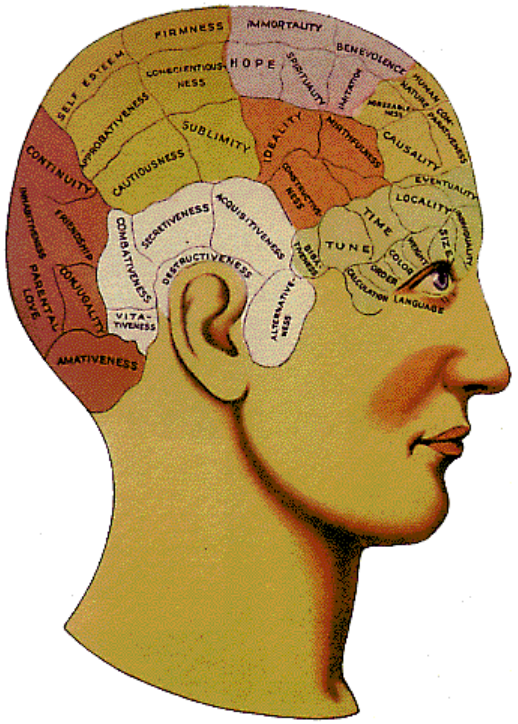
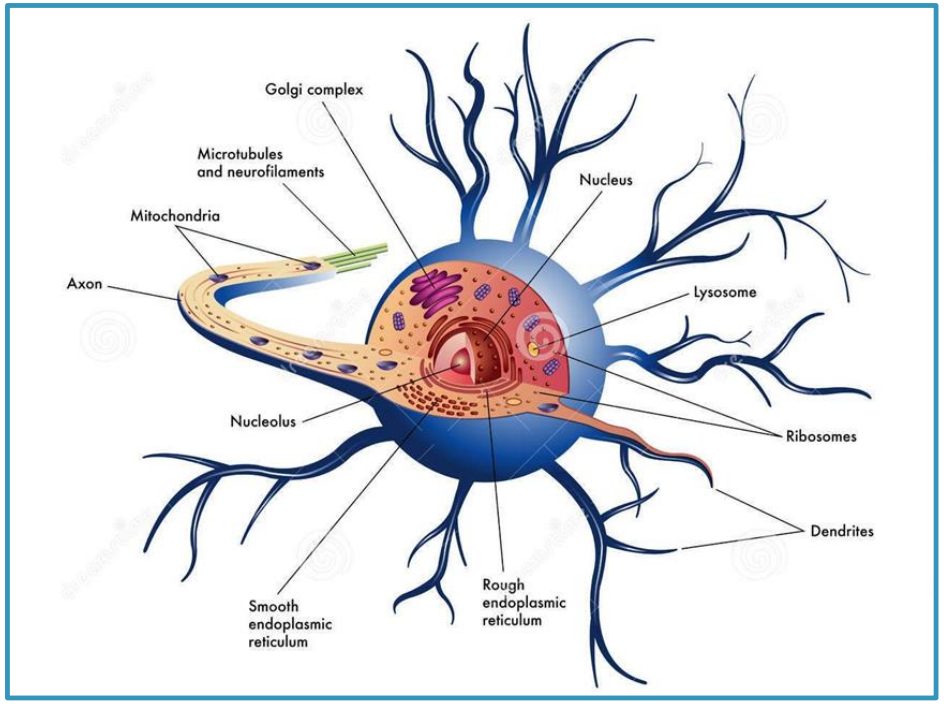


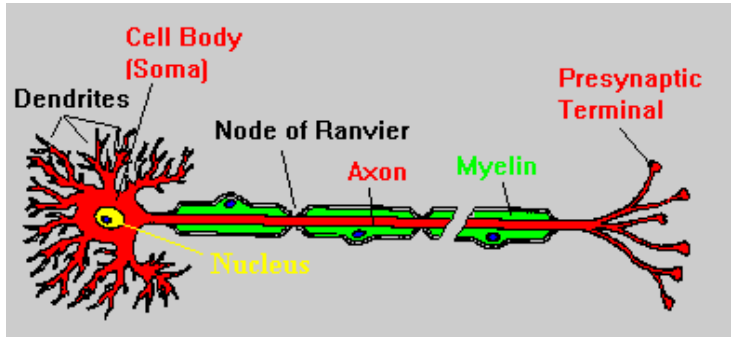
Chapters 10, 11

The Nervous System and Clinical Applications

COMD 6305 UTDALLAS

WILLIAM KATZ, PH.D.





Cells Of The Nervous System

The neuron

- Cell body
  - Nucleus
  - Nucleolus
- Dendrites
- Axon
- Terminal buttons

Myelin and Glia

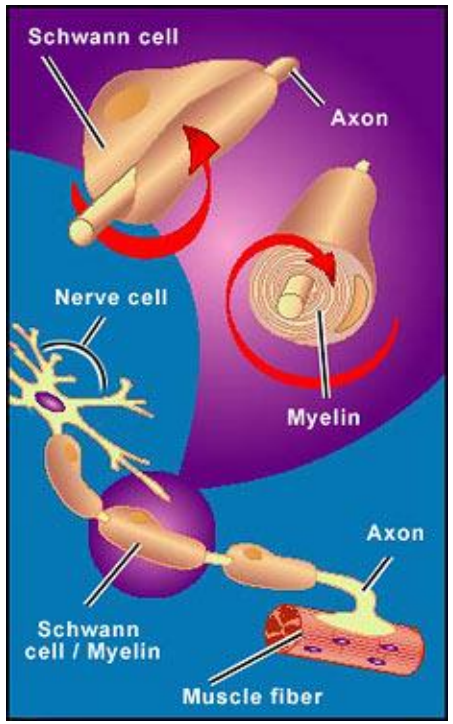
Myelin

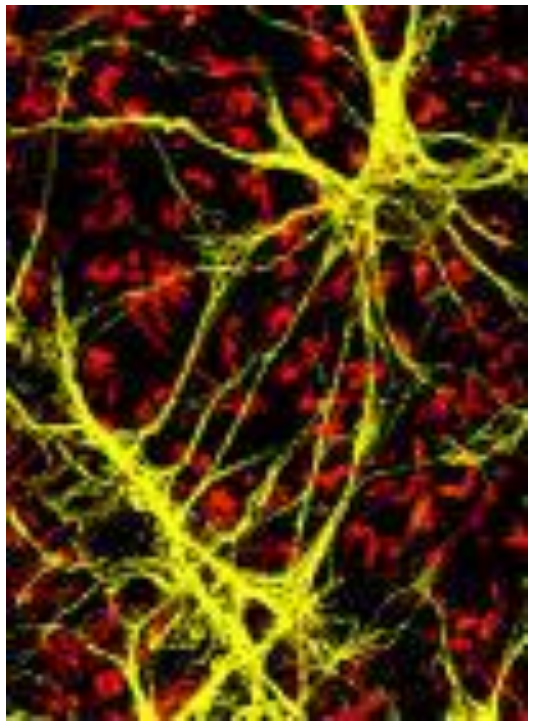
- Fatty substance that forms insulation for axons
- Increases speed of transmission of neural impulses
- Damaged in Amyotrophic Lateral Sclerosis

Glia

- Supporting cells
- 40 – 50x more prevalent than neurons
- Provide nutrients to neurons

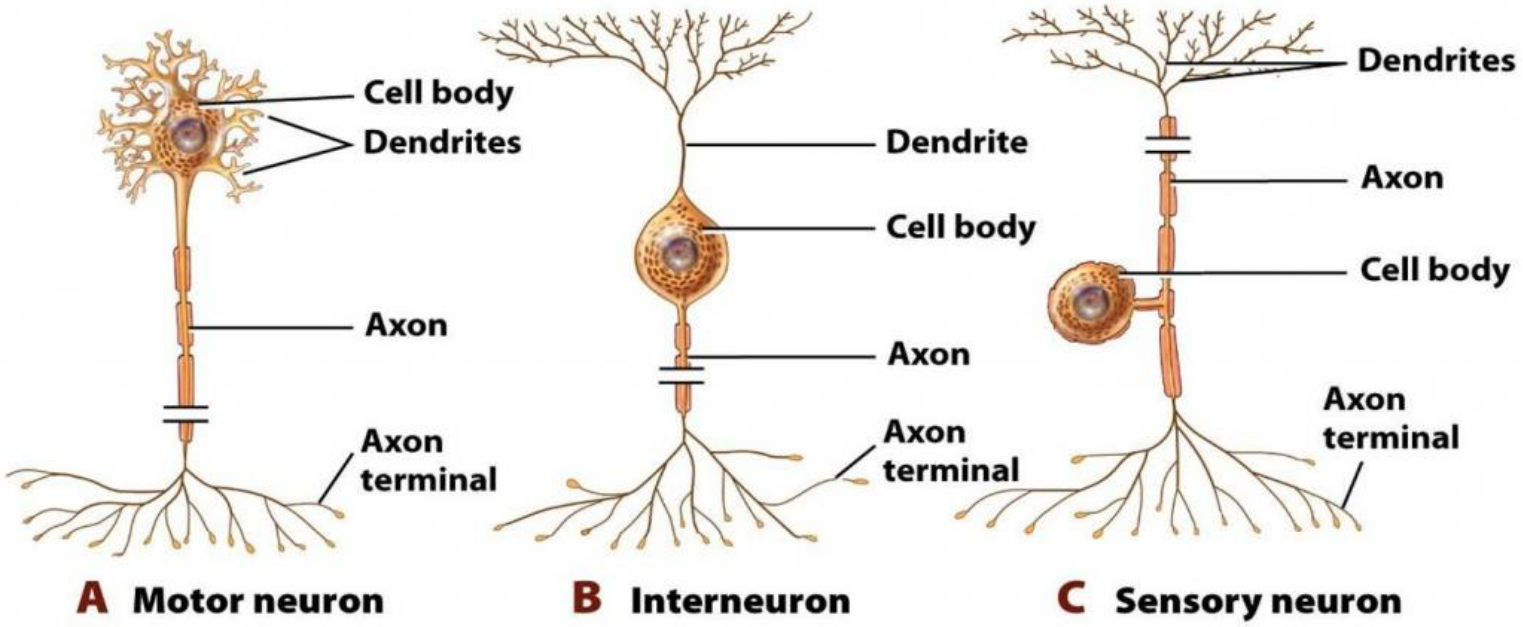
Myelin, Glia - details





(Human Retina)

Types of Neuron



(99% of all neurons in humans)

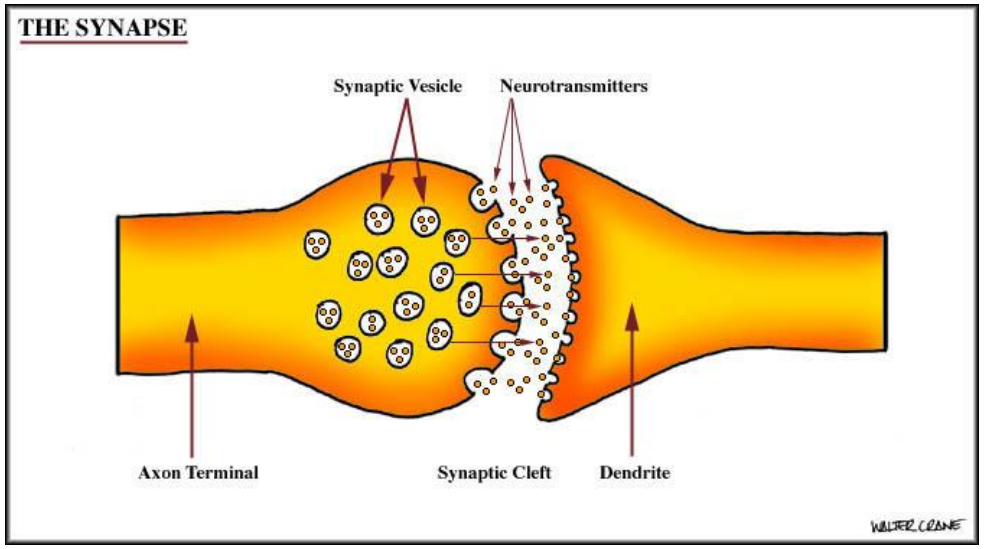
Neurons – polarity types

BIPOLAR

MULTIPOLAR

MONOPOLAR

Neuronal Connections



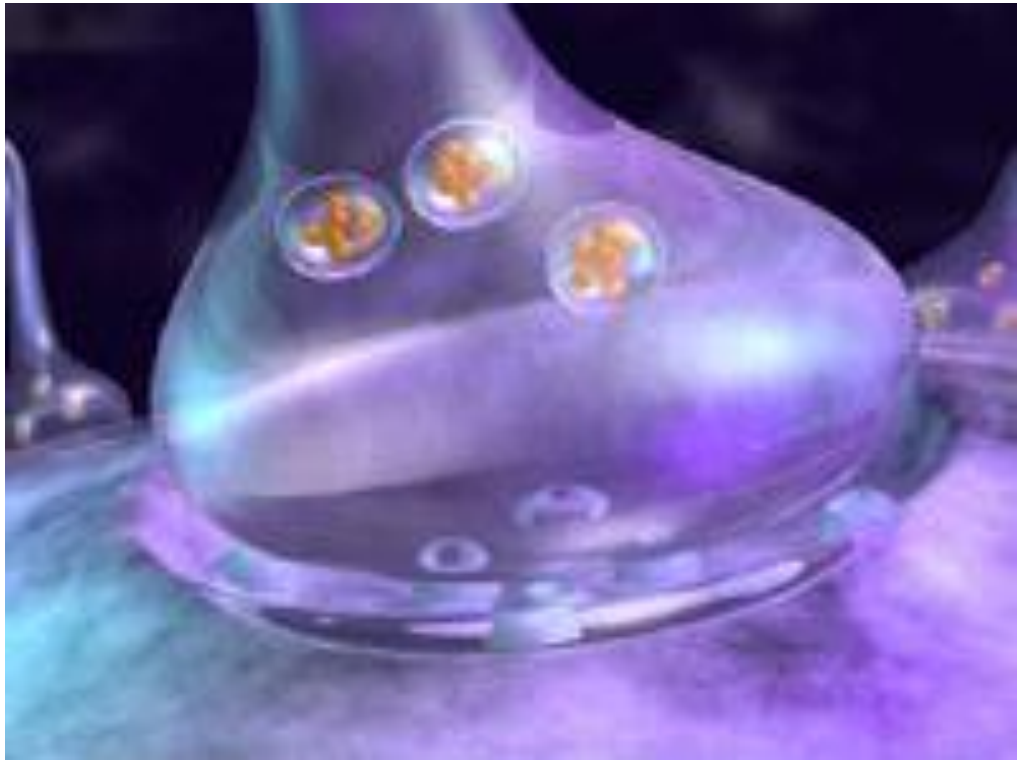
Pre- and post-synaptic

Synaptic cleft

- Neurotransmitter
- Neuromodulators

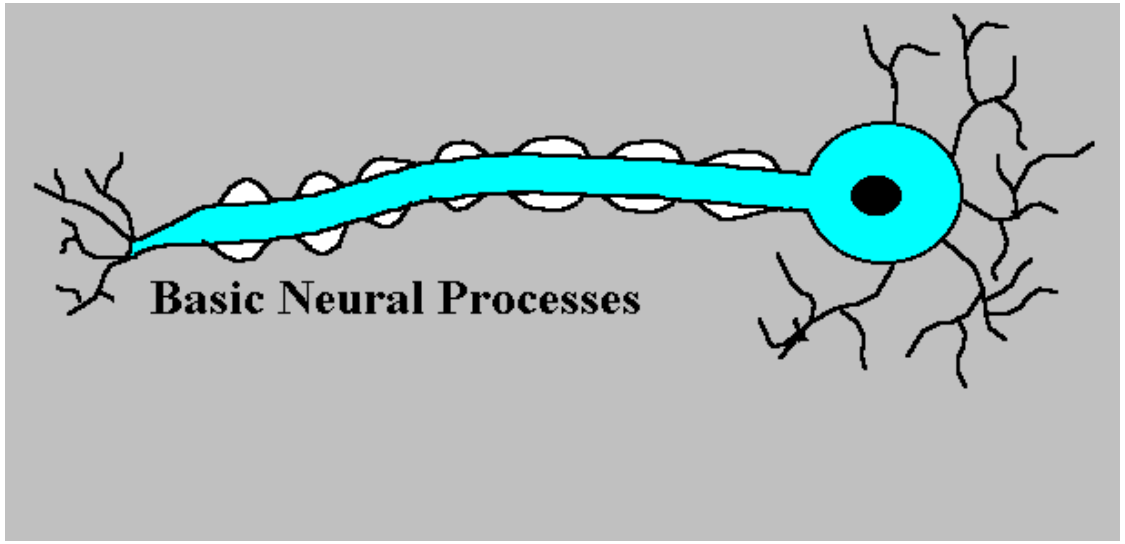
Actions

- Excitation
- Inhibition



Synapse – details

Neural Impulse



Resting potential

Depolarization

Action potential

Neural Impulse

- Extra and intracellular fluids Ions
- Resting membrane potential
- Sodium/ potassium pump
- Polarization
- Depolarization
- Action Potential
- Action spike

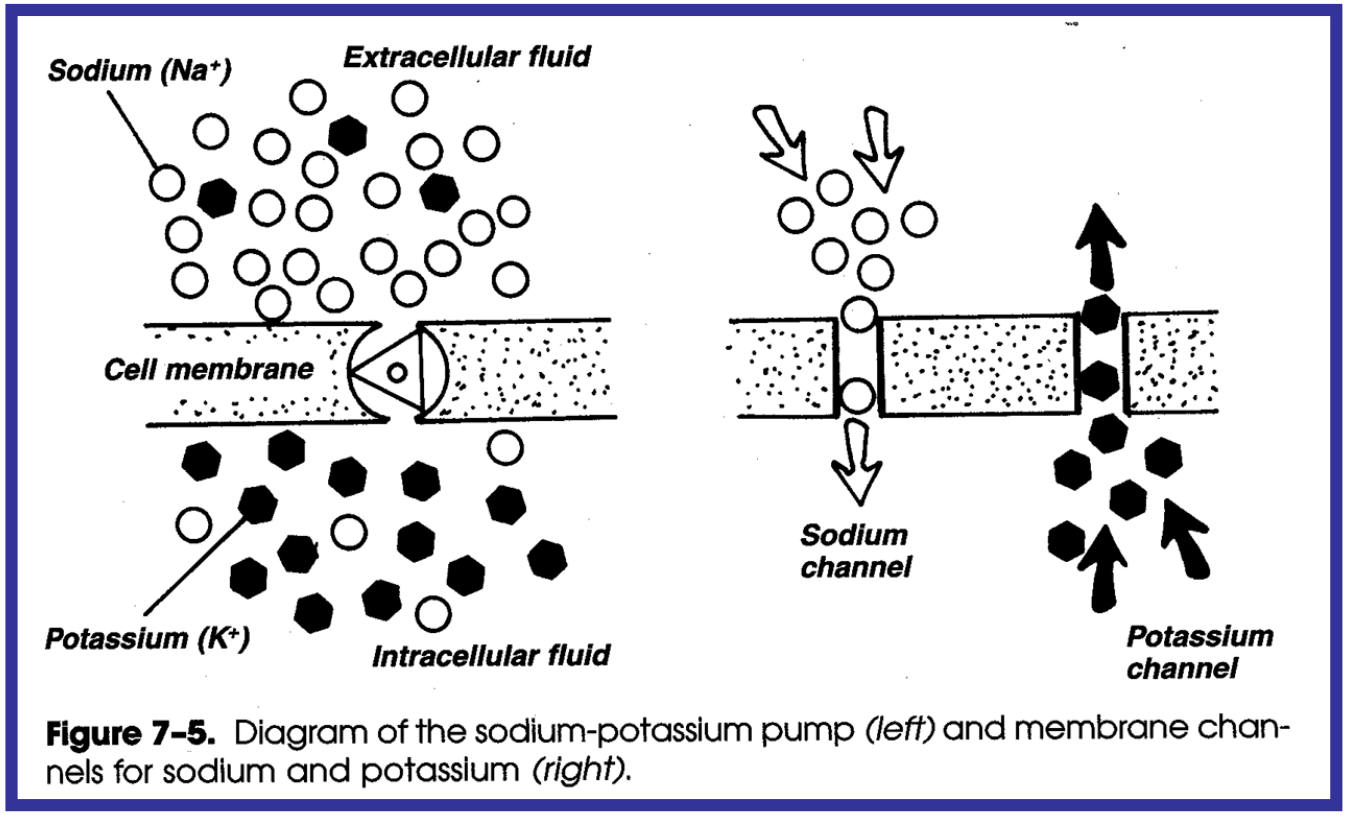


Figure 7–5. Diagram of the sodium-potassium pump *(left)* and membrane channels for sodium and potassium *(right)*.

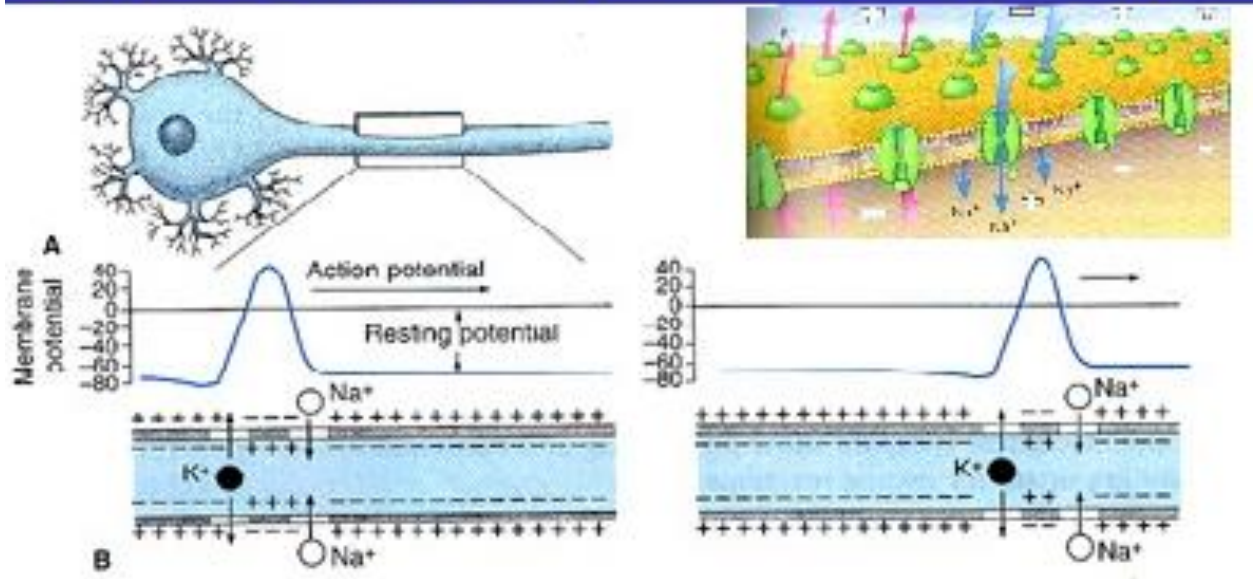
(fr. Kent, *The Speech Sciences*)

A. Resting potential:

- - 70 mV inside to out
- K+ diffuses out till electrostatic balance with diffusion occurs

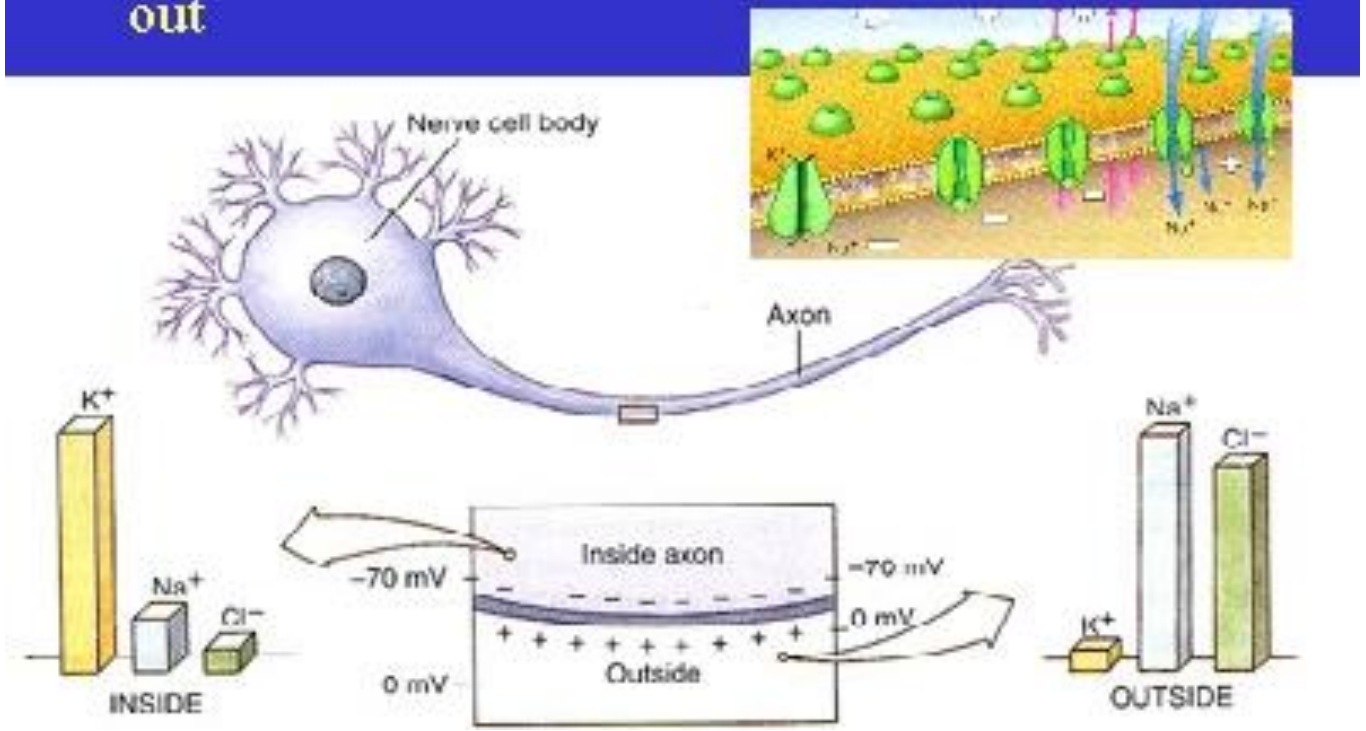
B. Action potential:

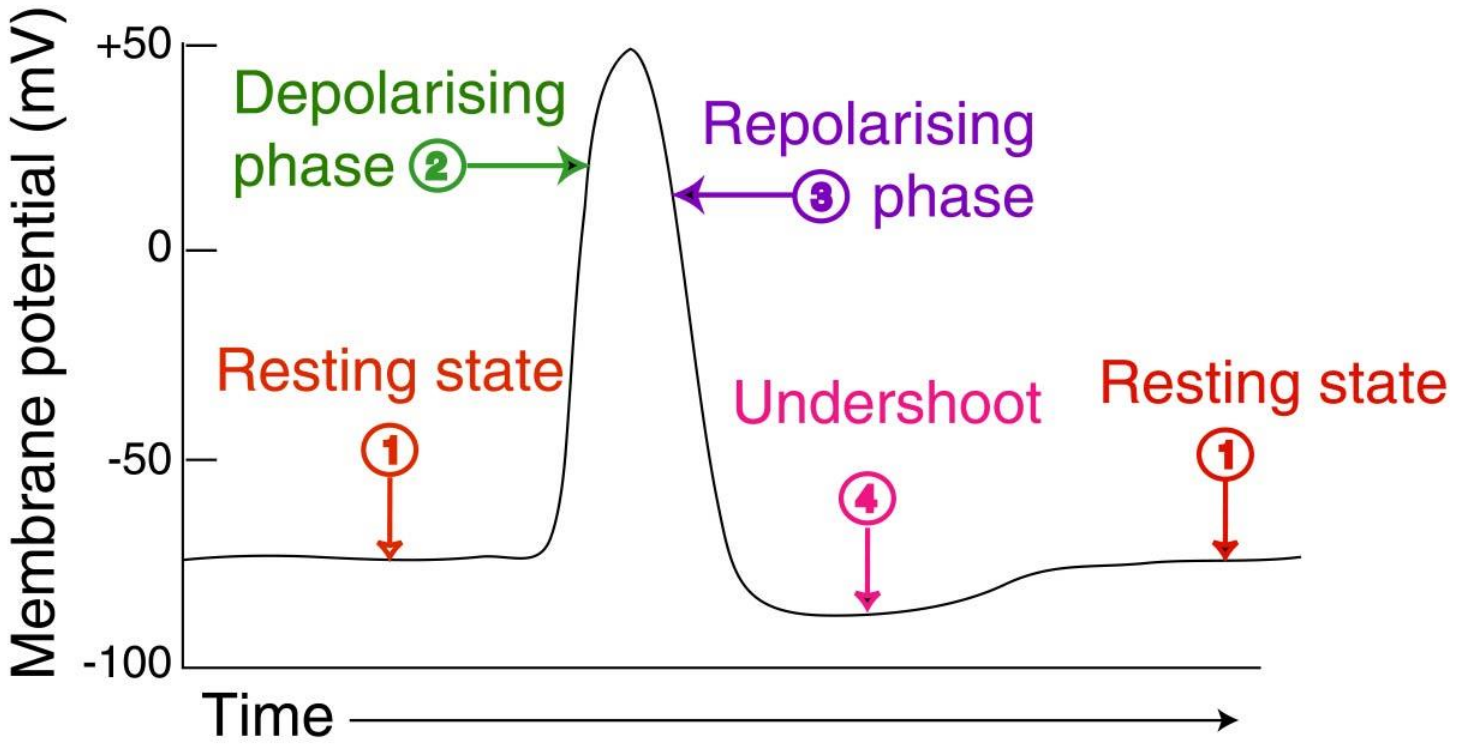
- **Na channels open Na rushes in - depolarization**
- **K rushes out stopping depolarization**
- Na channels close - 2 to 4 milliseconds, unidirectional!!



