Lecture 3

4 February, 2013

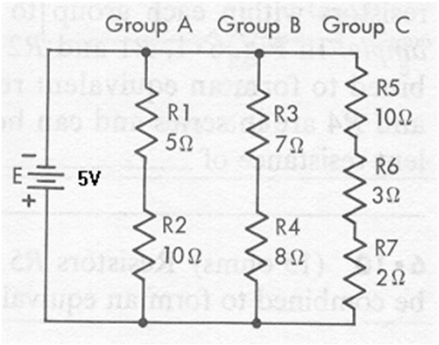
Announcements (2/4/13)

- 401B and 501B:
  - Meeting tomorrow at 4 pm for Skin Conductance Laboratory Session
- Electricity Test next week (Feb 11)
- Information on Papers next week too

Electricity Test Objectives

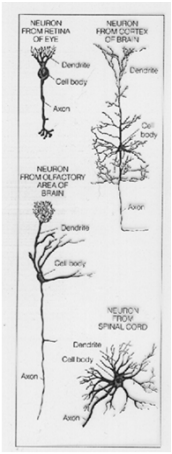
- Describe positive and negative charges
- State the law of attraction and repulsion
- Describe free electrons
- Describe the relationship between electromotive force, resistance, and flow (i.e. understand Ohm's Law)
- Draw a simple DC electric circuit comprised of a battery and:
  - Single resistor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

Brief Review

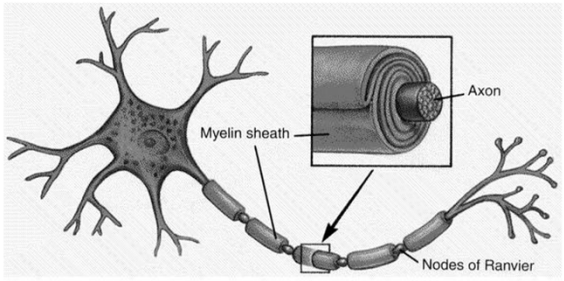


Today:

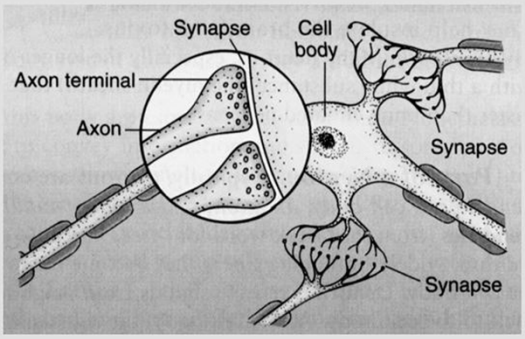
Basic Neurophysiology (brief, review)
Basic Neuroanatomy
The Electrodermal Response System



