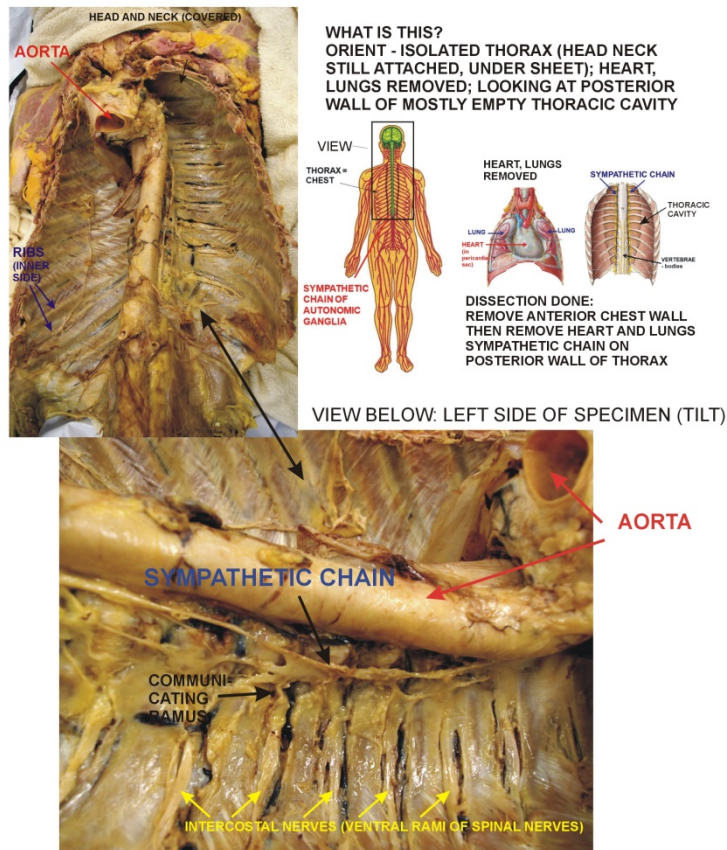


ANATOMY OF AUTONOMIC NERVOUS SYSTEM AND PATHWAYS

SYMPATHETIC CHAIN AND SPINAL NERVES IN THORAX

80



AUTONOMIC = VISCERAL NERVOUS SYSTEM - involuntary, imprecise sensation, localization of pain

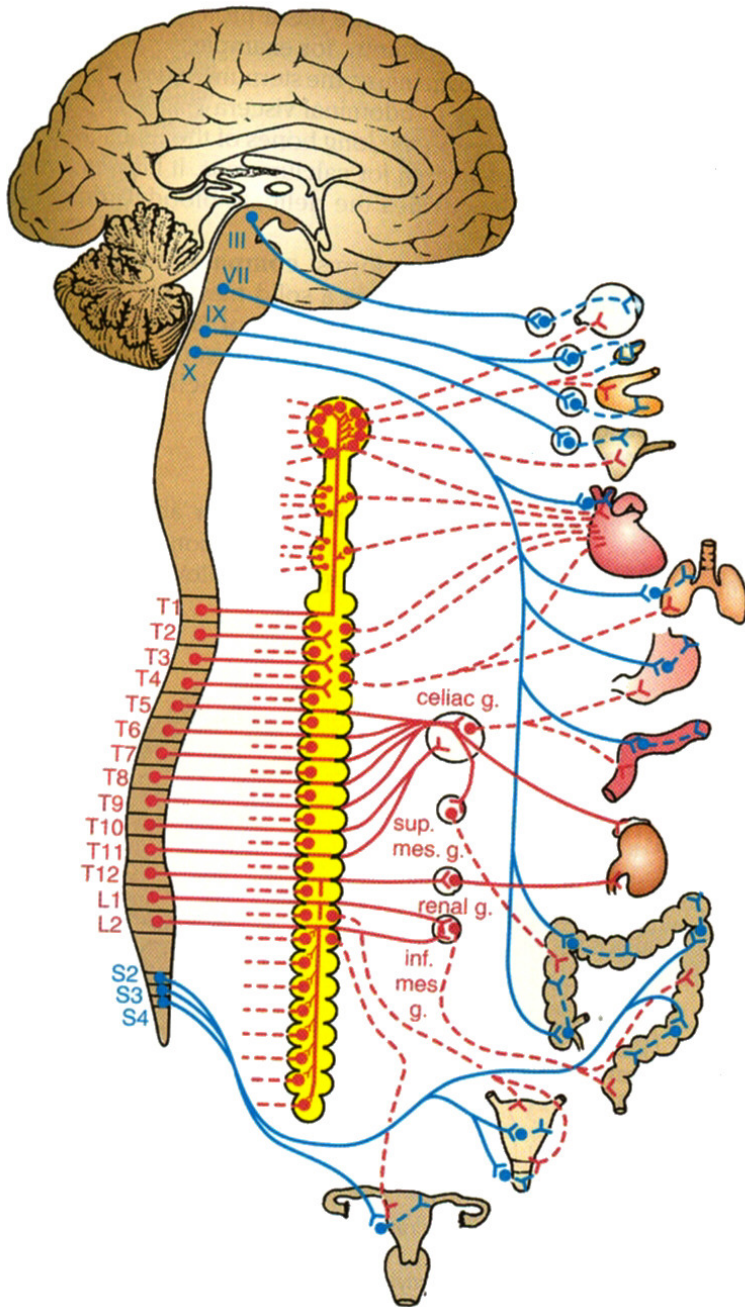
1- Arguably most important part of nervous system for practice of medicine.

2- Organization described as Sympathetic and Parasympathetic parts.

3- Structurally – Autonomic nervous system is a MESS

Note Definition - Viscera = internal organs (including blood vessels, cardiovascular system)

AUTONOMIC NERVOUS SYSTEM = VISCERAL NERVOUS SYSTEM



Autonomic Nervous system = Visceral nervous system - part of peripheral nervous system; **involuntary, unconscious part of nervous system**; (autonomic means self-regulating or automatic)

a. **Visceral Motor (parasympathetic and sympathetic efferents)** - innervate **smooth and cardiac muscle, blood vessels glands (ex. sweat glands) and internal organs**; largely unconscious actions.

b. **Visceral Sensory (afferents)** - sensory neurons that innervate internal organs, blood vessels; only provide **imprecise localization of sensation** and dull sense of pressure, pain, etc.

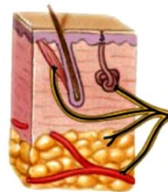
ASYMMETRY: SOME BODY STRUCTURES RECEIVE ONLY SYMPATHETICS NOT PARASYMPATHETICS

SYMPATHETICS

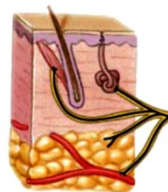
INNERVATE:

