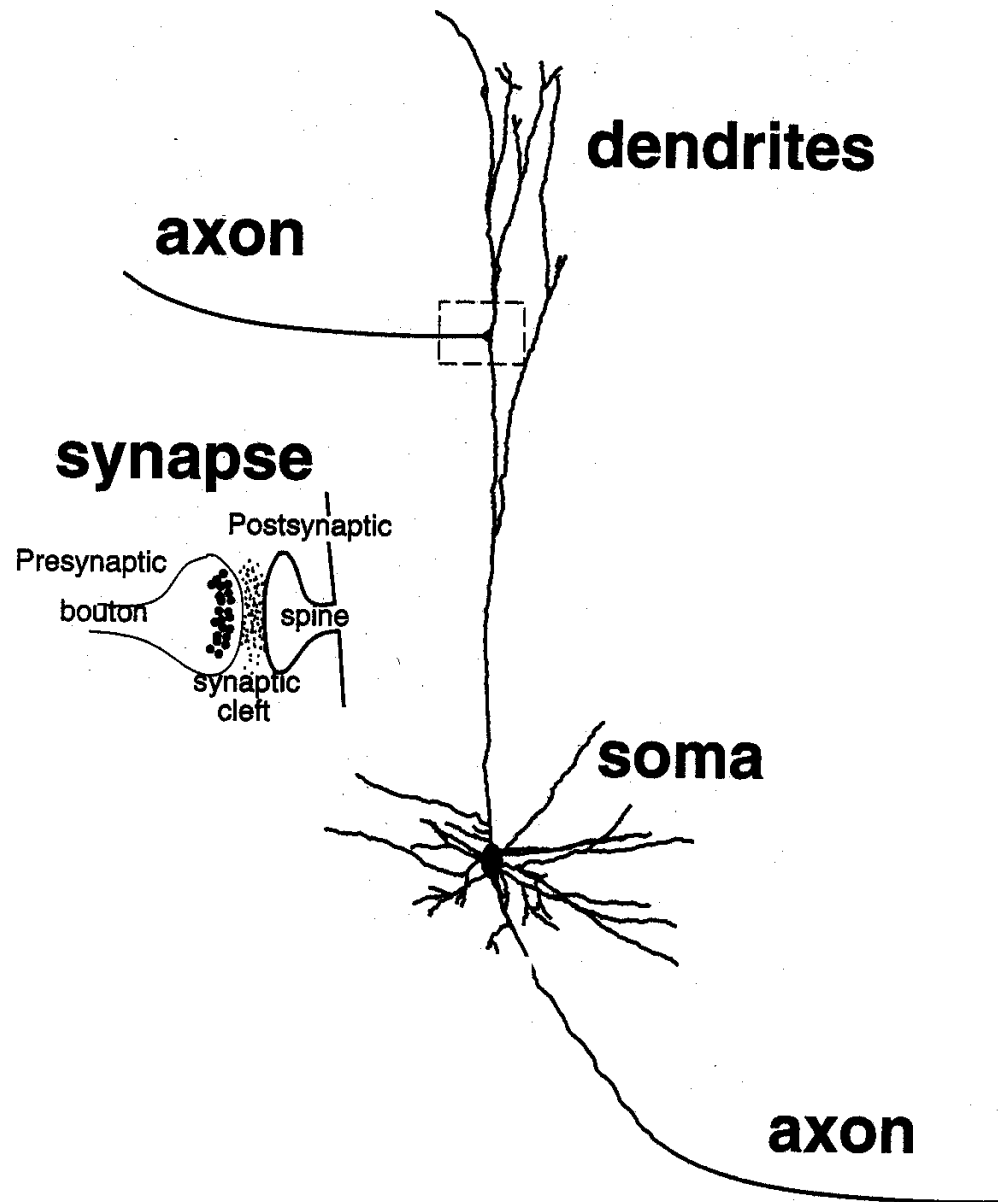
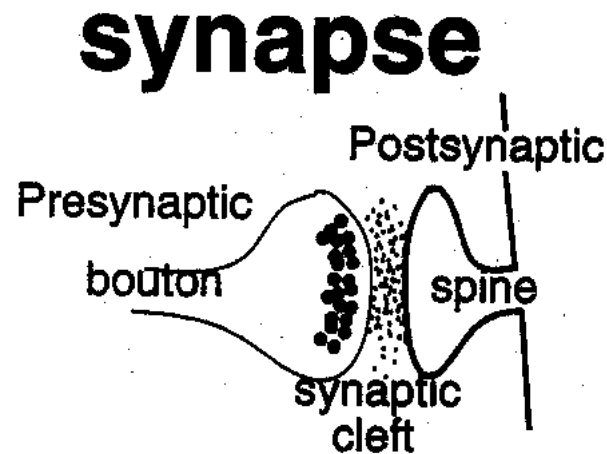


### 3.1.1 A typical pyramidal cell of the mammalian cortex:



- Pyramidal cells are considered principal cells because of their large size and long projections to other areas.
- The **cell body or soma** (small oval), which would be the bulk of the cell in other cell types, is dwarfed by the **dendrites**, which extend out in all directions.
- In this cell type, there are lots of small dendrites and then one major long dendrite with only a few branches.
- This major, **apical dendrite** can be a millimeter in length.
- The **axon** is typically much longer than the dendrites — several of them go from your lower back to your big toe, a distance of about a meter.
- Axons branch to connect with multiple targets.
- An axon branch from another cell is shown at the upper left forming a synapse on the cell (rectangle).