Myelin Sheath



The Synapse

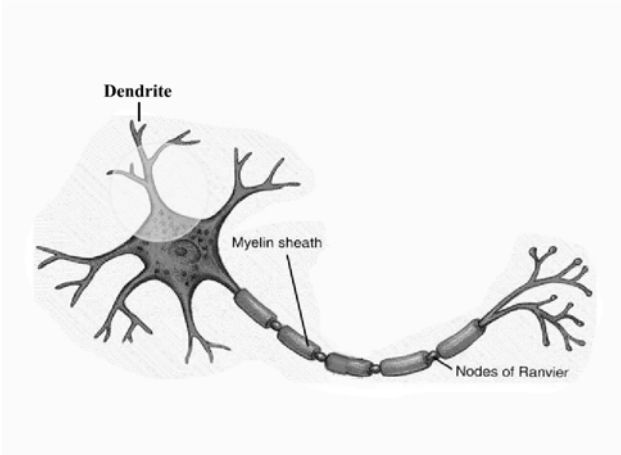


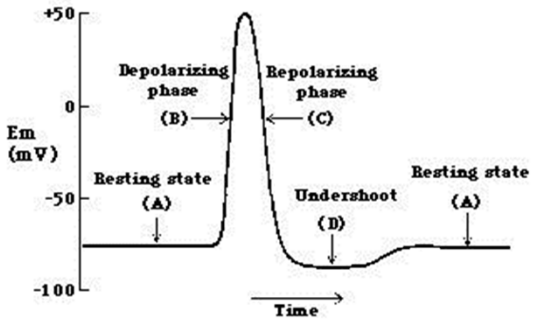
Neural Communication

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

Axonal Conduction

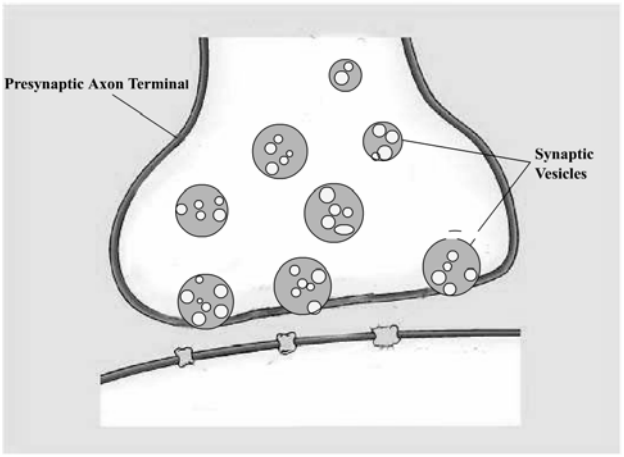
- Resting potential
  - Inside of cell slightly negative wrt outside, at rest
- Sufficient depolarization (above threshold) leads to action potential
- Action potential:
  - All-or-none
  - Propagation





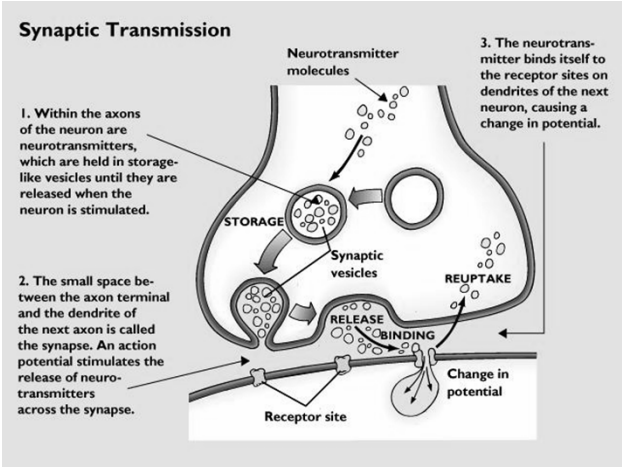
Synaptic Transmission

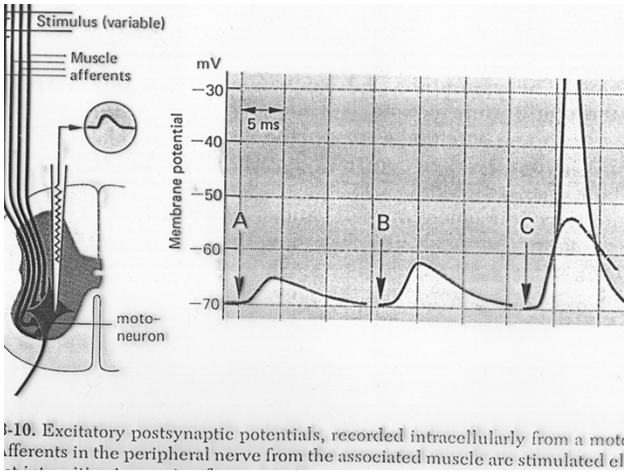
- Graded potentials resulting from changes in membrane permeability at the synaptic junction
- As action potential arrives at terminal button
  - Synaptic vesicles migrate to cell membrane fuse and release
  - Neurotransmitters diffuse across the synaptic cleft
  - combine with **post-synaptic receptors**
  - Binding creates a slow electrical potential (**post-synaptic potential**)
  - 5 to 20 mV at peak amplitude
  - 20-150 msec in duration (50 to 6 Hz)



Synaptic Transmission

- Post-synaptic potentials (PSP's);
  - Excitatory (EPSPs)
  - Inhibitory (IPSPs)
  - 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





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

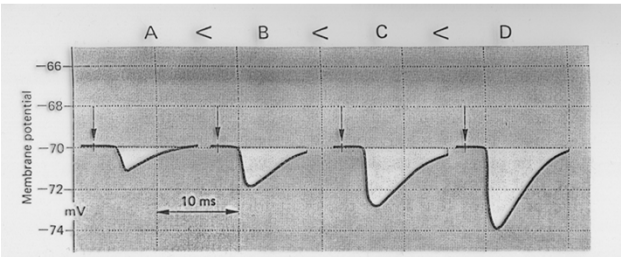


Fig. 3-11. Inhibitory postsynaptic potentials. Experimental arrangement as in Fig. 3-10, except that here an antagonist nerve is stimulated.

