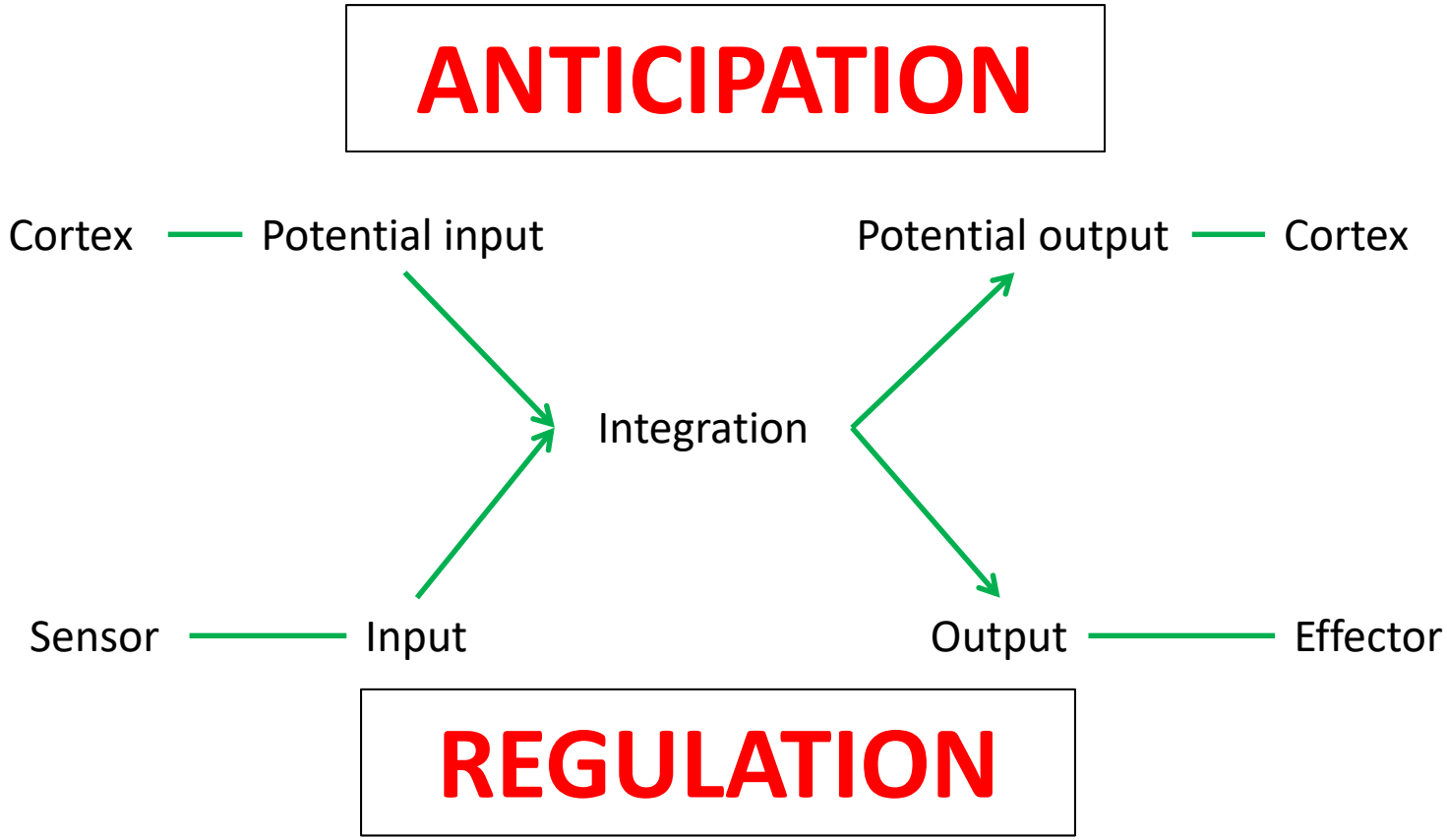
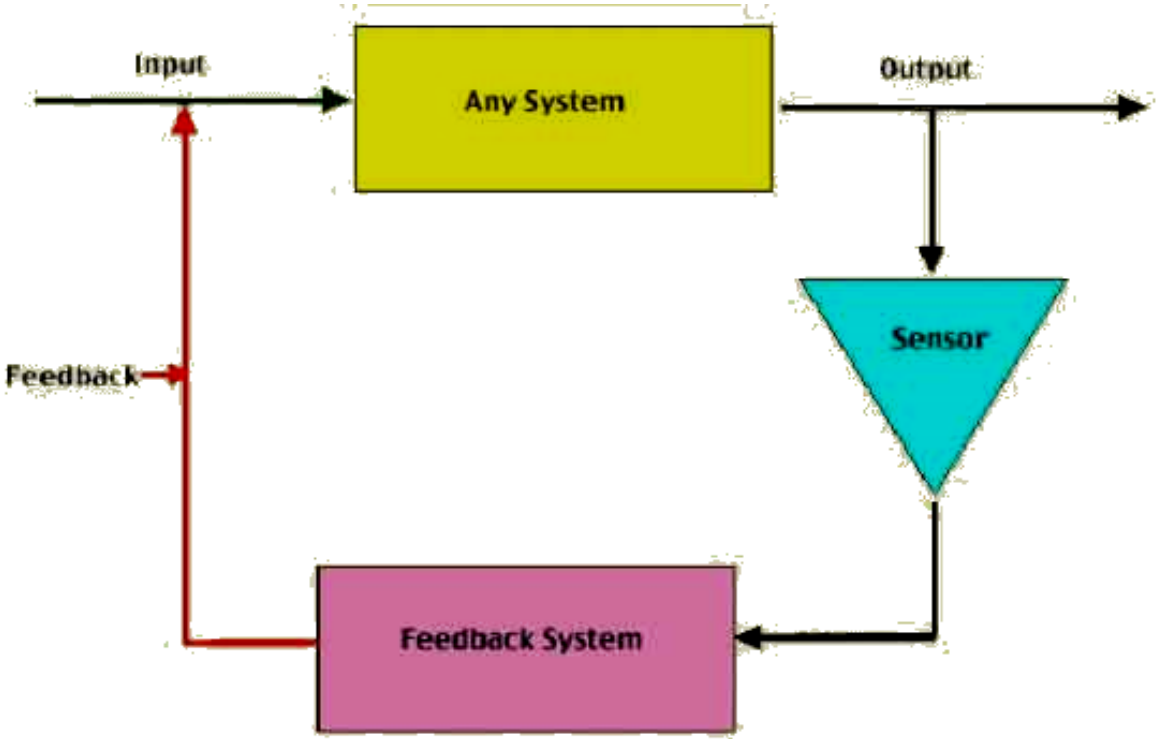
13

Autonomic nervous system

The role of nervous system



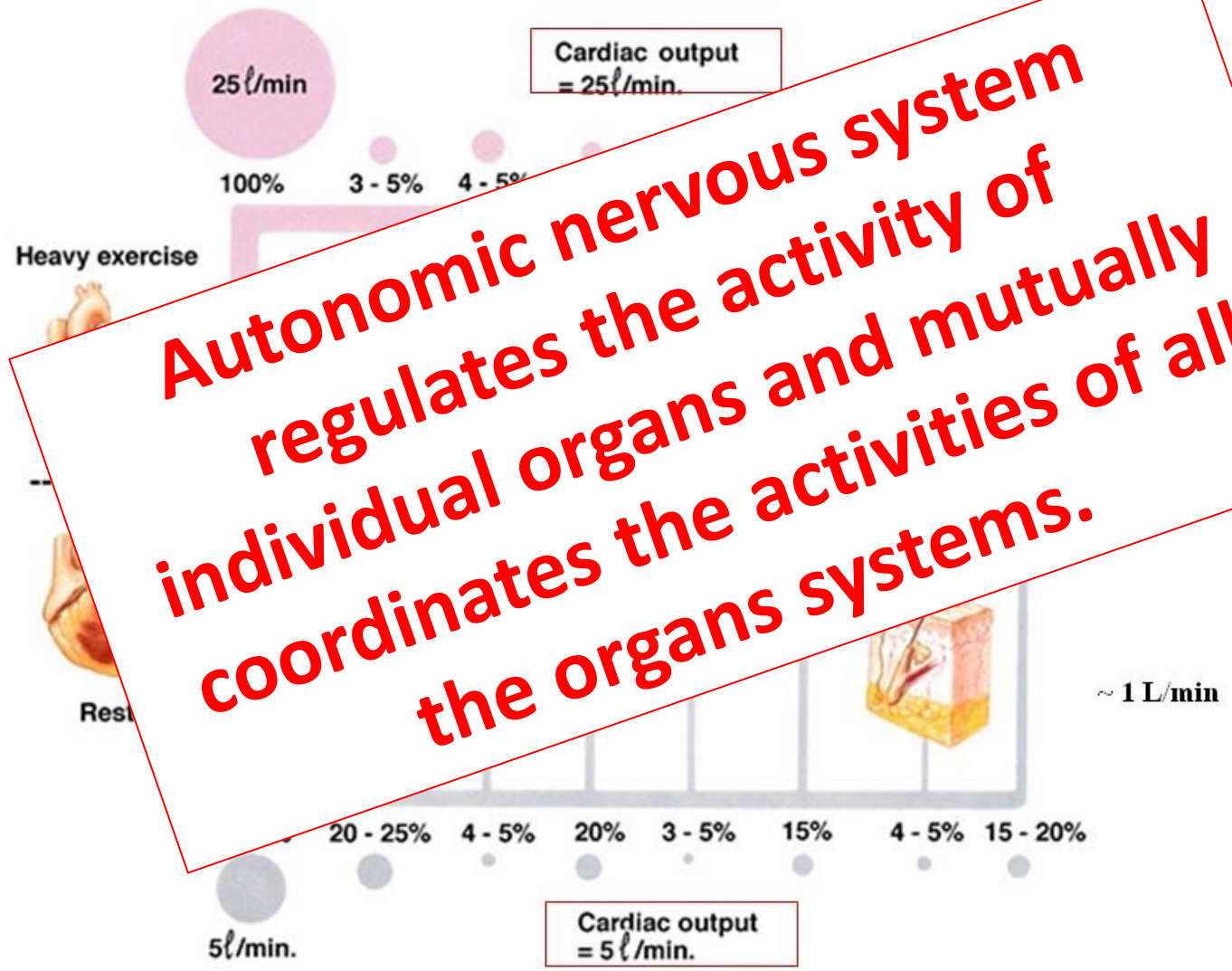
Feedback regulation



Simple Feedback Loop

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

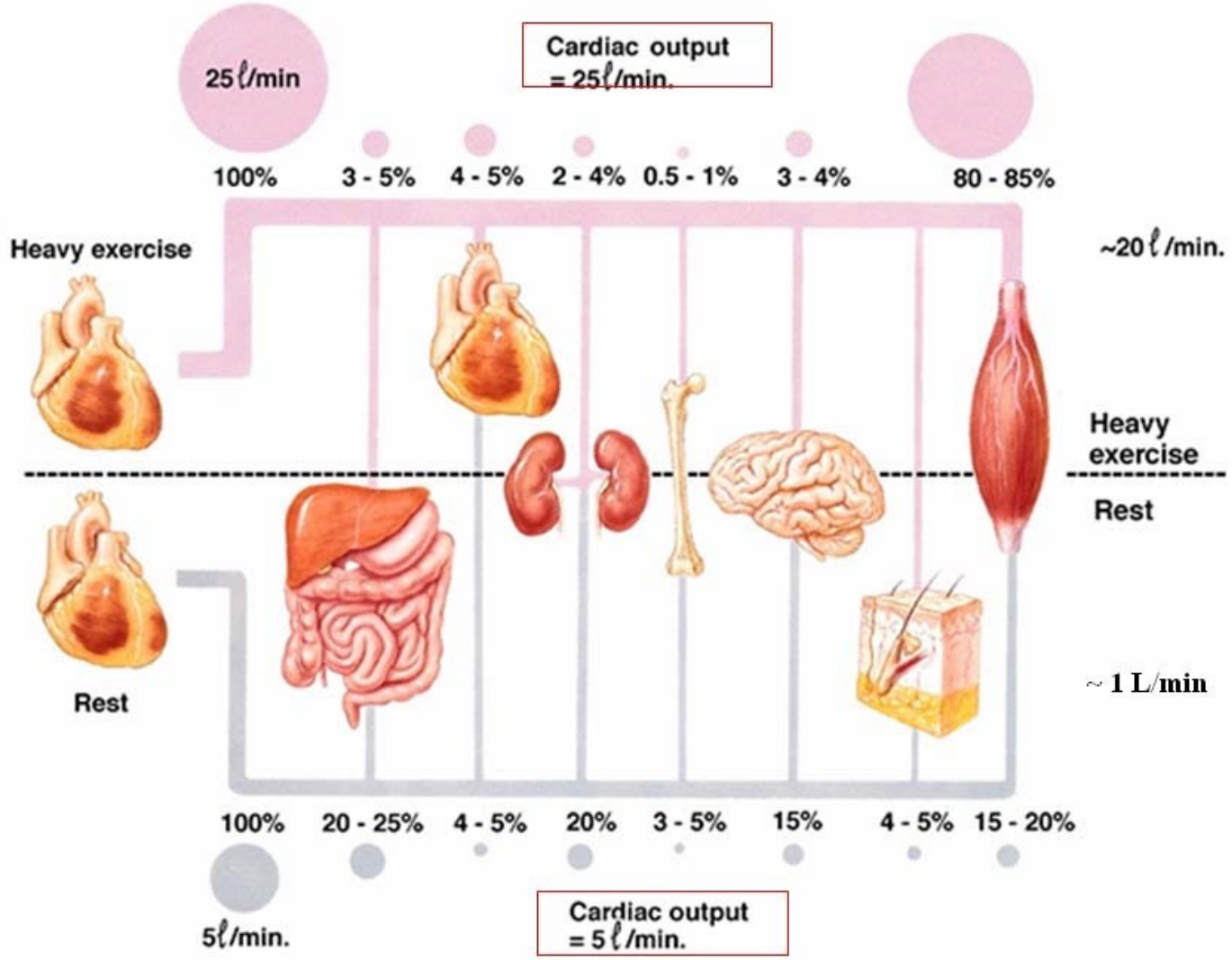
Redistribution of Blood Flow During Exercise



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

http://2.bp.blogspot.com/_MJUCEYnSB4U/S99IJTUruUI/AAAAAAAAACs/NPzsn8ydzjQ/s1600/redistributionofbloodflow.jpg

