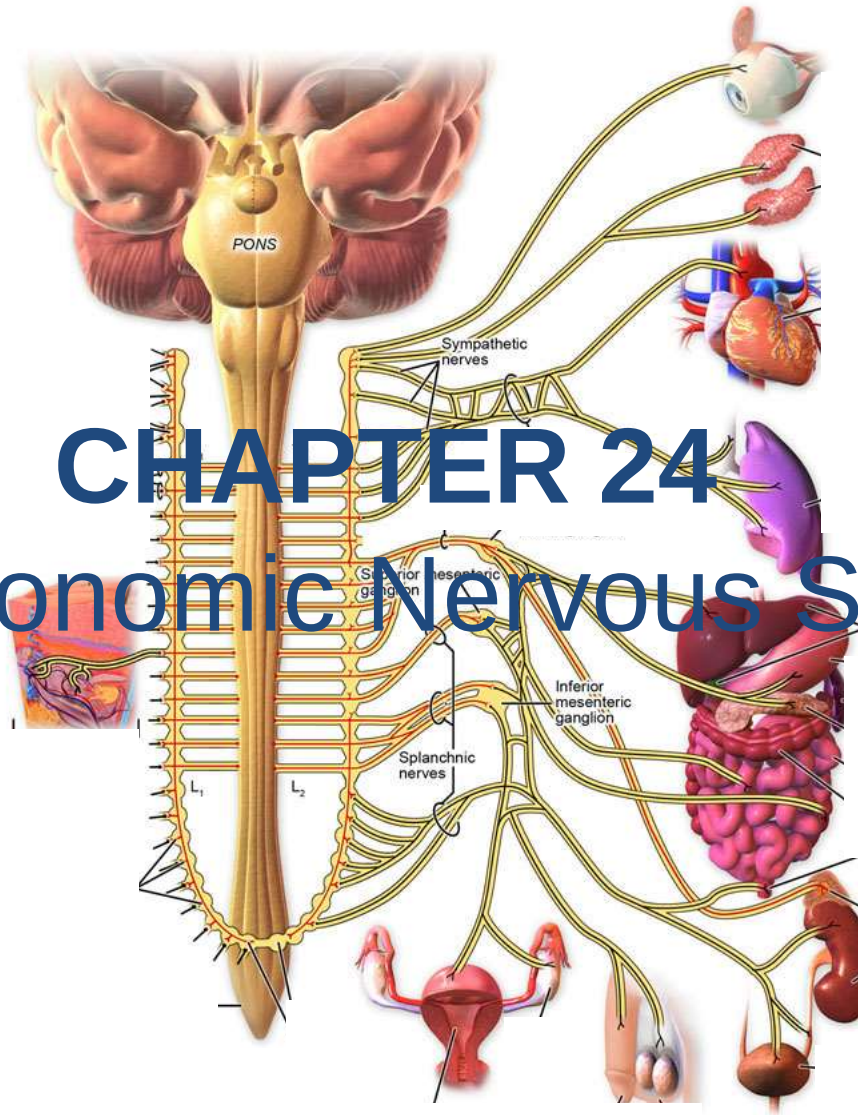




CHAPTER 24

The Autonomic Nervous System



Autonomic Nervous System *Interaction Animation*



- [Autonomic Nervous System](#)

R. Bishay

You must be connected to the internet to run this animation.



Introduction

- What makes up the autonomic nervous system (ANS)?
 - Autonomic sensory neurons
 - Integrating centers
 - Autonomic motor neurons



Comparison of Somatic and Autonomic Nervous Systems

- Somatic Nervous System
 - Includes both sensory and motor neurons
 - Conveys input from somatic senses and from receptors for special senses
- ANS
 - Main input comes from autonomic (visceral) sensory neurons.
 - Autonomic neurons regulate visceral activities.
 - Sympathetic and parasympathetic divisions

