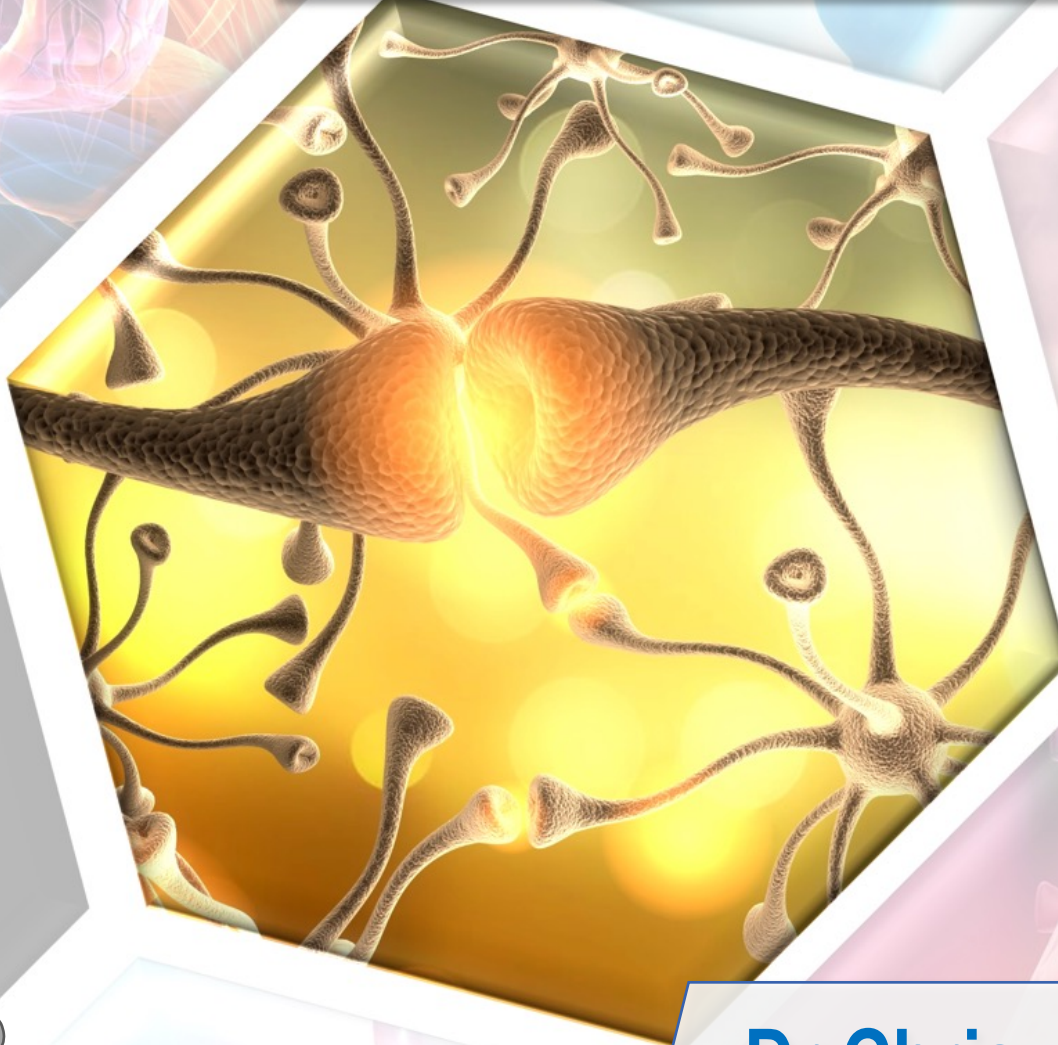


IMPERIAL

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

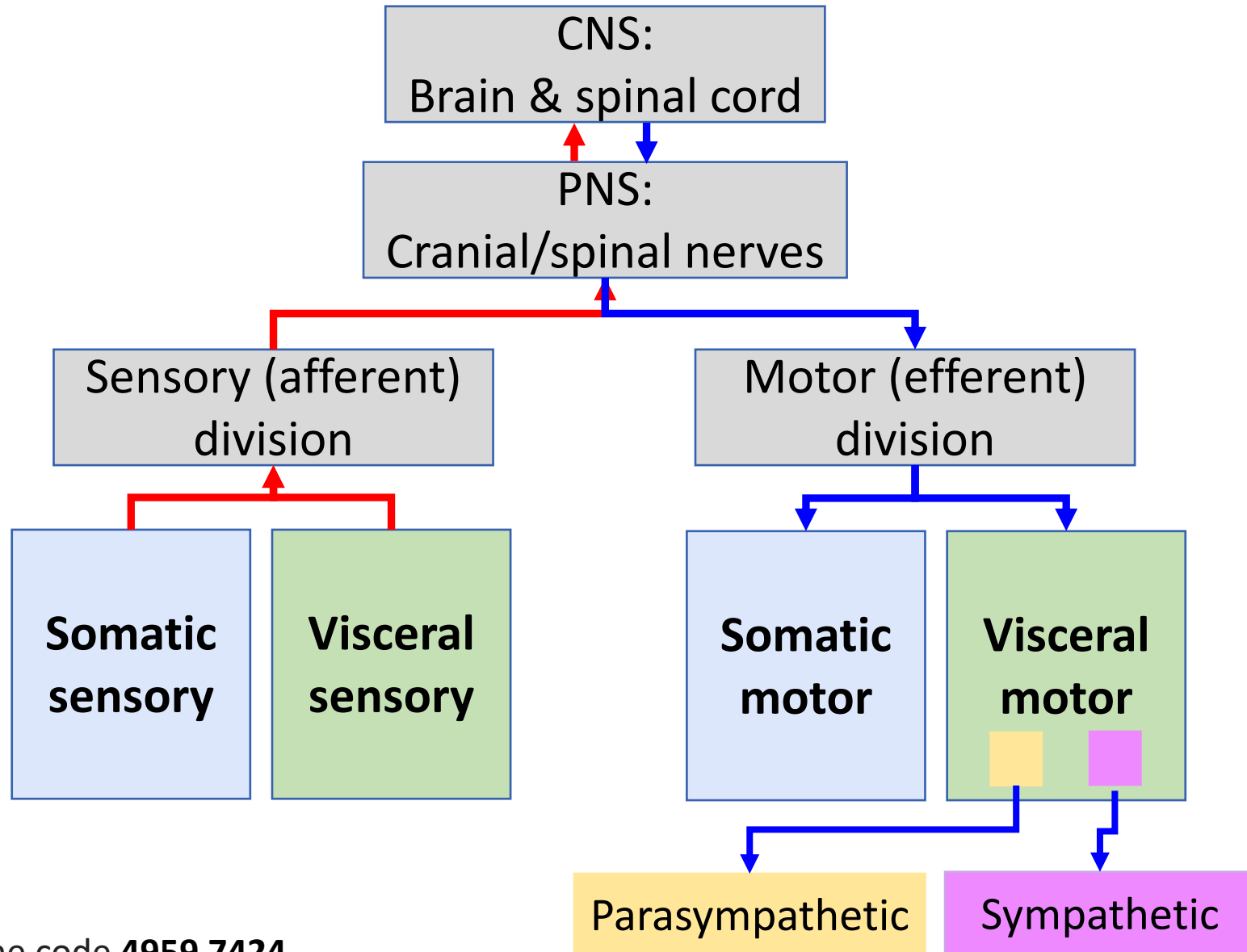


ANS - general

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**

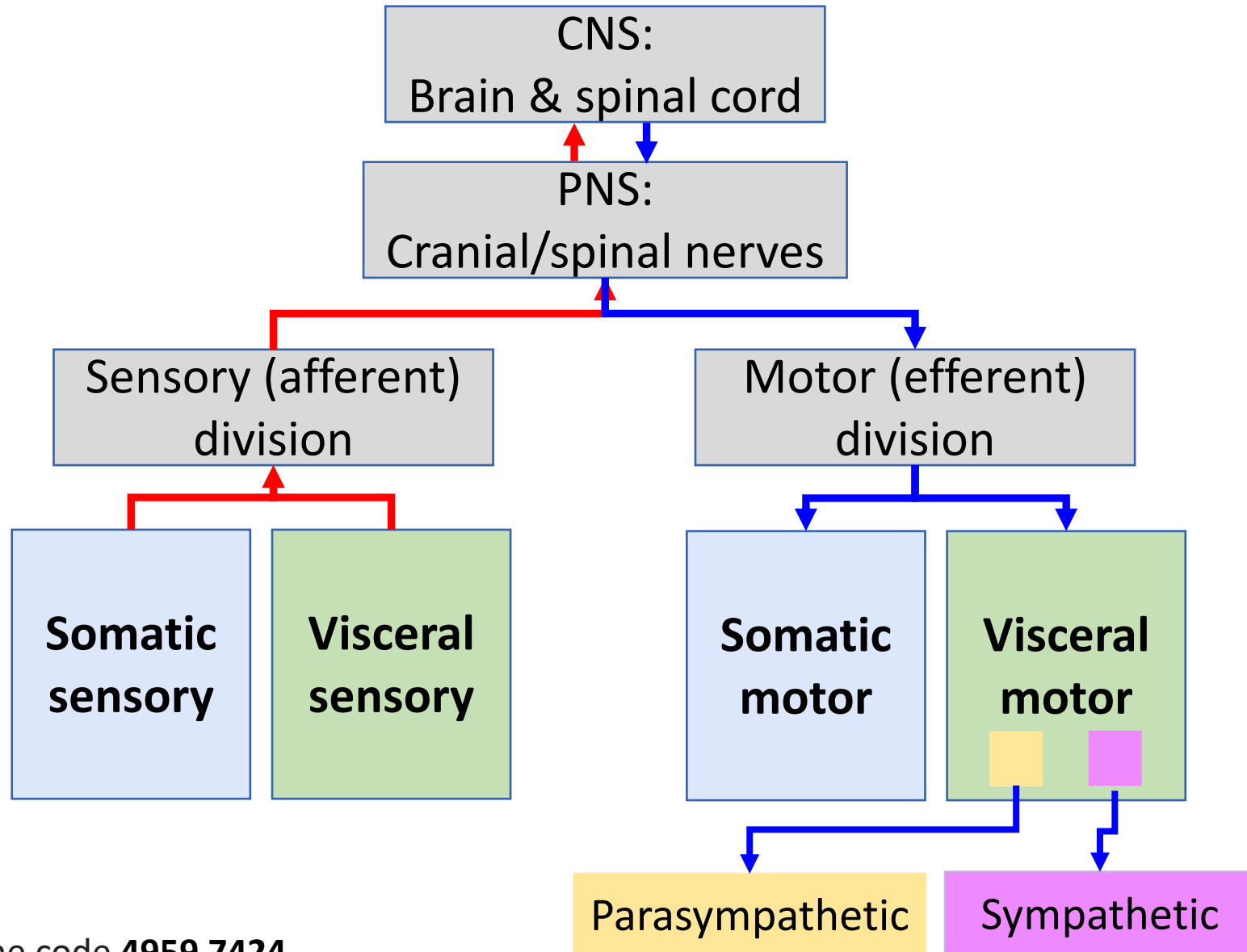


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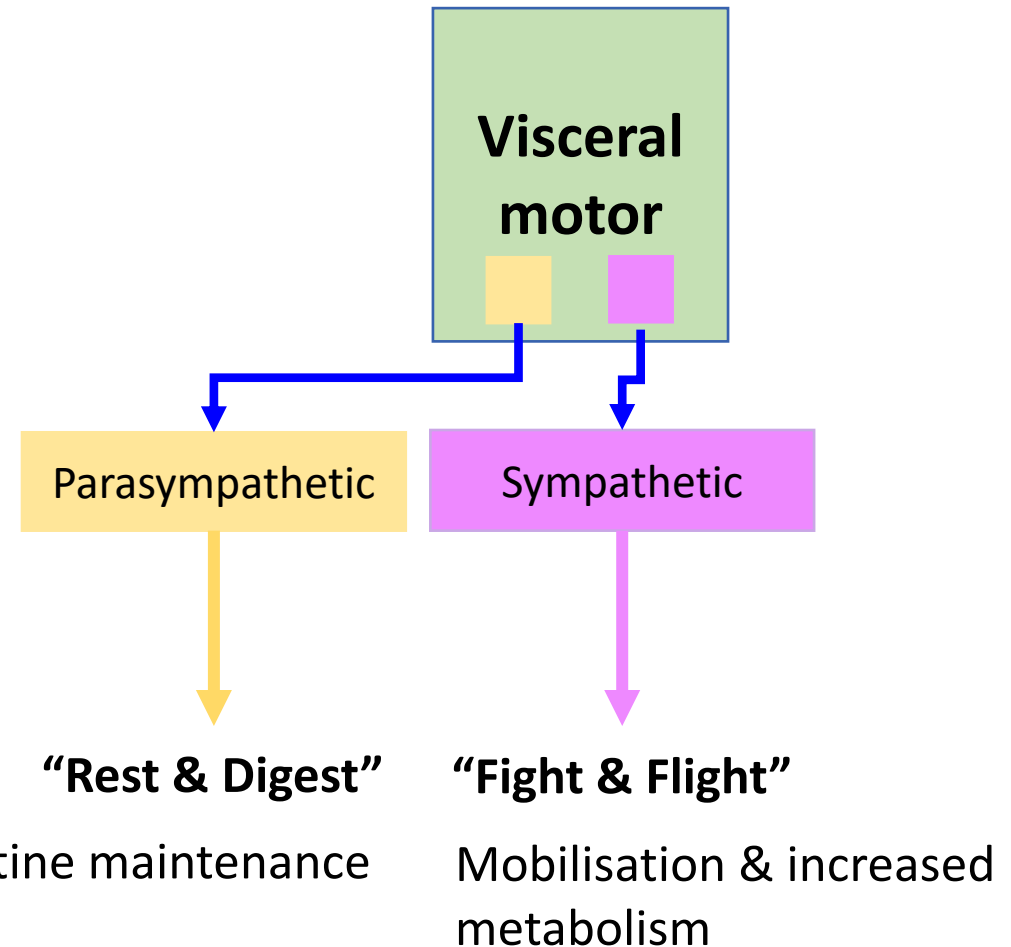
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Often innervate the same tissues and have opposing/antagonistic effects

