

The Muscular System

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- Skeletal muscles are formed of several bundles of skeletal muscle cells. They are attached by tendons to bones.
- When a skeletal muscle contracts, the tendon will be pulled and this will pull the bone resulting in Movement.
- The **belly** of the muscle is the fleshy (wide) part between the tendons.
- Muscles have more than one bony attachment:
 - the attachment of a tendon to the relatively stationary bone is called the **origin**.
 - the attachment of the muscle's other tendon to the relatively movable bone is called the **insertion**.
 - the **action/s** of a muscle are the main movements that occur during contraction (e.g., flexion or extension).

Muscular Tissue

Muscular tissue is the type of tissue whose cells are differentiated to optimally use the contractile ability of the cells.

Cell membrane = Sarcolemma

Cytoplasm = Sarcoplasm

Smooth endoplasmic reticulum = Sarcoplasmic reticulum

Types of Muscle Cells

➤ Muscle cells are relatively long, therefore, they're called *muscle fibers*

➤ There are three types of muscle cells:

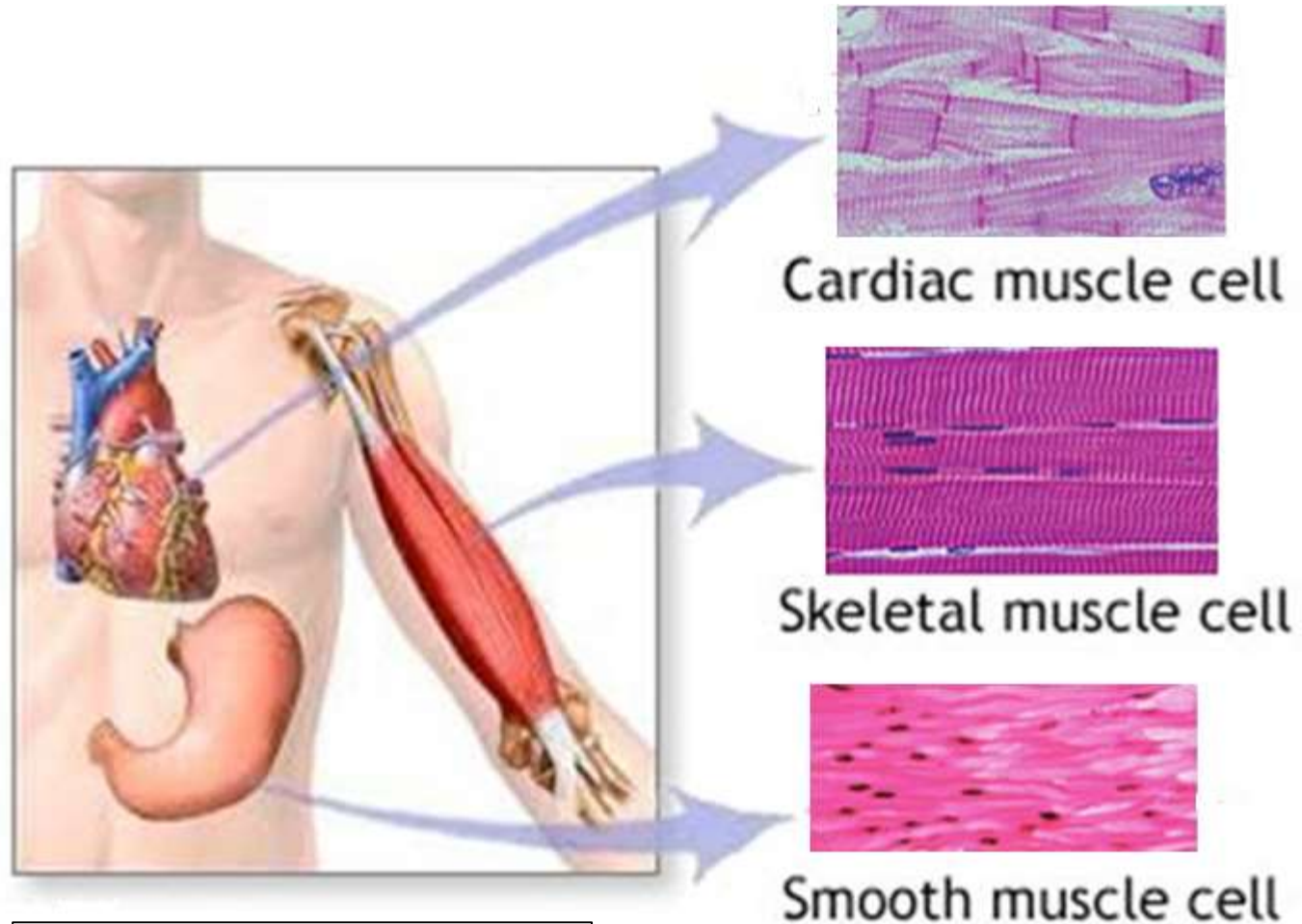
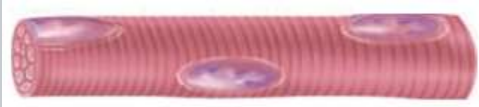
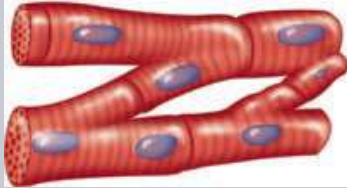


Fig.1: Types of muscle cells.

Comparison between the three types of muscle cells:

	<i>Skeletal</i>	<i>Cardiac</i>	<i>Smooth</i>
<i>Location</i>	Attached to bones	The heart	Internal organs and skin
<i>Shape</i>	Elongated and cylindrical 	Branched 	Spindle 
<i>Nucleus</i>	Several peripherally located nuclei	Single centrally located nucleus	Single centrally located nucleus
<i>Striation</i>	Striated	Striated	Non-striated
<i>Function</i>	• Movement of bone • Heat production	Beating of the heart	Movement of the viscera
<i>Control</i>	Voluntary	Involuntary	Involuntary

Notes

- Smooth muscle cells are held together by desmosomes. Also, gap junctions are present between the cells to allow the spread of Ca^{2+} (and thus contraction) rapidly between them.
- The branches of cardiac muscle cells meet each other at specialized structures called the ***intercalated discs*** which also contain desmosomes and gap junctions.

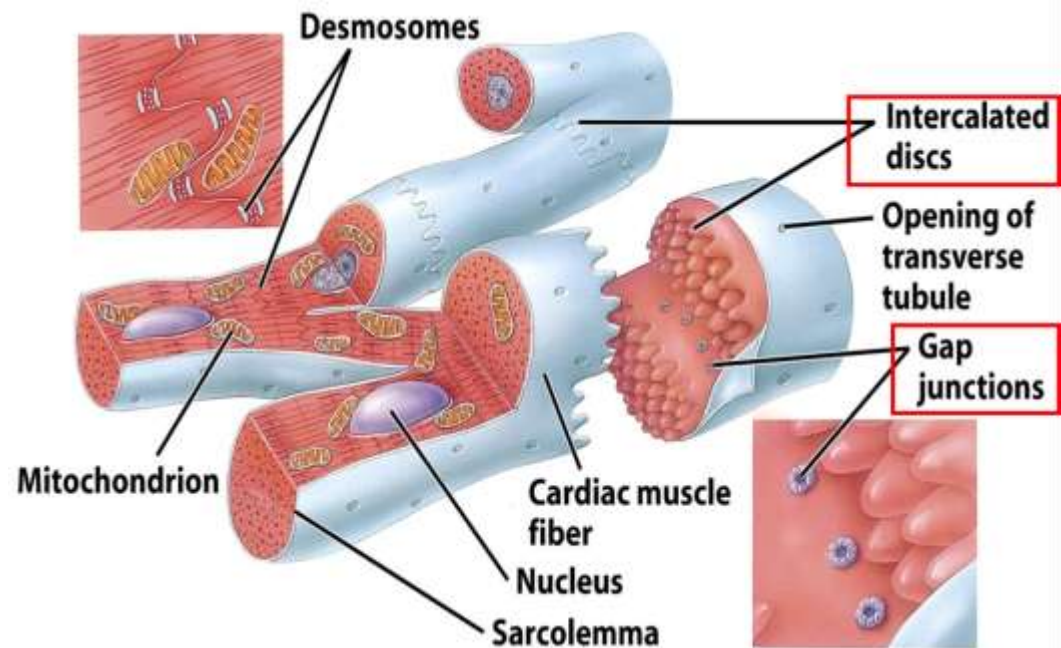


Fig.2: Cardiac muscle cells.

Organization of Skeletal muscles:

- Skeletal muscles are formed of several bundles of muscle fibers.
- Each fiber is surrounded by **Endomysium**: a loose areolar connective tissue layer. Each bundle is surrounded by connective tissue **Perimysium**. The whole muscle is surrounded by **Epimysium**: a dense connective tissue layer.
- The collagen fibers in these three connective tissue layers will extend beyond the fleshy part of the muscle to form the cord-like tendons or the broad aponeuroses that attach muscles to bones.



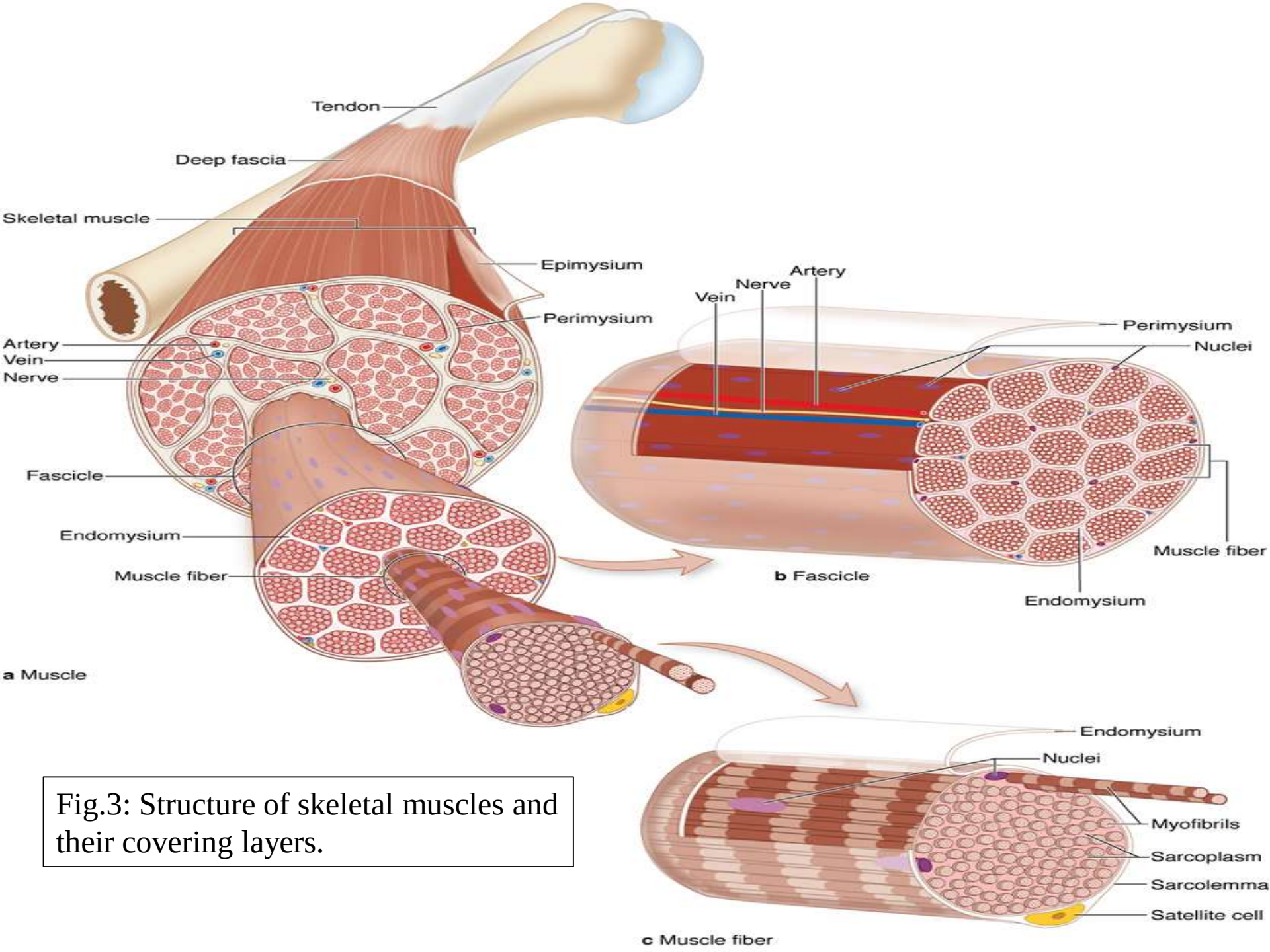


Fig.3: Structure of skeletal muscles and their covering layers.

