The Autonomic Nervous System

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The Autonomic Nervous System
The Autonomic Nervous System

A neuron, complete with axon, dendrites, and synapses.
Peripheral nervous system

is divided into

★ The somatic nervous system which controls organs under voluntary control (mainly muscles)

★ The Autonomic Nervous System (ANS) which regulates individual organ function and homeostasis, and for the most part is not subject to voluntary control
The Autonomic Nervous System (ANS)

• Acts below the level of consciousness

• Is predominantly an **efferent** system transmitting impulses from the CNS to peripheral organ.

• Also some **afferent** fibers transmit impulses from the periphery to the CNS.
Afferent autonomic fibers

- They are concerned with:
  - Mediation of visceral sensation.
  - Regulation of vasomotor and respiratory reflexes e.g. baroreceptors & chemoreceptors in the carotid sinus and aortic arch.

- These afferent fibers are usually carried to the CNS by major autonomic nerves such as the vagus, splanchnic or pelvic nerves.
The Autonomic Nervous System

ANS effects in general

- Control of heart rate and force of contraction.
- Constriction and dilatation of blood vessels.
- Contraction and relaxation of smooth muscle in various organs.
- Visual accommodation, pupillary size.
- Secretions from exocrine and endocrine glands.
The Autonomic Nervous System

Autonomic Nervous System Division

- The parasympathetic Nervous System PNS
- The sympathetic Nervous Systems SNS

- Both consist of myelinated preganglionic fibers which synapse with unmyelinated postganglionic fibers, and then innervate the effector organ.

- Most organs are innervated by fibers from both except sweats glands and spleen are only innervated only by SNS.
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Parasympathetic Nervous System

Promotes a "rest and digest" response, promotes calming of the nerves, return to regular function, and enhances digestion.

The preganglionic outflow arises from the cell bodies of the motor nuclei of cranial nerves III, VII, IX and X in the brain stem and from the 2nd, 3rd & 4th sacral segments of the spinal cord.

It is therefore also known as the cranio-sacral outflow.
The Autonomic Nervous System

Parasympathetic Nervous System

- The cranial nerves III, VII and IX affect the pupil and salivary gland secretion.

- The vagus nerve (X) carries fibers to the heart, lungs, stomach, upper intestine and ureter.

- The sacral fibers innervate the distal colon, rectum, bladder and reproductive organs.
The Autonomic Nervous System

Parasympathetic Nervous System

- Preganglionic fibers pass directly to the organs. Postganglionic bodies lie near or within the viscera of the organ.

- Ratio of postganglionic to preganglionic in many organs is 1:1 or 3:1 except distal colon 8000:1

- Limited PNS effect, e.g. bradycardia without changes in intestinal motility.
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Parasympathetic Nervous System

Parasympathetic (Sacral) 

Preganglionic 

Postganglionic 

Viscera 

(Postganglionic) 

ACh

ACh

Muscarinic
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Parasympathetic Nervous System

- In physiological terms, the parasympathetic system is concerned with conservation and restoration of energy.

- It causes a reduction in heart rate and blood pressure, facilitates digestion and absorption of nutrients, and consequently the excretion of waste products.
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Parasympathetic Nervous System Transmission

- The chemical transmitter at both pre and postganglionic synapses in the PNS is **Acetylcholine (Ach)**.

- The synthesis of Ach occurs in the cytoplasm of nerve endings and is stored in vesicles in the presynaptic terminal.

- Ach receptors have been subdivided pharmacologically by the actions of the alkaloids into muscarinic & nicotinic receptors.
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Parasympathetic Nervous System Transmission

- Most transmissions occur in two stages:
  - When stimulated, the preganglionic nerve releases ACh at the ganglion, which acts on nicotinic receptors of postganglionic neurons.
  - The postganglionic nerve then releases ACh to stimulate the muscarinic receptors of the target organ.

- The action of Ach is terminated when the enzyme acetylcholinesterase degrades the ACh.
Sympathetic Nervous System

- Promotes a "fight or flight" response.

- The cell bodies of the sympathetic preganglionic fibers are in the intermediolateral horns of the spinal segments T1-L3 (thoraco-lumbar) outflow.

