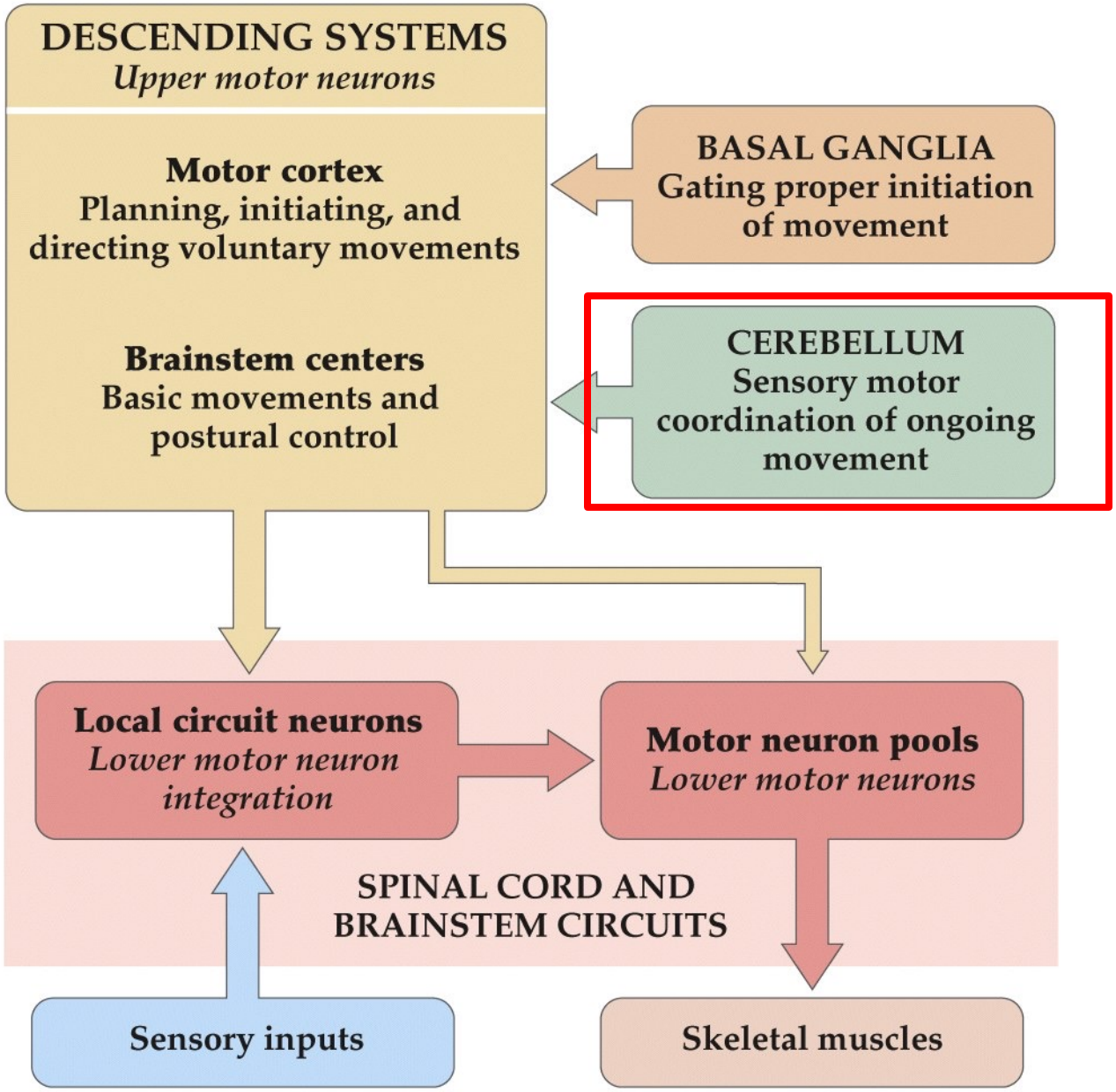
BMD ENG 301
Quantitative Systems Physiology
(Nervous System)

Cerebellum
2022_v1

Professor Malcolm MacIver

Organization of neural structures involved in the control of movement

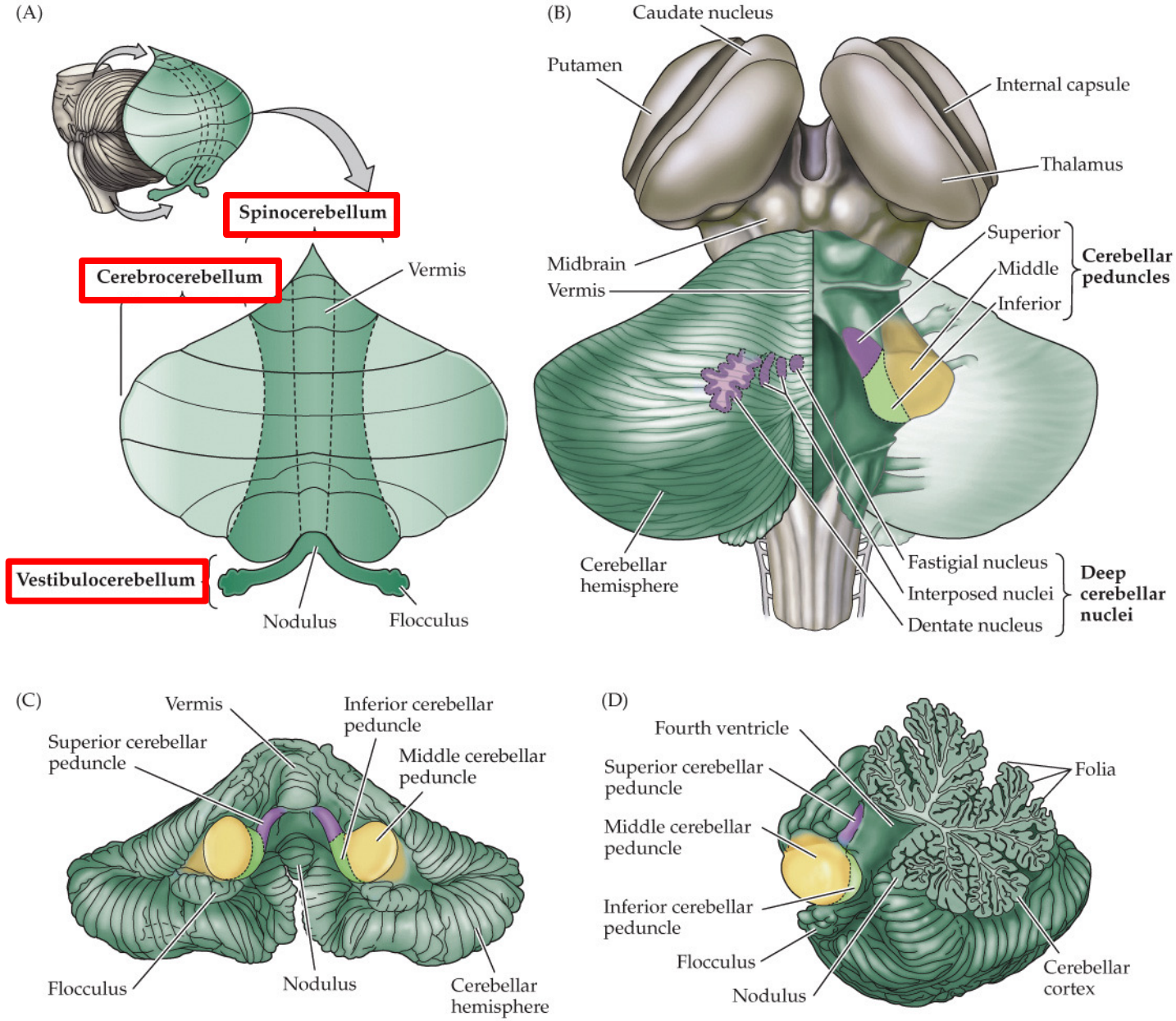


NEUROSCIENCE 5e, Figure 16.1

What does the cerebellum do?

