Neuroanatomy

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THE BRAIN STEM

It includes: Midbrain - Pons - Medulla oblongata

1. Optic chiasma
2. Optic nerve
3. Optic tract
4. Medial sulcus of the crus cerebri
5. Oculomotor nerve
6. Pons
7. Pyramidal eminence of the pons
8. Retroolivary fossa
9. Olive
10. Posterolateral sulcus
11. Decussation of the pyramids
12. Anterolateral sulcus
13. Lateral funiculus
14. Pyramid
15. Foramen caecum
16. Middle cerebellar pedunculus
17. Trigeminal nerve
18. Crus cerebi
19. Posterior perforated substance
20. Mammillary body
21. Tuber cinereum
22. Infundibulum

Anterior view
The midbrain

The cerebral aqueduct divides the midbrain into:

- **Tectum** (behind the duct).
- **2 cerebral peduncles**: each one consist of
  - Crus cerebri (2), Substantia nigra & Tegmentum.

Anterior surface of midbrain:
Is formed of the 2 crura enclosing interpeduncular fossa in between them. The oculomotor nerve (1) emerges from the medial aspect of the crus cerebri.

Posterior surface: Is formed of:

- 2 superior colliculi (3): connected to the lateral geniculate body (6) by superior brachium (5).
- 2 inferior colliculi (4): connected to the medial geniculate body (8) by inferior brachium (7).

The trochlear nerve emerges from the back of midbrain.
The interpeduncular Fossa

**Boundaries:**
- Anterior: Optic chiasma (1).
- Posterior: Pons
- Anterolateral:
  - Optic tract & crura cerebri

**Contents:**
- Tuber cinereum (2).
- Mammillary bodies (3)
- Posterior perforated substance (4)
- Oculomotor nerve (5) emerges from the medial aspect of crus cerebri.
The Pons

Anterior surface:
- Has a median basilar groove for basilar artery (15).
- Pyramidal eminence (16) on either side of basilar groove with transverse pontine fibers.
- Middle cerebellar peduncle (MCP).
- Trigeminal nerve (17) between the pons & MCP.

Posterior surface:
Forms the upper part of the floor of the 4th ventricle.
It is separated from the medulla by medullary stria (15).
It has a posterior median sulcus (8) with medial eminence (9) on either side.
Facial colliculus (16) is a small swelling in the lower part of the medial eminence.
Superior fovea (17) is a depression lateral to facial colliculus.
The Medulla Oblongata

- Its upper ½ has no central canal & is known as open medulla.
- Its lower ½ has central canal & is known as open medulla.

**Anterior surface:** Has:
- Anterior median fissure which is obliterated below by pyramidal decussation (11).
- Pyramid (14) on either side of the median fissure

**Lateral surface:** Has
- Olive (9) separated from the pyramid by anterolateral sulcus (12) to which rootlets of hypoglossal nerve are attached.
- Inferior cerebellar peduncle (ICP) separated from the olive by posterolateral sulcus (10) to which rootlets of glossopharyngeal, vagus & accessory nerves are attached.
**Posterior surface:**

**Upper part:** forms lower part of the floor of the 4th ventricle & has the following features:
- Posterior median sulcus.
- Inferior fovea ((19) which is an inverted V-shaped sulcus dividing the back of medulla into; Hypoglossal triangle (14), vagal triangle (13) & vestibular area (18).

**Lower part:** back of closed medulla which has the following features:
- Posterior median sulcus.
- On either side of the sulcus Gracile & Cuneate tracts ascend & expand above to form Gracile (10) & Cuneate tubercle (9).
The fourth ventricle

It is a diamond shaped cavity of the hindbrain. It lies behind the pons & open medulla & in front of the cerebellum.

Its **superior angle** is continuous with the cerebral aqueduct of midbrain & its **inferior angle** is continuous with the central canal of closed medulla (at the obex).

It has **2 lateral recesses** which curve around the inferior cerebellar peduncle & open by lateral apertures in the subarachnoid space at the flocculus.

