UNIVERSITY OF MORATUWA, SRI LANKA
Faculty of Engineering
Department of Electronic and Telecommunication Engineering
Semester 4 (Intake 2020)

# BM2012 - Anatomy and Physiology for Engineers
# Anatomy Models

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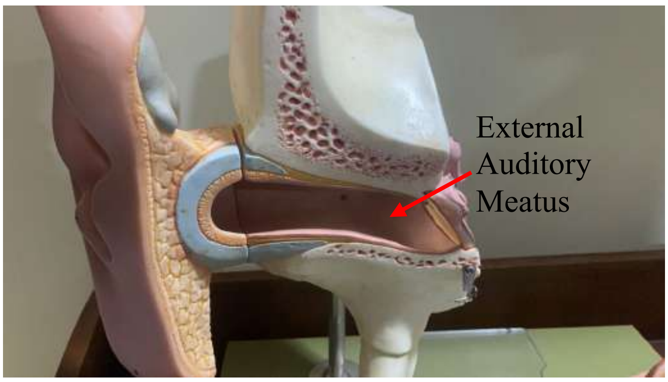
# 1. Special Senses

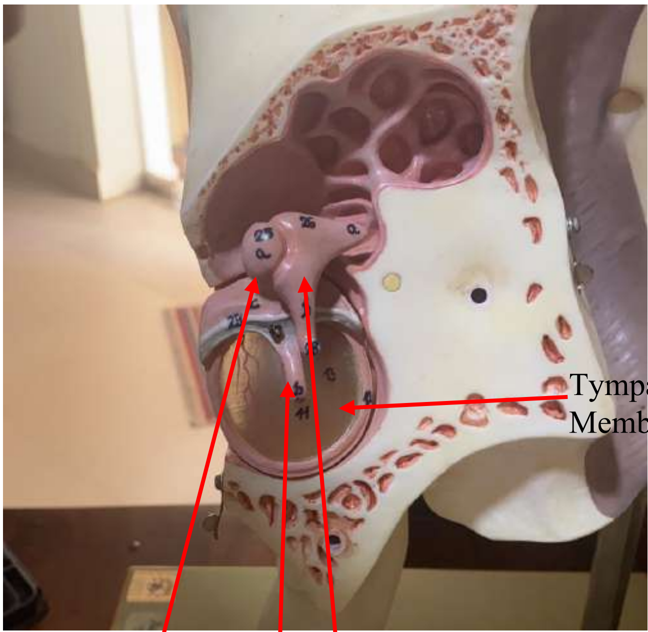
## 1.a Ear

### 1.1 Anatomical Structure


The auricle, also known as the pinna, is the visible outer part of the ear. It is made up of elastic cartilage covered by skin. The lobule is the fleshy, lower part of the auricle, which hangs down from the rest of the ear. The opening to the external auditory meatus (ear canal) is located in the auricle. It leads to the middle ear and is the entrance for sound waves to travel into the ear.




The external acoustic meatus, also known as the ear canal, is a tube-like structure that extends from the opening in the auricle to the tympanic membrane (eardrum). It is lined with skin and contains small hairs and ceruminous glands, which produce earwax (cerumen) to protect the ear canal.

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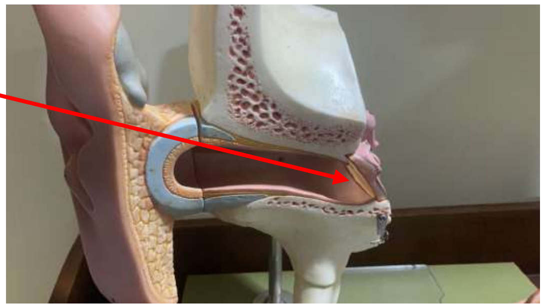
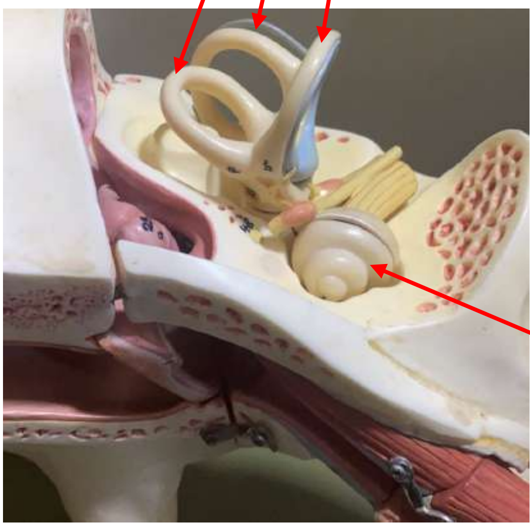


The auditory ossicles are three tiny bones located in the middle ear. They are named as follows:
Malleus (hammer): Attached to the tympanic membrane.
Incus (anvil): Located between the malleus and stapes.
Stapes (stirrup): Connected to the incus on one side and the oval window of the cochlea on the other side.




The cochlea is a spiral-shaped, bony structure responsible for hearing. It contains fluid-filled canals and houses the sensory hair cells that detect sound vibrations and send electrical signals to the brain.
The semicircular canals are three fluid-filled structures responsible for our sense of balance.

The bony labyrinth refers to the dense bone structure that surrounds the cochlea and semicircular canals. Inside the bony labyrinth, there is the membranous labyrinth, which is a series of fluid-filled sacs and tubes that contain sensory receptors for hearing and balance. The cochlear and semicircular canals are part of the membranous labyrinth within the bony labyrinth.

## 1.2 Boundaries of External, Middle and Inner ear cavities

The external ear cavity is bounded by the auricle on the outside and the tympanic membrane (eardrum) on the inside.
The middle ear cavity is located between the tympanic membrane (eardrum) on the outside and the bony wall of the inner ear, specifically the oval and round windows, on the inside.

