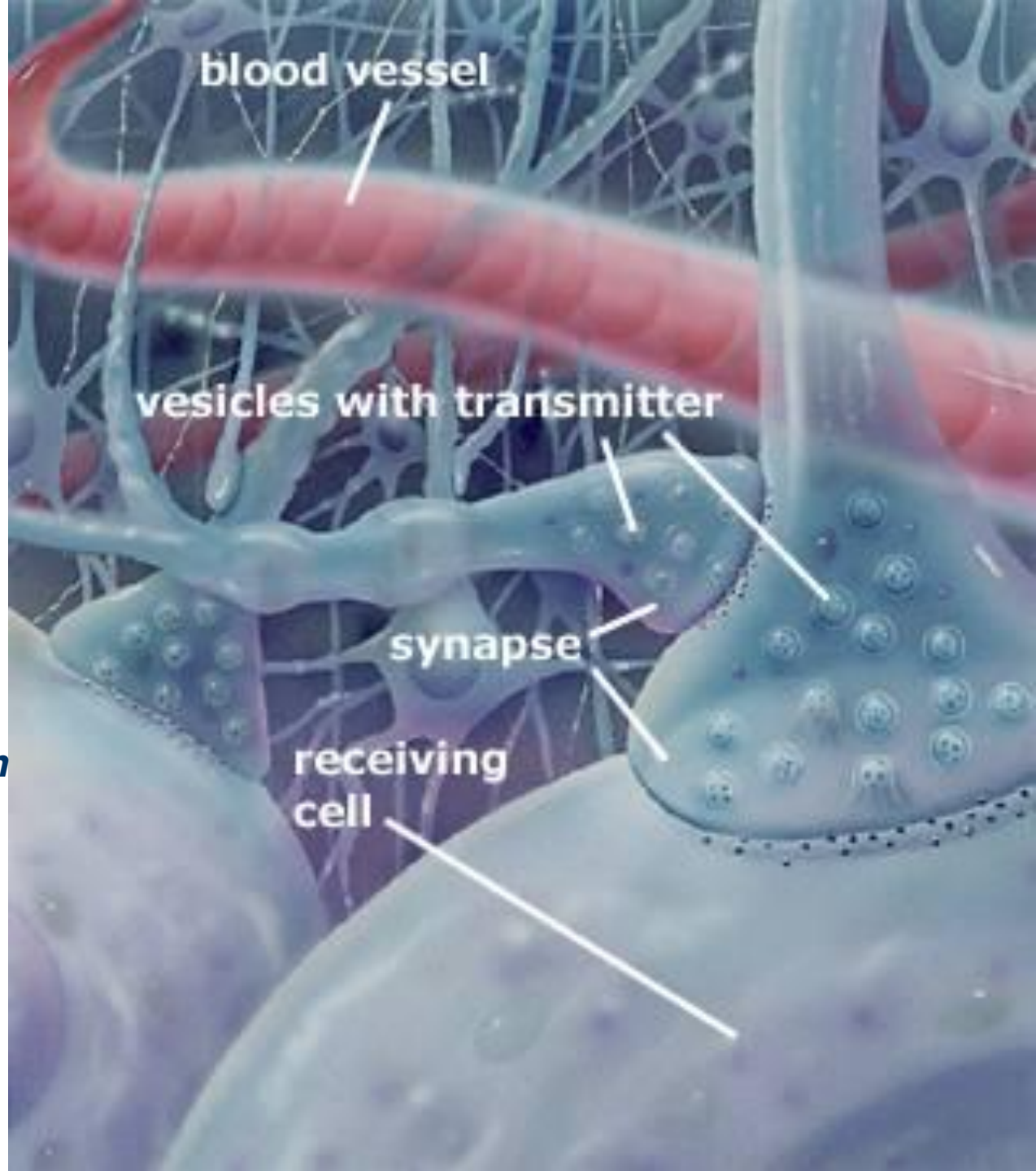


CSB 332

Neurobiology of the Synapse

***Melanie A. Woodin
January 2012***

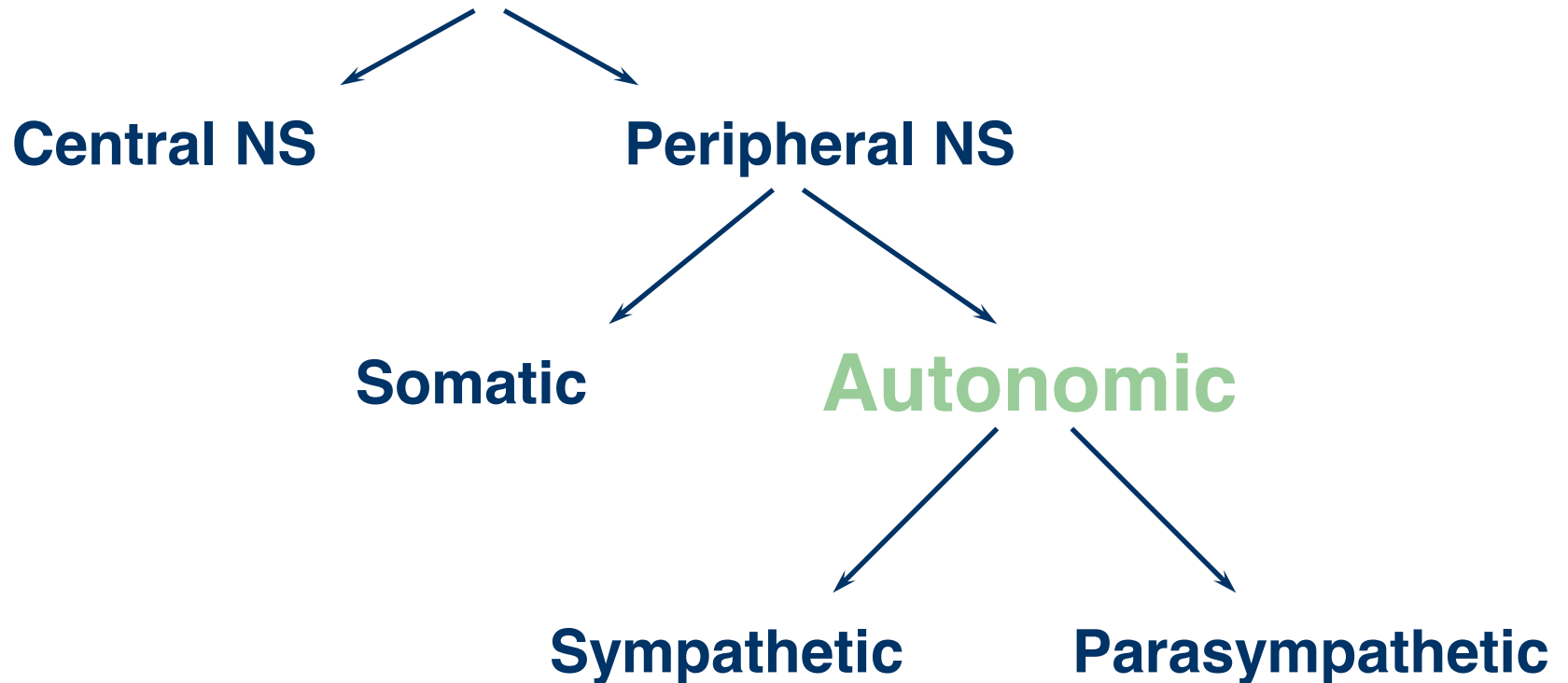
***Lecture 17
Autonomic Nervous System
Chpt 17***





Autonomic Nervous System

Nervous System







What is the most characteristic response of the Autonomic Nervous System?



The autonomic nervous system controls involuntary, fight or flight responses

Divisions of the ANS:

-  1. Sympathetic division: responsible for the “fight/flight” response as in tending to reduce digestive secretions, speeding up the heart, and contracting blood vessels
- 2. Parasympathetic division: opposes actions of the sympathetic division
-  3. Enteric nervous system: controls the gut

ANS:

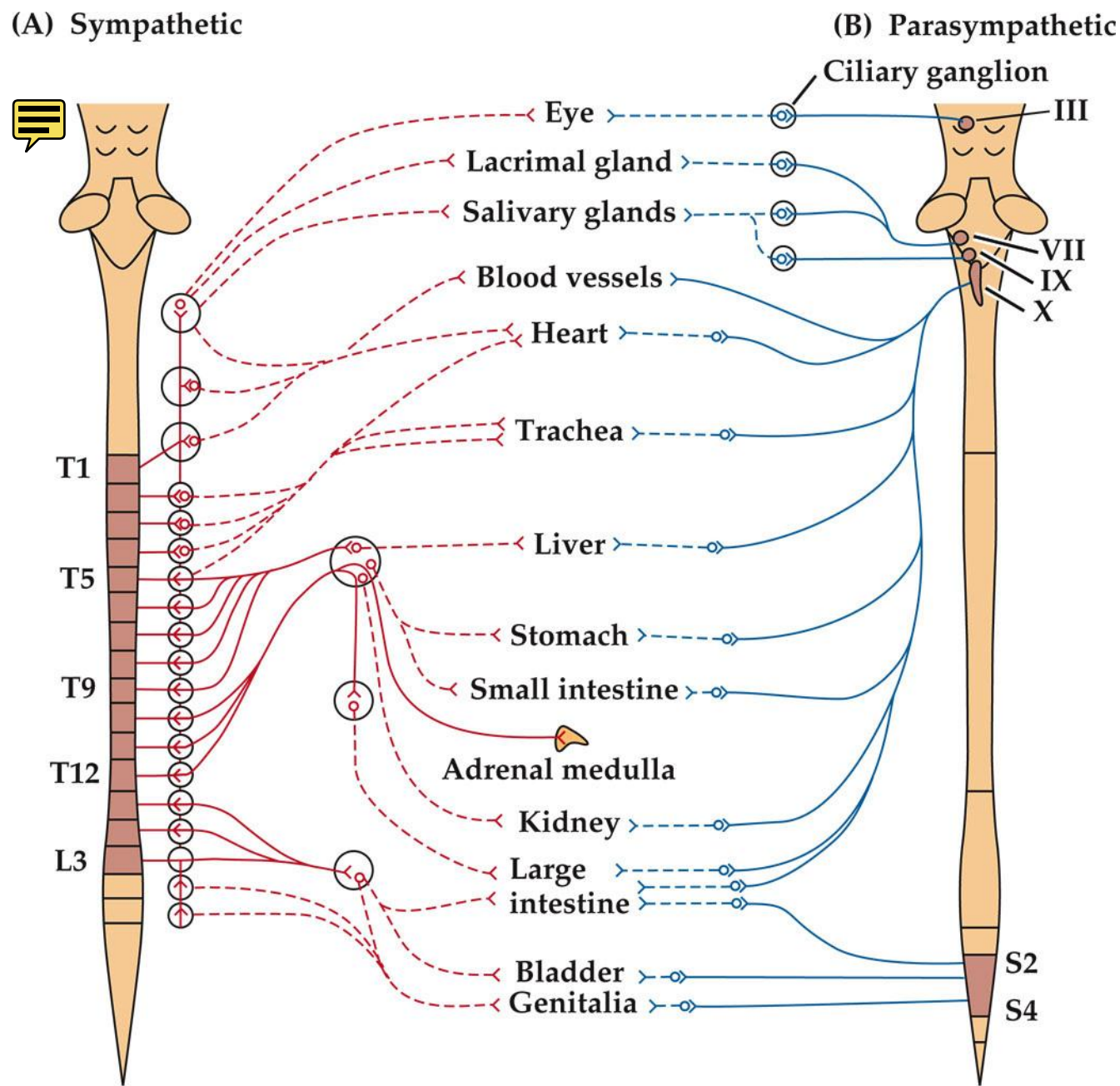
The ANS doesn't just deal with the flight-or-fight response, it really deals with all of the housekeeping maintenance work of the body:

- Exercise (diversion of blood to muscles, stimulation of sweat glands)
- Emotion (thinking of a test)
- Changes in body position (regulate blood pressure)
- Eating (reroute blood to stomach and intestines)

ANS:

- ANS regulates organs/processes not under conscious control including:
 - circulation
 - digestion
 - respiration
 - temperature
 - sweating
 - metabolism
 - some endocrine gland secretions

Figure 17.1 The Autonomic Nervous System



Solid lines are myelinated preganglionic axons

Dashed lines are unmyelinated postganglionic axons

ANS:




- Nearly all organs of the body are innervated by the ANS
- The actions of the 2 systems are most often antagonistic
- Non antagonistic actions include the ability of either system to increase glandular secretion and cause the contraction of smooth muscle (depending on the type of neurotransmitter released and the receptors present)



Sympathetic vs. Parasympathetic

- **Sympathetic Responses**

- heart rate increases
- blood pressure increases
- blood is shunted to skeletal muscles
- blood glucose increase
-  bronchioles dilate
- pupils dilate

- **Parasympathetic Responses**

- slows heart rate
- protects retina from excessive light
- lowers blood pressure
- empties the bowel and bladder
- increases gastrointestinal motility
- promotes absorption of nutrients

Stimulation by the Sympathetic System

The fight/flight stimulation:

- Heart
 - *stimulated*
- Blood vessels
 - *vasoconstrict*
- Lungs
 - *Dilate bronchi*
- Generalized responses of other body systems
 - *divert blood flow to vital areas, decrease to non vital organs*



Sympathetic Nervous System

- Sympathetic system is most active when the body needs to react to changes in the internal or external environment
- During rage or fright the sympathetic system can discharge as a unit-affecting multi-organ systems
- Sympathetic preganglionic neurons are located in spinal cord segments T1-L3
- Myelinated axons of these neurons pass through the ventral roots and form synapses in ganglia that run alongside the vertebral column (paravertebral ganglia), peripheral ganglia and adrenal medulla
- Unmyelinated axons run from these ganglia to the tissue
- The sympathetic division tends to be thrown into action as a whole, with widespread generalized consequences for the body



Adrenal Medulla

- Chromaffin cells in the adrenal medulla receive cholinergic input from preganglionic axons
- They secrete epinephrine, norepinephrine, peptides and ATP as hormones into the bloodstream
- The effect of hormonal action tends to augment the sympathetic ANS response
- These hormones can reach regions that do not receive direct neuronal innervation e.g. smooth muscle of the bronchi