- 1) Skin
- 2) Peripheral blood vessels

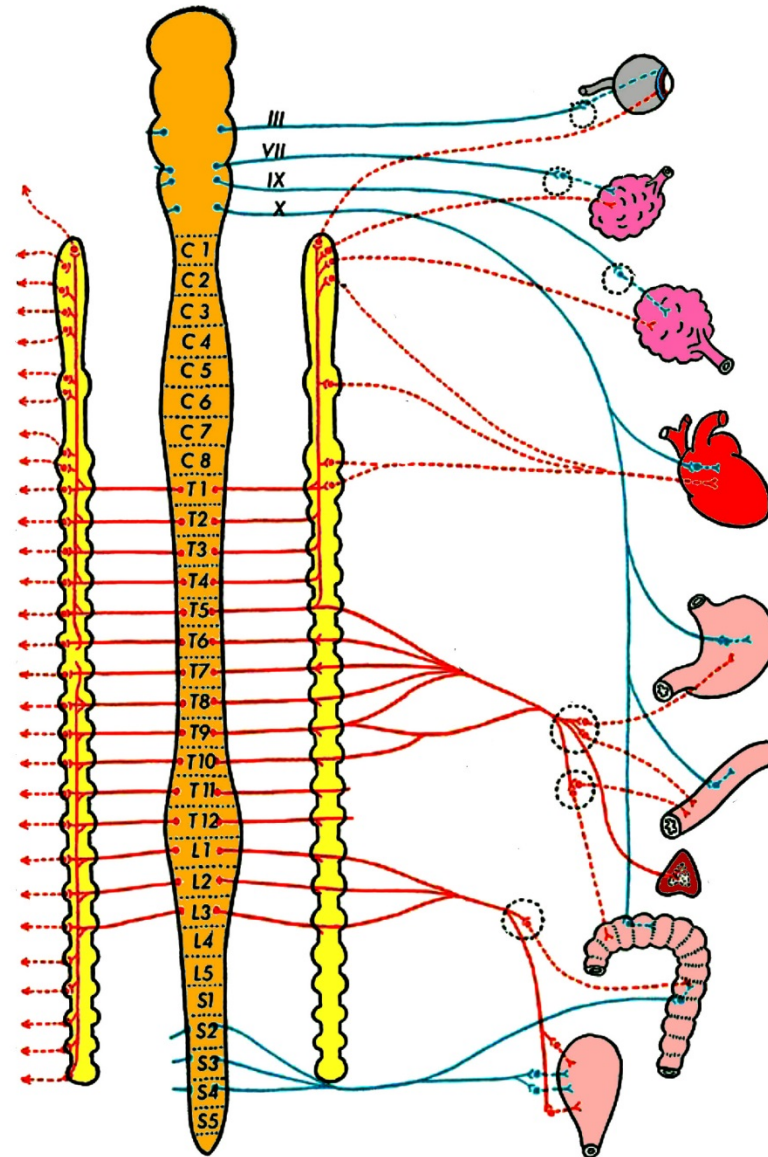
SKIN



SKIN



Sympa-
thetics go
to the
body
wall, i.e.
Skin



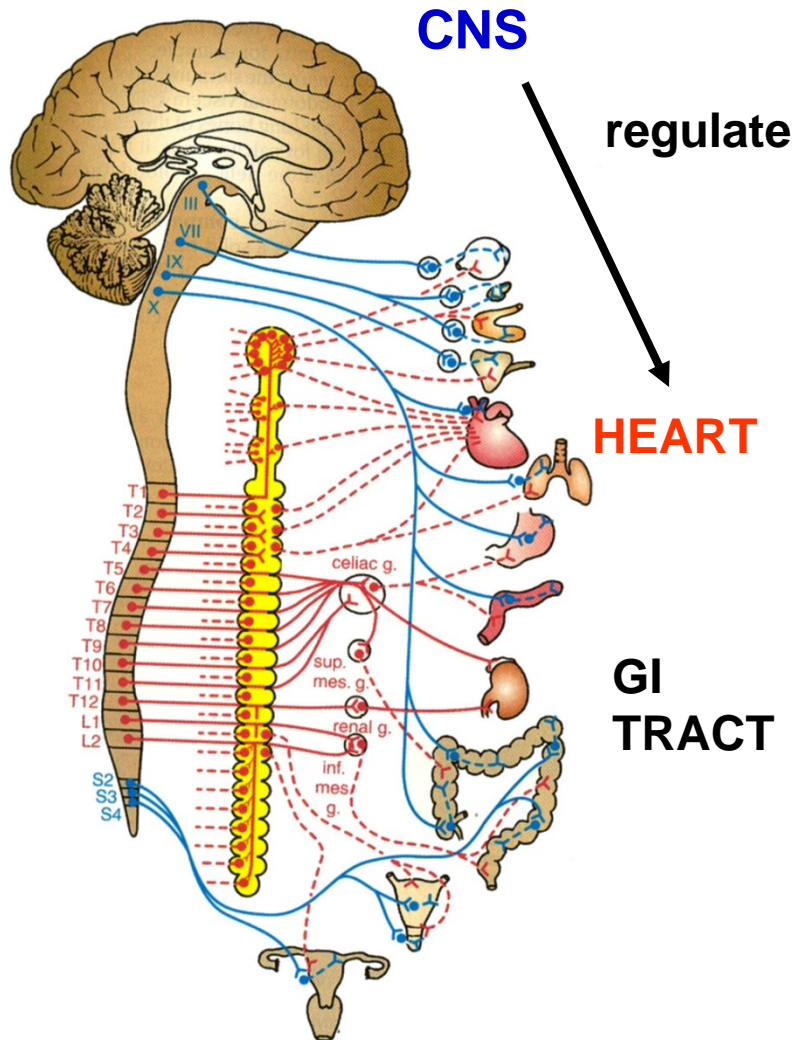
PARA- SYMPATHETICS

INNERVATE:

Do NOT innervate
skin and peripheral
blood vessels

Classic
description:
Para-
sympathetics
do not go to
the body wall

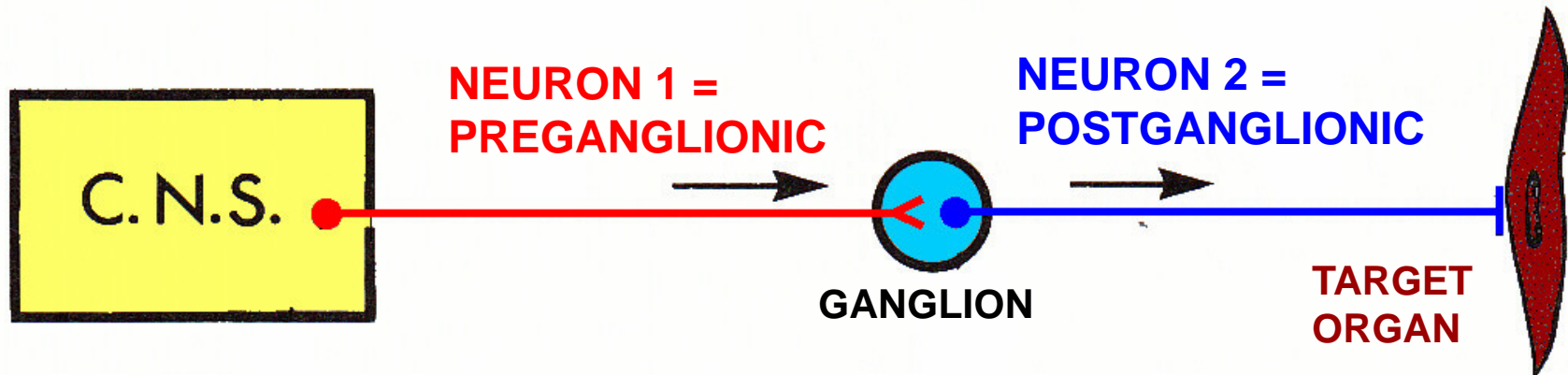
AUTONOMICS ARE NOT JUST REACTIVE BUT CONTINUOUSLY REGULATES AND CONTROLS BODY FUNCTIONS (HOMEOSTASIS)



The autonomic nervous system is often **thought of as reactive to stimuli (ex. fight or flight)**. However, many autonomies provide pathways for the CNS to **continuously regulate and control body functions:**
ex

- 1) Thermoregulation - regulate body temperature
- 2) Cardiovascular function in heart and blood vessels - monitor and regulate heart rate, blood pressure, etc.
- 3) GI function - secretion, motility

VISCERAL MOTOR = AUTONOMIC NERVOUS SYSTEM



All two neuron pathways:

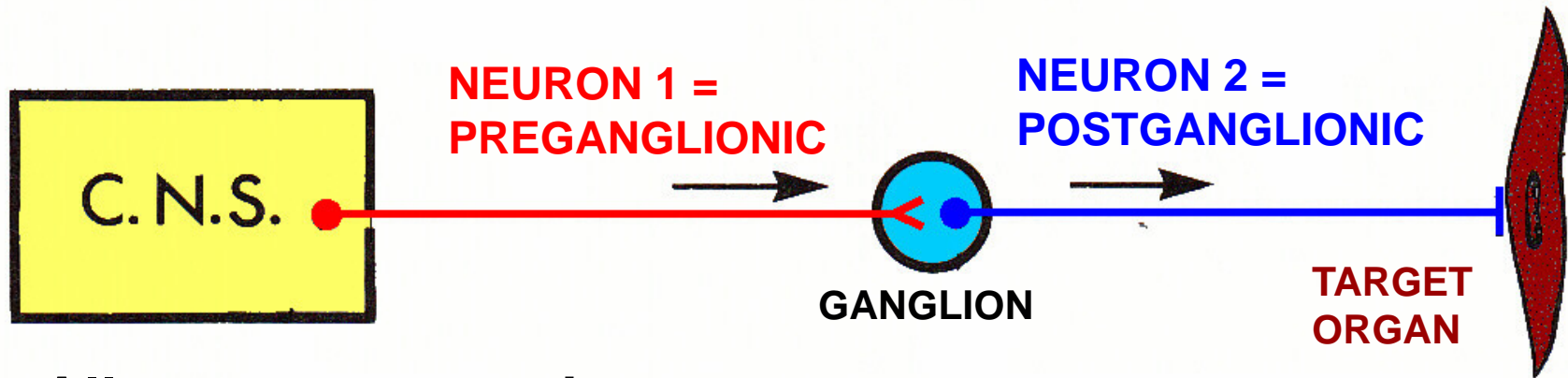
- 1) **Neuron 1 = Preganglionic neuron** - cell body in CNS; axon leaves CNS and synapses in autonomic ganglion
- 2) **Neuron 2 = Post ganglionic neuron** - cell body in autonomic ganglion; axon goes to target organ

note: **Sympathetic - ganglia close to vertebrae**
Parasympathetic - ganglia close to target organ

