

COGS500/CMPE489

Introduction to Cognitive Science

Week II

Emre Uğur
Computer Engineering
Bogazici University

With slides adapted from Albert Ali
Salah

Last Week

- Introduction to Cognitive Science
- Some philosophical background
- Artificial Intelligence lecture

Today

- Psychology
- Nervous system

Definition of Psychology

- “The scientific study of behavior and mental processes.” (Atkinson et al.)



Definition of Psychology

- “The scientific study of behavior and mental processes.” (Atkinson et al.)
- It should be objective: Repeatability
- It should be unbiased: No hypothesis is favored

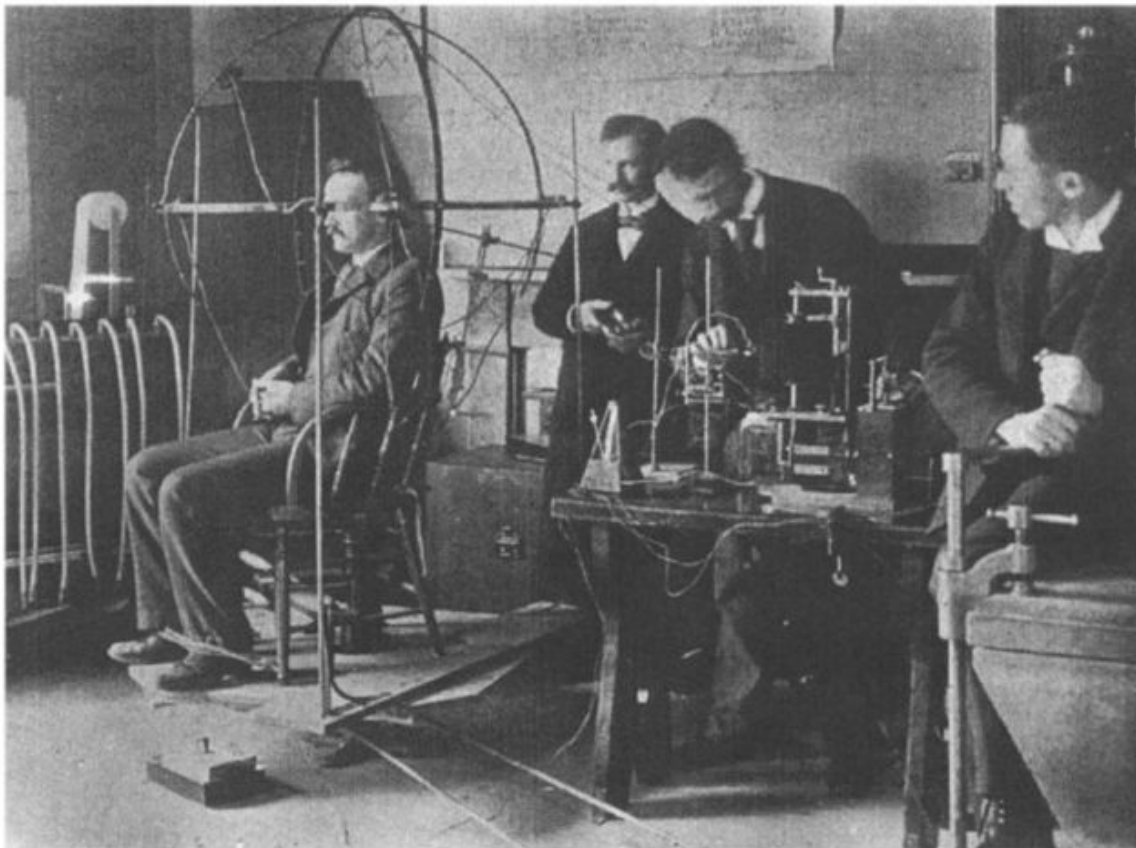
Nature–nurture debate

- Nature - nurture debate centers on the question of whether human capabilities are inborn or acquired through experience
- Early philosophers believed that this knowledge and understanding could be accessed through careful reasoning and **introspection**.

refers to observing and recording the nature of one's own perceptions, thoughts, and feelings.

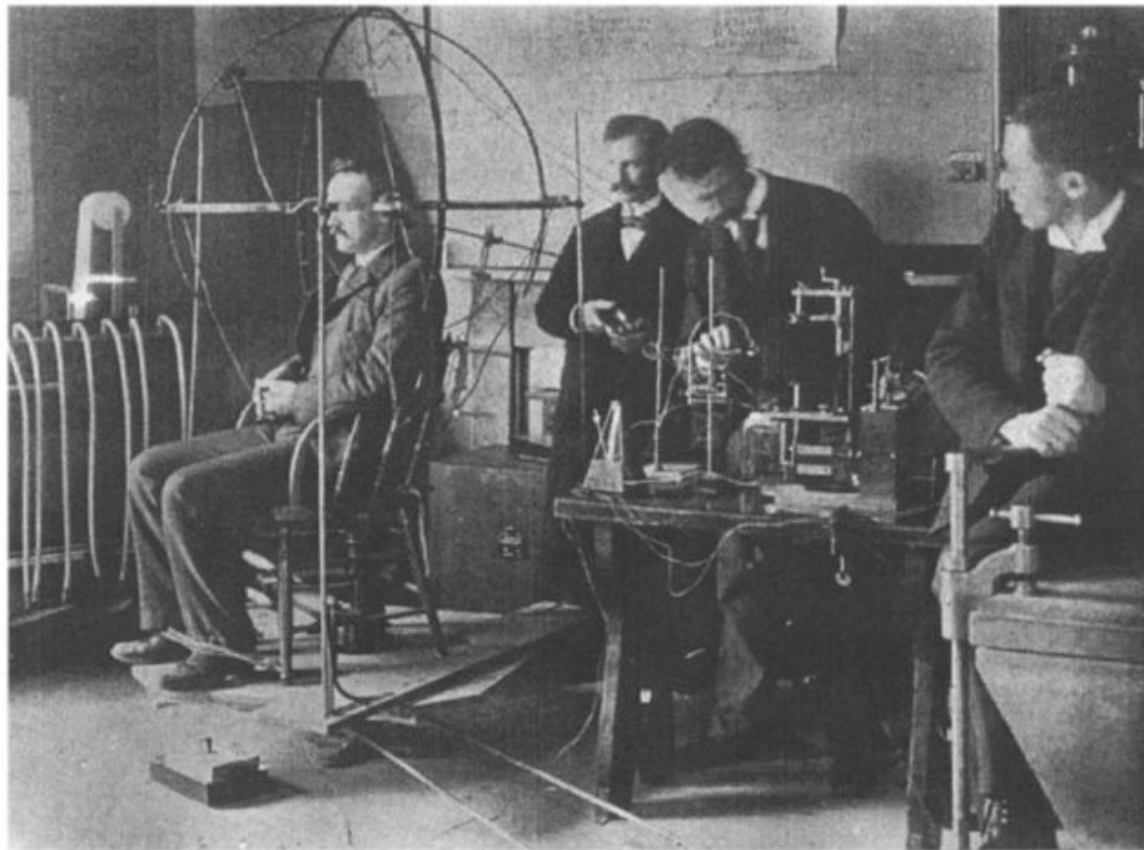
Introspection

- 1879, Wilhelm Wundt established the first psychological laboratory in Leipzig
- Mind and behavior subject (like planets) of scientific analysis.
- A new dimension. Pure self-observation was not sufficient; it had to be supplemented by experiments.



Introspection

- Not reliable, not repeatable, inconsistent

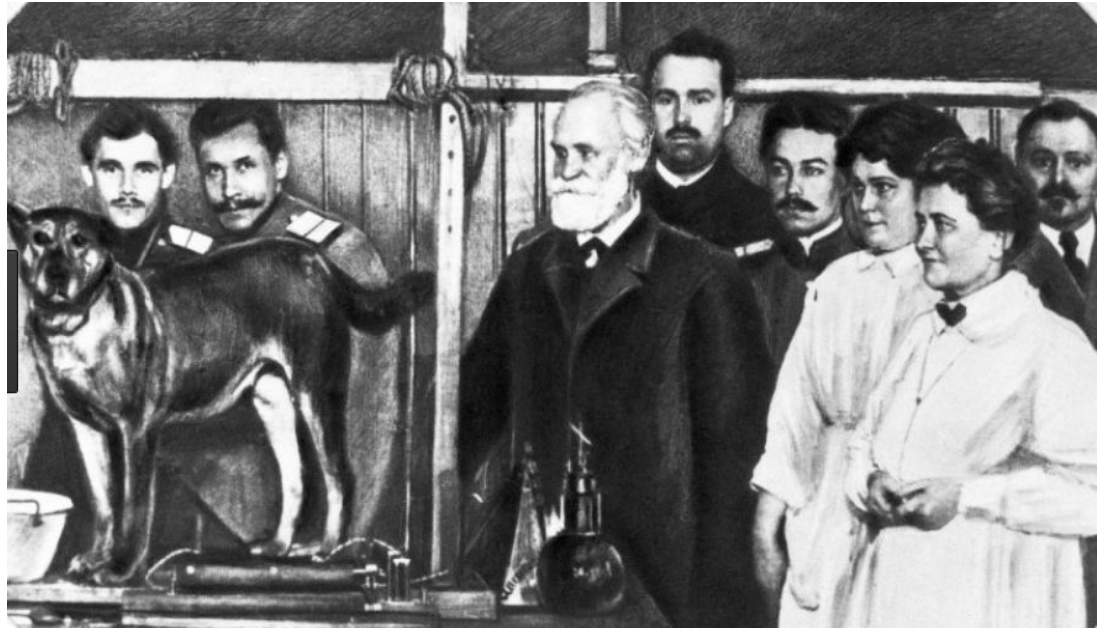


Behaviorists



The Little Albert Experiment (1920)

Source:youtube



Ivan Pavlov's dogs

Source:spiegel.de

- John B. Watson: against the view that conscious experience is the province of psychology
- Data must be open to public inspection
- Behavior is public, consciousness is private
- Almost all behavior is the result of conditioning
- More complicated behaviors can be created from conditioned response units. stimulus–response (S–R)

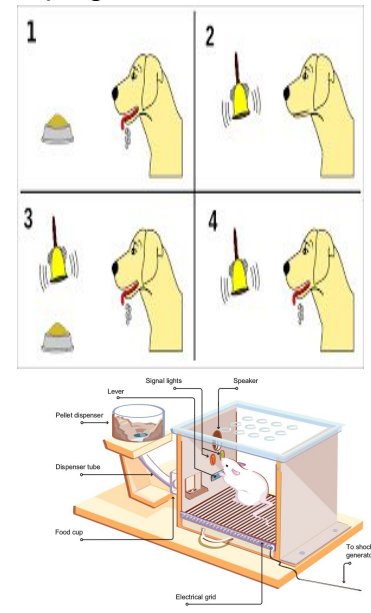


Figure 1.1 A rat in a Skinner box. The rat has a response lever controlling the delivery of food, as well as devices allowing different types of stimuli to be produced. (Adapted from Spivey 2007)

