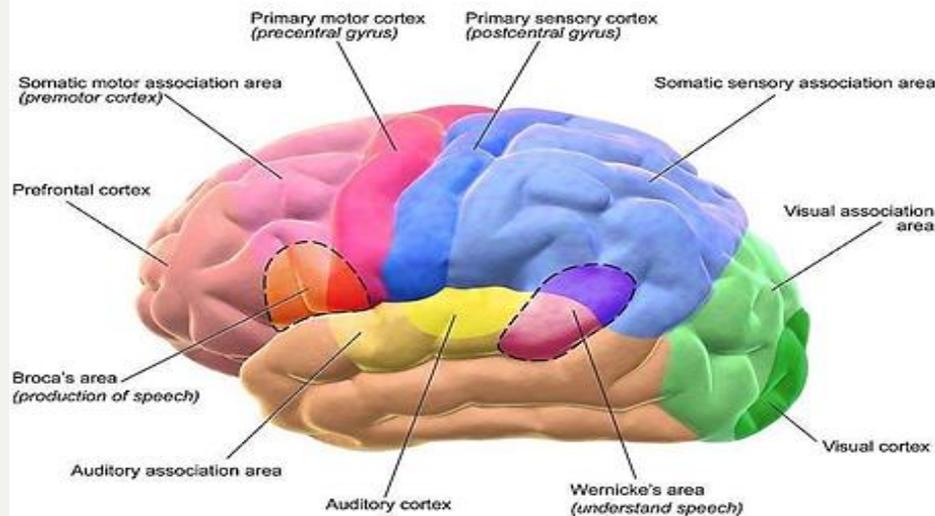


CNS MODULE

PHYSIOLOGY (LECTURE 8)

HIGHER FUNCTIONS OF NEOCORTEX

Motor and Sensory Regions of the Cerebral Cortex



BY

Dr. Fatma Farrag Ali

Associate Professor of Medical Physiology

Faculty of Medicine-Mutah University

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THE CEREBRAL CORTEX

The cerebral cortex contains the highest centers in CNS.

It is concerned with perception of fine and special sensations, initiation of skilled voluntary movements as well as consciousness and high intellectual functions as speech, learning and memory.

The whole of the cerebral cortex was divided into different areas known as Brodmann's areas.

In more general terms, the cortex is typically described as comprising three parts: sensory, motor, and association areas.

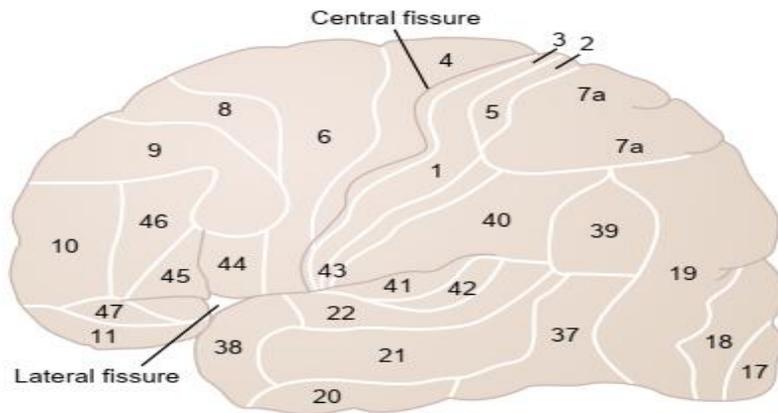
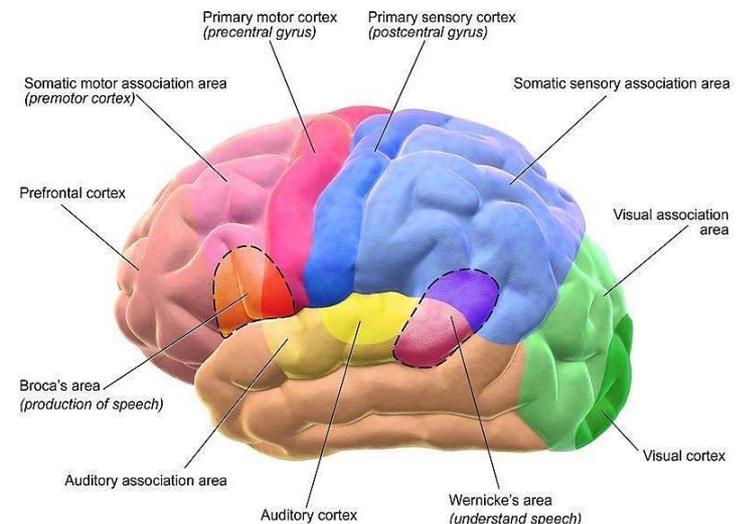


