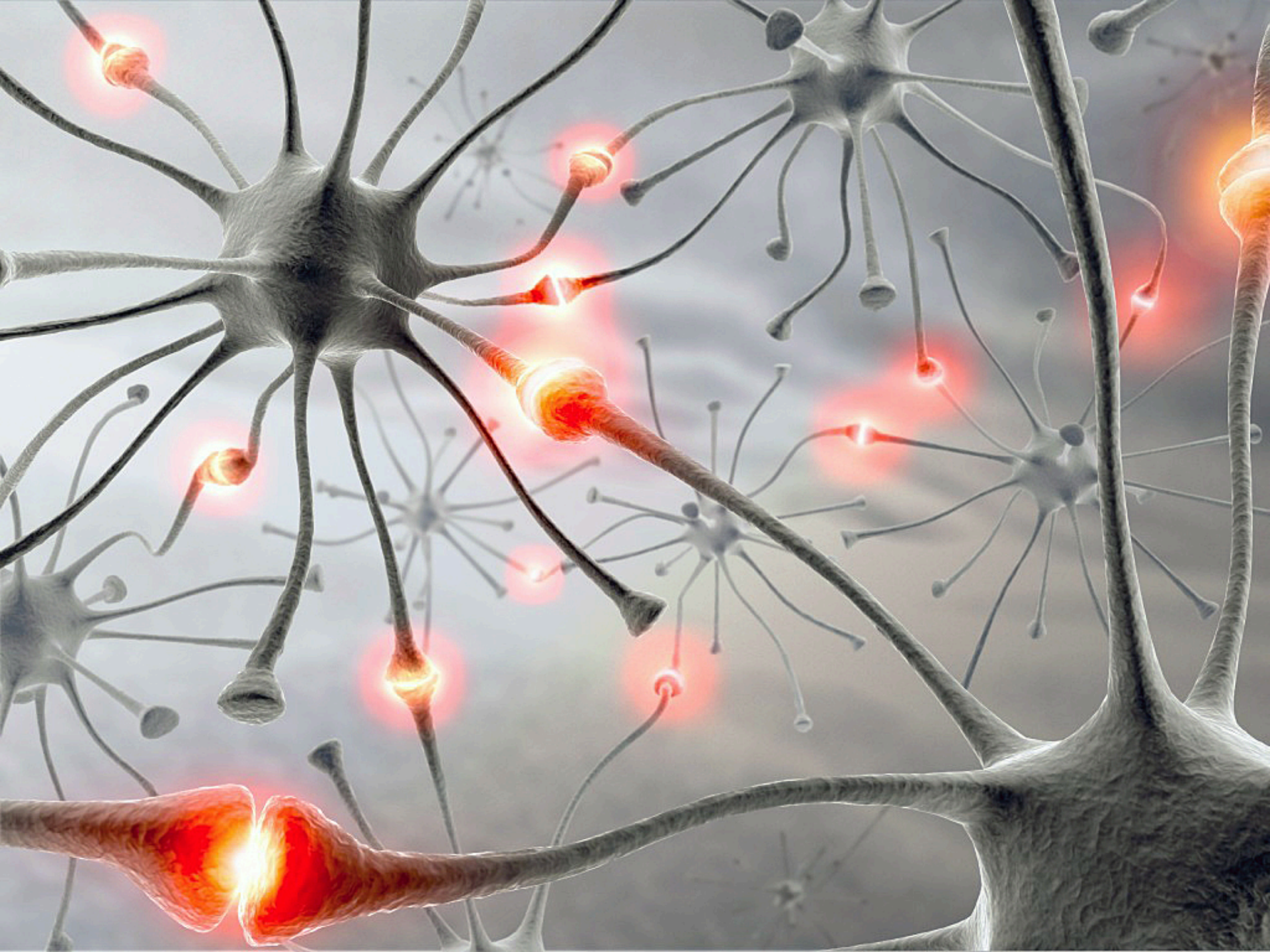
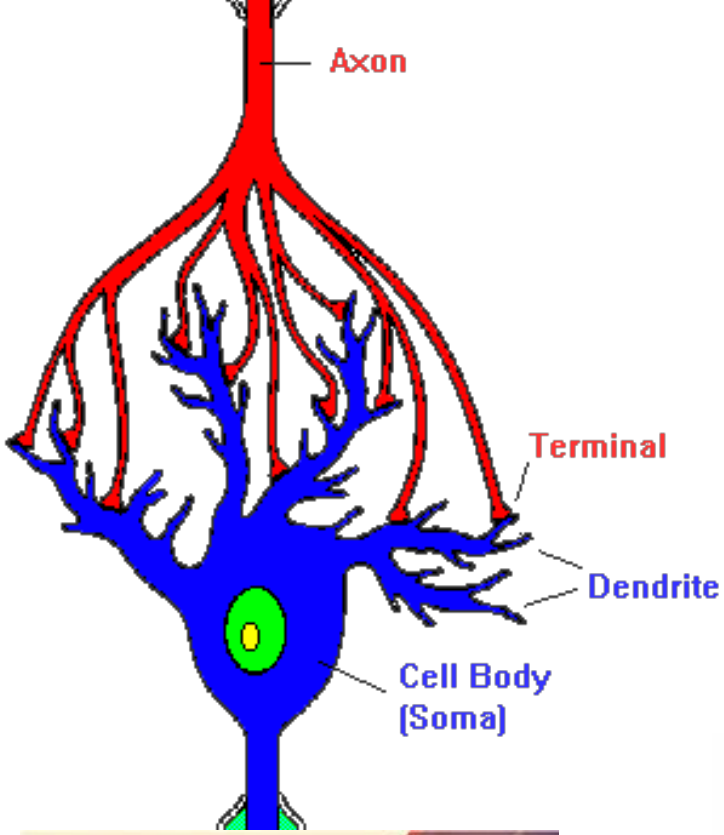
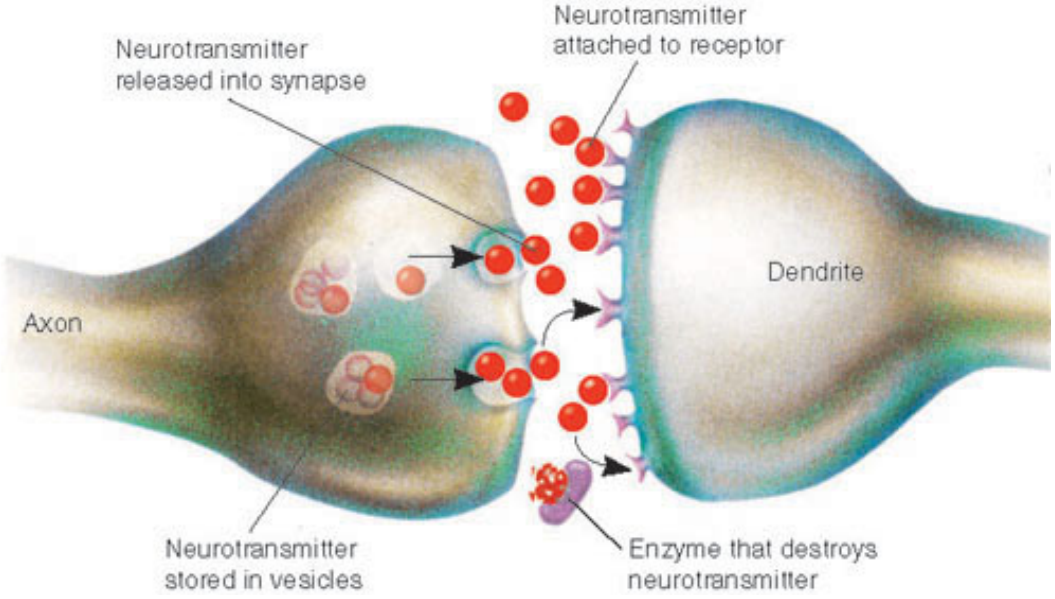
ELL788: Lecture 3-4, Date: 10,11-08-2016

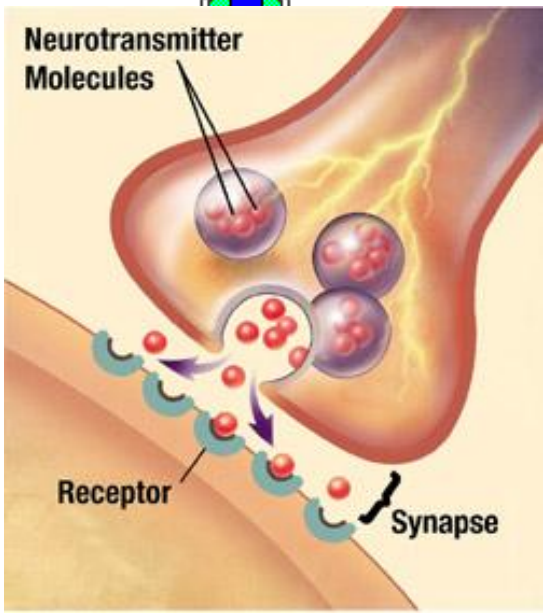
CSC

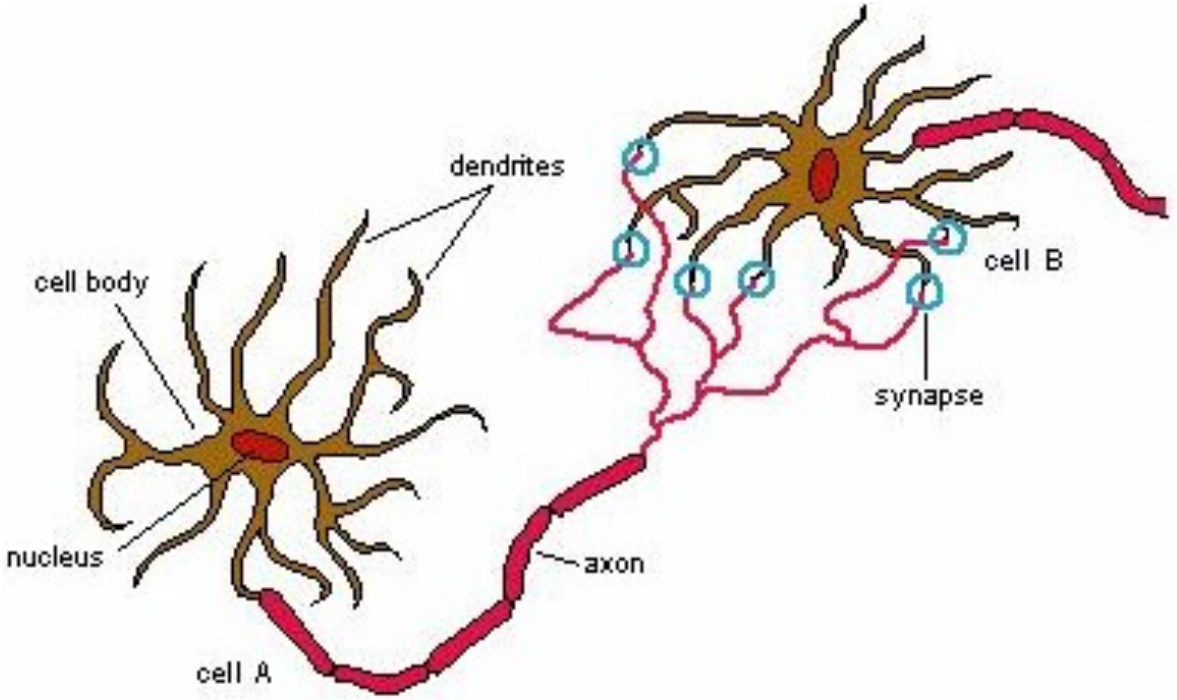
Instructor: TKG

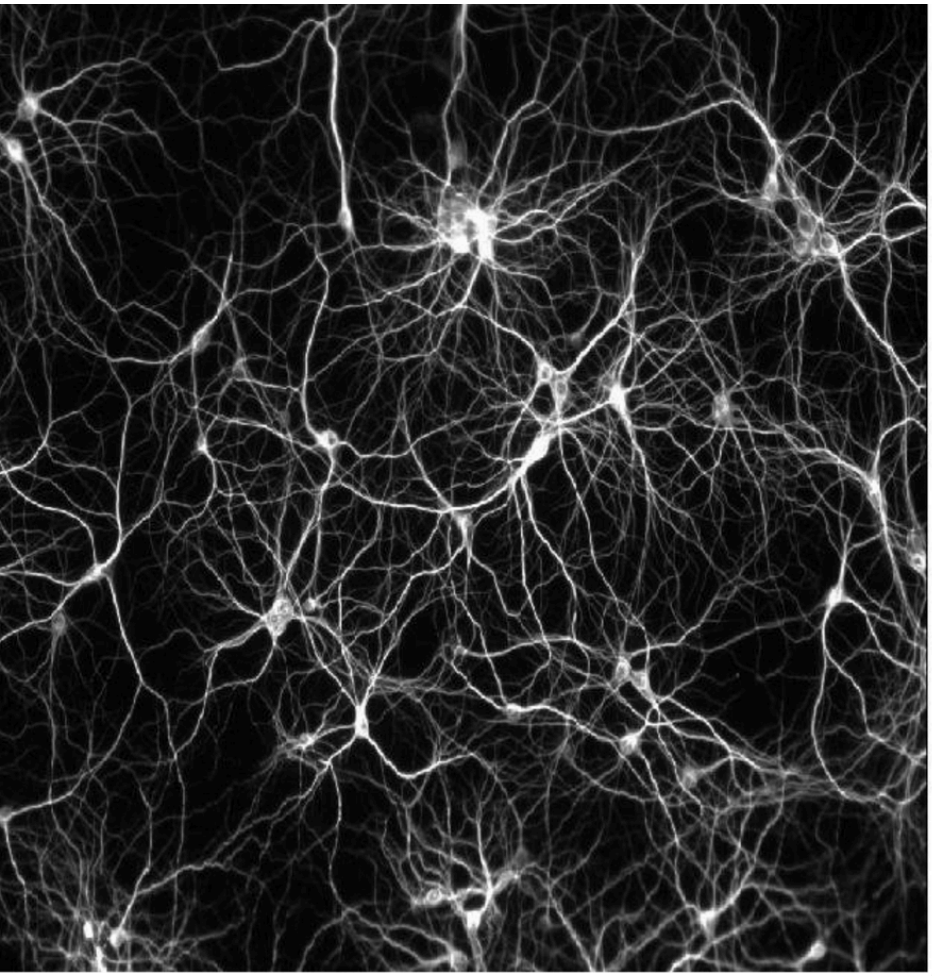



Axon
Terminal
Dendrite
Cell Body
(Soma)

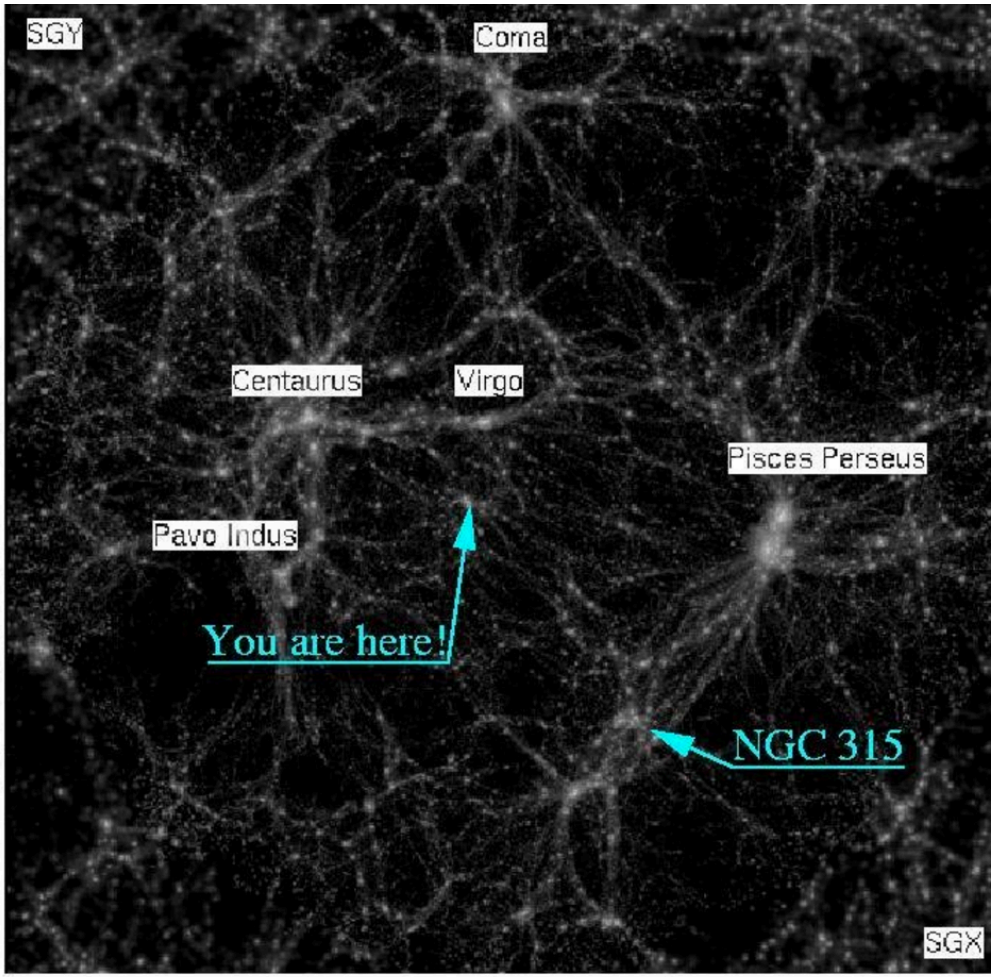

Neurotransmitter
released into synapse
Neurotransmitter
attached to receptor
Axon
Dendrite
Neurotransmitter
stored in vesicles
Enzyme that destroys
neurotransmitter


Neurotransmitter
Molecules
Receptor
Synapse

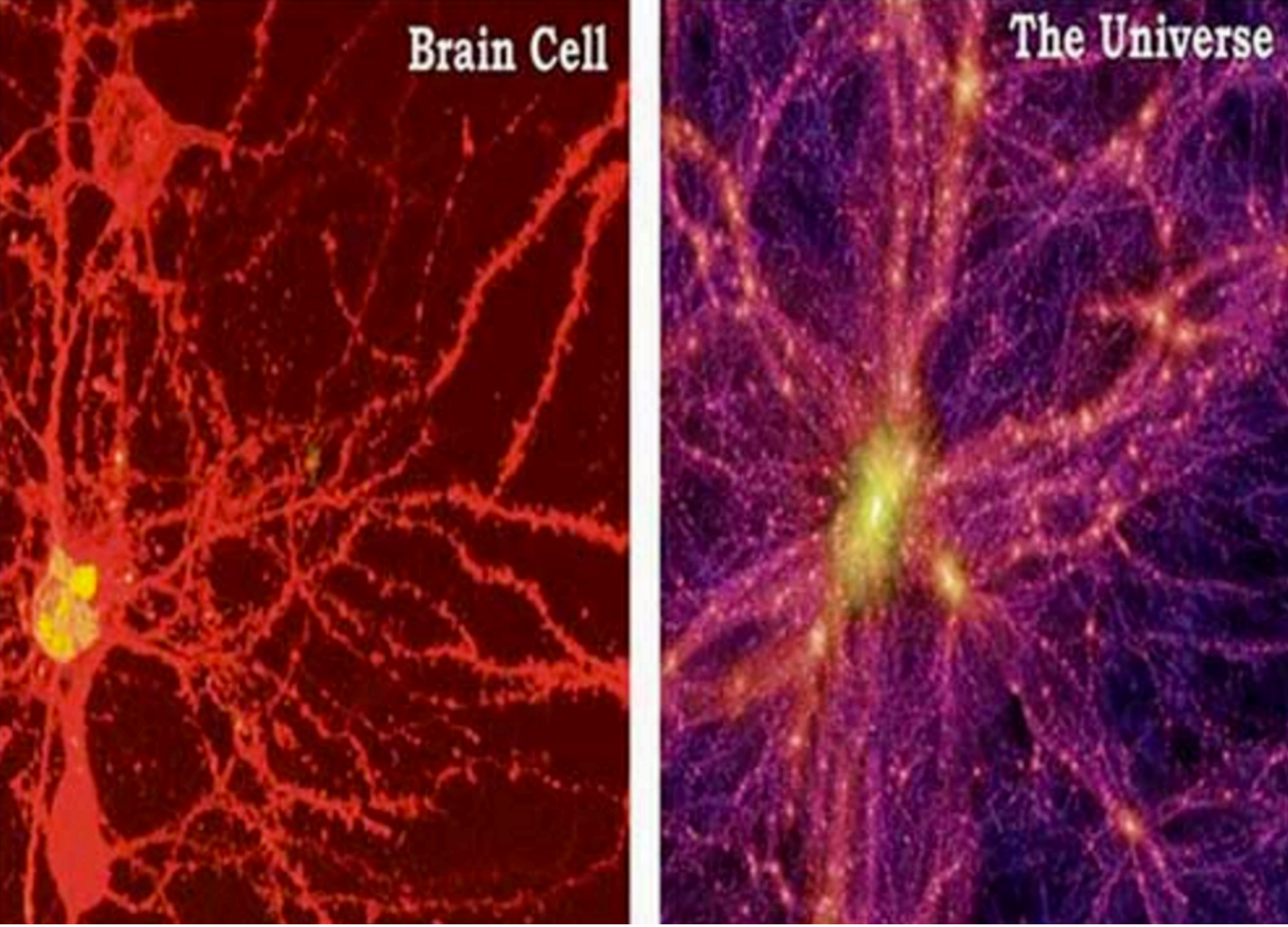

dendrites
cell body
cell B
synapse
nucleus
axon
cell A



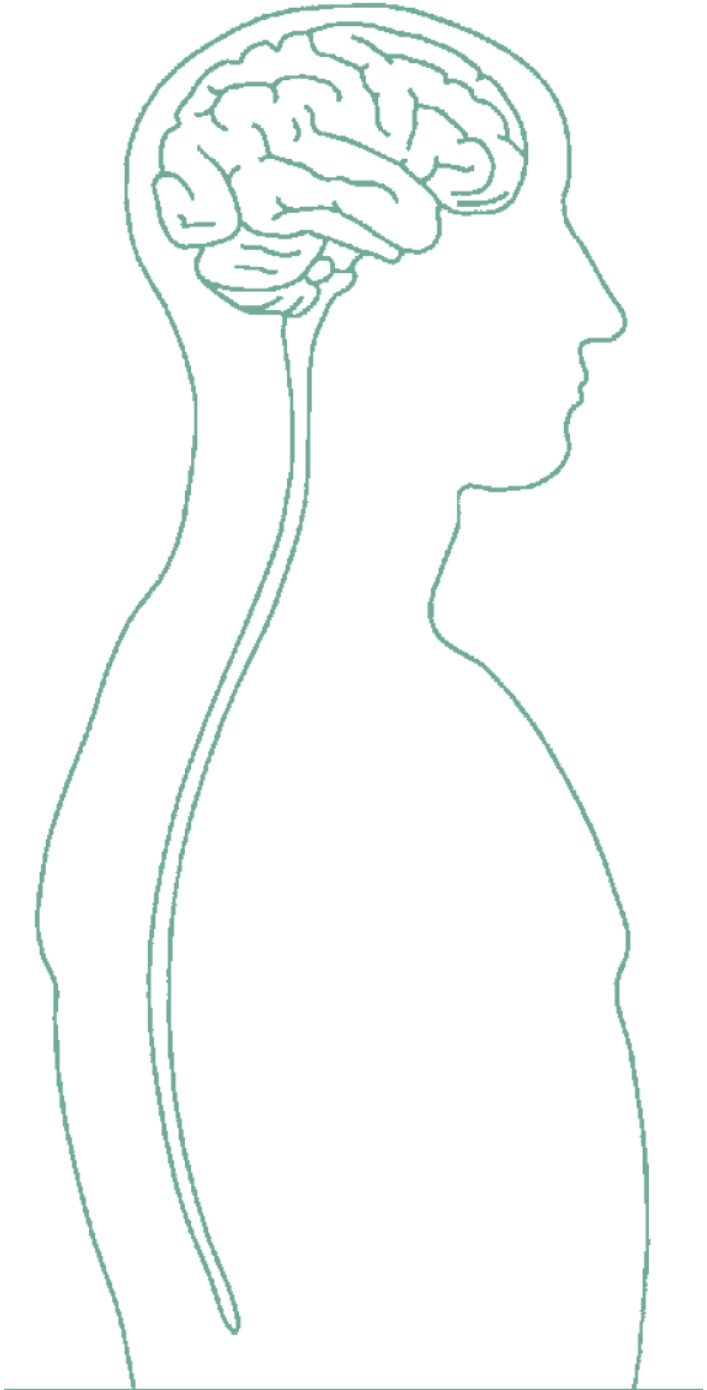
Neurons in the brain.



Galaxies in the Universe.


