

# PHYSIOLOGY OF SYMPATHETIC AND PARASYMPATHETIC NERVOUS SYSTEM

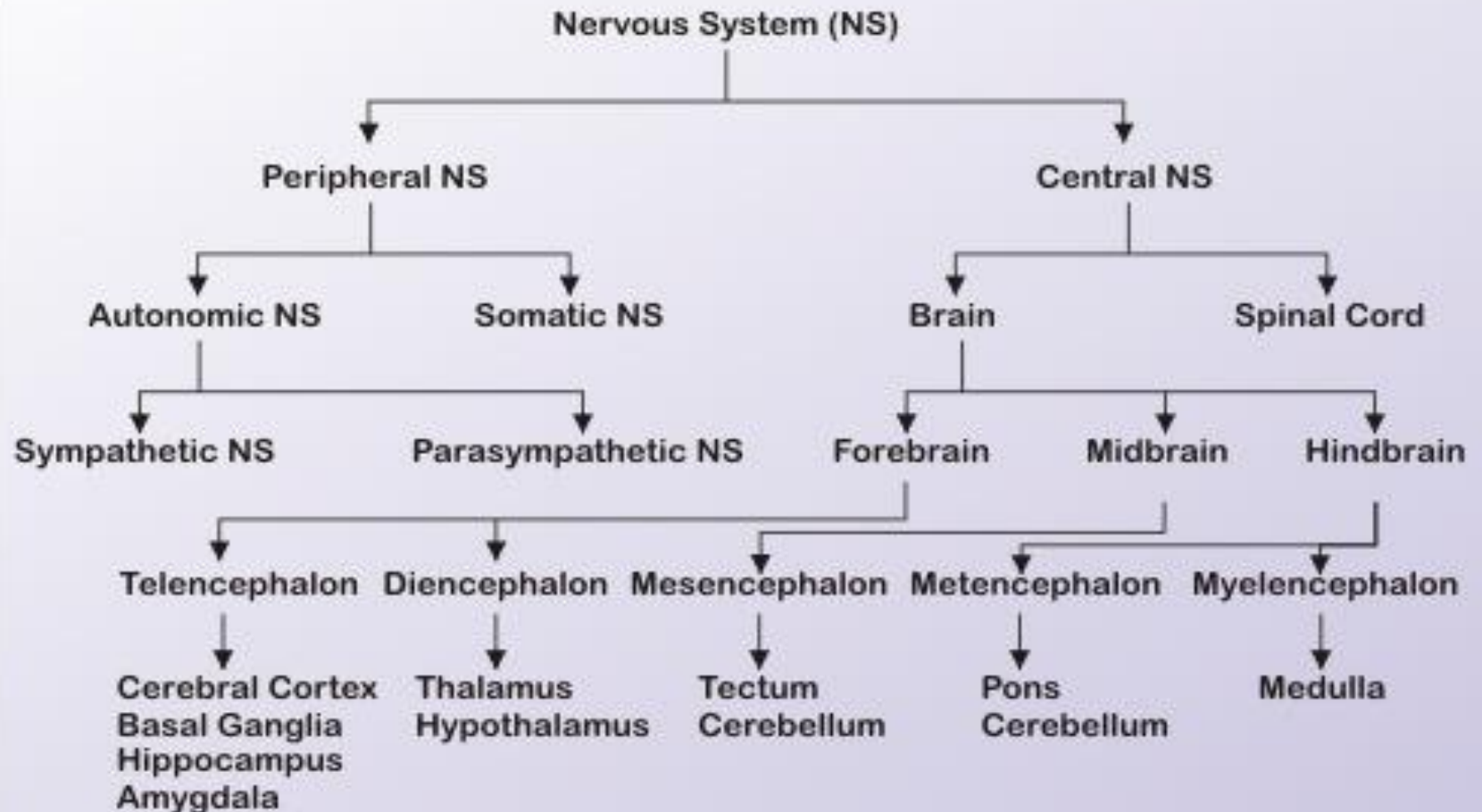


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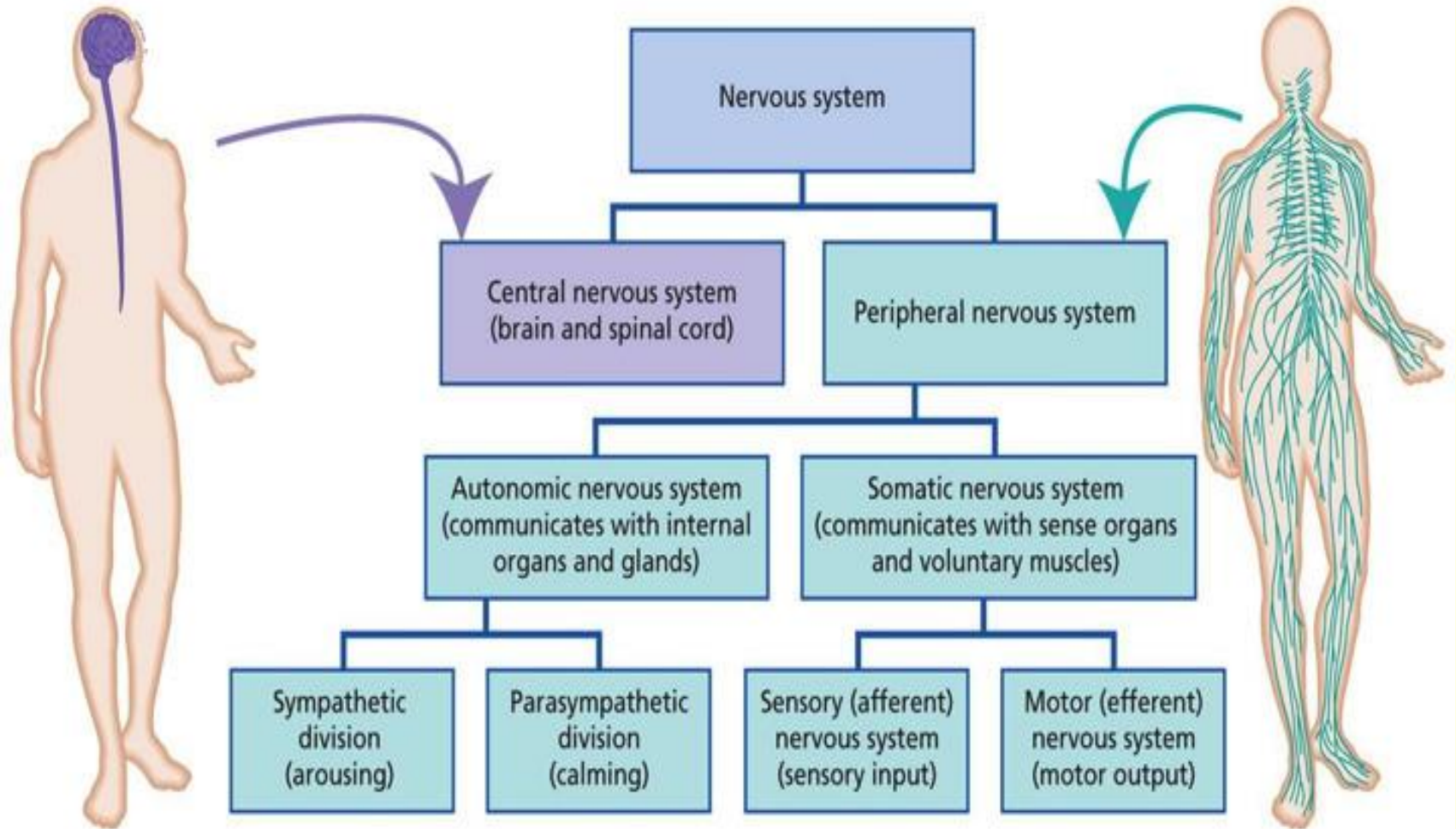
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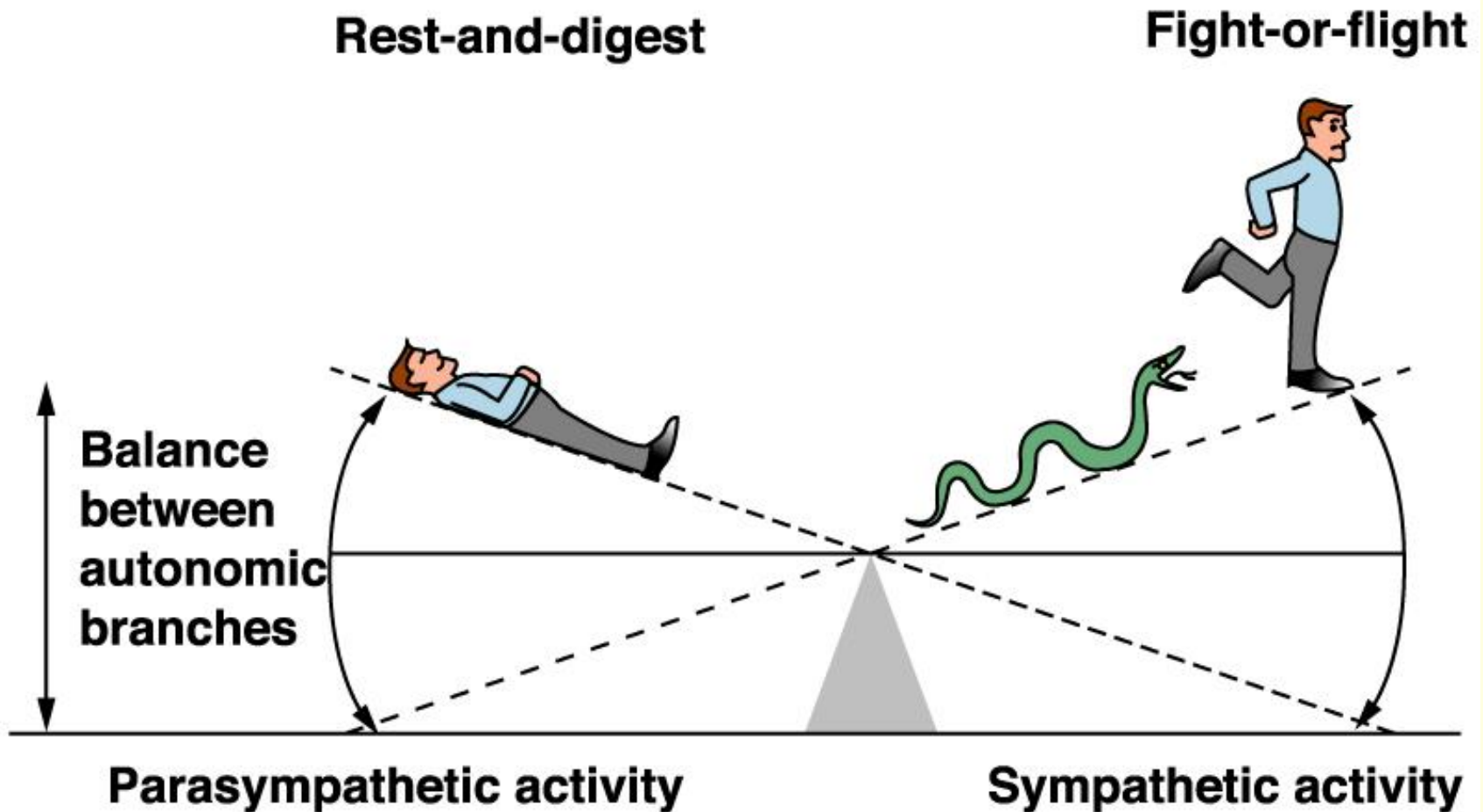
# THE NERVOUS SYSTEM



# THE NERVOUS SYSTEM



# THE AUTONOMIC NERVOUS SYSTEM



# THE AUTONOMIC NERVOUS SYSTEM



## SYMPATHETIC (GAS PEDAL)

- Fight or flight response
- Protection and survival
- Stress response
- Adrenal (stress) glands activated

