THE CENTRAL NERVOUS SÝSTEM

Yiannis P Panayiotopoulos, MD, PhD

THE SPINAL CORD

MACROSCOPIC APPEARANCE

Is 45cm long, contained within the spinal canal. Continues from the medulla oblongata and ends at the L1-L2 intervertebral disk. At the 3^{rd} foetal month the cord occupies the whole length of the spinal canal; at birth it terminates at the L3 level.

It tapers inferiorly, forming the **conus medullaris**, from which the pia matter prolongs distally as the **filum terminale**, attached to the coccyx.

- CHARACTERISTICS
- Anterior fissure [anterior white commissure]
- Posterior sulcus, divided by the...
- Posterior median septum
- Two posterolateral sulcuses capped by the substantia gelatinosa
- Two anterior and two posterior columns
- **Posterior [dorsal] roots**: arise from the posterolateral sulcus, pass behind the **dentate ligament** [on the sides of the cord, formed by a condensed pia], reach the **posterior ganglion** and then unite with the **anterior [motor] roots**, forming a...
- Spinal nerve: divides into a small posterior and a larger anterior primary ramus, containing both sensory and motor fibres.
- Cauda equina: the nerve roots lengthen downwards, forming a bunch of nerves that continues beyond the cord termination
- GREY MATTER
- Is **H-shaped** and is contained within the cord
 - **Posterior horns** [termination of sensory fibres]
 - Lateral horns [sympathetic cells, in the thoracic and lumbar regions]
 - Anterior horns [motor cells]

COVERINGS [MENINGES]

- 1. PIA MATTER
 - Adhered to the cord
 - Forms the **denticulate ligament** [attached to the dura] and **fillum terminale**
 - Above it lies the subarachnoid space
- 2. Arachnoid
 - Attached to the dura
 - Subrachnoid space beneath it, containing cerebrospinal fluid [CSF]
- 3. DURA



• The spinal cord & meninges

- Terminates at the **S2 level** [posterior superior iliac spine]
- Above it is the **epidural space** [when entered by a needle there is a feeling os "give"]

BLOOD SUPPLY

- ARTERIES
- Anterior and posterior spinal arteries [branches of the vertebral artery]
- Branches from:
 - Ascending pharyngeal artery
 - Intercostal arteries [forming the artery of Adamkiewits]
 - Lumbar arteries

• VENOUS PLEXUSES

There are 2 venous plexuses around the vertebrae, the **anterior** and the **posterior venous plexus**. These two communicate with the **basilvertebral veins** which ascend on the sides of the bodies. Each plexus has two components, the **external** [anterior and posterior side of the vertebral body respectively] and the **internal plexus**, on the anterior and posterior sides of the spinal canal. The two internal plexuses join together and drain through **the longitudinal sinuses** into the **intervertebral vein** [runs along the intervertebral disk], which communicates, at various levels, with the **occipital, thoracic [azygos & hemiazygos], lumbar and lateral sacral veins**.

PATHWAYS

1. PYRAMIDAL

[Lateral cerebrospinal, corticospinal, crossed motor tract]

On a transverse section of the spinal cord it is located in the **lateral column**, deep and somewhat posteriorly. The motor fibres of the tract arise in the cortex, cross to the opposite side in the medulla and reach the nerve cells in the anterior horns.

2. DIRECT PYRAMIDAL [UNCROSSED MOTOR]

In the anterior column, on the sides of the anterior fissure. The fibres cross to the opposite side at each myelotome segment.

3. EXTRAPYRAMIDAL PATHWAYS

They pass in front of the pyramidal tracts, lateral to the lateral horns

4. ANTERIOR SPINOCEREBELLAR TRACT

On the surface of the lateral white column. The fibres ascend on the same side of the cord to reach the cerebellar peduncles.

5. POSTERIOR SPINOCEREBELLAR

Surface of lateral column, posteriorly to the midline

6. ANTERIOR SPINOTHALAMIC

In front of the anterior horns

7. LATERAL SPINOTHALAMIC

Posterolateral to the anterior horns, infront of the the extrapyramidal and pyramidal tracts and behind the anterior spinocerebellar tract. Convey pain and temperature. The fibres enter the cord,



+1

3

• The spinal cord & tracts

ascend 2-3 segments and then decussate to the opposite side, reaching the thalamus and then the cortex

8. POSTERIOR COLUMNS

They convey touch and proprioception and their fibres are mostly uncrossed. They reach the gracillis and cuneatus nuclei in medula. Then they decussate to reach the thalamus and cortex.

- Fasciculus gracilis [tract of Goll]
- Fasciculus cuneatus [Burdach tract]

CLINICAL FEATURES

- COMPLETE TRANSECTION
- bilateral loss of sensation [below the level of injury]
- bilateral flaccid paralysis [below the level of injury]
- loss of voluntary sphincter controlreturn of the reflex sphincter control

• SYRINGOMYELIA

Affects the center of the cord. It first involves the spinothalamic tracts [especially the dcussating] with loss of the sensation of pain and temperature. The posterior columns are usually preserved.

• HEMISECTION [BROWN-SEQUARD SYNDROME]

- paralysis on the affected side
- loss of proprioception and fine touch discrimination on the affected side
- loss of pain and temperature on the opposite side
- small area of sensory loss at the injury side, exactly at the myelotomic level of injury
- TABES DORSALIS

Affects the posterior columns

- PAIN CONTROL PROCEDURES
- Posterior rhizotmy

• Cordotomy

The cord is severed in a 3mm depth from the lateral denticulate ligament forward. Thus the spinothalamic tracts are interrupted while the lateral pyramidal tract is preserved.

• CSF PRESSURE

80-130mm CSF fluid \approx water

• LUMBAR PUNCTURE

A line joining the two iliac crests crosses the L4 vertebra. The puncture is undertaken either on the above or below interspace. The patient should be positioned on his side and be "flexed" in order to open the interspinous processes. There is a distinct "give" when the dura is punctured and the epidural space is enterd.

• QUECKENSTED'S TEST

Lumbar puncture is performed and the pressure is measured. The neck is then flexed and the jugular veins are obstructed by external pressure. In normal cases there will be a distinct rise in pressure for more than 40mm, due to reflux of CSF. This rise is not present in obstructing spinal tumors.



• The motor pathways and diseases that can affect them on various levels

THE BRAIN

THE MEDULLA

25x20mm, a continuation of the pons [superiorly] and the spinal cord [inferiorly]. At the junction point with the pons, just above the puramids, exits the abducens nerve [VI] and slightly laterally, behind the middle cerebellar peduncle, the facial and vestibulocochlear nerve.

