Lecture 3

8 February, 2021

Announcements (2/8/19)

- Lab: Meet This Wednesday, Feb 10 via zoom
- UA moving to Flex-in-person Feb 22
- Electricity Test next week (Feb 15)
- Please do not forget to use the Comment/Question tool on the class website (gives you attendance credit)

Electricity Test Objectives

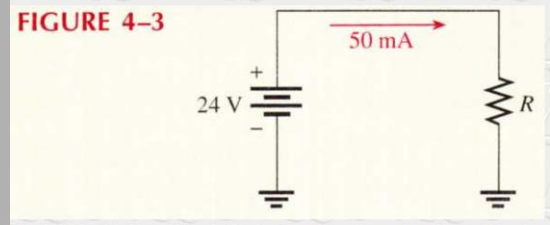
- Describe positive and negative charges
- State the law of attraction and repulsion
- Describe free electrons
- Describe the relationship between electromotive force, resistance, and flow (i.e. understand Ohm's Law)
- Draw a simple DC electric circuit comprised of a battery and:
  - Single resistor
  - 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

Questions and Feedback

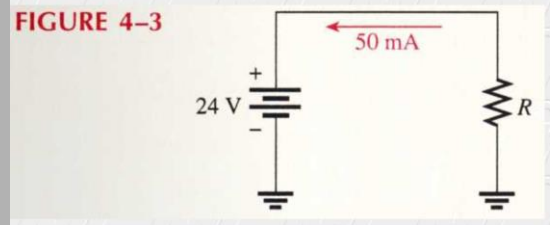
Could you please go over the process of reducing and expanding complex circuits or recommend some more videos to understand them more theoretically.

Conventional **Current** assumes that **current flows** out of the positive terminal, through the circuit and into the negative terminal of the source. ... **Electron Flow** is what actually happens and **electrons flow** out of the negative terminal, through the circuit and into the positive terminal of the source.

Both Conventional Current and Electron Flow are used. Many textbooks are available in both formats.



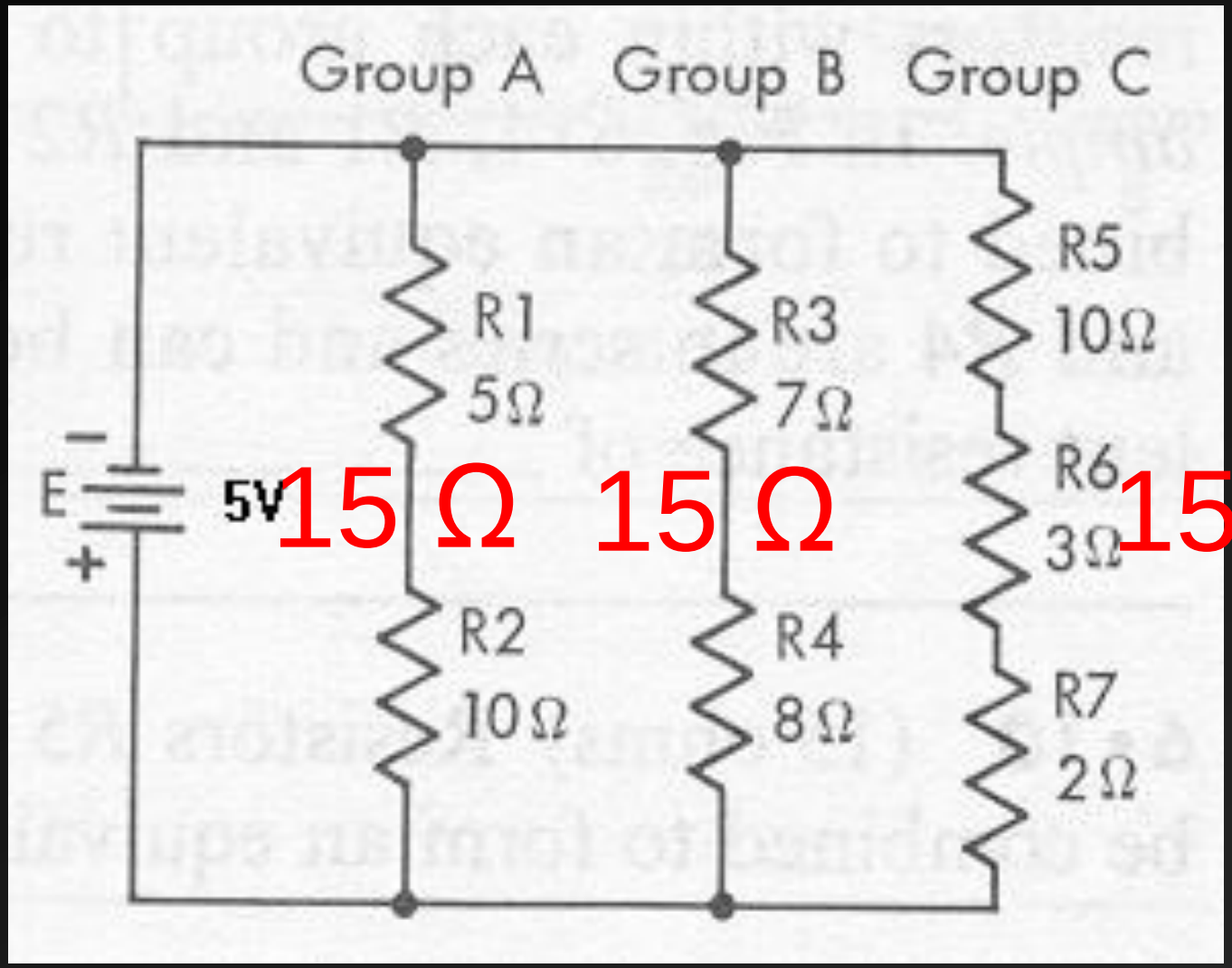
Floyd, 1989, *Principles of Electric Circuits*, 5th edition, Conventional Current Version.



Floyd, 1990, *Principles of Electric Circuits*, 4th edition, Electron Flow Version.

https://www.elprocus.com/types-of-analog-filters/

Brief Review



Calculate the total equivalent resistence of the circuit, and calculate the current running through each of the three parallel arms (Group A, B, C)

$1/R_t = 1/R_A+1/R_B+1/R_C = 3/15 = 1/5$

$R_t=5\Omega$

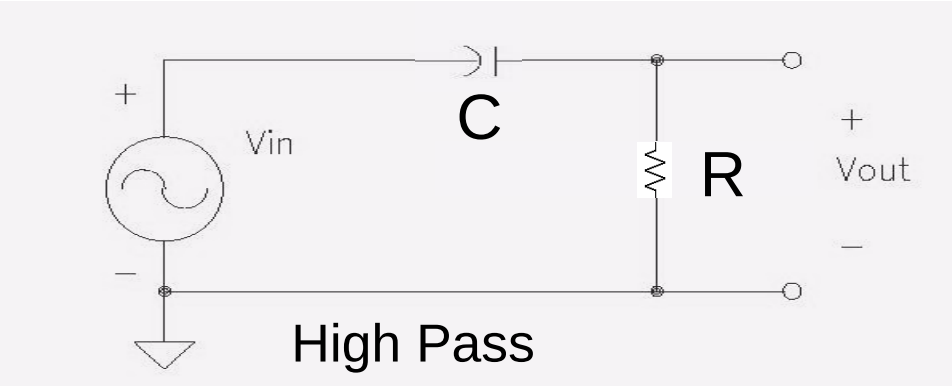
$I_A=E_s/R_A=5/15=1/3$ A

$I_B=E_s/R_A=5/15=1/3$ A

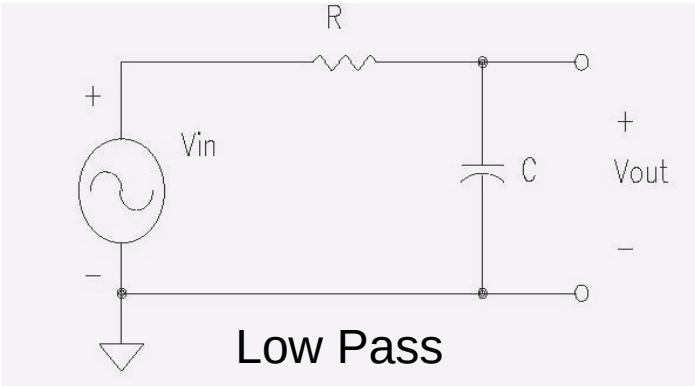
$I_C=E_s/R_A=5/15=1/3$ A

Double check:

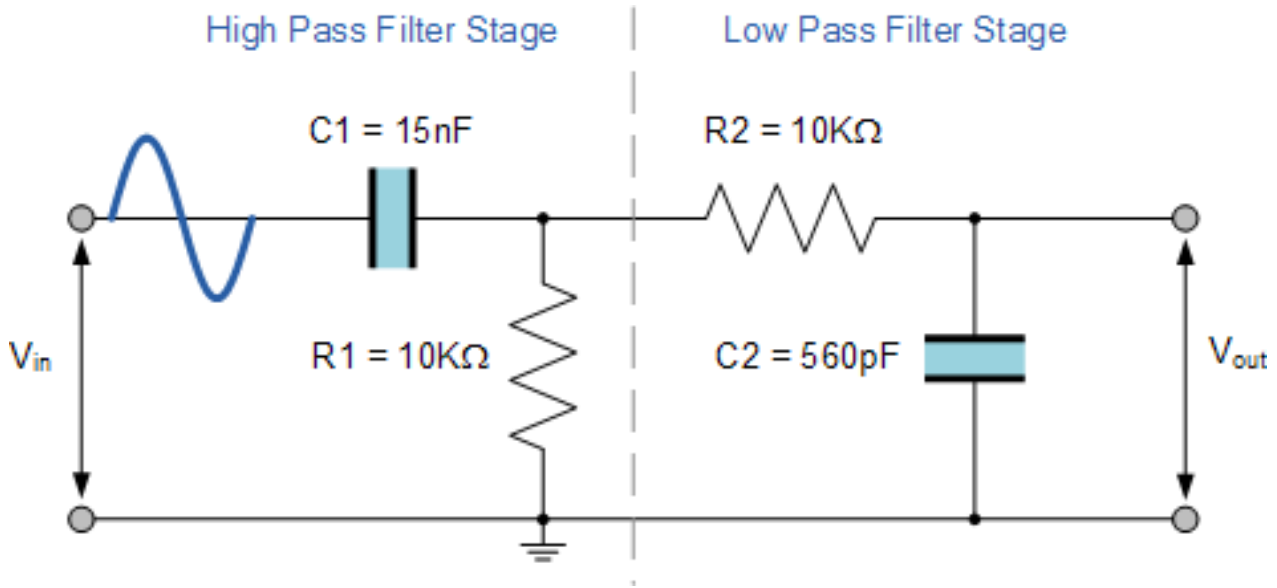
$I_t= E_t/R_t = 5V/5\Omega = 1A$



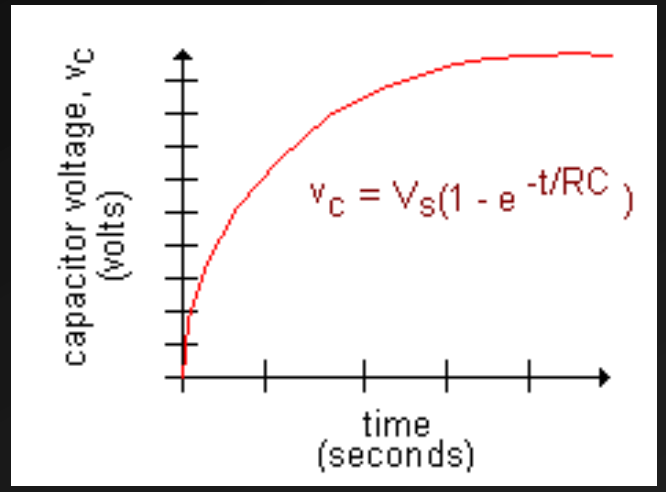
High Pass

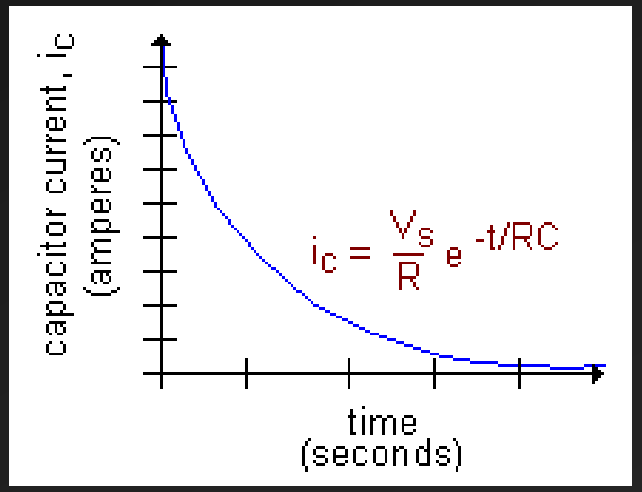


Low Pass



Capacitor Time Constants





Over time…

Capacitor's voltage increases

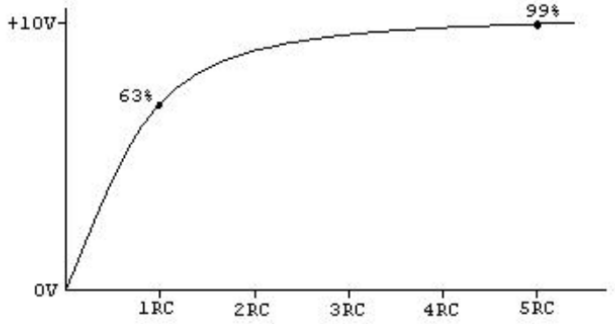
Current flow grinds to a halt

The capacitor's time constant TC=

- The time in seconds for it to become 63.2% charged ($1 - e^{-1} = .632$)
- The time in seconds for current flow have slowed by 63.2% from its starting value

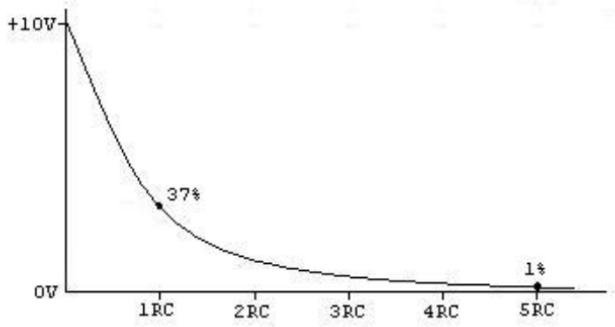
Capacitor Time Constants

Assuming the cap started with 0V, it's rise of voltage over time will look like this:



The key points here are to note that after 1 RC, the cap will have reached about 2/3 of the V-in, and after 5 RC's, the cap will be very close to V-in.

If, after charging the cap in our RC circuit to 10V, we brought V+ down to ground, the cap would discharge. And here again, the discharge time would be determined by the RC time constant. The RC curve for discharging looks like this:



The key points on the discharge curve are at 1 RC, where the voltage is about a third of the original, and at 5 RC, where the voltage across the cap is nearly 0.

Charging toward applied voltage (initially zero voltage across capacitor, constant V0 across resistor and capacitor together)

$$V_0: \quad V(t) = V_0(1 - e^{-t/\tau})$$

T = RC

Remember: $1 - e^{-1} = .632$

https://www.eecs.tufts.edu/~dsculley/tutorial/rc/rc3.html

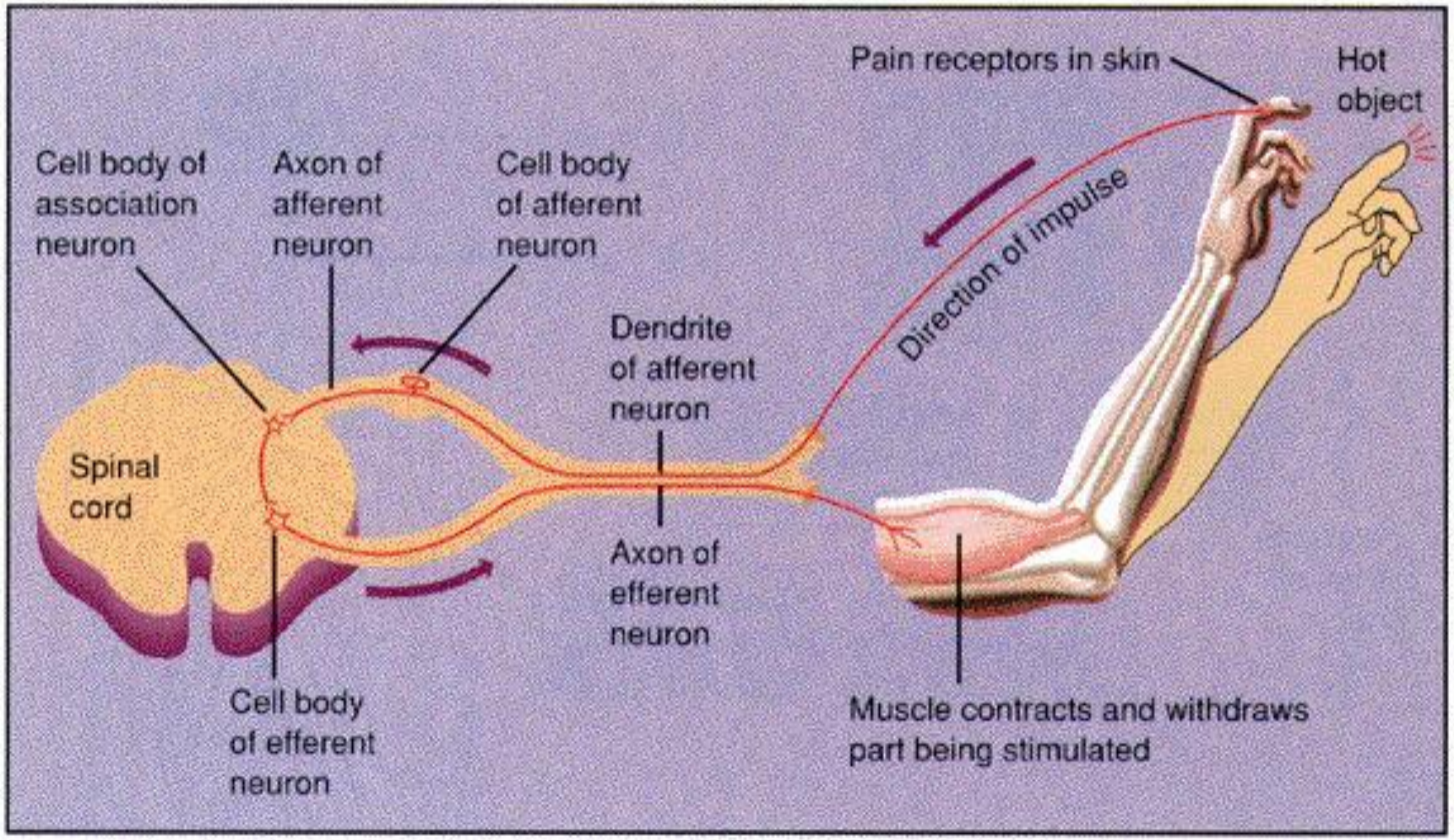
Today:

Basic Neurophysiology
Basic Neuroanatomy
The Electrodermal Response System

Basic Neurophysiology

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

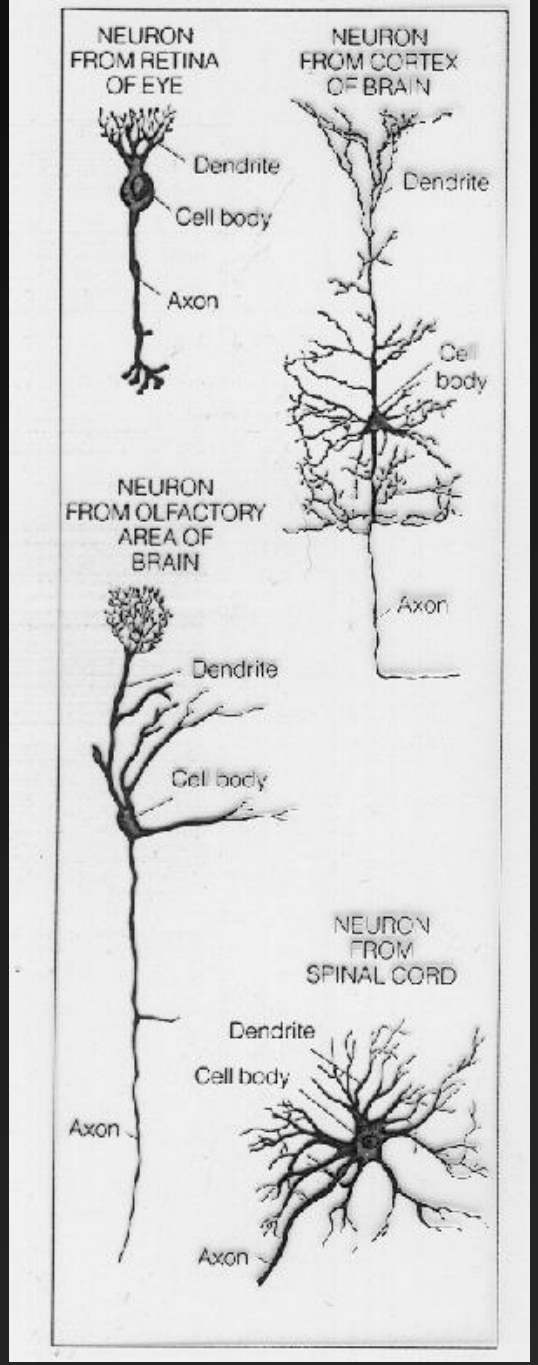
Withdrawal Reflex



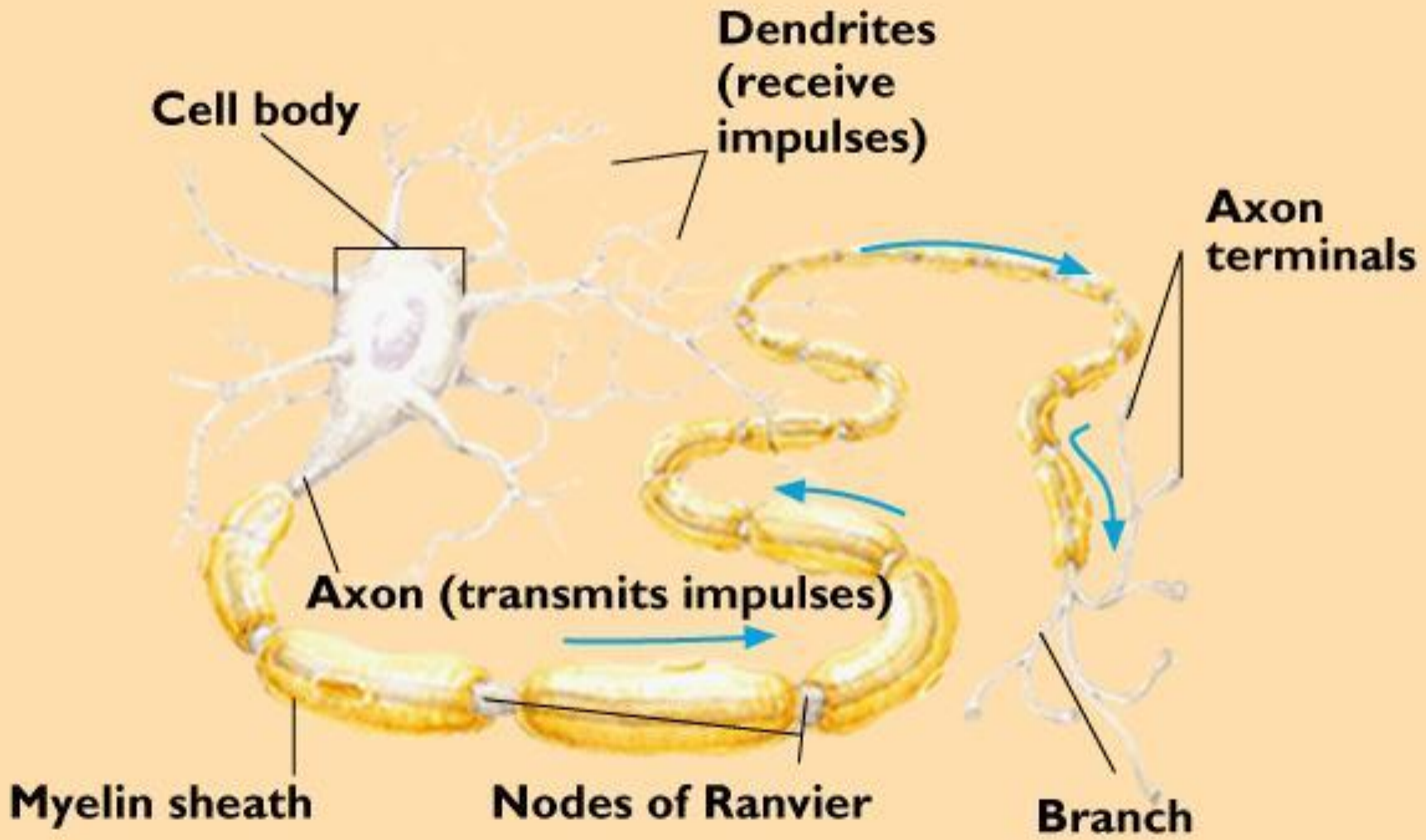
The Common Household Neuron

- 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

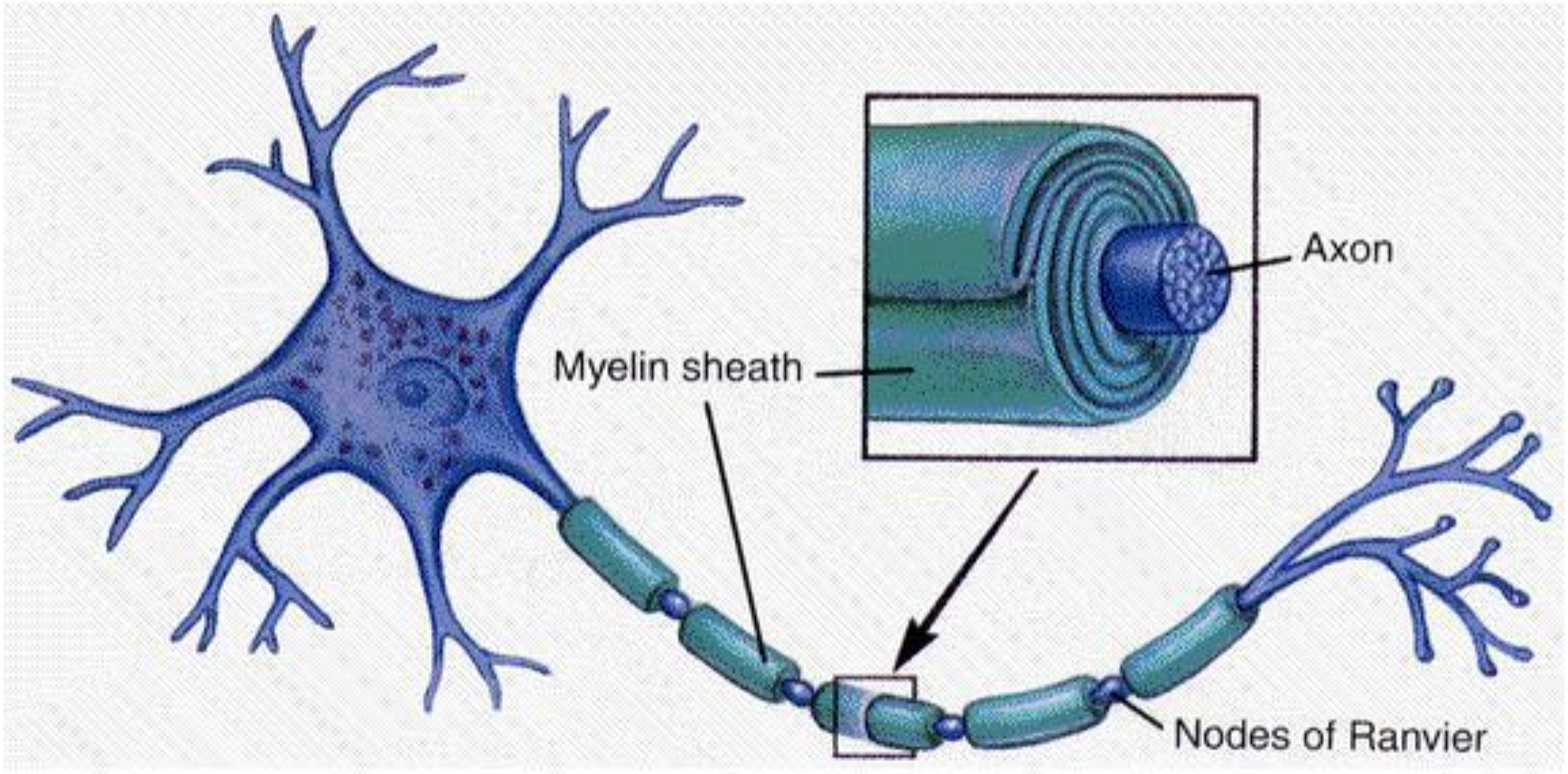
Jump to Next


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

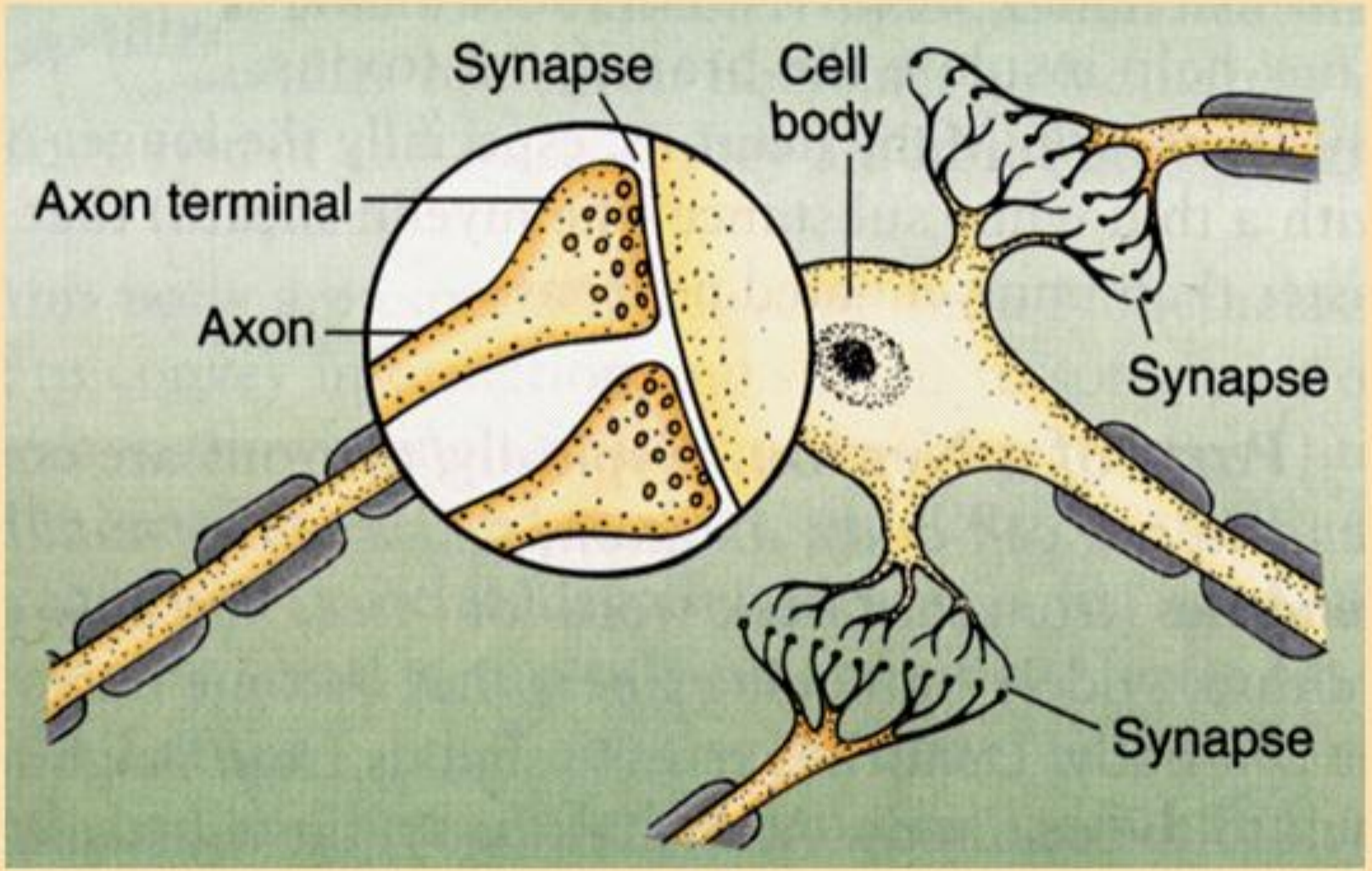
Neuron Structure



Myelin Sheath



The Synapse



Neural Communication

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

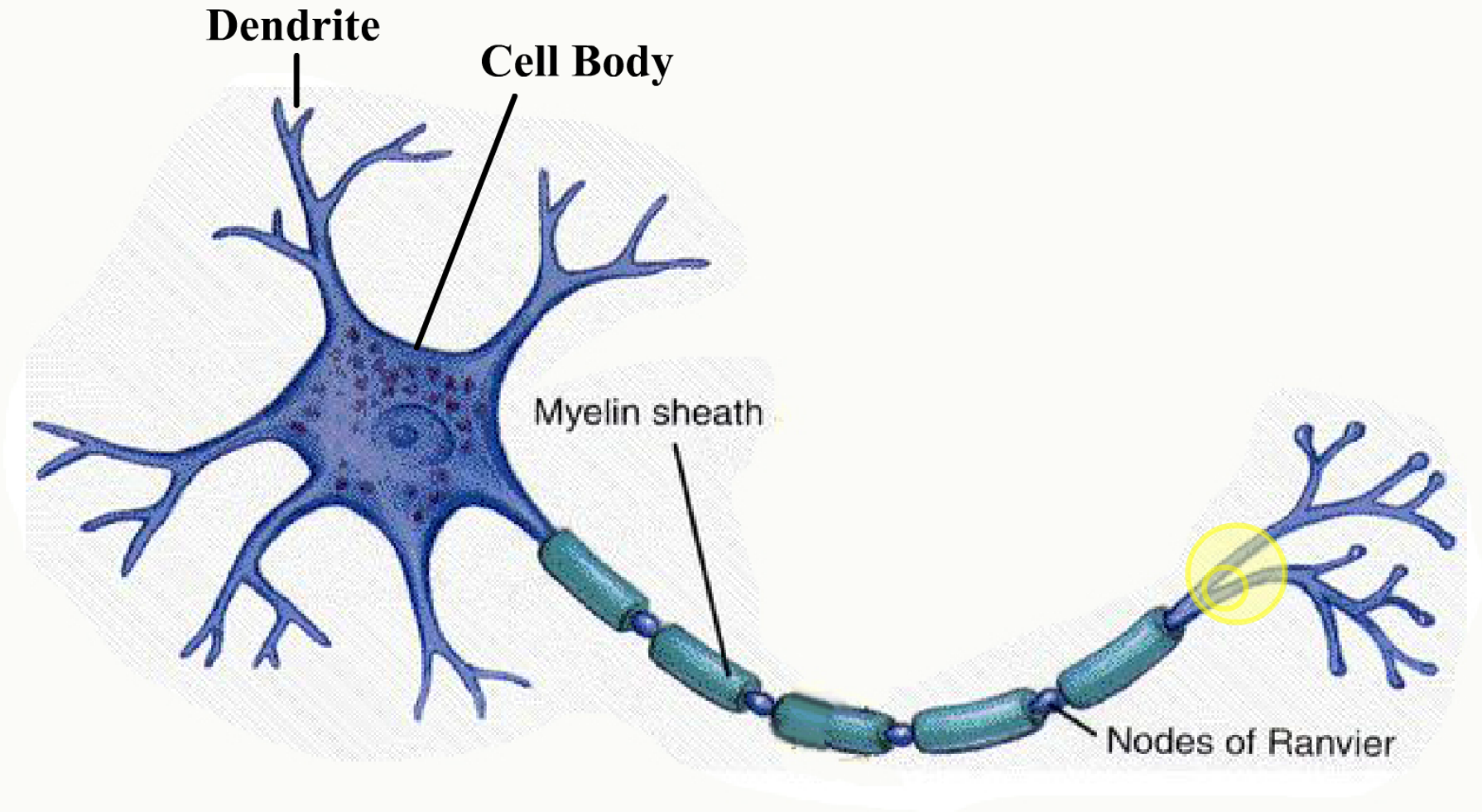
Axonal Conduction

- 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

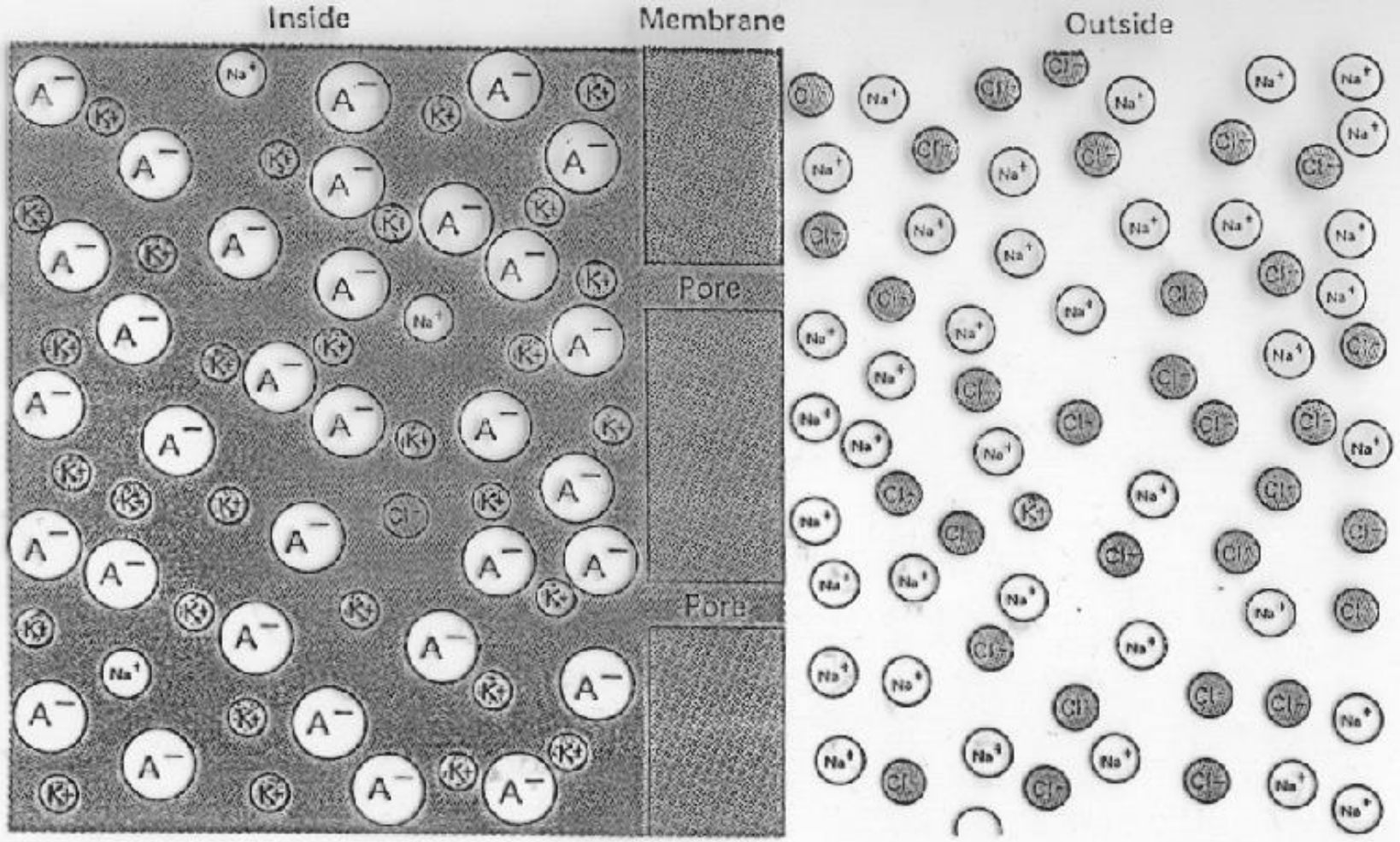
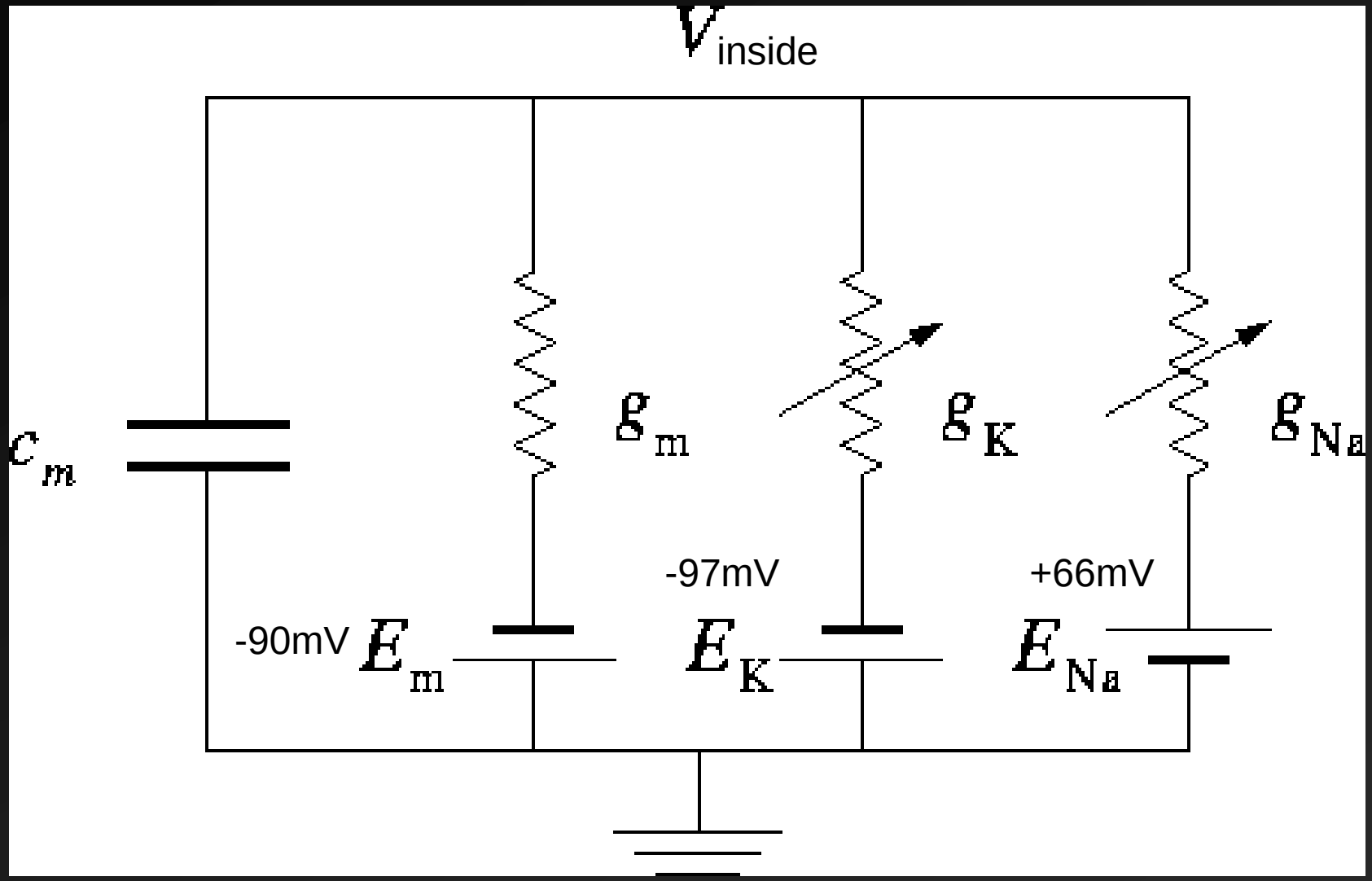
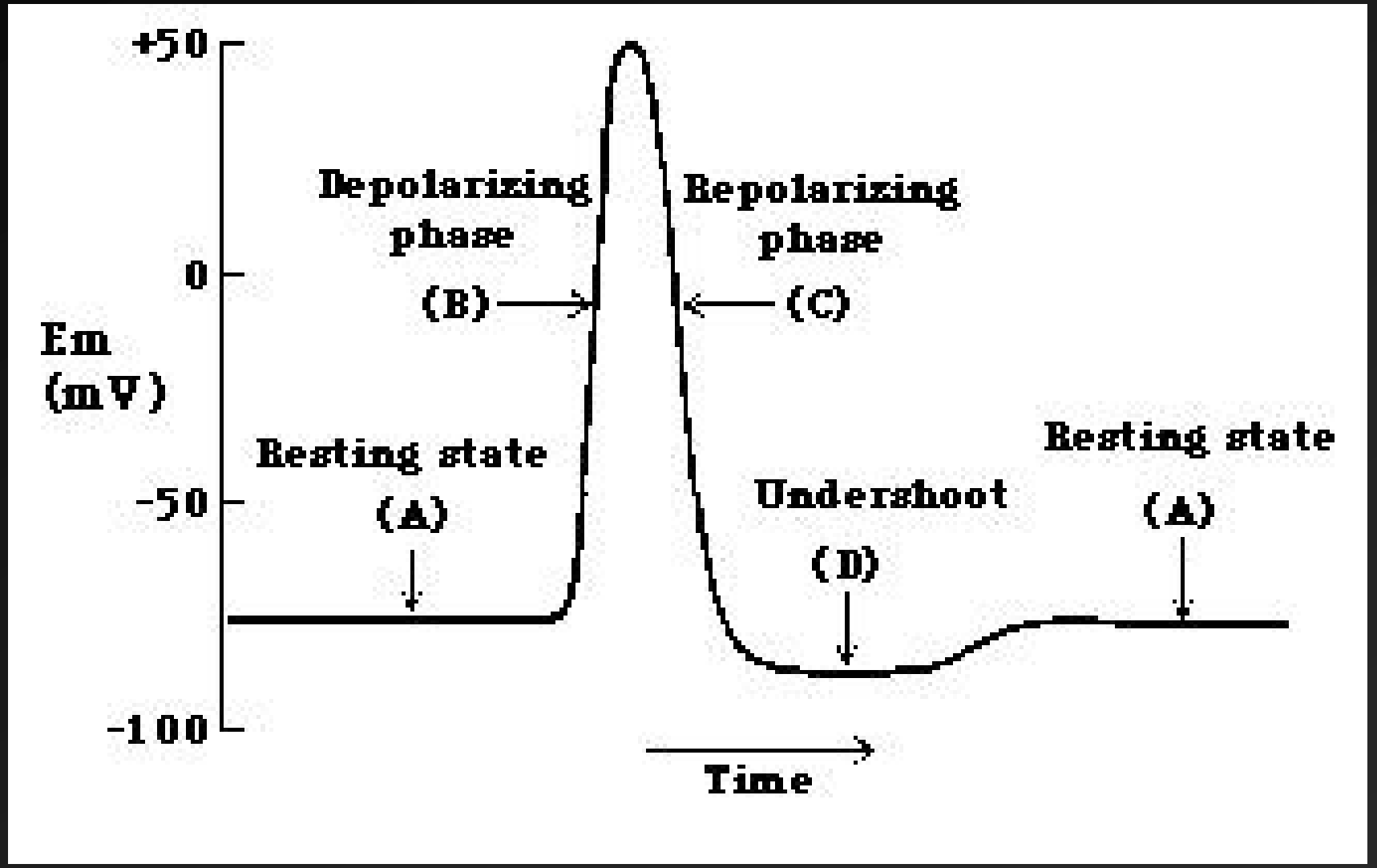
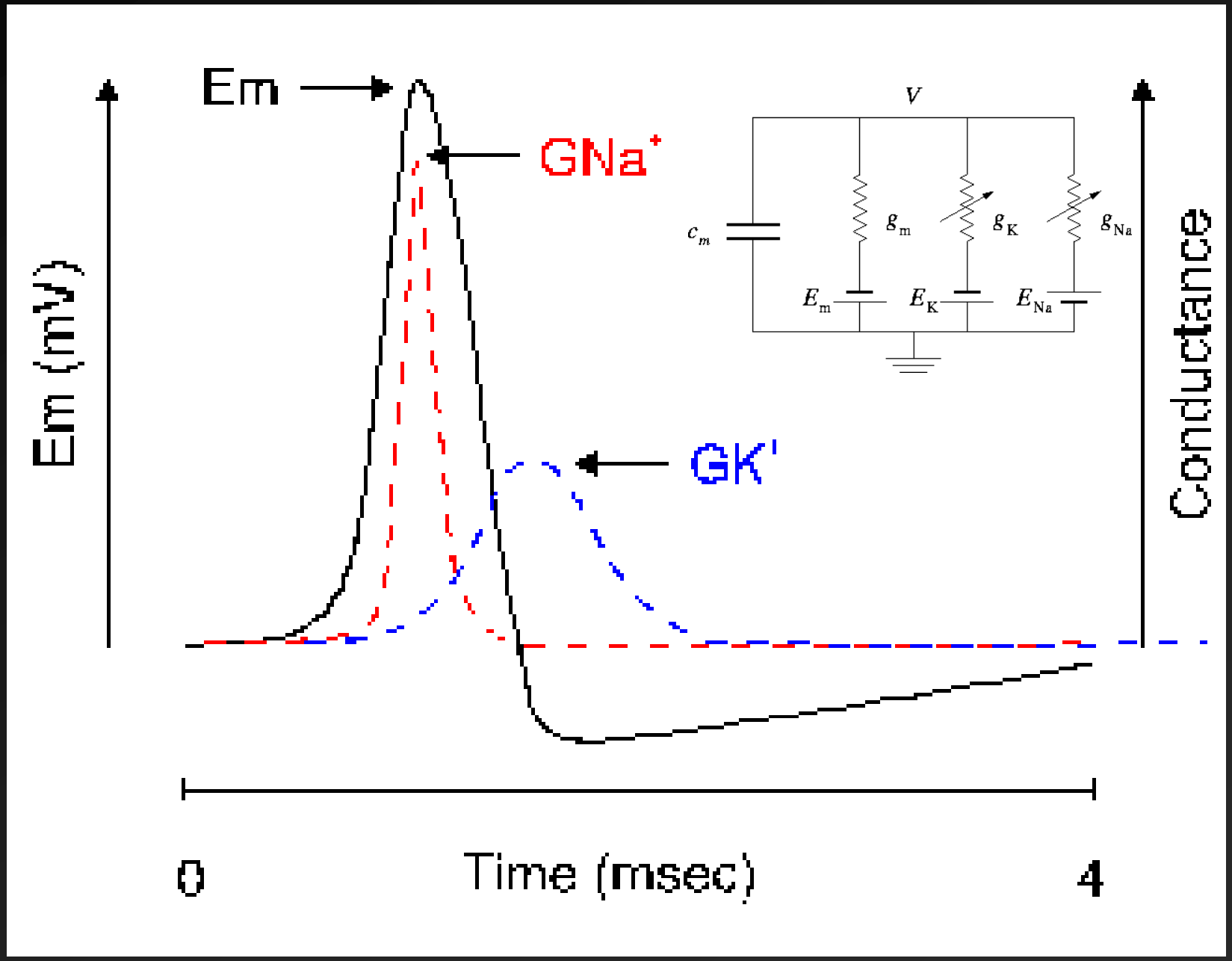
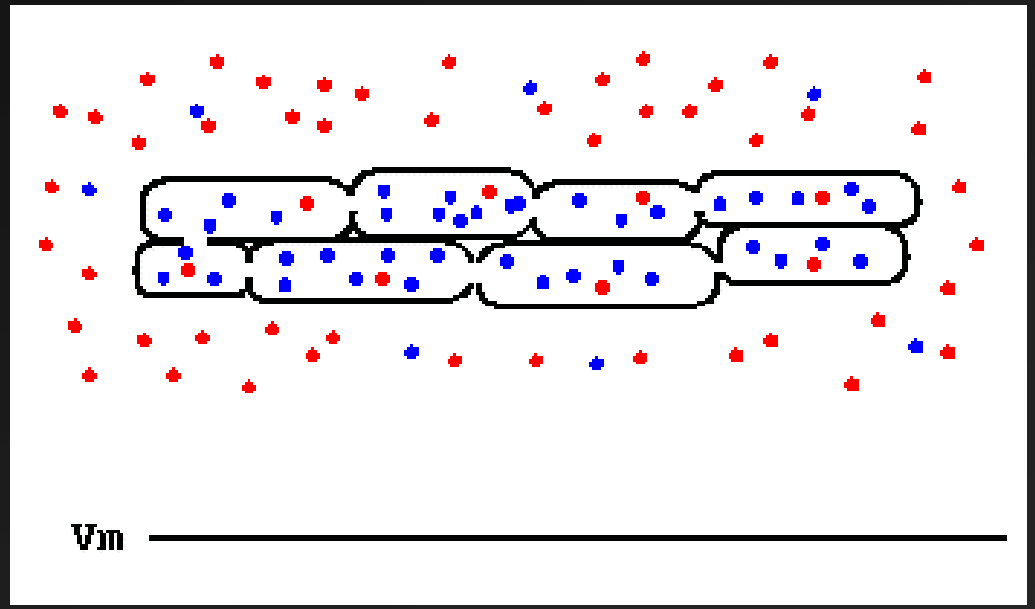


Fig. 2-3. Intra- and extracellular distribution of the ions. On both sides of the membrane, the different ions are indicated by *circles of different diameter*, proportional in each case to the diameter of the (hydrated) ion. A^- designates the large intracellular protein anions. The passages through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


V_{inside}
C_m
g_m
g_K
g_{Na}
-90mV
E_m
-97mV
E_K
+66mV
E_{Na}


+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
V
c_m
g_m
g_K
g_{Na}
E_m
E_K
E_{Na}
0
Time (msec)
4