The inner ear cavity is surrounded by the dense bone of the temporal bone and includes several interconnected structures, the cochlea, semilunar canals and the vestibule.

## 1.3 Conversion of sound waves into nerve impulses

Sound waves enter the ear through the external auditory meatus (ear canal) and reach the tympanic membrane in the middle ear, causing it to vibrate. The tympanic membrane is connected to the auditory ossicles (malleus, incus, and stapes) in the middle ear. The auditory ossicles form a chain, and as the tympanic membrane vibrates, these tiny bones also vibrate. They act as a mechanical amplifier, efficiently transmitting and amplifying the vibrations from the larger tympanic membrane to the smaller oval window in the cochlea, which leads to the inner ear. The stapes bone, the last of the auditory ossicles, is attached to the oval window. When it moves in and out of the oval window, it generates pressure waves in the fluid within the cochlea of the inner ear causing the basilar membrane (located in the cochlea) to flex. This bending of the basilar membrane stimulates the hair cells, leading to the bending of their projections (stereocilia). The bending of hair cells opens ion channels, resulting in the generation of nerve impulses. The auditory nerve carries these impulses from the cochlea to the brain.

## 1.4 Functional adaptations in the labyrinth to appreciate qualities of sound

The cochlea is tonotopically organized, meaning that different regions of the cochlea respond to specific frequencies of sound. High-frequency sounds are detected near the base of the cochlea, while low-frequency sounds are detected near the apex.

Within the cochlea, there are sensory hair cells that respond to different sound intensities (loudness or volume). Inner hair cells are responsible for transmitting most auditory information, while outer hair cells are involved in amplifying and fine-tuning sound responses. The sensitivity of hair cells allows us to perceive sounds ranging from soft whispers to loud noises.

In the vestibular system, particularly the semicircular canals, phase differences in the movement of fluid help with the localization of sounds in space. By comparing the differences in sound wave arrival times between the two ears, our brain can determine the direction from which a sound is coming.

## 1.5 Maintaining balance

The anatomical structures in the ear that are important for maintaining balance are Semicircular Canals, Vestibule, and Vestibular Nerve.

Semicircular Canals: When the head rotates or moves, the fluid in the semicircular canals also moves, stimulating hair cells that detect these movements. This information is sent to the brain, allowing us to sense rotational changes in our head position and maintain balance during activities like turning or spinning.

Vestibule: The utricle and saccule detect linear movements, such as walking or jumping, as well as changes in head position due to gravity. This information is critical for maintaining posture and stabilizing the head and body during different movements.

Vestibular Nerve: The vestibular nerve carries the sensory information from the semicircular canals, utricle, and saccule to the brainstem and cerebellum, where it is integrated with visual and proprioceptive inputs to coordinate balance and body position.

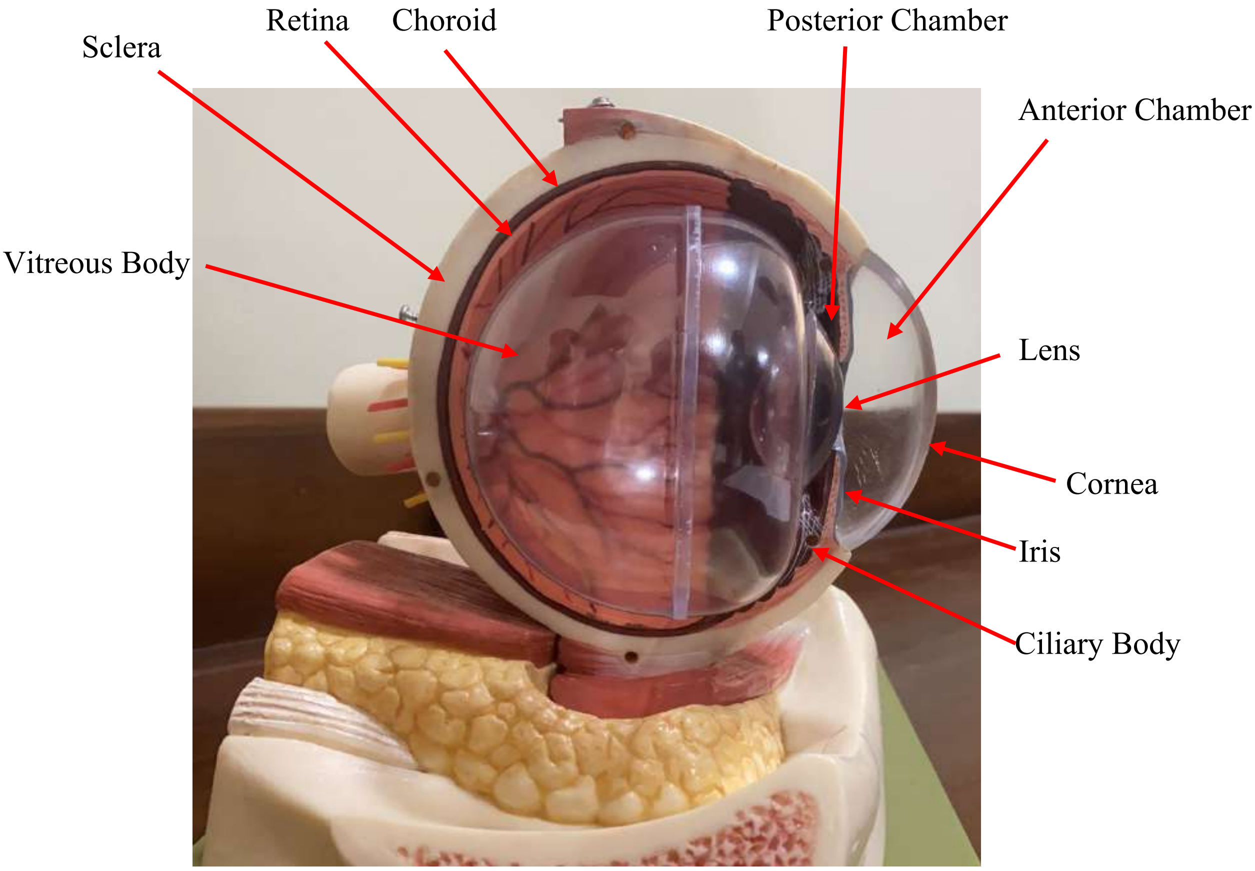
## 1.6 Imaging Methods

- Otoscope: An otoscope is a handheld instrument used by healthcare professionals to examine the external ear canal and the eardrum.

