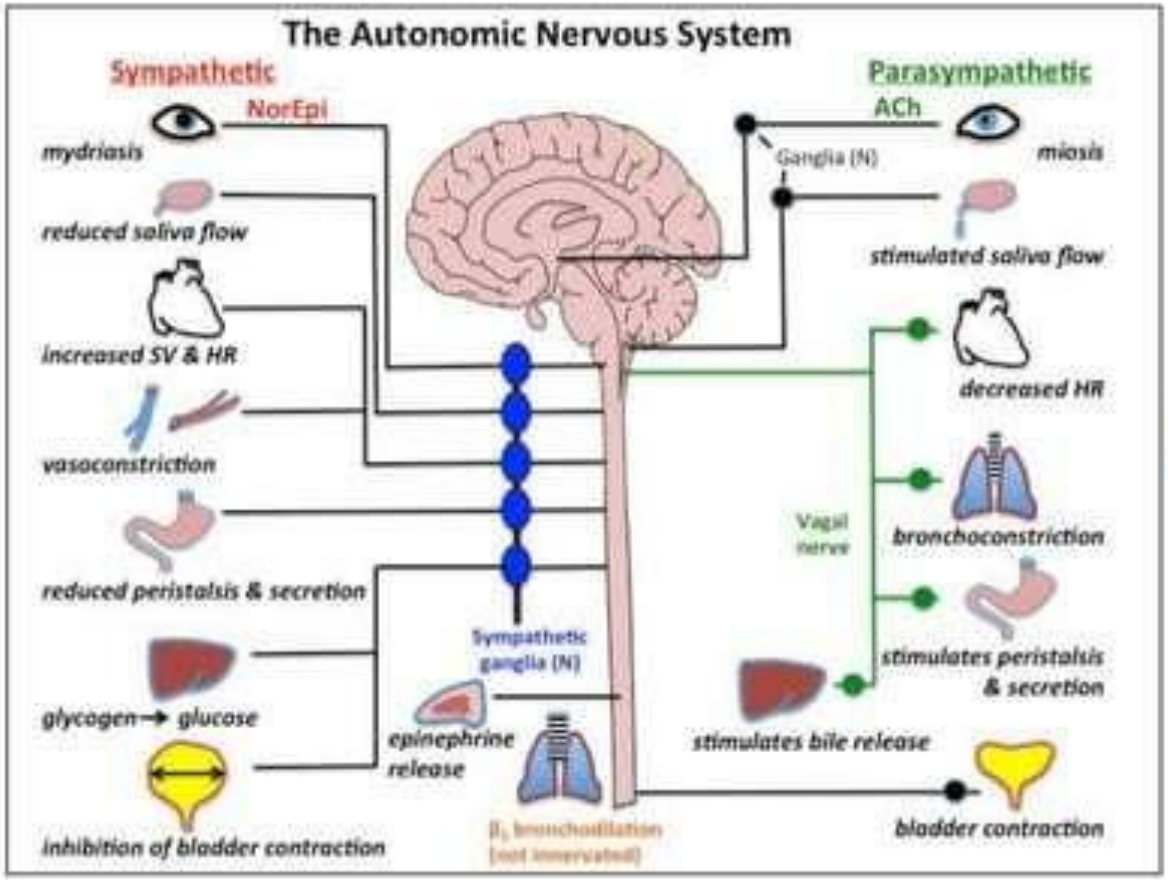

Autonomic Nervous system

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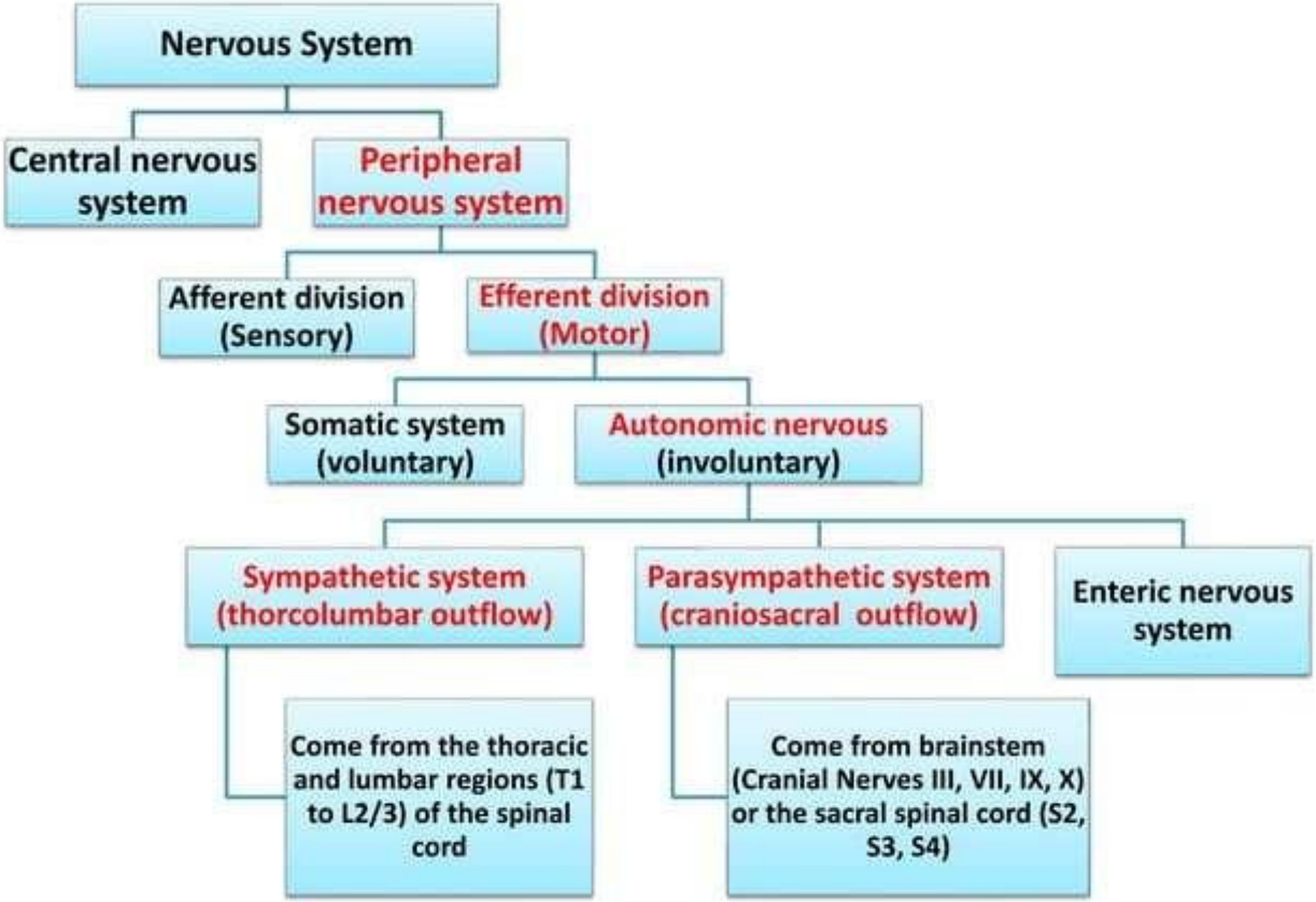
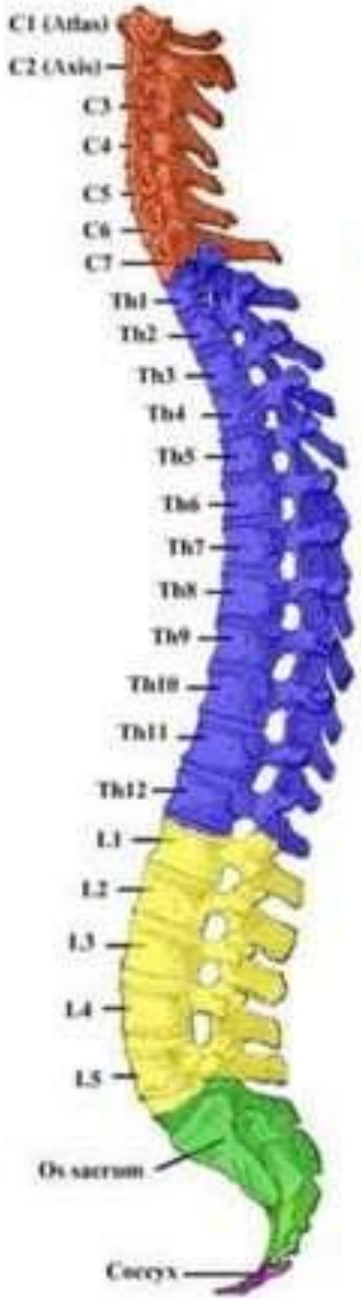
Learning Outcomes

- At the end of this session, the student would be able to:
  - Briefly describe Sympathetic and parasympathetic outflow and its functions.
  - List the differences between Sympathetic and Parasympathetic division.
  - Explain the adrenergic and cholinergic receptors


Nervous System
Central nervous system
Peripheral nervous system
Afferent division (Sensory)
Efferent division (Motor)
Somatic system (voluntary)
Autonomic nervous (involuntary)
Sympathetic system (thorcolumbar outflow)
Parasympathetic system (craniosacral outflow)
Enteric nervous system
Come from the thoracic and lumbar regions (T1 to L2/3) of the spinal cord
Come from brainstem (Cranial Nerves III, VII, IX, X) or the sacral spinal cord (S2, S3, S4)