Redistribution of Blood Flow During Exercise



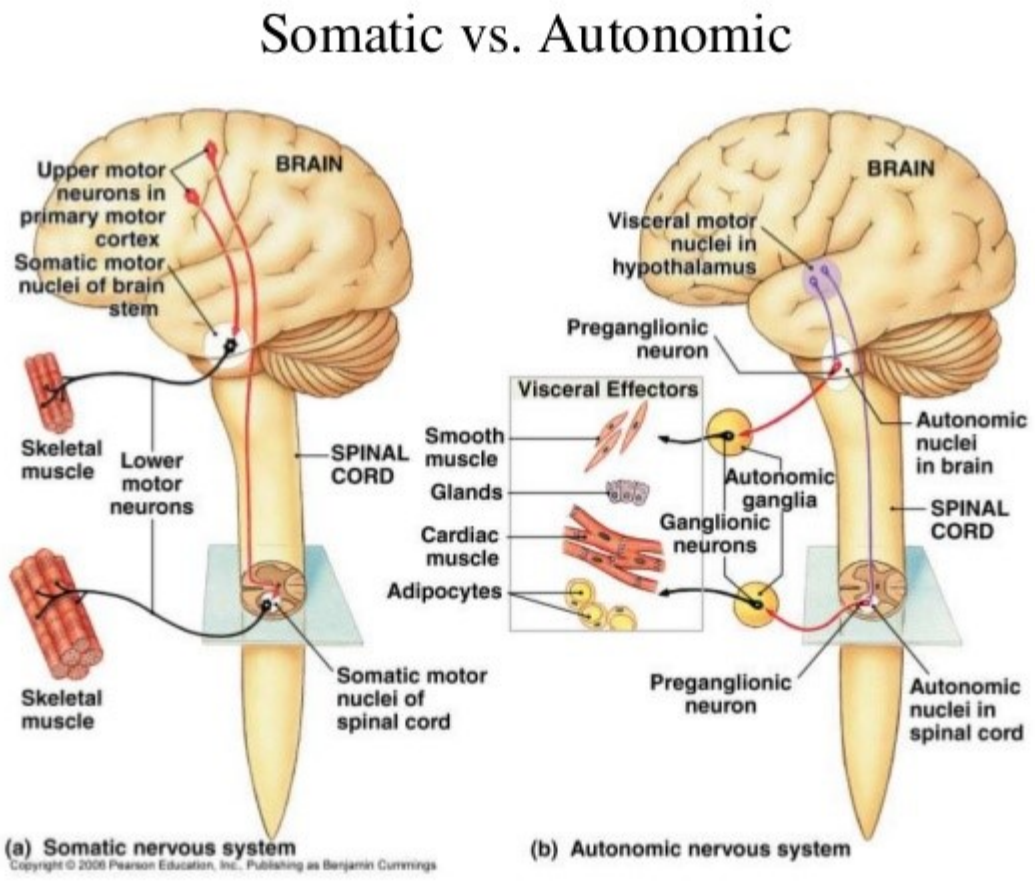
http://2.bp.blogspot.com/_MJUCEYnSB4U/S99IJTUruUI/AAAAAAAAACs/NPzsn8ydzJQ/s1600/redistributionofbloodflow.jpg

Somatic a autonomic nervous system

- „Voluntary“

✓Skeletal muscle

▪Direct connection between CNS and effector



- „Involuntary“

✓Cardiomyocyte
✓Visceral muscle
✓Gland

▪Autonomic ganglion inserted between CNS and effector

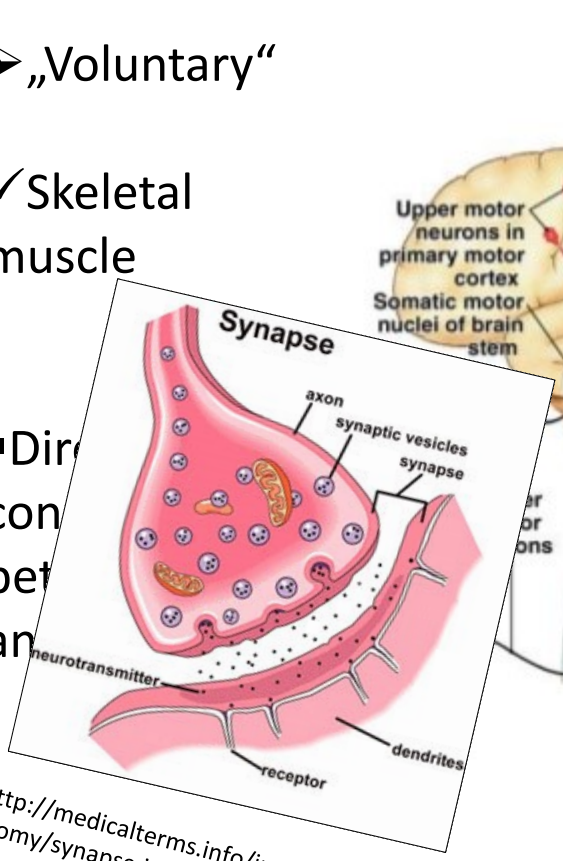
http://image.slidesharecdn.com/ans-130217134747-phpapp01/95/central-nervous-system-the-autonomic-nervous-system-7-638.jpg?cb=1361108947

Somatic a autonomic nervous system

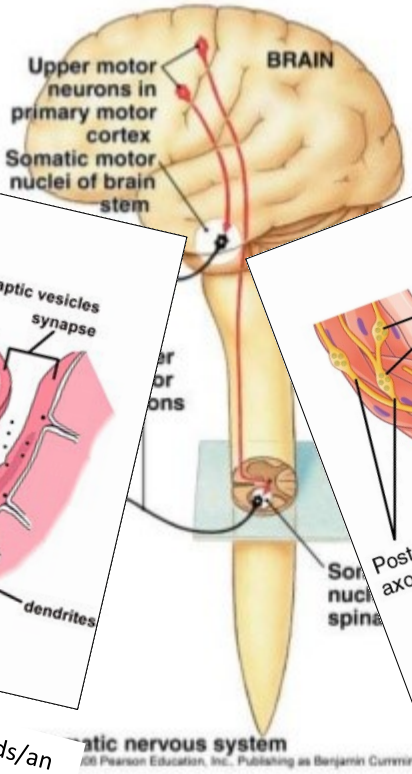
➢„Voluntary“

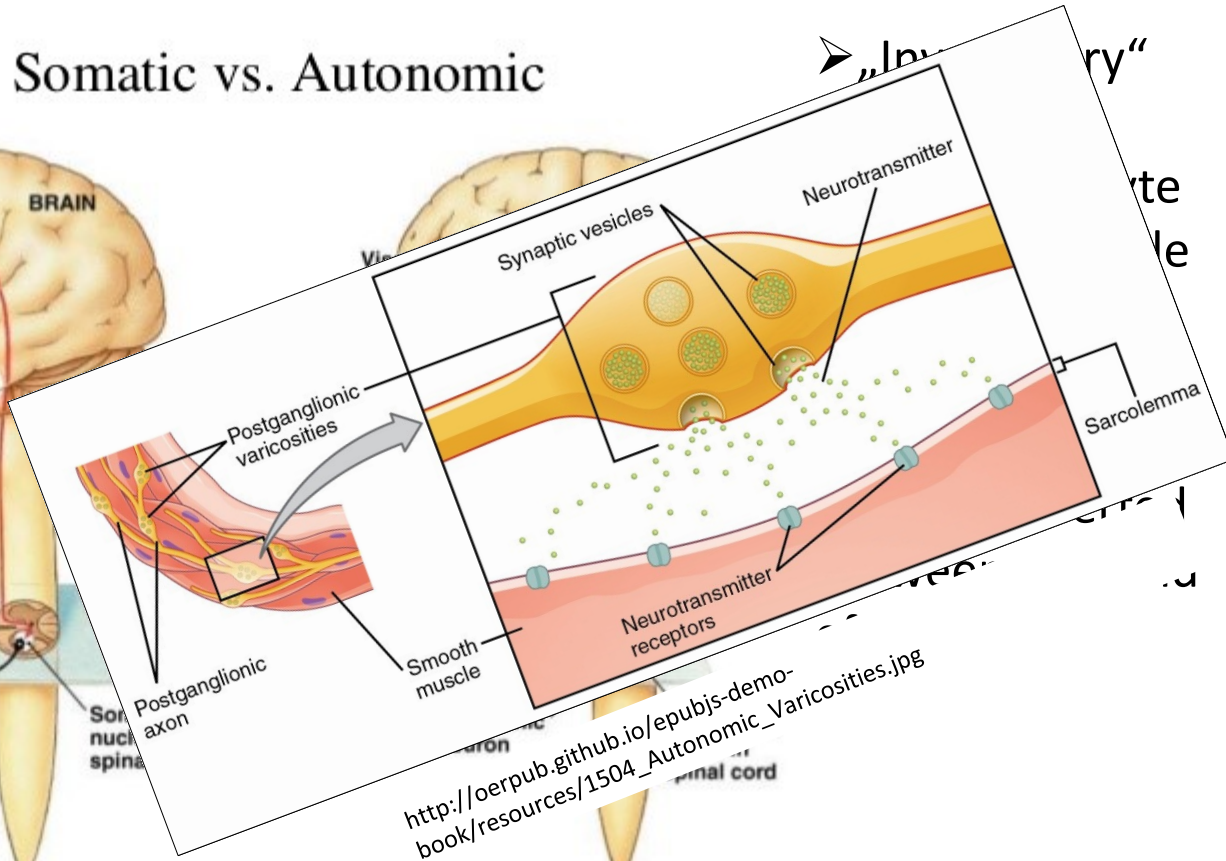
✓Skeletal muscle

▪Dir
con
bet
an



http://medicalterms.info/img/uploads/anatomy/synapse.jpg

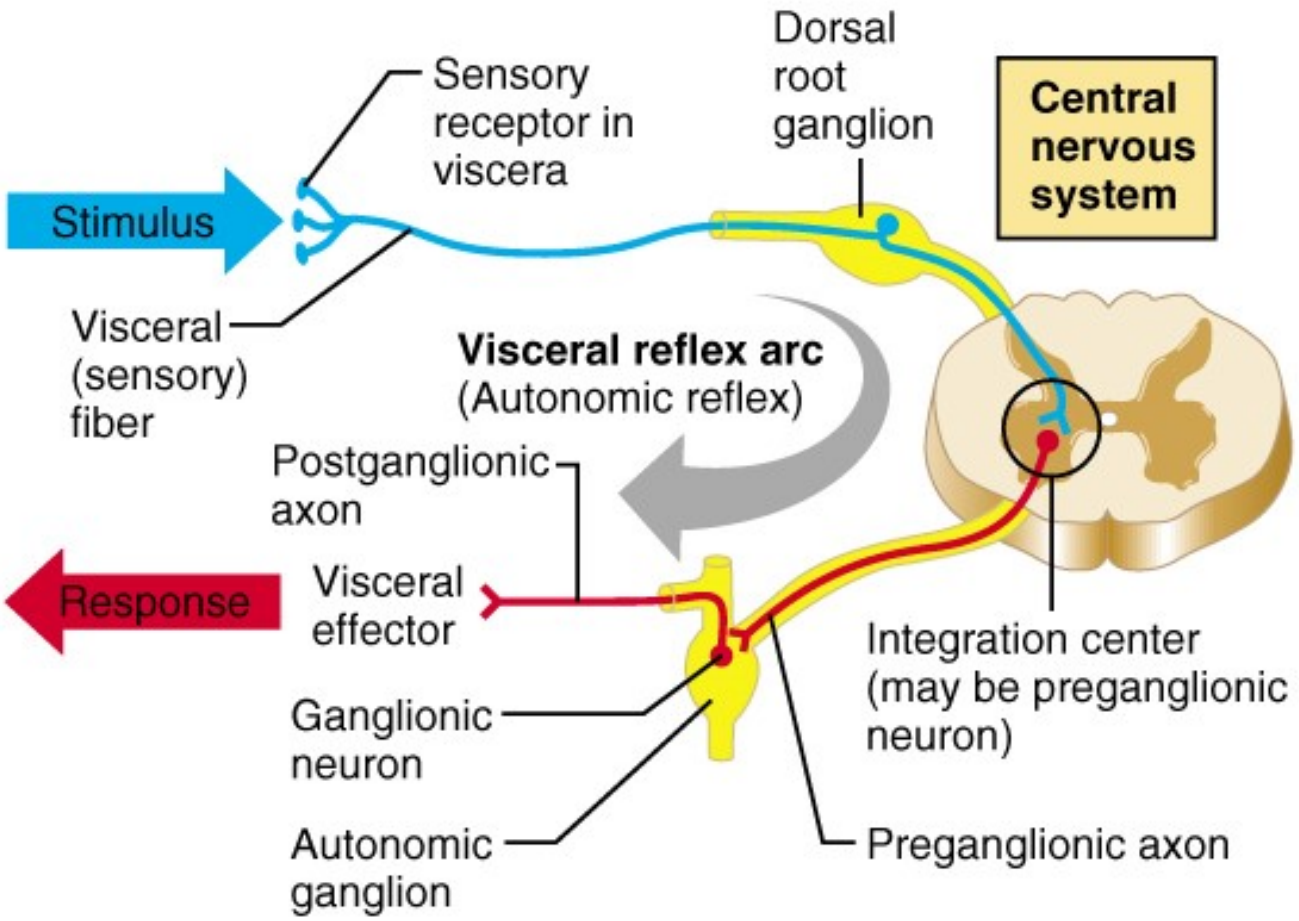




http://oerpub.github.io/epubjs-demo-book/resources/1504_Autonomic_Varicosities.jpg

