B.SC PSYCHOLOGY

2nd SEM COMPLEMENTARY COURSE
UNIVERSITY OF CALICUT

PSG2C01 Human Physiology

2019 ADMISSION

Prepared by
Dhanya Nair
Assistant Professor
Department of Psychology

COURSE CODE	**PSG2C01**
TITLE OF THE COURSE	**HUMAN PHYSIOLOGY II**
SEMESTER IN WHICH THE COURSE TO BE TAUGHT	**2nd**
NO. OF CREDITS	**3**
NO. OF CONTACT HOURS	**72 (4hrs/week)**

Objectives of the course:

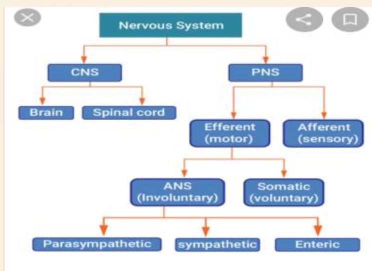
- **This course imparts extensive information to the Psychology student on the nervous system with special emphasis on the CNS.**
- **It also introduces the student to states of brain activities and techniques in neurophysiology.**

Course Details

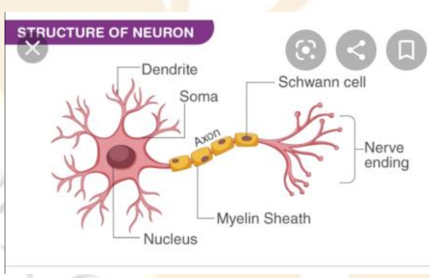
MODULE NO.	NAME OF MODULE	MODULE HOURS
1	THE NERVOUS SYSTEM	20
2	THE CENTRAL NERVOUS SYSTEM	14
3	THE CEREBELLUM AND THE BASAL GANGLIA	14
4	THE CEREBRAL CORTEX	12
5	STATES OF BRAIN ACTIVITY AND TECHNIQUES IN NEUROPHYSIOLOGY	12

Module 1: NERVOUS SYSTEM

- Nervous system: division: (CNS & PNS): NS is the major controlling, regulatory and communicating system in the body.
- NS divides two:
- Central NS: it includes brain and spinal cord
- Peripheral NS: made up of all nerves that leads into and out of the CNS.

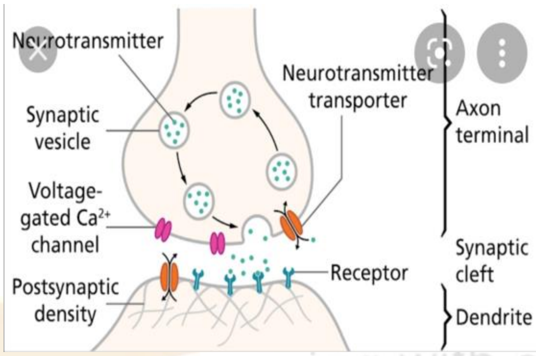


- Nervous tissues: structure of neuron: it is the basic structural and functional unit of NS. A neuron consist of three main parts- cell body, dendrites and axon.



- Nerve fibre: it is the cytoplasmic extension of the nerve cell known as dendrites and axon. Axons are usually called nerve fibre.
- Synapses: it is the junction between two neurons. Where neurotransmission of information takes place.
- Non nervous tissues
- Neuroglia: it do not conduct nerve impulses but instead they support, nourish, and protect the neuron.

- other associated components in NS:
- Meninges: covering of brain and spinal cord. There are three layers- dura mater, arachnoid mater and pia mater.
- Cerebro-spinal fliud: it is a clear clourless body fluid found in the brain and spinal cord.
- Blood-CSF barrier: it is fluid brain barrier that is composed of a pair of membrane that separate blood from CSF and CSF from brain tissues.
- Blood-brain barrier: it is a highly selective semi-permiable border that separates the blood from the brain and extracellular fluid in the CNS.
- Nerve Impulse And Its Conduction:
- Generation Of Nerve Impulse : nerve impulse is generated when the stimulus is strong. This stimulus triggers the electrical and chemical changes in the neuron. There are different ions on either side of the cell membrane. The exterior side has sodium ions (Na+)that are positively charged and are more in number. In innerside Potassium ions (K+)are more.
- Conduction Of Nerve Impulse : it occurs due to the presence of active and electronic potentials along the conductors. Transmission of signals internally between the cells is achieved through a synapse. The ionic currents pass through the two cell membrane when the action potential reaches the stage of such synapse.
- Synapses And Synaptic Transmission:
- Chemical synapse : it pass information directionally from a presynaptic cell to a postsynaptic cell. In chemical synaptic transmission involves the release of a neurotransmitter from the pre-synaptic neuron, and neurotransmitter binding to specific post-synaptic receptors.