Vm

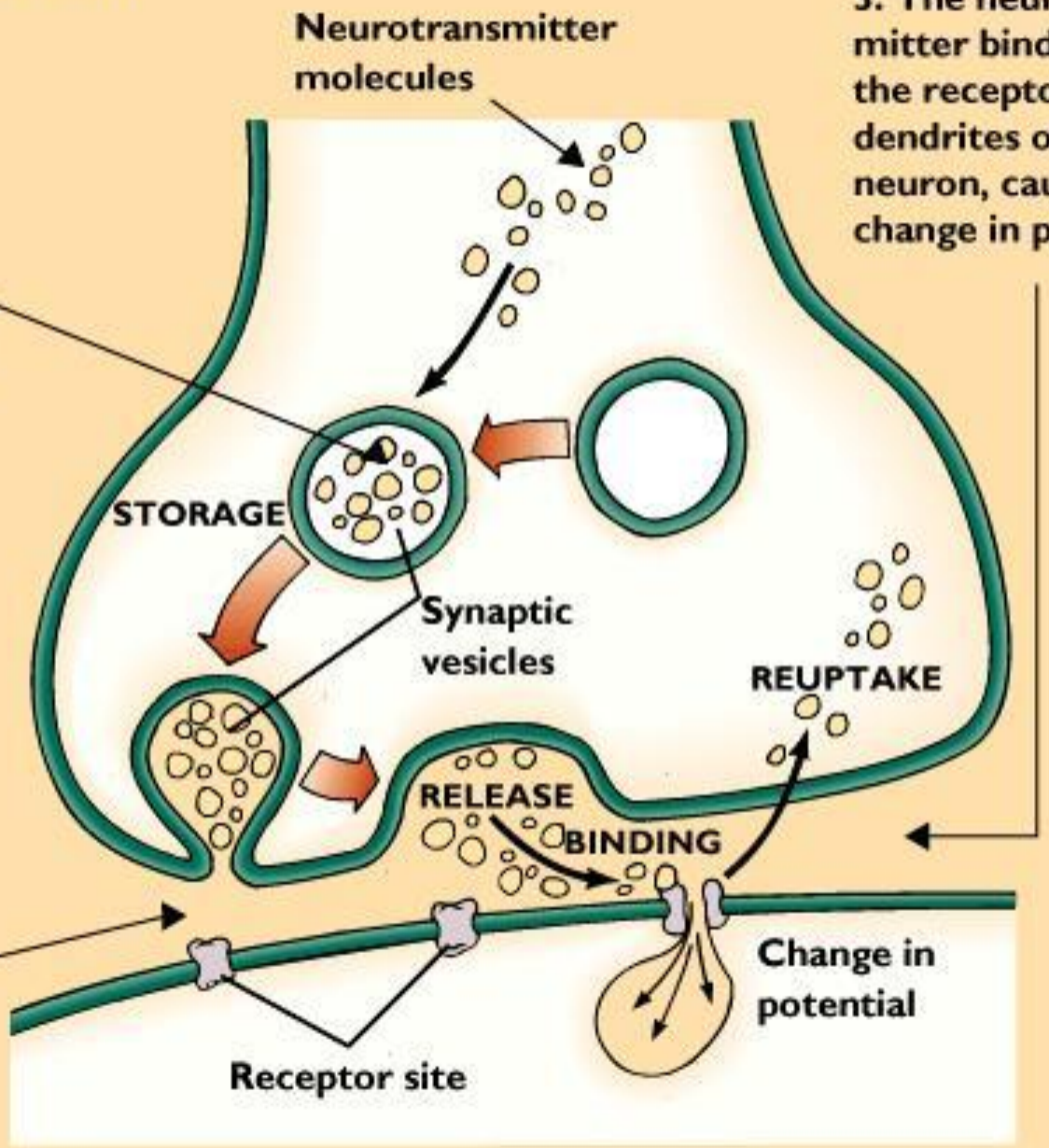
Synaptic Transmission

- 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)

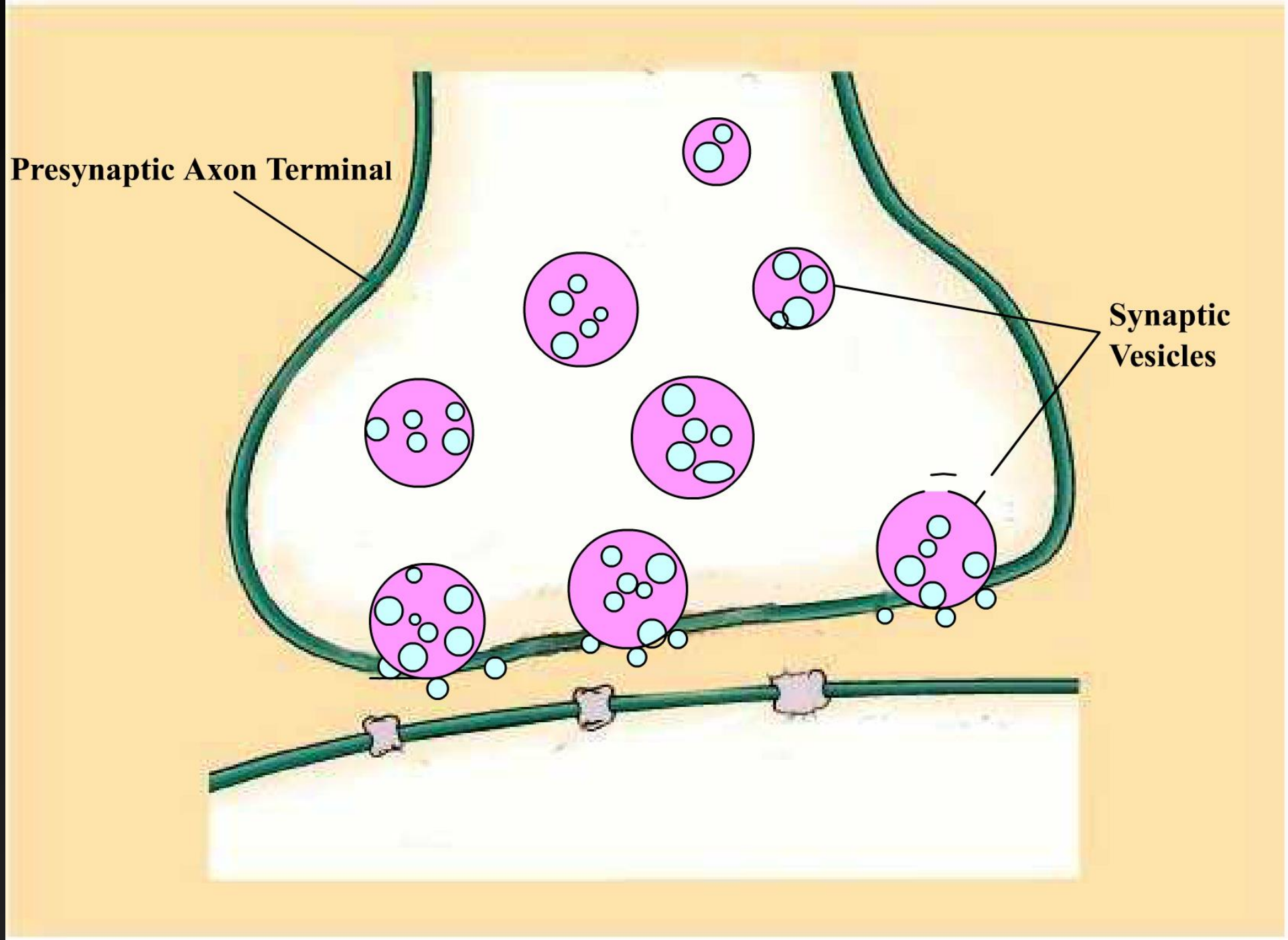
Synaptic Transmission

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.



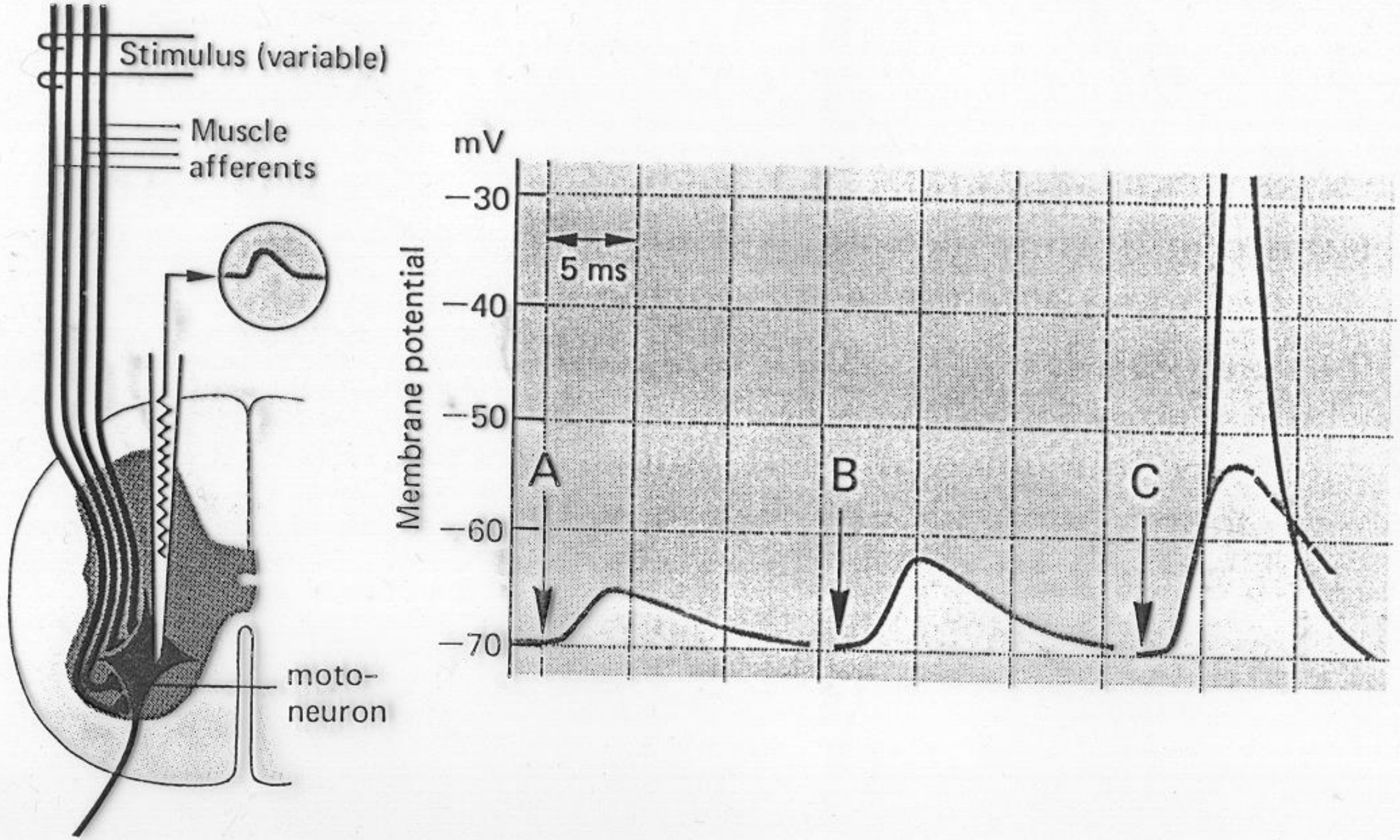
3. The neurotransmitter binds itself to the receptor sites on dendrites of the next neuron, causing a change in potential.


Presynaptic Axon Terminal
Synaptic Vesicles

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


Stimulus (variable)
Muscle afferents
moto-neuron
mV
−30
−40
−50
−60
−70
Membrane potential
5 ms
A
B
C

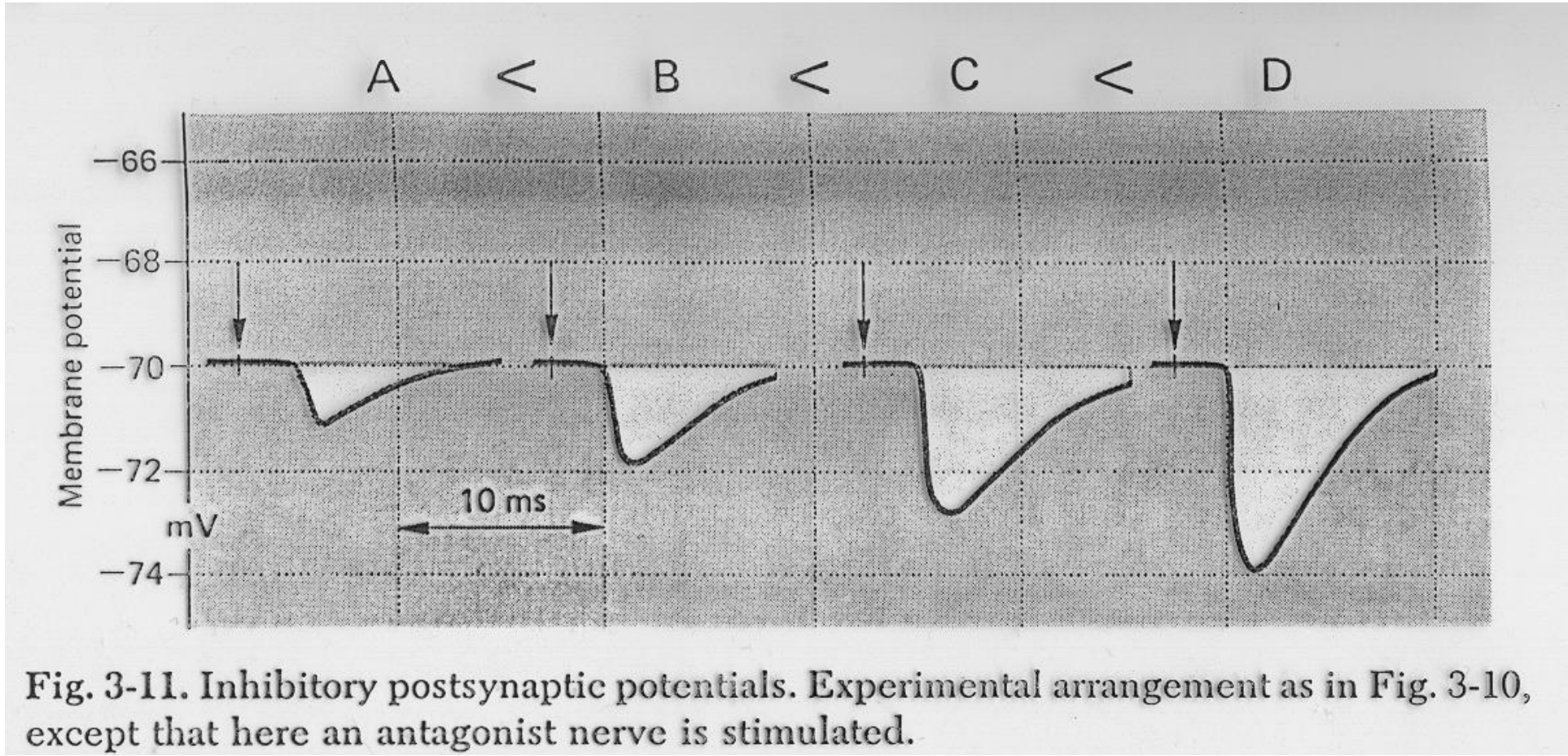


Fig. 3-11. Inhibitory postsynaptic potentials. Experimental arrangement as in Fig. 3-10, except that here an antagonist nerve is stimulated.

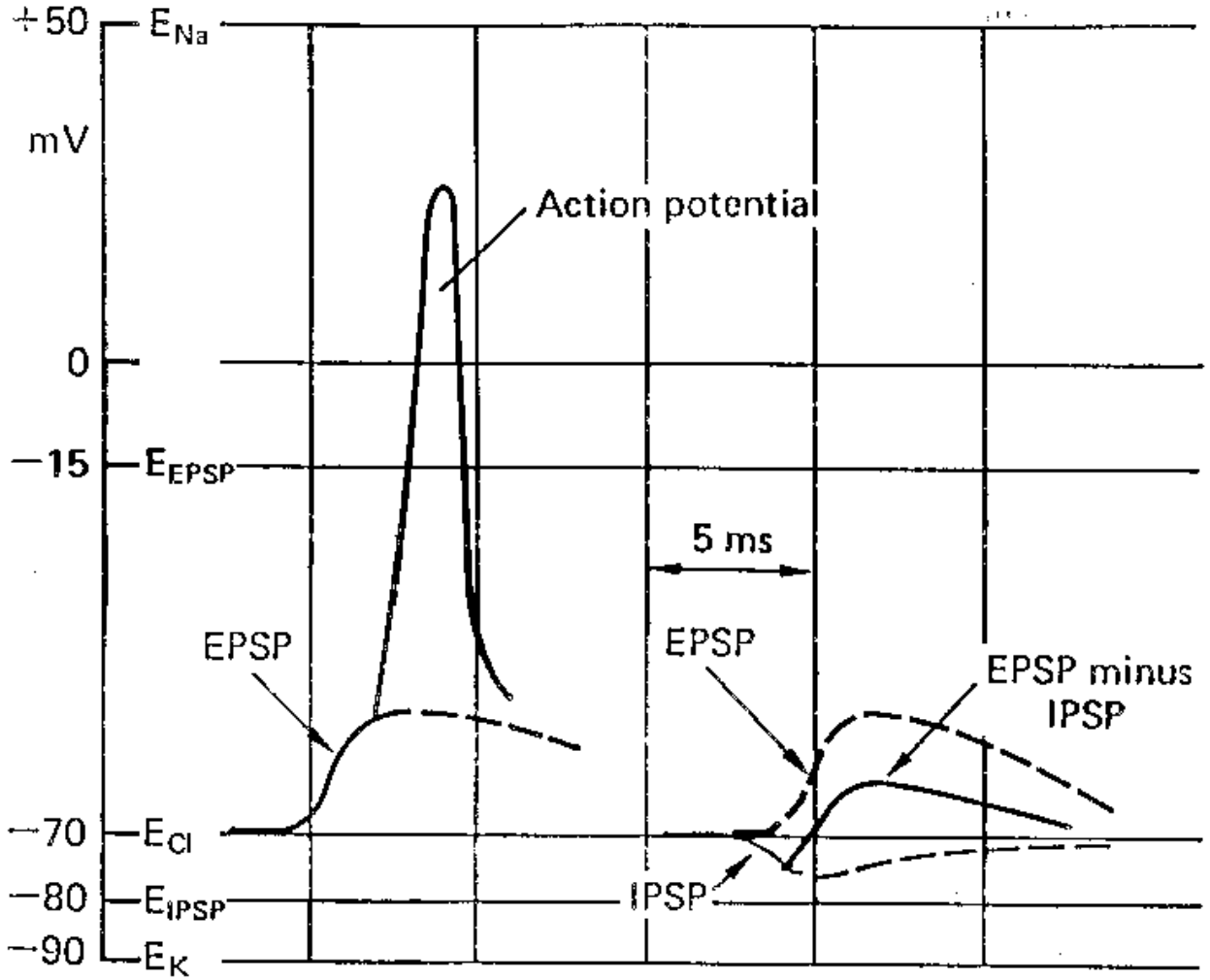
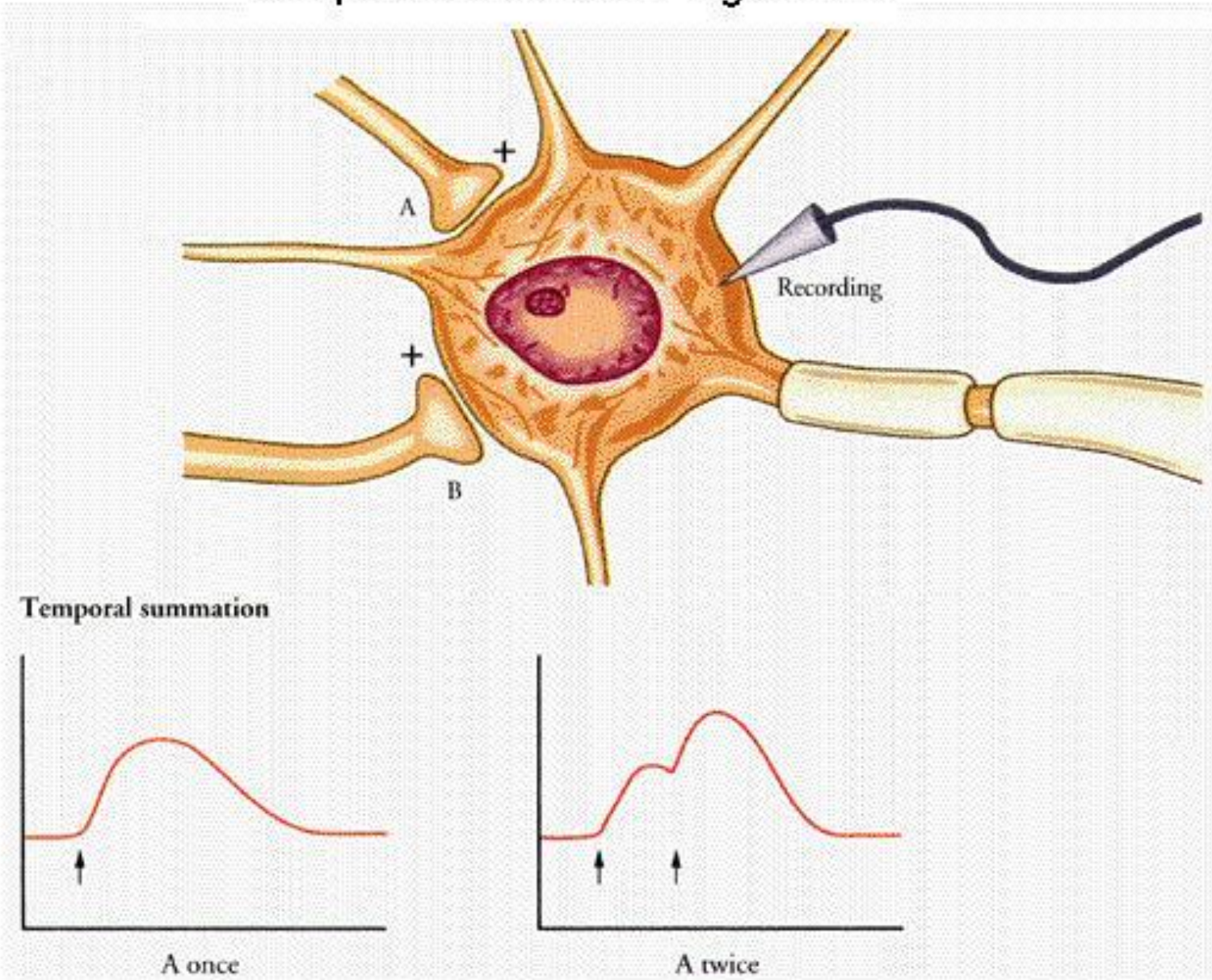
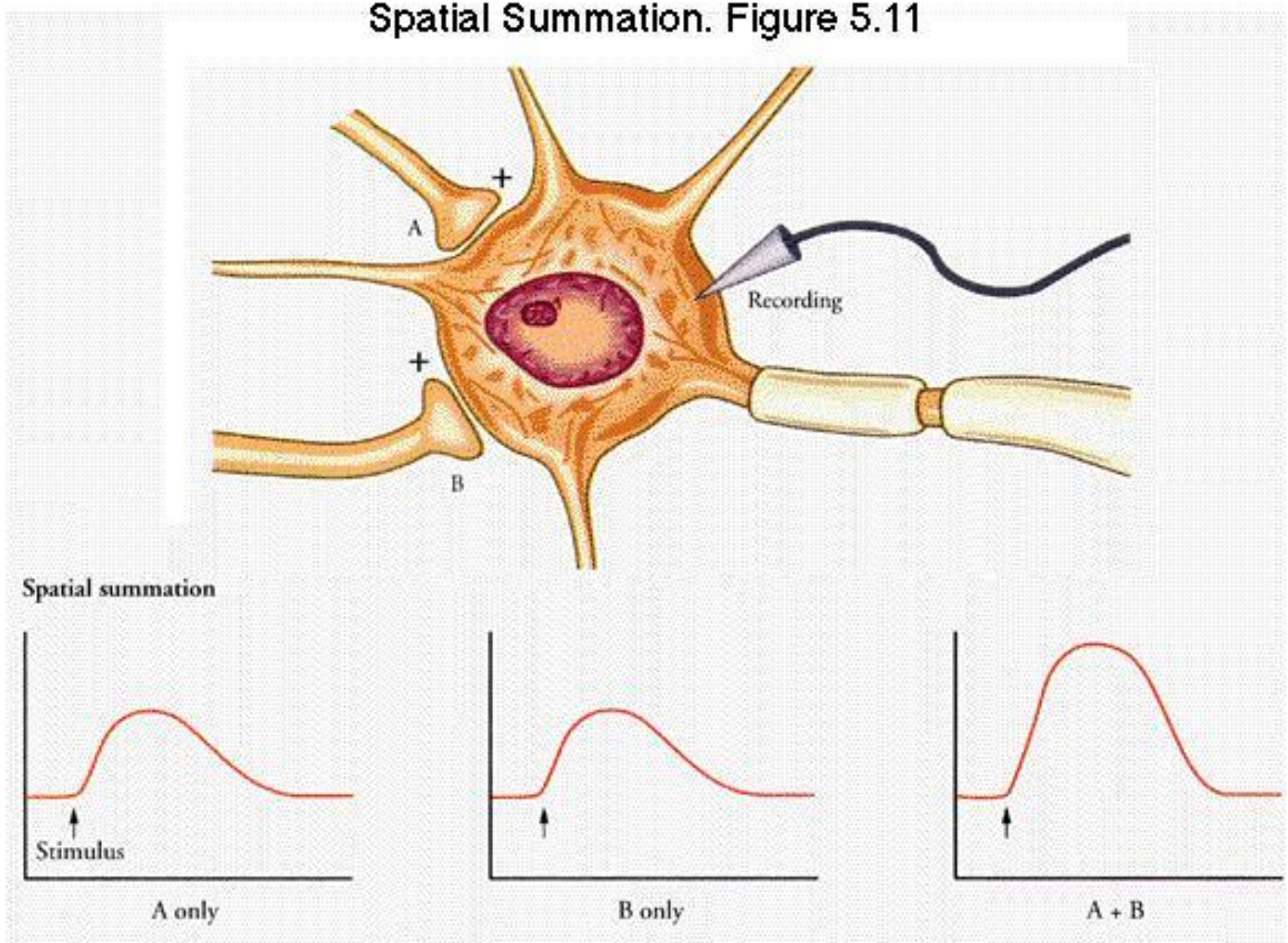


Fig. 3-14. The effect of an IPSP on the action potential; experimental arrangement as in Fig. 3-13. The homonymous nerve is stimulated strongly enough to produce a suprathreshold EPSP (*left*). On the *right*, the antagonist nerve is stimulated about 3 ms before the homonymous nerve. The equilibrium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

Temporal Summation. Figure 5.11



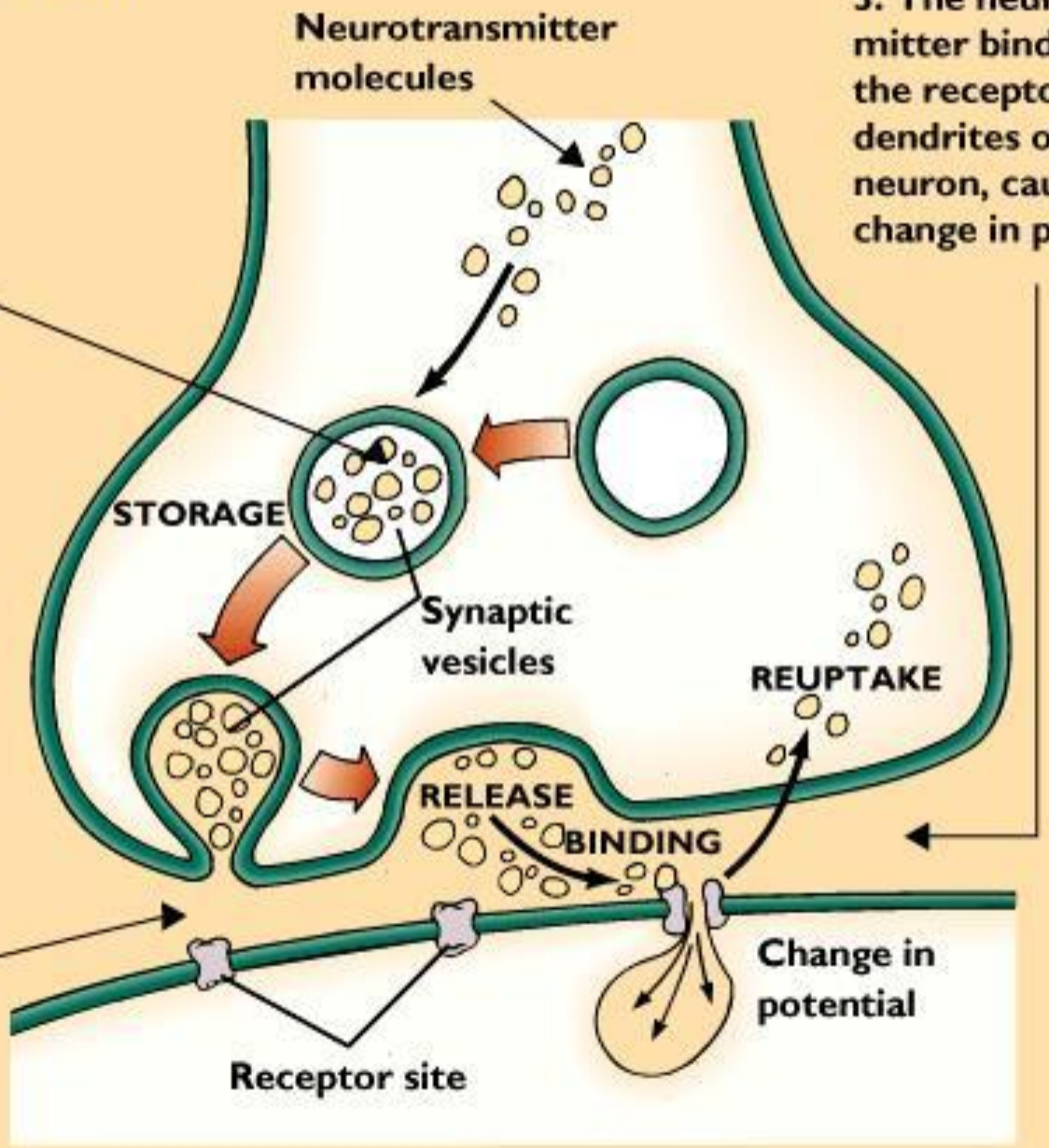
Spatial Summation. Figure 5.11



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.