Skinner Box

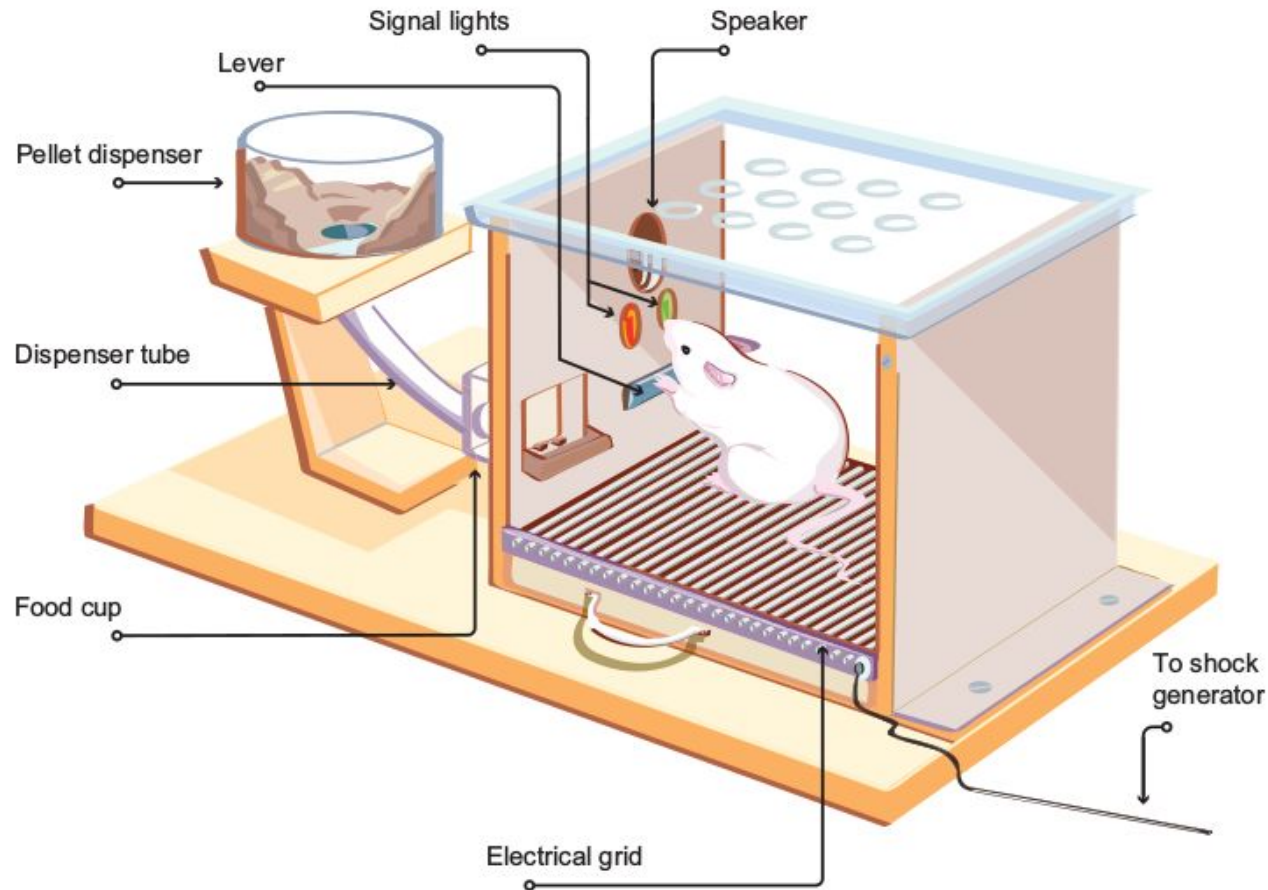
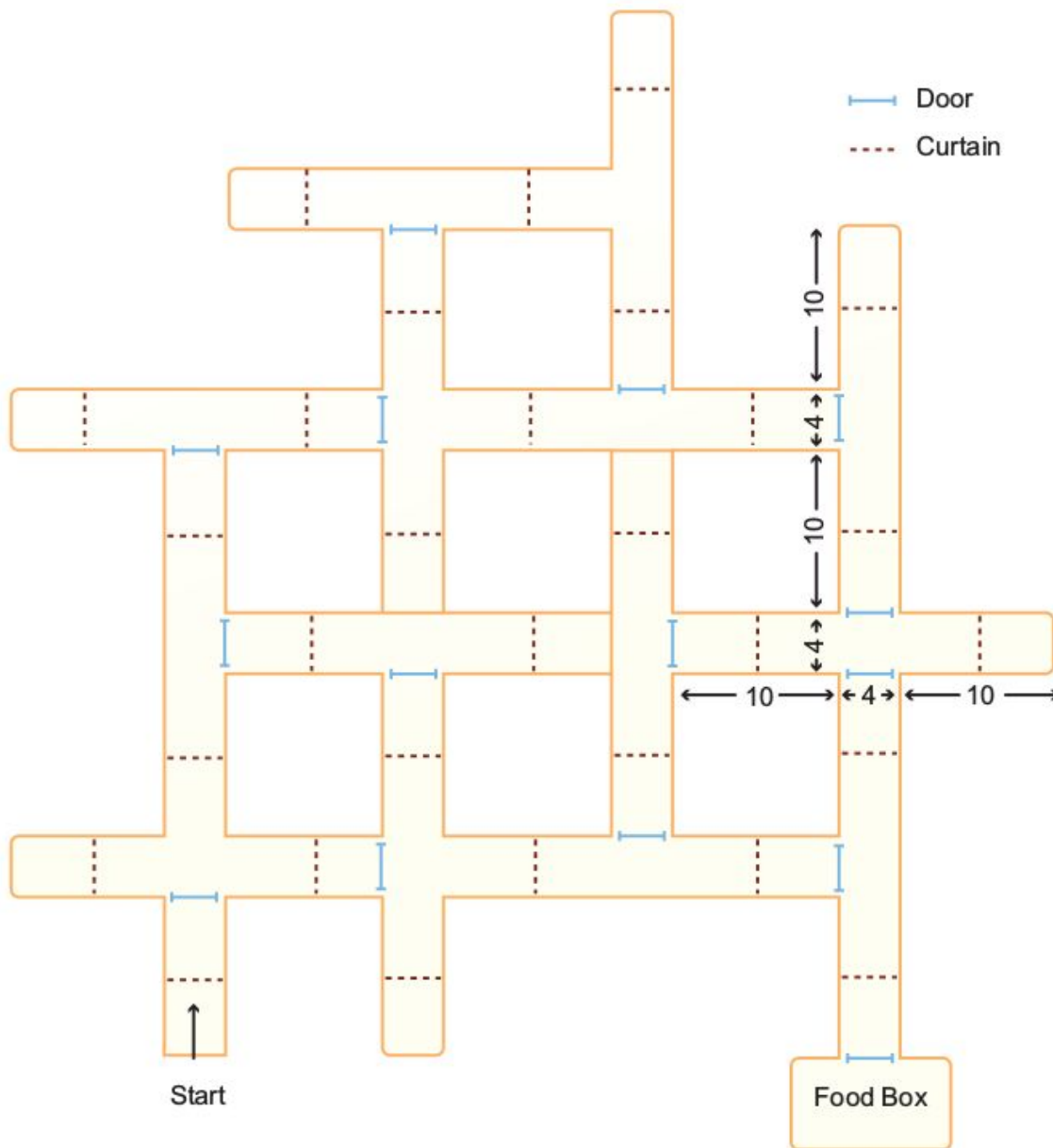


Figure 1.1 A rat in a Skinner box. The rat has a response lever controlling the delivery of food, as well as devices allowing different types of stimuli to be produced. (Adapted from Spivey 2007)

all learning, whether by rats or by human beings, takes place through processes of reinforcement and conditioning

Response by Tolman & Honzik 1930

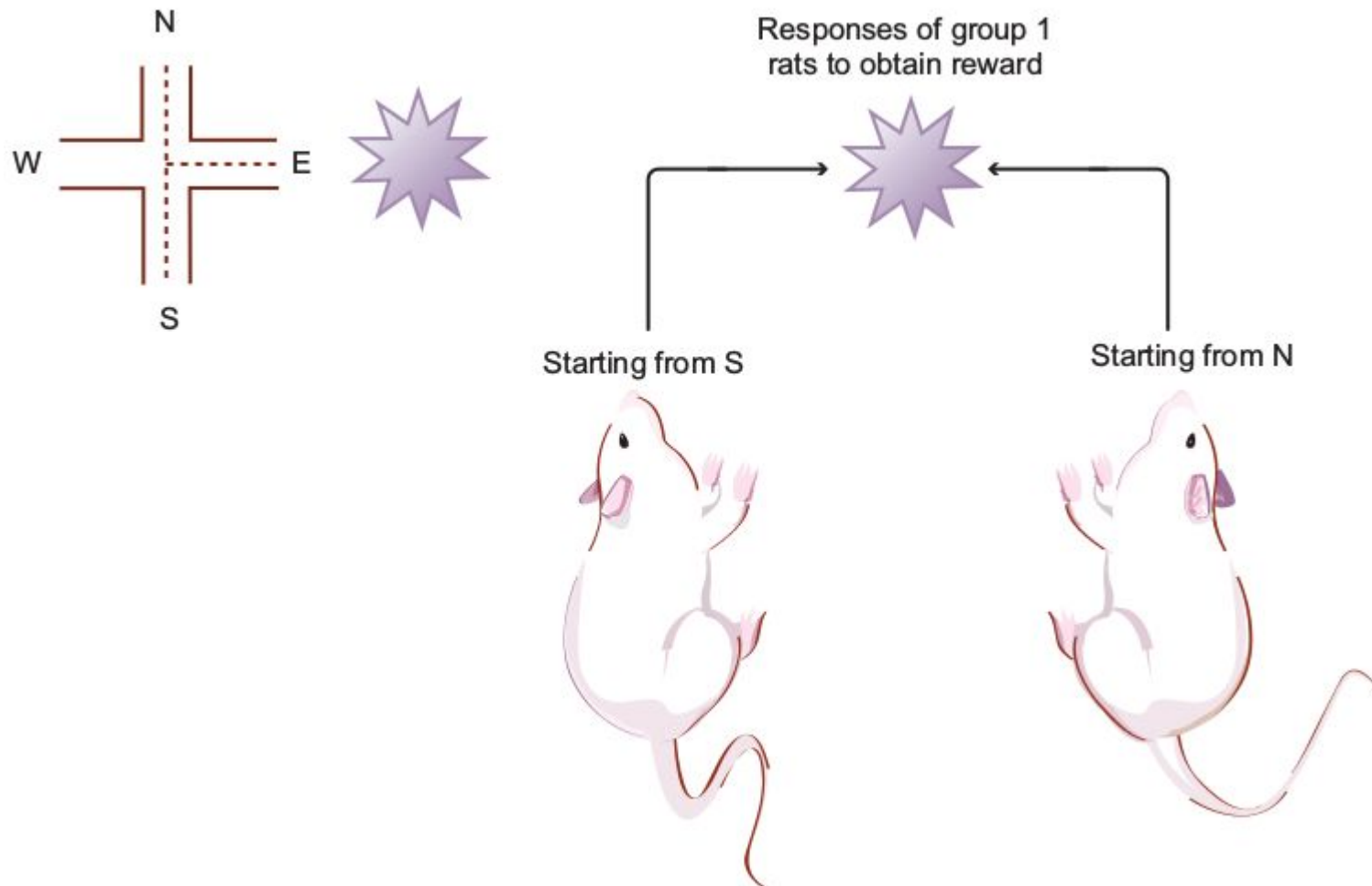


Three groups of rats

1. received a reward each success
2. never received a reward.
3. was unrewarded for the first ten days and then began to be rewarded

Cognitive maps, Tolman et al. (1946)

- Rats were started at North and South
- The first group: reward always at East
- The second group: reward shifted - the same turning response



Lashley (1951) – Complex behavior

- Previously: complex behavior is a chain of stimulus-responses.
- Lashley:
 - Organized hierarchically
 - Hypothesis of subconscious information processing
 - Hypothesis of task analysis

Other early schools

- Gestalt psychology
 - Gestalt: “form” or “configuration”
 - Max Wertheimer, Kurt Koffka, Wolfgang Kohler
 - The whole is different from the sum of the parts
- Psychoanalysis
 - At the core: concept of unconscious
 - Thoughts, attitudes, impulses, motivations, emotions
 - Show themselves in dreams, slips of tongue
 - Unconscious wishes involved sex or aggression



20th century

- 1950's: Computers offer a powerful tool for theorizing about psychological processes through simulation
- Many psychological studies: information-processing models
- Check earlier ideas about mind with concrete terms:
 - Memory as analogous computer stores and retrieves information
 - Transfer from temporary storage in its internal memory to hard drive, from working memory to long-term memory
- Development of modern linguistics: theorize about mental structures required to comprehend and speak a language.
- Information processing models, psycholinguistics, neuropsychology → cognitive psychology

Psychological Perspectives – Major approaches



Five perspectives within psychology

Biological perspective

An orientation toward understanding the neurobiological processes that underlie behavior and mental processes.