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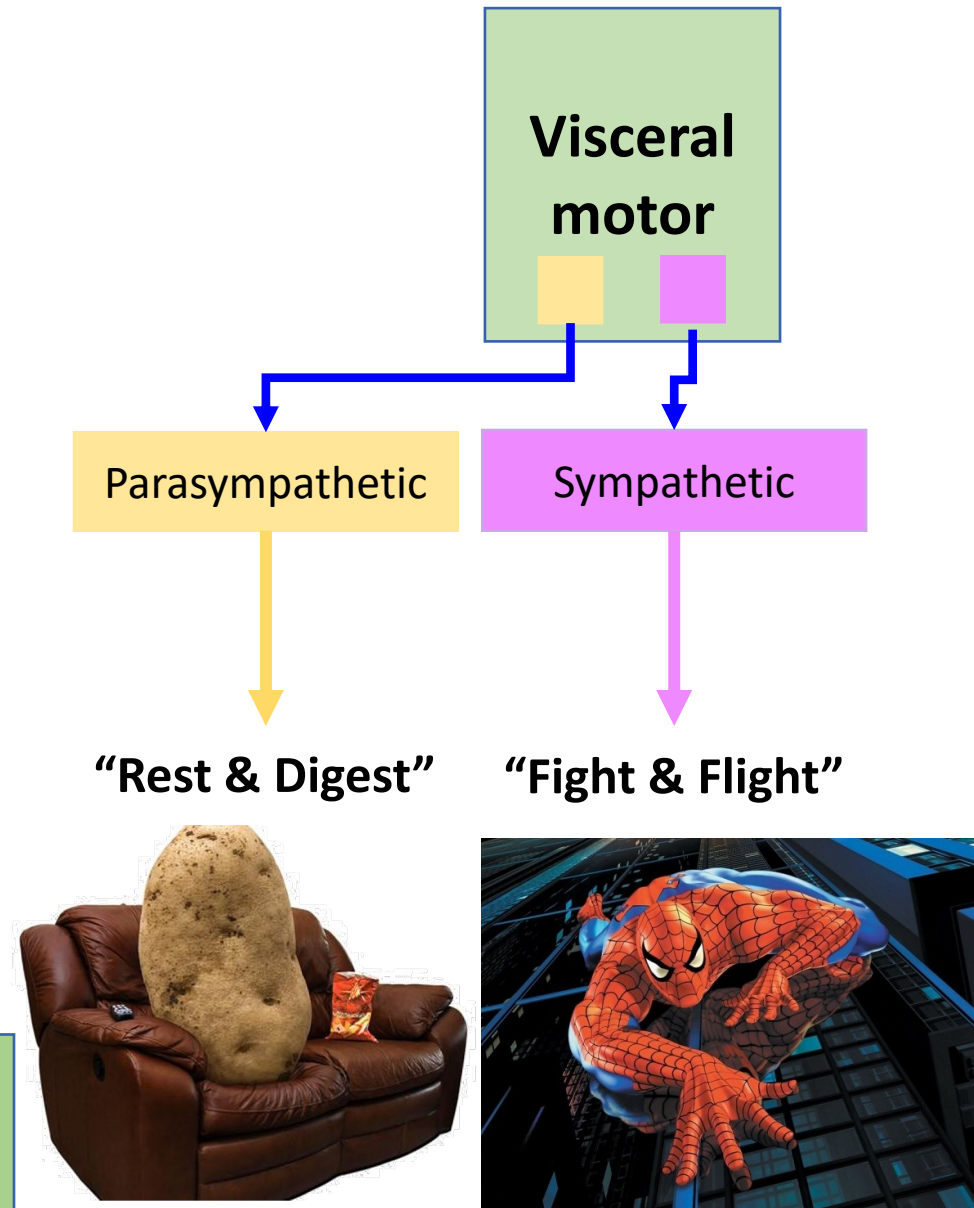
Cardiac muscle (heart)

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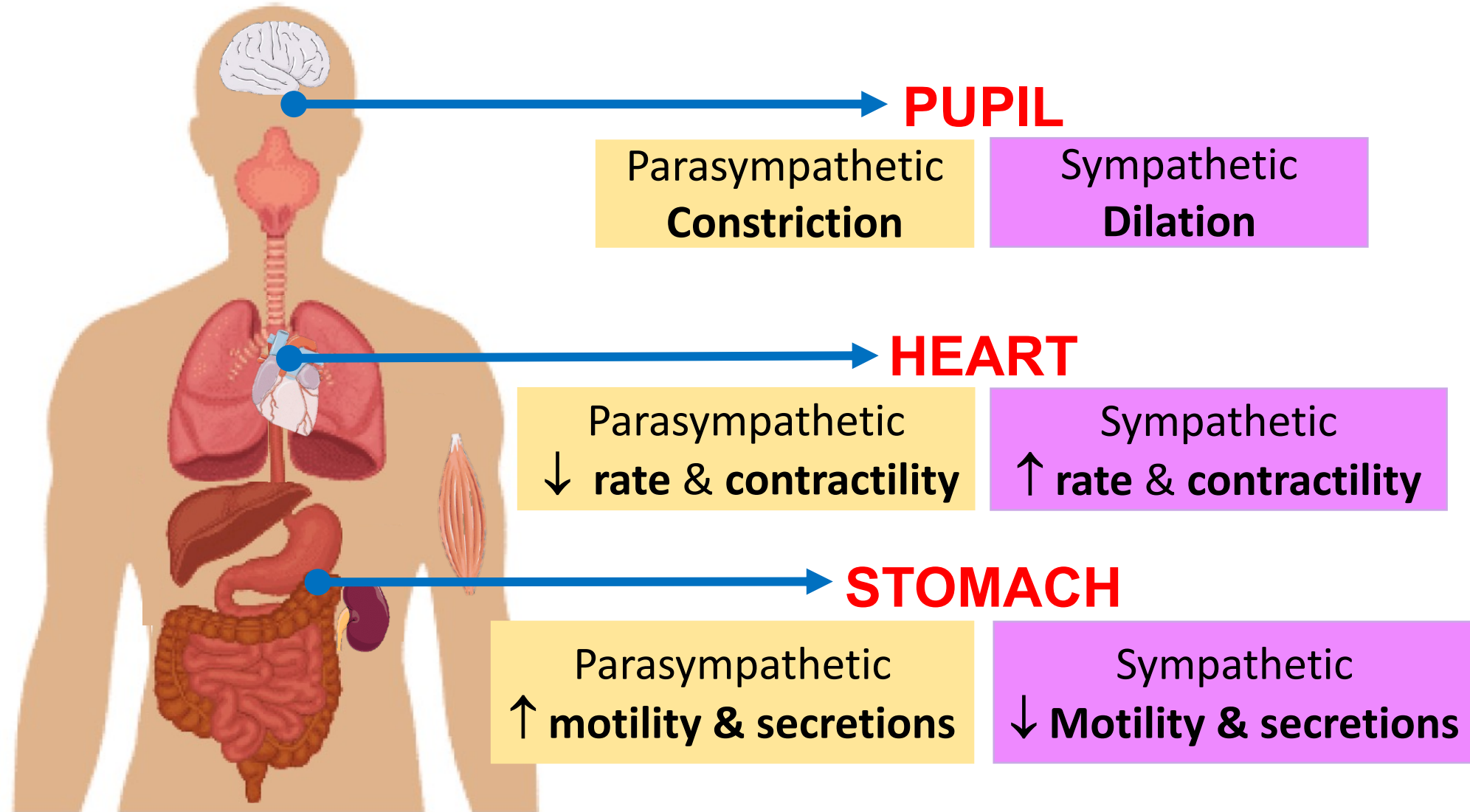
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ANS - general

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

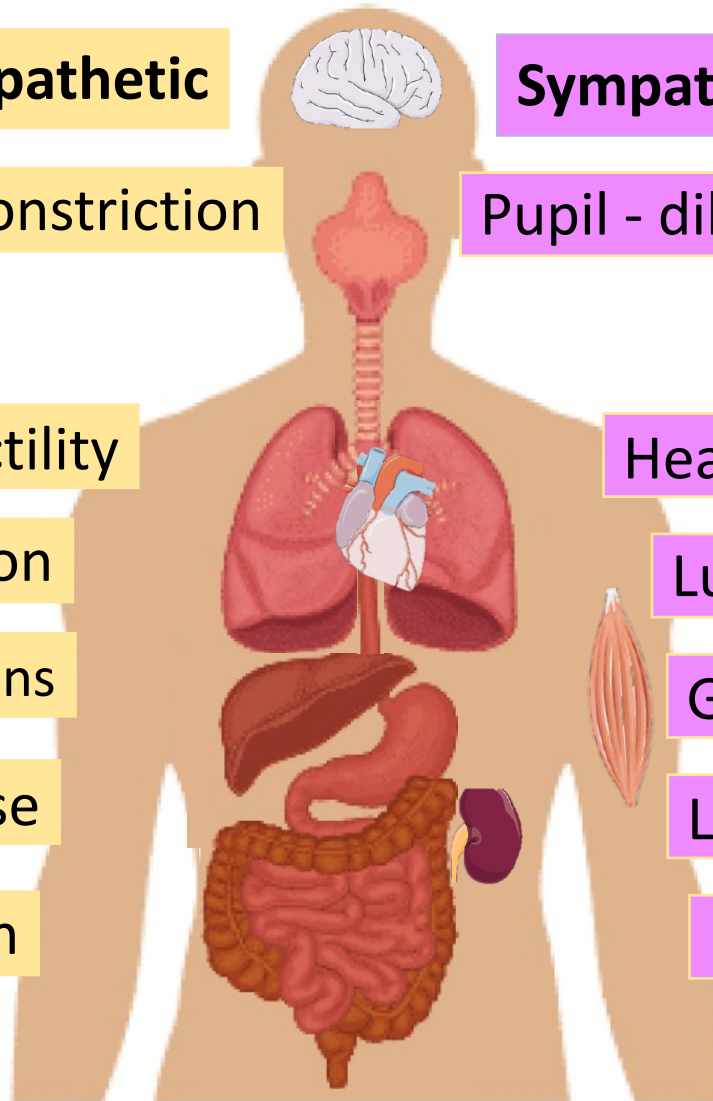
GIT - ↓ motility & secretions

Liver - ↑ glucose release

Bladder - relaxation

Not always the case:

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

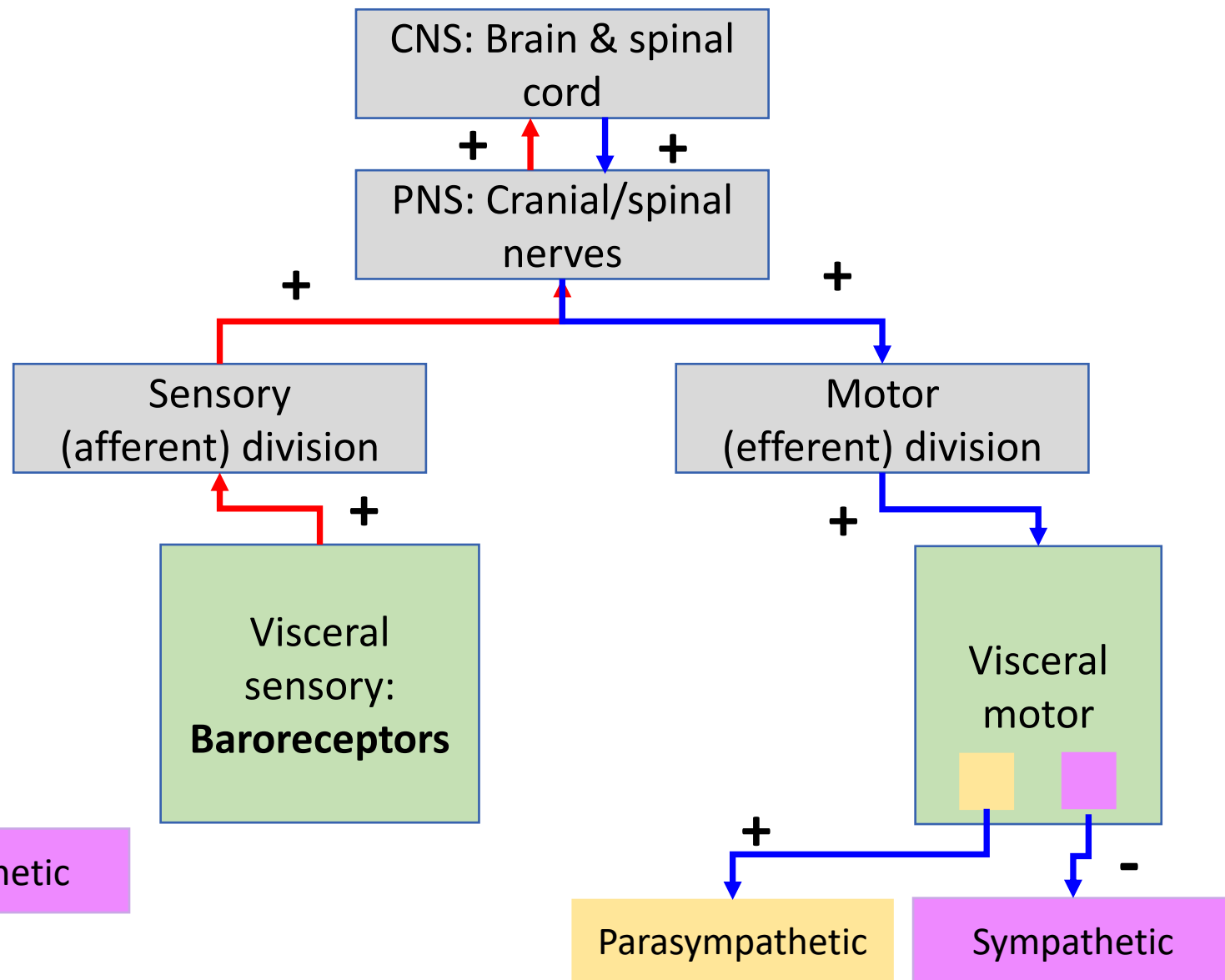
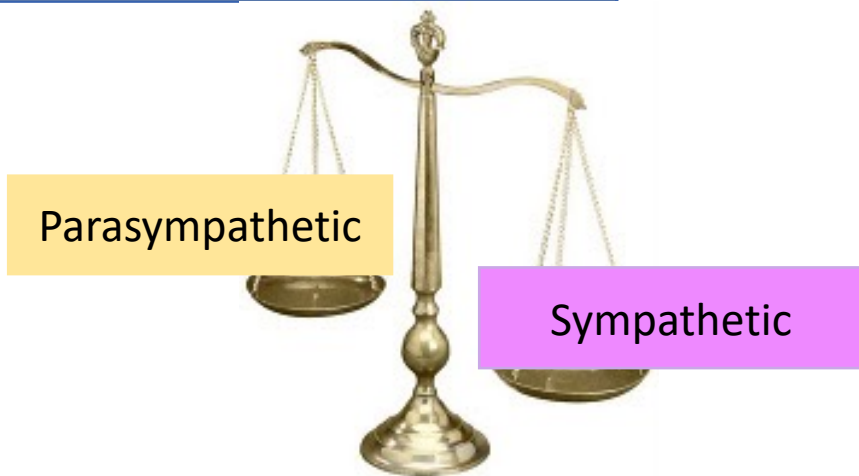




