Autonomic nervous system

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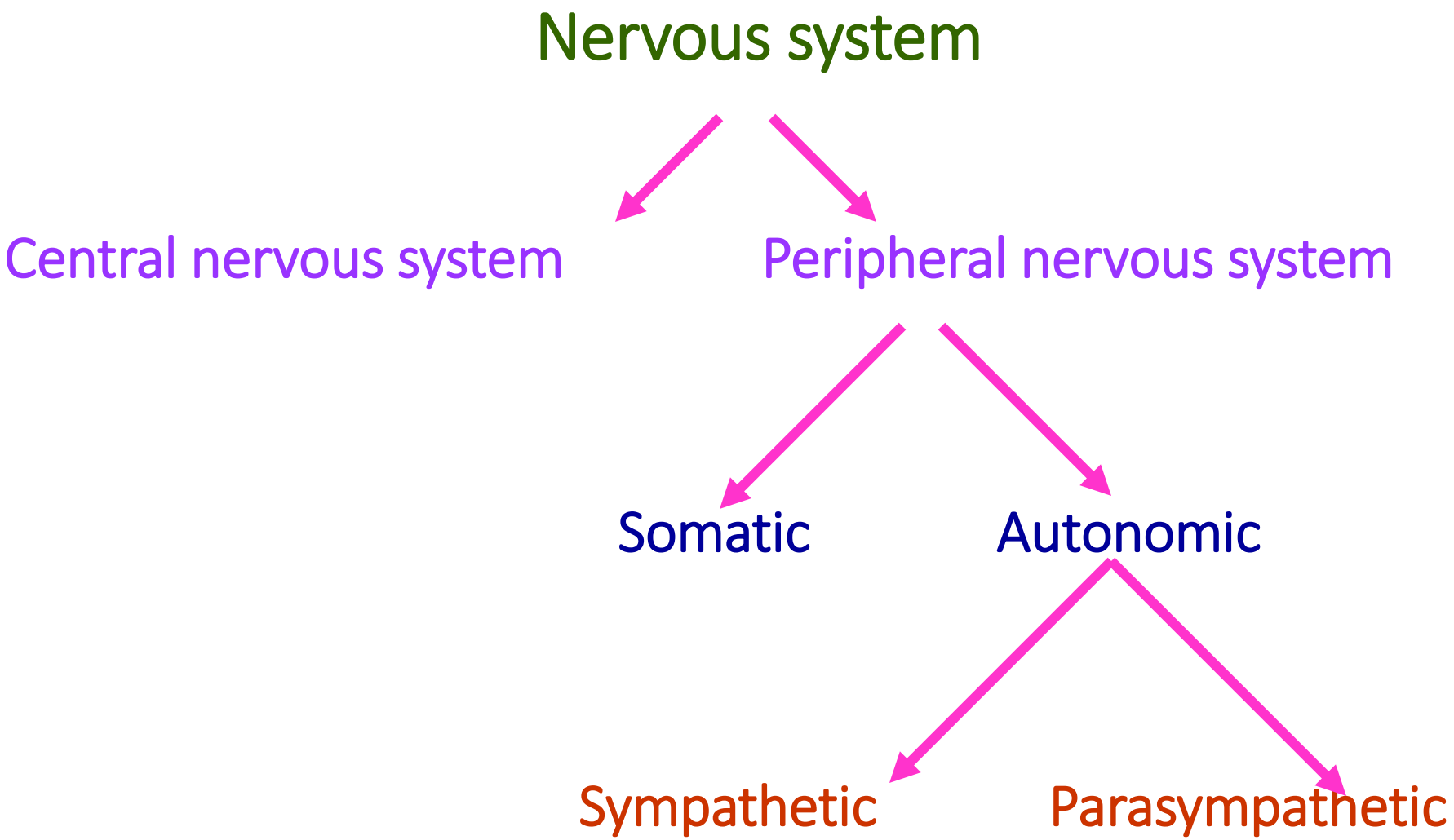
Objectives

- Describe the organization of the autonomic nervous system
- State the main neurotransmitters and receptors of the sympathetic and parasympathetic nervous systems.
- Outline the functions of the sympathetic and parasympathetic nervous systems.
- Outline the effects of the following drugs on autonomic nervous system.
  - atropine, beta agonists and antagonists, cholinergics anticholinergics, acetylcholine esterase inhibitors, prazosin,
- Outline the effects of following poisons and toxins on autonomic nervous system
  - organophosphate, parathion, nerve gas, Datura (Aththana)