Sympathetic - preganglionic short; postganglionic long

Parasympathetic - preganglionic long; postganglionic short

BASIC PATHWAY: 2 NEURON ARC

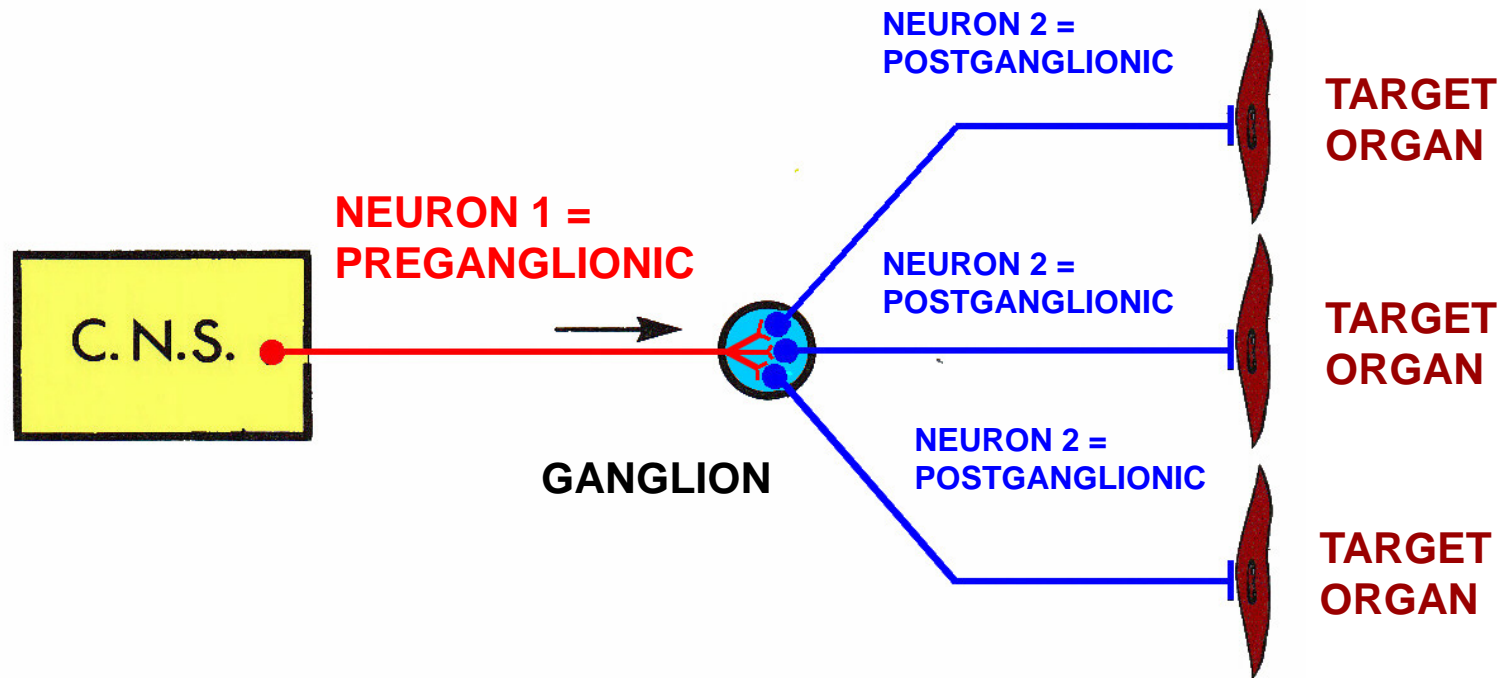


All two neuron pathways:

- 1) **Neuron 1 = Pre-ganglionic neuron** - cell body in CNS; axon leaves CNS and synapses in autonomic ganglion
- 2) **Neuron 2 = Post-ganglionic neuron** - cell body in autonomic ganglion; axon goes to target organ

WHY?

DIVERGENCE : AUTONOMICS CAN ACTIVATE MANY TARGETS SIMULTANEOUSLY



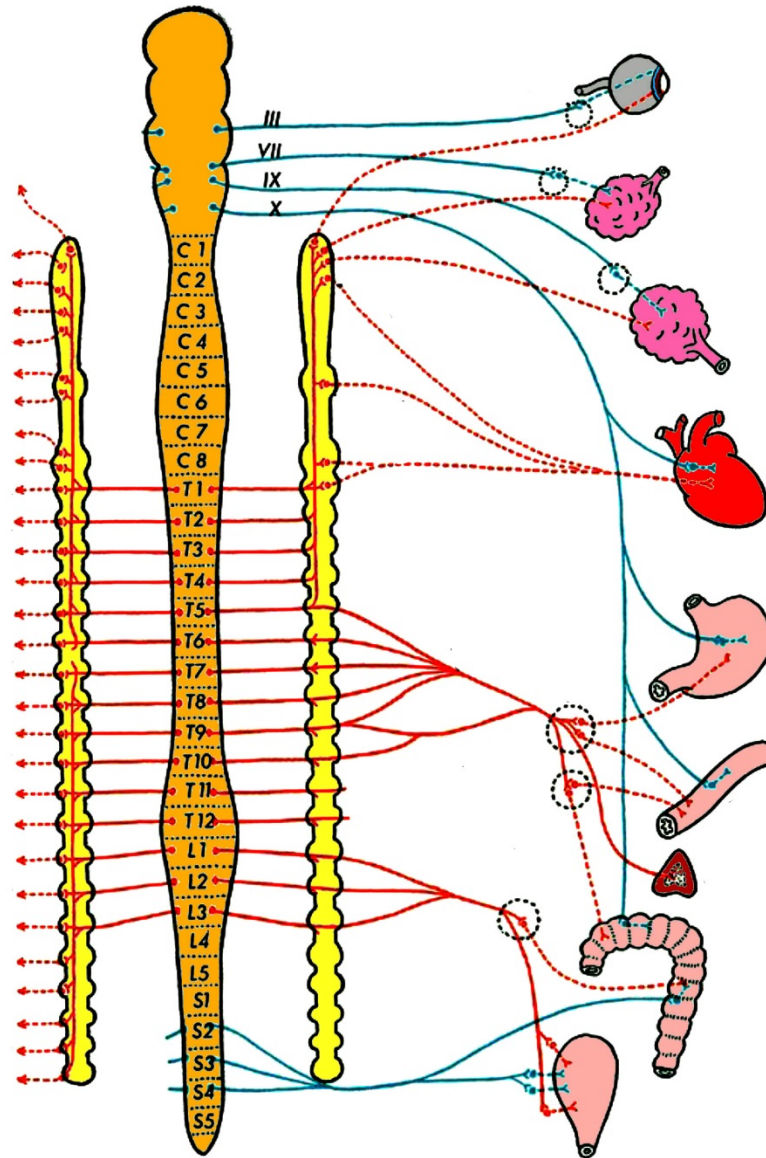
Considerable divergence of signal - One Pre-ganglionic neuron usually activates many (15 - 200) Post-ganglionic neurons; Autonomics can activate many targets simultaneously (ex. Thermoregulation - many sweat glands secrete at the same time)

PARTS OF AUTONOMIC NERVOUS SYSTEM: SYMPATHETICS AND PARASYMPATHETICS

SYMPATHETICS
– ‘FIGHT OR FLIGHT’

OUT: Thoraco-lumbar levels

GANGLIA: Near CNS (most)



PARA-SYMPATHETICS
– ‘REST AND DIGEST’

OUT: Cranio-sacral levels

GANGLIA: Near TARGET (all)

TWO DIVISIONS - PARASYMPATHETIC AND SYMPATHETIC - in some systems have opposite effects
examples:

SYSTEM	<u>SYMPATHETIC - 'FIGHT OR FLIGHT'</u>	<u>PARASYMPATHETIC - REST AND DIGEST</u>
HEART	INCREASE RATE, CONTRACTION	DECREASE RATE
GI SYSTEM	DECREASE STOMACH MOVEMENTS, DECREASE SECRETIONS	INCREASE STOMACH MOVEMENTS, INCREASE SECRETIONS
SALIVARY GLANDS	DECREASE SECRETION	INCREASE SECRETION

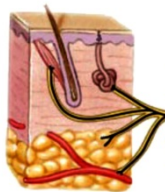
ASYMMETRY: SOME BODY STRUCTURES RECEIVE ONLY SYMPATHETICS NOT PARASYMPATHETICS

SYMPATHETICS

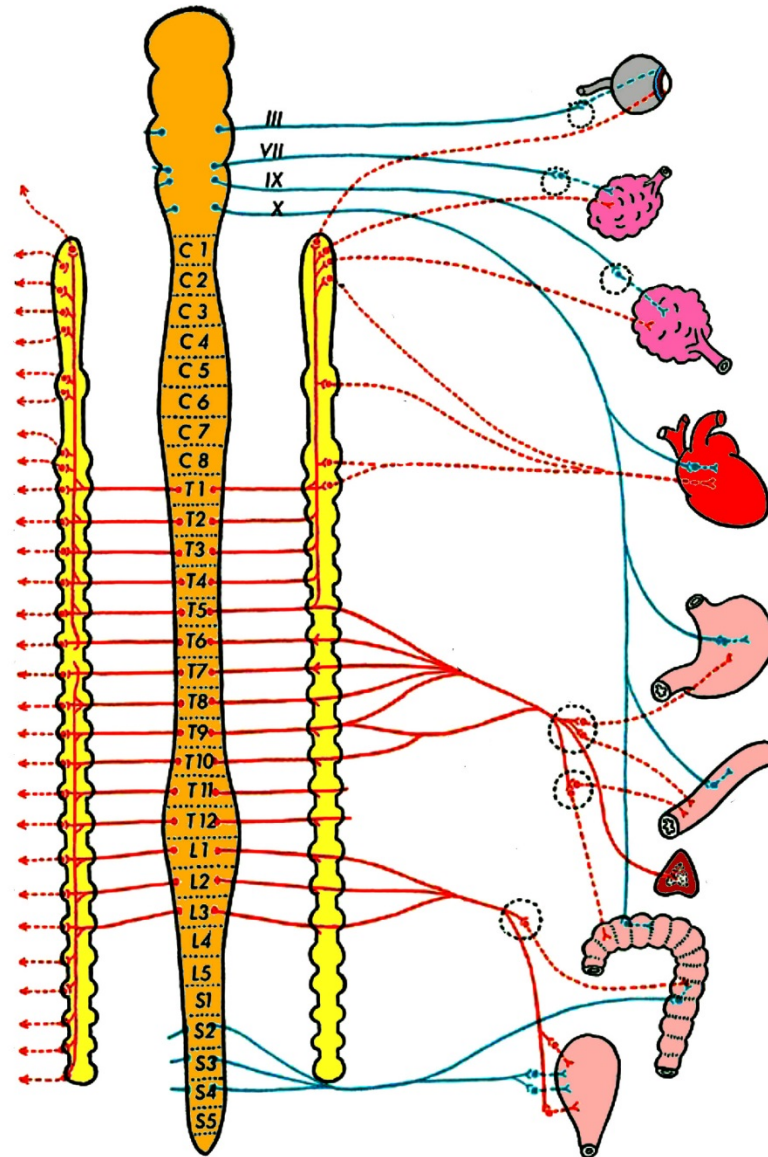
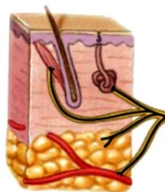
INNERVATE:

- 1) Skin
- 2) Peripheral blood vessels

SKIN



SKIN

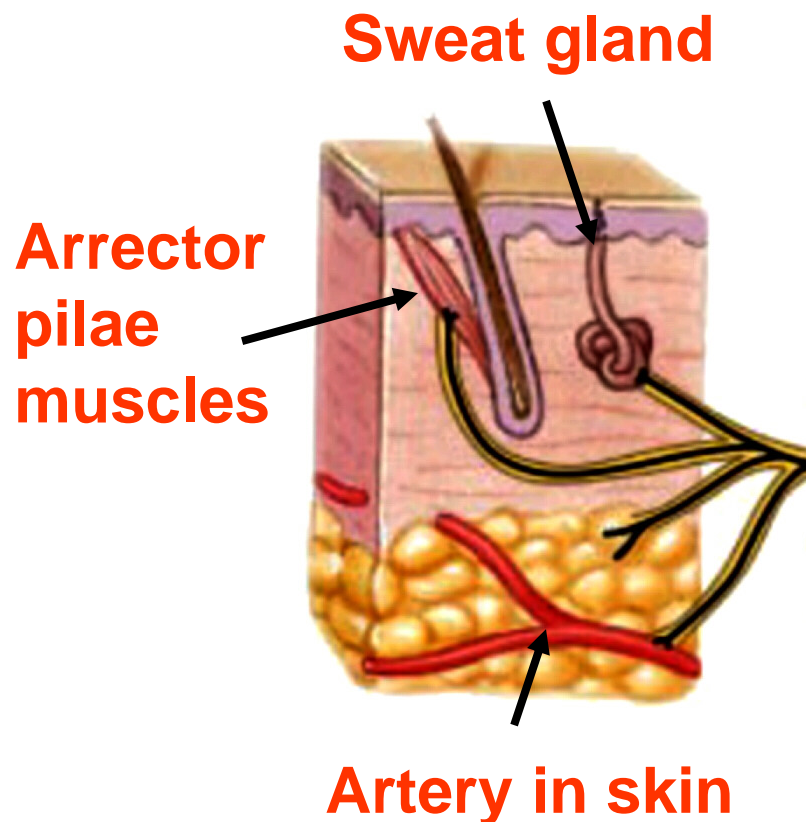


PARA-SYMPATHETICS

INNERVATE:

Do NOT innervate skin and peripheral blood vessels

STRUCTURES OF SKIN ARE INNERVATED ONLY BY SYMPATHETICS (NOT PARASYMPATHETICS)



**ONLY RECEIVE SYMPATHETICS,
NOT PARASYMPATHETICS
(examples)**

**1) SKIN - sweat glands, arrector
pilae muscles**

2) PERIPHERAL BLOOD VESSELS

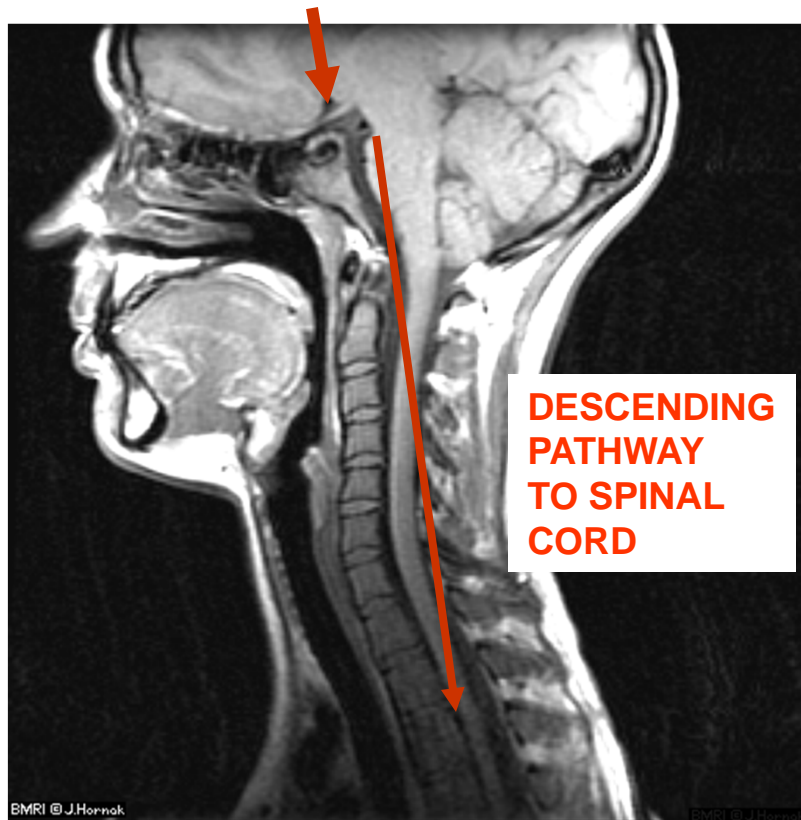
**Consequence; SYMPATHETICS
ARE ANATOMICALLY MUCH
MORE WIDESPREAD THAN PARA-
SYMPATHETICS; PATHWAYS
MORE COMPLEX**

CLINICAL

SWEAT GLANDS ARE ONLY INNERVATED BY SYMPATHETICS

THERMOREGULATION - controlled in HYPOTHALAMUS

HYPOTHALAMUS



SIGNALS FROM HYPOTHALAMUS PROJECT VIA HYPOTHALMOSPINAL TRACT (+brainstem) TO AUTONOMIC NUCLEI IN SPINAL CORD (LATERAL HORN)

RESPONSES TO INCREASED TEMPERATURE (Anterior Hypothalamus/Preoptic area)

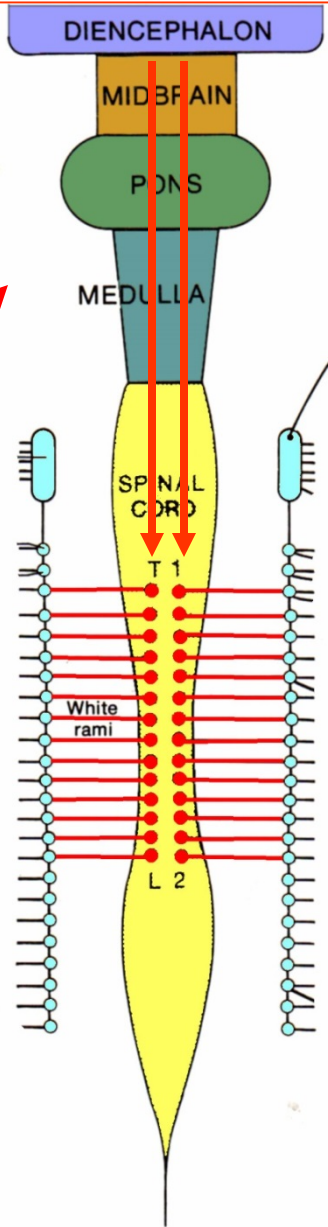
- Peripheral Vasodilation
- Increased Sweating
- Water and Electrolyte retention

RESPONSES TO DECREASED TEMPERATURE (Caudal hypothalamus)

- Peripheral vasoconstriction
- Decreased sweating
- Contract arrector pilae muscles
- Shivering

**BRAIN -
parts of
brainstem**

HYPOTHALAMUS



**HYPOTHALMUS:
CONTROL OF
SYMPATHETIC
FUNCTION**

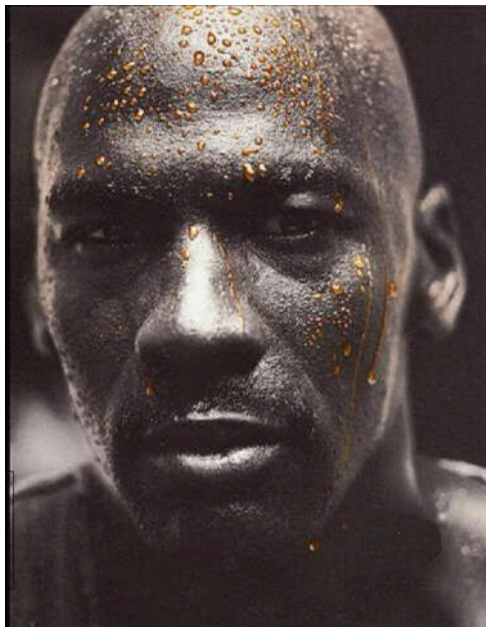
**Hypothalamo-
spinal tract -
descending
signals to
Pre-ganglionic
neurons in
Spinal Cord**

**Sympathetic
outflow at
Thoracic and
Lumbar
levels**

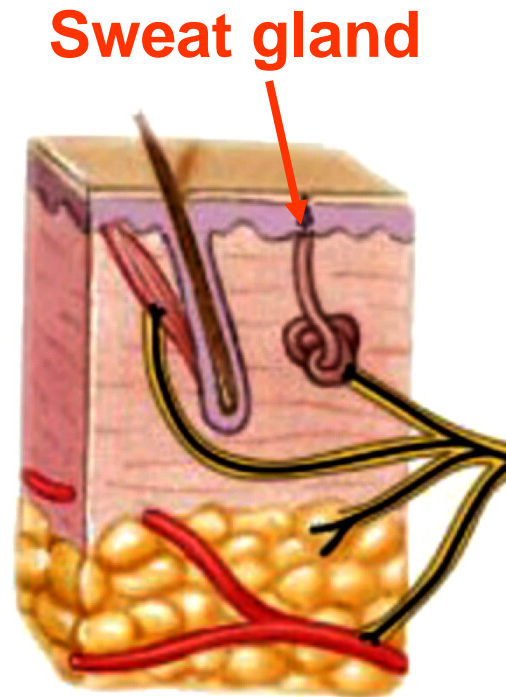
**MEDIATED BY
SYMPATHETICS**

SOME REGULATORY PROCESS REQUIRE WIDESPREAD ACTIVATION OF TARGET ORGANS

EXAMPLE: THERMOREGULATION



Michael Jordan sweating
Gatorade (\$)



