بسم الله الرحمن الرحيم

Anatomy Review File

اللهم لا سهل إلا ماجعلته سهلا وانت تجعل الحزن اذا شئت سهلا

This work was done by:

منيرة الزايد	ريما الشايع	اللولو الصليهم
غيداء السعيد	ريما العتيبي	أشواق الماجد
وجدان الزيد	روان الوادعي	جواهر ابانمي
نواف الخضيري	لمى التميمي	دعاء عبدالفتاح
خالد الدخيل	لمى الفوزان	صفاء العصيمي

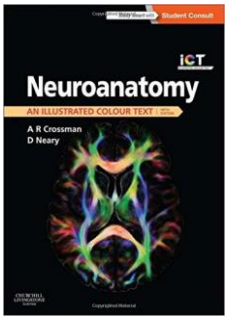
Topic	Slide Number
Cerebellum	3
Cerebral Hemispheres	5
Cerebral Blood Supply	7
Basal Ganglia	9
Thalamus and Limbic System	11
Meninges and CSF	13
Introduction	14
Spinal cord	16
Brachial and Lumbo-Sacral Plexus	19
Ascending Tracts	20
Brain Stem (external structures)	23
Brain Stem (internal structures)	24
Cranial Nerves (Introduction)	26
Cranial Nerve 1 + Nose	27
Cranial Nerve 2, 3, 4 & 6	28
Cranial Nerve 5, 7	30
Cranial Nerve 8 + Ear	32
Cranial Nerve 9, 10	35
Cranial Nerve 11, 12	37
Summary of Lesions	39

Covered in MIDTERM

Extra resources:

TeachMeAnatomy.info
Making Anatomy Simple

YouTube



Cerebellum

General

Origin: from Hindbrain.
Position: lies behind Pons & Medulla Separated from them by Fourth ventricle.
connections: to the brainstem by *Inferior, Middle* & *Superior* Cerebellar Peduncles.

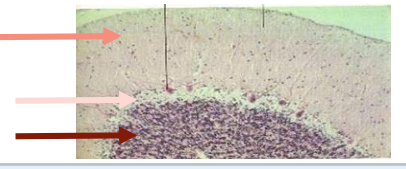
Features

External	internal
-It consists of two Cerebellar Hemispheres joined in midline by the **Vermis**. - Its surface is highly convoluted forming ***Folia*** , separated by **Fissures.** Anatomical Subdivision 1. **Anterior lobe**: in front of primary fissure, on the superior surface. 2. **Posterior (middle) lobe**: behind primary fissure (Between Primary & Secondary/posterolateral fissures). 3. **Flocculonodular lobe**: in front of secondary (Posterolateral) fissure, on the inferior surface .	**- Outer grey matter**: cerebellar cortex **- Inner white matter**: cerebellar medulla Deeply seated nuclei in white matter: from medial to lateral: • **Fastigial nucleus:** smallest one • **Globose nucleus.** • **Emboliform nucleus.** • **Dentate nucleus:** largest one.

Cerebellar Cortex

The cerebellar cortex is divided into 3 layers

1. Outer molecular layer
2. Intermediate Purkinje cell layer
3. Inner granular layer



Cerebellar Medulla

Afferent (sensory) fibers	Efferent Fibres
1- Climbing fibres: from inferior olivary nucleus, relay to purkinje cells **2- Mossy fibres:** rest of fibres: 1. From vestibular nuclei 2. From spinal cord 3. From pons They relay to granule cells which in turn relay to purkinje cells	**Axons of Purkinje Cells** are the **only** axons to leave the cortex to medulla, - and some of these axons leave cerebellum **as efferent fibres.** - Most of efferent fibres are axons of deep cerebellar nuclei. **Main Efferents go to:** 1. Vestibular nuclei (cerebello-vestibular tract). 2. Red nucleus (Dendato-rubro-thalamic tract). 3. Ventral lateral nucleus of thalamus (Dendato-thalamic).

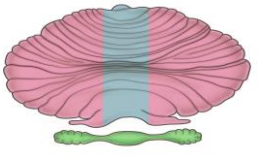
Functional Subdivisions

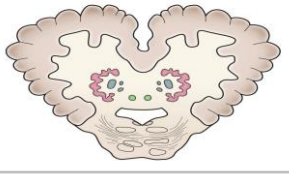
	1- Archicerebellum Vestibular Part of cerebellum: Flocculonodular lobe.	2- Paleocerebellum Spinal Part of cerebellum: Vermis & Paravermis	3- Neocerebellum Cerebral Part of cerebellum: Rest of Cerebellum.
Nuclei	**Fastigial**	**Globose & Emboliform**	**Dentate**
Afferents	from Vestibular nuclei (Vestibulocerebellar fibres), Through ICP	from spinal cord (dorsal spinocerebellar tracts through ICP & ventral spinocerebellar tract through SCP)	from Pons (Pontocerebellar fibres) through MCP
Efferent	to Fastigial nucleus, which projects to **vestibular nuclei** (through ICP) + **to Reticular formation**	to globose & embliform nuclei which project to **red nucleus** (through SCP)	to **Red nucleus** but mostly to **Ventral Lateral Nucleus of Thalamus** (through SCP) then to motor cortex
Function	1. controls body Balance 2. Control of eye movement	controls posture & muscle tone	coordination of voluntary movements

Lesions

- MIDLINE LESION: Loss of postural control.
- UNILATERAL LESION: "Cerebellar ataxia" causes ipsilateral:
  1. Incoordination of arm: intention tremors (on performing voluntary movements)
  2. Incoordination of leg: unsteady gait
  3. Incoordination of eye movements: nystagmus
  4. Slowness of speech: dysarthria (difficulty of speech)

Images





Cerebellum

A. Anatomical Lobes		
Anterior	**Fulliculonodular**	**Posterior**
In front of primary fissure	In front of posterolateral fissure	Between these two fissures

B. Deeply seated nuclei from medial to lateral:

- Fastigeal (smallest).
- Globose.
- Emboliform.
- Dentate (largest).

C. Afferents:

1. **Climbing fibers from**
- Inferior olivary nucleus.
2. **Mossy fibers from:**
- Vestibular nuclei.
- Spinal cord.
- Pons.

F. Lesions	
Midline	**Unilateral**
Loss of postural control	Ipsilateral ataxia

D. Efferents:

1. **Majority do not leave cerebellum and terminate in the dentate nuclei.**
2. **Some axons leave the cerebellum (efferents) going to:**
- Vestibular nuclei →cerebello-vestibular tract.
- Red nucleus → dentato-rubro-thalamic tract.
- Ventral lateral nucleus of thalamus → dendato-thalamic tract.

E. Functional Subdivisions			
Subdivision	**Archicerebellum**	**Paleocerebellum**	**Neocerebellum**
Nuclei	Fastigeal	Globose & Emboliform	Dentate
Afferent	Vestibulocerebellar	Dorsal and Ventral Spinocerebellar	Pontocerebellar
Efferent	Vestibular nuclei	Red nucleus	Motor Cortex
Function	Balance & eye movement	Posture & muscle tone	Voluntary coordination

Cerebral Hemispheres

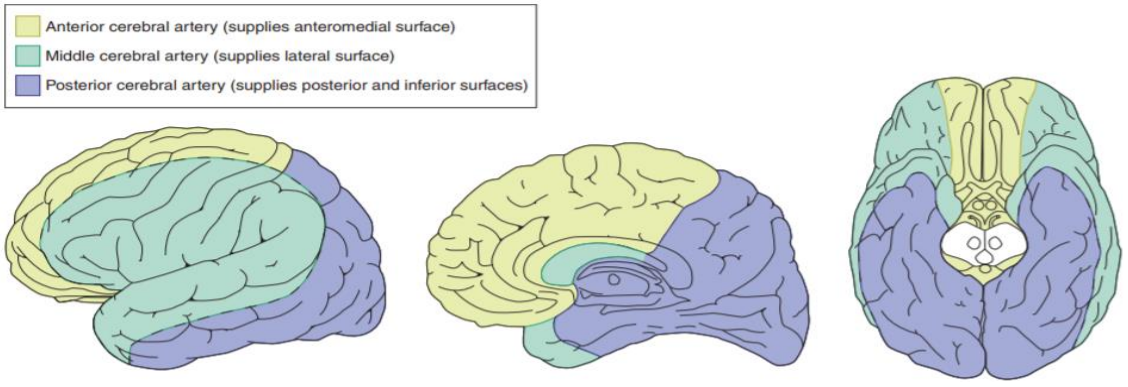
White mater		
Association fibers	**Commissural fibers**	**Projection fibers**
(1) Short **(2) Long:** • Uncinate fasciculus • Arcuate fasciculus • Superior longitudinal fasciculus • Inferior longitudinal fasciculus • Cingulum	(1) Corpus callosum. (Body, Splenium, Genu, Rostrum) (2) Anterior commissure. (3) Hippocampal commissure (commissure of fornix). (4) Posterior commissure.	**(1) Afferent** fibers **(2) Efferent** fibers (Corona radiata → Internal capsule → Crus cerebri → Basilar pons → pyramid of M.O)

Anatomical Divisions		
	Frontal Lobe	
	Precentral gyrus Superior **frontal** gyrus Middle **frontal** gyrus Inferior **frontal** gyrus	Superior **frontal** sulcus Inferior **frontal** sulcus
	Parietal Lobe	
	Postcentral gyrus Superior **parietal** lobules Inferior **parietal** lobules	**Intraparietal** sulcus
	Temporal lobe	
	Insula (covered by opercula) Superior **temporal** gyrus Middle **temporal** gyrus Inferior **temporal** gyrus	Superior **temporal** sulcus Inferior **temporal** sulcus
	Medial Surface	
	Cingulate, **Parahippocampal**	**Parietooccipital**, **Calcarine**, **Cingulate**

Functional Divisions

Frontal Lobe			
Primary motor cortex	Located in *precentral gyrus*	Brodman's area **4**	allows conscious control of skilled voluntary movement (i.e. controls skeletal muscles)
Premotor cortex:	Located in the region immediately *anterior to the precentral gyrus*	Brodmann's area **6**	Controls learned, repetitious, or patterned motor skills, typing, playing a musical instrument. Coordinates simultaneous or sequential actions. Involved in the planning of movements.
Prefrontal cortex:	Extensive region of the frontal lobe *anterior to premotor area*.		Involved with intellect, cognition, recall, and personality. Necessary for judgement, reasoning, persistence, and conscience. Also related to mood. Closely linked to limbic system (emotional part of brain)
Broca's (motor speech) area:	Located in the *inferior frontal gyrus* of the dominant hemisphere, usually left	Brodmann's area **44** & **45**	A motor speech area that directs muscles of the tongue. Is active as one prepares to speak.
Frontal eye field:	Located in the *middle frontal gyrus* immediately in front of premotor cortex	Brodmann's area **8**	
Parietal lobe			
Primary somatosensory cortex	located in *postcentral gyrus*	Brodmann's area **1**, **2**, **3**	Involved with conscious awareness of general somatic senses Receives information from the skin and skeletal muscles Exhibits spatial discrimination Precisely locates a stimulus
Parietal association cortex	located *posterior to primary somatosensory* cortex.		Integrates sensory information Forms comprehensive understanding of the stimulus Determines size, texture, and relationship of parts.
Temporal Lobe			
Primary auditory cortex	located in the superior surface of the *superior temporal gyrus*	Brodmann's area **41, 42**	Receives information related to pitch, rhythm, and loudness
Auditory association cortex	located immediately around the primary auditory cortex (also includes **Wernick's area**) Located posterior to the primary auditory cortex		Stores memories of sounds and permits perception of sounds Involved in recognizing and understanding speech Lies in the center of Wernicke's area
Parahippocampal gyrus:	located in the *inferomedial part of temporal lobe*.		Deep to this gyrus lies the **hippocampus** and the **amygdala**, which are parts of **limbic system**
Occipital lobe			
Primary visual cortex	located on the *medial surface of the hemisphere*, in the gyri surrounding the calcarine sulcus	Brodmann's area **17**	Receives visual information from the retinas
Visual association cortex	located *around the primary visual* cortex	Brodmann's area **19**	Interprets visual stimuli (e.g., color, form, and movement)