- Right cerebellum for right side of the body, Left cerebellum for left side of the body
- Minimizing motor error (efference copy)
  - Feedback
  - Learning – LTP/LTD

Organization and subdivisions of the cerebellum



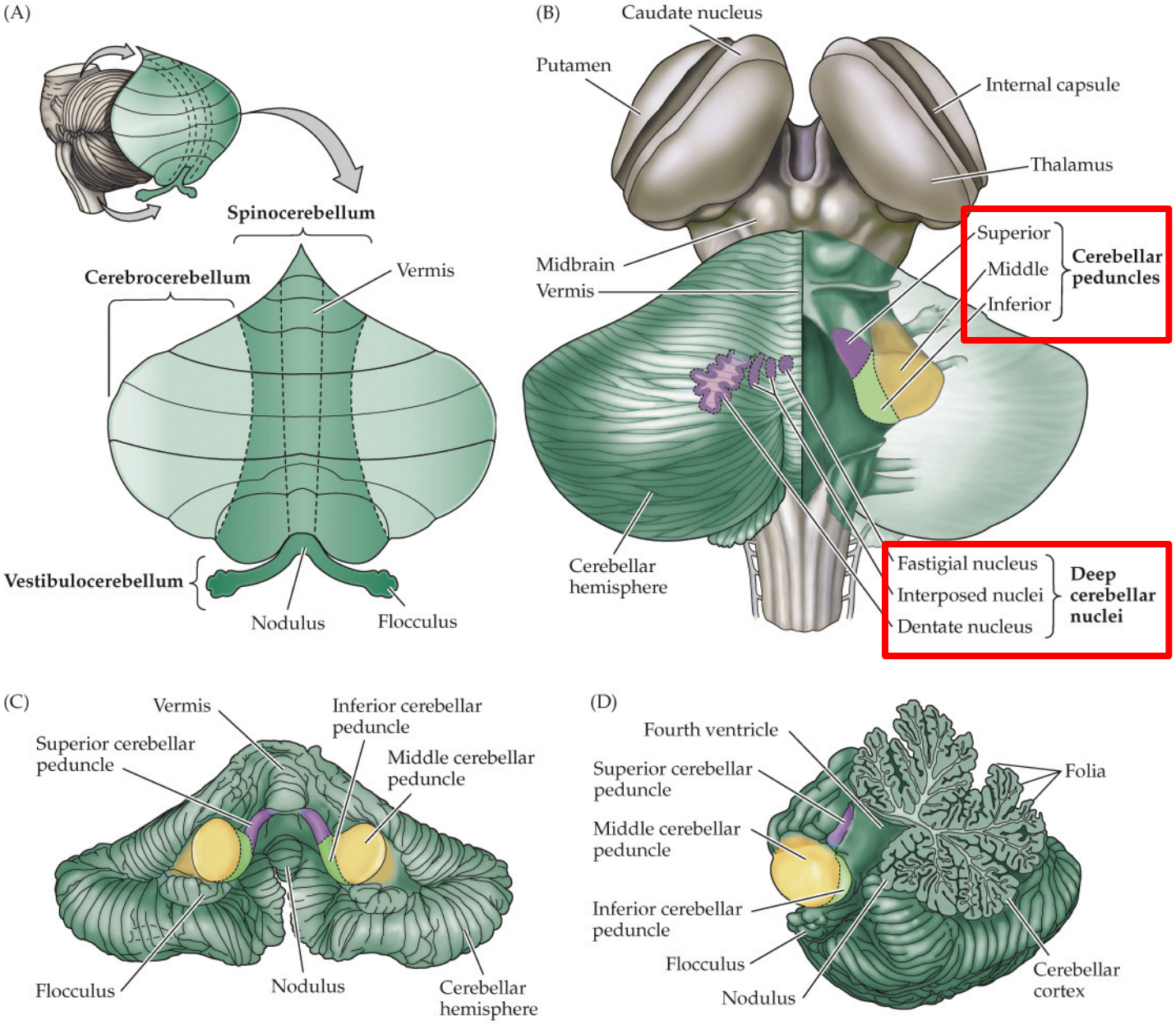
NEUROSCIENCE 6e, Figure 19.1

- **Cerebrocerebellum** – regulation of highly skilled movements, especially the planning and execution of complex spatial and temporal sequences of movement (including speech)

- **Vestibulocerebellum** – regulation of movements underlying posture and equilibrium

- **Spinocerebellum** – movements of the distal muscles, such as movements of the limbs in walking, movements of proximal muscles and regulation of eye movements in response to vestibular inputs

Organization and subdivisions of the cerebellum



NEUROSCIENCE 6e, Figure 19.1

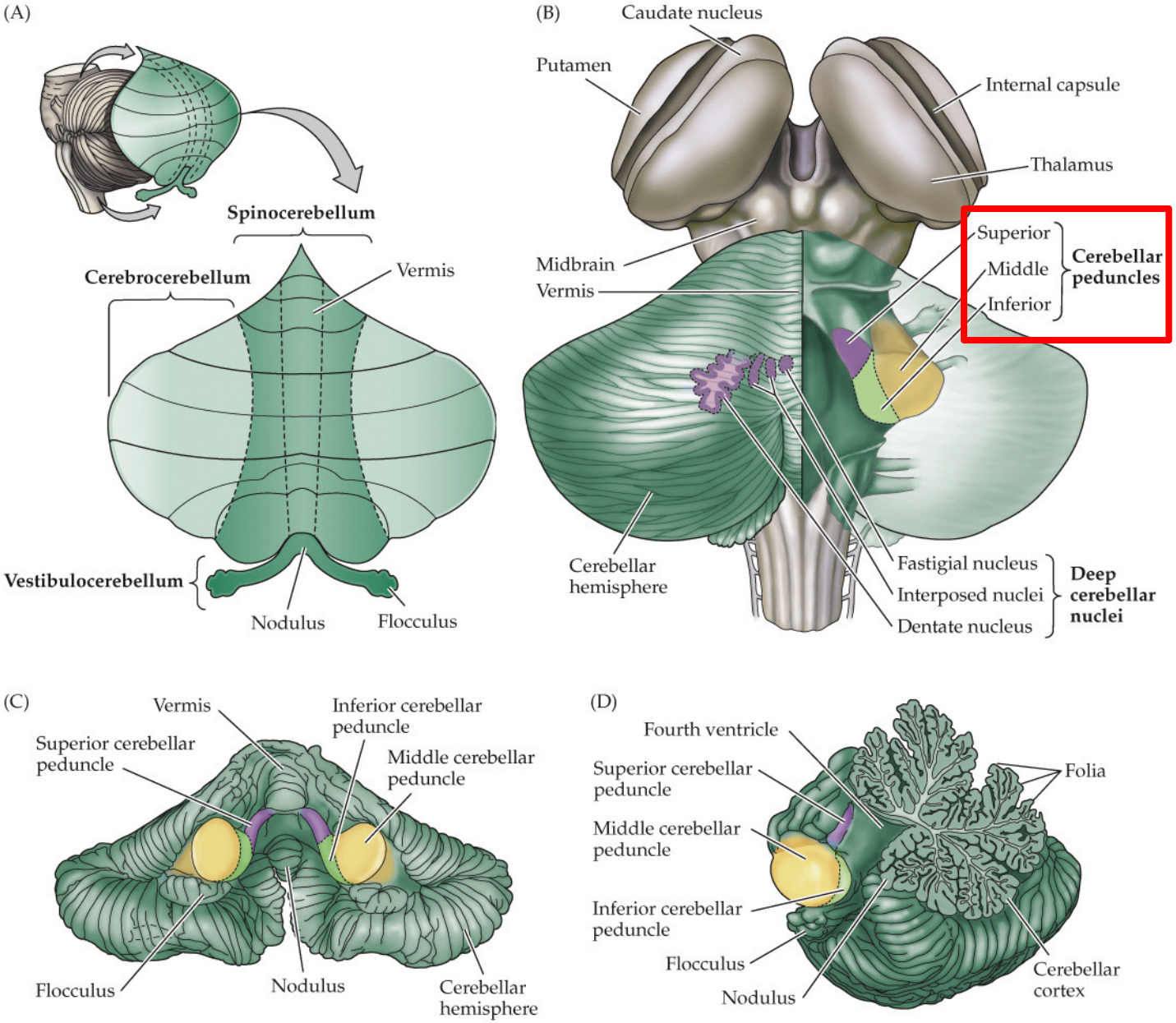
TABLE 19.1 ■ Major Components of the Cerebellum

Cerebellar cortex	Deep cerebellar nuclei	Cerebellar peduncles
Cerebrocerebellum	Dentate nucleus	Superior and middle peduncle
Spinocerebellum	Interposed nuclei	Inferior peduncle
Vestibulocerebel-lum	Fastigial nucleus	Inferior peduncle

NEUROSCIENCE 6e, Table 19.1

Exception: Output from vestibulocerebellum to vestibular nuclei – does not pass through a deep cerebellar nucleus

