Pharmacology

Mid Material – Lecture 10

The Autonomic Nervous System

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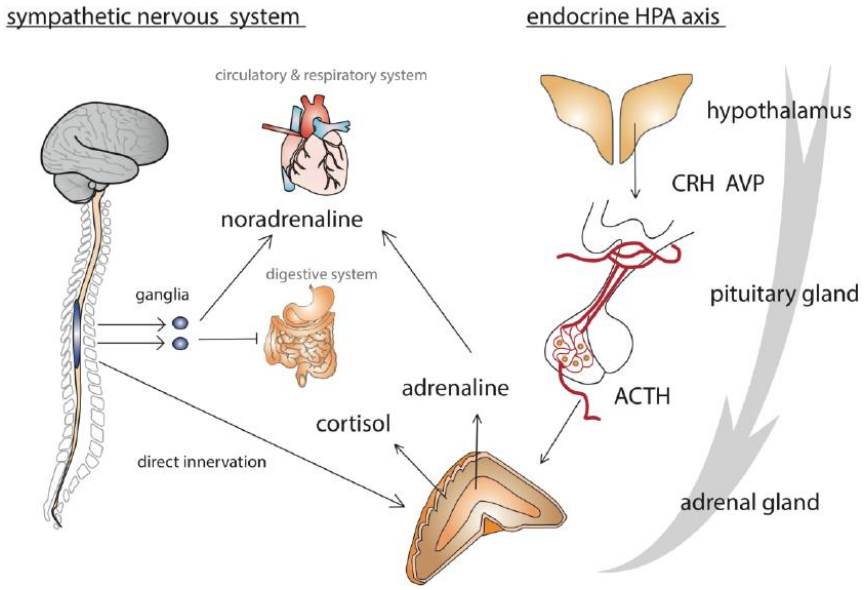
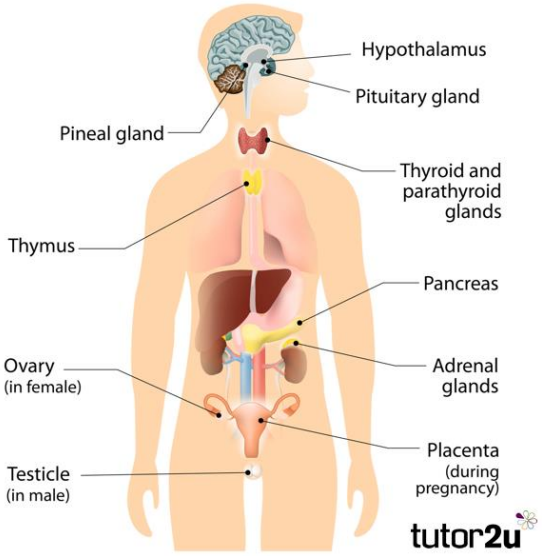
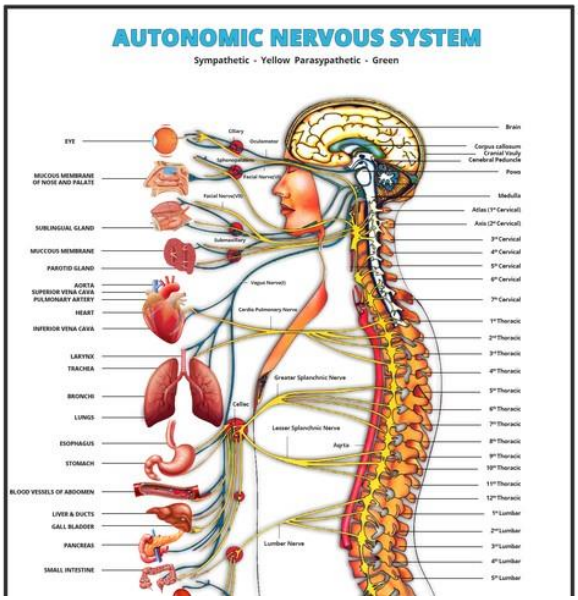
Contact me on Facebook or 0788330810 for any queries