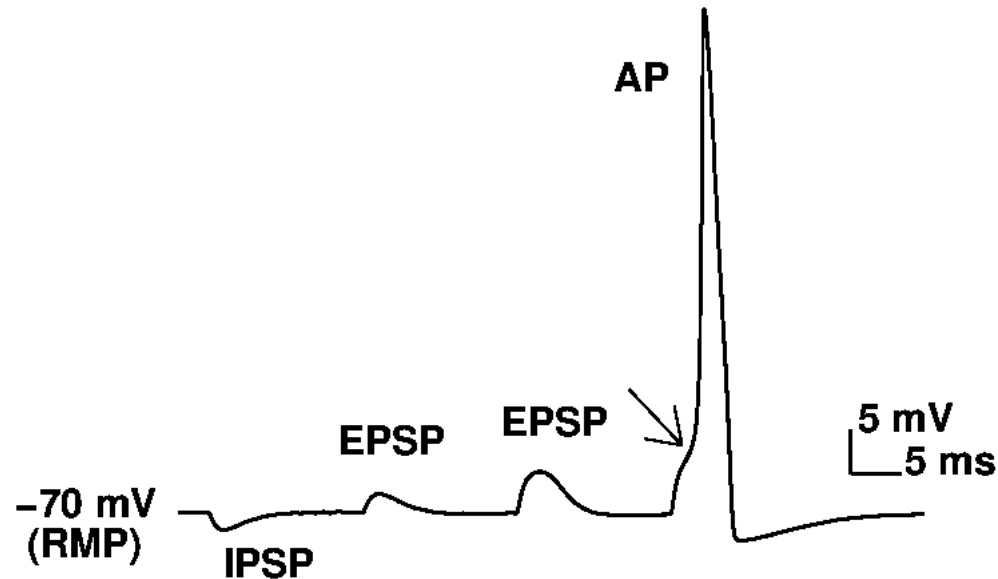
### 3.1.2 The synapse



- The **synapse** is a neuron input device and connects the axon of one neuron with the dendrite of the other.
- Note the **presynaptic**(axon) terminal at the end of the axon and a spine on the dendrite.
- The terminology of presynaptic and postsynaptic defines the direction of signal flow.
- **Transmitter** is released presynaptically, floats across the **synaptic cleft**, and activates receptors postsynaptically.
- The two neurons are not directly connected but communicate via this cleft.

### 3.1.3 The action potential

- The information in the neuron is in the form of electrical potentials (voltages) across the membrane.
- Information is conveyed via the synapse through arrival of neurotransmitter on receptors.

