

# The parasympathetic nervous system



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# The role of the autonomic nervous system

## **Claude Bernard**

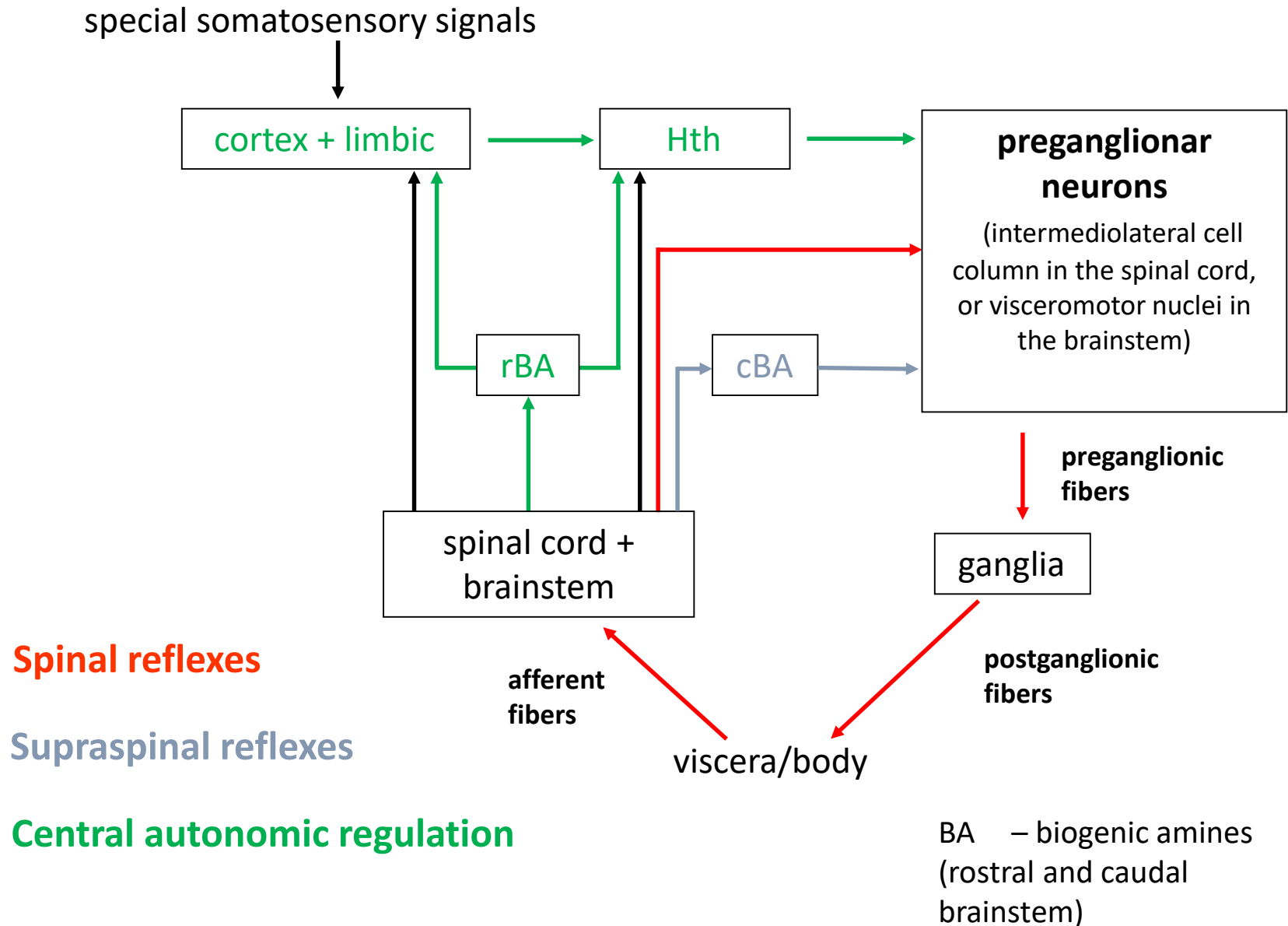
- „milieu intérieur” concept; every organism lives in its internal environment that is constant and independent from the external environment

## **Walter Bradford Cannon**

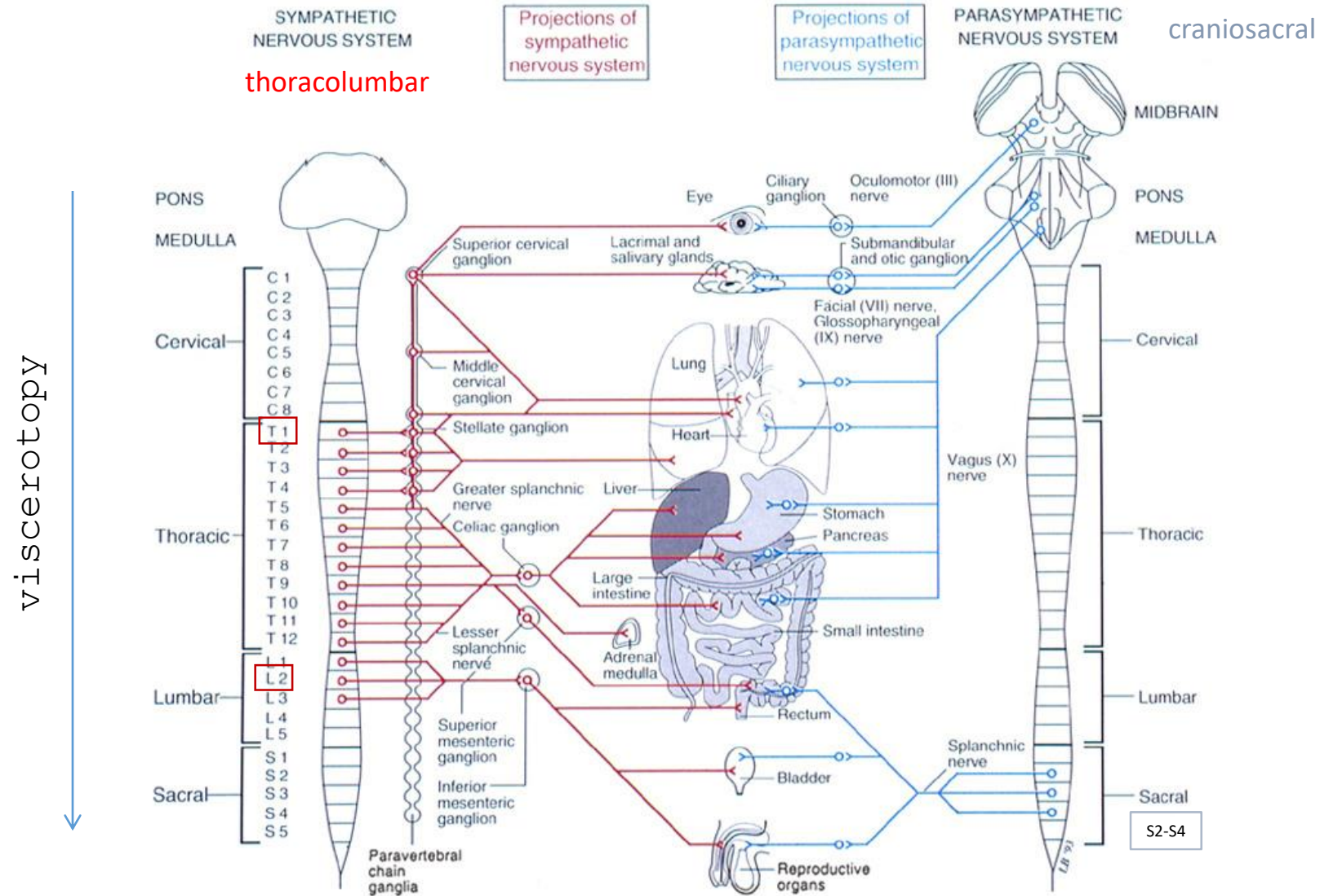
homeostasis;