Cross-Striation of skeletal and cardiac muscle cells:

- ✓ Skeletal and cardiac muscle fibers, under the LM, appear to have alternating dark and light areas. These are called the A and I bands respectively. The banding is due to the regular arrangement of the thin myofilament Actin and the thick myofilament Myosin.



Fig.4: Striation under light microscope.

- ✓ Under the EM, this arrangement proves to be more complex.

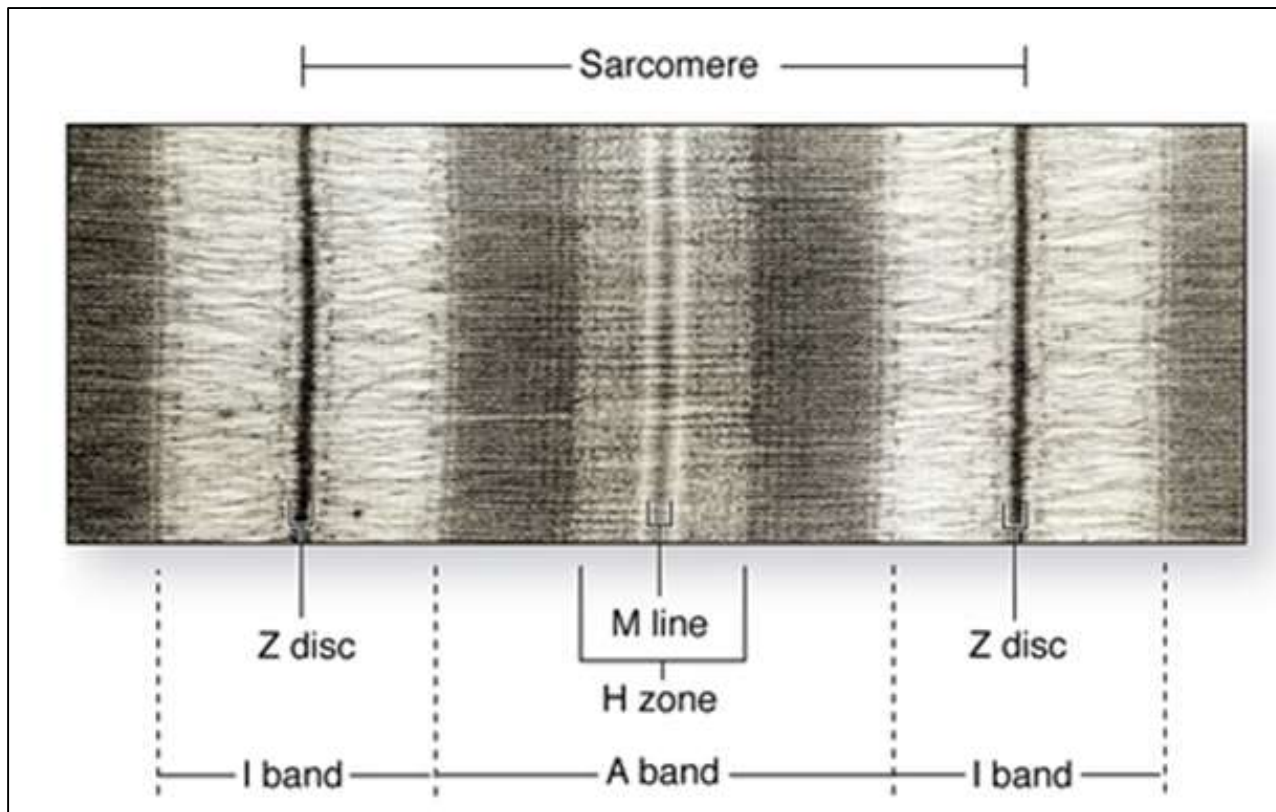
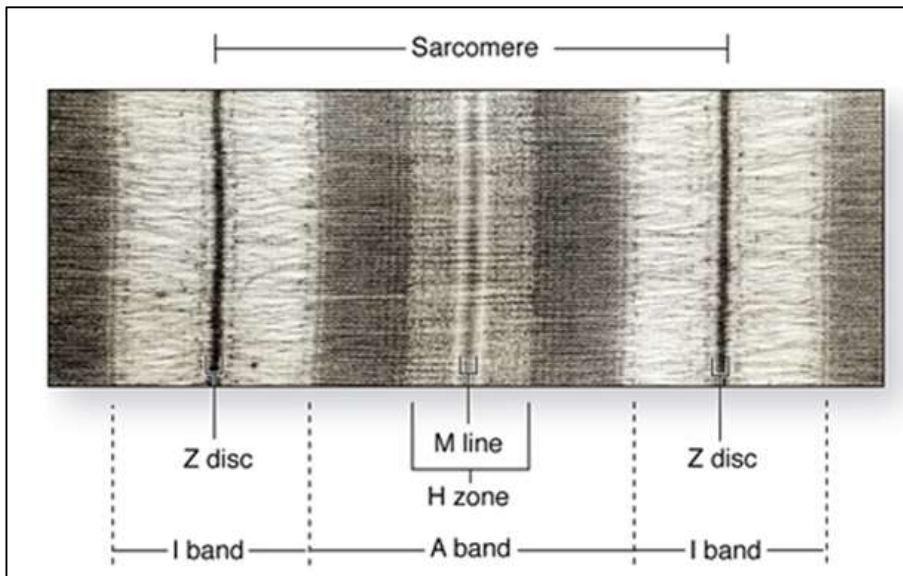
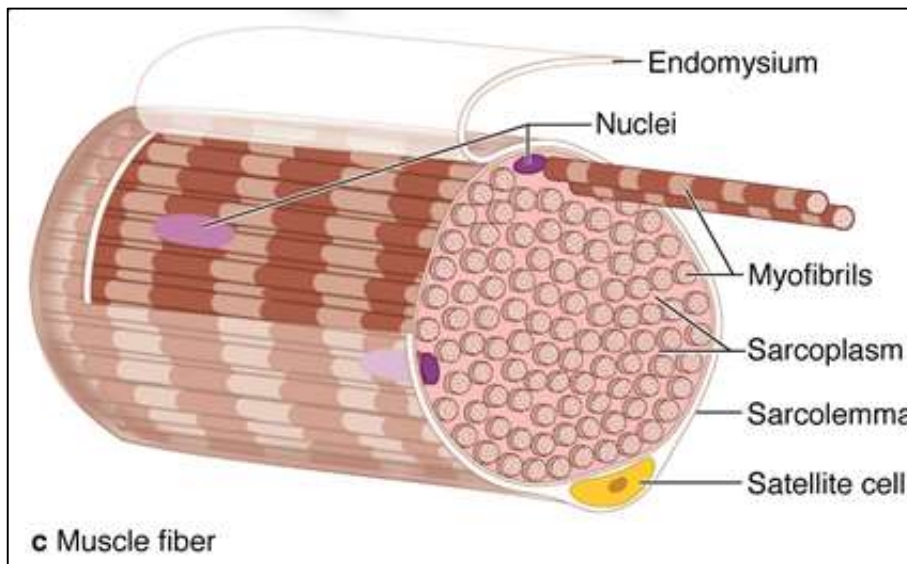


Fig.5: Striation under electron microscope.

- ✓ **H Zone**: a lighter colored area within the A band.
- ✓ **M Line**: darker colored line in the middle of the H zone.
- ✓ **Z Disc (Line)**: a dark line in the middle of the light I band.



✓ **The Sarcomere**: is the repetitive functional subunit of the contraction apparatus. It extends from one Z-line to the next Z-line.



✓ Several sarcomeres arranged end-to-end form the cylindrical myofibrils. Each muscle fiber contains several myofibrils.

Fig.6: Sarcomeres and myofibrils.

Muscle Regeneration

- ❖ Skeletal muscle cells cannot divide. Inactive *Satellite cells* are present close to the muscle fibers. When injury occurs, the satellite cells become active, divide and form new skeletal muscle fibers. This is also thought to be the mechanism by which skeletal muscles hypertrophy after exercise.
- ❖ Cardiac muscles cannot divide and they lack satellite cells. After injury, the damaged muscles are replaced by a connective tissue scar.
- ❖ Smooth muscle cells can divide, and, therefore, can easily replace damaged cells.

Muscles Of The Head

Muscles Of Facial Expression

- Muscles of facial expression:
 - Lie within the subcutaneous layer.
 - Usually originate from skull bones & insert into the skin.
 - Are all supplied by the Facial nerve.
- Because of their insertions, the muscles of facial expression move the skin rather than a joint when they contract. Because of this, these muscle produce the wide variety of facial expressions that humans have.

Zygomaticus major –
The muscle of true
smile

Risorius –
The muscle of false
smile (probably
present only in
humans and gorillas)

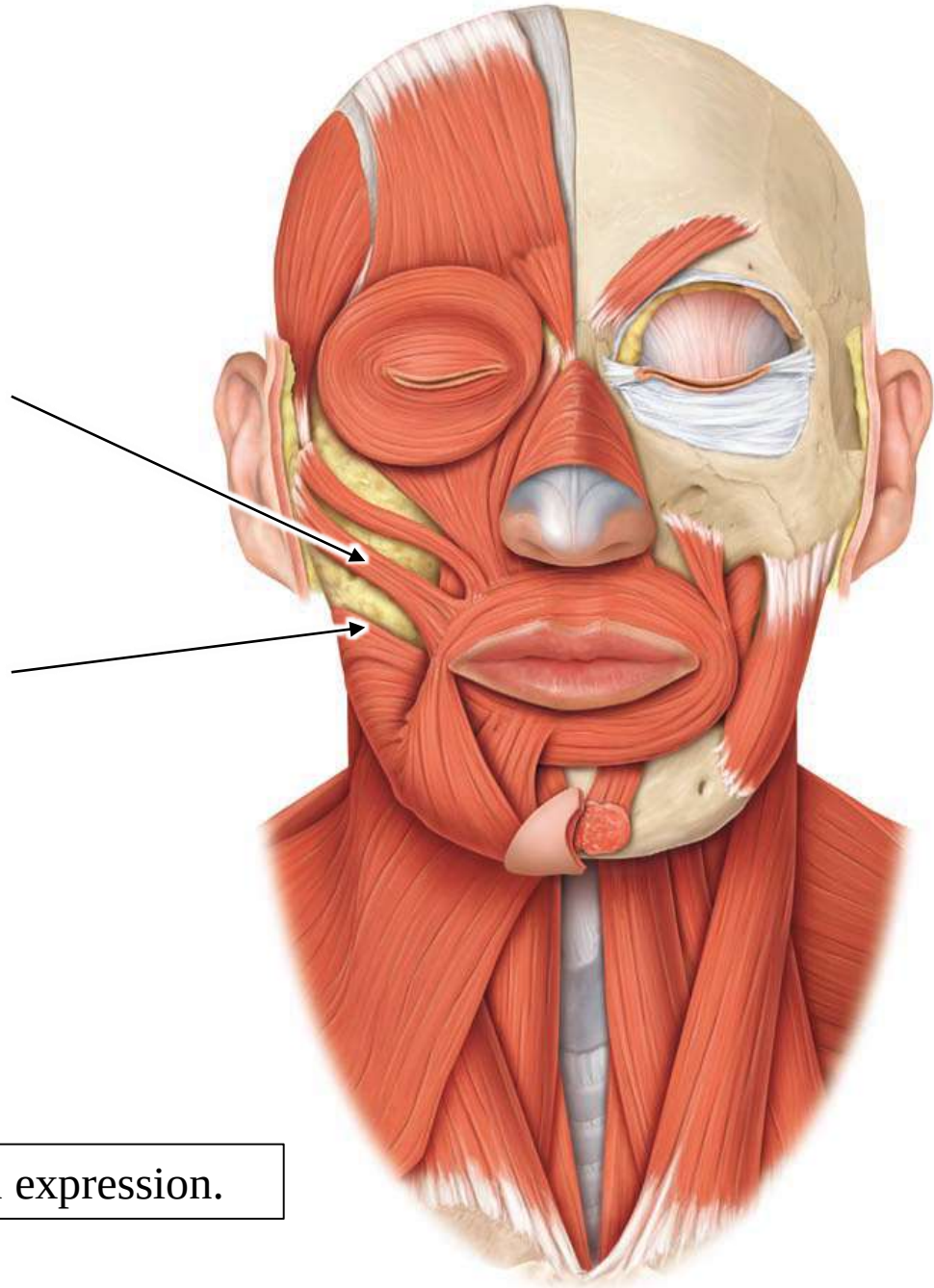


Fig.7: Muscles of facial expression.

Muscles of Mastication (Chewing)

- Four pairs of muscles move the mandible, and are known as ‘muscles of mastication’.
- They are all supplied by the **mandibular branch of the trigeminal nerve**.
- The **masseter**, **temporalis**, and **medial pterygoid** close the mouth and account for the strength of the bite.
- The medial and **lateral pterygoid** muscles help to chew by moving the mandible from side to side.
- The lateral pterygoid is also the main depresser of the mandible as in opening the mouth. Note that **Gravity** assists in depressing the mandible (plus other muscles).

