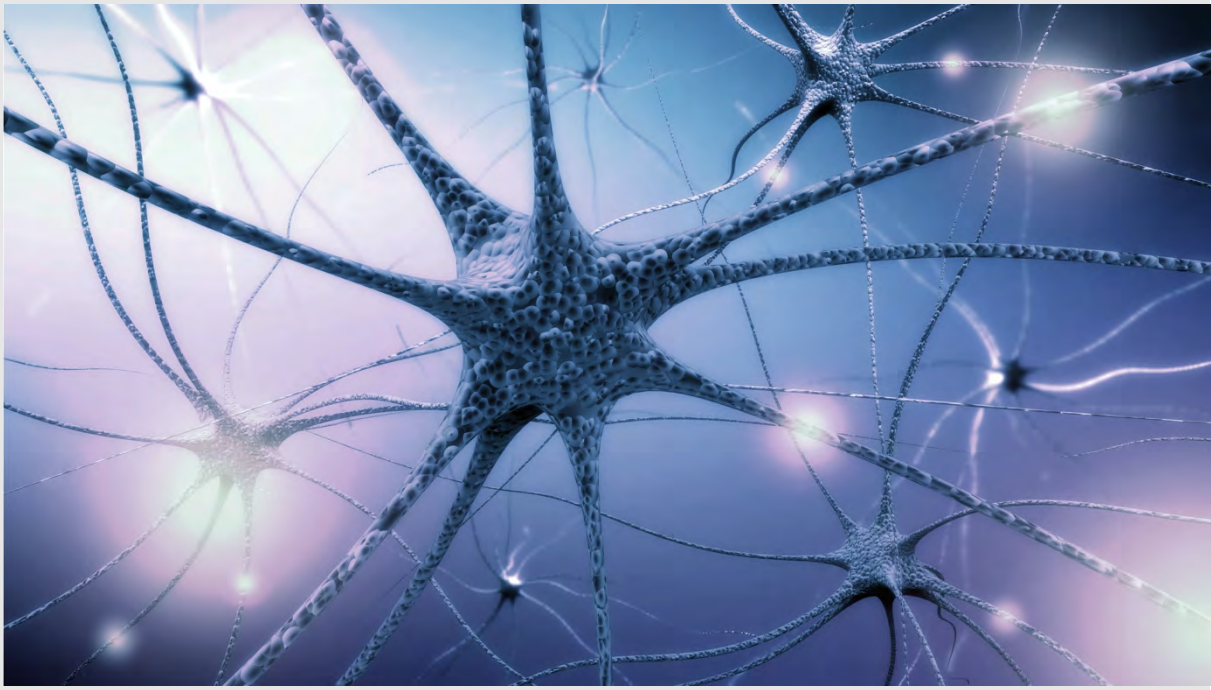
Understanding The Autonomic Nervous System and Its Scientific Osteopathic Approach



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Mostly, the effect of OMT on the ANS is an inhibition of the sympathetic system or a stimulation of the parasympathetic system. The effect can be local, segmental or general.

Schematic organization of the central nervous system - CNS

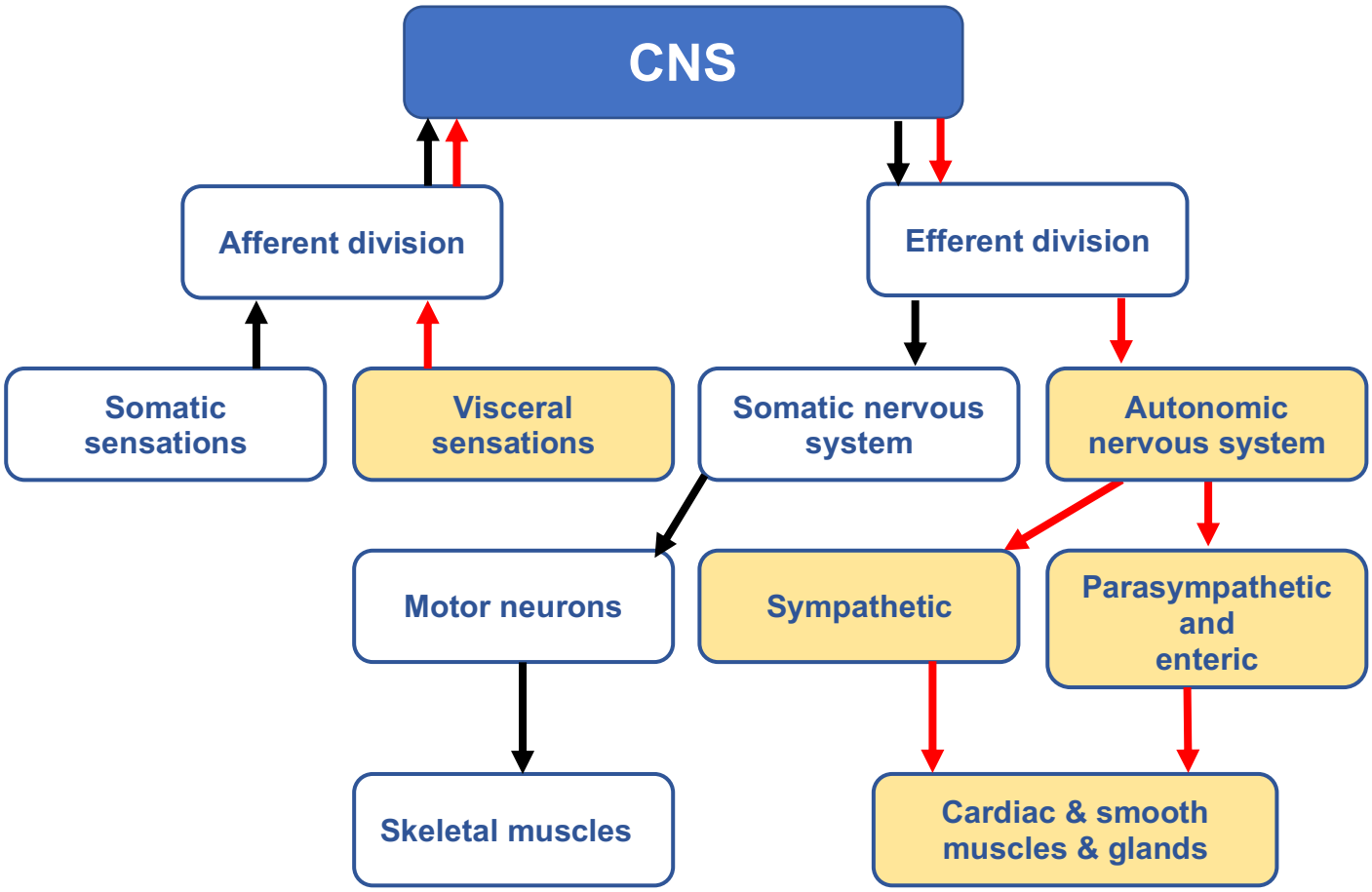


Figure 1 - Organization of the nervous system

Development of the ANS

The peripheral sympathetic neurons arise from the mesoderm, neural crest.

The ANS in general regulates physiological processes.