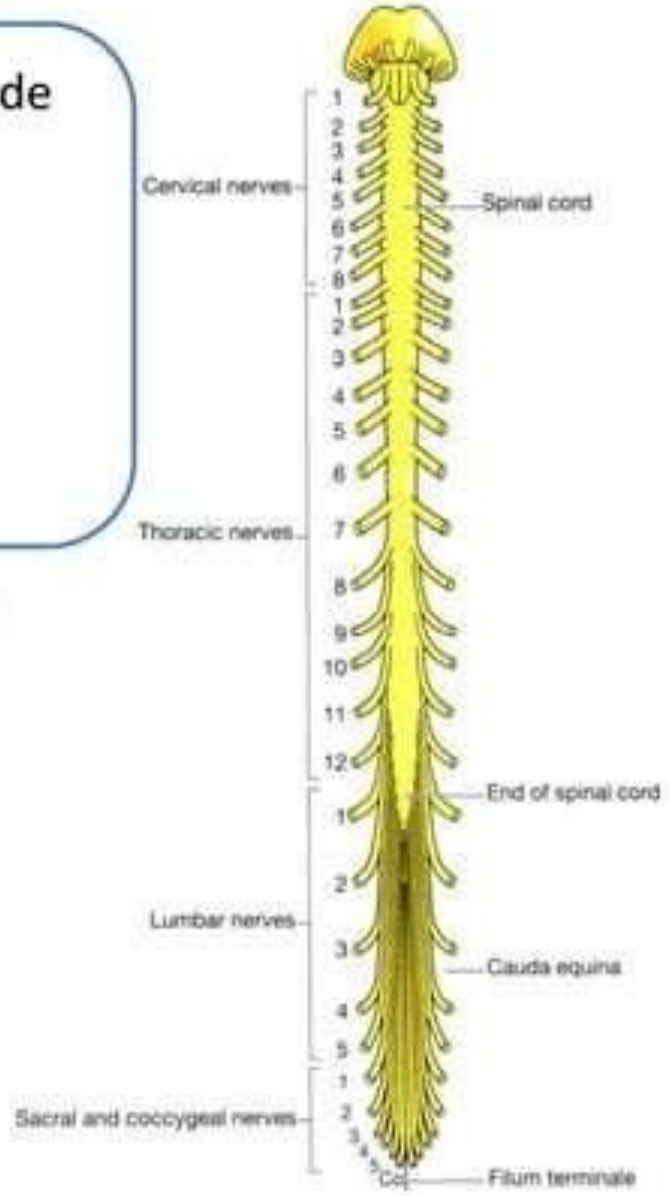


Spinal nerves

The human spinal column is made up of 33 bones.

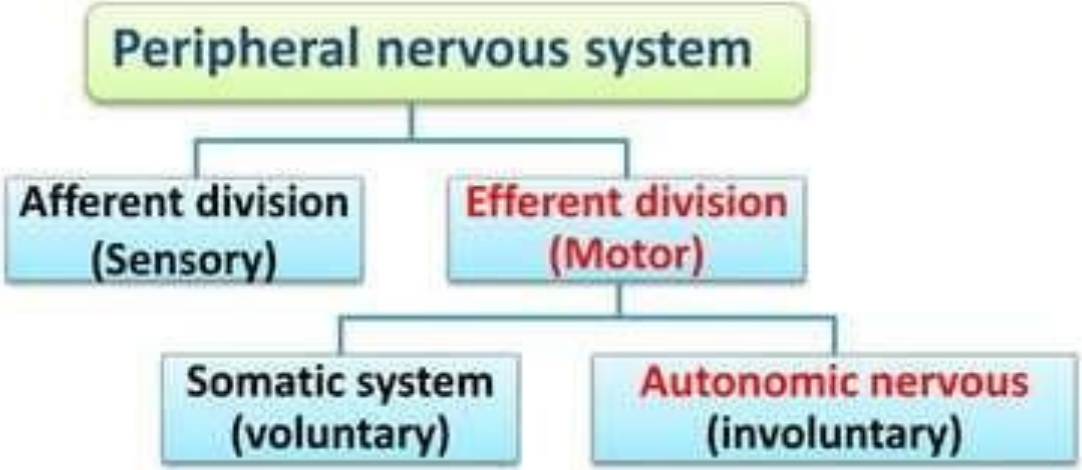
- 7 - cervical region
- 12 - thoracic region
- 5 - lumbar region
- 5 - sacral region
- 4 - coccygeal region

- **There are 31 pairs spinal nerves**
  - **8 cervical**
  - **12 thoracic**
  - **5 lumbar**
  - **5 sacral**
  - **1 coccygeal**



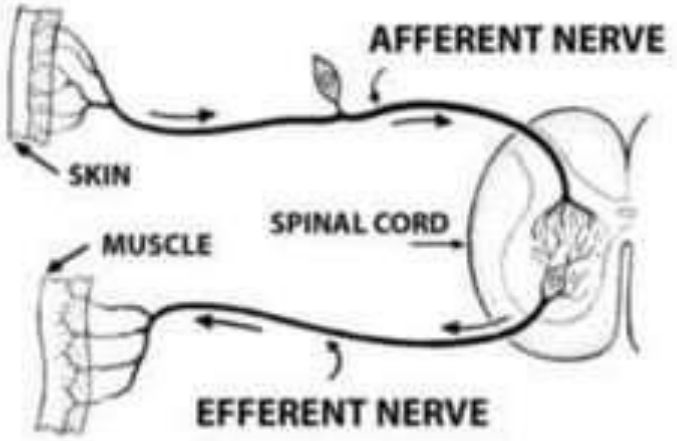
Peripheral Nervous System

- Most of the nerves of the peripheral nervous system are composed of **sensory nerve fibres conveying afferent impulses from sensory end organs to the brain** and **motor nerve fibres conveying efferent impulses from the brain through the spinal cord to the effector organs.**



Somatic Nervous System

- The somatic nervous system (SNS or voluntary nervous system) is the part of the peripheral nervous system.
- The somatic nervous system includes both **sensory** (**afferent nerves**) and **motor** (**efferent nerves**) neurons.
- Sensory neurons convey input from **receptors for somatic senses** (tactile, thermal, pain, and proprioceptive sensations) and from **receptors for the special senses** (sight, hearing, taste, smell, and equilibrium)



Autonomic Nervous System

- The autonomic nervous system is involved in a complex of reflex activities, which depend on sensory input to the brain or spinal cord, and on motor output.
- The majority of the organs of the body are supplied by both sympathetic and parasympathetic nerves which have opposite effects that are finely balanced to ensure the optimum functioning of the organ.