## PARASYMPATHETIC (BRAKE PEDAL)

- Rest
- Digest
- Relax
- Growth & development



The Human Nervous System

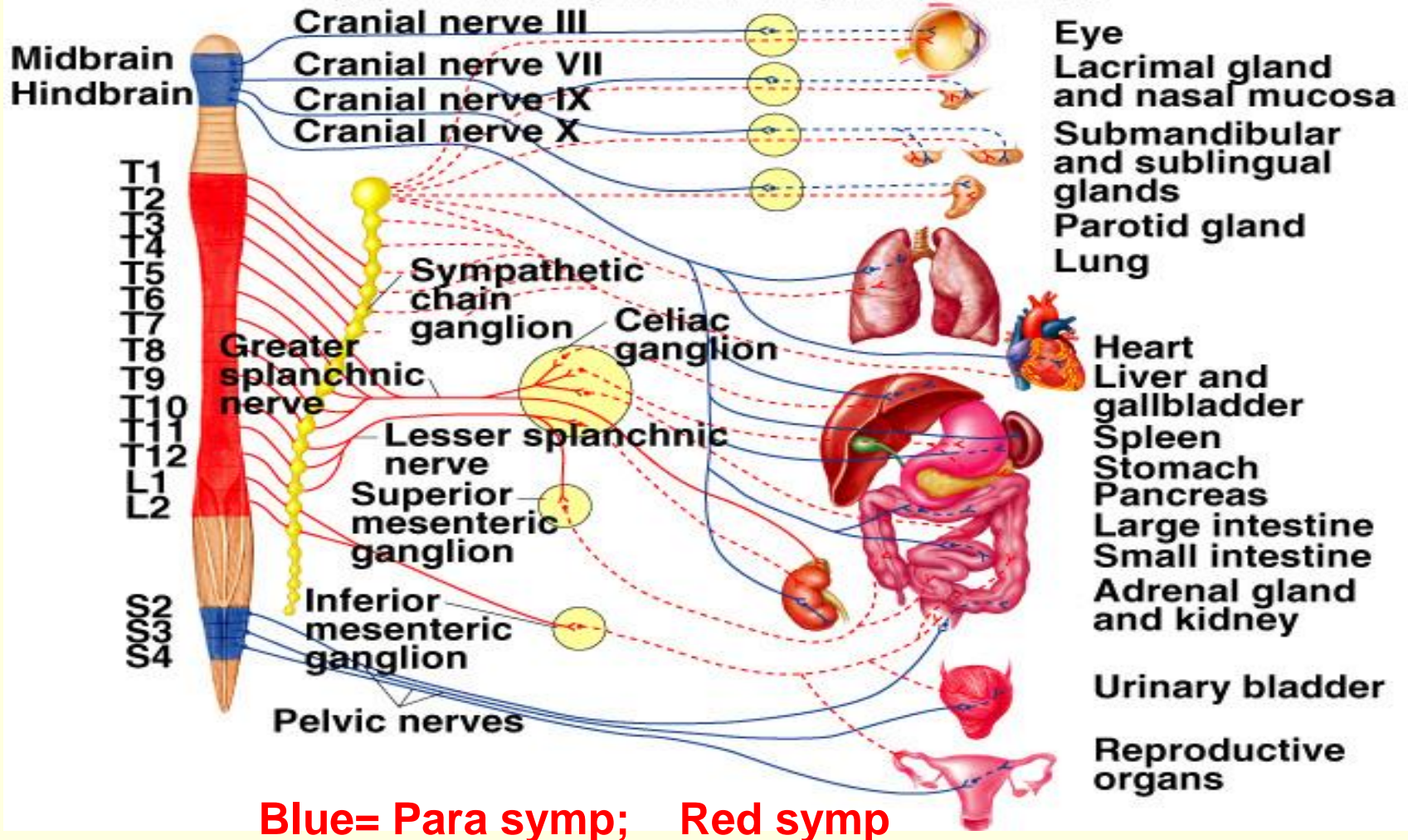


*"You can't be in growth and protection at the same time."  
— Dr. Bruce Lipton*



# DISTRIBUTION OF THE SYMPATHETIC AND PARASYMPATHETIC NERVOUS SYSTEM

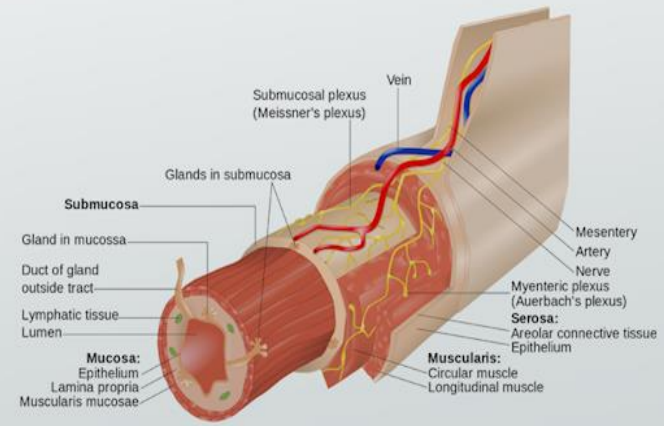
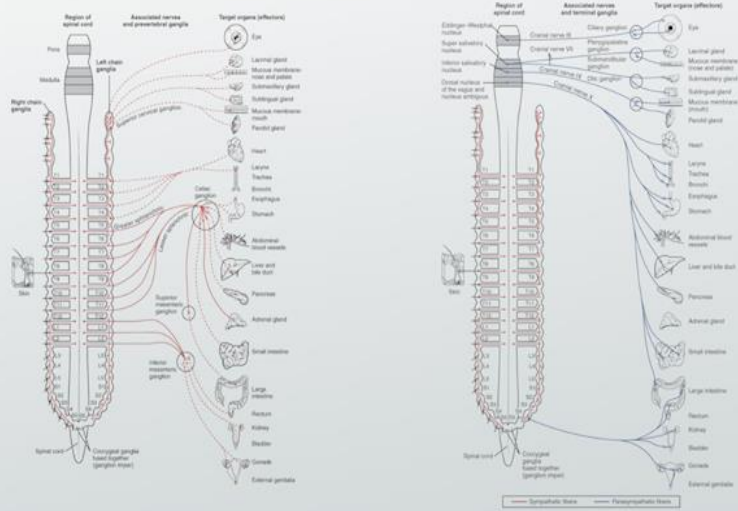
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# DISTRIBUTION OF THE SYMPATHETIC AND PARASYMPATHETIC NERVOUS SYSTEM

## Three divisions of the ANS:

*sympathetic nervous system,  
parasympathetic nervous system  
and enteric nervous system*



# THE AUTONOMIC NERVOUS SYSTEM

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**Somatic nervous system:** Controls organs under voluntary control (mainly skeletal muscles)

**Autonomic Nervous System (ANS):** Not under voluntary control. It regulates individual organ, visceral functions and homeostasis, known as the visceral or automatic system. Effectors includes cardiac, smooth muscles and glands.

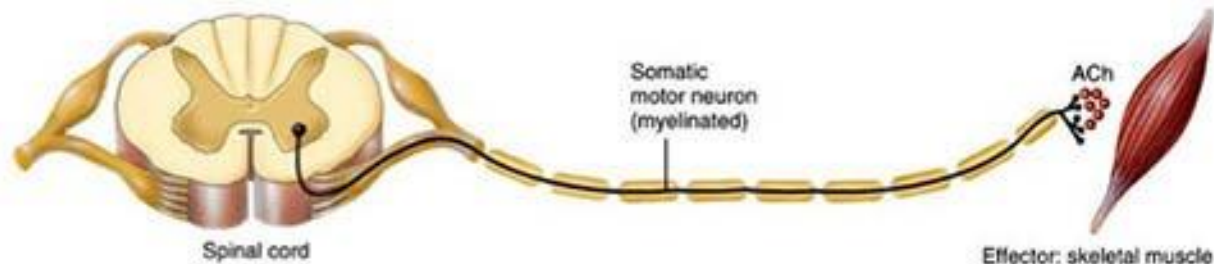
Helps to adapt the changes in environment. Adjusts or modifies functions in response to stress such as blood pressure, body temperature, sweating etc.