The newborn uses primitive brainstem-visceral circuits via ingestive (eating and drinking) behaviors as the primary mechanism to regulate physiological states.

During the first year of life (already starting in the third trimester of the pregnancy), the cortical regulation of the brainstem develops.

emergence of polyvagal speculations), there is no evidence to suggest that it has any control over whether a freeze response is triggered or not.

The capacity to regulate behavior is a critically function in relationships.

Those who are able to think and act flexible, maintain attentional control, and regulate emotions and behaviors are far more able to respond appropriately to interpersonal stressors and demands than those who lack these competencies.

Figure 2 - Resilience

Adaptability (resilience) is essential in life.

Further development

Next to develop is the sympathetic division of the ANS, which shows steady development throughout the fetal period.

The normal clear increase in vagus tone occurs around 37–38 weeks, at a time when premature newborns may already have been in an ex-utero environment for some time.

Dysmaturation

When there is environmental stress, prematurity or growth restrictions in the fetus or newborn, the immature ANS may undergo what is called ‘dysmaturation’.
Even maternal stress can evoke this dysmaturation.

This stress can limit the capacity to respond to physiologic changes and to the environment.

In severe cases: neuropsychiatric disorders *(depression, anxiety, behavioral dysfunction, attention-deficit hyperactivity disorder (ADHD), autism spectrum disorder, and others)* may follow.

Ex-utero third trimester development in the preterm newborn may lead to altered autonomic development with potential short- and long-term implications for health.

Autonomic imbalance and in particular decreased parasympathetic tone is implicated in anxiety, depression, post-traumatic stress disorder, schizophrenia and disturbances in normal social contact behavior.

Osteopathy: osteopaths recognize children with reduced vagus tone.

They recognize the symptoms in these children by observation, assessment and interview of the parents:

- Crying with no obvious reasons.
- Restlessness.
- Hyperkinetic.
- Bad sleep.
- Difficult swallowing and sucking.
- Strange (cramped) facial expressions.
- Cognitive rigidity.
- Dysfunctional behavior.
- Immune system reacts badly or slow.
- Respiration rate high.
- Difficulties to calm down fast.

When osteopaths recognize these symptoms, the most important treatment aim is to stimulate the vagus tone by:

- Mobilizing the upper cervicals (cranial base release, 4th ventricle compression…).

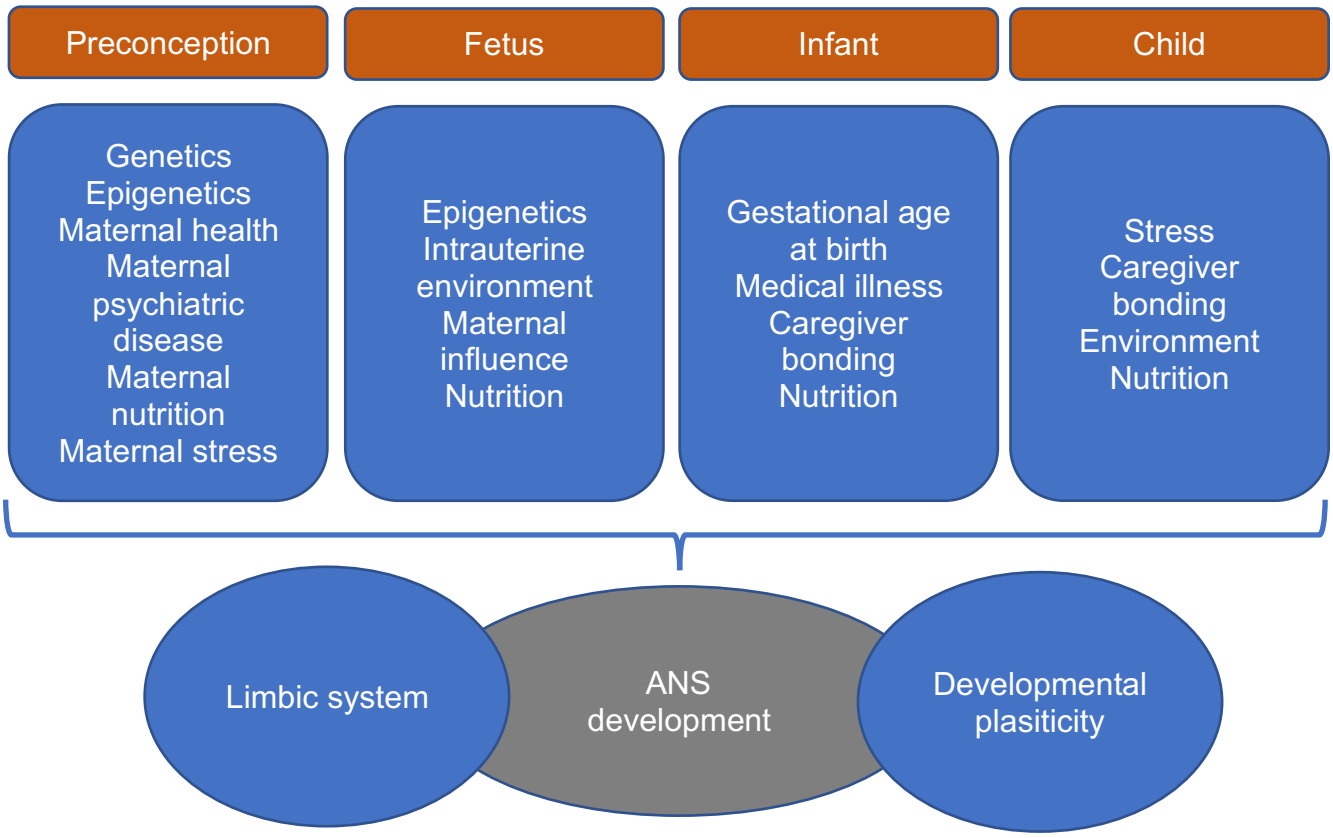


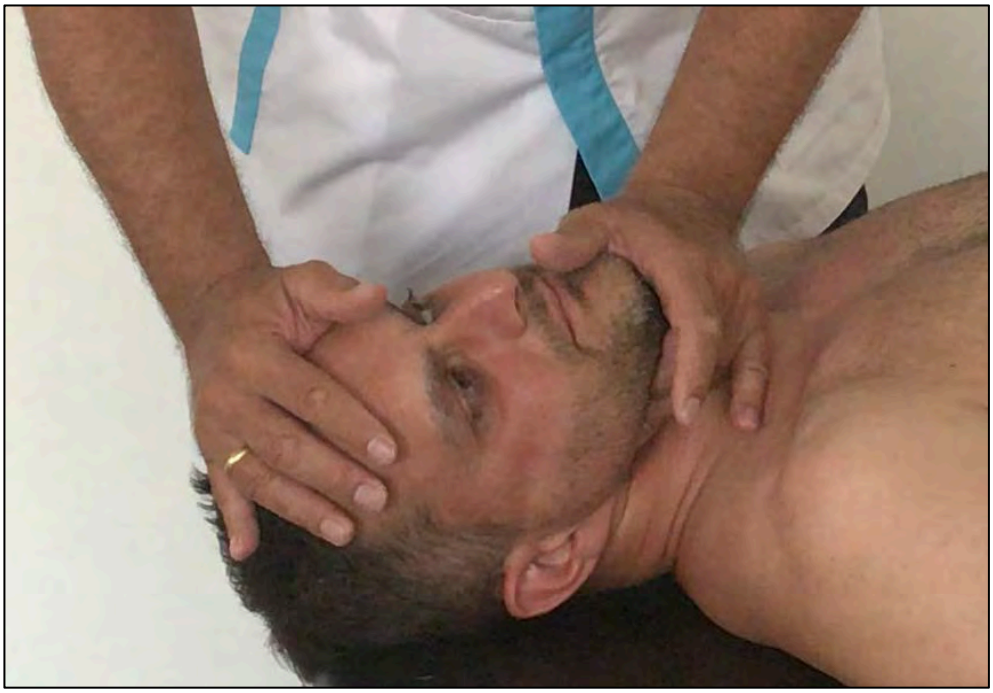
Figure 3 - Factors influencing ANS development