Autonomic Nervous System

- The autonomic nervous system (ANS) is a complex set of neurons that mediate **internal homeostasis** without conscious intervention or voluntary control.
- The ANS maintains blood pressure, regulates the rate of breathing, influences digestion, urination, and modulates sexual arousal.
- There are two main branches to the ANS – the **sympathetic nervous system** and the **parasympathetic nervous system**.

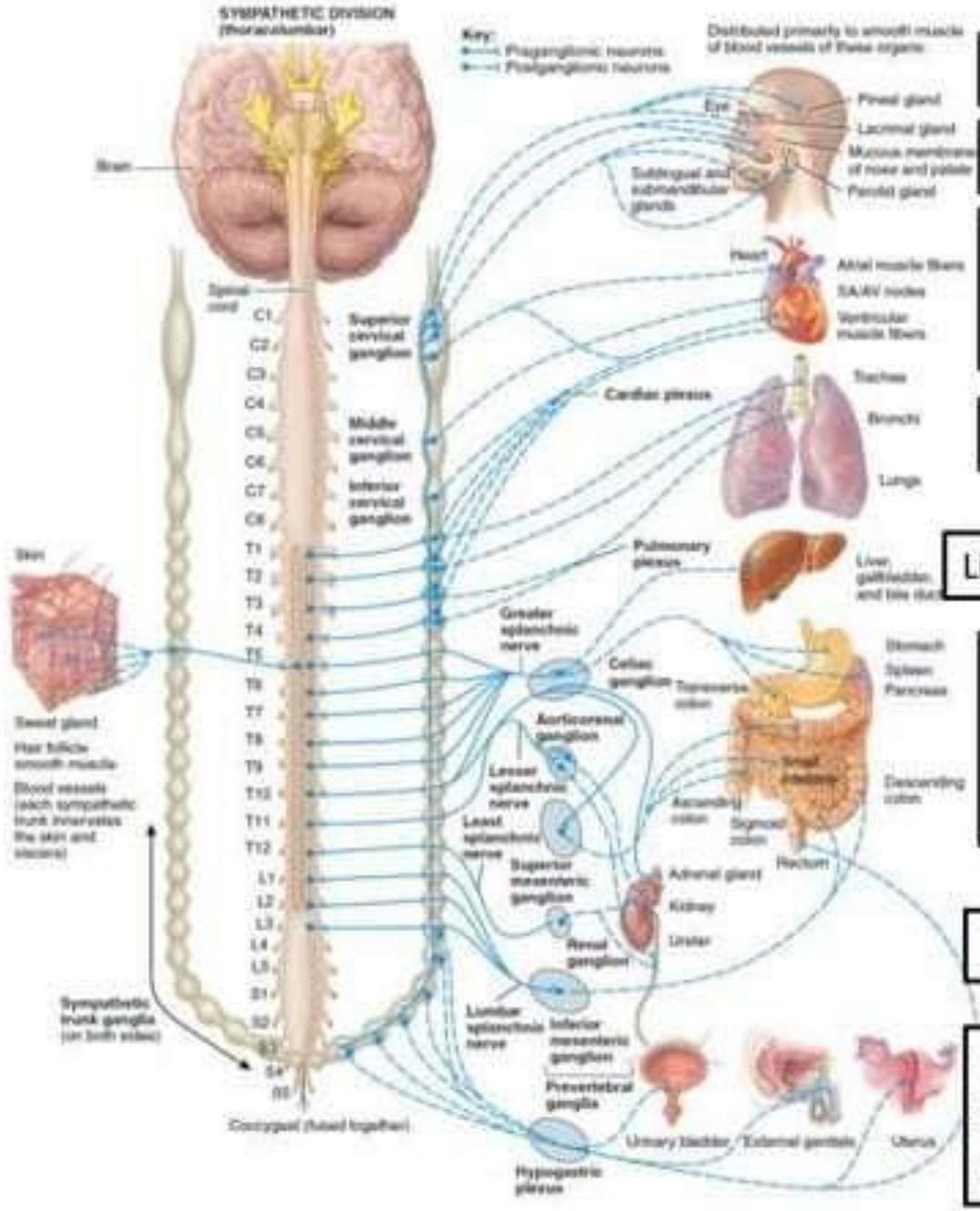
The effects of autonomic control are rapid and essential for homeostasis

Sympathetic nervous system

- Sympathetic nervous system otherwise called as thoracolumbar system.
- **Sympathetic stimulation** prepares the body to deal with exciting and **stressful situations**, e.g. **strengthening its defences in danger**. sympathetic stimulation mobilises the body for '**fight or flight**'.
- Neurones convey impulses from their origin in the hypothalamus, reticular formation and medulla oblongata to effector organs and tissues. The first neurone has its cell body in the brain and its fibre extends into the spinal cord.