# COMPARISON OF AUTONOMIC AND SOMATIC SYSTEMS

## Somatic system

- One motor neuron extends from the CNS to skeletal muscle
- Axons are well myelinated
- Conduct impulses rapidly



(a) Somatic nervous system

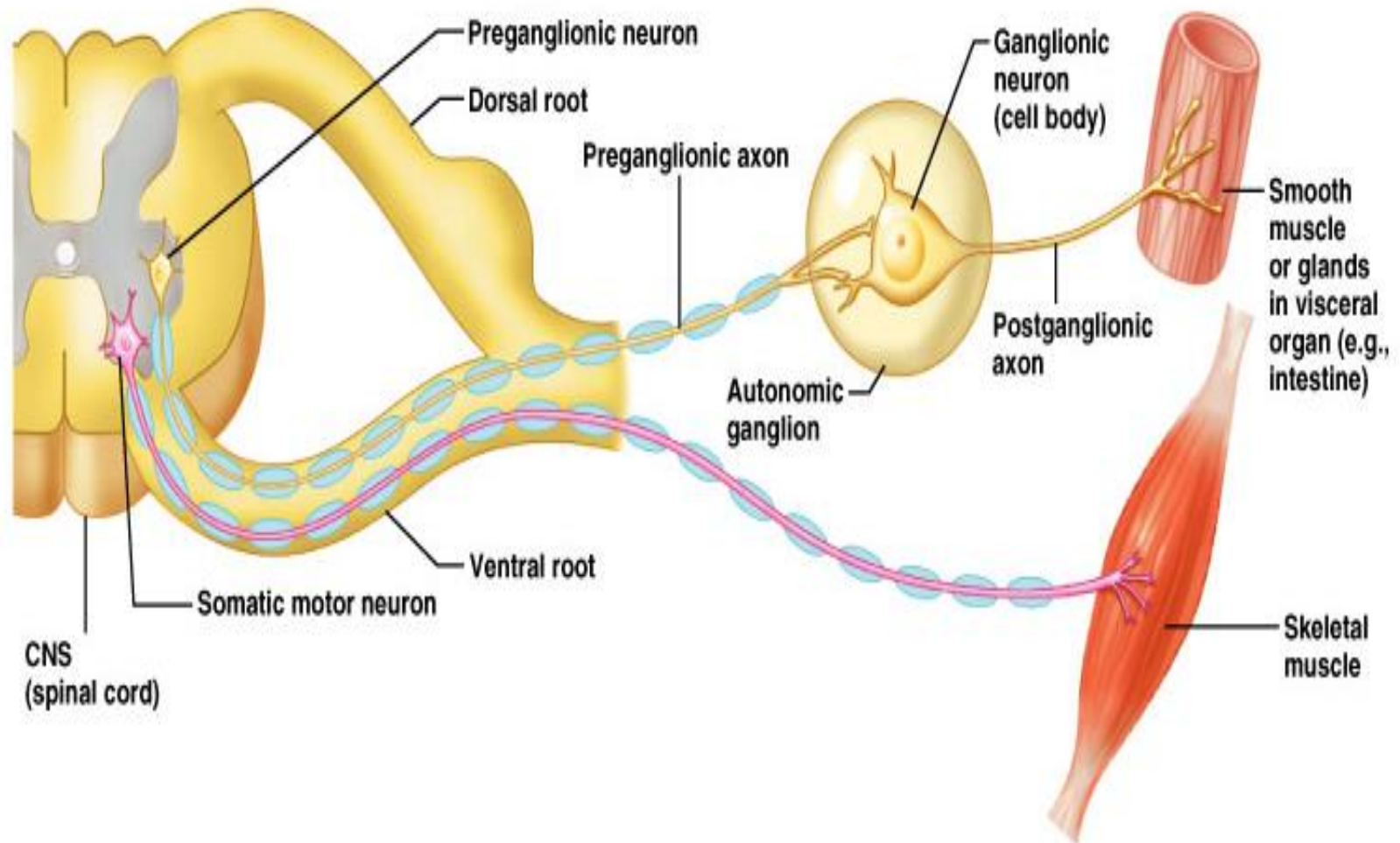
# COMPARISON OF AUTONOMIC AND SOMATIC MOTOR SYSTEMS

## Autonomic nervous system

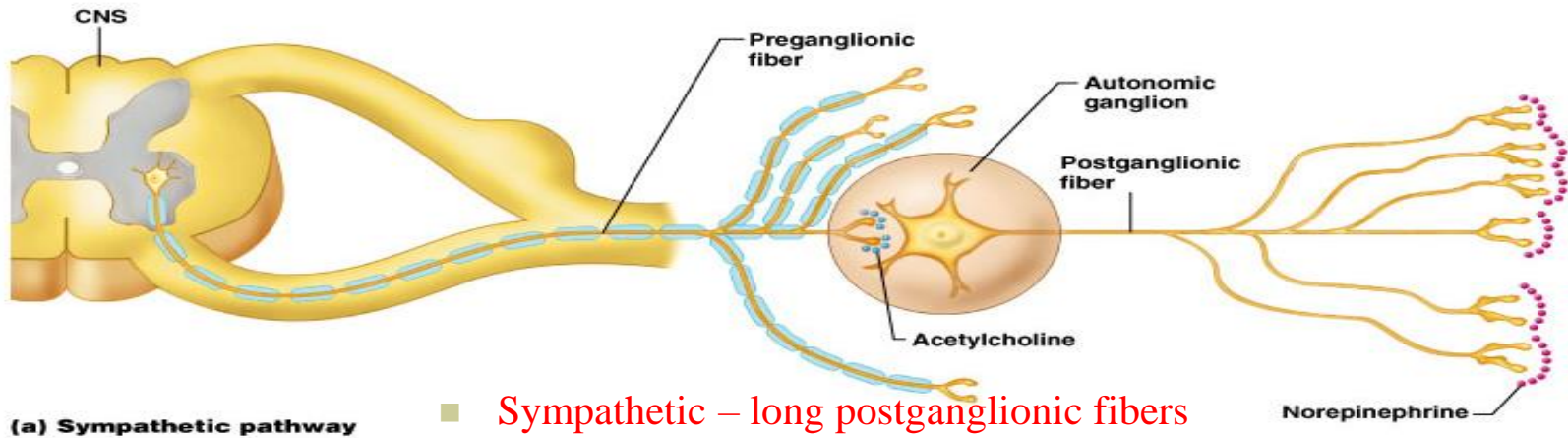
- Chain of two motor neurons
  - Preganglionic neuron
  - Postganglionic neuron
- Conduction is slower due to thin or unmyelinated axons