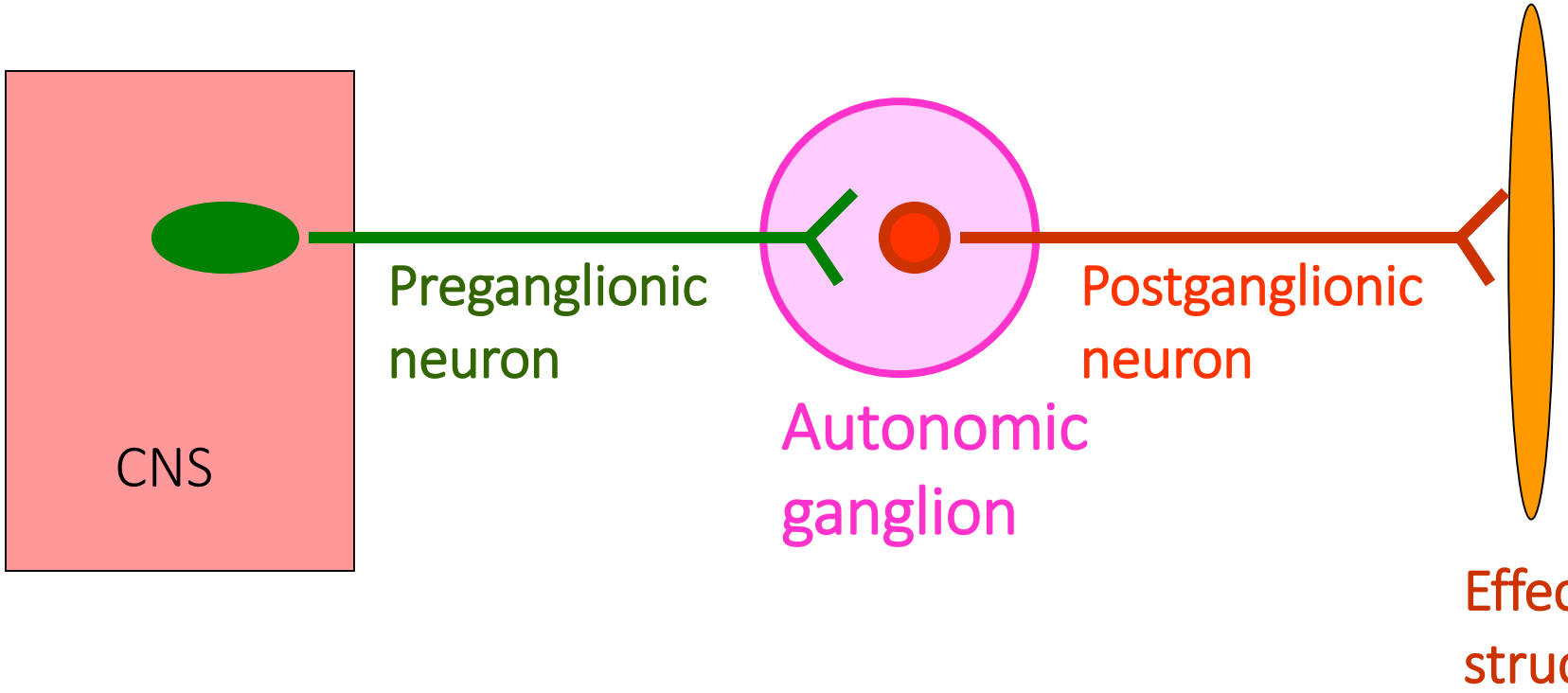

Nervous system
Central nervous system
Peripheral nervous system
Somatic
Autonomic
Sympathetic
Parasympathetic

Autonomic nervous system

- Regulates most of the involuntary activities of the body.
- Helps to control arterial pressure, gastrointestinal motility and secretions, sweating, body temperature etc.
- Innervate heart muscle, blood vessels, glands and smooth muscles in viscera

- Have 2 neurons between the central nervous system and the effector structure (the only exception is the innervation of the adrenal medulla)

- One preganglionic nerve connects with 8-9 postganglionic neurons



Neurotransmitters

- Acetylcholine -
  - Preganglionic authonomic
  - postganglionic parasympathetic
  - Some postganglionic sympathetic e.g. sweat gland, skeletal muscle blood vessels
- Noradrenalin
  - postganglionic sympathetic
- Dopamine
  - Interneurons in sympathetic ganglia
- GnRH
  - Some preganglionic nerves
- VIP
  - nonadrenergic/noncholinergic supply to bronchioles
- Neuropeptide Y