It is the complex interplay between the central ANS (brainstem) and the limbic system that creates a platform on which physical and emotional experiences can shape behavior, emotional, and neuropsychiatric health from the prenatal period into adulthood.

The limbic system consists out of:

- Amygdala.
- Thalamus.
- Fornix.
- Hippocampus.
- Hypothalamus.
- Cingulate gyrus.
- Olfactory cortex.

A behavioral response or stress influences the limbic system to affect the ANS tone which then results in physiologic effects on heart rate, respiratory rate, and blood pressure.



Video 3 - Stretching anterior high cervical soft tissues

Caudal of the inferior ganglion, the fibers of the ambiguus nucleus join the nerve.

Here, the meningeal ramus leaves the nerve and runs back intracranially to innervate the meninge below the tentorium.

The second branch that leaves the vagus nerve is the auricular nerve.

This nerve takes care of the somato-sensory innervation of:

- The skin behind the ear.
- The skin of the external acoustic meatus.
- A part of the external part of the eardrum.

The vagus nerve runs caudally in the sheet (part of the medial cervical fascia) between the internal carotid artery and the internal jugular vein.

In the cervical area, the vagus nerve gives several branches:

- **Pharyngeal branch:** most important nerve for the pharynx. He runs infero-medial between the internal and external carotid artery. He enters the pharynx at level of the upper border of the medial constrictor muscle and innervates:
    - All muscles of the pharynx and soft palate with exception of tensor veli palatine muscle and stylopharyngeal m.
    - Superior, inferior and medial constrictor muscles.
    - Levator palatine m.

Test

Indications for testing:

- Reflux.
- Digestive problems.
- Heart and lung problems.
- Hoarseness.
- Problems with the voice.

Observation

- Speech is observed (nasal or hoarseness).
- Uvula observation in rest: must be symmetrical.
- Observation uvula and palatine arches during ‘aaah’.

Inspection of uvula and palatine arches

The glossopharyngeal nerve is mostly tested together with the vagus nerve.

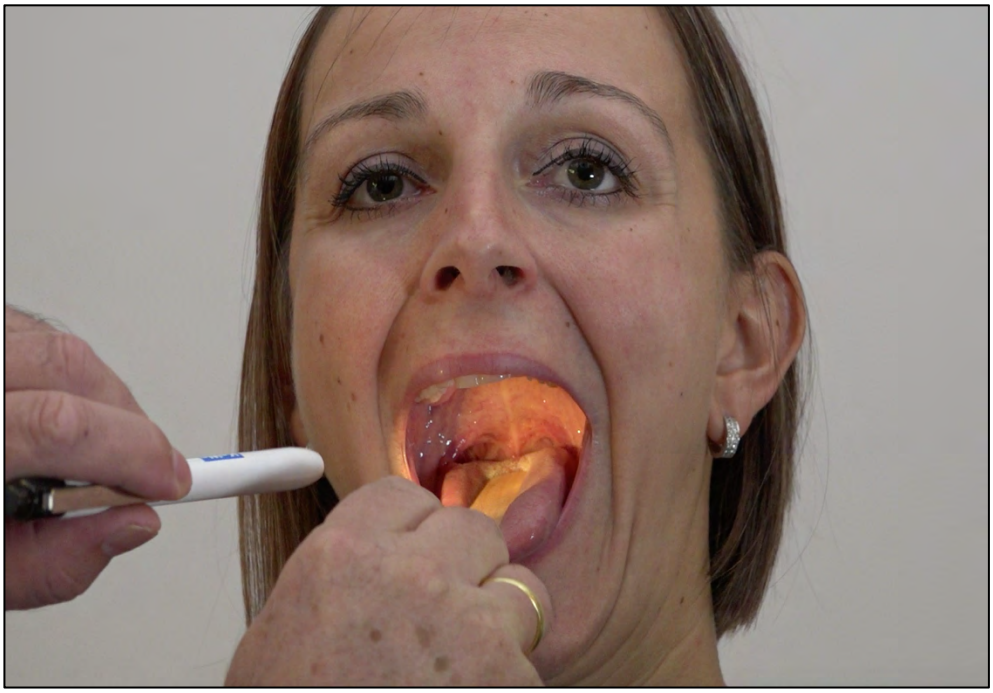
The patient opens his/her mouth and the examiner pushes the tongue down.

The patient says ‘aaah’.

The uvula and the palatine arches are inspected.

When the uvula deviates to the healthy side: this could be a glossopharyngeal lesion or a vagus lesion (overstretch or compression).

When the pharynx wall doesn’t lift, there is a glossopharyngeal or vagus lesion, or both.