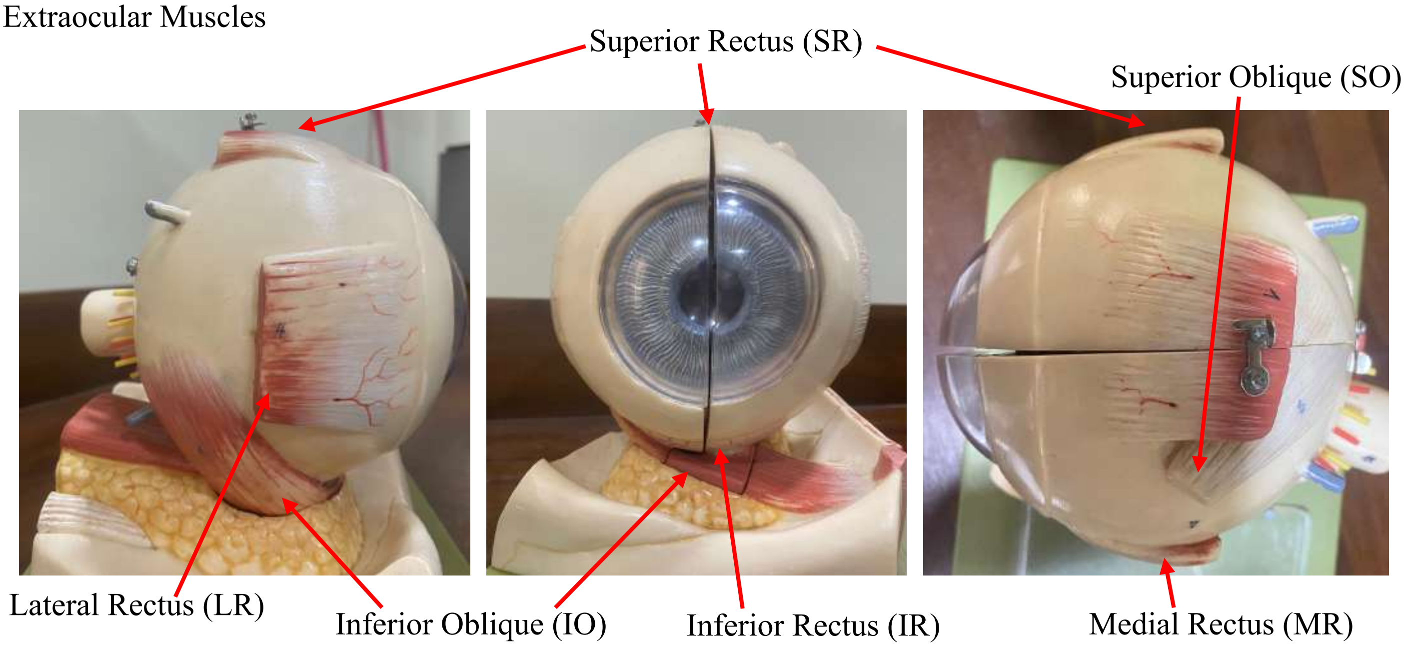
- Audiometry: Audiometry is a test that measures hearing ability. Pure-tone audiometry uses a machine called an audiometer to present different frequencies and sound intensities to the patient, who responds when they hear the sound.
- Tympanometry: Tympanometry measures the movement of the eardrum in response to air pressure changes.

## 1.b Eye

### 1.7 Anatomical Structure




Extraocular Muscles



## 1.8 Light focusing on the retina

The process of focusing light on the retina in the eye involves the refraction of light by the cornea, followed by further refraction by the lens to fine-tune the focus. The pupil controls the amount of light entering the eye, and the lens can adjust its shape through accommodation to focus on objects at different distances. The light is then directed onto the retina, which contains photoreceptor cells responsible for converting light into electrical signals.

## 1.9 Extraocular Muscles

- Medial Rectus: Responsible for inward eye movement, known as adduction. It brings the eye toward the nose.
- Lateral Rectus: Responsible for outward eye movement, known as abduction. It moves the eye away from the nose.
- Superior Rectus: Elevates the eye and helps with upward eye movement, known as elevation or looking up.
- Inferior Rectus: Depresses the eye and helps with downward eye movement, known as depression or looking down.
- Superior Oblique: Responsible for rotating the eye downward and outward. It also helps with intorsion (rotating the top of the eye inward).
- Inferior Oblique: Rotates the eye upward and outward. It also aids in extorsion (rotating the top of the eye outward).

