NEUROHISTOLOGY
CEREBRUM AND CEREBELLUM

Obimbo MM,

Objectives

- At the end of this lecture, the student should be able to:
  - Identify the histological slides of Cerebrum and cerebellum
  - List the layers and cell types found in cerebrum and cerebellum cortices and describe their connectivity
  - Describe the lamina organization of the cerebrum
  - State the applied neurohistology of cerebrum and cerebellum

Cerebrum

- Three parts
  - Cerebral cortex
  - Medulla
  - Deeper nuclei
- Main cell types
  - Pyramidal cells
  - Granule cells
  - Fusiform cells
  - Cells of Martinoti
  - Horizontal cells of Cajal

Cerebral cortex

- The layer of gray matter covering the entire surface of cerebral hemisphere
- Cell bodies are arranged in superimposed horizontal layers whose study is called archetectonics
- Accommodates enormous number of neurons
  - –Large surface area accommodates more neurons than deep nuclei
  - – Gyri and sulci also increase surface area
  - – Laminar organization also accommodates enormous number of neurons

Cerebral Cortex

Numerical Data

- Total surface area: 2200 cm^2 (2.5 ft^2)

  about 1/3 ------ surface area

  about 2/3 ------ hidden in the sulci

- Thickness: 1.5 mm (V I) - 4.5 mm (M I)

  Generally, thickest over the crest of the convolution

  and, thinnest in the depth of sulci

- Weight: 600 gm (40 % of total brain weight)

  180 gm --------- neurons

  420 gm --------- glial cells

Numerical Data

- Number of neuronal cells in cerebral cortex

  neurons ---------- 10-15 billion

  glial cells ---------- 50 billion

- Estimation of number of cortical neurons

von Economo and Koskinas (1925)	14.0 billion
Shariff (1953)	6.9 billion
Sholl (1956)	5.0 billion
Pakkenberg (1966)	2.6 billion

Subdivision of Cerebral Cortex

- Allocortex
  - Archicortex (Archipallium)
  - Palaeocortex (Paleopallium)
- Isocortex
  - Neocortex (Neopallium)

Layers of the Cerebral Cortex

I. Molecular layer; parallel nerve fibers, horizontal cells of Cajal, neuroglia
II. External granular layer; small pyramidal cells, granule (stellate) cells, neuroglia
III. External pyramidal layer; large pyramidal cells, neuroglia
IV. Internal granular layer; thin layer composed of closely arranged small granule (stellate) cells, neuroglia.
V. Internal pyramidal layer; largest pyramidal cells (Betz cells), neuroglia. This layer has the lowest cell density of the cerebral cortex
VI. Multiform layer; cells of various shapes (Martinotti cells, fusiform cells, pyramidal etc.), neuroglia

Histological Organization

Cellular Elements

1. Pyramidal Cell - output neuron

   giant pyramidal cell of Betz

2. Fusiform Cell --- modified pyramidal cell

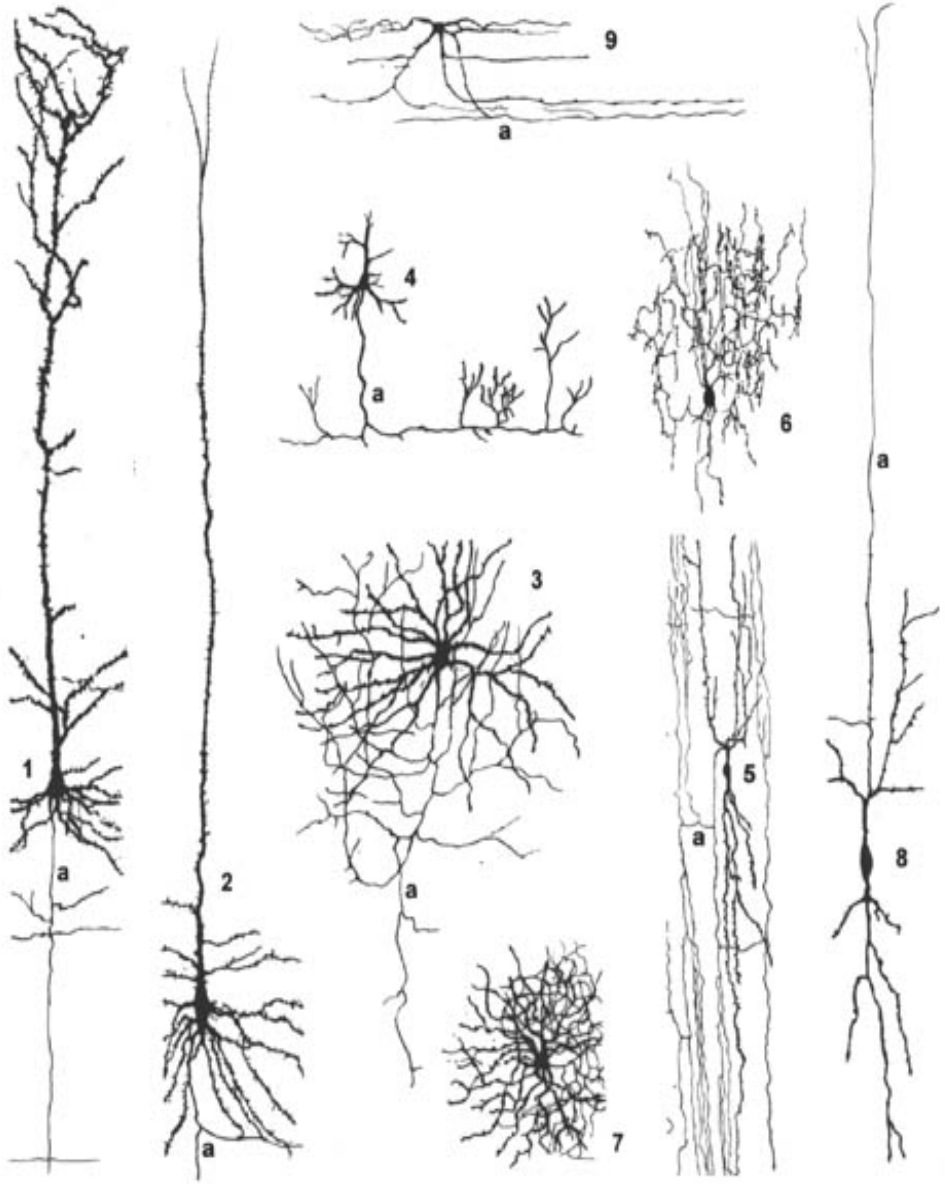
3. Granular (Stellate) Cell

   basket cell, double bouquet cell, bipolar cell, chandlier cell, neurogliform cell

