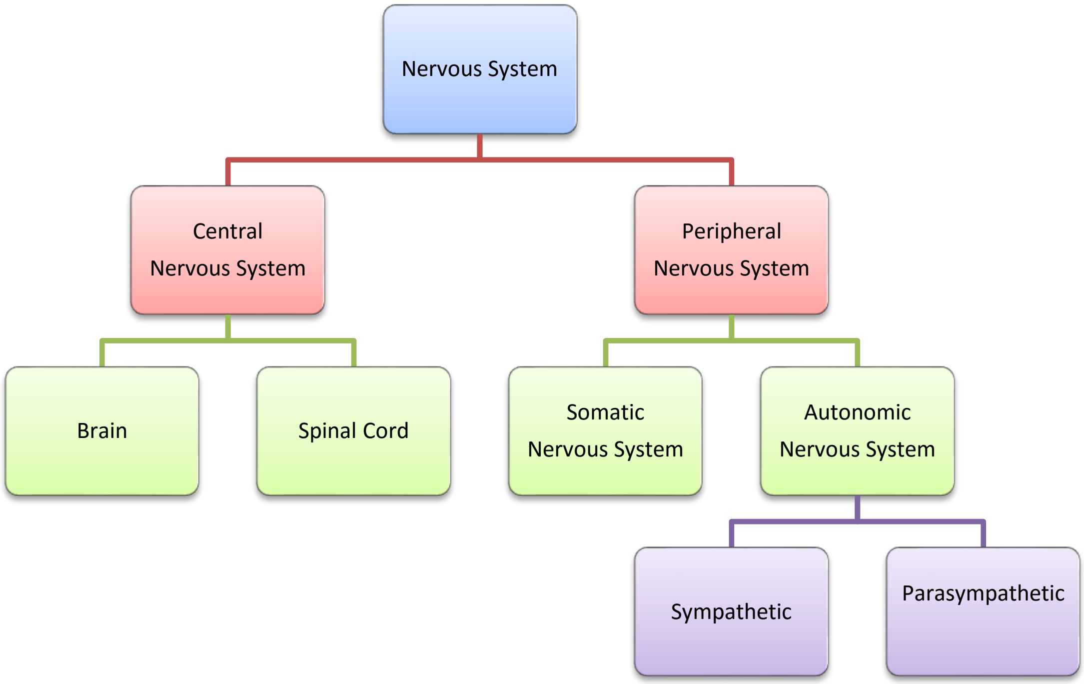
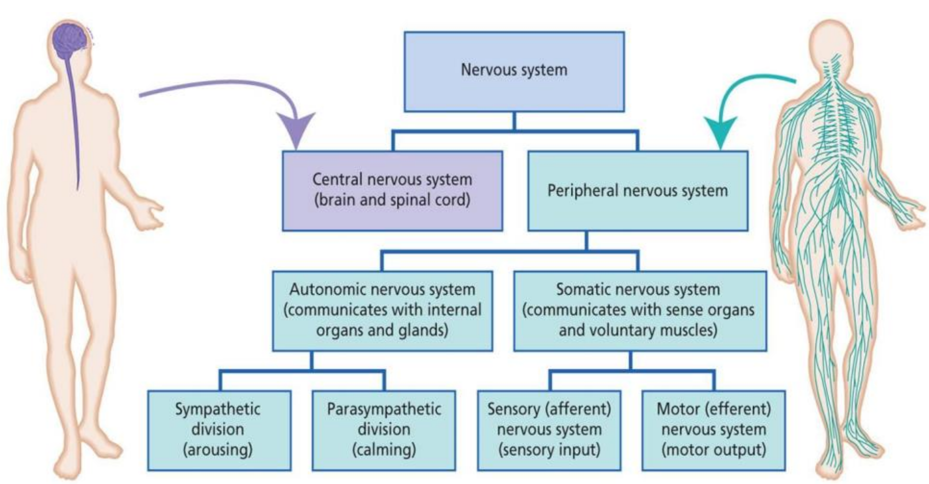
Psyc 10148/9: Nervous System and the Brain Notes

The nervous system is divided into various subsections:



The Central Nervous System (CNS) acts as the motherboard in a laptop or cellphone. It receives, processes, interprets and stores the information sent from the Peripheral Nervous System (PNS), which acts as the receiver or antennae and which includes all the other nerves in the body. The CNS also sends messages to muscles, glands and internal organs. The PNS is divided into the Somatic Nervous System and the Autonomic Nervous System. The somatic nervous system interacts with the external environment and is connected to sensory receptors (eg. touch, taste etc.) and skeletal muscles. The Autonomic Nervous System is involved in the control of internal organs (eg. heart, stomach etc.)

