

# Autonomic nervous system

# AUTONOMIC NERVOUS SYSTEM

- **autonomic nervous system participates in innervation of the visceral part of body, it controls autonomic functions, which takes place independently of our will**
- **It is consist of visceromotor nerve fibers**
- **It makes sensory innervation of visceral organs, vessels, motor innervation of smooth muscle and myocardium and glandular cells**
- **It includes neurons of CNS and PNS**
- **central part – hypothalamus**, reticular formation  
medulla oblongata, spinal cord, cortex
- **peripheral part** – nerve fibers (cranial nerves, spinal nerves)

# Types of stimuli

- Nuclei within CNS → **visceromotor fibers** – through anterior roots of spinal cord → autonomic ganglia along the spine – to the organs of abdomen, thorax, pelvis
- Free nerve endings in the wall of organs → pressure, thrust, pain- **viscerosensory** → autonomic ggl.- to posterior roots of spinal cord - ggl. spinale or ggl. VII., IX., X. and into visceromotor nuclei

- **Autonomic tracts don't go from CNS directly – they switch over in ganglia outside CNS**
- They are formed at least by two neurons, which switch over in so-called **autonomic ganglion**
- **Preganglionic neuron** : myelinated axon that goes from CNS to autonomic ganglion
- **Postganglionic neuron**: unmyelinated axon that goes from autonomic ganglion as a proper autonomic nerve

- autonomic (visceromotor) nerve fibers are of two types  
**sympathetic** *pars sympathica*  
**parasympathetic** *pars parasympathica*
- Glands and smooth muscle of almost each visceral organ are innervated by both sympathetic and parasympathetic
- One system is usually activating and the other inhibiting
- Exception are **smooth muscle of the skin and skin glands**, which are innervated only by sympathetic

# Main functions

- Contraction and relaxation of smooth muscle
- Function of all exocrine and some endocrine glands
- Heart rhythm
- Some metabolic processes

# Division of autonomic nerve system

- sympathetic – *fight or flight*
- parasympathetic – *rest or digest*
- enteric system

**Sympathetic**

*fight or flight*

**Parasympathetic**

*rest or digest*



**Pars sympathica:** nuclei in CNS and in the spinal cord (C8 – L3)

**Pars parasympathica:** nuclei in CNS (which belong to the cranial nerves), spinal cord (S2 – S4)

**craniosacral system (parasympathetic)**

**thoracolumbar system (sympathetic)**

**cranio-sacral system (parasympathetic)**

***Sympathetic and parasympathetic system differ in the arrangement of ganglia:***

**Sympathetic ganglia:**

- are far from **target organs (at spine)** – paravertebral ganglia – **truncus sympathicus dexter et sinister**

**Parasympathetic ganglia:**

- **closer to organs (ganglion ciliare, pterygopalatinum, oticum, submandibulare + scattered within organ walls)**

**Mediators of sympathetic and parasympathetic system:**

- preganglionic – the same (from CNS) – acetylcholine
- postganglionic - sympathetic – noradrenalin
- postganglionic - parasympathetic - acetylcholine

# SYMPATHETIC

„thoracolumbar system“

- Arises from the thoracic and lumbar parts of the spinal cord – from nucl. intermediolateralis C8-L3- so-called **thoracolumbar system**
- it leaves the spinal nerve as *ramus communicans albus* - it ends in sympathetic ganglion next to the spine - **preganglionic** section - to **paravertebral ganglia**
- single paravertebral ganglia form *truncus sympathicus*
- from the ganglia arise proper sympathetic nerves, **postganglionic** section
- Sympathetic nerves enter through different way the innervated organs

# Functions

- It controls the **catabolic** functions, activates functions of the visceral organs
  - **it accelerates** the heart activity and breathing
  - It causes **contraction** of smooth muscle of vessels within the skin and visceral organs and thereby increases blood pressure
  - **It increases** level of sugar in blood
  - **It expands** pupils (mydriasis)
  - It conversely slows digestion
  - It induces a **state of wakefulness** and it is used in stress reactions

# Truncus sympathicus

- ganglion trunci sympathici (21-25) = *paravertebral ganglia*
- rr. intergaglionares
- rr. communicantes albus + griseus
- rr. vasculares – periarterial plexuses
- rr. viscerales=nn. splanchnici - to **prevertebral ganglia**

**Cervical part**

**Thoracic part**

**Abdominal part**

**Pelvic part**

# Cervical part

**Ganglion cervicale superius**

**Ganglion cervicale medium**

**Ganglion cervicothoracicum /  
stellatum**

- It forms periarterial plexuses around a. carotis ext. et int. – intake of sympathicus to neck and head
- ***nn. cardiaci*** – innervation of the heart

