Central Nervous System

Chapter 5
Part I

The **nervous system** is one of the two major regulatory systems of the body, the other being the endocrine system. A complex interactive network of three basic types of nerve cells—afferent neurons, efferent neurons, and interneurons—constitutes the excitable cells of the nervous system. The **central nervous system (CNS)** is composed of the brain and spinal cord, which receive input about the external and internal environment from the afferent neurons. The CNS sorts and processes this input, then initiates appropriate directions in the efferent neurons, which carry the instructions to glands or muscles to bring about the desired response—some type of secretion or movement. Many of these neurally controlled activities are directed toward maintaining homeostasis. In general, the nervous system acts by means of its electrical signals (action potentials) to control the rapid responses of the body.

Introduction

- The nervous system regulates many body activities aimed at maintaining a stable internal fluid environment, which is essential for cells survival.

- Many of basic life-supporting neuronal patterns, e.g. controlling respiration and circulation, similar in all individuals, there must be subtle differences in neuronal integration between others.

- Some differences in nervous system are genetically endowed, the rest due to environmental encounters and experiences.

- When the immature nervous system develops according to its genetic plan, an over abundance of neurons and synapses is formed, depending on external stimuli and the extent these pathways are used, some are retained, firmly established and even enhanced, whereas others are eliminated, e.g. **amblyopia** (lazy eye).

- The maturation of the nervous system truly does involve instances of **“use it or lose it”**. So, ongoing modifications still occur after maturation, as we continue to learn from our unique set of experiences.

Hypothalamus
Pituitary
Parathyroids
Thyroid
Adrenals
Pancreas
Ovaries
(female)
Testes
(male)

▲ TABLE 5-1
Comparison of the Nervous System and the Endocrine System

Property	Nervous System	Endocrine System
Anatomic Arrangement	A "wired" system; specific structural arrangement between neurons and their target cells; structural continuity in the system	A "wireless" system; endocrine glands widely dispersed and not structurally related to one another or to their target cells
Type of Chemical Messenger	Neurotransmitters released into synaptic cleft	Hormones released into blood
Distance of Action of Chemical Messenger	Very short distance (diffuses across synaptic cleft)	Long distance (carried by blood)
Means of Specificity of Action on Target Cell	Dependent on close anatomic relationship between nerve cells and their target cells	Dependent on specificity of target cell binding and responsiveness to a particular hormone
Speed of Response	Rapid (milliseconds)	Slow (minutes to hours)
Duration of Action	Brief (milliseconds)	Long (minutes to days or longer)
Major Functions	Coordinates rapid, precise responses	Controls activities that require long duration rather than speed
Influence on Other Major Control System?	Yes	Yes

TABLE 4-5 Comparison of the Nervous System and the Endocrine System

Property	Nervous System	Endocrine System
Anatomic Arrangement	A "wired" system: specific structural arrangement between neurons and their target cells, with structural continuity in the system	A "wireless" system: endocrine glands widely dispersed and not structurally related to one another or to their target cells
Type of Chemical Messenger	Neurotransmitters released into synaptic cleft	Hormones released into blood
Distance of Action of Chemical Messenger	Very short distance (diffuses across synaptic cleft)	Long distance (carried by blood)
Specificity of Action on Target Cell	Dependent on close anatomic relationship between neurons and their target cells	Dependent on specificity of target cell binding and responsiveness to a particular hormone
Speed of Response	Generally rapid (milliseconds)	Generally slow (minutes to hours)
Duration of Action	Brief (milliseconds)	Long (minutes to days or longer)
Major Functions	Coordinates rapid, precise responses	Controls activities that require long duration rather than speed

The nervous system is a “wired” system, and the endocrine system is a “wireless” system

- These glands constitute a system in a functional sense, because they all secrete hormones and many interactions take place between various endocrine glands.

Neural specificity is due to anatomic proximity and endocrine specificity to receptor specialization

- The target cells for a particular neuron have receptors for the neurotransmitter, but so do many other cells in other locations, and they could respond to this same mediator if it were delivered to them, for example: All the motorneurons use Acetylcholine (Ach), while all the skeletal muscles contain Ach receptors. Yet, Ach released from the motor neurons that are specifically wired to the muscles controlling your toe.
- Despite this ubiquitousفي كل مكان distributions, only specific target cells are able to respond to each hormone. A receptor recognizes a specific hormone because the conformation of a portion of the receptor molecule matches a unique portion of its binding hormone in “lock-and-key” fashion.

The neurons and endocrine systems have their own realms of authority but interact functionally

- A neurally mediated response is not only rapid but brief, this permits either termination of the response, almost immediate repetition, or rapid initiation of an alternate response.
- The endocrine system is specialized to control activities that require duration rather than speed, e.g. **regulating organic metabolism, H2O and electrolyte balance, prompting smooth sequential growth and development, controlling reproduction and regulating RBCs production**.
- The endocrine system response more slowly to the triggering stimuli because, (1) it depend on blood flow to convey its hormonal messengers, (2) hormones' mechanism of action at their target cells is more complex than that of neurotransmitters.
- Although the endocrine and nervous systems have their own areas of specialization, they intimately interconnected functionally.
- Some nerve cells do not release neurotransmitters at synapses, but instead terminate at blood vessels and release their chemical messengers (neuronhormons) into the blood, where act as hormones, e.g. NE (which secreted from the adrenal medulla. In many instances the systems influences the same target cells in supplementary fashion, e.g. Circulatory and digestive systems.
- So, the study of these relationships is known as **neuroendocrinology**.

ORGANIZATION OF THE NERVOUS SYSTEM

FIGURE 5-1
Organization of the nervous system

The three classes of neurons are afferent, efferent and interneurons

- **Interneurons**: lie entirely within the CNS, between the afferent and efferent neurons. Estimated over 100 billion interneuron, about 99% of it.
- Interneurons are important in the integration of peripheral responses to peripheral information, and responsible for abstract phenomena associated with “mind” such as thoughts, emotions, memory, creativity, intellect and motivation. These activities are the least understood functions of he nervous system.

PROTECTION AND NOURISHMENT OF THE BRAIN

- 90% of the cells within the CNS are glial cells or neuroglia, occupying only about half the volume of the brain.

FIGURE 5-3

Glial cells of the central nervous system

The glial cells include the astrocytes, oligodendrocytes, microglia, and ependymal cells.

Gilial cells support the interneurons physically, metabolically and functionally

- Glial cells do not initiate or conduct nerve impulses.
- Without the glial cells, the neurons could not grow, nourish them selves, nor establish and use synapses effectively.
- They homeostatically maintain the composition of the specialized extra cellular environment surrounding the neurons within the narrow limits.
- The four major types of glial cells in the CNS are: (fig. 5-3, fig. 5-4 and table 5-2).

▲ TABLE 5-2
Functions of Glial Cells

Type of Glial Cell	Functions
Astrocytes	Physically support neurons in proper spatial relationships
	Serve as a scaffold during fetal brain development
	Induce formation of blood–brain barrier
	Form neural scar tissue
	Take up and degrade released neurotransmitters into raw materials for synthesis of more neurotransmitters by neurons
	Take up excess K^+ to help maintain proper brain ECF ion concentration and normal neural excitability
	Enhance synapse formation and strengthen synaptic transmission via chemical signaling with neurons
Oligodendrocytes	Form myelin sheaths in CNS
Microglia	Play a role in defense of brain as phagocytic scavengers
Ependymal Cells	Line internal cavities of brain and spinal cord
	Contribute to formation of cerebrospinal fluid
	Serve as neural stem cells with the potential to form new neurons and glial cells

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● FIGURE 5-4
Astrocytes
Note the starlike shape of these astrocytes, which have been grown in tissue culture.

Table 5-2

Functions of Gilal Cells

Types of Glial Cell	Function
Astrocytes	- Physically support neurons in proper spatial relationships. - Serve as a scaffold during fetal brain development. - Induce formation of blood-brain barrier. - Form neural scar tissue. - Take up excess K^+ to help maintain proper brain ECF ion concentration and normal neural excitability. - Enhance synapse formation and strengthen synaptic transmission via chemical signaling with neurons.
Oligodendrocytes	Form myeline sheaths in CNS.
Microglia	Play a role in defense of brain as phagocytic scavengers. (+ GF, Alzheimer's, Multiplee sclerosis, Dementia and others).
Ependymal Cells	•Line internal cavities of brain and spinal cord. •Contribute to formation of cerebrospinal fluid. •Serve as neural stem cells with the potential to form new neurons and glial cells.

Gilial cells support the interneurons physically, metabolically and functionally

FIGURE 4-15
Myelinated fibers
(a) A myelinated fiber is surrounded by myelin at regular intervals. The intervening unmyelinated regions are known as nodes of Ranvier. (b) In the peripheral nervous system, each patch of myelin is formed by a separate Schwann cell that wraps itself jelly-roll fashion around the nerve fiber. In the central nervous system, each of the several processes of a myelin forming oligodendrocyte forms a patch of myelin around a separate nerve fiber. (c) An electron micrograph of a myelinated fiber in cross section. (d) Membrane potential exists only at the nodes of Ranvier, where the bare axon is exposed to the ECF. No charges exist across the insulated unmyelinated regions.