Video 5 - Inspection of uvula and palatine arches

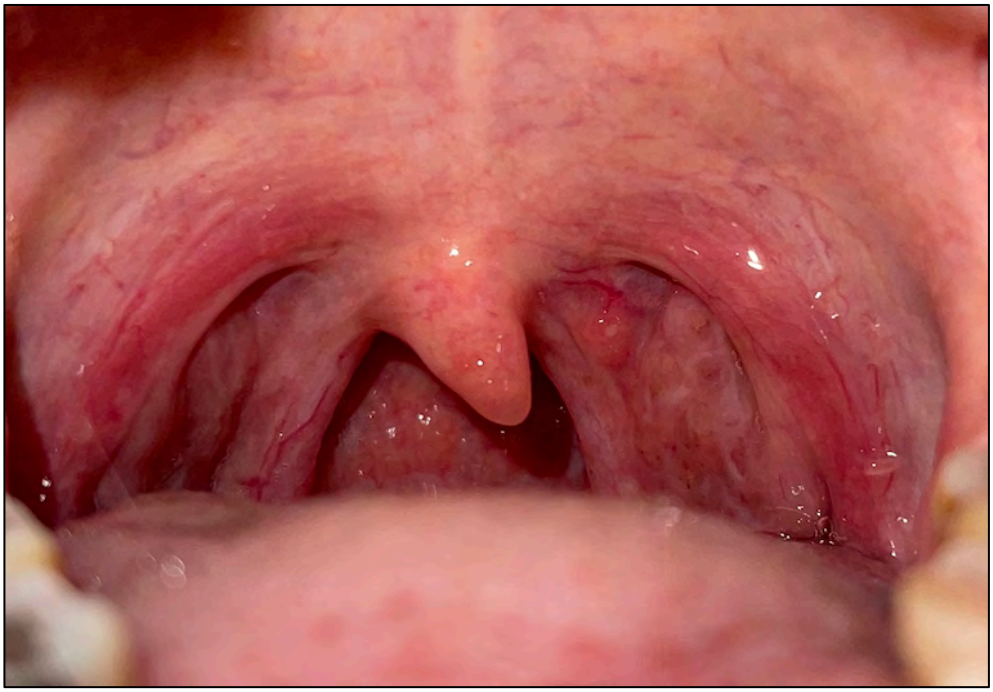


Figure 14 - Positive test

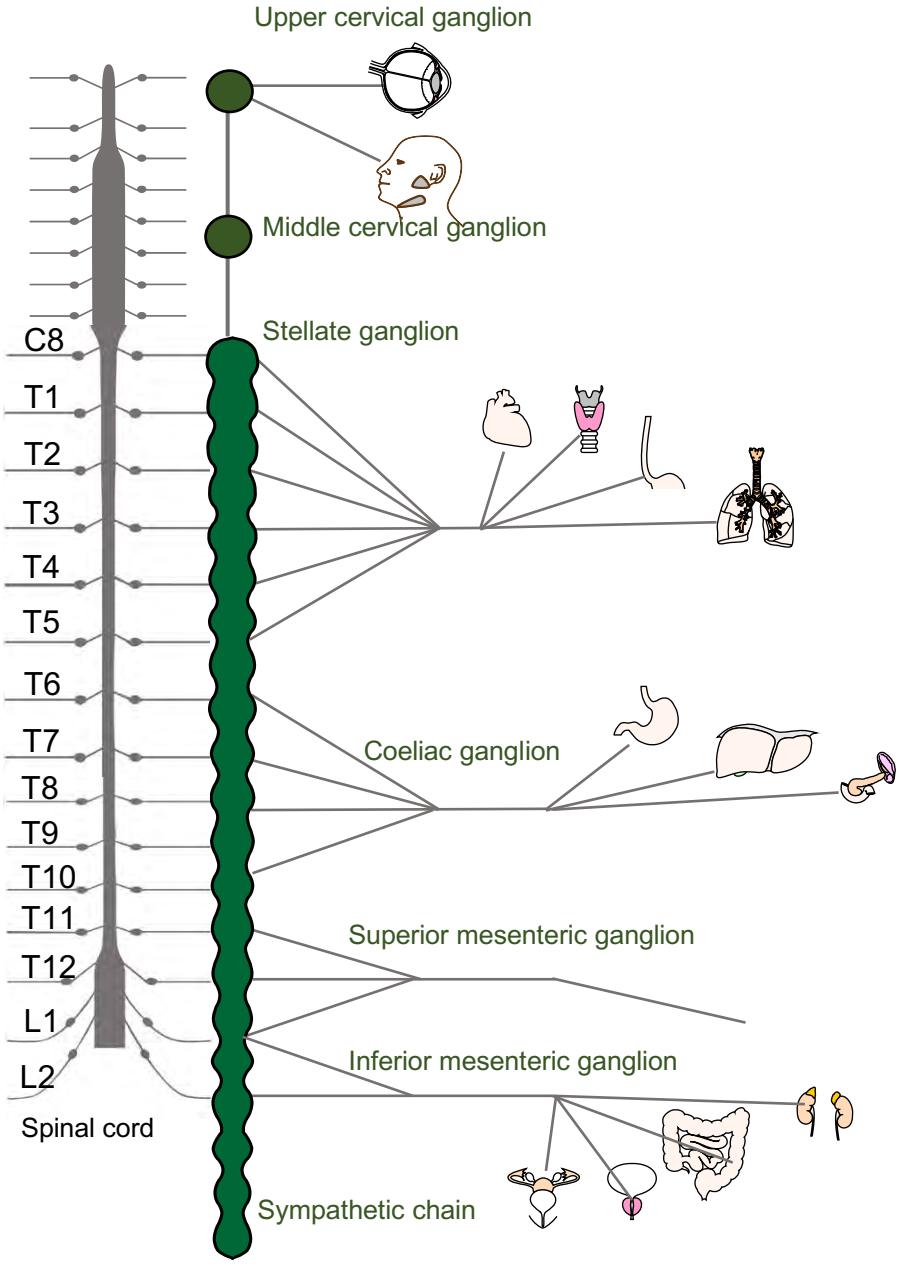


Figure 15 - Sympathetic nervous system

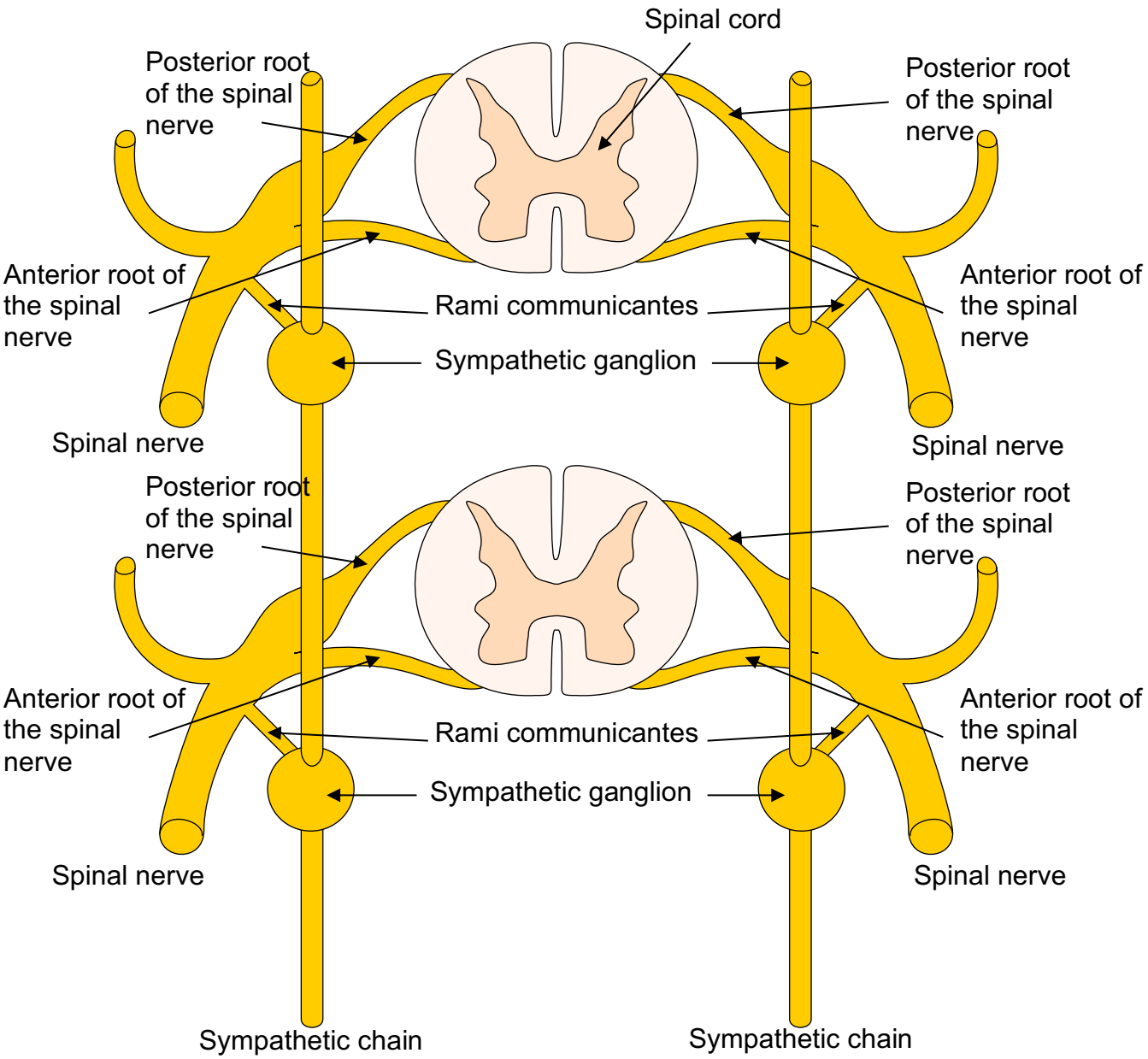


Figure 16 - Sympathetic chain

The connection between the different neurons is done by 2 major neurotransmitters (endogenous substances acting as signaling molecules that enable neurotransmission):

- **Acetylcholine (ACh):**
  - Parts in the body that use or are affected by acetylcholine are referred to as cholinergic.
  - Is produced by cholinergic fibers:
    - Preganglionic fibers.
    - Postganglionic parasympathetic fibers.

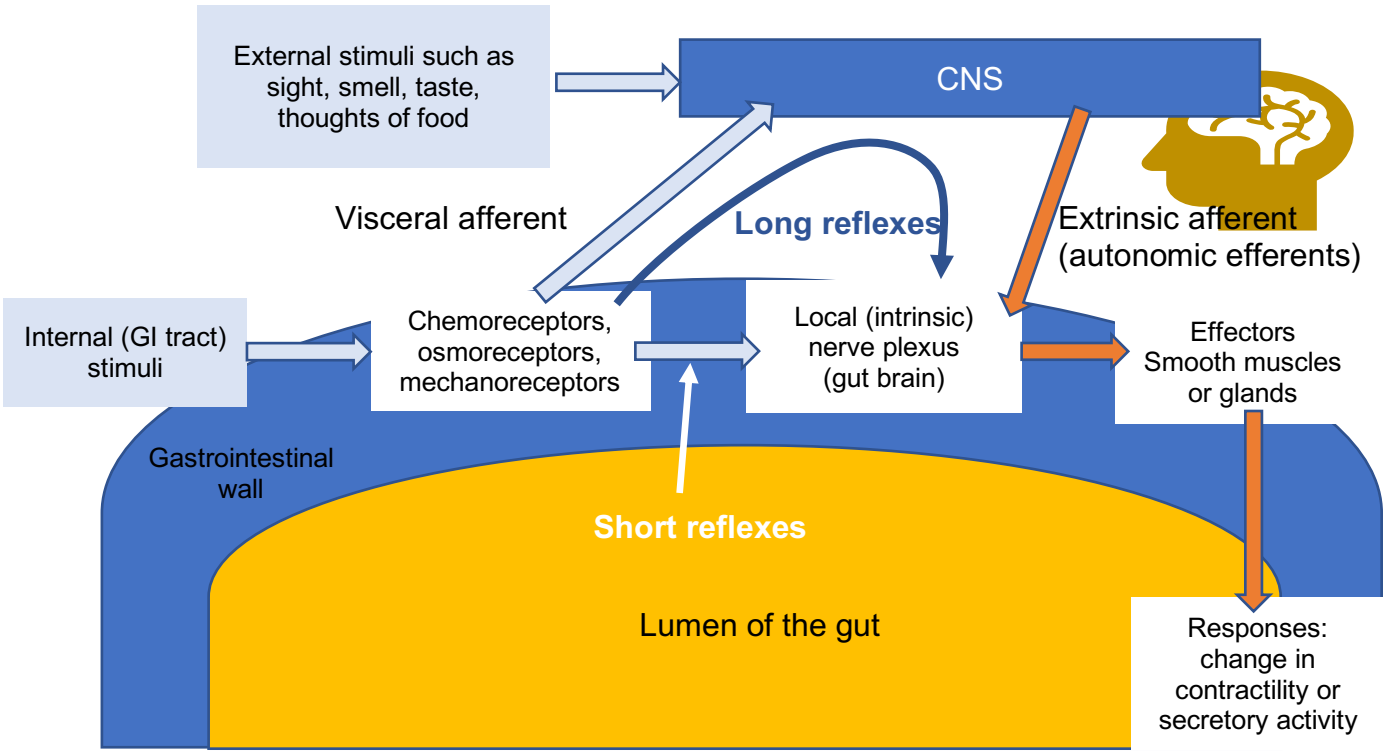


Figure 20 - Gut reflexes

The enteric nervous system normally communicates with the CNS through the parasympathetic (vagus nerve) and sympathetic (prevertebral ganglia) nervous systems but can still function when the vagus nerve is severed.

This means that the ENS has as well:

- **Efferent neurons.** They control gastrointestinal motility, secretion, and absorption. In performing these functions, motor neurons act directly on a large number of effector cells, including smooth muscle, secretory cells (chief, parietal, mucous, enterocytes, pancreatic exocrine cells) and gastrointestinal endocrine cells.
- **Afferent neurons.** At least five different sensory receptors have been identified in the mucosa, which respond to mechanical, thermal, osmotic and chemical stimuli. Chemoreceptors sensitive to acid, glucose and amino acids have been demonstrated which, in essence, allows ‘tasting’ of luminal contents. Sensory receptors in muscle respond to stretch and tension. Collectively, enteric sensory neurons compile a comprehensive battery of information on gut contents and the state of the gastrointestinal wall.
- **Interneurons.** They are largely responsible for integrating information from sensory neurons and providing it to enteric motor neurons.

