

# SYMPATHETIC DIVISION (1)

CN: This plate is part one of a two-part presentation of the sympathetic division, and many structures with the same titles and subscripts on this and the next plate should receive the same color. (1) Begin with the schematic of the spinal cord segments containing the cell bodies of preganglionic neurons. These neurons (not shown) leave the spinal cord to enter or pass through the sympathetic chain and relations at upper right. (2) Color the sympathetic chain and relations at upper right. (3) Color the pathways of the preganglionic and postganglionic neurons below. (4) Color the inset illustration.

## SPINAL CORD SEGMENTS T1-L2 A

### PREGANGLIONIC CELL BODY<sub>B</sub>

### PREGANGLIONIC AXON<sub>B'</sub>

### WHITE COMM. RAMUS<sub>C+</sub>

### SPLANCHNIC NERVE<sub>D</sub>

### PREVERTEBRAL GANGLION<sub>E</sub>

### SYMPATHETIC CHAIN<sub>F</sub>

### POSTGANGLIONIC CELL BODY<sub>G</sub>

### POSTGANGLIONIC AXON<sub>G'</sub>

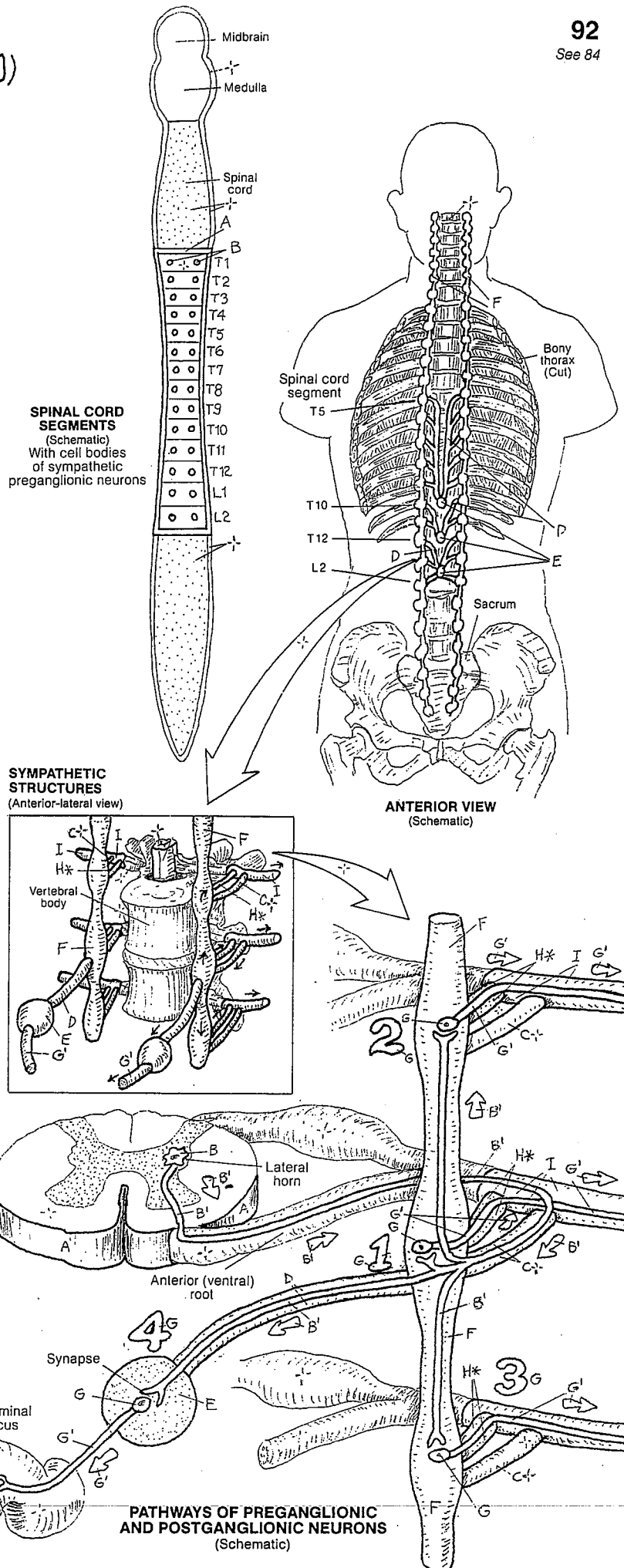
### GRAY COMM. RAMUS<sub>H\*</sub>

### SPINAL NERVE<sub>I</sub>

The autonomic nervous system (ANS; also visceral nervous system or VNS) is a part of the peripheral nervous system (PNS), responsible for the innervation of smooth muscle and glands in viscera and skin and of specialized cardiac muscle. It is a motor system uniquely characterized by two-neuron linkages and motor ganglia (pre- and post-ganglionic neurons). Sensory impulses from viscera are conducted by typical sensory neurons not generally described with the ANS but considered part of the VNS. The sympathetic (thoracolumbar) division of the ANS is concerned with degrees of "fight or flight" responses to stimuli: pupillary dilatation, increased heart and respiratory rates, increased blood flow to brain and skeletal muscles, and other related reactions.

The cell bodies of preganglionic neurons are restricted to the lateral horns of the *spinal cord segments T1 through L2*. The axons of these neurons leave the cord via the anterior roots, join with *spinal nerves* for a very short distance, and turn medially to enter the *sympathetic chain of ganglia* via the *white communicating rami* (white because the axons are myelinated and "white"). The chain is located bilaterally alongside the vertebral column (see inset illustration). Once in the chain, the preganglionic axons can take one or more of four courses: (1) synapse with the *postganglionic neuron* at the same level it entered the chain; (2) ascend and synapse at a higher level of the chain; (3) descend and synapse at a lower level of the chain; (4) pass straight through the chain, forming a nerve that runs from the chain to the front of the vertebral column (*splanchnic nerve*), and synapse with a *postganglionic neuron* there (*prevertebral ganglia*).