FIGURE 5-5
The ventricles of the brain

The delicate central nervous tissue is well protected

- Four major feature help protect CNS:

❶Cranium (skull) and vertebral column.

❷The menings:

① Pia mater.

② Arachnoid mater.

③ Dura mater.

❸ Cerebrospinal fluid (CSF).

❹Blood brain barrier (BBB).

Cerebrospinal fluid

1. is produced by the choroid plexuses,
2. circulates throughout the ventricles,
3. exits the fourth ventricle at the base of the brain,
4. flows in the subarachnoid space between the meningeal layers, and
5. is finally reabsorbed from the subarachnoid space into the venous blood across the arachnoid villi.

FIGURE 5-6

Relationship of the meninges and cerebrospinal fluid to the brain and spinal cord

(a) Brain, spinal cord, and meninges in sagittal section. The arrows and circled numbers with accompanying explanations indicate the direction of flow of cerebrospinal fluid (in yellow). (b) Frontal section in the region between the two cerebral hemispheres of the brain, depicting the meninges in greater detail.

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Relationship of the meninges and cerebrospinal fluid to the brain and spinal cord

(a) Brain, spinal cord, and meninges in sagittal section. The arrows and circled numbers with accompanying explanations indicate the direction of flow of cerebrospinal fluid (in yellow). (b) Frontal section in the region between the two cerebral hemispheres of the brain, depicting the meninges in greater detail.

Three memingial membrane warp, protect and nourish the central nervous system

{1} Dura mater: tough, inelastic, two layers (forming dural sinuses and venous sinuses).

{2} Arachnoids mater: delicate, richly vascularized layer, the subarachnoid space filled with CSF, contain arachnoid villi.

{3} Pia mater: fragile, closely adheres brain and spinal cord. It dips deeply and close contact to ependymal cells.

➢ The brain floats in its own special CSF:

- The major function of CSF is to serve as a shock-absorbing fluid.
- Choroid plexuses consists of richly vascularized mass of pia mater tissue formed by ependymal cells.
- The composition of CSF differs from that of plasma, e.g. CSF is lower in K^+ and higher in Na^+.
- Flow of CSF is facilitated by cilliary beating and postural factors.
- CSF volume = 125-150 ml replaced more than three times a day.
- Hydrocephalus “water on the brain” lead to damage and mental retardation if untreated, (by surgically shunting).

A highly selective blood-brain barrier carefully regulates exchanges between the blood and brain

- The brain is carefully shielded from harmful changes in the blood by a highly selective blood-brain barrier, example: doubled the level of K^+ in blood, little change in CSF.
- In the brain capillaries, the cells are joined by tight junctions,(fig.5-7). Only possible exchange: ①lipid soluble substances, e.g. O_2, CO_2, alcohol and steroid hormones. ② H_2O ③ carrier-mediated transport, e.g. K^+.
- Blood-brain barrier prevent transport because it is: ❶Anatomically prevented ❷ Physiologically restricted.

● FIGURE 3-4

Spot desmosome

Spot desmosomes are adhering junctions that anchor cells together in tissues subject to considerable stretching.

● FIGURE 3-5

Tight junction

- The brain capillaries are surrounded by astrocyte processes:

① They signal the cells to get tight.

② Participate in the cross-cellular transport, e.g. for K^+, some hormones and drugs.

- ***No BBB in a portion of hypothalamus, because***:

❶ Its function depends on its sampling the blood and adjusting its controlling out put according to maintain homeostasis.

❷ Some of its controlling output are hormones secreted in blood.

➢ The brain depends on constant delivery of O_2 and glucose by blood

- Unlike most tissues; (1) the brain cannot produce ATP in the absence of O_2. (2) the brain uses only glucose, and do not store it.
- Brain damage results if it is deprived of O_2 more than 4-5 minutes, and from glucose from 10-15 minutes.
- The most common cause of inadequate blood supply to the brain is a **stroke** (**Cerebrovascular accidents**).

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Central Nervous System

Chapter 5
Part II

The **nervous system** is one of the two major regulatory systems of the body, the other being the endocrine system. A complex interactive network of three basic types of nerve cells—afferent neurons, efferent neurons, and interneurons—constitutes the excitable cells of the nervous system. The **central nervous system (CNS)** is composed of the brain and spinal cord, which receive input about the external and internal environment from the afferent neurons. The CNS sorts and processes this input, then initiates appropriate directions in the efferent neurons, which carry the instructions to glands or muscles to bring about the desired response—some type of secretion or movement. Many of these neurally controlled activities are directed toward maintaining homeostasis. In general, the nervous system acts by means of its electrical signals (action potentials) to control the rapid responses of the body.

OVERVIEW OF THE CENTRAL NERVOUS SYSTEM

- **The brain enable us to:**
  - (1) Subconsciously regulate our internal environment.
  - (2) Experience emotions.
  - (3) Voluntarily control our movements.
  - (4) Perceive our own bodies and our surroundings.
  - (5) Engage in other higher cognitive processes such as thought and memory.

- **The brain can be classified according to anatomically, functionally and based of evolutionary development to:**
  1. Brain stem.
  2. Cerebellum.
  3. Forebrain
     - A. Diencephalon:
       - 1) Hypothalamus.
       - 2) Thalamus.
     - B. Cerebrum:
       - 1) Basal nuclei.
       - 2) Cerebral cortex.

▲ TABLE 5-3

Overview of Structures and Functions of the Major Components of the Brain

Brain Componen	Major Functions
Cerebrum: Cerebral cortex	1. Sensory perception 2. Voluntary control of movement 3. Language 4. Personality traits 5. Sophisticated mental events, such as thinking, memory, decision making, creativity, and self-consciousness
Basal nuclei	1. Inhibition of muscle tone 2. Coordination of slow, sustained movements 3. Suppression of useless patterns of movement
Diencephalon: Thalamus	1. Relay station for all synaptic input 2. Crude awareness of sensation 3. Some degree of consciousness 4. Role in motor control
Hypothalamus	1. Regulation of many homeostatic functions, such as temperature control, thirst, urine output, and food intake 2. Important link between nervous and endocrine systems 3. Extensive involvement with emotion and basic behavioral patterns
Cerebellum	1. Maintenance of balance 2. Enhancement of muscle tone 3. Coordination and planning of skilled voluntary muscle activity
Brain stem (midbrain, pons, and medulla)	1. Origin of majority of peripheral cranial nerves 2. Cardiovascular, respiratory, and digestive control centers 3. Regulation of muscle reflexes involved with equilibrium and posture 4. Reception and integration of all synaptic input from spinal cord; arousal and activation of cerebral cortex 5. Role in sleep–wake cycle

Cerebral cortex

1. Sensory perception
2. Voluntary control of movement
3. Language
4. Personality traits
5. Sophisticated mental events, such as thinking, memory, decision making, creativity, and self-consciousness

Basal nuclei

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4. Role in motor control

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Cerebellum

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Brain stem

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3. Regulation of muscle reflexes involved with equilibrium and posture
4. Reception and integration of all synaptic input from spinal cord; arousal and activation of cerebral cortex
5. Role in sleep–wake cycle

CEREBRAL CORTEX

- The two cerebral hemispheres are connected by the **corpus callosum** which consist of 300 million neuronal axons.

➢ **The cerebral cortex is an outer shell of gray matter covering an inner core of white matter**

- Gray matter consists of densely packaged neuronal cell bodies and their dendrites and most glial cells.
- White matter consists of bundles or tracts of myelinated nerve fibers (axons).
- Integration of neuronal input and initiation of neuronal output tack place at synapses within the gray matter. While the fiber tracts in the white matter transmit signals from one part of the cerebral cortex to another or between the cortex and other regions of the CNS, e.g. picking a flower.

(a)

(b)

(PHOTO: Mark Nielsen, Department of Biology, University of Utah)

FIGURE 5-8

Brain of human cadaver

(a) Dorsal view looking down on the top of the brain. Note that the deep longitudinal fissure divides the cerebrum into the right and left cerebral hemispheres. (b) Sagittal view of the right half of the brain. All major brain regions are visible from this midline interior view. The corpus callosum serves as a neural bridge between the two cerebral hemispheres.

The cerebral cortex is organized into layers and functional columns

- The cerebral cortex is organized into six layers, based on varying distribution of the cell bodies and locally associated fibers of several distinctive cell types.
- These layers are organized into functional vertical columns, and the functional differences between various areas of the cortex result from different layering patterns within the columns and from different input-output connections, for example; cortical layer 4 rich in **stellate cells** responsible for initial processing of sensory input to the cortex and layer 5 abundance of large **pyramidal cells** control output to skeletal muscles.

Figure 5-9 Layers of the cerebral cortex. Layer I is mostly glial cells and axons that run laterally. Layers II through VI contain different proportions of two main classes of cortical neurons: *pyramidal cells,* which are shaped like upside down pyramids and are the major output neurons, and *stellate cells,* which are shaped like stars. Stellate cells primarily receive input to the cortex and process local information.

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The four pairs of lobes in the cerebral cortex are specialized for different activities

- Deep folds divide the cortex into **four major lobes**, (fig. 5-9 and fig. 5-10a):

❶ **Occipital lobe;** responsible for initially processing visual input.

❷ **Temporal lobe;** sound sensation.