Brain Cell
The Universe


© 2015 Dawn Hardcastle



Nervous System:

-Brain, spinal cord & Peripheral Nerves

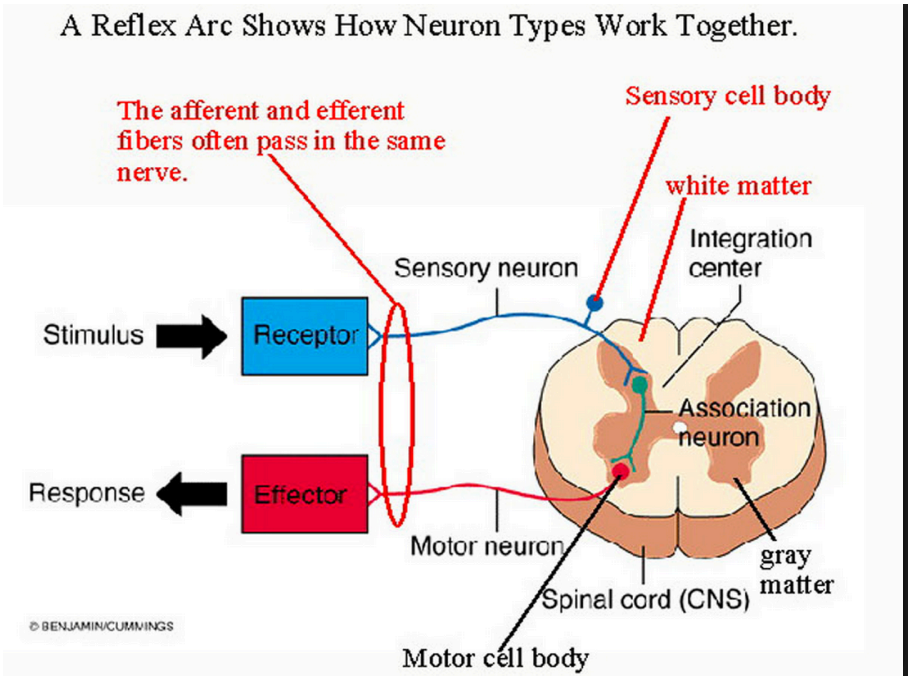
Made up of Neurons & supporting cells called glial cells

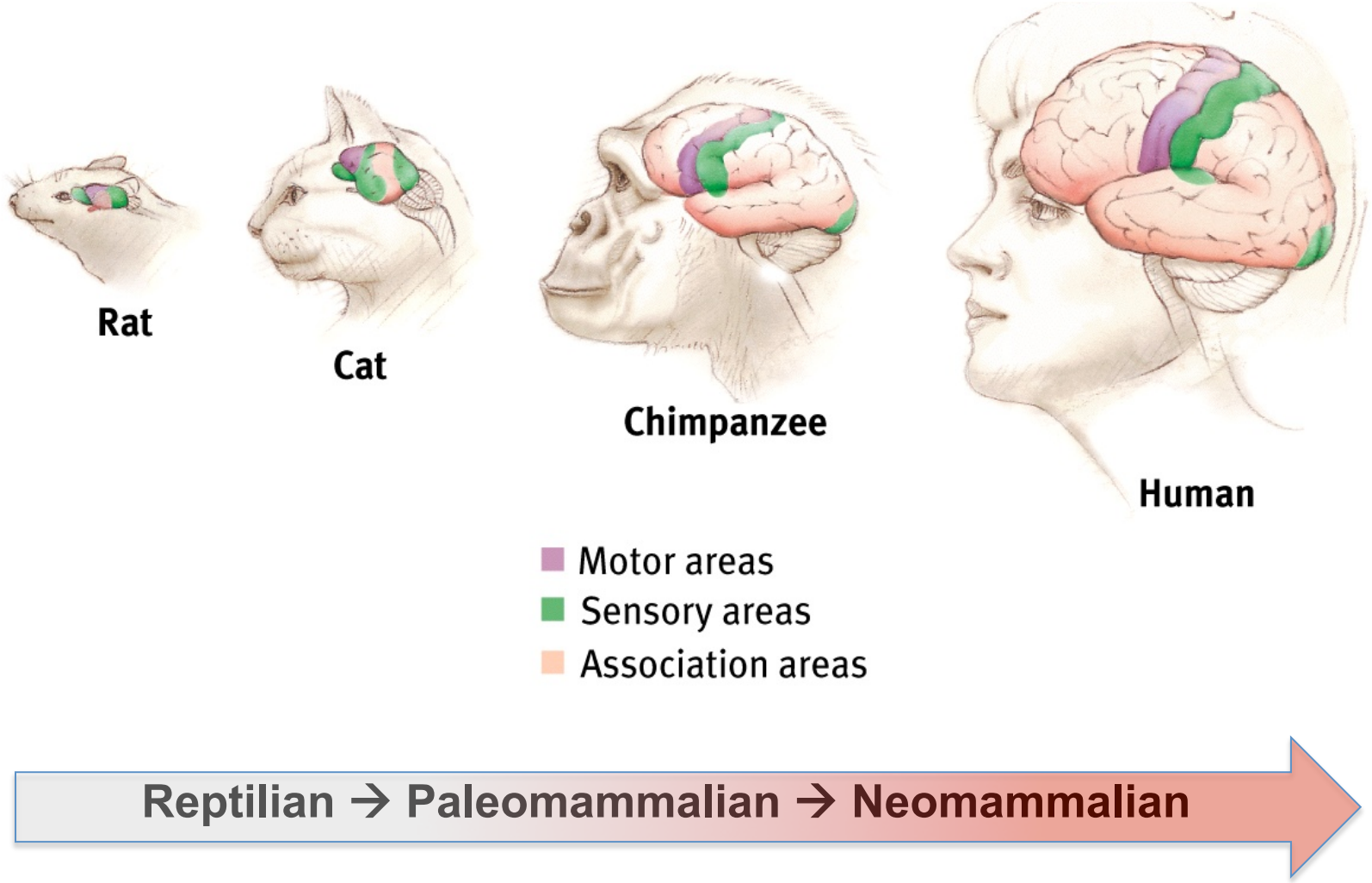
3 main kinds of Neuron

-Sensory

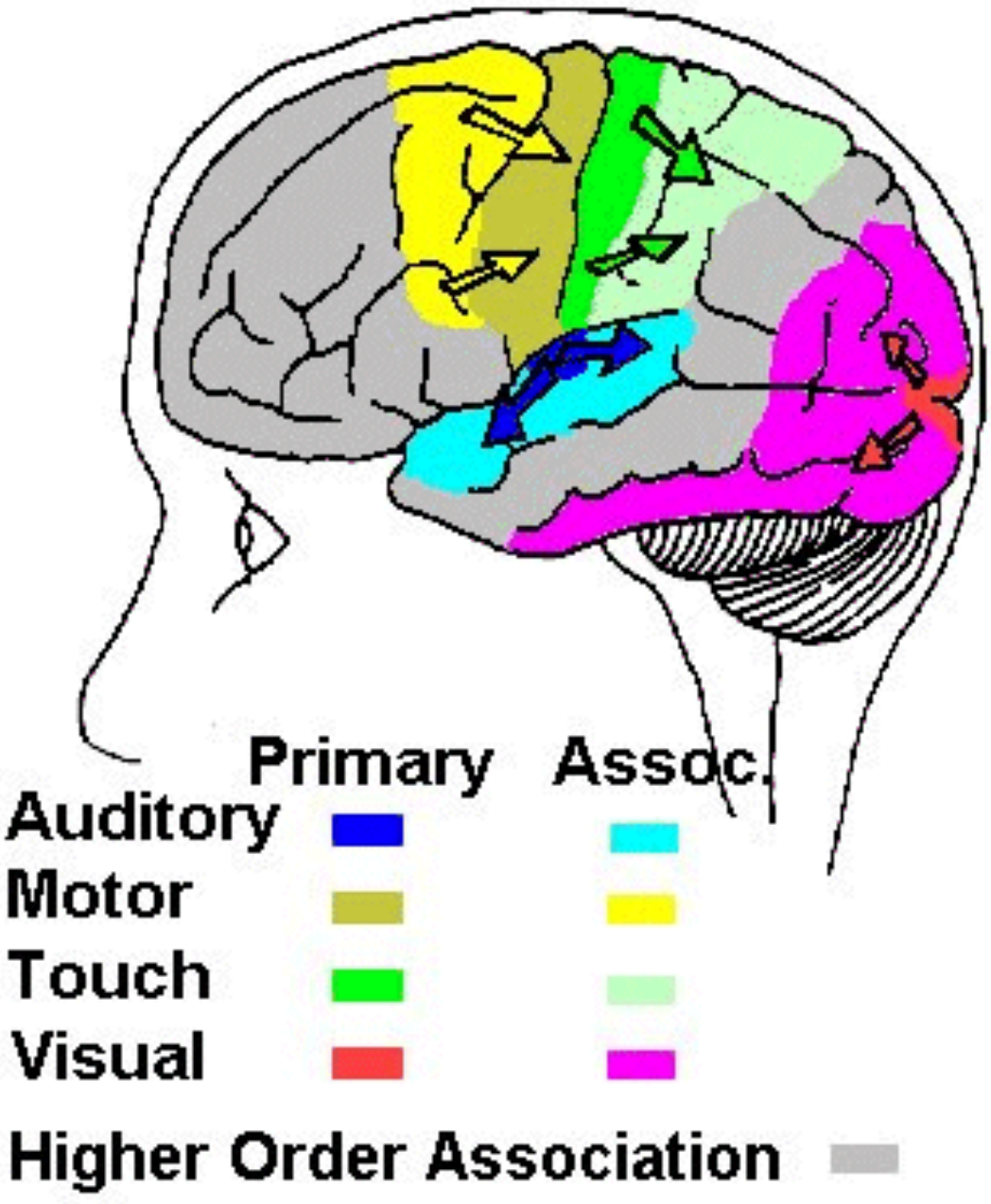
-Motor

-Interneurons





Reptilian → Paleomammalian → Neomammalian

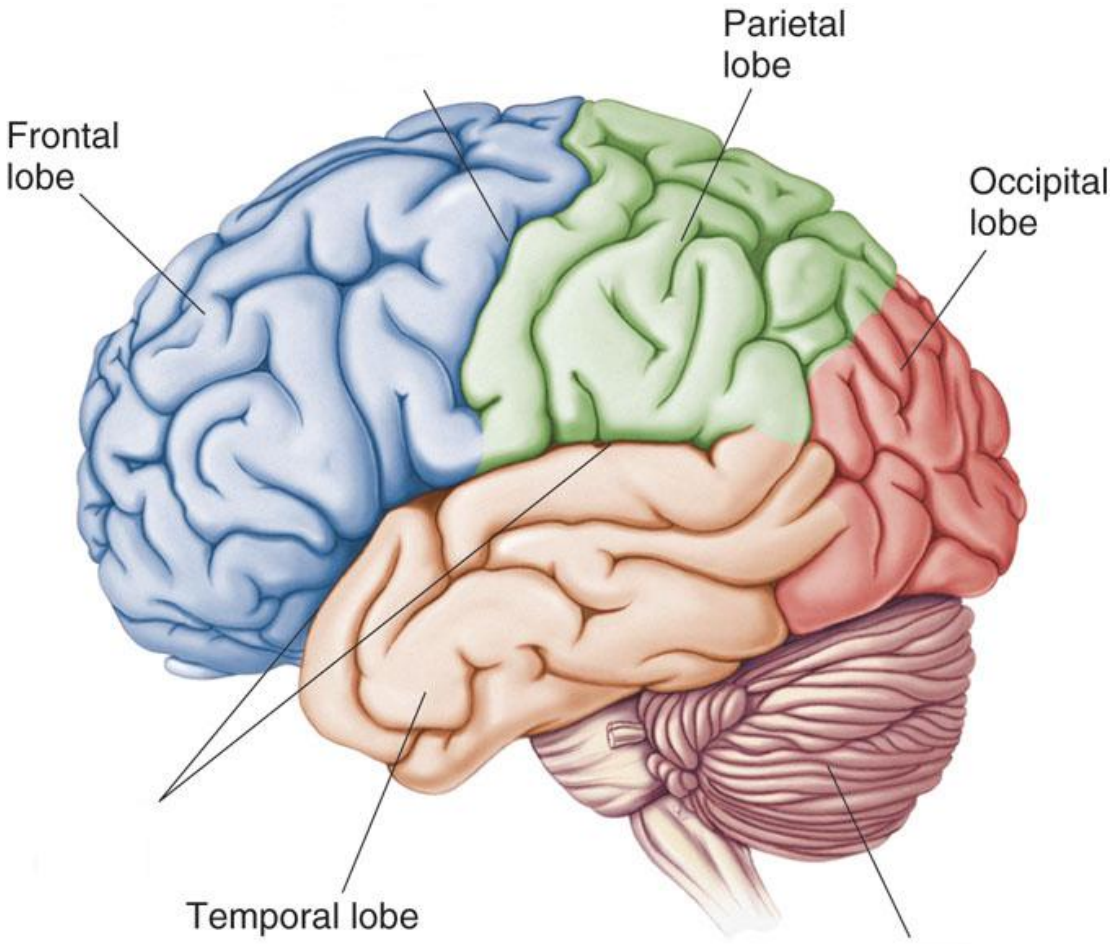

Primary
Assoc.
Auditory
Motor
Touch
Visual
Higher Order Association

Cerebrum -The largest division of the brain. It is divided into two hemispheres, each of which is divided into four lobes.

http://williamcalvin.com/BrainForAllSeasons/img/bonoboLH-humanLH-viaTWD.gif

Lobes of the Brain (4)

- Frontal
- Parietal
- Occipital
- Temporal



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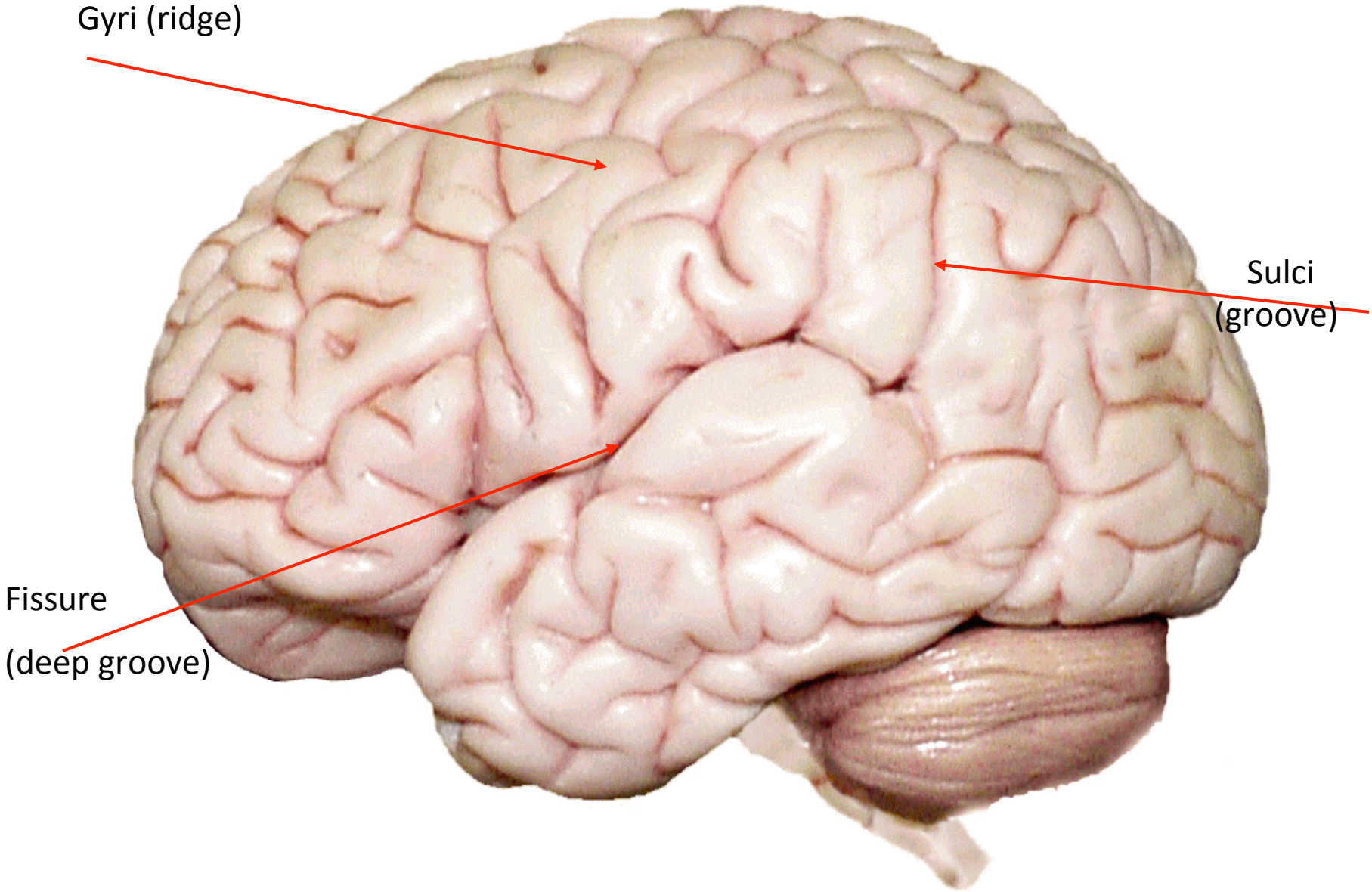
* Note: Occasionally, the Insula is considered the fifth lobe. It is located deep to the Temporal Lobe.



http://williamcalvin.com/BrainForAllSeasons/img/bonoboLH-humanLH-viaTWD.gif

Cerebral Features:

- **Gyri** – Elevated ridges "winding" around the brain.

- **Sulci** – Small grooves dividing the gyri

  – **Central Sulcus** – Divides the Frontal Lobe from the Parietal Lobe

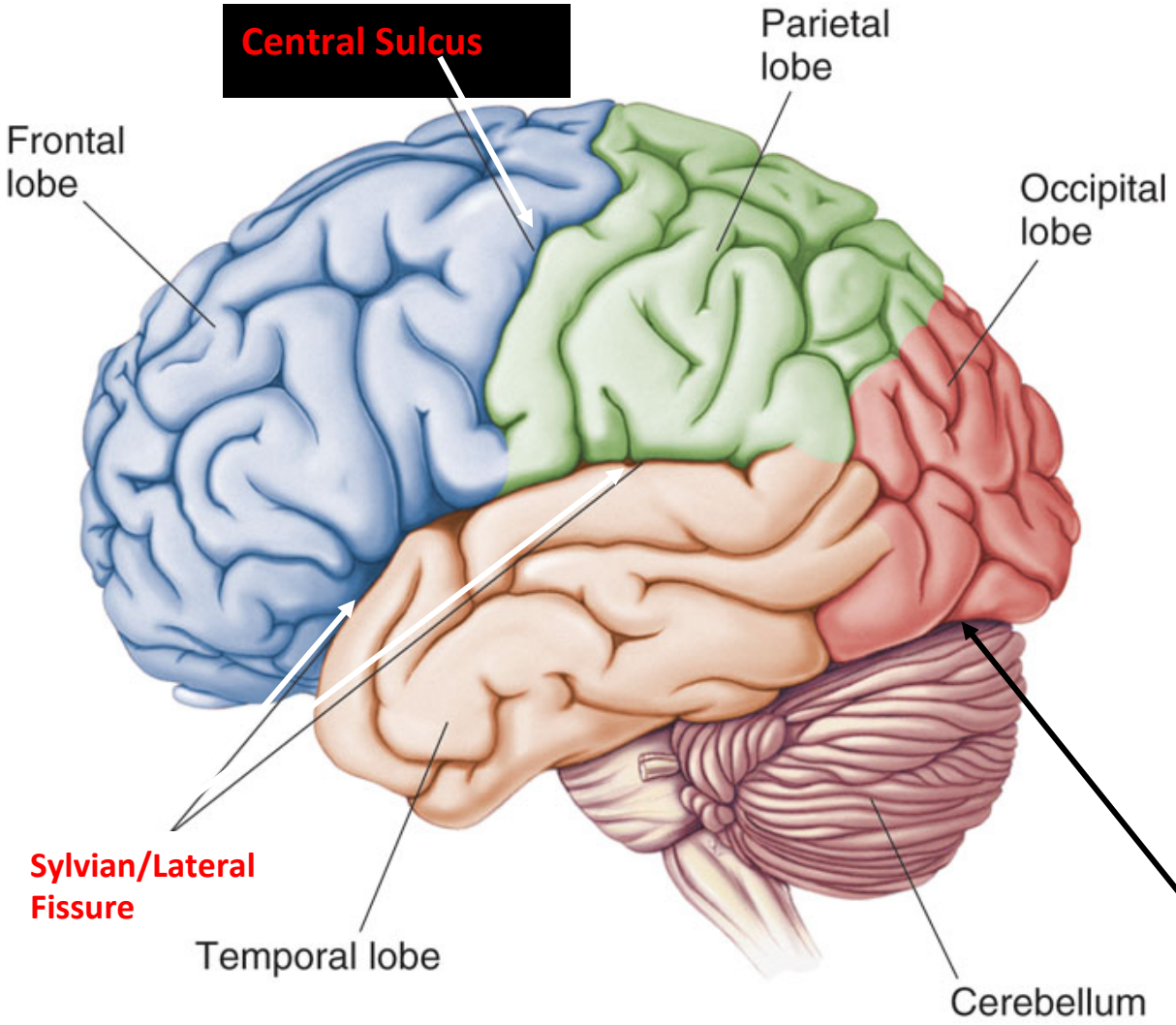
- **Fissures** – Deep grooves, generally dividing large regions/lobes of the brain

  – **Longitudinal Fissure** – Divides the two Cerebral Hemispheres

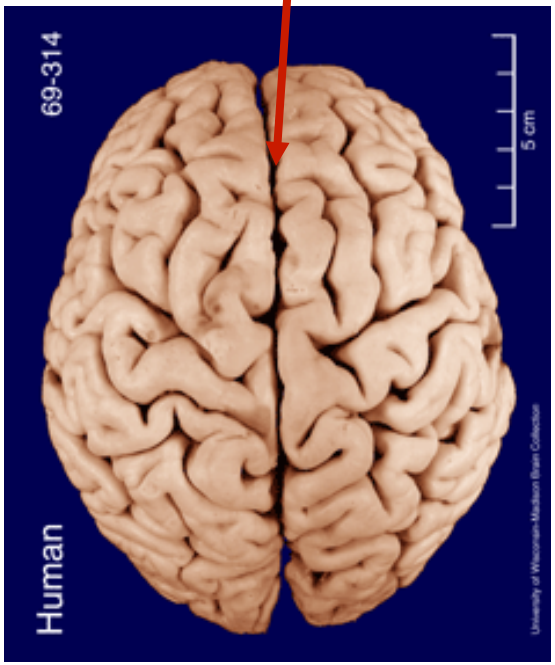
  – **Transverse Fissure** – Separates the Cerebrum from the Cerebellum

  – **Sylvian/Lateral Fissure** – Divides the Temporal Lobe from the Frontal and Parietal Lobes

Specific Sulci/Fissures:



Longitudinal Fissure



Transverse Fissure

http://www.bioon.com/book/biology/whole/image/1/1-8.tif.jpg

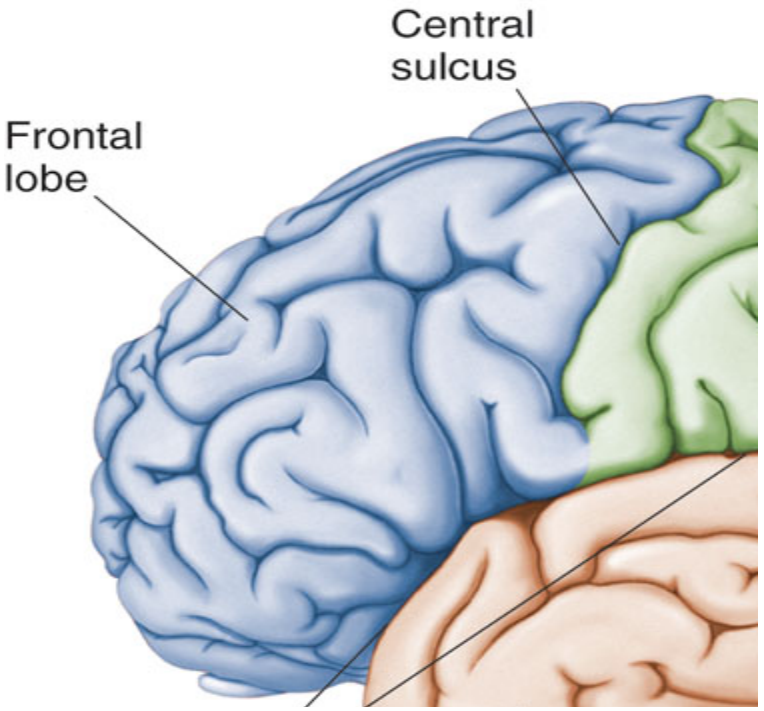
http://www.dalbsoutss.eq.edu.au/Sheepbrains_Me/human_brain.gi

Lobes of the Brain - Frontal

- The Frontal Lobe of the brain is located deep to the Frontal Bone of the skull.
- It plays an integral role in the following functions/actions:

  - Memory Formation
  - Emotions
  - Decision Making/Reasoning
  - Personality

Investigation (Phineas Gage)



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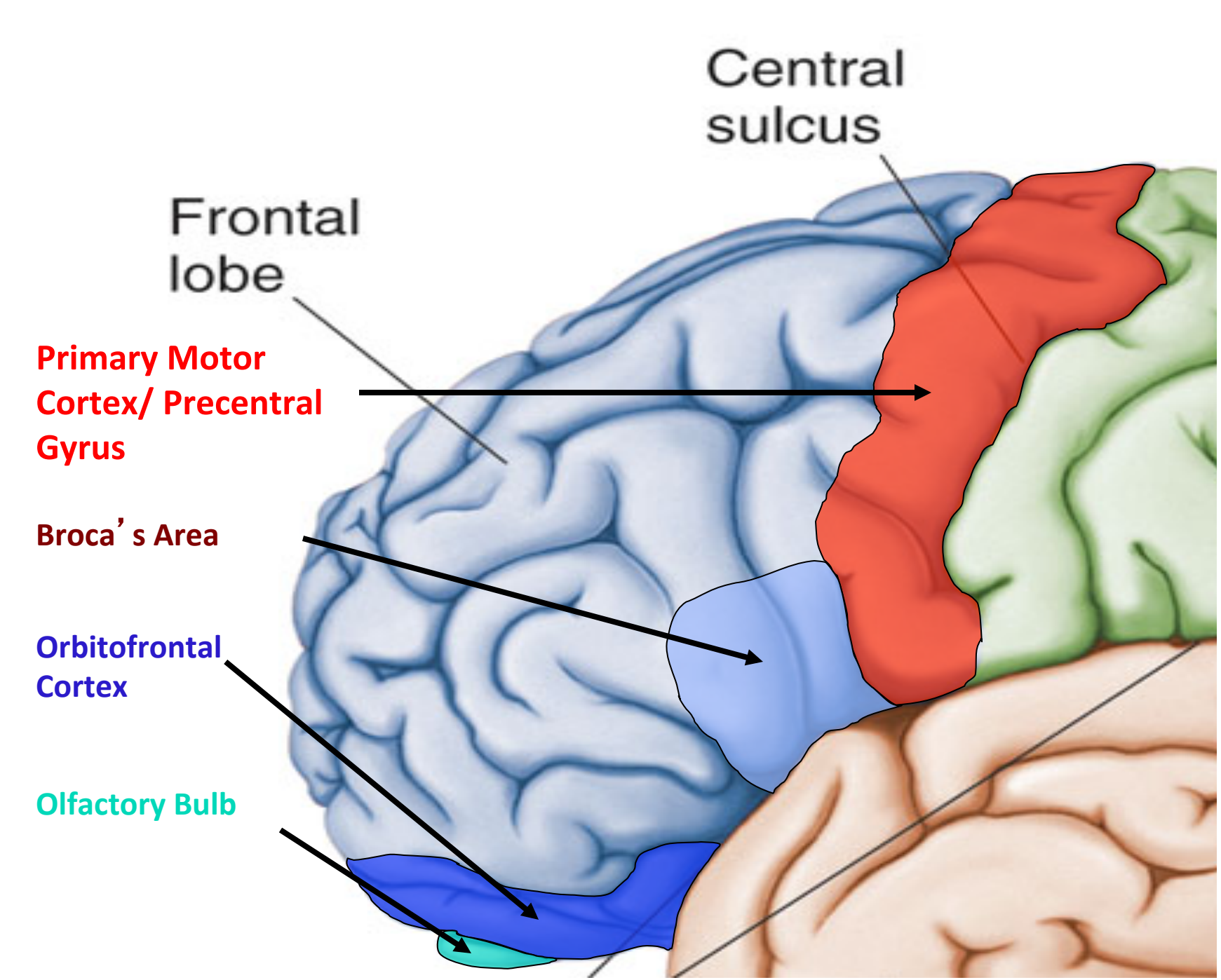

Regions

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Frontal Lobe - Cortical Regions

• **Primary Motor Cortex (Precentral Gyrus)** – Cortical site involved with controlling movements of the body.

• **Broca's Area** – Controls facial neurons, speech, and language comprehension. Located on ***Left*** Frontal Lobe.

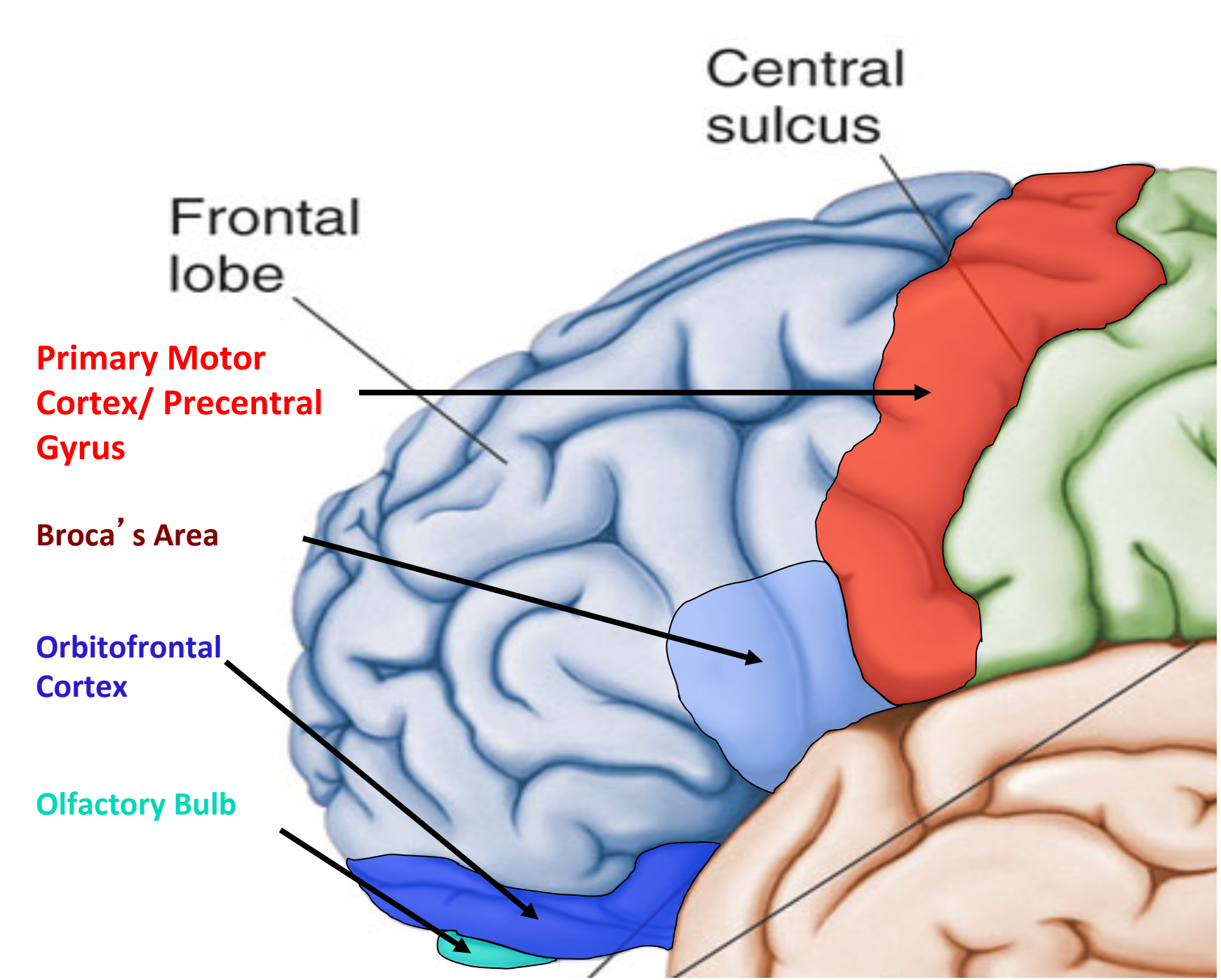
– **Broca's Aphasia** – Results in the ability to comprehend speech, but the decreased motor ability (or inability) to speak and form words.