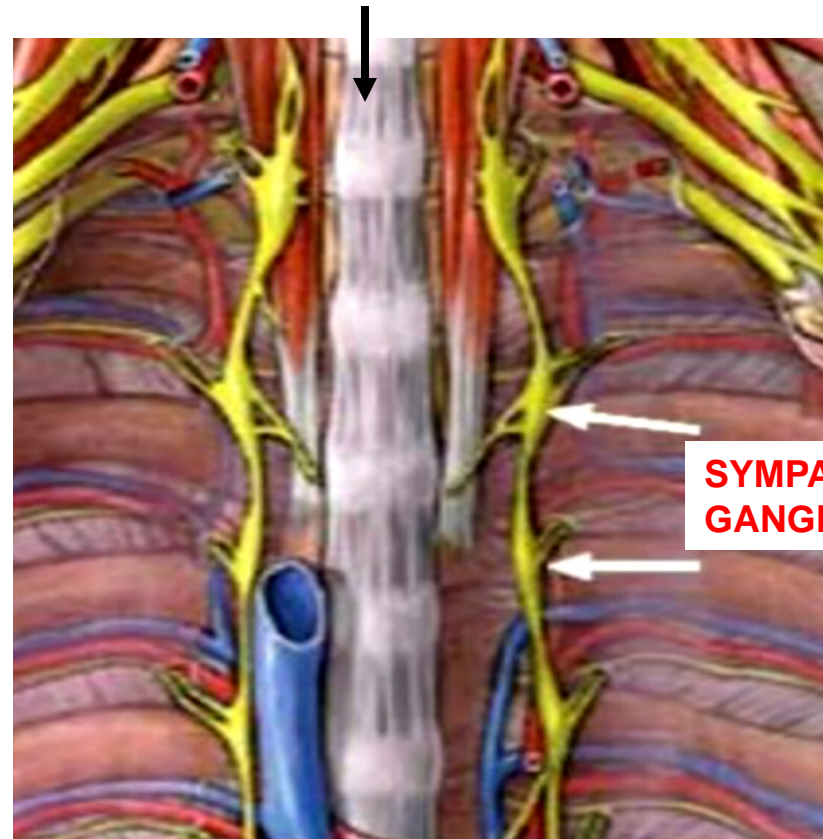
RESPONSE TO
CHANGES IN BODY
TEMPERATURE
MEDIATED BY
SYMPATHETICS (NOT
PARASYMPATHETICS)

INCREASED
TEMPERATURE
- increased secretion
of sweat glands

There are over 2 million sweat glands in the human body; how does the Nervous system activate them simultaneously?

SYMPATHETICS HAVE WIDESPREAD EFFECTS BY SYMPATHETIC CHAIN - called Paravertebral Ganglia

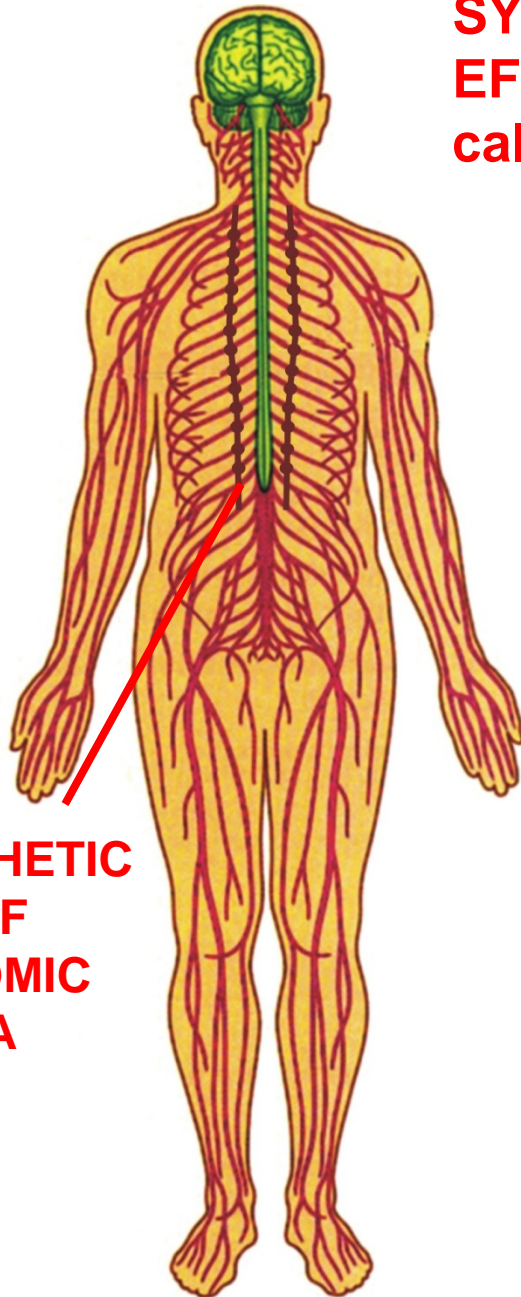
Bodies of Thoracic Vertebrae (anterior side)



SYMPATHETIC GANGLIA

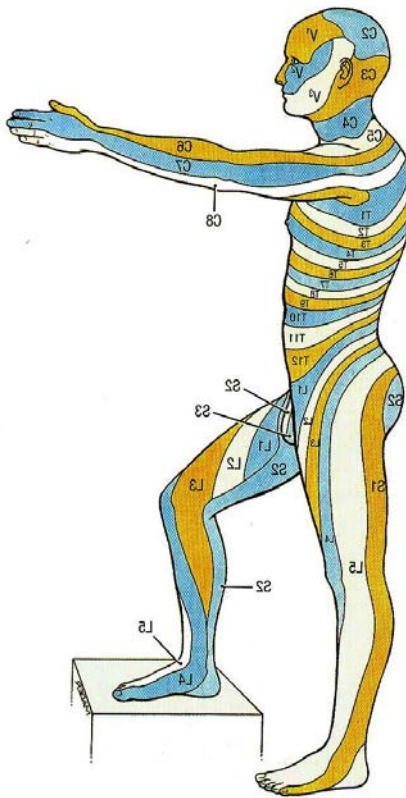
View of the anterior side (front) of vertebrae inside the thorax (chest cavity); chain of ganglia are on sides of vertebrae (paravertebral)

