

# NEUROANATOMY

## COURSE CONTENT

### COMPETENCIES

The first year medical student should be able to understand and describe the gross anatomy of central & peripheral nervous systems and correlate anatomical basis of clinical manifestations.

### NERVOUS TISSUE

Nerve cell types, neuroglia: types, functions, blood brain barrier

**Level 2:** Specific neuronal and neuroglial types with function

**Level 3:** Neurotransmitters

**Functional components:** Enumeration

Afferent / Efferent; Somatic / Visceral / Branchial; General / Special

**Level 2:** Equation with spinal and cranial nerves

**Level 3:** Neurobiotaxis

### DIVISIONS OF THE NERVOUS SYSTEM: MAJOR DIVISIONS

**Level 2:** Detailed division

**Level 3:** Embryological link

### RECEPTORS AND EFFECTORS:

Functional and anatomical classification; Dermatomes, myotomes

**Level 2:** Details of functions, microanatomy, neurotransmitters, Segmental awareness

**Level 3:** Special sense receptors (rods, cones, statoacoustic, taste buds), Axial lines, Neuromuscular junctions, muscle spindles, reflex arc

### SPINAL CORD

**Gross features:** Extent (child / adult), enlargements, conus medullaris, filum terminale, spinal meninges

**Level 2:** Spinal segments, vertebral correlation, significance of enlargements

**Level 3:** Development, comparison with other parts of CNS, anomalies

**Cross sections above / below T6:** TS draw and label, differences above and below T6, arrangement of grey and white matter at different levels

**Level 2:** Lamination, nuclei of grey matter at upper & lower cervical, mid-thoracic, Lumbar & sacral levels

**Level 3:** Details of lamination, nuclei

#### Tracts

##### Ascending:

Fasciculus gracilis, fasciculus cuneatus, spinothalamic (Lateral & ventral); spinocerebellar, site of third order neurons of each tract, general functions

##### Descending:

Corticospinal, course in different parts of the CNS

**Level 2:** Clinical correlation (effect of pressure, section)

**Level 3:** Applied anatomy, syringomyelia, prolapsed intervertebral disc, tumours, TB, trauma, dislocation, myelography

## **MEDULLA OBLONGATA**

**Gross features:** Ventral, lateral, dorsal surfaces, pyramid, olive, cranial nerves, inferior cerebellar peduncle, tubercles, floor of the fourth ventricle

**Level 2:** Tuber cinereum, pontobulbar body

**Level 3:** Medullary syndromes - medial & lateral, bulbar palsy, increased intracranial tension, Arnold-Chiari malformation

**Cross sections at the level of:**

**Motor decussation:** Corticospinal

**Level 2:** Percentage of crossing, structural and functional correlation

**Sensory decussation:** Internal arcuate fibres

**Level 2:** Order of neurons

**Inferior olivary nucleus**

Cranial nerve nuclei VIII, IX, X, XI, XII, nucleus ambiguus

**Level 2:** Details of nuclei and organisation of white matter

## **PONS**

**General features:**

**Ventral** Basilar groove, cranial nerves V, VI, VII, VIII, Peduncles

**Dorsal:** Floor of the fourth ventricle, facial colliculus

**Level 2:** Relations, nomenclature of pons, details

**Level 3:** Tumours, pontine haemorrhage, thrombosis / embolism, clinical equation of nuclear involvement

**Cross sections at the level of:**

**Facial colliculus**

Relation of VI & VII nerve nuclei, pontine nuclei, lemnisci, corticospinal tracts, corticonuclear, corticopontocerebellar

**Trigeminal nucleus**

Motor and sensory nuclei of trigeminal, trapezoid body, lemnisci

## **CEREBELLUM**

**Gross features:**

Lobes, gross relations, internal structure - cortex 3 layers

**Level 2:** Details, Embryological division, connections of cerebellar cortex and intracerebellar nuclei, white matter classification (climbing & mossy fibres), Purkinje neuron, details of function, differences in functional localisation of lesions in cerebrum from those in cerebellum

**Level 3:** Development, clinical anatomy, details of dysfunction - dysequilibrium, ataxia, hypotonia

**Nuclei:** Names of nuclei and important connections

**Peduncles:** Important tracts in the peduncles

**Functions:** Of archicerebellum, paleocerebellum & neocerebellum

## MIDBRAIN

**General features :**

**Ventral:** Interpeduncular fossa and cistern, IIIrd and IVth nerve

**Dorsal:** Colliculi, superior cerebellar peduncle, brachium

**Level 2:** Details, relations, contents of interpeduncular cistern, functional components of cranial nerve nuclei III and IV, connections of red nucleus