- The preganglionic fibers travel a short distance in the mixed spinal nerve, and then branch off as white rami (myelinated) to enter the sympathetic ganglia.
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Sympathetic Nervous System

Dorsal Root Ganglion (Sensory)
Ventral Horn Cell
Lateral Horn Cells
Ventral Root
Gray Ramus
White Ramus
Collateral Ganglion

Preganglionic Fibers
Postganglionic Fibers
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Sympathetic Nervous System

The preganglionic fibers may follow one of three ways:

1. Synapse with postganglionic fibers in ganglia at level of exit.

1. Path upward or downward in the trunk of the SNS chain to synapse in ganglia at other levels.

2. Track for variable distances through the sympathetic chain and exit without synapsing to terminate in an outlying, unpaired, SNS collateral ganglion.
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Sympathetic Nervous System

- Ganglia (plexus) are formed by merging of preganglionic fibers with many postganglionic neuron bodies.

- SNS ganglia lies mostly near spinal cord.

- Unmyelinated postganglionic fibers pass from the ganglia to the organs.

- Mass reflex or diffuse reaction because the ratio of postganglionic to preganglionic is 20:1 to 30:1.
Sympathetic Nervous System

- Sympathetic ganglionic chains: are 2 paravertebral chains, lie anterolateral to the vertebral bodies & extend from the cervical to the sacral region.

- Two neurotransmitters are primarily associated with this system: epinephrine and norepinephrine
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Sympathetic Nervous System

Fight or flight responses

- Heart and circulation:
  - Increase in heart rate.
  - Increased myocardial contractility.
  - Increase in blood pressure.

- Lungs:
  - Increase respiratory rate.
  - Dilatation of the bronchus.
Sympathetic Nervous System

Fight or flight responses

• Skin:
  – Increased sweating
  – Piloerection

• Metabolic:
  – Exemption of glucose by liver and muscle.
  – Inhibition of insulin release.
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Sympathetic Nervous System

Fight or flight responses

- Blood:
  - Reduced blood clotting time.
  - Mobilization of RBC from the spleen.

- Gastrointestinal system:
  - Decreased activity.

- At the same time, the activity of the PNS will be diminished
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Sympathetic Nervous System Transmitter

Catecholamine: are a group of neurotransmitters that arise in sequence from the amino acid phenylalanine.
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Chapter 15: Autonomic Nervous System

Phenylalanine → Tyrosine → Dopa → Dopamine → Norepinephrine → Epinephrine

- Phenylalanine
- Tyrosine
- Tyrosine Hydroxylase
- Dopa
- Dopa Decarboxylase
- Dopamine
- Dopamine β-Hydroxylase
- Norepinephrine
- Phenylethanolamine N-methyltransferase
- Epinephrine
The Autonomic Nervous System

Sympathetic Nervous System Transmitter

Adrenergic drugs

- **Dopamine**
  - ![Dopamine Chemical Structure](image)

- **Norepinephrine**
  - ![Norepinephrine Chemical Structure](image)

- **Epinephrine**
  - ![Epinephrine Chemical Structure](image)

Sympathomimetic drugs like clonidine

- ![Clonidine Chemical Structure](image)
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Sympathetic and Parasympathetic Receptors

- Receptors are target site that when activated by agonist → a response
- Agonist is a substance that reacts with the receptors to evoke a biological effect
- Ach, DA, NE, EPI & Adenosine triphosphate are the main agonist of the ANS
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### Cholinergic Receptors

**Muscarinic Receptors:**

- PNS postganglionic junctions
- Presynaptic membrane of SN terminals in myocardium, coronary vessels, & peripheral vasculature.
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Cholinergic Receptors

Muscarinic Receptors:

- Stimulation →
  - Bradycardia
  - -ve inotropic effect
  - bronchoconstriction
  - Miosis
  - salivation, gastrointestinal hypermotility, & ↑gastric acid secretion
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Cholinergic Receptors

Nicotinic Receptors:

- Synaptic junctions of both SNS and PNS ganglia.

- Ach or nicotine can stimulate these receptors.

- Nicotine in low doses induce stimulation while in high concentration induce blockade.