- an extension of the “milieu interieur” concept
- consistence in an open system requires mechanisms that act to maintain that consistency
- steady-state conditions require that any tendency toward change automatically meets with factors that resist that change
- *regulating systems that determine the homeostatic state :*
  - *autonomic nervous system ( sympathetic, parasympathetic, enteral)*
  - *endocrine system*

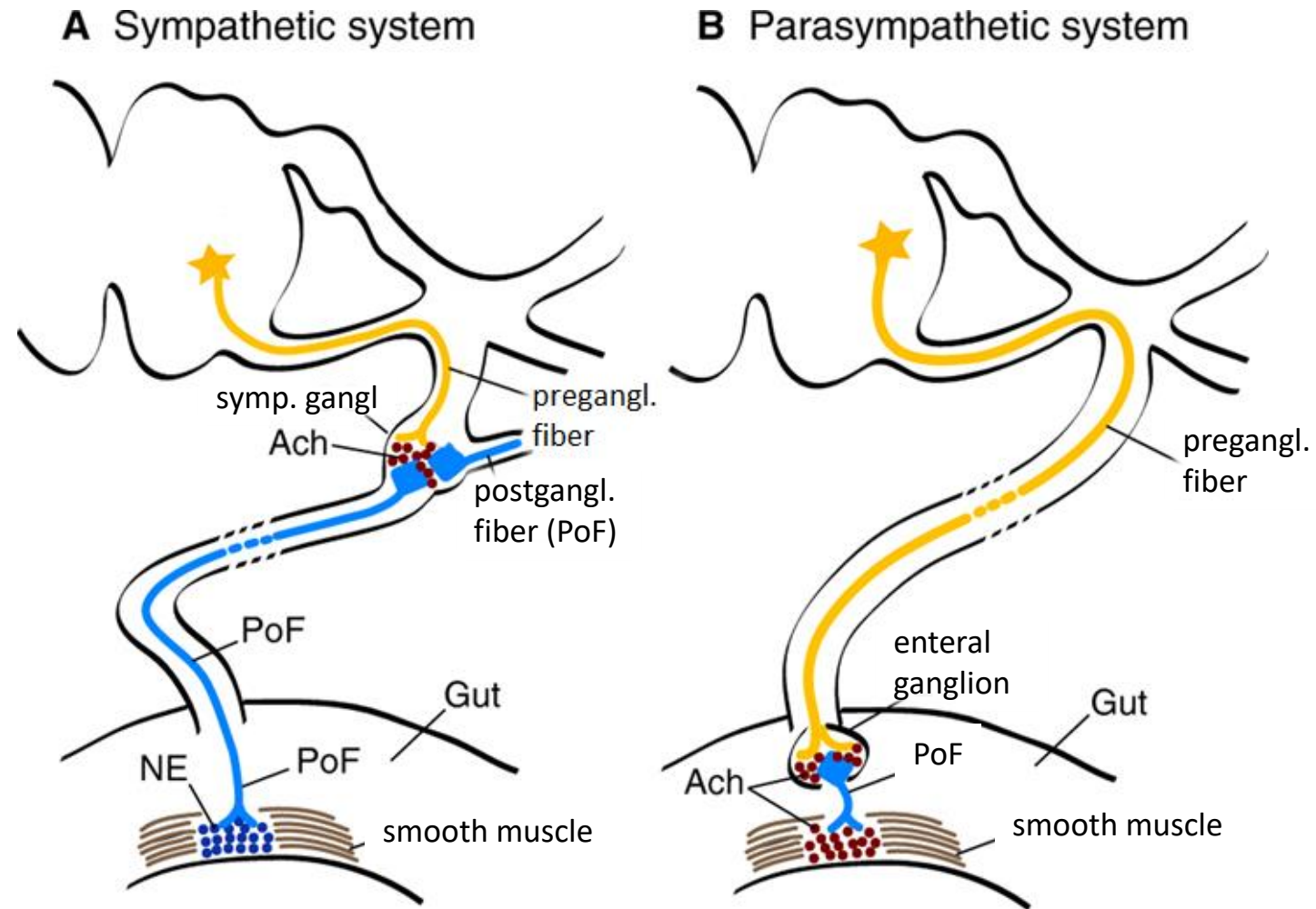
# Organization of the autonomic nervous system