C. Resting potential restored:

- Na pumps use ATP to pump Na ions back out





Schematic electrical signal

Anatomy Of The Nervous System

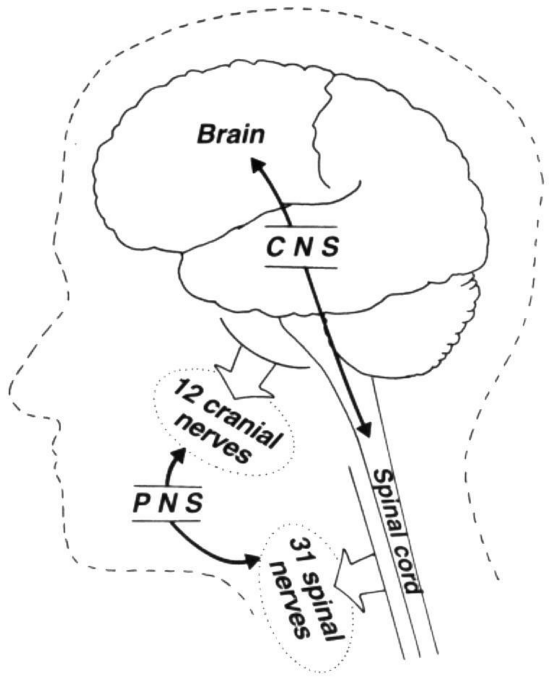


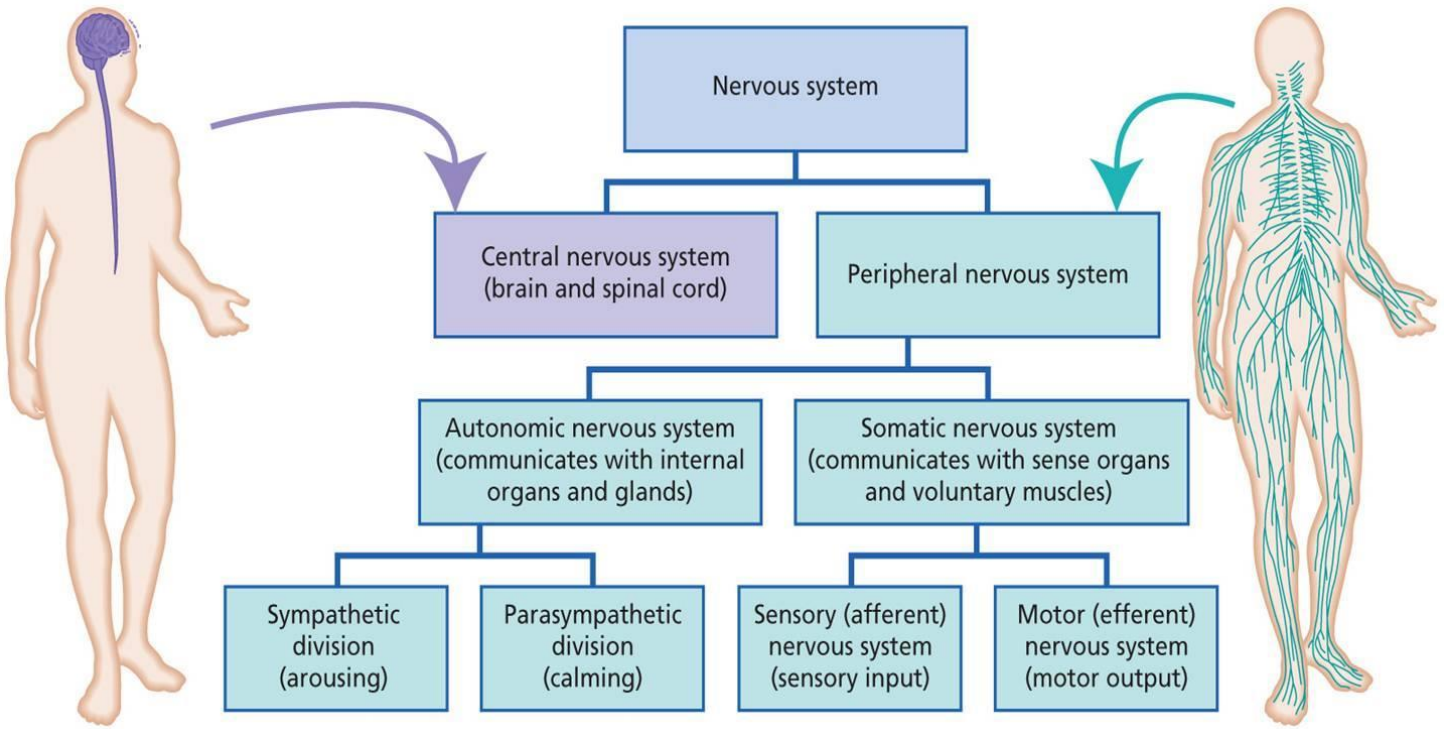
Figure 7–7. Diagram of the central nervous system (CNS) and peripheral nervous system (PNS).

- **Central nervous system (CNS)**

  [brain + spinal cord]

- **Peripheral nervous system (PNS)**

  [cranial nerves, spinal nerves]



Outline of NS

Divisions Of The CNS

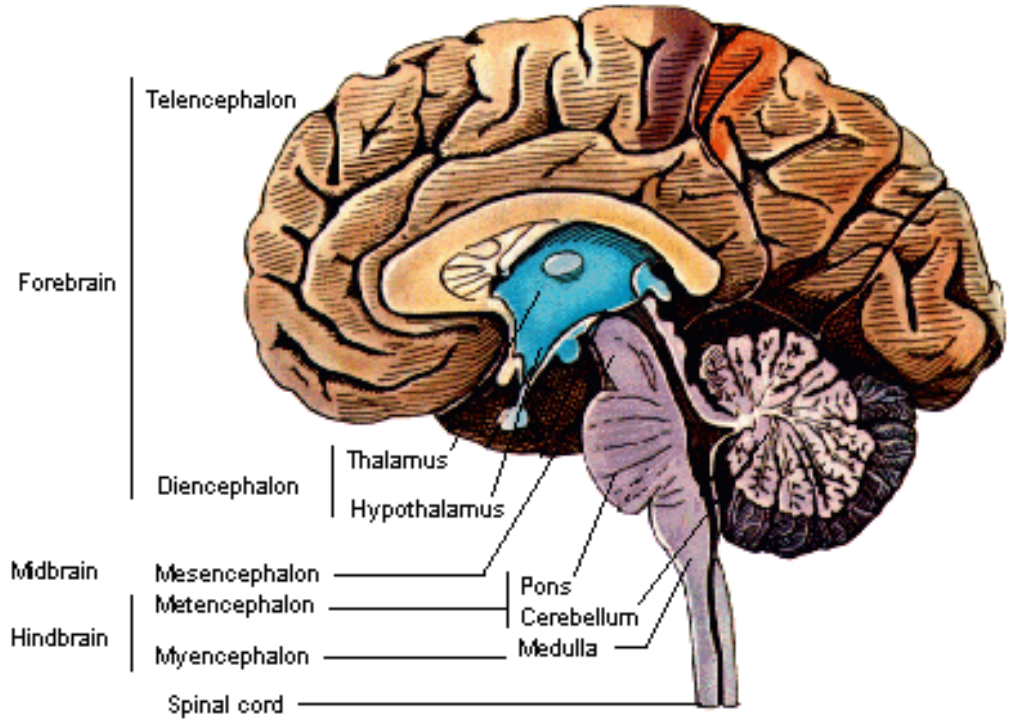
TELENCEPHALON
- (Cerebral hemispheres & basal nuclei)

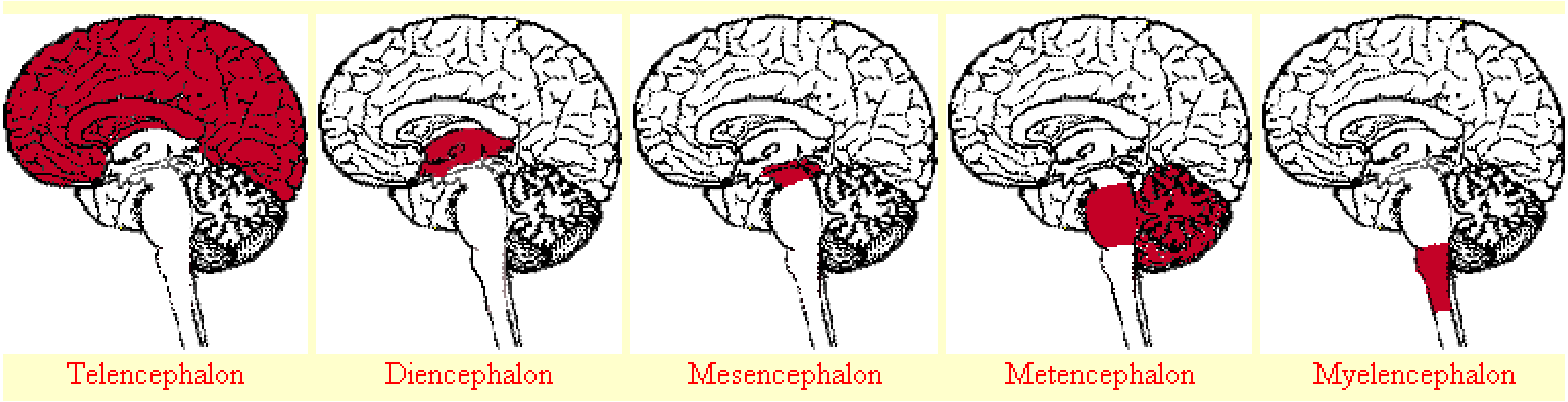
DIENCEPHALON
- (Thalamus and hypothalamus)

MESENCEPHALON
- (Midbrain – tectum, tegmentum)

METENCEPHALON
- (Pons, cerebellum)

MYELENCEPHALON
- (Medula Oblongata)



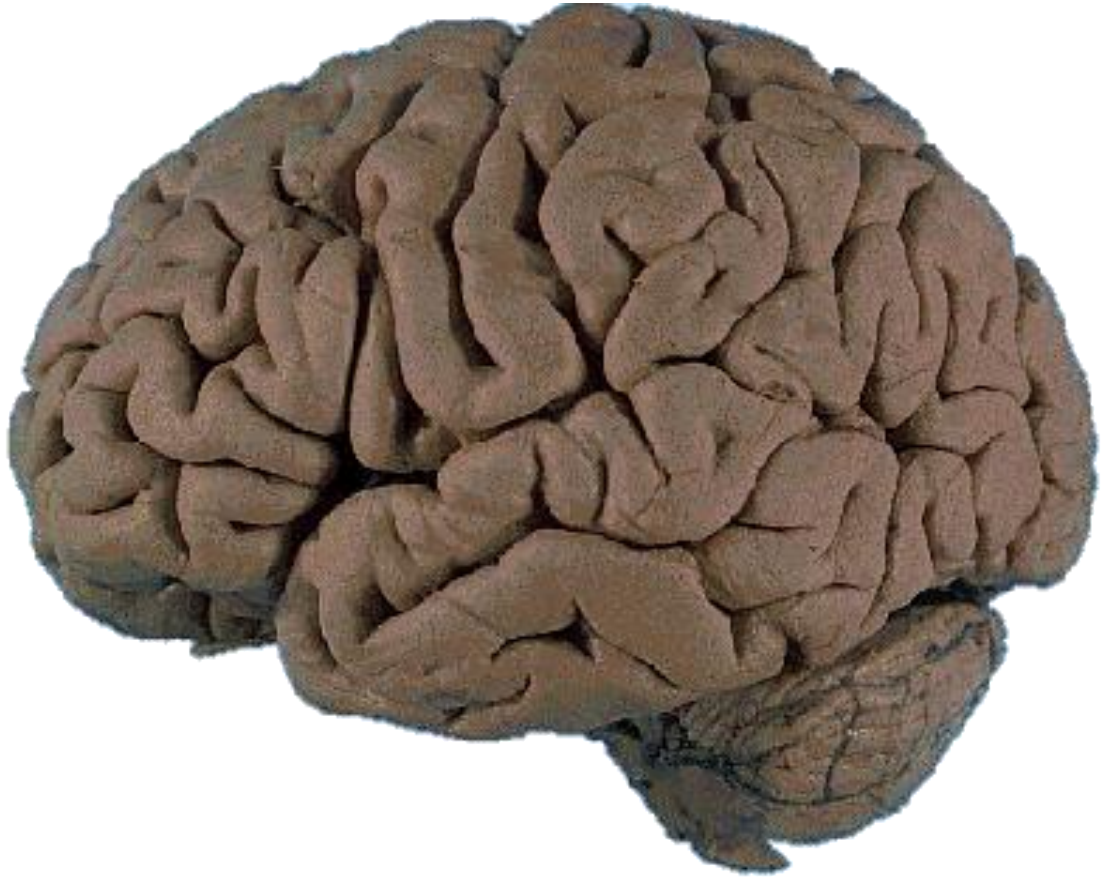


Divisions – continued

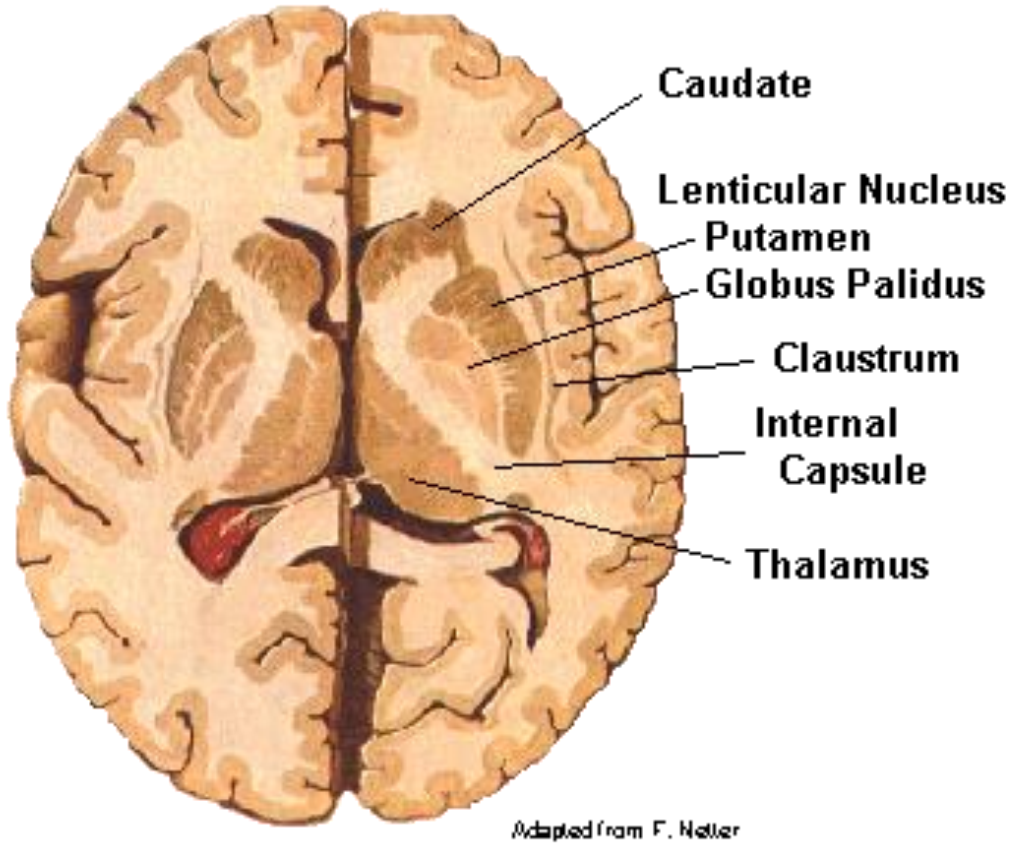
Cerebral Hemispheres

Gray matter

- LOBES
- GYRI
- SULCI
- FISSURES



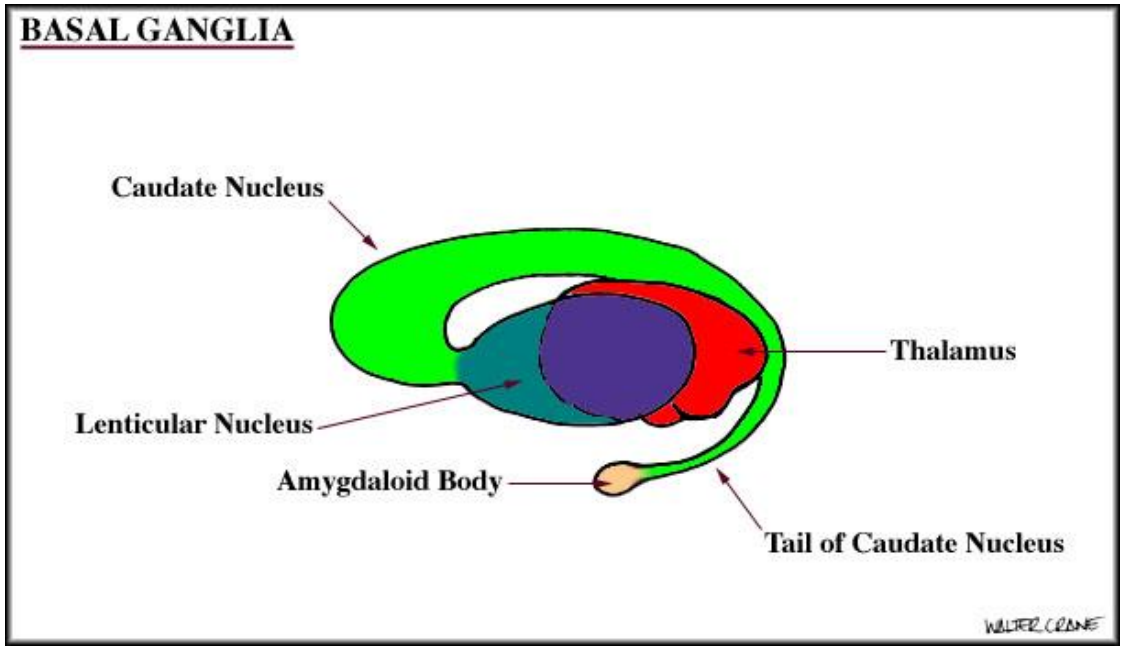
Transverse view



White matter

- FASICULI
- COMMISSURE

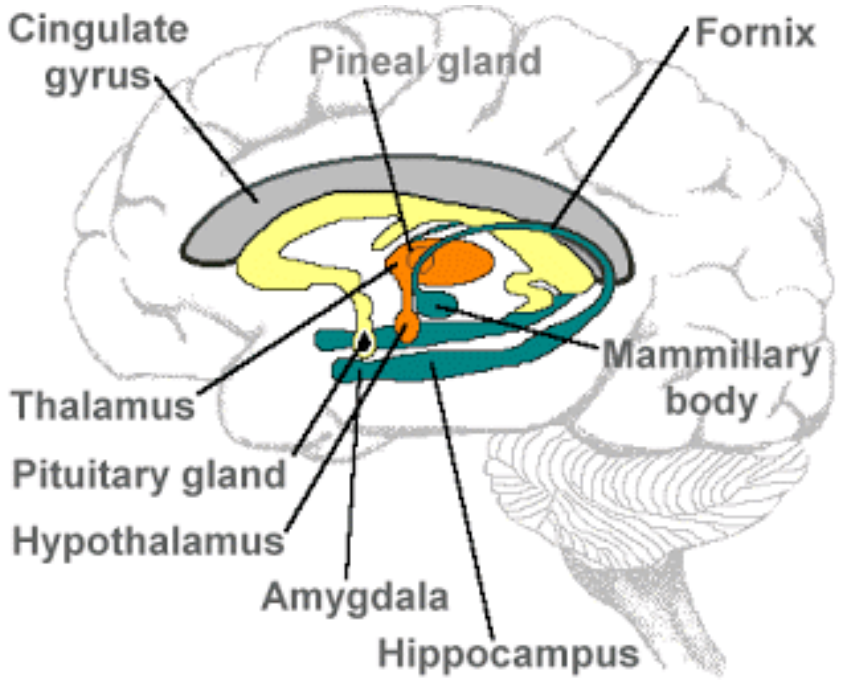
Subcortical Structures



- Basal ganglia/basal nuclei
- Thalamus & hypothalamus

Animation showing Basal Ganglia - UBC

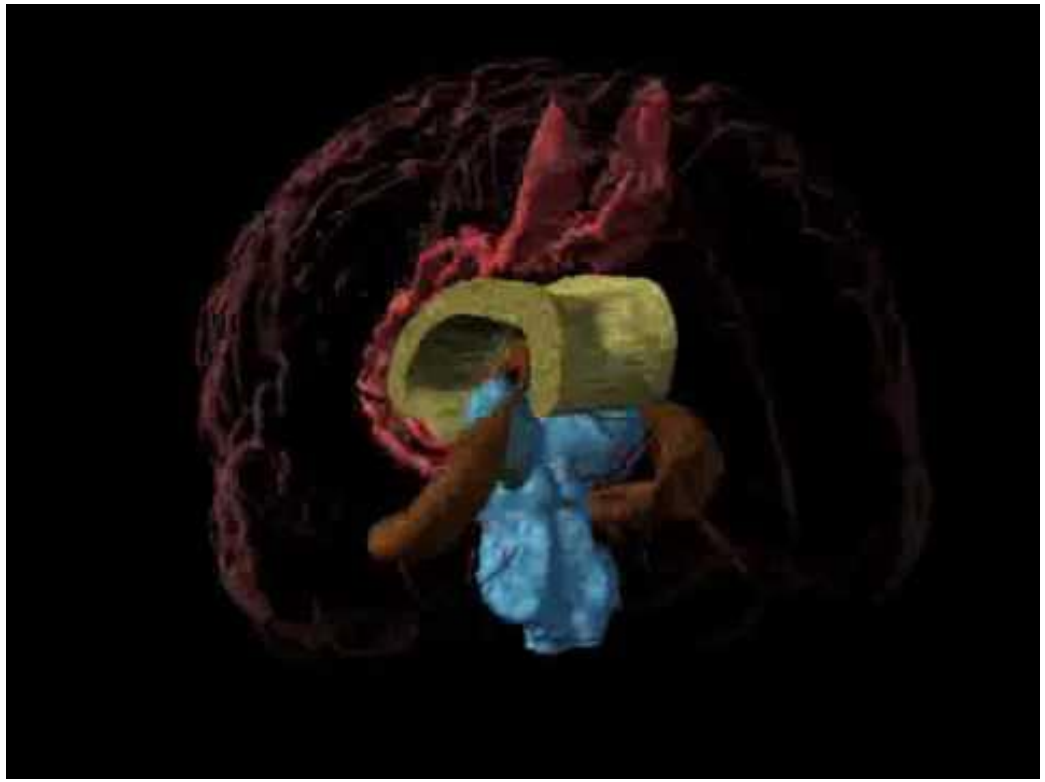
The Limbic System



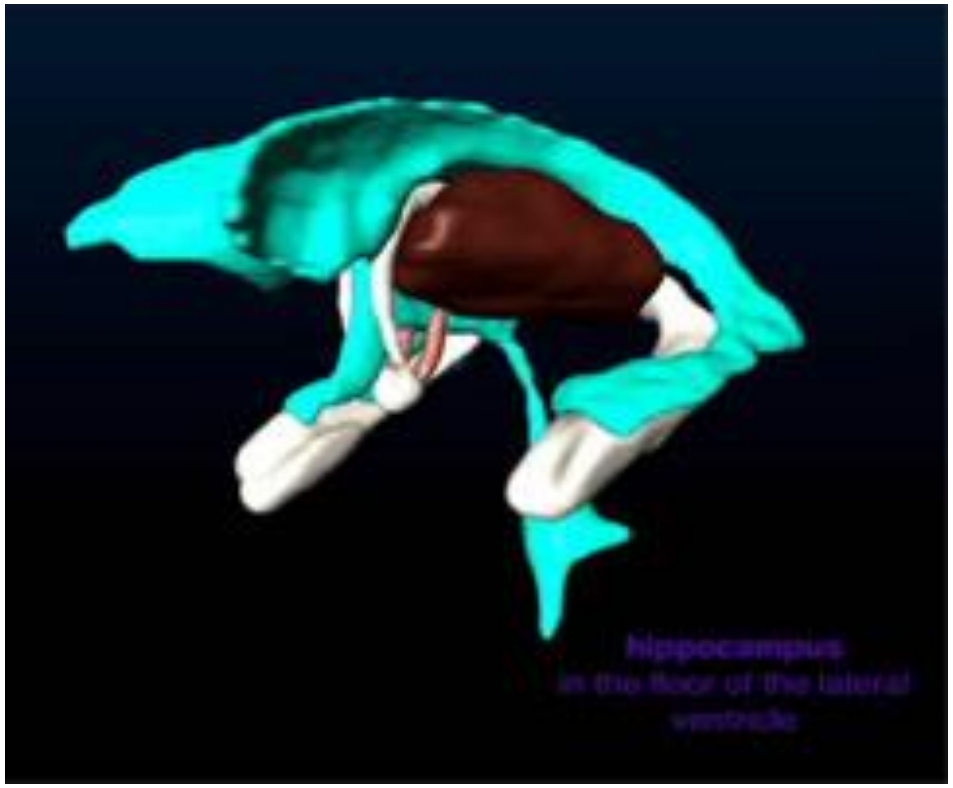
The Limbic System

The Limbic System Song! (good for memorizing)