Basic Neuroanatomy

If the human brain were so simple that we could understand it,

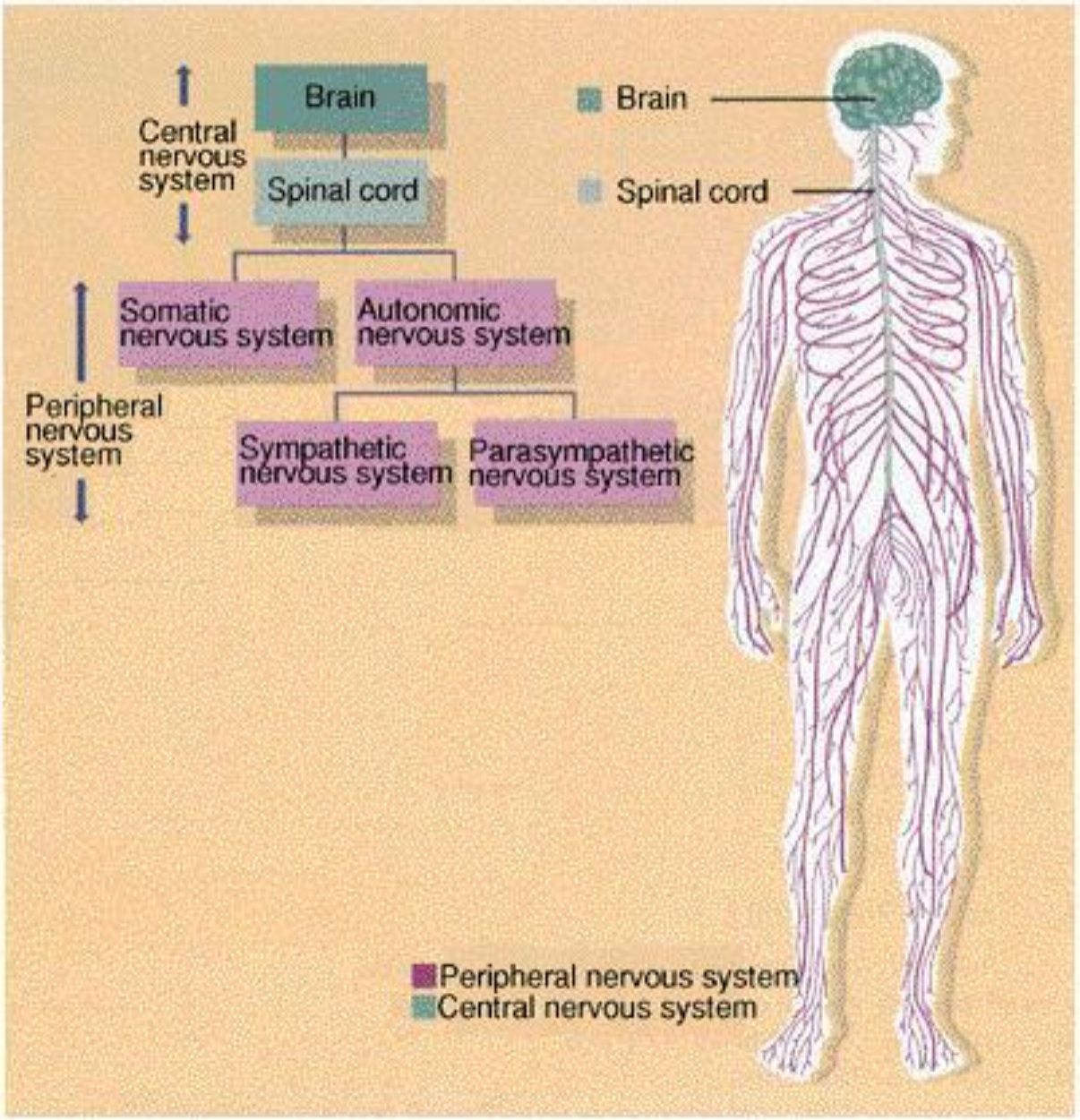
we would be so simple that we couldn't.

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

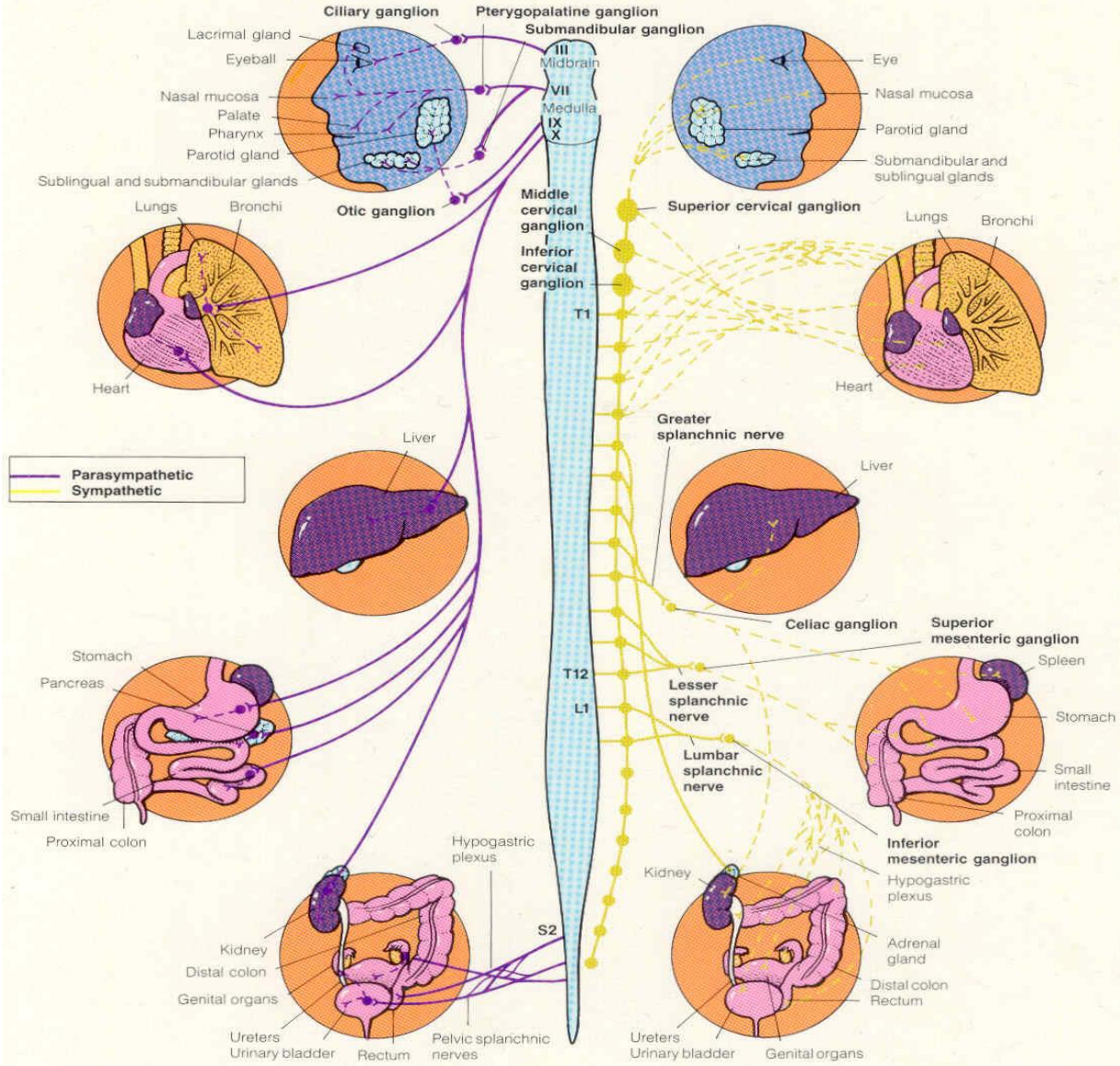
Somatic System

- 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
3. “rest and digest”

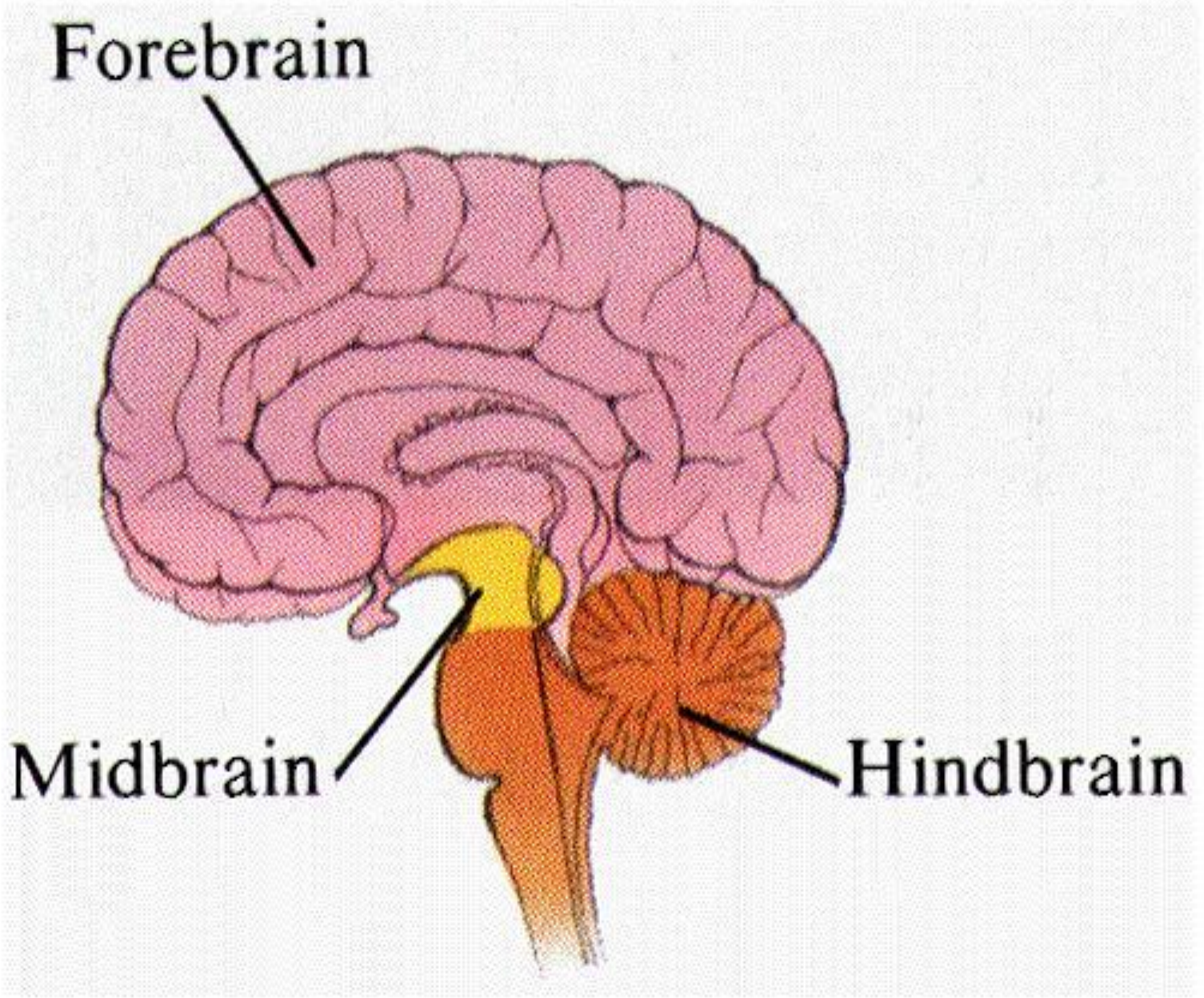
VI. The common household brain

A. Overview of brain

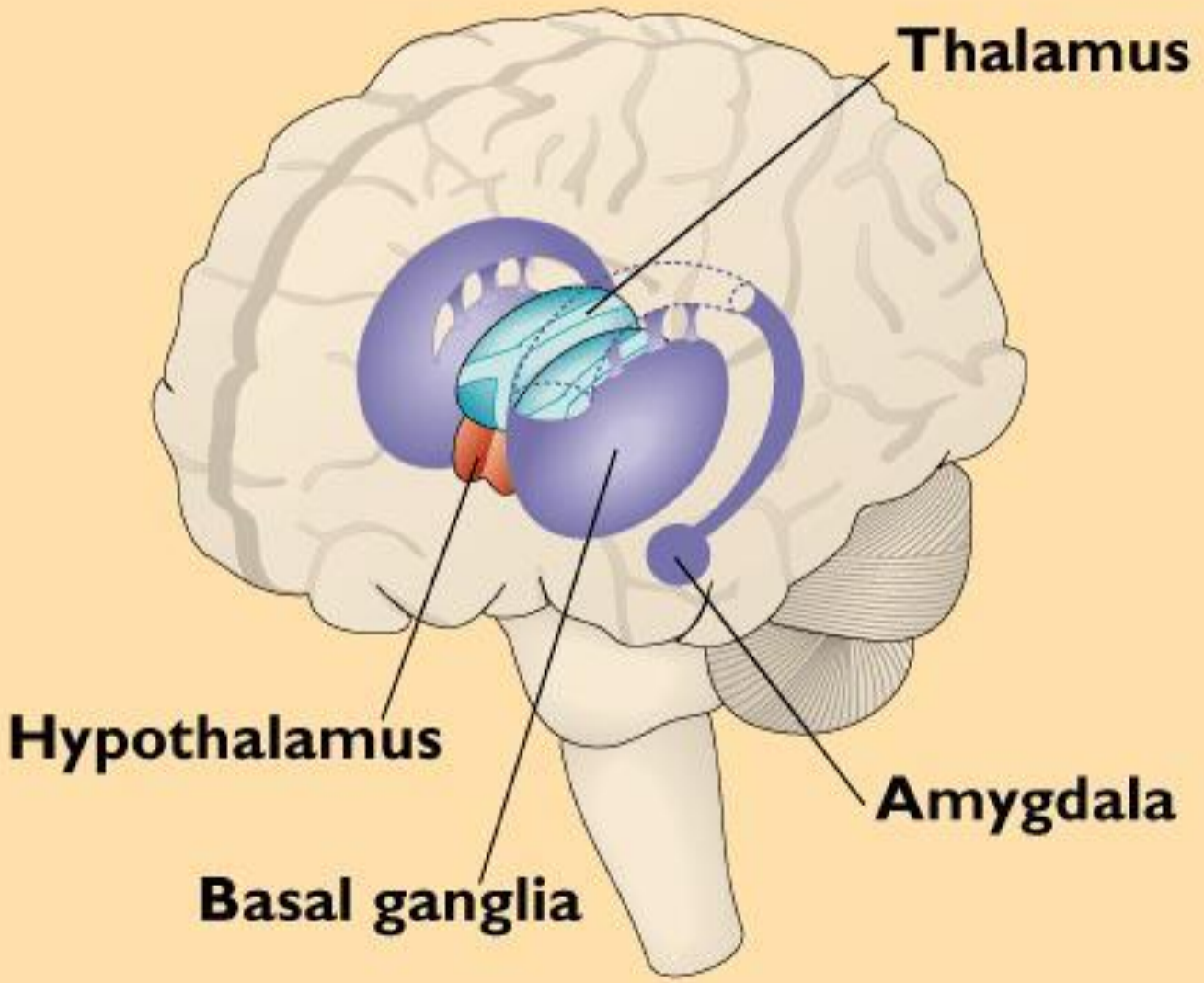
1. The primitive central core
2. Limbic system, or the "Inner Lizard"
3. Cerebrum (AKA cerebral hemispheres)
   a. Ontogeny
   b. Phylogeny
   c. Ontogeny recapitulates phylogeny
4. These three layers are interconnected extensively; do not function independently

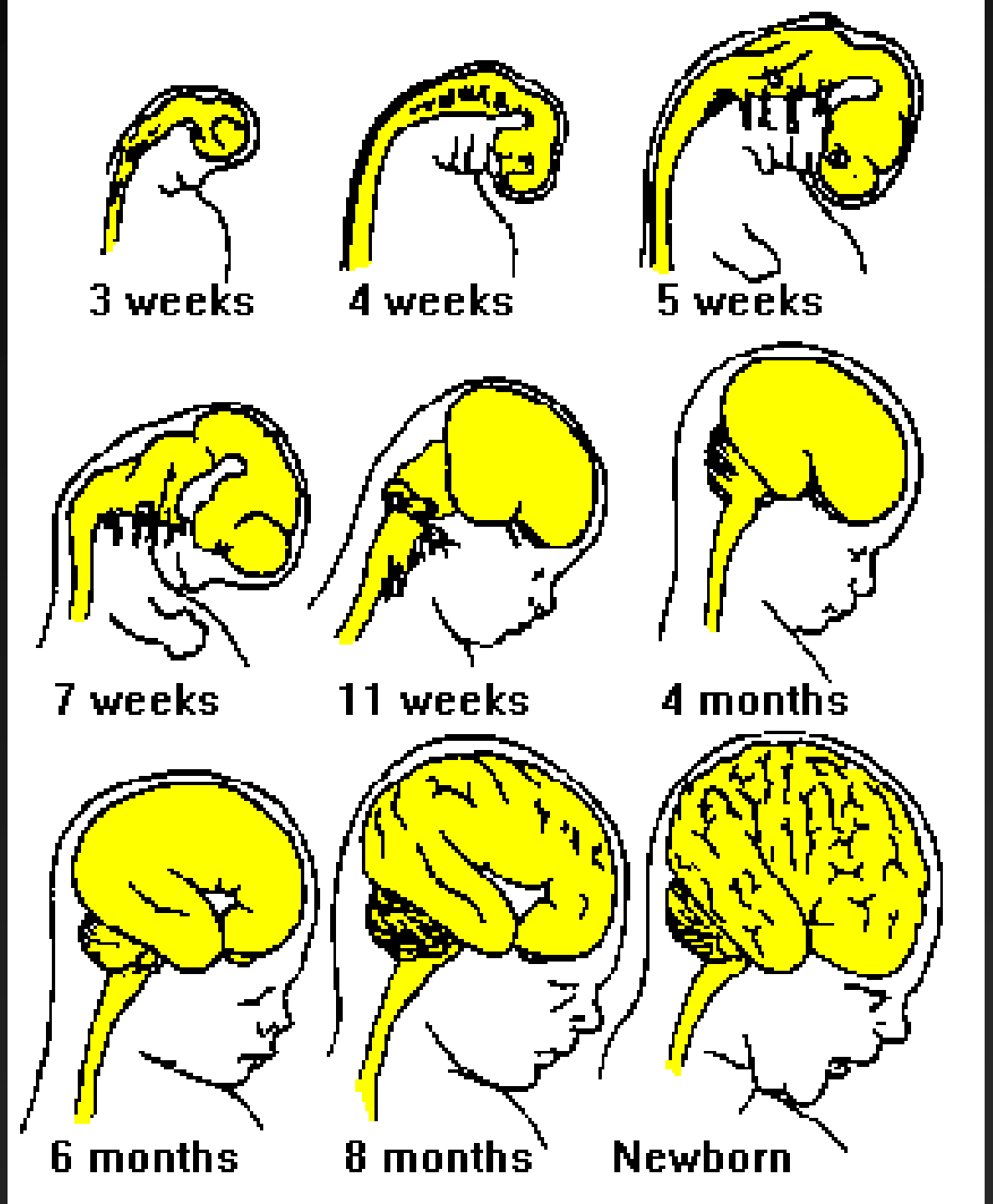
Next

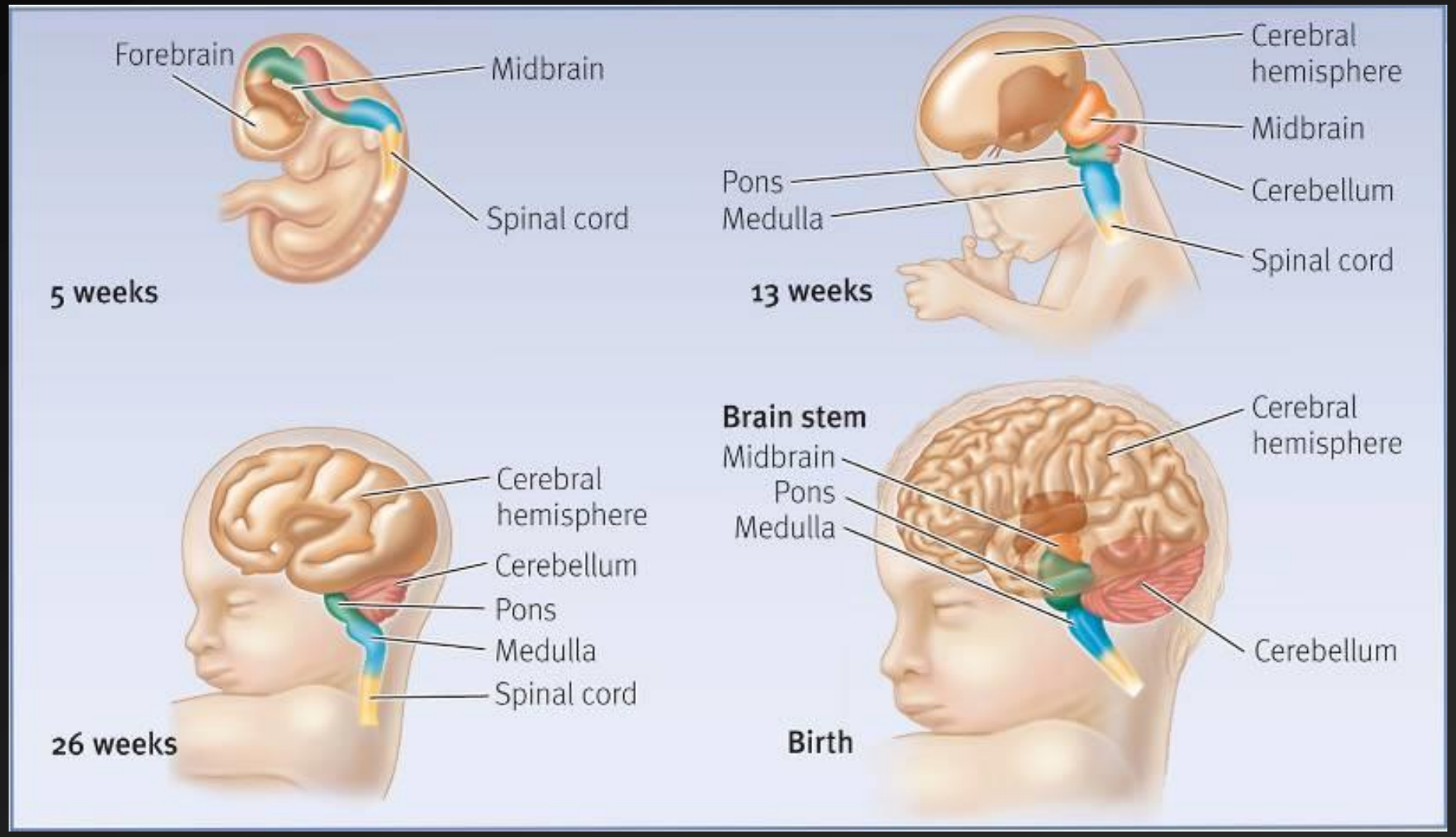
The Human Brain: Major Areas



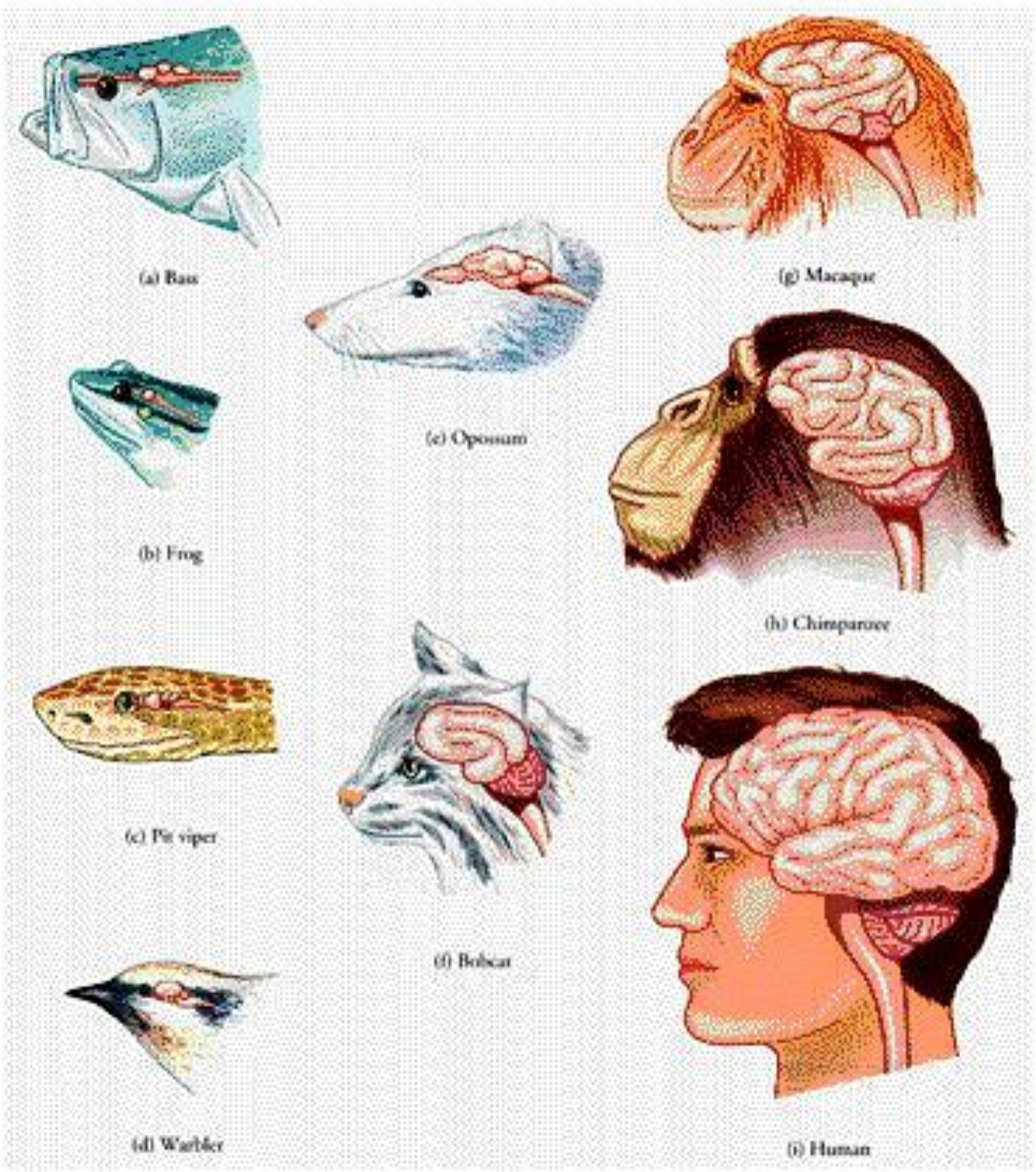
Principal Structures of the Limbic System