• ANTERIOR SURFACE CHARACTERISTICS

[from laterally to medially]

- Cerebellar peduncle
- Posterolateral structure
 - the rootlets of IX, X, XI cranial nerves arise
- Olivary eminence [olive]
- Anterolateral sulcus
 - origin of XII rootlets
- Pyramids
 - anteromedian fissure

• BLOOD SUPPLY

From the posterior inferior cerebellar branch of the vertebral artery

• DEEP STRUCTURE

a. SENSORY DECUSSATION LEVEL

At the posterolateral surface, behind and lateral to the **central canal**, is the **gracile nucleus** and anterolateral to it the **cuneate nucleus** is located. Fibres enter these nuclei coming from the **medial lemniscus** [sensory decussation], lying in the midline, behind the **pyramids**. In front of the central canal and behind the medial lemniscus lie the **roots of hypoglossal nerve** and slightly posterolateral to them the **dorsal nucleus of vagus**. Anterolateral to the cuneate nucleus lies the **spinal tract of trigeminal nerve fibres**.

b. Lower part of the 4^{th} ventricle level.

The **pyramids** are in the midline and the **olive nucleus** laterally. Behind the pyramids is the **medial lemniscus**, crossed by the **olivocerebellar tract**. Moving further posteriorly, the **spinothalamic tract** ascends at a level between olive and pyramids, having on its posteromedial site the **nucleus ambiguus**. Behind the latter lie the **spinal root of the Vth cranial nerve**[laterally] and the **hypoglossal nucleus** [medially]. Behind the XIIth nerve nucleus lies the **dorsal nucleus of vagus**, just in front and medially to the **inferior cerebellar peduncle**.

THE PONS

Sits on the medulla like a cap with multiple transverse **ridges** on its anterior surface.



• The brain [cerebrum]

Above it is the **midbrain** and the origin of the **occulomotor nerve**. The **superior cerebellar peduncle** arises on its posterosuperior aspect.

The **middle cerebellar peduncle** connects the pons with the cerebelum. On the inferior site of the peduncle is the origin point of the **vestibulocochlear** and **facial nerve** [lying side by side], while superiorly is the exit point of the **sensory and motor root of trigeminal nerve**. At the junction of pons with medulla arises the **abducens nerve**.

• DEEP STRUCTURE

Contains the **pontine nuclei**, **ascending and descending pathways**, the **pontine tegmentum**, the **nuclei of V**, **VI and V**th **cranial nerves** and the **decussating pontocerebellar tracts**. Blood supply is from the **basilar artery**.

• CROSS SECTION

On the posterior aspect lie the **superior cerebellar peduncles** on each side and the cavity of the **4th ventricle** in the midline. In front of the ventricle lies the **abducens nerve nucleus**, with the **facial nerve nucleus** lying anteromedially and the **motor nucleus of trigeminal nerve** anterolaterally. Laterally and slightly posteriorly lies the **sensory trigeminal nucleus**.

Anterior to the facial nucleus lies the **pyramidal tract** and in front of it the **medial lemniscus**.

CEREBELLUM

- Cortex of gray matter
- Mass of white matter
- Deep nuclei : the dentate nucleus is the largest
- Cerebellar peduncles
 - **Superior** \rightarrow back of midbrain
 - Middle \rightarrow dorsum of pons
 - Inferior \rightarrow dorsolateral medulla
- **RELATIONS**
- Anteriorly : 4th ventricle, medulla, pons
- Laterally: sigmoid sinus, mastoid antrum
- Above: tentorium cerebelli
- BLOOD SUPPLY
- Vertebral artery
 - Posterior inferior cerebellar artery
- Basilar artery
 - Anterior inferior cerebellar artery
 - Superior cerebellar artery
- TRACTS
- SUPERIOR PEDUNCLE
 - Anterior spinocerebellar tract, uncrossed, conveying afferent fibres



• The cerebellum, midbrain & stem

- MIDDLE PEDUNCLE
 - Pontocerebellar tract of crossed afferent fibres
- INFERIOR PEDUNCLE
 - Conveys uncrossed afferent fibres
 - vestibulocerebellar tract
 - olivocerebellar tract
 - posterior spinocerebellar tract
- FUNCTION

Regulates:

- Posture
- Muscular tone
- Muscular coordination

• CLINICAL FEATURES

Cerebellar lesions will be accompanied by symptoms on the same side of the body:

- unsteady gait
- hypotonia
- tremor
- nystagmus
- dysarthria
- leaning or falling towards the affected side

Thrombosis of the posterior inferior cerebellar artery will be accompanied by:

- ataxia
- homolateral hypotonia
- signs from cranial nerves V to X
- contralateral loss of pain and temperature sensation [spinothalamic tract of the pons]

MIDBRAIN

Contains the two cerebral peduncles [brainstem]which join the internal capsule to pons and the acqueduct of Sylvius.. From the interpendicular fossa arises the occulomotor nerve. Anterosuperiorly lie the mamillary bodies and the infundibulum of pituitary gland.

On its ventral surface are the bases of the cerbral pedunculi, and the mamillary bodies. On the dorsal surface lie the 4 corpora quadrigemina, the pineal gland [posterior wall of 3^{rd} ventricle], the tectum and the midbrain tegmentum.

• DEEP STRUCTURE

In the midline and posteriorly lies the **acqueduct of Sylvius** [joining 3rd and 4th ventricles]. Posterior to it and on each side lie the **corpora quadrigemina**. Just in front and laterally to the acqueduct lies the **occulomotor nucleus** and further lateral to it the **medial lemniscus**. Anteromedially to medial lemniscus is the **red nucleus of brainstem**, separated by the cerebral



• Motor nuclei of the brain stem

peduncle by the elliptically shaped **substantia nigra**. The **mamillary body** lies on the anteromedial side of the peduncle.

DIENCHEPHALON

Comprises the part of the brain surrounding the 3^{rd} ventricle: contains the thalamus and hypothalamus and the pituitary gland.