- Types of neurotransmitters:
- There are more than 200 chemical messengers have been uniquely identified so far.
- Eg: amino acids, gasotransmiters, monoamines, peptides, purines etc.

Module 2: THE CENTRAL NERVOUS SYSTEM

- The brain is a complex organ. It is the main controlling center of the central nervous system. It receives, processes, sends and directs sensory information. Moreover, the corpus callosum splits the brain into left and right hemispheres. The brain has three major divisions depending on their specific function. They are forebrain, midbrain, and hindbrain.
- The forebrain is the largest brain division. It accounts for about 2/3 of the brains mass. The cerebrum is a part of the forebrain. Hence, forebrain covers most brain structures. The forebrain has two subdivisions: the telencephalon and diencephalon.
- The diencephalon relays sensory information.
- The forebrain is the most important part of the brain since it is responsible for almost all types of major and complex functions of the body such as memory, intelligence, regulation of body temperature, etc.
- Midbrain is the region of the brain which connects the forebrain with the hindbrain. Together with the hindbrain, the midbrain forms the brain stem.
- The brain stem connects the cerebrum to the spinal cord. The cerebral aqueduct is present in the midbrain. It is the canal that connects the cerebral ventricles.
- The hindbrain is the region of the brain which controls visceral functions such as regulation of heart rate, respiration, blood pressure, and sleep, etc. The hindbrain is subdivided into two regions: the metencephalon and myelencephalon.
- In the metencephalon, trigeminal, abducent, facial, and vestibulocochlear nerves are present while in the myelencephalon, the glossopharyngeal, vagus, accessory, and hypoglossal nerves are present.

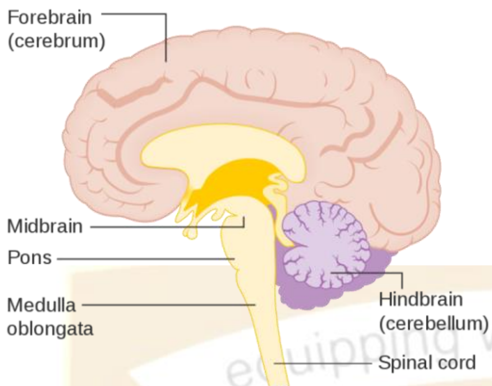
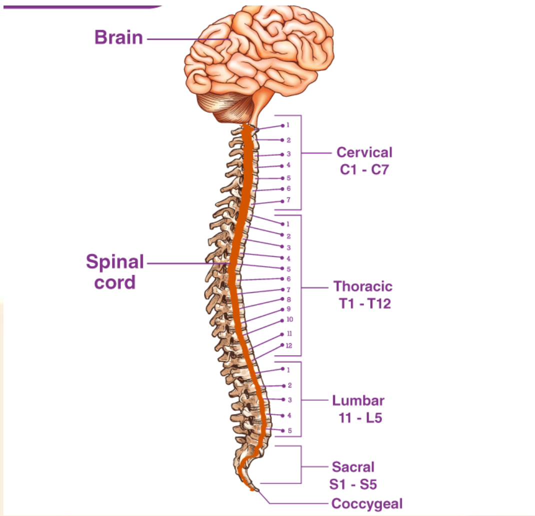


Fig: 2.1, major parts of Brain.

- The spinal cord is a part of the central nervous system. It is a long pipe-like structure arising from the medulla oblongata, part of the brain consisting of a collection of nerve fibres, running through the vertebral column of the backbone. It is segmented with a pair of roots (dorsal and ventral roots) consisting of nerve fibres joining to form the spinal nerves.
- The spinal cord is divided into five different parts.
- Sacral cord
- Lumbar cord
- Thoracic cord
- Cervical cord
- Coccygeal
- Several spinal nerves emerge out of each segment of the spinal cord. There are 8 pairs of cervical, 5 lumbar, 12 thoracics, 5 sacral and 1 coccygeal pair of spinal nerves



- The Spinal cord runs through a hollow case from the skull enclosed within the vertebral column. Spinal nerves arise from different regions of the vertebral column and are named accordingly, the regions are – Neck, chest, pelvic and abdominal.
- Three layers of meninges surround the spinal cord and spinal nerve roots.
- Dura mater
- Arachnoid mater
- Pia mater
- The spinal cord nerves can be grouped as:
- Cervical
- Thoracic
- Sacral
- Lumbar
- Coccygeal
- Important functions of Spinal Cord are mentioned below:
- Forms a connecting link between the brain and the PNS
- Provides structural support and builds a body posture
- Facilitates flexible movements

