Cerebellum Objectives:
Upon completion of this lecture, the following objectives should be completed.

1. Describe and identify on images the gross neuroanatomical cerebellar structures and areas including the 3 sets of cerebellar lobes, the cerebellar hemispheres, vermis, tonsils, 3 pairs of cerebellar peduncles, the 3 zones, and the dentate nucleus of the deep cerebellar nuclei.

2. Describe the types of fibers that are carried in each of the cerebellar peduncles.

3. On histological sections, be able to identify the gray and white matter and identify the 3 layers within the gray matter.

4. Be able to list the 4 nuclei that make up the deep cerebellar nuclei, but you only have to identify the dentate nucleus on images.

5. Describe what is contained in each of the 3 cerebellar modules. Describe the afferents entering each module and describe the efferents leaving each module and what their function is.

6. Describe the signs/symptoms of a patient with a lesion in each of these 3 cerebellar modules.

7. Be able to define the following terms:
    - ataxia
    - hypotonia
    - dyssynergia
    - dysmetria
    - tremor
    - dysdiadochokinesia

8. If given a set of cerebellar signs/symptoms, be able to describe if the lesion is in the vestibulocerebellum, spinocerebellum, or pontocerebellum.

Cerebellar Outline

I. Cerebellum overview

II. Anatomy of the cerebellum
    A. Lobes
    B. Hemispheres
    C. Cerebellar peduncles
    D. Zones
    E. Blood Supply
    F. Cerebellar cortex
        1. Gray matter
            a. Granule cell layer
            b. Purkinje cell layer
            c. Molecular cell layer
    G. Deep cerebellar nuclei
        1. Fastigial
        2. Globose and Emboliform
        3. Dentate

III. Cerebellar functional modules
    A. Vestibulocerebellar module
        1. Afferents
        2. Efferents
        3. Dysfunction/lesions
    B. Spinocerebellar module
        1. Afferents
        2. Efferents
        3. Dysfunction/lesions
    C. Pontocerebellar module
        1. Afferents
        2. Efferents
        3. Dysfunction/lesions

IV. Motor Systems Overview

Cerebellum
B. Puder, Ph.D.

The cerebellum (latin for little brain) coordinates movement and postural controls by comparing actual motor output to the intended movement and then adjusting the movement as necessary.

The intended movement travels via corticopontine fibers that synapse in the pontine nuclei and the pontocerebellar fibers synapse in the cerebellum.

Proprioceptive information from the muscle spindles and Golgi tendon organs travels via and dorsal and ventral spinocerebellar tracts(lower extremity) and the cuneocerebellar tacts (upper extremity) to the cerebellum.

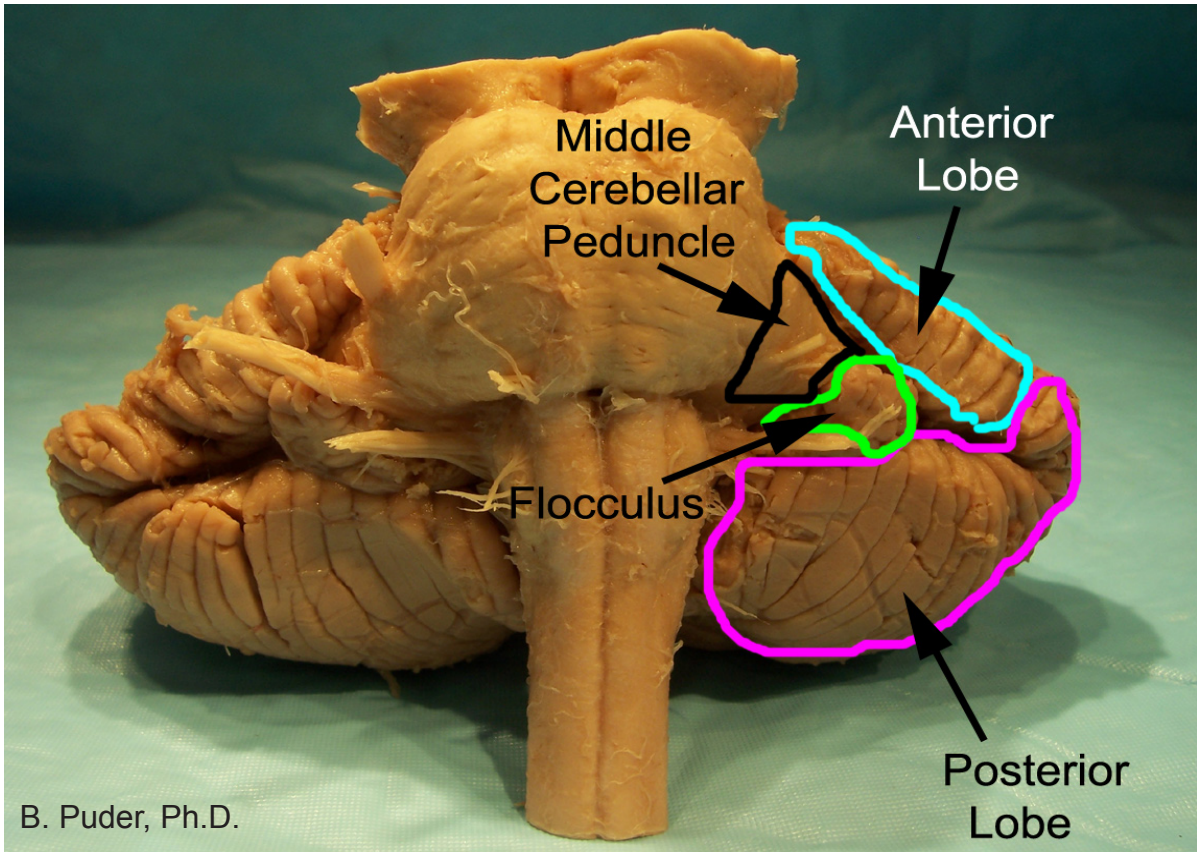
The cerebellum receives from many other areas as well.

Anatomy of the cerebellum

Gray matter (cell bodies) are located on exterior surface as the cerebellar cortex.
The cerebellar cortex has 3 cortical layers (we will talk about later).
Interior to the gray matter is the white matter (axons).
Deep in the cerebellum, deep to the white matter, there are 4 pairs of cerebellar nuclei (we'll talk about later).
The cerebellar nuclei will project to vestibular, reticular, motor thalamic, and red nuclei, therefore cerebellar output influences corticospinal, corticobulbar, rubrospinal, vestibulospinal, and reticulospinal tracts.