Organization and subdivisions of the cerebellum



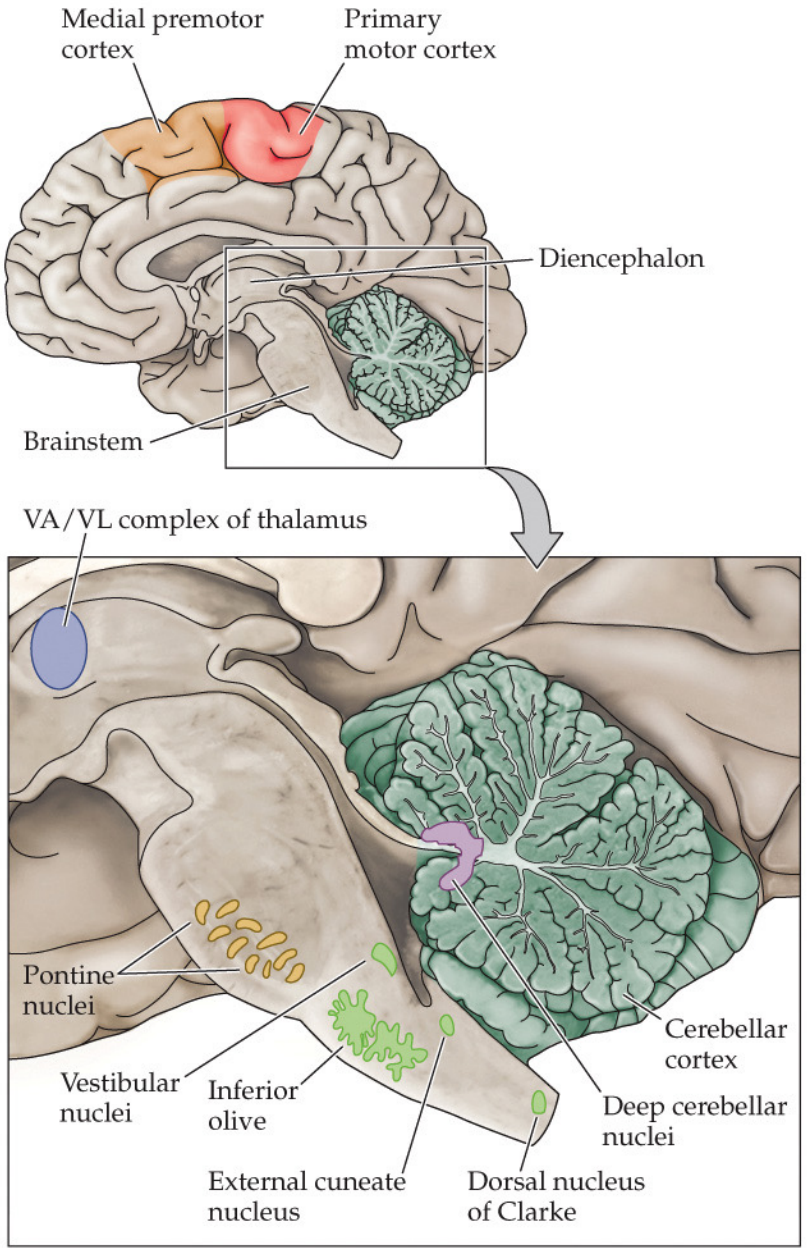
NEUROSCIENCE 6e, Figure 19.1

- **Superior peduncle** – mostly efferents from deep cerebellar nuclei – headed to red nucleus, deep layers of the superior colliculus and motor and premotor cortex via a thalamic relay

- **Middle peduncle** – mostly afferents from pontine nuclei (> 40 million axons) – pons receives input from almost all of the cerebral cortex and the superior colliculus

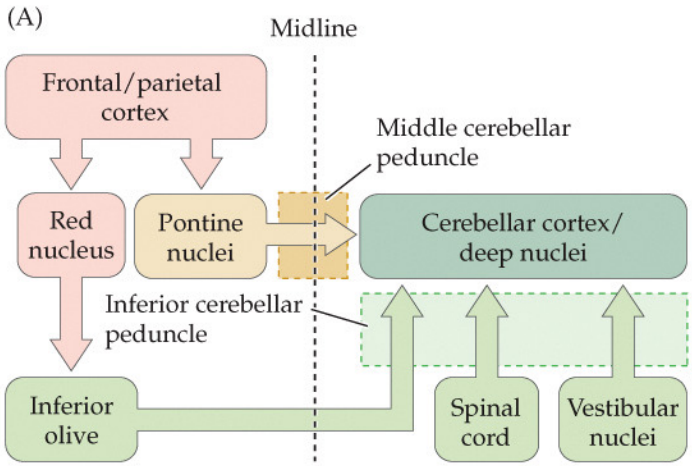
- **Inferior peduncle** – afferents and efferents – input from the vestibular nuclei, spinal cord and brainstem tegmentum – Brainstem input from the inferior olive and the locus coeruleus involved in learning and memory functions

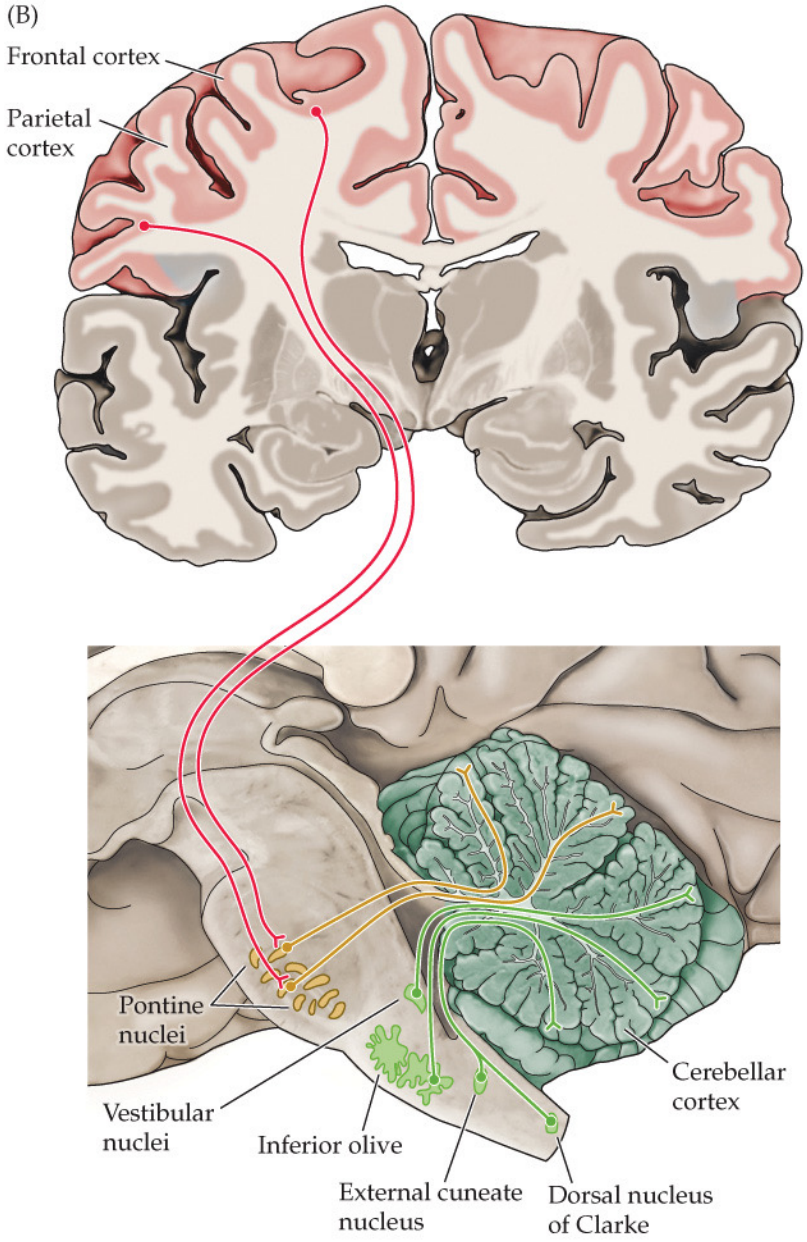
Components of the brainstem and diencephalon related to the cerebellum



NEUROSCIENCE 6e, Figure 19.2

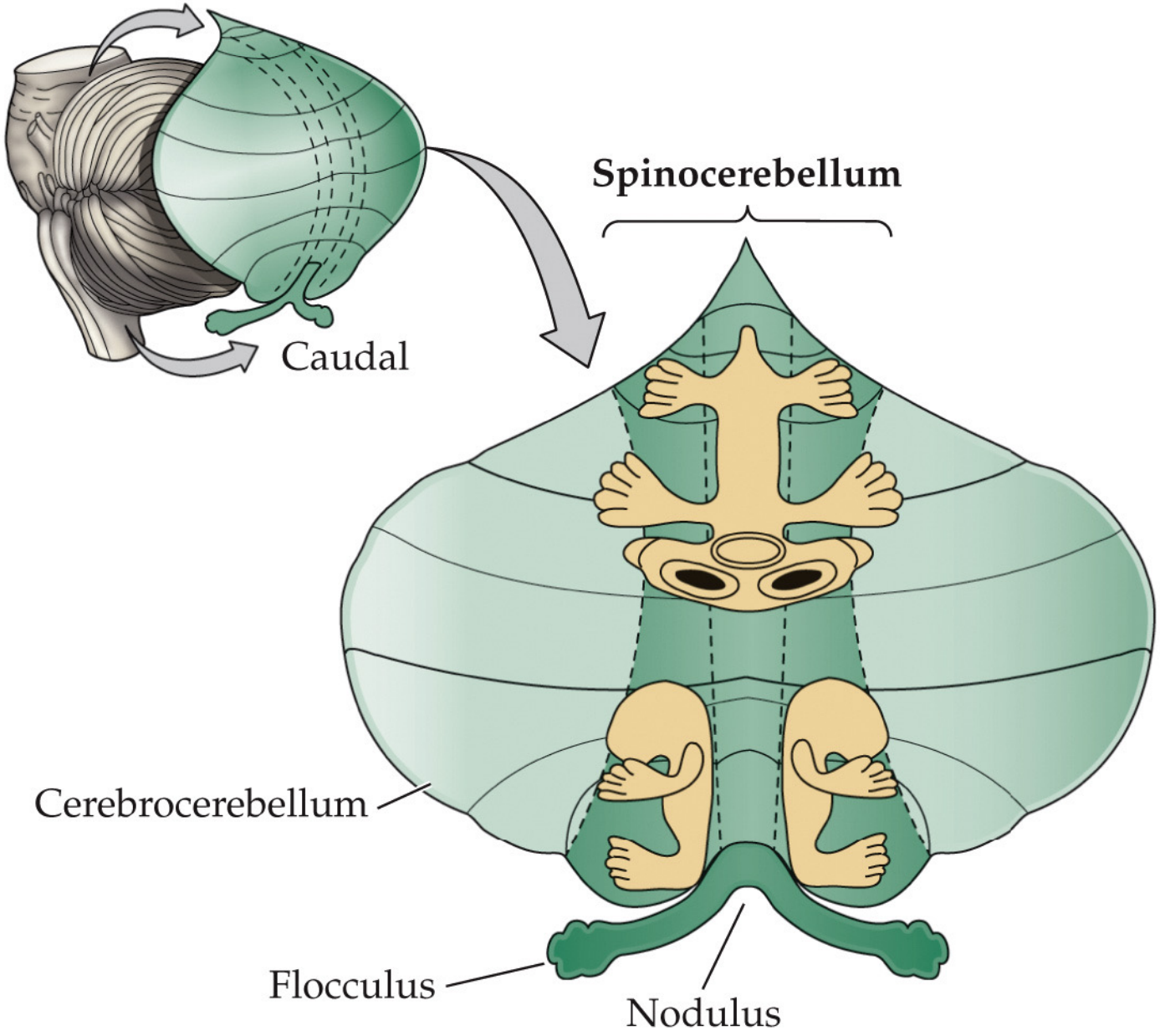
Functional organization of the inputs to the cerebellum