- Myelin present in the white matter acts as an electrical insulation
- Communicates messages from the brain to different parts of the body
- Coordinates reflexes
- Receives sensory information from receptors and approaches towards the brain for processing.
- Reflex action is a sudden and involuntary response to stimuli.
- Types of reflex Actions: Accommodation reflex, Pupillary light reflex, Acoustic Reflex, Ankle jerk reflex, Biceps reflex, Blushing, Corneal reflex, Cough reflex, Sneeze.
- Monosynaptic reflex: A simple reflex that involves transmission of information from a sensory neuron to the appropriate motor neuron across a single synapse in the spinal cord.
- Multisynaptic reflex: A multisynaptic reflex involves more than one neuron or interneurons within the reflex arc process.
- The crossed extensor reflex or crossed extensor response or crossed extension reflex is a reflex in which the contralateral limb compensates for loss of support when the ipsilateral limb withdraws from painful stimulus in a withdrawal reflex
- The crossed extensor reflex is a contralateral reflex that allows the body to compensate on one side for a stimulus on the other. For example, when one foot steps on a nail, the crossed extensor reflex shifts the body's weight onto the other foot, protecting and withdrawing the foot on the nail
- mass reflex Autonomic dysfunction that may occur as a late consequence of transection of the spinal cord. It is marked by episodes of sweating, bradycardia, hypotension, urinary incontinence, and muscular spasms of the legs.

Module 3: THE CEREBELLUM AND THE BASAL GANGLIA

- Cerebellum and Its Motor Functions: called a silent area of the brain, principally because electrical excitation of the cerebellum does not cause any conscious sensation and rarely causes any motor movement.
- The cerebellum receives continuously updated information about the desired sequence of muscle contractions from the brain motor control areas
- The cerebellum also aids the cerebral cortex in planning the next sequential movement a fraction of a second in advance while the current movement is still being executed, thus helping the person to progress smoothly from one movement to the next.

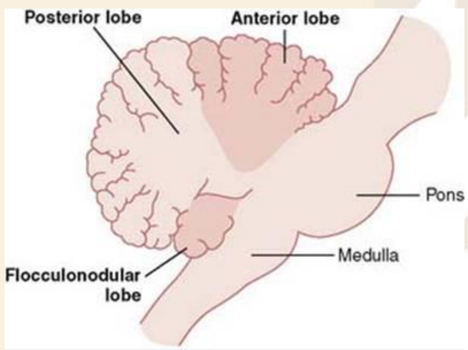


Fig 3.1: Anatomical lobes of the cerebellum as seen from the lateral side

- Anatomical Functional Areas of the Cerebellum: Anatomically, the cerebellum is divided into three lobes by two deep fissures,(1) the anterior lobe, (2) the posterior lobe, and (3) the flocculonodular lobe.

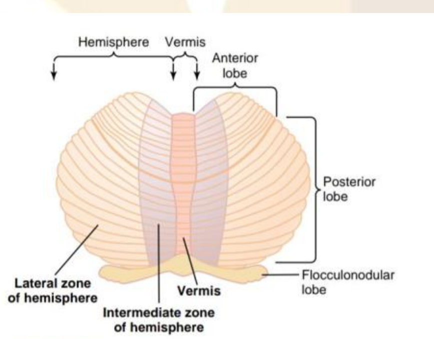


Figure 56–2

Functional parts of the cerebellum as seen from the posteroinferior view, with the inferiormost portion of the cerebellum rolled outward to flatten the surface.

- Longitudinal Functional Divisions of the Anterior and Posterior Lobes

- Topographical Representation of the Body in the Vermis and Intermediate Zones
- Neuronal Circuit of the Cerebellum: Afferent Pathways from Other Parts of the Brain, Afferent Pathways from the Periphery (input signals from the cerebellum). Deep Cerebellar Nuclei and the Efferent Pathways (output signals from the cerebellum).

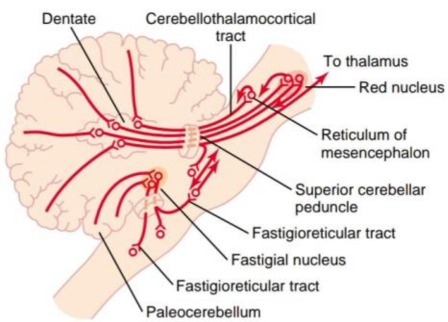


Figure 56–6

Principal *efferent* tracts from the cerebellum.