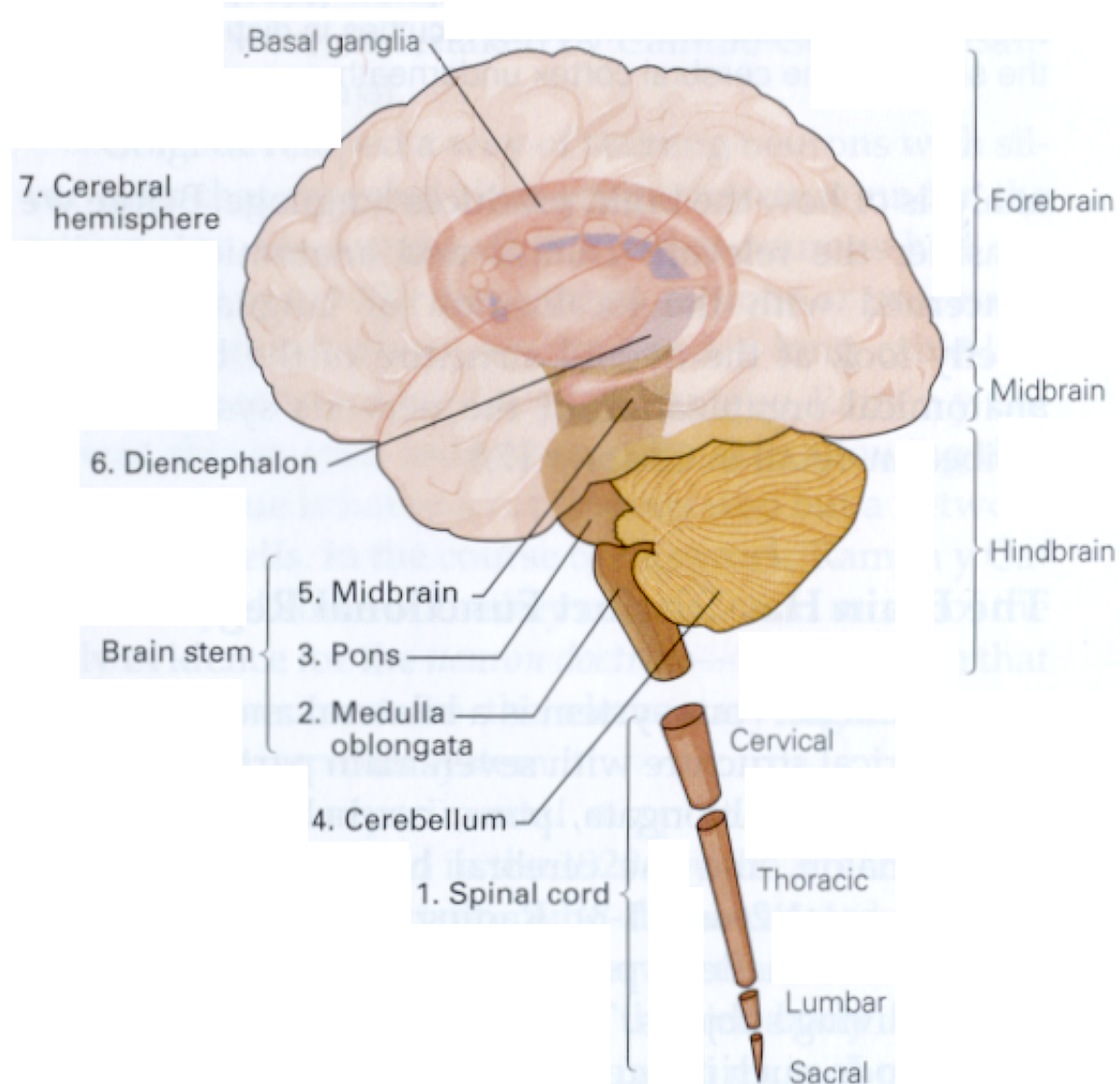


- Potentials can be **excitatory postsynaptic potentials** (EPSPs) or **inhibitory postsynaptic potentials** (IPSPs).
- The trace starts at a **resting membrane potential** (RMP) of about  $-70$  mV.
- A pair of EPSPs of increasing size move the potential in a positive direction, toward firing threshold.

- Finally a larger EPSP reaches the firing threshold and the cell fires a spike (**action potential, AP**, indicated by an arrow).
- An IPSP pushes the membrane potential down to more negative values and away from its firing potential.
- The action potential is the signal that can be sent down the axon to create a PSP in another neuron.

### 3.2 Macroscopic view of the nervous system

from Kandel, Schwartz and Jessel, *Principles of Neural Science*



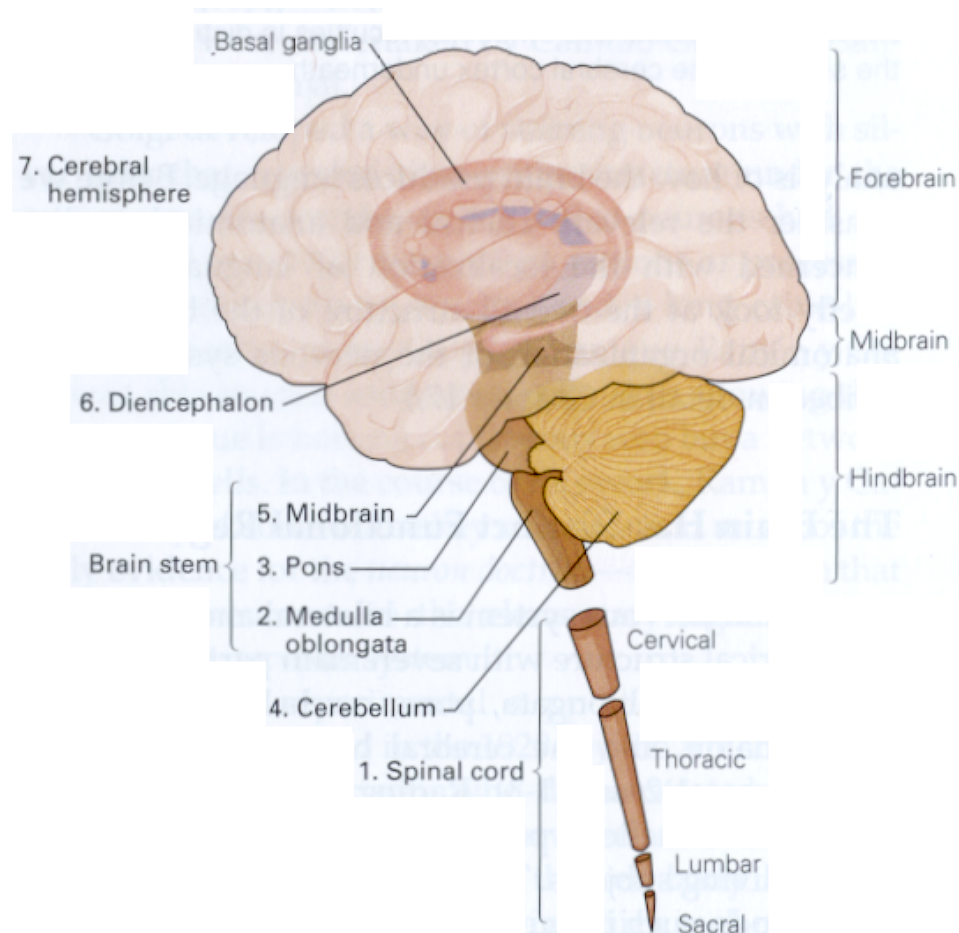
#### 3.2.1 Seven main parts of the Central Nervous System (CNS):