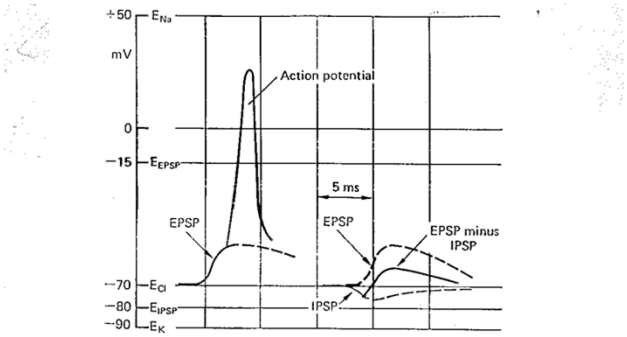


Fig. 3-14. The effect of an IPSP on the action potential; experimental arrangement as in Fig. 3-13. The homonymous nerve is stimulated strongly enough to produce a suprathreshold EPSP (*left*). On the *right*, the antagonist nerve is stimulated about 3 ms before the homonymous nerve. The equilibrium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

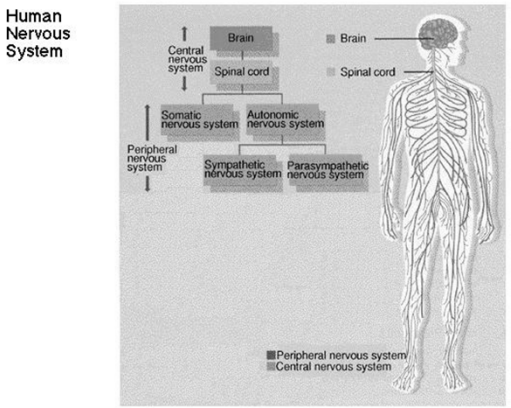
Part III: *Basic* Neuroanatomy

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



V. Organization of the nervous system

B. Peripheral nervous system

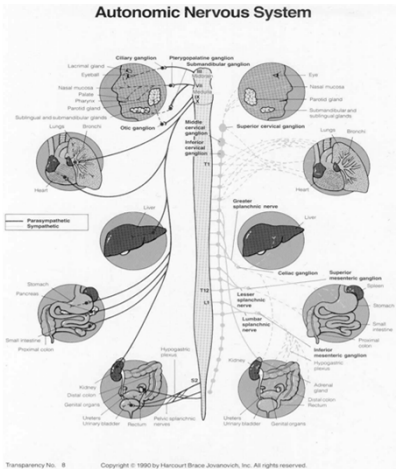
1. Somatic system
2. Autonomic system; two branches work in generally antagonistic fashion

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



V. Organization of the nervous system

B. Peripheral nervous system

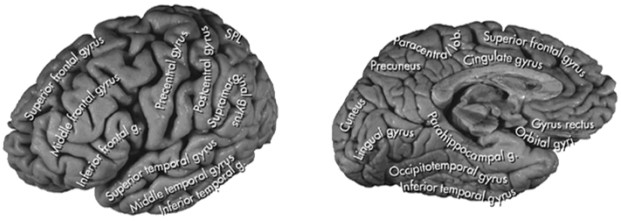
2. Autonomic system
   a. Sympathetic nervous system
      1. tends to have system-wide effects
      2. flight or flight; activity
   b. Parasympathetic nervous system
      1. tends to affect one organ at a time
      2. quiescent processes--digestion, protects and conserves energy
      3. "rest and digest"

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
• After synapse within grey-matter of spinal cord, the post-synaptic (pre-ganglionic) neurons exit in thoracic or lumbar regions	• After synapse within grey-matter of spinal cord, the post-synaptic (pre-ganglionic) neurons exit in cranial (especially cranial nerve #10, Vagus) or sacral regions
• *Thoracolumbar* system • pre-ganglionic neurons travel to sympathetic chain (series of connected sympathetic ganglia *"swelling or knot"*, chain of neurons) • post-ganglionic neurons generally travel a long distance to target organ	• *Craniosacral system* • pre-ganglionic neurons travel some distance before synapsing in the parasympathetic ganglia located in the immediate vicinity of the target organ • post-ganglionic neurons are therefore typically quite short

