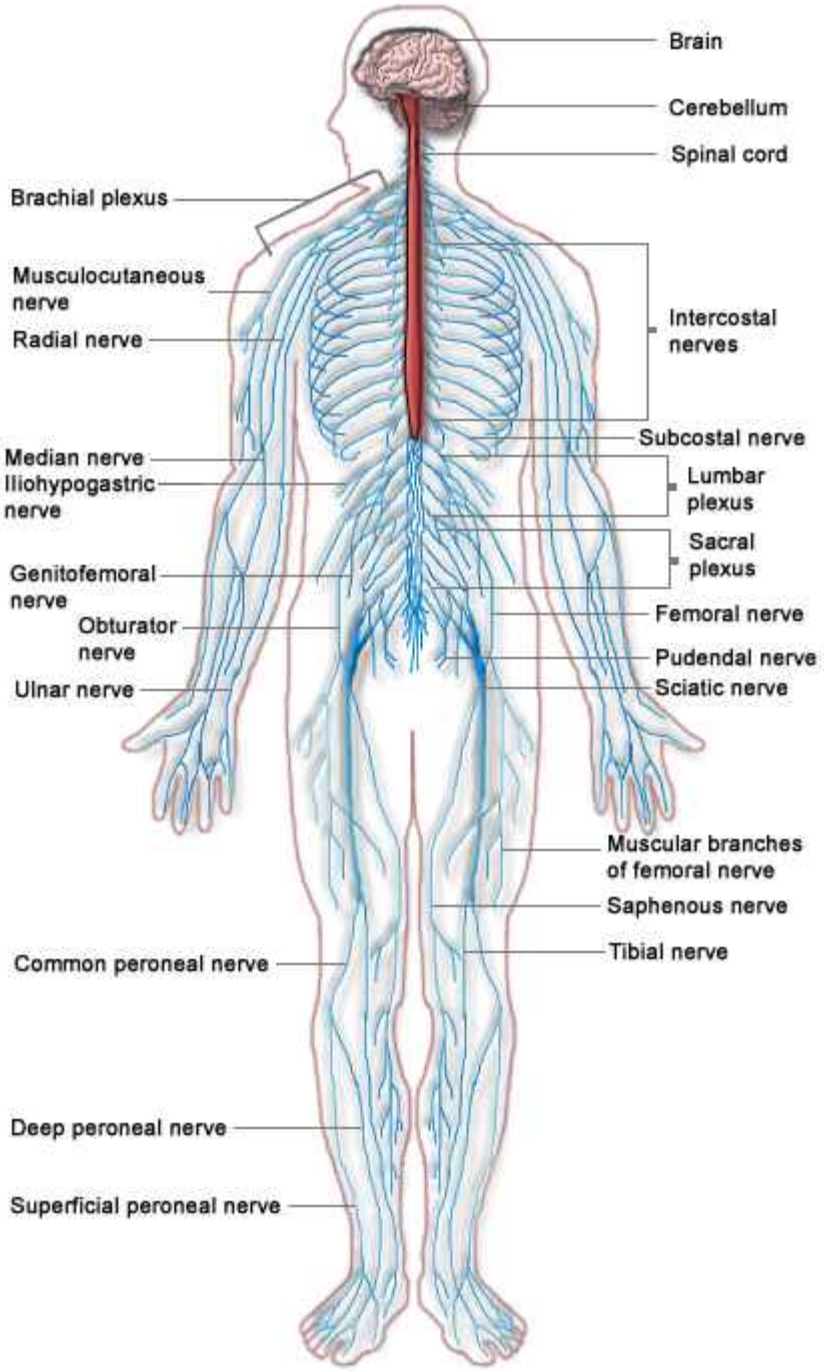
4 The Nervous System

live version • discussion • edit lesson • comment • report an error

The **central nervous system** includes the **brain** and **spinal cord**. The brain and spinal cord are protected by bony structures, membranes, and fluid. The brain is held in the cranial cavity of the skull and it consists of the **cerebrum**, **cerebellum**, and the **brain stem**. The nerves involved are cranial nerves and spinal nerves.



Overview of the entire nervous system

The nervous system has three main functions, sensory input, integration of data and motor output. Sensory input is when the body gathers information or data, by way of neurons, glia and synapses. The nervous system is composed of excitable nerve cells and synapses connecting the cells to one another, to centers throughout the body or to other neurons. These neurons operate on excitation or inhibition and although nerve cells can vary in size and location their communication with one another determines their function. These nerves conduct impulses from sensory receptors to the brain and spinal cord. The data is then processed by way of integration of data, which occurs only in the brain. After the brain has processed the information, impulses are then conducted from the brain and spinal cord to muscles and glands, which is called motor output. Glia cells are found within tissues and are not excitable but help with myelination, ionic regulation and extracellular fluid.

The nervous system is comprised of two major parts, or subdivisions, the central nervous system(CNS) and the peripheral nervous system(PNS). The CNS includes the brain and spinal cord. The brain is the body's "control center". The CNS has various centers located within it that carry out the sensory, motor and intergration of data. These centers can be subdivided to Lower Centers (including the spinal cord and brain stem) and Higher centers communicating with the brain via effectors. The PNS is a vast network of spinal and cranial nerves that are linked to the brain and the spinal cord. It contains sensory receptors which help in processing changes in the internal and external environment. This information is sent to the CNS via afferent sensory nerves. The PNS is then subdivided into the autonomic nervous system and the somatic nervous system. The autonomic has involuntary control of internal organs, blood vessels, smooth and cardiac muscles. The somatic has voluntary control of skin, bones, joints, and skeletal muscle. The two systems function together, by way of nerves from the PNS entering and becoming part of the CNS, and vice versa.

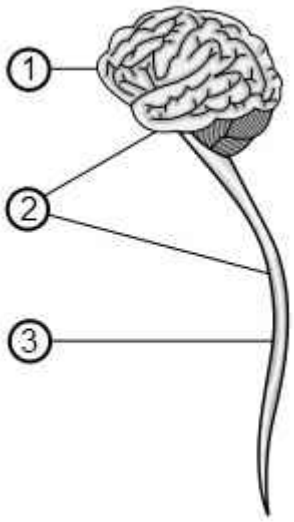
General functions of the CNS

The central nervous system (CNS) represents the largest part of the nervous system, including the brain and the spinal cord. Together, with the peripheral nervous system (PNS), it has a fundamental role in the control of behavior.

CNS:
The "Central Nervous System", comprised of brain, brainstem, and spinal cord.

The CNS is conceived as a system devoted to information processing, where an appropriate motor output is computed as a response to a sensory input. Many threads of research suggest that motor activity exists well before the maturation of the sensory systems, and senses only influence behavior without dictating it. This has brought the conception of the CNS as an autonomous system.

Structure and function of neurons



Brain, brain stem, and spinal chord.

Structure

Neurons are highly specialized for the processing and transmission of cellular signals. Given the diversity of functions performed by neurons in different parts of the nervous system, there is, as expected, a wide variety in the shape, size, and electrochemical properties of neurons. For instance, the soma of a neuron can vary in size from 4 to 100 micrometers in diameter.[1]

The soma (cell body) is the central part of the neuron. It contains the nucleus of the cell, and therefore is where most protein synthesis occurs. The nucleus ranges from 3 to 18 micrometers in diameter.[2] The dendrites of a neuron are cellular extensions with many branches, and metaphorically this overall shape and structure is referred to as a dendritic tree. This is where the majority of input to the neuron occurs. However, information outflow (i.e. from dendrites to other neurons) can also occur (except in chemical synapse in which backflow of impulse is inhibited by the fact that axon do not possess chemoreceptors and dendrites cannot secrete neurotransmitter chemical). This explains one way conduction of nerve impulse. The axon is a finer, cable-like projection which can extend tens, hundreds, or even tens of thousands of times the diameter of the soma in length. The axon carries nerve signals away from the soma (and also carry some types of information back to it). Many neurons have only one axon, but this axon may - and usually will - undergo extensive branching, enabling communication with many target cells. The part of the axon where it emerges from the soma is called the 'axon hillock'. Besides being an anatomical structure, the axon hillock is also the part of the neuron that has the greatest density of voltage-dependent sodium channels. This makes it the most easily-excited part of the neuron and the spike initiation zone for the axon: in neurological terms it has the greatest hyperpolarized action potential threshold. While the axon and axon hillock are generally involved in information outflow, this region can also receive input from other neurons as well. The axon terminal is a specialized structure at the end of the axon that is used to release neurotransmitter chemicals and communicate with target neurons. Although the canonical view of the neuron attributes dedicated functions to its various anatomical components, dendrites and axons often act in ways contrary to their so-called main function.