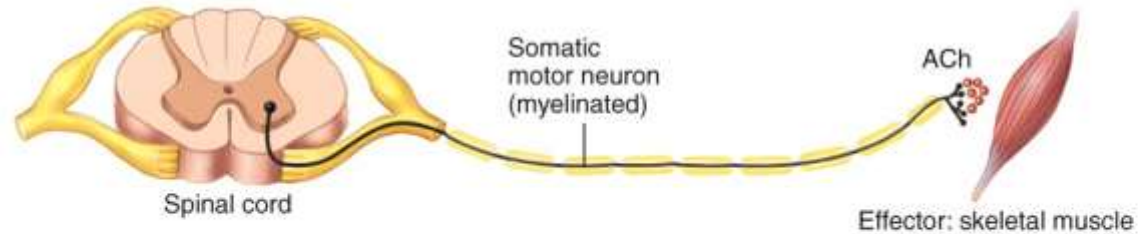


Comparison of Somatic and Autonomic Motor Neurons

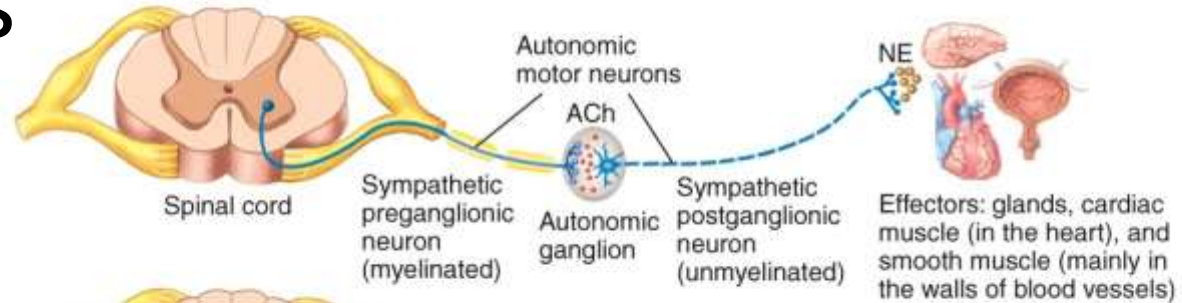
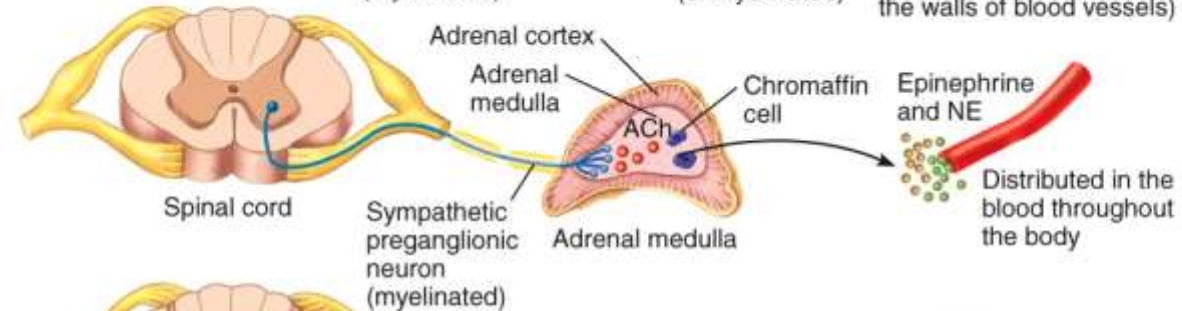
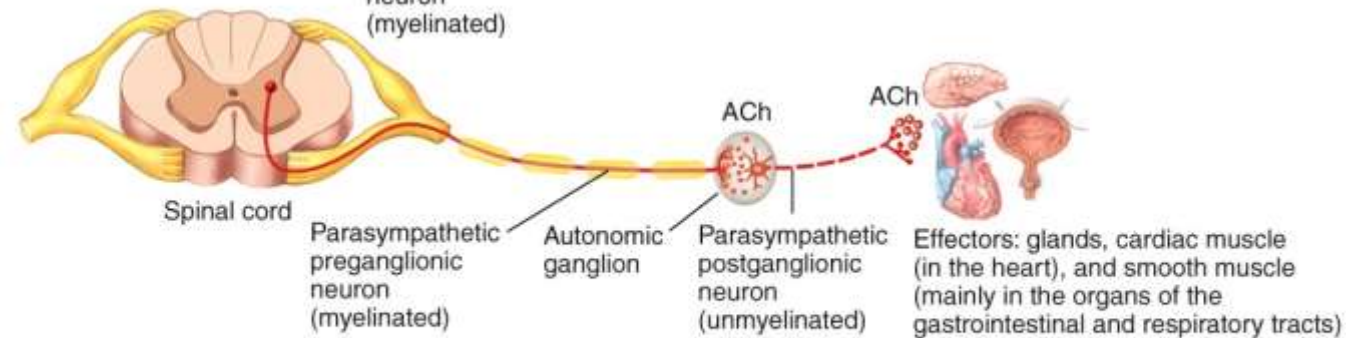
- Preganglionic neuron
- Cell body
- Autonomic ganglion
- Postganglionic neuron