Sympathetic nervous system

- Structure of the Sympathetic Division
  - Pathway from Spinal Cord to Sympathetic Trunk Ganglia
  - Organization of Sympathetic Trunk Ganglia
  - Pathways from Sympathetic Trunk Ganglia to Visceral Effectors



Iris muscle: Pupil dilated

Salivary glands: Secretion inhibited

Blood vessels in heart : Vasoconstriction
Heart: Rate and force of contraction increased

Trachea and bronchi: Bronchodilation

Liver: Glycogen glucose conversion increased

Stomach: Peristalsis reduced
Sphincters closed
Intestines: Peristalsis and tone decreased
Vasoconstriction

Kidney: Urine secretion decreased

Bladder: Smooth muscle wall relaxed
Sphincter closed
Sex organs: Generally Vasoconstriction

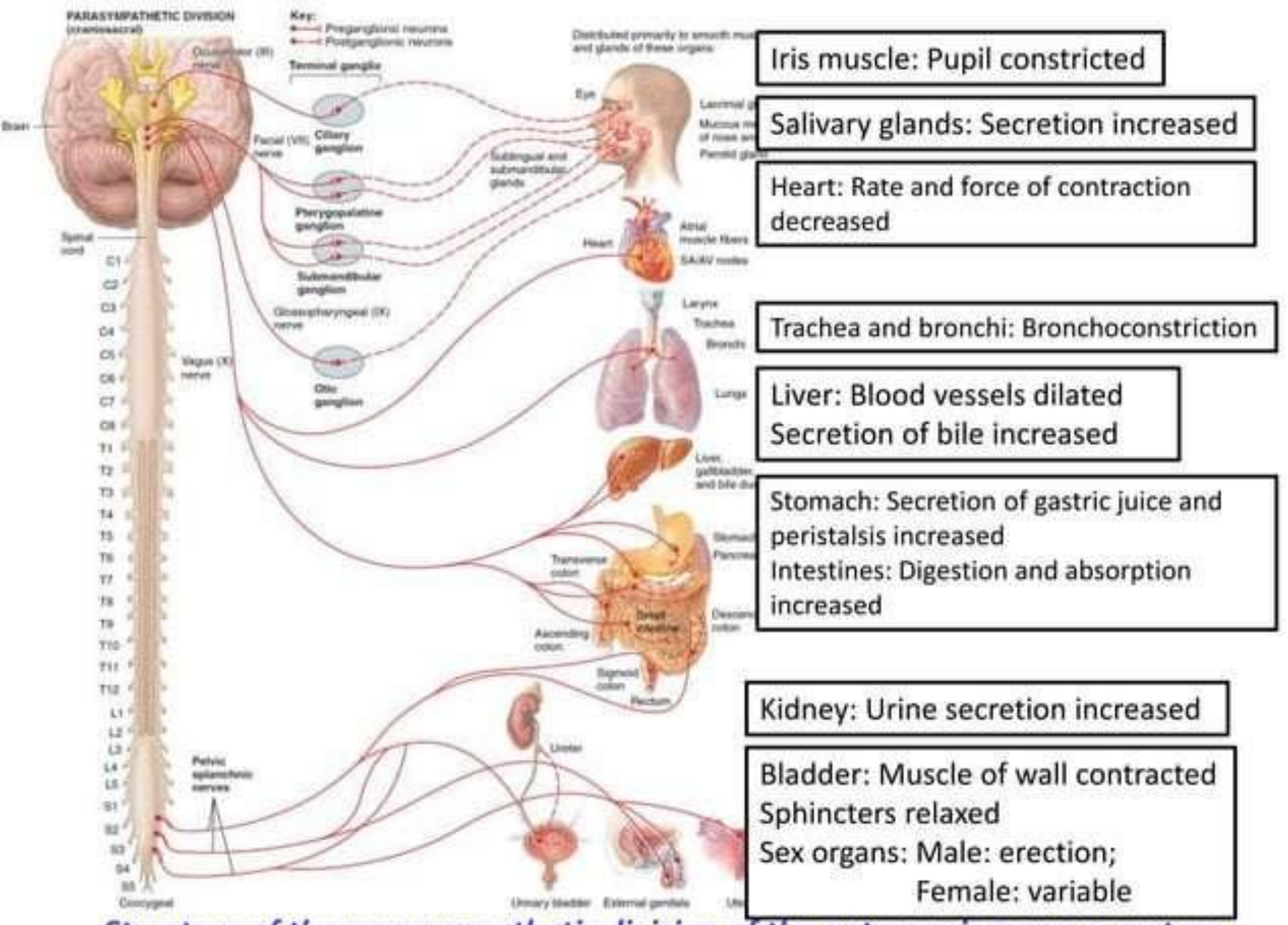
Structure of the sympathetic division of the autonomic nervous system

Parasympathetic nervous system

- Parasympathetic nervous system otherwise called as craniosacral outflow.
- **Parasympathetic stimulation** has a **tendency to slow down body** processes **except digestion and absorption of food** and **the functions of the genitourinary systems**. Its general effect is that of a '**peace maker**' allowing restoration processes to occur quietly and peacefully.
- Cell bodies of parasympathetic preganglionic neurons are found in nuclei in the brain stem.

Parasympathetic nervous system

- Structure of the Parasympathetic Division
  - The cranial parasympathetic outflow consists of preganglionic axons that extend from the brain stem in four cranial nerves. The cranial outflow has four pairs of ganglia and the ganglia associated with the vagus (X) nerve.
  - The sacral parasympathetic outflow consists of preganglionic axons in anterior roots of the second through fourth sacral spinal nerves.



