ANATOMY *Group C*

exam notes

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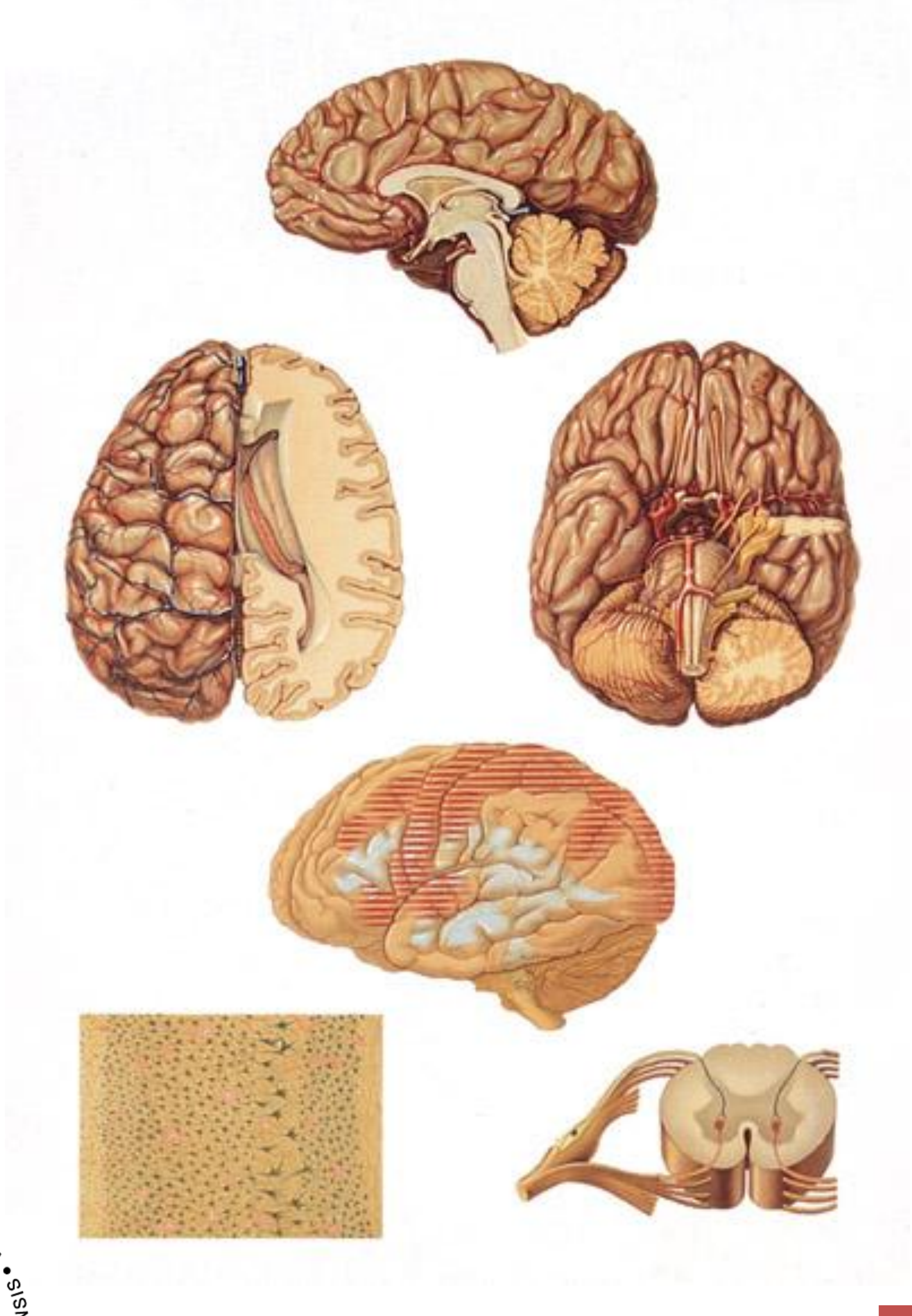


FACULTAS MEDICA UNIVERSITATIS MASARYKIANAE BRUNENSIS

Questions C

1. Composition of the peripheral nervous system, The spinal nerves

PERIPHERAL NERVOUS SYSTEM

The peripheral nervous system (PNS) consists of nerve fibers and cell bodies outside the CNS that conduct impulses to or away from the CNS. The PNS is organized into nerves that connect the CNS with peripheral structures.

A nerve fiber consists of an axon, its neurolemma and surrounding endoneurial connective tissue. The neurolemma consists of the cell membranes of Schwann cells that immediately surround the axon, separating it from other axons.

1. The neurolemma of myelinated nerve fibers consists of Schwann cells specific to an individual axon, organized into a continuous series of enwrapping cells that form myelin.

2. The neurolemma of unmyelinated nerve fibers is composed of Schwann cells that do not make up such an apparent series; multiple axons are separately embedded within the cytoplasm of each cell. These Schwann cells do not produce myelin.

A nerve consists of:

- a bundle of nerve fibers outside the CNS
- the connective tissue coverings that surround and bind the nerve fibers and fascicles together
- the blood vessels that nourish the nerve fibers and their coverings

Fibers are supported and protected by three connective tissue coverings

1. Endoneurium, delicate connective tissue immediately surrounding the neurolemma cells and axons.

2. Perineurium, a layer of dense connective tissue that encloses a fascicle of nerve fibers, providing an effective barrier against penetration of the nerve fibers by foreign substances.

3. Epineurium, a thick connective tissue sheath that surrounds and encloses a bundle of fascicles, forming the outermost covering of the nerve; it includes fatty tissue, blood vessels, and lymphatics.

A collection of neuron cell bodies outside the CNS is a ganglion. There are both motor (autonomic) and sensory ganglia.

TYPES OF NERVES

The PNS is anatomically and operationally continuous with the CNS. Its afferent (sensory) fibers convey neural impulses to the CNS from the sense organs and from sensory receptors in various parts of the body. Its efferent (motor) fibers convey neural impulses from the CNS to effector organs.

Nerves are either cranial nerves or spinal nerves, or derivatives of them:

- Cranial nerves - exit the cranial cavity through foramina in the cranium.
- Spinal (segmental) nerves - exit the vertebral column through intervertebral foramina. The 31 spinal cord segments and the 31 pairs of nerves arising

from them are identified by a letter and number designating the region of the spinal cord and their superior-to-inferior order.

SPINAL NERVES

Spinal nerves initially arise from the spinal cord as rootlets; the rootlest converge to form two nerve roots

1. An anterior (ventral) nerve root, consisting of motor (efferent) fibers passing from nerve cell bodies in the anterior horn of spinal cord gray matter to effector organs located peripherally.

2. A posterior (dorsal) nerve root, consisting of sensory (afferent) fibers from cell bodies in the spinal sensory or posterior (dorsal) root ganglion that extend peripherally to sensory endings and centrally to the posterior horn of spinal cord grey matter.

The posterior and anterior nerve roots unite proximal to the intervertebral foramen, to form a mixed spinal nerve, which immediately divides into two rami: a posterior ramus and an anterior ramus. As branches of the mixed spinal nerve, the posterior and anterior rami carry both motor and sensory fibers, as do all their subsequent branches.

The unilateral area of skin innervated by the sensory fibers of a single spinal nerve is called a dermatome; the unilateral muscle mass receiving innervation from the fibers conveyed by a single spinal nerve is a myotome.

As they emerge from the intervertebral foramina, spinal nerves are divided into two rami

1. Posterior (primary) rami of spinal nerves supply nerve fibers to the synovial joints of the vertebral column, deep muscles of the back, and the overlying skin in a segmental pattern.

2. Anterior (primary) rami of spinal nerves supply nerve fibers to the much larger remaining area, consisting of the anterior and lateral regions of the trunk and the upper and lower limbs. The anterior rami that are distributed exclusively to the trunk generally remain separate from each other. However, primarily in relationship to the innervation of the limbs, the majority of anterior rami merge with one or more adjacent anterior rami, forming the major somatic nerve plexuses.

SOMATIC AND VISCERAL FIBERS

The types of fibers conveyed by cranial or spinal nerves are as follows

- Somatic fibers
  - General sensory fibers transmit sensation from the body to the CNS; they may be exteroceptive sensations from the skin (pain, temperature, touch

and pressure) and proprioceptive sensations from muscles, tendons, and joints.

- Somatic motor fibers transmit impulses to skeletal (voluntary) muscles.

• Visceral fibers

- Visceral sensory fibers transmit pain or subconscious visceral reflex sensations (information concerning distention, blood gas and blood pressure levels) from hollow organs and blood vessels to the CNS.

- Visceral motor fibers transmit impulses to smooth (involuntary) muscle and glandular tissues.

Both types of sensory fibers - visceral sensory and general sensory - are processes of pseudounipolar neurons with cell bodies located outside of the CNS in spinal or cranial sensory ganglia. The motor fibers of nerves are axons of multipolar neurons. The cell bodies of somatic motor and presynaptic visceral motor neurons are located in the grey matter of spinal cord. Cell bodies of postsynaptic motor neurons are located outside the CNS in autonomic ganglia.

2. Rr. dorsales mm. spinalium, nn. intercostales

Rr. dorsales nn. spinalium

The posterior branches of the spinal nerves are as a rule smaller than the anterior divisions. They supply motor fibers to the deep (autochtonous) muscles of the back and sensory fibers to the skin areas on both sides of the vertebral column.

Dorsal rami remain distinct from each other, and each innervates a narrow strip of skin and muscle along the back, more or less at the level from which the ramus leaves the spinal nerve.

Each posterior branch divides into a medial and a lateral branch. Both supply motor fibers to the deep autochtonous back muscles. The medial branch of the dorsal ramus also supplies articular branches for zygapophyseal joints and periosteum of the vertebral arch. Sensory innervation of the back comes mainly from the lateral branches of the posterior rami.

The area supplied by the posterior rami of cervical spinal nerves expands widely and includes the occiput (greater occipital nerve) In the lumbar region, sensory innervation of the back comes from the posterior branches of the lumbar spinal nerves L1-L3 and the sacral spinal nerves S1-S3 (superior clunial nerves and medial clunial nerves).

INTERCOSTAL NERVES

The anterior rami of nerves T1-T11 form the intercostal nerves that run along the extent of the intercostal spaces. The anterior ramus of nerve T12, coursing inferior to the 12th rib, is the subcostal nerve.

Typical intercostal nerve

The 3rd - 6th intercostal nerves enter the medial-most parts of the posterior intercostal spaces, running initially within the endothoracic fascia between the parietal pleura and the internal intercostal membrane nearly in the middle of the intercostal spaces. Near the angles of the ribs, the nerves pass between the internal intercostal and the innermost intercostal muscles. At this point, the intercostal nerve pass to and then continue to course in or just inferior to the costal grooves, running inferior to the intercostal arteries (which, in turn run inferior to the intercostal veins). Collateral branches of these nerves arise near the angles of the ribs and run along the superior border of the rib below. The nerves continue anteriorly between the internal and the innermost intercostal muscles, supplying these and other muscles and giving rise to lateral cutaneous branches in approximately the midaxillary line (MAL).

Near the sternum, the intercostal nerves turn anteriorly, passing between the costal cartilages to become anterior cutaneous branches.

The branches of typical intercostal nerves are:

Rami communicantes, that connect each intercostal nerve to the ipsilateral sympathetic trunk. Sympathetic fibers are distributed through all branches of all spinal nerves (anterior and posterior) to reach the blood vessels, sweat glands, and smooth muscle of the body wall and limbs.

- Collateral branches that arise near the angles of the ribs and descend to course along the superior margin of the lower rib, helping supply intercostal muscles and parietal pleura.
- Lateral cutaneous branches that arise near the MAL, pierce the internal and external intercostal muscles, and divide in turn into anterior and posterior branches. These terminal branches supply the skin of the lateral thoracic and abdominal walls.
- Anterior cutaneous branches pierce the muscles and membranes of the intercostal space in the parasternal line and divide into medial and lateral branches. These terminal branches supply the skin on the anterior aspect of the thorax and abdomen.
- Muscular branches that supply the intercostal, subcostal, transversus thoracis, levatores costarum, and serratus posterior muscle.

✓ Atypical intercostal nerves

Although the anterior ramus of most thoracic spinal nerves is simply the intercostal nerve for that level, the anterior ramus of the 1st thoracic (T1) spinal nerve first divides into a large superior and a small inferior part. The superior part joins the brachial plexus and the inferior part becomes the

1st intercostal nerve. Other atypical features of specific intercostal nerves include the following:

- The 1st and 2nd intercostal nerves course on the internal surface of the 1st and 2nd ribs, instead of along the inferior margin in costal grooves.
- The 1st intercostal nerve has no anterior cutaneous branch and often no lateral cutaneous branch
- The 2nd (and sometimes the 3rd) intercostal nerve gives rise to a large lateral cutaneous branch, the intercostobrachial nerve; it emerges from the 2nd intercostal space at MAL, penetrates the serratus anterior, and enters the axilla and arm. The intercostobrachial nerve usually supplies the floor - skin and subcutaneous tissue - of the axilla and then continues with the medial brachial cutaneous nerve.
- The 7th - 11th intercostal nerves, after giving rise to lateral cutaneous branches, cross the costal margin posteriorly and continue on to supply abdominal skin and muscles. They now become thoracoabdominal nerves of the anterior abdominal wall.

3 The cervical plexus

The anterior rami of C1-C4 make up the roots of the cervical plexus. The cervical plexus consists of an irregular series of (primary) nerve loops and the branches that arise from the loops. Each participating ramus, except the first, divides into ascending and descending branches that unite with the branches of the adjacent spinal nerve to form the loops. The cervical plexus lies anteromedial to the levator scapulae and middle scalene muscles and deep to the SCM. The superficial branches of the plexus that initially pass posteriorly are cutaneous (sensory) branches. The deep branches passing anteromedially are motor branches, including the roots of the phrenic nerve (to the diaphragm) and the ansa cervicalis.

The anterior branches of C1-C3 form the deep cervical ansa: fibers from C1 and C2 temporarily appose the hypoglossal nerve and then leave it as the superior root: the fibers for the thyrohyoid muscle and the geniohyoid muscle then continue with the hypoglossal nerve. The inferior root of the ansa cervicalis arises from a loop between spinal nerves C2 and C3. The superior and inferior roots of the ansa cervicalis unite, forming a secondary loop; the ansa cervicalis, consisting of fibers from the C1-C3 spinal nerves, which branch from the secondary loop to supply the infrahyoid muscles, including the omohyoid, sternothyroid and sternohyoid.

Cutaneous branches of the cervical plexus emerge around the middle of the posterior border of the SCM, often called the nerve point of the neck, superolateral cervical wall, and scalp between the auricle and the external occipital protuberance.

Branches of cervical plexus arising from the nerve loop between the anterior

C2 and C3 are the:

Lesser occipital nerve (C2): supplies the skin of the neck a[...]
to the auricle.

Great auricular nerve (C2 and C3): ascends vertically across [...]
inferior pole of the parotid gland, where it divides to supply t[...]
sheath surrounding the gland, the mastoid process, and both [...]
and an area of skin extending from the angle of the mandibl[...]
cess.

Transverse cervical nerve (C2 and C3): supplies the skin covering [...]
It curves around the middle of the posterior border of the SCM [...]
auricular nerve and passes anteriorly and horizontally across [...]
platysma, dividing into superior and inferior branches.

Branches of the cervical plexus arising from the nerve loop form[...]
rami of C3-C4 are the:

Supraclavicular nerves (C3 and C4): emerge as a common trun[...]
SCM, sending small branches to the skin of the neck that cross the [...]
the skin over the shoulder.

[...] tion to the ansa cervicalis and phrenic nerves arising from the loop[...]
deep motor branches of the cervical plexus include branches arising [...]
[...] supply the rhomboids (dorsal scapular nerve; C4 and C5), serrat[...]
thoracic nerve; C5-C7), and nearby prevertebral muscles.

Phrenic nerves originate chiefly from the C4 nerve but receive contrib[...]
C3 and C5 nerves. These nerves provide the sole motor supply to th[...]
as well as sensation to its central part. In the thorax, each phrenic ner[...]
mediastinal pleura and pericardium.

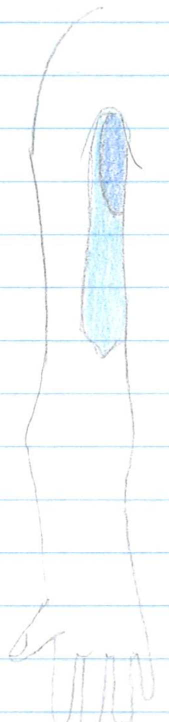
[...] phrenic nerve forms at the superior part of the lateral border of the
[...] muscle at the level of the superior border of the thyroid cartilage.
[...] nerve descends obliquely with the IJV across the anterior scalene, deep to
[...] layer of deep cervical fascia and the transverse cervical and supra-
[...] vies.
[...] th sides, the phrenic nerve runs posterior to the subclavian vein and
[...] internal thoracic artery as it enters the thorax.

Medial cutaneous nerve of the arm (C8-T1)

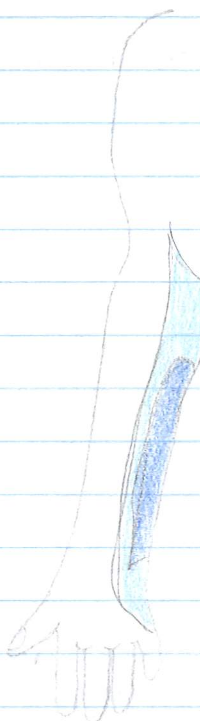
The nerve approaches the anterior surface of the upper arm below the axillary fossa. Here it ramifies and supplies the skin of the medial aspect between axilla and elbow joint. It reaches to the flexor side with its anterior branches and to the extensor side of the upper arm with its posterior branches.

Medial cutaneous nerve of the forearm (C8-T1)

The nerve runs below the fascia on the ulnar side of the forearm and passes in the lower third through the fascia with two branches, the anterior branch and the ulnar branch. The anterior branch supplies the medial flexor side of the forearm almost up to the midline, and the ulnar branch supplies the upper region of the medial extensor side almost up to the midline. The area innervated by the medial cutaneous nerve of the forearm extends slightly to the upper arm and to the hand.



Skin supplied by the medial cutaneous nerve of the arm



Skin supplied by the medial cutaneous nerve of the forearm

6. The median nerve

The median nerve runs distally in the arm on the lateral side of the brachial artery until it reaches the middle of the arm, where it crosses to the medial side and contacts the brachialis. The median nerve then descends into the cubital fossa, where it lies deep to the bicipital aponeurosis and median cubital vein. The median nerve has no branches in the axilla or arm, but it does supply articular branches to the elbow joint.

The median nerve is the principal nerve of the anterior compartment of the forearm. It supplies muscular branches directly to the muscles of the superficial and intermediate layers of forearm flexors (except the FCU), and deep muscles (except for the ulnar half of the FDP) via its branch, the anterior interosseous nerve.

Its major branch in the forearm is the anterior interosseous nerve. In addition, the following unnamed branches of the median nerve arise in the forearm:

- Articular branches. These branches pass to the elbow joint as the median nerve passes it.
- Muscular branches. The nerve to the pronator teres usually arises at the elbow and enters the lateral border of the muscle. A broad bundle of nerves pierces the superficial flexor group of muscles and innervates the FCR, the palmaris longus and the FDS.
- Anterior interosseous nerve. This branch runs distally on the interosseous membrane with the anterior interosseous branch of ulnar artery. After supplying the deep forearm flexors (except the ulnar part of the FDP, which sends tendons to 4^{th} and 5^{th} fingers), it passes deep to and supplies the pronator quadratus, then ends by sending articular branches to the wrist joint.
- Palmar cutaneous branch of the median nerve. This branch arises in the forearm, just proximal to the flexor retinaculum, but it distributed to skin of the central part of the palm.

7. The ulnar nerve

The ulnar nerve passes distally from the axilla anterior to the insertion of the teres major and to the long head of the triceps, on the medial side of the brachial artery. Around the middle of the arm, it pierces the medial intermuscular septum with the superior ulnar collateral artery and descends between the septum and the medial head of the triceps. The ulnar nerve passes posterior to the medial epicondyle and medial to the olecranon to enter the forearm. Posterior to the medial epicondyle it is superficial, easily palpable, and vulnerable to injury. Like the median nerve, the ulnar nerve has no branches in the arm, but it also supplies articular branches to the elbow joint.

Like the median nerve, the ulnar nerve does not give rise to branches during its passage through the arm. In the forearm it supplies only one and a half muscles, the FCU and the ulnar part of the FDP.

The ulnar nerve and artery emerge from beneath the FCU tendon and become superficial just proximal to the wrist. They pass superficial to the flexor retinaculum and enter the hand by passing through a groove between the pisiform and the hook of the hamate.

A band of fibrous tissue from the flexor retinaculum bridges the groove to form the small ulnar canal (Guyon canal). The branches of the ulnar nerve arising in the forearm include unnamed muscular and articular branches, and cutaneous branches that pass to the hand.

• Articular branches pass to the elbow joint while the nerve is between the olecranon and the medial epicondyle

• Muscular branches supply the FCU and the medial half of FDP

• The palmar and dorsal cutaneous branches arise from the ulnar nerve in the forearm, but their sensory fibers are distributed to the skin of the hand.

8. The radial and axillary nerves

The radial nerve supplies all the muscles in the posterior compartment of the arm (and forearm). The radial nerve enters the arm posterior to the brachial artery, medial to the humerus, and anterior to the long head of the triceps, where it gives branches to the long and medial heads of the triceps. The radial nerve then descends inferolaterally with the deep brachial artery and passes around the humeral shaft in the radial groove. The branch of the radial nerve to the lateral head of the triceps arises within the radial groove. When it reaches the lateral border of the humerus, it continues inferiorly in the anterior compartment of the arm between the brachialis and the brachioradialis to the level of the lateral epicondyle of the humerus.

Anterior to the lateral epicondyle, the radial nerve then divides into deep and superficial branches.

• The deep branch of the radial nerve is entirely muscular and articular in its distribution.

• The superficial branch of the radial nerve is entirely cutaneous in its distribution, supplying sensation to the dorsum of the hand and fingers.

Its sensory and motor fibers are distributed in the forearm by two separate branches, the superficial (sensory or cutaneous) and deep radial/posterior interosseous nerve (motor).

The two branches immediately part company, the deep branch winding laterally around the radius, piercing the supinator en route to the posterior compartment.

The posterior cutaneous nerve of the forearm arises from the radial nerve in the posterior compartment of the arm, as it runs along the radial groove of the humerus, and descends in the subcutaneous tissue of the posterior aspect of the forearm to the wrist, supplying the skin.

The superficial branch of the radial nerve is also a cutaneous nerve, but it gives rise to articular branches as well. It is distributed to skin on the dorsum of the hand and to a number of joints in the hand.

The deep branch of the radial nerve, after it pierces the supinator, runs in the fascial plane between superficial and deep extensor muscles in close proximity to the posterior interosseous artery; it is usually referred to as the posterior interosseous nerve. It supplies motor innervation to all the muscles with fleshy bellies located entirely in the posterior compartment of the forearm (distal to the lateral epicondyle of the humerus).

Axillary nerve

It is one of the terminal branches of posterior cord. It exits axillary fossa posteriorly, passing through quadrangular space with posterior circumflex humeral artery. It gives rise to superior lateral brachial cutaneous nerve, then winds around surgical neck of humerus deep to deltoid. It gives articular branches to gleno-humeral joint, motor branches to teres minor and deltoid and a cutaneous branch to the skin of superolateral arm (over inferior part of deltoid).

9. The lumbar plexus

The lumbar spinal nerves (L1-L5) pass from the spinal cord through the IV foramina inferior to the corresponding vertebrae, where they divide into posterior and anterior rami.

Each ramus contains sensory and motor fibers. The posterior rami pass posteriorly to supply the muscles of the back and overlying skin, whereas the anterior rami pass laterally and inferiorly, to supply the skin and muscles of the inferiormost trunk and lower limb. The initial portions of the anterior rami of the L1, L2, and occasionally L3 spinal nerves give rise to white communicating branches which convey presynaptic sympathetic fibers to the lumbar sympathetic trunks.

The lumbar plexus of nerves is formed anterior to the lumbar transverse processes, within the proximal attachment of the psoas major. This nerve network is composed of the anterior rami of L1 trough L4 nerves. The following nerves are branches of the lumbar plexus:

- The femoral nerve (L2-L4) emerges from the lateral border of the psoas major and innervates the iliacus and passes deep to the inguinal ligament to the anterior thigh, supplying the flexors of the hip and extensors of the knee.
- The obturator nerve (L2-L4) emerges from the medial border of the psoas major and passes into lesser pelvis, passing inferior to the superior pubic ramus (through the obturator foramen) to the medial thigh, supplying the adductor muscles.
- The lumbosacral trunk (L4, L5) passes over the ala of the sacrum and descends into the pelvis to participate in the formation of the sacral plexus with the anterior rami of S1-S4 nerves.
- The ilio-inguinal and iliohypogastric nerves (L1) arise from the anterior ramus of L1, entering the abdomen posterior to the medial arcuate ligament and passing inferolaterally, anterior to the quadratus lumborum. They run superior and parallel to the iliac crest, piercing the transversus abdominis near the ASIS. They then

pass through the internal and external obliques to supply the abdominal muscles and skin of the inguinal and pubic regions.

• The genitofemoral nerve (L1, L2) pierces the psoas major and runs inferiorly on its anterior surface, deep to the psoas fascia; it divides lateral to the common and external iliac arteries into femoral and genital branches.

- The genital branch runs in the abdominal wall along the inguinal ligament through the inguinal canal and reaches the scrotum with the spermatic cord, or in the female, the labia majora with the round ligament of the uterus. It innervates the cremaster muscle and supplies sensory fibers to the skin of the scrotum, or the labia majora, and the adjacent skin area of the thigh.

- The femoral branch continues to below the inguinal ligament and becomes subcutaneous in the saphenous hiatus. It supplies the skin of the thigh lateral to the region of the genital branch.

• The lateral cutaneous nerve of the thigh runs inferolaterally on the iliacus and enters the thigh deep to the inguinal ligament, just medial to the ASIS; it supplies skin on the anterolateral surface of the thigh.

10. The sacral plexus

The sacral plexus is located on the posterolateral wall of the lesser pelvis. The two main nerves arising from the sacral plexus, the sciatic and pudendal nerves, lie external to the parietal pelvic fascia. Most branches of the sacral plexus leave the pelvis through the greater sciatic foramen.

• The sciatic nerve is the largest nerve in the body. It is formed as the large anterior rami of spinal nerves L4 - S3 converge on the anterior surface of the piriformis. The sciatic nerve passes through the greater sciatic foramen, usually inferior to the piriformis (INFRAPIRIFORMIS FORAMEN), to enter the gluteal region. It then descends along the posterior aspect of the thigh to supply the posterior aspect of the thigh and the entire leg and foot.

• The pudendal nerve is the main nerve of the perineum and the chief sensory nerve of the external genitalia. Accompanied by the internal pudendal artery, it leaves the pelvis through the greater sciatic foramen between the piriformis and coccygeus muscles. It then enters the perineum through the lesser sciatic foramen. (INFRAPIRIFORMIS FORAMEN) → ischiorectal fossa

• The superior gluteal nerve leaves the pelvis through the greater sciatic foramen, superior to the piriformis to supply muscles in the gluteal region (SUPRAPIRIFORMIS FORAMEN)

• The inferior gluteal nerve leaves the pelvis through the greater sciatic foramen, inferior to the piriformis (INFRAPIRIFORMIS) and superficial to the sciatic nerve, accompanying the inferior gluteal artery. Both break up into several branches that enter the deep surface of the overlying gluteus maximus muscle.

Nerve	Origin	Distribution
Sciatic	L4, L5, S1, S2, S3	Articular branches to hip joint and muscular branches to flexors of knee in thigh and all muscles in leg and foot
Superior gluteal	L4, L5, S1	Gluteus medius and gluteus minimus muscles
Nerve to quadratus femoris (and inferior gemellus)	L4, L5, S1	Quadratus femoris and inferior gemellus muscles
Inferior gluteal	L5, S1, S2	Gluteus maximus
Nerve to obturator internus (and superior gemellus)	L5, S1, S2	Obturator internus and superior gemellus muscles
Nerve to piriformis	S1, S2	Piriformis muscle
Posterior cutaneous nerve of thigh	S2, S3	Cutaneous branches to buttock and uppermost medial and posterior surfaces of thigh
Perforating cutaneous	S2, S3	Cutaneous branches to medial part of buttock
Pudendal	S2, S3, S4	Structures in perineum: sensory to genitalia; muscular branches to perineal muscles, external urethral sphincter, and external anal sphincter
Pelvic splanchnic	S2, S3, S4	Pelvic viscera via inferior hypogastric and pelvic plexuses
Nerves to levator ani and coccygeus	S3, S4	Levator ani and coccygeus muscles

The sacral plexus (continued)

• Common peroneal nerve – it winds around the neck of the fibula to the anterior aspect of the lower leg and enters into the long peroneal (fibular) muscle. The common peroneal nerve divides within this muscle into the superficial peroneal nerve and the deep peroneal nerve. The superficial peroneal nerve is predominantly sensory and runs between the long peroneal muscle and the fibula to the back of the foot. The deep peroneal nerve is predominantly a motor nerve; it turns toward the front to the extensor muscles of the lower leg and extends on the lateral surface of the anterior tibial muscle to the back of the foot.

At the lateral margin of the popliteal fossa, the common peroneal nerve gives off two main branches for the skin, the lateral sural cutaneous nerve, which supplies the skin at the lateral aspect of the lower leg and fibulacommunicating branch which joins the medial sural cutaneous nerve form the sural nerve.

The superficial peroneal nerve gives off muscular branches to the long and short peroneal muscles. The rest of the nerve is exclusively sensory; it ramifies into terminal branches, the medial dorsal cutaneous nerve and the intermediate dorsal cutaneous nerve which supply the skin of the back of the foot except for the interdigital space between great toe and second toe.

The deep peroneal nerve gives off several muscular branches to the extensor muscles of the lower leg and the foot, namely, to the anterior tibial muscle, the long and short extensor muscles of toes, and the long and short extensor muscles of the great toe. The terminal branch is sensory and supplies the apposing skin surfaces of the interdigital space between great toe and second toe.

• Tibial nerve – several motor branches originate from the tibial portion of the sciatic nerve, namely, those for the proximal and distal parts of the semitendinous muscle.

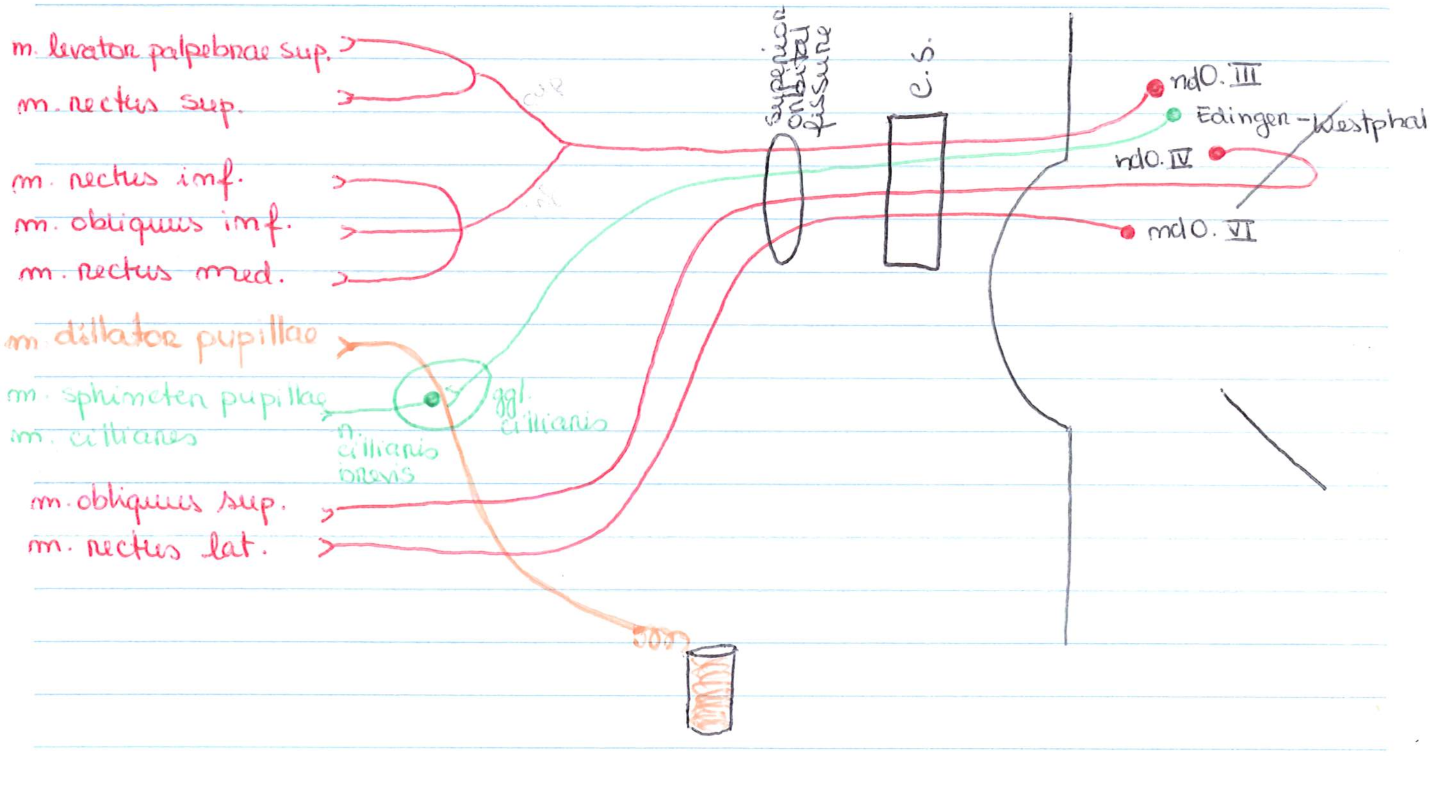
After the division of the sciatic nerve, the tibial nerve descends vertically through the middle of the popliteal fossa and underneath the gastrocnemius muscle. It then lies under the tendinous arch of the soleus muscle and, further distal, between the long flexor muscle of the great toe and the long flexor muscle of toes. It extends between the tendons of both muscles to the back of the medial ankle and winds around it. Below the ankle, it divides into two terminal branches, the medial plantar nerve and the lateral plantar nerve which supply the muscles of the foot.

The medial sural cutaneous nerve branches off in the popliteal fossa; it descends between the two heads of the gastrocnemius muscle and joints the communicating branch of the peroneal nerve to form the sural nerve. The latter extends laterally from the Achilles tendon behind the lateral ankle and around it to the lateral aspect of the foot. It gives off the lateral calcaneal branches to the skin of the lateral side of the heel and the lateral dorsal cutaneous nerve.

Also in the popliteal fossa, motor branches go off to the flexor muscles of the lower leg. The popliteal branch gives rise to the interosseous nerve of the leg which runs along the dorsal surface of the interosseous membrane and provides sensory innervation to the periosteum of the tibia, the upper ankle joint, and the tibiofibular joint.

Before the nerve trunk ramifies into terminal branches – medial plantar nerve and lateral plantar nerve – it sends off the medial calcaneal branches to the medial skin of the heel.

11. The III[rd], IV[th] and VI[th] cranial nerves



• Oculomotor nerve (CN III)

Function: Somatic motor and visceral motor.

Nuclei: There are two oculomotor nuclei. The somatic motor nucleus of the oculomotor nerve is in the midbrain. The visceral motor (parasympathetic) accessory (Edinger-Westphal) nucleus of the oculomotor nerve lies dorsal to the rostral two thirds of the somatic motor nucleus

The oculomotor nerve (CN III) provides the following:

- Motor to the striated muscle of four of the six extraocular muscles (superior, medial and inferior recti and inferior oblique) and superior eyelid (levator palpebrae superioris)
- Proprioceptive to the muscles listed above.
- Parasympathetic through the cilliary ganglion to the smooth muscle of the sphincter pupillae, which causes constriction of the pupil and ciliary muscle, which produces accomodation (allowing the lens to become more rounded) for near vision.

It emerges from the midbrain, pierces the dura mater lateral to the sellar diaphragm roofing over the hypophysis, and then runs through the roof and lateral wall of the cavernous sinus. CN III leaves the cranial cavity and enters the orbit through the superior orbital fissure. Within this fissure, CN III divides into a superior division and an inferior division.

• Trochlear nerve (CN IV)

Functions: Somatic motor and proprioceptive to one extraocular muscle (superior oblique).

Nucleus: The nucleus of the trochlear nerve is located in the midbrain, immediately caudal to the oculomotor nucleus.

The Trochlear nerve (CN IV) is the smallest cranial nerve. It emerges from the POSTERIOR (dorsal) surface of the midbrain (the only cranial nerve to do so), passing anteriorly around the brainstem.

The trochlear nerve pierces the dura mater at the margin of the tentorium cerebelli and passes anteriorly in the lateral wall of the cavernous sinus. Then CN IV continues through the superior orbital fissure into the orbital, where it supplies the superior oblique - the only extraocular muscle that uses a pulley, or trochlea, to redirect its line of action.

• Abducent nerve (CN VI)

Functions: Somatic motor to one extraocular muscle, the lateral rectus

Nucleus: The abducent nucleus is in the pons near the median plane

The abducent nerve (CN VI) emerge from the brainstem between the pons and the medulla and traverse the pontine cistern of the subarachnoid space. During its intradural course, it bends sharply over the crest of the petrous part of the temporal bone and then courses through the cavernous sinus, surrounded by the venous blood in the same manner as the internal carotid artery. It enters the orbit, running on and penetrating the medial surface of the lateral rectus, which abducts the eye.

12. Ophtalmic nerve

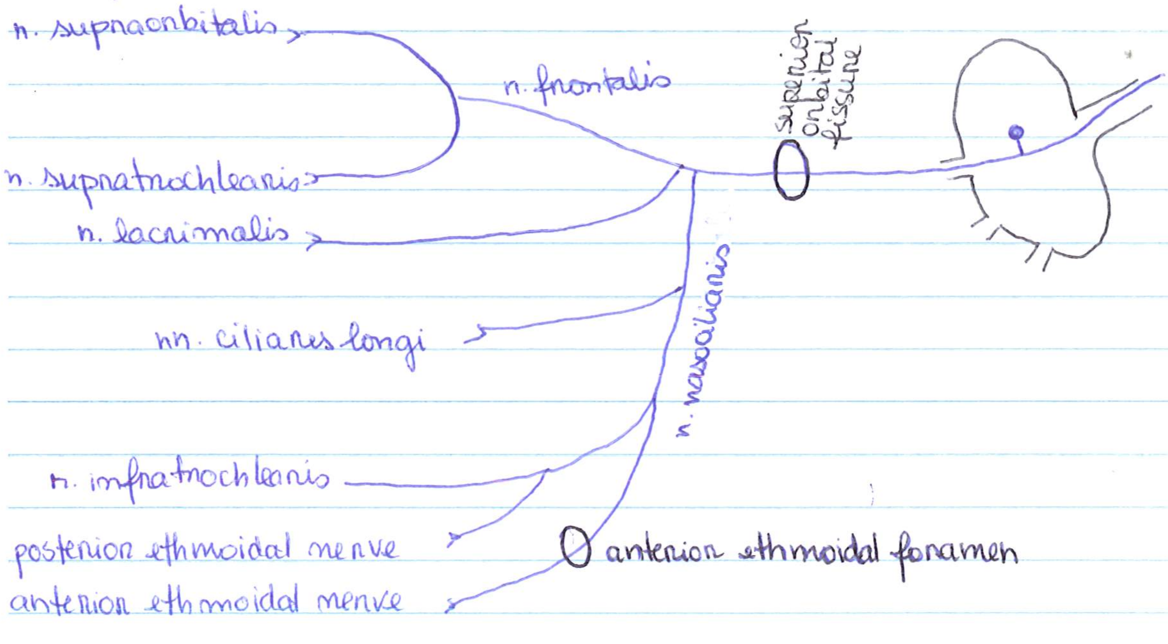
Trigeminal nerve (CN V)

Functions: Somatic sensory and somatic motor to derivatives of the 1st pharyngeal arch

Nuclei: There are four trigeminal nuclei - one motor (motor nucleus of trigeminal nerve) and three sensory (mesencephalic, principal sensory and spinal nuclei of trigeminal nerve).