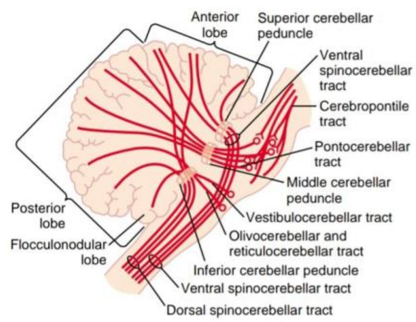


Figure 56–4

Principal *afferent* tracts to the cerebellum.

- Functional Unit of the Cerebellar Cortex— The Purkinje Cell and the Deep Nuclear Cell
- Other Inhibitory Cells in the Cerebellum
- Function of the Cerebellum in Overall Motor Control: vestibulocerebellum, spinocerebellum, cerebrocerebellum.
- Vestibulocerebellum—Its Function in Association with the Brain Stem and Spinal Cord to Control Equilibrium and Postural Movements
- Spinocerebellum—Feedback Control of Distal Limb Movements by Way of the Intermediate Cerebellar Cortex and the Interposed Nucleus

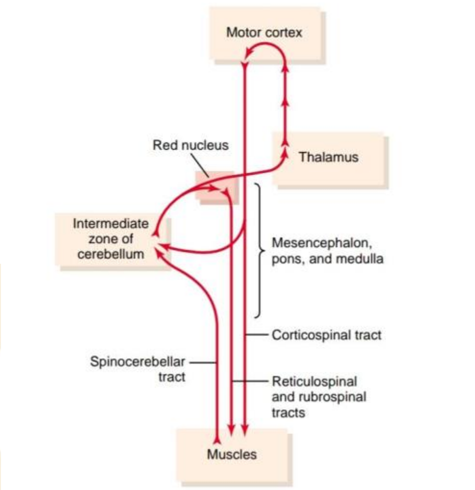
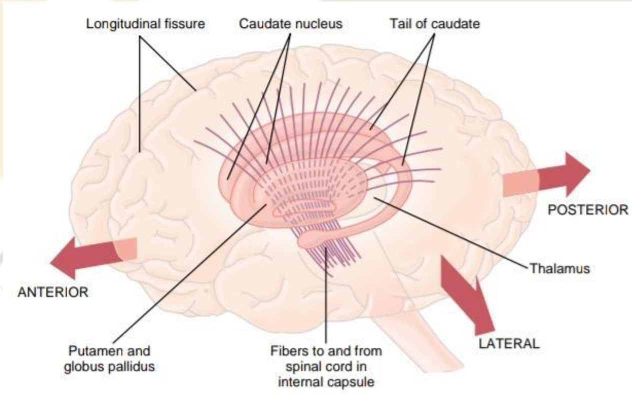


Figure 56–8

Cerebral and cerebellar control of voluntary movements, involving especially the intermediate zone of the cerebellum.

- Cerebrocerebellum—Function of the Large Lateral Zone of the Cerebellar Hemisphere to Plan, Sequence, and Time Complex Movements
- Planning of Sequential Movements
- Extramotor Predictive Functions of the Cerebrocerebellum.
- Clinical Abnormalities of the Cerebellum: Dysmetria and Ataxia, Past Pointing, Failure of Progression, Intention Tremor, Hypotonia.



- Basal Ganglia—Their Motor Functions: The basal ganglia, like the cerebellum, constitute another accessory motor system that functions usually not by itself but in close association with the cerebral cortex and corticospinal motor control system.

- On each side of the brain, these ganglia consist of the caudate nucleus, putamen, globus pallidus, substantia nigra, and subthalamic nucleus. They are located mainly lateral to and surrounding the thalamus, occupying a large portion of the interior regions of both cerebral hemispheres.
- Neuronal Circuitry of the Basal Ganglia: two major circuits, the putamen circuit and the caudate circuit.

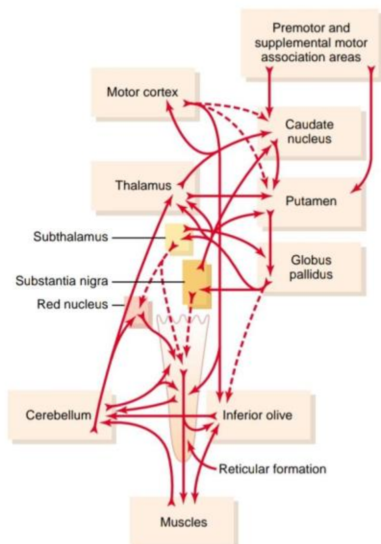


Figure 56–10

Relation of the basal ganglial circuitry to the corticospinal-cerebellar system for movement control.

