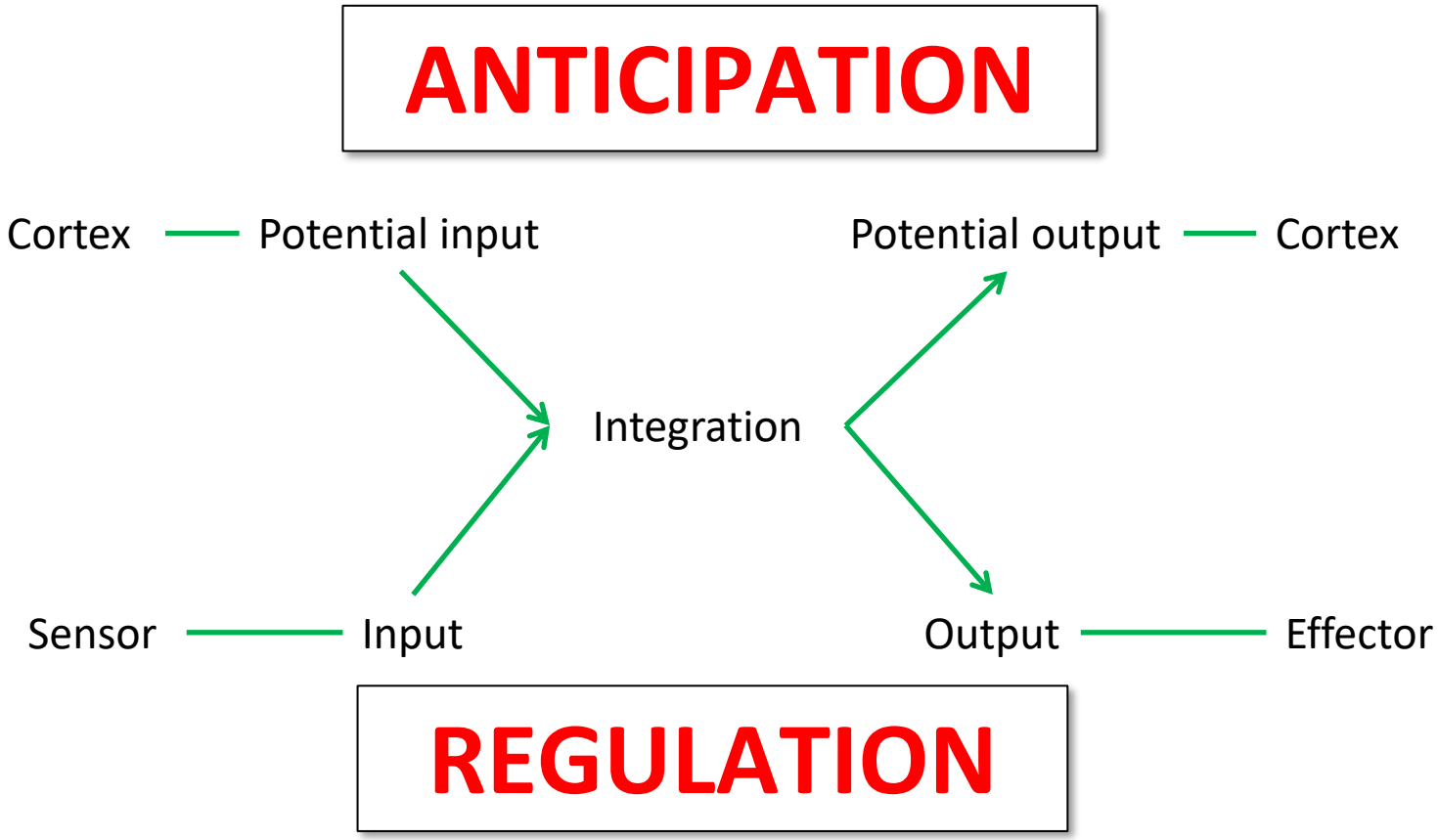
MUNI
MED

MUNI
MED

13

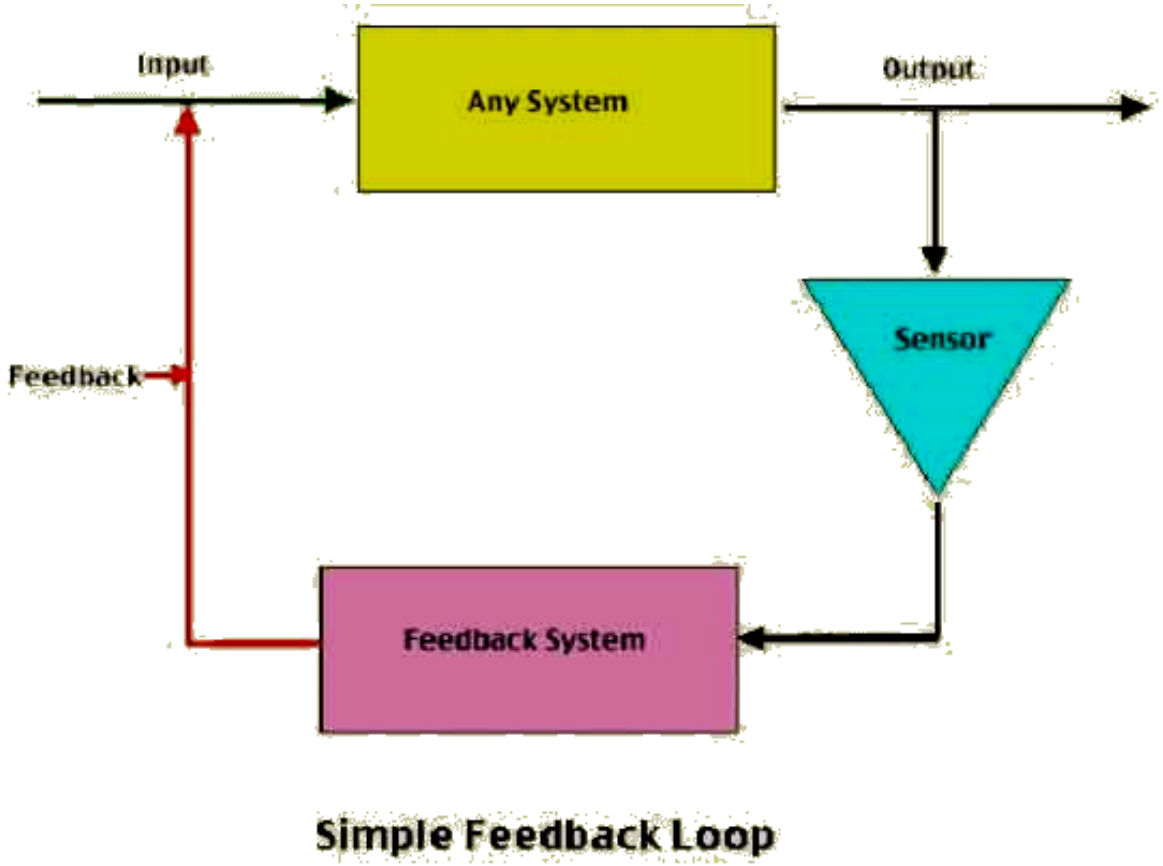
Autonomic nervous system

The role of nervous system



MUNI MED

Feedback regulation

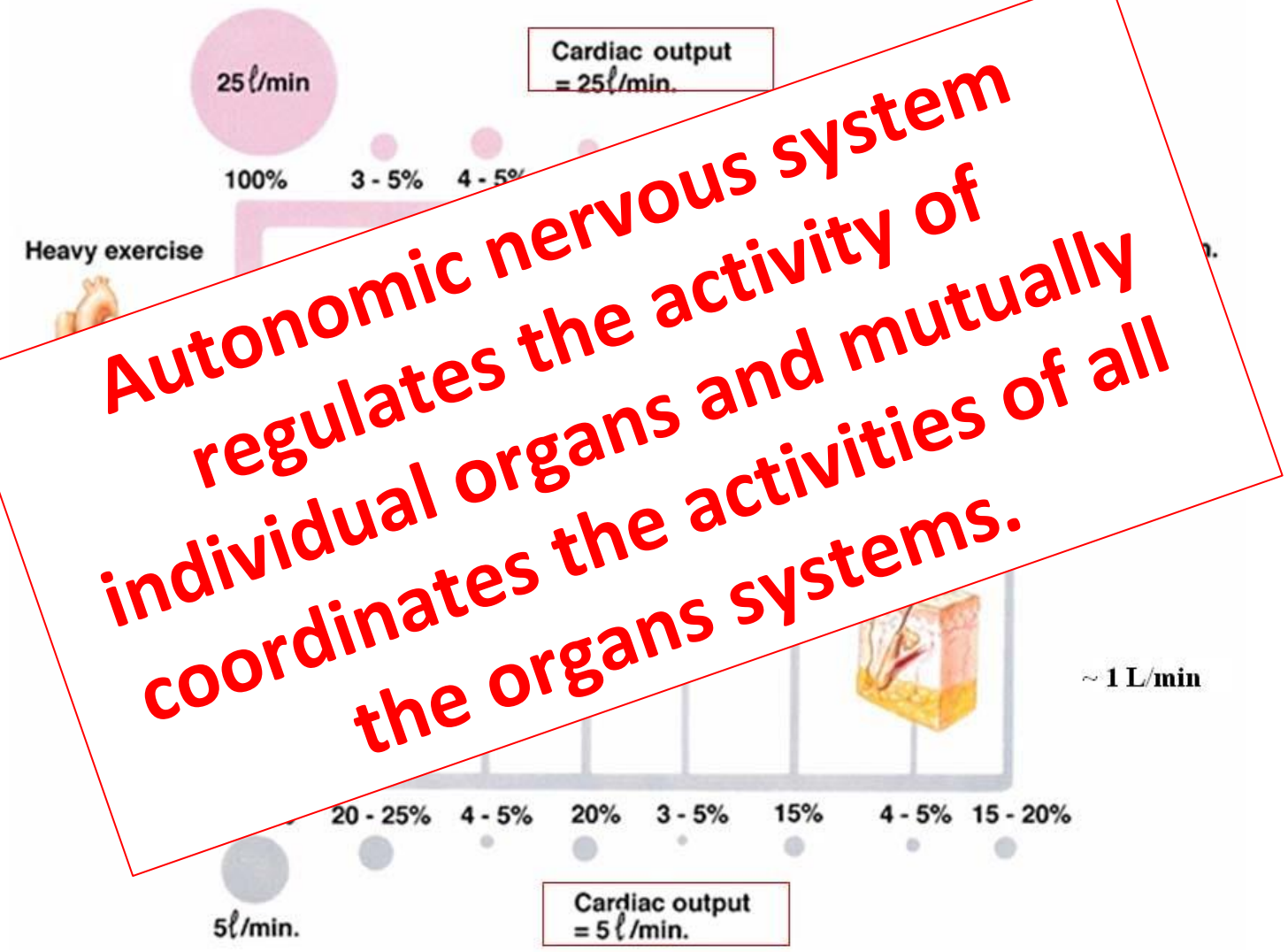


Simple Feedback Loop

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

MUNI MED

Redistribution of Blood Flow During Exercise

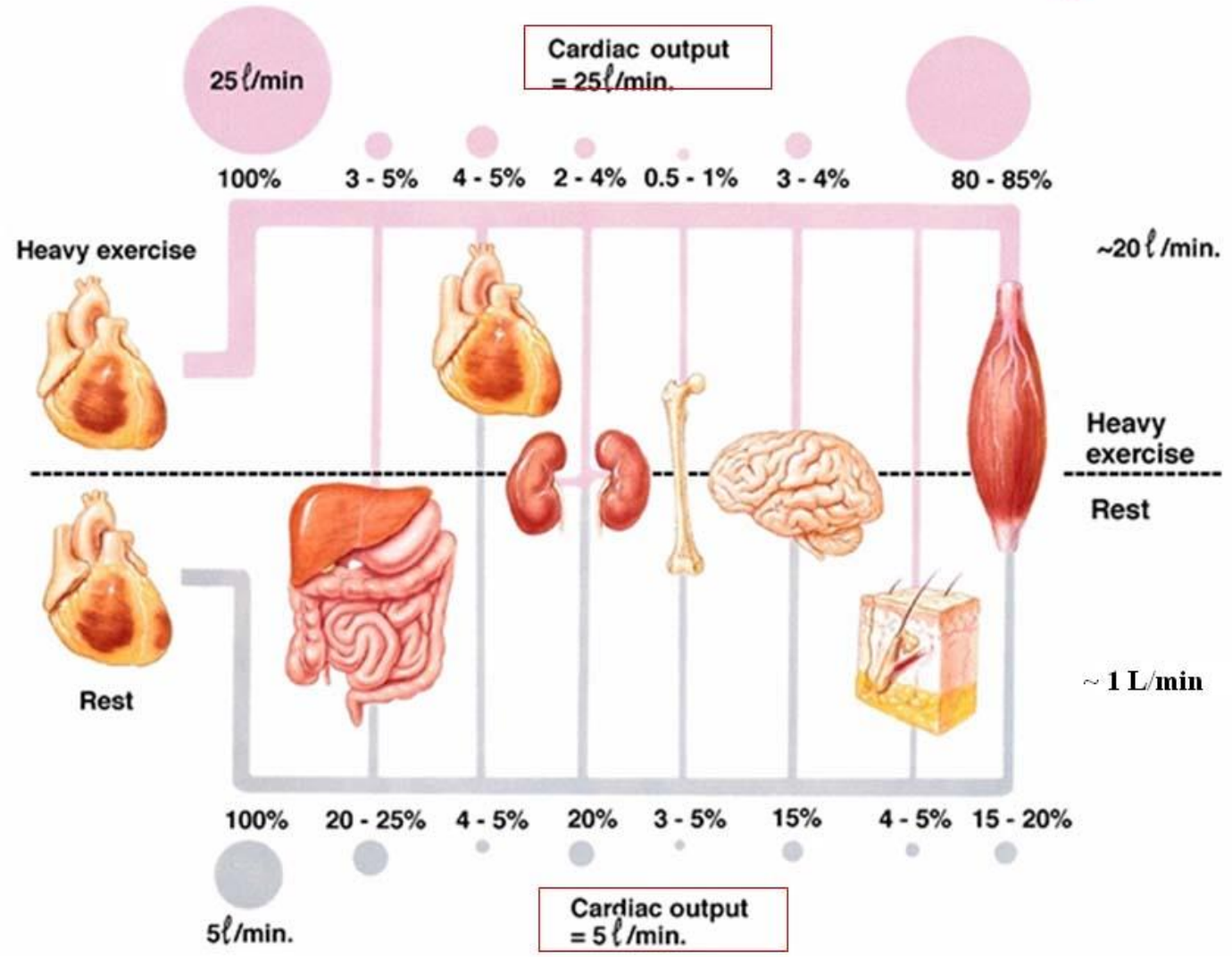


Autonomic nervous system regulates the activity of individual organs and mutually coordinates the activities of all the organs systems.