4. Horizontal Cell of Cajal (Retzius-Cajal cell)

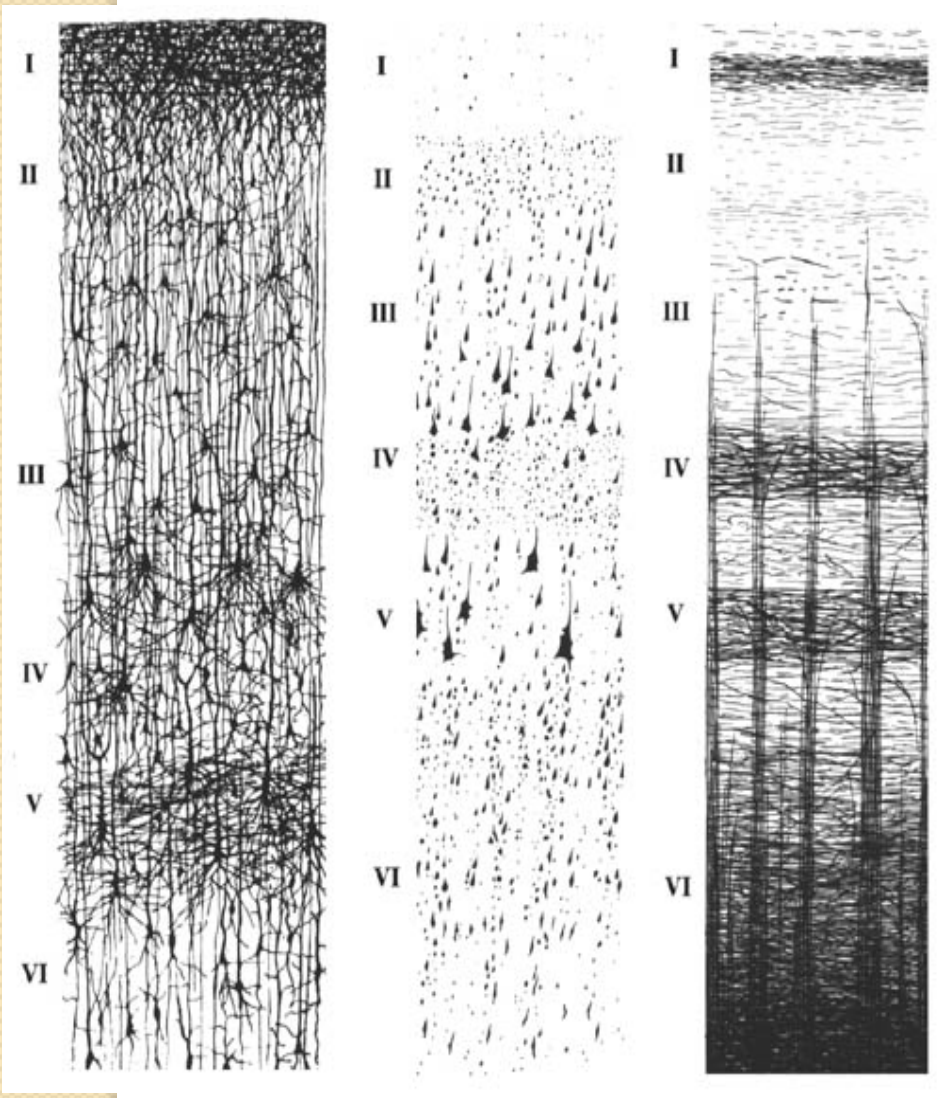
5. Cells of Martinotti

Cerebral Cortex



1. Pyramidal Cell
2. Fusiform Cell
3. Granular (Stellate) Cell
4. basket cell
5. double bouquet cell
6. chandlier cell
7. neurogliform cell
8. Horizontal Cell of Cajal
9. Cells of Martinotti

a: axon



Golgi

Nissl

Weigert

I. Molecular Layer

II. External Granular Layer

III. External Pyramidal Layer

Line of Kaes-Bechterew

IV. Internal Granular Layer

Outer band of Baillarger

- Line of Gennari in area 17

V. Internal Pyramidal Layer

Giant pyramidal cell of Betz

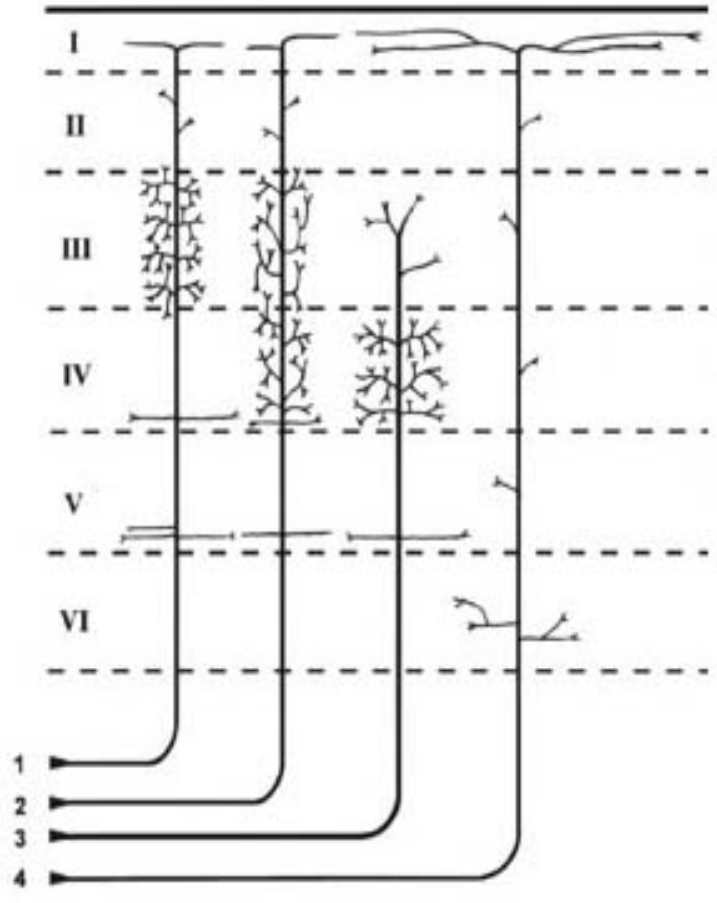
Inner Band of Baillarger

VI. Polymorphic Layer

Cortical Afferent Fiber

1. Corticocortical fiber
   - association fiber
   - commissural fiber
2. Thalamocortical fiber - specific and non-specific
3. Extrathalamic subcortical fiber
   - cholinergic fiber - acetylcholine
     - basal nucleus of Meynert
   - mesolimbic dopaminergic fiber - dopamine
     - ventral tegmental area
   - serotonergic fiber – serotonine - raphe nuclei
   - norepinephrinergic fiber - norepinephrine
     - nucleus locus ceruleus

Cortical Afferent Fiber



1. association fiber
2. commissural fiber
3. specific thalamocortical fiber
4. non-specific thalamocortical fiber

Cortical Efferent Fiber

1. Corticofugal Fiber - Projection Fiber
    - corticostriate fiber
    - corticothalamic fiber
    - corticorubral fiber
    - corticotectal fiber
    - corticopontine fiber
    - cortico-olivary fiber
    - corticobulbar fiber
    - corticospinal fiber
2. Corticocortical Fiber
    - Association fiber
    - Commissural fiber

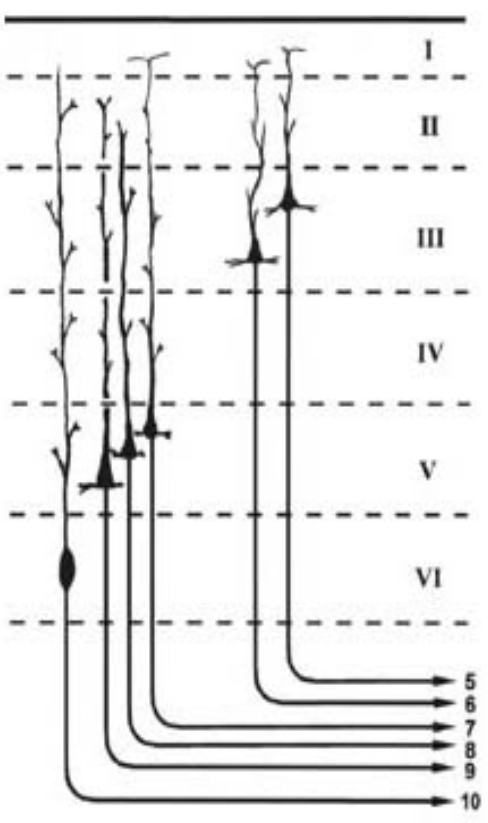
Cortical Efferent Fiber

5. association fiber
6. commissural fiber
7. corticostriate fiber
8. corticorubral fiber