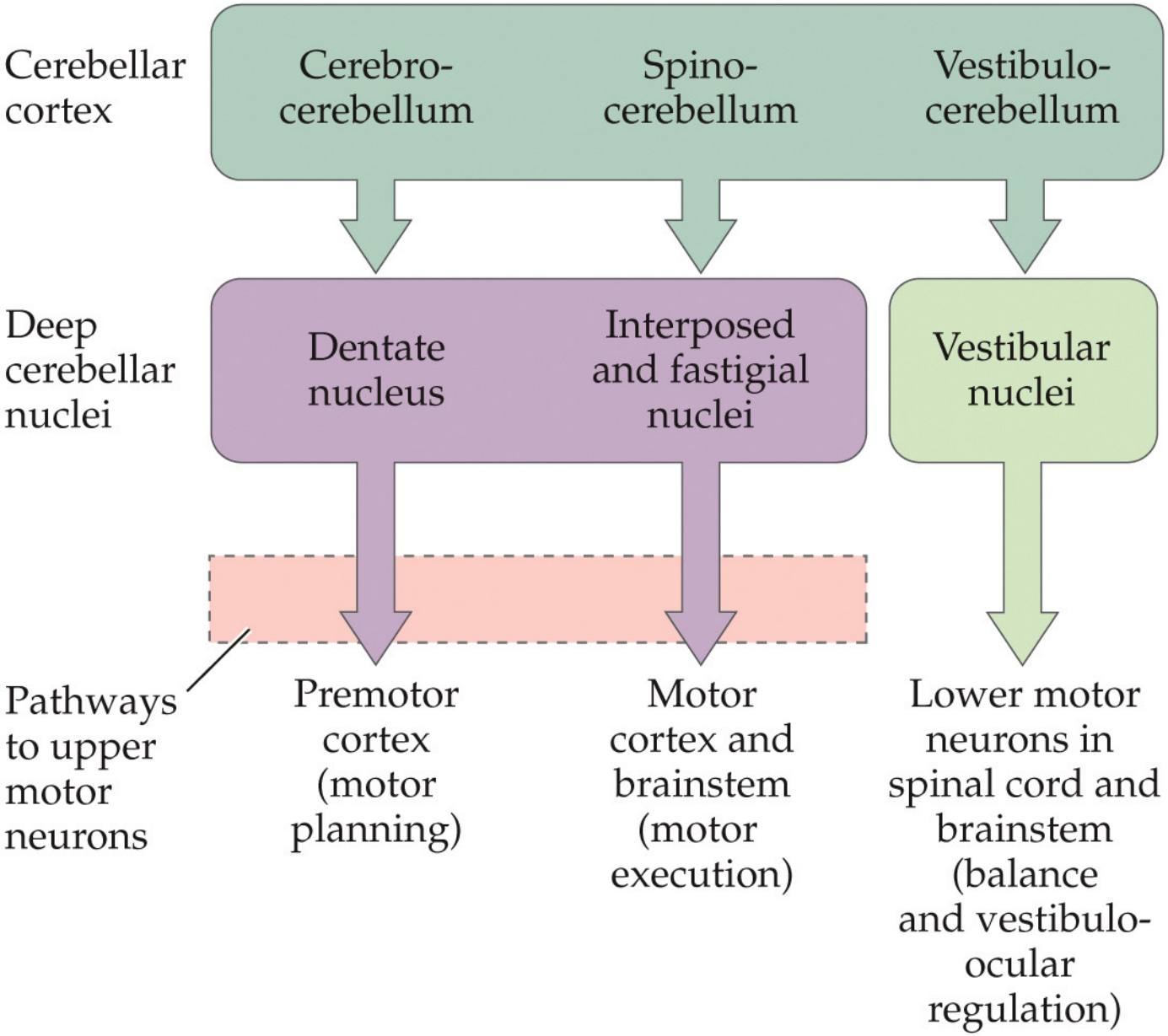
NEUROSCIENCE 6e, Figure 19.3

Somatotopic maps of the body surface in the cerebellum



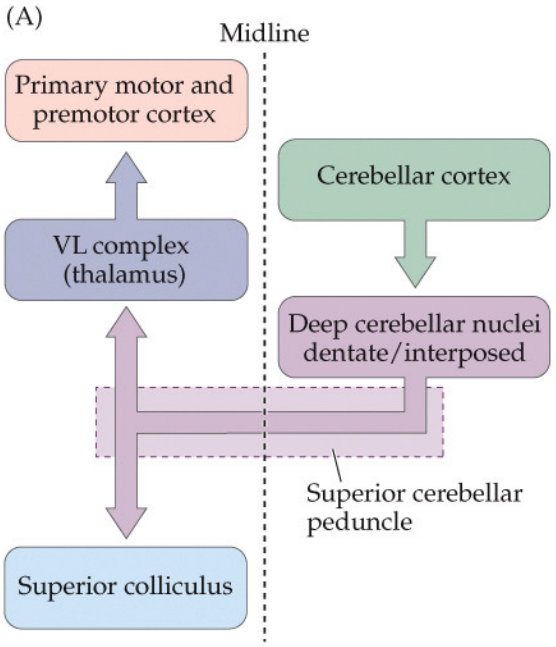
NEUROSCIENCE 6e, Figure 19.4

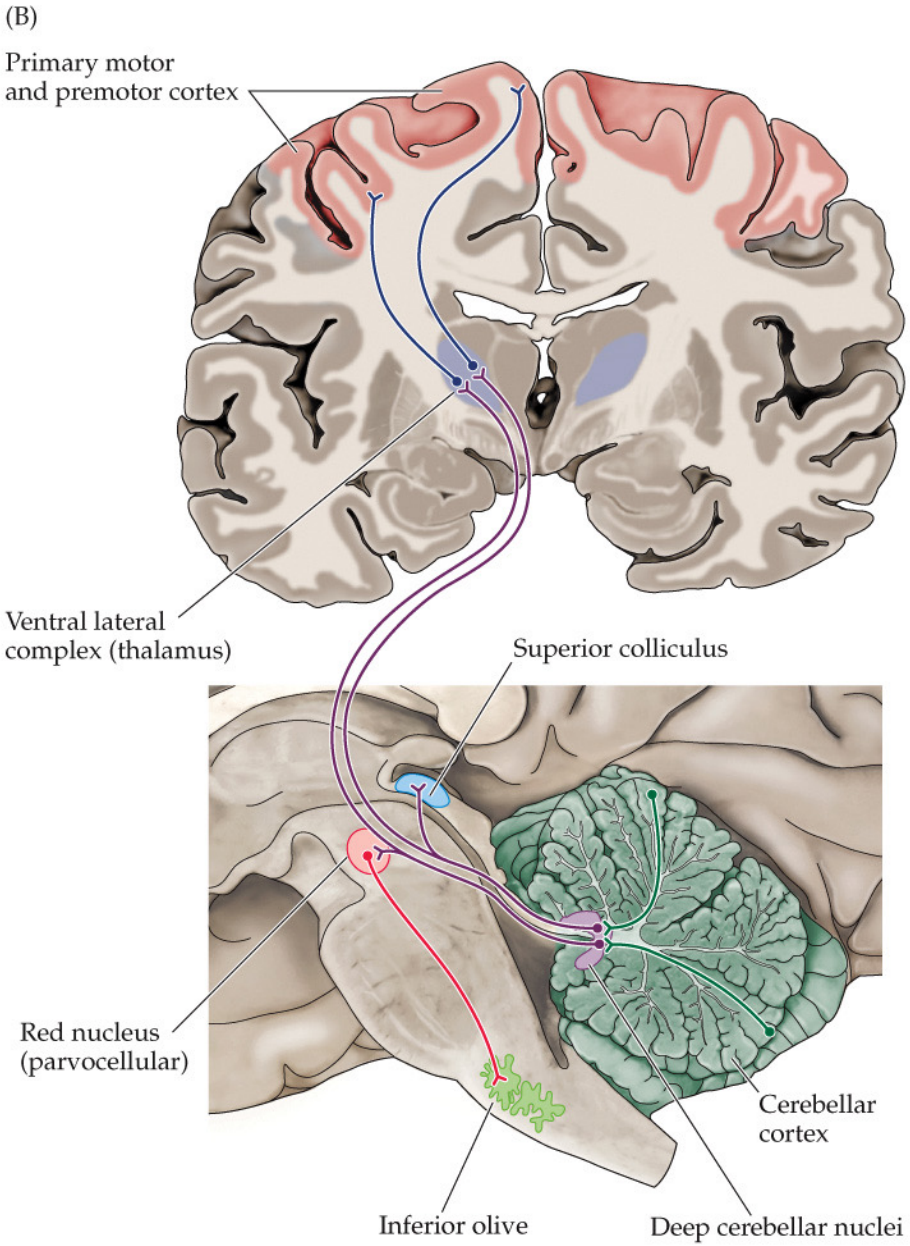
Functional organization of cerebellar outputs



