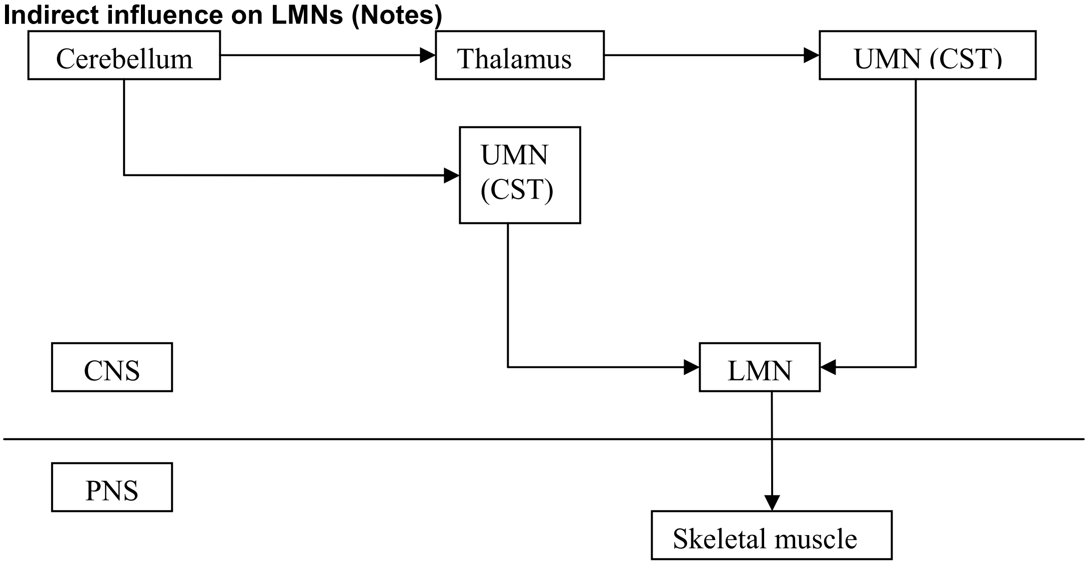
Lecture 21 - Cerebellum

Cerebellum (Nolte 5th Ed pp 487, Netter Plate 107/109)
The cerebellum is our “little brain”. It is located posterior to the brain stem and anchored to it by three cerebellar peduncles. Although virtually every sensory input finds it way to the cerebellum – it is part of the motor system – as damage to the cerebellum causes problems in equilibrium, coordination of voluntary movement and postural control (**generally: movement disorders)**

Think: **“The cerebellum compares what the body is doing, with what it should be doing”.**

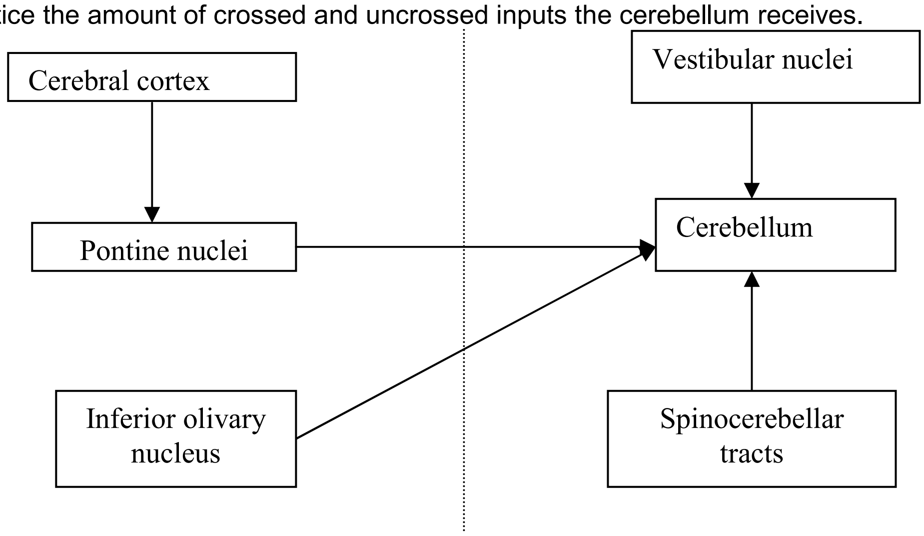
Indirect influence on LMNs (Notes)



