Lecture 3

7 February, 2011

Announcements (2/1/08)

- 401B and 501B:
  - Laboratory #1 Report due Tues Feb 15 – to Andrew
- Electricity Test next week (Feb 14)
- Information on Papers next week too

Electricity Test Objectives

- Describe positive and negative charges
- State the law of attraction and repulsion
- Describe free electrons
- Describe the relationship between electromotive force, resistance, and flow (i.e. understand Ohm's Law)
- Draw a simple DC electric circuit comprised of a battery and:
  - Single resistor
  - Resistors in series
  - Resistors in parallel
- Solve for voltage, current, or resistance in simple DC circuits:
  - In Series
  - In Parallel
- Reduce a compound circuit to a simple equivalent
- Describe the difference between alternating and direct current (AC/DC!)
- Describe the role of a capacitor in an AC and DC circuit

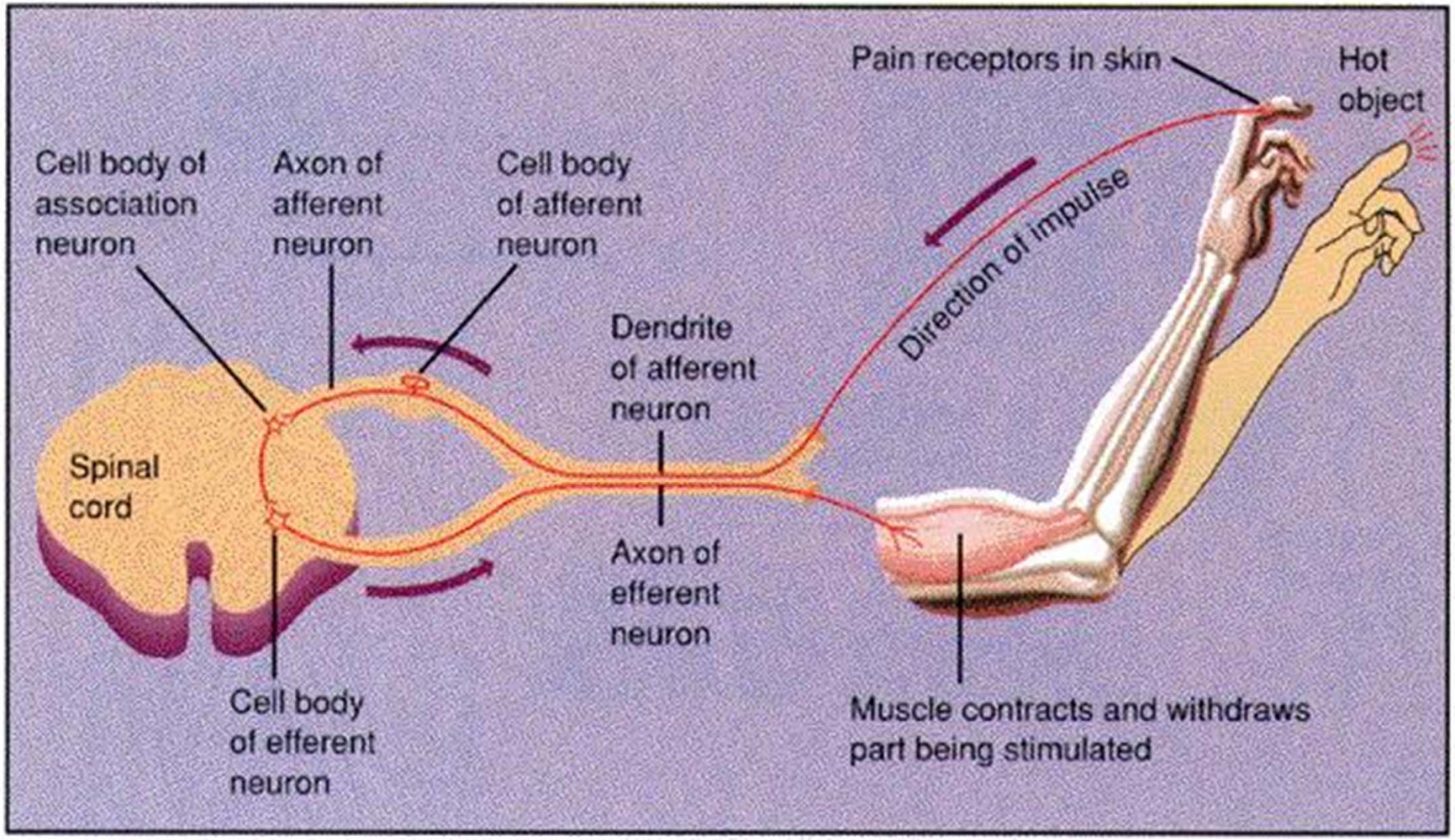
Today:

Basic Neurophysiology
Basic Neuroanatomy
The Electrodermal Response System

Part II: Basic Neurophysiology

- Three basic units inside the brain
  - Glial cells
  - Extracellular space: not really space
  - The neuron
    - Three types:
      - Sensory
      - Motor
      - Interneuron

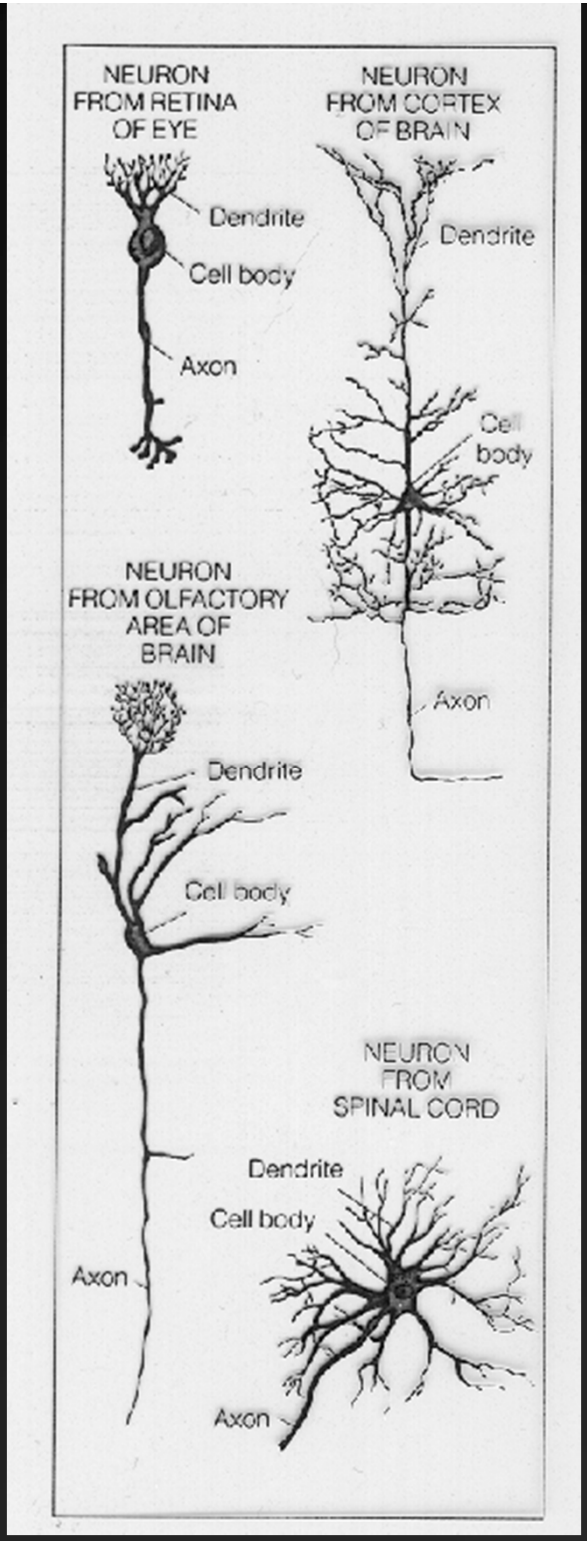
Withdrawal Reflex



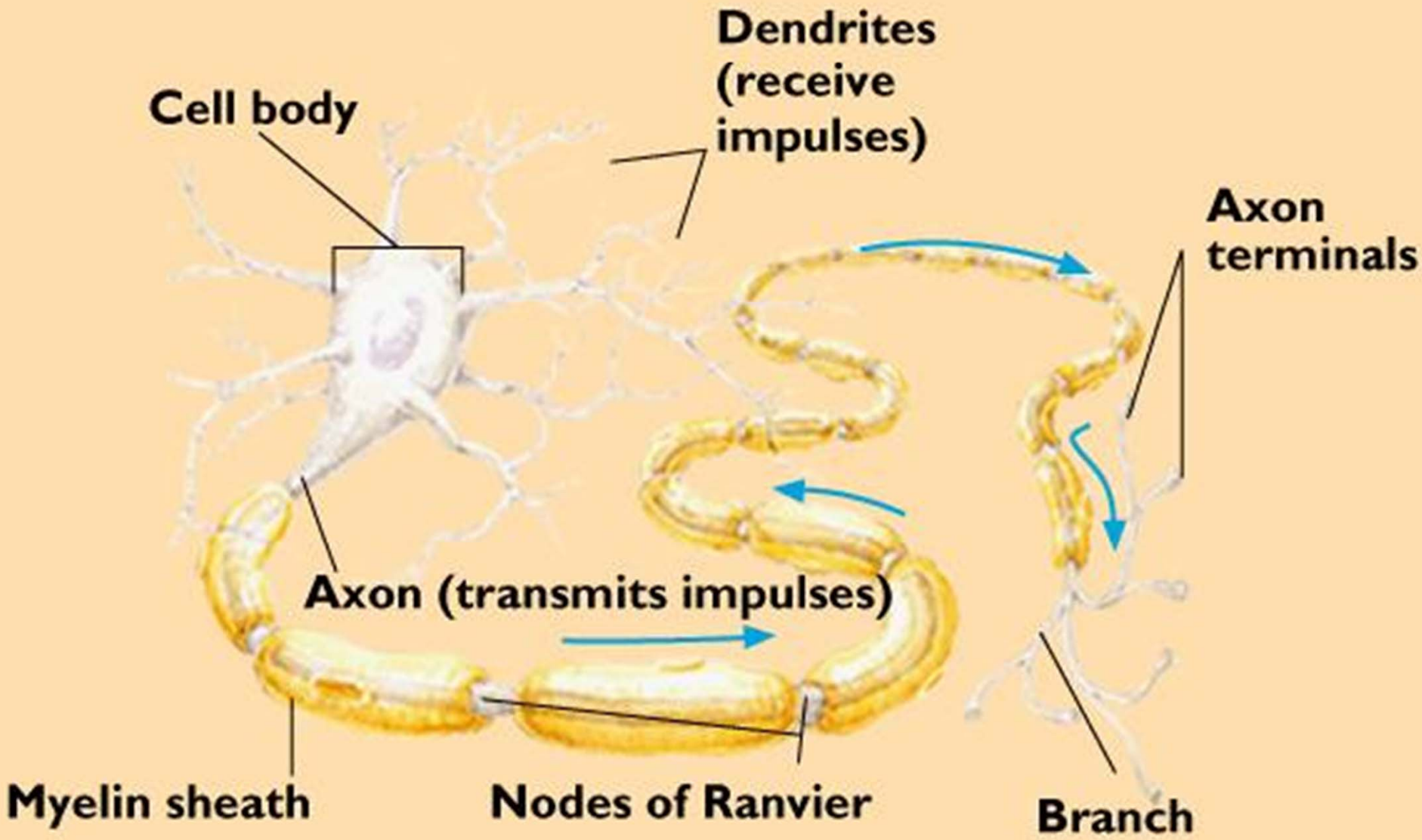
The Common Household Neuron

- Vary widely, but all have:
  - Cell body (soma)
  - Dendrites
  - Axon
    - Myelin sheath
    - Nodes of Ranvier
    - Microtubules
    - Terminal buttons (AKA synaptic knob)
- Nerve = a bundle of axons

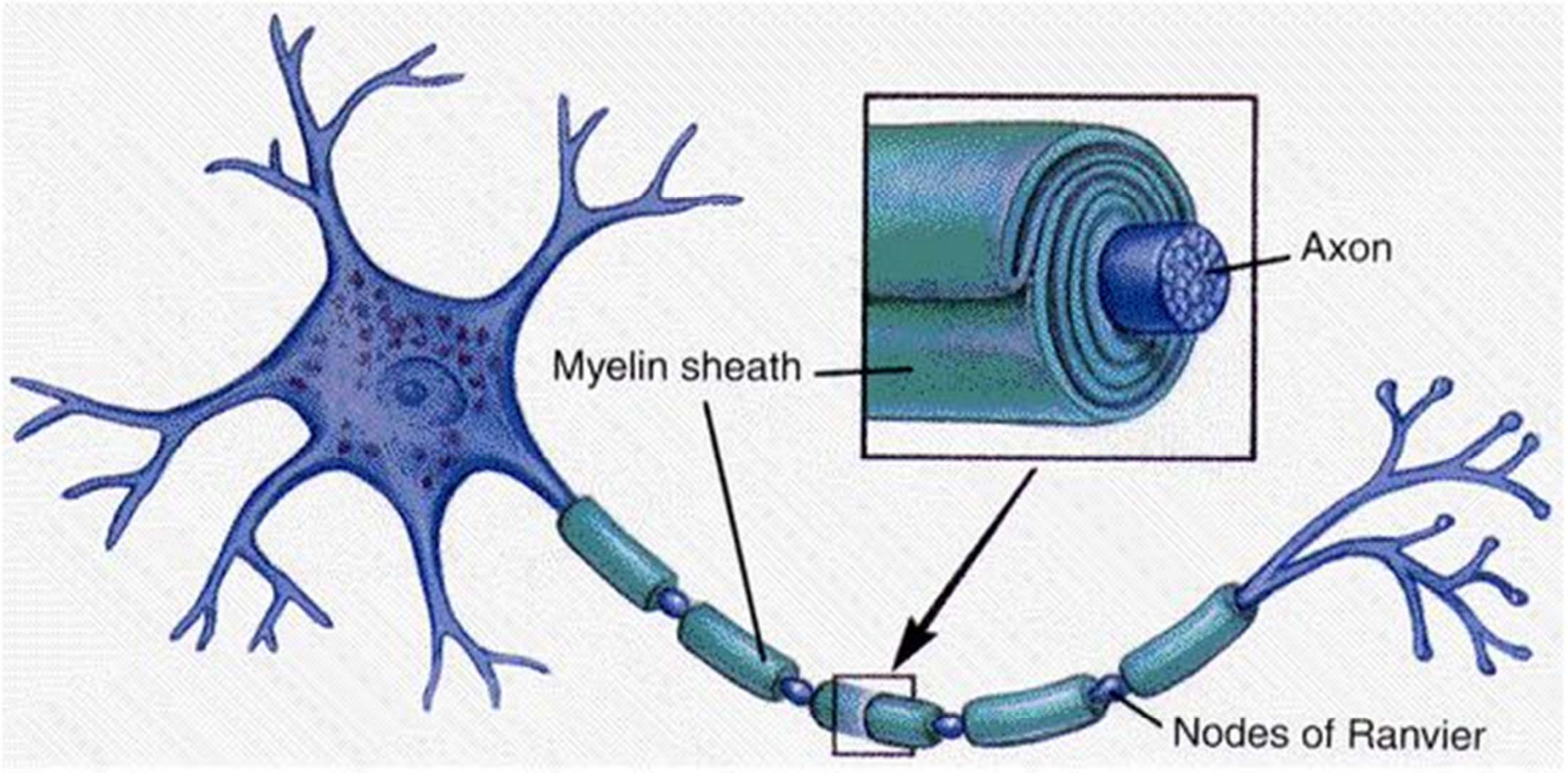
Jump to Next


NEURON FROM RETINA OF EYE
Dendrite
Cell body
Axon
NEURON FROM CORTEX OF BRAIN
Dendrite
Cell body
Axon
NEURON FROM OLFACTORY AREA OF BRAIN
Dendrite
Cell body
Axon
NEURON FROM SPINAL CORD
Dendrite
Cell body
Axon

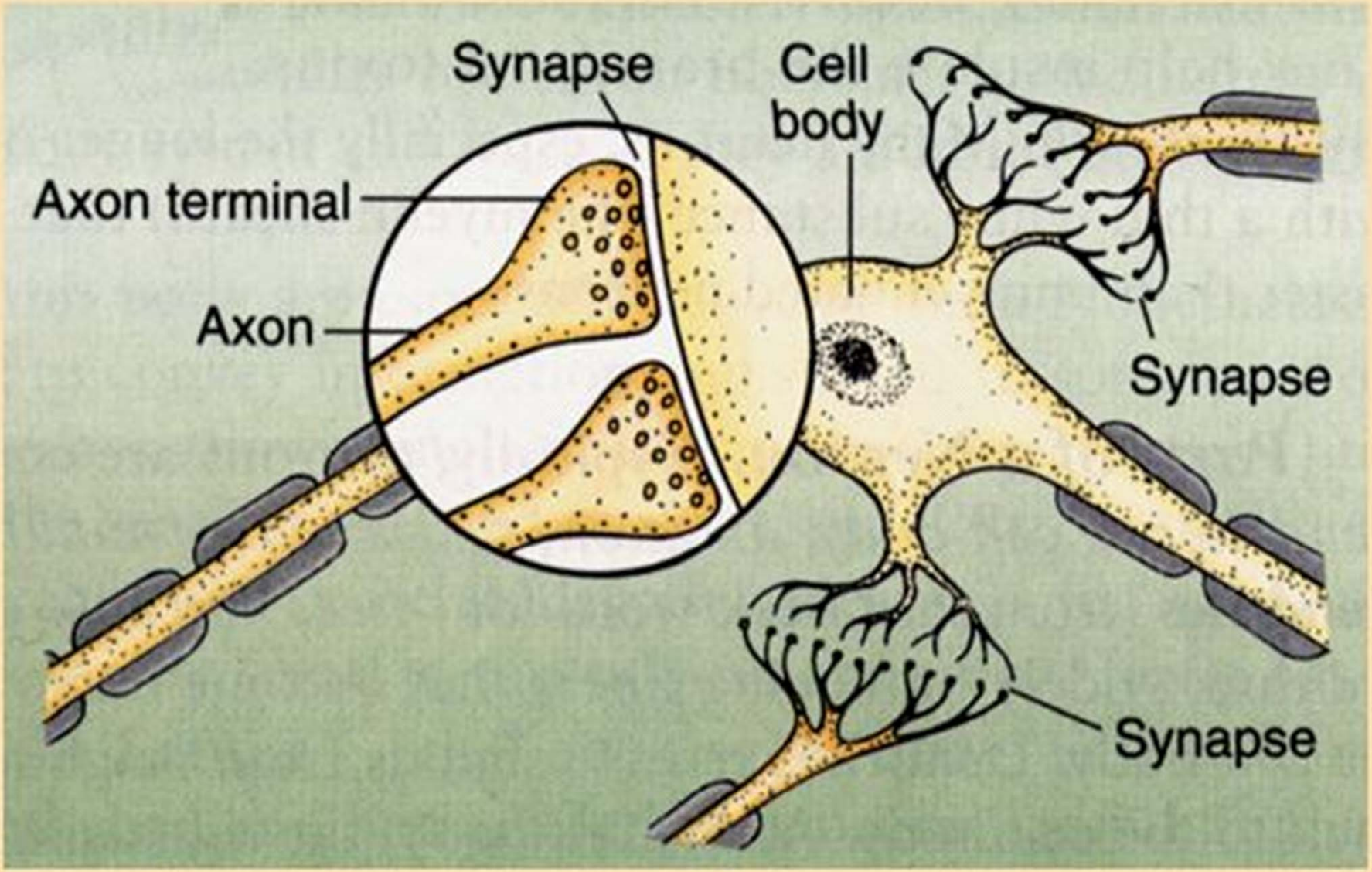
Neuron Structure



Myelin Sheath



The Synapse



Neural Communication

- Axonal Conduction (electro-chemical)
- Synaptic Transmission (chemico-eletrical)

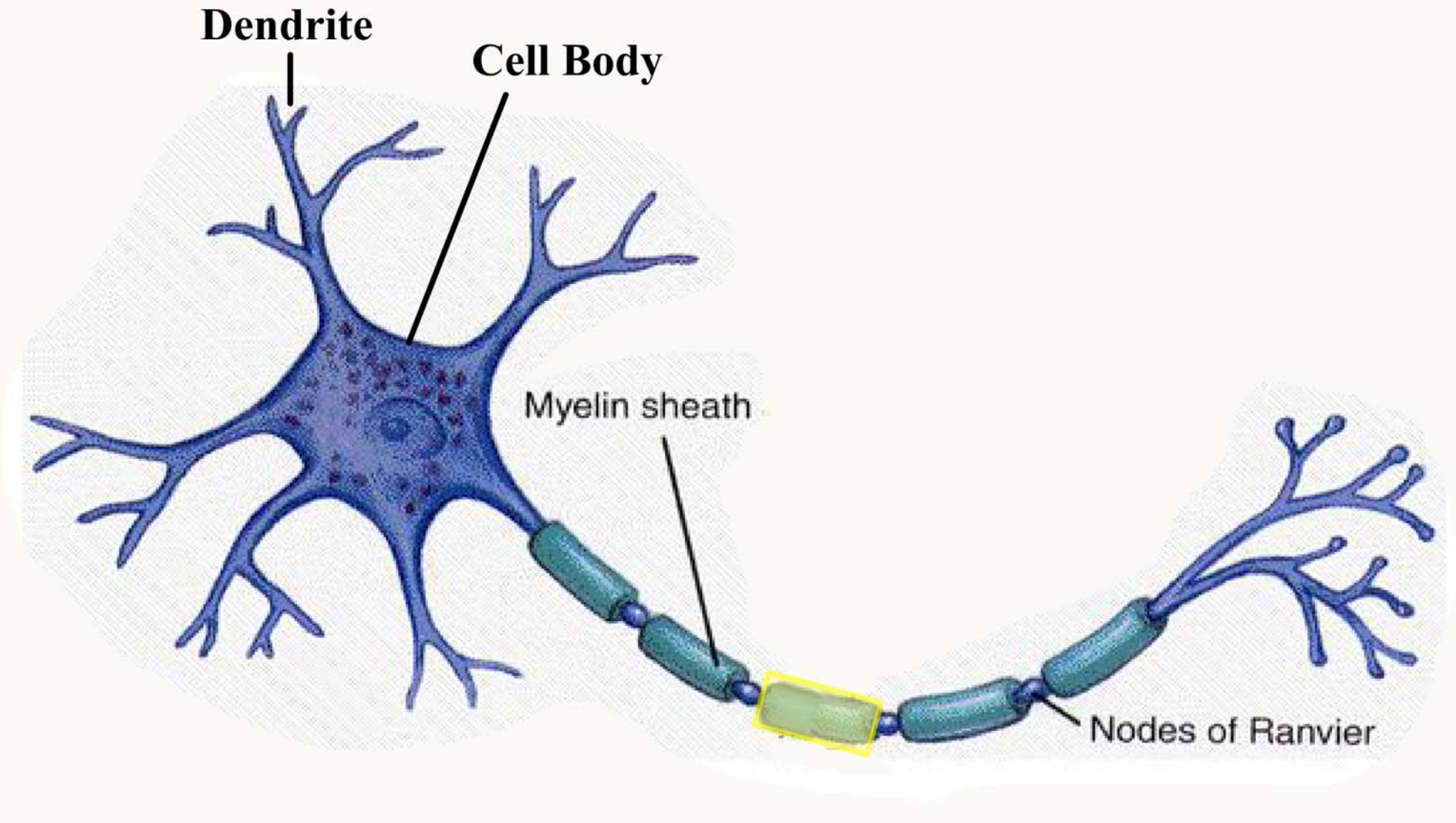
Axonal Conduction

- Resting potential
  - Inside of cell slightly negative
  - Two forces act upon these ions
    - Concentration gradient--osmotic force
    - Electromotive force
  - Equilibrium potential:
    - $E_{ion} = (R*T/z*F) * \ln(Conc_{Ex}/Conc_{In})$
    - where R is gas constant, T is temperature, z is ionic valence, and F is Faraday's constant.
  - The Hodgkin & Huxley Model

