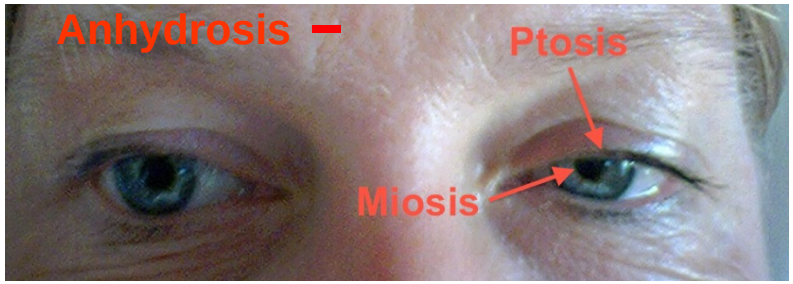
ANATOMY AND DIAGNOSTIC USE OF AUTONOMIC NERVOUS SYSTEM PATHWAYS

CLINICALLY IMPORTANT

HORNER'S SYNDROME



GOALS:

1) UNDERSTAND STRUCTURES AND PATHWAYS SEEN IN GROSS ANATOMY PROSECTIONS OF AUTONOMICS (NEXT BLOCK)

2) REVIEW AUTONOMICS TO EYE FOCUS: HORNER'S SYNDROME - damage to Sympathetic pathways:

SYMPTOMS -
MIOSIS - pupillary constriction
PTOSIS - drooping eyelid
ANHYDROSIS - lack of sweating

OUTLINE

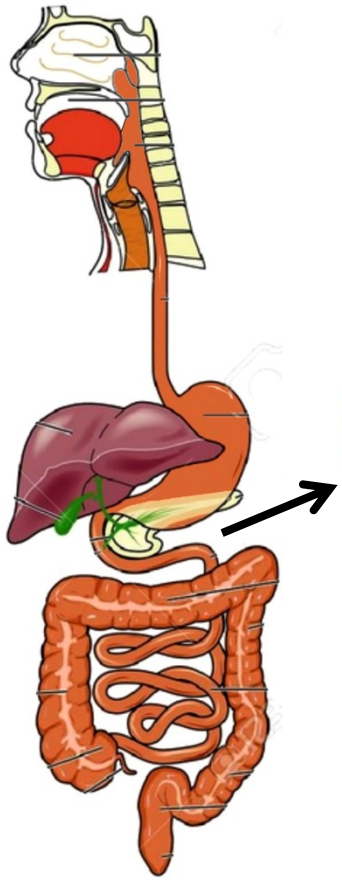
1. GENERAL REVIEW OF AUTONOMIC NERVOUS SYSTEM - Sympathetics and Parasympathetics - Asymmetry: Sympathetics are widespread; Parasympathetics are much more localized (except Vagus nerve)

Why? Sympathetics go to Skin, not ParasympathetIcs; ex. control of sweating

2. ANATOMY OF SYMPATHETIC PATHWAYS - structures can be seen in prosections in thorax.

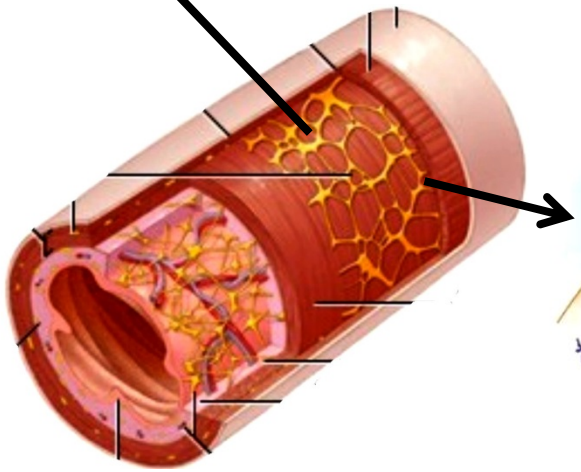
3. SYMPATHETICS TO HEAD AND HORNER'S SYNDROME (= damage to Sympathetics) - CLINICAL FOCUS: Autonomic pathways to EYE (and head) are used diagnostically

WHY IS THE AUTONOMIC NERVOUS SYSTEM A MESS? EVOLUTION OF NERVOUS SYSTEM - starts as primitive nerve net (meshwork of neurons) - organization preserved in human GUT (GI tract) = ENTERIC NERVOUS SYSTEM

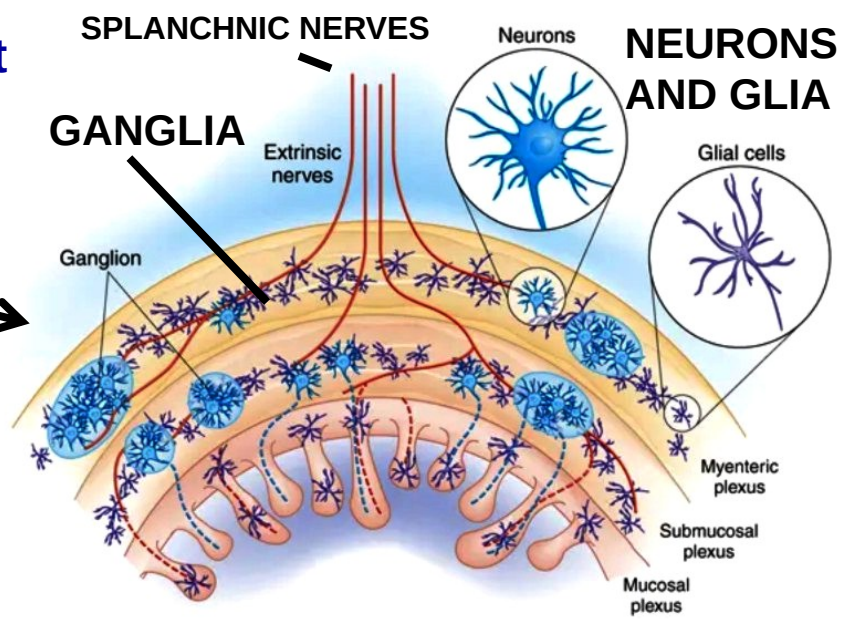


GUT (GI tract)

ENTERIC NERVOUS SYSTEM - in wall of gut



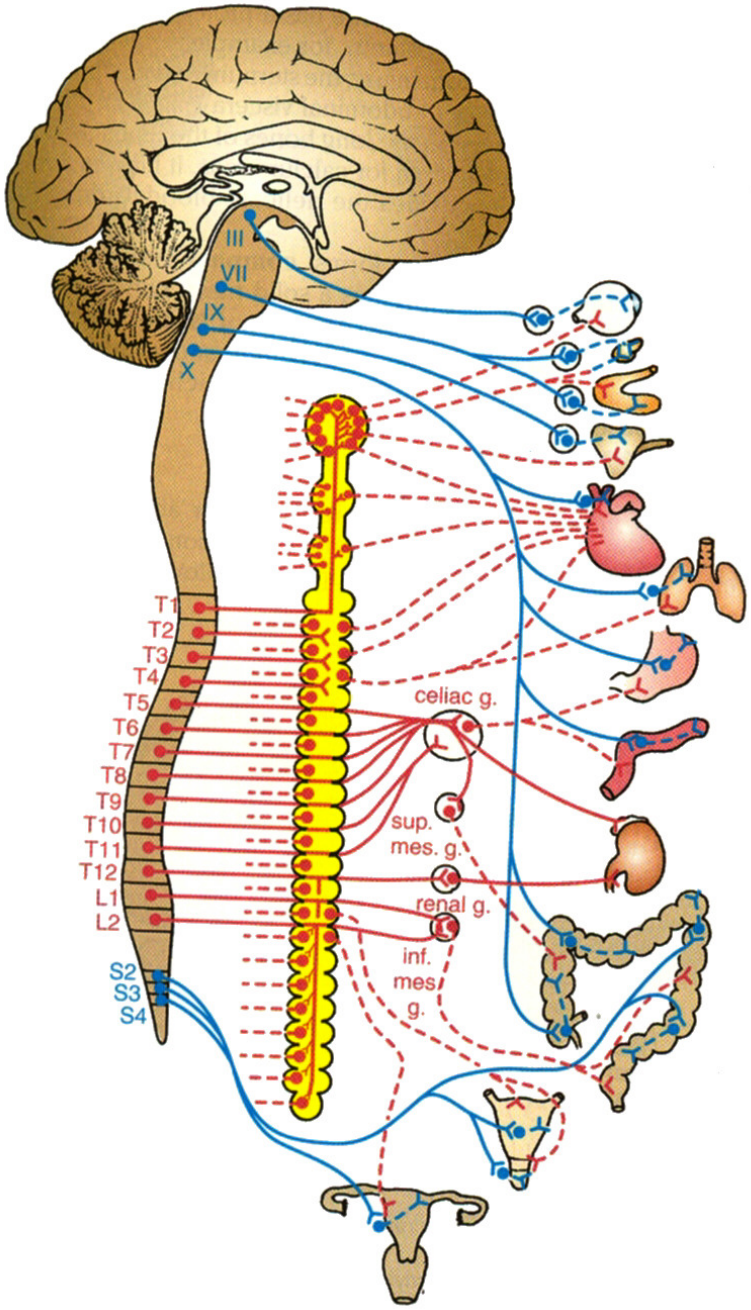
SECTION THROUGH WALL OF INTESTINE



COVERED IN GI SYSTEM: SPRING 2020

ENTERIC NERVOUS SYSTEM

- ganglia (neurons, glia) in wall of gut produces contractions (peristalsis) in gut muscle cells
- can operate independent of autonomic nervous system but modulated by it (Splanchnic nerves)
- recent research: immune system acts on Enteric nervous system



GENERAL REVIEW AUTONOMIC = 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.

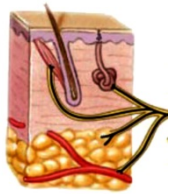
b. **Visceral Sensory (afferents)** - sensory neurons that innervate internal organs, blood vessels; only provide **imprecise localization of sensation** and dull sense of pressure, pain, etc.

ASYMMETRY: SOME BODY STRUCTURES RECEIVE ONLY SYMPATHETICS NOT PARASYMPATHETICS

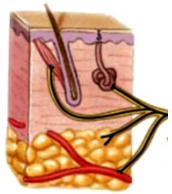
SYMPATHETICS

INNERVATE:
1) Skin
2) Peripheral blood vessels

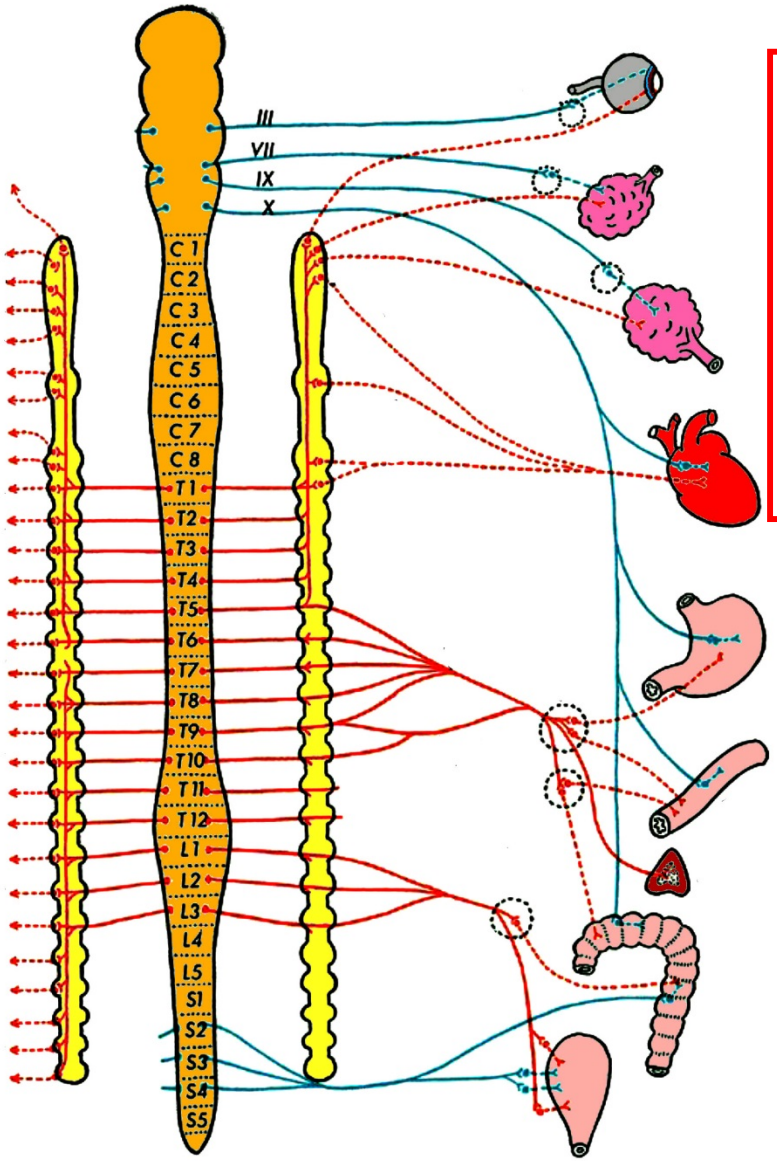
SKIN



SKIN



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

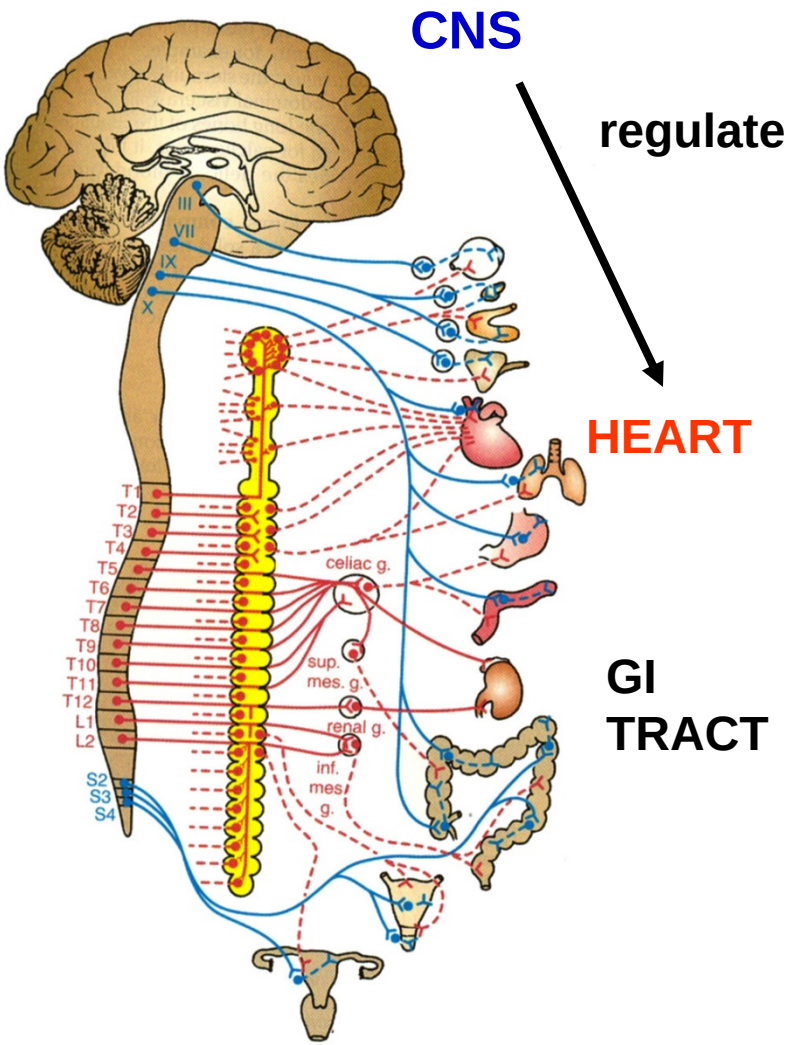


PARA-SYMPATHETICS

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 autonomics provide pathways for the CNS to continuously regulate and control body functions:

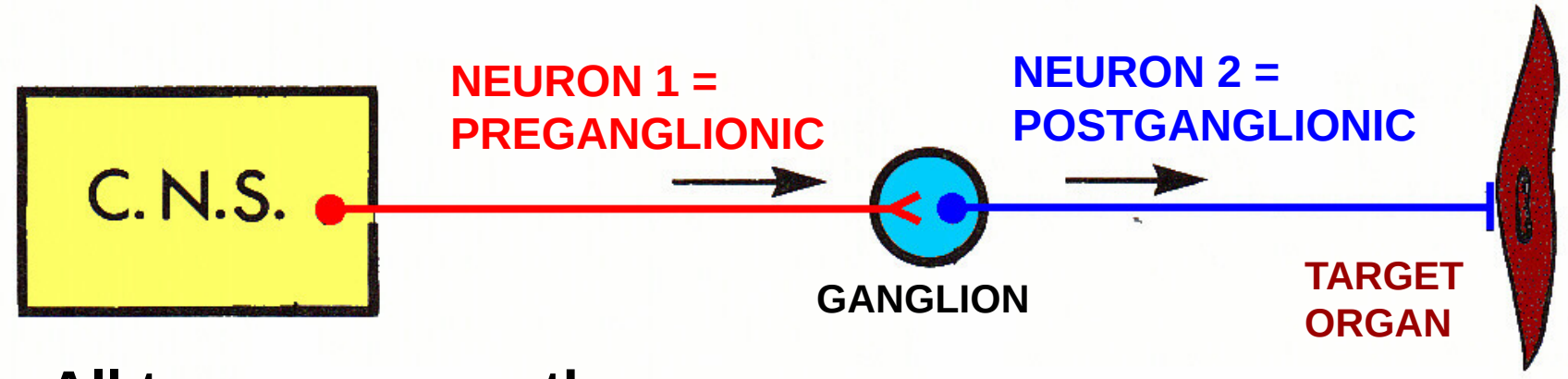
ex

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

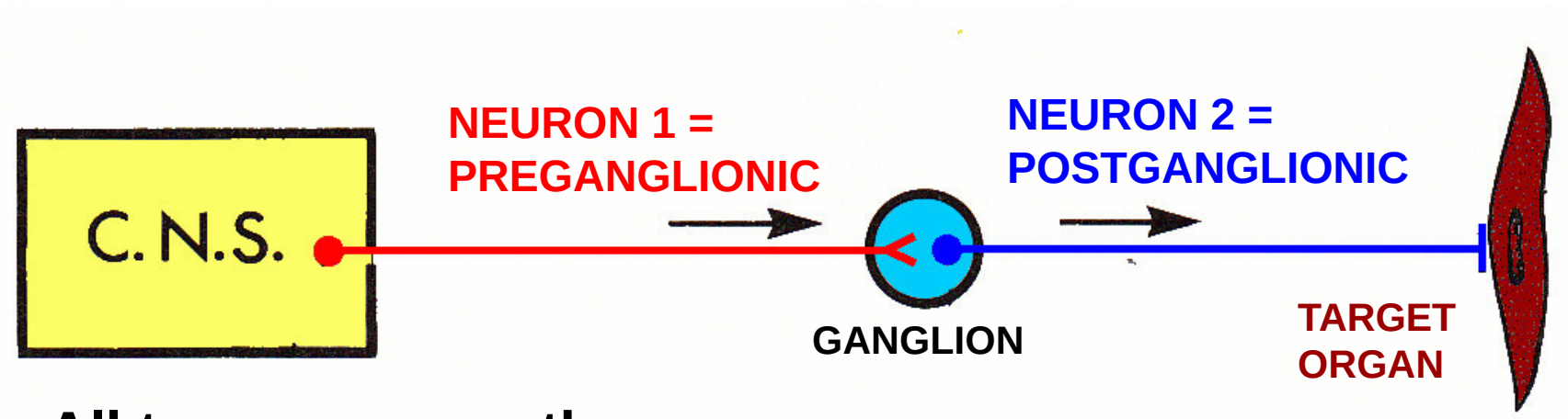
2) Neuron 2 = Post ganglionic neuron - cell body in autonomic ganglion; axon goes to target organ

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:

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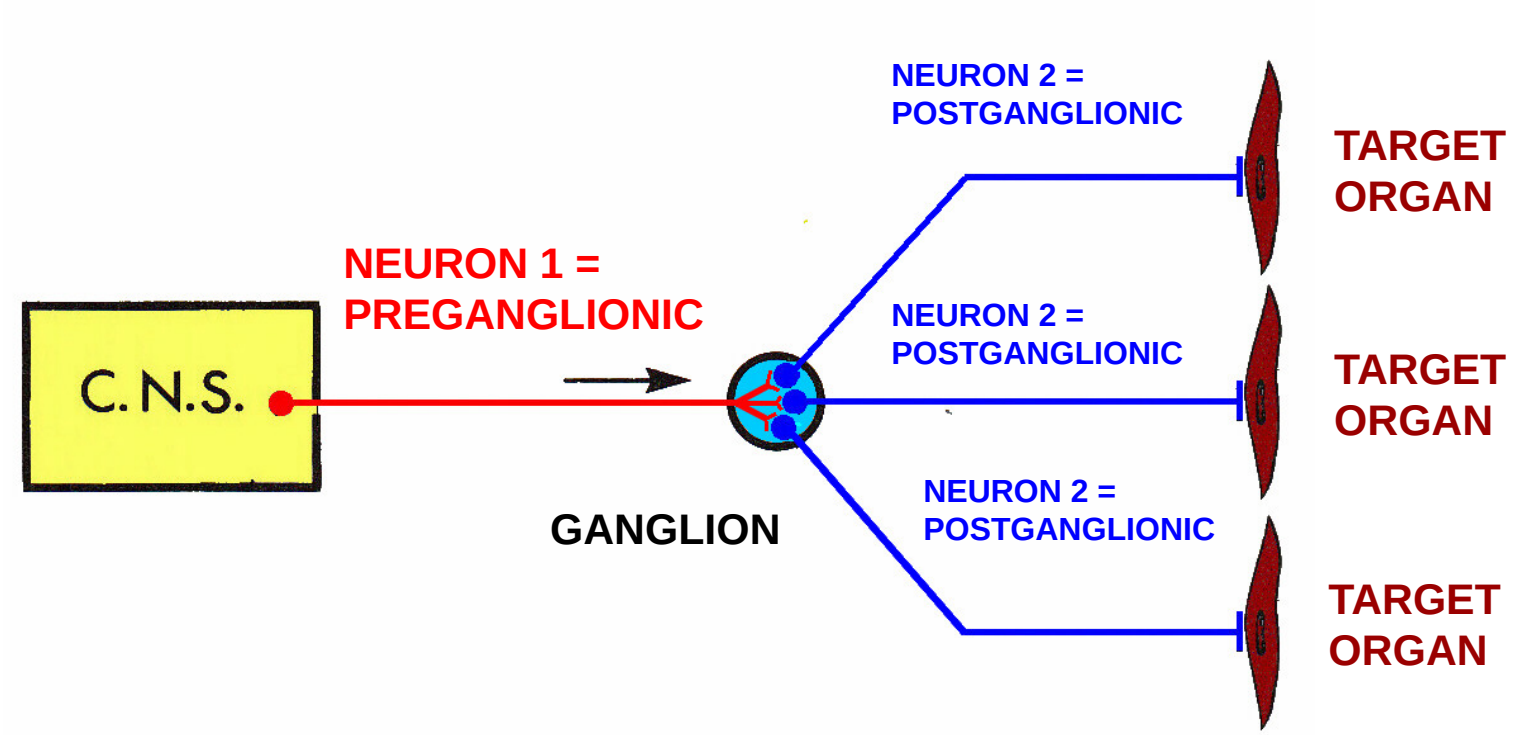
WHY?

DIVERGENCE : AUTONOMICS CAN ACTIVATE MANY TARGETS SIMULTANEOUSLY



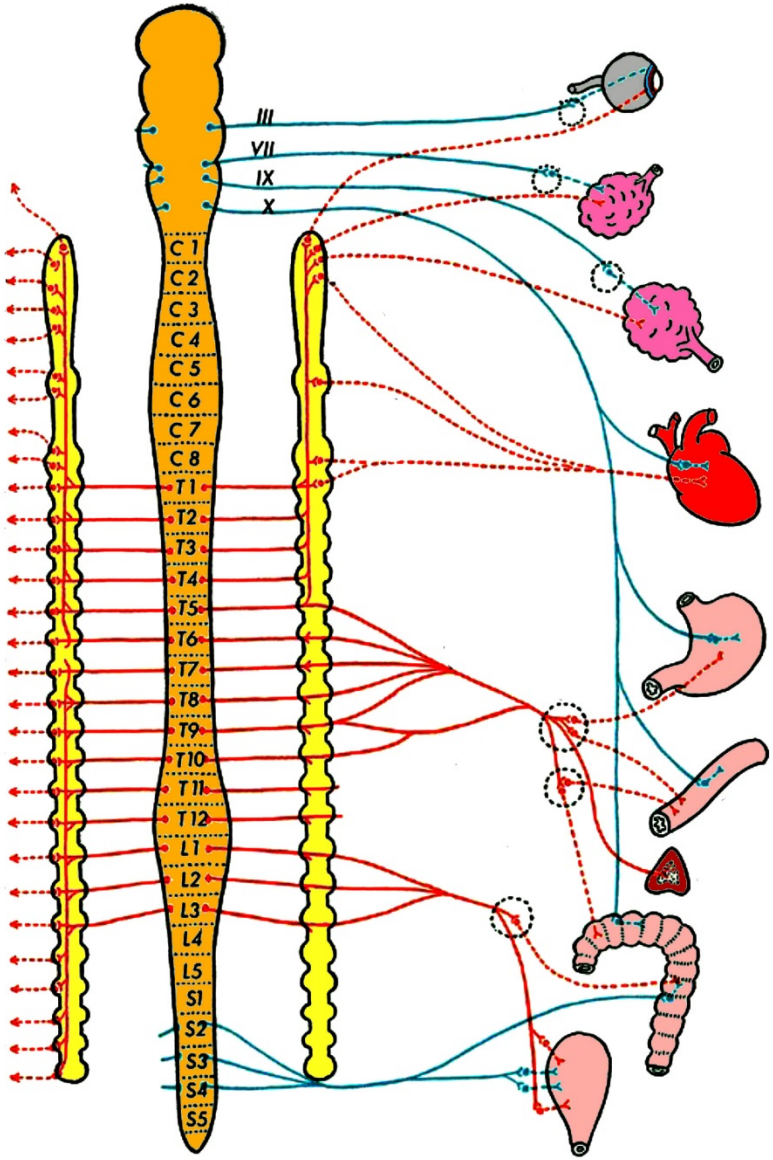
Considerable divergence of signal - One Pre-ganglionic neuron usually activates many (15 - 200) Post-ganglionic neurons; Autonomics can activate many targets simultaneously (ex. Thermoregulation - many sweat glands secrete at the same time)

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	SYMPATHETIC - 'FIGHT OR FLIGHT'	PARASYMPATHETIC - REST AND DIGEST
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

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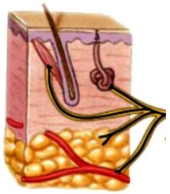
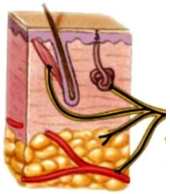
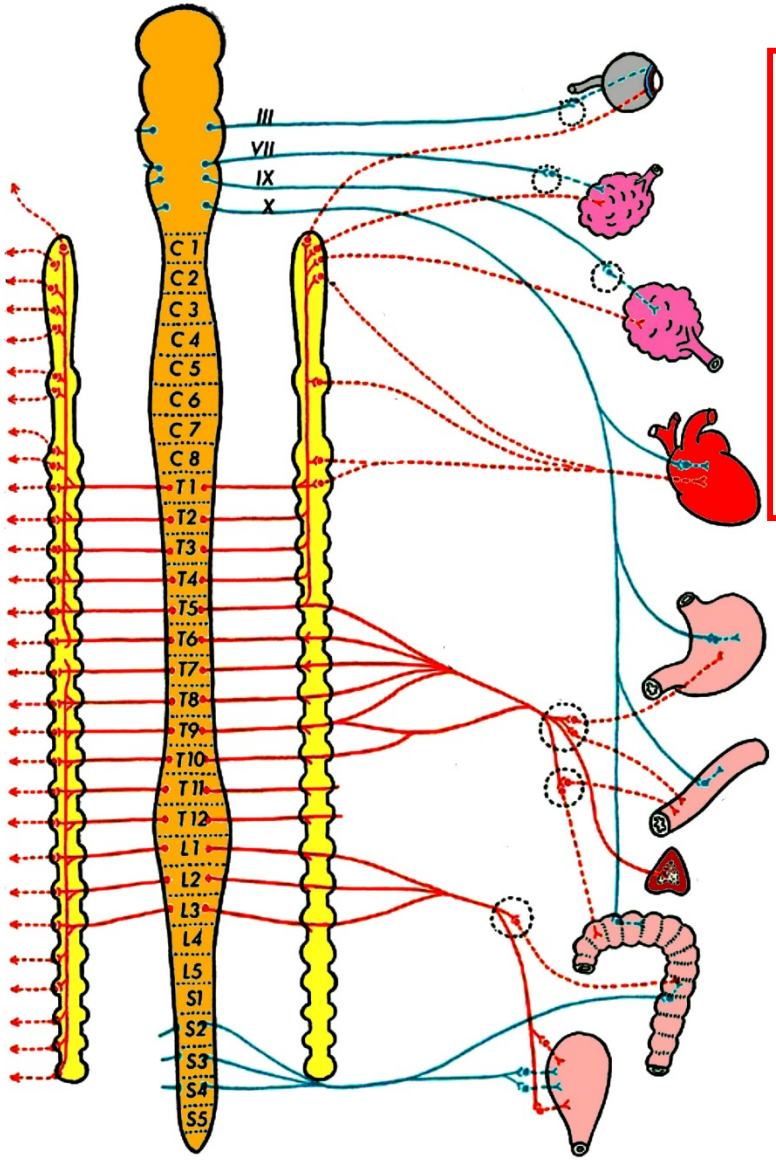