It emerges from the lateral aspect of the pons by a large sensory root and a small motor root. CN V is the principal somatic sensory nerve for the head (face, teeth, mouth, nasal cavity, and dura mater of the cranial cavity). The large sensory root of CN V is composed mainly of the central processes of the pseudounipolar neurons that make up the trigeminal ganglion, which is housed within a dural recess (trigeminal cave) lateral to the cavernous sinus at the apex of the pyramid of temporal bone.

The peripheral processes of the ganglionic neurons form three nerves or divisions: ophtalmic nerve ($CN V_1$), maxillary nerve ($CN V_2$) and sensory component of the mandibular nerve ($CN V_3$)

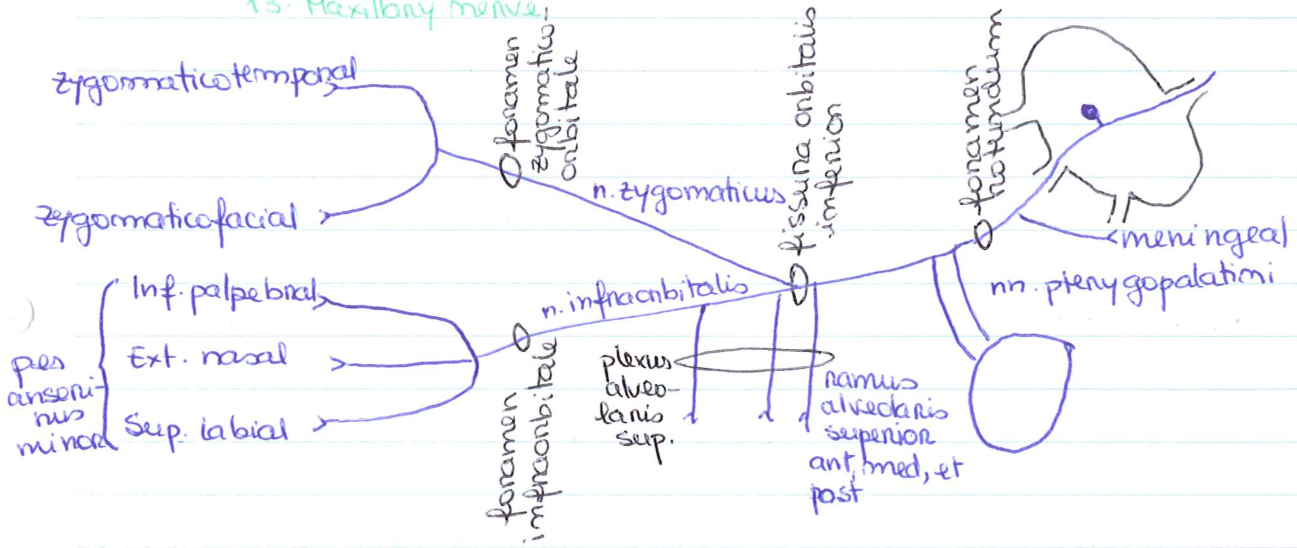


The ophtalmic nerve supplies the frontal and sphenoid sinuses as well as the nasal septum.

The ophtalmic nerve divides into the lacrimal nerve, the frontal nerve and the nasociliary nerve.

- The frontal nerve divides into the supratrochlear nerve (medial corner of the eye) and the supraorbital nerve, which passes through the supra orbital notch (conjunctiva, upper eyelid, and the skin of the forehead).
- The lacrimal nerve runs to the lacrimal gland and innervates the skin of the lateral corner of the eye. Via a communicating branch, it receives postganglionic secretory (parasympatetic) fibers from the zygomatic nerve for innervation of the lacrimal gland
- The nasociliary nerve runs to the medial corner of the eye and gives off the following branches: a communicating branch to the ciliary ganglion, the long ciliary nerves to the eyeball, the posterior ethmoidal sinuses and the anterior ethmoidal nerve; the latter runs through the anterior ethmoidal foramen to the ethmoidal plate through the plate into the nasal cavity.

13. Maxillary nerve:



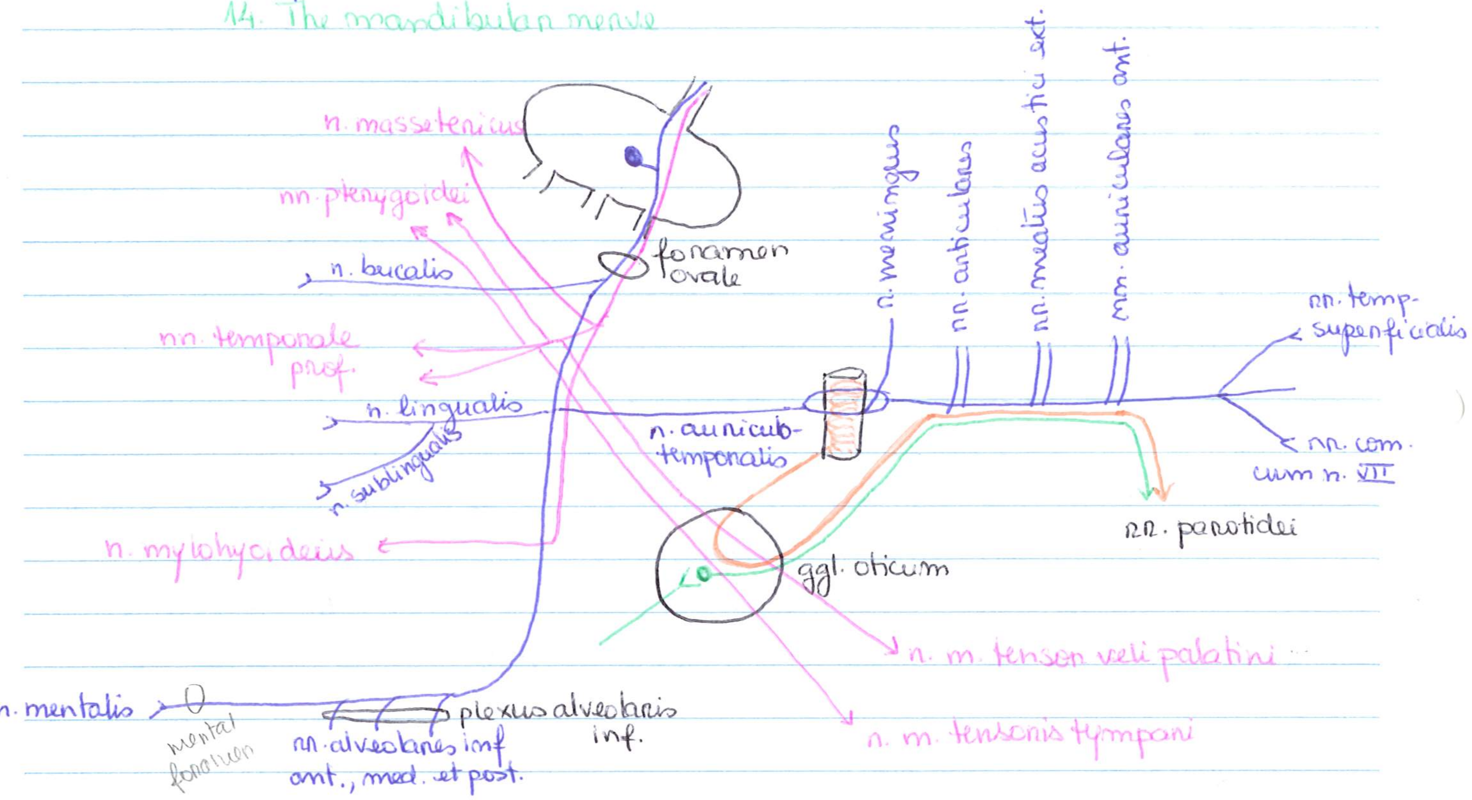
The maxillary nerve gives off a meningeal branch and then passes through the round foramen into the pterygopalatine fossa, where it divides into the zygomatic nerve, the ganglionic branches (pterygopalatine nerves) and the infraorbital nerve.

- The zygomatic nerve reaches through the inferior orbital fissure to the lateral wall of the orbit. It gives off a communicating branch, which contains postganglionic secretory (parasympathetic) fibers from the pterygopalatine ganglion for the lacrimal gland, to the lacrimal nerve and divides into the zygomaticotemporal branch (temple) and the zygomaticofacial branch (skin over the zygomatic arch)
- The ganglionic branches are two or three fine filaments running to the pterygopalatine ganglion. The fibers provide sensory innervation to the upper pharynx

nasal cavity, and hard and soft palates.

- The infraorbital nerve reaches through the inferior orbital fissure into the orbit and through the infraorbital canal to the cheek, where it supplies the skin between lower eyelid and upper lip. It gives off the posterior superior alveolar nerves (molar teeth), the middle superior alveolar nerve (premolar teeth) and the anterior superior alveolar nerve (incisors).

14. The mandibular nerve



After passing through the oval foramen and giving off a meningeal branch in the infratemporal fossa, the nerve divides into the auriculotemporal nerve, the lingual nerve, the inferior alveolar nerve, the buccal nerve and the pure motor branches.

The pure motor branches leave the mandibular nerve shortly after its passage through the foramen: the masseteric nerve for the masseter muscle, the deep temporal nerves for the temporal muscle and the pterygoid nerves for the pterygoid muscles. Motor fibers for the tensor veli palatini and tensor tympani run to the optic ganglion and emerge from it as nerve of the tensor tympani muscle and nerve of the tensor veli palatini muscle.

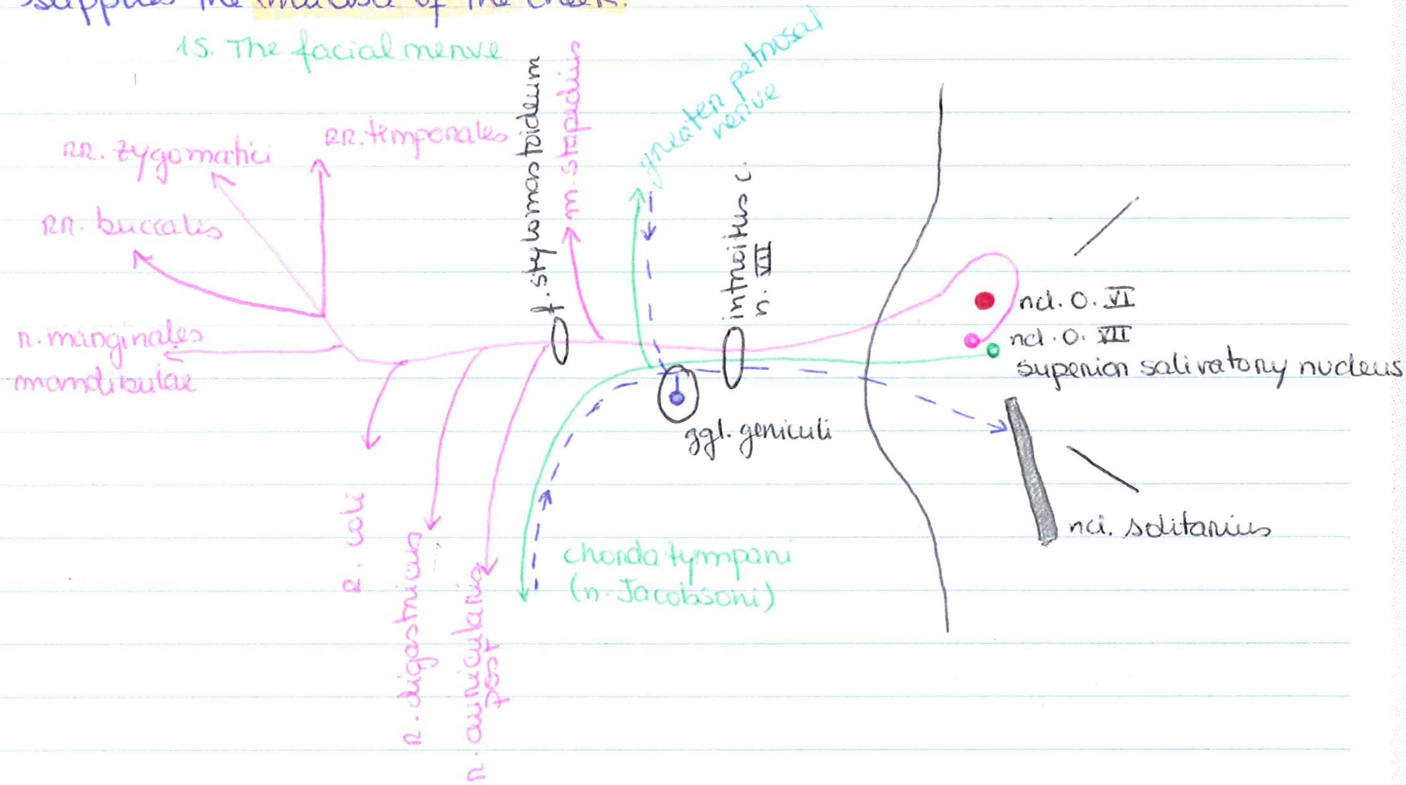
- The auriculotemporal nerve (temporal skin, external acustic meatus, and tympanic membrane) usually originates with two roots that embrace the middle meningeal artery and then unite to form the nerve.

- The lingual nerve descends in an arch to the base of the tongue and supplies sensory fibers to the anterior two-thirds of the tongue. It receives its taste fibers from the chorda tympani (facial nerve).

- The inferior alveolar nerve contains motor fibers for the mylohyoid muscle and the anterior belly of the digastric muscle, furthermore, it contains sensory fibers, which enter the mandibular canal and give off numerous inferior dental branches for the teeth of the lower jaw. The main branch of the nerve, the mental nerve, passes through the mental foramen and supplies sensory fibers to the chin, lower lip and the skin over the body of the mandible.

- The buccal nerve passes through the buccinator muscle and supplies the mucosa of the cheek.

15. The facial nerve



Functions: Sensory - special sensory (taste) and somatic sensory. Motor - somatic (branchial) motor and visceral (parasympathetic) motor. It also carries proprioceptive fibers from the muscles it innervates.

Nuclei: The motor nucleus of the facial nerve is a branchiomotor nucleus with multipolar neurons. The fibers arch around the abducens nucleus (internal genu of the facial nerve). The cell bodies of primary sensory neurons are in geniculate ganglion. The central processes of those concerned with taste end in the nuclei of the solitary tract of medulla. The processes of those concerned with general sensations (pain, touch, thermal) from around the external ear (V_3) end in the spinal nucleus of trigeminal nerve.

The facial nerve (CN. VII) emerges from the junction of the pons and medulla as two divisions: the motor root and the intermediate nerve. The larger motor root innervates the muscles of facial expression, and the smaller intermediate nerve carries taste, parasympathetic, and somatic sensory fibers. During its course, CN VII traverses the posterior cranial fossa, internal acustic meatus, facial canal, stylomastoid foramen of the temporal bone and parotid gland. After traversing the internal acoustic meatus, the nerve proceeds a short distance anteriorly within the temporal bone and then turns abruptly posteriorly to course along the medial wall of the tympanic cavity. The sharp bend, the geniculum of the facial nerve is the site of the geniculate ganglion, the sensory ganglion of CN VII. While traversing the temporal bone within the facial canal, CN VII gives rise to the:

- Greater petrosal nerve - preganglionic secretory fibers for the lacrimal gland, nasal glands and palatal glands. It extends through the hiatus for the ~~lesser~~ greater petrosal nerve into the cranial cavity and over the anterior aspect of the petrous bone through the foramen lacerum and finally through the pterygoid canal to the pterygopalatine ganglion.
- Nerve to stapedius - middle ear
- Chorda tympani - branches off above the stylomastoid foramen, runs beneath the mucosa through the tympanic cavity and further to the petro-tympanic fissure and finally joins the lingual nerve.

Then, CN VII emerges from the cranium via the stylomastoid foramen. Before it enters the parotid gland, the facial nerve gives off the posterior auricular nerve, as well as branches to the posterior belly of digastric muscle and to the stylohyoid muscle.

It enters the parotid gland and forms the parotid plexus which gives rise to the following five terminal motor branches: temporal, zygomatic, buccal, marginal mandibular, and cervical.

Ramifications of the cervical branch lying beneath the platysma form the superficial cervical ansa by anastomosing with branches of the sensory transverse cervical nerve.

SOMATIC (BRANCHIAL) MOTOR

The facial nerve supplies striated muscles, mainly the muscles of facial expression and auricular muscles. It also supplies the posterior bellies of digastric, stylohyoid and stapedius muscles.

VISCERAL (PARASYMPATHETIC) MOTOR

CN VII provides presynaptic parasympathetic fibers to the pterygopalatine ganglion for innervation of the lacrimal glands and to the submandibular ganglion for innervation of the sublingual and submandibular salivary glands. The pterygopalatine ganglion is associated with the maxillary nerve ($CN V_2$), which distributes its postsynaptic fibers, whereas the submandibular ganglion is associated with the mandibular nerve ($CN V_3$)

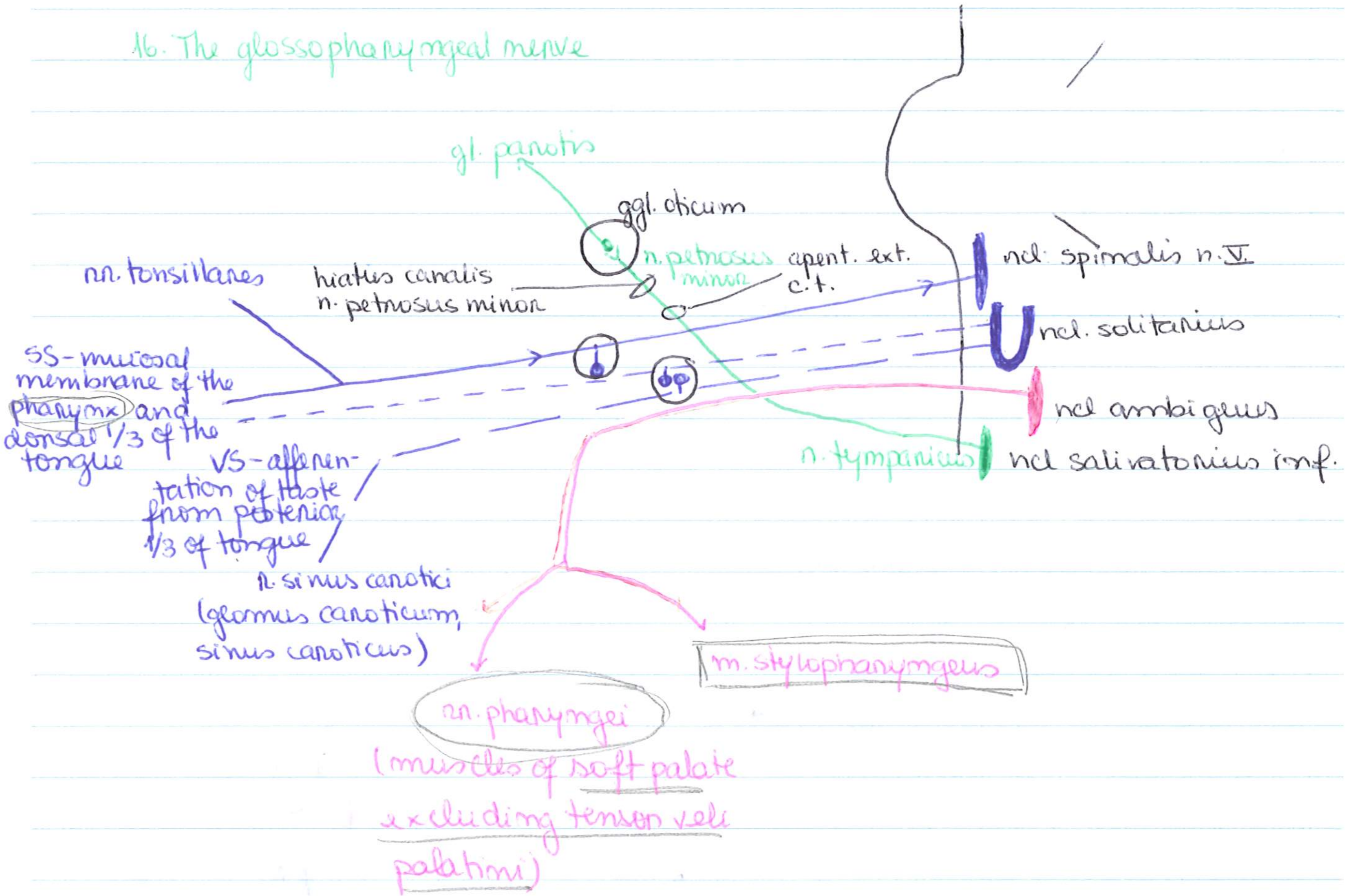
SOMATIC SENSORY

Some fibers from the geniculate ganglion supply a small area of the skin of the concha of the auricle, close to external acoustic meatus.

SPECIAL SENSORY

Fibers carried by the chorda tympani join the lingual nerve to convey taste sensation from the anterior 2/3 of the tongue and soft palate.

16. The glossopharyngeal nerve



Functions: Sensory - somatic sensory, special sensory (taste) and visceral sensory. Motor - somatic (branchial) motor, and visceral (parasympathetic) motor.

Nuclei: Four nuclei in the medulla send or receive fibers via CN IX: two motor (nucleus ambiguus and inferior salivary nucleus) and two sensory (sensory nuclei of the trigeminal nerve and nuclei of the solitary tract).

The glossopharyngeal nerve emerges from the medulla oblongata behind the olive and leaves the skull together with the vagus nerve through the jugular foramen. At this foramen are superior and inferior ganglia, which contain the pseudounipolar cell bodies for the afferent components of the nerve. CN IX follows the stylopharyngeus and passes between the superior and middle pharyngeal constrictor muscles to reach the oropharynx and tongue. It contributes sensory fibers to the pharyngeal plexus of nerves. CN IX is afferent from the tongue and pharynx and efferent to the stylopharyngeus and parotid gland.

SOMATIC (BRANCHIAL) MOTOR

Motor fibers pass to stylopharyngeus and muscles of soft palate excluding tensor veli palatini.

VISCERAL (PARASYMPATHETIC) MOTOR

Presynaptic parasympathetic fibers are provided to the otic ganglion for innervation of the parotid gland. The otic ganglion is associated with the mandibular nerve (CN V_3), branches of which convey the postsynaptic parasympathetic fibers to the parotid gland.

SOMATIC SENSORY

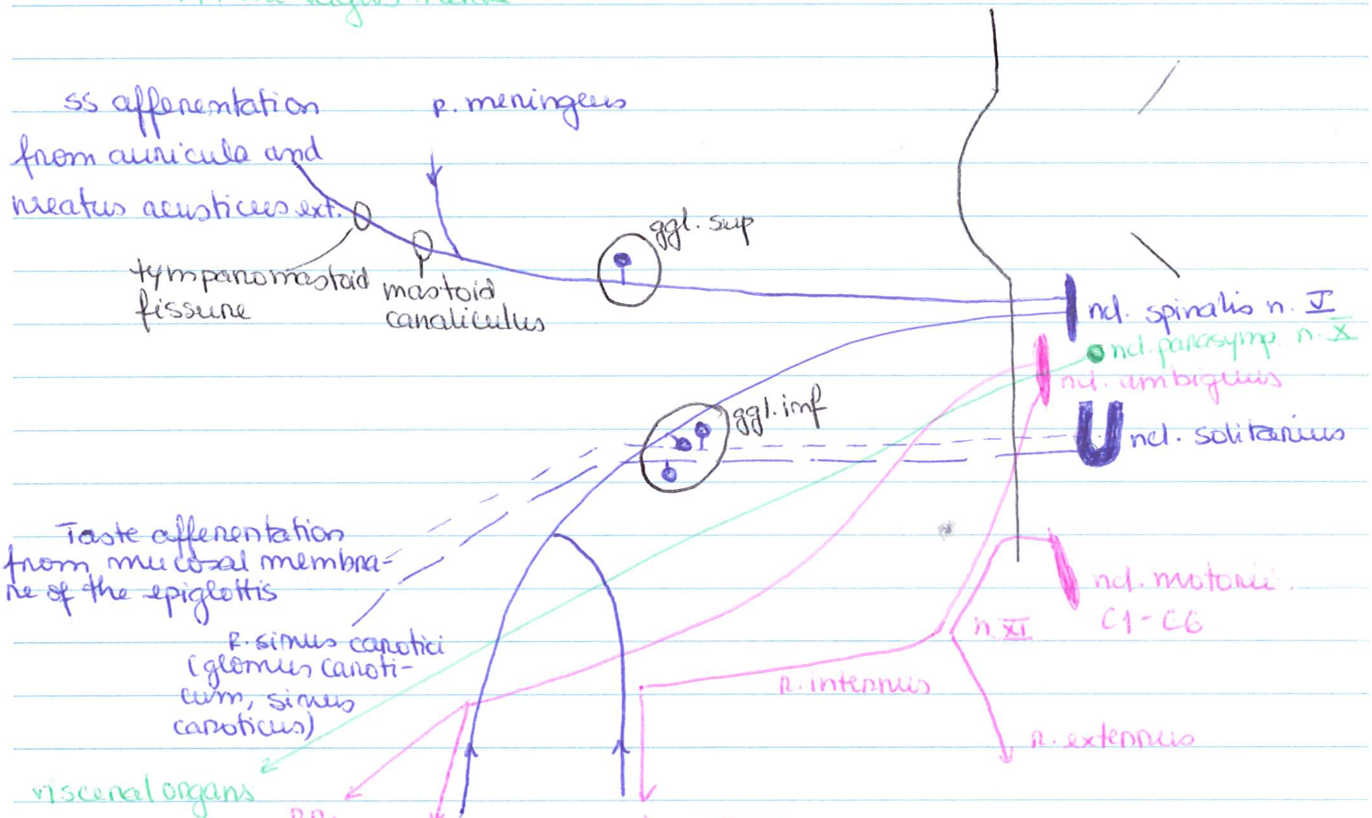
The general sensory branches of CN IX are as follows:

• The tympanic nerve – it runs through the tympanic canaliculus into the tympanic cavity, where it receives fibers from the plexus of the internal carotid artery via the caroticotympanic nerve and forms the tympanic plexus. It supplies sensory fibers to the mucosa of tympanic cavity and auditory (eustachian) tube. The secretory fibers run as lesser petrosal nerve to the otic ganglion.

SPECIAL SENSORY (TASTE)

Taste fibers are conveyed from the posterior third of the tongue to the sensory ganglia, the superior and inferior ganglia of CN IX

17. The vagus nerve



Functions: Sensory – somatic sensory, special sensory (taste), visceral sensory. Motor – somatic (branchial) motor and visceral (parasympathetic) motor

• Somatic (general) sensory from the inferior pharynx and larynx.
• Visceral sensory from the thoracic and abdominal organs.
• Taste and somatic (general) sensation from the root of the tongue and taste buds on the epiglottis. Branches of the internal laryngeal nerve (a branch of X) supply a small area, mostly somatic (general) sensory but also some special sensation (taste).
• Somatic (branchial) motor to the pharynx, intrinsic laryngeal muscles
• Proprioceptive to the muscles listed above.
• Visceral (parasympathetic) motor to thoracic and abdominal viscera.

Nuclei: Sensory - sensory nucleus of the trigeminal nerve (somatic sensory) and nuclei of the solitary tract (taste and visceral sensory). Motor - nucleus ambiguus (somatic [branchial] motor) and dorsal vagal nucleus (visceral [parasympathetic] motor).

It arises by a series of rootlets from the lateral aspect of the medulla that merge and leave the cranium through the jugular foramen positioned between CN IX and CN XI.

CN X has a superior ganglion in the jugular foramen that is mainly concerned with the general sensory component of the nerve. Inferior to the foramen is an inferior ganglion concerned with the visceral sensory components of the nerve.

- Cervical region

Inside a common connective-tissue sheath, the nerve descends in the neck together with the internal carotid artery, the common carotid artery, and the internal jugular vein; it emerges with them through the upper thoracic aperture.

It gives off 4 branches:

1. The pharyngeal branches at the level of the inferior ganglion. They combine in the pharynx with fibers of the glossopharyngeal nerve and the sympathetic nervous system to form the pharyngeal plexus. This branches innervate the constrictor muscles of the pharynx.

2. The superior laryngeal nerve originates below the inferior ganglion and divides at the level of the hyoid bone into an external branch (motor branch for the cricothyroid muscle) and an internal branch (sensory branch for the mucosa of the larynx as far down as the vocal cords).

3. The recurrent laryngeal nerve branches off in the thorax after the vagus nerve has extended on the left over the arch of the aorta and on the right across the subclavian artery. It passes on the left around the aorta and the ligamentum arteriosum and on the right around the subclavian artery and then ascends behind the artery. Between trachea and esophagus, to which it gives off the tracheal branches and the esophageal branches, it extends up to the larynx. Its terminal branch, the inferior laryngeal nerve supplies motor fibers to all laryngeal muscles except for the crycothyroid muscle.

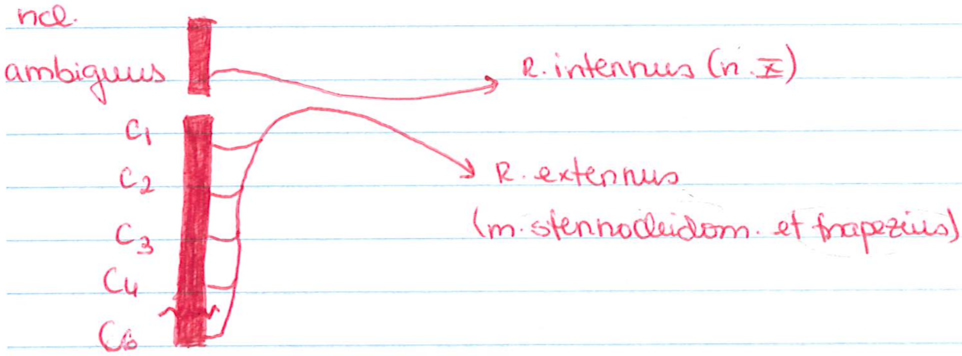
4. The cervical cardiac branches run with the large vessels to the heart, where they terminate in the parasympathetic ganglia of the cardiac plexus. One of the branches carries viscerosensory fibers that transmit information about aortic wall tension.

• Thoracic and Abdominal part

The vagus nerve loses its identity as a single nerve; as a visceral nerve, it spreads out like a network. It forms the pulmonary plexus at the hilum of the lung, which it crosses dorsally and the esophageal plexus from which the anterior vagal trunk and the posterior vagal trunk extend to the anterior and posterior aspects of the stomach, forming the anterior and posterior gastric branches. The hepatic branches run to the hepatic plexus, the celiac branches to the celiac plexus and the renal branches to the renal plexus.

18. The accessory and hypoglossal nerves

n. XI - accessory nerve

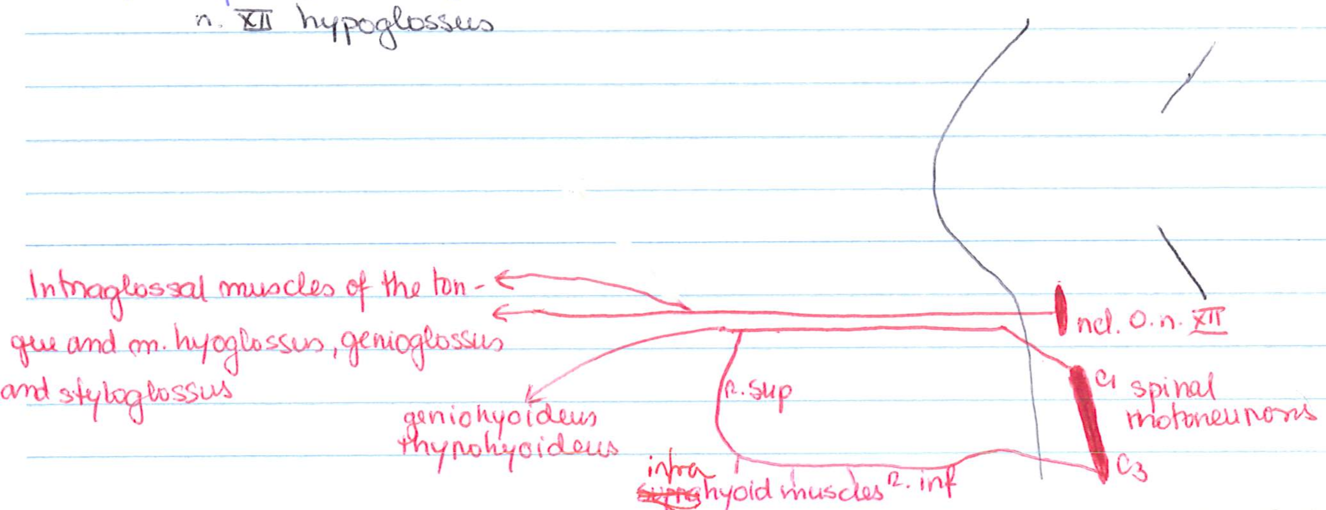


Functions: Somatic motor to the striated sternocleidomastoid and trapezius muscles.

Nuclei: The spinal accessory nerve arises from the nucleus of the spinal accessory nerve, a column of anterior horn motor neurons in the superior five or six cervical segments of the spinal cord.

The traditional "cranial root" of CN XI is actually a part of CN X. It is united for a short distance with the spinal accessory nerve (CN XI). CN XI emerges as a series of rootlets from the first five or six cervical segments of the spinal cord. It joins the CN X temporarily as they pass through the jugular foramen, separating again as they exit. CN XI descends along the internal carotid artery, penetrates and innervates the sternocleidomastoideus and emerges from the muscle near the middle of its posterior border. Next, CN XI crosses the posterior cervical region and passes deep to the superior border of the trapezius to descend on its deep surface, providing multiple branches to the muscle.

n. XII hypoglossus



Functions: Somatic motor to the intrinsic and extrinsic muscles of the tongue - styloglossus, hyoglossus and genioglossus.

The hypoglossal nerve (CN XII) arises as a purely motor nerve by several rootlets from the medulla and leaves the cranium through the hypoglossal canal. After exiting the cranial cavity, CN XII is joined by a branch or branches of the cervical plexus conveying general somatic motor fibers from C1 and C2 spinal nerves and somatic motor fibers from C_1 and C_2 spinal nerves and somatic (general) sensory fibers from the spinal ganglion of C_2. These spinal nerve fibers "hitch a ride" with CN XII to reach the hyoid muscles, with some of the sensory fibers passing retrograde along it to reach the dura mater of the posterior cranial fossa. CN XII passes inferiorly medial to the angle of the mandible and then curves anteriorly to enter the tongue.

CN XII ends in many branches that supply all the extrinsic muscles of the tongue, except the palatoglossus (which is actually a palatine muscle). CN XII has the following branches:

- A meningeal branch returns to the cranium through the hypoglossal canal and innervates the dura mater on the floor and posterior wall of the posterior cranial fossa. The nerve fibers conveyed are from the sensory spinal ganglion of spinal nerve C2 and are not hypoglossal fibers.
- The superior root of the ansa cervicalis branches from CN XII to supply the infrahyoid muscles (sternohyoid, sternothyroid and omohyoid). This branch actually conveys only fibers from the cervical plexus (the loop between the anterior rami of C1 and C2) that joined the nerve outside the cranial cavity, not hypoglossal fibers. Some fibers continue past the origin of the superior root to reach the thyrohyoid and geniohyoid muscles.
- Terminal lingual branches supply the styloglossus, hyoglossus, genioglossus and intrinsic muscles of the tongue.

19. Construction of autonomic (vegetative) nervous system

The autonomic nervous system (ANS), classically described as the visceral nervous system consists of motor fibers that stimulate smooth (involuntary) muscle, modified cardiac muscle (the intrinsic stimulating and conducting tissue of the heart), and glandular (secretory) cells. However, the visceral efferent fibers of the ANS are accompanied by visceral afferent fibers. As the afferent component of autonomic reflexes and in conducting visceral pain impulses, these visceral afferent fibers also play a role in the regulation of visceral function.

The efferent nerve fibers and ganglia of the ANS are organized into two systems or divisions: the sympathetic (thoracolumbar) division and the parasympathetic (craniosacral) division.

In both, divisions of the ANS, conduction of impulses from the CNS to the effector organ involves a series of two multipolar neurons. The nerve cell body of the first presynaptic (preganglionic) neuron is located in the gray matter of the CNS. Its fiber (axon) synapses only on the cell body of the postsynaptic (postganglionic) neuron, the second neuron in the series. The cell bodies of these second neurons are located outside the CNS in autonomic ganglia, with fibers terminating on the effector organ.

The anatomical distinction between the sympathetic and parasympathetic divisions of the ANS is based primarily on:

1. The location of the presynaptic cell bodies
2. Which nerves conduct the presynaptic fibers from the CNS.

Postsynaptic neurons of the two divisions generally liberate different neurotransmitter substances: norepinephrine by the sympathetic division (except in the case of sweat glands) and acetylcholine by the parasympathetic division.

The main function of the autonomic nervous system is to stabilize the internal environment of the organism and to regulate the function of the organs in accordance with the changing requirements of the surroundings.

— The sympathetic nervous system is stimulated by increased physical activity, resulting in elevated blood pressure, accelerated heart rate and respiratory rate, dilated pupils, raised hair, and increased perspiration. At the same time, the peristaltic activity of the gastrointestinal tract is suppressed and secretion by intestinal glands is reduced. When the parasympathetic system predominates, it increases peristaltic activity and intestinal secretion, stimulates defecation and urination, and reduces the heart rate and respiratory rate, while the pupils constrict. The sympathetic nervous system is responsible for increased performance under stress and in states of emergency, while the parasympathetic nervous, system promotes metabolism, regeneration, and the buildup of body reserves.

◆ SYMPATHETIC (THORACOLUMBAR) DIVISIONS OF ANS

The cell bodies of the presynaptic neurons of the sympathetic division of the ANS are found in only one location: the intermediolateral cell columns (IMLs) or nuclei of the spinal cord. The paired (right and left) IMLs are a part of the grey matter of the thoracic (T1 - 12) and the upper lumbar (L1-L2 or 3) segments of the spinal cord, the IMLs appear as small lateral horns of the H-shaped gray matter.

The cell bodies of the postsynaptic neurons of the sympathetic nervous system occur in two locations, the paravertebral and prevertebral ganglia:

• Paravertebral ganglia are linked to form right and left sympathetic trunks (chains) on each side of the vertebral column and extend essentially the length of this column. The superior paravertebral ganglion lies at the base of the cranium. The ganglion impar forms inferiorly where the two trunks unite at the level of the coccyx.

• Prevertebral ganglia are in plexuses that surround the origins of the main branches of the abdominal aorta (for which they are named), such as the two large celiac ganglia that surround the origin of the celiac trunk (a major artery arising from the aorta).

Because they are motor fibers, the axons of presynaptic neurons leave the spinal cord through anterior roots and enter the anterior rami of spinal nerves T1 - L2 or 3. Almost immediately after entering, all the presynaptic sympathetic fibers leave the anterior rami of these spinal nerves and pass to the sympathetic trunks through white rami communicantes. Within the sympathetic trunks, presynaptic fibers follow one of four possible courses:

✓ Ascend in the sympathetic trunk

✓ Descend in the sympathetic trunk

✓ Enter and synapse immediately with a postsynaptic neuron of the paravertebral ganglion at the level.