Limbic system - animations

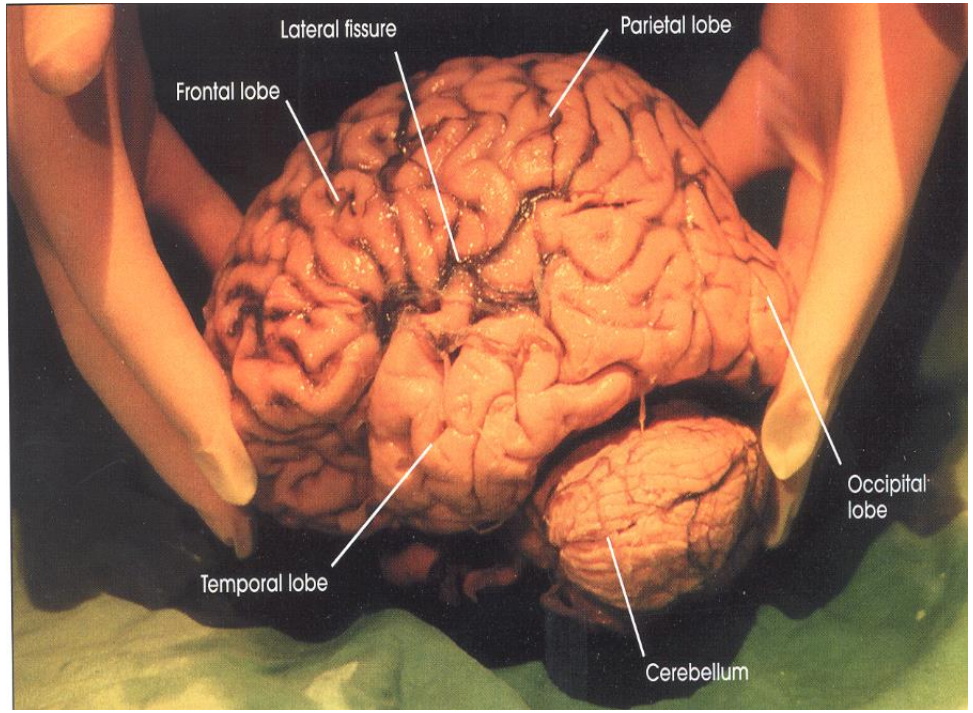


Animation of limbic system within cortex



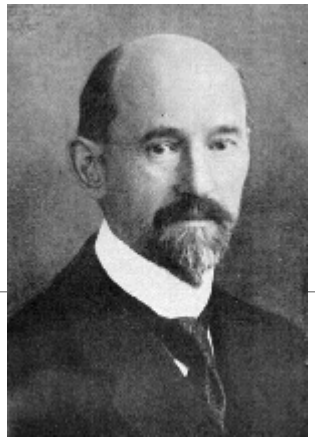
Labelled limbic system animation - UBC

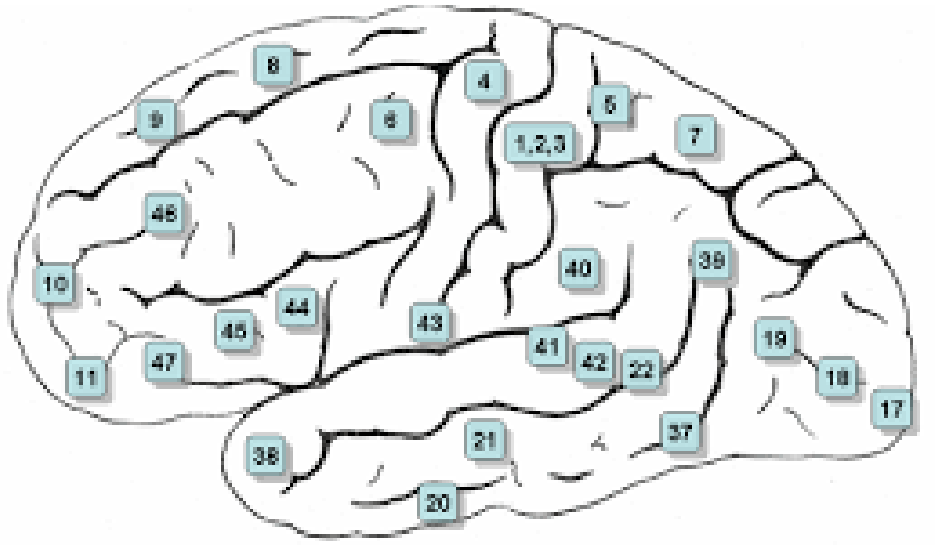
Cerebellum



- Part of the hindbrain
- Coordinates motor commands with sensory inputs to control movements
- Damage results in:
- Ataxia, gate deficits, problems with fine movements, control of rate and range of movement
- Dysarthria

Brodmann’s areas





- Korbinian Brodmann (1868 – 1918)
- Cytoarchitectonic regions

Cerebellar ataxia

Articulation

- imprecise consonant articulation
- distorted vowels (slurred quality)
- imprecise consonants, vowels

Prosody

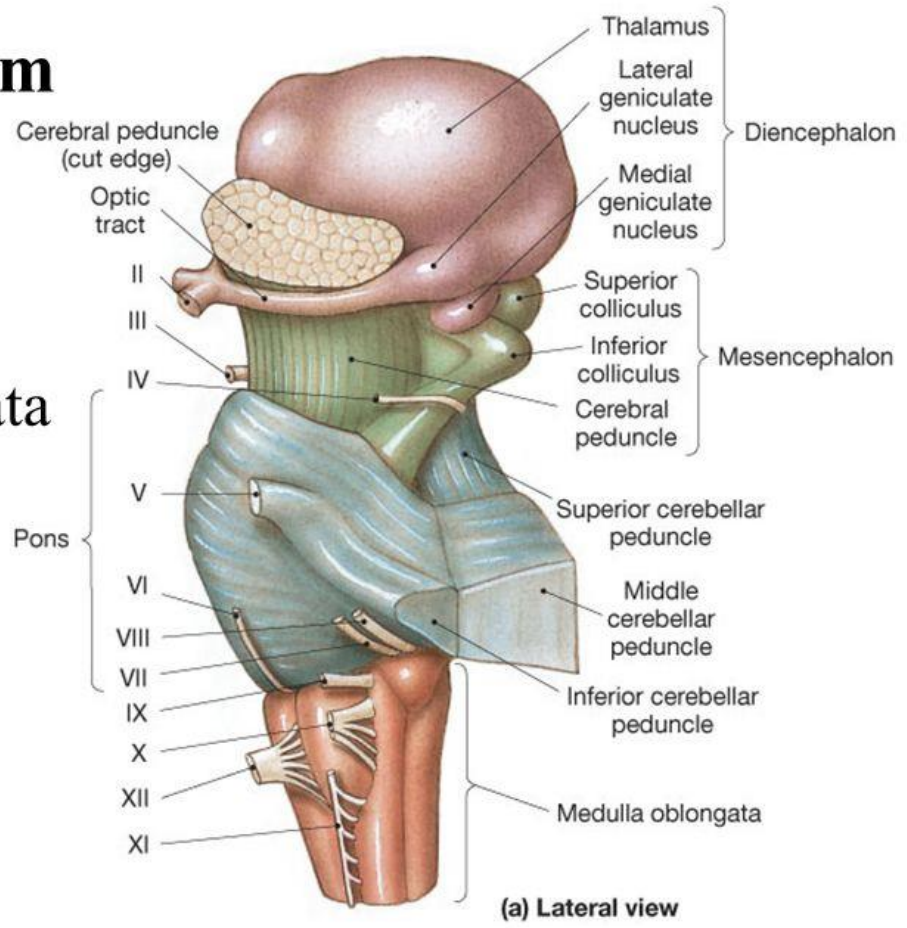
- equal and excess stress
- prolonged phonemes
- prolonged intervals between phonemes
- monopitch, loudness
- Ssow rate

Phonation: Harsh vocal quality, voice tremor

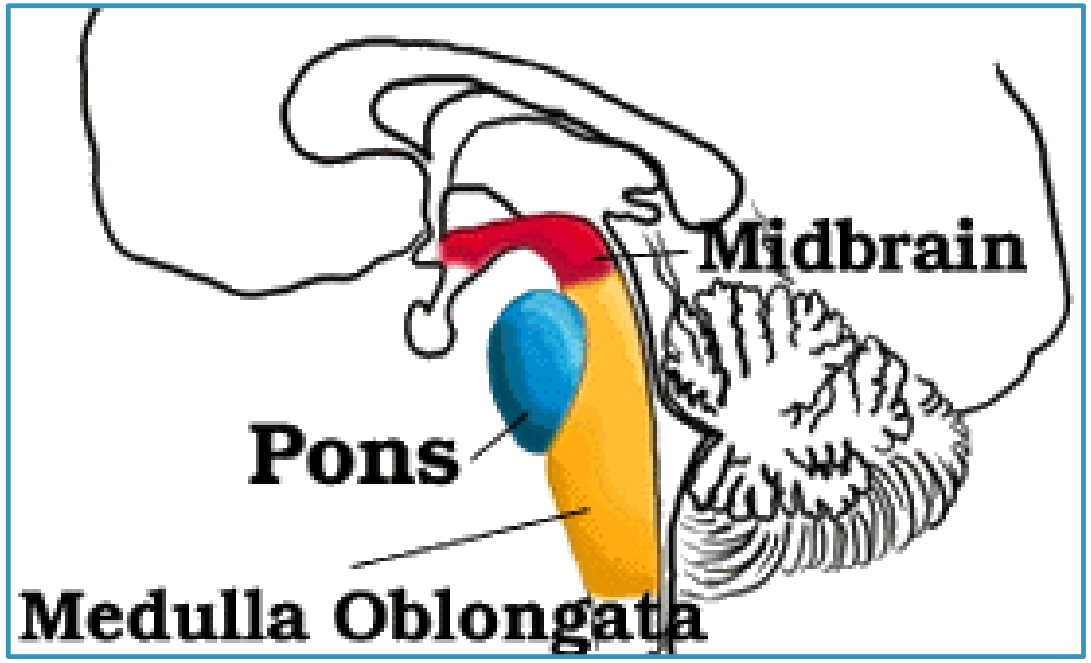
Video sample of speech

The Brain Stem

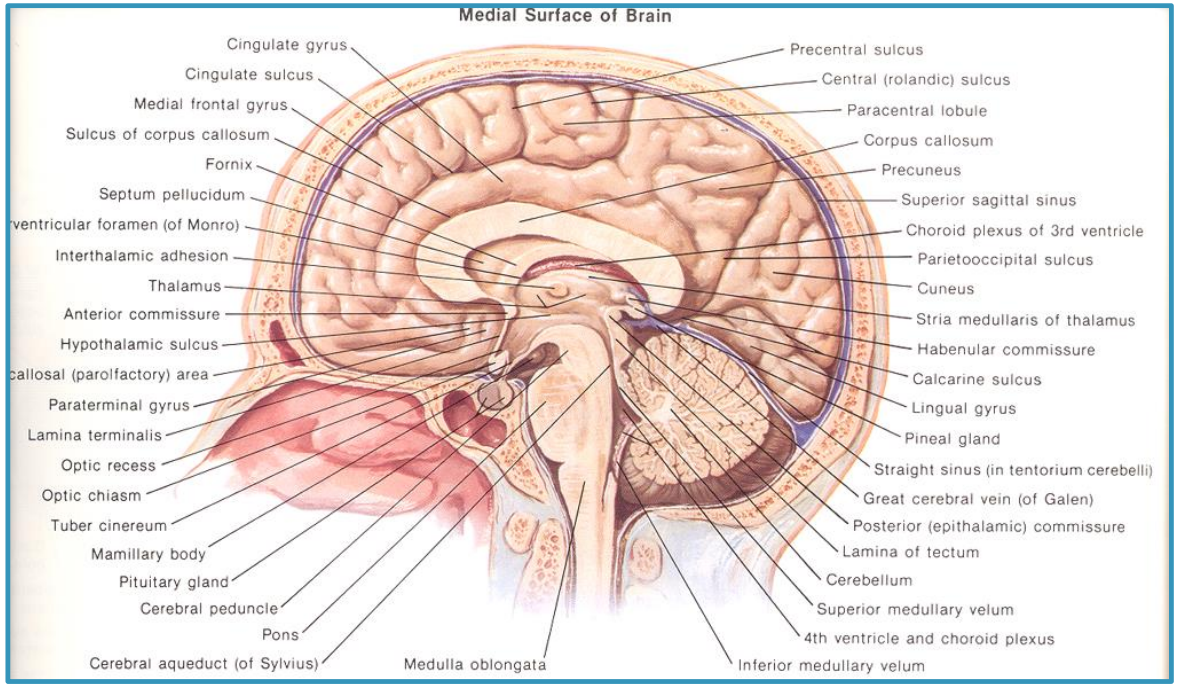
Midbrain,
Pons,
Medulla Oblongata



Brainstem



Brainstem - position



(F. Netter)

Sagittal view

Peripheral Nervous System

Spinal nerves

Cranial nerves

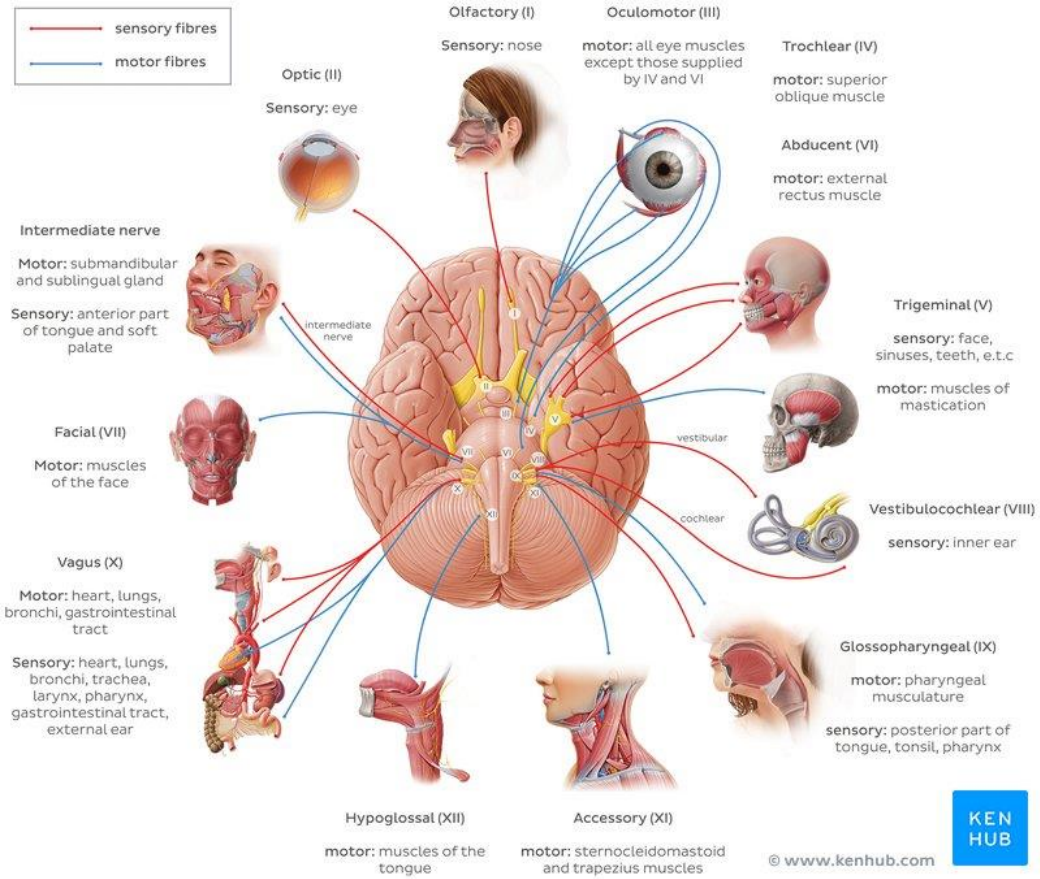


Table 7–2. Cranial nerves, listed by Roman numeral, type (S = sensory, M = motor) and innervated region, and function.

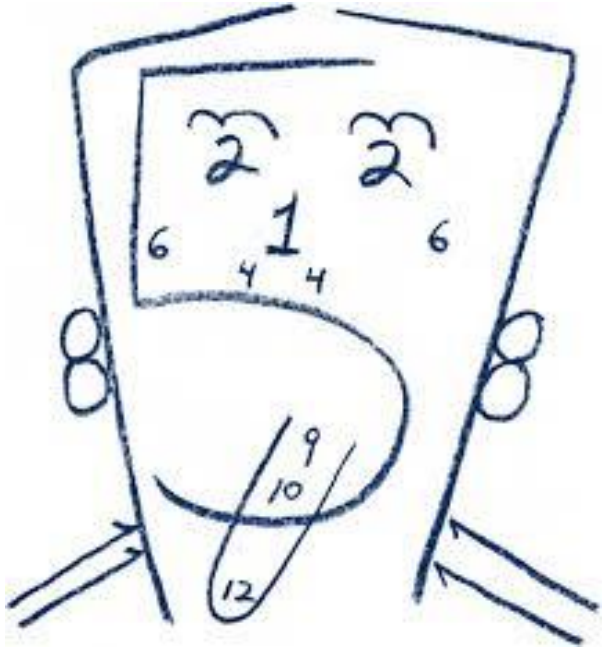
Nerve	Type / Innervated Region	Function
CN I	S / olfactory epithelium	Sense of smell
CN II	S / ganglion cells of retina	Sense of sight
CN III	M / eye muscles	Eye movement
CN IV	M / eye muscles	Eye movement
CN V	S / skin and head, dura mater S / muscle spindles and mechanoreceptors in jaw muscles M / jaw muscles, tensor tympani	Facial sensation Proprioception Chewing, ear drum
CN VI	M / eye muscles	Eye movement
CN VII	S / outer ear S / taste buds in anterior tongue S / portion of nasopharynx M / salivary glands, lacrimal gland muscles of facial expression and stapedius	Sensation Taste Taste Secretion Facial expression, stapedial reflex
CN VIII	S / Organ of Corti and vestibular apparatus	Hearing and balance
CN IX	S / outer ear S / taste of posterior tongue	Sensation Taste
CN X	S / carotid body and sinus mucosa M / parotid gland M / pharynx (stylopharyngeus) S / outer ear	Sensation Secretion Pharyngeal action in speech and swallowing Sensation
CN XI	M / shoulder and neck muscles	Head and shoulder movements
CN XII	M / tongue muscles	Tongue movements

12 Cranial Nerves - memory tools

The HIT SONG from UTSW Cranial Nerve Function!

🎧 “**O**n **O**ld **O**lympus **T**owering **T**ops **A** **F**inn **A**nd **G**erman **V**ended **A**t **H**ops”

Another way to memorize ‘em



Cranial Nerves – Speech

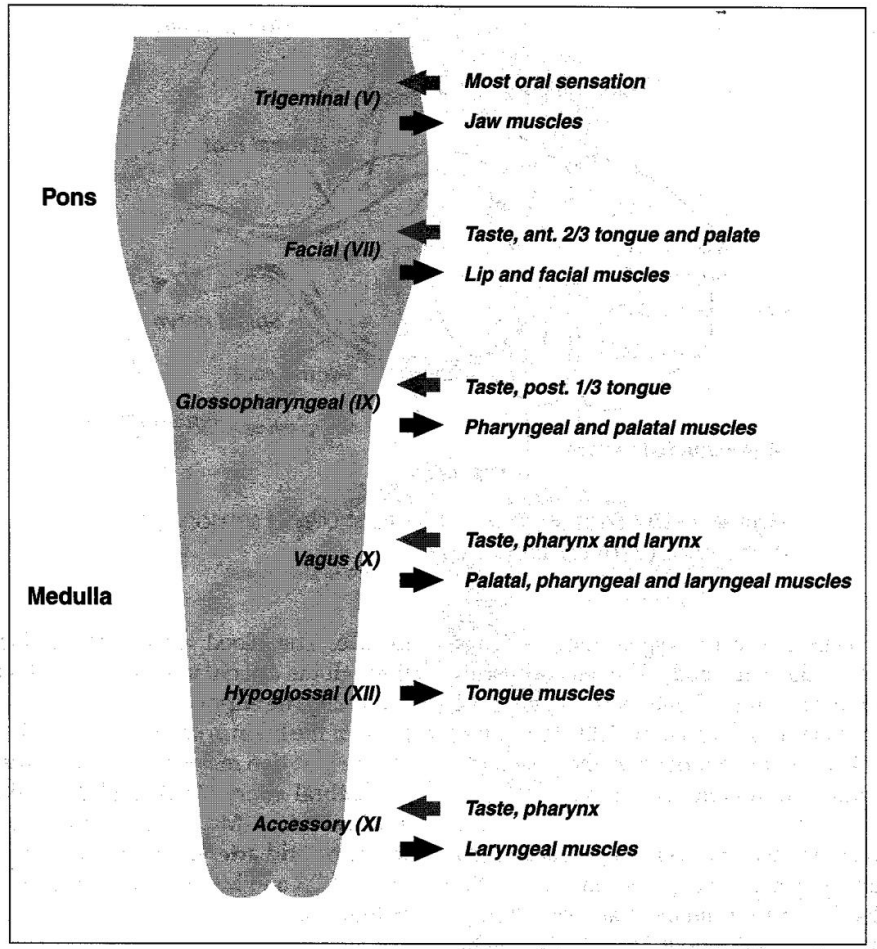


Figure 7–27. Schematic diagram of emergence of cranial nerves most relevant to speech. Motor and sensory functions are summarized.

(fr. Kent, *The Speech Sciences*)

Cranial Nerve Lesions (non-speech related)

I. Olfactory- (Anosmia) loss of sense of smell

II. Optic- Visual deficits

III. Occulomotor- inability to turn eyes inward, dilation of pupil

IV. Trochlear- inability to pull eye down

VI. Abducens- Eye is rotated inwards as a results of paralysis.

- Diplopia-Inability to fuse images from both eyes

Cranial Nerve Lesion (speech-related)

V. Trigeminal-Increased jaw jerk reflex

- Weakness of jaw, hypernasality, loss of sensation in anterior 2/3 tongue, altered sensation of E. tube, ear canal, tympanic membrane

VII. Facial- Bell's palsy

- Inability to close eyelids, loss of tone of facial muscles, drooling, smiling affected.

Cranial Nerve Lesion (speech-related/ continued)

VIII. Vestibulo-cochlear (auditory)-Hearing loss, disturbances in equilibrium, vertigo and nystagmus in case of head injury

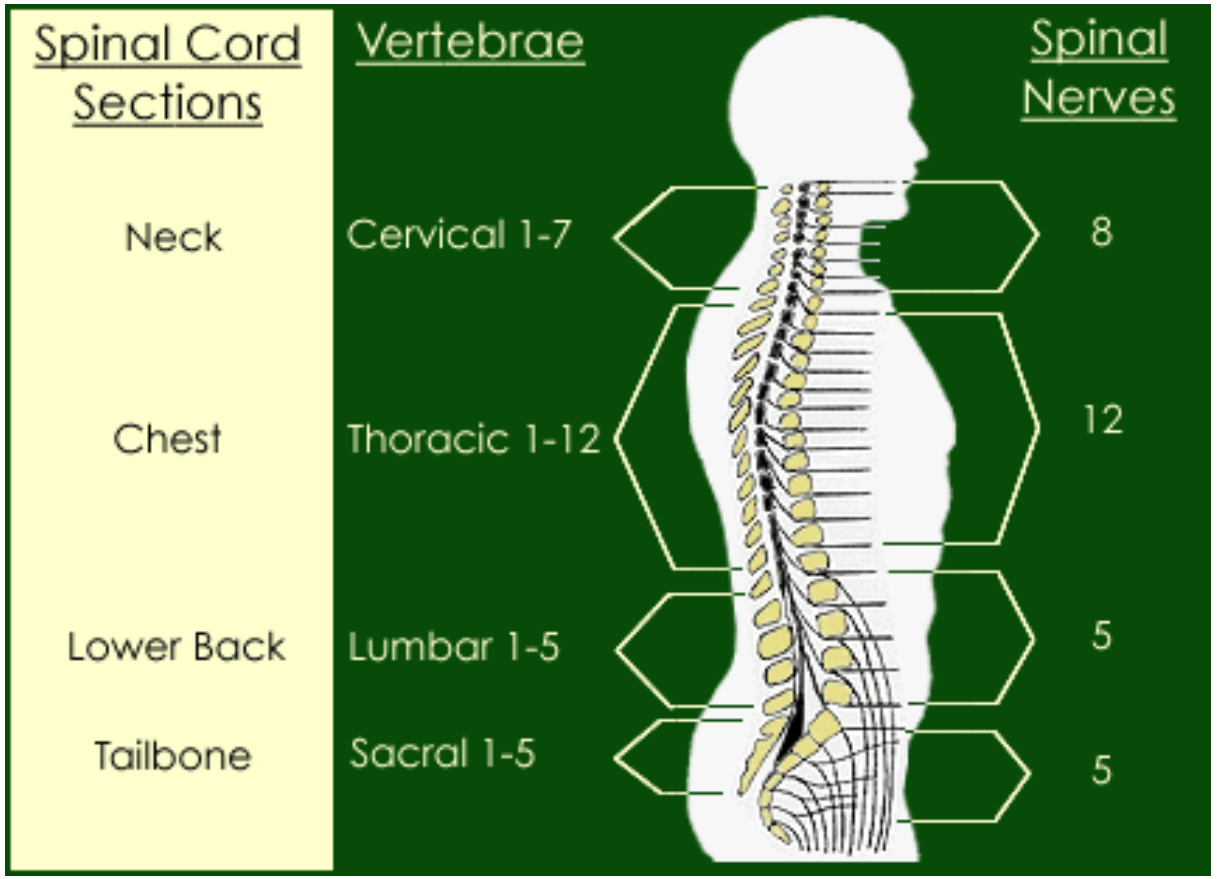
IX. Glossopharyngeal -paralysis of stylopharyngeus muscles and loss of sensation of posterior 1/3 of tongue, absence of gag.

X. Vagus -Loss of gag, hypernasality, swallowing, damage to SLN and RLN branches of vagus affect sensation and function of larynx.

Cranial Nerve Lesion (speech-related/ continued)

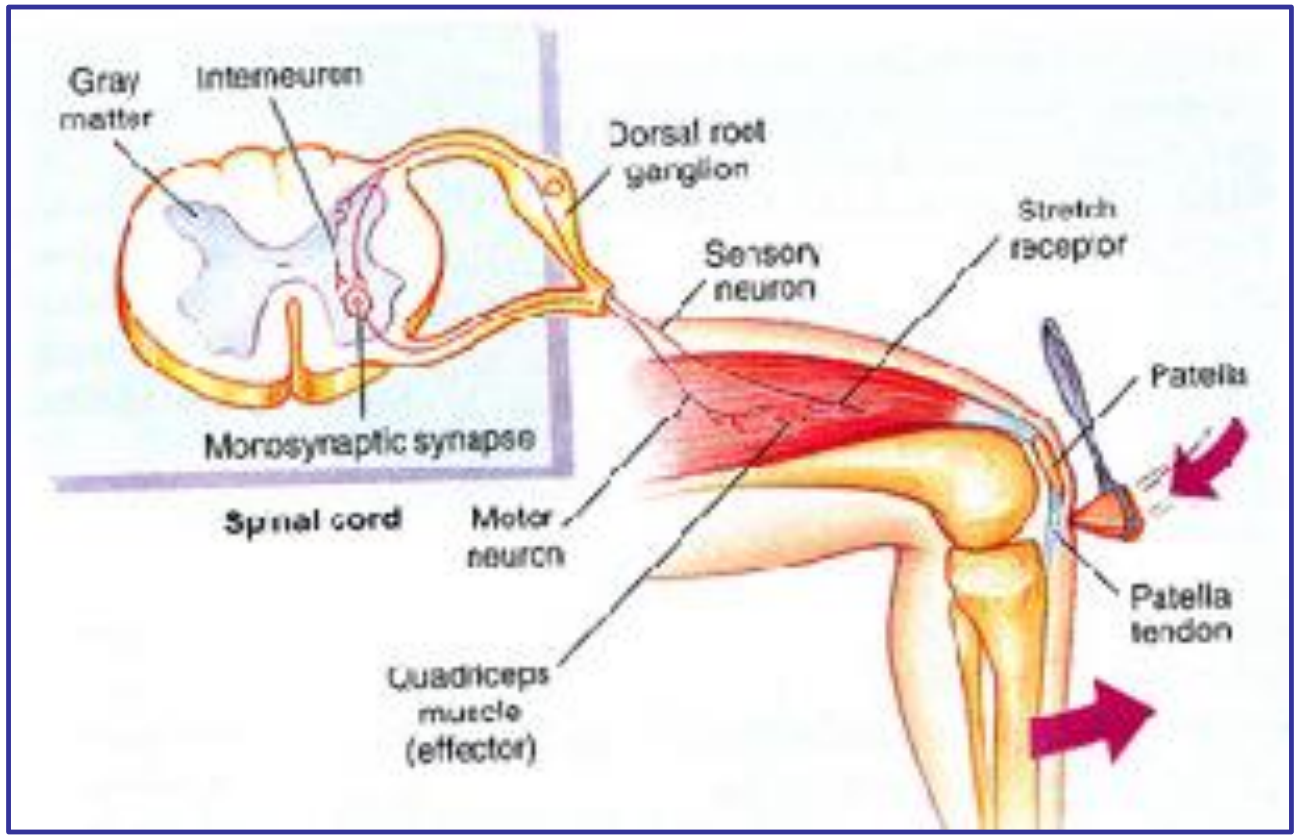
XI. Accessory - Affects trapezius and sternocleidomastoid, thus unable to lift arm or turn head respectively. May affect movement of larynx and velum.