## **Ganglia thoracica (thoracic part)**

- 10 pairs of ganglia
- nn. splanchnici – for smooth muscle of GIT and its vessels
- rr. communicantes grisei - to intercostal nerves
- Branches to heart, lungs, esophagus

## **Ganglia lumbalia (lumbar, abdominal part)**

- 4-5 pairs of ganglia
- rr. communicantes grisei
- nn. splanchnici lumbales
- rr. vasculares

## **Ganglia sacralia (pelvic part)**

- 4 pairs of ganglia
- rr. communicantes grisei – for pelvic organs
- Periarterial plexuses



# Prevertebral ganglia and plexuses

- They are formed by fibers arising from paravertebral ganglia
- On the anterior wall of abdominal aorta
- Mixed plexus—  
**nn. splanchnici + n. vagus**

# Abdominal aortal ganglia

**PARASYMPATHETIC**

- **pars cranialis- III.,VII.,IX.,X.** (cranial parasympathetic)
- **pars sacralis S2-S4** (sacral parasympathetic) - **craniosacral system** - ganglia are located close to the innervated organs, preganglionic section is therefore long and postganglionic section is short
- mediator is **acetylcholin** in whole section - cholinergic system

# Functions

- **pars cranialis:** most important is parasympathetic part of *nervus vagus* – it innervates the digestive tract till the border between colon transversum and colon descendens in the abdominal cavity
- **pars sacralis:** it innervates the digestive tract from the border between colon transversum and colon descendens till rectum and visceral organs located in the pelvis (urinary bladder, genital organs except gonads)

It controls **anabolic reactions** – preservation of energy, it induces **inhibition of organism:**

- **It slows** heart activity and breathing
- **It decreases** blood pressure
- **It narrows** pupils (miosis)
- **It accelerates digestion**, sweating and salivation
- It is used especially **at rest (sleep)** and during digestion

# Parasympathetic = craniosacral system

- **Nuclei of cranial nerves:**
  - ncl. oculomotorius accessorius** to ganglion ciliare (m. sphincter pupillae, m. ciliaris)
  - ncl. salivatorius superior** (VII.) to ganglion pterygopalatinum and submandibulare (lacrimal gland, mucosa of nasal cavity, palate, tongue, gl. sublingualis and submandibularis)
  - ncl. salivatorius inferior** (IX.) to ganglion oticum (glandula parotis and small salivatory glands of cheek)
  - ncl. dorsalis n. X** (together with n. vagus to organs)
- **ncl. intermediolateralis S2-4** (pars sacralis, pelvica) – to pelvic organs **nn. splanchnici pelvici**

***ganglia are located within the skull or organs walls***

## Ganglion ciliare

- Here end preganglionic fibers of *n. oculomotorius*
- **parasympathetic** (*m. sphincter pupillae, m. ciliaris*)  
**sympathetic** (*m. dilatator pupillae*)

## Ganglion pterygopalatinum

- Here end preganglionic fibers of *n. facialis*
- *Mucosa of posterior part of nasal cavity, upper teeth, mucosa of hard palate, lacrimal gland*

## Ganglion submandibulare

- Here end preganglionic fibers of *n. facialis*
- *gl. sublingualis, gl. submandibularis, salivary glands of tongue and bottom of oral cavity*

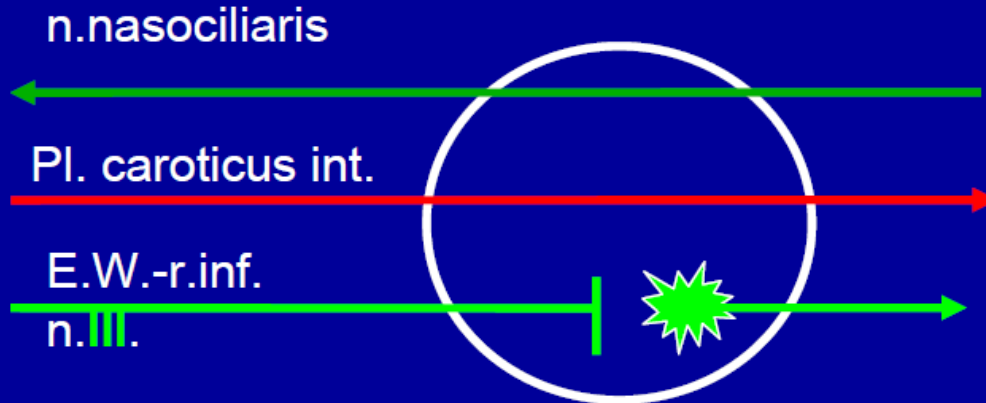
## Ganglion oticum

- Here end preganglionic fibers of *n. glossopharyngeus*
- *skin, mucosa, teeth and gingiva of lower jaw, gl. parotidea*