Cerebral Blood Supply



		supply	*blockage*
Internal Carotid	**Anterior** cerebral artery	1. Orbital and medial surfaces of **frontal** and **parietal** lobes. 2. A narrow part on the superolateral surface.	**1. Motor disturbance** in contralateral distal leg 2. Difficulty in **prefrontal lobe** functions: • Cognitive thinking • Judgement • Motor initiation • Self monitoring
	Middle cerebral artery	Entire Superolateral surface: 1. Somatosensory Cortex 2. Motor Cortex 3. Language areas: (**Broca's Area**: and **Wernicke's Area**) 4. Primary auditory area + **Heschl's Gyrus**	1. Contralateral **weakness** and **sensory loss** of face, arm, and hands more than legs 3. Visual field cut (damage to **optic radiation**) **4. Aphasia** (language disturbance).
Vertebro-Basilar	**Posterior** cerebral artery	1. Anterior and inferior **temporal** lobes **2. Uncus**: related to sense of **smell**. 3. Inferior temporal gyri 4. Inferior and Medial **Occipital lobe** (visual area)	**1. Visual** disturbances (contralateral homonymous hemianopsia or cortical blindness/Anton's Syndrome (bilateral lesion) **2. Memory** impairment (temporal lobe)

Circle of Willis		
Constituents	*Branches*	
2 **Anterior cerebral** arteries 2 **Internal carotid** arteries 2 **Posterior cerebral** arteries 2 **Posterior communicating** arteries 1 **Anterior communicating** artery	Anterior Perforating	Posterior Perforating
	Supply: 1. Large part of basal ganglia. 2. Optic chiasma. 3. Internal capsule 4. Hypothalamus	Supply: 1. Ventral portion of Midbrain. 2. Parts of Subthalamus and Hypothalamus.

Venous Drainage	
Superficial	**Deep**
1. Superior cerebral veins (superior sagittal sinus) 2. Inferior cerebral veins (transvers sinus) 3. Superficial middle cerebral veins (cavernous sinus)	deep cerebral veins → internal cerebral veins → great cerebral vein + inferior sagittal sinus → straight sinus
Dural Venous Sinuses	
Paired: 1. Transverse 2. Sigmoid 3. Cavernous 4. Superior petrosal 5. Inferior petrosal	**Single** 1. Superior sagittal 2. Inferior sagittal 3. Straight 4. Occipital
Blood flows from transverse & sigmoid sinuses into **Internal Jugular Vein.**	

Basal ganglia

Corpus striatum

Neostriatum (striatum)

Caudate nucleus

Head:
-**Rounded** in shape
-Lies **anterior** to thalamus *(in frontal lobe)*
-Completely separated from the putamen by the **internal capsule** *except* rostrally where it is continuous with the putamen

Body:
-**Long & narrow**
-Extends **above** thalamus (in parietal lobe)

Tail:
-**Long & tapering**
-Descends**, below** thalamus, into *temporal lobe*
-Continuous with **Amygdaloid Nucleus**

Putamen

Lenticular nucleus

SHAPE:
three sided, wedge-shaped mass of grey matter, with a **convex** outer surface and an **apex** which lies against the genu of the **internal capsule**

DIVISION:
1. Larger darker lateral portion called **Putamen**
2. Smaller, lighter medial portion called **Globus Pallidus**

Separated from **globus pallidus** by a thin sheath of nerve fibers, the **lateral medullary lamina**
The white matter is divided, by **a sheath of grey matter**, ***the claustrum*** into two layers:

1) *external capsule* between the putamen and claustrum.

2) *extreme capsule* between the claustrum and the insula

Paleostriatum

Globus pallidus (oldest part)

Consists of two divisions, **the lateral & the medial segments**, separated by a thin sheath of nerve fibers, **the medial medullary lamina**.

The medial segment is similar, in terms of cytology and connections with the **pars reticulata of substantia nigra**

Amygdala

Amygdaloid nucleus

(part of limbic system) is only embryologically related to Corpus Striatum

Characteristics	Corpus striatum	
Nomenclature	Bands of grey matter pass from **lentiform nucleus** across the **internal capsule** to the **caudate nucleus**, giving the striated appearance hence, the name *corpus striatum*.	
Function	• The corpus striatum **assists** in regulation of voluntary movement and learning of motor skills. • Their function is to **facilitate** behavior and movement that are required and appropriate, and inhibit unwanted or inappropriate movement.	
Dysfunction	Its dysfunction **does NOT** cause paralysis, sensory loss or ataxia <u>Its dysfunction leads to:</u> • Abnormal motor control: emergence of abnormal, involuntary movements **(dyskinesias)** • Alteration in muscle tone: **hypertonia/hypotonia**	
Important relations	**Head of Caudate Nucleus:** • Anterior to thalamus • **Medial to Lentiform** & separated from it by **anterior limb** of internal capsule	**Lentiform Nucleus:** **Lateral to thalamus** & separated from it by **posterior limb** of internal capsule

The **striatum** is the **input** region of corpus striatum,

while the medial segment of **globus pallidus** & pars reticulata of **substantia nigra** are the **output** portion.

Afferent fibers of striatum come from:
1. cerebral cortex,
2. intralaminar nucleus of thalamus &
3. pars compacta of substantia nigra.

Afferent fibers of both lateral & medial segments of globus pallidus come from:
1. striatum and
2. subthalamic nucleus.

Efferent fibers of striatum is directed to
1. globus pallidus &
2. pars reticulata of substantia nigra.

Efferent fibers of **lateral** segment is directed to subthalamic nucleus.

Efferent fibers of **medial** segment is directed to
1. ventral lateral,
2. ventral anterior &
3. centromedian nucleus of thalamus

Thalamus & Limbic System

Thalamus

largest nuclear mass of the whole body **, largest part** of the diencephalon
formed of: two oval masses of grey matter.
o It is the gateway **to the cortex**, Resemble a **small hen**.
o Together with the hypothalamus they form **the lateral wall of the 3rd ventricle**.
o There are some thalamic nuclei that **receive input** from:
1. Cerebellar nuclei 2. Basal ganglia 3. Limbic-related brain regions.

4 surface

Superior	Inferior	Medial	Lateral
Lateral ventricle and **fornix**	**Hypothalamus** , anteriorly & **Subthalamus** posteriorly.	The **3rd ventricle** In some people it is connected to the thalamus of the opposite side by the interthalamic connexus, (adhesion) **or Massa intermedia**.	Posterior limb of the **internal capsule**

2 ends

Anterior	Posterior
Forms a projection, called the **anterior tubercle**. It lies just **behind** the interventricular foramen.	Forms a projection called **Pulvinar** which lies **above** the superior colliculus and the lateral & medial Geniculate bodies.

Internal Structure (White matter)

External medullary lamina	Internal medullary lamina
Covers the lateral surface. •It consists of thalamocortical & corticothalamic fibers.	• Bundle of Y- shaped myelinated (afferent & efferent) fibers. • It divides the thalamus into: anterior , medial, lateral nuclear groups. • Each of these group is subdivided into a number of named nuclei.

Lateral Nuclear Group

Dorsal Tier	Lateral dorsal		Lateral posterior		Pulvinar	
Ventral tier	Ventral Anterior	Ventral Lateral	Ventral Intermediate	Ventral Posterior	Medial geniculate nuclei	Lateral geniculate nuclei

Projection of thalamic nuclei

Name of Nucleus	Afferent	Efferent
Anterior Thalamic Nucleus	Mammillary body.	Cingulate gyrus, (limbic system)
Medial Nucleus	Hypothalamus.	Prefrontal cortex
Ventral Anterior Nucleus	Globus pallidus and substania nigra	Premotor cortex.
Ventral Lateral Nucleus	Dentate Nucleus	Primary Motor Cortex
Ventral Posterior Lateral Nucleus	Medial and Spinal lemnisci.	Sensory Cortex.
Ventral Posterior Medial Nucleus	Trigeminal Lemniscus	Sensory Cortex.
Lateral Geniculate Nucleus	Optic tract	Visual Cortex.
Medial Geniculate Nucleus	Lateral Lemniscus	Auditory Cortex.

Limbic System

means "border" or "edge".
o It **separates** the **medial surface** of the cerebral cortex from the **diencephalon**
o It consists of a number of **cortical** & **subcortical** structures with looped connections that all **project to the hypothalamus.**
4 main Function**: Emotions, Memory, Visceral & Motor responses (pleasure), Olfaction.**
4 main structure **: Limbic cortex, Hippocampus "memory", Amygdala, Septal area.**
These structures form connections between the limbic system and the hypothalamus, thalamus and cerebral cortex.
o The hippocampus is important in memory and learning, while the limbic system itself is important in the control of the emotional responses.

Structure

Cortical structure

1. Limbic lobe.
- C-shaped ring of grey matter surrounding the corpus callosum.
- It includes: Subcallosal area ,Cingulate gyrus Isthmus, Parahippocampal gyrus and the Uncus.

2. Hippocampal formation.
3. **Septal areas** (Fornix, connecting the hippocampus with mammillary bodies and septal nuclei).
4. Prefrontal area (part of olfactory system).

Hippocampus

o It is a horseshoe paired structure, one in each cerebral hemisphere.
o **SITE:** inferomedial part of the temporal lobe.
o **FUNCTION**: Formation, Organization, and Storage of memories.
o It is important in forming new memories and connecting emotions and senses
o It acts as a memory indexer by sending memories to the cerebral hemisphere for long-term storage and retrieving them when necessary.
o The hippocampus & its connections are necessary for consolidation of new short-term memories.
o Its principal efferent pathway is called the: FORNIX
• It is C-shaped group of fibers connecting the hippocampus with mammillary body.
• it consists of: 2 Fimbria, 2 Crus, 1 Body & 2 Column.
• The Fornix is an important component of PAPEZ CIRCUIT

Amygdala

o **SITE**: almond shaped mass of nuclei that lies near the temporal pole, close to the tail of the caudate nucleus.
o **FUNCTION**: Emotions, Fear, Anger and Hormonal secretions
o **LESION**: Lack of emotional responses & docility
o main connection:
- **Inputs**: Association areas of **visual**, **auditory & somatosensory** cortices.
- **Outputs**: **Hypothalamus** & **Autonomic nuclei** in the brain stem.