Figure 47-5

Structurally distinct areas, called Brodmann's areas, of the human cerebral cortex. Note specifically areas 1, 2, and 3, which constitute *primary somatosensory area I*, and areas 5 and 7, which constitute the *somatosensory association area*.

Motor and Sensory Regions of the Cerebral Cortex



Somatosensory areas

1. Somatosensory area I, S I (areas 3,1,2)

It is located at the postcentral gyrus.

Characters of area S I:

- 1) The representation is crossed: The somatosensory area I of one side receives somatic sensations from the opposite side of the body.
- 2) The body is represented in an inverted manner.
- 3) The greater the sensory function of the part, the larger is the size of its area of representation.

Function:

It is the final destination of the sensory pathways projecting from the VPLN of the thalamus.

CORTICAL PLASTICITY:

The cortical area of representation of a given part of the body is not absolutely fixed, but it is liable to variations under different conditions.

This is called plasticity of the cortex.

Example:

When a limb is amputated, its cortical area of representation does not show disuse atrophy, but is associated with that of the surrounding limbs.

2. Somatosensory area II (S II) (area 40)

A small area that is located behind the lower part of area S I.

Characters:

- It receives signals from somatosensory area I and other sensory areas.
- The face is represented anteriorly, the arms centrally, and the legs posteriorly. However, there is no sharp demarcation between the different areas as present in somatosensory area I.

Function:

It potentiates the functions of area S I.

It also starts making meaning for sensory signals.

N.B. Areas S I and S II process sensory information in series not in parallel.

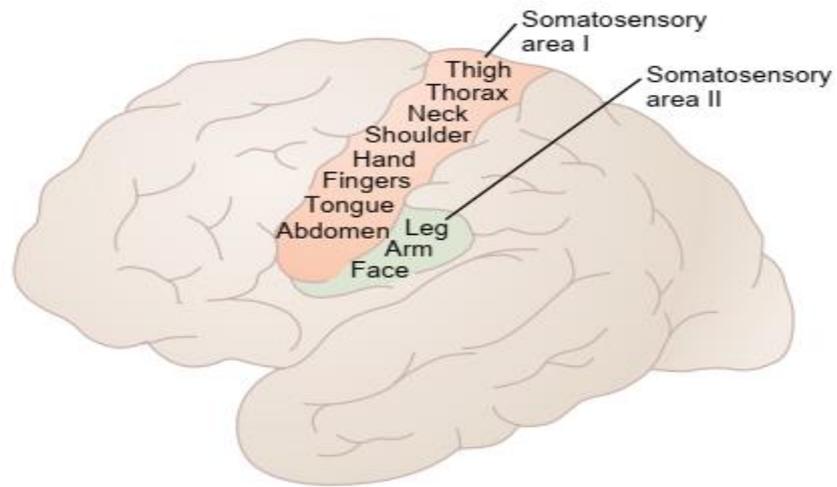


Figure 47-6

Two somatosensory cortical areas, somatosensory areas I and II.

