

4th Lecture

The Neurotransmitters & Receptors of Autonomic Nervous System

Physiology Team- 430

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The Neurotransmitters & Receptors of Autonomic Nervous System

- **ANS Neurotransmitters:**

Classified based on the neurotransmitter released at the **postganglionic** neuron to:

- **Cholinergic**
- **Adrenergic**

Sympathetic	Neurotransmitter Released
Preganglionic (Cholinergic)	Acetylcholine (Ach)
<u>Postganglionic</u> (Adrenergic)	Norepinephrine

Parasympathetic	Neurotransmitter Released
Preganglionic (Cholinergic)	Acetylcholine (Ach)
<u>Postganglionic</u> (Cholinergic)	Acetylcholine (Ach)

- **Chemical or neural transmitter :**

- All **preganglionic** fibers release **acetylcholine** (Ach).
- All **parasympathetic postganglionic** fibers release **Ach**.
- All **sympathetic postganglionic** fibers release **noradrenalin** except sweat glands & blood vessels to skeletal muscles.

Structure	Sympathetic Stimulation	Parasympathetic Stimulation
Iris (eye muscle)	Pupil dilation	Pupil constriction
Salivary Glands	Saliva production reduced	Saliva production increased
Oral/Nasal Mucosa	Mucus production reduced	Mucus production increased
Heart	Heart rate and force increased	Heart rate and force decreased
Lung	Bronchial muscle relaxed	Bronchial muscle contracted
Stomach	Peristalsis reduced	Gastric juice secreted; motility increased
Small Intes	Motility reduced	Digestion increased
Large Intes	Motility reduced	Secretions and motility increased
Liver	Increased conversion of glycogen to glucose	
Kidney	Decreased urine secretion	Increased urine secretion
Bladder	Wall relaxed Sphincter closed	Wall contracted Sphincter relaxed

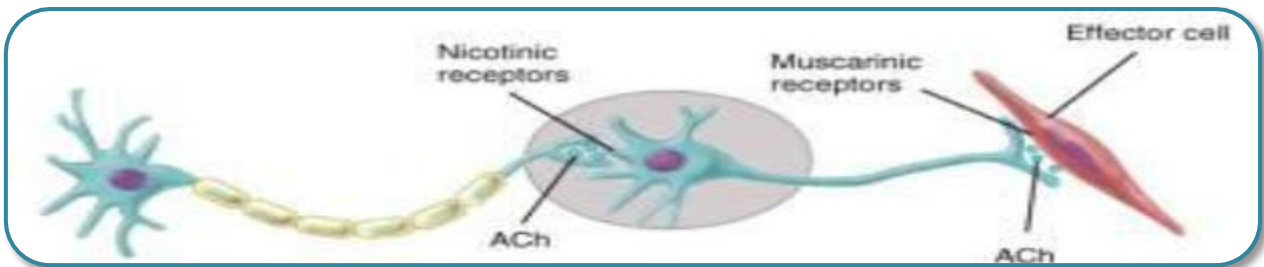
Sympathetic → Fear, Flight, Fright

Parasympatheic → Rest, Digest

• Receptors:

- Parasympathetic Nervous System acts on **two receptors**.
 - Muscarinic receptors.
 - Nicotinic Cholinergic receptors
- Most transmissions occur in **two stages**

Stimulation of **preganglionic** neuron (1st neuron) → **ACh release** → Acts on **nicotinic** receptors on **postganglionic** neuron (2nd neuron) → Release of **ACh** by the 2nd neuron → Stimulation of the **muscarinic** receptors on the target organ.



• Types of Muscarinic Receptors:

Receptor	Location	Action
M1	At the <u>Neural System</u>	
M2	At the <u>Heart</u>	<p>act to bring the heart back to normal after the actions of the sympathetic nervous system:</p> <p>slowing down the heart rate reducing contractile forces of the atrial cardiac muscle Reducing conduction velocity of the SA and AV node.</p> <p><i>*Note, they have no effect on the contractile forces of the ventricular muscle.</i></p>
M3	<u>At Many places in the body</u>	<ul style="list-style-type: none"> • smooth muscles of the blood vessels → <u>cause vasoconstriction</u> • lungs → cause <u>bronchioconstriction</u> • smooth muscles of the GIT → <u>help in increasing intestinal motility and dilating sphincters.</u> • many glands that help to stimulate secretion in salivary glands and other glands of the body.