The Autonomic Nervous System

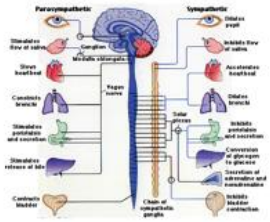


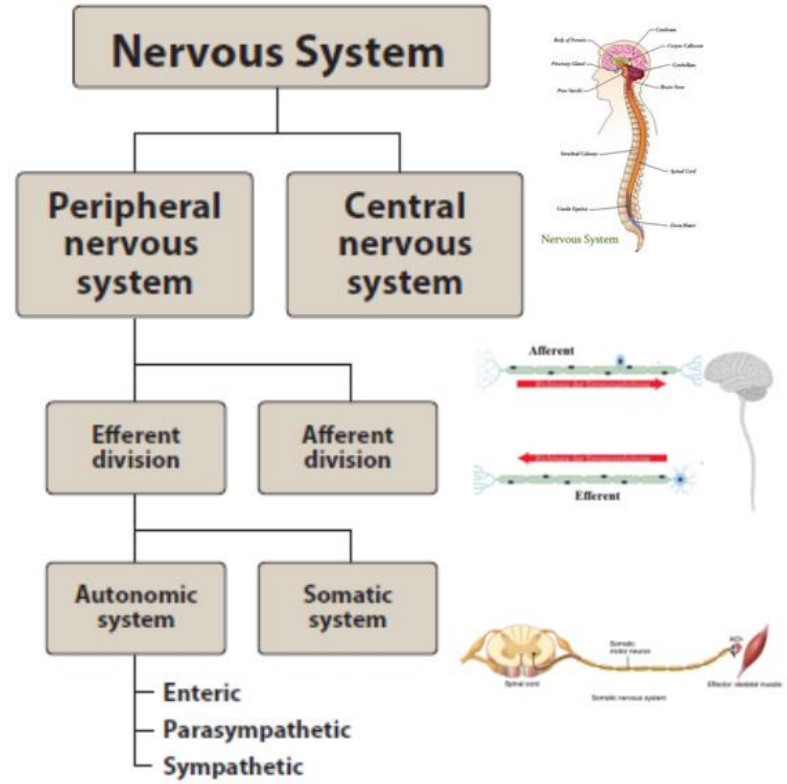
- The endocrine system sends signals to target tissues by varying the levels of blood-borne **hormones**
- The nervous system exerts its influence by the rapid transmission of electrical impulses over nerve fibres that terminate at effector cells, which specifically respond to the release of **neuromodulator** substances.
- Both endocrine sys and nervous Sys work together to control our physiological functions, and maintain our life.





Introduction to the Nervous System

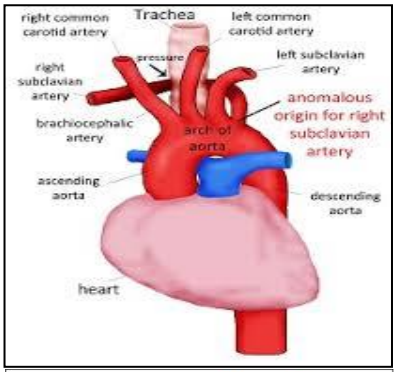




Afferent neurons provide <u>sensory input to modulate the function of the efferent</u> division through reflex arcs or neural pathways that mediate a reflex action

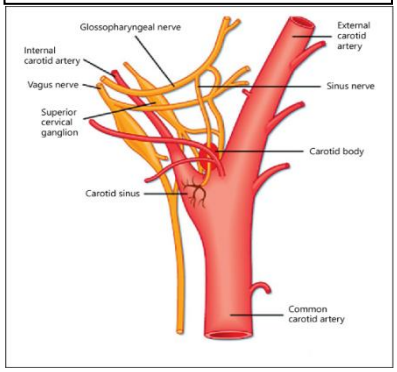
Functional divisions within the nervous system

1. **Afferent** peripheral nervous system
2. **Efferent** peripheral nervous system



Afferent Peripheral nervous system

- The afferent neurons (fibres) of the ANS are important in the <u>reflex regulation</u> of this system (for example, by sensing pressure in the **carotid sinus and aortic arch**) and in signalling the CNS to influence the efferent branch of the system to respond.