The **cerebral hemispheres** consisting of a heavily wrinkled outer layer:

- the **cerebral cortex** responsible for cognitive functions,

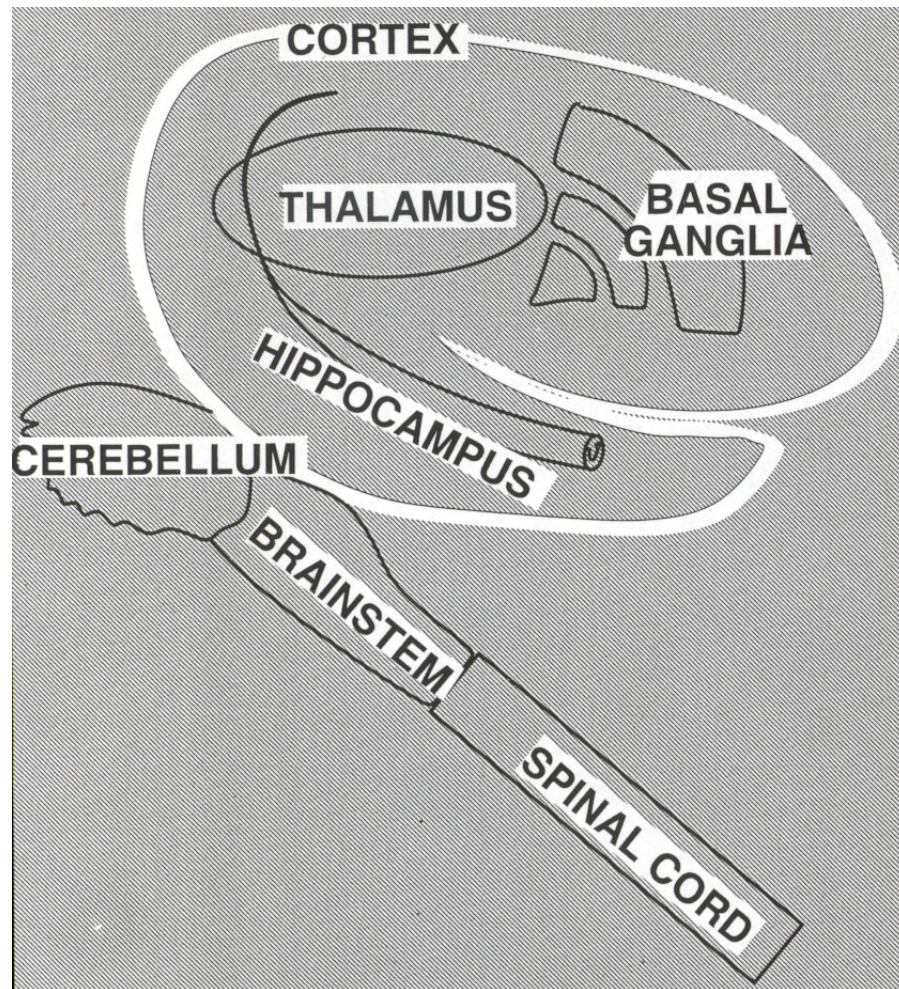
and three deep lying structures:

- the **basal ganglia**, which participate in regulating motor performance,
- the **hippocampus**, which is involved with aspects of memory storage,
- the **amygdaloid nuclei**, which coordinates the autonomic and endocrine responses of emotional states.



- The **diencephalon** (6) has two structures:
  - the **thalamus** processes most of the information reaching the cerebral cortex from the rest of the central nervous system.
  - the **hypothalamus** regulates autonomic, endocrine and visceral functions.
- The **midbrain** (5) controls many sensory and motor function, including eye movement and the coordination of visual and auditory reflexes.
- The **cerebellum** (4) modulates the force and range of movement and is involved in the learning of motor skills.
- The **pons** (3) conveys information about movement from the cerebral hemisphere to the cerebellum.
- The **medulla oblongata** (2) is responsible for vital autonomic functions such as digestion, breathing and control of heart rate.
- **The spinal cord** (1).

Labeled schematic of the brain in sagittal section  
(vertical plane “between the eyes”).