**The roof:** Is tent shaped & is formed of

- The superior cerebellar peduncles (SCPs).
- the superior medullary velum (SMV) stretching between the 2 SCPs.
- The inferior medullary velum (IMV) which has a median aperture (of Magendie) connecting the 4th ventricle to the subarachnoid space.
The floor:
Is formed of:

- The posterior surface of the pons: with posterior median sulcus, medial eminence (1), facial colliculus (2) & superior fovea (3).
- Medullary stria (4)
- The posterior surface of the open medulla: with inferior fovea, hypoglossal triangle (5), vagal triangle (6) & vestibular area,
1) **Olfactory (I) Nerve** is formed of about 20 rootlets which pass through the cribriform plate of ethmoid to end in the olfactory bulb.

2) **Optic (II) Nerve** is attached to the optic chiasma.

3) **Oculomotor (III) Nerve** is attached to the medial side of crus cerebri of the midbrain.

4) **Trochlear (IV) Nerve** emerges from the back of midbrain below the inferior colliculus then it winds around the midbrain to appear on its anterior aspect.

5) **Trigeminal (V) Nerve** is attached to the pons at its junction with the middle cerebellar peduncle.

6) **Abducent (VI) Nerve** arises from the pons at the pontomedullary junction between pons & the pyramid of the medulla.

7) **Facial (VII) Nerve** arises from the pons at the pontocerebellar angle.

8) **Auditory or Stato-Acoust or Vestibulocochlear (VIII) Nerve** arises from the pons at the pontocerebellar angle above the olive of the medulla.

9) **Glossopharyngeal (IX), Vagus (X) & Accessory (XI) Nerves** are attached to the posterolateral sulcus of the medulla.

10) **Hypoglossal (XII) Nerve** is attached to the anterolateral sulcus of the medulla between the pyramid & olive.
The Cerebellum

It is formed of median vermis & 2 cerebellar hemispheres.

It has 2 surfaces:
- **Superior surface**: facing the midbrain & tentorium cerebelli.
- **Inferior surface**: divided into anterior & posterior parts.
- The surfaces have many parallel folds called folia.

It has 2 notches:
- **Anterior notch** occupied by the brain stem.
- **Posterior notch** (vellecula) occupied by falx cerebelli.

The main fissures of the cerebellum:
- **Primary fissure**: separates the anterior & posterior lobes.
- **Horizontal fissure**: Extends between the middle cerebellar peduncles.
- **Posterolateral fissure**: Separates the flocculus & nodule from the rest of the cerebellum.
- **Cerebellar tonsil**: on either sides of uvula of inferior vermis.
- **Retrotonsillar fissure**: separates tonsil from the rest of cerebellum.
Lobes of the cerebellum: (Horizontal division)

- **Anterior lobe**: in front of the primary fissure.
- **Posterior lobe**: behind the primary fissure.
- **Flocculo-nodular lobe**: Consists of the flocculus & nodule.
Cerebellar nuclei:

- Dentate nucleus
- Interposed nuclei: Emboliform - Globose
- Fastigial

"Don't Eat Greasy Food"
Arbor vitae
In Latin “tree of life” it is the white matter of the white matter of cerebellum.

• It is so called because of the tree-like appearance.

• It brings sensory and motor sensation to and from cerebellum

Vertical subdivisions of the cerebellum

1- vermis (central part on superior and inferior surfaces) represents head, neck, trunk, shoulders and hips). Projects to Fastigeal N

2- Paravemis (lateral to vermis) represents muscles of upper and lower limbs Projects to Globose and Emboliform N

3- Rest of cerebellar hemispheres Project to Dentate N
Cerebellar peduncles:

Superior cerebellar peduncle (SCP):
Connects the cerebellum with the midbrain.

Middle cerebellar peduncle (MCP):
Connects the cerebellum with the pons.

Inferior cerebellar peduncle (ICP):
Connects the cerebellum with the medulla oblongata.
an cerebellum - posterior view
1-Lingula cerebelli
2-Lobulus centralis
3-Culmen
4-Declive
5-Folium vermis
6-Lobulus quadrangularis anterior, Pars anterior
7-Fissura prima
8-Lobulus simplex, Lobulus quadrangularis posterior
9-Lobulus semilunaris superior
10-Lobulus semilunaris inferior
11-Tuber vermis
Cerebellar lobules - Superior view

1. Central Lobule
2. Culmen
3. Declive
4. Quadriangular lobule
5. Simple lobule
6. Superior semilunar lobule
7. Inferior semilunar lobule
8. Primary fissure
9. Superior posterior fissure
10. Horizontal fissure
11. Posterior cerebellar incisure
Cerebellar lobules - Superior view