NEUROSCIENCE 6e, Figure 19.5

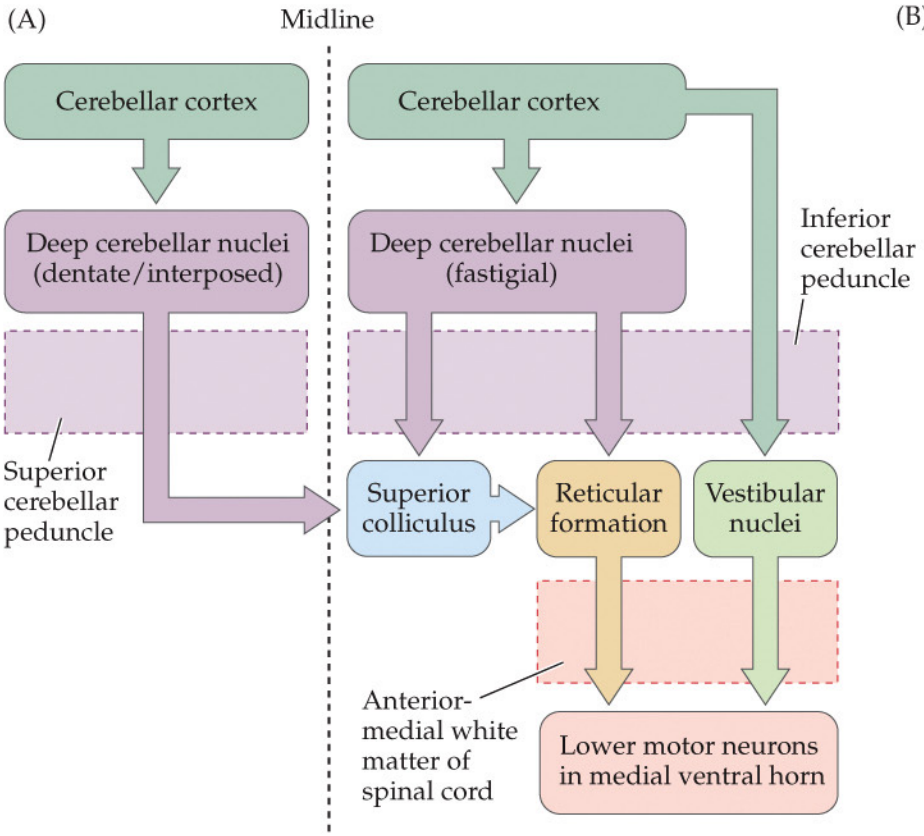
Functional organization of the major outputs from the cerebellum to cortical motor systems

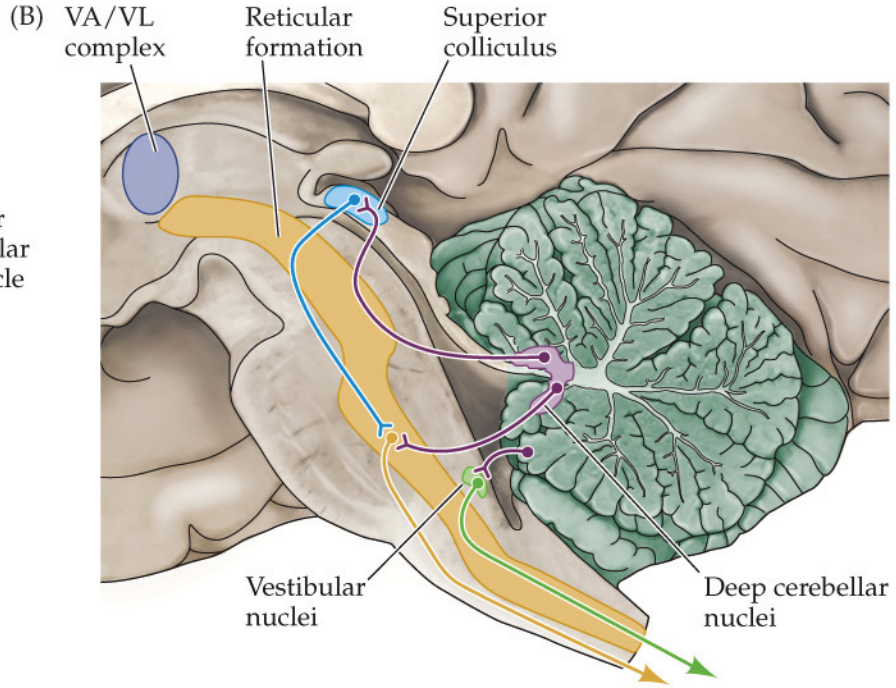




NEUROSCIENCE 6e, Figure 19.6

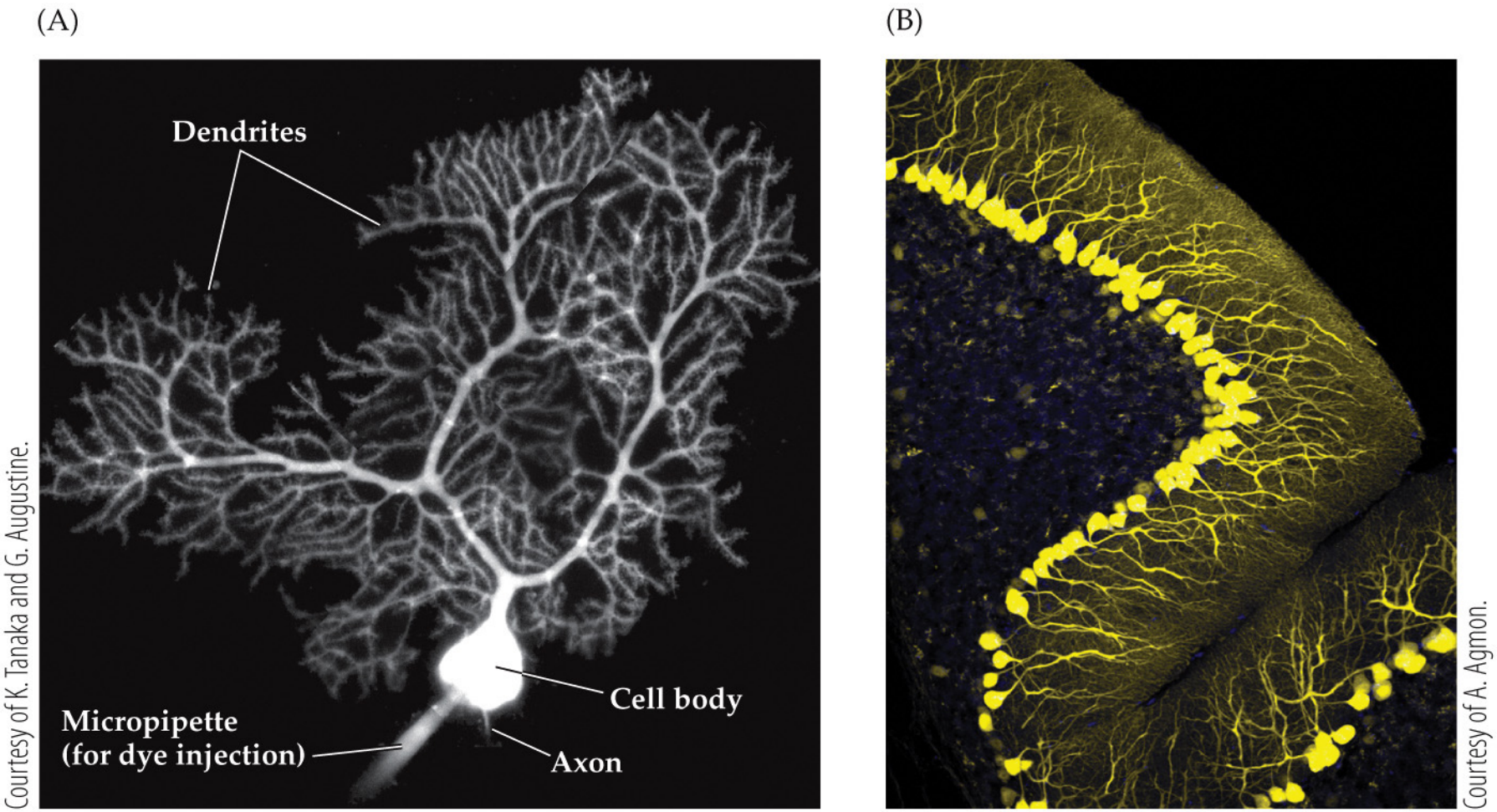
Functional organization of the major outputs from the cerebellum to brainstem motor systems