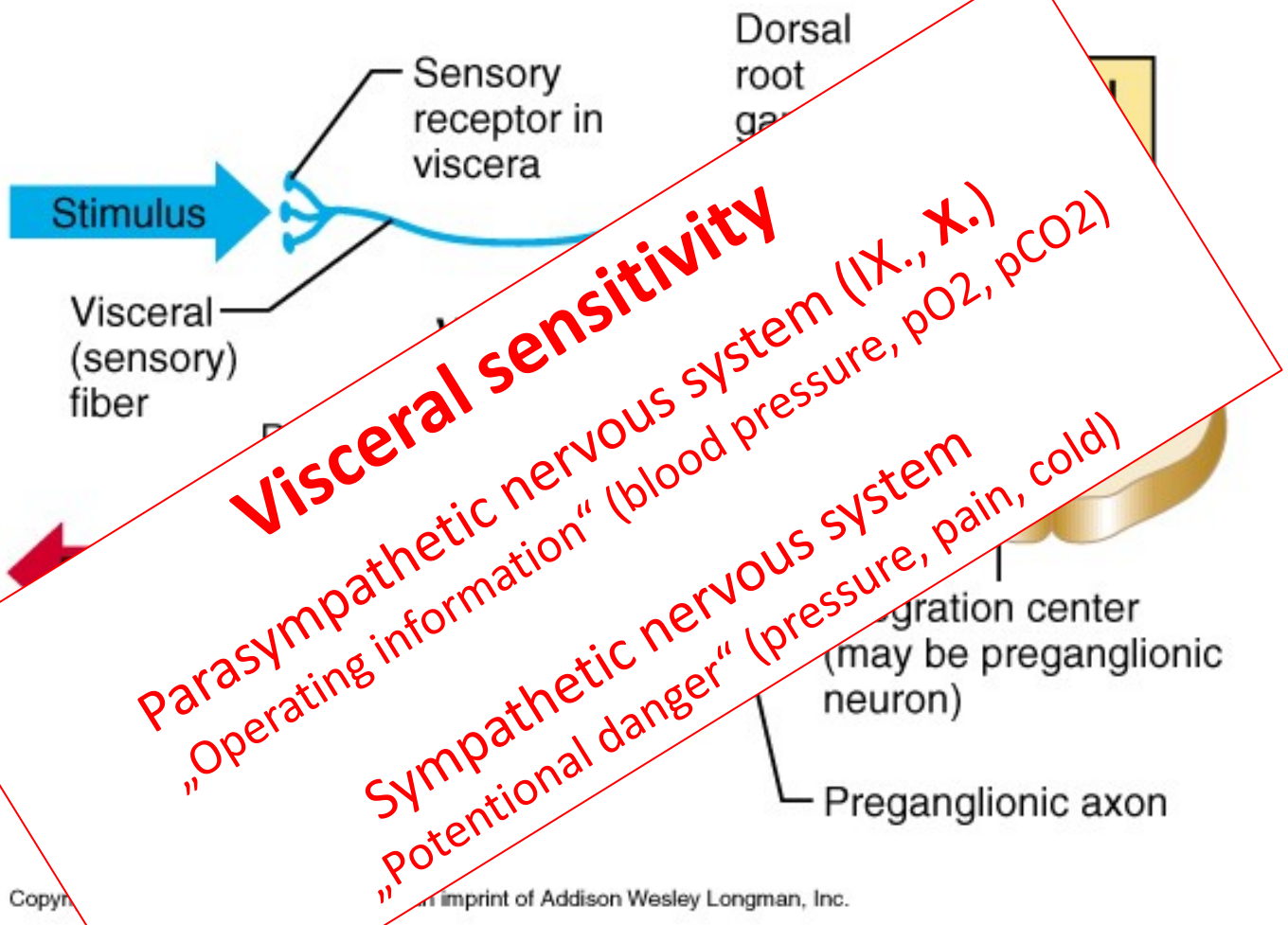
http://image.slidesharecdn.com/ans-130217134747-phpapp01/95/central-nervous-system-the-autonomic-nervous-system-7-638.jpg?cb=1361108947

Visceral reflex loop



http://slideplayer.com/slide/2810792/

Visceral reflex loop

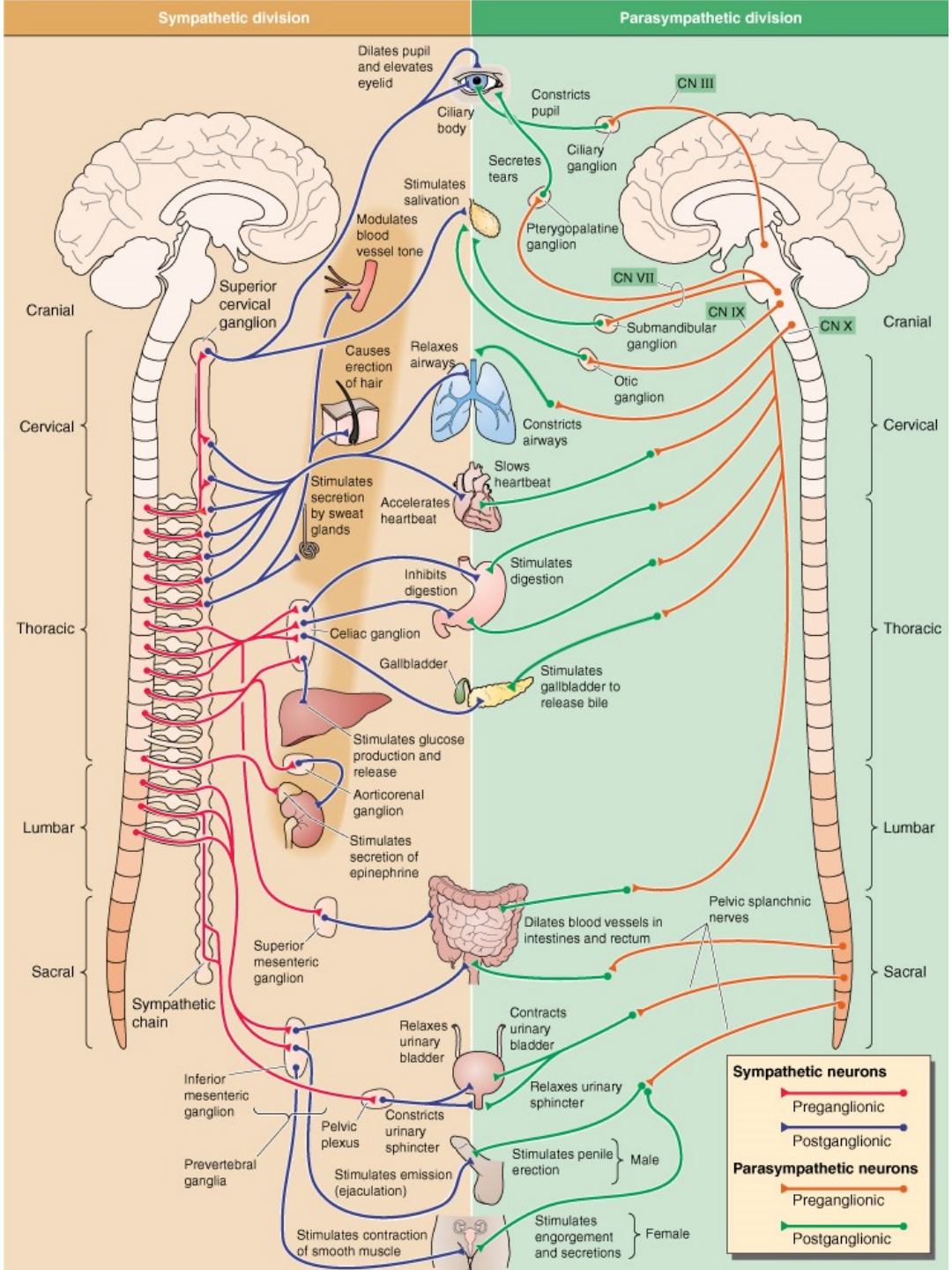


http://slid 10792/

Sympatthetic nervous system

Fight or flight response

Energy/store consumption



Parasympathetic nervous system

Rest and digest response

Energy conservation/energ

Sympatthetic nervous system

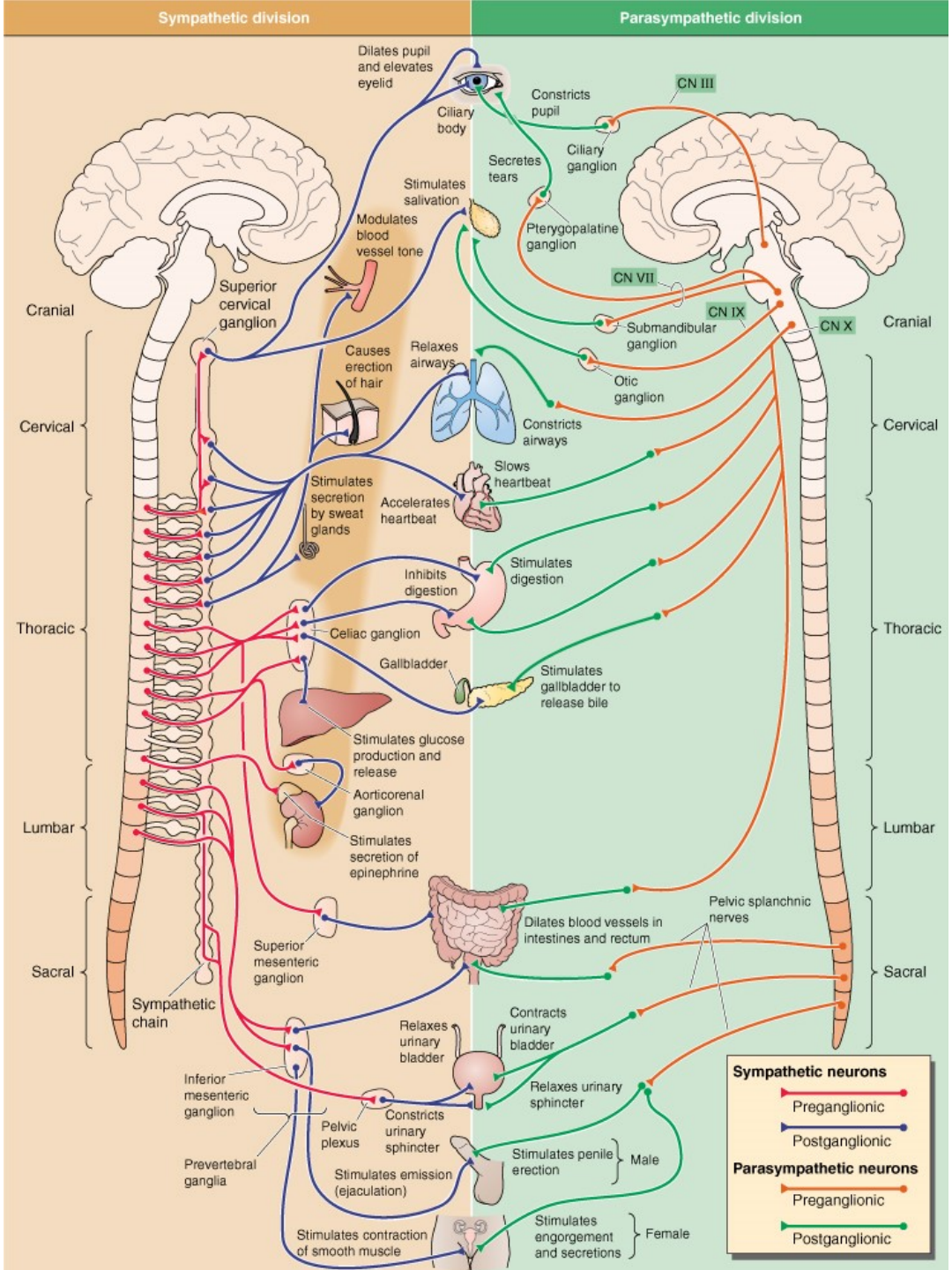
Fight or flight response

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

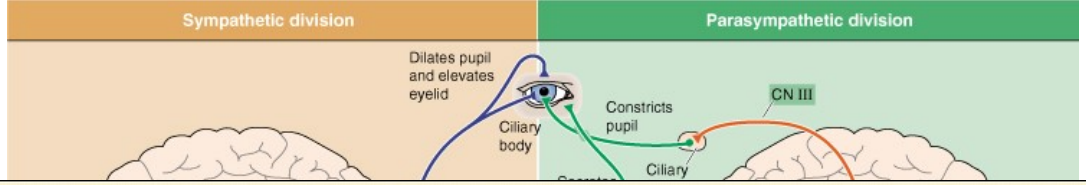
Preganglionic neuron
– Brain stem and spinal cord
– cranio-sacral system

Ganglia
Close to target organs or intramurally

Mostly local effect

Sympatthetic nervous system

Parasympathetic nervous system



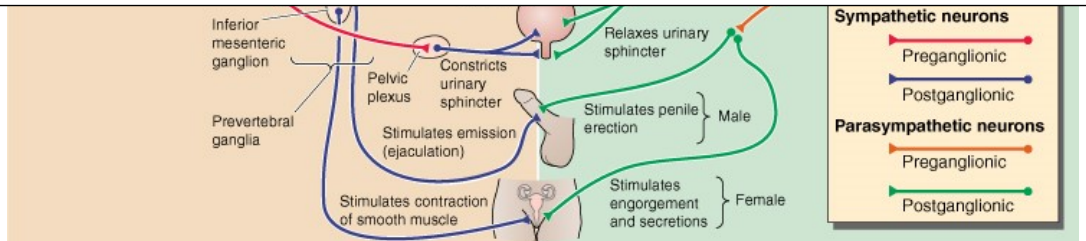
System/function	Parasympathetic	Sympathetic
Cardiovascular	Decreased cardiac output and heart rate	Increased contraction and heart rate; increased cardiac output
Pulmonary	Bronchial constriction	Bronchial dilatation
Musculoskeletal	Muscular relaxation	Muscular contraction
Pupillary	Constriction	Dilatation
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

Fight c … digest
resp … se

Energy … y
consu … n/energ
… duction

Pregan … ionic
neu … n
– Spin … nd spinal
-Thoraco … l system
syst

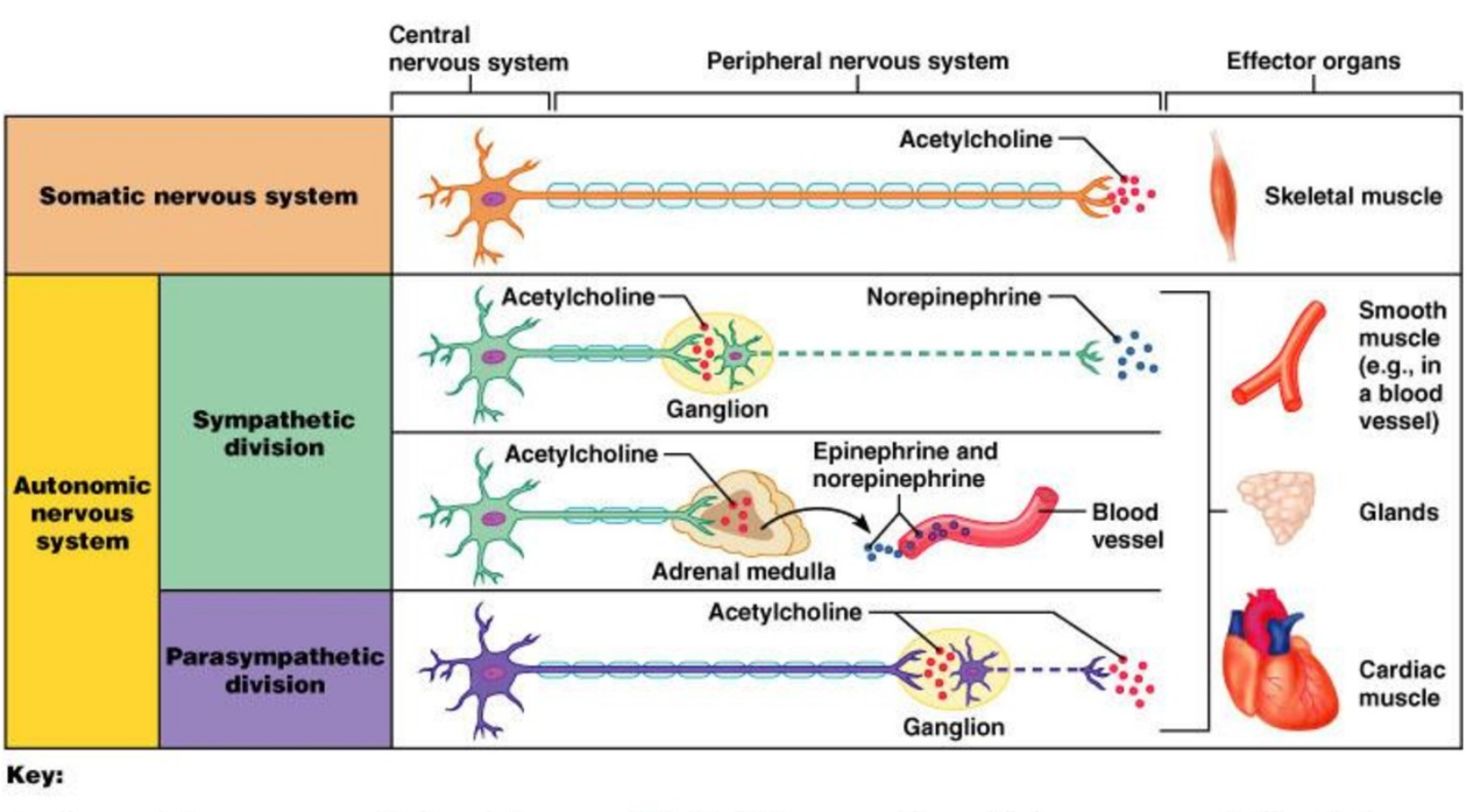
Gar … ia
Parave … arget
-Truncus sy … *or*
- Ma … *rally*
Prevel
-Plexus aorticus