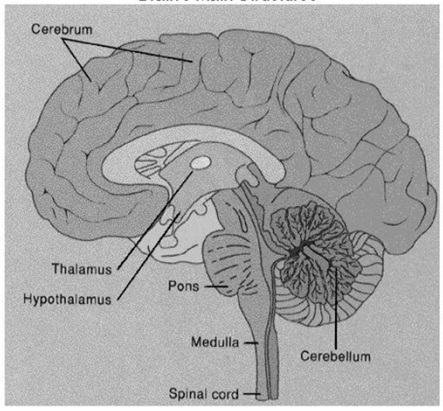
Sympathetic	*Parasympathetic*
Pharmacologically, • All synapses within the sympathetic ganglia are acetylcholinergic • Terminal buttons on target organs are noradrenergic (except sweat glands: acetylcholinergic)	Pharmacologically, • All synapses acetylcholinergic: both pre- and post-ganglionic neurons
• Quick diffuse action of system due to the sympathetic ganglionic chain prepares organism for *fight-or-flight*; in synchrony, many systems activate • dilation of bronchioles • dilation of pupils (the better to see you with my dear) • constriction of blood vessels to skin and gastrointestinal system • inhibition of gastrointestinal system • increased BP, stroke volume, cardiac output • increased sweating	• Slower and more specific action of this system works to restore and maintain bodily resources; only changes that are necessary generally occur (not all systems in synchrony) • decreased heart rate, blood pressure • constriction of pupils and bronchioles • increases in digestive functions

VI. The common household brain

- Commentary
- More commentary



Brain's Main Structures

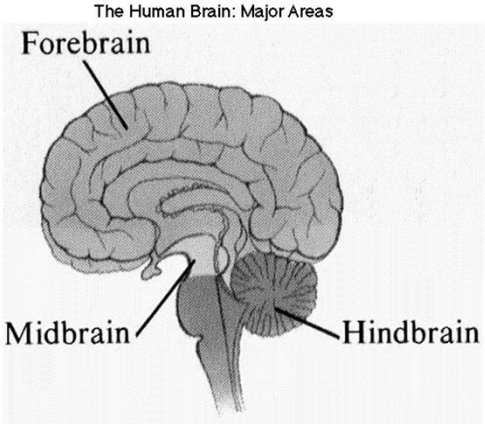


VI. The common household brain

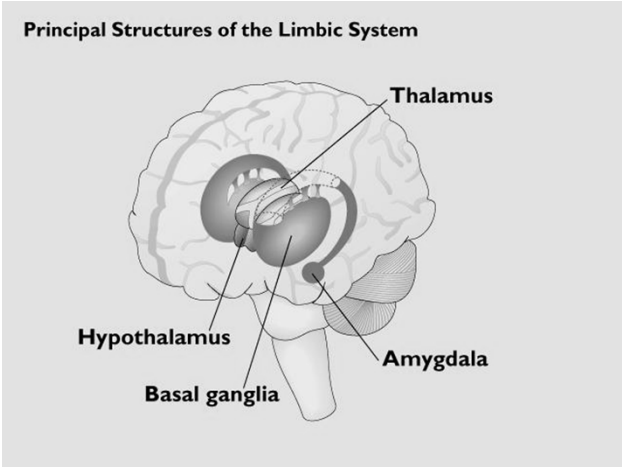
A. Overview of brain
   1. The primitive central core
   2. Limbic system, or the "Inner Lizard"
   3. Cerebrum (AKA cerebral hemispheres)
      a. Ontogeny
      b. Phylogeny
      c. Ontogeny recapitulates phylogeny
   4. These three layers are interconnected extensively; do not function independently