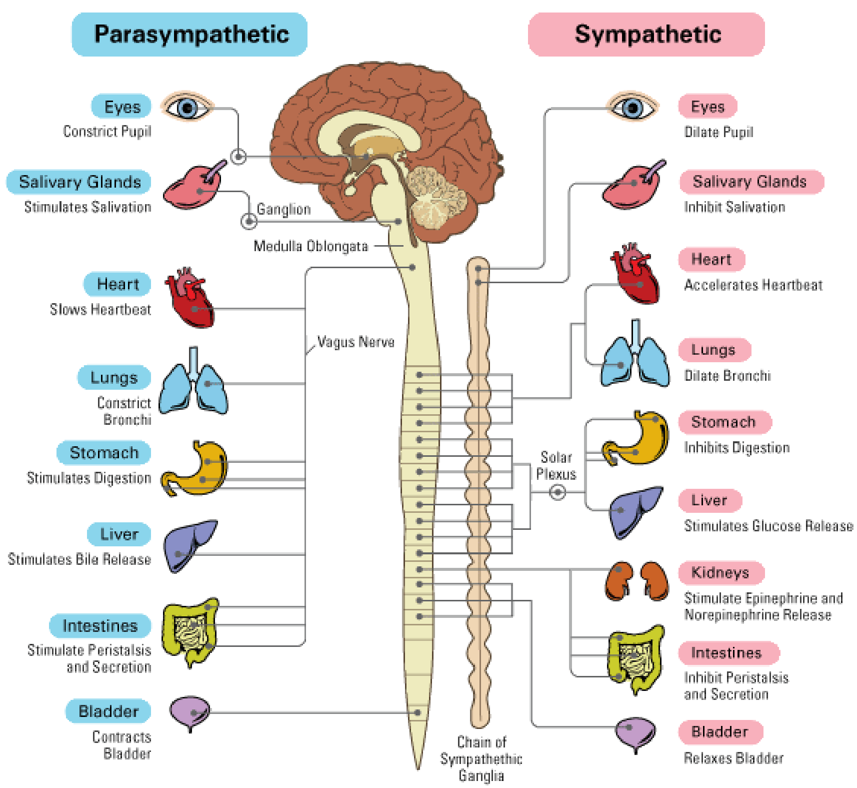


The Autonomic Nervous System is divided into the sympathetic and parasympathetic nervous system.

The **sympathetic nervous system is involved in activities that use up the body's energy**, usually as a response to a stressful event (Eg. being confronted by a dangerous animal). This is the 'fight or flight' principle. When the sympathetic nervous system is activated it involves an increase in blood flow, blood pressure, heart rate, sweating and a decrease in digestion and arousal.

The **parasympathetic nervous system** is associated with relaxation since it **acts to conserve energy and increase the body's supply of stored energy**. For example, it facilitates salivation, secretion of digestive juices, and increased blood flow to the gastrointestinal system for the purpose of eating. Food consumption increases the body's supply of energy since it allows for the ingestion of vitamins, nutrients and carbs.

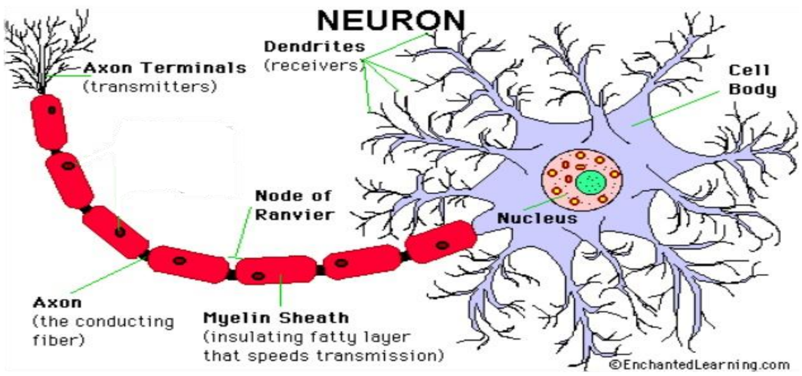
The activities of the Autonomic nervous system were generally thought to be automatic. However, **biofeedback**, for example, a technique which involves greater awareness and voluntary control over bodily functions suggests that the autonomic nervous system may not be as automatic we thought (Zillmer, Spiers, Culberston 2008).