SKIN

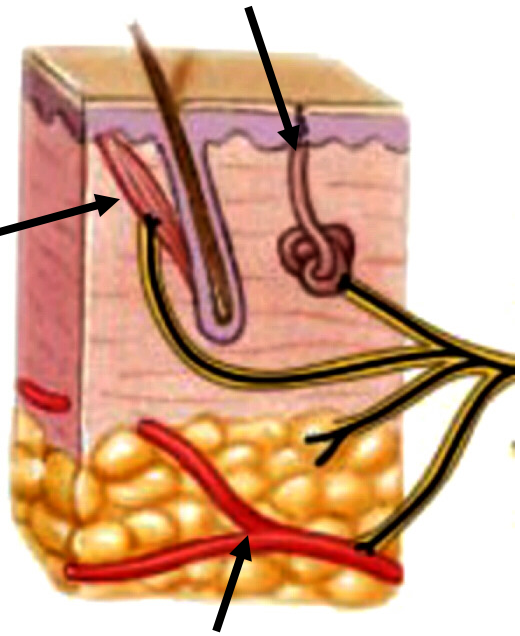




PARA-SYMPATHETICS

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

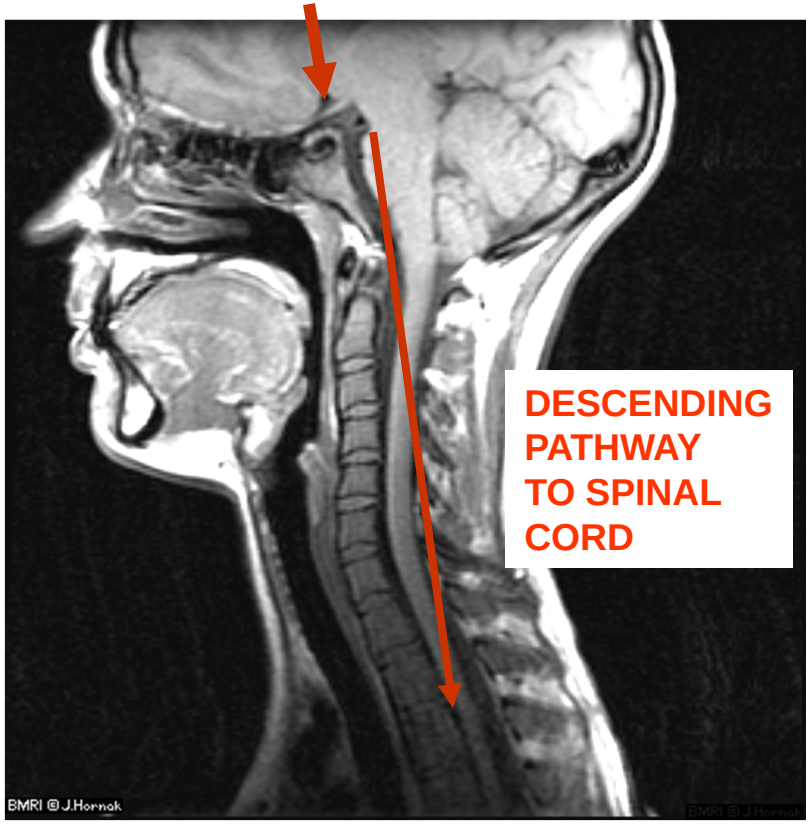
Consequence; SYMPATHETICS ARE ANATOMICALLY MUCH MORE WIDESPREAD THAN PARA-SYMPATHETICS; PATHWAYS MORE COMPLEX

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)

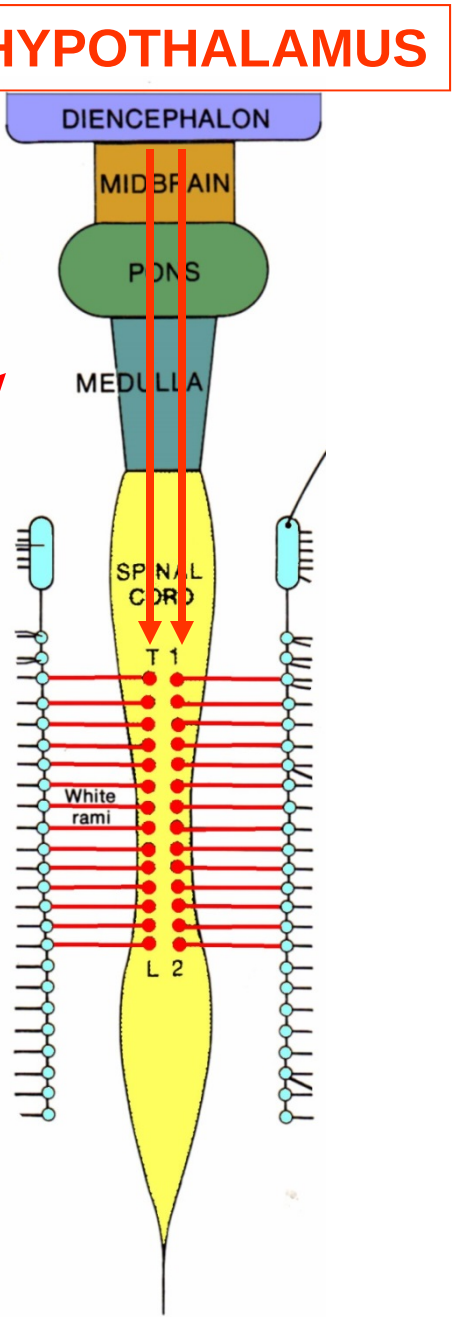
RESPONSES TO INCREASED TEMPERATURE (Anterior Hypothalamus/Preoptic area)

- 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



HYPOTHALMUS: CONTROL OF SYMPATHETIC FUNCTION

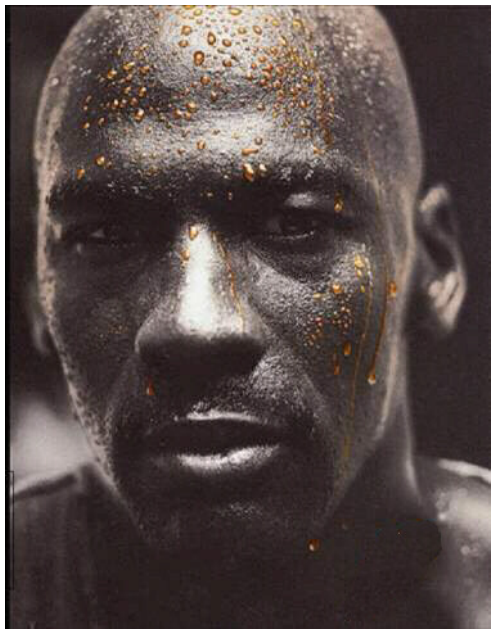
Hypothalamo-spinal tract - descending signals to Pre-ganglionic neurons in Spinal Cord

Sympathetic outflow at Thoracic and Lumbar levels

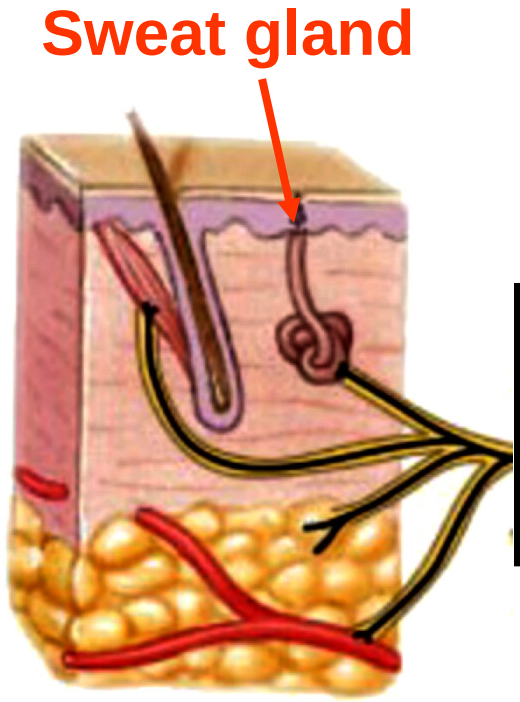
MEDIATED BY SYMPATHETICS

SOME REGULATORY PROCESS REQUIRE WIDESPREAD ACTIVATION OF TARGET ORGANS

EXAMPLE: THERMOREGULATION



Michael Jordan sweating Gatorade ($)

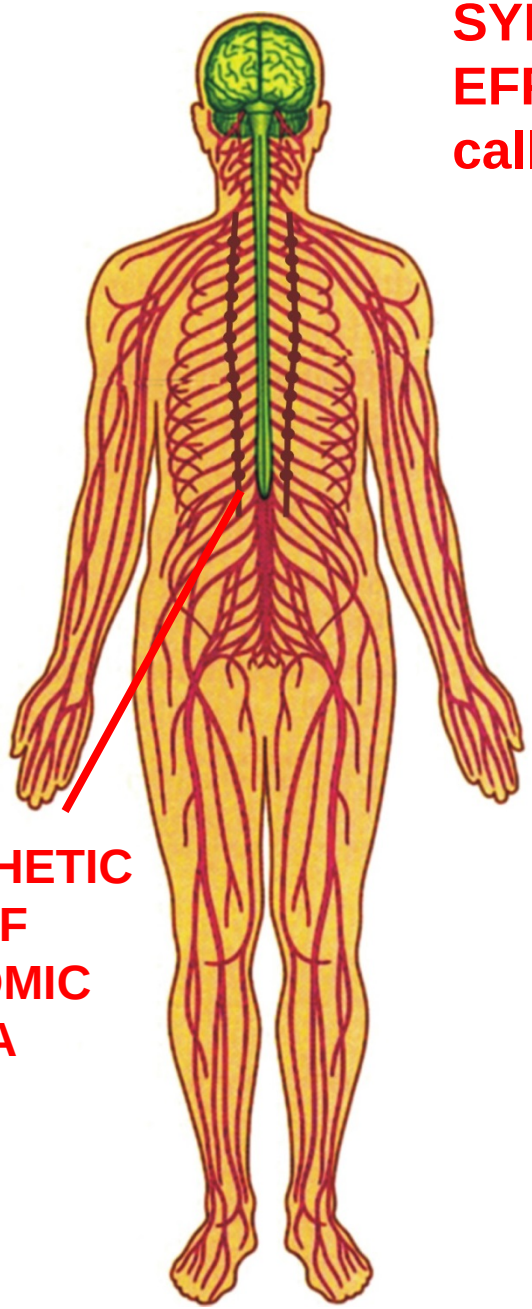


RESPONSE TO CHANGES IN BODY TEMPERATURE MEDIATED BY SYMPATHETICS (NOT PARASYMPATHETICS)

INCREASED TEMPERATURE
- increased secretion of sweat glands

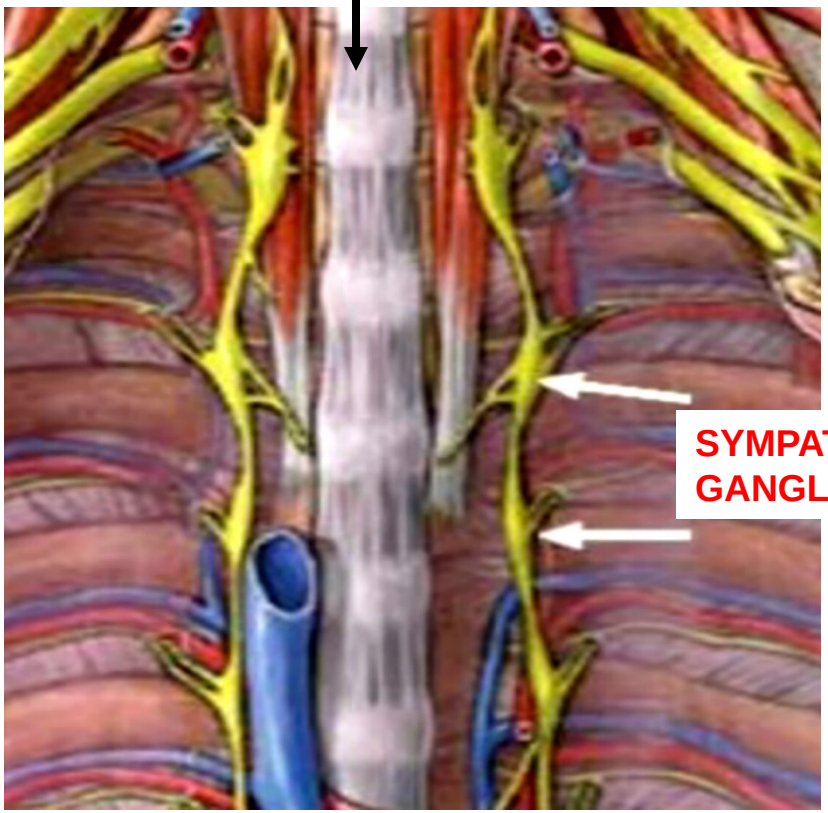
There are over 2 million sweat glands in the human body; how does the Nervous system activate them simultaneously?

SYMPATHETICS HAVE WIDESPREAD EFFECTS BY SYMPATHETIC CHAIN - called Paravertebral Ganglia



SYMPATHETIC CHAIN OF AUTONOMIC GANGLIA

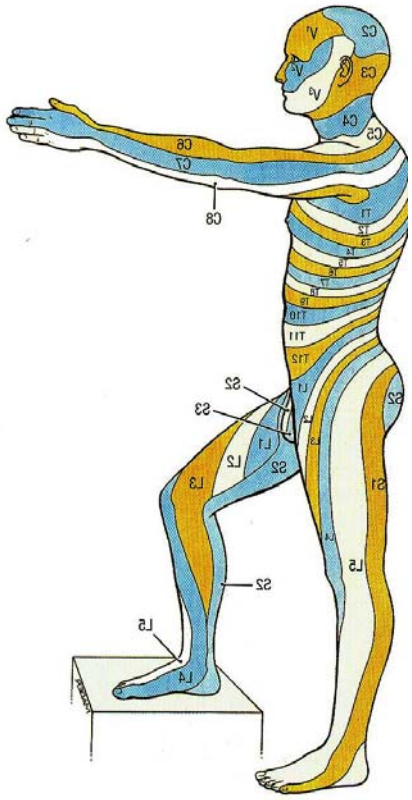
Bodies of Thoracic Vertebrae (anterior side)



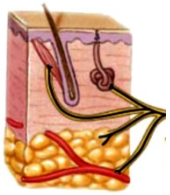
View of the anterior side (front) of vertebrae inside the thorax (chest cavity); chain of ganglia are on sides of vertebrae (paravertebral)

SYMPATHETICS ARE DISTRIBUTED WITH PERIPHERAL NERVES

PATHWAYS TO SKIN



SKIN



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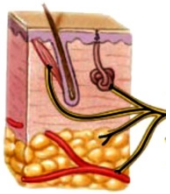
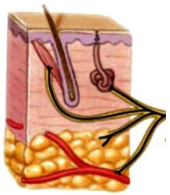
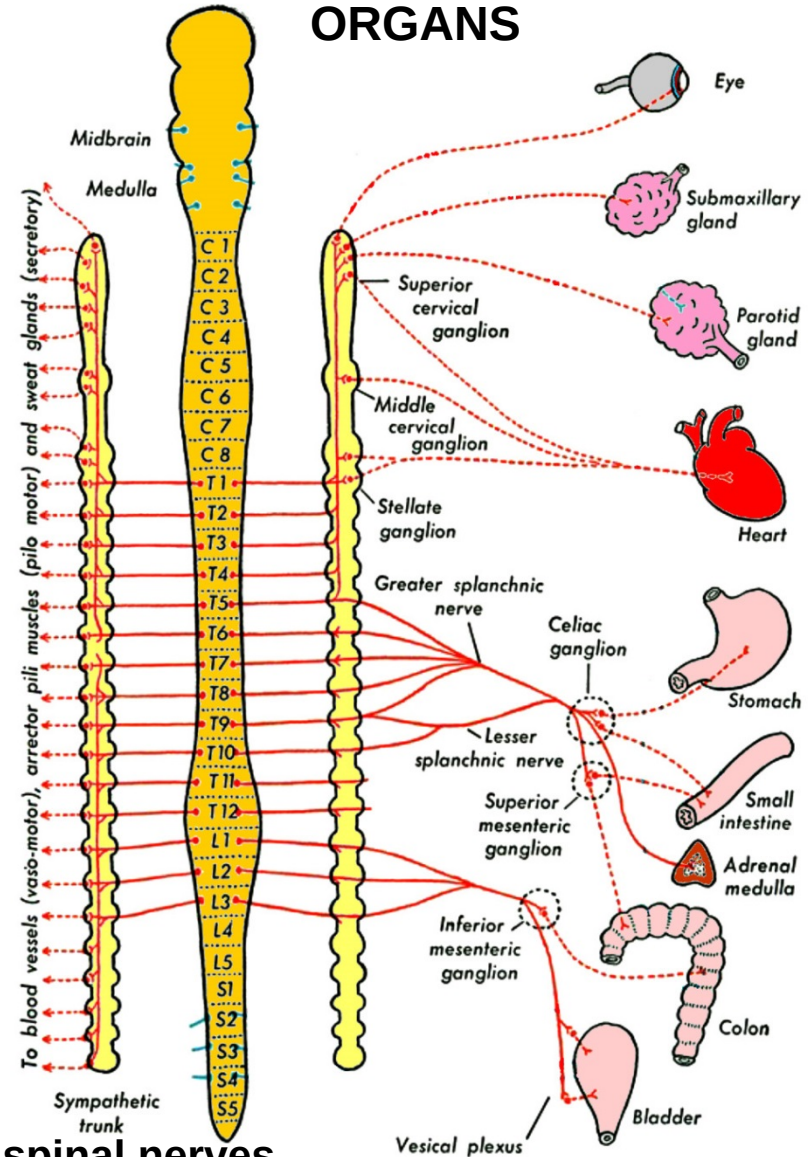


