Nervous system

Neurology: is the branch of medical science that deals with the normal functioning disorders of the nervous system.

Nervous system: is the body’s control center and communications network.

In humans, the nervous system serves three broad functions:

1- Sensory functions: it senses changes within the body and in the outside environment.
2- Integrative functions: it interprets the changes.
3- Motor function: it responds to the interpretation by initiating action in the form of muscular contraction or glandular secretion.

❖ The general organization of the nervous system:

1- Structural organization:

References:
Textbook of medical physiology (Guyton)
Textbook of medical physiology (N. Geetha)
## 2- Functional organization:

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<th>Processing</th>
<th>output (motor, efferent)</th>
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<td>brain</td>
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### Nerve tissue

Nerve tissue consists of nerve cells called *neurons* and some specialized cells found only in the nervous system. Neurons are capable of generating and transmitting electrochemical impulses. There are many different kinds of neurons, but they all have the same basic structure. A nerve impulse travels along the cell membrane of a neuron, and is electrical, but where neurons meet there is a small space called a *synapse*, which an electrical impulse cannot cross. At a synapse, between the axon of one neuron and the dendrite or cell body of the next neuron, impulse transmission depends upon chemicals called *neurotransmitters*.

Nerve tissue makes up the brain, spinal cord, and peripheral nerves. As you can imagine, each of these organs has very specific functions. These include feeling and interpreting sensation, initiation of movement, the rapid regulation of body functions such as heart rate and breathing, and the organization of information for learning and memory.
### Cells of nervous system:

Nervous tissues consists of two types of cells:

1. **The neurons** which conduct impulses & make up the impulse conducting protein of the brain, spinal cord, & nerves.

2. The **neurological** cells which perform other functions.

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<td>Neuron(nerve cell)</td>
<td>• Contains the nucleus</td>
<td>• Regulates the functioning of the neuron</td>
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<td>• Cellular process (extension)</td>
<td>• Carries impulses away from the cell body</td>
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<td>• Cellular process (extension)</td>
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<td>Cell body</td>
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<td>Axon</td>
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<td>Form the myelin sheaths around neurons</td>
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References: Text book of medical physiology(Guyton)  
Text book of medical physiology(N Geetha)
Neurons :- consists of a cell body (soma), an axon, & usually several dendrites. In general, the axon conducts impulses away from the cell body; while the dendrites conduct impulses toward the cell body.

- The cell body (sama): contains most of the cytoplasm and many of the organelles usually found in cells (mitochondria, Golgi apparatus, nucleus, & nucleolus). The cell body also contains Nissl granules (a complex of endoplasmic reticulum & ribosomes that serves as the site of protein synthesis for the neuron).

Neurofibrils are found in the cell body near the axon hillock (where the axon joins the cell body).

- The axon: of neuron is a long, thin process extending from the hillock. In most neurons it extends in only one direction from the cell body. Most axons are myelinated (that is they are surrounded by an insulating (عازلة) substance called myelin).

- Dendrites: are shorter processes than axons in most neurons. They connect directly with the cell body. Dendrites are Not myelinated.

- Schwan cells: (sometimes considered a kind of neuroglial cells). are found wrapped around the axons of myelinated neurons of the PNS. Many schwan cells are required to produce a myelin sheath on a single axon. The myelin sheath has numerous small constrictions called node of Ranveir. These nodes represented minute spaces between adjacent schwan cells.
structure of a typical neuron

References: Text book of medical physiology (Guyton)
Text book of medical physiology (N Geetha)
Neurons divided into three types according to the number of processes:

1- **Multipolar neurons**: consist of many dendrites and one axon e.g., pyramidal cells in the motor cerebral cortex.

2- **Bipolar neurons**: consist of one dendrite & one axon e.g., sensory neurons in the retina of the eye.

3- **Unipolar neurons**: consist of one process branched into two branches of opposite directions e.g., cells of sensory ganglia.

Neurons divided into two types according to its shape:

1- **Golgi type I cells**: contain long axon extend to outside CNS.