Lobes
There are 3 cerebellar lobes:

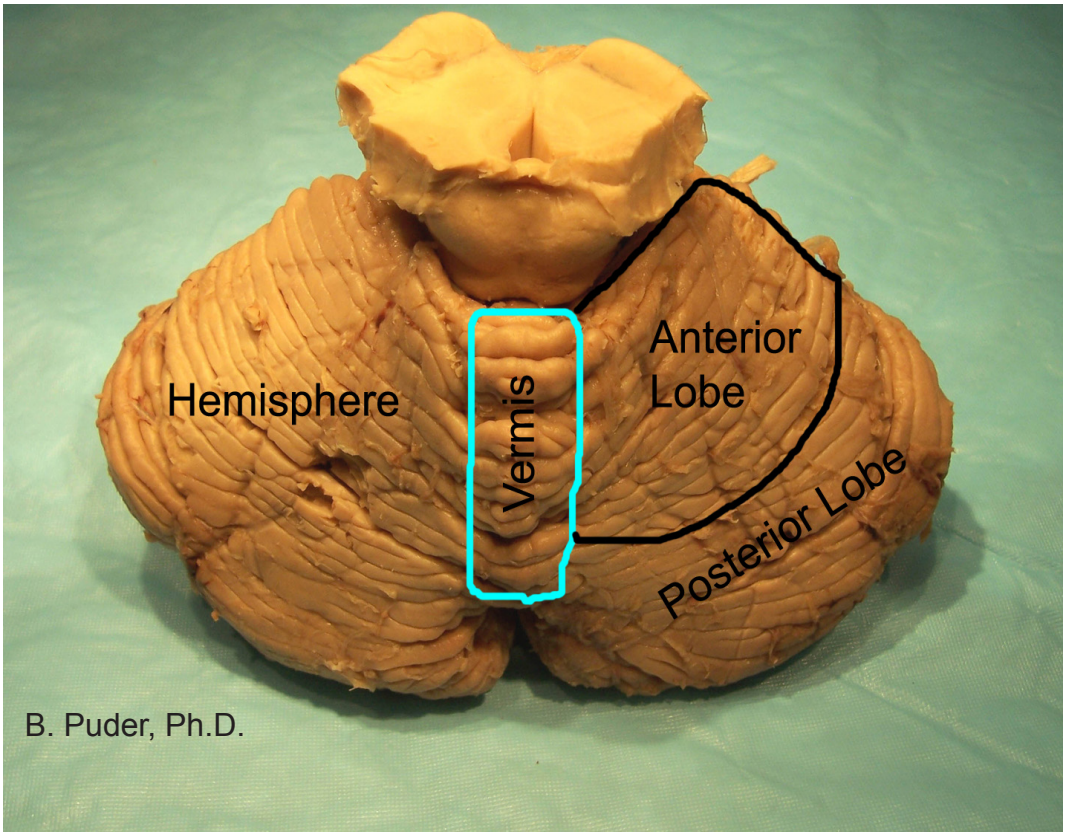
1. Anterior lobe
2. Posterior lobe
3. Flocculonodular lobe

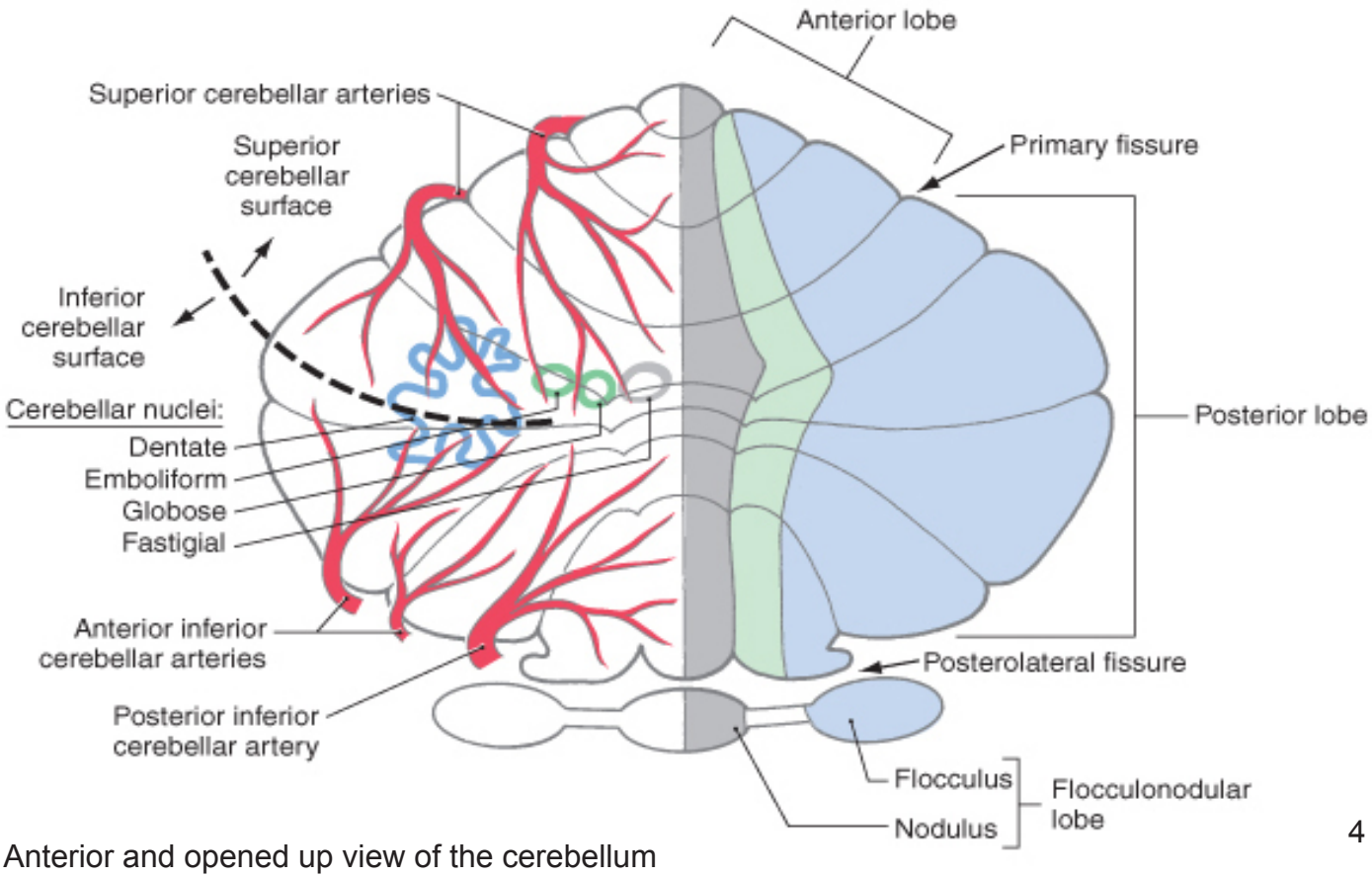


Anterior view of the brainstem and cerebellum

Hemispheres:
2 lateral hemispheres
2 paravermal hemispheres
1 midline vermis (worm)