**Level 3:** Details, clinical correlation with nuclei, Weber syndrome, Benedikt syndrome

### T.S. at inferior colliculus

Trochlear nucleus, Decussation of superior cerebellar peduncles, medial, trigeminal, spinal and lateral lemniscus, Mesencephalic nucleus of V nerve

**Level 2:** Details, relations, blood supply

### T.S. at superior colliculus

Red nucleus, tegmental decussations, IIIrd nerve nuclei, absence of lateral lemniscus, mesencephalic nucleus of V nerve

**Level 2:** Details, relations, blood supply

## CRANIAL NERVE NUCLEI

Names of 12 pairs of nerves, nuclei with their functional components, location of III, IV, V, VI, VII, VIII, IX, X, XI, XII, which are motor/sensory/mixed

**Level 2:** Extent and details of functional components of III, IV, V, VI, VII, VIII, IX, X, XI, XII

**Level 3:** Functional components of all cranial nerves in details, supra- and infra-nuclear connections, site of lesion, manifestations; embryological basis of functional components

## CEREBRUM

**HEMISPHERES :** cortex, white matter, basal nuclei, limbic lobe

Surfaces, borders, major sulci, gyri, poles, lobes, major functional areas, interior - grey and white matter

Grey - cortex - granular/agranular, striate, basal nuclei - names, white matter - classification with examples; components of limbic lobe

**Level 2:** Types of nuclei, classification, details of functional areas, motor and sensory homunculus, cerebral dominance, speech, handedness, connections of limbic lobe

**Level 3:** Embryological basis of neo-, paleo-, archi- cerebrum, details of sulci and gyri, functions of non-dominant hemisphere

## DIENCEPHALON

**Dorsal thalamus, Epithalamus, Metathalamus, Hypothalamus, Subthalamus**

Boundaries, parts, relations (gross), cavity, major nuclei, gross connections

**Level 2:** White matter, detailed connections

**Level 3:** Embryology, applied anatomy

## SECTIONS

### Mid-sagittal section

Identification, parts of corpus callosum, septum pellucidum, fornix, interventricular

foramen, thalamus, hypothalamus, mammillary body, optic chiasma, lateral and IIIrd ventricles, caudate nucleus - head, body

**Level 2:** Identification, other commissures, parts of fornix, hypothalamic sulcus, pineal body, inter-thalamic adhesions, choroid plexus, choroid fissure of lateral ventricles

**Level 3:** Recesses of IIIrd ventricle, boundaries in detail of IIIrd ventricle

#### Coronal sections at

- |                  |                    |
|------------------|--------------------|
| 1. Genu          | 4. Mammillary body |
| 2. Optic chiasma | 5. Crus cerebri    |
| 3. Infundibulum  | 6. Splenium        |

#### Identification

**Through anterior horn** - corpus striatum, anterior horn boundaries

**Level 2:** Through anterior horn - cingulate sulcus, internal capsule (anterior limb), cavum septi pellucidi

**Through body and inferior horn** - Shape of trunk, thalamus, basal nuclei, cavity of IIIrd ventricle, insula, stem of lateral sulcus; inferior horn - shape, boundaries, tail of caudate nucleus, stria terminalis, hippocampus, alveus, fimbria, collateral eminence

**Level 2:** Through body of lateral ventricle and body of caudate nucleus, thalamostriate vein / stria terminalis, choroid plexus, groove between thalamus and caudate nucleus, internal capsule

**Through posterior horn** - extent, calcar avis

**Level 3:** Additional sections and identifications with orientation

#### Horizontal section

Forceps minor, forceps major, fornix, IIIrd ventricle, anterior horn, posterior horn, basal nuclei, thalamus, internal capsule parts, frontal pole, occipital pole, lateral sulcus, optic radiation

**Level 2:** Through body of corpus callosum - longitudinal striae, indusium griseum, transverse fibres of corpus callosum, corona radiata; Through genu and splenium, interventricular foramen, tail of caudate nucleus, stria terminalis, parts of lentiform nucleus, crus of fornix, medullary laminae, extreme capsule (white matter of insula)

**Level 3:** Additional sections and identifications with orientation

### VENTRICULAR SYSTEM

Parts, boundaries, foramina, correlation with parts of brain

**Level 2:** Choroid fissure, recesses, Queckenstedt's test

**Level 3:** Hydrocephalus, ventriculo-atrial shunt, embryology, radiological procedures

### BLOOD SUPPLY

Circle of Willis, subarachnoid space, arteries, veins, no lymphatics, major area of distribution, major branches, tributaries