- The Sympathetic Nervous System acts on **two types of receptors**:

* Alpha α

* Beta β

- **Types of α -adrenergic receptors:**

Receptor	Location	Action
Alpha 1 (α_1)	Found in <u>smooth muscle, heart, and liver.</u>	effects including : <ul style="list-style-type: none"> Vasoconstriction intestinal relaxation uterine contraction pupillary dilation
Alpha 2 (α_2)	<u>Platelets, Vascular smooth muscles, Nerve termini, Pancreatic islets</u>	<ul style="list-style-type: none"> platelets \rightarrow <u>platelet aggregation</u> vascular smooth muscle \rightarrow <u>vasoconstriction</u> nerve termini \rightarrow <u>inhibition of norepinephrine</u> pancreatic islets \rightarrow <u>inhibition of insulin secretion.</u>

α -adrenergic receptors \rightarrow respond to **nor epinephrine** and to blocking agents as phenoxybenzamine.

- **β receptor types**

Receptor	Location
β_1	The <u>Heart</u>
β_2	<u>The lungs, gastrointestinal tract, liver, uterus, vascular smooth muscle, and skeletal muscle.</u>
β_3	located in <u>fat cells.</u>

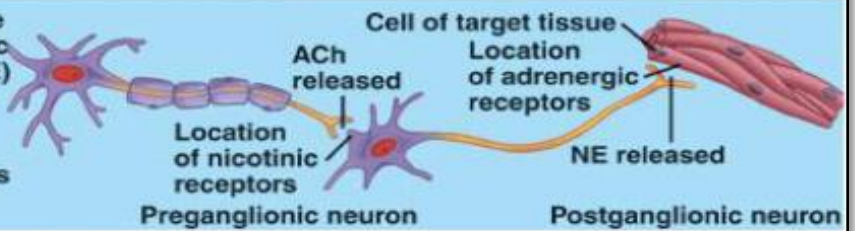
β -adrenergic receptors respond particularly to epinephrine and to such blocking agents as propranolol.

Neurotransmitters & Receptors

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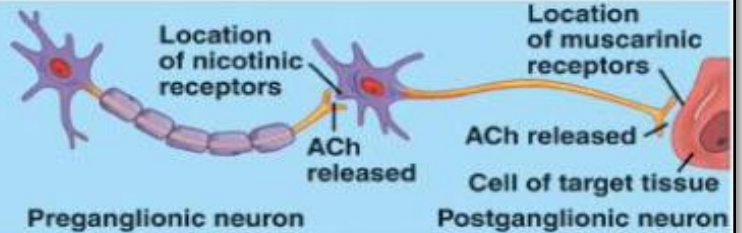
Sympathetic division

Most target tissues innervated by the sympathetic division have adrenergic receptors. When norepinephrine (NE) binds to adrenergic receptors, some target tissues are stimulated, and others are inhibited. For example, smooth muscle cells in blood vessels are stimulated to constrict, and stomach glands are inhibited.



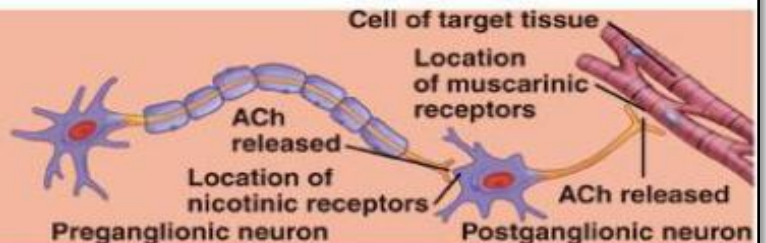
Sympathetic division

Some sympathetic target tissues, such as sweat glands, have muscarinic receptors, which respond to acetylcholine (ACh). Stimulation of sweat glands results in increased sweat production.



Parasympathetic division

All parasympathetic target tissues have muscarinic receptors. The general response to ACh is excitatory, but some target tissues, such as the heart, are inhibited.