✓ Pass through the sympathetic trunk without synapsing, continuing through an abdominopelvic splanchnic nerve (a branch of the trunk involved in innervating abdominopelvic viscera) to reach the prevertebral ganglia.

Presynaptic sympathetic fibers that provide automomic innervation within the head, neck, body wall, limbs, and thoracic cavity follow one of the first three courses. Presynaptic sympathetic fibers innervating viscera within the abdominopelvic cavity follow the fourth course.

The postsynaptic sympathetic fibers, destined for distribution within the neck, body wall, and limbs, pass from the paravertebral ganglia of the sympathetic trunks to adjacent anterior rami of spinal nerves through grey rami communicantes this means, they enter all branches of all 31 pairs of spinal nerves, including the posterior rami.

The postsynaptic sympathetic fibers stimulate contraction of the blood vessels (vasomotion) and arrector muscles associated with hairs (pilomotion) and to cause sweating (sudomotion). Postsynaptic sympathetic fibers that perform these functions in the head (plus innervation of the dilator muscle of the iris) all have their cell bodies in the superior cervical ganglion at the superior end of the sympathetic trunk. They pass from the ganglion by means of a cephalic arterial branch to form periarterial plexuses of nerves, which follow the branches of the carotid arteries, or they may pass directly to nearby cranial nerves, to reach their destination in the head.

Splanchnic nerves convey visceral efferent and afferent fibers to and from the viscera of the body cavities. Postsynaptic sympathetic fibers destined for the viscera of the thoracic cavity pass through cardiopulmonary splanchnic nerves to enter the cardiac, pulmonary, and esophageal plexuses. The presynaptic sympathetic fibers involved in the innervation of viscera of the abdominopelvic cavity pass to the prevertebral ganglia through abdominopelvic splanchnic nerves (making up the greater, lesser, least thoracic, and lumbar splanchnic nerves). All presynaptic sympathetic fibers of the abdominopelvic splanchnic nerves, except those involved in innervating the suprarenal (adrenal) glands, synapse in the prevertebral ganglia. The postsynaptic fibers from the prevertebral ganglia form periarterial plexuses, which follow branches of the abdominal aorta to reach their destination.

Some presynaptic sympathetic fibers pass through the celiac prevertebral ganglia without synapsing, continuing to terminate directly on cells of the medulla of the suprarenal gland.

The sympathetic nervous system reaches virtually all parts of the body, with the rare exception of such avascular tissues as cartilage and nails.

◆ PARASYMPATHETIC (CRANIOSACRAL) DIVISION OF ANS

Presynaptic parasympathetic nerve cell bodies are located in two sites within the CNS, and their fibers exit by two routes

- In the gray matter of the brainstem, the fibers exit the CNS within cranial nerves III, VII, IX and X
- In the gray matter of the sacral segments of the spinal cord (S2-4), the fibers exit the CNS through the anterior roots of sacral spinal nerves S2-4 and the pelvic splanchnic nerves that arise from their anterior rami.

The parasympathetic system is much more restricted than the sympathetic system in its distribution. The parasympathetic system distributes only to the head, visceral cavities of the trunk and erectile tissues of the external genitalia.

Presynaptic parasympathetic fibers synapse with postsynaptic cell bodies, which occur singly in or on the wall of the target organ.

Functions of divisions of ANS

In general, the sympathetic system is a catabolic (energy-expanding) system that enables the body to deal with stresses, such as when preparing the body for the fight-or-flight response. The parasympathetic system is primarily a homeostatic or anabolic (energy-conserving) system, promoting the quiet and orderly processes of the body, such as those that allow the body to feed and assimilate.

– Visceral sensation

Most visceral reflex (unconscious) sensation and some pain travel in visceral afferent fibers that accompany the parasympathetic fibers retrograde (backward). Most visceral pain impulses (from the heart and most organs of the peritoneal cavity) travel centrally along visceral afferent fibers accompanying sympathetic fibers.

20. The cervical portion of ... sympathetic system

The cervical ganglia are reduced to three; the uppermost, the superior cervical ganglion lies below the base of the skull near the inferior ganglion of the vagus nerve. It receives fibers from the upper thoracic segment via the interganglionic branches. Its postganglionic fibers from plexuses around the internal carotid artery and external carotid artery.

The middle cervical ganglion may be absent, and the inferior cervical ganglion has in most cases fused with the first thoracic ganglion to form the stellate ganglion. Its postganglionic fibers form plexuses around the subclavian artery and around the vertebral artery. It extends across the subclavian artery and form the subclavian ansa. Nerves from the cervical ganglia and nerves from the upper thoracic ganglia extend to the heart and to the hilum of the lungs, where they participate together with the parasympathetic fibers of the vagus nerve in the formation of the cardiac plexus and the pulmonary plexus.

21. The thoracic portion of ... sympathetic system (innervation of the heart)

INNERVATION OF THE HEART

◆ Sympathetic innervation

Generally, three cardiac nerves originate from the cervical portion of the sympathetic trunk at the level of the cervical ganglia: the superior cervical cardiac nerve, middle cervical cardiac nerve, and inferior cervical cardiac nerve. Coursing posterior to the neurovascular bundle, they travel caudally to the cardiac plexus. Additional thoracic cardiac branches arise from the upper thoracic ganglia the likewise pass to the cardiac plexus. The cardiac nerves of the sympathetic nervous system carry postganglionic autonomic fibers whose preganglionic segments arise from the upper segments of the thoracic spinal cord. The sympathetic cardiac nerves also contain viscerosensory fibers particularly pain fibers.

⇒ Stimulation of sympathetic cardiac nerves: leads to an increased heart rate, greater force of contraction and excitation, and accelerated impulse conduction in the atrioventricular node.

◆ Parasympathetic innervation

The parasympathetic cardiac nerves arise from the vagus nerve. They branch off at various levels from the cervical portion of the vagus nerve as the superior and inferior cervical cardiac branches and pass to the cardiac plexus. The thoracic cardiac branches also radiate from the thoracic portion of the vagus nerve and pass to the cardiac plexus. The vagal cardiac nerves contain mostly preganglionic autonomic fibers that synapse with postgangliomic fibers in subepicardial neurons at the base of the heart. The viscerosensory fibers of the parasympathetic cardiac branches mainly conduct impulses from baroreceptors and stretch receptors.

⇒ Stimulation of parasympathetic cardiac nerves leads to decreased heart rate and force of contraction, reduced excitation and slower impulse conduction in the atrioventricular node.

Cardiac Plexus

The sympathetic cardiac nerves and parasympathetic cardiac branches ramify and travel along the base of the heart where they join to form the cardiac plexus. Based on topographial features the cardiac plexus can be divided into superficial and deep parts. Embedded within the plexus are smaller and larger collections of nerve cells, including the cardiac ganglia. The superficial, or anterior, portion of the plexus lies below the aortic arch in front of the right pulmonary artery and is supplied mainly by fibers from the cardiac nerves on the left side. The deep, or posterior, portion of the plexus lies behind the aortic arch and anterior to the tracheal bifurcation. It contains fibers from the cardiac nerves on both sides. The two portions of the cardiac plexus are interconnected and ultimately give off the true cardiac branches, supplying all areas of the heart via plexuses lying along the coronary arteries and atria.

THORACIC PORTION OF SYMPATHETIC SYSTEM

The branches of the fifth to ninth sympathetic trunk ganglia join to form the greater splanchnic nerve which extends to the celiac ganglia.

Branches originating from the thoracic and upper lumbar sympathetic trunk ganglia extend to the prevertebral ganglia of the abdominal aortic plexus. There are several groups of ganglia. At the exit of the celiac trunk lie the celiac ganglia where the greater splanchnic nerve (T5-T9) and the lesser splanchnic nerve (T9-T11) terminate. Their postganglionic fibers extend with the branches of the aorta to stomach, duodenum, liver, pancreas, spleen (gastric plexuses, hepatic plexus, splenic plexus, pancreatic plexus).

The postganglionic fibers from the superior mesenteric ganglion supply the small intestine, the ascending colon, and the transverse colon. The fibers from the inferior mesenteric ganglion supply the descending colon, the sigmoid colon, and the rectum. Some branches extend to the renal plexus, which also contains fibers from the celiac ganglia.

22. The abdominal and pelvic portions of the sympathetic system

The pelvic organs are supplied by the superior hypogastric plexus and the inferior hypogastric plexus. Both plexuses receive preganglionic sympathetic fibers from the lower thoracic and upper lumbar spinal cord.

The urinary bladder is predominantly innervated by the parasympathetic fibers of the visceral plexus that supply the muscles for bladder contraction (detrusor muscle). The sympathetic fibers terminate at the smooth muscles of the orifice of the urethra and both urethral orifices. Regulation of bladder tone and urination takes place via spinal reflexes which, in turn, are controlled by the hypothalamus and by cortical areas.

The genitals are supplied by the prostatic plexus in the male and by the uterovaginal plexus in the female.

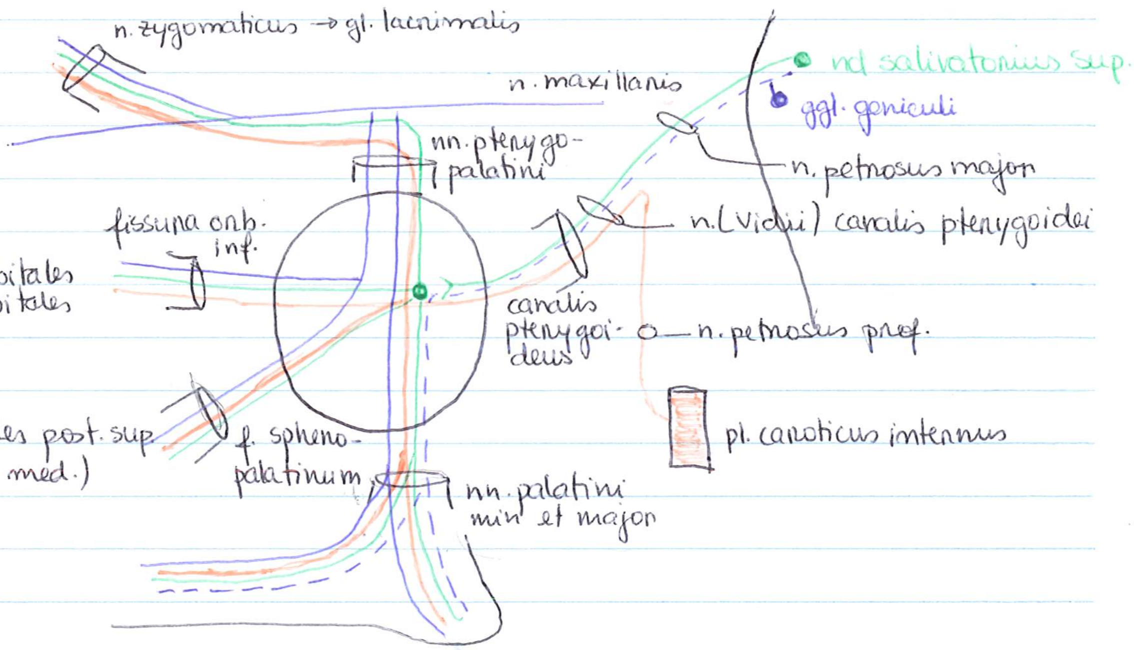
Stimulation of sympathetic fibers leads to vasoconstriction and to ejaculation. The uterine muscles are innervated by sympathetic and parasympathetic fibers.

23. Pars mesencephalica partis parasympathicae (the ciliary ganglion)

The ciliary ganglion is a small, flat body lying laterally to the optical nerve in the orbit. Its parasympathetic fibers from the Edinger-Westphal nucleus run in the oculomotor nerve and cross over to the ganglion as oculomotor root (parasympathetic root). These parasympathetic fibers are the only fibers that form synapses with the ciliary ganglion cells. The preganglionic sympathetic fibers originate from the lateral horn of the spinal cord C8-T2 (ciliospinal center) and synapse in the superior cervical ganglion. The postganglionic fibers ascend in the carotid plexus as sympathetic root to the ciliary ganglion. Sensory fibers originate from the nasociliary nerve (nasociliary root).

The short ciliary nerves extend from the ganglion to the eyeball. Their parasympathetic fibers innervate the ciliary muscle (accomodation) and the sphincter pupillae muscle; the sympathetic fibers innervate the dilator pupillae muscle.

24. Pars bulbaris partis parasympathicae (the pterygopalatine and submandibular ganglions)

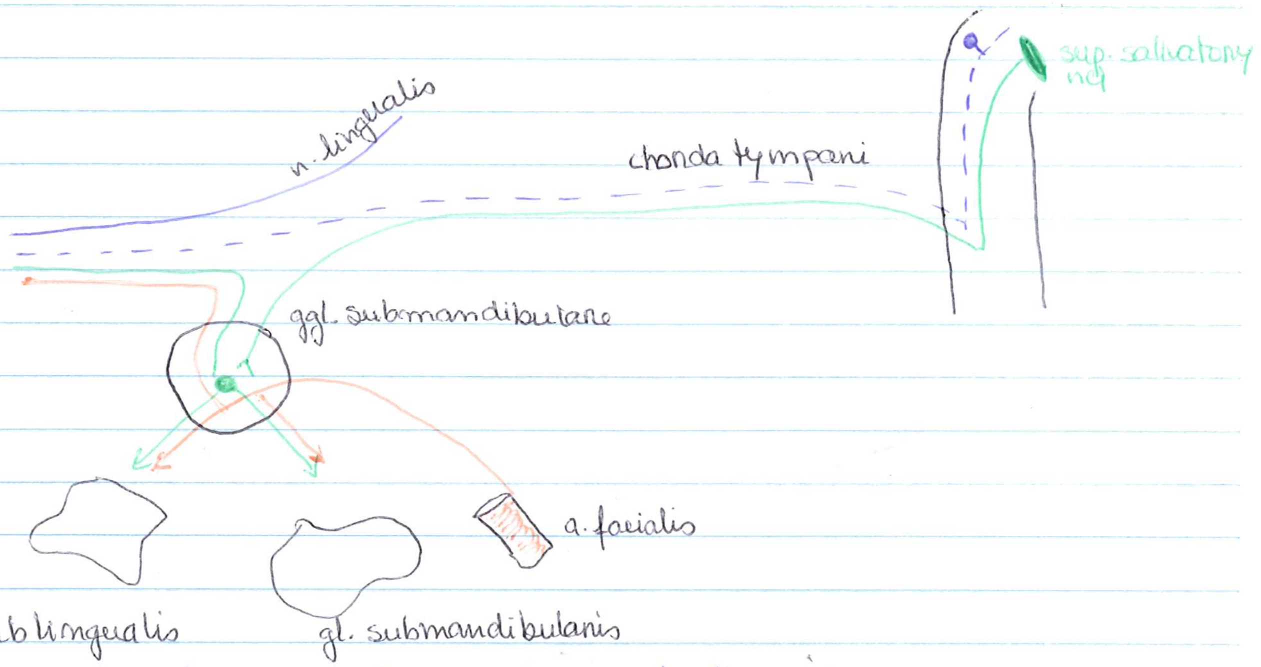


The pterygopalatine ganglion lies at the anterior wall of the pterygopalatine fossa below the maxillary nerve, which gives off ganglionic branches (pterygopalatine nerves) to the ganglion (sensory root). The parasympathetic secretory fibers from the superior salivatory nucleus extend in the facial nerve (intermediate nerve) up to the genu of the facial nerve where they branch off as the greater petrosal nerve. The nerve passes through the foramen lacerum to the base of the skull and through the pterygoid canal to the ganglion (parasympathetic root). Sympathetic fibers from the carotid plexus form the deep petrosal nerve (sympathetic root) and join the greater petrosal nerve to form the nerve of the pterygoid canal.

The branches leaving the ganglion carry secretory fibers for the lacrimal gland and for the glands of the nasal cavity. The parasympathetic fibers for the lacrimal gland synapse in the ganglion. The postganglionic fibers run in the ganglionic branches to the maxillary nerve and reach the lacrimal gland via the zygomatic nerve and its anastomosis with the lacrimal nerve.

The remaining parasympathetic secretory fibers run in the orbital branches to the posterior ethmoidal cells, in the lateral posterior nasal branches to the nasal conchae, in the nasopalatine nerve across the nasal septum and through the incisive canal, and in the palatine nerve to the hard and soft palates.

The taste fibers for the soft palate run in the palatine nerves and in the greater petrosal nerve.



The submandibular ganglion lies together with several small secondary ganglia in the floor of the mouth above the submandibular gland and below the lingual nerve to which it connects via several ganglionic branches. Its preganglionic parasympathetic fibers originate from the superior salivatory nucleus, run in the facial nerve (intermediate nerve), and leave the nerve together with the taste fibers in the chorda tympani. In the latter, the fibers reach the lingual nerve and

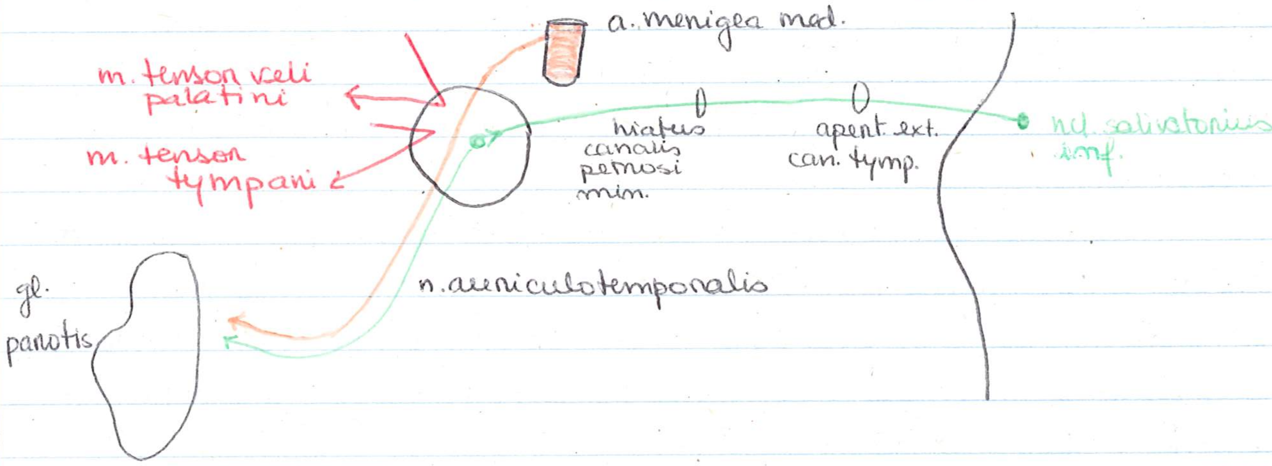
Questions C (continued)

24. Pars bulbaris partis parasympathicae (the pterygopalatine and submandibular ganglions) - continued

extend in it to the floor of the mouth where they cross over into the ganglion. Postganglionic sympathetic fibers from the plexus of the external carotid artery reach the ganglion via the sympathetic branch given off by the plexus of the facial artery; they pass through the ganglion without synapsing.

The postganglionic parasympathetic and sympathetic fibers pass partly in the glandular branches to the submandibular gland, partly in the lingual nerve to the sublingual gland and to the glands in the distal two-thirds of the tongue.

25. Pars bulbaris partis parasympathicae (the otic ganglion)



The otic ganglion lies below the oval foramen on the medial side of the mandibular nerve, from where motor fibers enter the ganglion and pass through without synapsing. The preganglionic parasympathetic fibers originate from the inferior salivatory nucleus. They run in the glossopharyngeal nerve. The fiber leave the tympanic cavity through the hiatus for the lesser petrosal nerve as a fine branch, the lesser petrosal nerve (parasympathetic root). The nerve runs beneath the dura mater along the surface of the petrous bone and reaches the otic ganglion after passing through the foramen lacerum. The fibers of the sympathetic root originate from the plexus of the middle meningeal artery.

The motor fibers from the motor root of the trigeminal nerve pass through the ganglion and leave it in the nerve to tensor veli palatini and in the nerve to tensor tympani.

The postganglionic secretory (parasympathetic) fibers together with sympathetic fibers enter the auriculotemporal nerve. The fibers then ramify in the parotid gland. Apart from the parotid gland, they supply the buccal and labial glands via the buccal nerve.

26. Pars sacralis partis parasympathicae

The cells lying in the intermediolateral nucleus and intermediomedial nucleus of the sacral spinal cord send their axons through the third and fourth sacral root to the pudendal nerve; from here the fibers pass as pelvic nerves into the inferior hypogastric plexus and to the pelvic organs (urinary bladder, rectum, and genitals). Synapses with postganglionic neurons are formed in the inferior hypogastric plexus or in small ganglia of the various organ plexuses. As is the case with the sympathetic nervous system, the peripheral supply is provided by two neurons: the first neuron (preganglion neuron) in the spinal cord, and the second neuron (postganglionic neuron) in the ganglia.

27. Development and partitions of the central nervous system

In highly differentiated organisms, an additional cell is interposed between the sensory cell and the muscle cell - the nerve cell, or neuron which takes on the transmission of messages. This cell can transmit the excitation to several muscle cells or to additional nerve cells, thus forming a neural network.

In vertebrates, the somatic nervous system developed in addition to the automomic nervous system; it consists of the central nervous system (CNS; brain and spinal cord), and the peripheral nervous system (PNS). It is responsible for conscious perception, for voluntary movement, and for the processing of information (integration).

The CNS develops from the neural plate of the ectoderm which then transforms into the neural groove and further into the neural tube. The neural tube finally differentiates into the spinal cord and the brain.

Functional circuits

Stimuli from the environment (exteroceptive stimuli) are conducted by sensory cells via sensory (afferent) nerves to the CNS. In response, there is a command from the CNS via motor (efferent) nerves to the muscles. For control and regulation of the muscular response, there is internal feedback from sensory cells in the muscles via sensory nerves to the CNS. This afferent tract does not transmit environmental stimuli but stimuli from within the body (proprioceptive stimuli). We therefore distinguish between exteroceptive and proprioceptive sensitivities.

In the same way as we distinguish between exteroceptive sensitivity and proprioceptive sensitivity we can subdivide the motor system in an environment-oriented somatomotor system and an visceromotor system.

The central nervous system (CNS) is divided into the brain, encephalon and the spinal cord (SC), medulla spinalis. The brain in the cranial cavity is surrounded by a bone capsule; the spinal cord in the vertebral canal is enclosed by the bony vertebral column. Both are covered by meninges that enclose a cavity filled with a fluid, the cerebrospinal fluid. Thus, the CNS is protected from all sides by bony walls and cushioning effect of a fluid.

The peripheral nervous system (PNS) includes the cranial nerves, which emerge through holes in the base of the skull, and the spinal nerves, which emerge through spaces between the vertebrae (intervertebral foramina). The peripheral nerves extend to muscles and skin areas. They form nerve plexuses before entering the limbs, in which the fibers of the spinal nerves intermingle. At the entry points of the afferent nerve fibres lie ganglia; these are small oval bodies containing sensory neurons.

The lower brain divisions, which merge into the spinal cord, are collectively called the brain stem.

The divisions of the brain stem have a common structural plan (consisting of basal plate and alar plate).

The forebrain, prosencephalon, consists of two parts, the diencephalon and the telencephalon or cerebrum. In the mature brain, the telencephalon forms the two hemispheres (cerebral hemispheres). The diencephalon lies between the two hemispheres.

Development of the Brain

The closure of the neural groove into the neural tube begins at the level of the upper cervical cord. From here, further closure runs in the oral direction up to the rostral end of the brain and in the caudal direction up to the end of the spinal cord. Further developmental events in the CNS proceed in the same directions.

Increasing growth causes the neural tube in the head region to expand and form several vesicles. The rostral vesicle is the future forebrain, prosencephalon; the caudal vesicles are the future brain stem, encephalic trunk. Two curvatures of the neural tube appear at this time: the cephalic flexure and the cervical flexure. Although the brain stem still shows a uniform structure at this early stage, the future divisions can already be identified: medulla oblongata, pons, cerebellum, mesencephalon. The brain stem is developmentally ahead of the prosencephalon; during the second month of human development, neurons have already differentiated in the brain stem (emergence of cranial nerves). The optic vesicle develops from the diencephalon

Anterior to it lies the telencephalic vesicle; initially its anlage is unpaired but it soon expands on both sides to form the two cerebral hemispheres.

During the third month, the prosencephalon enlarges. Telencephalon and diencephalon become separated by the telodiencephalic sulcus

The pituitary anlage and the mamillary eminence have formed at the base of the diencephalon. A deep transverse sulcus is formed between the cerebellar anlage and the medulla oblongata as a result of the pontine flexure.

During the fourth month, the cerebral hemispheres begin to overgrow the other parts of the brain. The center of the lateral surface of each hemisphere lags behind is growth and later becomes overlain with parts. This is the insula. During the sixth month the first grooves and convolutions appear on the previously smooth surfaces of the hemispheres.

Develop in the segment of the thickened wall, on commissural plate is the corpus callosum. The hemispheres grow mainly in the caudal direction; in parallel with their increase in size, the corpus callosum also expands in the caudal direction during its development and finally overlies the diencephalon.

28. The spinal cord (surface anatomy and structures)

The spinal cord is roughly cylindrical but flattened in its anterior-posterior dimension. Its diameter is about 2 cm in the midthoracic region, somewhat larger in the lower cervical and midlumbar regions, and smallest at the inferior tip. The length of the adult spinal cord ranges from 42 to 45 cm.

In the adult, it extends from the medulla oblongata, the most inferior part of the brain, to the upper border of the second lumbar vertebra (L2). An emergency of the first pair of the spinal nerves on decussatio of the pyramids is also considered as the cranial boundary of the spinal cord.

The spinal cord is located in the channel of the spinal column, the vertebral canal, and is surrounded by the cerebrospinal fluid

Two conspicuous spindle-shaped enlargements can be seen in external view of the spinal cord. The cervical enlargement (intumescentia cervicalis) extends from C4 to Th1 vertebra. The lumbar enlargement (intumescentia lumbalis) extends from Th9 to Th12. Both cervical and lumbar enlargements are produced by expansions of the grey matter providing nerves to and from the upper and lower extremities, respectively.

Below the lumbar enlargement, the spinal cord tapers to a conical portion known as the conus medullaris, which has a boundary at the level of intervertebral disc between the first and second lumbar vertebrae (L1-L2) in an adult. Arising from the conus medullaris is a fine thread, the fillum terminale, an extension of the pia mater that continues down the vertebral canal and attaches the spinal cord to the first segment of the coccyx.

The surface of the spinal cord is divided longitudinally into right and left halves by two longitudinal grooves, an anterior median fissure and a dorsal median sulcus. The anterior median fissure is a deeper groove on the ventral side containing connective tissue of the pia mater and branches of the anterior spinal artery. The posterior median sulcus is a shallower groove on the dorsal surface and from its base the dorsal septum from glial elements extends to the grey matter.

The dorsolateral sulcus is a longitudinal furrow corresponding to the position of the attachments of the dorsal roots of the spinal nerves on both halves. The ventral roots of the spinal nerves are attached in a shallow groove, the ventrolateral sulcus.

In the cervical region of the spinal cord, the dorsal intermediate sulcus lies between the dorsomedial and dorsolateral nuclei. It indicates the separation between the fasciculus gracilis and cuneatus.

The spinal nerves

31 pairs of spinal nerves originate from the spinal cord and pass through the intervertebral foramina. Each spinal nerve has a ventral root and a dorsal root which unit to form spinal nerves. The dorsal roots are expanded to form the spinal ganglia (dorsal root ganglia) that contain the primary sensory neurons of PSEUDOUNIPOLAR type.

The spinal nerves are:

- 8 pairs of cervical nerves (C1-C8) – the first pair emerges between occipital bone and atlas
- 12 pairs of thoracic nerves (T1-T12) – the first pair emerges between the first and second thoracic vertebrae
- 5 pairs of lumbar nerves (L1-L5) – the first pair emerges between the first and second lumbar vertebrae.
- 5 pairs of sacral nerves (S1-S5) – the first pair emerges through the upper sacral foramina
- 1 pair of coccygeal nerves. – emerge between the first and second coccygeal vertebrae.

The vertebral column grows quicker in length than the spinal cord. The spinal cord is fixed at its rostral end and thus the lower end of the spinal cord comes to lie higher in comparison with the surrounding vertebrae.

The roots of spinal nerves must run downward for a certain distance in the vertebral canal to reach their point of exit. The more caudal nerve roots take a progressively more oblique direction, so that the lumbar and sacral nerves pass almost vertically downward for a distance before reaching their corresponding foramina.

General arrangement of the grey and white matter

In the central position we can find the central canal, in man it is completely obliterated. The central canal is enveloped by a roughly H- or butterfly-shaped grey matter surrounded by a mantle of white matter.

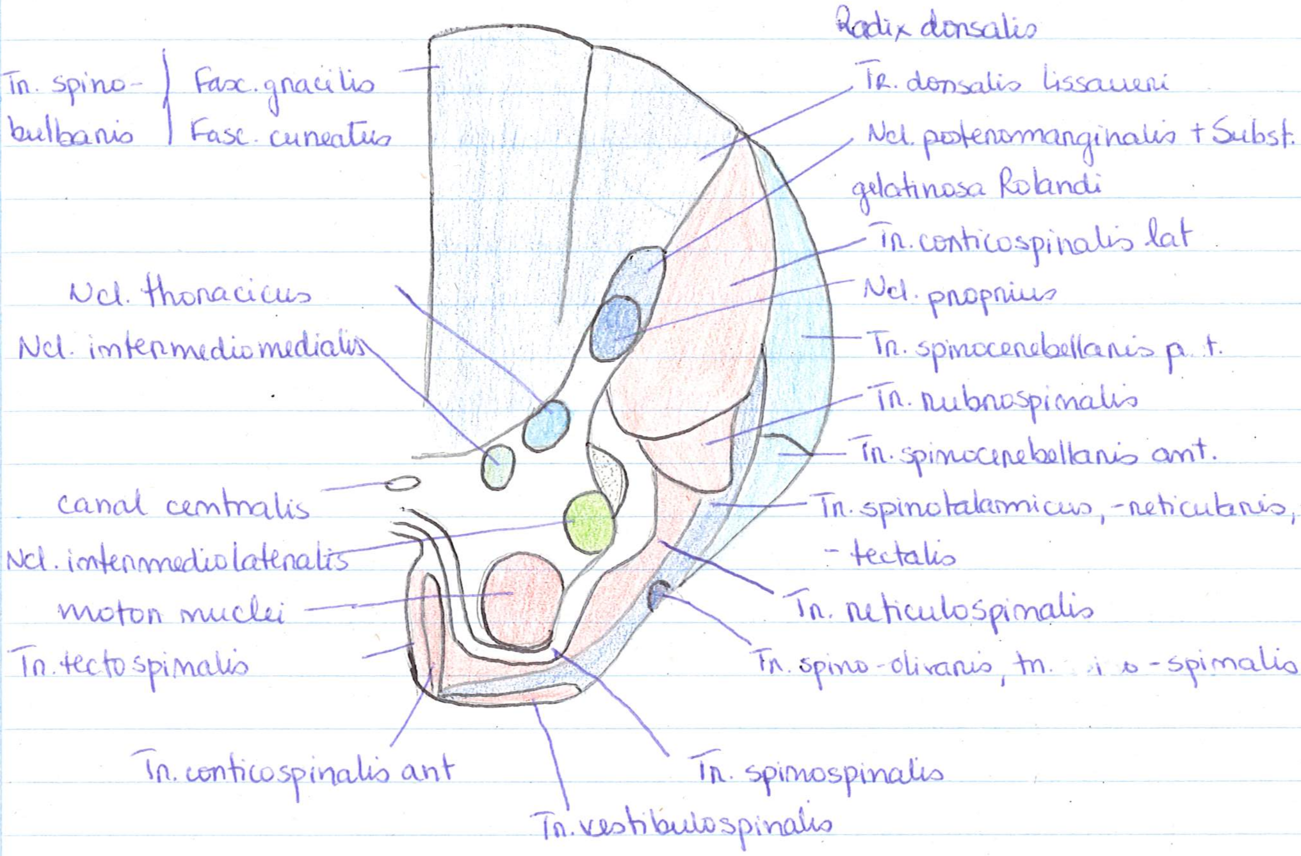
THE GRAY MATTER - the grey matter is generally composed of the neuron bodies and their dendrites. The grey matter on each side of the spinal cord consists of dorsal or ventral horns and intermediate zone. The dorsal horn extends posterolaterally almost to the surface, while the ventral horn extends ventrally but does not reach the surface. The dorsal horn is derived from the alar plate and contains neurons of the afferent system. The ventral horn, the basal plate derivative, contains motor neurons.

In the thoracic and upper lumbar segments (Th1-L2), the lateral horn is added, containing sympathetic neurons that give rise to preganglionic sympathetic fibers that run through ventral roots and project to various sympathetic ganglia.

More or less definite clusters of the neurons extending longitudinally are referred to as the nuclei. A nucleus consists of a mass of neurons with common morphological characteristics, which give rise to axons that usually follow a common path, have a common termination, and subserve the similar function.

THE WHITE MATTER - The white matter of the spinal cord is located superficially and is composed of bundles of myelinated axons that are either ascending or descending in paired funiculi which are limited by longitudinal furrows. The white matter between the posteromedian and each dorsolateral sulcus is the paired posterior funiculus. In the cervical and upper thoracic segments the posterior funiculus is subdivided into the fasciculus gracilis and fasciculus cuneatus by the intervening groove called the dorsal intermediate sulcus. The anterolateral funiculus is located between the posterolateral sulcus and anterior median fissure. The surface of this funiculus is subdivided by the ventrolateral sulcus the position of which is indicated by the exit of the ventral roots of the spinal nerves.

The bundles of myelinated axons of both motor and sensory neurons which have the same origin and target are termed as tracts. In contrast, bundles of myelinated axons from the neurons of various sources and having different targets are usually described as fasciculi.



29. The medulla oblongata (surface anatomy and structures)

The medulla extends from the decussatio pyramidum to the caudal margin of the pons. It is the place for outlet of the hypoglossal (n. XII), accessory (n. XI), vagus (n. X) and glossopharyngeal (n. IX) cranial nerves.

The longitudinal grooves of the spinal cord (the anterior median fissure, posterior median sulcus, anterior and posterior lateral sulci) extend on the surface of the medulla oblongata.

In the ventral view, the anterior funiculi are thicker to form the pyramids on both sides of the anterior median fissure. It is interrupted by the pyramidal decussation at the lower border of the medulla oblongata.

The anterior lateral sulcus is site of output of hypoglossal nerve (n. XII). The olive is a bulge between the anterior and posterior lateral sulci. The accessory, vagus, and glossopharyngeal (n. XI, X and IX) nerves arise in the posterior lateral sulcus in the caudorostral arrangement, respectively.

The inferior cerebellar peduncles, are slim bands of the white matter that connect the medulla with the cerebellum.

CAUDAL SECTION THROUGH THE MEDULLA OBLONGATA

The caudal section is cut through the medulla in the level of the decussatio pyramidum and the colliculus gracilis and cuneatus. Therefore, the section can be recognized according to typical presence of the ncl. gracilis and cuneatus.

THE GRAY MATTER

Somatosensory region

The spinal tract of n. V and spinal nucleus of n. V extend to the C2 level. They are rostral equivalents of the posterolateral tract and substantia gelatinosa of Rolando.

The ncl. gracilis and cuneatus contains the second-order neurons for termination of fibers in the fasciculus gracilis and cuneatus.

Viscerosensory region

The ncl. tr. solitarius and a strip of the white matter on its surface named tr. solitarii

Visceromotor region

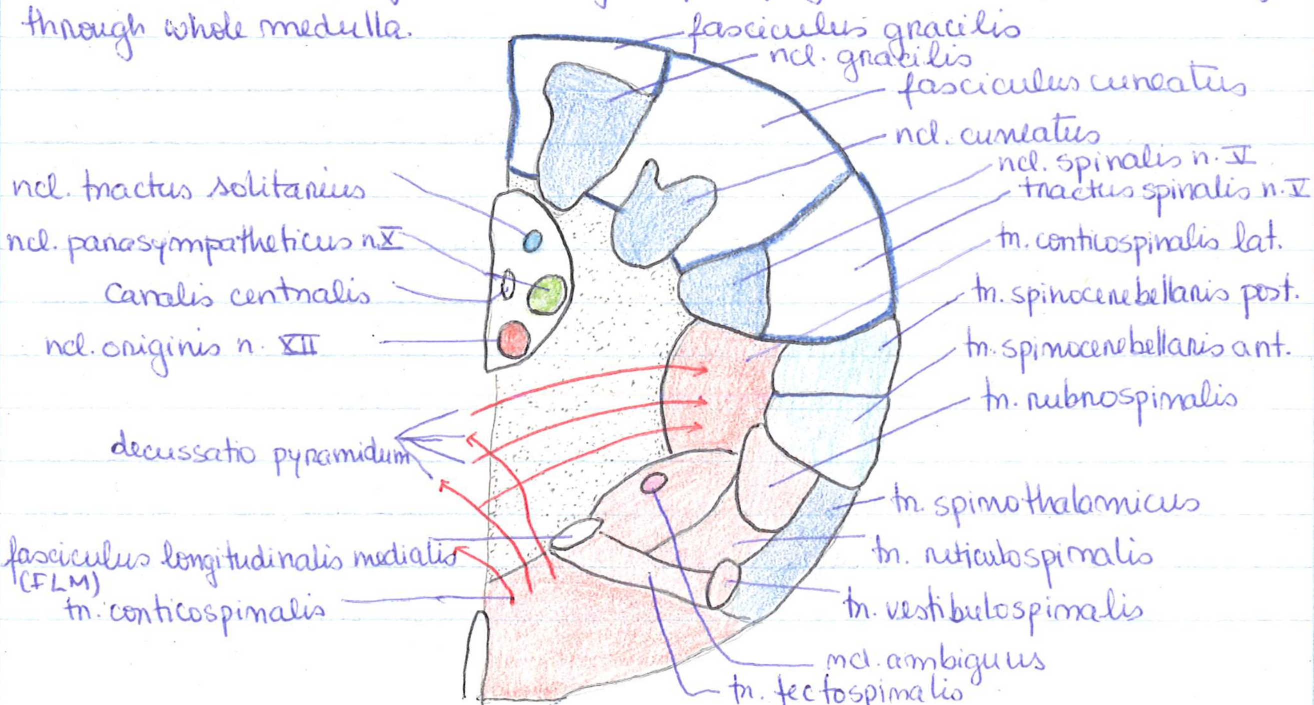
The ncl. originis dorsalis (parasympathicus) n. vagi is main source for preganglionic parasympathetic fibers of the vagus innervating the smooth muscles and glands.

Somatomotor region

The ncl originis n. hypoglossi contains the neurons that send off axons for innervation of the intrinsic tongue muscles.

Branchiomotor region

The ncl. ambiguus is a long common nucleus for motor axons in the accessory (XI), vagus (X) and glossopharyngeal (IX), nerves extending through whole medulla.



ROSTRAL SECTION THROUGH THE MEDULLA OBLONGATA

The distinguishing structural features of this level are the nuclei of the inferior olivary complex, and origin of the inferior cerebellar peduncle.

THE GREY MATTER

Somatosensory region

A continuation of the spinal tract of n. V and spinal nucleus of n. V

Sensory region

The functional region is located outside of the regular grey matter and contains the ncl. vestibularis lateralis (Deiters), medialis (Schwalbe), superior (Bechterev), inferior (Rollen).

The ncl. cochlearis dorsalis et ventralis contain the neurons that are the second-order in the cochlear (auditory) pathway.