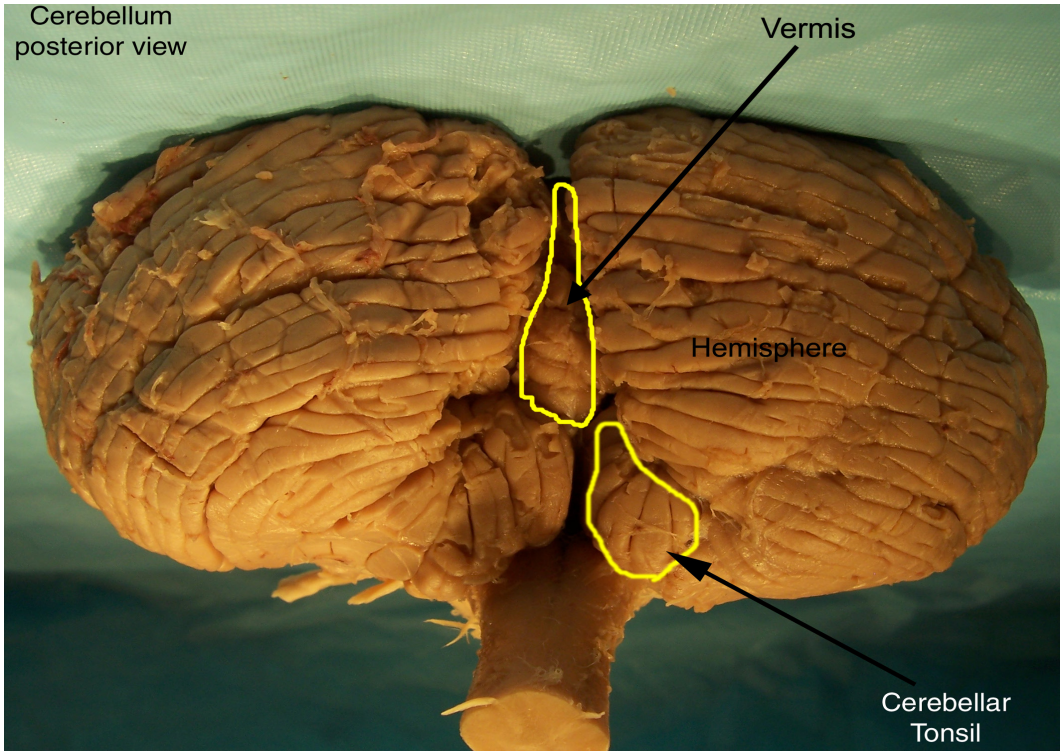
Posterior view of the midbrain and cerebellum depicting the lateral hemispheres and the midline vermis





Anterior and opened up view of the cerebellum

Adapted from Fundamental Neuroscience, Haines



B. Puder, Ph.D.

Posterior view of the cerebellum depicting the vermis and the tonsils

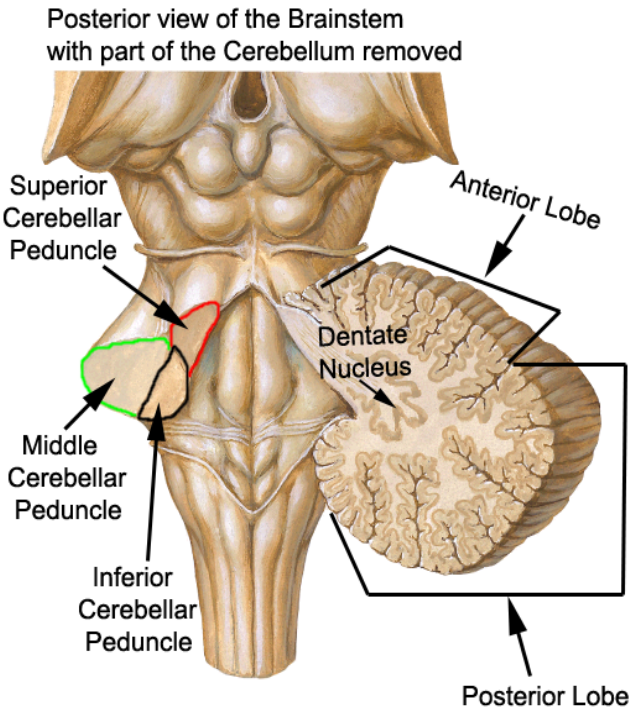
Cerebellar Peduncles:

There are 3 sets of cerebellar peduncles:

1. Inferior cerebellar peduncle - carries information from the spinal cord and medulla into the cerebellum. Connections to and from the vestibular nuclei use the inferior cerebellar peduncle to travel to and from the cerebellum.

2. Middle cerebellar peduncle - pontocerebellar fibers into the cerebellum

3. Superior cerebellar peduncle - carries fibers from the cerebellum out to the diencephalon and brainstem

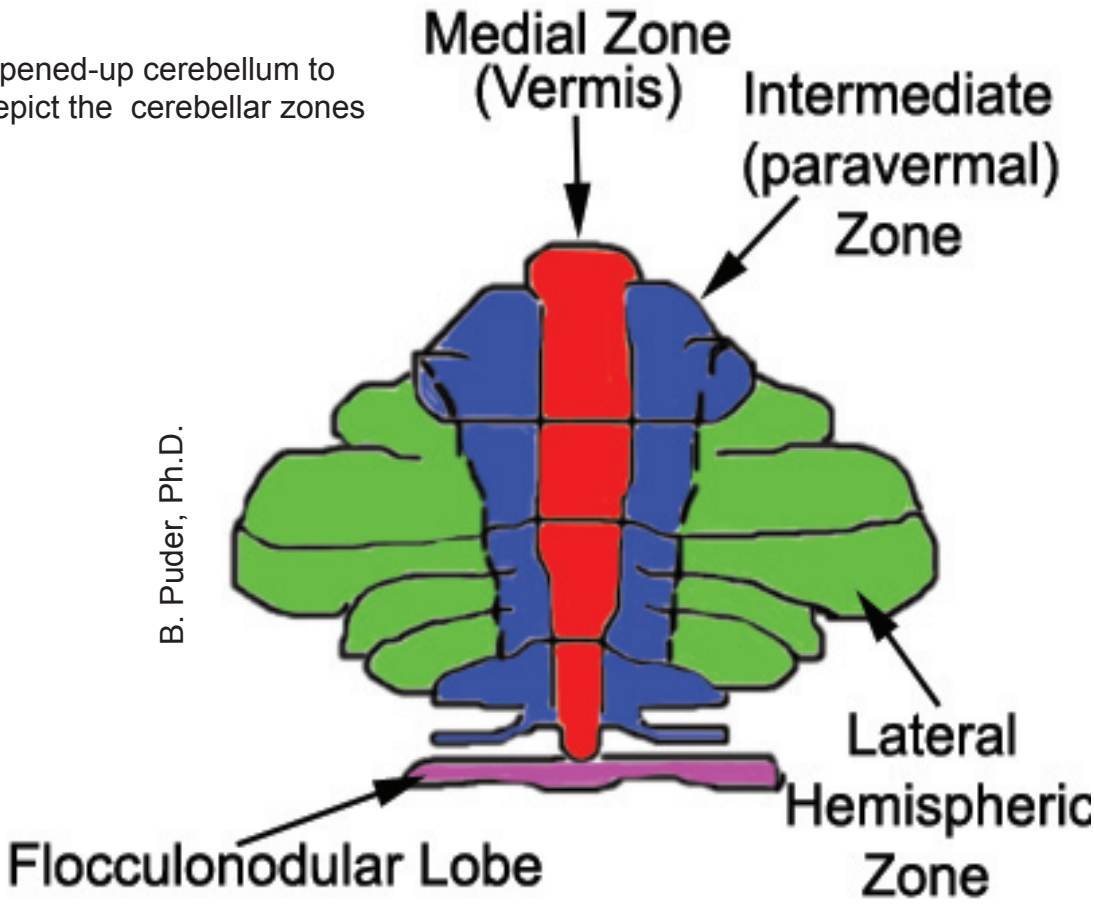


Cerebellar Zones

One can also divide the cerebellum into 3 paired zones:

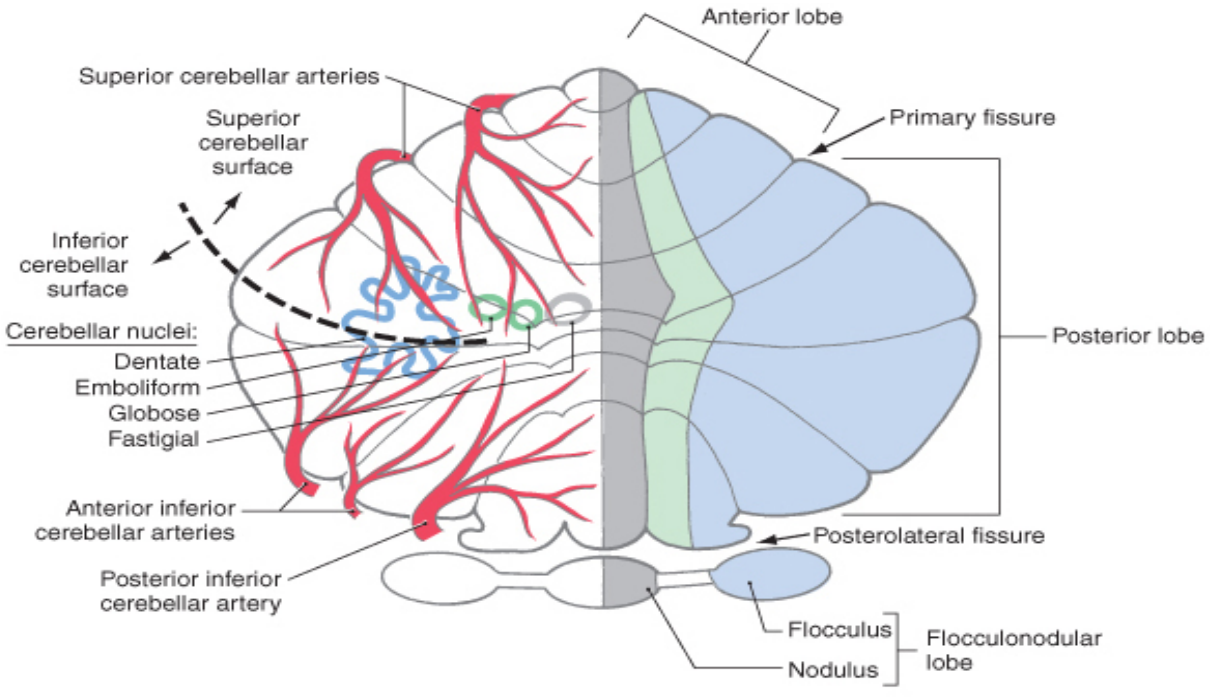
- 2 lateral hemispheric zones
- 2 intermediate (paravermal) zones
- 1 medial zone (vermis)

Opened-up cerebellum to depict the cerebellar zones



Blood Supply

Blood supply to the cerebellum is via the posterior or anterior inferior cerebellar arteries (PICA or AICA), or the superior cerebellar artery