Efferent peripheral nervous system:

1. Somatic: involved in the **voluntary control** of functions such as contraction of the skeletal muscles essential for locomotion.
2. Autonomic: regulates the everyday requirements of vital bodily functions **without the conscious** participation of the mind

1. Somatic nervous system

- The efferent somatic nervous system differs from the ANS in that a single myelinated motor neuron, originating in the CNS, travels directly to skeletal muscle without the mediation of ganglia.
- The somatic nervous system is under **voluntary** control, whereas the ANS is involuntary.
- Responses in the somatic division are generally **faster** than those in the ANS.
- The somatic nervous system innervates skeletal muscles.
- One somatic motor neuron axon is highly branched, and each branch innervates a single muscle fibre.
- Thus, one somatic motor neuron may innervate 100 muscle fibres.
- This arrangement leads to the formation of a motor unit.
- The **lack of ganglia** and the **myelination** of the motor nerves enable a fast response by the somatic nervous system.

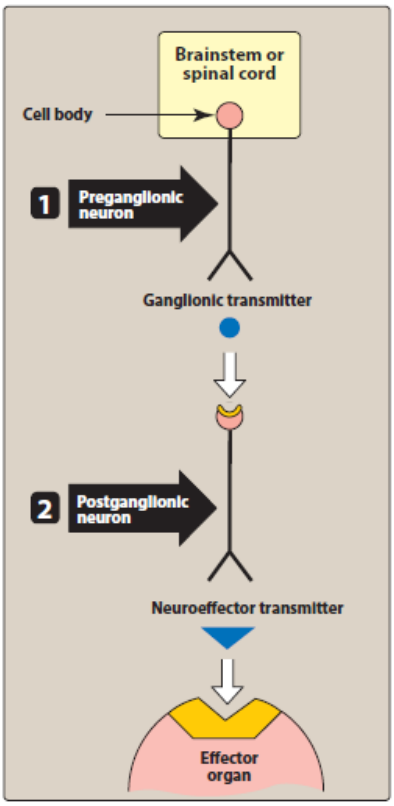
Somatic nervous system

2. Autonomic Nervous System

- It is also called the visceral, vegetative, or involuntary nervous system (because of its involuntary nature).
- It is composed of efferent neurons that innervate smooth muscle of the viscera, cardiac muscle, vasculature, and the exocrine glands, thereby controlling **digestion**, **cardiac output**, **blood flow**, and **glandular secretions.**

Anatomy of the ANS

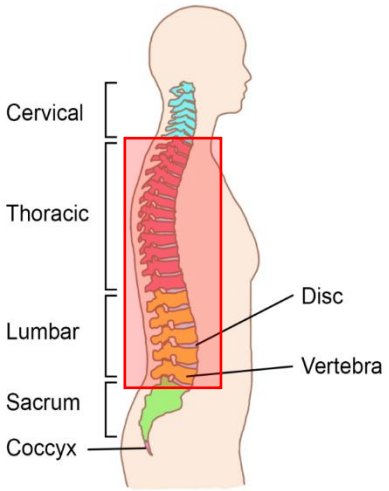
- **Efferent neurons:**
- The ANS carries nerve impulses from the CNS to the effector organs by way of two types of efferent neurons:
  1. The **pre**ganglionic neurons
  2. The **post**ganglionic neurons
- The cell body of the first nerve cell, the preganglionic neuron, is located within the **CNS**.
- The preganglionic neurons emerge from the brainstem or spinal cord and make a synaptic connection in **ganglia** (an aggregation of nerve cell bodies located in the peripheral nervous system).
- The ganglia function as relay **stations** between the preganglionic neuron and the second nerve cell, the postganglionic neuron.
- The cell body of the postganglionic neuron originates in the **ganglion**. It is generally nonmyelinated and terminates on effector organs, such as smooth muscles of the viscera, cardiac muscle, and the exocrine glands.