Axons and dendrites in the central nervous system are typically only about a micrometer thick, while some in the peripheral nervous system are much thicker. The soma is usually about 10–25 micrometers in diameter and often is not much larger than the cell nucleus it contains. The longest axon of a human motor neuron can be over a meter long, reaching from the base of the spine to the toes. Sensory neurons have axons that run from the toes to the dorsal columns, over 1.5 meters in adults. Giraffes have single axons several meters in length running along the entire length of their necks. Much of what is known about axonal function comes from studying the squids giant axon, an ideal experimental preparation because of its relatively immense size (0.5–1 millimeters thick, several centimeters long).

Function

Sensory afferent neurons convey information from tissues and organs into the central nervous

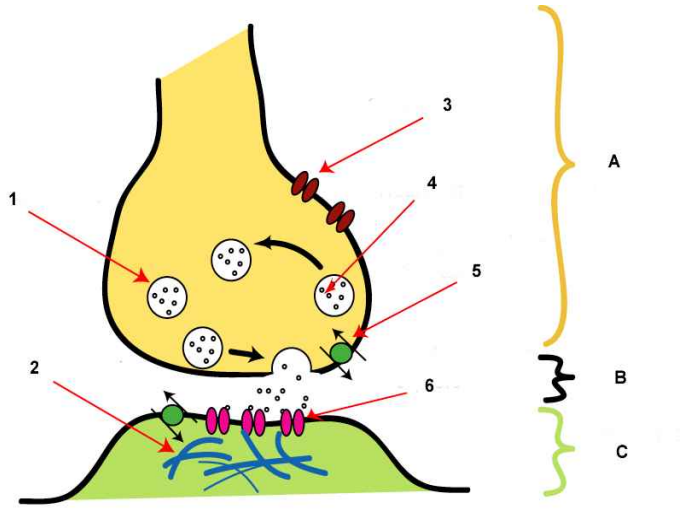
system. Efferent neurons transmit signals from the central nervous system to the effector cells and are sometimes called motor neurons. Interneurons connect neurons within specific regions of the central nervous system. Afferent and efferent can also refer generally to neurons which, respectively, bring information to or send information from brain region.

Classification by action on other neurons

Excitatory neurons excite their target postsynaptic neurons or target cells causing it to function. Motor neurons and somatic neurons are all excitatory neurons. Excitatory neurons in the brain are often glutamatergic. Spinal motor neurons, which synapse on muscle cells, use acetylcholine as their neurotransmitter. Inhibitory neurons inhibit their target neurons. Inhibitory neurons are also known as short axon neurons, interneurons or microneurons. The output of some brain structures (neostriatum, globus pallidus, cerebellum) are inhibitory. The primary inhibitory neurotransmitters are GABA and glycine. Modulatory neurons evoke more complex effects termed neuromodulation. These neurons use such neurotransmitters as dopamine, acetylcholine, serotonin and others. Each synapses can receive both excitatory and inhibitory signals and the outcome is determined by the adding up of summation.

Excitatory and inhibitory process

The release of a excitatory neurotransmitter (ACHe) at the synapses will cause an inflow of positively charged sodium ions (Na+) making a localized depolarization of the membrane. The current then flows to the resting (polarized) segment of the axon.



Nerve Synapse

Inhibitory synapse causes an inflow of Cl- (chlorine) or K+ (potassium) making the synaptic membrane hyperpolarized. This increase prevents depolarization, causing a decrease in the possibility of an axon discharge. If they are both equal to their charges, then the operation will cancel itself out. There are two types of summation: spatial and temporal. Spatial summation requires several excitatory synapses (firing several times) to add up,thus causing an axon discharge. It also occurs within inhibitory synapses, where just the opposite will occur. In temporal summation, it causes an increase of the frequency at the same synapses until it is large enough to cause a discharge. Spatial and temporal summation can occur at the same time as well.

Summation

When excitatory synapses exceed the amount of inhibitory synapses there are, then the excitatory synapses will prevail over the other. The same goes with inhibitory synapses, if there are more

inhibitory synapses than excitatory, the synapses will be inhibited. To determine all of this is called summation.

Classification by discharge patterns:

Neurons can be classified according to their electrophysiological characteristics (note that a single action potential is not enough to move a large muscle, and instead will cause a twitch).

Tonic or regular spiking: Some neurons are typically constantly (or tonically) active. Example: interneurons in neurostriatum.

Phasic or bursting: Neurons that fire in bursts are called phasic.

Fast spiking: Some neurons are notable for their fast firing rates. For example, some types of cortical inhibitory interneurons, cells in globus pallidus.

Thin-spike: Action potentials of some neurons are more narrow compared to the others. For example, interneurons in prefrontal cortex are thin-spike neurons.

Classification by neurotransmitter released:

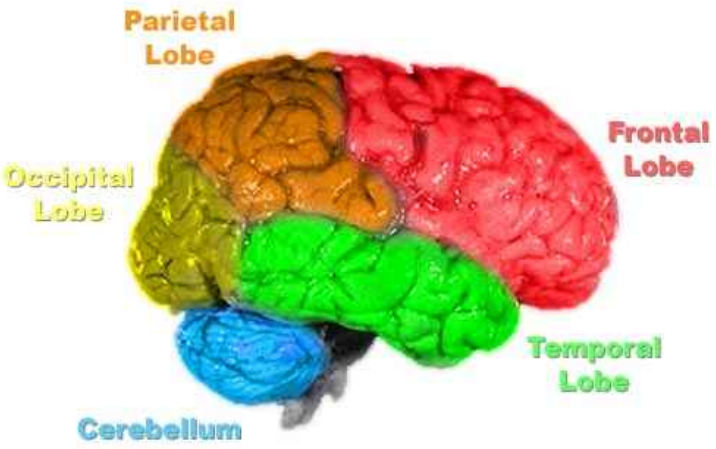
Some examples are cholinergic, GABAergic, glutamatergic and dopaminergic neurons.

Central Nervous System

The central nervous system is the control center for the body. It regulates organ function, higher thought, and movement of the body. The central nervous system consists of the brain and spinal cord.

Brain

The brain is found in the cranial cavity. Within it are found the higher nerve centers responsible for coordinating the sensory and motor systems of the body (forebrain). The brain stem houses the lower nerve centers (consisting of midbrain, pons, and medulla),



A color-coated image of the brain, showing the main sections.

Medulla

The medulla is the control center for respiratory, cardiovascular and digestive functions.

Pons

The pons houses the control centers for respiration and inhibitory functions. Here it will interact with the cerebellum.

Cerebrum

The cerebrum, or top portion of the brain, is divided by a deep crevice, called the longitudinal sulcus. The longitudinal sulcus separates the cerebrum in to the right and left hemispheres. In the hemispheres you will find the cerebral cortex, basal ganglia and the limbic system. The two hemispheres are connected by a bundle of nerve fibers called the corpus callosum. The right hemisphere is responsible for the left side of the body while the opposite is true of the left hemisphere. Each of the two hemispheres are divided into four separated lobes: the frontal in control of specialized motor control, learning,planning and speech; parietal in control of somatic sensory functions; occipital in control of vision; and temporal lobes which consists of hearing centers and some speech. Located deep to the temporal lobe of the cerebrum is the insula.