# General structure of the autonomic nervous system

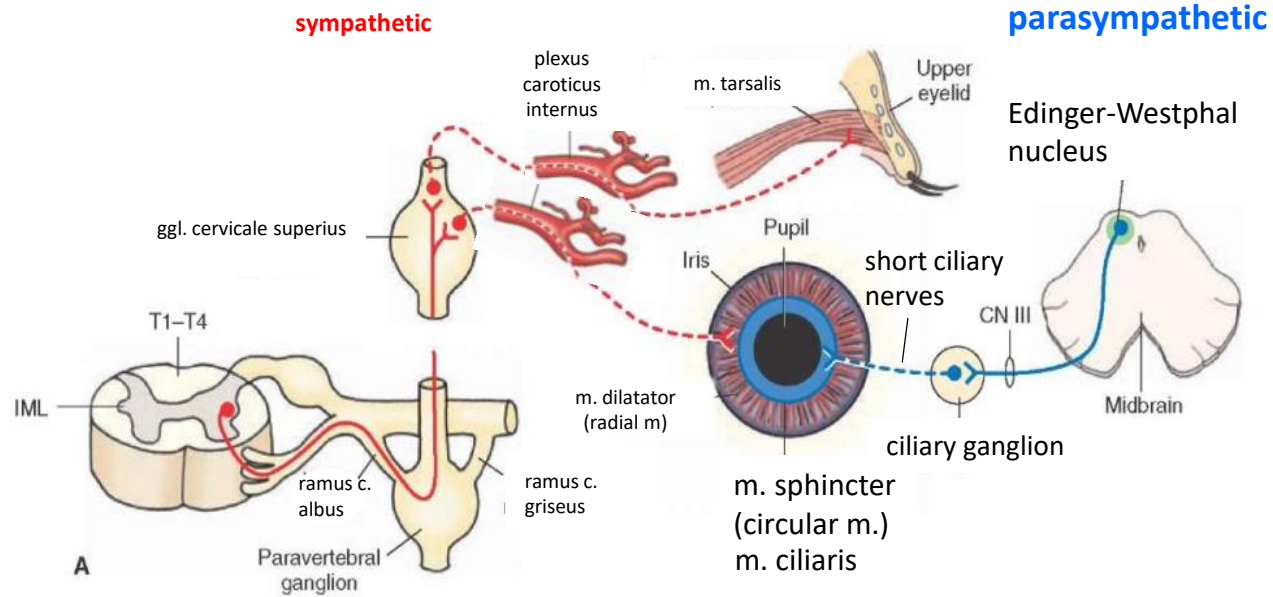


# Neurotransmitters



Kuratani S Development 2009;136:1585-1589

# Parasympathetic innervation of the iris

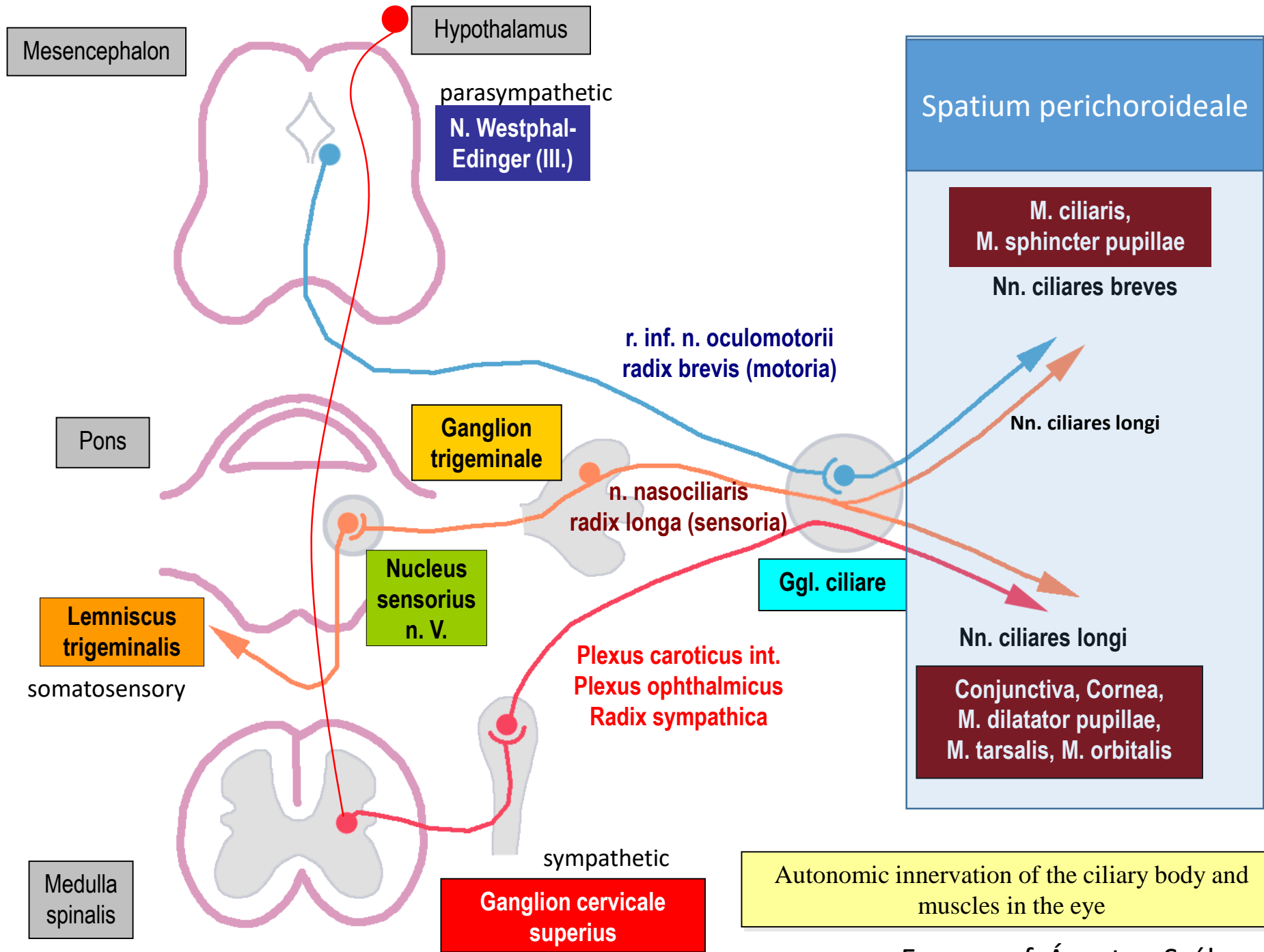


**Preganglionic fibers:** Edinger-Westphal nucleus, CN III

**Relay:** ciliary ganglion

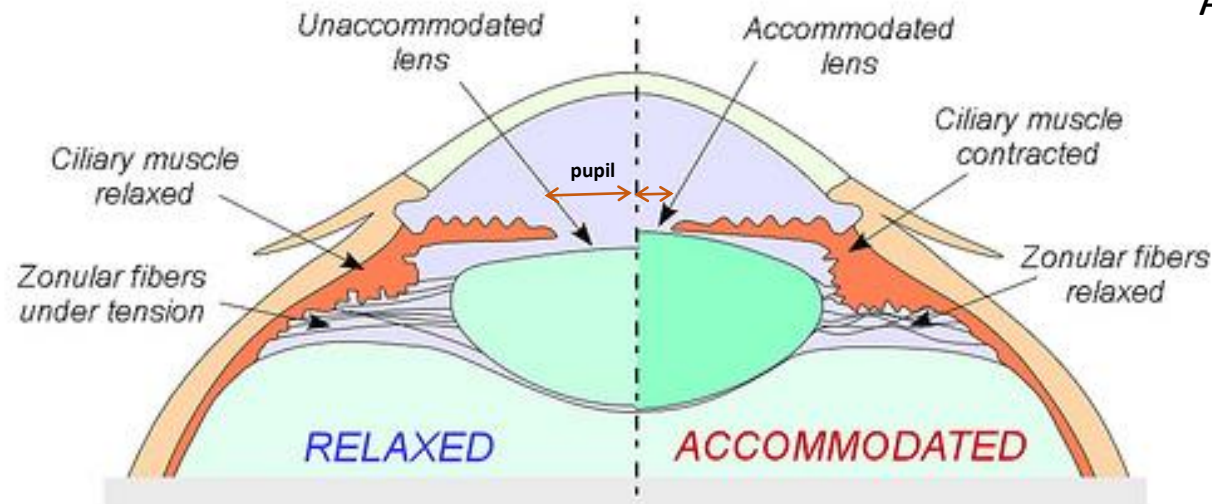
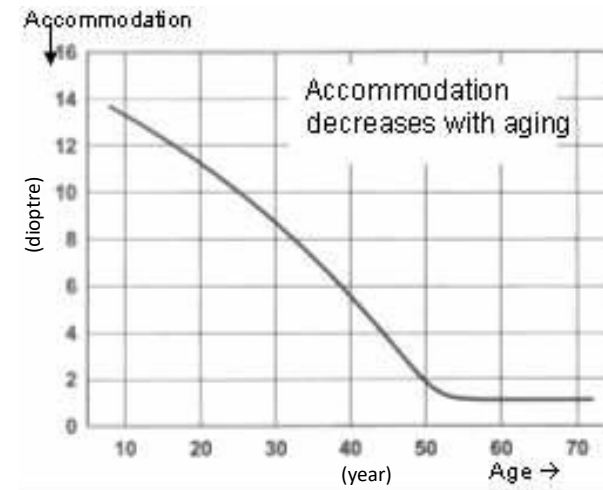
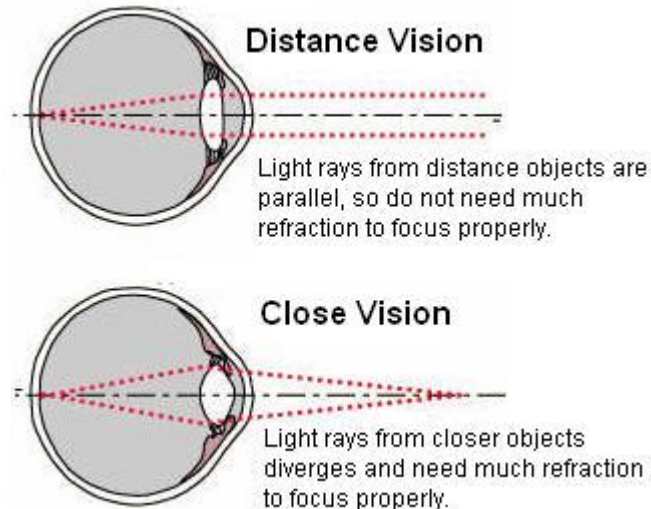
**Postganglionic fibers:** short ciliary nerves