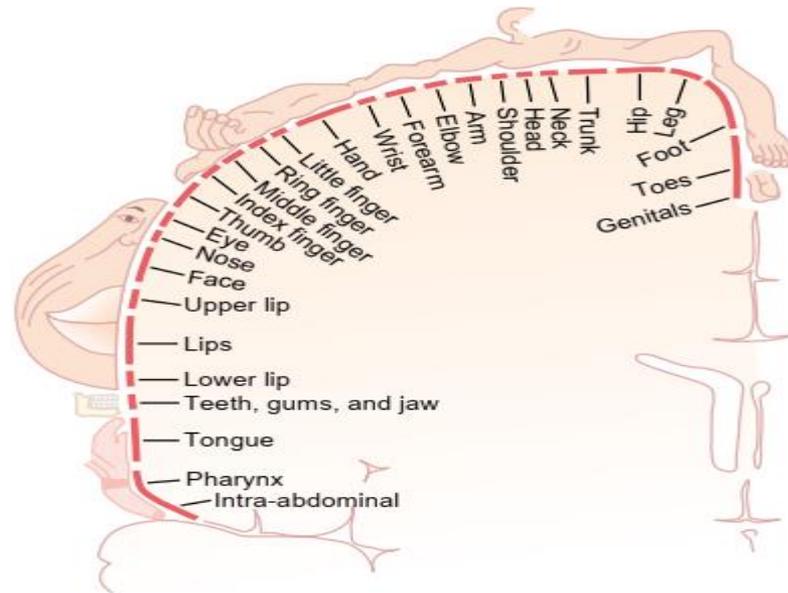


Figure 47-7

3. Somatosensory association area (areas 5, 7)

- It is located behind area S I and above area S II.
- It receives signals from areas S I and S II as well as from various thalamic nuclei and visual and auditory areas.

Function:

Interpretation of sensations (understanding and giving a meaning to them).

Clinical significance:

Damage or removal of the somatosensory association area leads to:

- Loss of the ability of the person to recognize complex objects (astereognosis).
- Forgetting the opposite side of the body (amorphosynthesis).

THE MOTOR CORTEX

The motor cortex is divided into 3 main areas:

- Primary motor cortex.
- Premotor area.
- Supplementary motor area.

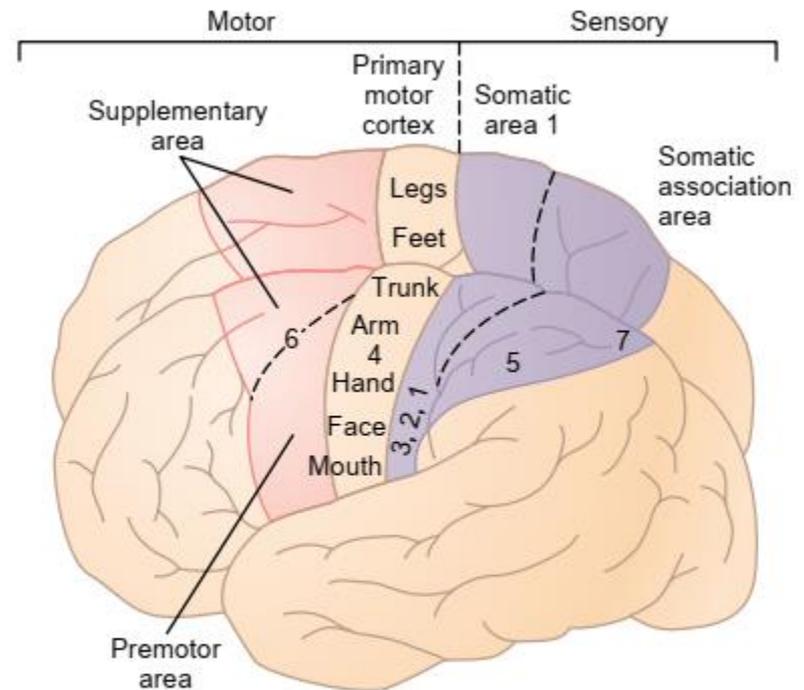


Figure 55-1

Motor and somatosensory functional areas of the cerebral cortex. The numbers 4, 5, 6, and 7 are Brodmann's cortical areas, as explained in Chapter 47.

Primary motor cortex

Primary motor cortex (area 4):

It is located at the precentral gyrus.

It controls muscle activity in the opposite side (but the upper half of face and the respiratory and abdominal muscles are bilaterally represented).

Representation of the body in area 4: (The motor homunculus)

- ✓ The representation is crossed: It controls muscle activity in the opposite side (but the upper half of face and the respiratory and abdominal muscles are bilaterally represented).
- ✓ The body is represented in an inverted manner: the feet at the top and the face at the bottom.
- ✓ The area of representation of each part is proportionate to the degree of skilled movements performed by the part: The greater and more complex the motor function of the part, the larger is the size of its area of representation.

The motor homunculus is a topographic representation of the body parts and its correspondents along the precentral gyrus of the frontal lobe. While the sensory homunculus is a topographic representation of the body parts along the postcentral gyrus of the parietal lobe.

