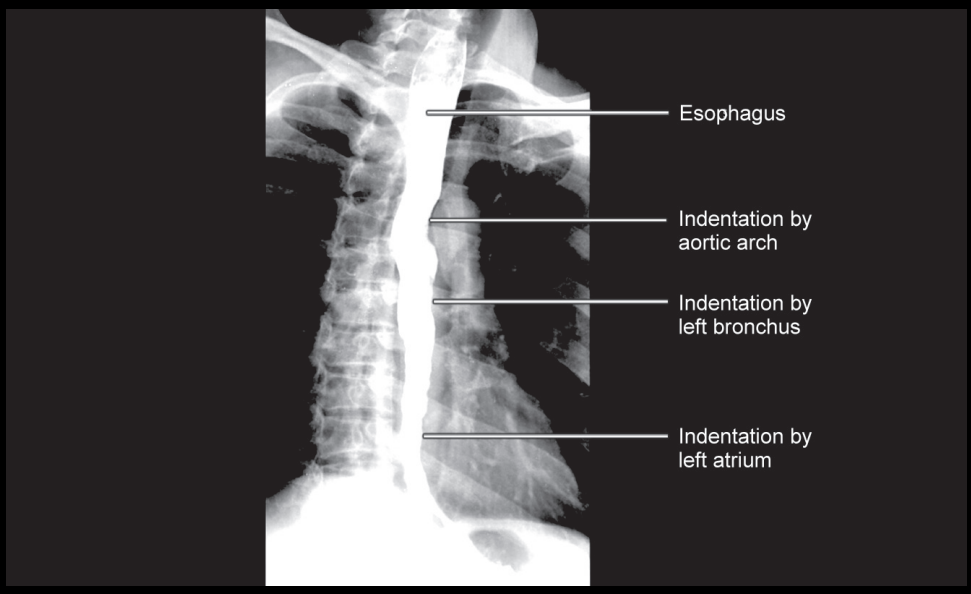


NECK : LATERAL VIEW

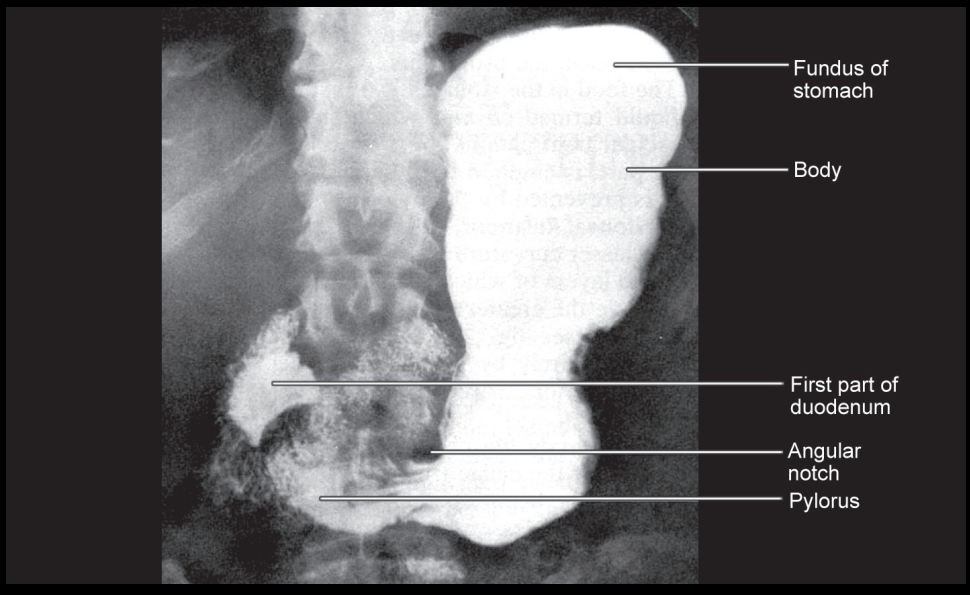


Contrast Radiographs

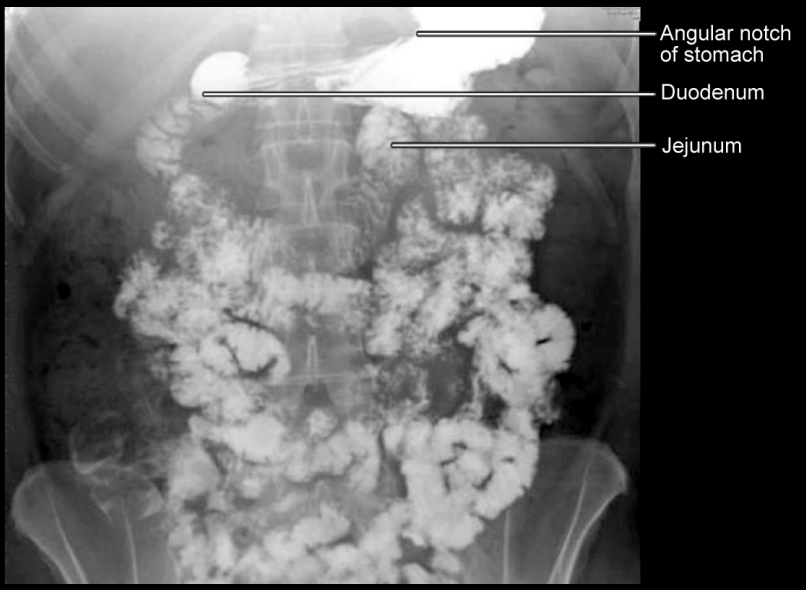
BARIUM SWALLOW



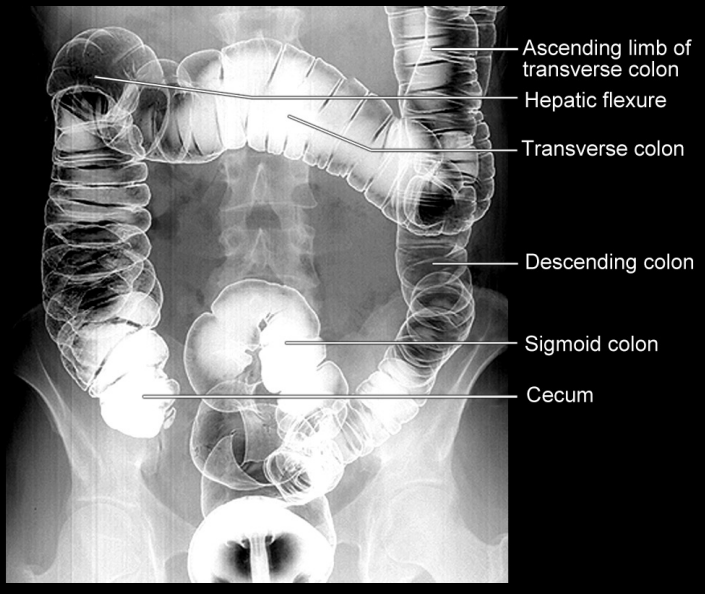
BARIUM MEAL



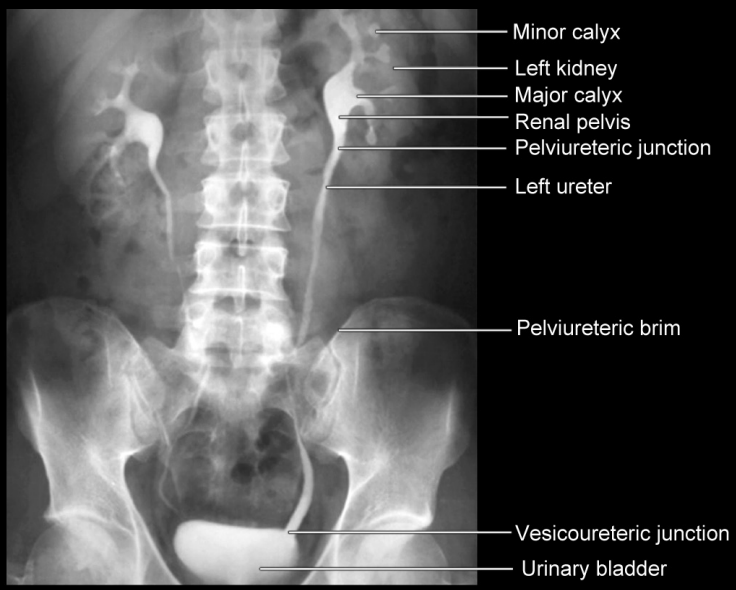
BARIUM MEAL FOLLOW THROUGH



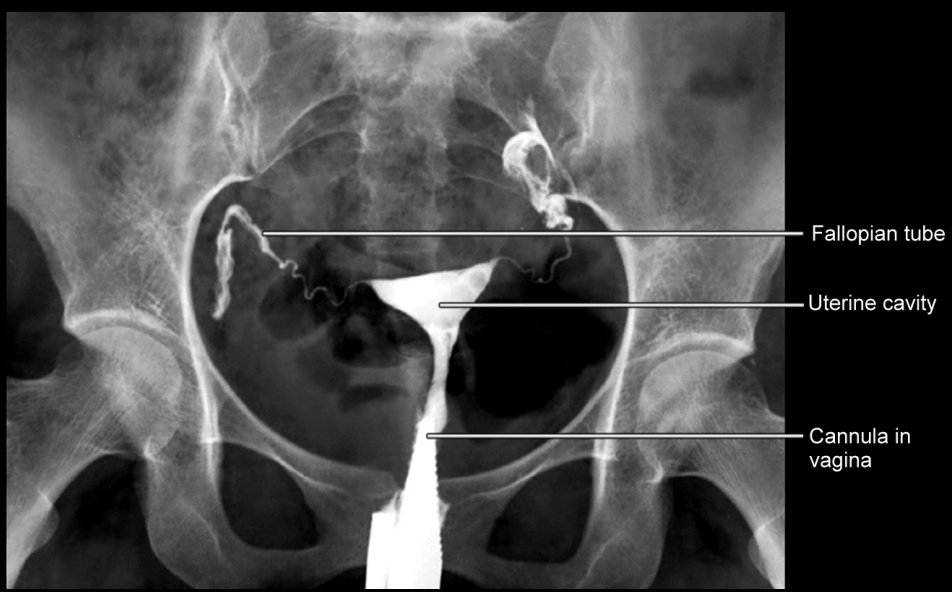
BARIUM ENEMA (DOUBLE CONTRAST)