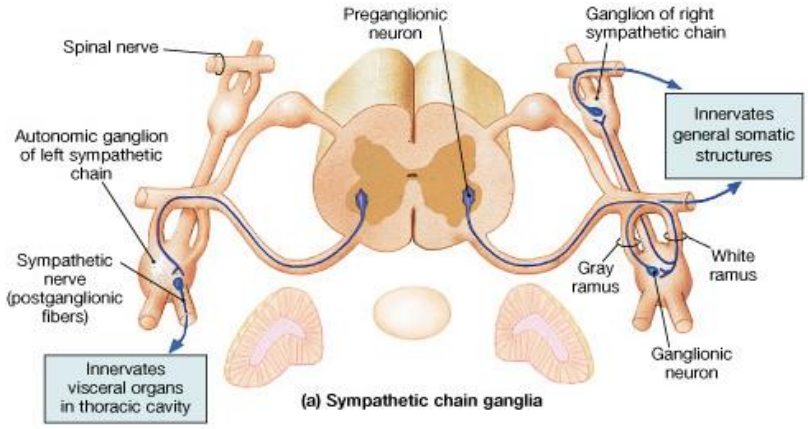


- The efferent ANS is divided into
  1. The sympathetic nervous system
  2. The parasympathetic nervous system
  3. The enteric nervous system

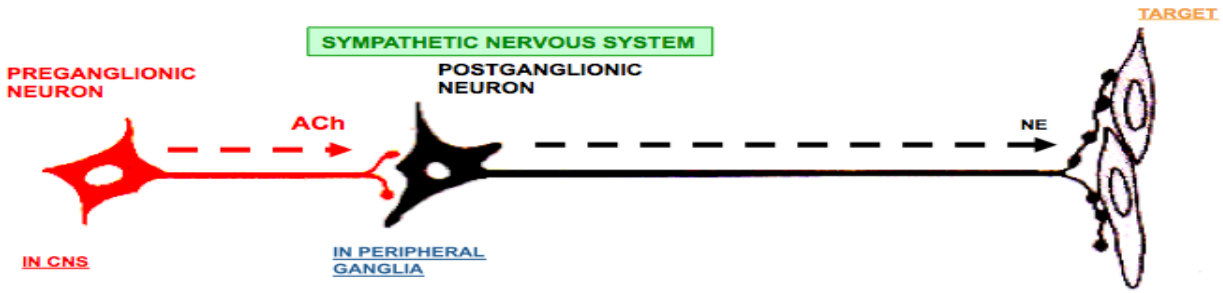
Sympathetic neurons

- Originate in the CNS and emerge from the spinal cord.
- The preganglionic neurons come from the thoracic and lumbar regions (T1 to L2) of the spinal cord, and they synapse in two cord-like chains of ganglia that run close to and in parallel on each side of the spinal cord.

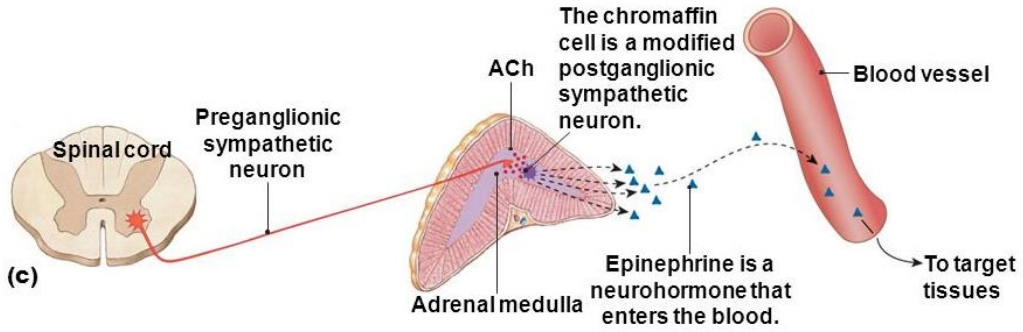




- The preganglionic neurons are short in comparison to the postganglionic ones.
- Axons of the postganglionic neuron extend from these ganglia to the tissues that they innervate and regulate.
- In most cases, the preganglionic nerve endings of the sympathetic nervous system are highly branched, enabling one preganglionic neuron to interact with many postganglionic neurons.
- This arrangement enables this division to activate numerous effector organs at the same time.