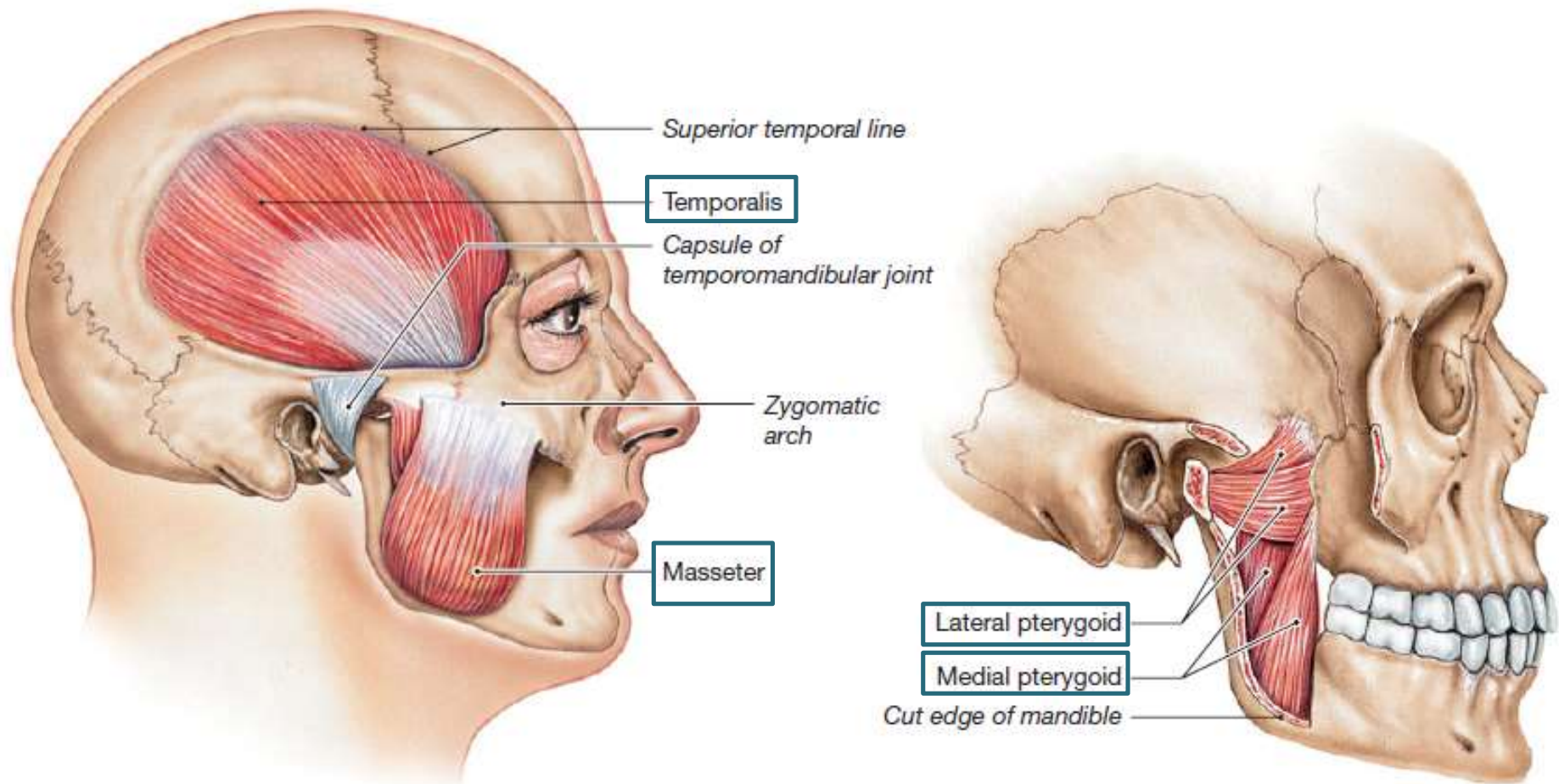


Fig.8: Muscles of mastication.

Muscles Of The Tongue

- Muscle of the tongue include:
 - Intrinsic muscles (originate and insert within tongue). These are responsible for changing the shape of the tongue.
 - Extrinsic muscles (originate outside the tongue, insert into tongue). These are responsible for moving the tongue.
- Genioglossus is one of these extrinsic muscles. It moves the tongue forwards.
- All muscles of the tongue are supplied by the Hypoglossal nerve, except the palatoglossus.

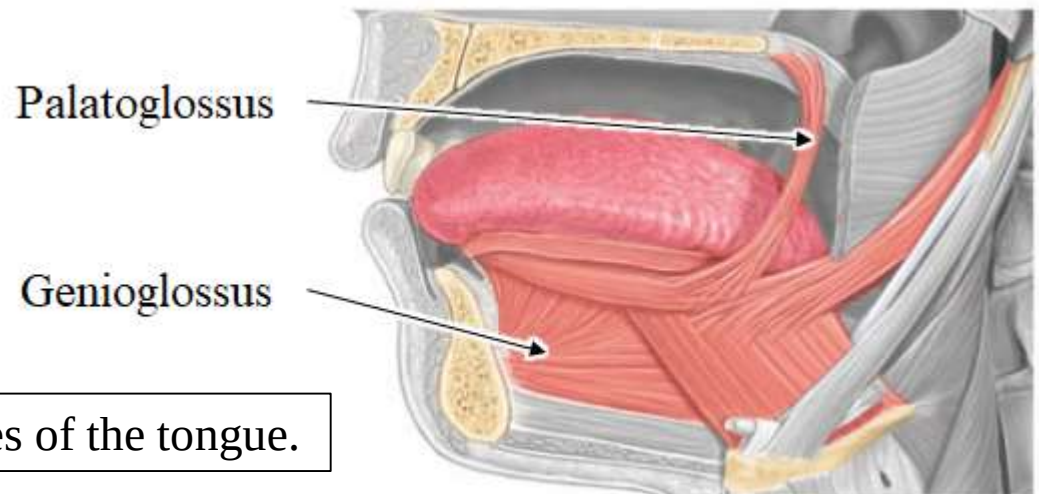


Fig.9: Muscles of the tongue.

Muscles Of The Neck

- The **Sternocleidomastoid** (SCM) muscle is an important anatomical landmark in the neck. It divides the neck into an anterior and a posterior triangle.
- The SCM muscle arises from the sternum and clavicle and is inserted into the mastoid process and the occipital bone. Its motor supply is by the accessory (XI) nerve. If the muscles on both sides contract, they'll flex the head. If the SCM muscle of one side contracts, it'll rotate the head to the opposite side.

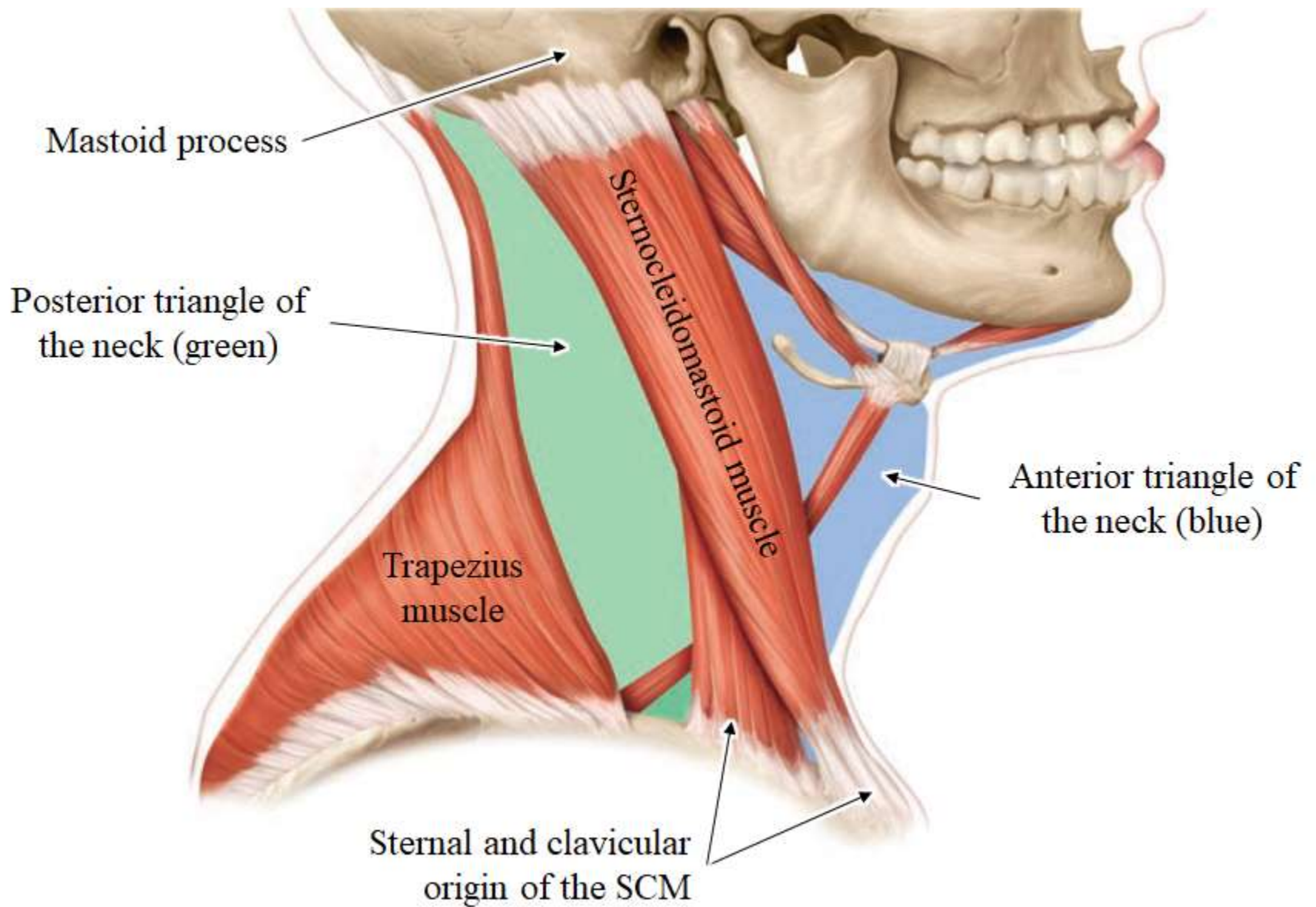


Fig.10: The sternocleidomastoid muscle.

■ **Anterior Triangle:**

1. **Anterior border:** midline
2. **Posterior border:** SCM muscle
3. **Superior border:** Mandible

■ **Posterior Triangle:**

1. **Anterior border:** SCM muscle
2. **Posterior border:** Trapezius muscle
3. **Inferior border:** Clavicle

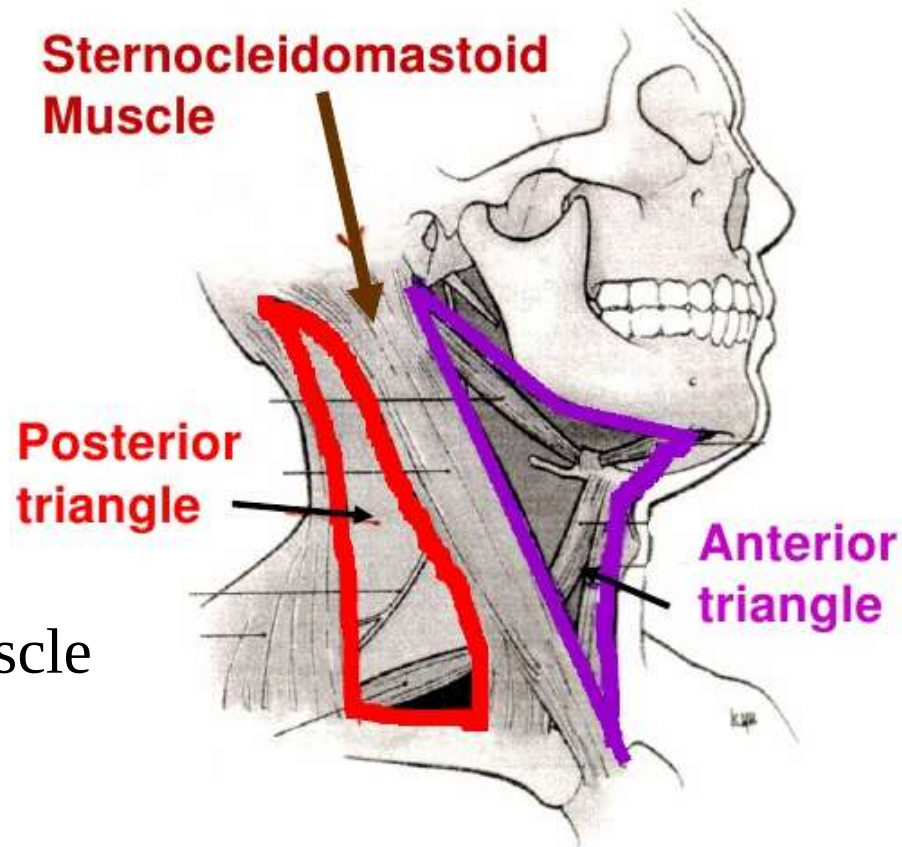


Fig.11: Boundaries of the triangles of the neck.