INTRAVENOUS PYELOGRAM



HYSTEROSALPINGOGRAM



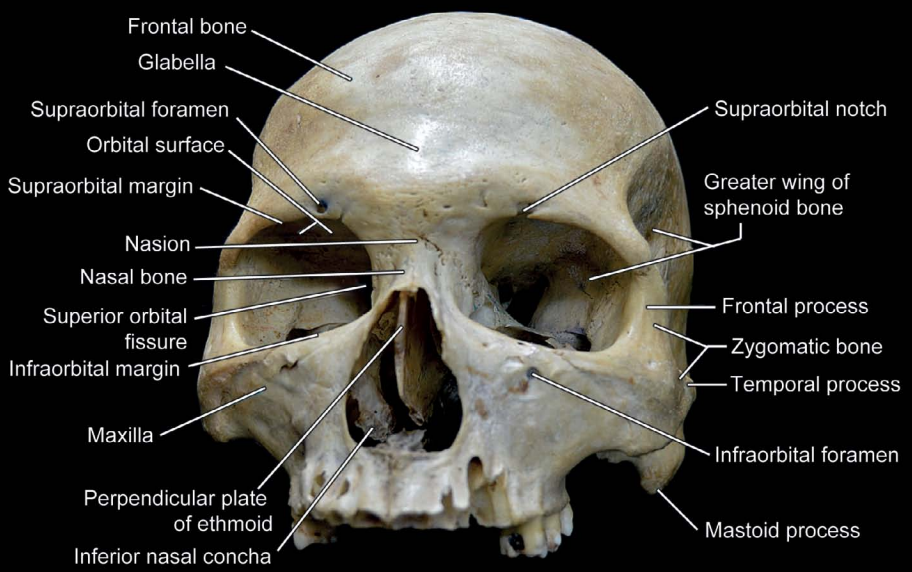
CHAPTER

4

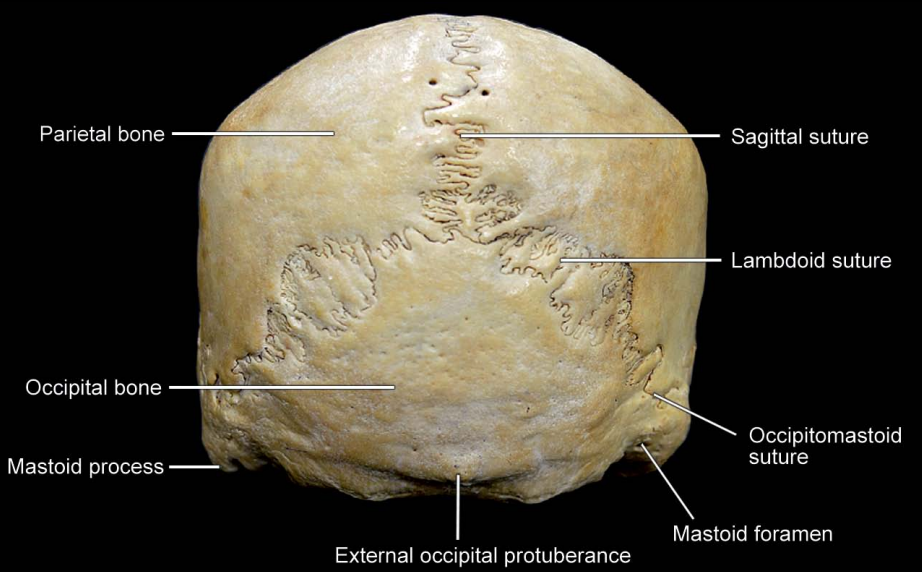
Osteology

Bones

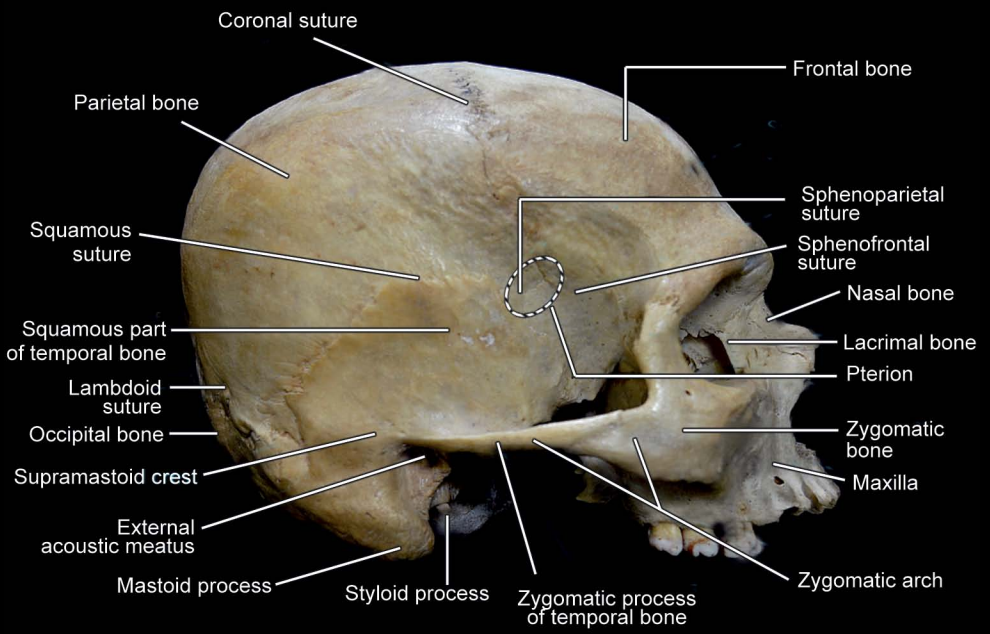
SKULL : ANTERIOR VIEW



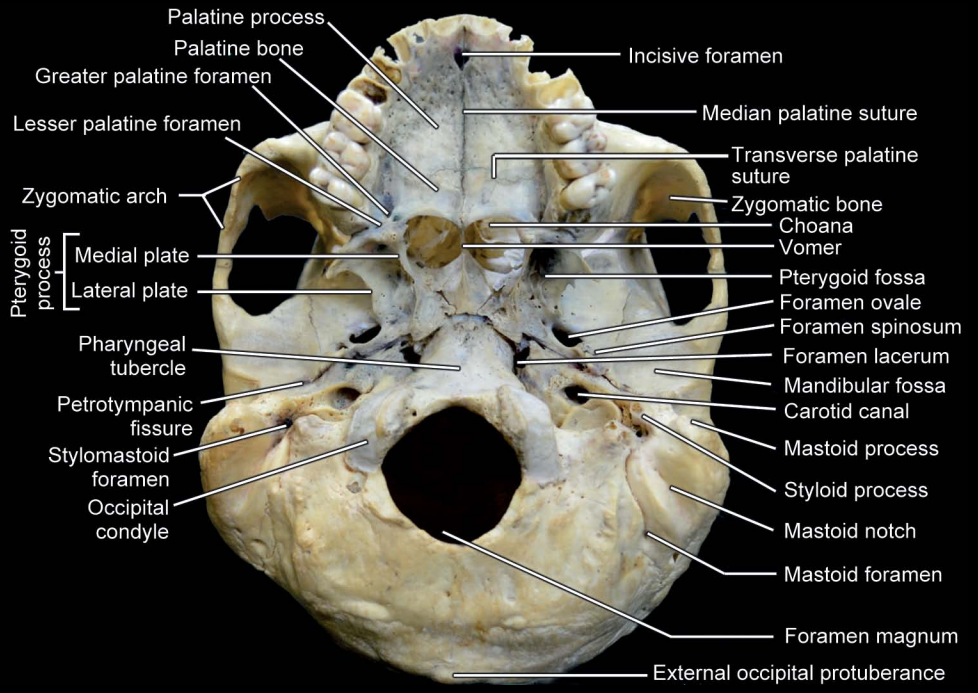
SKULL : POSTERIOR VIEW



SKULL : LATERAL VIEW



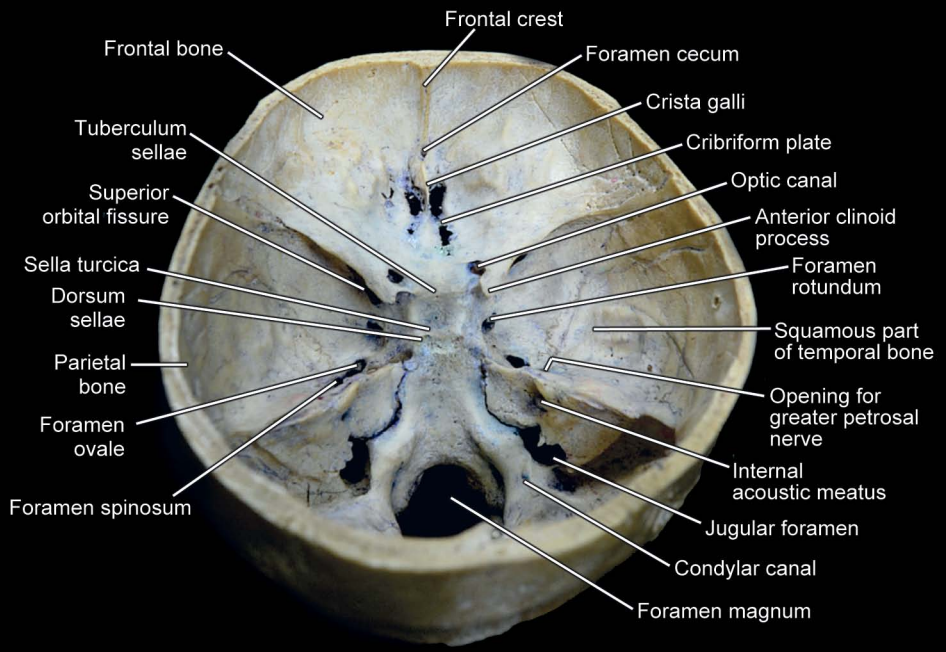
SKULL : INFERIOR VIEW



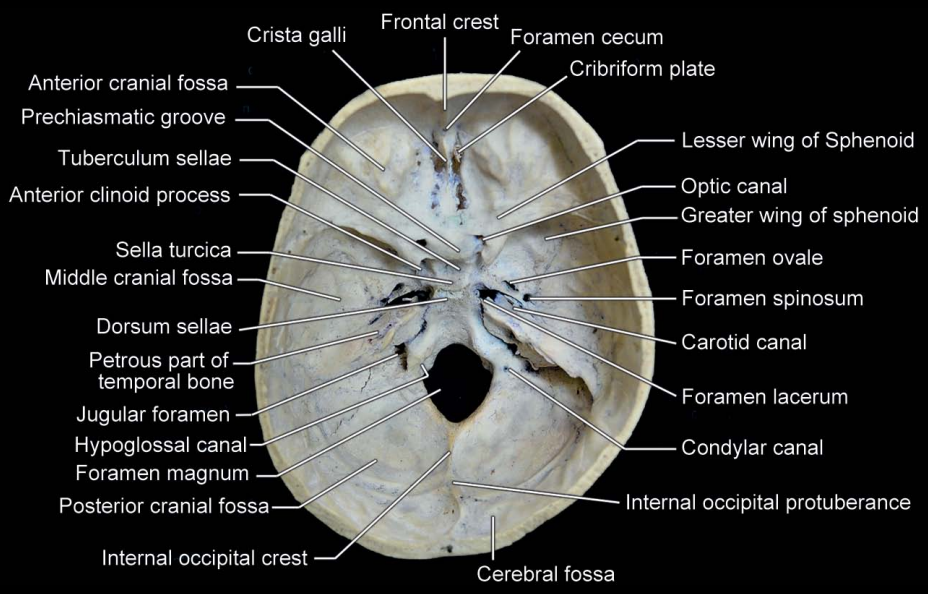
Structures Passing Through Foramina

- *Incisive fossa*: Nasopalatine nerve, sphenopalatine vessels
- *Greater palatine foramen*: Greater palatine nerve and vessels
- *Lesser palatine foramen*: Lesser palatine nerve and vessels
- *Foramen lacerum*: Greater petrosal nerve
- *Foramen ovale*: Lesser petrosal nerve, mandibular nerve, accessory meningeal artery
- *Foramen spinosum*: Middle meningeal vessels, meningeal branch of mandibular nerve
- *Carotid canal*: Internal carotid artery, carotid autonomic plexus
- *Petrotympanic fissure*: Chorda tympani of facial nerve
- *Tympanic canaliculus*: Tympanic branch of glossopharyngeal nerve
- *Mastoid canaliculus*: Auricular branch of vagus nerve
- *Stylomastoid foramen*: Facial nerve
- *Jugular fossa*: Glossopharyngeal nerve, vagus nerve, accessory nerve, superior bulb, internal jugular vein
- *Mastoid foramen*: Mastoid emisary vein, posterior meningeal artey
- *Hypoglossal canal*: Hypoglossal nerve
- *Foramen magnum*: Medulla oblongata, vertebral arteries and venous plexus, spinal accessory nerves.

FLOOR OF CRANIAL CAVITY: POSTEROSUPERIOR VIEW



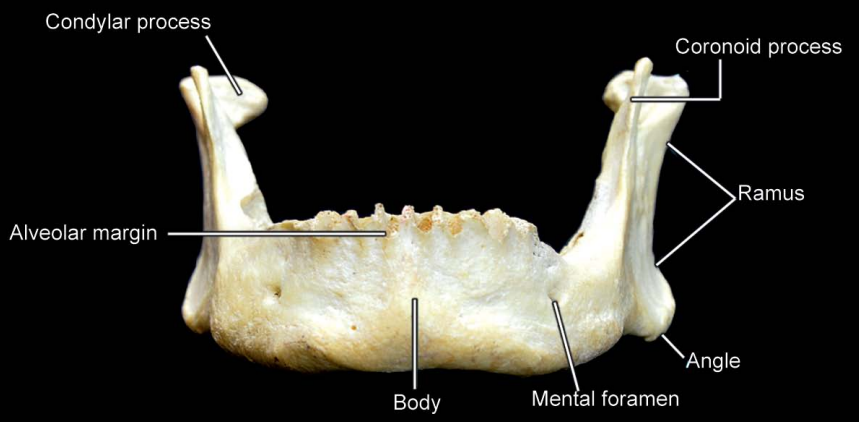
FLOOR OF CRANIAL CAVITY: SUPERIOR VIEW



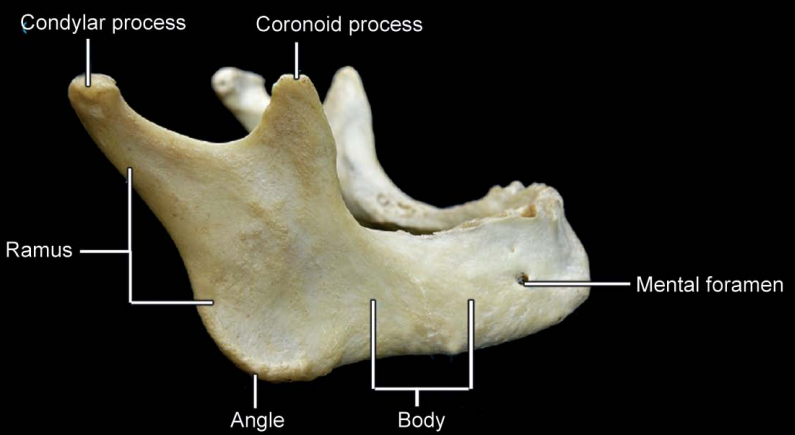
Structures Passing Through Foramina

- *Foramen cecum*: Emissary vein to superior sagittal sinus
- *Nasal slit and anterior ethmoidal foramen*: Anterior ethmoidal artery, vein and nerve
- *Foramina of cribriform plate*: Olfactory nerves
- *Posterior ethmoidal foramen*: Posterior ethmoidal artery, vein, and nerve
- *Optic canal*: Optic nerve, ophthalmic artery
- *Superior orbital fissure*: Oculomotor nerve, trochlear nerve, lacrimal, frontal, and nasociliary branches of ophthalmic nerve, abducent nerve, superior ophthalmic vein
- *Foramen rotundum*: Maxillary nerve
- *Foramen ovale*: Mandibular nerve, accessory meningeal artery, lesser petrosal nerve
- *Foramen spinosum*: Middle meningeal artery and vein, meningeal branch of mandibular nerve
- Sphenoidal emissary foramen (of Vesalius) (inconstant)
- *Carotid canal*: Internal carotid artery, internal carotid nerve plexus
- *Foramen lacerum*: Greater petrosal nerve
- Hiatus for lesser petrosal nerve
- Hiatus for greater petrosal nerve
- Internal acoustic meatus: Facial nerve, vestibulocochlear nerve, labyrinthine artery
- *Opening of vestibular aqueduct*: Endolymphatic duct
- *Mastoid foramen*: Emissary vein and occasional branch of occipital artery
- *Jugular foramen*: Inferior petrosal sinus, glossopharyngeal nerve, vagus nerve, accessory nerve, sigmoid sinus, posterior meningeal artery
- *Hypoglossal canal*: Hypoglossal nerve
- *Foramen magnum*: Medulla oblongata, meninges, vertebral arteries, meningeal branches of vertebral arteries, spinal roots of accessory nerves.