Autonomic nervous system I

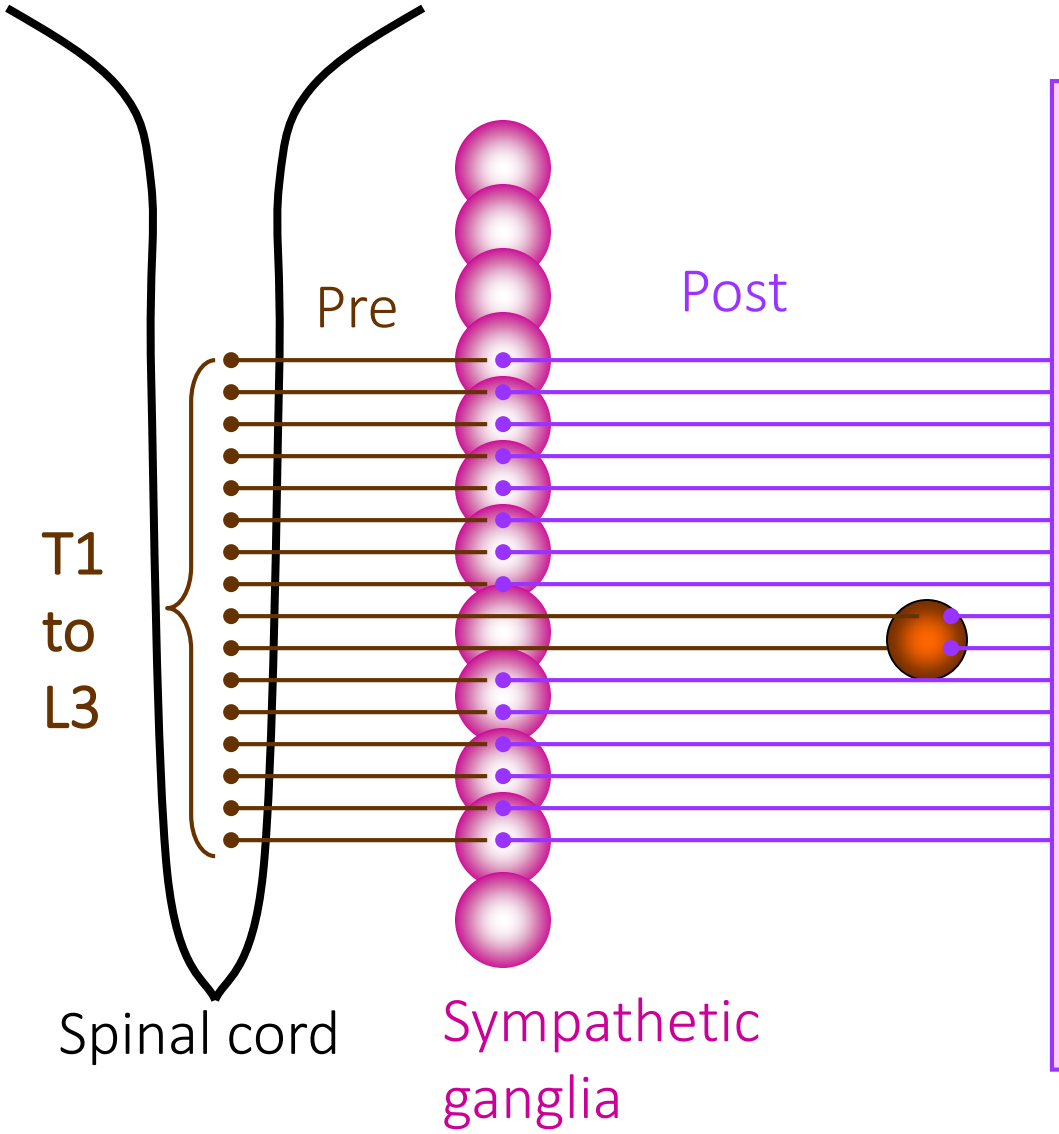
Sympathetic nervous system

Sympathetic nervous system

- Stimulated in a state of emergency.
  - Fright, fight and flight

- Effects are opposite of parasympathetic system.