R. Bishay

Motor Neuron Pathways in the SNS and ANS



(a) Somatic nervous system



(b) Autonomic nervous system

Comparison of Somatic and Autonomic Motor Neurons



- Sympathetic division
- Parasympathetic
- Dual innervation

R. Bishay

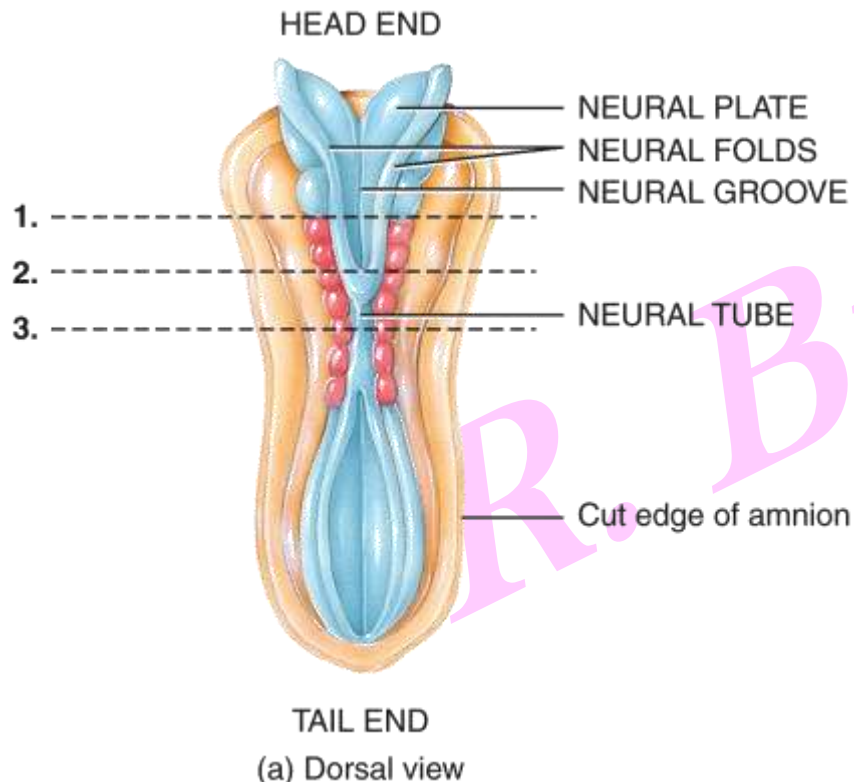
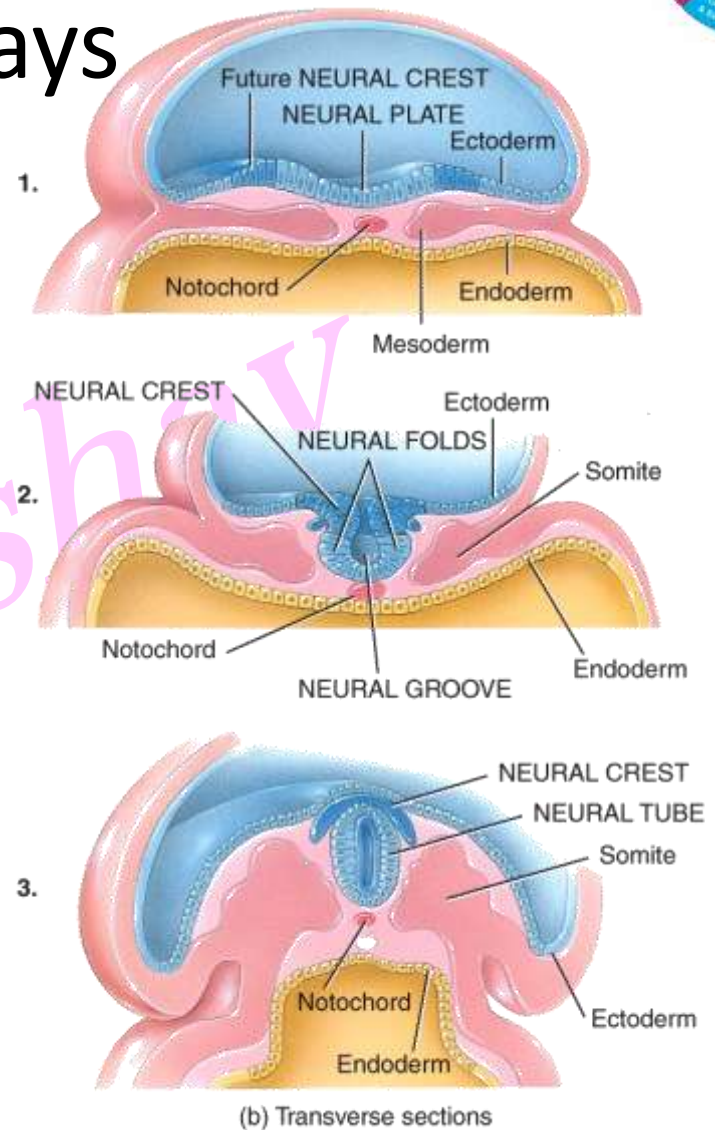
Anatomy of Autonomic Motor Pathways