- Nicotinic stimulation of SNS ganglia produces hypertension & tachycardia due to release of EPI and NE.
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Adrenergic Receptors

- They are targets for catecholamine.
- Adrenergic, the receptors are responsive to adrenaline (EPI).
- Noradrenergic, they are responsive to noradrenaline (NE).
- DA is a catecholamine but also works on the dopaminergic receptors.
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Adrenergic Receptors

Alpha 1 Receptors

- Vascular smooth muscle postsynaptic neurons
  - Vasoconstriction

- Myocardium
  - Positive Inotrope
  - Negative Chronotrope
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Adrenergic Receptors

Alpha 1 Receptors

- Eye
  - Radial muscle contraction

- Gastrointestinal and Genitourinary
  - Sphincter contraction
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Adrenergic Receptors

Peripheral Alpha 2 Receptors

- Vascular Smooth Muscle (mixed effect)
  - Modulates large vessel tone
  - Arteriolar and venous vasoconstriction
  - Inhibits norepinephrine release
  - Decreases adrenergic activity

- Gastrointestinal
  - Smooth muscle wall relaxation

Oppose alfa 1 effect
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Adrenergic Receptors

Alpha 2 Receptors

- Metabolic
  - Fat Cell Lipolysis

- Central
  - Peripheral vasodilatation
  - Inhibits Locus Ceruleus reflex arc
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Adrenergic Receptors

Alpha receptors effect: summary

- Alpha 1-postsynaptic vasoconstriction artery & veins.
- Cardiac alpha 1-receptors: inotropy & decrease heart rate

- Alpha 2-receptors in brain: antihypertension & sedation.
- Alpha 2-receptors postsynaptic mediate constriction of smooth muscle
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Adrenergic Receptors

Beta 1 Receptor

- Myocardium
  - Increases Myocardial Contractility
  - Increases Heart Rate
  - Accelerates sinoatrial node
  - Accelerates ectopic Pacemakers

- Metabolic: Fat Cell Lipolysis

- Kidney Renin Release
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Adrenergic Receptors

Beta 2 Receptor

- Vessel: Vasodilatation
- Lung: Bronchodilator
- Genitourinary and Gastrointestinal
  - Bladder wall relaxes
  - Pregnant Uterus relaxes
- Metabolic: Liver gluconeogenesis and glycogenolysis
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Adrenergic Receptors

Beta 3 Receptors

- No significant clinical effect
- May enhancement of lipolysis in adipose tissue
- May have some CNS effects
Dopaminergic receptors (DA)

- Found in CNS, blood vessels and postganglionic sympathetic nerves.

- Not founded in the myocardium

- Subdivided into DA 1 and DA 2.

- DA1 are postsynaptic receptors while DA 2 are both.

- Stimulation of DA2 presynaptic $\rightarrow$ inhibition of NE release $\rightarrow$ vasodilatation
Dopaminergic receptors (DA)

- Stimulation of DA2 postsynaptic receptors lead to vasoconstriction

- DA in esophagus, stomach, and small intestine $\rightarrow$ secretion & $\downarrow$ intestinal motility.

- Metoclopramide (primperam), a DA antagonist, is useful for aspiration prophylaxis.
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Dopaminergic receptors (DA)

CNS effect of DA

- Release of prolactin (hypothalamus)
- Parkinson disease (substantia nigra)
- Coordinate motor function (basal ganglia)
- Nausea and vomiting (chemoreceptors in medulla obligata)
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Adenosine Receptors

• Agonist is Adenosine

• Antagonist are caffeine, theophylline and dimethylxanthine

• Adenosine inhibit NE release

• Regulate myocardial oxygen consumption and coronary blood flow

• Regulating the release of other neurotransmitters as dopamine & glutamate
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Serotonin Receptors

- Also known as 5-hydroxytryptamine receptors 5-HT receptors
- G protein-coupled receptors and ligand-gated ion channels
- They mediate both excitatory and inhibitory neurotransmission
- Various biological and neurological effect such as aggression, anxiety, mood, nausea, sleep, and thermoregulation
- Zofran is a serotonin 5-HT3 receptor antagonist
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Still to be read

Still to read

prostaglandin E2 receptors

Pharmacology of autonomic nervous system

Paul G. Barash Clinical Anesthesia, 6th edition CHAPTER 1