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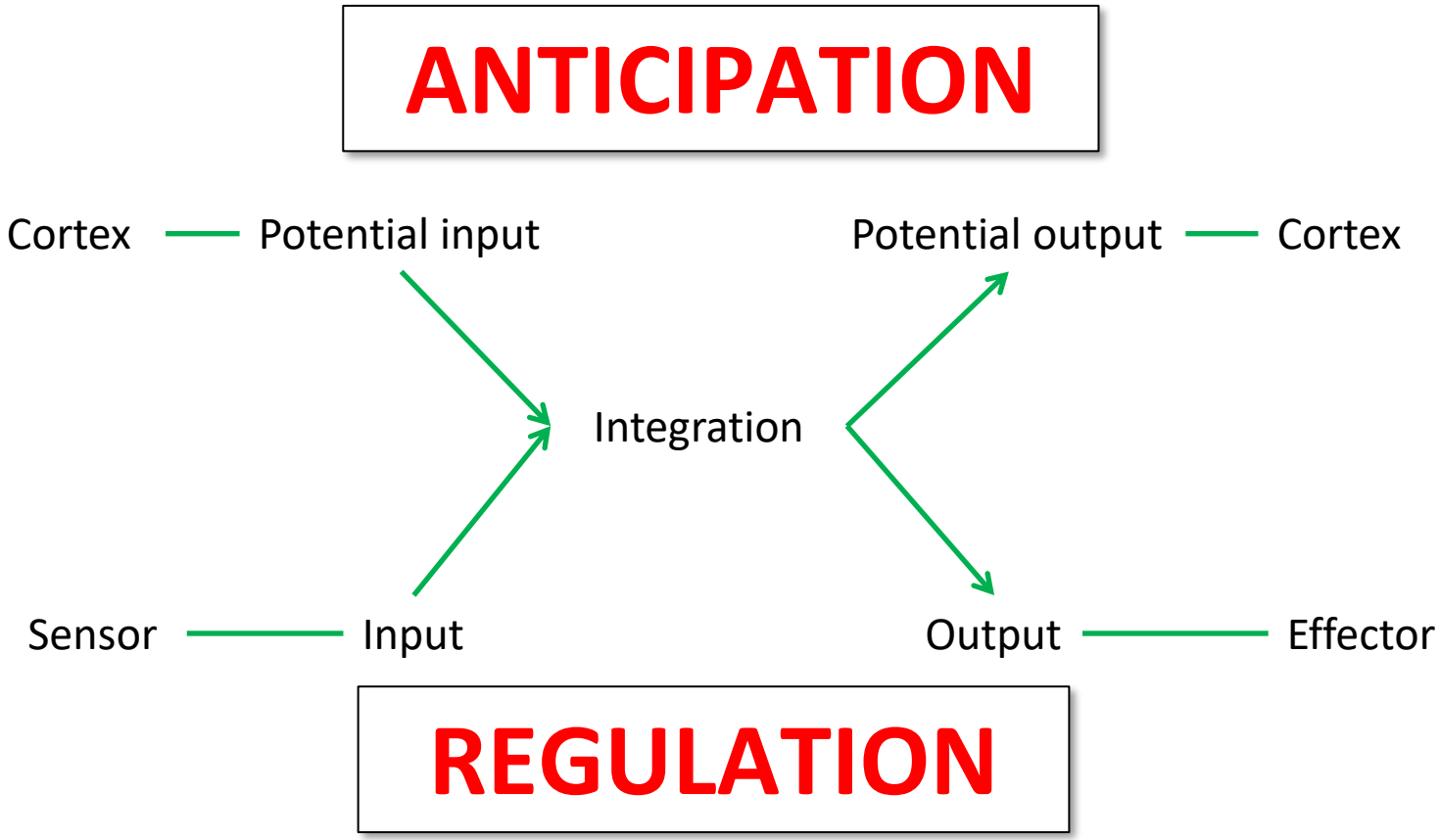
13

Autonomic nervous system

The role of nervous system



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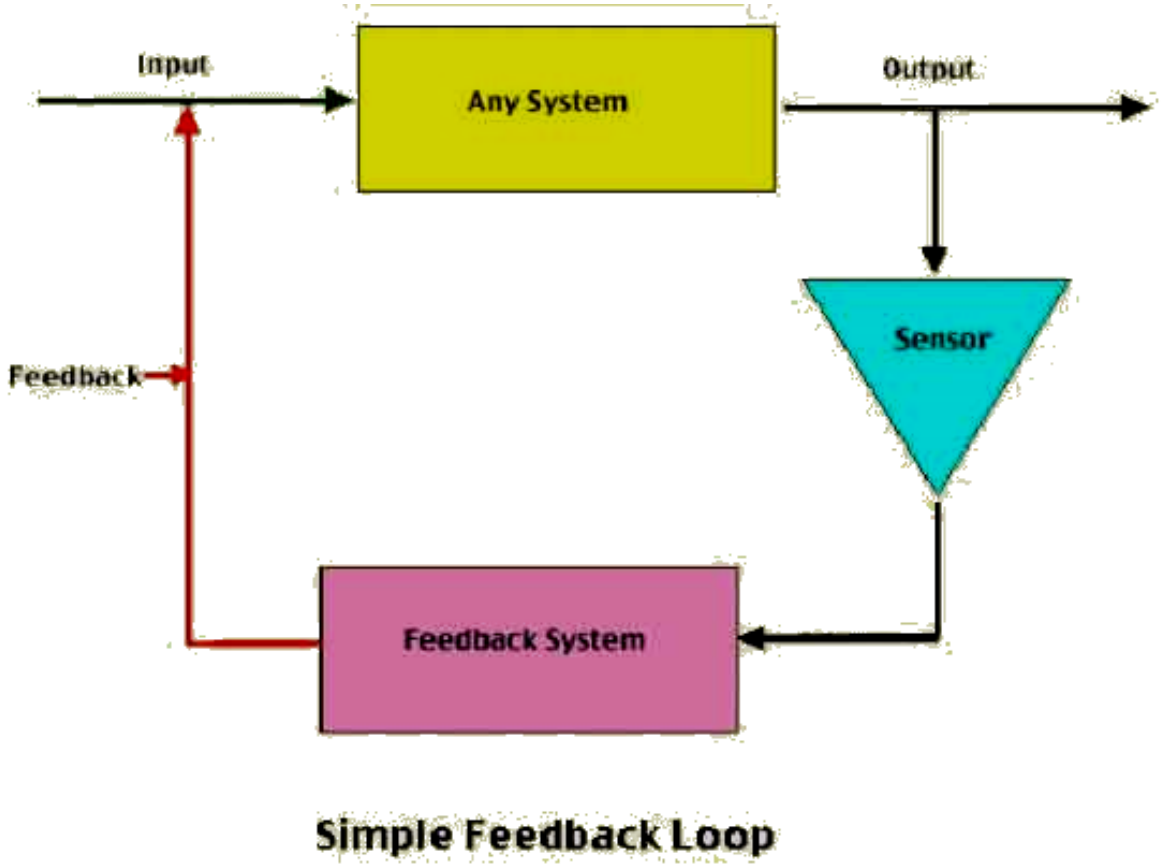
Feedback regulation



Simple Feedback Loop

http://www.slideshare.net/drpsdeb/presentations

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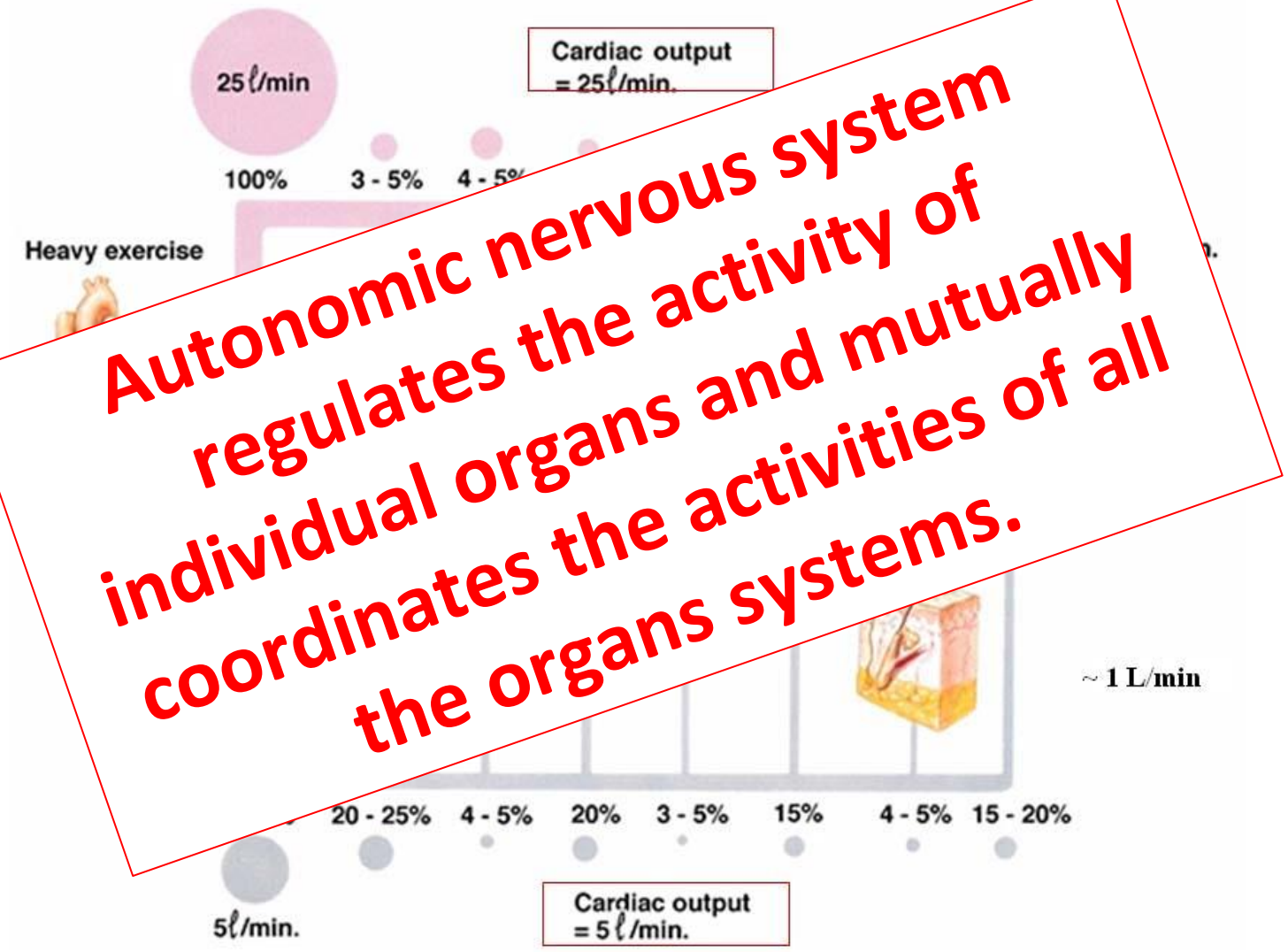
Redistribution of Blood Flow During Exercise



Autonomic nervous system regulates the activity of individual organs and mutually coordinates the activities of all the organs systems.

http://2.bp.blogspot.com/_MJ0CEYnSB4U/S99IJTUruOI/AAAAAAAAACs/NPzsh8ydzjQ/s1600/redistributionofbloodflow.jpg

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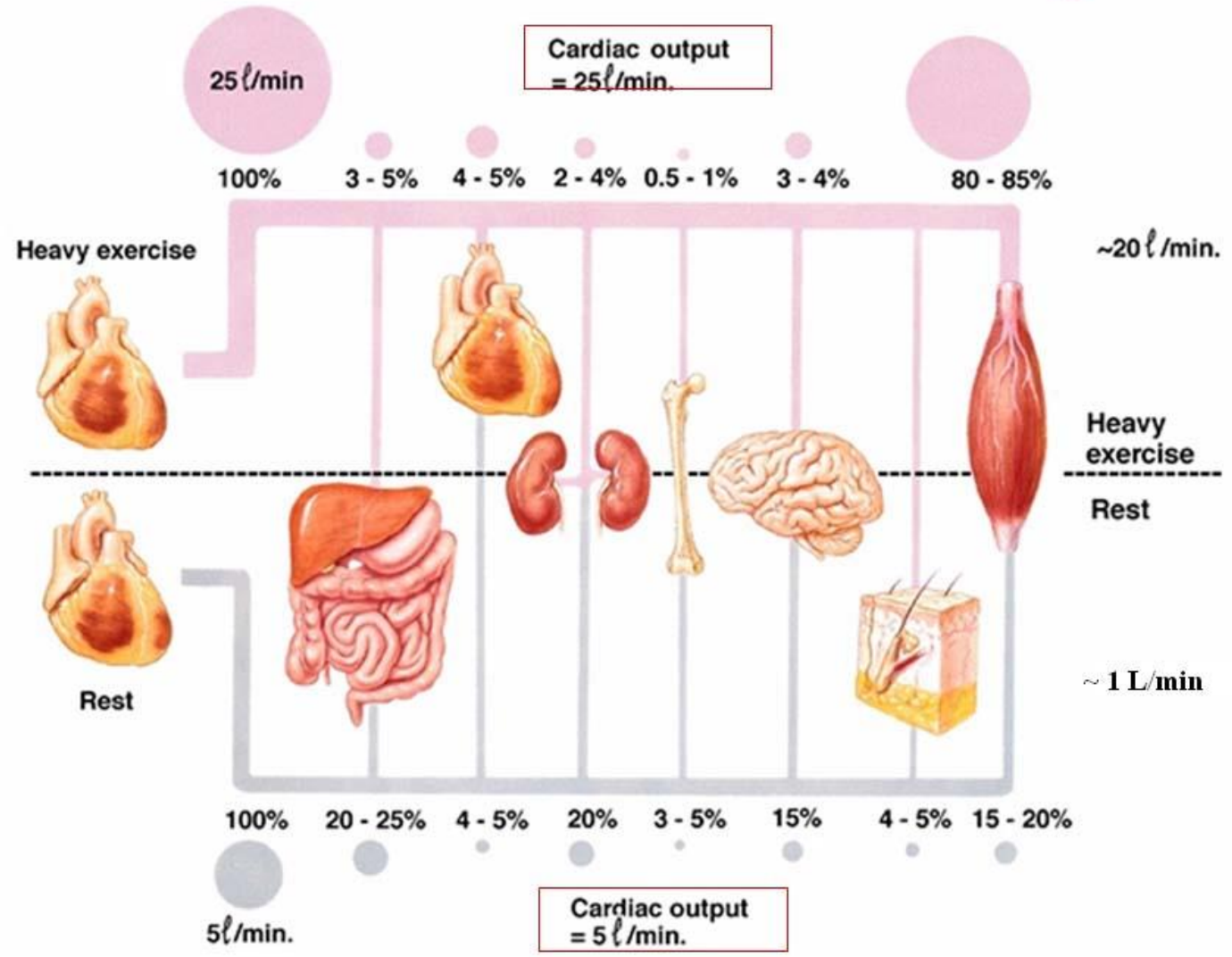
Redistribution of Blood Flow During Exercise