Preganglionic fibers of ***n. vagus*** end in prevertebral ganglia of thoracic and abdominal cavity

Preganglionic fibers of ***sacral parasympathetic*** are switched over in pelvic plexuses

## Ggl. ciliare



## nn.ciliares breves

m.dilator pupillae

mydriasa

m.sphincter pupillae, m. ciliaris

Miosa, akomodace

## Ggl. pterygopalatinum



rr.nasales posteriores sup. et inf.

n.palatinus major

nn.palatini minores

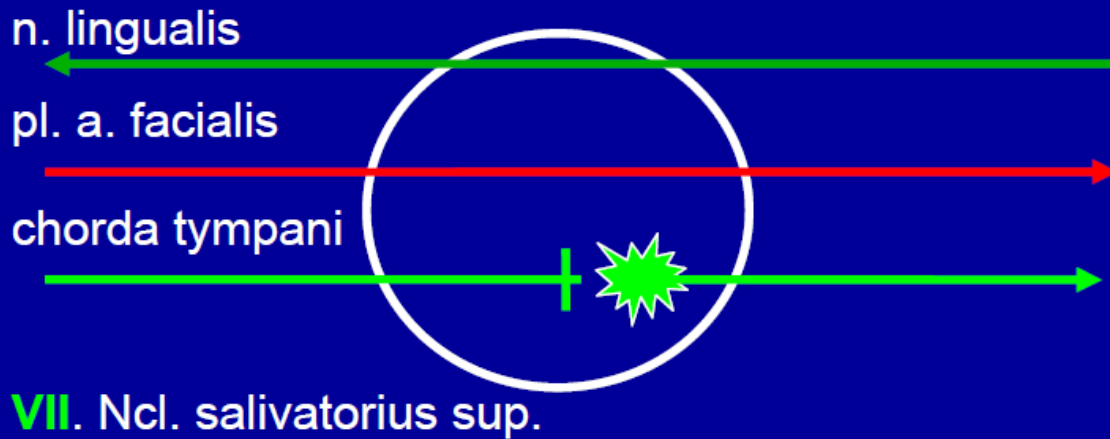
Žlásky dutiny nosní a patra

r.communicans cum n. lacrimali

Glandula lacrimalis



## Ggl. submandibulare



rr. glandulares pro

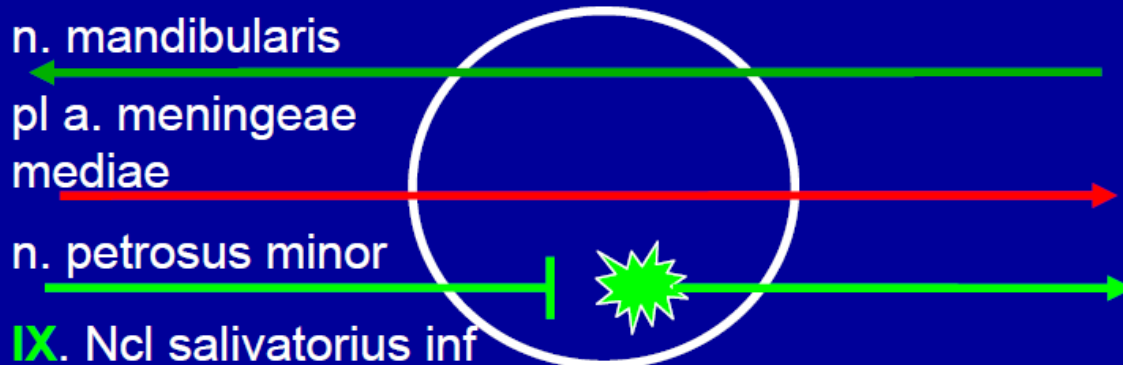
**gl. submandibularis a  
sublingualis**

Spojky do n. lingualis

**Drobné slinné žl. jazyka**

**VII.** Ncl. salivatorius sup.

## Ggl. oticum



rr. comm. cum n. auriculotemporalis

**Glandula parotis**

r. comm. cum n. buccali

**Slinné žl. tváře**

**IX.** Ncl salivatorius inf

Motorická vlákna pro m. tensor veli palatini a m. tensor tympani **VII**

m. pterygoideus medialis **V**

# Enteric system

- In the wall of digestive tract
- **plexus submucosus**
- **plexus myentericus**
- Separate and independent of connection with sympathetic and parasympathetic
- It works also after interruption of connections with **ANS**
- It controls tension and mobility of digestive tract, it regulates secretion of all glands and blood flow
- innervation and regulation of function of gall bladder and pancreas

# CNS

- The highest autonomic headquarters=  
**hypothalamus**
- It is controlled by  
**limbic system**