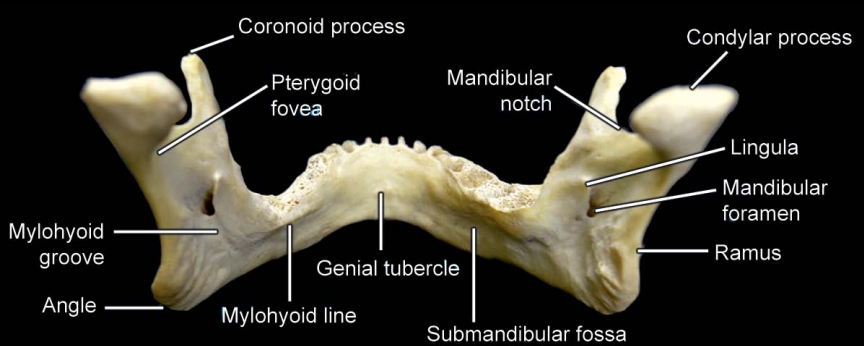
MANDIBLE : ANTERIOR VIEW



MANDIBLE : LATERAL VIEW

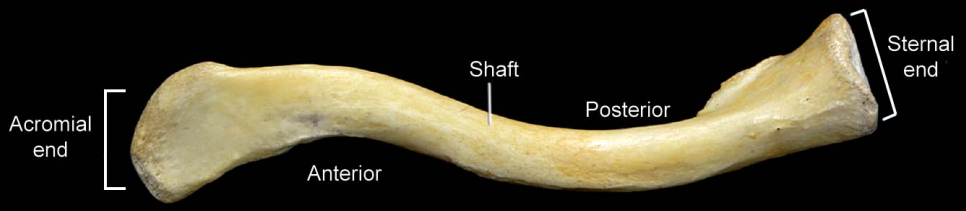


MANDIBLE : POSTERIOR VIEW

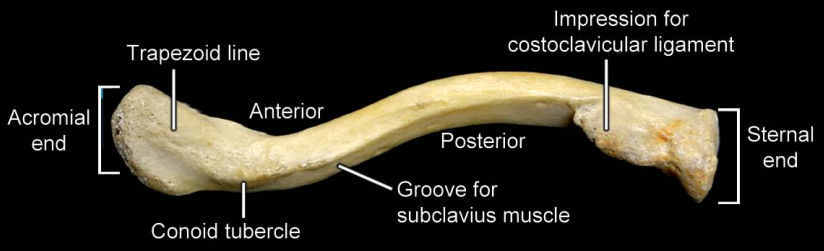


UPPER LIMB

CLAVICLE : SUPERIOR VIEW

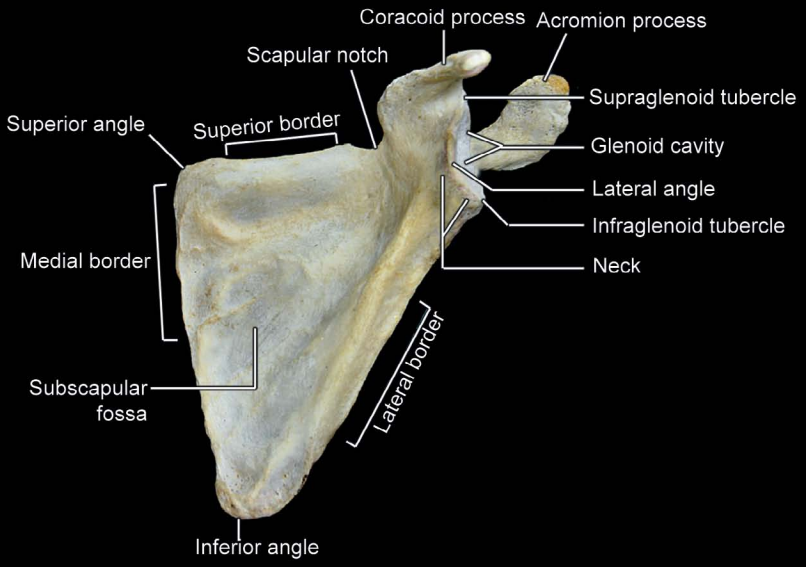


CLAVICLE : INFERIOR VIEW

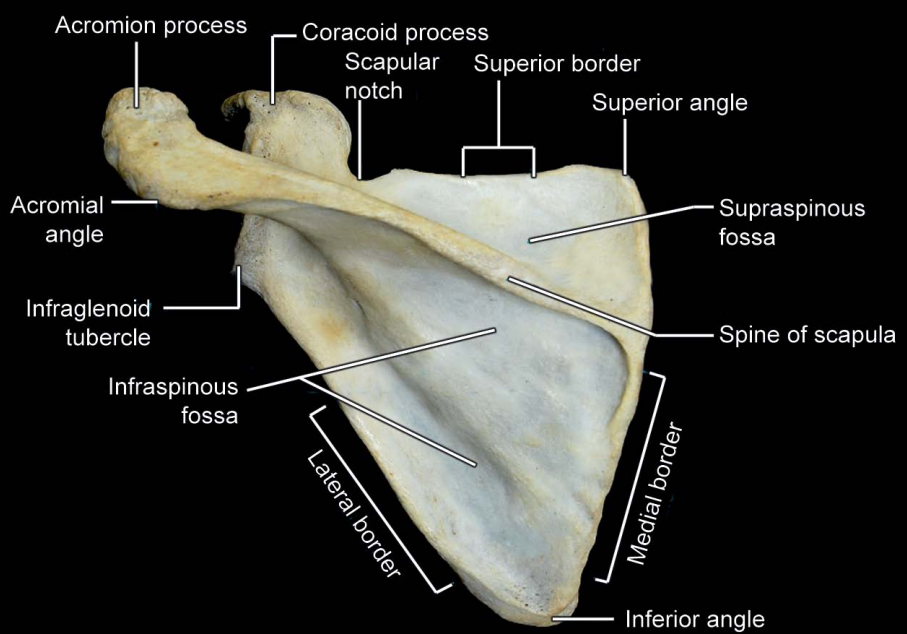


SCAPULA : ANTERIOR VIEW

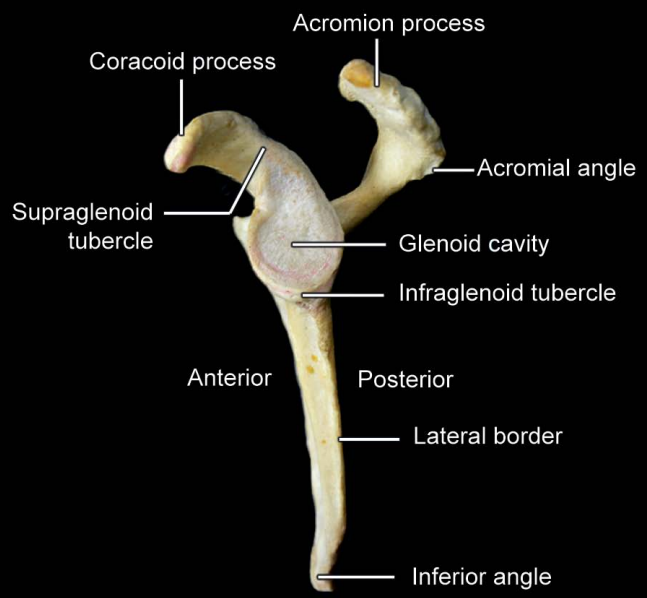
Left scapula anterior view



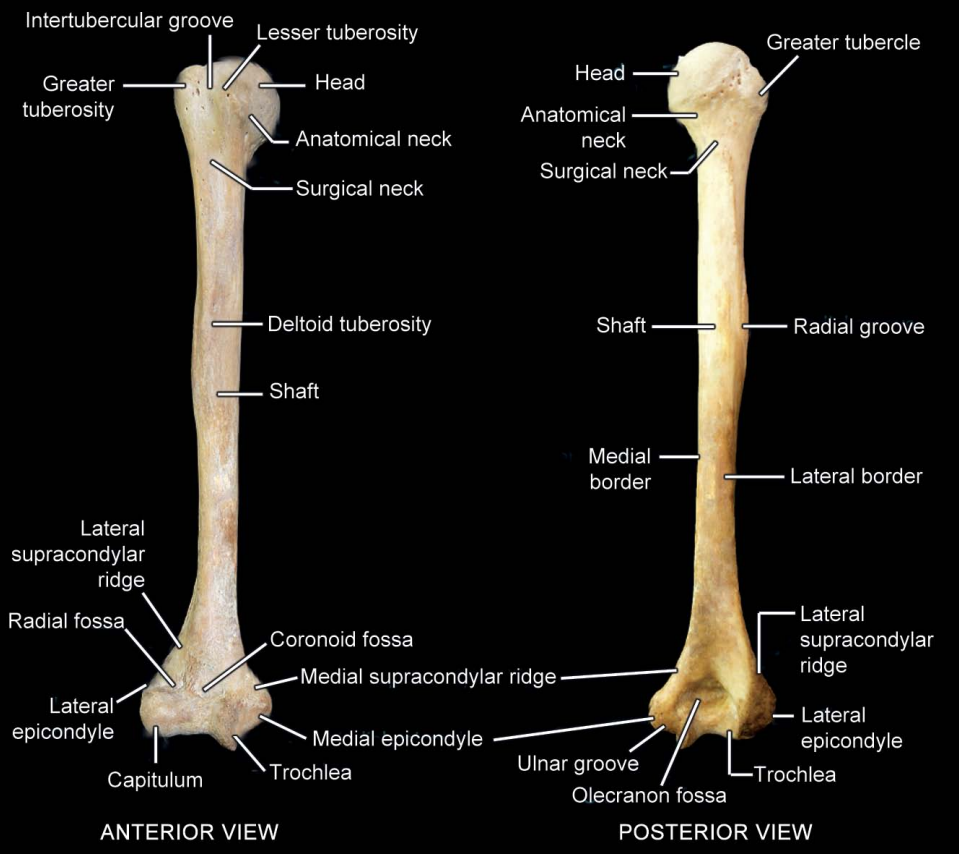
SCAPULA : POSTERIOR VIEW

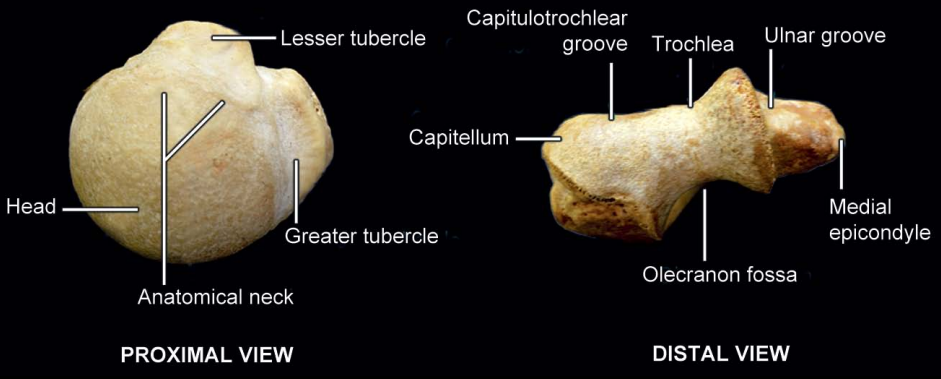


SCAPULA : LATERAL VIEW

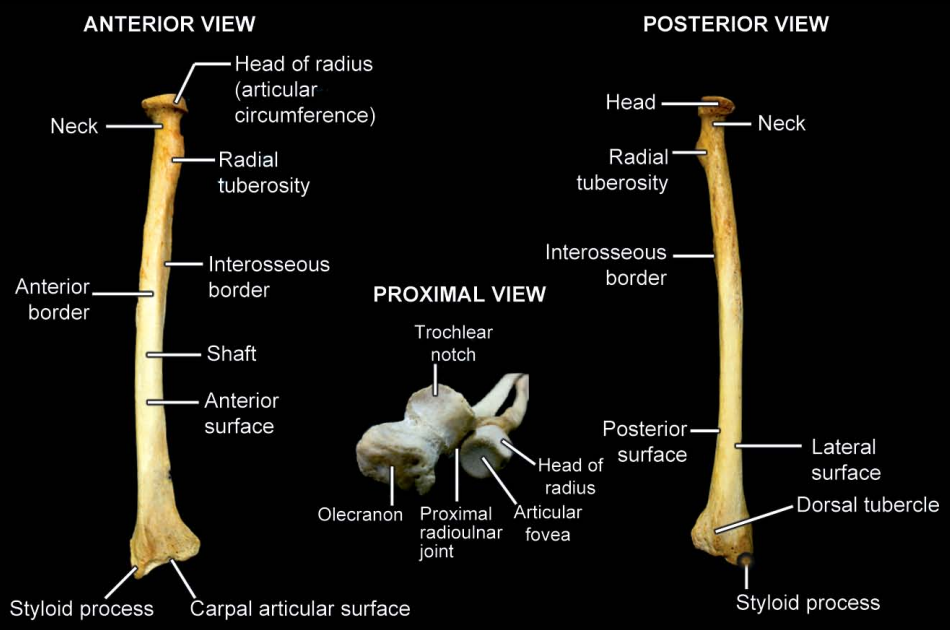


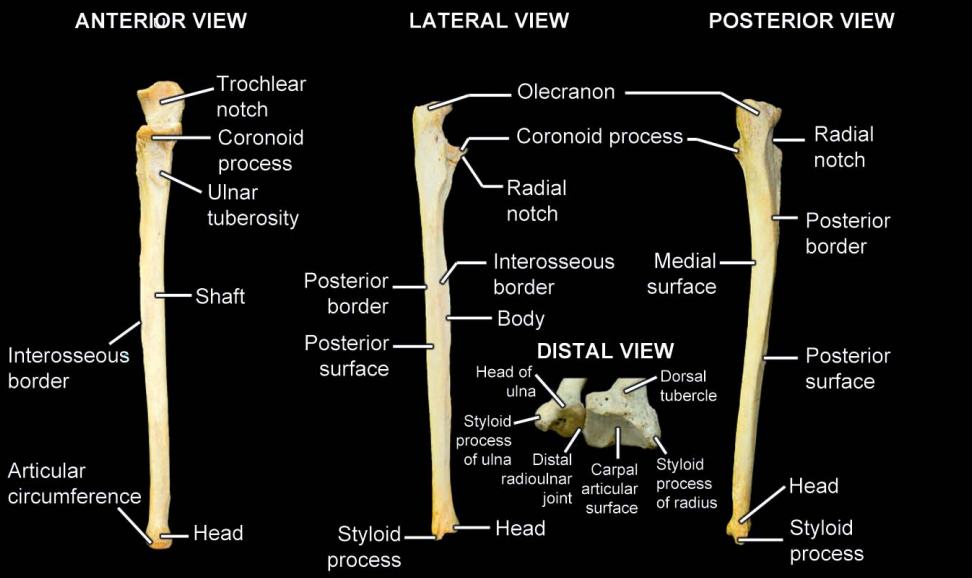
HUMERUS


Intertubercular groove
Lesser tuberosity
Greater tuberosity
Head
Anatomical neck
Surgical neck
Deltoid tuberosity
Shaft
Lateral supracondylar ridge
Radial fossa
Coronoid fossa
Medial supracondylar ridge
Lateral epicondyle
Medial epicondyle
Capitulum
Trochlea
ANTERIOR VIEW
Greater tubercle
Head
Anatomical neck
Surgical neck
Shaft
Radial groove
Medial border
Lateral border
Lateral supracondylar ridge
Lateral epicondyle
Ulnar groove
Trochlea
Olecranon fossa
POSTERIOR VIEW


Lesser tubercle
Head
Greater tubercle
Anatomical neck
PROXIMAL VIEW
Capitulotrochlear groove
Trochlea
Ulnar groove
Capitellum
Medial epicondyle
Olecranon fossa
DISTAL VIEW