Visceral sensory region

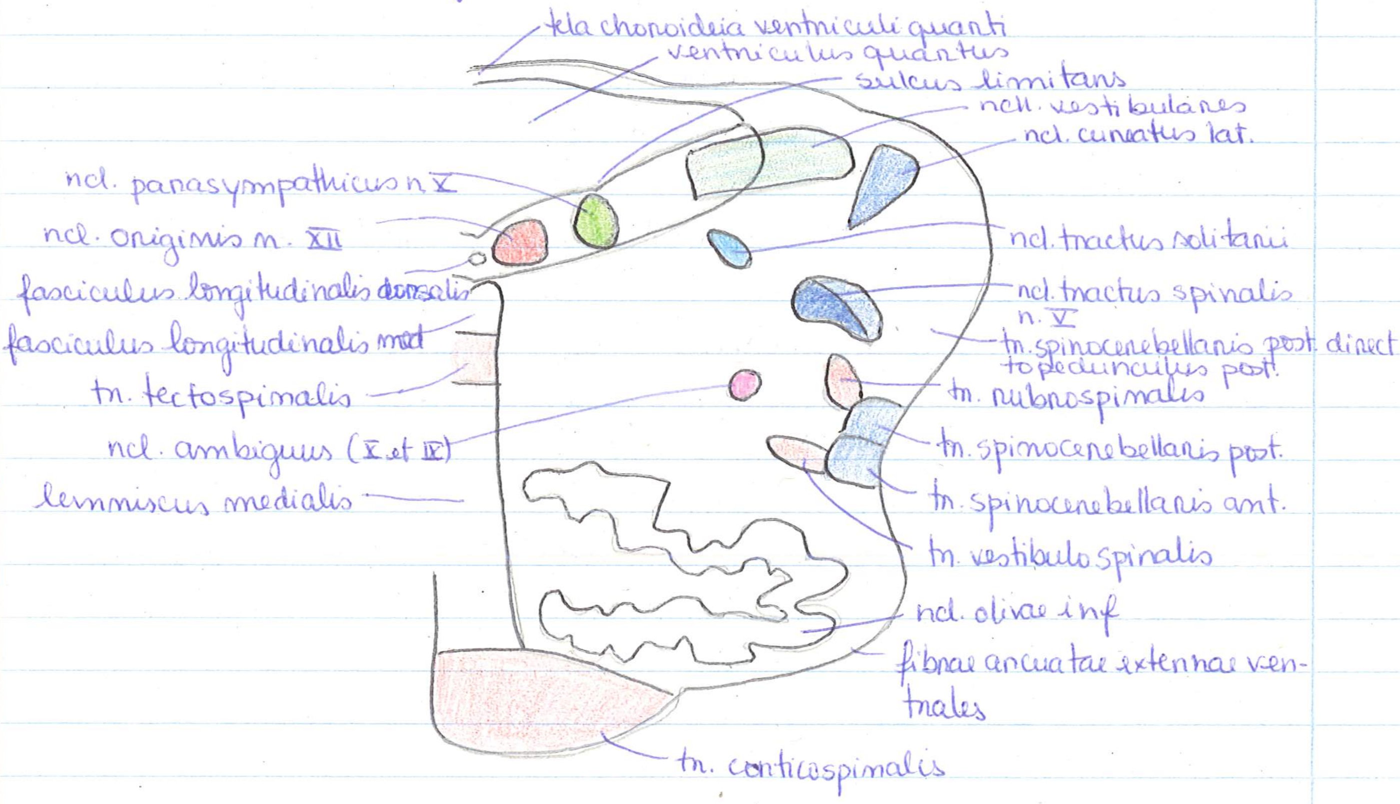
The ncl. solitarius and corresponding strip of the white matter on its surface, the tr. solitarius that contains the central arms of afferent axons from the facial (VII), glossopharyngeal (IX) and vagal (X) nerves.

Somatomotor region

A continuation of ncl. originis n. hypoglossi

Branchiomotor region

A rostral continuation of the ncl. ambiguus that is located in the reticular formation out regular grey matter. The neurons in rostral part of the nucleus constitute the ncl. originis n. X and IX



30. The pons (surface anatomy and structures)

It is source for following cranial nerves: the vestibulocochlear (n. VIII), facial (n. VII), abducent (n. VI), and trigeminal (n. V).

A mass of transverse fibres raises abundant ridges on the ventral surface. The basilar sulcus indicates a position of the basilar artery in the midline. The pons merges laterally into the middle cerebellar peduncles providing connection with the cerebellum. The dorsal surface of the pons is a part of floor of the fourth ventricle (fossa rhomboidea). The abducent nerve emerges at the caudal border, the facial and vestibulocochlear nerves emerge at the cerebello-pontine angle among the cerebellum, pons and medulla oblongata.

The ventral pons contains rostral continuation of the pyramids from the medulla and transversal fibers of the pontine nuclei directed to the cerebellum through the large middle cerebellar peduncle.

CAUDAL SECTION THROUGH THE PONS

The caudal section through the pons is recognized by presence of the internal loop of the facial nerve around the motor nucleus of the abducent nerve.

THE GREY MATTER

Somatosensory region

A continuation of the spinal tract of n. V and spinal nucleus of n. V.

Sensory region

The vestibular and cochlear nuclei. The nuclei and the tract of the auditory pathways are found at this level. The axons of cochlear nuclei run without or after relay in opposite side to constitute the lateral lemniscus located in the ventrolateral tegmentum. Auditory fibers decussating between superior olivary complexes constitute the trapezoid body.

Viscerosensory region

The ncl. solitarius and tr. solitarii for afferents from n. VII, IX, X

Visceromotor region

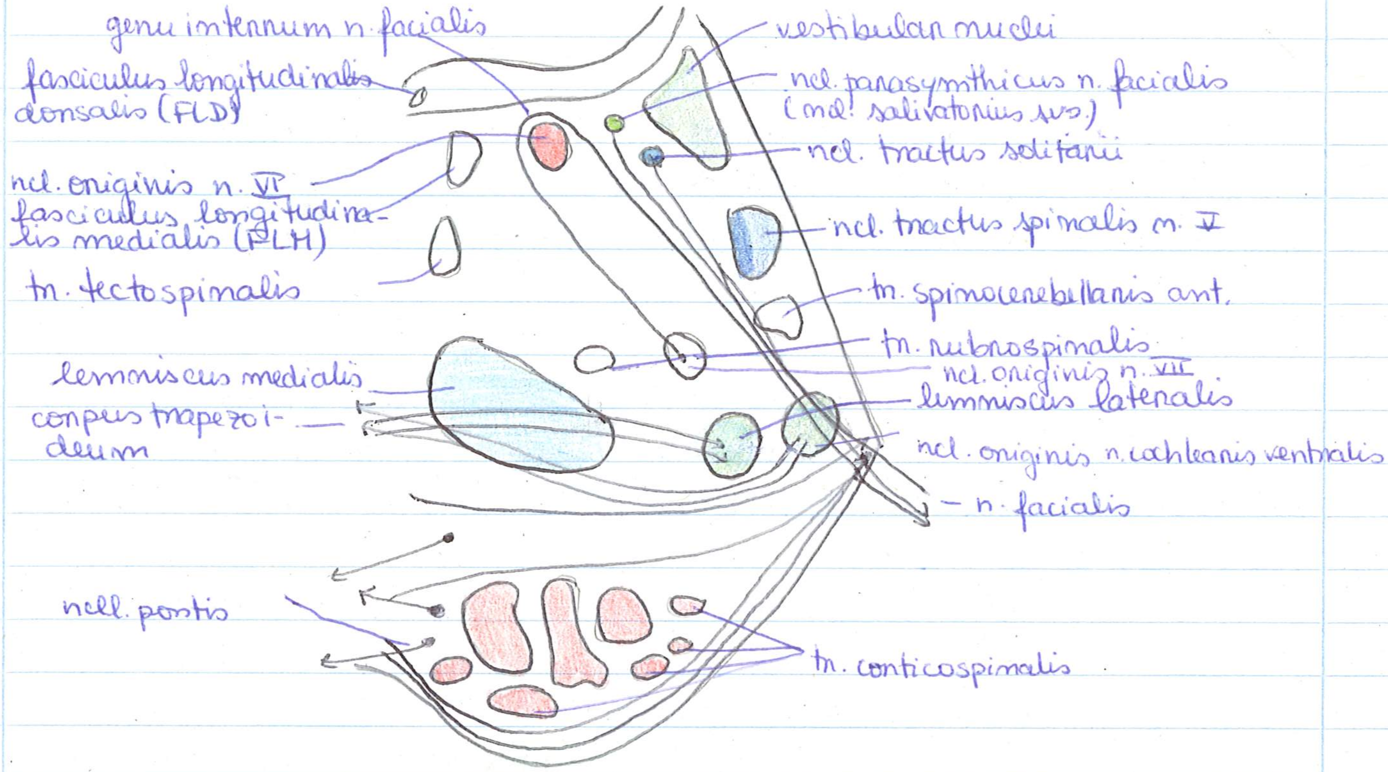
The ncl. parasympathicus n. VII (ncl. salivatorius superior) contains neurons that are source of preganglionic parasympathetic fibers for n. intermedius that is a part of the facial nerve (VII)

Somatomotor region

The ncl. originis nervi abducentis (VI) is located in the function region.

Branchiomotor region

The ncl. originis nervi facialis (VII) is present in the reticular formation.



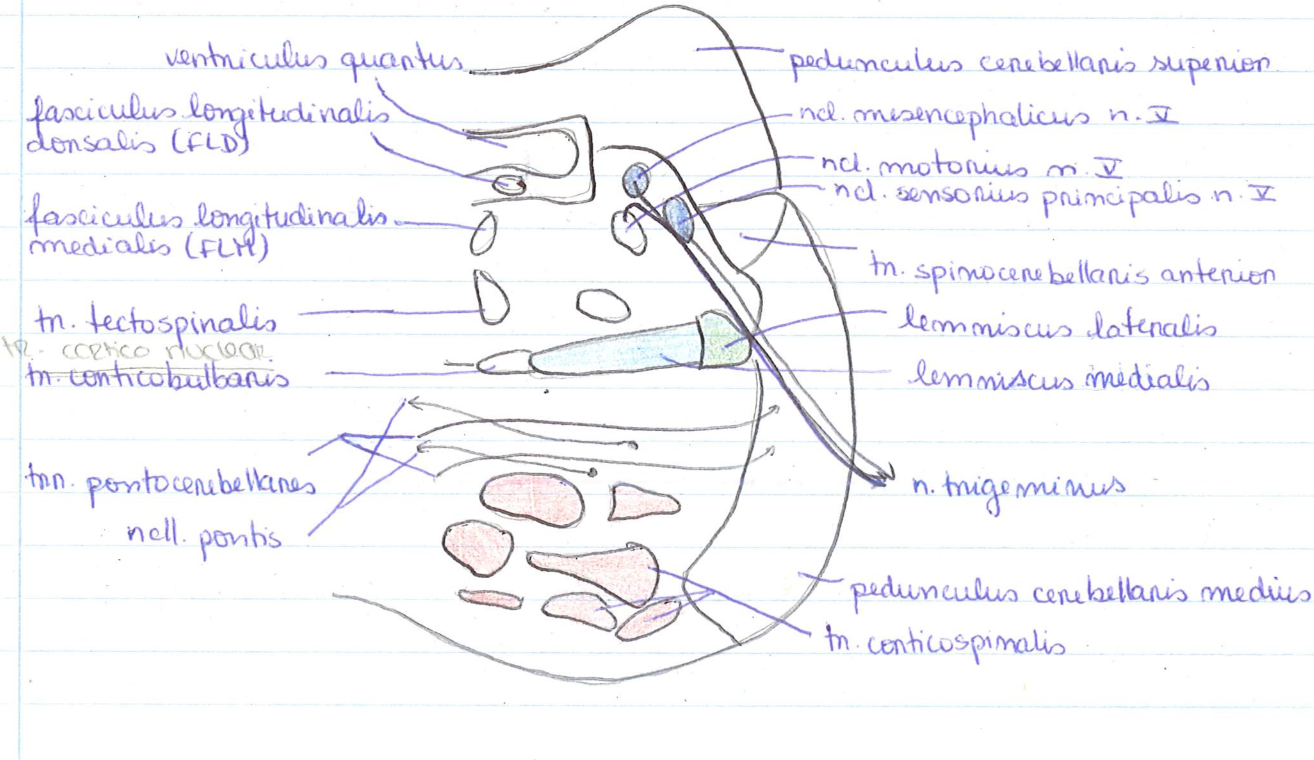
ROSTRAL SECTION THROUGH THE PONS

Somatosensory region

The region contains the principal nucleus of n. V and the beginning of the mesencephalic nucleus of n. V.

Branchiomotor region

The motor nucleus of n. V (ncl. motorius n. V) is located medial to the principal nucleus. It contains the cell bodies of lower motoneurons of the trigeminal nerve sending off axons that supply masticatory muscles, therefore, the nucleus is also termed as the masticatory nucleus (ncl. masticatorius).



31. The 4th ventricle - description of the rhomboid fossa

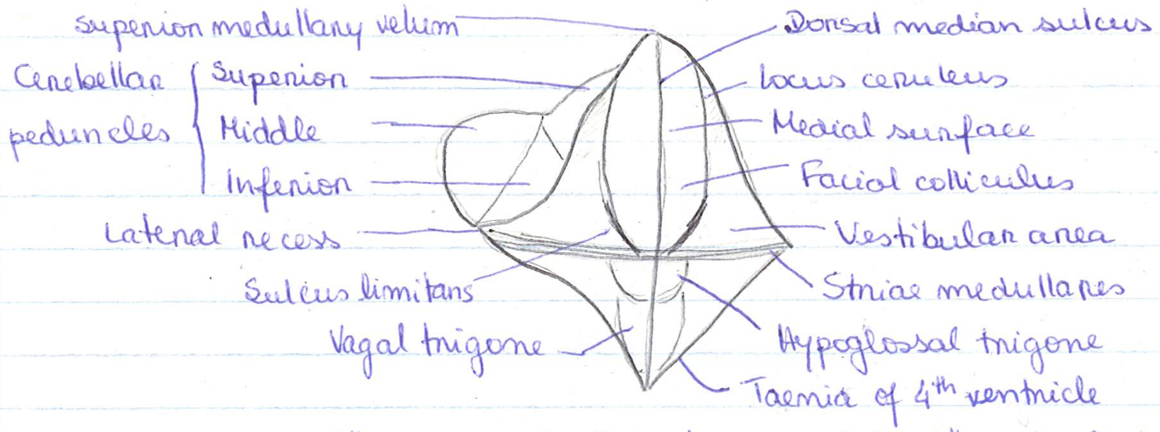
The rhomboid fossa is a floor of the 4th ventricle. It is divided into symmetrical halves by the median sulcus. The sulcus limitans divides each half into the median eminence and a lateral region called the vestibular area.

The rhomboid fossa can be divided transversely into the inferior, medial and superior parts.

Pars inferior is limited by the inferior cerebellar peduncles connecting the medulla with the cerebellum. This part contains the hypoglossal and vagal triangles corresponding with the nuclei of the same named cranial nerves, respectively.

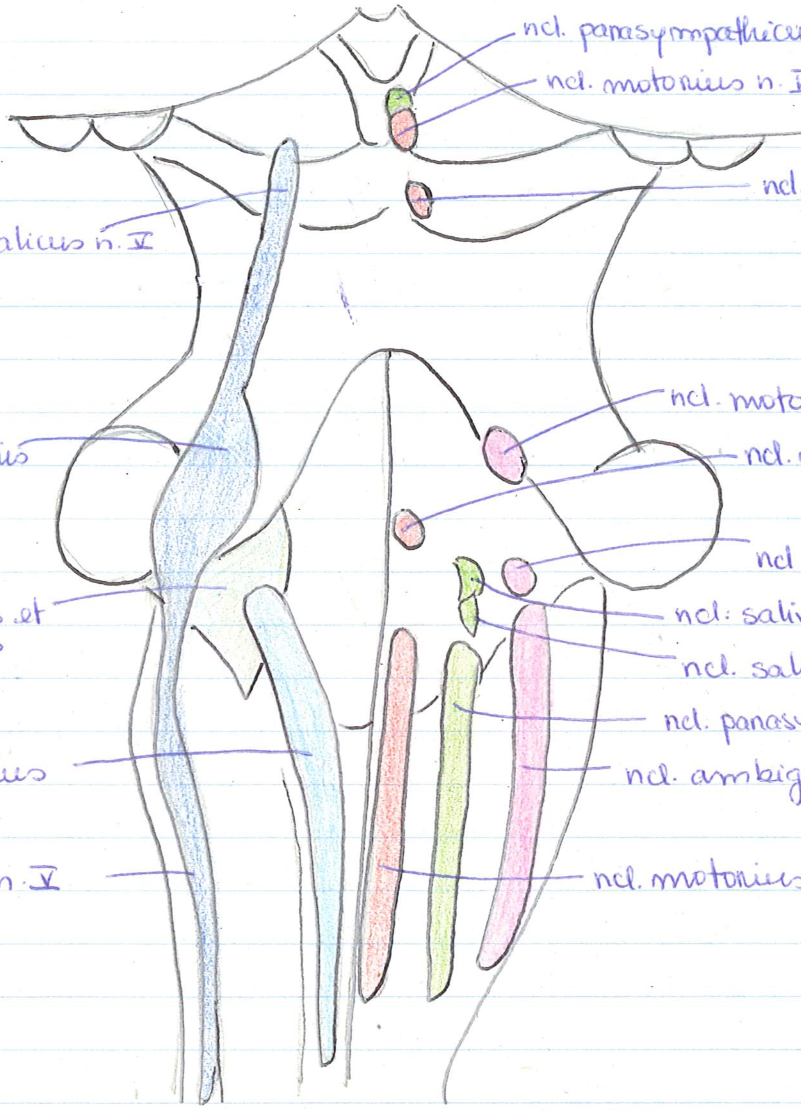
Pars medialis is extended laterally to form the lateral recess on each side. The vestibular nuclear complex is located beneath this area, therefore it is named as the vestibular area. The facial colliculus is is a slight hillock on the medial eminence. This protrusion is formed by fibers of the motor nucleus of the facial nerve looping over the abducent nucleus. Transversely coursing strands of nerve fibers form the striae medullares that run from the lateral recess toward the midline and disappear in the median sulcus.

Pars superior contains the locus ceruleus as a small grey area in medial position, indicating the site of a group of nerve cells containing melanin pigment. The pars superior of the rhomboid fossa is bounded laterally by the superior cerebellar peduncles forming connection of the midbrain with the cerebellum.



Above the 4th ventricle, the thela choroidea of the 4th ventricle is also formed as a duplication of the pia mater. The roof of the rhombencephalon becomes reduced to a thin epithelial layer and is pushed into the ventricle by the vascular loops originating from the tela. The tela choroidea of the 4th ventricle consists of pia mater only. At the attachment of the tela above a narrow medullary fold, lies the median aperture (foramen of Megendie). On both sides open the lateral apertures (foramina of Luschka), through which the lateral end of the choroid plexus protrudes

32. A survey of distribution of the cranial nuclei



33. The cerebellum (surface anatomy)

The cerebellum is the integrative organ for the coordination and fine-tuning of movement and for regulation of muscle tone and the maintenance of equilibrium. The cerebellum makes a special contribution to synergy of muscle action ensuring that there is contraction of the proper muscles at the appropriate time, each with the correct force.

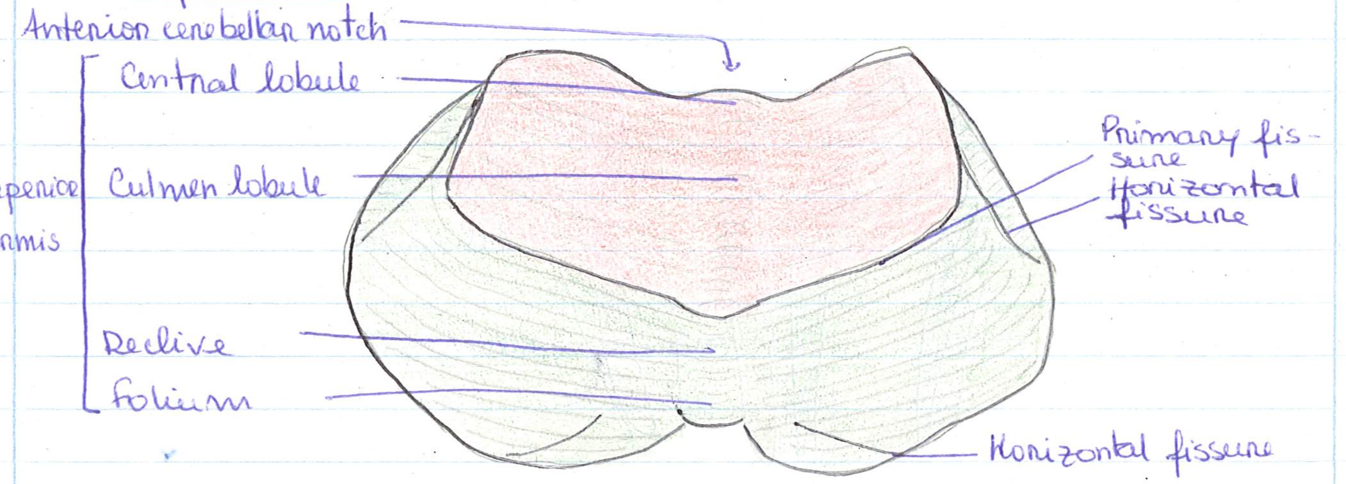
It develops from the alar plate of the brain stem. The tentorium cerebelli separates the cerebellum from the occipital lobes, and the falx cerebelli is placed in the deep posterior cerebellar fissure. The superior surface is somewhat flattened, while the inferior one is convex. A tent-shaped depression on the anterior surface (fastigium) constitutes a great part of the roof of the 4th ventricle.

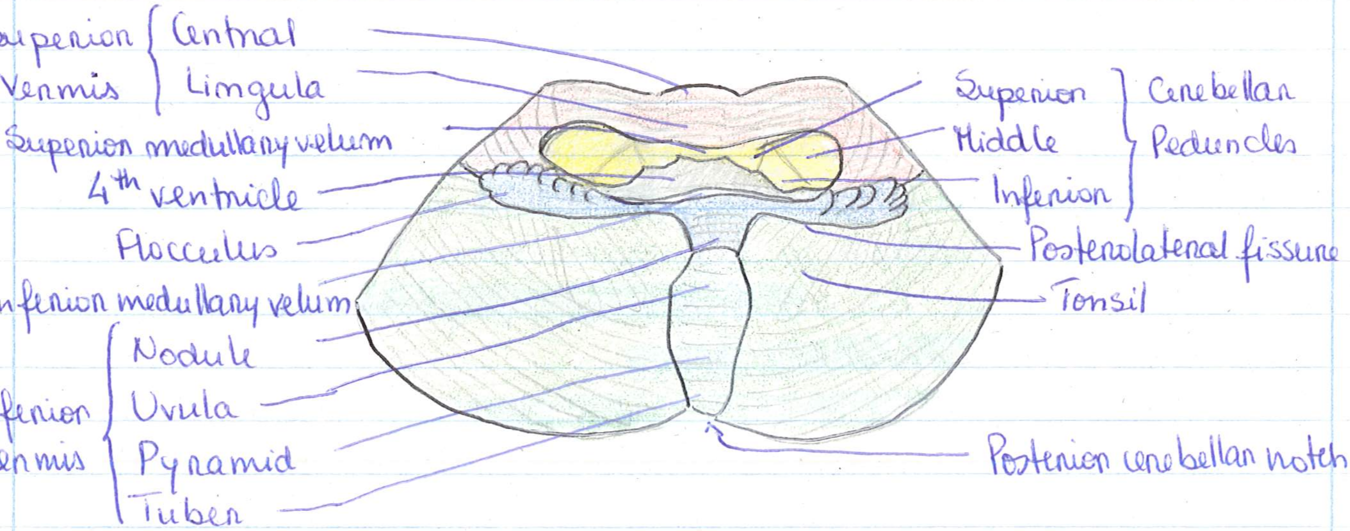
The superior surface of the cerebellum is covered by the cerebrum. Embeded into the inferior surface is the medulla oblongata. There is an unpaired central part, the vermis of the cerebellum, and the two cerebellar hemispheres. In transverse organization, the cerebellum consists of the flocculonodular, anterior and posterior lobes.

The flocculonodular lobe is a small lobe that lies at the edge of the inferior surface. The posterolateral fissure separating the flocculonodular lobe from the posterior lobe is the first fissure which appears during ontogenic development.

The anterior lobe is located rostral to the primary fissure. This, despite its name, is the second fissure which appears during embryological development.

The posterior lobe is located between the primary and posterolateral fissures.





The cerebellum lies in the posterior cranial fossa.
The surface of the cerebellum exhibits numerous narrow, almost parallel convolutions, the folia of the cerebellum.

The cerebellar grey matter is present as a cortex and four types of nuclei on each side. The cerebellar white matter is located as a medullary center, and the paired inferior, middle, and superior cerebellar peduncles.

In a midsaggital section the white and grey matter distribution resembles branches on a common trunk which have given rise to term arbor vitae.

CLINICAL REMARK - The cerebellar tonsils are often injured when a tumor or hemorrhage displace the brainstem and cerebellum downward through the foramen magnum → tonsilar herniation

THE CEREBELLAR CORTEX

The cortex lies immediatelly bellow the surface and follows the course of the sulci and folia. The cortex consists of 3 layers: the molecular, ganglionar and granular. The layers contain five main types of neurons: the stellate, basket, Purkyně, Golgi and granule cells.

- The molecular layer lies beneath the surface; it contains few cells and consists mainly of unmyelinated fibers. Among its neurons we can distinguish the scattered stellate and modified stellate cells named as basket cells; it is predominantly a synaptic layer.
- The ganglionar layer is formed by Purkyně cell bodies in a narrow layer. The Purkyně cell represents the largest and most characteristic cell of the cerebellum. The axons of these cells terminate at neurons of the cerebellar nuclei. They give off recurrent collaterals. Purkyně cells use GABA as neurotransmitter.
- The granular layer is very rich in small nerve cells. The larger Golgi cells and smaller granular cells. The axons of these cells extend into the molecular layer. The layer contains small clear "spots" called cerebellar glomeruli. It is complex of synaptic contacts formed by the granular layer cells with afferent (mossy) fibers.

Apart from the regular glial cell types there are also glial cells that are characteristic for the cerebellum: Bergmann's glia and the penniform glia of Fañanás.

The cell bodies of the Bergmann's cells lie between the Purkyně cells and send long supporting fibers vertically toward the surface, where their small end-feet form a limiting glial membrane against the meninges. Bergmann's glia begins to proliferate where Purkyně cells go dead.

⇒ Afferent fibers

The afferent fibers systems terminate in the cerebellar cortex and give off axon collaterals to the cerebellar nuclei. There are two principal types of the cerebellar afferent fibers:

1) The climbing fibers originate from neurons of the inferior olivary nucleus and terminate at the Purkyně cells. Each climbing fiber terminates at a single Purkyně cell and via axon collaterals also at some stellate and basket cells.

2) Mossy fibers terminate the spinocerebellar and pontocerebellar tracts from the contralateral nuclei of the spinal cord and also fibers from nuclei of contralateral side of brainstem and terminate in the granule cells of innermost layer.

⇒ Nuclei

Deep in the white matter are the cerebellar nuclei. They transmit together with the vestibular nuclei all outputs from the cerebellum.

✓ The fastigial nucleus lies close to the median line in the white matter of the vermis and is located close in contact with fastigium. It receives fibers from the cortex of the vermis, the vestibular nuclei, and the olive. It sends fibers to the vestibular nuclei and to other nuclei of the medulla oblongata.

✓ The globose nuclei and emboliform nuclei are located in the paramedial zone.

✓ The dentate nucleus is located in the lateral zone. The cortical fibers of the hemisphere terminate in the dentate nucleus, and fibers extend from here as superior cerebellar peduncles to the red nucleus and thalamus.

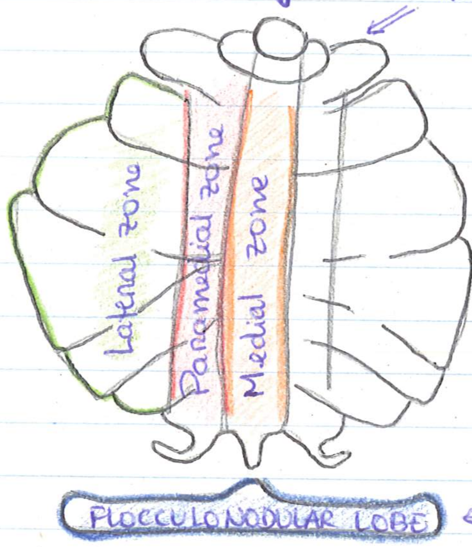
THE CEREBELLAR WHITE MATTER

• The inferior cerebellar peduncles consists of fibers entering the cerebellum, with the predominant originating in the inferior olivary complex (the olivocerebellar tract). The other afferent tracts are: the posterior spinocerebellar, cuneo-cerebellar, bulbocerebellar, vestibulocerebellar, reticulocerebellar (from the medullary reticular formation). Minor efferent fibers proceed from the flocculonodular lobe to the vestibular nuclei (the cerebello-vestibular tract) and the reticular formation in the medulla and pons (the cerebelloreticular tract).

• The middle cerebellar peduncles are formed by the fibers originating in the nuclei pontis, the bundle of these fibers is named as the ponto-cerebellar tract.

• The superior cerebellar peduncles contain mainly afferent fibers from the globose, emboliform and dentate nuclei. The afferent fibers of the peduncles include the superior spinocerebellar and rubrocerebellar tracts as well as fibers from the mesencephalic trigeminal nucleus.

CLINICAL TIP: The importance of the cerebellum in the coordination of motion becomes clear in acute intoxication. Symptoms include gait ataxia characterized by a faltering, staggering, wide-based gait. Coordinated movements such as touching the tip of the nose with the finger are impaired (dysmetria).



PHYLOGENETIC DIVISION OF THE CEREBELLUM

PHYLOGENETIC	ANATOMICAL	MAJOR CONNECTIONS	TYPE OF FUNCTION
Archicerebellum	flocculonodular lobe, lingula	vestibular nuclei	posture and eye movement
Paleocerebellum	spinocerebellum, (anterior and posterior vermis, close cortex)	spinal cord	progressive movement (walking, swimming)
Neocerebellum	pontocerebellum (lateral cortex of lobes)	cerebral cortex via ncl. pontis	manipulative movement and speech

34. The midbrain (surface anatomy and structures)

It is source of two cranial nerves: the trochlear nerve is unique cranial nerve in its appearence of the dorsal aspect of the brainstem; the oculomotor nerve originates at the ventral aspect of the mesencephalon, in the interpeduncular fossa.

The midbrain is traversed by the cerebral aqueduct (aqueduct of Sylvius) connecting the 4th and 3rd ventricles. The structure dorsal to the aqueduct are termed commonly as the tectum. It bears four rounded hillocks, the paired inferior and superior colliculi, termed together as the corpora quadrigemina. From its caudal end at medial position the frenulum veli is prolonged down over the superior medullary velum that is part of the roof of the 4th ventricle.

Both pairs of colliculi are constituted by the corresponding nuclei that are involved in the interconnection of the auditory (inferior) and visual (superior) pathway. Fibers connecting the nucleus colliculi inferioris with the specific thalamic nucleus (the medial geniculate nucleus) form the elevation called the inferior brachium. On the other hand, the superior brachium contains the axons proceeding from the the cerebral cortex and the retina to the superior colliculi nucleus.

The major portion of the midbrain at the ventral surface is occupied by the cerebral peduncles with the interpeduncular fossa between them. The internal side of each peduncle bear a medial sulcus, from which the oculomotor nerve emerges. Many small blood vessels penetrate the bottom of the interpeduncular fossa to form the posterior perforated substance.

For descriptive purposes structures of the midbrain are divided into the following regions:

- the tectum or roof, which is special to this part of the brainstem, consists of the paired inferior and superior colliculi (corpora quadrigemina).
- the crus cerebri contains a dense mass of descending fibers in the ventral part of the pedunculi cerebri.
- the tegmentum, a remainder of the midbrain mass between the tectum and the crura cerebri contains:
    - the central grey matter, including the reticular formation, surrounding the cerebral aqueduct called as periaquaeductal grey matter
    - the prominent red nuclei
    - the substantia nigra appears as a prominent zone of grey matter, immediately dorsal to the crus cerebri.

The term cerebral peduncle refers to all structures of the midbrain, of each side, exclusive of the tectum.

CAUDAL SECTION THROUGH THE MIDBRAIN

The caudal section is cut through the inferior colliculi which is involved in auditory pathways to the cortex.

THE GREY MATTER

Somatosensory region

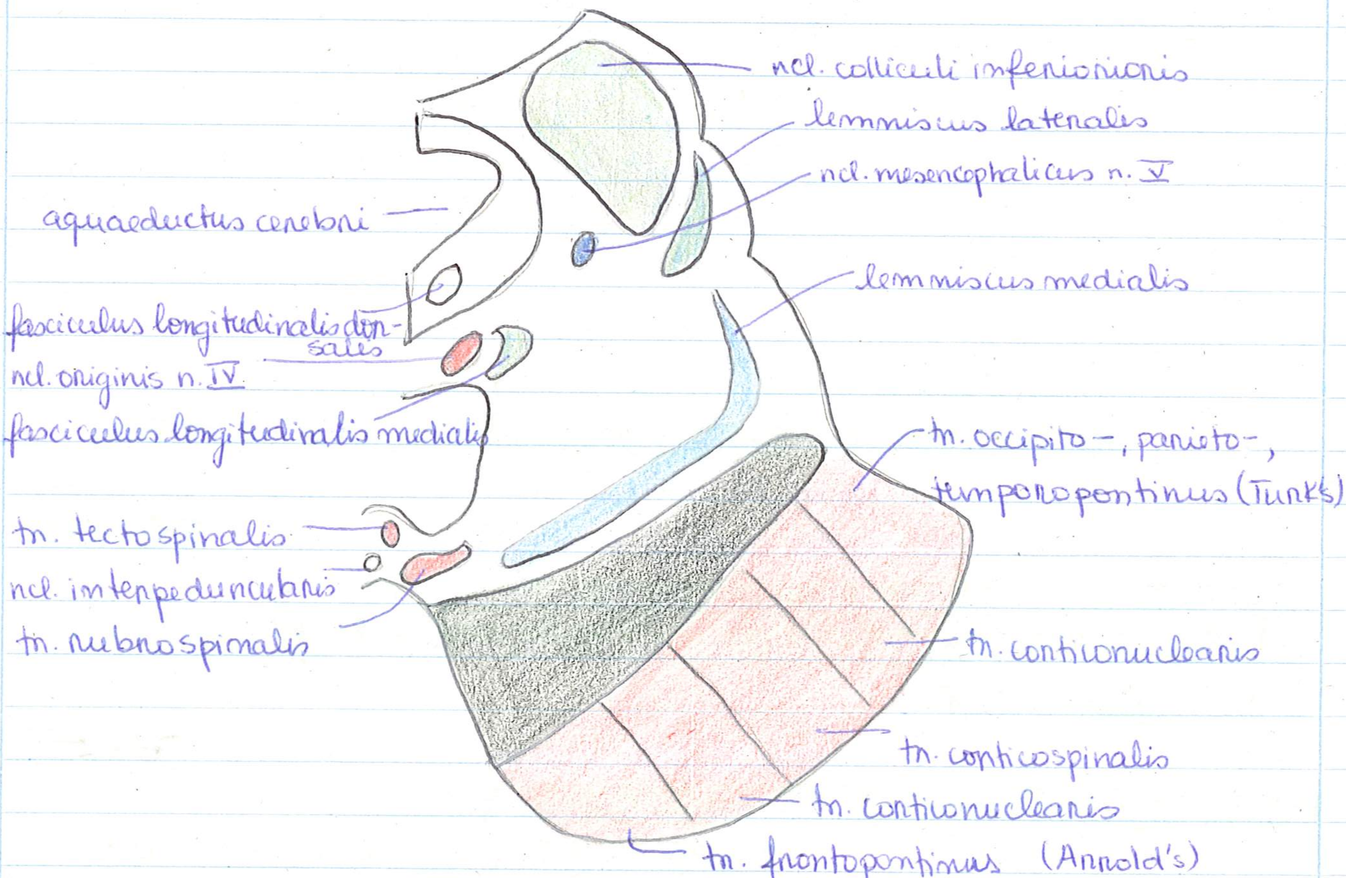
The ncl. mesencephalicus n. V continues from the pons. It contains pseudounipolar primary sensory neurons that are involved in proprioception from the masticatory muscles.

Sensory region

The ncl. colliculi inferioris is involved in the auditory pathways to the cortex. It receives input from ascending auditory fibers on the lateral lemniscus and descending fibers of the medial geniculate body.

Somatomotor region

The ncl. originis n. trochlearis, the fibers emerge the brainstem in the dorsal surface.



ROSTRAL SECTION THROUGH THE MIDBRAIN

The rostral section is cut through the paired superior colliculi

THE GREY MATTER

Somatosensory region

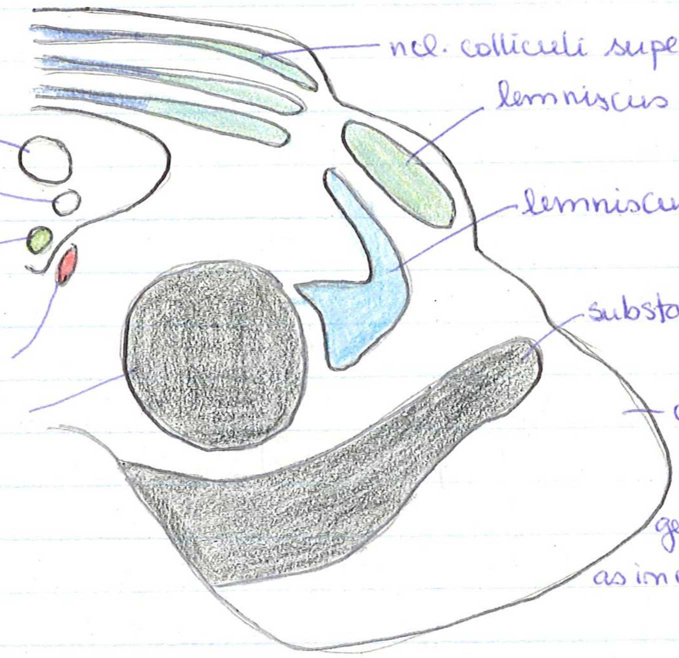
The colliculus superius nuclei is laminated into seven alternating layers of the white and grey mater. The superficial grey matter layers receive direct input from the retina and the visual cortex. The deep layers receive inputs from the auditory and somatosensory system.

Visceromotor region

The ncl. parasympathicus n. III (Edinger-Westphal nucleus) is origin of preganglionic parasympathetic fibers in the oculomotor nerve of each side.

Somatomotor region

The ncl. originis n. III, the neurons of which send off fibers innervating the extraocular muscles



35. The diencephalon (surface anatomy and its partition)

The diencephalon and telencephalon together constitute the cerebrum, of which the diencephalon forms the central core. The diencephalon is almost completely surrounded by the cerebral hemispheres. In addition, the diencephalon contains the slit-like space of the third ventricle with its thin floor. The third ventricle divides most structures of the diencephalon into two symmetric halves.

The diencephalon consists of four components on each side - the thalamus, hypothalamus, subthalamus and epithalamus.

- The epithalamus is a relay station for pathways between the olfatory centers and the brain stem, and of the pineal gland (epiphysis cerebri)
- The dorsal thalamus is the terminal station of sensor pathway (cutaneous sensibility; taste; visual; acoustic; and vestibular pathways). It is connected to the cerebral cortex by efferend and afferent fiber systems.
- The subthalamus is the continuation of the midbrain tegmentum. It may be regarded as the motor zone of the diencephalon.
- The hypothalamus is derived from the lowest layer and forms the floor of the diencephalon from which the neurohypophysis protrudes. It is

the highest regulatory center of the autonomous nervous system.