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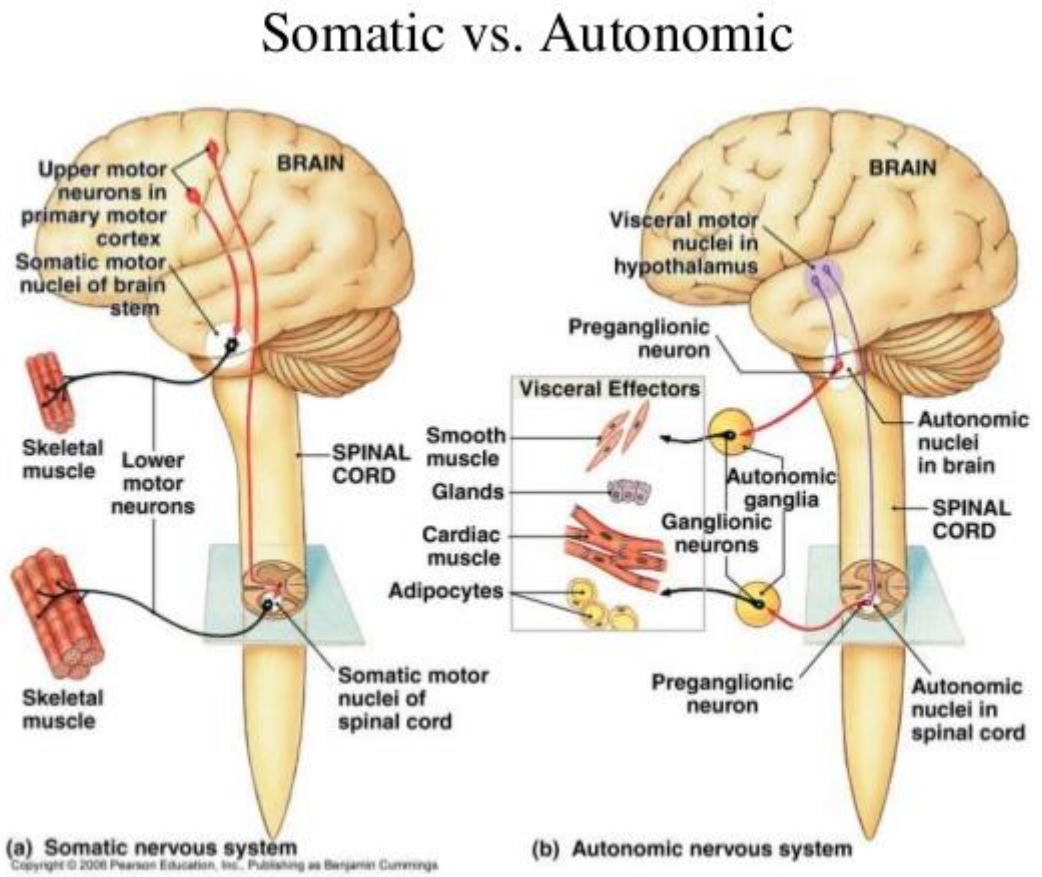
Somatic a autonomic nervous system

➢„Voluntary“

✓Skeletal muscle

▪Direct connection between CNS and effector



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➢„Involuntary“

✓Cardiomyocyte
✓Visceral muscle
✓Gland

▪Autonomic ganglion inserted between CNS and effector

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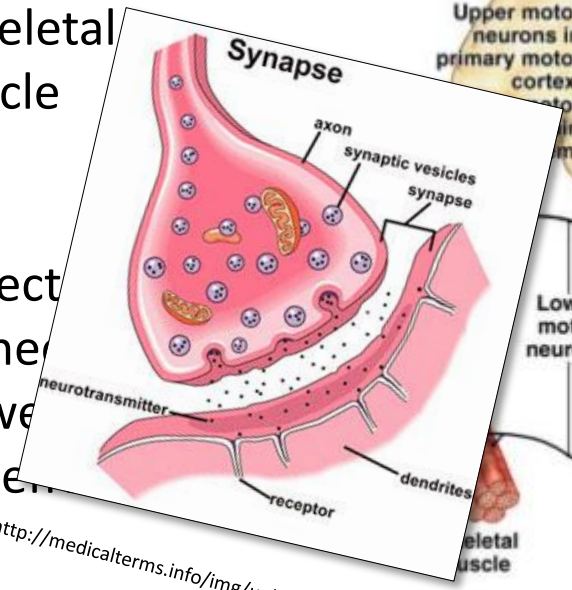
Somatic a autonomic nervous system

➢„Voluntary“

✓Skeletal muscle

▪Direct connec… betwe… and e…



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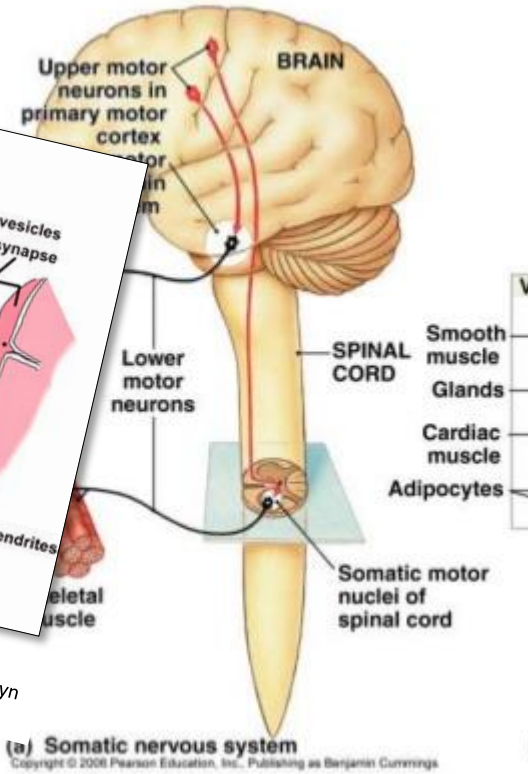

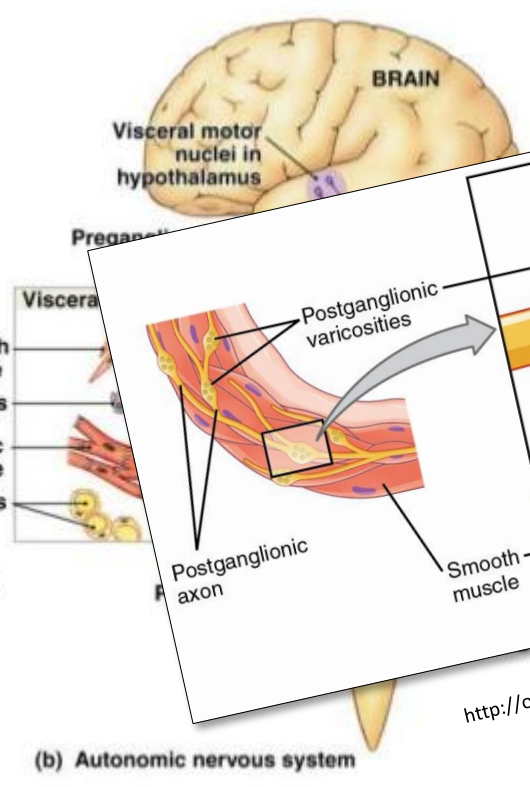

➢„Involuntary“

✓C…

http://oerpub.github.io/epubjs-demo-book/resources/1504_Autonomic_Varicosities.jpg

http://image.slidesharecdn.com/ans-130217134747-phpapp01/95/central-nervous-system-the-autonomic-nervous-system-7-638.jpg?cb=1361108947

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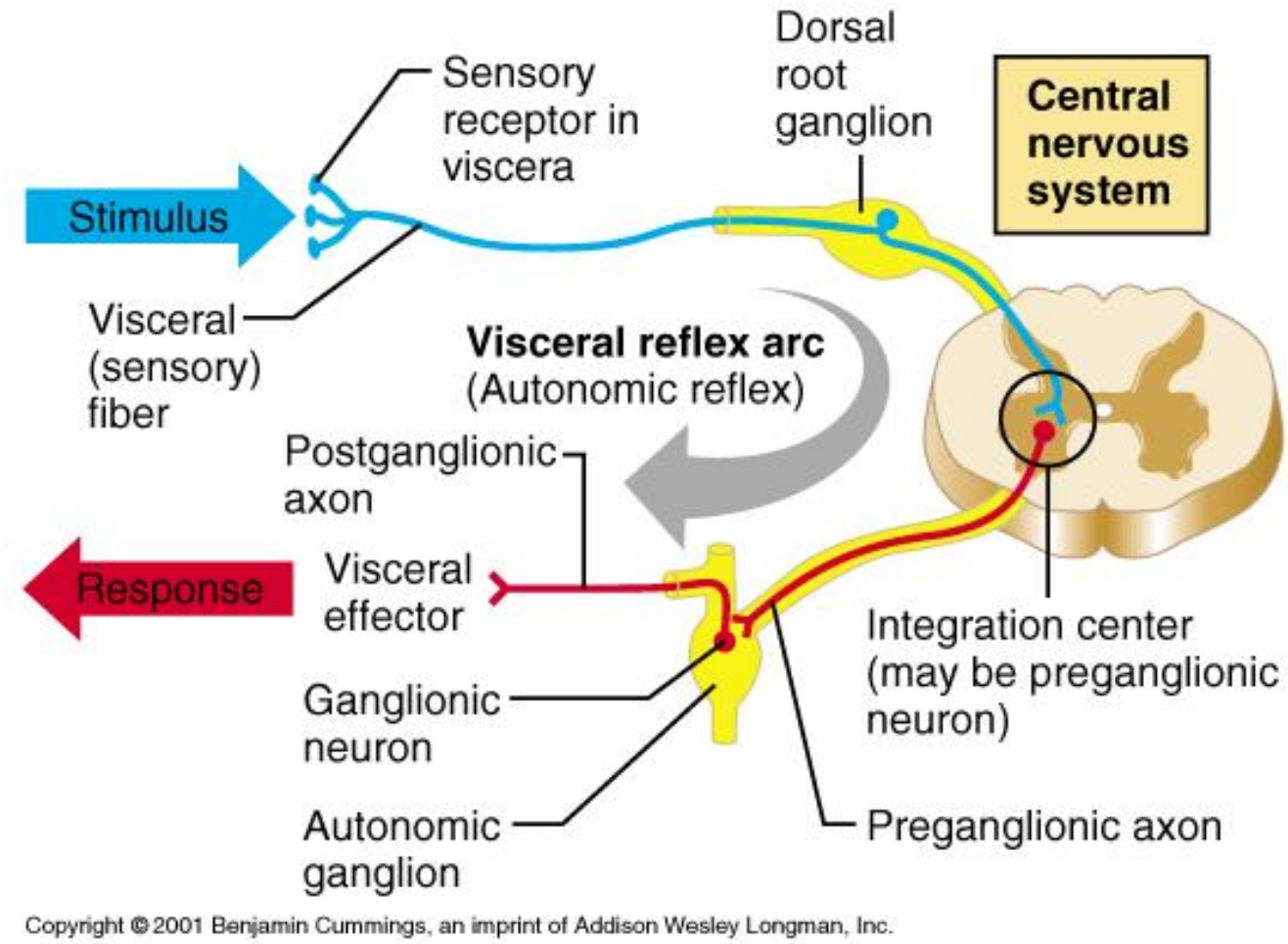
Visceral reflex loop



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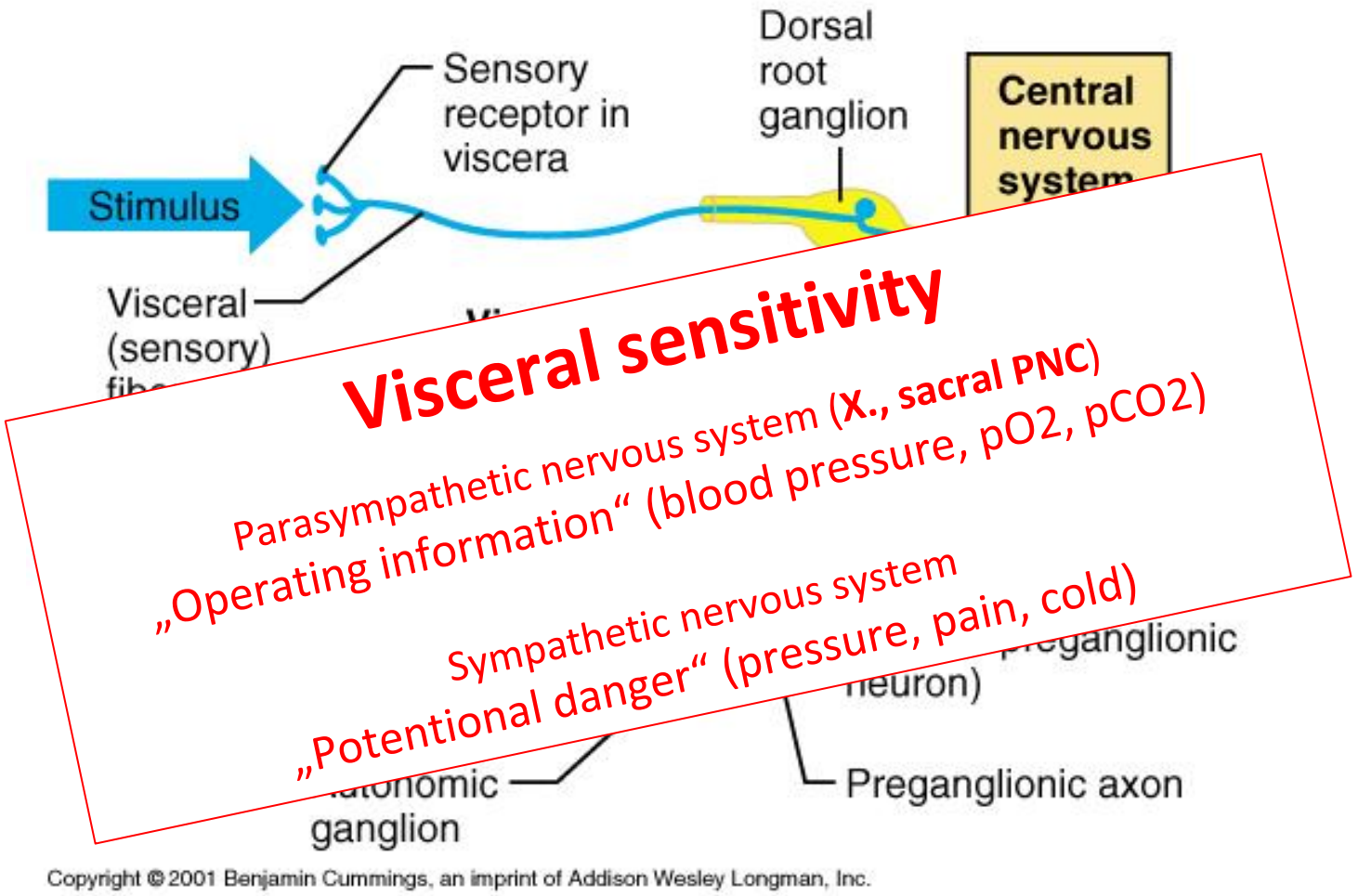
Visceral reflex loop