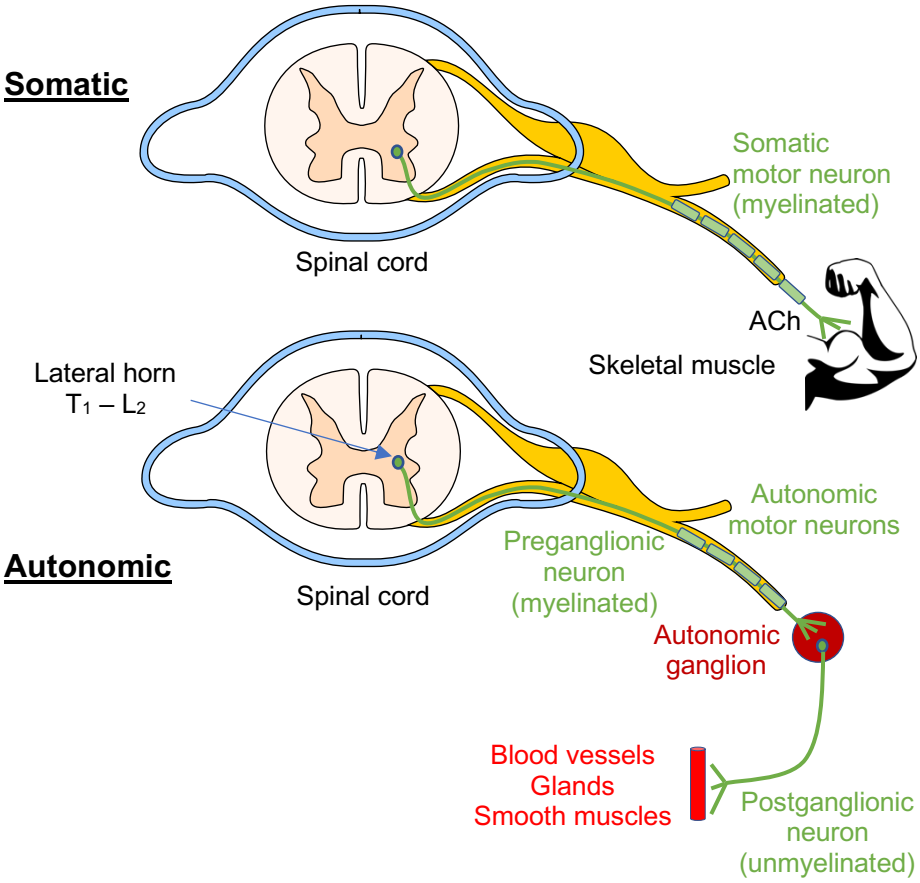


Figure 22 - Differences somatic - autonomic nervous system

1 preganglionic fiber synapse with some 20 postganglionic neurons.

Reflex arcs

The reflex arcs of the autonomic nervous system comprise a sensory (or afferent) part, and a motor (or efferent) part.

Examples:

- A fall in blood pressure causes pressure sensitive neurons (baroreceptors in the heart, vena cava, aortic arch, and carotid sinuses) to send fewer impulses to cardiovascular centers in the brain.
- This prompts a reflex response of increased sympathetic output to the heart and vasculature and decreased parasympathetic output to the heart, which results in a compensatory rise in blood pressure and tachycardia.

However, for others such as atherosclerosis, large arteries are predominantly affected.

For others, such as chronic hypertension, all segments of the circulation are affected.

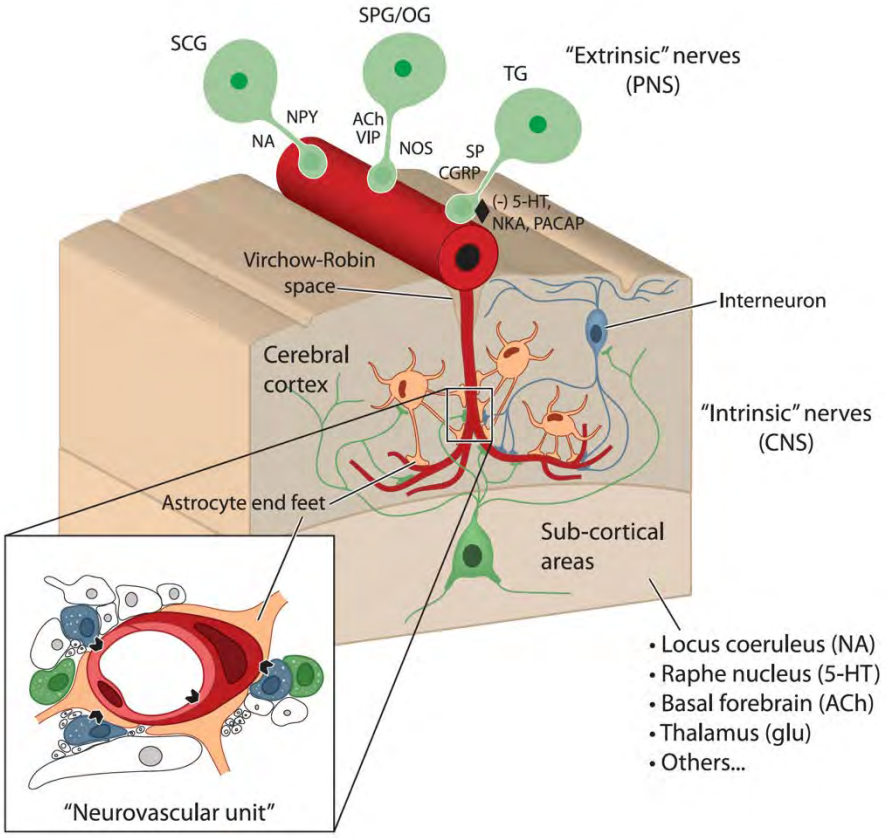


Figure 23 - The neurovascular unit

The human brain is exquisitely sensitive to changes in cerebral blood flow.

A good balance between oxygen supply and demand has to be maintained.

Cerebral blood flow is regulated by vasomotor, chemical, metabolic, and neurogenic mechanisms.

Under normal physiological conditions neurogenic control has little influence on cerebral autoregulation as other methods of control (vasomotor, chemical, and metabolic) are more dominant. The mechanisms of autoregulation in the brain are not completely understood and likely differ with increases vs. decreases in pressure.

Recently, a role for neuronal nitric oxide in modulating cerebral blood flow autoregulation has been shown, suggesting that although extrinsic innervation may not be involved, intrinsic innervation may have a role.

Patients presenting with a core temperature of less than 80.06°F (26.7°C) are usually unconscious, miotic, bradypnea, bradycardic, and hypotensive with generalized edema.

At core temperatures below 77°F (25°C) patients are in coma, areflexic and may show rigor mortis.

3.4. Autonomic Innervation of the Heart

3.4.1. General

Heart rate and cardiac output must vary in response to the needs of the body's cells for oxygen and nutrients under varying conditions. The autonomic nervous system regulates this.

Heartbeats originate from the rhythmic pacing discharge of the sinoatrial (SA) node within the heart itself (in the upper posterior wall of the right atrium).

In the absence of extrinsic neural or hormonal influences, the SA node pacing rate would be some 100 beats per minute.

The SA node is a part of the intrinsic conduction system of the heart.

The conduction system in order of rate of depolarization starts with the SA node (predominant pacemaker). This results in atrial depolarization and atrial contraction.

The internodal pathway, the AV node (where the impulse is delayed), AV bundle, the left and right branches of the bundle of His and lastly the Purkinje fibers result in ventricular depolarization and contraction.

All of the components of the intrinsic conduction system contain autorhythmic cells that spontaneously depolarize.