ANS - general

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





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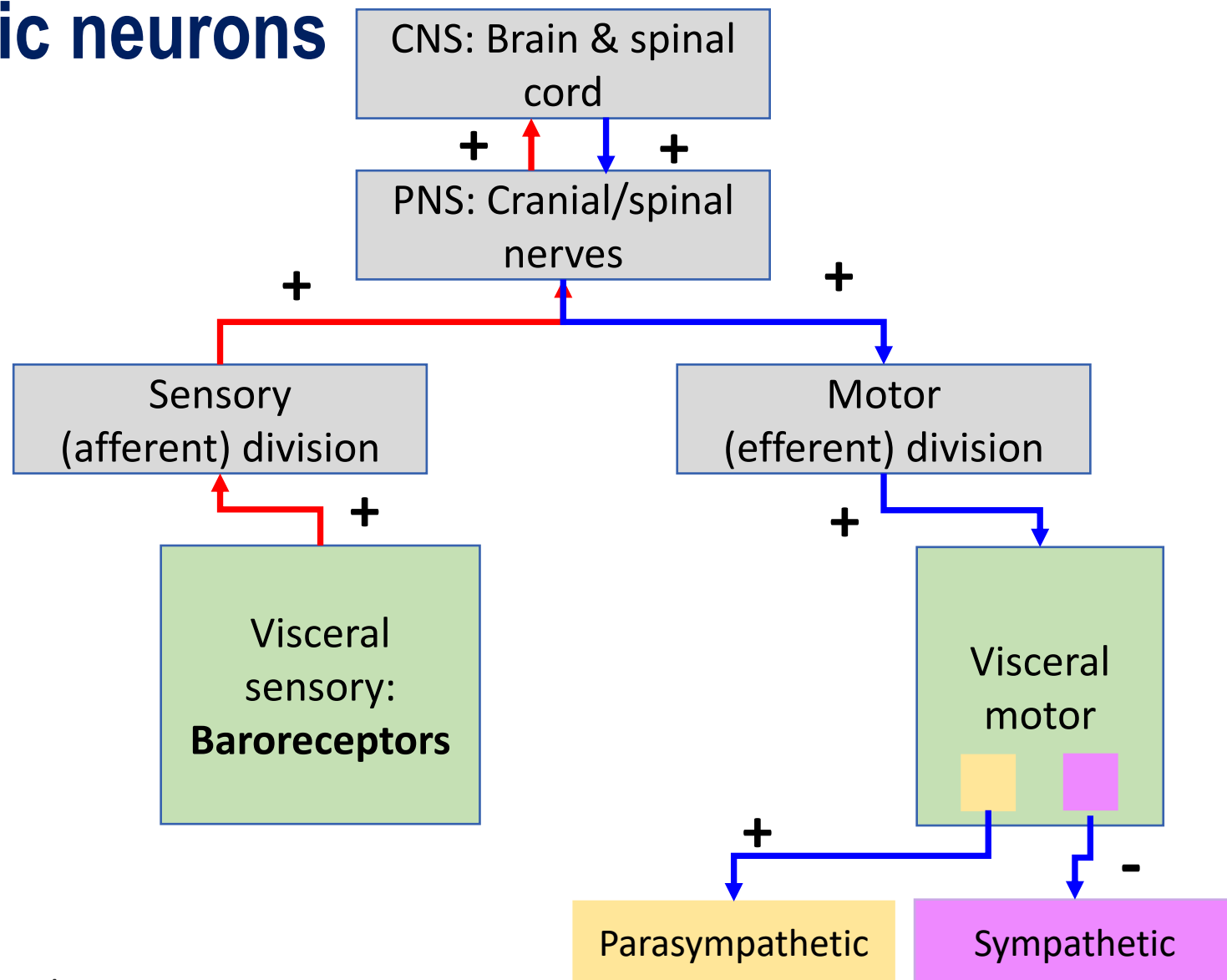
Biosynthesis and metabolism



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.

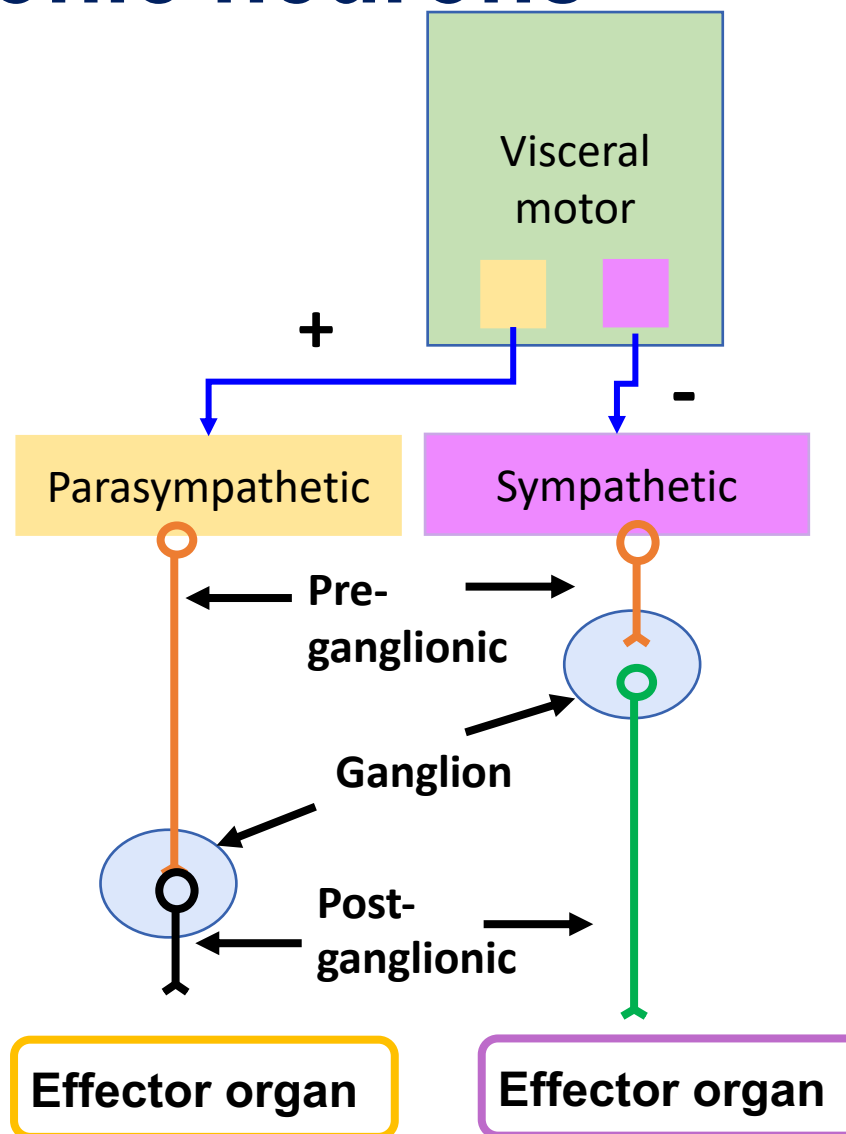
Short post-ganglionic fibres

SNS

Short pre-ganglionic fibres

Ganglions close to spinal cord.

Long post-ganglionic fibres



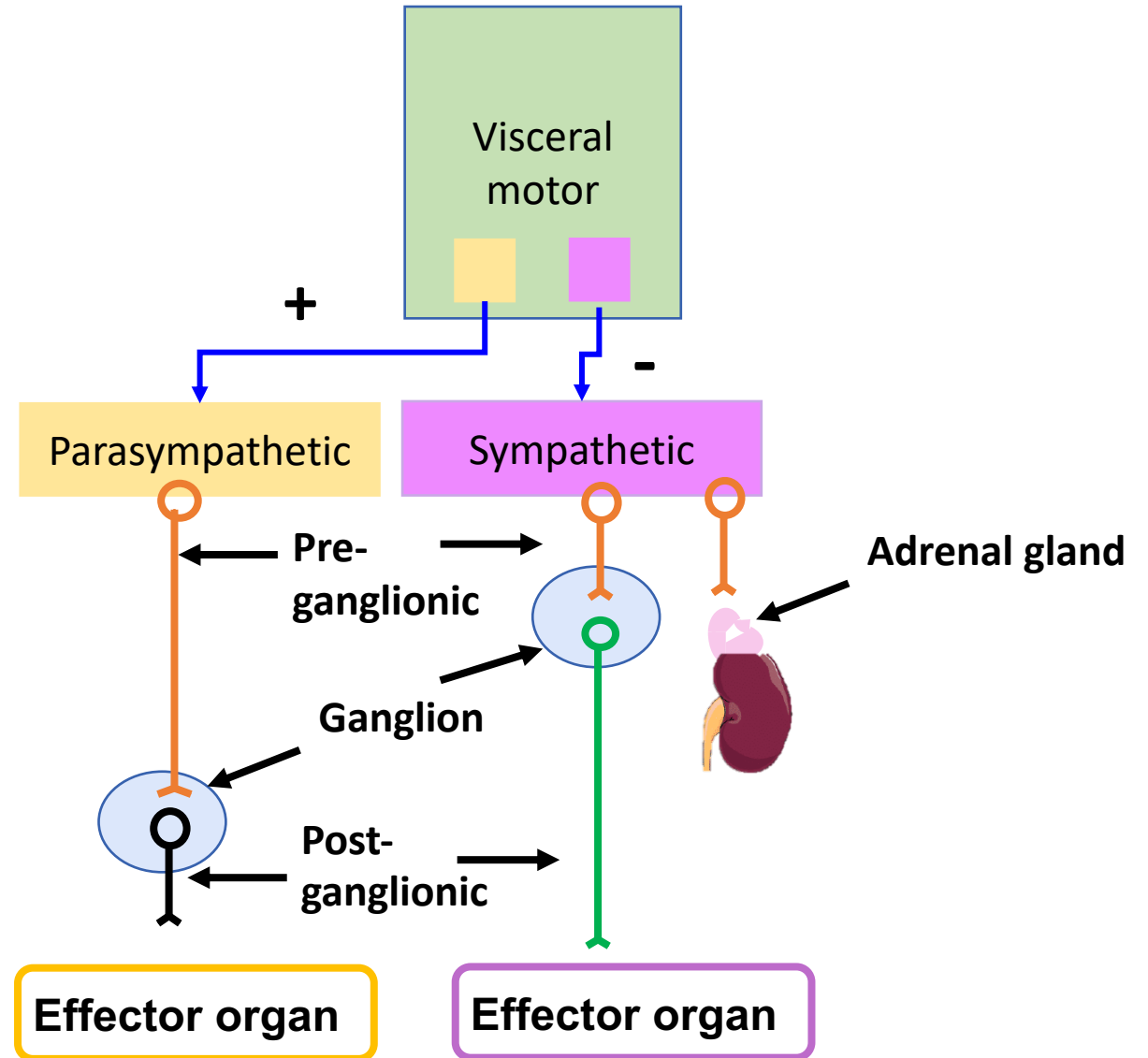


Adrenal gland

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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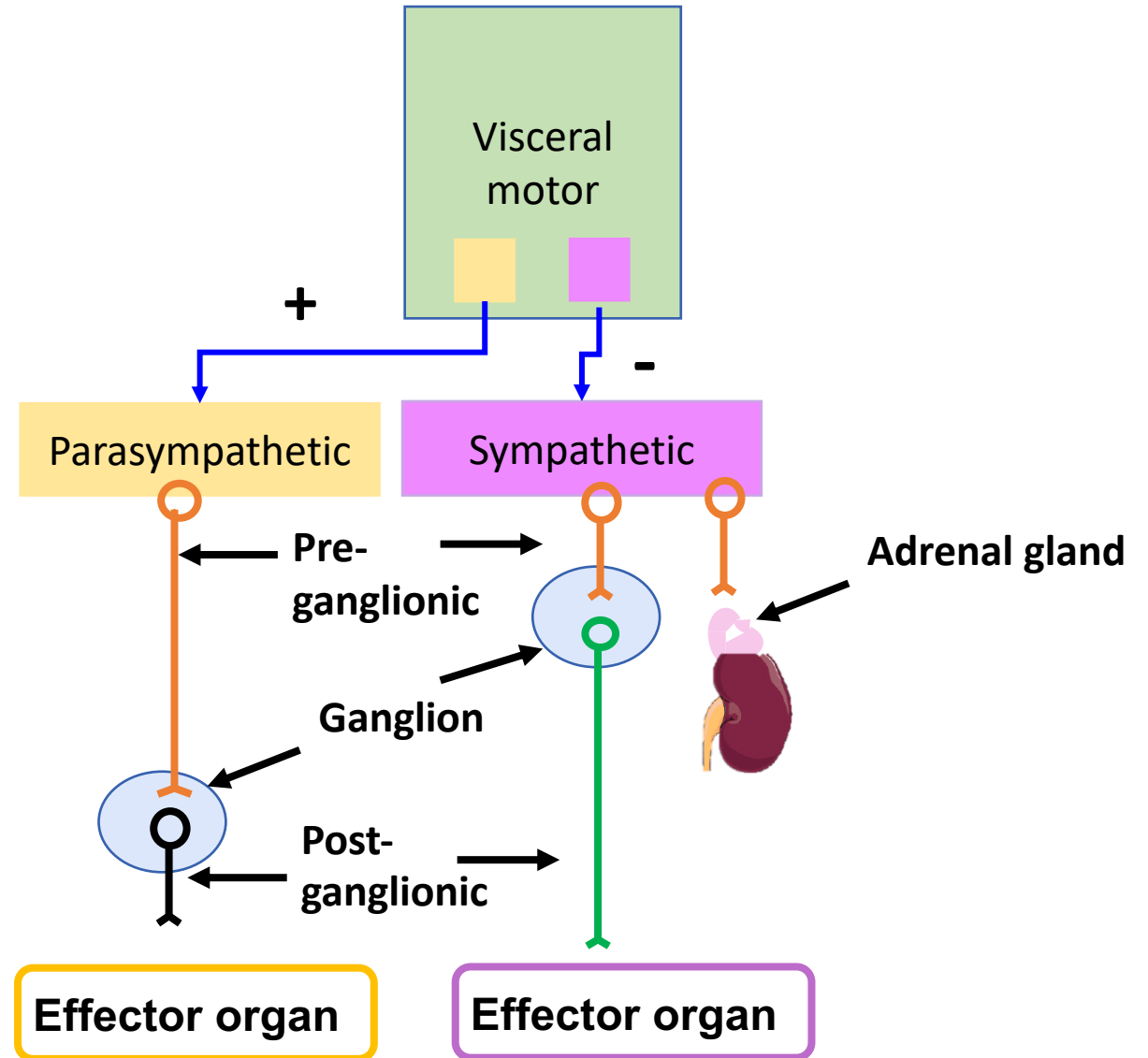
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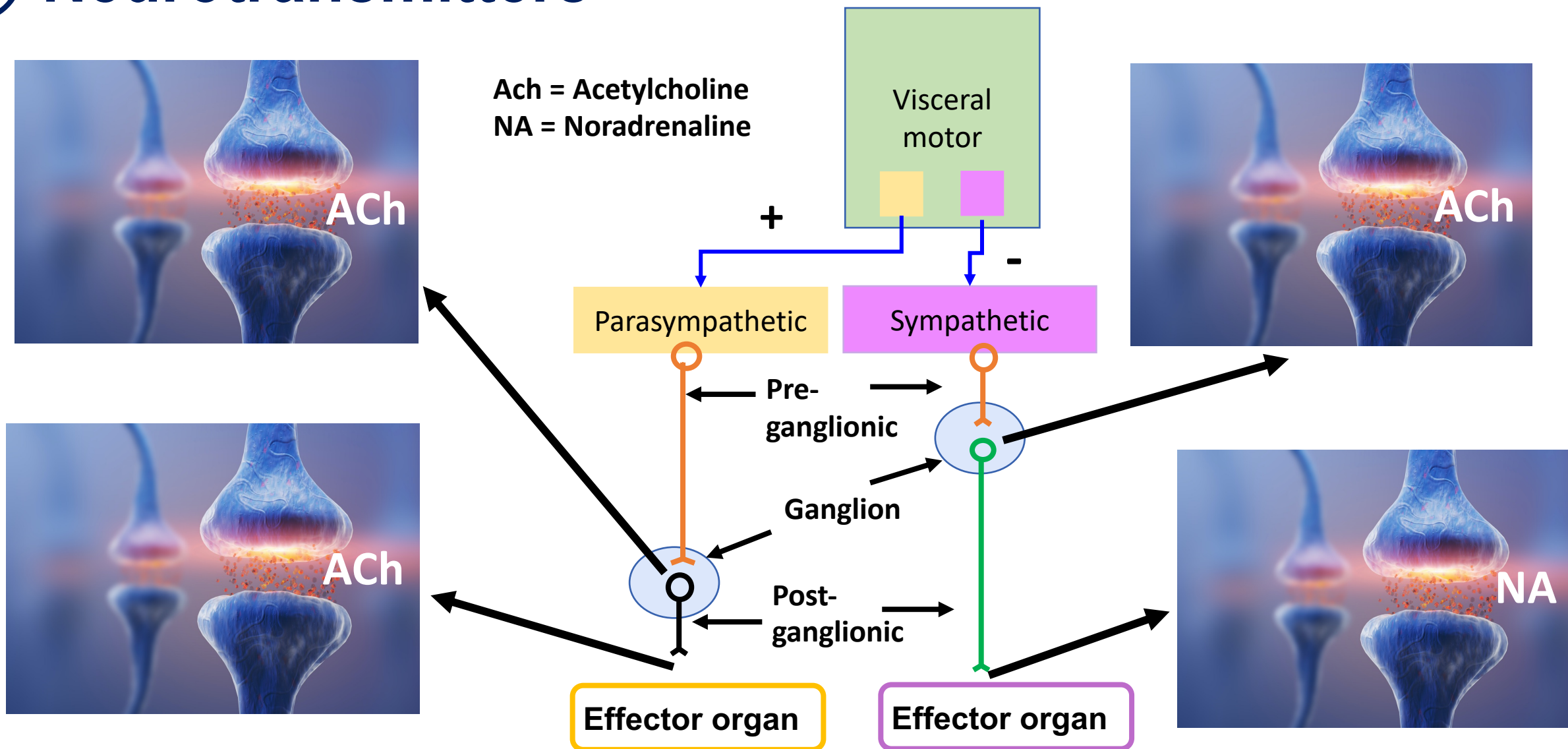
Neurotransmitters