The ventral view

The mamillary bodies (corpora mamillaria) are two round hillocks about 5 mm in diamater placed close to the midline between the cerebral peduncles.

The infundibular stem is a conical outgrowth projecting downward from the median eminence just behind the optic chiasma. The infundibular stem is expanded to form the infundibular process which is terminated in the posterior lobe of the pituitary body (the hypophysis cerebri).

The tuber cinereum is a protrusion of grey matter on the dorsal slope of the infundibulum.

The dorsal and medial view

The thalamus is an egg-shaped mass of the diencephalon originating from the alar plate. Its superior surface bears a rounded prominence named as the pulvinar thalami. The sulcus terminalis is a groove between the thalamus and caudate nucleus (telencephalon) contain thalamostriate vein. Close to the sulcus terminalis we can find a strip of fibers called the stria terminalis.

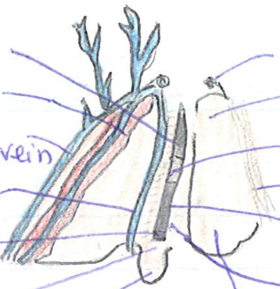
The medial surface of the thalamus forms the wall of the third ventricle. A boundle of fibers called the stria medullaris thalami constitutes an edge along the connection of the medial and superior surfaces of the thalamus. The trigonum habenullae is a dorsal triangular enlargement of the stria medullaris thalami on both sides. The habenular triangles of both sides are connected to to each other by the habenular commissure.

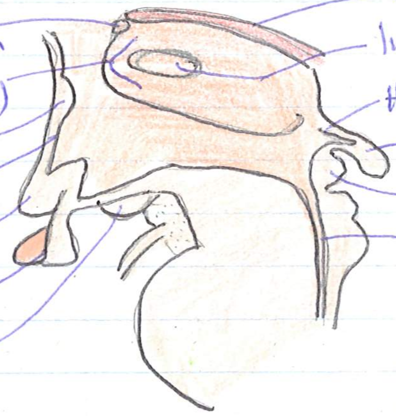
The posterior commissure is a bundle of white fibers that forms a cylinder crossing midline above the confluence of aqueduct with the 3rd ventricle.

The pineal body (corpus pineale) shaped like a pine cone is a glandular structure about 8 mm long.

The medial surfaces of both thalami are joined with the adhesio interthalamica across the ventricle.

The hypothalamic sulcus indicates the boundary between dorsal thalamus and hypothalamus located below this shallow groove. The hypothalamus forms the inferior and rostral part of the wall of the third ventricle and its floor including the externally visible structures: the mammillary bodies, infundibulum, tuber cinereum, hypophysis, and optic chiasma.





36. The thalamus, its nuclei and their functional function

The dorsal thalami are two large, ovoid nuclear complexes. Their medial surfaces form the wall of the third ventricle, while their lateral surfaces border on the internal capsule. They extend from the interventricular foramen (foramen of Monro) to the qudrigeminal plate of the midbrain.

The thalamus is a fine relay station where ascending pathways terminate before their transmission to the cerebral cortex. The thalamic neurons are organized in more or less distinct nuclei that receive all sensory pathways. The thalamus has significant roles in circuits of motor circuits.

The thalamus is connected to the cerebral cortex by the corona radiata. The fibers run obliquely through the internal capsule toward the cerebral cortex. The more prominent bundles are the anterior thalamic radiation (to the frontal lobe), the superior thalamic radiation (to the parietal lobe), the posterior thalamic radiation (to the occipital lobe), and the inferior thalamic radiation (to the temporal lobe).

A primary division of the thalamus is created by lamellar white matter complex with a rostral bifurcation, internal medullary lamina, dividing the thalamus into three main groups of nuclei: anterior, medial and lateral.

The anterior nuclear group is located in bifurcation of the internal medullary lamina.

The medial group of nuclei is mainly composed of the dorsomedial nucleus (DM). It is made up of several smaller nuclei with different morphological and physiological properties.

The lateral group is subdivided into ventral and dorsal rows.

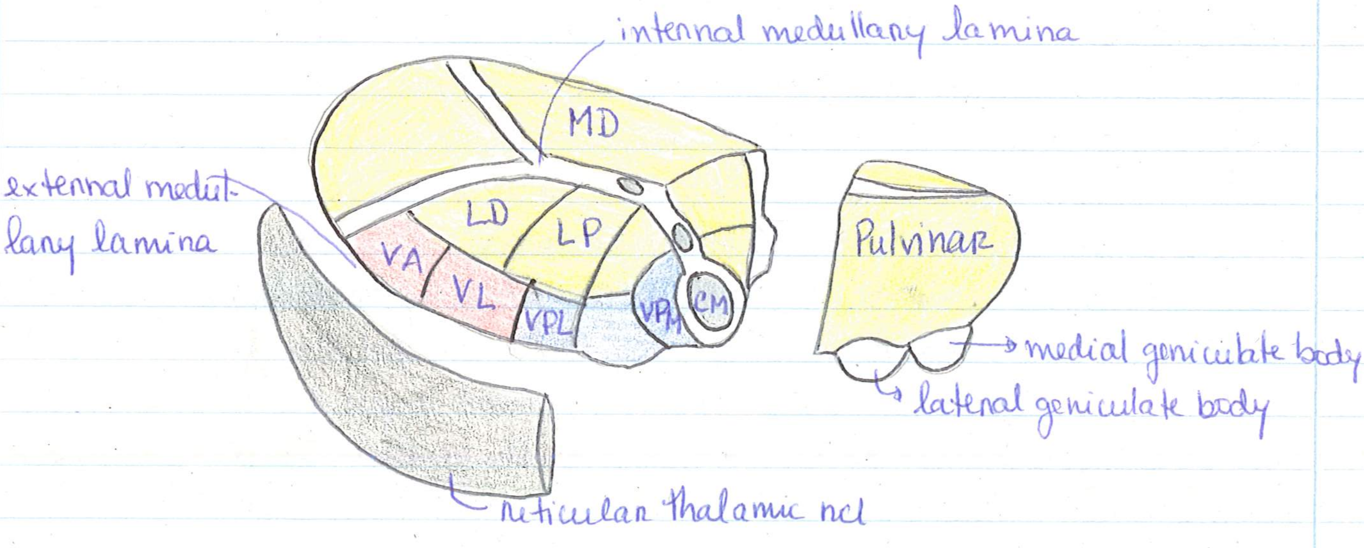
The ventral row includes also the medial geniculate (hearing) and lateral geniculate (vision) bodies located below the pulvinar. Rostrally in the ventral row there are the following nuclei: ventral posterior (VP), ventral lateral (VL) and ventral anterior (VA). The VP nucleus is subdivided into the ventral posterolateral (VPL) and ventral posteromedial (VPM) nucleus.

The nuclei of the dorsal row include the lateral dorsal (LD), lateral posterior (LP), and pulvinar (P) nuclei.

At the rostral end of the thalamus there is the reticular nucleus extending along the lateral aspect. The external medullary lamina is a thin layer of nerve fibers that covers the lateral surface of the thalamus and separates the reticular nucleus from the proper thalamus.

The intralaminar nuclei are present within the internal medullary lamina; one nucleus of this complex, the centromedian (CM) nucleus is well developed in humans.

The midline thalamic (paraventricular) nuclei are situated adjacent to the third ventricle



THE SPECIFIC RELAY NUCLEI

⇒ The specific sensory nuclei of the thalamus

The lateral geniculate body receives input from the retina via the optic tract and has reciprocal connections with the primary visual cortex

The medial geniculate body receives input from both ears via the fibers of the inferior brachium (brachium colliculi inferioris) and from the auditory cortex. The efferent fibers project to the primary auditory cortex and to the colliculi inferiores.

The ventral posterolateral (VPL) nucleus receives information by the spinothalamic tract (light touch, pain and thermal sense from the body) and by the medial lemniscus (pressure and vibratory sense from body).

The ventral posteromedial (VPM) nucleus is a nucleus of termination of the taste pathway from the solitarius nucleus and the trigeminothalamic pathway (somatosensory modalities from the head).

⇒ The specif motor nuclei of the thalamus

The ventral anterior (VA) nucleus receives afferents from the globus pallidus and projects to the prefrontal cortex.

The ventral lateral (VL) nucleus is an integral nucleus in the feedback circuits of cerebral and cerebellar cortex and cerebral cortex and cerebral cortex and basal ganglia

NON-SPECIFIC NUCLEI

The intralaminar and midline (paraventricular) nuclei have afferents from the brainstem reticular formation as well as other thalamic nuclei. The efferents project mainly to the neostriatum (ncl. caudatus and putamen) and back to other thalamic nuclei. The collateral branches of these efferents project diffusely to the cortex. This cortical projections is anatomical basis for consciousness and degrees of alertness. It also provides for vague awareness of sensory stimulation without specificity on discriminative qualities but with emotional responses, especially to painful stimuli.

The reticular nucleus has predominant input from cerebral cortex and other thalamic nuclei. Despite the name the nucleus is NOT involved in the ascending reticular activating system (ARAS). All the specific thalamic nuclei are associated with corresponding regions in the reticular nucleus, which must somehow modify the exchange of signals between the thalamus and cortex. The reticular nucleus is though to be a morphological portion of the reticular formation; it is associated with the zona incerta, which is rostral continuation of the reticular formation into the subthalamus.

ASSOCIATION NUCLEI

The association nuclei have extensive reciprocal connections with the association areas of the cerebral cortex.

The dorsomedial nuclei receive inputs from the olfactory and limbic systems and have output with the entire prefrontal cortex.

The pulvinar, lateral dorsal and lateral posterior nuclei have reciprocal connections with association cortex of the occipital, parietal and temporal lobes.

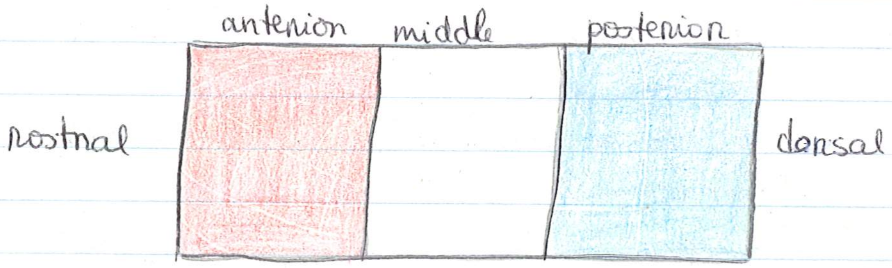
The anterior group of nuclei has reciprocal connections with the mammillary bodies (hypothalamus) and the cyngulate gyrus. They are integrated into the circuit of the limbic system and seem to have a function in relation to memory.

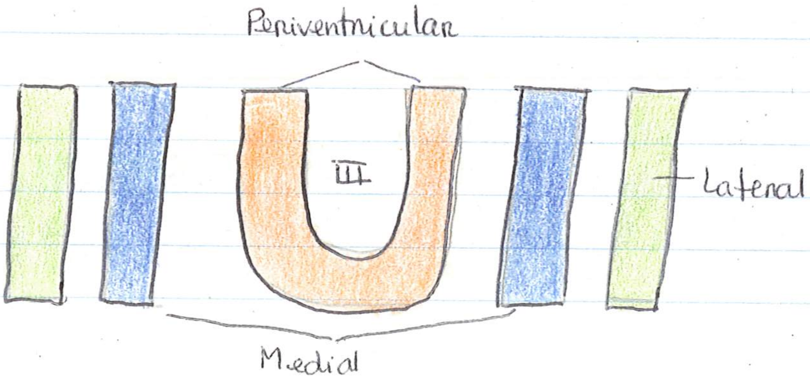
37. The hypothalamus and its nuclei

The hypothalamus forms the lowest layer and the floor of the diencephalon, consisting of the optic chiasm, the tuber cinereum tapering into the funnel-shaped infundibulum (hypophysial stalk), and the mammillary bodies.

It influences not only the autonomic nervous system but also the endocrine system via its connection to the hypophysis, and it coordinates the two.

The can be divided in the rostro-dorsal direction into anterior (suprachiasmatic), middle (tuberal) and posterior (mammillary) regions. Accordingly, we can say also about the anterior, middle and posterior hypothalamus.





An imaginary division into a periventricular, a medial, and a lateral zone in the frontal section through each region is very useful.

The periventricular nuclear zone borders the walls of the 3rd ventricle. A thin layer of cells contains most of the neurosecretory neurons regulating the anterior pituitary functions. The nuclear zone consists of paired suprachiasmatic and unpaired arcuate nucleus.

The columns of the fornix traverse the hypothalamus to reach the mammillary bodies. The structure divides each half of the hypothalamus into medial and lateral zones of nuclei.

The medial zone consists of medial preoptic, supraoptic, anterior, paraventricular, ventromedial, dorsomedial and mammillary nuclei.

The lateral zone contains the lateral tuberal nuclei as well as tuberomammillary nucleus.

⇒ THE ANTERIOR (SUPRACHIASMATIC) REGION

The periventricular zone of the anterior hypothalamus contains the suprachiasmatic nucleus. Axons of retinal origin convey visual information from both the retina and lateral geniculate body, and they are terminated on neurons of the nucleus. The nucleus serve as a circadian rhythm generator for many functions, including the sleep-wake-fulness rhythm. The suprachiasmatic nucleus has a special relation to the pineal gland.

The medial zone contains:

- The ... preoptic nucleus and adjacent anterior hypothalamus, which are involved in sexual and maternal behaviour. The preoptic nuclei are also implicated in the integration of several homeostatic functions including temperature regulation.
- The supraoptic nucleus consists of large neurons
- The paraventricular nucleus contains large neurons (magnocellular component) and a great amount of small (parvocellular component)

The large neurons of supraoptic and paraventricular nuclei elaborate neurohypophysial hormones. Axons from the neurons contribute to the hypothalamo - hypophyseal tract and terminate throughout the neurohypophysis where the hormones are released into the capillary blood.

- The anterior nucleus

→ THE MIDDLE (TUBERAL) REGION

The periventricular zone involves the arcuate nucleus, which is an unpaired nucleus. The neurons have termination on the hypophysial portal vessels in the median eminence.

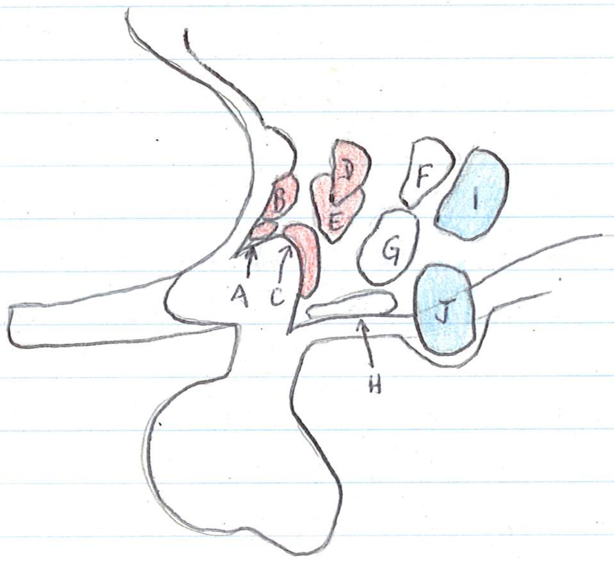
The medial zone of the middle hypothalamus contains mainly the ventromedial and dorsomedial nuclei

The lateral zone includes tuberomamillary nucleus. The large tuberomamillary neurons, which contain a number of different neurotransmitters including the histamine, are noted for their widespread connections to many parts of the CNS including the cerebral cortex.

⇒ THE POSTERIOR (MAMILLARY) REGION

The medial zone of the posterior hypothalamus consists of the posterior nucleus and the nuclear group of mamillary body.

The posterior hypothalamic nucleus is a large but poorly defined group of neurons that extend caudally into the mesencephalic reticular formation



Anterior group	Middle group	Posterior group
A. ncl. suprachiasmaticus	H. ncl. arcuatus	I. ncl. posterior
B. ncl. preopticus	F. ncl. dorsomedialis	J. ncl. mamillaris
C. ncl. supraopticus	G. ncl. ventromedialis	
D. ncl. paraventricularis	ncl. tuberomamillaris	
E. ncll. anteriores		

38. The neurohumoral function of the diencephalon and corresponding structures

Hypophysis

The hypophysis or pituitary gland is a pea-sized structure that placed in the sella turcica of the sphenoid bone. The pituitary gland comprises two anatomically and functionally different lobes: the adenohypophysis and neurohypophysis.

The adenohypophysis consists of the anterior lobe, pars tuberalis and pars intermedia. The anterior pituitary gland contains many glandular epithelial cells which form proper glandular part of the pituitary.

The neurohypophysis consists of the median eminence, infundibular stem and infundibular process. The neurohypophysis contains axons endings, blood vessels, and atypical astrocytes known as pituicytes. The median eminence and the infundibular stem are described as hypophyseotropic area.

The hypophysis is under the control of the hypothalamic centers. Unmyelinated fiber bundles from the hypothalamus run in the hypophysial stalk and in the hypophyseal posterior lobe.

Neurons in the hypothalamus produce substances that migrate within the axons into the hypophysis and enter there into the bloodstream. This endocrine function of neurons is called neurosecretion. The neurosecretory neurons function as neuroendocrine transducers that convert neural information into hormonal information.

The hypothalamus regulates endocrine activity:

- directly by neurons of the supraoptic and paraventricular nuclei that send off axons to constitute the hypothalamo-hypophyseal tract releasing hormones into capillaries of the general blood circulation within the neurohypophysis.
- indirectly via the blood vessels of the hypophyseal portal system (from the hypophyseotropic area to the adenohypophysis).

HYPOTHALAMO - HYPOPHYSEAL TRACTS

The tracts start in the supraoptic nucleus and in the paraventricular nucleus. The fibers run through the hypophysial stalk into the hypophyseal posterior lobe where they terminate at the capillaries. The hormones produced by the neurons of both hypothalamic nuclei migrate along this pathway to the axon terminals and enter from here into the bloodstream. Electrical stimulation of the supraoptic nucleus leads to an increased secretion of vasopressin (antidiuretic hormone), while stimulation of the paraventricular nucleus leads to an increased secretion of oxytocin.

At the sites of contact with axon terminals, the capillary walls lack the glial covering layer. It is here that the neurosecretory product enters the bloodstream.

The blood supply of the neurohypophysis is made by the inferior hypophyseal artery which rises from the internal carotid artery. The blood enriched by hormones streams into the cavernous sinuses.

PITUITARY (HYPOPHYSEAL) PORTAL SYSTEM

The substances produced (in the arcuate, ventromedial, dorsomedial, preoptic and paraventricular nuclei) enter from the axon terminals into the portal capillaries and pass through the portal veins into the capillary bed of the adenohypophysis. They are stimulating substances, releasing factors, which cause the release of glandotropic hormones (messengers that affect other endocrine glands) by the adenohypophysis, and release-inhibiting factors.

The superior hypophyseal artery rises from the internal carotid artery at the base of the brain and breaks up into capillary tufts and loops in the median eminence (the primary plexus). The capillaries are drained by the hypophyseal portal vein that enter the adenohypophysis, where they empty into the large capillaries or sinusoids (the second plexus) of the anterior pituitary gland.

The following hormones are produced in the pars distalis of the adenohypophysis: follicule stimulating hormone (FSH), luteinizing hormone (LH) / interstitiall cell-stimulating hormone (ICSH) in men, luteotropic hormone (LTH), thyroid-stimulating hormone (TSH); adenocorticotropic hormone (ACTH) and growth hormone (GH).

39. The reticular formation, the limbic forebrain

The reticular formation

The reticular formation is a network of intermingled neurons and fibers located among the more conspicuous white and grey matter. Extensive and widely distributed influences of this structure are involved with modulation of many physiologic and behavioral activities. The brainstem reticular formation continuous below with the cervical spinal intermediate grey matter and extends rostrally through the midbrain tegmentum to the zona incerta close to the subthalamic nucleus. The fibers of reticular formation have connections with neurons of the hypothalamus, thalamus, cerebellum, cerebrum and spinal cord.

Somatosensory and viscerosensory information reaches the neurons via spinoreticular fibers and sensory cranial nerves. They also receive information from many parts of the CNS, including the motor cranial nerves nuclei, cerebellum, hypothalamus, basal ganglia and cerebellar cortex.

Based on a classic division, the brainstem reticular formation is divisible into longitudinal columns: one median and paired medial and lateral.

The median column of reticular nuclei is placed in the midline and collectively is termed as the raphe nuclei. The raphe magnus nucleus is a prominent part of the pontine reticular formation. All raphe nuclei provide mainly serotominergic descending pathways terminating in the brainstem and spinal cord. Raphespinal projections are involved as a pain control.

The medial reticular column contains mainly the medullary and pontine gigantocellular (magnocellular) nuclei. Afferents to these nuclei include the spinoreticular projections and those from sensory of the cranial nerves. Efferents of the medial reticular nuclei project to the thalamic, mainly to the intralaminar nuclei. Serotominergic, noradrenergic, and histaminergic pathways, as well as the cholinergic ascending pathways related to the ascending activating system (ARAS), are also component of the medial reticular column.

Ascending activating system is a physiologic concept based on the presence of an arousal region in the brainstem. Many of the brainstem cholinergic pathways reach the intralaminar nuclei which project to the cerebral cortex. The ascending activating system, including direct cortico-reticular and indirect reticulo-thalamic-cortical pathways, is primarily responsible for the conscious state which is a prerequisit for cortical perception. Clinical observations give convincing evidence that the reticular formation is crucial structure for maintaining a state of wakefulness.

The lateral part is regarded as an association area.

The mesencephalic raphe system is interconnected rostrally with the limbic system, septum, prefrontal cortex and hypothalamus.

THE LIMBIC SYSTEM

The phylogenetically old parts of the parts of the telencephalon, together with its border zones and its connections to subcortical centers, are collectively known as the limbic system.

The cortical regions belonging to the limbic system form a C-shaped complex on the medial aspect of the hemisphere that consists of the parahippocampal gyrus, the cingulate gyrus and the subcallosal area (parolfactory area) – OUTER ARCH.

The INNER ARCH consists of archicortical and paleocortical regions, namely, the hippocampal formation, the fornix, the septal area, diagonal band of Broca and the paraterminal gyrus. An important component is also the amygdala. Some subcortical nuclei with close fiber connections to the limbic cortex are included in the system such as the mamillary bodies, the anterior nuclei of thalamus, the habenular nucleus, and additionally in the midbrain the posterior tegmental nucleus, the anterior tegmental nucleus and the interpeduncular nucleus.

The limbic system is connected with the olfactory centers through several fiber bundles. The fibers of the lateral olfactory stria terminate in the cortical parts of the amygdaloid body.

The limbic system influences the hypothalamus via 3 pathways:

- The fornix, the precommissural fibers of which terminate in the preoptic area and in the nuclei of the tuber cinereum
- The terminal stria which runs from amygdaloid body to the tuberal nuclei
- The ventral amygdalofugal fibers (amigdala → supraoptic nucleus)

The connection to the tegmental nuclei of the midbrain is established through the descending bundle of the habenular nucleus and through the pathways of the mamillary body.

Papez circuit is one of the major pathways of the limbic system and is chiefly involved in the cortical control of emotion and also plays a role in storing memory. The efferent fibers of the hippocampus reach the mamillary body through the fornix. Here the impulses are relayed to the bundle of Vicq d'Azyr which extends to the anterior nuclei of thalamus. The latter project to the cortex of the cingulate gyrus from where the cingulate fiber bundles return to the hippocampus.

Connections of the neocortex to the limbic system exist especially via the entorrhinal area in the parahippocampal gyrus which projects to the hippocampus.

40. Division of the telencephalon, surface anatomy of the hemispheres

GENERAL DISTRIBUTION OF THE GRAY AND WHITE MATTER

The grey and white matters of cerebral hemispheres are arranged as follows: a mantle of the grey matter on surface is named as the pallium or cerebral cortex; the underlying white matter. Internally located grey matter separated by intervening white matter laminae, collectively known as the basal ganglia or striatum.

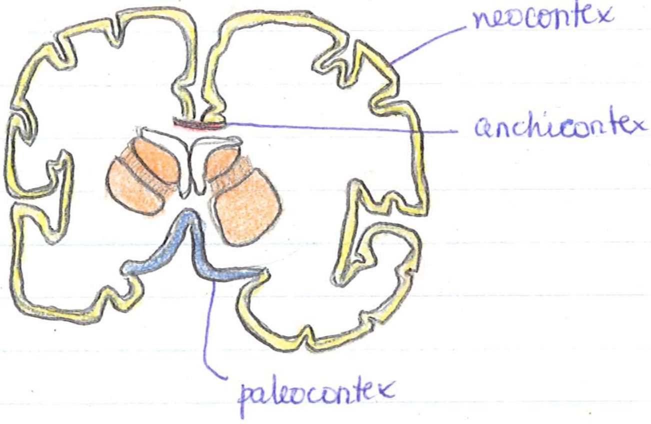
The pallium is a wall of the hemisphere

The paleo- and archicortex have 3 layers of neurons. Both are named as the allocortex. Neocortex is regularly 6-layered and referred as the isocortex.

The paleocortex is the oldest cortex placed in the floor of hemispheres. The paleocortex together with the olfactory bulb and the adjacent peripaleocortex is named as the olfactory brain, the rhiencephalon.

The archicortex is located predominantly in the medial wall of the human hemisphere which becomes rolled up to form the Ammon's horn.

The largest part of the human telencephalon is covered by the neocortex. The striatum is developed above the paleopallium.



PRINCIPAL FISSURE AND SULCI OF THE TELENCEPHALON

A deep median sagittal groove, the longitudinal cerebral fissure, divides the telencephalon in the right and left hemisphere. At the bottom of this fissure, the hemispheres are connected to each other by the great central white comissure, the corpus callosum.

The lateral sulcus (fissure of Sylvius) extends laterally between th frontal and temporal lobes. The anterior and ascending rami of this sulcus project for only a short distance into the inferior frontal gyrus. The cortex before the anterior ramis is named as the pars orbitalis, the pars triangularis is placed between the anterior and ascending rami, and the cortex behind the ascending ramus is referred as the pars opercularis.

The central sulcus (sulcus of Rolando) is an important landmark for the sensory-motor cortex because the general sensory cortex is immediately behind the sulcus and the motor cortex is closely in front of it.

The parietooccipital sulcus extends from the calcarine sulcus to the superior border and continues for a short distance on the lateral surface.

The calcarine sulcus on the medial surface of the hemisphere begins under the posterior end of the corpus callosum and follows an arched course in the occipital pole. The calcarine sulcus is an important landmark for the visual cortex, most of which lies in the walls of the sulcus.

The preoccipital notch is a small incisure on inferior surface of the hemisphere. It is a boundary between the occipital and temporal lobes.

LOBES OF THE TELENCEPHALON

The lateral and parietooccipital sulci appear early in fetal development, and are especially deep in the mature brain. These, together with the central sulcus, are the boundaries for division of the cerebral hemisphere into the frontal, parietal, temporal, and occipital lobes.

The frontal lobe occupies the entire area in front of the central sulcus and above the lateral sulcus on the superolateral surface. The inferior surface of the frontal lobe is located on the orbital plate of the frontal bone.

The natural boundaries of the parietal lobe on the superolateral surface are the central and the lateral sulci. The posterior imaginary boundary consists of a line drawn in continuation of the parietooccipital sulcus. On the medial surface the parietal lobe is separated from the frontal lobe by a line in continuation of the central sulcus. The corpus callosum is an inferior margin of the lobe.

The temporal lobe is inferior to the lateral sulcus The posterior boundary is referred a line drawn through the preoccipital notch.

An area of cortex called the insula lies at the bottom of the lateral sulcus and is hidden from surface view.

INFERIOR SURFACE OF THE TELENCEPHALON HEMISPHERES

THE FRONTAL LOBE

Most of the inferior surface of the frontal lobe consists of the orbital gyri separated from each other by the orbital sulci. The olfactory sulcus traverses the surface parallel with medial margin. It contains the slender olfactory bulb and its continuation, the olfactory tract. The gyrus rectus is a convolution on the medial side of the olfactory sulcus. The olfactory trigone, posterior to the olfactory tract, is limited on the medial side and lateral side by the stria olfactoria mediales and lateralis. The anterior perforated substance is placed behind the olfactory trigone.

THE TEMPORAL LOBE

The inferior surface of the temporal lobe is traversed by the collateral and occipitotemporal sulcus. The medial occipito temporal gyrus extends from the occipital to the temporal poles between the above mentioned sulci. The parahippocampal gyrus located medially from the collateral sulcus is terminated anteriorly as the uncus and posteriorly as the isthmus where it is continuous with the cingulate gyrus.

MEDIAL SURFACE OF THE TELENCEPHALON HEMISPHERES

The corpus callosum is the great central white commisure connecting both hemispheres. The rostrum, the genu, the trunk and the splenium are the compartments of the corpus callosum from the rostral to dorsal direction.

The preterminal gyrus and subcalosal are located in front of the terminal lamina, little below of the rostrum of the corpus callosum.

The cingulate gyrus begins beneath the genu of the corpus callosum and extends above the corpus callosum as far as the splenium. It continues to the parahippocampal gyrus through the narrow isthmus. The cingulate gyrus is separated from the corpus callosum by the callosal sulcus and by the cingulate sulcus from the neighbouring cortex.

A wedge-shaped area between the parietooccipital and the calcarine sulci is named as the cuneus.

SUPEROLATERAL SURFACE OF THE TELENCEPHALON

THE FRONTAL LOBE

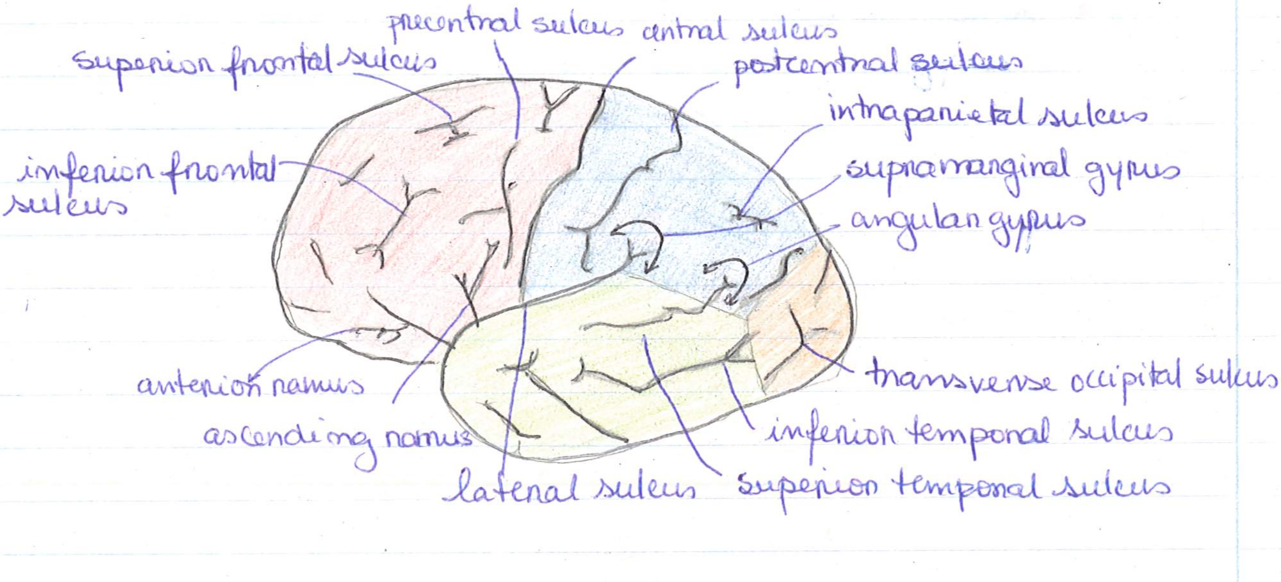
The superolateral surface of the frontal lobe is divided into 4 gyri. The precentral gyrus is located parallel to the central sulcus, rostrally limited by the precentral sulcus. The superior, midle and inferior gyri are separated by the superior and inferior sulci.

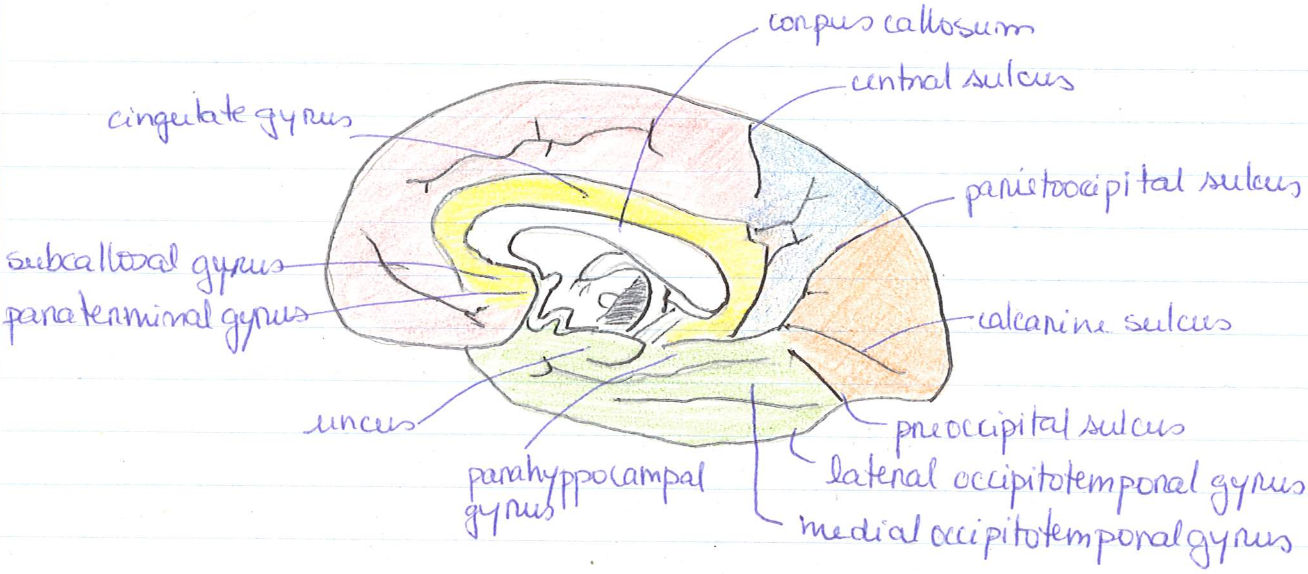
THE TEMPORAL LOBE

The temporal lobe is traversed by the superior and inferior sulci. They divide 3 parallel gyri, the superior, medial and inferior temporal gyri. Superior surface of the superior temporal gyrus is transversally grooved to the transversal gyri.

THE PARIETAL LOBE

The postcentral sulcus is posterior and parallel to the central one. The gyrus postcentralis is located between them. Remains of the surface are divided to the superior and inferior parietal lobules by the intraparietal sulcus. The supramarginal gyrus curved over the posterior end of the lateral sulcus and the angular gyrus arched over the end of the superior temporal sulcus.





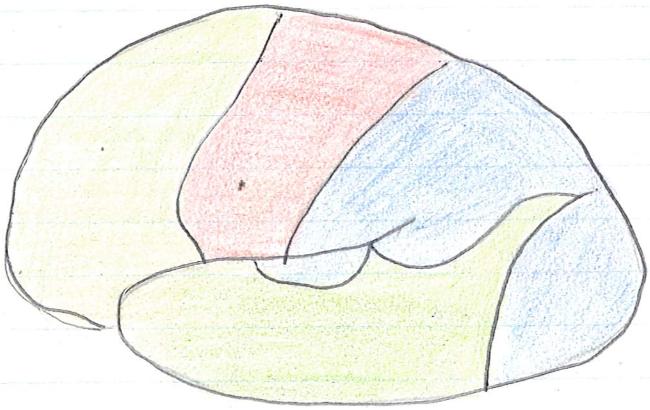
- FRONTAL LOBE
- TEMPORAL LOBE
- PARIETAL LOBE
- OCCIPITAL LOBE

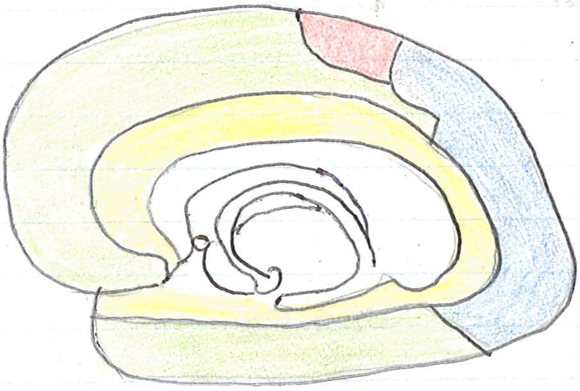
41. The cerebral cortex and its organization

On the surface of the hemisphere first there is formed a broad cellular layer, the cortical plate, which then becomes subdivided into six layers.

- Layer I - mollecular layer
- layer II - external granular layer
- layer III - external pyramidal layer
- layer IV - internal granular layer
- layer V - internal pyramidal layer
- layer VI - multiform layer

There are, however, considerable regional variations in the neocortex and a number of differently structured regions can be recognized, the cortical fields.





- MOTOR
- SOMATOSENSORY AND SENSORY
- LIMBIC FOREBRAIN
- ASSOCIATION CORTEX

ASSOCIATION CORTEX

Cortex out of the somatosensory, sensory and motor areas as well as cortex of limbic forebrain.

Injury of AC causes difficulty to test malfunction in psycho, behaviour and perception surroundings.

Brodmann's areas corresponding with main functional cortical fields

BRODMANN'S AREA	CORTICAL LOCATION	FUNCTIONAL INVOLVEMENT
a 3,2,1	postcentral gyrus	analysis of the somatosensory information
a 4,6	precentral gyrus	primary motor cortex
a 41, 42	gyri temporales transversi	analysis of the hearing
a 17	cortex parallel with the calcarine sulcus	primary visual cortex
a 18,19	cortex parallel with a 17	secondary visual cortex
a 43	caudal part of the postcentral gyrus	analysis of the taste

CORTICAL AREAS FOR SPEECH - I

Broca's motor cortical area - g. frontalis inferioris - a 44, 45

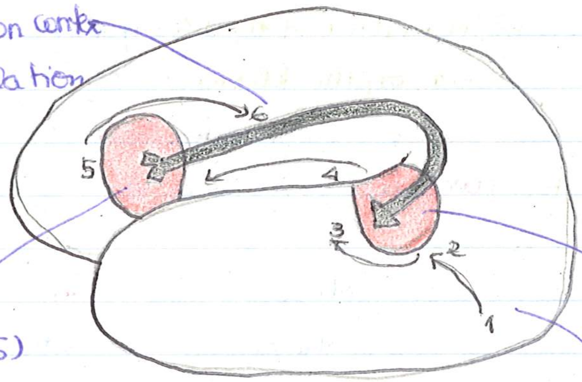
For righthanded in Left hemisphere, for left-handed in Right-hemisphere

LESION - expressive aphasia - the lack of speech, but understanding is OK

WERNICKE'S (SENSORY) CORTICAL AREA – a 22, 39, 40 in dominant hemisphere

- condition for normal function - intact visual and auditory cortex

LESION: receptive aphasia - the lack of understanding.



THE HIPPOCAMPAL FORMATION

The hippocampal formation includes the dentate gyrus, the proper hippocampus (Ammon's horn), the subicular complex (subiculum, presubiculum, parasubiculum) and entorhinal cortex.

The indusium griseum is a poorly differentiated layer of grey matter covering the superior aspect of the corpus callosum. Anteriorly, it passes around the genu and rostrum to merge with the paraterminal gyrus, which is continuous below with the diagonal band of Broca, and through this, with anterior perforate substance and periamygdaloid area. Posteriorly, the indusium griseum diverges delicate strips of grey matter curving to the posterior extremity of the dentate gyrus. Two narrow strips of fibers on each side, the medial and lateral longitudinal striae that are regarded as the reduced white matter.