Note: The cerebellum influences LMN via the thalamus or by directly influencing UMN systems. **Remember this diagram.**

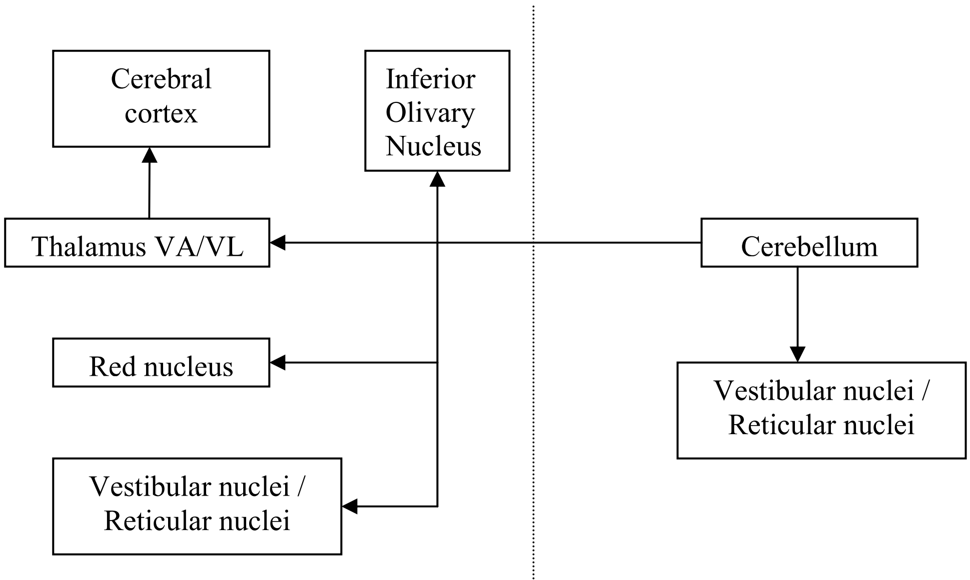
Damage on one side (Notes)
Notice that the cerebellum makes indirect (via thalamus) / direct contact with UMN systems (CST) → therefore one would expect damage to one cerebral hemisphere causes contralateral symptoms. But unilateral damage to one half of the cerebellar hemisphere produces ipsilateral symptoms. Fig 20-22 of Nolte 5th Ed pp 504, puts this nicely.

Overview of cerebellum: inputs (Notes)
Notice the amount of crossed and uncrossed inputs the cerebellum receives.



Bottom line: Right side of cerebellum receives information concerned with right side of body.

Overview of cerebellum: outputs (Notes)
The main point here is: right cerebellum sends outputs to left brain (i.e.: parts that control right side of body). Notice the amount of crossed/bilateral outputs.



Bottom line: Right cerebellum sends outputs to part of the cerebral cortex that controls the right side of the body (i.e.: left cortex)

Anatomy of the cerebellum (Nolte 5th Ed pp 487, Netter Plate 107/109)
The cerebellum is located on the posterior aspect of the brainstem. Therefore, it must be located in the posterior cranial fossa. It is separated from the occipital & temporal lobes by the tentorium cerebelli.

Anatomy of the cerebellum (Nolte 5th Ed pp 487, Netter Plate 107/109)
Fissures divide the cerebellum into lobes. The anterior and posterior lobes (visible on superior surface) are separated by the primary fissure – runs horizontally across the cerebellum (visible in sagittal section – Fig 20-2C). The posterolateral fissure (visible on inferior surface) separates the flocculonodular lobe from the posterior lobe. The tonsils are located on the inferior aspect of the cerebellum (visible in mid-sagittal section – Fig 20-2D).