• HYPOTHALAMUS

Forms the **floor of the 3rd ventricle**. On its inferior aspect lie:

- Optic chiasma
- Tuber cinereum
- Infundibular stalk [posterior lobe of hypophysis]
- Mamillary bodies

Is concerned with **autonomic activity**

- Anteromedial area \rightarrow parasympathetic
- Posteromedial area \rightarrow sympathetic

Hypothalamic injuries will cause:

- Somnolence
- Obesity
- Disturbances in temperature regulation

• PITUITARY GLAND [HYPOPHYSIS CEREBRI]

Lies in the pituitary fossa, connected to the midbrain by the infundibulum stalk

- Anterior lobe
 - chromophobe
 - eosinophilic
 - basophilic cells
- Pars intermedia, containing colloid vesicles
- **Posterior lobe**, connected to the stalk by nerve fibres and bears the **cerebral diverticulum** inside it
- **PITUITARY ADENOMAS**
- 1. Chromophobe [the commonest]
 - expands the pituitary fossa
 - bitemporal hemianopia
 - hypopituiterism [loss of sex characteristics, hypothyroidism]
 - hypothalamus insufficiency [obesity, diabetes]
- 2. Eosinophilic
 - gigantism
 - acromegaly [growth hormone]
- 3. Basophilic
 - Cushing's syndrome
- THE THALAMUS



• Diencephalon & hypophysis

Is an oval mass of gray matter forming the **side walls of the 3rd ventricle**. Laterally to thalamus lies the **internal capsule** [long pathways from cortex to spinal cord] and then the **basal ganglia**. On its inner aspect is a prominence seen from the inside of the3rd ventricle, the **massa intermedia**. Posteriorly, each thalamus has 3 eminences: the **pulvinar**, **lateral** and **medial geniculate bodies**.

Each thalamus is composed of **relay nuclei**, from which **thalamic radiations** [main sensory pathways] pass to the internal capsule and from there to the cortex.

THE CEREBRAL HEMISPHERES

• CEREBRAL CORTEX

Afferent input to the cortex comes through the **thalamus**. Efferent pathways condense to pass through the internal capsule. Commissural connections between the two hemispheres pass through the corpus callosum. There are also may association connections between parts of the same lobe or hemisphere.

1. FRONTAL LOBE

All areas in front of the central sulcus of Rolando.

- Motor cortex: precentral gyrus
- **Pre-motor cortex**: anterior part of **pre-central sulcus**, **lower frontal gyri**
- Eye motor field: area anterior to pre-motor
- **Broca's motor speech area**: the posterior part of the inferior frontal gyrus which lies anteriorly to the lower part of prec-entral gyrus
- Frontal association cortex [pre-frontal cortex]: concerned with intellectual activity
- 2. PARIETAL LOBE.

Extends from the occipital [parieto-occipital] notch to the posterior end of the lateral and central sulcus.

- Somatic sensory cortex: post-central gyrus
- Somatic association cortex of parietal lobe: concerned with recognition of somatic sensory stimuli
- 3. OCCIPITAL LOBE

The posterior part of the hemisphere, having 3 main sulcue: **parieto-occipital sulcus**, **calcarine sulcus** and **post-calcarine sulcus**.

- **Visual cortex**: the optic radiation starts from the lateral geniculate [striate] body and reaches the calcarine and postcalcarine gyri.
- Occipital association cortex: anteriorly to visual cortex [periatriate]
- 4. TEMPORAL LOBE

Extends inferolaterally to the lateral sulcus

- Auditory cortex: upper part of temporal lobe, concerned with reception of auditory stimuli [Heschle's gyrus]
- Temporal association cortex: recognition and integration of auditory stimuli
- Rest of temporal cortex ???? [not certain about its function]
- Hippocampal gyrus, on the medial undersurface of the temporal lobe
- **Rhinencephalon?:** hippocampus, uncus, alveus, fornix, fimbriae, may be associated with olfaction



• Cerebral cortex [postcentric & precentric gyri] functions

5. INSULA OF REIL

Is the **floor of the lateral sulcus**, with a number of small gyri, crossed by the middle cerebral artery. Its upper part may represent a **taste** recognition area. Its lower part may be associated with **autonomic** nervous activity.

• BASAL GANGLIA

They are compact masses of gray matter deep in the cerebral substance, lateral to the internal capsule.

1. CORPUS STRIATUM

- caudate nucleus
- putamen
- globus pallidus
- lentiform nucleus.

The first three lie lateral to the anterior horn of the lateral ventricle. They sent extrapyramidal fibres to the internal capsule. The lentiform nucleus lies next to the posterior limb of internal capsule and sends afferents to the cerebral cortex.

2. CLAUSTRUM

3. Amygdala

Efferents to thalamus and from there to hypothalamus, red nucleus, olivary nucleus and substantia nigra.

• LONG PATHWAYS

1. SOMATIC AFFERENT PATHWAYS

a. Proprioceptive & tactile stimuli

They enter the spinal cord through the **posterior root ganglia** and ascend in **the ipsilateral posterior columns** [fasciculus gracilis of Goll and fasciculus cuneatus of Burdah] to reach the **gracile and cuneate nuclei** in lower medulla. They decussate in medulla [sensory decussation] and pass to the medial lemniscus; from there they pass to the contralateral hypothalamus.

b. Pain, temperature & some tactile afferents

They enter the spinal cord through the **substantia gelatinosa** covering the posterior horns. Ascend a few myelotomes and then cross to the opposite side [through the anterior white commisure] to form the anterior and lateral spinothalamic tracts The fibres reach the thalamus and from there pass through the posterior limb of internal capsule to reach the post-central gyrus.

2. MOTOR PATHWAYS

They form the **pyramidal tract**.

From the **precentral gyrus** of motor cortex efferent fibres pass through the **genu of corpus callosum** and **posterior limb of internal capsule** to enter the **cerebral peduncle**. From there some fibers [**corticobulbar**] reach the **cranial nerve nuclei**. The rest enter the **pons** where they break to the **crossed [indirect]pyramidal tract** and the **uncrossed tract**. The latter descends in the ipsilateral side of the spinal cord and cross at the myelotome they are associated with, passing through the anterior white commisure. The crossed pyramidal tract enters the **ventral part of the medulla** and cross to the opposite side at the end of medulla



• The basal ganglia & thalamus

- Blood supply
 - Motor cortex:
 - leg area, anterior cerebral artery
 - hand & face area, middle cerebral artery
 - Internal capsule: middle cerebral artery
 - Cerebral peduncle: posterior cerebral artery
 - Pons: basilar artery
 - Medulla: posterior inferior cerebellar artery

• Clinical features

In the motor cortex, movements rather than individual muscles are represented.

Lesions of the cortex nerve cells [**upper motor neuron lesion**] will be associated with **spastic paralysis** [the muscles do not atrophy with this type of lesion]. Lesions of the second motor nerve cell [**lower motor lesion**] will be accompanied by **flaccid paralysis** and muscle atrophy.