Schema Explaining How Parasympathetic and Sympathetic Nervous Systems Regulate Functioning Organs

Neurons and Neuronal Communication

The Structure of a Neuron:



For a video on the structure of a neuron go to:
https://www.youtube.com/watch?v=6qS83wD29PY

Myelin wraps around the axon like the layers of an onion and is formed by glial cells called oligodendrocytes in the Central Nervous System and glial cells called Schwann cells in the Peripheral Nervous System.

The Myelin Sheath is interrupted by gaps called Nodes of Ranvier. When a message is sent through a neuron it jumps from node to node rather than running smoothly down the axon. Myelin serves as an electric insulator that increases conduction velocity.

Myelination begins after birth and its progress corresponds to behavior. Babies are unable to control their bladder and bowel functions due to insufficient myelination of neurons. This is why they cannot be potty trained until about ages 2 to 3.

Demyelination can occur as a result of disease such as Multiple Sclerosis.

Neurons are held in place by **glia** (*Greek=gliok, meaning Nerve Glue*). Glial cells help support neurons by physically and chemically buffering them from each other. They supply nutrients and oxygen to the neurons because neurons can't store their own nutrients. They also behave like garbage collectors by removing the dead carcasses of neurons that have been destroyed by illness or injury. They also form the Myelin Sheath.

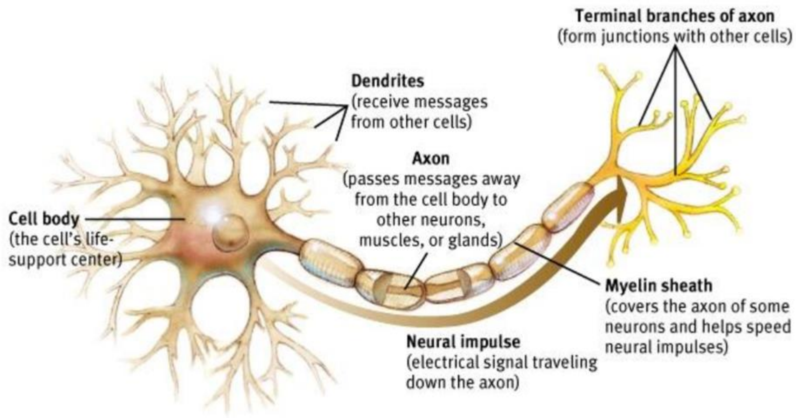
There are many types of glia. One type, called the Astrocyte (Astro means star), which is shaped like a star, protects the blood-brain barrier like a 'border patrol'. It protects the brain from micro-organisms that can be transported by blood to the brain. It also partially processes glucose before supplying it to neurons. It is believed to be involved in memory and learning since it can affect neurons in a number of ways. Astrocytes have been implicated in modifying the strength of connections between neurons as they can be found on the synaptic cleft. They are also involved in the formation of new synapses, which is the way by which neurons communicate, and they help to specify those connections. Einstein's brain, when studied, showed that he had the same number of neurons as anyone else. However, he had a higher percentage of glial cells in areas related to higher cognition (Zillmer, Spiers, Culberston 2008; Paterniti, 2000).

Neurons begin their development through a process called neurogenesis, where new nervous tissue, that is neurons, develop from stem cells during the period of human development known as the embryo. During early development neurons and synapses are on overdrive leading to numerous, and not always necessary, connections. The process of pruning eliminates weak or repetitive connections leading to neural efficiency. 40% of pruning occurs during childhood, with the rest occurring in adolescence and adulthood.

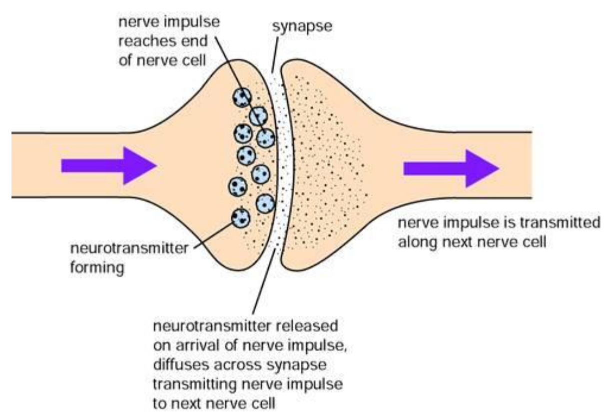
Neurons communicate through an electrochemical process called synaptic transmission.