- In the *anterior part of the neck*, we have the *suprahyoid* and *infrahyoid* muscles. These muscles move the hyoid bone and perform other functions.

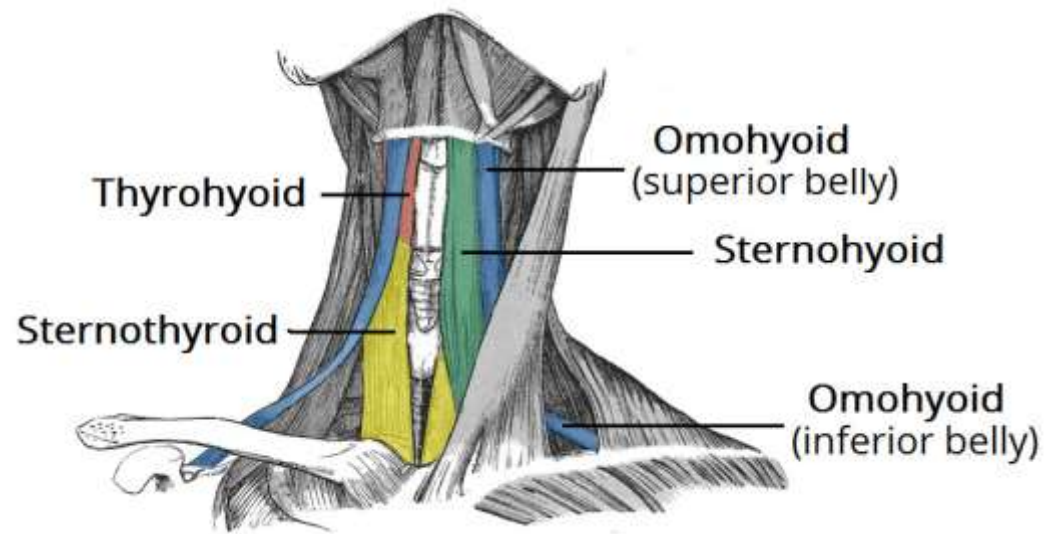
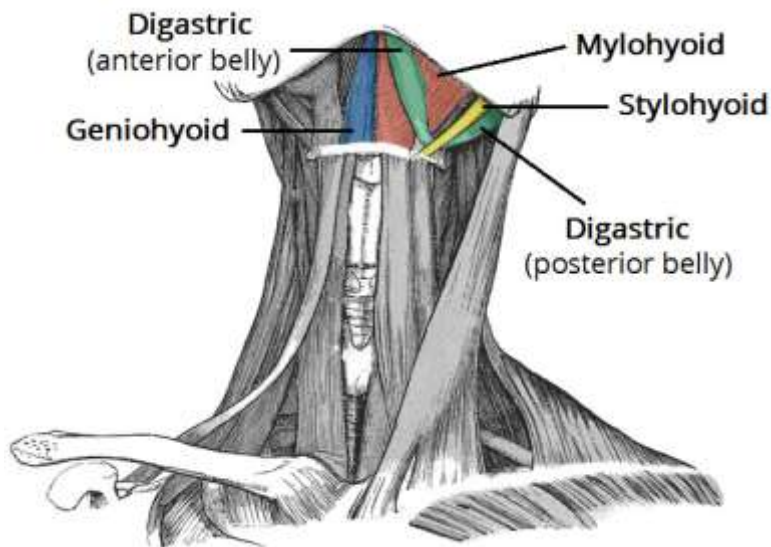


Fig.12: The suprahyoid (left) and infrahyoid muscles (right).

- In the ***lateral part of the neck***, we have the ***scaleni*** muscles. *Scalenus anterior* is an important landmark in the neck with several important relations. Among these relations we have: the subclavian artery and vein and the trunks of the brachial plexus.

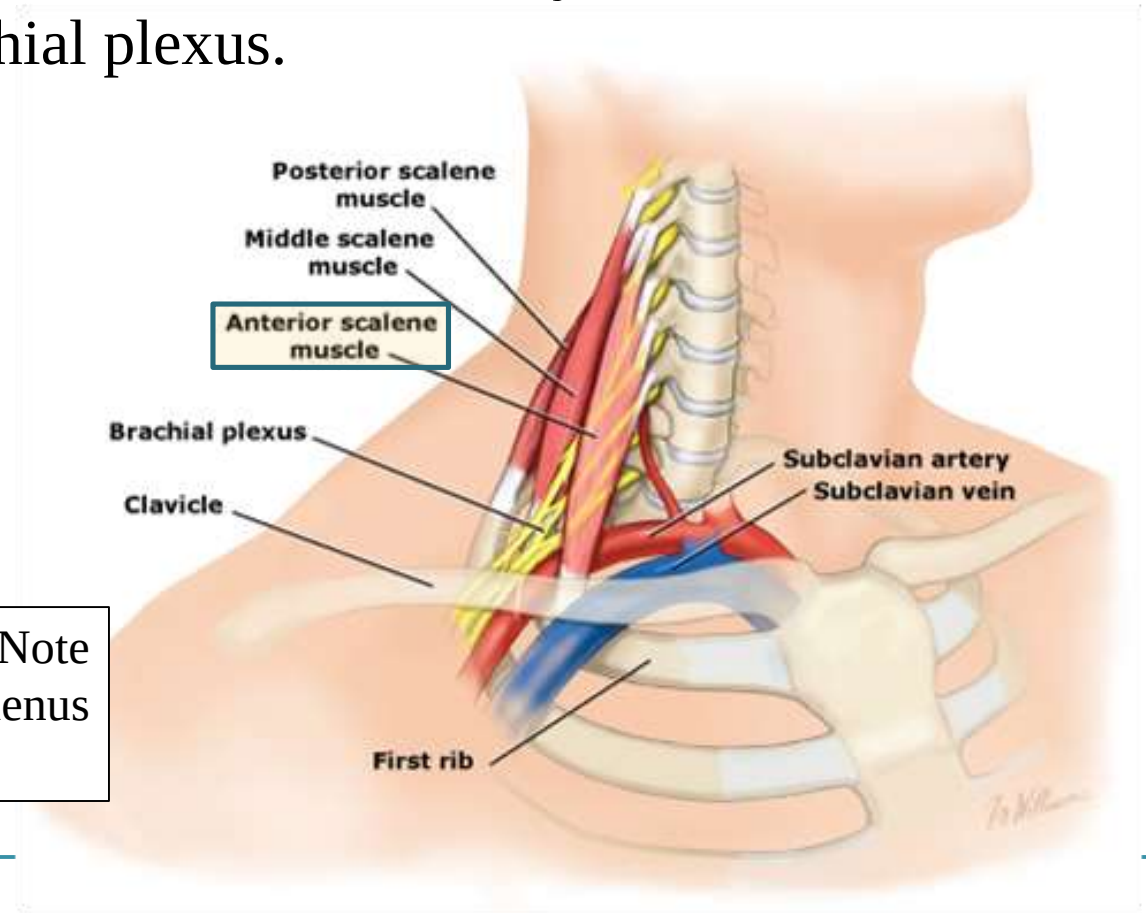


Fig.13: The scaleni. Note the relations of the scalenus anterior muscle.

Respiratory Muscles Of The Thorax

- Respiratory muscles alter the size of the thoracic cavity which affects the pressure in the lungs, and that determines whether we inhale or exhale.
- Between the ribs we have the intercostal muscles arranged in three layers: the **external, internal, and innermost intercostal muscles**. Between the internal and innermost intercostal muscles, we have the intercostal nerve and vessels.
- There are also a number of accessory muscles useful in forced breathing: SCM and the scaleni muscles.

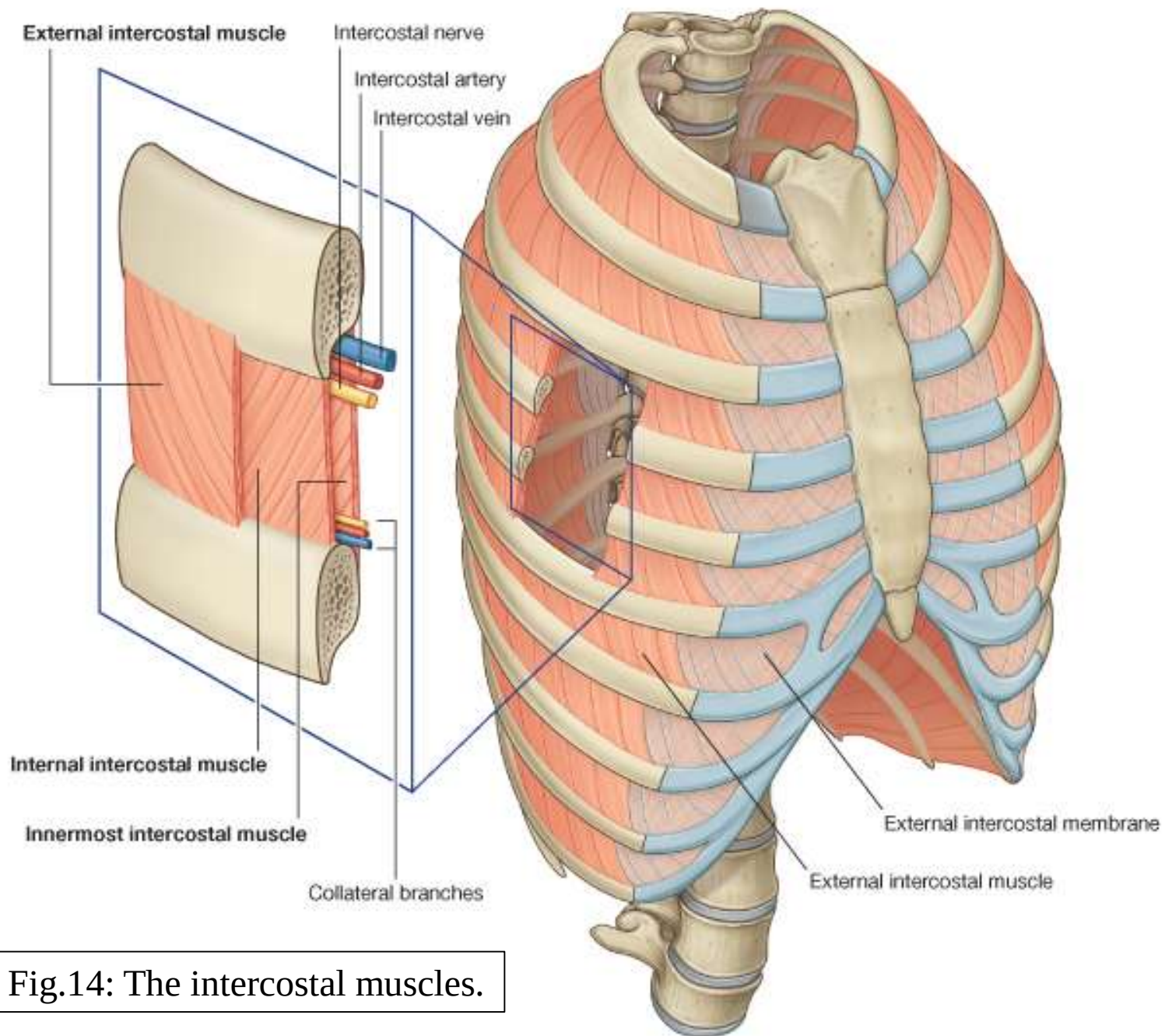


Fig.14: The intercostal muscles.

The Diaphragm

The diaphragm is the most important muscle of respiration

Muscle	Origin	Insertion	Nerve	Action
Diaphragm	1) Sternal part: Xiphoid process 2) Costal part: Lower 6 costal cartilages and adjacent ribs 3) Vertebral part: Upper 3 lumbar vertebrae and their discs	All muscle fibers converge to be inserted into a centrally located tendon	Phrenic nerve	Contraction of the diaphragm increases vertical diameter of thoracic cage causing inhalation. Its relaxation leads to exhalation.