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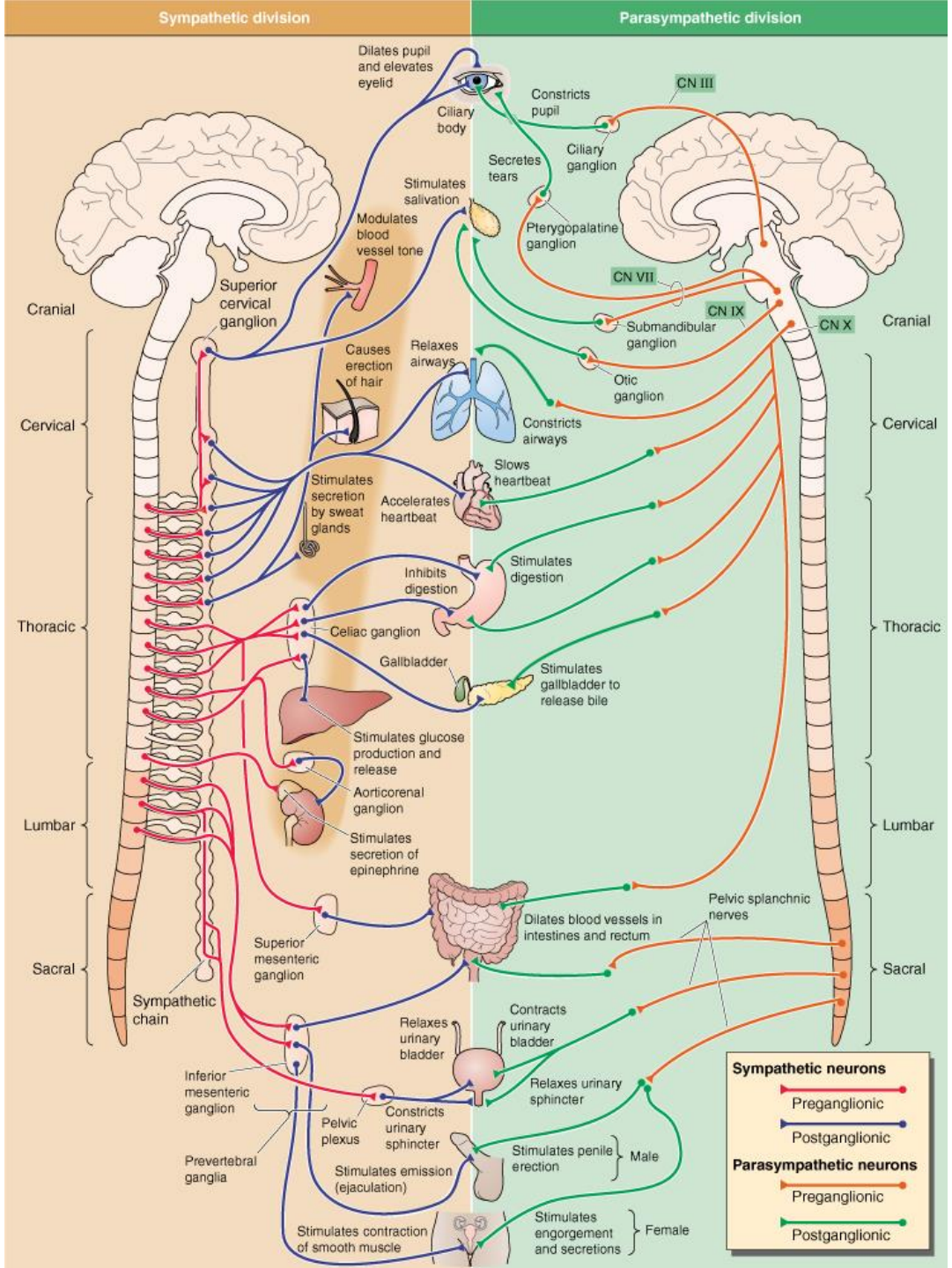
Sympatthetic nervous system

Fight or flight response

Energy/store consumption



Parasympathetic nervous system

Rest and digest response

Energy conservation/energy store production

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Sympatthetic nervous system

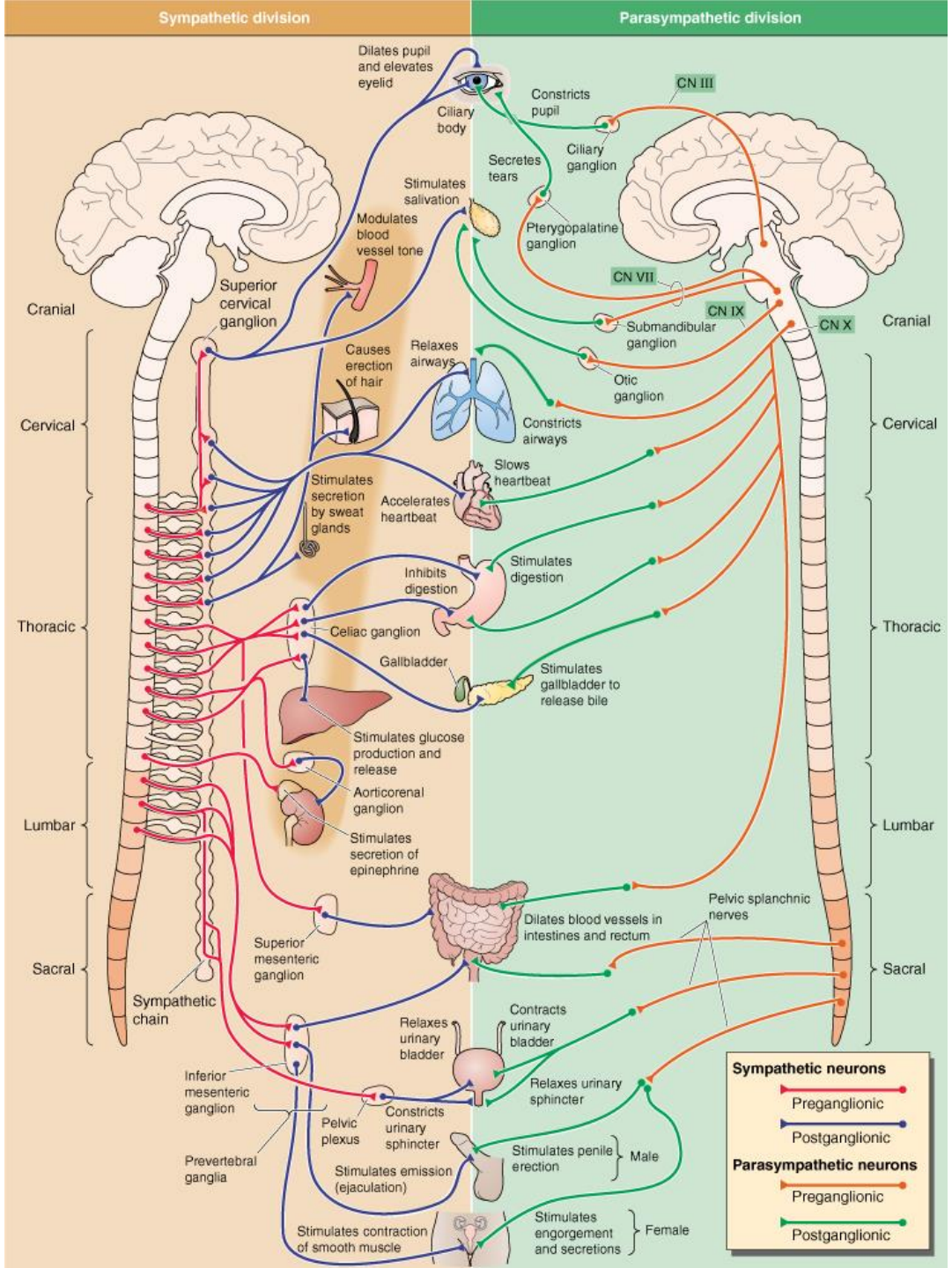
Fight or flight response

Energy/store consumption

Preganglionic neuron
– Spinal cord
-Thoraco - lumbar system

Ganglia *Paravertebral*
-Truncus sympathicus
- Majority
Prevertebral
-Plexus aorticus

Mostly diffuse effect



Parasympathetic nervous system

Rest and digest response

Energy conservation/energy store production

Preganglionic neuron
– Brain stem and spinal cord
– cranio-sacral system

Ganglia
Close to target organs or intramurally

Mostly local effect

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Sympatthetic nervous system

Fight or flight resp

Energy/store consur

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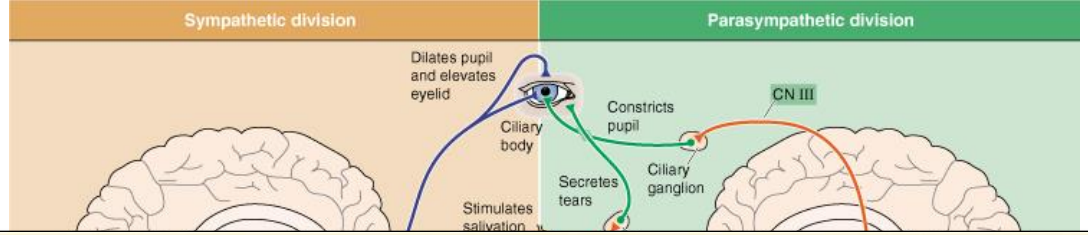
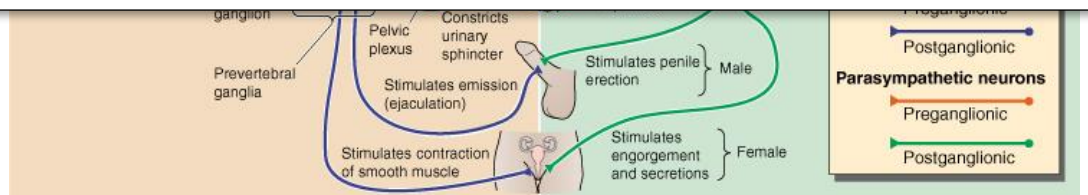


System/function	Parasympathetic	Sympathetic
Cardiovascular	Decreased cardiac output and heart rate	Increased contraction and heart rate; increased cardiac output
Pulmonary	Bronchial constriction	Bronchial dilatation
Musculoskeletal	Muscular relaxation	Muscular contraction
Pupillary	Constriction	Dilatation
Urinary	Increased urinary output; sphincter relaxation	Decreased urinary output; sphincter contraction
Gastrointestinal	Increased motility of stomach and gastrointestinal tract; increased secretions	Decreased motility of stomach and gastrointestinal tract; decreased secretions
Glycogen to glucose conversion	No involvement	Increased
Adrenal gland	No involvement	Release epinephrine and norepinephrine



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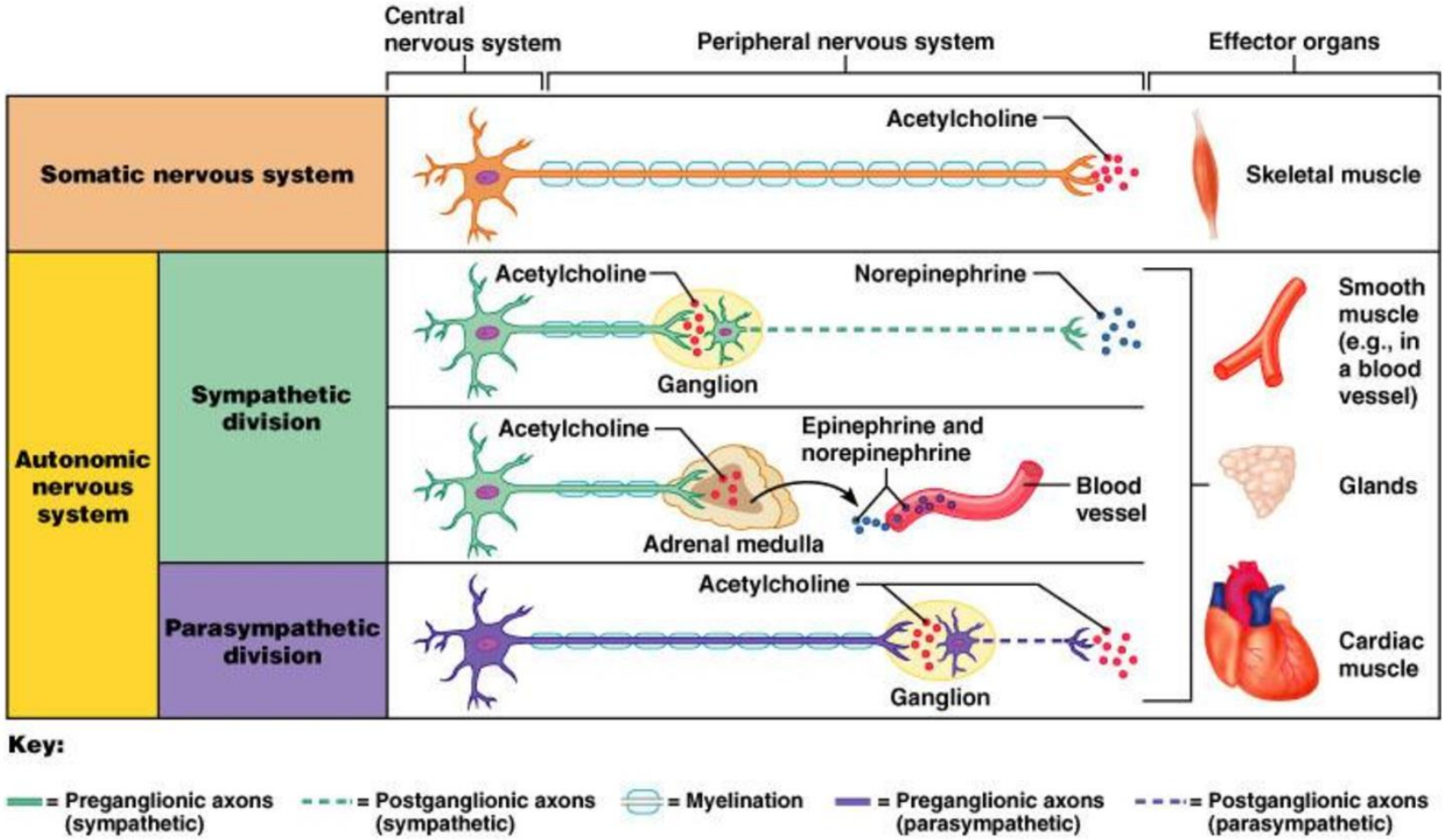
Mediators of somatic and autonomic nervous system



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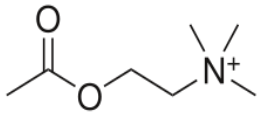
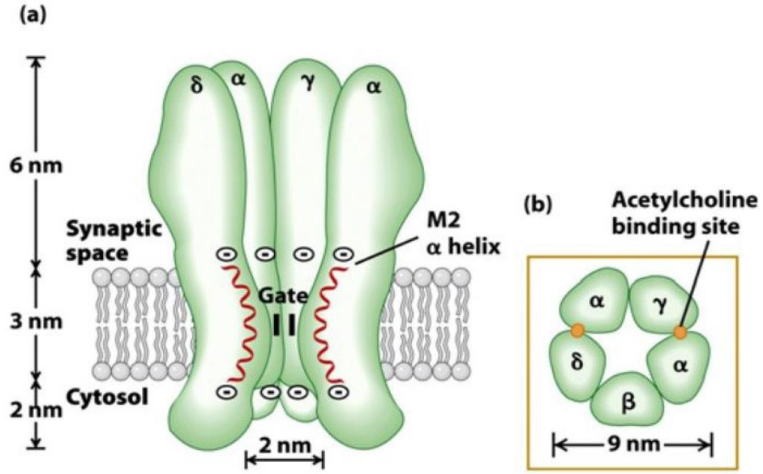


Acetylcholine

Preganglionic fibers

- Sympathetic
- Parasympathetic
- ✓ Nicotinic receptor
  - Ligand-gated ion channels
  - Na+, K+, Ca2+
  - Neuronal (N_N) and muscle (N_M) type
  - Excitatory



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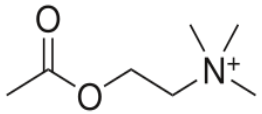