The subicular complex is generally subdivided into 3 main subdivisions, namely subiculum, pre- and parasubiculum. They can be divided in 3 layers. The human enthorhinal cortex has 6 layers, but it is quite distinct from those of the other neocortical regions.

The hippocampus migrates basally from its original dorsal position and comes to lie in the temporal lobe.

It lies deep on the medial surface of the temporal lobe, largely overlain by the parahippocampal gyrus. The hippocampal formation extends to the caudal end of the corpus callosum. Here it is reduced to a thin layer of grey matter, the indusium griseum.

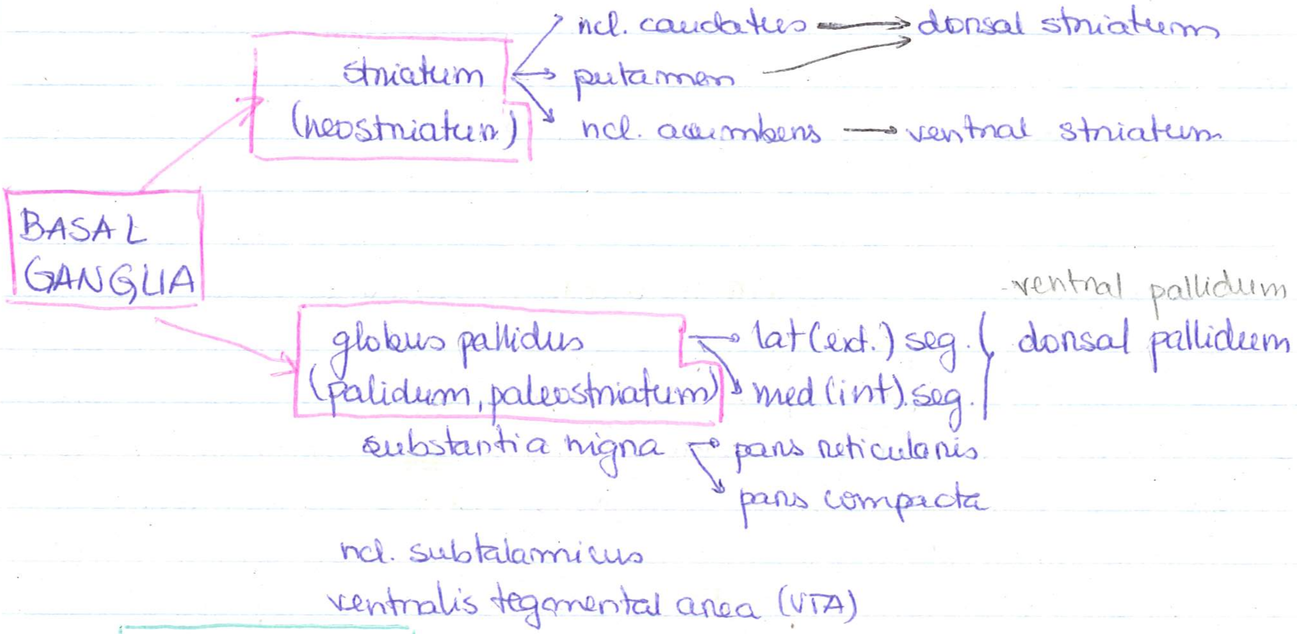
The hippocampus, formerly regarded as part of the olfactory system, has no direct connection with the sense of smell. It is an integrative organ, which influences the endocrine, visceral and emotional state through its connections with the hypothalamus, the septal nuclei and the cingulate gyrus.

42. The basal ganglia

The grey nuclear complexes which lie deep in the hemisphere are altogether called the basal ganglia.

The corpus striatum, claustrum, and amygdaloid body are sometimes referred to as the basal "ganglia" on the telencephalon. The claustrum is a thin sheet of gray matter of obscure significance situated lateral to the putamen, and the amygdaloid body in the temporal lobe is a component of the olfactory and limbic system.

Fibers connecting the cortex with subcortical centers traverse the neostriatum and run along the medial side of the smaller paleostriatum (globus pallidus) as the internal capsule.



THE NEOSTRIATUM

The caudate nucleus is an elongated, arched nucleus related throughout its extent to the surface of the lateral ventricle. The nucleus is divided into the head, corpus and tail. The head of caudate nucleus is enlarged anterior portion that lies rostral to the thalamus and bulges into the anterior horn of the lateral ventricle. The head is separated from the putamen by fibers of the anterior limb of the internal capsule. The body of the caudate nucleus extends along the dorsolateral border of the talamus, from which it is separated by the stria terminalis. The tail of the caudate nucleus is the roof of the inferior horn of the lateral ventricle. A tip of the tail comes into relationship with the amygdaloid complex.

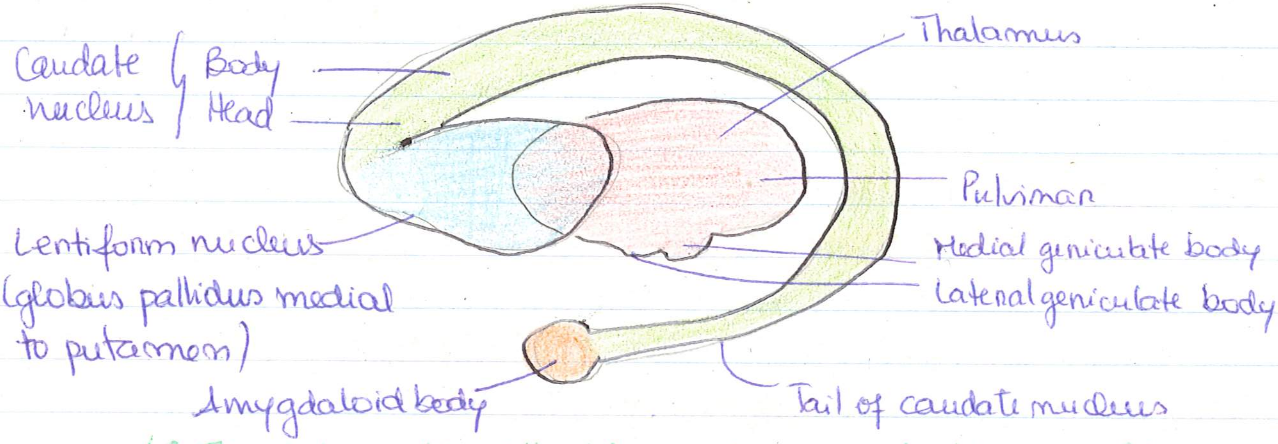
THE PALEOSTRIATUM

The nucleus is divided to a lateral part and a medial part. The globus pallidus and the putamen form a structural complex named as the lentiform nucleus.

The anterior limb of the internal capsule is located between the head of the caudate medially, and the lentiform nucleus laterally. The posterior limb of the internal capsule separates the lentiform nucleus on the lateral side from the thalamus on the medial side. The strip of white matter between the lentiform nucleus and claustrum is referred to as the external capsule while the claustrum is separated from the insular cortex by the extreme capsule.

THE AMIGDALOID NUCLEAR COMPLEX

The amygdaloid nuclear complex is a gray mass situated in the mediodorsal portion of the temporal lobe rostral to the tip of the inferior horn of the lateral ventricle and of the tail of the caudate nucleus. The amygdaloid nuclear complex is comprised of a number of irregularly shaped nuclei. The amygdaloid complex is subdivided into two main nuclear groups: the corticomedial group and the basolateral group.



4.3. The white matter of the telencephalon, classification of the fibres

A broad area of white matter myelinated nerve fibers lie between the cerebral cortex and the deep grey nuclei. The fibers arise either from cortical nerve cells or terminate on them: there are three different fiber systems: projection, association and commissural fibers.

PROJECTION FIBERS capsula interna !!

Projection fibers connect the cerebral cortex with the subcortical centers, either as ascending systems, which end in the cortex, or as descending systems which extend from the cerebral cortex to the deeper centers.

Descending tracts which arise from the diverse cortical regions combine in a fan-shape to form the internal capsule. The ascending fibers pass through the internal capsule and radiate outward, also in a fan shape. Thus, subcortical ascending and descending fibers form a fan-like fiber mass beneath the cortex, called the corona radiata.

The frontopontine tract and the anterior thalamic peduncle pass through the anterior limb. Corticonuclear fibers lie in the region of the genu of the internal capsule. The fibers of the corticospinal tract adjoin it in the posterior limb in a somatotopic arrangement of arm, trunk and leg. The thalamocortical fibers to area 4 run through the same region, and so do the cortico-rubro and cortico-tegmental fibers which stem from area 6. The caudal part of the posterior limb is occupied by fibers from the dorsal thalamic peduncle, which run through to the postcentral region. Fibers of the posterior thalamic peduncle and the temporopontine tract run obliquely through its caudal end.

The auditory and visual radiations are amogst the most important projection tracts. The fibers of the auditory radiation arise from the medial geniculate body, extend over the lateral geniculate body, and at the lower margin of the putamen they cross the internal capsule. The visual radiation arises from the lateral geniculate body and its fibers fan out to a form a wide myelin lamella. They extend into the temporal lobes where they form the temporal genu of the visual tract. They then run in an arc around the inferior horn of the lateral ventricle and pass through the white matter of the occipital lobe to the calcarine sulcus.

ASSOCIATION FIBERS

Association fibers connect the various parts of the cortex to each other and commissural fibers connect the cortex of the two hemispheres. We distinguish short and long association fibers. The short association fibers, arcuate fibers, provide connection within one cerebral lobe or from one convolution to the next. The shortest fibers connect adjacent parts of the cortex; after running a short course in the white matter the re-enter the cortex. They are called U-fibers. The layer of U-fibers lies directly beneath the cortical layer. The long association fibers connect the various lobes of the brain.

The subcallosal fasciculus lies dorsolateral to the caudate nucleus, beneath the radiation of the corpus callosum. Its fibers connect the frontal lobes with the temporal and occipital lobes.

The superior longitudinal fasciculus, which lies dorsolateral to the putamen, is a large association tract between the frontal and occipital lobes, and fibers pass from it to the parietal and temporal lobes. The inferior frontooccipital fasciculus, from the frontal lobes to the occipital lobes, passes through the ventral part of the extreme capsule. The inferior longitudinal fasciculus extends between the occipital and temporal lobes. The uncinate fasciculus connects the temporal and frontal cortex. Other fiber tracts are the vertical occipital fasciculus and the orbitofrontal fasciculus.

COMMISSURAL FIBERS

Interhemispheric association fibers pass through the corpus callosum, the rostral commissure and the commissure of the fornix to the collateral hemisphere. The most important commissure of the neocortex is the corpus callosum. The fibers of the corpus callosum spread through the white matter of both hemispheres and form the radiation of the corpus callosum. The fibers which run through the genu of the corpus callosum and join the two frontal lobes are called the forceps minor whilst those which pass through the splenium and join the two occipital lobes are called major forceps.

44. The internal capsule of the cerebrum

In horizontal section, the internal capsule forms an angle which has an anterior limb, limited by the head of the caudate nucleus, the pallidum and the putamen. The genu of the internal capsule lies between the two limbs. The various fiber tracts pass through specific parts of the internal capsule.

45. The ventricles of the central nervous system and the cerebrospinal fluid

The central nervous system (CNS) is completely surrounded by the cerebrospinal fluid which also fills the inner cavities of the brain, the ventricles.

The ventricular system consists of four ventricles, namely the two lateral ventricles of the telencephalon, the third ventricle of the diencephalon, and the fourth ventricle of the rhombencephalon (pons and medulla oblongata). The two lateral ventricles are connected with the third ventricle by the interventricular foramen (foramen of Monro) located on each side in front of the thalamus. The third ventricle, in turn, communicates with the fourth ventricle through a narrow channel, the cerebral aqueduct (aqueduct of Sylvius).

The lateral ventricle has a semicircular configuration with a caudally directed spur. We distinguish the following parts:

- The anterior horn, frontal horn in the frontal lobe is bordered laterally by the head of the caudate nucleus, medially by the septum pellucidum and dorsally by the corpus callosum
- The narrow central part above the thalamus
- The inferior horn, temporal horn, in the temporal lobe

• The posterior horn, occipital horn, in the occipital lobe.

The lateral wall of the third ventricle is formed by the thalamus with the intertalamic adhesion and the hypothalamus. The optic recess and the infundibular recess project rostrally, and the suprapineal recess and the pineal recess do so caudally.

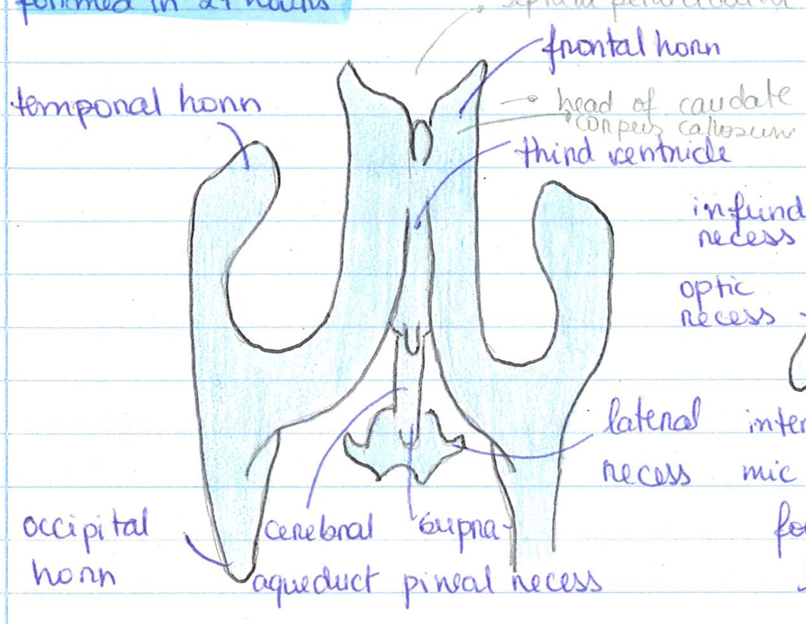
The fourth ventricle creates a tent-shaped space above the rhomboid fossa between cerebellum and medulla oblongata; on both sides, it sends out a long lateral recess. At the end of each lateral recess is the lateral aperture of the fourth ventricle (foramen of Luschka). At the attachment of the inferior medullary velum lies the median aperture (foramen of Magendie).

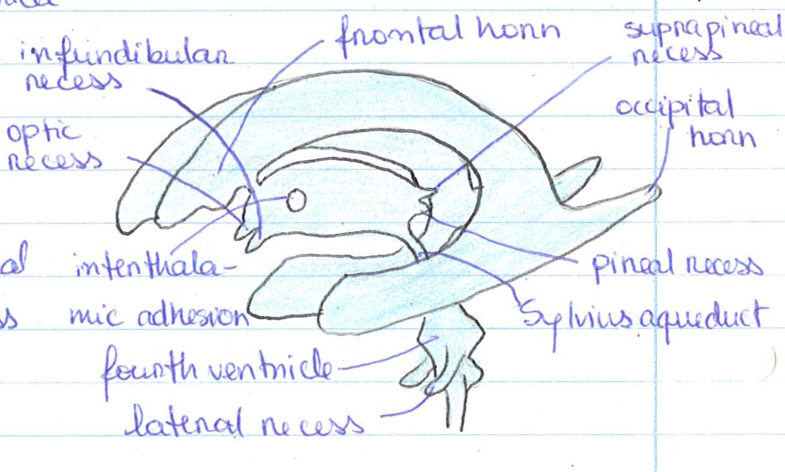
The Cerebrospinal Fluid

The cerebrospinal fluid is produced by the choroid plexus.

The choroid plexus consists of convolutions of blood vessels protruding into the ventricles from specific parts of the wall. All vascular convolutions are covered by a layer of epithelial cells, the plexus epithelium. Thus, the adult choroid plexus consists of two components, namely, the vascularized connective tissue of the pia mater and the plexus epithelium (transformed hemispheric wall). Once the choroid plexus has invaginated into the ventricular cavity, it remains connected with the external pia mater only through a narrow channel, the choroid fissure. The line of attachment is called taenia.

The CSF flows from the lateral ventricles into the third ventricle, and from there through the aqueduct into the fourth ventricle. Here it passes through the median and lateral apertures into the external cerebrospinal fluid space. NUMBERS: TOTAL: 80-150 ml; VENTRICULAR SYSTEM: 15-40 ml; 500 ml formed in 24 hours





46. The blood supply of the central nervous system

ARTERIAL SUPPLY OF THE BRAIN

The brain is supplied by the paired internal carotid and vertebral arteries through an extensive system of their branches.

✓ Internal carotid system

The internal carotid artery runs through the carotid canal in the base of the skull and enters the middle cranial fossa on both sides of the sella turcica. It continues forward in the cavernous venous sinus and then turns upward on the medial side of the anterior clinoid process to constitute the "carotid siphon". Close to the anterior perforated substance it is divided into the middle and anterior cerebral arteries.

The internal carotid artery before the terminal bifurcation gives rise to the following branches:

• HYPOPHYSIAL ARTERIES

These arteries originate from the cavernous and postclinoid portions of the internal carotid artery. In addition the supplying the infundibular process of the neurohypophysis. They enter the median eminence of the hypothalamus.

• OPHTALMIC ARTERY

This branch comes off immediately after the internal carotid artery enters the subarachnoid space. The ophtalmic artery passes through the optic foramen into the orbit, supplying the eye and other orbital contents, frontal area of the scalp, frontal and ethmoid paranasal sinuses, and parts of the nose.

• POSTERIOR COMMUNICATING ARTERY

Arises from the internal carotid artery close to its terminal bifurcation. The posterior communicating artery runs backward to join the proximal part of the posterior cerebral artery. The connection between the internal carotid and vertebral artery system at inferior surface of the brain is described as the arterial circle (circle of Willis)

• THE ANTERIOR CHOROIDAL ARTERY

This branch comes off the distal part of the internal carotid artery on the beginning of the middle cerebral artery. The artery passes back along the optic tract and the choroid fissure at the medial edge of the temporal lobe. In addition to supplying the choroid plexus in the temporal horn of the lateral ventricle, the anterior choroid artery gives off branches to the optic tract, uncus, amygdala, hippocampus, globus pallidus, lateral geniculate nucleus, and ventral part of the internal capsule. The further distribution of this artery varies considerably, but additional branches have been traced into the subthalamus, ventral portion of the thalamus, and rostral part of the midbrain including the red nucleus.

CLINICAL REMARK - The anterior choroidal artery is said to be prone to thrombosis because of its small caliber and rather long subarachnoid course. The globus pallidus and the hippocampus, both of which are supplied in part by the anterior choroidal artery, are considered to be predominant sites of neuronal degeneration as a result of circulatory deficiency (stroke).

• MIDDLE CEREBRAL ARTERY

The middle cerebral artery is a larger and more direct continuation of the internal carotid artery. Frontal, parietal, and temporal branches emerge from the stem of the middle cerebral artery and ramify over the superolateral surface of the cerebral hemisphere.

CLINICAL REMARK - Occlusion of the artery therefore results in contralateral paralysis most noticeable in the lower part of the face and arm, together with general sensory deficits of the cortical type. Occlusion of a branch of the middle cerebral artery in the left hemisphere is the principle cause of aphasia.

• ANTERIOR CEREBRAL ARTERY

The anterior cerebral artery is smaller terminal branch of the internal carotid artery. The paired anterior cerebral arteries are joined together by the anterior communicating artery. It bends backward around the genu of the corpus callosum. Branches given off just distal to the anterior communicating artery supply the medial portion of the orbital surface of the frontal lobe, including the olfactory bulb and olfactory tract.

The artery continues along the upper surface of the corpus callosum as the pericallosal artery, and a large branch, the callosomarginal artery, follows the cingulate sulcus. The anterior cerebral artery supplies thus the medial portions of the frontal and parietal lobes and the corpus callosum.

√ The vertebral system

The vertebral artery is a branch of the subclavian artery. It ascends through the foramina transversalia in the transverse processes of the upper six cervical vertebrae to reach the base of the skull. The artery is then placed in the lateral mass of the atlas (the sulcus vertebralis), pierces the posterior atlanto-occipital membrane, and penetrates into the subarachnoidal space to enter the cranium via the foramen magnum. The vertebral arteries of both sides run forward beneath the medulla, joint at the caudal border of the pons to form the basilar artery. The artery runs forward in the midline of the pons to be placed in a shallow groove on the pons, the sulcus basilaris, and terminates as the paired posterior cerebral arteries.

The vertebral arteries of both sides are united on the clivus to form the basilar artery that gives off the following branches before dividing into the posterior cerebral arteries at the rostral border of the pons.

- SPINAL ARTERIES

The upper portion of the cervical cord receives blood through spinal branches of the vertebral arteries. The single anterior spinal artery is formed by a contribution from each vertebral artery. The posterior spinal artery arises on each side as a branch of either the vertebral or the posterior inferior cerebellar artery. The posterior spinal artery descends as two branches, anterior and posterior to the dorsal roots of the spinal nerves. The anterior and posterior spinal arteries continue throughout the length of the spinal cord.

- POSTERIOR INFERIOR CEREBELLAR ARTERY

The branch is distributed to the posterior part of the cerebellar hemisphere, inferior vermis, central nuclei of the cerebellum, and choroid plexus of the fourth ventricle.

- ANTERIOR INFERIOR CEREBELLAR ARTERY

Arising from the caudal end of the basilar artery, the anterior inferior cerebellar artery supplies the cortex of the inferior surface of the cerebellum anteriorly and the underlying white matter; it contributes in the blood supply of the central cerebellar nuclei.

- LABYRINTHINE (INTERNAL AUDITORY) ARTERY

The branch of either the basilar artery or the anterior inferior cerebellar artery traverses the internal acoustic meatus and ramifies throughout the membranous labyrinth of the internal ear.

- PONTINE ARTERIES

These are thin branches arising from the basilar artery along its length. They penetrate the pons and ramify in both the ventral portion of the pons and pontine tegmentum.

- SUPERIOR CEREBELLAR ARTERY

This branch arises close to the terminal bifurcation of the basilar artery, ramifies over the dorsal surface of the cerebellum, and supplies the cortex, medullar centre, and central nuclei. Branches from the proximal part of the superior cerebellar artery are distributed to the pons, superior cerebellar peduncle, and inferior colliculus of the midbrain.

- POSTERIOR CEREBRAL ARTERY

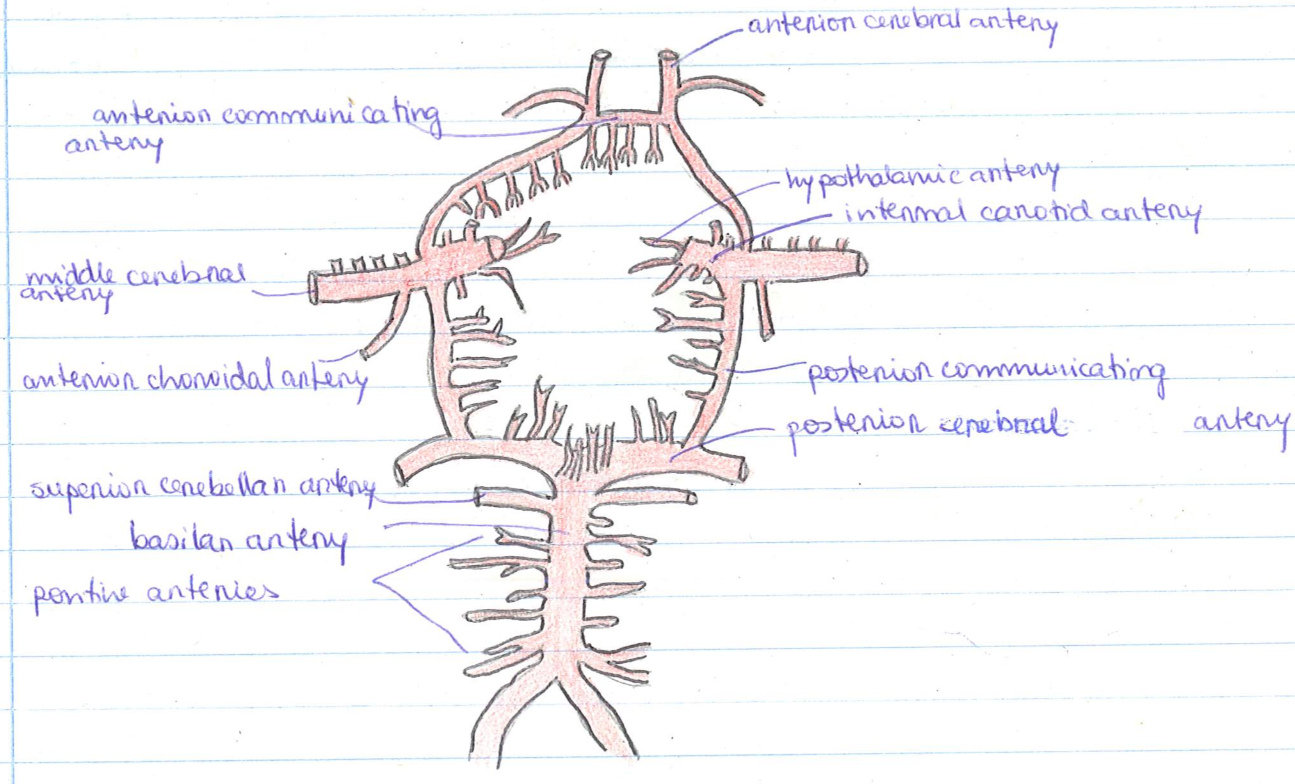
The artery gives off temporal branches, which ramify over the inferior surface of the temporal lobe, and the calcarine and parieto-occipital branches, which run along the corresponding sulci.

CLINICAL REMARK - The calcarine artery is of special significance because it supplies the visual area of cortex, and occlusion causes blindness in the contralateral field of vision.

The posterior choroid artery comes off the posterior cerebral artery in the region of the splenium and runs forward in the transverse fissure beneath the corpus callosum. The posterior choroidal artery supplies the choroid plexus of the central part of the lateral ventricle, choroid plexus of the third ventricle, posterior part of the thalamus, fornix, and tectum of the midbrain.

ARTERIAL CIRCLE (CIRCLE OF WILLIS)

Starting from the midline in front, the circle consists of the anterior communicating, anterior cerebral, internal carotid, posterior communicating, and posterior cerebral arteries. The arterial circle provides alternative routes when one of the major arterial systems is occluded.



47. The dura mater and its derivatives

The dura mater, a thick, dense, bilaminar membrane, is also called the pachymeninx. It is adherent to the internal table of the calvaria. The two layers of the cranial dura are an external periosteal layer, formed by the periosteum covering the internal surface of the calvaria, and an internal meningeal layer, a strong fibrous membrane that is continuous at the foramen magnum with the spinal dura covering the spinal cord.

The periosteal layer is attached along the suture lines and in the cranial foramina with the periosteum on the external surface of the calvaria.

Except where the dural sinuses and infoldings occur the internal meningeal layer is intimately fused with the periosteal layer and cannot be separated from it.

DURAL INFOLDINGS REFLECTIONS

The internal meningeal layer of dura mater reflects away from the external periosteal layer of dura to form dural infoldings. The dural infoldings include the:

- Falx cerebri
- Tentorium cerebelli
- Falx cerebelli
- Diaphragma sellae

The falx cerebri, the largest dural infolding, lies in the longitudinal cerebral fissure that separates the right and the left cerebral hemispheres. The falx cerebri attaches in the median plane to the internal surface of the calvaria from the frontal crest of the frontal bone and crista galli of the ethmoid bone anteriorly to the internal occipital protuberance posteriorly.

The tentorium cerebelli, the second largest dural infolding, is a wide crescentic septum that separates the occipital lobes of the cerebral hemispheres from the cerebellum. The tentorium cerebelli attaches rostrally to the clinoid processes of the sphenoid, rostrolaterally to the petrous part of the temporal bone, and posterolaterally to the internal surface of the occipital bone and part of the parietal bone.

The concave anteromedial border of the tentorium cerebelli is free, producing a gap called the tentorial notch through which the brainstem extends from the posterior into the middle cranial fossa.

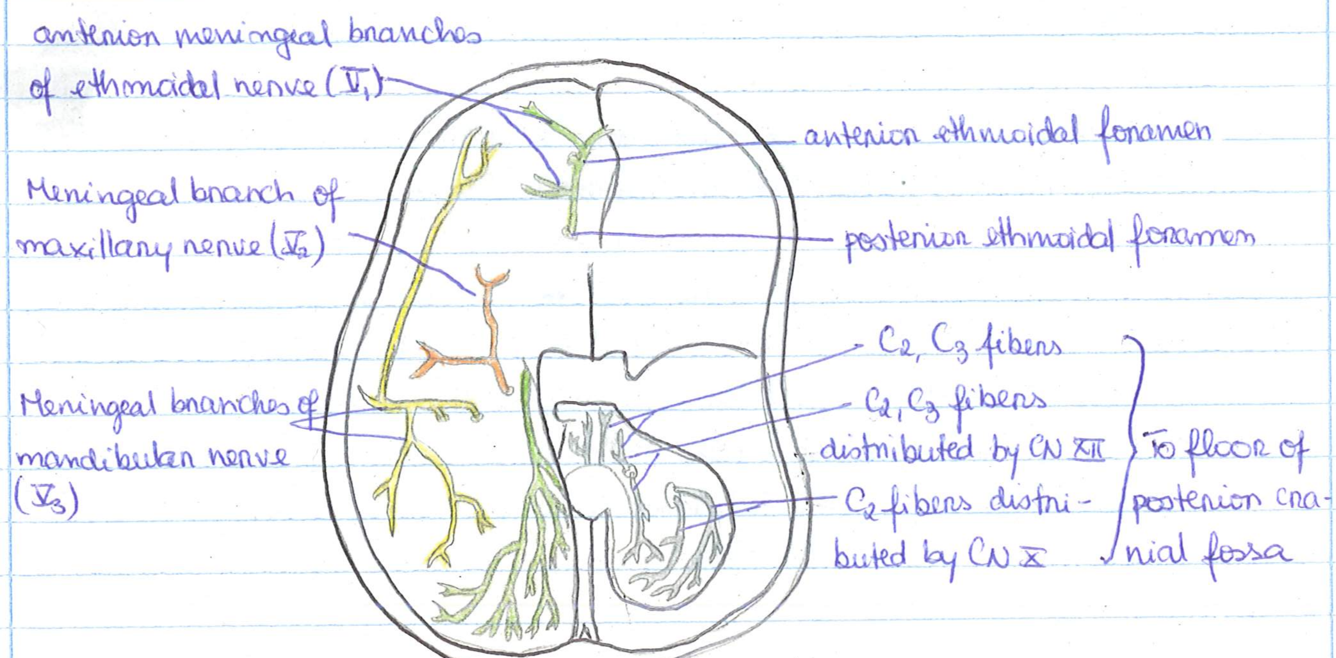
The falx cerebelli is a vertical dural infolding that lies inferior to the tentorium cerebelli in the posterior part of the posterior cranial fossa. It is attached to the internal occipital crest and partially separates the cerebellar hemispheres.

The diaphragma sellae, the smallest dural infolding, is a circular sheet of dura that is suspended between the clinoid processes forming a partial roof over the hypophyseal fossa in the sphenoid which has an aperture for passage of the infundibulum and hypophyseal veins.

NERVE SUPPLY OF DURA MATER

The dura on the floors of the anterior and middle cranial fossa and the roof of the posterior cranial fossa is innervated by meningeal branches arising directly or indirectly from the trigeminal nerve (CN V). The anterior meningeal branches of the ethmoidal nerves (CN V_1) and the meningeal branches of the maxillary (CN V_2) and mandibular (CN V_3) nerves supply the dura of the anterior cranial fossa. The latter two nerves also supply the dura of the middle cranial fossa. The meningeal branches of CN V_2 and CN V_3 are distributed as periarterial plexuses accompanying the branches of the middle meningeal artery.

The dura forming the roof of the posterior cranial fossa and posterior part of the falx cerebri is supplied by the tentorial nerve (a branch of the ophtalmic nerve), whereas the anterior falx cerebri is innervated by ascending branches of the anterior meningeal branches. The dura of the floor of the posterior cranial fossa receives sensory fibers from the spinal ganglia of C2 and C3 carried by those spinal nerves or by fibers transferred to and traveling centrally with the vagus (CN X) and hypoglossal (CN XII) nerves.



48. The leptomeninges (the arachnoid and pia mater)

The arachnoid mater and pia mater develop from a single layer of mesenchyme surrounding the embryonic brain, becoming the parietal part (arachnoid) and visceral part (pia) of the leptomeninx. There are numerous web-like arachnoid trabeculae passing between the arachnoid and the pia, which give the arachnoid its name. The trabeculae are composed of flattened, irregularly shaped fibroblasts that bridge the subarachnoid space. The arachnoid and pia are in continuity immediately proximal to the exit of each cranial nerve from the dura mater. The arachnoid mater contains fibroblasts, collagen fibers, and some elastic fibers. The avascular arachnoid, although closely applied to the meningeal layer of the dura, is not attached to the dura; it is held against the inner surface of the dura by the pressure of the CSF.

The pia mater is an even thinner membrane that is highly vascularized by a network of fine blood vessels. The pia is difficult to see, but it gives the surface of the brain a shiny appearance. The pia adheres to the surface of the brain and follows all its contours.

MENINGEAL SPACES

Of the 3 meningeal "spaces" commonly mentioned in relation to the cranial meninges, only ONE exists as a space in the absence of pathology:

- The dura-cranial interface is not a natural space between the cranium and the external periosteal layer of the dura because the dura is attached to the bones. The potential or pathological cranial epidural space is not continuous with the spinal epidural space (a natural space occupied by epidural fat and a venous plexus).
- The dura-arachnoid junction or interface ("subdural space") is likewise not a natural space between the dura and the arachnoid.
- The subarachnoidal space, between the arachnoid and the pia, is a real space that contains CSF, trabecular cells, arteries and veins.

49. The organs of smell and taste (organum olfactus et gustus)

The olfactory system comprises the olfactory epithelium which covers a region of nasal mucous membrane (regio olfactoria tunicae mucosae nasi), olfactory nerve and cortical structures (the olfactory bulb and tract, several patches of olfactory cortex).

The olfactory region of man has yellow-brownish color and occupies about 10 cm^2 at the upper margin of both superior nasal concha and the nasal septum. The olfactory region contains small mucous Bowman's glands that secrete a film of mucin covering the olfactory epithelium.

THE OLFACTORY EPITHELIUM

The olfactory epithelium is composed of the olfactory neurons, sustentacular and basal cells. The olfactory neurons are bipolar sensory neurons, with dendrites extending to the epithelial surface. Their unmyelinated axons contribute to the olfactory nerve. The knob-like enlarged dendrites are capped by a number of cilia containing molecular receptor sites.

The axons of olfactory neurons are grouped into bundles invested by Schwann-like cells to form the fila olfactoria. The fila olfactoria run upward through the cribiform plate and enter the olfactory bulb. The olfactory system is unique because the sensory neurons undergo continuous turnover, being replaced from stem basal cells.

THE OLFACTORY BULB AND TRACT

The olfactory bulb consists of 3-layered allocortex which receive the olfactory nerve fibers. The mitral cells are chief cortical neurons of the bulb. The axons of sensory neurons terminate on the dendrites of the mitral cells to form the so-called glomeruli containing innumerable synapses and their glial investment. The axons of mitral cells give rise to the olfactory tract that is divided dorsally into the medial olfactory stria and the lateral olfactory stria. The strips surround the olfactory trigone with a hillock of the olfactory tubercle and the anterior perforated substance.

THE SENSORY ORGAN OF TASTE

The taste sensations are registered by the taste buds which belong together with the olfactory epithelium to the so-called chemoreceptors. The taste buds are densely distributed in the vallate papillae; a smaller amount of the buds is placed in the fugiform and foliate papillae of the tongue. The taste buds are also present in the oral mucous membrane of the soft palate, in the mucous membrane of the epligottis and pharyngeal wall.

A taste bud consists of spindle-shaped cells arranged together like a cup with small opening, the taste pore on the surface of epithelium embedded by a mucous substance. The bud contains 3 types of cells, gustatory (sensory) cells, basal and supporting cells.

The spindle-shaped gustatory cells extend long cytoplasmatic processes into the taste pore where they are terminated by numerous microvilli. The opposite end of the sensory cells is innervated by dendritic zones of the afferent axons present in the vagus, glossopharyngeal and facial nerves. The taste buds in the posterior third of the tongue including those in the vallate papillae are innervated by the afferent axons in the tongue branches of the glossopharyngeal nerve. The afferent axons innervating the taste buds in the anterior 2/3 of the tongue are present in the branches of the lingual nerve, are continued in the chorda tympani and the facial nerve. The taste buds in the mucous membrane of the epiglottis are innervated by the afferent axons coming from the vagus nerve.

50. General anatomy of the skin

The skin (integument) has a total surface area of 1,6 - 2,0 m^2. Consisting of an epidermis and a dermis, the skin makes up about 16% of the total body weight.

In cross-section the epidermis is 0,03 - 0,1 mm thick (especially thick at sites exposed to strong mechanical forces such as the palms and soles).

Women tend to have thinner skin than men. At the openings of the body, the skin is continuous with the mucous membranes of the mouth, nose, rectum, urethra, and vagina.

FUNCTION

- As an organ, the skin fulfils a variety of functions, serving to protect the body from mechanical, chemical, and thermal trauma as well as multitude of pathogens.
- The immunocompetent cells of the skin are involved in immune processes.
- The skin also contributes to thermoregulation by adjusting blood circulation as well as fluid secretion from skin glands.
- It is also involved in maintaining fluid levels.
- The skin also contains nervous system structured that make it a sensory organ capable of detecting pressure, touch, temperature and pain.
- It also functions in the transformation of provitamin D into bioactive metabolites.
- The skin acts as an organ of communication (blushingh, paling, "hair-rising).

SKIN CHARACTERISTICS

The skin is characterized by its soft, elastic, distensible quality and by keratinization of its epithelium. Except for the palms, soles, and scalp, the skin is loosely attached to the underlying tissue and thus easily movable.

SKIN COLOR

The normal color of healthy skin is determined by 4 components:

1) Melanin, produced by melanocytes
2) Carotene, derived from dietary vegetables

3) oxygenated blood } in cutaneous vessels
4) deoxygenated blood

Pigmentation is partly related to factors such as sun exposure and nutrition, but it is mostly determined by an individual's sex and ethnicity.

SURFACE OF THE SKIN

The outward appearance of the skin is characterized by furrows and folds as well as plateaus and ridges.

Lines of greatest and least tension are visible on the skin. The lines of greatest tension, or relaxed skin tension lines, arise from the action of underlying muscles.

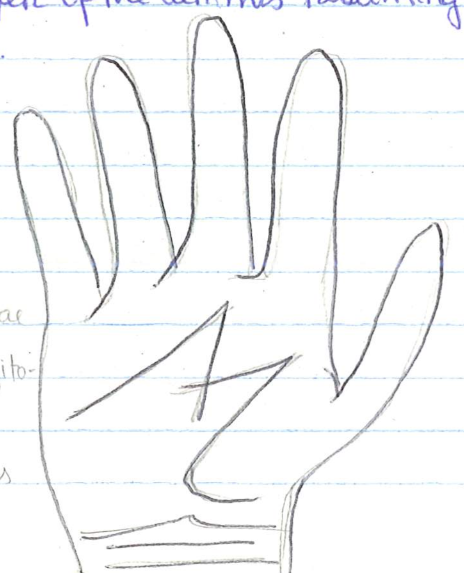
CLINICAL NOTE: Excessive stretching, such as of the abdominal skin during pregnancy or weight gain, can cause tears in the dermis. The resulting striae distensae, or stretch marks, are initially bluish red in color but later become white. They usually develop perpendicular to the direction of stretch.