SKIN



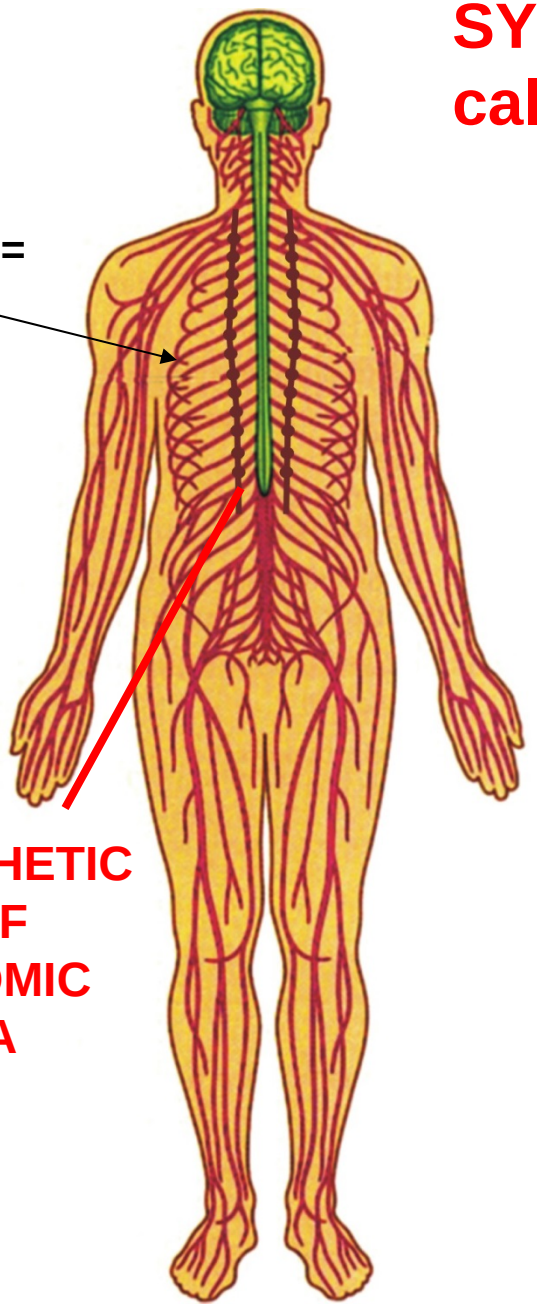
PATHWAYS TO INTERNAL ORGANS



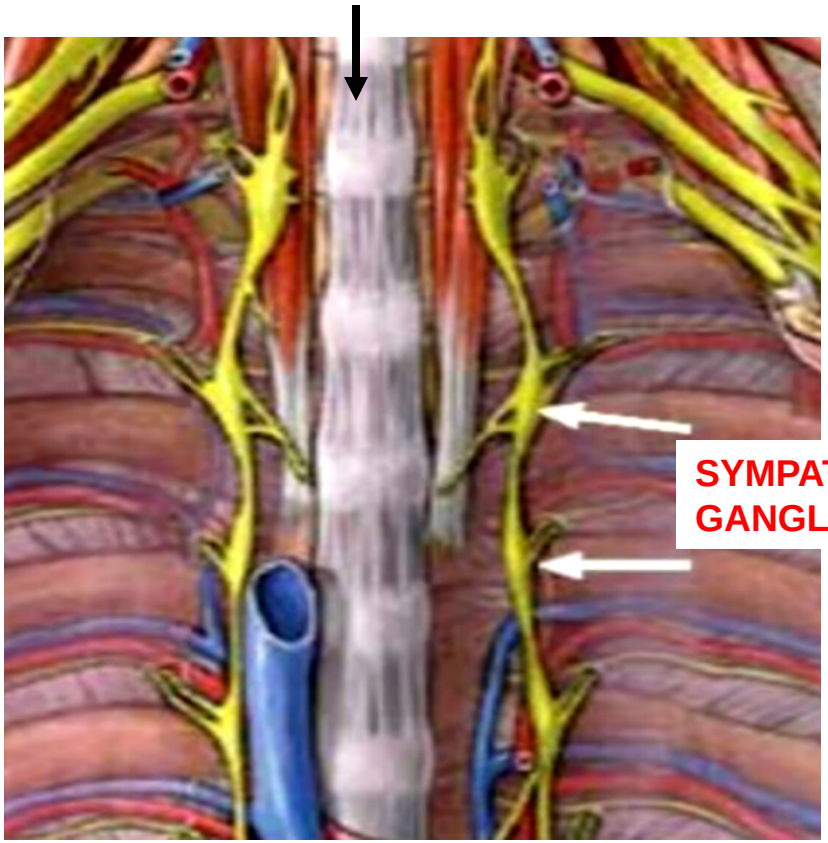
PATHWAYS TO SKIN

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

SYMPATHETIC CHAIN OF GANGLIA - called Paravertebral Ganglia

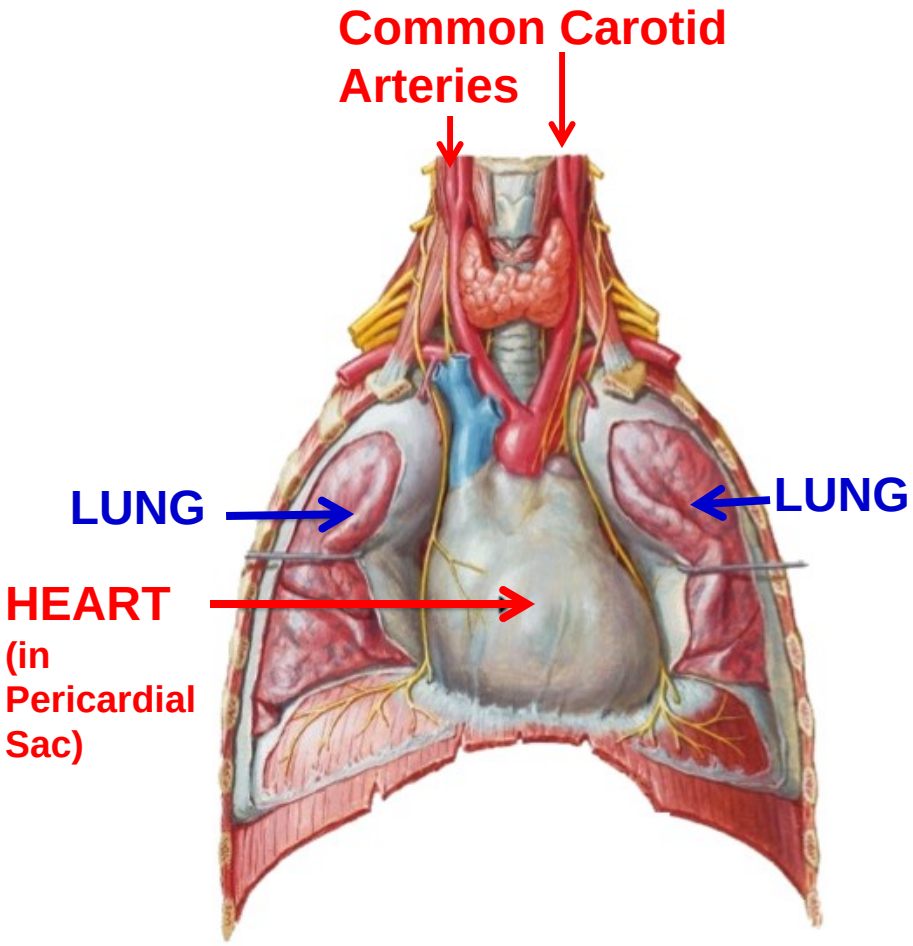


Bodies of Thoracic Vertebrae (anterior side)

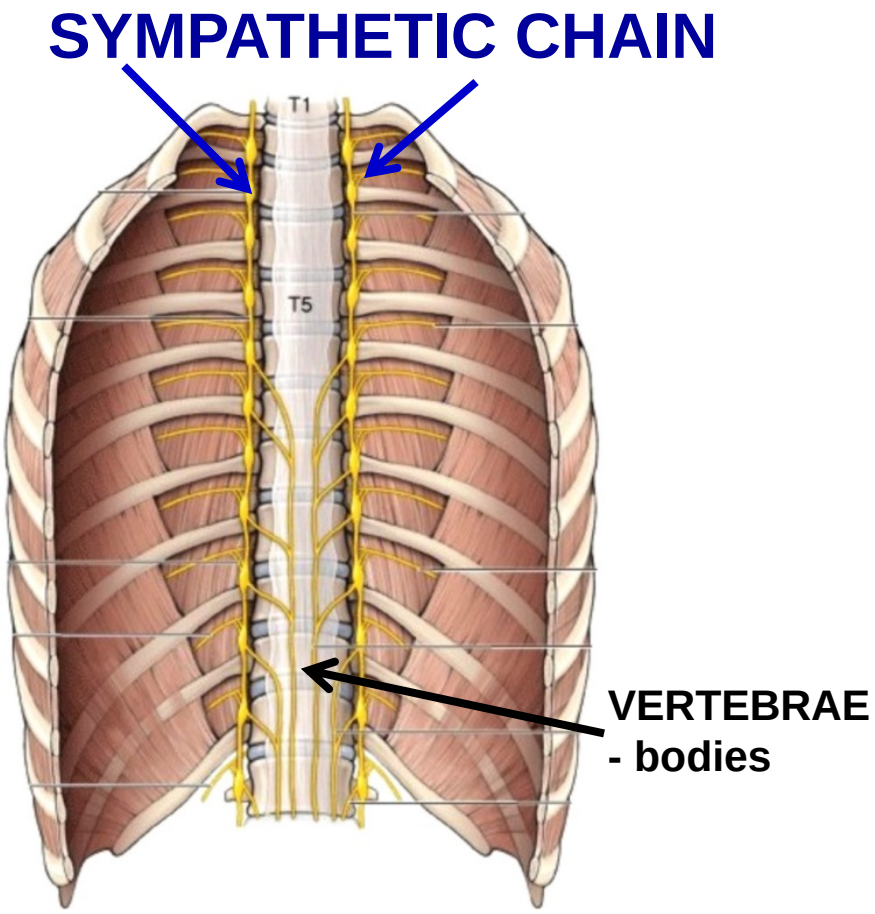


View of the anterior side (front) of vertebrae inside the thorax (chest cavity); chain of ganglia are on sides of vertebrae (paravertebral)

LOCATION OF SYMPATHETIC CHAIN



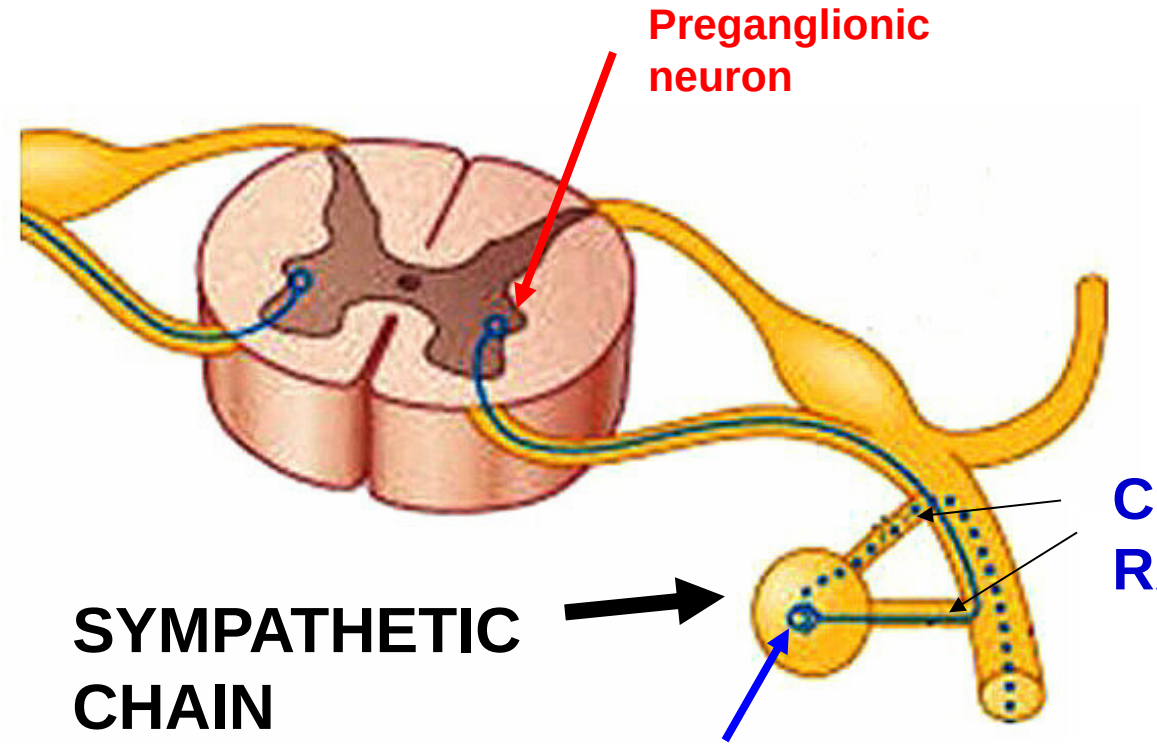
THORAX DISSECTION - remove ribs from anterior wall; see Heart and Lungs