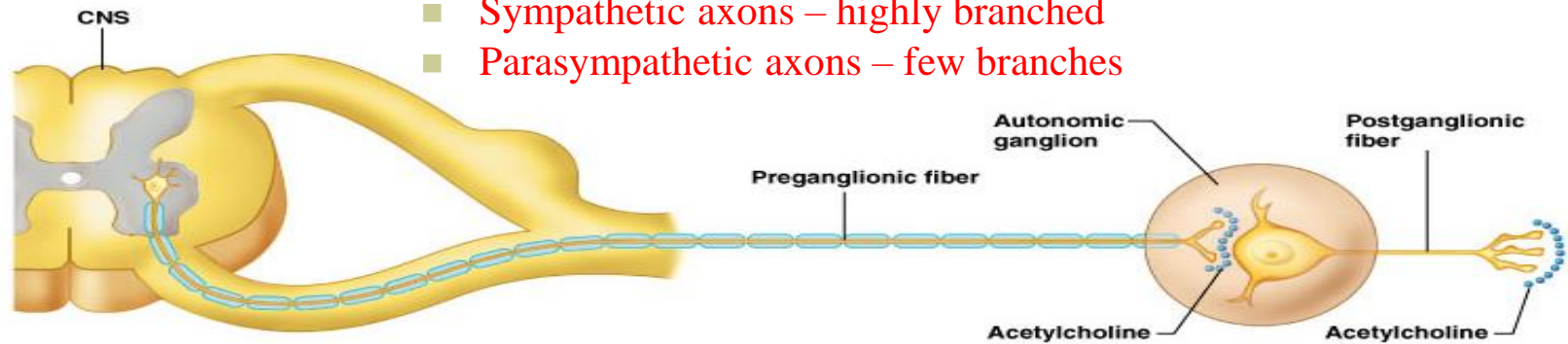
# COMPARISON OF AUTONOMIC AND SOMATIC MOTOR SYSTEMS



# DIFFERENCES IN SYMPATHETIC AND PARASYMPATHETIC DIVISIONS



- Sympathetic – long postganglionic fibers
- Parasympathetic – short postganglionic fibers
- Sympathetic axons – highly branched
- Parasympathetic axons – few branches



Sympathetic and parasympathetic systems are consists of myelinated pre-ganglionic fibers which make synaptic connections with un-myelinated postganglionic fibers and then innervate the effector organ. These synapses usually occur in clusters called ganglia.

# DIFFERENCES IN SYMPATHETIC AND PARASYMPATHETIC DIVISIONS

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## Preganglionic neuron:

- ❑ Cell body in brain or spinal cord
- ❑ Axon is myelinated type fiber that extends to autonomic ganglion

## Postganglionic neuron:

- ❑ Cell body lies outside the CNS in an autonomic ganglion
- ❑ Axon is unmyelinated type fiber that terminates in a visceral effector



# THE AUTONOMIC NERVOUS SYSTEM

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The ANS is predominantly an efferent system transmitting impulses from the Central Nervous System (CNS) to peripheral organ systems.

Its effects include:

- Control of heart rate and force of contraction
- Constriction and dilatation of blood vessels
- Contraction and relaxation of smooth muscle
- Visual accommodation
- Secretions from exocrine and endocrine glands.


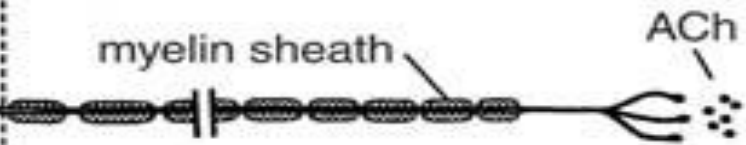

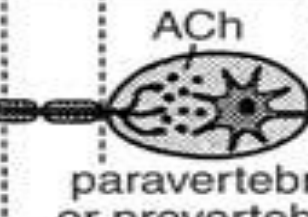
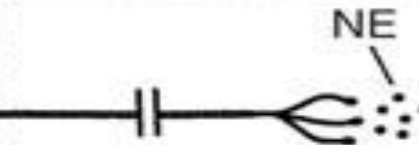



# THE AUTONOMIC NERVOUS SYSTEM

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**ANS activated by centers** located in the **spinal cord, brain stem, hypothalamus** and also **cerebral cortex** especially the **limbic cortex** can transmit signals to the lower centers, influence autonomic control.

**ANS operates by visceral reflexes.** *Subconscious sensory signals from a visceral organ enter the autonomic ganglia, brain stem or hypothalamus and then return subconscious reflex responses directly back to the visceral organ to control its activities.*

# DIFFERENCES IN SYMPATHETIC AND PARASYMPATHETIC DIVISIONS

	central nervous system	peripheral nervous system		target organs
somatic nervous system		 myelin sheath      ACh		skeletal muscle
sympathetic nervous system		 ACh paravertebral or prevertebral ganglion	 NE	smooth muscle glands cardiac muscle
para-sympathetic nervous system		 myelin sheath	 ACh terminal ganglion	
ACh = acetylcholine NE = norepinephrine		pre-ganglionic axon	ganglion	post-ganglionic axon

# NEUROTRANSMITTERS OF AUTONOMIC NERVOUS SYSTEM

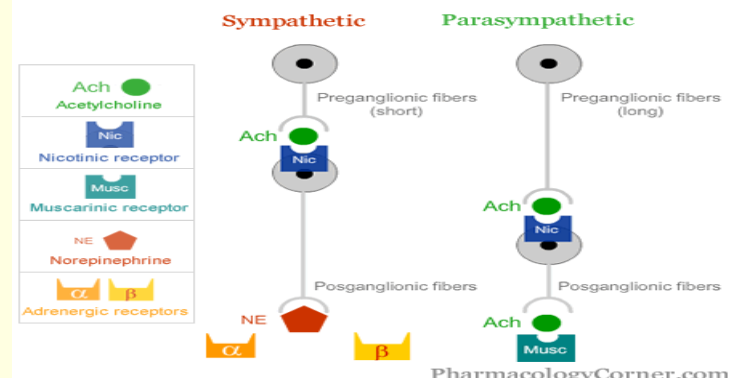
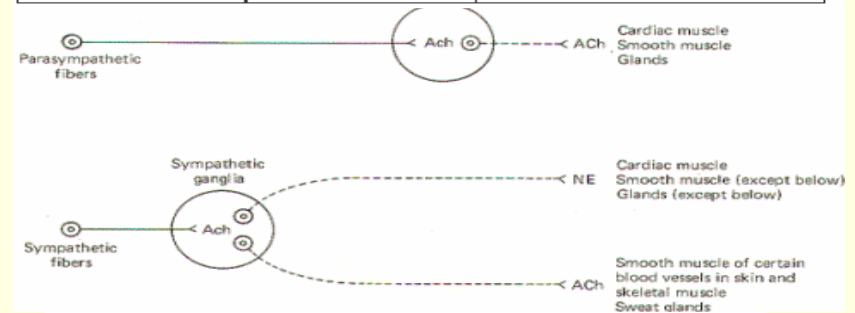
Neurotransmitter released by pre-ganglionic axons

- Acetylcholine for both branches (cholinergic)

Neurotransmitter released by postganglionic axons

- Sympathetic – most release norepinephrine (adrenergic)
- Parasympathetic – release acetylcholine

Feature	Sympathetic	Parasympathetic
Origin of pre-ganglionic fibers	Thoracolumbar nerves	Craniosacral nerves
Location of ganglia	Far from visceral effector organs; in sympathetic chain or collateral ganglia	Near or within viscera effector organs
Neurotransmitter	In ganglia, acetylcholine; in effector organs, norepinephrine	In ganglia, acetylcholine; in effector organs, acetylcholine