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

MUNI MED

Redistribution of Blood Flow During Exercise



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

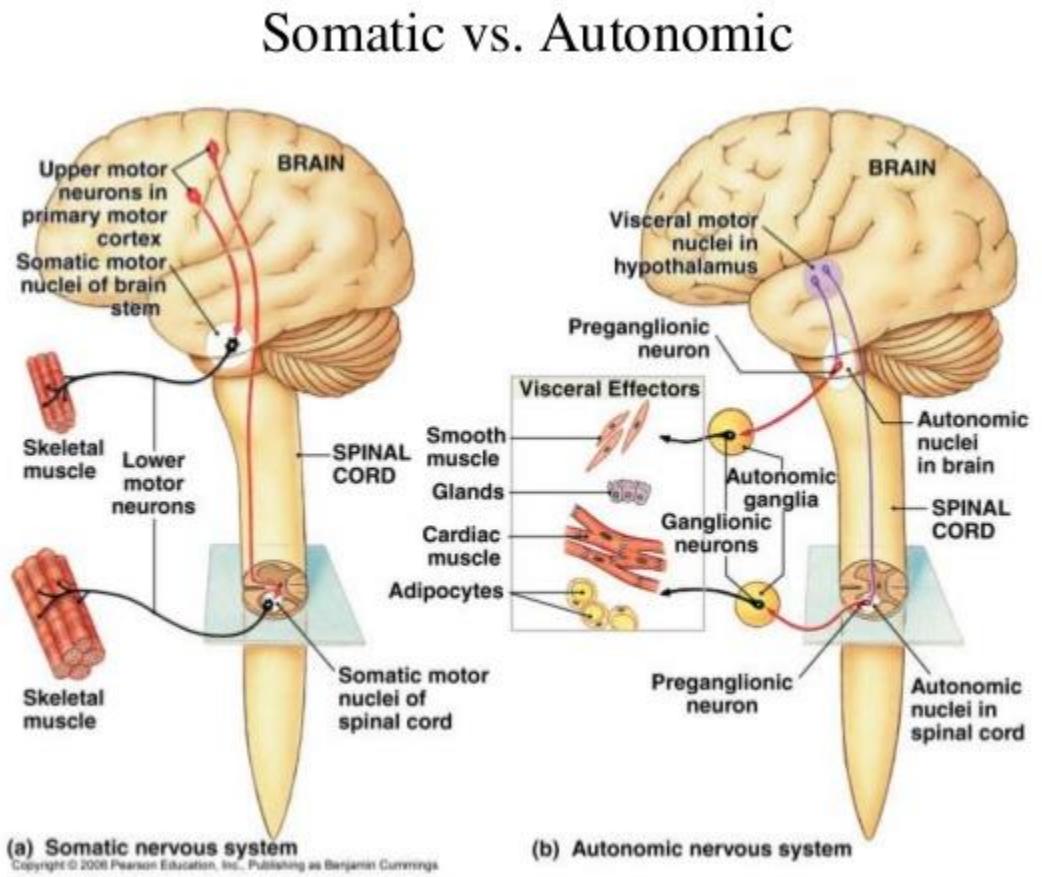
MUNI MED

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

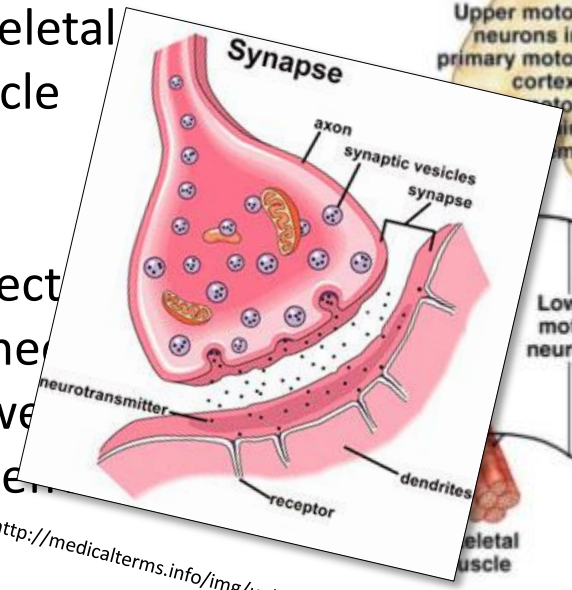
MUNI MED

Somatic a autonomic nervous system

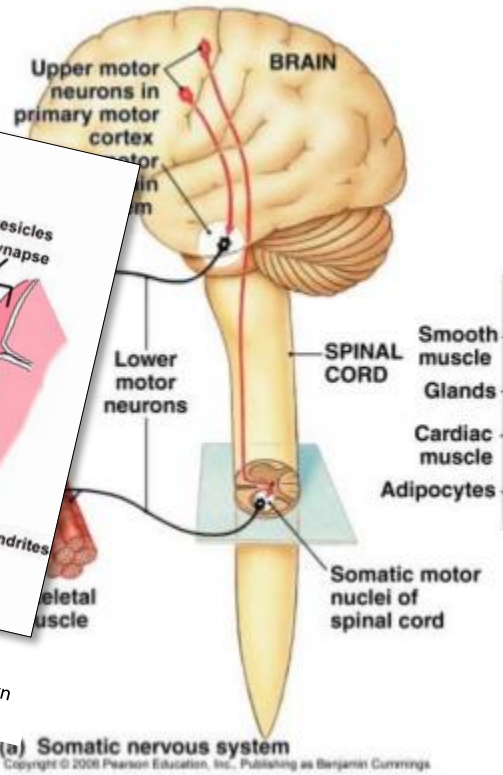
➢„Voluntary“

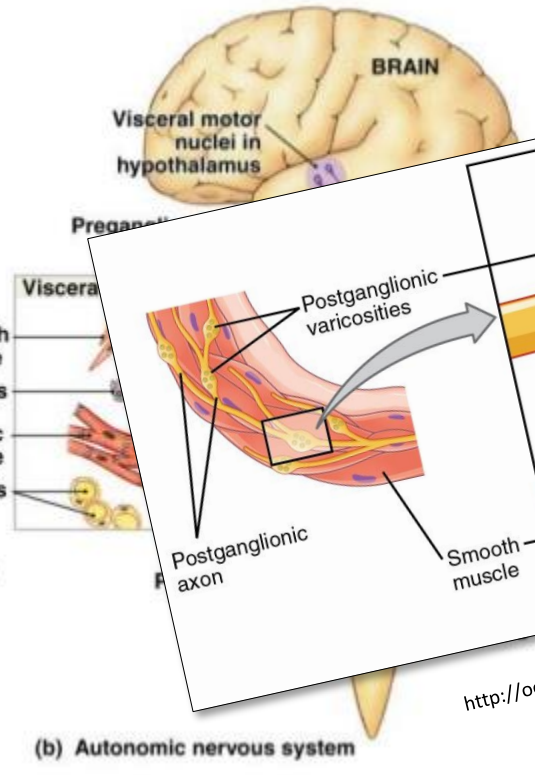
✓Skeletal muscle

▪Direct connec… betwe… and e…



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





➢„Involuntary“

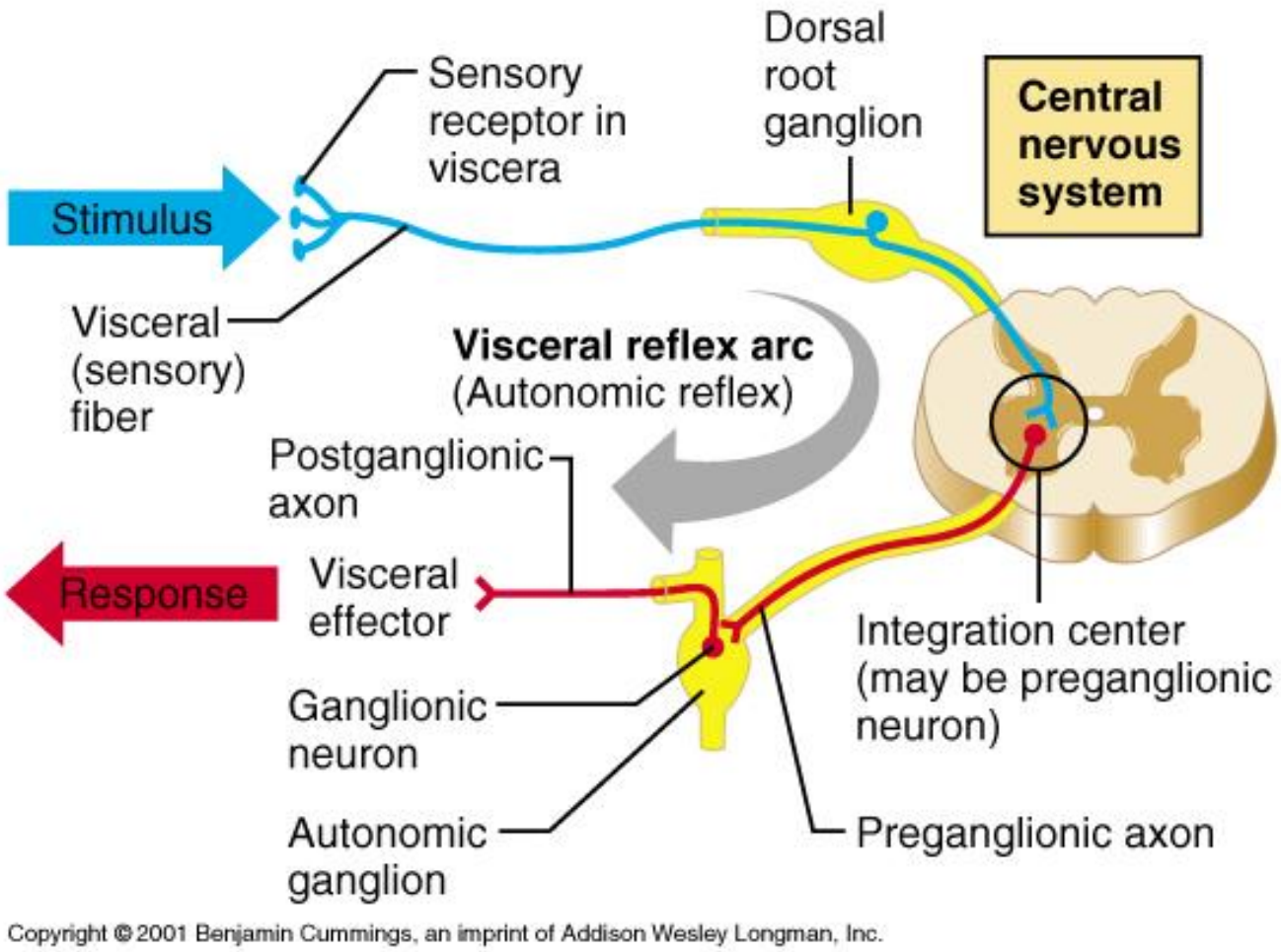
✓C…

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

MUNI MED

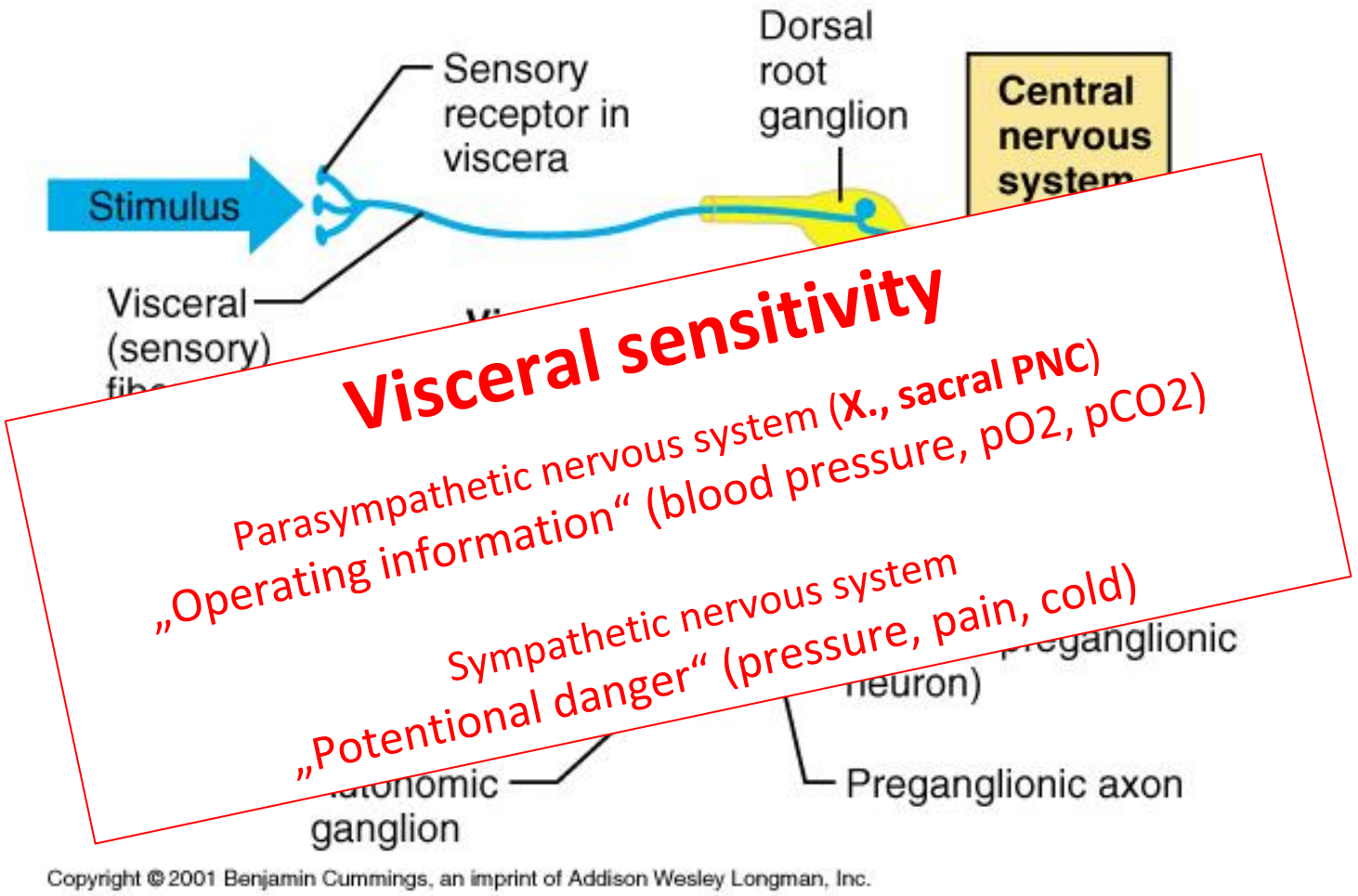
Visceral reflex loop



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

MUNI MED

Visceral reflex loop



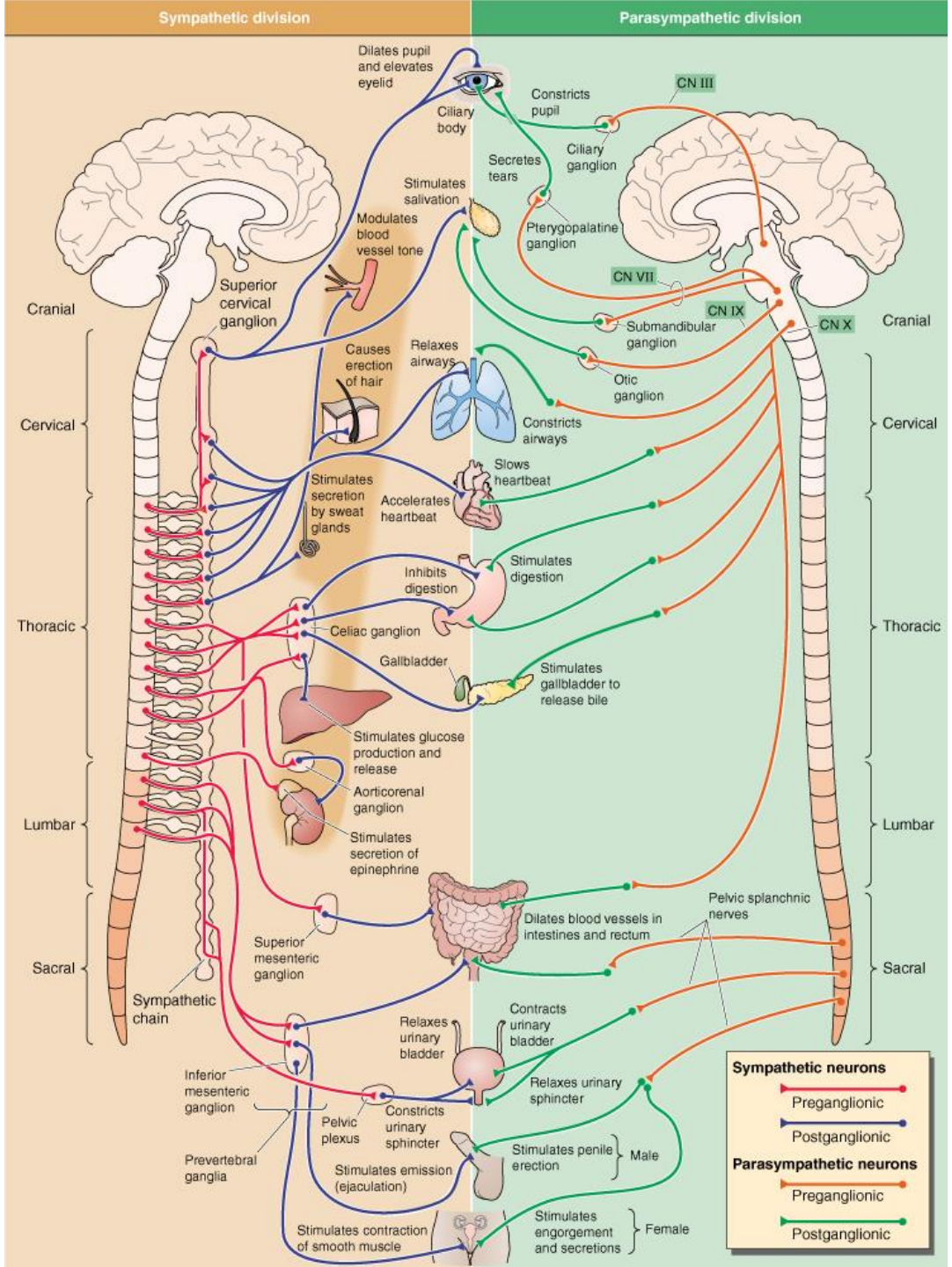
http://slideplayer.com/slide/2810792/