Cerebellum

The cerebellum is the part of the brain that is located posterior to the medulla oblongata and pons. It coordinates skeletal muscles to produce smooth, graceful motions. The cerebellum receives information from our eyes, ears, muscles, and joints about what position our body is currently in. It also receives output from the cerebral cortex about where these parts should be. After processing this information, the cerebellum sends motor impulses from the brainstem to the skeletal muscles. The main function of the cerebellum is coordination. The cerebellum is also responsible for balance and posture. It also assists us when we are learning a new motor skill, such as playing a sport or musical instrument.

The Limbic System and Higher Mental Functions

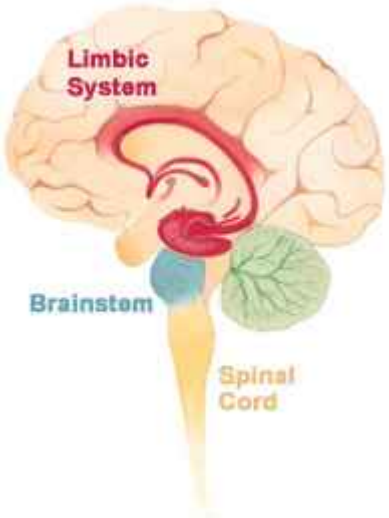


Image of the brain, showing the Limbic system.

The Limbic System

The Limbic System is a complex set of structures found just beneath the cerebrum and on both sides of the thalamus. It combines higher mental functions, and primitive emotion, into one system. It is often referred to as the emotional nervous system. It is not only responsible for our emotional lives, but also our higher mental functions, such as learning and formation of memories. The Limbic system explains why some things seem so pleasurable to us, such as eating and why some medical conditions are caused by mental stress, such as high blood pressure. There are two significant structures within the limbic system and several smaller structures that are important as well. They are:

1. The Hippocampus
2. The Amygdala
3. The Thalamus
4. The Hypothalamus
5. The Fornix and Parahippocampus
6. The Cingulate Gyrus

Structures of the Limbic System

Hippocampus

The Hippocampus is found deep in the temporal lobe, shaped like a seahorse. It consists of two horns that curve back from the amygdala. It is situated in the brain so as to make the prefrontal area aware of our past experiences stored in that area. The prefrontal area of the brain consults this structure to use memories to modify our behavior. The hippocampus is responsible for memory.

Amygdala

The Amygdala is a little almond shaped structure, deep inside the anteroinferior region of the temporal lobe, connects with the hippocampus, the septi nuclei, the prefrontal area and the medial dorsal nucleus of the thalamus. These connections make it possible for the amigdala to play its important role on the mediation and control of such activities and feelings as love, friendship, affection, and expression of mood. The amygdala is the center for identification of danger and is fundamental for self preservation. The amygdala is the nucleus responsible for fear.

Thalamus

Lesions or stimulation of the medial, dorsal, and anterior nuclei of the thalamus are associated with changes in emotional reactivity. However, the importance of these nuclei on the regulation of emotional behavior is not due to the thalamus itself, but to the connections of these nuclei with other limbic system structures. The medial dorsal nucleus makes connections with cortical zones of the prefrontal area and with the hypothalamus. The anterior nuclei connect with the mamillary bodies and through them, via fornix, with the hippocampus and the cingulated gyrus, thus taking

part in what is known as the Papez's circuit.

Case Study

Central Pain Syndrome

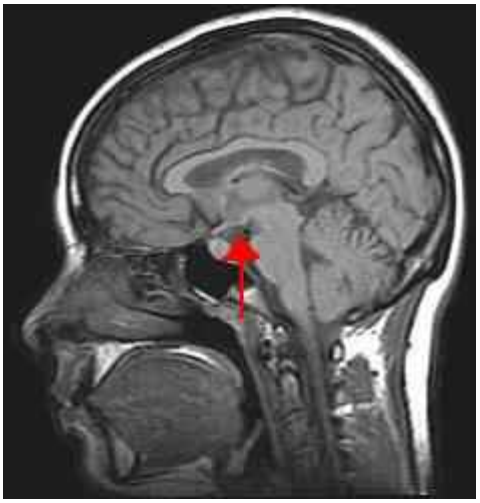


Image of the brain showing the location of the hypothalamus.

I was 42 years old when my life changed forever. I had a stroke. As an avid viewer of medical programs on television I assumed that I would have physical therapy for my paralyzed left side and get on with my life. No one ever mentioned pain or the possibility of pain, as a result of the stroke. I did experience unusual sensitivity to touch while still in the hospital, but nothing to prepare me for what was to come.

The part of my brain that is damaged is the Thalamus. This turns out to be the pain center and what I have now is an out of control Thalamus, resulting in Thalamic Pain syndrome, also called Central Pain Syndrome. This means that 24 hours a day, seven days a week, my brain sends messages of pain and it never goes away. I am under the care of physicians, who not only understand chronic pain, but are also willing to treat it with whatever medications offer some help. None of the medications, not even narcotic medications, take the pain away. They just allow me to manage it so I can function.

Hypothalamus

The Hypothalamus is a small part of the brain located just below the thalamus on both sides of the third ventricle. Lesions of the hypothalamus interfere with several vegetative functions and some so called motivated behaviors like sexuality, combativeness, and hunger. The hypothalamus also plays a role in emotion. Specifically, the lateral parts seem to be involved with pleasure and rage, while the medial part is linked to aversion, displeasure, and a tendency to uncontrollable and loud laughing. However, in general the hypothalamus has more to do with the expression of emotions. When the physical symptoms of emotion appear, the threat they pose returns, via the hypothalamus, to the limbic centers and then the prefrontal nuclei, increasing anxiety.

The Fornix and Parahippocampal

These small structures are important connecting pathways for the limbic system.

The Cingulate Gyrus

The Cingulate Gyrus is located in the medial side of the brain between the cingulated sulcus and the corpus callosum. There is still much to be learned about this gyrus, but it is already known that its frontal part coordinates smells and sights, with pleasant memories of previous emotions. The region participates in the emotional reaction to pain and in the regulation of aggressive behavior.

Memory and Learning

Memory is defined as : The mental faculty of retaining and recalling past experiences, the act or instance of remembering recollection. Learning takes place when we retain and utilize past memories.

There are three basic types of memory:

1. Sensory Memory
2. Short Term Memory
3. Long Term Memory

Sensory Memory

The sensory memories act as a buffer for stimuli through senses. A sensory memory retains an exact copy of what is seen or heard: *iconic memory for visual, echoic memory for aural and haptic memory for touch.* Information is passed from sensory memory into short term memory. Some believe it lasts only 300 milliseconds, it has unlimited capacity. Selective attention determines what information moves from sensory memory to short term memory.

Short Term Memory

Short Term Memory acts as a scratch pad for temporary recall of the information under process. For instance, in order to understand this sentence you need to hold in your mind the beginning of the sentence as you read the rest. Short term memory decays rapidly and also has a limited capacity. Chunking of information can lead to an increase in the short term memory capacity, this is the reason why a hyphenated phone number is easier to remember than a single long number. The successful formation of a chunk is known as *closure.* Interference often causes disturbance in short term memory retention. This accounts for the desire to complete a task held in short term memory as soon as possible.

Within short term memory there are three basic operations:

1. Iconic memory - the ability to hold visual images
2. Acoustic memory - the ability to hold sounds. Can be held longer than iconic.
3. Working memory - an active process to keep it until it is put to use. Note that the goal is not really to move the information from short term memory to long term memory, but merely to put it to immediate use.

The process of transferring information from short term to long term memory involves the encoding or consolidation of information. This is not a function of time, that is, the longer the memory stays in the short term the more likely it is to be placed in the long term memory. On organizing complex information in short term before it can be encoded into the long term memory, in this process the meaningfulness or emotional content of an item may play a greater role in its retention in the long term memory. The limbic system sets up local reverberating circuits such as the Papaz's Circuit.

Long Term Memory

Long Term Memory is used for storage of information over a long time. Information from short to long term memory is transferred after a short period. Unlike short term memory, long term memory has little decay. Long term potential is an enhanced response at the synapse within the hippocampus. It is essential to memory storage. The limbic system isn't directly involved in long term memory necessarily but it selects them from short term memory, consolidates these memories by playing them like a continuous tape, and involves the hippocampus and amygdala.