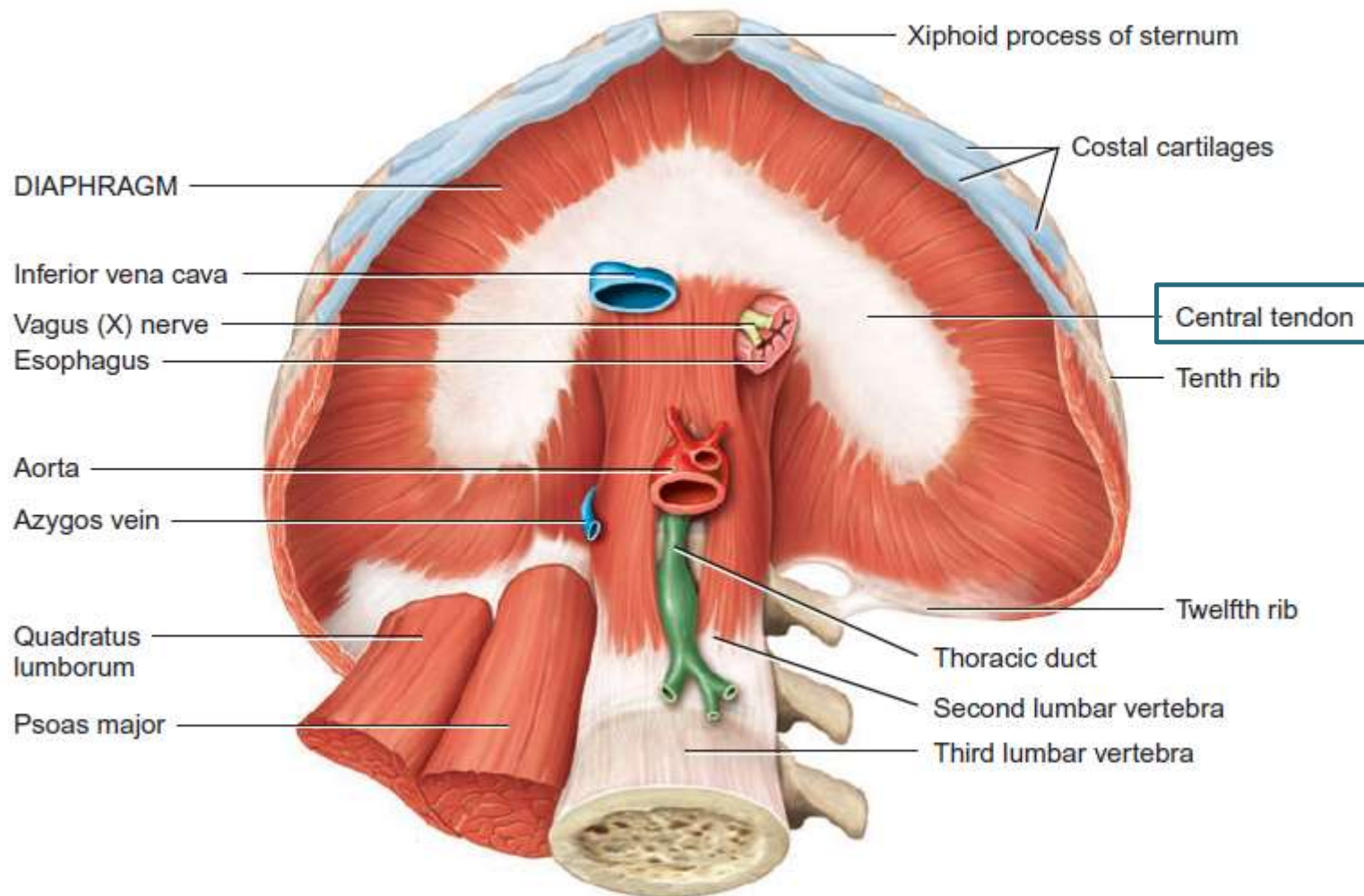


Fig.15: The diaphragm.

Anterolateral Abdominal Wall Muscles

- Include the **external oblique**, **internal oblique**, and **transversus abdominis**.
- The aponeurosis (broad tendon) of the external oblique forms the thick **inguinal ligament** inferiorly.
- The aponeuroses of these 3 muscles form the **rectus sheaths** which enclose the **rectus abdominis muscles**. The sheaths meet each other in the midline to form the **linea alba**, a connective tissue band extending from the xiphoid process to the pubic symphysis.
- **Actions:**
 1. They retain the organs within the abdominal cavity.
 2. The rectus abdominis flexes the lumbar vertebrae.
 3. They assist in micturition, defecation, vomiting, and labor.
 4. They assist in expiration.

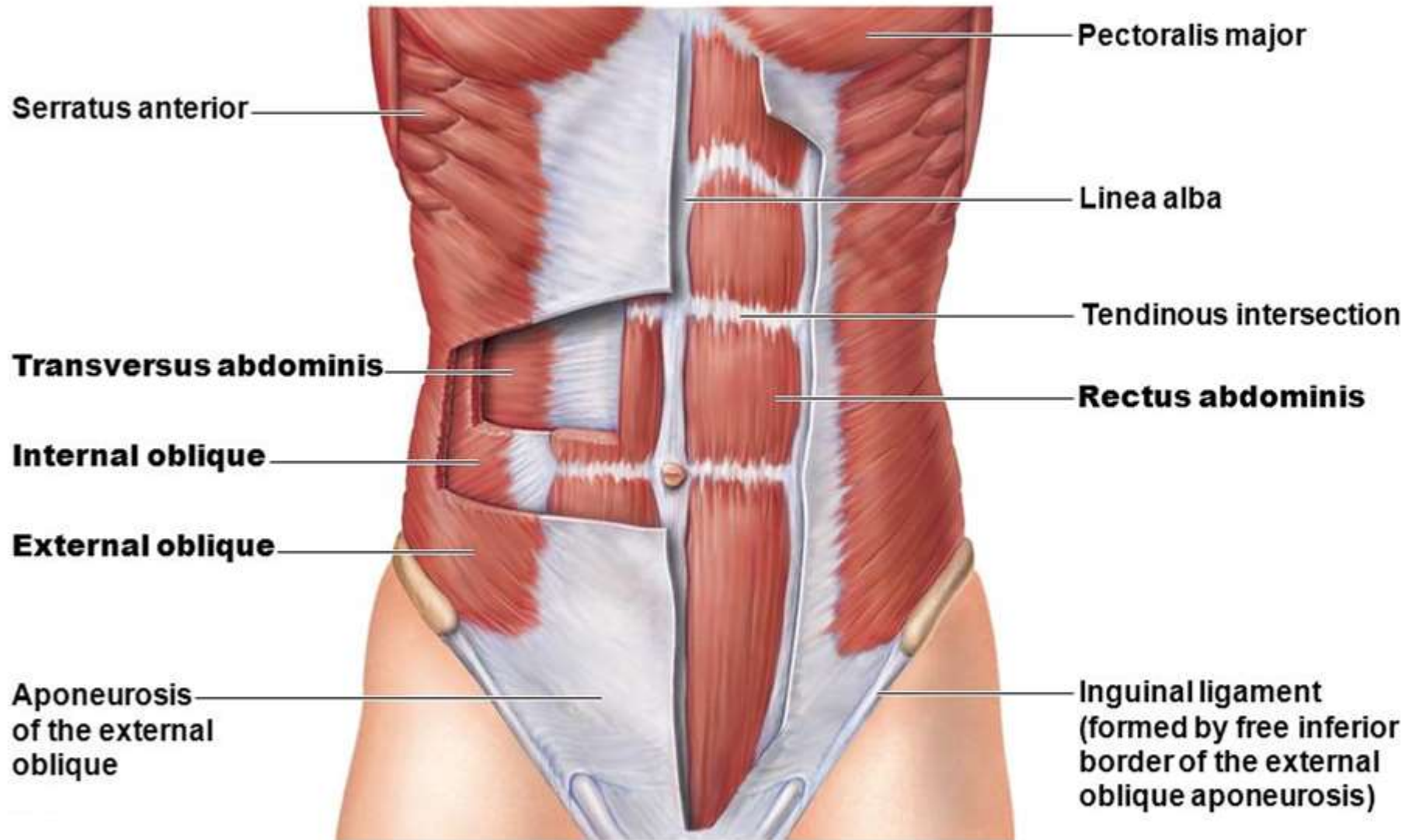


Fig.16: Anterior abdominal wall muscles.

Posterior Abdominal Wall Muscles

- Muscles of the posterior abdominal wall perform different functions.
- The most important are the ***psoas major*** and ***iliacus*** muscles. They are inserted by a common tendon into the thigh. When they contract, they flex the thigh on the trunk; if the thigh is fixed, they flex the trunk on the thigh.

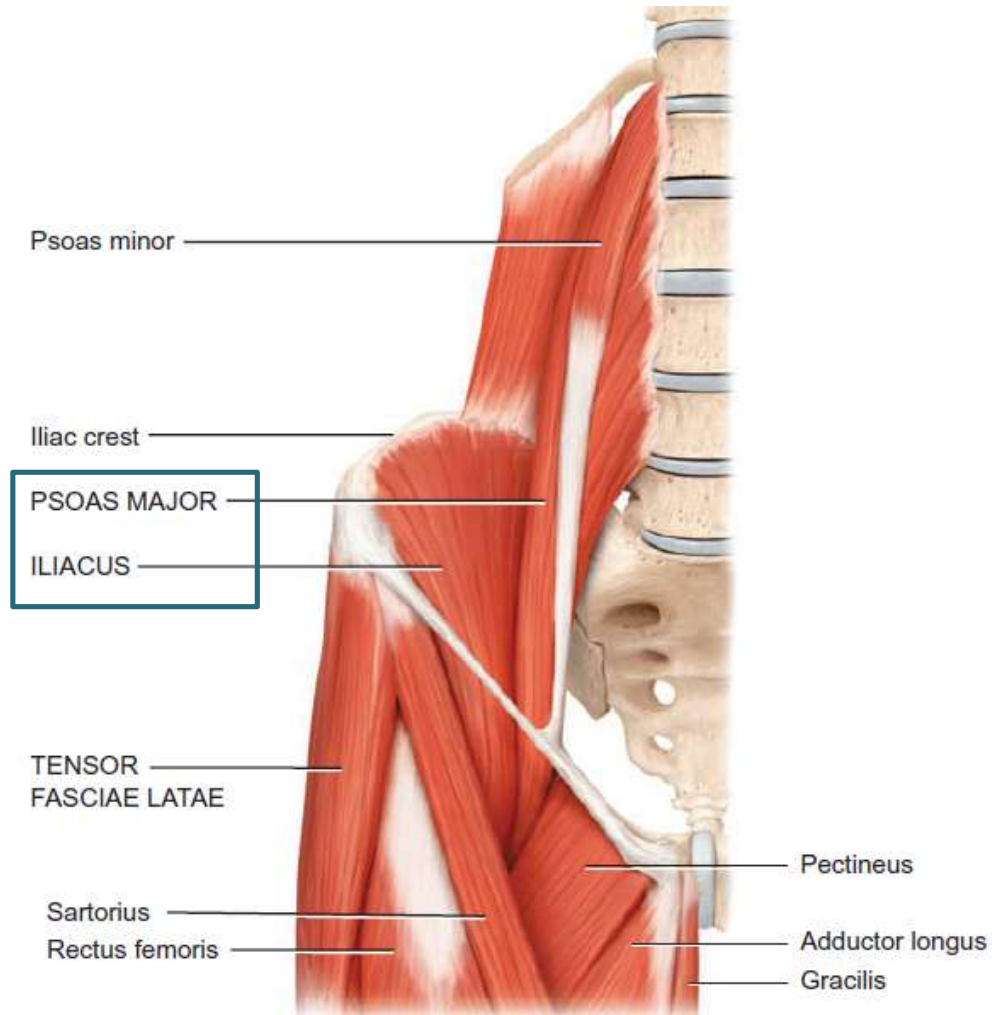
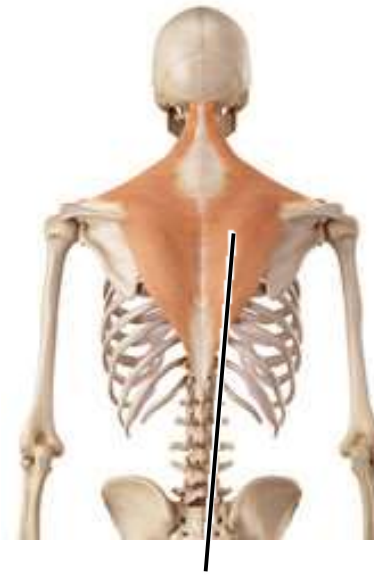


Fig.17: Posterior abdominal wall muscles.

Muscles Of The Upper Limb

Muscles that move the Pectoral Girdle

- Several muscles move and stabilize the pectoral girdle.
- The ***serratus anterior*** (punching) muscle fixes the scapula in position.
- ***Trapezius*** is a large muscle seen on the back. With the serratus anterior muscle, it rotates the scapula so that its glenoid cavity is raised. This allows the arm to be abducted above the head.