MUNI MED

Sympatthetic nervous system

Fight or flight response

Energy/store consumption



Parasympathetic nervous system

Rest and digest response

Energy conservation/energy store production

MUNI MED

Sympatthetic nervous system

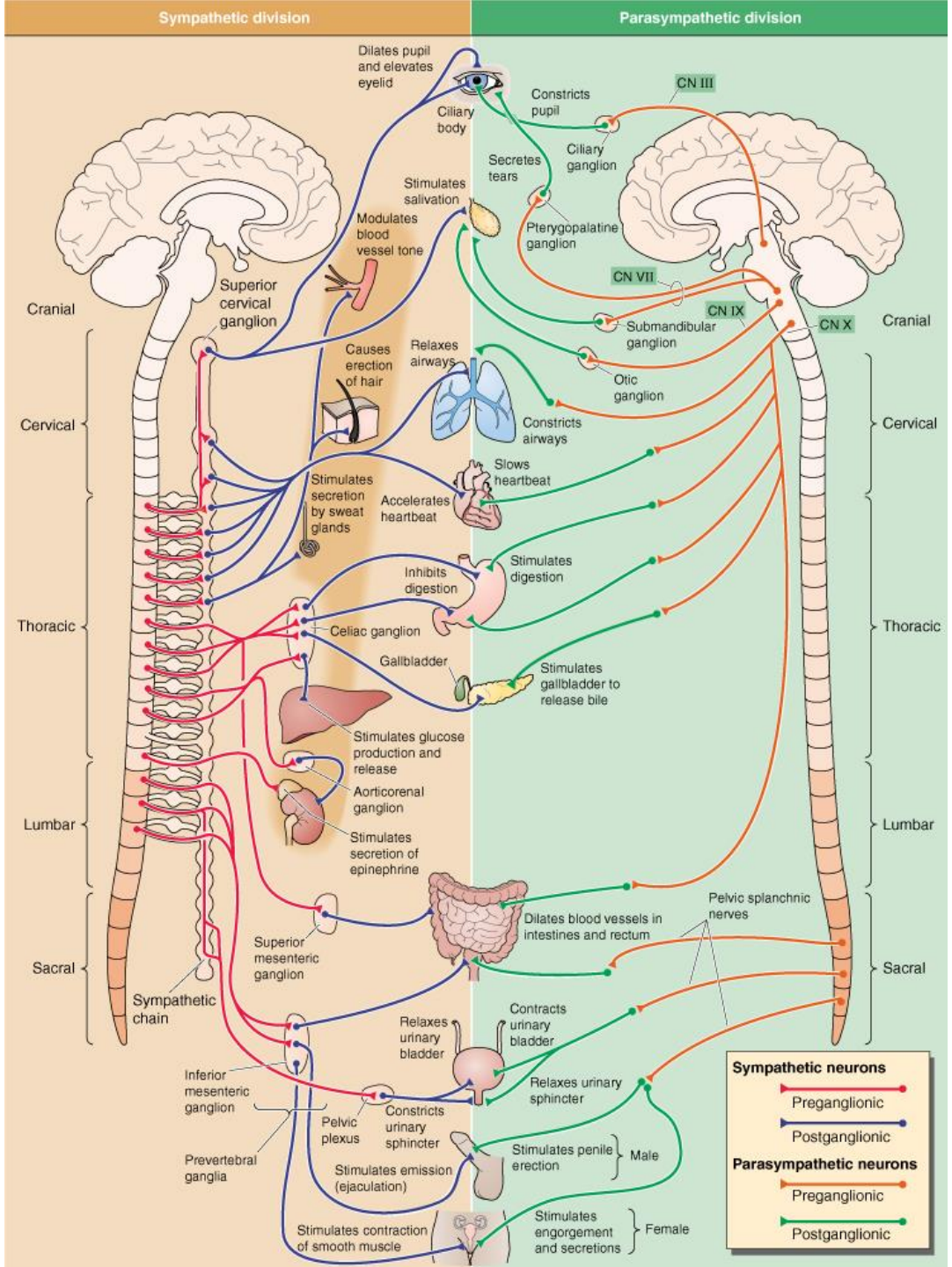
Fight or flight response

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

MUNI MED

Sympatthetic nervous system

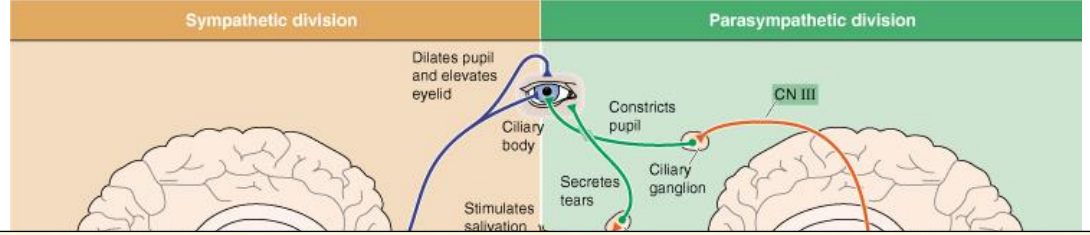
Fight or flight resp

Energy/store consur

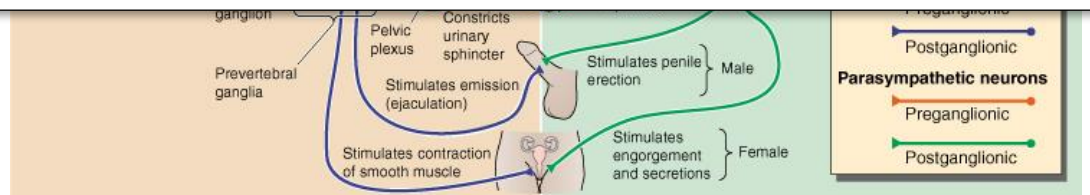
Preganglionic neu
– Spinal cord
-Thoraco - lumbar sys

Ganglia *Paraverte*
-Truncus sympathic
- Majority
Prevertebral
-Plexus aorticus

Mostly diffuse ef



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



Parasympathetic nervous system

and digest response

onservation/energy store production

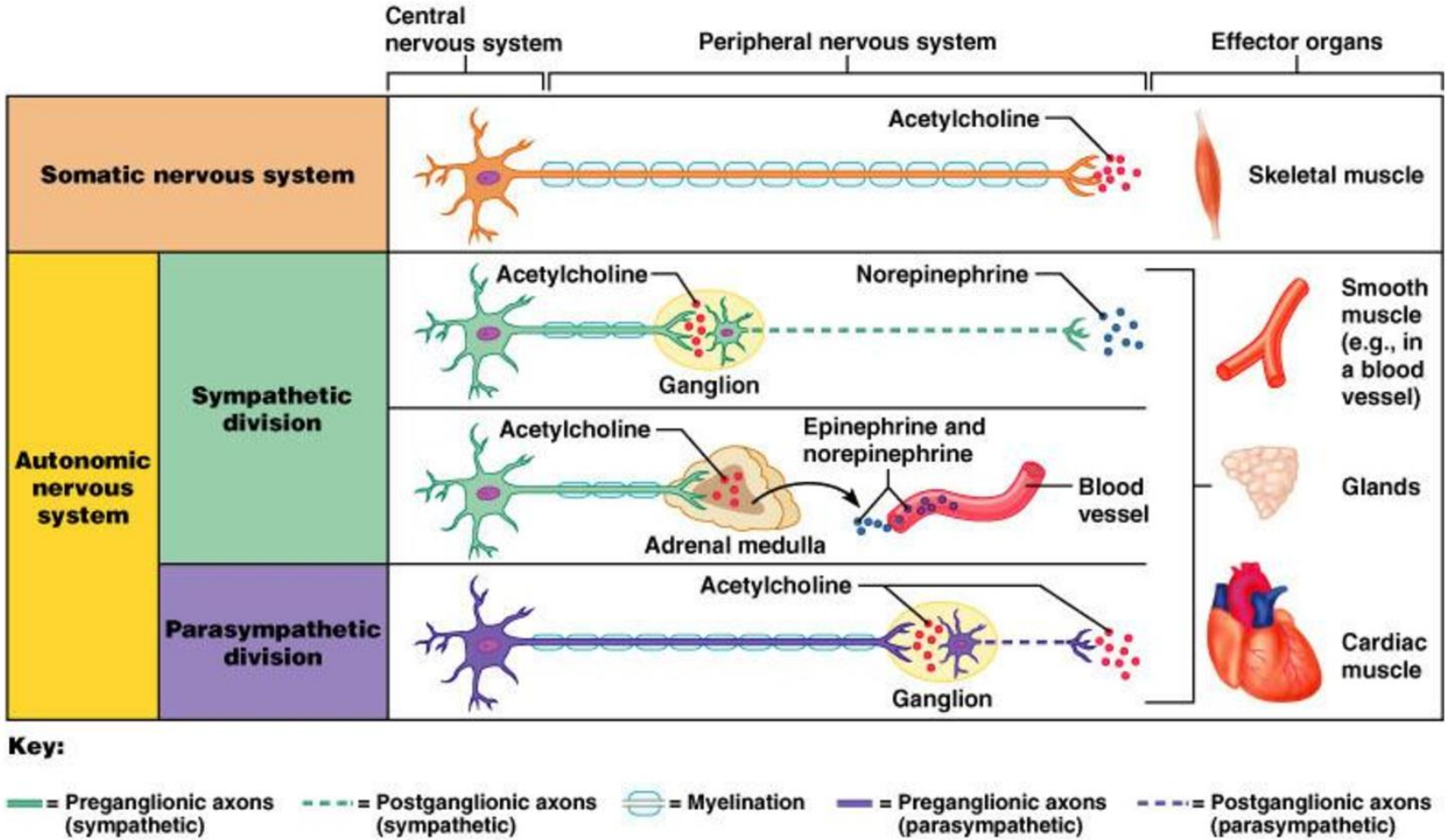
eganglionic neuron
ain stem and spinal cord
- cranio-sacral system