Axonal Conduction

- Depolarization
  - Threshold
  - Axon Hillock
  - Na ions rush in resulting in:
  - Action potential;
    - All or none phenomenon, high frequency
    - Afterpotentials; hyperpolarizing, depolarizing; slow frequency
    - Changes in membrane permeabilities
    - Propagation
- Refractory period

Jump to Next


Dendrite
Cell Body
Myelin sheath
Nodes of Ranvier

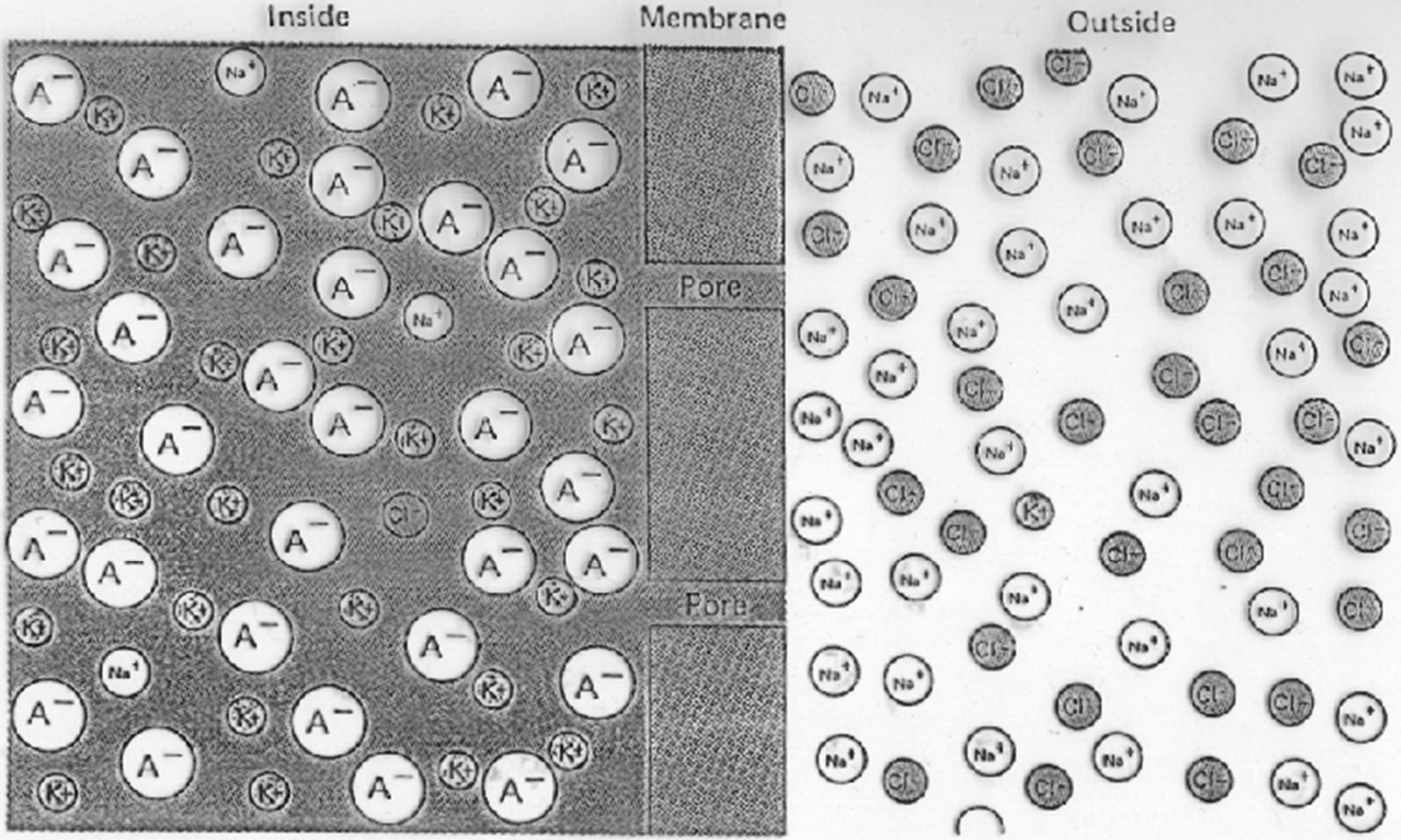
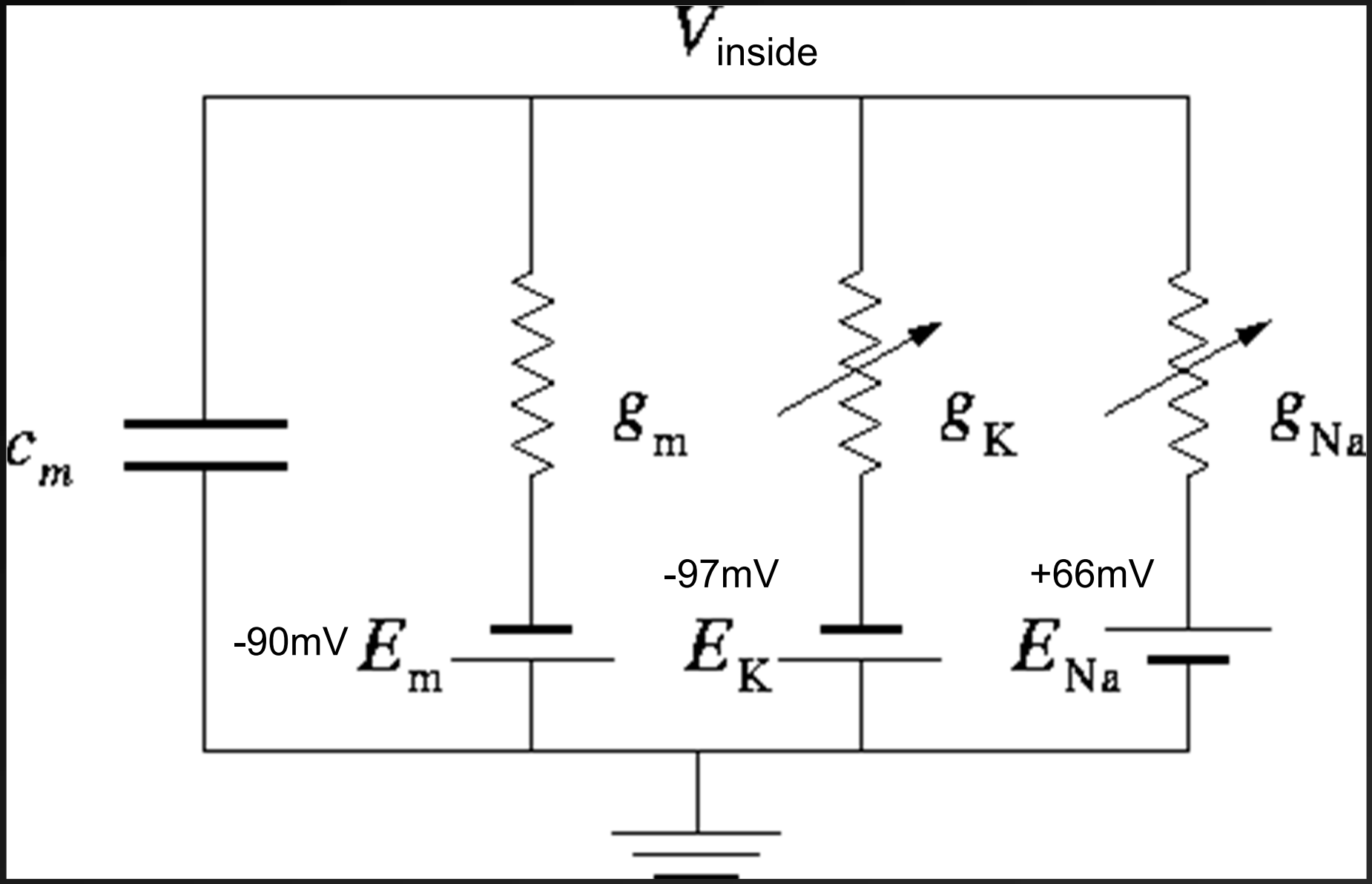
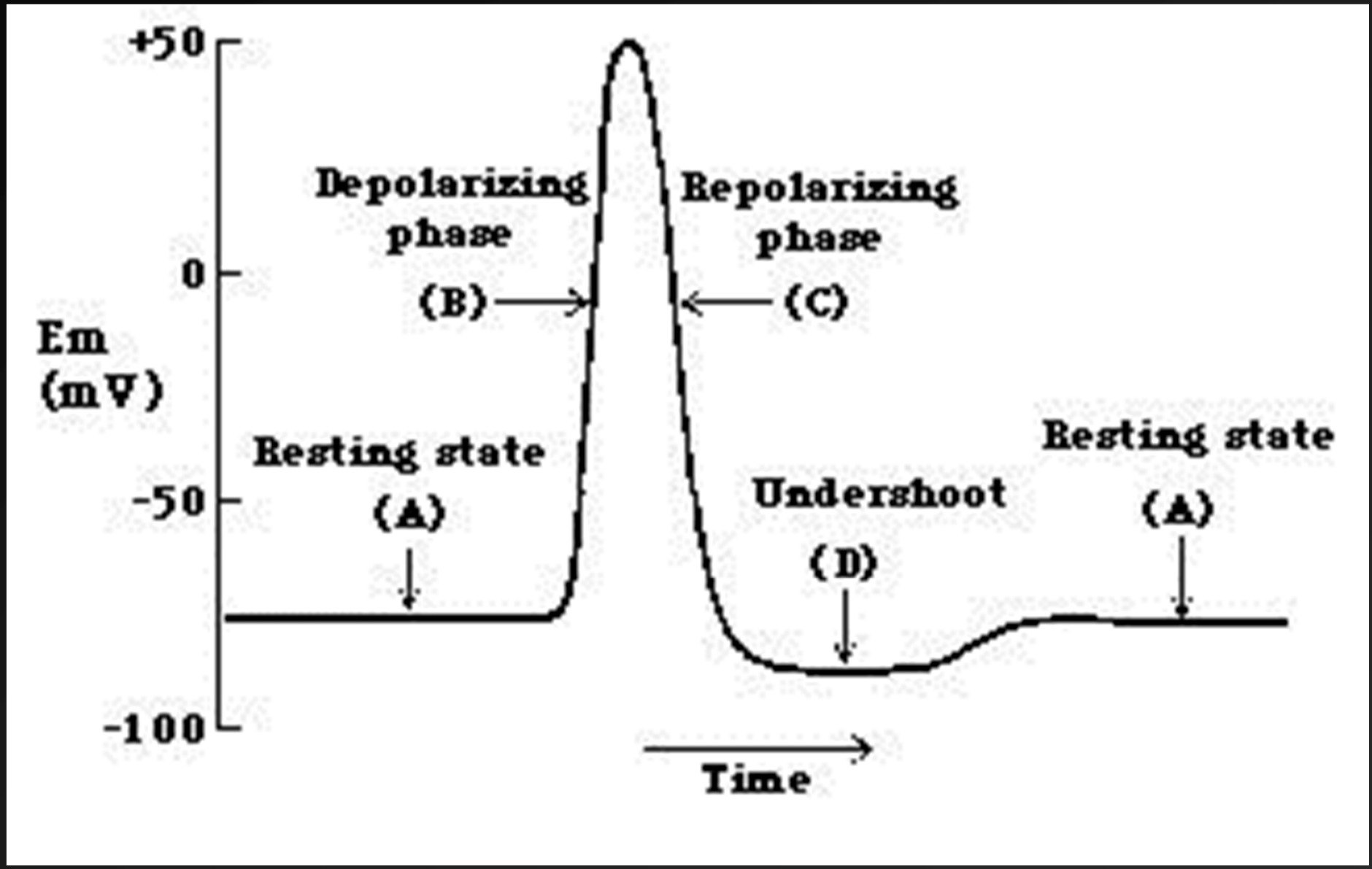
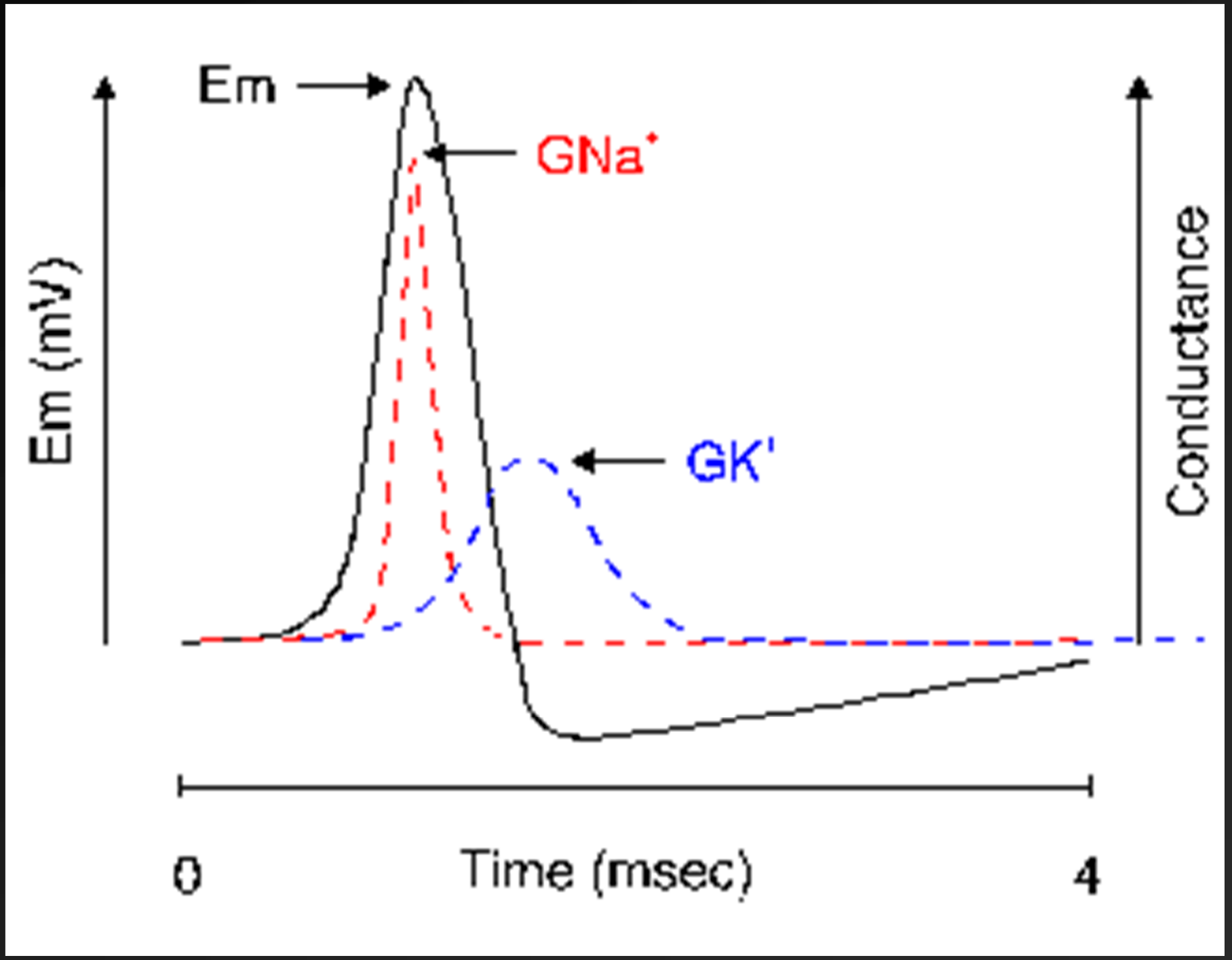


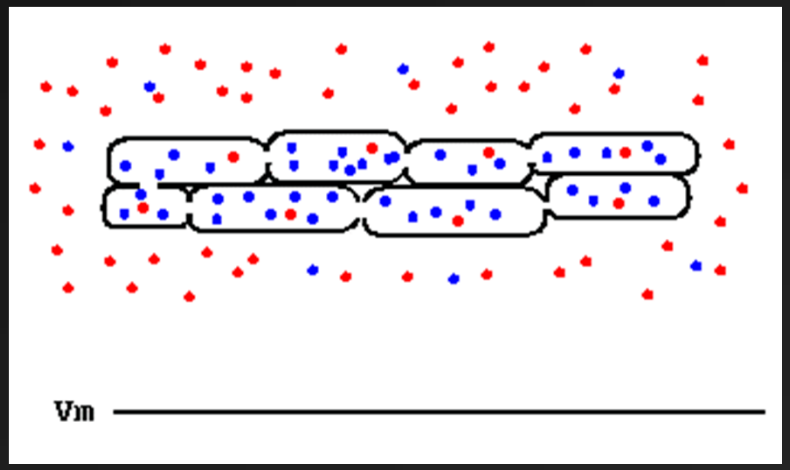
Fig. 2-3. Intra- and extracellular distribution of the ions. On both sides of the membrane, the different ions are indicated by *circles of different diameter*, proportional in each case to the diameter of the (hydrated) ion. A^- designates the large intracellular protein anions. The passages through the membrane, the "pores," are just large enough to permit the K^+ ions to diffuse through.



For interactive link: http://ssd1.bme.memphis.edu/icell/squid.htm

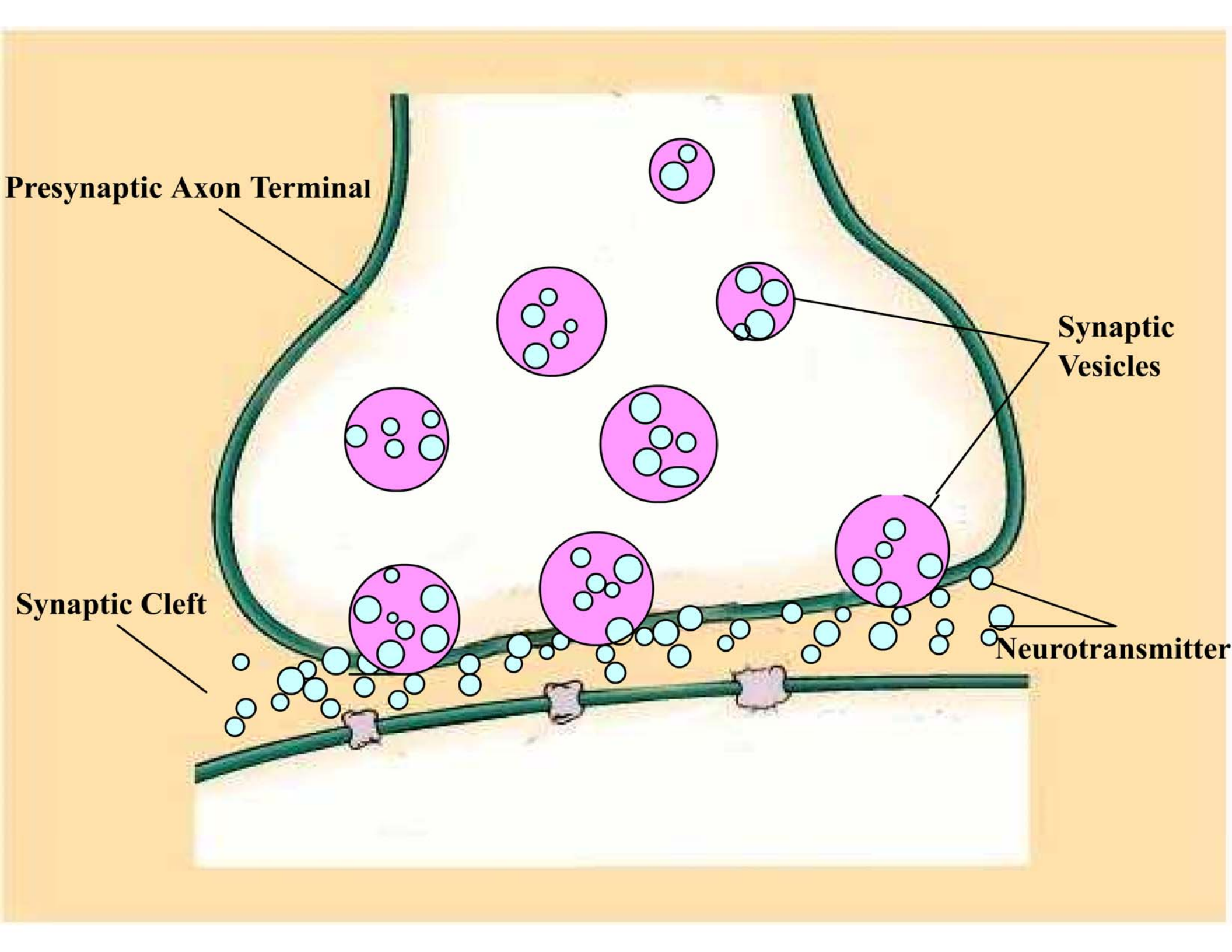

+50
0
-50
-100
Em
(mV)
Depolarizing
phase
(B)
Repolarizing
phase
(C)
Resting state
(A)
Undershoot
(D)
Resting state
(A)
Time