Parasympathetic Nervous System

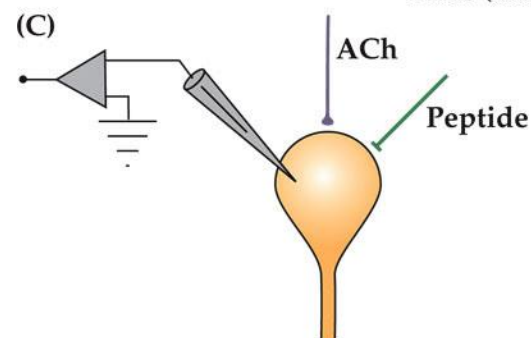
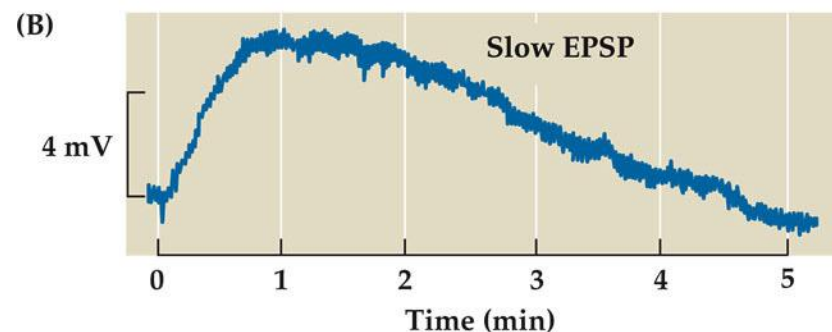
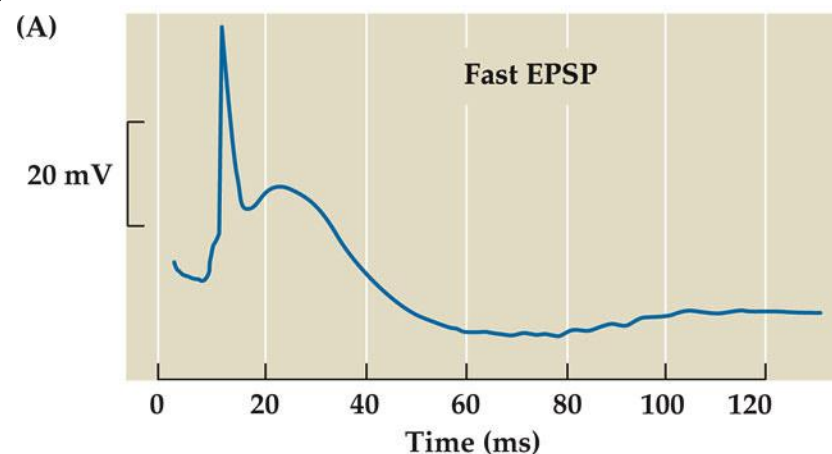
- More focused in its activity
- Parasympathetic outflow is restricted to cranial nerves III, VII, IX and X, and sacral roots S2, S3 and S4
- Parasympathetic ganglia are located close to the target tissue
- Thus the parasympathetic myelinated preganglionic axon is long, whereas the postganglionic axon is short



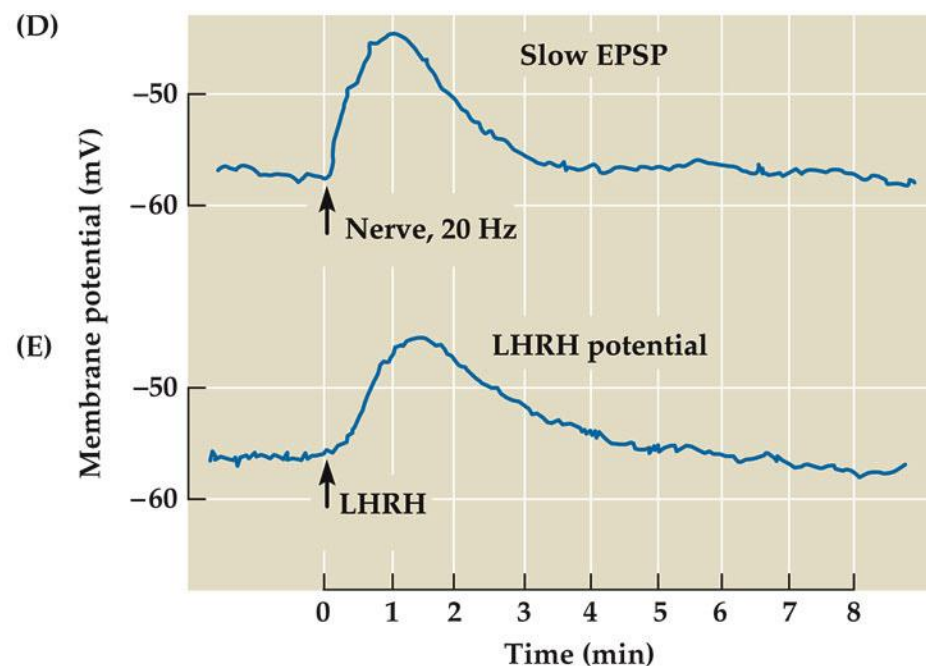
Neurotransmission at Autonomic Ganglia

- Autonomic ganglia – relay stations
- ACh is the main neurotransmitter at autonomic ganglia in both the sympathetic and parasympathetic divisions; ACh binds to nAChRs (ionotropic) producing a fast depolarization
- Muscarinic AChRs (mAChRs; a metabotropic R) are also found postsynaptically and can produce a slow synaptic potential

Figure 17.2 Fast and Slow Synaptic Potentials in Sympathetic Ganglion Cells



FROM NEURON TO BRAIN 5e, Figure 17.2
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Fast & Slow Synaptic Potentials in the Bullfrog

A single stimulus to the preganglionic input evokes a large fast EPSP and AP

Trains of APs (10/s for 5s) are required to elicit slow synaptic potentials; now a single fast depolarization will give rise to a burst of APs