RADIUS AND ULNA



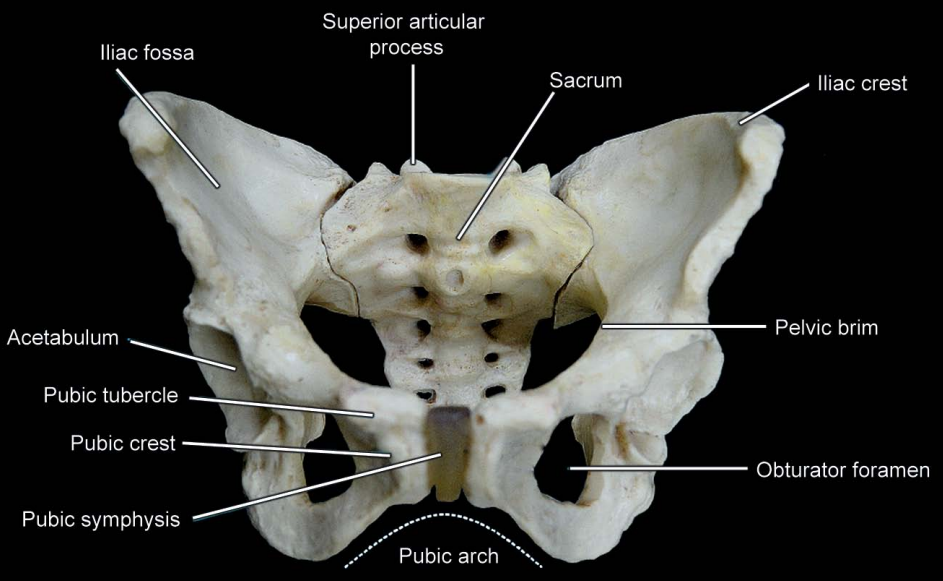


HAND : DORSAL VIEW

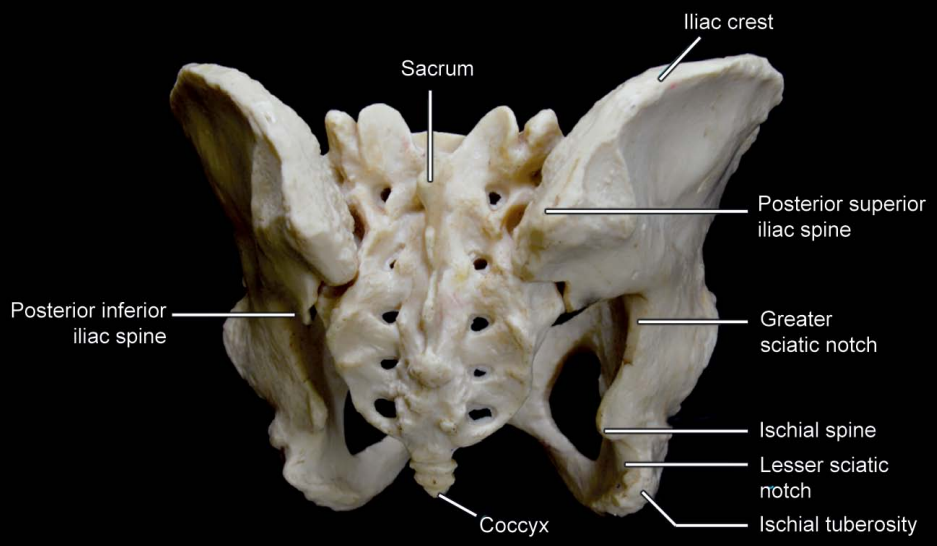
LEFT HAND DORSAL VIEW

LOWER LIMB

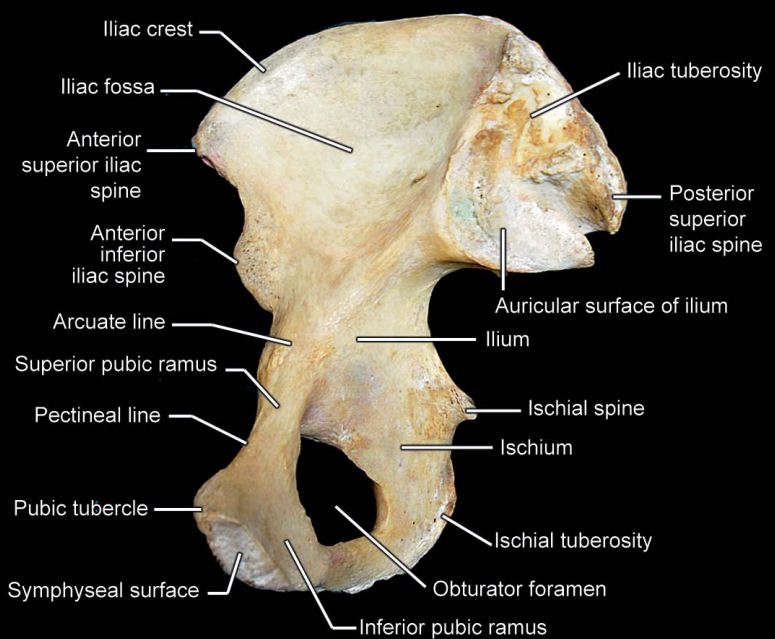
PELVIS : ANTERIOR VIEW



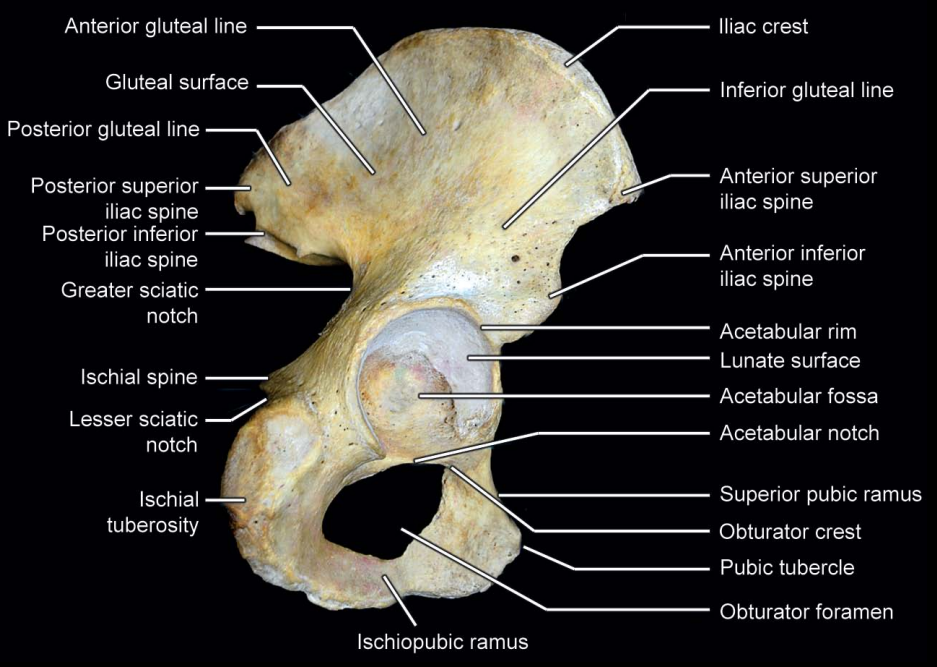
PELVIS : POSTERIOR VIEW



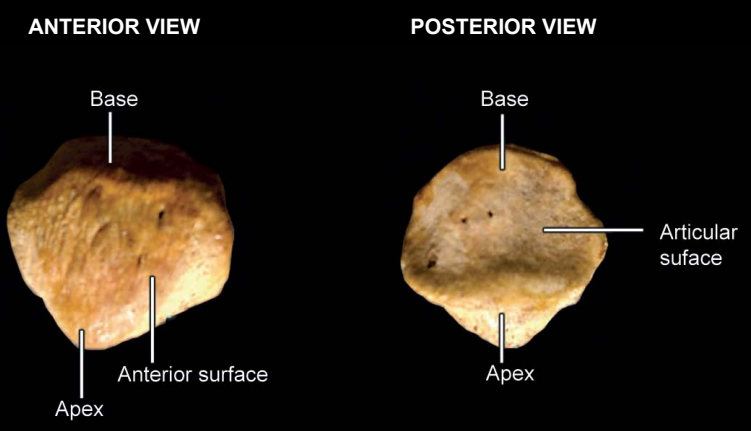
HIP BONE : MEDIAL VIEW



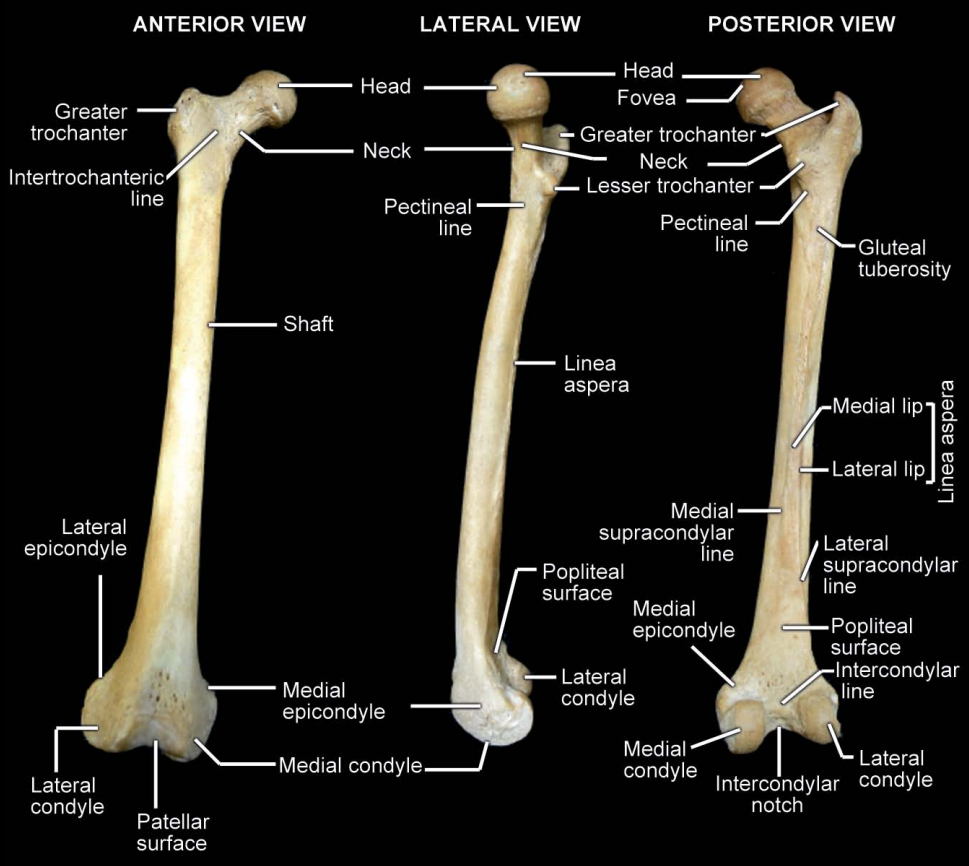
HIP BONE : LATERAL VIEW

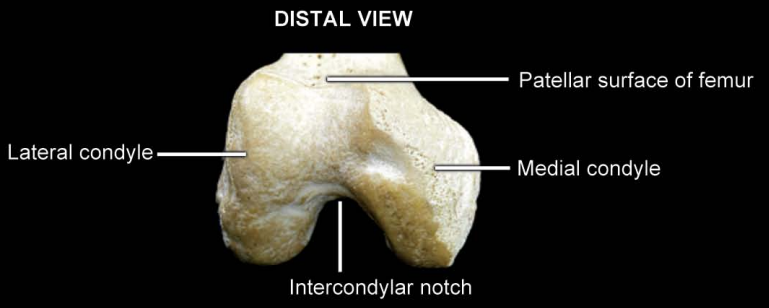


PATELLA

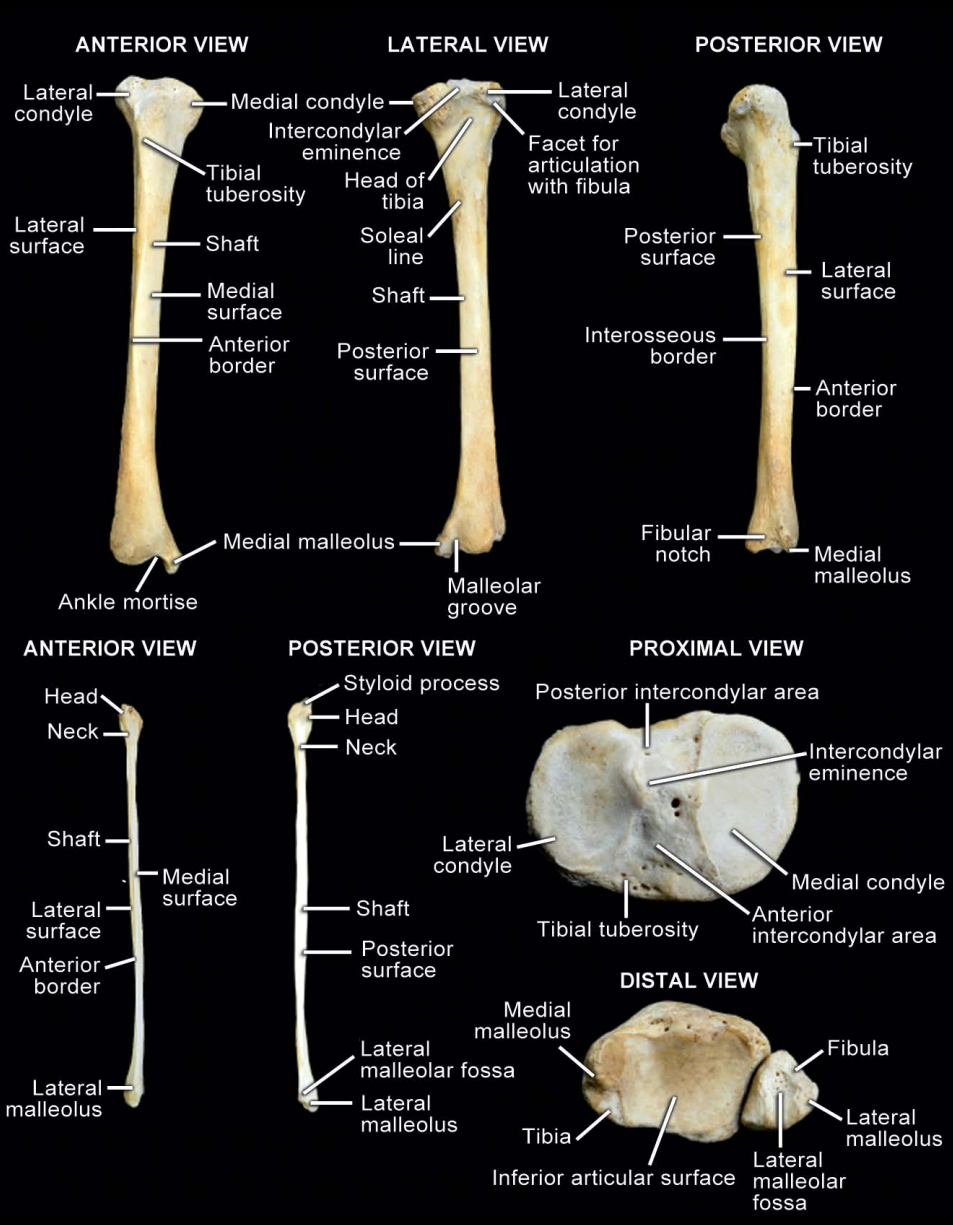


FEMUR

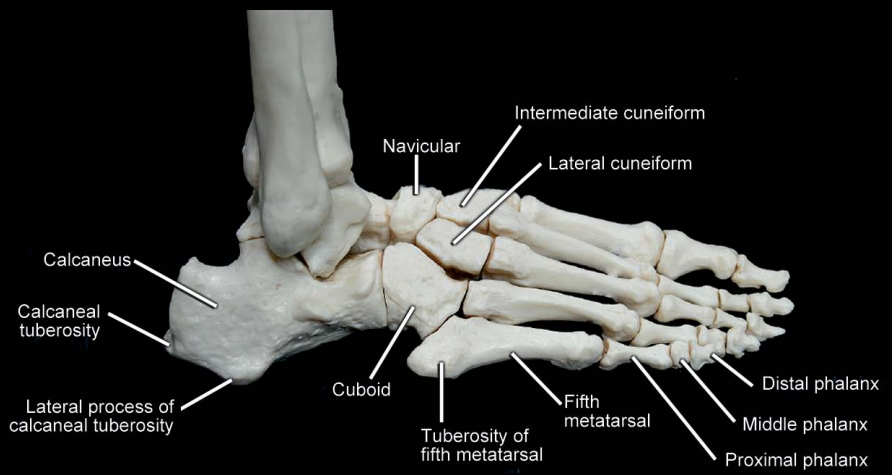




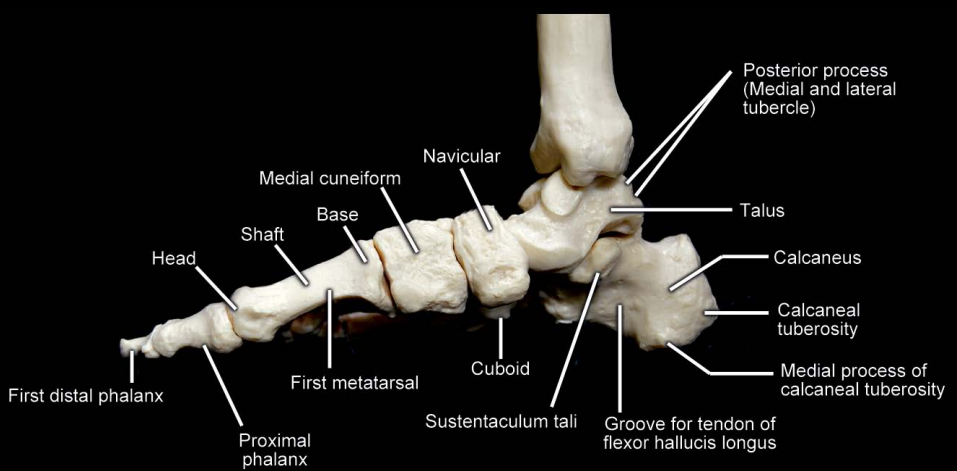
TIBIA AND FIBULA



FOOT : LATERAL VIEW

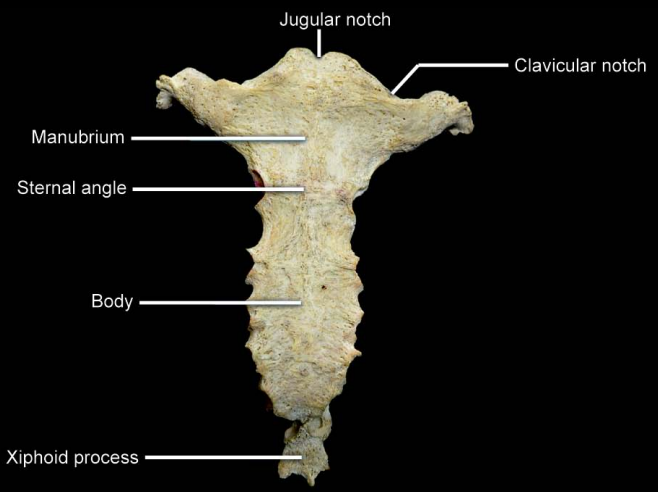


FOOT : MEDIAL VIEW

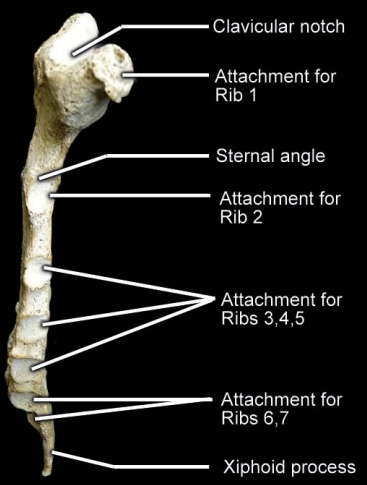


THORAX

STERNUM : ANTERIOR VIEW

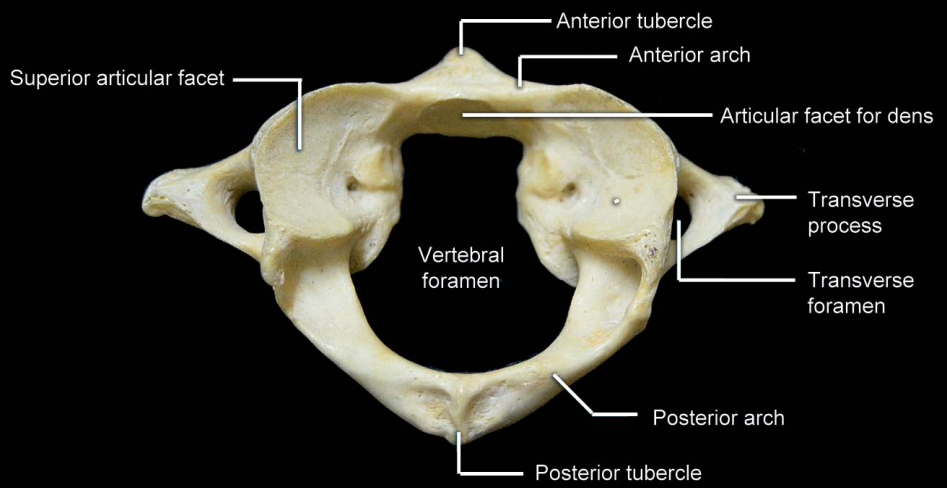


STERNUM : LATERAL VIEW

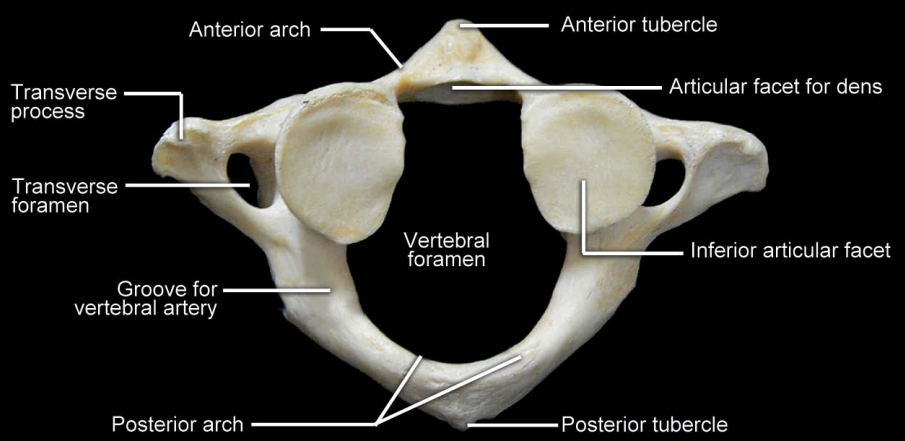


VERTEBRAE

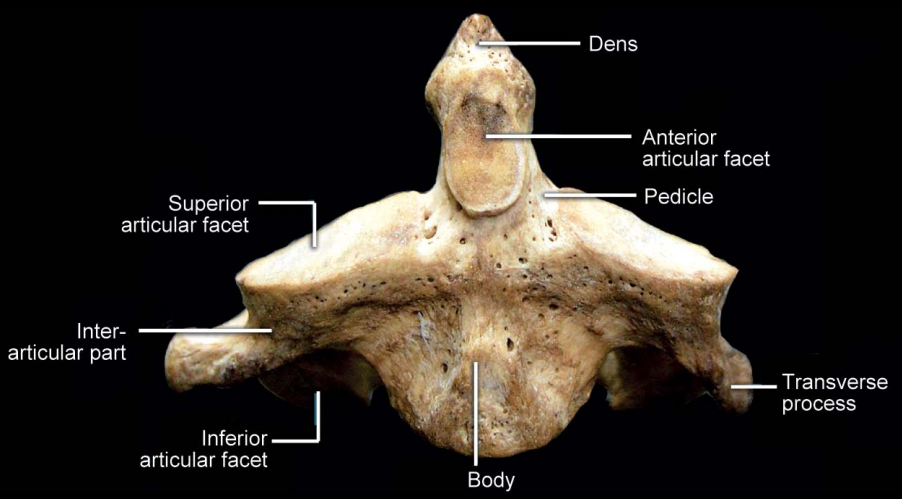
ATLAS : SUPERIOR VIEW



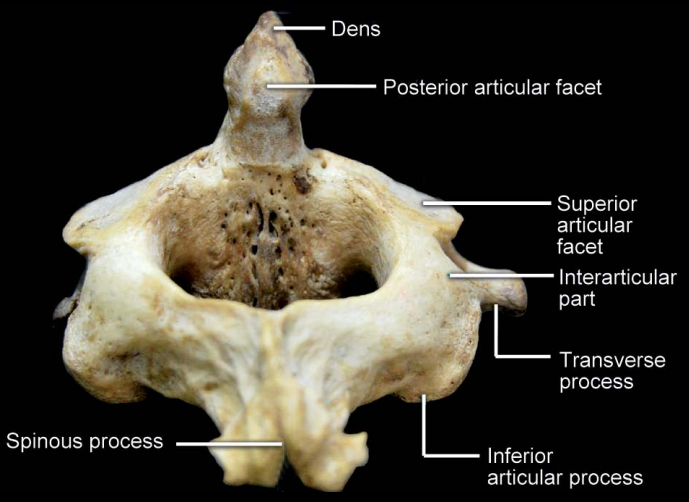
ATLAS : INFERIOR VIEW



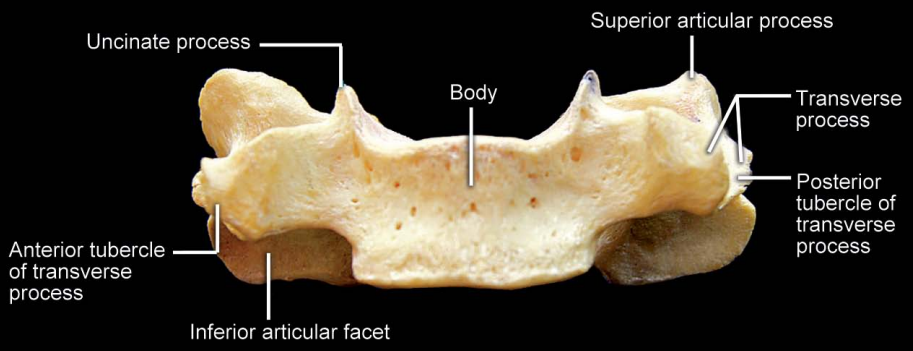
AXIS : ANTERIOR VIEW



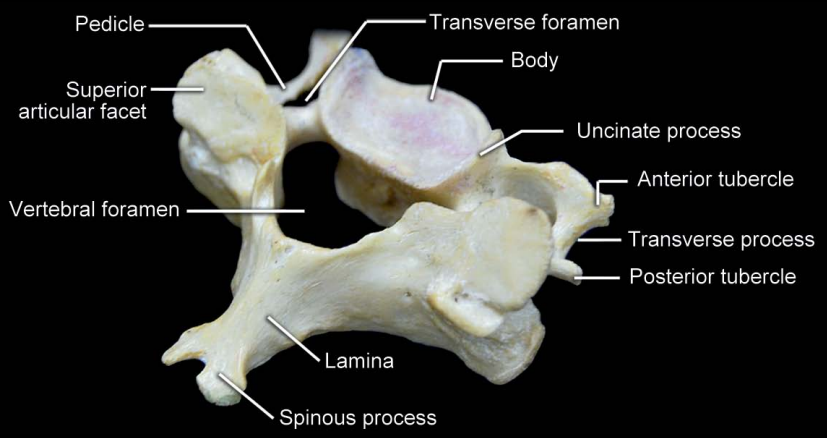
AXIS : POSTERIOR VIEW



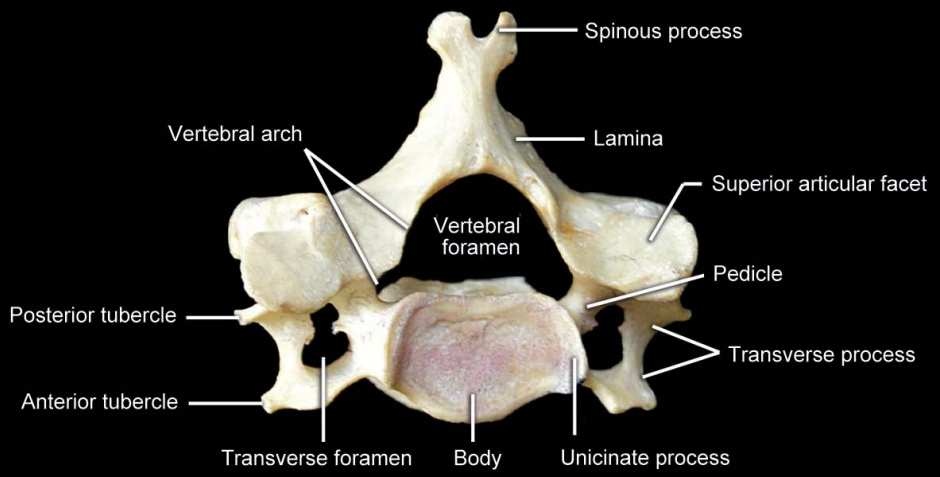
CERVICAL VERTEBRAE : ANTERIOR VIEW



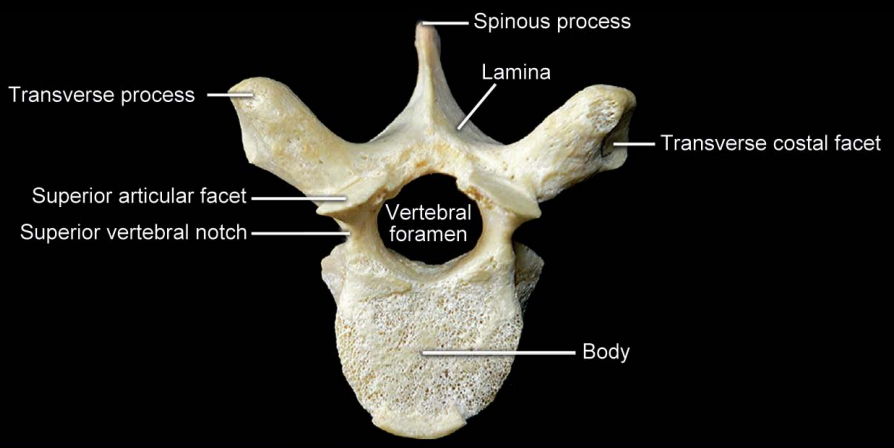
CERVICAL VERTEBRAE : POSTEROLATERAL OBLIQUE VIEW