Circulatory System	Sympathetic (Adrenergic)	Parasympathetic (Muscarine)
cardiac output	increases	M2: decreases
SA node: heart rate (chronotropic)	β_1 , β_2 : increases	M2: decreases
cardiac muscle: contractility (inotropic)	β_1 , β_2 : increases	M2: decreases (atria only)
conduction at AV node	β_1 : increases	M2: decreases
vascular smooth muscle	M3: contracts; α = contracts; β_2 = relaxes	---
platelets	α_2 : aggregates	---
mast cells-histamine	β_2 : inhibits	---

Respiratory System	Sympathetic (Adrenergic)	Parasympathetic (Muscarine)
smooth muscles of bronchioles	β_2 : relaxes (major contribution); α_1 : contracts (minor contribution)	M3: contracts

Endocrine	Sympathetic (Adrenergic)	Parasympathetic (Muscarine)
pancreas(islets)	α_2 : decreases secretion	---
adrenal medulla	secretes epinephrine	---

Urinary System	Sympathetic (Adrenergic)	Parasympathetic (Muscarine)
Bladder wall	β_2 : relaxes	Contracts
ureter	α_1 : contracts	relaxes
sphincter	α_1 : contracts; β_2 relaxes	relaxes

Reproductive System	Sympathetic (Adrenergic)	Parasympathetic (Muscarine)
uterus	$\alpha 1$: contracts; $\beta 2$: relaxes	---
genitalia	α : contracts	M3: erection
sweat gland secretions	M: stimulates (major contribution); $\alpha 1$: stimulates (minor contribution)	---
arrector pili	$\alpha 1$: stimulates	---

Nervous System	Sympathetic (Adrenergic)	Parasympathetic (Muscarine)
Pupil of eye	$\alpha 1$: relaxes	M3: contracts
ciliary muscle	$\beta 2$: relaxes	M3: contracts

<u>Digestive System</u>	Sympathetic (Adrenergic)	Parasympathetic (Muscarine)
salivary glands: secretions	β : stimulates viscous, amylase secretions; $\alpha 1$ = stimulates potassium	stimulates watery secretions
lacrimal glands(tears)	decreases	M3: increases
kidney(renin)	Secretes	---
parietal cells	---	M1: secretion
liver	$\alpha 1$, $\beta 2$: glycogenolysis, gluconeogenesis	---
Adipose cells	$\beta 3$: stimulates lipolysis	---
GI tract motility	decreases	M1, M3: increases
smooth muscles of GI tract	α , $\beta 2$: relaxes	M3: contracts
Sphincters of GI tract	$\alpha 1$: contracts	M3: relaxes
Glands of GI tract	Inhibits	M3: secretes

Summary

- Activation of **Alpha receptors** leads to **smooth muscle contraction**
- Activation of **Beta2 receptors** leads to **smooth muscle relaxation**
- Activation of **Beta1 receptors** leads to **smooth muscle contraction** (especially in heart)

■ Cholinergic Receptors:

- The two types of receptors that bind ACh are **nicotinic and muscarinic**
- These are named after drugs that bind to them and mimic ACh effects

■ Nicotinic Receptors

*Nicotinic receptors are found on:

- Motor end plates (somatic targets)
- All ganglionic neurons of both sympathetic and parasympathetic divisions
- The hormone-producing cells of the adrenal medulla

*The effect of ACh binding to nicotinic receptors is always **stimulatory**

■ Muscarinic Receptors

*Muscarinic receptors occur on all effector cells stimulated by **postganglionic cholinergic fibers**

*The effect of ACh binding:

- Can be either **inhibitory or excitatory**
- Depends on the receptor type of the target organ

■ Adrenergic Receptors

*The two types of adrenergic receptors are **alpha and beta**

*Effects of NE binding to:

- **Alpha** receptors is generally **stimulatory**
- **Beta** receptors is generally **inhibitory**

*A notable exception -NE binding to Beta receptors of the heart is **stimulatory**

■ Dual Innervations

- Most of viscera receive nerve fibers from both parasympathetic and sympathetic divisions
- Both divisions do not normally innervate an organ equally