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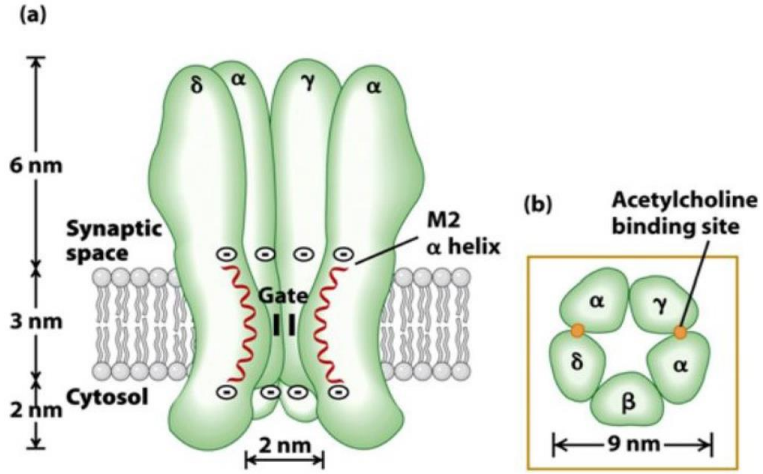

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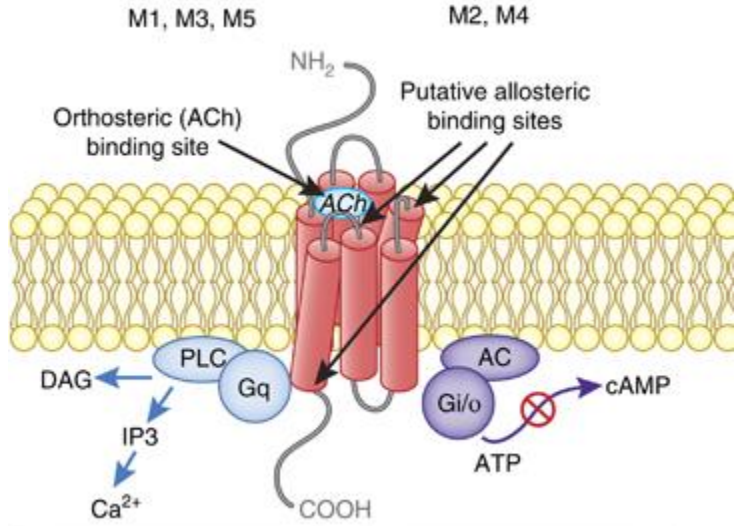
Postganglionic fibers

- Parasympathetic
- ✓ Muscarinic receptor
  - G-coupled
  - Excitatory
    - M1, M3, M5
  - Inhibitory
    - M2, M4



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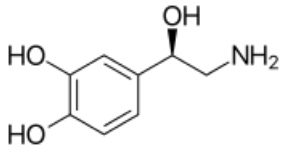
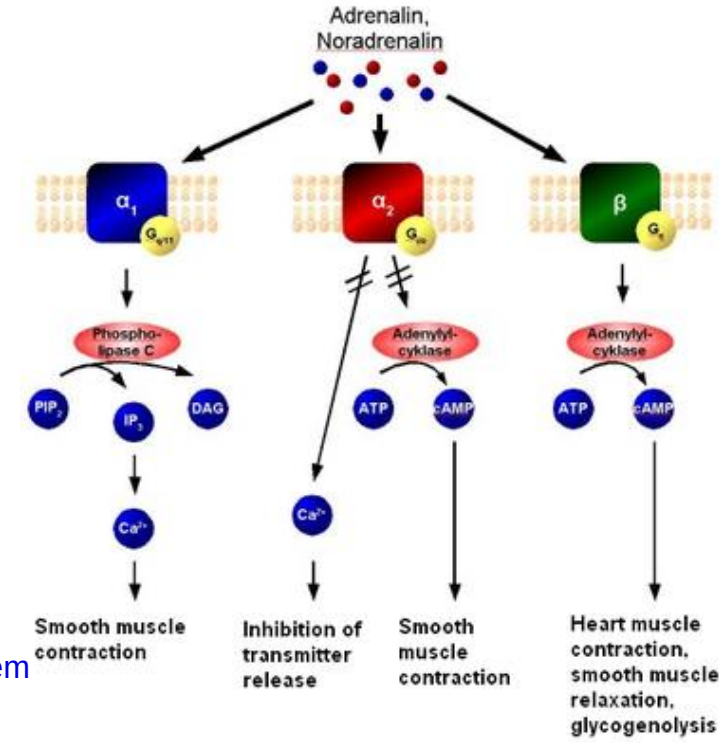


Norepinephrine

- Postganglionic sympathetic fibers
- Adrenergic receptor
  - G-coupled
  - α type– generally excitatory (contraction) with an exception of GIT
  - β type – generally inhibitory (relaxation) with an exception of !!! heart !!!

https://en.wikipedia.org/wiki/Adrenergic_receptor



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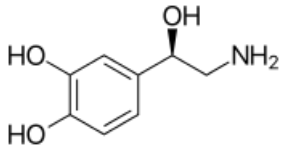

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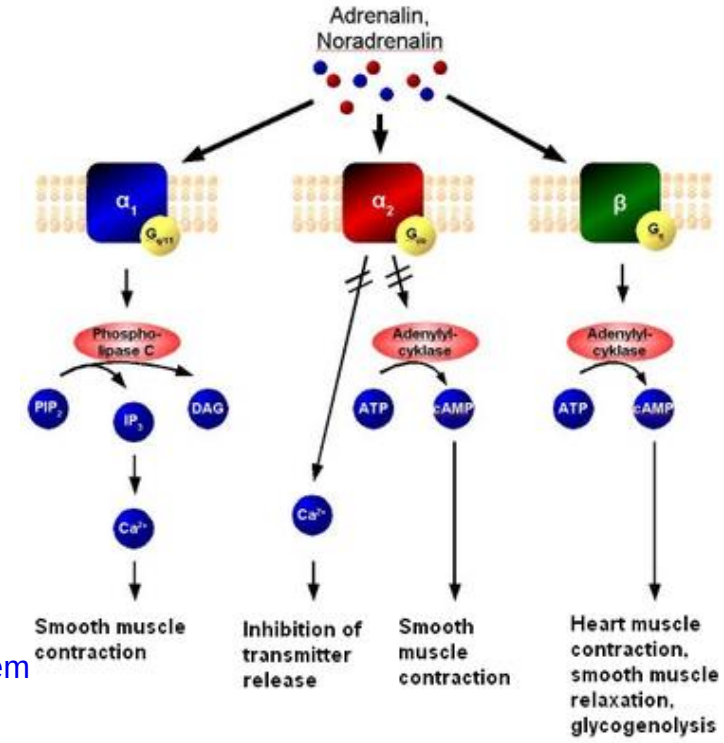
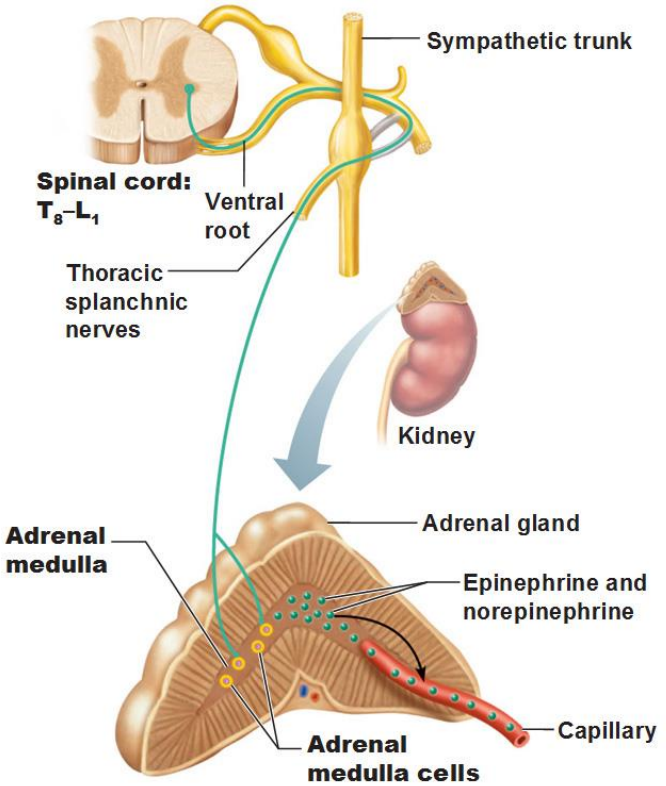


https://en.wikipedia.org/wiki/Adrenergic_receptor

- Adrenal medulla
  - Modified sympathetic ganglion
  - „Transmitters“ (stress hormones) secreted into the blood stream
    - Norepinephrine
    - Epinephrine



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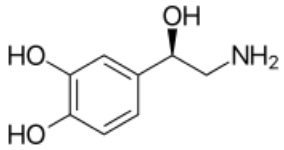

Norepinephrine

- Postganglionic sympathetic fibers
- Adrenergic receptor
  - G-coupled
- Adrenal medulla

Receptor	G protein and effectors	Agonists	Tissue	Responses
$Alpha_1$	Gq ↑phospholipase C, IP3 and DAG, intracellular Ca^{2+}	**Epi ≥ NE** >> Iso Phenylephrine	Vascular, GU smooth muscle Liver Intestinal smooth muscle Heart	Contraction Glycogenolysis; gluconeogenesis Hyperpolarization and relaxation Increased contractile force; arrhythmias
$Alpha_2$	Gi, Go ↓adenylyl cyclase ↓cAMP	**Epi ≥ NE** >> Iso Clonidine	Pancreatic islets (β cells) Platelets Nerve terminals Vascular smooth muscle	Decreased insulin secretion Aggregation Decreased release of NE Contraction
$Beta_1$	Gs ↑adenylyl cyclase, cAMP, L-type Ca^{2+} channel opening	Iso > **Epi = NE** Dobutamine	Juxtaglomerular cells Heart	Increased renin secretion Increased force and rate of contraction and AV nodal conduction velocity
$Beta_2$	Gs ↑adenylyl cyclase	Iso > **Epi >> NE** Terbutamine	Smooth muscle (vascular, bronchial, GI, GU) Skeletal muscle	Relaxation Glycogenolysis; uptake of K^+
$Beta_3$	Gs ↑adenylyl cyclase	Iso = **NE > Epi**	Adipose tissue	Lipolysis

Epi, epinephrine; NE, norepinephrine; Iso, isoproterenol

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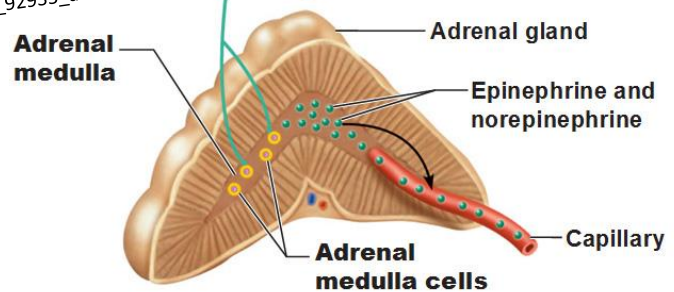
Smooth muscle contraction

Inhibition of transmitter release

Smooth muscle contraction

Heart muscle contraction, smooth muscle relaxation, glycogenolysis



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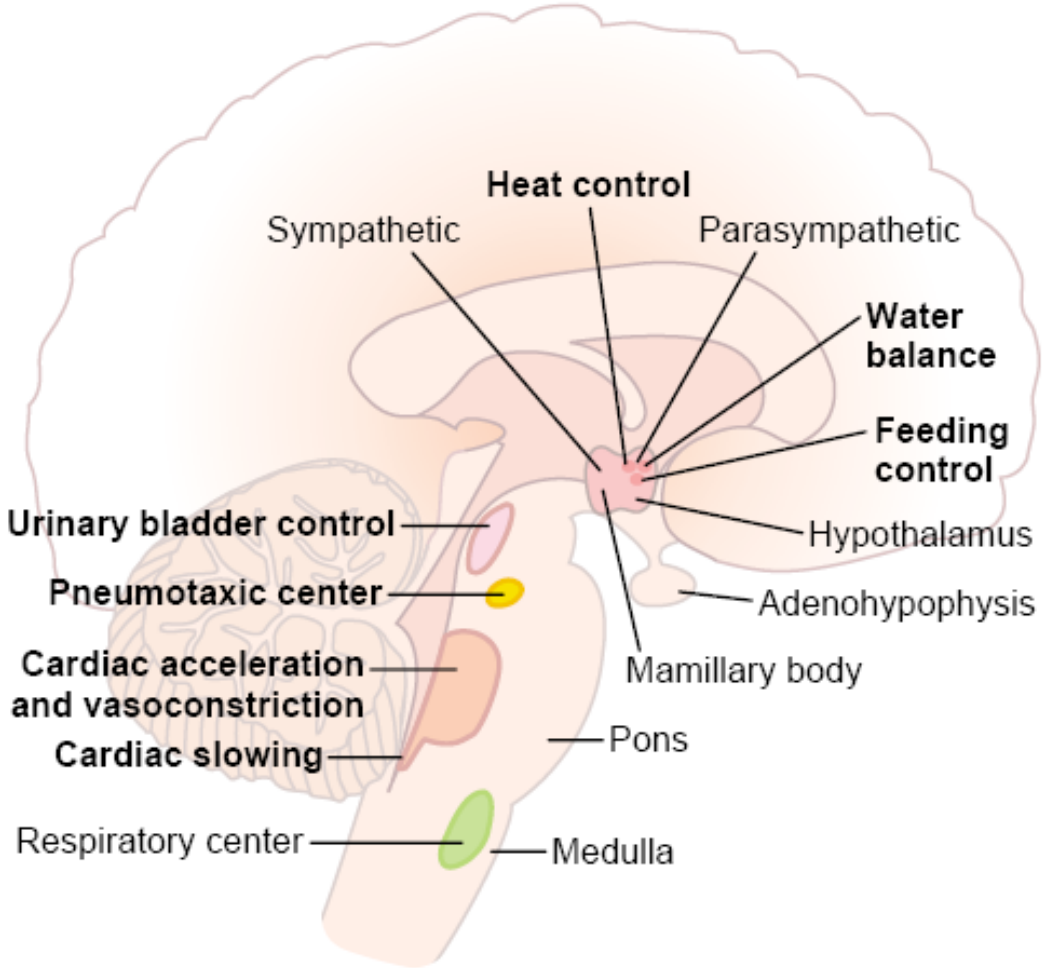
Brain centers controling autonomic nervous system