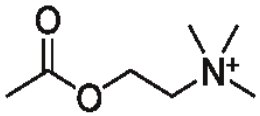
Mostly diffuse effect

Mostly local effect

Mediators of somatic and autonomic nervous system



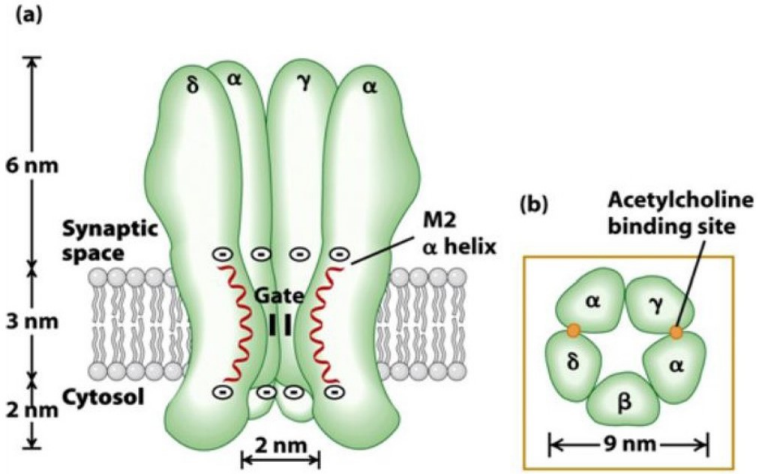
https://www.google.cz/url?sa=i&rct=j&q=&esrc=s&source=imgres&cd=&ved=0ahUKEwjujdLGieLPAhVJOhQKHay0BnUQjBwIBA&url=http%3A%2F%2Fimg.docstoccdn.com%2Ftb%2Forig%2F105365259.png&psig=AFQjCNFxrUy63llCAlny-Vhlyse4FHDMaw&ust=1476801796194278



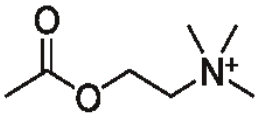
Acetylcholine

Preganglionic fibers

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



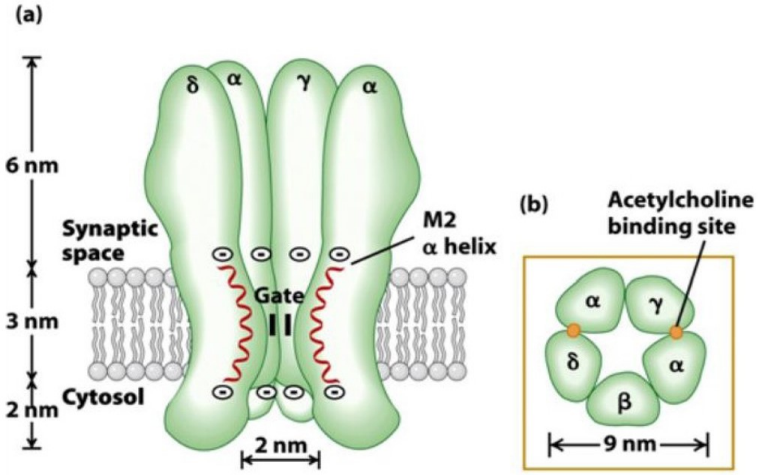
http://www.mdpi.com/marinedrugs/marinedrugs-12-02970/article_deploy/html/images/marinedrugs-12-02970-g013-1024.png



Acetylcholine

Preganglionic fibers

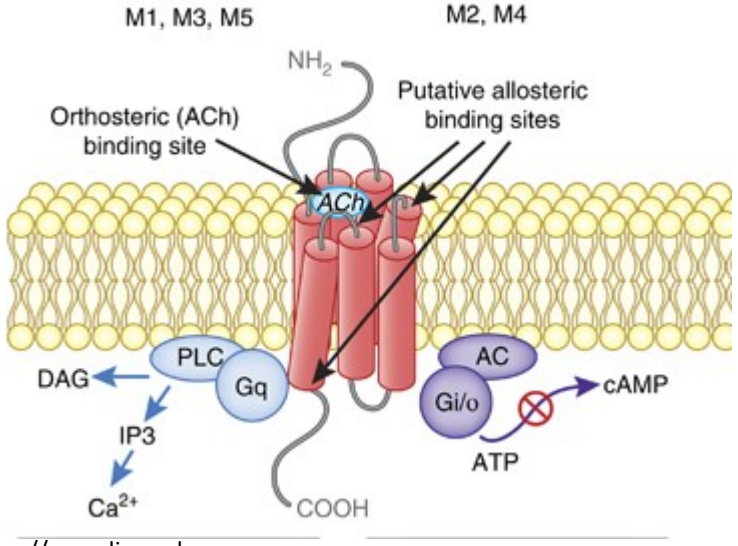
- Sympathetic
- Parasympathetic
- ✓ Nicotinic receptor
  - Ligand-gated ion channels
  - Na+, K+, Ca2+
  - Neuronal (N_N) and muscle (N_M) type
  - Excitatory



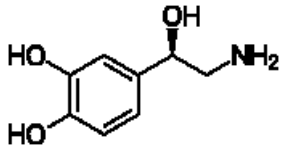
http://www.mdpi.com/marinedrugs/marinedrugs-12-02970/article_deploy/html/images/marinedrugs-12-02970-g013-1024.png

Postganglionic fibers

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

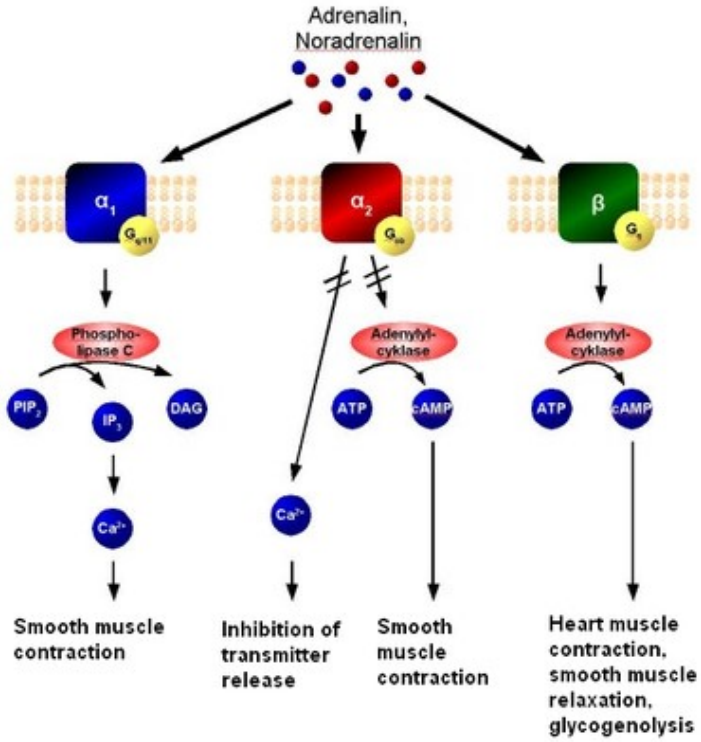


https://s-media-cache-ak0.pinimg.com/originals/ea/6c/3e/ea6c3e44afe638dca65fb4a3014bc095.jpg

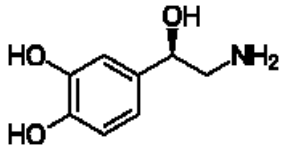


Norepinephrine

- 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 !!!

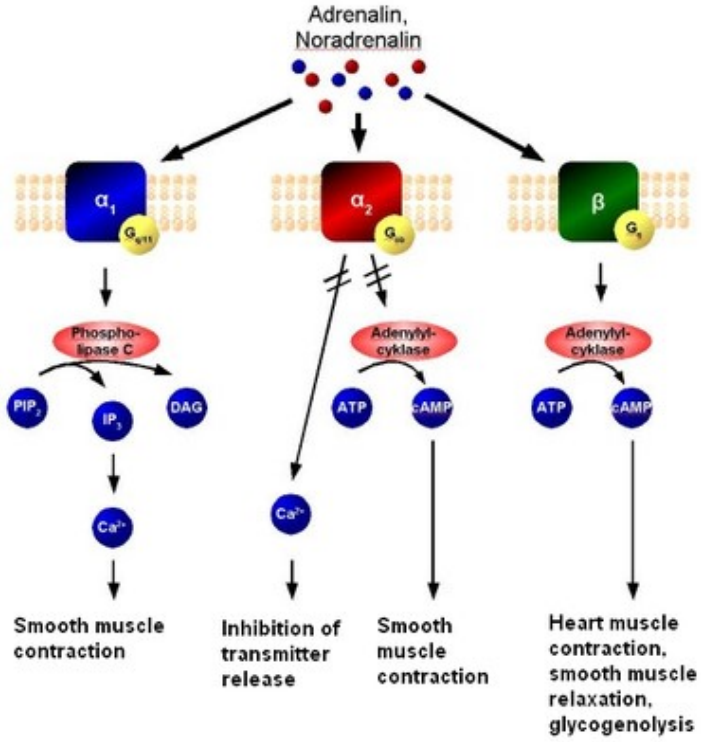


https://en.wikipedia.org/wiki/Adrenergic_receptor



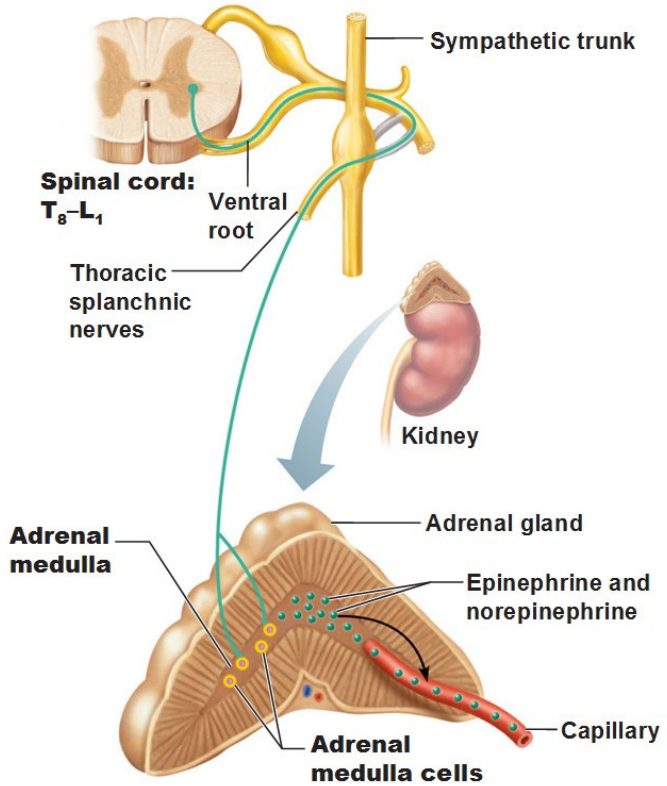
Norepinephrine

- 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 !!!

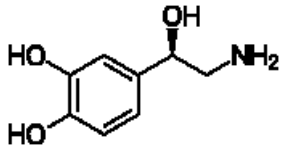


https://en.wikipedia.org/wiki/Adrenergic_receptor

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



http://antranik.org/wp-content/uploads/2011/11/the-adrenal-medulla-of-the-adrenal-gland-epinephrine-norepinephrine-splanchic-nerves.jpg



Norepinephrine

- Postganglionic sympathetic fibers
- Adrenergic receptor
  - G-coupled
  - α type– generally excitatory (contracti
  - β type – generally inhi
  with a

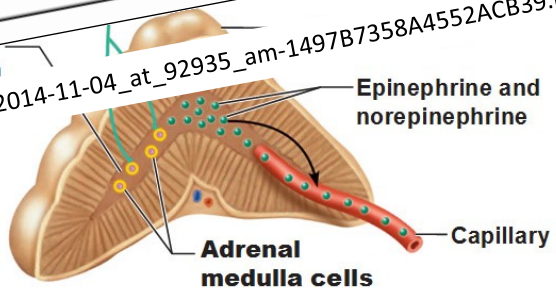
- Adrenal medulla
  - Modified sympathetic g
  - Tra

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

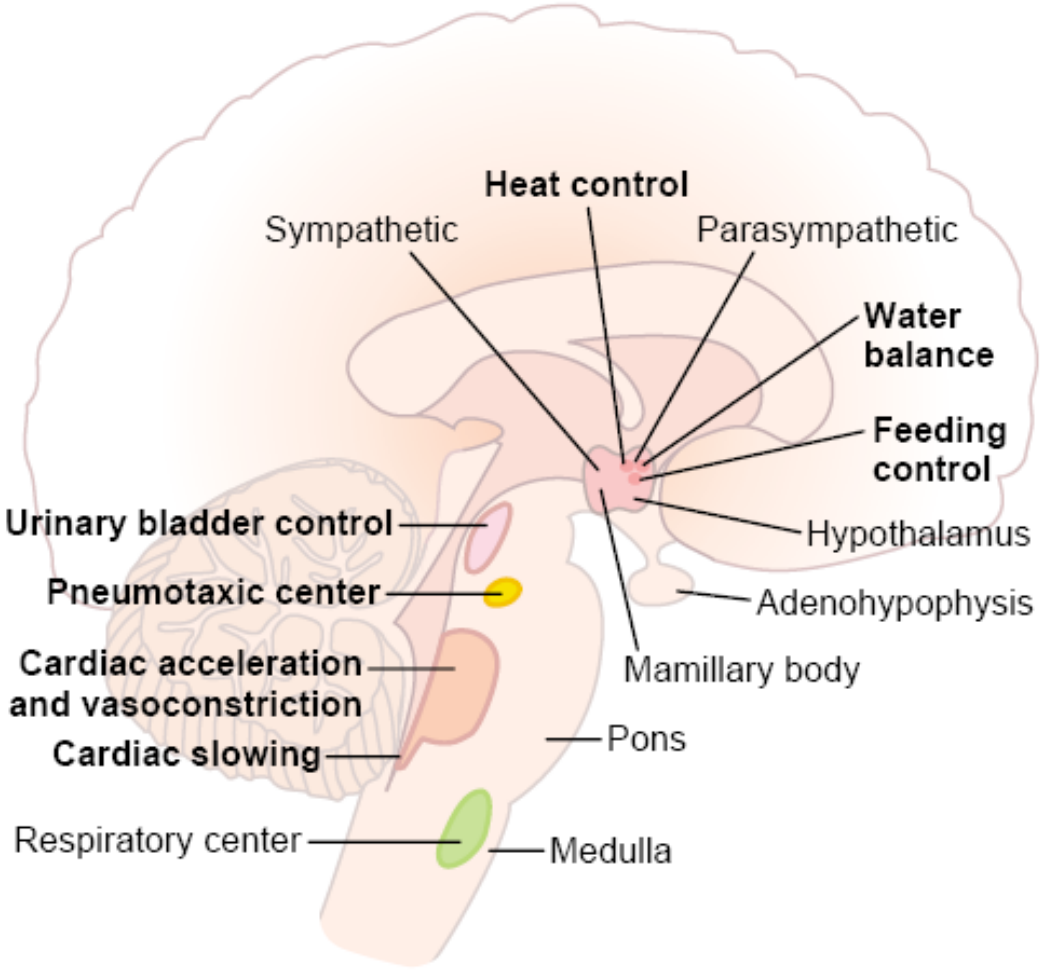
https://en.wikipedia.org/wiki/Adrenergic_receptor

https://s3.amazonaws.com/classconnection/769/flashcards/5928769/png/screen_shot_2014-11-04_at_92935_am-1497B7358A4552ACB39.png