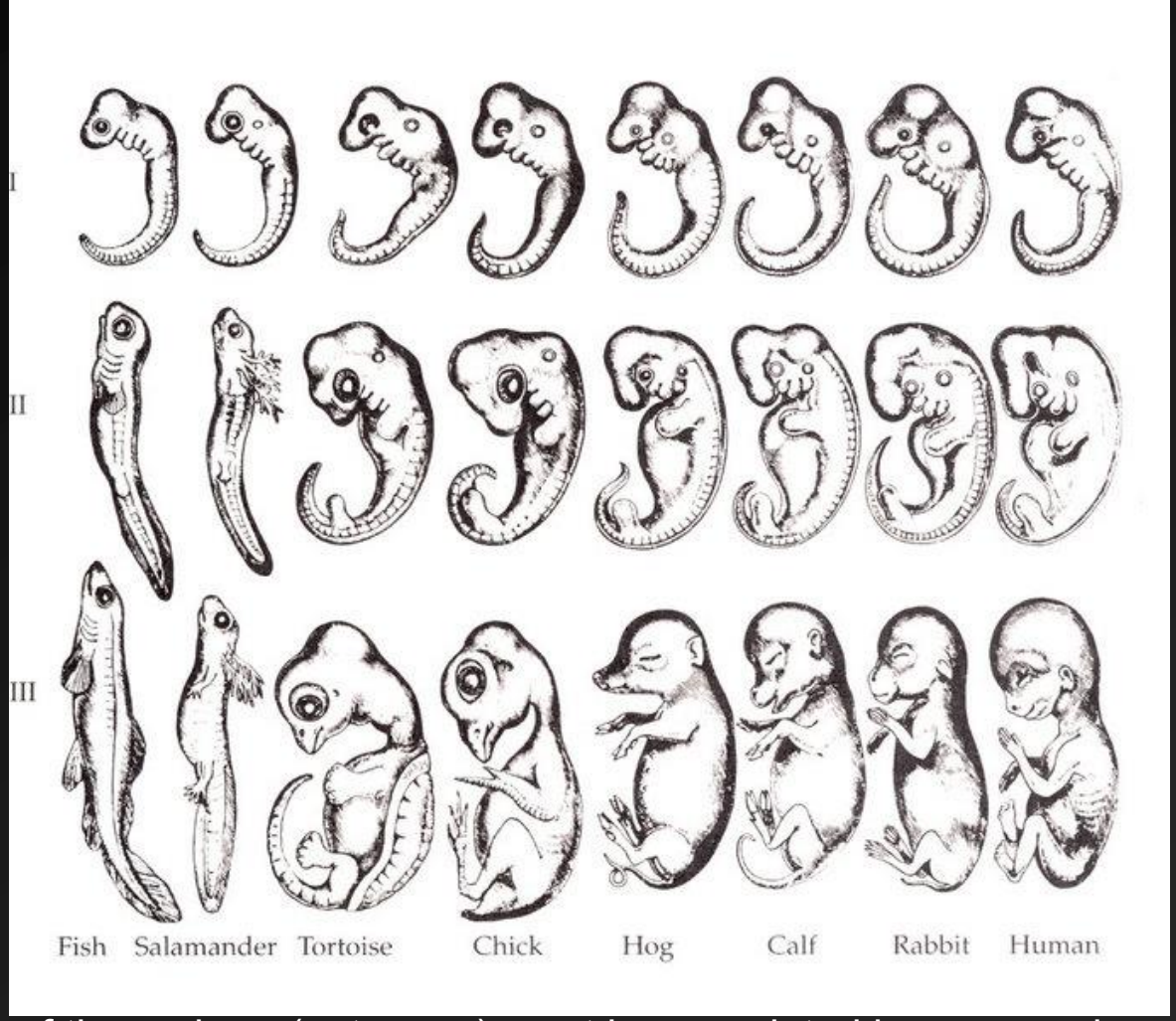



3 weeks
4 weeks
5 weeks
7 weeks
11 weeks
4 months
6 months
8 months
Newborn


Forebrain
Midbrain
Spinal cord
5 weeks
Cerebral hemisphere
Midbrain
Pons
Medulla
Cerebellum
Spinal cord
13 weeks
Cerebral hemisphere
Cerebellum
Pons
Medulla
Spinal cord
26 weeks
Brain stem
Midbrain
Pons
Medulla
Cerebral hemisphere
Cerebellum
Birth

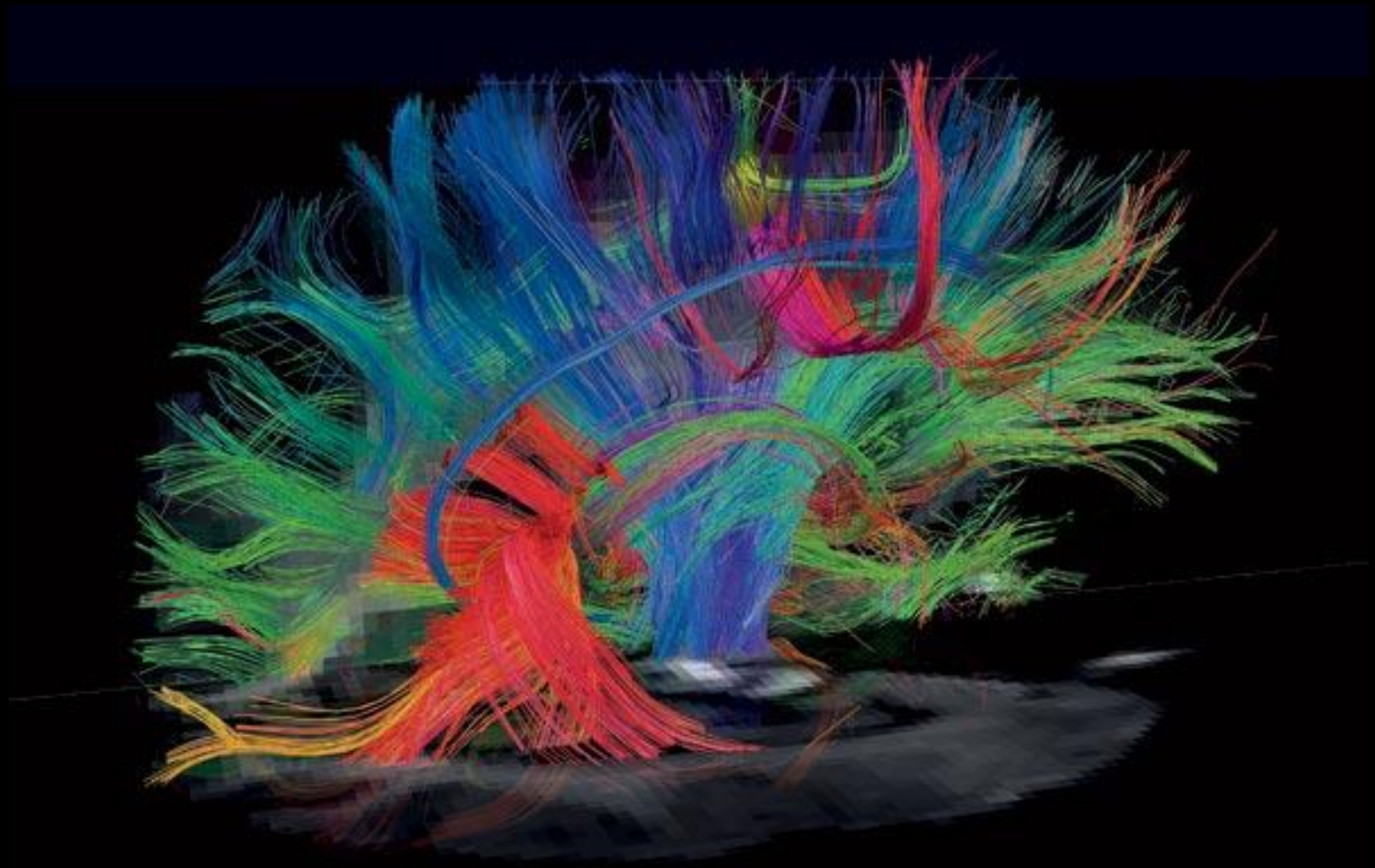
The Evolution of the Cerebrum*





“… 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).'"

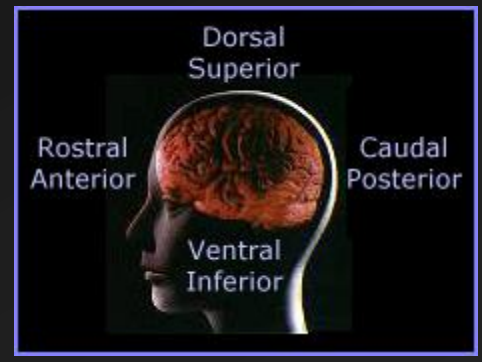
Haeckel, E. 1899. *Riddle of the Universe at the Close of the Nineteenth Century.*

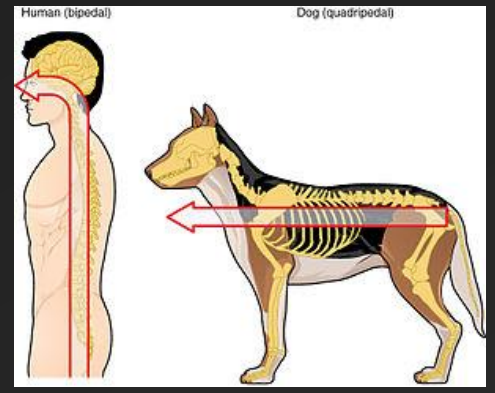


Left-Right Anterior-Posterior Superior-Inferior

Directions please!

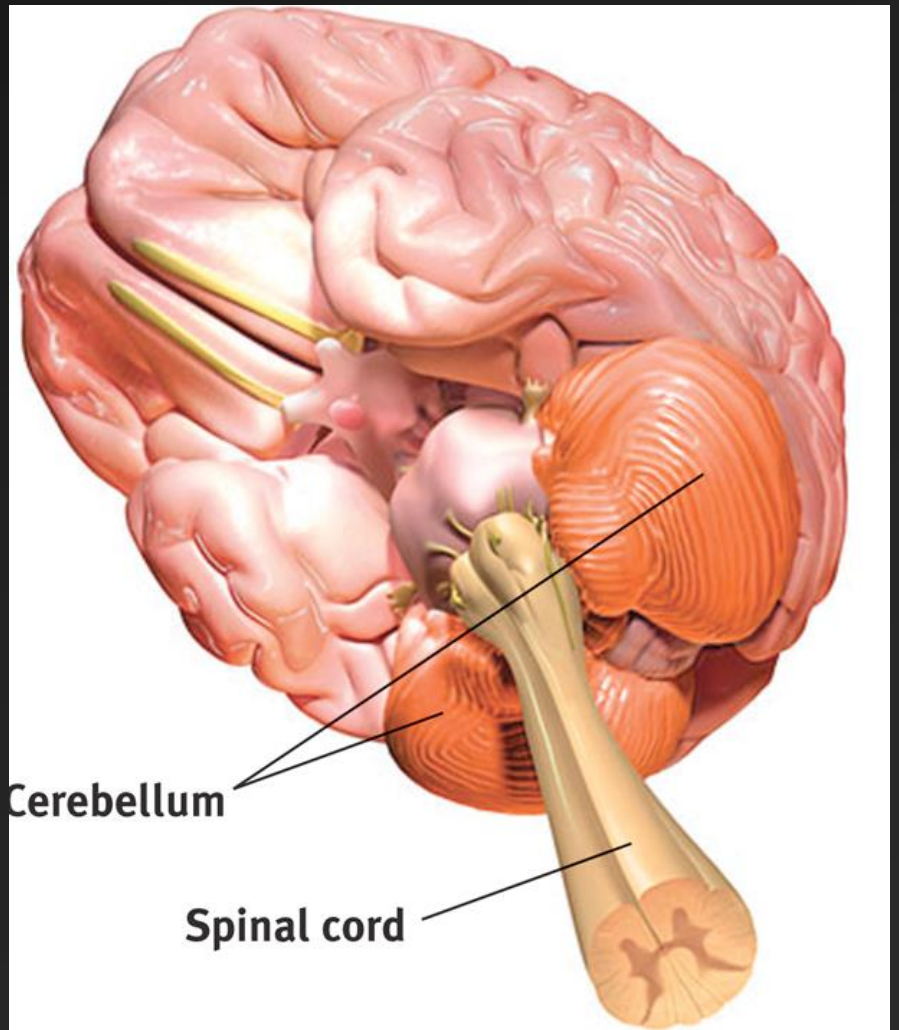
- lateral--side;
  medial--middle
- ipsilateral--same;
  contralateral--opposite
- proximal--toward the soma;
  distal--away from the soma
- anterior--front;
  posterior--back
- ventral--front
  dorsal--back
- rostral--towards the nose;
  caudal--towards the tail
- efferent--output/motor;
  afferent--receiving/sensory





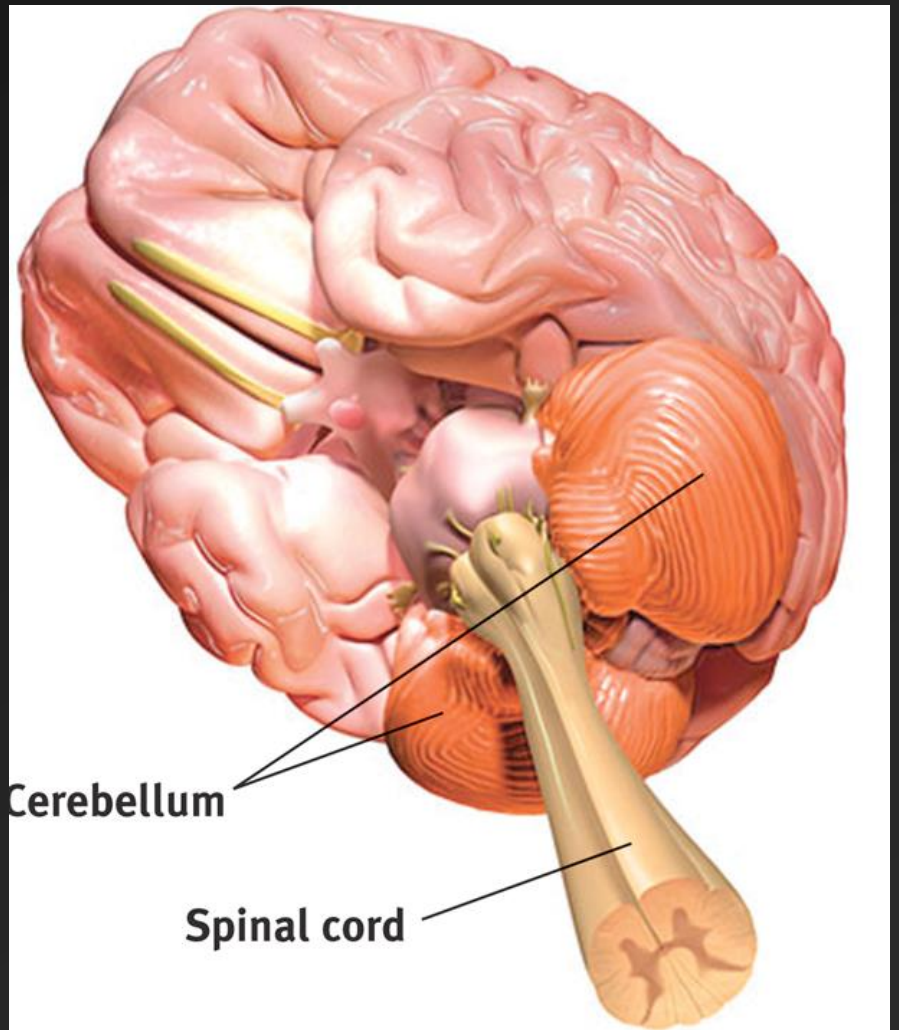
B. Brain Specifics

1. Primitive central core
   a. Cerebellum
      1. "little brain"
      2. smooth coordination of movements
      3. learning of complex motor activities



B. Brain Specifics

1. Primitive central core
    a. Cerebellum
        1. "little brain"
        2. smooth coordination of movements
        3. learning of complex motor activities



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

B. Brain Specifics

1. Primitive central core

b. Thalamus & Hypothalamus:

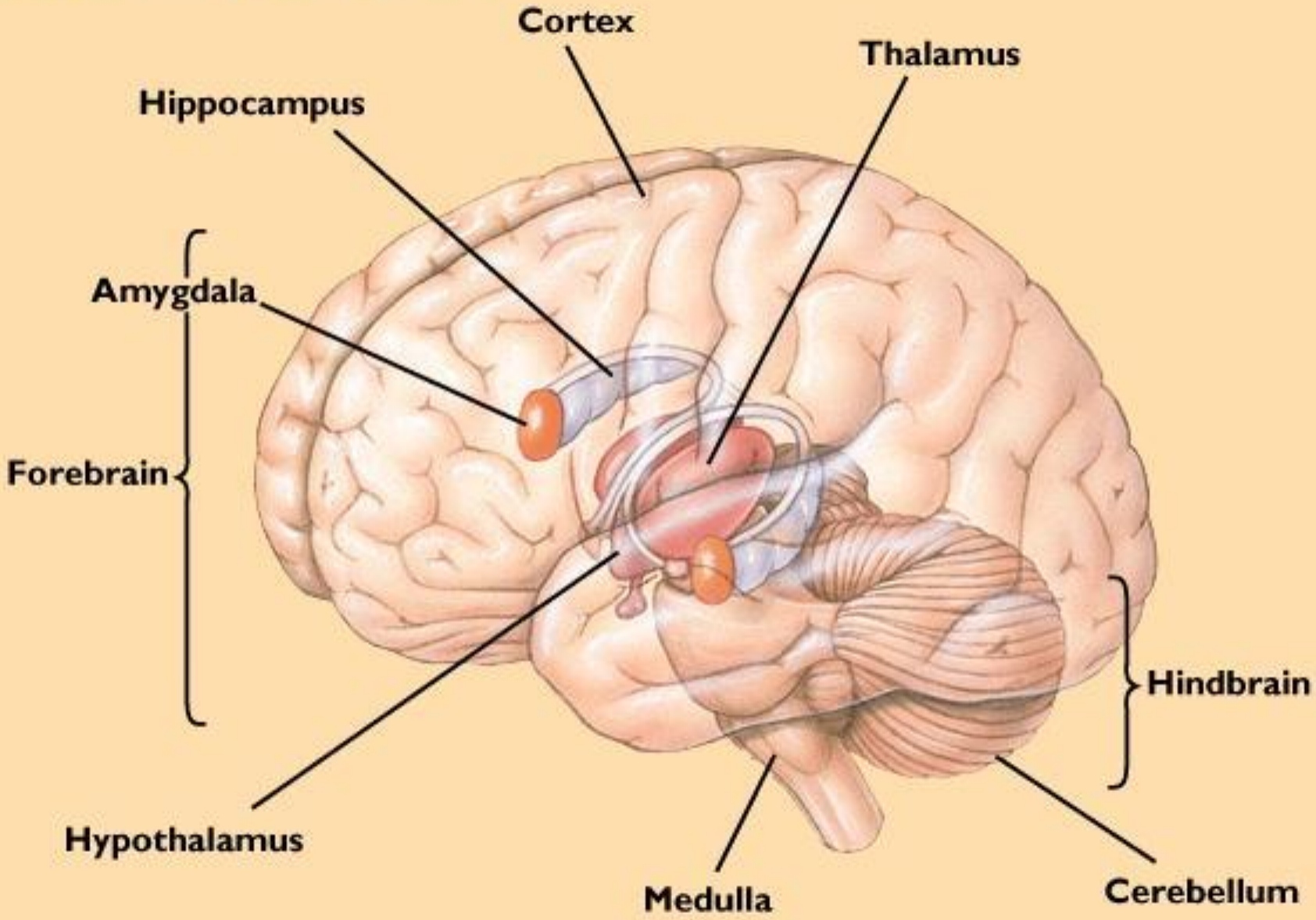
2.Hypothalamus

a. literally = "under thalamus"

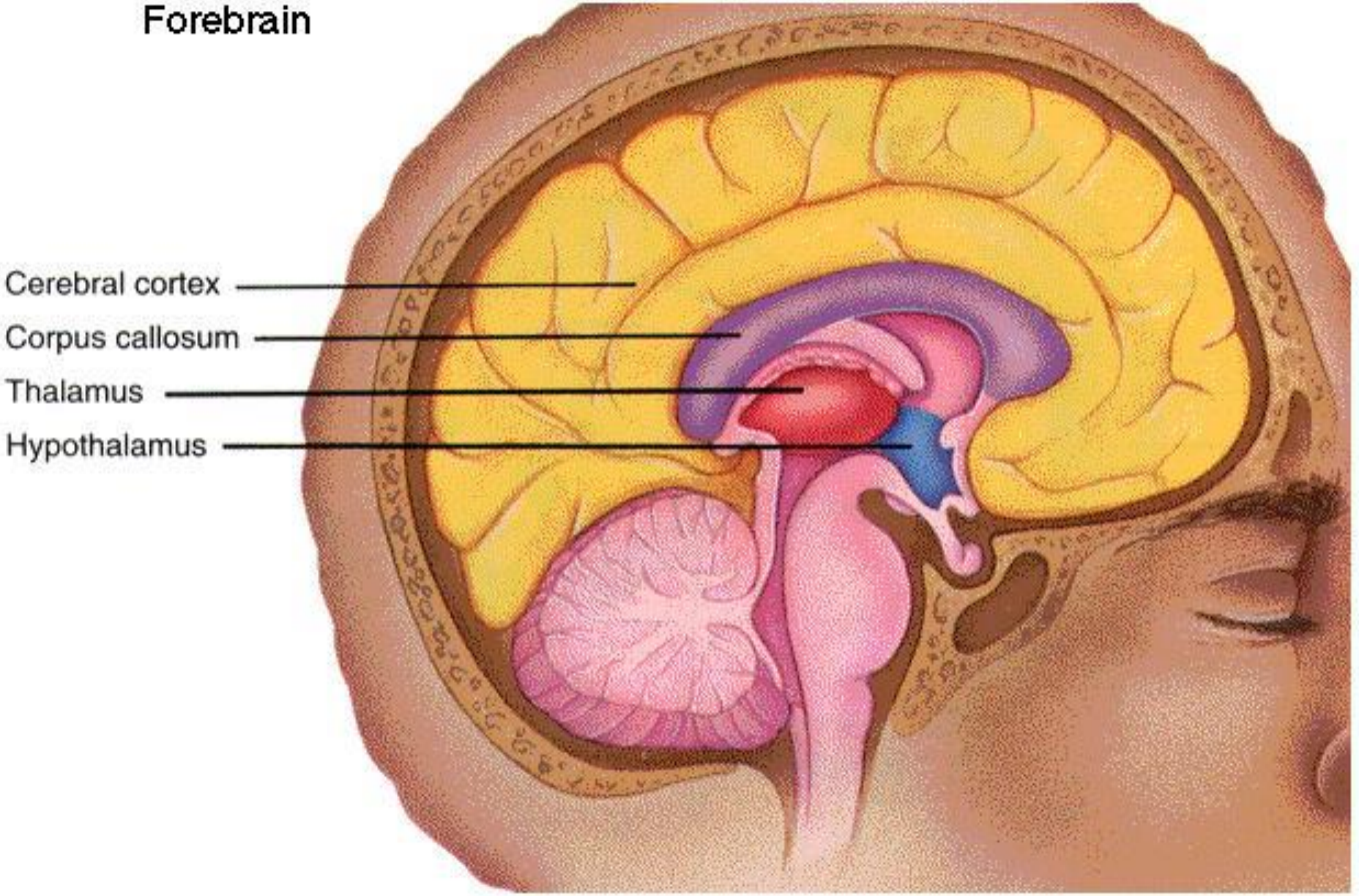
b. 4 F's:

Emotion/Motivation	Feelings/Fleeing/Fighting
Thirst/Hunger	Feeding
Body Temp	Fever
Sexual Drives	Fourth F

