

Autonomic nervous system

part 1 of 3

Dr Chris John c.john@imperial.ac.uk



Session plan

Autonomic nervous system

Neurons

Neurotransmitters and hormones

Regulation of function

Receptors

Biosynthesis and metabolism



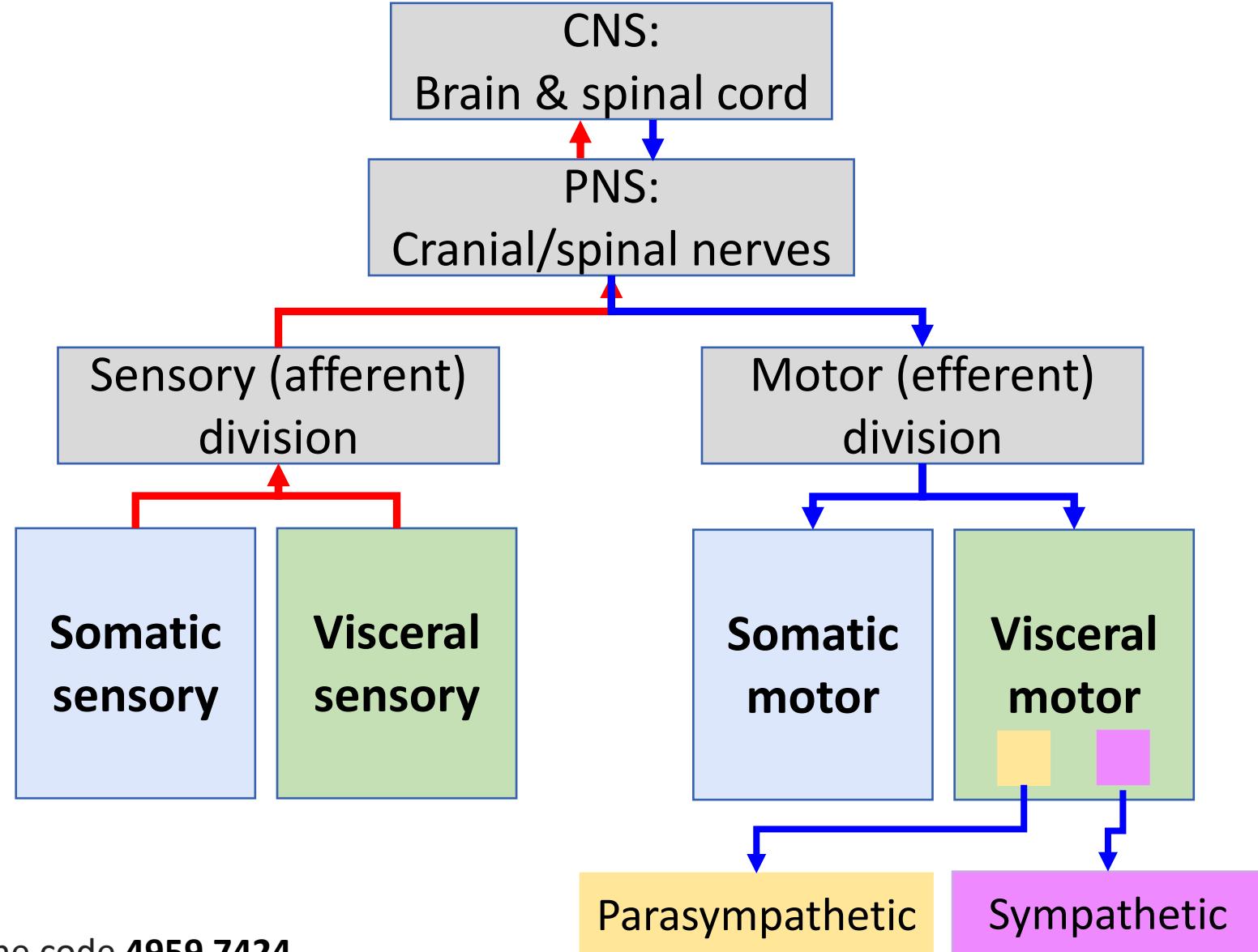
ANS - general

Sub-division of the peripheral nervous system

NOT under conscious control

Controls non-skeletal peripheral function:

Cardiac muscle (heart)
Smooth muscle
Internal organs
Skin



QUESTIONS: Go to www.menti.com and use the code 4959 7424



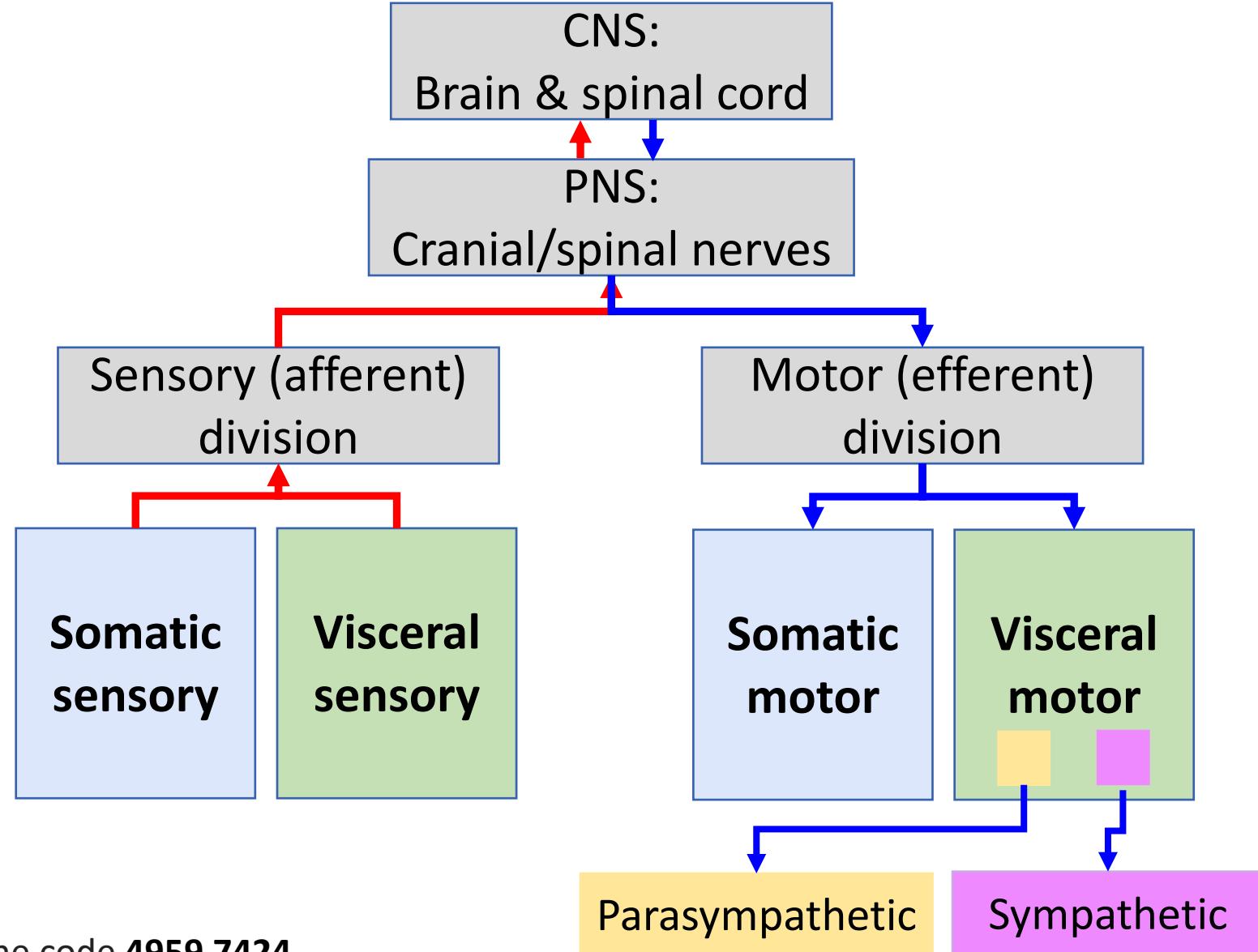
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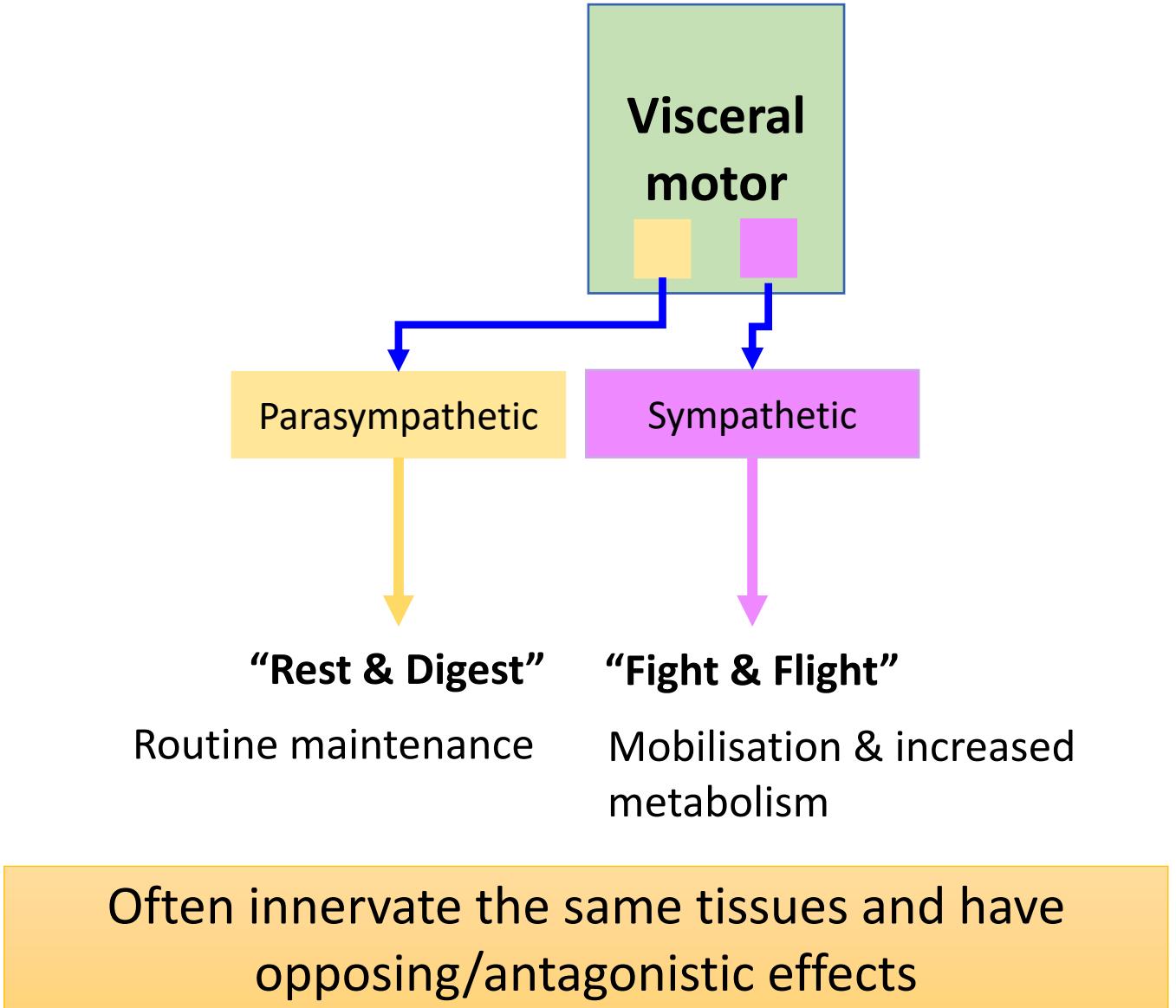
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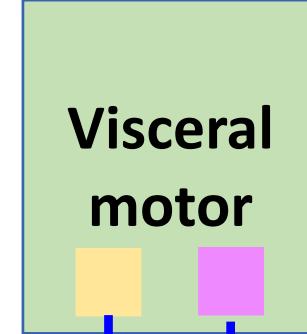
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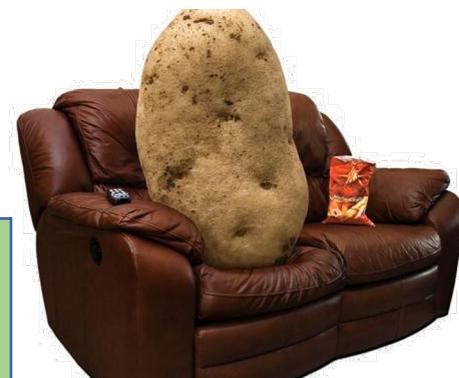


Parasympathetic

Sympathetic

“Rest & Digest”

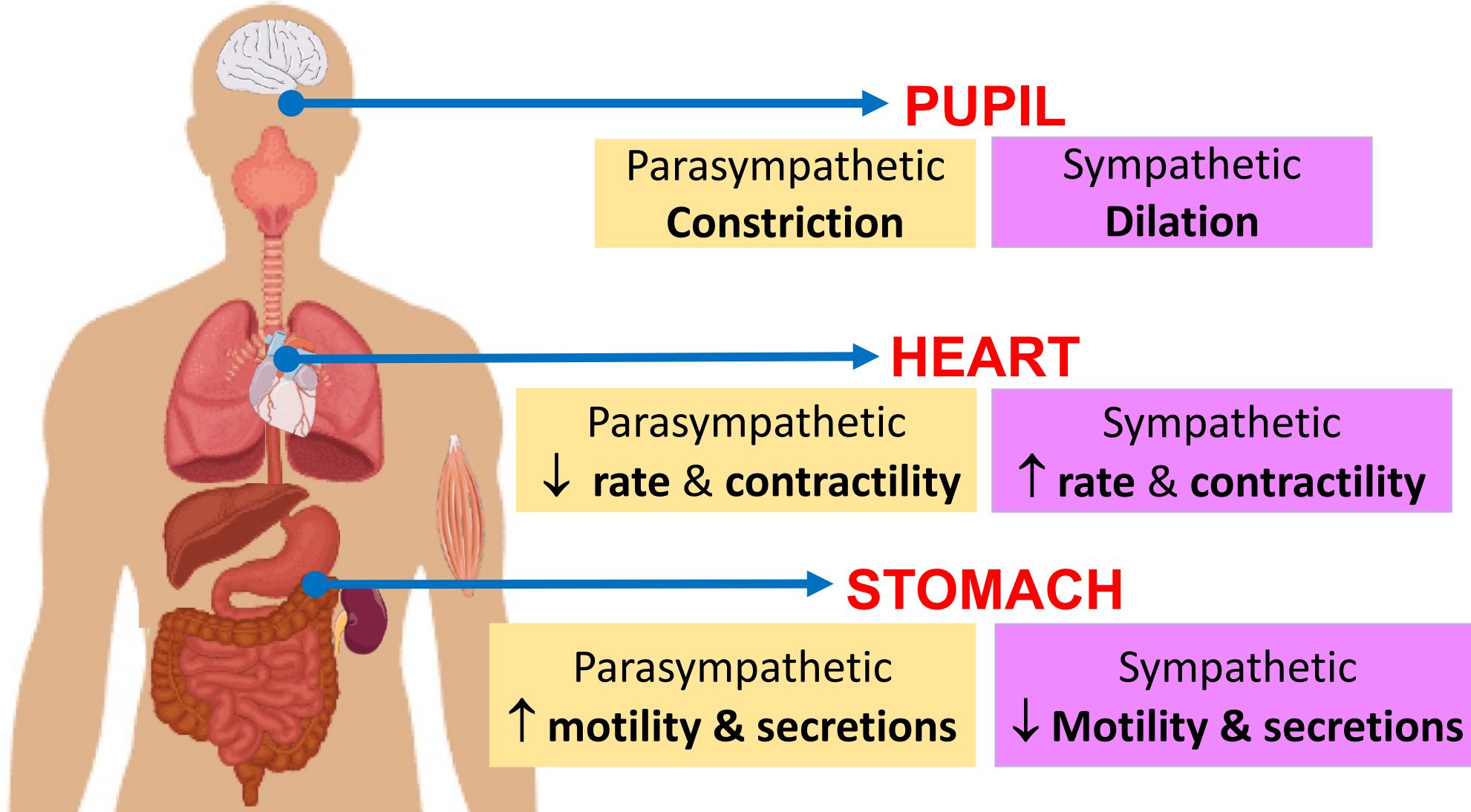
“Fight & Flight”