Septal area

o **SITE:** Located anterior to the interventricular septum.
o **FUNCTION:** It is the **pleasure zone**.
o **MAIN CONNECTIONS:** 1. To Hypothalamus 2. To Habenular nuclei

Lesions

Korsakoff's psychosis (chronic memory disorder)	Temporal lobe epilepsy	Alzheimer's disease	Schizophrenia
Deficiency of thiamine (vitamin B-1) & alcoholic intoxication. Will lead to: 1-**Retrograde** :loss of new memories at the time of lesion with retained old memories 2- **Anterograde amnesia**: inability to gain new memories.	The hippocampus is a common focus site in epilepsy can be damaged through chronic seizures. *sometimes damaged in diseases such as" herpes encephalitis"	The hippocampus is one of the first brain areas to show damage in Alzheimer's disease. **Anterograde amnesia:** Inability to form and retain new memories	Mental disorder with inappropriate action and feeling

Meninges and CSF

CRANIAL MENINGES

1. Dura (outermost)
Innervation: trigeminal, vagus, C1 – C3

Periosteal layer (attached to skull)	Meningeal layer (forms dural folds)	
	Falx cerebri	Tentoriam cerebelli
	Vertical, sickle-shaped, extends into great longitudinal fissure above corpus callosum	Horizontal, lies between cerebral hemispheres and cerebellum, separated from falx cerebri by straight sinus

Between dura and arachnoid: **Subdural Space**

2. Arachnoid mater (middle)

Translucent, loosely envelopes brain

Between arachnoid and pia: **Subarachnoid Space**

Cisterna magna (here CSF flows out of the 4th ventricle)	Interpeduncular cisterna (at base of brain, contains optic chiasma and circle of willis)

3. Pia Mater (innermost)

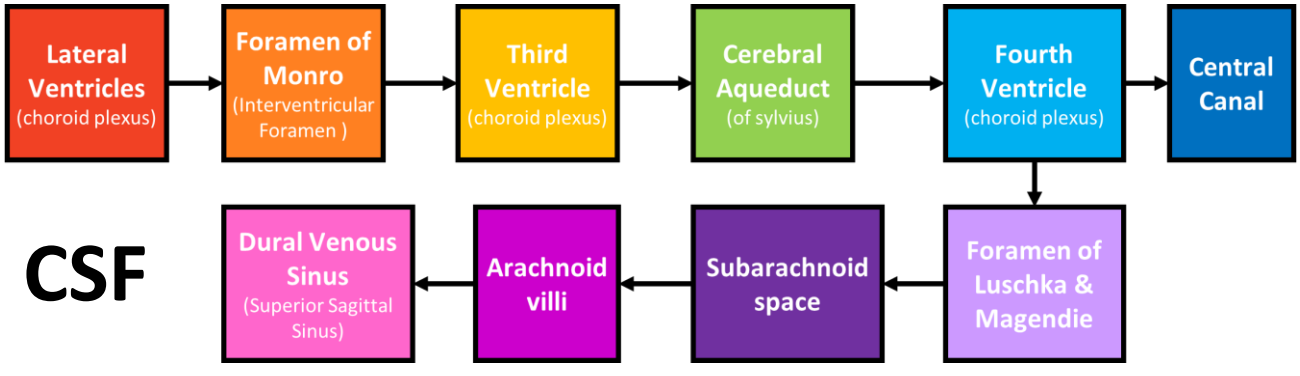
Thin, delicate, highly vascular, closely adherent to gyri and fitted into sulci

SPINAL MENINGES
(same as cranial with 2 differences)

1- epidural space (between bone and dura)	2- denticulate ligament (connects pia to dura)

Spinal cord ends at **L1 – L2**	Dura, subarachnoid, arachnoid end at **S2**	Pia → filum terminal → coccyx

CSF



Introduction

Sensory input → Integration → Motor output

Classification:

1- Anatomical or Structural classification:

CNS (in the dorsal body cavity) and PNS (outside the CNS)

2- Physiological or Functional classification:

Sensory Division (afferent) and Motor Division (efferent)

Together with the endocrine system, the nervous system is responsible for regulating and maintaining homeostasis.

Two types of cells in the nervous tissue:

1- Nerve cells or Neurons (It is the basic structural (anatomical), functional and embryological unit of the nervous system.)

2- Supporting cells or Neuroglia (glia) (NO role in information processing. they act as supporting and nutrition for neurons)

- The junction site of two neurons is called a "**synapse** or **relay**". In the synapses the membranes of adjacent cells are in close apposition (contiguity=contact, not continuity).
- Dendrites of Neurons function in receiving the information. Axons send the information away from the cell body. At the end of the axon, specializations called terminal buttons occur where information is transferred (neurotransmission) to the dendrites of other neurones.

Nucleus: A group of neurons within the CNS
Ganglion: A group of neurons outside the CNS
Tract: A group of nerve fibers (axons) within the CNS
Nerve:A group of nerve fibers (axons) outside the CNS

Grey matter:
1- Cell bodies. 2- Processes of the neurons. 3- Neuroglia. 4- Blood Vessels.
White matter:
Same as Grey matter except it has NO cell bodies.

Sympathetic = Thoracolumbar outflow
Parasympathetic = Craniosacral outflow.

Parts of brain:

1- Cerebral Hemispheres(largest part).
2- Diencephalon. 3- Brain stem. 4- Cerebellum

Cerebral hemispheres and cerebellum have an outer grey matter cortex and white matter inside.

Basal nuclei are gray matter that are located deep within the white matter in cerebral hemispheres. (Function? help the motor cortex in regulation of voluntary motor activities.)

Meninges (from outward to inward):

1- Dura mater. ↑ Subdural 2- Arachnoid mater. ↑ Subarachnoid space (contains CSF) 3-Pia mater.

Brain Ventricles (4 ventricles. Filled with CSF):

- 2 lateral ventricles: One in each hemisphere.
- 3rd ventricle: in the Diencephalon.
- 4th ventricle: between Pons, Medulla oblongata & Cerebellum.

Cerebral aqueduct (not a ventricle): connects the 3rd to the 4th ventricle.

Pathway of CSF: (produced by choroid plexus)
Lateral ventricle → 3rd ventricle → 4th ventricle → central canal (small portion)
remaining (large portion)
Subarachnoid space → through arachnoid villi → dural venous sinuses

Spinal Cord

Spinal meninges

1. **Dura mater**: tough outer layer, continuous with epineurium of the spinal nerves
2. **Arachnoid mater**: thin membrane deeper to dura mater
3. **Pia mater**: delicate membrane bound tightly to surface of brain and spinal cord and carries blood vessels.
   Forms the filum terminale, which anchors spinal cord to coccyx and the denticulate ligaments that attach the spinal cord to the dura mater

Spinal segments:

1. 8 Cervical 2. 12 thoracic 3. 5 lumbar 4. 5 sacral 5. 1 coccygeal

It has 2 enlargements:
Cervical enlargement: supplies upper limbs
Lumbosacral enlargement: supplies lower limbs

- The bundle of spinal nerves at the end of the spinal cord is called cauda equina.
- Grey matter consists of nerve **cell bodies** and their processes, neuroglia, and blood vessels
- The nerve cells are <u>multipolar</u> and are of **three** main categories:

Sensory neurons	receive impulses from the periphery of the body. Its axons constitute the ascending fasciculi of the white matter, are located in the **Dorsal** horns.
Lower motor neurons	transmit impulses to the skeletal muscles, are located in the **ventral horns**
Interneurons	Link sensory and motor neurons, at same or different levels, **which form spinal reflex arcs.**

Dorsal horn has 4 nerve cell groups:

Cell group	location	numeration	Description	function
Substantia gelatinosa	Located at the **apex of the posterior horn**	Rexed Laminae II	1. large neurons 2. Extends *through out the length* of spinal cord	**pain, temperature.**
Nucleus proprius	Located **anterior to substantia gelatinosa**	Rexed Lamina IV	1. large neurons 2. Extends *through out the length* of spinal cord	(proprioception) and **two point discrimiation** & **vibration)**
Nucleus dorsalis (Clark's column, nucleus thoracis)	Located at the **base of dorsal horn**	Rexed Lamina VII	1. large neurons 2. from *C8 to L3-4*	information from **muscle spindles** and **tendon organs.**
Visceral afferent nucleus	Located **lateral to nucleus dorsalis**	Rexed Lamina VII	1. medium size neurons 2. Extends from *T1 to L3* segments	Visceral afferents

Ventral horn has 2 cell groups

1.Motor neurons:

1)Large multipolar cells
Numerous, Axons pass out in the ventral roots of spinal nerves as **alpha** efferents,
Innervate **extrafusal muscle fibers**
2)Smaller multipolar cells
Less numerous ,Axons pass out in the ventral roots of spinal nerves as **gamma** efferents, Innervate **intrafusal muscle fibers** of neuromuscular spindles

2.Interneurons, the (**Renshaw cells)**, whose branched axons form **inhibitory** synaptic junctions on motor neurons

Lateral horn is a small column composed of small neurons that extend from:

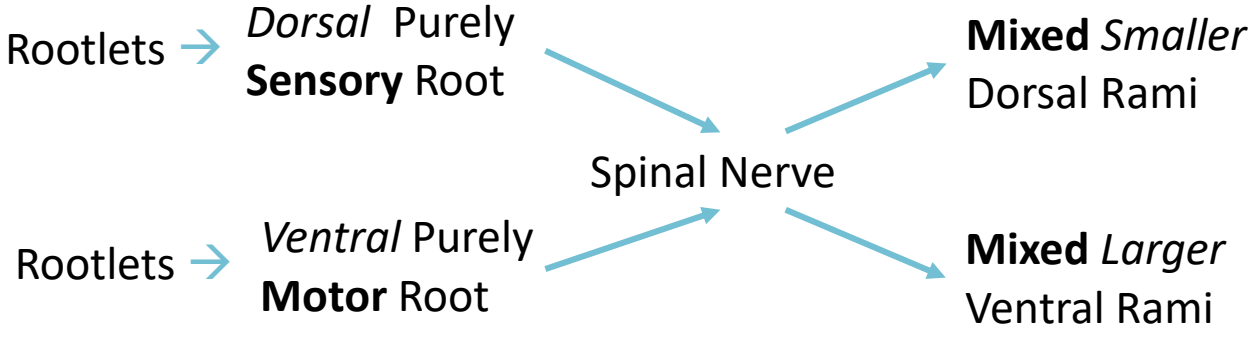
- **T1 to L2-3** segments, give rise to pre-ganglionic sympathetic fibers
- **S2-4** segments, give rise to preganglionic parasympathetic fibers

White matter Consists of mixture of nerve fibers, neuroglia and blood vessels.