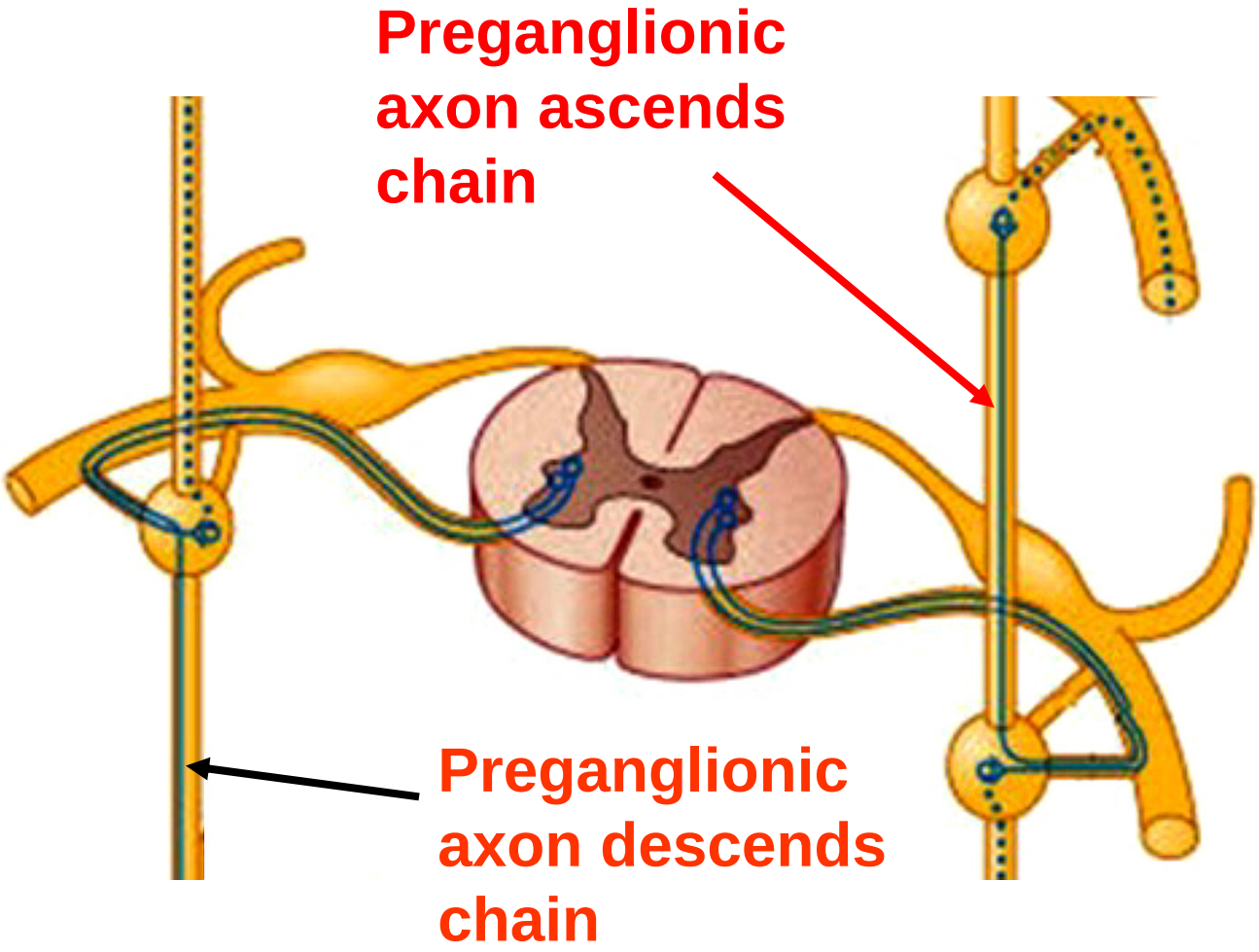
REMOVE HEART AND LUNGS - Thorax is hollow; Vertebral bodies on posterior wall; Sympathic chain on sides of vertebral bodies

II. ANATOMICAL ORGANIZATION SYMPATHETIC OUTFLOW OCCURS BY THREE PATHWAYS

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

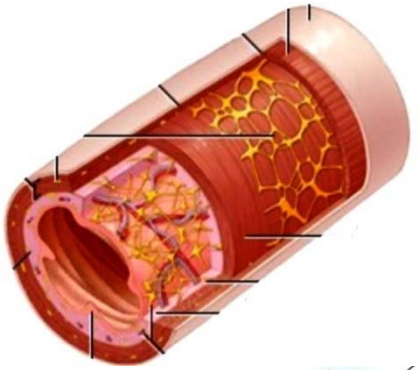


2) SYMPATHETICS ASCEND OR DESCEND SYMPATHETIC CHAIN TO TERMINATE IN OTHER GANGLIA

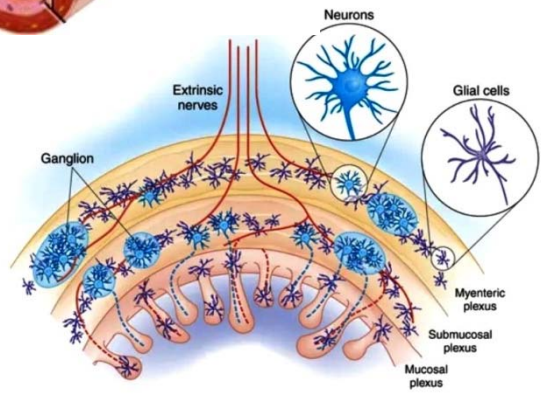


3) SYMPATHETICS LEAVE CHAIN WITHOUT SYNAPSING; FORM NERVES CALLED SPLANCHNIC NERVES - SYNAPSE IN PRE-AORTIC GANGLIA

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

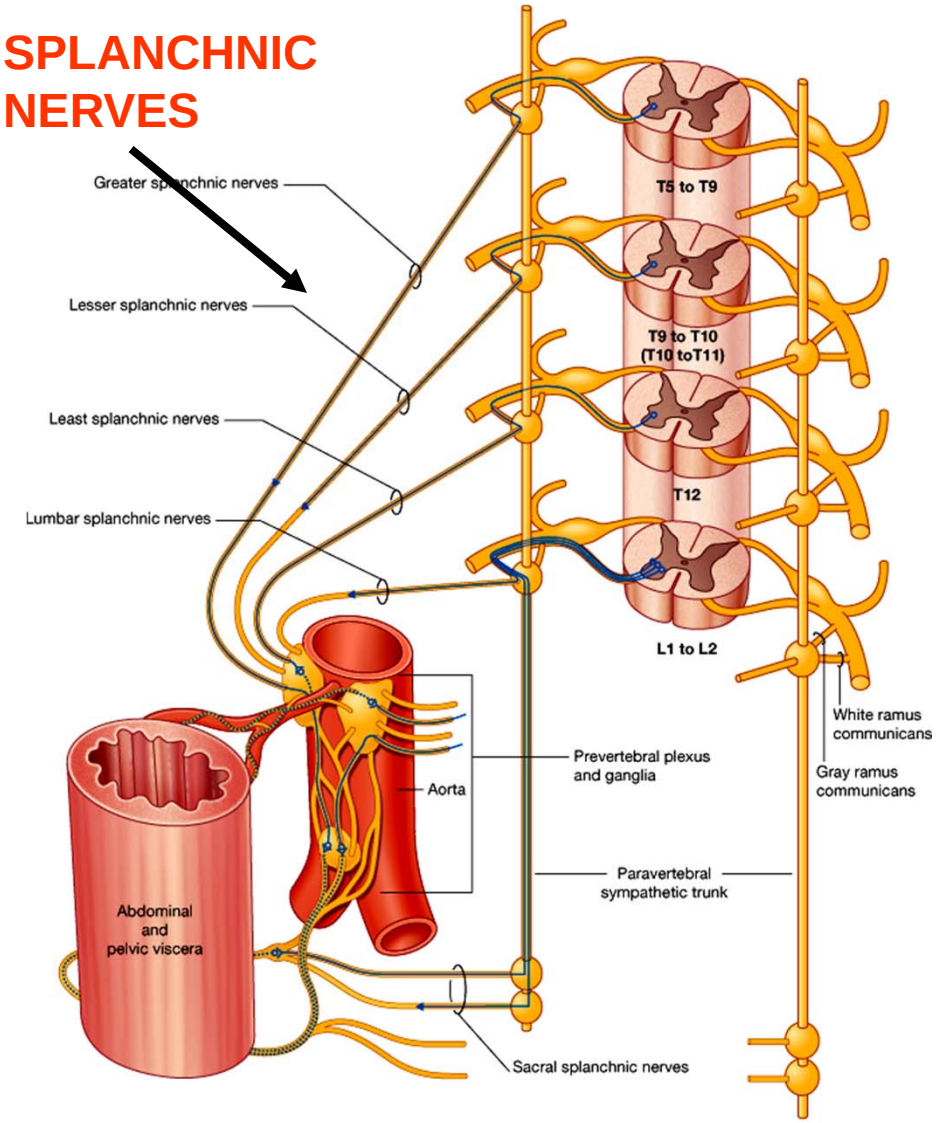


GUT - ENTERIC NERVOUS SYSTEM

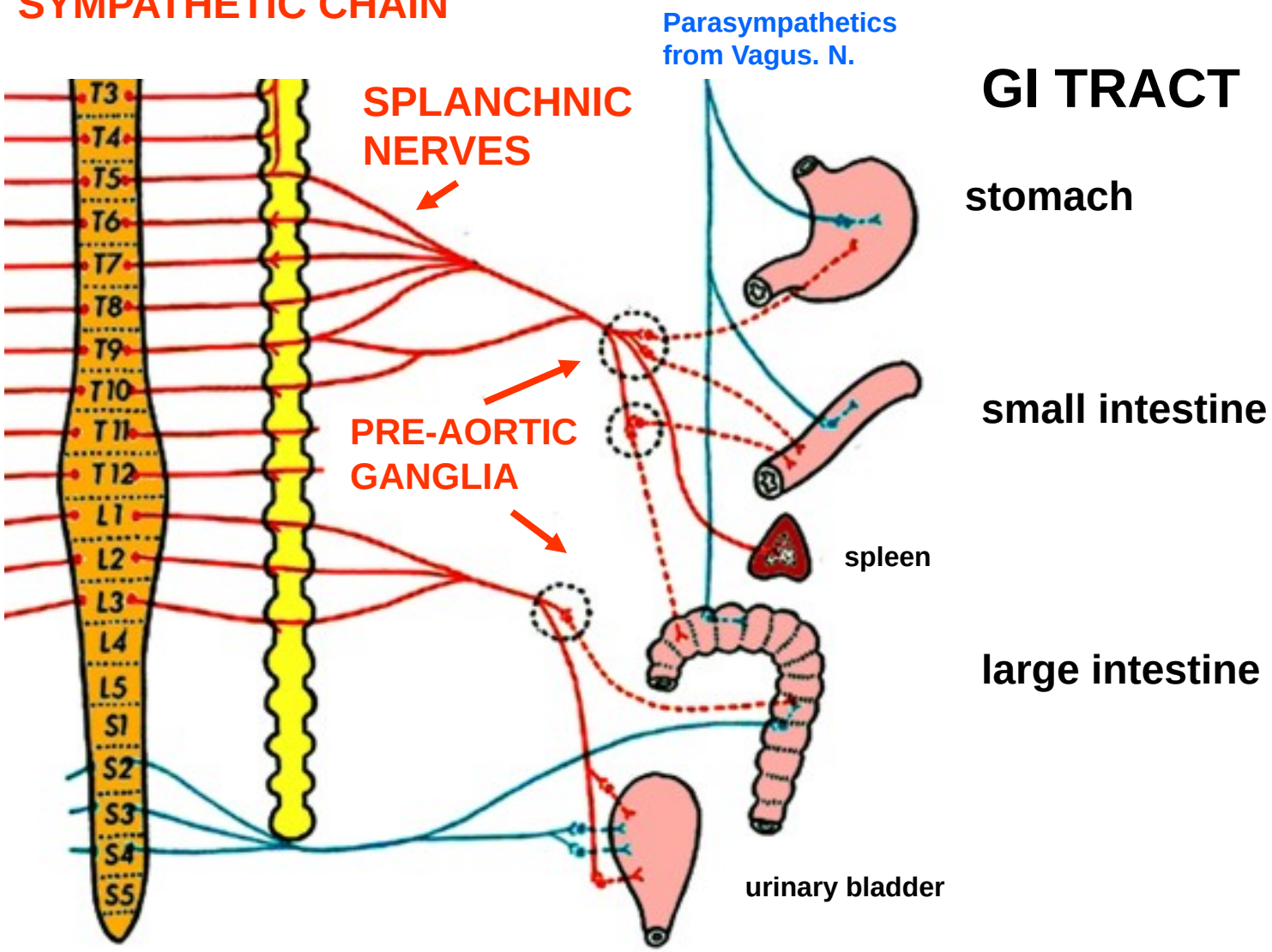


RECENT RESEARCH - INTERACTION BETWEEN IMMUNE SYSTEM AND NERVOUS SYSTEM: Rescigno, Nature 2008

SPLANCHNIC NERVES

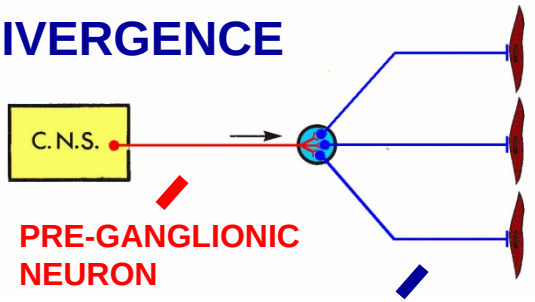


SPLANCHIC NERVES: SYMPATHETICS TO INTERNAL ORGANS IN ABDOMEN, PELVIS - COVERED IN SPRING



FUNCTION OF COMPLEXITY, 2 NEURON ARC: DIVERGENCE

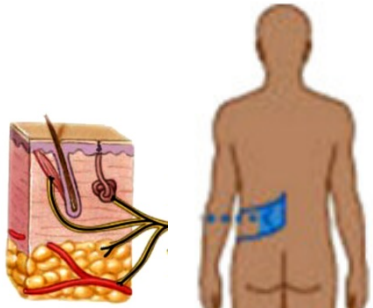
ONE PRE-GANGLIONIC NEURON ACTIVATES MANY POST-GANGLIONIC NEURONS

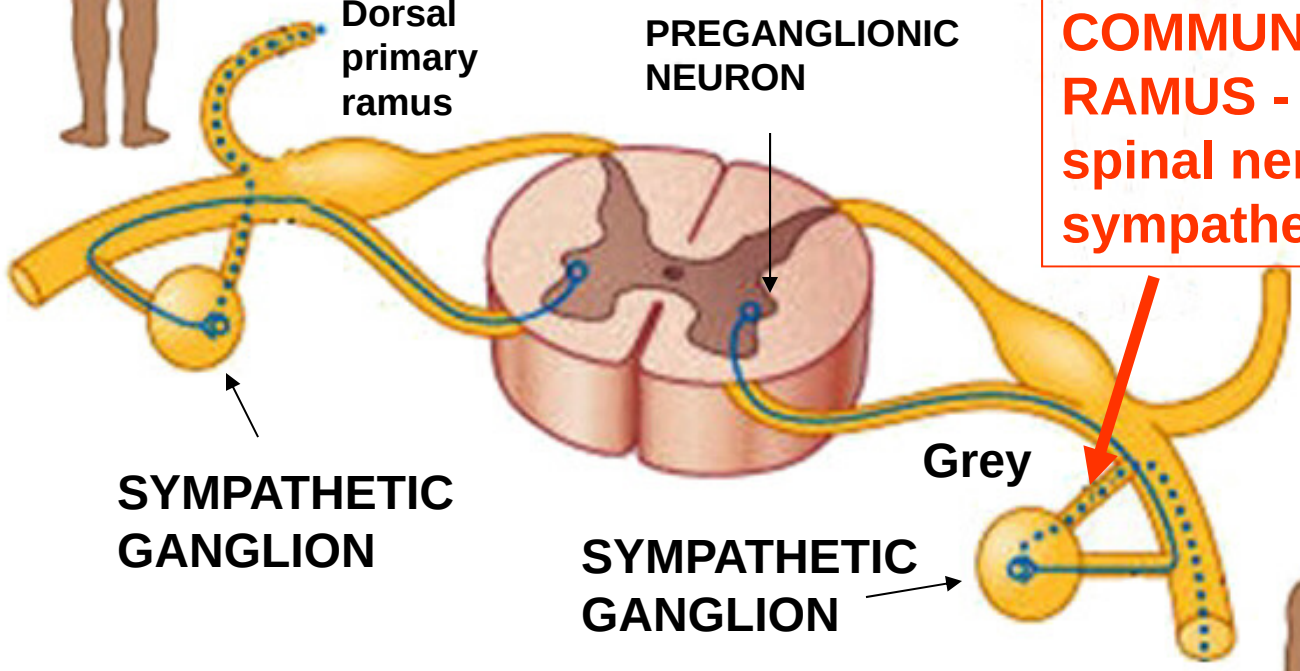


MIDNIGHT RIDE OF PAUL REVERE - 'British are coming, British are coming....'