Trapezius

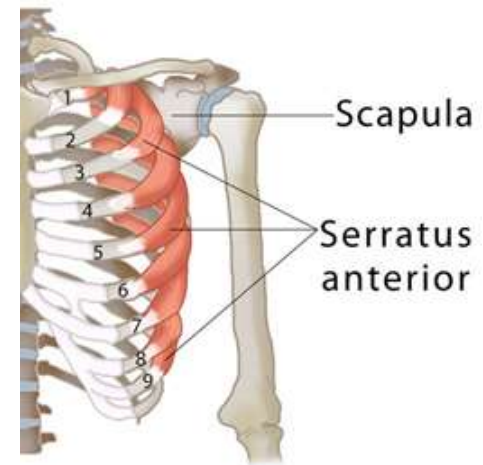
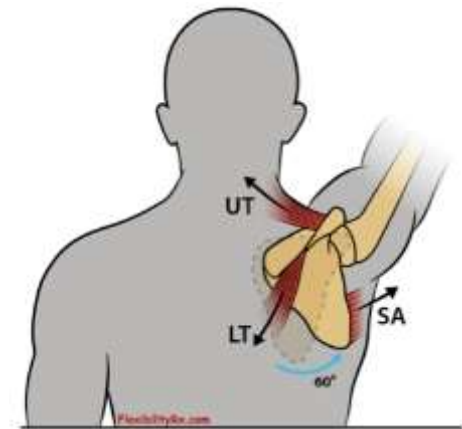


Fig.18: Serratus anterior and trapezius and their action together.



Muscles of shoulder and thorax that move the humerus

- The ***deltoid*** muscle arises from the clavicle and scapula and is inserted into the shaft of the humerus. It flexes, abducts, and extends the humerus.
 - The ***rotator cuff*** muscles (***subscapularis***, ***supraspinatous***, ***infraspinatous***, and ***teres minor***) arise from the scapula. Their tendons blend with the capsule of the shoulder joint stabilizing it. In addition, the supraspinatous initiates abduction of the arm.
 - The ***pectoralis major*** is a big anterior muscle that arises from the clavicle, sternum, and costal cartilages to be inserted into the humerus. It flexes, adducts, and medially rotates the arm. It's one of the main muscle used in swimming.
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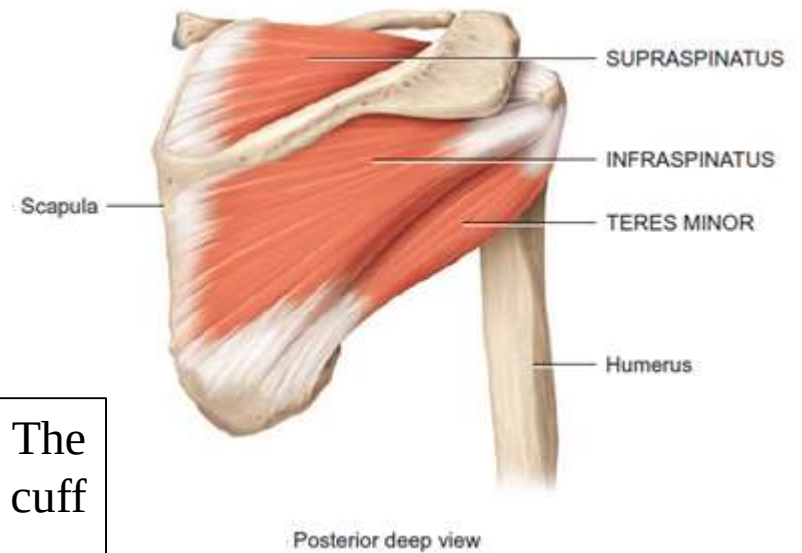
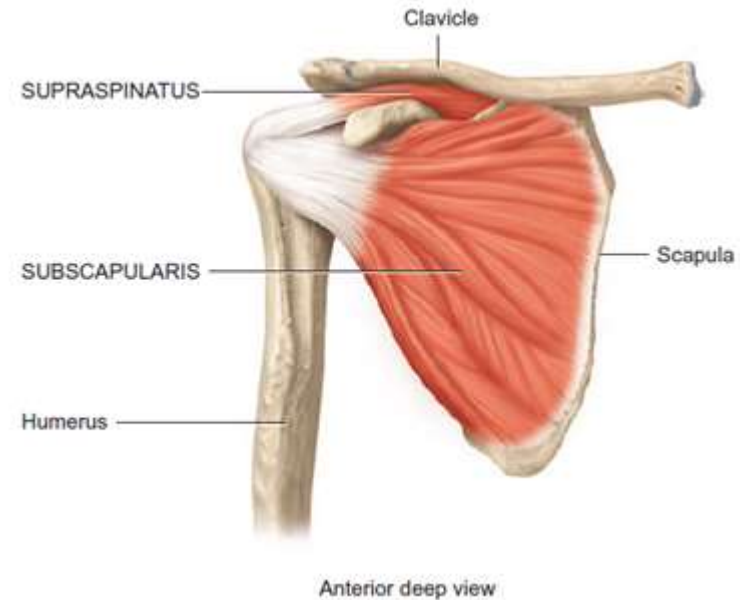
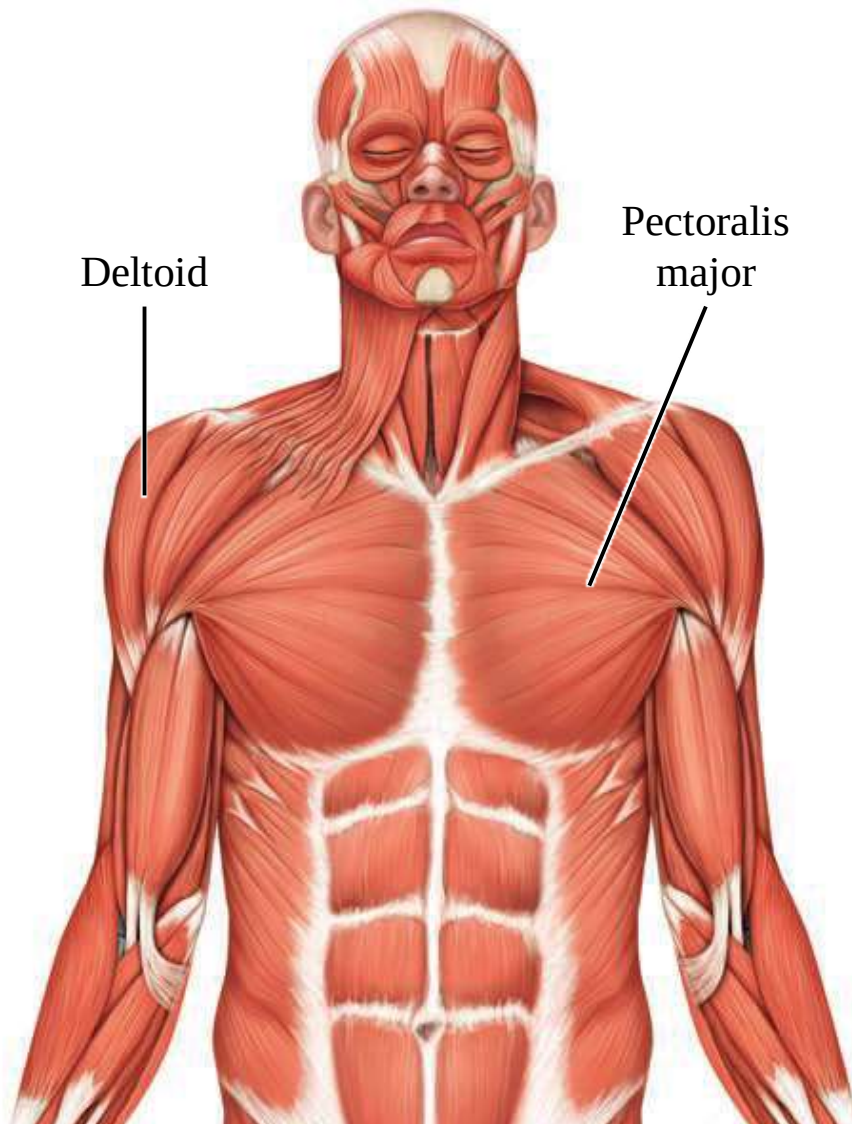


Fig.19: Deltoid and pectoralis major muscle. The two views of the scapula show the rotator cuff muscles.

Muscles of the arm (that move the forearm)

- The **biceps brachii**, **brachialis**, and **brachioradialis** are flexors. The **triceps brachii** extends the forearm.
- The biceps has two heads of origin. The long head passes through the intertubercular sulcus of the humerus. The biceps inserts into the radial tuberosity.
- It also forms an aponeurosis that inserts medially into fascia and that protects the underlying brachial artery and median nerve as they pass in the cubital fossa.

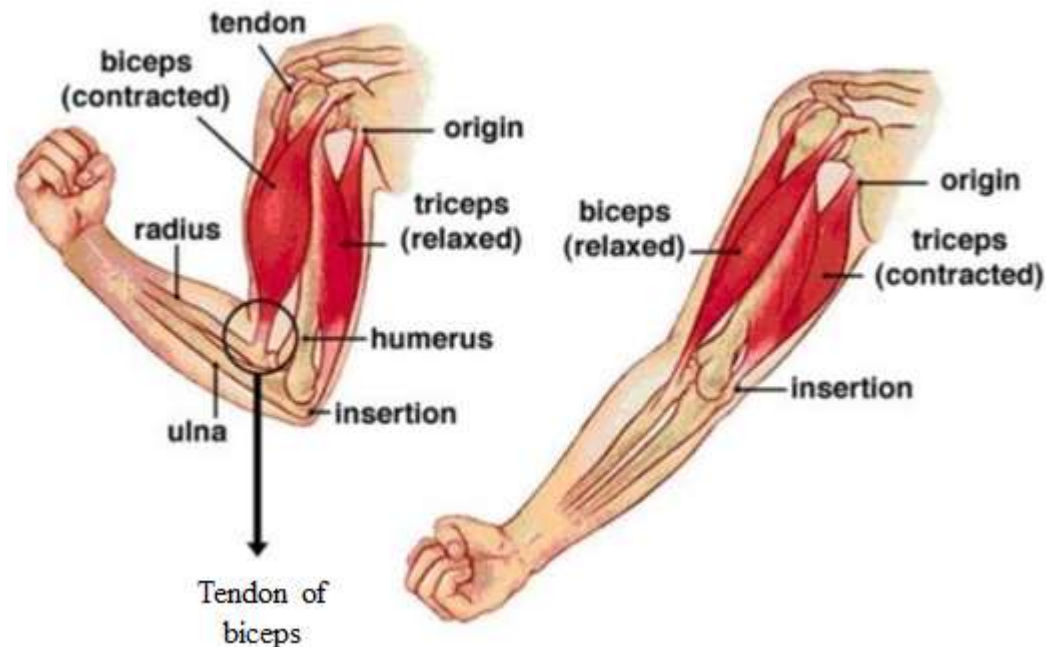


Fig.20: The biceps and triceps muscles.

The Cubital Fossa:

- Shallow triangular depression anterior to elbow joint.
- Tendon of biceps, brachial artery and median nerve pass through it.
- Site of measuring brachial artery pulse and taking blood pressure.
- The superficial veins passing in the skin overlying this fossa can be used to take blood samples.

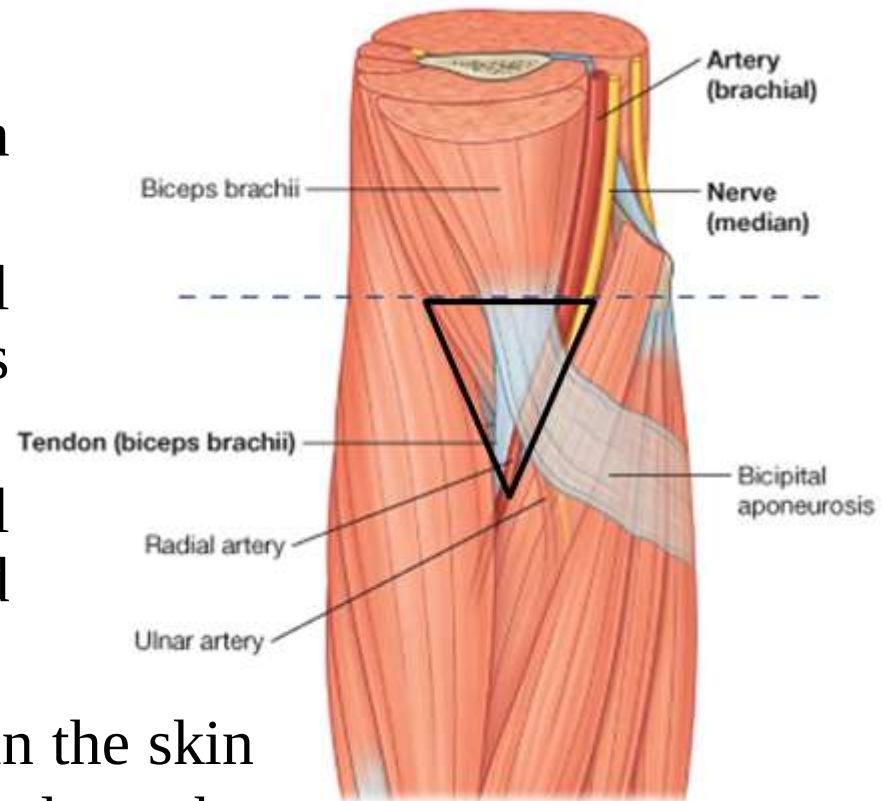


Fig.21: The cubital fossa.