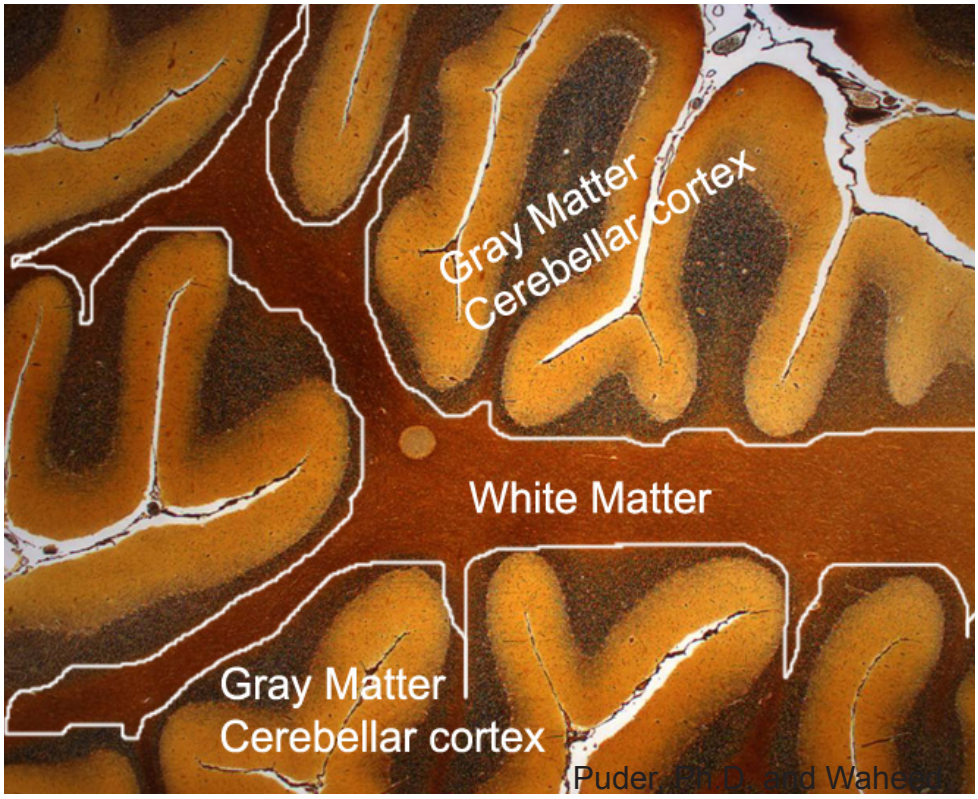


Cerebellar cortex

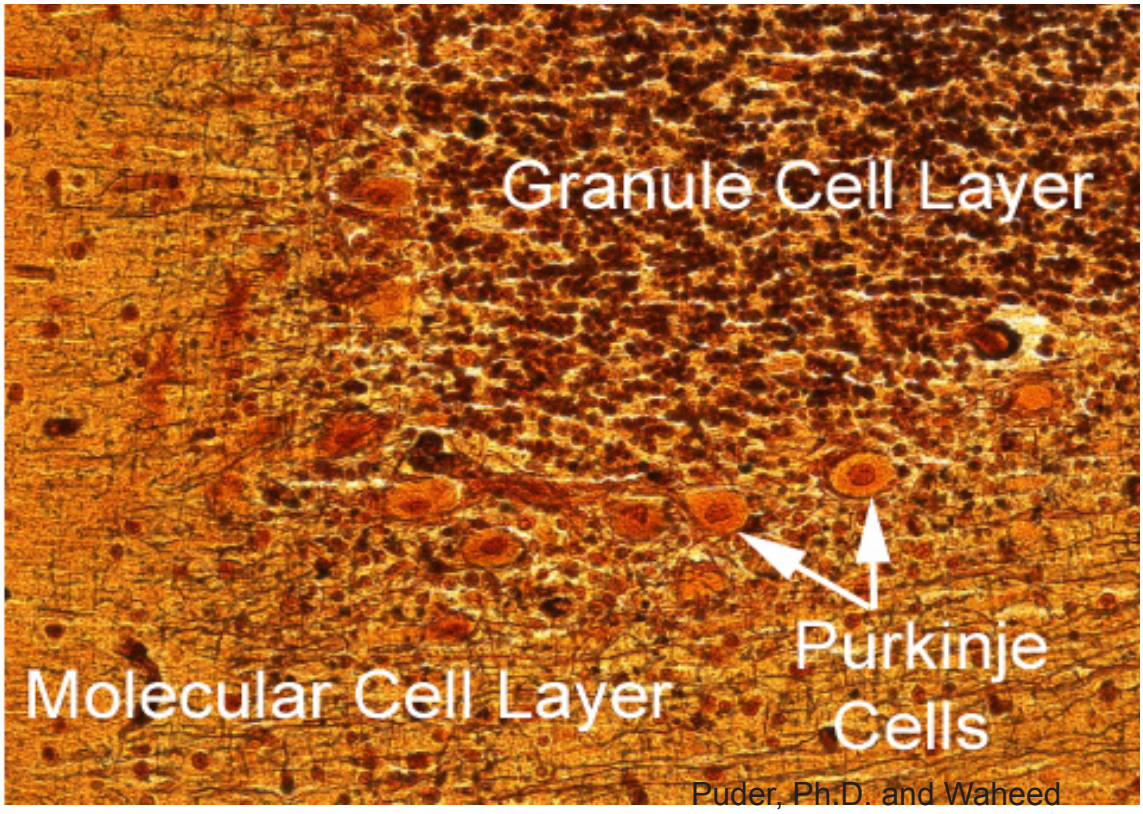
Cell bodies of cerebellar neurons are in the outermost layer of the cerebellum called the cortex. The cortex has 3 cellular layers:

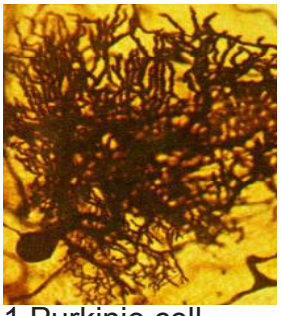
1. Granule cell layer
2. Purkinje cell layer - the only efferent neurons of the cerebellar cortex (send axons to cerebellar or vestibular nuclei and release inhibitory neurotransmitter GABA)
3. Molecular cell layer

Histological section depicting the cerebellar gray matter (exterior) and white matter (interior)