# THE AUTONOMIC NERVOUS SYSTEM

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Subdivision	Nerves Employed	Location of Ganglia	Chemical Messenger	General Function
Sympathetic	Thoracolumbar	Alongside vertebral column	Norepinephrine	Fight or flight
Parasympathetic	Craniosacral	On or near an effector organ	Acetylcholine	Conservation of body energy



# THE AUTONOMIC NERVOUS SYSTEM

Organization of the Autonomic Nervous System

Characteristics	Sympathetic Division	Parasympathetic Division	Somatic Nervous System*
Origin of preganglionic neurons	Spinal cord segments T1–L3 (thoracolumbar)	Nuclei of CN III, VII, IX, and X; spinal cord segments S2–S4 (craniosacral)	—
Location of autonomic ganglia	Paravertebral and prevertebral	In or near effector organs	—
Length of preganglionic axons	Short	Long	—
Length of postganglionic axons	Long	Short	—
Effector organs	Smooth muscle; cardiac muscle; glands	Smooth muscle; cardiac muscle; glands	Skeletal muscle
Neurotransmitter and receptor type in ganglion	ACh/nicotinic receptor	ACh/nicotinic receptor	—
Neurotransmitter in effector organs	Norepinephrine (except sweat glands)	ACh	ACh
Receptor types in effector organs	$\alpha_1$ , $\alpha_2$ , $\beta_1$ , $\beta_2$	Muscarinic	Nicotinic

ACh, Acetylcholine; CN, cranial nerve.

# SEGMENTAL DISTRIBUTION OF THE SYMPATHETIC AND PARASYMPATHETIC NERVOUS SYSTEM

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**Sympathetic:** Originate in the thoracic and lumbar regions of the spinal cord (**Thoracolumbar**)

**Parasympathetic:** Originate from cranial nerves (3<sup>rd</sup>, 7<sup>th</sup>, 9<sup>th</sup>, 10<sup>th</sup>), and sacral spinal nerves (**craniosacral**)

# SEGMENTAL DISTRIBUTION OF THE SYMPATHETIC NERVOUS SYSTEM

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Sympathetic fibers from cord segment T-1 generally pass up the sympathetic chain to terminate in the head;

T-2 to terminate in the neck

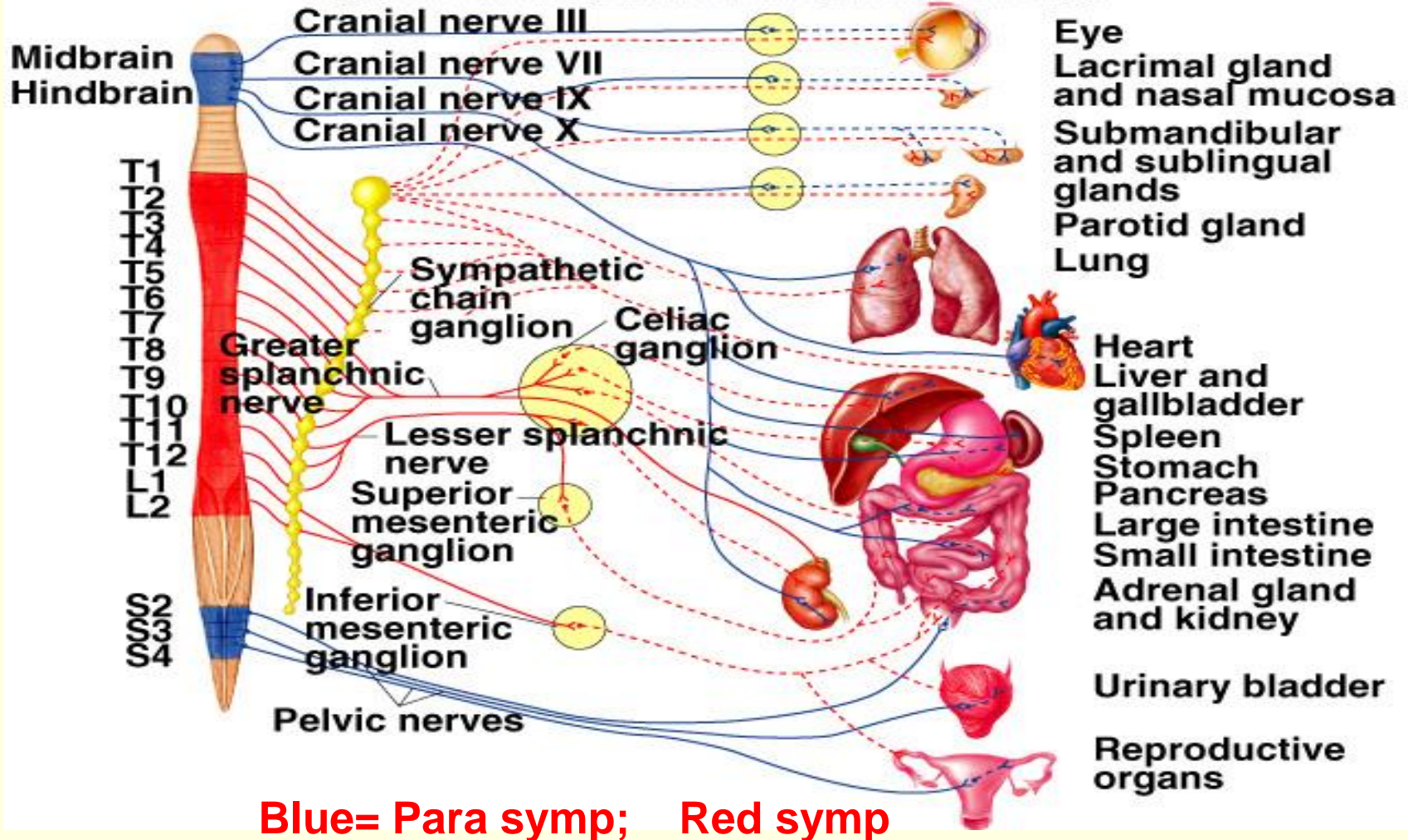
T-3, T-4, T-5, and T-6 into the thorax

T-7, T-8, T-9, T-10, and T-11 into the abdomen

T-12, L-1, and L-2 into the legs.