- Neural plate
- Neural groove
- Neural folds
- **All are from neural tube**

R. Bishay

Development of Autonomic Motor Pathways

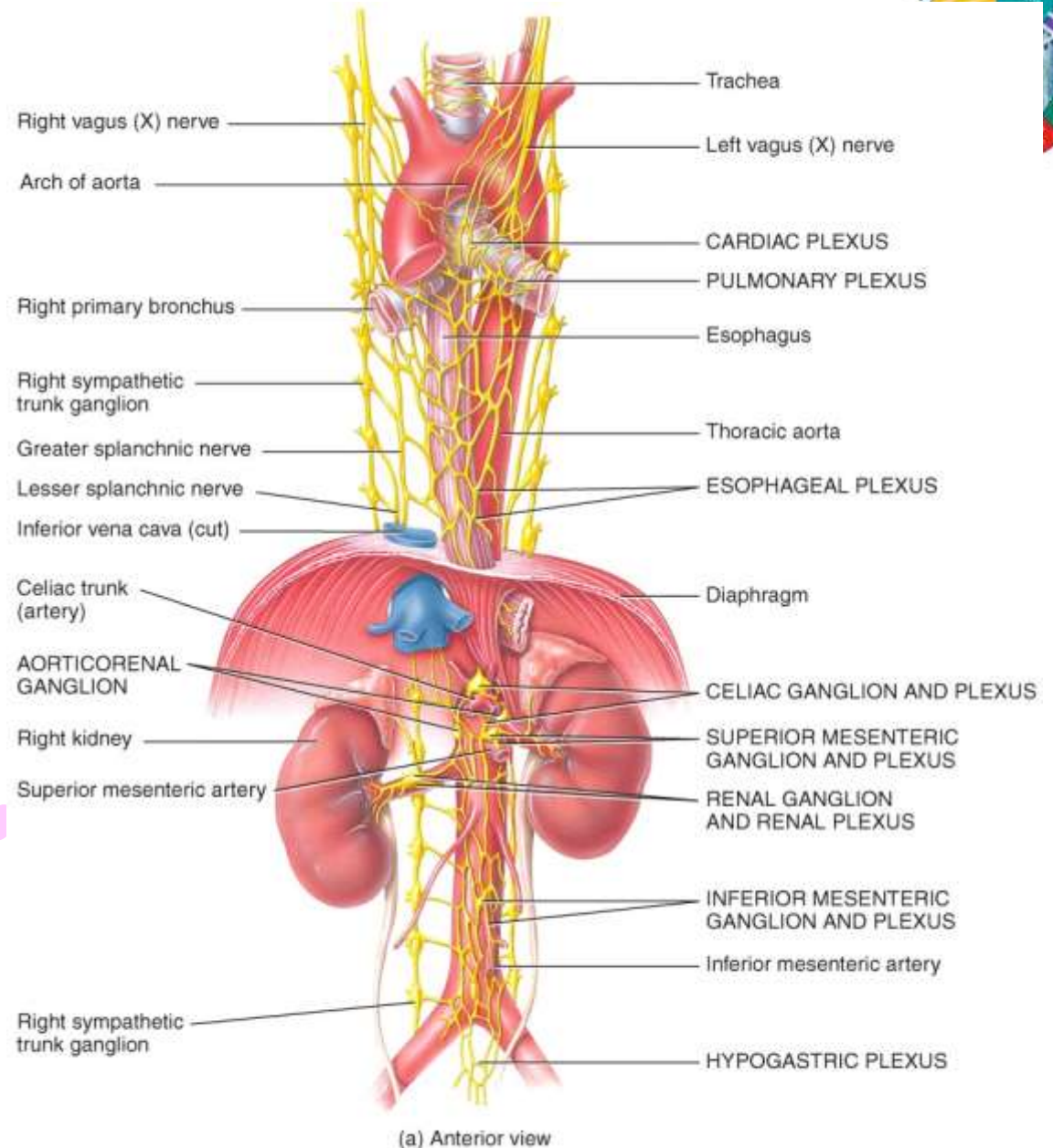




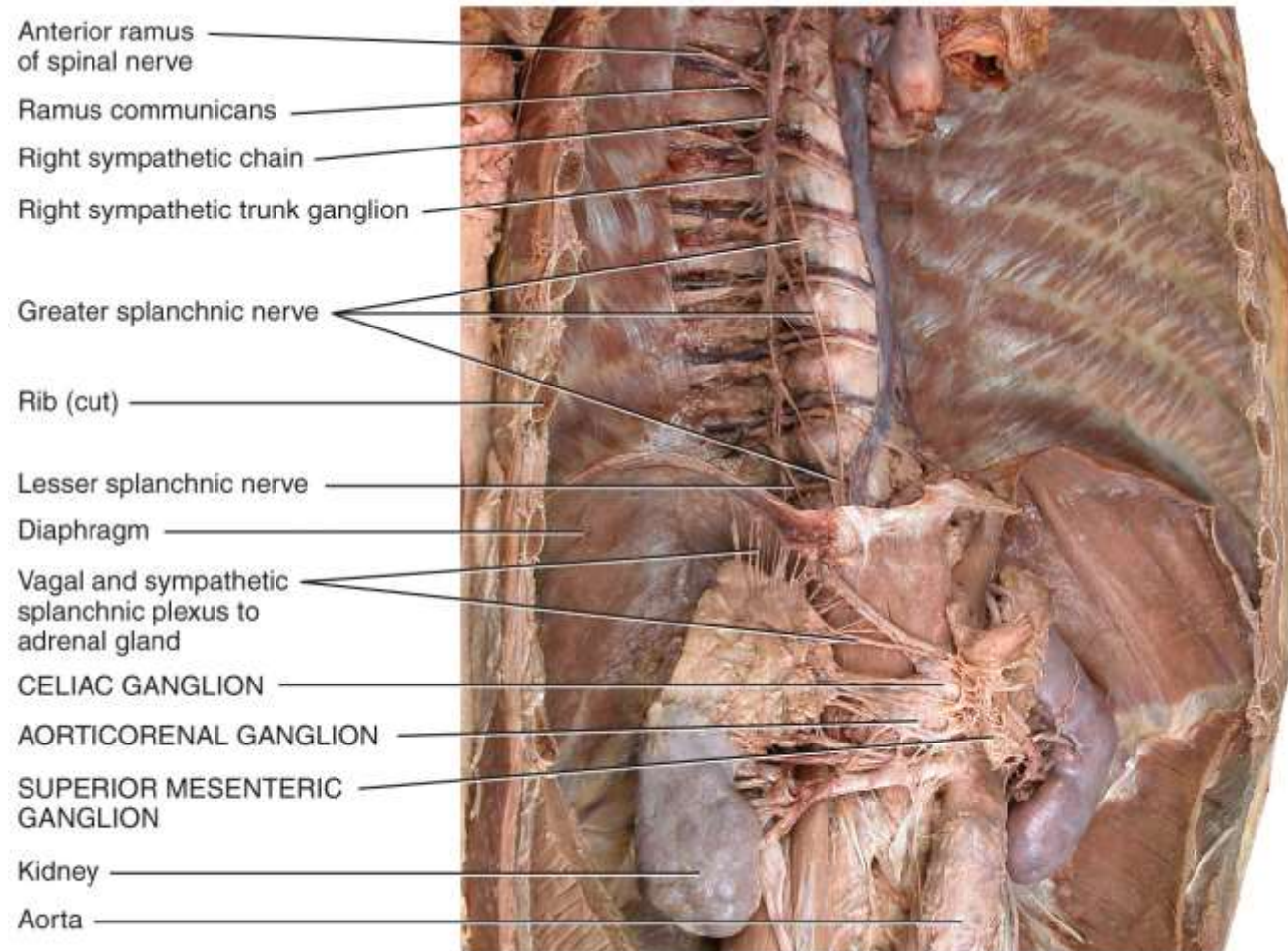
Shared Anatomical Components of an Autonomic Motor Pathway