• **Orbitofrontal Cortex** – Site of Frontal Lobotomies

* **Desired Effects:**
- Diminished Rage
- Decreased Aggression
- Poor Emotional Responses

* **Possible Side Effects:**
- Epilepsy
- Poor Emotional Responses
- Perseveration (Uncontrolled, repetitive actions, gestures, or words)

• **Olfactory Bulb** - Cranial Nerve I, Responsible for sensation of Smell



Regions

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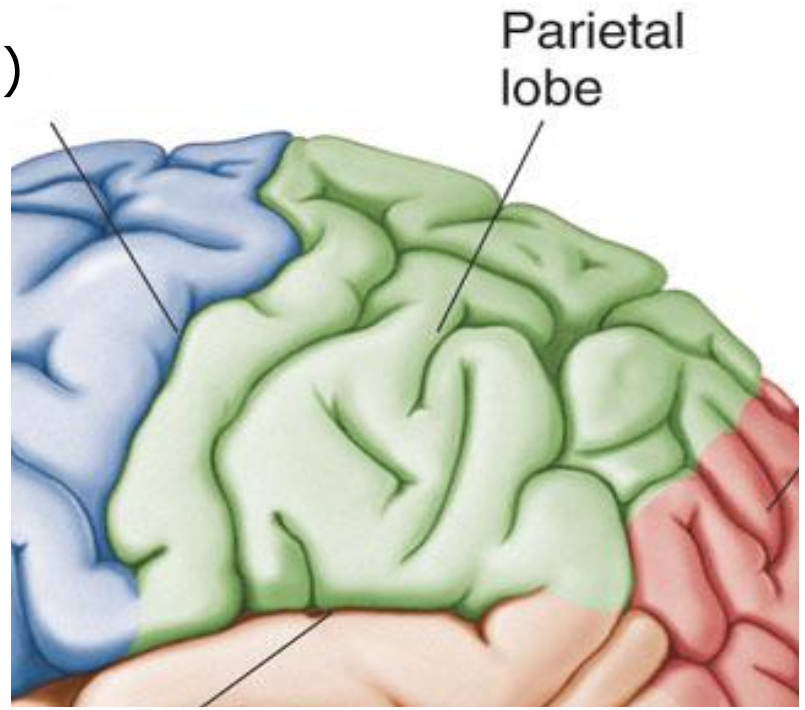
Lobes of the Brain - Parietal Lobe

- The Parietal Lobe of the brain is located deep to the Parietal Bone of the skull.

- It plays a major role in the following functions/actions:

  - Senses and integrates sensation(s)

  - Spatial awareness and perception (Proprioception - Awareness of body/ body parts in space and in relation to each other)



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Parietal Lobe - Cortical Regions

- **Primary Somatosensory Cortex (Postcentral Gyrus)** – Site involved with processing of tactile and proprioceptive information.

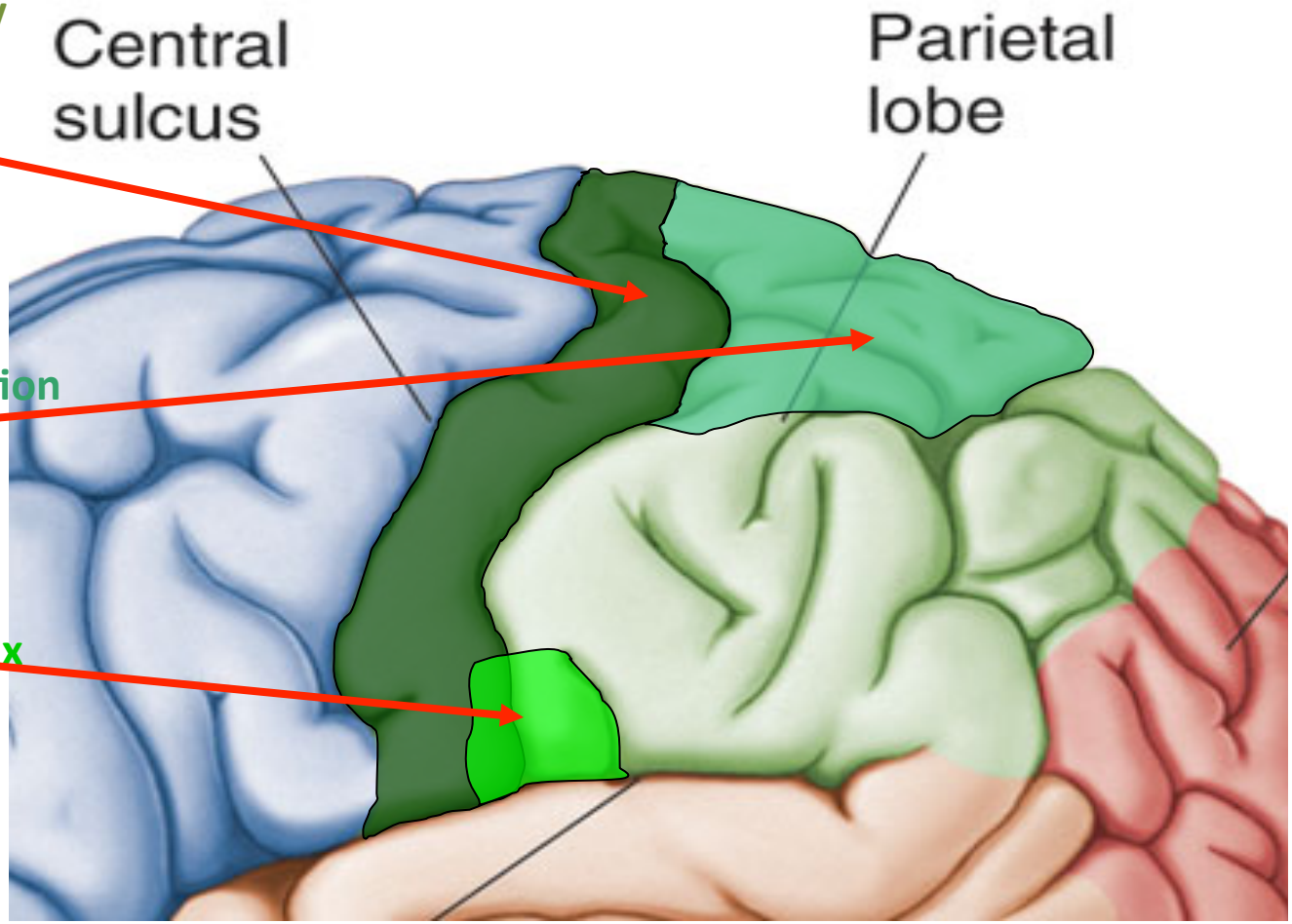
• **Somatosensory Association Cortex -** Assists with the integration and interpretation of sensations relative to body position and orientation in space. May assist with visuo-motor coordination.

• **Primary Gustatory Cortex** – Primary site involved with the interpretation of the sensation of Taste.

Primary Somatosensory Cortex/ Postcentral Gyrus

Somatosensory Association Cortex

Primary Gustatory Cortex



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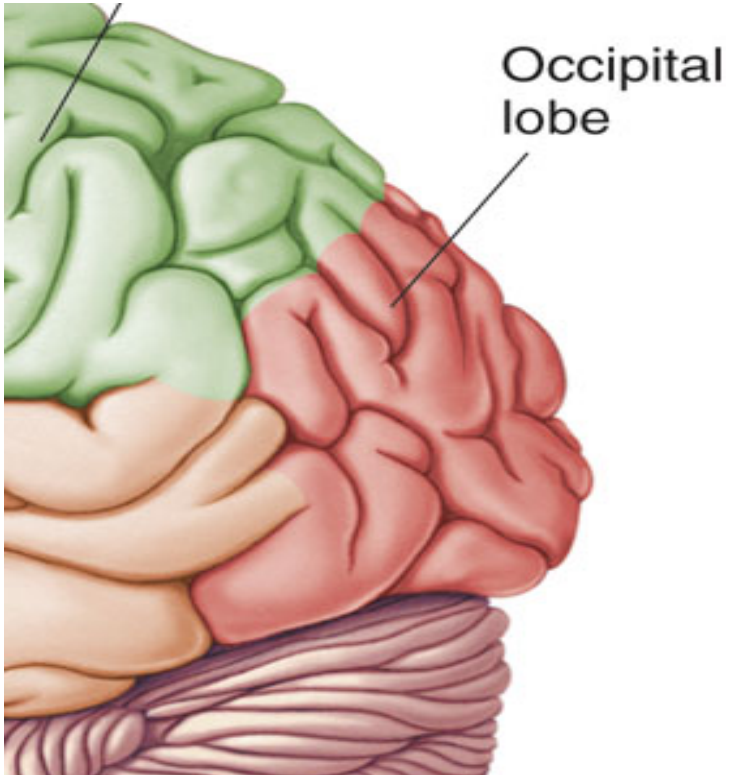
Regions

Lobes of the Brain – Occipital Lobe

- The Occipital Lobe of the Brain is located deep to the Occipital Bone of the Skull.
- Its primary function is the processing, integration, interpretation, etc. of VISION and visual stimuli.



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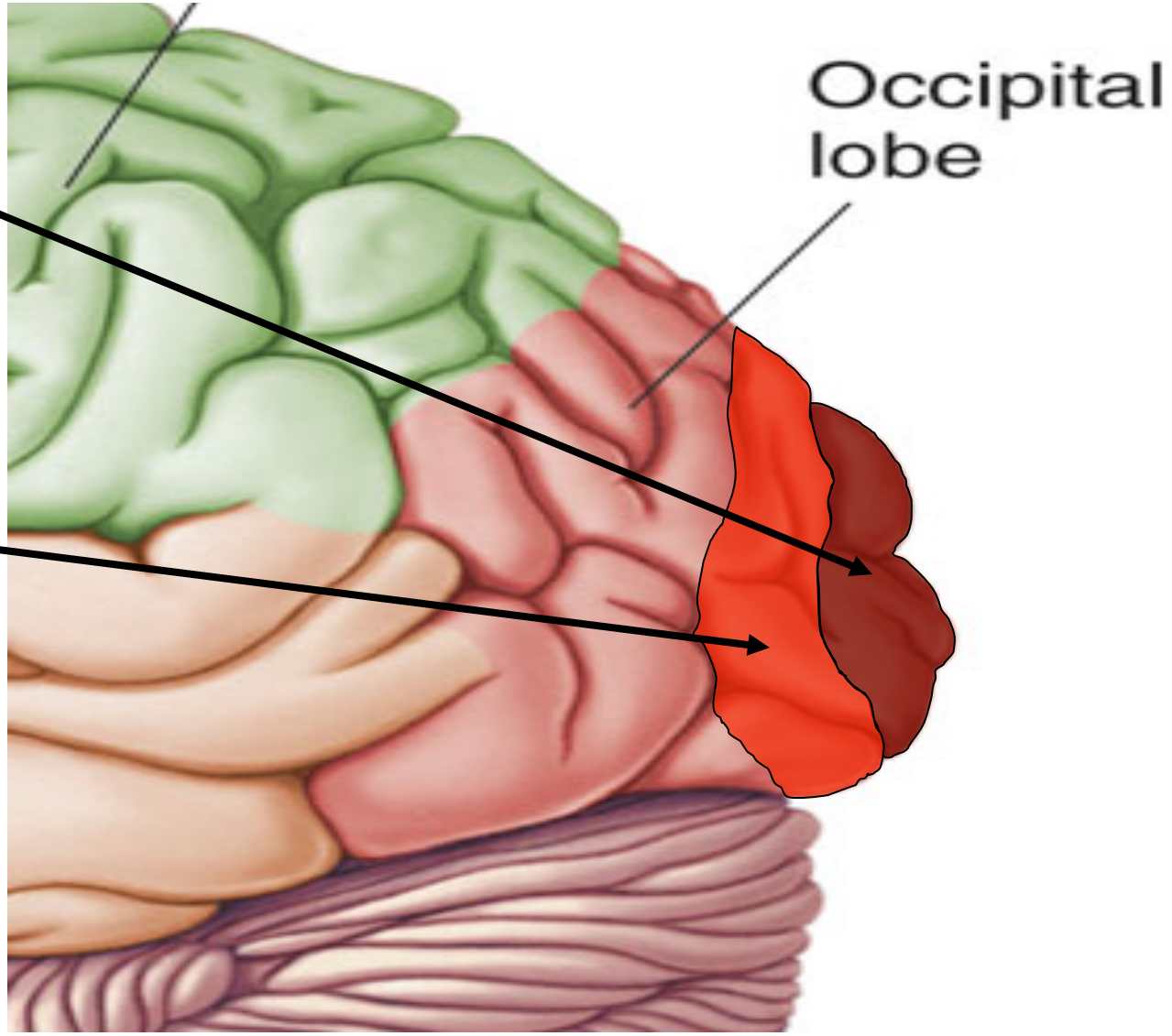
Occipital Lobe – Cortical Regions

- **Primary Visual Cortex** – This is the primary area of the brain responsible for sight - recognition of size, color, light, motion, dimensions, etc.

- **Visual Association Area** – Interprets information acquired through the primary visual cortex.

Primary Visual Cortex

Visual Association Area



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Lobes of the Brain – Temporal Lobe

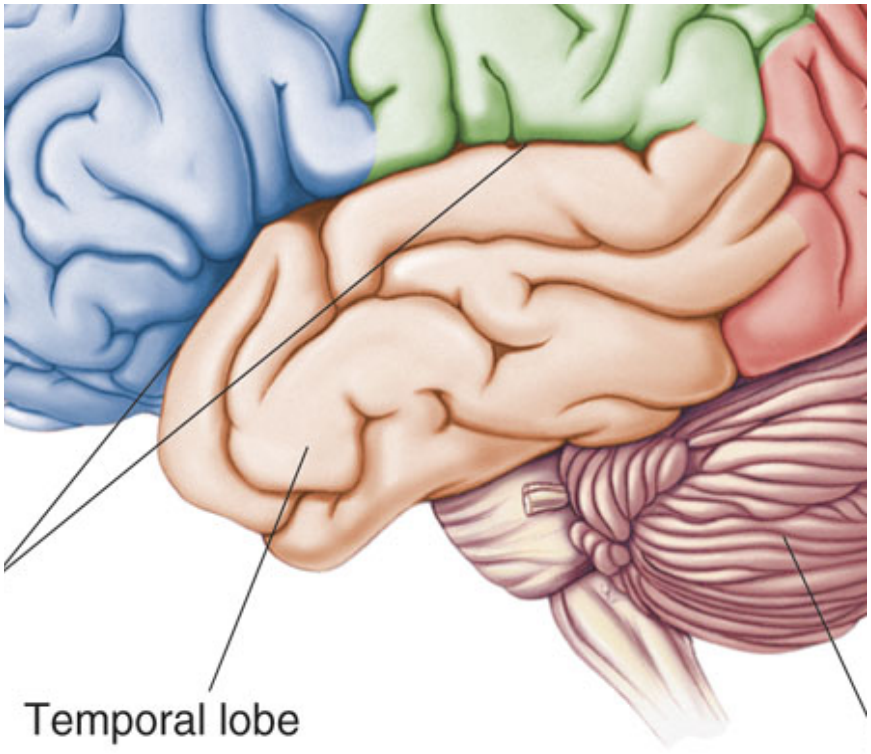
- The Temporal Lobes are located on the sides of the brain, deep to the Temporal Bones of the skull.

- They play an integral role in the following functions:

  - Hearing

  - Organization/Comprehension of language

  - Information Retrieval (Memory and Memory Formation)



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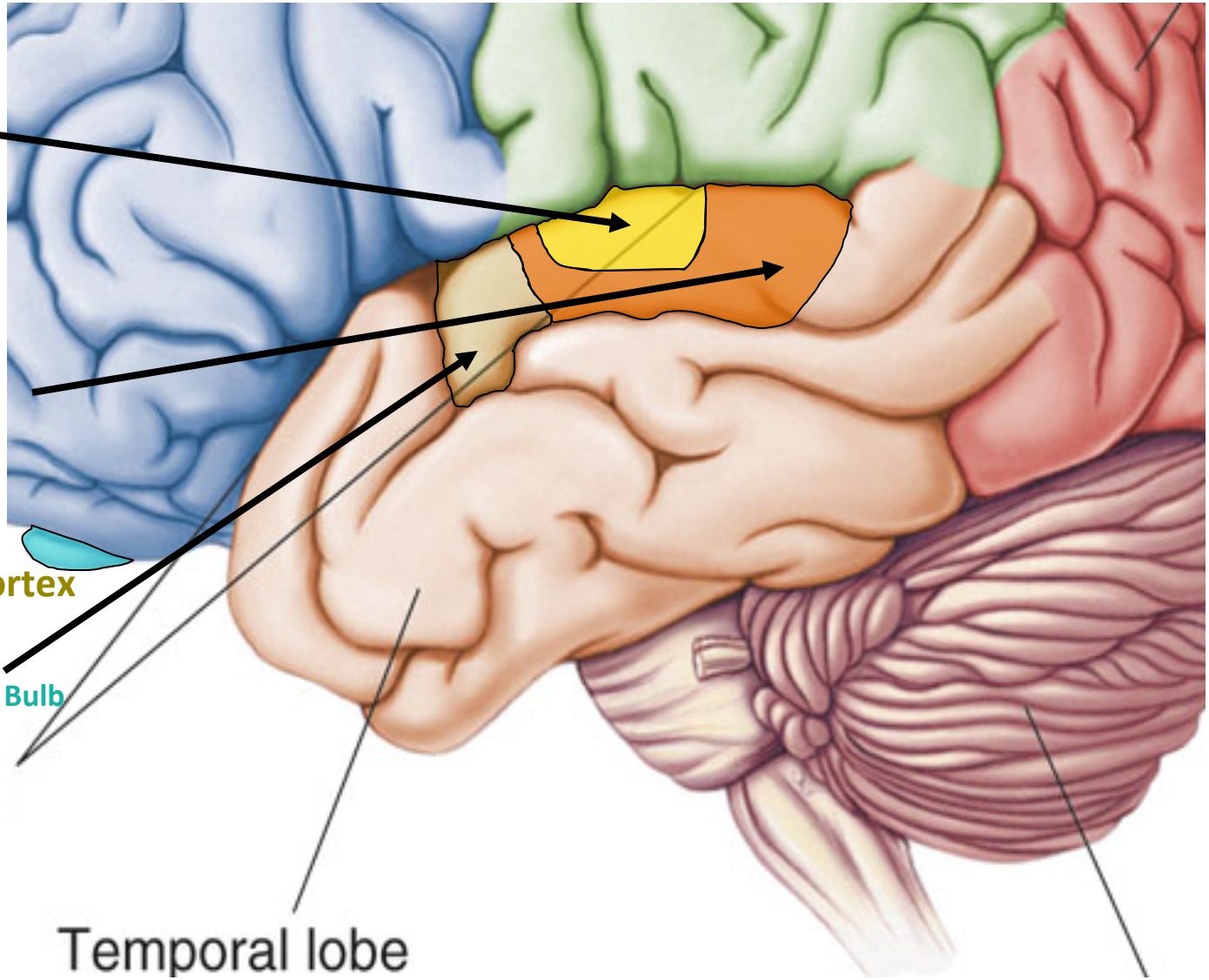
Temporal Lobe – Cortical Regions

- **Primary Auditory Cortex** – Responsible for hearing

- **Primary Olfactory Cortex** – Interprets the sense of smell once it reaches the cortex via the olfactory bulbs. (Not visible on the superficial cortex)

- **Wernicke's Area** – Language comprehension. Located on the ***Left*** Temporal Lobe.

  - Wernicke's Aphasia – Language comprehension is inhibited. Words and sentences are not clearly understood, and sentence formation may be inhibited or non-sensical.



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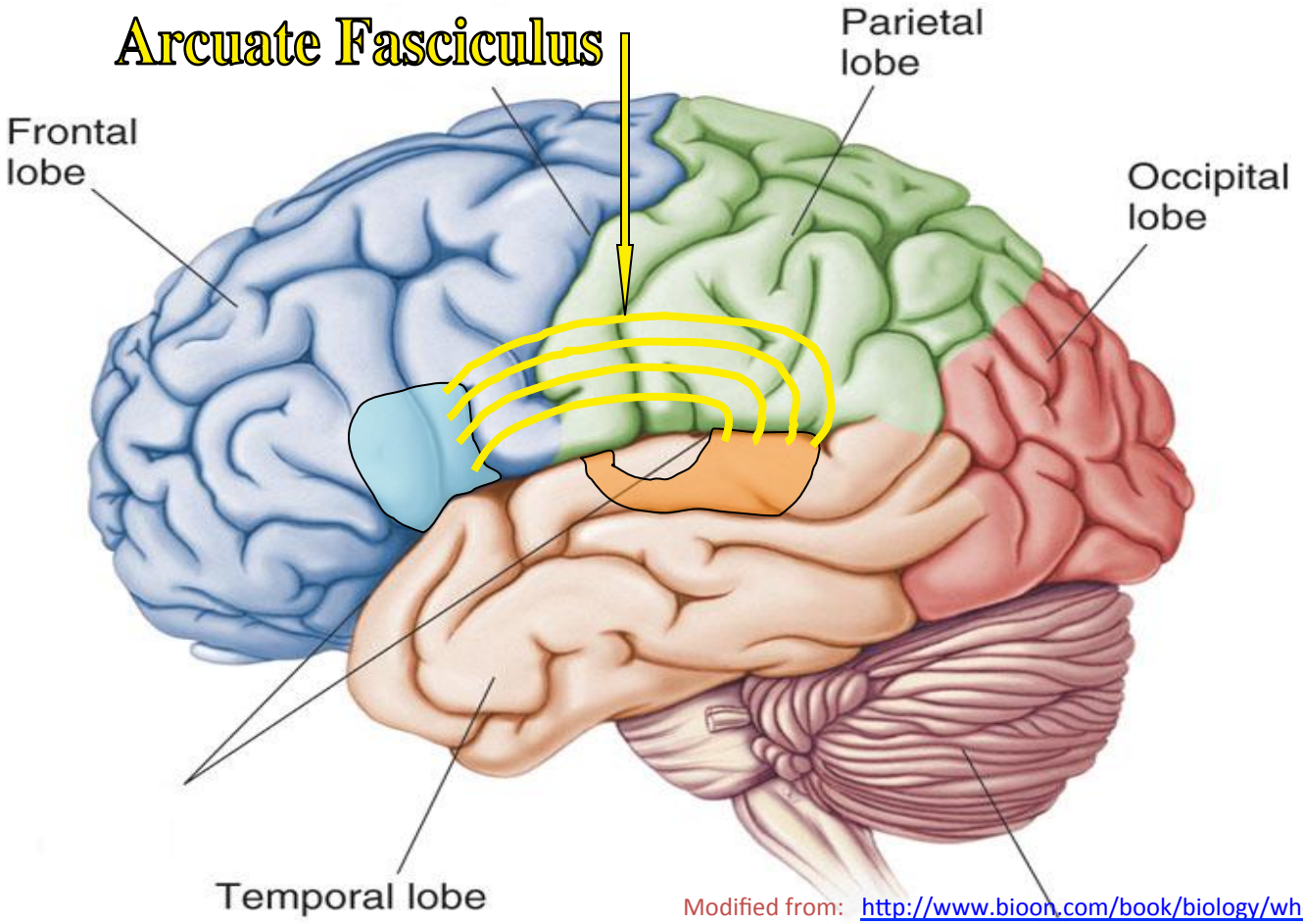
Regions

- **Arcuate Fasciculus** - A white matter tract that connects Broca's Area and Wernicke's Area through the Temporal, Parietal and Frontal Lobes. Allows for coordinated, comprehensible speech. Damage may result in:

- **Conduction Aphasia** - Where auditory comprehension and speech articulation are preserved, but people find it difficult to repeat heard speech.