SYMPATHETICS GET TO SKIN: BY TWO OF THE PATHWAYS

1) SYMPATHETICS IN THORAX EXIT AND CAN SYNAPSE IN THE GANGLION AT THAT LEVEL

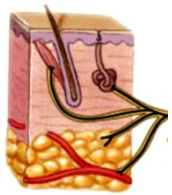




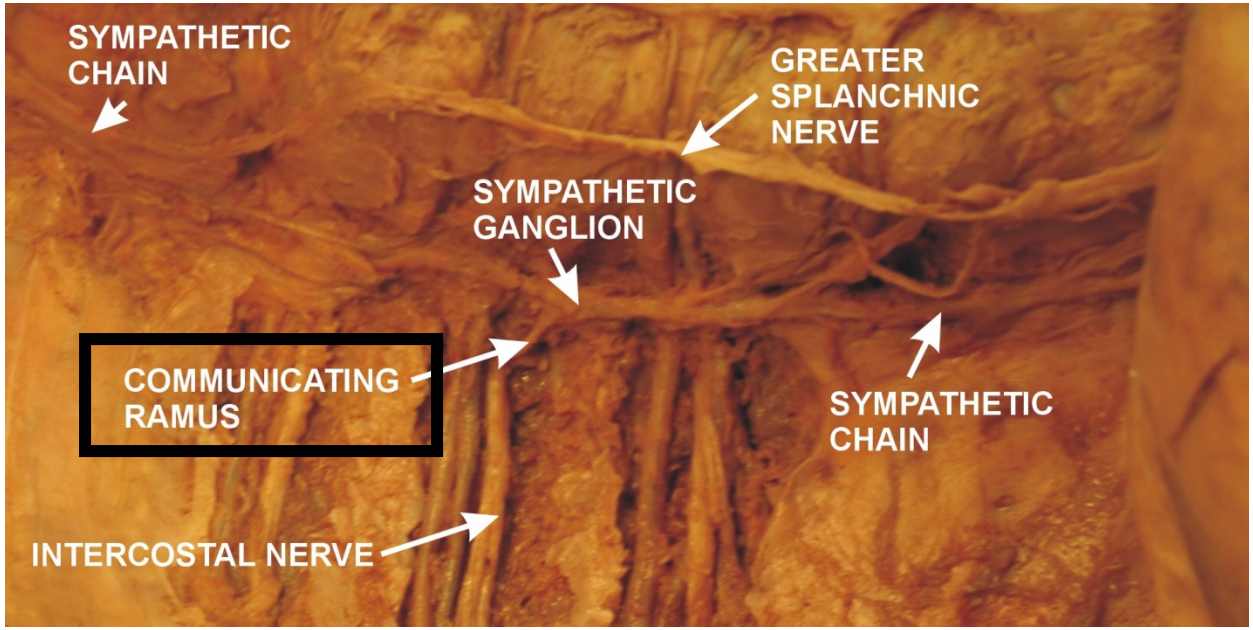
COMMUNICATING RAMUS - connects spinal nerve and sympathetic ganglion

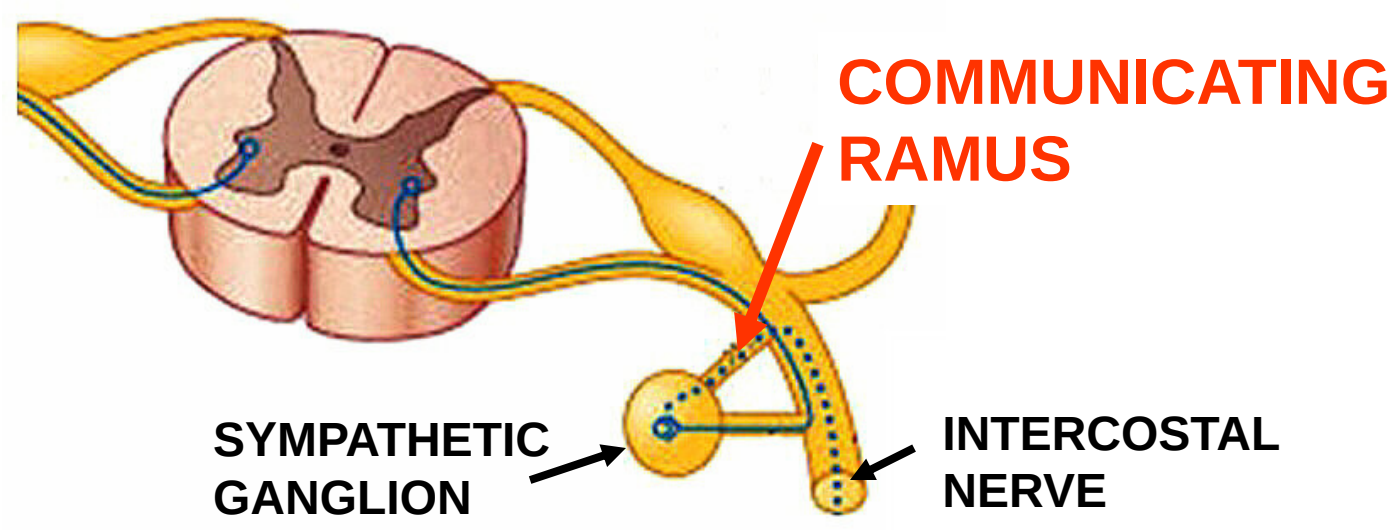
IN THORAX, POST-GANGLIONIC NEURONS THEN JOIN INTERCOSTAL NERVES; DISTRIBUTED TO SKIN

INTERCOSTAL NERVE TO SKIN OF THORAX

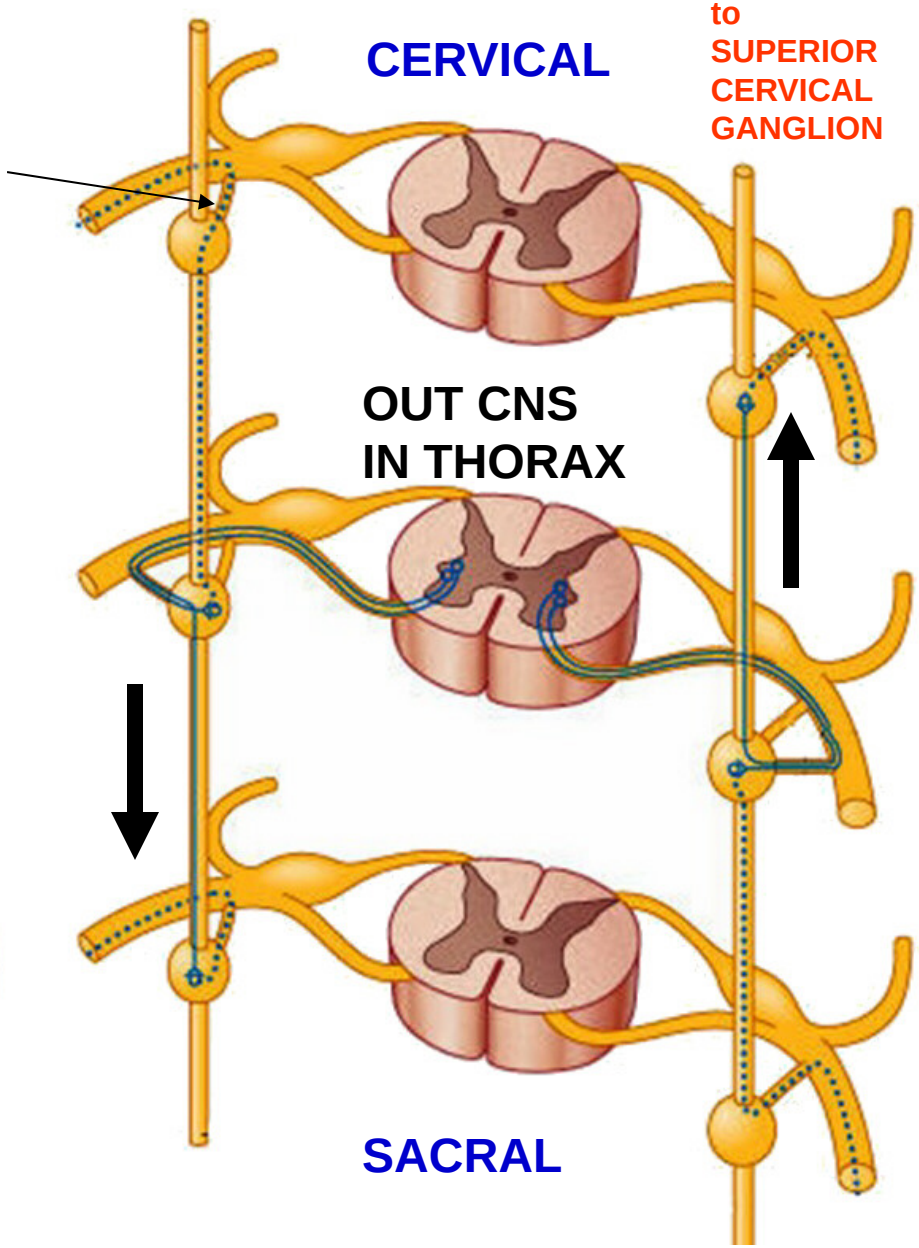


Ventral primary ramus

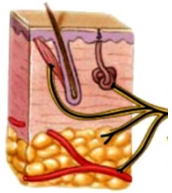

SYMPATHETIC CHAIN
GREATER SPLANCHNIC NERVE
SYMPATHETIC GANGLION
COMMUNICATING RAMUS
SYMPATHETIC CHAIN
INTERCOSTAL NERVE

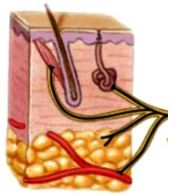

COMMUNICATING RAMUS
SYMPATHETIC GANGLION
INTERCOSTAL NERVE

2) SYMPATHETICS TO SKIN - IN THORAX CAN COME OUT AND ASCEND OR DESCEND CHAIN OF GANGLIA



SYMPATHETICS TO SKIN, BLOOD VESSELS BELOW L3





EX. join nerves of Brachial Plexus to Skin of Arm, Hand

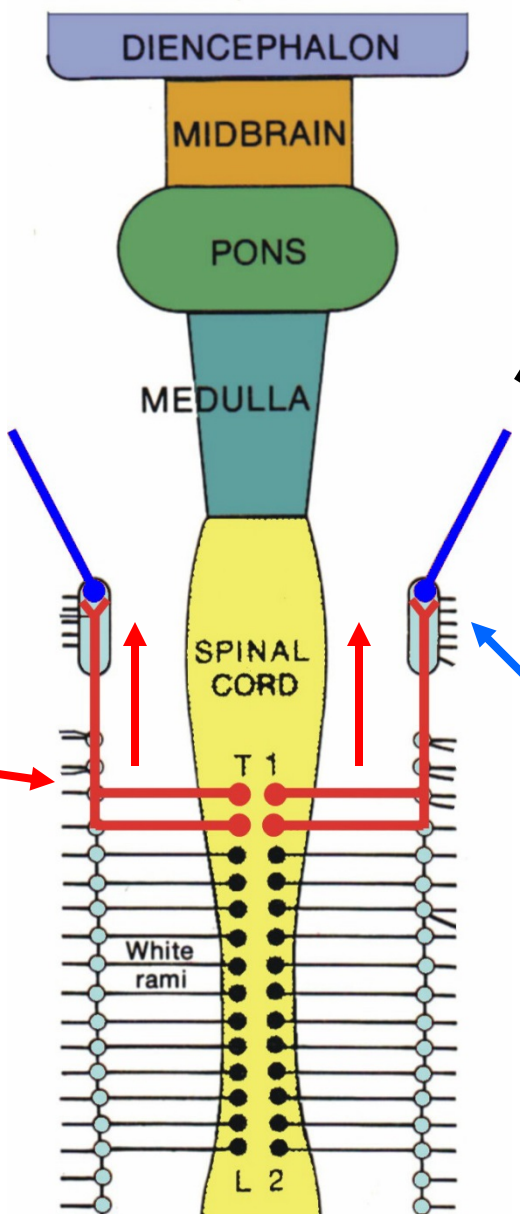
SYMPATHETICS TO SKIN, BLOOD VESSELS ABOVE T1

SYMPATHETICS TO HEAD

PATHWAY TO HEAD -

1) Neuron 1 (Preganglionic neuron) in spinal cord at T1, T2

- leaves and ascends sympathetic chain



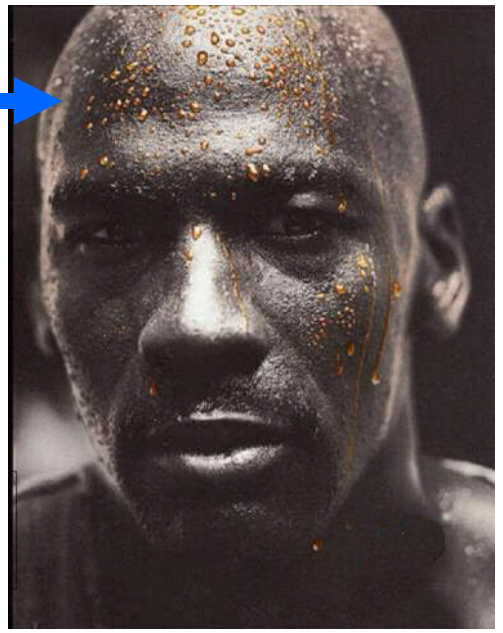
to Target Organ

Joins Plexus on Internal and External Carotid Arteries in mostly Unnamed branches