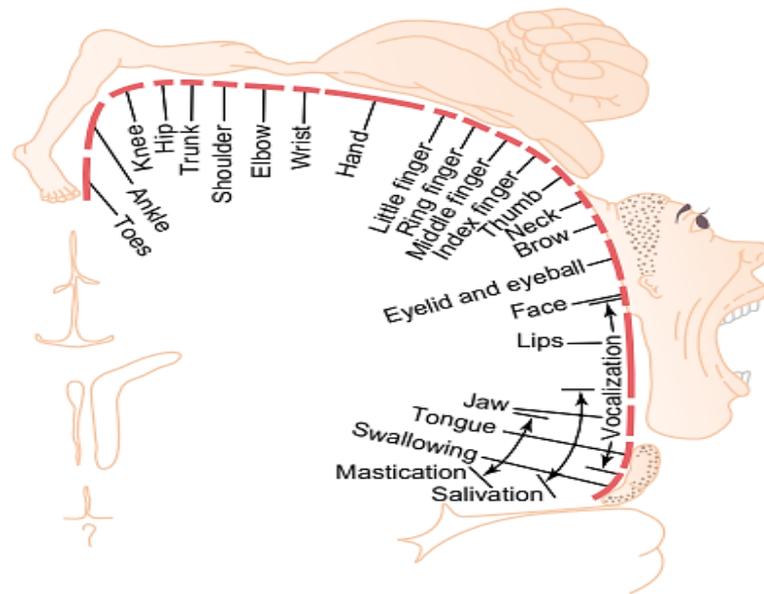
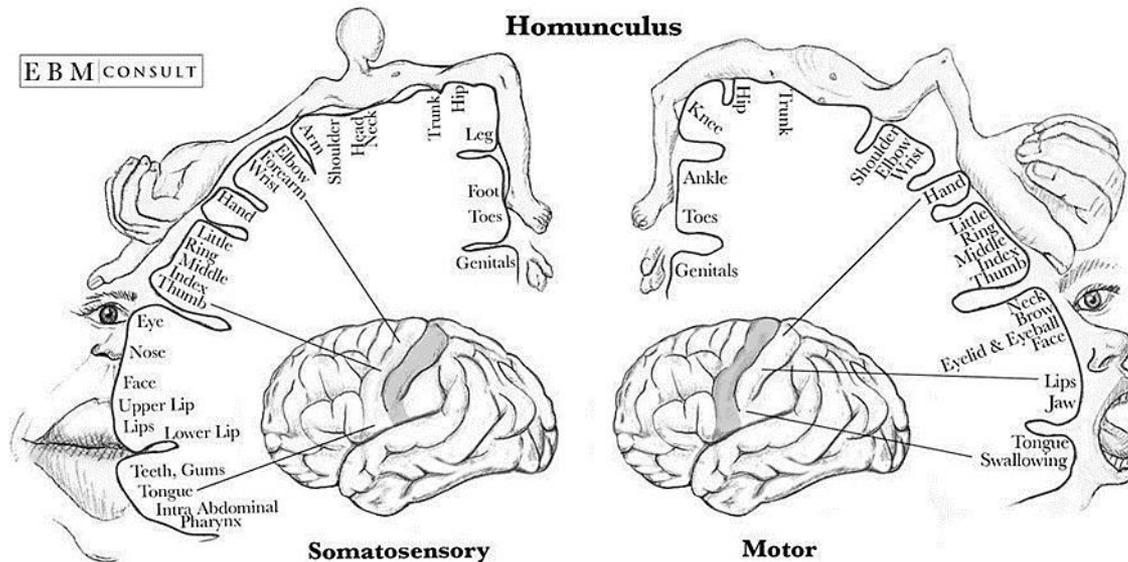


Figure 55-2

Degree of representation of the different muscles of the body in the motor cortex. (Redrawn from Penfield W, Rasmussen T: *The Cerebral Cortex of Man: A Clinical Study of Localization of Function*. New York: Hafner, 1968.)



Functions of area 4:

- ✓ It is the only area that initiates the voluntary fine skilled movements specially of hands and fingers.
- ✓ It shares area 6 in initiating gross movements.
- ✓ It sends facilitatory impulses to the spinal centers of the stretch reflex.
- ✓ It is necessary for occurrence of superficial reflexes.