Muscles of the Forearm

- Muscles in this group that act on the wrist and fingers are known as **extrinsic muscles of the hand** because they originate *outside* the hand and *insert* within it.
- Based on location and function, these muscles are divided into an **anterior (flexor) compartment** and a **posterior (extensor) compartment**.
- Anconeus, supinator and pronator quadratus are muscles in the forearm that act on the forearm.

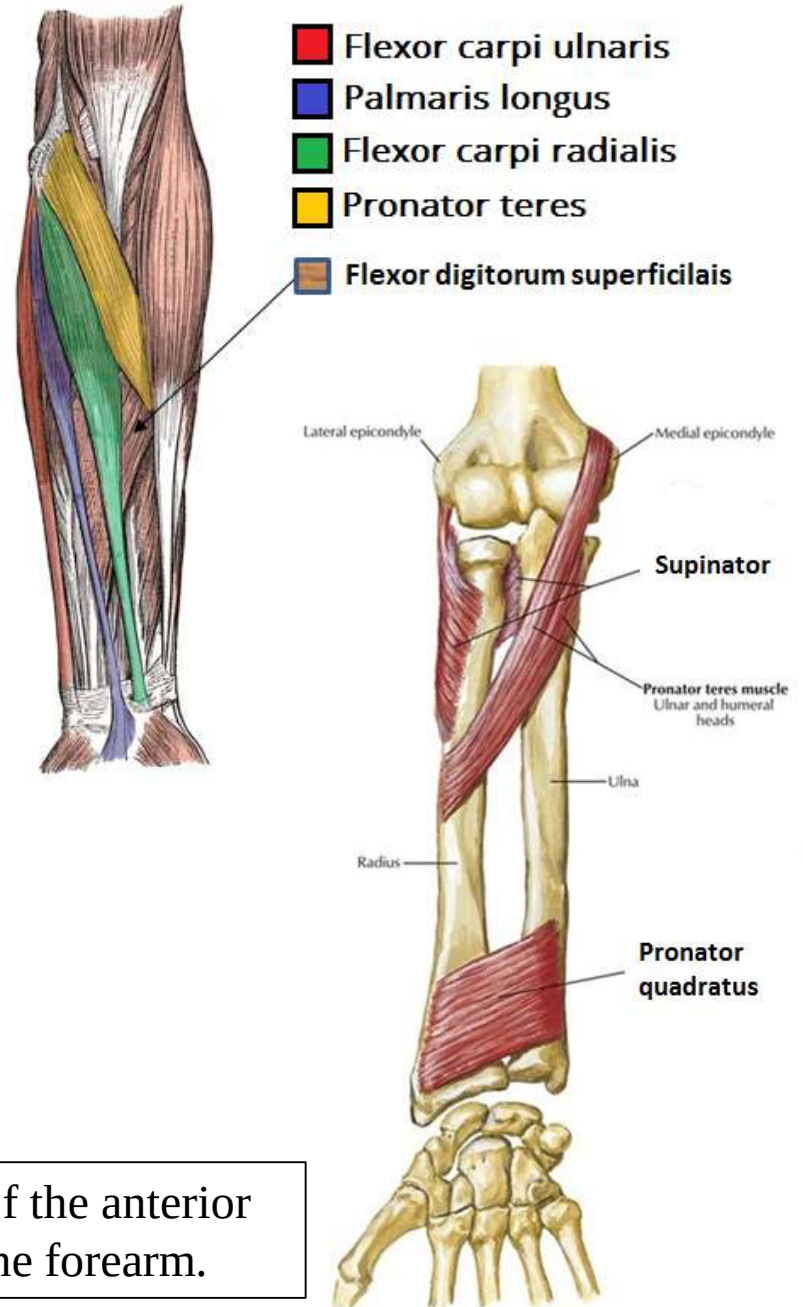


Fig.22: Muscles of the anterior compartment of the forearm.

- As the long muscles of the anterior forearm pass over the carpal bones, they are held in place by a thick band of connective tissue called the ***flexor retinaculum (transverse carpal ligament)***. This band with the carpal bones form a tunnel called the ***carpal tunnel***.
- Also passing through this tunnel is the median nerve.
- Certain conditions may affect this tunnel (like inflammation of the tendons or the joints) leading to compression of the median nerve. This is called ***Carpal Tunnel Syndrome***.
- The affected person may have pain in the hand, change in sensations and even weakness in the hand muscles supplied by the median nerve.

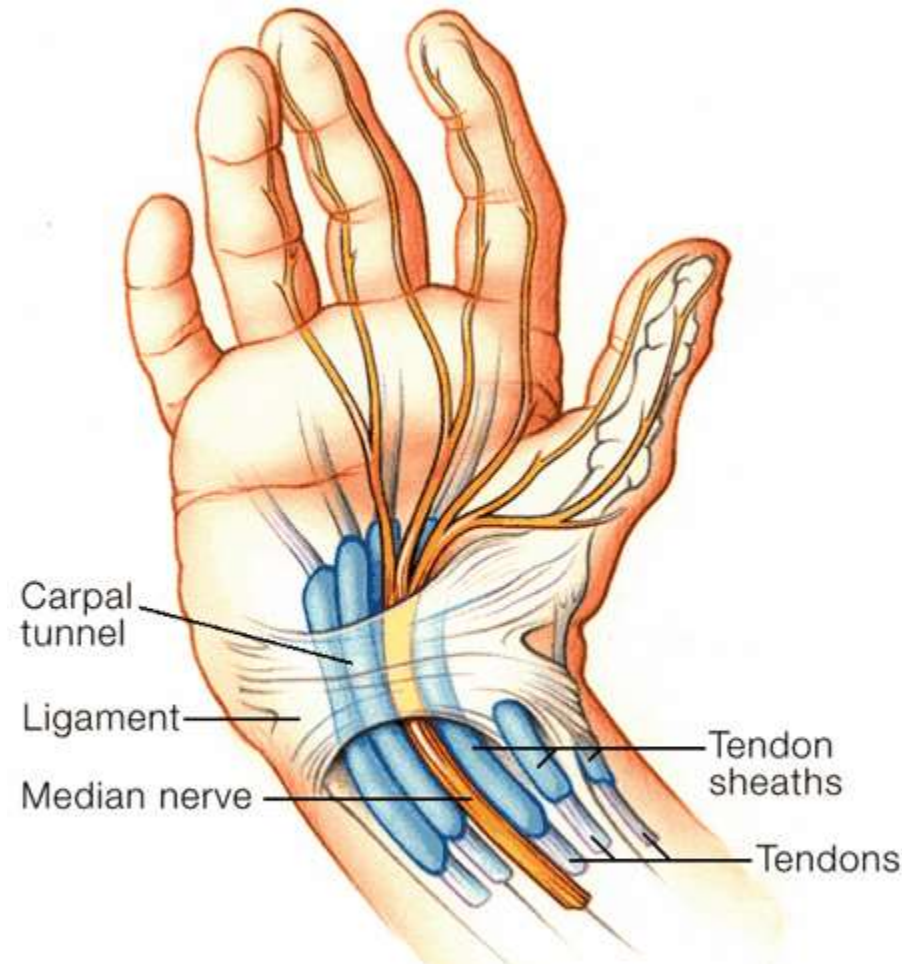


Fig.23: The carpal tunnel.

Movement of Forearm	Muscles that produce them
Flexion	Biceps Brachialis Brachioradialis
Extension	Triceps Anconeus
Supination	Biceps Supinator
Pronation	Pronator teres Pronator quadratus

Intrinsic Muscles of the Hand (3 groups)

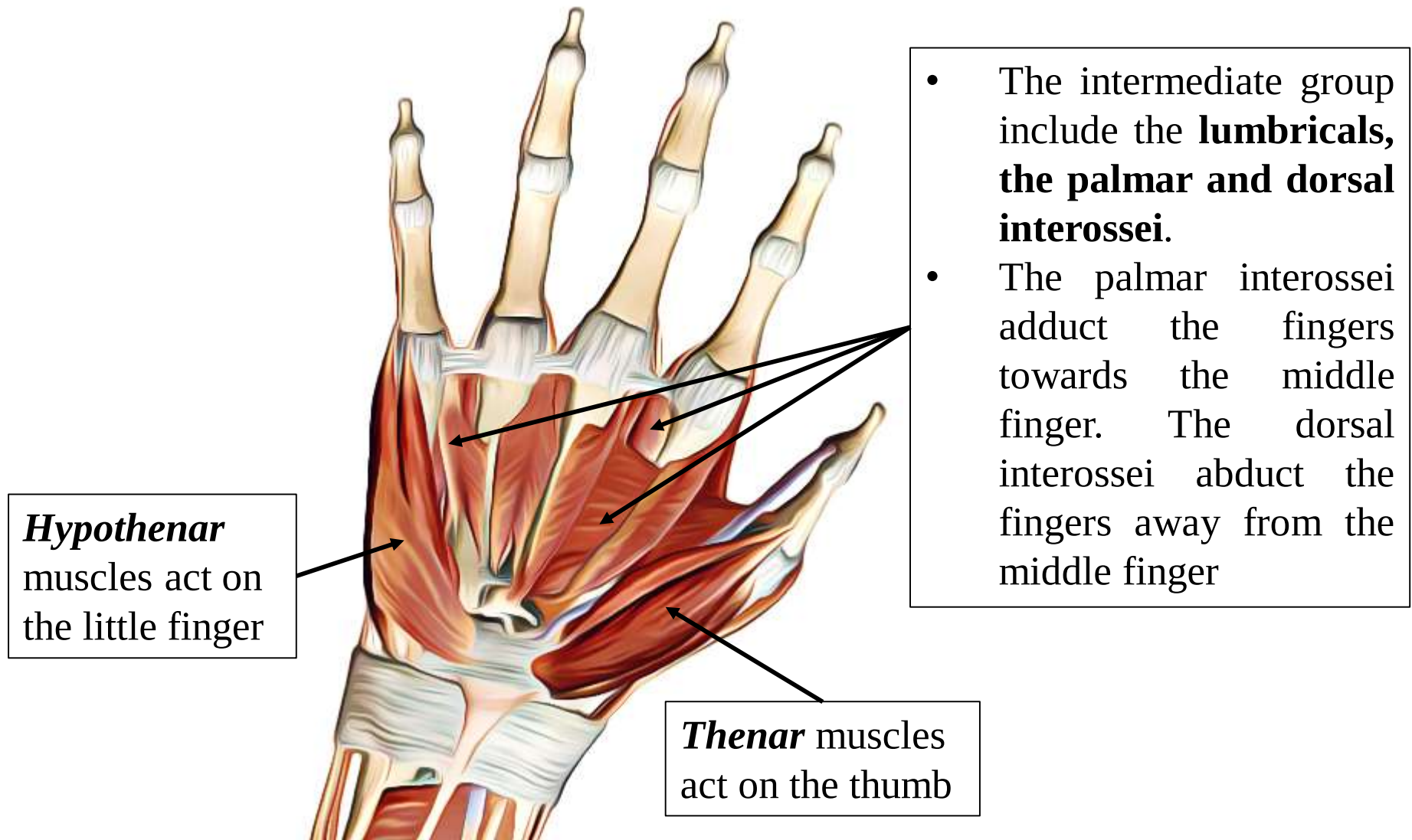


Fig.24: Intrinsic muscles of the hand.

Muscles Of The Lower Limb

- Lower limb muscles function in stability, locomotion, and maintaining posture. In contrast, upper limb muscles are characterized by versatility of movement.
- Muscles of the lower limbs often cross two joints and can act equally on both.
- Most muscles that move the femur originate from the pelvic girdle and insert on the femur.