ANS - general

QUESTIONS: Go to www.menti.com and use the code 4959 7424





ANS - general

Parasympathetic

Pupil - constriction

Heart - ↓ rate/contractility

Lungs - constriction

GIT - ↑ motility & secretions

Liver - ↑ bile release

Bladder - contraction

Sympathetic

Pupil - dilation

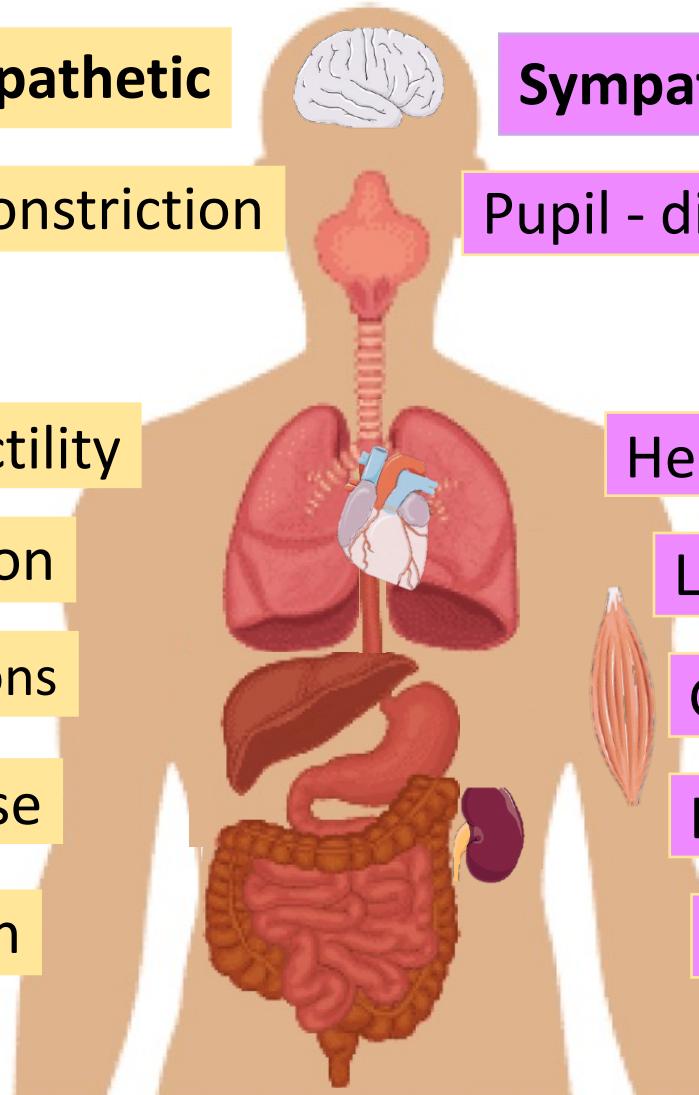
Heart - ↑ rate/contractility

Lungs - dilation

GIT - ↓ motility & secretions

Liver - ↑ glucose release

Bladder - relaxation



Not always the case:

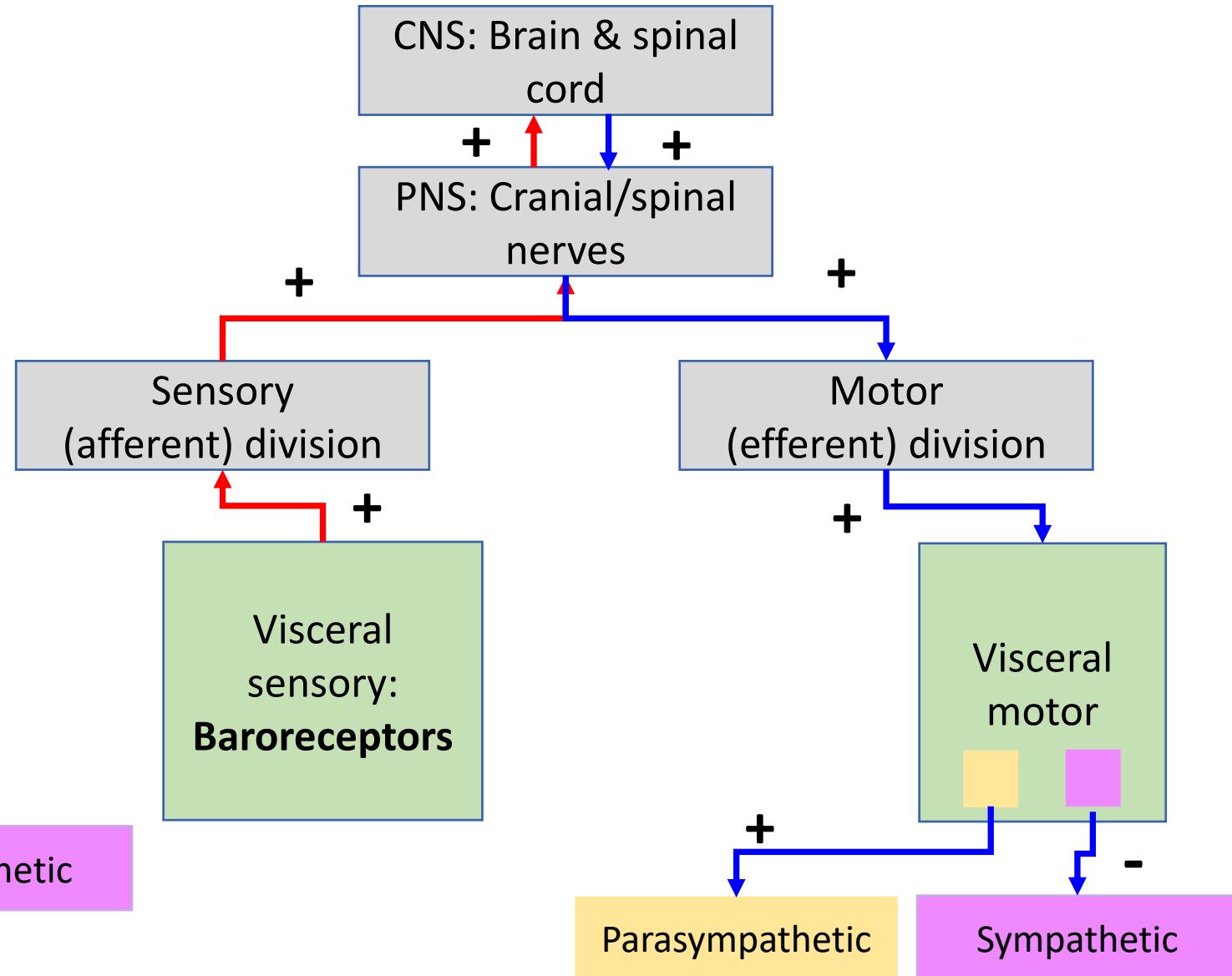
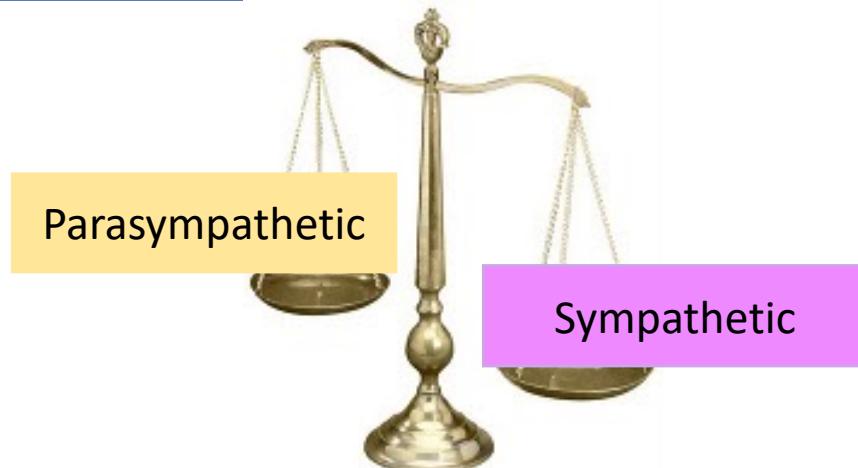
e.g. SNS controls blood vessel tone – both constriction and dilation



ANS - general

Parasympathetic/sympathetic nervous system reacts to sensory information received in the integrating centre.

For example – sensory information relayed by baroreceptors determines parasympathetic/sympathetic control of heart rate





Session review

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Neurons

Regulation of function

Receptors

Neurotransmitters and hormones

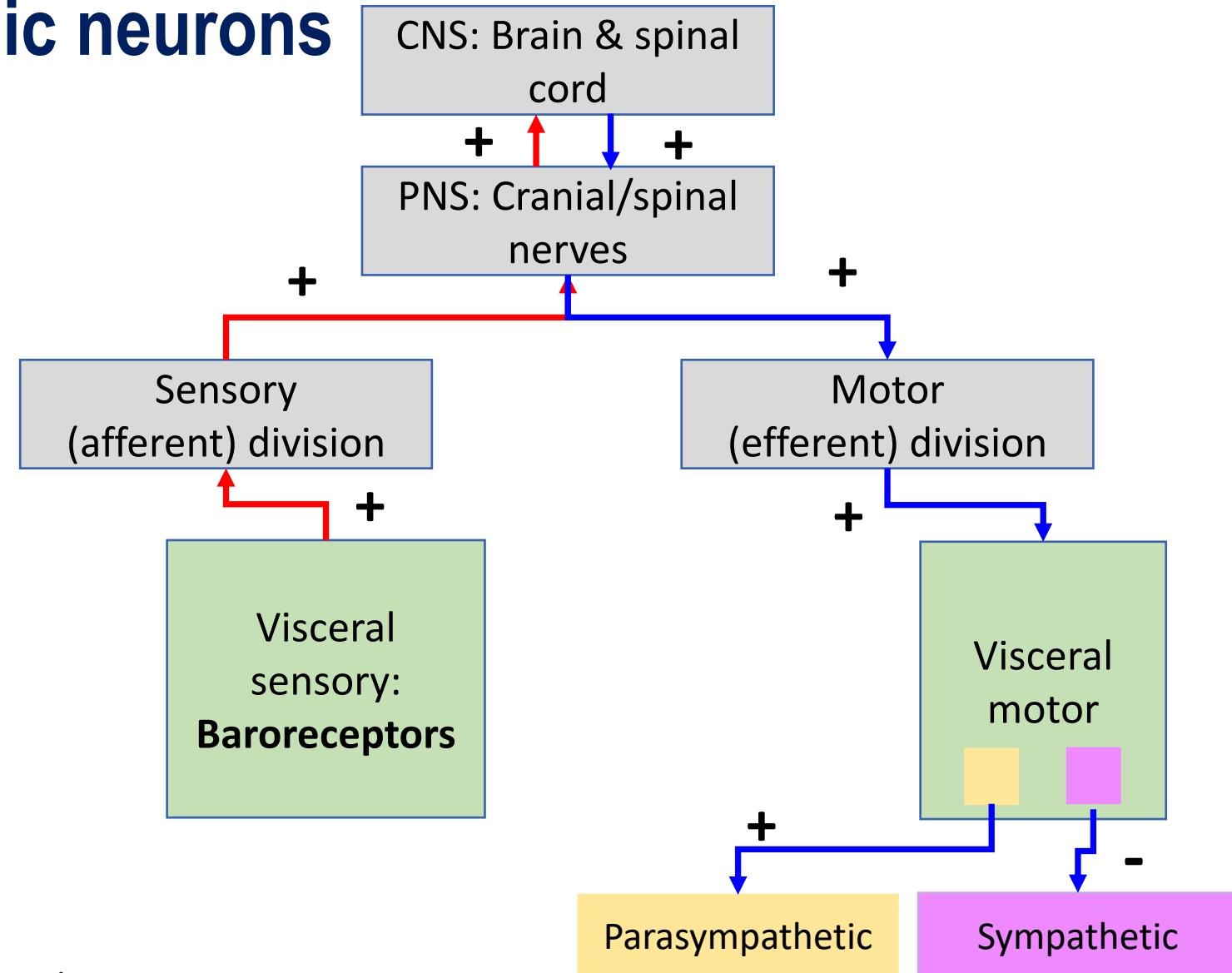
Biosynthesis and metabolism



Pre- and post-ganglionic neurons

Visceral motor nuclei originate in the **hypothalamus**.

These visceral motor neurons project to the **brainstem** or the **spinal cord** where they synapse with autonomic neurons (parasympathetic or sympathetic)



QUESTIONS: Go to www.menti.com and use the code 4959 7424



Pre- and post-ganglionic neurons

In general, autonomic nerves consist of **two neurons** – a pre-ganglionic and a post-ganglionic neuron

A **ganglion** is a nerve cell cluster or group of nerve cell bodies

PNS

Long pre-ganglionic fibres

Ganglions close to (or embedded within) effector tissues.