- Function of the Basal Ganglia in Executing Patterns of Motor Activity— The Putamen Circuit: One of the principal roles of the basal ganglia in motor control is to function in association with the corticospinal system to control complex patterns of motor activity.
- Neural Pathways of the Putamen Circuit: the putamen circuit has its inputs mainly from those parts of the brain adjacent to the primary motor cortex but not much from the primary motor cortex itself.

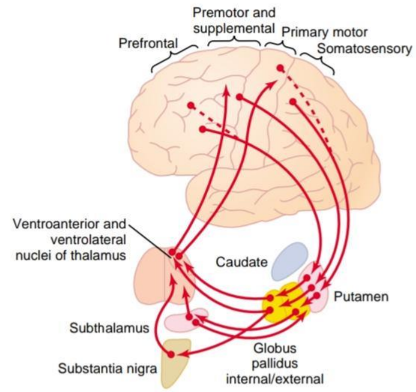


Figure 56–11

Putamen circuit through the basal ganglia for subconscious execution of learned patterns of movement.

- Abnormal Function in the Putamen Circuit: Athetosis, Hemiballismus, and Chorea.
- Role of the Basal Ganglia for Cognitive Control of Sequences of Motor Patterns—The Caudate Circuit: y. Most of our motor actions occur as a consequence of thoughts generated in the mind, a process called cognitive control of motor activity. The caudate nucleus plays a major role in this cognitive control of motor activity.

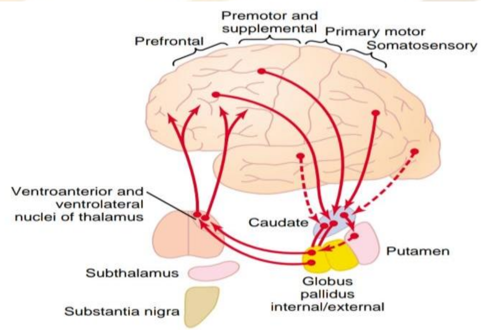


Figure 56–12

Caudate circuit through the basal ganglia for cognitive planning of sequential and parallel motor patterns to achieve specific conscious goals.

- the caudate nucleus receives large amounts of its input from the association areas of the cerebral cortex overlying the caudate nucleus, mainly areas that also integrate the different types of sensory and motor information into usable thought patterns.
- Function of the Basal Ganglia to Change the Timing and to Scale the Intensity of Movements.
- Functions of Specific Neurotransmitter Substances in the Basal Ganglial System

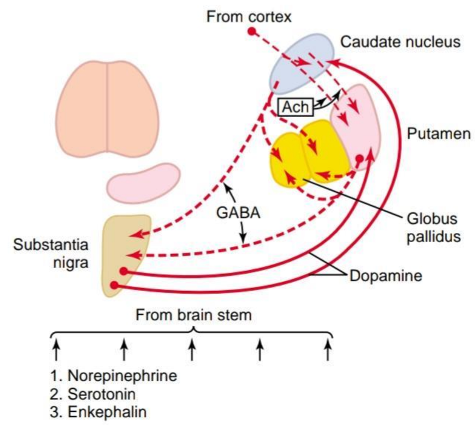


Figure 56–14

Neuronal pathways that secrete different types of neurotransmitter substances in the basal ganglia. Ach, acetylcholine; GABA, gamma-aminobutyric acid.

- Clinical Syndromes Resulting from Damage to the Basal Ganglia: Parkinson's Disease, Huntington's Disease (Huntington's Chorea).
- Associated Functions of the Basal Ganglia.

Module 4: THE CEREBRAL CORTEX

- Physiologic Anatomy of the Cerebral Cortex
- neurons are of three types: (1) granular (also called stellate), (2) fusiform, and (3) pyramidal, the last named for their characteristic pyramidal shape.
- the inhibitory neurotransmitter gamma-aminobutyric acid (GABA)
- The pyramidal and fusiform cells give rise to almost all the output fibers from the cortex.
- Anatomical and Functional Relations of the Cerebral Cortex to the Thalamus and Other Lower Centers.
- the thalamus and the cortex together are sometimes called the thalamocortical system.

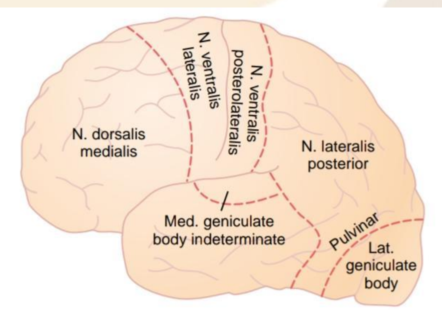


Figure 57–2

Areas of the cerebral cortex that connect with specific portions of the thalamus.