Neurotransmission at Autonomic Ganglia

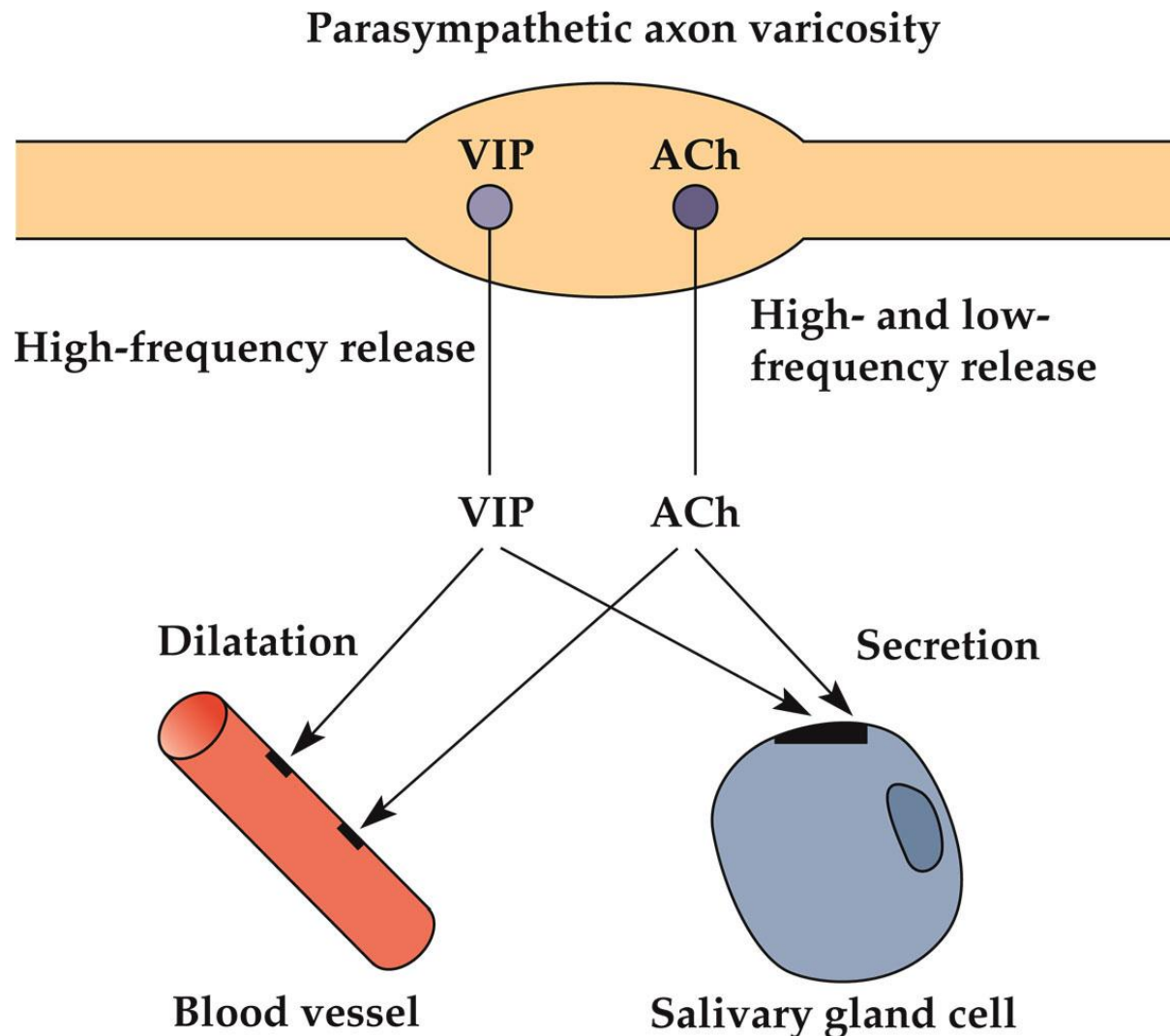
- The preganglionic neurons release ACh, and the ganglionic neuron expresses both: ionotropic nicotinic AChRs (similar to NMJ) and muscarinic AChRs (modulate the timing of the synaptic potential)
-  Co-release of transmitters also occurs at this synapse

Neurotransmission by Parasympathetic Postganglionic Axons



- ACh is the primary transmitter used by the parasympathetic division
- This synapse also co-releases other neurotransmitters (peptides)

Figure 17.4 Cotransmission by Parasympathetic Postganglionic Neurons



FROM NEURON TO BRAIN 5e, Figure 17.4
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ACh released by parasympathetic axons causes secretion of saliva from salivary glands; with high-frequency stimulation this synapse also releases VIP, which causes vasodilation and further increases the release of saliva