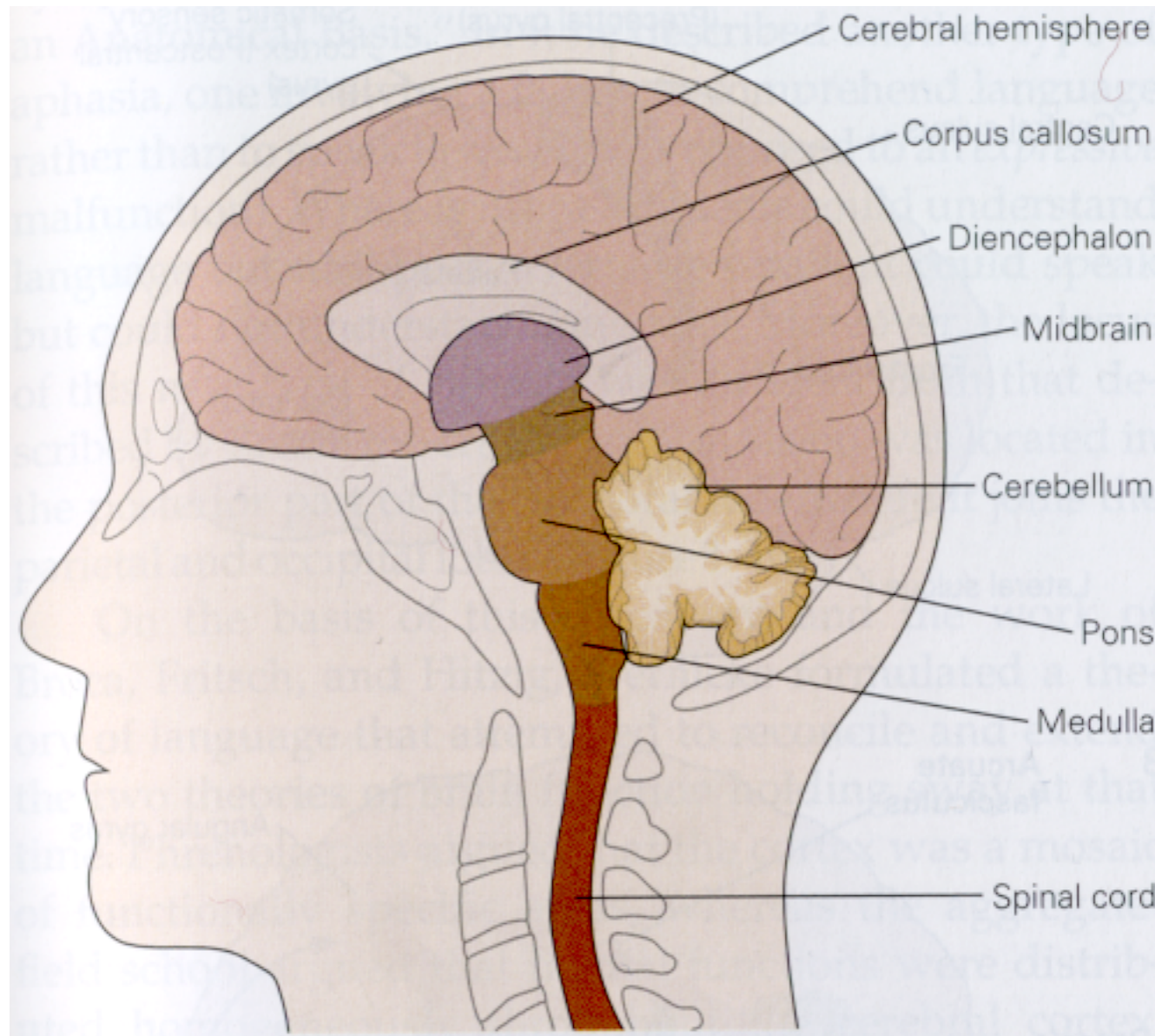


### 3.2.2 Simplified view at parts of the brain

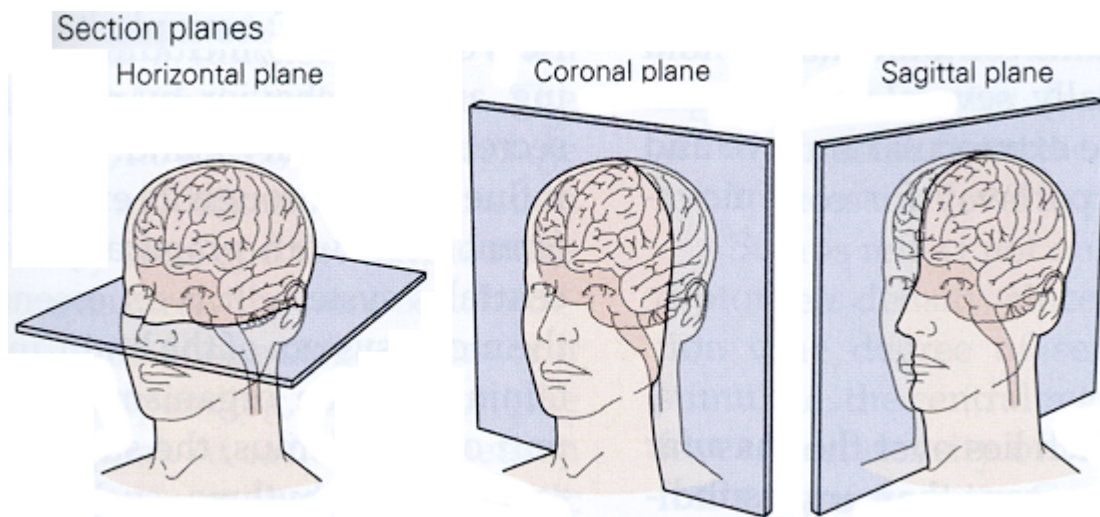
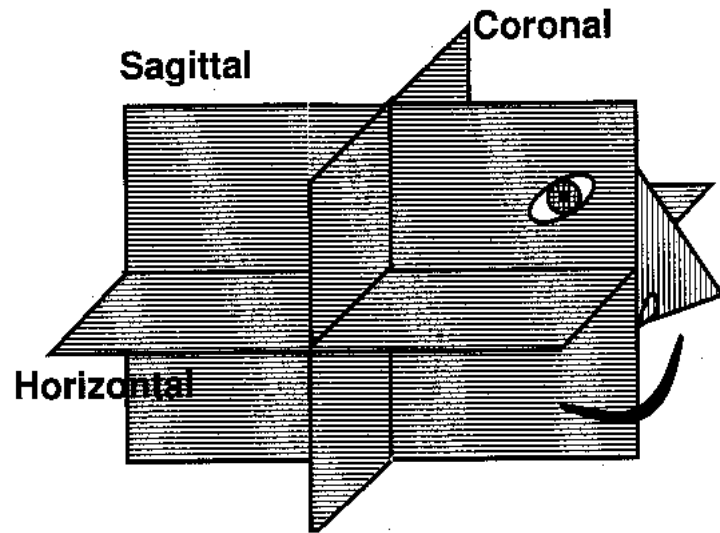
- The brain is subdivided into an outer rind called the **cortex** and multiple internal nuclei.
- The **cerebellum** is an additional “mini-brain” stuck on behind; it has its own nuclei and cortex.
- Major deep nuclear complexes are the **thalamus** and the **basal ganglia**.
- Along with the wiring to and from the cortex, these fill up most of the brain.
- The nuclei and cortex are **gray matter**, made up primarily of **cell bodies and dendrites**, and
- the subcortical connections are **white matter**, made up of **axons**.

### 3.2.3 Another view at major brain divisions

from Kandel, Schwartz and Jessel, *Principles of Neural Science*