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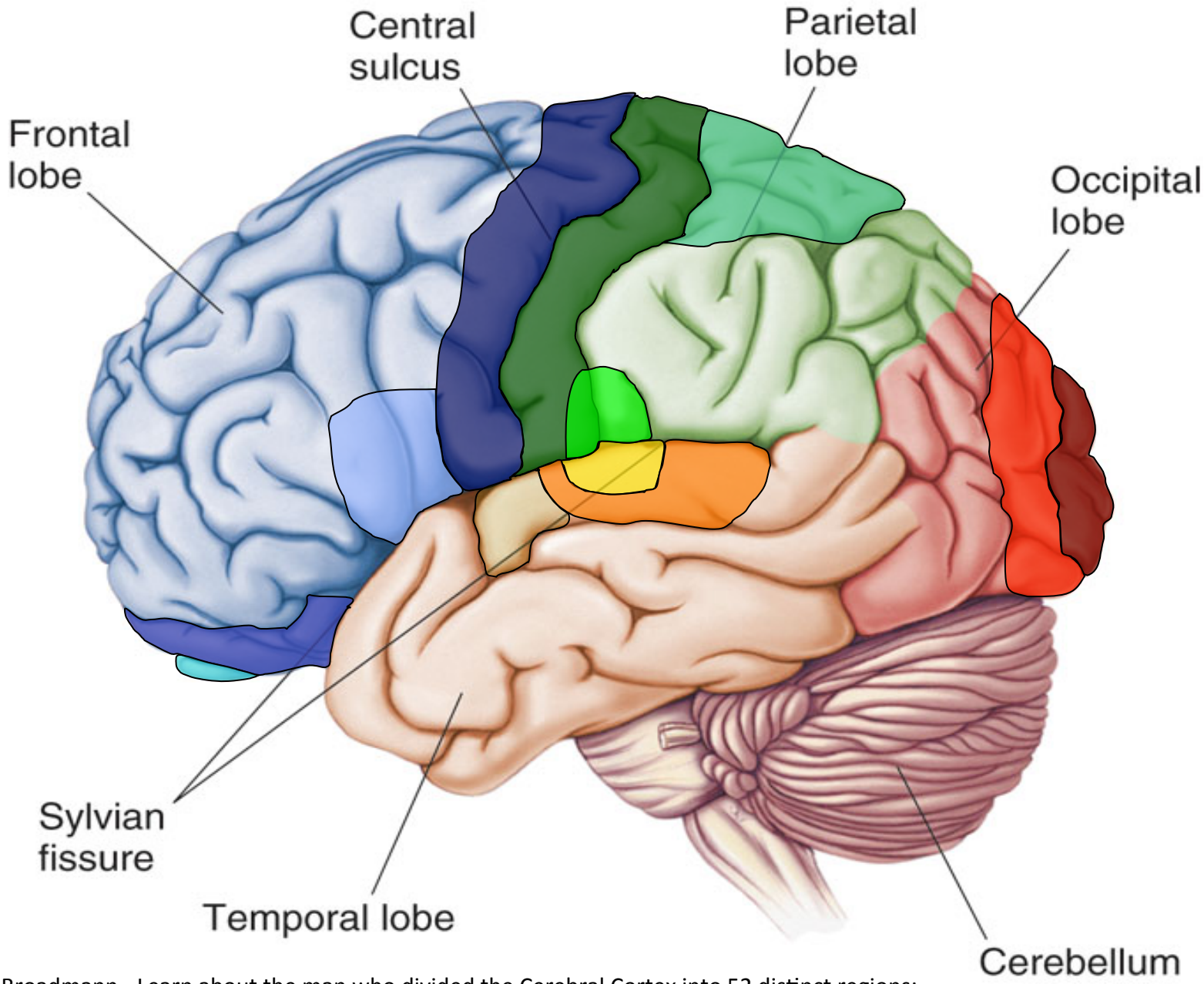

Korbinian Broadmann - Learn about the man who divided the Cerebral Cortex into 52 distinct regions:
http://en.wikipedia.org/wiki/Korbinian_Brodmann

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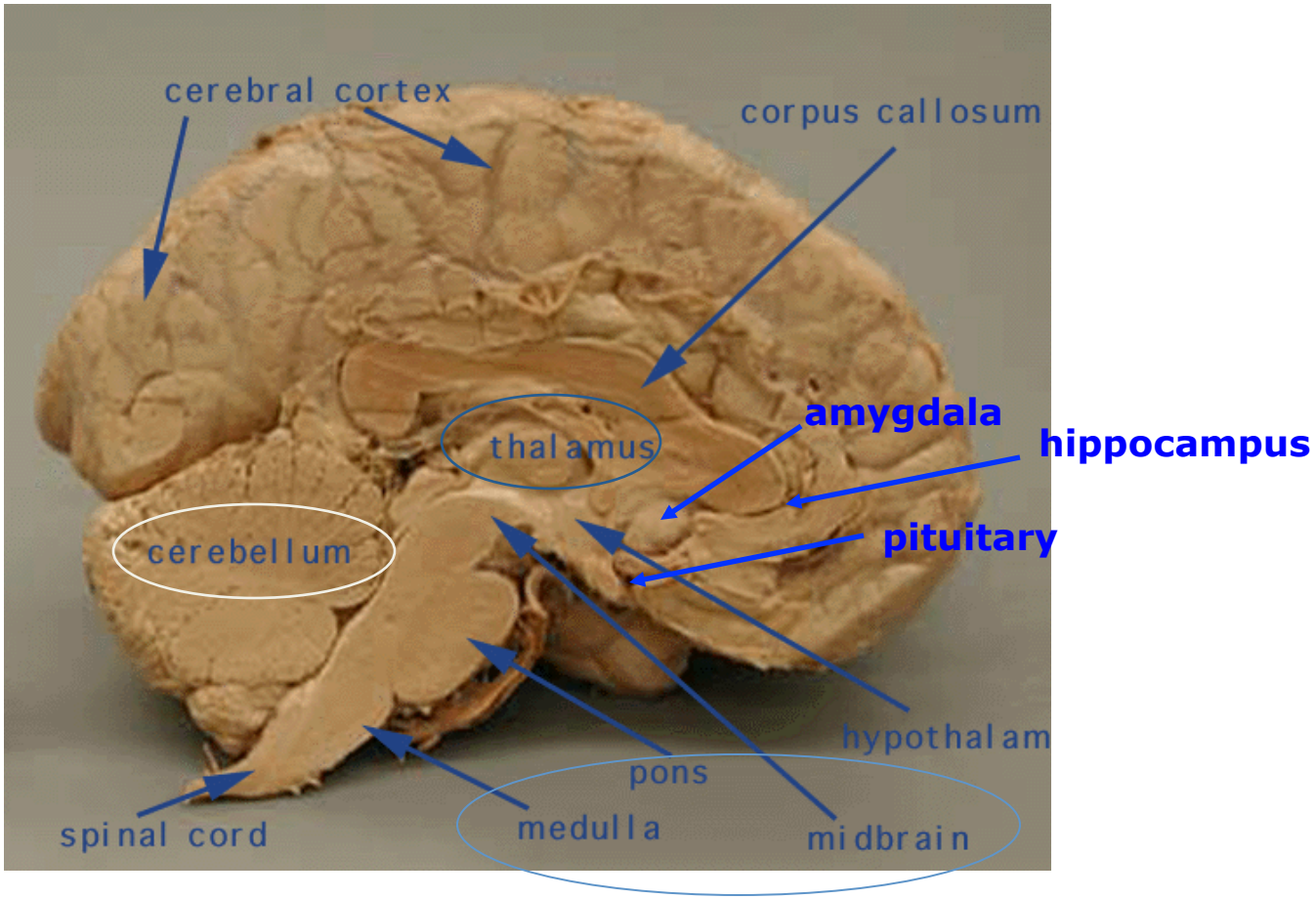
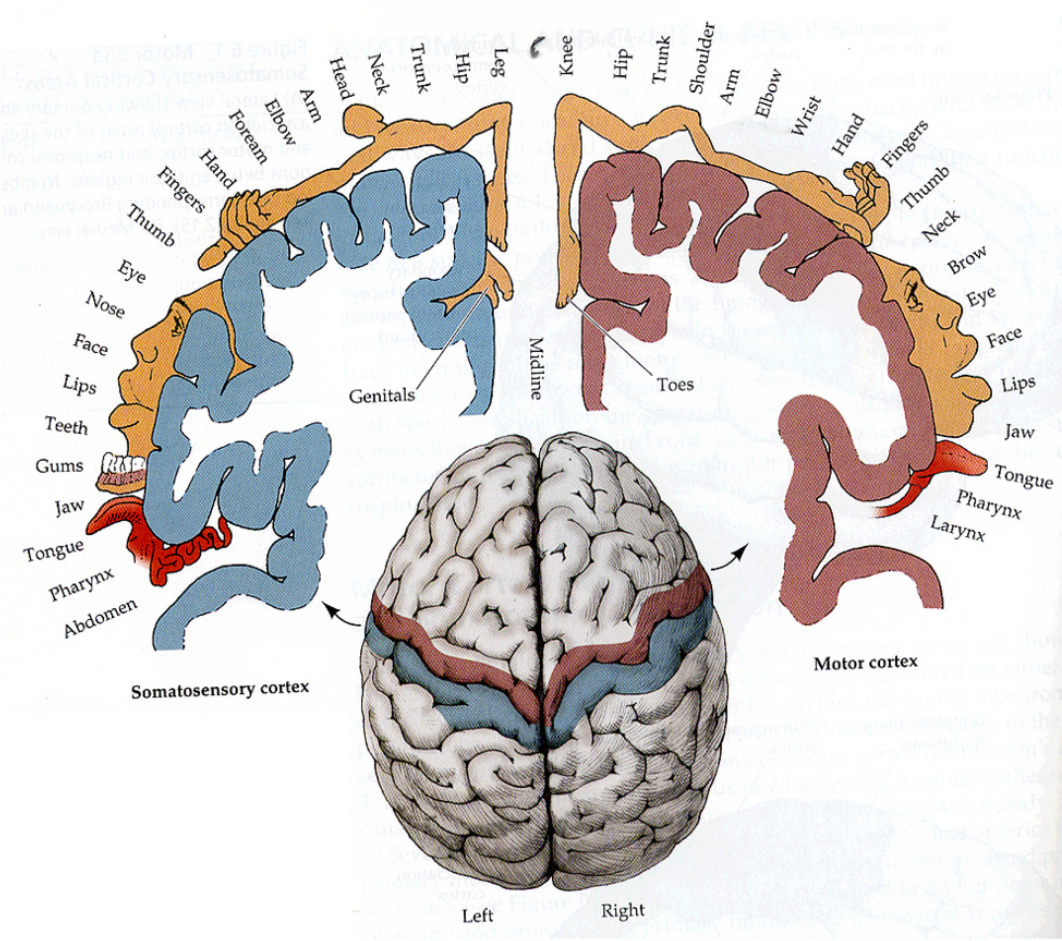
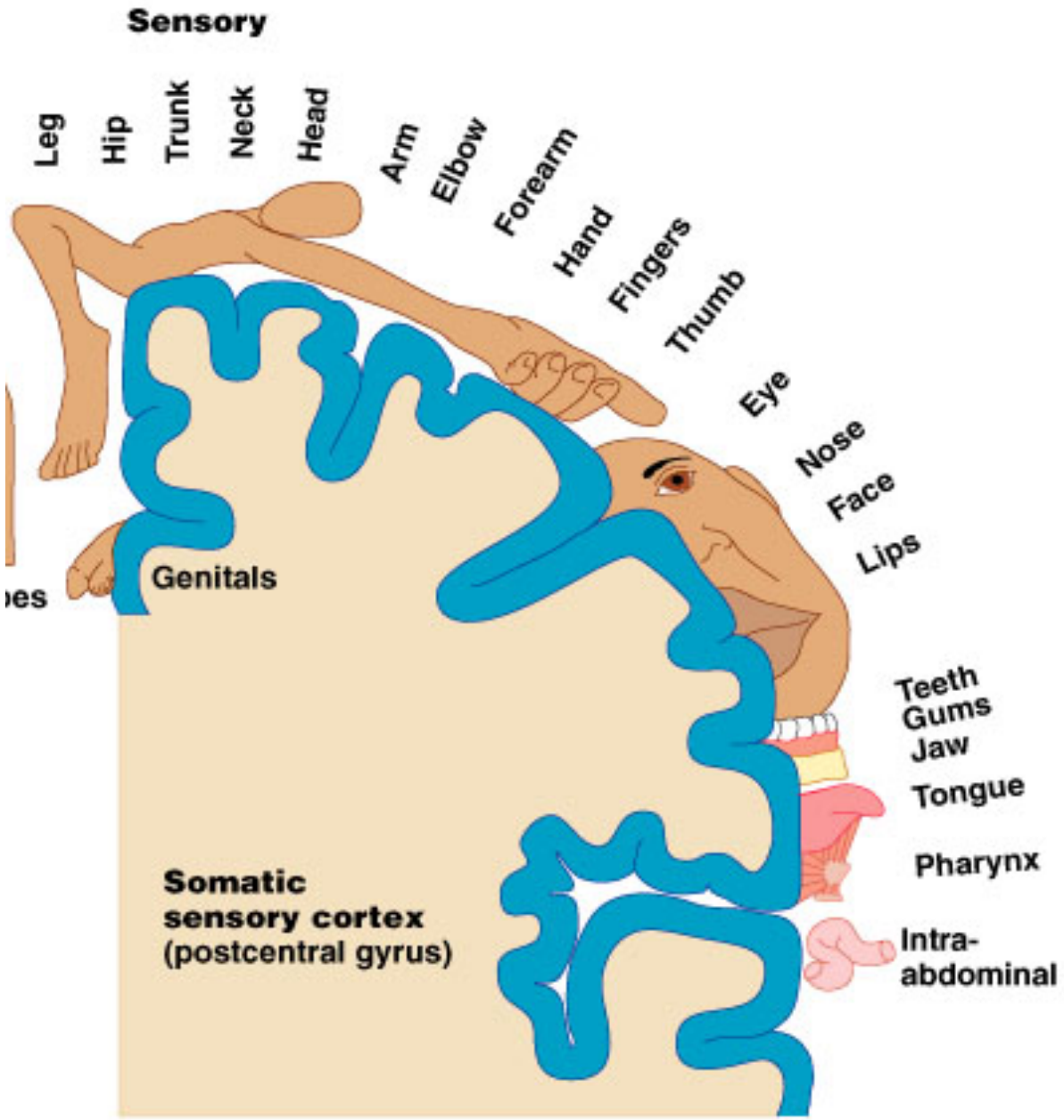

cerebral cortex
corpus callosum
thalamus
amygdala
hippocampus
cerebellum
pituitary
hypothalam
pons
spinal cord
medulla
midbrain


Leg
Hip
Trunk
Neck
Head
Arm
Elbow
Forearm
Hand
Fingers
Thumb
Eye
Nose
Face
Lips
Teeth
Gums
Jaw
Tongue
Pharynx
Abdomen
Genitals
Somatosensory cortex
Knee
Hip
Trunk
Shoulder
Arm
Elbow
Wrist
Hand
Fingers
Thumb
Neck
Brow
Eye
Face
Lips
Jaw
Tongue
Pharynx
Larynx
Midline
Toes
Motor cortex
Left
Right


Sensory
Leg
Hip
Trunk
Neck
Head
Arm
Elbow
Forearm
Hand
Fingers
Thumb
Eye
Nose
Face
Lips
Genitals
Teeth
Gums
Jaw
Tongue
Pharynx
Intra-
abdominal
Somatic
sensory cortex
(postcentral gyrus)

	processing elements	element size	energy use	processing speed	style of computation	fault tolerant	learns	intelligent, conscious
	10^{14} synapses	10^{-6} m	30 W	100 Hz	parallel, distributed	yes	yes	usually
	10^{8} transistors	10^{-6} m	30 W (CPU)	10^{9} Hz	serial, centralized	no	a little	not (yet)

A. Primary Motor Cortex/ Precentral Gyrus

B. Broca's Area

C. Orbitofrontal Cortex

D. Primary Olfactory Cortex (Deep)

E. Primary Auditory Cortex

F. Wernike's Area

G. Primary Visual Cortex

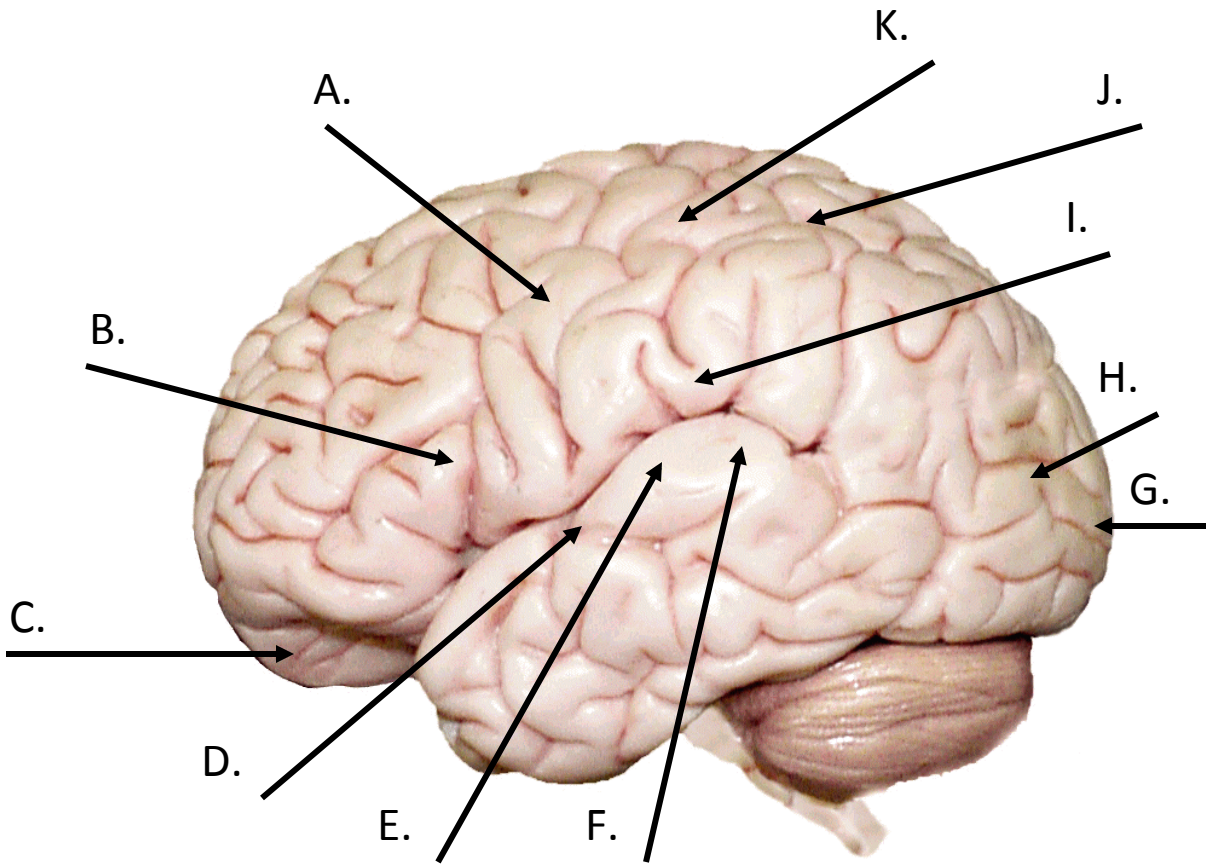
H. Visual Association Area

I. Primary Gustatory Cortex

J. Somatosensory Association Cortex

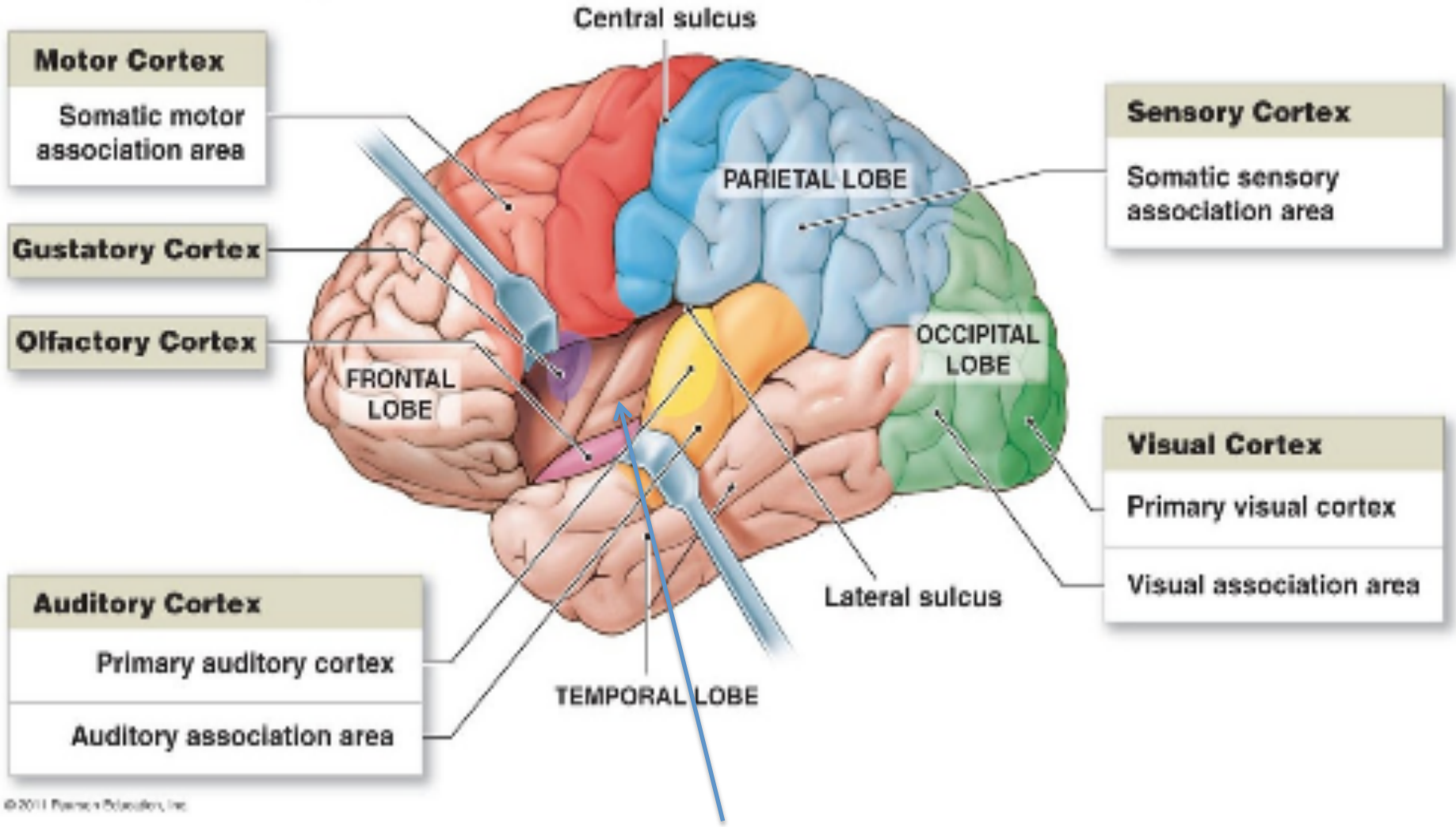
K. Primary Somatosensory Cortex/ Postcentral Gyrus

Cortical Regions

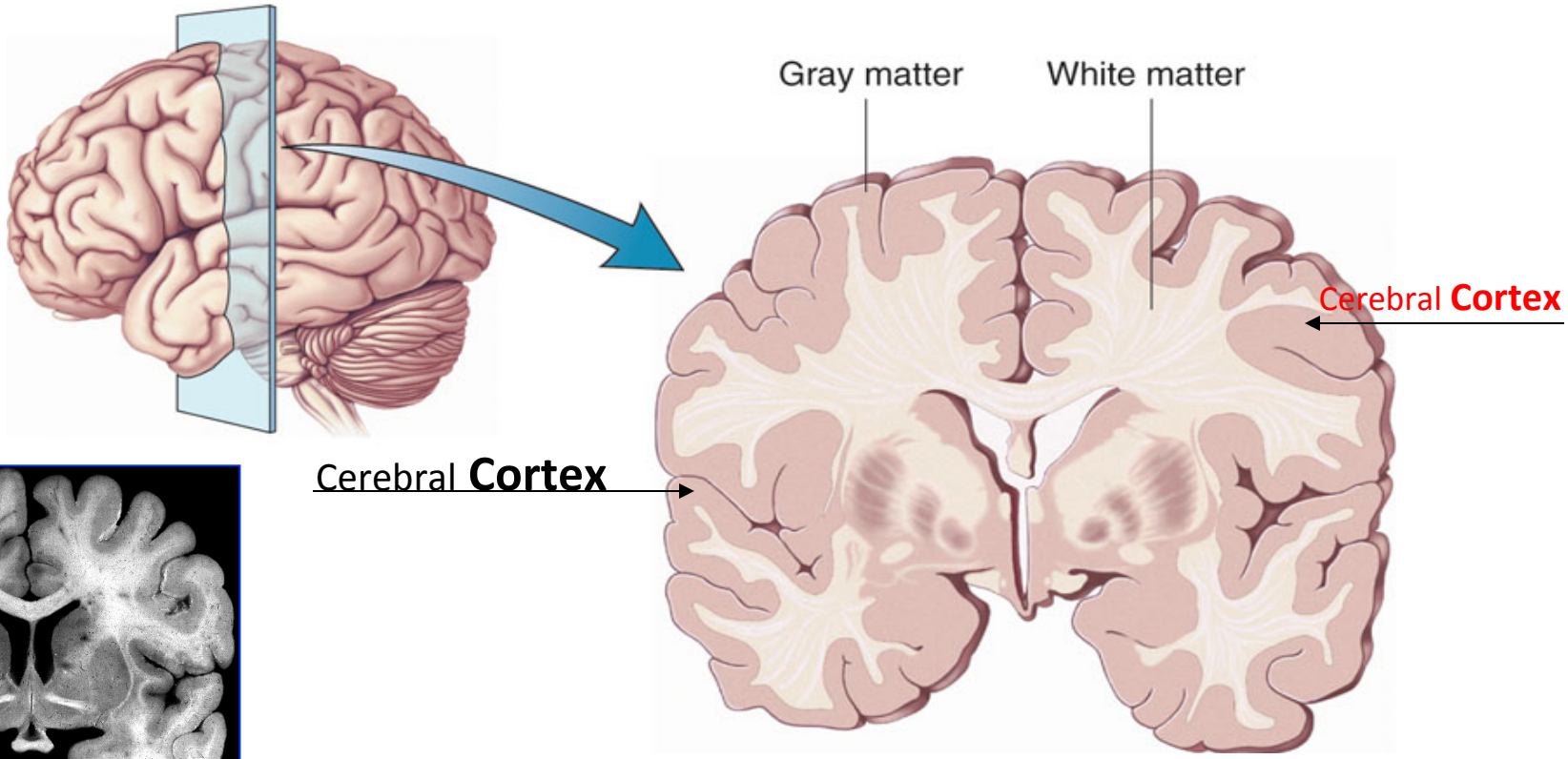


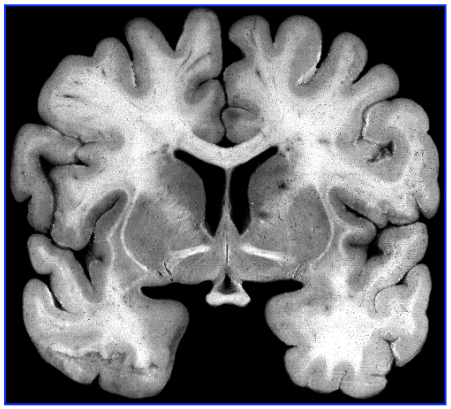
http://williamcalvin.com/BrainForAllSeasons/img/bonoboLH-humanLH-viaTWD.gif

The motor and sensory cortexes and the association areas for each



Cerebral Cortex - The outermost layer of gray matter making up the superficial aspect of the cerebrum.





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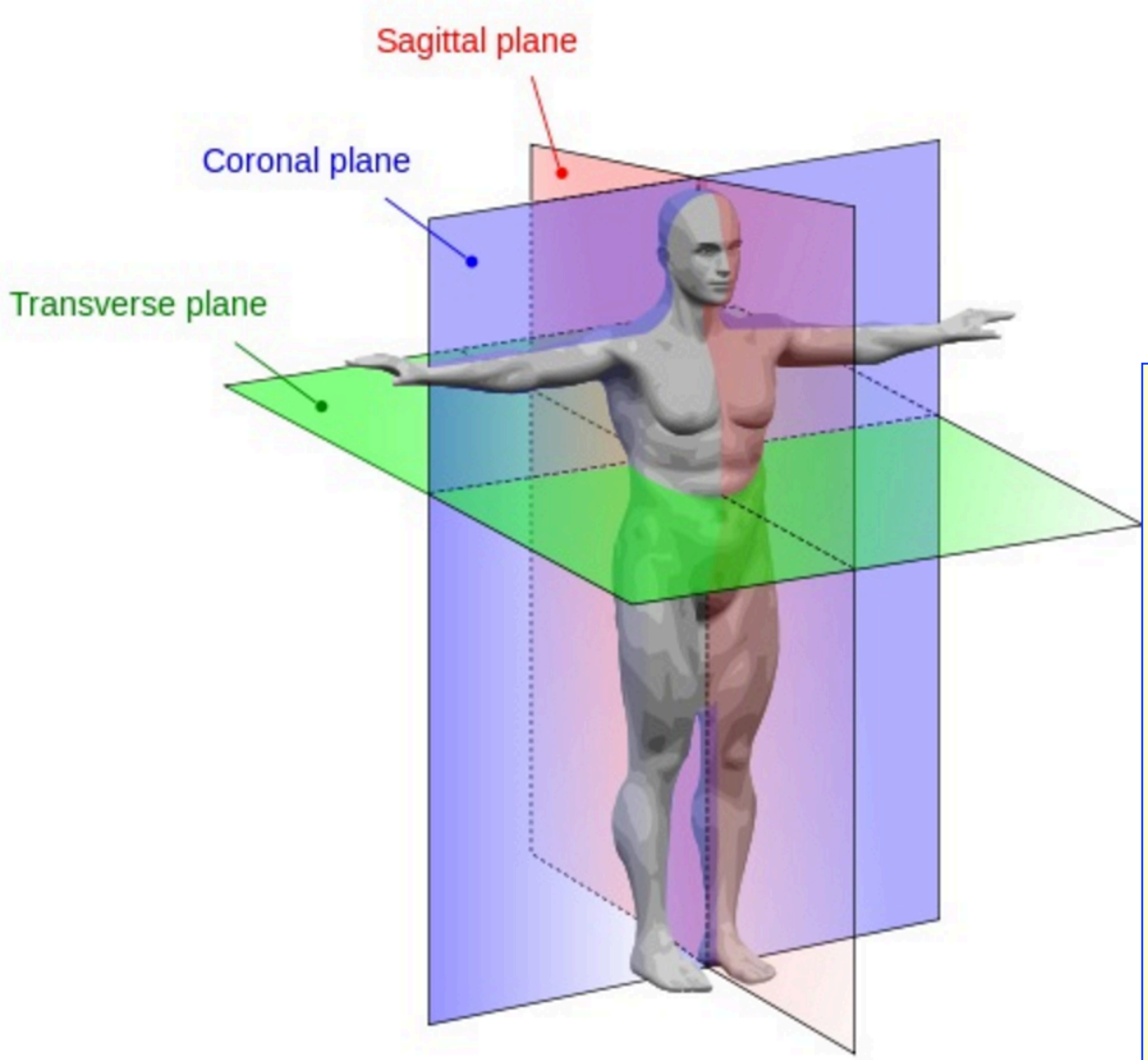
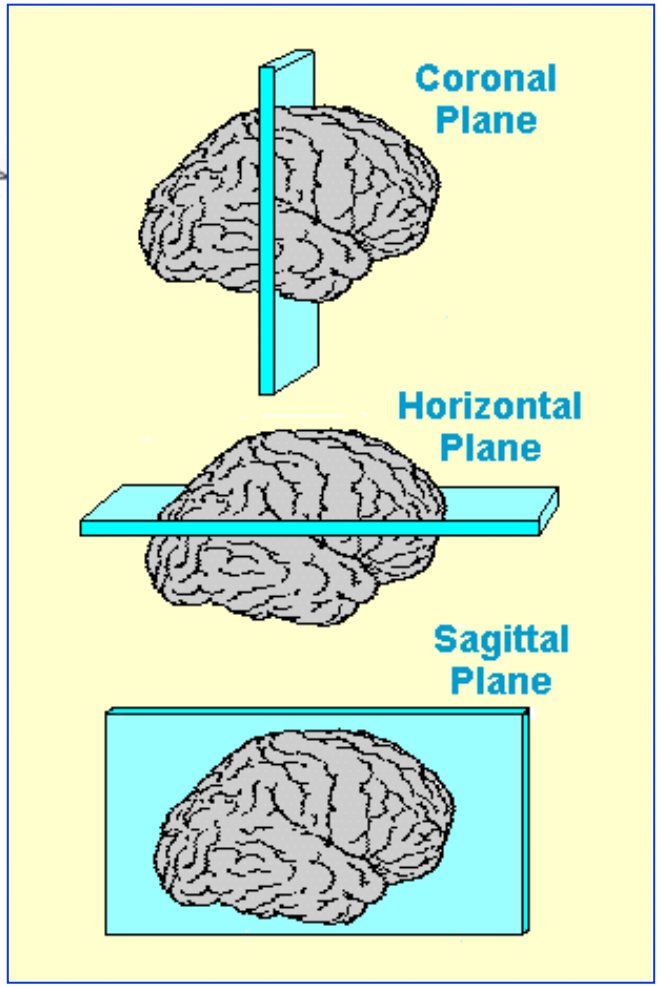
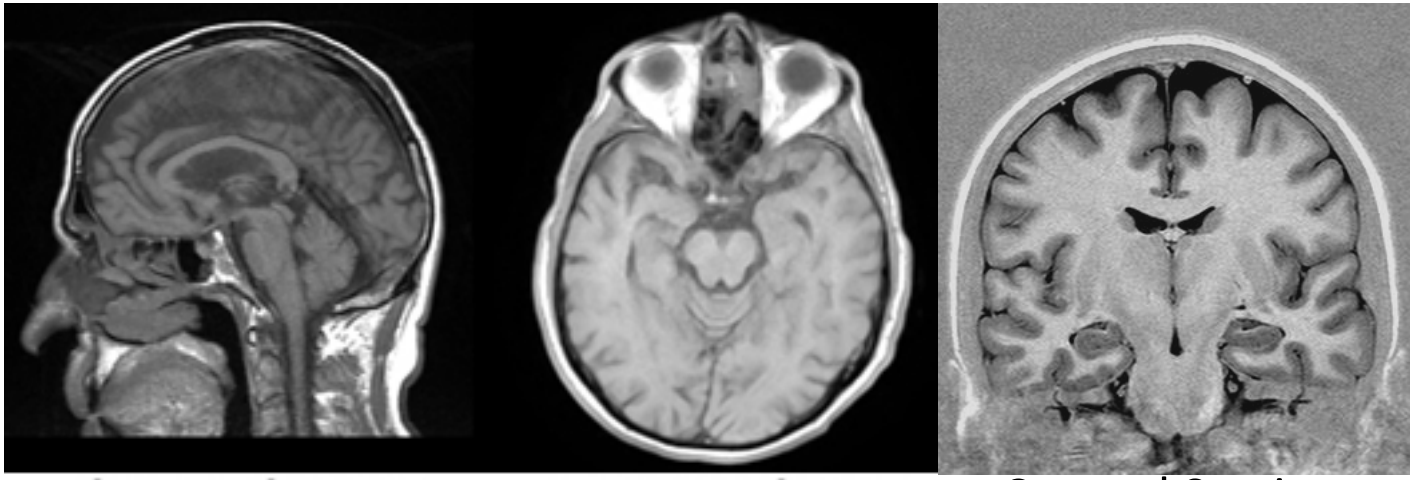
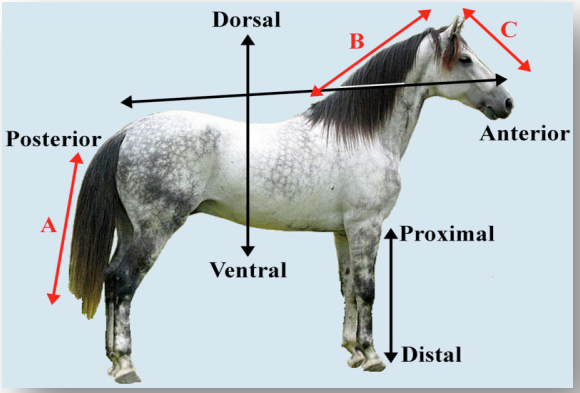