Premotor Cortex

Premotor cortex lies anterior to primary motor area 4 in the frontal lobe. It includes mainly **premotor area 6**.

Functions of area 6 (premotor area or motor association area):

- ✓ It is responsible for gross movements performed by proximal joints on the opposite side of the body.
- ✓ **Inhibition of:** the stretch reflex- the grasp reflex.
- ✓ It initiates subconscious automatic movements e.g. swinging of the arms during walking.
- ✓ It contains specialized areas that control specific movements:

1. Broca's area for speech (Word formation area, area 44):

- It lies anterior to lower part of area 4 (in left hemisphere in right-handed persons).
- It is essential for normal speech.
- Its stimulation produces movements of the lips, tongue, and larynx with spoken vocalization.

2. Eye movement area (Frontal eye field area, area 8):

- It lies above Broca's area.
- It directs the eyes voluntarily towards the desired object and also controls the movements of the eyelids e.g. blinking.

3. Head rotation area:

- It lies above and close to the eye movement area.
- It directs the head towards different objects.

3. Hand skills area:

- It lies anterior to primary motor area for the hands and fingers.
- It is essential for performance of skilled movements by the hands.

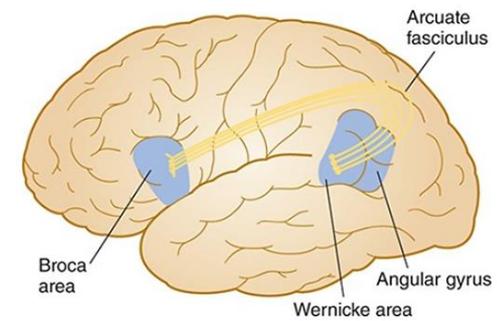
Supplementary motor area

- It lies anterior and superior to area 6 and extends on the medial surface of frontal lobe. So, it is sometimes called medial area 6.
- It is connected to other motor areas but relatively less excitable than them.

Function:

- It helps area 6.

SPEECH



Speech: It is the means of communication between persons.

- ✓ It is either spoken or written speech.
- ✓ It requires the integrity of the speech-dominant hemisphere.
- ✓ It has two aspects:

Sensory aspect (language input):

- This requires the integrity of the centers that interpret the spoken and written words (in addition to normal hearing and vision), which include:
- The auditory sensory and interpretative areas: Areas 41,42 and 22 respectively for spoken words.
- The visual sensory and interpretative areas: Areas 17 and 18 respectively for written words.
- In addition, Wernicke's area (general interpretative area) is required in both cases.

Motor aspect (language output):

This requires the integrity of the centers that control vocalization and writing (in addition to the involved muscles and their nerve supply), which include the following:

- ✓ The speech motor area (word formation area or Broca's area, area 44).
- ✓ Writing or Exner's area.
- ✓ The primary motor area (area 4).

MECHANISM OF SPEECH

A. Spoken Speech:

- Spoken words are perceived at areas 41 and 42 (auditory sensory areas) which discharge to area 22; auditory association area (where individual words are interpreted) and this in turn discharges to Wernicke's area in which full comprehension of the auditory information occurs.
- Signals are then discharged to Broca's area. This area stores the motor programs for different words and projects signals to area 4 (face area) which in turn stimulates the speech muscles (lips, tongue and pharynx) resulting in speech.

B. Written Speech:

- Written words are perceived in area 17 (visual sensory area) which discharges to area 18, visual association area (where individual words are interpreted) and this discharges first to angular gyrus (where early comprehension of words occurs) which in turn projects to Wernicke's area.
- The sequence is then the same as for spoken speech, resulting in speech (reading).