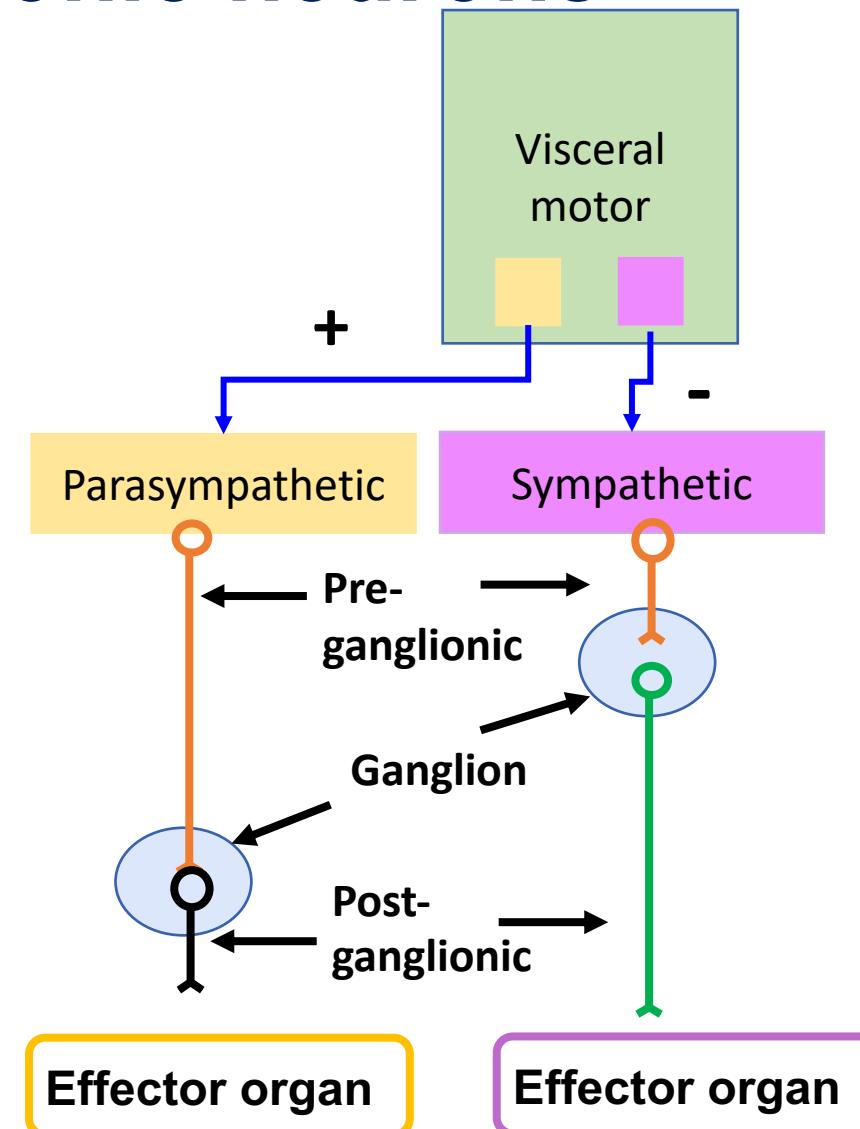
Short post-ganglionic fibres

SNS

Short pre-ganglionic fibres

Ganglions close to spinal cord.

Long post-ganglionic fibres



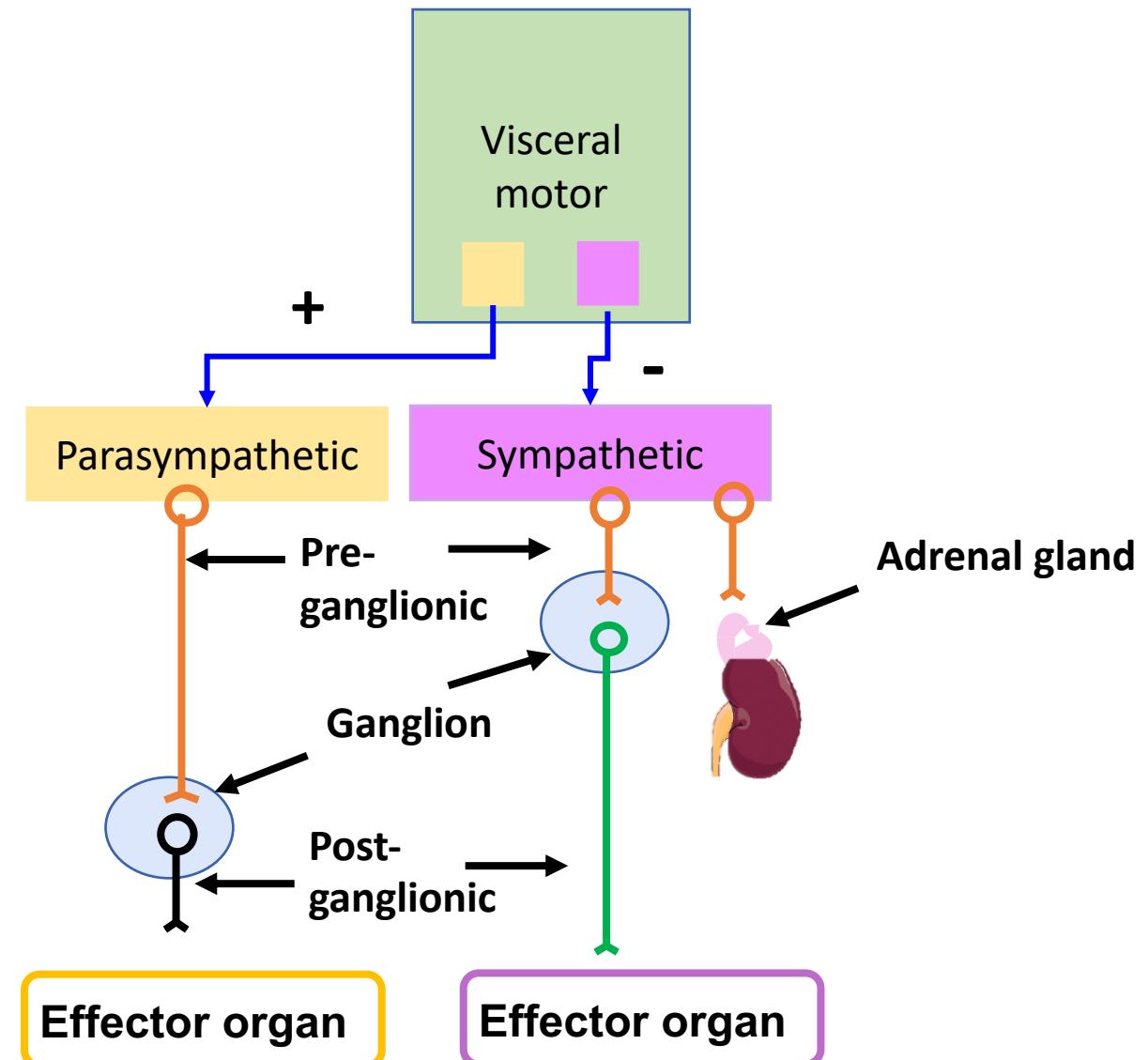


Adrenal gland

One exception to two neuron arrangement in ANS

Adrenal Gland

QUESTIONS: Go to www.menti.com and use the code 8949 3445





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Neurotransmitters and hormones

Regulation of function

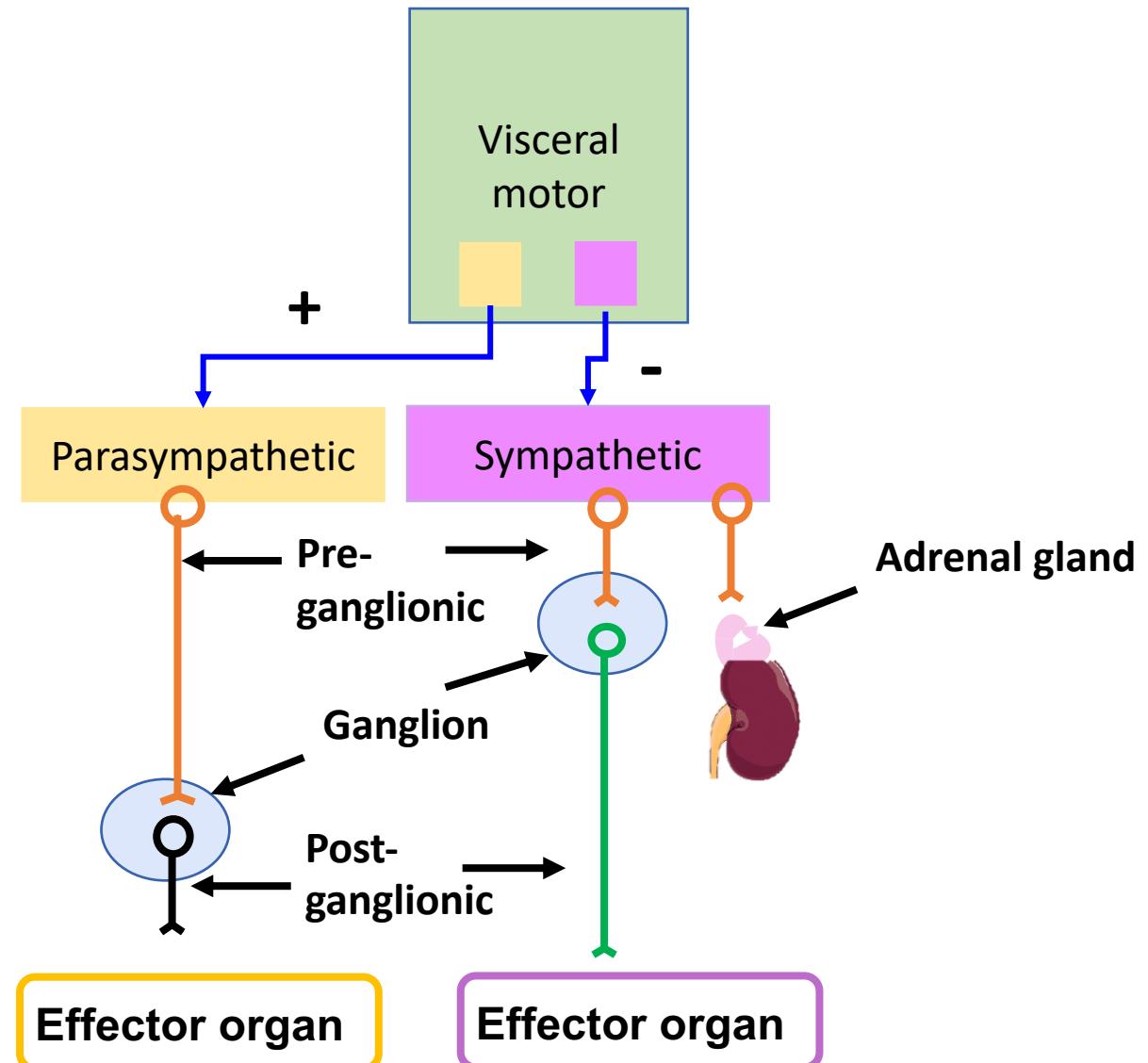
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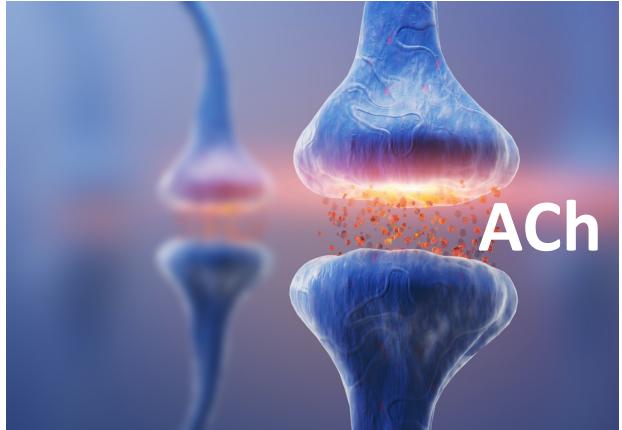
Neurotransmitters

Which neurotransmitters are released at each autonomic synapse?