Behavioral perspective

An orientation toward understanding observable behavior in terms of conditioning and reinforcement.

Cognitive perspective

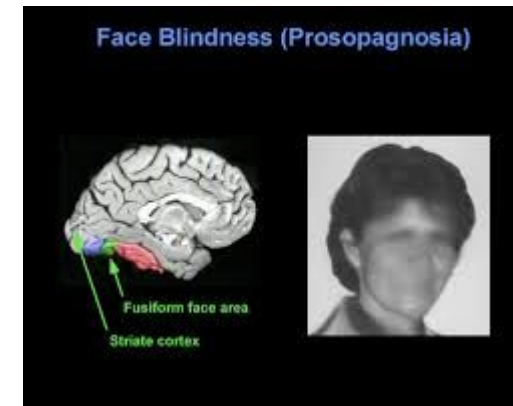
An orientation toward understanding mental processes such as perceiving, remembering, reasoning, deciding, and problem solving and their relationship to behavior.

Psychoanalytic perspective

An orientation toward understanding behavior in terms of unconscious motives stemming from sexual and aggressive impulses.

Subjectivist perspective

An orientation toward understanding behavior and mental processes in terms of the subjective realities people actively construct.



Following an insult, punch someone in the face

Topics of psychology

- Biological psychology
 - Relationship, biological processes and behavior
- Cognitive psychology
 - Mental processes, problem solving, memory, language
- Developmental psychology
 - Human development, factors (language or period or..)
- Social and personality psychology
 - Perception and interpretation of social world, social relationships
- Clinical and counseling psychology
 - Diagnosis and treatment of emotional and behavioral problems
- School and educational psychology
 - Evaluate learning and emotion problems, teaching. In schools
- Organizational and engineering psychology
 - Job selection, facilitate teamwork, relationship between man and machines

Methods of Psychology

- Scientific methods:

- ☐ Unbiased
- ☐ Repeatable

- Experimental method

- ☐ Variable (sleep, memory) independent vs dependent
- ☐ Controlling conditions
- ☐ Measurement
- ☐ Relationships between dependent and independent variables
- ☐ Experimental design
- ☐ Experimental group vs. control group
- ☐ Random assignment
- ☐ Statistics, mean, significance

Design and Analysis of an Experiment

- Identify the issue or question of interest
- Review the relevant theories and research
- Develop research hypothesis
- Identify the independent and dependent variables
- Conduct the experiment
- Use descriptive statistics to evaluate the statistical hypotheses
- Draw conclusions regarding the research hypotheses
- Prepare a formal report for publication or presentation

Keppel et al., Intro. to Design and Analysis

Experimental Method

- Hypothesis: Marijuana affects memory
- Variables: marijuana amount(indep); amount of recalled items (dep)
- Experiment:
 - Keep all conditions constant
 - Use enough subjects
 - Provide different sets of subjects different amounts of marijuana. Give same information to memorize
 - One week later, see the recalled items

Analysis of results

- Mean (μ): The average of scores
- Median (m): The middle value when we order the scores (more robust to outliers)
- Variance (S): Average of squared deviations from the mean: $\sum_i (x_i - \mu)^2 / (n-1)$

Analysis

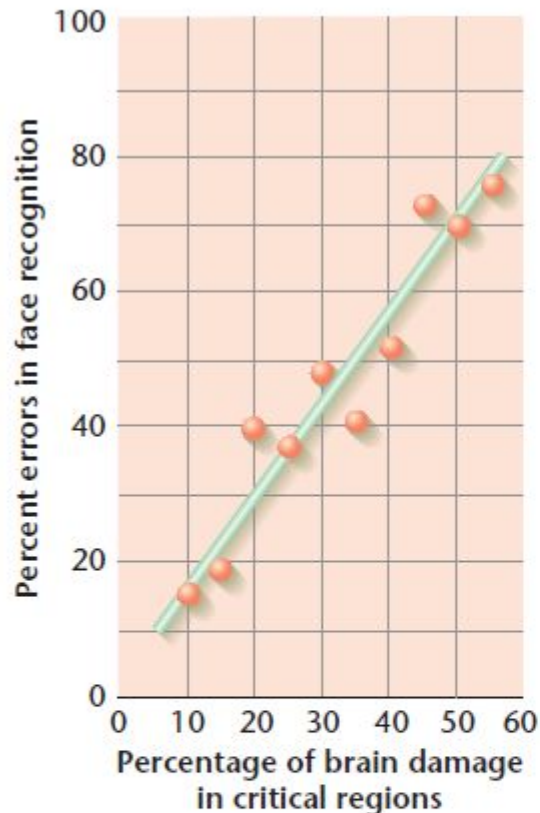
- What if we cannot control the variables under investigation?

Correlational method

- Correlational method
 - Naturally occurring differences
 - Coefficient of correlation (r)
 - 0: no correlation
 - 1: perfect positive correlation
 - -1: perfect negative correlation
 - Tests
 - Cause-and-effect relations
 - Double dissociation

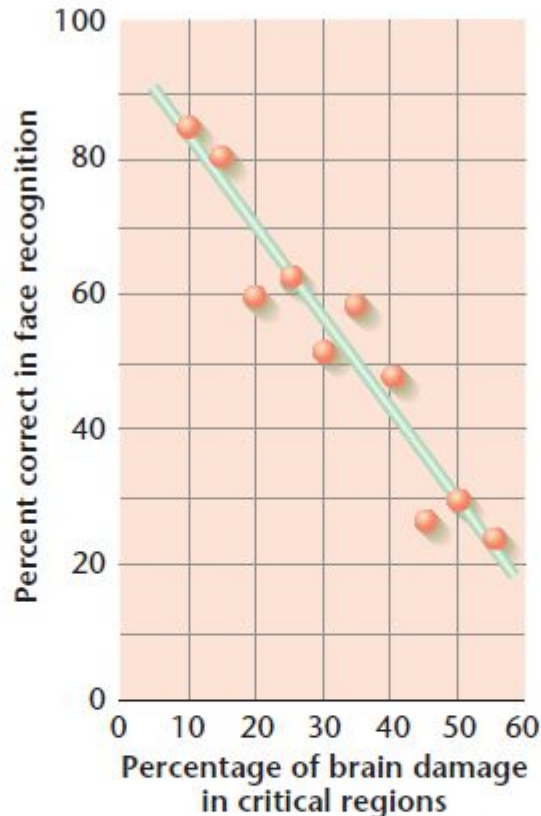
Correlational method

a) Positive correlation



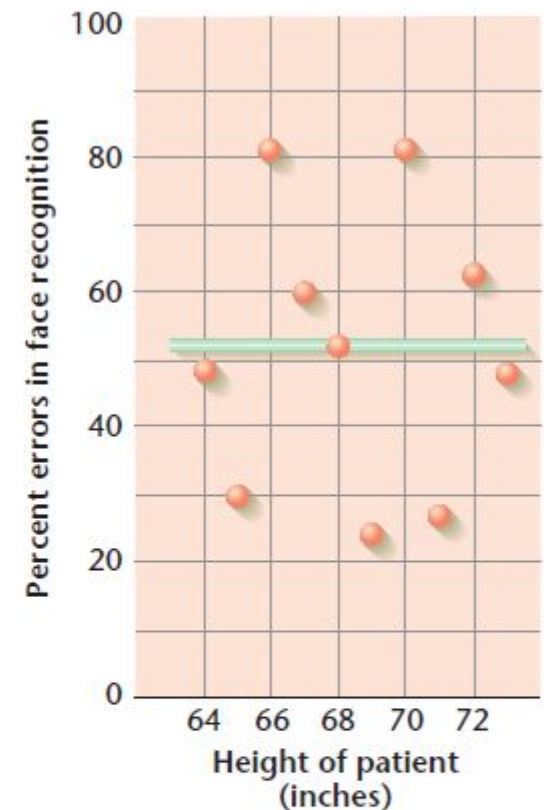
The patients are ordered along the horizontal axis with respect to the amount of brain damage, with the patient represented by the leftmost point having the least brain damage (10%) and the patient represented by the rightmost point having the most brain damage (55%). Each point on the graph represents a single patient's score on a test of face recognition. The correlation is a positive .90.

b) Negative correlation



The same data are depicted, but we now focus on the percentage of correct responses (rather than errors). Now the correlation is a negative .90.

c) Zero correlation



The patients' performance on the face recognition test is graphed as a function of their height. Now the correlation is 0.