High magnification view of the cerebellar gray matter depicting the 3 layers



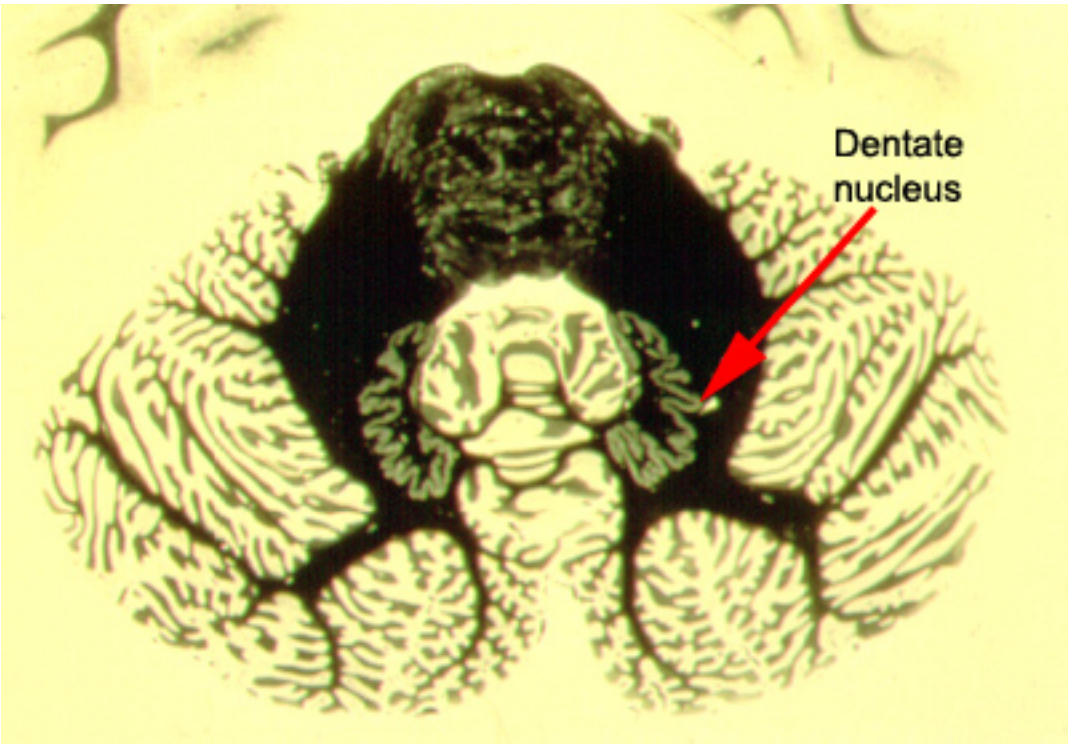


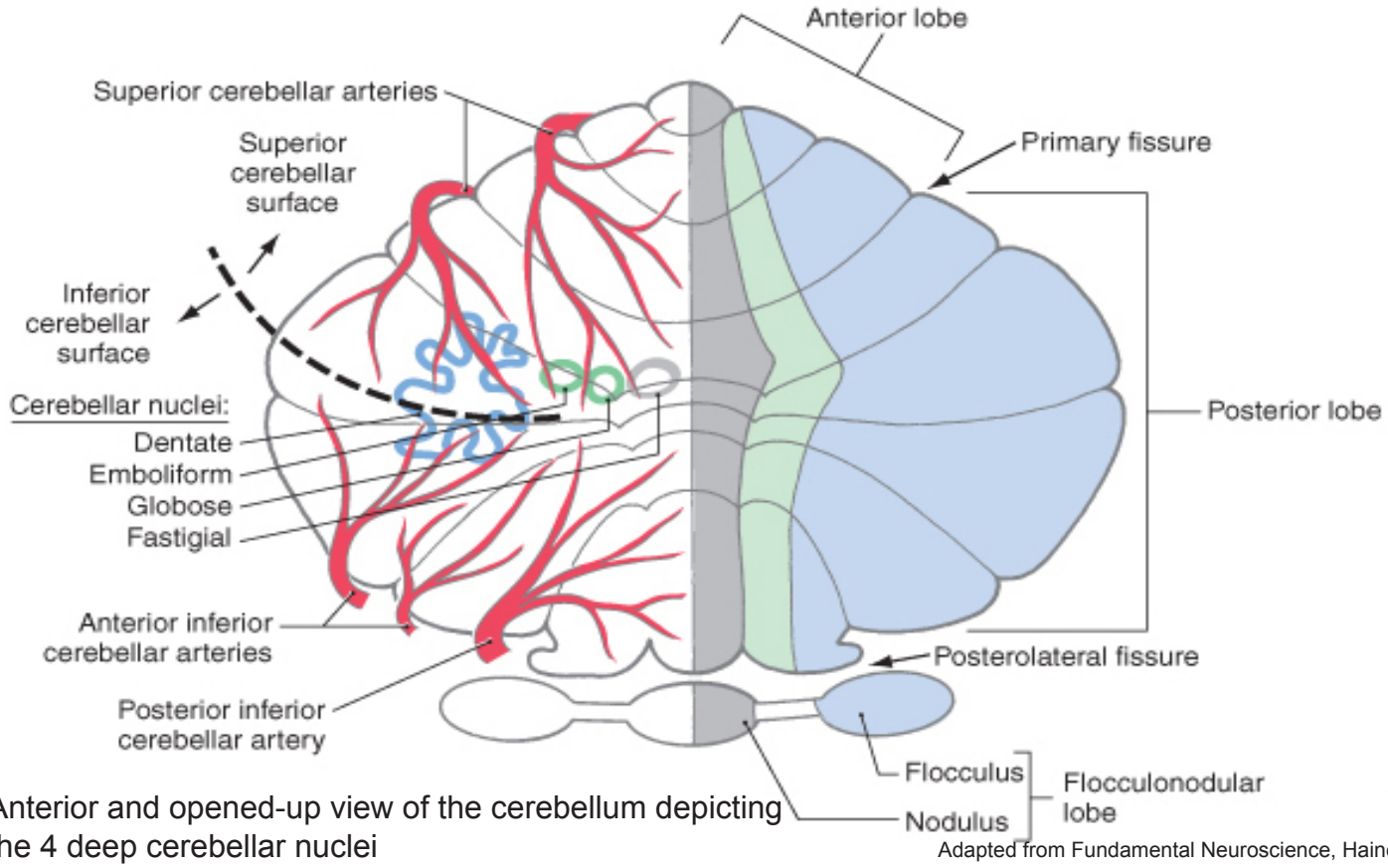
1 Purkinje cell with its massive dendritic tree

Cerebellar nuclei - these cell bodies project their axons out of the cerebellum and release excitatory neurotransmitters

There are 4 pairs of cerebellar nuclei:

1. Fastigal nuclei (medial) - functionally related to the medial zone
2. Globose and Emboliform nuclei (intermediate) - functionally related to the intermediate zone
3. Dentate nuclei (lateral) - functionally related to the lateral zone





Anterior and opened-up view of the cerebellum depicting the 4 deep cerebellar nuclei

Adapted from Fundamental Neuroscience, Haines

Functional Cerebellar Modules

There are 3 functional cerebellar modules:

1. Vestibulocerebellar Module
2. Spinocerebellar Module
3. Pontocerebellar Module

Each module consists of:

a portion of the cerebellar cortex
white matter
at least 1 deep cerebellar nucleus

Vestibulocerebellar module

consists of:

Flocculonodular lobe and vermis (and their associated cortex and white matter)
Fastigial nucleus

afferents:

vestibular ganglia - info about position of head and body in space and eye orientation
brainstem and diencephalon (via pontocerebellar fibers) - info regarding eye movements

efferents:

Purkinje cell in the cerebellar cortex of flocculonodular lobe and vermis project their axons via the inferior cerebellar peduncles to inhibit ipsilateral vestibular nuclei

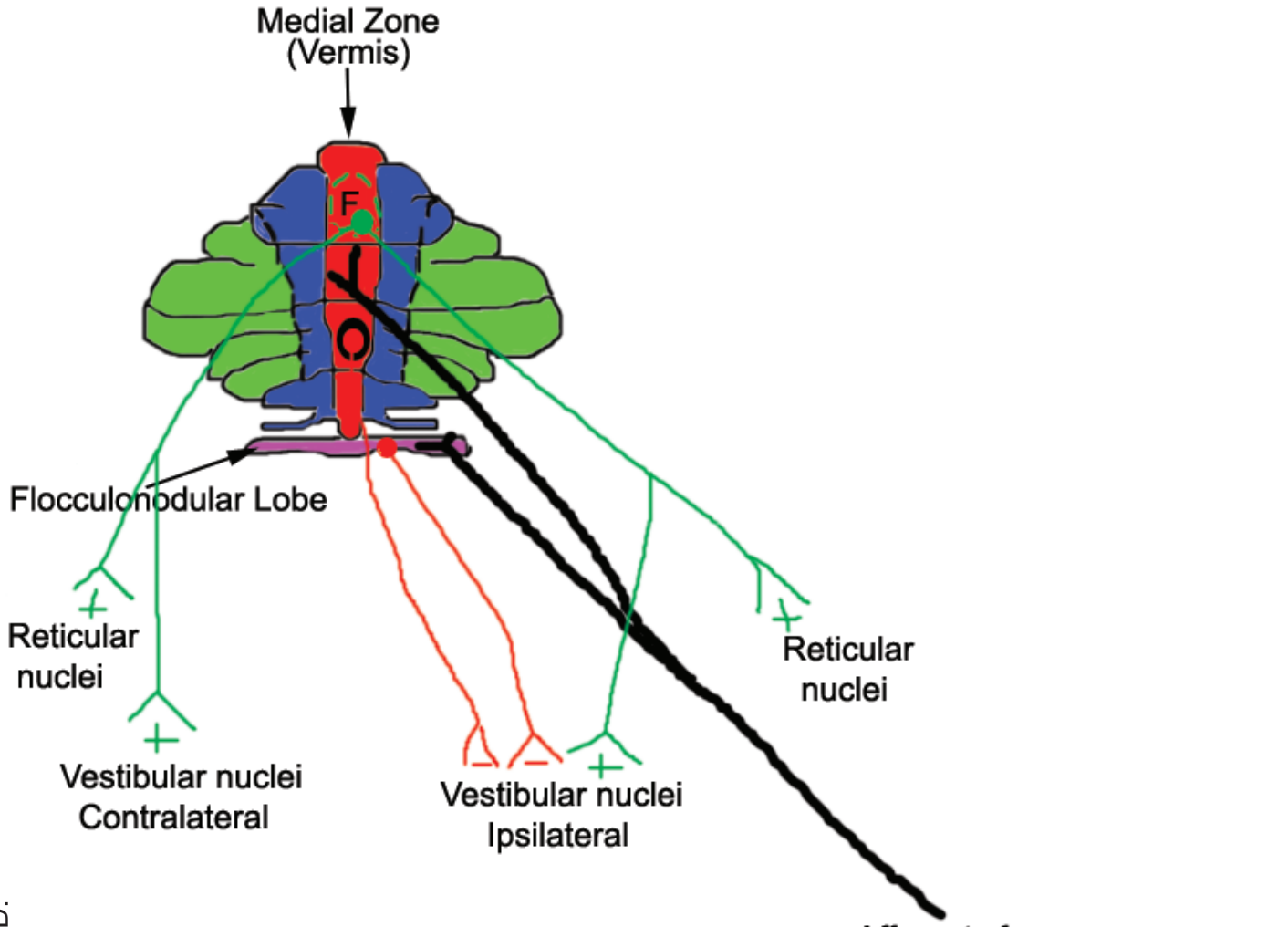
Fastigial nuclei (of the deep cerebellar nuclei) project their axons bilaterally to excite vestibular and reticular nuclei