Structure of sympathetic nervous system



Effector organs

Heart and blood vessels

Lungs

Eyes

Stomach and Intestine

Gallbladder and ducts

Urinary bladder and Ureters

Uterus and male genital organs

Sympathetic ganglia

To head

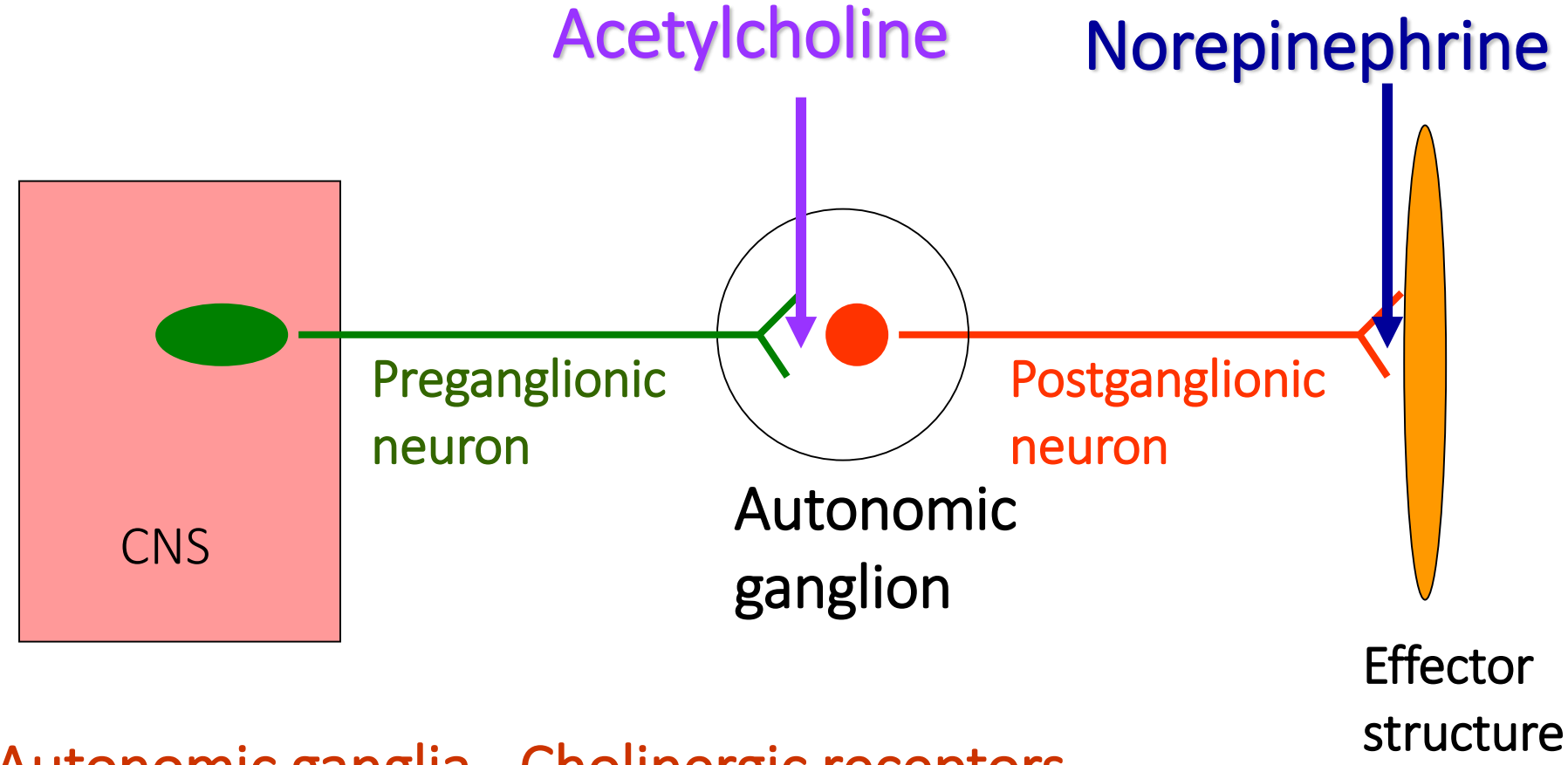
- Superior
- Middle
- Stellate ganglia

To body

- T1-L3 spinal segments

- Most sympathetic nerves have long postganglionic nerves

- Exceptions
  - Short noradrenergic neurons to uterus and male genital tract
  - Ganglia in or near the organ



Autonomic ganglia - Cholinergic receptors

Receptor type -Nicotinic

Effector organs - Adrenergic receptors

Receptor types - α and β

Main neurotransmitters

- preganglionic sympathetic nerve ending - Acetylcholine

- postganglionic sympathetic nerve ending – Norepinephrine (Noradrenaline)

- **Postganglionic receptors**
  - adrenalin and noradrenalin both act on these receptors.
  - Noradrenaline strongly activates α receptors.
  - The response depends on the type of the receptor stimulated

- **Exceptions**
  - postganglionic sympathetic nerves to sweat glands, erector pilori muscles, some blood vessels in skeletal muscles release acetylcholine as neurotransmitter.

Effector organs

- Glands
  - skin, GI tract, respiratory tract, genito-urinary systems
- Smooth muscles
  - walls of the GI tract, respiratory system, genito-urinary tracts, skin, iris and cilliary body of the eye.
- Cardiac muscle

Main functions

Prepare the individual to cope with an emergency:

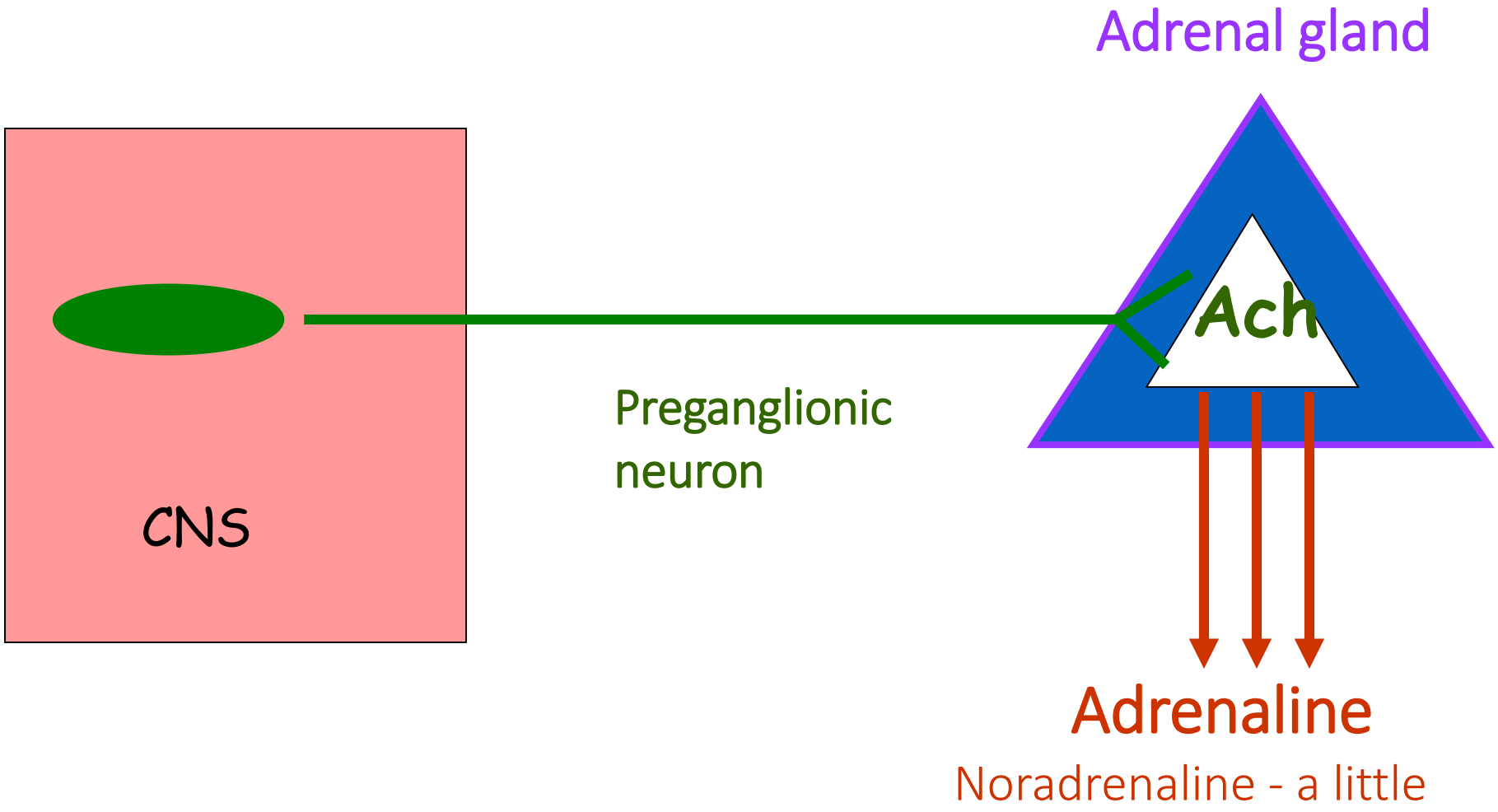
- dilate pupils - letting more light into eyes
- heart rate and the pumping action of the heart - supply more blood to vital organs and muscles
- constrict cutaneous and other peripheral vessels - limits bleeding form the wounds
- reinforce the alert, aroused state
- elevate plasma glucose and free fatty acids - supply more energy
- inhibit gastrointestinal motility and secretions
- urinary bladder relaxation and contraction of sphincter