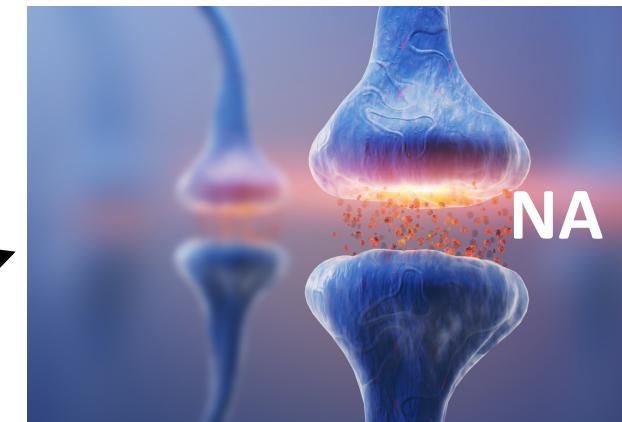
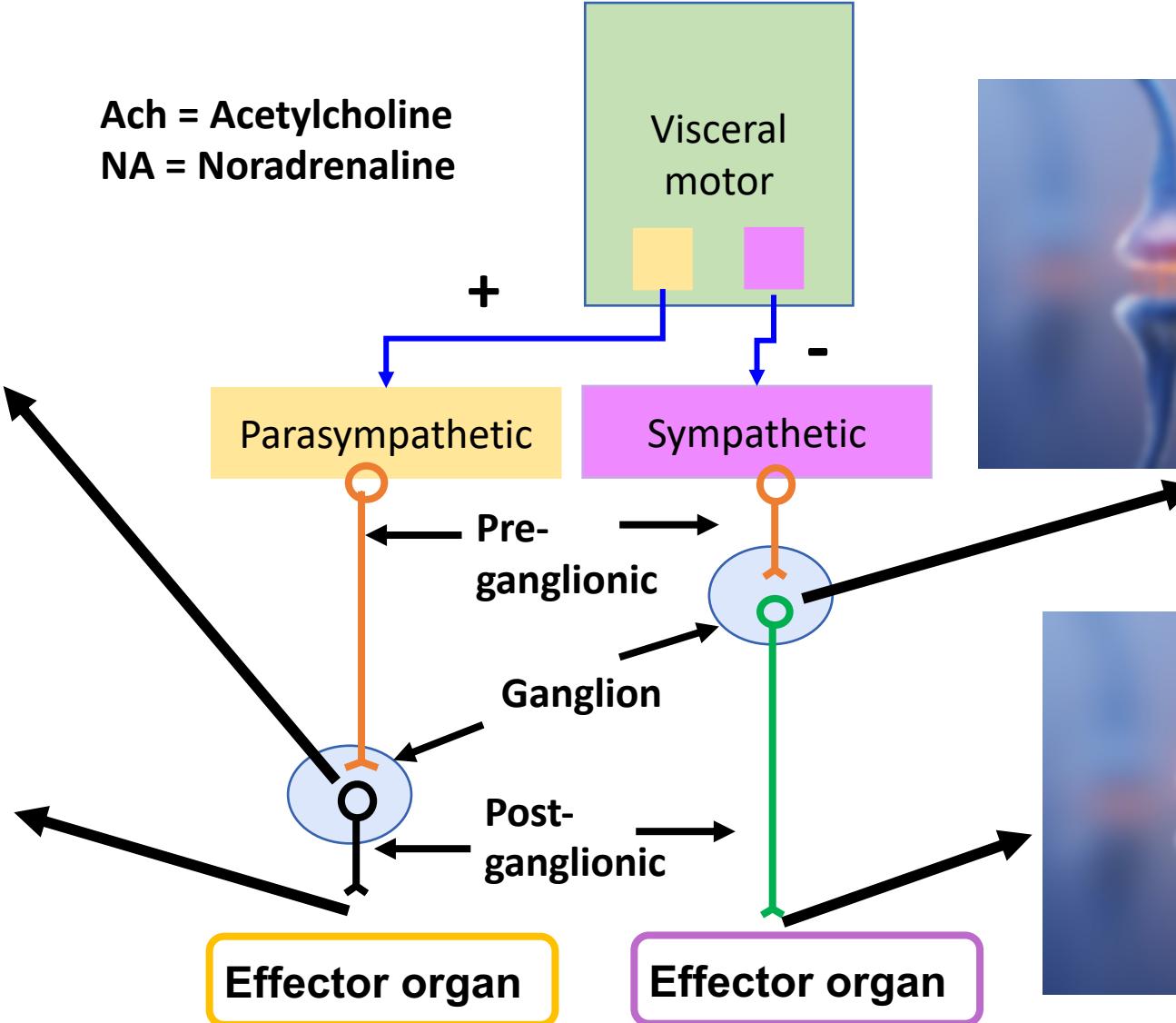
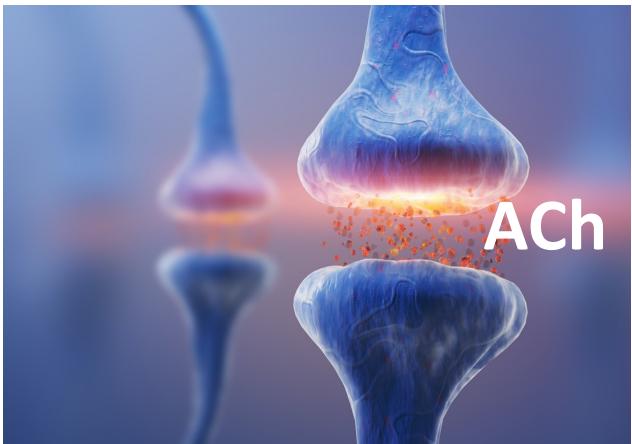
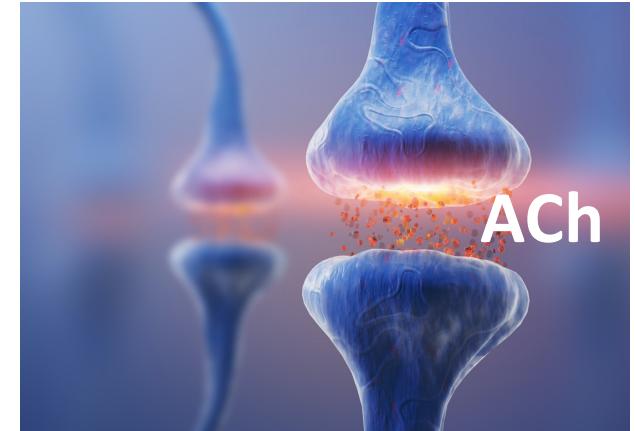
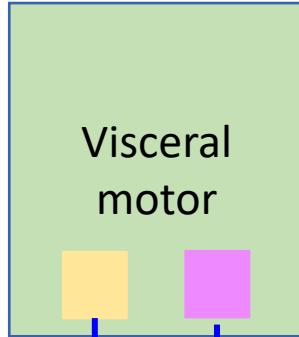




Neurotransmitters



Ach = Acetylcholine
NA = Noradrenaline



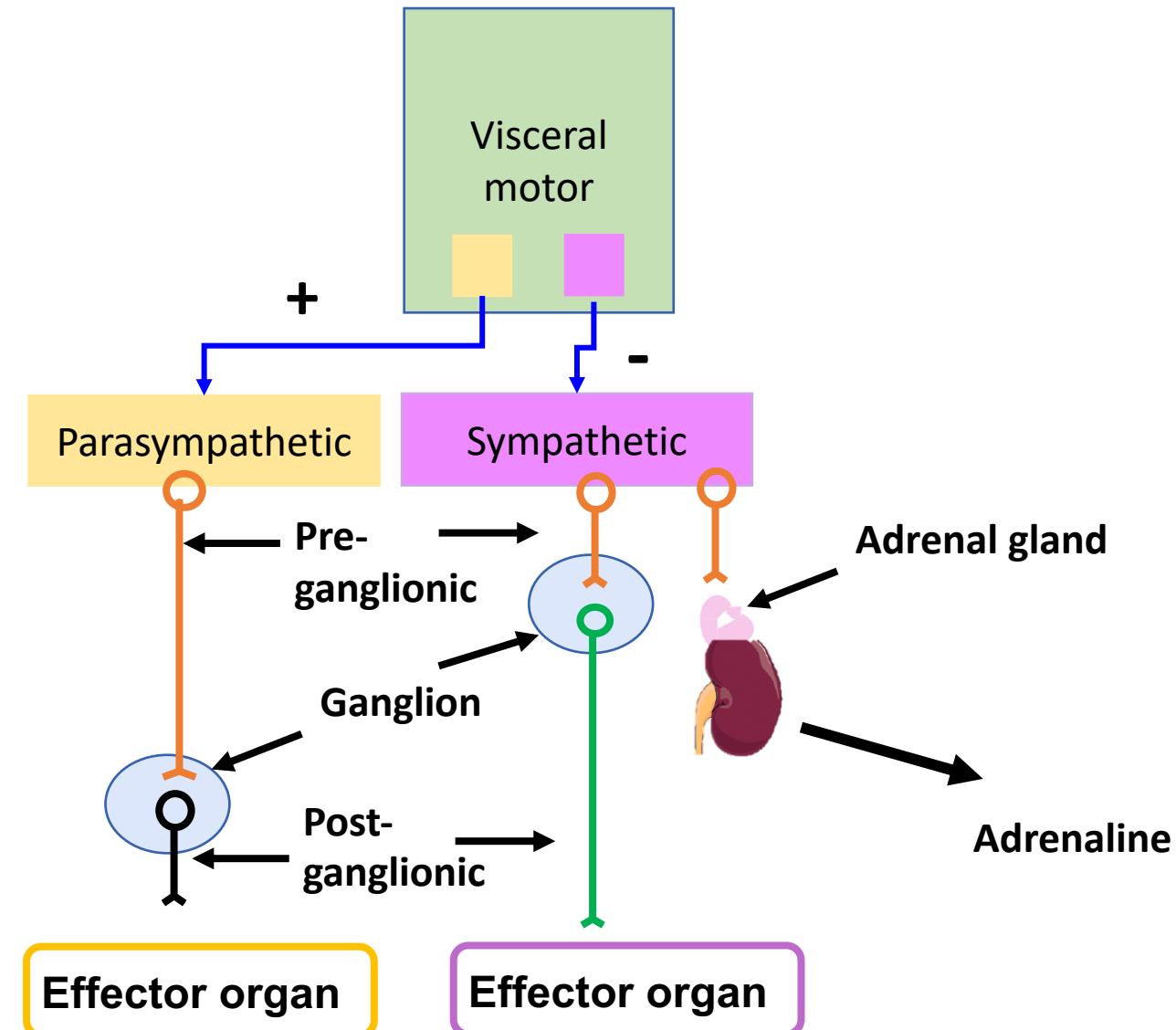


Neurotransmitters

Adrenal gland secretes a **hormone**
NOT a **neurotransmitter**

Adrenaline (and some
noradrenaline)

Secreted into **bloodstream**
NOT synapse





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Regulation of function

Receptors

Biosynthesis and metabolism

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part 2 of 3

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Regulation of function

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What effect do you think the PNS/SNS will have on

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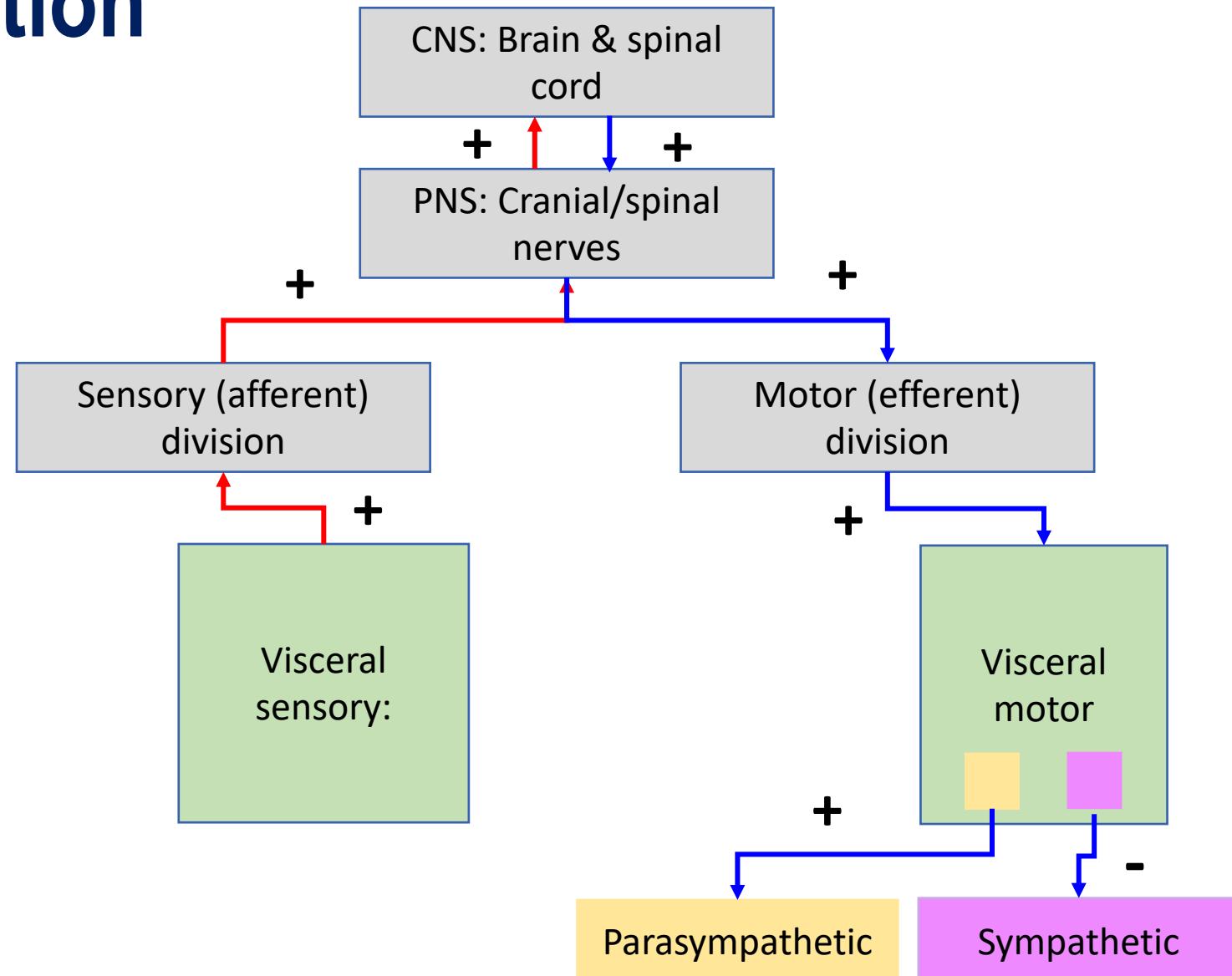
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Q: What effect would following stimuli have on ANS function?

A drop in blood pressure - a) the heart

The smell of food - b) the stomach

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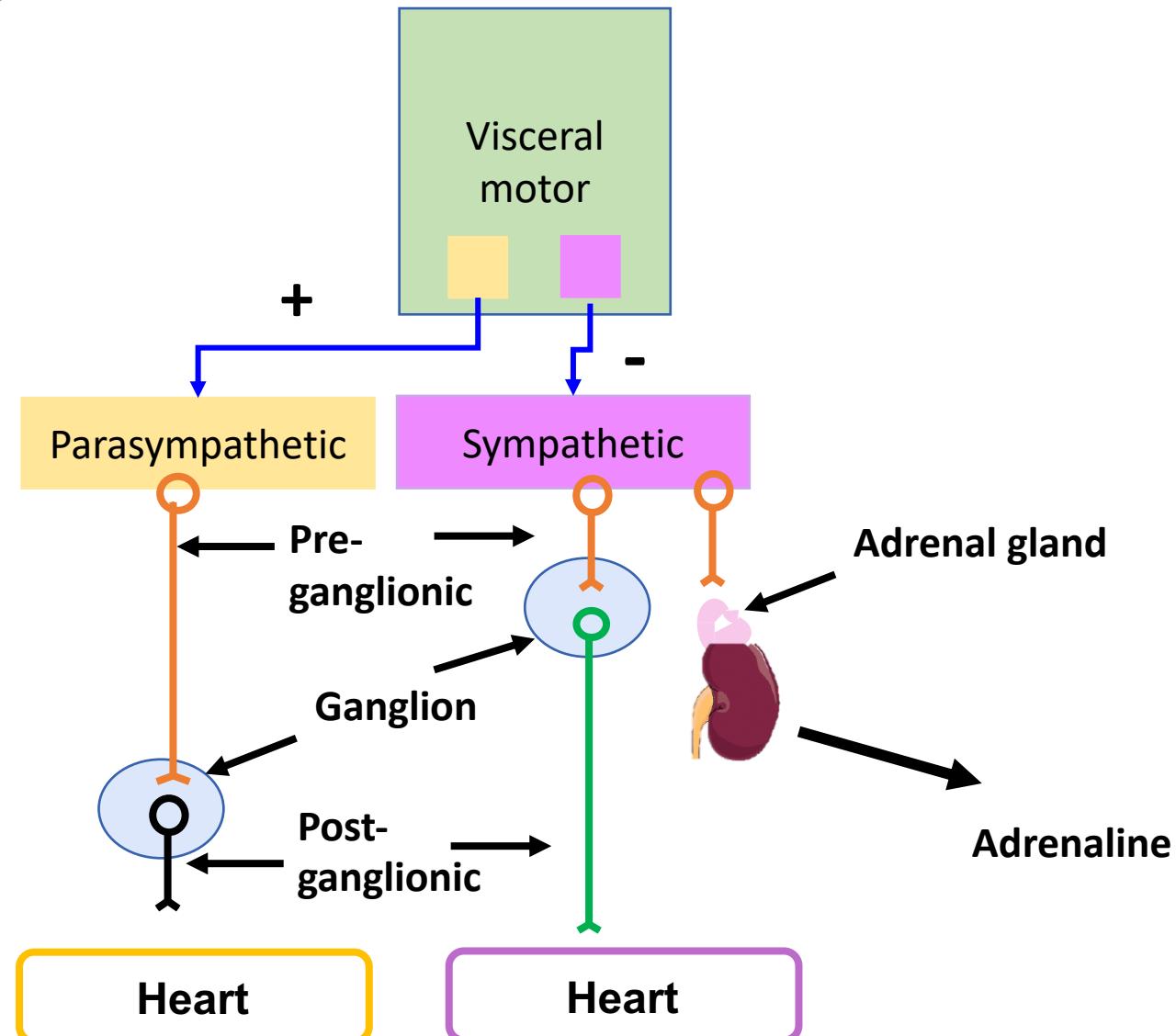
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Regulation of function