- The posterior root leads both somatosensory,



and  
viscerosensory



# The neural tracts tractus nervosi

# THE SENSORY TRACTS

- **receptor→CNS**
- **A) specific:specific information**
- **B) nonspecific: through interneurons, general information, preparation of CNS for income of specific information**
- **1<sup>th</sup> neuron: pseudounipolar cell of spinal ganglion (ganglion of cranial nerves)  
→(cerebellum)→thalamus→cortex**
- **SOMATOSENSORY TRACTS: protopathic sensibility  
epicritic sensibility  
proprioception**
- **VISCEROSENSORY TRACTS**

- **Protopathic sensibility**: tactile information (warmth, cold, pressure, pain, rough skin sensibility)

1) Limbs and trunk: *tractus spino-thalamo-corticalis*

1<sup>st</sup> Pseudounipolar neuron of spinal ganglion → 2<sup>nd</sup> nucleus proprius → 3<sup>rd</sup> thalamus → cortex (gyrus postcentralis, area 1, 2, 3)

2) Head area: *tractus trigemino-thalamo-corticalis*

1<sup>st</sup> Pseudounipolar neurons of sensory ganglia of CN (V., VII., IX., X.) → 2<sup>nd</sup> nucleus tractus spinalis (V.) → 3<sup>rd</sup> thalamus → cortex



- **Epicritic sensibility**: discriminatory sensation (tactile resolution of shape of object etc.)

1) Limbs and trunk: *tractus spino-bulbo-thalamo-corticalis*

1<sup>st</sup> Pseudounipolar neuron of spinal ganglion → fasciculus gracilis, fasciculus cuneatus → 2<sup>nd</sup> nucleus gracilis, cuneatus medialis → 3<sup>rd</sup> thalamus → cortex (gyrus postcentralis, area 1, 2, 3)

2) Head area: *tractus trigemino-thalamo-corticalis*

1<sup>st</sup> Pseudounipolar neurons of sensory ganglia of CN (V., VII., IX., X.) → 2<sup>nd</sup> nucleus principalis (V.) → 3<sup>rd</sup> thalamus → cortex

- **Proprioception**: from the locomotor system to the cerebellum

1) LL and trunk: 1<sup>st</sup> Pseudounipolar neuron of spinal ganglion → 2<sup>nd</sup> nucleus thoracicus → 3<sup>rd</sup> cerebellum → 4<sup>th</sup> thalamus → cortex

2) UL: 1<sup>st</sup> Pseudounipolar neuron of spinal ganglion → fasciculus cuneatus → 2<sup>nd</sup> nucleus cuneatus lateralis → 3<sup>rd</sup> cerebellum → 4<sup>th</sup> thalamus → cortex

3) Head area: *tractus trigemino-thalamo-corticalis*

1<sup>st</sup> Pseudounipolar neurons of nucleus mesencephalicus nervi V. → 2<sup>nd</sup> cerebellum → 3<sup>rd</sup> thalamus → cortex

- **VISCEROSENSORY TRACTS**

1<sup>st</sup> Pseudounipolar neuron of spinal ganglion → 2<sup>nd</sup> nucleus intermediomedialis

→ nucleus intermediolateralis

→ FR → thalamus → cortex

# MOTOR TRACTS

- Set of all neural tracts, which are are connected into the regulation of movement. To them belong **pyramidal** and **extrapyramidal tracts**.

# PYRAMIDAL TRACTS (direct)

- projection **direct** motor tracts of **voluntary movement**
- They interconnect motor cortex of hemisphere with motoneurons of anterior spinal horns and with motoneurons of nuclei of cranial nerves
- It is only one-neuron way
- They start in primary motor cortex, to them belong **tractus cortico-spinalis (tract of voluntary movement of trunk and limbs)** and **tractus cortico-nuclearis (tract of voluntary movement of striated muscles of the head)**.

# EXTRAPYRAMIDAL TRACTS (indirect)

- Control of involuntary movement
- **Projection extrapyramidal tracts** (connect motor cortex of hemisphere with motoneurons of anterior spinal horns; they are switched over in motor nuclei of brainstem)
- **Connections of (motor) basal ganglia** (BG are interconnected with each other and with other motor structures of brain (e.g. motor cortex and motor parts of thalamus))
- **Tracts of cerebellum**
- They further interconnect **motor nuclei of thalamus, RF and e.g. nucleus ruber, substantia nigra etc.**

- **Association tracts:**
- The same hemisphere: *fibrae arcuatae*, *fasciculus longitudinalis superior*, *et inferior*, *fasciculus uncinatus*, *fasciculus arcuatus*
- **Commissural tracts:**
- Right and left side of CNS: *commissura anterior et posterior*, *commissura fornicis*, *corpus callosum*