Main functions

Prepare the individual to cope with an emergency:

Prepare for fight and flight

Innervation of adrenal gland



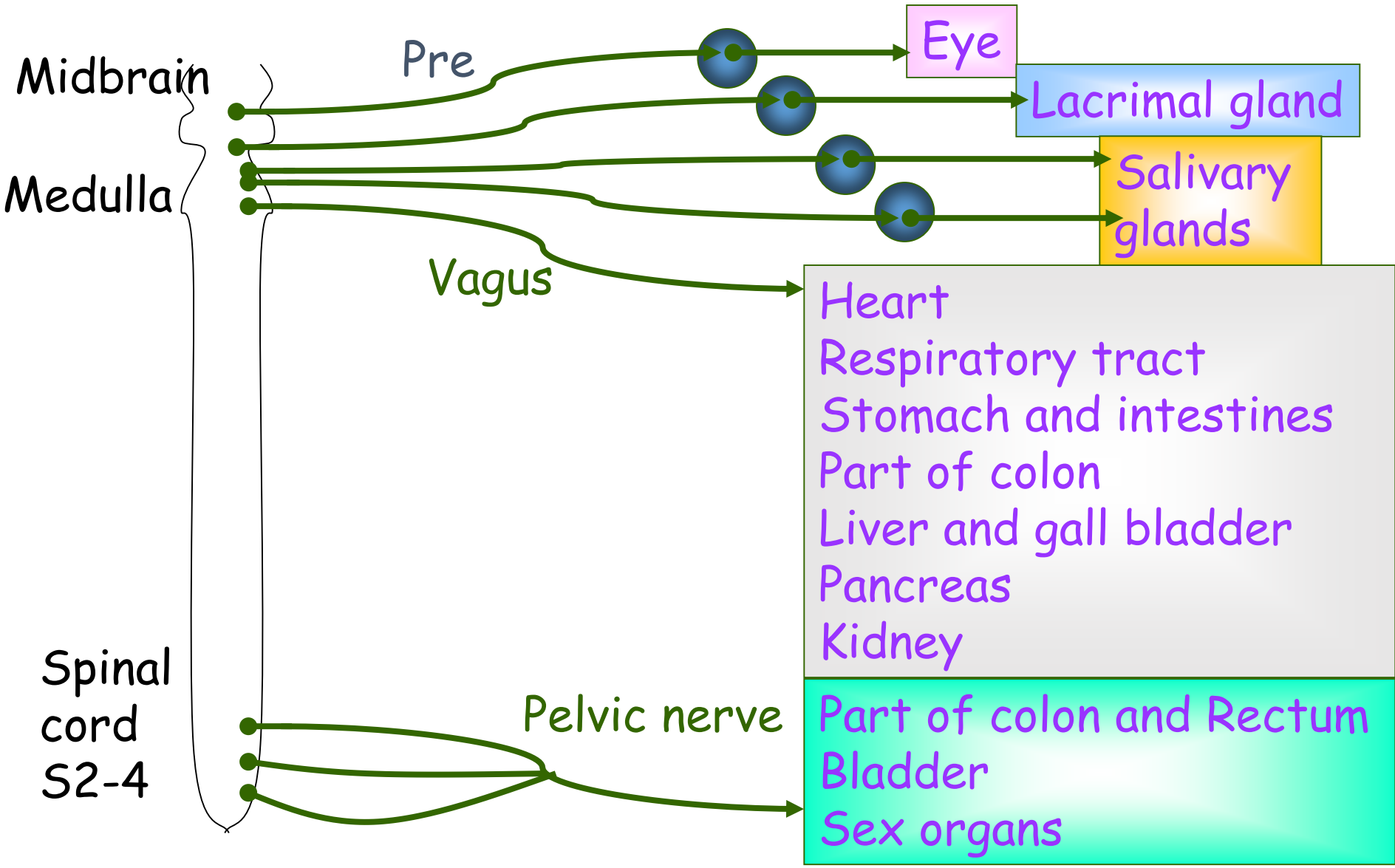
Sympathetic stimulation to adrenal medulla

- Cholinergic preganglionic sympathetic fibres directly innervate the medulla of the adrenal gland.
- Stimulation of preganglionic fibres stimulates release of adrenaline and noradrenaline by adrenal medulla into the blood stream.
- These hormones intensify the effects of sympathetic stimulation by binding to adrenergic receptors.