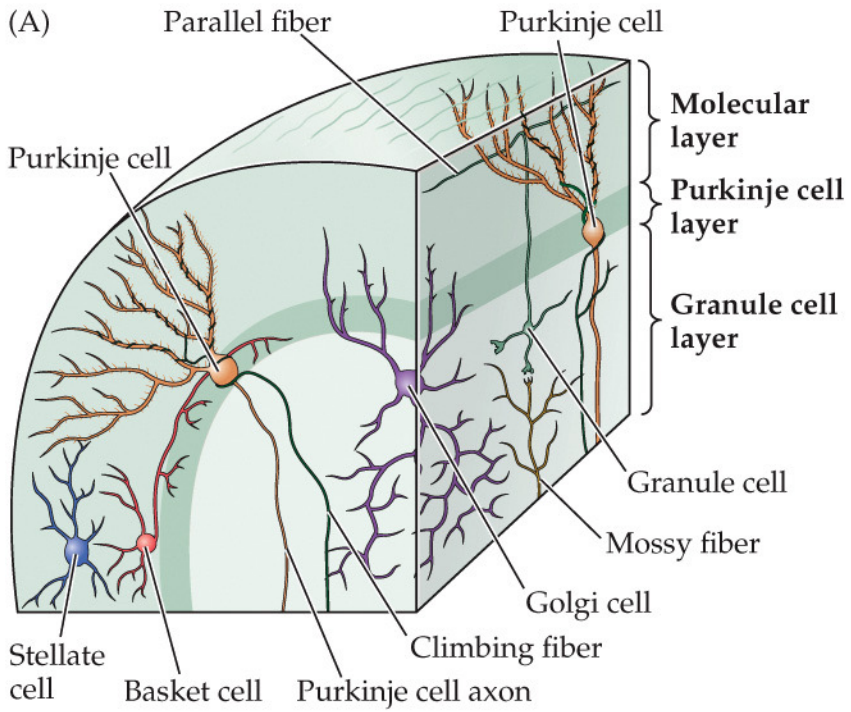
NEUROSCIENCE 6e, Figure 19.7

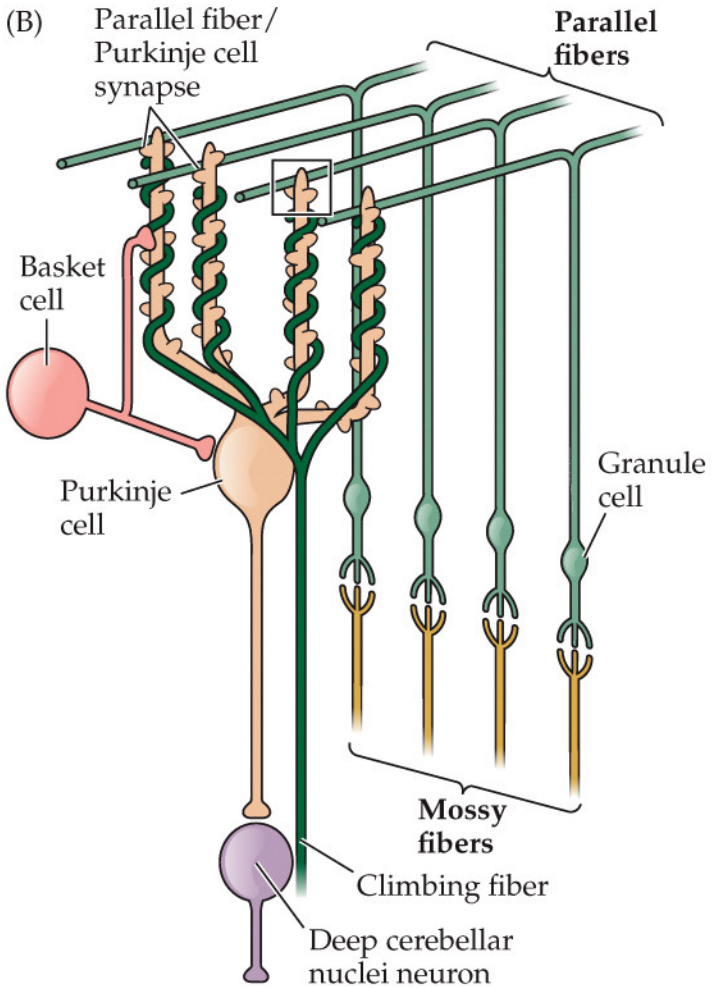
Cerebellar cortical neurons

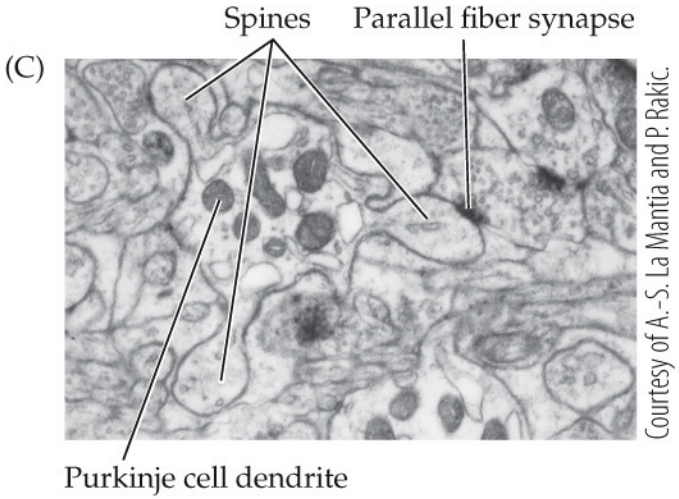


NEUROSCIENCE 6e, Figure 19.8

Neurons and circuits of the cerebellum

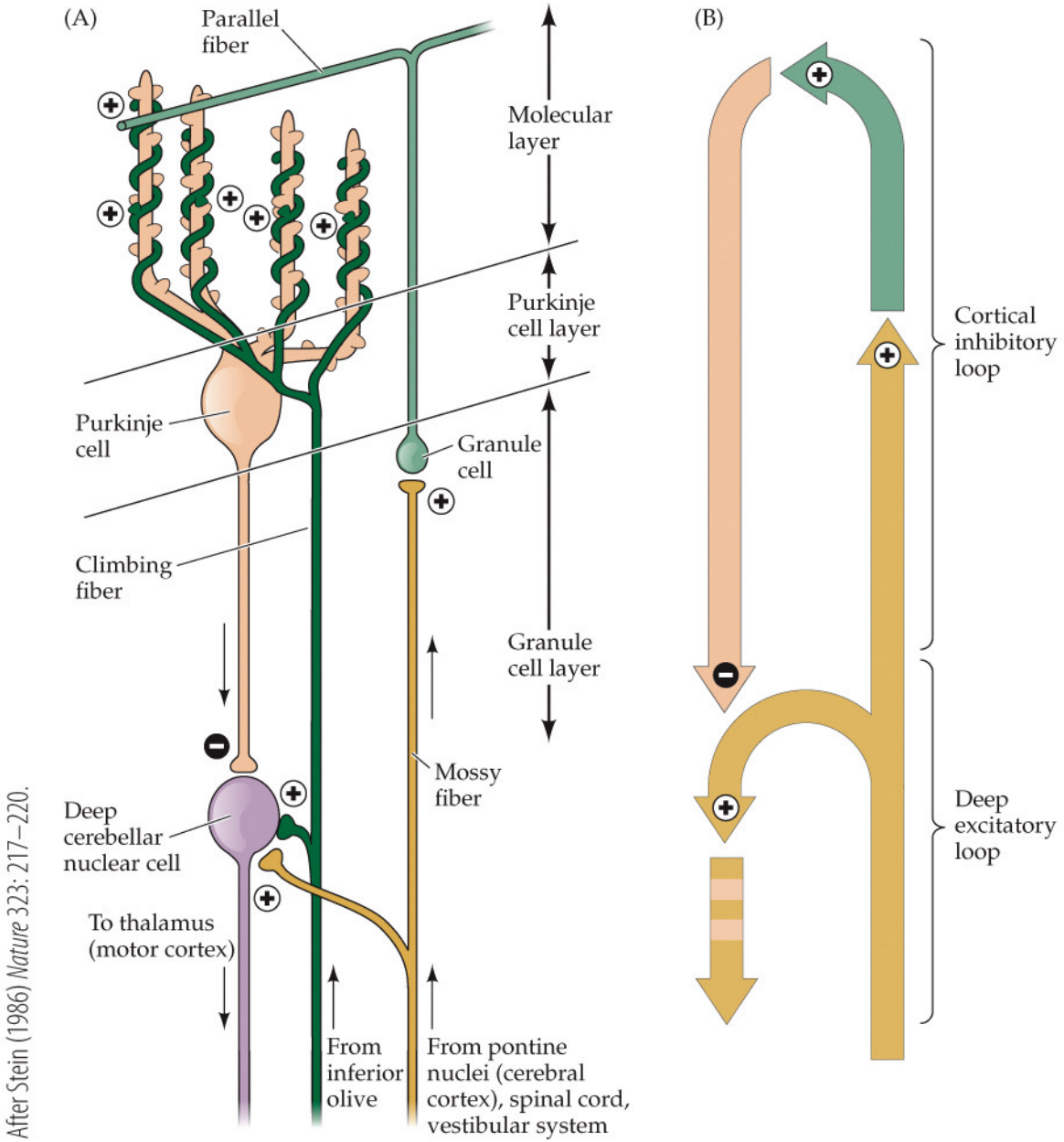






NEUROSCIENCE 6e, Figure 19.9

Excitatory and inhibitory connections in the cerebellar cortex and deep cerebellar nuclei