❸ **Parietal lobe;** receiving and processing sensory input.

❹ **Frontal lobe;** responsible for:

1. **Voluntary motor activity.**
2. **Speaking ability.**
3. **Elaboration of thought.**

● FIGURE 5-9

Cortical lobes

Each half of the cerebral cortex is divided into the occipital, temporal, parietal, and frontal lobes, as depicted in this schematic lateral view of the brain.

Primary motor cortex
(voluntary movement)
Supplementary motor area
(on inner surface—not visible;
programming of complex movements)
Central
sulcus
Somatosensory cortex
(somesthetic sensation
and proprioception)
Premotor cortex (coordination
of complex movements)
Posterior parietal cortex
(integration of somato-
sensory and visual input;
important for complex
movements)
Prefrontal association cortex
(planning for voluntary
activity; decision making;
personality traits)
Wernicke's area
(speech understanding)
Frontal lobe
Parietal lobe
Broca's area
(speech formation)
Parietal-temporal-occipital
association cortex
(integration of all
sensory input; important
in language)
Primary auditory cortex
surrounded by higher-order
auditory cortex (hearing)
Occipital lobe
Primary visual cortex
surrounded by higher-
order visual cortex (sight)
Limbic association cortex
(mostly on inner and bottom
surface of temporal lobe;
motivation and emotion; memory)
Temporal lobe
Cerebellum
Brain stem
Spinal cord

(a)

(a)

(b)

● FIGURE 5-10

Functional areas of the cerebral cortex

(a) Various regions of the cerebral cortex are primarily responsible for various aspects of neural processing, as indicated in this schematic lateral view of the brain. (b) Different areas of the brain "light up" on positron emission tomography (PET) scans as a person performs different tasks. PET scans detect the magnitude of blood flow in various regions of the brain. Because more blood flows into a particular region of the brain when it is more active, neuroscientists can use PET scans to "take pictures" of the brain at work on various tasks.

The parietal lobes are responsible for somatosensory processing

- **Somesthetic sensation**= body feeling; sensation from the surface of the body such as: touch, pressure, heat, cold and pain.
- **Somatosensory cortex** is located in the parietal lobe behind the central sulcus. It is the site of for initial cortical processing and perception of somesthetic input as well as **proprioceptive** input (awareness of body position).
- Each region within the somatosensory cortex receives somethetic and proprioceptive input from a specific area of the body, (fig. 5-11).
- **Sensory homunculus:** the body is represented upside down on the somatosensory cortex and different parts of the body are note equally represented.

FIGURE 5-11
Somatotopic map of the somatosensory cortex

● FIGURE 5-11

Somatotopic map of the somatosensory cortex

(a) Top view of cerebral hemispheres. (b) Sensory homunculus showing the distribution of sensory input to the somatosensory cortex from different parts of the body. The distorted graphic representation of the body parts indicate the relative proportion of the somatosensory cortex devoted to reception of sensory input from each area.

● FIGURE 5-12

Somatotopic map of the primary motor cortex

(a) Top view of cerebral hemispheres. (b) Motor homunculus showing the distribution of motor output from the primary motor cortex to different parts of the body. The distorted graphic representation of the body parts is indicative of the relative proportion of the primary motor cortex devoted to controlling skeletal muscles in each area.

Sensory homunculus

(b)

Motor homunculus

(b)

- The somatosensory cortex on each side of the brain receives sensory input from the opposite side of the body, ***because*** ascending pathway (afferent) crossover before terminating in the cortex.
- Simple awareness of touch, pressure, temperature or pain is detected by the thalamus, table 5-3) . But, the somatosensory cortex goes to fuller sensory perception, e.g. touching a texture.

The primary motor cortex is located in the frontal lobes controls the skeletal muscles

- Primary motor cortex:
  - In front of the central sulcus, (fig.5-12a).
  - Confers voluntary control over movement of skeletal muscles.
  - The motor cortex on each side of the brain controls muscles on the opposite side of the body.
  - The extent of representation in the motor cortex is proportional to the precision and complexity of motor skills required of the respective part, (fig.5-12b).

● FIGURE 5-12

Somatotopic map of the primary motor cortex

(a) Top view of cerebral hemispheres. (b) Motor homunculus showing the distribution of motor output from the primary motor cortex to different parts of the body. The distorted graphic representation of the body parts is indicative of the relative proportion of the primary motor cortex devoted to controlling skeletal muscles in each area.

Other brain regions besides the primary motor cortex are important in motor control

- The motor cortex is not the only region of the brain involved with motor control:
  1. Lower brain regions and spinal cord control involuntary skeletal muscle activity, e.g. posture maintenance.
  2. Motor cortex itself does not initiate voluntary movement, higher areas all command the primary motor cortex by **readiness potential**, (750 msec) before motor cortex action potential.
- The higher motor areas of the brain believed to be involved in this voluntary decision-making period include:
  1) **The supplementary motor area;** plays a preparatory role in programming complex sequences of movement. So brings about complex patterns of movements. Lesions may interfere with performance of more complex, useful integrated movements.
  2) **The premotor cortex;** is important in orienting the body and arms towards a specific target.
  3) **Posterior parietal cortex;** inform the premotor cortex with the body's momentary position in relation to the target. Damage of any of these areas affect the purposeful movement in a spatial context.

Supplementary motor area
(on inner surface—not visible; programming of complex movements)
Primary motor cortex
(voluntary movement)
Central sulcus
Somatosensory cortex
(somesthetic sensation and proprioception)
Premotor cortex (coordination of complex movements)
Posterior parietal cortex
(integration of somato-sensory and visual input; important for complex movements)
Prefrontal association cortex
(planning for voluntary activity; decision making; personality traits)
Wernicke's area
(speech understanding)
Frontal lobe
Parietal lobe
Broca's area
(speech formation)
Parietal-temporal-occipital association cortex
(integration of all sensory input; important in language)
Primary auditory cortex
surrounded by higher-order auditory cortex (hearing)
Occipital lobe
Primary visual cortex
surrounded by higher-order visual cortex (sight)
Limbic association cortex
(mostly on inner and bottom surface of temporal lobe; motivation and emotion; memory)
Temporal lobe
Cerebellum
Brain stem
Spinal cord
(a)

Somatotopic maps vary slightly between individuals and are dynamic, not static

- An individual's somatotopic mapping is not "carved in stone", but modified based on use.
- It is influenced by **use-dependent** competition, genetic and development process.
- ***Examples***:
  1. Middle fingers of experimental monkeys.
  2. String musician; there left hand represented by larger area of the somatosensory cortex (the touch-sensing region of the cortex).

FIGURE 5-11
Somatotopic map of the somatosensory cortex

Because of its plasticity, the brain can be remodeled in response to varying demands

- The brain displays a degree of **plasticity;** an ability to change or be functionally remodeled in response to the demands placed on it.
- When an area of the brain associated with a particular activity is destroyed, other areas of the brain may gradually assume some or all of the responsibilities of the damaged region.
- Current evidence suggests that the formation of new neuronal pathways (not new neurons but new connections between existing neurons) mediated in part by alteration:
  1. In dendritic shape resulting from modifications in certain cytoskeleton elements.
  2. As its dendritic become more branched and elongated, a neuron is able to receive and integrate more signals from other neurons.

➢ Gradual modification of each person's brain by a unique set of experiences provides a biological basis for individuality.

➢ Some limits are genetically established and there are developmental limits, e.g. old brain.

Different aspects of language are controlled by different regions of the cortex

- Language ability is excellent example of early cortical plasticity coupled with later performance.
- The area responsible for language ability are found in only one hemisphere (left) in vast majority of the population.
- Up to age 10, after damage to the left hemisphere, language ability can usually be reestablished in the right hemisphere following a temporary period of loss, but after the early teens, language ability is permanently impaired.
- The regions of the brain involved in comprehending and expressing language apparently are permanently assigned before adolescence.
- In normal individuals evidence for early plasticity and later permanence in language development, e.g. infants and Japanese.

Role of Broca's area and Wernick's area

- **Language**: is a complex form of communication in which written or spoken words symbolize objects and convey ideas.
- It involves the integration of two capabilities; ❶ ***Expression,*** related to the **Broca's** area, which is responsible for speaking ability, and located in the left frontal lobe in association with the motor area, and ❷ ***Comprehension***, related to the **Wernicke's area**, concerned with language comprehension. It is located in the left cortex at the juncture of the parietal, temporal and occipital lobes.

FIGURE 5-13

Cortical pathway for speaking a written word or naming a visual object

The red arrows and circled numbers with accompanying explanation indicate the pathway used to speak about something seen. Similarly, appropriate muscles of the hand can be commanded to write the desired words.

1a To speak about something seen, the brain transfers the visual information from the primary visual cortex to the angular gyrus of the parietal–temporal–occipital association cortex, which integrates inputs such as sight, sound, and touch.

1b To speak about something heard, the brain transfers the auditory information from the primary auditory cortex to the angular gyrus.

2 The information is transferred to Wernicke's area, where the choice and sequence of words to be spoken are formulated.

3 This language command is then transmitted to Broca's area, which translates the message into a programmed sound pattern.

4 This sound program is conveyed to the precise areas of the primary motor cortex that activate the appropriate facial and tongue muscles for causing the desired words to be spoken.