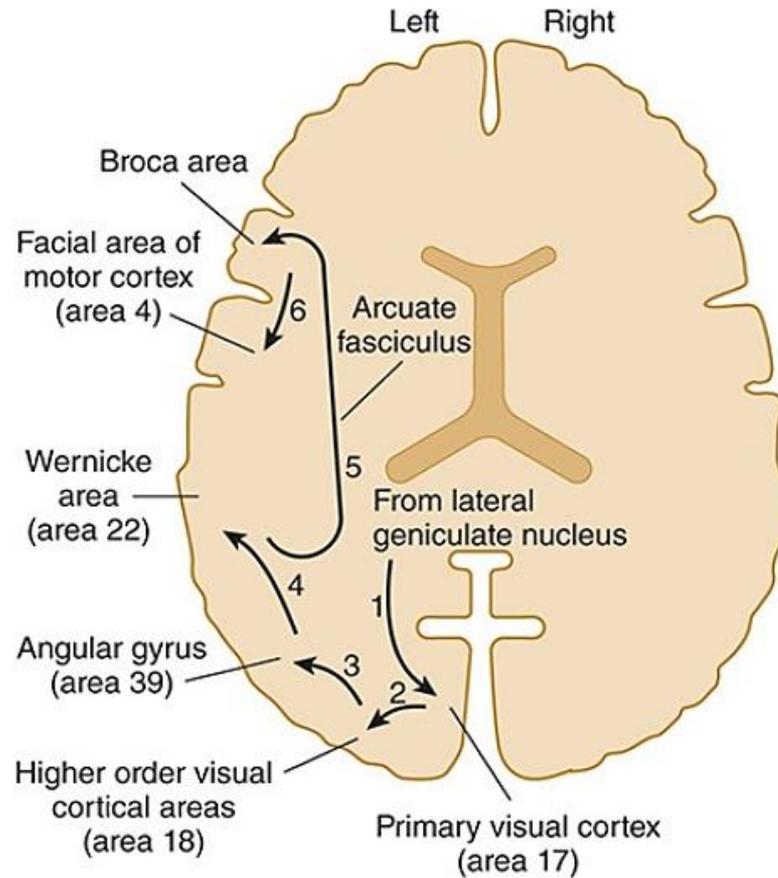


FIGURE 15–6 Path taken by impulses when a subject identifies a visual object, projected on a horizontal section of the human brain. Information travels from the lateral geniculate nucleus in the thalamus to the primary visual cortex, to higher order visual critical areas, and to the angular gyrus. Information then travels from Wernicke area to Broca area via the arcuate fasciculus. Broca area processes the information into a detailed and coordinated pattern for vocalization and then projects the pattern via a speech articulation area in the insula to the motor cortex, which initiates the appropriate movements of the lips, tongue, and larynx to produce speech.

DISORDERS OF SPEECH

Speech disorders include: Aphasia and dysarthria.

I. Aphasia:

- A speech abnormality that is not due to defects in vision or hearing or paralysis of speech muscles.
- It often occurs as a result of blockage of blood flow to the dominant hemisphere.
- It includes the following types:

1. Sensory (receptive) aphasia:

- It is a type of agnosia.
 - It is characterized by excessive meaningless speech.
 - It may be either :
- ✓ **Auditory aphasia (word deafness):** It is due to damage of the auditory association area.
 - ✓ **Visual aphasia (word blindness):** It is due to damage of the visual association areas.
 - ✓ **Wernicke's aphasia:** It is due to damage of Wernicke's area. The patient can see and hear words but fails to comprehend the meaning of spoken or written words. Thus, he can't formulate thoughts (or put the appropriate sequence of words to express the thoughts) resulting in speech that is normal but it is full of jargon that make little sense.

2. Motor aphasia (expressive or Broca's aphasia):

- ✓ It is due to lesions involving Broca's area (area 44).
- ✓ The patient understands both spoken and written words, but his speech is slow and words are hard to come by, and it may be limited.
- ✓ Patients with severe damage to this area are limited to two or three words to express the whole range of meaning and emotion.

3. Global (general) aphasia:

- It is due to damage of most speech centers.
- General aphasia involves both receptive and expressive functions.

Agraphia (writing aphasia):

- It is inability to write words or draw figures to express thoughts.
- It is due to damage of the **writing (Exner's)** area.

II. Dysarthria:

- A speech abnormality due to disorders in the act of articulation.
- It occurs as a result of muscle diseases or lesions in either the nerve centers that control voluntary movements, pyramidal and extrapyramidal tracts or the lower neurons that supply speech muscles.
- The following are examples:
 - ✓ Cerebellar disease causes ataxic dysarthria (staccato speech).
 - ✓ Parkinsonism causes slow monotonous speech.