- White color is due to high proportion of **myelinated nerve fibers.**
- Arranged in columns **anterior, posterior and lateral**.
- The nerve fibers are arranged as bundles, running vertically through the cord. A group of nerve fibers that share a common origin, termination and function form a **tract** or **fasciculus**
- The **amount of white matter** increases in a caudal-to-cranial direction because fibers are added to ascending tracts
- The **gray matter** is increased in volume in cervical & lumbosacral enlargements for innervation of upper & lower limbs.

Spinal nerves

- **There are Thirty-one pairs** of spinal nerves.
- **Eight** pair cervical, **twelve** pair thoracic, **five** pair lumbar, **five** pair sacral, **one** pair coccygeal



- Dorsal root has a ganglion (**dorsal root/sensory ganglion**) that contains the *cell bodies of the sensory neurons.*

Dorsal Rami innervate:

- Deep muscles of the trunk responsible for movements of the vertebral column
- Skin near the midline of the back.

The spinal nerves are connected to sympathetic chain of ganglia by communicating rami.

Ventral Rami:

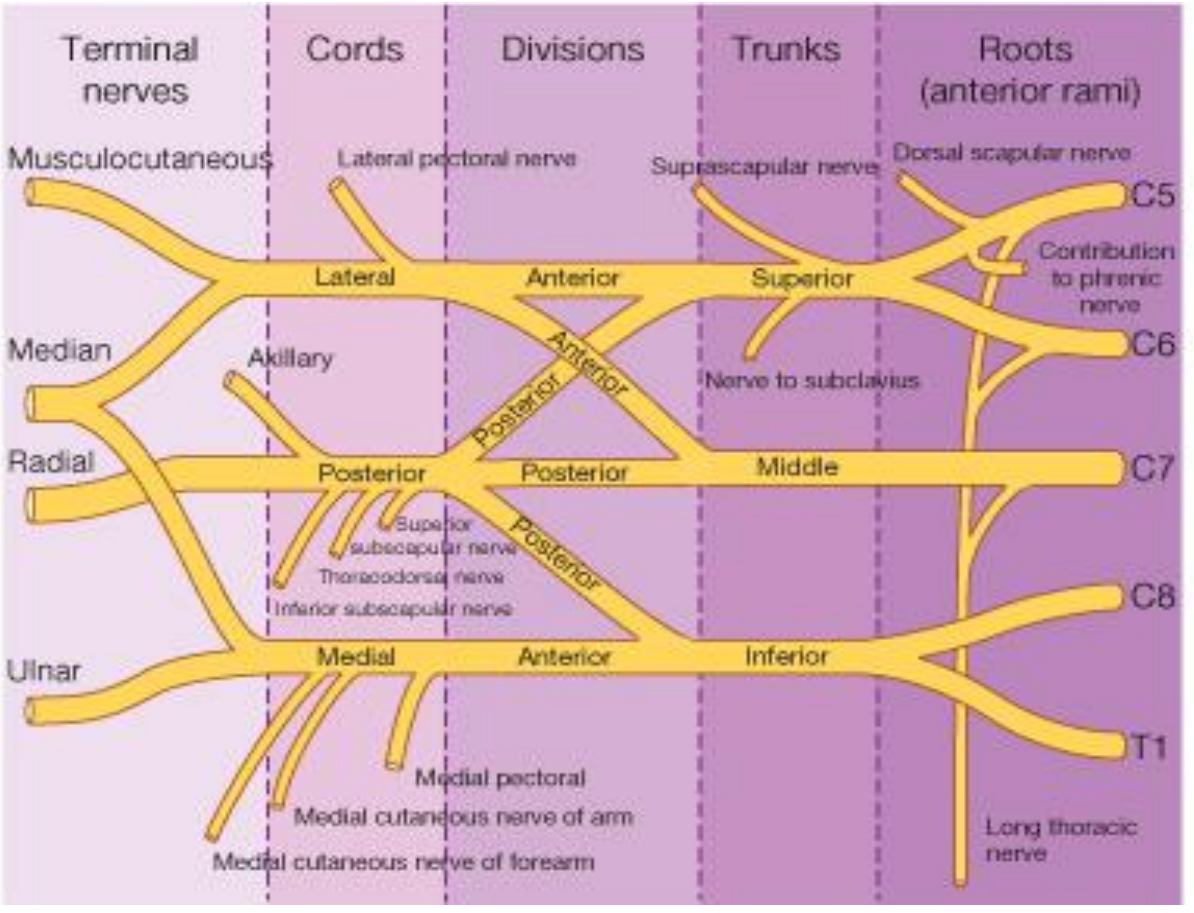
*In the thoracic region form **intercostal nerves** that innervate the intercostal muscles and the skin over the thorax*

Remaining ventral rami form **five plexuses:**

C1 - C4= **Cervical** plexus
C5 - T1= **Brachial** plexus
L1 - L4= **Lumbar** plexus
L4 - S4= **Sacral** plexus
S5 & Co= **Coccygeal** plexus

Brachial Plexus & Lumbosacral Plexus

	Brachial Plexus	Lumbar plexus	Sacral Plexus
Stages	Read The Details Carefully Roots, Trunk, Divisions , Cords.	-	-
Roots (by ventral rami)	C5, C6, C7, C8 and T1.	L1,L2, L3 and most of L4.	L4 (part), L5 **(Lumbosacral Trunk)** + S1, S2, S3 and most of S4.
Site	**Posterior of the neck** → Behind clavicle → Axilla	In psoas major muscle	In front of piriformis muscle
Trunks	**Upper Trunk=** union of C5, C6 . **Middle Trunk =** continuation of C7. **Lower Trunk** = union of C8, T1. Each trunk divides into anterior and posterior division.	-	-
Branches	**Lateral Cord :** • Lateral root of median n. • Musculocutaneous nerve. **Posterior cord:** • Axillary nerve. • Radial nerve. **Medial Cord:** • Ulnar nerve. • Median root of median n.	**L1** (to anterior abdominal wall): • Iliohypogastric n. • Ilioinguinal n. **L2, L3 & L4:** • Obturator (to medial compartment of thigh). • Femoral (to anterior compartment of thigh).	• Pelvic splanchnic n. • Pudendal n. • Sciatic n.
Injuries	**Upper trunk C5, C6:** • Waiter's tip (Erb-Duchenne Palsy). **Lower trunk C8, T1 :** • Klumpke Palsy • Median nerve = Ape hand (Pop's Blessings). • Ulnar nerve = Claw hand.	**Femoral nerve injury** • Motor effect -Wasting of quadriceps femoris. -Loss of extension of knee -Weak flexion of hip • Sensory effect: Loss of sensation of 1- anteromedial aspect of thigh. 2- medial side of leg and foot.	**Sciatic nerve Injury** will affect the *flexion of knee*, *extension o f hip*, *all movements of leg & foot*, as well as *loss of sensation* of skin of *leg and foot* (except areas supplied by saphenous branch of femoral nerve).



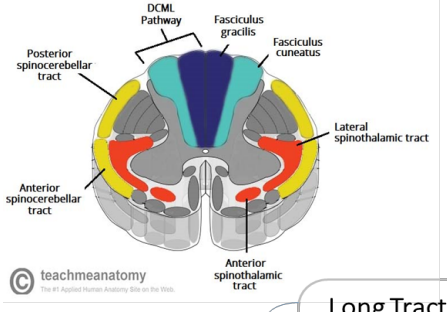
Sciatic nerve:

- Origin: sacral plexus (L4, L5 ,S1, S2& S3)
- It divides into tibial & common peroneal (fibular) nerves .

Ascending Sensory Tracts

White matter

- The **white matter** of the spinal cord consists of **Ascending** and **Descending** *Nerve Fibers*.
- It is divided into **Dorsal**, **Lateral** & **Ventral** Columns or Funiculi



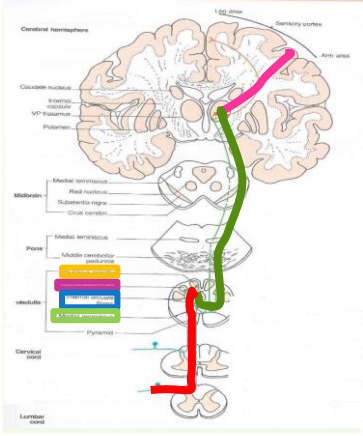
White matter tracts are classified:

- **Long Tracts**: They serve to join the brain to the spinal cord
  - Ascending (sensory or afferent).
    - conscious level (impulses at the cerebral cortex), Have the three neurons sequence pathway.
    - subconscious centers: impulses reach other parts of the brain (e.g at the cerebellum).
  - Descending (motor or efferent).
- **Short Tracts**: interconnect spinal segments and permit **intersegmental coordination**. occupy (**fasciculus proprius**).

Sensory Pathways

1- Dorsal column

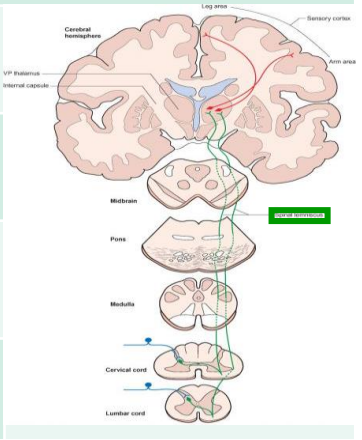
Function		Carry impulses concerned with proprioception and discriminative. (conscious sensation)	
Types/Tracts		**Fasciculus Gracilis** contains fibers that are received at sacral, lumbar and lower thoracic levels	**Fasciculus Cuneatus** contains fibers that are received at upper thoracic and cervical levels
Pathway	1st order neurons	ascend until it terminates upon 2nd order neurons in nucleus gracilis and nucleus cuneatus	
	2nd order neurons	decussate in the medulla as internal arcuate fibers, and ascend through the brain stem as **Medial Lemniscus**.	
	3rd order neurons	medial lemniscus terminates in the ventral posterior nucleus of the thalamus (3rd order neurons), which project to the somatosensory cortex (thalamocortical fibers)	



Lesions	**Tabes Dorsalis** A late manifestation of syphilitic infection on the CNS. Leads to loss of proprioception which is manifested by a high Step Page and unsteady gait (sensory ataxia)	**Subacute Combined Degeneration of the spinal cord** -A systemic disease results from B12 deficiency -It produces Sensory Ataxia -Lateral columns are also affected (combined) causing weak and spastic limbs	**Multiple Sclerosis** An immune disease affects specifically fasciculus Cuneatus of the cervical region. Leads to loss of proprioception in hands and fingers (Asteriognosis)