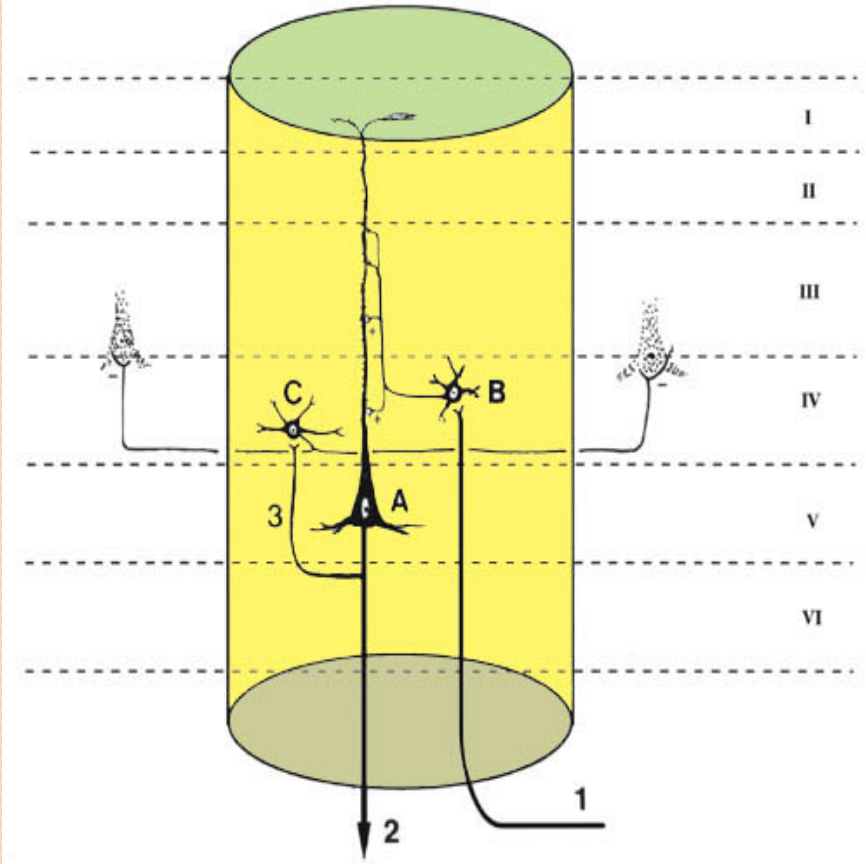
   corticopontine fiber

   corticobulbar fiber
9. corticospinal fiber

   corticotectal fiber
10. corticothalamic fiber



Columnar Cortical Unit and Cortical Circuitary



A. pyramidal neuron

B. excitatory granular cell

C. inhibitory granular cell

1. afferent fiber
2. efferent fiber
3. corticothalamic fiber

Characteristics of cerebral module

- Neurons are all related to the same peripheral receptor field
- Neurons of the same module are activated by the same kind of peripheral stimulus
- All cells of the module are arranged radially, perpendicular to cortical layers
- Intracortical circuits involve cells in all parts of the module
- Excitation of one module is accompanied by inhibition of adjacent columns

Regional Variation of Cortical Lamination

A. Homotypical isocortex

------- association cortex

B. Heterotypical isocortex

1. granular cortex

--- primary sensory cortex

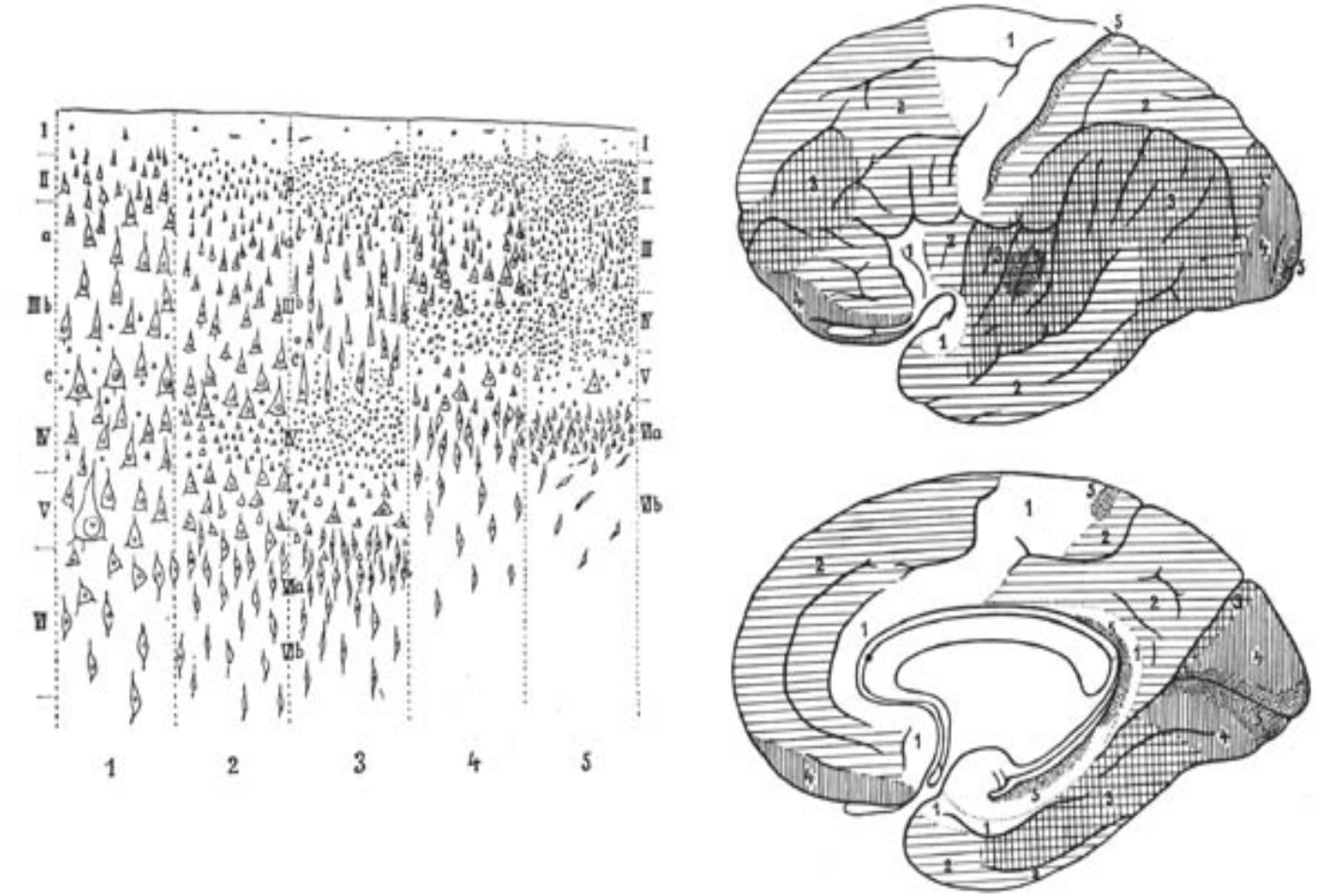
V 1 (17), S 1 (3), A 1 (41)

2. agranular cortex

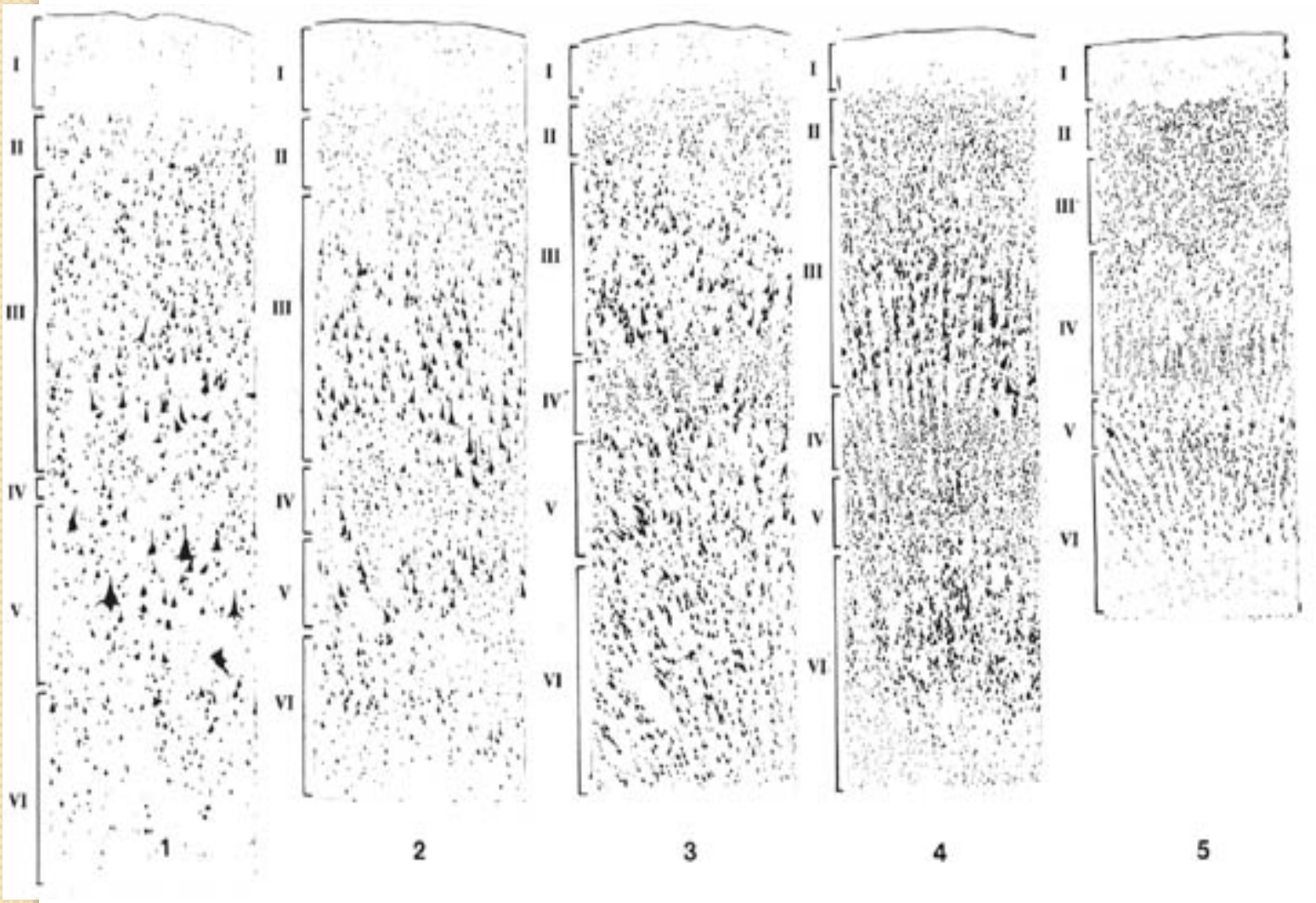
--- motor cortex

M 1 (4), PM (6)