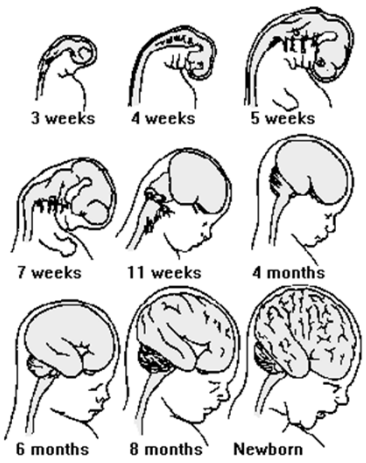
Next

The Human Brain: Major Areas

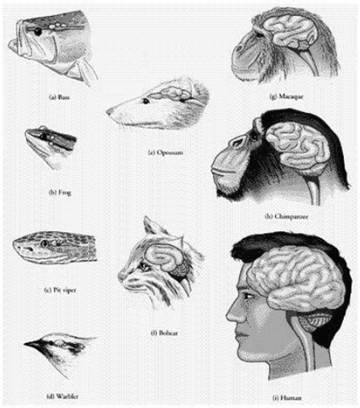


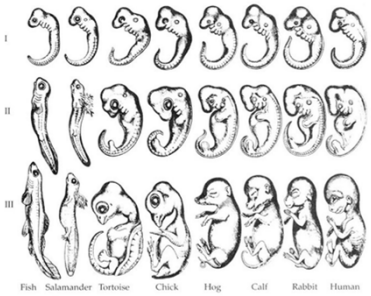
Principal Structures of the Limbic System





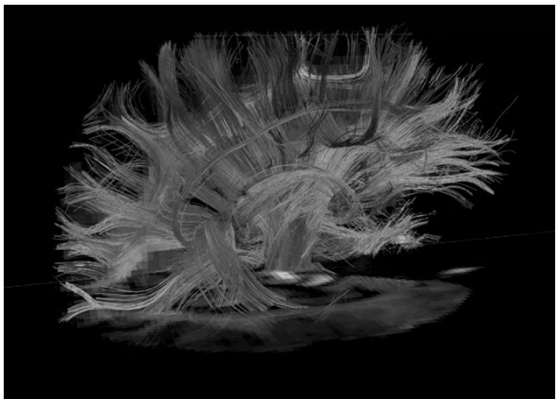
The Evolution of the Cerebrum*





"… 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!

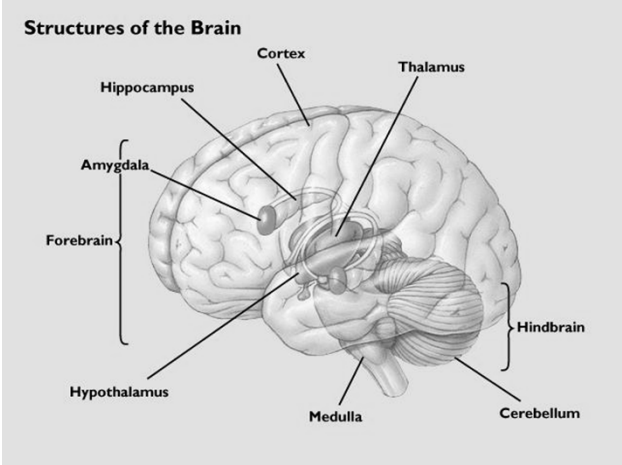
- lateral--side; medial--middle
- ipsilateral--same; contralateral--opposite
- proximal--toward the soma; distal--away from the soma
- anterior--front; posterior/dorsal--back
- rostral--towards the nose; caudal--towards the tail
- efferent--output/motor; afferent--receiving/sensory