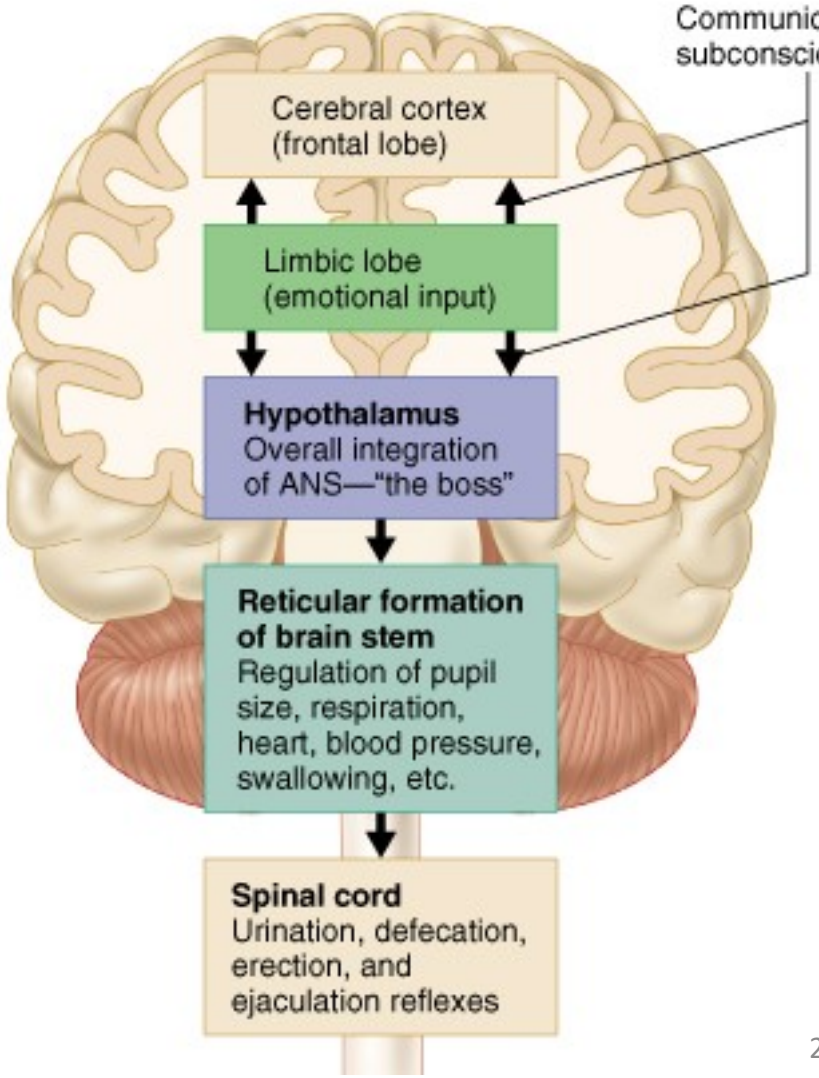
http://antranik.org/wp-content/u… adrenal-medulla-of-the-adrenal-gland-epinephrine-nor…nephrine-splanchic-nerves.jpg

Brain centers controling autonomic nervous system



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)



http://slideplayer.com/slide/2810792/

Hypothalamus

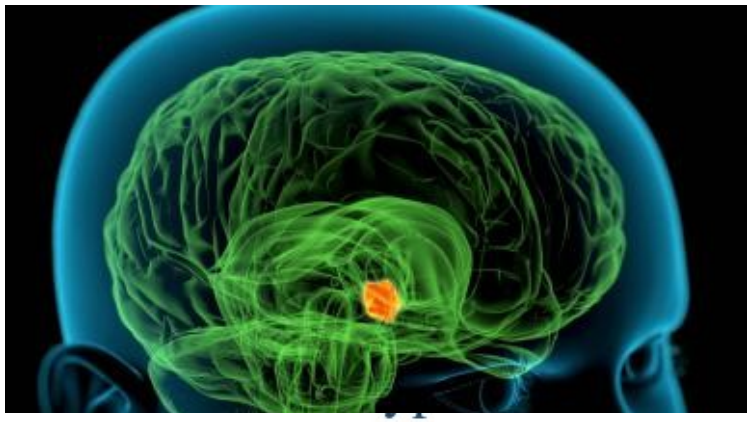
- Key center of autonomic regulations and coordination
- Integration of the information from inner and outer environment

↓

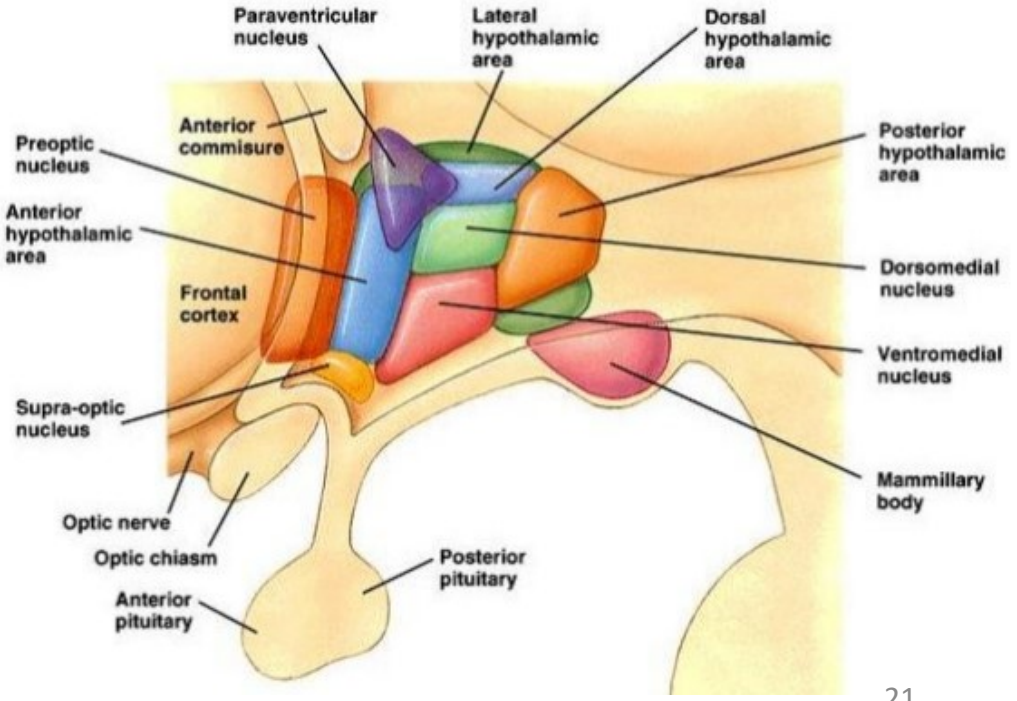
- Behavioral modulation
- Regulation of autonomic nervous system

↓

- **Maintenance of homeostasis**



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

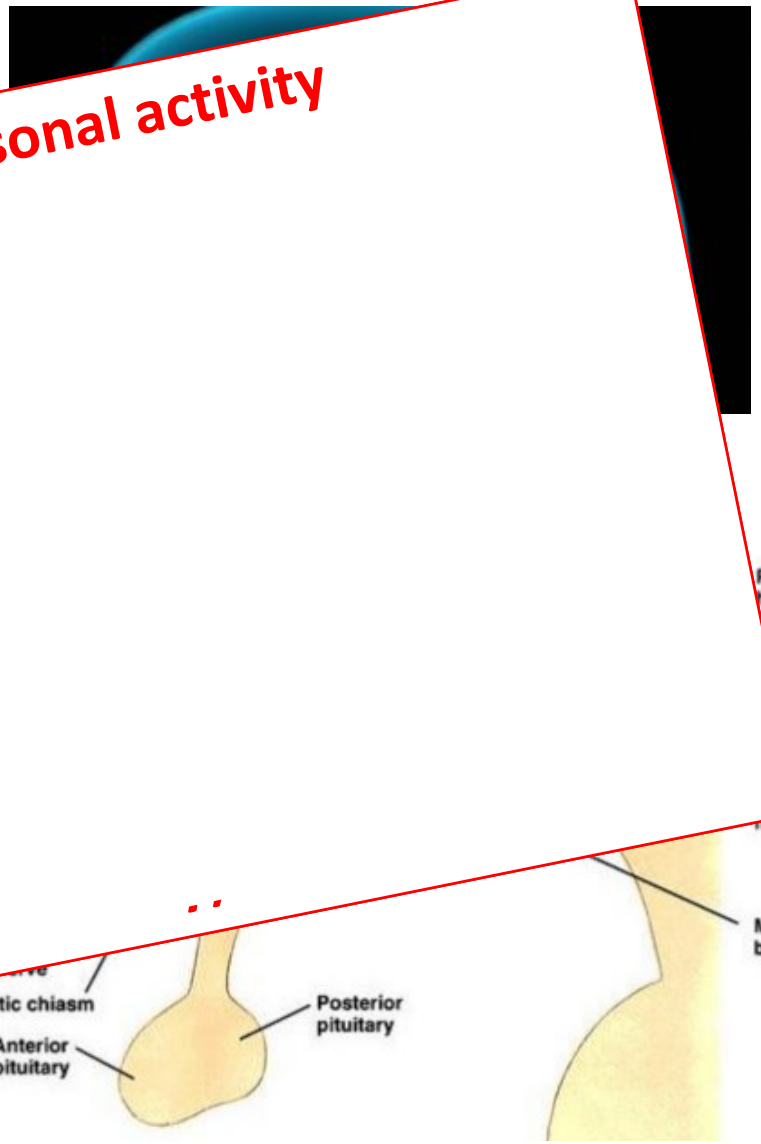


http://www.slideshare.net/physiologymgmcri/hypothalamus-15-apr-2016

Hypothalamus

- Key center of autonomic regulations and coordi
- Integ
  f
  e
- Be
- Reg
  nerv
- **Main**

✓**Biological clock – circadian /seasonal activity**



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

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

Hypothalamus

- Key center of autonomic regulations and coordi
- Integ
  f
  e
- Be
- Reg
  nerv
- **Main**

✓Biological clock – circadian /seasonal activity

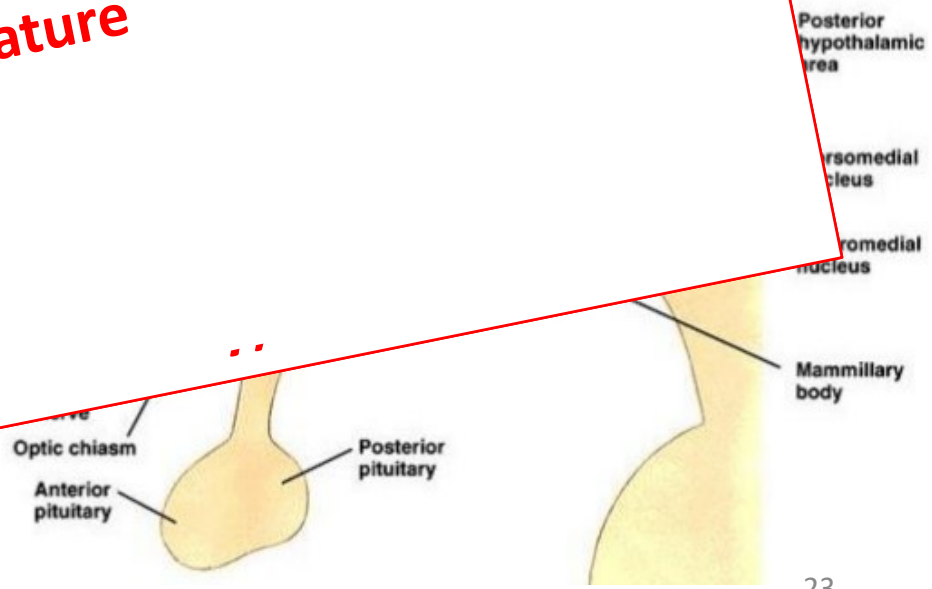
✓Autonomic nervous system regulation

✓Endocrine system regulation

✓Food and water intake regulation

✓Regulation of body temperature

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

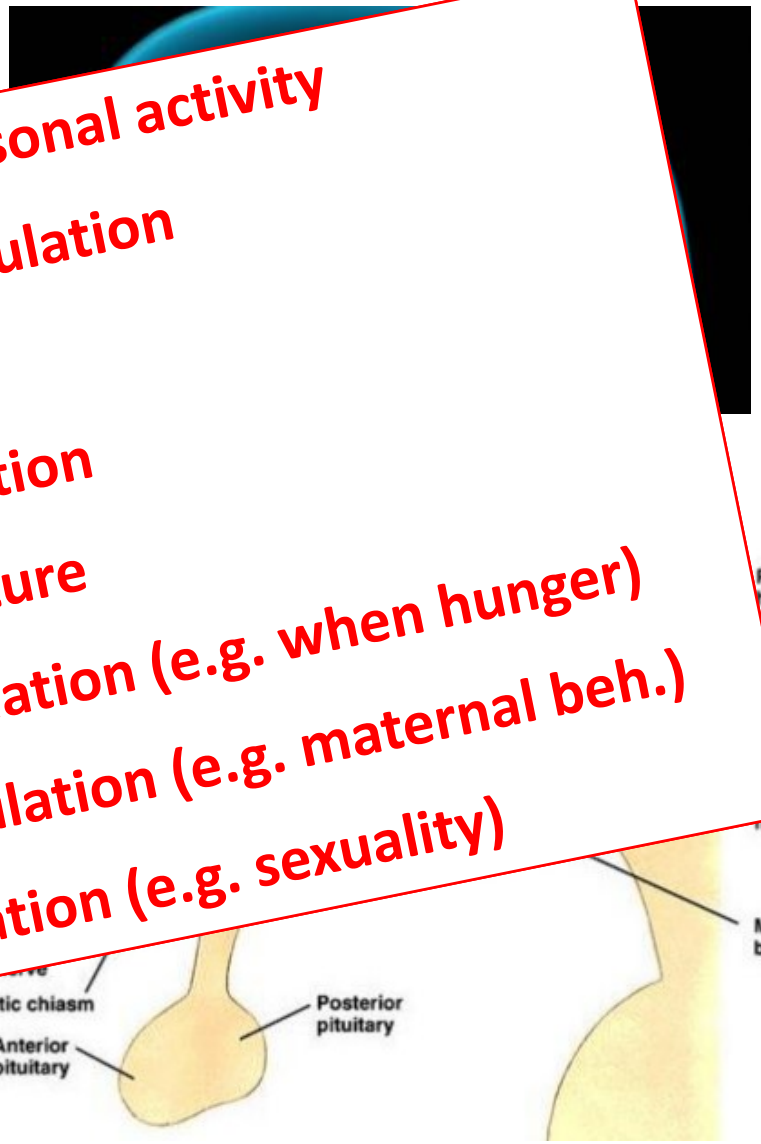


http://www.slideshare.net/physiologymgmcri/hypothalamus-15-apr-2016

Hypothalamus

- Key center of autonomic regulations and coordi
- Integ
  t
  e
- Be
- Reg
  nerv
- **Main**