Ganglia
e to target organs or intramurally

Mostly local effect

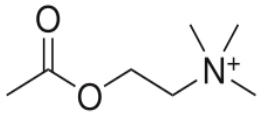
MUNI MED

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%2Fthumb%2Forig%2F105365259.png&psig=AFQjCNFxrUy63llCAlny-Vhlyse4FHDMaw&ust=1476801796194278

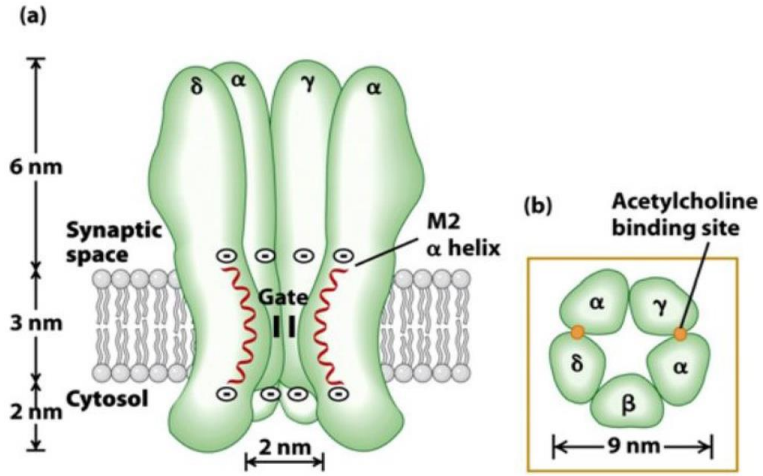
MUNI MED



Acetylcholine

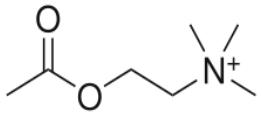
Preganglionic fibers

- 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

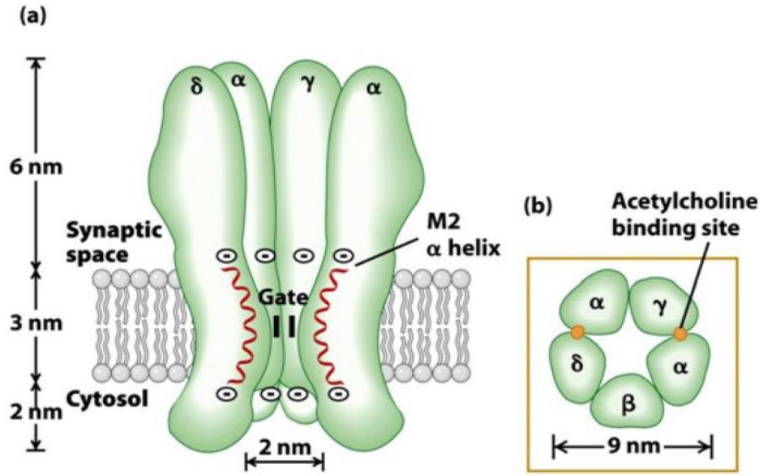
MUNI MED



Acetylcholine

Preganglionic fibers

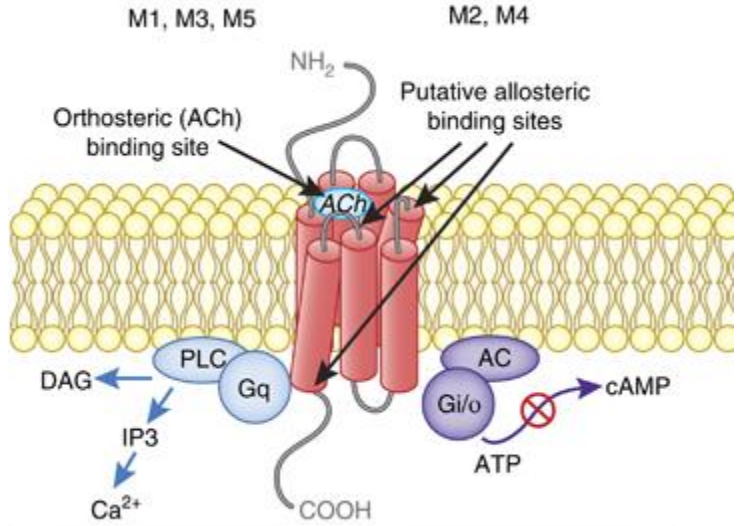
- Sympathetic
- Parasympathetic
- ✓ Nicotinic receptor
  - Ligand-gated ion channels
  - Na+, K+, Ca2+
  - Neuronal (N_N) and muscle (N_M) type
  - Excitatory



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

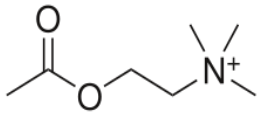
Postganglionic fibers

- 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

MUNI MED



Acetylcholine

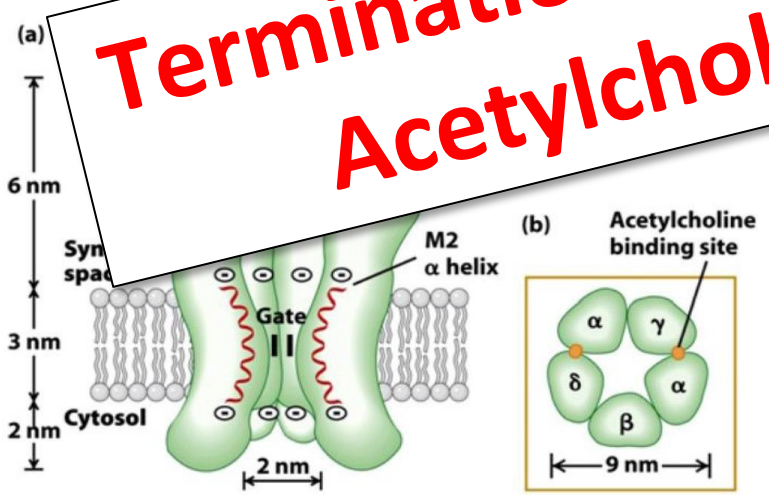
Preganglionic fibers

- Sympathetic
- Parasympathetic
- ✓ Nicotinic receptor
  - Ligand-gated ion channels
  - Na+, K+, Ca2+
  - Neuronal (N_N) and mu
  - Excitat

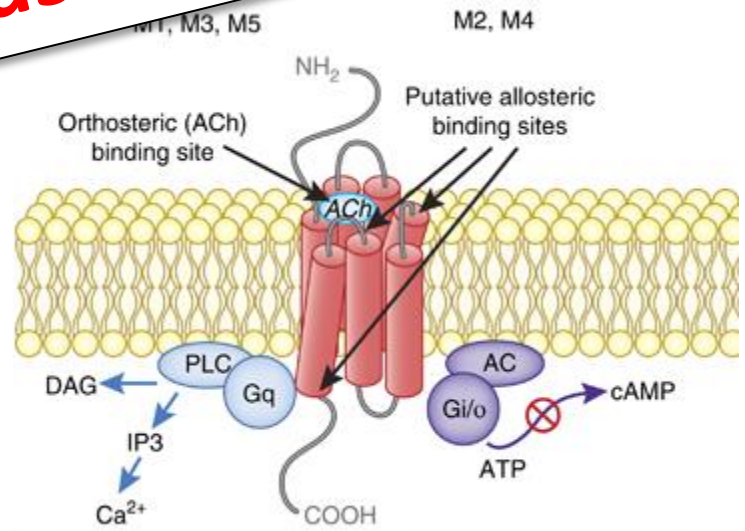
Postganglionic fibers

- Parasympathetic
- ✓ Muscarinic receptor
  - G-co

Termination of synaptic transmission
Acetylcholinesterase (AChE)

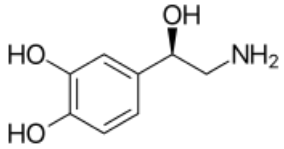


http://www.mdpi.com/marinedrugs/marinedrugs-12-02970/article_deploy/html/images/marinedrugs-12-02970-g013-1024.png



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

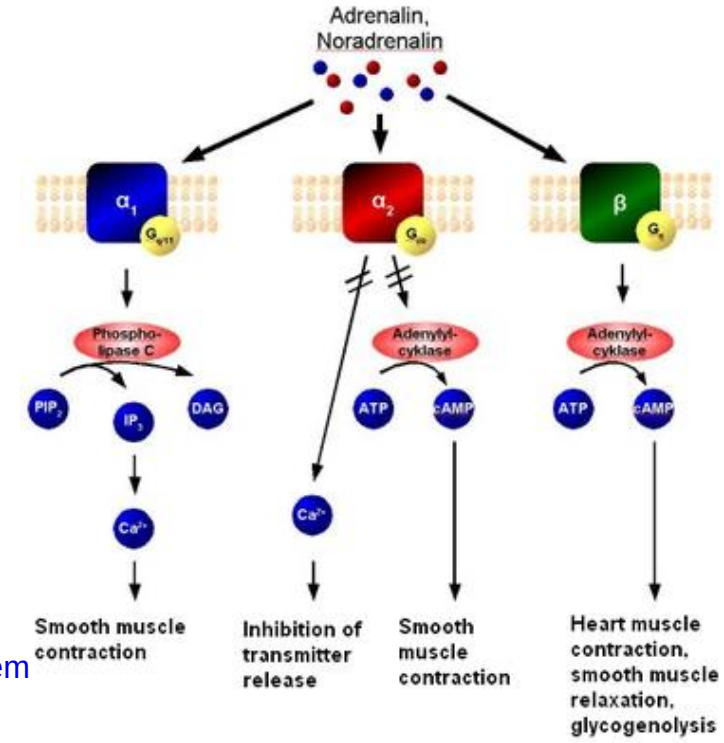
MUNI MED



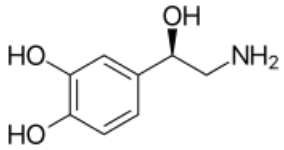
Norepinephrine

- 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



MUNI MED



Norepinephrine

- Postganglionic sympathetic fibers
- Adrenergic receptor
  - G-coupled
  - α type– general
    with
  - β typ

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://s3.amazonaws.com/classconnection/769/flashcards/5928769/png/screen_shot_2014-11-04_at_92935_am-1497B7358A4552ACB39.png0

Vasoconstriction

Glucose metabolism

Increased HRV and contractility

Bronchodilation

Lipid metabolism

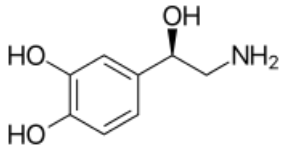
Smooth muscle contraction

Inhibition of transmitter release

Smooth muscle contraction

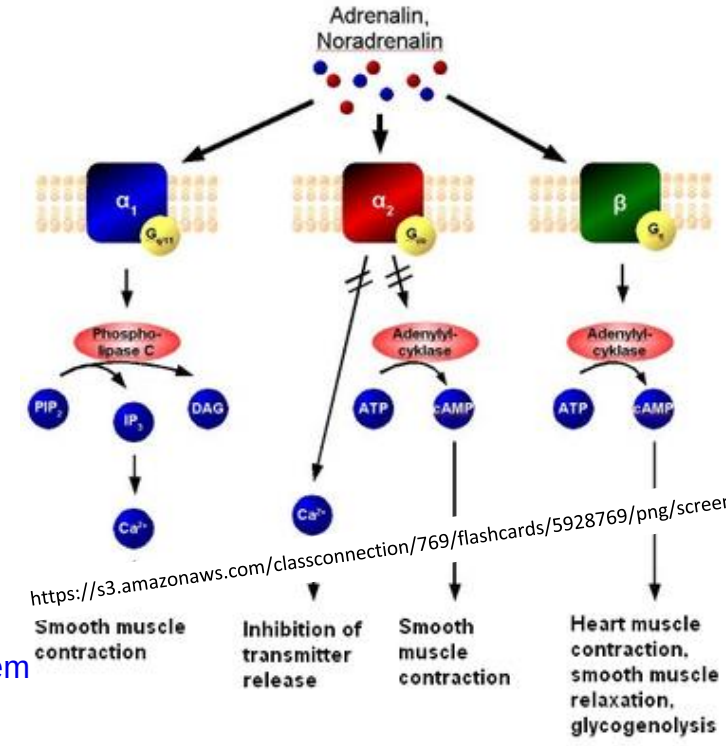
Heart muscle contraction, smooth muscle relaxation, glycogenolysis

MUNI MED



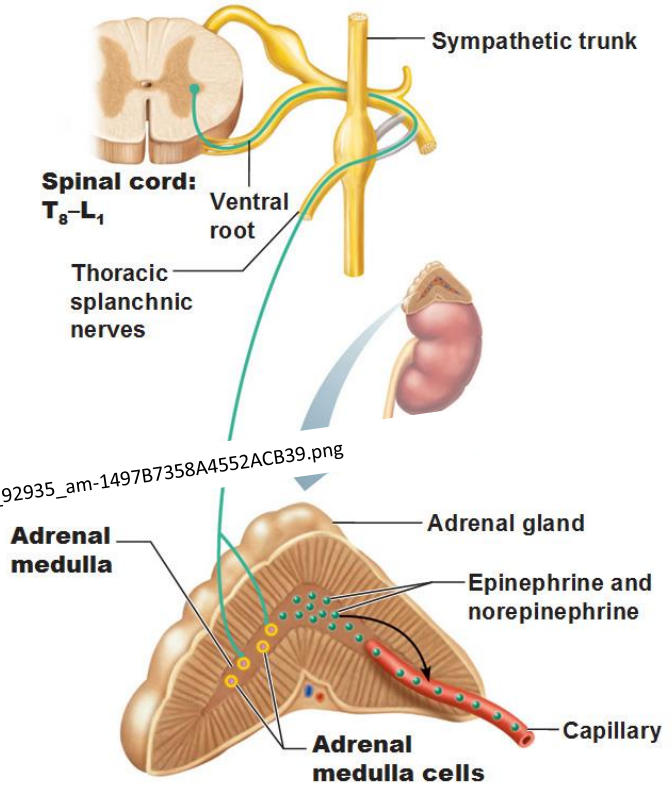
Norepinephrine

- 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

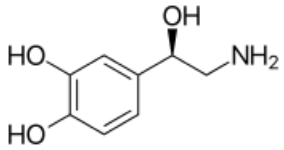
- Adrenal medulla
  - Modified sympathetic ganglion
  - „Transmitters“ (stress hormones) secreted into the blood stream
    - Norepinephrine
    - Epinephrine