The postganglionic neuron within the chain leaves via the *gray communicating ramus* to join the *spinal nerve*. There are gray rami bilaterally at every segment of the spinal cord; white rami exist only from T1 to L2. Gray rami are so called because the resident axons are unmyelinated and collectively have a duller color than those of the white rami. Postganglionic axons from prevertebral ganglia travel in a plexus configuration to the viscera they supply. Plate 92 puts this division into a more meaningful perspective.



SYMPATHETIC STRUCTURES (Anterior-lateral view)

ANTERIOR VIEW (Schematic)

PATHWAYS OF PREGANGLIONIC AND POSTGANGLIONIC NEURONS (Schematic)

# SYMPATHETIC DIVISION (2)

**CN:** Use the same colors as you used on the preceding plate for preganglionic neurons (B), splanchnic nerves (D), and postganglionic neurons (G), all of which have been given the subscripts they had on Plate 92. First orient yourself to this diagram. Note the spinal cord in the center with sympathetic chains of ganglia on either side. Not all connections of both chains are shown. Here, the pathways on the left are to the skin. Pathways on the right are to viscera in the

head and body cavities. Start with the preganglionic neurons on the left (B) and color the chain and related parts (G, G<sup>3</sup>) on the left. Then read the related text. Color the preganglionic neurons (B) on the right and the splanchnic nerves (D) to the abdominal viscera. Color the postganglionic (G, G<sup>1</sup>, G<sup>2</sup>) to the head and thorax, and then the postganglionic (G<sup>4</sup>, G<sup>5</sup>) from the prevertebral ganglia to the abdominal and pelvic/perineal organs.

## PREGANGLIONIC NEURONS<sub>B</sub>

## SPLANCHNIC N<sub>D</sub>

## POSTGANGLIONIC NEURONS<sub>G</sub>

TO HEAD & NECK G<sup>1</sup>

TO THORACIC VISCERA G<sup>2</sup>

TO SKIN G<sup>3</sup>

SWEAT GLANDS G<sup>3</sup>

ARRECTOR PILI G<sup>3</sup>

BLOOD VESSELS G<sup>3</sup>

TO ABDOMINAL VISCERA G<sup>4</sup>

TO PELVIC/  
PERINEAL VISC<sub>G<sup>5</sup></sub>

Sympathetic innervation of skin (and viscera as well) begins with the *preganglionic neurons* in the thoracolumbar part of the spinal cord. The axons leave the cord via the anterior rami of spinal nerves, enter and leave the spinal nerves to join the white communicating rami. These rami bring the axons into the sympathetic chain. Axons from the upper thoracic cord ascend the chain up to the highest ganglion (superior cervical ganglion at the level of the first cervical vertebra). Axons from the lower thoracic and upper lumbar cord enter the chain and descend as far as the lowest ganglion (ganglion impar at the level of the coccyx). At every level of the chain (roughly coincident with spinal cord segments), the preganglionic axons synapse with *postganglionic neurons*. The postganglionic axons leave the chain via the gray communicating rami, enter the spinal nerves from C1 through Co1, and reach the skin via cutaneous branches of these nerves. These axons induce secretory activity in sweat glands, contraction of arrector pili muscles, and vasoconstriction in skin arterial vessels.