Autonomic nervous system II

Parasympathetic nervous system

Organization of parasympathetic nervous system

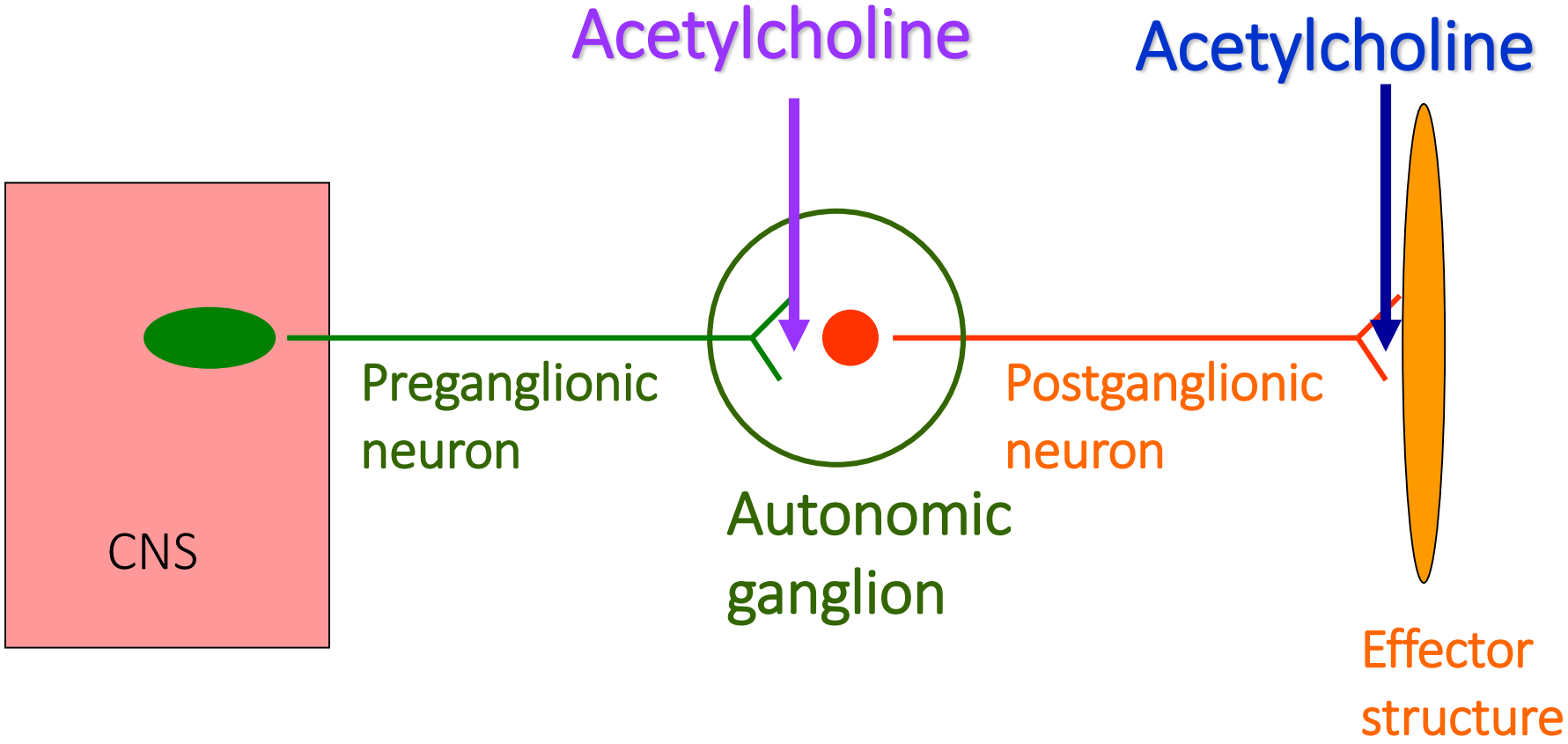


Parasympathetic nervous system

- Parasympathetic fibres leave CNS through cranial nerves III, VII, IX and X and 2nd 3rd and 4th sacral nerves.

- About 75% of all parasympathetic nerve fibres in the Vagus (X^{th} cranial) nerve.

- Ganglia are situated close or in the wall of the effector organ.



Autonomic ganglia - Cholinergic receptors
Receptor type -Nicotinic

Effector organs - Cholinergic receptors
Receptor type - Muscarinic

- Muscarinic receptor found in
  - all cells stimulated by postganglionic parasympathetic neurons and postganglionic cholinergic neurons of sympathetic system.

- Nicotinic receptors found in
  - preganglionic synapses of both sympathetic and parasympathetic systems.

Effects of parasympathetic nervous system

Promotes inactivity and the build up of food reserve by digestion.

- reduce heart rate and contractility
- increase gastrointestinal motility and sphincter relaxation.
- Promote micturition and defecation.
- increase secretions from glands in respiratory, gastrointestinal, salivary and lachrymal glands.
- Papillary constriction

Higher center control

- Autonomic functions are regulated by centers located in the lower brain stem, hypothalamus and cerebral cortex.

  E.g..