- Motor neurons and autonomic ganglia
- **Autonomic plexuses** (HR is Cost Per Click)
 - Cardiac plexus
 - Pulmonary plexus
 - Celiac (solar) plexus
 - Superior mesenteric plexus
 - Inferior mesenteric plexus
 - Hypogastric plexus
 - Renal plexuses

Autonomic Plexuses in the Thorax, Abdomen, and Pelvis



Autonomic Plexuses in the Thorax, Abdomen, and Pelvis



Dissection Shawn Miller, Photograph Mark Nielsen

(b) Anterior view

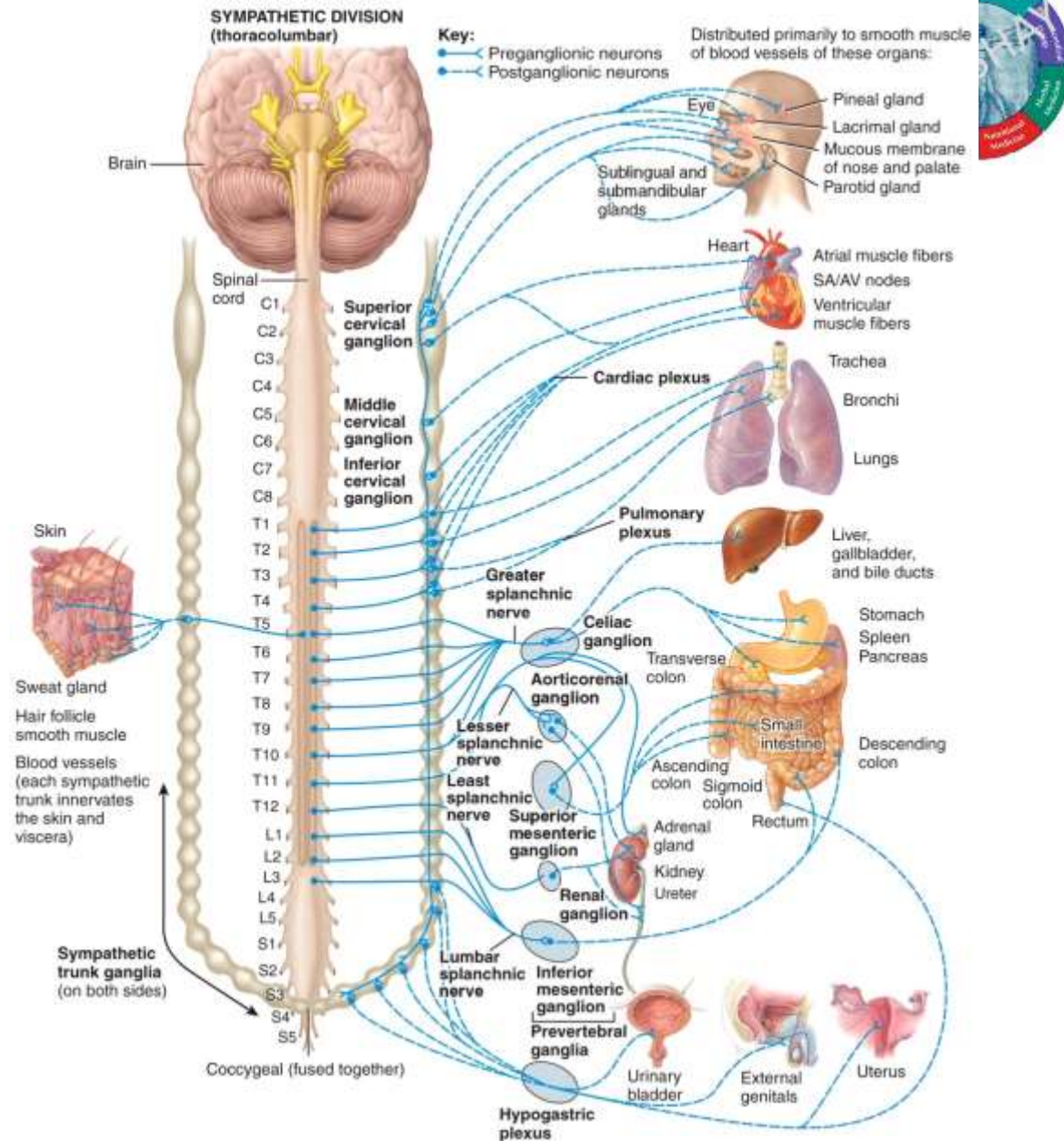


Sympathetic Preganglionic Neurons

- Cell bodies of sympathetic preganglionic neurons are located in the lateral horns of the gray matter in the 12 thoracic segments and the first two or three lumbar segments of the spinal cord i.e. **neurons are myelinated OR unmyelinated?**
 - Thoracolumbar division
 - White ramus
 - White rami communicantes

The Sympathetic Divisions of the ANS

R.