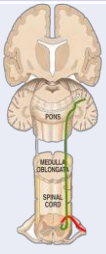
2- Spinothalamic (anterolateral) Tracts

Function		Carry impulses concerned with; pain and thermal sensations , and nondiscriminative/crude touch and pressure to the cerebral cortex . (conscious sensation)	
Types/Tracts		**Lateral Spinothalamic Tract:** Carries pain & Temperature.	**Anterior Spinothalamic Tract** Carries crude touch (non discriminative) & pressure.
Pathway	1st order neurons	Small cells in the dorsal root ganglia.	Medium sized cells in the dorsal root ganglia.
	2nd order neurons	Cells of **substantia gelatinosa** of Rolandi (contralater) in the posterior horn.	Cells of main sensory nucleus or **(nucleus proprius).**
	3rd order neurons	Cells of (ventral posterior) nucleus of the thalamus.	Cells of ventral posterior nucleus of thalamus



notes	-In brain stem, the two tracts constitute the **Spinal Lemniscus** -Fibers arising from Substantia Gelatinosa (lateral) & Nucleus Proprius (anterior) decussate in the Anterior White Commissar
lesions	**Syringomyelia** - The central canal becomes enlarged forming a cavity compressing the adjacent nerve fibres - Fibres serving pain and temperature (lateral spinothalamic) are damaged as they decussate in the ventral white commissure close to the central canal causing selective loss of pain and temperature in the upper limbs - Joints of the limbs become disorganized without discomfort (Charcot's joint)

Sensory Pathways

3-Spinocerebellar Tracts				
function		Carry information derived from muscle spindles, Golgi tendon and tactile receptors to the cerebellum for the control of posture and coordination of movements (**subconscious sensations)**		
types/tracts		**Dorsal (*uncrossed)* : Present only above level L3**		**Ventral *(crossed)***
Pathway	**1st order neurons**	Large cells of dorsal root ganglia		
	2nd order neurons	cell bodies of 2nd order neuron lie in **Clark's column** and the Axons of 2nd order neuron terminate **ipsilaterally** (**uncrossed**) in the cerebellar cortex		- The cell bodies of 2nd order neuron lie in base of the dorsal horn of the lumbosacral segments - Axons of 2nd order neuron **cross to opposite side**, ascend to the midbrain, and then make a sharp turn caudally (the fibers **cross** the midline for the **second time)** and enter the **superior cerebellar peduncle to** terminate in the cerebellar cortex
		They both convey information to the same side		
lesions		**Friedrichs ataxia** - An inherited degenerated disease - Affecting the spinocerebellar tracts - Leading to **incoordination of arms, intense tremor, wide base reeling gait ataxia** - It begins in child hood and become Wheelchair is bound by 20 years of age		

		4- Spinotectal Tract	5-Spino-olivary Tract	6- Spinoreticular Tract
function		Involved in reflexive turning of the head and eyes toward a point of cutaneous stimulation	**Indirect spinocerebellar pathway**. Carries sensation to the cerebellum (**unconscious**) Contribute to movement coordination associated primarily with balance. - Impulses from the spinal cord are relayed to the cerebellum via **inferior olivary nucleus** - Fibers arise at all levels of the spinal cord.	Involved in perception of dull aching (slow pain) -(conscious)
Pathway	1st order neurons	Primary afferents reach dorsal horn through **dorsal roots** and terminate on 2nd order neurons		- Originates in the dorsal horn, and ascend in the ventrolateral region of the cord
	2nd order neurons	- The cell bodies of 2nd order neuron lie in **base of the dorsal horn**. - Axons of 2nd order neuron cross to opposite side, and project to the **periaquiductal gray matter** and **superior colliculus in the midbrain.**		- Contains uncrossed fibers that end in **medullary reticular formation** & both crossed & uncrossed fibers that terminate in **pontine reticular formation**, finally to the thalamus; that activate the cerebral cortex - Forms part of the ascending reticular activating system

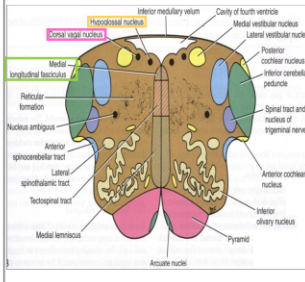
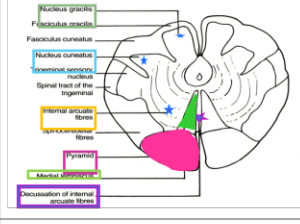
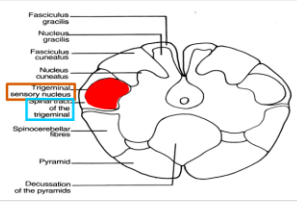
Brain Stem (External Features)

- Brainstem is composed (from above downwards) of: **midbrain**, **pons** & **medulla oblongata**.
- Continuous with diencephalon above & with spinal cord below.
- Connected with cerebellum through cerebellar peduncles.
- Contains **reticular formation (**groups of nuclei & fibers**)** responsible for: control of level of *consciousness*, *perception of pain*, *regulation of* **cardiovascular** & **respiratory** *systems*.
- the site of:
  (1) **cranial nuclei**
  (2) pathway of ascending & descending tracts
  (3) emergence of cranial nerves (from **3rd** to **12th**).

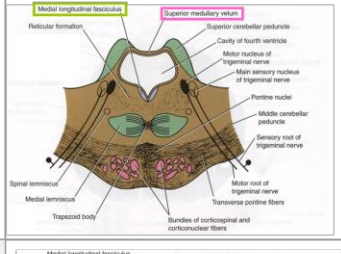
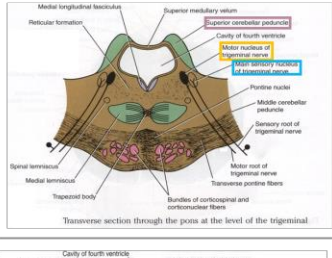
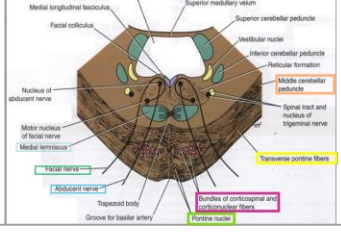
	Medulla Oblongata	Pons	Midbrain
Ventral Surface	1- Ventral median **fissure** 2- **Pyramid** (elevation produced by corticospinal tract) 3- **Olive** (elevation produced by inferior olivary nucleus) 4- Nerves emerging from Medulla: - (**12th**): sulcus between pyramid & olive - (**9th**), (**10th**) &(**11th**) sulcus dorsolateral to olive	1- Basilar **sulcus** 2- Transverse pontine **(pontocerebellar) fibers** 3- Nerves emerging from pons: - (**5th**) - (**6th**): between pons & pyramid - (**7th**) & (**8th**): junction between medulla, pons & cerebellum	1- **crus cerebri** (large descending fibers) 2- inter-peduncular **fossa** 3- Nerve emerging from midbrain: - (**3th**)
Dorsal Surface	1- caudal part (closed medulla): - Fasciculus gracilis + Gracile tubercle - Fasciculus cuneatus + Cuneate tubercle 2- cranial part (open medulla): 1- **Hypoglossal triangle**: hypoglossal nucleus. 2- **Vagal triangle**: dorsal vagal nucleus. 3- **Vestibular area**: vestibular nuclei.	1- median **sulcus** 2- **Medial eminence** & facial colliculus: abducent nucleus 3- **Vestibular area**: vestibular nuclei.	1- 4 elevations: - Two **superior** colliculi: **visual** reflexes. - Two **inferior** colliculi: **auditory** pathway 2- Nerve emerging from Midbrain: **- (4th)**

Brain Stem (Internal Structures)

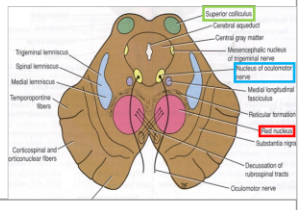
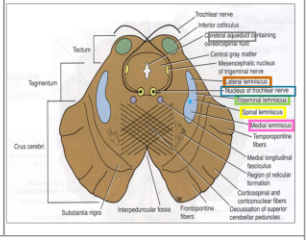
Medulla oblongata

Parts	Structures	Nucleus	Fibers	image
Open (rostral) Medulla	• floor of the 4th ventricle. • Inferior Cerebellar Peduncle	**1- Cochlear nuclei** **2- Spinal nucleus of trigeminal nerve** **3- Inferior olivary nucleus** Beneath the floor of *4th ventricle* lie : **4- Hypoglossal Nucleus** **5- Dorsal Nucleus of Vagus:** contains preganglionic parasympathetic fibres. **6- Nucleus Ambiguus**: (motor nucleus) : gives motor fibers along glossopharyngeal N. & vagus N. to Ms. of the pharynx, larynx & palate. **7- Solitary nucleus** (sensory nucleus) : receive taste sensation from the tongue along the facial (VII), glossopharyngeal (IX) and vagus (X).	**7-Medial longitudinal fasciculus:** Links vestibula nuclei above (with nuclei of extraocular muscles 3, 4 & 6) and below (with anterior horn cells of cervical and upper thoracic) **8-Tectospinal tract** : between tectum of midbrain and spinal cord (involved in head movements during visual and auditory tracking).	
Mid Medulla	• Central Canal • **Sensory decussation**	**1- Spinal Nucleus of Trigeminal nerve** 2- Large size **Gracile nuclei** 3- Large size **Cuneate nuclei**	4- Axons of Gracile & Cuneate nuclei form the **internal arcuate fibers:** Sensory Decussation **5-Pyramids** **6- Medial Lemniscus**	
Closed (Caudal) Medulla	• Central Canal • **Motor Decussation**	**1- Spinal Nucleus of Trigeminal nerve** (continuation of the Substantia Gelatinosa):It receives pain and temperature from face and forehead .	**2-Spinal tract of the trigeminal** **3-pyramidal fibers:** 1)(75-90%) lateral corticospinal tract. Forming motor decussation 2)(10-25%) anterior corticospinal tract.	