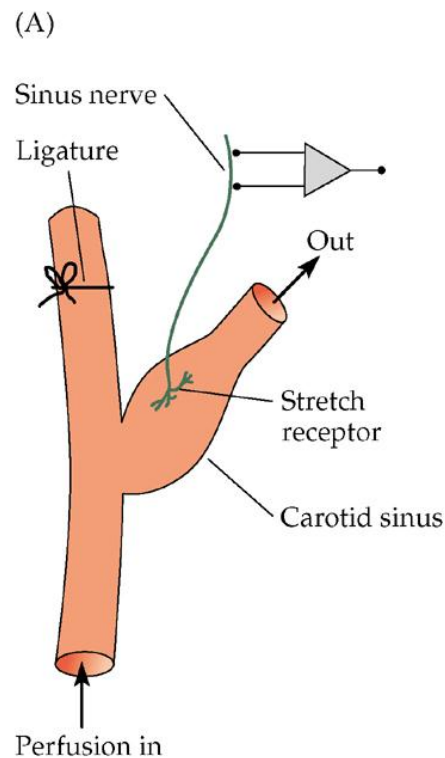


Neurotransmission by Sympathetic Postganglionic Axons

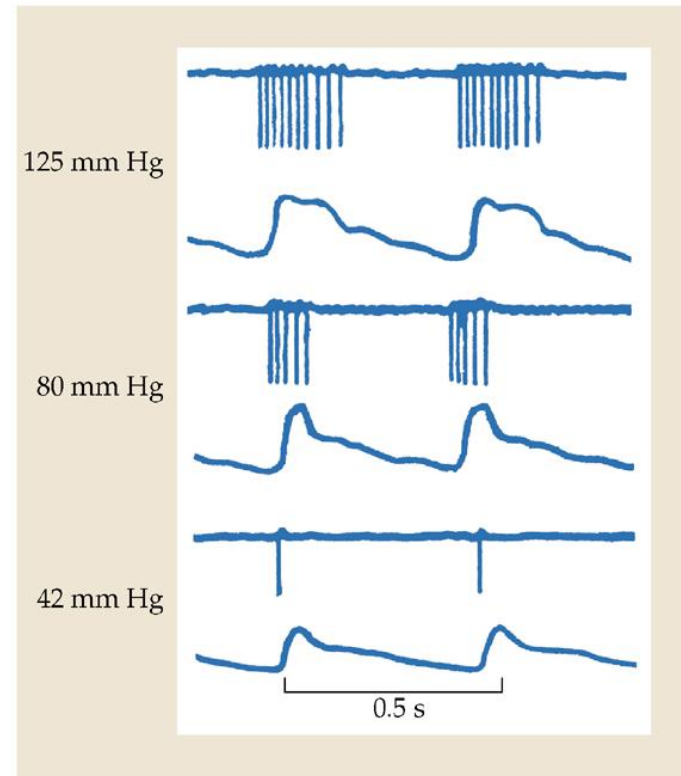
- Norepinephrine is the primary transmitter used by the sympathetic division
- Exception: sympathetic axons innervating sweat glands and blood vessels in skeletal muscle secrete acetylcholine (not norepinephrine)
- Many of the synapses in the sympathetic division also co-release ATP or peptides

Sensory Inputs to the ANS

- The ANS needs to receive constant sensory input from the targets it innervates
- e.g. body position – when lying flat there is no difference in blood pressure between the head & legs; with no ANS standing-up would cause a drop in BP above heart (lose consciousness due to lack of blood to brain); with ANS Rs in carotid artery signal change in blood pressure causing a rise in cardiac output and heart rate



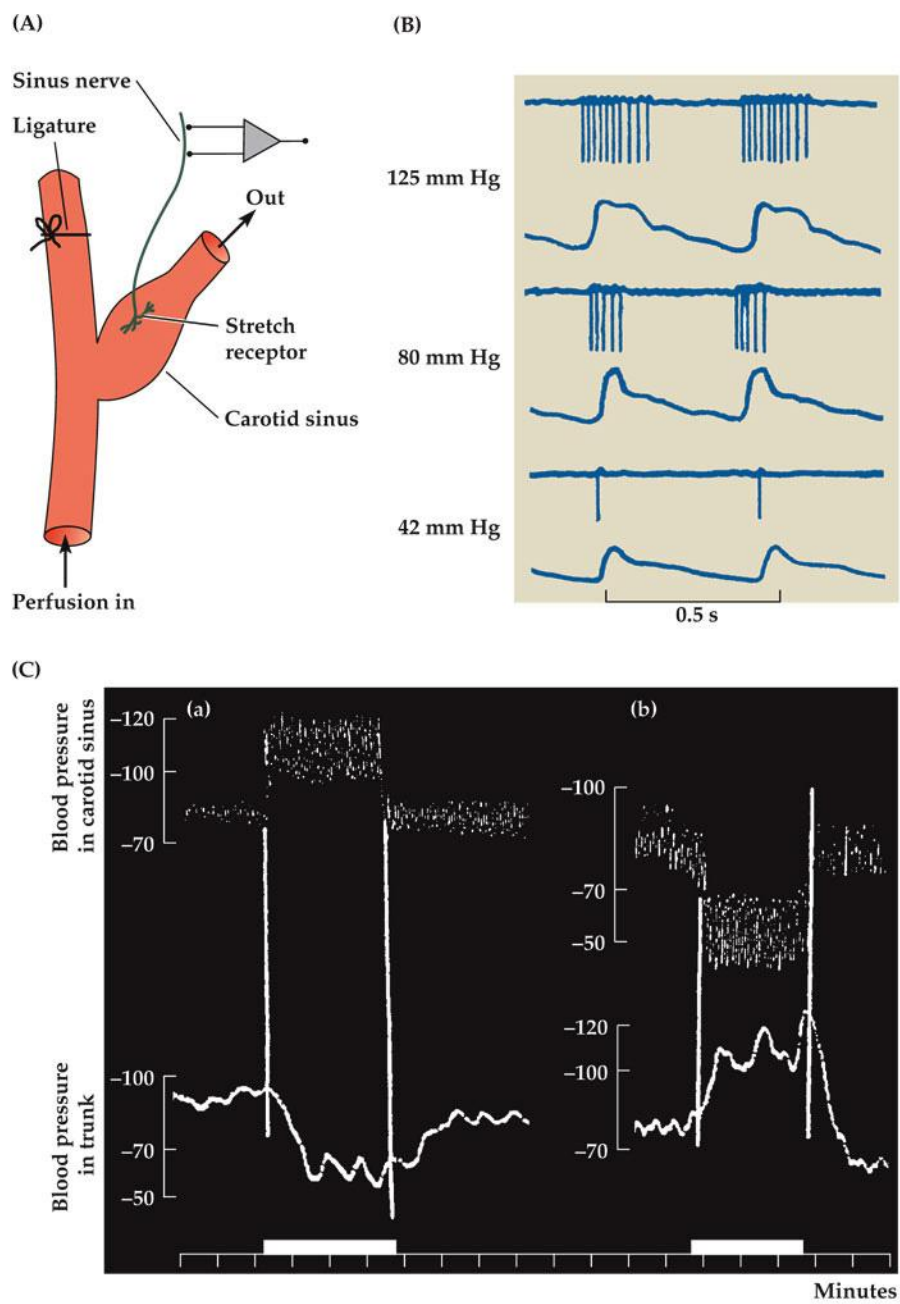
(B)