2) Neuron 2 (Postganglionic neuron) In Superior Cervical Ganglia

SYMPATHETICS TO SKIN OF HEAD

INTERNAL CAROTID PLEXUS



2) PRE-GANGLIONIC AXONS ASCEND CHAIN AND SYNAPSE IN SUPERIOR CERVICAL GANGLION

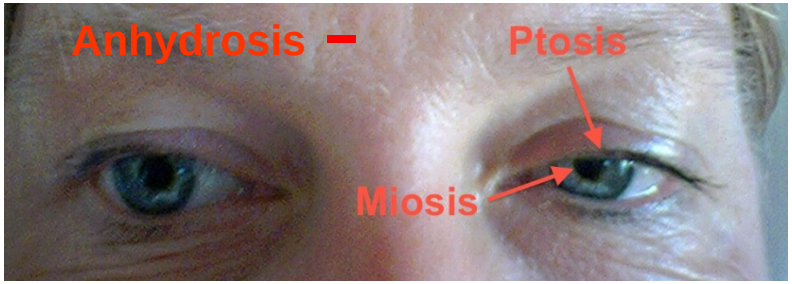
1) OUT T1, T2

3) POST-GANGLIONIC FIBERS JOIN PLEXUS ON INTERNAL CAROTID ARTERY

4) POST-GANGLIONIC FIBERS END IN SKIN OF FACE; MICHAEL JORDAN SWEATS

LESIONS OF SYMPATHETICS PRODUCE SYMPTOMS IN EYE: HORNER'S SYNDROME

HORNER'S SYNDROME

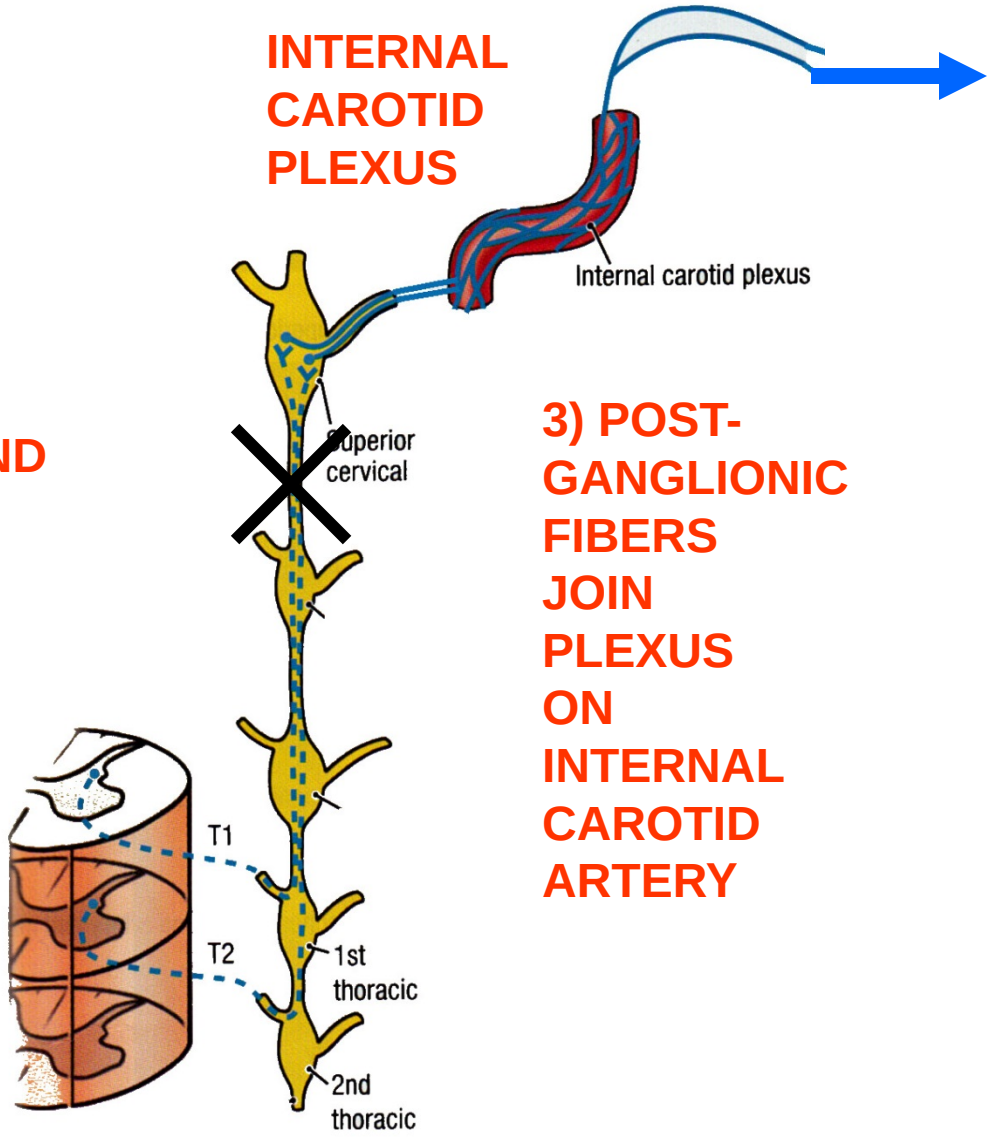


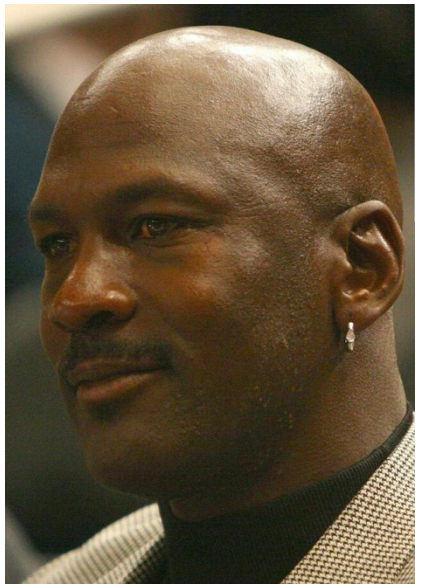
HORNER'S SYNDROME - damage to Sympathetic pathways: symptoms involve structures of eye and head -

SYMPTOMS -
MIOSIS - pupillary constriction
PTOSIS - drooping eyelid
ANHYDROSIS - lack of sweating

1) ANHYDROSIS - LESION TO SYMPATHETICS BLOCKS SWEATING

INTERNAL CAROTID PLEXUS





2) PRE-GANGLIONIC AXONS ASCEND CHAIN AND SYNAPSE IN SUPERIOR CERVICAL GANGLION

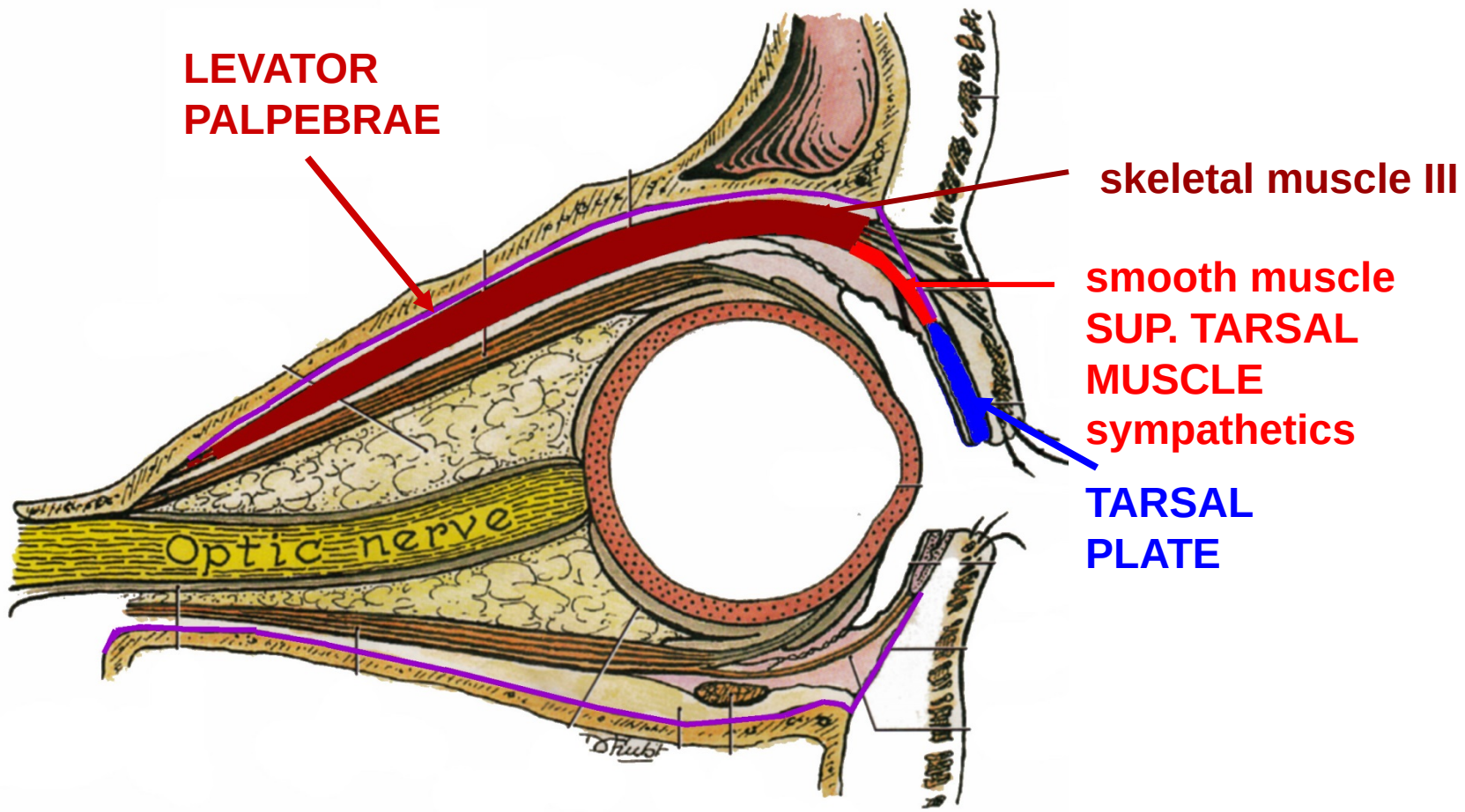
3) POST-GANGLIONIC FIBERS JOIN PLEXUS ON INTERNAL CAROTID ARTERY

LACK OF SWEATING = ANHYDROSIS

1) OUT T1, T2

CAN LESION SYMPATHETIC CHAIN (EX. PANCOST TUMOR OF LUNG)

2) PTOSIS: MUSCLE OF EYELID: LEVATOR PALPEBRAE SUPERIORIS

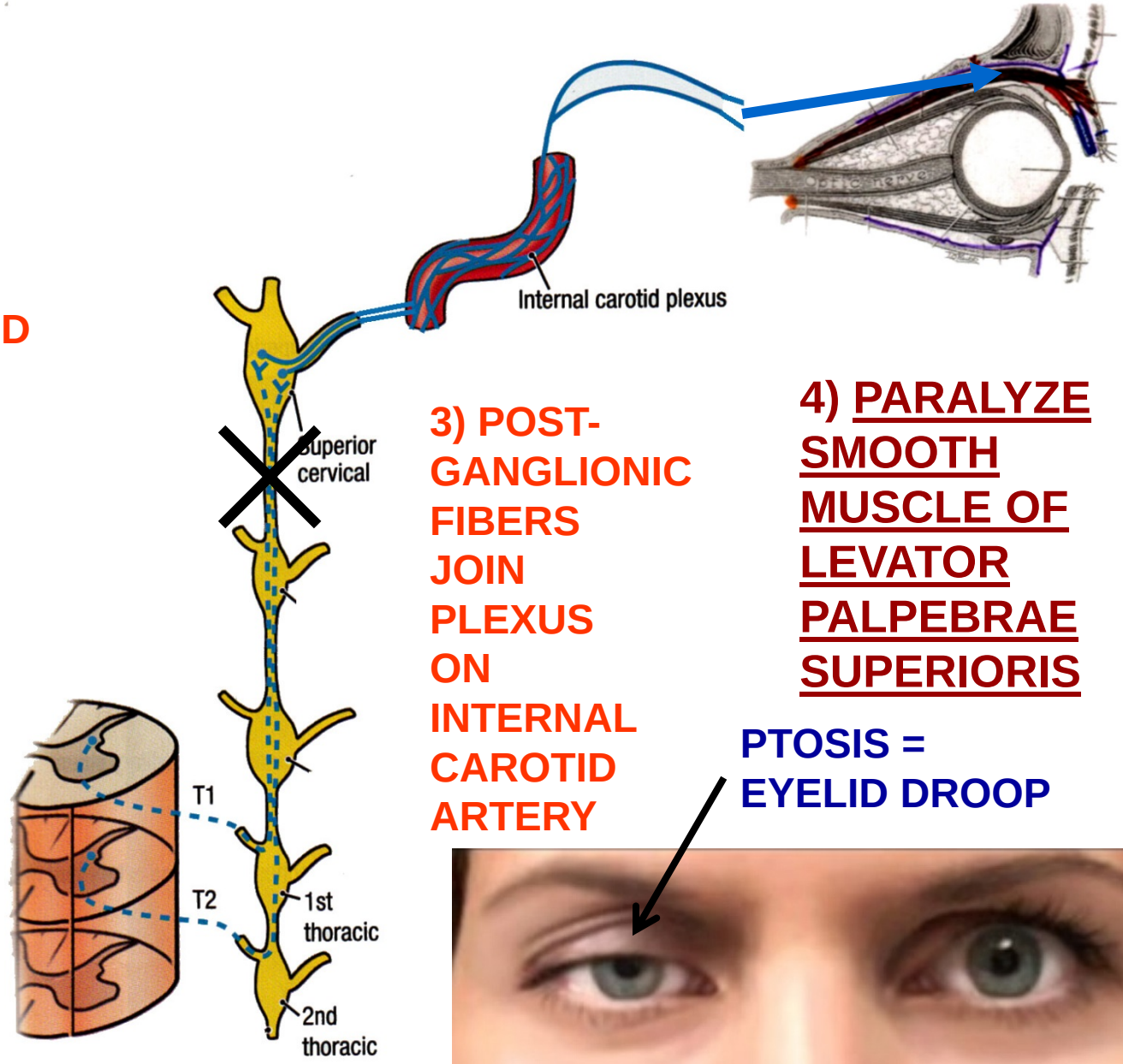


LEVATOR PALPEBRAE SUPERIORIS MUSCLE - ORIGIN FROM TENDINOUS RING - COMPOSED OF SKELETAL (CN III) & SMOOTH (SYMPATHETICS) MUSCLE PARTS

DAMAGE INNERVATION PTOSIS = DROOPING EYELID

2) PTOSIS - DAMAGE PATHWAY OF SYMPATHETICS TO EYE

2) PRE-GANGLIONIC AXONS ASCEND CHAIN AND SYNAPSE IN SUPERIOR CERVICAL GANGLION



1) OUT T1, T2

3) POST-GANGLIONIC FIBERS JOIN PLEXUS ON INTERNAL CAROTID ARTERY

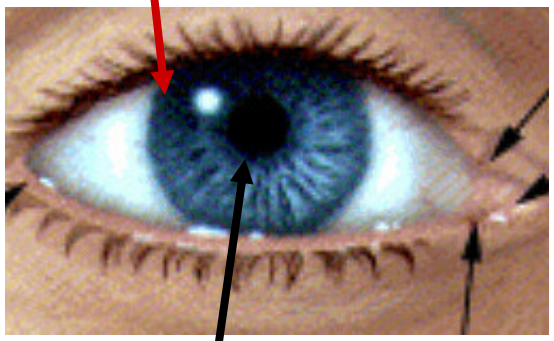
4) PARALYZE SMOOTH MUSCLE OF LEVATOR PALPEBRAE SUPERIORIS