Anatomy of the cerebellum (Nolte 5th Ed pp 489, Fig 20-4)

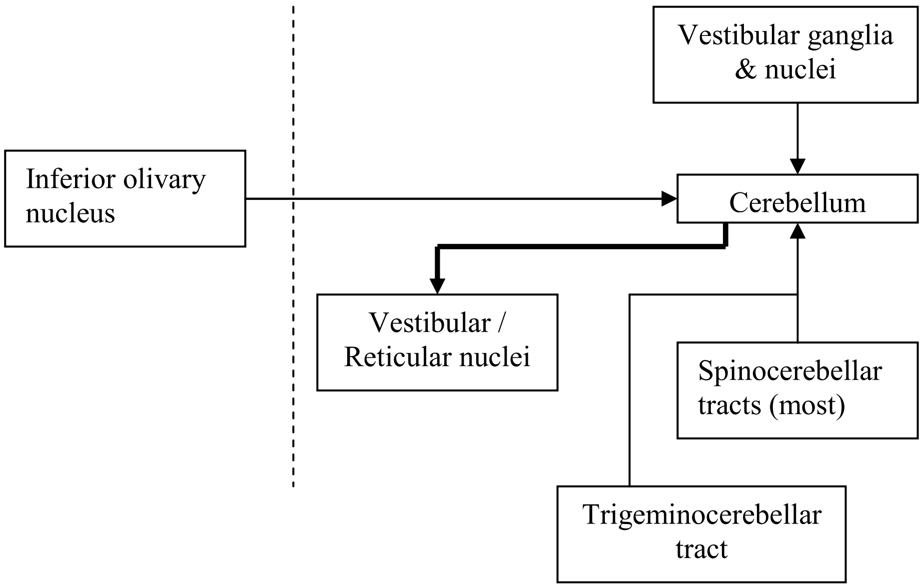
So far the cerebellum has been divided into horizontal zones. The cerebellum may also be divided into longitudinal zones. The central zone (located between the two hemispheres) is the vermis – referred to as the medial zone (coordinates movement of trunk). The zone just adjacent to the vermis is the paravermis – referred to as the intermediate zone (coordinates movement of limbs). The large lateral zone (mainly hemisphere) is involved in coordinating movement of limbs and motor planning.

Blood supply of cerebellum (Notes)
The blood supply to the cerebellum arises from the vertebrobasilar system. The branches that supply the cerebellum are: **PICA** (vertebral artery), **AICA** (basilar artery), **SCA** (basilar artery – just prior to posterior cerebral artery).

Cerebellar peduncles (Nolte 5th Ed pp 489 Fig 20-5/6)
Revise the location of the cerebellar peduncles. The cerebellum is attached to the brainstem via three cerebellar peduncles named: superior, middle, inferior. The inferior cerebellar peduncle conveys mainly afferents to the cerebellum from the medulla & spinal cord. The middle cerebellar peduncle (largest) is composed of mainly afferents to the cerebellum from the contralateral pontine nuclei (refer to inputs diagram drawn before). The superior cerebellar peduncle conveys efferents to the red nucleus & thalamus (refer to outputs diagram drawn before). Detailed discussion given below.

Inferior cerebellar peduncle (Nolte 5th Ed pp 489 Fig 20-5/6)
We noted the inferior cerebellar peduncle conveys afferents from the medulla and spinal cord. It also conveys some efferent fibres to the medulla.

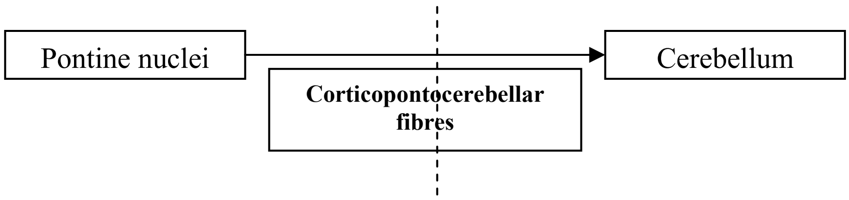
Inferior cerebellar peduncles: inputs/**outputs** (Note the crossed/uncrossed fibres)



The above diagram represents the fibres conveyed via the inferior cerebellar peduncle (outputs are in **bold**). Basically: 1) Principal inputs are: ipsilateral vestibular ganglia & nuclei, ipsilateral spinocerebellar tracts, ipsilateral trigeminocerebellar tracts, contralateral inferior olivary nucleus. 2) Principal outputs are: ipsilateral vestibular & reticular nuclei. *Relate this to the overview diagrams of inputs/outputs of cerebellum drawn on pp 2 of notes.*