Which neurotransmitters are released at each autonomic synapse?





Neurotransmitters



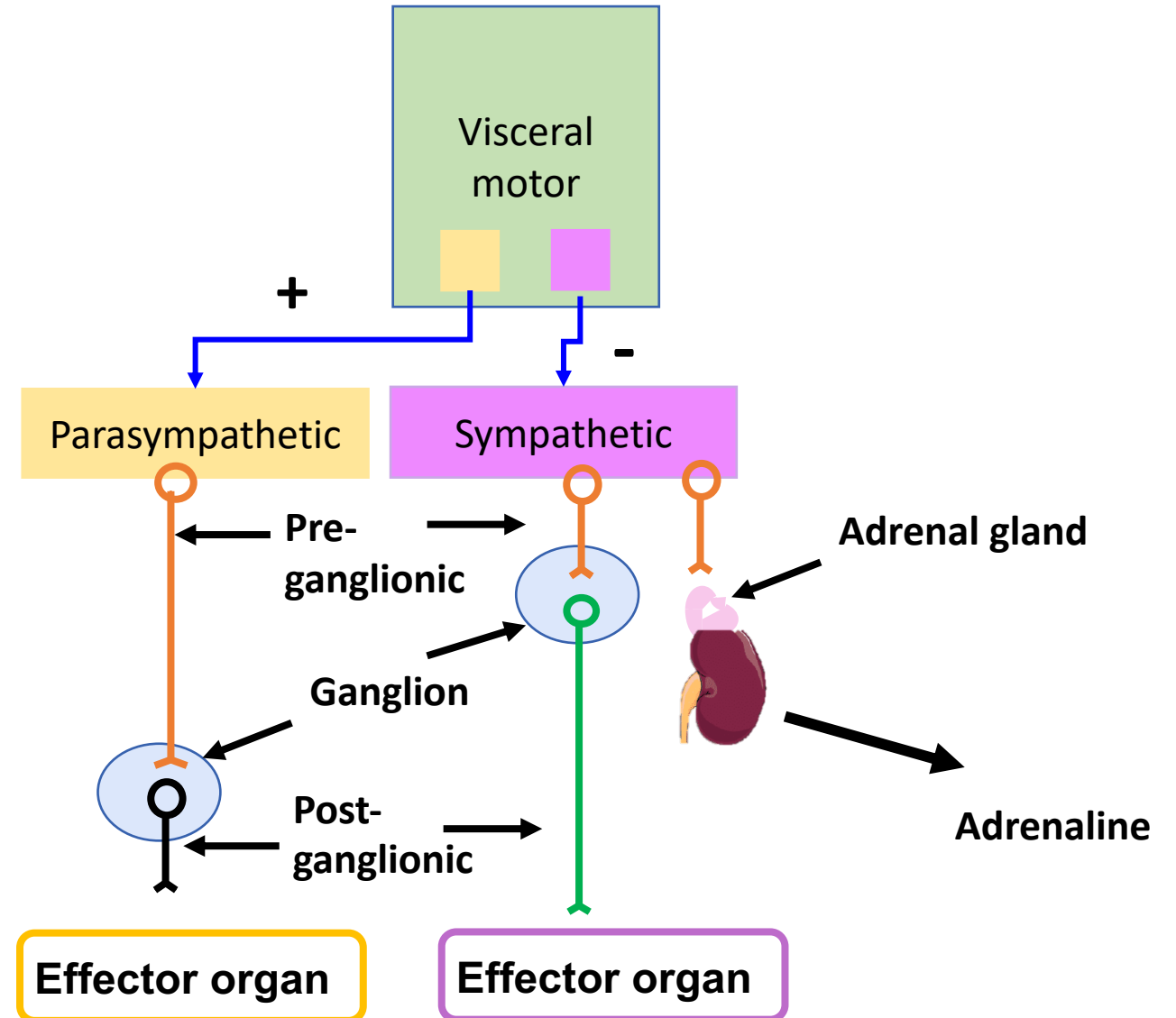


Neurotransmitters

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

Adrenaline (and some
noradrenaline)

Secreted into **bloodstream**
NOT **synapse**





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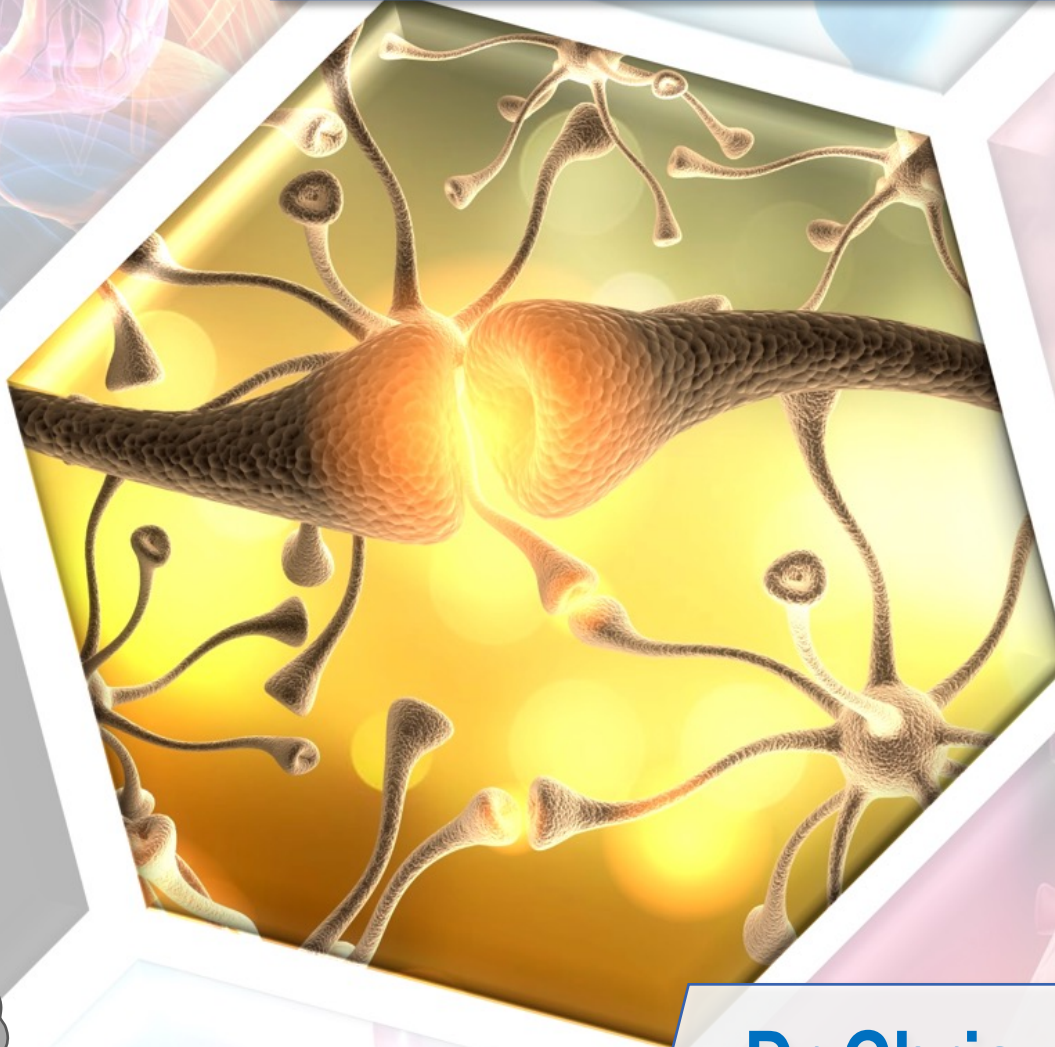
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IMPERIAL

Autonomic nervous system



part 2 of 3

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Regulation of function

Receptors

Biosynthesis and metabolism

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



Regulation of function

3 questions asked earlier:

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

a) the heart, b) the stomach, c) the pupil

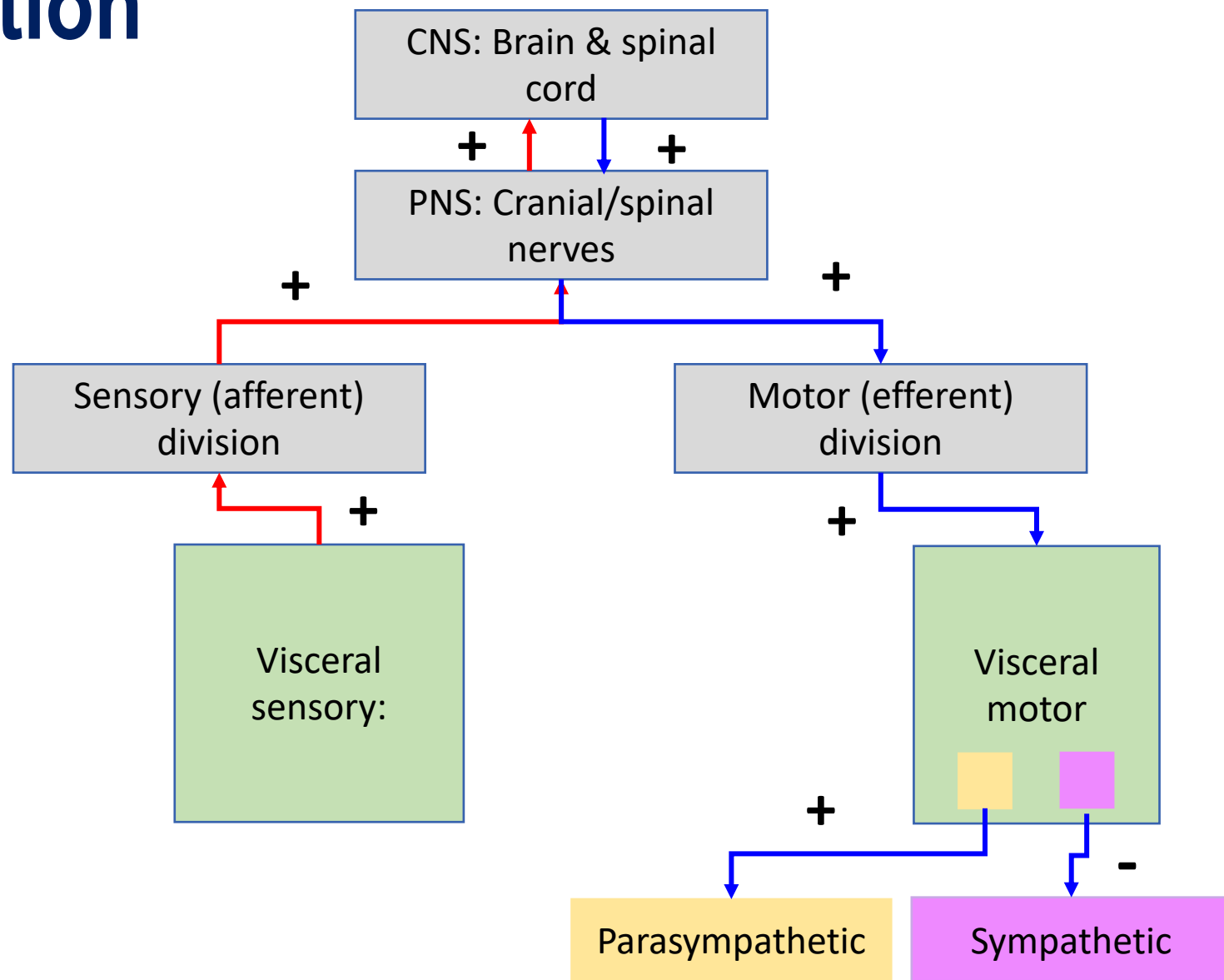
What sort of sensory information is relayed to the brain?