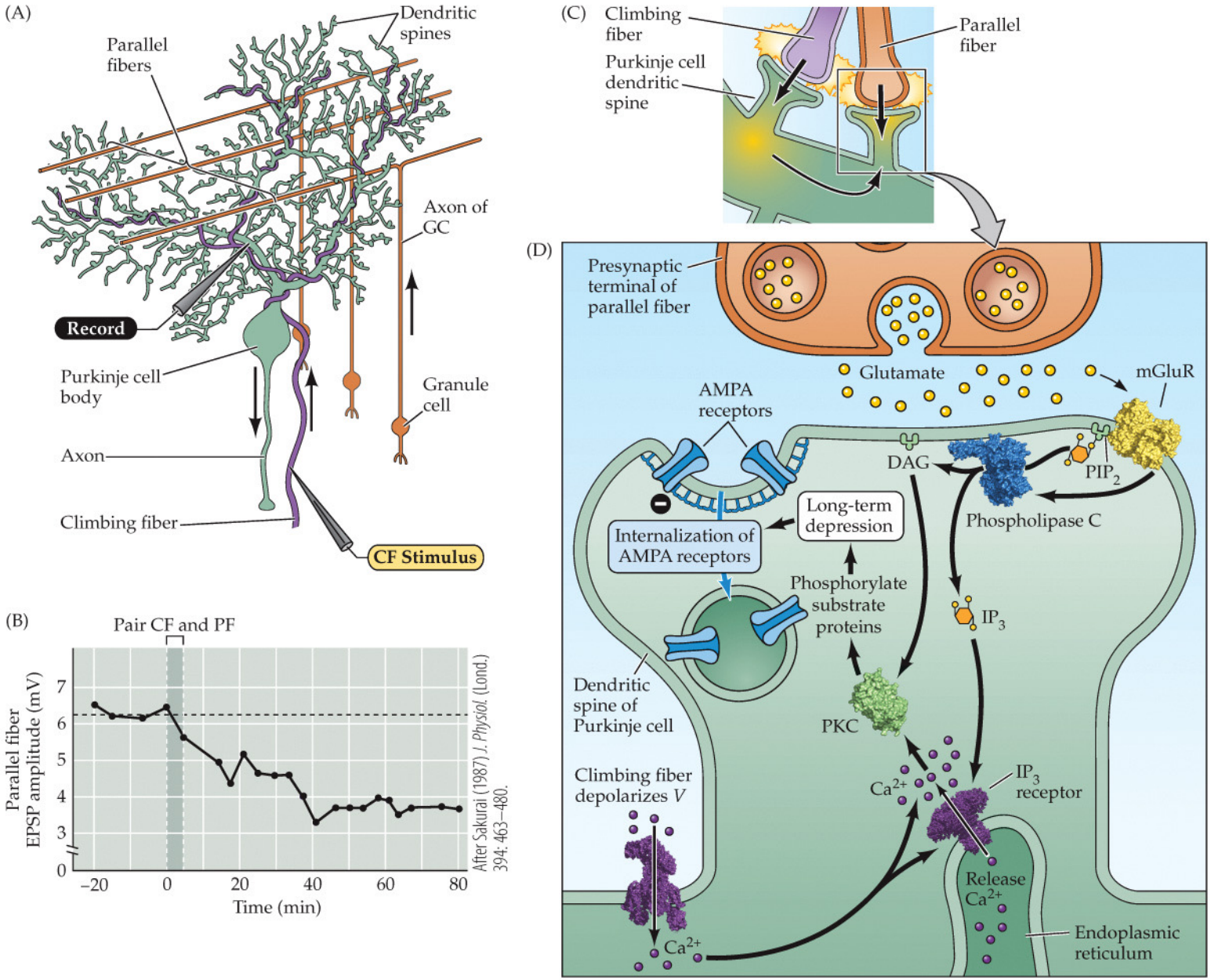
After Stein (1986) *Nature* 323: 217–220.

NEUROSCIENCE 6e, Figure 19.10

- Weak excitation from as many as 800,000 granule cell axons (parallel fibers) that end on its dendritic spines

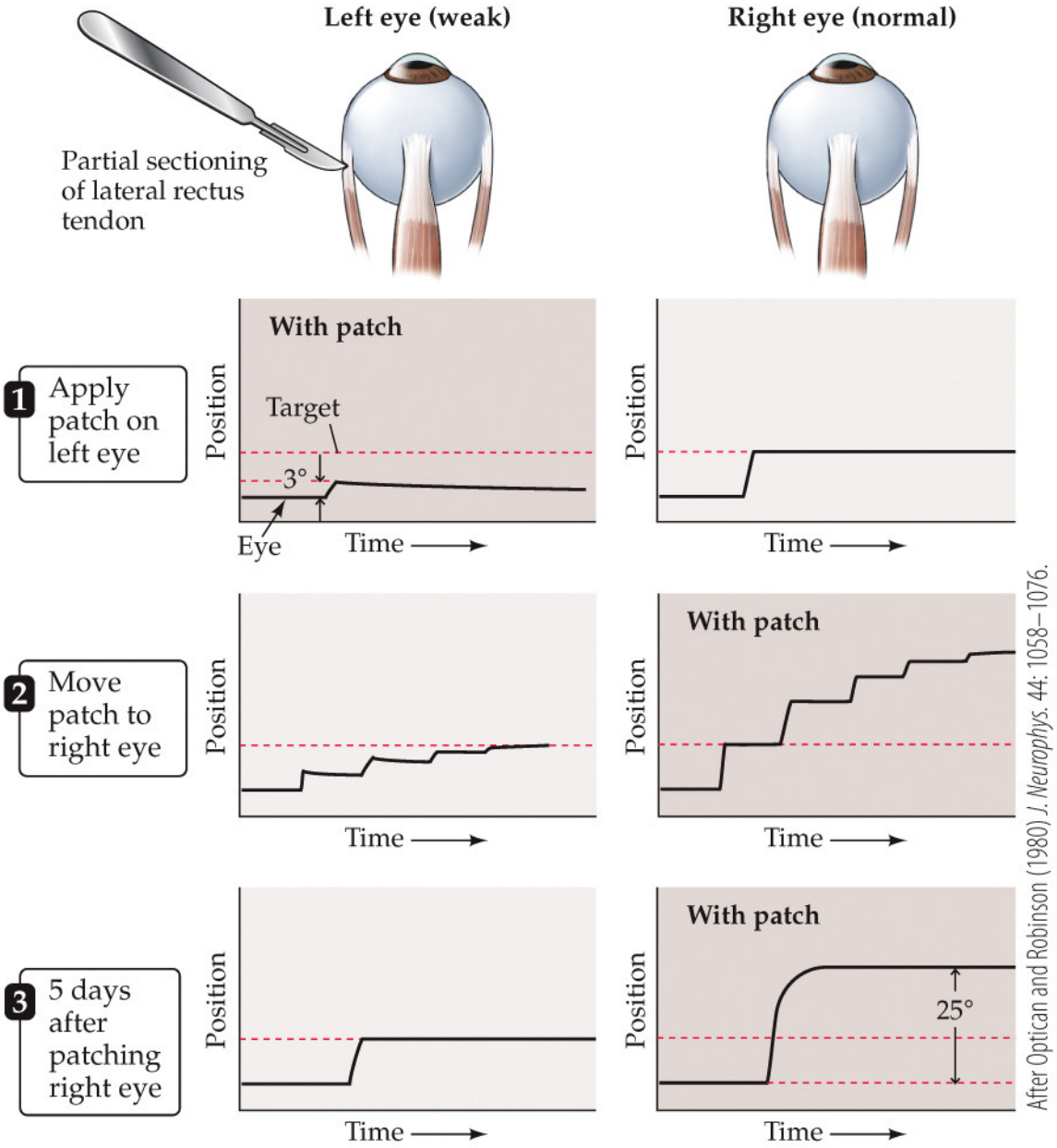
- Very strong excitation, overriding everything-else, is exerted by a single climbing fiber that runs over the soma and the entire dendritic tree

Long-term synaptic depression in the cerebellum



NEUROSCIENCE 6e, Figure 8.17

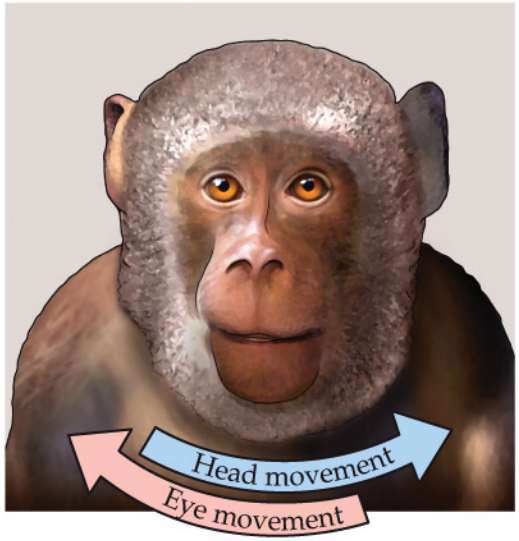
Contribution of the cerebellum to experience-dependent modification of saccadic eye movements



NEUROSCIENCE 6e, Figure 19.13

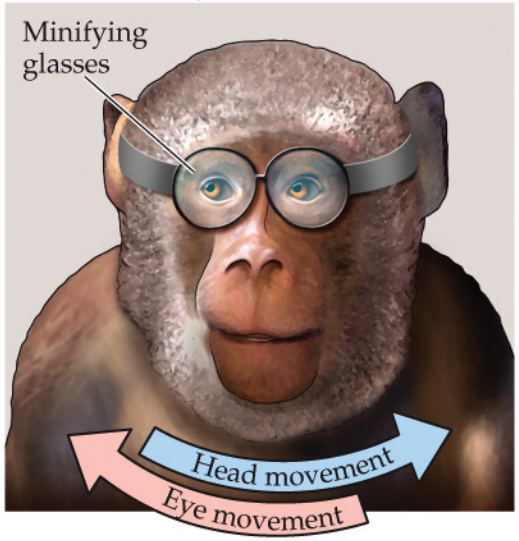
Learned changes in the vestibulo-ocular reflex in monkeys

Normal vestibulo-ocular reflex (VOR)



Head and eyes move in a coordinated manner to keep image on retina.