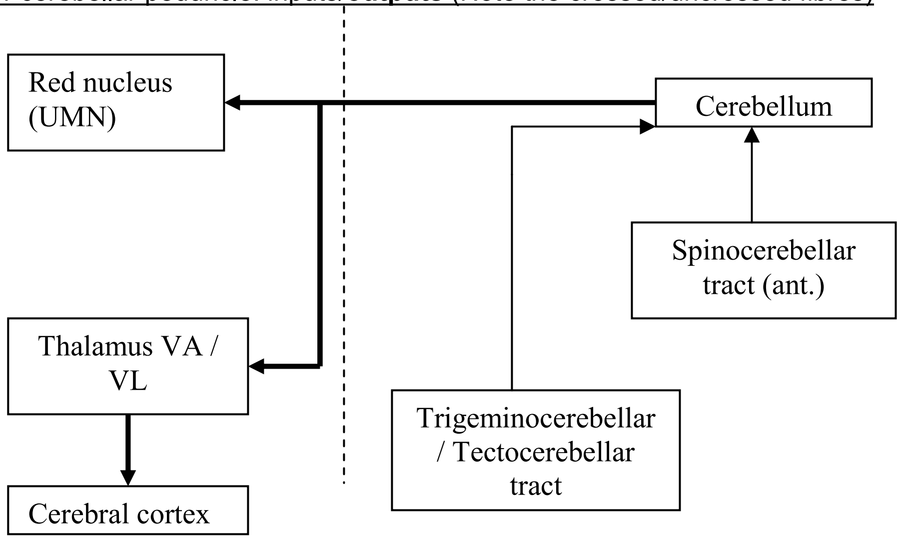
Middle cerebellar peduncle (Nolte 5th Ed pp 489 Fig 20-5/6)
We noted earlier that the middle cerebellar peduncle conveys afferents to the cerebellum from the contralateral pontine nuclei.

Middle cerebellar peduncles: inputs (Note the crossed fibres)



Superior cerebellar peduncle (Nolte 5th Ed pp 489 Fig 20-5/6)
We noted earlier that the superior cerebellar peduncle conveys efferents to the red nucleus and thalamus. It conveys afferents too (fairly minor though).

Superior cerebellar peduncle: inputs/**outputs** (Note the crossed/uncrossed fibres)



The above diagram represents fibres conveyed via the superior cerebellar peduncle (outputs are in **bold).** Basically: 1) Principal inputs are (fairly minor): ipsilateral anterior spinocerebellar tract, ipsilateral trigeminocerebellar tract, ipsilateral tectocerebellar tract. 2) Principal outputs are (mainly this): contralateral red nucleus, contralateral cerebral cortex (via VA/VL of thalamus). *Relate this to the overview diagrams of inputs/outputs of cerebellum drawn on pp 2 of notes.*

Deep cerebellar nuclei (Nolte 5th Ed pp 491, Fig 20-7)
Deep cerebellar nuclei are embedded within the medullar center of each cerebellar hemisphere (i.e.: each side contains 1 of each of their nuclei). The most lateral nucleus is the dentate. Fibres conveyed by the superior cerebellar peduncle begin here. Medial to the dentate nucleus are the *interposed nuclei*, composed of two nuclei located superior: emboliform nuclei, & inferior: globus nuclei, to one another. Close to the midline is the fastigial nucleus.

Cerebellar cortex (Nolte 5th Ed pp 493, Fig 20-9, 1st Exploration)
The traffic of the cerebellum is quite simple. Inputs arrive at the cerebellar cortex. Some of these inputs travel directly to the deep cerebellar nuclei. The cerebellar cortex process these inputs, and projects to the deep cerebellar nuclei. The outputs are then conveyed by the deep cerebellar nuclei – via the superior/inferior cerebellar peduncles. Refer to diagram in lecture notes.

The cerebellar cortex is made up of three layers, histologically. The outermost layer: **molecular layer**, consists of axons and dendrites of cerebellar neurons. Deep to this is a single layer of large neurons called **Purkinje cells**. The inner most layer (adjacent to medullary centre of cerebellum) is the **granular layer**, composed of small granule cells.

Cerebellar cortex: cell types and connections (Nolte 5th Ed pp 493 Fig 20-14)

The cell types of the cerebellar cortex have been explained above. The Purkinje cells are the only output neurons from the cerebellum. Therefore these cells must project to the deep cerebellar nuclei (refer to 1st paragraph of last heading above). The purkinje cell has a huge dendritic tree.