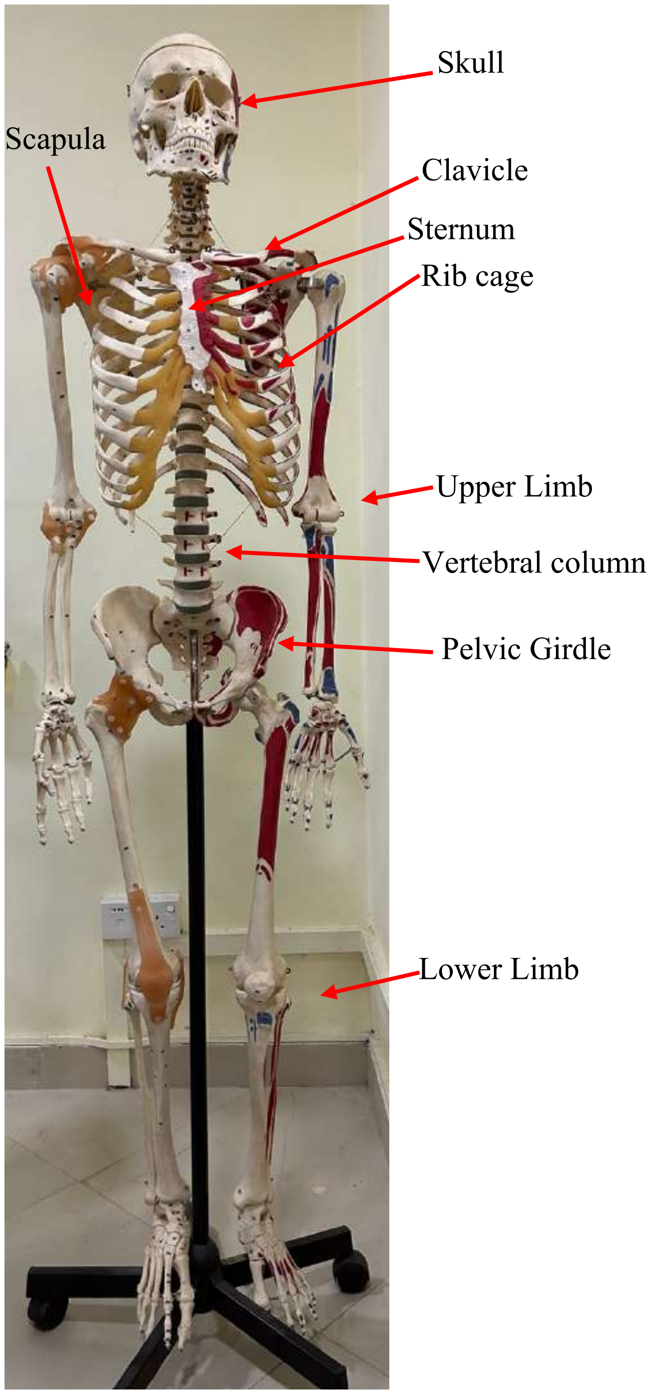
## 1.10 Route taken by the nerve impulses from the retina to the cerebrum

The nerve impulses from the retina travel through the optic nerve, optic chiasm, optic tracts, and thalamus before reaching the primary visual cortex in the cerebrum. From there, the impulses are relayed to visual association areas for further processing and interpretation.

## 1.11 Physiological process in close vision/ accommodation

The physiological process of accommodation in close vision involves the ciliary muscle contracting, which changes the shape of the lens to become more rounded and thicker. This increased curvature increases the lens's refractive power, allowing it to focus on nearby objects. As a result, the eye can see close objects clearly. When shifting focus to distant objects, the ciliary muscle relaxes, and the lens becomes flatter and thinner, reducing its refractive power for clear distance vision. Accommodation allows the eye to adjust its focus quickly and automatically to see objects at different distances.