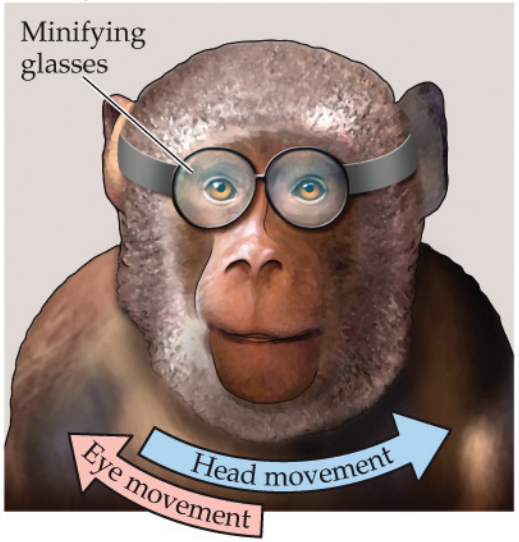
VOR out of register



Eyes move too far in relation to image movement on the retina when the head moves.

After several hours

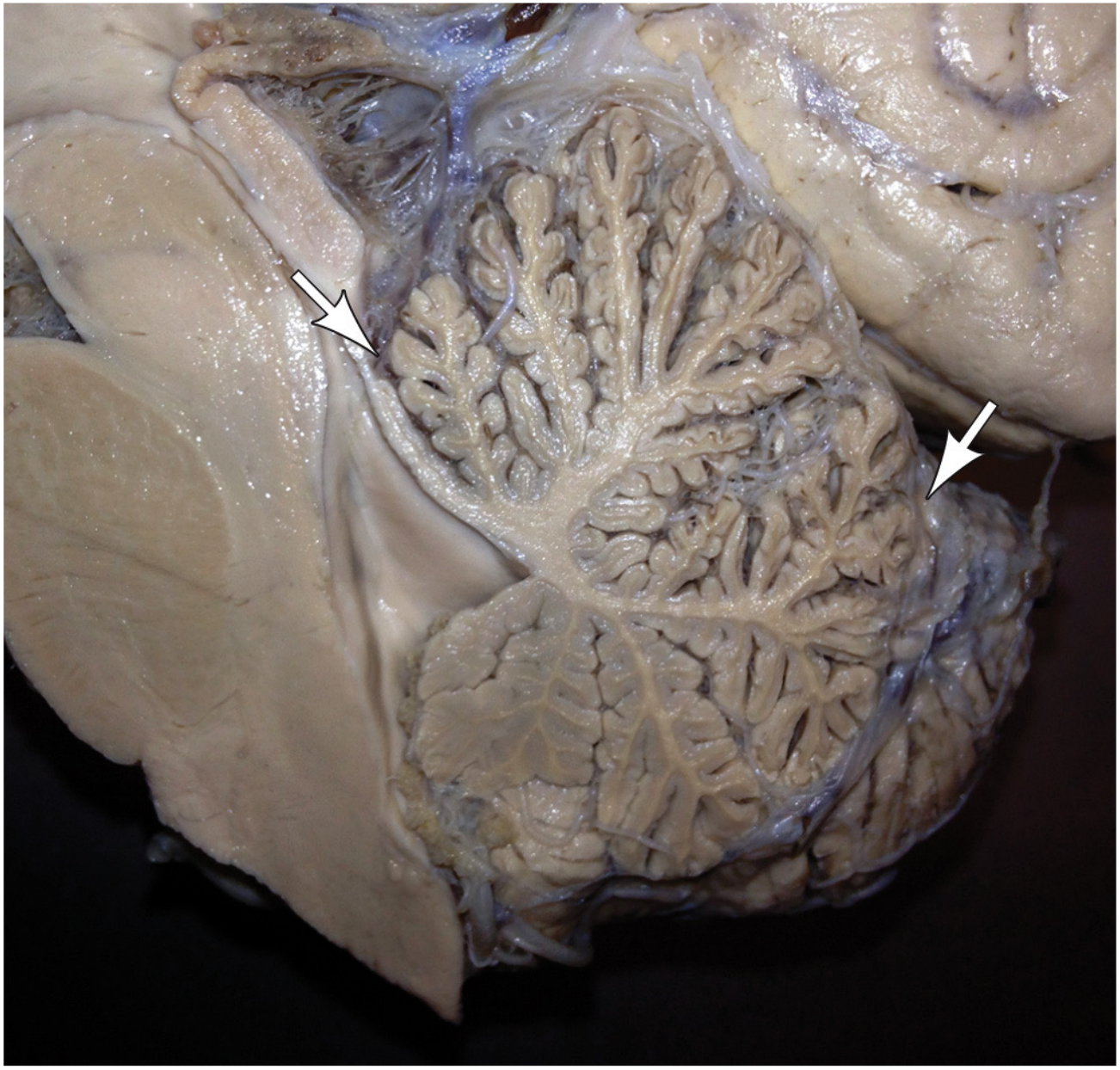
VOR gain reset



Eyes move smaller distances in relation to head movement to compensate.

NEUROSCIENCE 6e, Figure 19.14

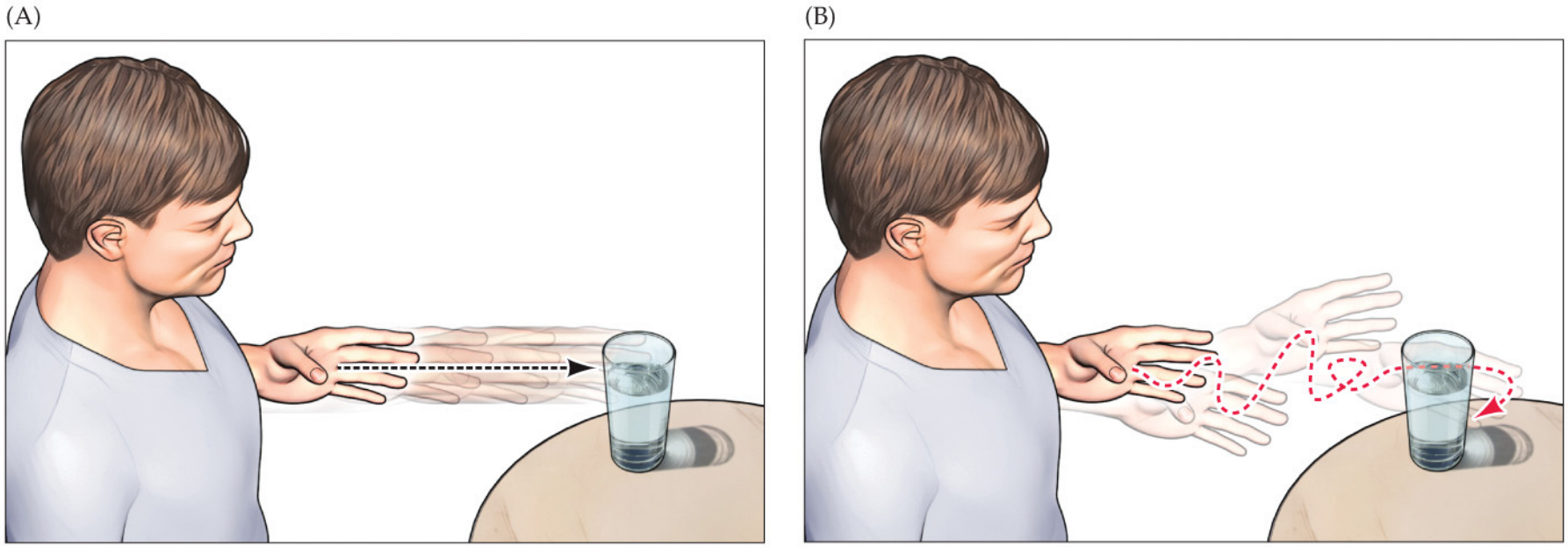
Chronic Alcohol Abuse



Courtesy of L. E. White.

NEUROSCIENCE 6e, Figure 19.15

Appendicular Ataxia



NEUROSCIENCE 6e, Figure 19.16