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

Exposure to bright sunlight - c) the pupil





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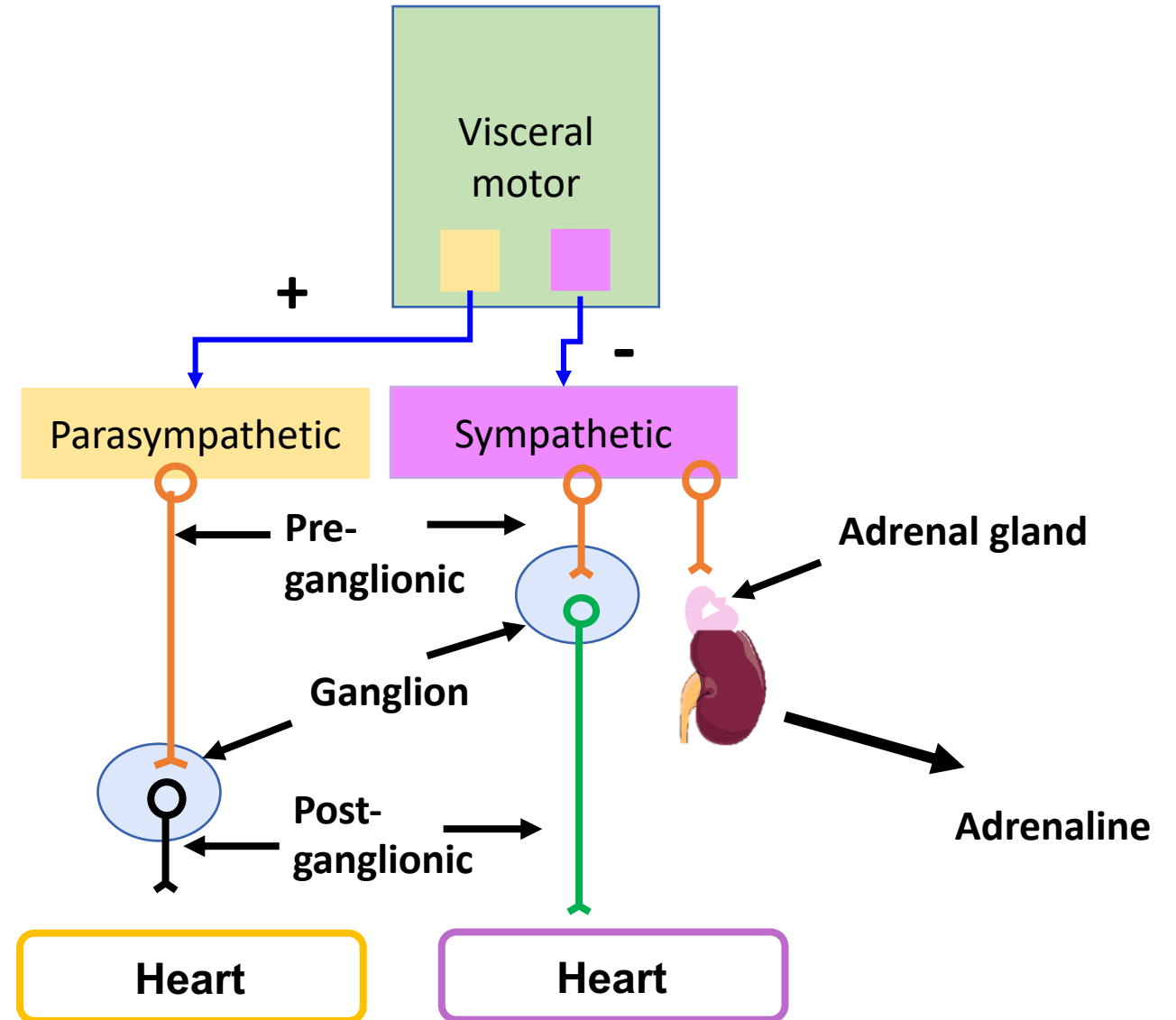
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Regulation of function

Gastro: Control of
gut function
(February/March)

3 questions asked earlier:

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PNS/SNS will have on

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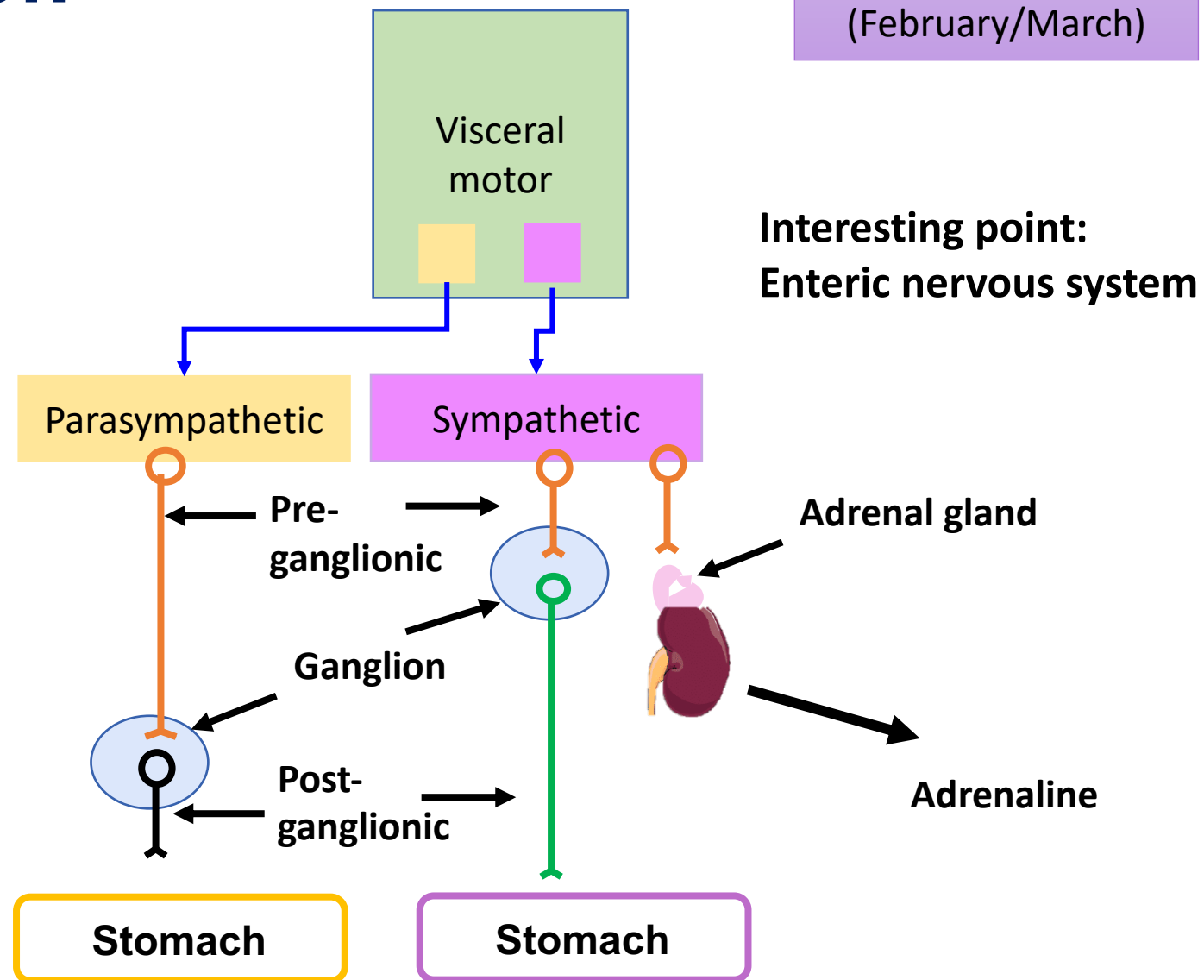
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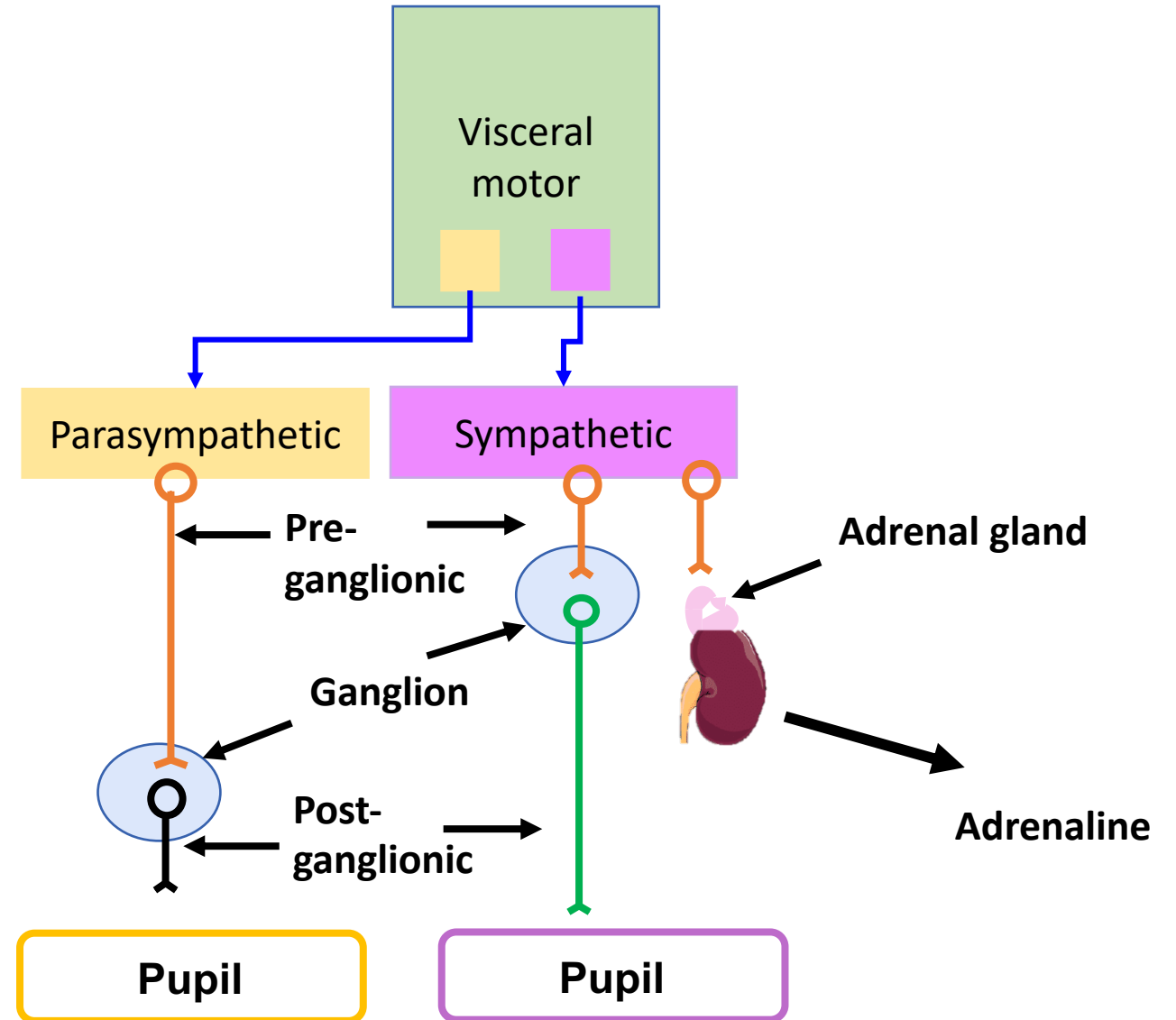
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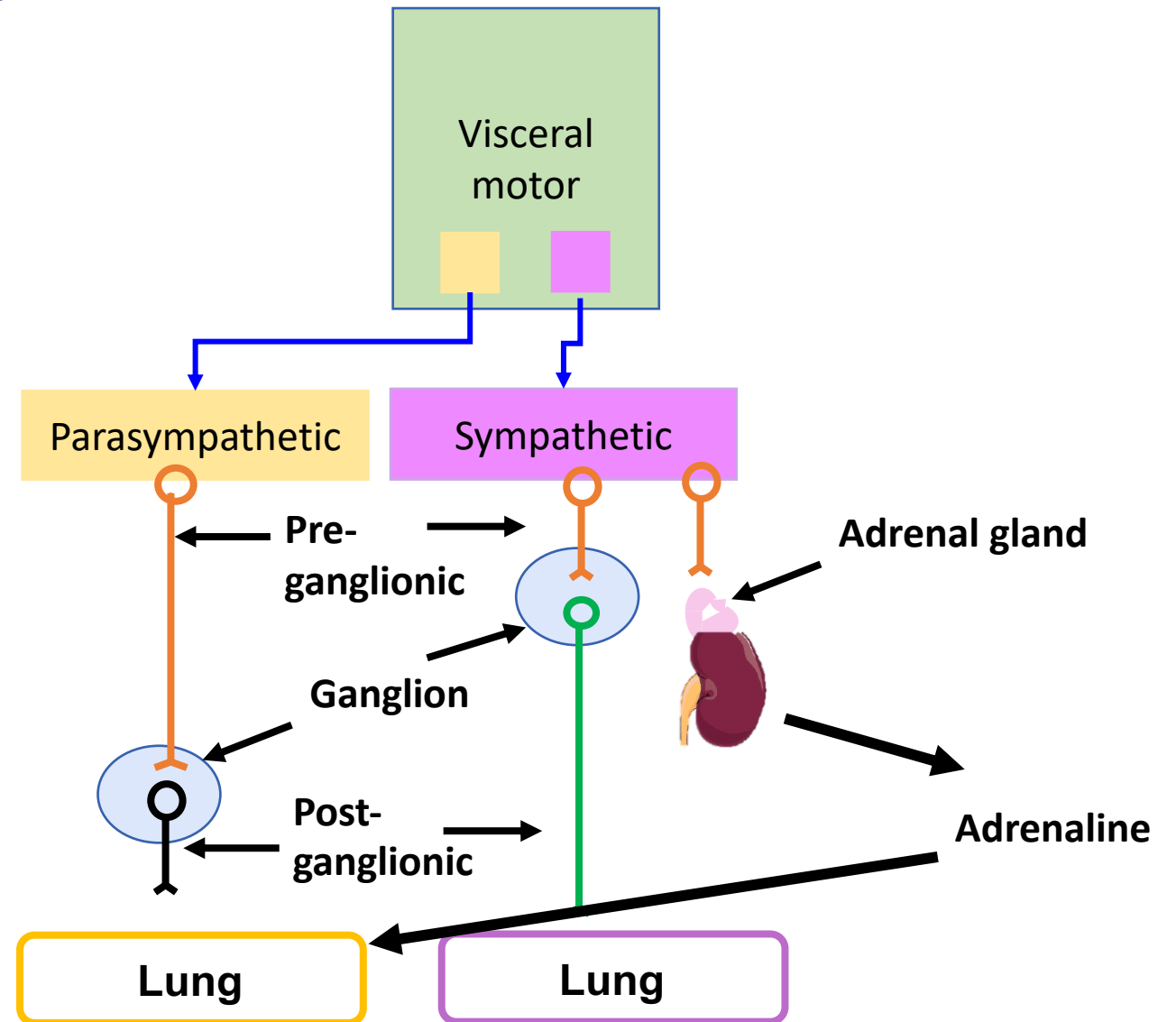
QUESTIONS: Go to www.menti.com and use the code **4959 7424**