## 2. Musculoskeletal System



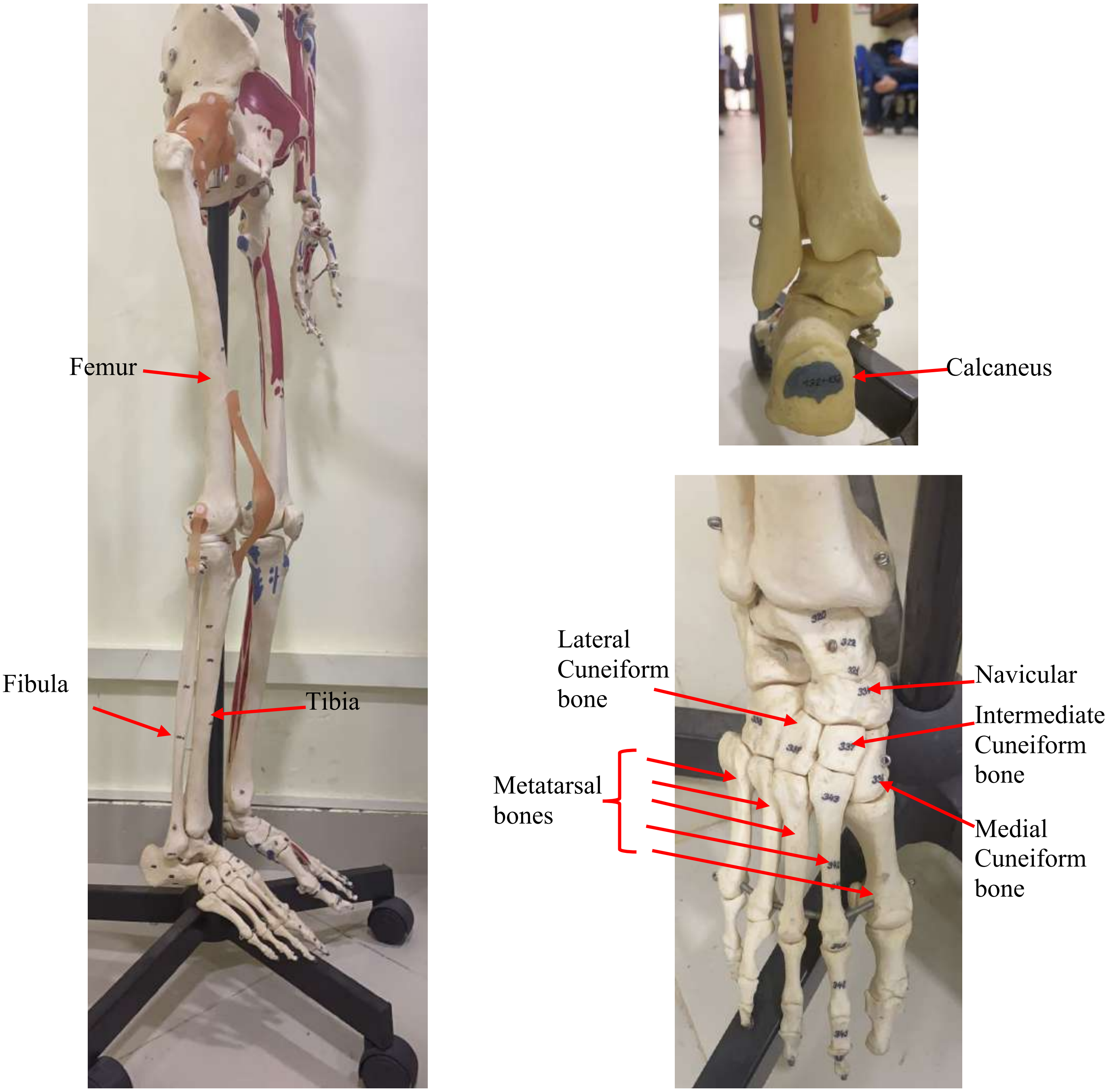

**Axial Skeleton**

- Skull
- Vertebral Column
- Thoracic Cage (Ribs and Sternum)

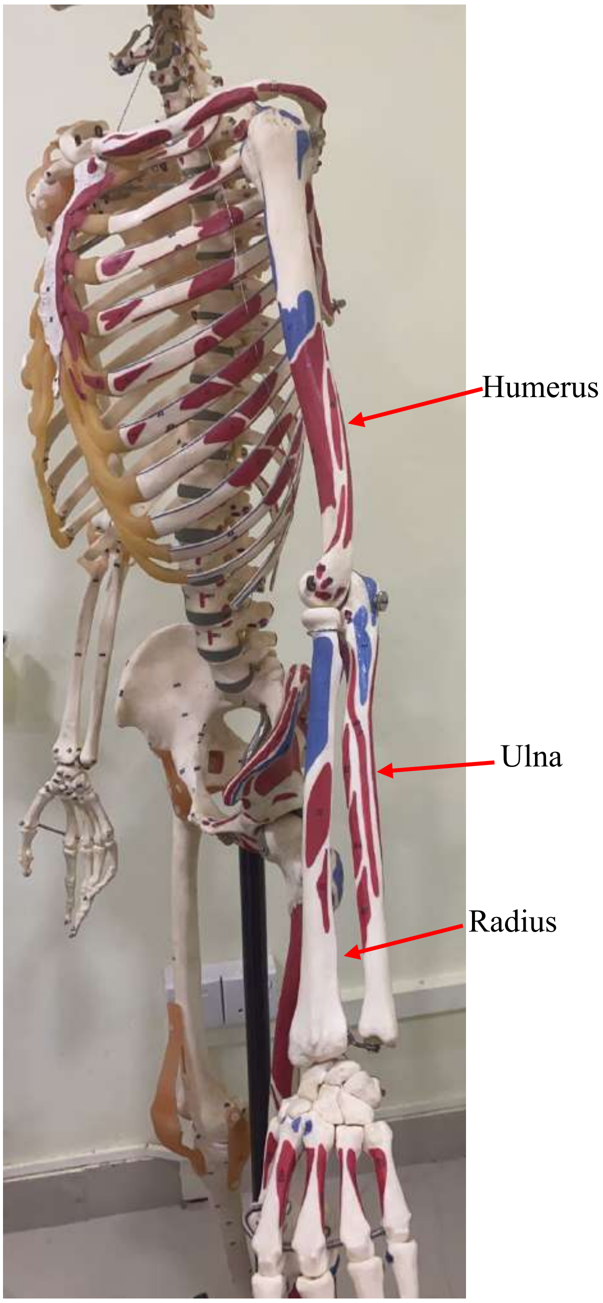
**Appendicular Skeleton**

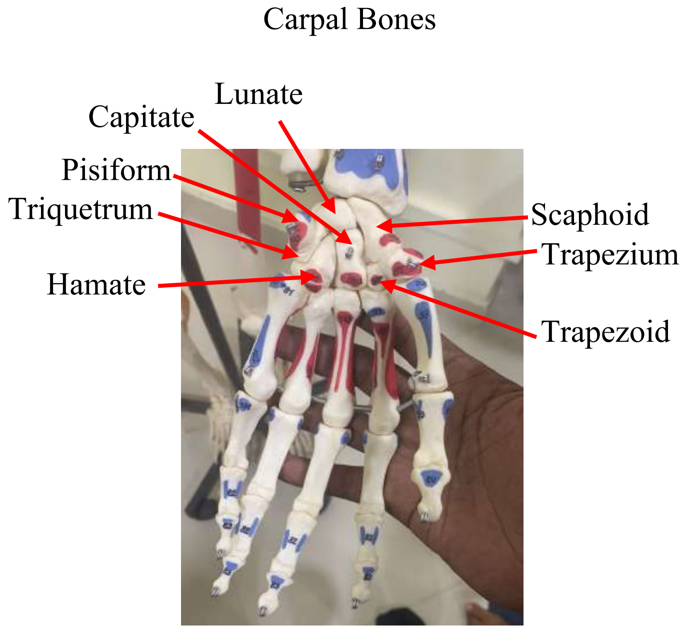
- Upper Limbs
- Lower Limbs
- Pectoral Girdle (Scapula and Clavicle)
- Pelvic Girdle