**Level 2:** Specific supply and drainage, blood brain barrier, hemiplegia

**Level 3:** End arteries, CSF formation, syndromes, embryology

## **MENINGES**

**Coverings:** Cerebral and spinal meninges, folds of dura, contents of subarachnoid spaces, arachnoid villi and granulations, direction of flow of CSF, lumbar puncture

**Level 2:** Details, blood supply, nerve supply, cisternal puncture, Queckenstedt's test, vertebral venous plexus, choroid plexus

**Level 3:** Applied anatomy, developmental link, epidural space and anastomosis

**Cisterns:** Definition, terminology, cisterna magna

**Level 2:** Extracerebral and intracerebral communication, CSF block, radiological procedures - myelography

**Level 3:** Embryological link

## **PERIPHERAL (SOMATIC) NERVOUS SYSTEM**

Components and organization

**Level 2:** Details

**AUTONOMIC (VISCERAL) NERVOUS SYSTEM:** Components, Functions

**Level 2:** Control, representation, detailed pathway

**Level 3:** Surgical anatomy

## **CLINICAL NEURONATOMY**

**(Anatomical basis of neurological deficit only)**

### **GENERAL NEUROANATOMY**

Hydrocephalus; herniation; intracranial haemorrhage; space-occupying-lesions (SOL) of the cranial cavity; neural tube defects (NTD); peripheral neuropathy; lower-motor-neuron (LMN) lesion—amyotrophy, hypotonia, flaccid paralysis, areflexia, fasciculations, and fibrillations on EMG; upper-motor-neuron (UMN) lesion—disuse atrophy, hypertonia, spastic paralysis, hyper-reflexia, clonus, loss of superficial reflex, and Babinski's sign

**Level 2:** Communicating and non-communicating hydrocephalus; subfalcial, transtentorial (uncal), transforaminal (tonsillar) herniation; subarachnoid, subdural, extradural haemorrhage; NTDs—anencephaly, holoprosencephaly, Arnold-Chiari malformation, spina bifida, meningo-encephalocele, meningo-myelocele

### **SPINAL CORD**

Segmental levels of involvement—upper cervical, lower cervical, thoracic, and lumbar

**Level 2:** Extent of involvement—complete transection, incomplete transection, hemisection (Brown-Séquard syndrome), degeneration of tracts, degeneration of neurons, and cavitation

**Level 3:** Aetiology—congenital (meningo-myelocele); traumatic (compression fracture, prolapsed intervertebral disc); infective (post-viral transverse myelitis or Guillain-Barré syndrome, poliomyelitis); neoplastic (intramedullary, extramedullary); metabolic (subacute combined degeneration); degenerative (motor neuron disease or amyotrophic lateral sclerosis, multiple sclerosis, syringomyelia)

## BRAIN STEM

Lateral medullary syndrome (Wallenberg syndrome or PICA syndrome); Millard-Gubler syndrome (AICA syndrome or lower pons syndrome); Weber syndrome

**Level 2:** Medial medullary syndrome (Dejerine syndrome); Raymond syndrome; Foville syndrome; Benedikt syndrome; cerebello-pontine angle tumour; neurological deficits in subclavian steal syndrome; pontine haemorrhage

**Level 3:** "Locked-in" syndrome or bilateral involvement of pontine base; Parinaud syndrome

## CEREBELLUM

Archicerebellar syndrome (dysequilibrium); paleocerebellar syndrome (gait ataxia, extensor hypertonia); neocerebellar syndrome (hypotonia, dyssynergia and intention tremor)

## VISUAL SYSTEM

Anisocoria (unequal pupils); papilloedema; hemianopia

**Level 2:** III nerve involvement in internuclear ophthalmoplegia and in uncus herniation

**Level 3:** Argyll-Robertson pupil; Marcus-Gunn pupil

## FOREBRAIN

Parkinson disease; chorea-athetosis; hemiballismus; internal capsule hemiplegia; Broca's motor aphasia; Wernicke's sensory aphasia; apraxia; agnosia;

**Level 2:** Klüver-Bucy syndrome; Korsakoff syndrome; cortical hemiplegia

**Level 3:** Dystonia; parasylvian syndrome in dominant (Gertsmann syndrome) and non-dominant cerebral hemisphere; thalamic syndrome (Dejerine-Roussy syndrome); receptive and expressive dysprosody; bilateral prefrontal cortex involvement (Phineas Gage syndrome)

**Herophilus**  
(335–280 BC)



He was a Greek physician deemed to be the first anatomist.

He is also known as the father of ancient Anatomy.

He was the first scientist to systematically perform scientific dissections of human cadavers and recorded his findings in over nine works which are all lost.

Torcular Herophili – Confluence of venous sinuses