Em
GNa+
GK+
Em (mV)
Conductance
0
Time (msec)
4


Vm

Synaptic Transmission

- Not an all-or-none phenomenon
- Synaptic gap or cleft at the synaptic junction
- Single axon splits near end--**terminal arborization**
- As action potential arrives
  - Synaptic vesicles migrate to cell membrane fuse and release
  - Neurotransmitters diffuse across the synaptic cleft
  - combine with **post-synaptic receptors**
  - When neurotransmitter binds to a receptor on the post-synaptic cell, a slow electrical potential (**post-synaptic potential**) is generated:
  - 5 to 20 mV at peak amplitude
  - 20-150 msec in duration (50 to 6 Hz)


Presynaptic Axon Terminal
Synaptic Vesicles
Synaptic Cleft
Neurotransmitter

Synaptic Transmission

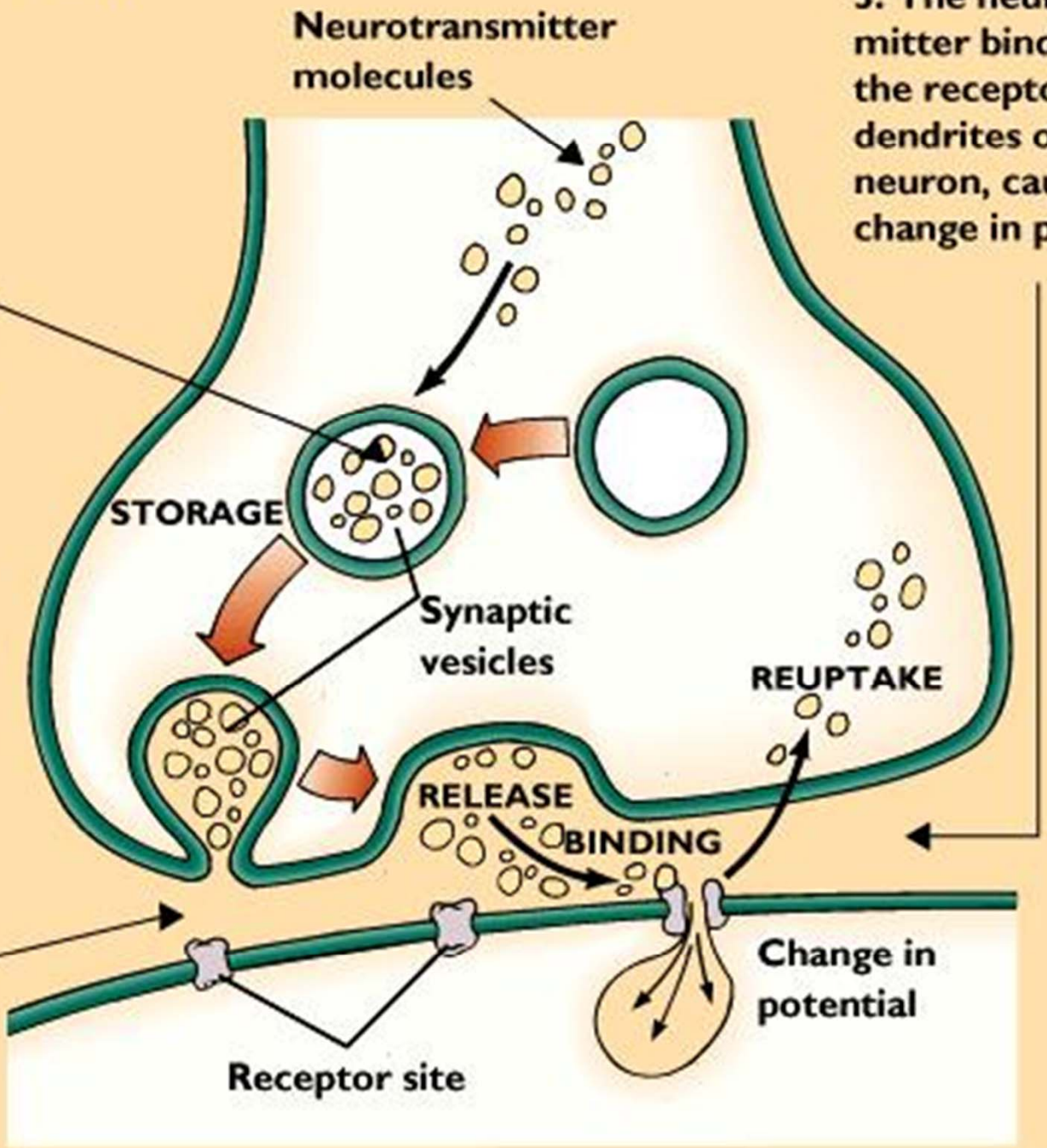
- Post-synaptic potentials (PSP's);
  - Excitatory
  - Inhibitory
  - Interaction
- **Summation/Integration**
  - **temporal**
  - **spatial**
  - **decremental conduction** on dendrites and soma
  - axon hillock is critical area at which threshold must be reached
- After release of neurotransmitter,
  - reuptake
  - degradation
- **Functional Synaptic Units**

Jump to Next

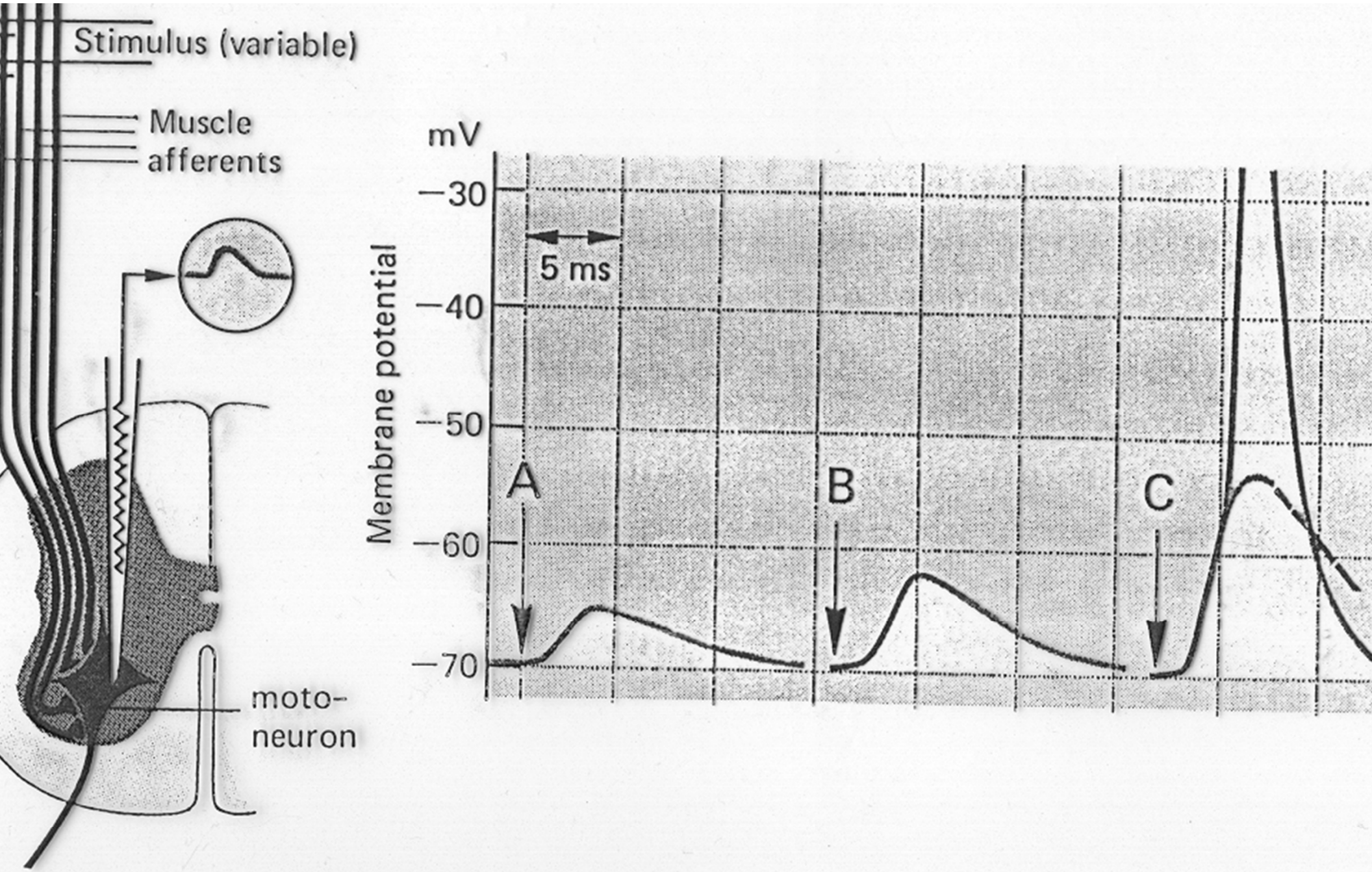
Synaptic Transmission

1. Within the axons of the neuron are neurotransmitters, which are held in storage-like vesicles until they are released when the neuron is stimulated.

2. The small space between the axon terminal and the dendrite of the next axon is called the synapse. An action potential stimulates the release of neurotransmitters across the synapse.



3. The neurotransmitter binds itself to the receptor sites on dendrites of the next neuron, causing a change in potential.



3-10. Excitatory postsynaptic potentials, recorded intracellularly from a moto
Afferents in the peripheral nerve from the associated muscle are stimulated el

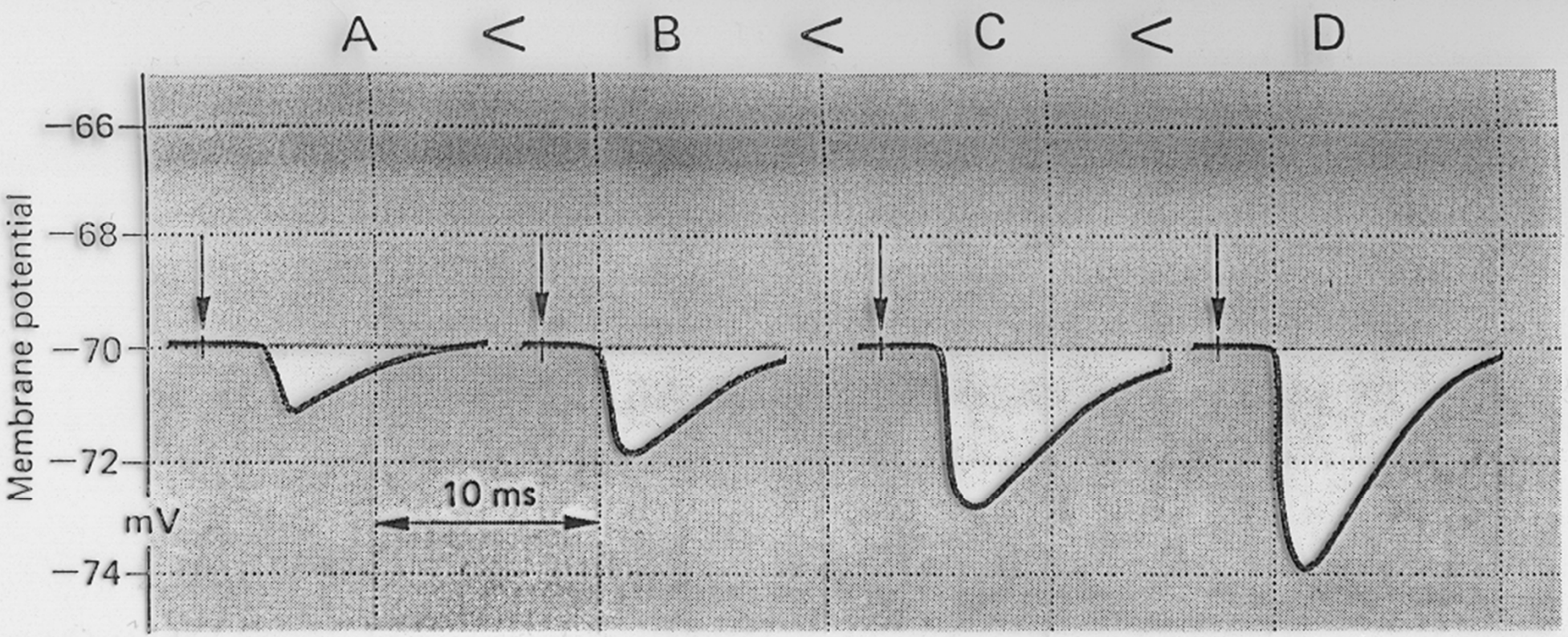


Fig. 3-11. Inhibitory postsynaptic potentials. Experimental arrangement as in Fig. 3-10, except that here an antagonist nerve is stimulated.

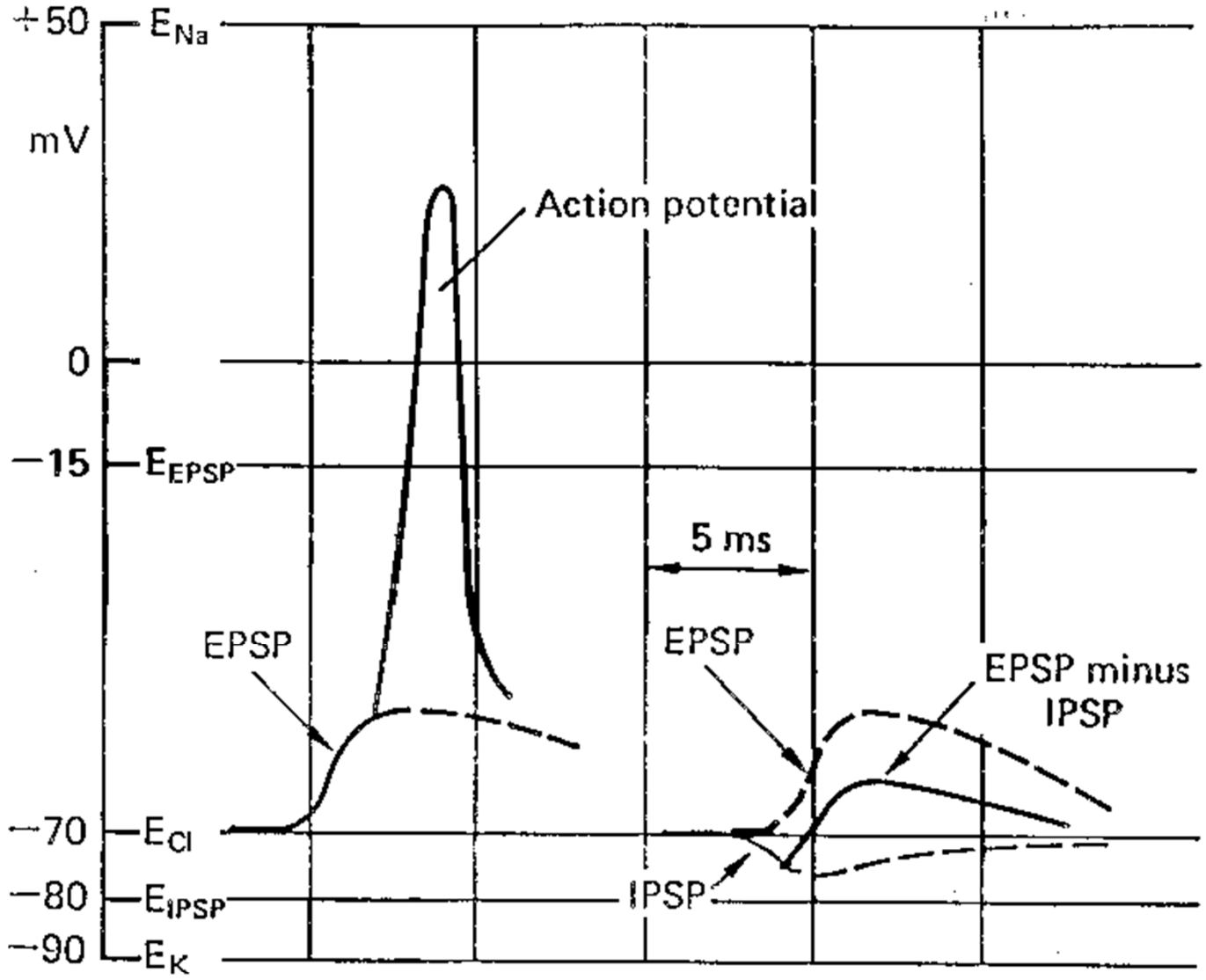
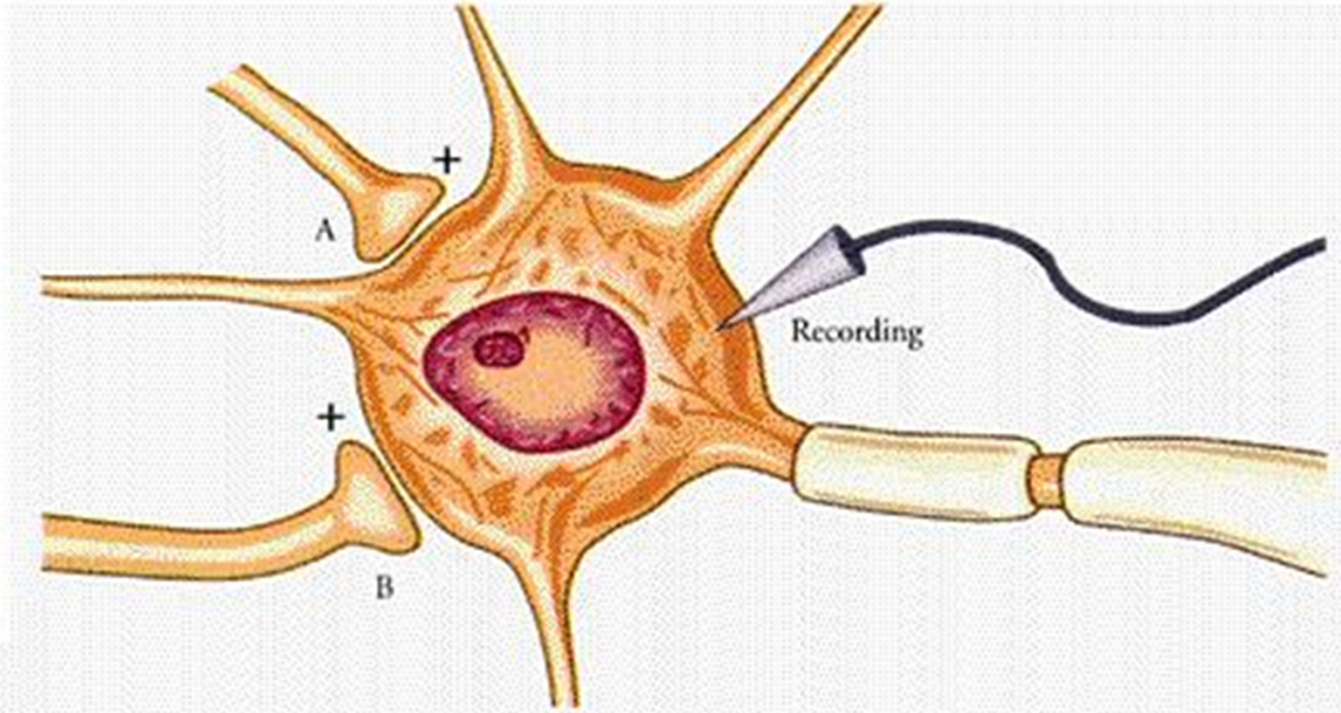
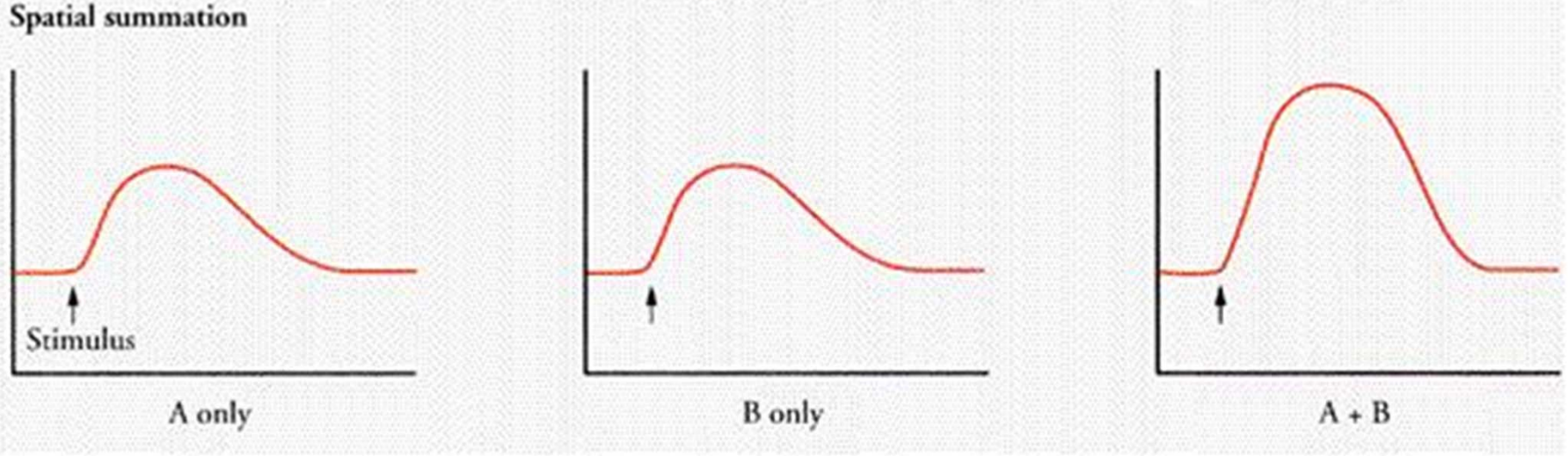