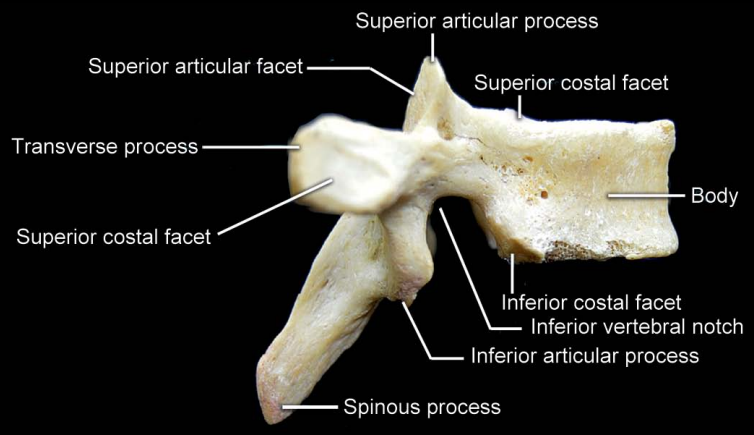
CERVICAL VERTEBRAE : SUPERIOR VIEW



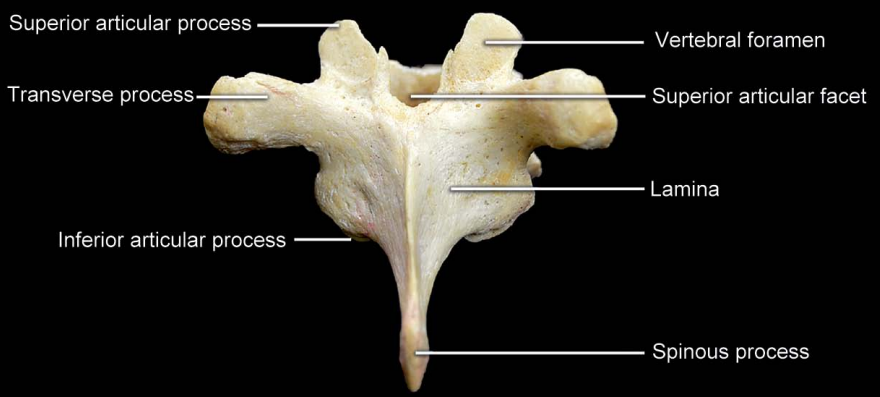
THORACIC VERTEBRAE : SUPERIOR VIEW



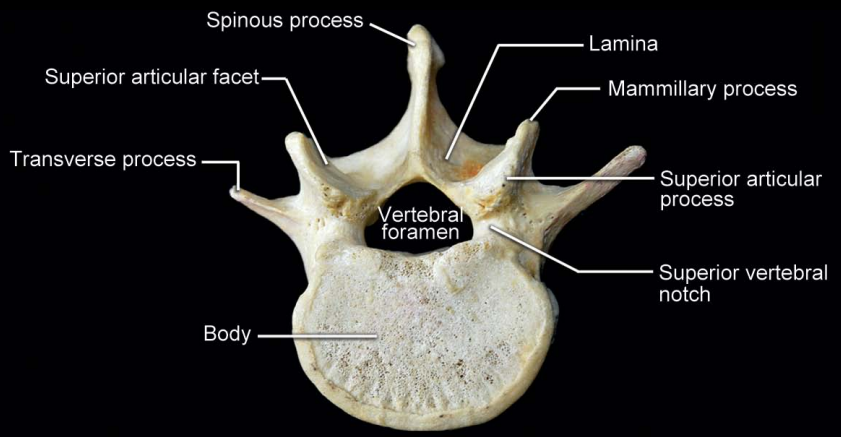
THORACIC VERTEBRAE : LATERAL VIEW



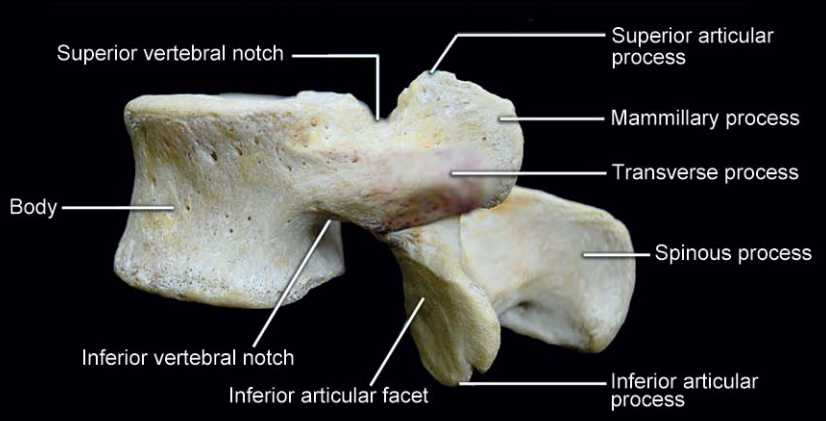
THORACIC VERTEBRAE : POSTERIOR VIEW



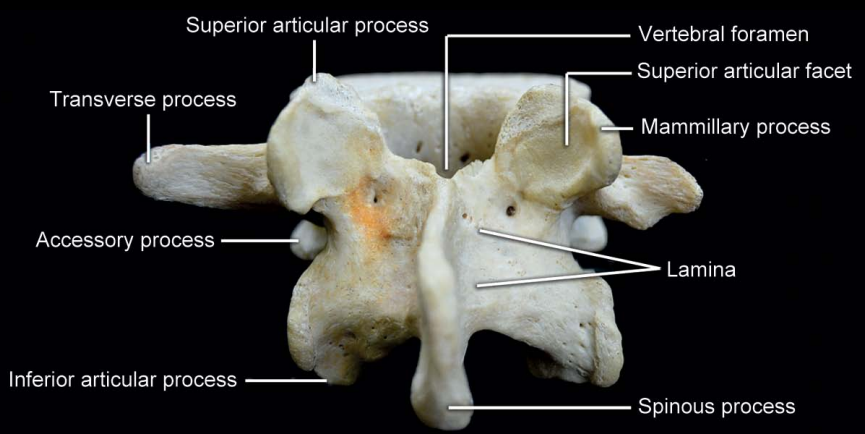
LUMBAR VERTEBRAE : SUPERIOR VIEW



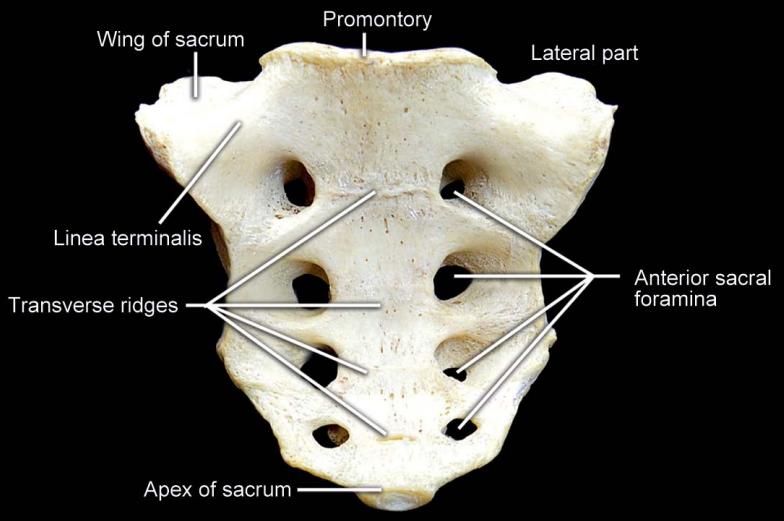
LUMBAR VERTEBRAE : LATERAL VIEW



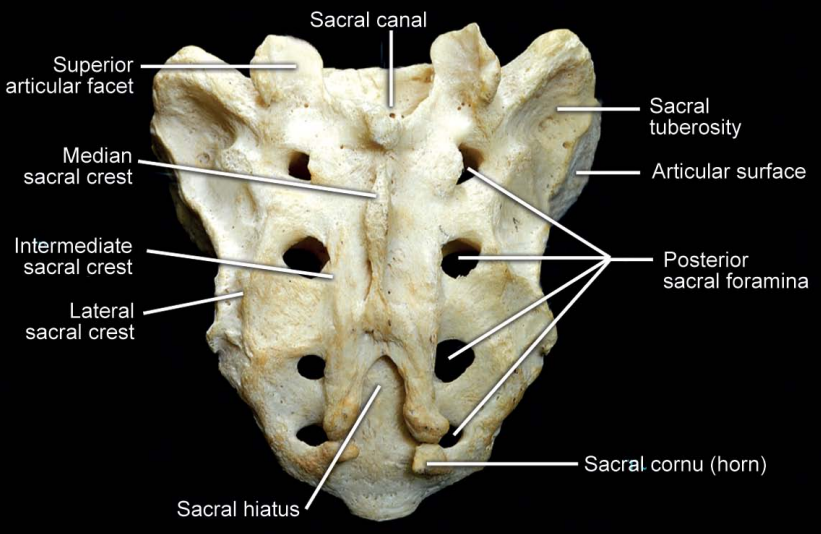
LUMBAR VERTEBRAE : POSTERIOR VIEW



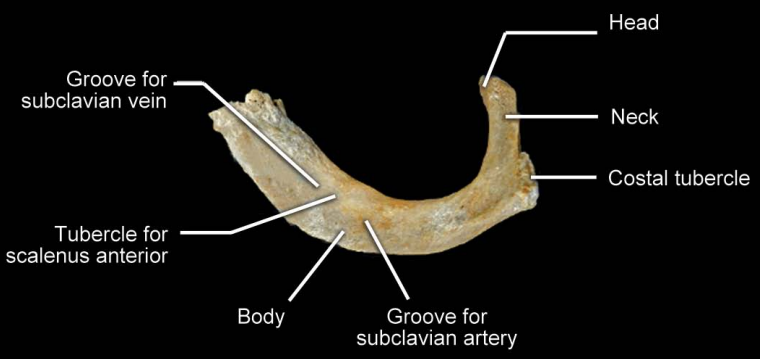
SACRUM : ANTERIOR VIEW



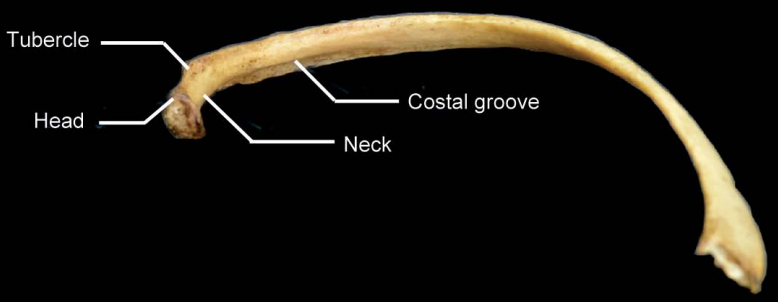
SACRUM : POSTERIOR VIEW



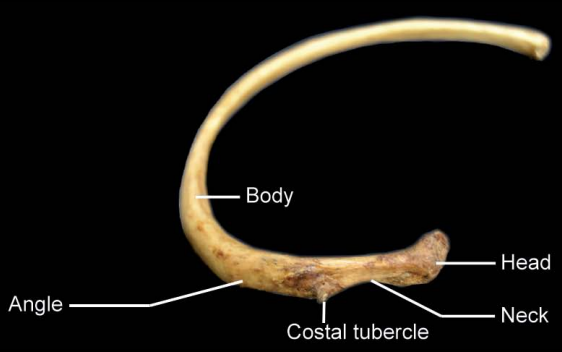
RIB 1 : SUPERIOR VIEW



RIB 5 : MEDIAL VIEW



RIB 5 : LATERAL VIEW



Anatomical Position, Side Determination and Features

CLAVICLE

Clavicle has a shaft and two ends, sternal (M) and acromial (L).

Side Determination

- Curvatures lie in a horizontal plane
- Lateral end is flattened and medial end is quadrilateral
- Inferior surface of middle 1/3rd has a longitudinal groove
- Medial 2/3rd of the clavicle is convex forwards and lateral 1/3rd is concave forwards.

Anatomical Position

The clavicle extends laterally almost horizontally at the root of neck.

Features

- Subcutaneous bone.
- Only long bone lying horizontally in the body.
- No medullary cavity.
- First bone to ossify in the body.
- Ossification—2 primary center and 1 secondary center.
- Only long bone having membranous ossification (other long bones—cartilaginous ossification).
- It may be pierced by intermediate supraclavicular nerve.

SCAPULA

Consists of:

- Two surfaces—costal and dorsal
- Three borders—superior, lateral and medial borders
- Three angles—superior, inferior, lateral or glenoid angle
- Three processes—spinous, acromion and coracoid
- Ossification—one primary center and seven secondary centers.

Side Determination

- The glenoid cavity of scapula faces laterally.
- Spine of scapula, is directed posteriorly.

- Scapula's upper border is marked by coracoid process and a notch called as suprascapular notch near the root of coracoid process.

Anatomical Position

Keep scapula in such a way that:
- Glenoid cavity is directed laterally, forwards and slightly upwards
- Coracoid process is directed forwards.

HUMERUS

- Vertical bone located in the arm
- Largest and longest bone of upper limb.

Side Determination

- The rounded end (head) is superior
- The head is directed medially
- Lesser tuberosity at the upper end faces forward.

Anatomical Position

Humerus is placed vertically in such a way that the head at its upper end faces medially, backwards and upwards.

Features

Humerus has two ends (upper and lower) and a shaft.

Upper End

It includes head, neck, greater and lesser tubercles and intertubercular sulcus.

Lower End

- It is flattened from before backwards.
- It is expanded from side to side.
- It consists of articular parts like capitulum and trochlea and nonarticular parts like medial and lateral epicondyles, coronoid fossa, radial fossa, and olecranon fossa.

Shaft

- It is rounded in upper half and triangular in lower half.
- It has 3 borders anterior, medial and lateral.
- It has 3 surfaces anterolateral, anteromedial and posterior.

RADIUS

- Lateral bone of forearm
- Homologous with tibia of leg
- Consists of upper and lower ends and a shaft
- Upper end consists of head neck and tuberosity.
- Shaft consists of 3 borders—anterior border, posterior border and medial or interosseous border and 3 surfaces anterior surface, posterior surface and lateral surface.
- Lower end consists of 5 surfaces—anterior, posterior with listers tubercle, medial, lateral elongated as styloid process and inferior surface.

Side Determination

- Place the bone vertically in such a way that the narrow end is superior while the wider end is inferior
- Styloid process located in lower end is directed laterally
- Interosseous border of shaft directed medially.

Anatomical Position

Vertically place it with the head superior, radial tuberosity and interosseous border medially, styloid process lateral and Lister's tubercle posterior.

ULNA

- It is the medial bone of forearm and is homologous with fibula of lower limb
- It consists of an upper end, lower end and a shaft
- Upper end consists of two processes (olecranon and coronoid) and 2 notches (trochlear and radial)
- Shaft consists of 3 borders (lateral, anterior and posterior) and 3 surfaces (anterior medial and posterior)
- Lower end consists of head and styloid process.

Side Determination

- Keep the bone vertically in such a way that the hook-like end is upwards
- The concavity of hook and the coronoid process are looking forwards
- Sharp crest like border of shaft is directed laterally.

Anatomical Position

Ulna is the medial bone of forearm lying vertically in such a way that the concavity at the upper end faces forwards and interosseous border is directed towards lateral bone of forearm, i.e. radius.

HIP BONE

- Made up of the three parts namely ilium, ischium and pubis.
- Ilium forms the upper fan shaped portion. It consists of 2 ends (upper and lower), 3 borders (anterior, posterior and medial) and 2 surfaces (lateral and medial).
- Ischium is the posteroanterior part, comprises of body and acetabulum.
- Pubis—anteroinferior part, consists of a body, superior and inferior ramus.

Side Determination

- Hip bone is expanded superiorly and inferiorly with a middle constricted part.
- The inferior expanded part contains obturator foramen.
- Acetabulum directed laterally.
- Pubis is directed anteriorly while ischium is relatively posterior.

Anatomical Position

- Pubic symphysis surface lies anteriorly in the median plane.
- Pubic tubercle and anterior superior iliac spine lie in the same coronal plane. Acetabulum should be directed laterally.
- Ischial spine and upper border of pubic symphysis is placed in such a way that they lie in the same horizontal plane.

FEMUR

- It consists of an upper end, lower end and a shaft.
- Upper end consists of head, neck, greater and lesser trochanters.
- Lower end consists of 2 condyles (medial and lateral), a deep space between them (intercondylar fossa or notch) and articular surfaces for tibia and fibula.
- Shaft is divided into 3:
  - Upper 1/3rd consisting of 4 borders (medial, lateral, linea aspera, gluteal tuberosity) and 4 surfaces (anterior, medial, lateral, posterior)
  - Middle 1/3rd consisting of 3 borders (medial, lateral, posterior) and 3 surfaces (anterior, medial, lateral)
  - Lower 1/3rd consisting of 4 borders (anterior, lateral, medial, and lateral supracondylar line) and 4 surfaces (anterior, medial, lateral and popliteal).

Side Determination

- Upper end bears a rounded head.
- Head is directed medially.
- Convexity of shaft is directed anteriorly.
- Lower end is expanded.

Anatomical Position

- Head faces upwards, medially and slightly forwards.
- The long axis of shaft should be directed medially downwards.

TIBIA

- Consists of an upper end lower end and a shaft.
- Upper end consists of 2 condyles (medial and lateral), an intercondylar area and tuberosity.
- It consists of 5 surfaces (anterior, posterior, medial, lateral and inferior) and a downward projection called medial malleolus.
- Shaft has 3 borders (anterior, medial, lateral) and 3 surfaces (lateral, medial and posterior).

Side Determination

- The larger end is the upper end of tibia
- A downward projection directed medially called medial malleolus is present at the lower end.
- Most prominent border of the shaft is positioned anteriorly (anterior border).

Anatomical Position

- Hold the bone in its corresponding hand
- Keep the bone vertically such that superior surface of the upper end of tibia lies in horizontal plane.

FIBULA

- It has an upper end, lower end and shaft.
- Upper end also called head consists of styloid process
- Shaft has 3 borders (anterior, posterior and medial) and 3 surfaces (medial, lateral and posterior)
- Lower end or the lateral malleolus has 4 surfaces (medial, lateral, anterior and posterior).

Side Determination

- Rounded end of the bone or head is present superiorly.
- The lower end or lateral malleolus is relatively flattened and is directed laterally.
- Medial side of lower end has a triangular articular facet anteriorly and deep fossa (malleolar fossa) posteriorly.

Anatomical Position

Hold the bone vertically in hand of corresponding side, with lateral malleolus directed laterally and malleolar fossa posteriorly.

PATELLA

- Triangular shaped bone.
- Consists of an apex, 3 borders (superior, lateral and medial) and 2 surfaces (anterior and posterior).

Side Determination

- Has a rough anterior surface and smooth posterior surface which is articular.
- Base and apex are directed upwards and downwards respectively.
- A vertical ridge is present on the articular surface, which divides the posterior surface into smaller medial and larger lateral part.

VERTEBRAE

Consists of five types:

Cervical Vertebrae

- Seven in number
- 3-6 typical and others atypical
- Identified by the presence of a foramen transversarium in each transverse process.

Thoracic Vertebrae

- 12 in number
- 2-8 are typical, others being atypical
- Ossifies in cartilage from 3 primary and 5 secondary centers
- Identified by the presence of costal facets on the body.

Lumbar Vertebrae

- Five in number
- First four are typical vertebrae
- Larger in size, wider from side to side than from before backwards
- Vertebral foramen is triangular in shape
- Lacks foramen transversarium and costal facets.

Sacrum

- Formed by fusion of five sacral vertebrae
- Triangular and curved
- Ossification from 21 primary centers

Coccyx

- Formed by the fusion of four coccygeal vertebrae
- Ossification from 4 primary centers
- Triangular in shape, directed downwards and forwards

RIBS

True ribs 1-7
False Ribs 8-12
Vertebrochondral ribs 8, 9, 10
Floating ribs 11, 12

PARTS

It consists of head, neck, tubercle and a shaft.

Ossification

Age	*Center of ossification*	*Union of bone and epiphysis*
5th year	Head of radius, trapezoid; scaphoid, lesser tubercle	Greater tubercle fuses with head of humerus
6th year	distal end of ulna; trapezium	Fusion of ishiopubic rami
7th year	Medial epicondyle of humerus	
9th year	Olecranon, upper end of ulna	
9th to 11th year	Trochlea of humerus	
10th to 11th year	Pisiform, tip of coracoid	
11th year	Lateral epicondyle of humerus, trochlea	
13th year	Seperate centers in triradiate cartilage of acetabulum.	
12th to 14th year	Lesser trochanter of femur	
14th year	Iliac crest, head and tubercles of ribs	Medial epicondyle of humerus; lateral epicondyle with trochlea; patella complete
15th year	Acromion	Coracoid process with scapula, triradiate cartilage
16th year	Ischial tuberosity	Lower end of humerus; olecranon to ulna; upper end of radius; metacarpals; proximal phalanges, lower end of tibia and fibula
17th to 18th year		Head of femur, lesser and greater trochanter of femur; acromion; lower end of ulna, upper end of radius
18th to 19th year	Sternal end of clavicle	Lower end of femur; upper end of tibia and fibula; head of humerus; lower end of radius
20th to 21st year		Iliac crest; sternal end of clavicle; ischial tuberosity; head of the ribs.