Correlational method

- Correlational method
 - Naturally occurring differences
 - Coefficient of correlation (r)
 - 0: no correlation
 - 1: perfect positive correlation
 - -1: perfect negative correlation
 - Cause-and-effect relations

$$\rho_{X,Y} = \frac{\text{cov}(X, Y)}{\sigma_X \sigma_Y}$$

$$\text{Var}(X) = \sigma^2 = \frac{1}{n} \sum_{i=1}^n (x_i - \mu)^2$$

$$\text{cov}(X, Y) = \frac{1}{n} \sum_{i=1}^n (x_i - E(X))(y_i - E(Y)).$$

Methods of Psychology

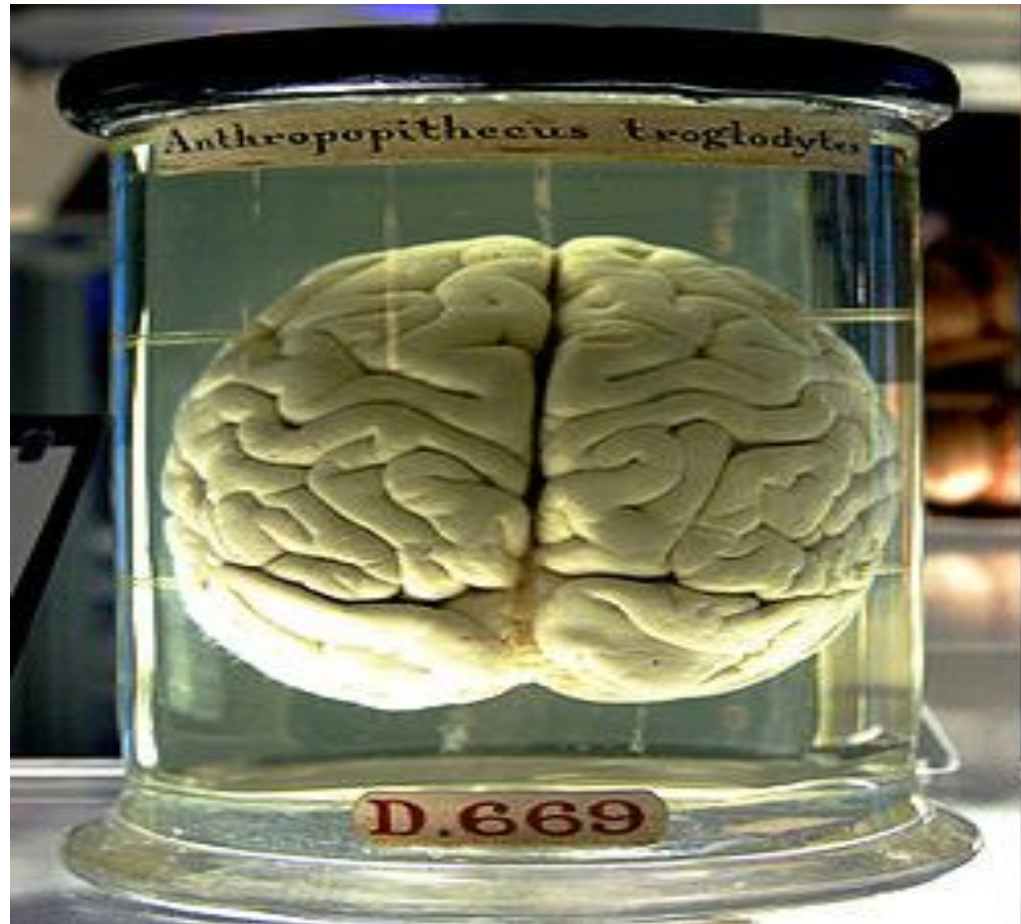
- Observational method
 - Direct observation
 - Survey method
 - Case histories



Field studies can often tell us more about social behavior than experimental studies can. Professor Shirley Strum has been observing the same troop of baboons in Kenya for more than 20 years, identifying individual animals, and making daily recordings of their behaviors and social interactions. Her data have provided remarkable information about the mental abilities of baboons and the role of friendships in their social system.

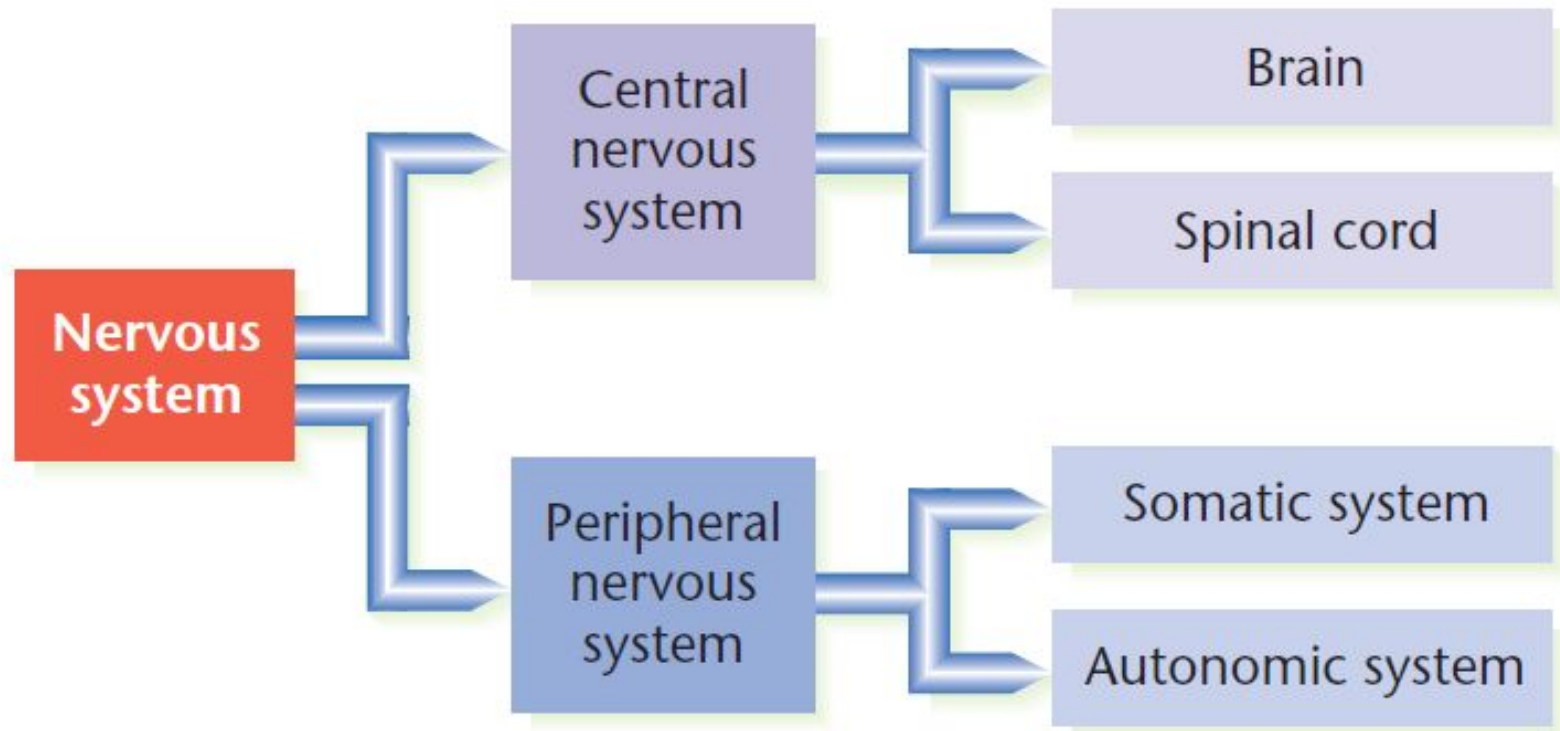
Nervous system and brain

Brain



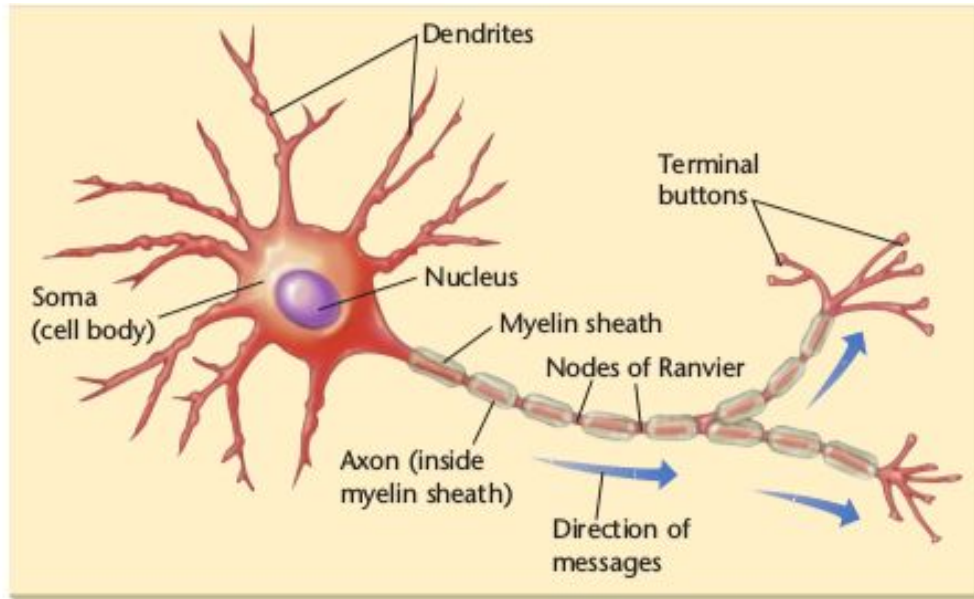
**15-30 billion neurons
each thousands of connections**

Nervous system



+ endocrine system

Neurons – basics



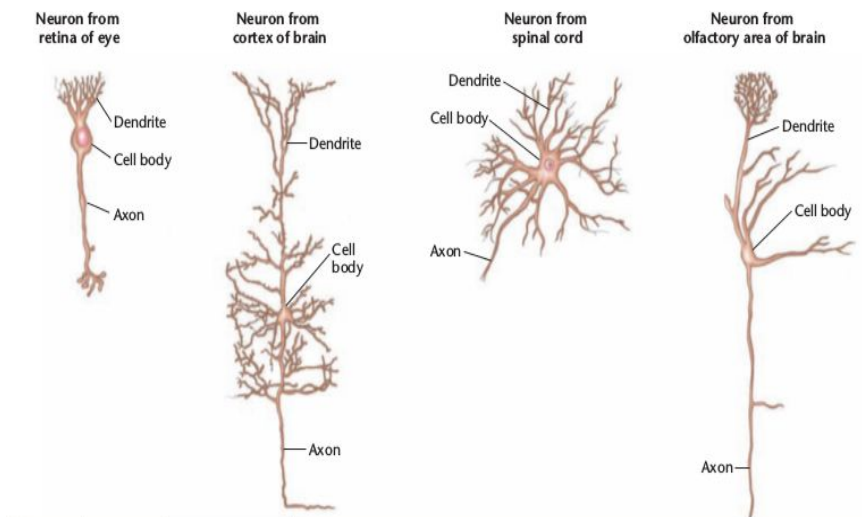
Transmits neural impulses to other neurons, glands, muscles.

Basics known but..

Dendrites, soma, axon, terminals..