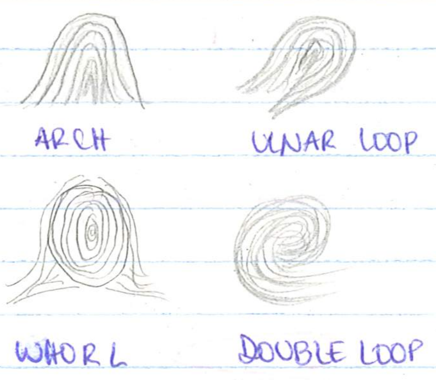
- Hair-bearing skin - most of the skin covering the human body has furrows that form triangular, rhombic, or polygonal plateaus. On top of these plateaus eccrine sweat glands open, and at certain sites apocrine sweat glands as well. The furrows contain the hair and the pores of the sebaceous glands.

apocrine → release of secreation decreases cytoplasm
eccrine = merocrine → release of secretion without changing the cell → this sweat is odorless

In the surface of the hair-bearing skin, the dermal papillae are arranged with hair follicles and sweat gland excretory ducts to form what may be described as cockade-shaped epithelial ridges and rosette-shaped epithelial rows.

- Glabrous skin - The skin on the soles and the palms possesses fine, parallel ridges measuring about 0,5 mm wide, on top of which the sweat glands open. This skin is hairless and does not contain any sebaceous or apocrine sweat glands. The ridges are formed by rows of papillae of the papillary layer of the dermis resulting in a rougher texture that enhances gripping.





The four types of ridge patterns on the finger pads are highly variable: arch, loop, whorl and double loop.

• The skin has an efficient renewal system. Following an injury, the surface is re-epithelized as skin grows from around the periphery of the injury site over the regenerating connective tissue. Accessory skin structures cease to form at the site of the scar.

• Age related skin changes - the effects of aging on the skin include degeneration (atrophy) of the dermis, thinning of the epidermis, flattening of the dermal papillae, and loss of subcutaneous fatty tissue. Age-related changes are most evident in fair-skinned people and on sun exposed parts of the body. Changing chemical properties of the connective tissue ground substance causes fluid loss and a reduction in elastic fibers in the dermis and subcutaneous tissue. The skin becomes increasingly loose, thin, slack, susceptible to wrinkling, and fragile. Pigmentation becomes irregular.

5.1 Epidermis and its derivatives

THE LAYERS OF THE SKIN

The skin is made up of the epidermis which consists of stratified, keratinizing, squamous epithelium, and the dermis (corium) which is a layer of connective tissue.

⇒ EPIDERMIS

New cells are continuously being produced by mitosis in the basal layer of the epidermis. These cells migrate to the surface of the skin within 30 days.

✓ Regeneration layer — the germinative layer comprises the basal and spinous layers of the epidermis. The basal layer of the epidermis consists of a single layer of cells lying directly on the basement membrane. Above the basal layer is the spinous layer consisting of 2-5 layers of large polygonal keratinocytes. Cells in mitoses of both strata are called by a common term - stratum germinativum.

* The lower cell layers contain melanocytes which produce the pigment melanin. The cell bodies of the melanocytes rest directly on the basement membrane. Melanocytes transfer their pigment directly to the basal epidermal cells. Melanin protects the basal layer from harmful UV rays.

* Also contained in the basal layer are a small number of Merkel cells. They resemble keratinocytes but contain small dense granule in their cytoplasm. Numerous nerve endings terminate at the base of each Merkel cells → sensory mechanoreceptor.

✓ Keratinization layer – the flattened keratinocytes, which now lie parallel to the skin surface, forming the thin granular layer (2-3 layers of cells), contain lamellar bodies and basophilic keratohyaline granules, which indicate the beginning of keratinization. The contents of the lamellar undergo extracellular transformation, forming lipid lamellae that fill in the intercellular spaces and make them impermeable. The barrier created by the lipids protects against fluid loss.

The stratum lucidum is translucent and thin. It lacks regularly in the thin skin. The layer contains dead, anucleated and eosinophilic cells.

The stratum corneum lies at the surface and consists of 15-20 layers of flattened non-nucleated keratinised cells whose cytoplasm is filled with a birefringent filamentous scleroprotein – keratin.

* Langerhans cells are located in the spinous layer. These dendritic cells have extensive processes and are involved in the activity of the immune system. Originating in the bone marrow, Langerhans cells present antigens to resting helper T cells.

⇒ DERMIS (CORIUM)

The dermis (corium) is much thicker than the epidermis. It contains accessory epidermal structures, blood and lymph vessels, connective tissue cells, free immune cells, nerves, and nerve endings and associated structures. A highly durable latticework of interlacing bundles of collagen fibers interspersed with elastic fiber networks make the dermis tough and elastic. The dermis consists of two layers (with rather indistinct boundaries):

• Reticular layer – as a tough collagen fiber bundles, forming a dense fiber meshwork (type I collagen) and are accompanied by a network of elastic fibers. Fibroblasts, macrophages, mast cells, and small numbers of lymphocytes lie between the bundles of fibers.

⇒ SUBCUTANEOUS TISSUE (SUBCUTIS)

The subcutaneous tissue, or subcutis, forms the connection between the skin and the fascia covering the body or periosteum and allows movement of the skin. It contains adipose tissue in various amounts depending on the body site.

Distribution of fat is genetically determined and is also influenced by hormones. In certain places the subcutaneous tissue is loose and devoid of fat (eyelids, auricles, lips, penis, scrotum, etc.).

• Blood vessels - the arteries form a network between the skin and subcutaneous tissue, supplying branches to the hair roots, sweat glands, subcutaneous adipose tissue, and dermal papillae. The subpapillary plexus sends capillary loops into the individual dermal papillae. The veins form networks beneath the papillae called cutaneous venous plexuses. Changes in cutaneous circulation are an essential part of thermoregulation. Lymphatic vessels also form plexuses.

5.2. The skin glands, mammary gland.

The skin glands like the hair and nails, are also accessory structures of the skin. They derive from solid epithelial masses that project downward from the epidermis into the mesenchyme.

• SWEAT GLANDS

✓ Eccrine sweat glands - the 2-4 million eccrine glands are distributed over the entire body in a pattern that varies individually and from region to region. They are densely clustered on the forehead, palms, and soles. Eccrine sweat glands are narrow, unbranched epithelial tubes that penetrate deep into the dermis. Their terminal parts form a coil 0,3-0,5 mm in diameter. The secretory cells contain lipid droplets, glycogen granules, and pigment granules. Between the glandular epithelium and the basement membrane is a discontinuous arrangement of contractile, ectodermal myoepithelial cells. The secretory unit is continuous with the rather tortuous, corkscrew-shaped excretory duct. It has a rich capillary and nerve supply.

The acid secretion (pH 4,5) of the eccrine glands inhibits bacterial growth aids thermoregulation by means of perspiration and evaporation (cooling the body). Normally about 100-200 ml of sweat is excreted per day.

✓ Apocrine sweat glands - The apocrine glands are present on the hair-bearing skin as well as on the nipple, the areola, and in the nasal vestibule. Apocrine glands are simple coiled tubular glands. They are located in the subcutaneous tissue and empty into hair follicles.

Apocrine sweat glands produce an alkaline secretion that contains odorants which play a role in sexual and social behavior.

✓ Sebaceous glands - are holocrine glands that primarily originate from the hair germ and open into the infundibulum of the hair follicle. Each pear-shaped acinus contains mitotically dividing cells and is surrounded by a peripheral layer. The cells are ultimately completely transformed into sebum. About 1-2 g of sebum are produced daily and secreted onto the surface of the hair and epidermis.

• HAIR

Hairs are pliable keratinous filaments that possess a degree of tensile strength. The hair originates from the epidermis. Different types of hair may be distinguished: lanugo hair appears during fetal life and is present on the newborn until six months of age. It is short, thin, virtually colorless, and rooted in the dermis. Lanugo hair is replaced by an intermediate coat of hair which starts to be replaced by terminal hair at puberty. Terminal hairs are longer, coarser, pigmented, and grouped together; they are rooted in the upper part of the subcutaneous layer.

Terminal hairs are positioned at an angle to the skin surface. Opening into the root sheath is the sebaceous gland. Above the level of the opening of the sebaceous gland, the upper part of the hair follicle is known as the infundibulum; below the level of the sebaceous duct the smooth arrector pili muscle has its origin. Passing beneath the epidermis, the arrector pili muscles contract in response to cold or psychological stress such as alarm or fear, causing the hair to stand upright.

The bulb, papilla, and surrounding connective tissue comprise the hair follicle.

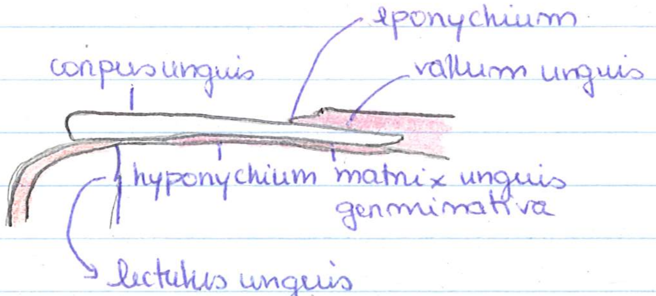
Hair growth is cyclical. Growth (0,3-0,4 mm daily, anagen phase) is followed by regression (catagen phase) and a resting state (telogen phase), after which the hair falls out.

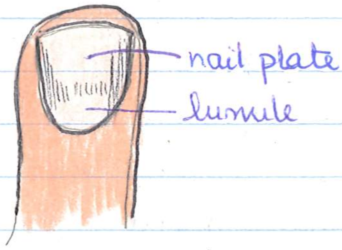
• NAILS

The nails also develop from the epidermis. They serve to protect the phalanges of the fingers and toes, and also aid tactile perception by providing a counter-force for tactile-pad pressure.

The nails are translucent, curved keratin plates about 0,5 mm thick. They are composed of layers of polygonal, flattened cornified cells and are reinforced by 3 layers of crossing tonofibrils. The nail lies on a nail bed hyponychium. At its proximal end it is surrounded by the nail wall which forms the approximately 0,5 cm deep sinus unguis near the nail root. Deep in the sinus ungeis is the nail matrix, the anterior boundary of which forms the white area known as the lunule. Growing from the free margin of the nail wall is a thin layer of epithelium called the eponychondium.

The nail bed is produced by the nail matrix a proximal area of epithelial tissue located under the nail root. The nail grows 0,14-0,4 mm daily. The dermis is connected with the periosteum of the distal phalanges of the fingers by strong retinacula. The capillary loops in the dermal ridges give the nail its pink appearance.





• BREAST AND MAMMARY GLANDS

The breasts and mammary glands are epithelial derivatives. In newborns of both sexes the mammary glands develop under the influence of maternal placental hormones forming visible and palpable eminences on the surface of the body. In the initial days of postnatal life they secrete colostral milk. During childhood breast development is gradual; its growth accelerates with the onset of puberty, and breast buds develop. Development of the female breast during puberty is influenced by estrogen, prolactin, and growth hormone. The amount of adipose tissue is another important determinant. During pregnancy there is strong growth of the mammary glands, and toward the end of gestation, the glands, begin to produce milk. When lactation ceases (ablactation) the mammary glands revert to the inactive state, and there is increased formation of connective tissue.

The breasts lie on either side of the body on the pectoral fascia between the 3rd to 7th ribs midway between the sternum and axilla. Between the breast and the fascia is a thin layer of interstitial connective tissue that permits movement of the breast against the anterior wall of the thorax. Each breast is fixed in position by collagen fiber bundles known as the suspensory ligaments of breast between the dermis and connective tissue system of the breast. An axial process or axillary tail frequently projects above the margin of the pectoral muscles into the axilla. The space (cleavage) between the two breasts is called the intermammary cleft.

The nipple is usually located in the center of the breast, measuring 10-12 mm in diameter. It is surrounded by the areola on which the lactiferous ducts open via 10-12 pore-like openings. In the periphery of the areola are 10-15 usually circularly arranged nodular elevations called the areolar glands. They contain apocrine and eccrine sweat glands as well as sebaceous glands which increase their secretion during lactation.

The breast consists of the mammary gland, composed of the conical lobes of the mammary gland and adipose tissue which is surrounded and partitioned by connective tissue.

• NONLACTATING MAMMARY GLAND - the architecture of the nonlactating mammary gland in the sexually mature woman is characterized by an irregular arrangement of 15-20 individual, branching tubular glands whose coiled terminal ends form the lobes of the mammary gland. Each lobe contains a collecting duct. Its branches, the lactiferous ducts, are separated by connective tissue. Beneath the nipple, at the level of its base, the lactiferous ducts expand to form the 1-2 mm wide spindle-shaped lactiferous sinuses. The sinuses are continuous with narrow excretory ducts which open on the surface of the breast.

• LACTATING MAMMARY GLAND - during week 5 or 6 of pregnancy the lactiferous ducts begin to sprout under the influence of estrogen. At the same time, new terminal buds develop, and the connective tissue is pushed aside. As parenchymal tissue increases, the amount of connective and adipose tissue decreases. The breasts become enlarged, and their consistency changes. In the ninth gestational month, prolactin induces the production of colostrum. About 3 days postpartum the milk "comes in" (transitional milk). It contains lipid droplets, proteins, lactose, ions, and antibodies. Secretion of mature breast milk begins on about day 14 post partum.

53. The fibrous tunic of the eye

This supporting coat of the eye consists of a transparent anterior one-sixth called the cornea (Ø 7-8 mm), and a white, opaque posterior five-sixths, called the sclera. Its anterior surface is formed by a multilayered, nonkeratinizing squamous epithelium that rests upon a thick basement membrane, called the anterior limiting lamina. Below this lies the stroma of the cornea; its straight collagen fibers form lamellae that lie parallel to the surface of the cornea. At the posterior surface lies another basement membrane, the posterior limiting lamina and a single-layered endothelium.

The cornea is a nonvascular, transparent, fibrous coat that covers the colored iris. The cornea bulges like a watch-glass on the eyeball. The outer surface of cornea is covered by an epithelial layer that is continuous with the epithelium of the bulbar conjunctiva. The external edge of the cornea, limbus corneae, is continuous peripherally with the sclera at the sclerocorneal junction. The cornea contains unmyelinated nerve fibers, but no blood vessels. In transparency is due to a certain fluid content and state of turgor of its components. Any change in the tungor produces cloudiness of the cornea.

The sclera (Ø 11-12 mm) is a dense, taut connective tissue capsule mainly consisting of collagen and some elastic fibers. The sclera gives shape to the eyeball, makes it more rigid, and protects its inner parts, which in conjunction with the intraocular pressure maintains the shape of the eyeball.

The posterior surface of sclera is pierced by the optic nerve (together with the arteria centralis retina) to form the optic foramen. Around the entrance of the optic nerve are numerous small apertures for the transmission of the ciliary vessels and nerves, and about midway between the optic foramen and the sclerocorneal junction are four of five large apertures for the transmission of veins, the venae vorticosae. The sulcus sclerae is a circular depression at the juntion of the sclera and cornea.

54. The vascular layer of the eye

From the posterior to anterior, this heavily pigmented vascular layer consists of the choroid, ciliary body, and iris.

= CHOROID =

The highly vascularized choroid is the posterior portion of the vascular tunic and lines most of the internal surface of the sclera. Choroid inner surface is attached to the pigmented layer of the retina. The choroid contains venous plexuses and layers of capillaries that are responsible for nutrition of the adjacent layers of the retina, the posterior surface of the retina.

= CILIARY BODY =

The ciliary body is the anterior thickening of the vascular tunic containing ciliary muscles, where the suspensory ligament of the lens is attached. It extends from the ora serrata, the jagged anterior margin of the retina, to a point just behind the sclerocorneal junction, where it continues into the iris. The posterior surface of the ciliary body is covered by the pars ciliaris retinae (one of the parts of pars caeca retinae)

The ciliary body comprises two zones, the orbiculus ciliaris and the ciliary processes.

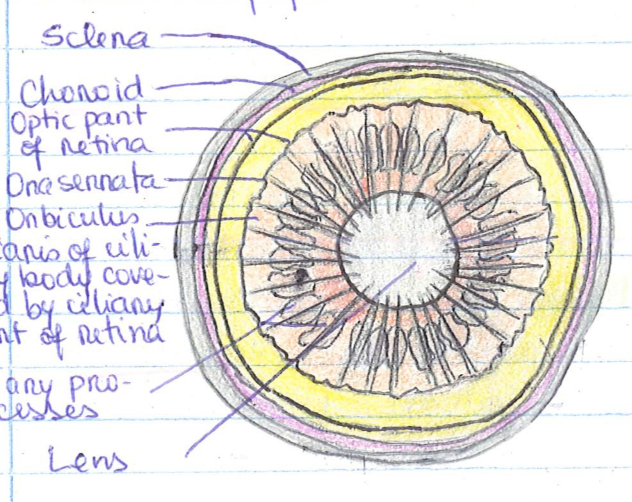
The orbiculus ciliaris is 4 mm wide ring extending from the ora serrata to the ciliary processes on its central margin. The choroid layer is thicker here than over the optical part of the retina. The ciliary processes (processus ciliaris) are numerous (about 80) small, radially arranged ridges on the posterior surface of the ciliary body, forming a sort of frill around the margin of the lens (corona ciliaris). Anteriorly, the ciliary processes are united with the periphery of the iris, the posterior surface is connected with the suspensory ligament of the lens. The epithelial cells lining the ciliary processes secrete the aqueous humor.

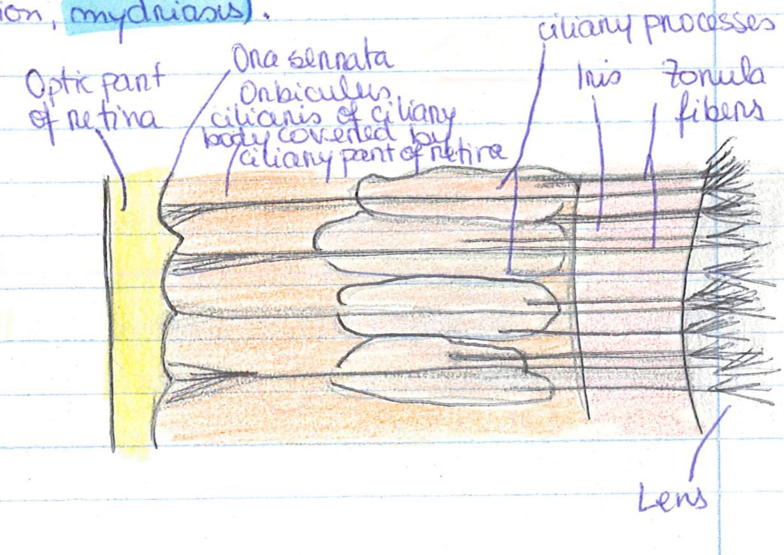
The suspensory apparatus of the lens is attached to the circular ciliary body. Its muscles regulate the degree of curvature of the lens and thus controls focusing of the lens for close and distant vision. The anterior part of the orbiculus ciliaris is occupied by the ciliary muscle the fibrae meridionales, are stretched between the ora serrata and the pectinate ligament. Radial muscle fibers extend inward from these structures and bend to follow a circular course (fibrae circulares). Very thin fibers, fibrae zonulares, pass from the ciliary body to the lens and form the ciliary zone. Many fibers leave at the level of the ora serrata and extend to the anterior surface of the lens. They cross the short fibers, coming from the ciliary processes and ending on the posterior surface of the lens.

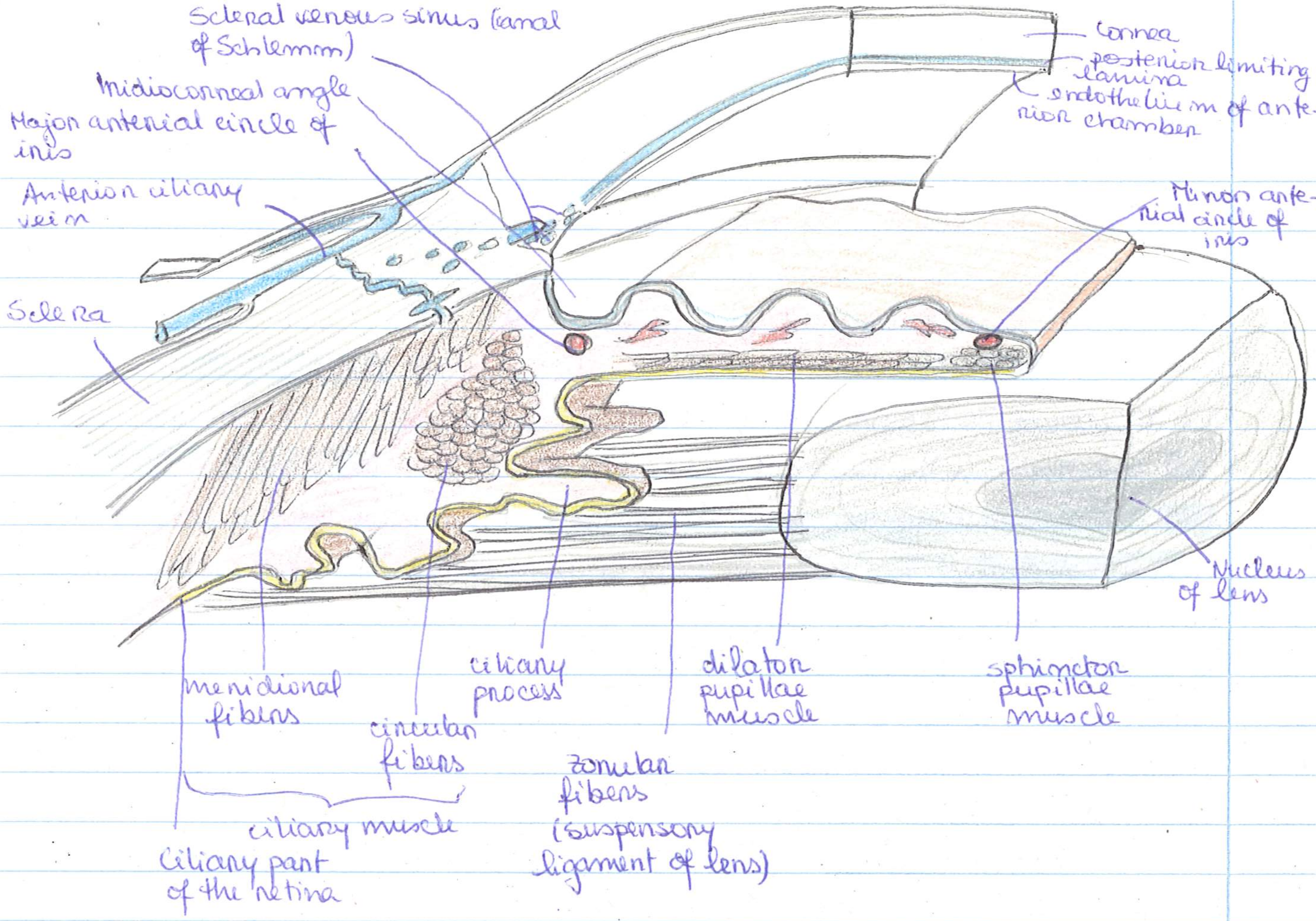
=IRIS=

The iris is the colored disc with a hole, the pupil, in the center; it is extended between the cornea and the lens. It divides the space between the lens and the cornea into an anterior and a posterior chamber, which communicate through the pupil. External surface has an individual color and drawing.

The iris consisting of circular and radial smooth muscle fibers. A principal function of the iris is to regulate the amount of light entering the posterior cavity of the eyeball through the pupil. When bright light stimulates the eye, parasympathetic nerve fibers stimulate the sphincter (constrictor) pupillae muscle to contract and decrease the size of the pupil (constriction, MIOSIS). In dim light, sympathetic nerve fibers stimulate the dilator pupillae muscle, the radial iris smooth muscle to contract and increase the pupil's size (dilatation, mydriasis).







55. The internal tunic of the eye

The layers of retinal neurons are arranged in the order in which they process visual input. Note that light passes through the bipolar and ganglion cell layers before reaching the photoreceptor layer.

There are two other types of cells present in the retina called horizontal and amacrine cells. These cells form laterally directed pathways that modify the signals being transmitted along the pathway from photoreceptors to bipolar and to ganglion cells.

- Stratum pigmenti retinae - the pigment epithelium is a sheet of melanin - containing epithelial cells that lies between the choroid and the neural portion of the retina.
- Stratum neuroepitheliale contains the photoreceptors that are specialized to transduce light rays into receptor potentials. The two types of photoreceptors are rods and cones which nestl among finger-like extensions of the pigment epithelium cells. Each retina has about 6 million cones and 120 million rods. Rods are most important for black-and-white vision in dim light. Cones provide color vision and high visual acuity (sharpness of vision) in bright light.

Cones are most densely concentrated in the fovea centralis, a small depression in the center of the retina. The macula lutea is in the posterior portion of the retina, at the visual axis of eyeball.

- Stratum ganglionare retinae is composed by the bipolar neurons.
- Stratum ganglionare nervi optici is formed by multipolar ganglionic

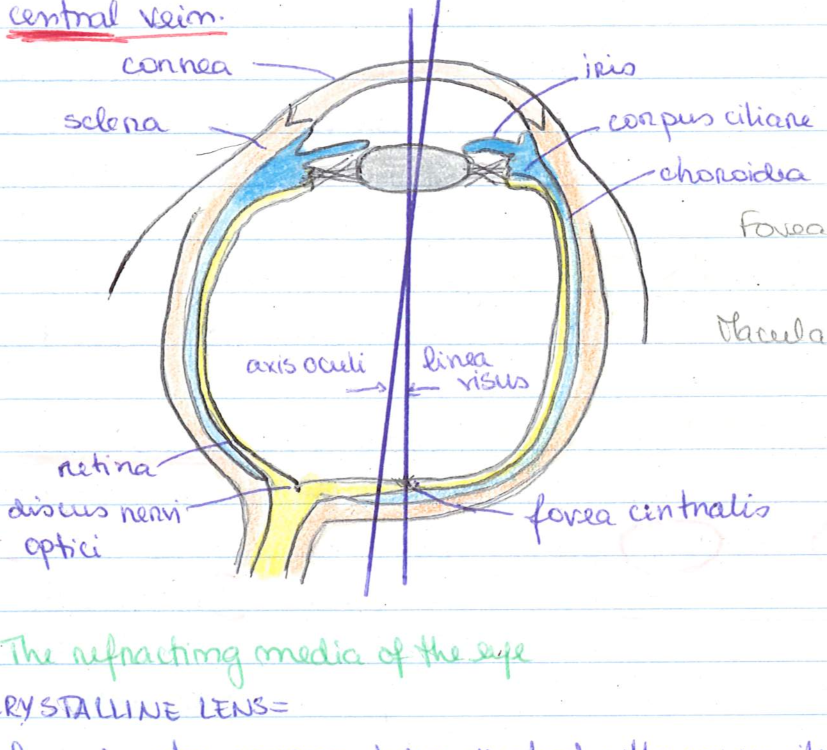
neurons. The axons of the ganglionic neurons constitute the optic nerve.

Macula lutea, fovea centralis and blind spot

The macula does not contain any rods but ONLY CONES. The ganglionic layers of the retina and of the optic nerve are great thickened in the macula but disappear in the region of the central fovea. Thus, incoming light in the fovea has immediate access to the receptors. The macula and fovea are the zones of greatest acuity of vision, not only because of the absence of the superficial retinal layers, but also because of a special neuronal relay. On the fovea each cone is in contact with a bipolar cell. In the perifovea each bipolar cell synapses with 6 cones and at the periphery of the retina there are convergence synapses. Altogether 130 million receptors correspond to only 1 million optic nerve fibers.

The optic disc is also called blind spot. Since it contains no rods or cones, we cannot see an image that strikes the blind spot.

The papilla of the optic nerve, in which all nerve fibers of the retina collect to leave the eye as the optic nerve, lies in the nasal half of the eye. In the papilla the central artery divides into several branches and the veins join to form the central vein.



Fovea centralis → linea visus

Macula lutea → cones

56. The refracting media of the eye

= CRYSTALLINE LENS =

The lens is a transparent, biconvex body, the convexity of its anterior being less than that of its posterior surface. It is situated immediately between the iris and the vitreous body. The lens is formed by elongated epithelial cells, the lens fibers, which lie on top of each other in a lamellar arrangement.

= AQUEOUS HUMOR AND ANTERIOR CHAMBER OF THE EYE =

Aqueous humor is clear watery fluid in the anterior and posterior chambers of the eye that is continuously produced by the vessels of the iris and epithelial cells covering the ciliary body. The aqueous humor provides nutrients for the avascular cornea and lens. After passing through the pupil from the posterior chamber into the anterior chamber, the aqueous humor is drained off through spaces at the iridiocorneal angle. This angle of the anterior chamber consists of loose connective tissue trabeculae, the pectinate ligaments among the interstices of which the aqueous humor can flow toward the sinus venosus sclerae (Schlemm's canal). The sinus drains into the scleral venous plexuses.

= VITREOUS BODY =

This material fills the eyeball posterior to the lens. It consists of a jelly-like substance called the vitreous humor, in which there is a meshwork of fine collagenous fibrils.

The vitreous body consists of about 99% water and in addition to transmitting light, it holds the retina in place and provides support for the lens. In contrast to the aqueous humor, the vitreous body is not continuously replaced. It is developed during the embryonic period and is not exchanged.

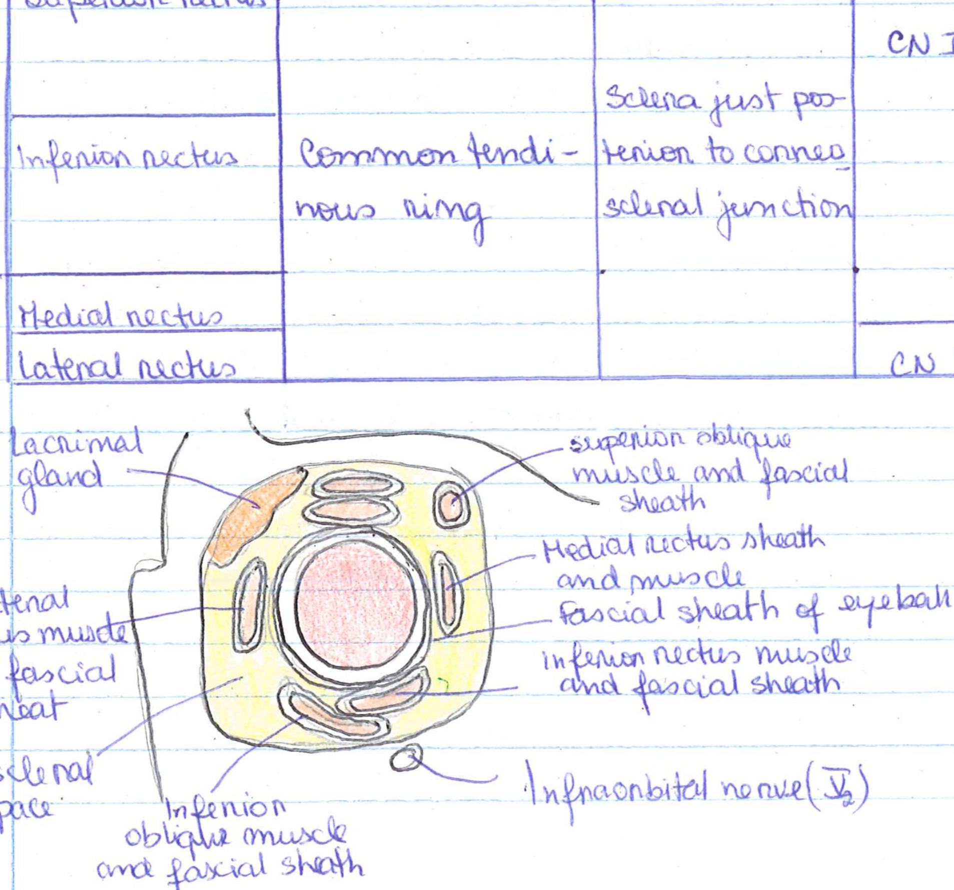
57. The extraocular muscles and their fascia

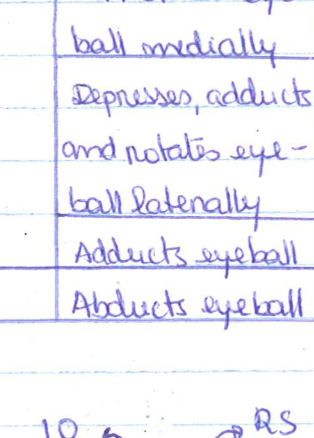
The levator palpebrae superioris muscle is triangular which elevates the upper eyelid. It has origin in roof of the orbit, anterior to the optic canal. It inserts into the skin of the upper eyelid. The inferior part of the aponeurosis contains some smooth muscle fibers that form the superior tarsal muscle. These involuntary muscle fibers insert into the tarsal plate. The muscle elevates the upper eyelid. Superior fibers of the muscle are innervated by the oculomotor nerve, whereas the superior tarsal muscle is innervated by fibers from the cervical sympathetic trunk and the internal carotid plexus. The movements of eyeball are made by 6 muscles, 4 straigh and 2 oblique. The tendons of origin of the muscles form a funnel-shaped ring around the optic canal, the anulus tendineus communis. From this common origin, each straight muscle (superior, inferior, medial and lateral) passes anteriorly, close to the walls of the orbit in the position implied by its name. They are attached to the eyeball just posterior to the sclerocorneal junction.

The superior oblique muscle (the trochlear nerve) arises from the body of the sphenoid bone and extends medially almost to the orbital margin. Near the orbital margin its tendon runs through a pulley-like loop, called the trochlea, consisting of fibrous cartilage and lined by a synovial sheath. The tendon then bends posteriorly at an acute angle and inserts beneath the superior rectus muscle at the posteroinferior aspect of the lateral side of the eyeball.

The inferior oblique muscle (the oculomotor nerve) is narrow muscle that arises from the maxilla in the floor of the orbit and runs to be attached to the inferior, temporal surface of the eyeball

MUSCLE	ORIGIN	INSERTION	INNERV.	FUNCTION
Levator palpebrae superioris	Lesser wing of sphenoid bone, superior and anterior to optic canal	Superior tarsus and skin of superior eyelid	CN III; sup. tarsal-sympathetic fibers	Elevates superior eyelids
Superior oblique	Body of sphenoid	Its tendon passes through the trochlea changes direction and inserts deep to sup. rectus	CN IV	Abducts, depresses and medially rotates the eyeball
Inferior oblique	Anterior part of floor of orbit	Sclera deep to lateral rectus muscle		Abducts, elevates and laterally rotates eyeball
Superior rectus			CN III	Elevates, adducts and rotates eyeball medially
Inferior rectus	Common tendinous ring	Sclera just posterior to corneoscleral junction		Depresses, adducts and rotates eyeball laterally
Medial rectus				Adducts eyeball
Lateral rectus			CN VI	Abducts eyeball





TENON'S CAPSULE

The fascia bulbi is a thin membrane which envelops the eyeball from the optic nerve to the limbus, separating it from the orbital fat and forming a socket in which it plays.

It is perforated by the tendons of the ocular muscles, and is reflected backward on each as a tubular sheath.

The sheath of the obligue superior is carried as far as the fibrous pulley of that muscle, that on the inferior oblique reaches as far as the floor of the orbit, to which it gives off a slip.

The sheaths on the recti are gradually lost in the perimysium, but they give off important expansions. The expansion from the rectus superior blends with the tendon of the levator palpabrae; that of the rectus inferior is attached to the inferior tarsus. The expansions from the sheaths of the recti lateralis and medialis are strong and are attached to the lacrimal and zygomatic bones; they have been named the medial and lateral check ligaments.

58. The eyelids, conjunctiva and lacrimal apparatus

= EYELIDS =

The upper and lower eyelids (palpebrae) shade the eyes during sleep, protect the eyes from excessive light and foreign objects, and spread lubricating secretions over the eyeballs. From superficial to deep, each eyelid consists of epidermis, dermis, subcutaneous tissue, fibers of the orbicularis oculi muscle, a tarsal plate, tarsal glands and conjunctiva.

The tarsal plate is a thick fold of connective tissue that gives form and support to the eyelids. Embedded in each tarsal plate is a row of elongated modified sebaceous known as tarsal or Meibomian glands. Infection of the tarsal glands produces a tumor or cyst on the eyelid called a chalazion.

The conjunctiva is a thin, protective mucous membrane. The palpebral conjunctiva lines the inner aspect of the eyelids and the bulbar (ocular) conjunctiva from the upper eyelid on to the anterior surface of the eyeball. The transition of the conjunctiva from the upper eyelid on to the eyeball is named the superior fornix and that from the lower eyelid the inferior fornix. The conjunctiva forms semilunar folds at the medial angle referred as the plica semilunaris.

= EYELASHES =

They project from the border of each eyelid and together with the eyebrows, which arch transversely above the upper eyelids, help protect

GLANDS OF EYELIDS
→ Meibomian → Sebacious (open in rima)
→ Molli → Sudoriferous (open in cilia)
→ Zeiss → Sebacious (open in cilia)

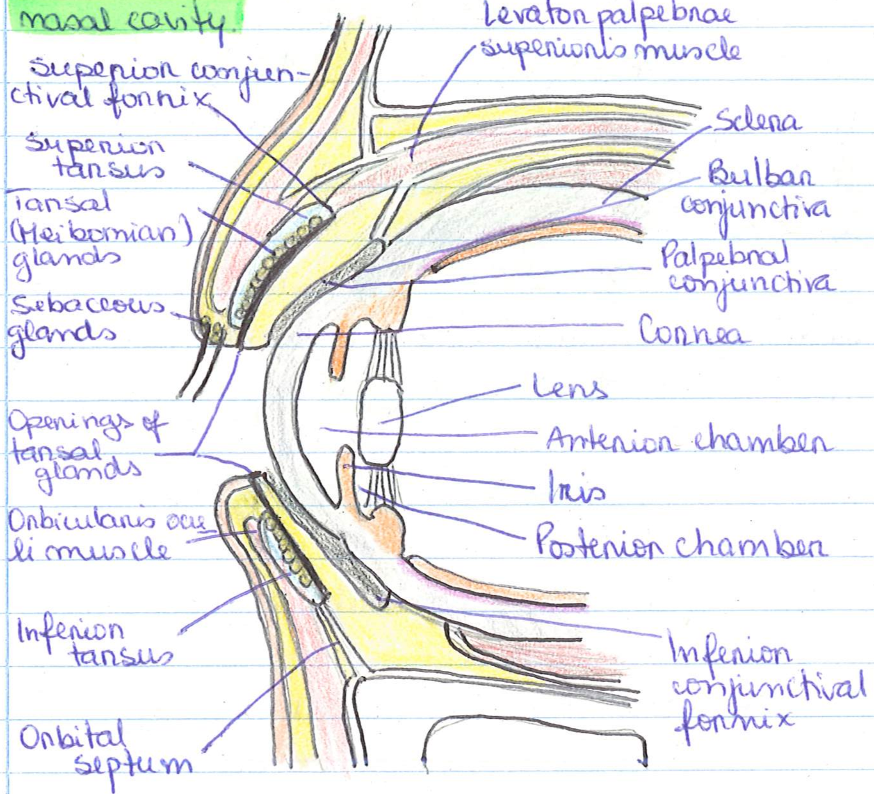
the eyeballs from foreign objects, perspiration, and the direct rays of the sun. Sebaceous glands at the base of the hair follicles of the eyelashes are called the sebaceous ciliary glands or glands of Zeiss; they secrete pour a lubricating fluid into the follicles. Infection of these glands is called sty.