Medical and Legal Importance

Clavicle

Clavicle usually breaks at the junction of medial 2/3rd and lateral 1/3rd and is the most commonly fractured bone in the body.

Fibula

In first degree Pott's fracture lateral malleolus is fractured.

Femur

Secondary ossification center at the lower end of femur appear almost at the time of birth, only if the newborn was viable. This feature is made used in medicolegal cases to know whether the newborn was born viable or not.

Hip Bone

Weavers bottom—clinical condition arising due to inflammation of ischial tuberosity bursa in persons sitting for long time.

Humerus

Axillary, radial and ulnar nerves can damaged in fractures of humerus, due to their contacts at different points.

Vertebrae

Spina bifida—occurs due to incomplete closure of spinal canal due to failure of fusion of posterior neural arches of developing vertebrae, most commonly occur at lumbosacral region.

Patella

Patella lacks periosteum therefore patellectomy is often a choice of treatment for fracture of patella since there is no chance for regeneration. Removal of patella does not seriously effect on the movements at knee.

Radius

- Smith's fracture—fracture of distal end of radius, occurs from fall on the back of hand
- Colle's fracture—fracture of radius about 1 inch proximal to wrist due to fall on outstretched hand.

Scapula

Winging of scapula is a clinical condition arising due to the paralysis of serratus anterior, the medial border of the bone become unduly prominent at this condition.

Tibia

- Tibia is commonly fractured at the junction of upper 2/3rd and lower 1/3rd of shaft
- For bone graft, bone piece is taken from subcutaneous medial aspect of tibia.

Ulna

Night stick fracture—Fracture of shaft of ulna due to direct injury when night watchman raises forearm for protection against blow from a stick.

Hyoid Bone

- Hyoid bone is a U-shaped bone situated at the midline of the neck.
- In case of manual strangulated death, the grasping hand squeezes the ends of the 'U' towards each other, displacing the bone inwards and resultant fracture.
- In hanging, anteroposterior compression fracture (fractured and displaced outwards) is seen.

Adductor Tubercle

- Popliteal artery is palpable against adductor tubercle.
- Epiphyseal line passes through adductor tubercle.

Angle of Mandible

The angle is everted in males and the angle is inverted in females.

Axis

Hangman's fracture: Fracture of both pedicles of the axis vertebra (C2). Injury occurs due to impacts of high force causing hyperextension of the neck and great axial load onto the C2 vertebrae. It occurs in case of judicial hanging, during falls usually in older adults and motor accidents.

Sternum

Clinical significance of a sternal angle is that:

- It lies anterior to the arch of the aorta.
- It lies anterior to the carina (point of bifurcation of trachea).
- It corresponds to intervertebral disc between the T4 and T5 vertebra or level 2nd costal cartilage. So any injury at the point of sternal angle could be lethal.

Scaphoid

Scaphoid fracture is common during falling on outstretched hand; since scaphoid has very low blood supply as a result fracture of scaphoid (especially proximal part) is vulnerable to loss of the blood supply to that part leading to avascular necrosis. Referred to as scaphoid nonunion.

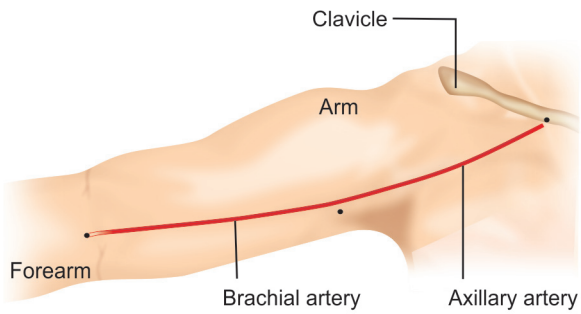
CHAPTER

5

Surface Marking

Upper Limb

AXILLARY ARTERY



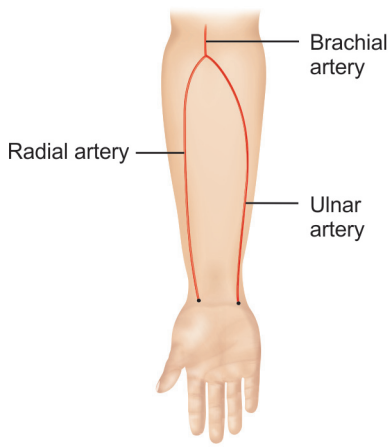
- Abduct the arm at 90 degrees.
- Mark the midpoint of clavicle.
- Mark another point at lower limit of lateral wall of axilla (junction of anterior and middle thirds of outer axillary wall).
- Mark a point in front of posterior axillary fold.
- Join these points by a broad line to get the surface marking.

BRACHIAL ARTERY

- Mark a point just in front of posterior axillary fold.
- Mark a point in the middle line of limb at the level of neck of radius.
- Join the points.

RADIAL ARTERY

- Mark a point at level of neck of radius in the elbow medial to tendon of biceps.
- Mark a point at wrist in the interval between tendon of flexi carpi radialis medially and anterior border of radius laterally.
- Join the points with curved line having convexity to lateral side to get surface marking.



ULNAR ARTERY

- Mark a point in the middle line of forearm opposite to the neck of the radius.
- Mark another point at the junction of upper 1/3rd and lower 2/3rd of the forearm near its medial border.
- Mark the third point at the lateral edge of pisiform.
- Join the first two points by a curved line which passes downwards and medially.
- Then join the second point with third one to get the surface marking.

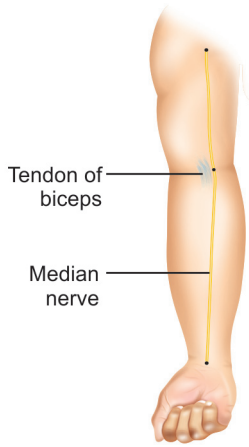
AXILLARY NERVE

- Mark the midpoint of the line joining the tip of the acromion to the deltoid tuberosity.
- Mark another point 2 cm above the midpoint of the above line.
- Draw a transverse line from the second point across the deltoid muscle to get the surface marking.

MEDIAN NERVE

Arm

- Mark brachial artery first.
- Median nerve lies lateral to artery in the upper half, medial to the artery in the lower half.
- It crosses the vessel ventrally in the middle of the arm.



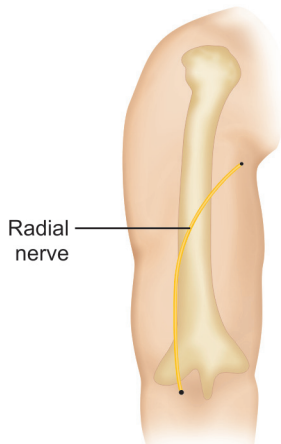
Forearm

- Mark the first point at the level of neck of the radius in the middle line of the forearm.
- Mark second point at the wrist 1 cm medial to the flexor carpi radialis tendon.
- Join the two points.
- At wrist nerve runs laterally from undercover of palmaris longus tendon.

MUSCULOCUTANEOUS NERVE

- Mark a point 5 cm below the coracoid process.
- Mark the midpoint of elevation caused by the biceps.
- Third point is marked just lateral to tendon of biceps.
- Join these points.

RADIAL NERVE



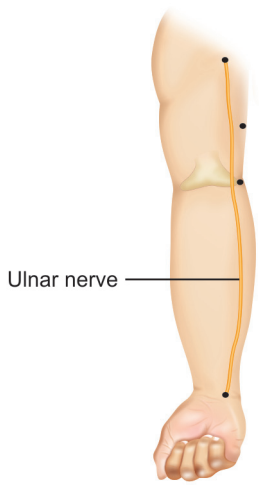
Arm

- Mark a point at the lower end of axillary artery.
- Mark the junction between the upper 1/3rd and lower 2/3rd of the line joining insertion of deltoid to the lateral epicondyle.
- Mark a point 1 cm lateral to the tendon of biceps at the level of lateral epicondyle.
- Join these points.

Forearm

- Mark a point 1 cm lateral to tendon of biceps at the level of lateral epicondyle of humerus.
- Mark a point at the junction of middle and lower 1/3rd of lateral border of forearm.
- Mark a point in the anatomical snuff box.
- Join these three points.

ULNAR NERVE

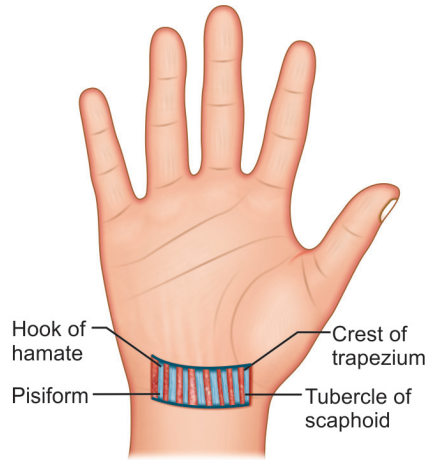


Arm

- Mark a point medial to lower end of axillary artery.
- Mark another point just medial to midpoint of brachial artery.
- Mark a point on the posterior aspect of the medial epicondyle of humerus. Join these 3 points.

Forearm

- Mark a mark on the base of medial epicondyle of humerus.
- Mark a point at the lateral edge of pisiform bone.
- Join these points by a line which should follow the lateral side of the tendon of flexor carpi ulnaris in the lower part of the forearm.



FLEXOR RETINACULUM

- Mark the hook of hamate.
- Mark the crest of trapezium.
- Mark a point on the pisiform bone.
- Mark the tubercle of scaphoid.
- Join first two points by a line concave downwards.
- And last two points by a line concave upwards.
- Wide band between these two lines represent the flexor retinaculum.

EXTENSOR RETINACULUM

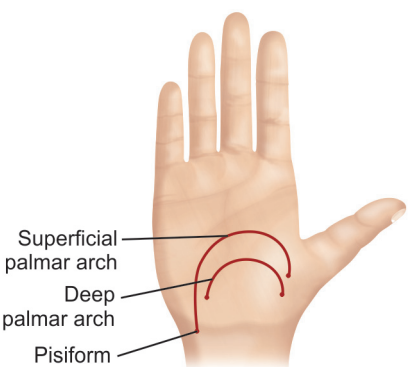
- Mark a point on the anterior border of radius above its styloid process.
- Mark a point on the styloid process of ulna.
- Mark the lower border of anterior end of radius.
- Mark a point on the triquetral bone.
- Join first two points to get upper border.
- Draw a line by joining the last two points parallel to upper border to get lower border.

SUPERFICIAL PALMAR ARCH

- Mark a point just lateral and distal side to the pisiform bone.
- Mark the hook of hamate.
- Mark a point on the center of the palm, at the level of distal margin of extended thumb.
- Superficial palmar arch is marked as a curved line with convexity towards fingers on joining these points.

DEEP PALMAR ARCH

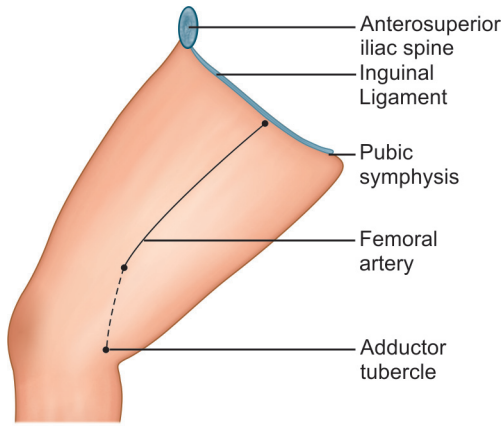
- Mark a point near the proximal end of first intermetacarpal space.
- Mark another point just distal to hook of hamate.
- Join these points by a 4 cm horizontal line with a slight distal convexity (towards fingers) about one finger's breadth above the level of superficial palmar arch.



Lower Limb

Midinguinal point: Midpoint between anterosuperior iliac spine and symphysis pubis.

Midpoint of inguinal ligament: Midpoint of anterosuperior iliac spine and pubic tubercle.

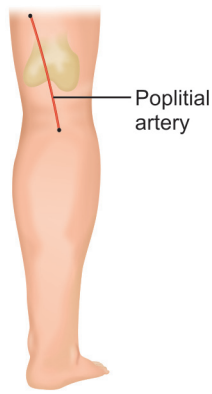


FEMORAL ARTERY

- Mark the midinguinal point.
- Mark another point at adductor tubercle.
- Join the two points to obtain a line.
- Artery lies at upper 2/3rd of the line obtained.

POPLITEAL ARTERY

- First point is marked at junction of middle and lower 1/3rd of thigh, 2.5 cm medial to midline on the back of lower limb.
- Mark the second point in the midline of back of knee.
- Mark the third point at level of tibial tuberosity in the midline of back of leg.
- Join the three points.



POSTERIOR TIBIAL ARTERY

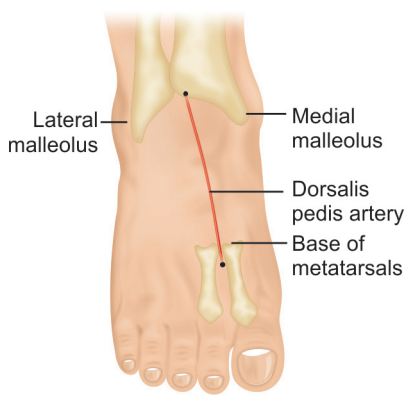
- Mark a point in the middle line of the leg at the level of neck of fibula.
- Mark another point midway between medial malleolus and tendocalcaneous.
- Join these points.

DORSALIS PEDIS ARTERY

- Mark a point midway between two malleoli.
- Mark another point at the proximal end of first intermetatarsal space.
- Join these points.

SAPHENOUS OPENING

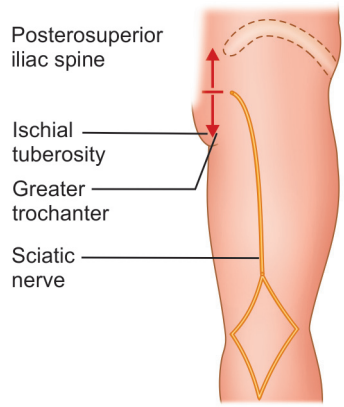
- Mark a point 4 cm lateral and 4 cm below the pubic tubercle.
- It gives the center of saphenous opening.
- It is 2.5 cm long and 2 cm broad.



GREAT SAPHENOUS VEIN

- Mark a point on dorsum of foot at medial end of dorsal venous arch.
- Mark the next point at the anterior surface of medial malleolus.
- Third point on the medial border of tibia at the junction of upper 2/3rd and lower 1/3rd of the leg.

- Next point at the adductor tubercle and mark 5th point below the center of saphenous opening.
- Join these points.

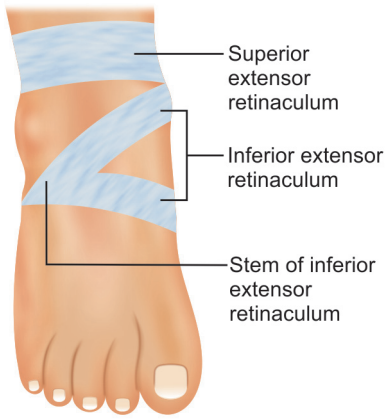


SCIATIC NERVE

- Draw a line joining the posterosuperior iliac spine and ischial tuberosity.
- Mark a point 2.5 cm lateral to midpoint of above line.
- Second point is marked just medial to midpoint between ischial tuberosity and greater trochanter.
- Third point is marked at junction of upper 1/3rd and lower 1/3rd in the midline of back of thigh.
- Join the 3 points.

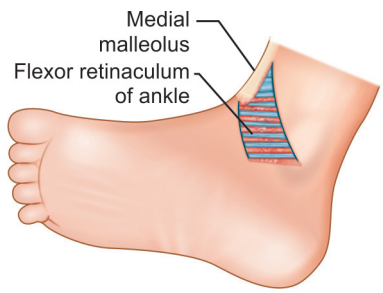
SUPERIOR EXTENSOR RETINACULUM

- Draw a 3 cm wide band, running medially and little upwards.
- From anterior border of triangular subcutaneous area of fibula.
- To lower part of anterior borders of tibia.



INFERIOR EXTENSOR RETINACULUM

- Draw a band passing medially on the dorsum of the foot.
- Band should be 1.5 cm wide and the band is the stem.
- Extend the band from anterior part of the upper surface of calcaneum to a point on the medial side of the tendons of extensor digitorum longus.
- At the second point, band divides into two limbs.
- Upper limb passes to medial malleolus.
- Lower limb passes round the medial aspect of foot.



FLEXOR RETINACULUM

- Draw a band 2.5 cm thick passing downwards and backwards from the medial malleolus to the medial side of the heel.

Thorax

HEART

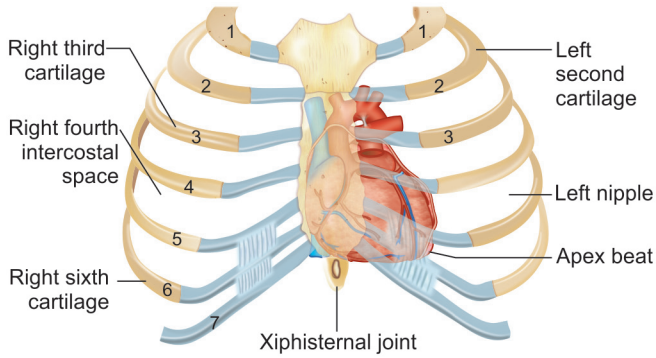
Upper Border

- Mark a point at the lower border of the second left costal cartilage about 1.3 cm from sternal margin.

- Mark another point at the upper border of third right costal cartilage, 0.8 cm from sternal margin.
- Join these two points by a straight line to mark the upper border.

Lower Border

- Mark a point at the lower border of the sixth right costal cartilage 2 cm from the sternal margin.
- Mark another point in the fifth left intercostal space 9 cm from midsternal line (point represents apex of heart).
- Join these points by a straight line to mark the lower border.



Right Border

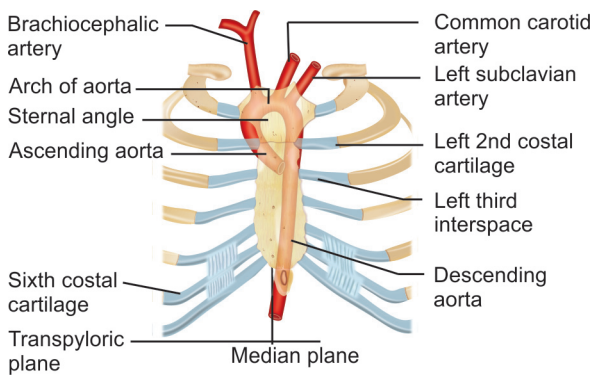
- Join the right ends of upper and lower borders.
- Line should be slightly convex to the right.
- Maximum convexity is marked 3.7 cm lateral to median plane in the right fourth intercostal space.

Left Border

Draw a line showing convexity towards left by joining the left ends of upper and lower borders of heart.