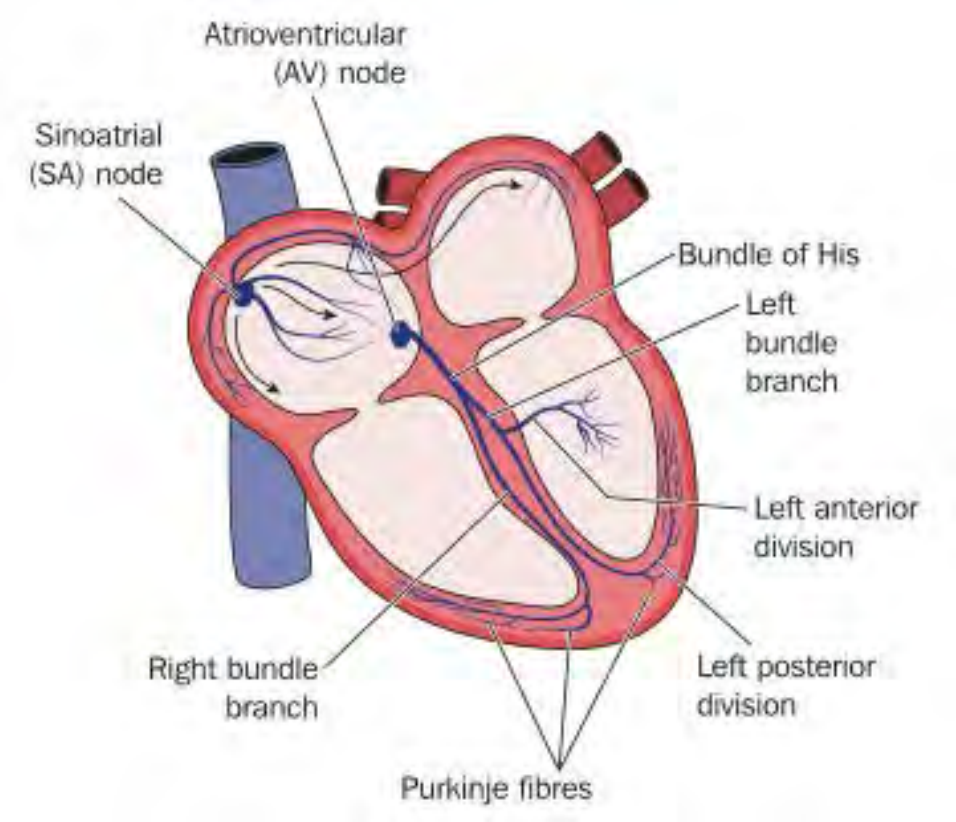


Figure 29 - Intrinsic system

The ANS to the heart has three interacting systems: the sympathetic, the parasympathetic system and the intrinsic system (nodes).

Sympathetic and parasympathetic neurons exert antagonistic effects on the heart.

The sympathetic nervous system releases norepinephrine (NE) while the parasympathetic nervous system releases acetylcholine (ACh).

Sympathetic stimulation also increases heart rate and myocardial contractility (through intense contact with the cardiomyocytes).

The whole heart muscle is innervated by the ANS. The ANS enters the heart from the epicardium and extends throughout the myocardial interstitium, running parallel to the capillary vessels.

The control on heart activity, orchestrated by the cardiac ANS, is without doubt one of the most comprehensive mechanisms for allowing physiological adaptation to the ever-changing internal and external environment.

In contrast, parasympathetic stimulation decreases heart rate and constricts the pupils. The vagus nerve inhibits the SA node and therefore lowers the heartbeat.

It also increases secretion of the eye glands, increases peristalsis, increases secretion of salivary and pancreatic glands, and constricts bronchioles.

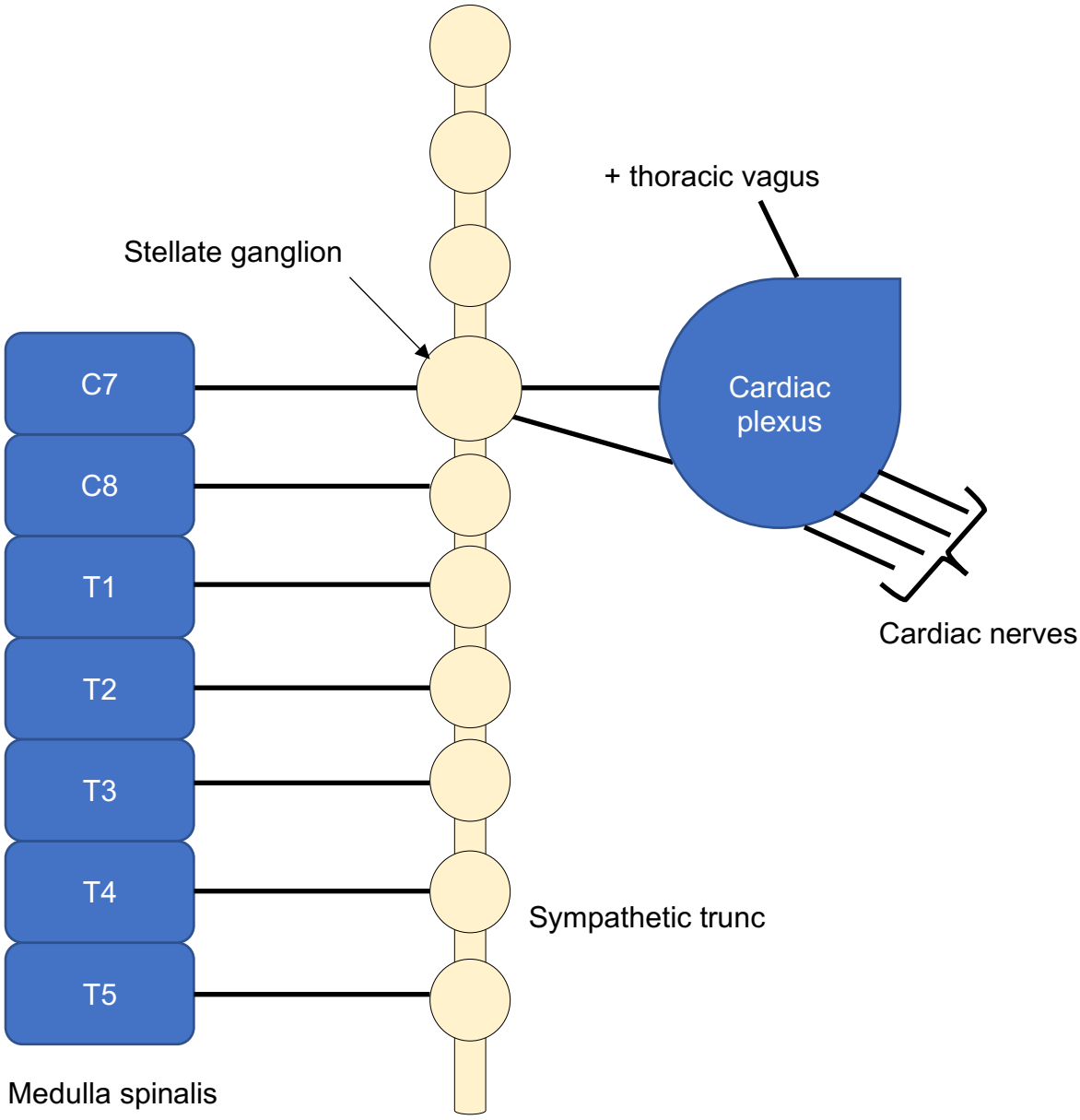


Figure 30 - Sympathetic control

Cardiac myelinated sympathetic preganglionic nerves emerge from the upper thoracic segments of the spinal cord ($T_{1\text{-}4}$).