XII. Hypoglossus - Profound impact on articulation. Muscular weakness-affecting tongue movements, fasciculation or involuntary twitching, spasticity.



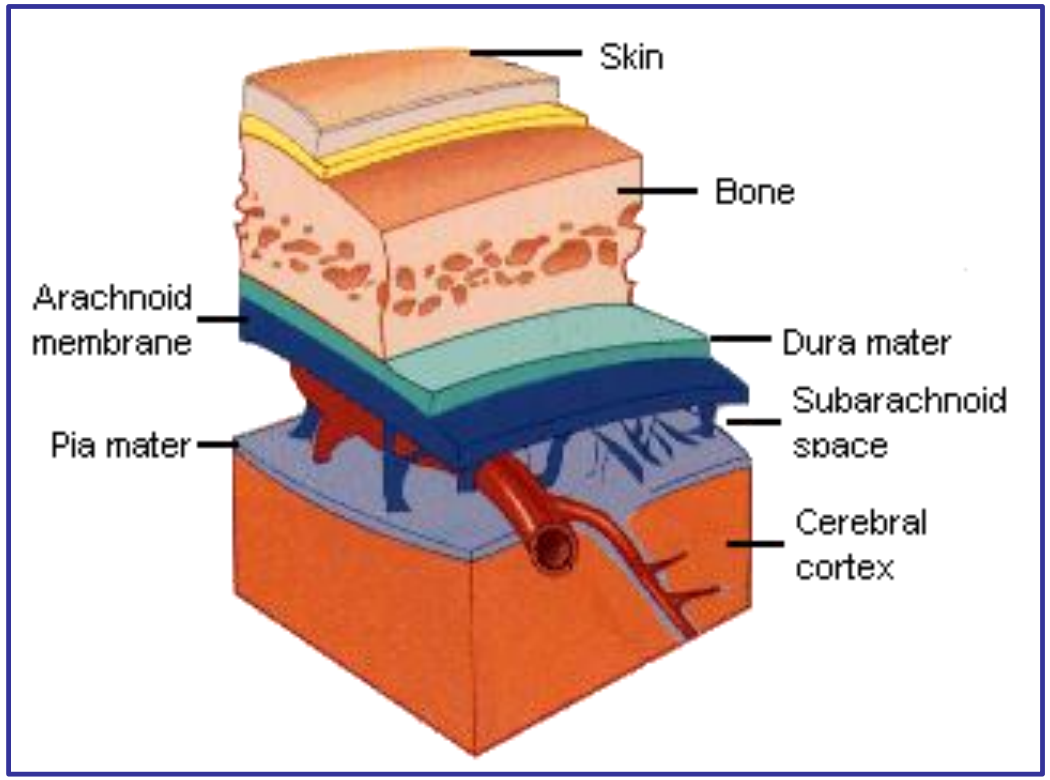
PNS - details

Spinal nerves


Gray matter
Interneuron
Dorsal root ganglion
Stretch receptor
Sensory neuron
Patella
Monosynaptic synapse
Spinal cord
Motor neuron
Patella tendon
Quadriceps muscle (effector)

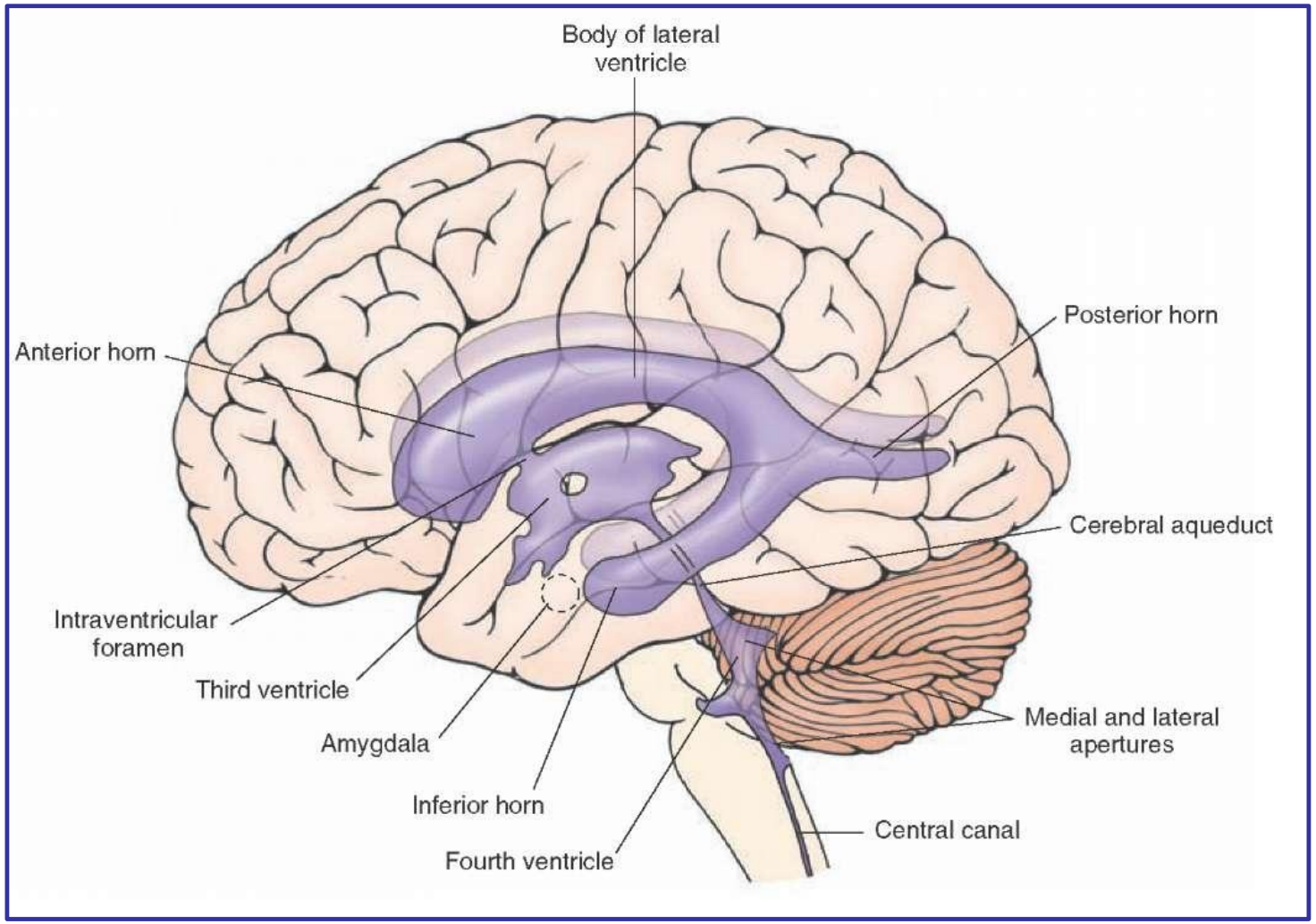
Reflex arc

Brain Coverings



Meninges

- Dura matter
- Arachnoid matter
- Pia matter
- Extradural space
- Subdural space
- Subarachnoid space
- Falx cerebelli
- Tentorium cerebelli


Body of lateral ventricle
Anterior horn
Posterior horn
Cerebral aqueduct
Intraventricular foramen
Third ventricle
Amygdala
Inferior horn
Fourth ventricle
Medial and lateral apertures
Central canal

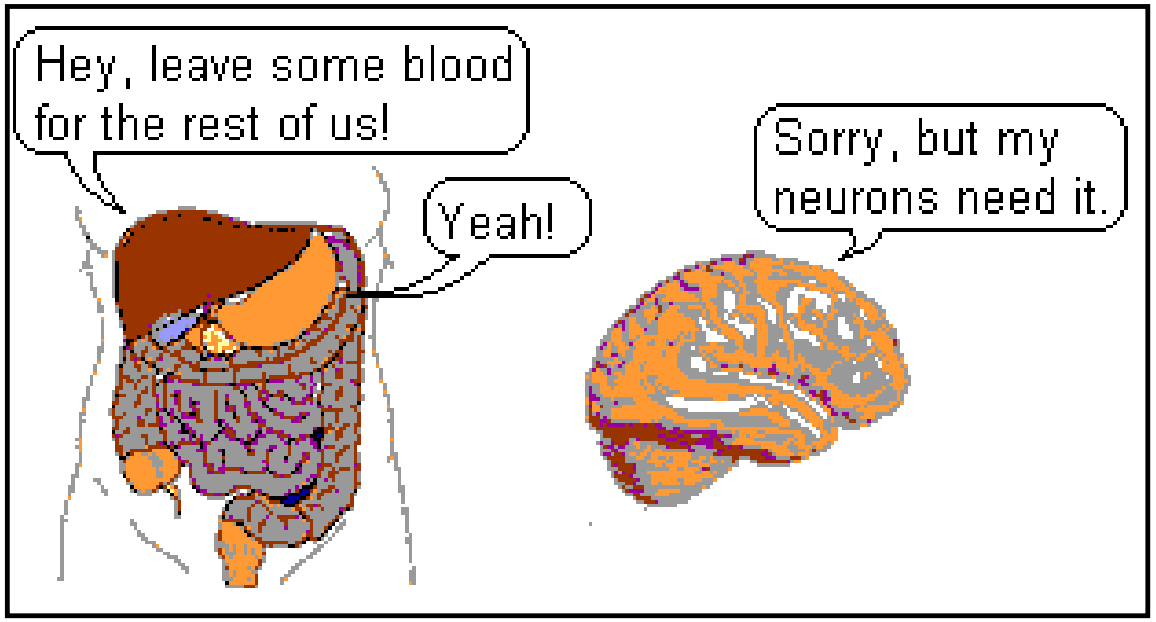
Ventricles

Nourishment Of The Brain

20% of blood supply

Plasma
- Red corpuscles
- White corpuscles
- Platelets

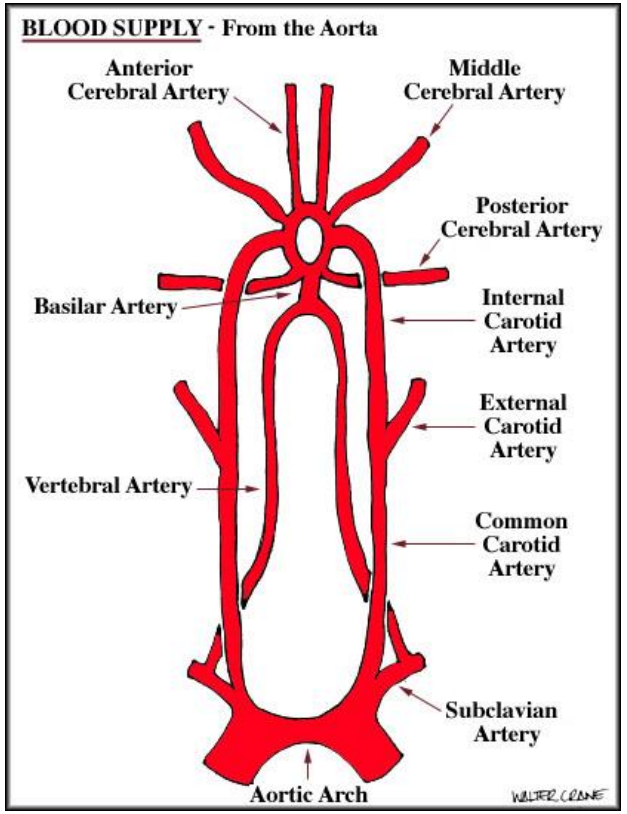
Glycogen



Nourishment Of The Brain

Arteries

- Carotid
- Anterior cerebral
- Middle cerebral
- Subclavian
- Vertebral
- Basilar
- Posterior cerebral
- cerebellar



Blood Supply- Continued

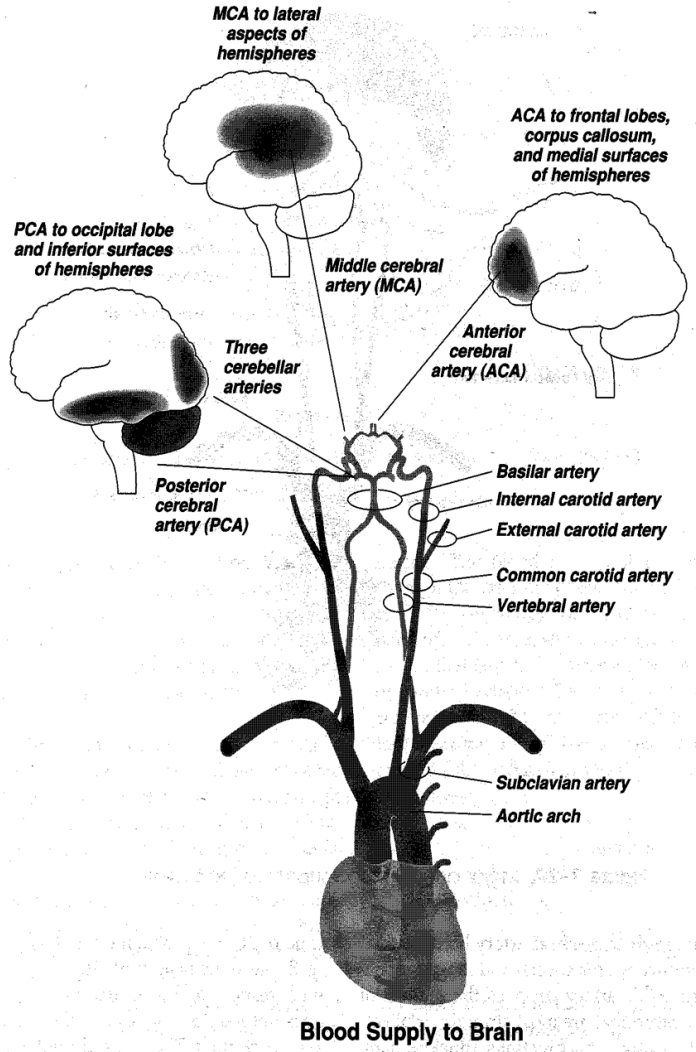
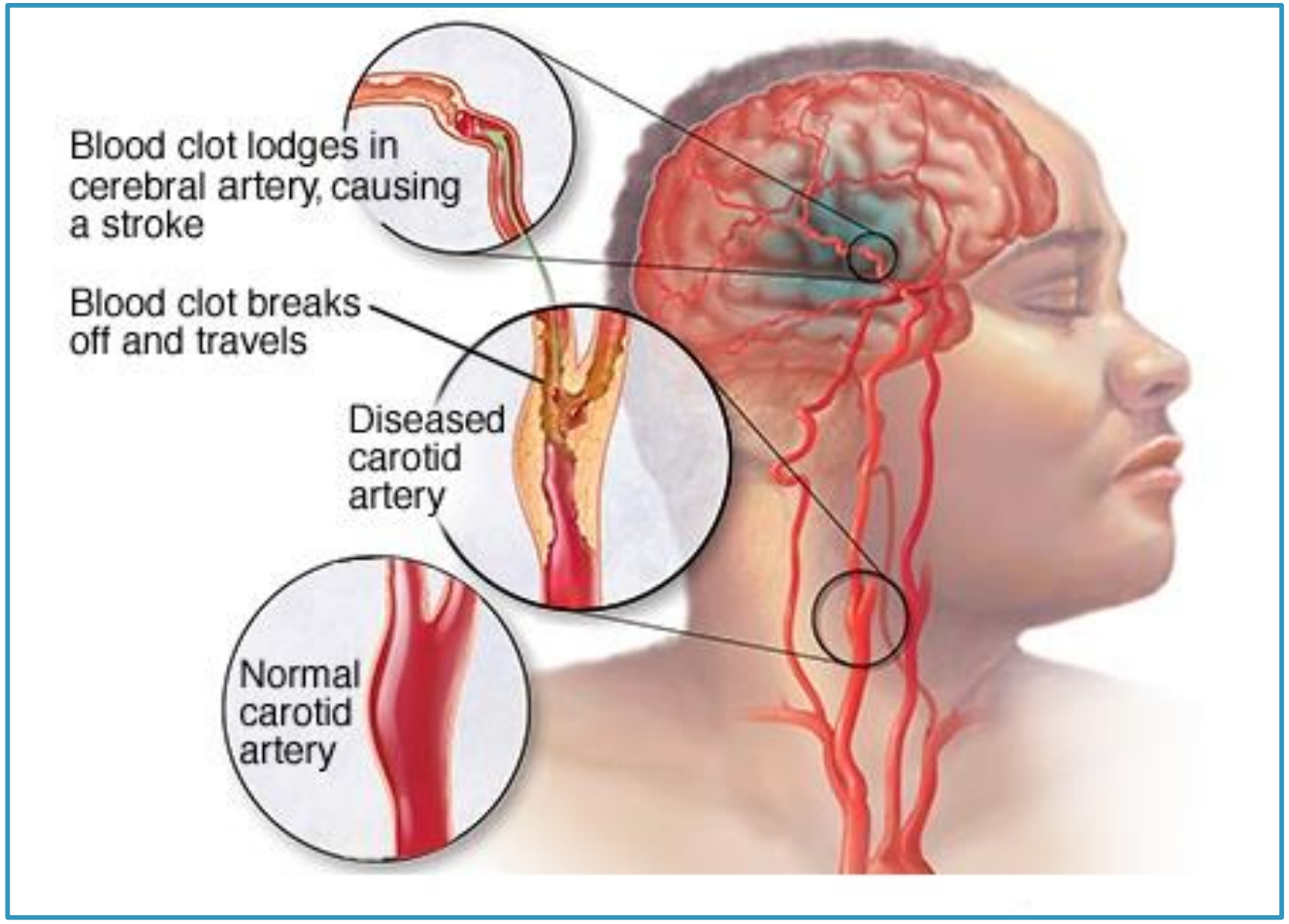
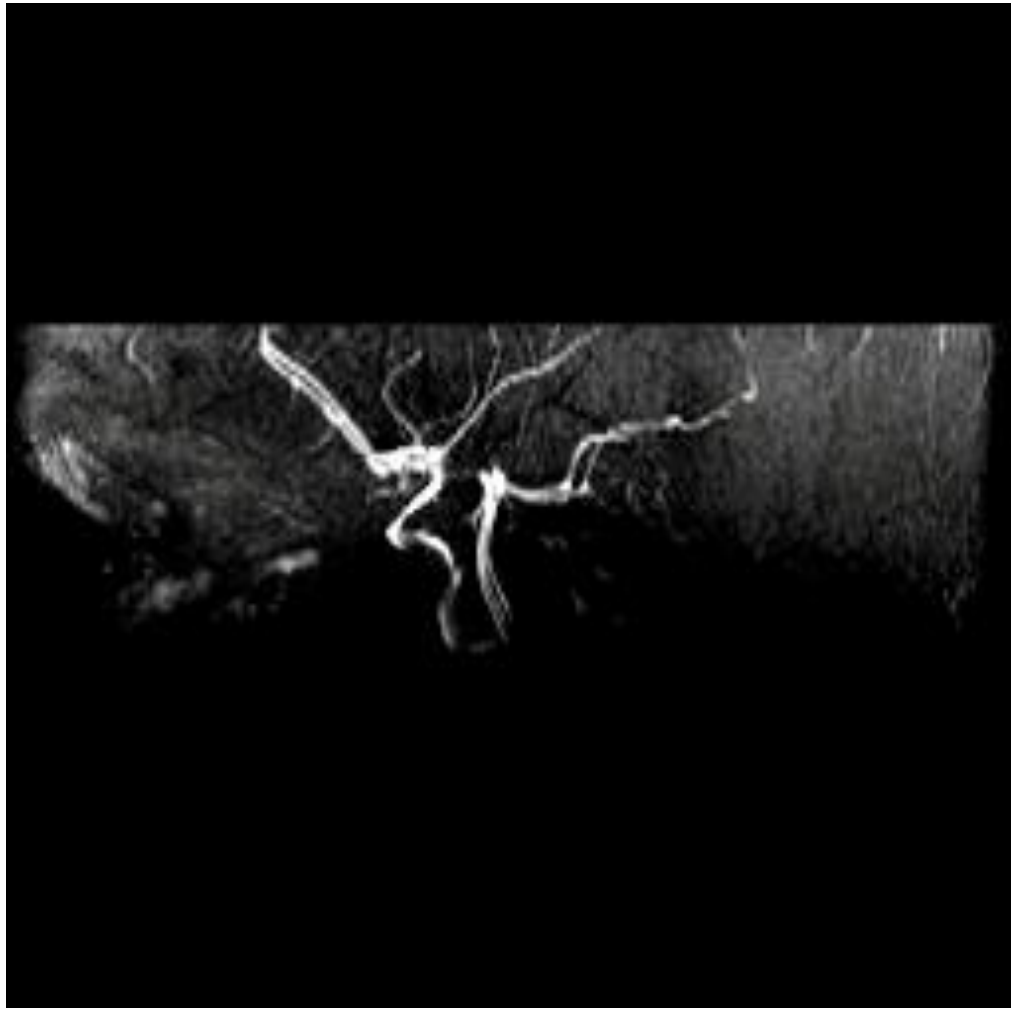


Figure 7-30. Blood supply to major regions of the cerebrum and cerebellum.



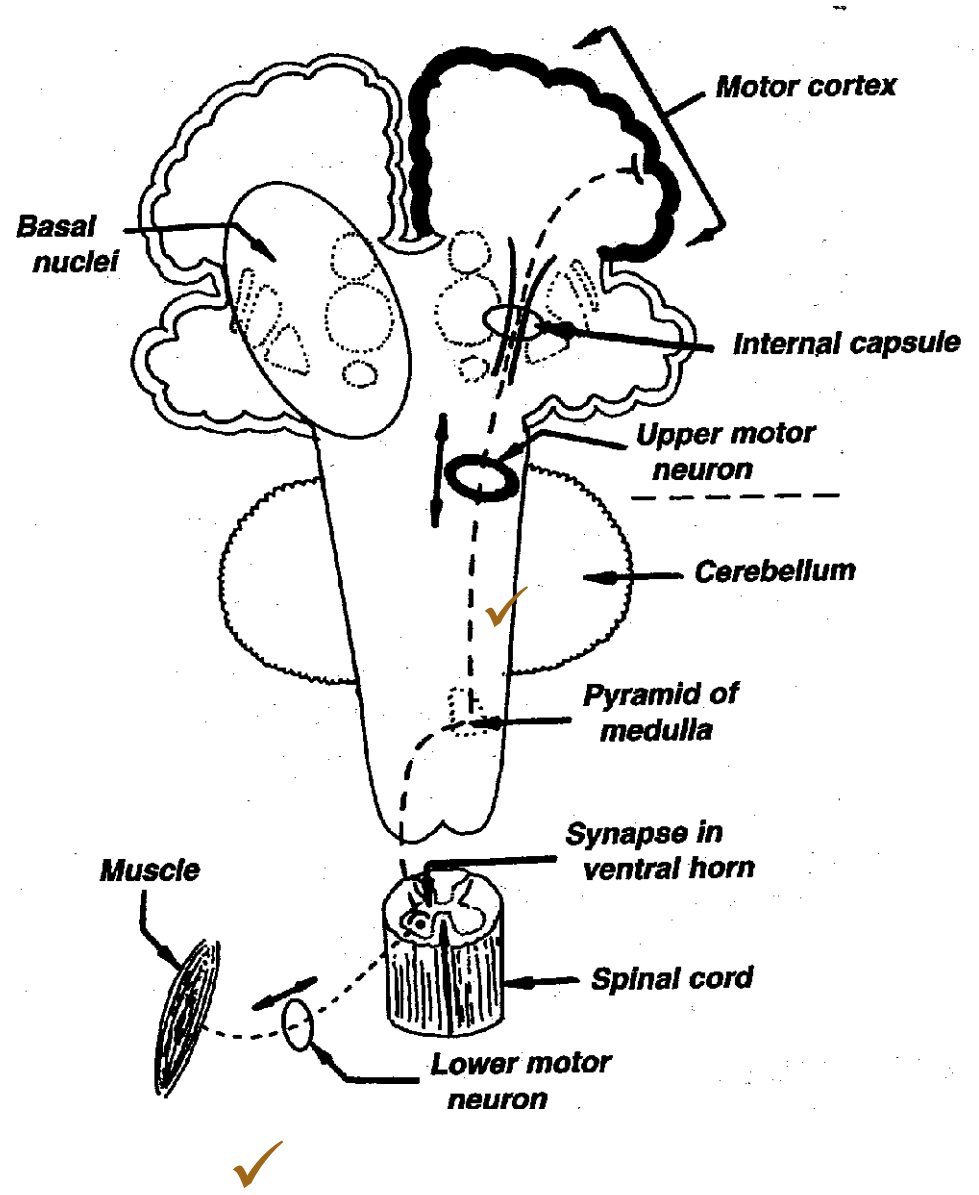
Stroke - apoplexy



Circle of Willis

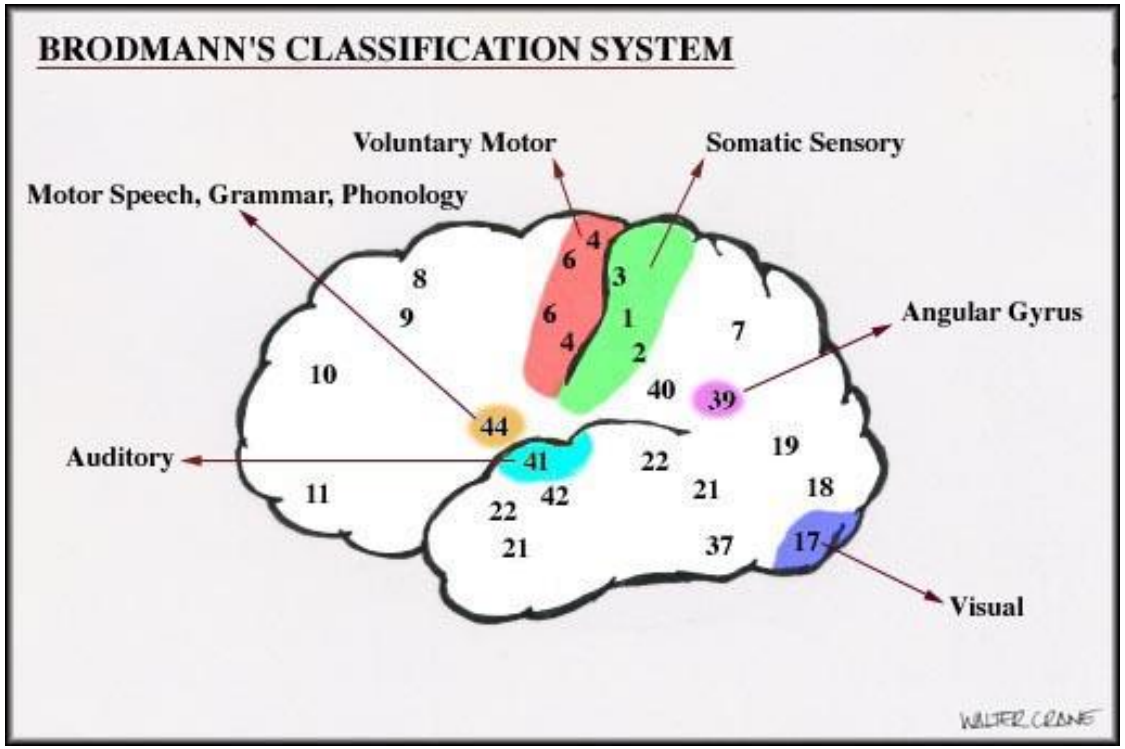
ANGIOGRAM, CONTRAST VIA RADIO-OPAQUE TRACER