Iris muscle: Pupil constricted

Salivary glands: Secretion increased

Heart: Rate and force of contraction decreased

Trachea and bronchi: Bronchoconstriction

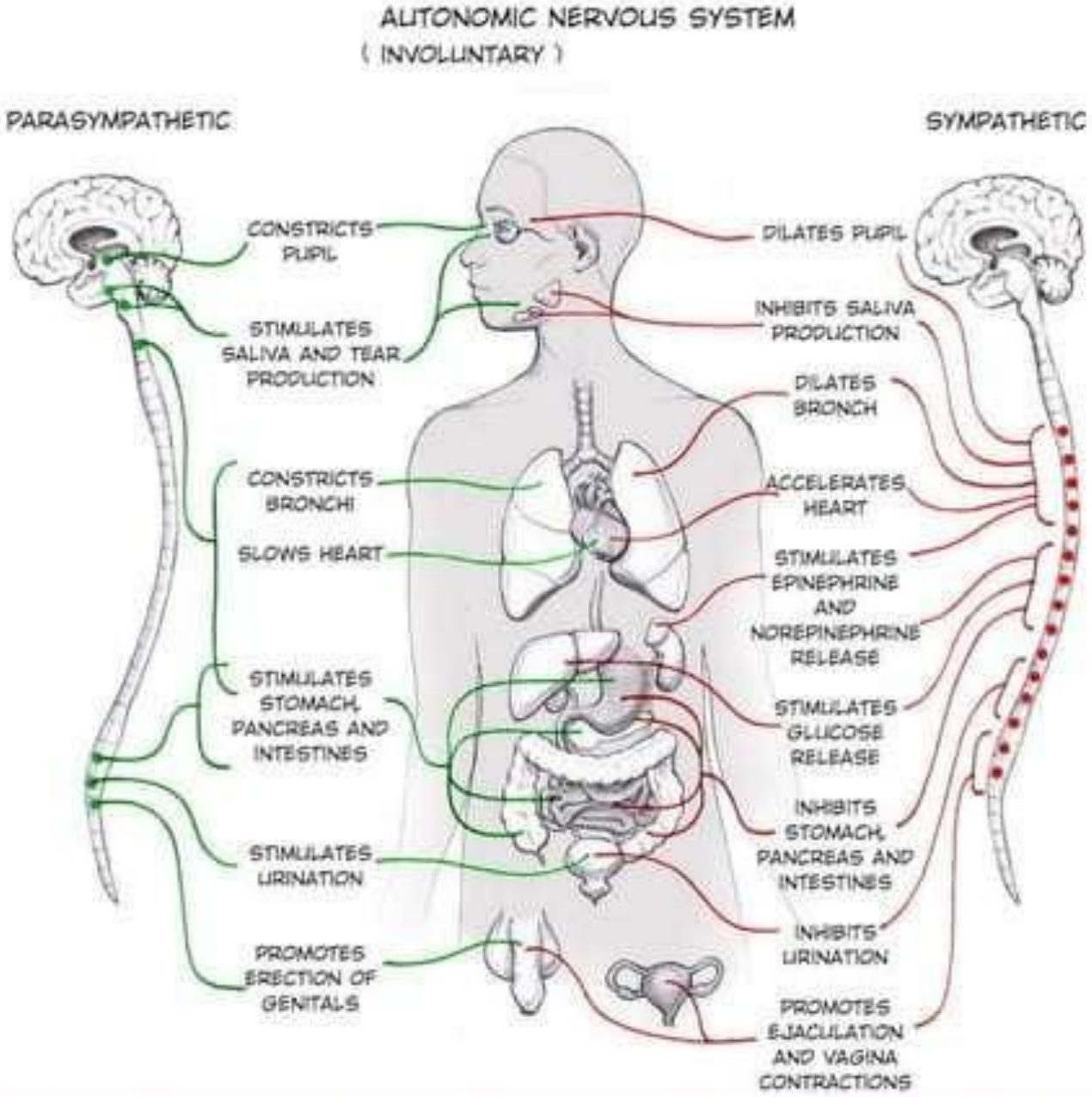
Liver: Blood vessels dilated
Secretion of bile increased

Stomach: Secretion of gastric juice and peristalsis increased
Intestines: Digestion and absorption increased

Kidney: Urine secretion increased

Bladder: Muscle of wall contracted
Sphincters relaxed
Sex organs: Male: erection;
Female: variable

Structure of the parasympathetic division of the autonomic nervous system



Ref: https://backyardbrains.com/experiments/img/AutonomicNervousSystem_web.jpg

Autonomic Motor Pathways

Autonomic Motor Pathways

- Each division of the ANS has two motor neurons (**preganglionic** and **postganglionic neuron**).
- **Preganglionic Neurons**
  - In the **sympathetic division (thoracolumbar division/ thoracolumbar outflow)**, the preganglionic neurons have their cell bodies in the lateral horns of the gray matter in the 12 thoracic segments and the first two (and sometimes three) lumbar segments of the spinal cord.
  - In the para**sympathetic division (craniosacral division/ craniosacral outflow)**, the preganglionic neurons have their cell bodies in in the nuclei of four cranial nerves in the brain stem (III, VII, IX, and X) and in the lateral gray matter of the second through fourth sacral segments of the spinal cord.

Autonomic Motor Pathways

Preganglionic Neurons

- **Autonomic Ganglia**
  - There are two major groups of autonomic ganglia
    - sympathetic ganglia
    - parasympathetic ganglia
- Sympathetic Ganglia:
  - The sympathetic ganglia are the sites of synapses between sympathetic preganglionic and postganglionic neurons.
  - There are two major types of sympathetic ganglia:
    - **sympathetic trunk ganglia** (also called vertebral chain ganglia or paravertebral ganglia)
    - **prevertebral ganglia** (collateral)- Five types of prevertebral ganglia are celiac ganglion, superior mesenteric ganglion, inferior mesenteric ganglion, aorticorenal ganglion and renal ganglion.