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

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

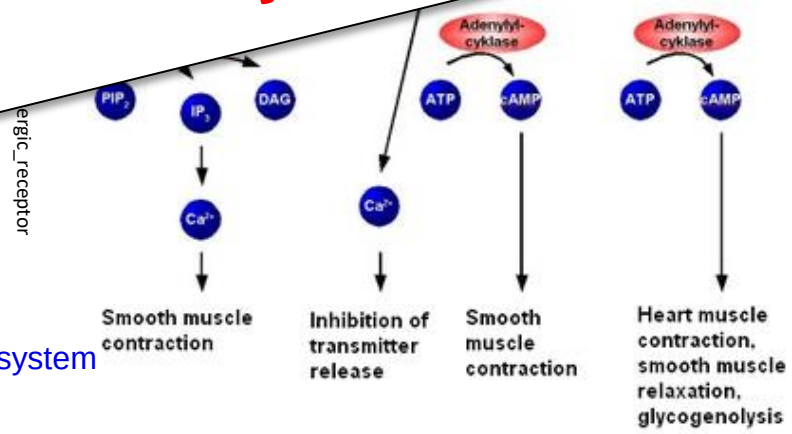
MUNI MED

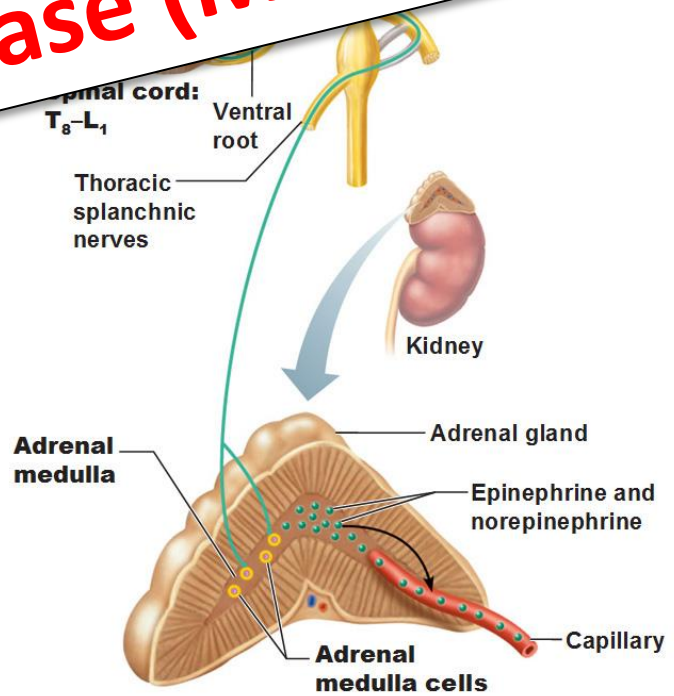


Norepinephrine

- Postganglionic sympathetic fibers
- Adrenergic receptor
  - G-coupled
  - α type– generally excitatory (contracti
    with an exception of GIT
  - β type – ge
- Adrenal medulla
  - Modified s

Termination of synaptic transmission
Catechol – O - methyltransferase(COMT)
Monoamine oxidase (MAO)

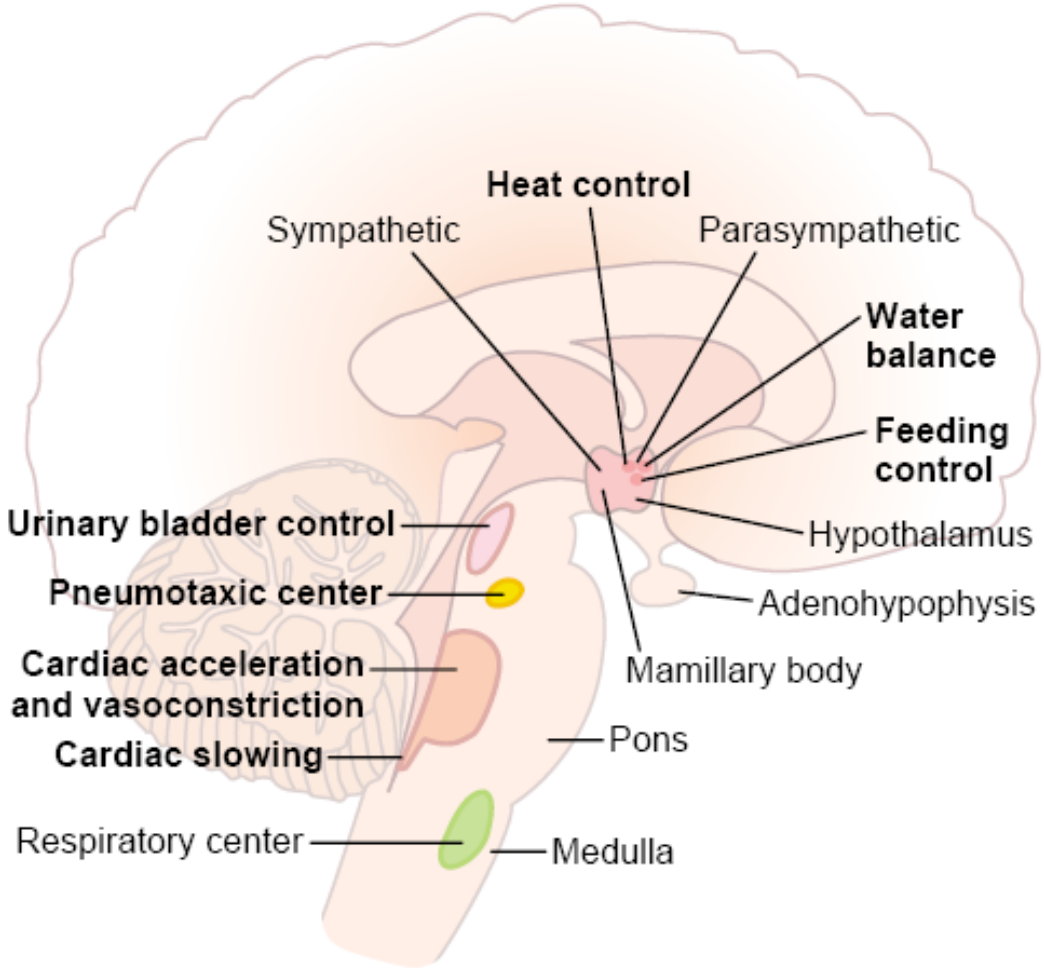




http://antranik.org/wp-content/uploads/2011/11/the-adrenal-medulla-of-the-adrenal-gland-epinephrine-norepinephrine-splanchic-nerves.jpg

MUNI MED

Brain centers controling autonomic nervous system

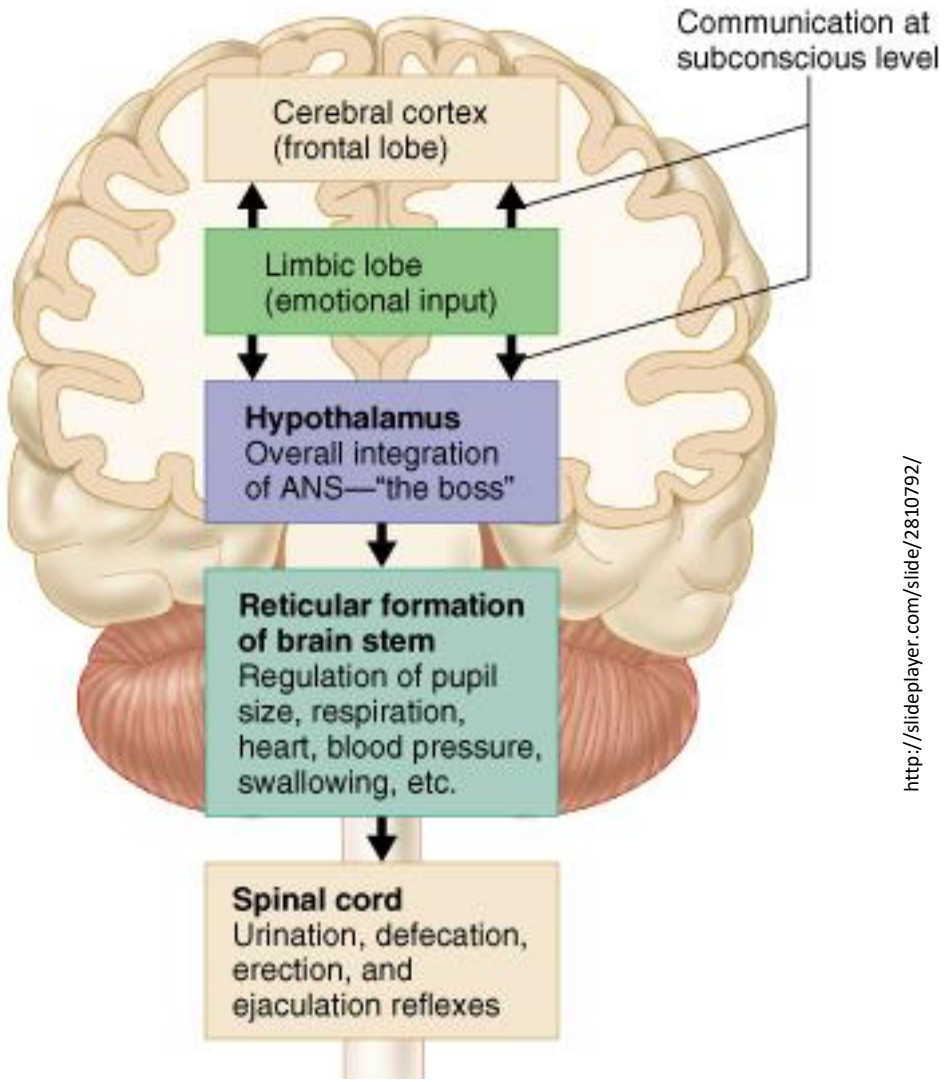


http://www.slideshare.net/drpsdeb/presentations

MUNI MED

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/

MUNI MED

Hypothalamus

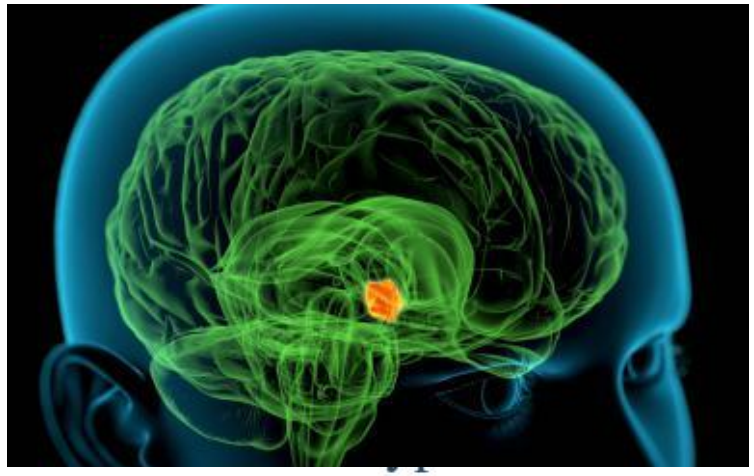
- Key center of autonomic regulations and coordination
- Integration of the information from inner and outer environment

↓

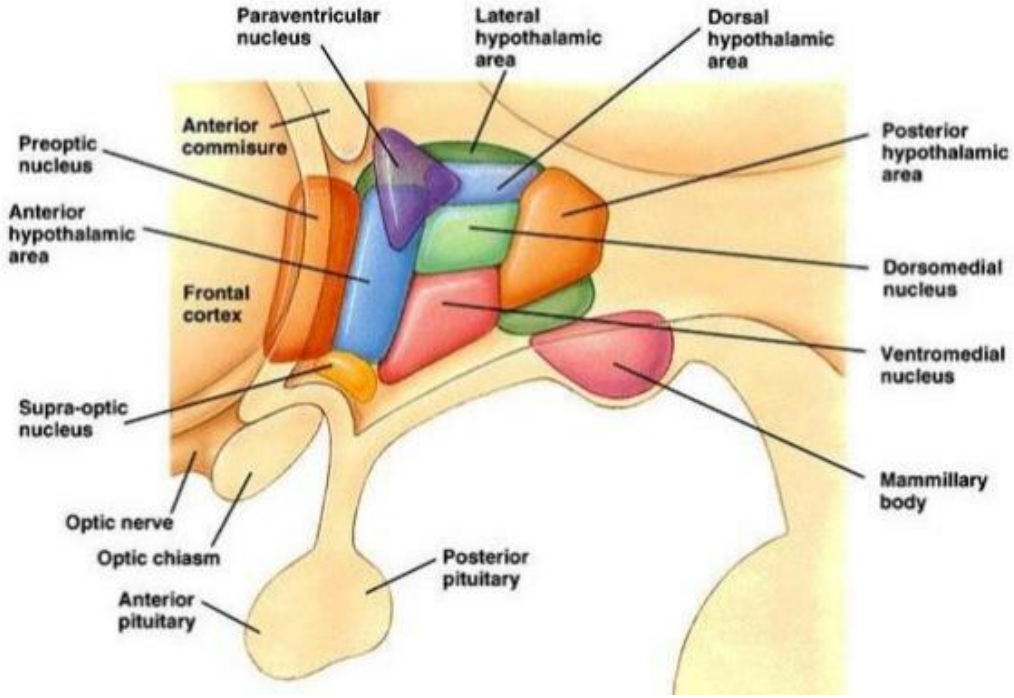
- Behavioral modulation
- Regulation of autonomic nervous system

↓

- **Maintenance of homeostasis**



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



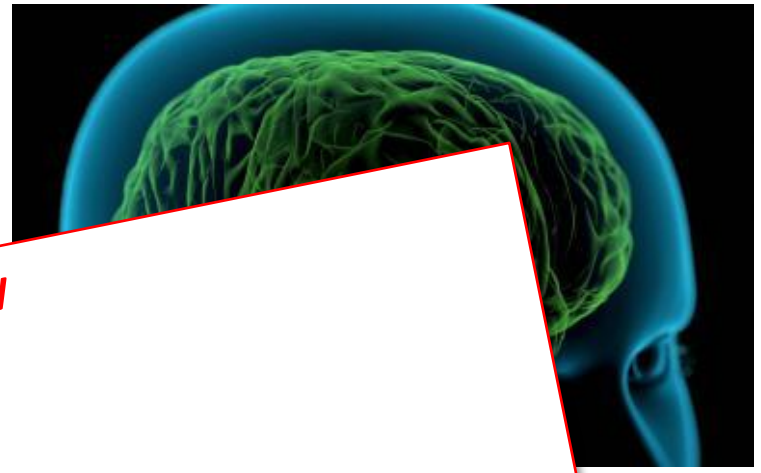
http://www.slideshare.net/physiologymgmcri/hypothalamus-15-apr-2016