Figure 5-13 Cortical pathway for speaking a word seen or heard. The arrows and numbered steps describe the pathway used to speak about something seen or heard. Similarly, appropriate muscles of the hand can be commanded to write the desired words.

- **Aphasia:** caused by damage to cortical areas results from strokes.
- Damage to Broca's area results in a failure of word formation while, patients with a lesion in Wernicke's area cannot understand words they see or hear.
- **Speech impediments:** caused by a defect in mechanical aspect of speech e.g. weakness and incoordination of the muscle controlling the vocal apparatus.

➢ **Dyslexia: (Dyslexia)ƨƏəɐʁ**

- is language disorder, is a difficulty in learning to read because of inappropriate interpretation of words.
- Arises from developmental abnormalities in connections between visual and language areas (faulty wiring within language processing system).
- Emerging evidence suggests that dyslexia stems from a deficit in phonological processing.
- Not related to intellectual ability.

teapot
tapot
tapot
teapot
teapot
teapot

The owl was a bird.
Teh owl saw a brid.
The owl was

Dyslexia
wikiHow

Learn Some Japanese Words!

by loitumachan
Font: JayCons

〇	一	二	三	四	五	六	七	八	九
Zero	One	Two	Three	Four	Five	Six	Seven	Eight	Nine
日	絵	水	月	楽	夜	考	雪	犬	鳥
Sun	Picture	Water	Moon	Fun	Night	Think	Snow	Dog	Bird
夢	人	火	友	心	雨	宝	金	花	朝
Dream	Person	Fire	Friend	Heart	Rain	Treasure	Gold	Flower	Morning
空	風	強	土	猫	星	冬	夏	勇	死
Sky	Wind	Strength	Earth	Cat	Star	Winter	Summer	Courage	Death

子	喜	良	神	悪	美	男	ナ
Child	Joy	Good	God	Bad	Beauty	Boy	Strer
父	家	命	天	優	祈	悲	
Father	Home	Soul	Heaven	Kind	Pray	Sad	

天使

नम	बाल:	बाला	स	सा	तौ	ते	
bow (namaste)	boy	girl	he	she	they (m)	they(f)	many
पठ	पठति	लिख	पच	खाद	चल	हस	धाव
read	reads	write	cook	eat	walk	laugh	run
खेल	वद	शाखा	पत	अम्बा	जनक		
play	speak	branch	fall	mother	father		
पुत्र	एव	च	न	कुत्र	अत्र	तत्र	
son	also	and	no	where ?	here	there	
अज	गज	अश्व	सिंह	ति	त:	न्ति	
goat	elephant	horse	lion	does-singular	does-(two)	does -many	

英雄

The association areas of the cortex are involved in many higher functions

- There are three association areas, (fig. 5-10a and b):

❶ ***The prefrontal association cortex:***

the roles attributed to this region are:

① Planning for voluntary activity.

② Decision making.

③ Creativity.

④ Personality traits.

- Deficits in this area result in changes in personality and social behavior.

❷ ***The parietal-temporal-occipital association cortex:*** in this strategic location, it pools and integrates somatic, auditory and visual sensation.

❸ ***Limbic association cortex:***

- On the bottom and adjuring inner portion of temporal lobes.
- Concerned with motivation and emotion and memory.

Supplementary motor area
(on inner surface—not visible; programming of complex movements)
Primary motor cortex
(voluntary movement)
Central sulcus
Somatosensory cortex
(somesthetic sensation and proprioception)
Premotor cortex (coordination of complex movements)
Posterior parietal cortex
(integration of somato-sensory and visual input; important for complex movements)
Prefrontal association cortex
(planning for voluntary activity; decision making; personality traits)
Wernicke's area
(speech understanding)
Parietal lobe
Frontal lobe
Broca's area
(speech formation)
Parietal-temporal-occipital association cortex
(integration of all sensory input; important in language)
Primary auditory cortex
surrounded by higher-order auditory cortex (hearing)
Occipital lobe
Primary visual cortex
surrounded by higher-order visual cortex (sight)
Limbic association cortex
(mostly on inner and bottom surface of temporal lobe; motivation and emotion; memory)
Temporal lobe
Cerebellum
Brain stem
Spinal cord

(a)

FIGURE 5-14

Schematic linking of various regions of the cortex

For simplicity, a number of interconnections have been omitted.

The cerebral hemispheres have some degree of specialization

- The left side is also most commonly the dominant hemisphere for fine motor control, thus most people are right-handed, because the left side of the brain controls the right side of the body.

- **The left cerebral hemisphere**:
  - ❶ Excels in the performance of logical, analytic sequential and verbal tasks, such as math, language forms and philosophy.
  - ❷ Process information in fine-details (fragmentary way; e.g. *thinkers*).

- **The right cerebral hemisphere**:
  - ① Excels in non-logical skills, especially spatial perceptions, artistic and musical talents.
  - ② Views the world in a big-picture (holistic way; e.g. creators).

An electroencephalogram (EEG) is a record of postsynaptic activity in cortical neurons

- **EEG** is a graphic record “brain waves” for most part are not due to action potentials but instead represent the momentary collective postsynaptic potential activity, (EPSPs and IPSPs).
- Electrical activity can always be recorded from the living brain, depending of the degree of activity of the cerebral cortex, e.g. in (fig.5-15) the EEG waveform recorded over the occipital cortex changes markedly in response to simply opening and closing the eyes.
- What for ***??***

FIGURE 5-15

Replacement of an alpha rhythm on an EEG with a beta rhythm when th eyes are opened

The EEG has three major uses

❶ Used as a clinical tool in the diagnosis of cerebral dysfunction, e.g. epilepsy.

- Epilepsy (epileptic seizures), occur when a large collection of neurons abnormally undergo synchronous action potentials that produce stereotypical, involuntary spasms and alterations in behavior.
- Different problems can lead to **the neuronal hyperexcitability** including:
  ①Genetic defects.
  ②Traumatic brain injuries.
  ③Inhibitory neurotransmitter GABA.
  ④Prolonged action of glutamate.

❷ Used to distinguish various stages of sleep.

❸ Used in the legal determination of brain death. Because of the susceptibility of the brain to O_2 deprivation, resulting in the paradoxical situation of a dead brain in a living body.

- Coma and brain death.
- Organ donors.

➢ Electrocerebral silences the accepted indication of brain death coupled with stringent criteria, e.g. absence of eye reflexes. To guard against a false terminal diagnosis with reversible flat EEG in certain kids of drug intoxication.

Neurons in different regions of the cerebral cortex may fire in rhythmic synchrony

- We know that: the greater the triggering event, the greater the firing rate of the neurons, from studying a single neuron. But studying interacting neurons suggests that;

①It may transiently fire together for fraction of a second.

②The brain encodes information by:

(a) Changing firing rates "frequency".

(b) Changing the patterns of these brief neural synchronization.

- So, the neurons within an assembly the fire together may be widely scattered, e.g. bouncing ball.

➢ **How the brain accomplishes these integration?**

- Might lie in: the synchronous firing of neurons in separate regions of the brain that are functionally linked together by virtue of being responsive to different aspects of the same objects.

الحمد لله رب العالمين

Central Nervous System

Chapter 5
Part III

The **nervous system** is one of the two major regulatory systems of the body, the other being the endocrine system. A complex interactive network of three basic types of nerve cells—afferent neurons, efferent neurons, and interneurons—constitutes the excitable cells of the nervous system. The **central nervous system (CNS)** is composed of the brain and spinal cord, which receive input about the external and internal environment from the afferent neurons. The CNS sorts and processes this input, then initiates appropriate directions in the efferent neurons, which carry the instructions to glands or muscles to bring about the desired response—some type of secretion or movement. Many of these neurally controlled activities are directed toward maintaining homeostasis. In general, the nervous system acts by means of its electrical signals (action potentials) to control the rapid responses of the body.

BASAL NUCLEI, THALAMUS, AND HYPOTHALAMUS

➢The basal nuclei play an important inhibitory role in motor control:

❑ Basal nuclei consist of several masses of gray matter located deep within the cerebral white matter, and is a functional aggregation of neuronal cell bodies, (Fig.5-16).

❑ Play a complex role in the control of movement and less understood non-motor functions.

❑ Its functions has been listed in (Table 5-3).

❑ The basal nuclei do not directly influence the efferent motor neurons but act by modifying ongoing in motor pathway.

❑ The thalamus positively reinforces voluntary motor behavior initiated by the cortex, whereas the basal nuclei modulate this activity by exerting an inhibitory effect on thalamus (also on brain stem), to eliminate antagonistic and unnecessary movements.

(a)

(b)

● FIGURE 5-16

Frontal section of the brain

(a) Schematic frontal section of the brain. The cerebral cortex, an outer shell of gray matter, surrounds an inner core of white matter. Deep within the cerebral white matter are several masses of gray matter, the basal nuclei. The ventricles are cavities in the brain through which the cerebrospinal fluid flows. The thalamus forms the walls of the third ventricle. (b) Photograph of a frontal section of the brain of a cadaver.