Gastro: Control of gut function
(February/March)

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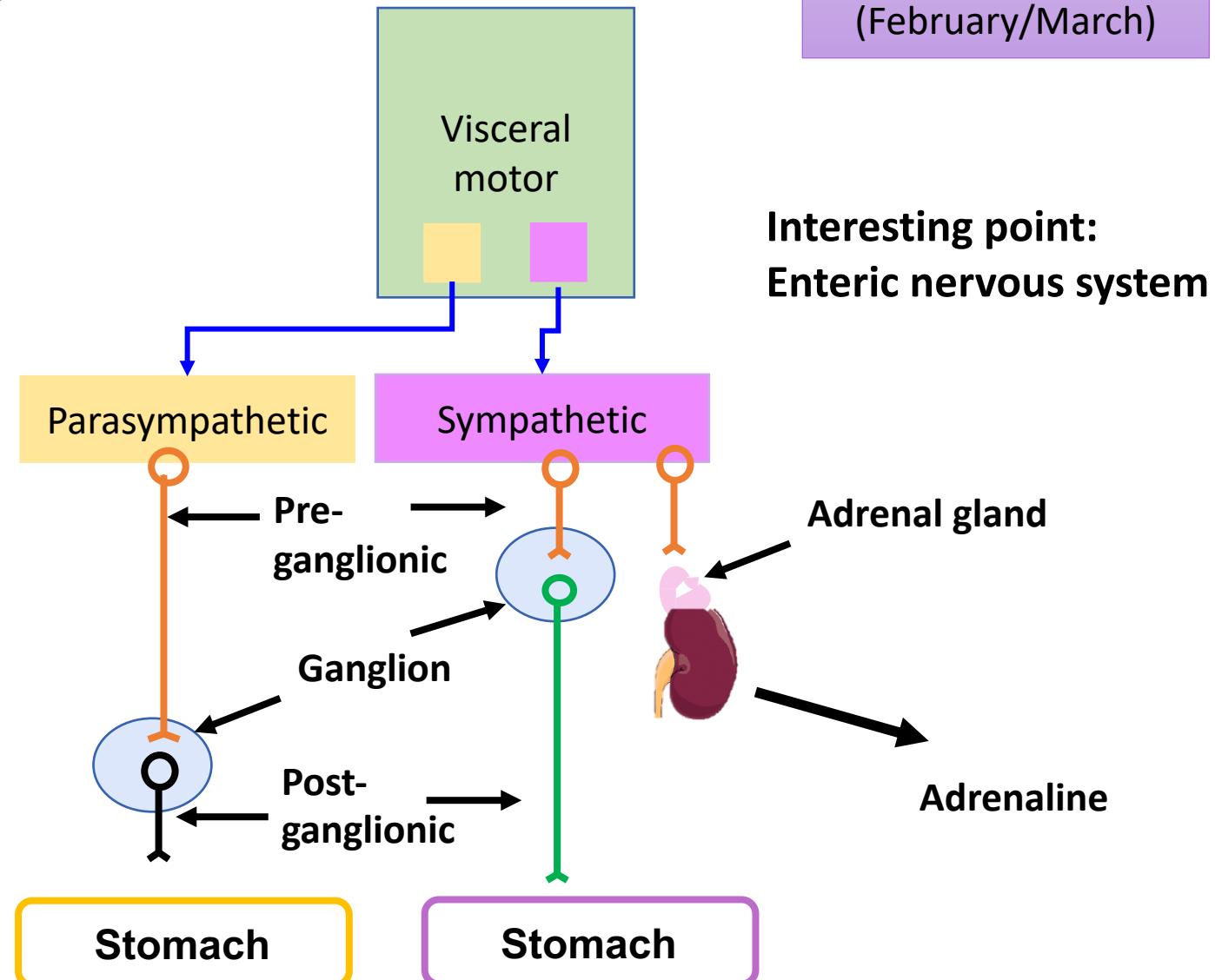
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Interesting point:
Enteric nervous system



Regulation of function

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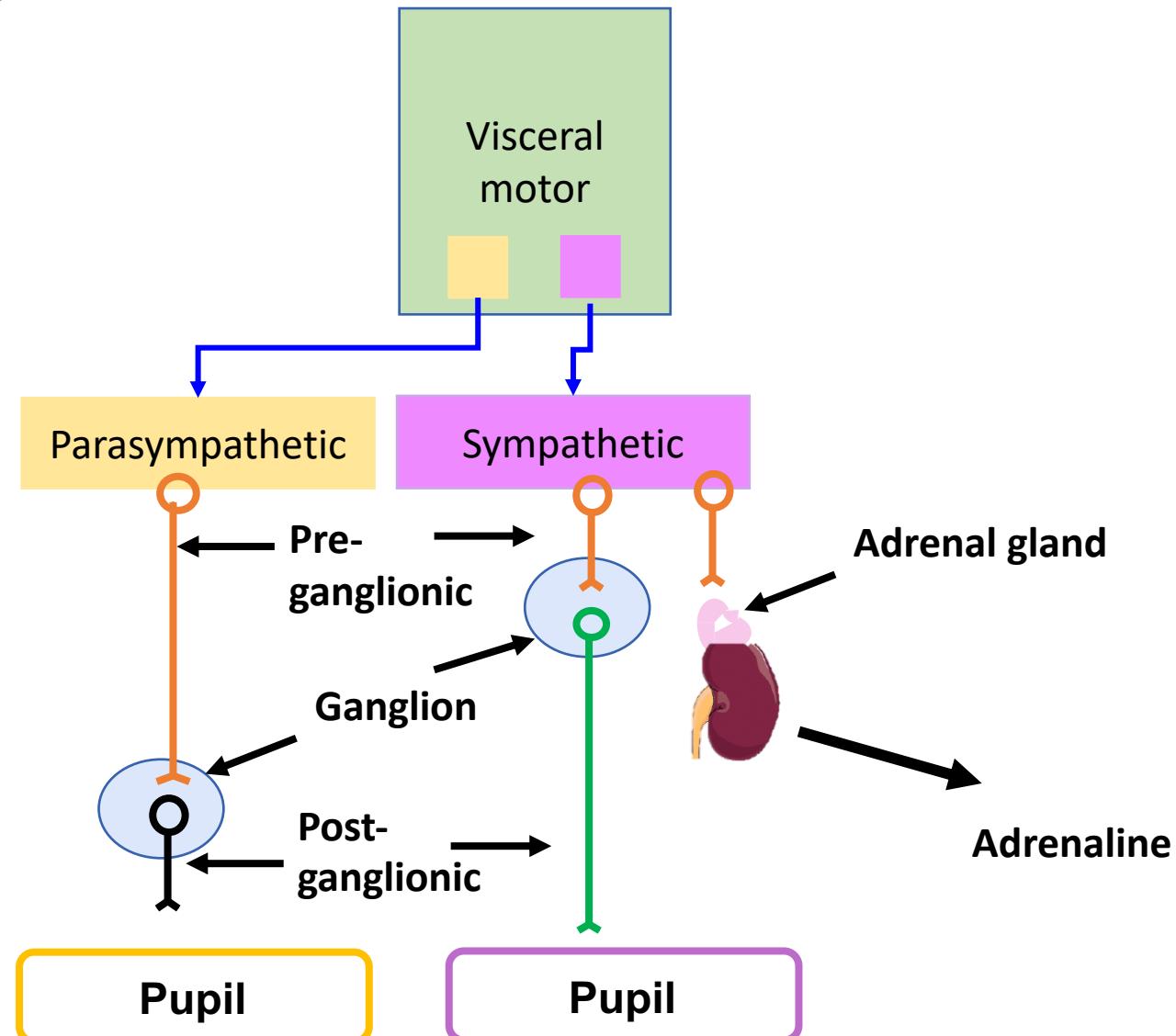
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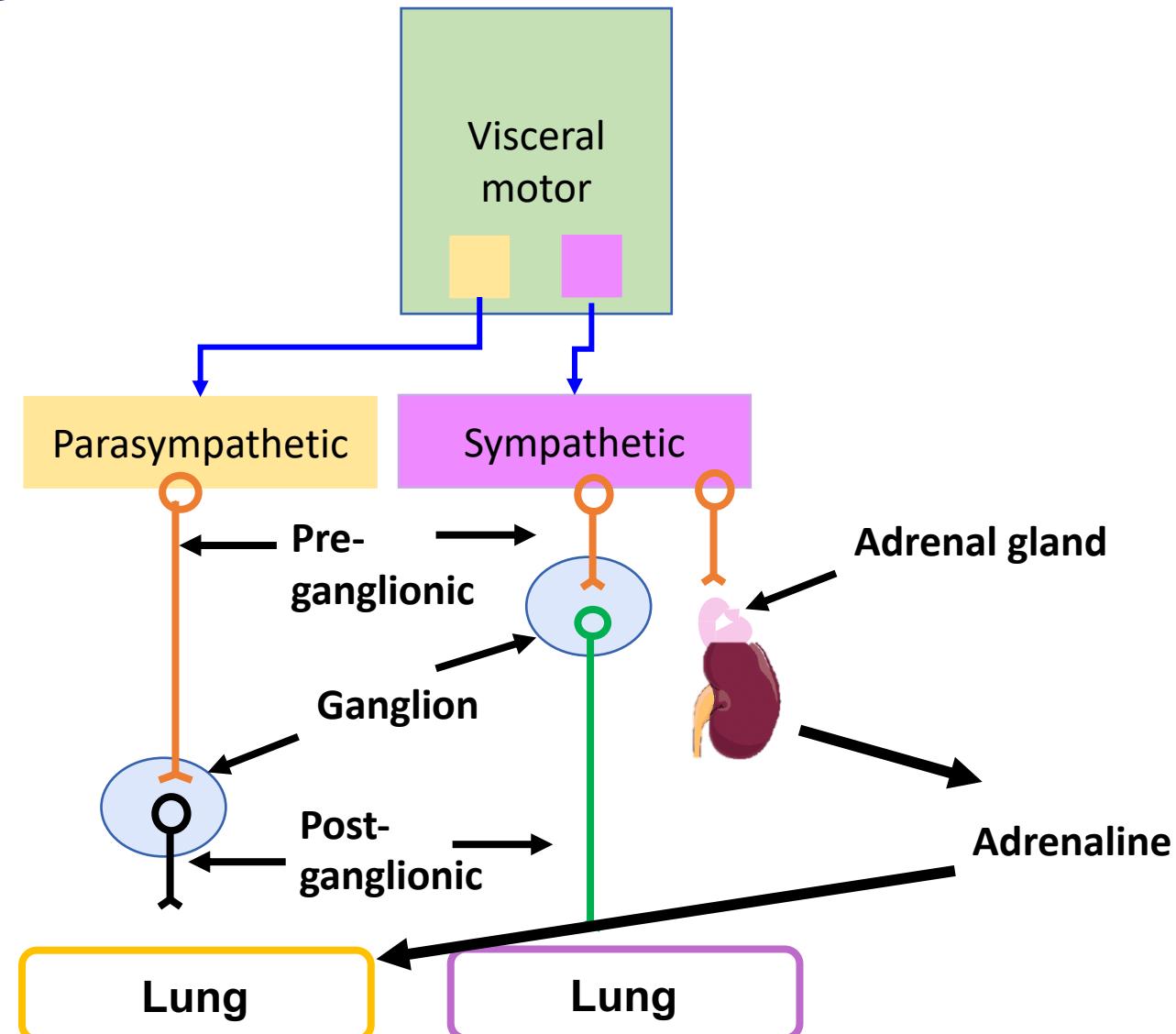
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The lung

Unusual situation – there are parasympathetic nerves innervating the lung tissue.

There are **NO sympathetic neurons** innervating the lung tissue

Q: How does the sympathetic nervous system influence lung function?





Regulation of function

The ANS is therefore a regulatory system that controls many of the body's organ systems and **homeostatic mechanisms**.

