

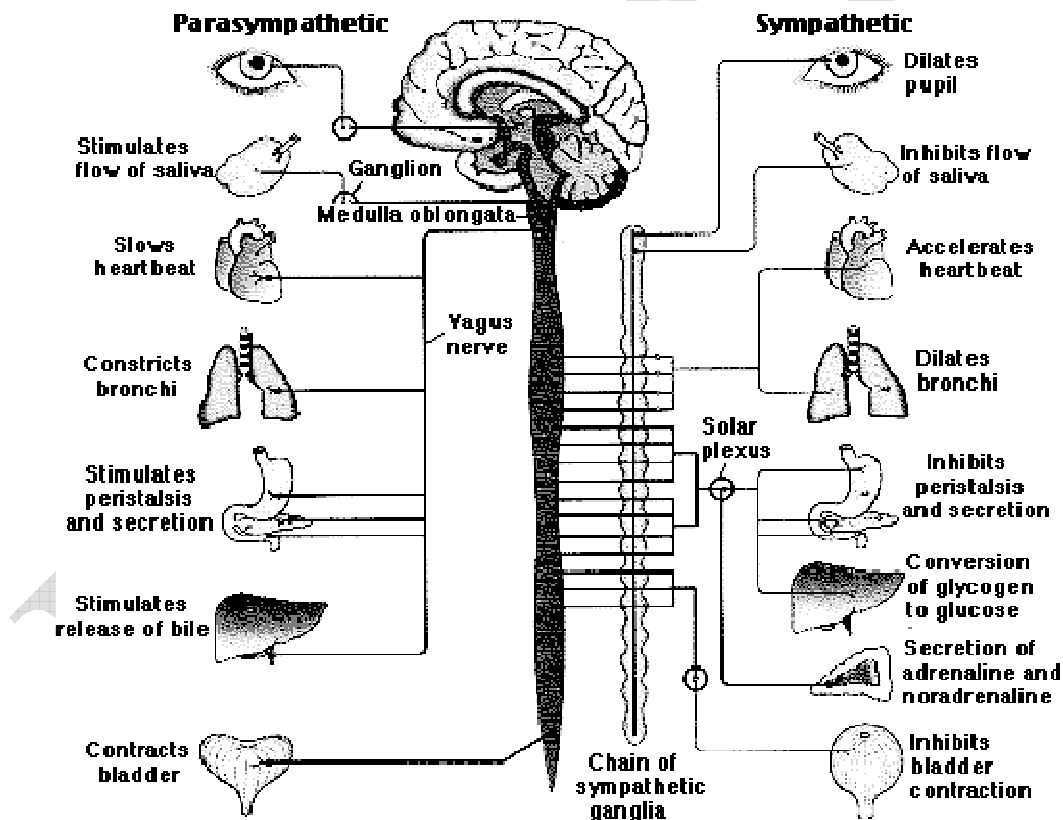
Chapter 4

Autonomic Nervous System (ANS)

The autonomic nervous system consists of sensory neurons and motor neurons that run between the central nervous system (especially the **hypothalamus** and **medulla oblongata**) and various internal organs such as the: heart, lungs, viscera and glands (both **exocrine** and **endocrine**). It is responsible for monitoring conditions in the internal environment and bringing about appropriate changes in them. The contraction of both **smooth muscle** and **cardiac muscle** is controlled by motor neurons of the autonomic system.

The actions of the autonomic nervous system are largely **involuntary** (in contrast to those of the sensory-somatic system). It also differs from the sensory-somatic system is using two groups of motor neurons to stimulate the effectors instead of one. The first, the **preganglionic neurons**, arise in the CNS and run to a **ganglion** in the body. Here they **synapse** with **postganglionic neurons**, which run to the effector organ (cardiac muscle, smooth muscle, or a gland).

The autonomic nervous system has two subdivisions, the **sympathetic nervous system** and the **parasympathetic nervous system**.

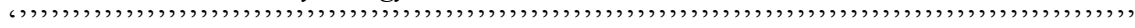


The Autonomic Nervous System

2.3.1. The Sympathetic Nervous System

The preganglionic motor neurons of the sympathetic system arise in the spinal cord. They pass into sympathetic **ganglia** which are organized into two chains that run parallel to and on either side of the spinal cord. The preganglionic neuron may do one of three things in the sympathetic ganglion:

1. Synapse with postganglionic neurons which then re-enter the spinal nerve and ultimately pass out to the sweat glands and the walls of blood vessels near the surface of the body.
2. Pass up or down the sympathetic chain and finally synapse with postganglionic neurons in a higher or lower ganglion



3. Leave the ganglion by way of a cord leading to special ganglia (e.g. the solar plexus) in the viscera. Here it may synapse with postganglionic sympathetic neurons running to the smooth muscular walls of the viscera. However, some of these preganglionic neurons pass right on through this second ganglion and into the **adrenal medulla**. Here they synapse with the highly-modified postganglionic cells that make up the secretory portion of the adrenal medulla.