Von Economo's classification of cortical types



1. agranular, 2. frontal, 3. parietal, 4. polar, 5. granular

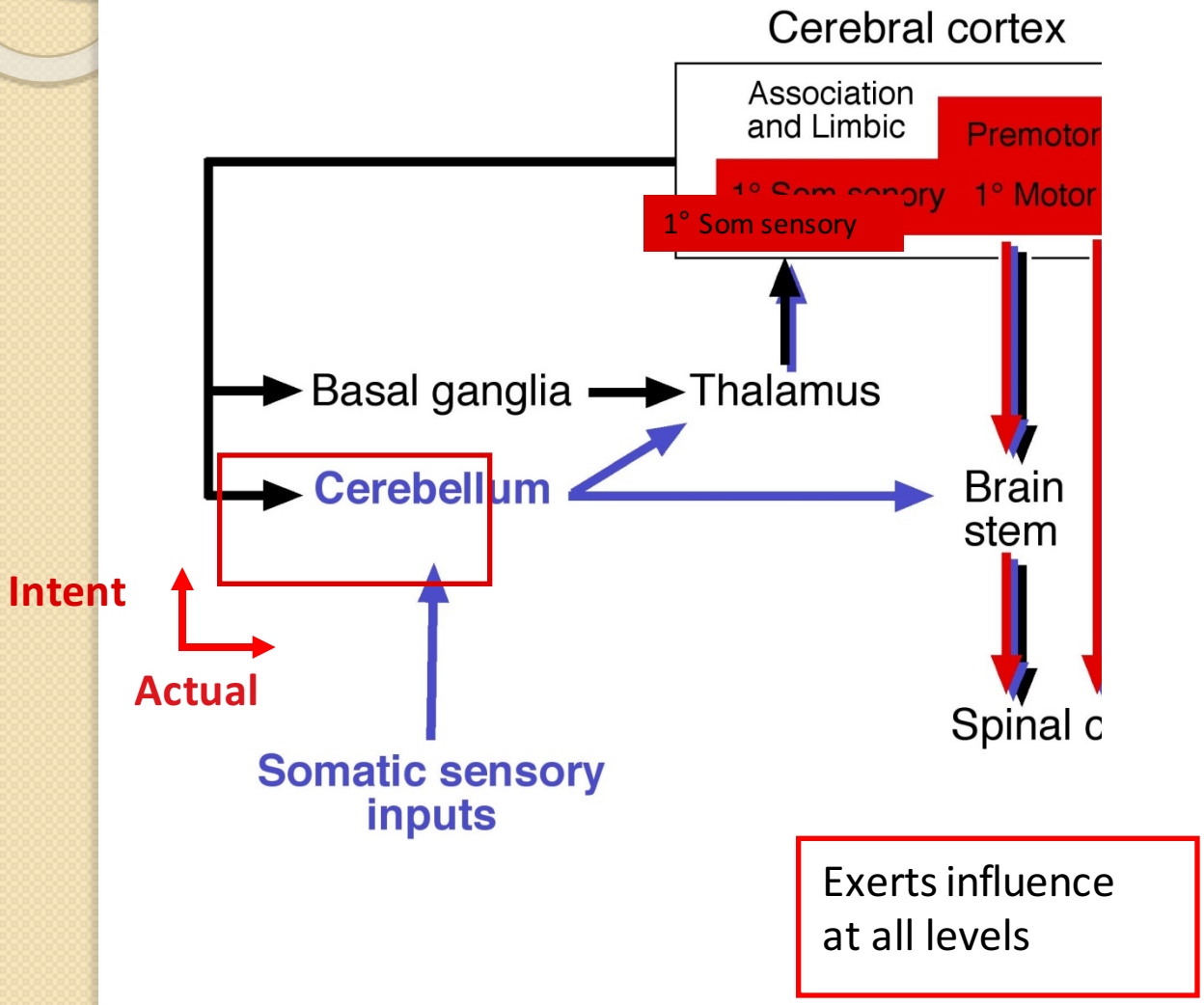


1. agranular, 2. frontal, 3. parietal, 4. polar, 5. granular

Cerebellum

- Outer gray matter “cortex”
  - Molecular layer- Purkinje cell layer
  - Granular layer
- Inner white matter “medulla”
- Surrounded by piamater

Motor Hierarchy



Exerts influence at all levels

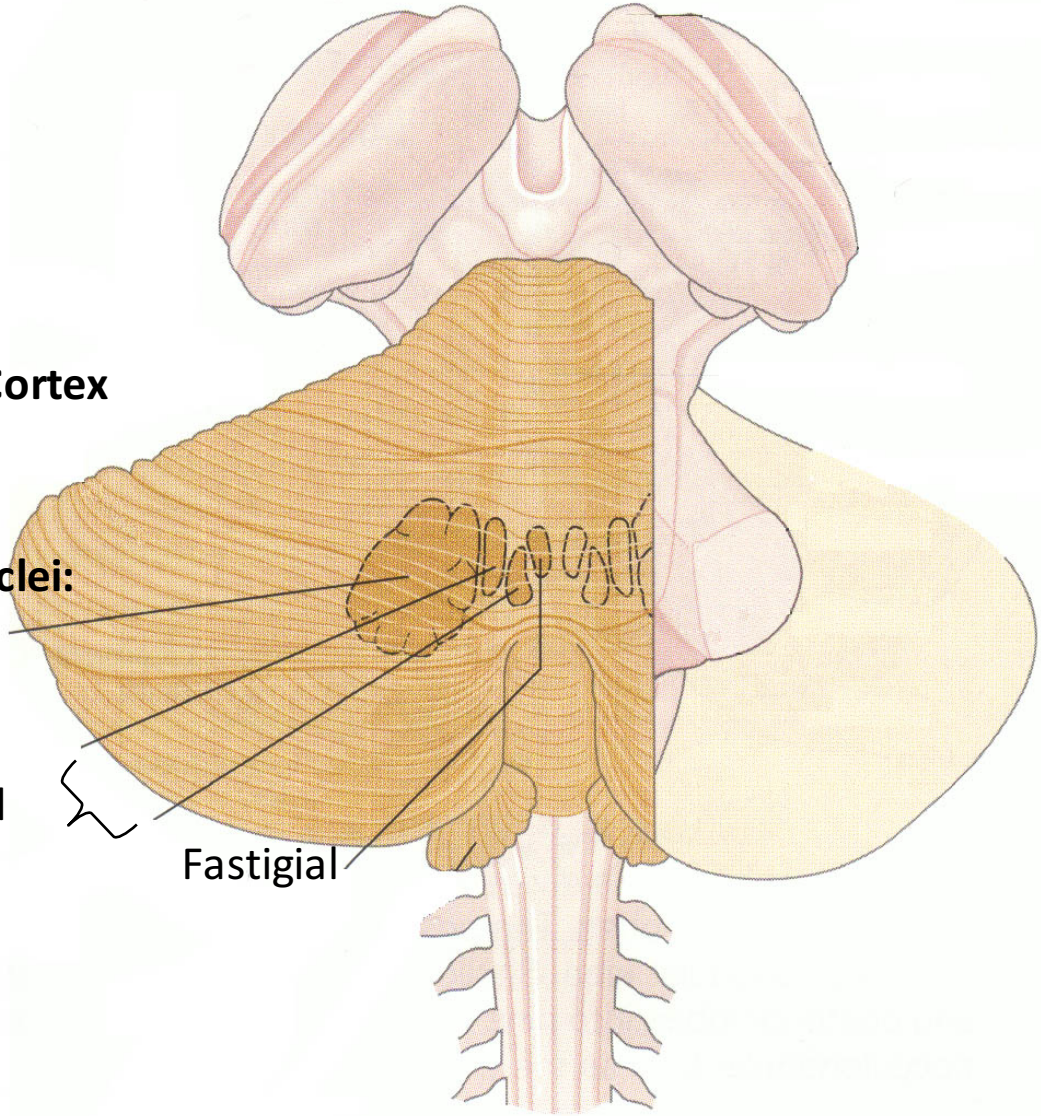
Cerebellar Cortex

Deep Cerebellar Nuclei:

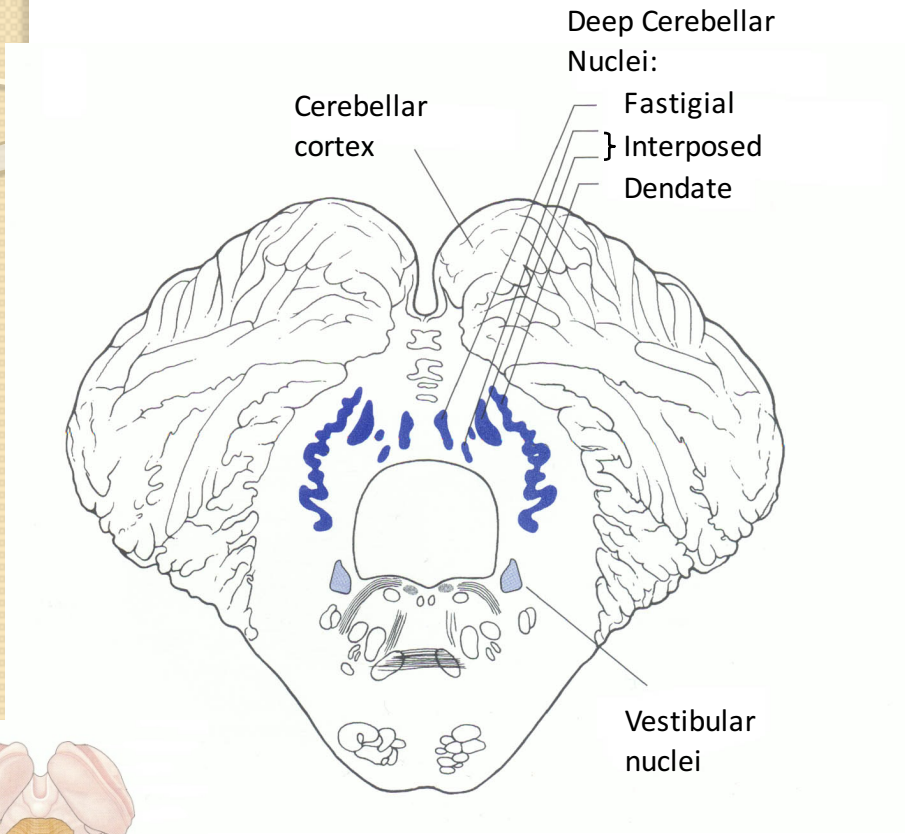
Dentate

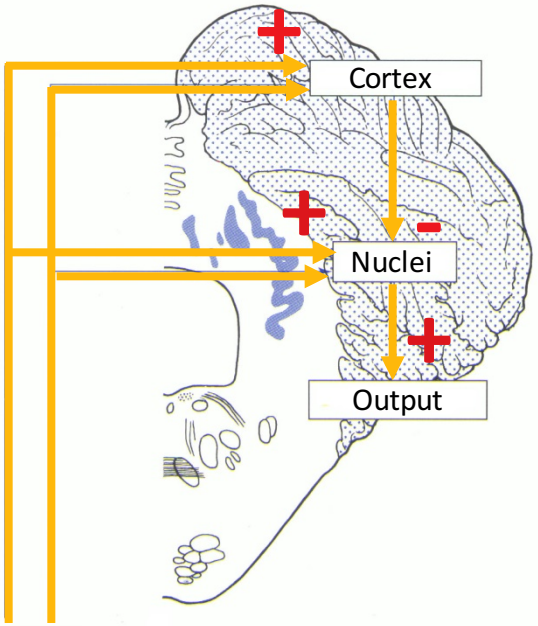
Interposed

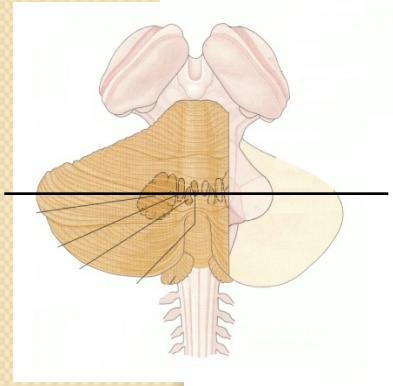
Fastigial



Input-output Organization







Extrinsic inputs:
- mossy fiber
- climbing fiber

Cerebellar divisi

Spinocerebellum
(Vermis + Intermed. Hem)

Control of limbs
and trunk

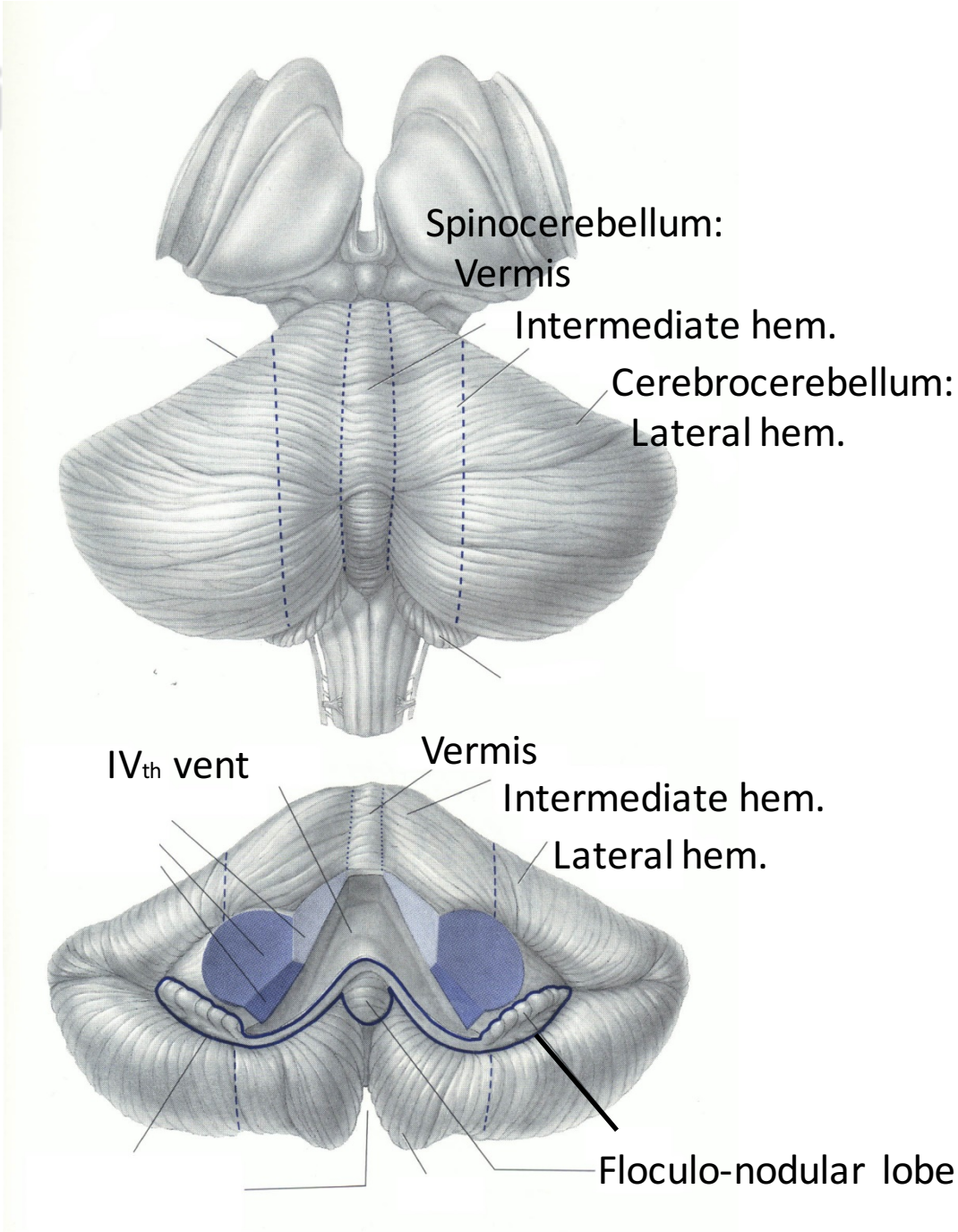
Cerebrocerebellum
(Lateral hemisphere)