Vestibulocerebellar dysfunction:

This area influences posture, balance, equilibrium.
A lesion to the vestibulocerebellar module causes:

truncal ataxia
falls
a wide based stance
inability to walk in a heel to toe fashion
nystagmus

Vestibulocerebelllum



B. Puder, Ph.D.

Spinocerebellar Module

consists of:

Vermal and intermediate zones

Fastigial and globose and emboliform nuclei

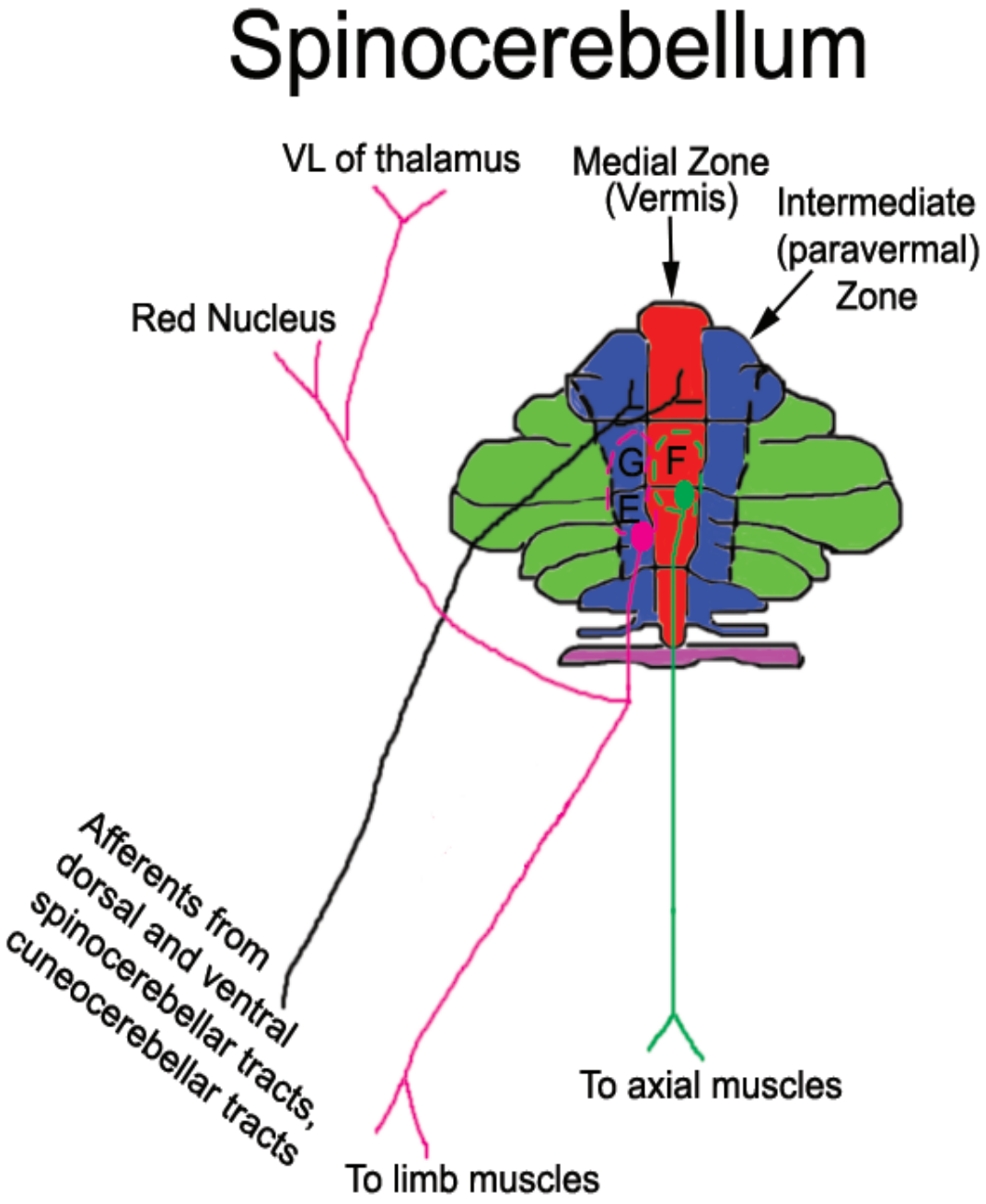
afferents:

dorsal and ventral spinocerebellar and cuneocerebellar tracts

efferents:

Fastigial nuclei project out to control axial muscles

Emboliform and Globose nuclei project out to control limbs, to the red nucleus in the midbrain, and VL of the thalamus



Pontocerebellar Module

consists of:

- Lateral zone
- Dentate nucleus

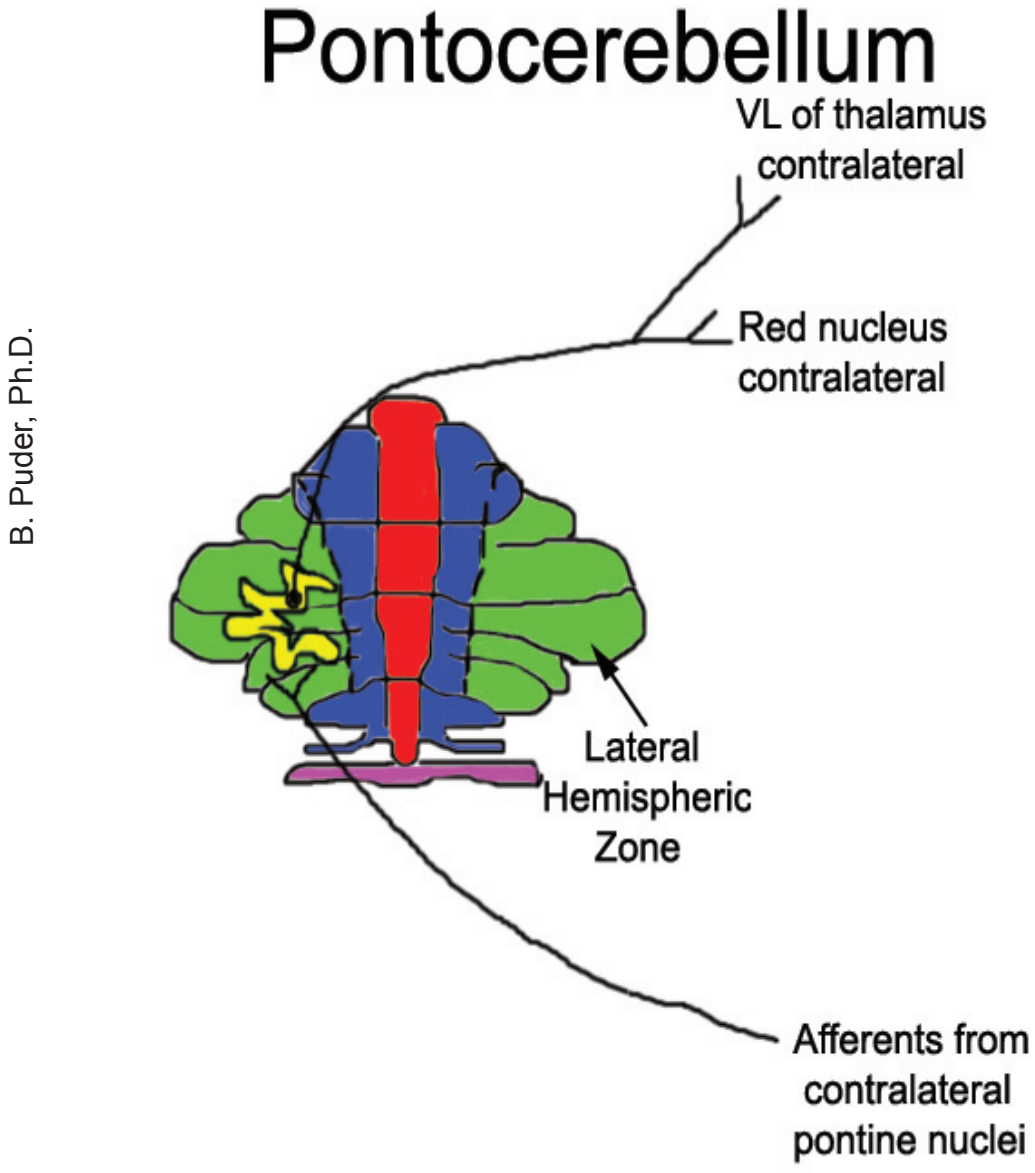
afferents:

- Pontocerebellar fibers from the contralateral pontine nuclei
- Inferior Olivary nucleus

efferents:

- dentate nucleus projects axons up and out via the superior cerebellar peduncles to
  - Motor areas
  - Contralateral red nucleus
  - Contralateral VL of thalamus

Pontocerebellar module is responsible for planning and control of precise dexterous movements in the arm and forearm and hand and timing of these movements



Cerebellar Lesions

Cerebellar lesions are always ipsilateral

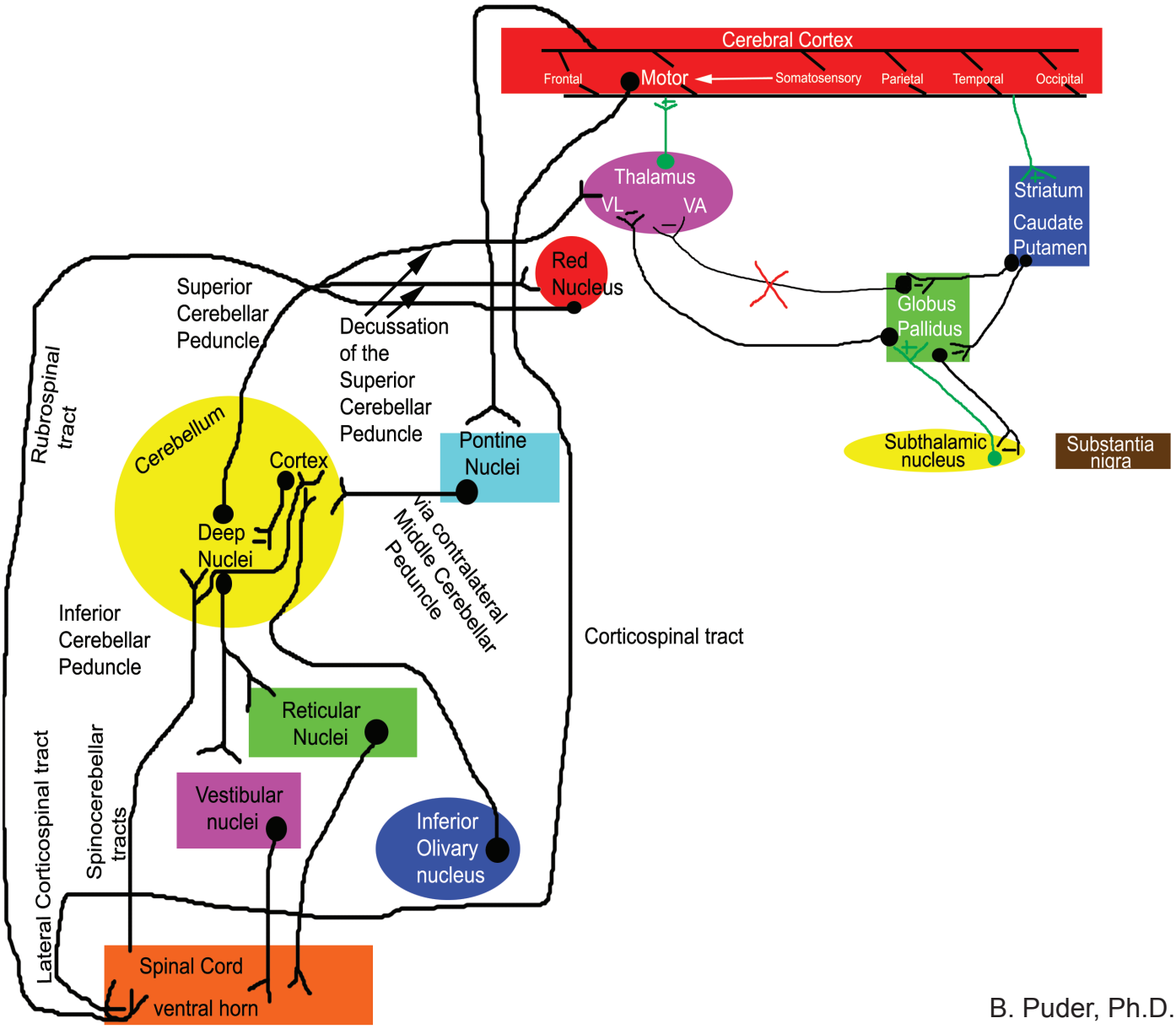
ataxia = voluntary, normal strength, jerky, inaccurate movements

Flocculonodular and vermal lesions = truncal ataxia
Paravermal (intermediate) lesions = gait and limb ataxia
Lateral lesions = hand ataxia

Pontocerebellar and Spinocerebellar dysfunction:

Dyssynergia - deterioration of coordinated movement and decomposition of movement
Hypotonia - decreased muscle tone and deep tendon reflexes
Ataxia - jerky, inaccurate movements
Dysmetria = past pointing either by overshooting the target (hypermetria)
or undershooting the target (hypometria)
Tremor - (intention tremor) during performance of a voluntary movement,
the tremor becomes more obvious as movement is nearing the end point
Dysdiadochokinesia - awkward performance of rapidly alternating movements

Overview of the motor systems



B. Puder, Ph.D.