- Functions of Specific Cortical Areas: Studies in human beings by neurosurgeons, neurologists, and neuropathologists have shown that different cerebral cortical areas have separate functions

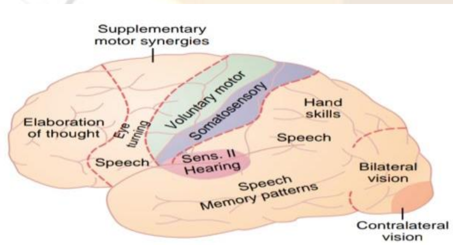


Figure 57–3

Functional areas of the human cerebral cortex as determined by electrical stimulation of the cortex during neurosurgical operations and by neurological examinations of patients with destroyed cortical regions. (Redrawn from Penfield W, Rasmussen T: The Cerebral Cortex of Man: A Clinical Study of Localization of Function. New York: Hafner Co, 1968.)

- Association Areas: association areas are (1) the parieto-occipitotemporal association area, (2) the prefrontal association area, and (3) the limbic association area.
- Parieto-occipitotemporal Association Area: Analysis of the Spatial Coordinates of the Body, Area for Language Comprehension, Area for Initial Processing of Visual Language (Reading), Area for Naming Objects.

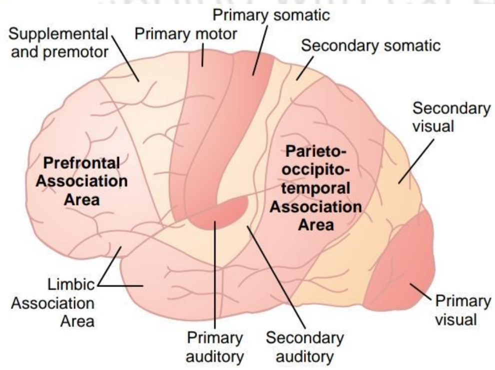
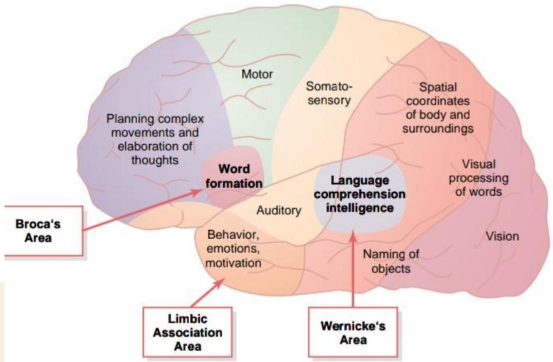


Figure 57–4

Locations of major association areas of the cerebral cortex, as well as primary and secondary motor and sensory areas.

- Prefrontal Association Area: The prefrontal association area is also essential to carrying out "thought" processes in the mind.
- Broca's Area. A special region in the frontal cortex, called Broca's area, provides the neural circuitry for word formation. This area also works in close association with Wernicke's language comprehension center in the temporal association cortex.
- Limbic Association Area: association area called the limbic association area. This area is found in the anterior pole of the temporal lobe, in the ventral portion of the frontal lobe, and in the cingulate gyrus lying deep in the longitudinal fissure on the midsurface of each cerebral hemisphere. It is concerned primarily with behavior, emotions, and motivation.
- This limbic system provides most of the emotional drives for activating other areas of the brain and even provides motivational drive for the process of learning itself.



- Area for Recognition of Faces: An interesting type of brain abnormality called prosophenosia is inability to recognize faces.
- The occipital portion of this facial recognition area is contiguous with the visual cortex, and the temporal portion is closely associated with the limbic system that has to do with emotions, brain activation, and control of one's behavioral response to the environment.

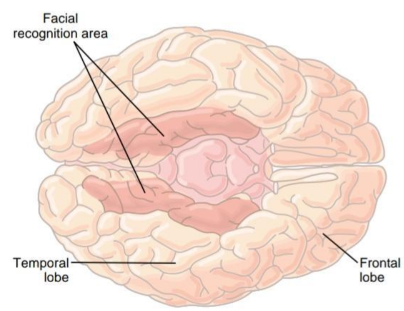


Figure 57–6

Facial recognition areas located on the underside of the brain in the medial occipital and temporal lobes. (Redrawn from Geschwind N: Specializations of the human brain. Sci Am 241:180, 1979. ® 1979 by Scientific American, Inc. All rights reserved.)