SYMPATHETIC CHAIN OF AUTONOMIC GANGLIA

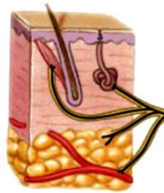


SYMPATHETICS ARE DISTRIBUTED WITH PERIPHERAL NERVES

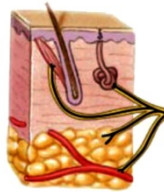
PATHWAYS TO SKIN



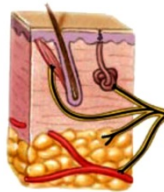
SKIN



SKIN



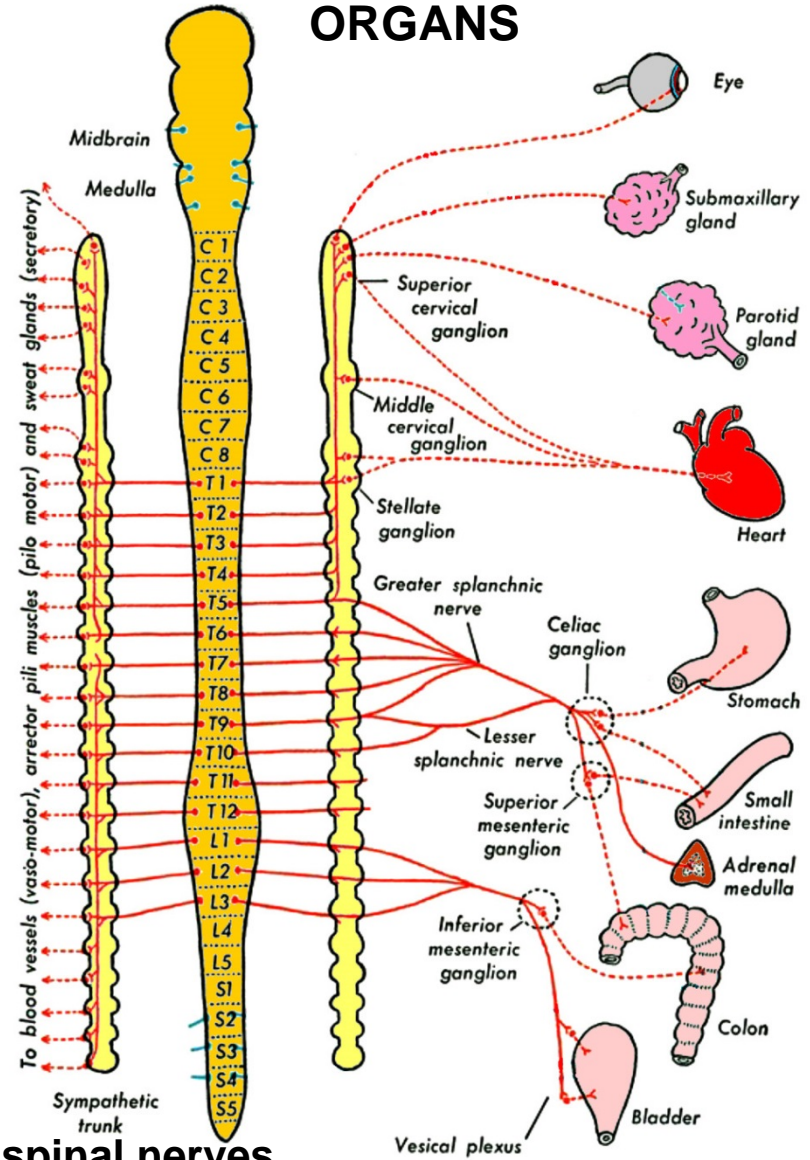
SKIN



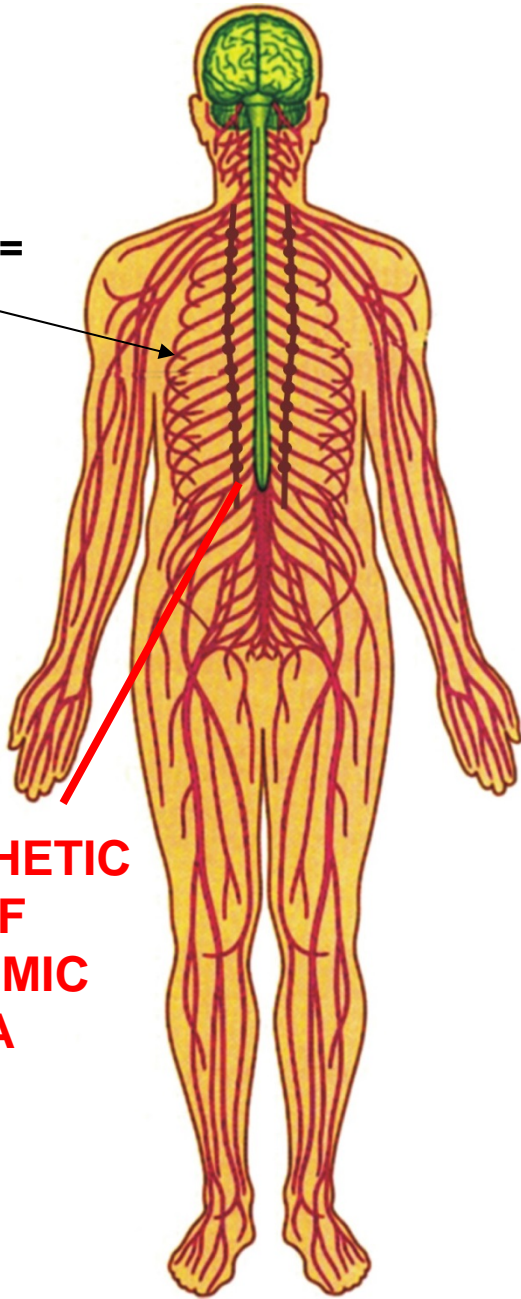
PATHWAYS TO SKIN

- sympathetics make up ~8% of axons in spinal nerves

PATHWAYS TO INTERNAL ORGANS

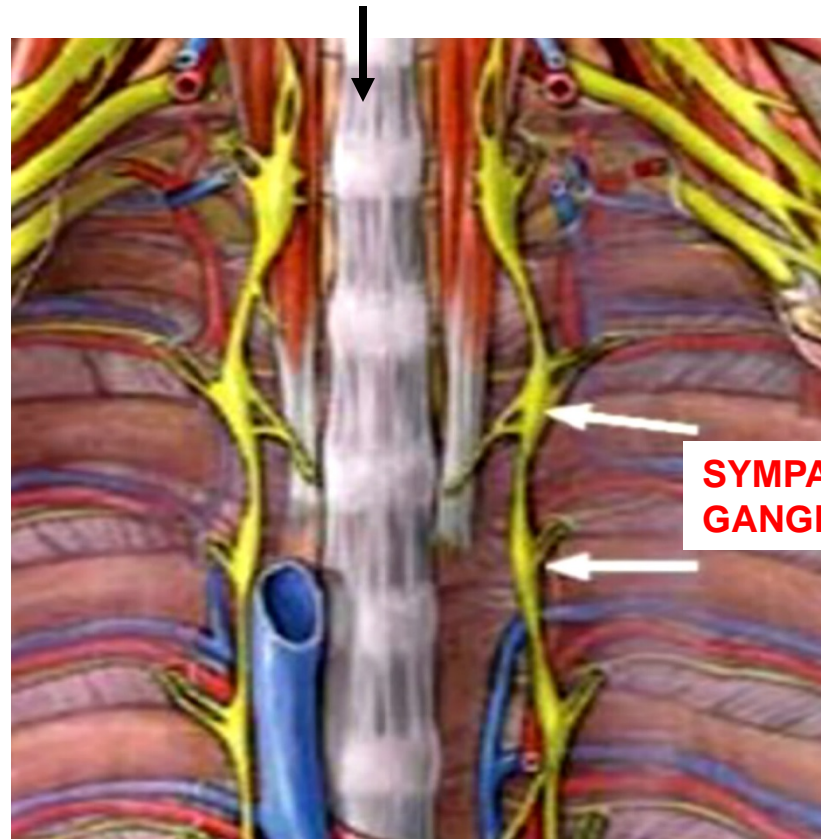


**THORAX =
CHEST**



**SYMPATHETIC
CHAIN OF
AUTONOMIC
GANGLIA**

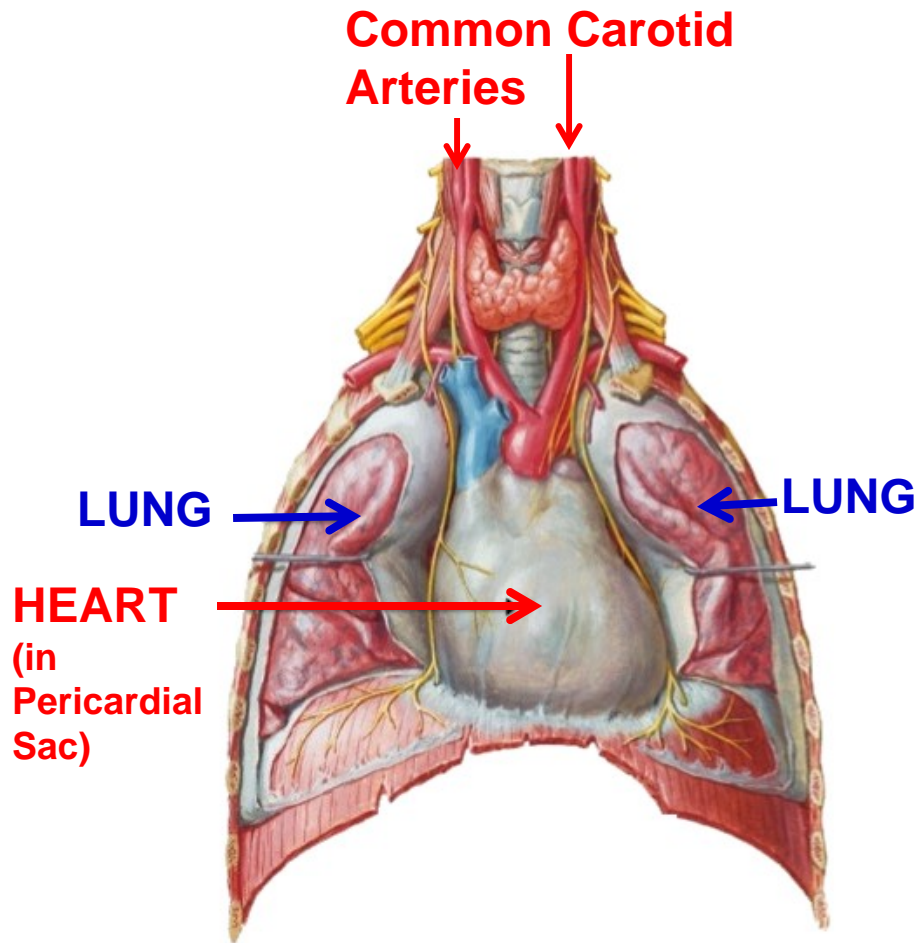
Bodies of Thoracic Vertebrae (anterior side)



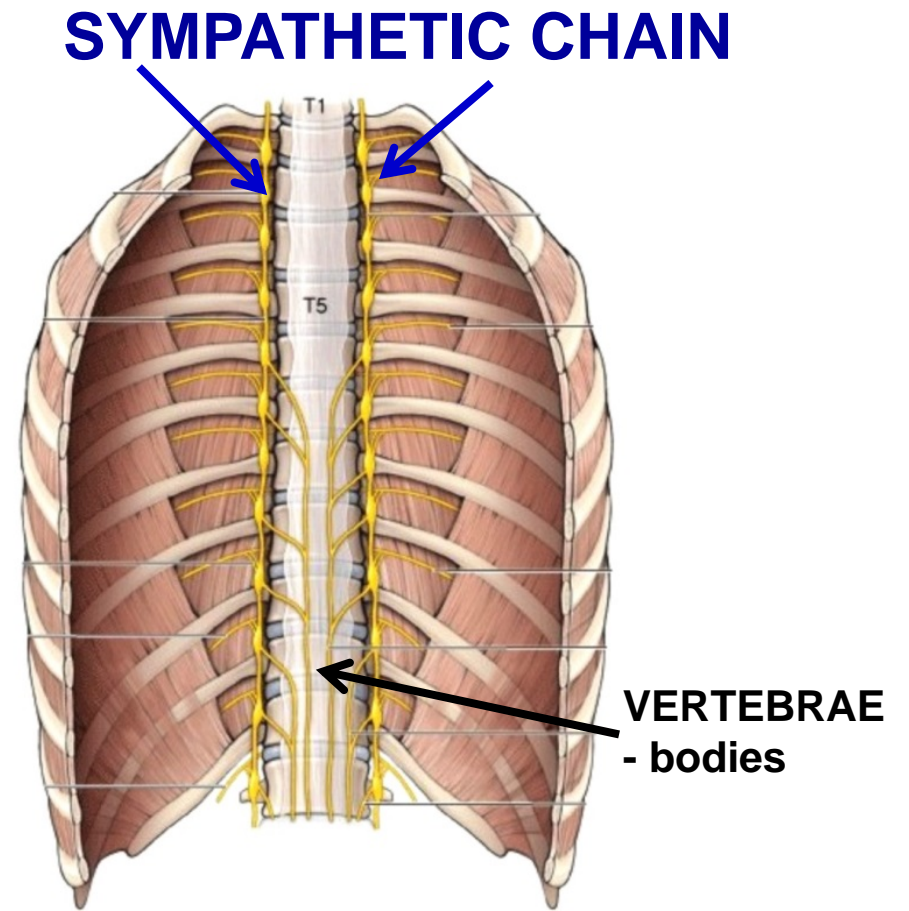
**SYMPATHETIC
GANGLIA**

**View of the anterior side (front) of vertebrae
inside the thorax (chest cavity); chain of
ganglia are on sides of vertebrae (paravertebral)**