Structures of the Brain



Forebrain



B. Brain Specifics

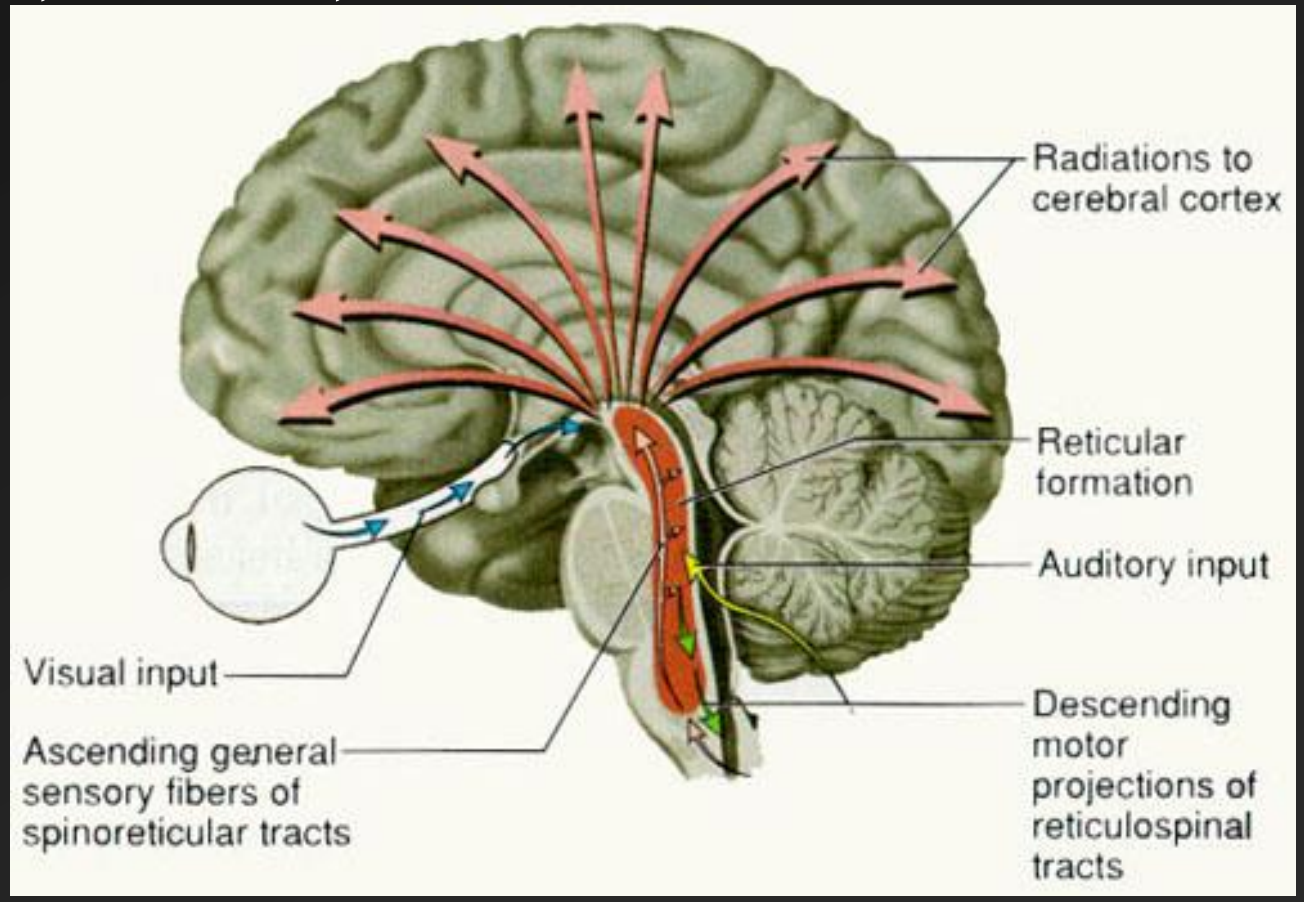
1. Primitive central core
    b. Basal Ganglia:
        1. Necessary for voluntary motor movements
        2. Involved in numerous disorders
            a. Parkinson’s
            b. Obsessive-Compulsive

B. Brain Specifics

1. Primitive central core

c. Reticular system

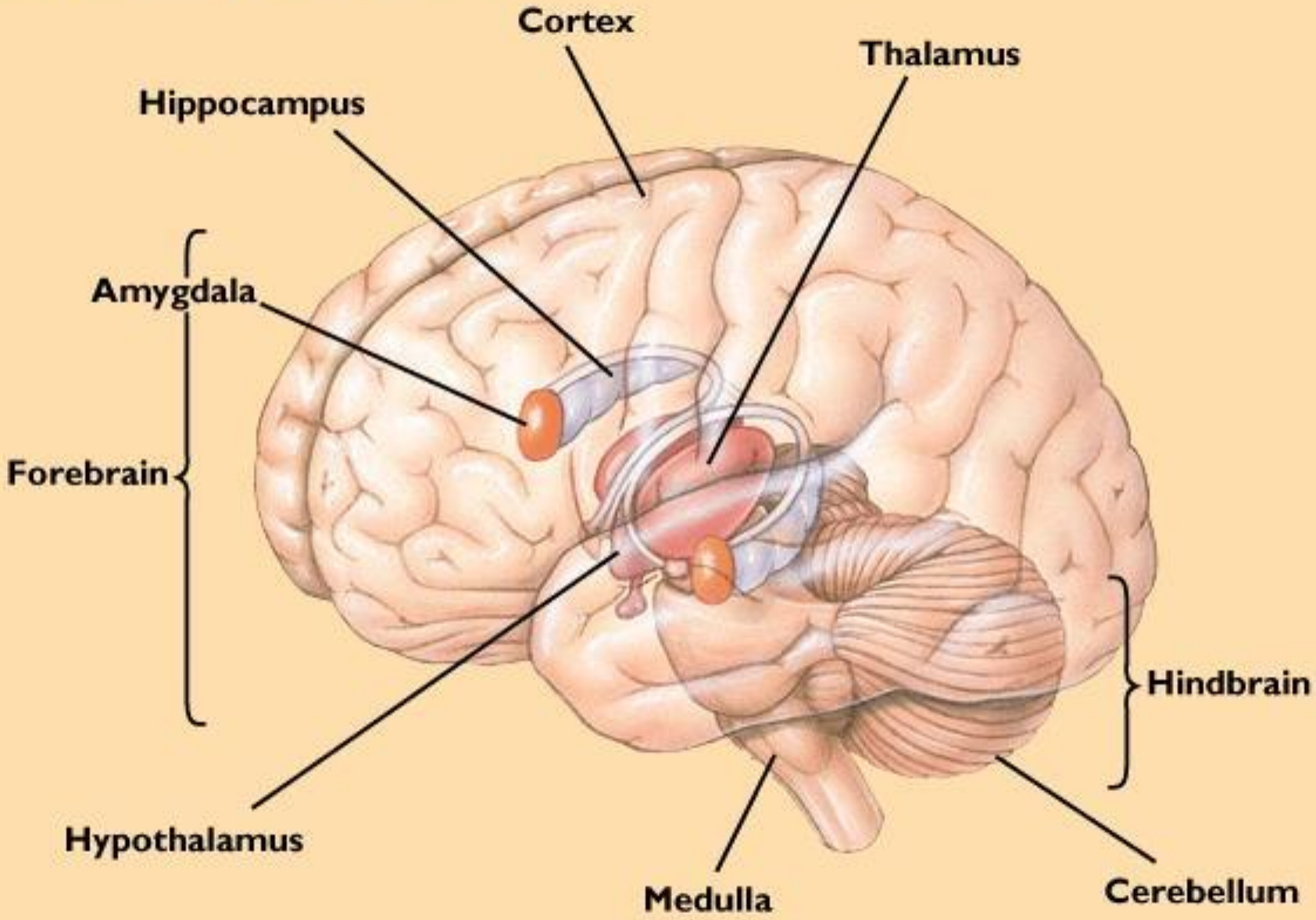
1. diffuse from brainstem to thalamus
2. 3 A's, arousal, awareness, attention



B. Brain Specifics

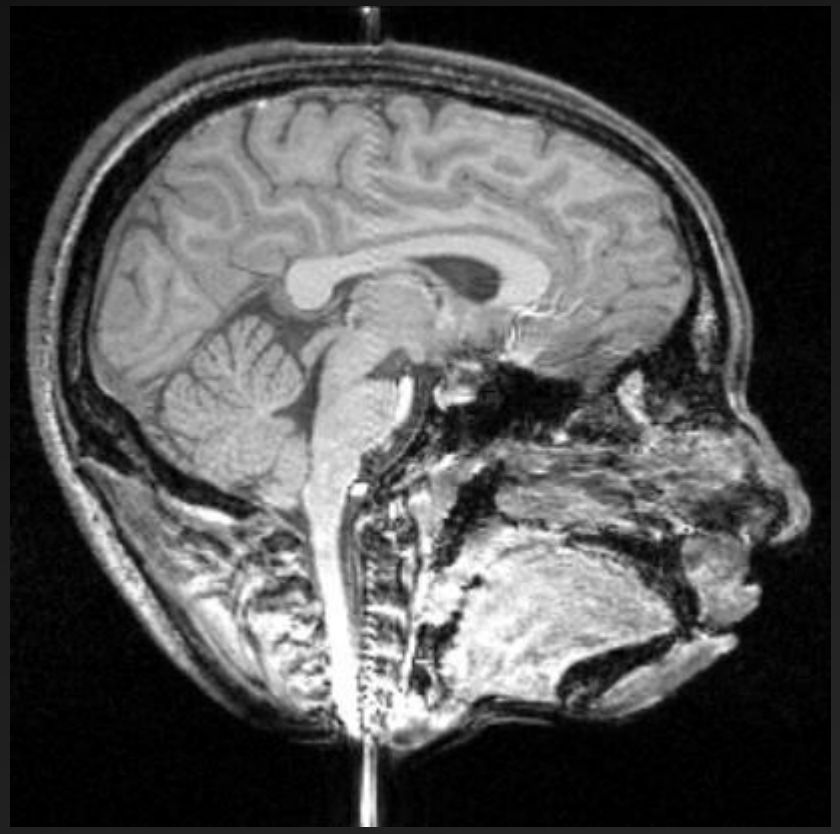
2. Limbic system
    a. a group of structures lying along the innermost edge of the cerebral hemispheres
    b. involved in instinctual behaviors in lower animals (caring for young, mating, fleeing from attackers, fleeing from prey)
    c. involved in memory and emotion in humans
    d. Especially important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

Structures of the Brain

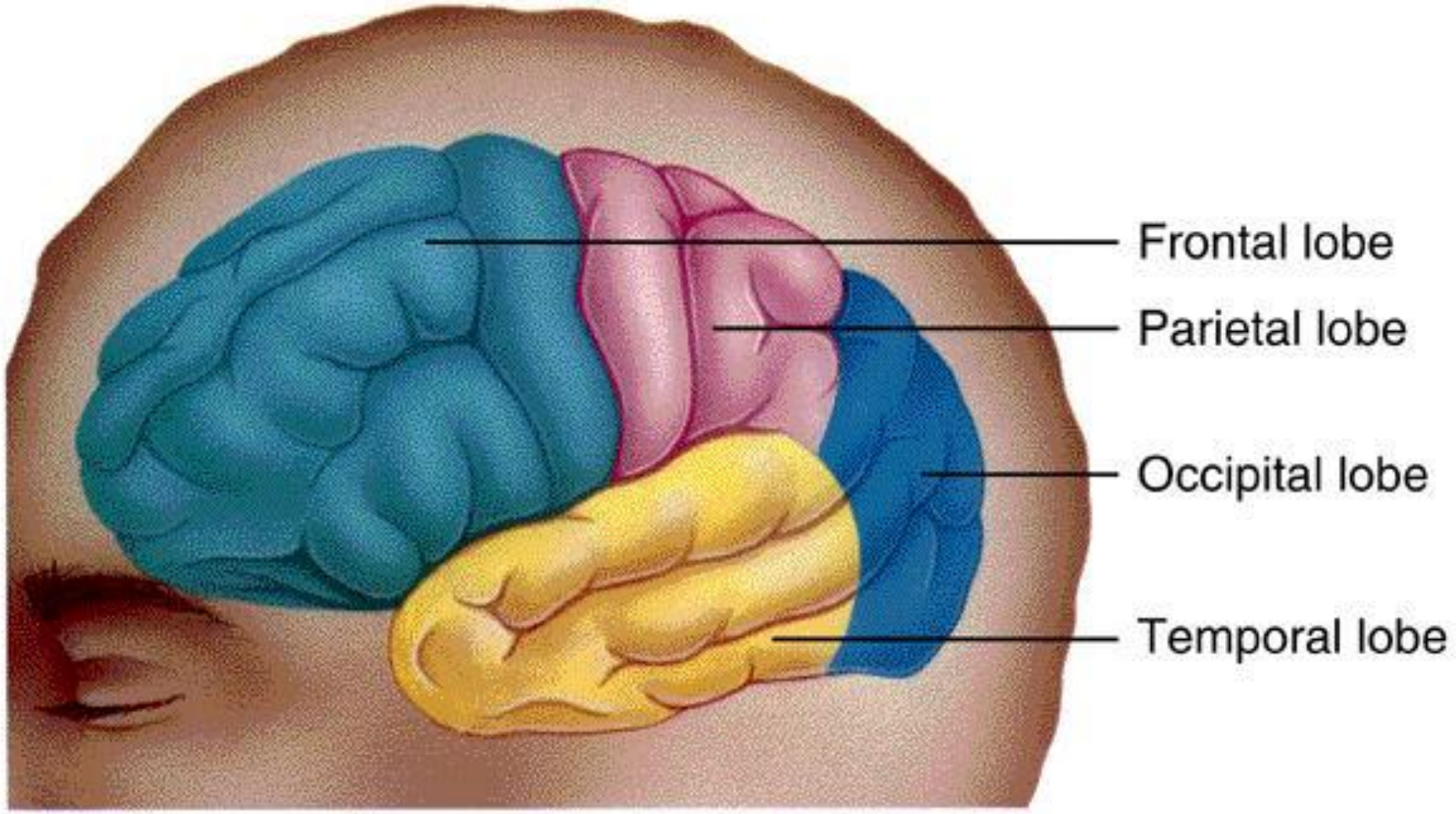


The common household brain

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

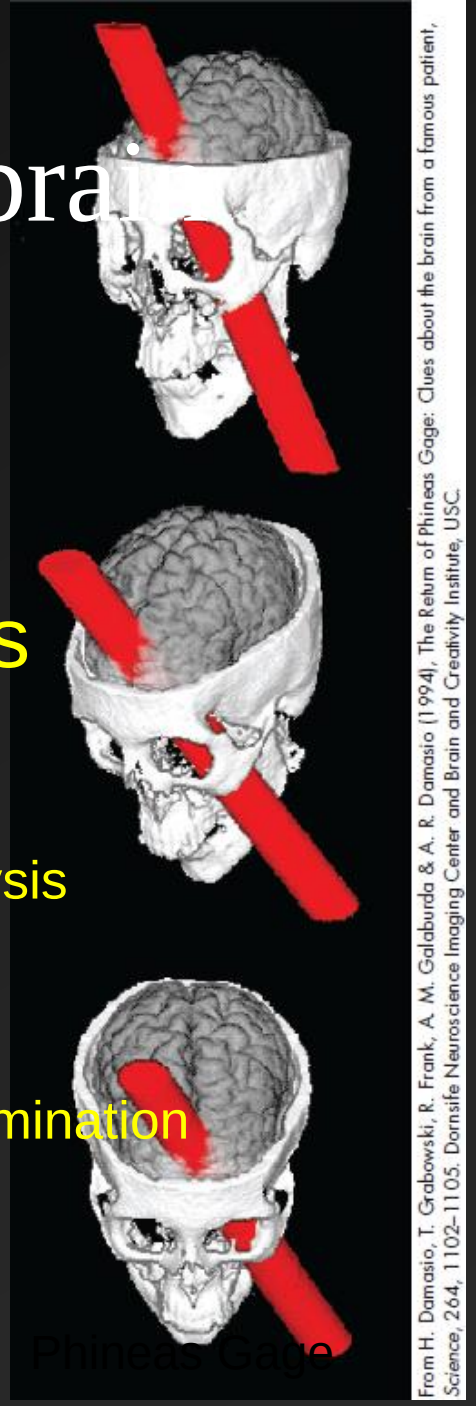


Four Lobes of the Cerebral Cortex



The common household bra

3. The cerebral hemispheres
   b. Four lobes: Sample Functions
      1. frontal — Planning, Abstract thought, Motor
      2. parietal — Sensory Integration, Spatial analysis
      3. occipital — Visual Perception
      4. temporal — Object Identification, sound discrimination

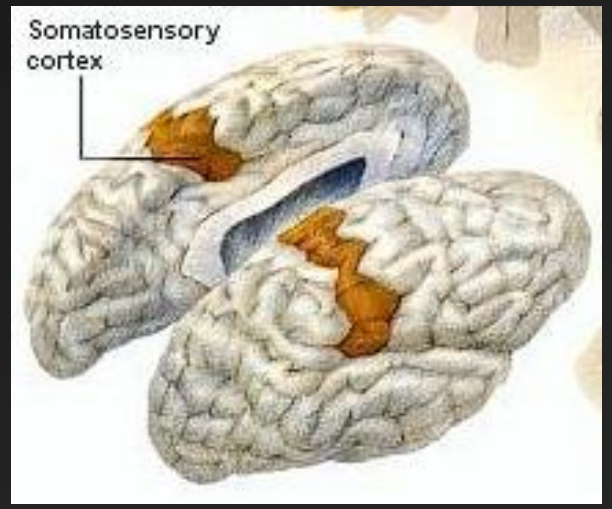


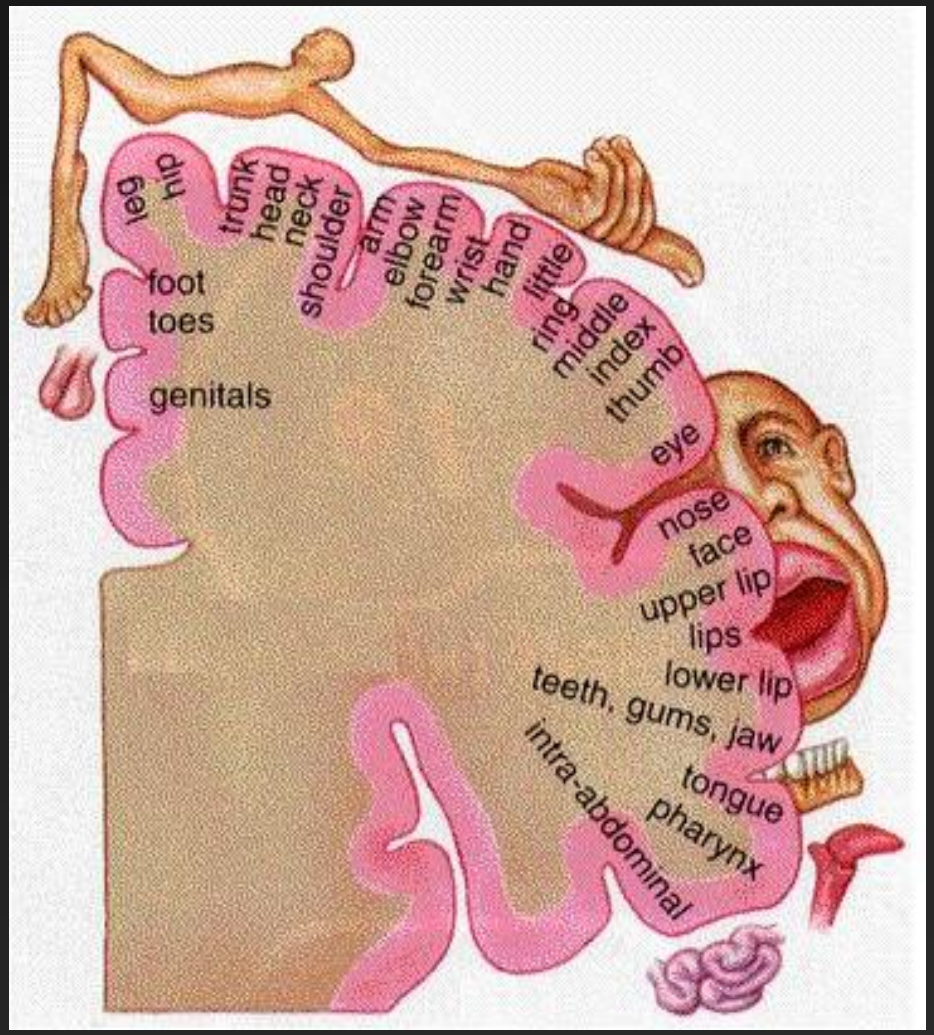
Phineas Gage

From H. Damasio, T. Grabowski, R. Frank, A. M. Galaburda & A. R. Damasio (1994), The Return of Phineas Gage: Clues about the brain from a famous patient, *Science*, 264, 1102–1105. Dornsife Neuroscience Imaging Center and Brain and Creativity Institute, USC.

The common household brain

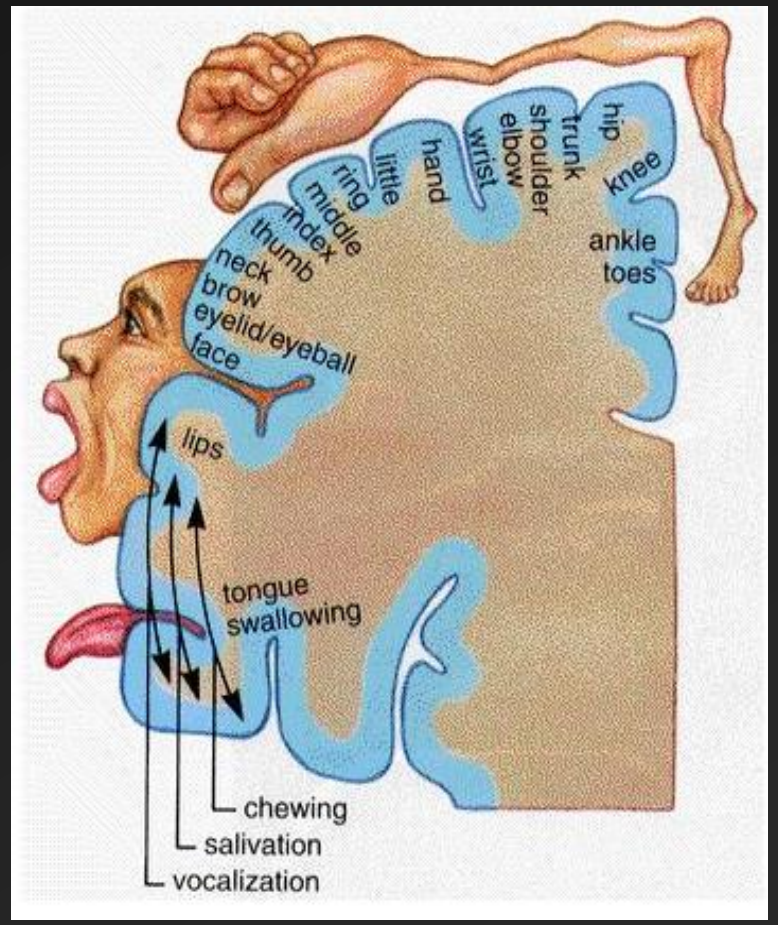
3. The cerebral hemispheres
   c. Somatosensory area
      1. heat, cold, touch, pain, sense of body movement
      2. contralateral
      3. space appropriated in accord to amount of use or need

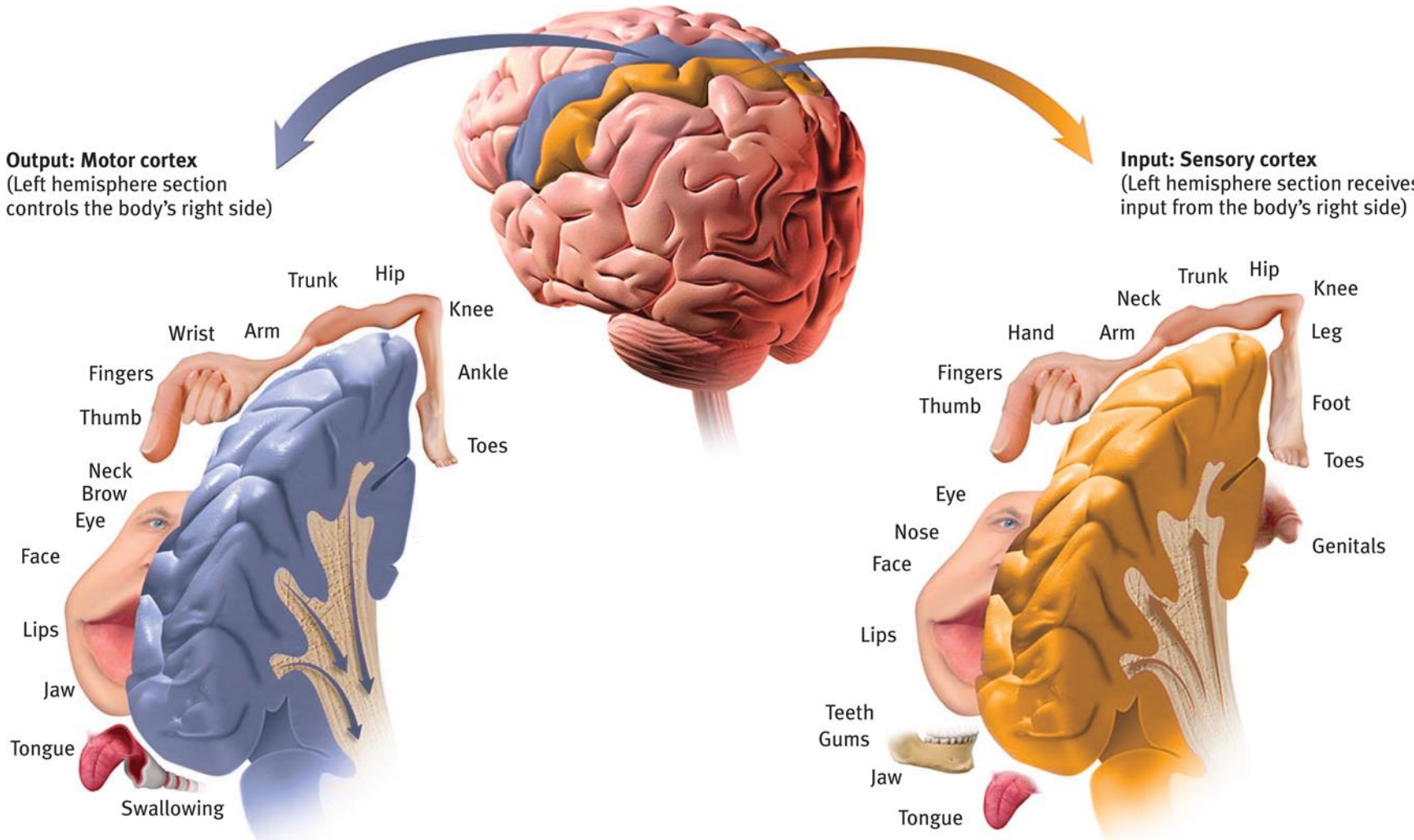




The common household brain

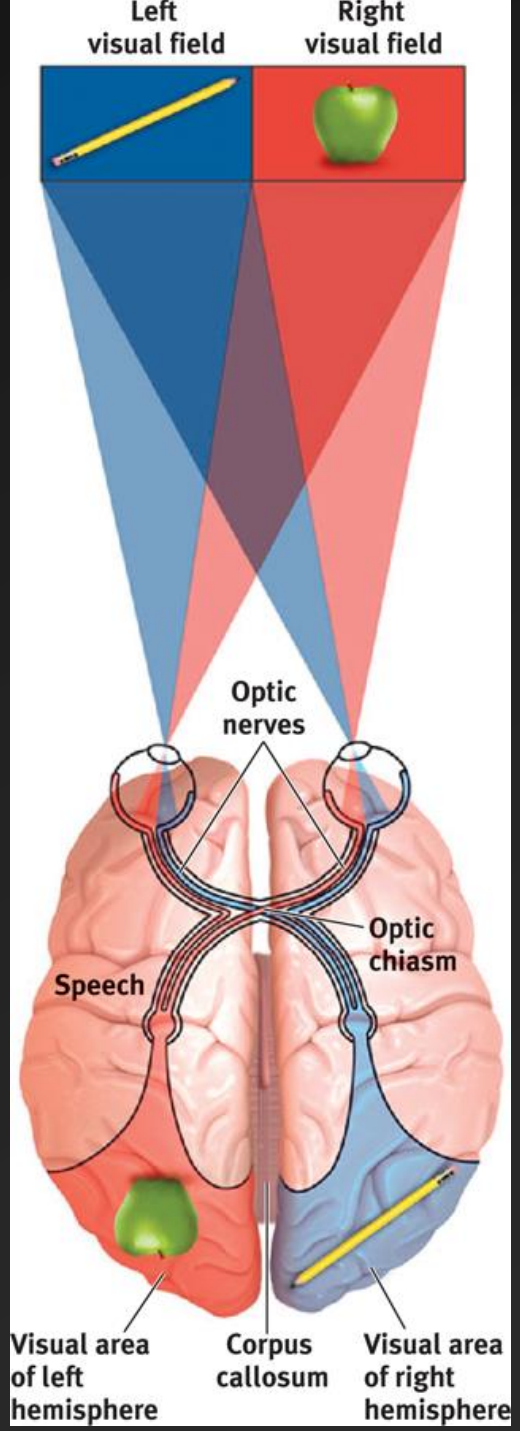
3. The cerebral hemispheres
    d. Motor area
        1. topographic organization--Homunculus
        2. contralateral control of body