(PHOTO: Mark Nielsen, Department of Biology, University of Utah)

Cerebral cortex

1. Sensory perception
2. Voluntary control of movement
3. Language
4. Personality traits
5. Sophisticated mental events, such as thinking, memory, decision making, creativity, and self-consciousness

Basal nuclei

1. Inhibition of muscle tone
2. Coordination of slow, sustained movements
3. Suppression of useless patterns of movement

Thalamus

1. Relay station for all synaptic input
2. Crude awareness of sensation
3. Some degree of consciousness
4. Role in motor control

Hypothalamus

1. Regulation of many homeostatic functions, such as temperature control, thirst, urine output, and food intake
2. Important link between nervous and endocrine systems
3. Extensive involvement with emotion and basic behavioral patterns
4. Role in sleep–wake cycle

Cerebellum

1. Maintenance of balance
2. Enhancement of muscle tone
3. Coordination and planning of skilled voluntary muscle activity

Brain stem

1. Origin of majority of peripheral cranial nerves
2. Cardiovascular, respiratory, and digestive control centers
3. Regulation of muscle reflexes involved with equilibrium and posture
4. Reception and integration of all synaptic input from spinal cord; arousal and activation of cerebral cortex
5. Role in sleep–wake cycle

Parkinson's Disease (PD)

- **As a result of the basal nuclei lacking sufficient dopamine to exert their normal role:**

➢ **Three types of motor disturbances characterize (PD):**

1- Increase muscle tone (or rigidity).

2- Involuntary, useless or unwanted movements (*resting tremors*).

3- Slowness in initiating and carrying out different motor behaviors.

- So, it is difficult to stop ongoing activities. If sitting down, they tend to remain seated, and if they get up, they do so very slowly.

➢ The thalamus is a sensory relay station and is important in motor control

- The thalamus function has been mentioned in (table 5-3).

➢ The hypothalamus regulates many homeostatic functions

- Return to the specifications of hypothalamus in (table 5-3) .

FIGURE 5-17
Location of the thalamus, hypothalamus, and cerebellum in sagittal section

The Limbic System

- **A ring of forebrain structures that surround the brain stem and are interconnected by intricate neural pathways.**

- **Include portions of :**

- Limbic association cortex.
- Basal nuclei, thalamus and hypothalamus.

- **Limbic system is associated with:**

(1) Emotions.

(2) Basal survival and sociosexual behavioral patterns.

(3) Motivation and learning.

FIGURE 5-18

Limbic system

This partially transparent view of the brain reveals the structures composing the limbic system.

The limbic system plays a key role in emotions

- The concept of **emotion** encompasses:
  1- Subjective emotional feelings and moods, e.g. anger, fear and happiness.
  2- The overt physical responses, e.g. preparation for attack or defense.
  3- Observable emotional expressions, e.g. laughing, crying or blushing.
- Limbic system play a central role in all aspects of emotions.
- Stimulation of specific regions during brain surgery produce joy, satisfaction or pleasure and discouragement, fear or anxiety in another, for example; **Amygdala** is an especially important region for processing inputs that give risk to the sensation of fear.

➢ **Limbic system and higher cortex control basic behavioral patterns:**

1) Those aimed at survival of the individual (attack, searching for food, ..etc).
2) Those directed toward perpetuation of the species (Sociosexual behaviors conductive to mating).

In experimental animals:

- Stimulation of one area can elicit responses of anger and rage in a normal docile animal, whereas
- Stimulation of another area results in placidity and tameness in vicious animals.
- Yet, in another limbic area can induce sexual behaviors such as copulatory movements.

Hypothalamus role in basic behavioral patterns

- **It seems that hypothalamus is responsible for involuntary internal responses of various body systems in preparation for appropriate action to accompany a particular emotional state:**

For example:

- Increased heart rate (HR).
- Increased respiratory rate.
- Elevation of Blood pressure (BP).
- Diversion of blood to skeletal muscles.
- and otherssssss.

- **It occurs anticipation of attack or when angered with no conscious control, without any conscious control.**

Higher cortex role in basic behavioral patterns

- In executive complex behavioral activities such as attack, flight or mating the individual must interact with the external environment.

So, higher cortical mechanisms are called to connect limbic system and hypothalamus with the outer world. So, that appropriate overt behaviors are manifested.

For example:

Skeletal muscle activity required to approach or avoid an adversary, participate in sexual activity or display emotional expression, e.g. the universal human emotional expression of smiling ☺.

- Higher cortical levels are also capable of reinforcing, modifying, or suppressing basic behavioral responses so that actions can be guided by planning, strategy and judgment based on an under standing of the situation.

Reward and Punishment Centers

- Certain regions of the limbic system have been designated as “reward” and “punishment” centers, because stimulation in these respective areas gives rise to pleasant or unpleasant sensations.
- Experimental animal implanted with self-stimulation device give 5000 stimulation/hr.

Motivated behaviors are goal directed

- ***Motivation:*** is the ability to direct behavior toward specific goals.
- Some of it are aimed satisfying physical needs related to homeostasis.
- ***Homeostatic drives:*** represent the subjective urges associated with specific body needs, e.g. the sensation of thirst accompanying a water deficit in the body.
- So, Reward centers are found most abundantly in region involved in mediated the highly motivated behavioral activities of eating, drinking and sexual activities.
- Motivational drives unrelated to homeostasis, (e.g. pursue a particular career or win a certain race) is unknown if any involved with reward and punished center.
- In dead, some individuals motivated toward a particular goal may even deliberately متعمد punish them selves in short to achieve their long range gratification, e. g. Athletics and students.

Norepinephrine, Dopamine and Serotonin:
in emotions & behavior pathways

- The neurophysiological mechanisms responsible for the psychological observations of emotions and motivated behavior remain a *Mystery.*
- Although the neurotransmitters involved in these pathways:

(1) NE and Dopamine (Catecholamines).

(2) Serotonin.

- NE and Dopamine are known to be transmitters in the regions that elicit the highest rates of self-stimulation in animals equipped with do-it-your self devices.
- Psychoactive drugs affect moods in humans, e.g. Amphetamine.

➢ **Psychoactive drug abuse and tolerance**

- Used to treat various mental disorders but when abused it is act by enhancing the effectiveness of dopamine in the “pleasure” pathways, thus initially giving rise to an intense sensation of pleasure, e.g. Cocaine which blocks reuptake of dopamine at synapse.
- Tolerance: a desensitization to the drug, so that the user needs greater quantities of drug to achieve the same effect.
- Over the course of abuse, the user after no longer can derive pleasure from the drug but suffers unpleasant *withdrawal symptoms* once the effect of the drug has worn off .

Examples of mental disorders associated with defects in limbic system neurotransmitters

- ***Schizophrenia.***
- ***Depression.***

➢ ***Schizophrenia:***

A mental disorder characterized by delusions, hallucinations, blunted بليد (inappropriate emotions), pronounced apathy بدون رأي/لا مبالاة and social withdrawal منعزل/منطوي اجتماعياً.

- Results from excess dopamine, but where is the anatomical site of this abnormality?

1. Among these are neural networks linked to the limbic system.
2. And because the limbic system involved in emotions and in triggering behaviors that are abnormal in schizophrenic patients.

So, it is believed that this is the defect site in schizophrenia.

- ***Depression:***

- A disorder characterized by a pervasive negative mood accompanied by a generalized loss of interests, an inability to experience pleasure, and suicidal tendencies.
- Implicated to a functional deficiency of serotonin or norepinephrine or both.

- All effective antidepressant drugs increase the neurotransmitters concentration in CNS e.g. **Prozac** ® Fluoxetine by blocking the reuptake of released serotonin, thus prolonging serotonin activity at synapses.
- Serotonin & NE in the limbic system involved in pleasure and motivation, so it is suggested that there disruption of these regions by deficiencies or decreased effectiveness related to sadness and lack of interest (no motivation).

- Understanding of the molecular mechanisms of mental disorders optimize the researchers to correct or better manage psychiatric problems through drug intervention.

Learning is acquisition of knowledge as a result of experiences

- **Learning:** is the acquisition of knowledge or skills as a consequence of experience or both.

  : is a change in behavior that occurs as a result of experience.

- Rewards and punishments are integral parts of many types of learning.
- If an animal is rewarded on responding in a particular way to a stimulus, the likelihood increases that animal will respond in the same way again to the same stimulus as a consequence of this experience and vice versa.
- When behavioral responses that give rise to pleasure are reinforced or those accompanied by punishment are avoided, learning take place, Example; a puppy.
- The only limits to the effects that environmental influences can have on learning are:

1. The biological constraints imposed by species-specific and
2. Individual genetic endowments موهبة.

Memory is laid down in stages

- **Memory :** is the storage of acquired knowledge for later recall.
- Learning and memory form the basis by which individuals adapt their behavior to their particular external circumstances, or planning for successful interactions and intentional avoidance of predictable disagreeable circumstances would be impossible.
- The neural change responsible for retention or storage of knowledge is known as the **memory trace**, (Figure 5-19).
- Generally, concepts not verbatim information, are stored.

- Storage of acquired information is accomplished in at least two stages:
  1. Short-term memory which lasts for seconds to hours.
  2. Long-term memory which retained for days to years.
- The process of transferring and fixing STM traces into LTM stores is known as **Consolidation.**
- **Working memory:** (the erasable blackboard of the mind), working memory temporarily holds and interrelates various pieces of information that are relevant to a current mental task.
- This integrative function is crucial to your ability to reason, plan and make judgments, by comparing and manipulating new and old information.