- Comprehensive Interpretative Function of the Posterior Superior Temporal Lobe "Wernicke's Area" (a General Interpretative Area).
- The somatic, visual, and auditory association areas all meet one another in the posterior part of the superior temporal lobe.
- This area of confluence of the different sensory interpretative areas is especially highly developed in the dominant side of the brain—the left side in almost all right-handed

people—and it plays the greatest single role of any part of the cerebral cortex for the higher comprehension levels of brain function that we call intelligence.

- After severe damage in Wernicke's area, a person might hear perfectly well and even recognize differrent words but still be unable to arrange these words into a coherent thought.
- it is believed that activation of Wernicke's area can call forth complicated memory patterns that involve more than one sensory modality even though most of the individual memories may be stored elsewhere.
- Angular Gyrus—Interpretation of Visual Information: The angular gyrus is the most inferior portion of the posterior parietal lobe, lying immediately behind Wernicke's area and fusing posteriorly into the visual areas of the occipital lobe as well. If this region is destroyed while Wernicke's area in the temporal lobe is still intact, the person can still interpret auditory experiences as usual, but the stream of visual experiences passing into Wernicke's area from the visual cortex is mainly blocked.
- Concept of the Dominant Hemisphere
- Role of Language in the Function of Wernicke's Area and in Intellectual Functions
- Functions of the Parieto-occipitotemporal Cortex in the Nondominant Hemisphere
- Higher Intellectual Functions of the Prefrontal Association Areas
- Decreased Aggressiveness and Inappropriate Social Responses
- Function of the Brain in Communication—Language Input and Language Output
- Sensory Aspects of Communication, Wernicke's Aphasia and Global Aphasia.
- Motor Aspects of Communication, Loss of Broca's Area Causes Motor Aphasia, Articulation.

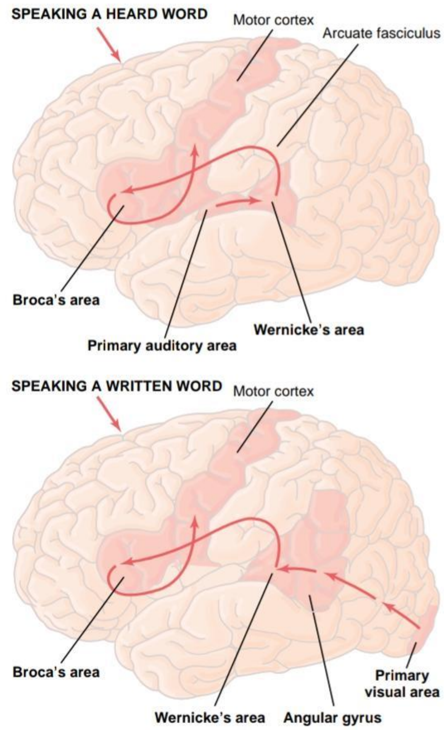


Figure 57–8

Brain pathways for *(top)* perceiving a heard word and then speaking the same word, and *(bottom)* perceiving a written word and then speaking the same word. (Redrawn from Geschwind N: Specializations of the human brain. Sci Am 241:180, 1979. ® 1979 by Scientific American, Inc. All rights reserved.)

- Thoughts, Consciousness, and Memory

Module 5: STATES OF BRAIN ACTIVITY AND TECHNIQUES IN NEUROPHYSIOLOGY.

- All of us are aware of the many different states of brain activity, including sleep, wakefulness, extreme excitement, and even different levels of mood such as exhilaration, depression, and fear. All these states result from different activating or inhibiting forces generated usually within the brain itself.
- Sleep is defined as unconsciousness from which the person can be aroused by sensory or other stimuli. It is to be distinguished from coma, which is unconsciousness from which the person cannot be aroused.
- Two Types of Sleep: They are called (1) slow-wave sleep, because in this type of sleep the brain waves are very strong and very low frequency, as we discuss later, and (2) rapid eye movement sleep (REM sleep), because in this type of sleep the eyes undergo rapid movements despite the fact that the person is still asleep.
- Slow-Wave Sleep: is frequently called "dreamless sleep," dreams and sometimes even nightmares do occur during slow-wave sleep.
- REM Sleep (Paradoxical Sleep, Desynchronized Sleep) and its characteristics.
- Basic Theories of Sleep: passive theory of sleep (Sleep Is Believed to Be Caused by an Active Inhibitory Process).
- Neuronal Centers, Neurohumoral Substances, and Mechanisms That Can Cause Sleep—A Possible Specific Role for Serotonin.
- the raphe nuclei in the lower half of the pons and in the medulla.
- the nucleus of the tractus solitarius
- Lesions in Sleep-Promoting Centers Can Cause Intense Wakefulness.
- Other Possible Transmitter Substances Related to Sleep.