Pons

Parts	Structures	Nucleus + special structures	Fibers	image
Rostral pons	- Divided into an anterior part **(Basis Pontis)** & a posterior part **(Tegmentum)** by the **Trapezoid Body** The ventral portion contain: pontocerebellar **(transvers) fibres from pontine nuclei** and that pass to the *contralateral side* of the cerebellum through the massive **middle cerebellar peduncle** -cavity of the 4th ventricle	• Superior Medullary Velum	**1- Medial longitudinal fasciculus**	
Level of Trigeminal Nerve		**1- Motor nucleus of the trigeminal nerve.** **2- Main sensory nucleus of the trigeminal nerve.** • Superior cerebellar peduncles : form the lateral boundary of the 4th ventricle		
Caudal pons		**1- Pontine Nuclei:** receive cortico pontine fibers, and Their axons form the **transverse pontocerebellar fibers.** **2- Spinal Nucleus of Trigeminal nerve** **3- Abducent nucleus** **4- Facial motor nucleus**	5-**Bundles of corticospinal & corticonuclear fibres (Pyramidal fibres)** 6- **Spinal tract of the trigeminal** 7- **medial lemniscus:** separates from the pyramid and displace ,rotates 90 degrees and lies almost horizontally	

Midbrain

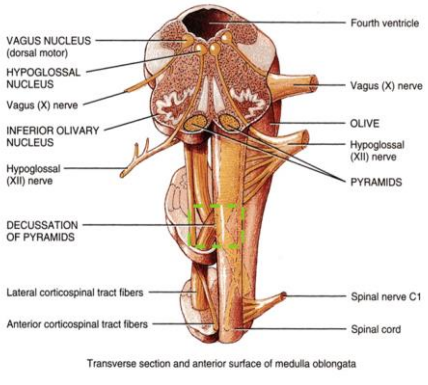
Parts	Structures	Nucleus	Fibers	
Superior Colliculus Level	• It is divided at the level of the cerebral aqueduct into : *dorsal* part (**Tectum**) *ventral* part (**Tegmentum**) • The **cerebral aqueduct** is surrounded by a pear shaped periaqueductal (central) gray matter.	**1- Superior colliculus nuclei** :A large *nucleus of gray matter* that lies beneath corresponding elevation.**(visual)** **2- Oculomotor nucleus** **3- Red nucleus :** red coloration is due to its *vascularity* and the presence of an iron containing pigment in the cytoplasm of its neurons. It is involved in **motor control**.		
Inferior Colliculus Level	• **Crus Cerebri** It is a massive mass *ventral* to the **substantia nigra**. It consists of **descending cortical efferent fibers, (Frontopontine, Corticospinal & corticobulbar and Temporopontine Fibres)** to the *motor cranial nerve nuclei* and to *anterior horn cells.* Involved in the **coordination of movement.**	**1-Inferior colliculus** is a large nucleus of gray matter that lies beneath a corresponding surface elevation.**(*auditory*)** **2- Trochlear nucleus:** The fibers of the trochlear nerve decussate in the *superior medullary velum*. • **Decussation of the superior cerebellar peduncles in the mid line**	**3- Substantia nigra** : It consists of pigmented, melanin containing neurons. It projects to the basal ganglia. Its degeneration is associated with Parkinson's disease. 4 -. **Ascending Leminisci**: Composed Of: - Medial lemniscus. - Spinal (Lateral & anterior spinothalamic tracts) -Trigeminal (Lateral & medial). - Lateral lemniscus.	

Reticular Formation
It is a complex matrix of nerve fibers & small groups of nerve cells that extends *throughout the brain stem*.
It has a number of important functions i.e. **Respiratory** and **Cardio- vascular centers** are located in the *medullary* and *caudal pontine* reticular formation.

Reticular Tract:-
-Reticulospinal tracts:
Influence a muscle tone & posture
-Reticular Activating system:
Formed of some of the ascending fibers of the reticular formation.
They activate the cerebral cortex through the thalamus.

Reticular Neurons
-Raphe Nuclei:
Midline reticular nuclei., They are serotonergic.
Its ascending fibers to the cerebral cortex are involved in the mechanisms of sleep.
Its descending fibers to the spinal cord are involved in the modulation of Pain.
-Locus Ceruleus:
Pigmented neurons that lie in the tegmentum of the caudal midbrain & rostral pons
It is the main noradrenergic cell group of the brain., Helps in arousal and sleep-wake cycles

Decussation		
Motor (Pyramidal)	Corticospinal tract	Caudal medulla
Sensory	Internal arcuate fibers (after crossing form medial lemniscus)	Mid medulla



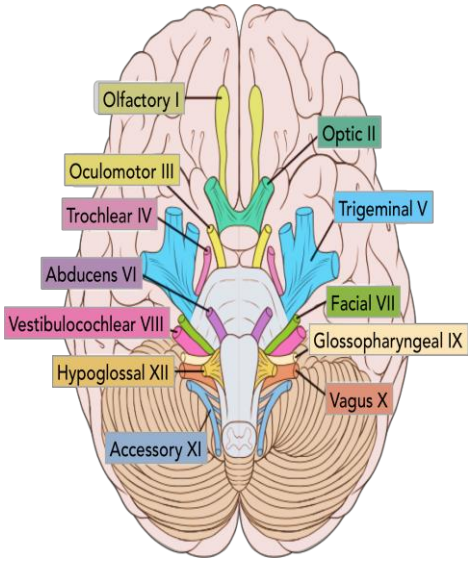
Transverse section and anterior surface of medulla oblongata

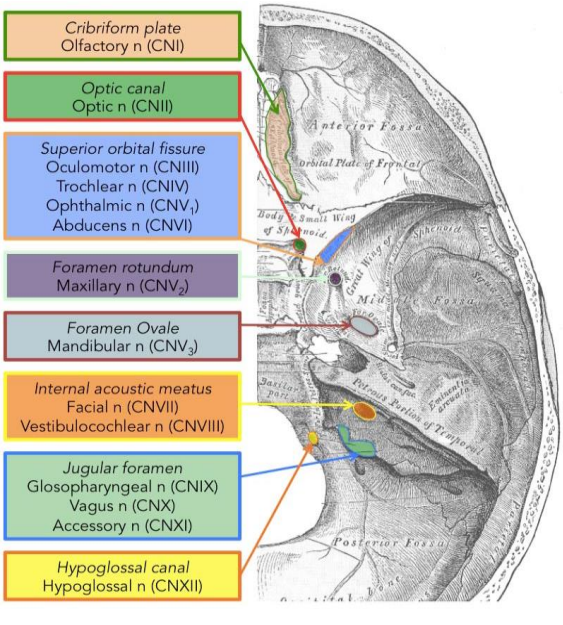
Lemnisci		
Medial	Ascending internal arcuate fibers after crossing	Terminate in thalamus
Lateral	Acoustic fibers from cochlear nuclei	Terminate in inferior colliculus (then efferents of inferior colliculus pass to thalamus)
Spinal	Spinothalamic tracts (lateral and anterior)	

Cranial Nerves

Cranial nerve		Component fibres	Structures innervated	Central connections	Functions
I	Olfactory	Sensory	Olfactory epithelium	Olfactory bulb	Olfaction
II	Optic	Sensory	Retina	Lateral geniculate nucleus; pretectal nucleus	Vision; pupillary light reflex
III	Oculomotor	Motor	Superior, inferior and medial rectus muscles; inferior oblique muscle; levator palpebrae superioris muscle	Oculomotor nucleus	Movement of eyeball; elevation of upper eyelid
		Parasympathetic	Sphincter pupillae and ciliary muscle of the eyeball, via ciliary ganglion	Edinger–Westphal nucleus	Pupillary constriction and accommodation
IV	Trochlear	Motor	Superior oblique muscle	Trochlear nucleus	Movement of eyeball
V	Trigeminal	Sensory	Face, scalp, cornea, nasal and oral cavities, cranial dura mater	Trigeminal sensory nucleus	General sensation
		Motor	Muscles of mastication; tensor tympani	Trigeminal motor nucleus	Opening and closing mouth; tension on tympanic membrane
VI	Abducens	Motor	Lateral rectus muscle	Abducens nucleus	Movement of eyeball
VII	Facial	Sensory	Anterior two-thirds of tongue	Nucleus solitarius	Taste
		Motor	Muscles of facial expression; stapedius muscle	Facial nucleus	Facial movement; tension on bones of middle ear
		Parasympathetic	Salivary and lacrimal glands, via submandibular and pterygopalatine ganglia	Superior salivatory nucleus	Salivation and lacrimation
VIII	Vestibulocochlear	Sensory	Vestibular apparatus; cochlea	Vestibular nuclei; cochlear nuclei	Vestibular sensation (position and movement of head); hearing
IX	Glossopharyngeal	Sensory	Pharynx, posterior third of tongue, Eustachian tube, middle ear	Trigeminal sensory nucleus	General sensation
			Posterior third of tongue; carotid body, carotid sinus	Nucleus solitarius	Taste; chemoreception, baroreception
		Motor	Stylopharyngeus muscle	Nucleus ambiguus	Swallowing
		Parasympathetic	Parotid salivary gland, via otic ganglion	Inferior salivatory nucleus	Salivation
X	Vagus	Sensory	Pharynx, larynx, trachea, oesophagus, external ear	Trigeminal sensory nucleus	General sensation
			Thoracic and abdominal viscera; aortic bodies, aortic arch	Nucleus solitarius	Visceral sensation; chemoreception, baroreception
		Motor	Soft palate, pharynx, larynx, upper oesophagus	Nucleus ambiguus	Speech, swallowing
		Parasympathetic	Thoracic and abdominal viscera	Dorsal motor nucleus of vagus	Innervation of cardiac muscle. Innervation of smooth muscle and glands of cardiovascular system, respiratory and gastrointestinal tracts
XI	Accessory (spinal roots)	Motor	Sternomastoid and trapezius muscles	Spinal cord	Movement of head and shoulder
XII	Hypoglossal	Motor	Intrinsic and extrinsic muscles of tongue	Hypoglossal nucleus	Movement of tongue

Exit from Brain Stem	
3	**Midbrain** (medial aspect of crus cerebri)
4	**Midbrain** (caudal to inferior colliculus)
5	**Pons** (ventrolateral)
6	**Pons** (junction b/w pons & pyramid)
7	**Pons** (cerebellopontine angle: between medulla pons and cerebellum)
8	
9	**Medulla** (sulcus dorsolateral to olive)
10	
11	
12	**Medulla** (sulcus b/w pyramid & olive)





Cranial Nerve 1 + Nose

Nasal cavity:
Floor (nasal surface of hard palate, palatine process of maxilla, horizontal plate of palatine bone)
Roof (body of sphenoid, cribriform plate of ethmoid, frontal, and nasal bones)
Medial wall/nasal septum (vertical plate of ethmoid, septal cartilage, vomer)
Lateral wall (3 conchae, 3 meatus, sphenoethmoidal recess)

Parasinuses: maxilla , frontal bone, sphenoid bone, ethmoid bone
Function:
1- lighten the skull weight
2- amplify the sound as we speak
Note : **all sinuses open into the middle meatus** EXCEPT:
Sphenoidal sinus : in sphenoethmoidal recess.
Posterior ethmoidal sinus : in superior meatus.

Olfactory mucosa: present in the upper part of nasal cavity
Respiratory mucosa: It lines the lower part of the nasal cavity (from skin of *vestibule* to the *superior concha*).

Nerve supply of nasal cavity: (*general sensation*)
Anterio part: anterior ethmoidal
Posterior part: nasopalatine, nasal, palatine (they are all branches of pterygopalatine ganglion)

Olfactory nerve (CN1): *nerve of special sensation*
1st neuron: ciliated nerve cells in **olfactory epithelium**, axons of ciliated **bipolar nerve cells** join to form olfactory nerve fibers and they join the **olfactory bulb**
2nd neuron: It is formed by the **Mitral cells** of olfactory bulb and axons of which form **olfactory tract**. Each tract will dived into:
1- lateral root: Carries olfactory fibers to end in **cortex of the Uncus & adjacent part of Hippocampal gyrus** (center of smell).
2- medial root: crosses the midline and joins the lateral root of the opposite side to connect the 2 cerebral hemisphere so each olfactory center receive smell sensation from both halves. (olfactory only sense **does not pass through thalamus**)

Arterial supply:
Sphenopalatine artery (branch of maxillary) .
Anterior and Posterior Ethmoidal (branch of ophthalmic).
Superior labial (branch of facial).
Little's area: at the anterior and inferior part of nasal septum full of anastomosis and common site for epistaxis

Venous drainage:
Venous plexus in the sub mucosa formed by veins accompanying the arteries
They drain into cavernous sinus & pterygoid venous plexus.