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- Firing of Carotid Sinus Stretch Receptors in Response to Raised Blood Pressure.
- Relationship between b.p. (lower trace) and the firing of a single afferent fiber from the carotid sinus at different levels of mean arterial pressure (mm of mercury measured on a manometer)

Figure 17.6 Firing of Carotid Sinus Stretch Receptors



Firing of Carotid Sinus Stretch Receptors in Response to Raised Blood Pressure.


Relationship between blood pressure (lower trace) and the firing of a single afferent fiber from the carotid sinus at different levels of mean arterial pressure (mm of mercury measured on a manometer)

Recording from 1924. The head of this animals was supplied with blood from a different animal so that b.p. in the head arteries could be controlled separately by the experimenters

Increased pressure in the head caused a fall in b.p. in the trunk and vice versa



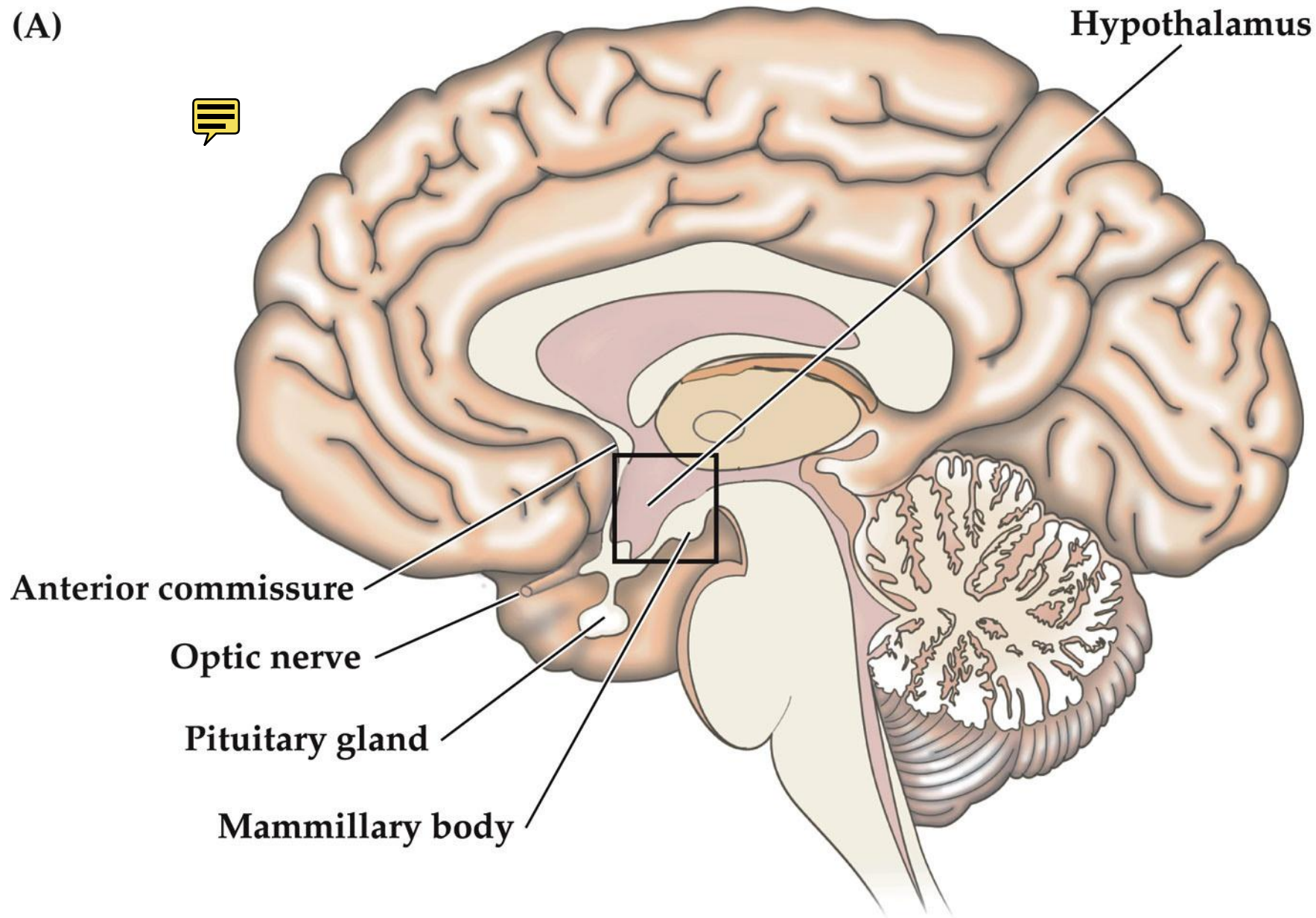
Enteric Nervous System

- There are more than 10 million nerves in the intestinal wall with every known transmitter present
- The leading model system for study of the enteric NS is the stomatogastric ganglion of the lobster 
- Many neurotransmitters were first identified in the gut