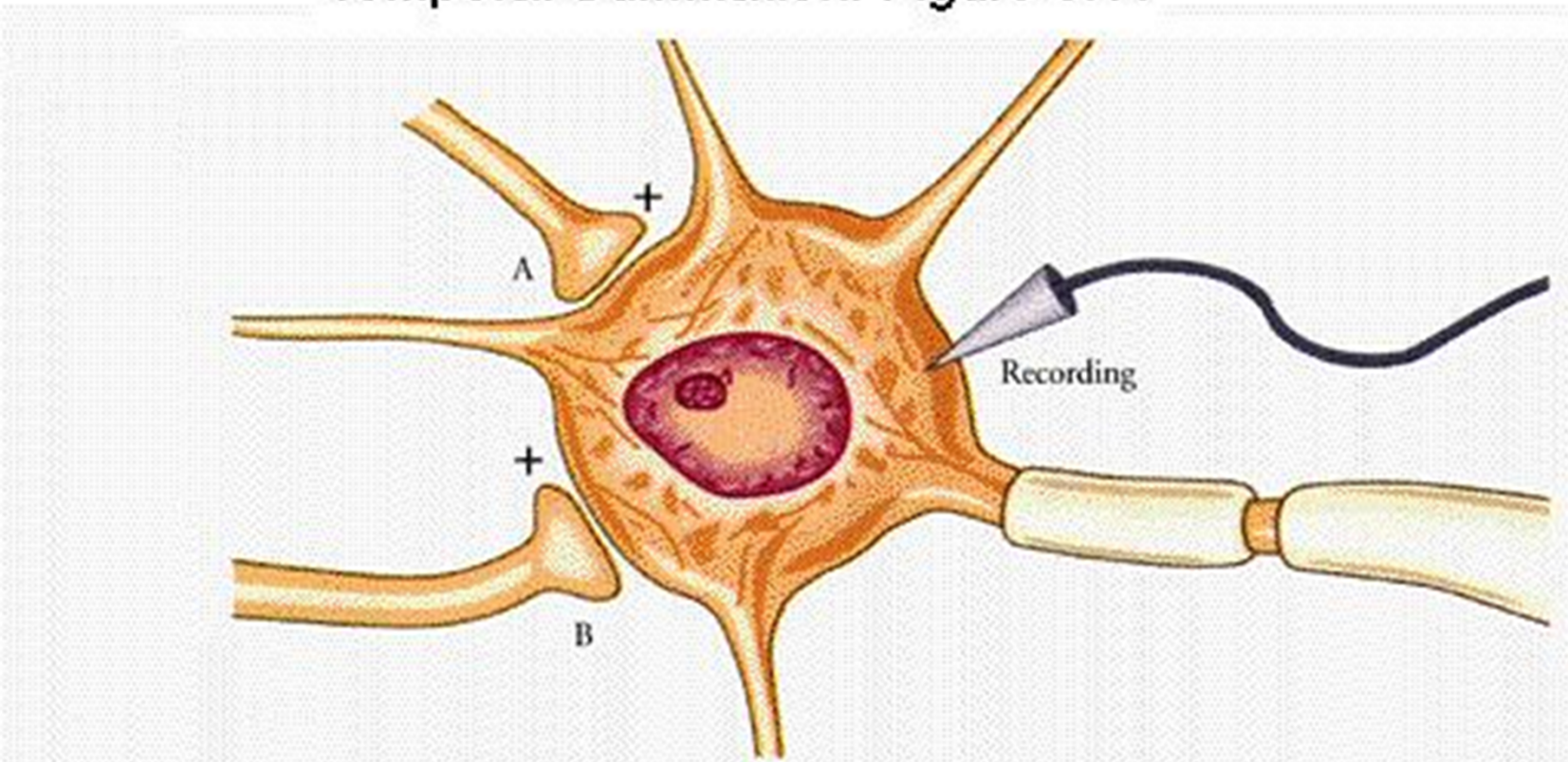
Fig. 3-14. The effect of an IPSP on the action potential; experimental arrangement as in Fig. 3-13. The homonymous nerve is stimulated strongly enough to produce a suprathreshold EPSP (*left*). On the *right*, the antagonist nerve is stimulated about 3 ms before the homonymous nerve. The equilibrium potentials of Na^+, K^+, Cl^-, EPSP, and IPSP are shown.

Spatial Summation. Figure 5.11

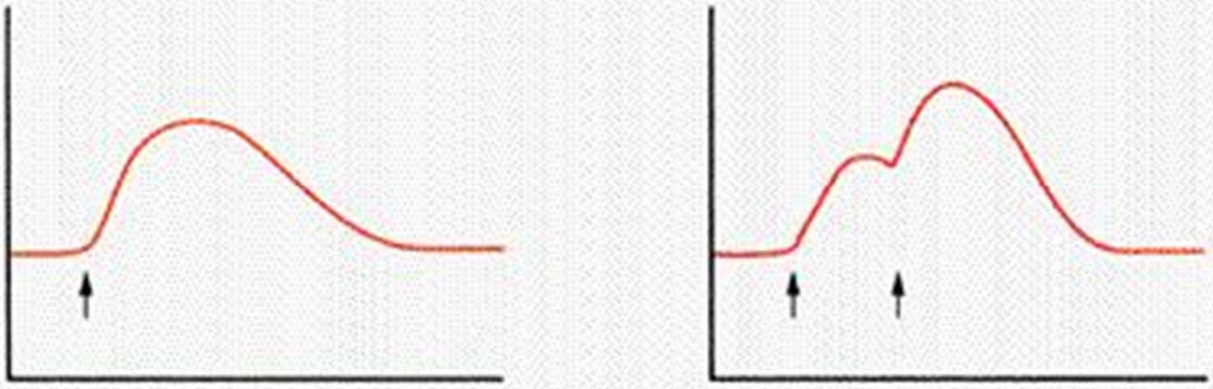




Temporal Summation. Figure 5.11



Temporal summation



A once

A twice

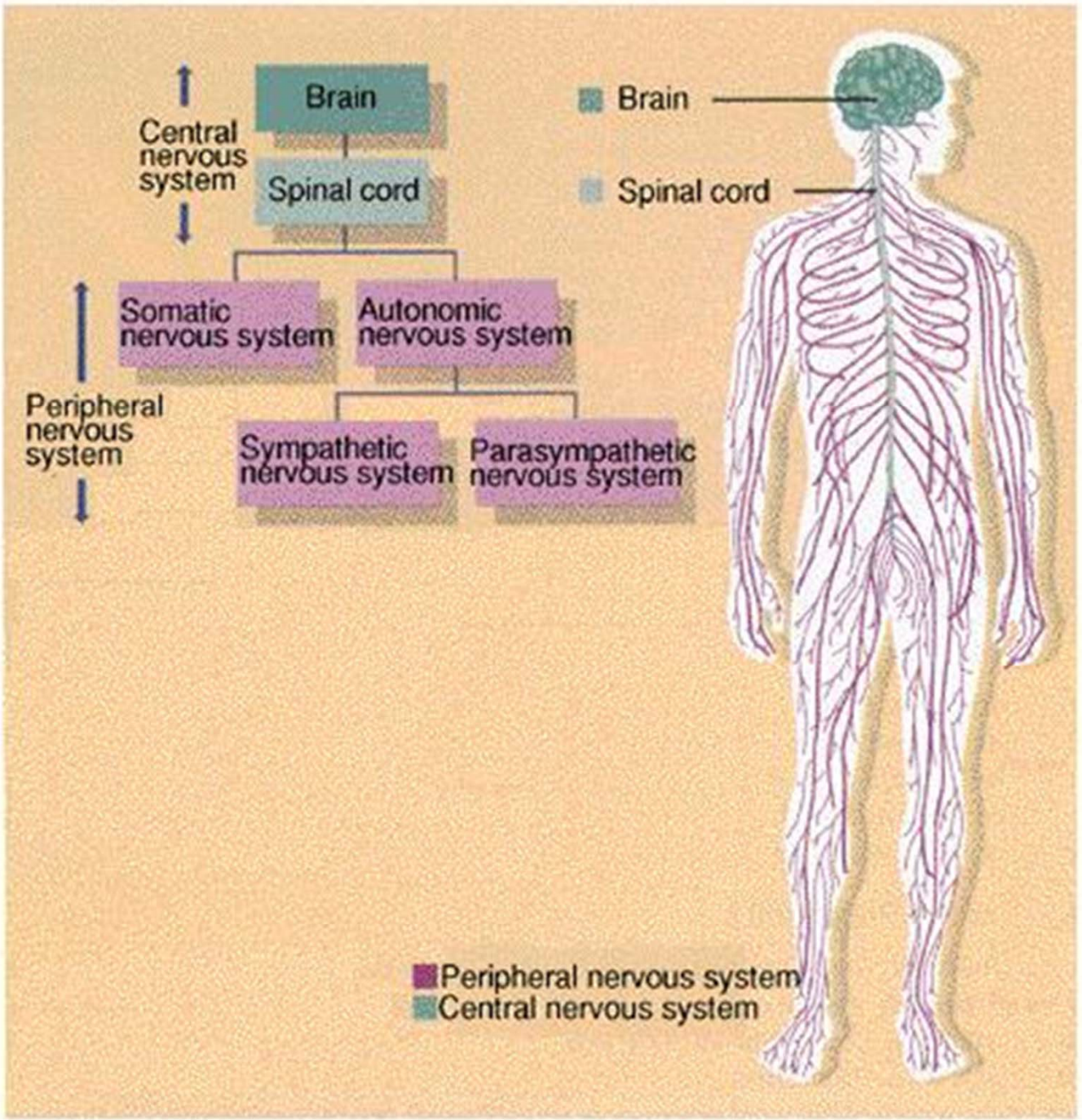
Part III: Basic Neuroanatomy

V. Organization of the nervous system

A. Central nervous system

1. Brain
2. Spinal cord

Human Nervous System



V. Organization of the nervous system

B. Peripheral nervous system

1. Somatic system
2. Autonomic system; two branches work in generally antagonistic fashion

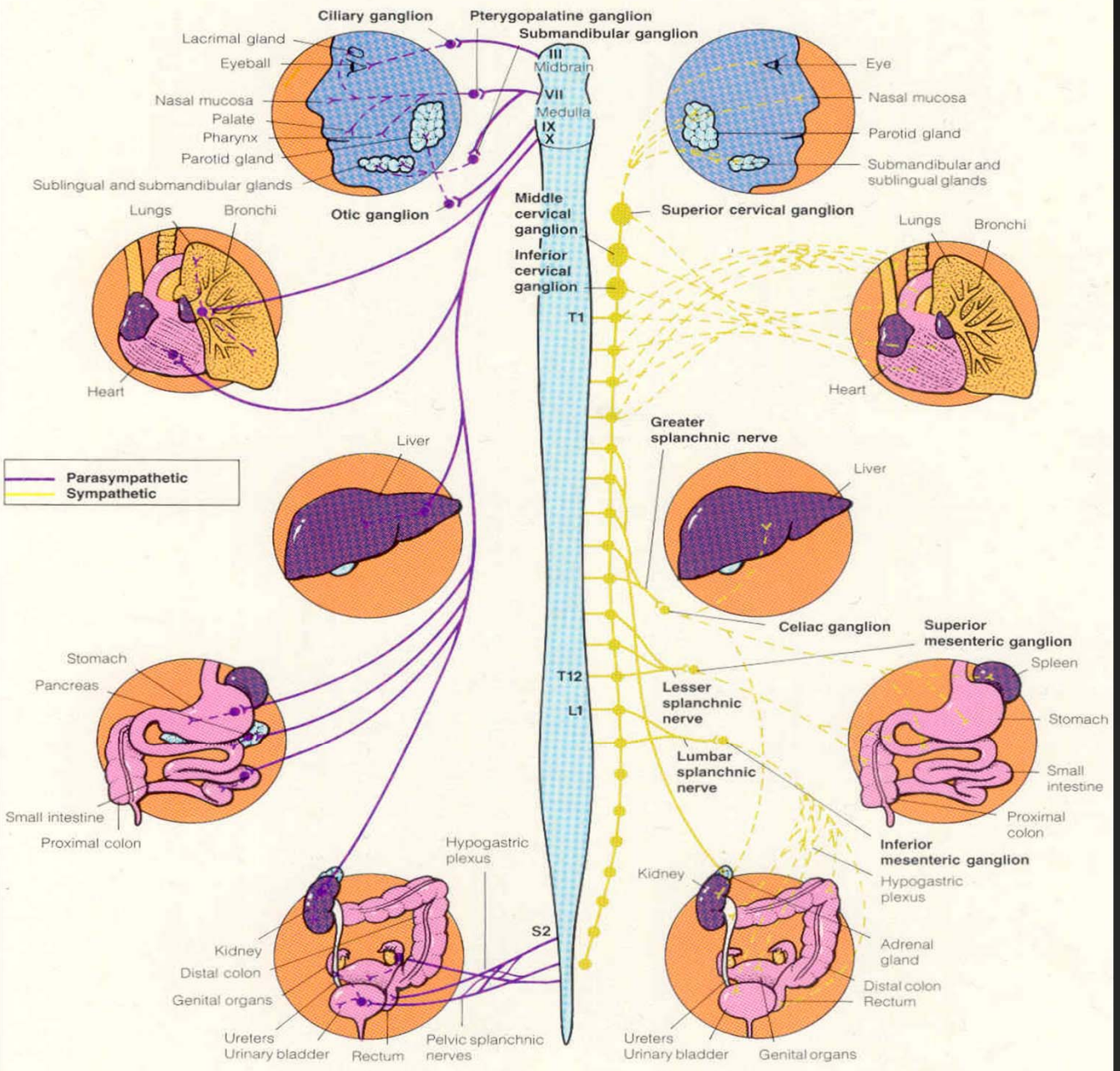
Somatic System

- Descending motor tracts within spinal cord synapse at approximate level of exit
- Post-synaptic neuron directly innervates target
- 2-neuron system

Autonomic System

- Descending motor tracts within spinal cord synapse not necessarily at level of exit
- After exit, synapse again before innervating target
- 3-neuron system

Autonomic Nervous System



Transparency No. 8

V. Organization of the nervous system

B. Peripheral nervous system

2. Autonomic system

a. Sympathetic nervous system

1. tends to have system-wide effects
2. flight or flight; activity

b. Parasympathetic nervous system

1. tends to affect one organ at a time
2. quiescent processes--digestion, protects and conserves energy

Sympathetic	*Parasympathetic*
• Prepares body for action • Catabolic processes that require energy expenditure	• Restores and maintains body resources • Anabolic processes that increase the body's supply of stored energy

Sympathetic

Pharmacologically,

• All synapses within the sympathetic ganglia are acetylcholinergic

• Terminal buttons on target organs are noradrenergic (except sweat glands: acetylcholinergic)

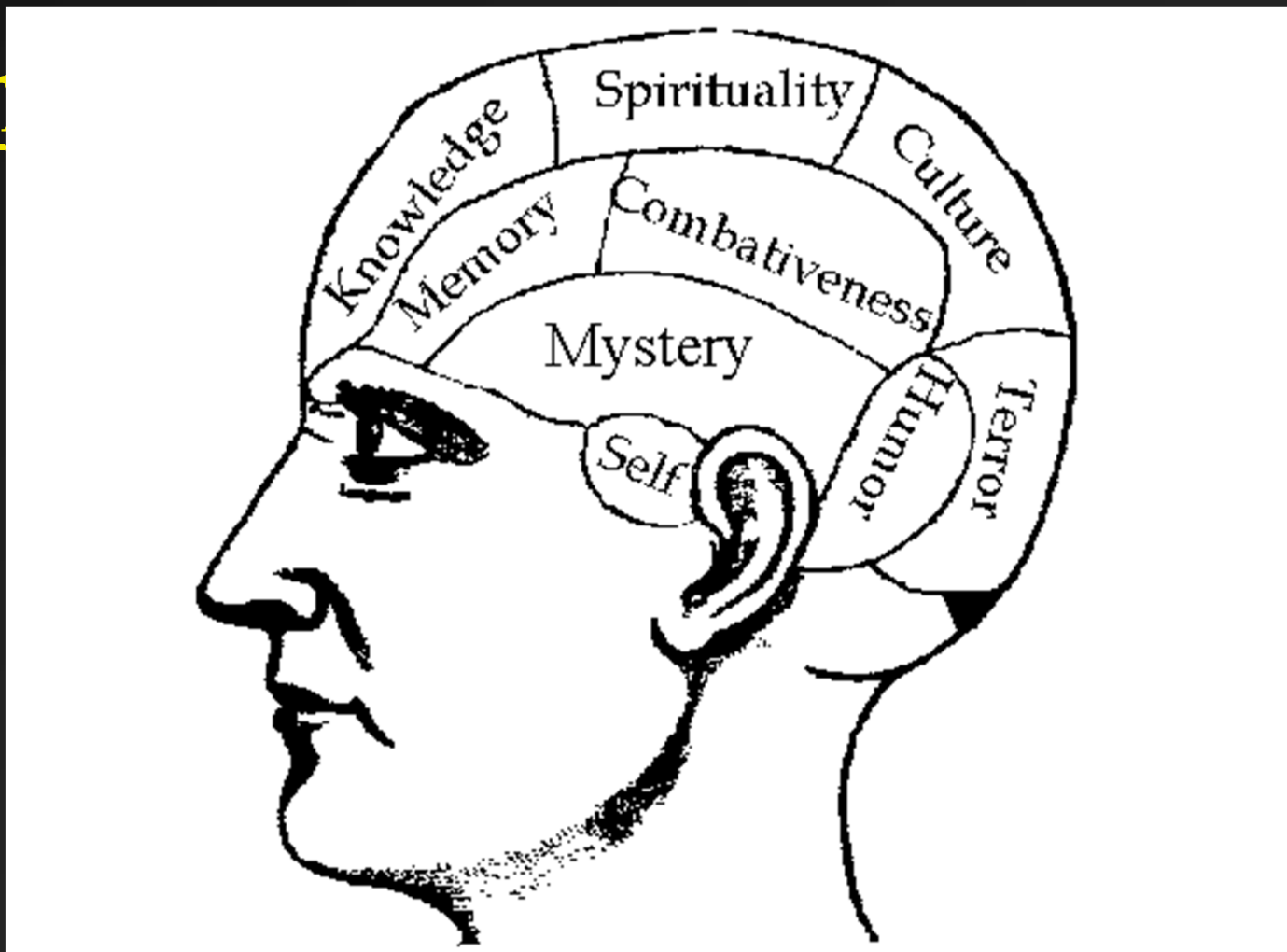
Parasympathetic

Pharmacologically,

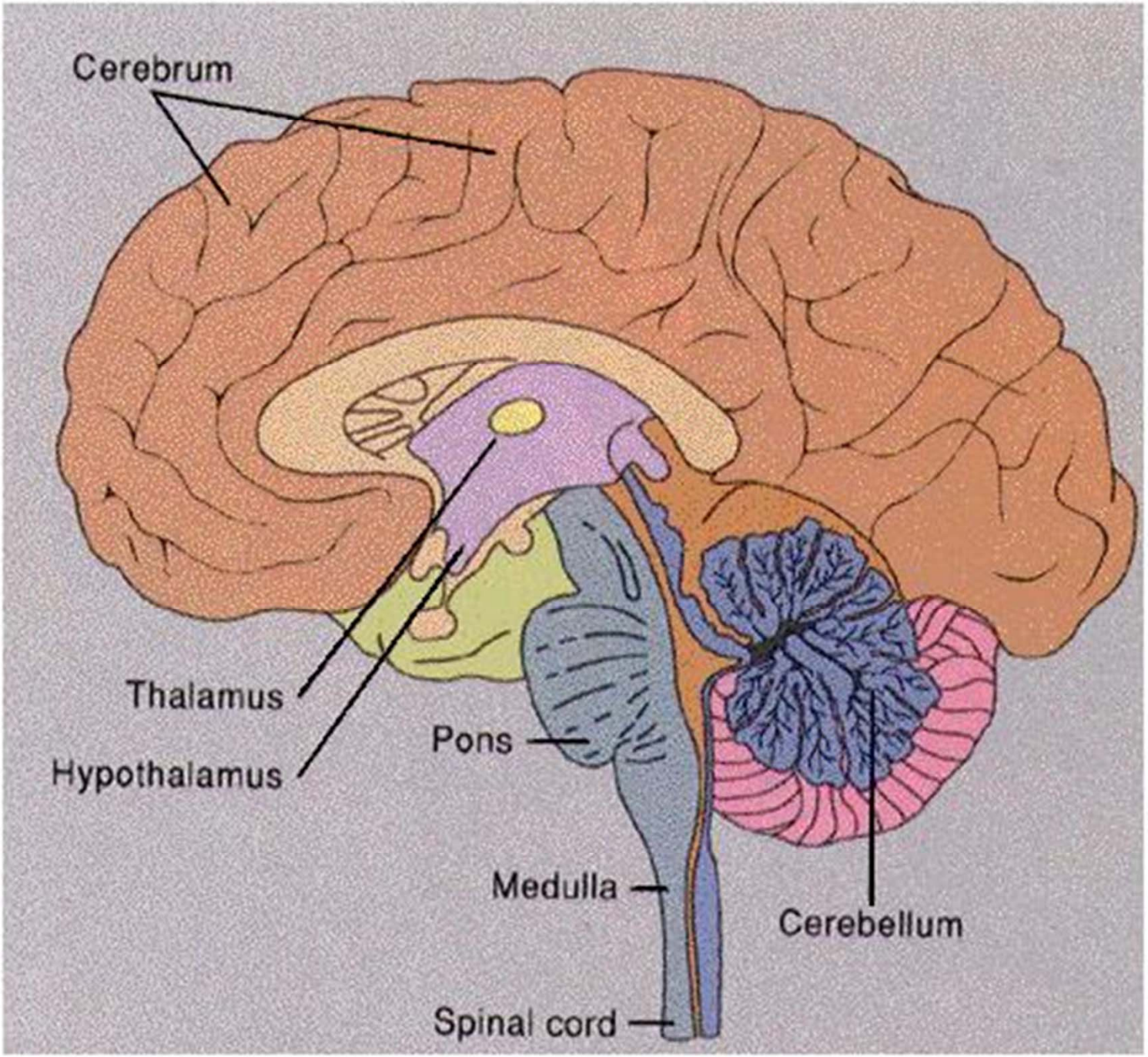
• All synapses acetylcholinergic: both pre- and post-ganglionic neurons