  - CVS control - vasomotor center in medulla
  - Respiration - respiratory center in medulla

Drugs acting on autonomic nervous system

Drug	Action
Neostigmine	Inhibit acetylcholine esterase
Ephedrine	Release norepinephrine
Atropine	Block muscarinic receptors
Prazosin	Inhibit α_1 receptors
Salbutamole	Stimulate β_2 receptors
Propranalol	Non-selective β blocker
Atenolol	Selective β_1 blocker

Toxins acting on autonomic nervous system

Questions

Describe the effects of following toxins and poisons on the body

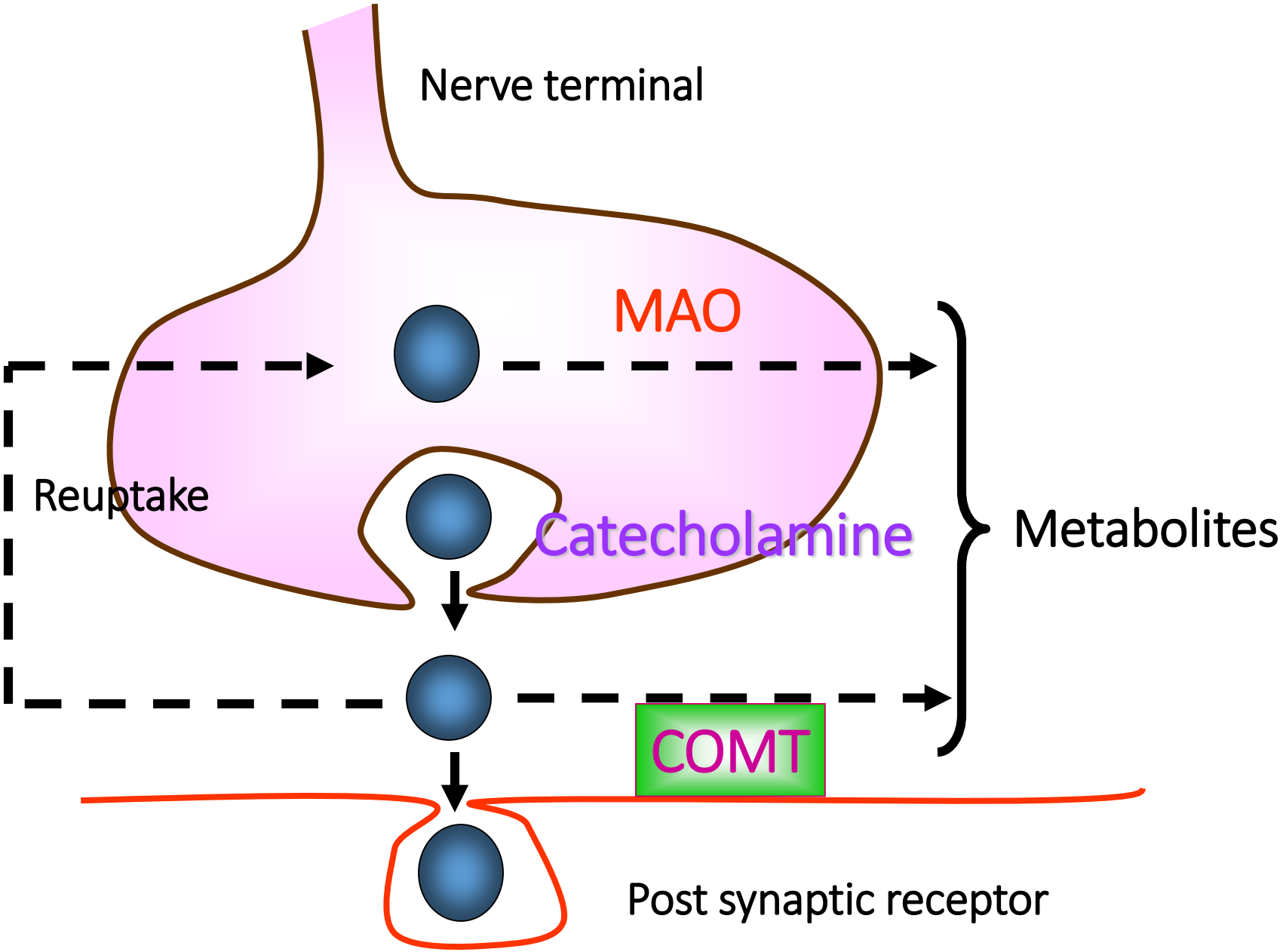
1. Organophosphate

   parathion, nerve gas

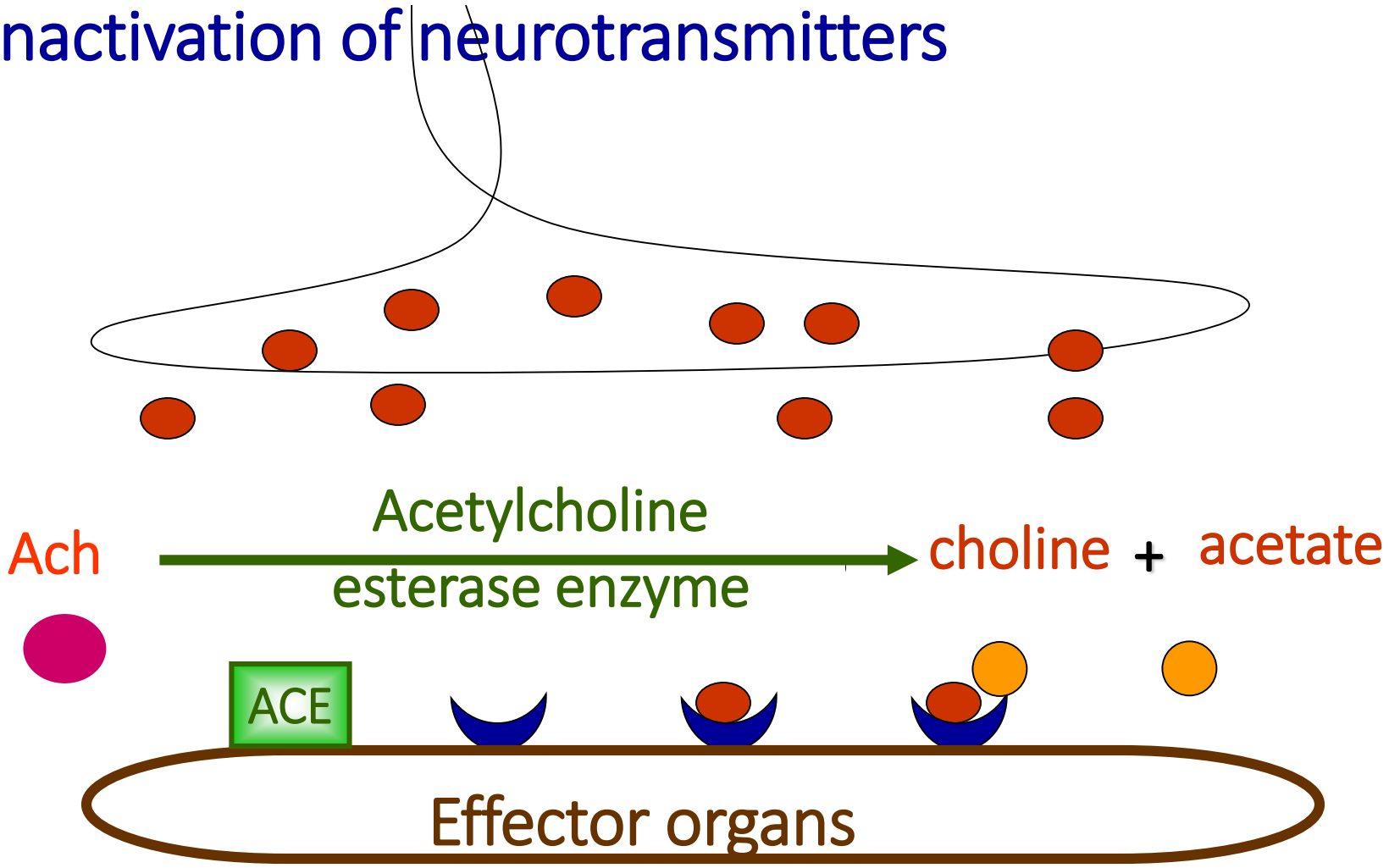
2. Datura (Aththana)

Catecholamines

1. Broken down in synapse by enzyme Catecol-O-Methyl Transferase (COMT)
2. Reuptake into the axon terminal and recycled.
3. Broken down by Monoamine Oxidase (MOA) in the mitochondria.


Nerve terminal
MAO
Reuptake
Catecholamine
Metabolites
COMT
Post synaptic receptor

Inactivation of neurotransmitters



Home work

TABLE 13–1 - Responses of some effector organs to autonomic nerve activity

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TABLE 13–1 Responses of some effector organs to autonomic nerve activity.

		Sympathetic Nervous System	
Effector Organs	**Parasympathetic Nervous System**	**Receptor Type**	**Response**
Eyes			
Radial muscle of iris	—	α_1	Contraction (mydriasis)
Sphincter muscle of iris	Contraction (miosis)		—
Ciliary muscle	Contraction for near vision		—
Heart			
SA node	Decreased heart rate	β_1	Increased heart rate