2- **Golgi type II cells**: contain short axon inside the gray matter of CNS.
● **Neuroglia**: for types of neuroglia are found primarily in the CNS:

1. **Ependymal cells**: form a sheet that lines the ventricles of the brain (spaces that form & circulate cerebrospinal fluid) and the central canal of the spinal cord.

2. **Astrocytes**: Star shaped cells with numerous processes. They are of two types:
   a. **Protoplasmic astrocytes**: are found in the gray matter of the CNS.
   b. **Fibrous astrocytes**: are found in the white matter of the CNS. Its functions in *create a supporting network for neurons & blood vessels*, *help to transport nutrients from blood to neurons*.

3. **Oligodendrocytes**: resemble astrocytes in some ways, but processes are fewer & shorter. It have supporting function by:
   a. **Forming semi-rigid connective tissue rows** between neurons in the brain & spinal cord.
   b. **Produce a phospholipid myelin sheath** around axons of neurons of CNS.

4. **Microglia**: small cells with few processes derived from monocytes (also called brain macrophage). They are thought to protect nerve cells against infection. These cells are phagocytic cells migrate to the site of an injury in the CNS and destroy microorganisms & cellular debris.

● **Nerves and nerve Tracts**: 

**Nerves** contain mostly myelinated & a few unmyelinated axons, surrounded by several C.T. sheaths. Most nerves, except for some cranial nerves (nerves that branch directly from brain), contain both sensory & motor fibers. A connective tissue sheath, (the **endoneurium**), surround each fiber. Another C.T. sheath (the **perineurium**) binds groups of fibers together in to **fascicles**. Yet another C.T. sheath (the **epineurium**) cover the whole nerve (including its several fascicles). Blood & lymph vessels are often located within the C.T. between fascicles of large nerves.

*References: Text book of medical physiology(Guyton) Text book of medical physiology(N Geetha)*
Nerve fibers in **Tracts** of the CNS are mostly myelinated (they acquire their myelin from the activities of oligodendrocytes rather than from schwan cells). The myelin that surrounds the fibers of tracts gives the tracts a whitish color (thus they are recognized as **white matter** of the CNS). Cell bodies and dendrites lack myelin, & these areas are recognized as **gray matter**.

**Ganglia and Nuclei:**

The cell bodies of the fibers of both nerves and tracts are usually aggregated in large groups to the side of the main pathway of the fibers. In the PNS these aggregations are called **ganglia**. Within the CNS they are called **nuclei** (but they are not be confused with cellular nuclei). Each nucleus in the brain consists of many cell bodies, each having its own cellular nuclei.

- Nerve cells is one of the **excitable** cells because of its ability to generate bioelectrical changes in its membranes & propagate this change to other sites of the membrane. This change called the **action potential**.

**Properties of the excitable cells:**

1. **Ion distribution across cell membrane:** there is a higher concentration of $K^+$ & large organic anions & lower concentration of $Na^+$, $Cl^-$, & $Ca^{++}$ in the intracellular fluid of the excitable cells. While the extracellular fluid contain higher concentration of $Na^+$, $Cl^-$, & $Ca^{++}$ and lower concentration of $K^+$.

2. **Membrane potential:** There is a potential differences between the outside & the inside of the cell. The inside is negative when compared to the outside, this is called **resting action potential**.

3. **Membrane permeability:** the cellular membrane is not permeable to proteins & other large organic anions inside the cell, while the membrane is permeable to $Na^+$, $K^+$, $Cl^-$ in different pattern through special ion channels called $Na^+$ channels, $K^+$ channels, $Cl^-$ channels.

**References:** Text book of medical physiology(Guyton)  
Text book of medical physiology(N Geetha)
4- **Action potential production** :- normally, the excitable cells are polarized. When a neuron membrane stimulated by a stimulus, the membrane potential will decreased to come in to depolarized state. This depolarization will reach a critical degree called **firing level** & a complete depolarization will occur rapidly. After that, the potential will return to its original resting membrane potential (called **Repolarization**).