Lymphatic drainage:
Submandibular &Upper deep cervical nodes.

Cranial Nerves 2, 3, 4 & 6

Occulomotor nerve (3)

Type	Motor : for all extra ocular muscles except Lateral Rectus (CN 6) + Superior oblique (CN 4) Preganglionic parasympathetic fibers
Nuclei	1- Main occulomotor nucleus 2- Accessory nucleus (Edinger-Westphal nucleus). **Level of the nuclei** : Mid brain superior colliculus
Receives	Corticonuclear fibers: accommodation reflex Pretectal nucleus : pupillary reflexes
Supplies	Superior, Inferior, Medial Rectus+Levator Palpebrae Superioris +Inferior Oblique / **Parasympathatic** : pupillary constrictor + ciliary muscles
Action	Elevation of upper eyelid Turning the eyeball upward, downward, medially
Pathway	**Fibers of oculomotor nucleus** passes through red nucleus(without synapses)→ interpeduncular fossa→middle cranial fossa→lateral wall of the cavernous sinus→superior orbital fissure. **Preganglionic fibers of Edinger-Westphal nucleus** has the same pathway but terminate in ciliary ganglion → short ciliary nerves → eyeball where it supply constrictor pupillae + ciliary muscles .
Lesion	Lateral squint , Ptosis , Pupillary dilatation , loss of accommodation Parasympathetic fibers affected before motor fibers.

Trochlear nerve (4)

Type	Motor: to Superior Oblique muscle
Nuclei	Small motor nucleus at **the level of** inferior colliculus.
Action	Rotate the eyeball downward and laterally.
pathway	**From dorsal surface of brainstem**→ forward to middle cranial fossa → Lateral to cavernous sinus → superior orbital fissure .
Lesion	Diplopia + Inability to rotate the eyeball infero-laterally Causes difficulty in Walking downstairs.

Abducent nerve (6)

Type	Motor : to Lateral Rectus muscle.
Nuclei	One motor nucleus**. Level of** caudal pons in floor of 4 ventricle.
Action	Abduction (rotate the eyeball laterally).
pathway	from Ventral aspect→ cavernous sinus → superior orbital fissure. # It forms the **facial colliculus**
Lesion	**Medial squint**. If nuclear lesion : Facial nerve manifestations may appear.

Optic nerve (2)

Type	Special sensory. **Function:** vision
3 neurons pathway	**1st order neuron**: bipolar cells of the retina→ **2nd order neuron:** ganglion cells of the retina→ **3rd order neuron:** Lateral geniculate body (nucleus).
Visual pathway	**optic nerve** exits from optic canal→ middle cranial fossa → optic chiasma → optic tracts → lateral geniculate body → optic radiation → visual cortex (calcarine sulcus.
Visual field	**right visual field** ~ left optic tract ~ Left temporal + Right nasal fibers **Left visual field** ~ right optic tract ~ Right temporal + left nasal fibers
Lesion (visual field deficits)	1- Diseases of the optic nerve and eyeball like cataract, intraocular hemorrhage, retinal detachment MS and nerve tumor → **monocular blindness.** 2- Compression of the optic chiasm (pituitary gland tumor) → **bitemporal hemianopia** **3-** Vascular or neoplastic lesions of the optic tract, occipital cortex and optic radiation → **homonymous hemianopia**

Cranial Nerves 5 & 7

nerve	*ganglion*	*fibers*	*nuclei*	*branches*	*lesion*
Trigeminal (mixed)	**Trigeminal Ganglion** *Site*: Occupies a depression in the middle cranial fossa.	**GSA** (Carrying general sensations from **face,** and anterior part of **scalp**.)	**-Mesencephalic nucleus:** (midbrain &pons): receives *proprioceptive* fibers from muscles of mastication. **-Principal (main) sensory nucleus:** (pons): receives *touch* fibers from face & scalp **-Spinal nucleus :**(pons, medulla & upper 2-3 cervical segments of spinal cord): receives *pain & temperature* sensations from face & scalp.	**1. Ophthalmic nerve** (PURE SENSORY): All supply skin of face . 1. **Frontal:** scalp. 2. **Lacrimal**: lacrimal gland. 3. **Nasociliary**: nasal cavity & eyeball. **2. Maxillary nerve (PURE SENSORY):** 1. **Upper teeth, gums & maxillary air sinus** (posterior, middle & anterior superior alveolar nerves). 2. **Face:** (zygomaticofacial & infraorbital nerves). **Mandibular (mixed) :** - ***Sensory Branches*** - **Lingual:** receives General sensations from anterior 2/3 the of tongue**.** - **Inferior alveolar:** supplies Lower teeth, gums & face. - **Buccal:** supplies Face (cheek on upper jaw) - **Auriculotemporal:** supplies auricle, temple, parotid gland & TMJ	**Trigeminal Neuralgia:** This condition is characterized by *recurring episodes of intense stabbing excruciating pain* radiating from the angle of the jaw along a branches of the trigeminal nerve , due to *Compression, degeneration* or *inflammation* of the nerve
		SVE (Supplying **muscles developed from the 1st pharyngeal arch**, (8 muscles)	**Motor nucleus** (pons): supplies: Four Muscles of mastication (temporalis, masseter, medial & lateral pterygoid). **Other four muscles** (anterior belly of digastric, mylohyoid, tensor palati, &tensor tympani)	- ***Motor Branches of mandibular :****to 8 muscles (4 muscles of mastication & other 4 muscles).*	-

Nerve	*Fibers*	*nuclei*	*function*	*branches*	*lesion*
*Facial : **Mixed** (Motor, special sensory, parasympathetic) .*	GVE	**superior salivatory nucleus**	sends preganglionic parasympathetic secretory fibers	**In facial canal :** **1-Greater petrosal nerve**: *carries* preganglionic parasympathetic fibers to **pterygopalatine** ganglion then postganglionic to lacrimal, nasal & palatine gland. **2. Chorda tympani:** carries a) preganglionic parasympathetic fibers to submandibular & sublingual glands. b) taste fibers from anterior 2/3 of tongue. **3. Nerve to stapedius**: control the amplitude of sound waves from the external environment to the inner ear. -As it emerges from the **stylomastoid foramen :** **1. Posterior auricular**: to occipitofrontalis muscle. *2. **Muscular** branches to:* Stylohyoid , posterior belly of digastric **-Inside parotid gland:** gives 5 motor to the muscles of the face: temporal , zygomatic , buccal , mandibular , cervical .	**Bell's Palsy (LMN lesion) :** Damage of the facial nerve results in paralysis of muscles of facial expressions . Drooping of lower eyelid, Sagging of mouth angle, Dribbling of saliva, Loss of facial expressions, chewing, blowing, sucking, Unable to show teeth or close the eye **<u>on that side</u>**.
	SVE	**motor nucleus of facial nerve**	supplies: **M**uscles of the face, **M**uscles of scalp, (Occipitofrontalis). **M**uscles of the auricle. **P**osterior belly of digastric, **P**latysma, **S**tylohyoid, **S**tapedius,		
	SVA	**nucleus solitarius**	receives *taste from the anterior 2/3 of tongue*.		

Cranial Nerve 8 + Ear

	PART	FUNCTION	NERVE SUPPLY
EXTERNAL EAR	**-auricle**	• collects air vibrations • receives the insertion of extrinsic muscles, which are supplied by the facial nerve.	Sensation is carried by great auricular & auriculotemporal nerves.
	- external auditory meatus.	• conducts & collects sound waves from the auricle to the tympanic membrane. Its outer 1/3rd is elastic cartilage, while its inner 2/3rds are boney. • its outer 1/3rd is provided with hairs, sebaceous and Ceruminous Glands	
MIDDLE EAR (Tympanic Cavity)	**- in the petrous temporal bone.**	• lined with mucous membrane.	*Tympanic nerve: It is a branch of the glossopharyngeal: - Tympanic plexus - Lesser petrosal. - supply to the parotid gland. * Facial nerve: - Greater Petrosal nerve. - Nerve to Stapedius. - Chorda Tympani.
	- auditory ossicles **1. Malleus** **2. Incus** **3. Stapes**	• which transmit the vibrations of the tympanic membrane (eardrum) to the internal ear.	
	- Auditory Tube	• Communicates the middle ear anteriorly with the Nasopharynx. • The posterior 1/3rd of the canal is bony, and its anterior 2/3rds are cartilaginous. • equalize the pressure on both sides of the ear drum.	
	The middle ear has: • Roof: tegmen tympani, • Floor: formed by a thin plate of bone separates it from internal jugular v. -4 walls: 1. Anterior: canal for the tensor tympani muscle, auditory tube. 2. Posterior: aditus to the mastoid antrum, the pyramid. 3. Lateral: tympanic membrane. 4. Medial: Promontory, Fenestra Vestibuli, Fenestra Cochleae.		Nerve supply of ear drum: • Outer surface: - Auriculotemporal nerve. - Auricular branch of vagus. • Inner surface: Tympanic branch of the glossopharyngeal nerve.
	Muscles of the Ossicles	- TENSOR TYMPANI	Mandibular nerve.
		- STAPEDIUS	Facial nerve.
INTERNAL EAR (Labyrinth)	Bony labyrinth	-contain a clear fluid, the perilymph, in which is suspended the membranous labyrinth, consists of: • Cochlea • Vestibule, • Semicircular canals(has a swelling at one end called the ampulla).	
	Membranous labyrinth	-series of membranous sacs and ducts within the bony labyrinth, it is filled with endolymph (Four ducts & Two sacs): **-Sacs**: Utricle & Saccule lodged in the bony vestibule. (In their walls located specialized sensory receptors, which are sensitive to the orientation of the head to gravity or other acceleration forces.) **-Ducts:** Three semicircular ducts lie within the bony semicircular canals. (The utricle, saccule and semicircular ducts are concerned with maintenance of Equilibrium.) -Cochlear Duct: lies within the bony cochlea. The highly specialized epithelium on the floor of cochlear duct forms the Spiral organ of Corti that contains the sensory receptors for Hearing.	

Vestibulocochlear Nerve

Type: special Sensory Afferent (SSA)

Origin: ventral surface of brainstem through the cerebellopontine angle

Course: run laterally in posterior cranial fossa and enter the internal acoustic meatus along with 7th

Vestibular Part
conveys impulses associated with body posture, balance and coordination of head & eye movements

Afferent

1st Order Neurons
are located in the vestibular ganglion within the internal auditory meatus.