The granule cells (granular layer) send their axons into the molecular layer, where they bifurcate to form fine **parallel fibres**. These parallel fibres then synapse onto the huge purkinje cell dendritic tree. Note how this forms a pathway now. Now, there are two sets of afferent fibres that project to the cerebellar cortex: **climbing fibres & mossy fibres.** Climbing fibres arise in the contralateral inferior olivary nucleus and *climbs up* to synapse onto the proximal Purkinje cell dendrites. The remaining afferents (mossy fibres) end on the dendrites of granule cells – and these cells end on Purkinje cells. You can see how this pathway is indirect to the cerebellar cortex.

Draw your version of the diagram here:

Input, cerebellar cortex, deep nuclei, output (Notes)
The traffic of the cerebellum is quite simple. Inputs arrive at the cerebellar cortex. Some of these inputs travel directly to the deep cerebellar nuclei. The cerebellar cortex process these inputs, and projects to the deep cerebellar nuclei. The outputs are then conveyed by the deep cerebellar nuclei – via the superior/inferior cerebellar peduncles. Refer to diagram in lecture notes.

The following occurs (follow on diagram):

- Vestibular nuclei sends input to flocculonodular lobe → fibres project to fastigial nucleus (located along midline) → output to vestibular + reticular nuclei.
- Spinocerebellar tract sends input from trunk to vermis → projects to fastigial nucleus (located along midline) → output to vestibular + reticular nuclei. Spinocerebellar tract sends input from limbs to paravermis → projects to interposed nuclei (globus + emboliform) → output to red nucleus.
- Cerebral cortex sends input to vermis + paravermis + lateral part. Vermis projects via pathway described above. Paravermis projects via pathway described above. Lateral part → fibres project to dentate nucleus → output to VA/VL of thalamus → cerebral cortex.
- Inferior olivary nucleus sends input to all parts of cerebellum + receives output from all parts of cerebellum.

Function of cerebellum (Notes, Nolte 5th Ed pp 505-507)
The cerebellum is composed of its cortex and deep cerebellar nuclei. We know the main function of the cerebellum is to receive **sensory input** (spinocerebellar tracts = unconscious proprioception; vestibular nuclei = vestibular information) and **compare** it **with** the **motor plan** (corticopontocerebellar fibres) – to make adjustments to UMN activity so that **smooth coordinated movement** occurs. The deep nuclei make "coarse adjustments", while the cortex makes "fine adjustments".

It also helps in the following functions:

- Planning movements
- Encodes programs of learned, skilled movements
- Motor learning (i.e.: the more you practice suturing, the better you get at it)
- Cognitive function (i.e.: ability to think)
- Eye movements (i.e.:

Cerebellar involvement in control of eye movements (Nolte 5th Ed pp 509)
The **flocculus** (part of the flocculonodular lobe) is involved in **smooth pursuit eye movements** and is also involved in **cancelling** the **vestibuloocular reflex** (i.e.: move your head as you read these notes, then look at something else. If you are able to do this – you are using your flocculus of cerebellum).

Damage to the cerebellum (Nolte 5th Ed pp 507-509)
As with all things in the Nervous system, damage to a particular part causes particular functional deficits. Thus damage to particular zones of the cerebellum correspond to particular functional deficits.

What is Ataxia?: uncoordinated movement (i.e.: classic example: alcoholism)

Midline damage affects: vermis: causes ataxia of trunk
Lateral damage affects: ipsilateral ataxia of limbs. Structures affected include: paravermis, lateral hemisphere, deep nuclei. Produces following symptoms:

- Intentional tremor
- Dysmetria (inaccurate reaching)
- Decomposition of movement: inability to move joints concurrently, so move one joint at a time (e.g.: reaching out to grab something → shoulder → elbow → wrist).
- Dysdiadochokinesis (inability to perform rapid alternating movements)

Flocculus damage: affects smooth pursuit

Diseases affecting the cerebellum (Nolte 5th Ed pp 509)
Damage to the flocculus can occur as a result of a tumour arising in the roof of the fourth ventricle → medulloblastomas. Astrocytomas can occur – as a result of granule cells dividing. Strokes (haemorrhagic / ischaemic), alcoholism (thiamine deficiency), spinocerebellar degeneration all affect cerebellum.