➢ The action potential of a neuron membrane divided in to five phases:
1- Firing level  2- Spike potential 3- after depolarization  4- after hyperpolarization

5- refractory period : The state in which the excitable membrane not respond to any another stimulus during spike potential. Refractory period divided in to two types :

1- **absolute refractory period** : the time between the firing level & the third part of depolarization. During which, the neuron cannot be stimulated with any stimulus.
2- **Relative refractory period**: the time between the absolute refractory period & the onset of the period of after depolarization during which, the strongest stimulus will stimulate the neuron.

- **Excitability**: the ability to respond to a stimulus and initiate & conduct an electrical impulse.

In the living cells potential differences are created by charged particles (ions) in and out the cells. Each cell contains intracellular fluid and is surrounded by extracellular fluid. Both of these fluids contain ions, but the concentrations of the various ions in each of the fluids differ. The concentration of $(\text{Na}^+)$ in extracellular fluids, is about 20 times greater than that in intracellular. The concentration of $(\text{K}^+)$ in intracellular fluids is about 25 times greater than that in extracellular fluid. Intracellular fluids also contain large numbers of negatively charged protein molecules. Differences in the concentrations of charged particles create a potential difference across the cell membrane, and the cell is said to be polarized.

In resting, polarized neurons, the potential differences about $(-70 \text{ mV})$ is called the **resting potential**. Thus, the inside of the membrane is more negative than the outside by $70 \text{ mV}$.

In resting, cell potassium ions tend to diffuse out of the cell more easily than sodium ions diffuse in. Because large protein molecules and negatively charged ions cannot easily diffuse across the cell membrane, the inside of a cell tends to become more negative than the outside. These events created the negative potential differences. Furthermore, as $\text{Na}^+$ leak out of the cell, they are actively transported back in to the cell by the action of **$\text{Na - K}$ pump**.

*References: Text book of medical physiology(Guyton)*
*Text book of medical physiology(N Geetha)*
Initiation & conduction of nerve impulses:

The property of excitability: means 1- the ability of the neurons respond to a stimulus & to conduct an impulse 2- make it possible for the NS to receive information & use it to regulate function.

✓ The processes of initiation and conduction of an impulse along a neuron occur as follows:-

1- When a neuron is stimulated, the movement of ions across its membrane creates a change in the potential differences.

2- When a resting neuron is stimulated, a small number of Na\(^+\) move in to the cell, creating an action potential, which moves along the membrane as an impulse.

3- Following a wave of depolarization is a wave of repolarization, which prepares the neuron to receive another stimulus.

✓ Factors that affect the generation & conduction of an impulse include:

1- Strength of stimulus
2- Summation
3- The all-or-none principle
4- Refractoriness
5- Myelination
6- Axon diameter.

References: Text book of medical physiology(Guyton)
Text book of medical physiology(N Geetha)
**Autonomic nervous system (ANS):**

The **ANS** (in association with the endocrine system) is primarily responsible for maintaining a nearly constant internal environment of the body, regardless of the changes that take place in the external environment. This is done by regulation of the activities of smooth muscle, cardiac muscle, and certain glands.

The ANS itself is a system of efferent motor nerves. However, afferent, sensory fibers from several different sources stimulate the ANS. Impulses from sense organs are relayed to the centers in the spinal cord, brainstem, and the hypothalamus where impulses are relayed again to autonomic neurons. In addition, the cerebral cortex itself can stimulate autonomic activity by exciting one of these centers. Sensory information from the internal organs travels along the vagus nerve and some afferent fibers of the spinal nerves to centers in the brain that initiate autonomic activity. These stimuli from the organs themselves constitute a kind of feedback in which information about the level of function of an organ is used to adjust its functional level.

**All autonomic neural pathways are composed of two neurons:**

1. **A preganglionic neuron**
2. **A postganglionic neuron**

   Impulses from the preganglionic neuron are transmitted by way of acetylcholine across a synapse in a ganglion to the postganglionic neuron.