Learning

Definition:

- It is the process of acquiring knowledge and new responses.
- It can be developed by trial & error and by imitation.

TWO main ways are involved:

- (A) Non-associative learning.
- (B) Associative learning.

(A) Non-associative learning

- **Definition:** It is learning about a single stimulus that is repeated many times.
- **Types:** it is 2 types:
 - 1) **Habituation.**
 - 2) **Sensitization.**

	Habituation	Sensitization
Definition	Gradual decrease in the response to a specific stimulus when repeated. It is considered a “-ve memory”	Potentialiation of the response to a specific stimulus when repeated, if it is paired with a noxious stimulus. It is considered a “+ve memory”
Mechanism	Decreased release of neurotransmitter from the presynaptic terminal because of decreased intracellular Ca^{2+} . The decrease in intracellular Ca^{2+} is due to a gradual inactivation of Ca^{2+} channels.	Presynaptic facilitation by noxious stimulus \rightarrow closure of K^+ channels \rightarrow depolarization \rightarrow opening of Ca^{2+} channels in presynaptic terminals \rightarrow \uparrow Ca^{2+} inflow \rightarrow \uparrow release of Neurotransmitter.

(B) Associative learning

- ✓ **Definition:** It is learning by pairing of stimuli.
- ✓ **Example: Conditioned reflexes:**
- ✓ In these reflexes, the subject is learned to respond to stimuli that normally don't produce responses which are called conditioned stimuli (CS) and their responses are called conditioned responses (CR), in contrast to the stimuli that normally produce the response which are called unconditioned stimuli (US).

The development of these reflexes is called conditioning and in order to occur:

1. CS should precede US
2. CS & US should not be separated by a long time or by disturbing stimuli.
3. Pairing of CS & US should be continued for several times.

There are several types of conditioning:

1. Classical conditioning:

This is produced by repeated pairing of the CS with US.

Example: Pavlov's experiments.

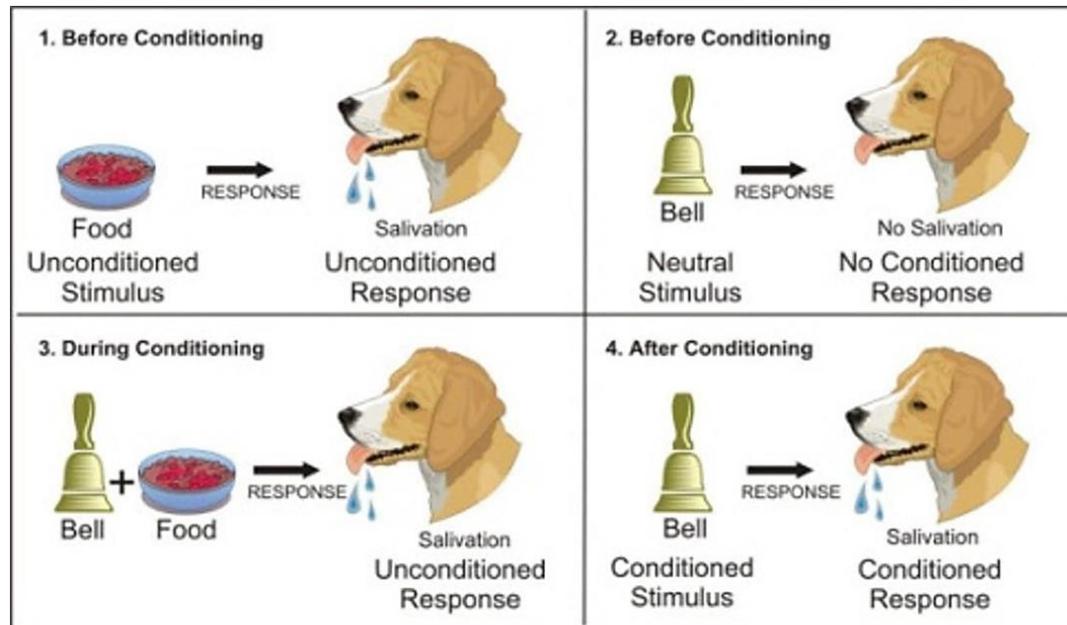
2. Reconditioning:

- The persistence of conditioned reflexes through their reinforcement.
- Pairing of CS & US from time to time → Persistence of CR.