Autonomic Motor Pathways

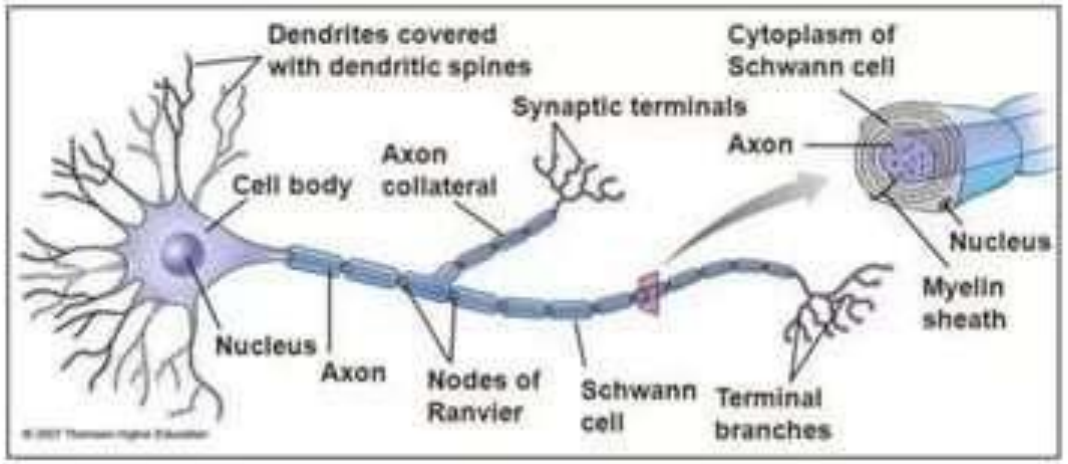
Preganglionic Neurons

- **Autonomic Ganglia**
  - There are two major groups of autonomic ganglia
    - sympathetic ganglia
    - parasympathetic ganglia
- parasympathetic ganglia:
  - Preganglionic axons of the parasympathetic division synapse with postganglionic neurons in terminal (intramural) ganglia. They are the ciliary ganglion, pterygopalatine ganglion, submandibular ganglion, and otic ganglion

Autonomic Motor Pathways

Postganglionic Neurons

- Once axons of sympathetic preganglionic neurons pass to sympathetic trunk ganglia, they may connect with postganglionic neurons.
- A **single sympathetic preganglionic fiber** has many axon collaterals (branches) and may **synapse with 20 or more postganglionic neurons**.



Autonomic Motor Pathways

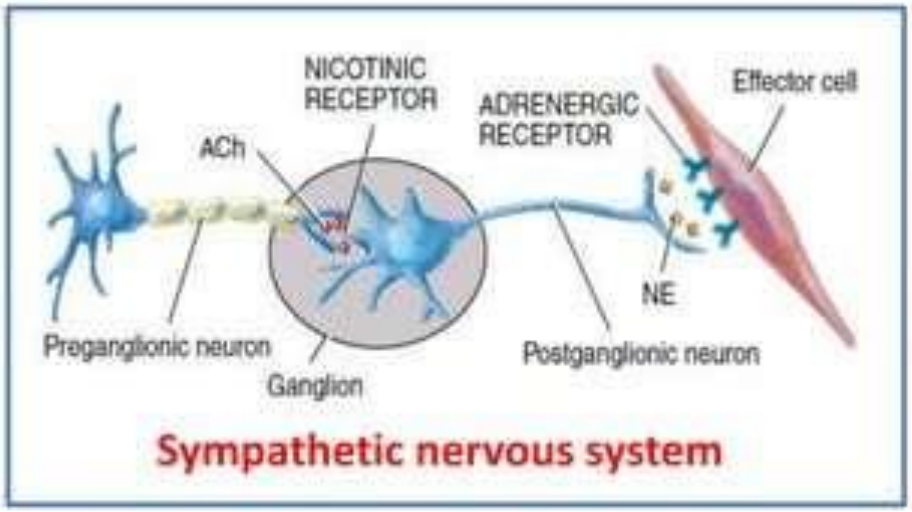
Postganglionic Neurons

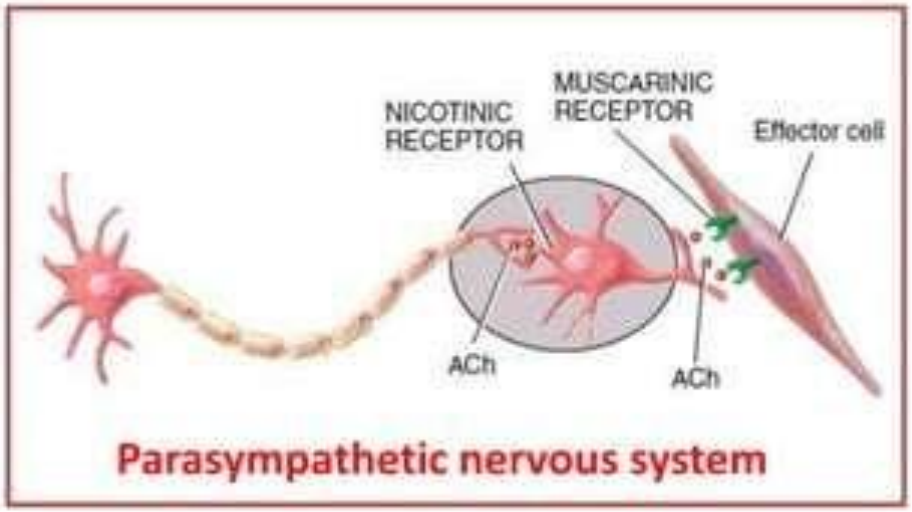
- Axons of preganglionic neurons of the **parasympathetic division** pass to terminal ganglia near or within a visceral effector. In the ganglion, the **presynaptic neuron usually synapses with only four or five postsynaptic neurons**, all of which supply a single visceral effector, allowing parasympathetic responses to be localized to a single effector.