   Preganglionic neurons are myelinated; postganglionic neurons are unmyelinated.
The properties of the ANS are distinctly different from those of the somatic NS as summated bellow:

<table>
<thead>
<tr>
<th>Somatic</th>
<th>Autonomic</th>
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<tbody>
<tr>
<td>1- Innervate Sk. M.</td>
<td>1- Innervate smooth M. &amp; cardiac m.</td>
</tr>
<tr>
<td>2- Efferent axons synapse directly on effectors</td>
<td>2- Efferent axons synapse in ganglia</td>
</tr>
<tr>
<td>3- Innervations are always excitatory</td>
<td>3- Innervations may be excitatory or inhibitory.</td>
</tr>
<tr>
<td>4- Transmitter is acetylcholine</td>
<td>4- Transmitter is acetylcholine or nor-epinephrine.</td>
</tr>
<tr>
<td>5- Motor impulse leads to voluntary activity.</td>
<td>5- Motor impulse leads to involuntary activity.</td>
</tr>
</tbody>
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The ANS is divided into two parts:

1- The **sympathetic** division which originate in the thoracolumbar region of the spinal cord.

2- The **parasympathetic** division which originate in the medulla, Pons, the midbrain, & the sacral regions of the spinal cord.

Thus, these parts of the ANS are sometimes referred to as the thoracolumbar & the craniosacral divisions respectively.

Fibers from each of the divisions of the ANS supply nearly every one of the visceral organs.
sympathetic division:
The sympathetic division consist of:

1- **ganglia** located in a paravertebral chain in the thoracolumbar region.

2- **preganglionic** fibers that extend from the lateral horns of the thoracolumbar region of the spinal cord to the ganglia.

3- **postganglionic** fibers that extend from the ganglia to the organ being served.
The sympathetic division functions are:

1- interacts with the parasympathetic nervous system to regulate the functioning of internal organs.
   a- ↑ heart rate & respiratory rate.
   b- Dilate bronchioles (small air passage in the lung).
   c- Stimulate sweating.
   d- ↑ the glucose level in the blood.
   e- ↓ the activities of the digestive tract.

2- prepares the body to meet emergencies or stressful situations.

3- is augmented by the action of adrenal medulla.

❖ **parasympathetic division**:

consist of:

1- **ganglia** located in or near the organs they serve.

2- **preganglionic** fibers that extend from the nuclei of cranial nerves or the sacral portion of the spinal cord to the ganglia.

3- **postganglionic** fibers that extend from the ganglia to the organ being served.

functions:

1- interacts with the sympathetic division to regulate the functioning of internal organs.
   a- ↓ heart rate & respiratory rate.
   b- ↑ the activities of the digestive tract.
   c- Stimulate the storage of glucose in the liver.

2- return the body to normal functional levels after an emergency or stressful situation.

References: Text book of medical physiology (Guyton)
Text book of medical physiology (N Geetha)
relationship between sympathetic & parasympathetic divisions:

Or how the sympathetic & parasympathetic divisions work together to maintain homeostasis.

1- both systems act continuously, resulting in sympathetic tone & parasympathetic tone.
2- under normal circumstance these systems work together to make small changes in functional levels of the internal organs.
3- the actions of the sympathetic & the parasympathetic divisions are generally antagonistic (if one augments a function, the other usually diminishes it, and vice versa).
4- during emergencies & stressful situations the sympathetic division prepares the body to meet the stress, & the parasympathetic division helps the body return to normal functional levels after the stressful situation is over.

Neurotransmitters

Neurons of the ANS synthesize & secrete neurotransmitters just as other neurons do. And like other transmitters these must be inactivated to prevent continuous stimulation and to allow repolarization of the postsynaptic neurons.

The different functions of the sympathetic & parasympathetic divisions of the ANS are determined by * the particular neurotransmitter released & * how that transmitter interact with the receptor it reaches.

When acetylcholine is released by cholinergic neurons, its effects are determined by the nature of the receptor with which it interact. Two types of receptors exist:
1- **Nicotinic** receptors (so named because *nicotine* mimics the action of acetylcholine at such receptors).

2- **muscarine** receptors (so named because *muscarine* mimics the action of acetylcholine at these receptors).

(the action of acetylcholine at such receptors are said to be *nicotinic* or *muscarine* actions, respectively).