There are two types of long term memory:

1. Episodic Memory

2. Semantic Memory

Episodic memory represents our memory of events and experiences in a serial form. It is from this memory that we can reconstruct the actual events that took place at a given point in our lives. Semantic memory, on the other hand, is a structured record of facts, concepts, and skills that we have acquired. The information in the semantic memory is derived from our own episode memory, such as that we can learn new facts or concepts from experiences.

There are three main activities that are related to long term memory:

1. Storage
2. Deletion
3. Retrieval

Information for short term memory is stored in long term memory by rehearsal. The repeated exposure to a stimulus or the rehearsal of a piece of information transfers it into long term memory. Experiments also suggest that learning is most effective if it is distributed over time. Deletion is mainly caused by decay and interference. Emotional factors also affect long term memory. However, it is debatable whether we actually ever forget anything or whether it just sometimes becomes increasingly difficult to retrieve it. Information may not be recalled sometimes but may be recognized, or may be recalled only with prompting. This leads us to the third operation of memory, information retrieval.

There are two types of information retrieval:

1. Recall
2. Recognition

In recall, the information is reproduced from memory. In recognition the presentation of the information provides the knowledge that the information has been seen before. Recognition is of lesser complexity, as the information is provided as a cue. However, the recall may be assisted by the provision of retrieval cues which enable the subject to quickly access the information in memory.

Language and Speech

Language depends on semantic memory so some of the same areas in the brain are involved in both memory and language. Articulation, the forming of speech, is represented bilaterally in the motor areas. However, language analysis and speech formation take place in most individuals in regions of the left hemisphere only. The two regions involved are:

1. Broca's Area
2. Wernicke's Area

Broca's area is located just in front of the voice control area of the left motor cortex. This region assembles the motor of speech and writing. For example, patients with lesions in this area:

1. Understand language perfectly
2. May be able to write perfectly
3. Seldom speak spontaneously

Wernicke's area is part of the auditory and visual associations cortex. This region is responsible for the analysis and formation of language content. For example, patients with lesions in this area:

1. Are unable to name objects
2. Are unable to understand the meaning of words
3. Articulate speech readily but usually nonsensically

Diseases of the Limbic System

There are several well known diseases that are disorders of the limbic system. A few are:

1. Psychosis
2. Schizophrenia
3. Depression

An increased DA response in the limbic system results in schizophrenia. DA may be synthesized or secreted in excess, DA receptors may be supersensitive, and DA regulatory mechanism may be defective. Symptoms are decreased by drugs which block DA receptors. Symptoms of schizophrenia are:

1. Loss of touch with reality
2. Decreased ability to think and reason
3. Decreased ability to concentrate
4. Decreased memory
5. Regress in child-like behavior
6. Altered mood and impulsive behavior
7. Auditory hallucinations

Symptoms may be so severe that the individual cannot function.

Depression is caused by decreased levels of NE and/or serotonin in the limbic system. Drugs which increase NE and/or serotonin decrease the symptoms of depression. Depression is the most common major mental illness and is characterized by both emotional and physical symptoms. Symptoms of depression are:

1. Intense sadness and despair
2. Anxiety
3. Loss of ability to concentrate
4. Pessimism
5. Feelings of low self esteem
6. Insomnia or hypersomnia
7. Increased or decreased appetite
8. Changes in body temperature and endocrine gland function

10 to 15% of depressed individuals display suicidal behavior during their lifetime.

Another common form of depression is manic depression. Manic is an acute state characterized by:

1. Excessive elation and impaired judgment
2. Insomnia and irritability
3. Hyperactivity
4. Uncontrolled speech

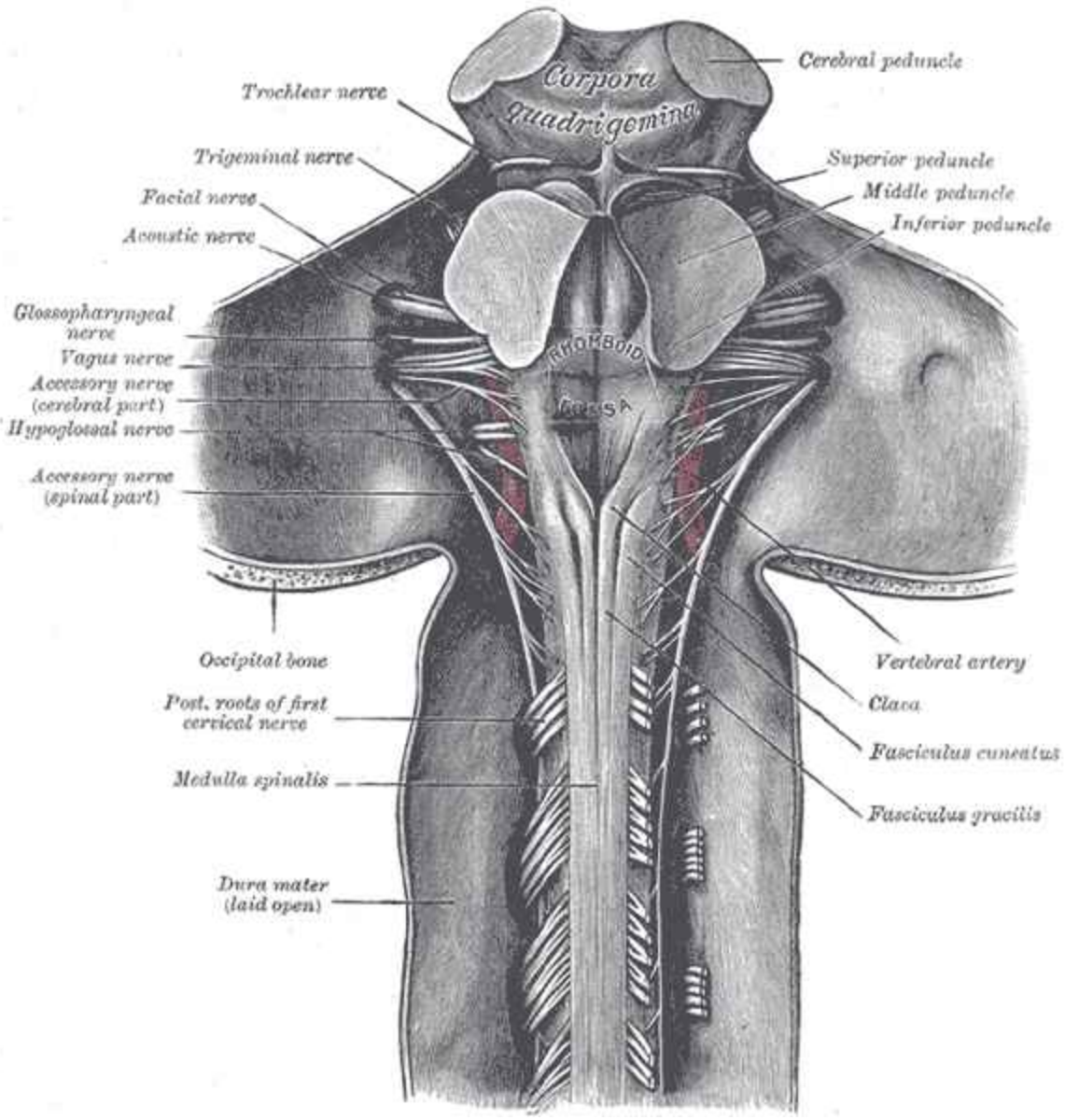
Manic depression, also known as bipolar disorder, displays mood swings between manic and depression. The limbic system receptors are unregulated. Drugs used are unique mood stabilizers.

The hippocampus is particularly vulnerable to several disease processes, including ischemia, which is any obstruction of blood flow or oxygen deprivation, Alzheimer's disease, and epilepsy. These diseases selectively attack CA1, which effectively cuts through the hippocampal circuit.

A connection between autism and the limbic system has also been noted as well. URL: http://www.autism.org/limbic.html

The Peripheral Nervous System

The **peripheral nervous system** includes 12 cranial nerves 31 pairs of spinal nerves. It can be subdivided into the **somatic** and **autonomic** systems. It is a way of communication from the central nervous system to the rest of the body by nerve impulses that regulate the functions of the human body.