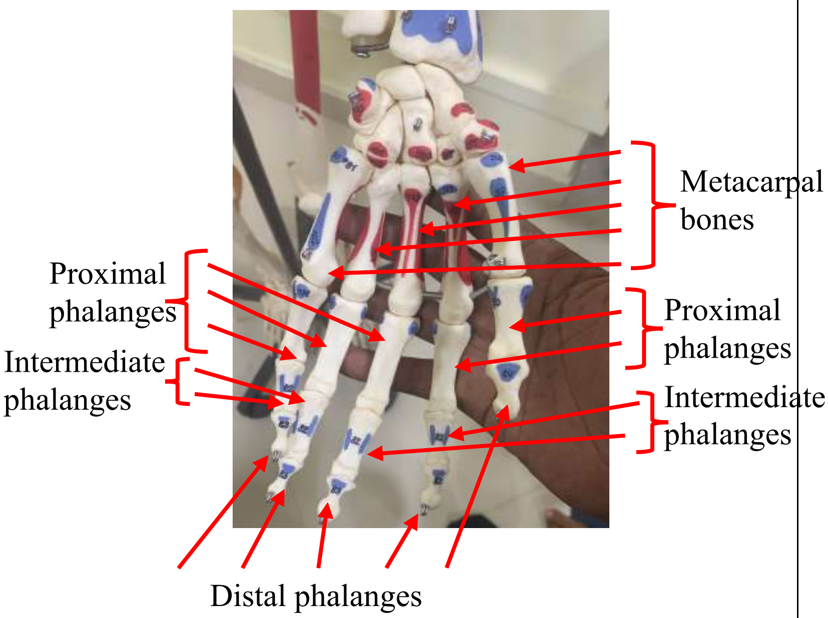
## 2.2.1 Lower Limb



2.2.2 Upper Limb




2.3 Types of Bones observed in the Skeleton

**Long Bones**: Long bones are longer than they are wide and have a shaft (diaphysis) with expanded ends (epiphyses). They provide support, act as levers for movement, and contain bone marrow for blood cell production. Examples are Femur, Humerus.
**Short Bones**: Short bones have nearly equal dimensions in all directions and provide stability and support with limited movement. They are primarily found in the wrist and ankle joints. Example are Carpals, Tarsals.
**Flat Bones**: Flat bones are thin, flat, and usually curved. They provide protection to internal organs and have large surface areas for muscle attachment. Example are Scapula, Skull bones.
**Irregular Bones**: Irregular bones have complex shapes and do not fit into the other bone categories. They often have multiple functions, such as protecting delicate structures and providing sites for muscle attachment. Example are Vertebrae, Facial bones.
**Sesamoid Bones**: Sesamoid bones are small, round bones embedded within tendons. They protect tendons from excessive wear and tear and improve mechanical efficiency. Example are Patella (kneecap).

Differences:
**Shape**: The primary difference among the types of bones lies in their shape. Long bones are elongated with expanded ends, short bones are nearly equal in length and width, flat bones are thin and flat, irregular bones have complex shapes, and sesamoid bones are small and round.
**Function**: Each type of bone serves specific functions. Long bones act as levers for movement, short bones provide stability, flat bones protect organs, irregular bones have various functions, and sesamoid bones protect tendons.
**Location**: Different types of bones are found in specific regions of the body. For example, long bones are mainly in the limbs, flat bones are in the skull and shoulder girdle, short bones are in the wrists and ankles, irregular bones are in the spine and face, and sesamoid bones are within certain tendons.

## 2.4 Types of Joints

1. Fibrous Joints: Fibrous joints are connected by fibrous connective tissue and allow minimal to no movement between the bones.
- Sutures: Found between the bones of the skull. Example: Sagittal suture.
- Syndesmoses: Connected by ligaments, allowing limited movement. Example: Distal tibiofibular joint.
- Gomphoses: Peg-in-socket joints, found in tooth sockets. Example: Tooth in its socket (dental gomphosis).

2. Cartilaginous Joints: Cartilaginous joints are connected by cartilage and allow limited movement.
- Synchondroses: Connected by hyaline cartilage, found between the rib and sternum. Example: Sternal (costal) cartilage.
- Symphyses: Connected by fibrocartilage, providing more flexibility. Example: Intervertebral discs between vertebrae.

3. Synovial Joints: Synovial joints are the most common and complex type of joints in the body. They have a synovial cavity filled with synovial fluid, allowing free movement between the bones.
- Ball-and-Socket Joint: Allows a wide range of motion in multiple planes. Example: Hip joint and shoulder joint.
- Hinge Joint: Allows movement in one plane. Example: Elbow joint and knee joint.
- Pivot Joint: Allows rotational movement around a central axis. Example: Proximal radioulnar joint.
- Ellipsoid Joint: Allows movement in two planes. Example: Wrist joint (radiocarpal joint).
- Saddle Joint: Allows movement in two planes, with each bone having a convex and concave surface. Example: Thumb carpometacarpal joint.
- Gliding Joint: Allows limited gliding or sliding movement between flat bone surfaces. Example: Intercarpal joints in the wrist.

2.5 Comparing of the range of movements of the different types of joints has been done in 2.4

## 2.6 Arrangement of Bones

2.6.1 Thoracic Cage:
- The thoracic cage consists of ribs and sternum.
- Ribs: There are 12 pairs of ribs, with the first 7 pairs called true ribs (directly attached to the sternum), the next 3 pairs called false ribs (indirectly attached to the sternum via cartilage), and the last 2 pairs called floating ribs (not attached to the sternum).
- Sternum: The sternum is a flat bone in the center of the chest, divided into the manubrium, body, and xiphoid process.