LOCATION OF SYMPATHETIC CHAIN



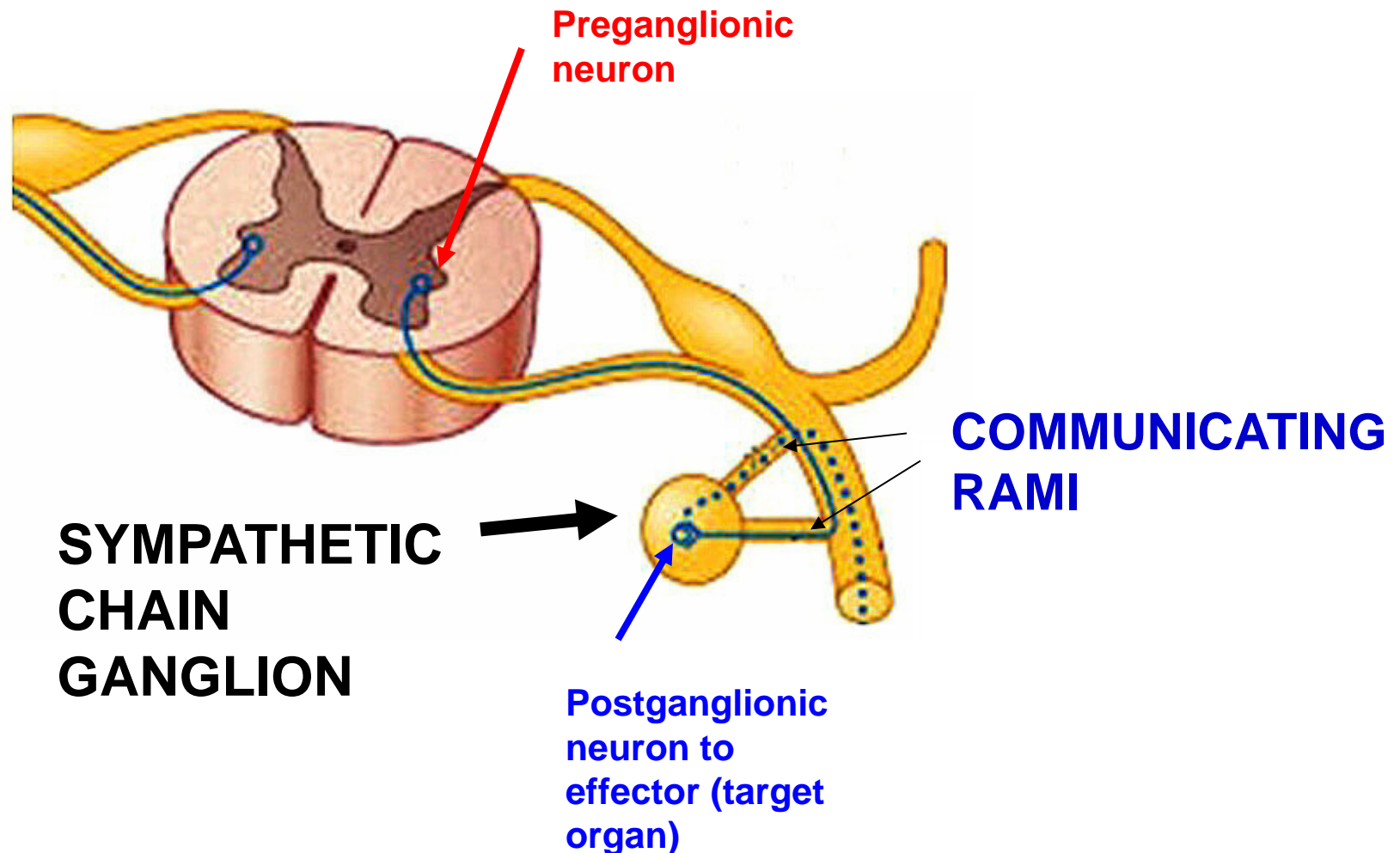
THORAX DISSECTION - remove ribs from anterior wall; see Heart and Lungs



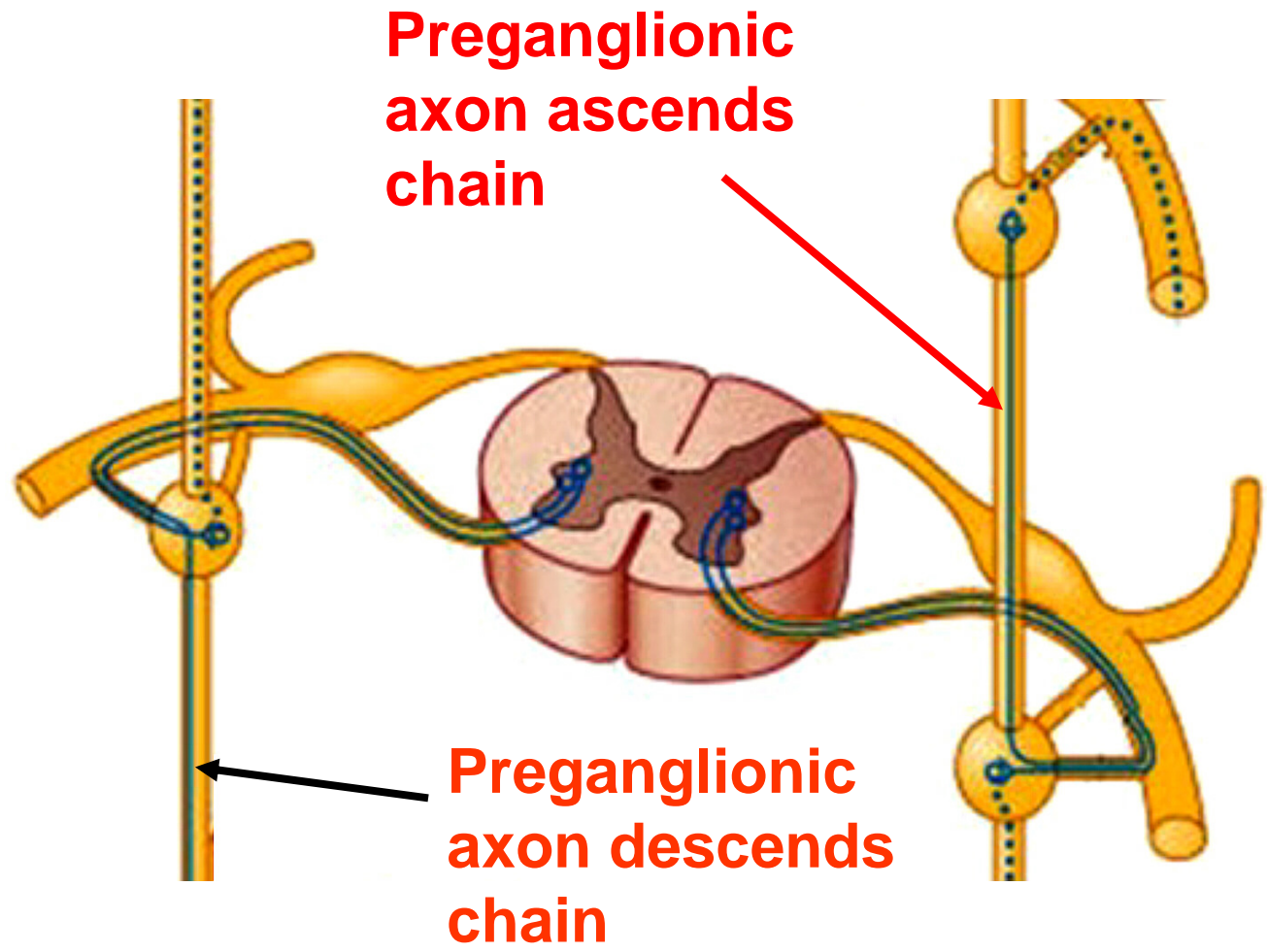
REMOVE HEART AND LUNGS - Thorax is hollow; Vertebral bodies on posterior wall; Sympathetic chain on sides of vertebral bodies