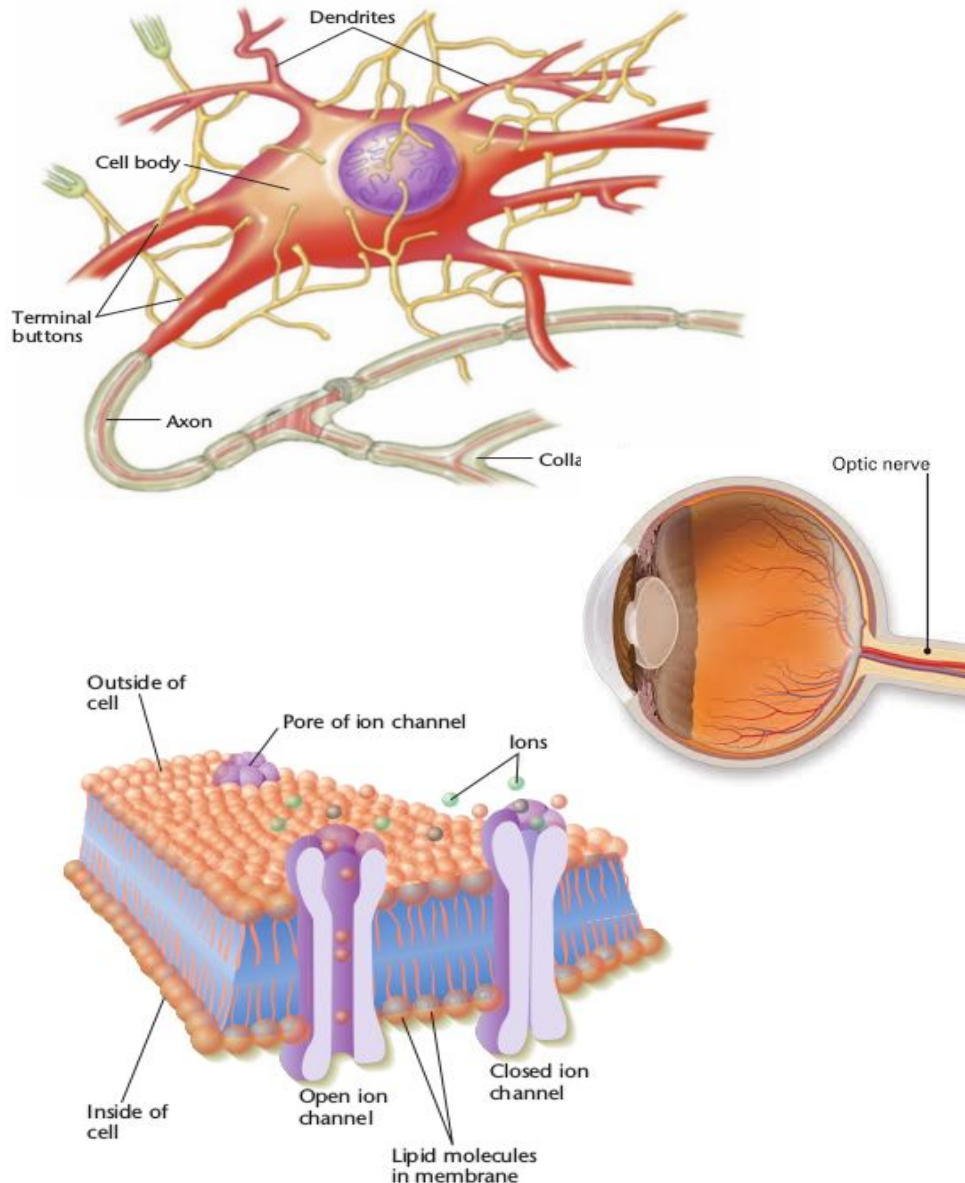
Neurotransmitters across gap

Integrate pre-synaptic impulses



<https://www.youtube.com/watch?v=90cj4NX87Yk>

Neurons – basic structure



Sensory & motor neurons

Nerve: a bundle. e.g. optic nerve

Glial cells more than half of brain – glue and nutrients

Information moves through electrochemical impulse, movement of ions

Semi-permeable cell membrane

Figure 2.5 Ion Channels. Ions such as sodium (Na^+), potassium (K^+), and chloride (Cl^-) pass through the cell membrane via doughnut-shaped protein molecules called ion channels.

Neurons – resting state

Resting state: membrane not permeable (high Na^+ outside, K^+ inside)

Ion channels and pumps

Action potential from stimulation by other neurons. Caused by neurotransmitters released by pre-synaptic neurons.

Change small: ion pumps restore

Excitation threshold: -55 mV

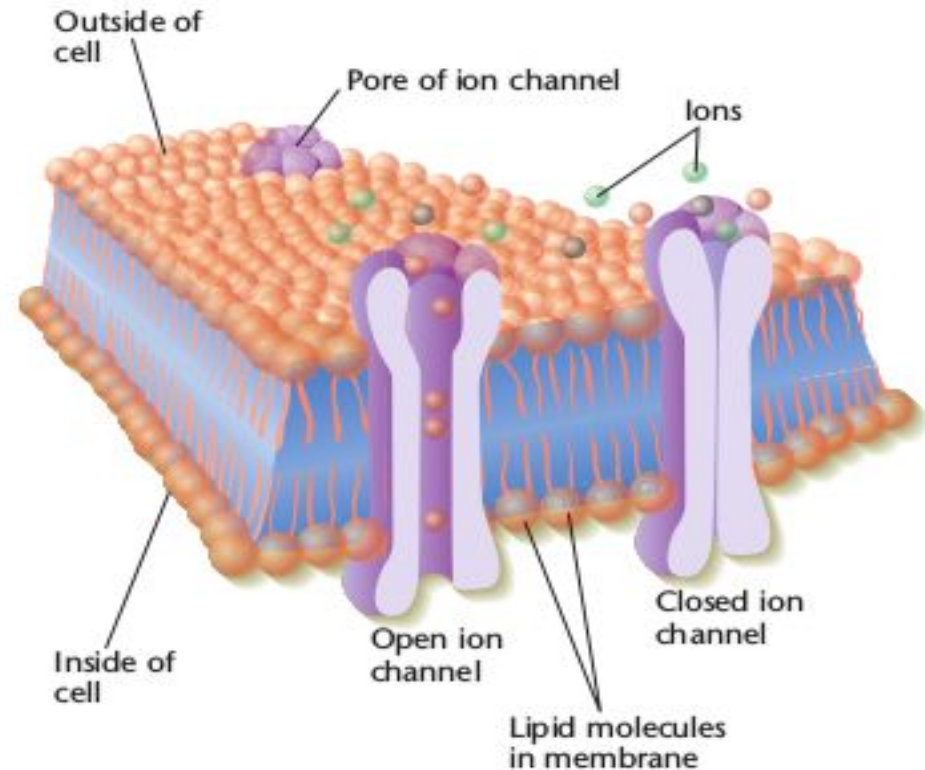
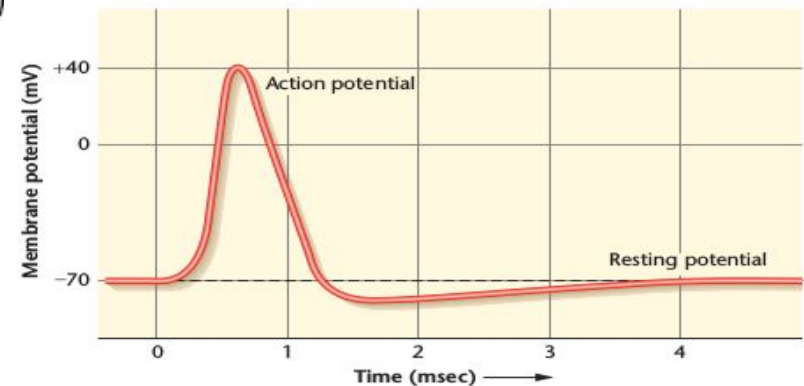
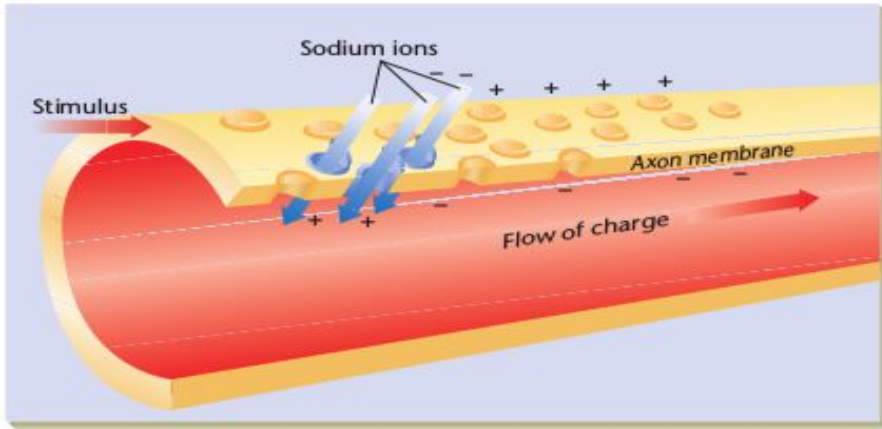


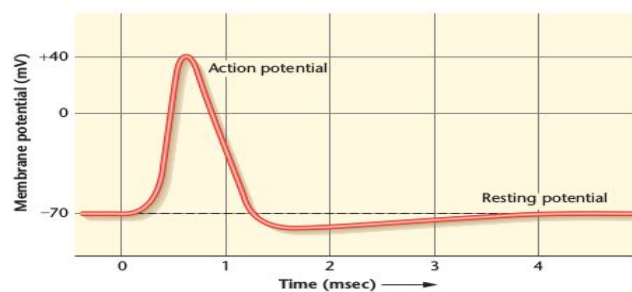
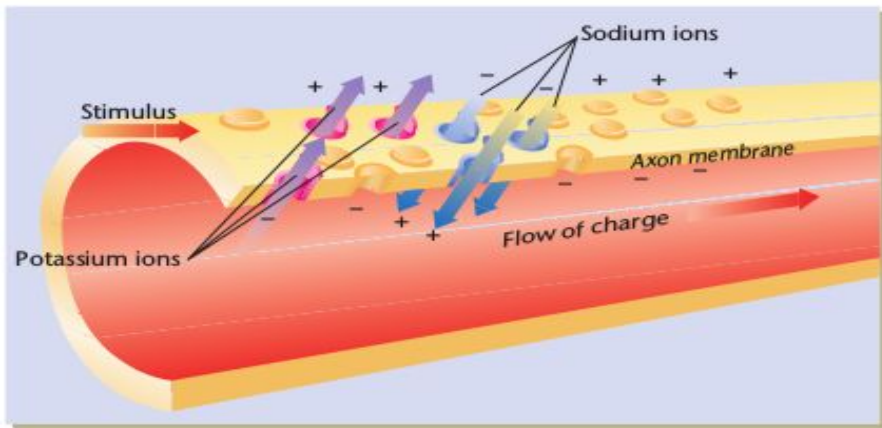
Figure 2.5 Ion Channels. Ions such as sodium (Na^+), potassium (K^+), and chloride (Cl^-) pass through the cell membrane via



Neurons – action potential



a) During an action potential, sodium gates in the neuron membrane open and sodium ions enter the axon, bringing a positive charge with them.



the axon, the sodium ions flow along the axon. When potassium ions flow

Unstable membrane

Na^+ ions in

inside +40 mV

Ion pumps restore

“spike” in only milliseconds

Refractory period. only in one direction

<https://www.youtube.com/watch?v=90cj4NX87Yk>

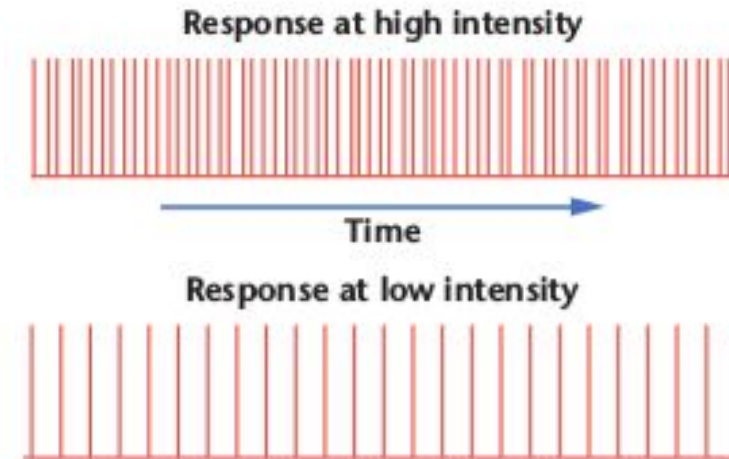
Neurons - characteristics

All a neuron can do: fire!