ARCH OF AORTA

- Mark the right extremity of the sternal angle.
- Mark the second point on the center of manubrium.
- Mark the third point at sternal extremity of second left costal cartilage.
- Draw a convex (directed upwards) line through these points.
- *Note:* The beginning and end of the arch lie at same level.



LUNGS

Apex

- Mark a point in the neck 2.5 cm above medial 1/3rd of clavicle.
- Draw a convex line directed upwards through this point.

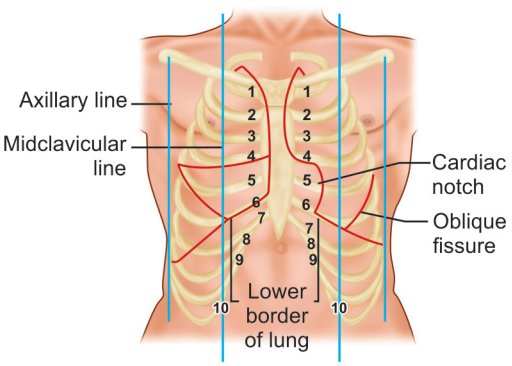
Anterior Border

Right Lung

- *First point*: At the right sternoclavicular joint.
- *Second point*: At the midpoint of sternal angle.
- *Third point*: On the sixth right chondrosternal junction.
- Join these points to get anterior border of right lung.

Left Lung

- *First point*: At the left sternoclavicular joint.
- *Second point*: In the midpoint of the sternal angle.
- *Third point*: On the fourth left chondrosternal junction.
- *Fourth point*: On the sixth costal cartilage 3.5 cm from the left margin of sternum.
- Join these points to get a line representing anterior border of left lung.
- Line becomes concave (directed medially) between last two points, represents cardiac notch.



Posterior Border

- *First point*: 2 cm from midline at level of spinous process of tenth thoracic vertebrae.
- *Second point*: 2 cm lateral to second thoracic spine.
- Join these points by a vertical line to get the posterior border.

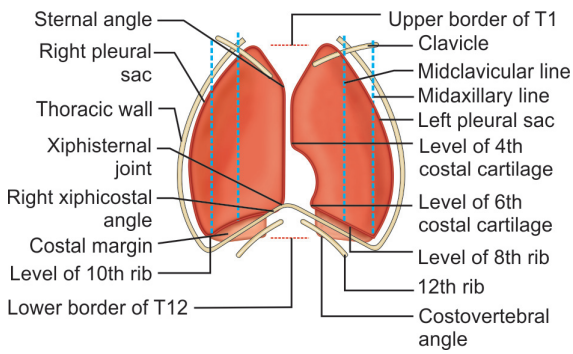
Inferior Border

- *First point:*
  - *Right lung*: Mark a point on sixth chondrosternal junction.
  - *Left lung*: Mark a point on sixth costal cartilage 2.5 cm from left margin of sternum.
- *Second point*: Where mid clavicular line cuts with sixth rib.
- *Third point*: Where mid axillary line cuts the eight rib.
- *Fourth point*: 2 cm lateral to T10 spine.
- Join these points by a line which goes a little upwards posteriorly.

PLEURAL REFLECTION

Right Costomediastinal Reflection

- *First point*: At sternoclavicular joint.
- *Second point*: On the midpoint of sternal angle.
- *Third point*: At midpoint of xiphisternal joint.
- Draw a line joining these points.



Left Costomediastinal Reflection

- *First point*: At sternoclavicular joint.
- *Second point*: Midpoint of sternal angle.
- *Third point* in midline at the level of left fourth costal cartilage.
- *Fourth point*: At left extremity of xiphisternal joint.
- Draw a line by joining the first three points and extend it to the left sternal margin.
- Follow the margin to reach the fourth point.

Cervical Pleura

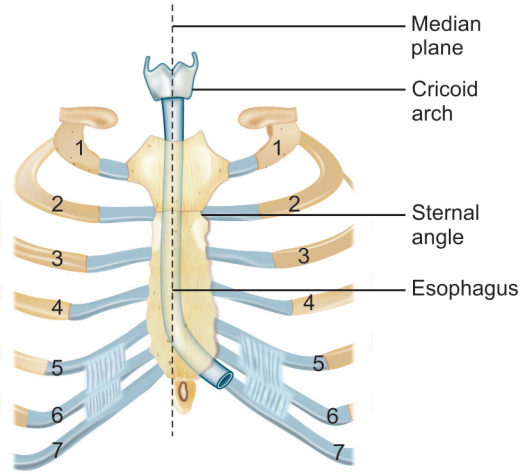
- *First point*: At sternoclavicular joint.
- *Second point*: On the junction of medial and middle third of clavicle.
- *Third point*: Between the above two points, about 2.5 cm above clavicle.
- Draw a line joining these points.

Costodiaphragmatic Reflection

- *First point*: Xiphisternal joint.
- *Second point*: Where the midclavicular line passes over 8th rib.
- *Third point*: Where midaxillary line passes over 10th rib.
- *Fourth point*: At the tip of 12th costal cartilage.
- *Fifth point*: 2 cm lateral to upper border of T12 spine.
- Draw a line joining these points.

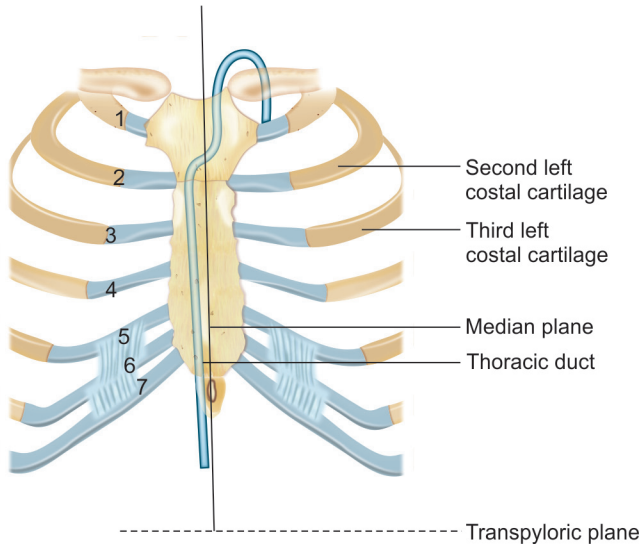
ESOPHAGUS

- Mark two points 2.5 cm apart.
- First at the lower border of cricoid cartilage across median plane.
- Second in the root of the neck a little to the left of the median plane.
- Third at sternal angle across the median plane.
- Fourth on the left 7th costal cartilage 2.5 cm from the median plane.
- Esophagus is marked by two parallel lines formed by joining these points.



THORACIC DUCT

- Mark a point 2 cm above transpyloric plane and just 2 cm right of median plane.
- Mark midpoint of sternal angle (approx 5 cm below suprasternal notch).
- Mark another point 2 cm lateral to median plane and 2.5 cm above left clavicle.
- Mark a point 1.2 cm lateral to previous point. Join these points and end it behind clavicle.



Abdomen and Pelvis

MEDIAN VERTICAL PLANE

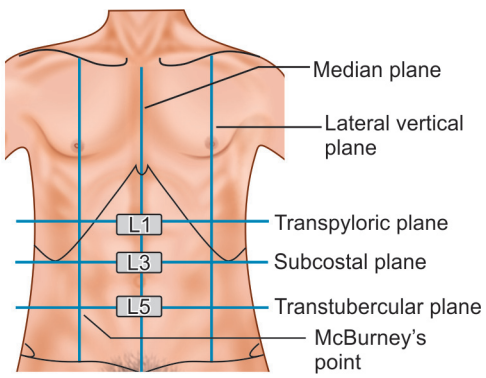
Plane passing through suprasternal notch and pubic symphysis.

Lateral Vertical Plane

Plane passing through midway between mid-inguinal point and middle of clavicle.

Transpyloric Plane of Addison

- Plane passing through the tip of 9th costal cartilage and midway between median vertical plane.
- Anteriorly it passes through tip of 9th costal cartilage and posteriorly it passes through lower part of body of L1 vertebra.
- Pylorus, inferior margin of liver, neck of gallbladder, anterior end of spleen, hilum of kidney, portal vein, etc. lie at this level.



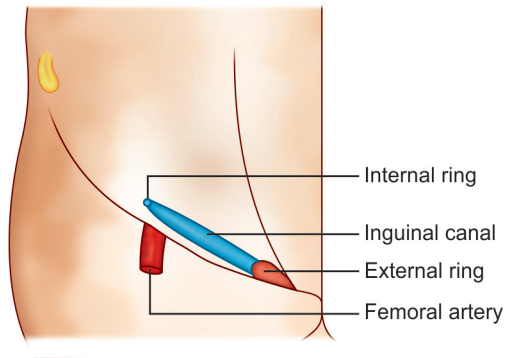
Subcostal Plane

- Transverse plane passing just below 10th rib.
- Lies at the upper border of L3 vertebra.

Transtubercular Plane

- Transverse passing through the level of tubercle on iliac crest.
- Lies at the upper border of L5 vertebra.

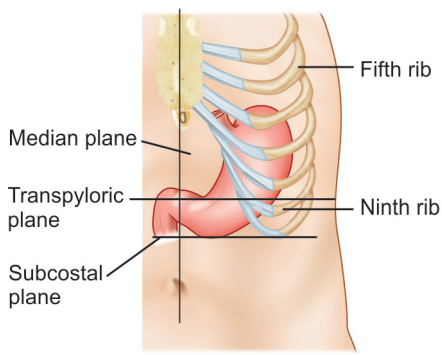
INGUINAL CANAL



- *First point*: 1.25 cm above midpoint of the inguinal ligament, it corresponds to deep inguinal ring.
- *Second point*: Mark immediately above the pubic tubercle, it corresponds to superficial inguinal ring.
- Join these points by two parallel lines 1 cm apart and 3.7 cm long above the medial half of inguinal ligament to surface mark the inguinal canal.

STOMACH

Cardiac Orifice



- Draw the median vertical plane.
- Mark a point 2.5 cm to the left of median plane on the 7th costal cartilage.
- Draw a band 2 cm thick, from the above point inclining downwards to the left.

Pylorus

- Draw the transpyloric plane.
- Mark a point on the above plane 1.2 cm to the right of the median plane.
- Draw a band 2 cm thick, directed to upwards and right.

Fundus

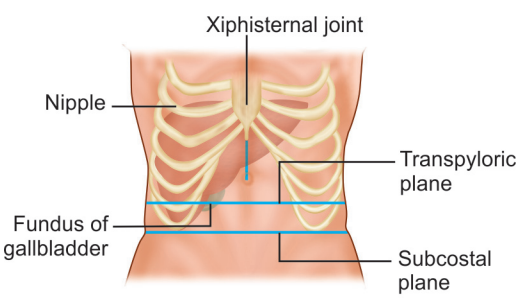
- Mark a point at the left 5th intercostal space just below the nipple.
- Draw an upward convex line from the above point to the left margin of cardiac orifice.

Greater Curvature

- Draw the subcostal plane.
- Mark a point between the tips of left 9th and 10th costal cartilages.
- Draw a curved line convex to the left and downwards from fundus to above point which extends to the subcostal plane and lower margin of pylorus orifice.

LIVER

Upper Border



- *First point*: In left 5th intercostal space 9 cm from median plane.
- *Second point*: At the xiphisternal joint.
- *Third point*: At 6th rib in midaxillary line.
- Join the first 2 points by a convex line and the 2nd and 3rd points by another convex line (both directed upwards and laterally).

Right Border

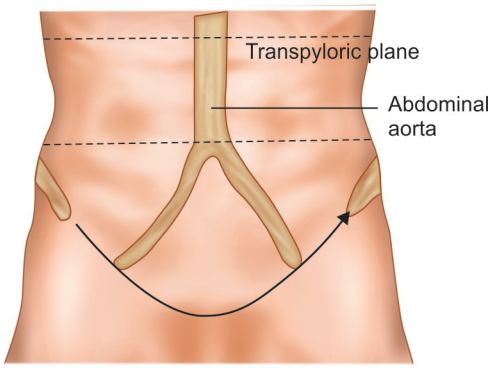
- *First point*: A little below right nipple.
- *Second point*: At 1 cm below the tip of right 10th costal cartilage.
- Draw a convex line (directed laterally) joining the above points.

Lower Border

- Draw median and transpyloric planes.
- Mark a point at the tip of right 9th costal cartilage.
- Join the lower end of the right border to left end of upper border by a line crossing the median plane at transpyloric plane.

FUNDUS OF GALLBLADDER

It is marked at the angle between right costal margin and outer border of rectus abdominis.



ABDOMINAL AORTA

- Mark a point 2.5 cm above transpyloric plane.
- Mark another point 1.2 cm below and left of umbilicus (At L4 vertebra level).
- Join these points by parallel lines 2 cm apart.

SPLEEN

- First point marked 4 cm lateral to spine of T10 vertebra, represents upper pole.
- Second point it is marked where the left 11th rib is crossed by the midaxillary line, represents lower pole.
- Join 2 points by 2 convex lines passing along the upper border of 9th (convexity directed upwards) and lower border of 11th rib (convexity directed downwards).
- Width of spleen corresponds to width of 9th and 10th intercostal spaces and width of 9th, 10th and 11th ribs.

ROOT OF MESENTRY

- Mark a point 1 cm below transpyloric plane and 3 cm to left of the median plane.
- Mark second point on the junction between right lateral and transtubercular plane.
- Join these two points by 2 parallel lines close together.

McBURNEY'S POINT

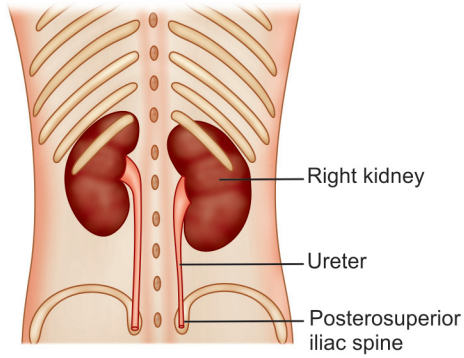
Point at the junction of lateral 1/3rd and medial 2/3rd of the line joining anterosuperior iliac spine and umbilicus.

KIDNEY

On Back

Marked within Morris parallelogram drawn in following way:

- Two horizontal lines are drawn, one at level of the 11th thoracic spine and other at the level of 3rd lumbar spine.
- Then two vertical lines are drawn, one 2.5 cm and other 9 cm from median plane.
- Hilum lies opposite the lower border of 1st lumbar spine. Lower on right side.



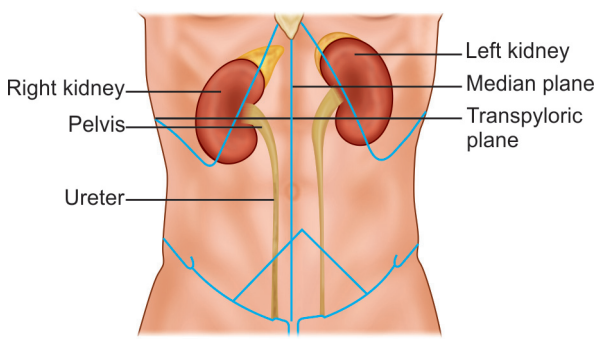
On Front

- On right side the center of hilum lies 5 cm from median plane a little below the transpyloric plane.
- On left side it lies 5 cm from median plane a little above transpyloric plane, just medial to tip of 9th costal cartilage.
- Upper pole 4-5 cm from midline, midway between xiphisternum and transpyloric plane. Right one little lower.
- Lower pole lies 6-7 cm from the midline on right side at umbilical plane and on left side subcostal plane.

URETER

On Front

- Mark a point slightly medial to tip of 9th costal cartilage.
- Mark a point on pubic tubercle.
- Join these 2 points, the upper 5 cm represents renal pelvis.

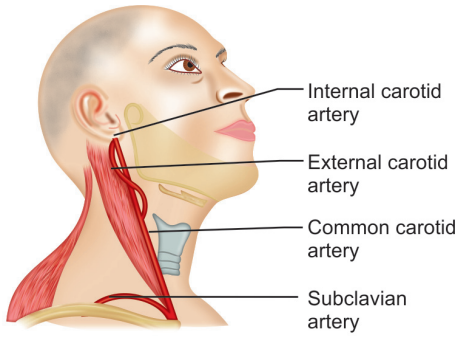


On Back

- Mark a point 4 cm from median plane at the level of L2 vertebrae.
- Mark a point on posterosuperior iliac spine.
- Join these lines.

Head and Neck

COMMON CAROTID ARTERY

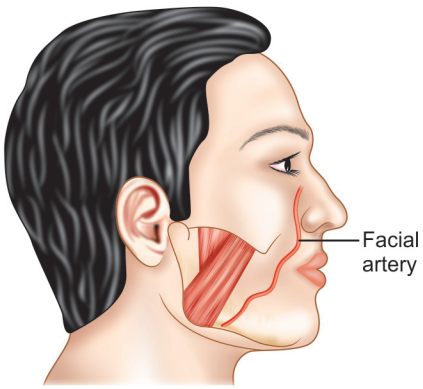


- Mark the first point at sternoclavicular joint.
- Second point marked on the anterior border of the sternocleidomastoid at the level of upper border of thyroid cartilage.
- Join the points by a broad line along anterior border of sternocleidomastoid.

EXTERNAL CAROTID ARTERY

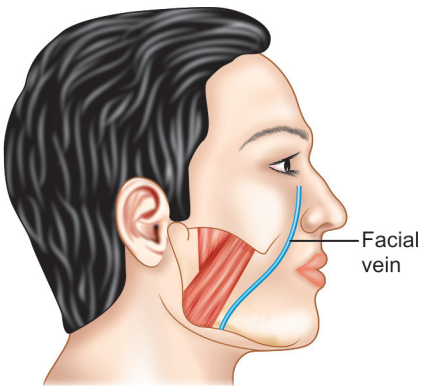
- Mark a point on the anterior border of sternocleidomastoid at the level of upper border of thyroid cartilage.
- Mark the second point on the posterior border of the neck of mandible.
- Join the points with a line which is convex forwards in lower half and concave forwards in upper half.

FACIAL ARTERY



- Mark a point on the base of mandible at the anterior border of the masseter muscle.
- Mark another point 1.5 cm lateral to angle of the mouth.
- Third point is given at the medial angle of the eye.
- Join these points.

FACIAL VEIN



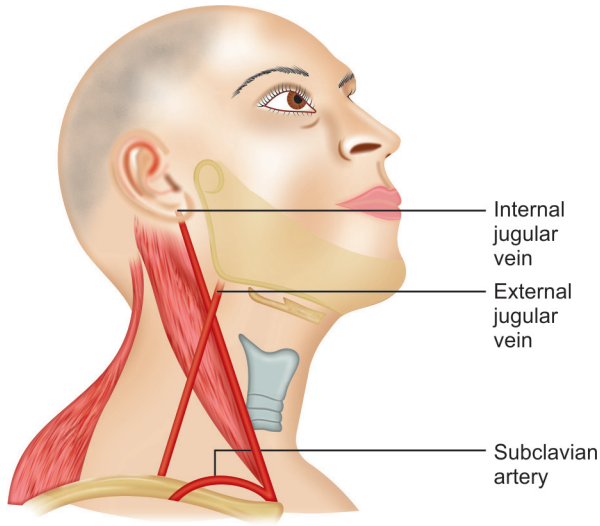
Represented by a line drawn just behind the facial artery.