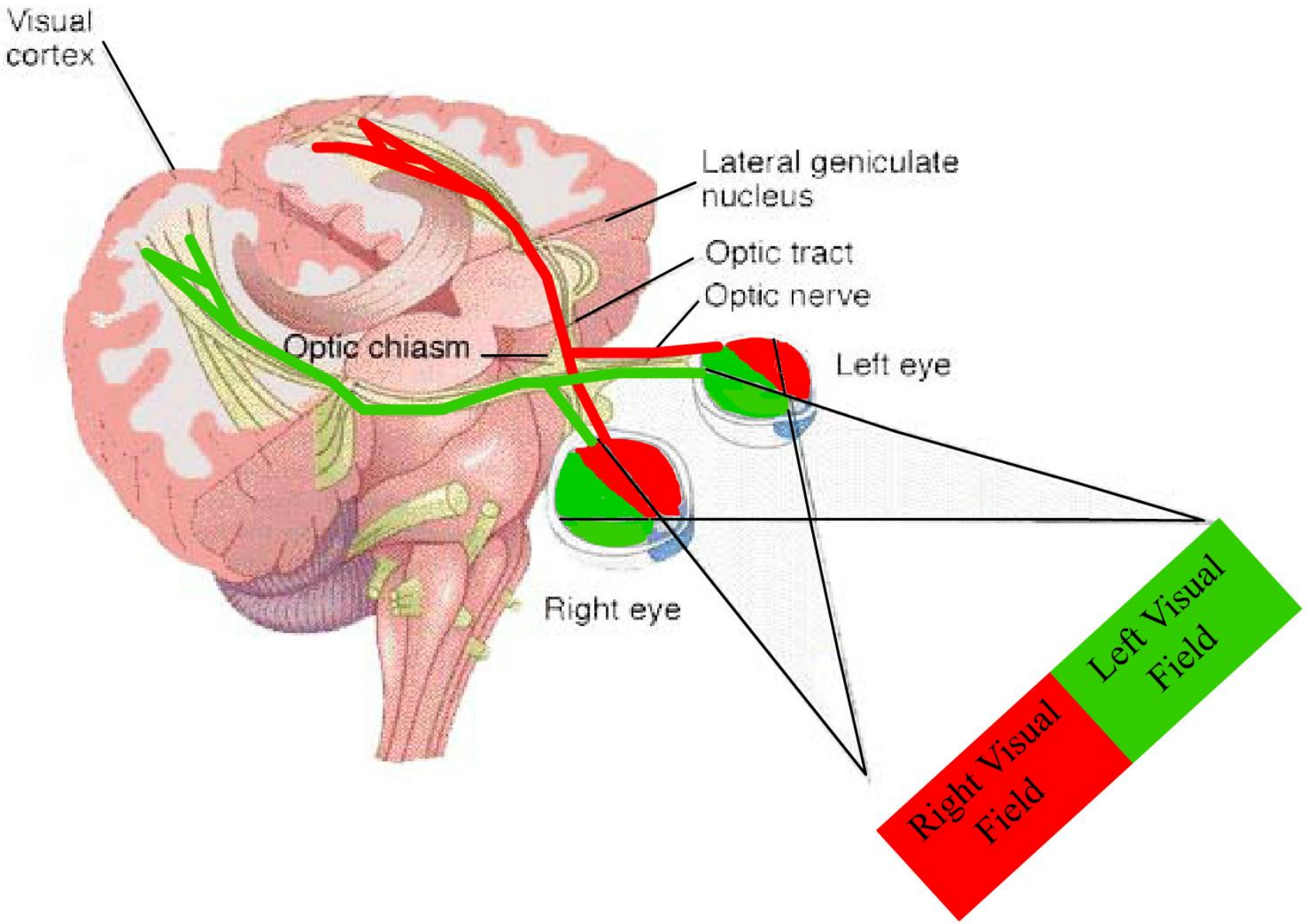



Output: Motor cortex
(Left hemisphere section controls the body's right side)
Trunk
Hip
Knee
Wrist
Arm
Fingers
Ankle
Thumb
Toes
Neck
Brow
Eye
Face
Lips
Jaw
Tongue
Swallowing
Input: Sensory cortex
(Left hemisphere section receives input from the body's right side)
Trunk
Hip
Knee
Neck
Hand
Arm
Leg
Fingers
Thumb
Foot
Toes
Eye
Nose
Face
Genitals
Lips
Teeth
Gums
Jaw
Tongue

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

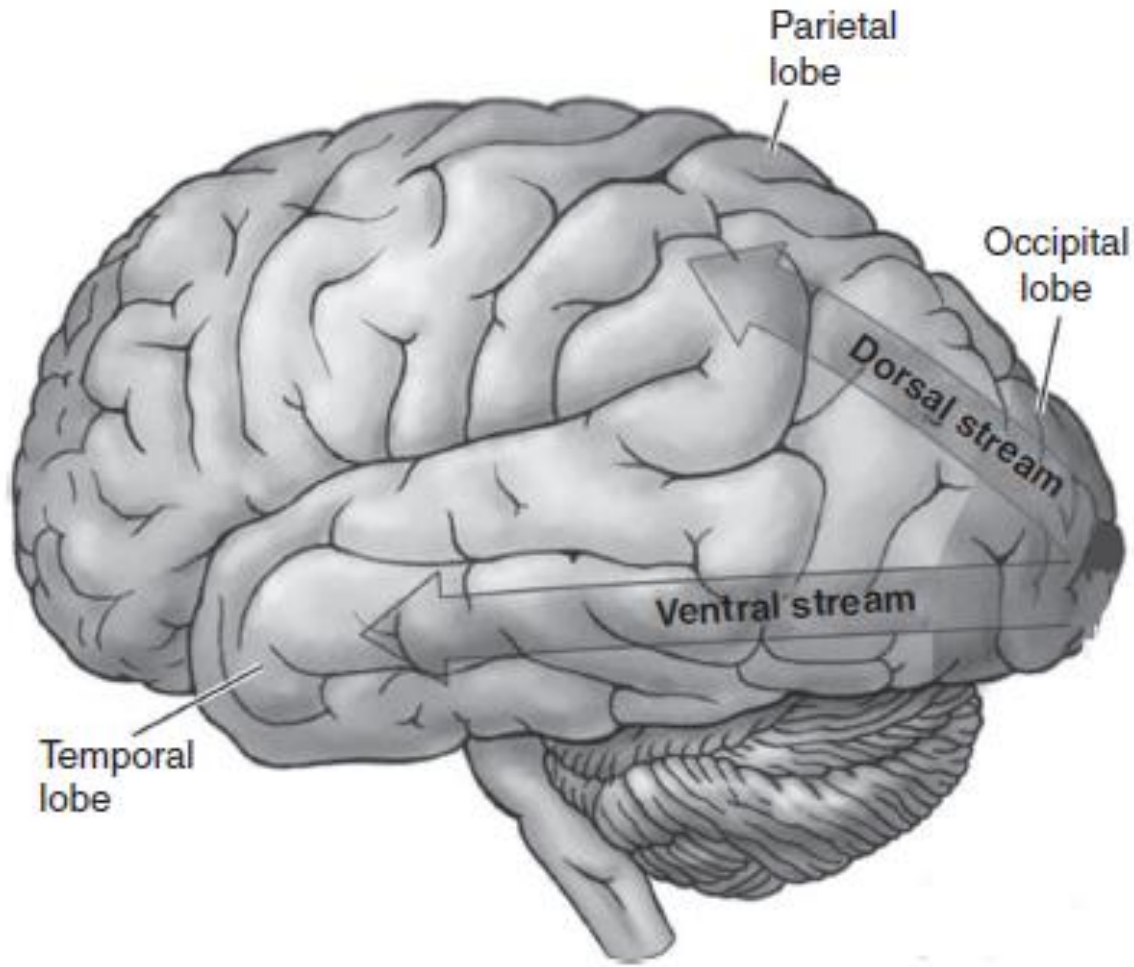
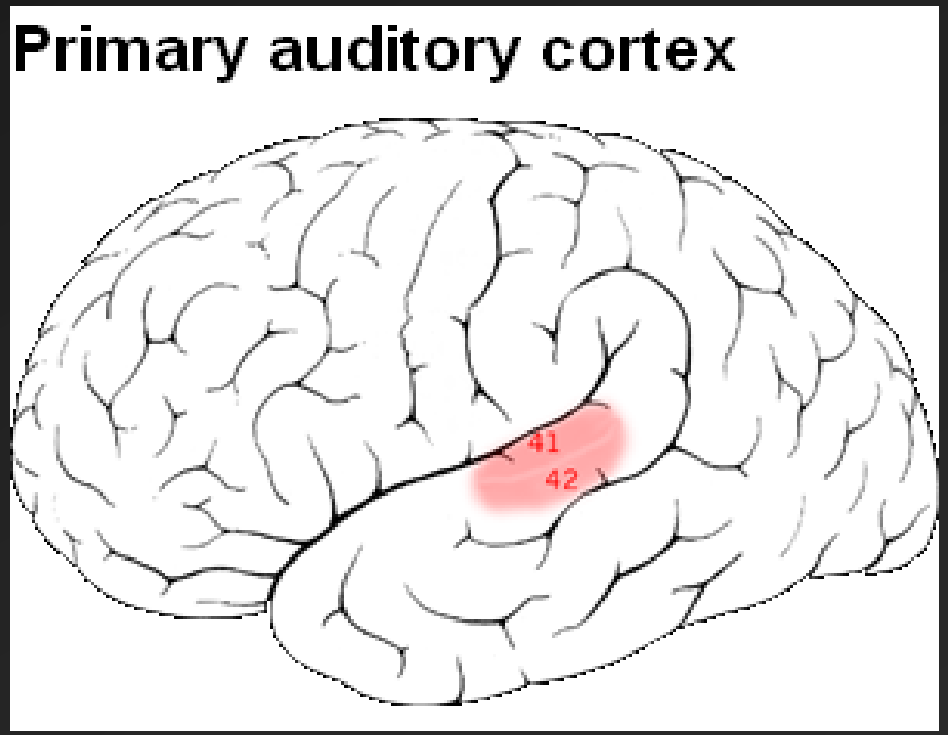


Figure 3.1 Two streams of visual processing. The dorsal stream is an unconscious online control of movement. The ventral stream is a conscious system for object recognition. (Adapted from Kolb & Whishaw, 2003.)

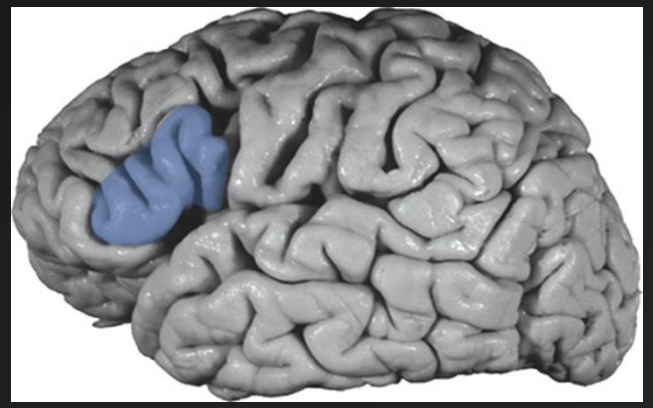
The common household brain

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

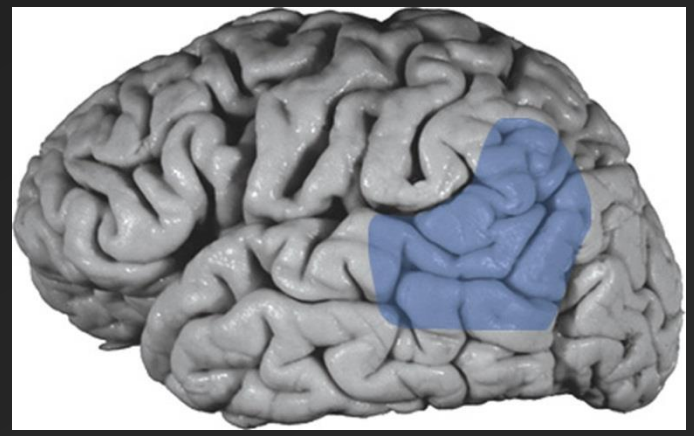


The common household brain

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)



Broca's



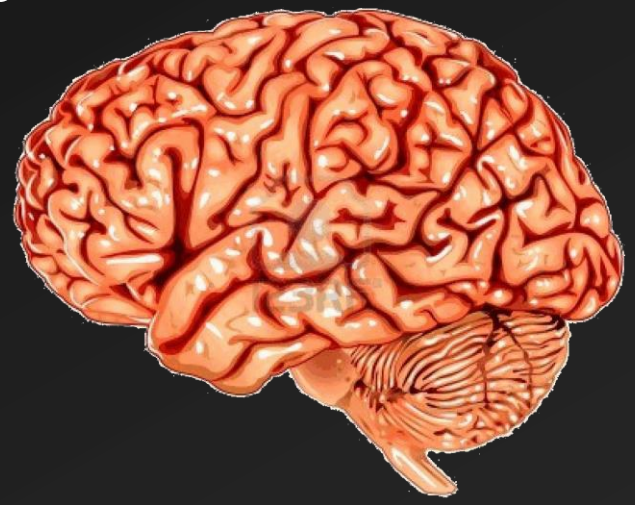
Wernicke's

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)

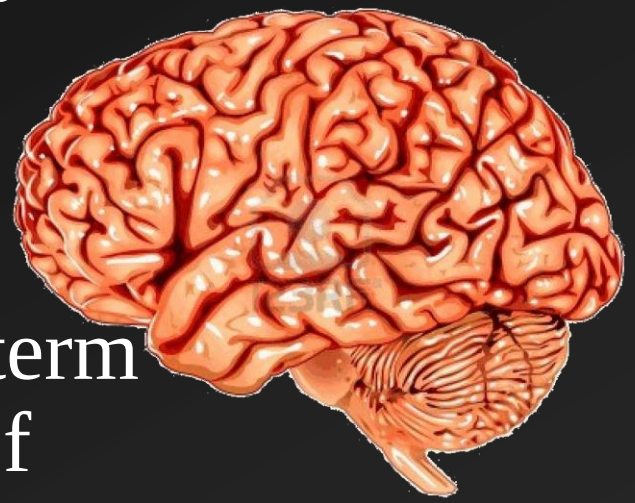
Luria’s Functional Systems



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 and to some extent temporal): **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 with hair follicles
  - dense under armpits and genital areas
  - function in humans remains a matter of debate
  - not widely studied by 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

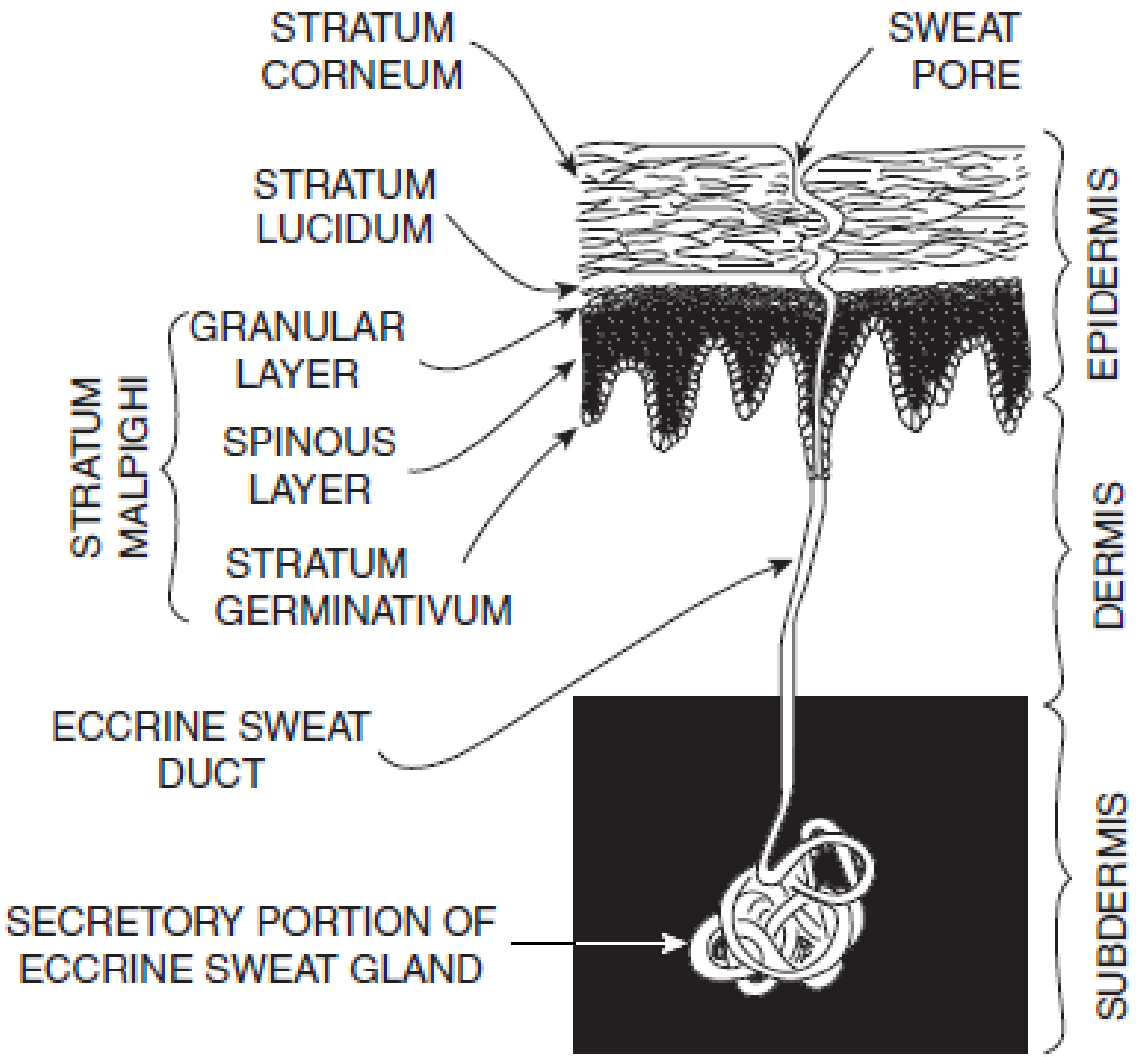


Figure 10.1 Anatomy of the eccrine sweat gland in various layers of skin. (Adapted from Hassett, 1978.)

- 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 2016

Central Control

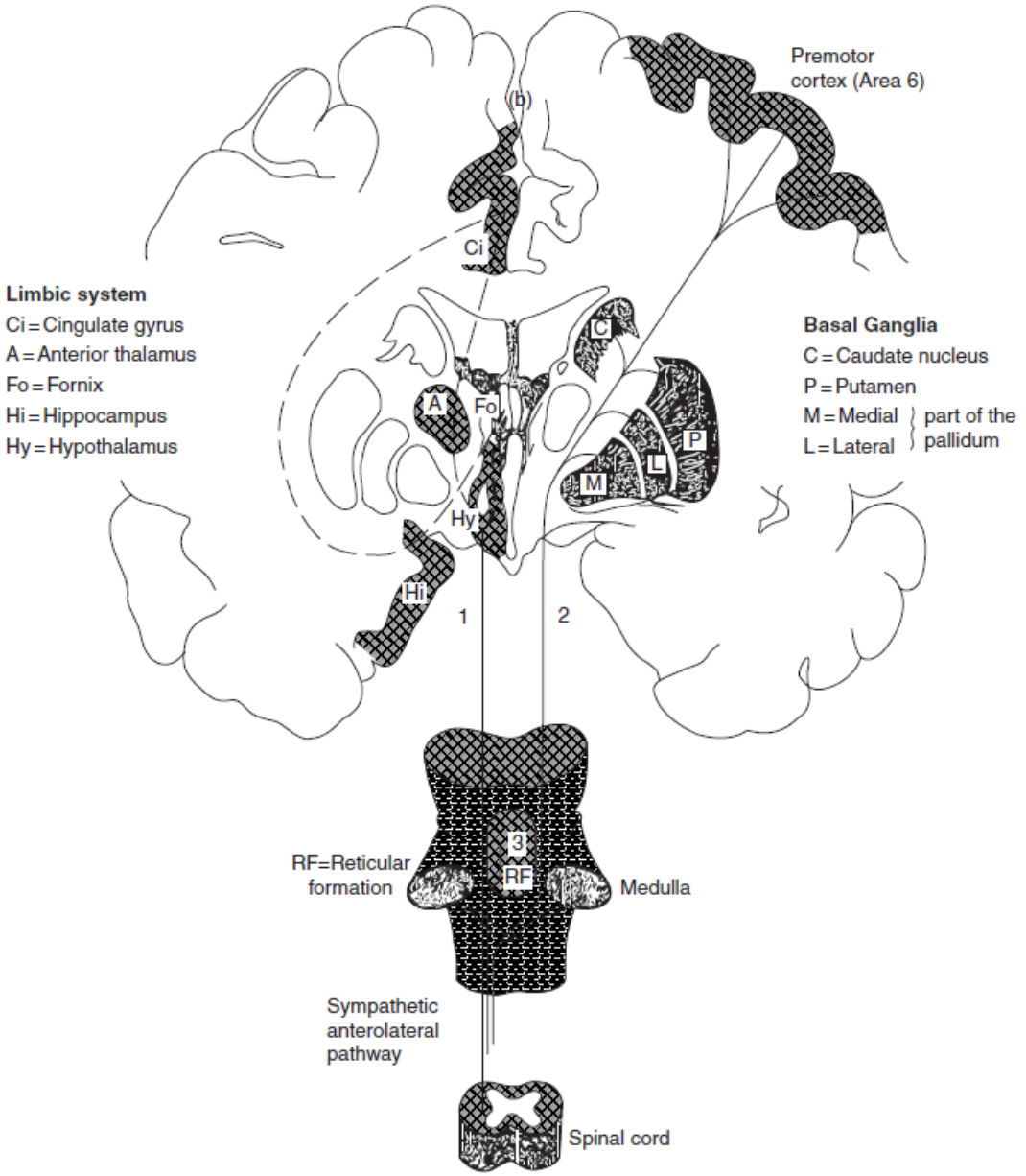


Figure 10.2 Central nervous system determiners of EDA in humans. (From Boucsein, 2012.)

Distributed, multiple pathways

- Contralateral cortical and basal ganglion influences
  - Premotor Cortex:
    - Excitatory
    - Situations requiring fine motor control
  - Frontal Cortex:
    - Excitatory and inhibitory
    - Attention, orienting
- Ipsilateral hypothalamus and limbic system
  - Thermoregulation
  - Emotion
- Reticular formation
  - EDA associated with:
    - Gross movements
    - Increased muscle tone

From Dawson et al 2016

Acronym Glossary

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

Werner von Siemens 1816-1892
The “Father of Electrical Engineering” in Germany

Unfounded is the complaint that the study of science and the technical application of the forces of nature gives to mankind a thoroughly material direction, makes them proud of their knowledge and power, and alienates ideal endeavours. The deeper we penetrate into the harmonious action of natural forces regulated by eternal unalterable laws, and yet so thickly veiled from our complete comprehension, the more we feel on the contrary moved to humble modesty, the smaller appears to us the extent of our knowledge, the more active is our endeavour to draw more from the inexhaustible fountain of knowledge, and understanding, and the higher rises our admiration of the endless wisdom which ordains and penetrates the whole creation

en.wikipedia.org/wiki/Werner_von_Siemens

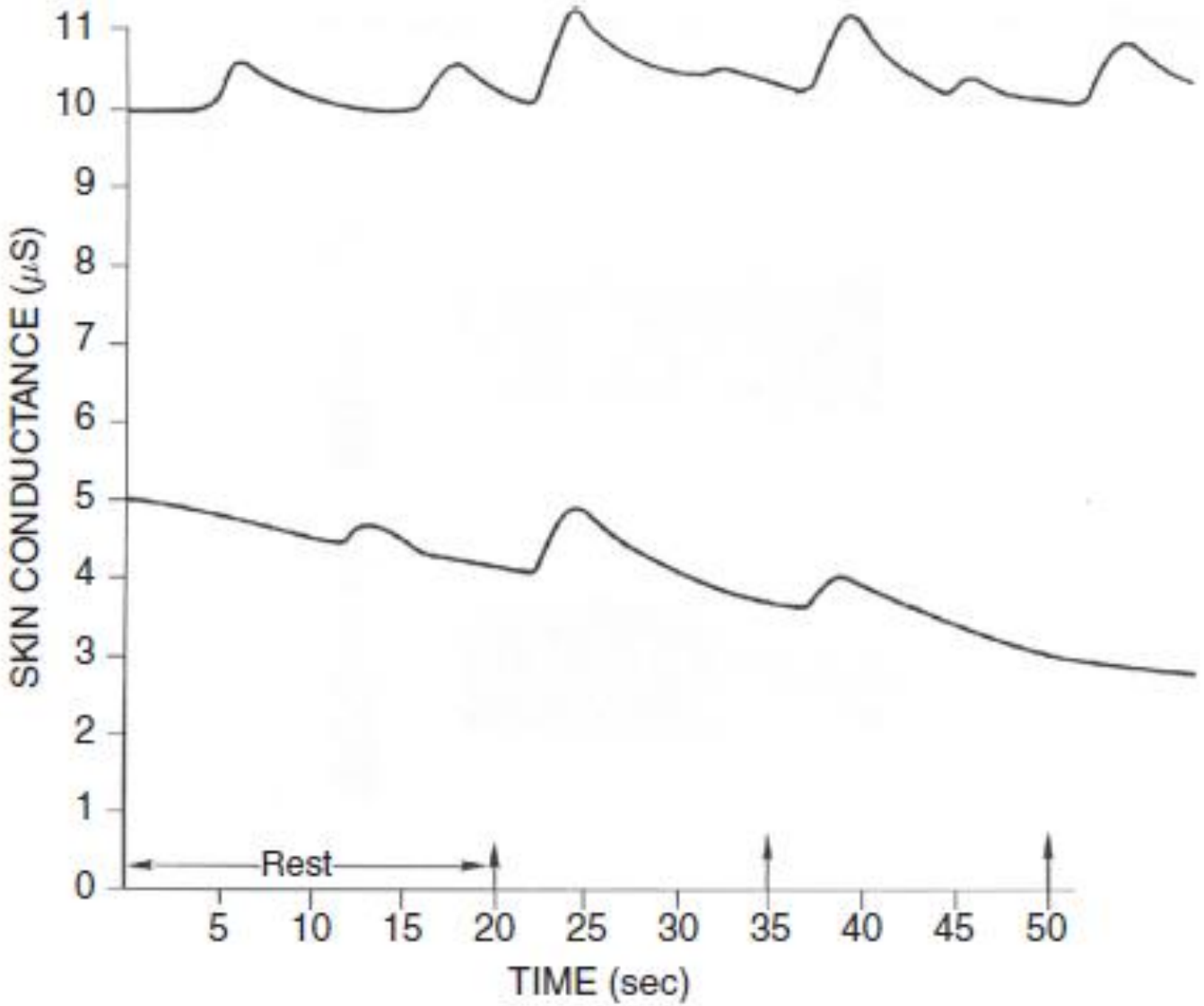


Figure 10.4 Two hypothetical skin conductance recordings during 20 sec of rest followed by three repetitions of a simple discrete stimulus. Arrows represent the presentation of a stimulus. (From Dawson & Nuechterlein, 1984.)