II. ANATOMICAL ORGANIZATION SYMPATHETIC OUTFLOW OCCURS BY THREE PATHWAYS

1) COME OUT THORACIC AND LUMBAR VENTRAL ROOTS AND SYNAPSE IN GANGLION AT THAT LEVEL

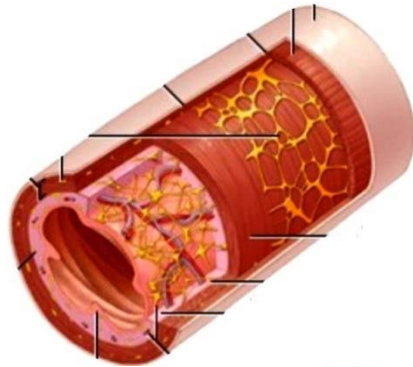


2) SYMPATHETICS ASCEND OR DESCEND SYMPATHETIC CHAIN TO TERMINATE IN OTHER GANGLIA

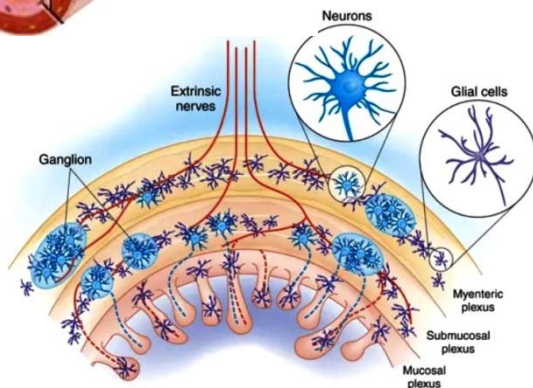


3) SYMPATHETICS LEAVE CHAIN WITHOUT SYNAPSING; FORM NERVES CALLED SPLANCHNIC NERVES - SYNAPSE IN PRE-AORTIC GANGLIA

Preganglionic axon leaves chain in Splanchnic nerve; nerves descending to abdomen; synapse on Pre-aortic ganglia, Gut

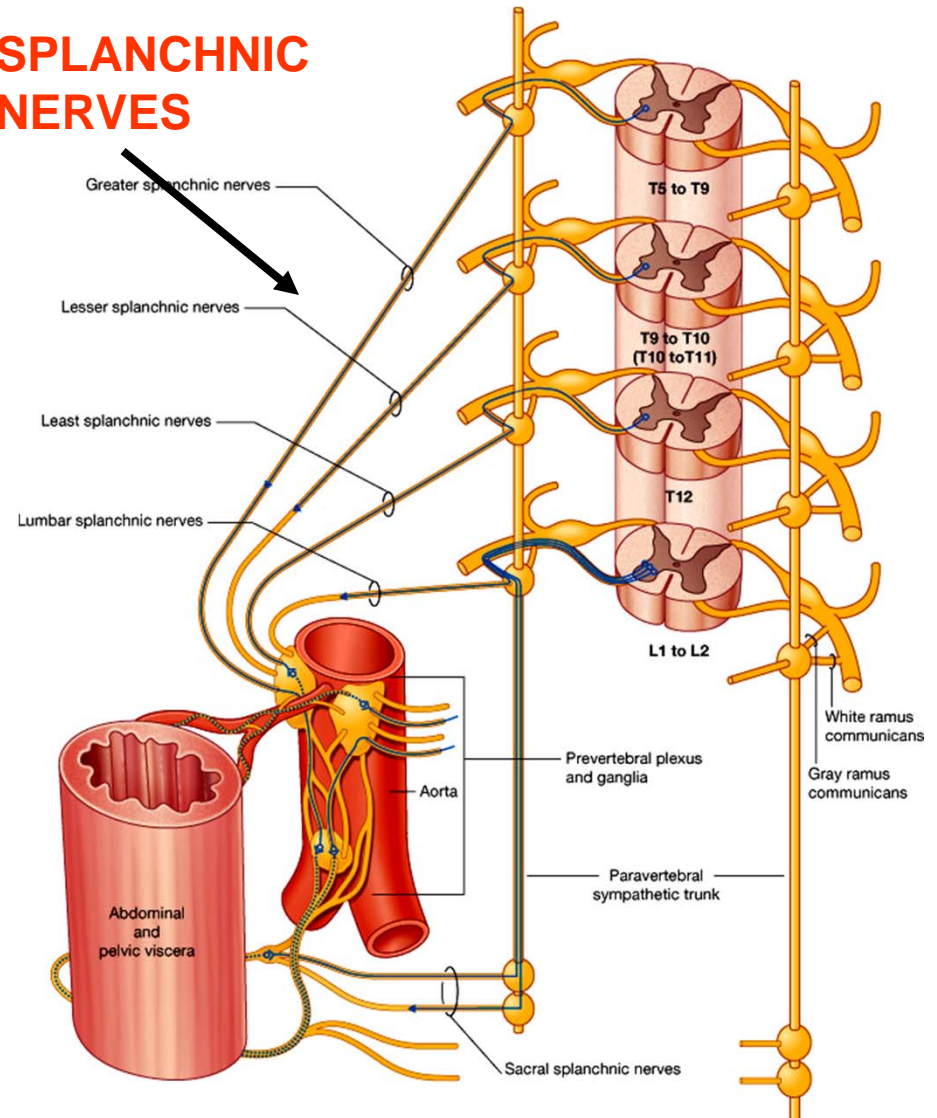


GUT - ENTERIC NERVOUS SYSTEM



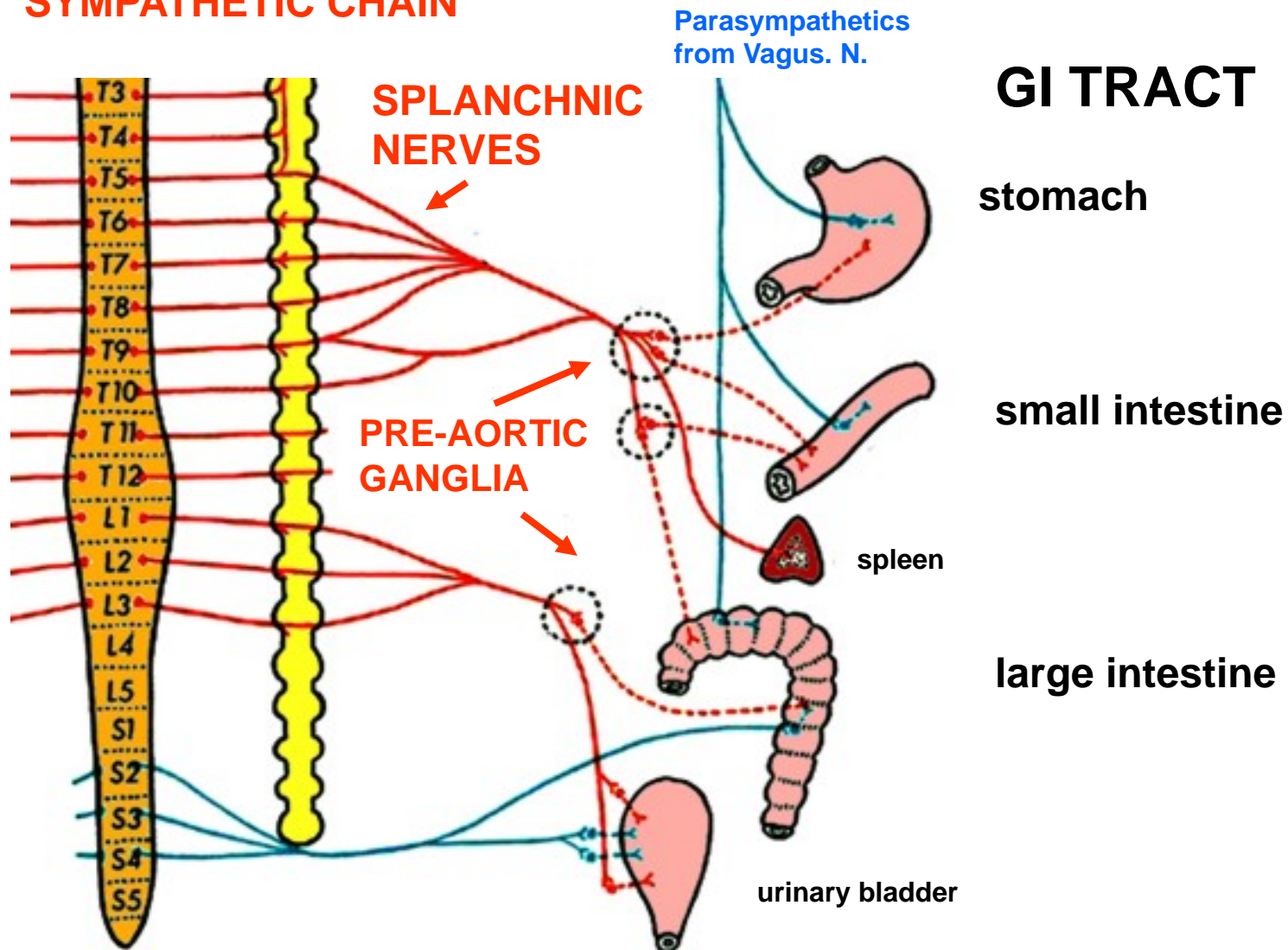
RECENT RESEARCH - INTERACTION BETWEEN IMMUNE SYSTEM AND NERVOUS SYSTEM

SPLANCHNIC NERVES



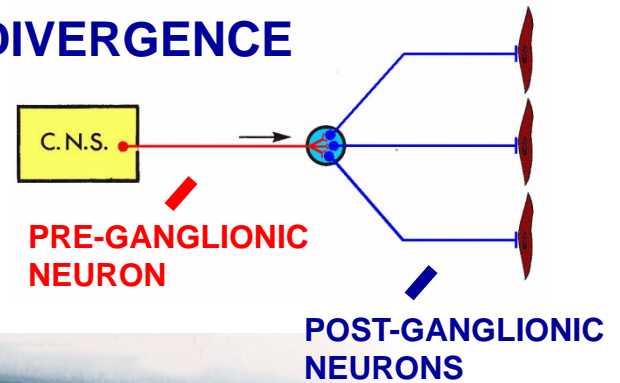
SPLANCHNIC NERVES: SYMPATHETICS TO INTERNAL ORGANS IN ABDOMEN, PELVIS - COVERED IN SPRING

SYMPATHETIC CHAIN



FUNCTION OF COMPLEXITY, 2 NEURON ARC: DIVERGENCE

ONE PRE-GANGLIONIC NEURON ACTIVATES MANY POST-GANGLIONIC NEURONS



MIDNIGHT RIDE OF PAUL REVERE - 'British are coming, British are coming....'