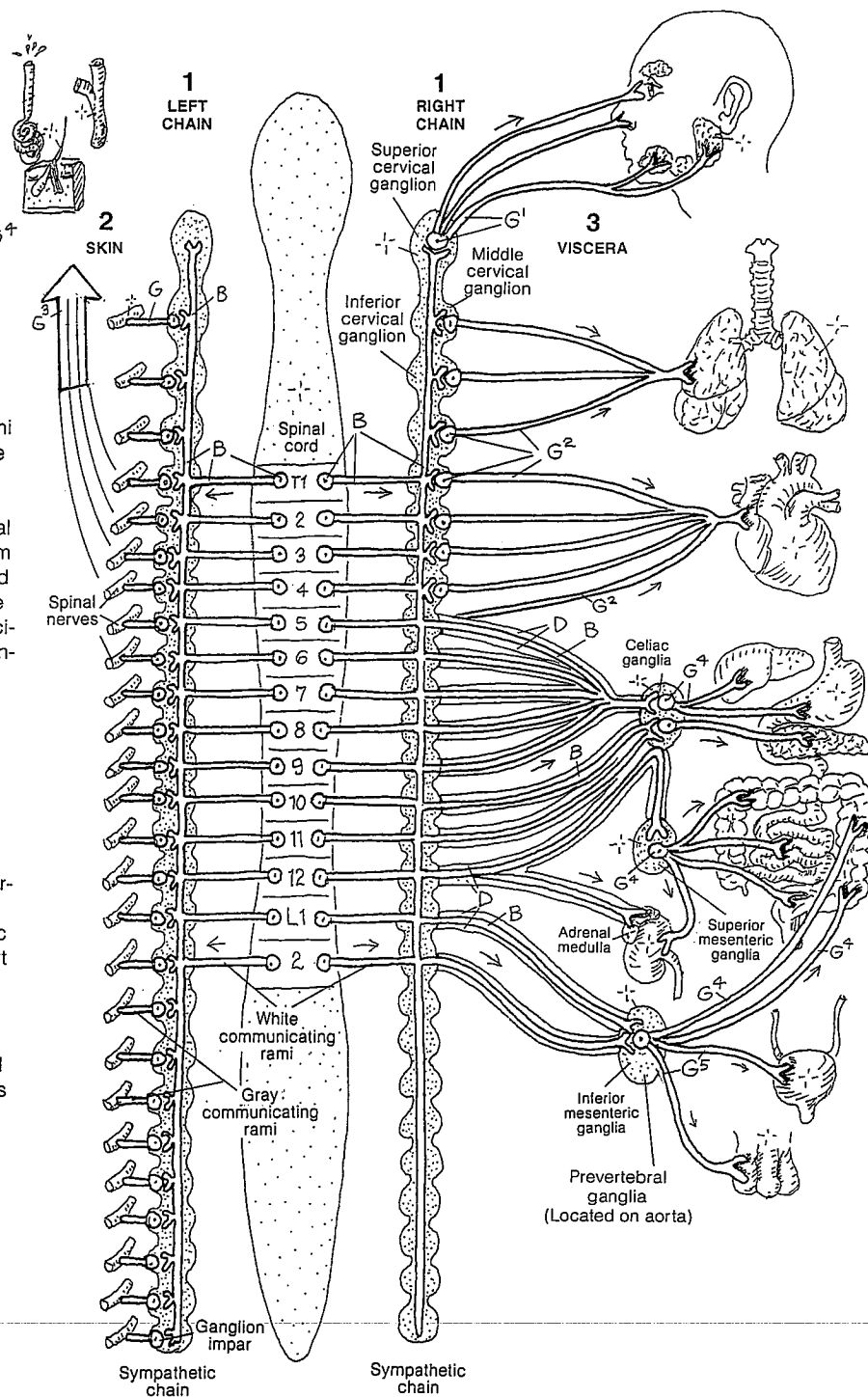
Postganglionics to the head (vessels and glands) leave the superior cervical ganglia and entwine about arteries enroute to the head (in the absence of spinal nerves) to reach their target organs. *Postganglionics to the heart and lungs* leave the upper ganglia of the chain, reaching these organs via cardiac nerves and the pulmonary plexus. These neurons act on heart muscle and the cardiac conduction system to increase heart rate; they induce relaxation of bronchial musculature, facilitating easier breathing.