### 3.2.4 The three planes of body sectioning:



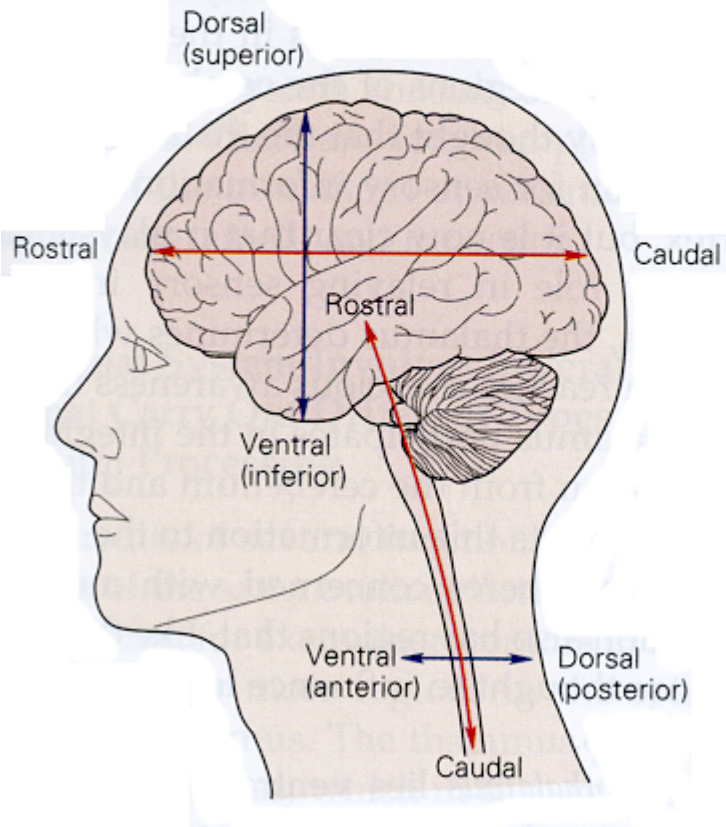
- We can conceptually (or actually) slice the body in three orthogonal planes: horizontally (a plane horizontal to the ground), sagittally (a vertical plane passing from belly to back), and coronally (a vertical plane running from ear to ear).
- In the horizontal plane, directions are anterior vs. posterior (toward or away from the nose), left vs. right, and medial vs. lateral (toward the middle or toward the edge).
- For the coronal plane, left vs. right and medial vs. lateral also pertain.
- For the brain coronal, up is dorsal and down is ventral.
- In the sagittal plane, we have anterior to posterior and dorsal to ventral.