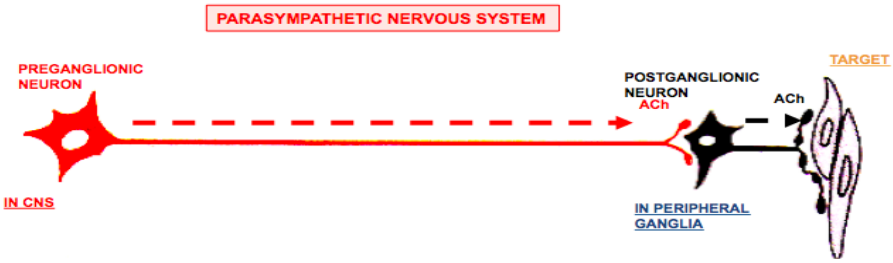


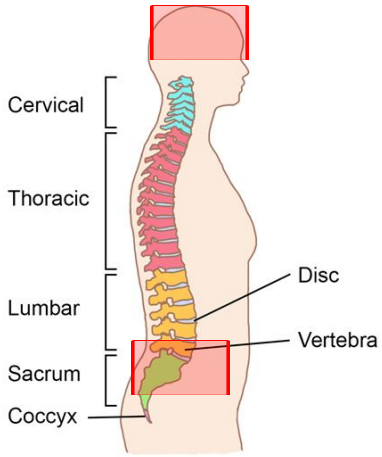
- The adrenal medulla, like the sympathetic ganglia, receives preganglionic fibres from the sympathetic system.
- The adrenal medulla, in response to stimulation by the ganglionic neurotransmitter **acetylcholine**, secretes epinephrine (adrenaline), and lesser amounts of norepinephrine, directly into the blood.



Parasympathetic neurons

- The preganglionic fibres arise from cranial nerves III (oculomotor), VII (facial), IX (glossopharyngeal), and X (Vagus), as well as from the sacral region (S2 to S4) of the spinal cord.
- They synapse in ganglia near or on the effector organs





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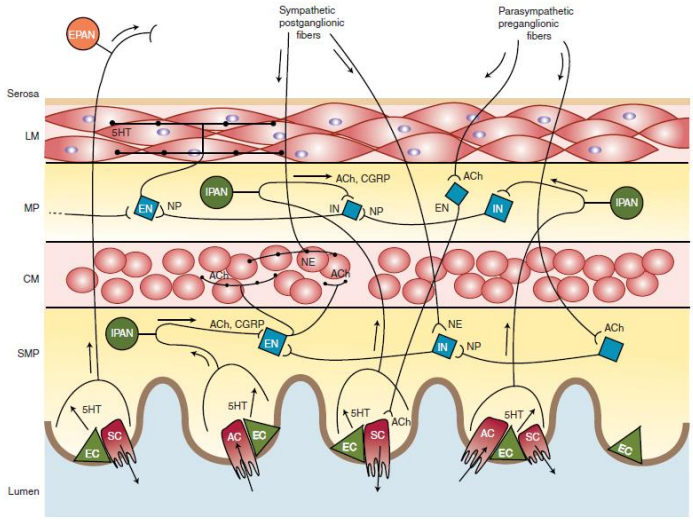
- The Vagus nerve accounts for 90% of preganglionic parasympathetic fibres in the body.
- Postganglionic neurons from this nerve innervate most of the organs in the thoracic and abdominal cavity
- In most instances, there is a **one-to-one** connection between the preganglionic and postganglionic neurons, enabling discrete response of this system

Enteric neurons

- They are a collection of nerve fibres that innervate the gastrointestinal (GI) tract, pancreas, and gallbladder, and it constitutes the "brain of the gut."
- This system functions **independently of the CNS** and controls the motility, exocrine and endocrine secretions, and microcirculation of the GI tract.
- It is modulated by both the sympathetic and parasympathetic nervous systems.



Functions of the sympathetic nervous system

- Although continually active to some degree (for example, in maintaining the tone of vascular beds), the sympathetic division has the property of adjusting in response to **stressful situations**, such as trauma, fear, hypoglycaemia, cold, and exercise.