▲ TABLE 5-4
Comparison of Short-Term and Long-Term Memory

Characteristic	Short-Term Memory	Long-Term Memory
Time of Storage after Acquisition of New Information	Immediate	Later; must be transferred from short-term to long-term memory through consolidation; enhanced by practice or recycling of information through short-term mode
Capacity of Storage	Limited	Very large
Retrieval Time (remembering)	Rapid retrieval	Slower retrieval, except for thoroughly ingrained memories, which are rapidly retrieved
Inability to Retrieve (forgetting)	Permanently forgotten; memory fades quickly unless consolidated into long-term memory	Usually only transiently unable to access; relatively stable memory trace
Mechanism of Storage	Involves transient modifications in functions of pre-existing synapses, such as altering amount of neuro-transmitter released	Involves relatively permanent functional or structural changes between existing neurons, such as formation of new synapses; synthesis of new proteins plays a key role

Studies suggest a regulatory role for the cAMP second-messenger pathway in the development and maintenance of LTP in addition to the Ca^{2+} second-messenger pathway. Participation of cAMP may hold a key to linking short-term memory to long-term memory consolidation.

Long-term memory involves formation of new, permanent synaptic connections.

Whereas short-term memory involves transient strengthening of preexisting synapses, long-term memory storage requires activation of specific genes that control synthesis of proteins, needed for lasting structural or functional changes at specific synapses. Examples of such changes include formation of new synaptic connections or permanent changes in presynaptic or postsyn-

1 Glutamate is released from activated presynaptic neuron.

2 Glutamate binds with both AMPA and NMDA receptors.

3 Binding opens AMPA receptor-channel.

4 Na^+ entry through open AMPA channel depolarizes postsynaptic neuron, producing EPSP.

5 Binding opens gate of NMDA receptor-channel but Mg^{2+} still blocks channel. Sufficient depolarization from this AMPA opening plus other EPSPs drives Mg^{2+} out.

6 Ca^{2+} entry through open NMDA channel activates Ca^{2+} second-messenger pathway.

7 Second-messenger pathway promotes insertion of additional AMPA receptors in postsynaptic membrane, increasing its sensitivity to glutamate.

8 Second-messenger pathway also triggers release of retrograde paracrine (likely nitric oxide).

9 Nitric oxide stimulates long-lasting increase in glutamate release by presynaptic neuron.

Figure 5-17 Possible pathways for long-term potentiation.

***FIGURE FOCUS:** Would simultaneous binding of glutamate from a presynaptic neuron to both AMPA and NMDA receptors at a postsynaptic neuron automatically trigger a chain of events leading to long-term potentiation? Explain why or why not.*

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Amnesia النسيان/ فقدان الذاكرة

- ***Amnesia:*** a lack of memory that involves whole portions of time rather than isolated bits of information.
- There are two forms:

1) **Retrograde amnesia:** (going backward)

   - is the inability to recall recent past events (about half an hour).

   - follows traumatic event interferes with electrical activity of the brain, and may access to long term stores as well.

2) **Anterograde amnesia:** (going forward)نسيان الحاضر

   - Is the inability to store memory in long-term storage for later retrieval.
   - Associated with lesions of the medial portions of the temporal lobes, which are generally considered critical regions for memory consolidation. Fig. 5-10 (a)

e.g. So, they may be able to recall things they learned before the onset of their problem, but they are unable to establish new permanent memories, example; where is the bathroom *??*

Memory traces are present in multiple regions of the brain

- There is no single **“memory center”** in the neurons involved in memory traces are distributed throughout the subcortical and cortical regions of the brain which include:
  - Hippocampus.
  - Associate structures of the medial temporal lobes.
  - The limbic system.
  - The cerebellum.
  - The prefrontal cortex.
  - Other regions of the cerebral cortex.

The hippocampus and declarative memories

- **The hippocampus:** plays a vital role in short-term memory involving the integration of various related stimuli and is also crucial for consolidation into long-term memory.
- It is believed to store new long-term memories only ***temporarily*** and then transfer them to other cortical sites for mere permanent storage.
- The hippocampus & surrounding regions play an especially important role in **declarative memories;** the "***What***" memories of **specific people**, **places**, **objects**, **facts** and **events** that often result after only one experience.
- They are especially important in maintaining a durable record of the every day episodic events in our lives.
- Individuals with hippocampal damage are profoundly بعمقforgetful of facts critical to daily functioning .
- Interestingly, extensive damage in the hippocampus region is evident in **Alzheimer's patients** during autopsy.
- Who is the most famous Alzheimer patient??

The cerebellum and procedural memories

- The cerebellum and relevant cortical regions such as:
  - the primary motor cortex
  - Somatosensory cortex and
  - visual processing areas.

Play an essential role in the "***How to***" procedural memories involving motor skills gained through repetitive training, such as memorizing a particular dance routine.

- The cortical areas important for a given procedural memory are the specific motor or sensory systems engaged in performing the routine, and these procedural memories can be brought forth تحدث without conscious effort, For example: an Ice skater.
- The distinct localization in different parts of the brain of these two types of memory is apparent in individuals who have temporal/limbic lesions, for example: they are able to perform a skill, such as playing a piano, but the next day they have no recollection that they played it.

The prefrontal cortex and working memory

➢ **Where ?**

- The prefrontal cortex is the major orchestrator of working memory, it is :

1. Serves as a temporary storage site for holding relevant data online.
2. Responsible for executive functions (planning, problem solving and organizing activities).

- Researchers, have identified storage bins in the prefrontal cortex, depending on the nature of current relevant data, for example: spatial cues is distinct from verbal cues or cues about an object's appearance.

- It is suggested that, how intelligent a person is may be determined by the capacity of his or her working memory to temporarily hold and relate a variety of relevant data.

The prefrontal cortex and working memory

- **How ?**
- Less is known.
- A single memory does not reside in a single neuron <u>but rather</u> على العكس in the pattern of signals transmitted across synapses within vast neural network.

- **Mechanisms of STM and LTM:**

1. STM involves transient modification in the function of pre-existing synapses e.g. temporary alternation in the amount of neurotransmitter released.
2. LTM involves relatively permanent functional or structural changes between existing neurons in the brain.

Short-term memory involves transient changes in synaptic activity

- Ingenious experiments in the sea snail, ***Aplasia***, have shown that two forms of STM due to modification of different channel proteins in presynaptic terminals of specific afferent neurons involved in the pathway that mediates the behavior being modified lead to change in neurotransmitter release.

- **Habituation:**

  Is a decreased responsiveness to repetitive presentations of an indifferent stimulus.

- **Sensitization:**

  Is an increased responsiveness to mild stimuli following a strong or noxious /ضار مؤذي stimulus.

FIGURE 5-20
Habituation and sensitization in *Aplysia*

Mechanism of Long-Term Potentiation
in Hippocampus

- LTP refers to prolonged increase in the strength of existing synaptic connections in activated pathways following brief periods of repetitive stimulation.

- LTP has been shown to last for days or even weeks, long enough for this short-term memory to be consolidated into more permanent long-term memory.

- When LTP occurs, simultaneous activation of both the presynaptic and postsynaptic neurons across a given excitatory synapse results in long-lasting modifications that enhance the ability of the presynaptic neuron to excite the postsynaptic neuron.

- So, the development of LTP is restricted to the pathway that is stimulated, and the signals become stronger with repeated use, thus results in the formation of more EPSPs and more Action potentials.

- Enhanced synaptic transmission could theoretically result from either change:
  1. In the postsynaptic neuron (such as increased responsiveness to the neurotransmitters).
  2. In the presynaptic neuron (such as increased release of neurotransmitter).
- Figure 5-21
- This heightened sensitivity of the postsynaptic neuron to glutamate from the presynaptic cell helps maintain LTP.
- This positive feedback strengthens the signaling process at this synapse, helping sustain LTP.

Possible pathways for long-term potentiation

1. Glutamate released from an activated presynaptic neuron binds with NMDA receptors on the postsynaptic neuron, resulting in opening of receptor-related Ca^{2+} channels.

2. Calcium enters through these opened channels.

3. Calcium entry activates a second-messenger system that can initiate two separate intracellular pathways that enhance the effectiveness of this synapse.

4a. In the first pathway, the Ca^{2+}-dependent second-messenger system increases the availability of AMPA receptors.

4b. In an alternate pathway, the Ca^{2+}-dependent second-messenger system causes the postsynaptic neuron to release nitric oxide.

5a. These receptors also bind with glutamate.

5b. This retrograde messenger enhances the release of more glutamate from the presynaptic neuron.

6a. This binding results in the formation of EPSPs. Thus this pathway strengthens the synapse by increasing postsynaptic excitatory responsiveness.

6b. This positive feedback strengthens the signaling process at this synapse.

Long-term memory involves formation of new permanent synaptic connections

- LTM storage requires the activation of specific genes that control protein synthesis, that needed for formation of new synaptic connections.
- Observable microscopic differences demonstrated between experimental animals reared تربى/نشأ in a sensory-deprived environment and those raised in a sensory-rich environment, which displayed greater branching and elongation of dendrites in nerve cells in regions of the brain suspected to be involved with memory storage.