In general, ANS effects are **involuntary** i.e. they are reflex responses to visceral stimuli

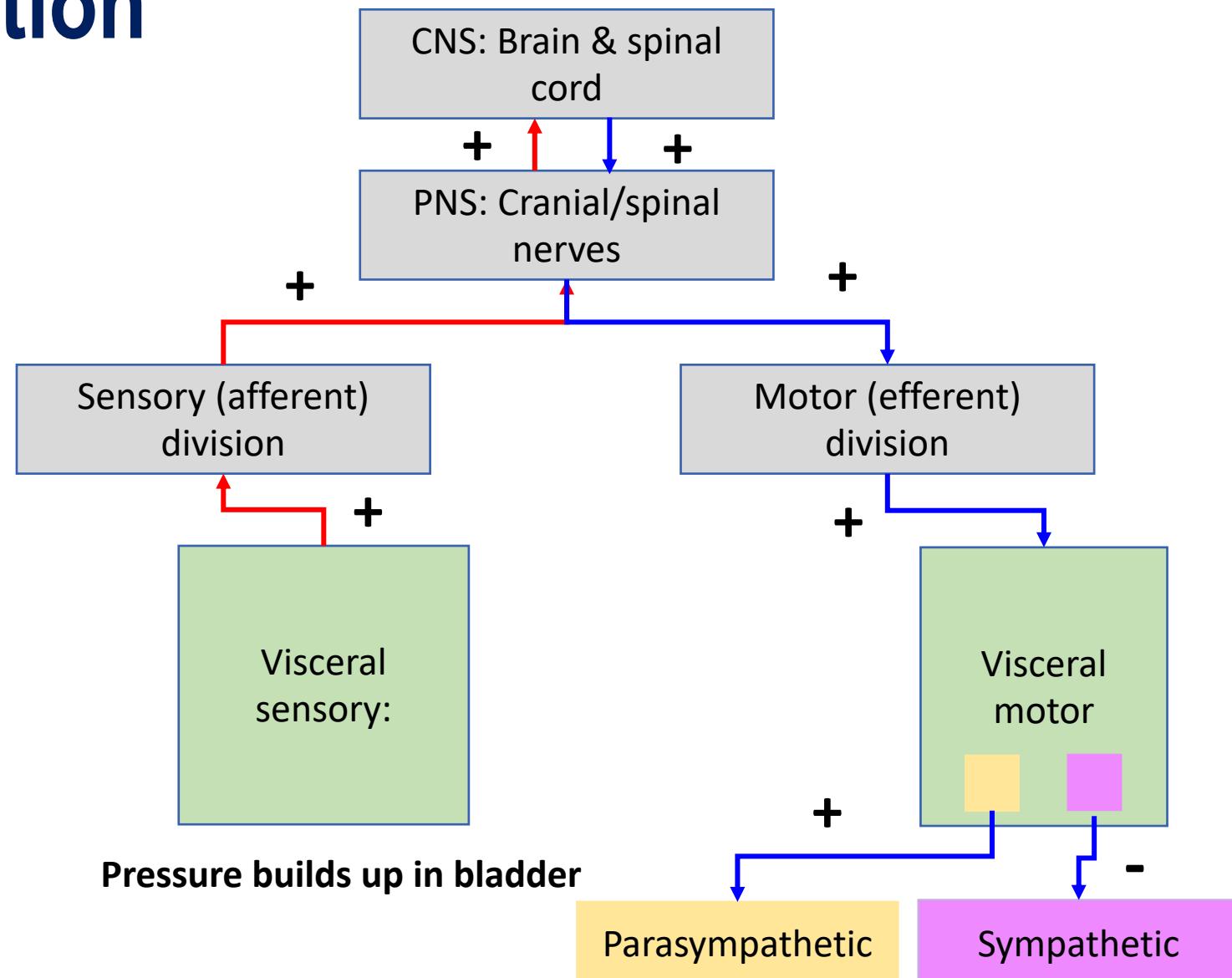
We've covered:

Response of the heart to a drop in blood pressure (baroreceptor reflex)

Pupil constriction in response to light (pupillary reflex)

Enteric nervous system adds layer of complexity to GI responses.

Consider one more reflex – **micturition reflex**





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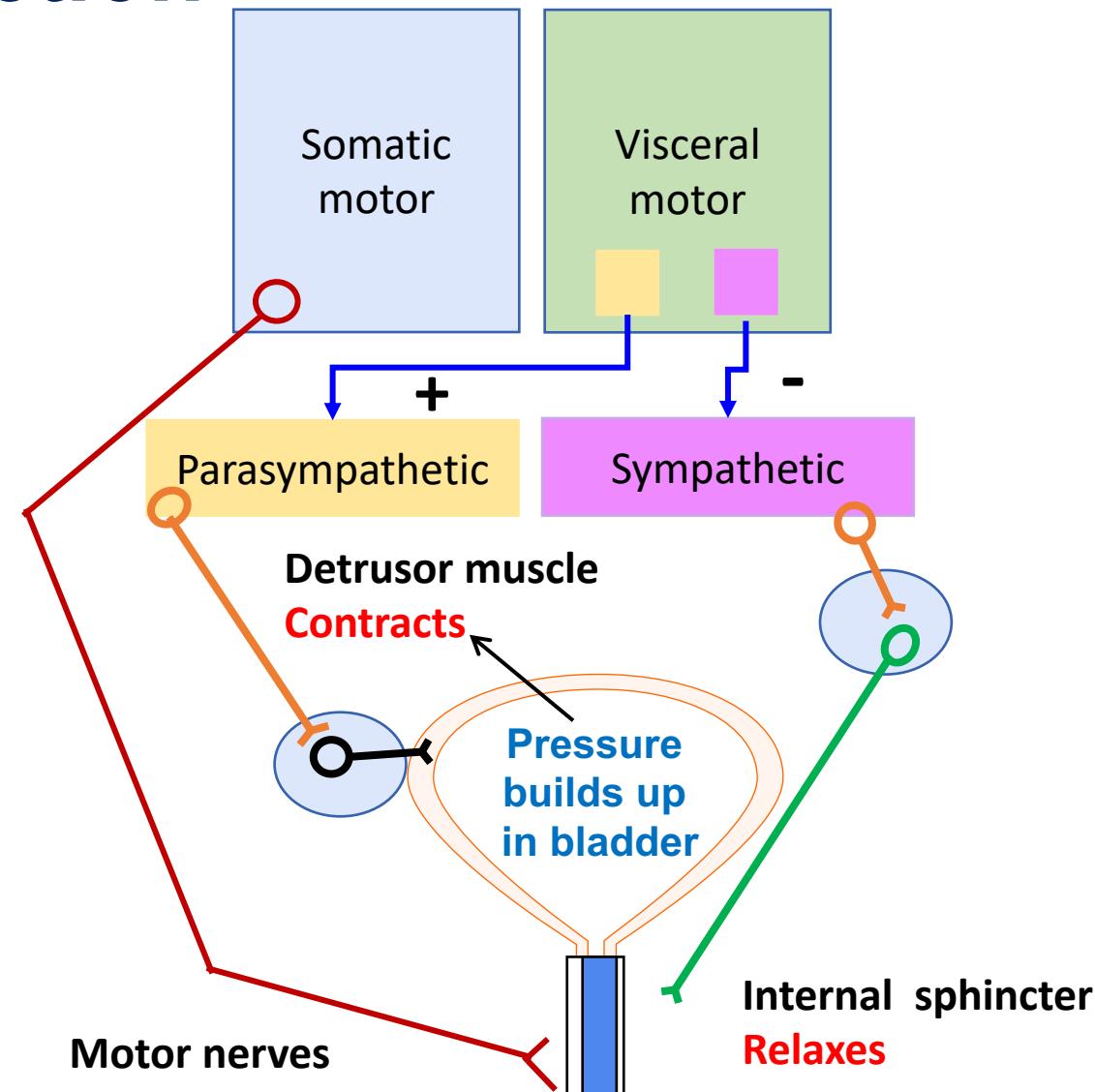
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Reflex activation of the ANS – can be PNS or SNS depending on stimulus.

Enteric nervous system – ‘mini-brain’ of GIT

Receptors

Biosynthesis and metabolism

Autonomic nervous system

part 3 of 3

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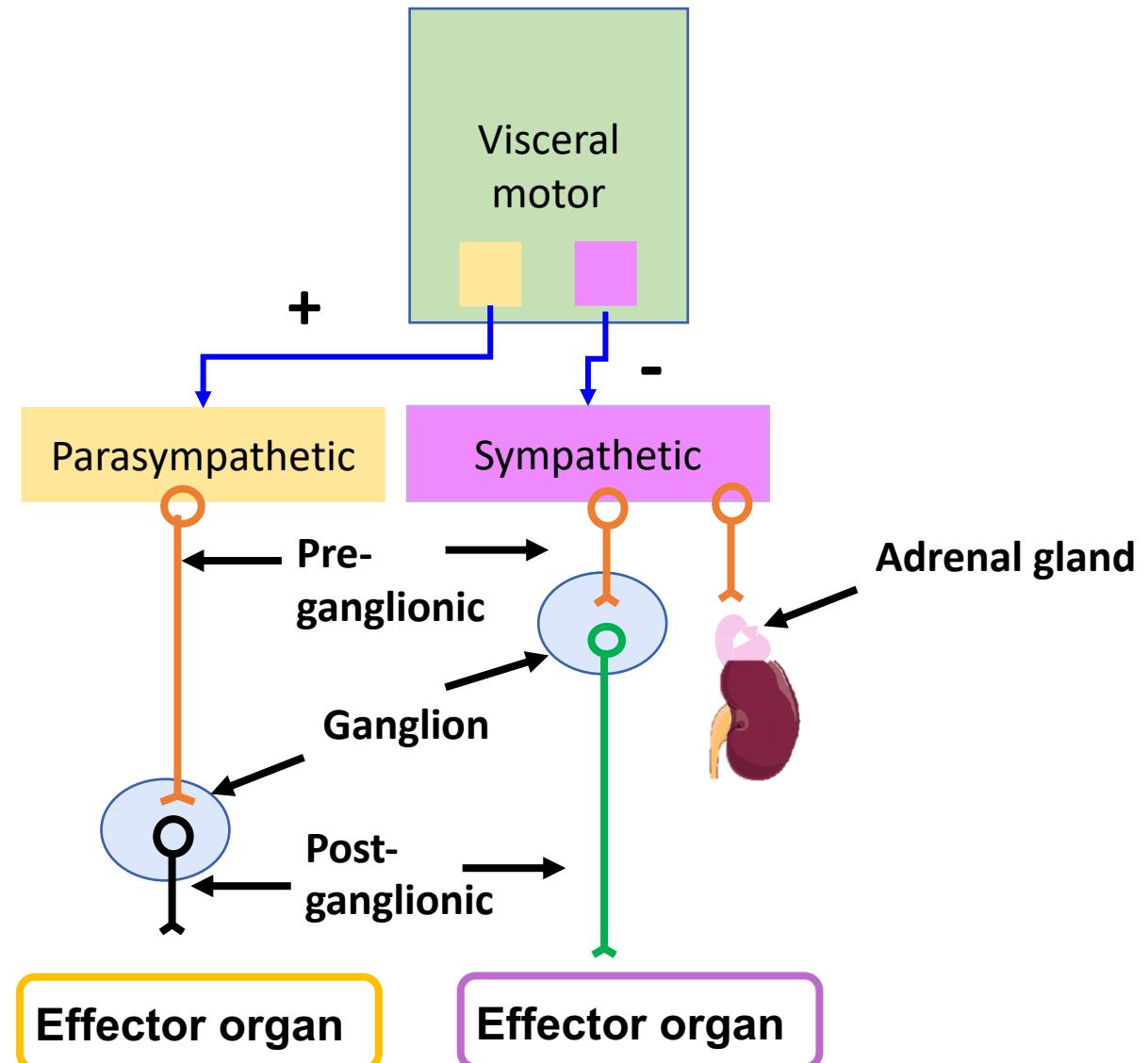
Biosynthesis and metabolism



Receptors

Which receptors mediate the effects within the autonomic nervous system?

Q: What type of receptor would you want at autonomic ganglia?





Receptors

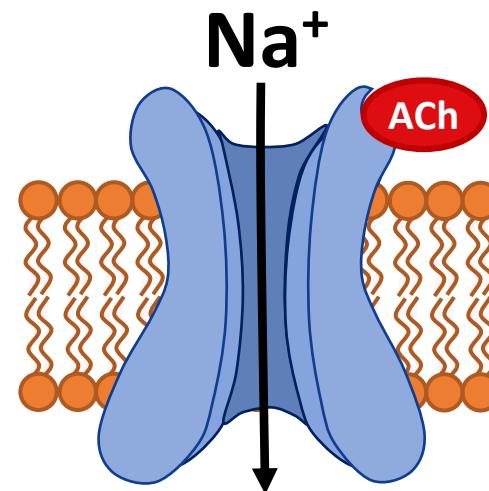
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Nicotinic acetylcholine receptor

Ion channel receptor

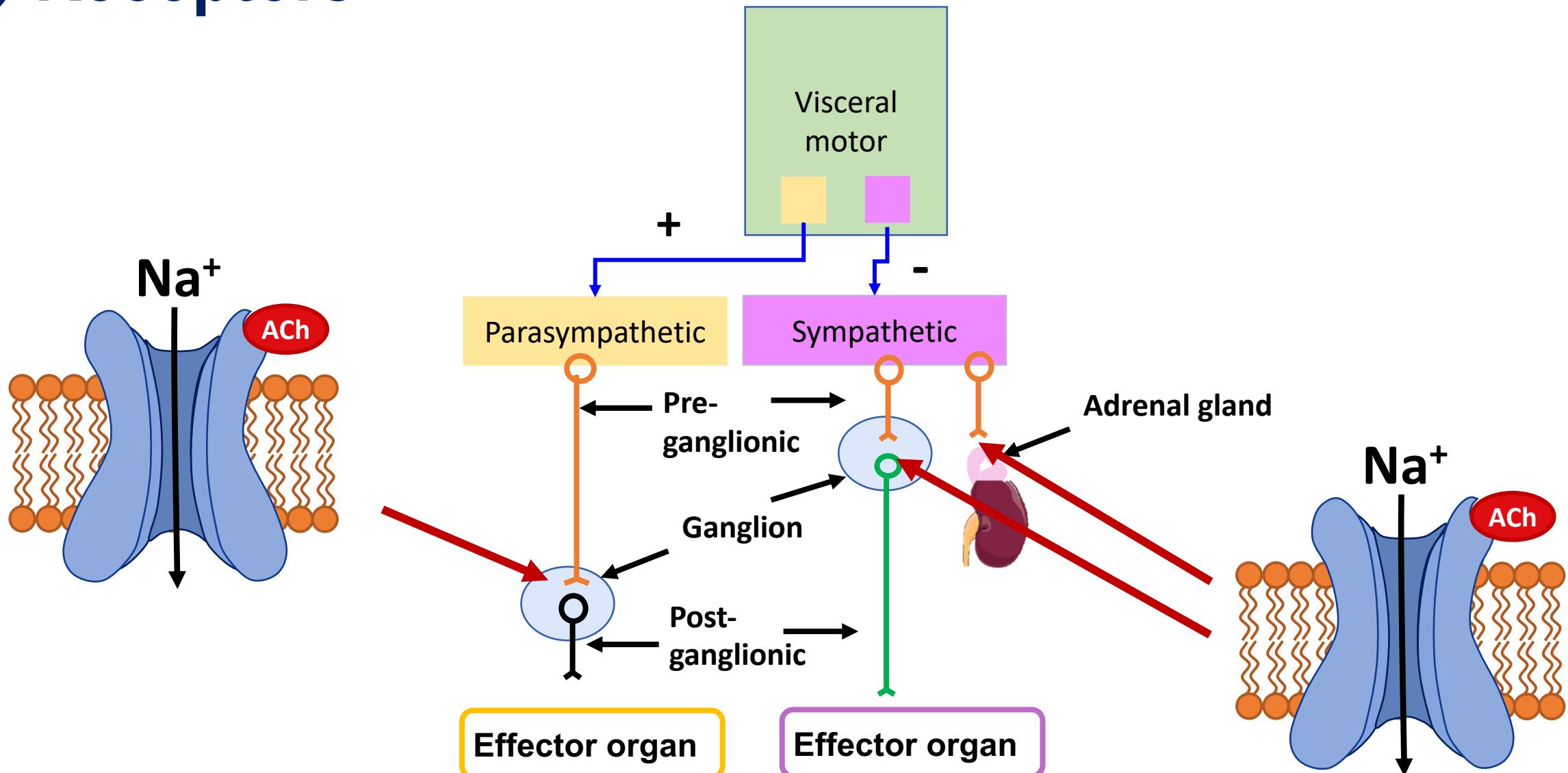
FAST response (msecs)



Mediate all fast excitatory and inhibitory transmission



Receptors



1-BRS-NEU-3: Organisation of the nervous system: Compare and contrast the structure of the central, peripheral and autonomic (sympathetic and parasympathetic) nervous systems.