From Dawson et al 2016

Table 10.1 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	0.2–1.0 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 habituation (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: non-specific skin conductance response.

From Dawson et al 2016

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

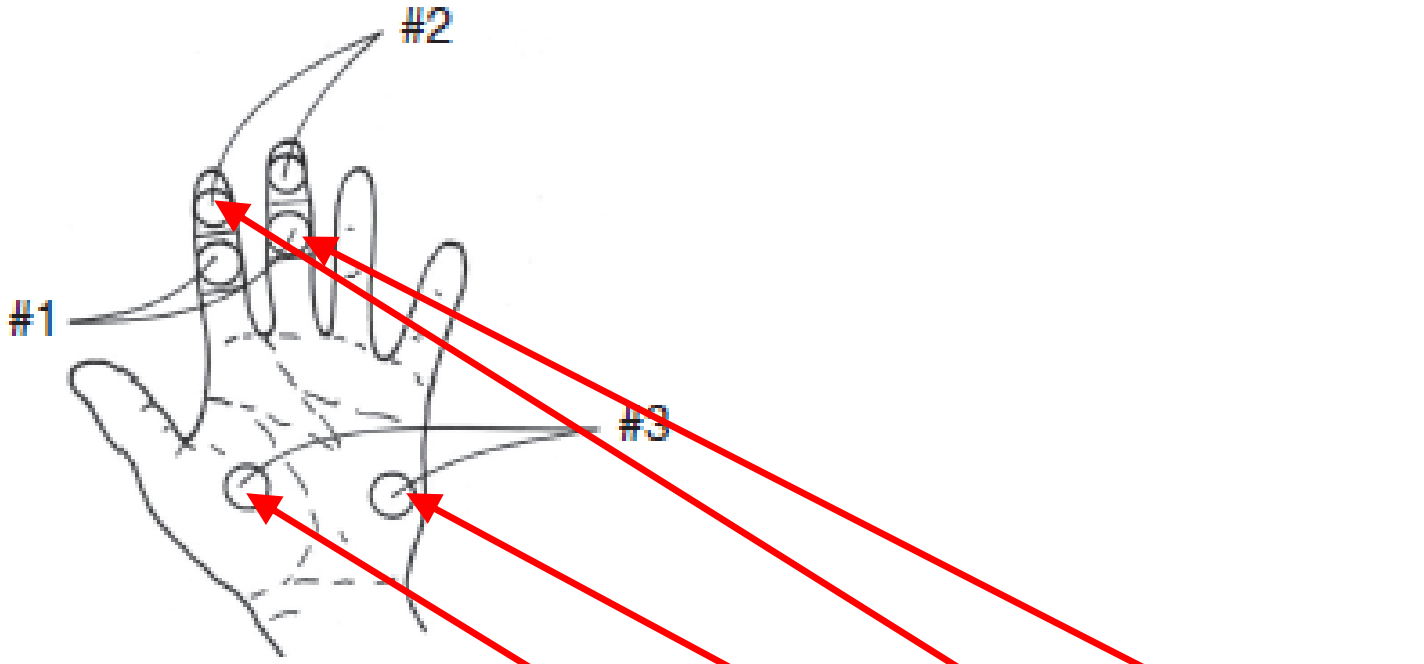


Figure 10.3 Three electrode placements for recording electrodermal activity. Placement #1 involves volar surfaces on medial phalanges, placement #2 involves volar surfaces of distal phalanges, and placement #3 involves thenar and hypothenar eminences of palms.

From Dawson et al 2016

PSYCHOPHYSIOLOGY
Vol. 29, No. 2

Printed in U.S.A.

Methodology

A Major Effect of Recording Site on Measurement of Electrodermal Activity

ANGELA SCARPA SCERBO, LAUREN WEINSTOCK FREEDMAN,
ADRIAN RAINE, MICHAEL E. DAWSON,
Department of Psychology, University of Southern California

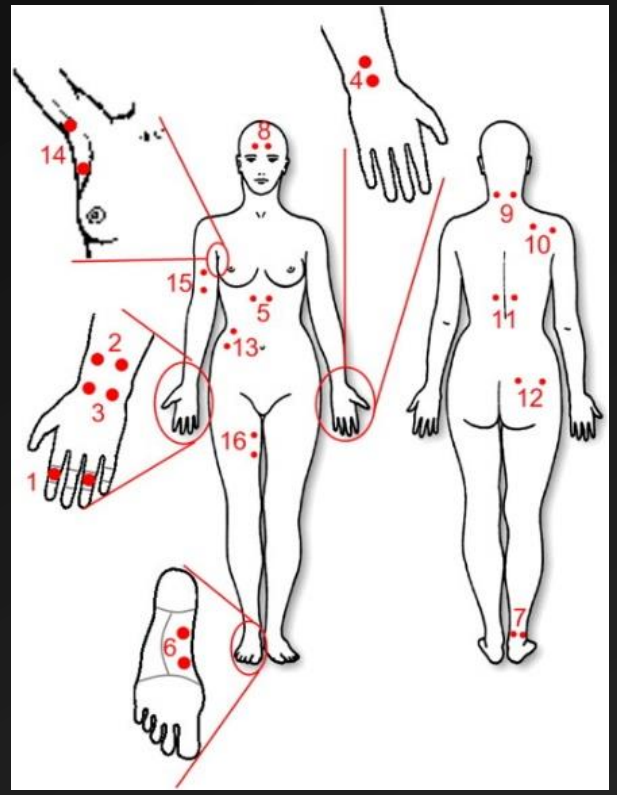
AND PETER H. VENABLES
Department of Psychology, University of York, England

ABSTRACT

Although the medial phalanx has been recommended as the preferred site for recording skin conductance activity, a review of articles published in *Psychophysiology* indicates that a large minority (34%) of studies employ the distal phalanx. Informal observations also suggest that the distal site may be more reactive than the medial site. This study formally tests this observation by recording skin conductance from both medial and distal phalanges. Twenty-four right-handed subjects (12 male, 12 female) were exposed to a series of 10 orienting and defensive stimuli. Electrodes were placed on the fore and middle fingers of each hand, with distal sites used on one hand and medial sites on the other for each subject. Skin conductance amplitudes were 3.5 times larger at distal than medial sites ($p<.002$), while skin conductance levels were 2.08 times larger at distal sites ($p<.0005$). A significant Site × Stimulus interaction ($p<.025$) indicated that the distal site was more sensitive to habituation over trials and to increases in skin conductance amplitudes with increasing stimulus intensity than the medial site. On the basis of these findings it is recommended that distal sites be used in preference to medial sites in the recording of skin conductance activity.

Recording locations compared

https://www.sciencedirect.com/science/article/pii/S0031938412000613?via%3Dihub



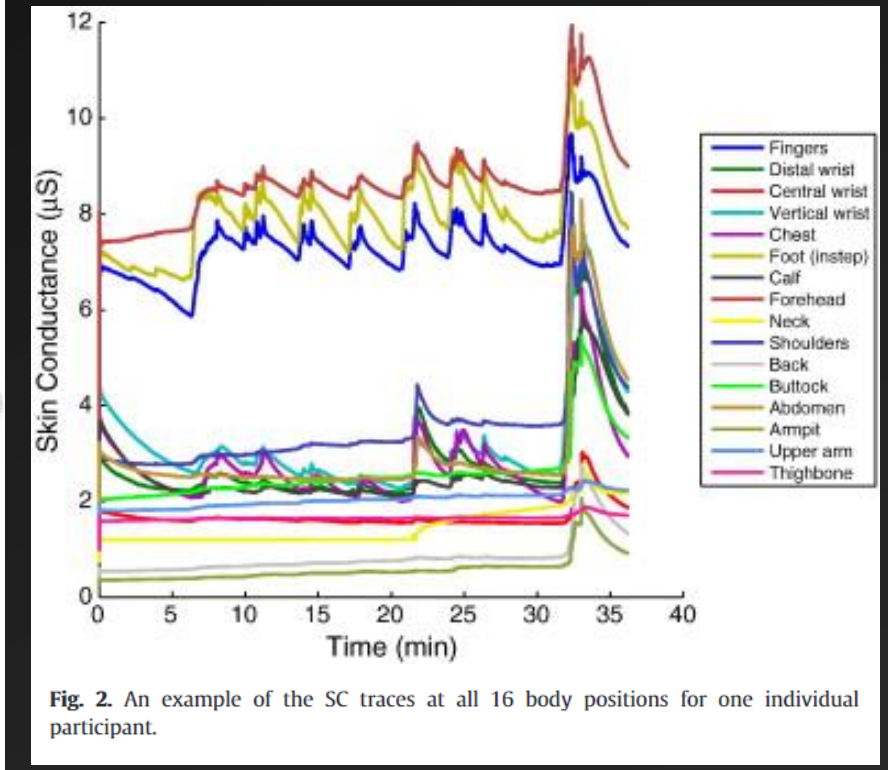


Fig. 2. An example of the SC traces at all 16 body positions for one individual participant.

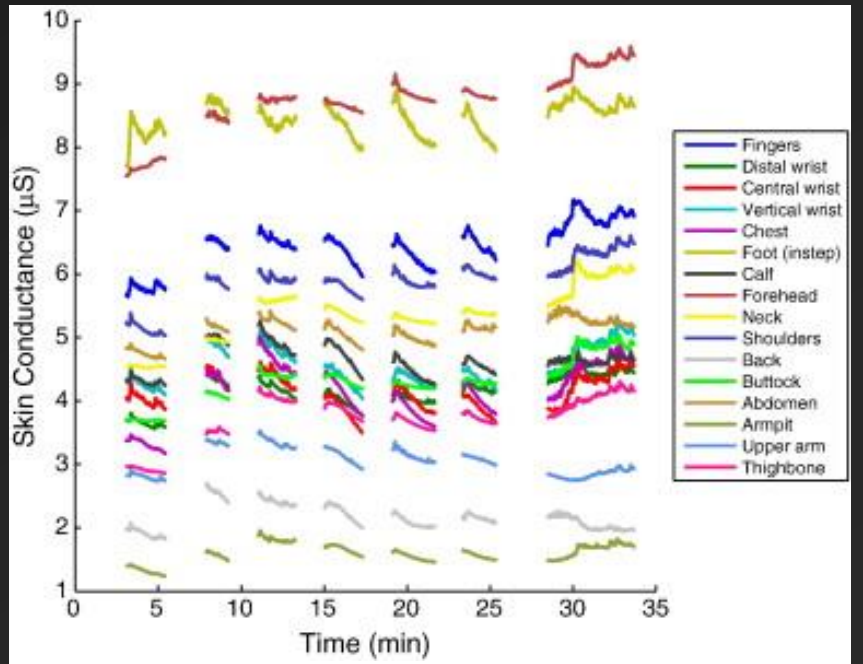


Fig. 4. Mean skin conductance for the sixteen different measurement locations over time. The vertical axis depicts the skin conductance and the horizontal axis depicts time. Parts not involving movie watching are left out as they are not the same duration for each participant.

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

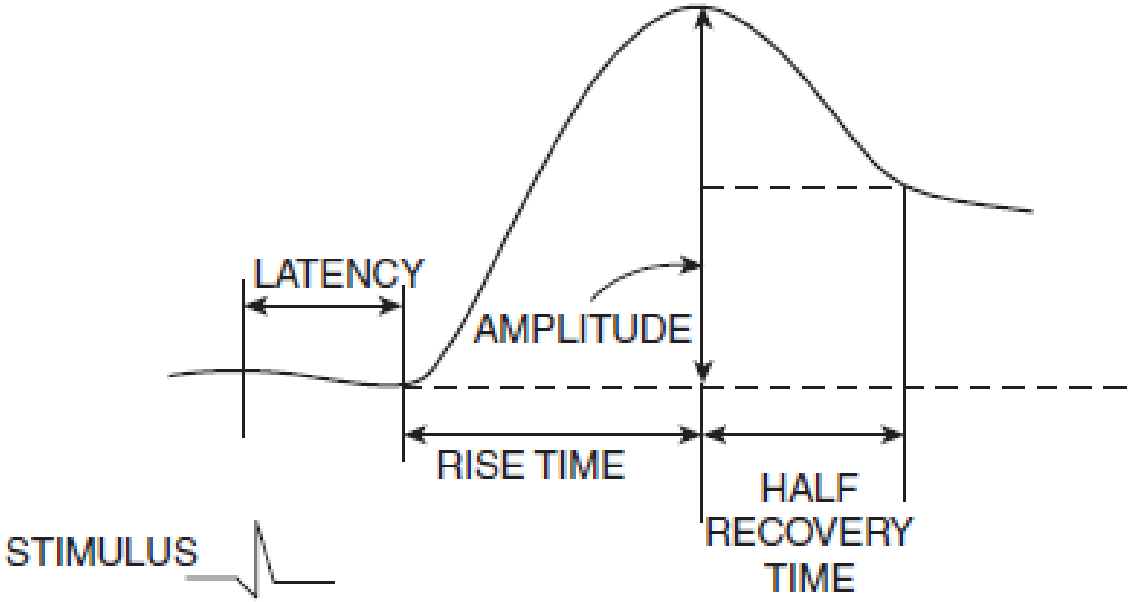


Figure 10.5 Graphical representation of principal EDA components.

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

From Dawson et al 2016

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 Differenc
- Deficient anticipato (Hare)
- Deception Detectio

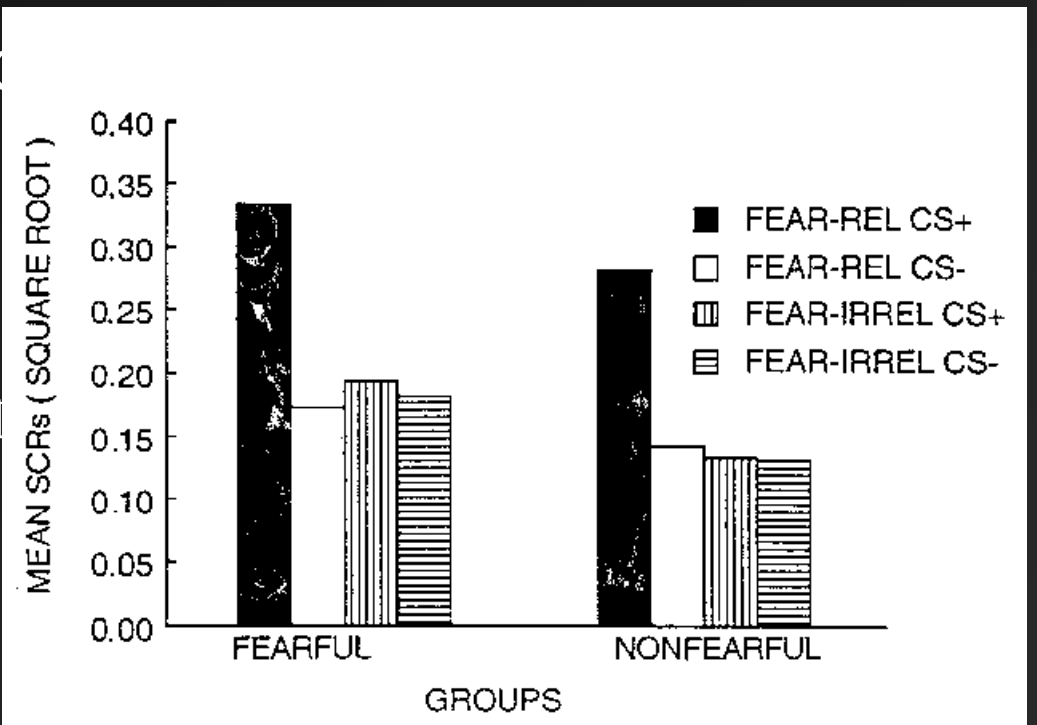


Figure 1. Mean skin conductance responses (SCRs) (square-root transformed) to fear-relevant (snakes, spiders, and rats) or fear-irrelevant (flowers and mushrooms) stimuli previously followed (CS+) or not followed (CS−) by an electric shock unconditioned stimulus among the fearful and nonfearful groups of subjects during extinction.

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*

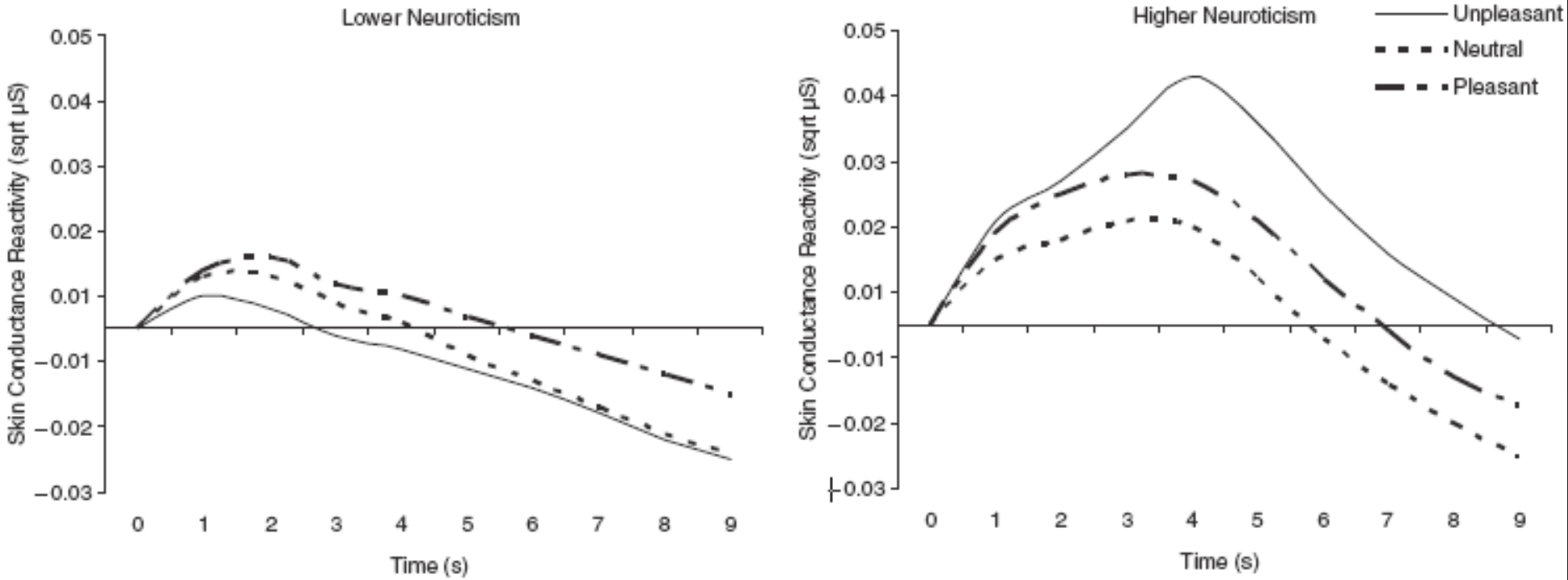


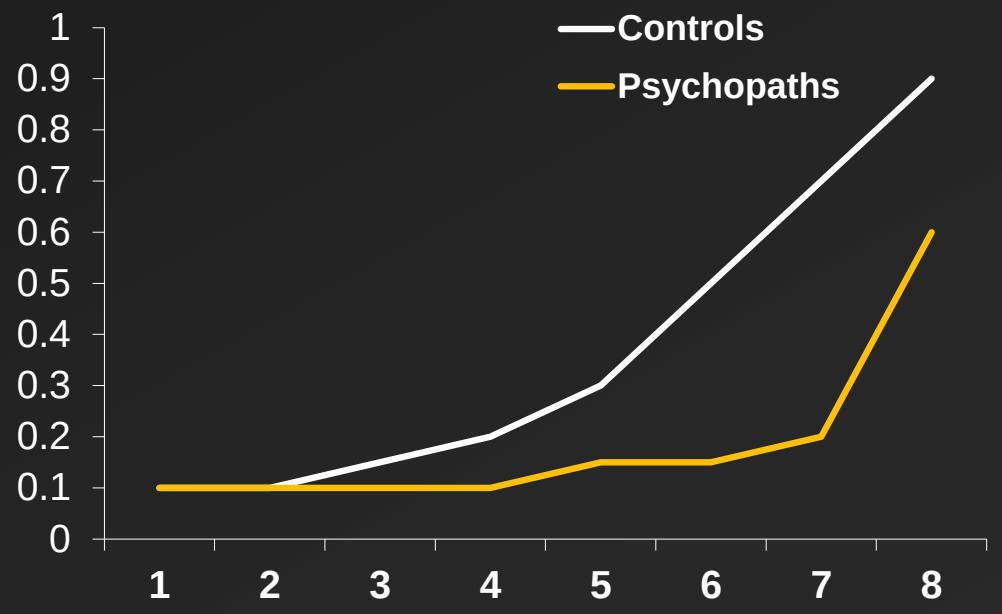
Figure 1. Skin conductance reactivity as a function of picture valence, time, and neuroticism. Pictures were presented from 1–6 s. Estimated means for participants lower (1 *SD* below the mean) and higher (1 *SD* above the mean) in neuroticism are plotted separately.

Applications

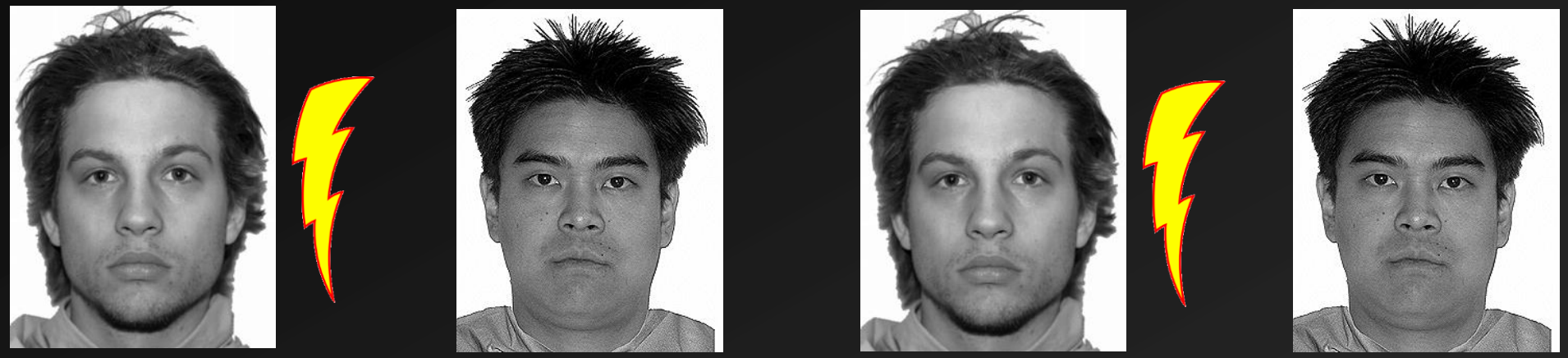
- Orienting (Bauer, 1984; Tranel and Damasio, 1985)
- Fear conditioning (Őhman)
- Individual Differences in Neuroticism
- Deficient anticipatory anxiety in psychopathy (Hare)
- Deception Detection (Myriad authors)

Anticipatory Arousal in Psychopathy

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



Fearless Dominance
(dual-process model of Psychopathy)



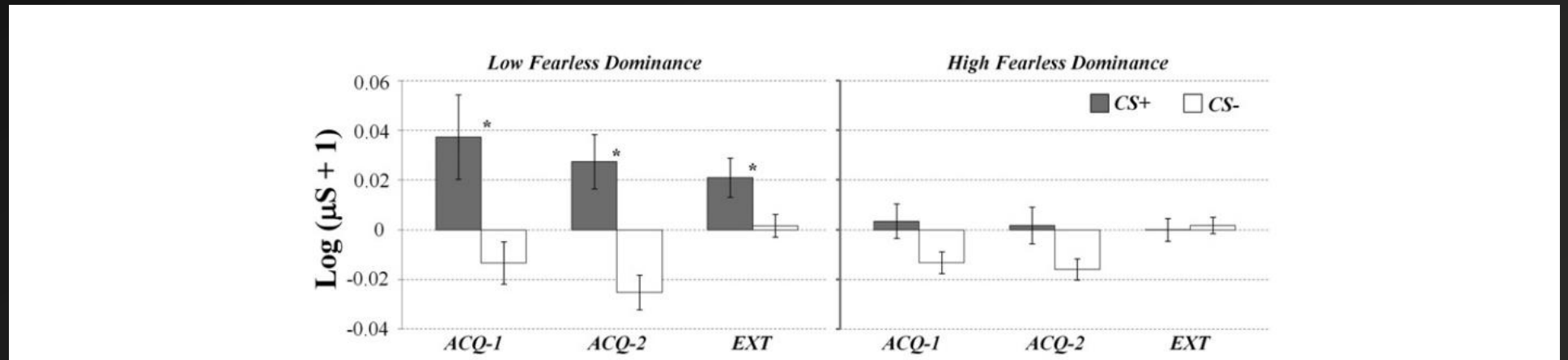


Figure 1. Mean skin conductance change (log [μS + 1]) for high and low fearless dominance groups when viewing CS+ and CS− during acquisition (ACQ-1 and ACQ-2) and extinction (EXT) phases of the fear conditioning procedure.

López,R., Poy, R., Patrick, C.J., & Moltó, J. (2013) *Psychophysiology*