Preganglionics to abdominal and pelvic viscera leave the cord at levels T5-L2, enter the white communicating rami, and pass through the sympathetic chain without synapsing. They form three pairs of *splanchnic nerves* between the chain and the prevertebral ganglia on the aorta. These axons synapse with the postganglionic neurons in the prevertebral ganglia. The axons of these neurons reach for smooth muscle, inducing contraction of sphincters and decreasing intestinal motility, relaxing bladder muscle and constricting the urinary sphincter. These axons stimulate the adrenal medulla to secrete mostly epinephrine and some norepinephrine, stimulate secretion of glands and muscle contraction in the male genital ducts (ejaculation), and stimulate uterine contractions.

## SYMPATHETIC DIVISION

(Schema showing the following)

- 1 Bilateral chains of ganglia with white rami connections to spinal cord. Each chain has both connections (2) and (3), and they are mirror-images of one another.
- 2 Left chain with postganglionic connections to skin.
- 3 Right chain with splanchnic nerves/postganglionic connections to viscera.



# PARASYMPATHETIC DIVISION

CN: Continue using the same colors you used on Plates 91 and 92 for subscripts B, D, and G. Use a bright color for E. This drawing shows the parasympathetic scheme on one side of the body only (nerve distribution is identical for both sides). (1) Start with the preganglionic neurons in the head and work

through the postganglionic neurons, noting the structures innervated. Note particularly the extensive pattern associated with the vagus nerve. (2) Continue with the sacral preganglionics and postganglionics, noting the target organs. (3) Color the diagram describing ganglia location in the two ANS divisions.