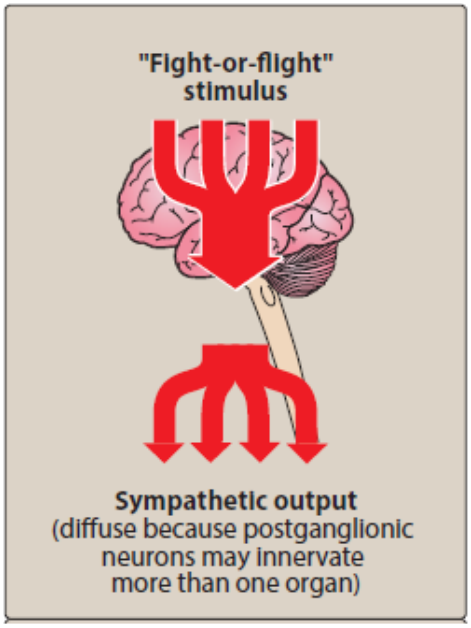
Effects of stimulation of the sympathetic division

- The effect of sympathetic output is to increase heart rate and blood pressure, to mobilize energy stores of the body, and to increase blood flow to skeletal muscles and the heart while diverting flow from the skin and internal organs.
- Sympathetic stimulation results in dilation of the pupils and the bronchioles. It also affects GI motility and the function of the bladder and sexual organs.

Fight-or-flight response:

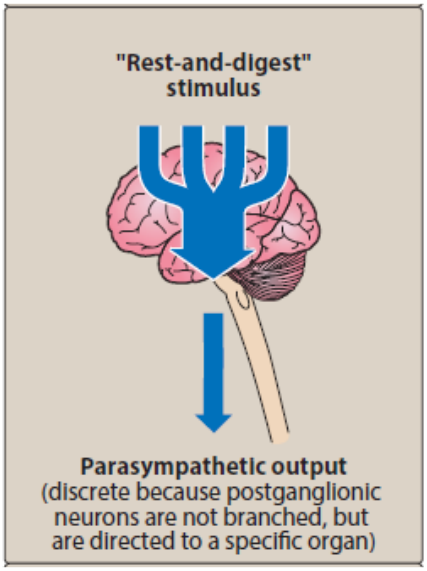
- The changes experienced by the body during emergencies are referred to as the "**fight or flight**" response.
- These reactions are triggered both by direct sympathetic activation of the effector organs and by stimulation of the adrenal medulla to release epinephrine and lesser amounts of norepinephrine.
- Hormones released by the adrenal medulla directly enter the bloodstream and promote responses in effector organs that contain adrenergic receptors.

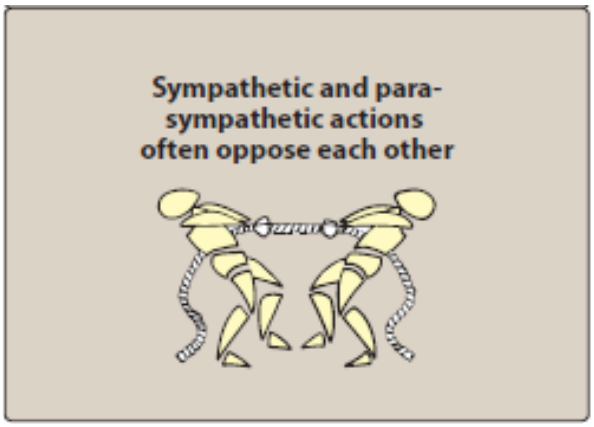
- The sympathetic nervous system tends to function as a unit and often **discharges as a complete system**, for example, during severe exercise or in reactions to fear.
- This system, with its diffuse distribution of postganglionic fibres, is involved in a wide array of physiologic activities.
- Although it is **not essential for survival**, it is nevertheless an important system that prepares the body to handle uncertain situations and unexpected stimuli.



Functions of the parasympathetic nervous system

- The parasympathetic division is involved with **maintaining homeostasis within the body**.
- It is required for life, since it maintains essential bodily functions, such as digestion and elimination of wastes.
- The parasympathetic division usually acts to oppose or balance the actions of the sympathetic division and generally predominates the sympathetic system in "**rest-and-digest**" situations.
- Unlike the sympathetic system, the parasympathetic system **never** discharges as a complete system.
- If it did, it would produce massive, undesirable, and unpleasant symptoms, such as involuntary urination and defecation.
- Instead, parasympathetic fibres innervating specific organs such as the gut, heart, or eye are activated separately, and the system functions to affect these organs individually.