(+ve reinforcement: if US is pleasant & -ve reinforcement: if US is unpleasant)

3. Operant conditioning:

- This is a form of conditioning in which the animal is taught to perform (operate) some task in order to obtain a reward or avoid punishment.
- The US is the pleasant or unpleasant event and the CS is a signal (e.g. light) that alerts the animal to perform the task.



Classical Conditioning

Operant Conditioning

Specific consequences are associated with a voluntary behavior

Rewards introduced to increase a behavior



Punishment introduced to decrease a behavior



MEMORY

Definition: It is the ability of the brain to store & recall information.

Types: It is 2 main types:

Type	Reflexive (non-declarative)	Declarative
Characters	Unconscious. Its retention does not usually involve processing in the hippocampus.	Conscious. It is dependent on the hippocampus.
Examples	Habits & Skills	Knowledge about people, places, things, and events. N.B. Declarative memory can be converted into reflexive memory by constant repetition or training (e.g., driving a car or playing a piano).

Declarative memory includes the following types:

Types	Immediate (sensory)	Primary (short - term or recent)	Secondary (long - term or remote)
Duration	Lasts few seconds to few minutes	Lasts for few minutes to few hours	Lasts for long times (several hours up to several years)
Capacity of brain	Very small	Small	Large
Recall	Very rapid	Rapid	Slow
Fate	Either fades or changes into primary or secondary	Retroactive inhibition (The new information replace the old ones which will be forgotten) OR changes into secondary long-term	Forgotten by proactive inhibition (the old information inhibits storage of new ones) (or) changes into tertiary (permanent) memory (e.g. One's name)

Mechanisms and Consolidation of Memory

Mechanism:

Memories develop by enhancement of synaptic transmission and development of new and facilitated pathways for signal transmission at the synapses called “ memory traces”.

Consolidation of Memory:

Definition: It is conversion of short-term memory into long-term memory.

Duration: 5 – 10 minutes (for minimal consolidation) and about 4 hours (for maximal consolidation).

Mechanism: By rehearsal of information in the mind.

This requires:

- A. Normal continued brain activity, so:
 1. Short-term memory is liable to be lost during the first 5 minutes if disrupted by external stimuli (as by deep anesthesia or brain concussion), while long-term memory is not affected
 2. Normal quiet sleep consolidates the memory of information received before the onset of sleep, while mental fatigue ↓↓ the consolidation.
- B. New protein synthesis in the neurons.

Encoding of memory:

- It is an important part of consolidation.
- It is the processing & classification of information.
- Information are first processed in hippocampus then what proves significant is stored with other memories of the same type in the appropriate sites, where it is consolidated.
- This is necessary to search for various memories when required.

Centers of memory encoding & storage:

A. Declarative memory:

- Short-term memory is encoded in the hippocampus.
- To be consolidated, signals are projected to mammillary bodies → anterior thalamic nucleus → prefrontal cortex → basal forebrain (nucleus basalis of Meynert) which projects diffuse cholinergic fibers to →
 1. Neocortex (the storage center for long-term memory)
 2. Amygdala (which is responsible for emotional responses to memories).
 3. Hippocampus.

B. Non-declarative memory:

- Memory is stored in basal ganglia & cerebellum.

Disorders of memory:

Amnesia:

Definition: Loss of memory

Types of Amnesia:

- Retrograde.
- Anterograde.
- Global.
- Hysterical (Psychogenic).

Alzheimer's disease:

It is the most common age-related neurodegenerative disorder.

Memory decline initially manifests as a loss of episodic memory, which impedes recollection of recent events.

Loss of short-term memory is followed by general loss of cognitive and other brain functions, agitation, depression, the need for constant care, and, eventually, death.

Treatment: Anticholinesterases.

Thank
you

The image features the words "Thank you" written in a highly decorative, cursive script. The letters are a dark teal color with a white outline and a soft grey drop shadow, giving them a three-dimensional appearance. The text is centered and surrounded by a variety of colorful floral and leaf motifs. These include small pink and red flowers, orange and yellow leaves, and green sprigs with tiny buds. The overall composition is circular and vibrant, set against a plain white background.