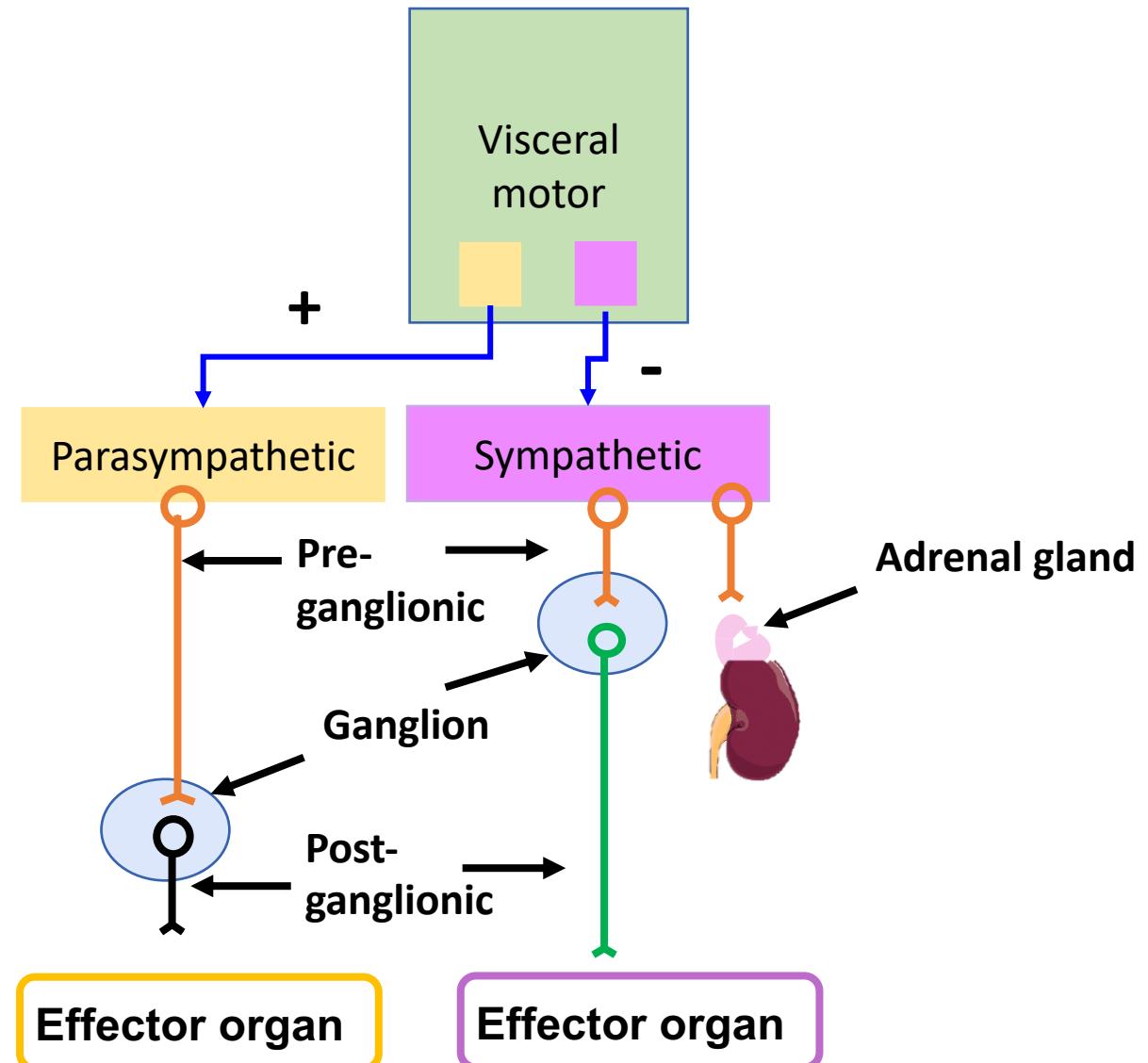


Receptors

Nicotinic acetylcholine (nACh) receptors mediate the responses to **acetylcholine** released from preganglionic fibres at all autonomic ganglia.

In addition, they also mediate the response to acetylcholine released by sympathetic nerves innervating the **adrenal medulla**.

Different receptors mediate the effects of neurotransmitters released from postganglionic fibres.





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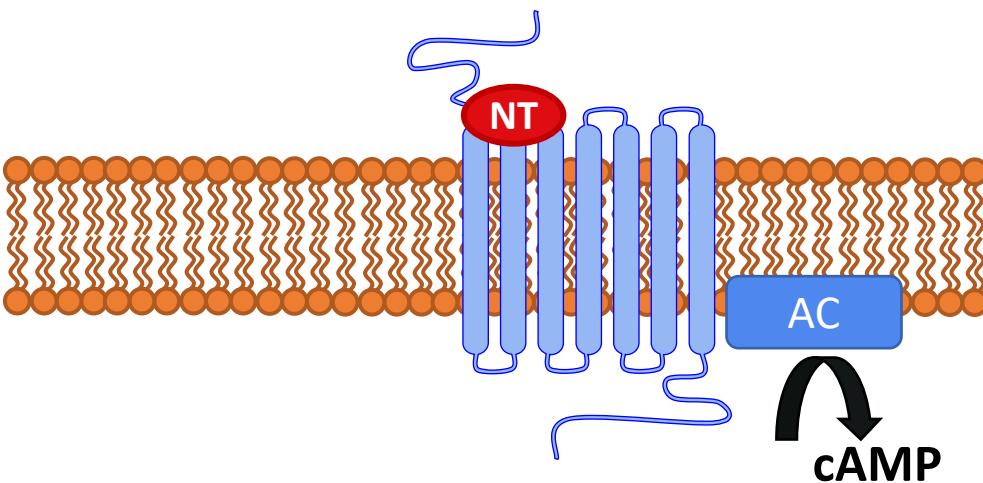
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Different receptors mediate the effects of neurotransmitters released from postganglionic fibres.

G-protein coupled receptor

SLOW response (secs/mins)

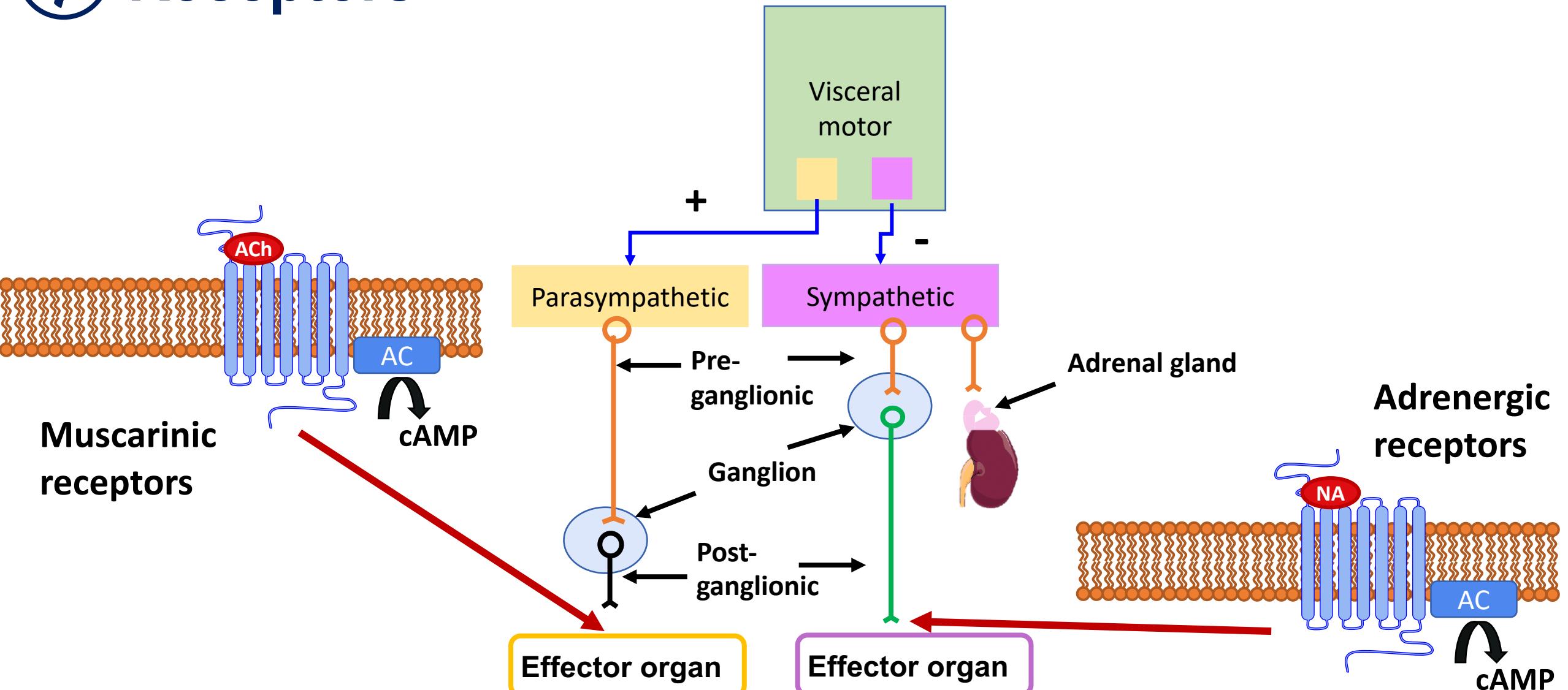
**Muscarinic
or
Adrenergic
receptors**



Effectors may be enzymes (adenyl cyclase, phospholipase C, cGMP-PDE) or channels (e.g. Ca^{2+} or K^+)



Receptors



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Enteric nervous system – ‘mini-brain’ of GIT

Receptors

Nicotinic ACh receptor – present within all autonomic ganglia. Ion channel linked.

Muscarinic Ach receptor – respond to Ach release from post-ganglionic PNS fibres.

Adrenergic receptors – respond to NA release from post-ganglionic SNS fibres or adrenaline via blood.

Biosynthesis and metabolism



Biosynthesis & metabolism

1. Precursor enzymatically converted to neurotransmitter

2. Packaged into vesicles

1.
2.

3. Action potential

Ca²⁺

Presynaptic nerve terminal

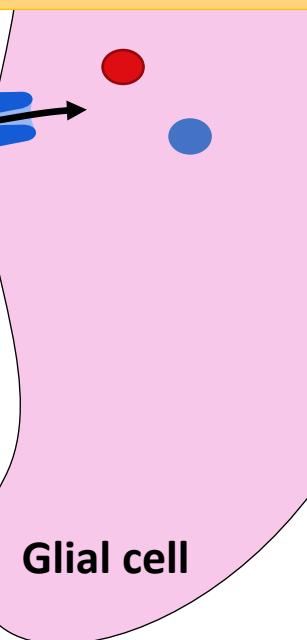
3. Action potential causes Ca²⁺ influx and exocytosis

Postsynaptic nerve terminal

4. Exocytosis and neurotransmitter release

5. Receptor activation

6. Removal of neurotransmitter from synapse via uptake into pre-synaptic terminal or glial cell;
Can be metabolised in the synapse prior to uptake

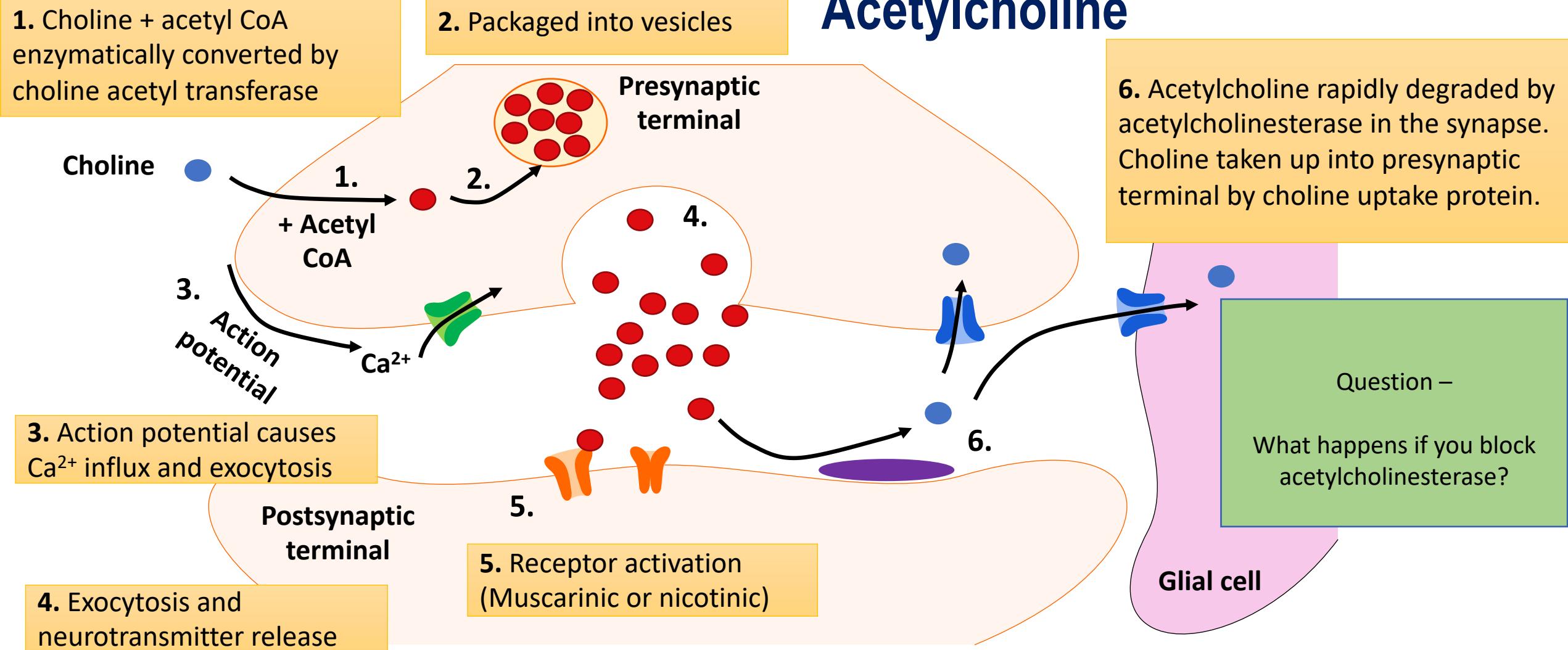


Intercellular communication: Outline communication between nerve cells, nerve and glial cells, and nerve and effector cells, including mechanisms of neurotransmission.