## REGANGLIONIC NEURONS:

III CRANIAL  $N_{cE^1}$

VII CRANIAL  $N_{cE^2}$

IX CRANIAL  $N_{cE^3}$

X CRANIAL  $N_{cE^4}$

PELVIC SPLANCHNIC  $N_{cD}$

## GANGLIA:

CILIARY  $G^1$

PTERYGO PALATINE  $G^2$

SUBMANDIBULAR  $G^3$

OTIC  $G^4$

INTRAMURAL  $G^5$

## POSTGANGLIONIC NEURONS:

EYE  $E^1$

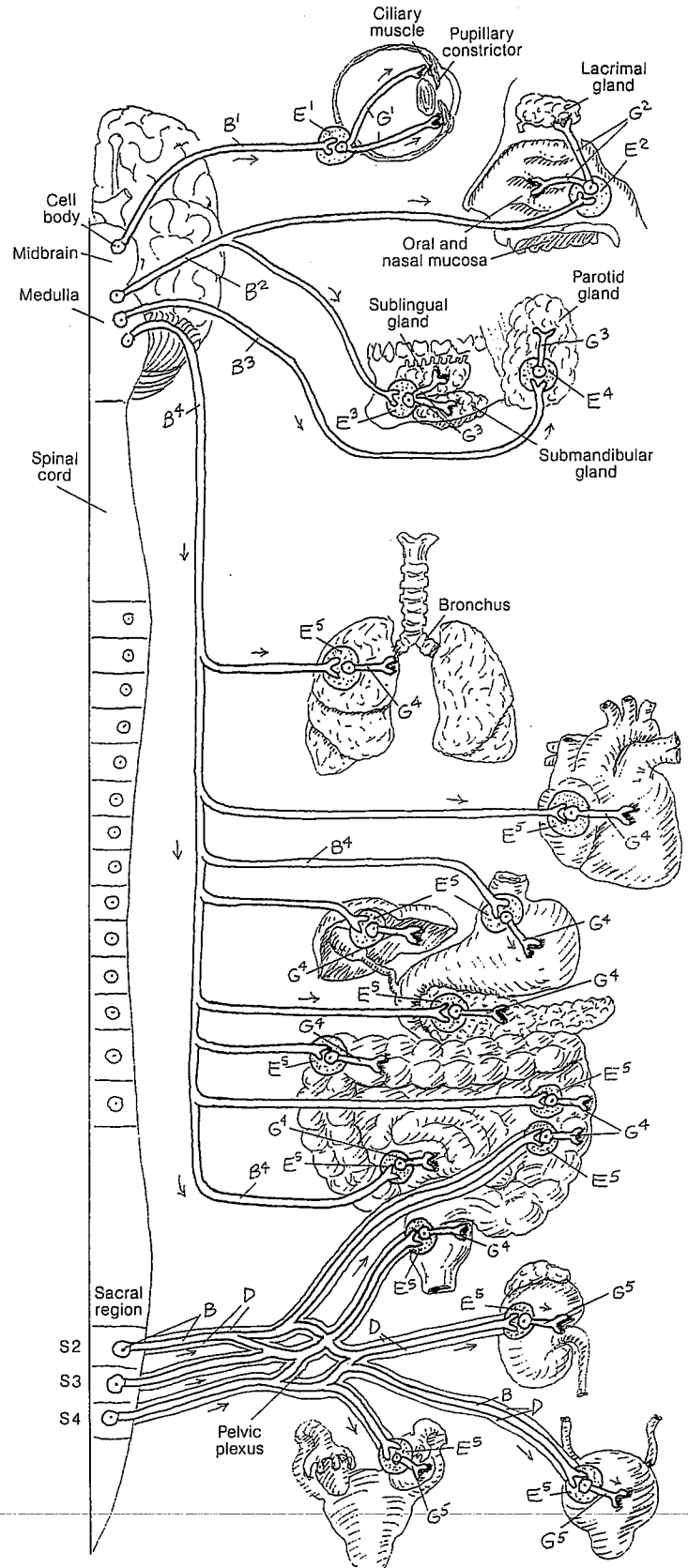
NASAL/ORAL CAVITIES  $E^2$

SALIVARY GLANDS  $E^3$

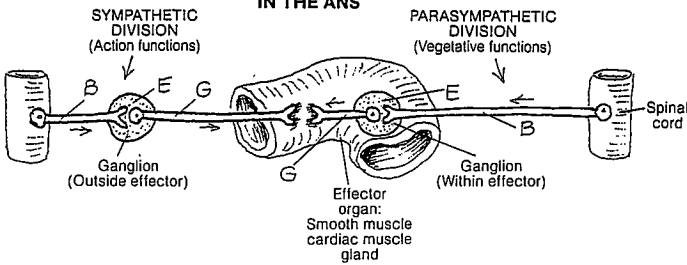
THORACIC/ABDOMINAL VISCERA  $E^4$

PELVIC/PERINEAL VISCERA  $E^5$

## PARASYMPATHETIC DIVISION (Schema showing only one side)



### LOCATION OF GANGLIA IN THE ANS



The parasympathetic division of the ANS is concerned with vegetative functions—e.g., it encourages secretory activity on the body's mucous and serous membranes, promotes digestion by increased peristalsis and glandular secretion, and induces contraction of the urinary bladder.

The parasympathetic preganglionic neuronal cell bodies in the head are located in the brain stem associated with certain cranial nerves. The preganglionic axons leave the brain stem with their cranial nerve and synapse at one of the cranial ganglia. The postganglionic neurons tend to be short, terminating in salivary glands and other glands of the nasal and oral cavities. The preganglionic fibers associated with the vagus (X cranial) nerve are unusually long, descending the neck, the esophagus, and through the esophageal hiatus to the gastrointestinal tract. The axons of these neurons extend as far as the descending colon. The ganglia are in the muscular walls of the organ they supply (intramural ganglia); the postganglionic axons are very short, terminating in smooth muscle and glands.

The cell bodies of the sacral preganglionic neurons are located in the lateral horns of sacral segments 2, 3, and 4 of the spinal cord. Their axons leave the cord via the anterior rami but form their own nerves, called the pelvic splanchnic nerves (nervi erigentes). These nerves project to the pelvis, mix with sympathetic postganglionics in the pelvic plexus, and depart for their target organs. They synapse with the postganglionic neurons in intramural ganglia in the walls of the organ supplied. These fibers stimulate contraction of rectal and bladder musculature and induce vasodilatation of vessels to the penis and clitoris (erection).

The parasympathetic and sympathetic divisions of the autonomic nervous system are not antagonistic. Their respective activities are coordinated and synchronized to achieve dynamic stability of body function during a broad range of life functions, such as eating, running, fear, or relaxation.