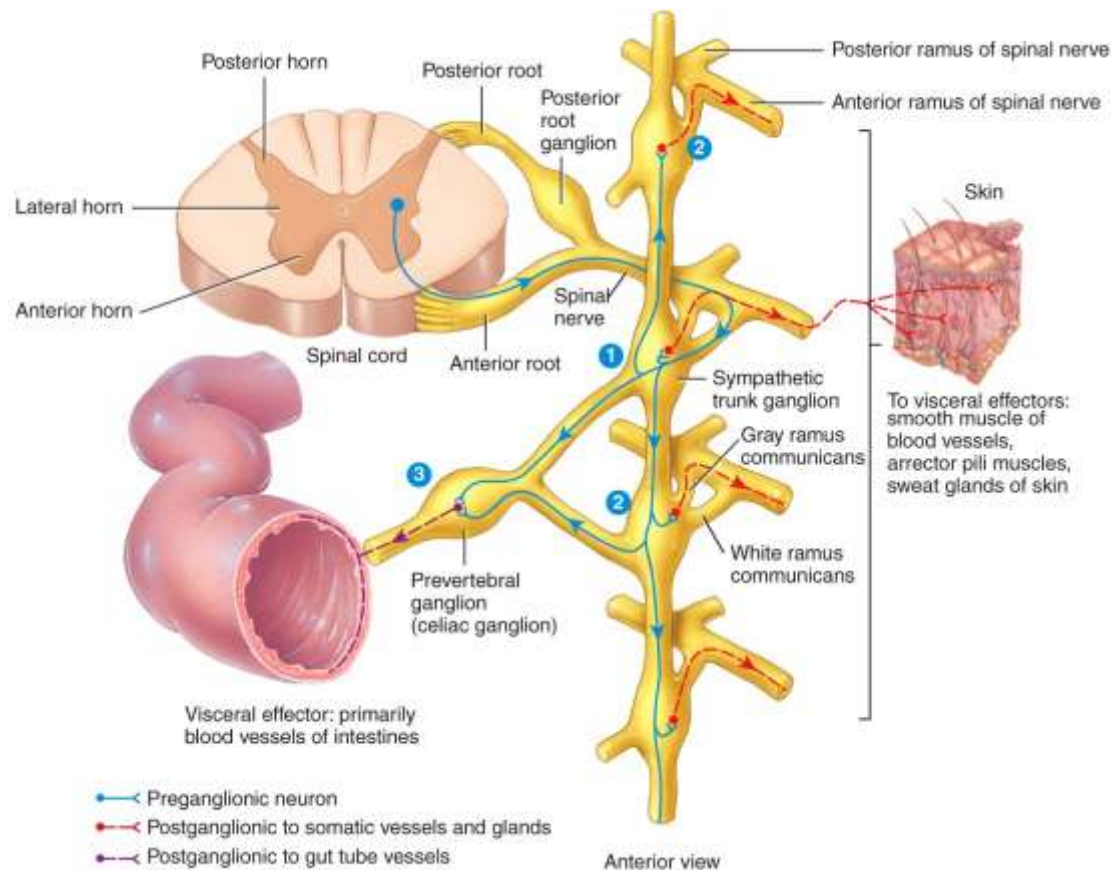




Sympathetic Preganglionic Neurons

- Preganglionic axons extend from white rami communicantes into the sympathetic trunk ganglion, giving off axon collaterals that terminate and synapse in several ways:
 - In the first ganglion at the level of entry
 - Form sympathetic chains
 - Form splanchnic nerves

Connections Between Ganglia and Postganglionic Neurons in the Sympathetic Division of the ANS





Sympathetic Ganglia and Postganglionic Neurons

- Sympathetic **trunk** ganglia
- Postganglionic neurons arise from sympathetic trunk ganglia and do one of the following:
 - Return via gray communicating rami to the anterior ramus of spinal nerve
 - Exit into nerve branches that supply the heart
 - Exit the trunk in nerves that enter plexuses that follow blood vessels in that region
- Superior, middle, and inferior cervical ganglion

Parasympathetic Preganglionic Neurons



- Cell bodies of preganglionic neurons of the parasympathetic division are located in the nuclei of ***four cranial nerves*** in the brain stem (III, VII, IX, and X) and in the lateral ***gray horns*** of the ***second through fourth sacral*** segments of the spinal cord.
 - Craniosacral division

Parasympathetic Preganglionic Neurons



- The cell body axons emerge as part of a cranial nerve or as part of the anterior root of a spinal nerve.
- Cranial parasympathetic outflow
- Sacral parasympathetic outflow