Neural pathways to motor control

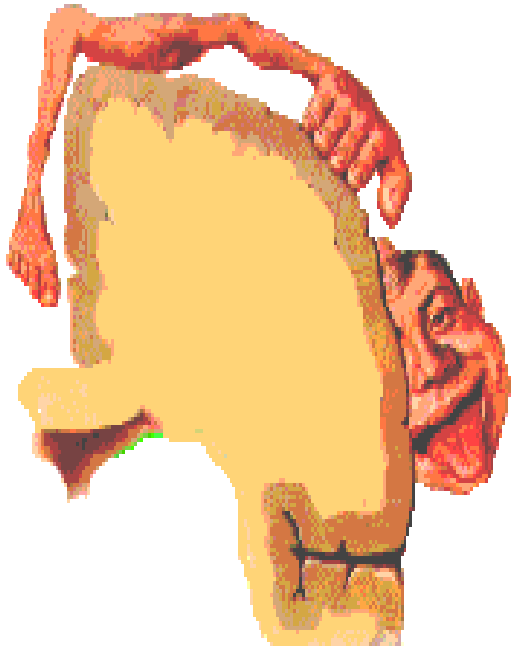


Afferent And Efferent Neural Pathways

- Somatosensory cortex
- Motor cortex



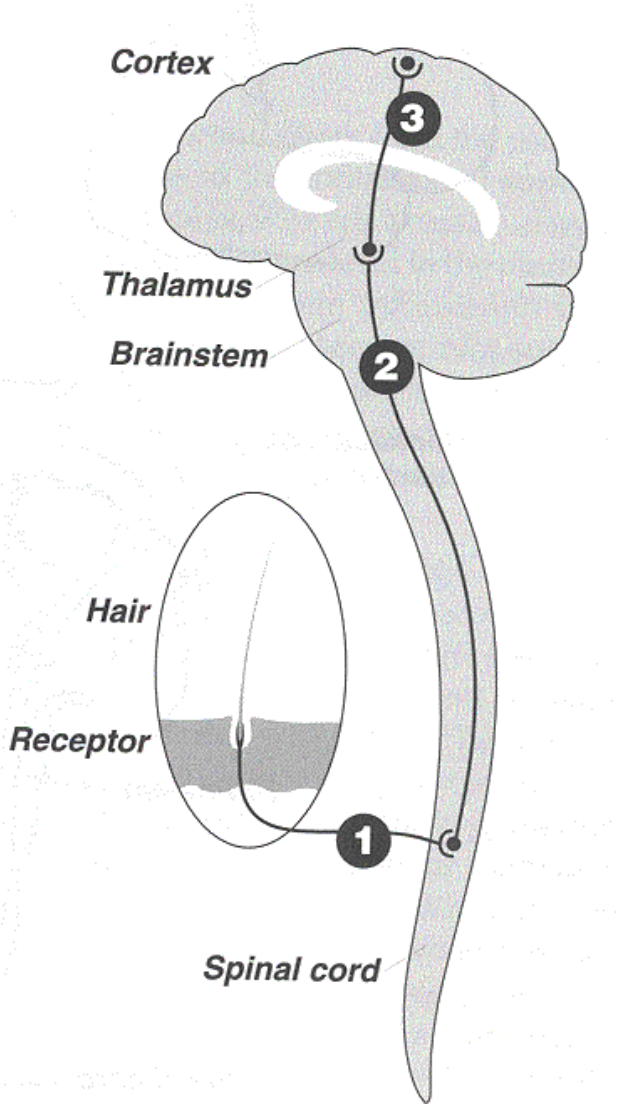
Sensory Homunculus



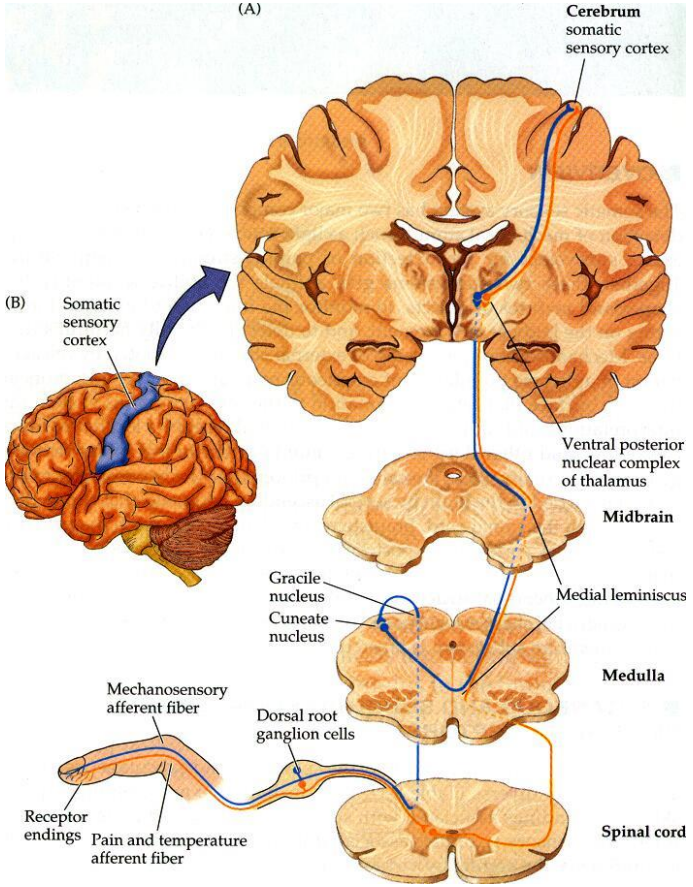
A sensory "Mouseunculus" ➔

Motor Homunculus

Somatosensory Pathways



Somatosensory Pathways



First order sensory neuron

- -- Dorsal root ganglion

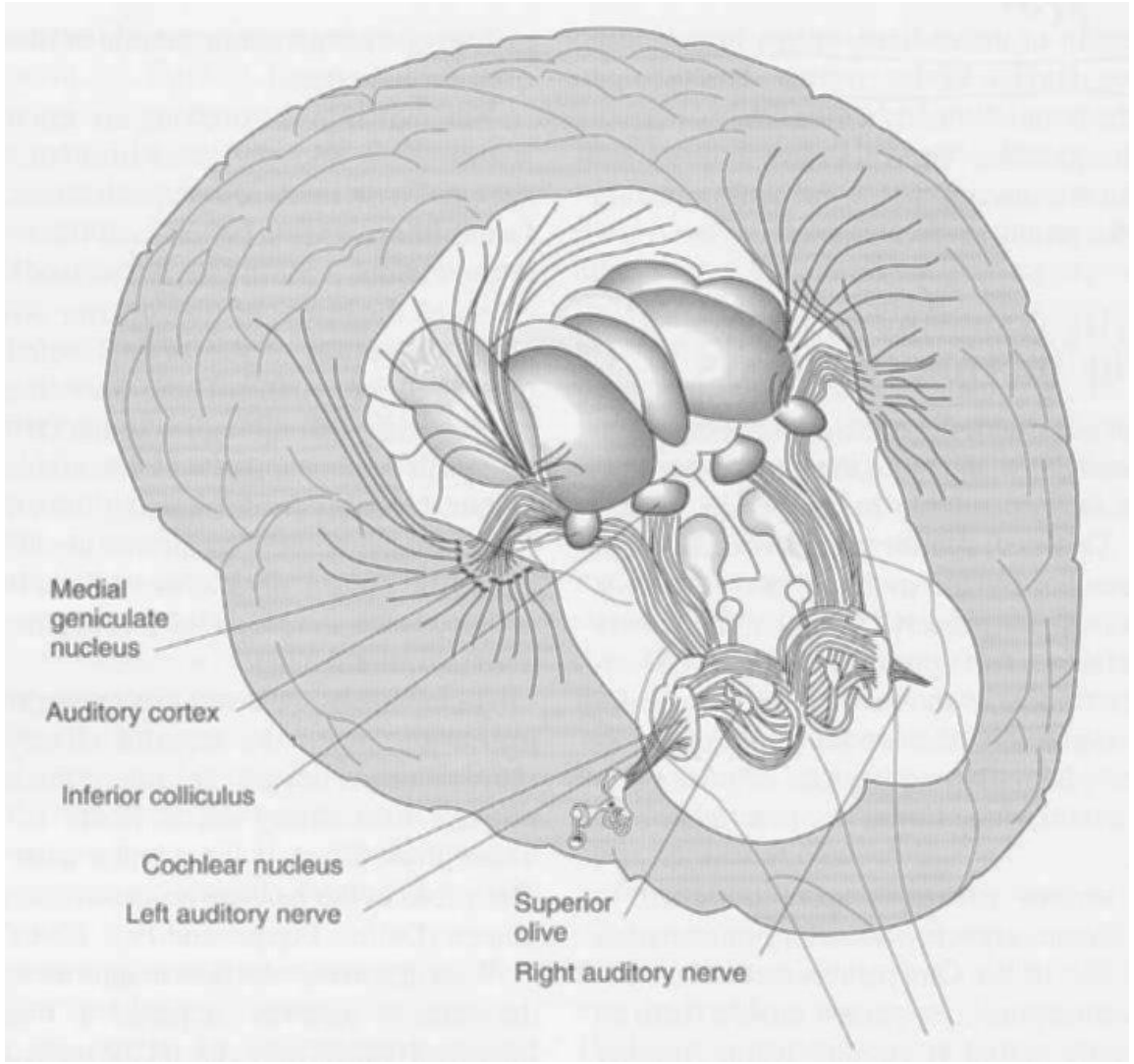
Second-order

- -- Dorsal gray matter

Third-order

-- Thalamus

Primary sensory cortex



Neural Pathway Of Audition

Cochlea

Cochlear nucleus

Superior olivary complex

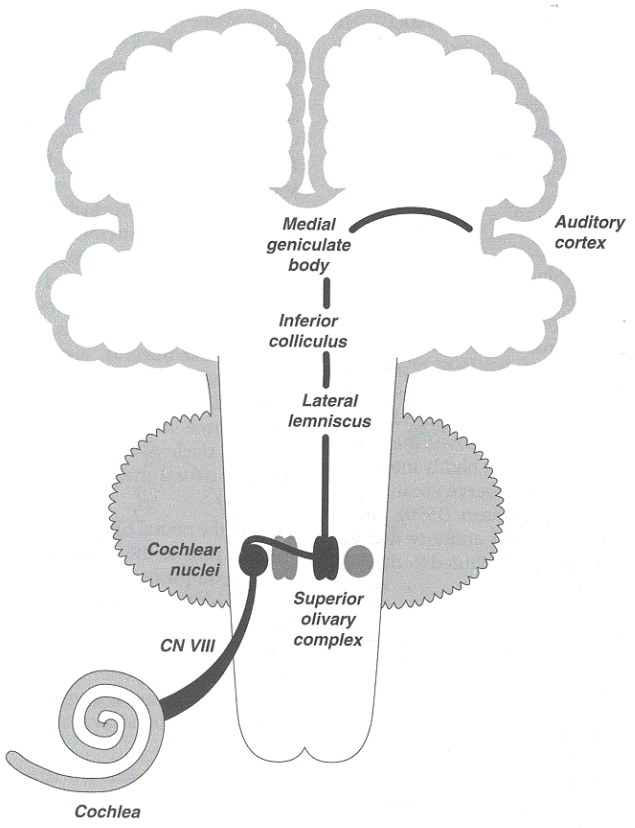
Lateral lemniscus

Inferior colliculus

Medial geniculate nucleus (thalamus)

Auditory cortex

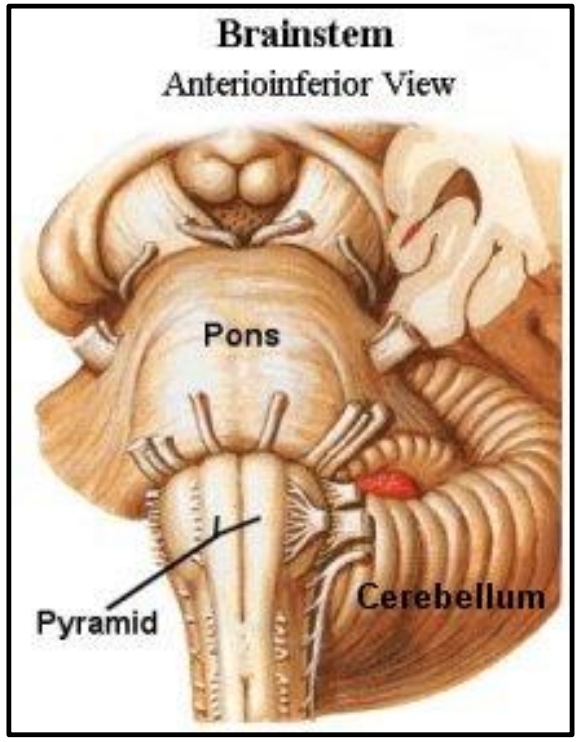
Auditory Neural Pathway -details



Auditory Neural Pathway

- **CN** - actually a bundle of 3 nuclei
- **SO** - binaural interaction; sound localization
- **LL**- 6 parallel pathways projecting to IC
- **IC**- -biologically- significant sound processing
- **MG** -involved in reading disability(?)

Pyramidal System



Receive input from cerebrum, thalamus

Carry efferent messages allowing voluntarily movement (muscles of face, trunk, arms, and legs)

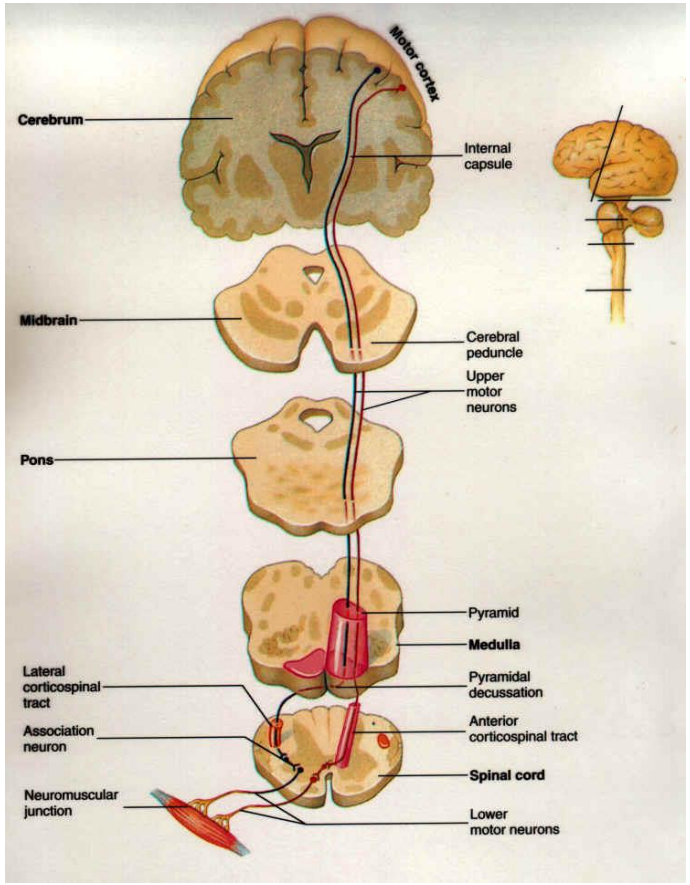
Fibers converge in brainstem, then cross

Fibers visible as triangular, pyramid-like structures, hence the name.

Pathways Of Motor Control

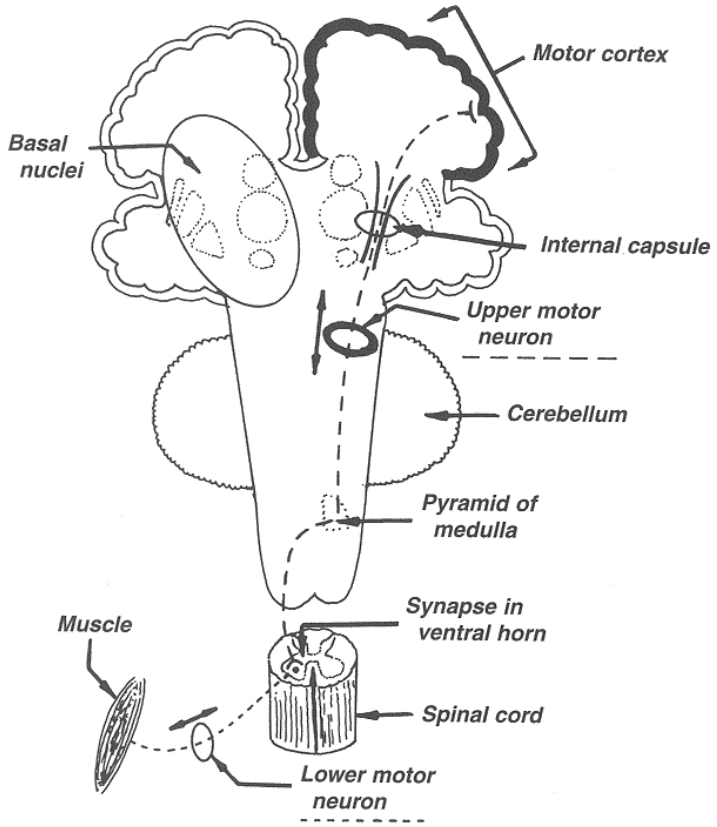
Pyramidal motor system

- Upper motor neuron
- * Lower motor neuron (common pathway)
- Motor unit



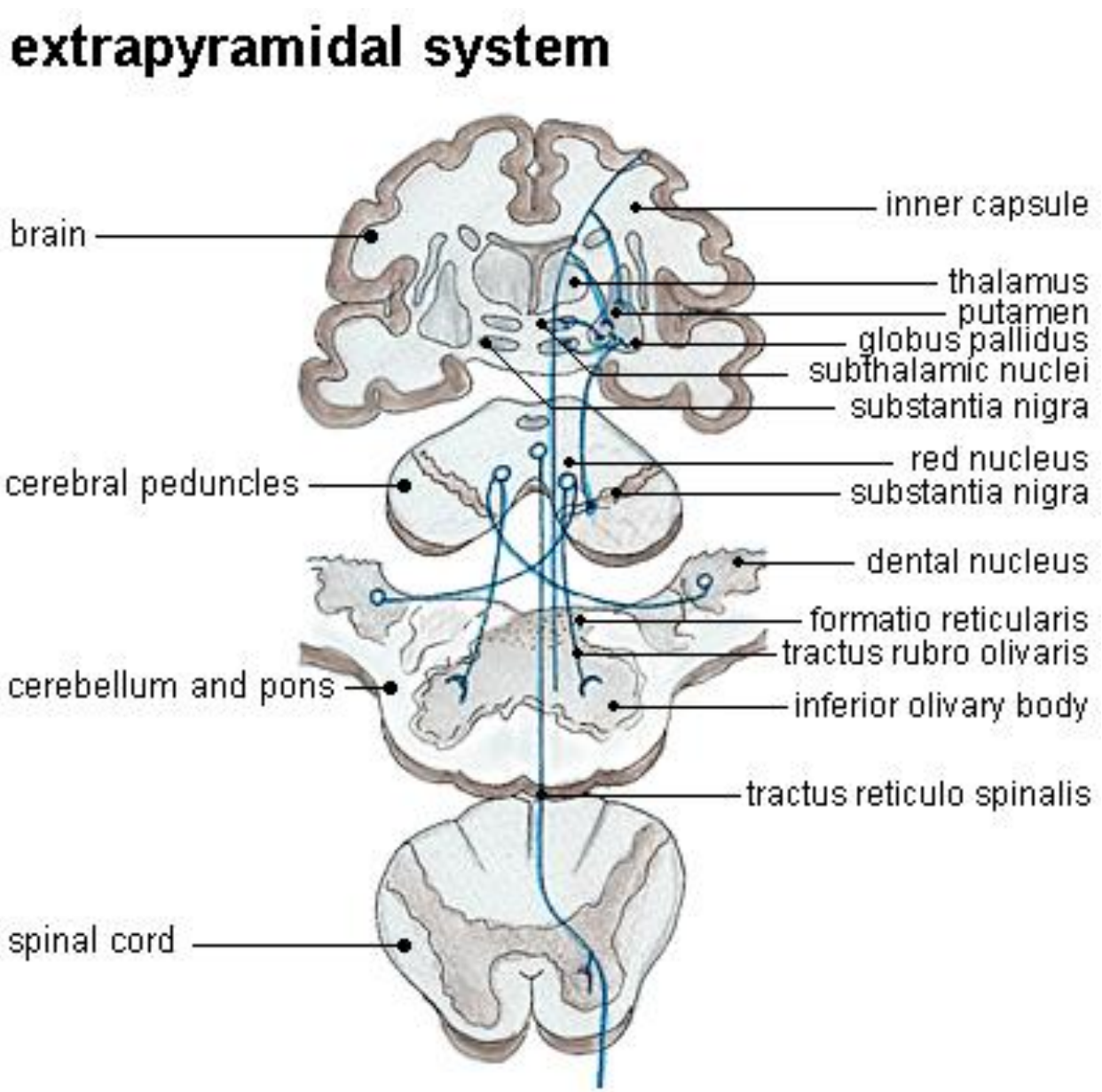
← *

Pyramidal Motor System/ Damage



Hypertonic (spastic) behavior with damage to UMN system

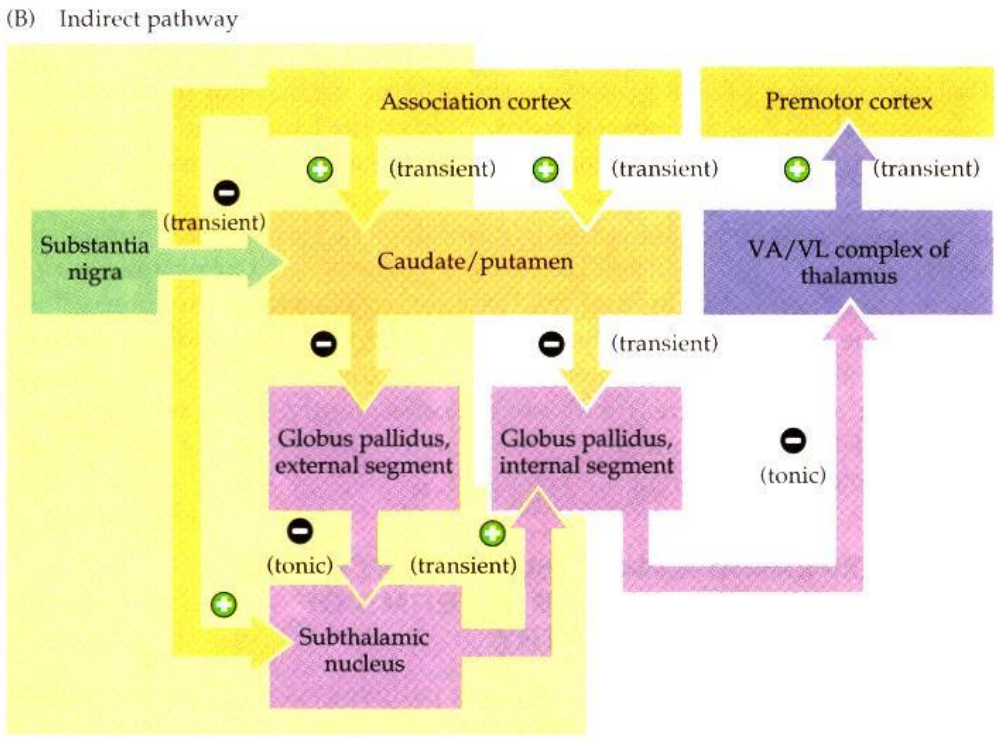
Hypotonic (flaccid) behavior with damage to LMN *['common pathway']* system



Extrapyramidal system

- In the brainstem
- All downward traveling fibers NOT inside the pyramids
- After receiving info from thalamus, regulates repetitive, rhythmical activity (e.g., walking, climbing, hopping, and turning).
- Voluntary or involuntary
- Disorders can result in involuntary, repetitive, rhythmical movements (e.g., tremor or twitching).

EPS –continued/ Flow chart



- Complex!
- Influences motor signals sent to periphery
- Damage can cause characteristic dystonias
- (..*next slide*)

Extrapyramidal signs and symptoms

Reversible :

- Akinesia (lack of movement, Parkinson-like)
- Dystonic Reaction (muscle spasms of face, neck, back)
- Dyskinesia (Blinking or twitches)
- Akathesia (Inability to sit still)

Irreversible:

- Tardive Dyskinesia
- Hyperkinesia (lingual or facial)
  - Blinking
  - Lip smacking
  - Sucking or chewing
  - Rolls or protrudes Tongue
  - Grimaces
- Choreathetoid extremity movement
  - Clonic jerking fingers, ankles, toes
- Tonic contractions of neck or back

Sensorimotor Regulation

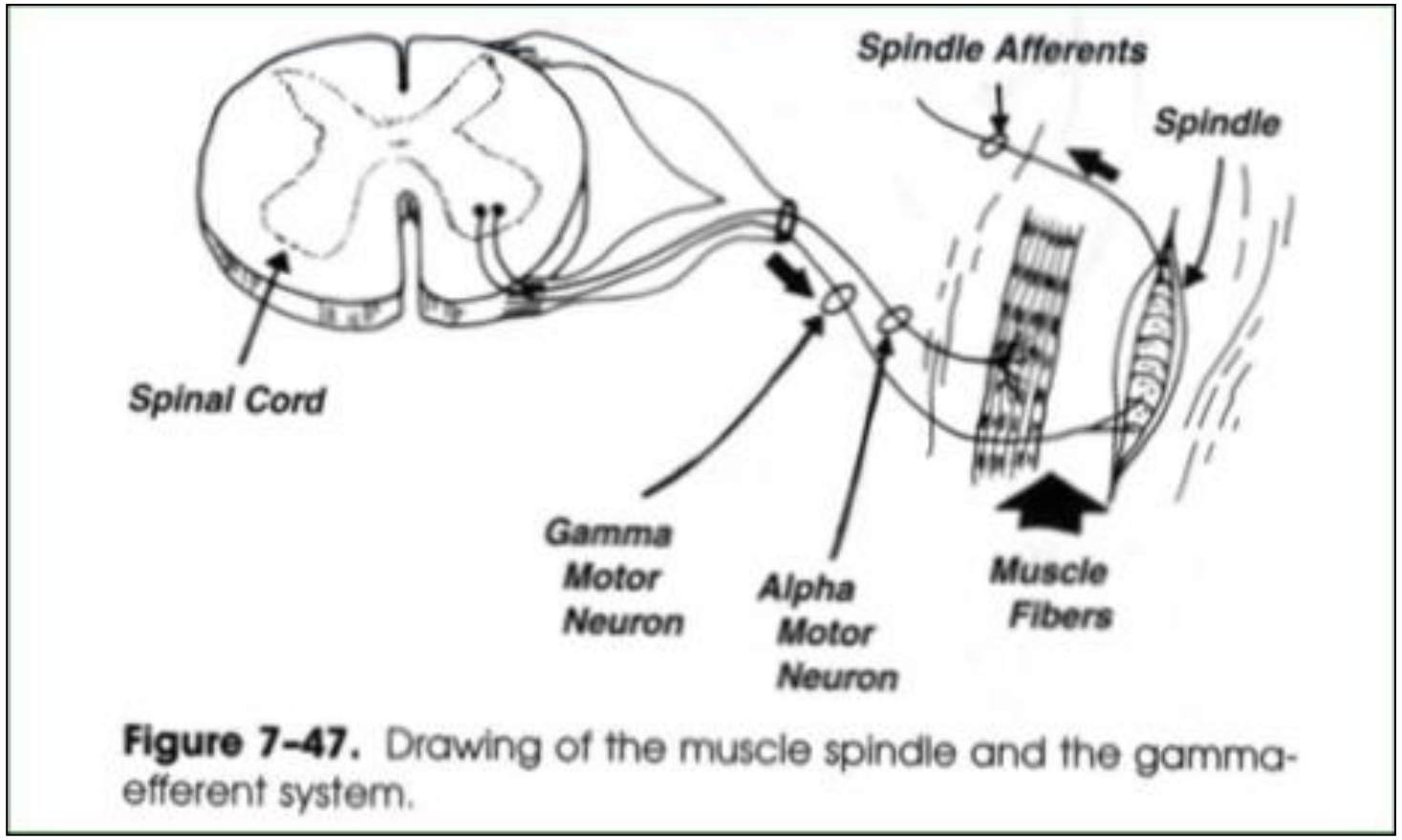
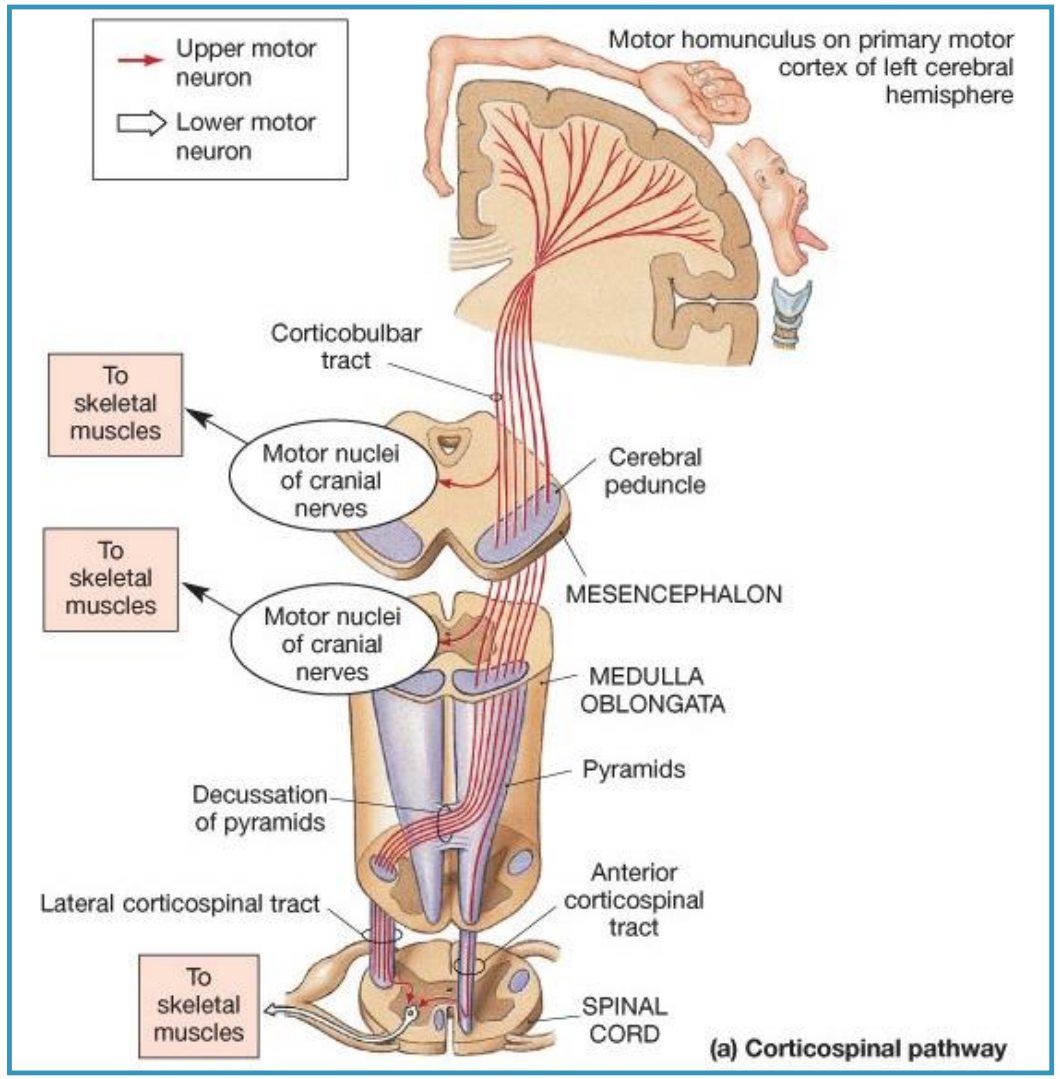


Figure 7–47. Drawing of the muscle spindle and the gamma-efferent system.