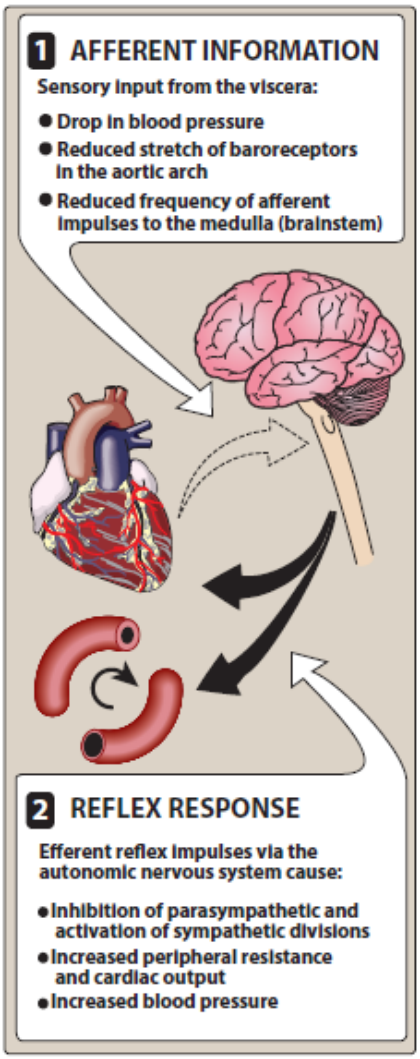
Role of the CNS in the control of autonomic functions

- Although the ANS is a motor system, it does require sensory input from peripheral structures to provide information on the current state of the body.
- This feedback is provided by streams of afferent impulses, originating in the viscera and other autonomically innervated structures that travel to integrating centres in the CNS, such as the hypothalamus, medulla oblongata, and spinal cord. These centres respond to the stimuli by sending out efferent reflex impulses via the ANS.

Reflex arcs

- Most of the afferent impulses are involuntarily translated into reflex responses.

- For example, a **fall in blood pressure** causes pressure-sensitive neurons (baroreceptors in the heart, vena cava, aortic arch, and carotid sinuses) to send fewer impulses to cardiovascular centres in the brain.
- This prompts a reflex response of increased sympathetic output to the heart and vasculature and decreased parasympathetic output to the heart, which results in a compensatory rise in blood pressure and tachycardia.
- In each case, the reflex arcs of the ANS comprise a sensory (or afferent) arm and a motor (or efferent or effector) arm.



Emotions and the ANS

- Stimuli that evoke strong feelings, such as rage, fear, and pleasure, can modify the activities of the ANS.