After traveling a short distance, preganglionic fibers leave the spinal nerves through branches called white rami and enter sympathetic ganglia.

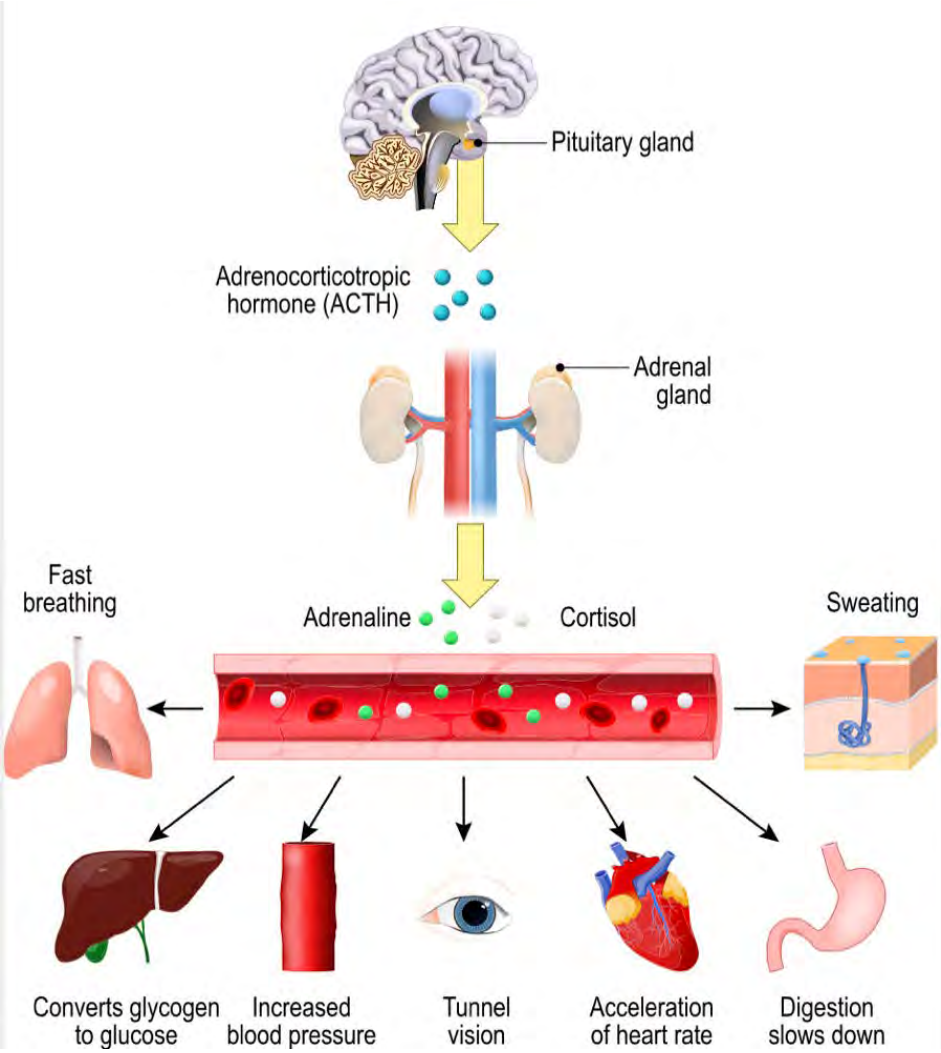


Figure 34 - Adrenal function

3.6. Autonomic Innervation of the Blood Vessels

Most arteries and veins in the body are innervated by sympathetic adrenergic nerves, which release norepinephrine (NE) as a neurotransmitter.

NE preferentially binds α1-adrenoceptors to cause smooth muscle contraction and vasoconstriction.

Similar responses occur when NE binds to postjunctional α2-adrenoceptors located on some blood vessels. NE also binds weakly to postjunctional β2-adrenoceptors, which causes vasodilation.

Some blood vessels are innervated by parasympathetic cholinergic or sympathetic cholinergic nerves, both of which release acetylcholine (ACh) as their primary neurotransmitter.

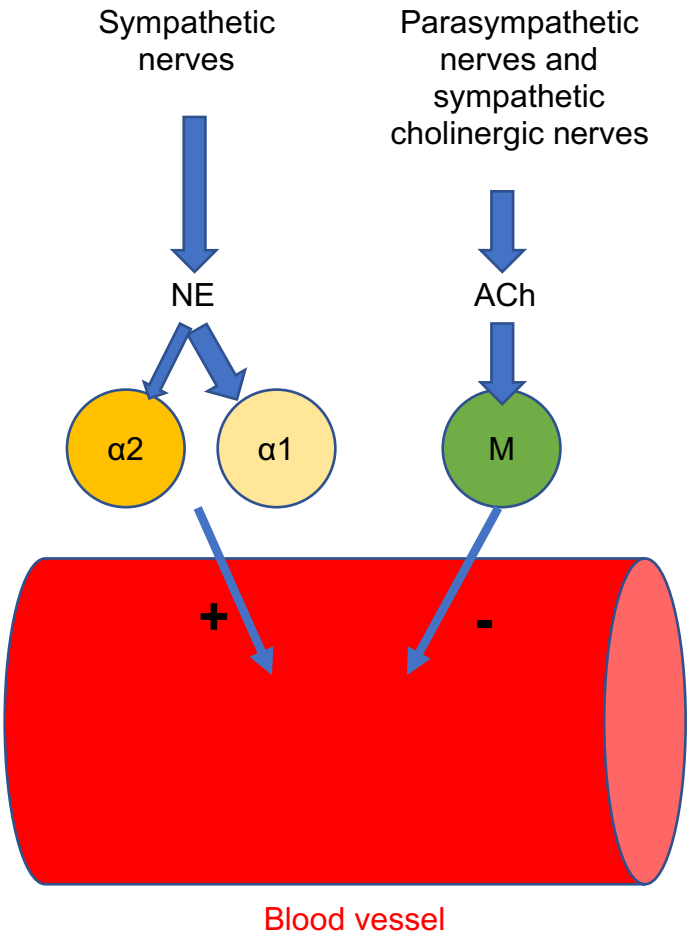


Figure 35 - Sympathetic and parasympathetic influences on blood vessels

Basal tone of the vascular wall

The inherent tone, or basal contractile activity, of vascular smooth muscle varies substantially between different arterial structures, ranging from relatively high in the coronary circulation to low or absent in the pulmonary circulation, and it can increase or decrease dramatically.

Autonomic control of most blood vessels can be affected only by the sympathetic vasoconstrictor nerves without any innervation by parasympathetic vasodilator nerves.

Although most vascular beds are innervated by sympathetic nerves, they are not equally responsive to changes in sympathetic neural activity.

In general, arterioles of the skin, muscle, renal, and splanchnic circulations show robust constriction in response to sympathetic activation, whereas cerebral and coronary arterioles are less responsive.

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Luc Peeters is an osteopath since 1985. He was the Joint-Principal of the largest Academy of Osteopathy in Europe from 1987 till 2020.

This book gives a practical overview of the autonomic nervous system and its scientific osteopathic approach.

The theory and procedures in this book are checked on their scientific background and esotericism is avoided.

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