Planning of movement+

Vestibulo-cerebellum
(Floculo-nodular lobe)

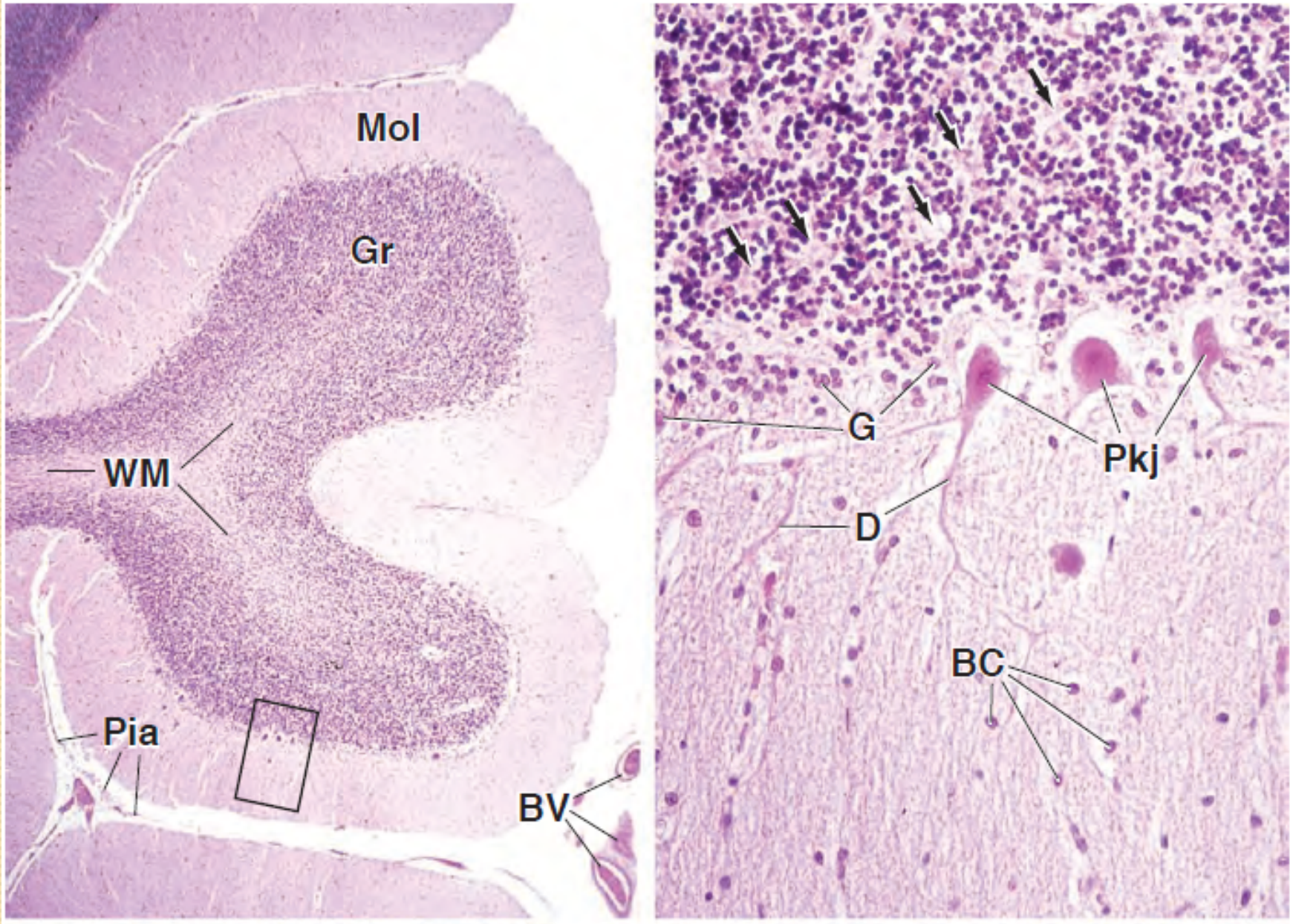
Control of eye &
head movements
Balance

NTA Fig. 13-1



Cerebellum cortex

- The cerebellar cortex has the same appearance regardless of which region is examined.
  - Outermost layer, the molecular layer *(Mol)*, is lightly stained with eosin.
  - Under this is the granular layer *(Gr)*, which stains intensely with hematoxylin.
  - Embedded in between is the purkinje layer
  - The three layers constitute the cortex of the cerebellum.


Mol
Gr
WM
Pia
BV
G
Pkj
D
BC

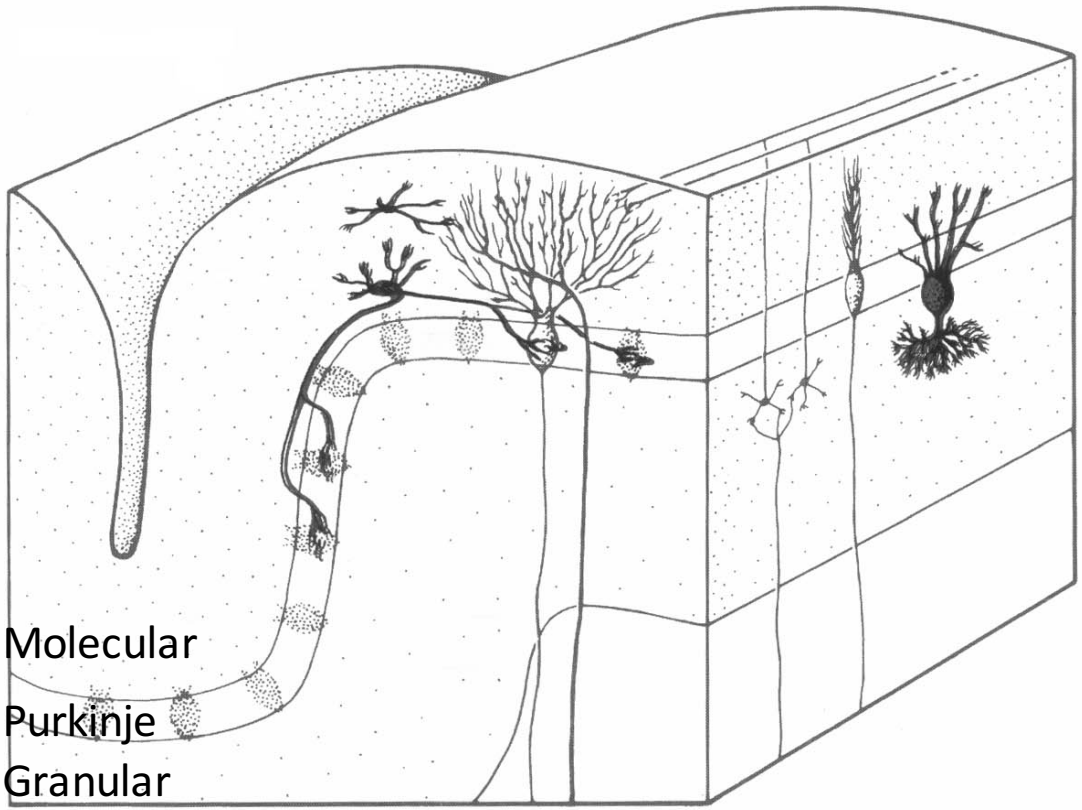
Molecular layer

- lies directly below the pia mater
- contains
  - superficially located stellate cells
  - basket cells
  - Purkinje cells and their dendrites
  - unmyelinated axons from the granular layer (parallel fibers)
- Purkinje cells
  - large pear-shaped cells
  - arborized dendrites projecting into the molecular layer
  - myelinated axons project into the white matter
  - only cell of the cerebellar cortex that sends information (always inhibitory) to the outside

Granular layer

- Contains
  - small granule cells
  - Golgi type II cells
  - glomeruli; synaptic regions between axons entering the cerebellum and the granule cells.
- Axons of the granule cells extend to the molecular layer and synapse with the dendrites of Purkinje cells and basket cells (parallel fibers).
- Parallel fibers extend parallel to the longitudinal axis of the folium in the molecular layer.