PTOSIS = EYELID DROOP

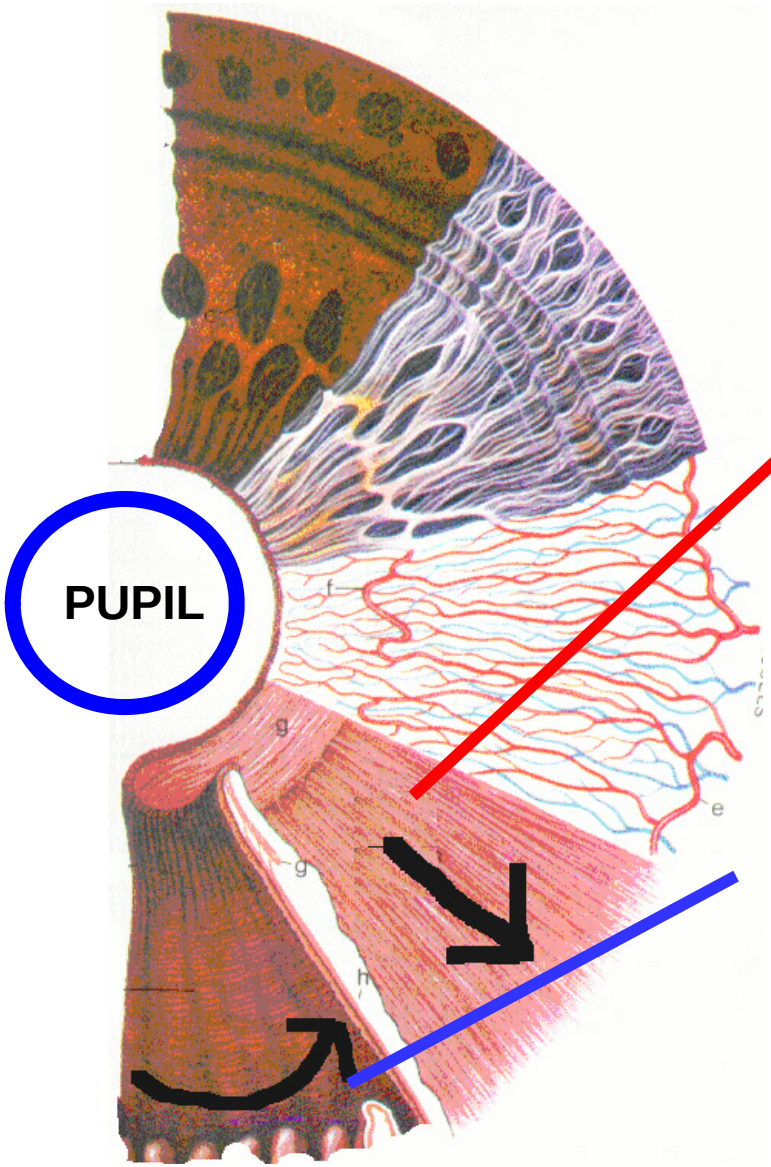
3) MIOSIS - CONSTRICTED PUPIL

IRIS - PIGMENTED, CONTRACTILE LAYER SURROUNDING PUPIL

IRIS - PIGMENTED



PUPIL



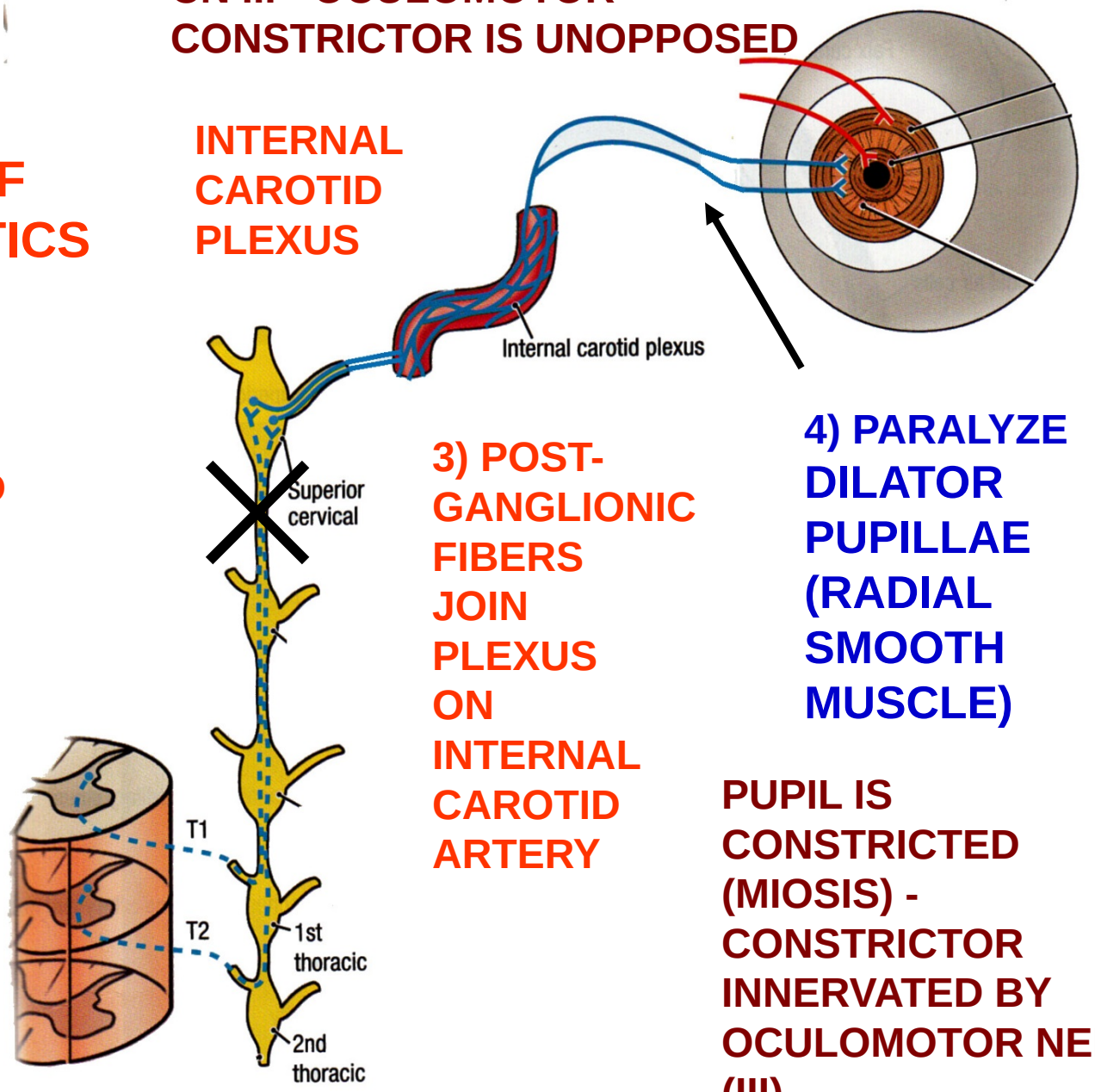
DILATOR PUPIL M.- RADIAL SMOOTH MUSCLE; SYMPA-THETICS

CONSTRICTOR PUPIL M. - CIRCULAR SMOOTH MUSCLE; PARA-SYMPATHETICS III

CN III - OCULOMOTOR CONSTRICTOR IS UNOPPOSED

3) MIOSIS - DAMAGE PATHWAY OF SYMPATHETICS TO EYE

INTERNAL CAROTID PLEXUS



2) PRE-GANGLIONIC AXONS ASCEND CHAIN AND SYNAPSE IN SUPERIOR CERVICAL GANGLION

1) OUT T1, T2

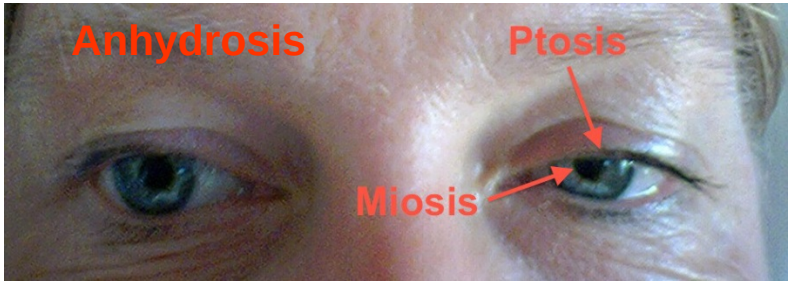
3) POST-GANGLIONIC FIBERS JOIN PLEXUS ON INTERNAL CAROTID ARTERY

4) PARALYZE DILATOR PUPILLAE (RADIAL SMOOTH MUSCLE)

PUPIL IS CONSTRICTED (MIOSIS) - CONSTRICTOR INNERVATED BY OCULOMOTOR NERVE (III)

LESIONS OF SYMPATHETICS PRODUCE SYMPTOMS IN EYE: HORNER'S SYNDROME

HORNER'S SYNDROME



CLINICAL

CAN DAMAGE SYMPATHETIC CHAIN IN NECK; SHOW SYMPTOMS IN EYE AND FACE

HORNER'S SYNDROME - damage to Sympathetic pathways: symptoms involve structures of eye and head -

SYMPTOMS -

1) MIOSIS - pupillary constriction;
PARALYSIS OF PUPILLARY DILATOR MUSCLE

2) PTOSIS - drooping eyelid;
PARALYSIS OF SMOOTH MUSCLE PART OF LEVATOR PALPEBRAE SUPERIORIS

3) ANHYDROSIS - lack of sweating;
LOSS OF INNERVATION OF SWEAT GLANDS

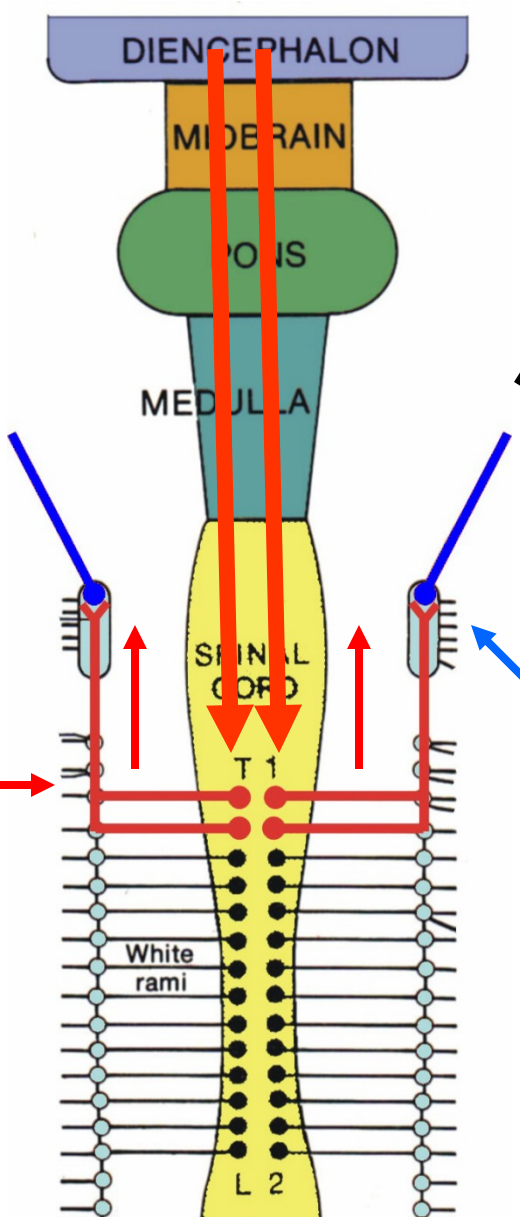
SUMMARY CHART: HORNER'S SYNDROME

Symptom	Structure innervated	Damage
Anhydrosis (lack of sweating)	Sweat glands in skin	lack of sweating in skin (ex. forehead)
Ptosis (eyelid droop)	Levator Palpebrae Superioris - sympathetics to Smooth muscle part	Levator lifts upper eyelid; damage produce eyelid droop
Miosis (constricted pupil)	Pupillary dilator muscle	Damage paralyzes Dilator muscle; pupil is constricted (Constrictor pupillae muscle is intact)

HYPOTHALAMUS

LESIONS CAN OCCUR IN MANY PLACES IN PATHWAY

HYPOTHALAMO-SPINAL TRACT



to Target Organ

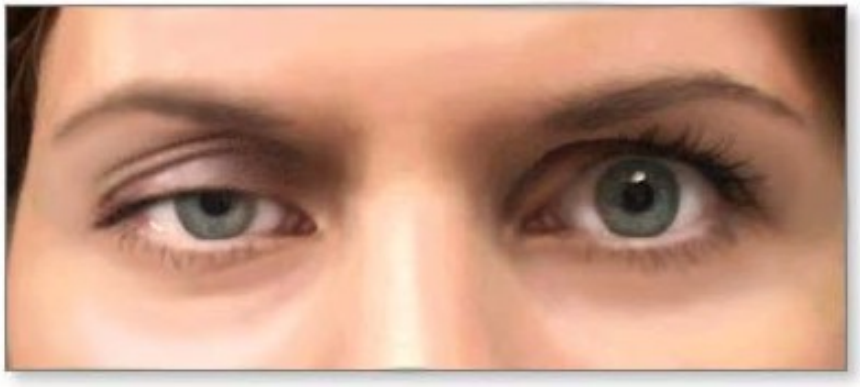
PATHWAY TO HEAD -

1) Neuron 1 (Preganglionic neuron) in spinal cord at T1, T2

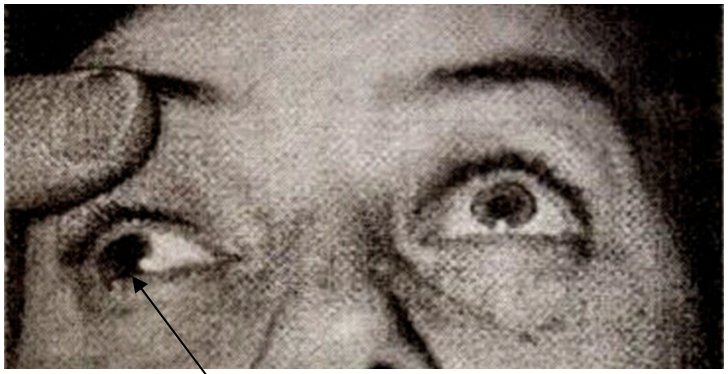
2) Neuron 2 (Postganglionic neuron) In Superior Cervical Ganglia

PTOSIS = DROOPING EYELID; CAN BE SIGN OF DAMAGE TO <u>OCULOMOTOR NERVE (III) OR</u> SYMPATHETICS

Ptosis (drooping of the eyelid)

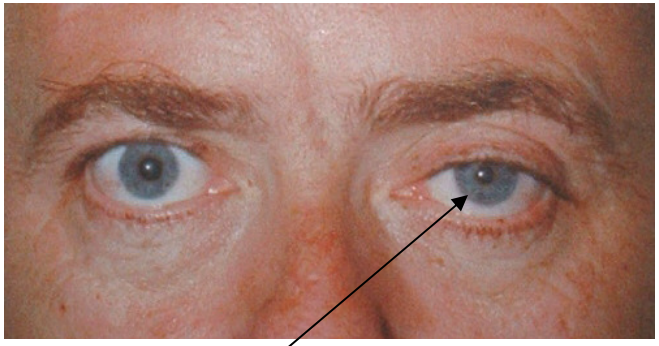


SKELETAL MUSCLE PART



OCULOMOTOR NERVE PALSY
other symptoms:
- <u>Pupil is dilated - denervate Pupillary constrictor (Mydriasis)</u>
- Also affect Eye movements
- Accommodation

SMOOTH MUSCLE PART



SYMPATHETICS - HORNER'S SYNDROME -
- <u>Miosis - denervate Pupillary dilator; constricted pupil</u>
- Anhydrosis - lack of sweating

**

SYMPTOM – EYELID DROOP + CONSTRICTED PUPIL

SUMMARY CHART: HORNER'S SYNDROME VS OCULOMOTOR PALSY **

Structure	Horner's Syndrome	Oculomotor Palsy (nerve damage)
Upper eyelid	Ptosis (eyelid droop) - paralyze Smooth muscle part of Levator Palpebrae Superioris	Ptosis (eyelid droop) - paralyze Skeletal muscle part of Levator Palpebrae Superioris
Pupil of eye	Pupil constricted (Miosis) - Pupillary Dilator muscle paralyzed; Pupillary constrictor muscle intact	Pupil dilated (Mydriasis) - pupilllary constrictor muscle paralyzed; Dilator muscle is intact
Sweat glands in skin	Anhydrosis - lack of sweating in skin (ex. forehead)	No effect (parasympathetics do not innervate skin)

also: Eye movements - affect by Oculomotor Palsy; no effect if damage Sympathetics.