**Function:** constriction of the pupil (miosis) and the ciliary muscle (accommodation)



From prof. Ágoston Szél

# Accomodation



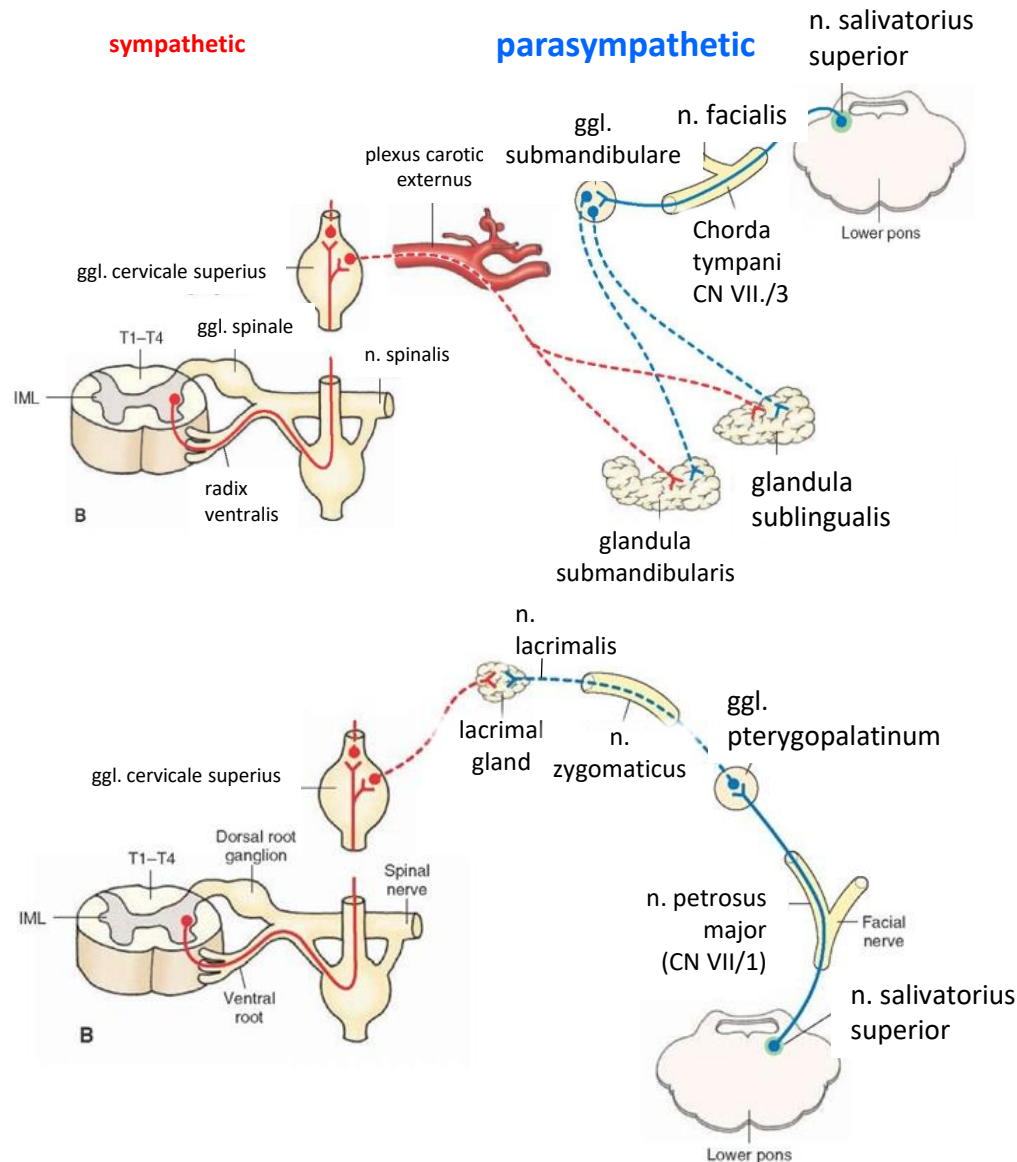
ACCOMMODATION IN THE NORMAL EYE

## Actions during accomodation:

1. Pupil constiction (paraszimp.)
2. Ciliary muscle contract (parasymp.)
3. Convergence of m. rectus medialis



# Parasympathetic innervation the submandibular, sublingual and lacrimal glands



## **Submandibular and sublingual glands**

### **Preganglionic fibers:**

- superior salivatory nucleus, chorda tympani (CN VII/3)

**Relay:** submandibular ganglion

**Function:** secretion of watery saliva

## **Lacrimal gland**

### **Preganglionic fibers:**

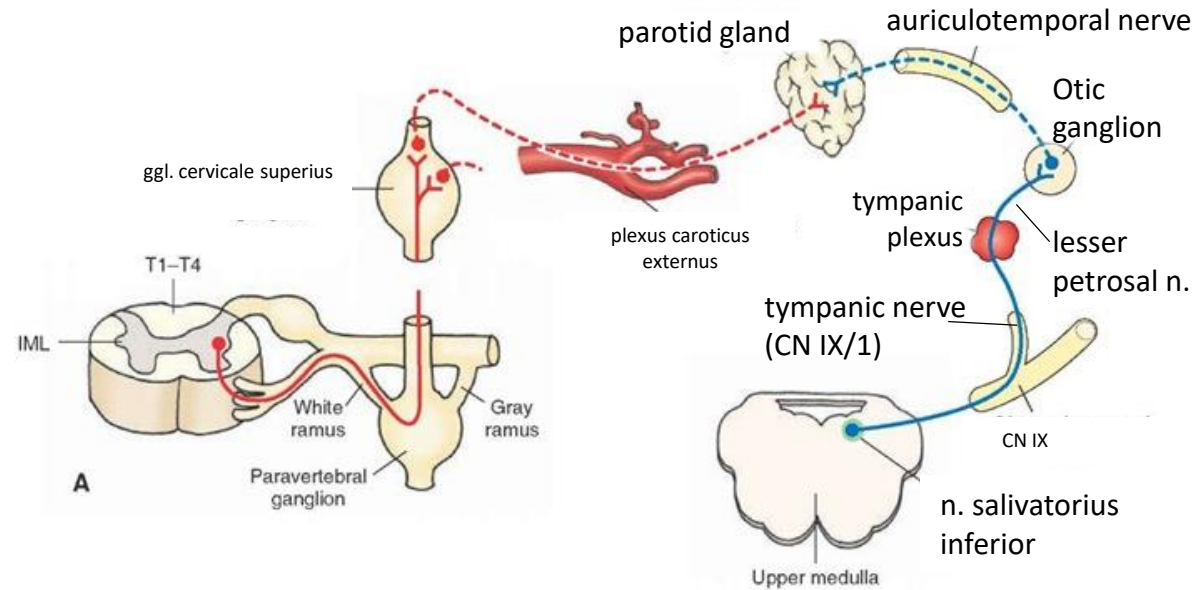
- superior salivatory nucleus, greater petrosal nerve (CN VII/1)