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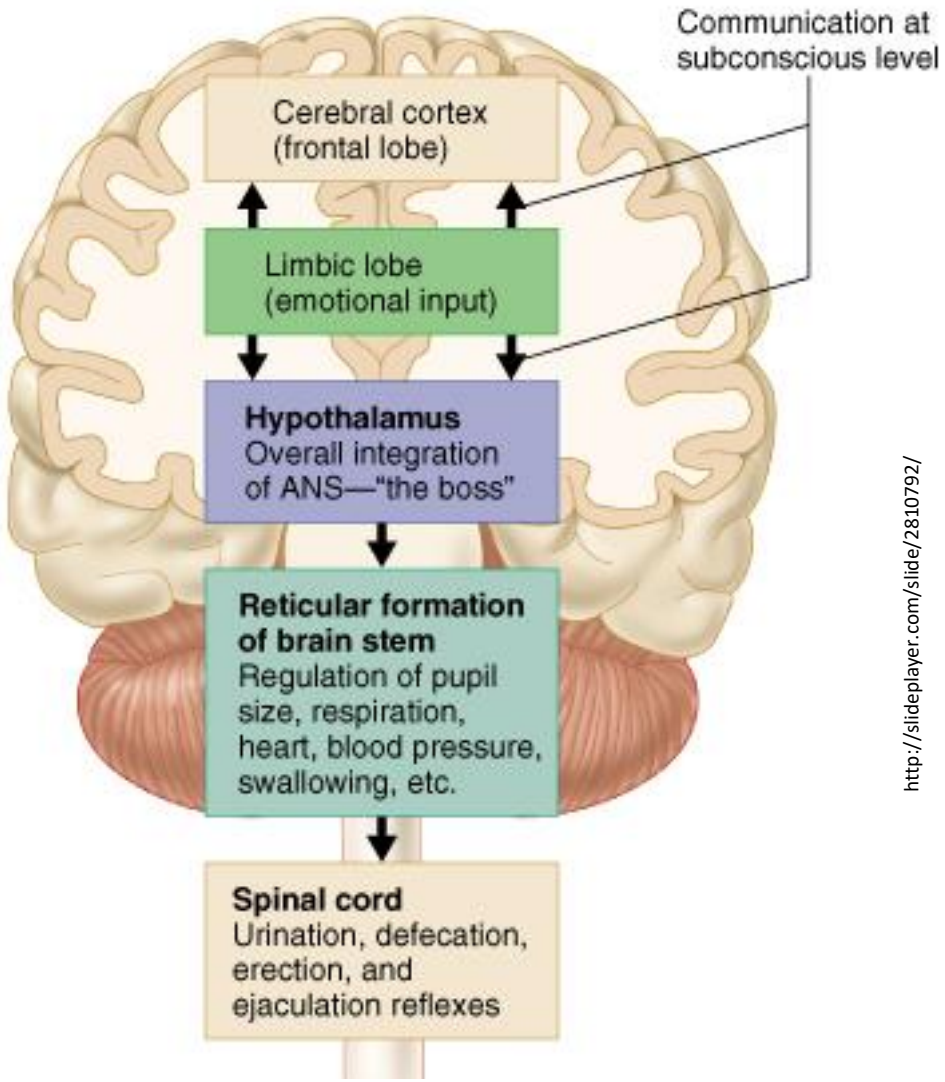
Brain centers controling autonomic nervous system

- Most of the regulations are unconscious and originate from the hypothalamus
- Strong emotional experiences or strong emotional memories can trigger autonomic response (usually sympathetic)



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Hypothalamus

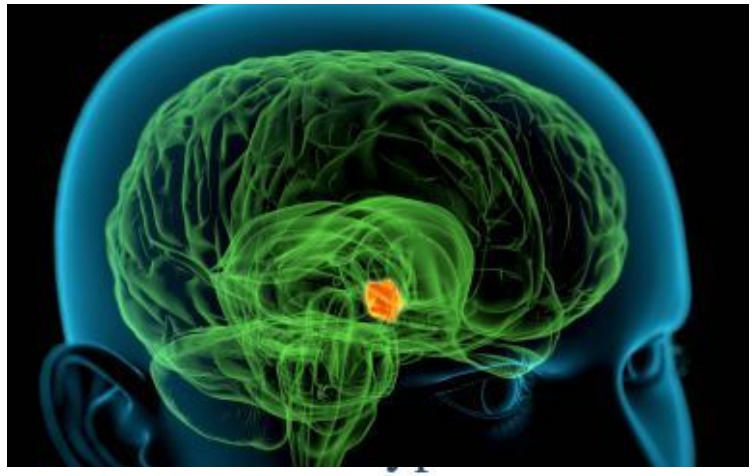
- Key center of autonomic regulations and coordination
- Integration of the information from inner and outer environment

↓

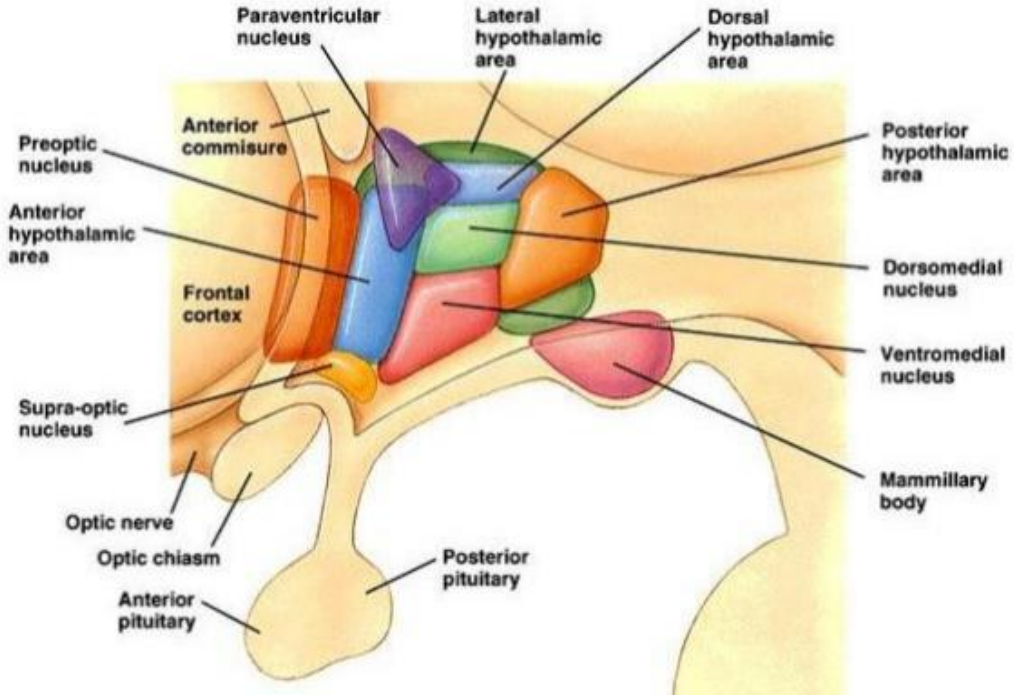
- Behavioral modulation
- Regulation of autonomic nervous system

↓

- **Maintenance of homeostasis**



http://biology.about.com/od/anatomy/p/Hypothalamus.htm



http://www.slideshare.net/physiologymgmcri/hypothalamus-15-apr-2016

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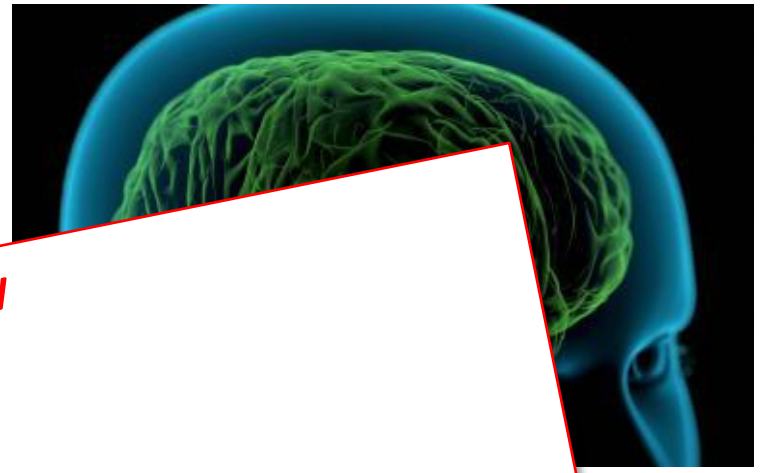
Hypothalamus

- Key center of autonomic regulations and coordination
- Integration of the inform… from inner… enviro…
- Behavic…
- Regulati… nervous …
- **Maintena…**

✓Biological clock – circadian /seasonal activity



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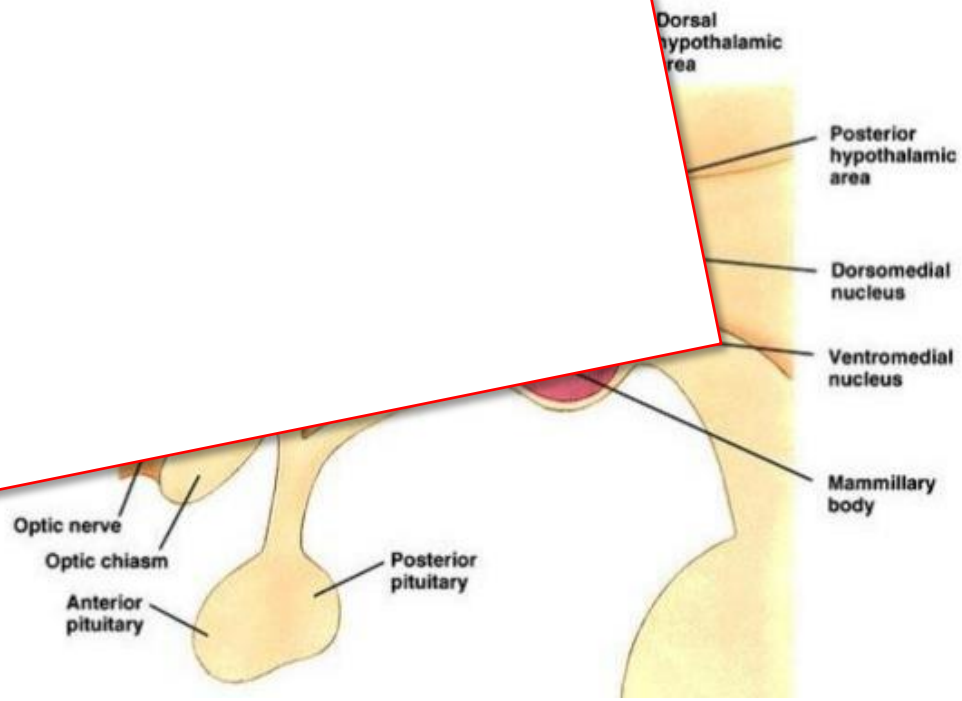

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- Behavic…
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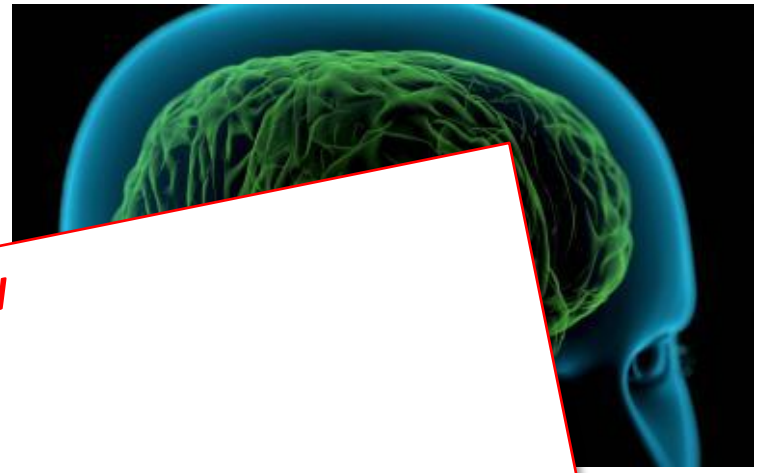
- **Maintena…**

✓Biological clock – circadian /seasonal activity
✓Autonomic nervous system regulation
✓Endocrine system regulation
✓Food and water intake regulation
✓Regulation of body temperature



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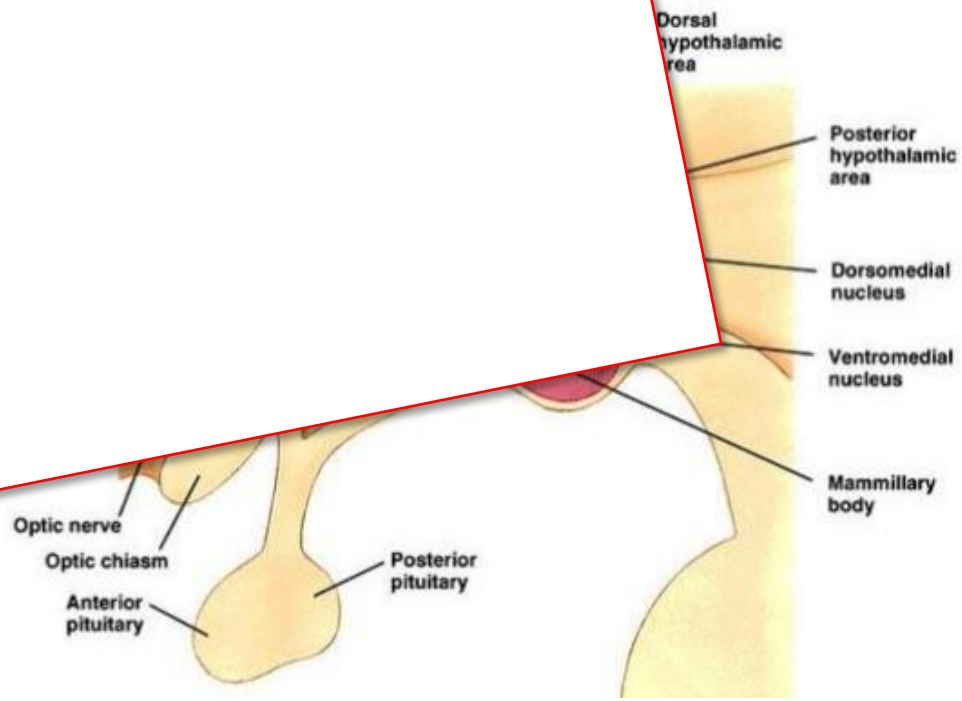

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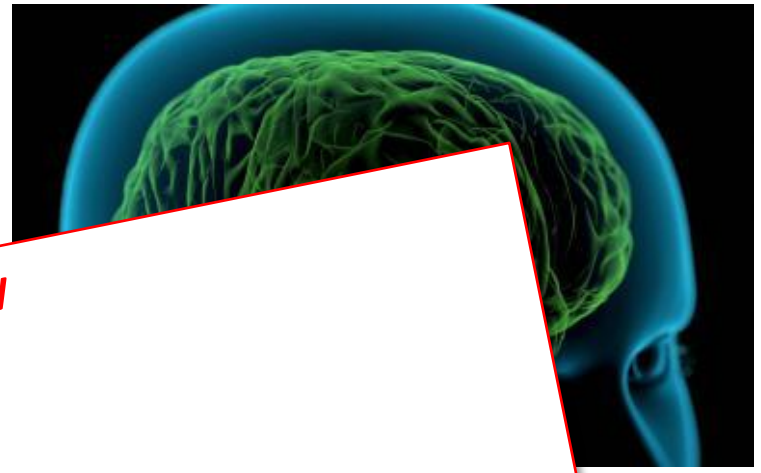
- **Maintena…**

✓Biological clock – circadian /seasonal activity
✓Autonomic nervous system regulation
✓Endocrine system regulation
✓Food and water intake regulation
✓Regulation of body temperature
✓„Immediate“ behavior regulation (e.g. when hunger)
✓ „Long-term“ behavior regulation (e.g. maternal beh.)
✓Instinctive behavior regulation (e.g. sexuality)