1. Crus cerebri
2. Substantia nigra
3. Red nucleus
4. Cerebral aqueduct
5. Tectum
6. Central lobule
7. Culmen
8. Declive
9. Wing of the central lobule
10. Quadrangular lobule
11. Simple lobule
12. Superior semilunar lobule
13. Horizontal fissure
14. Superior posterior fissure
15. Primary fissure
16. Posterior cerebellar incisure
17. Interpeduncular fossa
Cerebellar Lobules (inferior view)

1. Uvula
2. Pyramis
3. Tuber vermis
4. Tonsils
5. Biventer lobule
6. Gracile lobule
7. Inferior semilunar lobule
8. Superior semilunar lobule
9. Flocculus
10. Secondary fissure
11. Retrotonsillar fissure
12. Inferior anterior fissure
13. Inferior posterior fissure
14. Horizontal fissure
15. Postpyramidal fissure
Structure of the cerebellum

1- Cerebellar Cortex

**Outer Molecular Layer** *(stellate and basket cells)*

**Middle Pyrkinje Cell Layer** *(inhibitory to all other cells)*

**Inner Granular Layer**
*Include 2G cells (granule and golgi)*
*Granule cells are the only (excitatory to all other cells).*

2- Corpus Medullare (Medullary Center)

3- Deep Cerebellar Nuclei
White matter of the cerebellum

- Consists of three types of nerve fibers in the white matter

A. Mossy fibres (afferent)
They end in the granular layer first then pyrkinje layer (indirect activation of pyrkinje).

B. Climbing fibers (afferent)
They end directly in pyrkinje (direct activation) or molecular layer (olivocerebellar tracts mainly)

C- Axons of purkinje cells (efferent)
The only axons to leave cerebellar cortex to end in deep cerebellar nuclei (inhibitory). These fibers then projects to brain stem nuclei, thalamus and cerebral cortex.
Functional Subdivisions of The Human Cerebellum
Functional Subdivisions of vestibulo-cerebellum

Archicerebellum (Vestibulo-cerebellum):
- Flocculo-Nodular Lobe, Lingual Lobule
- It receives afferent Fibers From vestibular apparatus of internal ear Via vestibulo-cerebellar tracts either directly from vestibular ganglia or from vestibular nuclei.
- Pyrkinje neurons of each lobe project its inhibitory axons directly to ipsilateral vestibular nuclei

Efferent: vestibular nuclei give rise to:
- Vestibulospinal tracts to antigravity extensor muscles.
- Vestibulo-ocular fibers
- Vestibulo-cerebellar
- Vestivulo-cortical

Paleocerebellum (Spino-cerebellllum):

1- Anterior lobe + midline vermis (fastigeal N)
2- surrounding paravermis + globose & emboliform nuclei.

1- Vermal zone of the spino-cerebellum

Pyrkinje neurons of each hemivermis projects inhibitory axons to ipsilateral fastigeal nuclei.

**Afferent**: ventral and dorsal spinocerebellar, olivocerebellar and cuneocereellar tracts.

**Projects to fastigeal N**
Fastigeal N gives **bilateral** excitatory fibers to the **medial motor system** that controls axial and proximal limb muscles through:

**Efferent:**
- Fasigeo-Vestibulo-spinal (ipsilateral and contralateral vestibular nuclei)
- Fastigeo-Reticulo-spinal (Ipsilateral and contralateral RF)
- Anterior cortico-spinal (ipsilateral and contralateral VL nucleus of thalamus which project to trunk part of area 4. (cerebello-fastigeo-thalamo-cortico-spinal)

**Function**: Regulate muscle tone of axial and proximal limb muscles
2- para-vermal zone of spino-cerebellum

It receives afferent proprioceptive impulses from Ms. & tendons via spino-cerebellar tracts (dorsal & ventral), olivo-cerebellar and cuneorebellar

Project to Globose-Emboliform N
• it sends efferent to lateral motor pathway:
Contralateral VL nuclei of thalamus which project to precentral gyrus (distal limbs area) from which lateral corticospinal fibers arise (control distal limb muscles)
Cerebello-Globose-Emboliform-thalamo-cortical-spinal pathway

Contralateral red nucleus of midbrain (controlling distal limb muscles)
Cerebello-Globose-Embolicform-Rubral-spinal pathway

Function: it is concerned with muscle tone (mainly flexors) and regulation of voluntary movements of the distal muscles.
**Neocerebellum (cerebro-cerebellum)**

*It includes the most 2-cerebellar hemispheres + dendate nuclei.*

It receives **afferent** impulses from the **cerebral cortex + pons** Via **cerebro-ponto-cerebellar** pathway which project to dentate N. it sends **efferents** to contralateral red nucleus that projects to Ventro lateral nucleus of thalamus (VL).