**Relay:** pterygopalatin ganglion

**Postganglionic fibers:** zygomatic nerve, communicating branch, lacrimal nerve

**Function:** secretion of tears

# Parasympathetic innervation of the parotid gland



**Preganglionic fibers:** inferior salivatory nucleus, glossopharyngeal nerve (CN IX)

tympanic nerve (CN IX/1), tympanic plexus, lesser petrosal nerve

**Relay:** otic ganglion

**Postganglionic fibers:** auriculotemporal nerve (V/3)

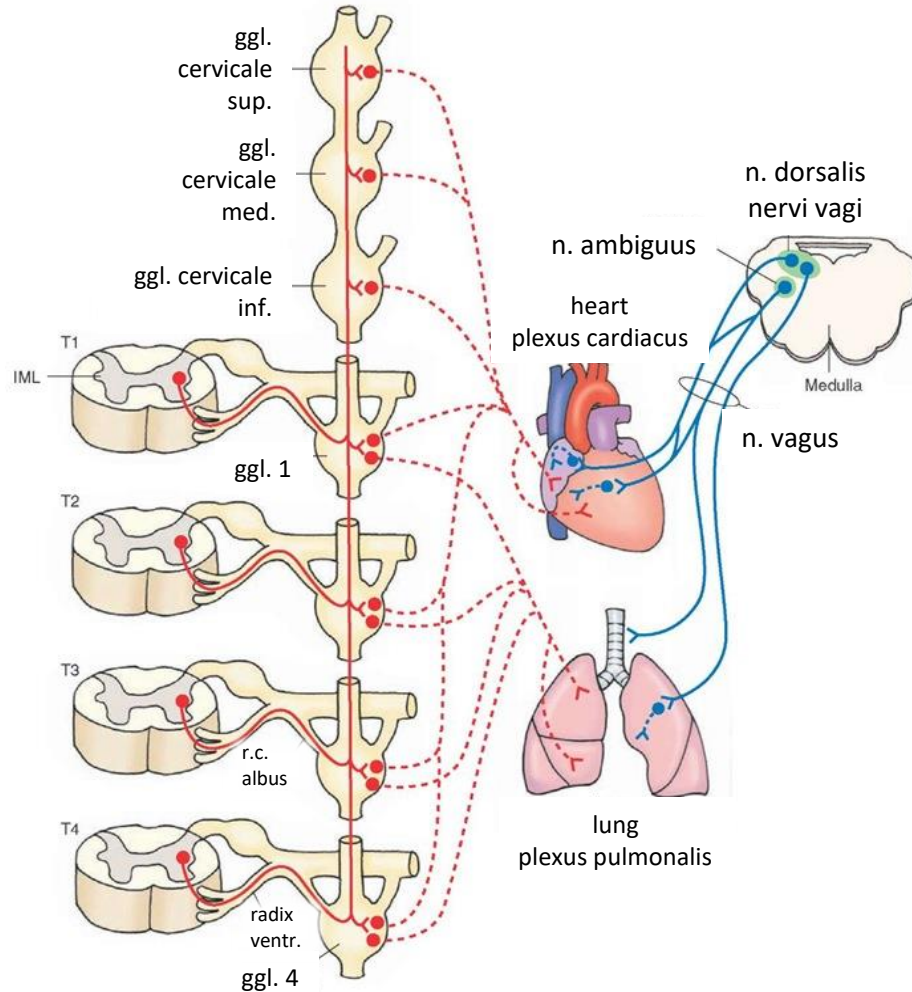
**Function:** secretion of watery saliva

# Parasympathetic innervation of the heart and lung

The vagus or “wandering” nerve

sympathetic

parasympathetic



## Heart:

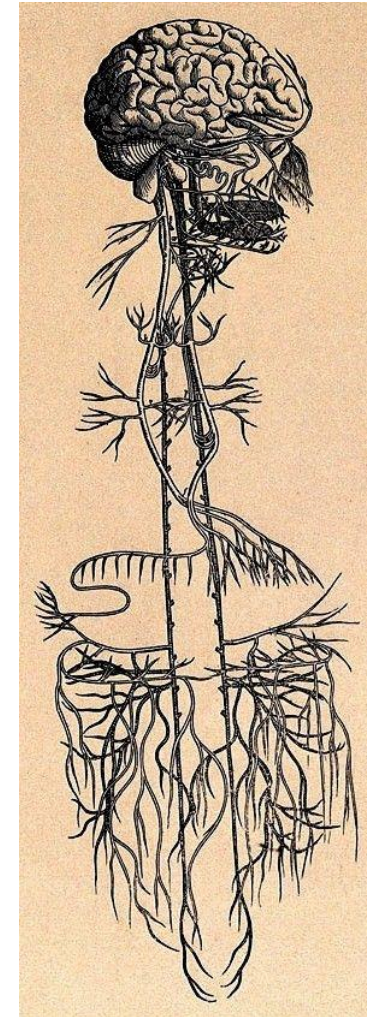
- **Preganglionic fibers:** n. ambiguus, dorsal motor nucleus of vagus- vagus nerve
- **Relay:** cardiac plexus
- **Function:** fibers innervate SA and AV nodes, - heart rate decreases, force does not change