INTERNAL JUGULAR VEIN

- Mark a point on the neck medial to lobule of the ear.
- Mark the medial end of the clavicle.
- Join these points by a broad line to mark the internal jugular vein.

EXTERNAL JUGULAR VEIN

- Mark a point little below and behind the angle of mandible.
- Mark the next point on the clavicle lateral to posterior border of sternocleidomastoid.
- Join these points.



FACIAL NERVE

- Mark a point on the middle of the anterior border of the mastoid process.
- Second point given behind neck of mandible.
- Facial nerve is marked by a short horizontal line joining these two points.

PAROTID DUCT

- First point at the lower border of tragus.
- Second point it is marked midway between ala of nose and the red margin of the upper lip.
- Draw a line by joining these two points.
- Middle third of the line represents the parotid duct.

CHAPTER

6

Spotters and Discussion Topics

Spotters

- Study the important attachments and side identification of the bones.
- For a nerve study the formation, root value, branches and supply.
- For an artery study the origin and main branches.
- For a vein study the formation, tributaries and termination.
- For a muscle study origin, insertion, nerve supply and actions.
- For every paired organ, study side identification and relevant applied anatomy.

UPPER LIMB

1. Anatomical snuff box
2. Articular capsule of shoulder joint
3. Cubital fossa
4. Palmar aponeurosis
5. Flexor retinaculum
6. Extensor retinaculum
7. Clavicle
8. Scapula
9. Humerus
10. Radius
11. Ulna
12. Carpal bones
13. Quadrangular and triangular spaces
14. Axillary nerve and artery
15. Musculocutaneous nerve
16. Radial nerve (in radial groove imp)
17. Median nerve
18. Ulnar nerve
19. Median cubital vein
20. Cephalic vein
21. Posterior interosseous artery and nerve
22. Anterior interosseous artery
23. Brachial artery
24. Dorsal venous arch
25. Radial artery and deep palmar arch
26. Ulnar artery and superficial palmar arch
27. Biceps brachi
28. Deltoid
29. Coracobrachialis
30. Brachialis

31. Brachioradialis
32. Triceps
33. Anconeus
34. Pronator teres
35. Supinator
36. Palmaris longus
37. Pronator quadratus
38. Interossei and lumbricals

LOWER LIMB

1. Hip bone (attachments on iliac crest)
2. Femur (attachments on linea aspera)
3. Tibia and fibula
4. Patella
5. Talus and calcaneum
6. Femoral artery
7. Profunda femoris artery
8. Obturator artery
9. Popliteal artery
10. Internal pudental artery
11. Anterior tibial artery
12. Dorsalis pedis artery
13. Great saphenous vein
14. Femoral vein
15. Femoral nerve
16. Obturator nerve
17. Pudental nerve and nerve to obturator internus
18. Tibial nerve
19. Sciatic nerve
20. Common peroneal nerve
21. Deep peroneal nerve
22. Iliotibial tract
23. Femoral sheath
24. Flexor, extensor and peroneal retinacula
25. Tendocalcaneous
26. Plantar aponeurosis
27. Ligamentum patellae
28. Tibial and fibular collateral ligament
29. Cruciate ligaments and menisci of knee joint
30. Spring ligament
31. Adductor canal
32. Sartorius
33. Vastus medialis and lateralis
34. Adductor magnus

35. Gluteus maximus, medius and minimus
36. Piriformis
37. Peroneus longus and brevis
38. Plantaris
39. Popliteus
40. Tibialis posterior

THORAX

1. 1st rib
2. Typical and nontypical rib
3. Sternum
4. Thoracic vertebrae
5. Internal thoracic artery
6. Aorta
7. Subclavian artery
8. Coronary arteries
9. Azygos vein
10. Great cardiac vein
11. Superior vena cava
12. Coronary sinus
13. Thoracic duct
14. Recurrent laryngeal nerve
15. Phrenic nerve
16. Pulmonary ligament
17. Fossa ovalis
18. Ligamentum arteriosum
19. Arterioventricular valves
20. Interventricular septum
21. Pleura
22. Intercostal muscles (direction-fibers)
23. Root of lung
24. Sinuses of pericardium
25. Fissures of lung
26. Right atrium

ABDOMEN AND PELVIS

1. Superior mesenteric artery
2. Inferior mesenteric artery
3. Abdominal aorta
4. Common iliac artery
5. Internal iliac artery
6. Inferior vena cava
7. Portal vein

8. Obturator nerve
9. Rectus sheath and rectus abdominis
10. Inguinal canal
11. Ligaments of liver
12. Broad ligament
13. Epiploic foramen
14. Anterior abdominal wall muscles
15. Diaphragm (openings)
16. Greater omentum
17. Stomach
18. Duodenum (both papilla)
19. Pancreas (parts)
20. Liver (impressions, bare area)
21. Spleen (splenic ridge)
22. Gallbladder
23. Sigmoid colon
24. Appendix
25. Cecum
26. Kidney (structures at hilum)
27. Suprarenal gland
28. Ureters
29. Urinary bladder (trigone)
30. Testis (sinus)
31. Spermatic cord (contents)
32. Vas deferens
33. Prostate
34. Ovary
35. Fallopian tube
36. Psoas major
37. Hip bone (sex differences)

HEAD AND NECK

1. Parietal bone
2. Temporal bone
3. Frontal bone
4. Palatine bone
5. Occipital bone
6. Sphenoid bone
7. Atlas, axis
8. Mandible
9. Hyoid bone
10. Hard and soft palate
11. Styloid process
12. Mastoid process

13. Crista galli
14. Tentorium cerebelli
15. Falx cerebri
16. Foramen ovale
17. Styloid foramen, foramen spinosum
18. Jugular foramen
19. Hypoglossal canal
20. Frontal air sinuses
21. Constrictors of pharynx
22. Facial artery
23. Basilar artery
24. Vertebral artery
25. External carotid artery
26. Middle meningeal artery
27. Maxillary artery
28. Greater palatine artery
29. Jugular vein
30. Internal and external jugular vein
31. Cranial nerves
32. Facial nerve
33. Glossopharyngeal nerve
34. Hypoglossal nerve
35. Greater auricular nerve
36. Vagus
37. Spinal root of accessory nerve
38. Ansa cervicalis
39. Vocal folds
40. Conchae and meatuses
41. Temporalis muscle
42. Masseter
43. Buccinator
44. Sternocleidomastoid
45. Scalenus anterior
46. Posterior belly of digastric
47. Posterior cricoarytenoid
48. Cricothyroid
49. Genioglossus
50. Hyoglossus
51. Stylohyoid
52. Mylohyoid
53. Extraocular muscles
54. Auditory tube
55. Infrahyoid membrane
56. Interna acoustic meatus
57. Maxillary sinus

58. Superior sagittal sinus
59. Nasal septum
60. Submandibular gland and duct
61. Parotid gland and duct

BRAIN

1. Dura mater
2. Superior colliculus
3. Cerebral peduncle
4. Cerebral aqueduct
5. Flocculus and lingula of cerebellum
6. Horizontal fissure of cerebellum
7. Corpus callosum
8. Fornix
9. Anterior commissure
10. Mamillary body
11. Optic chiasma
12. Interthalamic adhesion
13. Lateral ventricle
14. Fourth ventricle
15. Internal capsule
16. Caudate and lentiform nuclei

Discussion Topics

1. Arm, forearm-flexor and extensor compartment
2. Triangular and quadrangular spaces
3. Cubital and popliteal fossa
4. Palm and sole
5. Femoral triangle and adductor canal, knee joint
6. Structures under cover of gluteus maximus
7. Thigh and leg (all compartments)
8. Lungs (root, pleura, bronchopulmonary segments)
9. Heart (blood supply, chambers)
10. Diaphragm (openings)
11. Stomach, liver, spleen, pancreas, kidney
12. Small and large intestine, appendix, anal canal
13. Testis, uterus, urinary bladder
14. Midline structures of neck, thyroid gland
15. Lateral and medial wall of nose, pharynx
16. Parotid gland, palate
17. Surfaces of brain, brainstem.

CHAPTER

7

Red Alert

This chapter includes the must study questions in anatomy before facing the final exams inorder to ensure minimum pass marks.

Paper 1

UPPER LIMB

1. Breast-extent, blood supply and lymphatic drainage, applied—carcinoma and metastasis, peau d'orange, etc.
2. Brachial plexus (Erb's and Klumpke's paralysis*)
3. Clavipectoral fascia
4. Axillary artery and its branches
5. Shoulder joint (muscles producing movements*)
6. Rotator cuff
7. Intermuscular spaces (quadrangular and triangular)
8. Deltoid muscle and its applied anatomy
9. Radial and musculocutaneous nerve
10. Cubital fossa
11. Superior radioulnar joint
12. Flexor retinaculum
13. Superficial and deep palmar arches
14. Midpalmar and pulp space
15. First carpometacarpal joint
16. Axillary lymph nodes
17. Cutaneous supply of upper limb and dermatomes
18. Root value of each nerves
19. Superficial veins of upper limb
20. Intrinsic muscles of hand, nerve supply and actions
21. Axillary nerve injury
22. Carpal tunnel syndrome and Ape thumb deformity
23. Wrist drop
24. Claw hand
25. Boxers palsy
26. Tennis elbow, Golfer's elbow, and student's elbow.

LOWER LIMB

1. Superficial inguinal lymph nodes
2. Femoral triangle, boundaries, contents, etc.
3. Femoral sheath
4. Great saphenous vein
5. Fascia lata, its modifications (iliotibial tract*)
6. Adductor canal/subsartorial canal/Hunter's canal
7. Popliteal fossa—boundaries, contents, popliteal aneurysm
8. Sciatic nerve

9. Structures under cover of gluteus maximus
10. Dorsalis pedis artery
11. Venous drainage of lower limb and clinical importance
12. Hip joints (relations, movements, ligaments*)
13. Knee joint (medial and lateral ligament, menisci, relations, blood supply, locking and unlocking*)
14. Muscles producing movements at the knee joint
15. Subtalar joint
16. Arches of foot (medial long arch*)
17. Inversion and eversion
18. Cutaneous supply of foot
19. Root values of all nerves.

THORAX

1. Typical intercostal spaces—muscles, nerves and blood supply
2. Lungs—bronchopulmonary segments, blood supply and lymphatic drainage
3. Root of lung
4. Pleura and its recess
5. Sinuses of pericardium
6. Posterior mediastinum
7. Right atrium
8. Blood supply of hearts and cardiac dominance
9. Coronary sinus
10. Cardiac plexus
11. Azygos vein and hemiazygos vein
12. Openings of diaphragm
13. Arch of aorta and its development
14. Esophagus and its constrictions
15. Thoracic duct

GENERAL HISTOLOGY

1. All 3 cartilages.
2. Compact bone (LS and TS)
3. Skeletal muscle
4. Smooth muscle
5. Cardiac muscle
6. Artery (large and medium sized)
7. Vein (large and medium sized)
8. Lymph node
9. Spleen
10. Thymus
11. Palatine tonsil
12. Spinal ganglion
13. Sympathetic ganglion
14. Thick and thin skin

GENERAL EMBRYOLOGY

1. Implantation
2. Fertilization
3. Decidua
4. Yolk sac
5. Chorion
6. Amnion
7. Primitive streak
8. Intraembryonic mesoderm
9. Somites
10. Notochord
11. Neurulation
12. Neural crest
13. Placenta
14. Amniocentesis
15. Structure of spermatozoa

GENERAL ANATOMY

1. Classification and examples of joints
2. Long bone—blood supply
3. Cartilage (hyaline cartilage*)
4. Connective tissue fibers and cells
5. Epiphysis
6. Dermatomes
7. Neuroglia

Paper 2

HEAD AND NECK

1. Scalp
2. Face—nerve (motor and sensory) and blood supply (dangerous area of face*)
3. Lacrimal apparatus
4. Carotid sheath
5. Sternocleidomastoid
6. Trigeminal ganglion
7. Lymph nodes of neck
8. Deep cervical fascia
9. Posterior triangle of neck
10. Thyroid gland (blood supply*) and its development
11. Submandibular gland and its secretomotor pathway
12. Parotid gland (secretomotor pathway and parotid duct)

13. Temporomandibular joint
14. Cavernous sinus
15. Palatine tonsil
16. Lateral wall of nose (arterial and nerve supply)
17. Nasal septum-formation, arterial and nerve supply, little's area
18. Tongue (development and nerve supply*)
19. Middle ear (medial wall*)
20. Extraocular muscles
21. Pharynx—boundaries, constrictors, Killian's dehiscence
22. Relations of hyoglosus
23. Muscles of mastication (lateral pterygoid*)
24. Carotid triangle
25. Tentorium cerebelli
26. Cilliary ganglion
27. Pterygopalatine ganglion
28. Mandibular nerve
29. Palate development
30. Maxillary artery
31. Auditory tube
32. Tympanic membrane

NEUROANATOMY

1. Cerebellum—subdivisions and fissures*
2. Brain—sulcus, gyrus and functional areas
3. Third ventricle
4. Interpeduncular fossa
5. Insula
6. Superior colliculus
7. Superiolateral surface of brain
8. Spinal cord (blood supply*)
9. Circle of Willis
10. Corpus callosum
11. Internal capsule and its blood supply
12. Functional areas of brain
13. Lateral ventricle
14. Floor of fourth ventricle
15. Lateral geniculate body
16. Association fibers of cerebrum
17. Cerebellar peduncles
18. Blood supply of superolateral surface of brain
19. Crux cerebri
20. Red nucleus
21. Choroid plexus

ABDOMEN AND PELVIS

1. Rectus sheath
2. Inguinal canal and inguinal hernia
3. Cryptorchidism
4. Stomach—bed, lymphatic drainage and blood supply
5. Duodenum—parts (2nd*) relations and blood supply
6. Portal vein and portocaval anastomoses
7. Pancreas and its development
8. Extrahepatic biliary aparatus
9. Liver and its development (hepatic segments and relations of inferior surface*)
10. Greater omentum
11. Greater and lesser sac
12. Mesentry
13. Kidney—coverings, Morri's parallelogram, position, relations (posterior*)
14. Spleen—surfaces, relations and blood supply
15. Vermiform appendix (positions*)
16. Cecum
17. Superior mesenteric artery
18. Maeckels diverticulum
19. Urinary bladder and its development (trigone of bladder*)
20. Uterus—parts, supports (true) and development
21. Prostate and its development
22. Urethra (male urethra—parts) and development
23. Perineal body
24. Ischiorectal fossa—boundaries and contents
25. Superficial and deep perineal pouches
26. Rectum and anal canal

HISTOLOGY

1. Stomach (fundus and pylorus)
2. Colon
3. Appendix
4. Ileum
5. Jejunum
6. Duodenum
7. Liver
8. Pancreas
9. Gallbladder
10. Kidney
11. Urinary bladder
12. Trachea
13. Ovary
14. Uterus

15. Testis
16. Epididymis
17. Prostate gland
18. Cerebellum
19. Cerebrum
20. Spinal cord
21. Cornea
22. Retina
23. Suprarenal gland
24. Thyroid gland
25. Pituitary gland

SYSTEMIC EMBRYOLOGY

Thorax

1. Heart tube formation
2. Right atrium
3. Interatrial septum
4. Aortic arches
5. Fallot's tetralogy
6. Diaphragm

Head and Neck

1. Pharyngeal arches
2. Palate and cleft palate
3. Face
4. Upper lip
5. Tongue
6. Thyroid

Abdomen and Pelvis

1. Derivatives of foregut, midgut and hindgut
2. Stomach
3. Meckel's diverticulum
4. Pancreas
5. Liver and gallbladder
6. Kidney
7. Urinary bladder
8. Uterus
9. Testis and descend of testis
10. Rectum and anal canal
11. Prostate

Important Diagrams

Please draw atleast one diagram and try to write two applied anatomy along with each question:

1. Axillary lymph nodes
2. Branches of axillary artery
3. Clavipectoral fascia
4. Transverse section (TS) of arm through middle
5. Sagittal section through shoulder joint
6. Brachial plexus
7. Rotator cuff
8. Superficial veins of upper limb
9. Superficial and deep palmar arches
10. Cutaneous supply of upper limb, especially hand
11. Typical intercostal nerve
12. Mediastinal surface of right and left lungs
13. Azygous and hemiazygous veins
14. Pleural recesses
15. Root of right and left lungs
16. Bronchopulmonary segments (costal aspects and distal portion of adjacent segments)
17. Transverse section (TS) through body at the level of T4 vertebra
18. Sinuses of pericardium
19. Blood supply of heart
20. Transverse section (TS) of upper one-third of thigh
21. Cutaneous supply of lower limb
22. Femoral triangle
23. Structures under cover of gluteus maximus
24. Hip joint
25. Transverse section (TS) of leg
26. Knee joint (tibial and fibular collateral ligaments)
27. Transverse section (TS) through knee joint showing relations.
28. Popliteal fossa
29. Long and short saphenous vein
30. Extensor retinaculum
31. Arches of foot
32. Boundaries of inguinal canal
33. Sagittal section through abdomen to show reflections of peritoneum
34. Stomach bed
35. Relations of 1st, 2nd, and 3rd part of duodenum
36. Inferior surface of liver and impressions
37. Tributaries of portal vein
38. Relations of pancreas
39. Anterior and posterior relations of kidney
40. Relations of cecum
41. Positions of appendix

42. Coronal section through ischiorectal fossa
43. Sagittal section through male and female pelvis
44. Anterior view of male urethra
45. Superior view of pelvic diaphragm
46. Prostate gland
47. Coronal section through anal canal
48. Sensory nerve supply of face
49. Layers of scalp
50. Arterial and nerve supply of scalp
51. Lacrimal apparatus
52. Carotid sheath
53. Posterior triangle of neck with contents
54. Tentorium cerebelli
55. Cavernous sinus
56. Veins of face and communications
57. Orbit with extraocular muscles
58. Carotid triangle with contents
59. Ansa cervicalis
60. Parotid gland and relations
61. Relations of hyoglossus muscle
62. Medial wall of middle ear
63. Distribution of mandibular nerve
64. Temporomandibular joint
65. Blood supply of thyroid gland
66. Styloid apparatus
67. Palatine tonsil, blood supply and relations
68. Waldeyer's ring
69. Blood supply, nerve supply of nasal septum
70. Blood supply lateral wall of nose
71. Coronal section through larynx
72. Movements of vocal cord
73. Nerve supply of tongue
74. TS of medulla, pons and midbrain
75. Sulci and gyri of superolateral and medial surface of brain
76. Lateral ventricle
77. Floor of fourth ventricle
78. Blood supply of superolateral surface of brain
79. Corpus callosum
80. Functional areas of brain
81. Cerebellum—lobes and morphological subdivisions
82. Blood supply of spinal cord
83. Circle of Willis

---

* is meant for giving a clue that the given part in brackets is **important** among the other topics coming under the main topic.

Index

Page numbers followed by *f* refer to figure

D

E

F

G

M

N

O

P

R

S