In synaptic transmission important messages are sent through an **axon potential** or nerve impulse which travels down the **axon** of the neuron to its **terminal buttons** which connects to the **dendrites** of another neuron.

For a video on synaptic transmission go to: https://www.youtube.com/watch?v=WhowH0kb7n0



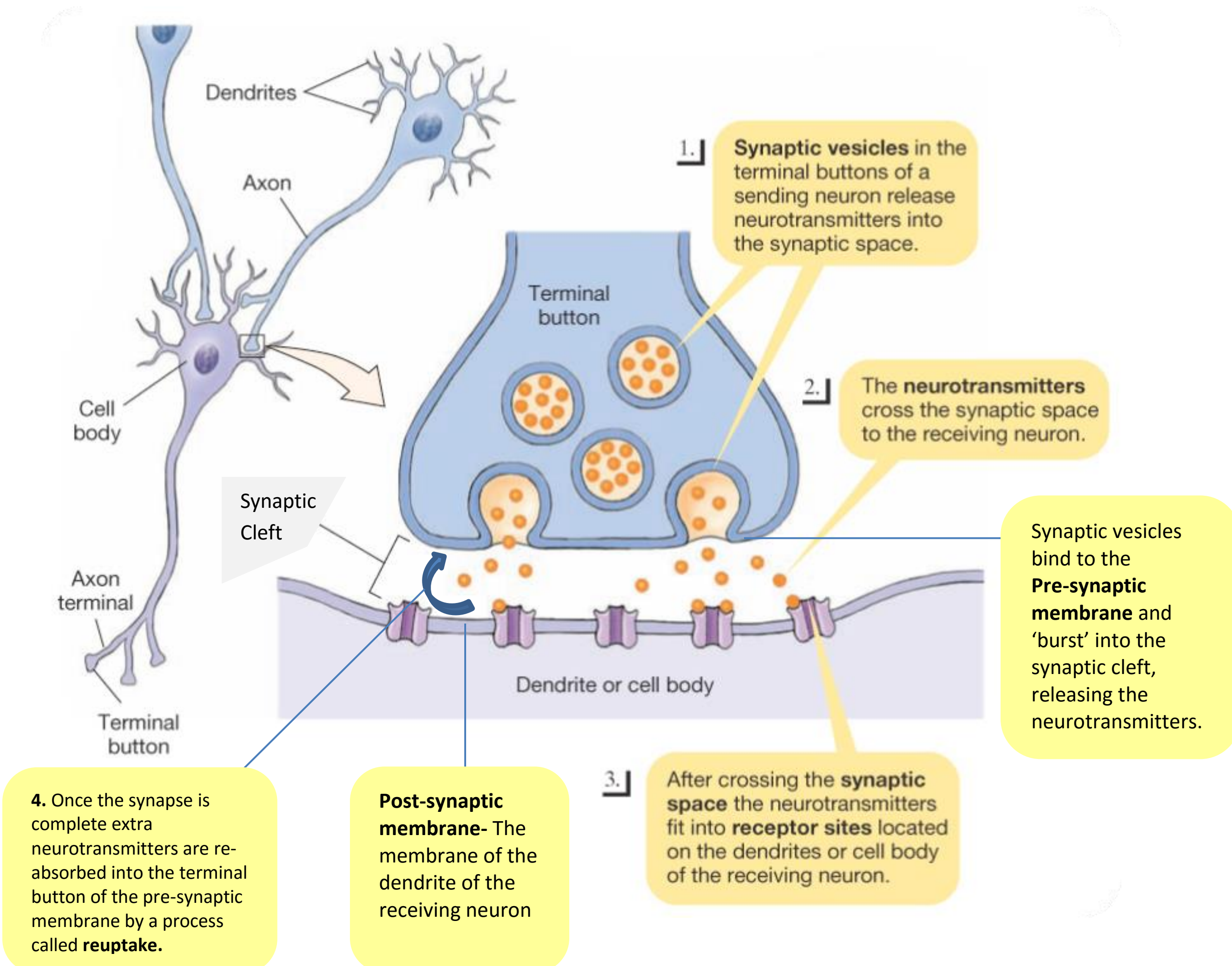
When the action potential (nerve impulse) arrives at the terminal button of the neuron it is sent to the dendrite of the receiving neuron. through messengers called **neurotransmitters**.