- Cause of REM Sleep
- Cycle Between Sleep and Wakefulness
- Physiologic Effects of Sleep
- Brain Waves:

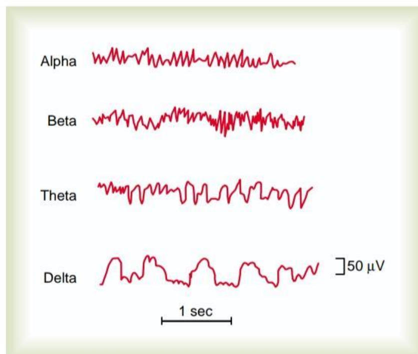


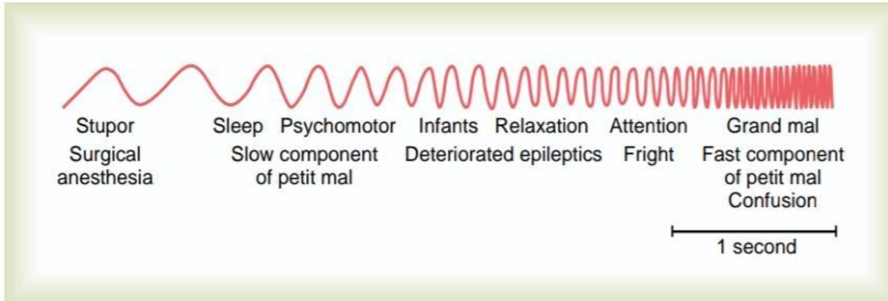
Figure 59–1

Different types of *brain waves* in the normal electroencephalogram.

- Origin of Alpha Waves. Alpha waves will not occur in the cerebral cortex without cortical connections with the thalamus. Conversely, stimulation in the nonspecific layer of reticular nuclei that surround the thalamus or in "diffuse" nuclei deep inside the thalamus often sets up electrical waves in the thalamocortical system at a frequency between 8 and 13 per second, which is the natural frequency of the alpha waves.
- Origin of Delta Waves. Transection of the fiber tracts from the thalamus to the cerebral cortex, which blocks thalamic activation of the cortex and thereby eliminates the alpha waves, nevertheless does not block delta waves in the cortex. This indicates that some synchronizing mechanism can occur in the cortical neuronal system by itself mainly independent of lower structures in the brain to cause the delta waves.
- Effect of Varying Levels of Cerebral Activity on the Frequency of the EEG

Figure 59–3

Effect of varying degrees of cerebral activity on the basic rhythm of the electroencephalogram. (Redrawn from Gibbs FA, Gibbs EL: Atlas of Electroencephalography, 2nd ed, Vol I: Methodology and Controls. ® 1974. Reprinted by permission of Prentice-Hall, Inc., Upper Saddle River, NJ.)



- Stages of sleep: Stage 1, 2,3 and REM sleep

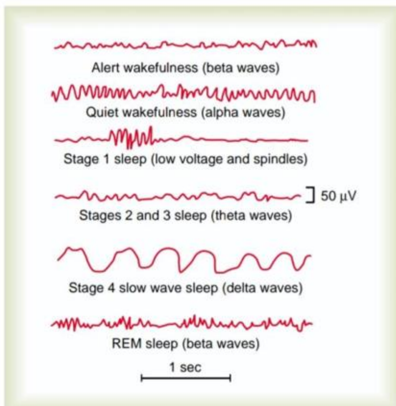


Figure 59–4

Progressive change in the characteristics of the brain waves during different stages of wakefulness and sleep.

- Alert wakefulness is characterized by high-frequency beta waves, whereas quiet wakefulness is usually associated with alpha waves, as demonstrated by the first two EEGs of the figure.
- Slow-wave sleep is divided into four stages. In the first stage, a stage of very light sleep, the voltage of the EEG waves becomes very low; this is broken by “sleep spindles,” that is, short spindle-shaped bursts of alpha waves that occur periodically.
- In stages 2, 3, and 4 of slow-wave sleep, the frequency of the EEG becomes progressively slower until it reaches a frequency of only 1 to 3 waves per second in stage 4; these are delta waves.
- Finally, the bottom record shows the EEG during REM sleep. It is often difficult to tell the difference between this brain wave pattern and that of an awake, active person.

- Epilepsy and its different types like Grand Mal Epilepsy, Petit mal Epilepsy, Focal Epilepsy
- Neurophysiological Brain imaging Techniques - CT, MRI, PET, CBF, EEG, Lesioning and Electrical Stimulation of Brain (ESB)

REFERENCE

- Guyton & Hall - Textbook of Medical Physiology, 12 Edn., Saunders.