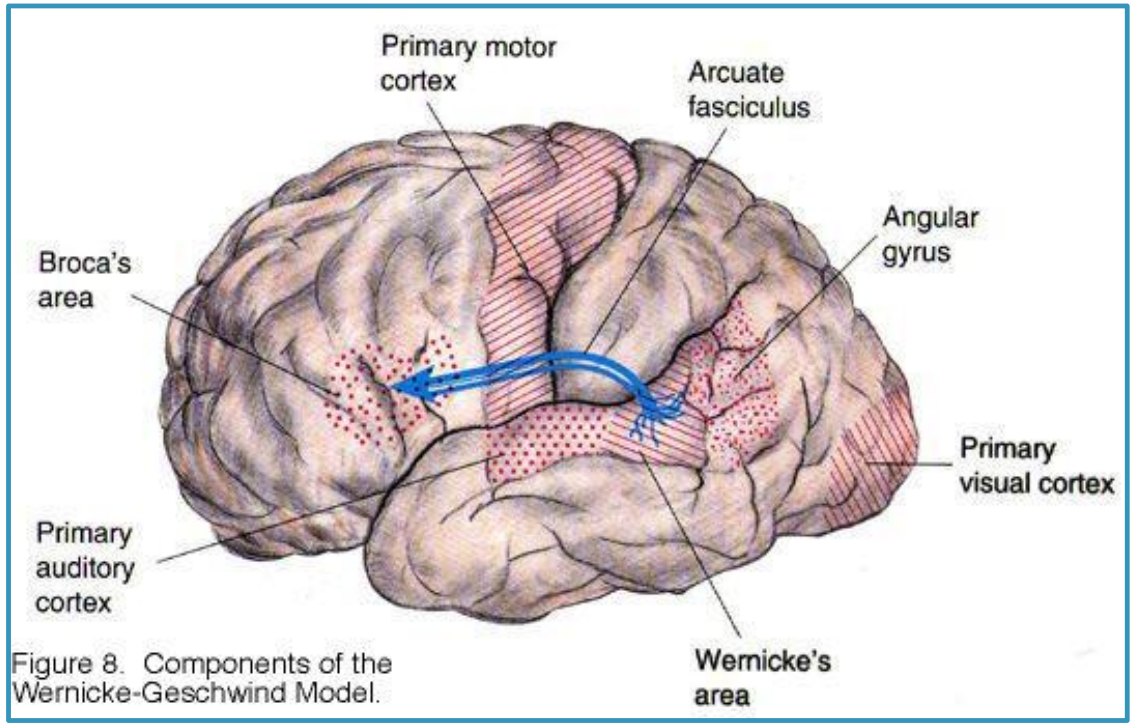
Joint receptors

- Free nerve endings
- Golgi tendon organs
- Muscle spindles
  - intrafusal fibers
  - extrafusal fibers
  - Alpha motor neurons
  - Gamma motor neurons



Corticospinal vs. corticobulbar (corticonuclear)

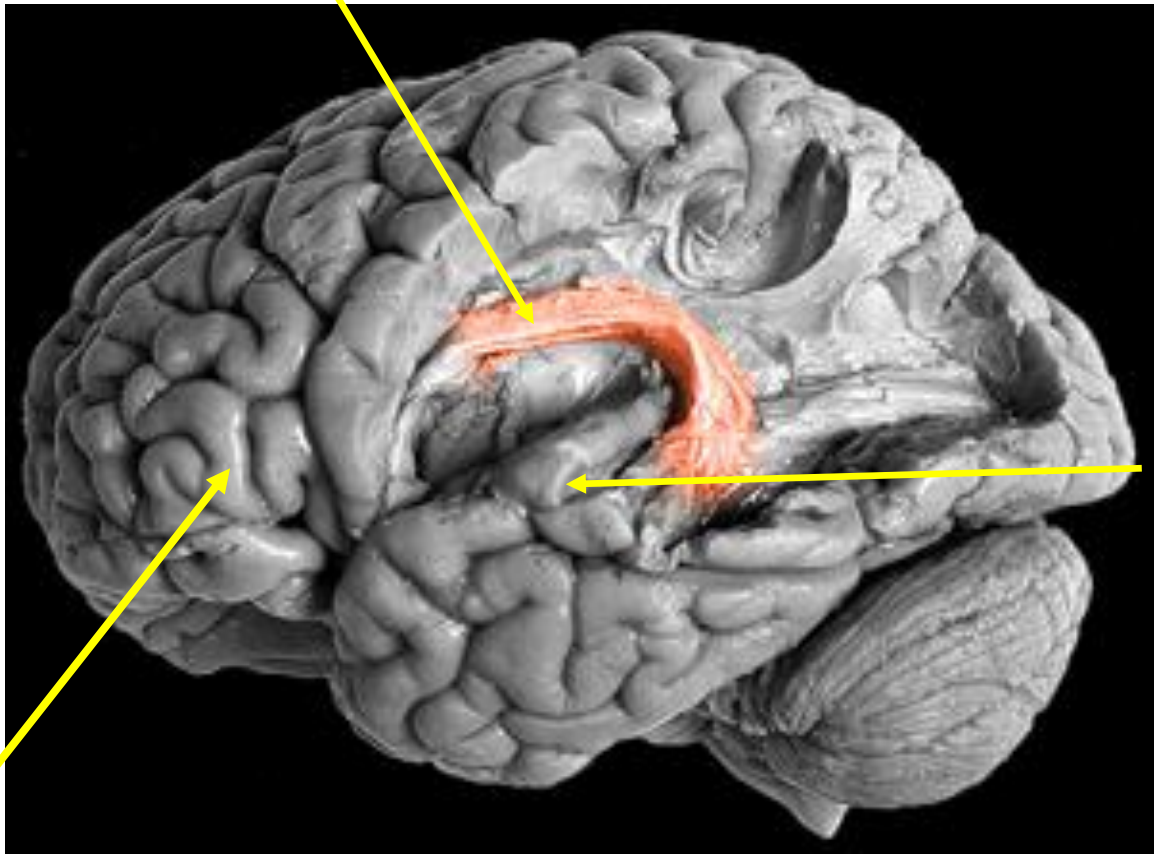
Neural Control Of Speech



"Traditional model"

- Broca's area
- Wernicke's area
- Angular gyrus
- Supramarginal gyrus
- Supplementary motor cortex
- Orofacial motor area

Arcuate Fasciculus



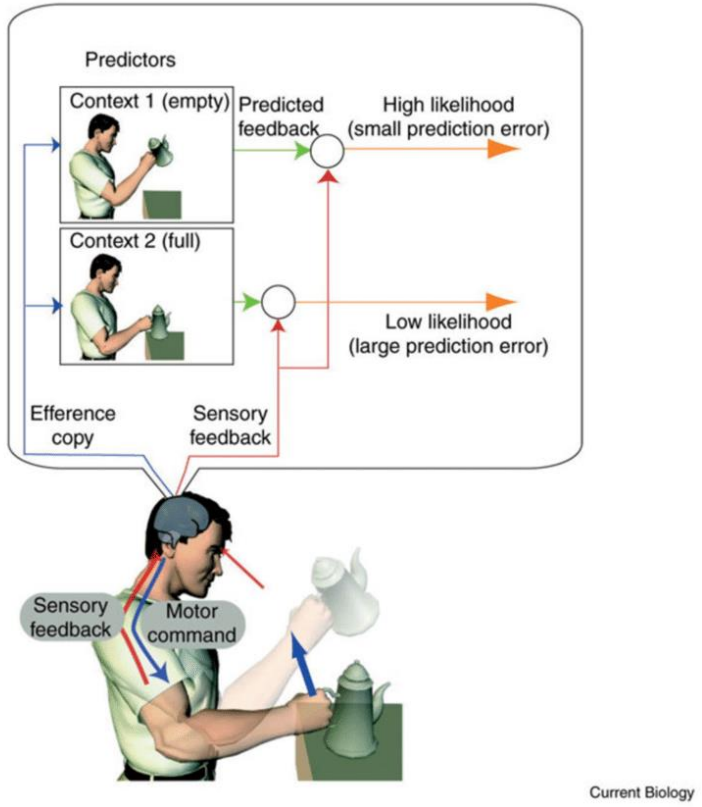
Wernicke’s Area

Broca’s area

Principles of motor control

Feedback/Feedforward systems

Sensory information used in motor control



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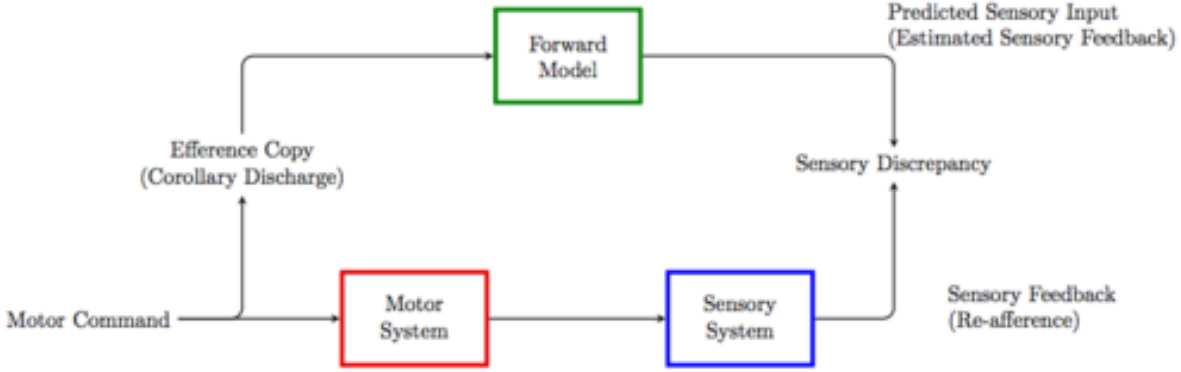
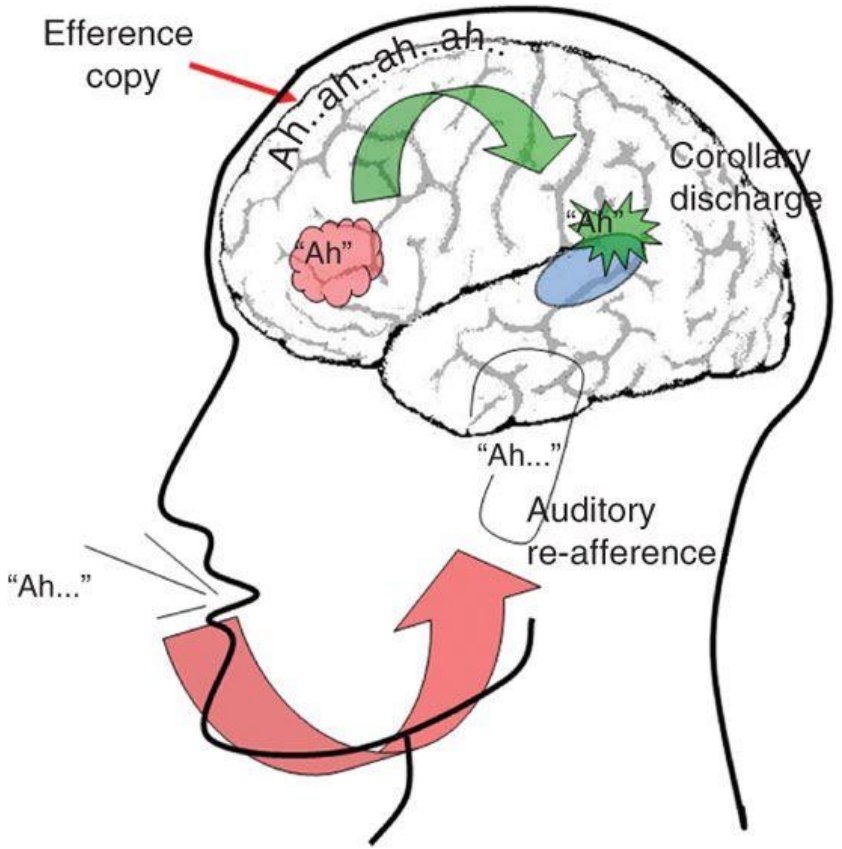




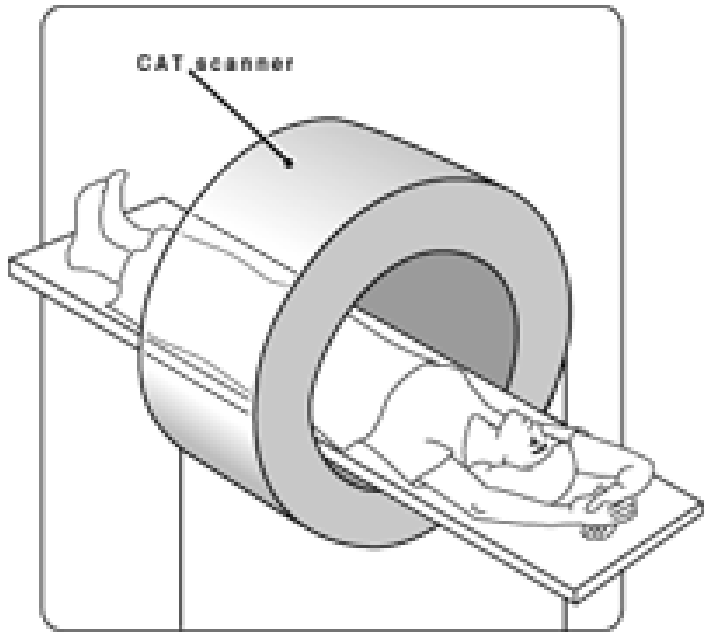
Chap 11
Neuroimaging Methods

STRUCTURAL

- Computed Tomography (CT)
- Magnetic resonance imaging (MRI)

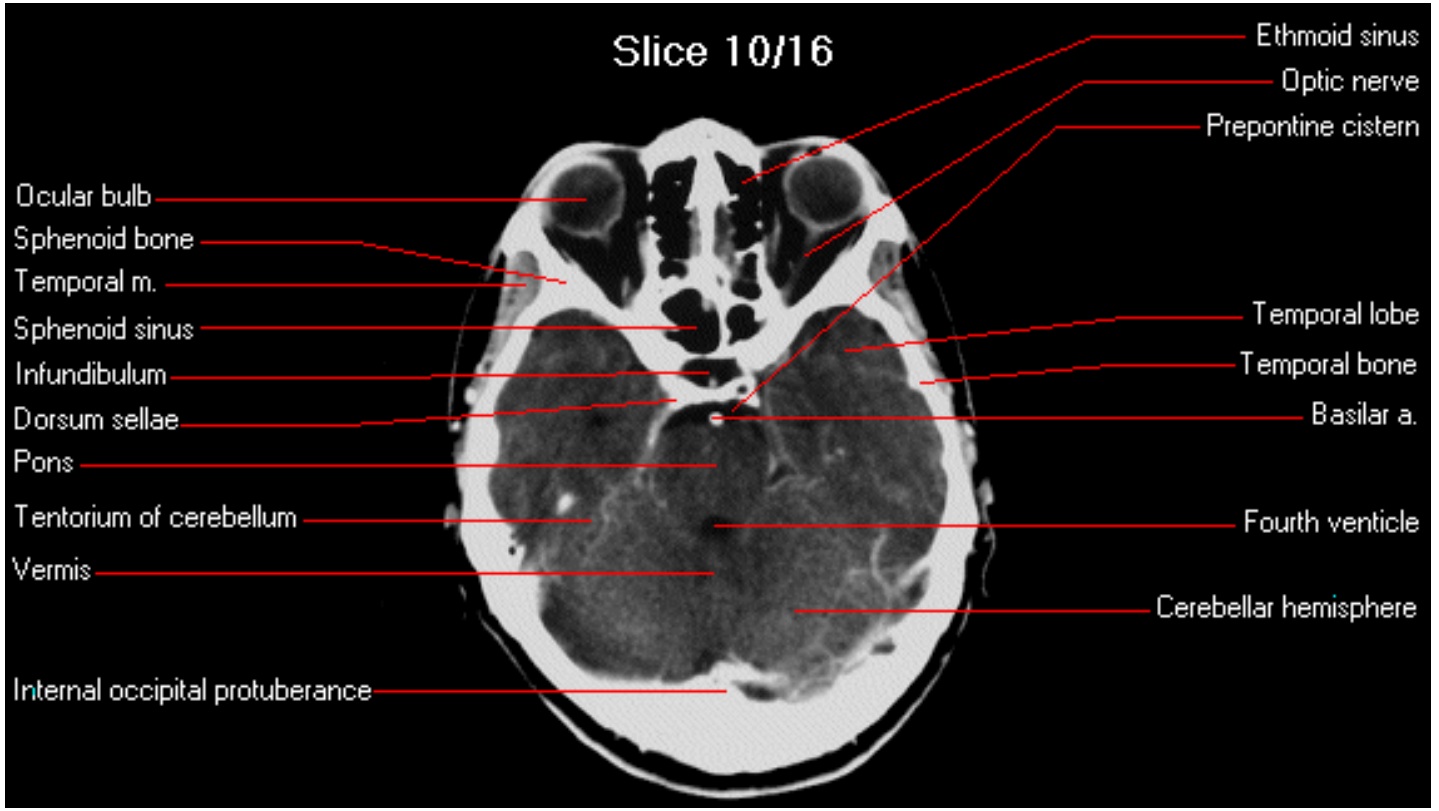
FUNCTIONAL

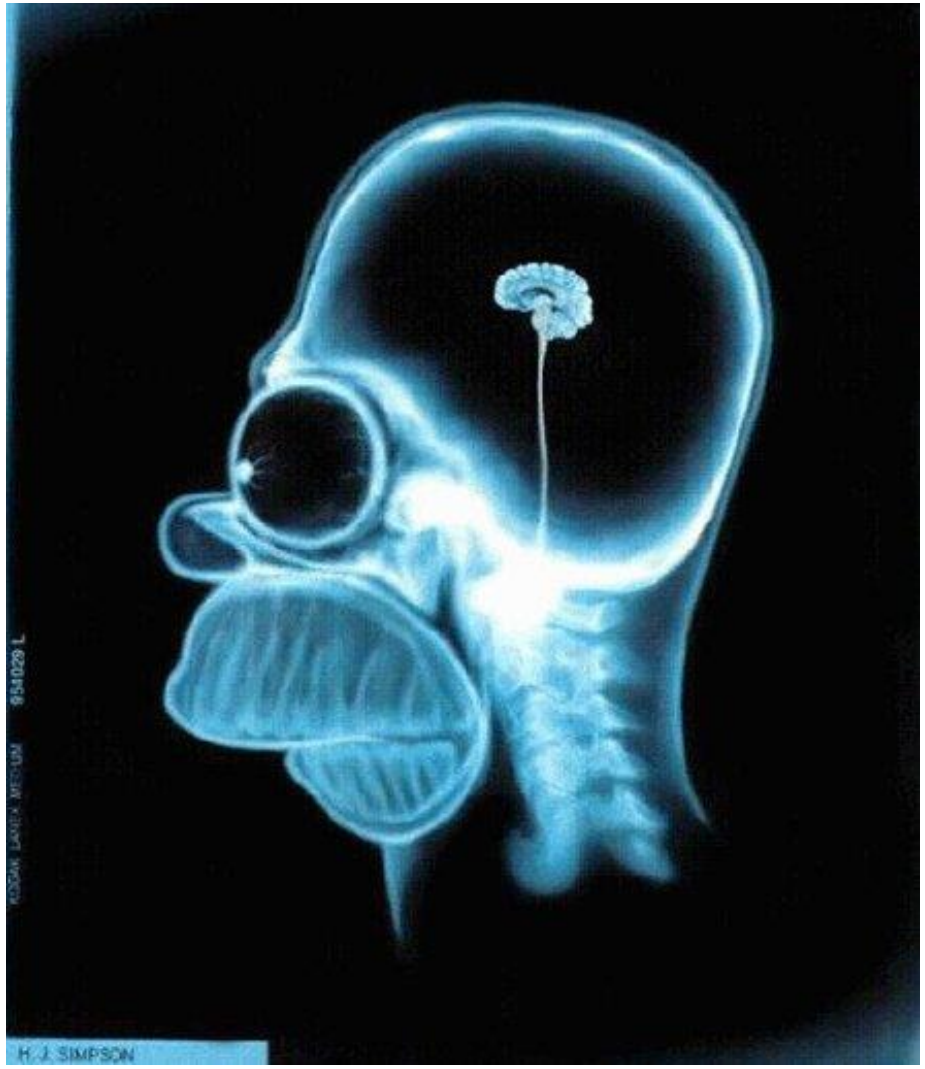
- Single photon emission computed tomography (SPECT)
- Positron emission tomography (PET)
- Functional magnetic resonance imaging (fMRI)
- Electroencephalography (EEG)
- Magnetoencephalography (MEG)



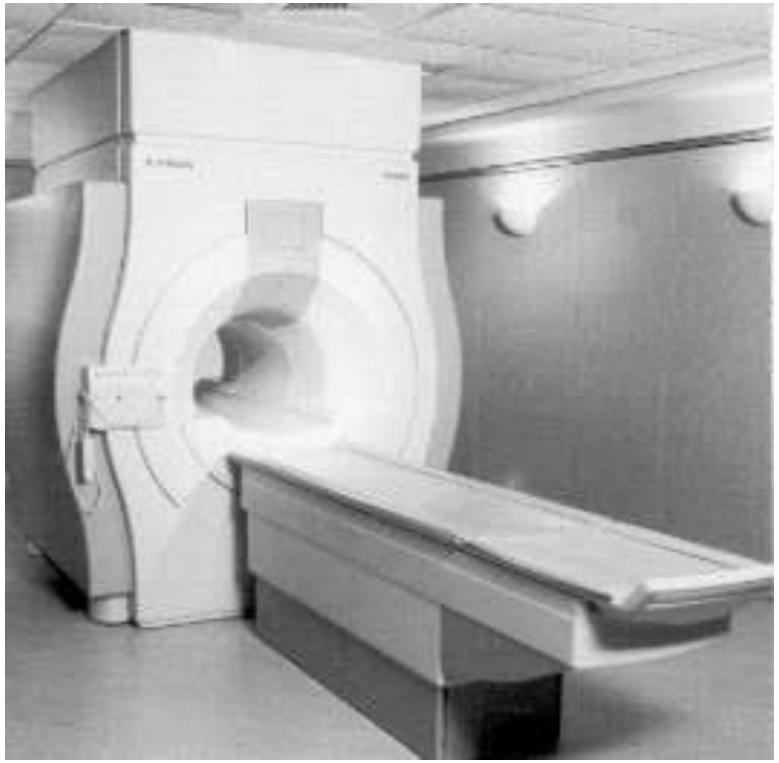
CT Scanner/ Principles

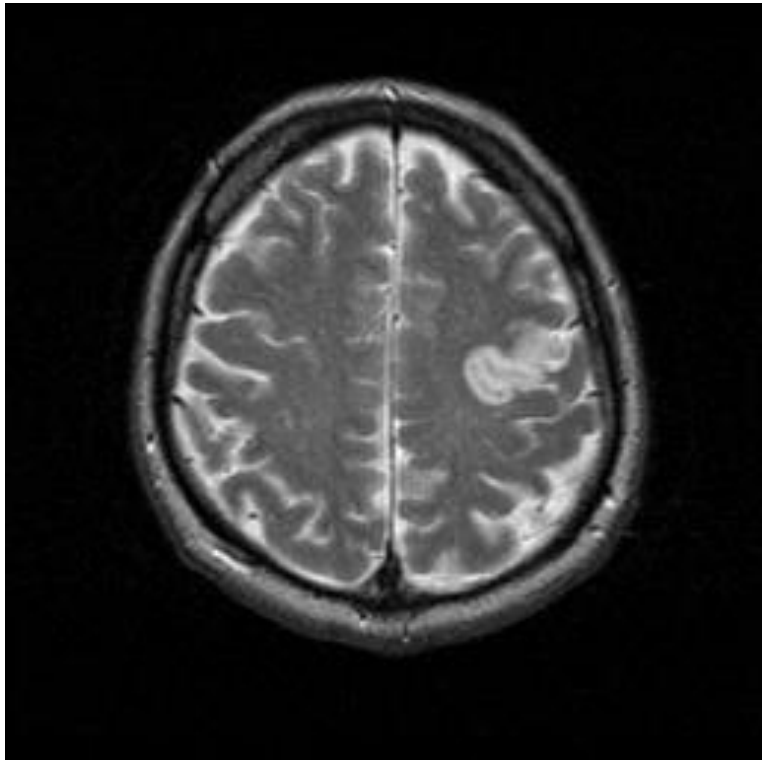
Computed Axial Tomoraphy (CAT or CT)





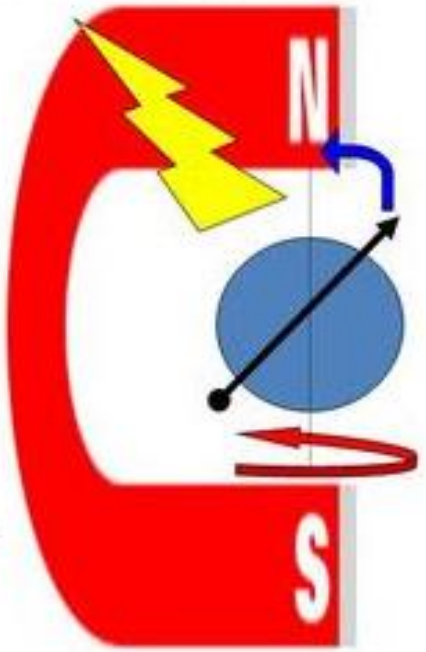
Oops..