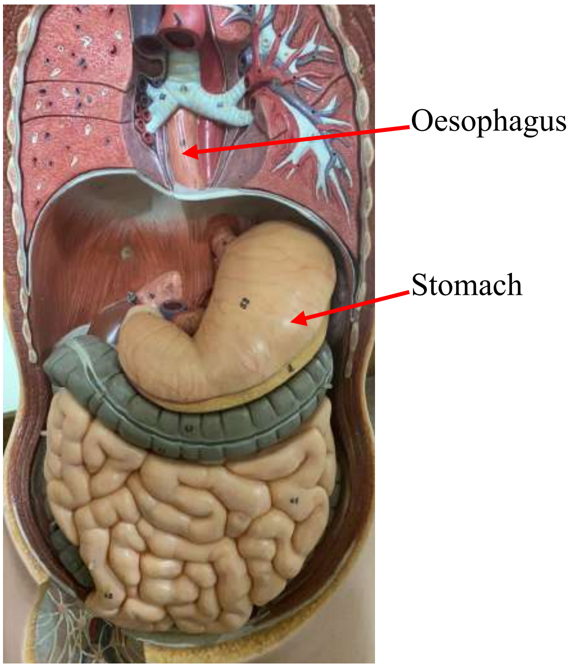
2.6.2 Vertebral Column:

- The vertebral column, also known as the spine or backbone, is made up of individual vertebrae stacked on top of each other.
- It includes 7 cervical vertebrae (C1-C7) in the neck, 12 thoracic vertebrae (T1-T12) in the upper back (each associated with a pair of ribs), 5 lumbar vertebrae (L1-L5) in the lower back, the sacrum (fused 5 sacral vertebrae), and the coccyx.

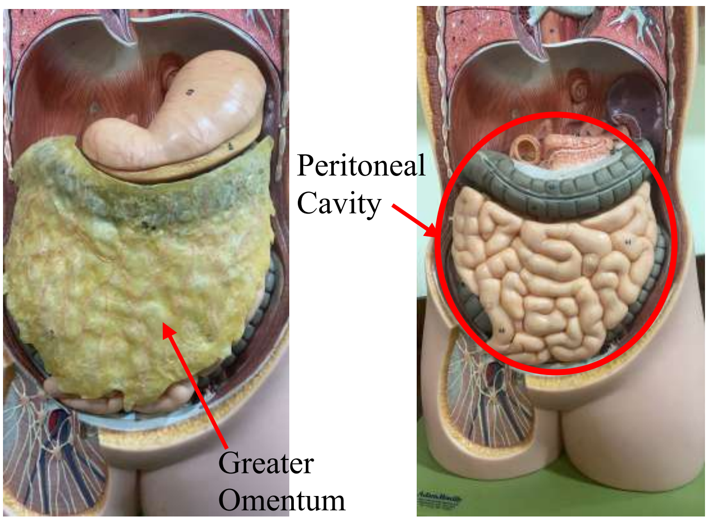
2.6.3 Skull:

- The skull is divided into the cranium and facial bones.
- Cranium: The cranium is the rounded structure that protects the brain and includes the frontal, parietal, temporal, occipital, sphenoid, and ethmoid bones.
- Facial Bones: The facial bones form the face and include the maxilla, mandible, nasal bones, zygomatic bones, lacrimal bones, palatine bones, vomer, and inferior nasal conchae.

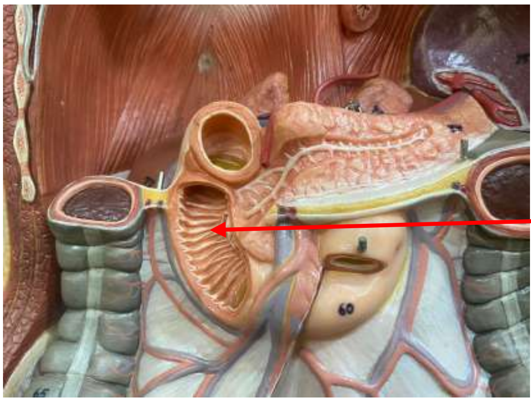
## 3. Abdomen




<u>3.1.1 Stomach and Esophagus:</u>
Spatial Relationship: The esophagus connects the throat to the stomach.
Blood Supply: The stomach and esophagus receive blood from branches of the celiac trunk.



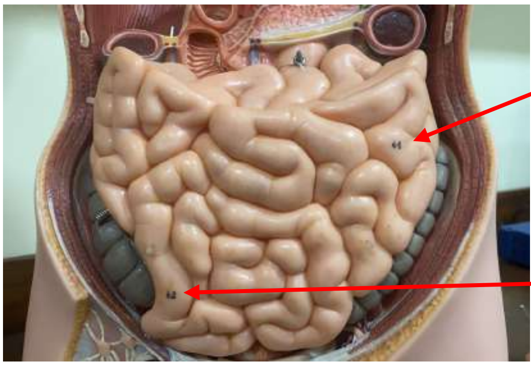

<u>3.1.2 Greater Omentum and Peritoneal Cavity:</u>
Spatial Relationship: The greater omentum hangs down from the stomach and covers the abdominal organs within the peritoneal cavity.
Blood Supply: The greater omentum is supplied by the right and left gastroepiploic arteries from the gastroduodenal artery (a branch of the celiac trunk).




3.1.3 Duodenum:

Spatial Relationship: The duodenum curves around the head of the pancreas.