The Cranial Nerves

The twelve cranial nerves are

I **Olfactory Nerve** for smell
II **Optic Nerve** for vision
III **Oculomotor** for looking around
IV **Trochlear** for moving eye
V **Trigeminal** for feeling touch on face
VI **Abducens** to move eye muscles
VII **Facial** to smile, wink, and help us taste
VIII **Vestibulocochlear** to help with balance, equilibrium, and hearing
IX **Glossopharengeal** for swallowing and gagging
X **Vagus** for swallowing, talking, and parasympathetic actions of digestion
XI **Spinal accessory** for shrugging shoulders
XII **Hypoglossal** for tongue more divided into different regions as muscles

The 10 out of the 12 cranial nerves originate from the brainstem, and mainly control the functions of the anatomic structures of the head with some exceptions. CN X receives visceral sensory information from the thorax and abdomen, and CN XI is responsible for innervating the sternocleidomastoid and trapezius muscles, neither of which is exclusively in the head.

Spinal nerves take their origins from the spinal cord. They control the functions of the rest of the body. In humans, there are 31 pairs of spinal nerves: 8 cervical, 12 thoracic, 5 lumbar, 5 sacral and 1 coccygeal. The naming convention for spinal nerves is to name it after the vertebra immediately above it. Thus the fourth thoracic nerve originates just below the fourth thoracic vertebra. This convention breaks down in the cervical spine. The first spinal nerve originates above the first cervical vertebra and is called C1. This continues down to the last cervical spinal nerve, C8. There are only 7 cervical vertebrae and 8 cervical spinal nerves.

Lateral cord

The **lateral cord** gives rise to the following nerves:

- The lateral pectoral nerve, C5, C6 and C7 to the pectoralis major muscle, or musculus pectoralis major.
- The musculocutaneous nerve which innervates the biceps muscle
- The median nerve, partly. The other part comes from the medial cord. See below for details.

Posterior cord

The **posterior cord** gives rise to the following nerves:

- The upper subscapular nerve, C7 and C8, to the subscapularis muscle, or musculus supca of the rotator cuff.
- The lower subscapular nerve, C5 and C6, to the teres major muscle, or the musculus teres major, also of the rotator cuff.
- The thoracodorsal nerve, C6, C7 and C8, to the latissimus dorsi muscle, or musculus latissimus dorsi.
- The axillary nerve, which supplies sensation to the shoulder and motor to the deltoid muscle or musculus deltoideus, and the teres minor muscle, or musculus teres minor.
- The radial nerve, or nervus radialis, which innervates the triceps brachii muscle, the brachioradialis muscle, or musculus brachioradialis,, the extensor muscles of the fingers and wrist (extensor carpi radialis muscle), and the extensor and abductor muscles of the thumb. See radial nerve injuries.

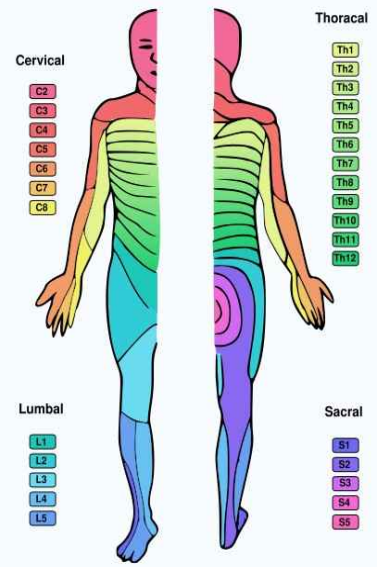


Diagram showing human dermatoms, i.e., skin regions with respect to the routing of their nerve connection of their afferent nerves through the spinal cord.

Medial cord

The **medial cord** gives rise to the following nerves:

- The median pectoral nerve, C8 and T1, to the pectoralis muscle
- The medial brachial cutaneous nerve, T1
- The medial antebrachial cutaneous nerve, C8 and T1
- The median nerve, partly. The other part comes from the lateral cord. C7, C8 and T1 nerve roots. The first branch of the median nerve is to the pronator teres muscle, then the flexor carpi radialis, the palmaris longus and the flexor digitorum superficialis. The median nerve provides sensation to the anterior palm, the anterior thumb, index finger and middle finger. It is the nerve compressed in carpal tunnel syndrome.
- The ulnar nerve originates in nerve roots C7, C8 and T1. It provides sensation to the ring and pinky fingers. It innervates the flexor carpi ulnaris muscle, the flexor digitorum profundus muscle to the ring and pinky fingers, and the intrinsic muscles of the hand (the interosseous muscle, the lumbrical muscles and the flexor pollicus brevis muscle). This nerve traverses a groove on the elbow called the cubital tunnel, also known as the funny bone. Striking the nerve at this point produces an unpleasant sensation in the ring and little fingers.

Other thoracic spinal nerves (T3-T12)

The remainder of the thoracic spinal nerves, T3 through T12, do little recombining. They form the **intercostal nerves**, so named because they run between the ribs. For points of reference, the 7th intercostal nerve terminates at the lower end of the sternum, also known as the xyphoid process. The 10th intercostal nerve terminates at the umbilicus, or the belly button.

The **somatic nervous system** is that part of the peripheral nervous system associated with the voluntary control of body movements through the action of skeletal muscles, and also reception of external stimuli. The somatic nervous system consists of afferent fibers that receive information from external sources, and efferent fibers that are responsible for muscle contraction. The somatic system includes the pathways from the skin and skeletal muscles to the Central Nervous System. It is also described as involved with activities that involve consciousness.

The basic route of the efferent somatic nervous system includes a two neuron sequence. The first is the upper motor neuron, whose cell body is located in the precentral gyrus (Brodman Area 4) of the brain. It receives stimuli from this area to control skeletal (voluntary) muscle. The upper motor neuron carries this stimulus down the corticospinal tract and synapses in the ventral horn of the spinal cord with the alpha motor neuron, a lower motor neuron. The upper motor neuron releases acetylcholine from its axon terminal knobs and these are received by nicotinic receptors on the alpha motor neuron. The alpha motor neurons cell body sends the stimulus down its axon via the ventral root of the spinal cord and proceeds to its neuromuscular junction of its skeletal muscle. There, it releases acetylcholine from its axon terminal knobs to the muscles nicotinic receptors, resulting in stimulus to contract the muscle.

The somatic system includes all the neurons connected with the muscles, sense organs and skin. It deals with sensory information and controls the movement of the body.

The Autonomic System

The **Autonomic system** deals with the visceral organs, like the heart, stomach, gland, and the intestines. It regulates systems that are unconsciously carried out to keep our body alive and well, such

as breathing, digestion (peristalsis), and regulation of the heartbeat. The Autonomic system consists of the **sympathetic** and the **parasympathetic** divisions. Both divisions work without conscious effort, and they have similar nerve pathways, but the sympathetic and parasympathetic systems generally have opposite effects on target tissues (they are antagonistic). By controlling the relative input from each division, the autonomic system regulates many aspects of homeostasis. One of the main nerves for the parasympathetic autonomic system is Cranial Nerve X, the Vegas nerve.