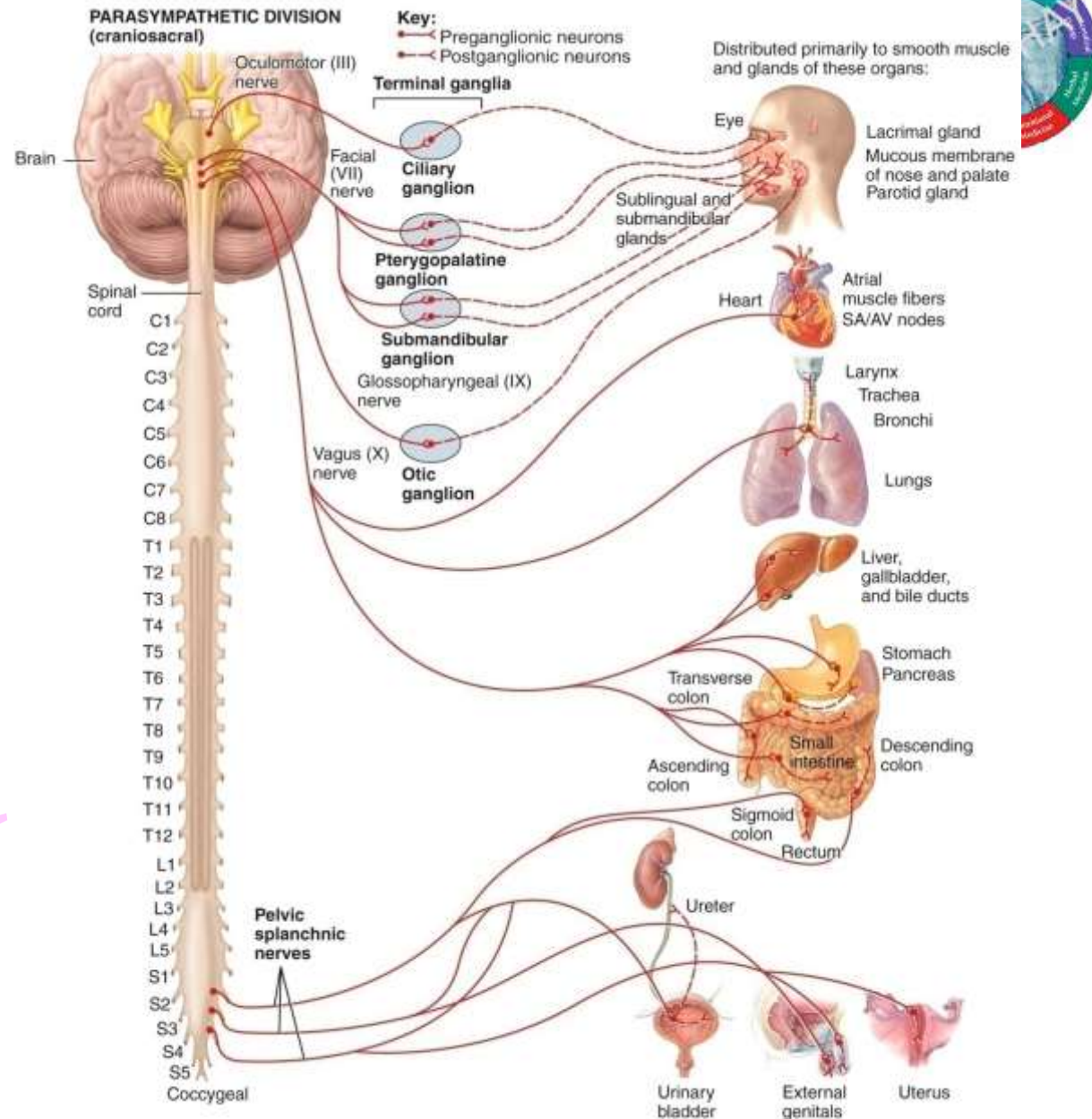


Parasympathetic Ganglia and Postganglionic Neurons

- Preganglionic axons of the parasympathetic division synapse with postganglionic neurons in terminal ganglia.
- Terminal ganglia are located close to or within the wall of a visceral organ, and they are longer than most of the axons of sympathetic preganglionic neurons.
- **Cranio-sacral division**

The Para-sympathetic Division of the ANS

R





Structure of the Enteric Division

- It is important to realize that the gastrointestinal tract forms an extensive area of contact with the environment.
- The enteric division of the ANS is the specialized network of nerves and ganglia forming an integrated neuronal network.
 - Myenteric plexus
 - Submucosal plexus



Myenteric plexus & Submucosal plexus

- **Submucosa:** Highly vascular and contains the submucosal plexus, or plexus of Meissner, a portion of the ANS called the enteric nervous system (ENS)
- The submucosal plexus regulates **movements of the mucosa** and vasoconstriction of blood vessels.
- **Musculosa:** Contains the myenteric plexus, or plexus of Auerbach
- This plexus mostly controls GI tract motility (movement).



Clinical Connection

- Autonomic dysreflexia: Gastro paresis in uncontrolled DM cases

R. Bishay



Cholinergic Neurons and Receptors

- Release of the neurotransmitter acetylcholine
- In the ANS, the cholinergic neurons include:
 - All sympathetic and parasympathetic preganglionic neurons
 - Sympathetic postganglionic neurons that innervate most sweat glands
 - All parasympathetic postganglionic neurons
- Two types of cholinergic receptors
 - Nicotinic receptors
 - Muscarinic receptors



Nicotinic receptors

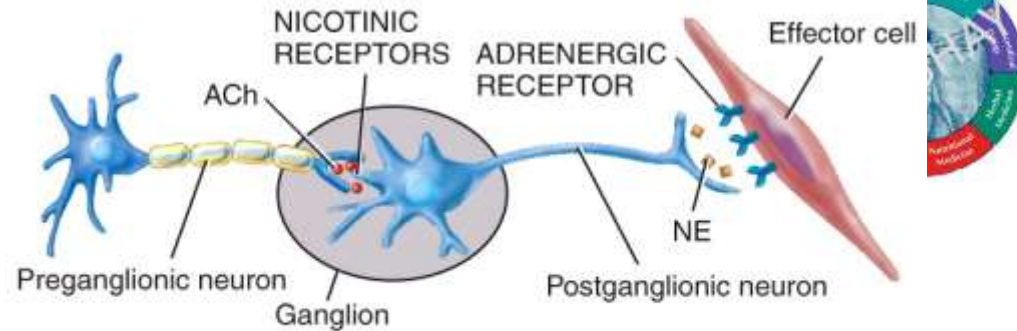
- Nicotinic acetylcholine receptors, or nAChRs, are receptor polypeptides that respond to the neurotransmitter acetylcholine. Nicotinic receptors also respond to drugs such as the agonist nicotine.
They are found in the central and peripheral nervous system, muscle, and many other tissues of many organisms
- A key function of nicotinic receptors is to trigger rapid neural and neuromuscular transmission. Nicotinic receptors are found in:
The somatic nervous system (neuromuscular junctions in skeletal muscles).
The sympathetic and parasympathetic nervous system (autonomic ganglia)