- Formation of enduring باقية /ثابتة memories involves:
  1. Activation of positive regulatory factors (CREB) which activates the genes important in LTM storage.

  these immediate early genes (IEG) play a critical role in memory consolidation by governing the synthesis of the proteins that encode LTM.

  2. Turning off of inhibitory constraining factors (CREB2) which repressor يكبح that prevent memory storage.

* Some researchers suggest that the conversion from short-term to long-term memory may involve the turning of CREB by cAMP.

الحمد لله رب العالمين

الأحد
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أكتوبر ٢٠١٨

صلّ على الحبيب.. قلبك يطيب
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في صاحبي بقلي فيلم اسمه City lights
هو شافه حلو جدا وكوميدي
شارلي شابلن
شارك فيه
فيلم قديم طبعا
في نقطه تحرك
Action Point
كوميدي
Like Father
كوميدي
شوفهم

hostel
مش موجود على موقع أفلامي Hunter's
Prayer 2017
فيلم الكوميديا والاثارة للكبار فقط +١٨
the dictator

فلم Mouse hunt

فلم الأساطير السبعة أو السبعة الرائعة
Mechanic:_Resurrection_2016
الذئاب جين وبيوكا
the last witch hunter
the puresuit of happyness،

Star running

فتح الأجهزة والطابعات
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Central Nervous System

Chapter 5
Part IV

The **nervous system** is one of the two major regulatory systems of the body, the other being the endocrine system. A complex interactive network of three basic types of nerve cells—afferent neurons, efferent neurons, and interneurons—constitutes the excitable cells of the nervous system. The **central nervous system (CNS)** is composed of the brain and spinal cord, which receive input about the external and internal environment from the afferent neurons. The CNS sorts and processes this input, then initiates appropriate directions in the efferent neurons, which carry the instructions to glands or muscles to bring about the desired response—some type of secretion or movement. Many of these neurally controlled activities are directed toward maintaining homeostasis. In general, the nervous system acts by means of its electrical signals (action potentials) to control the rapid responses of the body.

CEREBELLUM

- The cerebellum consists of three functionally distinct parts as they have different sets of inputs and outputs and different functions, (Table 5-3).

1. **The Vestibulocerebellum:**

   Maintenance of balance and control of eye movement.

2. **The Spinocerebellum:**

   (1) Enhances muscle tone and coordinates skilled, voluntary movements ensure the accurate timing of various muscle contractions to coordinate movements involving multiple joints.

   (2) It is essentially acts as “middle management”, comparing the “intentions” or “orders of the higher centers with the “performance” of the muscles and then correcting any “errors” or deviations from the intended movement, (Fig 5-23).

3. **The Cerebrocerebellum:**

   Play a role in the planning and initiation of voluntary activity by providing input to the cortical motor areas.

   this is also the cerebellum region involved in procedural memories.

● FIGURE 5-22

Cerebellum

(a) Gross structure of the cerebellum. (b) Unfolded cerebellum, revealing its three functionally distinct parts. (c) Internal structure of the cerebellum.

- Cerebral diseases have the following symptoms:
  - Poor balance.
  - Nystagmus (rhythmic, oscillating eye movements).
  - Reduced muscle tone (but no paralysis).
  - In ability to perform rapid movements, smoothly.
  - In ability to stop and start skeletal muscle action quickly.
  - Latter, intention tremor: characterized by oscillating to-and-fro movements of a limb as it approaches its intended destination.

FIGURE 5-23

Role of the spinocerebellum in subconscious control of voluntary motor activity

In coordinating rapid, phasic motor activity, the spinocerebellum compares the "intentions" of higher motor centers with the "performance" of the muscles and corrects any "errors" by making the necessary adjustments to accomplish the intended movement.

The cerebellum and basal nuclei

- **Both:**

  + Monitor and adjust motor activity commanded from motor cortex.

  + Function indirectly by modifying the out put of major motor systems of the brain.

  + Help to subconsciously coordinate voluntary motor activity.

- **But :**

  The cerebellum

  - Helps maintain balance.
  - Helps coordinate fast, phasic motor activity, like typing.
  - Enhance muscle tone.

  The basal nuclei are important in:

  - Coordinating slow , sustained movement related to posture and support.
  - Function in inhibiting muscle tone.

➢BRAIN STEM:

is a vital link between the spinal cord and higher brain regions

▲ TABLE 5-3
Overview of Structures and Functions of the Major Components of the Brain

Brain Componen	Major Functions
Cerebral cortex	1. Sensory perception 2. Voluntary control of movement 3. Language 4. Personality traits 5. Sophisticated mental events, such as thinking, memory, decision making, creativity, and self-consciousness
Basal nuclei	1. Inhibition of muscle tone 2. Coordination of slow, sustained movements 3. Suppression of useless patterns of movement
Thalamus	1. Relay station for all synaptic input 2. Crude awareness of sensation 3. Some degree of consciousness 4. Role in motor control
Hypothalamus	1. Regulation of many homeostatic functions, such as temperature control, thirst, urine output, and food intake 2. Important link between nervous and endocrine systems 3. Extensive involvement with emotion and basic behavioral patterns
Cerebellum	1. Maintenance of balance 2. Enhancement of muscle tone 3. Coordination and planning of skilled voluntary muscle activity
Brain stem (midbrain, pons, and medulla)	1. Origin of majority of peripheral cranial nerves 2. Cardiovascular, respiratory, and digestive control centers 3. Regulation of muscle reflexes involved with equilibrium and posture 4. Reception and integration of all synaptic input from spinal cord; arousal and activation of cerebral cortex 5. Role in sleep–wake cycle **6. Play a role in modulating the sense of pain.**

Olfactory nerve (I)
= Motor fibers
= Sensory fibers
Mucosa of nasal cavity
Retina
Oculomotor nerve (III)
Extrinsic eye muscles; ciliary muscle; muscles of iris
Trochlear nerve (IV)
Superior oblique (extrinsic eye muscle)
Termination of fibers of olfactory nerve (I)
Olfactory bulb
Optic nerve (II)
Abducens nerve (VI)
Lateral rectus (extrinsic eye muscle)
Trigeminal nerve (V)
Motor—muscles of mastication
Sensory—face and head
Motor—muscles of face and scalp; salivary and tear glands
Facial nerve (VII)
Sensory—taste buds on anterior tongue
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Cochlea, vestibule, and semicircular canals of inner ear
Motor—muscles of pharynx; parotid gland
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Glossopharyngeal nerve (IX)
Vagus nerve (X)
Hypoglossal nerve (XII)
Accessory nerve (XI)
Tongue muscles
Muscles of larynx, pharynx, soft palate, shoulder, and neck
Motor—muscles of pharynx and larynx; thoracic and abdominal organs
Sensory—taste buds on tongue and pharynx; thoracic and abdominal organs

● FIGURE 5-24

Cranial nerves
Inferior (underside) view of the brain, showing the attachments of the 12 pairs of cranial nerves to the brain and many of the structures innervated by those nerves.

● FIGURE 5-25

The reticular activating system (RAS)
The reticular formation, a widespread network of neurons within the brain stem (in red), receives and integrates all synaptic input. The reticular activating system, which promotes cortical alertness and helps direct attention toward specific events, consists of ascending fibers (in blue) that originate in the reticular formation and carry signals upward to arouse and activate the cerebral cortex.

Sleep is an active process consisting of alternating periods of slow-wave and paradoxical sleep

- **Consciousness:**

  --> refers to subjective awareness of external world and self.
- **States of consciousness:** (based on the extent of interaction between peripheral stimuli and the brain):
  - Maximum alertness .
  - Wakefulness.
  - Sleep (two types): (1) Slow wave sleep. (2) Paradoxical (REM).
  - Coma.

▲ TABLE 5-5
Comparison of Slow-Wave and Paradoxical Sleep

	Type of Sleep	
Characteristic	Slow-wave sleep	Paradoxical sleep
EEG	Displays slow waves	Similar to EEG of alert, awake person
Motor Activity	Considerable muscle tone; frequent shifting	Abrupt inhibition of muscle tone; no movement
Heart Rate, Respiratory Rate, Blood Pressure	Minor reductions	Irregular
Dreaming	Rare (mental activity is extension of waking-time thoughts)	Common
Arousal	Sleeper easily awakened	Sleeper hard to arouse but apt to wake up spontaneously
Percentage of Sleeping Time	80%	20%
Other Important Characteristics	Has four stages; sleeper must pass through this type of sleep first	Rapid eye movements

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At the onset of sleep, an individual moves from the light sleep of stage 1 to the deep sleep of stage 4 of slow-wave sleep during a period of 30- 45 minutes, then reverses through the same stages in the same amount of time.

A 10-15 min episode of paradoxical sleep punctuates the end of each slow-wave sleep cycle.

The sleep-wake cycle control

- It is due to the cyclical interplay of three different neural system:
  1. An arousal system (part of RAS).
  2. Slow-wave center.
  3. Paradoxical sleep center.
- The interaction between the three neuronal regions is the subject of intense investigation.
- The arousal system can be activated by afferent sensory input, or by input descending to the brain stem from higher brain regions.