MUNI MED

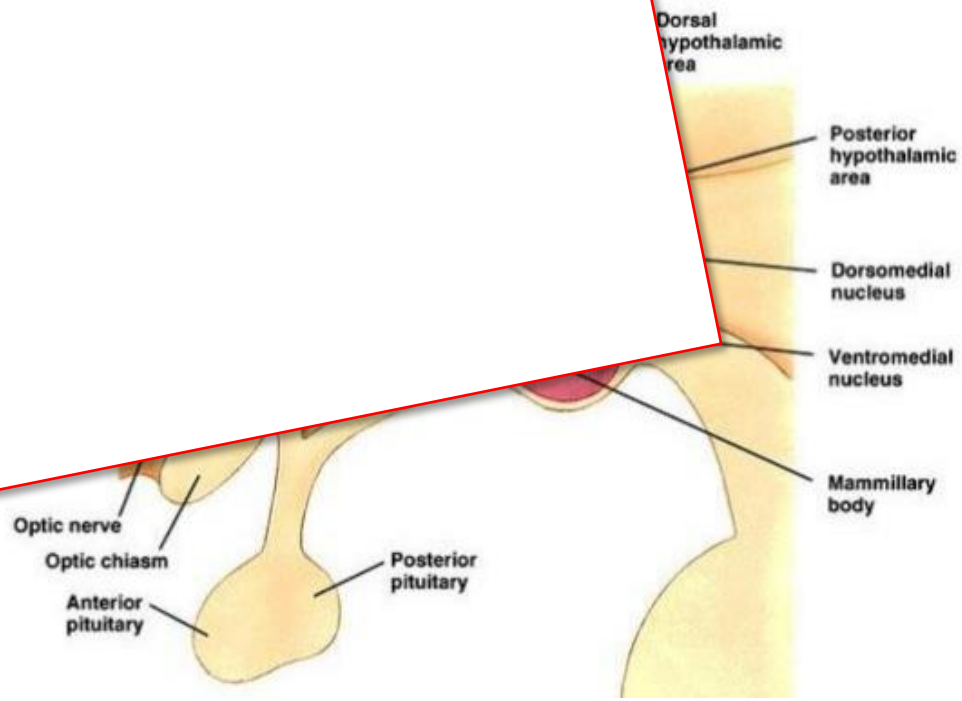
Hypothalamus

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

✓Biological clock – circadian /seasonal activity



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



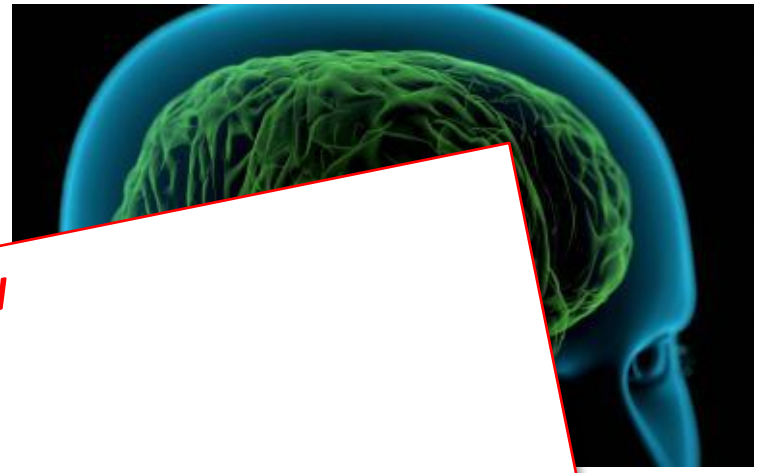
http://www.slideshare.net/physiologymgmcri/hypothalamus-15-apr-2016

MUNI MED

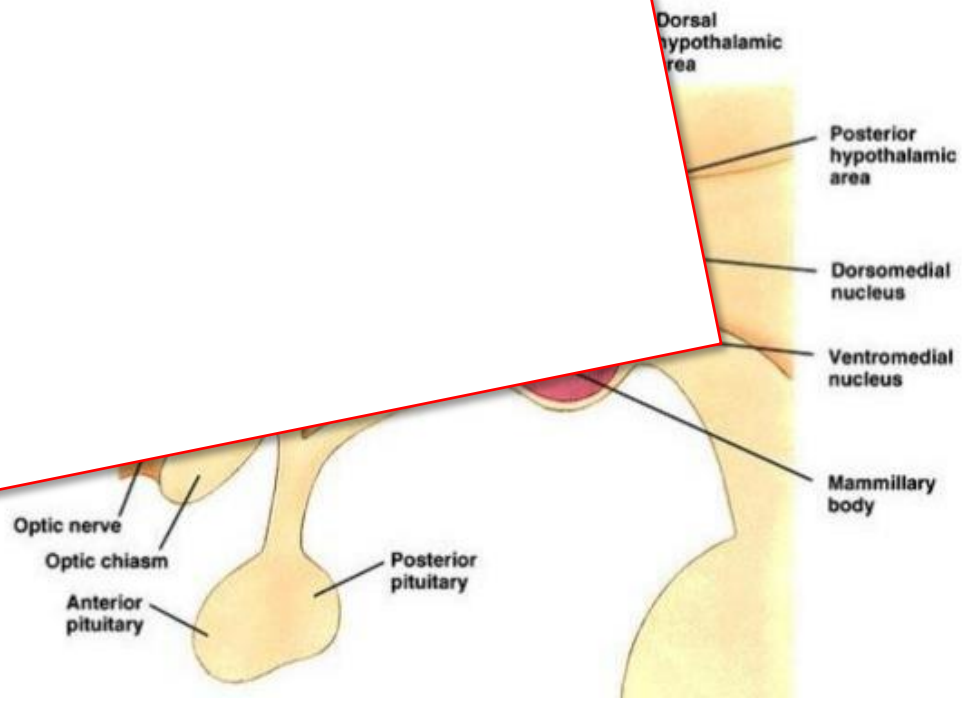
Hypothalamus

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

✓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

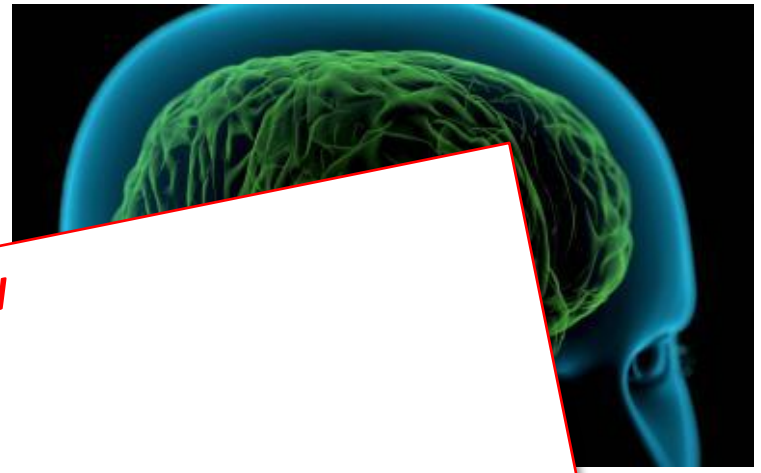


http://www.slideshare.net/physiologymgmcri/hypothalamus-15-apr-2016

MUNI MED

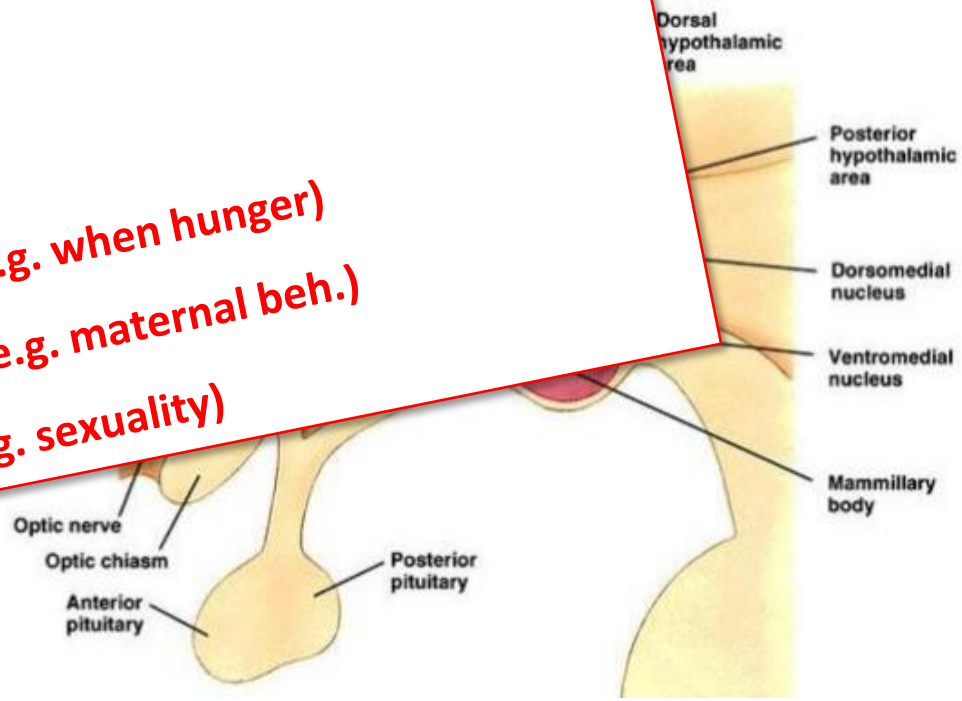
Hypothalamus

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



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

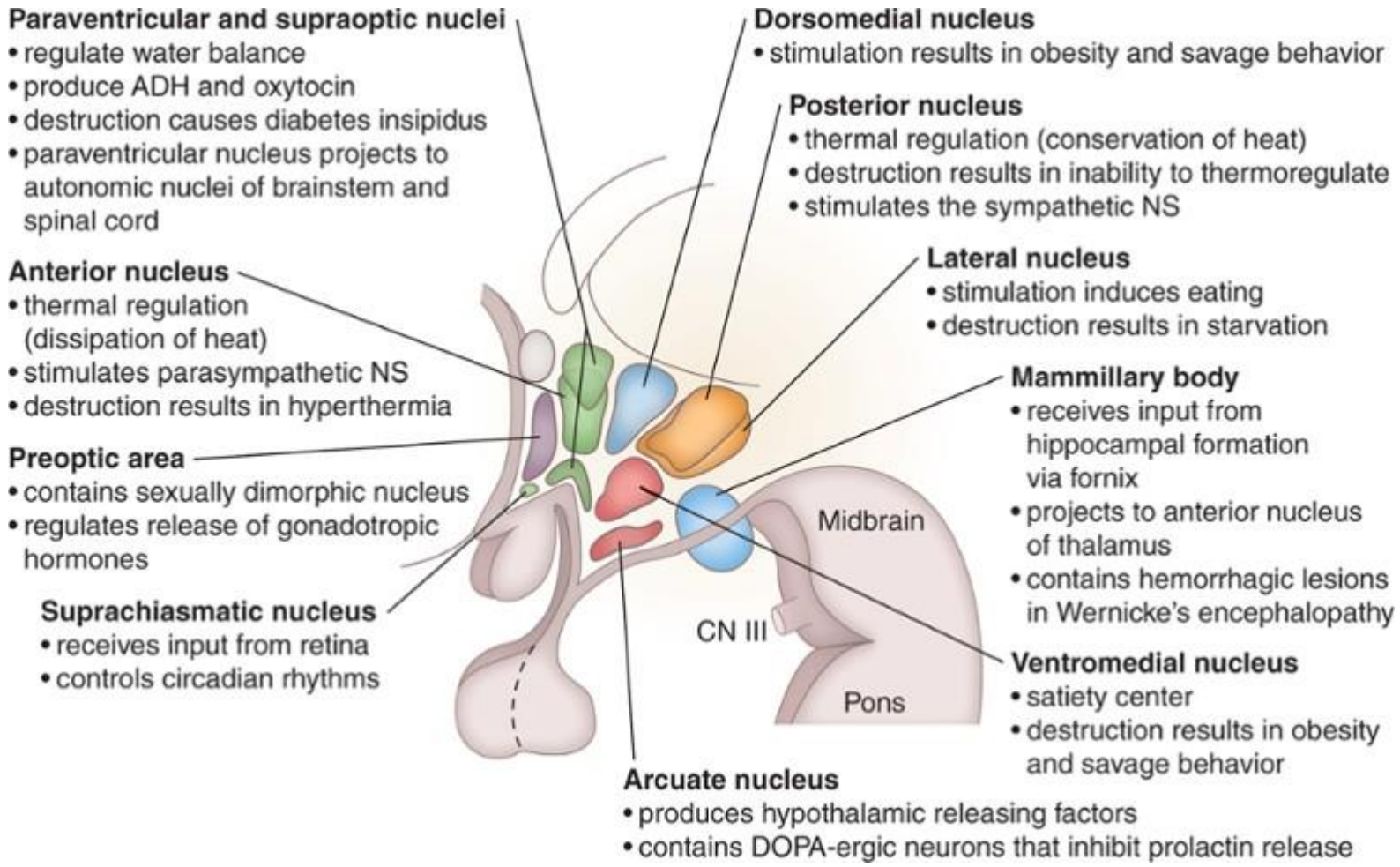
- ✓Biological clock – circadian /seasonal activity
- ✓Autonomic nervous system regulation
- ✓Endocrine system regulation
- ✓Food and water intake regulation
- ✓Regulation of body temperature
- ✓„Immediate“ behavior regulation (e.g. when hunger)
- ✓ „Long-term“ behavior regulation (e.g. maternal beh.)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