## Lung:

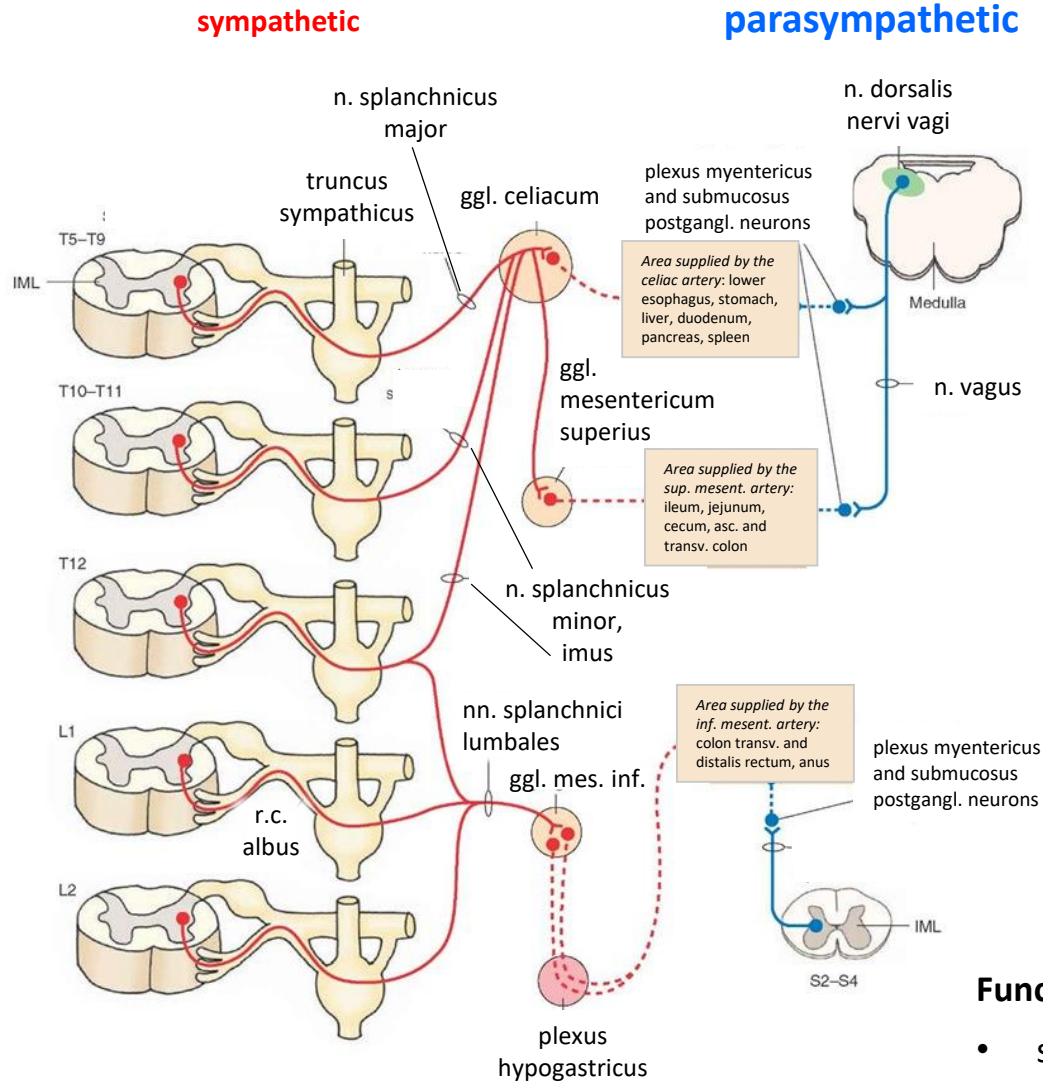
- **Preganglionic fibers:** dorsal motor nucleus of vagus- vagus nerve
- **Relay:** pulmonal plexus
- **Function:**-bronchoconstriction, increase in the secretion of the bronchial glands

## Others:

- pharynx, larynx –vagus – innervation of the musculature
- *pia mater vessels vasodilatation!*
- corpus pineale no functional relevance



# Parasympathetic innervation of the GI tract



## From the esophagus till the Cannon point

esophagus, stomach, liver, spleen, pancreas, small intestine, cecum, ascending and transverse (2/3rd) colon:

- **Preganglionic fibers:** dorsal motor nucleus of vagus, vagus nerve
- **Relay:** submucosal and myenteric plexuses

## From the Cannon point

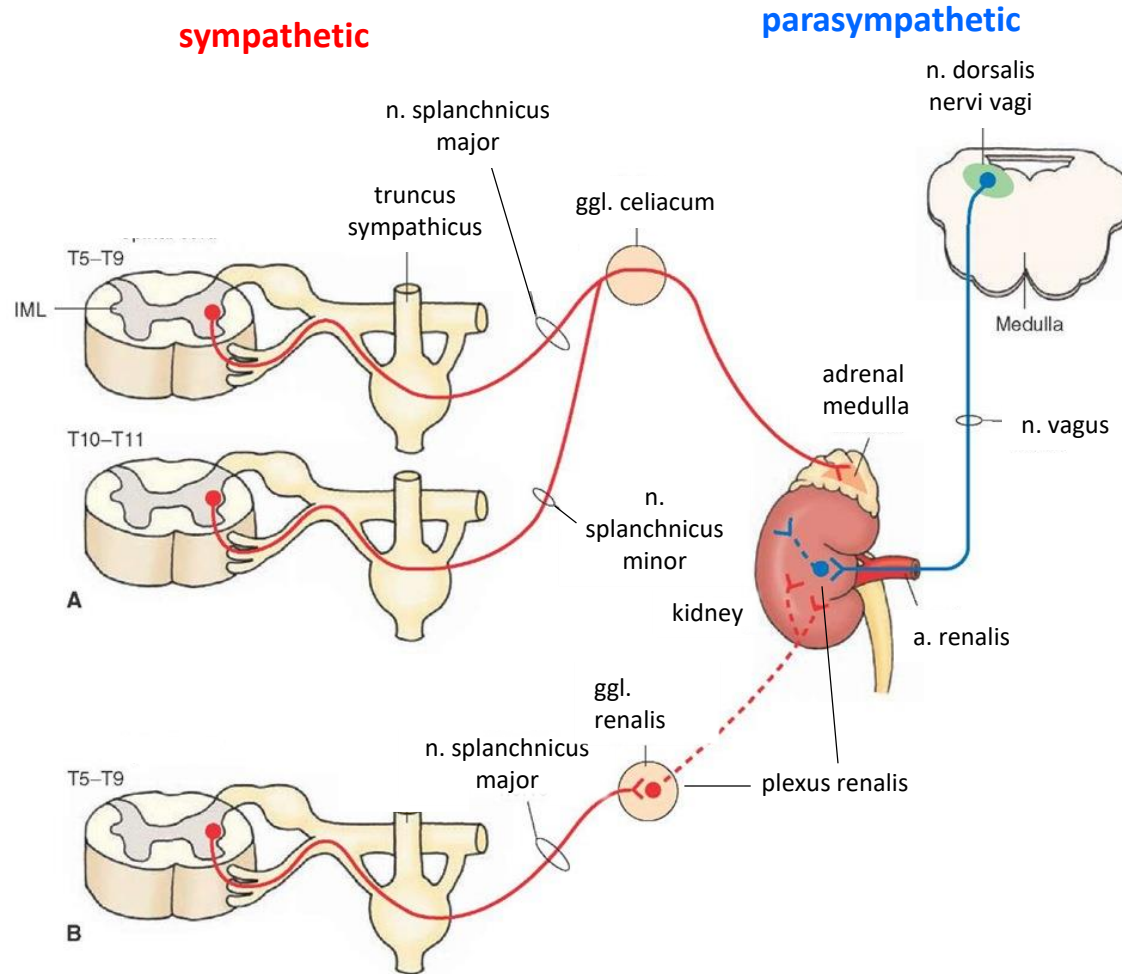
Transverse (1/3rd), descending, sigmoid colon, rectum, anus:

- **Preganglionic fibers:** IML S2-S4, ventral root of the spinal nerves, pelvic nerves
- **Relay:** submucosal and myenteric plexuses

## Functions:

- stimulation of peristalsis and secretions of glands
- relaxation of the sphincters
- no direct effect on vessels