Hypothalamus

- Large control of the ANS is provided by hormones
- The hypothalamus is a brain area controlling integrative ANS functions (body temperature, appetite, water intake, arterial pressure, etc).
- The hypothalamus is also the area where emotions are coupled to autonomic responses
- It is influenced by higher centres of the CNS and by hormones (providing feedback)
- It is linked by a network of neurons to the cerebral cortex; together they form part of the limbic system

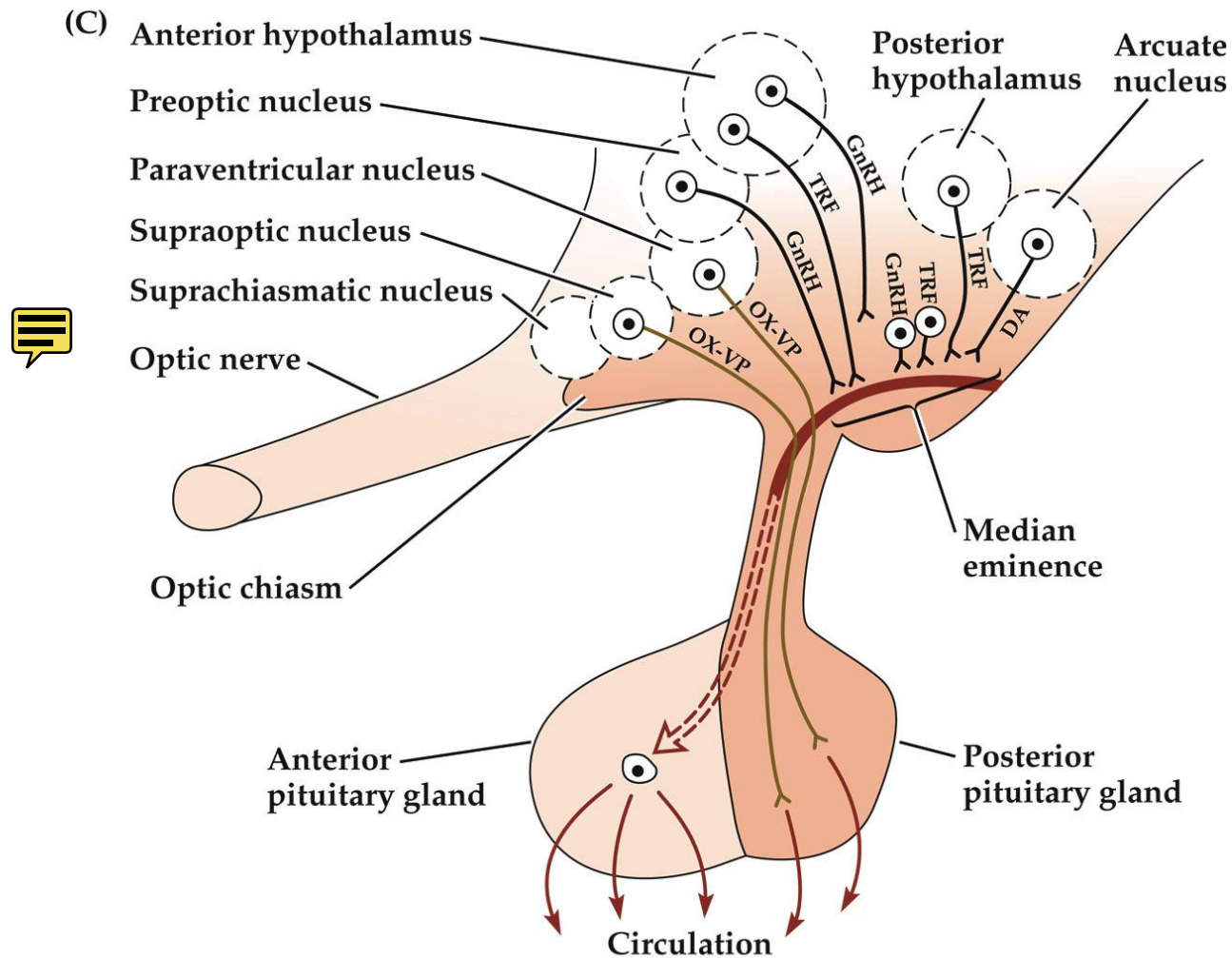
Figure 17.8 Hypothalamus and Pituitary Gland (Part 1)



Hypothalamic Neurons that Release Hormones

- e.g the release of gonadotropin-releasing hormone (GnRH) into a portal system of blood vessels that from directly from the hypothalamus to the anterior pituitary gland controlling hormone secretion
- GnRH stimulates specific cells to secrete gonadotropin (a hormone essential for sexual and reproductive rhythms)

Figure 17.8 Hypothalamus and Pituitary Gland (Part 3)



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Connections of Hypothalamic Neurons with the Pituitary

Releasing hormones released by neurons in the hypothalamus reach the adenohypophysis in high concentrations through a dedicated group of portal vessels. They activate secretory cells which liberate hormones into the circulation.