The Sympathetic System

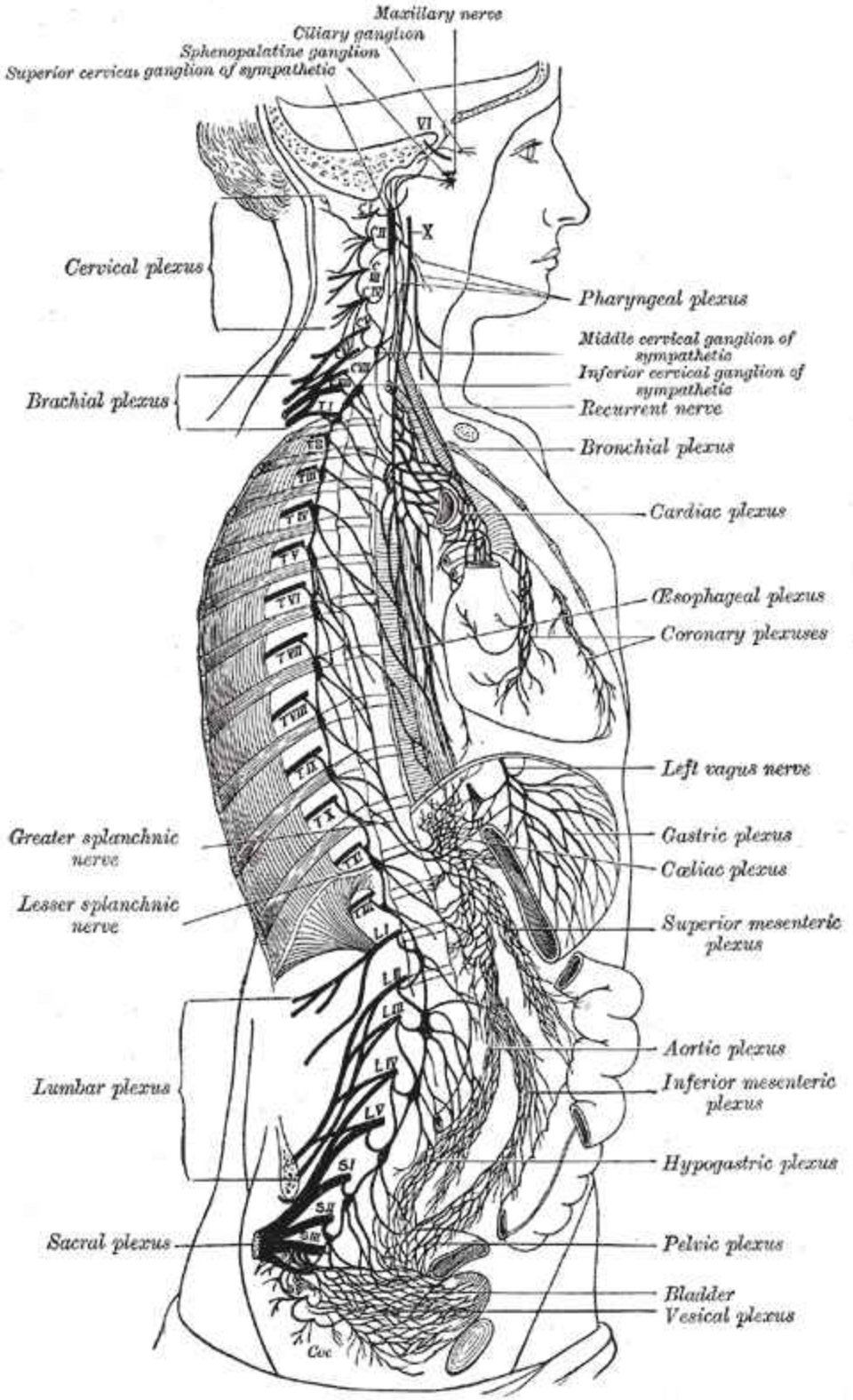
The sympathetic nervous system activates what is often termed the fight or flight response, as it is most active under sudden stressful circumstances (such as being attacked). This response is also known as sympathetico-adrenal response of the body, as the pre-ganglionic sympathetic fibers that end in the adrenal medulla (but also all other sympathetic fibers) secrete acetylcholine, which activates the secretion of adrenaline (epinephrine) and to a lesser extent noradrenaline (norepinephrine) from it. Therefore, this response that acts primarily on the cardiovascular system is mediated directly via impulses transmitted through the sympathetic nervous system and indirectly via catecholamines secreted from the adrenal medulla.

Western science typically looks at the SNS as an automatic regulation system, that is, one that operates without the intervention of conscious thought. Some evolutionary theorists suggest that the sympathetic nervous system operated in early organisms to maintain survival (Origins of Consciousness, Robert Ornstein; et al.), as the sympathetic nervous system is responsible for priming the body for action. One example of this priming is in the moments before waking, in which sympathetic outflow spontaneously increases in preparation for action.

The parasympathetic nervous system is part of the autonomic nervous system. Sometimes called the rest and digest system or feed and breed. The parasympathetic system conserves energy as it slows the heart rate, increases intestinal and gland activity, and relaxes sphincter muscles in the gastrointestinal tract.

Organization

Sympathetic nerves originate inside the vertebral column, toward the middle of the spinal cord in the intermediolateral cell column (or lateral horn), beginning at the first thoracic segment of the spinal cord and extending into the second or third lumbar segments. Because its cells begin in the thoracic and lumbar regions of the spinal cord, the SNS is said to have a thoracolumbar outflow. Axons of these nerves leave the spinal cord in the ventral branches (rami) of the spinal nerves, and then separate out as 'white rami' (so called from the shiny white sheaths of myelin around each axon) which connect to two chain ganglia extending alongside the vertebral column on the left and right. These elongated ganglia are also known as paravertebral ganglia or sympathetic trunks. In these hubs, connections (synapses) are made which then distribute the nerves to major organs, glands, and other parts of the body.



The right sympathetic chain and its connections with the thoracic, abdominal, and pelvic plexuses. (After Schwalbe.)

In order to reach the target organs and glands, the axons must travel long distances in the body, and, to accomplish this, many axons link up with the axon of a second cell. The ends of the axons do not make direct contact, but rather link across a space, the synapse.

In the SNS and other components of the peripheral nervous system, these synapses are made at sites called ganglia. The cell that sends its fiber is called a preganglionic cell, while the cell whose fiber leaves the ganglion is called a postganglionic cell. As mentioned previously, the preganglionic cells of the SNS are located between the first thoracic segment and the second or third lumbar segments of the spinal cord. Postganglionic cells have their cell bodies in the ganglia and send their axons to target organs or glands.

The ganglia include not just the sympathetic trunks but also the superior cervical ganglion (which sends sympathetic nerve fibers to the head), and the celiac and mesenteric ganglia (which send sympathetic fibers to the gut).

Information transmission

Messages travel through the SNS in a bidirectional flow. Efferent messages can trigger changes in different parts of the body simultaneously. For example, the sympathetic nervous system can accelerate heart rate; widen bronchial passages; decrease motility (movement) of the large intestine; constrict blood vessels; increase peristalsis in the esophagus; cause pupil dilation, piloerection (goose bumps) and perspiration (sweating); and raise blood pressure. Afferent messages carry sensations such as heat, cold, or pain.

The first synapse (in the sympathetic chain) is mediated by nicotinic receptors physiologically activated by acetylcholine, and the target synapse is mediated by adrenergic receptors physiologically activated by either noradrenaline or adrenaline. An exception is with sweat glands which receive sympathetic innervation but have muscarinic acetylcholine receptors which are normally characteristic of PNS. Another exception is with certain deep muscle blood vessels, which have acetylcholine receptors and which dilate (rather than constrict) with an increase in sympathetic tone. The sympathetic system cell bodies are located on the spinal cord excluding the cranial and sacral regions. The preganglonic neurons exit from the vertebral column and synapse with the postganglonic nerouns in the sympathetic trunk.

The parasympathetic nervous system is one of three divisions of the autonomic nervous system. Sometimes called the rest and digest system, the parasympathetic system conserves energy as it slows the heart rate, increases intestinal and gland activity, and relaxes sphincter muscles in the gastrointestinal tract.

Relationship to sympathetic

While an oversimplification, it is said that the parasympathetic system acts in a reciprocal manner to the effects of the sympathetic nervous system; in fact, in some tissues innervated by both systems, the effects are synergistic.

Receptors

The parasympathetic nervous system uses only acetylcholine (ACh) as its neurotransmitter. The ACh acts on two types of receptors, the muscarinic and nicotinic cholinergic receptors. Most transmissions occur in two stages: When stimulated, the preganglionic nerve releases ACh at the

ganglion, which acts on nicotinic receptors of the postganglionic nerve. The postganglionic nerve then releases ACh to stimulate the muscarinic receptors of the target organ.