There are a number of important terms to know relating to the synapse. These are:

1. **Pre-synaptic membrane**- The membrane of the terminal button sending the neurotransmitter.
2. **Post-synaptic membrane**- The membrane of the dendrite receiving the neurotransmitter.
3. **Synaptic cleft**- The space between the pre-synaptic membrane and the post-synaptic membrane.
4. **Neurotransmitter**- The chemical messengers that transmit information across neurons.
5. **Synaptic Vesicle**- The sack-like structure that carries the neurotransmitters.
6. **Receptor**- The channel to which the neurotransmitter binds when it arrives at the post-synaptic membrane.
7. **Excitatory Neurotransmitter**- Neurotransmitters that cause action potentials.
8. **Action Potential**- The rapid change in electrical charge within a neuron which travels down the axon to the terminal buttons.
9. **Inhibitory Neurotransmitter**- Neurotransmitters that prevent action potentials from occurring.
10. **Reuptake**- The process by which neurotransmitters are re-absorbed into the terminal button of the pre-synaptic membrane.

The structure of a synapse is as follows:



The inside of a neuron has a negative charge.

If the neurotransmitter crossing the synaptic cleft is **an excitatory neurotransmitter**, Sodium (Na+), which can be **found outside** the neuron floods into the neuron causing a change in charge within the post-synaptic neuron. The negative charge changes into a positive charge due to the influx of positively charged Sodium ions (Na+). As a result, an **action potential** is created and is sent down the axon of the post-synaptic neuron

If the neurotransmitter crossing the synaptic cleft is an inhibitory neurotransmitter, positively charged Potassium ions (K+), which can be **found inside** the neuron flow out of the neuron. This **increases the negative charge inside the post-synaptic neuron and therefore no action potential is released.**

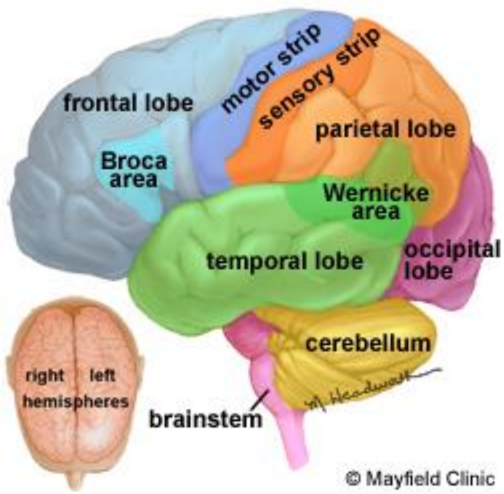
Neurotransmitters: Common neurotransmitters acting on the body are as follows:

Neurotransmitter	Action	Inhibitory vs. Excitatory
Acetylcholine	All muscular movement is accomplished by the release of acetylcholine. Communicates with the **pons** to affect **sleep**, particularly REM sleep, where most dreaming takes place. Activates cerebral cortex to facilitate **learning**. Communicates with the hippocampus to create **memories**.	Both inhibitory and excitatory neurotransmitter
Dopamine	Involved in voluntary movement. Voluntary movement refers to movements we are aware of and direct our limbs to do. For example, when you want to grab a glass of water and 'tell' your arm to do so, this is a voluntary movement. Involuntary movements are movements that happen without our awareness and mental direction. For example, spinal reflexes are involuntary movements. Degeneration of the neurons that transport Dopamine can lead to a movement disorder called **Parkinson's Disease**. Watch 2 videos on Parkinson's here: https://www.youtube.com/watch?v=hu4eTijdIv0 https://www.youtube.com/watch?v=ECkPVTZlfP8 Communicates with the prefrontal cortex found in the frontal lobe. It facilitates formation of short term memories, planning and problem solving. It's also involved in attention and learning. Reinforces effects of drugs and is involved in the process of drug abuse/ drug addiction.	Both inhibitory and excitatory neurotransmitter
Norepinephrine	Found in the neurons of the autonomic system. Almost every region in the brain receives communication from this neurotransmitter. Involved in vigilance (alertness in the fight or flight response), learning, memory, daydreaming, waking from sleep, and emotion.	Excitatory neurotransmitter