# DISTRIBUTION OF THE SYMPATHETIC AND PARASYMPATHETIC NERVOUS SYSTEM

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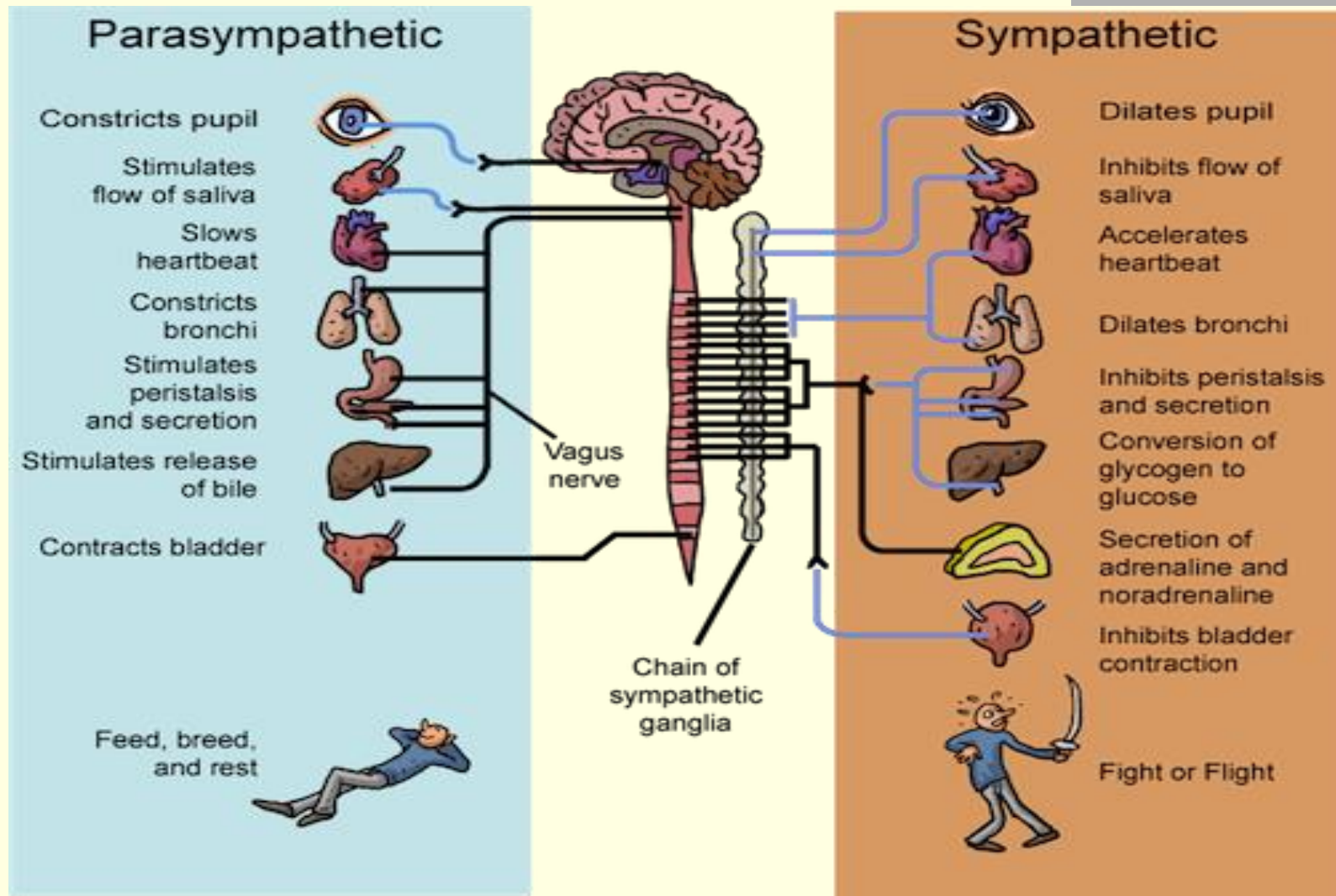
- Eye
- Lacrimal gland and nasal mucosa
- Submandibular and sublingual glands
- Parotid gland
- Lung
- Heart
- Liver and gallbladder
- Spleen
- Stomach
- Pancreas
- Large intestine
- Small intestine
- Adrenal gland and kidney
- Urinary bladder
- Reproductive organs

# FUNCTIONS OF THE SYMPATHETIC AND PARASYMPATHETIC NERVOUS SYSTEM

<b>Structure</b>	<b>Sympathetic Stimulation</b>	<b>Parasympathetic Stimulation</b>
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