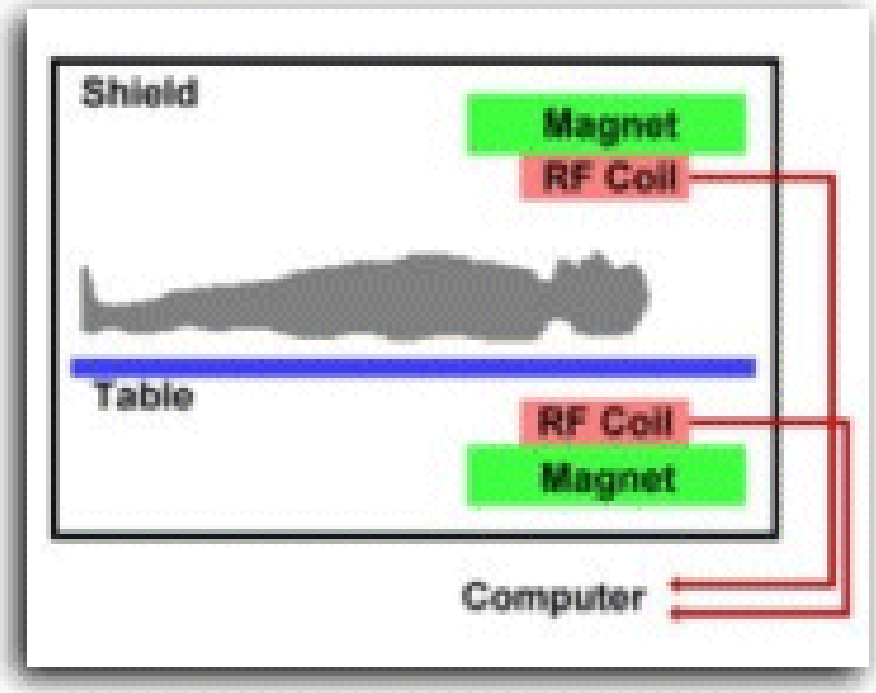




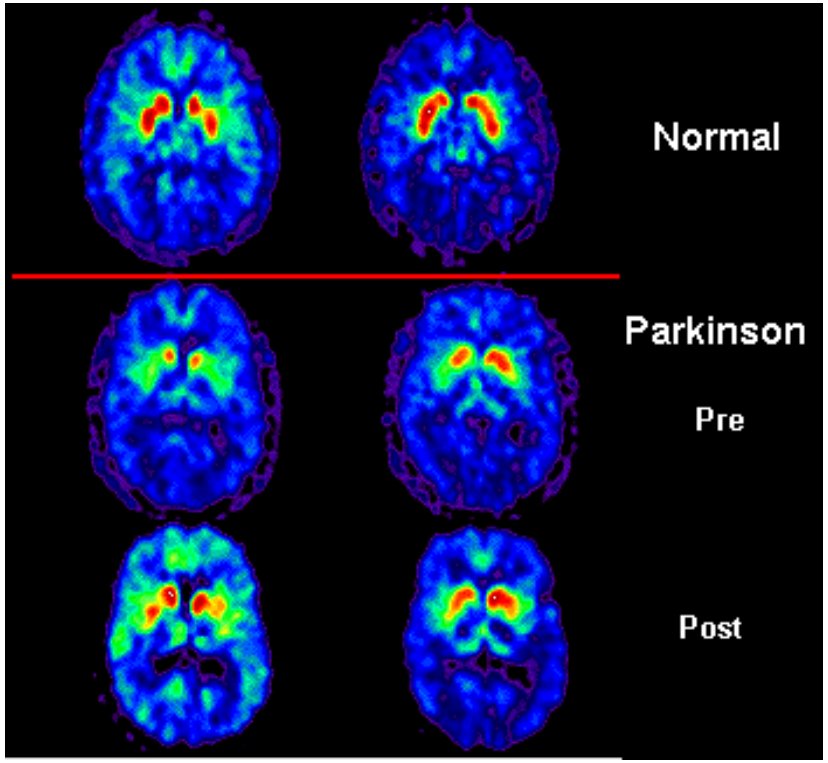
Magnetic Resonance Imaging (MRI)

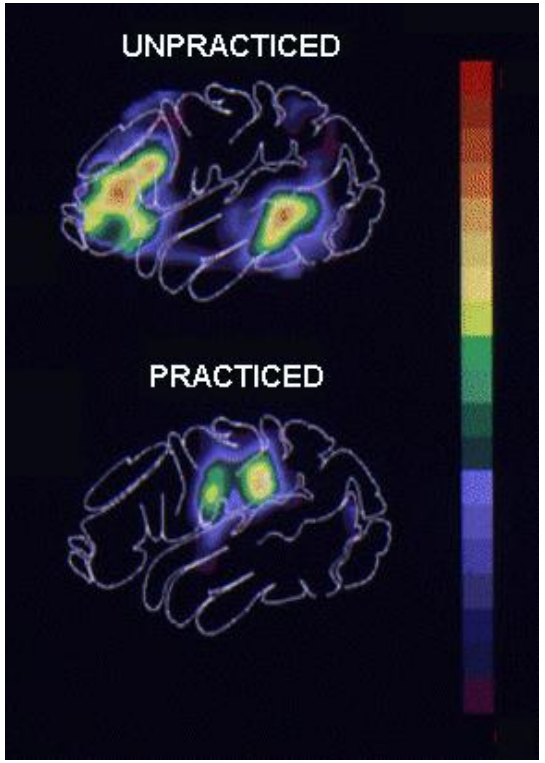
- Protons are like little magnets
  - Radio Frequency pulse will knock protons at an angle relative to the magnetic field
  - once out of alignment, the protons begin to precess
  - protons gradually realign with field (relaxation)
  - protons "echo" back the radio frequency that originally tipped them over
  - That radio "echo" forms the basis of the MRI image



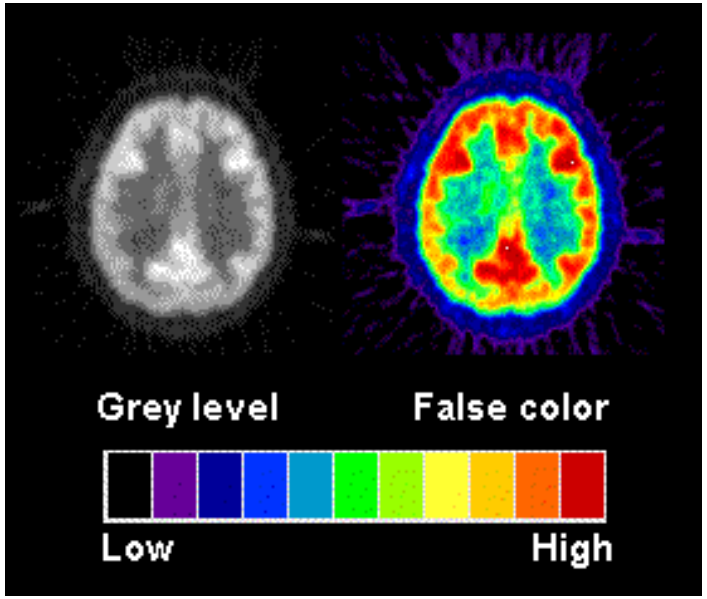


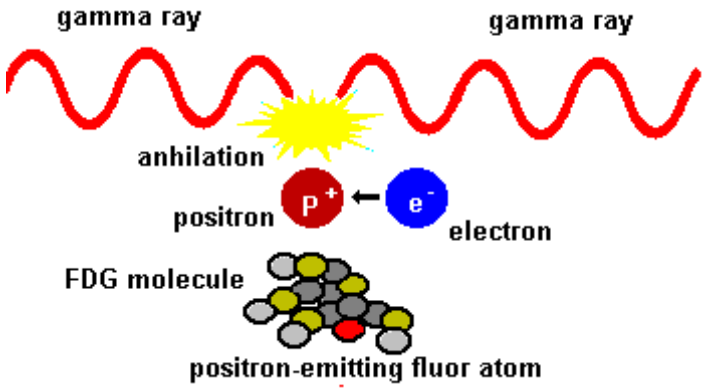
MRI principles





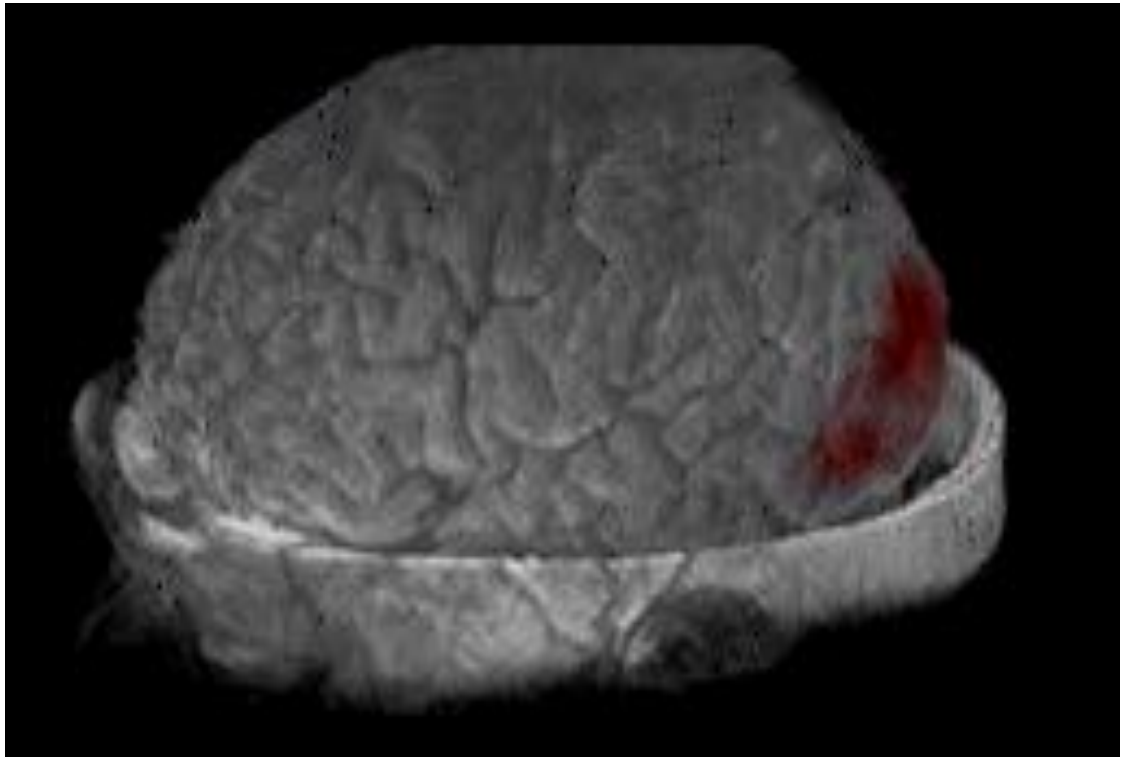
Positron Emission Tomography





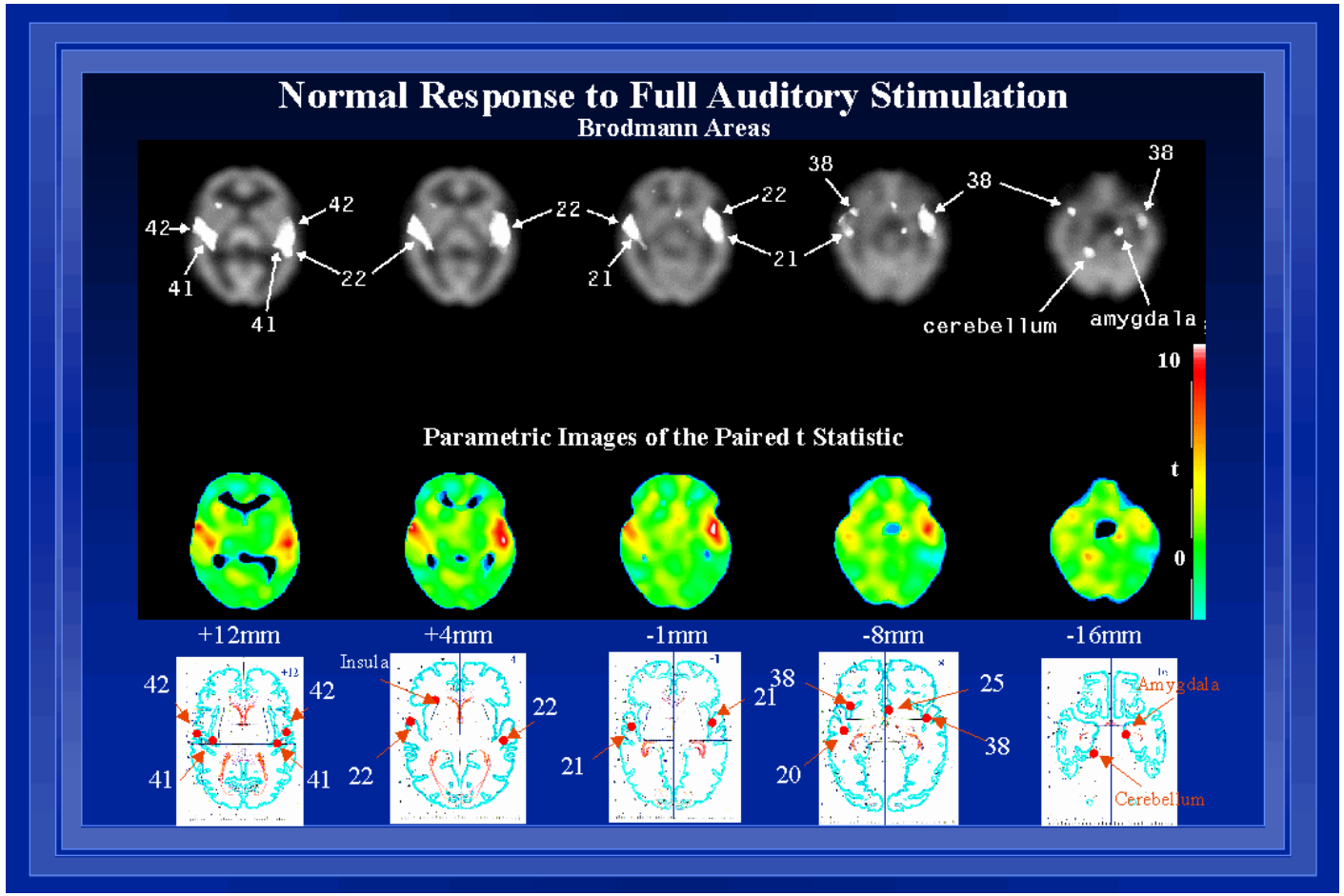
PET imaging - principles

Visual Activation PET (overlaid on MR)

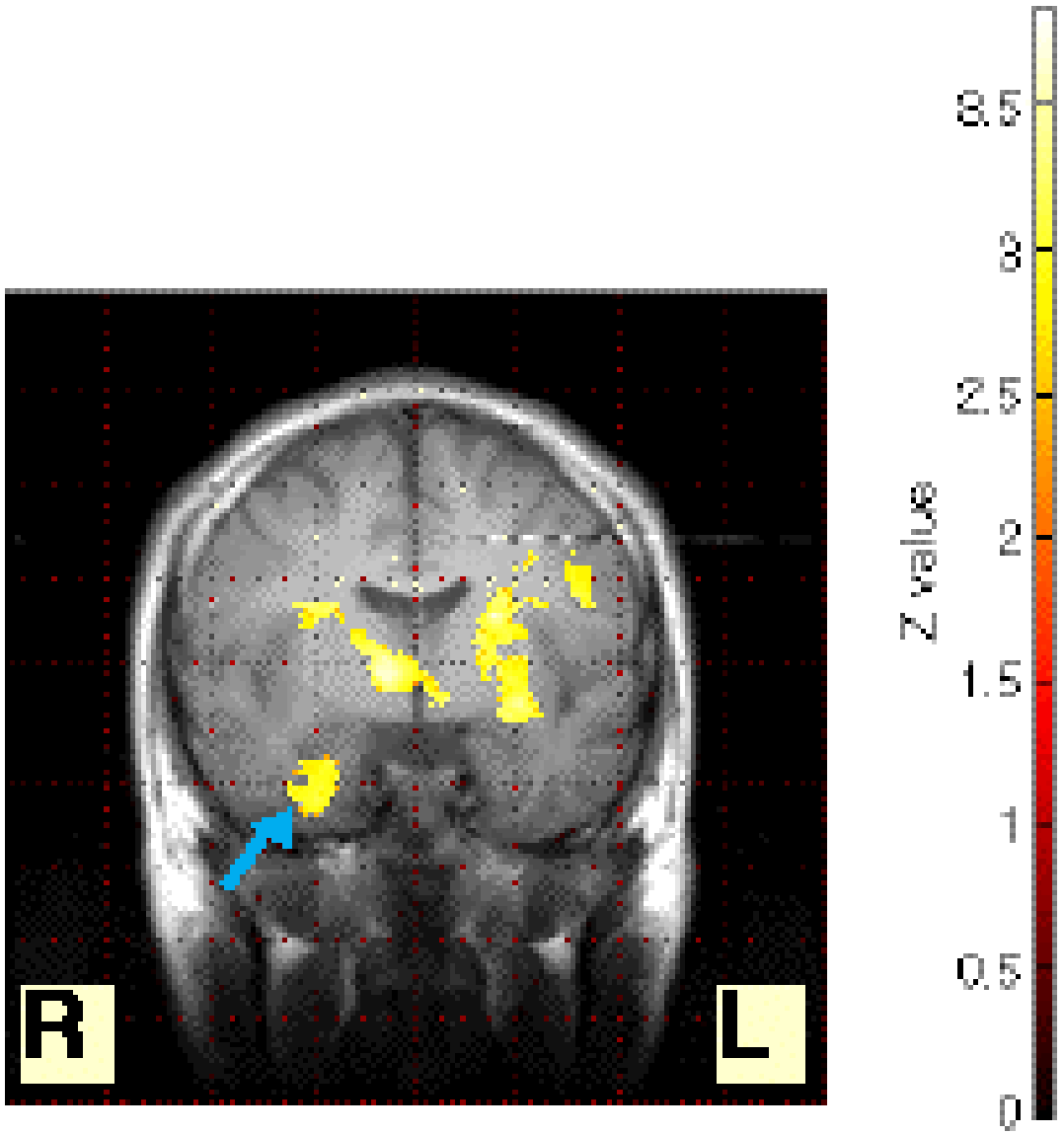


- Baseline condition: subjects viewed a simple white cross on a black background.
-
- Activation condition: view B&W drawings of animals.
- Red shows the increase of CBF in the associative visual cortex at the occipital part of the brain.

Functional imaging: Single Photon Emission Computed Tomography



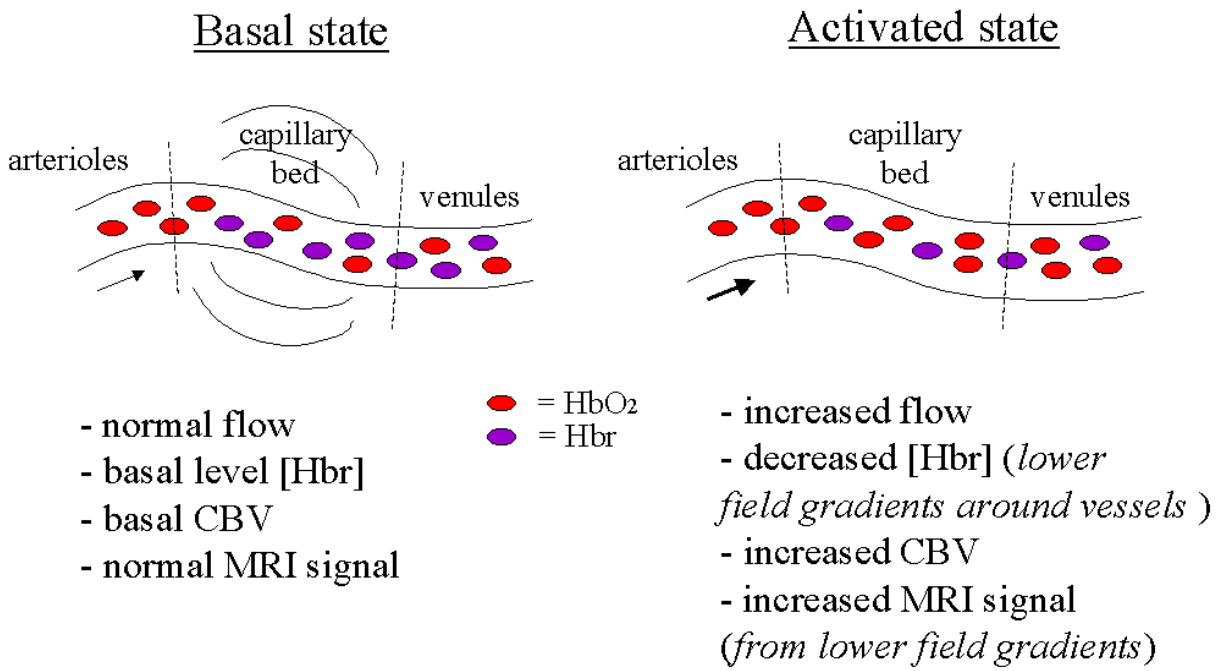
SPECT IMAGES – example



Functional Magnetic Resonance Imaging (fMRI)

Blood Oxygenation Level Dependent (BOLD) imaging

fMRI BOLD: Rapid Overview

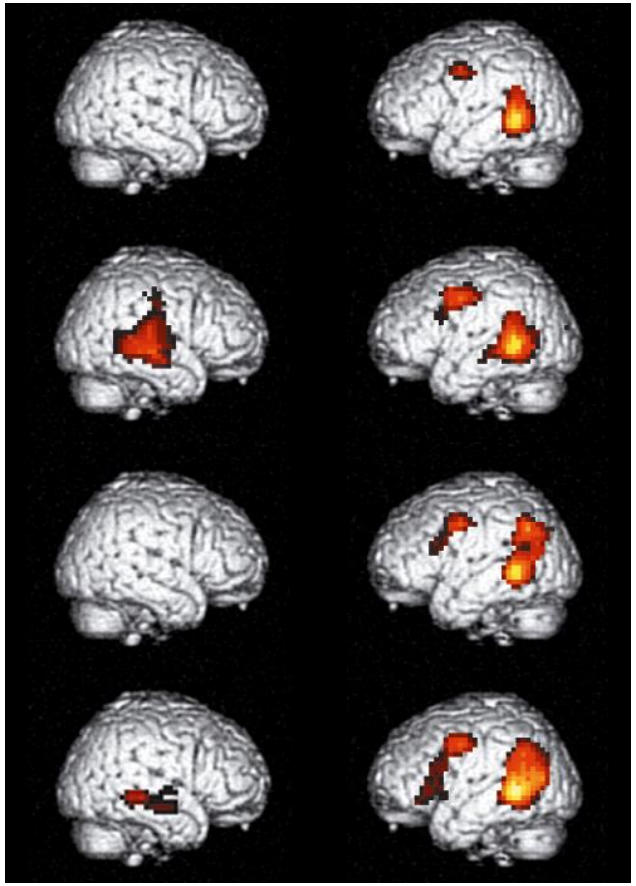


BOLD = (neural) “Cell poop” ??

fMRI example: sentence comprehension

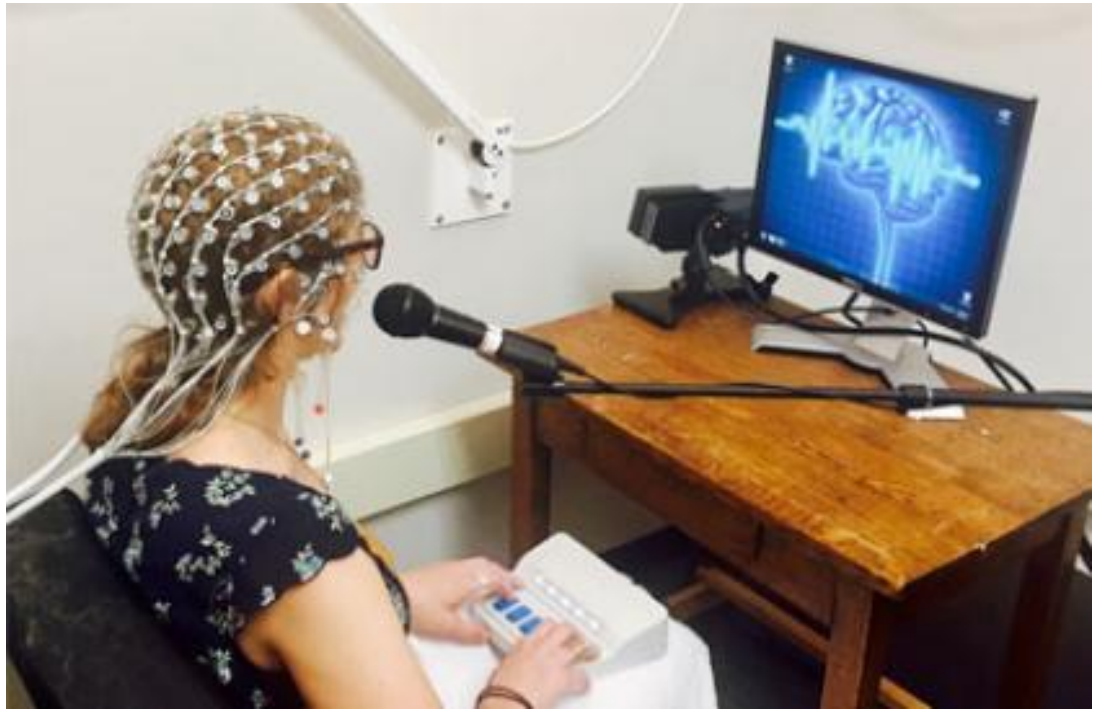
Sentence comprehension compared to pseudofont baseline in 15 young healthy adults

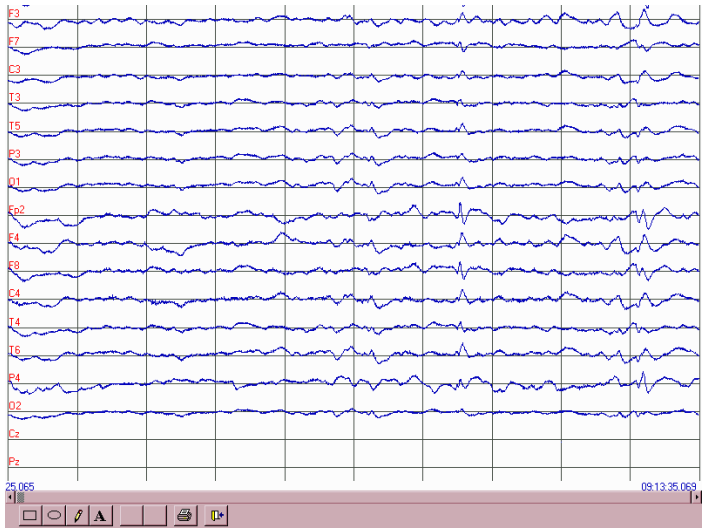
- A: subject-relative short linkage
- B: subject-relative long linkage
- C: object-relative short linkage
- D: object-relative long linkage

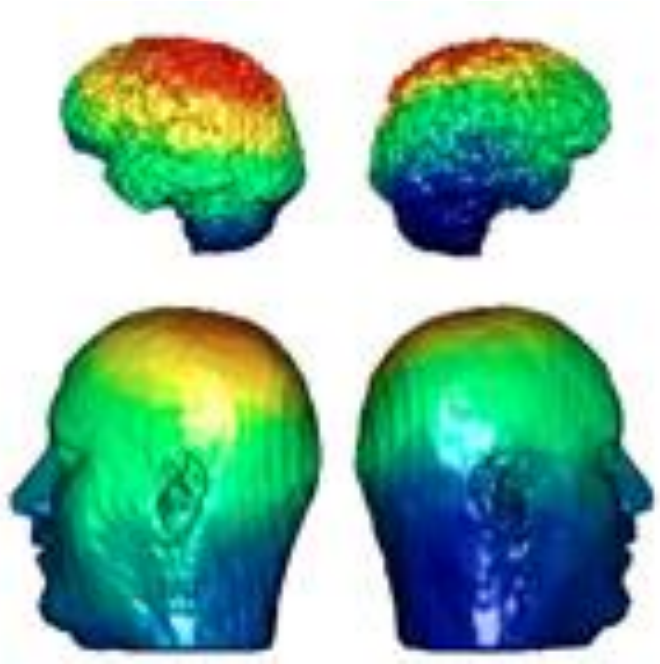


EEG - Electroencephalography

Electrodes, placed on or just under the scalp, are linked to an amplifier connected to a mechanism that converts electrical impulses into recorded images