Sagittal plane
Coronal plane
Transverse plane


Coronal Plane
Horizontal Plane
Sagittal Plane



Sagittal Section Horizontal Section Coronal Section

Directions



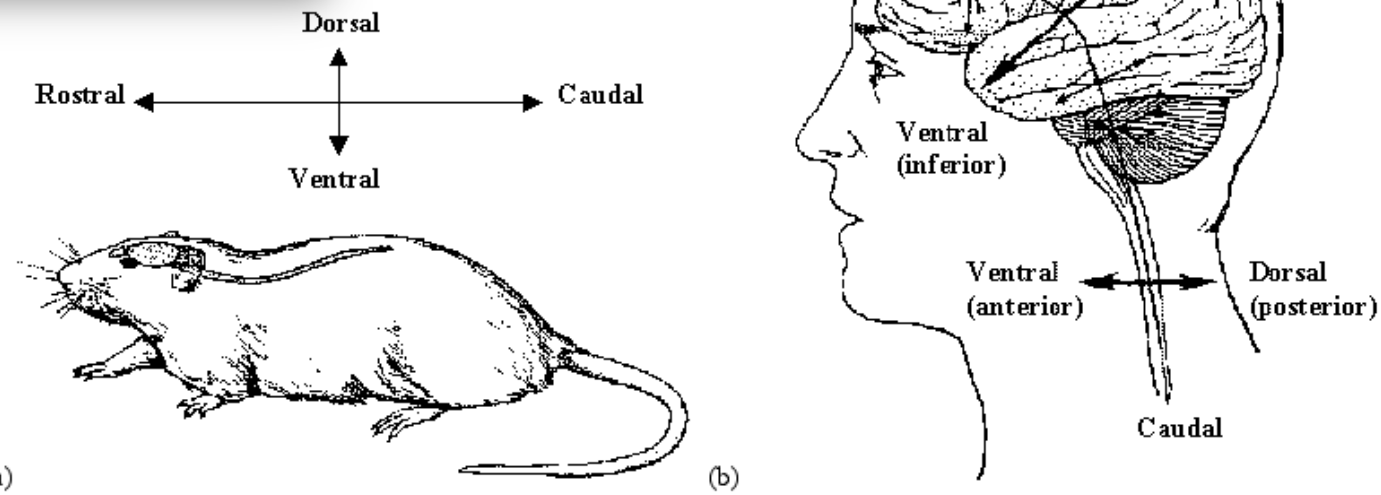


Figure 3.4 The axes of the central nervous system. (a) In animals, where the spinal cord runs horizontally. (b) In humans, where the spinal cord runs vertically.

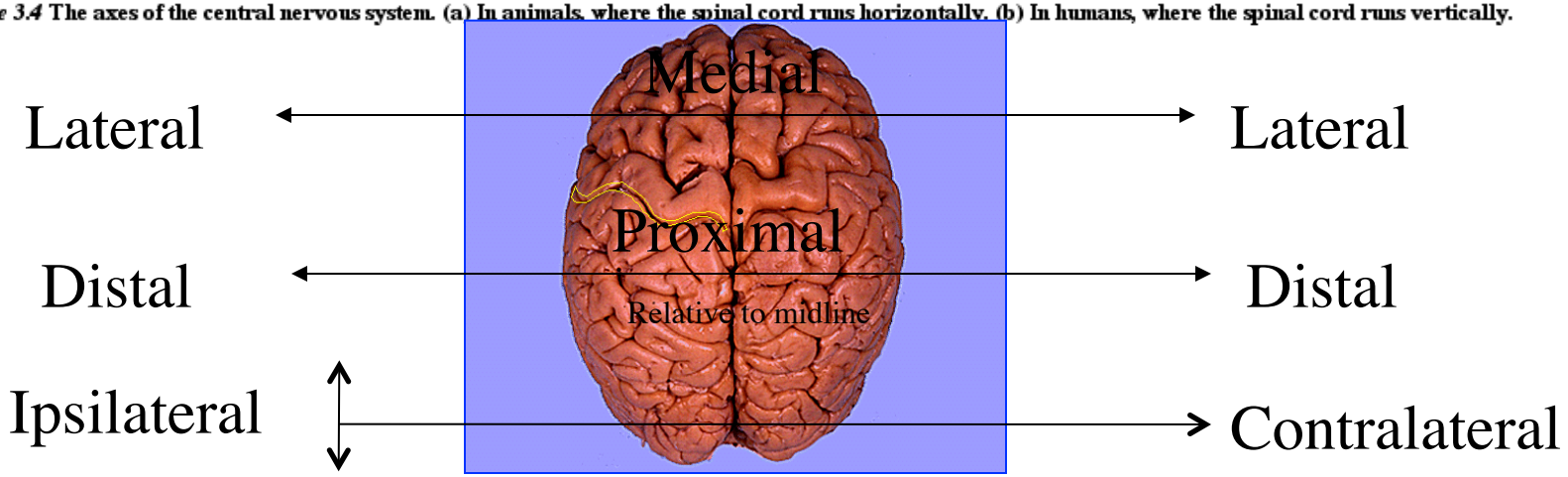
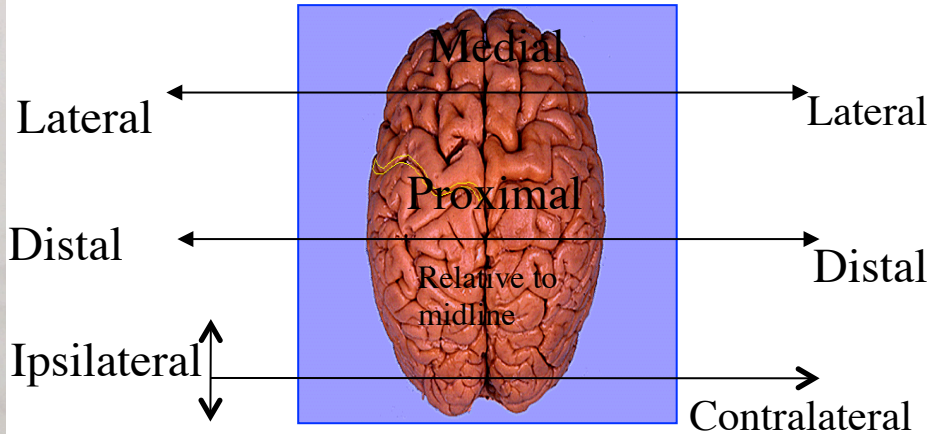
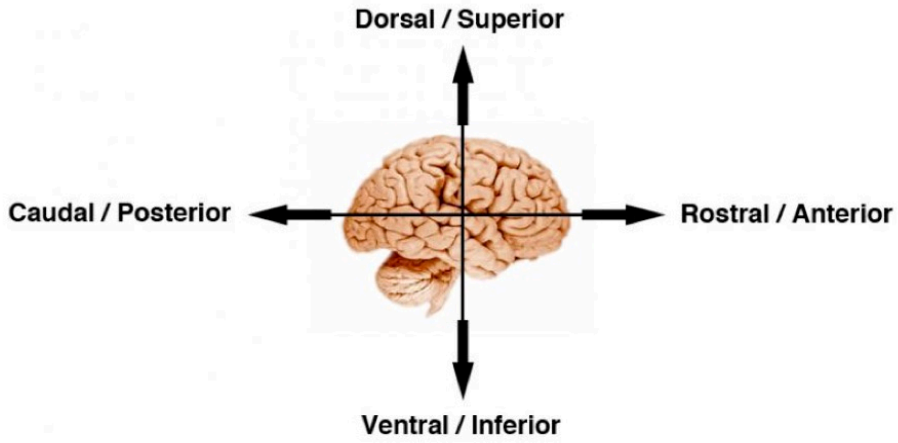
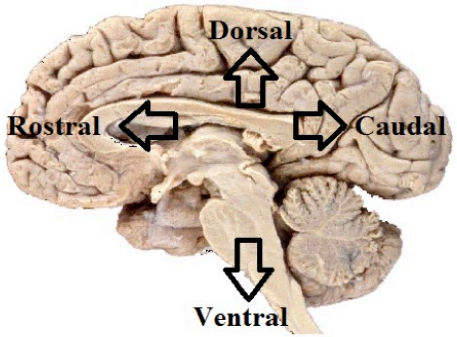


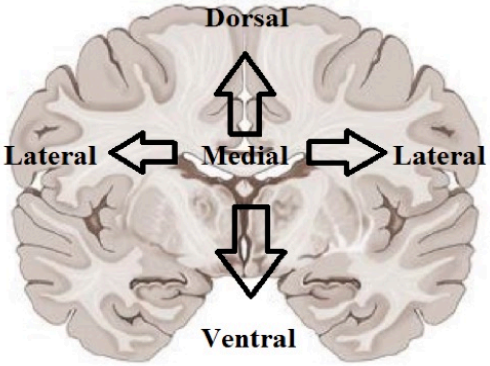
TABLE 3.1 Anatomical Terms Referring to Directions

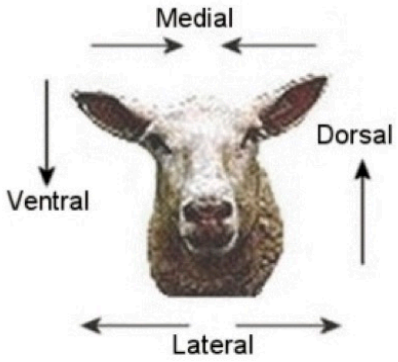
Term	Definition
Dorsal	Toward the back, away from the ventral (stomach) side. The top of the brain is considered dorsal because it has that position in four-legged animals.
Ventral	Toward the stomach, away from the dorsal (back) side
Anterior	Toward the front end
Posterior	Toward the rear end
Superior	Above another part
Inferior	Below another part
Lateral	Toward the side, away from the midline
Medial	Toward the midline, away from the side
Proximal	Located close (approximate) to the point of origin or attachment
Distal	Located more distant from the point of origin or attachment
Ipsilateral	On the same side of the body (e.g., two parts on the left or two on the right)
Contralateral	On the opposite side of the body (one on the left and one on the right)
Coronal plane (or frontal plane)	A plane that shows brain structures as seen from the front
Sagittal plane	A plane that shows brain structures as seen from the side
Horizontal plane (or transverse plane)	A plane that shows brain structures as seen from above

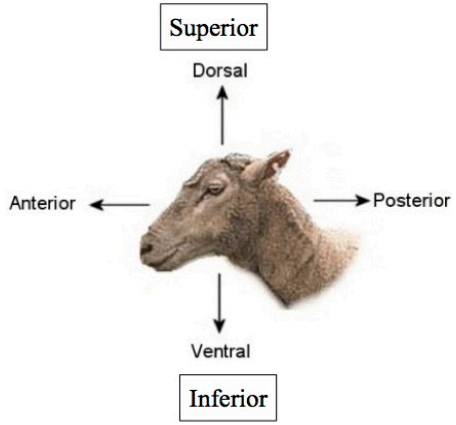




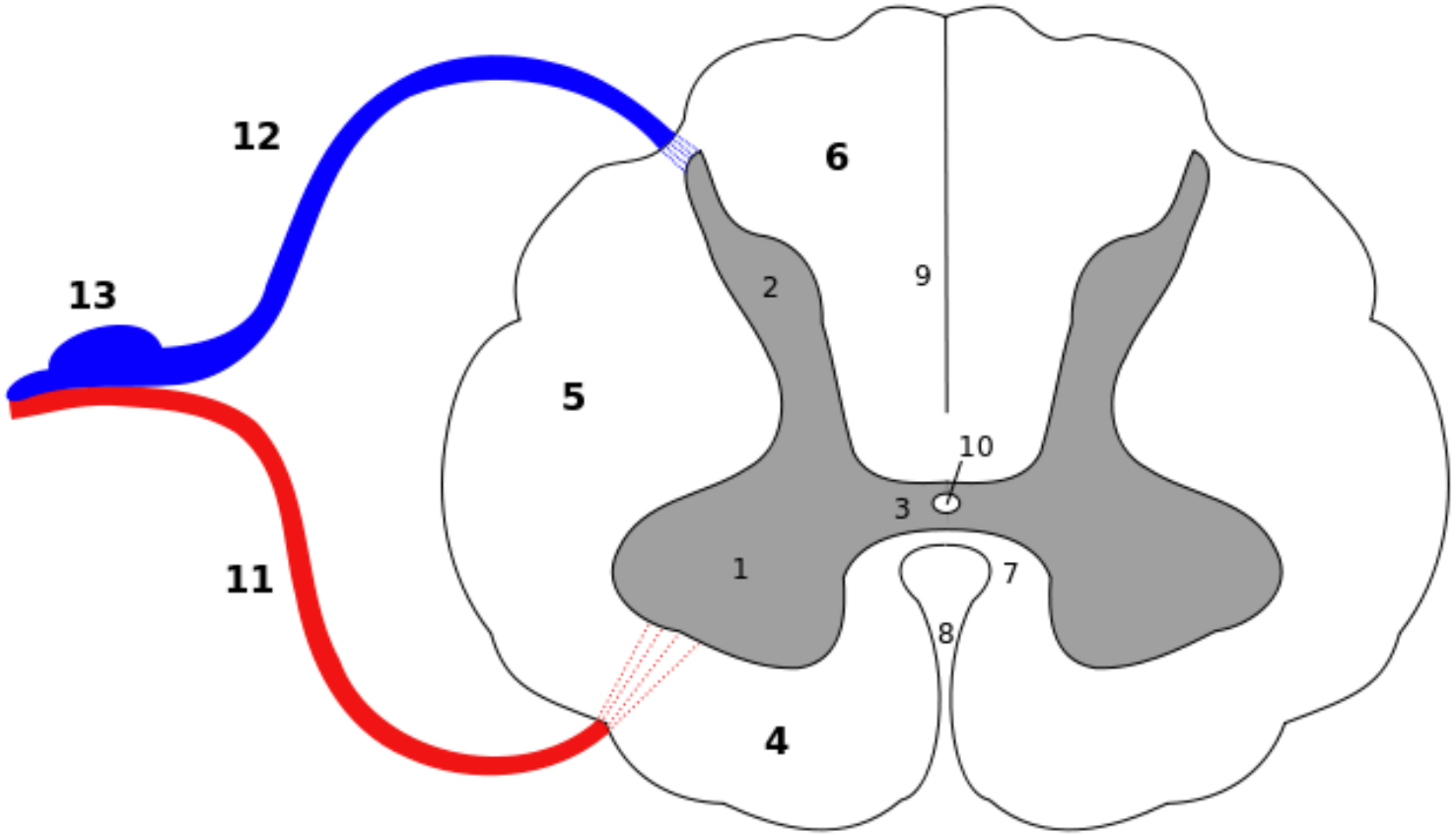








Directional terms



Gray matter

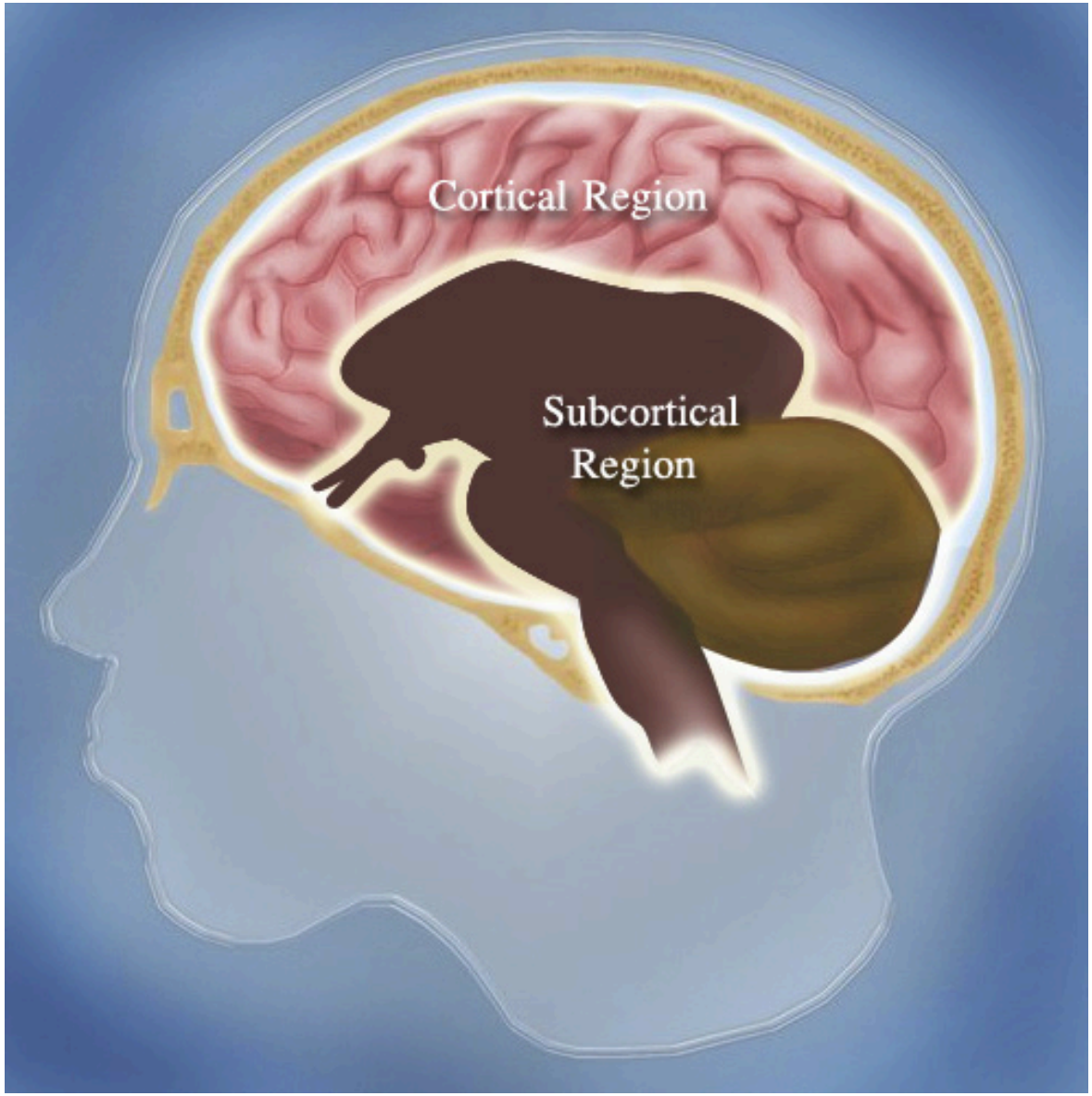
1. Anterior horn
2. Posterior horn
3. Gray commisure

White matter

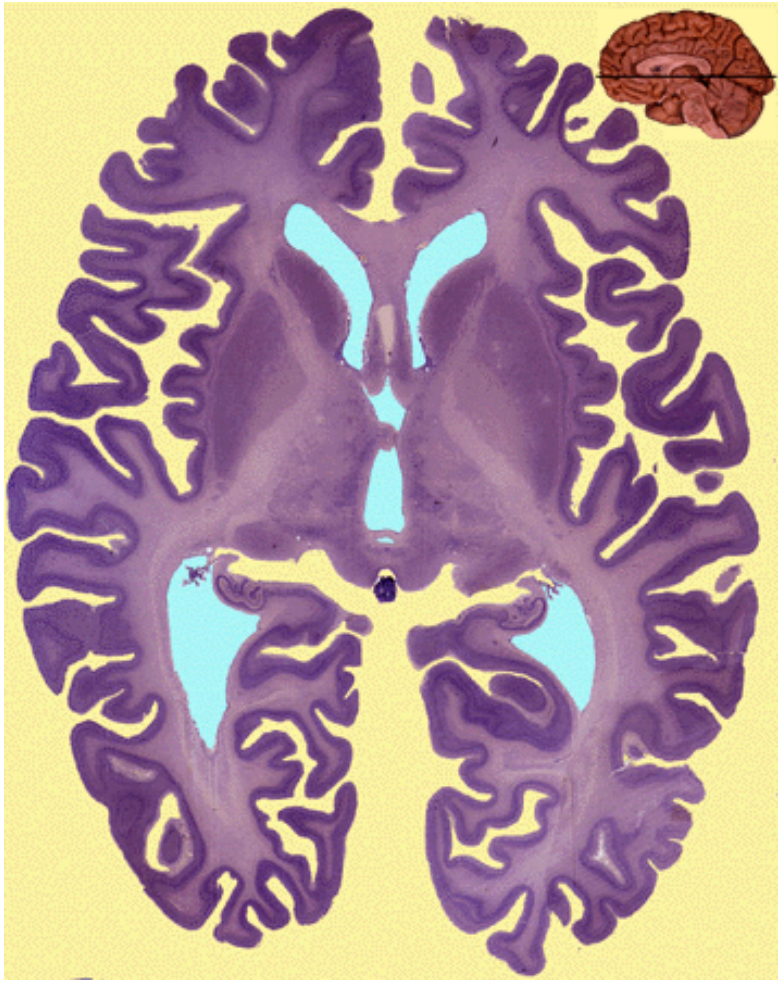
4. Anterior funiculus
5. Lateral funiculus
6. Posterior funiculus
7. Anterior commisure
8. Anterior median fissure
9. Posterior median sulcus