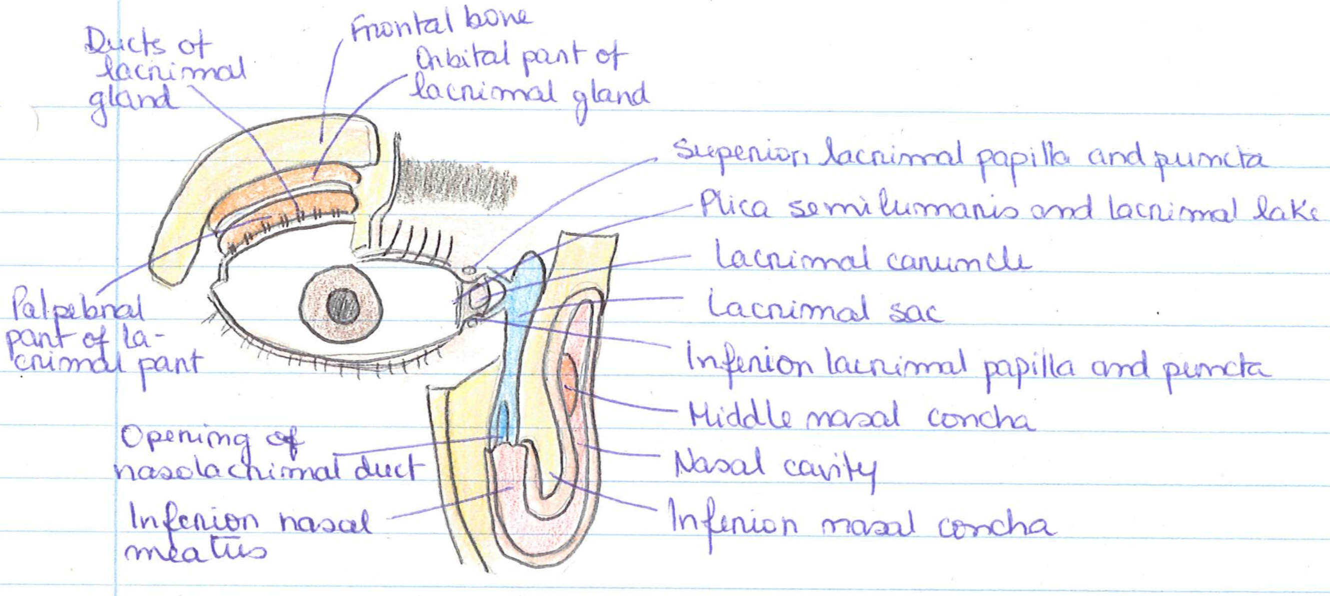
= LACRIMAL APPARATUS =

The lacrimal glands secrete lacrimal fluid, or tears, a watery solution containing salts, some mucus and a bactericidal enzyme called lysozyme. The tear cleans, lubricates, and moistens the eyeball.

The lacrimal gland lies above the lateral corner of the eyelid and is subdivided by the tendon of the levator palpebrae superioris muscle into an orbital and a palpebral part. Lacrimal ducts empty tears at the superior fornix of the conjunctiva. The tears pass medially over the surface of the eyeball by the blinking of the eyelids. Each gland produces about 1ml per day.

Tears are collected eventually in the lacus lacrimalis of the medial corner of the eye with a small reddish hillock, the caruncula lacrimalis. There, at the inner surface of each lid, is a small opening, the punctum lacrimale, which leads into the lacrimal canal. They unite and open into the lacrimal sac, which extends from the nasolacrimal duct into the inferior meatus of the nasal cavity.





59. The external ear and tympanic membrane

♦ THE AURICLE (PINNA)

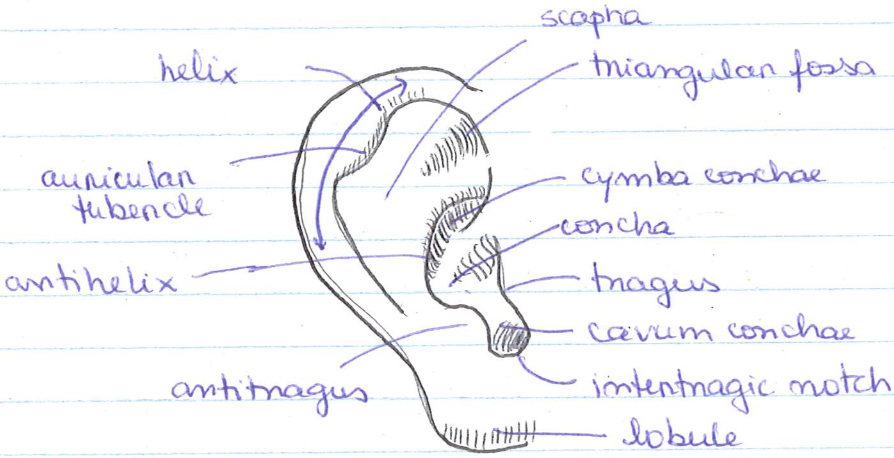
With the exception of the lobule, it contains a scaffold of elastic cartilage. The auricle is attached to the head by ligaments and extrinsic muscles. The prominent rim is named the helix containing a small tubercle, the auricle tubercle (of Darwin) that is distinct about the 6th month of fetal life. The curved prominence parallel with the helix is called the antihelix. It is divided above into two crura, between which is the triangular fossa. The narrow depression between the helix and antihelix is named the scapha. A large depression, the concha is divided into two parts by crus of the helix forming its beginning. The superior part of the concha is termed the cymba conchae, the inferior part the cavum conchae. The tragus is an eminence located anteriorly to the concha. The antitragus is other small tubercle opposite to the tragus. The tragus and antitragus are separated by the intertragic notch. The lobule (lobus auricularis) is composed of areolar and adipose tissues and thus the lobule is not firm and elastic as the rest of the auricula

The medial surface of the auricula contains elevations that correspond with the depressions on its lateral surface, and they are named as the eminentia cochlae and eminentia triangularis.

♦ THE EXTERNAL ACOUSTIC MEATUS

It is a tube of about 2,5 cm long between the auricle and eardrum. The first part of the external acoustic meatus is formed by a groove-shaped elongation of the auricular cartilage. This cartilaginous portion is about 8mm in length, defficient at the upper and posterior part of the meatus, and here it is supplied by fibrous membrane. The second part of the external acoustic meatus, the osseous portion is about 17 mm in length, formed by a curved plate of bone (the pars tympanica of the temporal bone).

Hairs (tragi) in combination with the cerumen prevent dust and other foreign objects from entering the ear.

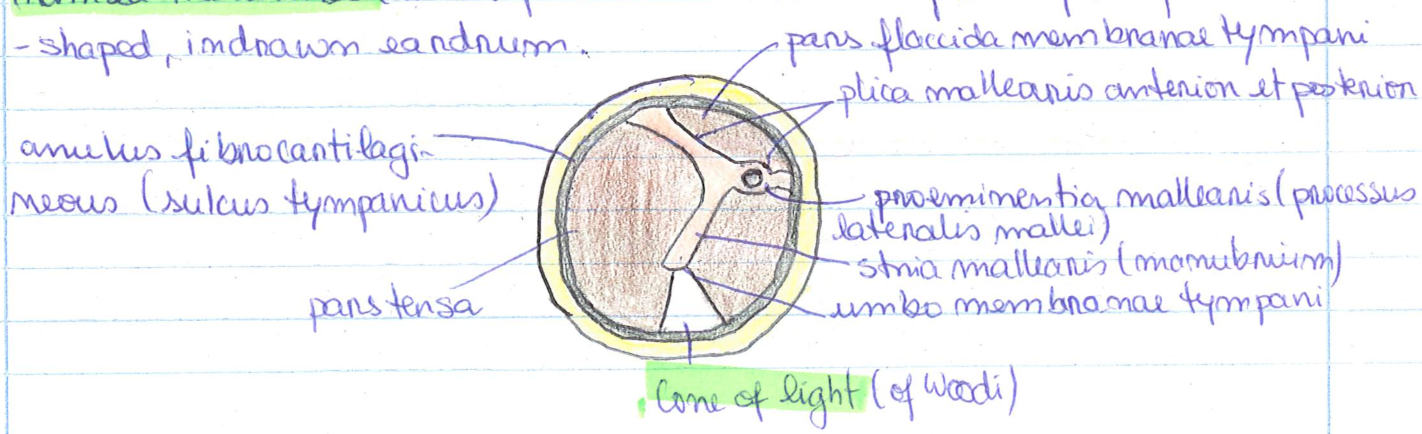


◆ THE TYMPANIC MEMBRANE

The tympanic membrane separates the tympanic cavity from the external acoustic meatus. It is a thin, semitransparent oval membrane, measures from 9 to 10 mm in longer diameter and 8 to 9 mm in shorter diameter. The eardrum is a fibrous membrane that is covered with very thin skin externally and mucous membrane internally. The greater part of tympanic circumference is thickened to form a fibrocartilaginous ring which is attached in the tympanic sulcus.

The anterior and posterior malleolar folds are directed from the ends of the notch to the malleolar prominence (prominentia mallearis) that is due to the lateral process of the malleus. The triangular part of the membrane located up to these folds is reddish and loose, therefore, is named the pars flaccida in contrast to the rest of the membrane ~~in contrast to the rest of the membrane~~, called the pars tensa that is grey and shiny.

The malleolar stria, which is formed by the attachment of the handle (manubrium) of the malleus to the internal surface of the eardrum, is seen from the malleolar prominence to the central depression named the umbo (which forms the innermost point of the funnel-shaped, indrawn eardrum.



60. The tympanic cavity

To simplify description of the tympanic cavity, we can imagine it as narrow rectangular space which looks like a biconcave lens.

The roof or the tegmental wall (paries tegmentalis) is a thin bony plate, the tegmen tympani, that separates the tympanic from the cranial cavity. The tegmen tympani is situated on the anterior surface of the pyramid of the petrous bone. It bear the hiatus for the lesser petrosal nerve (hiatus canalis nervi petrosi minoris).

The floor or jugular wall (paries jugularis) is a thin bony plate which separates tympanic cavity from the jugular fossa; here there is close relation of the tympanic cavity with the jugular vein. The floor contains a small aperture for the passage of the tympanic nerve (apertura externa canaliculi tympanici).

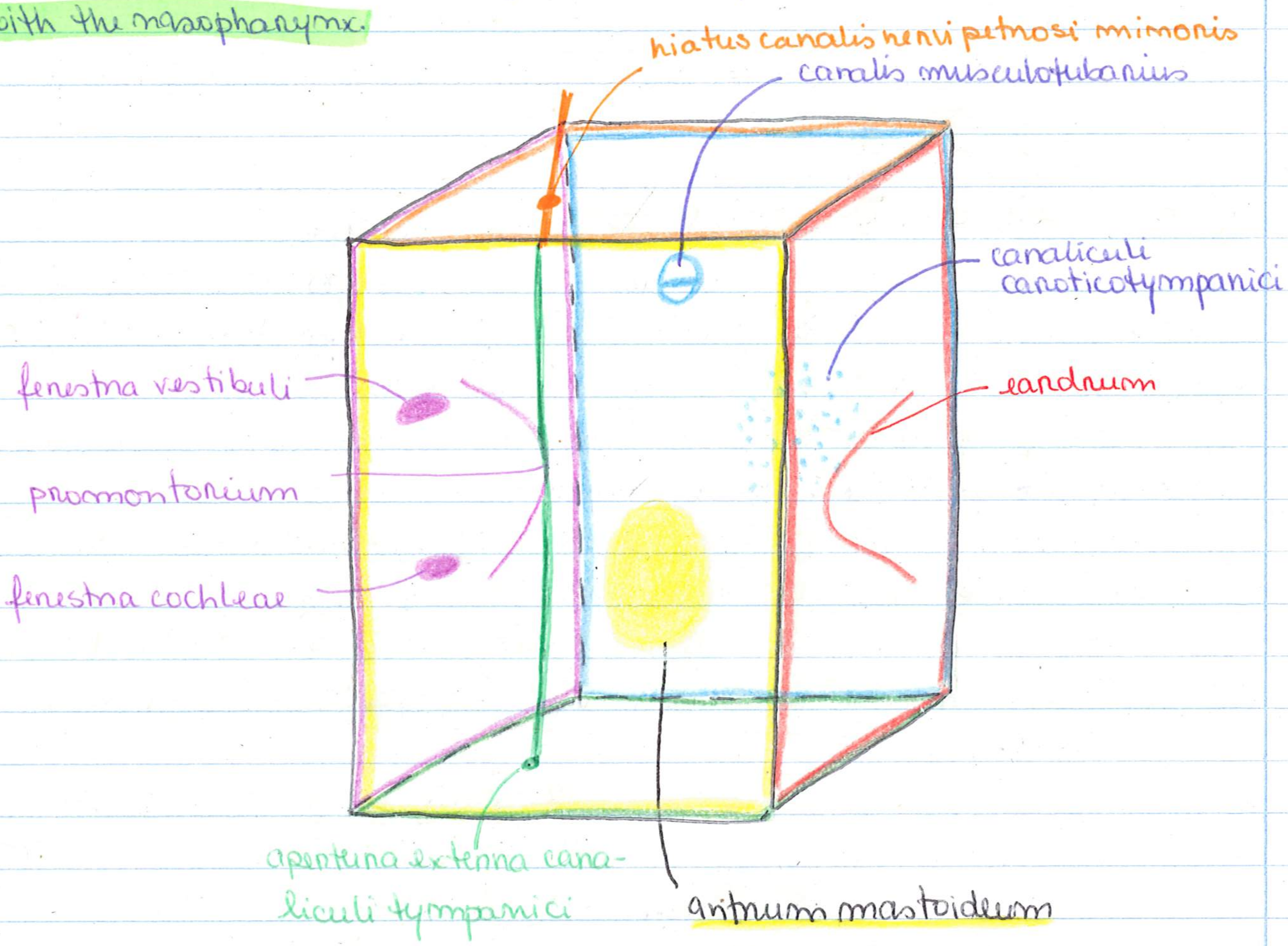
The lateral or membranous wall (paries membranaceus) is formed by the tympanic membrane.

The medial or labyrintic wall (paries labyrinthicus) is convex wall between the tympanic cavity and the inner ear. The promontory is a rounded prominence that is caused by the basal convolution (first turn) of the cochlea. A shallow groove (sulcus promontorii) is a bed for the tympanic plexus; it consists of the tympanic nerve (a branch of the glossopharyngeal nerve) and sympathetic fibers (the caroticotympanic nerves) from the carotid plexus alongside the internal carotid artery. The fenestra vestibuli (fenestra ovalis, oval window) is opening from the tympanic cavity into the vestibule of the inner ear; it is closed by the base of the stapes. The fenestra cochlae (fenestra rotund, round window) is opening through the medial wall into the inner ear. The round window is closed by the secondary tympanic membrane.

At the posterior or mastoid wall (paries mastoideus), the tympanic cavity continues through a large irregular aperture into the mastoid antrum that leads posteriorly and inferiorly into the mastoid air cells; they vary considerably in number and size. The antrum and mastoid cells are lined by mucous membrane that is continuous with that lining the tympanic cavity. The posterior wall bears a small opening for the chorda tympani (apertura tympanica canaliculi chordae tympani)

Two prominences run at transition of the posterior and medial walls. The prominence of the lateral semicircular canal (prominentia canalis semicircularis lateralis) is located in upper position. The prominence of the facial canal (prominentia canalis facialis) indicates the position of the bony canal containing the facial nerve. The pyramidal eminence is hollow and contains the stapedius muscle, the tendon of which passes through a small aperture at the tip.

The anterior or carotid wall (paries caroticus) corresponds with the carotid wall. It is perforated by small openings for the carotic tympanic nerves which coming from the sympathetic plexus of the internal carotid artery. The superior part of the anterior wall contains the tympanic orifices for the semicanal of the tensor tympani muscle and for the semicanal of the auditory tube. The musculotubarius canal is subdivided in two floors by the septum canalis musculotubarii. The semicanal of the tensor tympani muscle is the superior floor of the musculotubarius canal. The semicanal of the auditory tube is a inferior channel containing the auditory tube (tuba auditiva, Eustachian tube) through which the tympanic cavity communicates with the nasopharynx.



- paries mastoideus
- paries membranaceus
- paries caroticus
- paries labyrinthicus
- paries jugularis
- paries tegmentalis

61. The auditory ossicles, their junctions, and the muscles of the tympanic cavity

Three little bones called the malleus, the incus and the stapes form a chain across the tympanic cavity from the tympanic membrane to the fenestra vestibuli (oval window). The malleus is attached to the tympanic membrane and the stapes closes the fenestra vestibuli.

The malleus consists of a head, neck and 3 processes: the manubrium, the anterior and lateral processes. The manubrium of the malleus is firmly attached to the tympanic membrane, and is connected to the head of the malleus by a neck. The head of the malleus has a saddle-shaped articular surface for connection with the body of the incus.

The incus contains the body and two roots (crura). They differ in length (crus longum, crus breve), and diverge from each other at right angles. The lenticular process of the incus bears the articular surface for the head of the stapes.

The stapes consists of a head, a neck, base and two crura between them. The crus anterius and crus posterius are connected with the neck and with an oval foot-plate, the base (basis stapedis). The base of the stapes occupies the oval window where is attached at the margin by the annular ligament of the stapes.

LIGAMENTS OF THE AUDITORY OSSICLES

- The superior ligament of the malleus and the superior ligament of the incus, both are located between the heads of corresponding ossicle and the roof of the epitympanic recess.
- The anterior ligament of the malleus is stretched between the neck of the malleus and the anterior wall of the tympanic cavity near the petrotympanic fissure.
- The lateral ligament of the malleus joins the neck of the malleus with the edge of the tympanic incisure's border.
- The posterior ligament of the incus connects the end of its short process to the ~~lateral~~ posterior wall of the tympanic cavity.
- The annular ligament of the stapes is an elastic ring attached between rim of the stapedial base and the margin of the fenestra vestibuli.

THE JOINTS OF THE AUDITORY OSSICLES

These are typical synovial joints. The incudomallear joint is saddle-shaped articulation and the incudostapedial joint is a ball and socket articulation. The ossicles transmit vibrations of the tympanic membrane produced by sound waves to the internal ear.

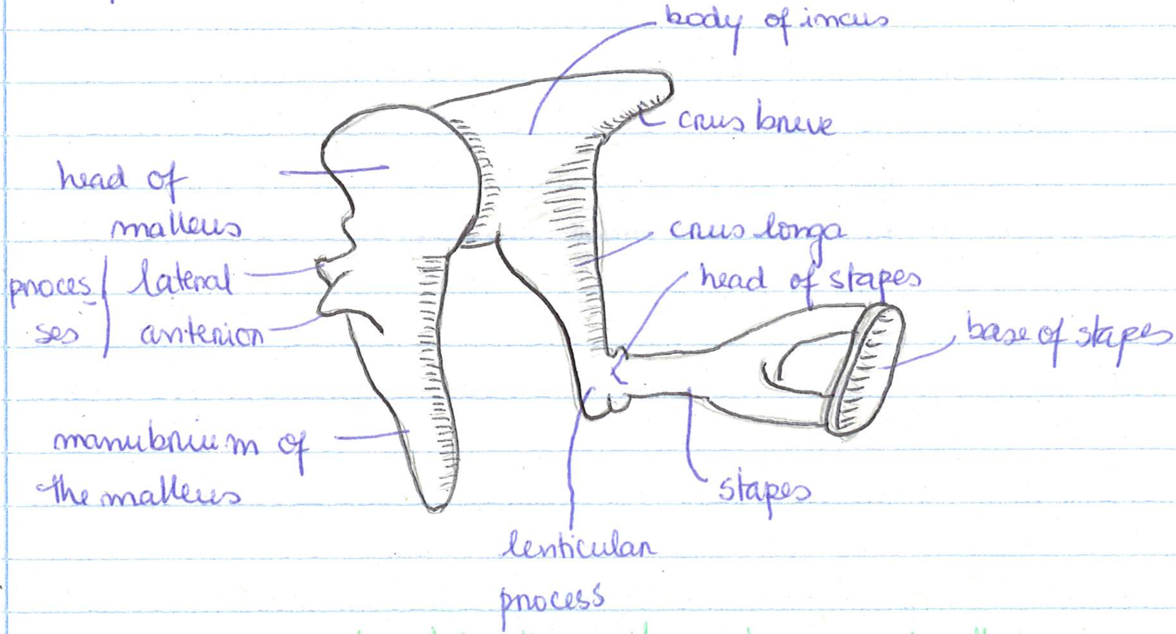
MUSCLES OF TYMPANIC CAVITY

Tension in the system of tympanic ossicles is regulated by 2 muscles: the tensor tympani muscle and the stapedius muscle.

⇒ The tensor tympani muscle has origin in the superior surface of the cartilaginous part of the auditory tube as well as from the wall of its own canal. Its tendon bends laterally around the cochleariform process before inserting into the handle of malleus. The tensor tympani muscle pulls the handle of the malleus inward; this movement prevents a damage of the internal ear when is exposed to loud sounds. In addition, the muscle pushes indirectly the foot plate of the stapes into the vestibular window. By this way it increases the sensitivity of transmission.

⇒ The stapedius muscle arises from the conical cavity inside of the pyramid. Its fine tendon appears from the apex of the pyramidal eminence, and is attached into the posterior surface of the neck of the stape. The stapedius muscle levers the foot plate of the stapes out of the oval window, thereby reducing the ocillatory range.

CLINICAL REMARK - Facial nerve paralysis causes loss of function of the stapedius muscle and with the loss of dampening of sound stimuli, patients suffer from hyperacusis, an increased sensitivity to sound.



62. The auditory tube, the mastoid antrum and cells

The tympanic cavity is lined by the mucous membrane that continues with pharynx, via the auditory tube. It also forms the inner layer of the tympanic membrane (eardrum) and spreads into the mastoid antrum and air cells.

THE AUDITORY (PHARYNGOTYMPANIC) TUBE

The auditory tube connects the tympanic cavity to the nasopharynx and allows the passage of air between these spaces. The tube length is about 35 mm, it extends downward and forward with an angle of about 45° with the sagittal plane approximately in the transition between its bony and fibrocartilaginous parts; the transition is narrowest part of the tube named the isthmus of the auditory tube.

The osseus portion (pars ossea tubae auditivae) is about 12 mm in length with the beginning in the carotid wall of the tympanic cavity (ostium tympanicum tubae auditivae). Opposite ending is located at the angle of junction between the pars squamosa and pars petrosa of the temporal bone.

The fibrocartilaginous portion (pars fibrocartilaginea tubae auditivae) is about 23 mm in length, formed by elastic fibrocartilage. It lies under the mucous membrane of the nasopharynx (ostium pharyngeum) to form a tubal elevation, the torus tubarius.

Near the pharyngeal orifice it contains a variable amount of the lymphoid mass, the tubal tonsil.

The auditory tube provides a communication of the tympanic cavity with the pharynx and thus permit equalization of air pressure in the middle ear with surrounding.

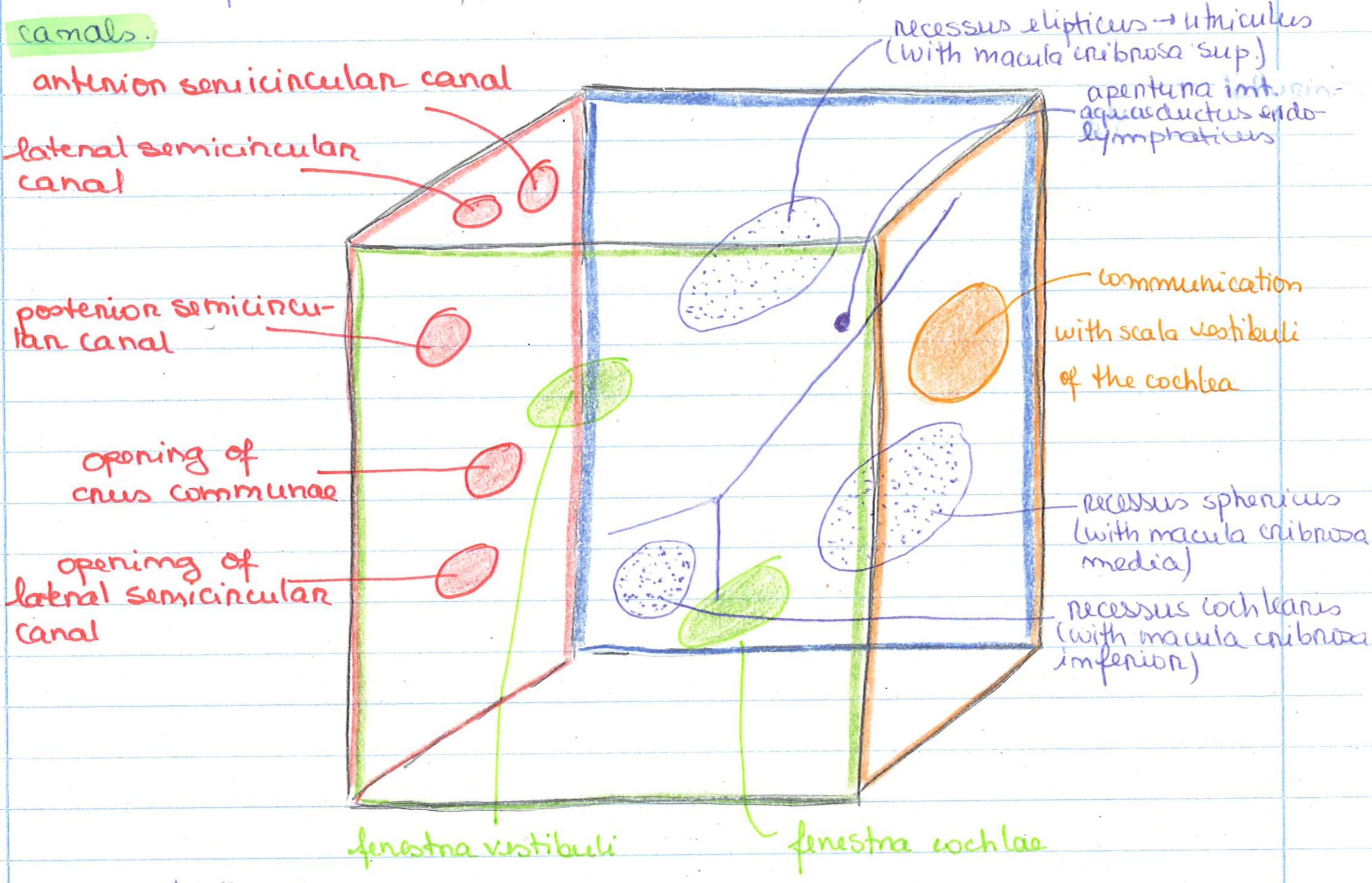
63. The osseous labyrinth of the internal ear

= THE VESTIBULE =

- The lateral (tympanic) wall contains the fenestra vestibuli that is closed by the stapedial base and its annular ligament.
- The medial wall bears an oblique ridge, the vestibular crest (crista vestibuli) which bifurcates to a small depression named the cochlear recess. It is perforated by a number of openings (macula cribrosa inferior). Anteriorly to the vestibular crest, a small circular depression named as the spherical recess contains a perforated patch (macula cribrosa media) for entrance of n. saccularis and n. ampullae posterior. These structures correspond with the inferior vestibular area in the bottom of the internal acoustic meatus. The orifice of the aquaeductus vestibuli is located at the posterior part of the medial wall. This canal contains the ductus endolymphaticus, a tubular prolongation of the membranous labyrinth which ends between the layers of dura mater on the posterior surface of the petrous portion of the temporal bone. The eliptical recess is located behind the crista vestibuli in the transition between the roof and the medial wall of the vestibule. This oval depression

contains the utricle. Bottom of the elliptical recess is perforated by a number of holes (macula cribrosa superior) for the nerve fibres consisting the utricular nerve and the ampullary nerve the fibres of which supply the ampullary cristae of the lateral and anterior semicircular canals. All the structures corresponds with the superior vestibular area in the bottom of the internal acoustic meatus.

- The anterior wall of vestibule contains large opening for communication with the scala vestibuli of the cochlea.
- The posterior wall of the vestibule bears 5 orifices of the semicircular canals.



- anterior wall
- lateral wall
- posterior wall
- medial wall

= THE SEMICIRCULAR CANALS

Three bony semicircular canals, anterior, posterior and lateral are tubes, about 0,8 mm in diameter. The semicircular canals are arranged at right angles to each other. Each canal contains the ampulla, a dilatation at one end measuring more than twice the diameter of the semicircular canal.

The anterior semicircular canal is vertical in direction and oriented perpendicularly to the long axis of the petrous bone. The ampullated end opens into the superior part of the vestibule, while opposite end joints with the similar arm of the posterior semicircular canal to form the crus communae.

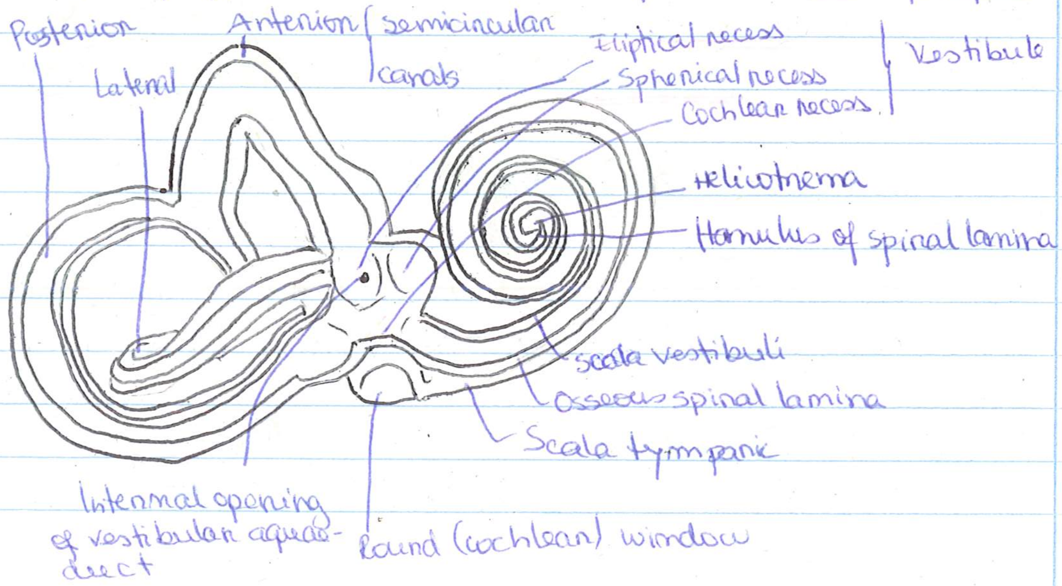
The posterior semicircular canal is also vertical, directed posteriorly and nearly parallel to the long axis of the petrous bone. The ampulled end of this canal opens into the posterior wall of the vestibule, while the opposite end contributes to formation of the crus communae.

The lateral semicircular canal is directed horizontally and posterolaterally. Its ampulled end opens into the upper and posterior angle of the vestibule; the orifice of its opposite end (crus simplex) is located below the orifice of the crus commune.

= THE COCHLEA =

It forms the anterior part of the labyrinth. It has a central conical axis named as the modiolus with the spinal canal of about two and three-quarters convolutions around it. The base of modiolus is perforated by numerous apertures of the tractus spiralis foraminosus for the passage of the cochlear division of the vestibulocochlear nerve and corresponds with the bottom of the internal acoustic meatus (the area cochleae).

The cochlear canal diminishes gradually in diameter from the base to the summit, where it terminates in the cupula which forms the apex of the cochlea. A bony ridge, the osseous spiral lamina projects from the modiolus into the cochlear canal cavity and partially subdivides it into two passages or scalae. The superior is named scala vestibuli, the inferior is termed the scala tympani. Near the summit of the cochlea the lamina ends in a hook-shaped process, the hamulus laminae spiralis. The helicotrema is an opening through which the two scalae communicate with each other. The osseus labyrinth is lined by thin fibrous membrane covered with a layer of epithelium that secretes a fluid, the perilymph.



64. The membranous labyrinth of the internal ear, the VIII[th] cranial nerve

= THE UTRICLE =

The utricle is a larger sac lying in contact with the recessus ellipticus. The anterior wall of the utricle contains thickening to form the utricular macula which is located HORIZONTALLY. The utricle is connected through the utriculosaccular duct with the ductus endolymphaticus.

= THE SACCULE =

The saccule is a smaller sac which lies in the recessus sphericus. Its anterior part exhibits an oval thickening, the macula of the saccule, in a plane set at right angles to the utricular macula, i.e. in a VERTICAL position.

= THE MACULA UTRICULI AND SACCULI

On the sensory hair epithelium of the macula utriculi and sacculi there is a jelly-like membrane, statolithic membrane with the cristalline particles of calcium carbonate, the statoliths.

The maculae lie at right angles to each other: the macula utriculi lies almost HORIZONTALLY on the lower surface of the utriculus and the macula sacculi lies VERTICALLY on the anterior wall of the sacculus.

= THE SEMICIRCULAR DUCTS =

They open into the utricle by 5 orifices. The wall is thickened in the ampullae; it projects into the cavity as placed elevation, the ampullary crest.

The crista forms a ridge which lies in the ampulla, transverse to the course of the semicircular duct. It contains supporting and sensory hair cells on its surface like those in the utricular and saccular macula. They carry stereocilia or modified microvilli of varying length that are embedded in a dome-shaped gelatinous mass, the cupula. It swings in response to currents in the endolymph.

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= THE ORGAN OF BALANCE =

The sacculus, the utriculus and the three associated semicircular ducts form the organ of balance, the so-called vestibular apparatus. These structures register acceleration and changes of position, and thus an orientation in space.

= THE COCHLEAR DUCT =

The cochlear canal contains the cochlear duct, which is filled with the ENDOLYMPH. It begins as a blind end, the vestibular caecum, and terminates in the cupula as the caecum cupulare. Above the duct lies the scala vestibuli and below it the scala tympani, both contain the PERILYMPH.

The cochlear duct is triangular in section; its floor is formed by the basilar membrane, which bears the receptor apparatus, the organ of Corti. The second, more delicate membrane, the vestibular membrane (Reissner's membrane) extends from the thickened endosteum on the osseous spiral lamina (the lamina spiralis ossea) to the outer wall of the cochlea. The outer wall of the cochlear duct has a special stratified epithelium containing a dense capillary plexus producing the endolymph, it is called the stria vascularis.

= ORGAN OF CORTI =

The basal lamina supports of organ of Corti. Lateral to it, the epithelium continues into the stria vascularis, which contains many intraepithelial capillaries.

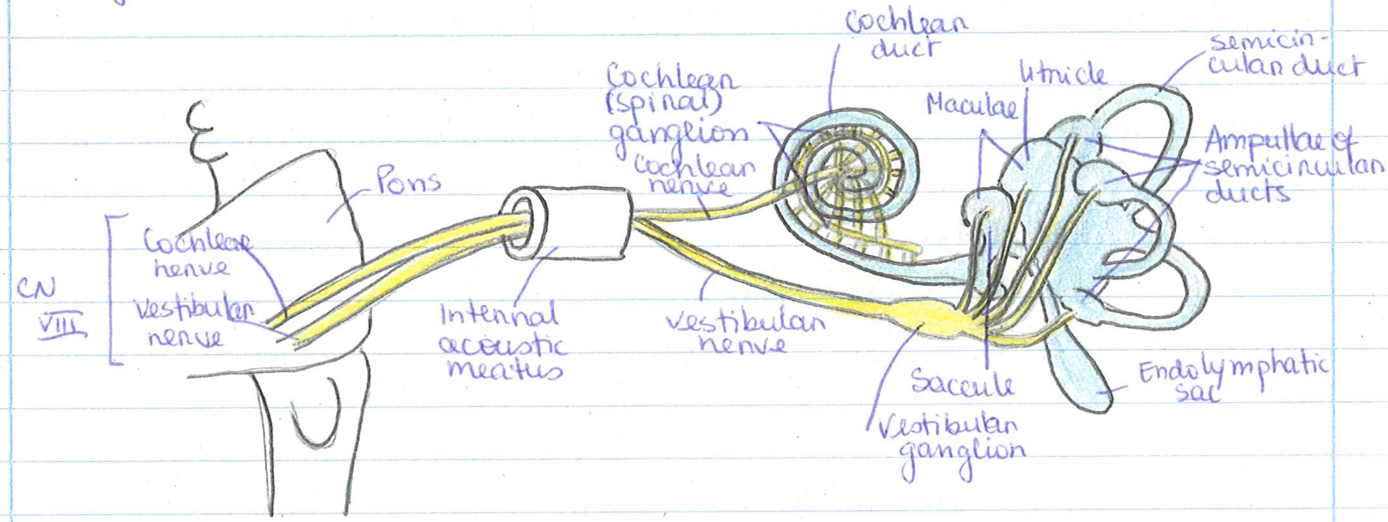
The organ of Corti expands spirally from the basal convolution to the cupula of the cochlea. It consists of hairy sensory cells and a variety of supporting cells. Its medial wall is formed by the inner pillar cells, and its lateral wall by the obliquely lying outer pillar cells. Pillar cells have a wide basal part, in which lies the nucleus, a narrow middle part and an apical part.

The sensory cells consist of the inner hair cells, which only form one row, and the outer hair cells, which form 3 rows in the basal convolution of the cochlea, 4 in the middle convolution and 5 in the upper convolution. On the upper surface of all the hair cells there is a dense cuticular layer in which the small sensory hairs are anchored. Nerve fibers with synapse-like contacts end at the base of the hair cells. A gelatinous layer, the tectorial membrane, extends from the vestibular lip of the limbus spirale over the hair cells.

= SPIRAL AND VESTIBULAR GANGLIA =

The spinal ganglion consists of a chain of clusters of neurons lying in the modiolus, as the exit of the osseous spinal lamina. Together they form a spinal chain of ganglia. These contain true bipolar neurons, whose peripheral processes extend to the hair cells of the organ of Corti and whose central processes run as the tract of the spinal foramen to the axis of the modiolus where they combine to form the cochlear root.

The vestibular ganglion lies at the base of the internal acoustic meatus. It consists of a superior and an inferior part. The bipolar neurons of the superior part send their peripheral processes to the ampullary cristae of the anterior (anterior or superior ampullary nerve) and lateral semicircular canals (lateral ampullary nerve) to the macula of the utricle (utricular nerve) and to part of the macula of the sacculus. The neurons of the inferior part supply the ampullary crista of the posterior semicircular canal (posterior ampullary nerve) and part of the macula of the sacculus (saccular nerve). The central processes form the vestibular division, which runs in a common sheath with the cochlear division, through the internal acoustic meatus into the middle cranial fossa.



Questions D

1. Calvaria and its coverings

External view:

- Made by: frontal, parietal, temporal and occipital bones
- coronal, sagittal and lambdoid suture (bregma, lambda)
- superior and inferior temporal lines

* Cranial bones are plane bones with internal and external plates with diploe in between.

Internal view:

- frontal crest: attachment of falx cerebri
- groove for sagittal sinus
- arterial grooves
- granular foveolae

2. Reg. temporalis

- Superior: temporal lines
- Lateral: temporal fascia
- Anterior: posterior surface of the frontal process of zygomatic bone and the posterior surface of the zygomatic process of the temporal bone
- Inferior: zygomatic arch laterally and infratemporal crest of the greater wing of the sphenoid bone medially. Communicates with infratemporal fossa

Contents:

- Temporal muscle (inferior temporal line to coronoid process of mandible and related margin of the ramus of mandible. Elevation and retraction of mandible)
- Deep temporal nerves (from V_3)
- Deep temporal arteries (from maxillary a.)

} From infratemporal fossa, pass superiorly under temporal m. and supply it.

- Zygomaticoorbital nerve (from V_2) - enters through 1 or more small foramina on the temporal fossa surface of the zygomatic bone. Goes between zygomatic bone and temporal m. and supplies the skin of the temple.
- Middle temporal artery (from superficial temporal a.) → same as deep arteries