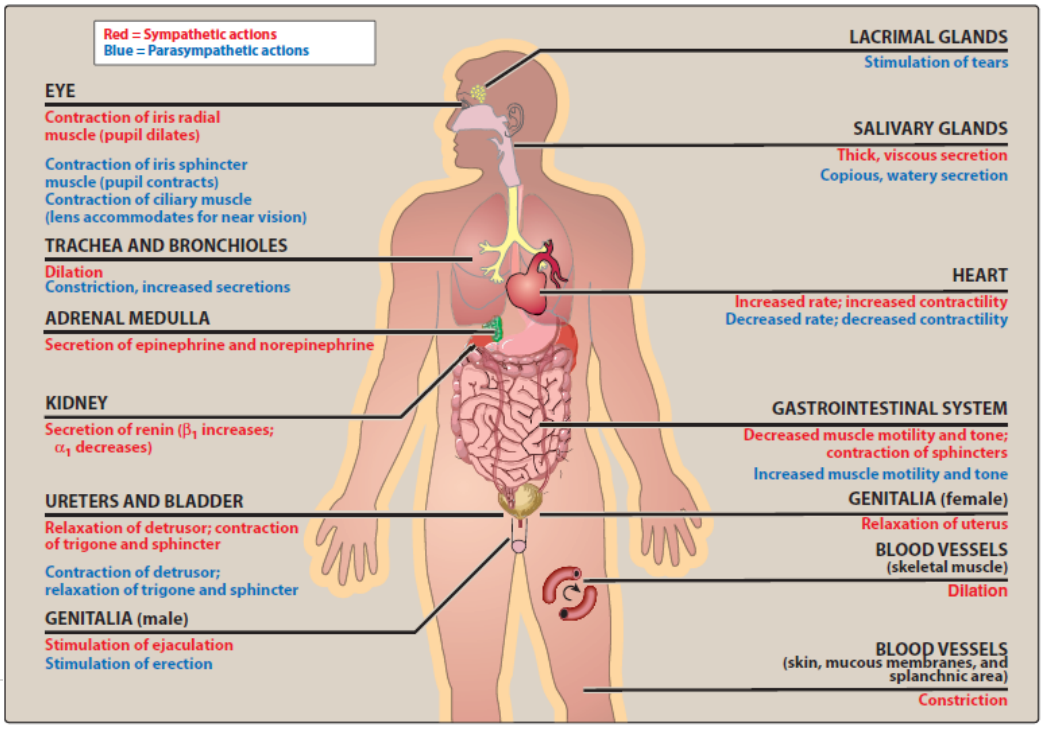
Innervation by the ANS

1. Dual innervation:

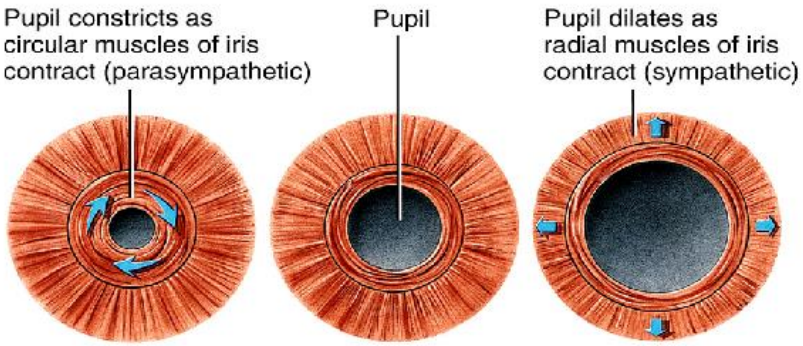
- Most organs in the body are innervated by both divisions of the ANS. Thus, vagal parasympathetic innervation slows the **heart rate**, and sympathetic innervation increases the heart rate.
- Despite this dual innervation, one system usually predominates in controlling the activity of a given organ.
- For example,
- in the heart, the Vagus nerve is the predominant factor for controlling rate.
- This type of antagonism is considered to be dynamic and is fine-tuned continually to control homeostatic organ functions.

2. Organs receiving only sympathetic innervation:

- Although most tissues receive dual innervation, some effector organs, such as the
  1. Adrenal medulla,
  2. Kidney,
  3. Pilomotor muscles, and
  4. Sweat glands,
- receive innervation only from the sympathetic system.



The eye



- **Summary of differences between sympathetic, parasympathetic,**

	SYMPATHETIC	PARASYMPATHETIC
Sites of origin	Thoracic and lumbar region of the spinal cord (thoracolumbar)	Brain and sacral area of the spinal cord (craniosacral)
Length of fibers	Short preganglionic Long postganglionic	Long preganglionic Short postganglionic
Location of ganglia	Close to the spinal cord	Within or near effector organs
Preganglionic fiber branching	Extensive	Minimal
Distribution	Wide	Limited
Type of response	Diffuse	Discrete

Autonomic drugs

- Autonomic drugs: drugs that produce their primary therapeutic effect by <u>mimicking or altering the functions of the ANS</u>

- Autonomic drugs act by:
  1. **Stimulating** portions of the ANS
  2. **Blocking** the action of the autonomic nerves (nerves, affecter cells, glands)

Test Yourself

Overdose Midterm selected questions:

1. Regarding to Sympathetic neurons, all statements are true except:
   a) Preganglionic neurons are short.
   b) use Ach for sweat glands.
   c) stimulates adrenal medulla, in response to adrenaline, release epinephrine and lesser amount of nor-epinephrine.

   Answer: C

Vagus Midterm selected questions:

1. Which one of the following organs receives a dual innervation (innervated by both divisions of the ANS)?
   Answer: Eye

2. Which one of the following is FALSE regarding the somatic nervous system?
   Answer: The somatic nervous system is involuntary (voluntary)

3. Which one of the following is TRUE regarding the ANS neurons?
   Answer: The sympathetic preganglionic neurons are short in comparison to the postganglionic neurons