The neurotransmitter of the preganglionic sympathetic neurons is **acetylcholine (ACh)**. It stimulates action potentials in the postganglionic neurons. The neurotransmitter released by the postganglionic neurons is **noradrenaline** (also called **norepinephrine**). The action of noradrenaline on a particular gland or muscle is excitatory in some cases, inhibitory in others. (At excitatory terminals, **ATP** may be released along with noradrenaline.)

The **release of noradrenaline** stimulates **heartbeat**, raises **blood pressure**, dilates the pupils, dilates the **trachea and bronchi**, stimulates the conversion of liver **glycogen** into glucose, shunts blood away from the skin and viscera to the skeletal muscles, brain, and heart, inhibits peristalsis in the gastrointestinal (GI) tract and inhibits contraction of the bladder and rectum. In short, stimulation of the sympathetic branch of the autonomic nervous system prepares the body for emergencies: for "**fight or flight**". Activation of the sympathetic system is quite general because a single preganglionic neuron usually synapses with many postganglionic neurons; the release of **adrenaline** from the **adrenal medulla** into the blood ensures that all the cells of the body will be exposed to sympathetic stimulation even if no postganglionic neurons reach them directly.

2.3.2. The Parasympathetic Nervous System

The main nerves of the parasympathetic system are the tenth cranial nerves, the **vagus nerves**. They originate in the **medulla oblongata**. Other preganglionic parasympathetic neurons also extend from the brain as well as from the lower tip of the spinal cord. Each preganglionic parasympathetic neuron synapses with just a few postganglionic neurons, which are located near - or in - the effector organ, a muscle or gland. **Acetylcholine (ACh)** is the neurotransmitter at all the pre- and many of the postganglionic neurons of the parasympathetic system. However, some of the postganglionic neurons release **nitric oxide (NO)** as their neurotransmitter.

Parasympathetic stimulation causes slowing down of the heartbeat, lowering of blood pressure, constriction of the pupils, increased blood flow to the skin and viscera and peristalsis of the GI tract. In short, the parasympathetic system returns the body functions to normal after they have been altered by sympathetic stimulation. In times of danger, the sympathetic system prepares the body for violent activity. The parasympathetic system reverses these changes when the danger is over.

The vagus nerves also help keep **inflammation** under control. Inflammation stimulates nearby sensory neurons of the vagus. When these nerve impulses reach the medulla oblongata, they are relayed back along motor fibres to the inflamed area. The acetylcholine from the motor neurons suppresses the release of inflammatory cytokines, e.g., **tumour necrosis factor (TNF)**, from macrophages in the inflamed tissue. Although the autonomic nervous system is considered to be involuntary, this is not entirely true. A certain amount of conscious control can be exerted over it as has long been demonstrated by practitioners of Yoga and Zen Buddhism. During their periods of meditation, these people are clearly able to alter a number of autonomic functions including heart rate and the rate of oxygen consumption. These changes are not simply a reflection of decreased physical activity because they exceed the amount of change occurring during sleep or hypnosis.

2.3.3. The Sensory-Somatic Nervous System

The sensory-somatic system consists of 12 pairs of **cranial nerves** and 31 pairs of **spinal nerves**.

(a) The Cranial Nerves

Nerves	Type	Function
I Olfactory	sensory	olfaction (smell)
II Optic	sensory	Vision (Contain 38% of all the axons connecting to the bra

III Oculomotor	motor*	eyelid and eyeball muscles
IV Trochlear	motor*	eyeball muscles
V Trigeminal	mixed	Sensory: facial and mouth sensation Motor: chewing
VI Abducens	motor*	eyeball movement
VII Facial	mixed	Sensory: taste Motor: facial muscles and salivary glands
VIII Auditory	sensory	hearing and balance
IX Glossopharyngeal	mixed	Sensory: taste Motor: swallowing
X Vagus	mixed	main nerve of the parasympathetic nervous system (PNS)
XI Accessory	motor	swallowing; moving head and shoulder
XII Hypoglossal	motor*	tongue muscles

***Note:** These do contain a few sensory neurons that bring back signals from the muscle spindles in the muscles they control.

(b) The Spinal Nerves

All of the spinal nerves are "mixed"; that is, they contain both sensory and motor neurons. All our conscious awareness of the external environment and all our motor activity to cope with it operate through the sensory-somatic division of the PNS.