Peripheral Processes
(vestibular nerve fibers) make dendritic contact with hair cells of the membranous labyrinth (inner ear)

Central Processes
(form the vestibular nerve)
1- Mostly end up in the lateral, medial, inferior and superior vestibular nuclei (**2nd order neurons**) of the rostral medulla, located beneath the lateral part of the floor of 4th ventricle
2- Some fibers go to the cerebellum through the inferior cerebellar peduncle

Efferent

From the vestibular nuclei project:

1- To ipsilateral flocculonodular lobe of cerebellum (vestibulo- cerebellar tract) through inferior cerebellar peduncle
2- Bilaterally to ventral posterior nucleus of thalamus, which in turn project to the cerebral cortex
3- Bilaterally to motor nuclei of cranial nerves (vestibulo- ocular tract) through MLF
4- To Motor neurons of the spinal cord as lateral (ipsilateral) directly & medial vestibulospinal (bilateral) tracts through MLF

Medial Longitudinal Fasciculus

Extends throughout the brain stem. Projects bilaterally

Ascending Vestibulo-Ocular
establishes connections with the nuclei of the Oculomotor, Trochlear & Abducent nerves (motor nuclei for extraocular muscles) for coordination of head & eye movements.

Descending Vestibulo-Spinal
extends into the spinal cord as the medial vestibulospinal tract, for control the body posture.

Lateral
arises from lateral vestibular (Deiter's) nucleus, descends ipsilaterally

Medial
Is the descending part of the medial longitudinal fasciculus, projects bilaterally

Vestibulocochlear Nerve

Cochlear Part

conveys impulses associated with hearing.

The representation of cochlea is essentially bilateral at all levels.

Afferent

1st Order Neurons		2nd Order Neurons	3rd Order Neurons	4th Order Neurons
are located in the spiral ganglion within the cochlea (organ of Corti in inner ear)		From the cochlear nuclei, fibers ascend into the pons, where: Most fibers cross the midline in trapezoid body and terminate in the nucleus of trapezoid body, or in the contralateral superior olivary nucleus. Some fibers run ipsilaterally and terminate in the superior olivary nucleus.	From the superior olivary nuclei, ascending fibers comprise the lateral lemniscus containing both crossed (mainly) and direct (few) cochlear fibers, which runs through tegmentum of pons and terminate in the inferior colliculus of the midbrain. Some axons within lateral lemniscus terminate in small nucleus of the lateral lemniscus.	The inferior colliculi project to medial geniculate nuclei of thalamus. The axons originating from the medial geniculate nucleus pass through sublenticular part of the internal capsule to the primary auditory cortex (Brodmann s areas 41, 42) located in the dorsal surface of the superior temporal gyrus (Heschl s gyrus)
Peripheral Processes make dendritic contact with hair cells of the organ of Corti within the cochlear duct of the inner ear.	**Central Processes** terminate in the dorsal and ventral cochlear nuclei (2nd order neurons), which lie close to the inferior cerebellar peduncle in open rostral medulla.			

Lesions of 8th Cranial Nerve

- produces deafness tinnitus, vertigo, dizziness, nausea, nystagmus, loss of balance and ataxia.
- Acoustic neuroma: a benign tumor of 8th nerve leads to compression of the nerve leading to attacks of dizziness, and profound deafness and ataxia.
- Lesions anywhere along the pathway usually have no obvious effect on hearing, producing weakness of hearing in both ears but mostly in the opposite ear.
- Complete Deafness of the affected ear is essentially only caused by damage to the middle ear , cochlea, or auditory nerve.

Cranial Nerves 9 & 10

nerve	9 / IX / glossopharyngeal	10/ X / vagus
type	Mixed but most of the fiber sensory.	Mixed
General information	no real nucleus to itself. shares nuclei with VII (facial) and X (vagus)	• the longest and most widely distributed cranial nerve • Provide parasympathetic supply to organs thorax and upper abdomen. • sensory and motor supply to the pharynx and larynx.
Arises from (rootlets)	between olive and inferior cerebellar peduncle	
Leaves the cranial cavity	the glossopharyngeal (9), Vagus (10), Acessory (11), nerves and the Internal jugular vein leave the skull By passing through the jugular foramen.	
Special Visceral Efferent (SVE)	nucleus ambiguus (NA)	
	supply stylopharyngeus muscle	to muscles of pharynx and larynx
General Visceral Efferent (GVE)	inferior salivatory nucleus (ISN) , supply parotid gland	Dorsal Nucleus of Vagus, innervate cardiac muscle, smooth muscles and glands of viscera.
Special Visceral Afferent (SVA)	nucleus of solitary tract (NST), supply the taste buds on posterior third of tongue	Spinal Tract & Nucleus of Trigeminal, sensation from auricle, external acoustic meatus and cerebral dura mater
General Visceral Afferent (GVA)	nucleus of solitary tract. visceral sensation (pain and temp.) from mucosa of posterior third of tongue, pharynx, auditory tube and tympanic cavity, carotid sinus	Nucleus of Solitary Tract, carry impulse from viscera in neck, thoracic and abdominal cavities

Superior ganglion	• Small, with no branches. • It is connected to the Superior Cervical sympathetic ganglion.	• in the jugular foramen • inferior ganglion of glossopharyngeal nerve, • Superior cervical sympathetic ganglion & Facial nerve
Inferior ganglion	• Large and carries general sensations from pharynx, soft palate and tonsil. • It is connected to Auricular Branch of Vagus. • The Trunk of the nerve is connected to the Facial nerve at the stylomastoid foramen	• just below the jugular foramen • Cranial part of accessory nerve. • Hypoglossal nerve, • Superior cervical sympathetic ganglion. • 1 st cervical nerve.
Branches	1. Tympanic: in the otic ganglion and gives secretomotor to the parotid gland 2. Nerve to stylopharyngeus muscle 3. Pharyngeal: mucosa of pharynx 4. Tonsillar 5. Lingual: sensory branches, general and special (taste) from the posterior ⅓ of the tongue 6. Sensory branches: from the carotid sinus and body (baroreceptors and chemoreceptors)	1. Meningeal : to the dura 2. Auricular: to external acoustic meatus and tympanic membrane 3. Pharyngeal: supplies mucus membrane of the pharynx, superior and middle constrictor muscles, and all the muscles of the palate EXCEPT tensor palati 4. To carotid body 5. Superior Laryngeal: -Internal Laryngeal: sensation to the hypopharynx, epiglottis, and part of the larynx above the vocal folds -External Laryngeal: supplies the cricothyroid muscle 6. Recurrent Laryngeal :motor supply to muscles of the larynx EXCEPT cricothyroid
Nerve Lesions	• Difficulty of swallowing • Impairment of taste and sensation over the posterior one-third of the tongue ,palate and pharynx. • Absent gag reflex. • Dysfunction of the parotid gland	• palatal and pharyngeal and laryngeal paralysis. • Abnormalities of esophageal motility, gastric acid secretion, gallbladder emptying, and heart rate; and other autonomic dysfunction
	1. Lateral medullary syndrome	2- Tumors

Cranial Nerves 11 & 12

Accessory (11th) Cranial Nerve	
Type	Motor
Roots	Cranial part (originate in the caudal part of nucleus ambiguous) • Emerges from lateral aspect of the medulla caudal to rootlets of the vagus nerve. • At the side of medulla it joins the spinal root. • At the level of jugular foramen these fibres join the vagus nerve.
	Spinal part (spinal nucleus) • The axons leave the cord (via series of rootlets), emerge laterally between the dorsal and ventral roots of the spinal nerves. • Courses rostrally and enter the cranial cavity through the foramen magnum. • Supplies the sternomastoid and trapezius muscles
Exit	Jugular Foramen
Receives	Nucleus ambiguous receives bilateral corticonuclear or corticospinal fibers (from both cerebral hemispheres)
Function	• Movements of the soft palate, larynx, pharynx (cranial part). • Controls the movements of neck
Injury of Spinal Root it may be damaged by penetrating trauma as stab wounds. It is considered the most commonly iatrgenically injured nerve as during removal of malignant lymph nodes in the posterior triangle. 	• It produces atrophy and weakness of trapezius. • Unilateral paralysis of trapezius, inability to elevate (retract) the shoulder, difficulty in elevating the arm • Dropping of the shoulder is an obvious sign of 11th CN. Injury.

Hypoglossal (12th) Cranial Nerve	
Type	Motor
Origin	Hypoglossal nucleus
Foramen of exit	Hypoglossal canal
Receives	• corticonuclear fibers from both (bilateral) cerebral hemispheres EXCEPT the region that supplies genioglossus muscle • afferent fibers from nucleus solitarius and trigeminal sensory nucleus
Function	• Supplies motor innervation to all of the muscles of the tongue Except the palatoglossus (Controls the movements and shape of the tongue during speech and swallowing) • Carries proprioceptive afferents from the tongue muscles.
Lesion 	• Loss of tongue movements • Difficulty in chewing and speech • The tongue paralyses, atrophies, becomes shrunken and furrowed on the affected side • On protrusion, tongue deviates to the affected side • If both nerves are damaged, person can't protrude tongue

Summary of Lesions

Lesion/Disease	Affects	Cause
Erb-Duchenne Palsy (Waiter /policeman's tip)	lesion of Upper Trunk of brachial plexus	Excessive displacement of head to opposite side and depression of shoulder on same side
Klumpke Palsy	lesion of Lower Trunk of brachial plexus	Traction injuries: person falling from height and clutching an object to save himself.
Ape hand (Pope's Blessings).	Median nerve injury	
Claw hand	Ulnar nerve injury	
Tabes Dorsalis	Dorsal Column (ascending sensory tract)	A late manifestation of syphilitic infection
Subacute Combined Degeneration of the spinal cord	Dorsal Column (lateral column may also be affected) (ascending sensory tract)	A systemic disease results from B12 deficiency
Multiple Sclerosis	Fasciculus Cuneatus of dorsal column	Autoimmune disease.
Syringomyelia	(Lateral) spinothalamic tract	Enlargement of central canal.
Friedrichs ataxia	Spinocerebellar tracts	Inherited degenerated disease

Cranial Nerve Lesions	
Monocular blindness	**Optic 2** (optic nerve)
Bitemporal hemianopia	**Optic 2** (optic chiasm)
Contralateral homonymous hemianopia	**Optic 2** (optic tract, radiation, occipital cortex)
Lateral squint, ptosis, diplopia, pupillary dilation, loss of accommodation	**Occulomotor 3**
Diplopia & inability to rotate eyeball infero-laterally	**Trochlear 4**
Trigeminal neuralgia/ tic douloureux	**Trigeminal 5**
Medial squint	**Abducens 6**
Bells palsy	**Facial 7**
Deafness, tinnitus, vertigo, dizziness, nausea, nystagmus, loss of balance, ataxia	**Vestibulocochlear 8**
Absent gag reflex, difficulty swallowing, impairment of taste of posterior 1/3rd of tongue	**Glossopharyngeal 9**
Palatal, pharyngeal, and laryngeal paralysis, autonomic dysfunction	**Vagus 10**
Atrophy and weakness of trapezius, inability to elevate & retract shoulder, difficulty elevating arm, dropping of shoulder.	**Accessory 11** (spinal root)
Loss of tongue movement, difficulty in chewing and speech, tongue paralyses, atrophies, and deviates to affected side (if both nerves are damaged can't protrude tongue)	**Hypoglossal 12**