10. Central canal
11. Anterior root
12. Posterior root
13. Dorsal root ganglion

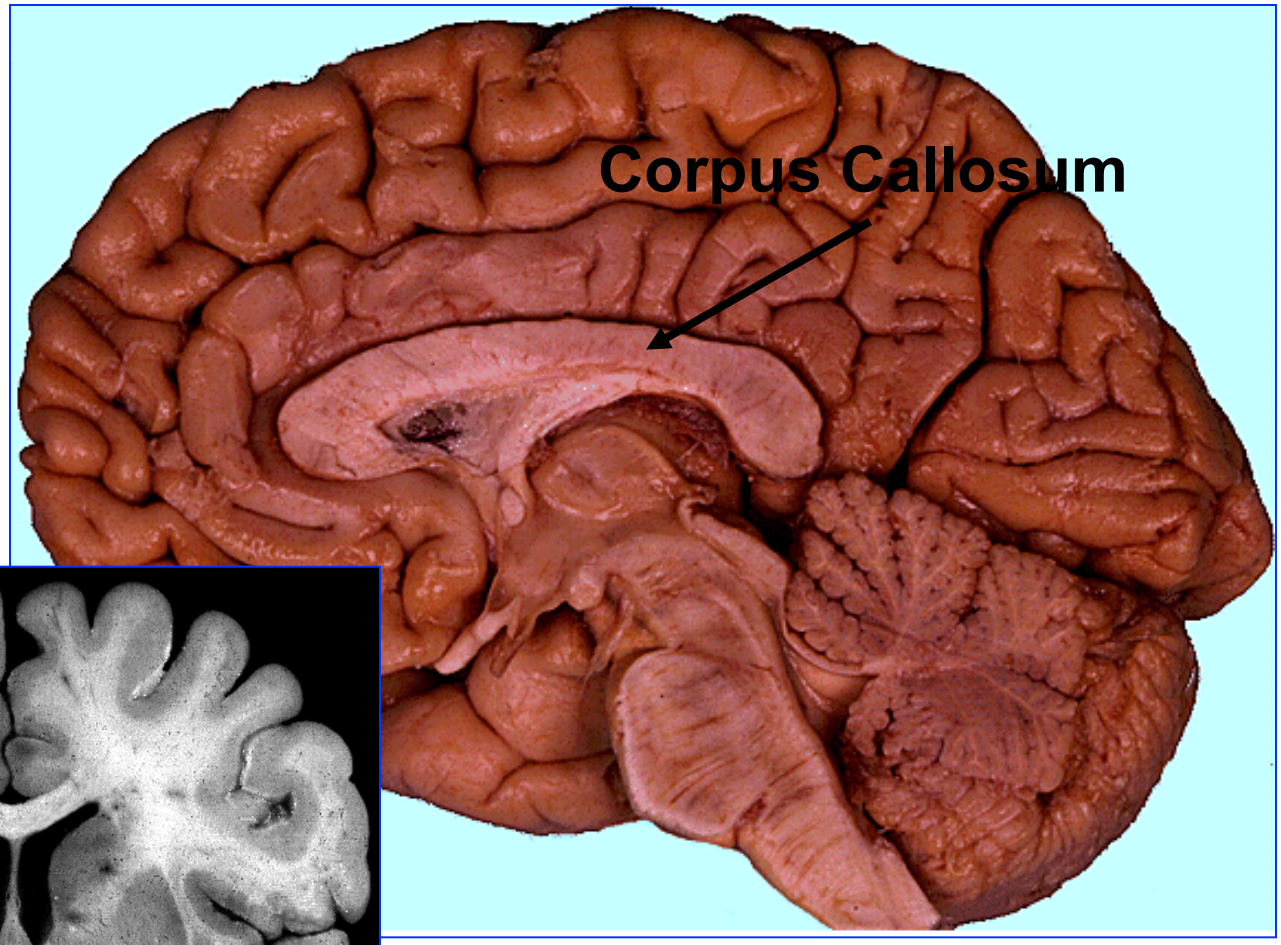
Dividing up the brain

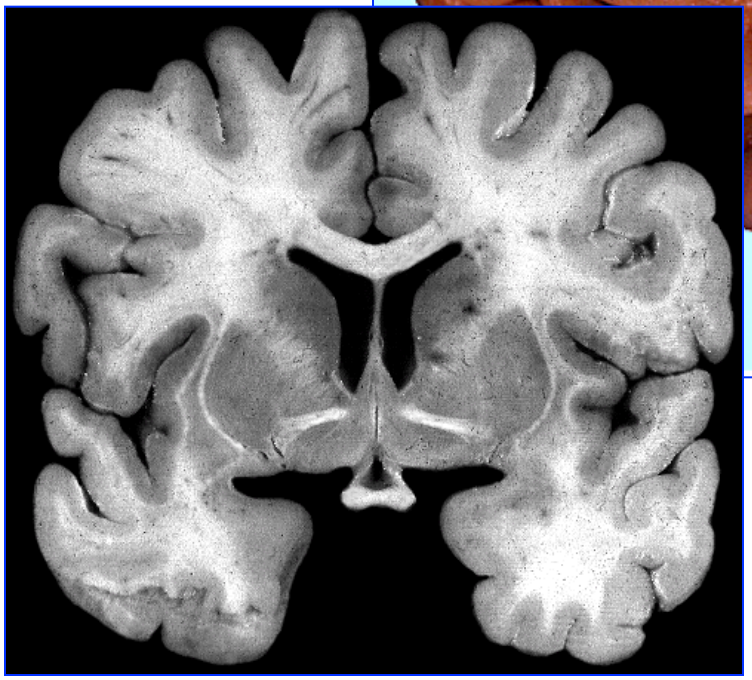


Nissl vs Myelin Stain



Callosum (L): hard, tough





Commissure vs decussation

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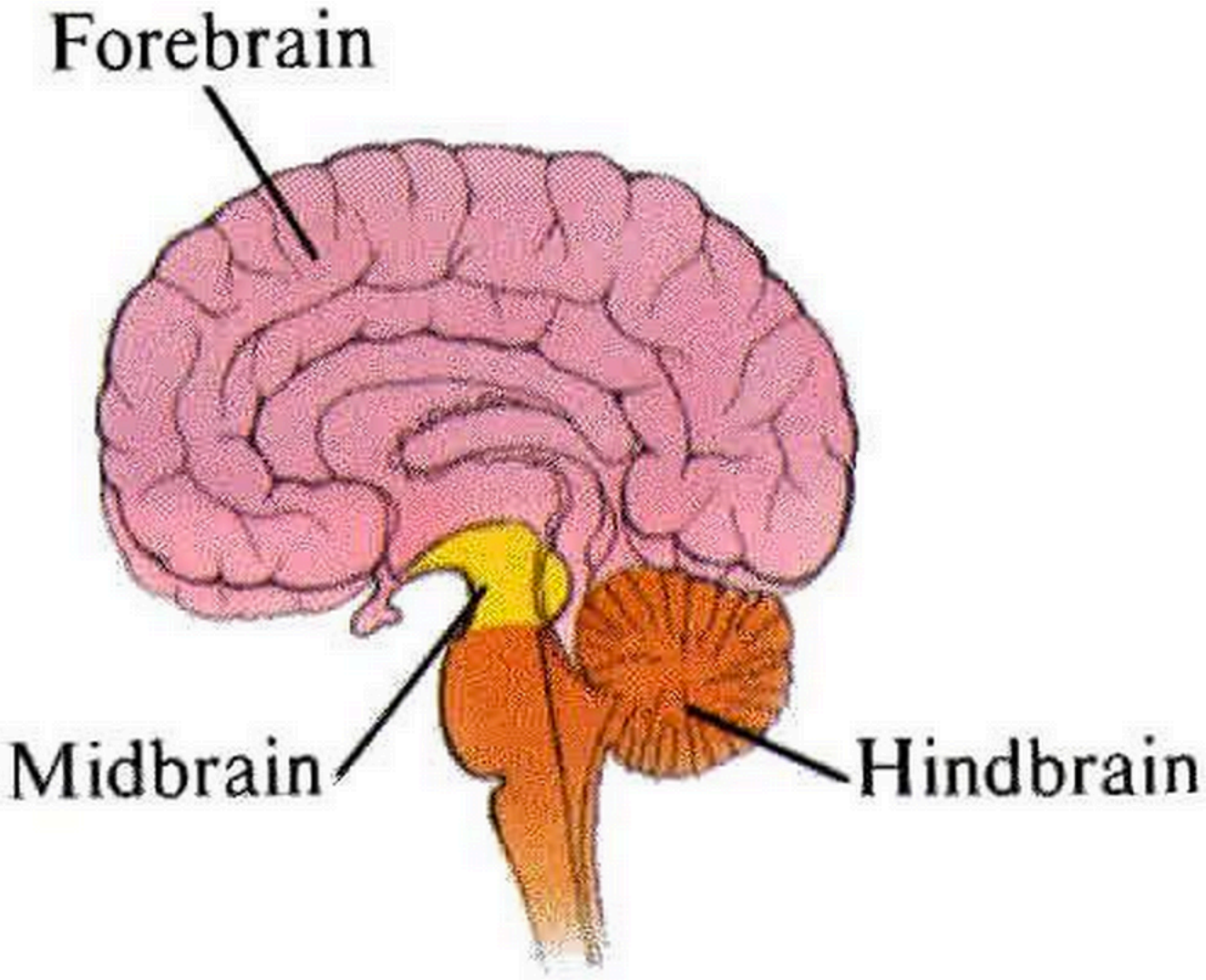
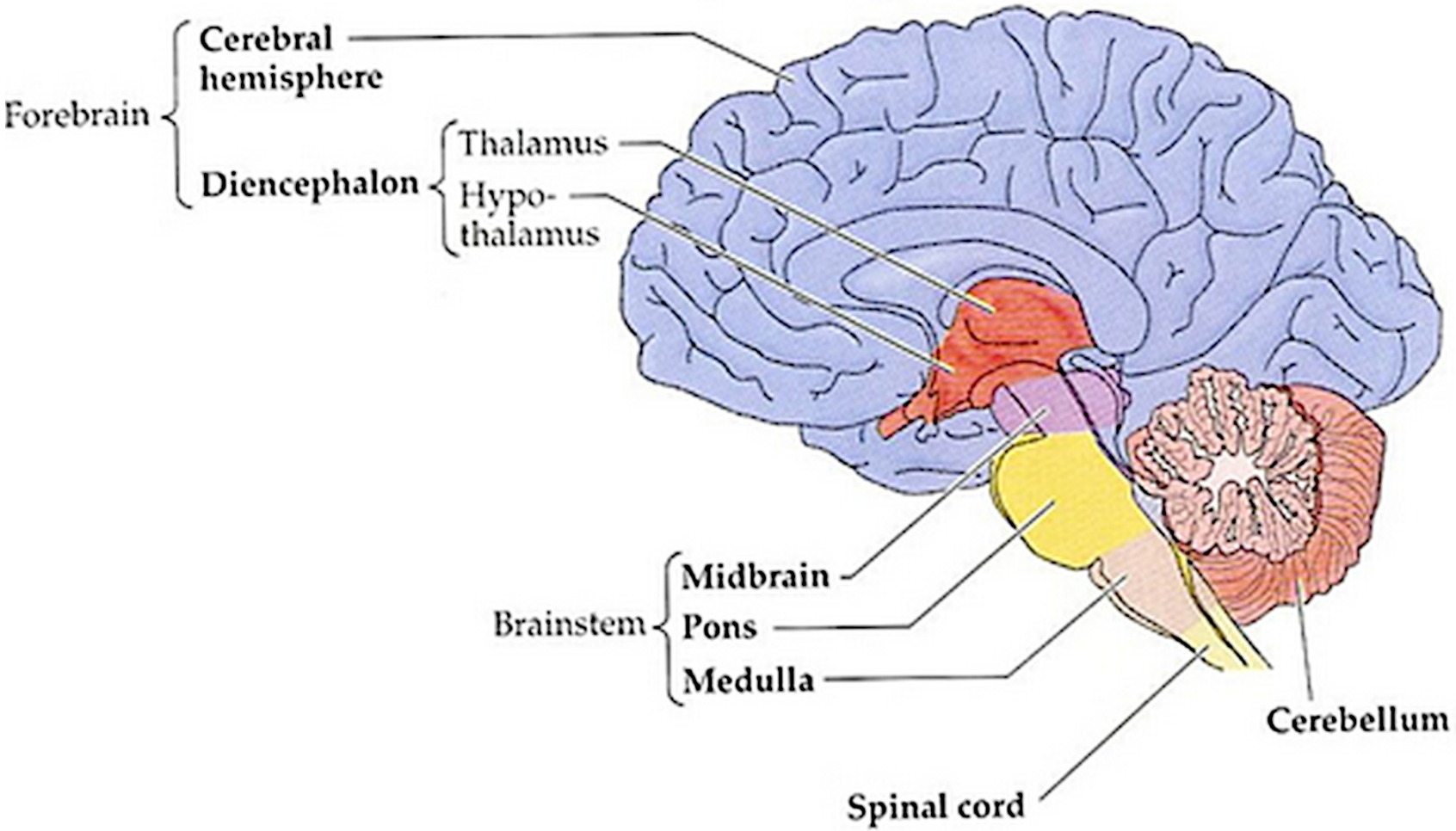
The Human Brain: Major Areas

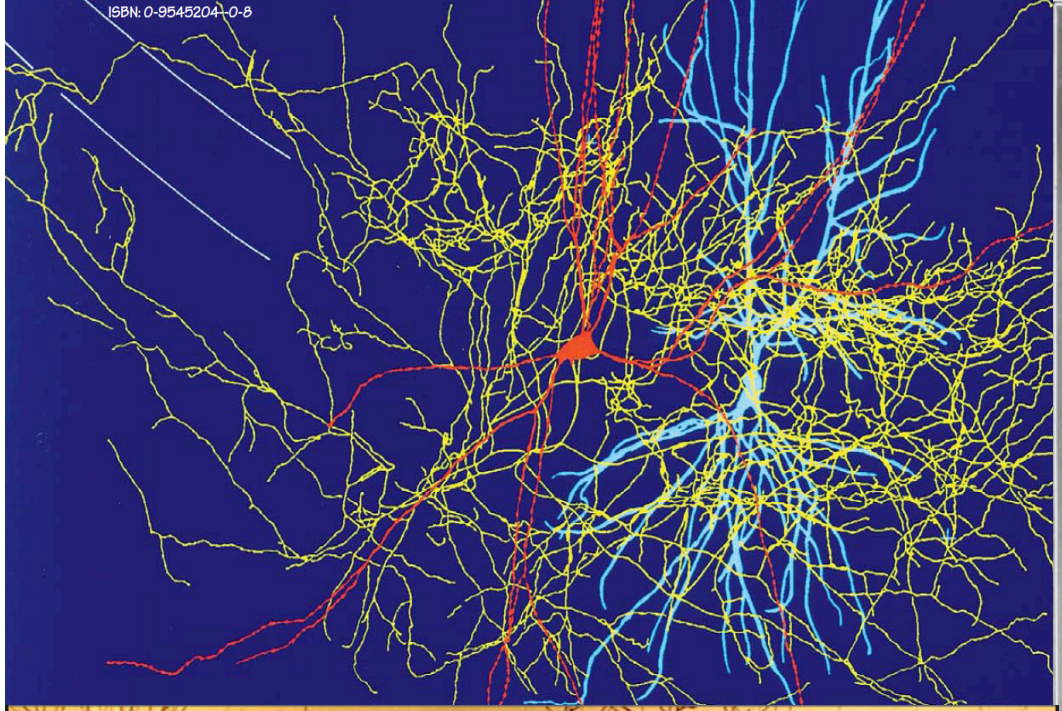


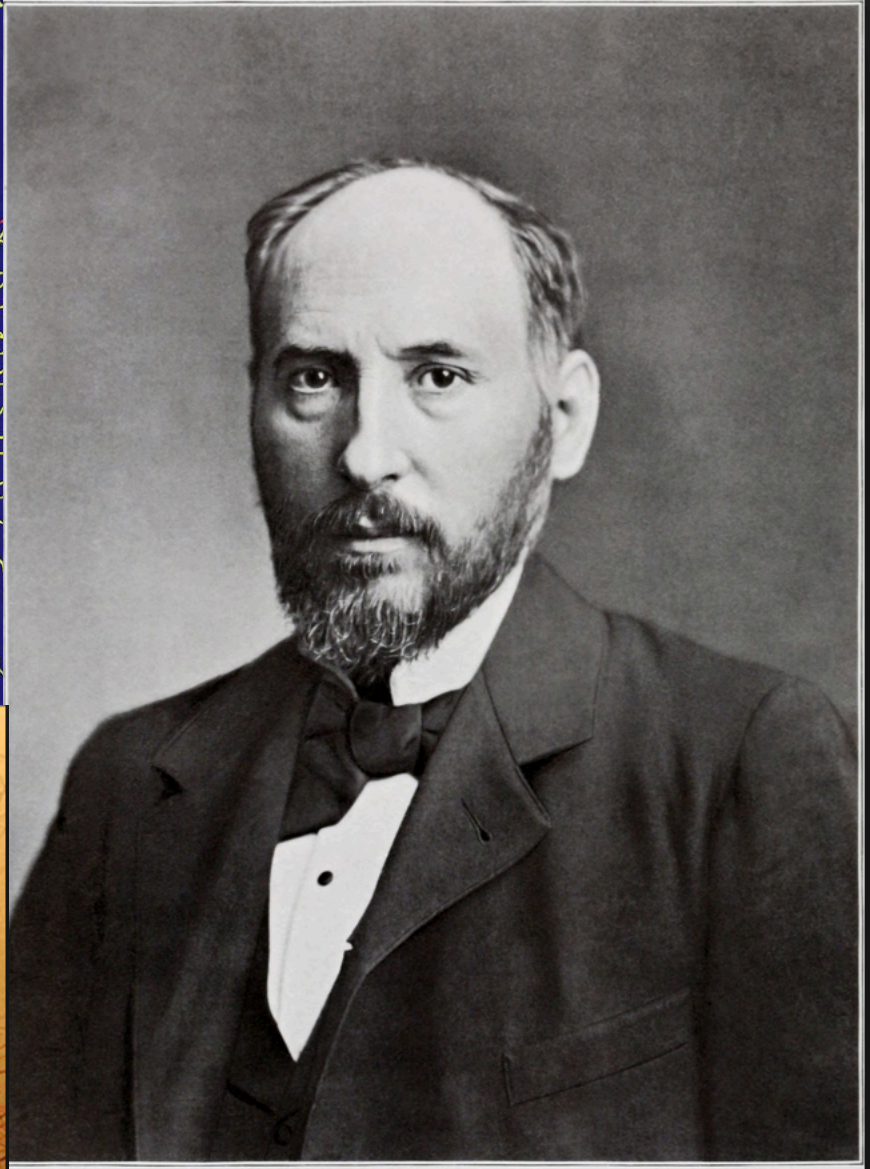

Forebrain
Cerebral hemisphere
Diencephalon
Thalamus
Hypo-thalamus
Brainstem
Midbrain
Pons
Medulla
Cerebellum
Spinal cord

Approximate Minimum Stimulus for Each Sense

SENSE	MINIMUM STIMULUS
Vision	A candle flame seen at 30 miles on a dark, clear night
Hearing	The tick of a clock at 20 feet under quiet conditions
Taste	One teaspoon of sugar in 2 gallons of water
Smell	One drop of perfume diffused into the entire volume of six rooms
Touch	The wing of a fly falling on your cheek from a distance of 1 centimeter

ISBN: 0-9545204-0-8



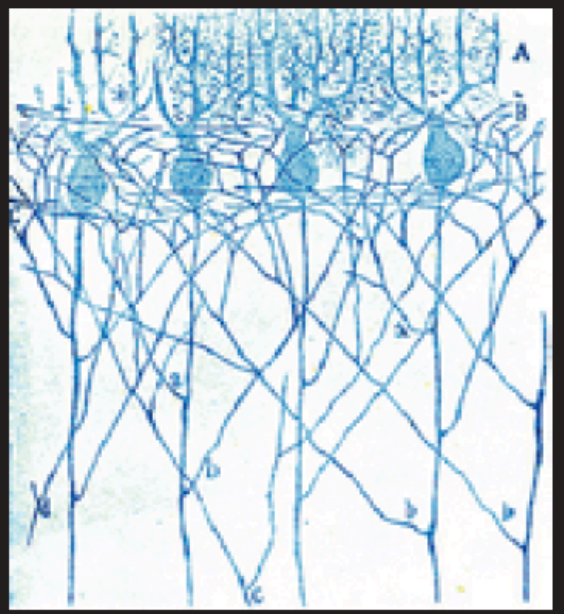


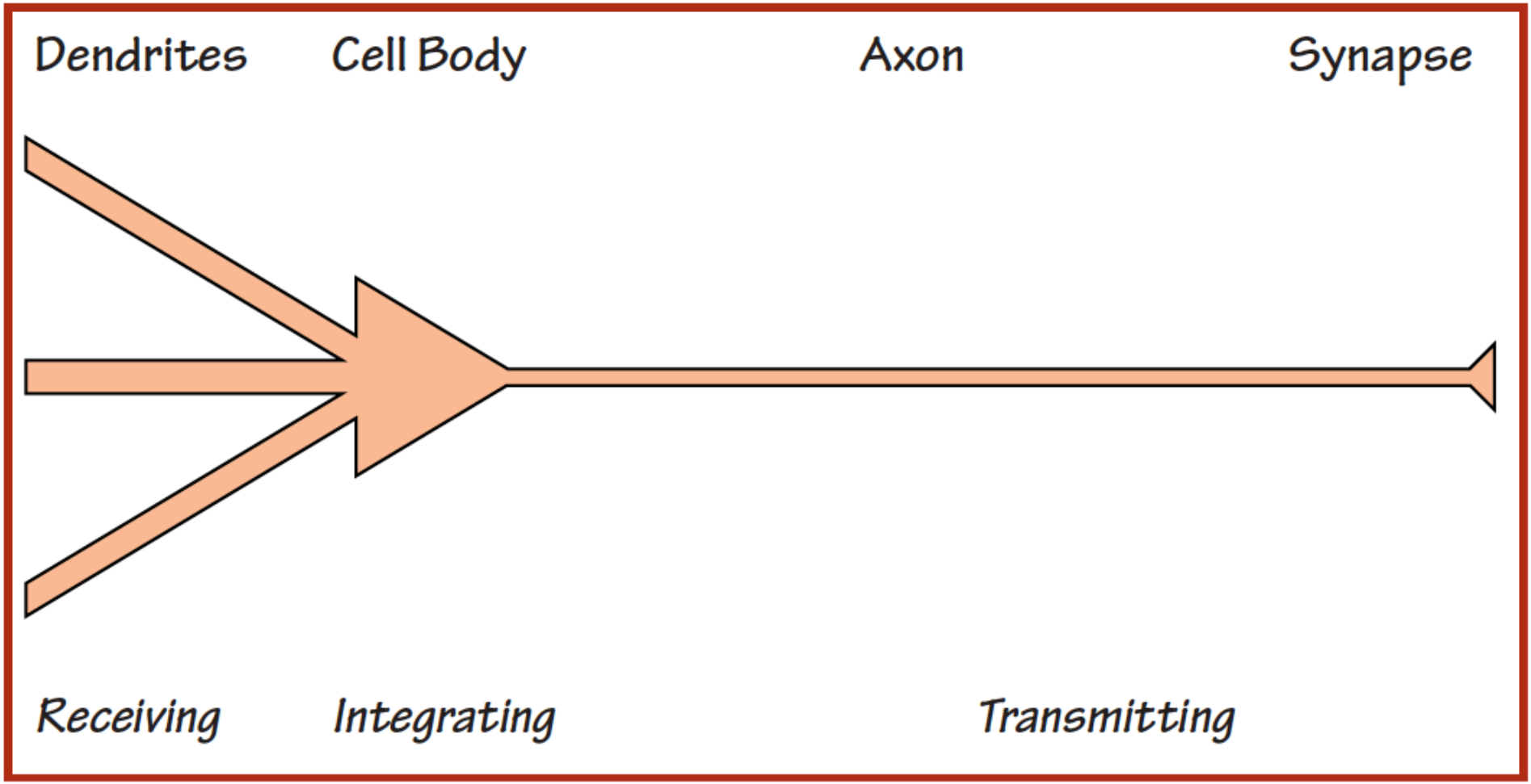
S. Ramon Cajal

The father of modern neuroscience, Ramon y Cajal, at his microscope in 1890.

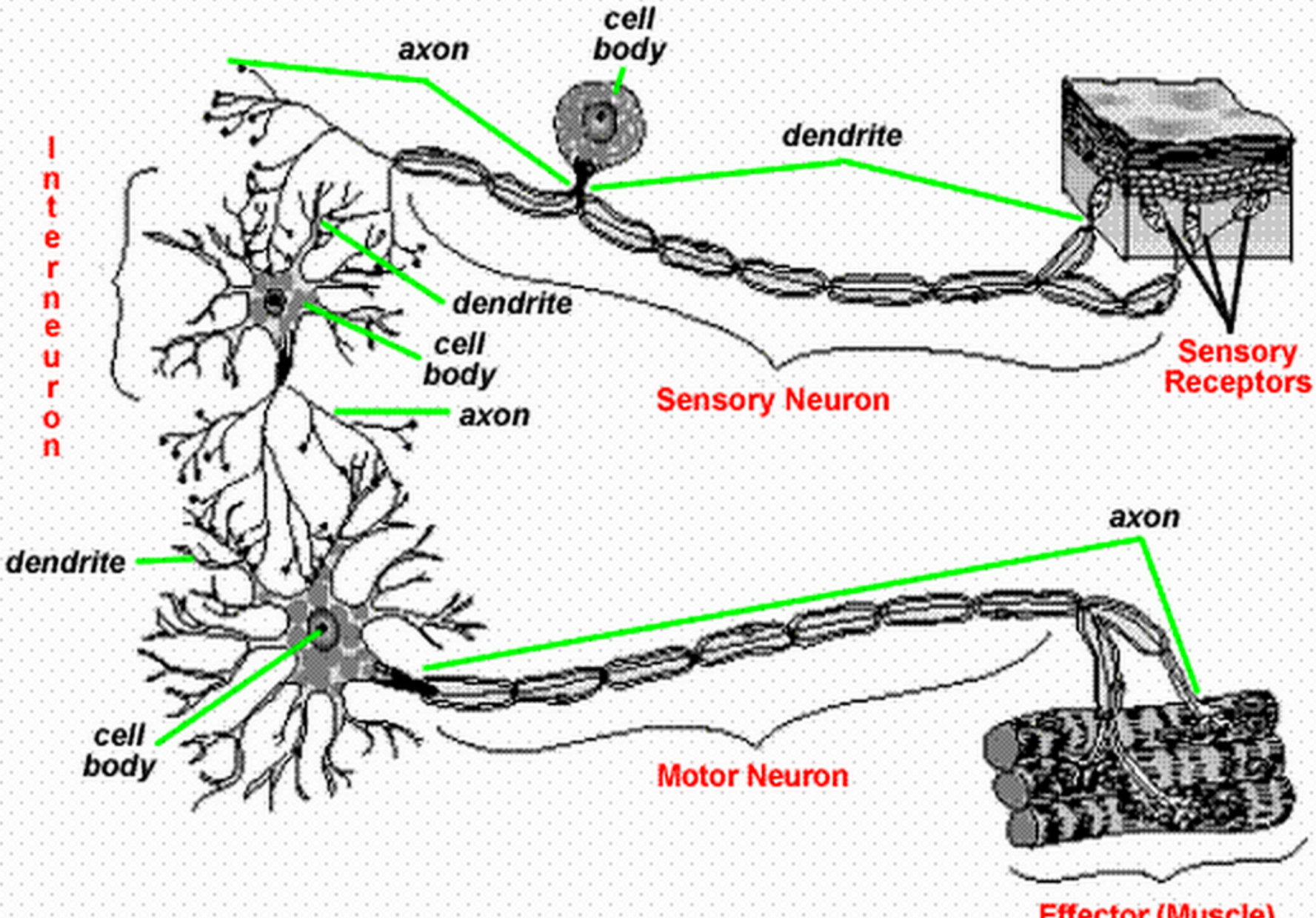
Cajal's first pictures of neurons and their dendrites.

Cajal's exquisite neuron drawings - these are of the cerebellum.