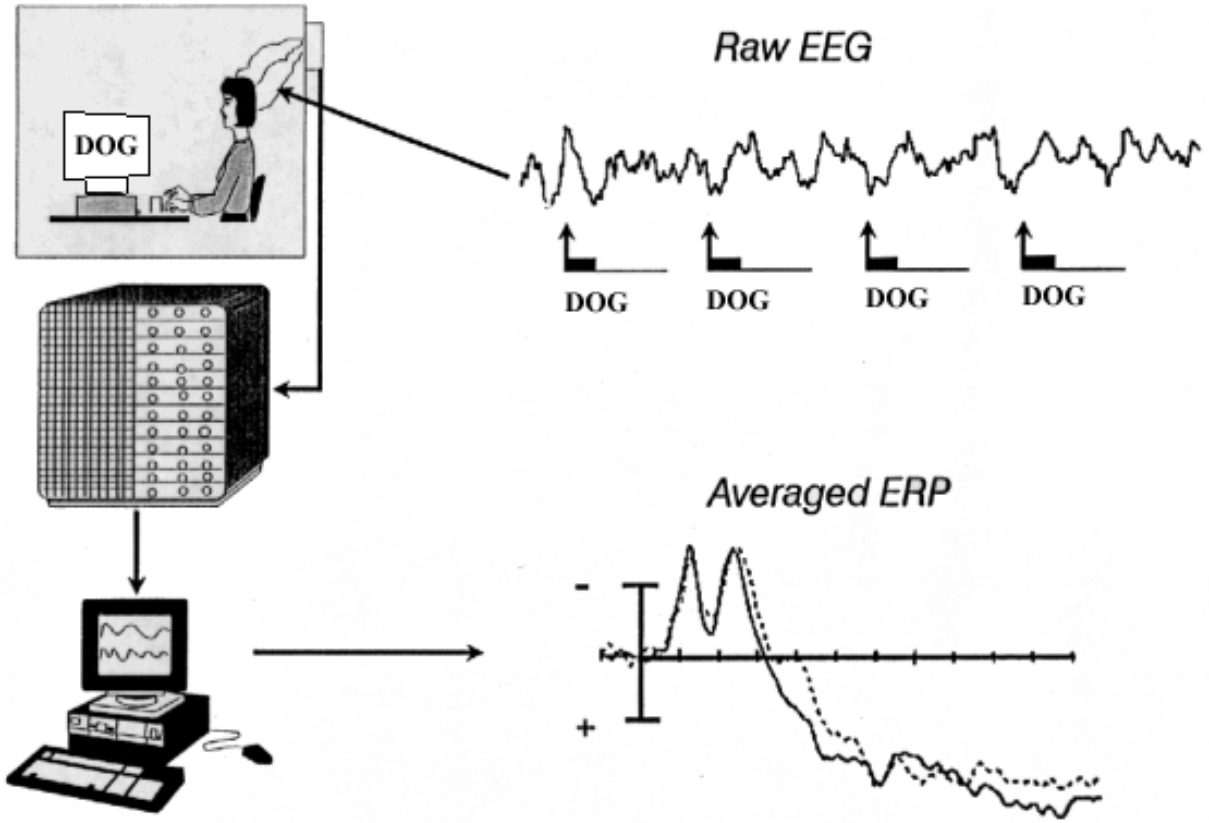


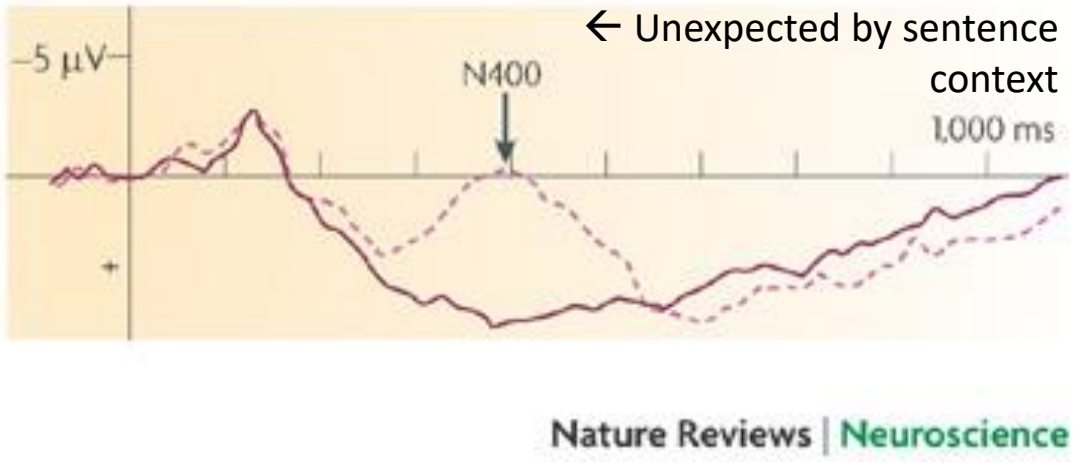


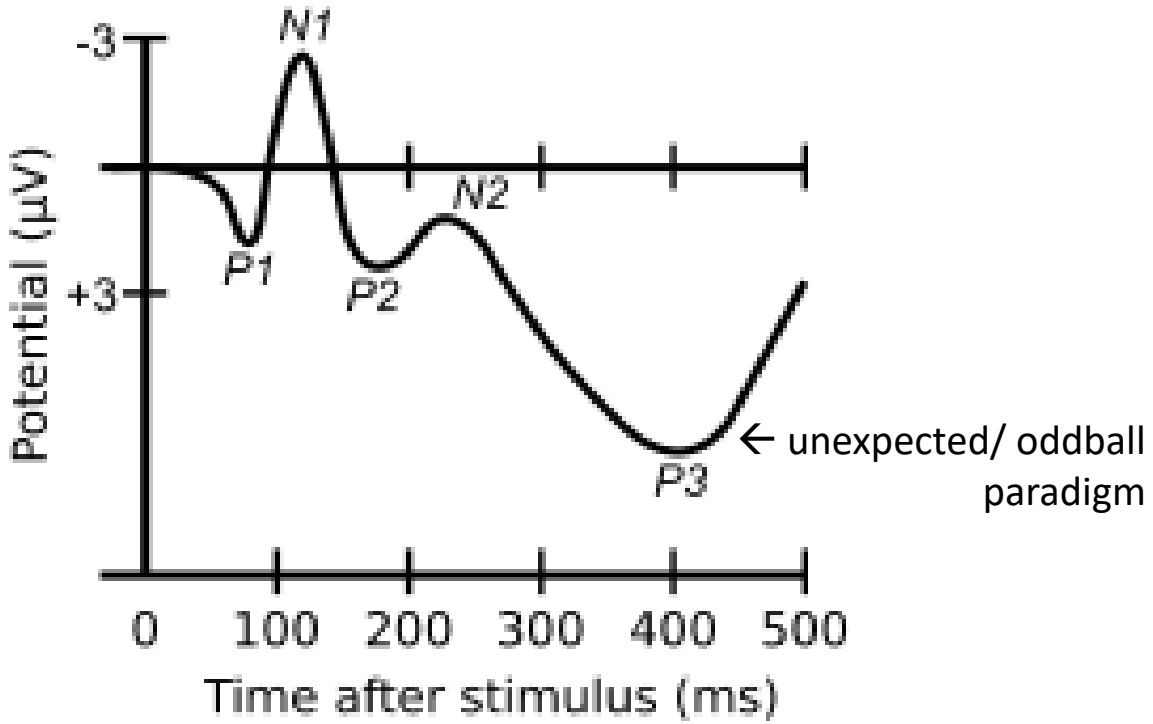


EEG – continued – electrode cap, forms of data display

Event-Related Potential Technique



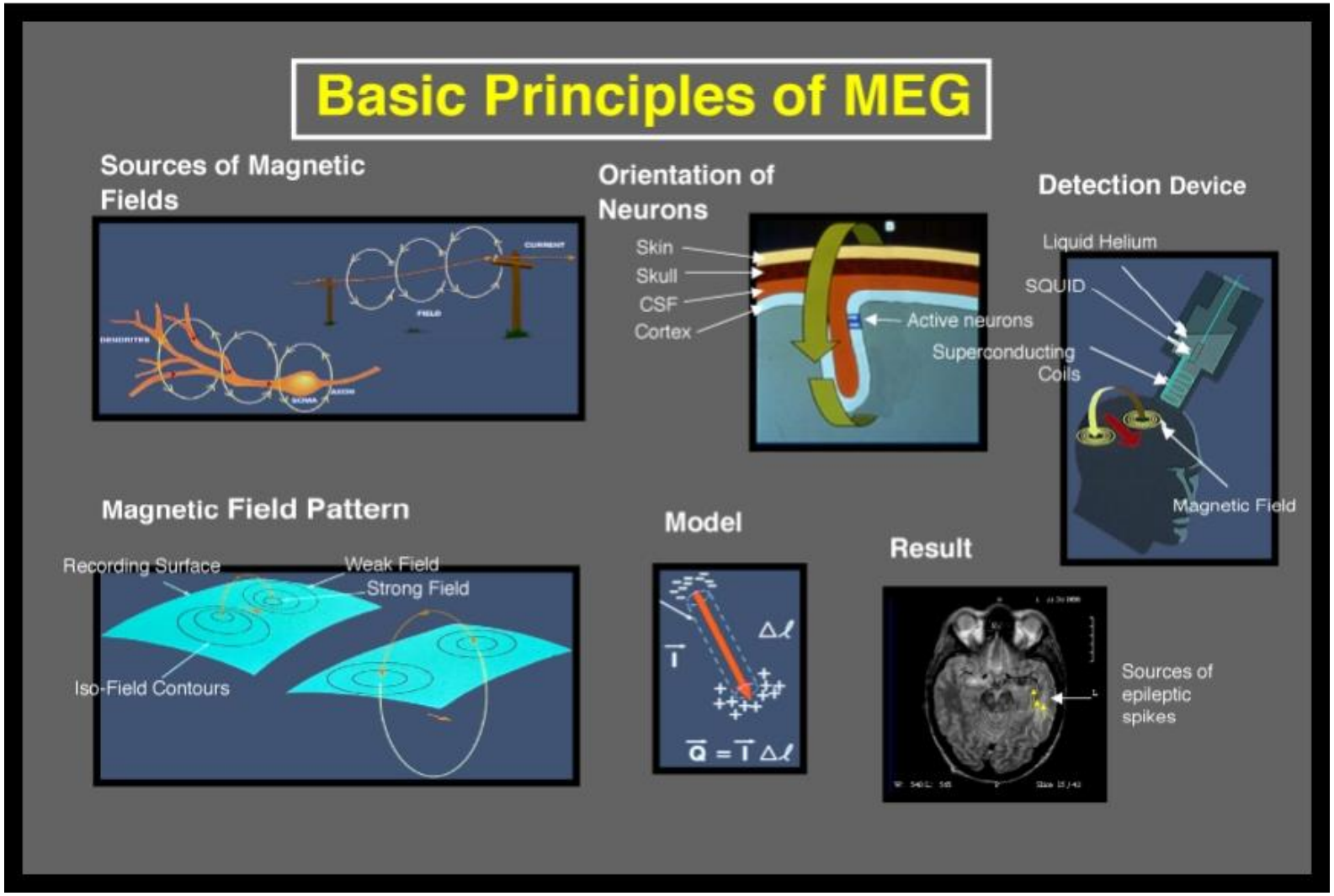

← Unexpected by sentence context
−5 μV
N400
1,000 ms
+
Nature Reviews | Neuroscience


N1
-3
N2
P1
P2
+3
Potential (μV)
P3
← unexpected/ oddball paradigm
0
100
200
300
400
500
Time after stimulus (ms)

P300, n400

MEG

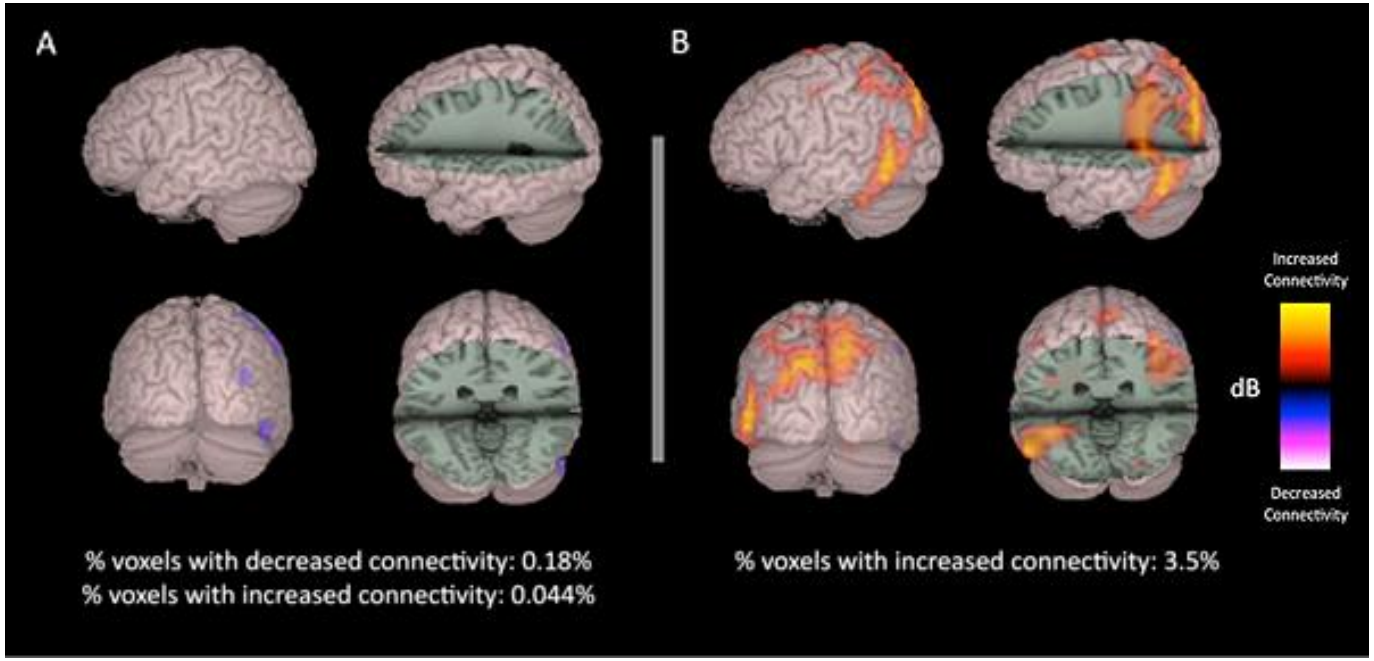
MAGNETOENCEPHALOGRAPY


Basic Principles of MEG
Sources of Magnetic Fields
Orientation of Neurons
Skin
Skull
CSF
Cortex
Active neurons
Detection Device
Liquid Helium
SQUID
Superconducting Coils
Magnetic Field
Magnetic Field Pattern
Recording Surface
Weak Field
Strong Field
Iso-Field Contours
Model
Result
Sources of epileptic spikes

MEG – images

A) Initial resting state MEG scan after mild TBI.
B) Resting state MEG scan 26 months later showing improved connections with time.

(Dr. P. Mukherjee, UCSF, Dept. Radiology)



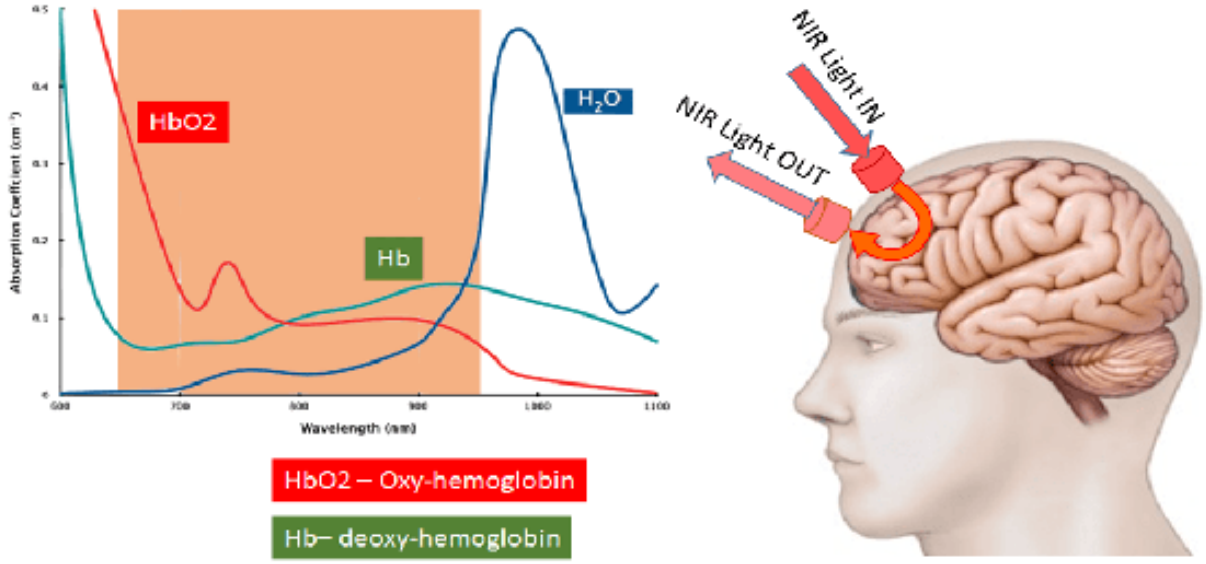
NEW

fNIRS – Functional near-infrared spectroscopy

Measuring speaker–listener neural coupling with functional near infrared spectroscopy

Yichuan Liu, Elise A. Piazza, Erez Simony, Patricia A. Shewokis, Banu Onaral, Uri Hasson & Hasan Ayaz

Scientific Reports volume7, Article number: 43293 (2017)



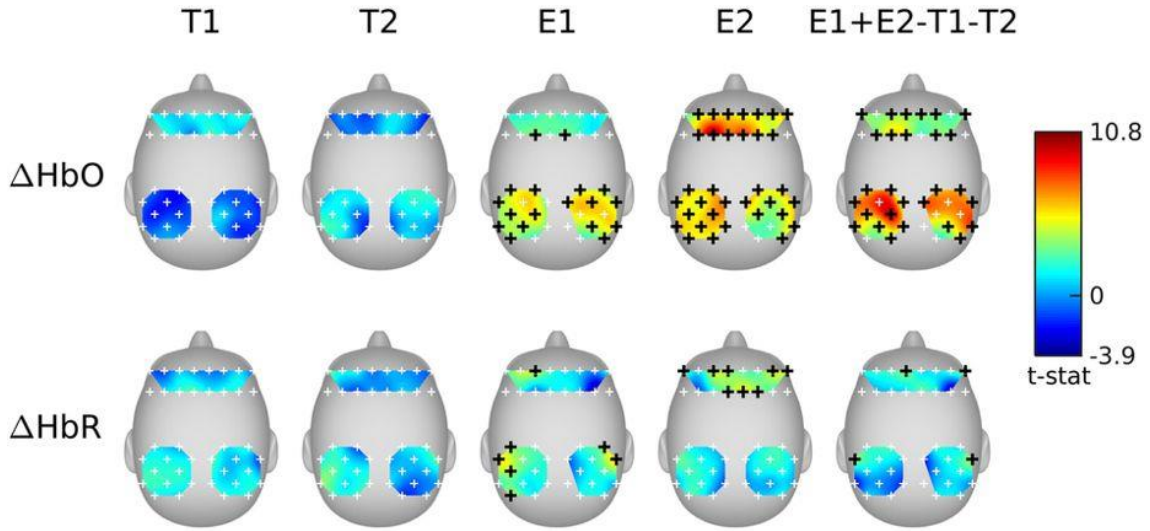


Figure 1 : Listener-listener fNIRS inter-subject correlation.

Aphasia

- Literally “not speak” Gk. *a phatos*
- An acquired language disorder that results from damage to portions of the brain that are responsible for language (-NIH)

Aphasia: Causes

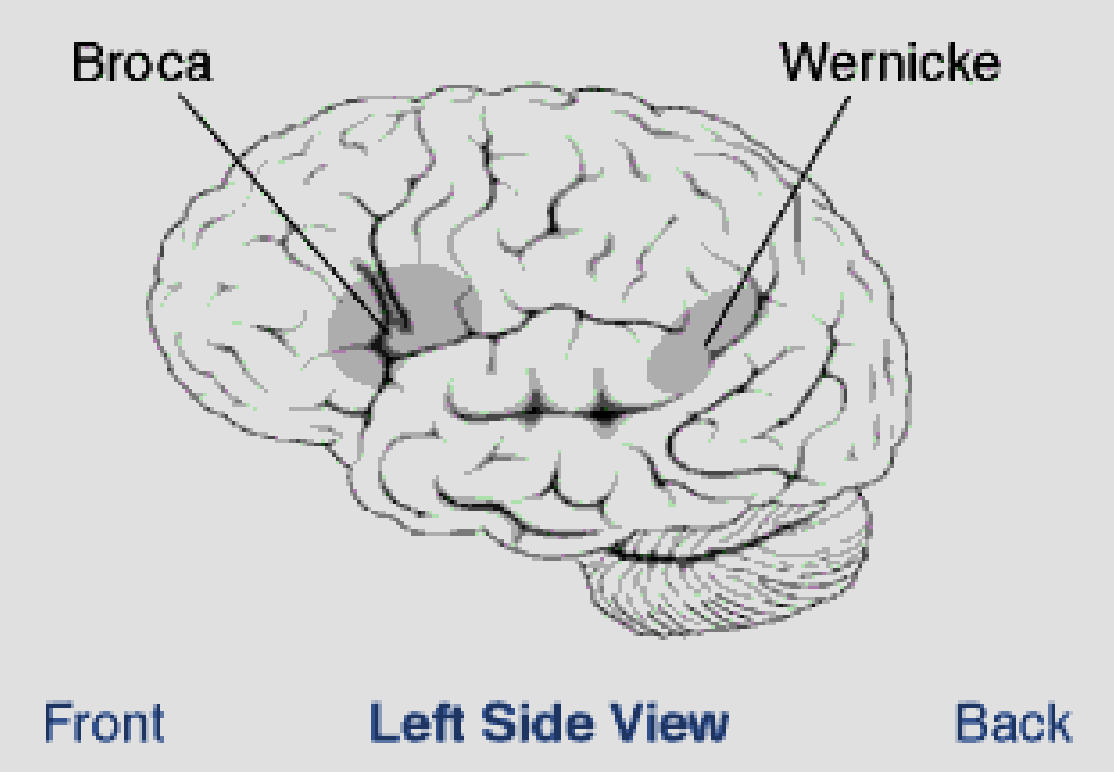
Stroke

Head injury

Tumors

Degenerative conditions (e.g. Alzheimer's)

Aphasia: Traditional Distinction

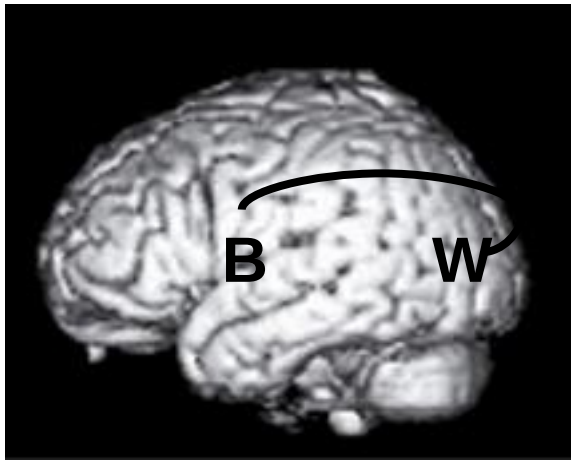


Broca's: Non-fluent speech; function words and morphemes omitted; comprehension ok.

Wernicke's: Fluent speech, but filled with non-sense or filler words; comprehension impaired.

APHASIA SYNDROMES

	FLUENCY	COMPREHENSION	REPETITION	NAMING
NON-FLUENT				
Broca's	poor	good	poor	poor
Global	poor	poor	poor	poor
FLUENT				
Wernicke's	good	poor	poor	poor
Conduction	good	good	poor	good



CLINICIAN: "Can you tell me what happened to you?"

NON-FLUENT BROCA'S APHASIC:

"Alright…. Uh… stroke and uh….I …. Huh tawanna guy…. h…h…hot tub and…. And the …..two days when un…hos…uh…huh hos-pital and uh...amet….am…. ambulance."

FLUENT WERNICKE'S (jargon) APHASIC:

"It just suddenly had a feffort and all the feffort had gone with it. It even stepped my horn. They took them from earth you know. They make my favorite nine to severed and now I'm a been habed by the …. Uh…. stam of fortment of my annulment which is now forever."

Broca's

Speech: Nonfluent, halting, agrammatic

Comprehension: Good, but difficulty with semantically difficult materials (e.g., reversible passives)

Basic Idea: Damage to areas in which speech motor programming takes place

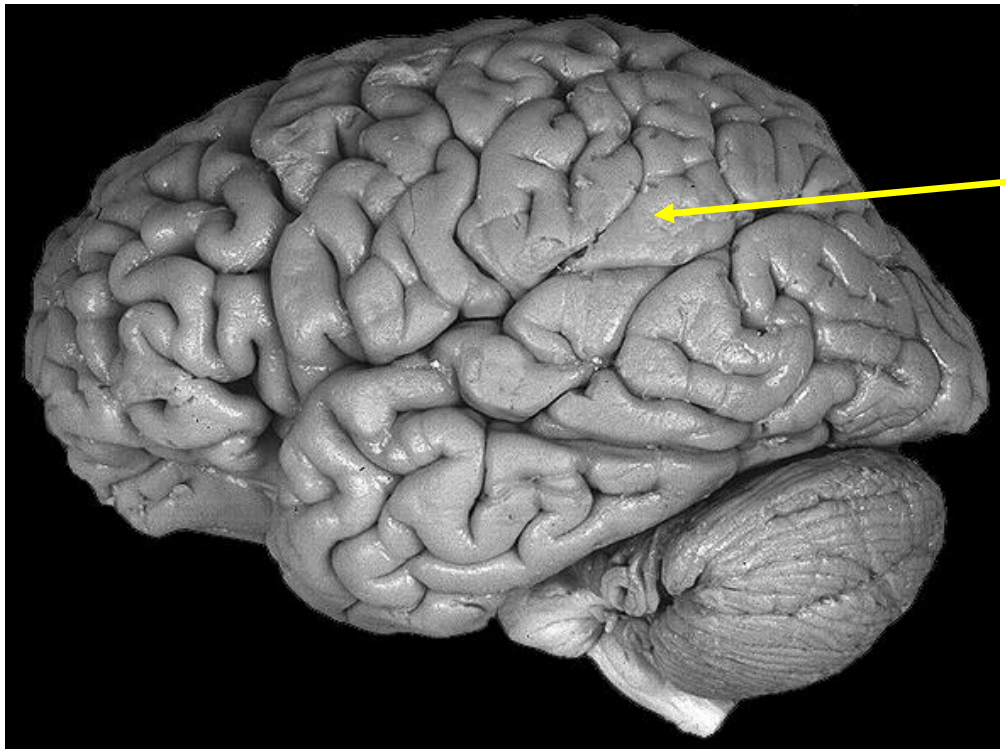
Wernicke's

Speech: Fluent and well-articulated; but semantically impoverished. Contains many non-words, or filler words

Comprehension: Poor

Basic Idea: Damage to areas in which words are stored, or in which the phonological forms of words are associated with meanings.

Conduction Aphasia



Lesion: Affects areas connecting Wernicke's and Broca's areas (?)

Supramarginal gyrus

Also arcuate fasciculus, which is underneath

Conduction - continued

Speech: Relatively unimpaired; but many speech errors, or non-words are used. Also defective naming ability

Comprehension: Also good, but unlike Wernicke's repetition is difficult

Idea: Network that builds meaningful units out of speech sounds is disabled

Global Aphasia

Lesion: Covers entire system of language areas in the dominant hemisphere (left perisylvian cortex)

Abilities: Almost total inability to produce or comprehend speech.

Idea: Combines features of Broca's and Wernicke's aphasias