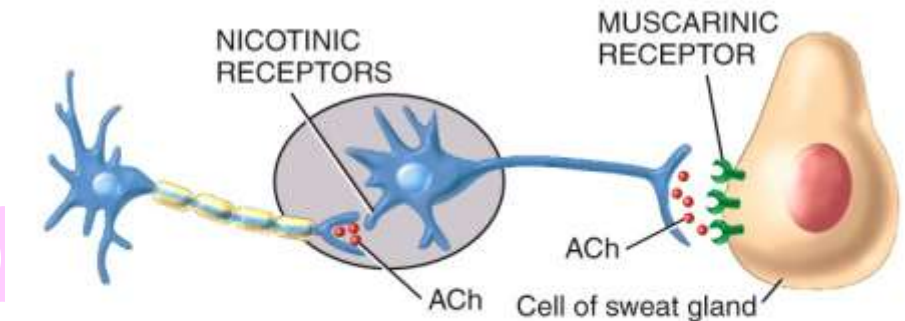
Muscarinic receptors

- •Muscarinic acetylcholine receptors, or mAChRs, are acetylcholine receptors that form G protein- coupled receptor complexes in the cell membranes of certain neurons and other cells. ... Muscarinic receptors are so named because they are more sensitive to muscarine than to nicotine
- Muscarinic receptors have a different mechanism of action. The main difference between them is their mechanism of action: one uses ions and the other uses G- proteins. Nicotinic receptors are all excitatory, but muscarinic receptors can be both excitatory and inhibitory depending on the subtype

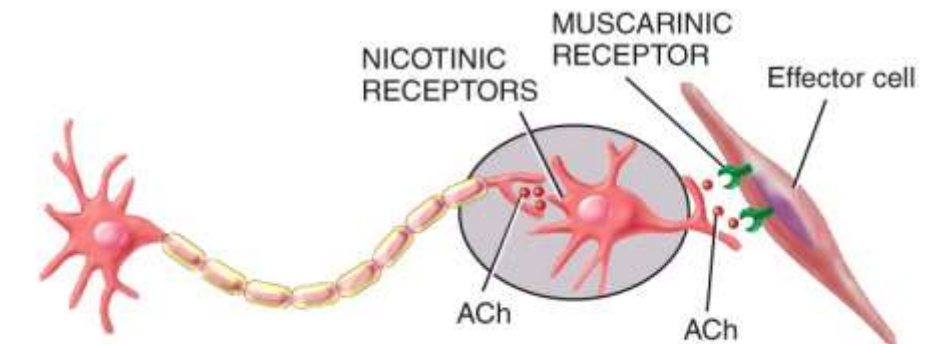
Cholinergic Neurons and Adrenergic Neurons in the Sympathetic and Parasympathetic Divisions



(a) Sympathetic division—innervation to most effector tissues



(b) Sympathetic division—innervation to most sweat glands



(c) Parasympathetic division



Adrenergic Neurons and Receptors

- In the ANS, adrenergic neurons release norepinephrine (NE), also known as noradrenalin.
- Most sympathetic postganglionic neurons are adrenergic; like ACh, NE is synthesized and stored in synaptic vesicles and released by exocytosis.
- Adrenergic receptors bind NE and epinephrine.
- The main types of adrenergic receptors:
 - Alpha (α) receptors
 - Beta (β) receptors



Alpha (α) & Beta (β) receptors

- The types of sympathetic or adrenergic receptors are alpha, beta 1 and beta 2.
- **Alpha-receptors are located on the arteries.** When the alpha receptor is stimulated by epinephrine or norepinephrine, the arteries constrict. This increases the blood pressure and the blood flow returning to the heart.
- **Beta 1 receptors are located in the heart.**
- When Beta 1 receptors are stimulated they increase the heart rate and increase the heart's strength of contraction or contractility.
- **The beta 2 receptors are located in the bronchioles** of the lungs and the arteries of the skeletal muscles.

Nervous System: Organization of the ANS

Anatomy Overview



- [Nervous System: Organization of the ANS](#)

R. Bishay

You must be connected to the internet to run this animation.



Functions of the ANS

- The role of Control of the ANS
- Production of hormones
- Regulation of emotional and behavioural patterns
- Regulation of eating and drinking
- Control of body temperature
- Regulation of circadian rhythms and states of consciousness



Sympathetic Responses

- **Fear-Fight-Flight** response and/or **Freeze**
 - ☐ Heart rate, force of heart contraction, and blood pressure increase.
 - ☐ The airways dilate, allowing faster movement of air **into** and out of the lungs.
 - ☐ Pupils of the eyes dilate.



Sympathetic Responses

- **Fear-Fight-Flight** response and/or **Freeze** (continued)
 - ☐ Blood vessels supplying organs involved in exercise or fighting off danger dilate.
 - ☐ Liver cells perform glycogenolysis, and adipose tissue cells perform lipolysis.
 - ☐ Release of glucose by the liver increases blood glucose level.
 - ☐ Processes that are not essential for meeting the stressful situation are inhibited.



Parasympathetic Responses

- Rest-Digest and/or Do the best activities
- **SLUDD** (*Salivation, lacrimation, urination, digestion and defecation*)
- Parasympathetic responses support body functions that conserve and restore body energy during times of rest and recovery.
- In the quiet intervals between periods of exercise, parasympathetic impulses to the digestive glands and the smooth muscle of the gastrointestinal tract predominate over sympathetic impulses.



Integration and Control of Autonomic Functions

Autonomic reflexes are responses that occur when nerve impulses travel over an autonomic reflex arc, which consists of:

- Receptor
- Sensory neuron
- Integrating center
- Motor neurons
- Effector



Reflexes

Interactions Animation

- [Reflexes](#)

R. Bishay

You must be connected to the internet to run this animation.