- **Nicotinic** receptors are found on the both sympathetic & parasympathetic postganglionic neurons. The result of the interaction of acetylcholine with the nicotinic receptors depends on the concentration of acetylcholine (small amounts stimulate & large amount block transmission).

- **Muscarine** receptors are found on organs innervated by postganglionic parasympathetic neurons (the heart, smooth m. & sweat glands). The result of the interaction of acetylcholine with muscarine receptors is muscle contraction and sweat secretion.

When norepinephrine (NE) is released by adrenergic neurons, its effect are similarly determined by the nature of the receptor with which it interacts. However, the action of the NE is augmented by the release of both NE & epinephrine (ep) from the adrenal medulla (are organ associated with, but not part of, the sympathetic division). When the adrenal medulla is stimulated, it releases both of the hormones (ep. & NE) into the blood stream (the amount of ep. is 4 times more than the amount of NE).

**Note**: compared with the rapid action of NE released by an axon directly into a tissue, ep. & NE released into the blood stream are slower to act. However, their actions are more sustained because they circulate in the blood & stimulate the organs for several minutes before they are destroyed by the liver.
Organs that respond to ep. or NE (either via the blood or via sympathetic postganglionic neurons) have one or both of two kinds of receptors:

1- **Alpha** receptors  
2- **Beta** receptors

- Epinephrine stimulates both alpha & beta receptors.
- NE stimulate alpha receptors to a greater extent than beta receptors.
- The effect of either of these transmitters on an organ depends on the quality of & sensitivity of each type of receptor found in the organ.
- The effects of stimulating **alpha** receptors include vasoconstriction, relaxation of the intestinal smooth m., dilation of the iris of the eye.
- The effects of stimulating **Beta** receptors include vasodilatation, acceleration of the heart rate & strengthening of its contraction, bronchodilation & relaxation of the intestinal smooth m.
Sensory Part of the Nervous System—Sensory Receptors:

Most activities of the nervous system are initiated by sensory experience exciting sensory receptors, whether visual receptors in the eyes, auditory receptors in the ears, tactile receptors on the surface of the body, or other kinds of receptors.

This sensory experience can either cause immediate reaction from the brain, or memory of the experience can be stored in the brain for minutes, weeks, or years and determine bodily reactions at some future date.

The somatic portion of the sensory system, which transmits sensory information from the receptors of the entire body surface and from some deep structures. This information enters the central nervous system through peripheral nerves and is conducted immediately to multiple sensory areas in (1) the spinal cord at all levels; (2) the reticular substance of the medulla, pons, & mesencephalon of the brain; (3) the cerebellum; (4) the thalamus; and (5) areas of the cerebral cortex.

Sensory Pathways for Transmitting Somatic Signals into the Central Nervous System:

Almost all sensory information from the somatic segments of the body enters the spinal cord through the dorsal roots of the spinal nerves. However, from the entry point into the cord and then to the brain, the sensory signals are carried through one of two alternative sensory pathways: (1) the dorsal column–medial lemniscal system or (2) the antero-lateral system. These two systems come back together partially at the level of the thalamus.

The dorsal column–medial lemniscal system, as its name implies, carries signals upward to the medulla of the brain mainly in the dorsal columns of the cord. Then, after the signals synapse and cross to the opposite side in the medulla, they continue upward through the brain stem to the thalamus by way of the medial
lemniscus. Conversely, signals in the anterolateral system, immediately after entering the spinal cord from the dorsal spinal nerve roots, synapse in the dorsal horns of the spinal gray matter, then cross to the opposite side of the cord and ascend through the anterior and lateral white columns of the cord. They terminate at all levels of the lower brain stem and in the thalamus.

The dorsal column–medial lemniscal system is composed of large, myelinated nerve fibers that transmit signals to the brain at velocities of 30 to 110 m/sec, whereas the anterolateral system is composed of smaller myelinated fibers that transmit signals at velocities ranging from a few meters per second up to 40 m/sec.

Another difference between the two systems is that the dorsal column–medial lemniscal system has a high degree of spatial orientation of the nerve fibers with respect to their origin, while the anterolateral system has much less spatial orientation. These differences immediately characterize the types of sensory information that can be transmitted by the two systems. That is, sensory information that must be transmitted rapidly and with temporal and is transmitted mainly in the dorsal column–medial lemniscal system; that which does not need to be transmitted rapidly is transmitted mainly in the anterolateral system.