Cerebellar Cortex



Inputs

Climbing fibers
- from Inferior olive

Mossy fibers

Output

Purkinje neurons

Interneurons

Granule neurons

Stellate neurons

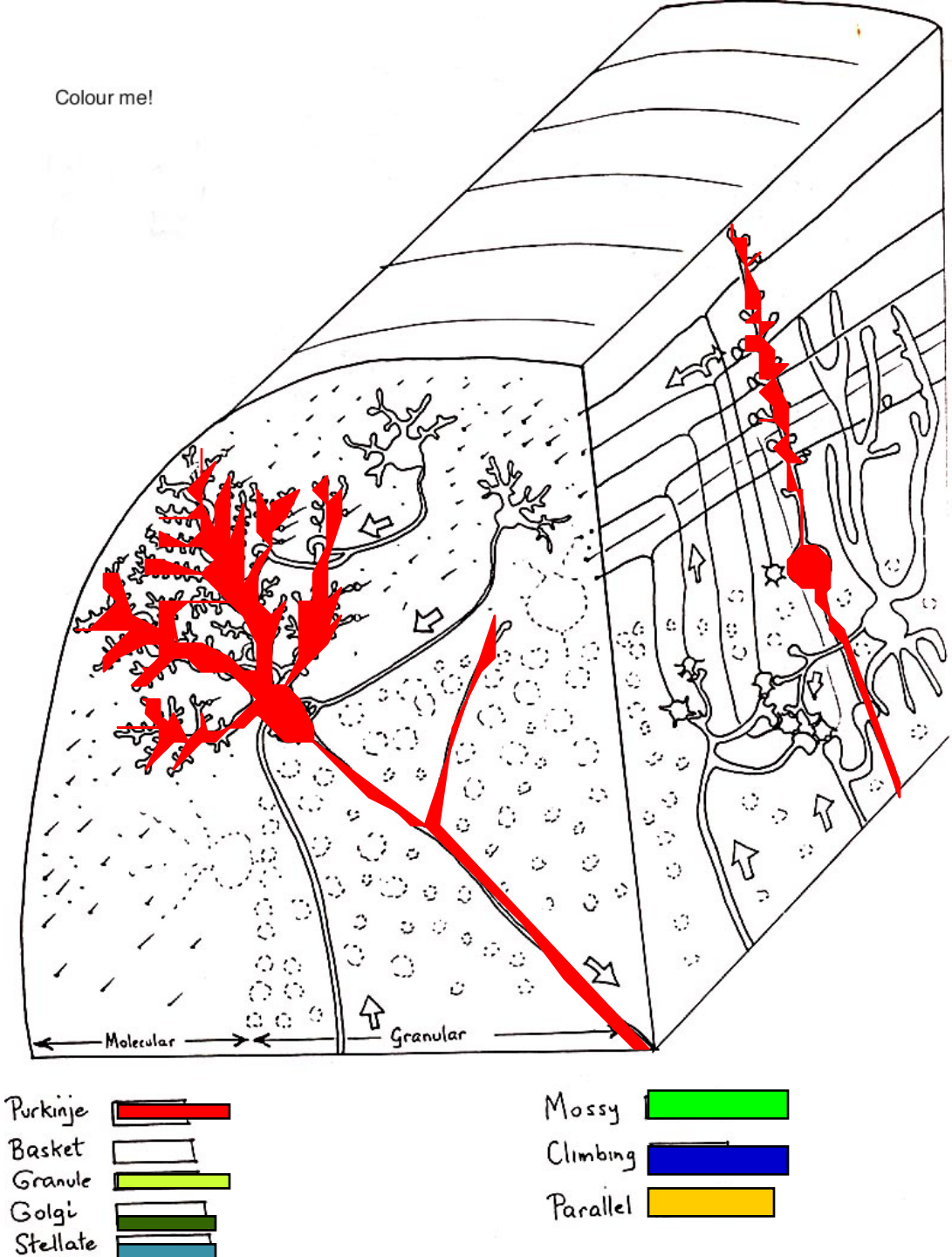
Basket neurons

Golgi neurons

NTA Fig. 13-11

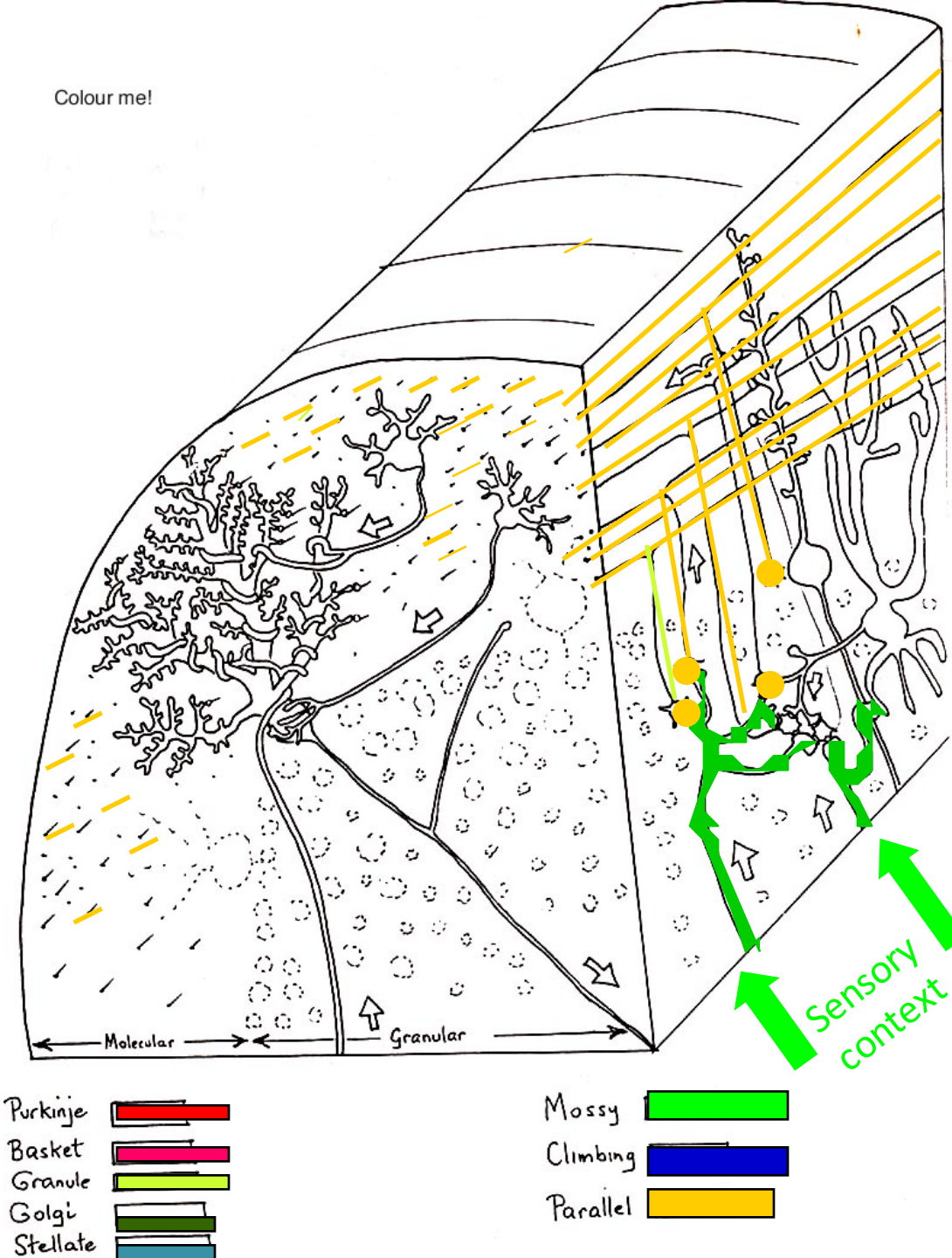
Purkinje Cell.