**Function:** 1- controls voluntary movements, planning of sequence of intended movements (even before execution of motor activity) i.e anticipation
2- Regulation of force and timing Of Movement.
3- Learning new complex movements

**The whole pathway**

**Cortico-ponto-cerebellar-Dentato-rubro-thalamo-cortical**
Cerebellar Output

spinocerebellum

fastigial

interposed

dentate

vestibular nuclei

medial descending systems

lateral descending systems

areas 4 & 6

motor planning

balance & eye movements

motor execution

cerebrocerebellum

vestibulocerebellum
Fibers entering and leaving through cerebellar peduncles

Superior cerebellar peduncle (major efferent)

Fibres entering the cerebellum

- Ventral spino-cerebellar tract
- Trigimino-cerebellar from Mesencephalic nucleus
- Tecto-cerebellar fibres

Fibres leaving the cerebellum

- Cerebello-rubral fibres (Globose-Emboliform-rubral)
- Cerebello-thalamic fibres (Dentato-thalamo-cortical)
- Cerebello-reticular fibres (Fastigeal nucleus)
**Middle cerebellar peduncle (afferent)**
Pontocerebellar fibres
(cortico-ponto-cerebellum) to dentate nucleus

**Inferior cerebellar peduncle (afferent)**
Fibres entering cerebellum
(restiform body)

- Posterior spino cerebellar tract
- Cuneo-cerebellar tract
- **Olivo-cerebellar fibres**
- Reticulo-cerebellar tract
- Vestibulo-cerebellar fibres
- Trigemino-cerebellar fibres
- Anterior external arcuate fibers

Fibres Leaving the cerebellum
(juxta-restiform body)

- **Cerebello-olivary fibres**
- Cerebello (Fastigio)-vestibular fibres
- Cerebello (Fastigio)- reticular fibres
Blood Supply of the Cerebellum

It is supplied by 3 cerebellar arteries

- **Superior cerebellar artery**: from the basilar artery
- **Anterior inferior cerebellar artery**: from the basilar artery
- **Posterior inferior cerebellar artery**: from the vertebral artery
## Basal ganglia and cerebellum

Cerebellum and basal nuclei are the 2 major subcortical centers which affect cortical activity.
Both receive input from cortex.
Both project output to the cortex via the thalamus.

<table>
<thead>
<tr>
<th>Cerebellum</th>
<th>Basal ganglia</th>
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<tbody>
<tr>
<td>Receive cortico-ponto-cerebellar from contralateral cerebral cortex</td>
<td>Receives cortico-striate fibres from ipsilateral cerebral cortex</td>
</tr>
<tr>
<td>Projects to VL nucleus of the contralateral thalamus projects directly to areas 4,6</td>
<td>Projects to VA nucleus of the ipsilateral thalamus which projects first to SMA then to areas 4,6</td>
</tr>
<tr>
<td>Controls movement of the ipsilateral half of the body</td>
<td>Controls movement of the contralateral half of the body</td>
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Cerebellar lesion Syndromes

**Ataxia:** incoordination of movement  
- decomposition of movement  
- dysmetria, past-pointing  
- dysarthria  
- dysdiadochokinesia  
- rebound phenomenon of Holmes  
- gait ataxia, truncal ataxia  
- Intention Tremor Hypotonia, Nystagmus

**Archicerebellar Lesion:**  
*Medulloblastoma (see later)*

**Paleocerebellar Lesion:**  
*gait Disturbance, tested by heel shin test*

**Neocerebellar Lesion:**  
hypotonia, upper Limb ataxia, tremor, dysmetria.  
Tested by finger to nose test.
The child in this picture:
- would not try to stand unsupported
- would not let go of the bed rail if she was stood on the floor.

Cerebellar tumors on vermis
• Truncal Ataxia
• Frequent Falling

Cerebellar Medulloblastoma
THANK YOU