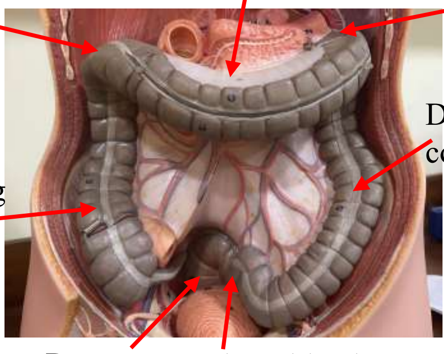
Blood Supply: The duodenum is supplied by the gastroduodenal artery (from the celiac trunk) and the superior pancreaticoduodenal artery (from the superior mesenteric artery).




3.1.4 Small Intestine (Jejunum and Ileum):

Spatial Relationship: The jejunum is in the upper left quadrant, and the ileum is in the lower right quadrant of the abdomen.

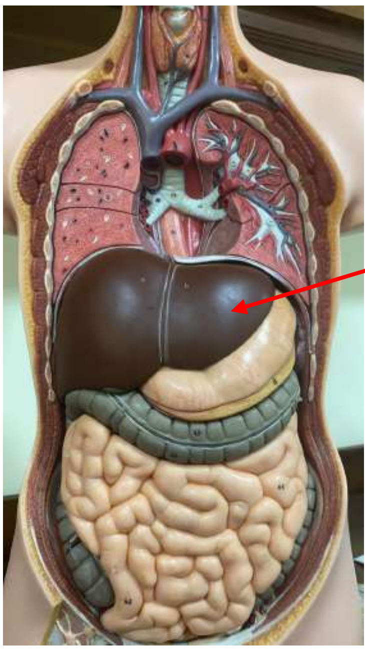
Blood Supply: The small intestine receives blood mainly from the superior mesenteric artery.




3.1.5 Large Intestine:

Spatial Relationship: The large intestine forms segments across the abdomen and down to the pelvic region.

Blood Supply: The large intestine is supplied by branches of the superior mesenteric artery (for the right side) and the inferior mesenteric artery (for the left side and rectum).





3.1.6 Liver & Gallbladder:

Spatial Relationship: The gallbladder is located on the undersurface of the liver.

Blood Supply: The liver receives blood from both the hepatic portal vein (75%) and the hepatic artery (25%), while the gallbladder is supplied by the cystic artery (from the right hepatic artery).

3.2 Structures aiding in digestion and absorption of food and excretion of waste

- Stomach and Esophagus:
  Esophagus: Transports food from the mouth to the stomach through peristalsis.
  Stomach: Stores and mixes food with gastric juices, initiating protein digestion.

- Greater Omentum and Peritoneal Cavity:
  Greater Omentum: Contains adipose tissue for insulation and protection.
  Peritoneal Cavity: Contains serous fluid for lubrication and friction reduction.

- Duodenum:
  Receives partially digested food from the stomach and mixes it with bile and pancreatic enzymes for further digestion.

- Small Intestine (Jejunum and Ileum):
  Primary site of nutrient absorption, thanks to villi and microvilli that increase surface area.
  Absorbs nutrients (carbohydrates, proteins, fats, vitamins, and minerals) into the bloodstream.

- Large Intestine:
  Absorbs water and electrolytes from undigested food, converting chyme into feces.
  Stores feces until elimination during defecation.

- Liver & Gallbladder:
  Liver: Produces bile to digest fats and detoxifies harmful substances.
  Gallbladder: Stores and concentrates bile, releasing it into the small intestine during digestion.

3.3 Diagnostic instruments

- Ultrasound:
  Used for imaging abdominal organs like the liver, gallbladder, pancreas, and kidneys.
  Can help identify conditions such as gallstones, and pancreatic tumors.

- Computed Tomography (CT) Scan:
  Provides detailed cross-sectional images of the abdomen and pelvis.
  Useful for detecting conditions in various GI organs, including the liver, spleen, kidneys, and intestines.
  Can diagnose conditions like appendicitis, diverticulitis, and abdominal tumors.

- Magnetic Resonance Imaging (MRI):
  Produces detailed images of the GI tract using magnetic fields and radio waves.
  Particularly useful for visualizing soft tissues, blood vessels, and organs.

- Endoscopy:
  Involves using a thin, flexible tube with a camera (endoscope) to examine the inside of the GI tract.
  Different types of endoscopy include:
  - Esophagogastroduodenoscopy (EGD) for the esophagus, stomach, and duodenum.
  - Colonoscopy for the colon and rectum.
  - Enteroscopy for the small intestine.

- Laparoscopy:
  Performed through small incisions in the abdomen using a laparoscope.
  Used for both diagnostic and therapeutic purposes.
  Also used for surgical interventions, such as gallbladder removal and appendix removal.

### 3.4 Functions of the Liver

- Metabolism: The liver is involved in the metabolism of carbohydrates, fats, and proteins. It helps regulate blood glucose levels by storing excess glucose as glycogen and releasing it when needed.

- Detoxification: The liver filters and neutralizes harmful substances, including drugs, alcohol, and metabolic waste products. It converts these toxins into less harmful forms for excretion.

- Bile Production: The liver produces bile that aids in the digestion and absorption of fats in the small intestine. Bile is stored in the gallbladder and released into the intestine when needed.

- Storage: The liver acts as a storage organ for essential nutrients such as vitamins (A, D, E, K, and B12) and minerals (iron and copper). It also stores glycogen for energy reserves.

- Protein Synthesis: The liver synthesizes many important proteins, including blood clotting factors, albumin (a protein that helps maintain fluid balance), and various proteins involved in the immune system.

- Regulation of Cholesterol and Lipid Levels: The liver helps regulate cholesterol and lipid levels in the bloodstream by producing and breaking down lipoproteins.

- Bilirubin Processing: The liver processes bilirubin, a waste product derived from the breakdown of hemoglobin in old red blood cells. It converts bilirubin into a form that can be excreted in bile.

- Hormone Regulation: The liver plays a role in the regulation of various hormones and their levels in the blood.