VI. The common household brain

- Commentary
- More com



Brain's Main Structures



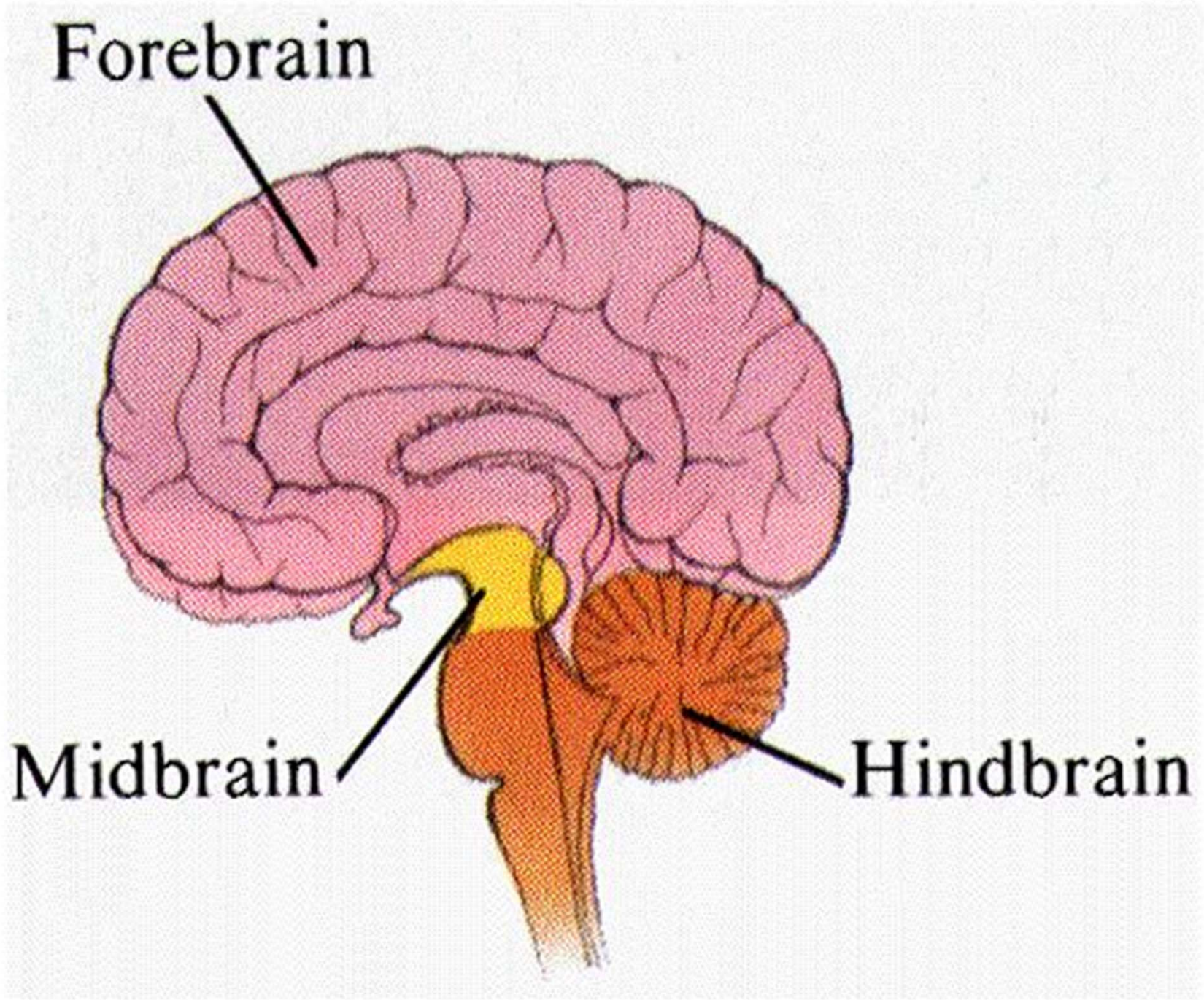
VI. The common household brain

A. Overview of brain

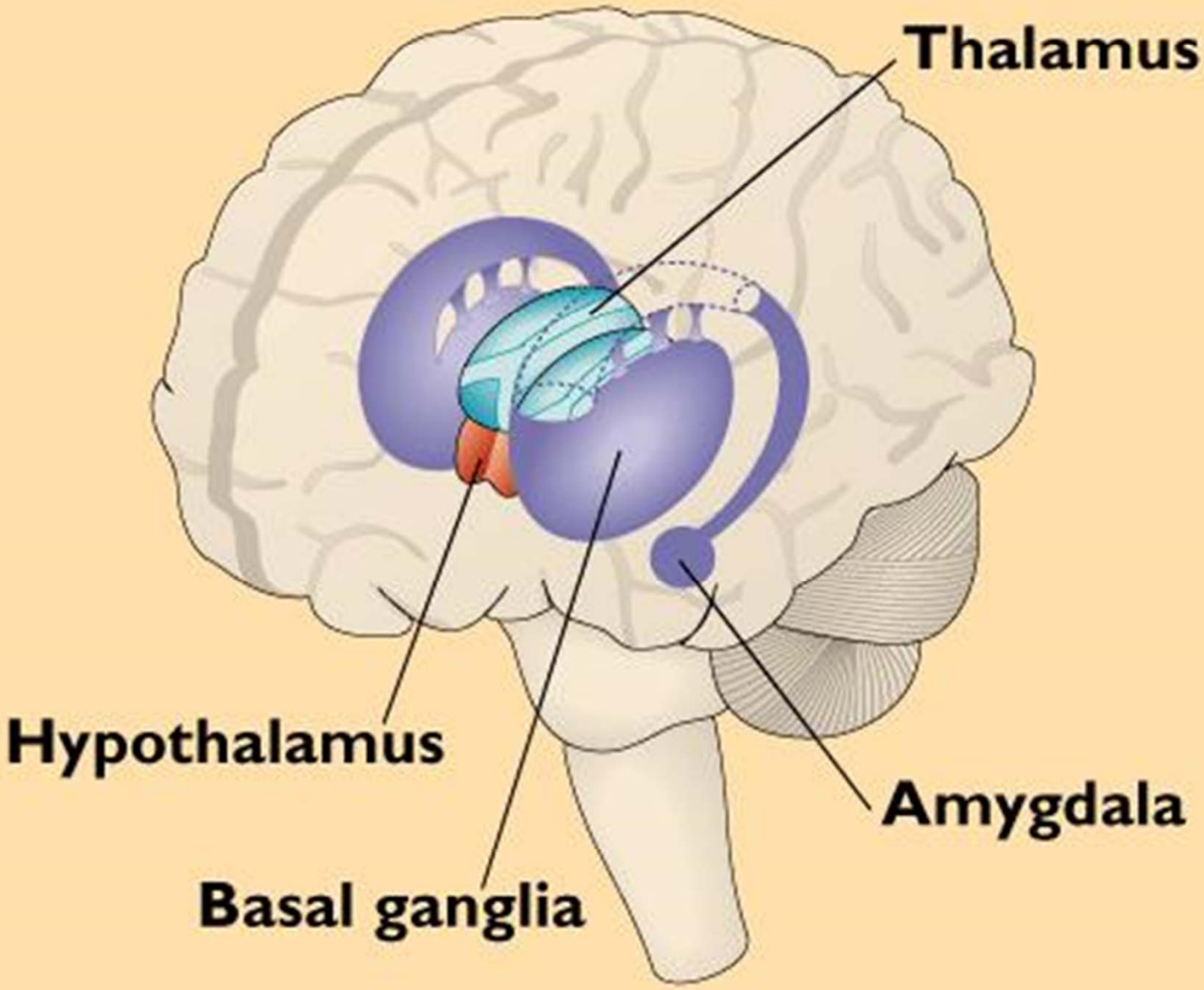
1. The primitive central core
2. Limbic system, or the "Inner Lizard"
3. Cerebrum (AKA cerebral hemispheres)
   a. Ontogeny
   b. Phylogeny
   c. Ontogeny recapitulates phylogeny
4. These three layers are interconnected extensively; do not function independently

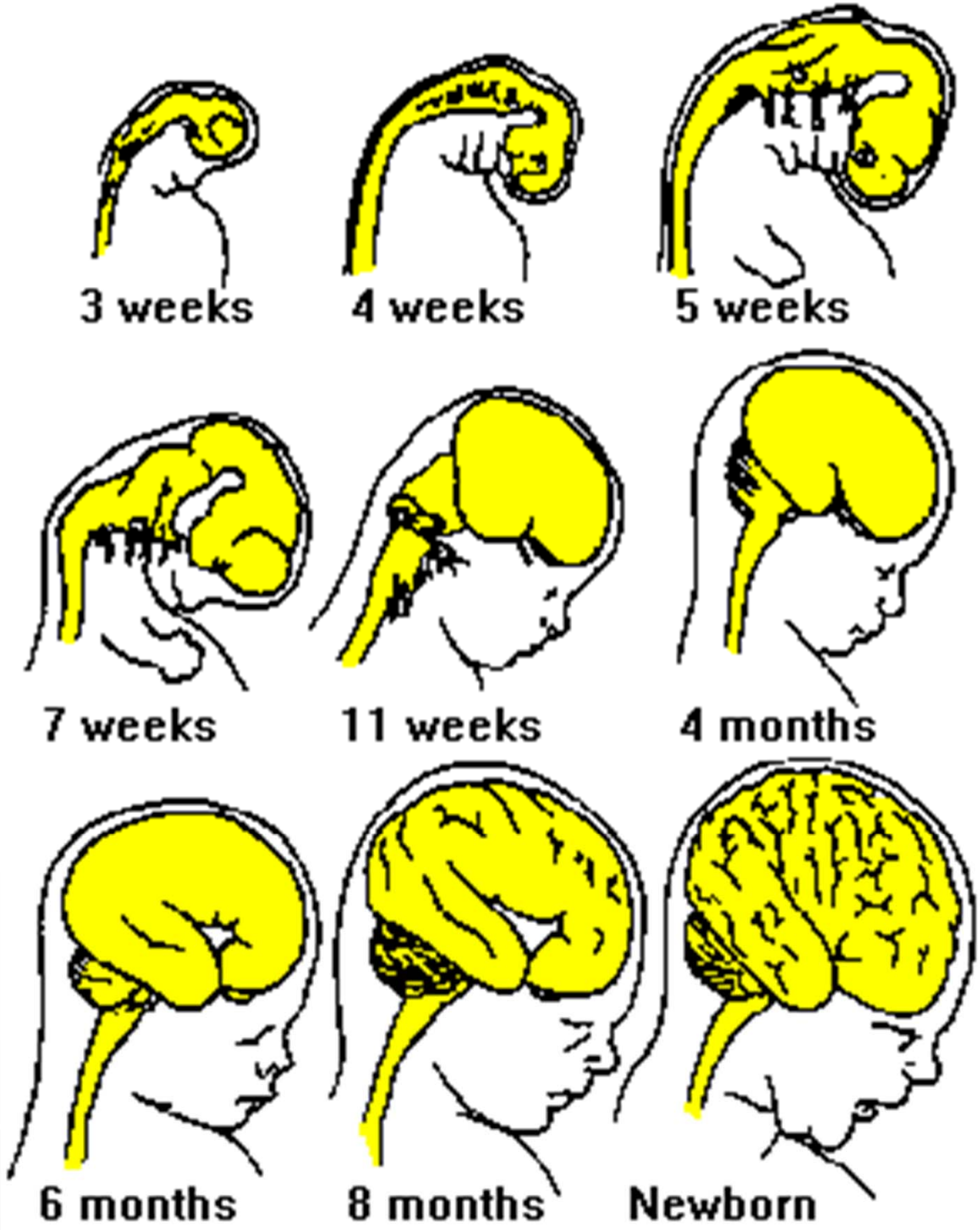
Next

The Human Brain: Major Areas

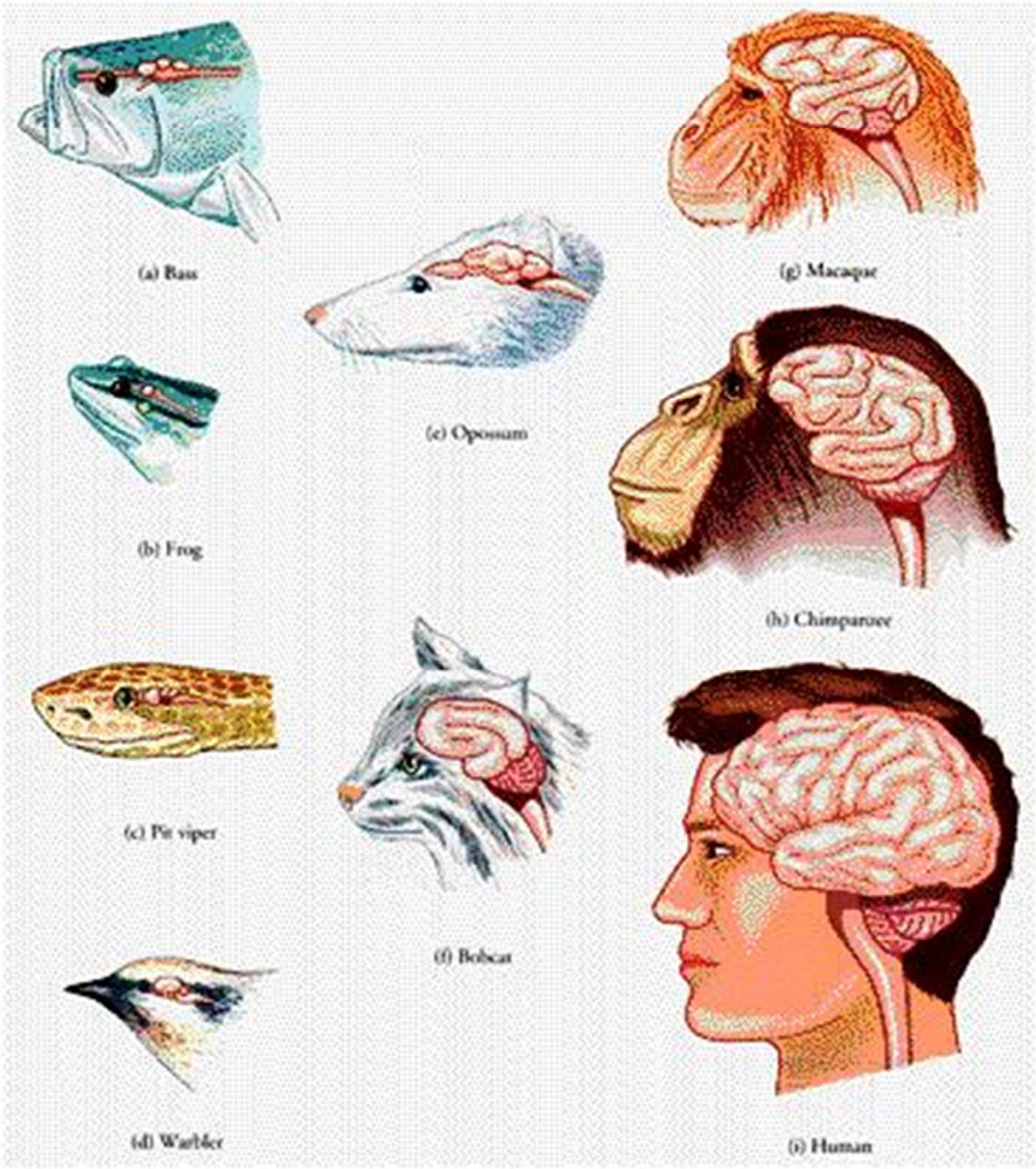


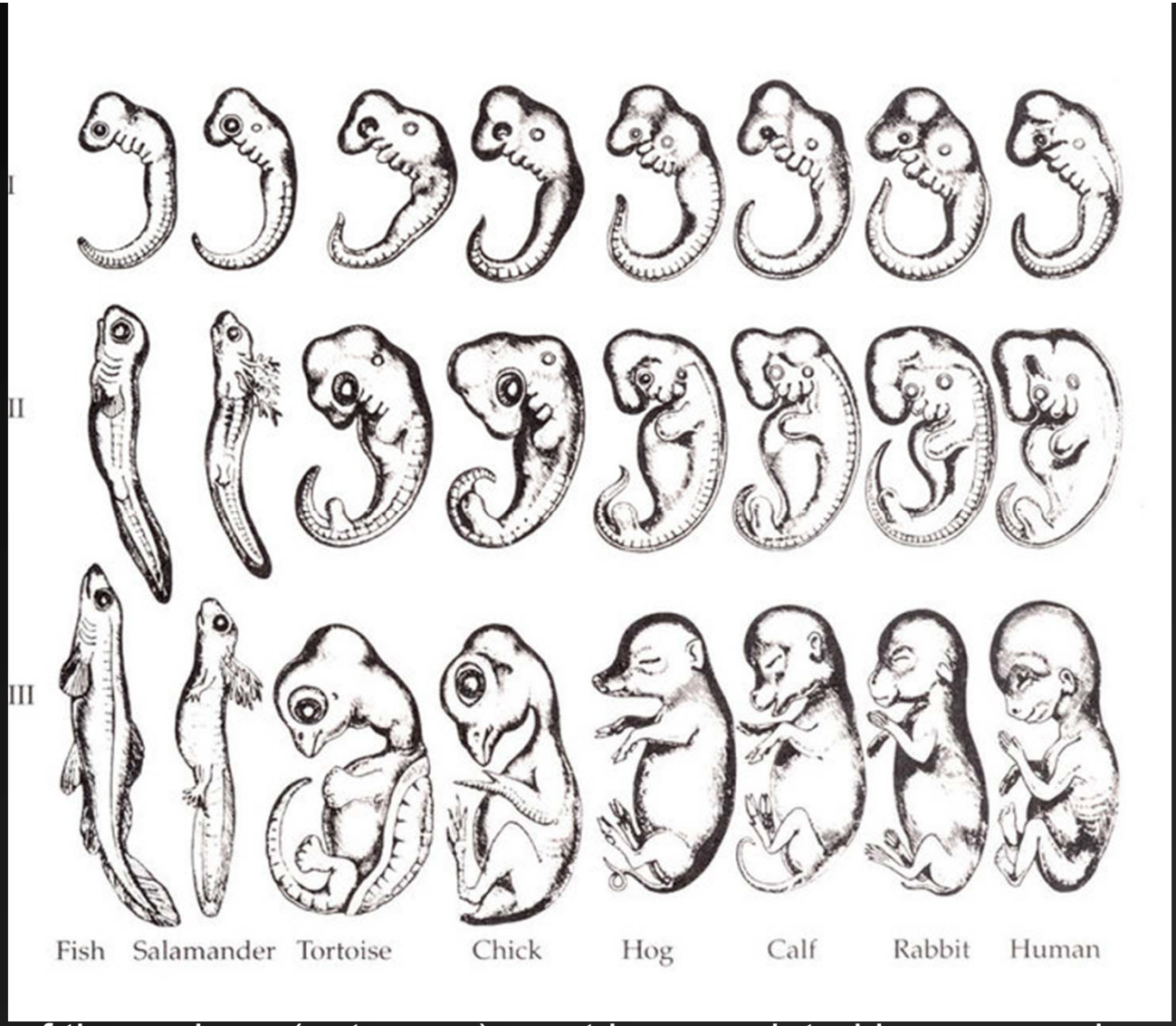
Principal Structures of the Limbic System




3 weeks
4 weeks
5 weeks
7 weeks
11 weeks
4 months
6 months
8 months
Newborn

The Evolution of the Cerebrum*





"… this history of the embryo (ontogeny) must be completed by a second, equally valuable, and closely connected branch of thought - the history of race (phylogeny). Both of these branches of evolutionary science, are, in my opinion, in the closest causal connection; this arises from the reciprocal action of the laws of heredity and adaptation... 'ontogenesis is a brief and rapid recapitulation of phylogenesis, determined by the physiological functions of heredity (generation) and adaptation (maintenance).'"

Haeckel, E. 1899. *Riddle of the Universe at the Close of the Nineteenth Century.*

Directions please!