# FUNCTIONS OF THE SYMPATHETIC AND PARASYMPATHETIC NERVOUS SYSTEM

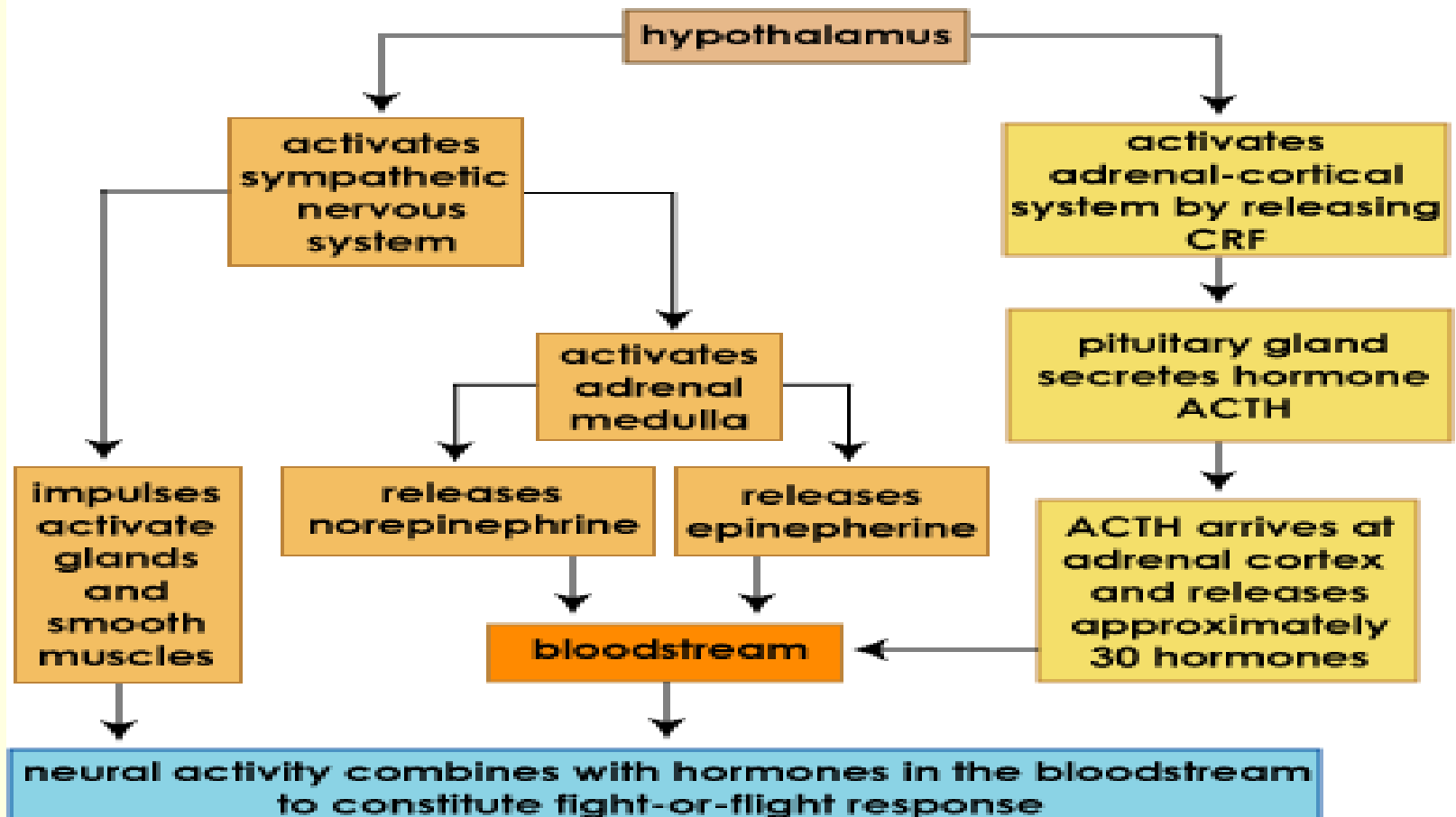


# THE SYMPATHETIC NERVOUS SYSTEM



# THE SYMPATHETIC NERVOUS SYSTEM

## Fight-or-flight Response



# THE SYMPATHETIC NERVOUS SYSTEM

## FEAR, FIGHT- FLIGHT RESPONSE

- ❑ The sympathetic system enables the body to be prepared for fear, flight or fight
- ❑ Sympathetic responses include an increase in heart rate, blood pressure and cardiac output
- ❑ Diversion of blood flow from the skin and splanchnic vessels to those supplying skeletal muscle
- ❑ Increased pupil size, bronchiolar dilation, contraction of sphincters and metabolic changes such as the mobilisation of fat and glycogen.

# THE SYMPATHETIC NERVOUS SYSTEM

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Frequently referred to as the **fear, fight or flight response**

It has a stimulatory effect on organs and physiological systems, responsible for rapid sensory activity (pupils in the eye) and movement (skeletal muscle).

**It diverts blood flow away from the GIT and skin via vasoconstriction.**

**Blood flow to skeletal muscles, lungs is not only maintained, but enhanced (by as much as 1200%), in case of skeletal muscles.**



# THE SYMPATHETIC NERVOUS SYSTEM

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**Dominance by the sympathetic system is caused by physical or emotional stress “E situations”**

**Emergency, Embarrassment, Excitement, Exercise**

**Alarm reaction = flight or fight response:**

- Dilation of pupils
- Increase heart rate, force of contraction & BP
- Decrease in blood flow to nonessential organs
- Increase in blood flow to skeletal & cardiac muscle
- Airways dilate & respiratory rate increases
- Blood glucose level increase

# THE PARASYMPATHETIC DIVISION

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- ❑ The parasympathetic nervous system has "rest and digest" activity.
- ❑ Concerned with conservation and restoration of energy, as it causes a reduction in heart rate and blood pressure, and facilitates digestion and absorption of nutrients, and consequently the excretion of waste products
- ❑ The chemical transmitter at both pre and postganglionic synapses in the parasympathetic system is Acetylcholine (Ach).

# THE PARASYMPATHETIC DIVISION

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Enhance “rest-and-digest” activities

Normally dominate over sympathetic impulses

**SLUDD** type responses: salivation, lacrimation, urination, digestion & defecation

3 “Decreases” decreased HR, diameter of airways and diameter of pupil

- Paradoxical fear when there is no escape route or no way to win causes massive activation of parasympathetic division  
loss of control over urination and defecation

# THE AUTONOMIC NERVOUS SYSTEM

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**Acetylcholine activates** mainly two types of *receptors*. They are called *muscarinic* and *nicotinic* receptors.

Muscarine activates only muscarinic receptors whereas nicotine activates only nicotinic receptors; **acetylcholine activates both of them.**

**Muscarinic receptors** are found on all effector cells that are stimulated by the postganglionic cholinergic neurons of either the parasympathetic nervous system or the sympathetic system.

**Nicotinic receptors** are found in the autonomic ganglia at the synapses between the preganglionic and postganglionic neurons of both the sympathetic and parasympathetic systems.

# THE AUTONOMIC NERVOUS SYSTEM

	<u>Sympathetic</u> ( <u>adrenergic</u> , exceptions)	with <u>Parasympathetic</u> ( <u>muscarinic</u> )
<u>circulatory system</u>		
<u>cardiac output</u>	increases	M2: decreases
<u>SA node: heart rate</u> ( <u>chronotropic</u> )	$\beta 1, \beta 2$ : increases	M2: decreases
<u>cardiac muscle:</u> <u>contractility</u> ( <u>inotropic</u> )	$\beta 1, \beta 2$ : increases	M2: decreases ( <u>atria</u> only)
<u>conduction at AV node</u>	$\beta 1$ : increases	M2: decreases
<u>vascular smooth</u> <u>muscle</u>	M3: contracts; $\alpha =$ contracts; $\beta 2 =$ relaxes	---
<u>platelets</u>	$\alpha 2$ : aggregates	---
<u>mast cells - histamine</u>	$\beta 2$ : inhibits	---

# THE AUTONOMIC NERVOUS SYSTEM

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## Sympathetic (adrenergic)

## Parasympathetic (muscarinic)

### respiratory system

smooth muscles of bronchioles

$\beta$ 2: relaxes (major contribution);  $\alpha$ 1: contracts (minor contribution)

M3: contracts

### nervous system

pupil of eye

$\alpha$ 1: relaxes

M3: contracts

ciliary muscle

$\beta$ 2: relaxes

M3: contracts



# THE AUTONOMIC NERVOUS SYSTEM

	<u>Sympathetic</u> ( <u>adrenergic</u> , with exceptions)	<u>Parasympathetic</u> ( <u>muscarinic</u> )
<u>digestive system</u>		
<u>salivary glands</u> : secretions	$\beta$ : stimulates viscous, <u>amylase</u> secretions; $\alpha 1$ = stimulates <u>potassium</u> cation	stimulates watery secretions
<u>lacrimal glands</u> (tears)	decreases	M3: increases
<u>kidney</u> ( <u>renin</u> )	secretes	---
<u>parietal cells</u>	---	M1: secretion
<u>liver</u>	$\alpha 1, \beta 2$ : <u>glycogenolysis</u> , <u>gluconeogenesis</u>	---
<u>GI tract</u> motility	decreases	M1, M3: increases
<u>smooth muscles</u> of <u>GI tract</u>	$\alpha, \beta 2$ : relaxes	M3: contracts
<u>sphincters</u> of <u>GI tract</u>	$\alpha 1$ : contracts	M3: relaxes

# THE AUTONOMIC NERVOUS SYSTEM

## Sympathetic (adrenergic)

## Parasympathetic (muscarinic)

### ENDOCRINE

pancreas (islets)

$\alpha 2$ : decreases secretion

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adrenal medulla

N: secretes epinephrine

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urinary system

bladder wall

$\beta 2$ : relaxes

contracts

ureter

$\alpha 1$ : contracts

relaxes

sphincter

$\alpha 1$ : contracts;  $\beta 2$  relaxes

relaxes

sweat gland

M: stimulates (major contribution);

---

secretions

$\alpha 1$ : stimulates (minor contribution)

arrector pili

$\alpha 1$ : stimulates

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# THANK YOU