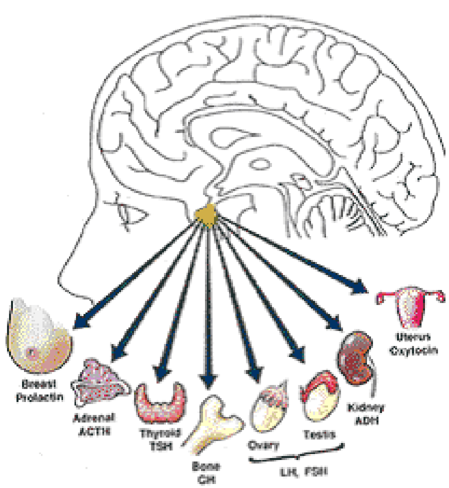
Serotonin	Helps to regulate mood and pain. Helps to control eating, sleep and arousal. Also involved in dreaming. One of the main neurotransmitters involved in Depression. Depression affects our mood, sleeping patterns and appetite. Individuals who are depressed tend to either sleep too much or too little, eat too much or too little and have difficulty controlling their mood. Taking drugs called **serotonin reuptake inhibitors**, which prevent the reuptake of serotonin at the synapse, help to alleviate symptoms of depression. Serotonin reuptake inhibitors allow Serotonin to stay at the synapse longer and therefore have inhibitory effects on the the post-synaptic membrane for longer or more effectively. Here's a brief video on Serotonin-Reuptake Inhibitors also known as SSRI's: https://www.youtube.com/watch?v=3c-KTc923Bc	Inhibitory neurotransmitter Helps mood, eating and sleep, for example, from getting out of control by the process of inhibition.
Glutamate	Main excitatory neurotransmitter in the brain	Excitatory
GABA	Main inhibitory neurotransmitter in the brain. Abnormalities in GABA transmission is involved in epilepsy. Epilepsy is a condition in which neurons 'overfire' in the brain. Without the effect of inhibitory neurotransmitters, the brain becomes unstable. For example, without inhibitory neurotransmitters, the excitatory neurotransmitters cause a neuron to fire, which would other neurons around it fire and cause their neighbors to fire etc. until most of the neurons in the brain are firing uncontrollably. When this happens it is called a **seizure.** Epilepsy is characterized by the presence of seizures.	Inhibitory

The Brain:

The brain is divided into four lobes, with each lobe serving particular functions.



Frontal Lobe	Lobe involved in planning, creativity & initiative. Contains Broca's area involved in speech production. Contains motor cortex.
Parietal Lobe	Lobe containing the somatosensory cortex which receives information about pressure, pain, touch and temperature.
Temporal Lobe	Lobe found just above the ears involved in perception and emotion. Contains auditory cortex; processes sound. Contains Wernicke's Area involved in language comprehension.
Occipital Lobe	Lobe found in the lower back of the brain where visual signals are processed. Contains visual cortex.



The **limbic system** is composed of various structures in the brain such as: the olfactory bulb, thalamus, hypothalamus, hippocampus, amygdala and pituitary gland *(see diagram left)*.

The pituitary gland sends hormones to the relevant glands in the body. For example, it may send sex-hormones to the ovaries and testes.

The thalamus acts as a switch board and sends sensory information to the relevant higher structures in the brain. The olfactory bulb, connected to the nose (sense of smell) bypasses the thalamus and connects directly to the structures related to emotion.

Other structures in the Brain:

Structure	Function
Brain Stem: Pons Medulla	Pons: involved in Sleeping, Walking, & Daydreaming
	Medulla: Involved in breathing, heart rate & other bodily functions that do not have to be consciously regulated.
Thalamus	Directs sensory messages (sight, hearing, touch etc.) that come through the Brain to higher centers.
	The olfactory bulb, which processes the sense of smell, bypasses this brain structure.
Cerebellum	Involved in balance and coordination. Is also involved in analyzing sensory information and solving problems.
Cerebrum	Divided into two hemispheres connected by the corpus callosum
Amygdala	Attaches emotional importance to sensory information. Part of the limbic system and is involved in assessing danger or threat.
Hippocampus	Helps us to form memories. Compares information received with what we already know. Communicates with the Reticular Activating System.
Hypothalamus	Regulates body temperature by triggering sweating or shivering and controls the autonomic nervous system. Involved in survival needs such as hunger and thirst