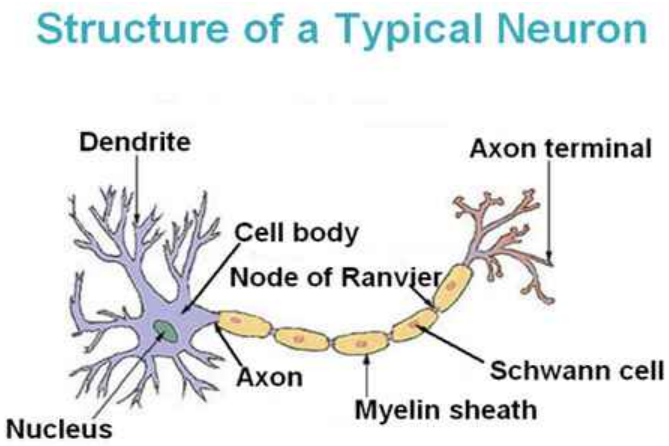
The three main types of muscarinic receptors that are well characterised are:

- The M1 muscarinic receptors are located in the neural system.
- The M2 muscarinic receptors are located in the heart, and act to bring the heart back to normal after the actions of the sympathetic nervous system: slowing down the heart rate, reducing contractile forces of the atrial cardiac muscle, and reducing conduction velocity of the atrioventricular node (AV node). Note, they have no effect on the contractile forces of the ventricular muscle.
- The M3 muscarinic receptors are located at many places in the body, such as the smooth muscles of the blood vessels, as well as the lungs, which means that they cause vasoconstriction and bronchoconstriction. They are also in the smooth muscles of the gastrointestinal tract (GIT), which help in increasing intestinal motility and dilating sphincters. The M3 receptors are also located in many glands that help to stimulate secretion in salivary glands and other glands of the body.

Nervous Tissue

The nervous system coordinates the activity of the muscles, monitors the organs, constructs and also stops input from the senses, and initiates actions. Prominent participants in a nervous system include neurons and nerves, which play roles in such coordination.Our nervous tissue only consists of two types of cells. These cells are neurons and neuroglia cells. The neurons are responsible for transmitting nerve impulses. Neuroglia cells are responsible for supporting and nourishing the neuron cells.

Types of Neurons



There are three types of neurons in the body. We have sensory neurons, interneurons, and motor neurons. Neurons are a major class of cells in the nervous system. Neurons are sometimes called nerve cells, though this term is technically imprecise, as many neurons do not form nerves. In vertebrates, neurons are found in the brain, the spinal cord and in the nerves and ganglia of the peripheral nervous system. Their main role is to process and transmit information. Neurons have excitable membranes, which allow them to generate and propagate electrical impulses. Sensory neuron takes nerve impulses or messages right from the sensory receptor and delivers it to the central nervous system. A sensory receptor is a structure that can find any kind of change in it's surroundings or environment.

Structure of a neuron

Neurons have three different parts to them. They all have an axon, a cell body and dendrites. The axon is the part of the neuron that conducts nerve impulses. Axons can get to be quite long. When an axon is present in nerves, it is called a nerve fiber. A cell body has a nucleous and it also has other organelles. The dendrites are the short pieces that come off of the cell body that receive the signals from sensory receptors and other neurons.

Myelin Sheath

Schwann cells contain a lipid substance called myelin in their plasma membranes. When schwann cells wrap around axons, a myelin sheath forms. There are gaps that have no myelin sheath around them; these gaps are called nodes of Ranvier. Myelin sheathes make excellent insulators. Axons that are longer have a myelin sheath, while shorter axons do not. The disease multiple sclerosis is an autoimune disease where the body attacks the myelin sheath of the central nervous system.

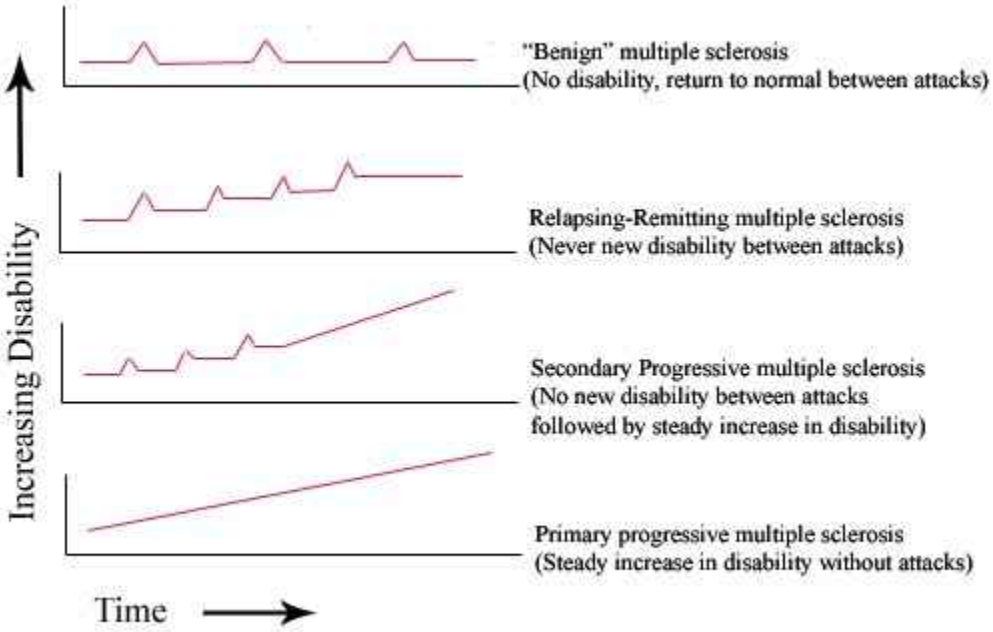
Case Study

A 35-year-old male in 1986 had been admitted to a hospital in Florida three weeks previous to being diagnosed, with complaints of weakness and spasticity in the right leg, difficulties with balance, and fatigue and malaise. Tests performed at the Florida hospital had revealed abnormalities in spinal fluid and MRI brain scan. The patient complained of being severely depressed and anxious. He had anger at his circumstances and frequent crying spells. One month previously he had noticed aching and loss of vision in the left eye that had since improved.

This man was diagnosed with Multiple Sclerosis. MS is a chronic, degenerative, and progressive disorder that affects the nerve fibers in the brain and spinal cord. Myelin is a fatty substance that surrounds and insulates the nerve fibers and facilitates the conduction of the nerve impulse transmissions. MS is characterized by intermittent damage to myelin (called demyelination) caused by the destruction of specialized cells (oligodendrocytes) that form the substance. Demyelination causes scarring and hardening (sclerosis) of nerve fibers usually in the spinal cord, brain stem, and optic nerves, which slows nerve impulses and results in weakness, numbness, pain, and vision loss. Because different nerves are affected at different times, MS symptoms often worsen (exacerbate), improve, and develop in different areas of the body. Early symptoms of the disorder may include vision changes (blurred vision, blind spots) and muscle weakness. MS can progress steadily or cause acute attacks (exacerbations) followed by partial or complete reduction in symptoms (remission). Most patients with the disease have a normal lifespan.

There are different types of MS

Multiple sclerosis is classified according to frequency and severity of neurological symptoms, the ability of the CNS to recover, and the accumulation of damage.



Treating Depression

Every now and then we all feel a little blue, these feelings can be caused by losing a loved one. Clinical depression goes much further than just feeling down. Depression has many symptoms, including lack of energy, abnormal eating habits (either too much or too little)and sleeping problems (also too much or too little). Often a person can feel worthless and have thoughts of committing suicide. The cause of depression and its symptoms are a mystery but we do understand that it is an illness associated with biochemical changes in the brain. A lot of research goes on to explain that it is associated with a lack of amines serotonin and norephinephrine. Therefore pharmacological treatment strategies often try to increase amine concentrations in the brain.

One class of antidepressants is monoamine oxidase inhibitors. Mono amine oxidase is a enzyme that breaks down your amines like norephinephrine and serotonin. Because the antidepressants inhibit their degradation they will remain in the synaptic cleft for a longer period of time making the effect just as if you had increased theses types of neurotransmitters.