- lateral--side; medial--middle
- anterior--front; posterior/dorsal--back
- rostral--towards the nose; caudal--towards the tail
- ipsilateral--same; contralateral--opposite
- proximal--toward the soma; distal--away from the soma
- efferent--output/motor; afferent--receiving/sensory

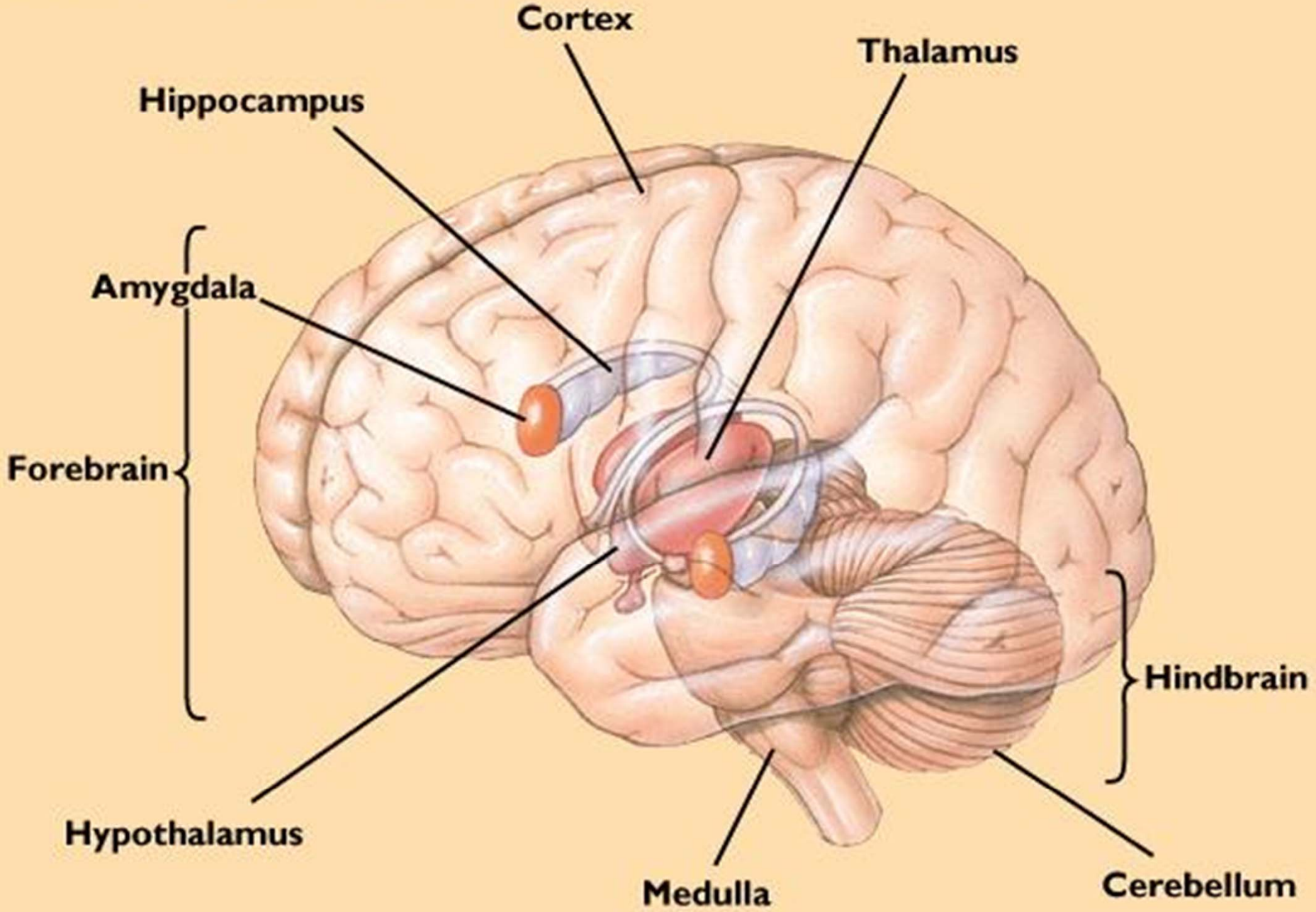
B. Brain Specifics

1. Primitive central core
    a. Cerebellum
        1. "little brain" located to rear of brain stem
        2. involved in smooth coordination of movements
        3. learning of complex motor activities (e.g., piano, skiing)

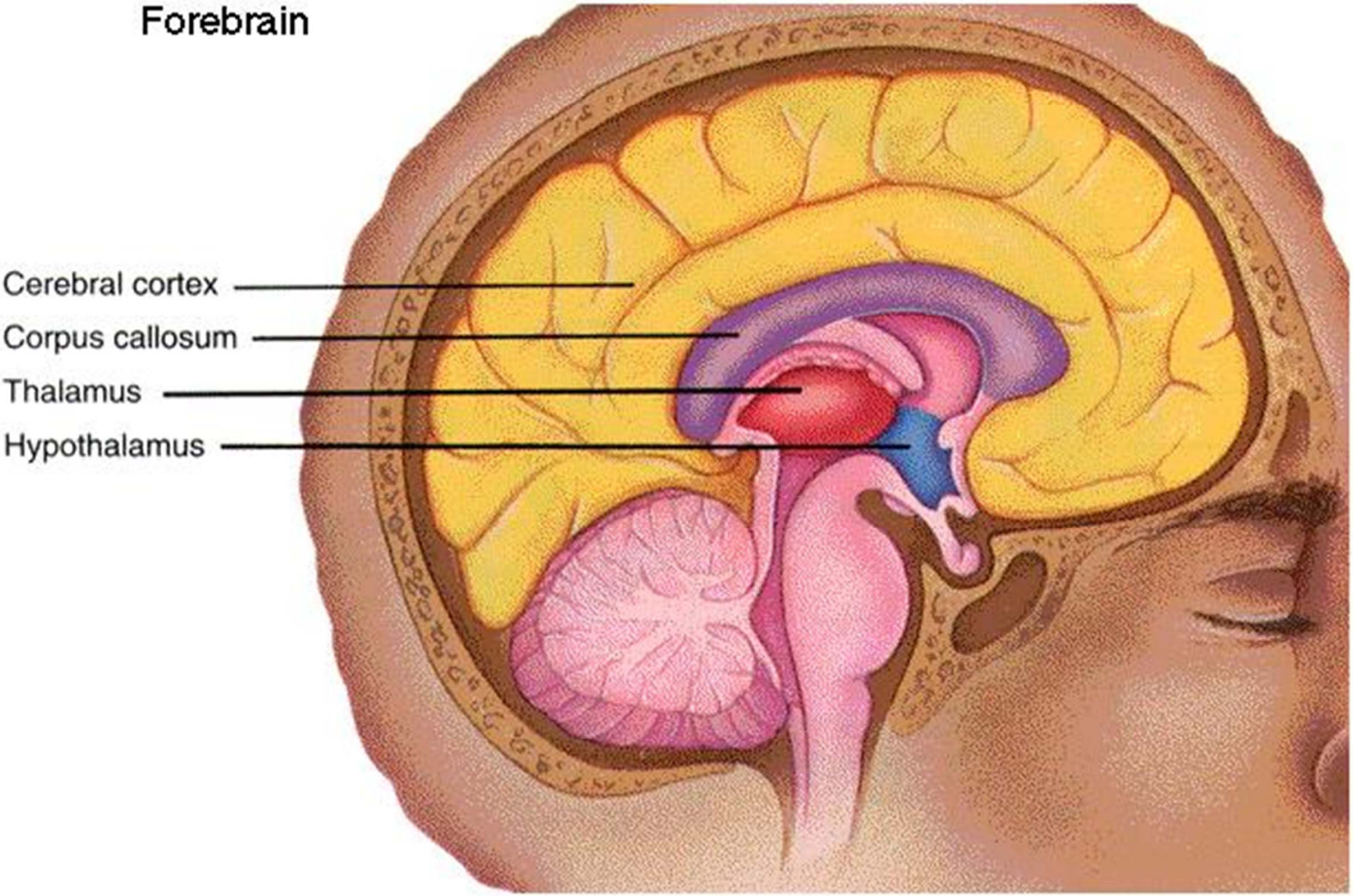
B. Brain Specifics

1. Primitive central core
   b. Thalamus & Hypothalamus: located just above the brain stem & tucked inside the cerebral hemispheres
      1. Thalamus is a relay station for sensory information
         a. "Gateway to the cortex"
         b. coming from spinal cord to cortex
         c. taste touch hearing vision -- olfaction is exception
      2. Hypothalamus
         a. literally = "under thalamus" ; much smaller, but very important
         b. 4 F's:

Structures of the Brain



Forebrain



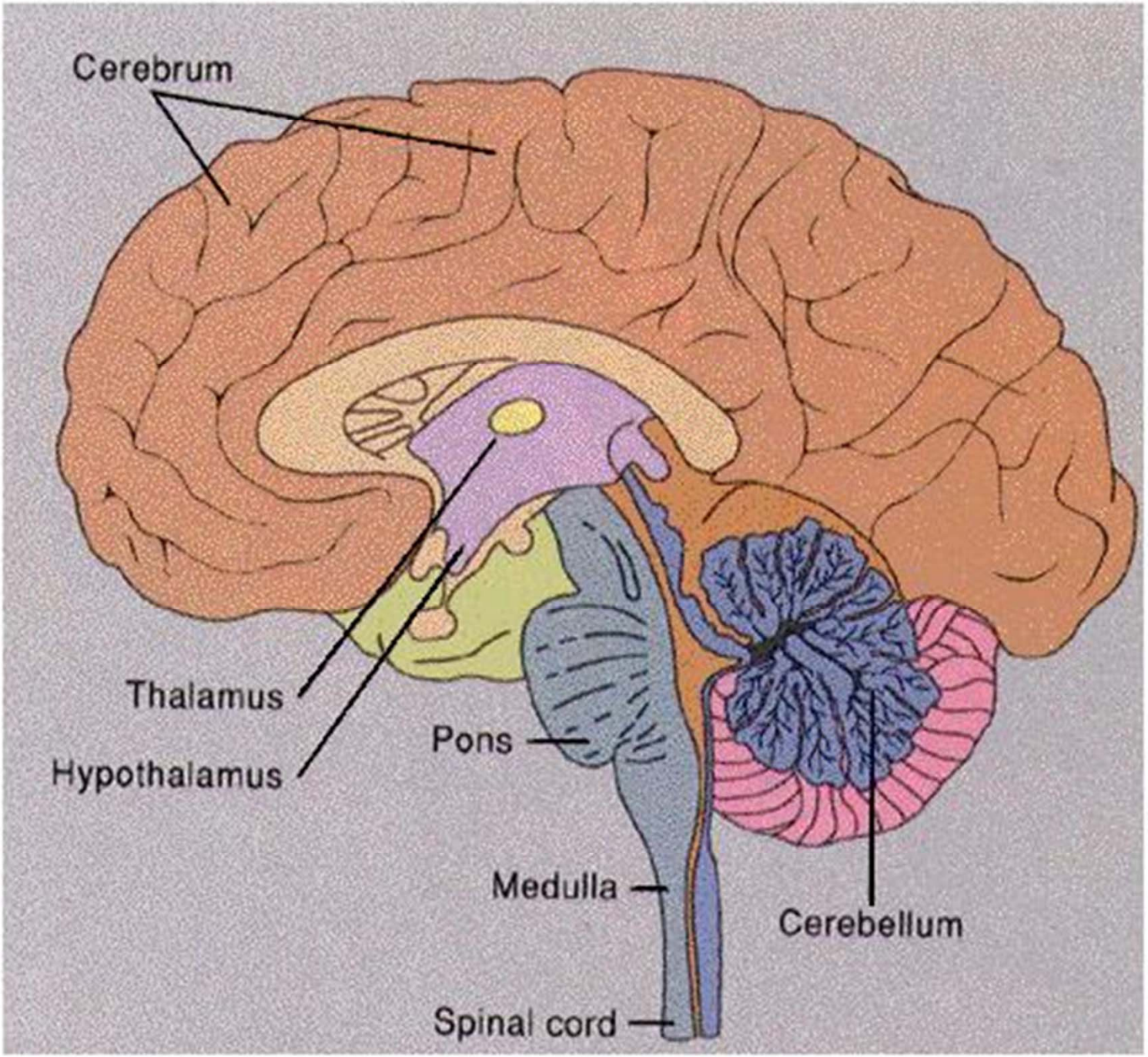
B. Brain Specifics

1. Primitive central core
    c. Reticular system
        a. diffuse from brainstem to thalamus
        b. 3 A's, arousal, awareness, attention

B. Brain Specifics

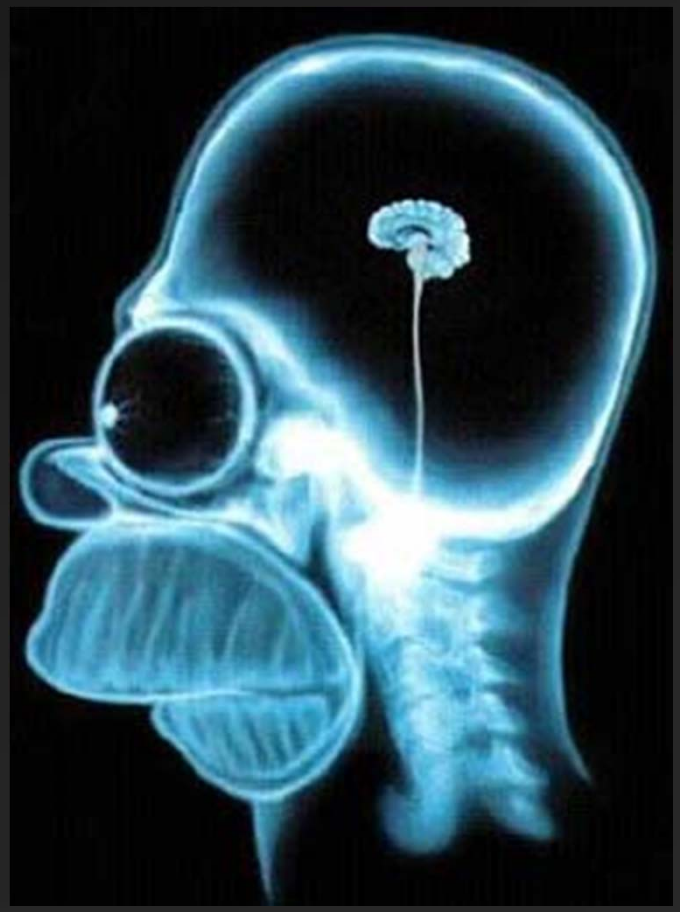
2. Limbic system
   a. a group of structures lying along the innermost edge of the cerebral hemispheres
   b. involved in instinctual behaviors in lower animals (caring for young, mating, fleeing from attackers, fleeing from prey)
   c. involved in memory and emotion in humans
   d. Especially important structures within the Limbic system:
      i.. Hippocampus
      ii. Amygdala

Brain's Main Structures

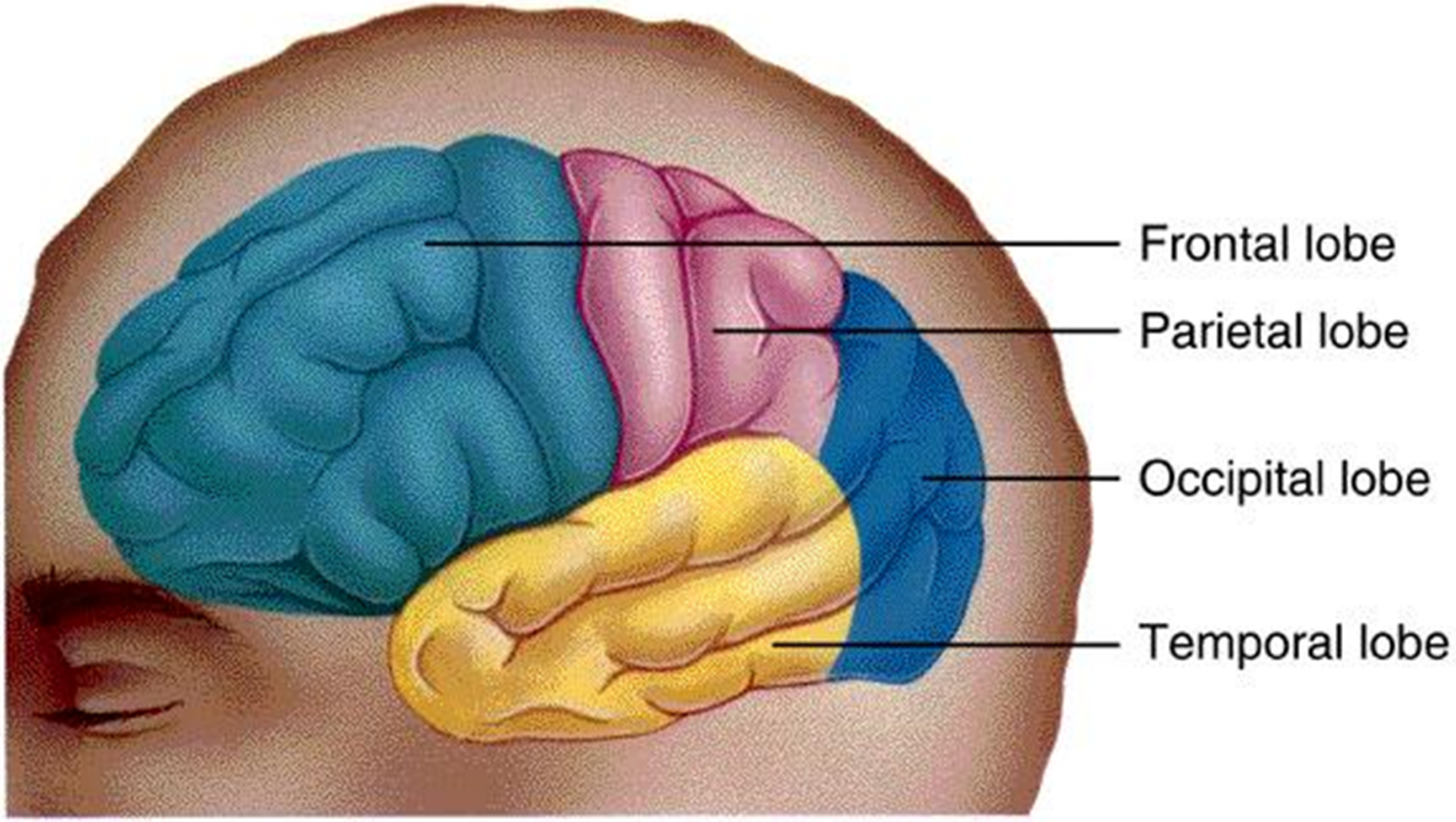


The common household brain

- 3. The cerebral hemispheres
  - a. Grey matter vs white matter

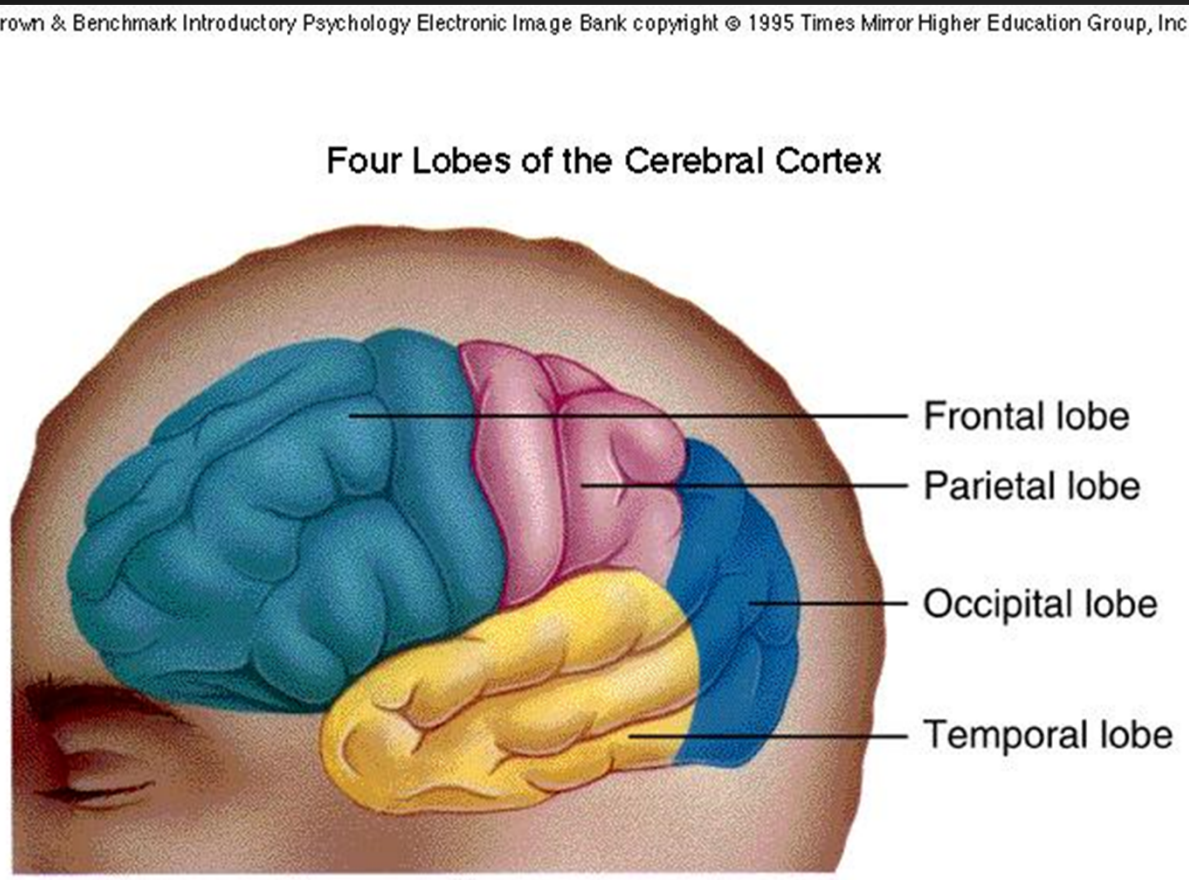


Four Lobes of the Cerebral Cortex



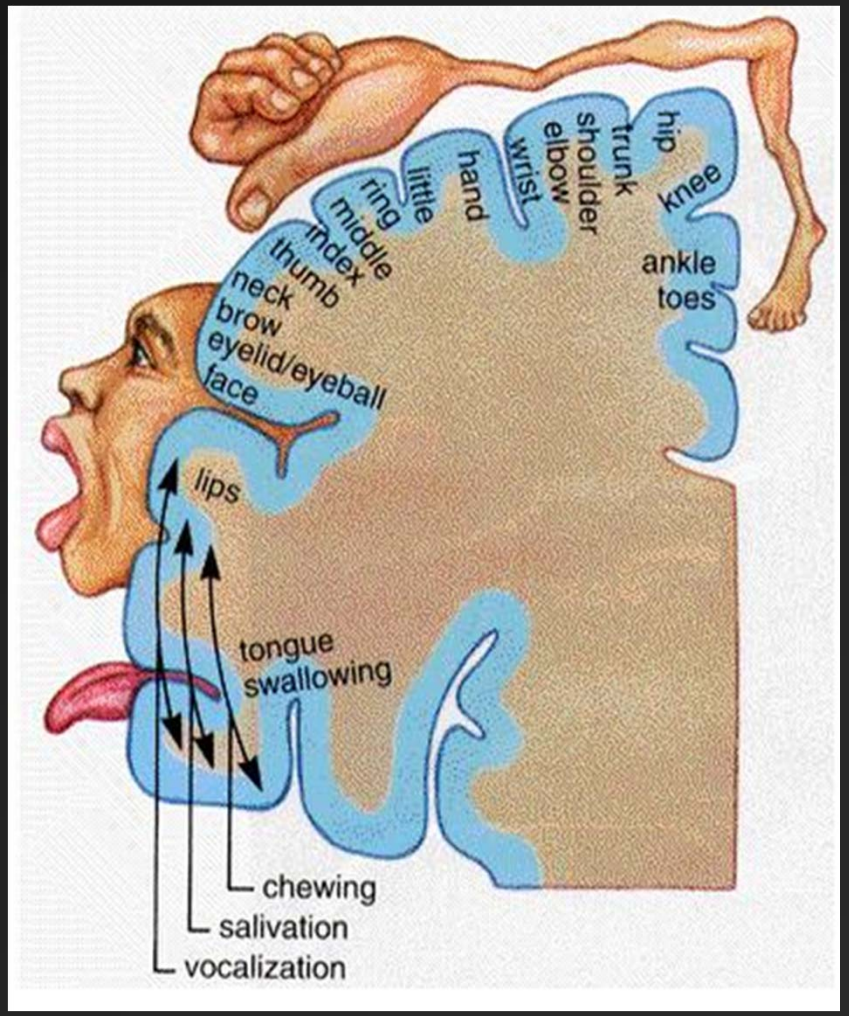
The common household brain

3. The cerebral hemispheres
    b. Four lobes:
        1. frontal
        2. parietal
        3. occipital
        4. temporal