# Parasympathetic innervation of the kidney

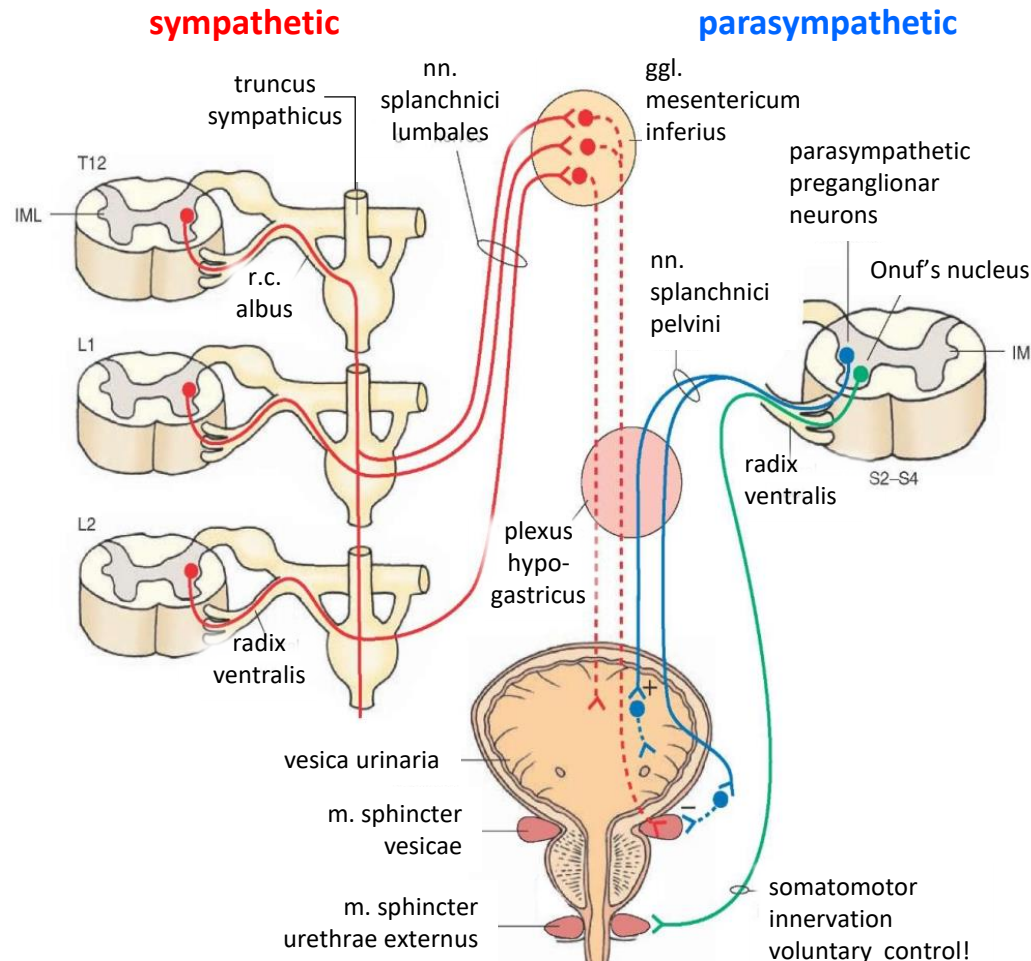


## Parasympathetic:

- **Preganglionic:** dorsal motor nucleus, of vagus, vagus nerve
- **Relay:** renal plexus
- functional relevance is questioned

**Effects on kidney arteries:**  
sympathetic: vasoconstriction

# Autonomic innervation of the bladder



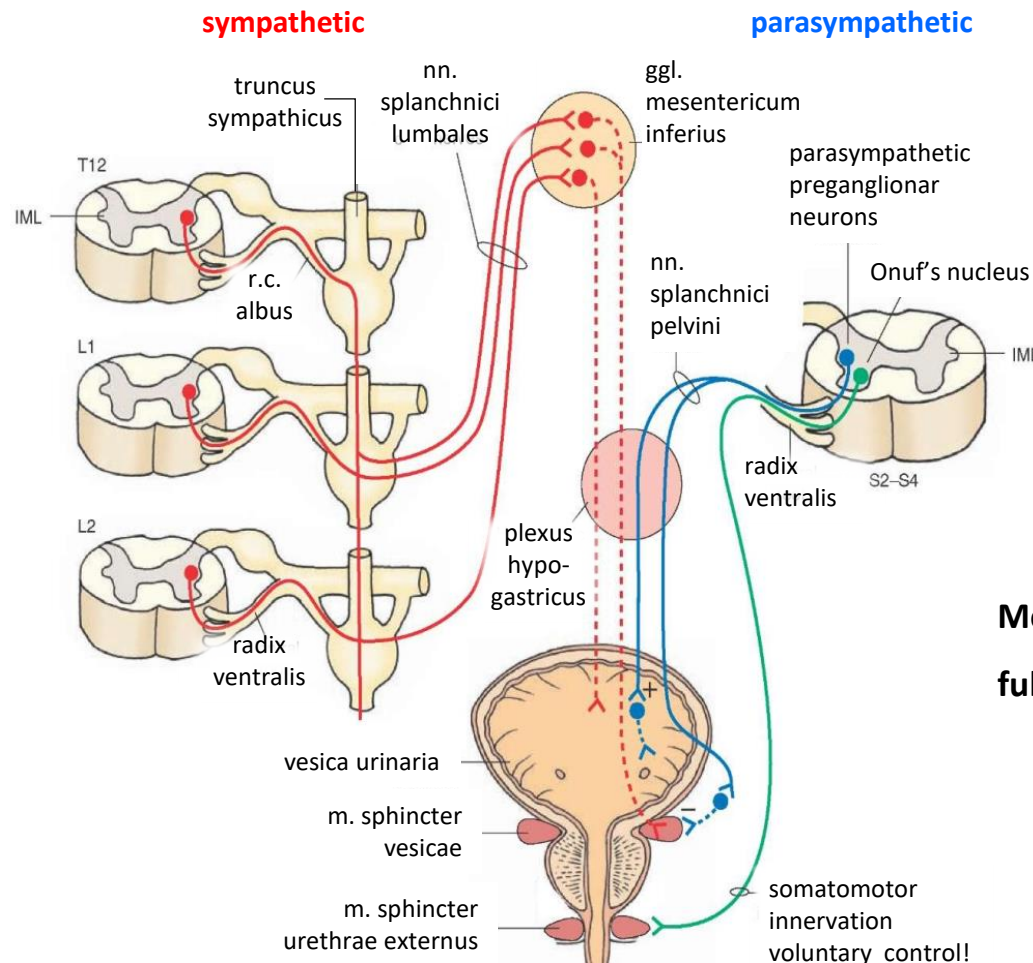
## Sympathetic:

- **Preganglionic fibers:** IML T12-L2(3), lumbar splanchnic nerves
- **Relay:** A, inferior mesenteric ganglion  
B, inferior hypogastric plexus (rectal, uterovaginal, prostatic and vesical plexuses)
- **Postganglionic fibers:** pelvic and hypogastric nerves

## Parasympathetic:

- **Preganglionic fibers:** IML S2-S4, ventral roots, **nn. splanchnici pelvini**, passing through the hypogastric plexus
- **Relay:** postganglionic neurons in the bladder wall

# Control of micruition



## Sympathetic effects

**Allows the bladder to fill, inhibits emptying:**

- closing the internal sphincter
- relaxing the detrusor muscle (bladderwall)