- Single brief pulse
- Threshold level
- Response size same
- All-or-none law

How to code complexity? If basic is so simple.

E.g. Sound of increasing intensity?



Neurons - synapse

Not connected

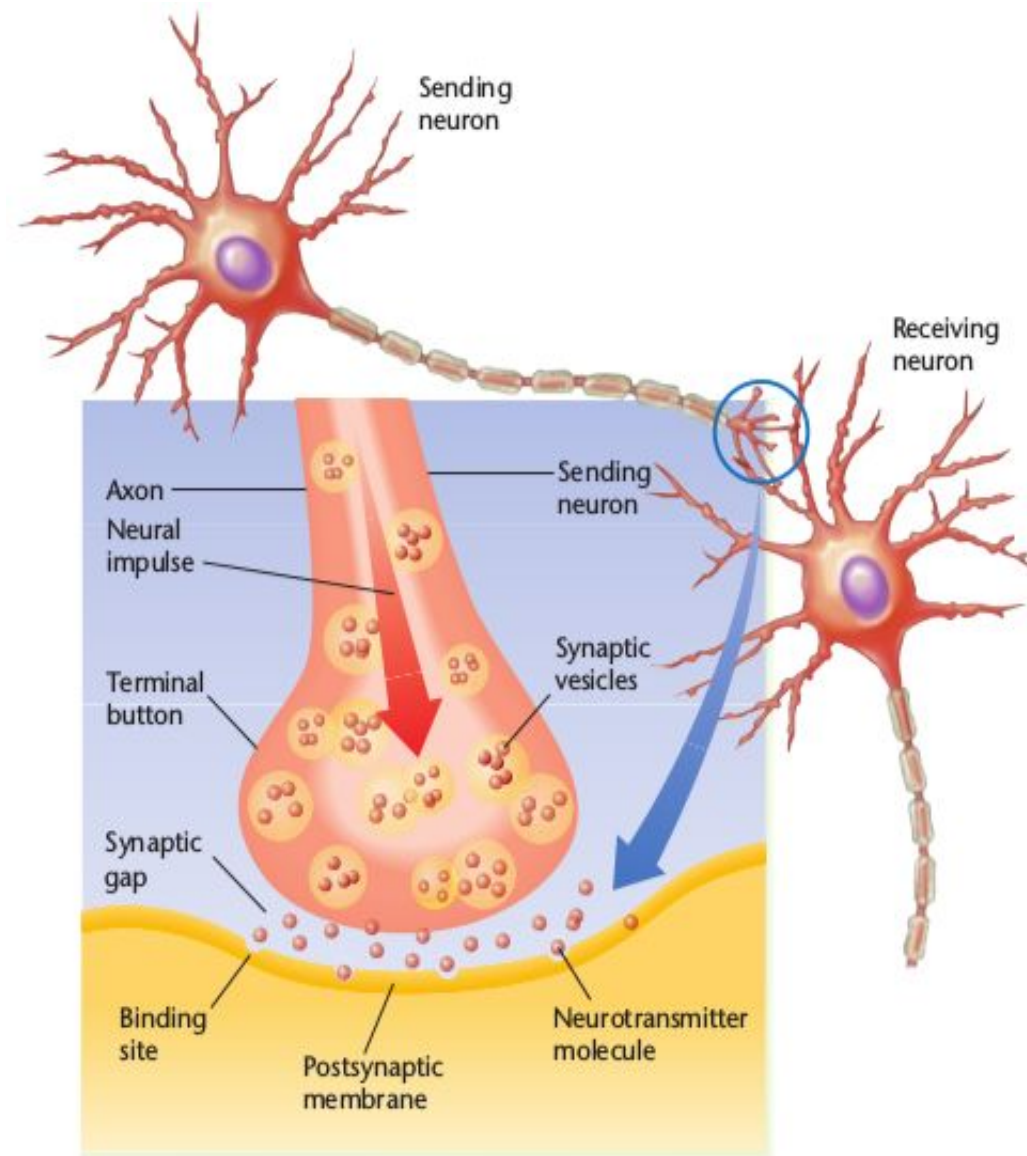
Stimulate synaptic vesicles that contain neurotransmitters

Diffuse from neuron and bind to receptors (proteins) in the dendritic membrane – lock&key

Change permeability of ion channels

Excitatory or inhibitory

Excitatory: towards reaching excitation threshold

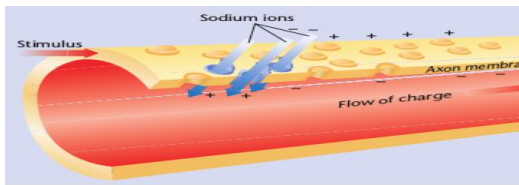
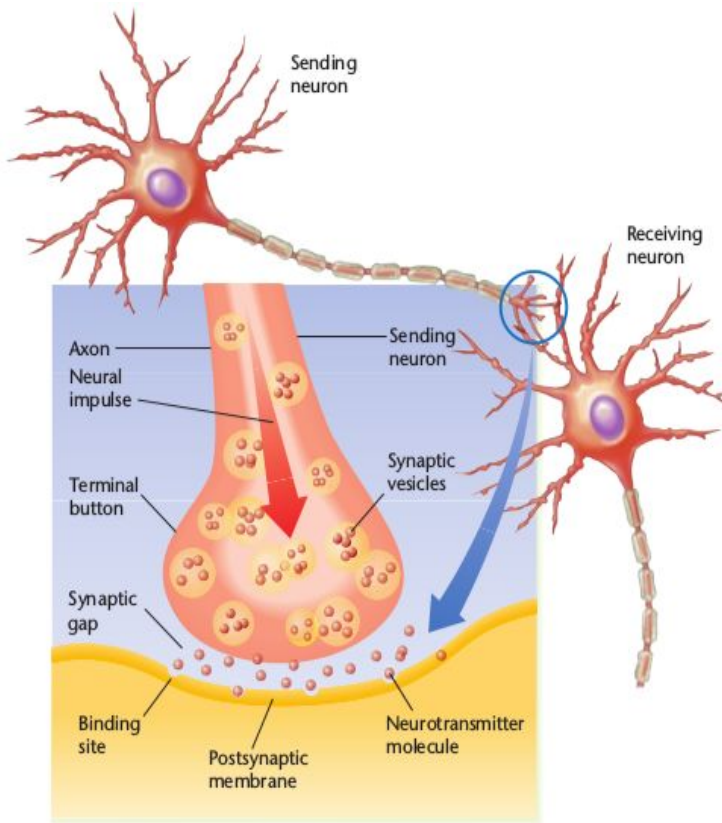


Neurons – input summation

Receive from many.
Summates the input it
receives

Excitatory effect >
inhibitory effect

– Depolarization



Neurotransmitters

More than 70. Different types:
Some can bind to more than one type of receptor.

Acetylcholine, Norepinephrine,
GABA, Glutamate,
Serotonin, Dopamine

Acetylcholine: new memories,
activation of muscles

Dopamine: release in certain
areas produces intense
feelings of pleasure.

Serotonin: mood regulation.
Low levels: associated with
feelings of depression.

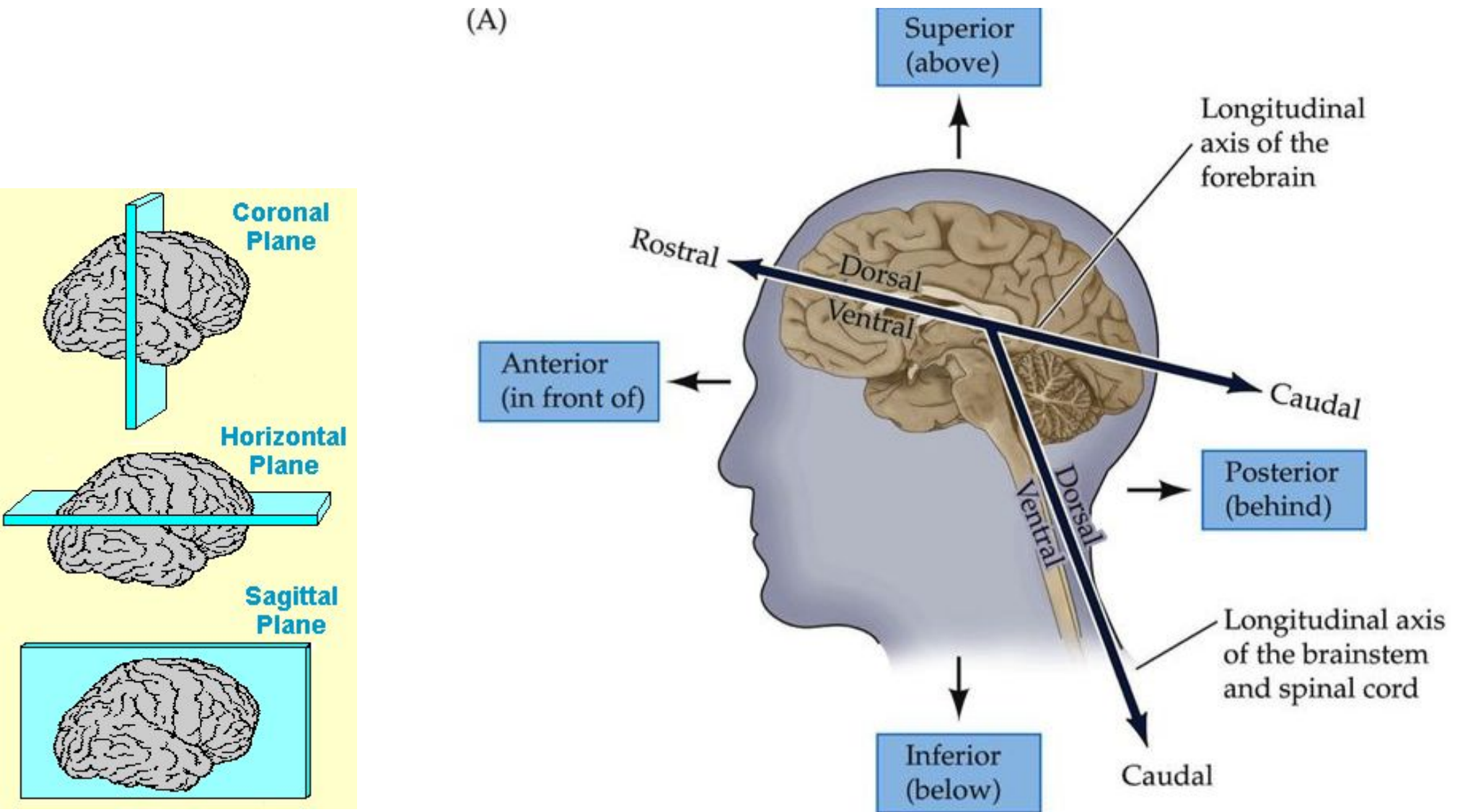
CONCEPT REVIEW TABLE



Neurotransmitters and Their Functions

<i>Neurotransmitter</i>	<i>Function</i>
Acetylcholine	Involved in memory and attention; decreases associated with Alzheimer's disease. Also transmits signals between nerve and muscle.
Norepinephrine	Increased by psycho-stimulants. Low levels contribute to depression.
Dopamine	Mediates the effects of natural rewards (food and sex, for example) and drugs of abuse.
Serotonin	Important in mood and social behavior. Drugs that alleviate depression and anxiety increase serotonin levels in synapse.
Glutamate	Major excitatory neurotransmitter in brain. Involved in learning and memory.
GABA	Major inhibitory neurotransmitter in brain. Drugs that alleviate anxiety enhance activity of GABA.