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

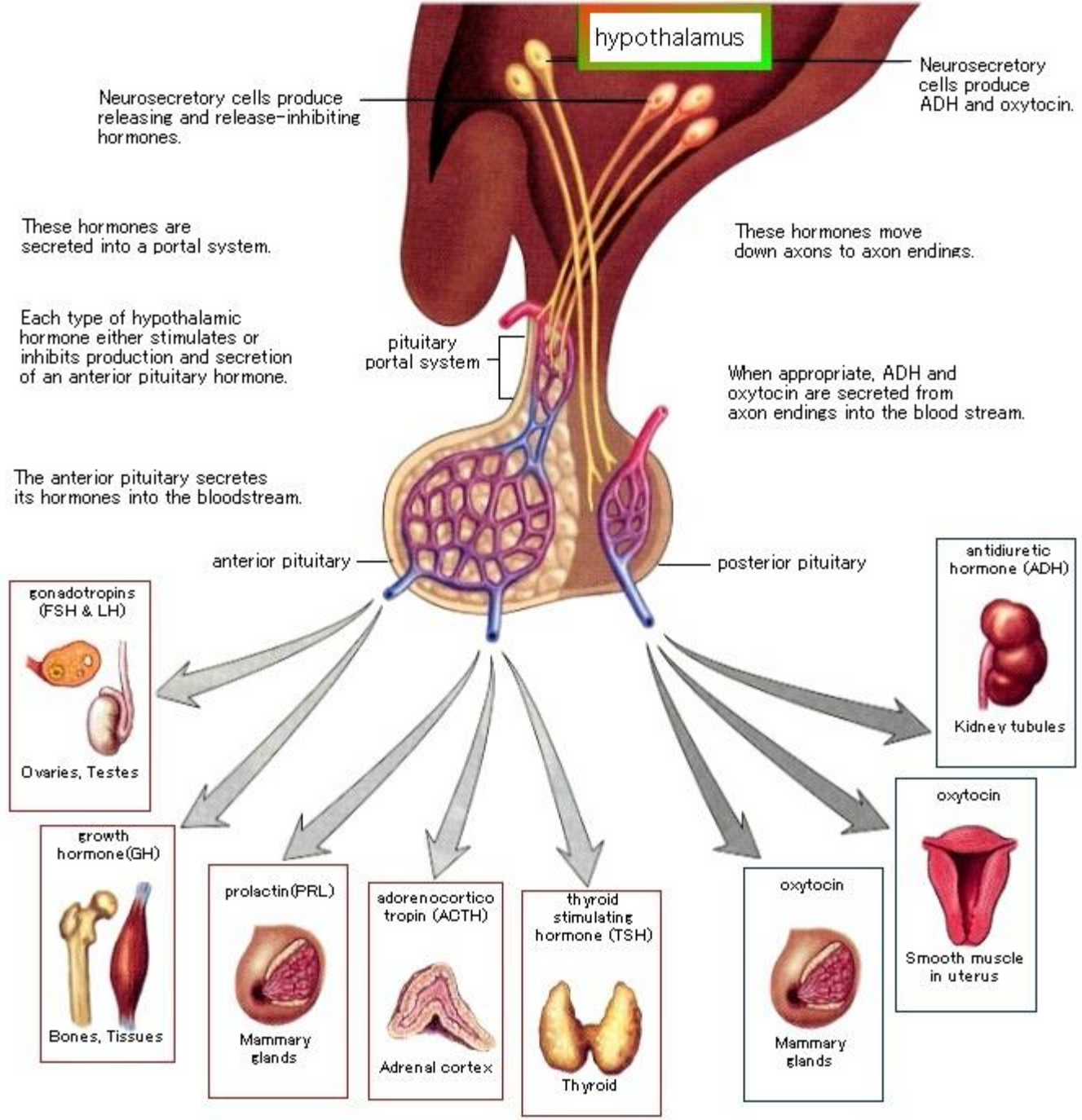
MUNI MED

Hypothalamus



https://d26zfesik67yjk.cloudfront.net/361c35841d554b30a85962e9a342c8a9/c7af8f76e1dd465ba5b886ad34a65c20/e21bfc6faf2b4e4c82dd247369a7f260/40cbc004f494419eab4552fbc298e645.jpg?Policy=eyJTdGF0ZW1lbnQiOiBbeyJSZXNvdXJjZSI6ICJodHRwczovL2QyNnpmZXNpazY3eWprLmNsb3VkZnJvbnQubmV0LzM2MWMzNTg0MWQ1NTRiMzBhODU5NjJlOWEzNDJjOGE5L2M3YWY4Zjc2ZTFkZDQ2NWJhNWI4ODZhZDM0YTY1YzIwLyoiLCAiQ29uZGl0aW9uIjogeyJEYXRlTGVzc1RoYW4iOiB7IkFXUzpFcG9jaFRpbWUiOiAxNTc3ODY1NjAwfX19XX0_&Signature=OOebw4KROVFSKJaiJxCjFmaoIrqY0gYGE--PMkJbJ5cdHF-twpl3a-1J~Ltufp4SQQI3~LyWEmkxqMhfq-WV-D3Z-y~yb-TDc~BWTFnf77cAbQdAm1CTrPbrHEqfB36ho4B5nZdKO4hit4WiR6kHloxXfZk69QrdJt5ulGuPrbbimAHLwGW-qRsx4bsW2nj41kxIN7Zd6MS8DIe7~-XMAPsuQ1UkmYlawBBEz~75vs4Q6cylCLePT3B2e8qBpVR8y54h9gY63Uw4iohFPk2mmoa~FAWmc6yfPZU9kK~u7cq~39~uJElYXKC8W5Vy2IsDGeBtJfkAg3qWYdV9N2bXiA__&Key-Pair-Id=APKAJY4Y3HIBJJ7SJ76A

MUNI MED

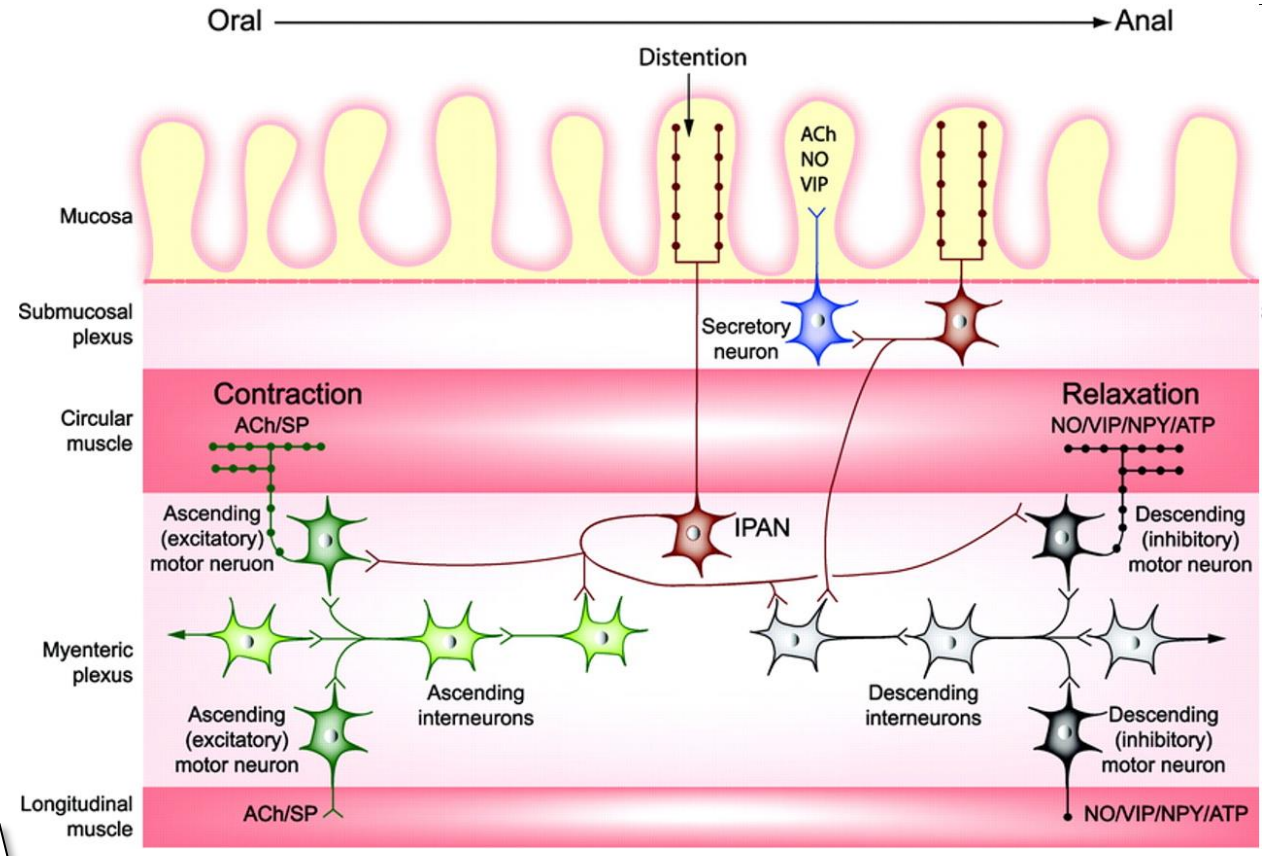


https://s-media-cache-ak0.pinimg.com/originals/5a/0a/78/5a0a78d64a682fcf9c5eb3b10d37a2a1.jpg

MUNI MED

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“



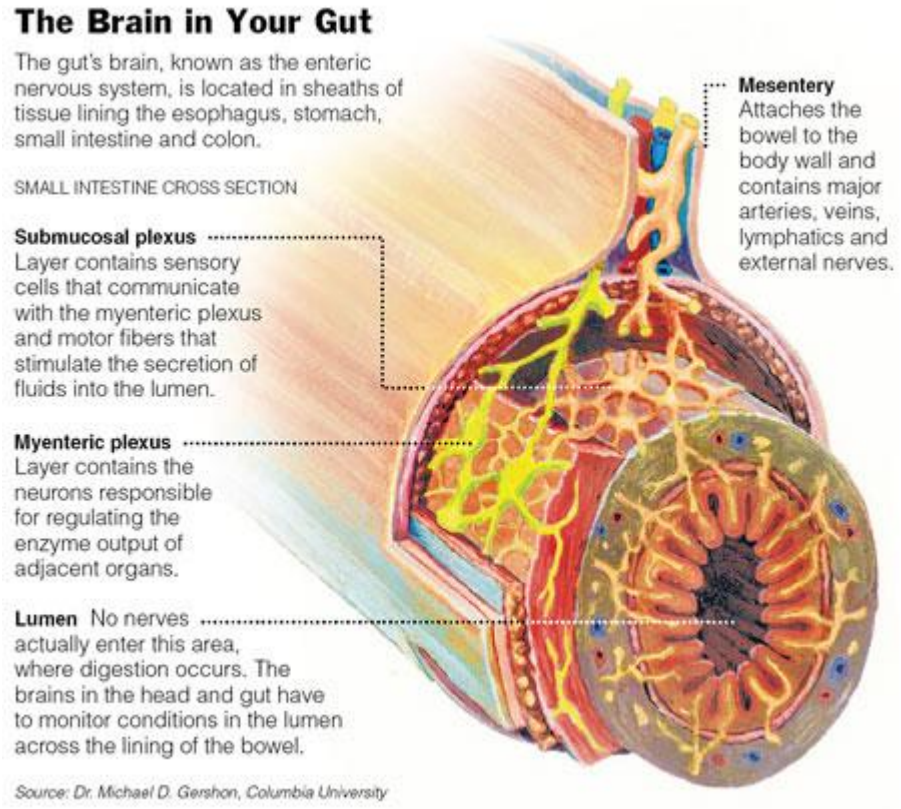
http://www.slideshare.net/carmencrivii/central-nervous-system-the-autonomic-nervous-system?qid=d1502190-93fe-4b05-9d92-6a42e3ca72fc&v=&b=&from_search=8

Microbiome

MUNI MED

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

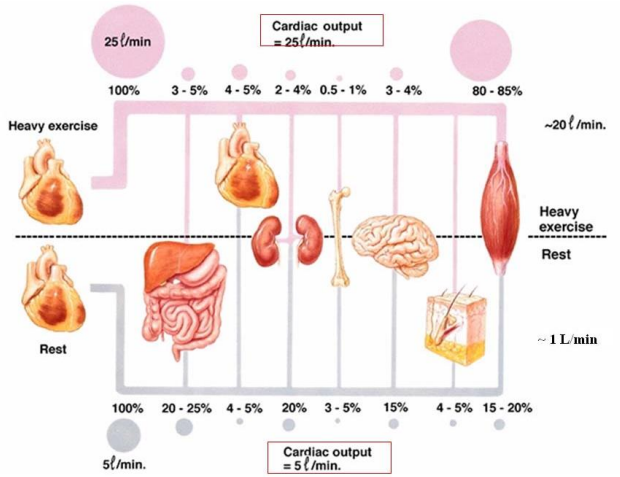


https://kin450-neurophysiology.wikispaces.com/file/view/gut.jpg/187924395/gut.jpg