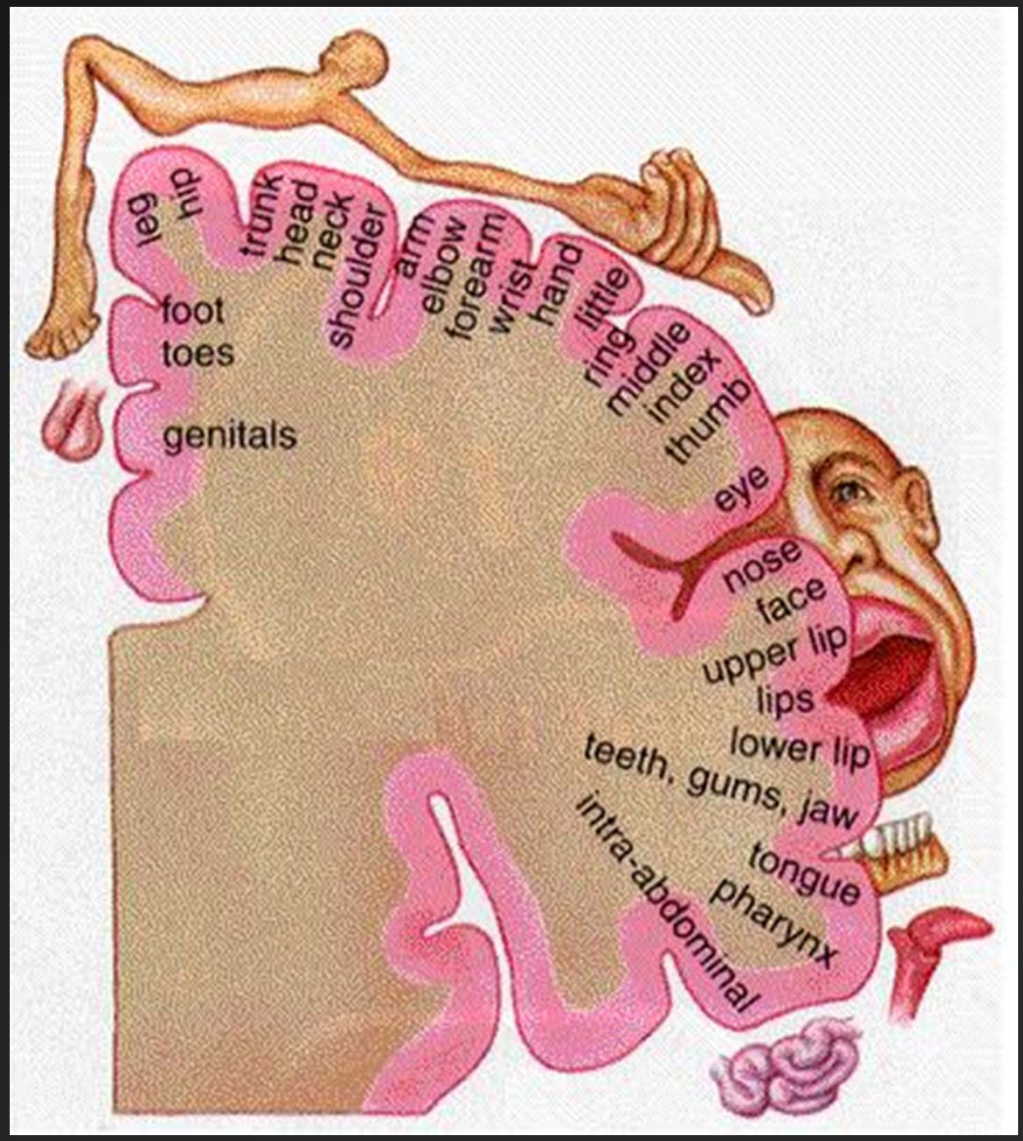
The common household brain

3. The cerebral hemispheres
   b. Motor area
      1. topographic organization-- Homunculus
      2. contralateral control of body



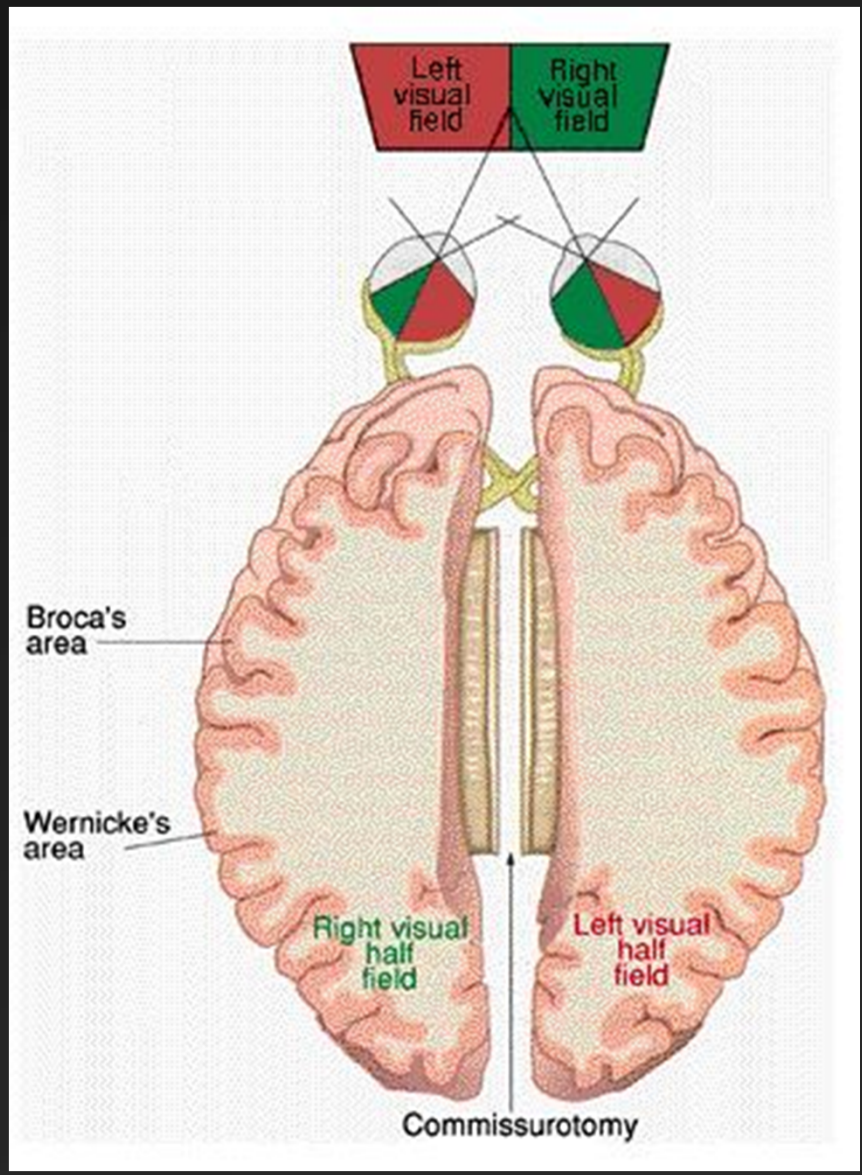
The common household brain

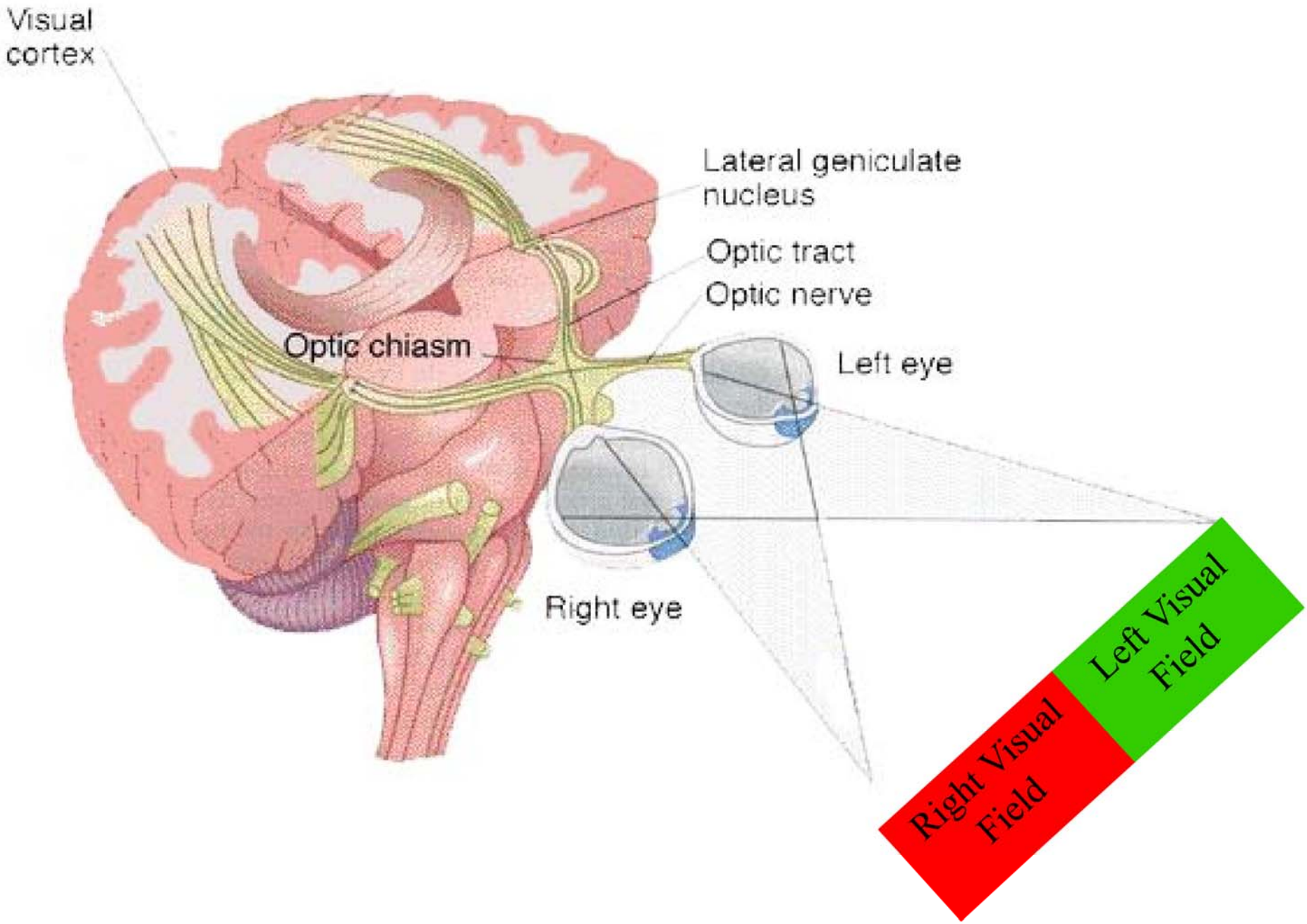
3. The cerebral hemispheres
   d. Somatosensory area
      1. heat, cold, touch, pain, sense of body movement
      2. contralateral
      3. space appropriated in accord to amount of use or need



The common household brain

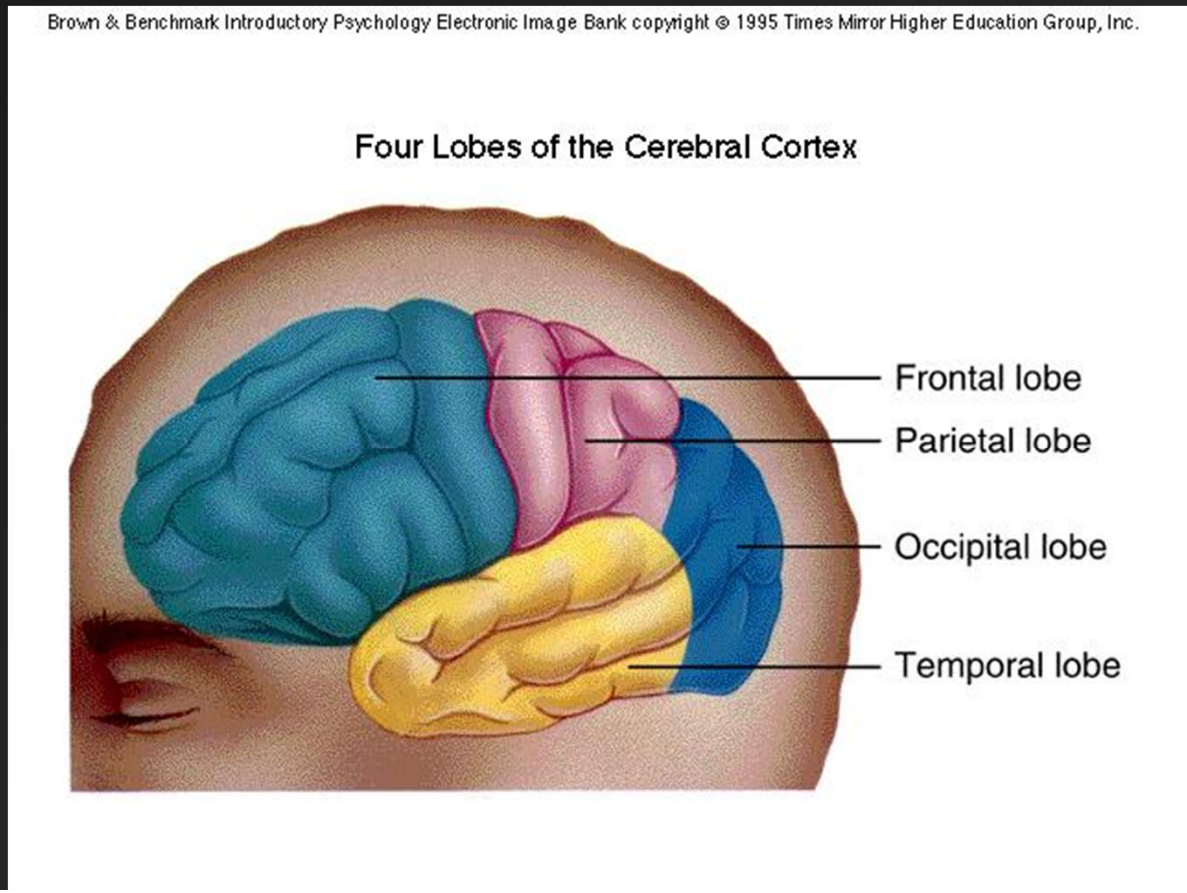
3. The cerebral hemispheres
    e. Visual area
        1. Contralateral visual field
        2. Primary vs Secondary




Visual cortex
Lateral geniculate nucleus
Optic tract
Optic nerve
Optic chiasm
Left eye
Right eye
Left Visual Field
Right Visual Field

The common household brain

f. Auditory area
   1. bilateral representation
   2. contralateral stronger



The common household brain

g. Association areas
    1. functions which are not directly sensory or motor
    2. Examples:
        a. motor planning
        b. thought
        c. speech
        d. problem solving
        e. complex object recognition (e.g. prosopagnosia)
        f. Phylogeny of Association Cortex

Luria's Functional Systems

1. **Primary**
   a. Motor (precentral gyrus);
      (1) topographic organization

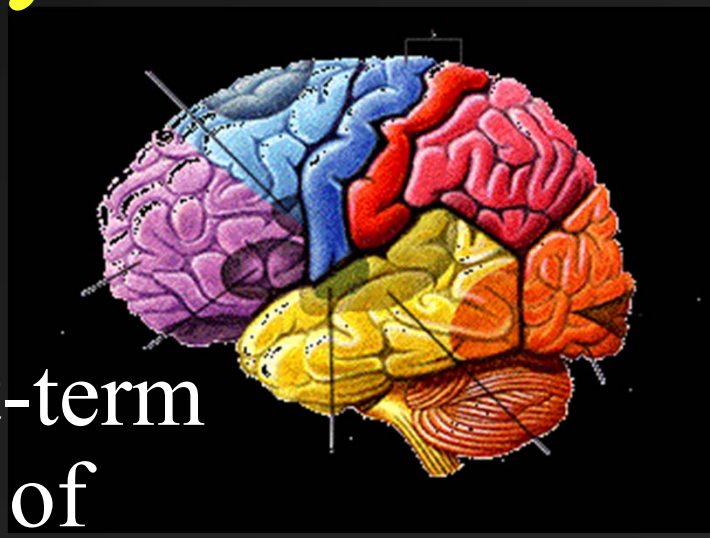
   b. Sensory
      (1) Somatosensory (post central gyrus)
      (2) Visual (Occipital cortex)
      (3) Auditory (Banks of Lateral Sulcus)

Luria's Functional Systems

2. **Secondary**
   a. Motor (rostral to precentral gyrus): motor programming, sequences of movements

   b. Sensory (caudal to postcentral gyrus): **unimodal** sensory integration

Luria's Functional Systems



3. **Tertiary**

   a. Motor (frontal lobes): goal directed acts, long-term & short-term planning, internal manipulation of "ideas" and representational systems that are basic to abstract thought

   b. Sensory (parietal-temporal-occipital junction): **cross-modal** integration of sensory information

Skin Conductance:

Pontificating about sweat

Two types of Sweat Glands

- Eccrine
  - forms basis of skin conductance recording
  - located all over body, but dense concentrations on surface of hands and feet
  - has many functions
- Apocrine
  - found under armpits and genital areas
  - function a matter of debate
  - not of great interest to psychophysiologists

Functions of Sweat Glands

- Thermoregulation
- Thermal Preparation
- Facilitate manipulative contact
- Minimize abrasion
- Accentuate Tactile Acuity
- Odiferous communication? (Apocrine)

After Edelberg, 1972

Anatomy of a Gland and the Skin

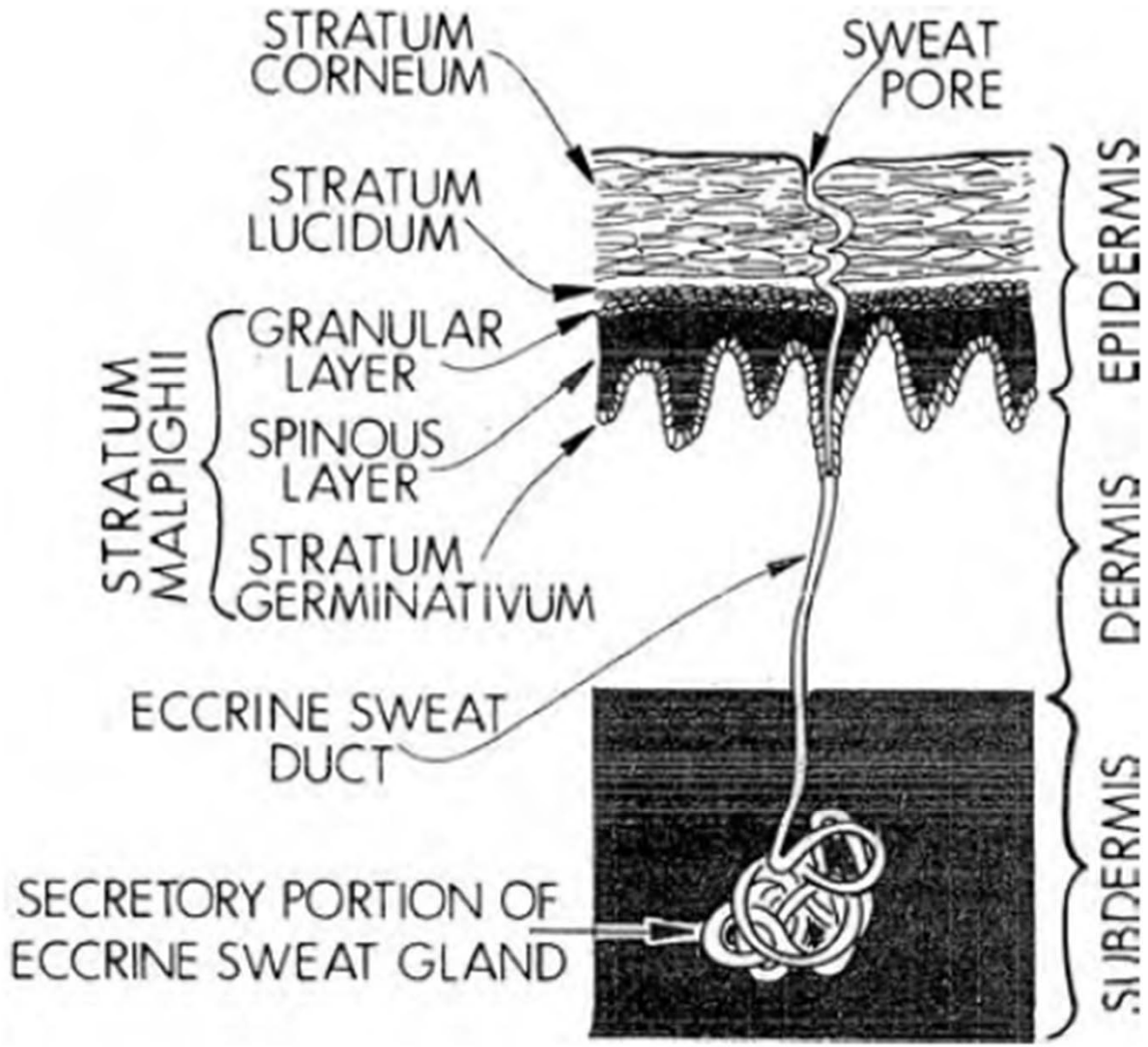
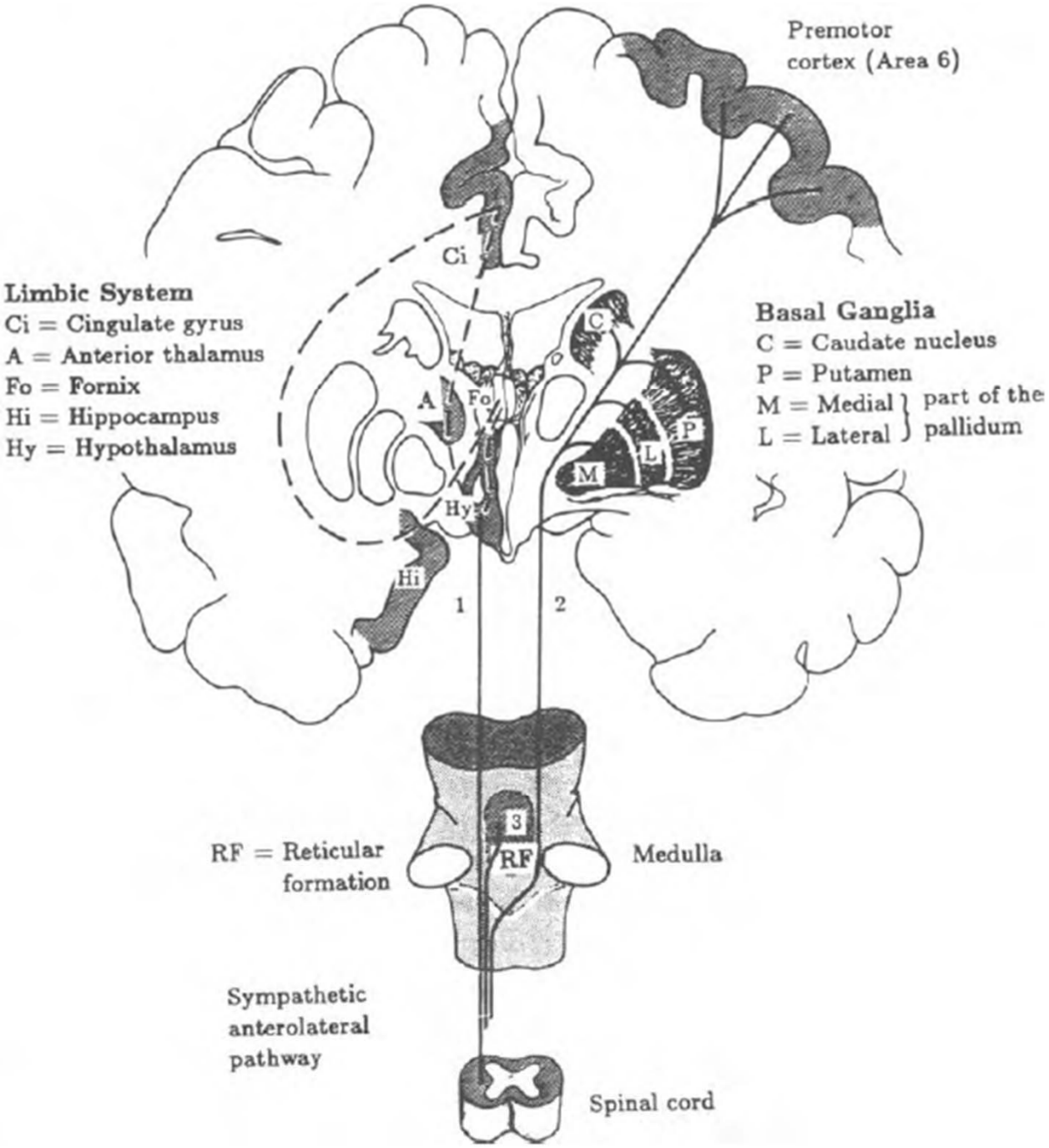