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

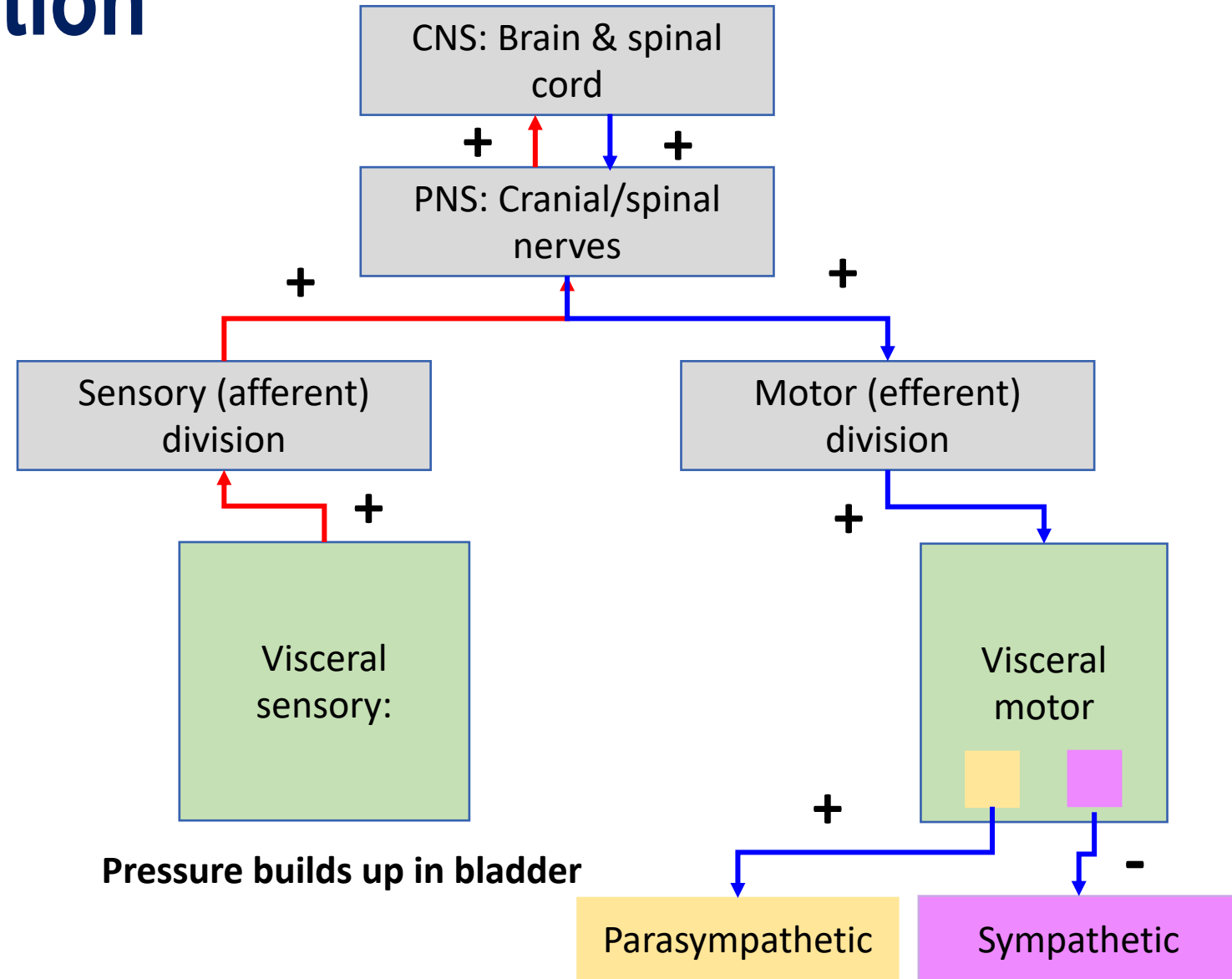
We've covered:

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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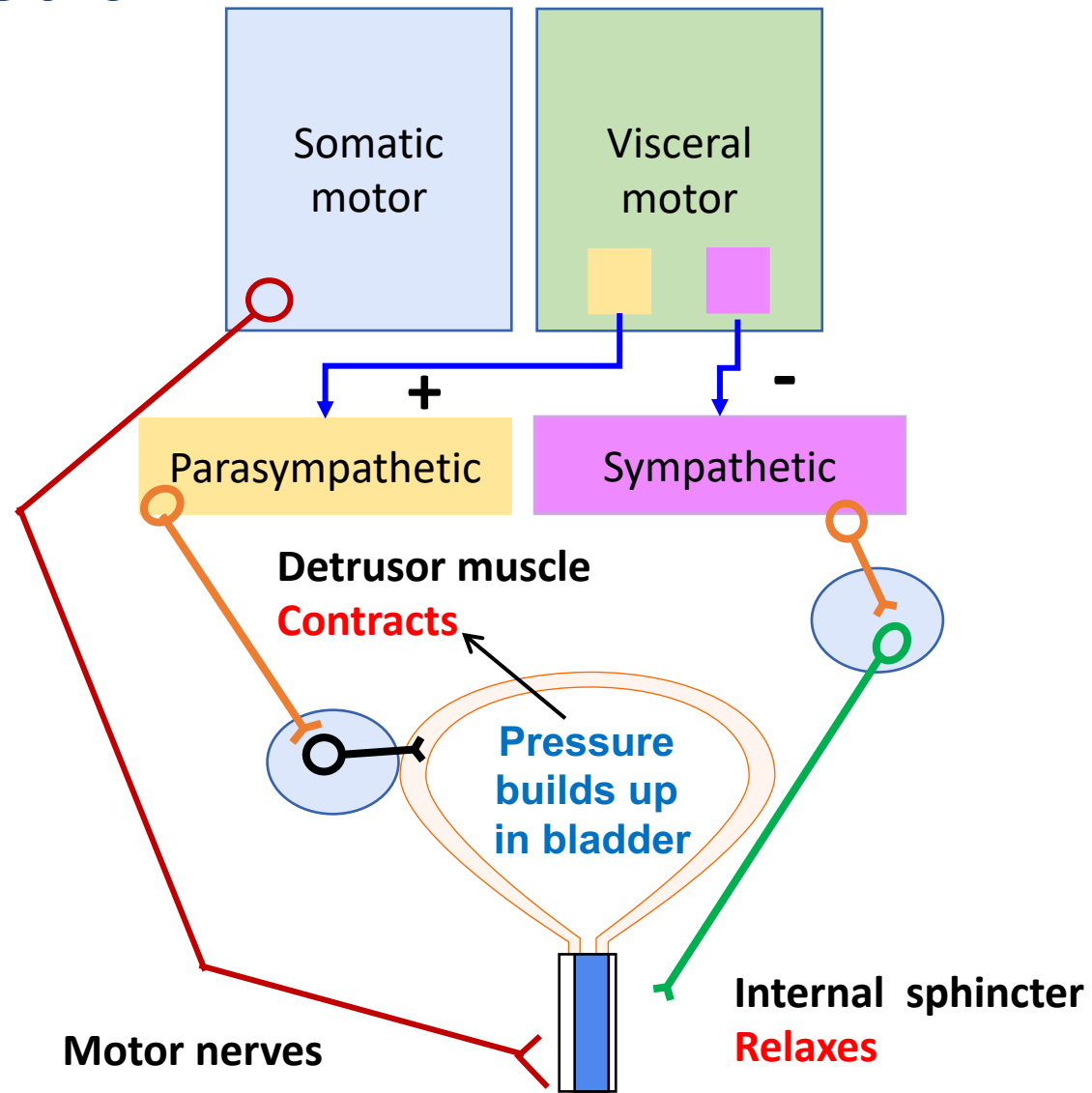
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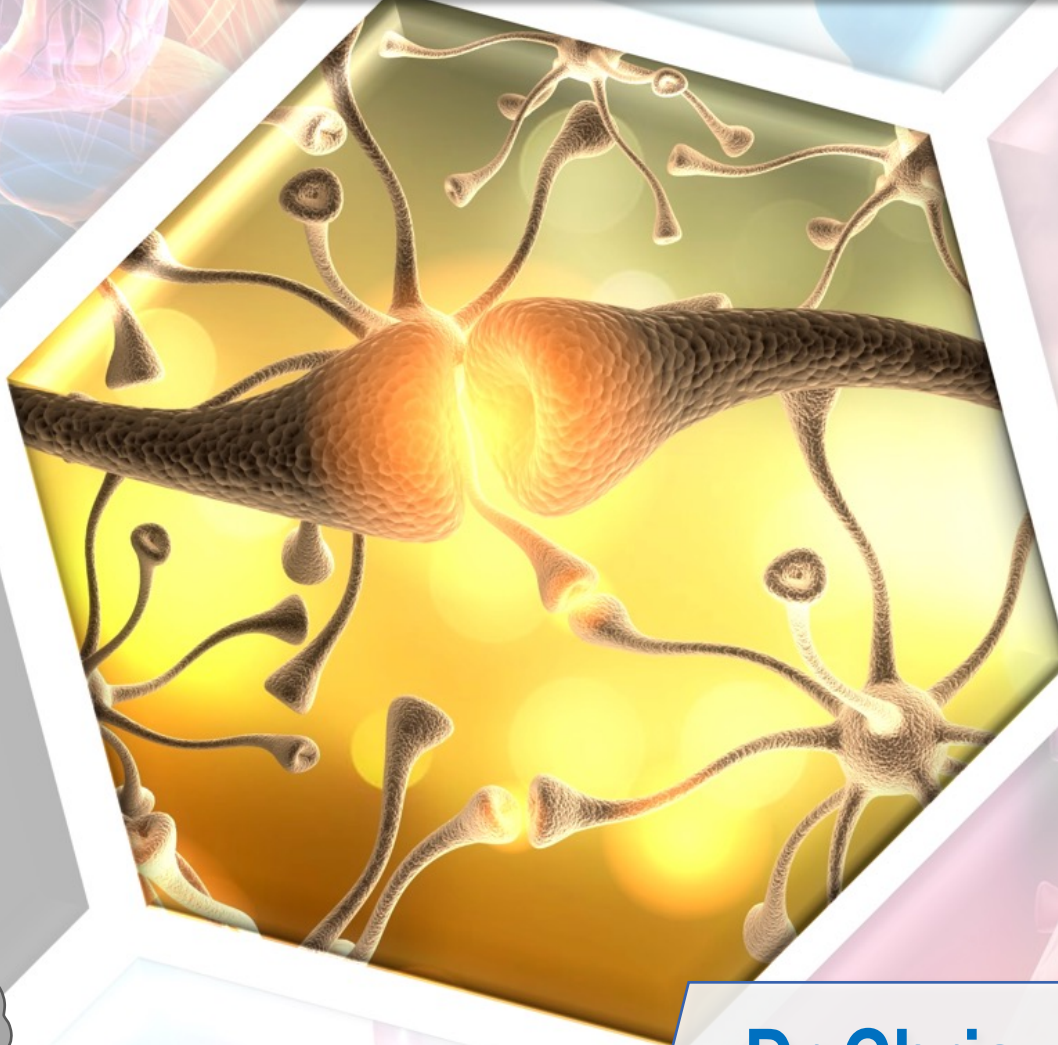
Enteric nervous system – ‘**mini-brain**’ of GIT

Receptors

Biosynthesis and metabolism

IMPERIAL

Autonomic nervous system



part 3 of 3

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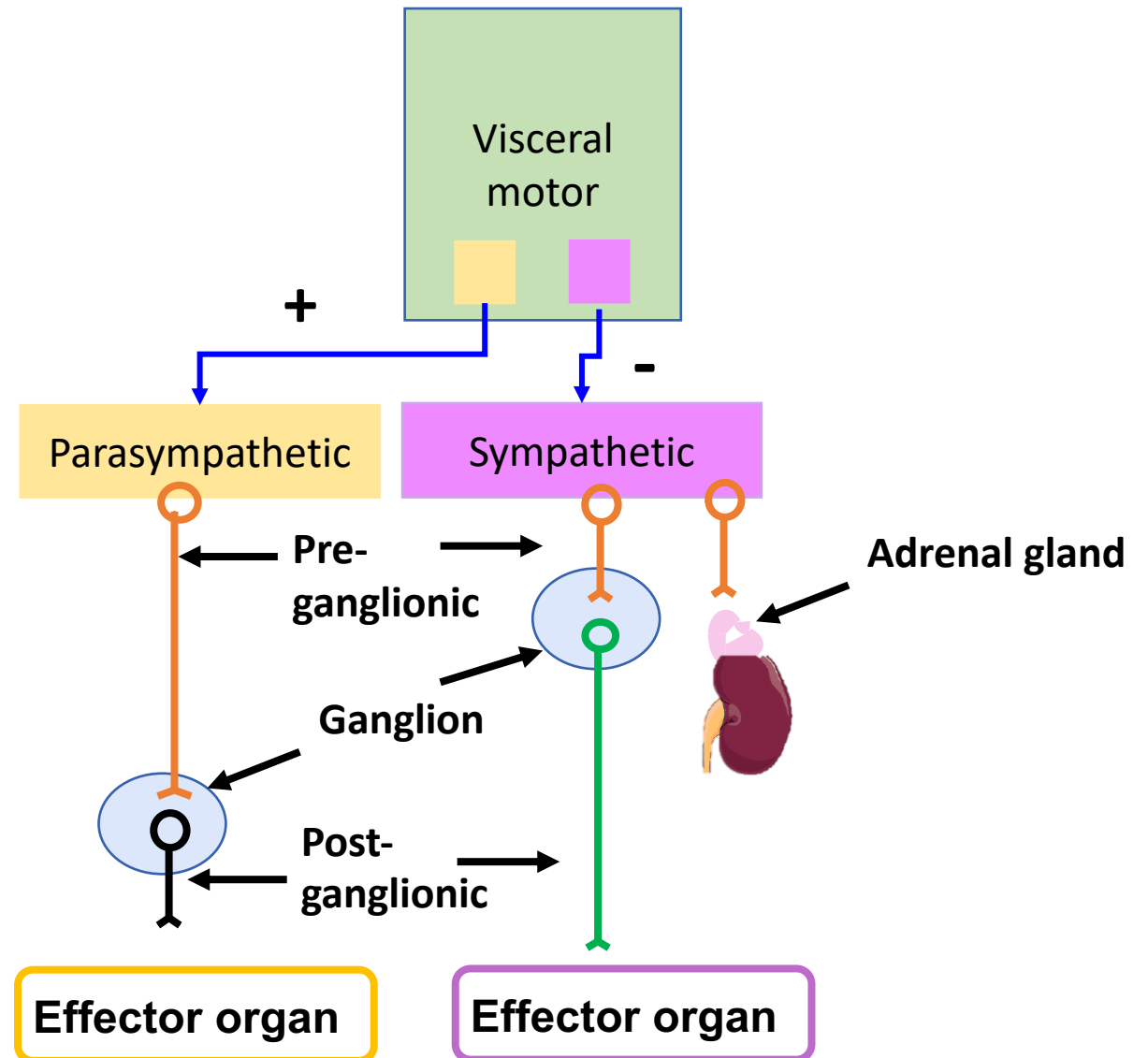
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Which receptors mediate the effects within the autonomic nervous system?

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



Receptors

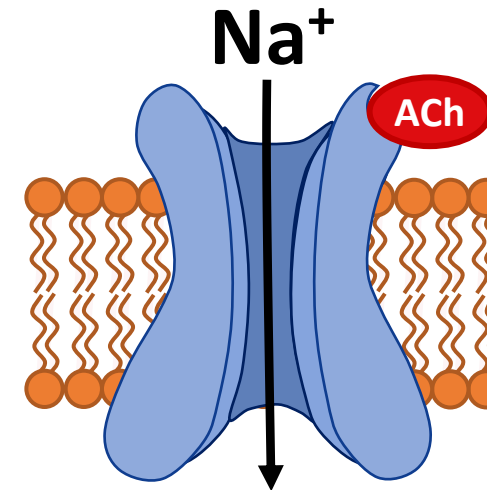
Which receptors mediate the effects within the autonomic nervous system?