Autonomic Receptors

ANS Neurotransmitters and Receptors

ANS	Receptor	Receptor Sub-type
Parasympathetic nervous system	Nicotinic cholinergic receptors	Nn, Nm
	Muscarinic cholinergic receptors	M1, M2, M3, M4, M5
Sympathetic nervous system	α adrenergic receptor	α1, α2
	β adrenergic receptor	β1, β2, β3



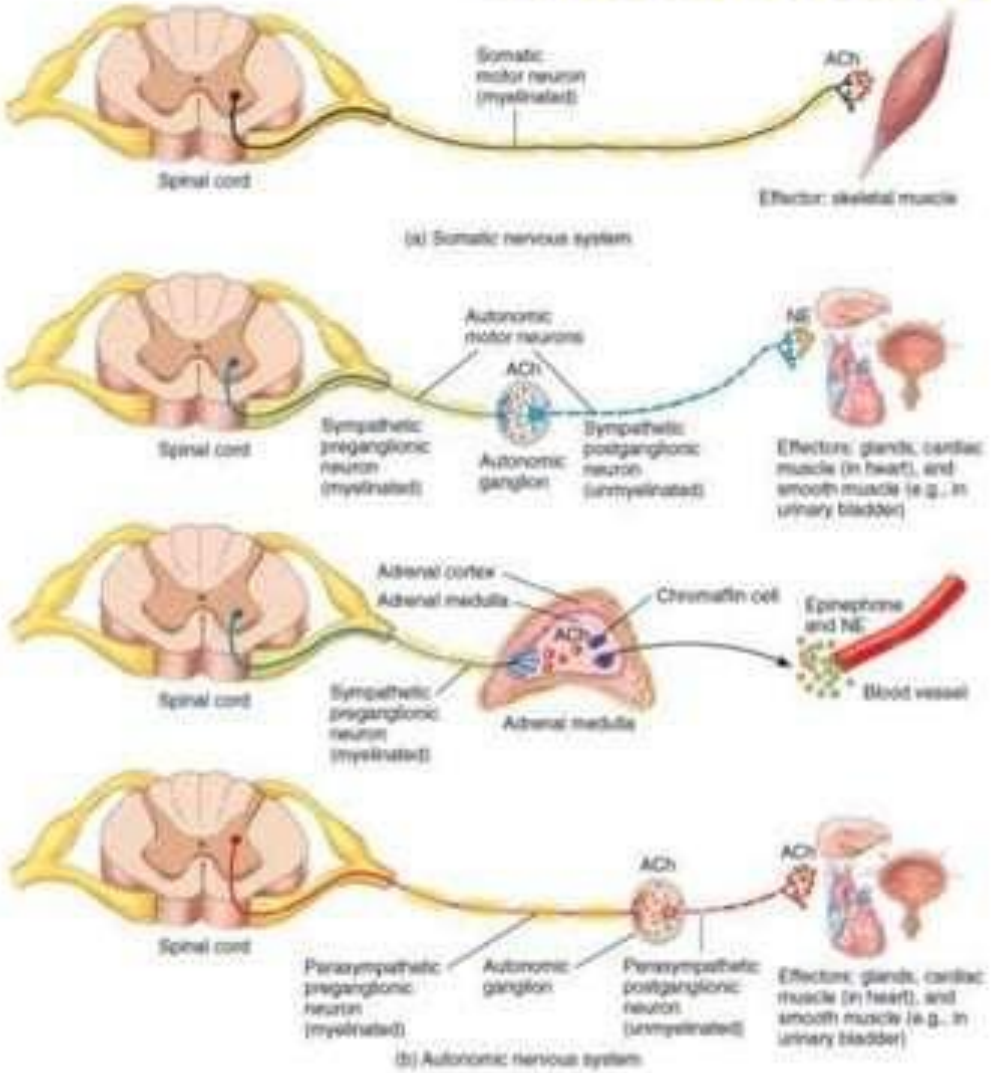


Comparison of Somatic and Autonomic Motor Neurons

Comparison of Somatic and Autonomic Motor Neurons

Somatic	Autonomic
Voluntary effectors: striated muscles	Involuntary effectors: smooth & cardiac muscles, glands
single motor neuron from spinal cord to target organ	usually 2 neurons with synapse (ganglion) between from spinal cord to target organ
Neurotransmitter always stimulatory	Neurotransmitter stimulatory or inhibitory
ACh released at synapse	ACh and NE released at synapses
No firing at rest	Baseline firing – speeds up when Stimulated
Effector at rest is flaccid	Effector at rest has intrinsic tone

Comparison of Somatic and Autonomic Motor Neurons



Motor neuron pathways in the (a) somatic nervous system and (b) autonomic nervous system

Thank you