Atria & ventricle	Decreased atrial contractility	β_1, β_2	Increased contractility
AV node & Purkinje	Decreased conduction velocity	β_1	Increased conduction velocity
Arterioles			
Skin, splanchnic vessels	—	α_1	Constriction
Skeletal muscle	—	α_1 / β_2, M	Constriction/Dilation
Systemic veins	—	$\alpha_1, \alpha_2 / \beta_2$	Constriction/Dilation
Bronchial smooth muscle	Contraction	β_2	Relaxation
Stomach & Intestine			

TABLE 13–2 Examples of drugs that affect processes involved in autonomic neurotransmission

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TABLE 13–2 Examples of drugs that affect processes involved in autonomic neurotransmission.

Transmission Process	Drug	Site of Drug Action	Drug Action
Neurotransmitter synthesis	Hemicholinium	Membrane of cholinergic nerve terminals	Blocks choline uptake; slows synthesis
	Metyrosine	Cytoplasm of noradrenergic nerve terminals	Inhibits tyrosine hydroxylase; blocks synthesis
Neurotransmitter storage mechanism	Vesamicol	Vesicles in cholinergic nerve terminals	Prevents storage of acetylcholine
	Reserpine	Vesicles in noradrenergic nerve terminals	Prevents storage of norepinephrine
Neurotransmitter release mechanism	Norepinephrine, dopamine, acetylcholine, prostaglandins	Receptors on cholinergic and adrenergic nerve terminals	Modulates transmitter release
Neurotransmitter reuptake mechanism	Cocaine, tricyclic antidepressants	Adrenergic nerve terminals	Inhibits uptake; prolongs transmitter's action on postsynaptic receptors
Inactivation of	Edrophonium,	Acetylcholinesterase in cholinergic	Inhibits enzyme; prolongs and