Biosynthesis & metabolism

Acetylcholine

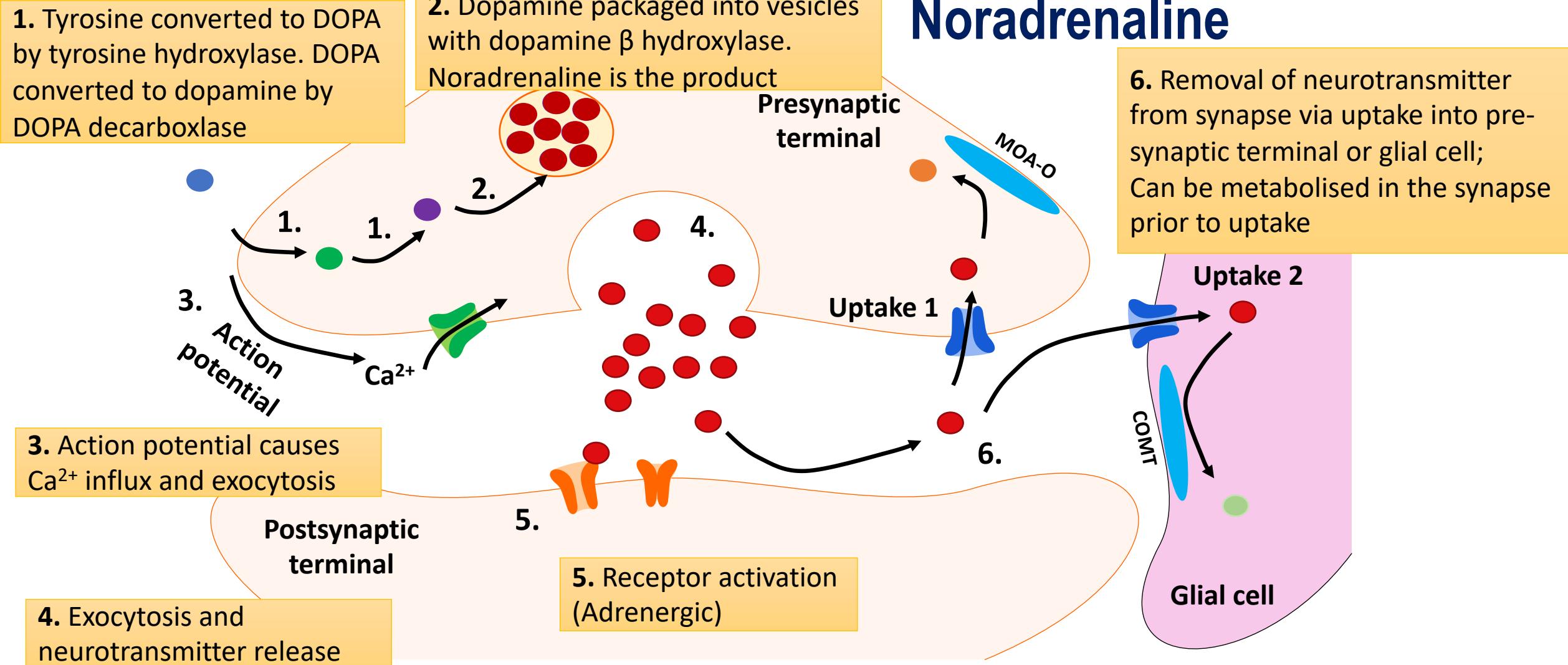


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Biosynthesis & metabolism

Noradrenaline

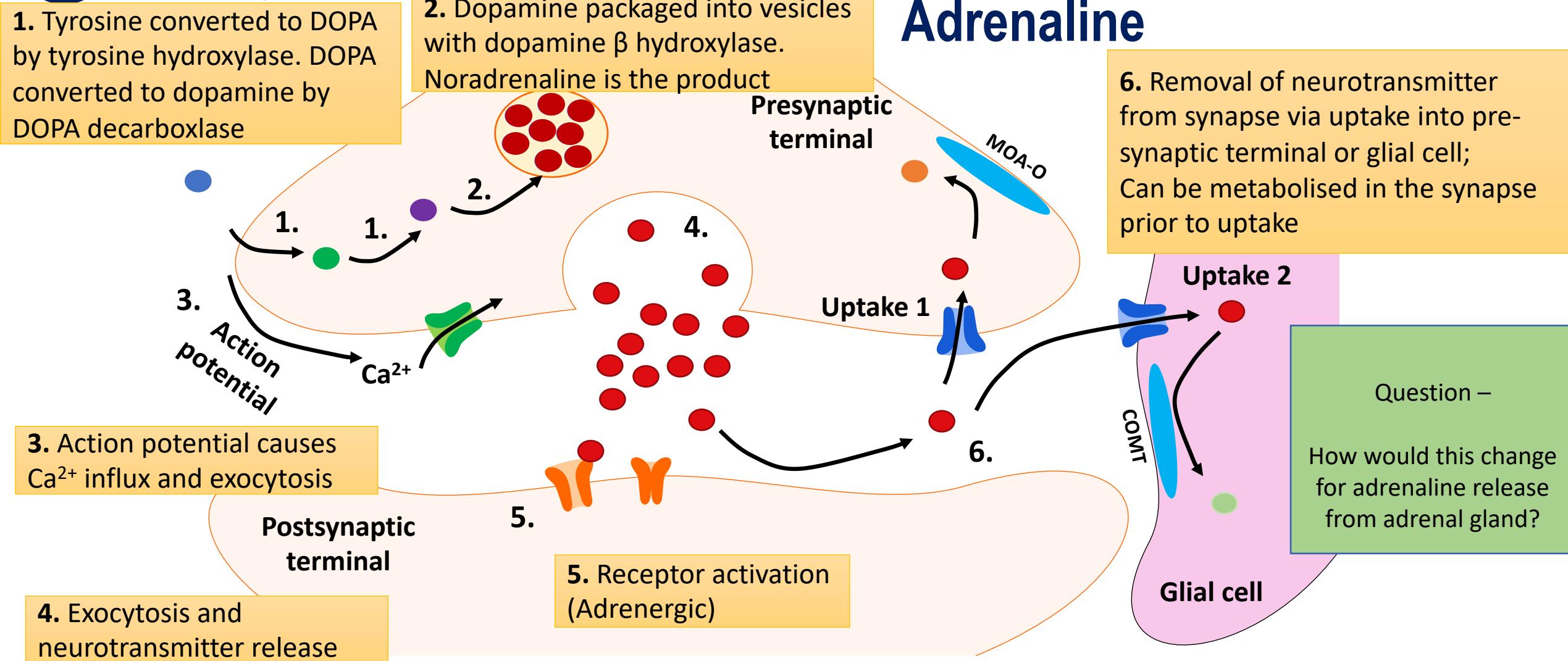


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Biosynthesis & metabolism

Adrenaline

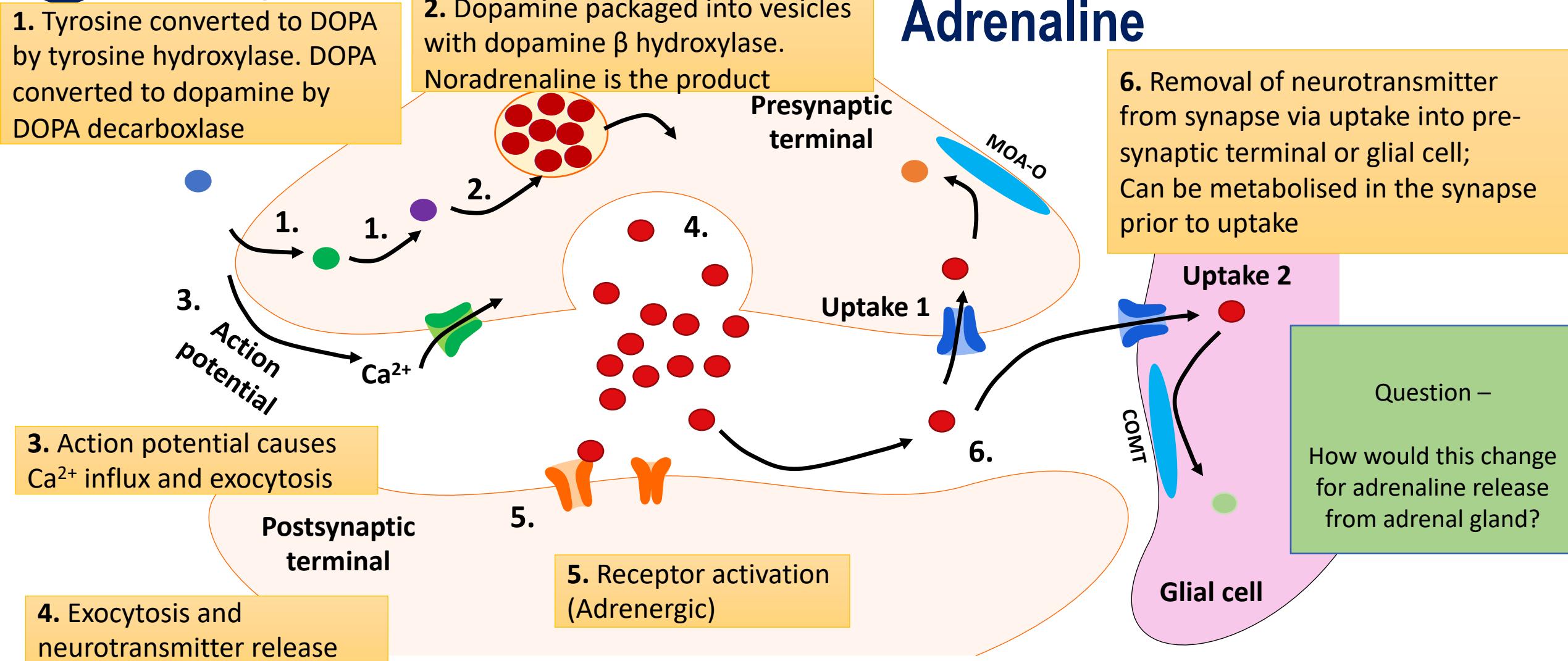


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Biosynthesis & metabolism

Adrenaline

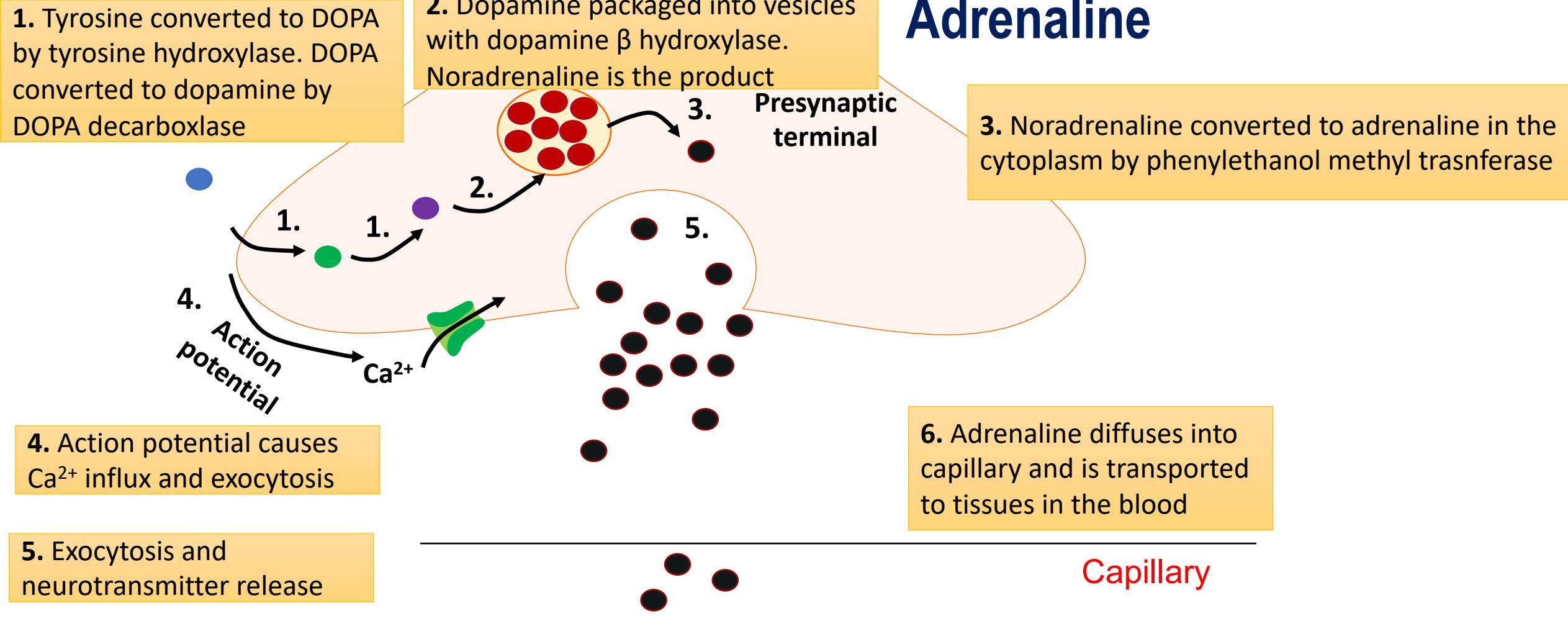


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Adrenergic receptors – respond to NA release from post-ganglionic SNS fibres or adrenaline via blood.

Biosynthesis and metabolism

Neurotransmitter biosynthesis – **similar in all ANS neurons**.

Differences: **Multiple enzymatic reactions to generate NA/adrenaline vs one for ACh**

ACh metabolised in synapse and metabolites transported back to pre-synaptic neuron.

NA transported back to pre-synaptic neuron and **then metabolised**