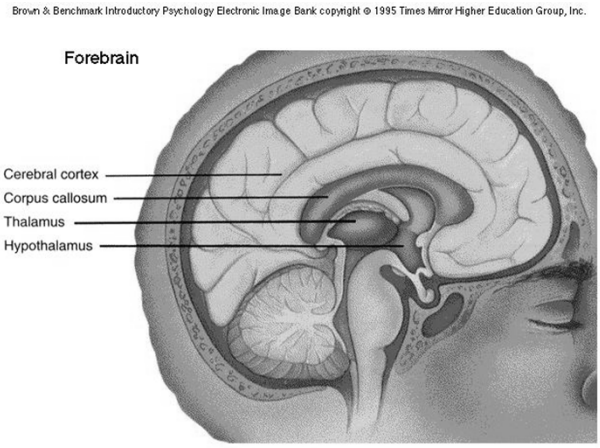
B. Brain Specifics

1. Primitive central core
   a. Cerebellum
      1. "little brain" 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

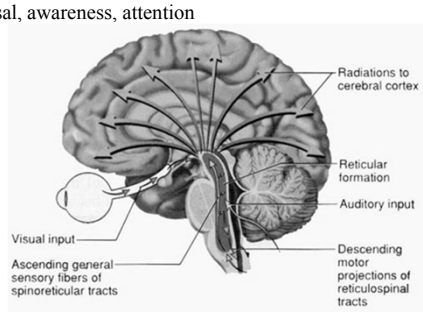
1. Primitive central core
   b. Thalamus & Hypothalamus: located just above the brain stem & tucked inside the cerebral hemispheres
      1. Thalamus is a relay station for sensory information
         a. "Gateway to the cortex"
         b. coming from spinal cord to cortex
         c. taste touch hearing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





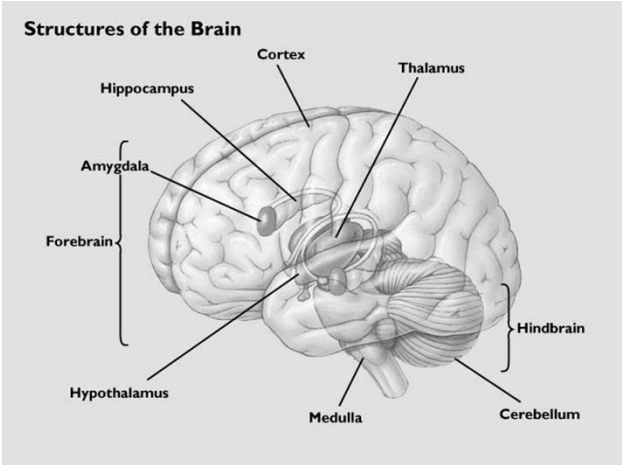
B. Brain Specifics

1. Primitive central core
   c. Reticular system
      1. diffuse from brainstem to thalamus
      2. 3 A's, arousal, awareness, attention



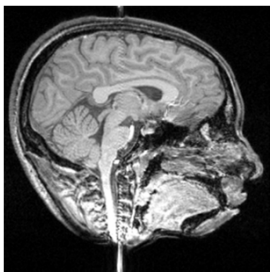
B. Brain Specifics

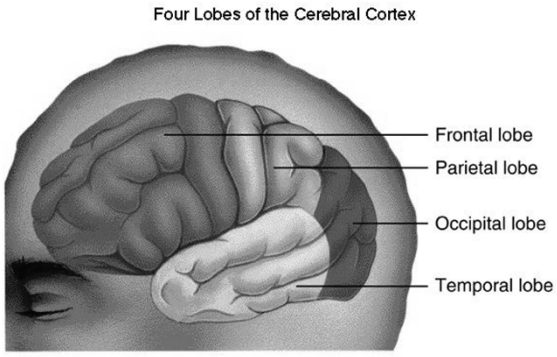
2. Limbic system
   a. a group of structures lying along the innermost edge of the cerebral hemispheres
   b. involved in instinctual behaviors in lower animals (caring for young, mating, fleeing from attackers, fleeing from prey)
   c. involved in memory and emotion in humans
   d. Especially important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



The common household brain

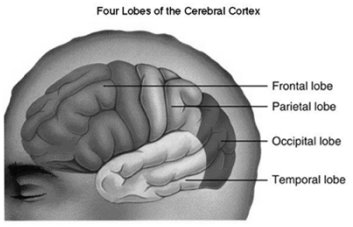
- 3. The cerebral hemispheres
  - a. Grey matter vs white matter





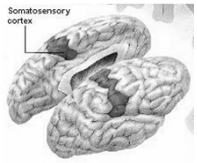
The common household brain

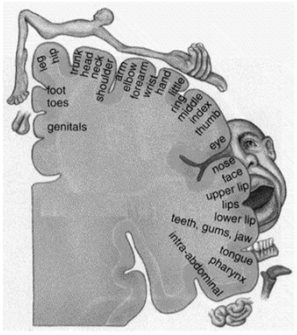
3. The cerebral hemispheres
   - b. Four lobes:
     1. frontal
     2. parietal
     3. occipital
     4. temporal



The common household brain

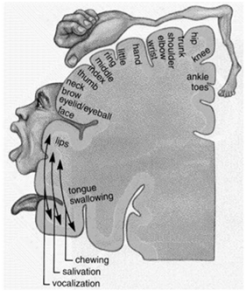
3. The cerebral hemispheres
   - c. Somatosensory area
     1. heat, cold, touch, pain, sense of body movement
     2. contralateral
     3. space appropriated in accord to amount of use or need