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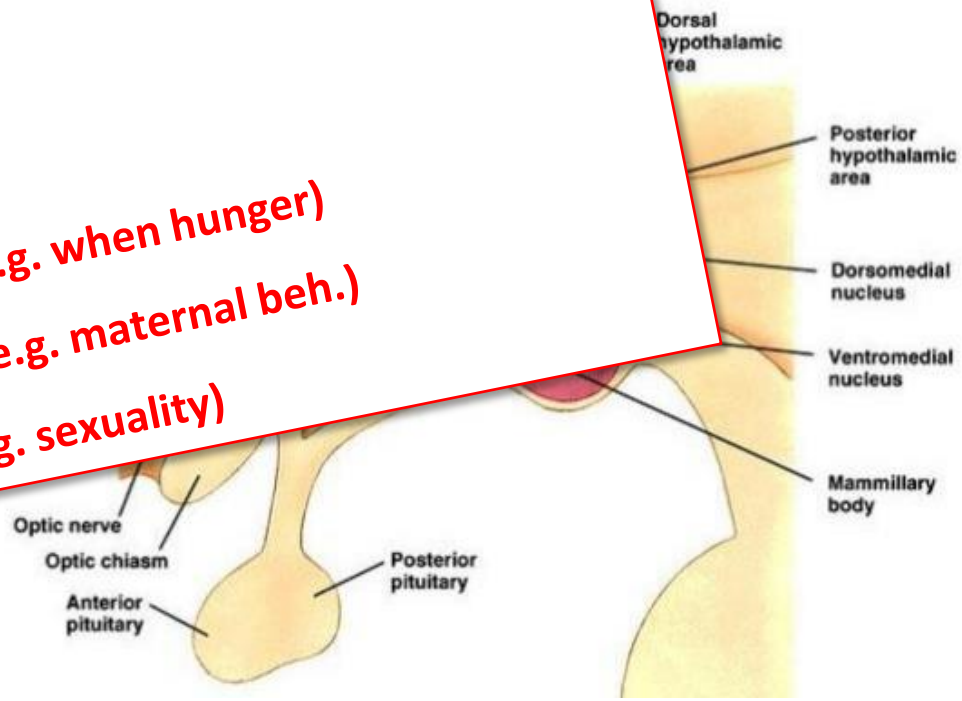

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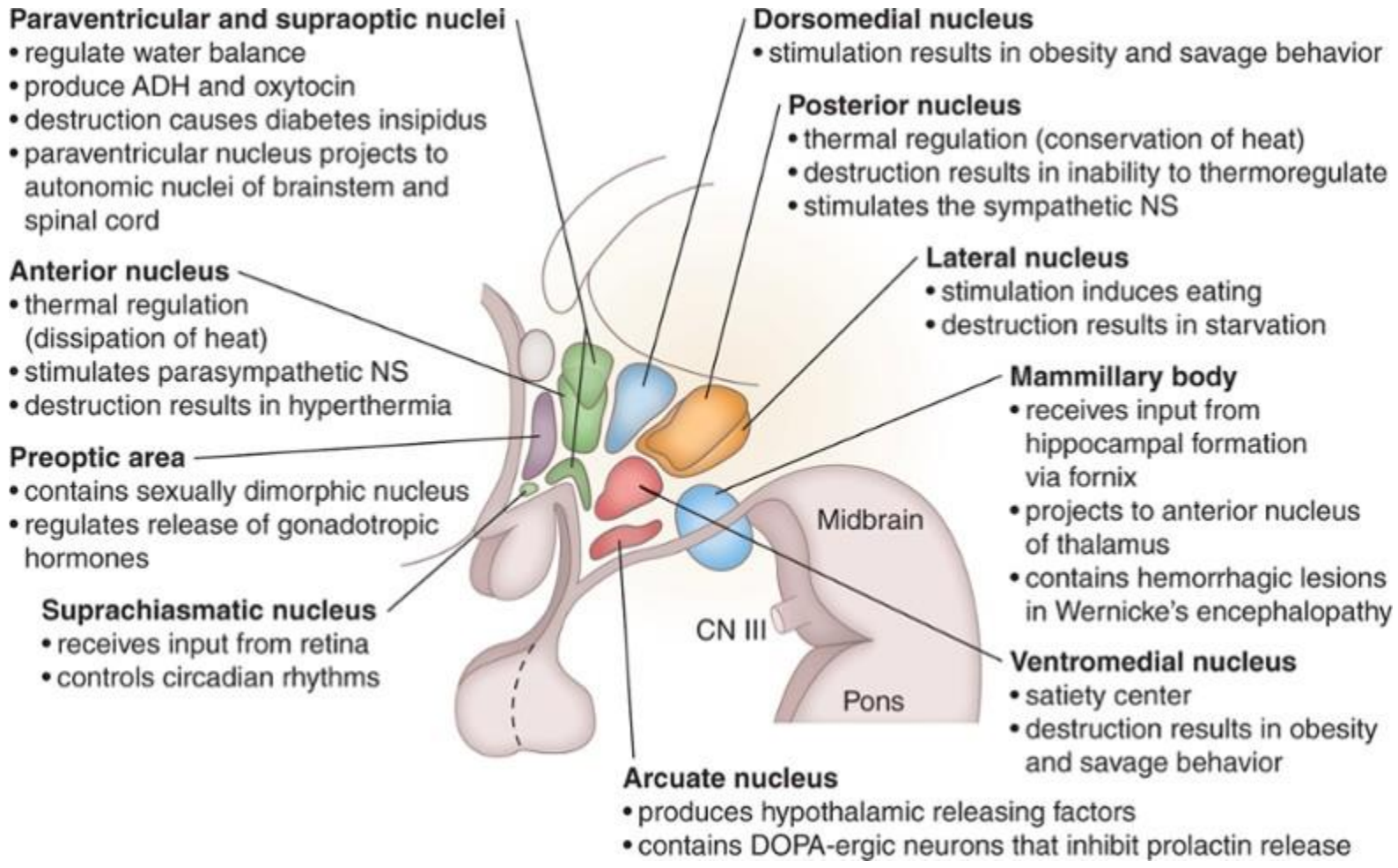
Hypothalamus



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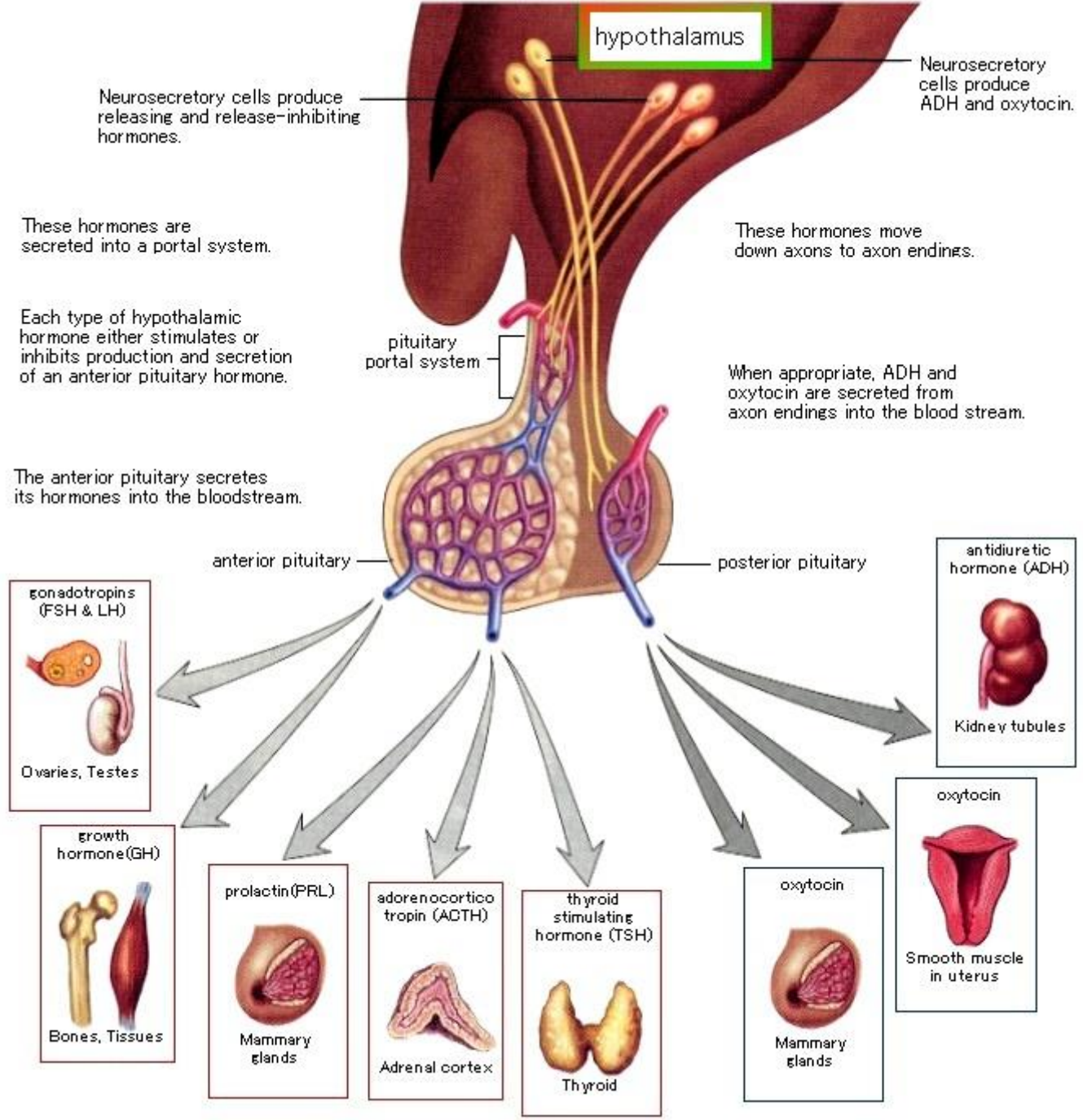

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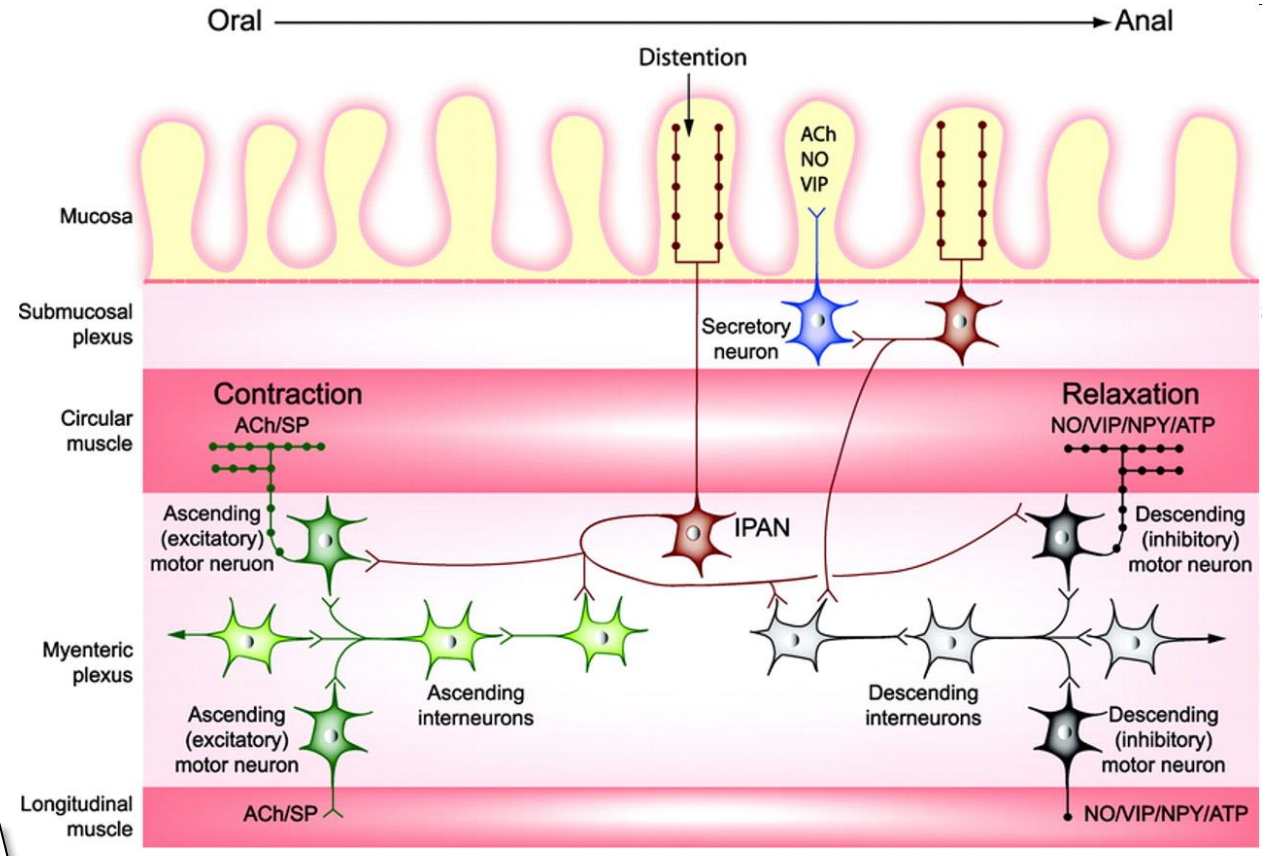
Enteric nervous system

- aprox. 500 mil. neurons
  - (brain aprox. 100 bil.)
  - (spinal cord aprox. 100 mil.)
- Plexus myentericus
- Plexus submucosus
- Sensory component
- Executive component
- Interneurons
- High level of autonomy
  - „brain in the gut“



http://www.slideshare.net/carmencrivii/central-nervous-system-the-autonomic-nervous-system?qid=d1502190-93fe-4b05-9d92-6a42e3ca72fc&v=&b=&from_search=8

Microbiome

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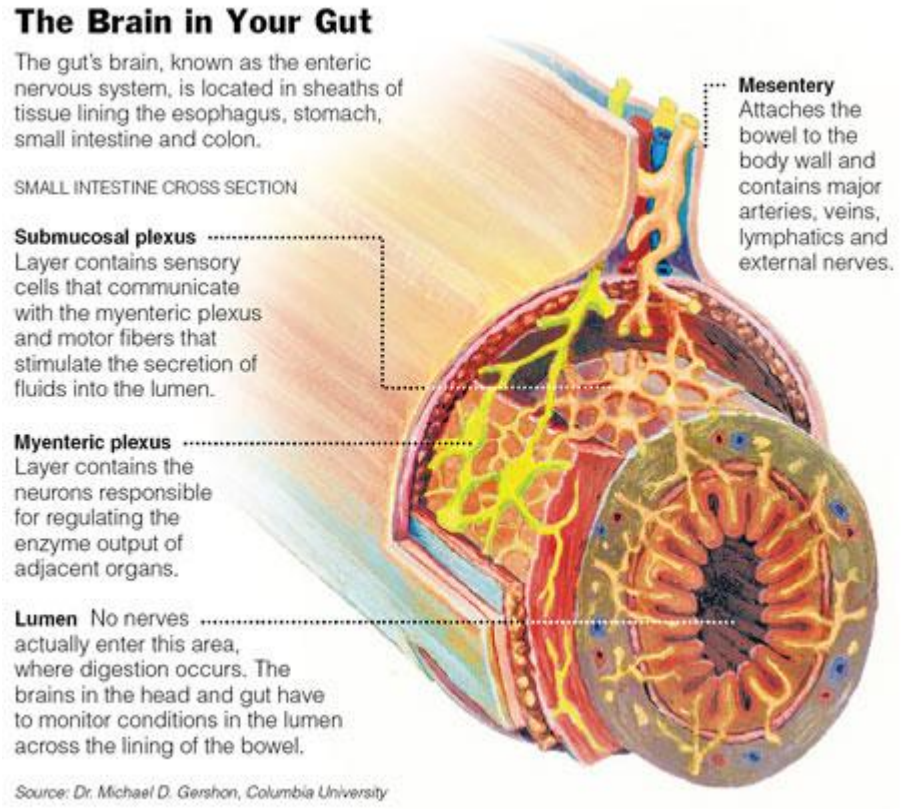
Enteric nervous system