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Ion channel receptor

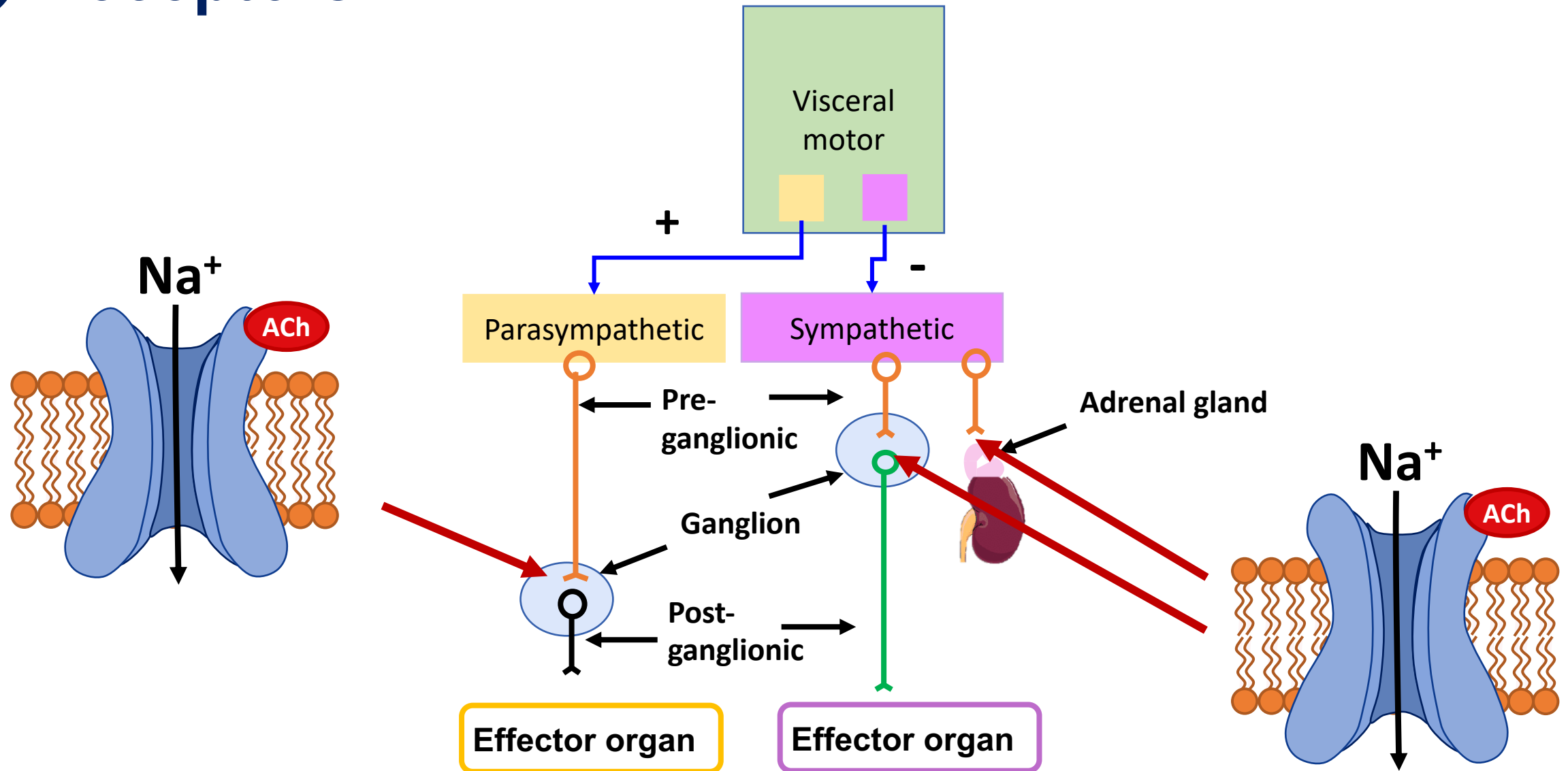
FAST response (msecs)

Nicotinic acetylcholine receptor



Mediate all fast excitatory and inhibitory transmission

Receptors

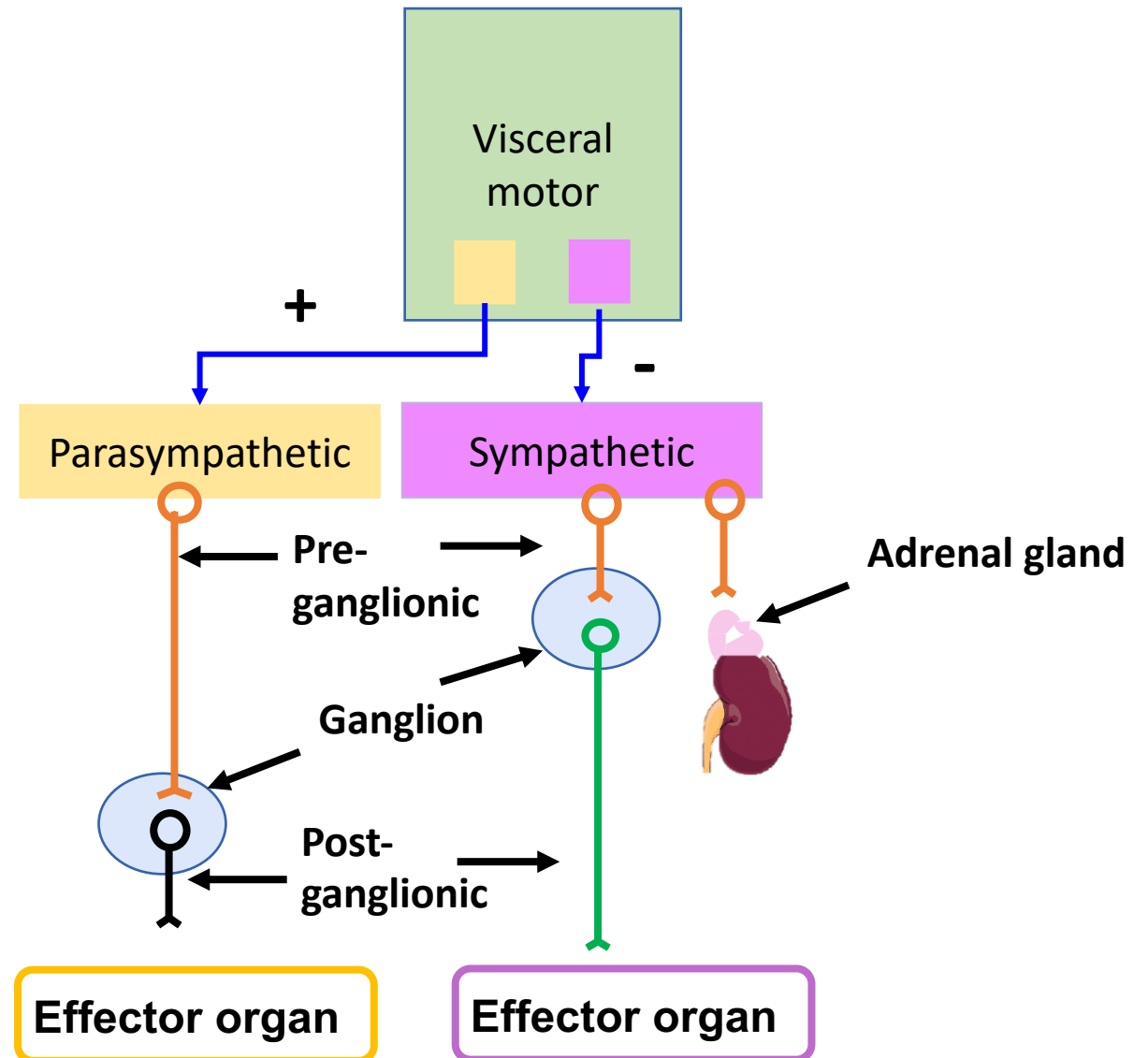


Receptors

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.



Receptors

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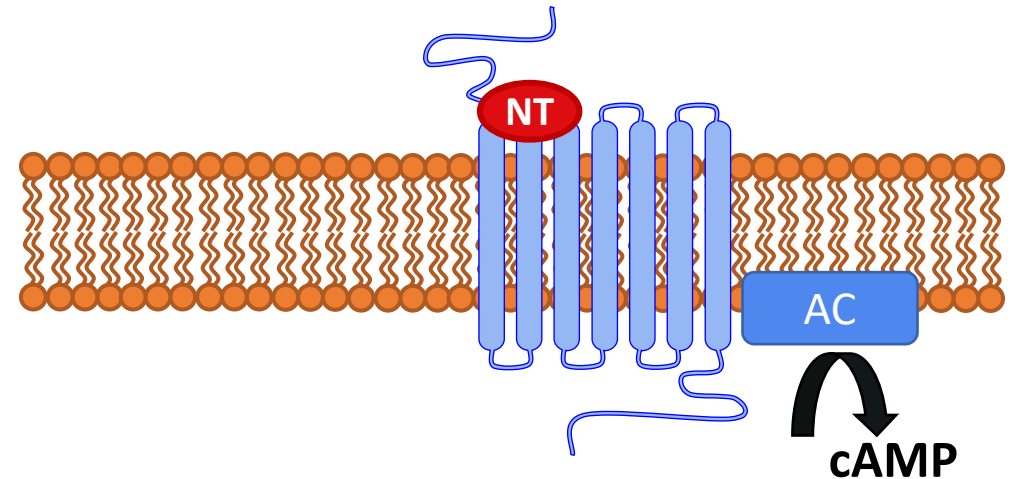
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Different receptors mediate the effects of neurotransmitters released from postganglionic fibres.

G-protein coupled receptor

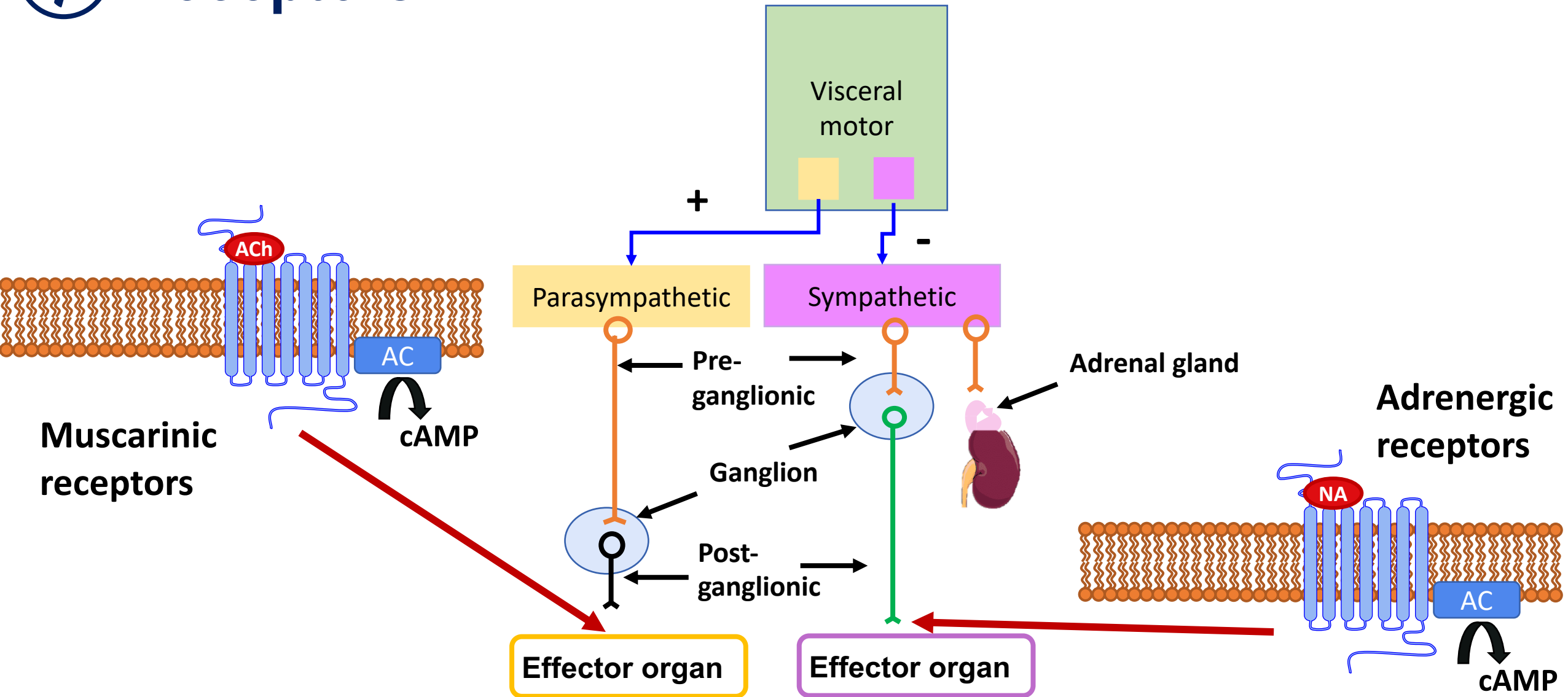
SLOW response (secs/mins)

**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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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