Figure 7.1. Anatomy of the eccrine sweat gland in various layers of skin. (Adapted from Hassett, 1978).

- Sweat glands primarily driven by sympathetic innervation that is cholinergic
- Sudomotor fibers originate in the sympathetic chain, terminate on sudomotor cell of sweat gland
- Stratum Corneum acts as a variable resistor, with decreased resistance due to sweat

From
Dawson et al 2007

Central Control



From Dawson et al 2007

Figure 7.2. Central nervous system determiners of EDA in humans (From Boucsein, 1992).

Acronym Glossary

- Generic terms
  - EDA = electrodermal activity
  - GSR = galvanic skin response
- Skin Resistance
  - SRL = skin resistance level (tonic); 10,000-500,000Ω
  - SRR = skin resistance response (phasic); 100-10,000 Ω
- Skin Conductance
  - SCL = skin conductance level (tonic); 2-50 μsiemens
  - SCR = skin conductance response (phasic); .05-5 μsiemens
  - SSCR or NSSCR = spontaneous or non-specific skin conductance response
- Skin Potential
  - SPL = skin potential level (tonic); 0-60 mV
  - SPR = skin potential response (phasic); .1-10 mV

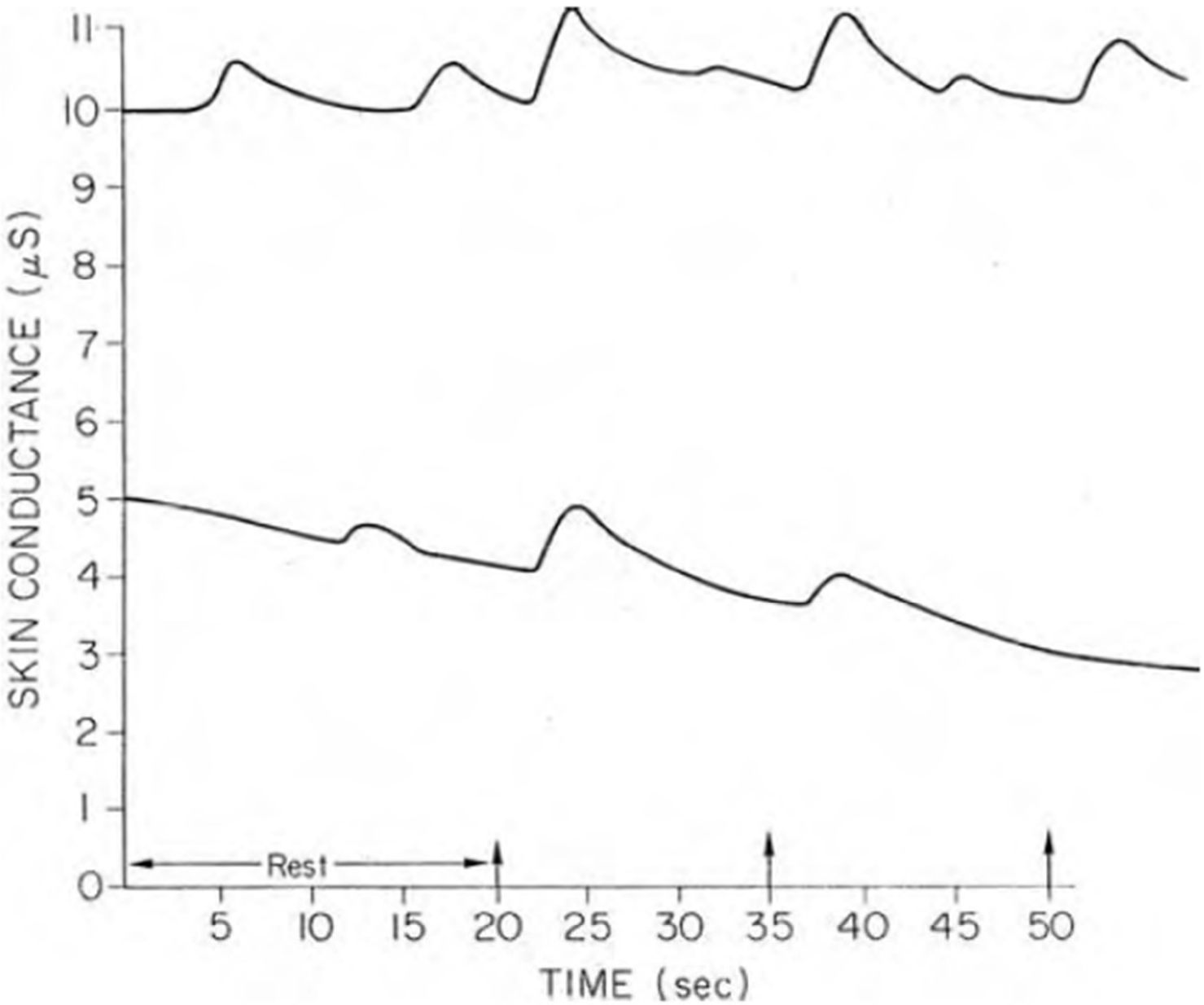


Figure 7.4. Two hypothetical skin conductance recordings during 20 s of rest followed by three repetitions of a simple discrete stimulus. Arrows represent the presentation of a stimulus (From Dawson & Nuechterlein, 1984).

Table 7.1. Electrodermal measures, definitions, and typical values

Measure	Definition	Typical Values
Skin conductance level (SCL)	Tonic level of electrical conductivity of skin	2–20 μS
Change in SCL	Gradual changes in SCL measured at two or more points in time	1–3 μS
Frequency of NS-SCRs	Number of SCRs in absence of identifiable eliciting stimulus	1–3 per min
SCR amplitude	Phasic increase in conductance shortly following stimulus onset	0.1–1.0 μS
SCR latency	Temporal interval between stimulus onset and SCR initiation	1–3 s
SCR rise time	Temporal interval between SCR initiation and SCR peak	1–3 s
SCR half recovery time	Temporal interval between SCR peak and point of 50% recovery of SCR amplitude	2–10 s
SCR habitation (trials to habituation)	Number of stimulus presentations before two or three trials with no response	2–8 stimulus presentations
SCR habituation (slope)	Rate of change of ER-SCR amplitude	0.01–0.5 μS per trial

Key: SCL, skin conductance level; SCR, skin conductance response; NS-SCR, nonspecific skin conductance response.

DEMO!

Glands Act as Resistors in Parallel

- Resistance will therefore decrease with increased recording surface area – keep surface area constant across subjects
- Resistance is not linearly related to the # of resistors

$$\frac{1}{R_t} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$$

- Conductance, however, is linearly related to the number of resistors in the circuit
  - Therefore, there exists a linear relation between measures of conductance and sweat secretion
  - Not so for Resistance
  - The metric of conductance more accurately reflects the activity of the system

	SRL (Ω)	SCL(μS)	SRR	SCR
R1 Pre	100,000	10		
R1 Post	99,000	10.1	1000	0.1
R2 Pre	20,000	50		
R2 Post	19,000	52.6	1000	2.6

- Conductance is the Reciprocal of Resistance
- This shows how two vastly different responses will appear the same using skin resistance response metrics

Recording -- Placement

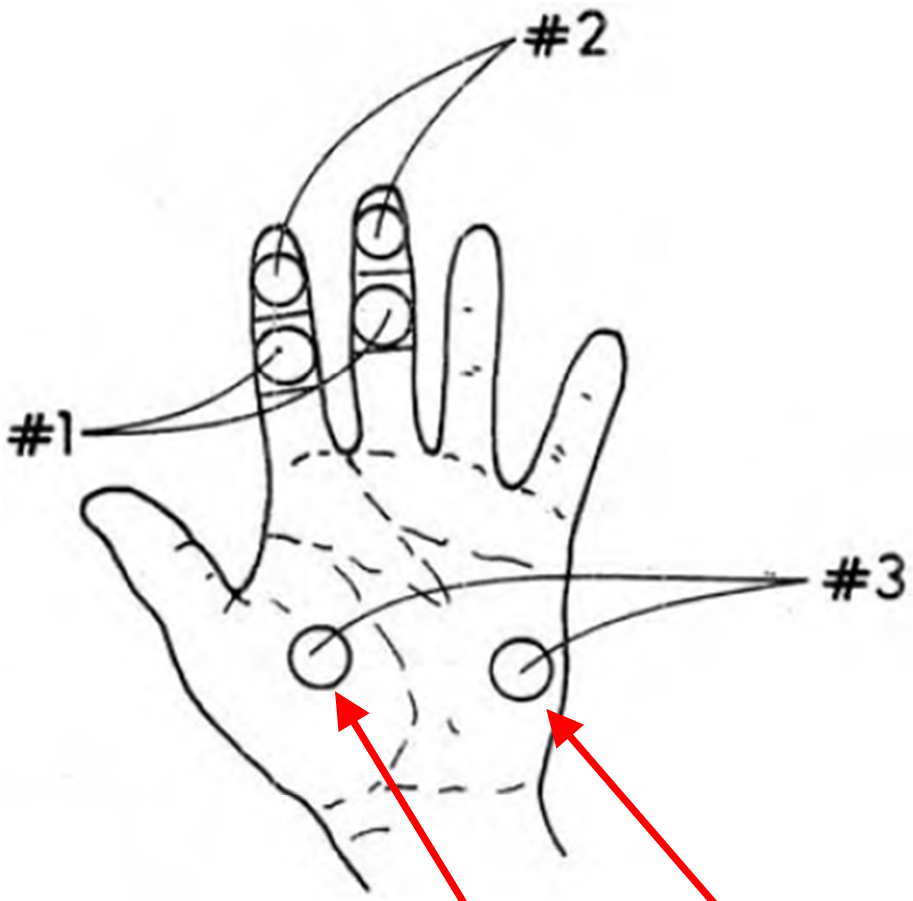


Figure 7.3. Three electrode placements for recording electrodermal activity. Placement #1 involves volar surfaces on medial phalanges, placement #2 involves volar surfaces of distal phalanges, and placement #3 involves thenar and hypothenar eminences of palms.

From Dawson et al 2007

Recording Considerations

- Prep the Skin?
  - Never abrade
  - Don't use other agents (ETOH)
  - Washing with soap and H2O recommended to standardize across subjects
- Electrodes – Ag-AgCl
  - More expensive and fragile (unless sintered)
  - But well worth it – resist polarization
- Conductive Paste
  - Because current passed continuously, can interact with with the tissue
  - Unibase + physiological saline (Fowles et al, 1981) will keep properties of tissue and paste constant over duration of recording session
  - Other gels are bad news;
    - highly conductive, but saturated with NaCl,
    - over time will migrate to skin tissue, inflating SCL
- Surface Area Exposed
  - Keep constant across subjects and session
- Constant Voltage Amplification
  - Preferred over Constant current (Lykken and Venables, 1971)
- Temporal responsivity – SC system is S…L…O…W

The Generic SCR

- Latency typically 1-3 secs
- Rise time typically 1-4 secs

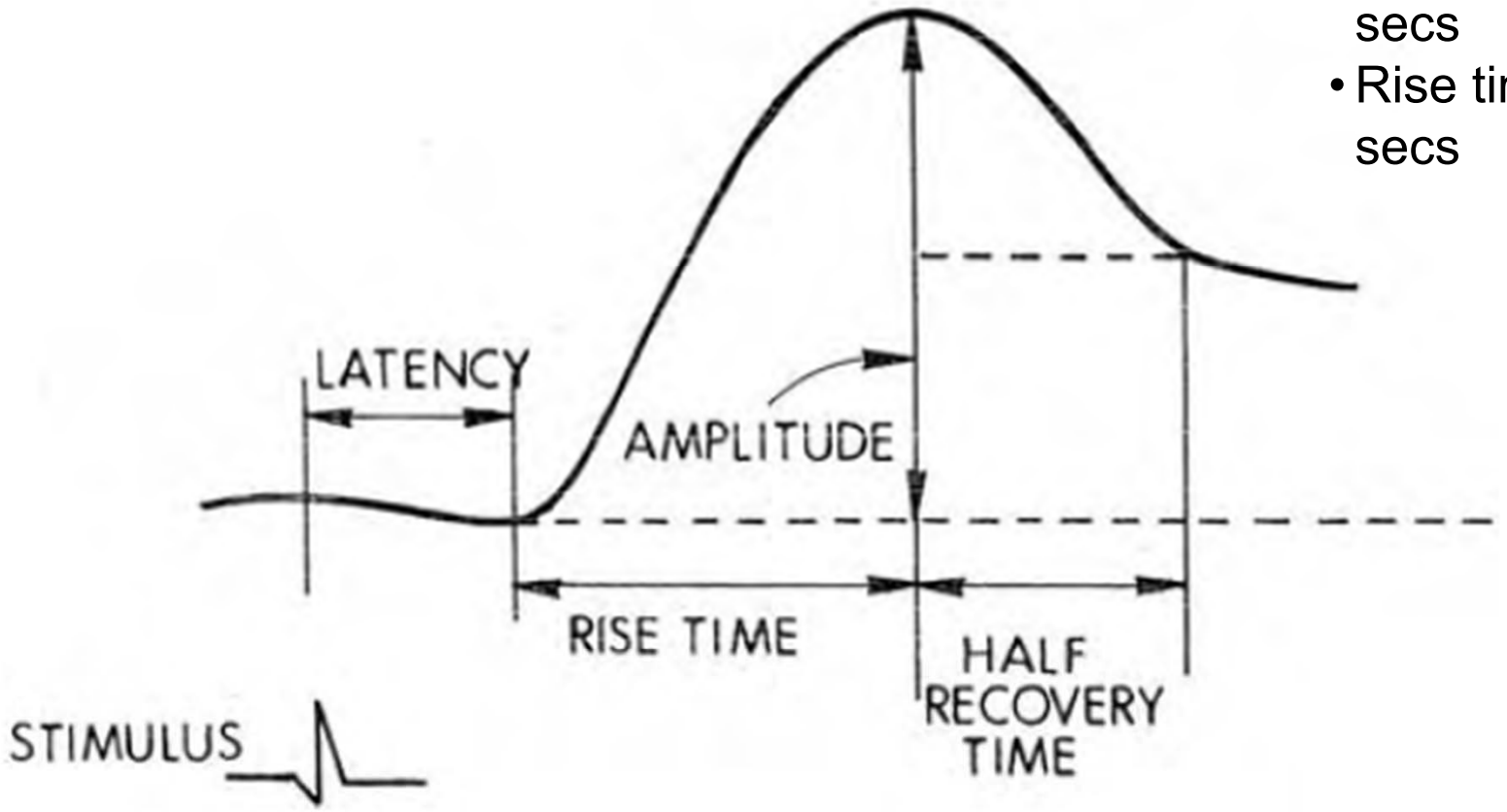


Figure 7.5. Graphical representation of principal EDA components.

From Dawson et al 2007

Scoring Issues

- Responses that ride on responses
- Range Correction (Lykken et al., 1966)
  - Level

$$\frac{(SCL_{observed} - SCL_{\min})}{(SCL_{\max} - SCL_{\min})}$$

  - Response

$$\frac{(SCR_{observed})}{(SCR_{\max})}$$

- Note also slope and intercept regression approaches

Applications

- Orienting (Bauer, 1984; Tranel and Damasio, 1985)
- Fear conditioning (Őhman)
- Individual Differences in Neuroticism
- Deficient anticipatory anxiety in psychopathy (Hare)
- Deception Detection (Myriad authors)

Neuroticism

- A trait-like tendency to experience negative affect and for increased reactivity to stress and aversive stimuli
- Would skin conductance reflect greater physiological reactivity to negative stimuli, and poorer physiological recovery?

Norris, Larsen, & Cacioppo (2007), *Psychophysiology*

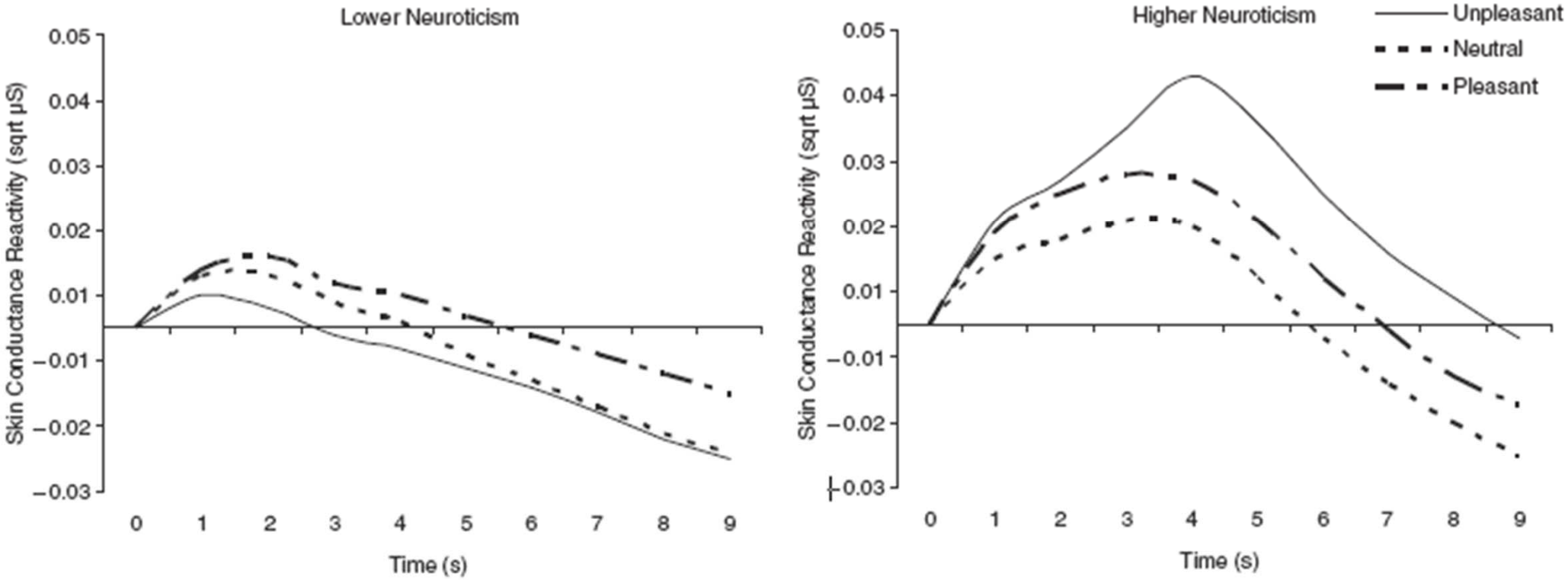


Figure 1. Skin conductance reactivity as a function of picture valence, time, and neuroticism. Pictures were presented from 1–6 s. Estimated means for participants lower (1 *SD* below the mean) and higher (1 *SD* above the mean) in neuroticism are plotted separately.

Anticipatory Arousal in Psychopathy

- Hare Countdown Task (1965)
- #'s appear from 1..8
- At "8" punishment is given (shock):