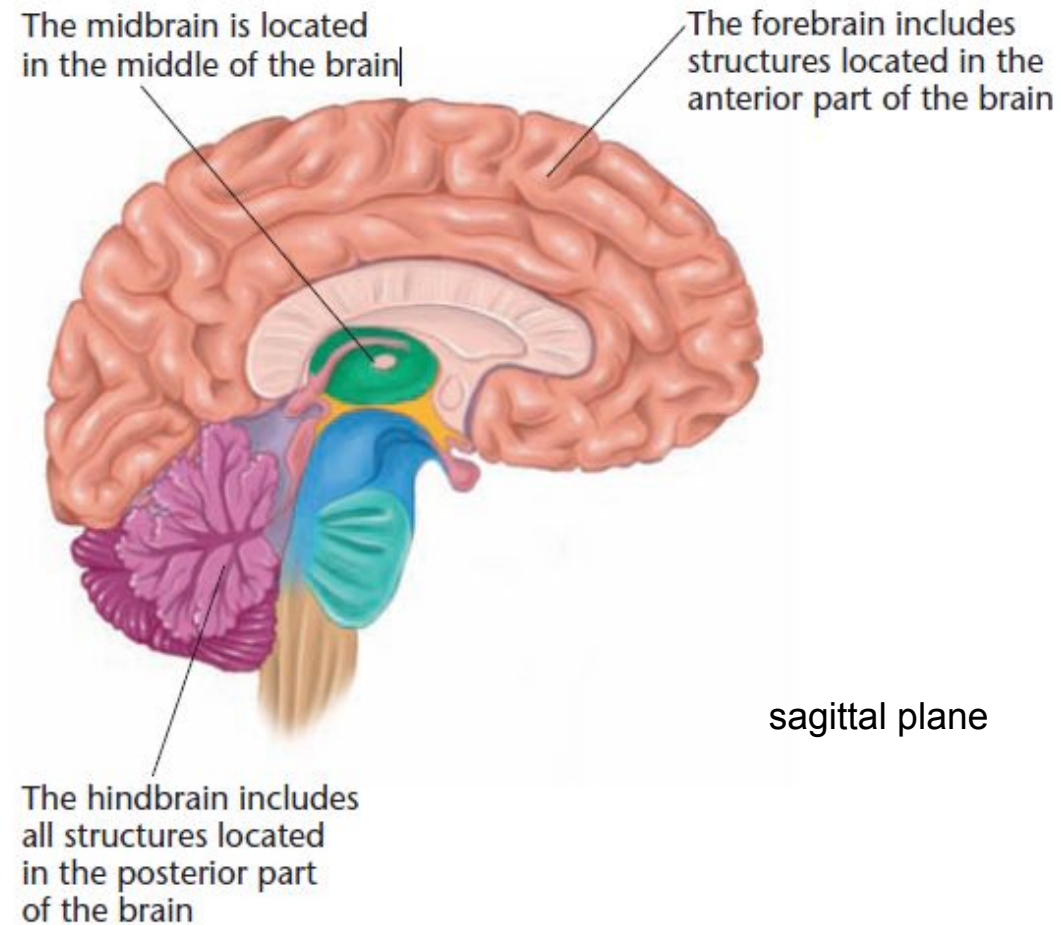
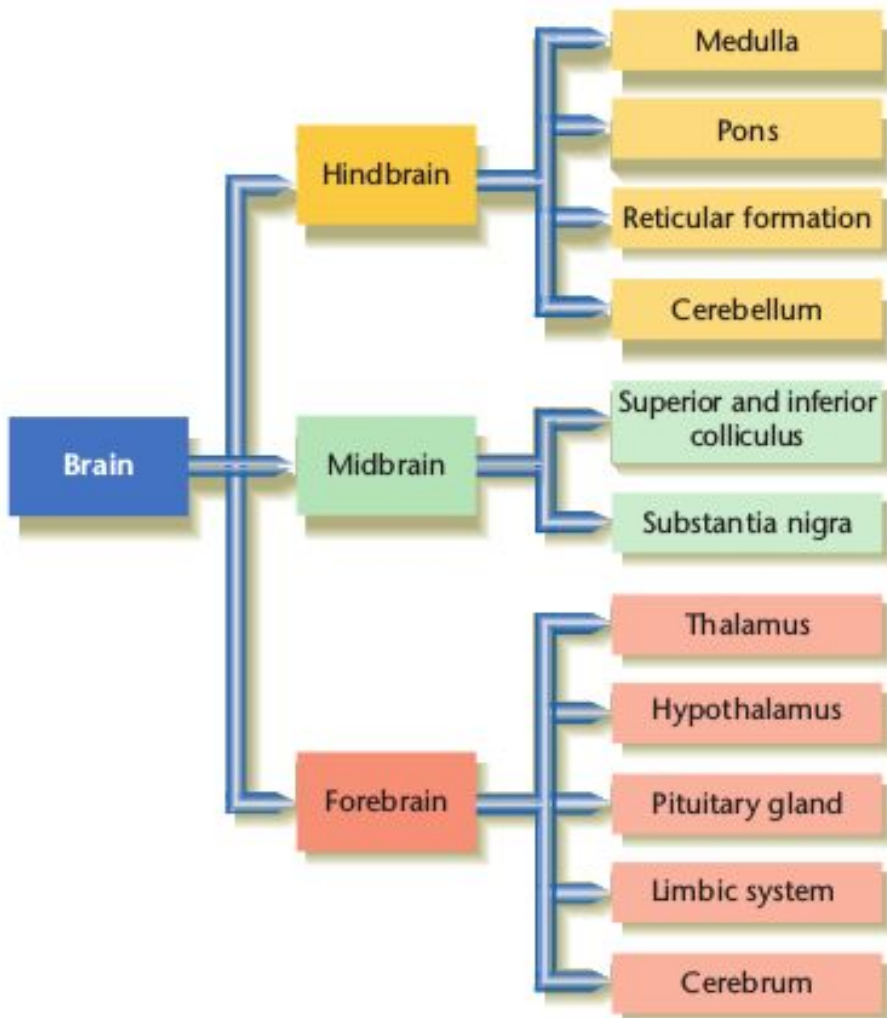
Terminology



NEUROSCIENCE, Fourth Edition, Appendix, Figure A1 (Part 1)

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The organization of the brain