Only output of cerebellum
GABAergic inhibition

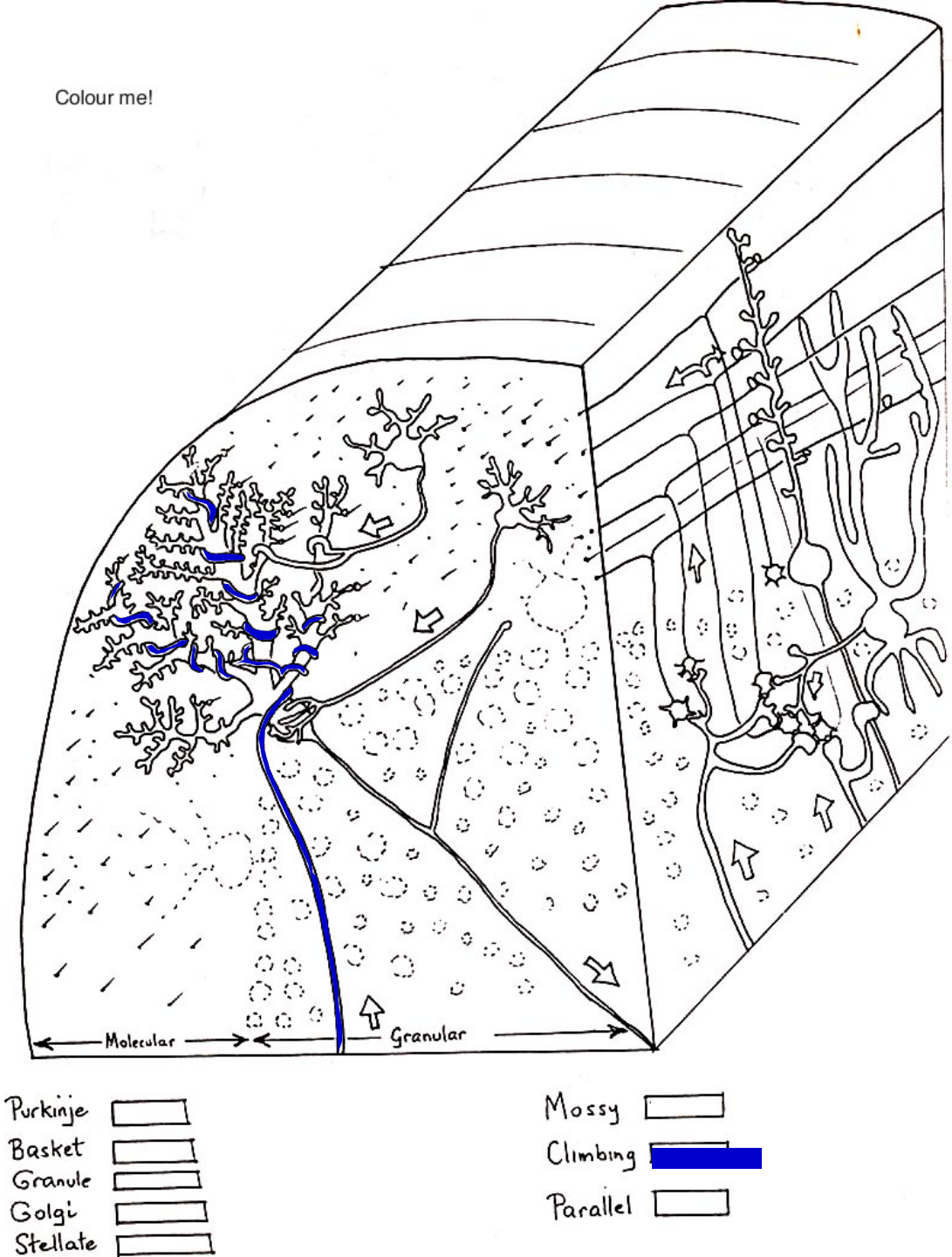


Excitatory Inputs.

Mossy fibre to granule cells to parallel fibres to spine synapses on Purkinje cells
Vast combinations provide the sensory context



Climbing fibre
Covers whole
dendritic tree of
Purkinke cell
All-or-nothing activation



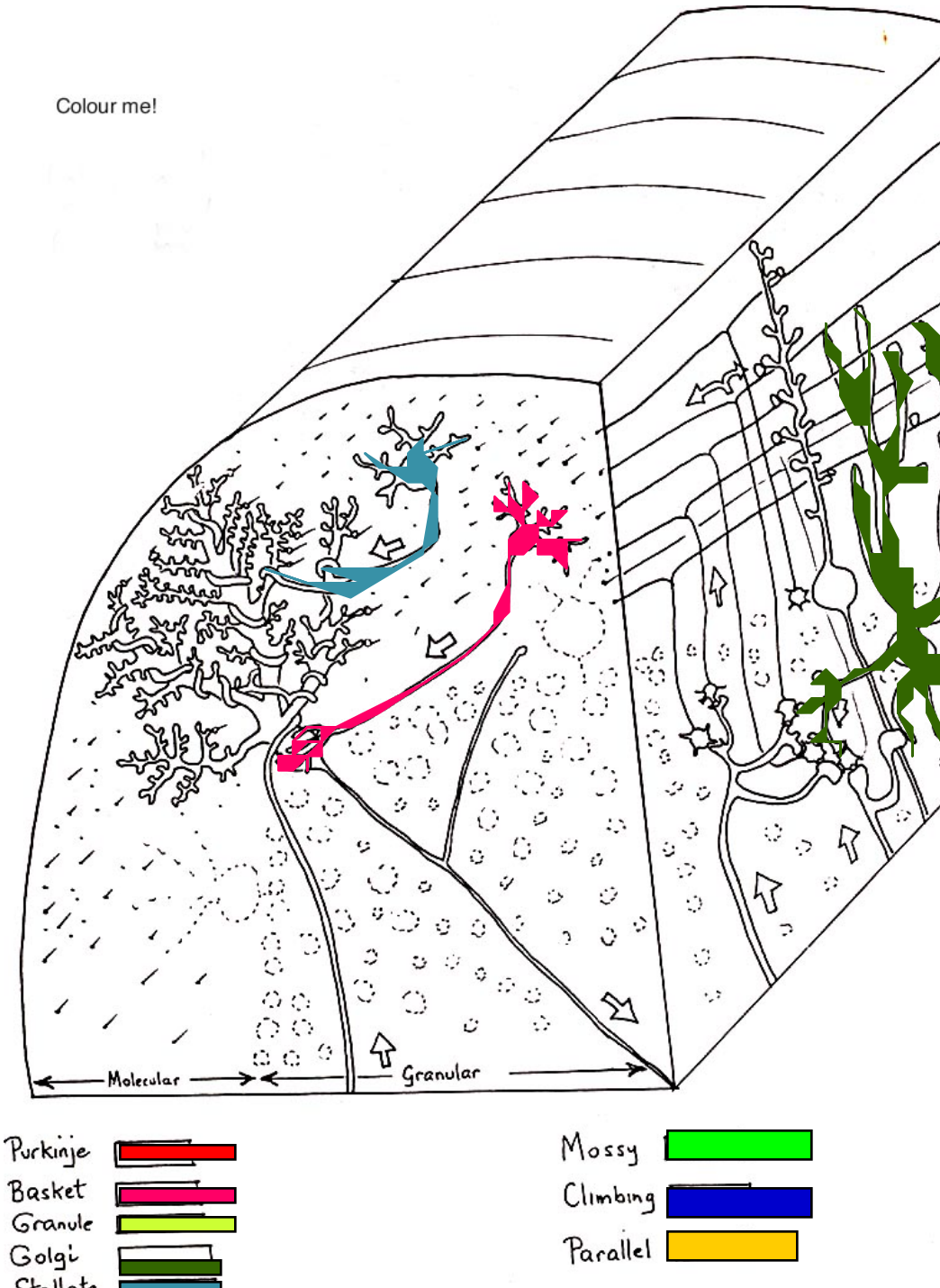
Interneurons.

Golgi for **G**ranule cells

Basket and Stellate for Purkinje cells

Inhibitory (GABA, glycine etc)

Diversity increases With cerebellar complexity (greatest variety in anthropoid primates)



Cerebellar Cognitive Affective Disorder

- Lesions of the posterior cortex and vermis
- Impairment of executive functions
  - Planning, verbal fluency, abstract reasoning
- Difficulties with spatial cognition
  - Visuo-spatial organization, visual memory
- Personality changes
  - Blunting of affect, inappropriate behaviors
- Language disorders
  - Agrammatism

Thank you!

THANK YOU