- 1. Cortex lesion: isolated groups will be affected, dysphasia
- 2. Internal capsule: complete hemiplegia and sensory loss [both on the opposite side]
- 3. Cerebral peduncle: as above, plus occulomotor nerve involvement
- 4. **Pons**: contralateral hemiplegia and involvement of the abducens and facial nerve [ipsilateral to the lesion lower motor lesion on the facial nerve distribution]
- 5. **Medulla**: both pyramids may be involved

tongue paralysis to the side of the lesion [hypoglossal nucleus] involvement of respiratory and vasomotor centers

3. EXTRAPYRAMIDAL SYSTEM

Includes all motor mechanisms whose fibers do not pass through the pyramids. it is usually restricted to:

- non-pyramidal motor cortex area
- basal ganglia
- brain stem motor mechanisms

Efferent fibers from the **premotor cortex** [? sensory cortex] reach the **corpus striatum**, which also receives afferents from all sensory areas of cerebellum. From there they reach the **reticular formation of brain stem** [comprising from the substantia nigra and red nucleus] as well as the thalamus and **subthalamic nucleus**. From these cells arises the **reticulospinal pathway** which descends the spinal cord to reach, at various myelotomes, the **anterior horn cells**.

The main function of the extrapyramidal fibers is to set the background for subsequent pyramidal activity, i.e. regulate the muscle tone.

- Clinical syndromes involving the extrapyramidal system
- 1. Parkinson's : \rightarrow globus pallidus
- 2. Wilson's disease: \rightarrow putamen
- 3. Athetosis: \rightarrow putamen
- 4. Syndenham's chorea \rightarrow basal ganglia
- 5. Huntington's chorea \rightarrow basal ganglia

• THE MEMBRANES OF THE BRAIN

1. **DURA MATTER**



• The dura matter and venous sinuses

Is a dense membrane having two layers in the cranium:

- Outer, adherent to the inner skull surface, containing the dural venous sinuses
- Inner, forming the
 - falx cerebri
 - falx cerebelli
 - tentorium cerebelli
 - diaphragma sellae

2. Arachnoid

Forms projections into the subdural space, the **arachnoid villi** which form the **Pacchionian bodies**

3. PIA MATTER

Has trabeculae of fine fibrous strands. The space between pia and arachnoid [subarachnoid space] contains the cerebrospinal fluid

Absorption of CSF is passive. One fifth of it is contained with the spinal canal. The total CSF capacity is 250ml [25ml maximum in the spinal theca].

The CSF pressure is 80-180mmCSF, on average 100mmH₂O

CISTERNS

They represent considerable enlargements of the subarachnoid space

- Cisterna magna [between cerebellum and the back of medulla]
- Cisterna pontis
- Interpendicular cistern
- Chiasmatic cistern

• VENTRICULAR SYSTEM

The cerebrospinal fluid is formed by the **ependymal cells** of the **choroid plexuses** of the cerebral ventricles.

• TWO LATERAL VENTRICLES

They lie within the hemispheres

- anterior horn, communicating with the 3rd ventricle by the interventricular foramen of Monro
- **posterior horn**, extending in the occipital lobe
- **inferior horn**, within the temporal lobe

• 3RD VENTRICLE

Lies between the two thalami. The hypothalamus forms its floor and the pineal body its posterior wall. Communicates with the 4th ventricle by the **acqueduct of Sylvius** which descends on the posterior surface of the brainstem.

• 4th ventricle

Diamond [tent] shaped. Its floor is the medulla and the pons and its roof is the cerebellum. Communicates with the subarachnoid space by the:

- median aperture of Magentie
- lateral aperture of Luschka

Superior sagittal sinus	Arachnoid villus Great cerebral v. of Galen Straight sinus
Foramen of Monro-	Confluence of sinuses
Cerebral aqueduct	Fourth ventricle
of Sylvius	Cerebromedullary cistern
Pontine cistern	Choroid plexus of fourth ventricle
Pia mater	Medial foramen of
Arachnoid	Magendie
Dura mater	Subarachnoid space
No.	Central canal
k	
A PROM SHITL ADDA A PARA	

• The ventricular system of the brain

CRANIAL NERVES

TOPOGRAPHIC ANATOMY OF THE CRANIAL NERVES ON THE INFERIOR CEREBRAL SURFACE

From anteriorly to posteriorly:

- I. **Olfactory bulb and tract**, [parallel to the longitudinal cerebral fissure, on the inferior aspect of the frontal lobes]. At the level of the chiasma they pass laterally between the temporal and frontal lobe.
- II. **Optic nerve**, on the inferior frontal surface, crossing the olfactory tract to reach the chiasma in front of the pituitary gland. The optic tracts then disappear behind the uncus of the temporal lobe.
- III. Occulomotor nerve, arising from the interpendicular fossa, on the anteromedial surface of the brain stem
- IV. **Trochlear nerve**: superolateral aspect of pons, running on the inferior surface of uncus, to exit the cranium through the superior orbital fissure.
- V. **Sensory and motor root of trigeminal nerve**: lateral surface of pons, superior to the middle cerebellar peduncle.
- VI. Abducens nerve: close to the midline, at the junction between pons and medulla
- VII. **Facial nerve**: Inferior to the middle cerebellar peduncle and lateral to the junction of medulla to pons [olive].
- VIII. Vestibulocochlear nerve: right next to facial nerve, posterolaterally to it.
- IX. **Glossopharyngeal nerve**: small rootlets arising from the posterolateral sulcus of medulla, between the olive prominence and the inferior cerebellar peduncle, inferiorly to the VIIIth nerve and medially to the lateral recess of the 4th ventricle.
- X. Vagus nerve: posterolateral sulcus of medulla, just below the IXth nerve.
- XI. Accessory nerve: its rootlets arise from the posterolateral sulcus of the lower part of the medulla and come to join the spinal root of the nerve.
- XII. Hypoglossal nerve: anteromedial sulcus of the upper part of medulla

OLFACTORY NERVE {I}

It is the only nerve whose fibers are the central processes of receptive cells [olfactory cells] and not ganglia.

The olfactory mucosa is situated at the upper superior nasal conchae. It is supplied by the nerve endings of the mitral cells located in the olfactory bulb [anteroinferior part of frontal lobe, lateral to the frontal commisure] which penetrate the cribriform plate of the ethmoid bone to enter the nasal space. From the olfactory bulb the mitral cells axons form the olfactory tract, which dissapears behind the uncus, to reach, hypothetically, the hippocampal gyri. CLINICAL FEATURES

• Unilateral anosmia is a finding usually associated with frontal lobe tumors.



• Topographic anatomy of cranial nerves at the base of the brain

- Olfactory hallucinations are associated with lesions of the uncus
- Bilateral anosmia may accompany head injuries with fractures of the anterior cranial fossa.