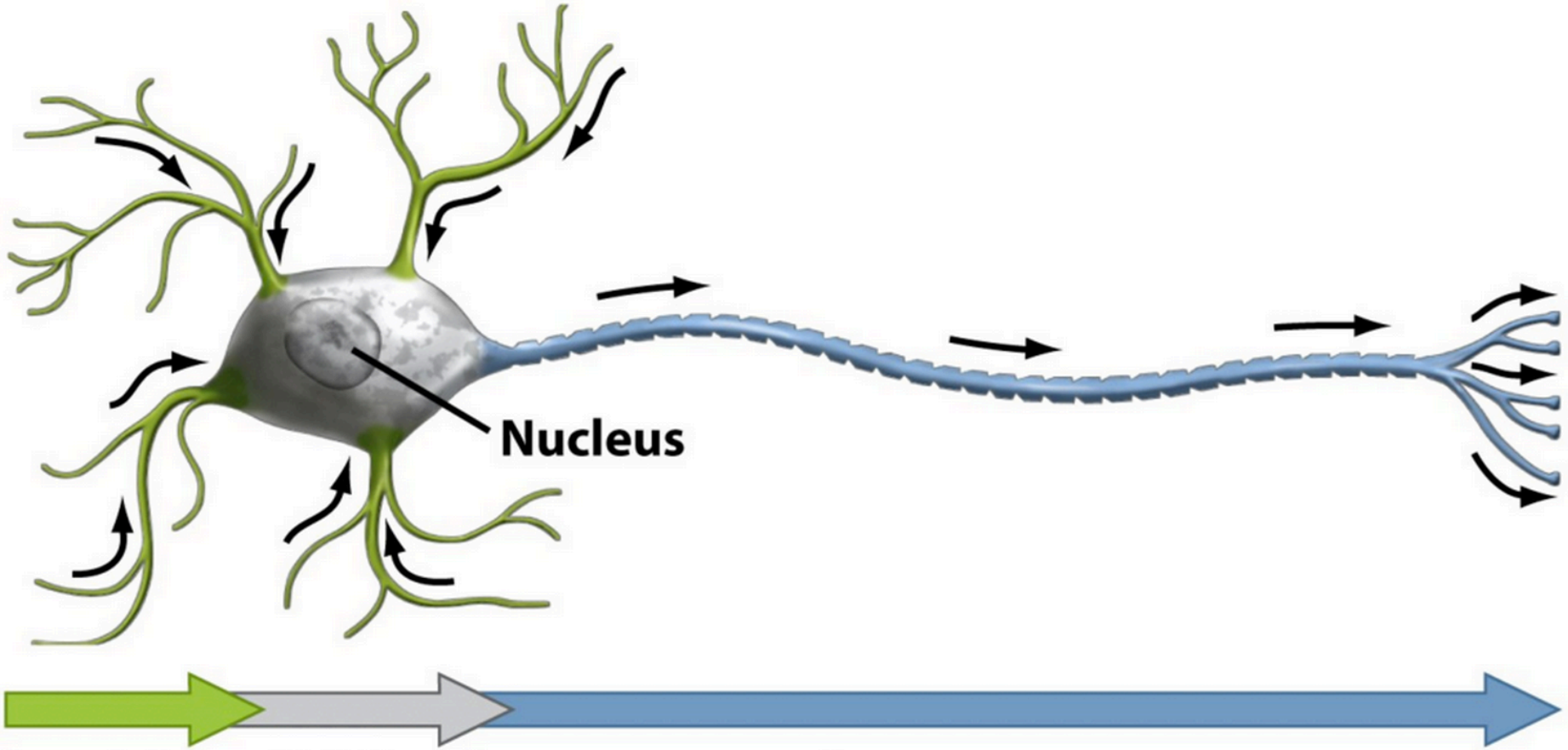



Dendrites
Cell Body
Axon
Synapse
Receiving
Integrating
Transmitting

The 3 main types of Neurons



Information flow through neurons



Dendrites
Collect electrical signals

Cell body
Integrates incoming signals and generates outgoing signal to axon

Axon
Passes electrical signals to dendrites of another cell or to an effector cell

Figure 45-2b Biological Science, 2/e
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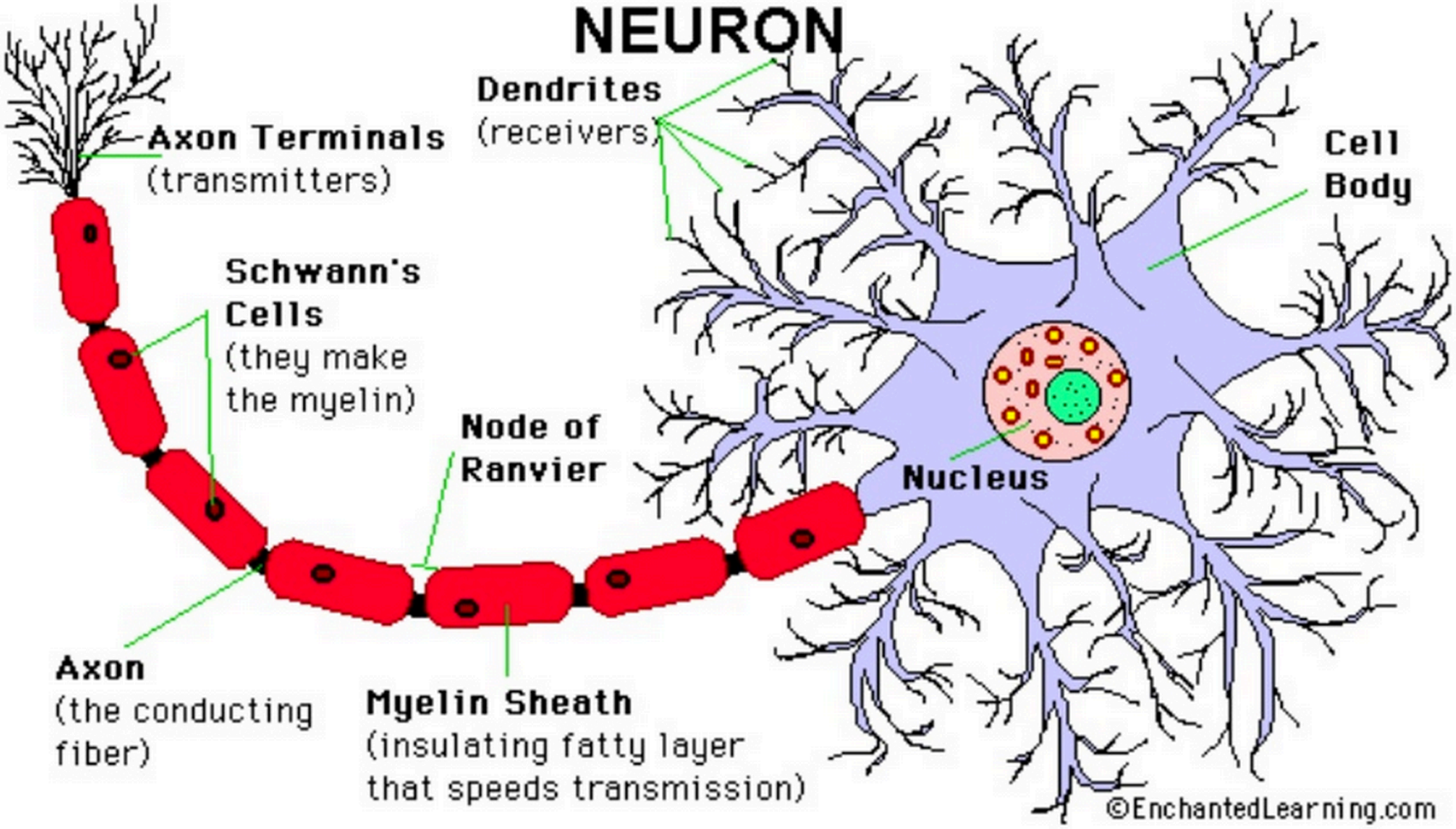
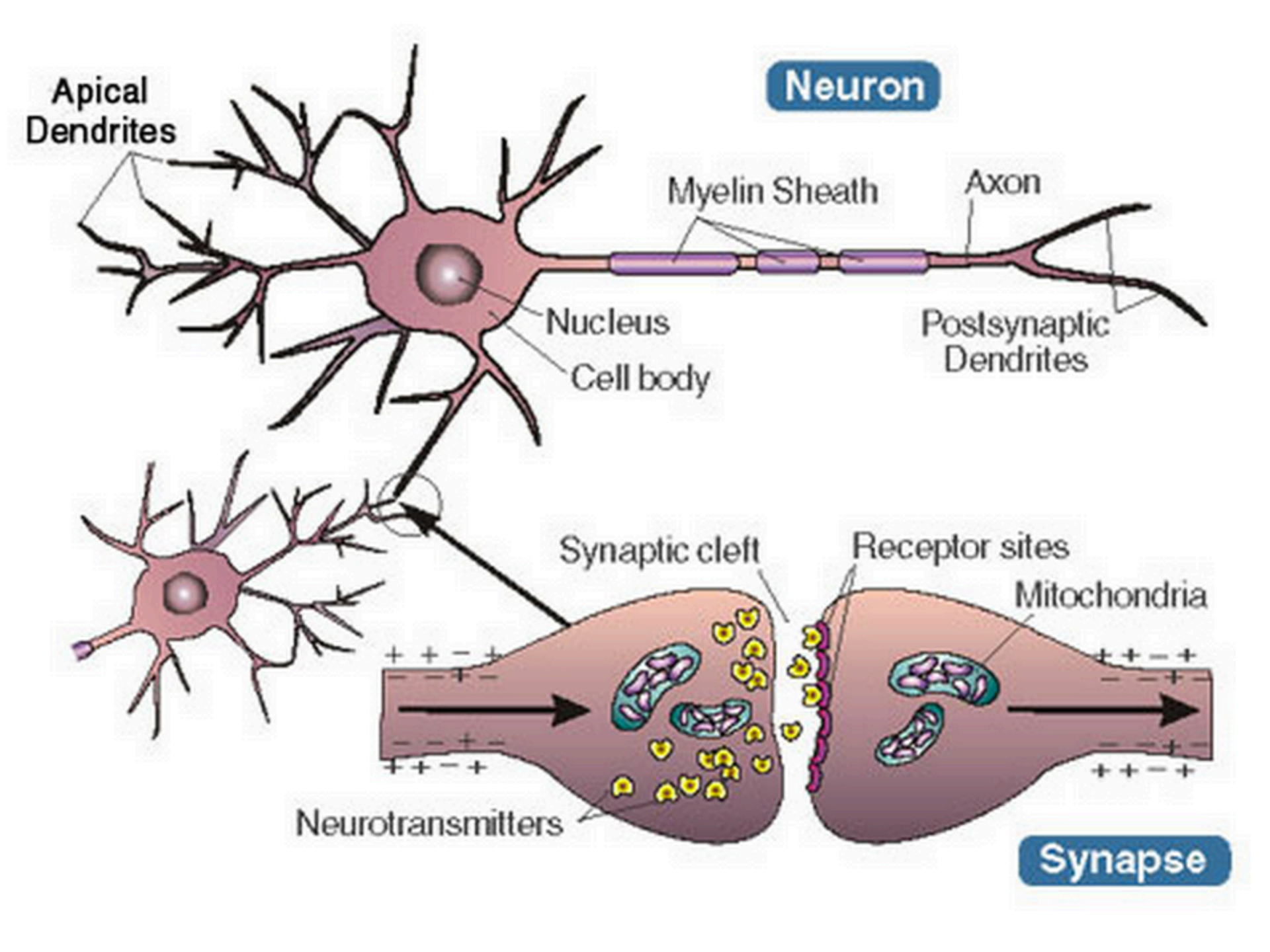
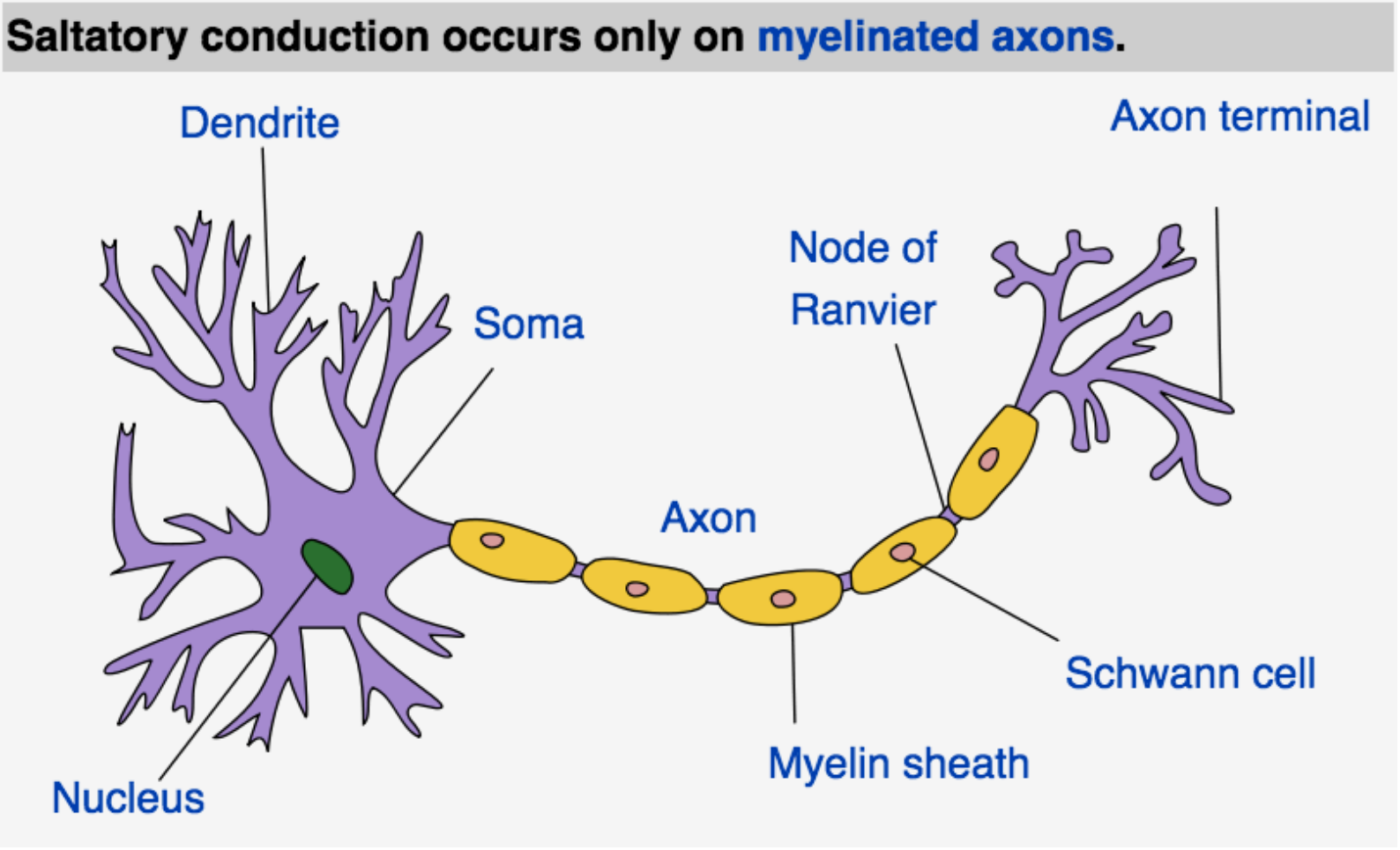


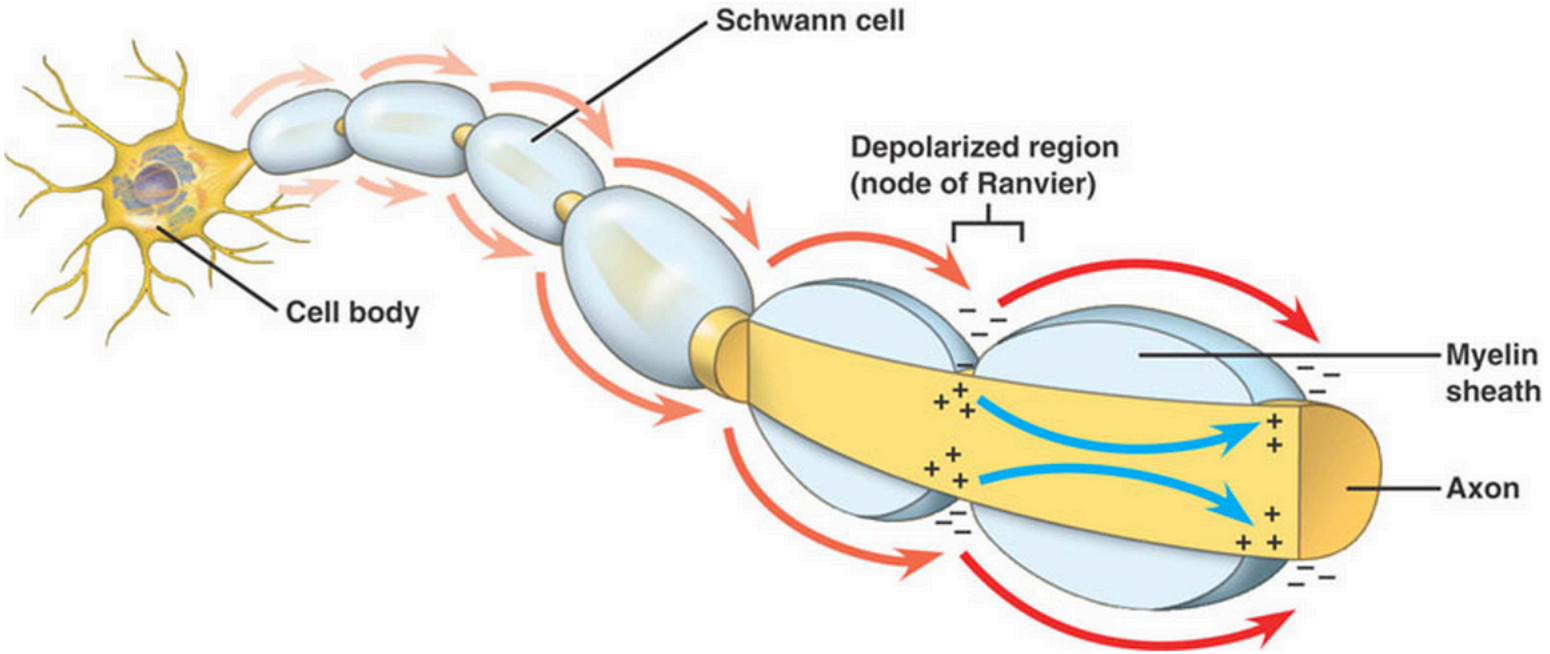
Cell Body+ 2 sets of Processes (Axons, Dendrites)

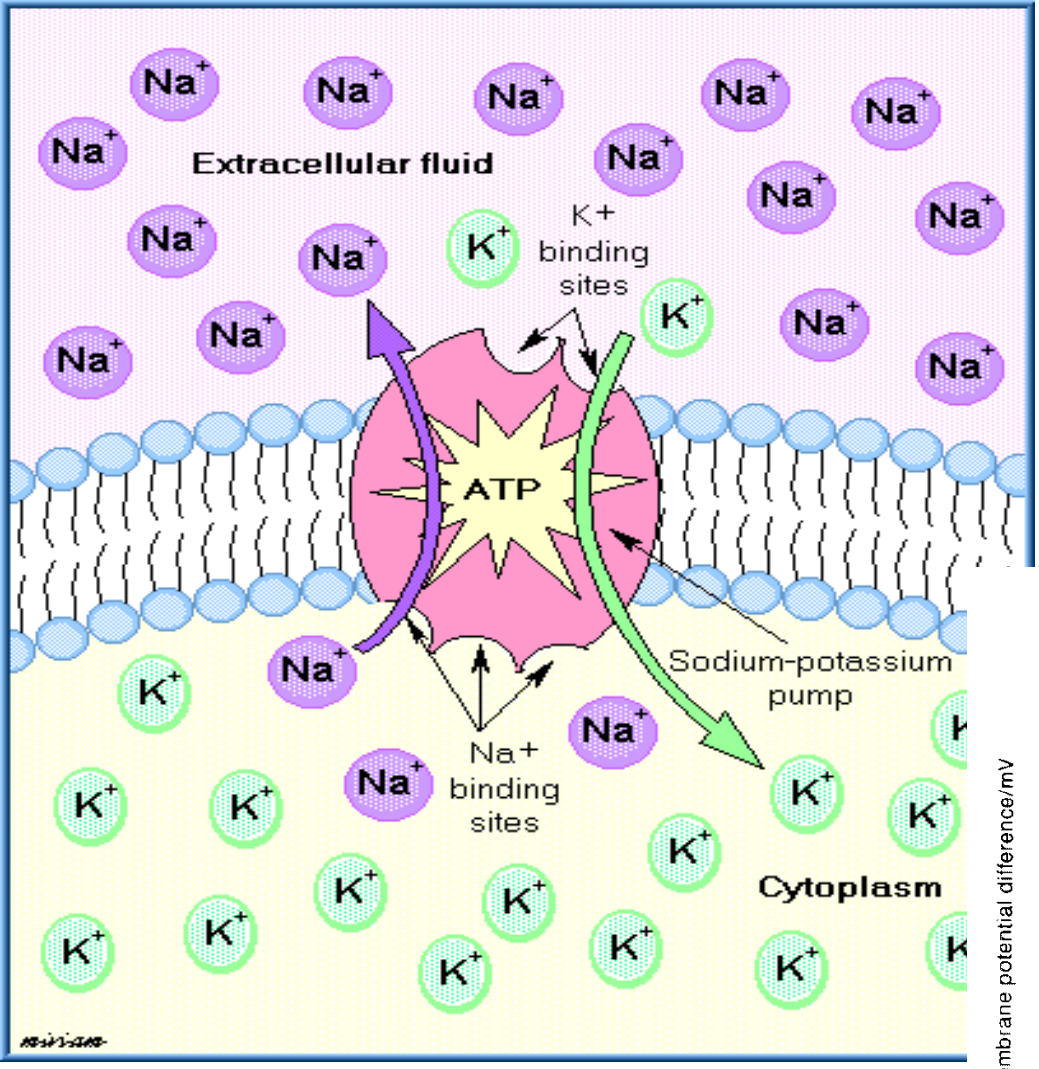

Neuron
Apical Dendrites
Myelin Sheath
Axon
Nucleus
Cell body
Postsynaptic Dendrites
Synaptic cleft
Receptor sites
Mitochondria
Neurotransmitters
Synapse

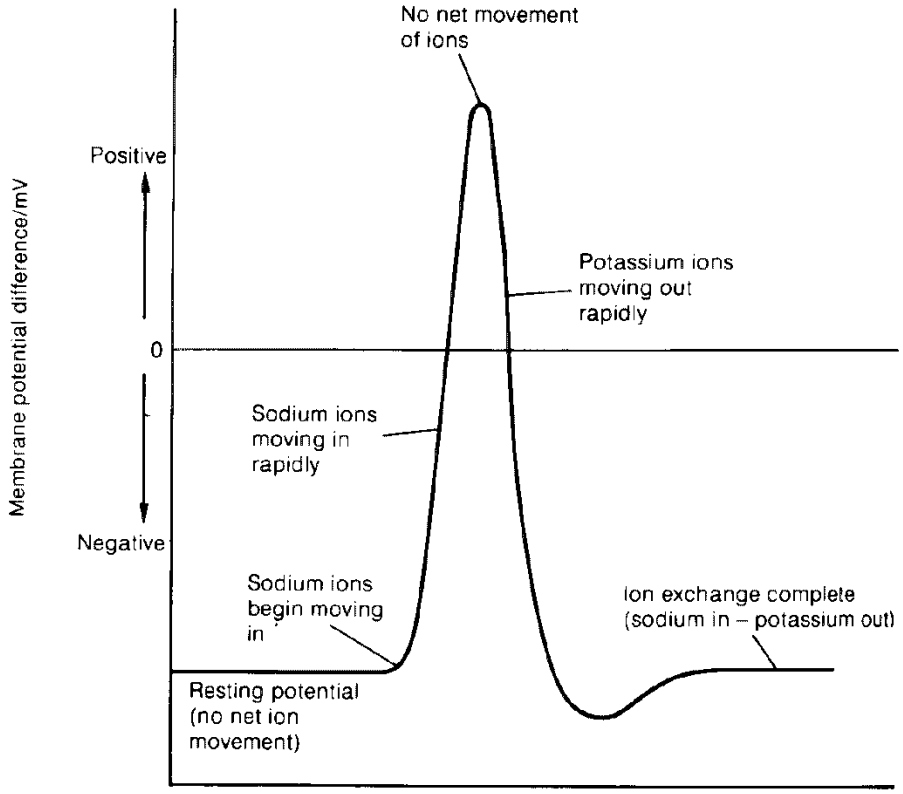


AP generation unlike simple electrical circuit
Saltatory conduction (200m/s)
Unmyelinated conduction (2m/s)
This rapid conduction of electrical signal reaches the next node and creates another action potential, thus refreshing the signal. In this manner, saltatory conduction allows electrical nerve signals to be propagated long distances at high rates without any degradation of the signal. Although the action potential appears to jump along the axon, this phenomenon is actually just the rapid, almost instantaneous, conduction of the signal inside the myelinated portion of the axon.

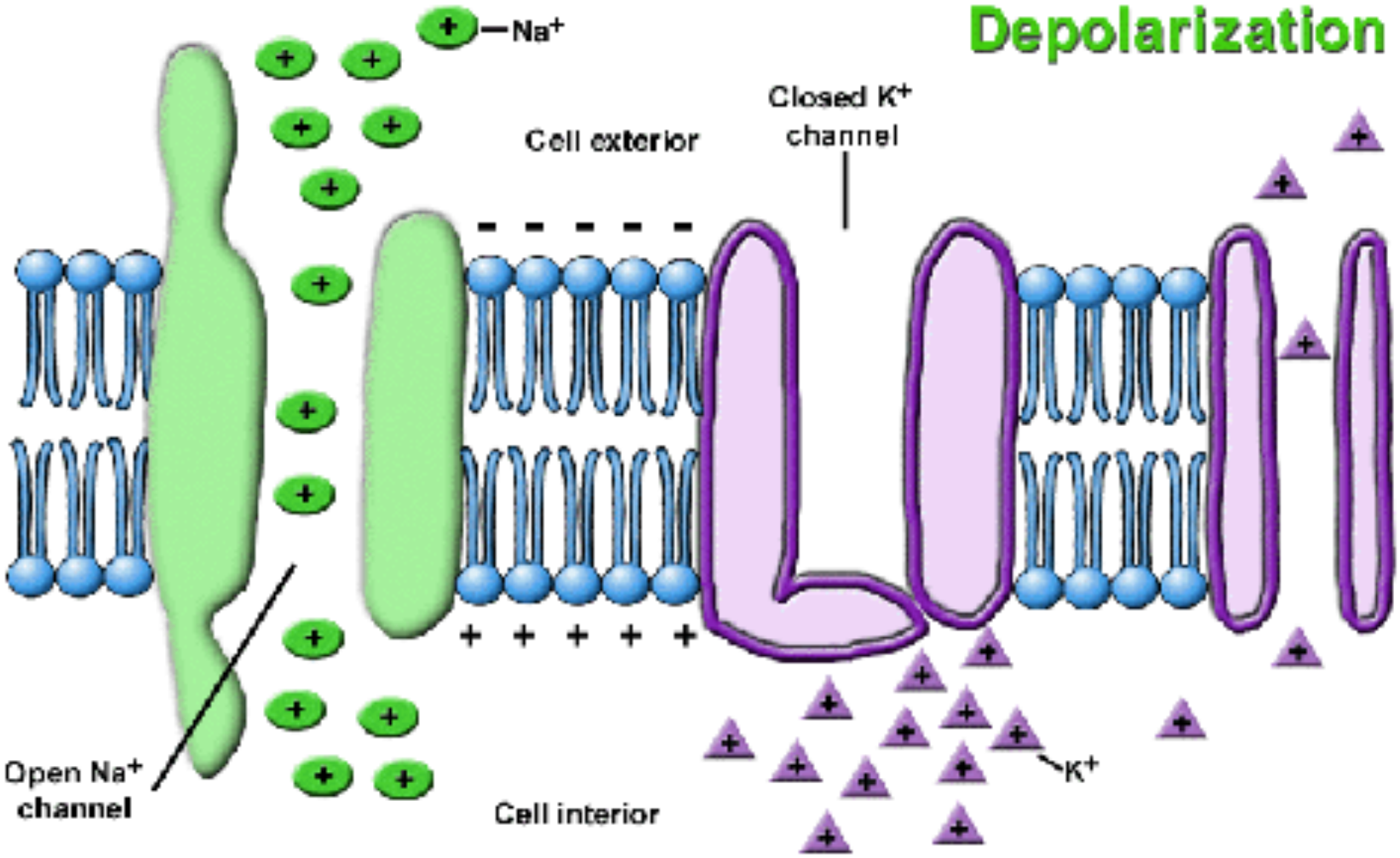
In addition to increasing the speed of the nerve impulse, the myelin sheath helps in reducing energy expenditure over the axon membrane as a whole, because the amount of sodium and potassium ions that need to be pumped to bring the concentrations back to the resting state following each action potential is decreased.