- Autonomy
  - Control of motility
  - Control of secretion
  - Control of blood flow
- Autonomic nervous system
  - Whole GIT regulation
  - Coordination of all organ systems activities



https://kin450-neurophysiology.wikispaces.com/file/view/gut.jpg/187924395/gut.jpg

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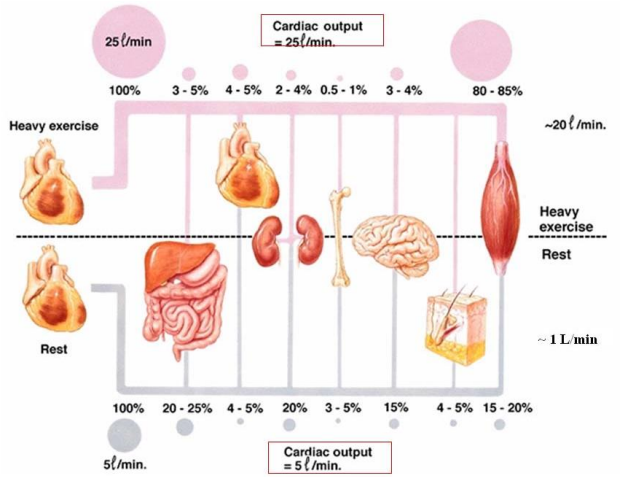
Enteric nervous system

- Autonomy
  - Control of motility
  - Control of secretion
  - Control of blood flow
- Autonomic nervous system
  - Whole GIT regulation
  - Coordination of all organ systems activities



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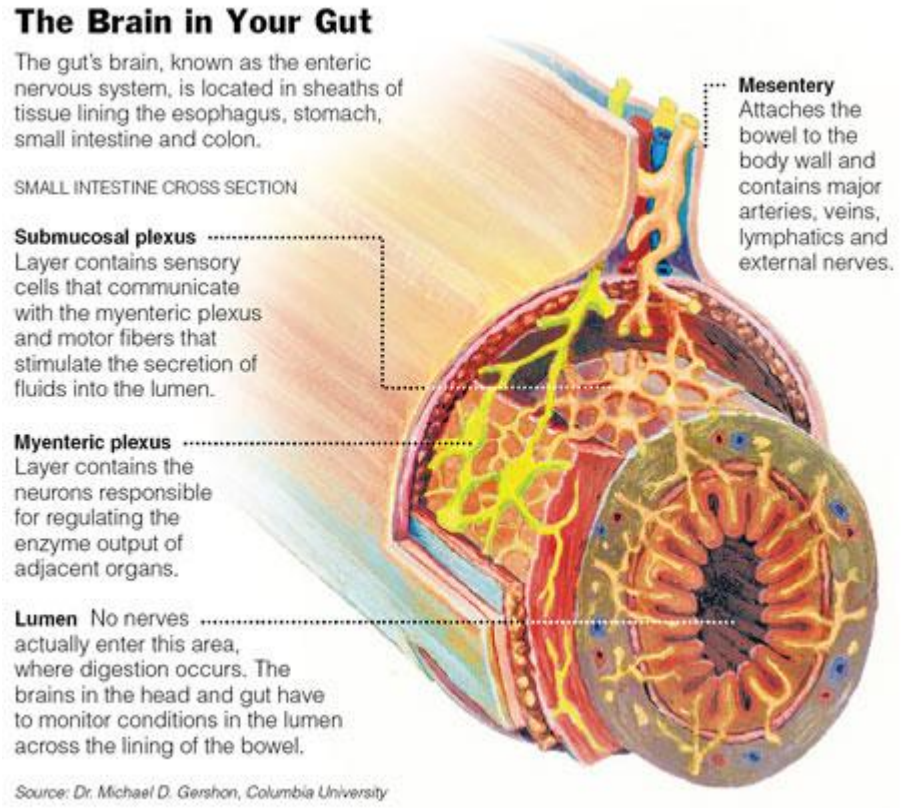
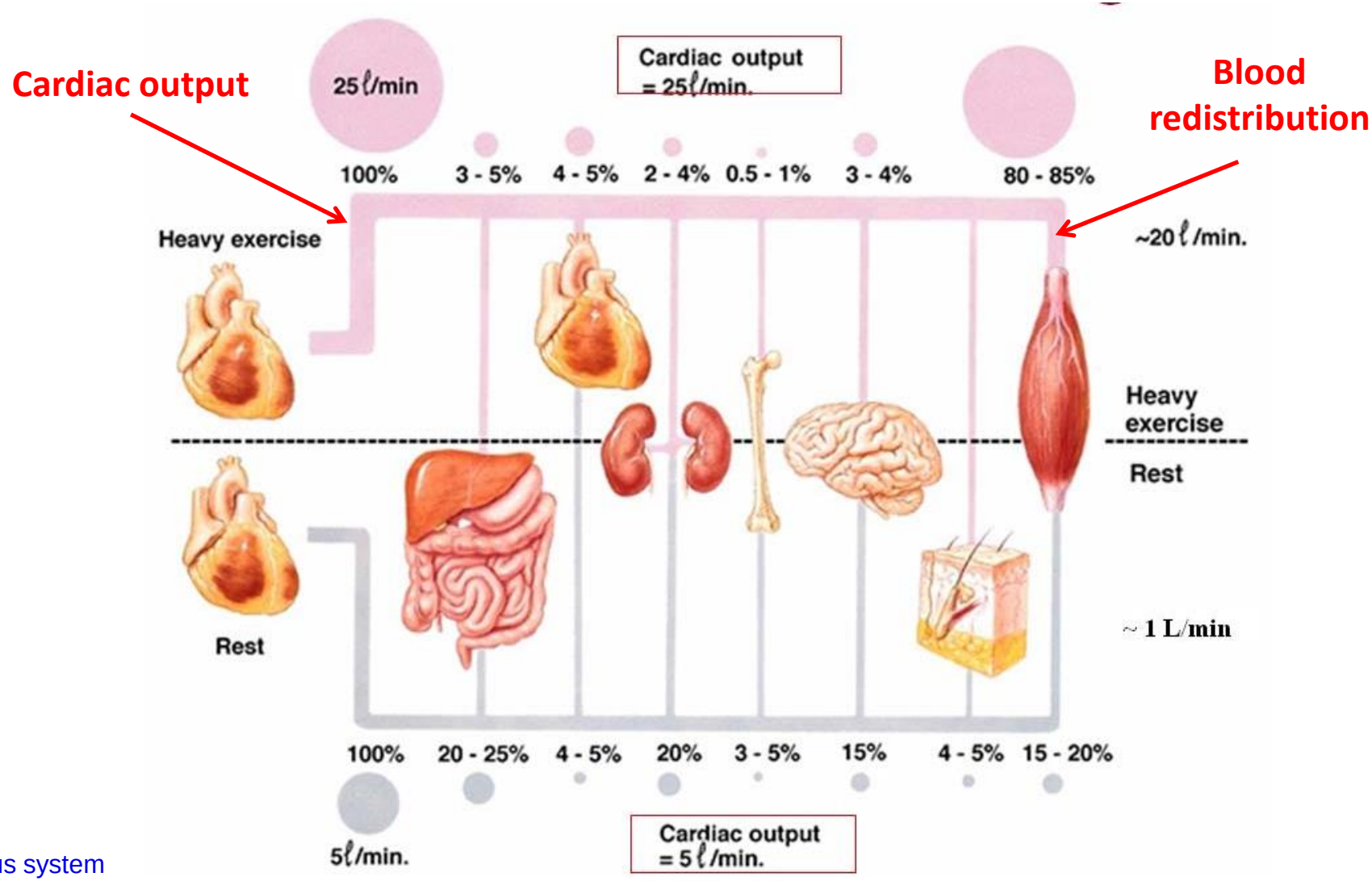


https://kin450-neurophysiology.wikispaces.com/file/view/gut.jpg/187924395/gut.jpg

ANS and cardiovascular system



http://2.bp.blogspot.com/_MJ0CEYnSB4U/S99IJTUruOI/AAAAAAAAACs/NPzsh8ydzjQ/s1600/redistributionofbloodflow.jpg

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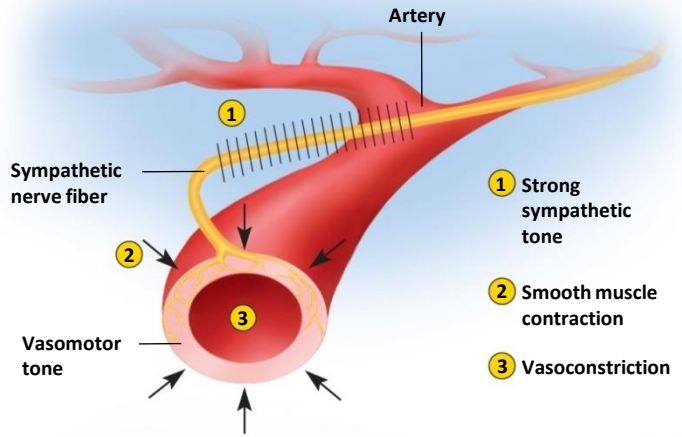
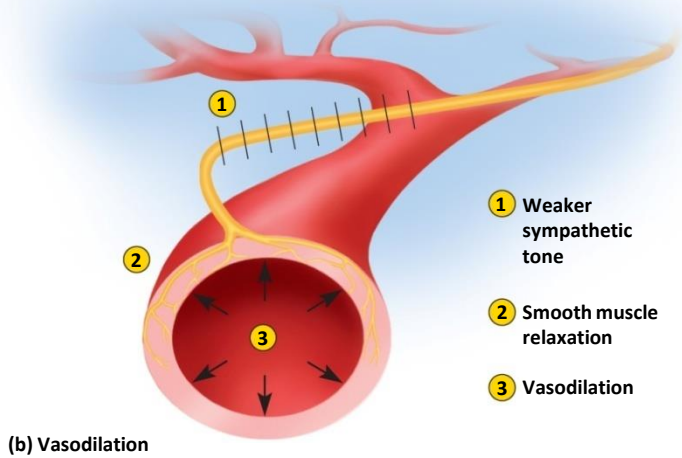
ANS and cardiovascular system

- Local regulatory mechanisms play major role in vasoreactivity
- Sympathetic regulation
  - Skin vessels contraction
  - Muscle vessels dilatation
- Parsympathetic regulation
  - GIT vessels dilation



(a) Vasoconstriction



(b) Vasodilation

http://www.slideshare.net/getyourcheaton/autonomic-nervous-system-and-visceral-reflexes

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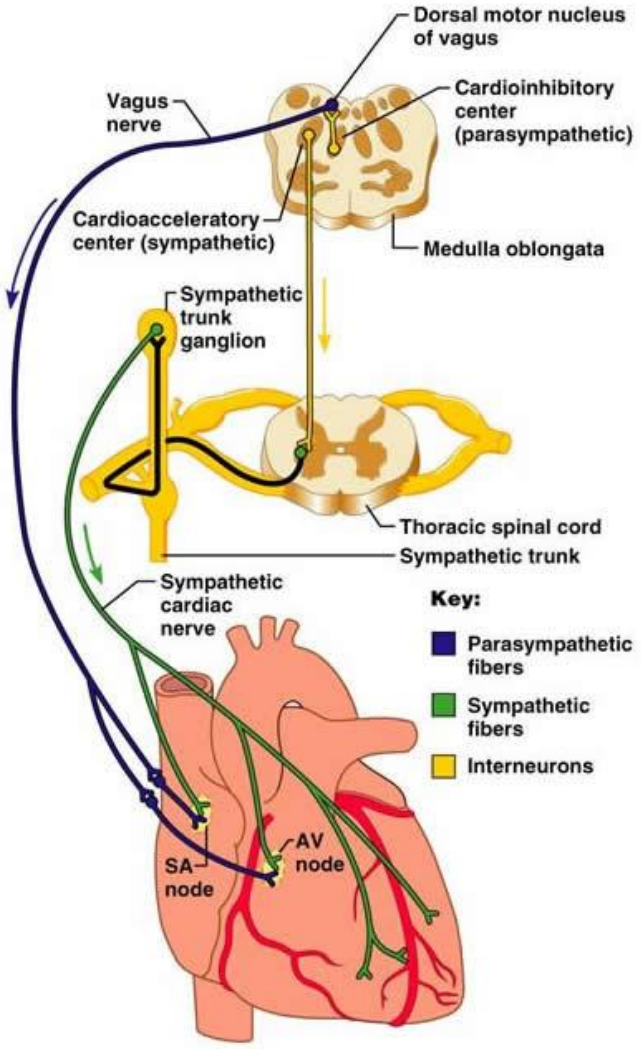
ANS and cardiovascular system

- Sympathetic regulation
  - Heart rate increase
  - Contractility increase
  - Conductivity increase
- Parasympathetic regulation
  - Heart rate decrease
  - Contractility decrease
  - Conductivity decrease



https://medwrite.biz/58603_vagus_nerve_anatomy/

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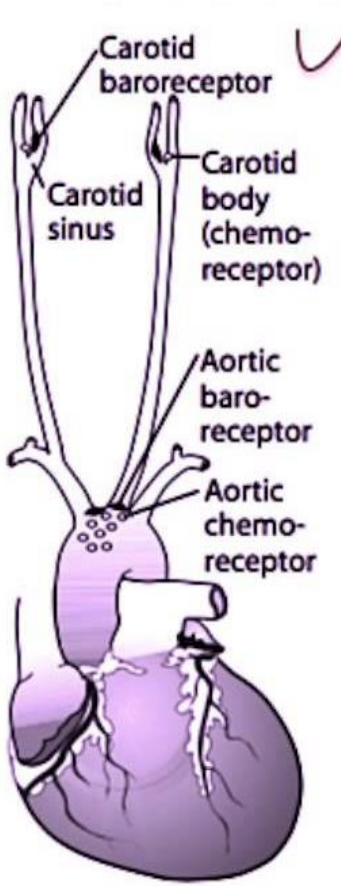
Baroreceptors a chemoreceptors



Receptors:

1. Aortic arch transmits via vagus nerve to medulla (responds **only** to ↑ BP)
2. Carotid sinus transmits via glossopharyngeal nerve to solitary nucleus of medulla (responds to ↓ and ↑ in BP).

Baroreceptors:

1. Hypotension—↓ arterial pressure → ↓ stretch → ↓ afferent baroreceptor firing → ↑ efferent sympathetic firing and ↓ efferent parasympathetic stimulation → vasoconstriction, ↑ HR, ↑ contractility, ↑ BP. Important in the response to severe hemorrhage.
2. Carotid massage—↑ pressure on carotid artery → ↑ stretch → ↑ afferent baroreceptor firing → ↓ HR.