A newer class of antidepressants is selective serotonin reuptake inhibitors (SSRI's). With SSRI's decreasing the uptake of serotonin back into the cell that will increase the amount of serotonin present in the synaptic cleft. SSRI's are more specific than the monoamine oxidase inhibitors because they only affect serotonergic synapses. You might recognize these SSRI's by name as Prozac and Paxil.

Drug Abuse

PCP in both crystalline form and a vial of PCP dissolved in water

Scientists have long accepted that there is a biological basis for drug addiction, though the exact mechanisms responsible are only now being identified. It is believed that addictive substances create dependence in the user by changing the brain's reward functions, located in the mesolimbic dopamine system—the part of the brain that reinforces certain behaviors such as eating, sexual intercourse, exercise, and social interaction. Addictive substances, through various means and to different degrees, cause the synapses of this system to flood with excessive amounts of dopamine, creating a brief rush of euphoria more commonly called a "high". Some say that abuse begins when the user begins shirking responsibility in order to afford drugs or to have enough time to use them. Some say it begins when a person uses "excessive" amounts, while others draw the line at the point of legality, and others believe it amounts to chronic use despite degenerating mental and physical health in the user. Some think that any intoxicant consumption is an inappropriate activity. Here are some drugs that are abused frequently: Acid/LSD, Alcohol, Club Drugs, Cocaine, Ecstasy/MDMA, Heroin, Inhalants, Marijuana, Methamphetamine, PCP/Phencyclidine, Prescription Medications, Smoking/Nicotine and Steroids.

Methamphetamine

Illegal methlab.

In the US, medically prescribed **methamphetamine** is distributed in tablet form under the brand name Desoxyn®.

Illicit methamphetamine comes in a variety of forms. Most commonly it is found as a colorless crystalline solid, sold on the street under a variety of names, such as: crystal meth or crystal. Crystal methamphetamine may also be referred to as shards, rock, P, upside-down b, pony, crissie, crystal, glass, ice, devil's dandruff, chimichanga, Jib, critter, Tina, Crawford, Working Man's Cocaine, Pook, tik, or "broken glass". People may confuse crack cocaine with methamphetamine.

It is also sold as a less-pure crystalline powder called crank or speed, or in crystalline rock form called dope, shit, tina, or tweak; both "dope" and "speed" are often used to refer to other drugs. Colorful flavored pills containing methamphetamine and caffeine are known as yaba (Thai for "crazy medicine"). At its most impure, it is sold as a crumbly brown or off-white rock commonly referred to as peanut butter crank. See the list of street names for a more comprehensive list of common street names for methamphetamine.

Methamphetamine found on the street may be pure, or adulterated with chemicals that were used to synthesize it. In some instances, it may be diluted or cut with non-psychoactive substances like inositol. In other instances, it may be mixed with other psychoactive drugs.

Marijuana

The drug cannabis is produced from parts of the cannabis plant, primarily the cured flowers and gathered trichomes of the female plant. The major active chemical compound tetrahydrocannabinol, commonly referred to as THC, has psychoactive and medicinal effects when consumed, usually by smoking or ingestion. Cannabis has been consumed by humans for thousands of years; in the 20th century there was an upswing in the use of cannabis for recreational and religious purposes.

The possession, use, or sale of psychoactive cannabis products became illegal in many parts of the world in the early 20th century. Since then, while some countries have intensified the enforcement of cannabis prohibition, others have reduced the priority of enforcement to the point of de facto legality. Cannabis remains illegal in the vast majority of the world's countries.

The nature and intensity of the immediate effects of cannabis consumption vary according to the dose, the species or hybridization of the source plant, the method of consumption, the user's mental and physical characteristics (such as possible tolerance), and the environment of consumption. This is sometimes referred to as set and setting. Smoking the same cannabis either in a different frame of mind (set) or in a different location (setting) can alter the effects or perception of the effects by the individual. Effects of cannabis consumption may be loosely classified as cognitive and physical. Anecdotal evidence suggests that the Cannabis sativa species tends to produce more of the cognitive or perceptual effects, while Cannabis indica tends to produce more of the physical effects.

Review Questions

1. The junction between one neuron and the next, or between a neuron and an effector is called:

A) A synapse
B) A dendrite
C) A neuotransmitter
D) A ventricle
E) None of the above

2. A fast excitatory synapses follows this order:

A) (1) neurotransmitter released (2) diffused across the synaptic cleft to a receptor protein (3) binding of the transmitter opens pores in the ion channels and positive ions move in.
B) (1) neurotransmitter released (2) diffused across the synaptic cleft to a receptor protein (3) binding of the transmitter opens pores in the ion channels and negative ions move in.
C) (1) neurotransmitter released (2) diffused across the synaptic cleft to a receptor amino acid (3) binding of the transmitter opens pores in the ion channels and positive ions move in.
D) (1) diffused across the synaptic cleft to a receptor protein (2) neurotransmitter released (3) binding of the transmitter opens pores in the ion channels and positive ions move in.
E) None of the above

3. Resting potential is

A) excess positive ions accumulate inside the plasma membrane
B) excess negative ions accumulate inside the plasma membrane
C) excess positive ions accumulate outside the plasma membrane
D) excess positive ions accumulate outside the plasma membrane
E) both b & d
F) both a & b

4. Sensory neurons have:

A) A short dendrite and a long axon
B) A short dendrite and a short axon
C) A long dendrite and a short axon
D) A long dendrite and a long axon
E) Their axons and dendrites may be either long or short

5. _____blocks Acetylcholine receptor sites causing muscle relaxation.

A) Novocain
B) curare
C) Nicotine
D) Nerve gases

6. Transmission across a synapse is dependent on the release of _____?

A) neurotransmitters

B) synaptic vesicle
C) neurons
D) receptor proteins

7. Motor neurons take messages

A) from the muscle fiber to the central nervous system
B) away from the central nervous system to the central nervous system
C) that are classified
D) away from the central nervous system to muscle fiber

8. The medulla oblongata helps to regulate which of the following:

A) Breathing
B) Heartbeat
C) Sneezing
D) Vomiting
E) All of the above

Glossary

Afferent Messages: carry sensations such as heat, cold, or pain

Autonomic System: deals with the visceral organs, like the heart, stomach, gland, and the intestines

Axon: the part of the neuron that conducts nerve impulses

Cannabis: drug produced from parts of the cannabis plant, causes paralyzation

Central Nervous System: the system that includes the brain and the spinal cord

Cerebellum: part of the brain that is located posterior to the medulla oblongata and pons, coordinates skeletal muscles to produce smooth, graceful motions

Cerebrospinal Fluid: acts a shock absorber for the central nervous system, protecting the brain and spinal cord from injury; it also has a high glucose content which serves as a nutritional factor

Dendrites: short pieces that come off of the cell body that receive the signals from sensory receptors and other neurons

Episodic Memory: represents our memory of events and experiences in a serial form

Excitatory Neurotransmitter: a neurotransmitter that acts to elicit an action potential by opening chloride ion channels

Longitudinal Sulcus: separates the cerebrum in to the right and left hemispheres

Long Term Memory: used for storage of information over a long time

Myelin: a fatty substance that surrounds and insulates the nerve fibers and facilitates the conduction of the nerve impulse transmissions

Multiple Sclerosis: disease that affects the CNS by causing hardening and scaring of the myelin

Nodes of Ranvier: unmyelinated gaps between sections of myelin

Peripheral Nervous System: a way of communication from the central nervous system to the rest of the body by nerve impulses that regulate the functions of the human body

Postganglionic Cells: have their cell bodies in the ganglia and send their axons to target organs or glands

Sensory Receptor: structure that can find any kind of change in it's surroundings or environment

Somatic Nervous System: the part of the peripheral nervous system associated with the voluntary control of body movements through the action of skeletal muscles, and also reception of external stimuli

Synapses: the gap between two neurons; new synapses lead to learning

References

http://action.painfoundation.org/site/News2?page=NewsArticle&id=5135&security=1&news_iv_ctrl=1061 Esther Wednesday, October 19, 2005

http://www.neurologychannel.com/multiplesclerosis/

http://www.theraj.com/ms/casestudy.html

live version • discussion • edit lesson • comment • report an error