3. Action potential causes Ca^{2+} influx and exocytosis

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Postsynaptic nerve terminal

4. Exocytosis and neurotransmitter release

5. Receptor activation

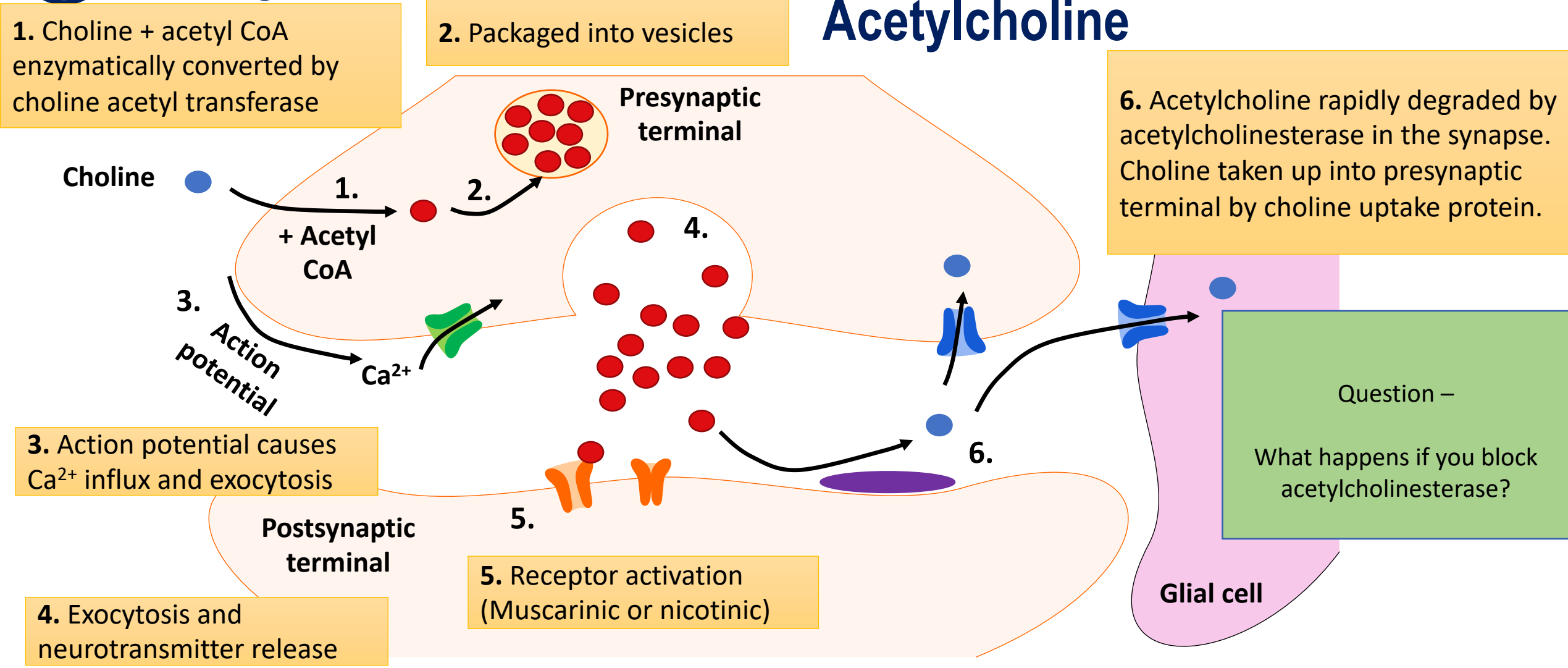
6. Removal of neurotransmitter from synapse via uptake into pre-synaptic terminal or glial cell; Can be metabolised in the synapse prior to uptake

Glial cell

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

Biosynthesis & metabolism

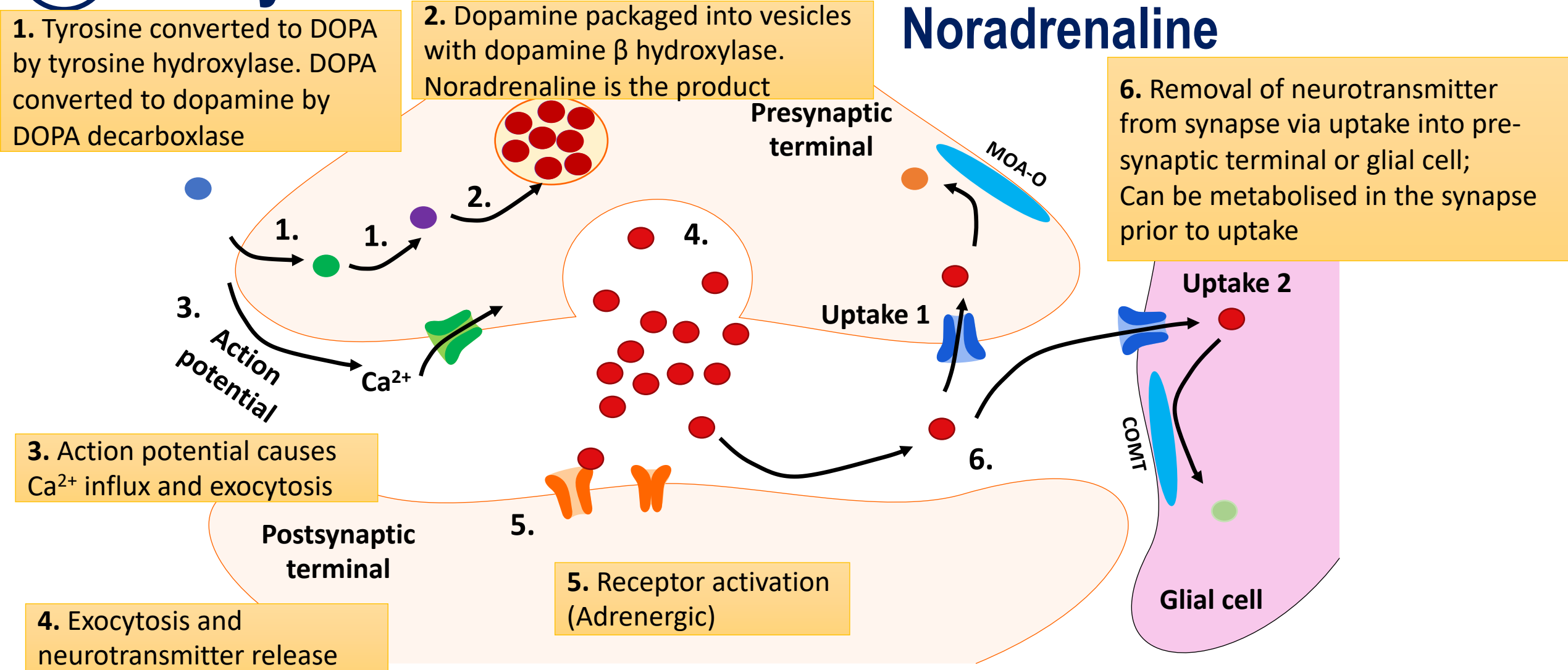
Acetylcholine





Biosynthesis & metabolism

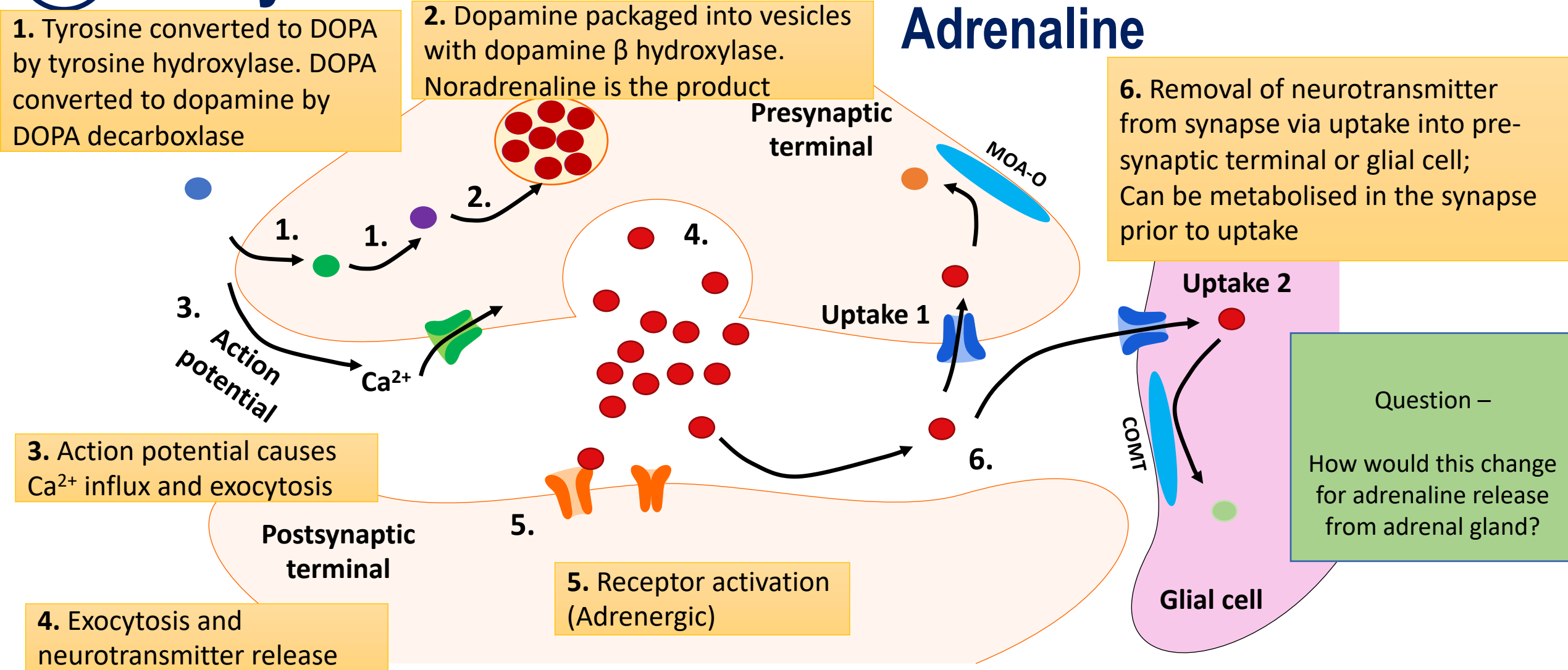
Noradrenaline





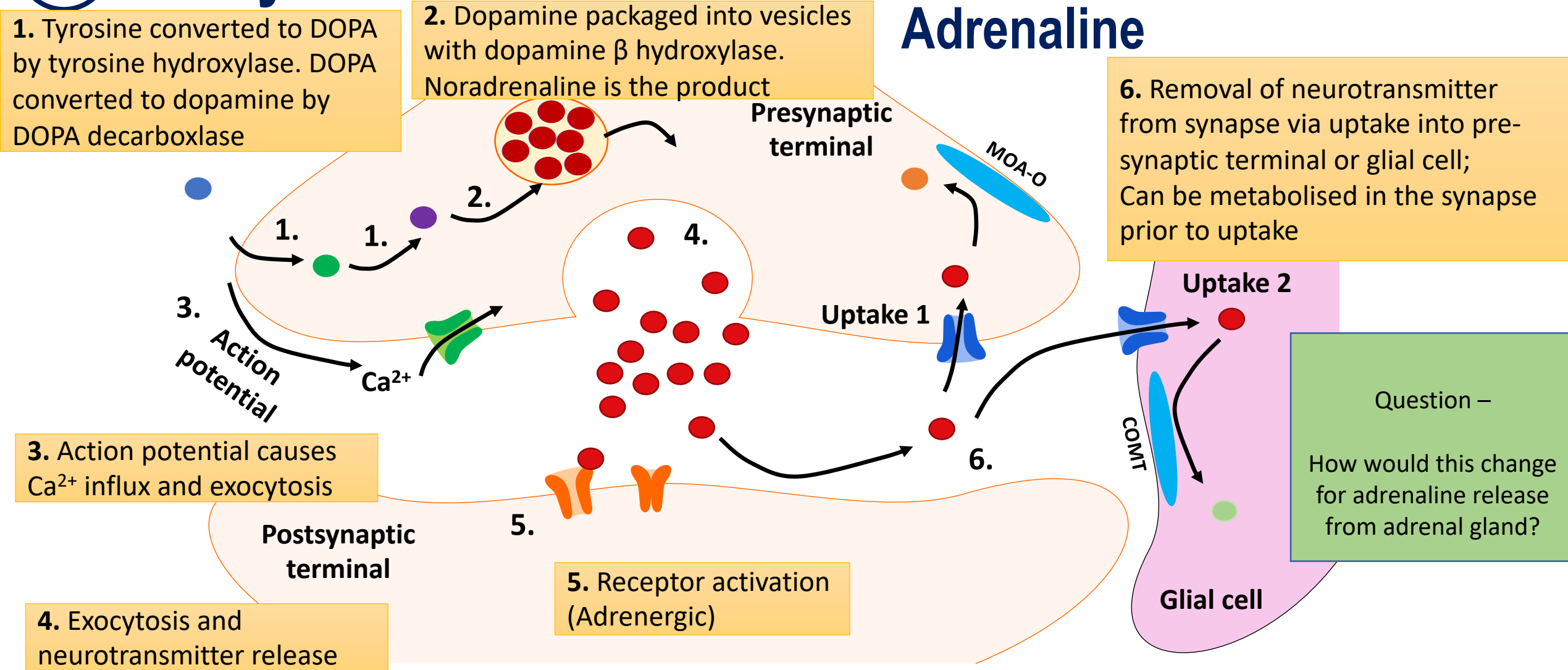
Biosynthesis & metabolism

Adrenaline





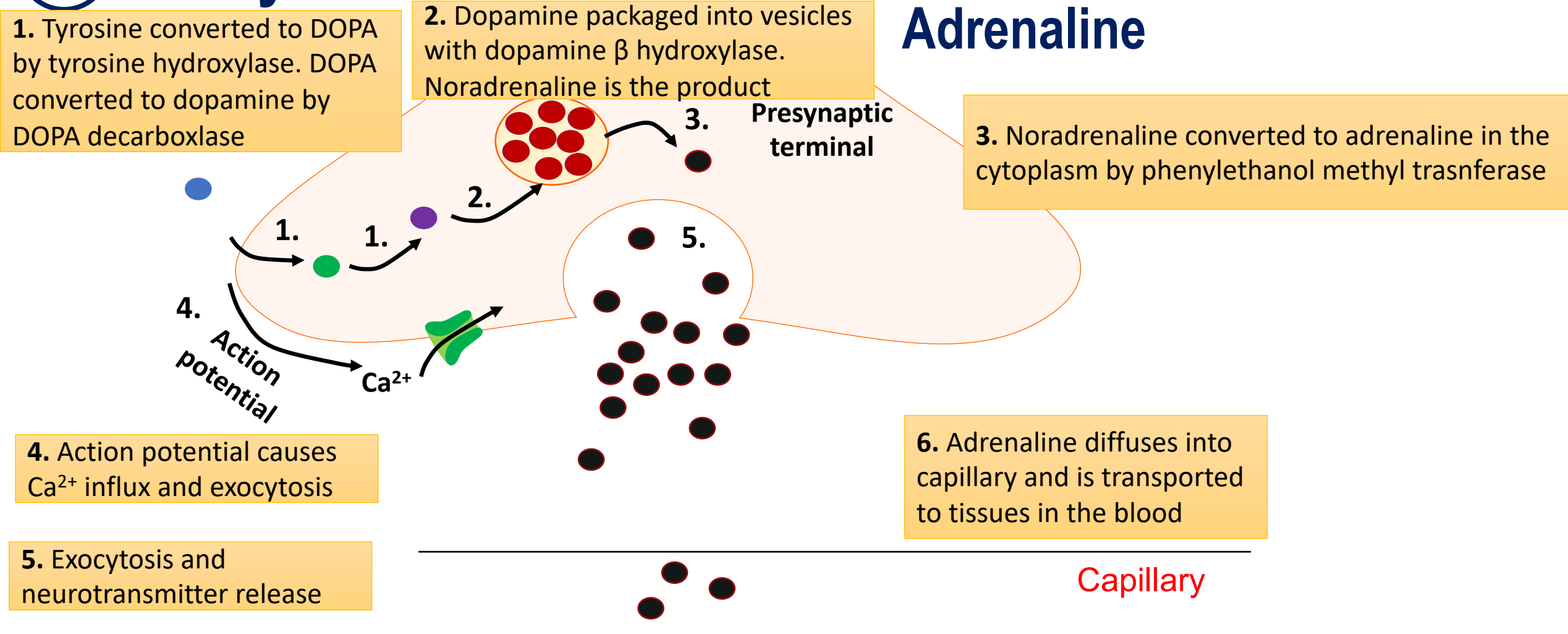
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Biosynthesis & metabolism

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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

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**