Chemoreceptors:

1. Peripheral—carotid and aortic bodies respond to ↓ P_{O_2} (< 60 mmHg), ↑ P_{CO_2}, and ↓ pH of blood.
2. Central—respond to changes in pH and P_{CO_2} of brain interstitial fluid, which in turn are influenced by arterial CO_2. Do not directly respond to P_{O_2}. Responsible for Cushing reaction— ↑ intracranial pressure constricts arterioles → cerebral ischemia → hypertension (sympathetic response) → reflex bradycardia. Note: Cushing triad = hypertension, bradycardia, respiratory depression.

https://i.ytimg.com/vi/RAhqTAcdh_4/maxresdefault.jpg

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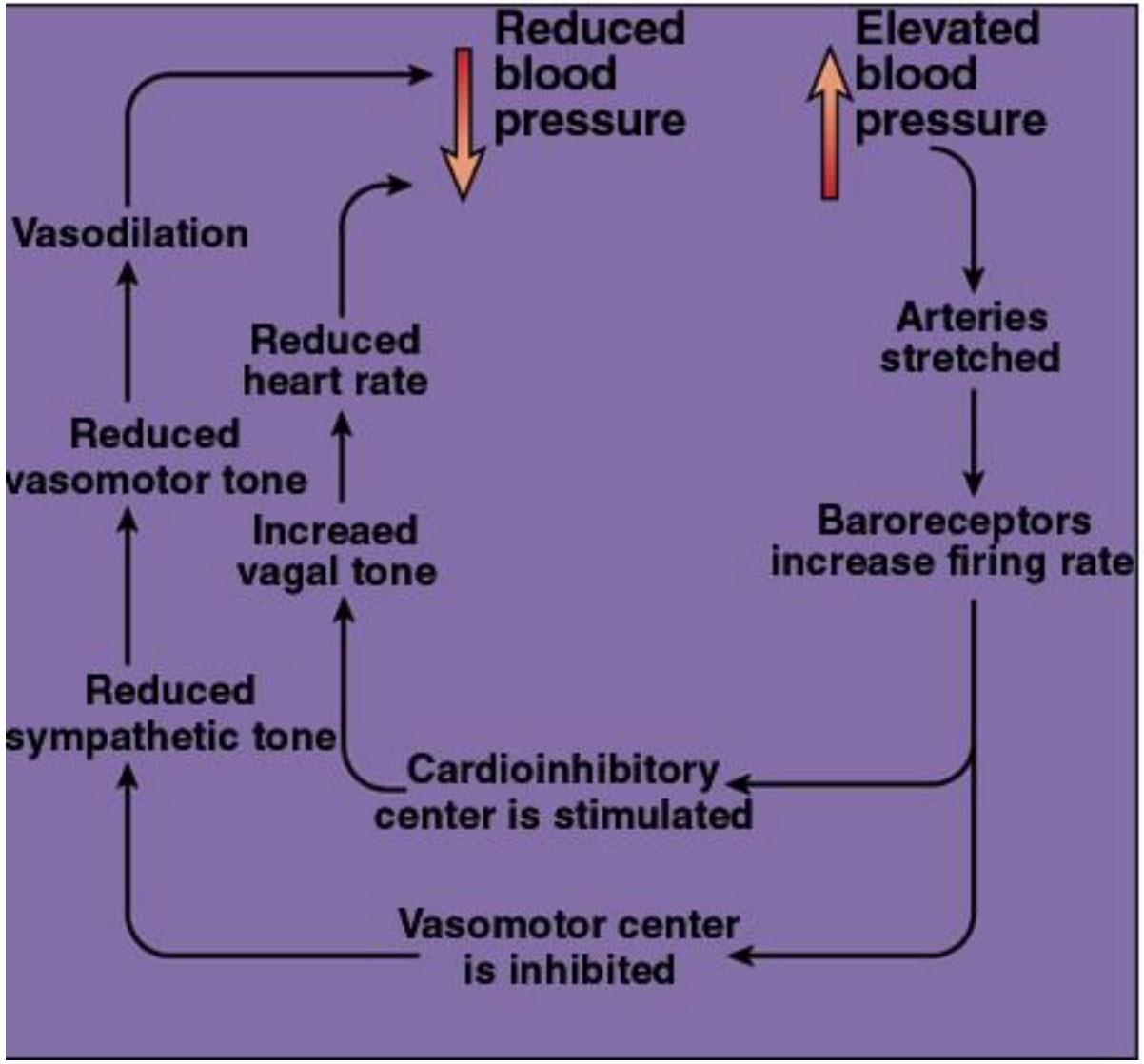
Baroreflex



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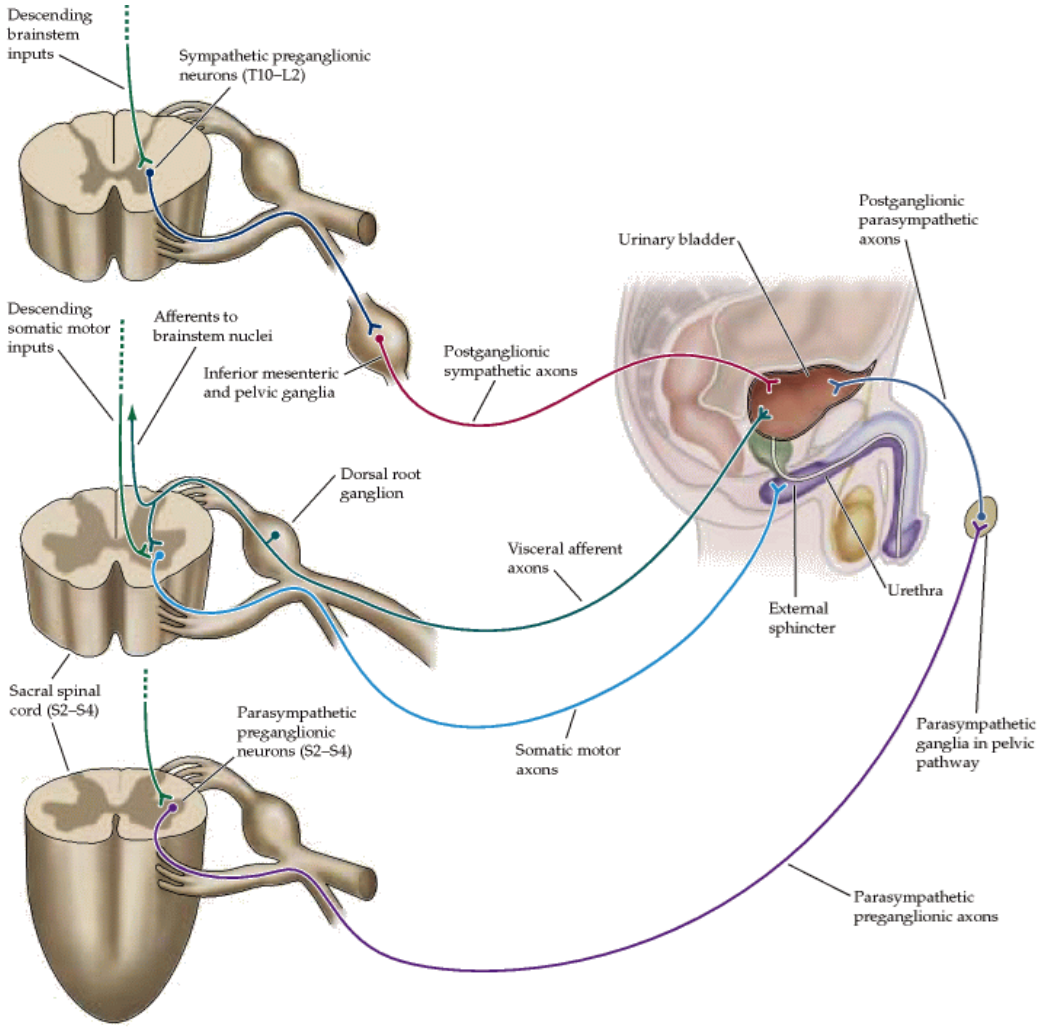
ANS and urinary bladder

- Sympathetic regulation
  - Detrusor relaxation
  - Sphincter contraction
- Parasympathetic regulation
  - Detrusor contraction
  - Sphincter relaxation



http://www.slideshare.net/drpsdeb/presentations

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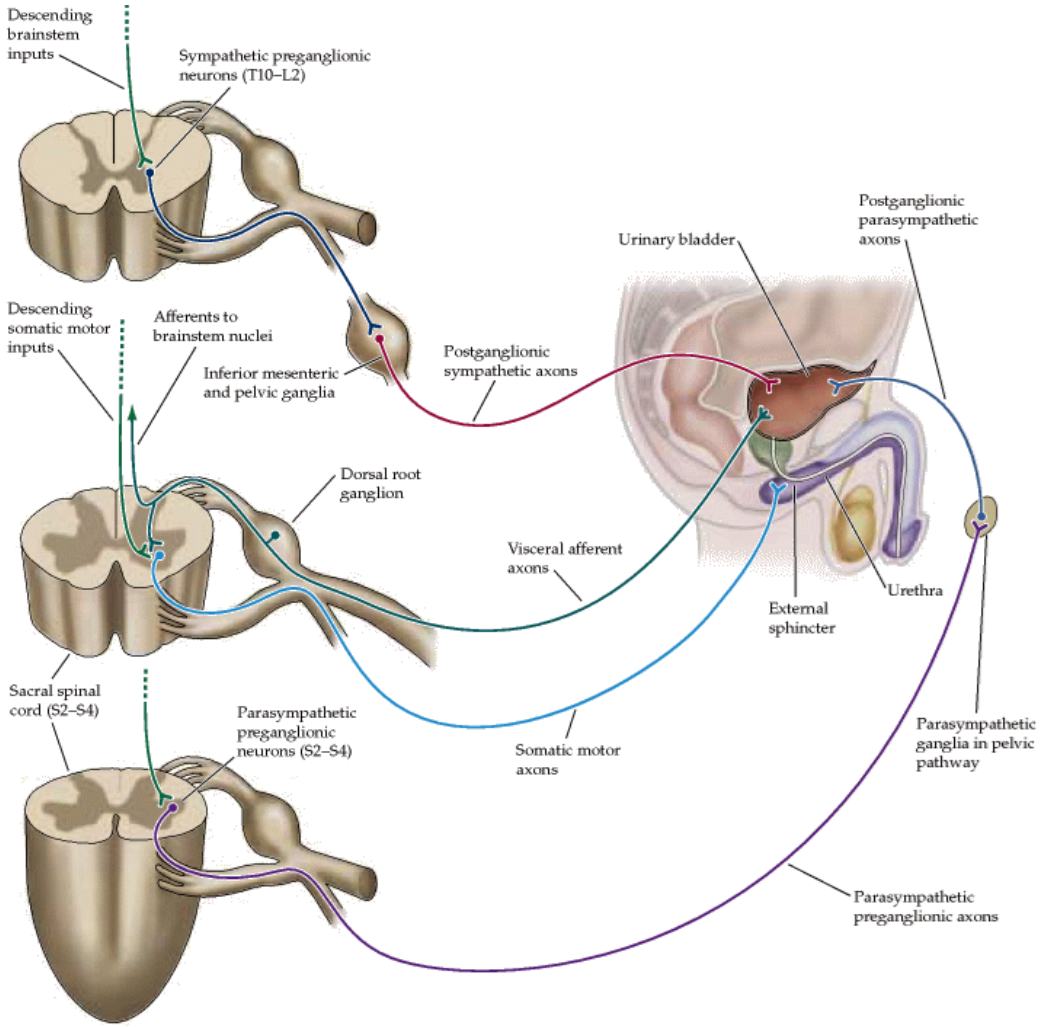
ANS and male reproductive system

- Parasympathetic reg.
  - Erection
- Sympathetic reg.
  - Ejaculation



http://www.slideshare.net/drpsdeb/presentations

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ANS and female reproductive system

Very complicated....

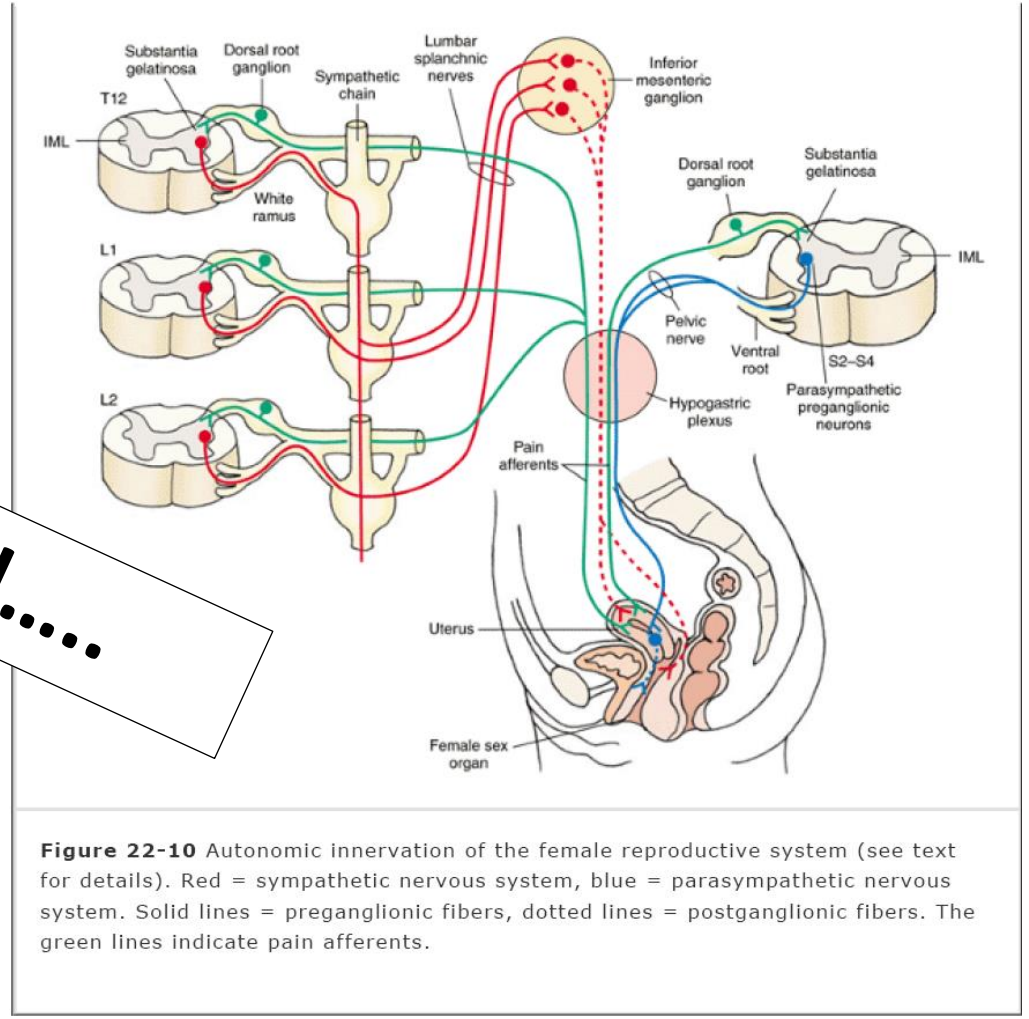

Figure 22-10 Autonomic innervation of the female reproductive system (see text for details). Red = sympathetic nervous system, blue = parasympathetic nervous system. Solid lines = preganglionic fibers, dotted lines = postganglionic fibers. The green lines indicate pain afferents.

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82. The basic division and functions of autonomic nervous system

- Definition of autonomic nervous system
- Somatic and autonomic nervous system comparison (function, synapse reflex circuit…)
- Comparison of sympathetic and parasympathetic division
- Basic charateristics of neurotransmitter and receptor systems (description of autonomic inervation of particular systems is covered in each organ system separately)
- Examples of brain centers controlling the autonomic nervous system (both in hypothalamus, brain stem…)
- Pupillary light reflex
- Role of hypothalamus in essential regulations
- Brief characterization of enteric nervous system and its specifics

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