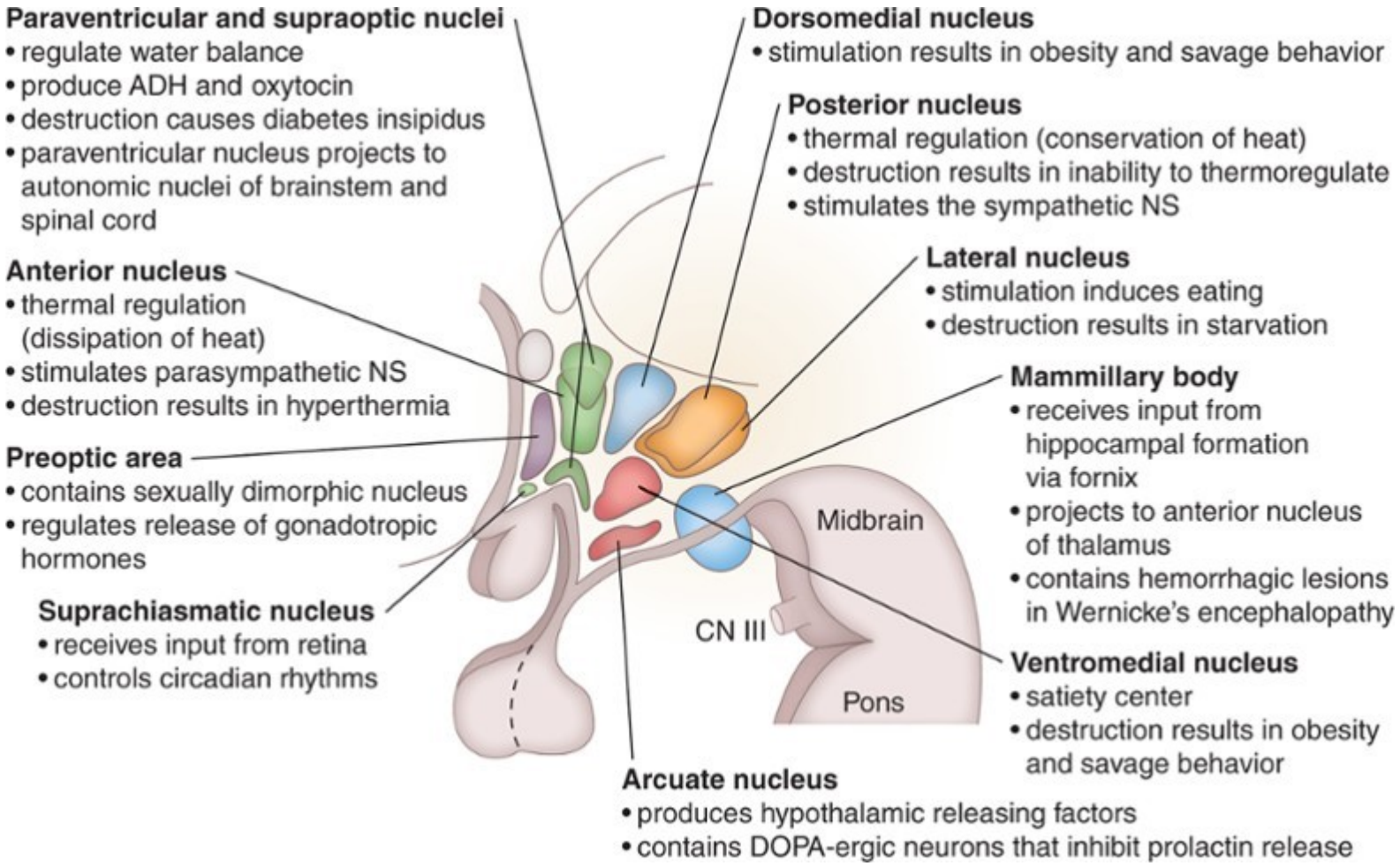
✓Biological clock – circadian /seasonal activity
✓Autonomic nervous system regulation
✓Endocrine system regulation
✓Food and water intake regulation
✓Regulation of body temperature
✓„Immediate“ behavior regulation (e.g. when hunger)
✓ „Long-term“ behavior regulation (e.g. maternal beh.)
✓Instinctive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

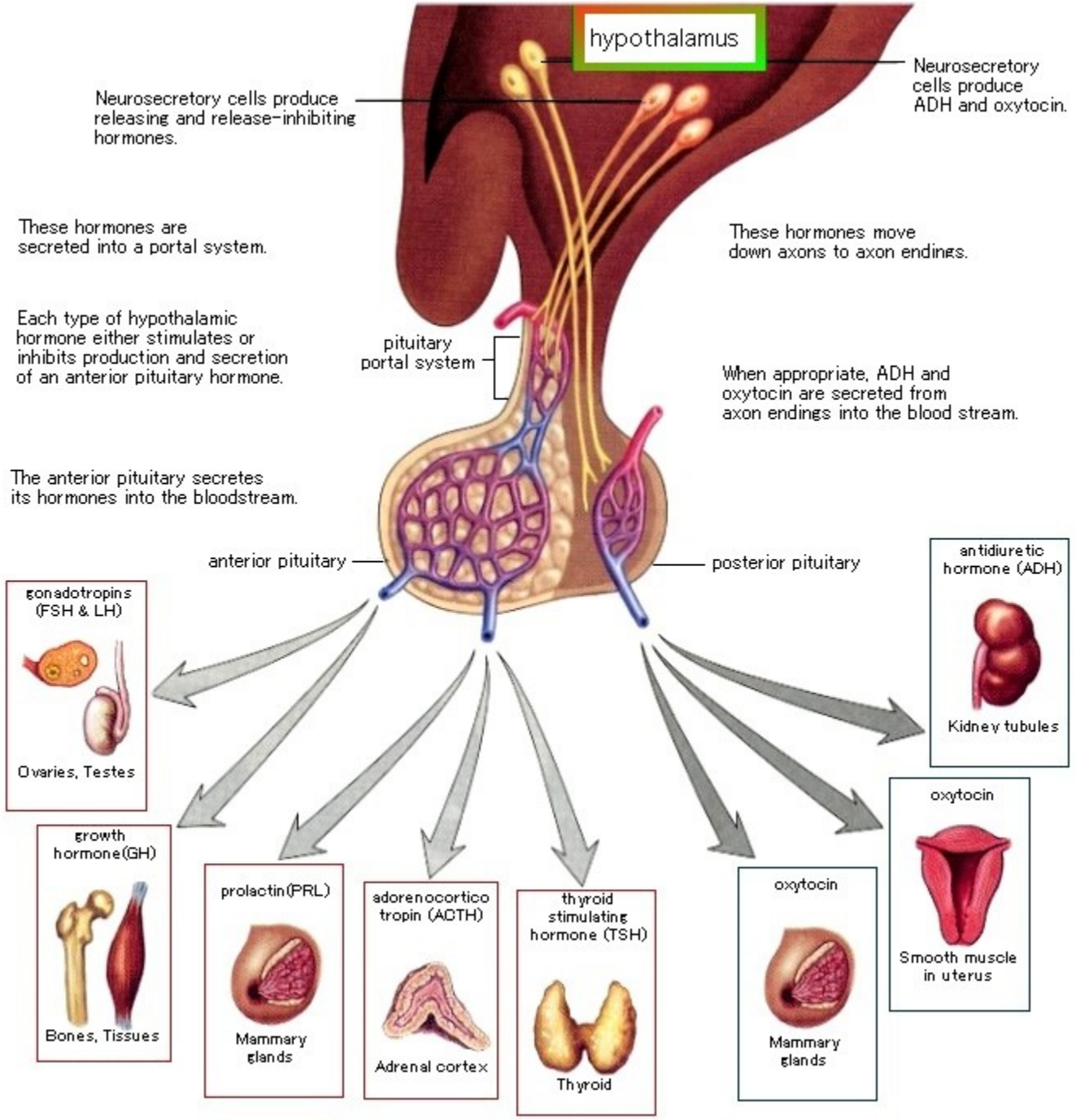


http://biology.about.com/od/anatomy/p/Hypothalamus.htm

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

Hypothalamus

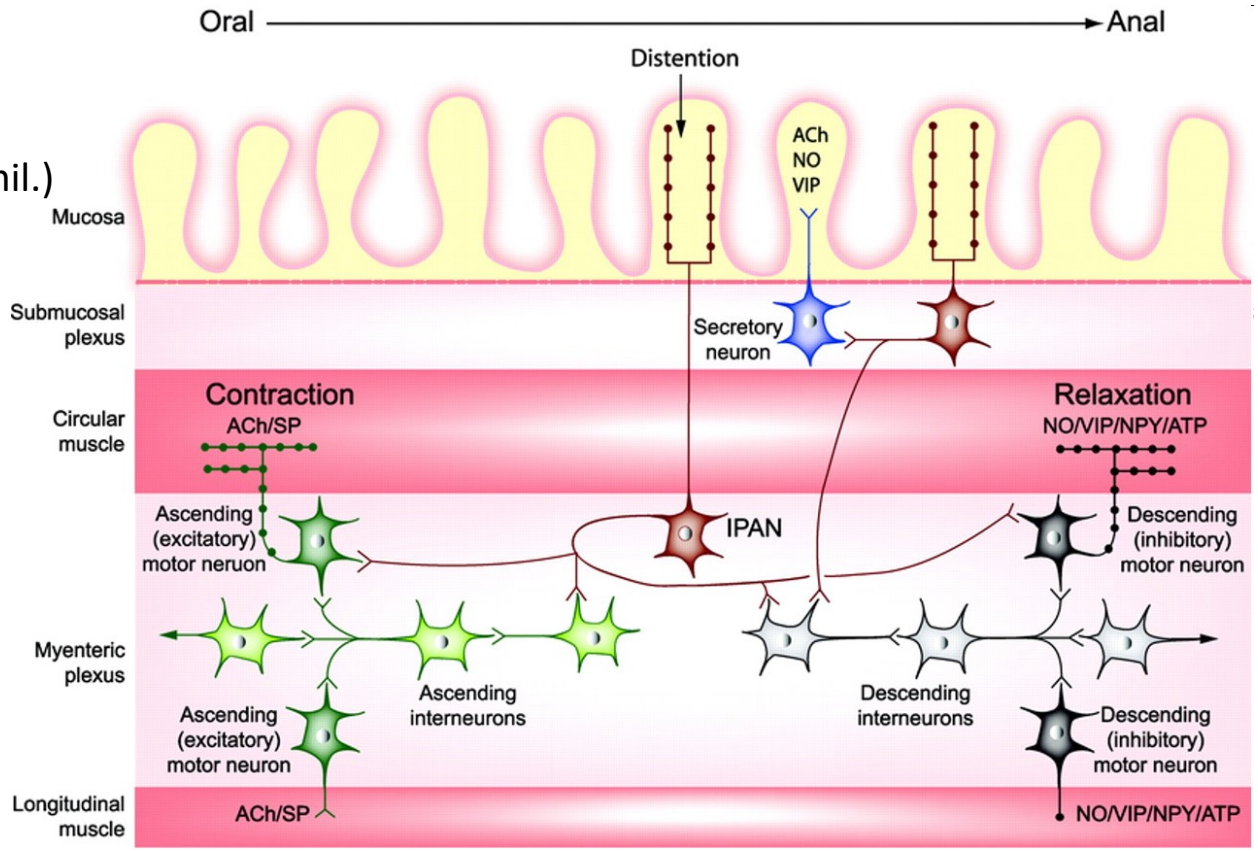




https://s-media-cache-ak0.pinimg.com/originals/5a/0a/78/5a0a78d64a682fcf9c5eb3b10d37a2a1.jpg

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“

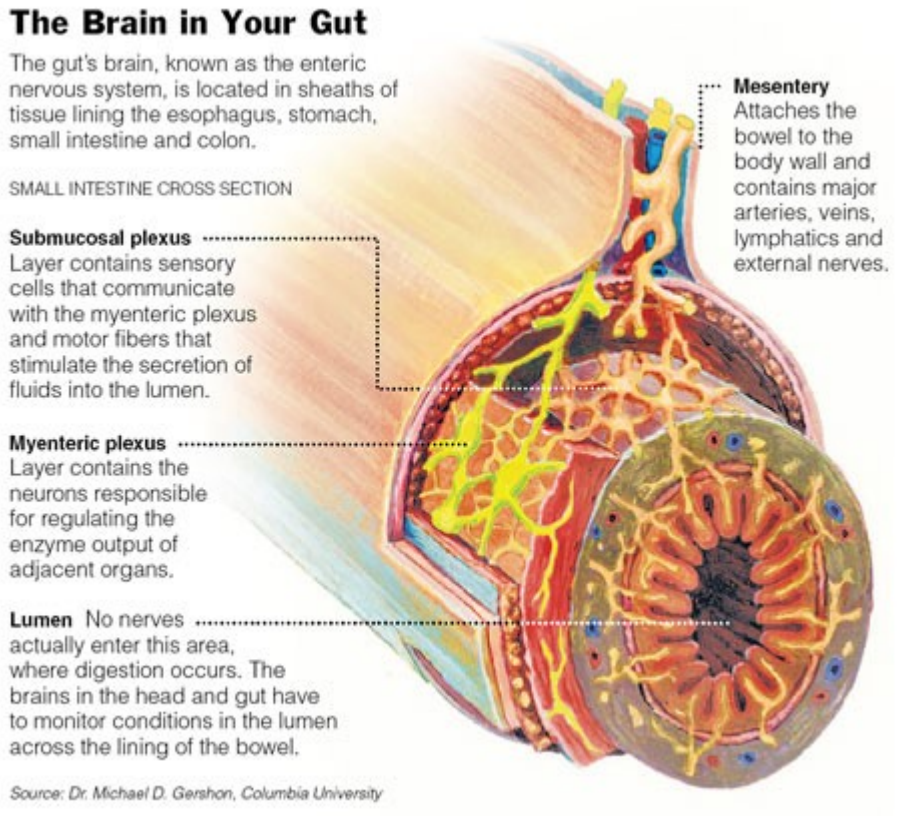


Furness JB (2006) The Enteric Nervous System. Blackwell, Oxford, pp 274

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

Enteric nervous system

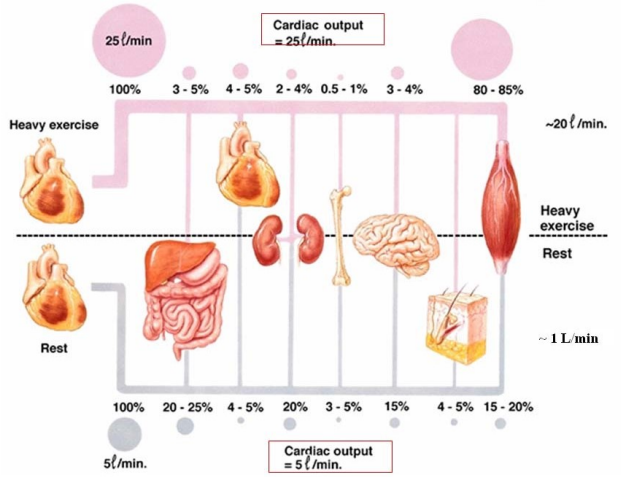
- Autonomy
  - Control of motility
  - Control of secretion
  - Control of blood flow