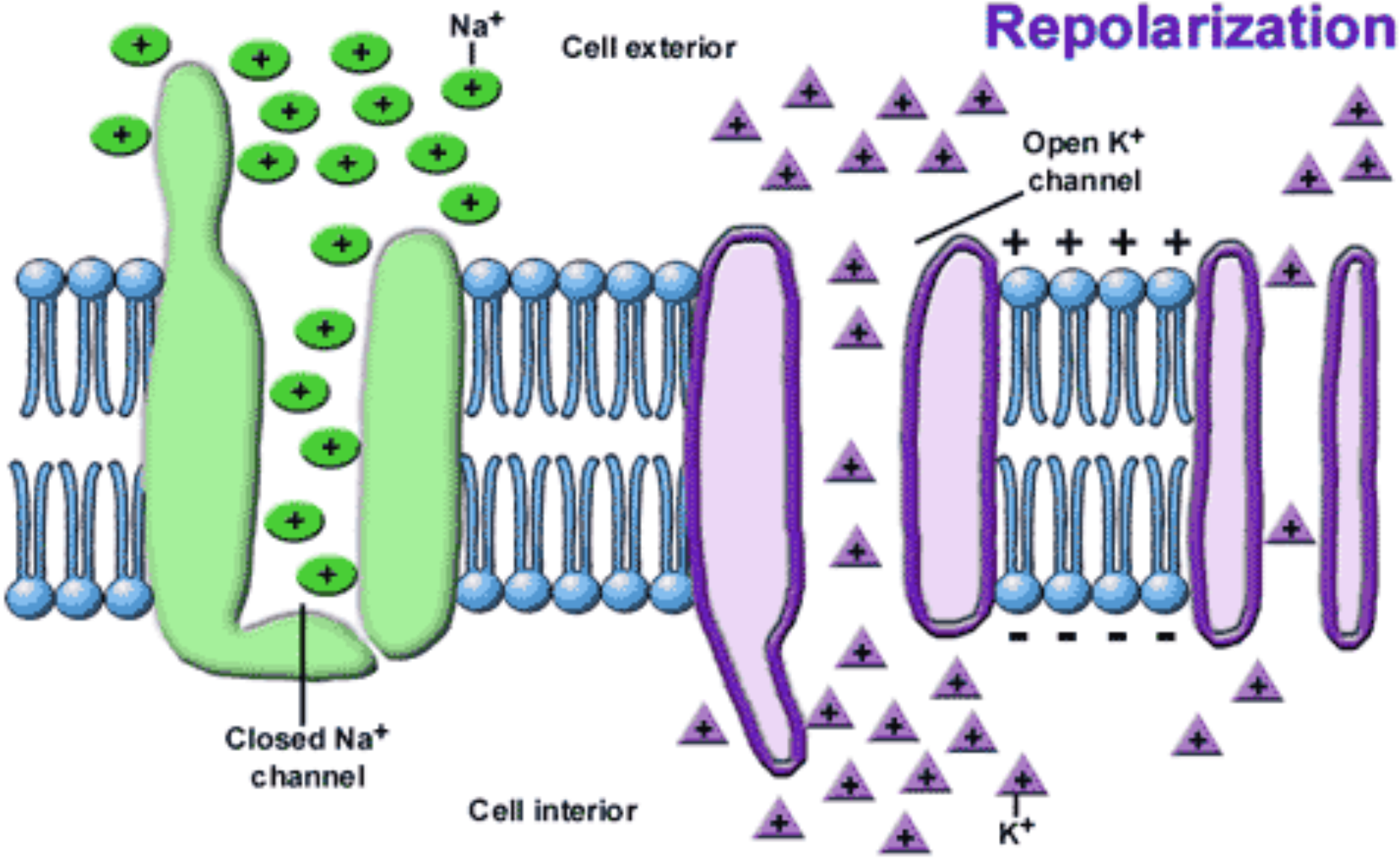

Schwann cell
Depolarized region
(node of Ranvier)
Cell body
Myelin
sheath
Axon

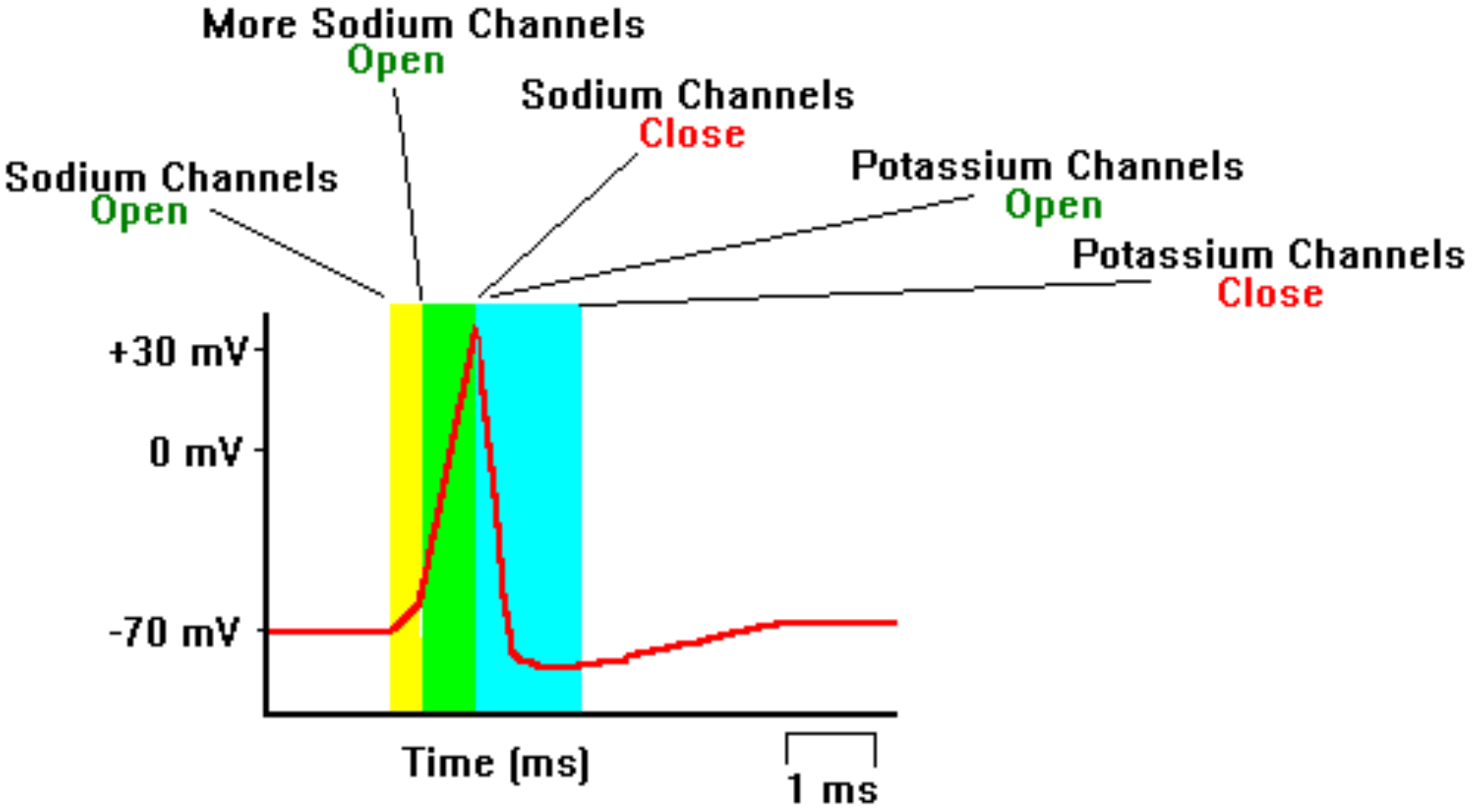


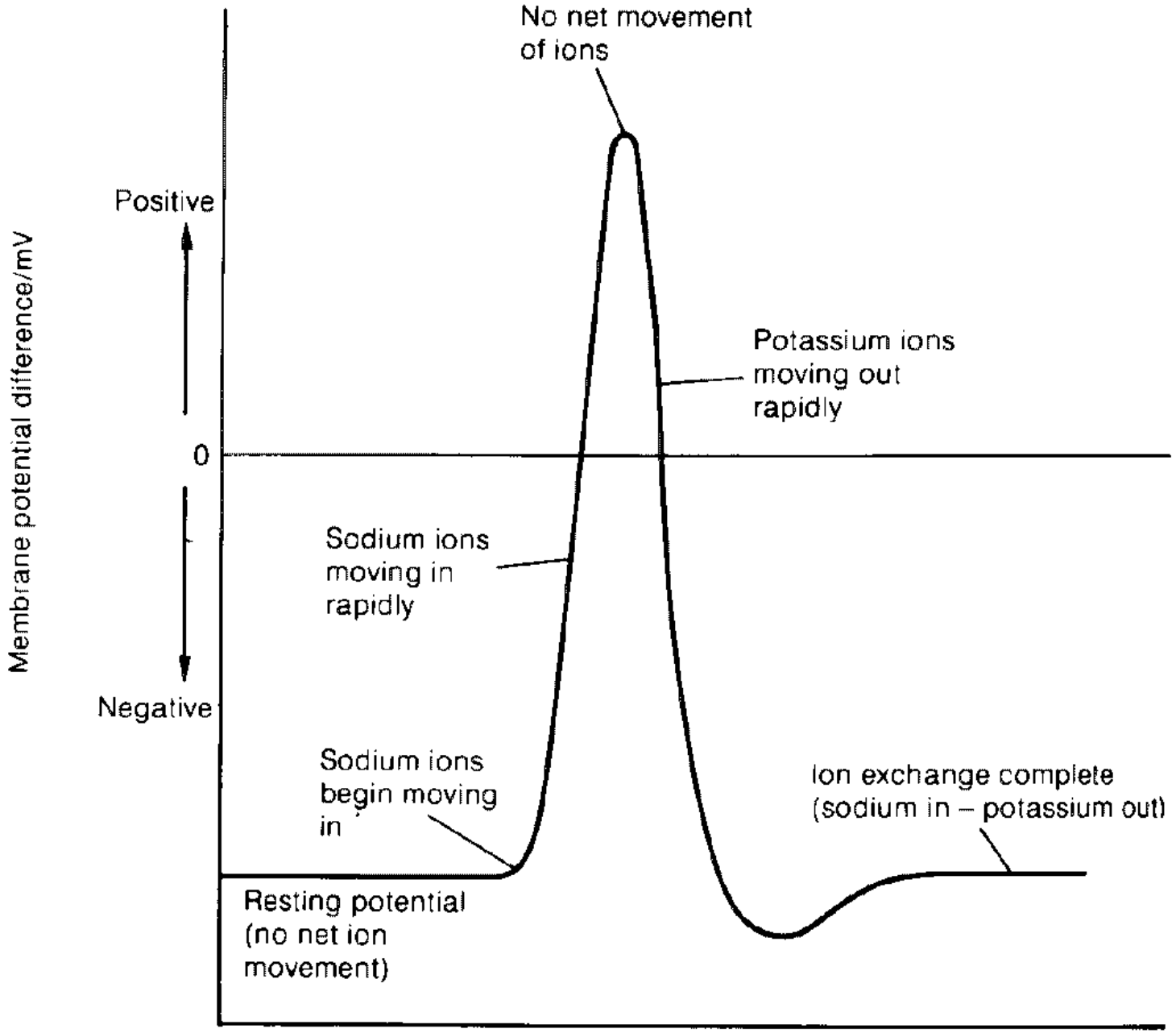


Ion movements during an action potential

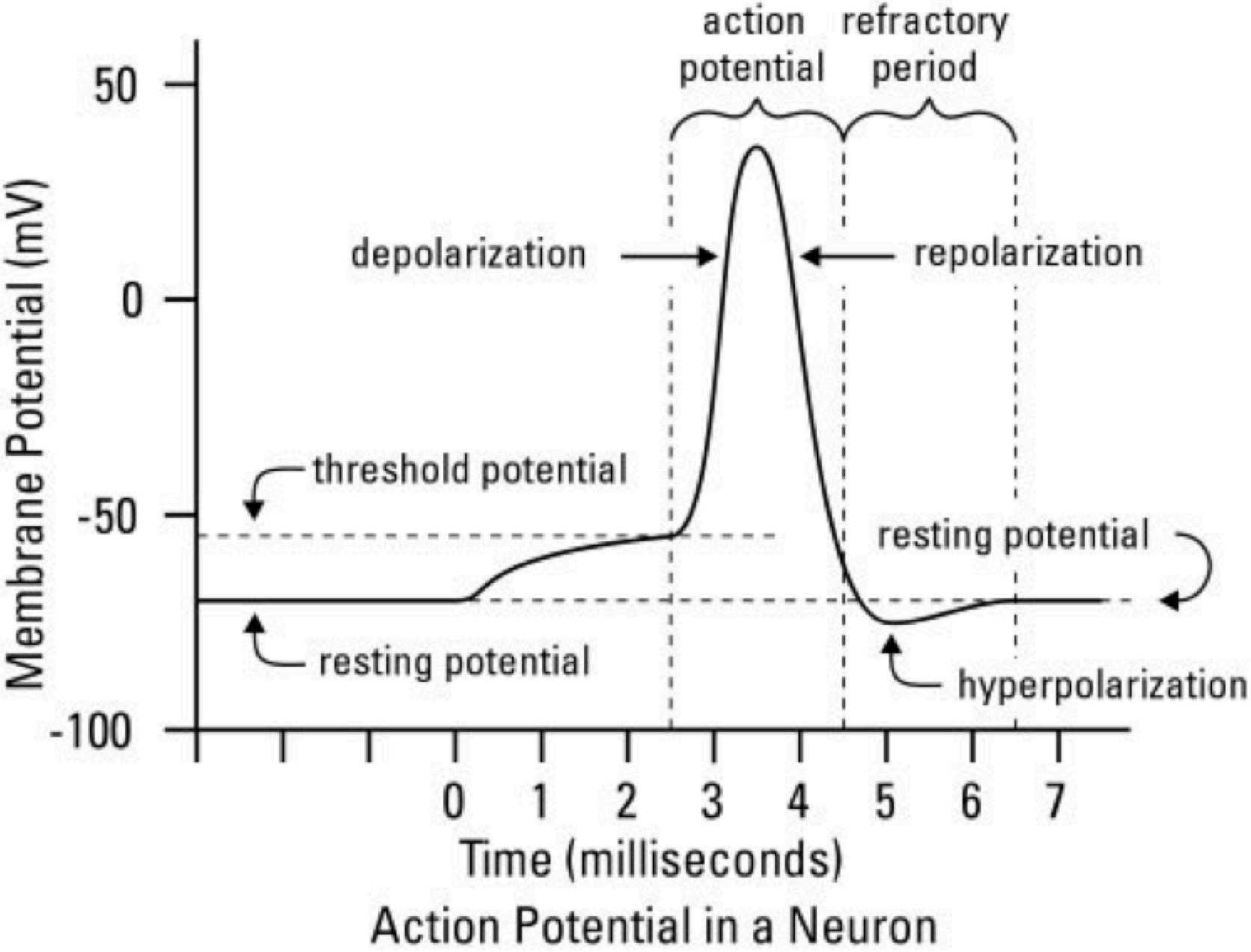

Depolarization
Na+
Cell exterior
Closed K+ channel
Open Na+ channel
Cell interior
K+


Repolarization
Na+
Cell exterior
Open K+ channel
Closed Na+ channel
Cell interior
K+

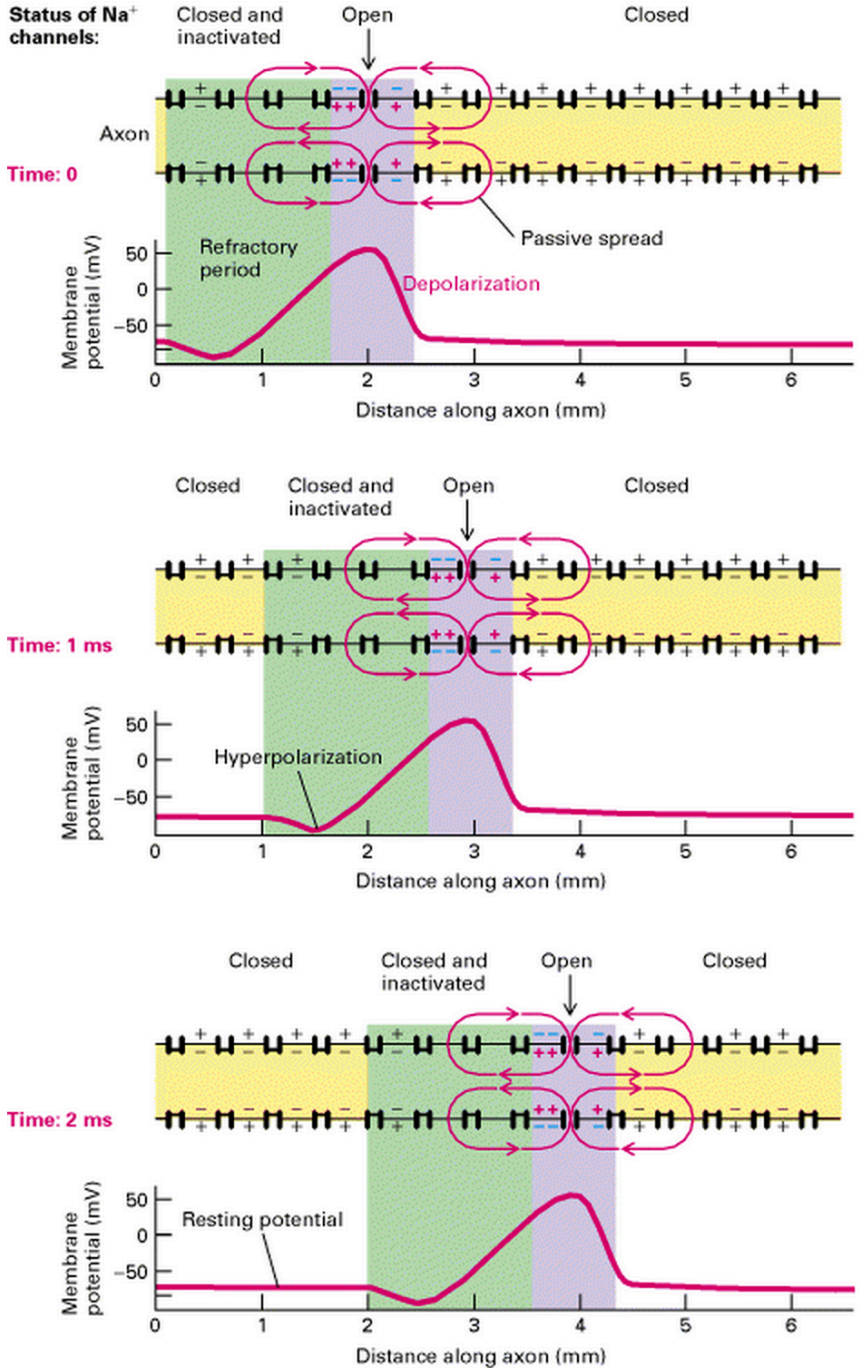

More Sodium Channels
Open
Sodium Channels
Close
Sodium Channels
Open
Potassium Channels
Open
Potassium Channels
Close
+30 mV
0 mV
-70 mV
Time (ms)
1 ms



Ion movements during an action potential



Action Potential in a Neuron

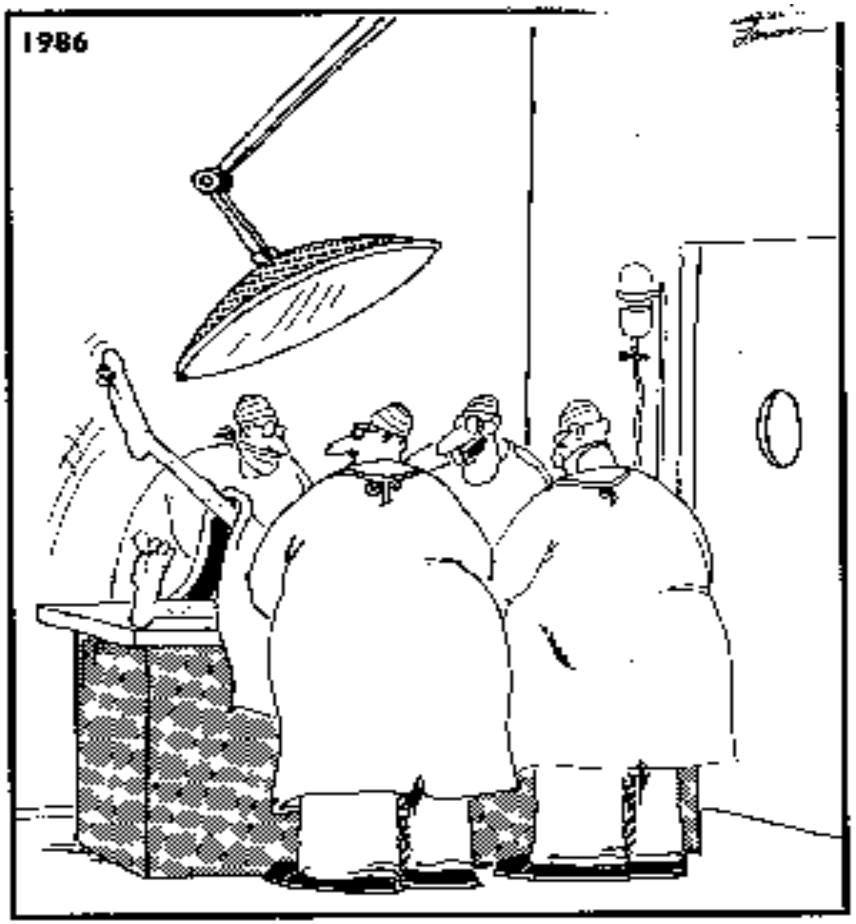

Status of Na+ channels:
Closed and inactivated
Open
Closed
Axon
Time: 0
Passive spread
Refractory period
Depolarization
Membrane potential (mV)
50
0
−50
0
1
2
3
4
5
6
Distance along axon (mm)
Closed
Closed and inactivated
Open
Closed
Time: 1 ms
Hyperpolarization
Membrane potential (mV)
50
0
−50
0
1
2
3
4
5
6
Distance along axon (mm)
Closed
Closed and inactivated
Open
Closed
Time: 2 ms
Resting potential
Membrane potential (mV)
50
0
−50
0
1
2
3
4
5
6
Distance along axon (mm)

NEURAL TRANSMISSION

RESPONSE TO ENVIRONMENTAL STIMULI

CLICK TO BEGIN.

How does the pain you experience when you burn your hand result so quickly in an action by your muscles?



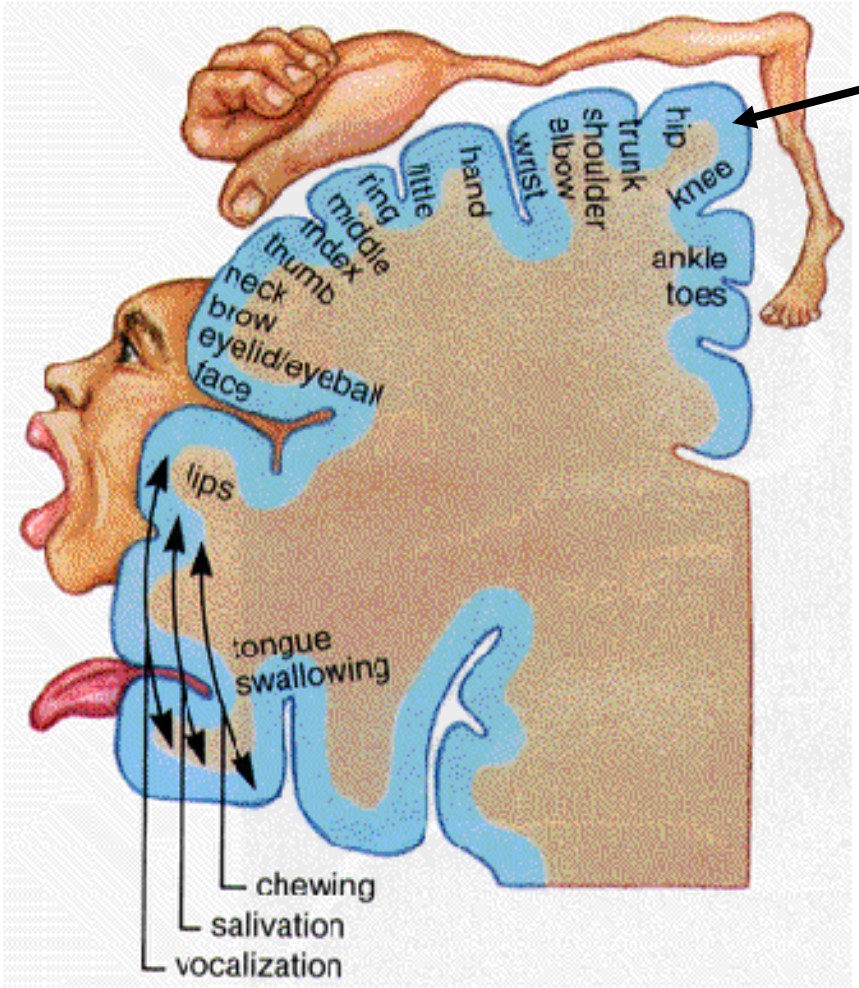
"Whoa! *That* was a good one! Try it, Hobbs—just poke his brain right where my finger is."

Copyright: Gary Larson

Q: Assuming this comical situation was factually accurate, what Cortical Region of the brain would these doctors be stimulating?

Thanks!

A: Primary Motor Cortex



* This graphic representation of the regions of the Primary Motor Cortex and Primary Sensory Cortex is one example of a HOMUNCULUS:

Homunculus

* Note: Homunculus literally means "little person," and may refer to one whose body shape is governed by the cortical area devoted to that body region.

Q: What do you notice about the proportions depicted in the aforementioned homunculus?

A: They are not depicted in the same scale representative of the human body.

Q: What is meant by depicting these body parts in such outrageous proportions?

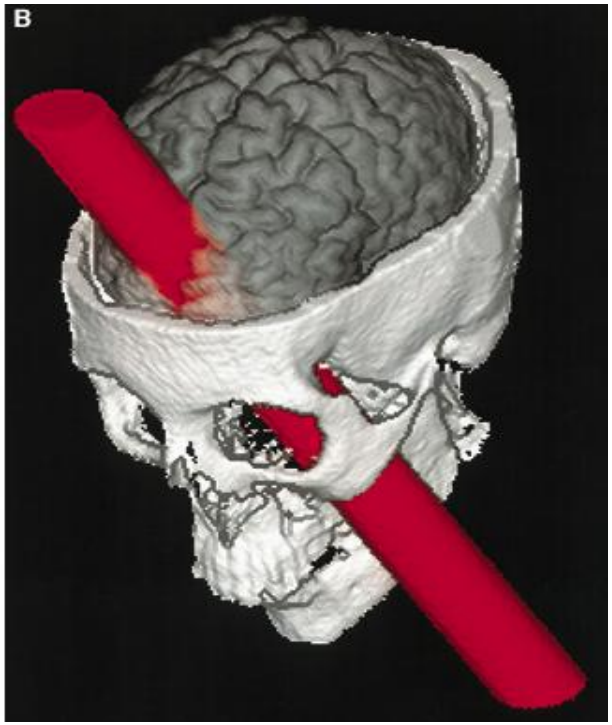
A: These outrageous proportions depict the cortical area devoted to each structure.

- Ex: Your hands require many intricate movements and sensations to function properly. This requires a great deal of cortical surface area to control these detailed actions. Your back is quite the opposite, requiring limited cortical area to carry out its actions and functions, or detect sensation.

Back-Hom.

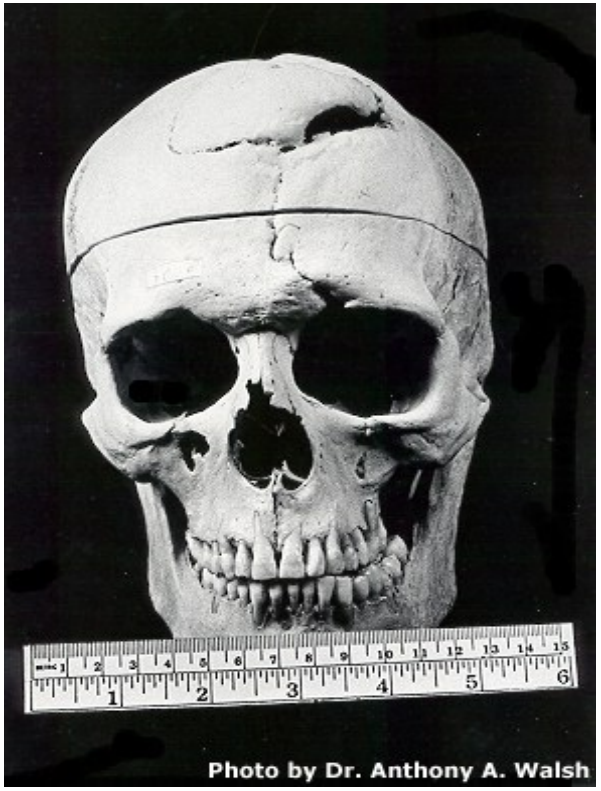
Further Investigation

Phineas Gage: Phineas Gage was a railroad worker in the 19th century living in Cavendish, Vermont. One of his jobs was to set off explosive charges in large rock in order to break them into smaller pieces. On one of these instances, the detonation occurred prior to his expectations, resulting in a 42 inch long, 1.2 inch wide, metal rod to be blown right up through his skull and out the top. The rod entered his skull below his left cheek bone and exited after passing through the anterior frontal lobe of his brain.



Frontal

Remarkably, Gage never lost consciousness, or quickly regained it (there is still some debate), suffered little to no pain, and was awake and alert when he reached a doctor approximately 45 minutes later. He had a normal pulse and normal vision, and following a short period of rest, returned to work several days later. However, he was not unaffected by this accident.



http://www.sruweb.com/~walsh/gage5.jpg

Learn more about Phineas Gage: http://en.wikipedia.org/wiki/Phineas_Gage

Frontal

Q: **Recalling what you have just learned regarding the frontal lobe, what possible problems or abnormalities may Gage have presented with subsequent to this type of injury** (remember the precise location of the rod through his brain)**?**

A: **Gage's personality, reasoning, and capacity to understand and follow social norms had been diminished or destroyed. He illustrated little to no interest in hobbies or other involvements that at one time he cared for greatly. 'After the accident, Gage became a nasty, vulgar, irresponsible vagrant. His former employer, who regarded him as "the most efficient and capable foreman in their employ previous to his injury," refused to rehire him because he was so different.'**

Q: **It is suggested that Gage's injury inspired the development of what at one time was a widely used medical procedure. What might this procedure be, and how does it relate to Gage's injury?**

A: **The frontal lobotomy. This has been used with the intention to diminish aggression and rage in mental patients, but generally results in drastic personality changes, and an inability to relate socially. This procedure is largely frowned upon today, with the development of neurological drugs as treatments.**

Frontal

Resources

Images:

- http://www.dalbsoutss.eq.edu.au/Sheepbrains_Me/human_brain.gif
- http://www.bioon.com/book/biology/whole/image/1/1-8.tif.jpg
- http://www.bioon.com/book/biology/whole/image/1/1-6.tif.jpg
- http://williamcalvin.com/BrainForAllSeasons/img/bonoboLH-humanLH-viaTWD.gif
- http://www.math.tu-dresden.de/~belov/brain/motorcor2.gif
- Larson, Gary. The Far Side.

Phineas Gage:

- http://www.sruweb.com/~walsh/gage5.jpg
- http://soma.npa.uiuc.edu/courses/bio303/Image7.jpg
- http://en.wikipedia.org/wiki/Phineas_Gage
- http://science-education.nih.gov/nihHTML/ose/snapshots/multimedia/ritn/Gage/Broken_brain1.html