FIGURE 5-26

EEG patterns during different types of sleep
Note that the EEG pattern during paradoxical sleep is similar to that of an alert, awake person, whereas the pattern during slow-wave sleep displays distinctly different waves.

The function of sleep is unclear

- The reason sleep is needed largely remains a mystery.
- Sleep is not accompanied by reduction in neural activity, but rather by a profound change in activity.

1) A widely accepted proposal:

- Sleep provides the brain “catch up” time to restore biochemical or physiological processes that have progressively degraded during a wakefulness.
- The most direct evidence that supports this proposal is the potential role of **adenosine** as a neural sleep factor.
- **Adenosine,** which act as a neuromodulator, has been shown experimentally to *inactivate* the arousal center, this action can bring on slow-wave sleep.
- Injections of adenosine induce apparently normal sleep, whereas **caffeine**, which blocks adenosin receptors in brain, revives ينشطايعزز drowsy people by removing adenosine inhibitory influence on the arousal center.

2) **Alternative theory** (speculation):

- Sleep (especially paradoxical) is necessary to allow the brain to “ shift gears”, to accomplish the long-term structural and chemical adjustments necessary for learning and memory, especially consolidation of procedural memories.
- Infants highly plastic brains undergo rapidly profound synaptic modifications, so require much sleep, and vice versa.
- Individuals experimentally deprived of paradoxical sleep for a night or two, appeared suffered **hallucinations,** and spent more time later in paradoxical sleep.

- **Narcolepsy:**

- Unusual sleep disturbance, characterized by brief 5-30 min irresistible sleep attacks during the day.
- It is suspected of being linked to abnormal activation of neurons in the paradoxical sleep center during the wake state.
- Narcoleptic patient, can enter into paradoxical sleep directly without the normal prerequisite passage though slow-wave sleep.

Spinal cord

FIGURE 5-27

Location of the spinal cord relative to the vertebral column

(SOURCE: Adapted from Cecie Starr and Ralph Taggart, *Biology: The Unity and Diversity of Life*, Eighth Edition, Fig. 35.9a, p. 577. Copyright 1998 Wadsworth Publishing Company.)

- **The spinal cord extends through the vertebral canal and is connected to the spinal nerves:**
- The spinal nerves are named according to the region of the vertebral column from which they emerge

e.g. C1-C2 / T3-T4 / L4-L5.

- During development, the vertebral column grows about 25cm longer than the spinal cord, so spinal nerves are not aligned with the corresponding intervertebral space.
- The thick bundle of elongated nerve roots within the lower vertebral canal is known as the **Cauda equina,** where CSF samples are taken.

FIGURE 5-28

Spinal nerves

There are 31 pairs of spinal nerves named according to the region of the vertebral column from which they emerge. Because the spinal cord is shorter than the vertebral column, spinal nerve roots must descend along the cord before emerging from the vertebral column at the corresponding intervertebral space, especially those beyond the level of the first lumbar vertebra (L1). Collectively these rootlets are called the cauda equina, literally "horse's tail." (a) Posterior view of the brain, spinal cord, and spinal nerves (on the right side only). (b) Lateral view of the spinal cord and spinal nerves emerging from the vertebral column.

➢The white matter of the spinal cord is organized into tracts

- The spinal cord is generally the same throughout its length, and the gray matter in the spinal cord forms a butterfly-shaped region on the inside.
- The cord gray matter consists primarily of neuronal cell bodies and their dendrites, short interneurons and glial cells.
- The bundles are grouped into columns that extend the length of the cord.

FIGURE 5-29

- Some are **ascending tracts** (cord to brain) and other are **descending tracts** (brain to cord).
- The tracts are generally named for their origin and termination, for example: **- Ventral corticospinal tract.**

  - Lateral spinothamic tract.

● FIGURE 5-30

Ascending and descending tracts in the white matter of the spinal cord

(a) Location and functions of the major ascending and descending tracts in the spinal cord in cross section. *Continued*

(SOURCE: Adapted from Cecie Starr and Ralph Taggart, *Biology: The Unity and Diversity of Life*, Eighth Edition, Fig. 34.10, p. 566. Copyright 1998 Wadsworth Publishing Company.)

● FIGURE 5-30

Ascending and descending tracts in the white matter of the spinal cord *(continued)*

(b) Cord-to-brain pathways of several ascending tracts (fasciculus cuneatus and ventral spinocerebellar tract).

(c) Brain-to-cord pathways of several descending tracts (lateral corticospinal and ventral corticospinal tracts).

Each horn of the spinal cord gray matter houses a different type of neuronal cell body

+ Cardiac, smooth muscles and exocrine gland

FIGURE 5-31

Regions of the gray matter

Spinal nerves carry both afferent and efferent fibers

- Afferent fibers carrying incoming signals enter the spinal cord throughout the dorsal root, efferent fibers carrying outgoing signals leaves through the ventral root.
- The cell bodies for the afferent neurons at each level are clustered together in a **dorsal root ganglion**.

- A nerve is a bundle of peripheral neuronal axons, some afferent and some efferent, enclosed by a connective tissue covering and following the same pathway.

- A 31 pairs of spinal nerves, along with 12 pairs of cranial nerves that arise from the brain constitute the peripheral nervous system (PNS).

FIGURE 5-32

Structure of a nerve

Diagrammatic view of a nerve, showing neuronal axons (both afferent and efferent fibers) bundled together into connective-tissue–wrapped fascicles. A nerve consists of a group of fascicles enclosed by a connective tissue covering and following the same pathway. The photograph is a scanning electron micrograph of several nerve fascicles in cross section.

- Each segment of the spinal cord gives rise to a pair of spinal nerves that ultimately supply a particular region of the body with both afferent and efferent fibers.
- A particular spinal nerve that supply a specific region of the body surface (a dermatome) may carry fibers that branch off to supply internal organs.

- **Referred pain**:

The pain origination from one of the organs is “referred” to the corresponding dermatome supplied by the same spinal nerve,

e.g. Heart and left shoulder.

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TABLE 5-3 Functions of Cranial Nerves

Number	Name	Fiber Types	Functions
I	Olfactory	Sensory	Smell
II	Optic	Sensory	Vision
III	Oculomotor	Mixed (mainly motor)	Eyeball and eyelid movement, pupil constriction, change of lens shape for near vision.
			Proprioception (awareness of position of body parts)
IV	Trochlear	Mixed (mainly motor)	Eyeball movement
			Proprioception
V	Trigeminal	Mixed	Chewing
			Somatic sensations (touch, pressure, pain, and temperature) of face and mouth
VI	Abducens	Mixed (mainly motor)	Eyeball movement
			Proprioception
VII	Facial	Mixed	Facial expression, secretion of saliva and tears
			Taste from front of tongue
VIII	Vestibulocochlear	Sensory	Hearing, sense of equilibrium
IX	Glossopharyngeal	Mixed	Swallowing, secretion of saliva
			Taste from back of tongue, somatic sensation of oral cavity, blood-pressure monitoring
X	Vagus	Mixed	Efferent output for skeletal muscles of pharynx (throat) and larynx (voice box) and for smooth muscle and glands of thoracic and abdominal organs and for cardiac muscle of heart
			Afferent input from thoracic and abdominal organs, blood-pressure monitoring
XI	Accessory	Motor	Efferent output for skeletal muscles of pharynx, larynx, neck, and shoulder
XII	Hypoglossal	Motor	Tongue movement

Carried by afferent fibers Carried by efferent fibers

The spinal cord is responsible for the integration of many basic reflexes

- The spinal cord function:
  - Link between brain and peripheral nervous system.
  - Spinal reflex.

➢ **Reflex:**

it is any response that occurs automatically without conscious effort.

➢ **Reflex types:**

1. Simple or basic reflex (touching hot objects).
2. Acquired or conditional reflexes (pianist).

➢ **Reflex arc:**

Is the neuronal pathway involved in accomplishing reflex activity, includes:

1) **Receptor.**
2) **Afferent pathway.**
3) **Integrating center.**
4) **Efferent pathway.**
5) **Effector.**

Withdrawal reflex :

FIGURE 5-33
The withdrawal reflex

The spinal cord is responsible for the integration of many basic reflexes

- **Stretch reflex:** (a monosynaps)

  In which an afferent neuron originating at a stretch detecting receptor in a skeletal muscle terminates directly on the efferent neuron supplying the same skeletal muscle to cause it to contract and counteract the stretch.

- **Other reflex activity:**

  The crossed extensor reflex ensures that the opposite limb will be in a position to bear the weight of the body as the injured limb is withdrawn from the stimulus, (Fig 5-34).

- Basic spinal reflexes, also mediate emptying of pelvic organs (e.g. urination, defecation and expulsion of semen).
- All spinal reflexes can be voluntarily over ridden at least temporarily by higher brain centers.

- **Another pathways for unconscious responsiveness digress from the typical reflex arc in two general ways:**

  1. Responses mediated at least in part by hormones.
  2. Local responses that do not involves either nerves or hormones, exercising muscle dilate because of local metabolic changes.

● FIGURE 5-34

The crossed extensor reflex coupled with the withdrawal reflex

(a) The withdrawal reflex, which causes flexion of the injured extremity to withdraw from a painful stimulus. (b) The crossed extensor reflex, which extends the opposite limb to support the full weight of the body.

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