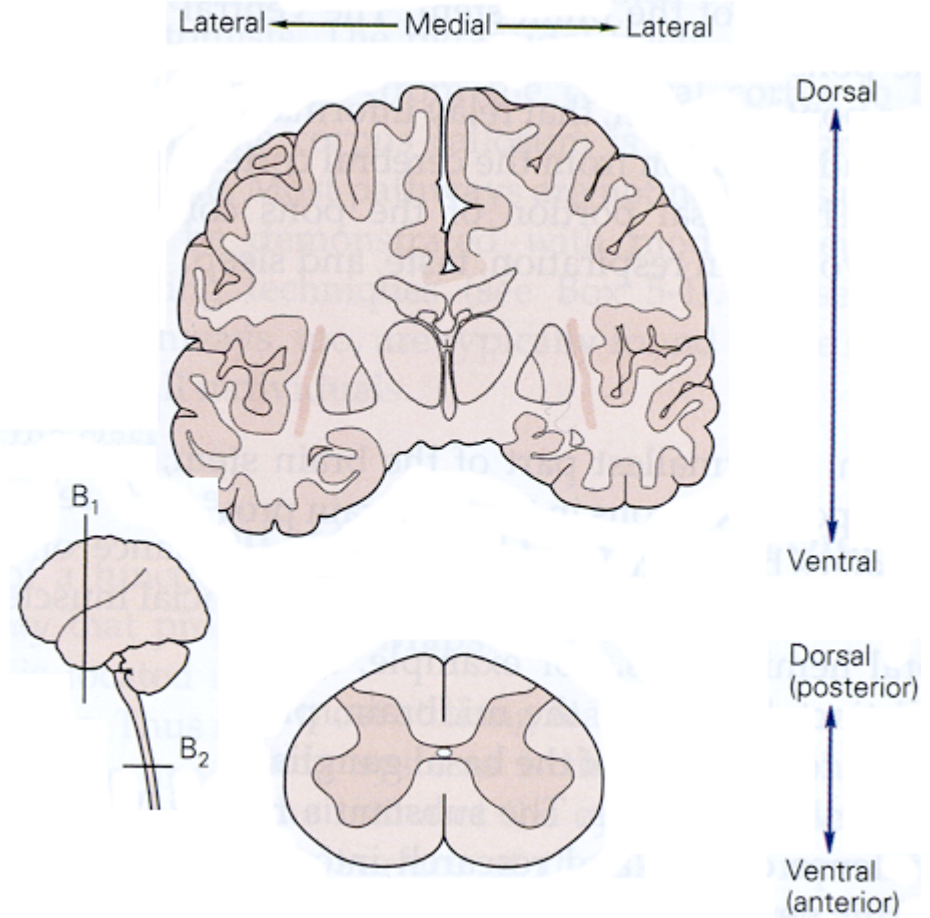
### 3.2.5 Another view at neuronal axes

from Kandel, Schwartz and Jessel, *Principles of Neural Science*

A Rostral-caudal and dorsal-ventral axes



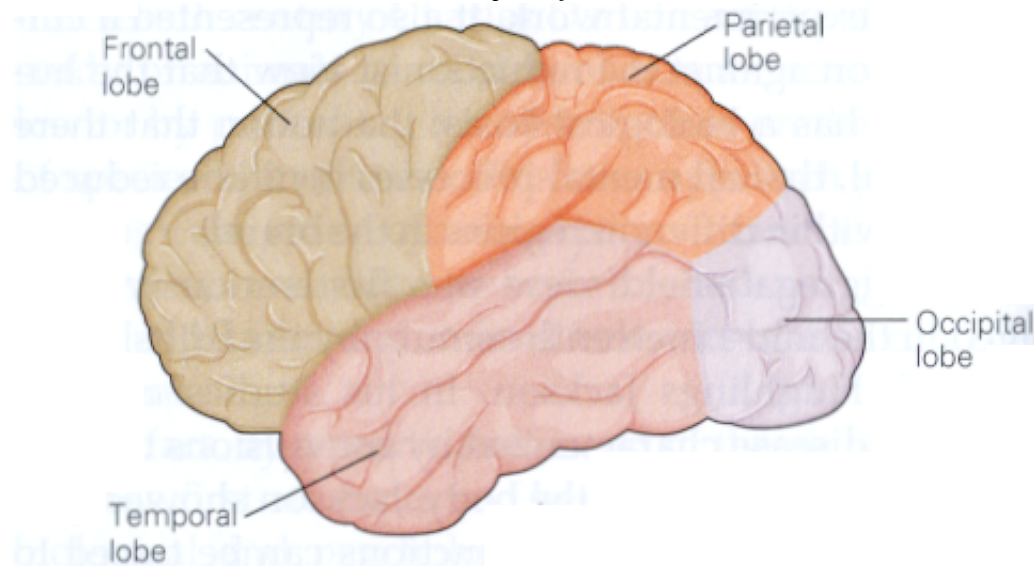
B Medial-lateral axis



### 3.2.6 The cortex

- The **cortex** is one of the most popular brain bits for humans since it is a major part that makes us different from other creatures.
- The major parts of the cortex, called **neocortex** (new cortex), form the outer layer of the brain. The cortex is heavily folded, giving it greater surface area.
- Human cortices are considerably more folded than those of most monkeys.
- Cortex can also be subdivided into different areas that are responsible for different aspects of sensory processing, motor control, and cognition.