OPTIC NERVE {II}

The **retina** is the receptive mechanism. It contains 3 cell layers:

a. Receptor cells [rods & cones]

b. Bipolar cells

c. Ganglion cells

The axons of the ganglion cells form the **optic nerve fibers**, which condense at the back of the retina to form the **optic disk**. The **optic nerve** enters the anterior cranial fossa passing through the **optic foramen** and courses posteromedially to reach the **pituitary fossa**. At that point the the temporal fibers [lying on the medial aspect] of each nerve cross to the opposite site [**optic chiasma**] while the nasal fibers remain on the ipsilateral site. The optic tracts dissapear behind the uncus to reache the **lateral geniculate body** of the thalamus; from there the fibers expand, forming the **optic radiation**, which courses posteriorly to reach the **visual cortex of the occipital lobe** [**calcarine fissure**].

OCCULOMOTOR NERVE {III}

- Supplies the **extrinsic eye muscles**, with the exception of superior oblique [trochlear nerve IV] and lateral rectus [abducens nerve VI].
- It also caries **pre-gamglionic parasympathetic fibers** for the **pupil sphincter**, which reach the muscle via the **ciliary ganglion**.

• The occulomotor nerve nucleus lies in the midbrain tegmentum, on the floor of the Sylvius acqueduct. It gives off the somatic efferent fibers of the nerve, while the parasympathetic efferents arise from the Eddinger-Westfphal nucleus. The nerve emerges on the anteromedial surface of the cerebral peduncle [interpedincular fossa of the brain stem] and pierces the dura to run by the side of cavernus sinus. Exits the skull through the superior orbital fissure and divides into two branches:

a. **superior branch** which innervates:

- superior rectus
- levator palpebrae superioris
- b. inferior branch
 - medial rectus
 - inferior rectus
 - inferior oblique
 - parasympathetic fibers to the ciliary ganglion

□ CILIARY GANGLION

Lies at the apex of orbit, lateral to the optic nerve

1. Afferent fibers



• The specific optic field anomalies and their causes

- 1. Circumferential blindness [hysteria, optic or postbulbar neuritis]
- 2. Total blindness [Compklete disruption of optic nerve by tumour, trauma]
- 3. Bilateral temporal hemianopia [Lesions of the chiasm, like pituitary tumours]
- 4. Right renal hemianopia [Lesion affecting the side of the chiasm]
- 5. Right homonymous hemianopia [lesion of the optic tract, more commonly parietal or frontal lobes]
- 6. *Right homonymous hemianopia without affecting movement of iris [Complete lesion of the optic radiation]*
- 7. Right inferior quarter cycle hemianopia [Partial lesion of the superior part of the left optic radiation]

- preganglionic parasympathetic fibers from Eddinger-Westphal nucleus
- sympathetic postganglionic rootlets from the carotid plexus
- sensory rootlets from the nasociliary nerve, i.e. sympathetic fibers to the dilator pupil

2. Efferent fibers

They form the short ciliary nerves which innervate the ciliary muscle of iris, resulting in:

- a. papillary constriction
- b. accomodation of lens
- c. vasoconstriction
- d. sensory input

□ **COMPLETE DIVISION OF III** will result in:

- 1. ptosis [paralysis of levator palpebrae]
- 2. divergent squint [the eyeball tilts laterally due to paralysis of the medial rectus]
- 3. dilatation of pupil [loss of parasympathetic innervation]
- 4. loss of lens accomodation
- 5. double vision

TROCHLEAR NERVE {IV}

Is a slender nerve with a long course, supplying only the **superior oblique** eye muscle.

The **trochlear nucleus** lies in the **midbrain**. The nerve fibers decussate within the midbrain and the nerve emerges from the dorsum of the brain stem, below the posterior cerebral peduncle. It passes between the posterior cerebral and the superior cerebellar artery to reach the **lateral wall of the cavernus sinus**. It exits the skull through the **superior orbital fissure**.

Nerve injury causes diplopia only when looking down and laterally.

TRIGEMINAL NERVE {V}

The Vth nerve transmits sensory fibers for the greater part of the face and head skin, the mucous membranes of mouth nose and paranasal sinuses as well as motor fibers for the muscles of mastication

- NUCLEI
- 1. Midbrain sensory nucleus of Vth nerve [proprioception fibers]
- 2. Main sensory nucleus in pons [touch]
- 3. Motor nucleus [upper pons]
- 4. Spinal nucleus [elongated, through some myelotomes, pain and temperature]
- GASSERIAN GANGLION & MAIN NERVE TRUNK

The fibers arising from the nuclei above join to reach the **trigeminal ganglion [Gasserian]** which lies near the **apex of the petrous part of temporal bone**, inferior to tentorium cerebelli. The main nerve arises from the ganglion and **emerges laterally to the pons**, **above the middle cerebellar peduncle**, with the motor roots lying on its medial aspect. It gives off 3 main branches as it passes along the lateral wall of the cavernous sinus:



• The occulomotor [III], trochlear [IV] and abducens [VI} nerves

• **BRANCHES**

1. Ophthalmic division, V1

Is a **pure sensory** branch supplying the forehead, upper eyelid and nose. It exits through the **superior orbital fissure** and gives off 3 branches:

a. **Frontal nerve**, coursing on the roof of the orbit, subdividing into the **supratrochlear** and **supraorbital nerves**.

b. Lacrimal nerve, supplying the lacrimal gland, the conjuctiva and the upper eyelid.

c. **Nasociliary nerve**, supplying the mucosa and skin of nose, conveying also parasympathetic impulses for **dilatation of pupil**, which reach it via fibers originating from the **ciliary ganglion**

2. MAXILLARY NERVE, V2

Passes close to the cavernus sinus and exits through the foramen rotundum to enter the pterygopalatine fossa. There it gives off

a. Infraorbital nerve which subdivides into the

- zygomatic nerve, supplying the temple and skin of cheek
- superior dental nerve, supplying the upper jaw

b. The main nerve reaches the **sphenopalatine ganglion** which receives afferents and efferent fibers arise

• Afferents

1. great superficial petrosal nerve [runs with the VII and conveys

parasympathetic fibers]

2. sympathetic fibers [from carotid plexus]

- Efferents
 - 1. greater and lesser palatine nerves
 - 2. nasal branches
 - 3. pharyngeal branches
 - 4. long & short sphenopalatine nerves

3. MANDIBULAR NERVE, V3

Is the largest division and is a **mixed nerve** with motor fibers for the masseters and sensory fibers for the skin of temple, part of the auricle, the mucosa of the anterior two thirds of the tongue, the mucous membranes of the floor of the mouth and the parotid gland [secretion].