The anterolateral system has a special capability that the dorsal system does not have: the ability to transmit a broad spectrum of sensory modalities— pain, warmth, cold, and crude tactile sensations.

The dorsal system is limited to discrete types of Mechano-receptive sensations.
With this differentiation in mind, we can now list the types of sensations transmitted in the two systems:

- **Dorsal Column–Medial Lemniscal System:**
  1. Touch sensations requiring a high degree of localization of the stimulus
  2. Touch sensations requiring transmission of fine gradations of intensity
  3. Phasic sensations, such as vibratory sensations
  4. Sensations that signal movement against the skin
  5. Position sensations from the joints
  6. Pressure sensations having to do with fine degrees of judgment of pressure intensity

- **Anterolateral System**
  1. Pain
  2. Thermal sensations, including both warmth and cold sensations
  3. Crude touch and pressure sensations capable only of crude localizing ability on the surface of the body
  4. Tickle and itch sensations
  5. Sexual sensations
Pain:

Pain is a *Protective* Mechanism. Pain occurs whenever any tissues are being damaged, and it causes the individual to react to remove the pain stimulus. Even simple activities as sitting for a long time on the Ischia can cause tissue destruction because of lack of blood flow to the skin where it is compressed by the weight of the body. When the skin becomes painful as a result of the ischemia, the person normally shifts weight subconsciously. But a person who has lost the pain sense, as after spinal cord injury, fails to feel the pain and, therefore, fails to shift. This soon results in total breakdown and desquamation of the skin at the areas of pressure.

**Types of Pain and Their Qualities:**

Pain has been classified into two major types: *fast* pain and *slow* pain. Fast pain is felt within about 0.1 second after a pain stimulus is applied, whereas slow pain begins only after 1 second or more and then increases slowly over many seconds and sometimes even minutes. Fast pain is also described by many alternative names, such as *sharp* قاطع pain, *pricking* حاد pain, *acute* مغة pain, and *electric* خفيف pain. This type of pain is felt when a needle is stuck into the skin, when the skin is cut with a knife, or when the skin is acutely burned. It is also felt when the skin is subjected to electric shock. Fast-sharp pain is not felt in most deeper tissues of the body.

Slow pain also goes by many names, such as slow burning pain, aching متواصل خفيف pain, *throbbing* نبضي pain, *nauseous* مغثث pain, and *chronic* خفيف pain. This type of pain is usually associated with tissue destruction. It can lead to prolonged, unbearable suffering. It can occur both in the skin and in almost any deep tissue or organ.
Three Types of Stimuli Excite Pain Receptors

Pain can be elicited by multiple types of stimuli. They are classified as:

1. Mechanical,
2. Thermal,
3. Chemical.

In general, fast pain is elicited by the mechanical and thermal types of stimuli, whereas slow pain can be elicited by all three types.

Some of the chemicals that excite the chemical type of pain are bradykinin, serotonin, histamine, potassium ions, acids, acetylcholine, and proteolytic enzymes. The chemical substances are especially important in stimulating the slow, suffering type of pain that occurs after tissue injury.

Pain Suppression (Analgesia) System in the Brain and Spinal Cord

The degree to which a person reacts to pain varies greatly. This results partly from a capability of the brain itself to suppress input of pain signals to the nervous system by activating a pain control system, called an analgesia system.

Several transmitter substances are involved in the analgesia system; especially involved are enkephalin and serotonin. Thus, the analgesia system can block pain signals at the initial entry point to the spinal cord. In fact, it can also block many local cord reflexes that result from pain signals.

Referred Pain

Often a person feels pain in a part of the body that is fairly remote from the tissue causing the pain. This is called referred pain. For instance, pain in one of the visceral organs often is referred to an area on the body surface. Knowledge of the different types of referred pain is important in clinical diagnosis because in many visceral ailments the only clinical sign is referred pain.
Mechanism of Referred Pain. the probable mechanism by which most pain is referred. When the visceral pain fibers are stimulated, pain signals from the viscera are conducted through at least some of the same neurons that conduct pain signals from the skin, and the person has the feeling that the sensations originate in the skin itself.