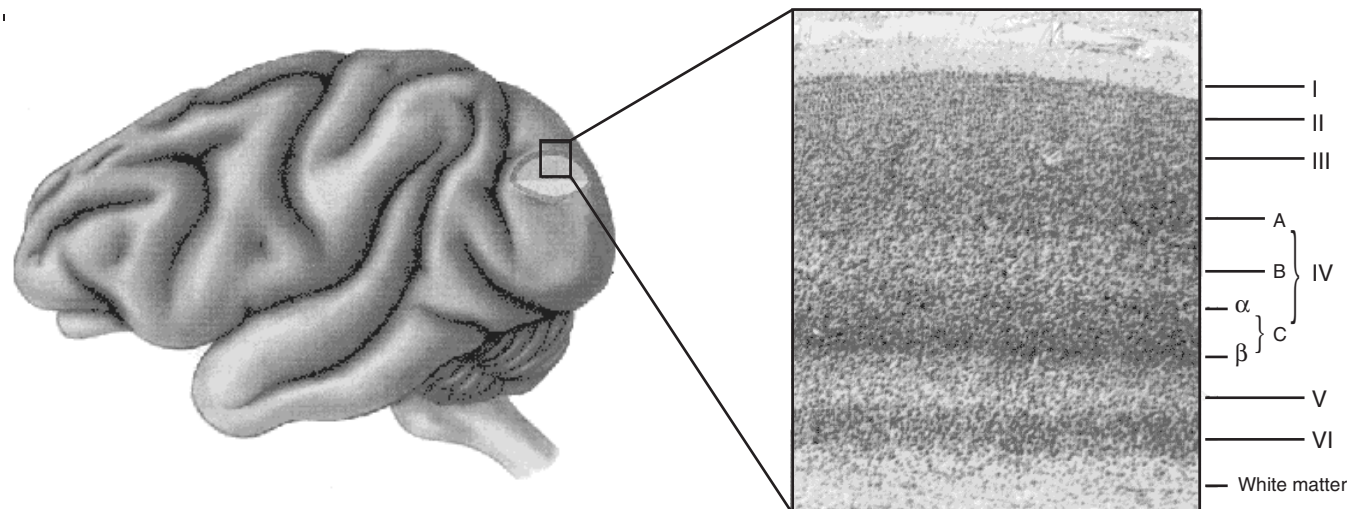
from Kandel, Schwartz and Jessel, *Principles of Neural Science*



**Figure 1-2B** The four lobes of the cerebral cortex.

- **Occipital cortex**, in the back, does vision.
- **Frontal cortex**, in the front, does socializing and judgment.
- **Left temporal cortex** (lateral and ventral) does speech recognition.
- **Right parietal cortex** (more dorsal) does spatial orientation.
- The left brain is literate and numerate and the right brain is good at pictures.
- Areas of the brain may increase in size depending on their usage so that highly musical people will have a larger auditory area.

- Cortical areas are generally represented as forming a **hierarchy** from the **simple perceptions** of primary sensory areas, through **perceptual integration**, up to the **multimodal representations** of association areas.
- Cortical areas typically feature strong **recurrent loops** between connected areas, and there is much evidence to suggest that even lower areas participate in high-level perception.
- Moving down into neocortex, **six layers of interconnected axons, dendrites, and cell bodies** can be identified.



- The cortical layers are only a few millimeters thick and contain about 30 billion neurons.

### 3.2.7 The columnar organization of the neocortex

The cortex seems to be **functionally organized into columns** laid out in a two-dimensional array.

from Mountcastle *The columnar organization of the neocortex*, Brain 1997

**Fig. 16** Diagram of the arrangement of neurons, dendrites and axons in vertical modules of the striate cortex of the macaque monkey.

*Left.* A drawing to show the arrangement of the apical dendrites of pyramidal cells; for clarity, only one-half of the neurons present are shown.

The pyramidal cells in layers II/III, IVA and V are shown in red, those in layer VI in green.

Neurons of IVB and IVC are shown without dendrites, in grey; GABAergic neurons in azure. Total numbers of GABAergic and non-GABAergic cells are given to the right of the drawing.

*Right.* A drawing to represent the pyramidal cell modules (columns) showing the arrangement of dendrites and axons. Colour scheme the same as for the left, pyramidal cell axons are shown in blue.

(From Peters and Sethares, 1996, with permission from Wiley-Liss.)