It exits the cranium through the **foramen ovale** to enter the **infratemporal fossa**.

There it gives off 2 branches, before dividing into the anterior and posterior trunks.

a. Nervus spinosus, supplying the dura

b. Nerve to the medial pterygoid muscle, which also conveys fibers originating from the otic ganglion. The latter has motor, sensory and autonomic [para- and sympathetic] components and sends fibers to the tensor palati and tensor tympani muscles as well.

c. Anterior trunk

- **buccal nerve** for the buccinator muscle
- motor roots for the masseter, temporalis and lateral pterygoid muscles [muscles of mastication]

d. Posterior trunk [sensory]

1. auriculo-temporal nerve [sensation over temple and auricle and parotid secretion]

2. **lingual nerve**: it joins the **submandibular ganglion** from where fibers from the **chorda tymani nerve** [taste buds of the anterior two thirds of the tongue innervation



• The trigeminal nerve [V]

and secretomotor for the sublingual and submandibular salivary glands] which comes off the facial nerve, join it

3. **inferior dental nerve**, which passes through the mandibular canal, to innervate the teeth of mandible and the skin of chin and lower lip. It gives off the

 \bullet **nerve to mylohyoid** , for the innervation of mylohyoid and posterior digastric belly

ABDUCENS NERVE {VI}

Innervates only the lateral rectus muscle.

Arises from the **abducens nucleus** in upper **pons** and emerges at the junction between pons and medulla, laterally to the midline. It enters the cavernus sinus and exits through the **superior orbital fissure** to enter the orbit.

Abducens nerve lesions will be accompanied by diplopia and convergent squint.

FACIAL NERVE {VII}

It conveys motor roots for the facial muscles of expression and secretomotor fibers [through the chorda tymani] for the submandibular, sublingual and lacrimal glands and fibers for the taste buds of the anterior two thirds of the tongue. All the secretomotor fibers reach their targets via the lingual nerve, joining it at the submandibular ganglion.

The facial nerve nucleus lies in the ventral aspect of lower pons. The efferent fibers pass to the lateral pons, receiving fibers from the superior salivary nucleus [bilateral innervation of muscles above the palpebral fissure], and exit between the olive and inferior cerebellar peduncle, forming the main facial nerve.

It exits the cranium passing through the **internal auditory meatus** [accompanied by the VIIIth nerve to enter the **facial canal**, forming a **genu** in the nerves course. It then reaches the **geniculate ganglion**, from which the sensory fibers arise. It gives off the **great superficial petrosal nerve** [which is **secretomotor to the lacrimal gland and is distributed via the V2**] and continues downwards, medial to the middle ear to exit the skull through the **stylomastoid foramen**, between the stylohyoid muscle and the posterior belly of digastor muscle. At that point it gives off the **chorda tympani** which conveys **taste fibers and joins the lingual nerve**. The remaining facial nerve **enters the parotid gland** [between superficial and deep lobes] and branches within the gland, giving off:

- superior trunk
 - temporal
 - zygomatic
- inferior trunk
 - buccal
 - mandibular



• The course and distribution of facial nerve

• carvical branches

• CLINICAL FEATURES

1. Supranuclear palsy:

The muscles above the palpebral fissure are not affected, as they receive bilateral innervation from the superior salivary nucleus of facial nerve.

2. Nuclear, infranuclear lesions:

All muscles are affected [i.e. Bell's palsy]

VESTIBULOCOCHLEAR NERVE {VIII}

The axons of the **bipolar spiral ganglion of cochlea cells** [hearing] pass through the **internal auditory meatus** and join the **vestibular fibers** [equilibrium], forming the VIIIth

nerve, at the lateral aspect of medulla. From there,

a. VESTIBULAR FIBERS:

They reach the **vestibular nucleus** and from there afferents [uncrossed] reach the **cerebellum**, passing through the **inferior cerebellar peduncle**.

b. AUDITORY FIBERS

They reach the **dorsal and ventral cochlear nuclei**, from which they **cross** to the opposite side and pass to the ventral pons to reach the **trapezoid body**. The afferent fibers pass to the **lateral lemniscus** and then to the **corpus quadrigeminum [medial geniculate body**]. From there starts the **auditory radiation** [expanded tract] which reaches the **auditory cortex** in the **superficial temporal gyrus**.

GLOSSOPHARÝNGEAL NERVE {IX}

• Sensory: pharynx

posterior third of tongue and taste buds

- Secretomotor: parotid
- Motor: stylopharyngeus muscle

The **IXth nerve nucleus** lies in the **upper medulla**. 4-5 rootlets emerge from the **posterolateral sulcus** between inferior cerebellar peduncle and olivary eminence which join to form the main nerve trunk. It exits the cranium [posterior fossa] through the **jugular foramen**. It gives off the

a. tympanic branch and the

b. **lesser superficial petrosal** nerve which conveys preganglionic parasympathetic fibers to the **otic ganglion** and from there to the **parotid gland**. The main nerve continues downwards between the internal carotid and the internal jugular vein, giving off the

c. **carotid nerve** for the carotid body sinus. The rest of the nerve passes behind the styloid process and along the stylopharyngeus muscle to enter the pharynx between superior and middle pharyngeal constrictors.



• The glossopharyngeal [IX] nerve

VAGUS NERVE {X}

• NUCLEI:

a. **Dorsal nucleus**, in the posterior part of medulla, which is a mixed nucleus [afferent and efferent fibers]

- b. Nucleus ambiguus, in the lateral part of mid-medulla
- c. Tractus solitarius
- The nerve emerges in form of rootlets on the **side of the medulla**, together with the glossopharyngeal nerve [**posterolateral sulcus**]. It passes bneath the inferior cerebelar peduncle to exit through the **jugular foramen**, contained in the same sheath with the accessory nerve. It receives sensory rootlets from **two sensory ganglia**. It courses into the root of neck, enclosed in the **carotid sheath** [posterolaterally]
- **BRANCHES**

1. **Pharyngeal branches** which join the pharyngeal plexus for innervation of the pharyngeal and palatiine muscles.

- 2. Superior laryngeal nerve
 - external branch [cricothyroid muscle]
 - internal branch [innervation of the remaining laryngeal muscles plus sensory component]
- 3. Cardiac branches [inhibitory impulses]

4. **Right recurrent laryngeal nerve**, which winds around the subclavian artery to ascend to the neck.

The rest of the nerve enters the **superior mediastinum**, running at the side of the trachea and behind the great veins, in front of the arteries, to pass **behind the root of the lung**. It gives off:

- 5. Branches to the pulmonary plexus
- 6. Oesophageal branches

7. Left recurrent laryngeal nerve which comes from behind to wind around the aorta and ligamentum arteriosum before starting to ascend towards the neck.