Muscles of the Gluteal region (Buttocks)

Muscle	Action	Notes
Gluteus maximus	Extends thigh	With fat forms the buttocks
Gluteus medius	1. Abduct thigh 2. Medial rotation of thigh 3. Tilt hip	These muscles are essential in initiating walking, because they allow the legs to be lifted off the ground
Gluteus minimus		
Piriformis	1. Abduct thigh 2. Lateral rotation of the thigh	Between the piriformis and gemellus superior muscles is a small space through which pass the big Sciatic nerve
Gemellus superior		
Obturator internus		
Gemellus inferior		
Quadratus femoris		

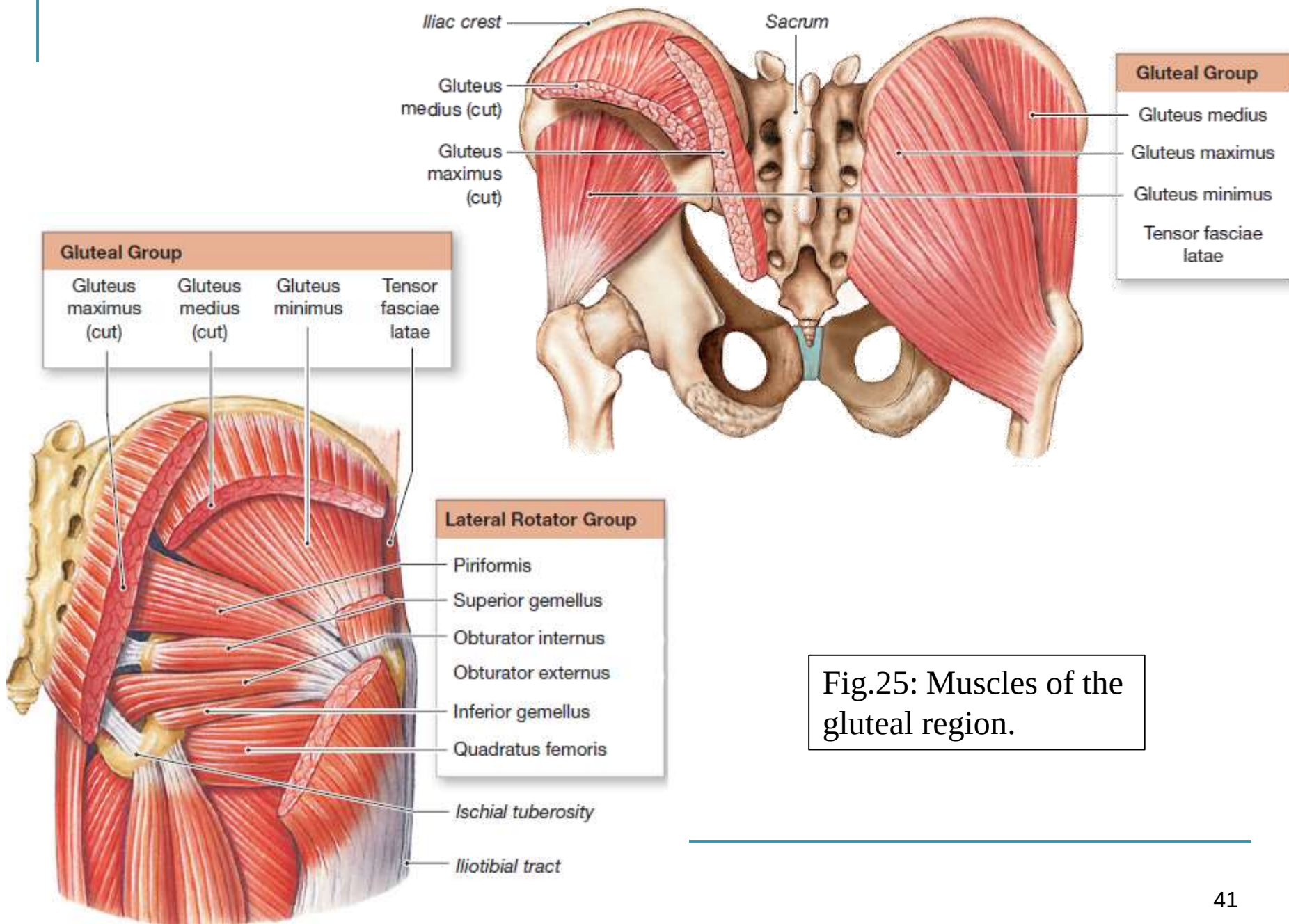


Fig.25: Muscles of the gluteal region.

Muscles of the Thigh

- Divided into anterior, medial, and posterior compartments.
 - **Anterior (extensor) compartment** of the thigh extend the leg (and flex the thigh). Supplied by the femoral nerve.
 - **Medial (adductor) compartment** of the thigh adduct the femur at the hip joint. Supplied by the obturator nerve.
 - **Posterior (flexor) compartment** of the thigh flex the leg (and extend the thigh). Supplied by the sciatic nerve.
- The **anterior compartment** of the thigh is divided into 2 triangles by the Sartorius muscle. The **sartorius** (cross-leg, tailor's) muscle is the longest muscle in the body. It originates from the anterior superior iliac spine and is inserted into the medial surface of the upper part of the shaft of tibia. It flexes, abduct and laterally rotates the thigh, it also flexes the leg.

- Below the sartorius, we have the **quadriceps femoris** muscle which is formed of the *rectus femoris*, *vastus medialis*, *vastus intermedius* and *vastus lateralis*. The tendon of the quadriceps inserts into the patellar base. The patellar ligament arises from the apex of the patella and inserts into the tibial tuberosity.
- The quadriceps extends the leg at the knee joint. The rectus femoris muscle also flexes thigh at the hip joint.

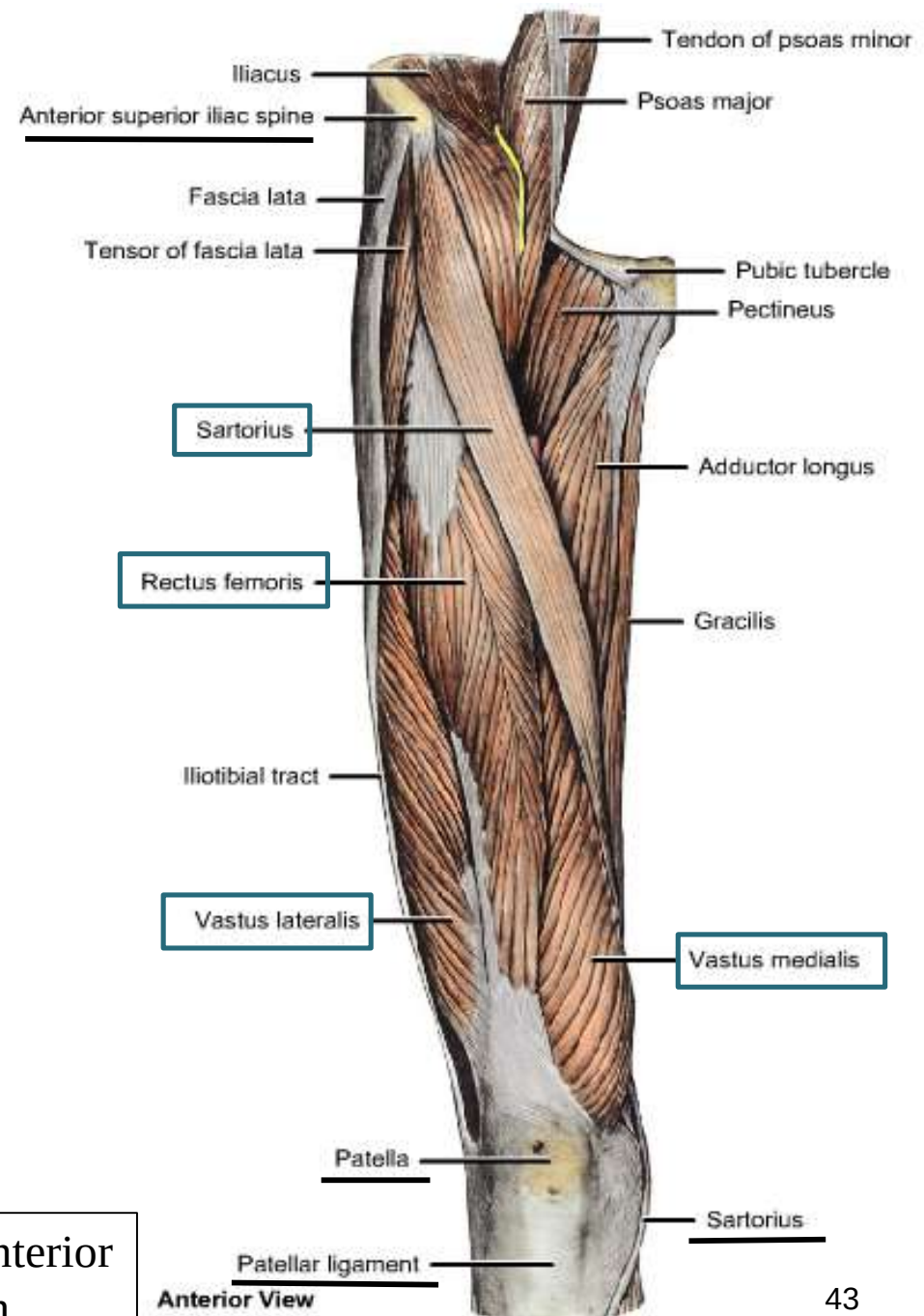


Fig.26: Muscles of the anterior compartment of the thigh.

Muscles of the Leg

- Leg muscles, like those of the thigh, are divided into three compartments: anterior, lateral, and posterior.
 - ❑ **Anterior compartment** muscles dorsiflex the foot.
 - ❑ **Lateral compartment** muscles plantar flex & evert the foot.
 - ❑ **Posterior compartment** muscles are split into a superficial group: the gastrocnemius, soleus and plantaris; and a deep group (e.g., tibialis posterior). The superficial muscles share a common tendon of insertion, the **calcaneal tendon (Achilles tendon)** – the largest and strongest tendon in the body). They plantar flex the foot and the gastrocnemius also flexes the leg.

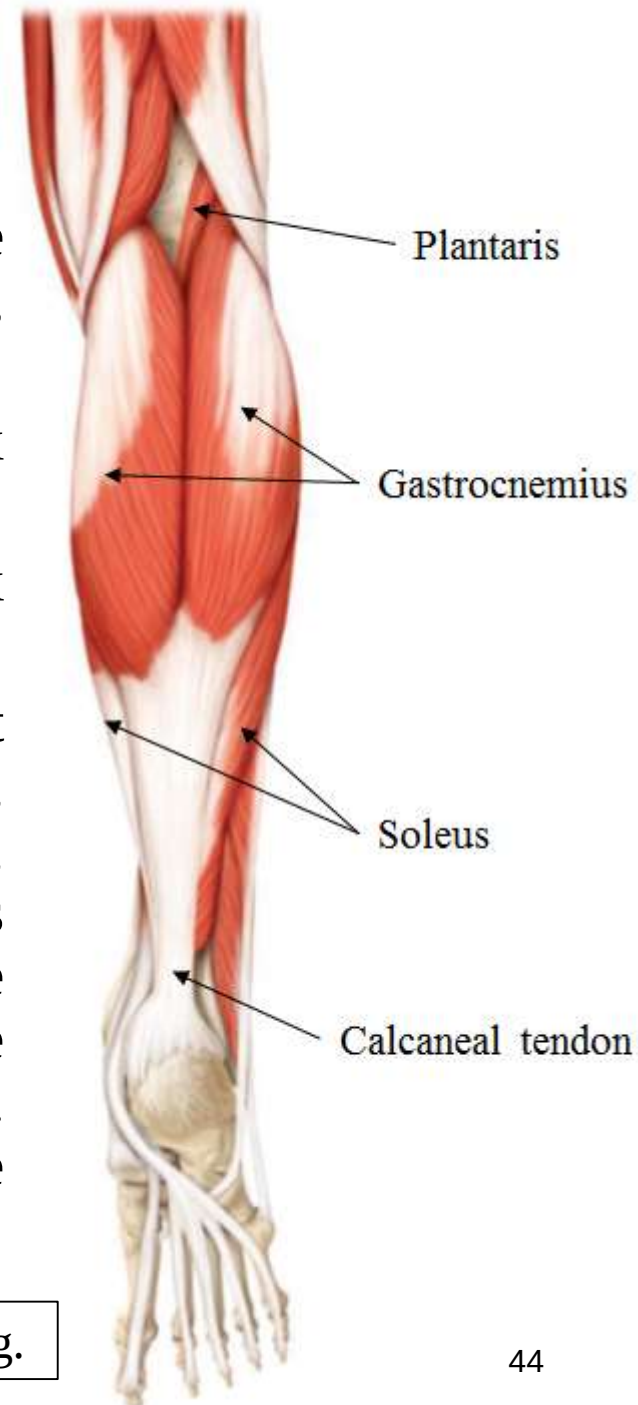


Fig.27: Muscles of the posterior compartment of the leg.

Intrinsic Muscles of the Foot

- These muscles are termed **intrinsic** because they originate & insert *within* the foot.
- These muscles are limited in action. They're designed for locomotion and support (of the arches).
- They include **dorsal** and **plantar groups**.



Fig.28: Intrinsic muscle of the foot (plantar group).