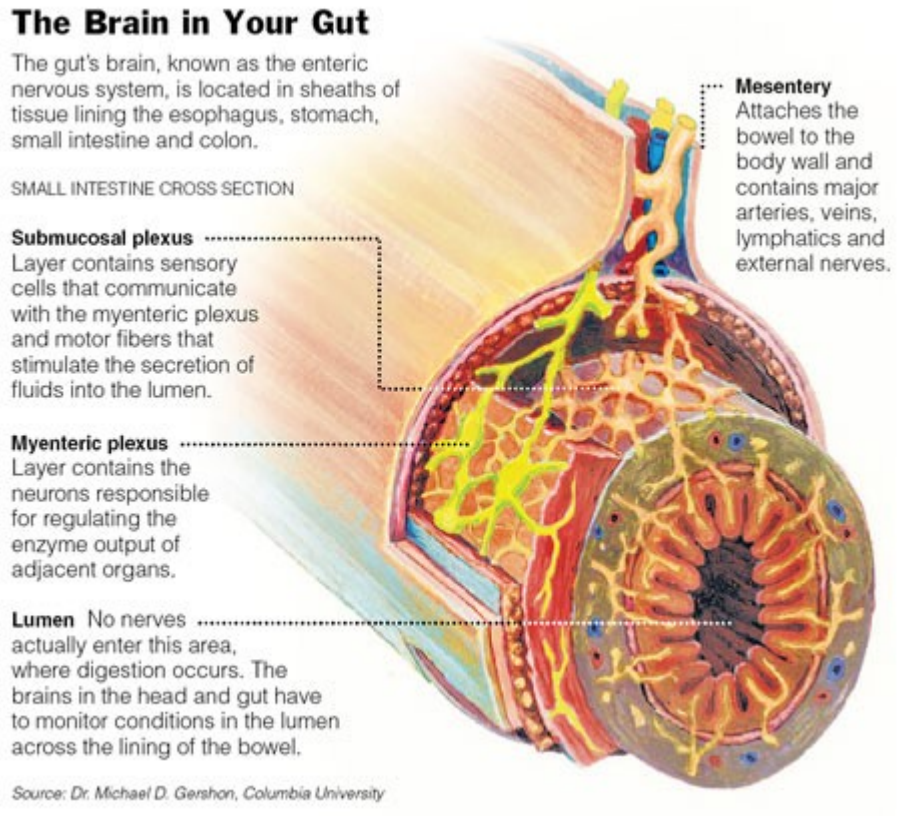
https://kin450-neurophysiology.wikispaces.com/file/view/gut.jpg/187924395/gut.jpg

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

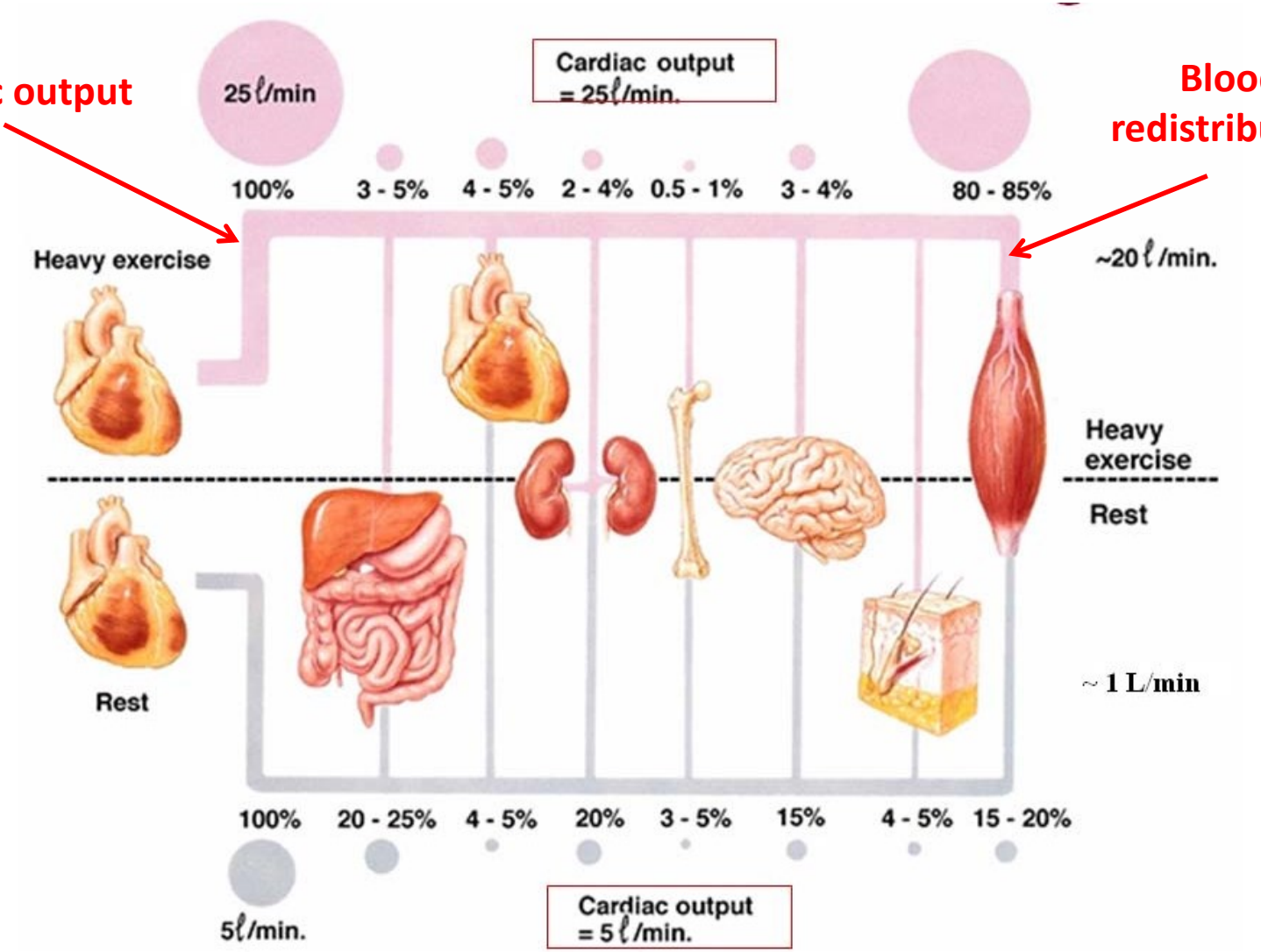


http://2.bp.blogspot.com/_MJ0CEYnSB4U/S99IJTUruOI/AAAAAAAAACs/NPzsh8ydzjQ/s1600/redistributionofbloodflow.jpg



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

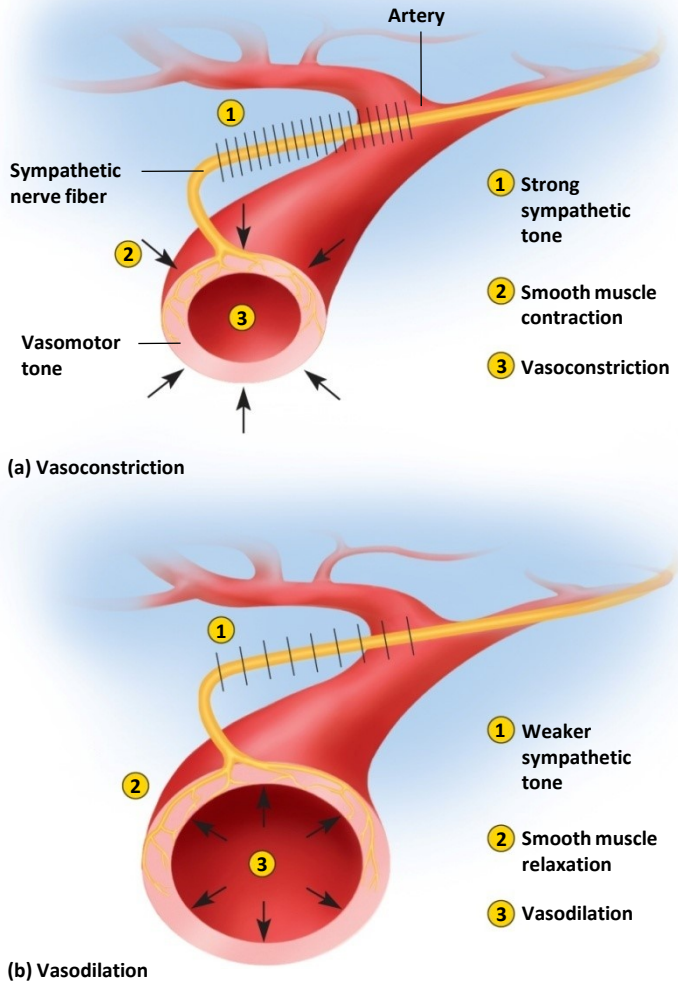
ANS and cardiovascular system



http://2.bp.blogspot.com/_MJUCEYnSB4U/S99IJTUruUI/AAAAAAAAACs/NPzsn8ydzjQ/s1600/redistributionofbloodflow.jpg

ANS and cardiovascular system

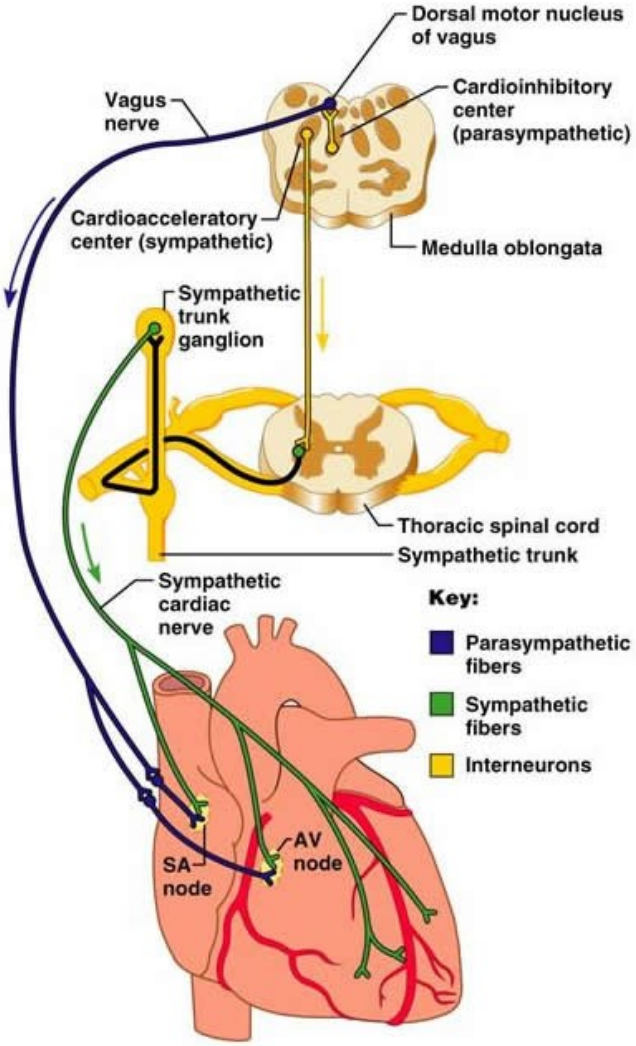
- Local regulatory mechanisms play major role in vasoreactivity
- Sympathetic regulation
  - Skin vessels contraction
  - Muscle vessels dilatation
- Parsympathetic regulation
  - GIT vessels dilation



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

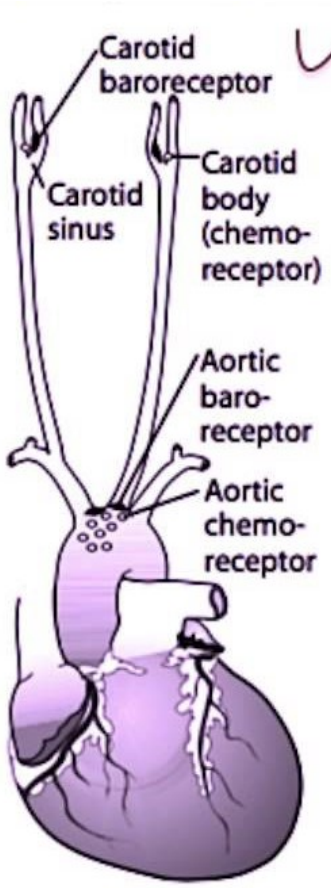
ANS and cardiovascular system

- 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/

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:

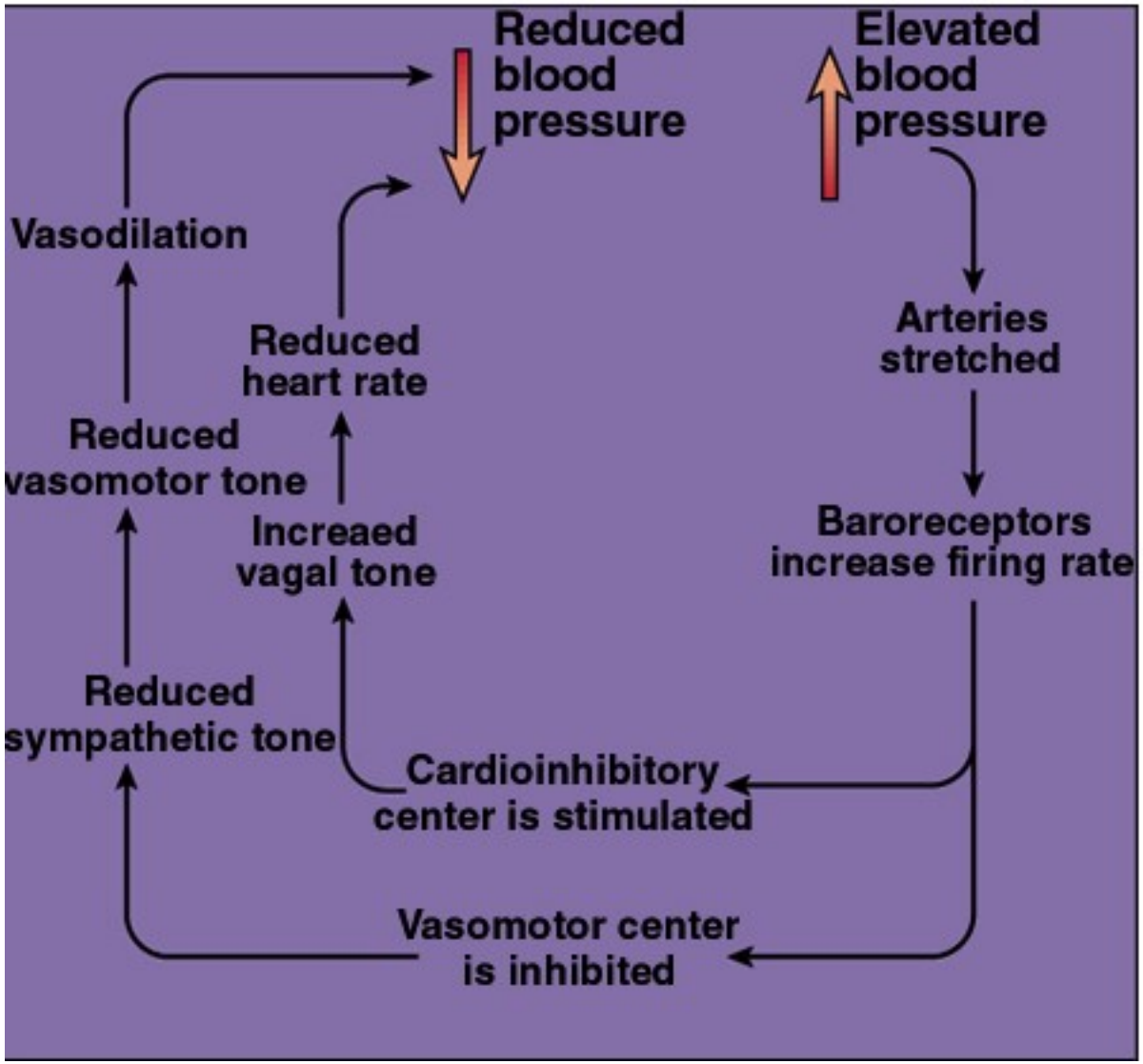
1. Hypotension—↓ arterial pressure → ↓ stretch → ↓ afferent baroreceptor firing → ↑ efferent sympathetic firing and ↓ efferent parasympathetic stimulation → vasoconstriction, ↑ HR, ↑ contractility, ↑ BP. Important in the response to severe hemorrhage.
2. Carotid massage—↑ pressure on carotid artery →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

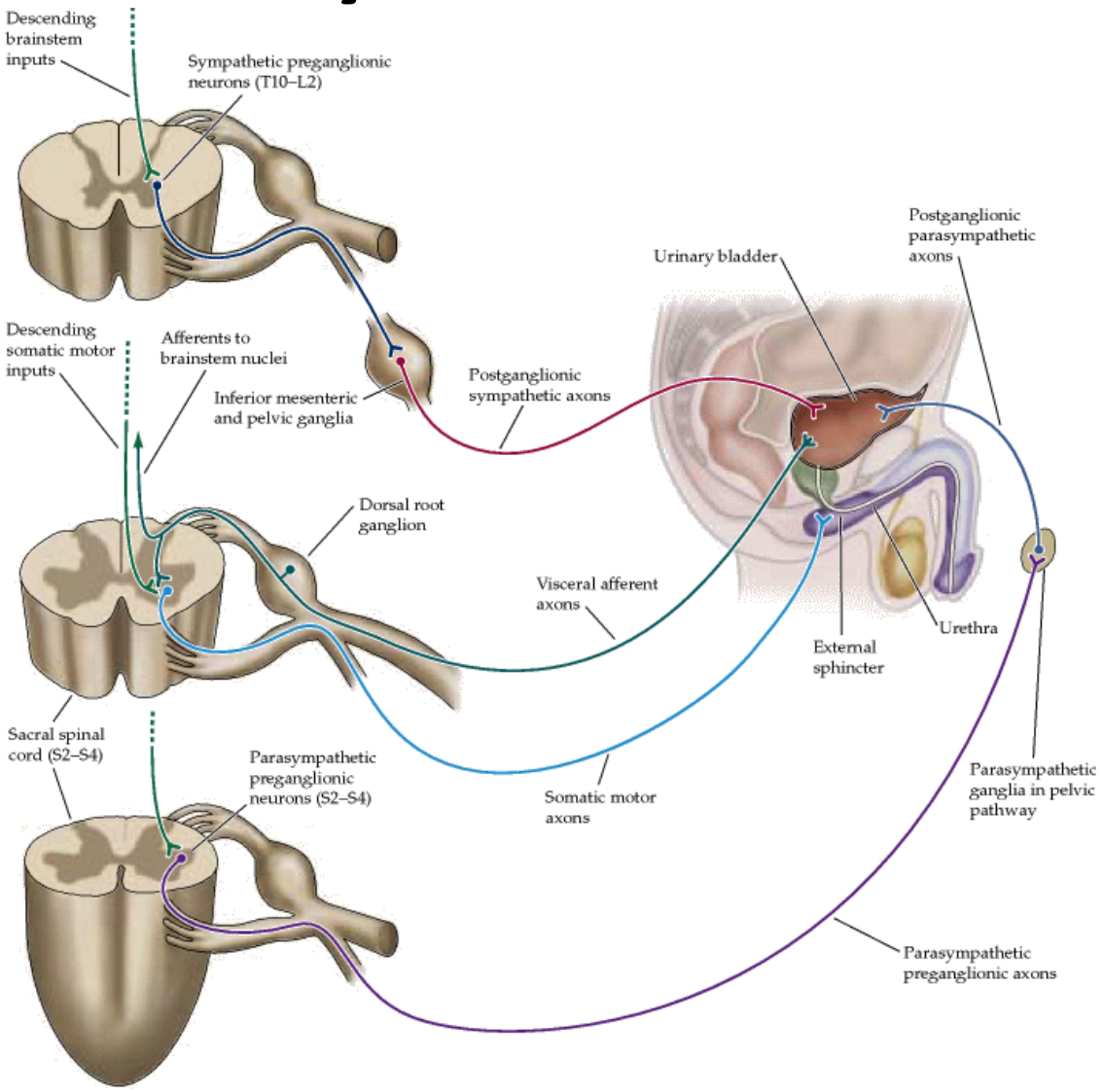
https://i.ytimg.com/vi/RAhqTAcdh_4/maxresdefault.jpg

Baroreflex


Reduced blood pressure
Elevated blood pressure
Vasodilation
Arteries stretched
Reduced heart rate
Reduced vasomotor tone
Increaed vagal tone
Baroreceptors increase firing rate
Reduced sympathetic tone
Cardioinhibitory center is stimulated
Vasomotor center is inhibited

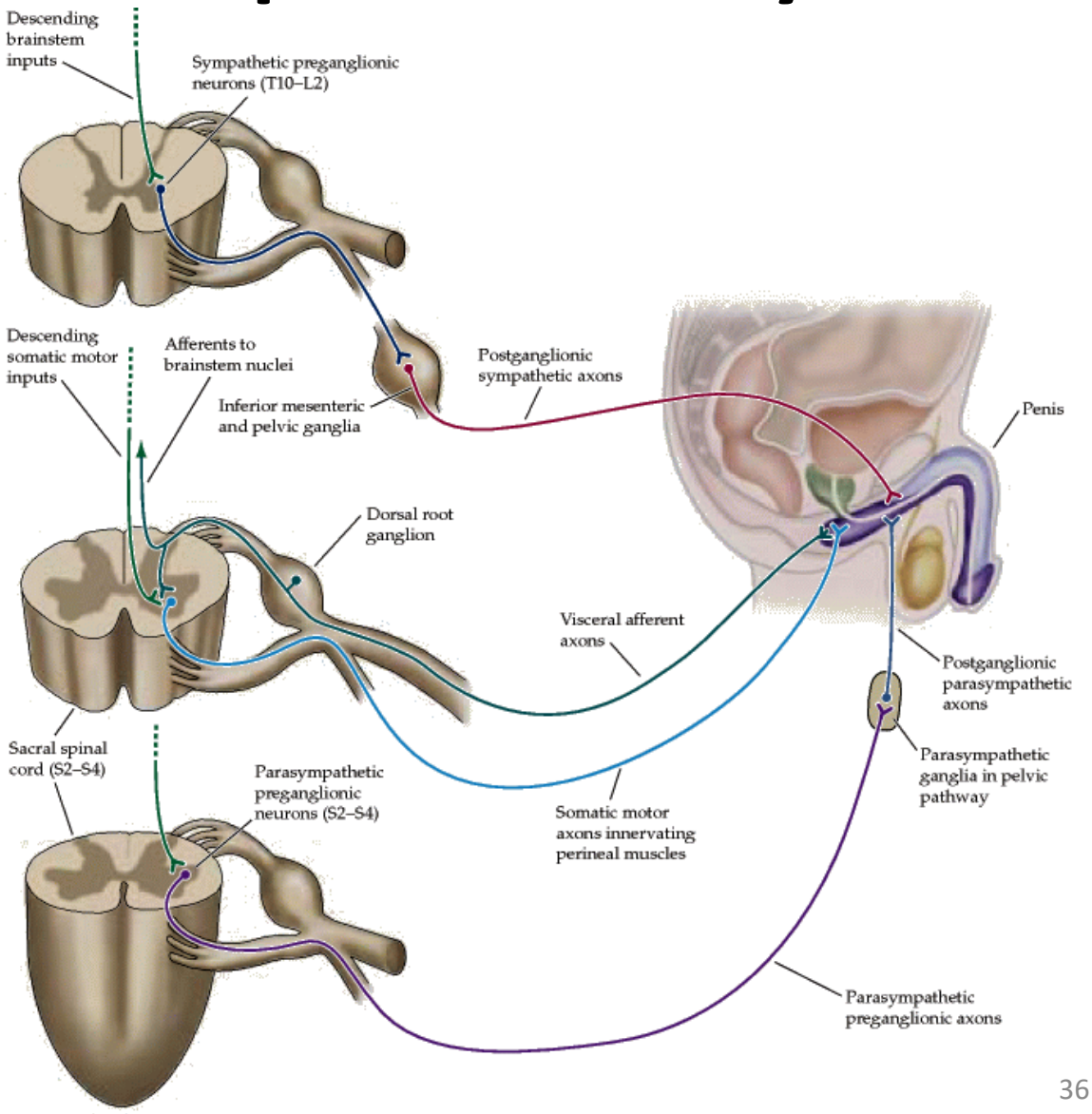
ANS and urinary bladder

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



ANS and male reproductive system

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



ANS and female reproductive system

Very complicated.....

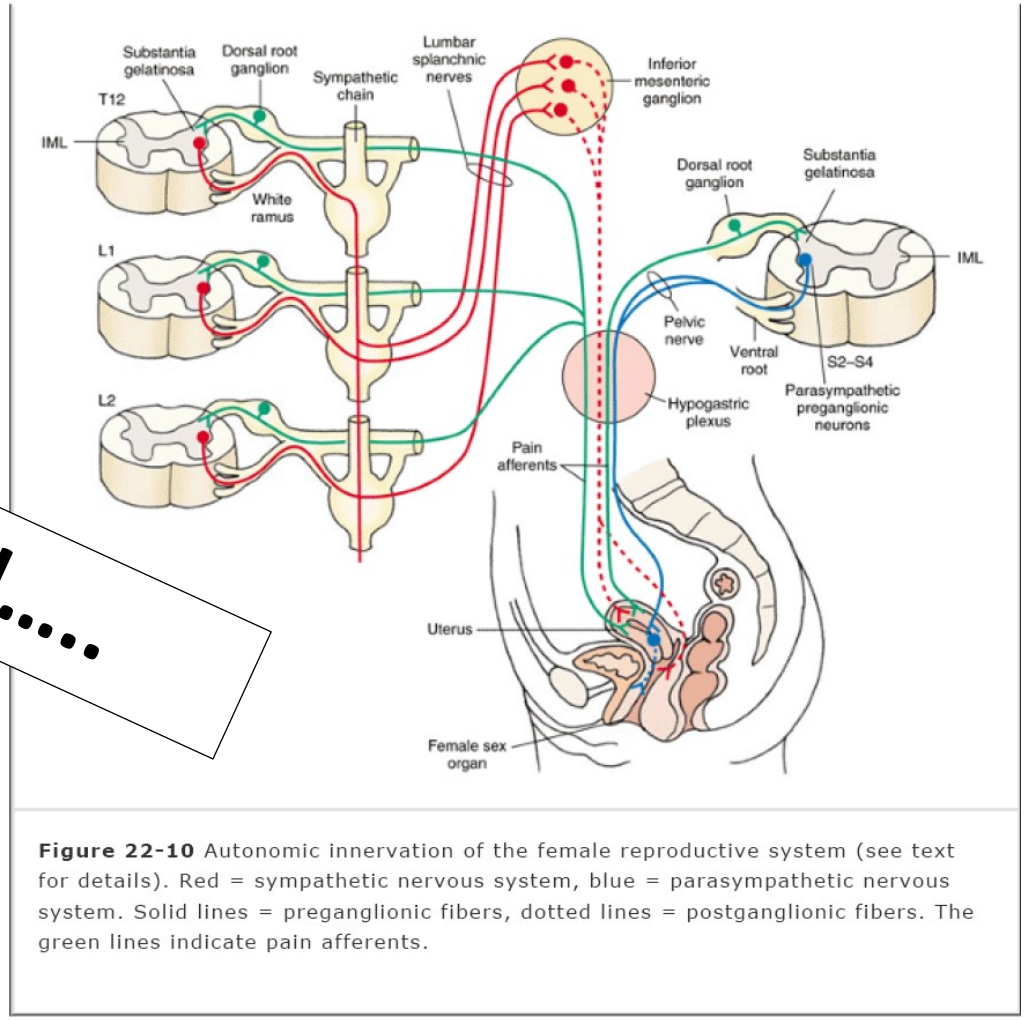


Figure 22-10 Autonomic innervation of the female reproductive system (see text for details). Red = sympathetic nervous system, blue = parasympathetic nervous system. Solid lines = preganglionic fibers, dotted lines = postganglionic fibers. The green lines indicate pain afferents.