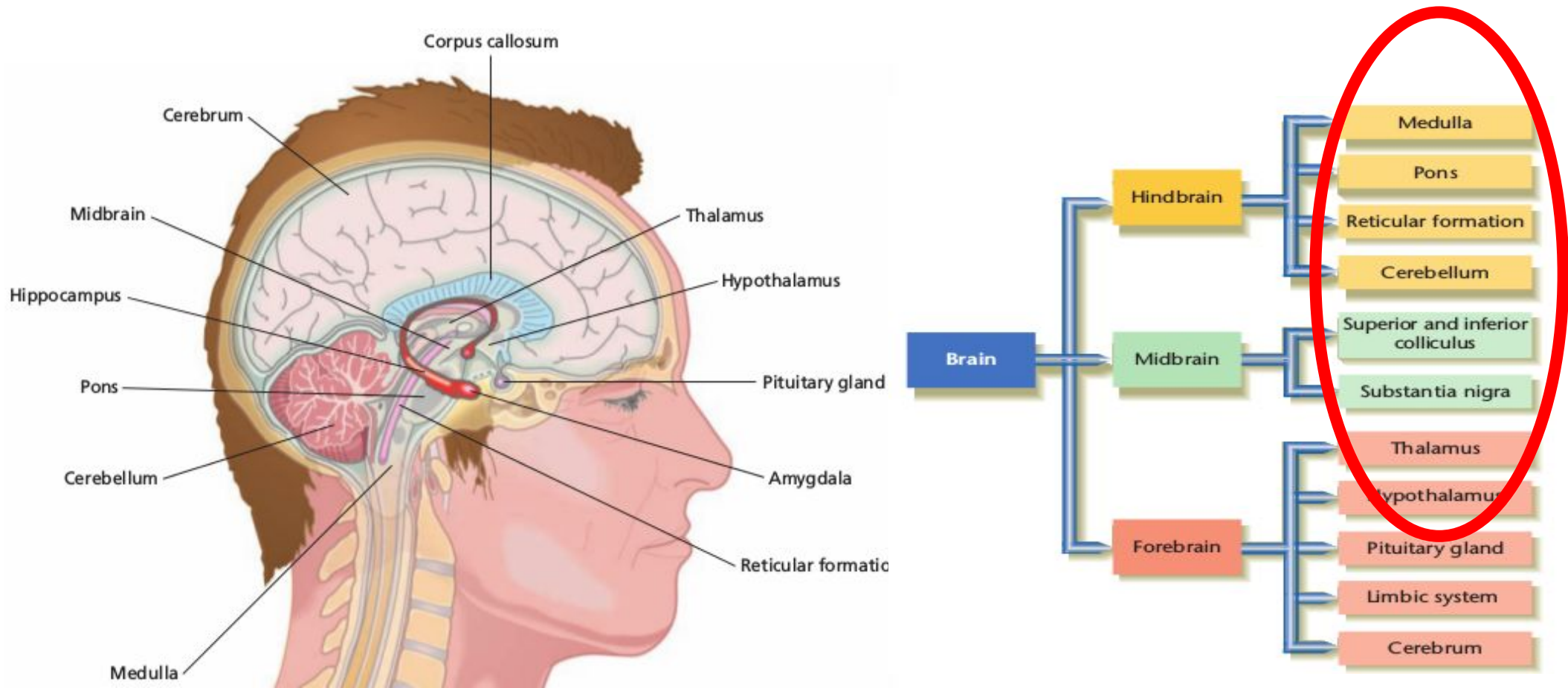


Functional organization

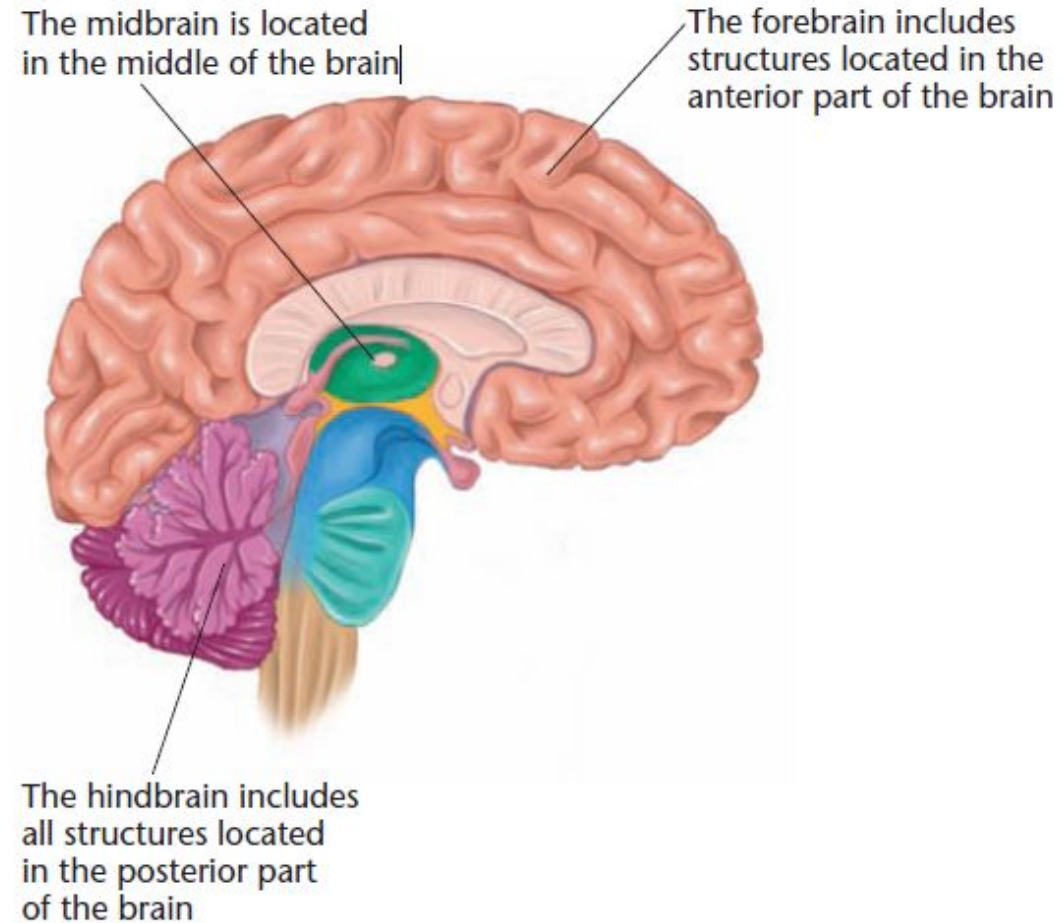
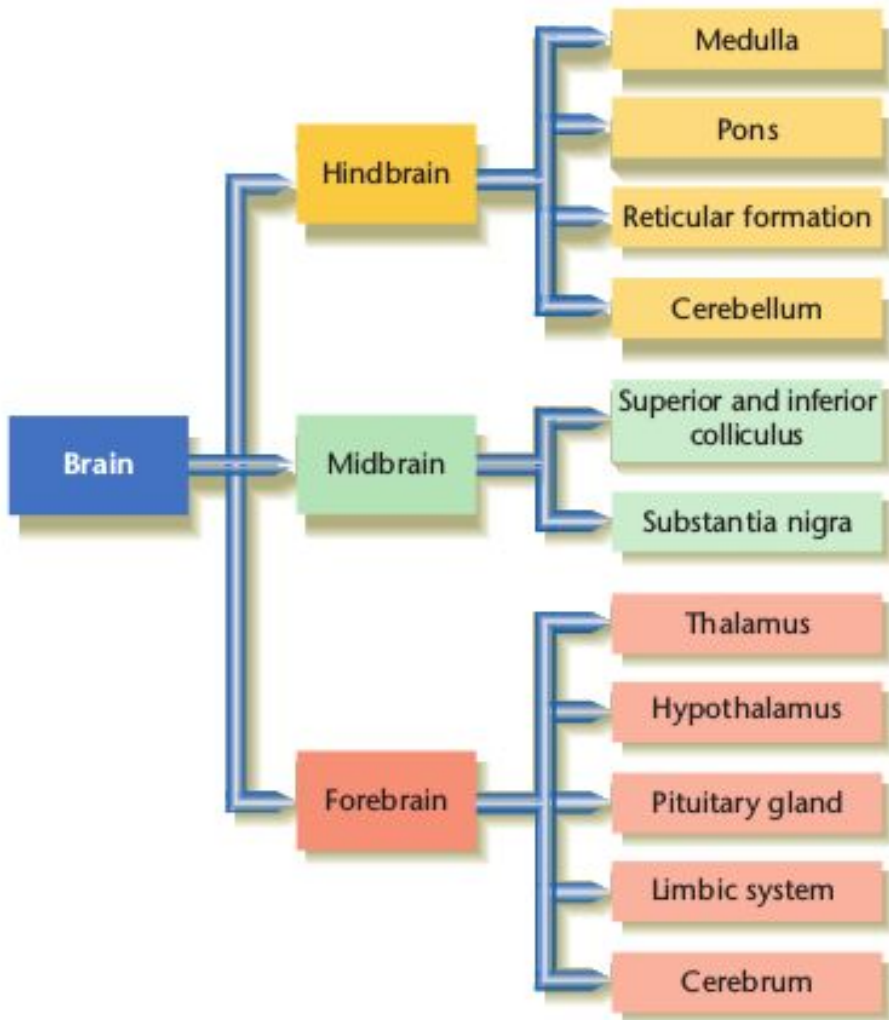
Central core: the most primitive behaviors

Limbic system: controls our emotions

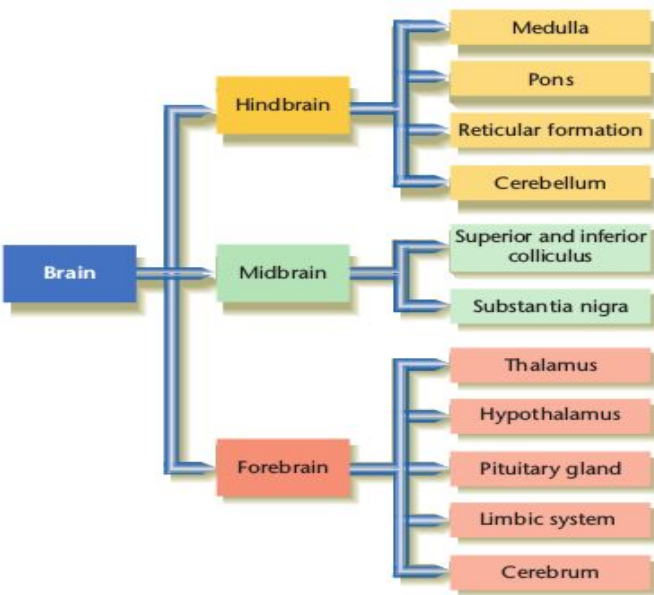
Cerebrum: regulates our higher intellectual processes



The organization of the brain



The organization of the brain - Hindbrain



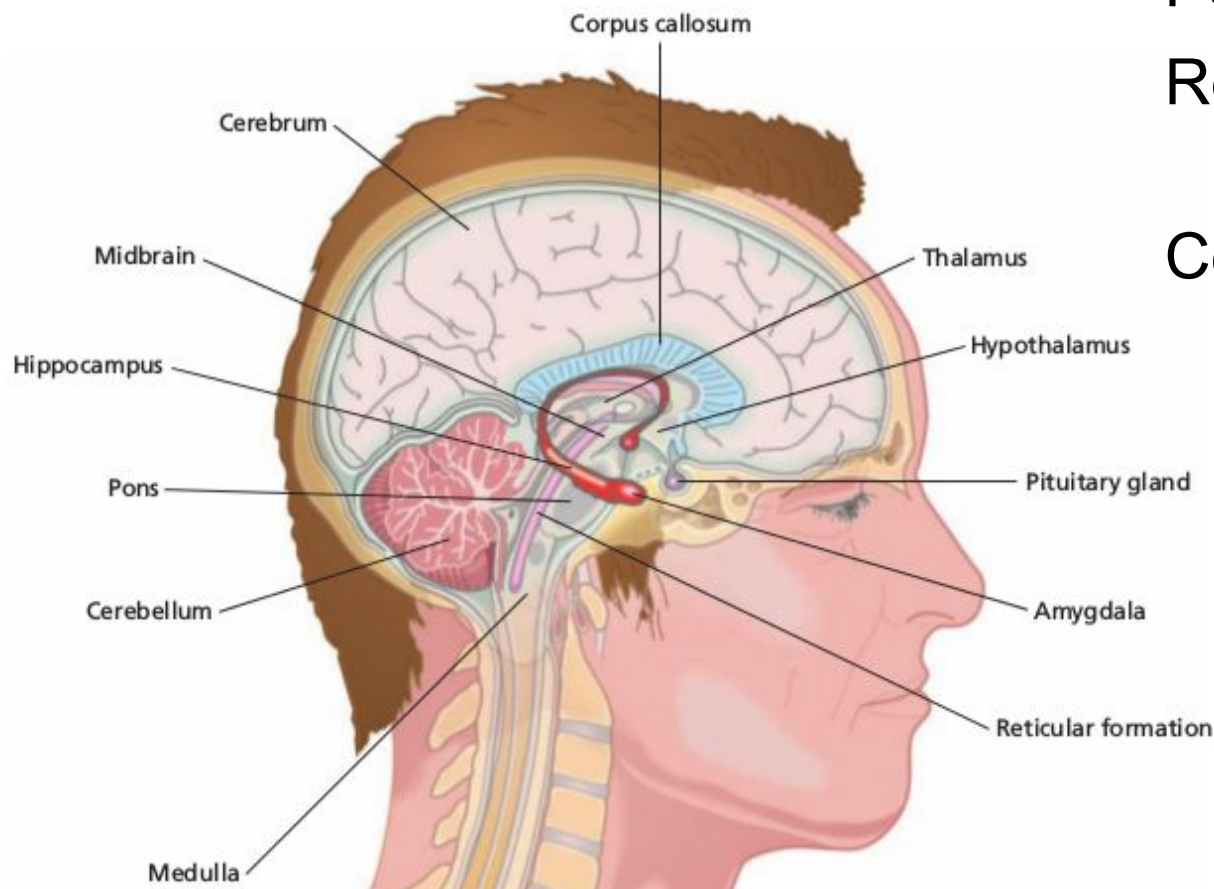
Medulla: reflexes (breathing and posture)

Pons: Attentiveness and sleep

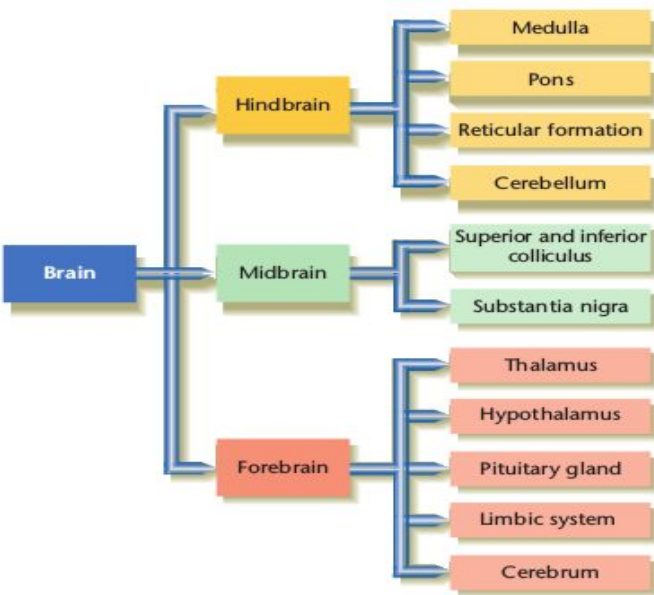
Reticular formation: Behavioral arousal and consciousness

Cerebellum: coordination of movement. Damage?

- Learning new movements
- Direct connections to frontal



The organization of the brain - Midbrain



Relaying sensory information to the brain and for movement control (including eye)

Important part of dopamine-containing pathway (reward pathway).