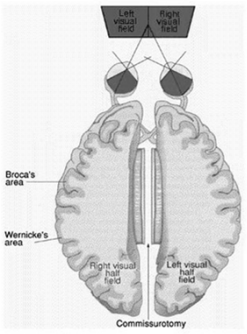
The common household brain

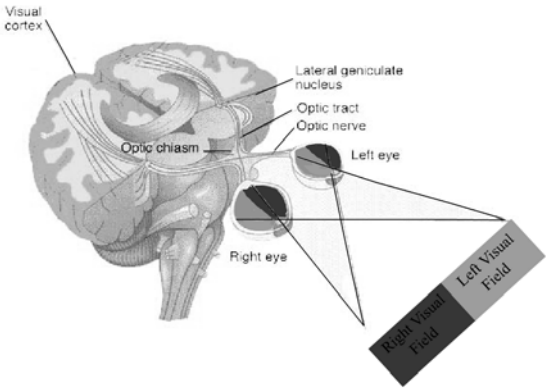
3. The cerebral hemispheres
   - d. Motor area
     1. topographic organization-- Homunculus
     2. contralateral control of body



The common household brain

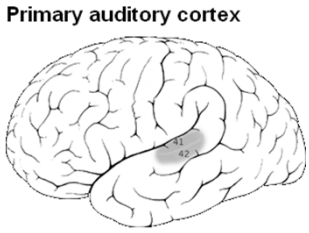
3. The cerebral hemispheres
   e. Visual area
      1. Contralateral visual field
      2. Primary vs Secondary





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


Broca's


Wernicke's

Luria's Functional Systems

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

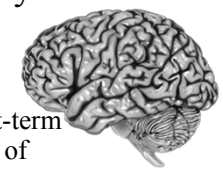
   b. Sensory
      (1) Somatosensory (post central gyrus)
      (2) Visual (Occipital cortex)
      (3) Auditory (Banks of Lateral Sulcus)

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 under armpits and genital areas
  - function 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

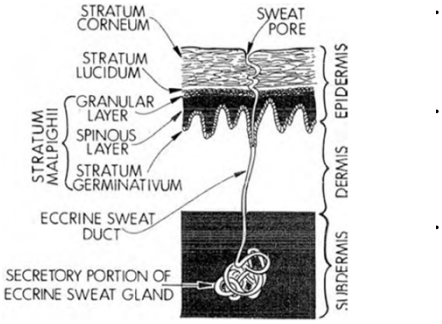


Figure 7.1. Anatomy of the eccrine sweat gland in various layers of skin. (Adapted from Hassett, 1978).

- 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

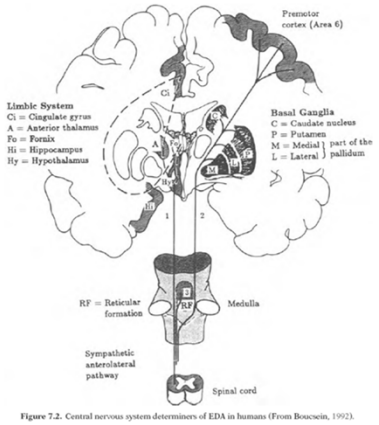


Figure 7.2. Central nervous system determiners of EDA in humans (From Boucsein, 1992).

From Dawson et al 2007

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

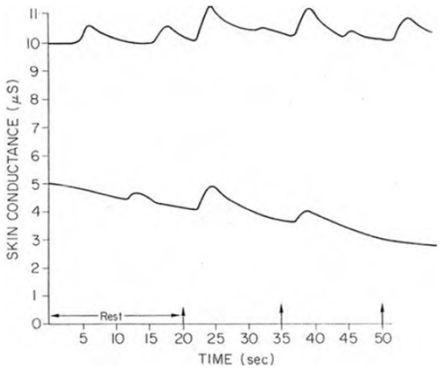


Figure 7.4. Two hypothetical skin conductance recordings during 20 s of rest followed by three repetitions of a simple discrete stimulus. Arrows represent the presentation of a stimulus (From Dawson & Nuechterlein, 1984).

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