Visceral Pain: In clinical diagnosis, pain from the different viscera of the abdomen and chest is one of the few criteria that can be used for diagnosing visceral inflammation, visceral infectious disease, and other visceral ailments.

Often, the viscera have sensory receptors for no other modalities of sensation besides pain. Also, visceral pain differs from surface pain in several important aspects. One of the most important differences between surface pain and visceral pain is that highly localized types of damage to the viscera seldom cause severe pain. For instance, a surgeon can cut the gut entirely in two in a patient who is awake without causing significant pain. Conversely, any stimulus that causes diffuse stimulation of pain nerve endings throughout a viscus causes pain that can be severe.
Motor Part of the Nervous System—Effectors:

The most important eventual role of the nervous system is to control the various bodily activities. This is achieved by controlling:

1. contraction of appropriate skeletal muscles throughout the body
2. contraction of smooth muscle in the internal organs
3. secretion of active chemical substances by both exocrine and endocrine glands in many parts of the body.

These activities are collectively called motor functions of the nervous system, and the muscles and glands are called effectors because they are the actual anatomical structures that perform the functions dictated by the nerve signals.

Operating parallel to this axis is another system, called the autonomic nervous system, for controlling smooth muscles, glands, and other internal bodily systems.

The skeletal muscles can be controlled from many levels of the central nervous system, including (1) the spinal cord; (2) the reticular substance of the medulla, pons, and mesencephalon; (3) the basal ganglia; (4) the cerebellum; and (5) the motor cortex. Each of these areas plays its own specific role, the lower regions concerned primarily with automatic, instantaneous muscle responses to sensory stimuli, and the higher regions with deliberate complex muscle movements controlled by the thought processes of the brain.
Organization of the Spinal Cord for Motor Functions

The cord gray matter is the integrative area for the cord reflexes. Sensory signals enter the cord almost entirely through the sensory (posterior) roots. After entering the cord, every sensory signal travels to two separate destinations:

1. One branch of the sensory nerve terminates almost immediately in the gray matter of the cord and elicits local segmental cord reflexes and other local effects.

2. Another branch transmits signals to higher levels of the nervous system—to higher levels in the cord itself, to the brain stem, or even to the cerebral cortex.

Autonomic Reflexes in the Spinal Cord

Many types of segmental autonomic reflexes are integrated in the spinal cord. Briefly, these include:

1. Changes in vascular tone resulting from changes in local skin heat
2. Sweating, which results from localized heat on the surface of the body
3. Intestinointestinal reflexes that control some motor functions of the gut
4. Peritoneointestinal reflexes that inhibit gastrointestinal motility in response to peritoneal irritation
5. Evacuation reflexes for emptying the full bladder or the colon.

In addition, all the segmental reflexes can at times be elicited simultaneously in the form of the so-called mass reflex,

Mass Reflex. In a spinal animal or human being, sometimes the spinal cord suddenly becomes excessively active, causing massive discharge in large portions of the cord. The usual stimulus that causes this is a strong pain stimulus to the skin or excessive filling of a viscus, such as over distention of the bladder or the gut. Regardless of the type of stimulus, the resulting reflex, called the mass reflex, involves large portions or even all of the cord.
The effects are (1) a major portion of the body’s skeletal muscles goes into strong flexor spasm; (2) the colon and bladder are likely to evacuate; (3) the arterial pressure often rises to maximal values, sometimes to a systolic pressure well over 200 mm Hg; and (4) large areas of the body break out into profuse sweating. Because the mass reflex can last for minutes, it presumably results from activation of great numbers of reverberating circuits that excite large areas of the cord at once. This is similar to the mechanism of epileptic seizures, which involve reverberating circuits that occur in the brain instead of in the cord.
The “skeletal” motor nerve axis of the nervous system for controlling skeletal muscle contraction.
A.L. Wafa’a sameer
2014
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