The nerves course downwards and rotate to the right, so at the hiatus the **left lies anterior** to the oesophagus while the **right posteriorly**, in front of the aorta. they give

- 8. Hepatic plexus branch
- 9. Coeliac plexus branch
- 10. Gastric branches [nerves of Latarjet]
- 11. Renal branches

ACCESSORY NERVE {XI}

• Small cranial root with its fibers reaching the larynx and pharynx via the vagus

• **Spinal root**: an elongated nucleus on the **anterior horns of C1-C5**. Afferents ascend and enter the skull through the **foramen magnum** to exit through the **jugular foramen**. The nerve then passes **over the jugular vein** at the upper corner of the anterior neck triangle, courses posterolaterally and 5cm below the mastoid process it pierces the **sternomastoid** [or passes behind it], crosses the **posterior triangle** to reach the **trapezoid muscle**.

Supplies the sternomastoid and trapezoid muscle.



• The vagus nerve

HYPOGLOSSAL NERVE {XII}

- Supplies **all intrinsic and extrinsic tongue muscles except palatoglossus**, which is supplied by the pharyngeal branches of vagus.
- The hypoglossal nucleus lies in the medulla at the floor of the 4th ventricle. The nerve emerges as rootlets between the olive eminence andthe pyramids which join to form the main trunk. It enters the anterior condylar [hypoglossal] canal to exit the skull. It lies first deep to the internal carotid artery and internal jugular vein, but soon passes between them and then crosses them, passing above the internal and external carotids at the level of the jaw. At that point it gives off the descending branch [ansa hypoglossi] which receives some fibers from the C2-3 myelotomes and courses downwards, overlying the carotid sheath, to supply the strap muscles.
- The main nerve passes behind the **digastric and stylohyoid muscles** and runs on the **lateral surface of hyoglossus** muscle to reach the tongue.
- If injured, the tongue will deviate towards the affected side.



• The hypoglossal nerve [XII]

SPECIAL SENSES

THE AUTONOMIC NERVOUS SYSTEM

- CNS \rightarrow regulates the body response to external environment
- ANS \rightarrow controls **internal environment**

• The ANS efferents are **myelinated fibers** which are interrupted in a **peripheral ganglion** and continue to the target cells as unmyelinated postgagnglionic fibers. The target cells are usually a third nerve cell located nearby the target organ, so **3 motor neurons** are involved [compared to 2 neurons in the voluntary CNS system]

• **PREGANGLIONIC NEURON**

1. Sympathetic:

Lateral gray columns of T1-L2

2. Parasympathetic:

a. Cranial outflow: \rightarrow cranial nerves II, VII, IX, X

4 ganglia: ciliary

sphenopalatine submandibular

otic

b. Sacral outflow \rightarrow S2-S4

pelvic splanchnic nerves [regulate mechanism of "emptying"]

FUNCTIONS

A. SYMPATHETIC

- 1. Dilatation of pupils
- 2. Constriction of vessels
- 3. Increse in heart rate, heart contraction force and oxygen consumption
- 4. Dilatation of bronchial tree
- 5. Diminished visceral peristalsis by inhibiting motility and increasing sphincter tone
- 6. Glyconeogenesis
- 7. Stimulation of adrenal medulla

8. Cutaneous sweating [however, the fibers in thi sinstance are cholinergeic, not adrenergic as in the rest of sympathetic functions]

9. Piloerection

10. Inhibition of bladder contraction

11. Indirect increase in coronary flow

The **adrenal medulla** [chromaffin cells] could be considered as sympathetic cells without postganglionic fibers.

The sympathetic trunk has a "**mass action effect**" leading to a widespread response. In contrast to this, the parasympathetic activity is more discrete and localised.

B. PARASYMPATHETIC

1. Constriction of pupils

3. Secretomotor to salivary glands



• Autonomic visceral afferents

- 3. Secretomotor to lacrimal glands
- 4. Inhibitory to heart [reduces heart rate, oxygen consumption and force of contraction]
- 5. Bronchoconstrictor and secretomotor to mucous glands
- 6. Visceromotor to alimentary canal muscles [increases peristalsis]
- 7. Inhibitory to sphincters [pylorus, internal anal sphincter, sphincter of the bladder]
- 8. Motor to bladder muscle

THE SYMPATHETIC TRUNK

A ganglionated nerve chain from the base of the skull to the coccyx. There are 3 cervical, less than 12 thoracic, 2-4 lumbar and 4 sacral ganglia.

- Superior cervical ganglion at the base of the skull
- The chain descends behind the carotid sheath and in front of the prevertebral fascia
- forms the carotid plexus
- Enters the thorax anterior to the neck of the first rib
- Descends 2.5cm laterally to sides of the vertebrae, crossing the heads of the ribs
- Forms the cardiac, pulmonary and oesophageal plexus
- Enters the abdomen behiand the median arcuate ligament
- forms the coeliac plexus from which the coeliac nerves emerge
- Passes between the psoas and the sides of the vertebrae, overlapped by either the aorta [left] or the inferior vena cava [right]
- Passes behind the common iliacs
- Forms the hypogastric and pelvic plexus
- Enters the pelvis anterior to the ala of sacrum
- Continues downwards in front of the sacral foramina
- The last ganglion joins the one from the other side, forming the ganglion impar.

AUTONOMIC "TRUNKOTOMES"

- Head & neck \rightarrow T1-2
- Upper limb \rightarrow T2-T5
- Thoracic viscera \rightarrow T1-T4
- Abdominal viscera \rightarrow T4-L2
- Pelvic viscera \rightarrow T10-L2
- Lower limb \rightarrow T11-L2

OLFACTION / THE NOSE

• EXTERNAL NOSE

Has a bony and cartilaginous framework, covered by skin and fibrofatty tissue. Its bony structure comprises the **two nasal bones** and the **frontal process of the maxilla**.

- NASAL CAVITY
- Nasal septum [arising from the perpendicular plate of ethmoid bone]
- Septal cartilage
- Vomer



• The nose & olfaction

- Anterior nares [nostrils]: they open posteriorly to the nasopharynx.
- *Lateral wall:* is formed by the **3 conchae** [superior, middle, inferior] and the **3 underlying** meatuses
 - Superior: communicates with the posterior ethmoidal cells and the sphenoid
 - Middle: with the frontal sinus, maxillary sinus and anterior and middle ethmoidal cells
 - Inferior: nasolacrimal duct
- *Roof:* cribriform plate of the ethmoid, nasal and frontal bones plus the sphenoid.
- Floor: palatine process of the maxilla, palatine bone and soft palate
- OLFACTORY MUCOSA

The olfactory portion of the nasal mucosa is located on the superior concha and upper part of the nasal septum. It is thin and dull yellow, while the rest of the mucosa is ciliated [respiratory].