## Parasympathetic effects

**Allows the bladder to empty:**

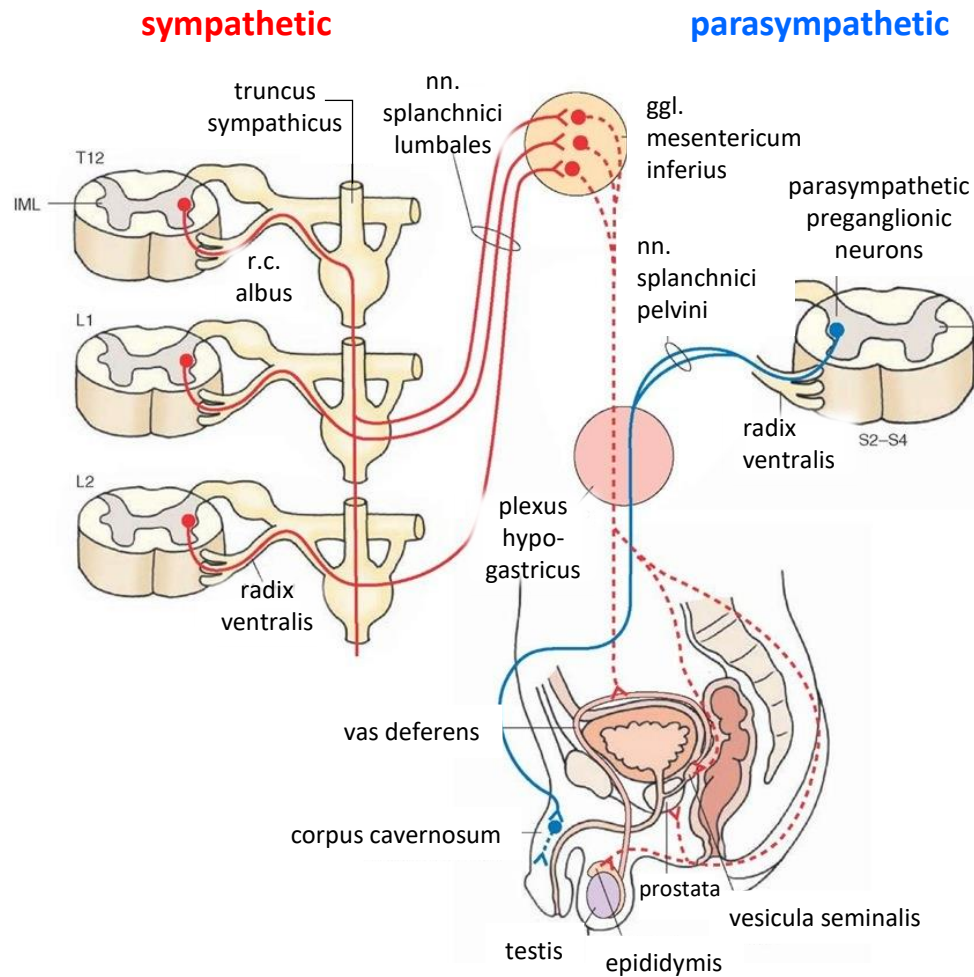
- relaxing the internal sphincter
- contraction the detrusor muscle

**Moderate bladder distension inhibits parasympathetic activity, fullness of the bladder stimulates it (afferents).**

**Voluntary control of m. sphincter urethrae externus:**

- S2-4 ventral horn alpha motoneurons (Onuf's n.)
- tonic activity
- central coordination: pons and higher centers

# Autonomic innervation of the sexual organs



## Sympathetic:

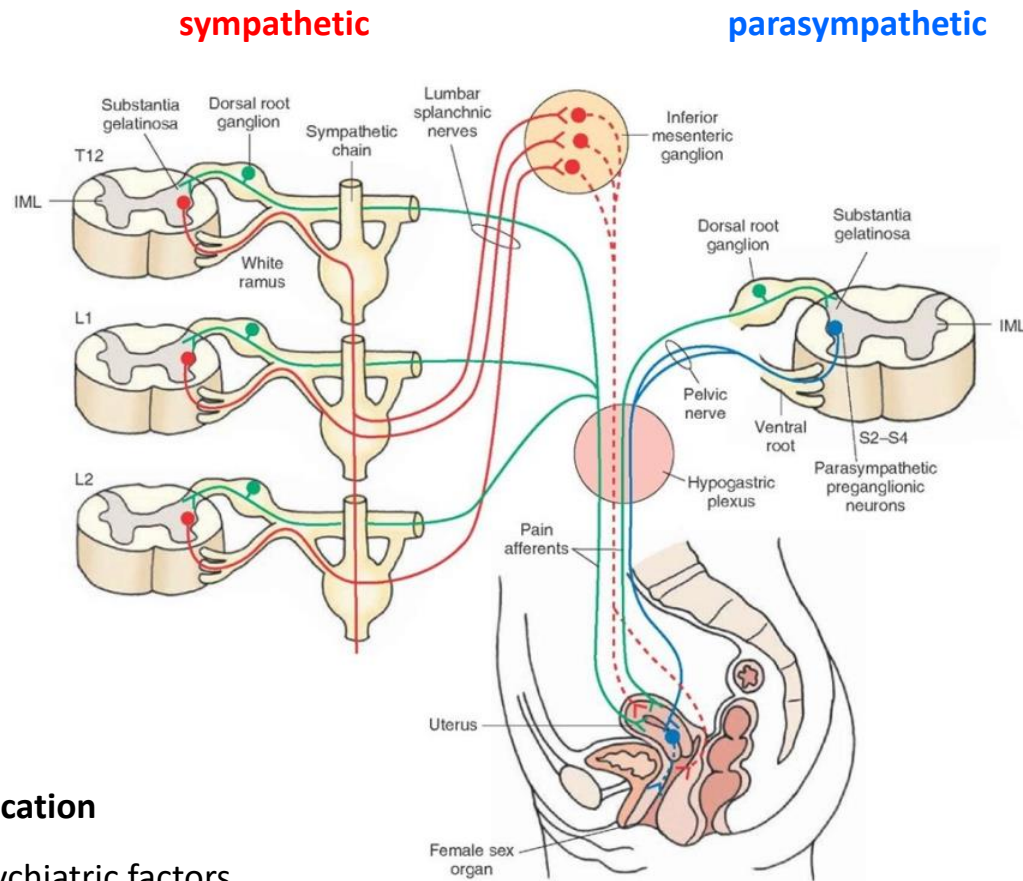
- **Preganglionic fibers:** IML T12-L2(3), lumbar splanchnic nerves
- **Relay:**
  - A, inferior mesenteric ganglion (epididymis, vas deferens, seminal vesicles, and prostate glands/ vagina, uterus)
  - B, inferior hypogastric plexus (penis/clitoris)
- **Postganglionic fibers:** pelvic and hypogastric nerves

## Parasympathetic:

- **Preganglionic fibers:** IML S2-S4, ventral roots, **nn. splanchnici pelvini**, passing through the hypogastric plexus
- **Relay:** neurons in corpora cavernosa or clitoris



# Autonomic innervation of the sexual organs



## Modification

- psychiatric factors
- somatosensory inputs
- integration in higher centers (cortex, limbic system, sexually dimorph nuclei)

## Parasympathetic effects

- dilation of the arteries
- increased blood flow in the corpora cavernosa causes erection

## Non-adrenergic and non-cholinergic terminals:

- nitric oxide (NO) release
- cGMP level increase in the nonvascular smooth muscle -relaxation
- indirect contribution to erection

## Sympathetic effects

- contraction of smooth muscles;
- vas deferens, seminal vesicles, and prostate - ejaculation
- contraction of uterine musculature

**Thank you for your attention!**