- BLOOD SUPPLY
- Arteries
 - Ethmoidal branches of ophthalmic artery [from internal carotid] \rightarrow upper part
 - Sphenopalatine branch of maxillary artery [from external carotid] \rightarrow lower part
 - Septal branch of facial artery [from external carotid] which forms the Kieselbach's [or Little's] area at the antero-inferior part of the septum. It is the bleeding point in 90% of cases of rhinorrhagia.

• Veins

They drain intto:

- Facial vein [draining into jugular vein]
- Etmoidal tributaries, which drain into the ophthalmic vein, the latter emptying into the cavernous sinus. So nose infection can spead to the sinus will all its complications [i.e. thrombosis]

BALANCE AND HEARING / THE EAR

• EXTERNAL EAR

- 1. AURICLE
- A cartilaginous framework to which the skin is closely applied.

2. EXTERNAL AUDITORY MEATUS

S-shaped, 37mm long, with its outer third being cartilaginous while the inner third is bony. All the canal is **lined by skin** which bears the subcutaneous **ceruminous glands**.

3. TYMPANIC MEMBRANE [EAR DRUM]

Oval shaped, 12mm in diameter, with its outer layer consisting of **skin**, the middle layer of **fibrous tissue** and the inner layer of **mucosa**. Is translucent and subdivided into two parts, the **pars tensa** [tought] and the **pars flaccida**, which is triangular and comprises the part above the malleolar folds.

The handle of malleus is attached to the tympanic membrane.

• MIDDLE EAR [TYMPANIC CAVITY]

Comprises a narrow slit in the **petrous temporal bone**, containing the **3 auditory ossicles**:

- malleus
- incus



• The ear

• stapes

Laterally and postero-superiorly it communicates with the **mastoid air cells** through the **tympanic antrum**. The latter appears postnatally and forms the **epitympanic recess**, called **attic**. Anteriorly it communicates with the pharynx via the **pharyngotympanic [Eustachian] tube** [37mm long].

- Floor: thin layer of bone separating it from the jugular bulb
- Roof: mastoid cells and above them the sigmoid sinus and cerebellum
- Medial wall is formed by the bony labyrinth
 - fenestra cochlea [round window], covered by membrane
 - **fenestra vestibuli** [oval window], covered by the stapes
 - promontory of cochlea
 - a bony prominence due to the underlying **facial canal**
- MUSCLES
- 1. Stapedius, attached to the neck of stapes, innervated by the facial nerve

2. **Tensor tympani**, attached to the **handle of malleus**, innervated by the **trigeminal nerve [V3]** Both muscles aim into dumping high frequencies.

- INTERNAL EAR
- BONY LABYRINTH
 - central vestibule
 - 3 semicircular ducts [in 3 vertical planes on right angles] posteriorly
 - spiral cochlea, anteriorly
- MEMBRANOUS LABYRINTH, filled with endolymph
 - **utricle**, communicating with the semicircular canals
 - saccule, communicating with the cochlear canal
- **Receptors**
 - maculae of utricle and saccule [position and balance]
 - ampullary crests of semicircular canals [position and balance]
 - organ of Corti, within the cochlea, for sound vibrations

VISION / THE EYE

• EYEBALL

25mm in diameter.

• TENON'S CAPSULE

A fascial sheath enclosing the eyeball.

- FIBROUS COAT
 - Conjuctiva
 - Cornea, anteriorly, which is transparent, joining the sclera at the sclerocorneal junction, the point where starts the iris.
 - Sclera, opaque
- VACULAR COAT
 - **Ciliary body** for the accomodation of lens, bearing the;
 - ciliary ring
 - ciliary process

• ciliary muscle



• The eyeball

- Choroid, on the inner surface of sclera
- **RETINA**
 - cones & rodes
 - bipolar cells
 - ganglion cells, whose axons are the optic nerve fibers.

Forms the **macula lutea** [lack of blood vessels] responsible for central vision [**fovea**], at the central part of retina, laterally to the optic disk.

The **optic disk** is a pale spot at the central retina from where the optic axons exit the eyebulb. As it doesn't contain receptor cells, it is blind.

• CONTENTS OF EYEBALL

1. **Iris**

A contractile disk comprising of **4 layers** [mesothelial lining, connective pigmented tissue, dilator/sphincter muscle fibers, pigmented cells layer], which separates the anterior chamber [papillary aperture] with the posterior chamber where aqueous humor is secreted.

2. Lens

Biconcave, with the ability to accommodate. Is held in place by ciliary muscle of the ciliary body.

3. ACQUEOUS HUMOR

Is a filtrate of plasma, secreted by the vessels of iris and ciliary body, contained in the anterior chamber. Is reabsorbed into the ciliary veins by the **sinus venosus sclerae** [Schlemm's canal]

4. VITREOUS BODY

A thin, transparent gel, contained in the **hyaloid membrane**, filling the posterior chamber of the eye. Its anterior part gives rise to the **suspensory ligament of lens**.

• ORBITAL MUSCLES

They arise from a tendinous ring around the optic foramen and insert into the sclera.

- Superior rectus [III] \rightarrow turns the eye upwards and medially
- Medial rectus [III] \rightarrow turns the eye medially
- Inferior rectus [III] \rightarrow turns the eye downwards and laterally
- Superior oblique $[IV] \rightarrow$ when tought, the ball will face downwards and laterally
- Lateral rectus $[VI] \rightarrow$ the eye looks laterally when the muscle is tought
- Inferior oblique [III] \rightarrow turns the eye upwards and medially

• EYELIDS

From the two eyelids the superior is larger and has the **levator palpebrae superioris** [innervated by the IIIrd nerve.

- LAYERS
- 1. Skin
- 2. Loose connective tissue
- 3. Orbicularis occuli muscle
- 4. Tarsal plate
 - Moebian [tarsal] glands
 - Eye lashes
- 5. Conjuctiva



• The orbital muscles

• THE LACRIMAL APPARATUS

Is almond shaped, located within the upper lateral part of the orbit, within the **lacrimal fossa**. It has 8-15 small ducts opening through the conjuctiva.

The tears drain through the **two lacrimal canaliculi** whose openings [**lacrimal puncta**] are near the medial corner of the eyelids. They drain into the **lacrimal sac** and from there, through the **nasolacrimal duct**, they drain into the anterior part of **inferior meatus**.

CONTENTS