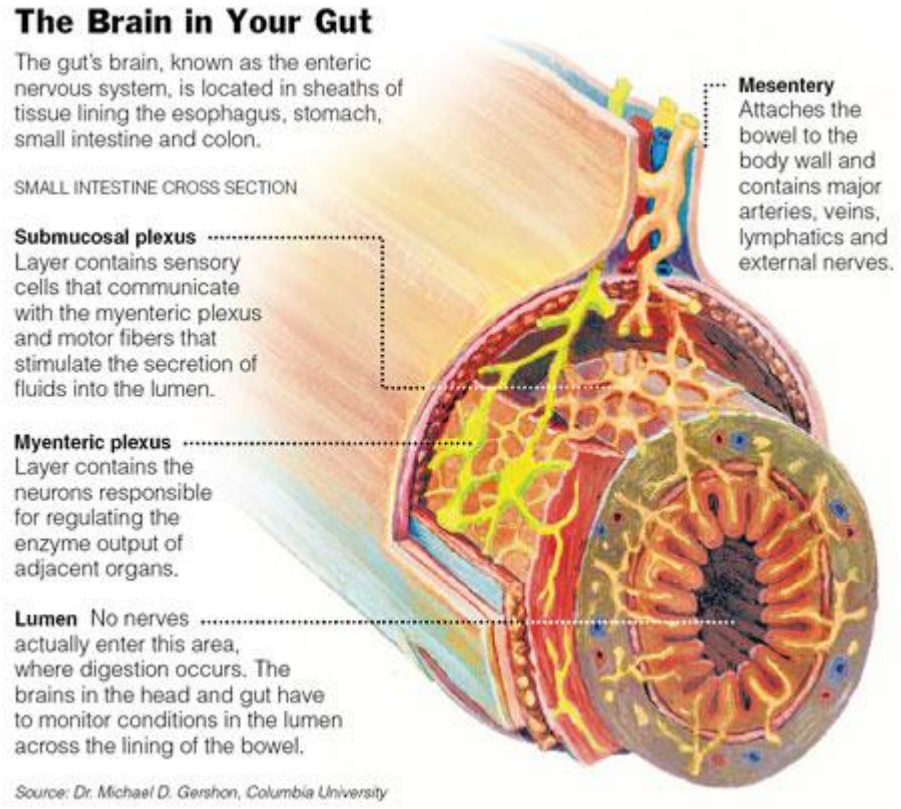
MUNI MED

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



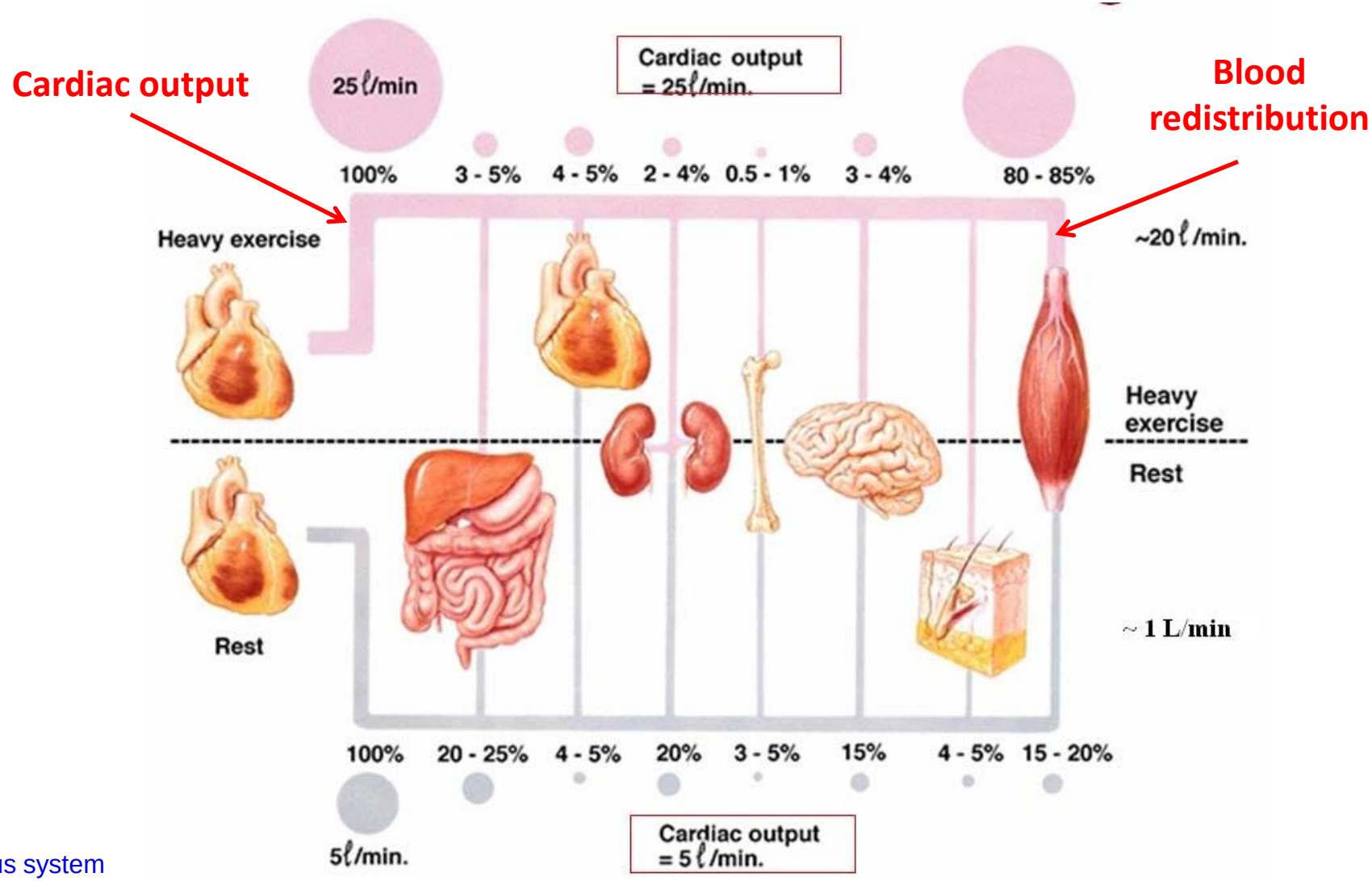
http://2.bp.blogspot.com/_MJ0CEYnSB4U/S99IJTUruOI/AAAAAAAAACs/NPzsh8ydzjQ/s1600/redistributionofbloodflow.jpg



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

MUNI MED

ANS and cardiovascular system

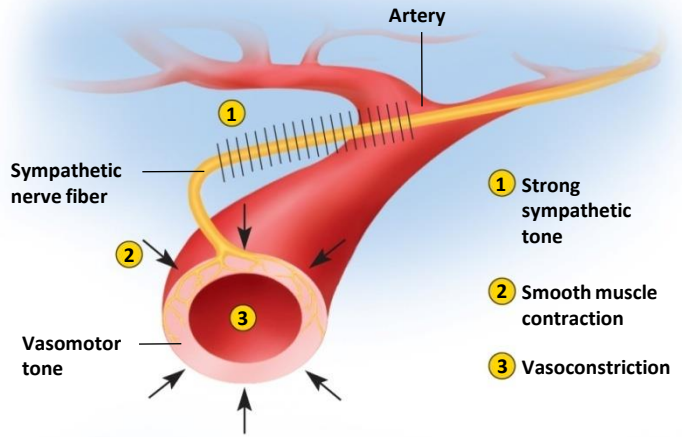


http://2.bp.blogspot.com/_MJ0CEYnSB4U/S99IJTUruOI/AAAAAAAAACs/NPzsh8ydzjQ/s1600/redistributionofbloodflow.jpg

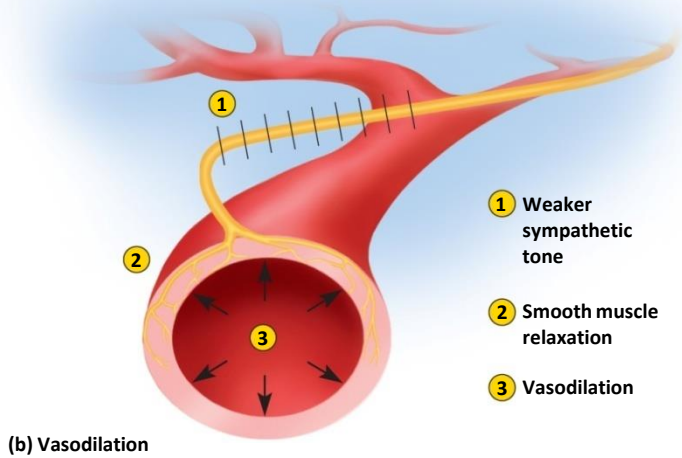
MUNI MED

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



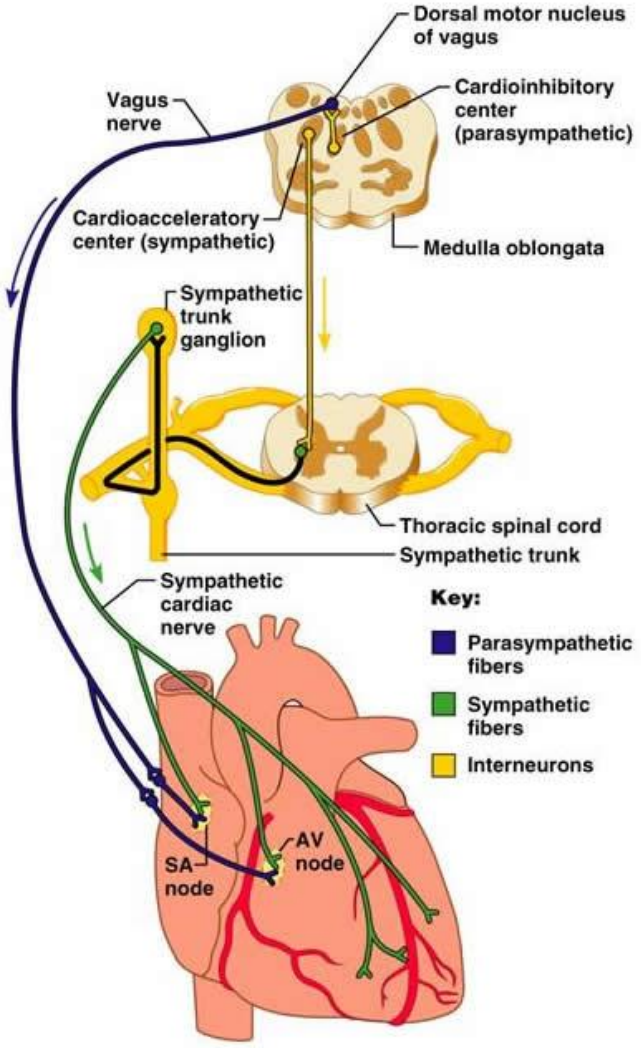
(b) Vasodilation

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

MUNI MED

ANS and cardiovascular system

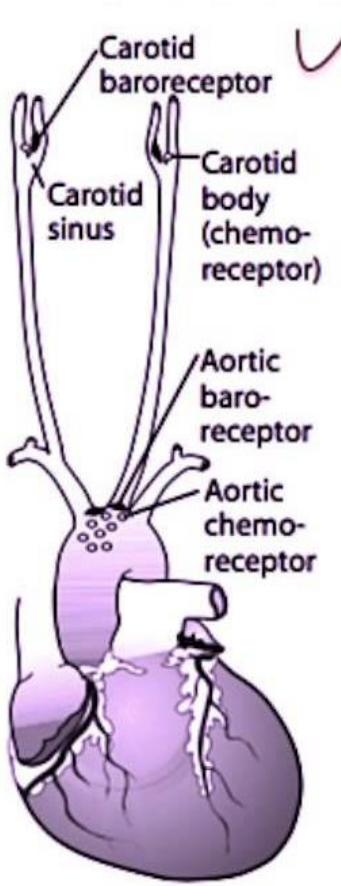
- Sympathetic regulation
  - Heart rate increase
  - Contractility increase
  - Conductivity increase
- Parasympathetic regulation
  - Heart rate decrease
  - Contractility decrease
  - Conductivity decrease



https://medwrite.biz/58603_vagus_nerve_anatomy/

MUNI MED

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.

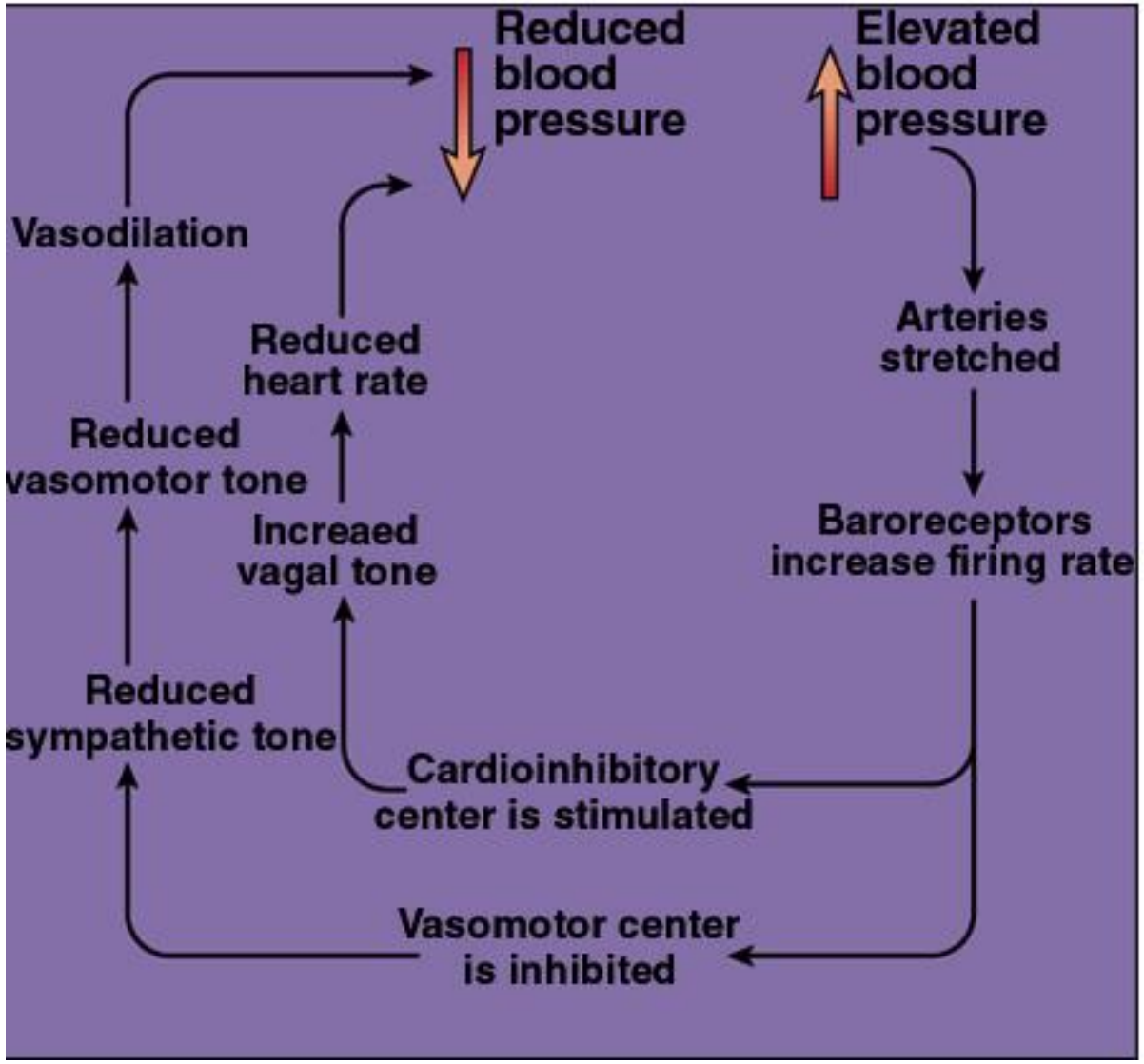
Chemoreceptors:

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

MUNI MED

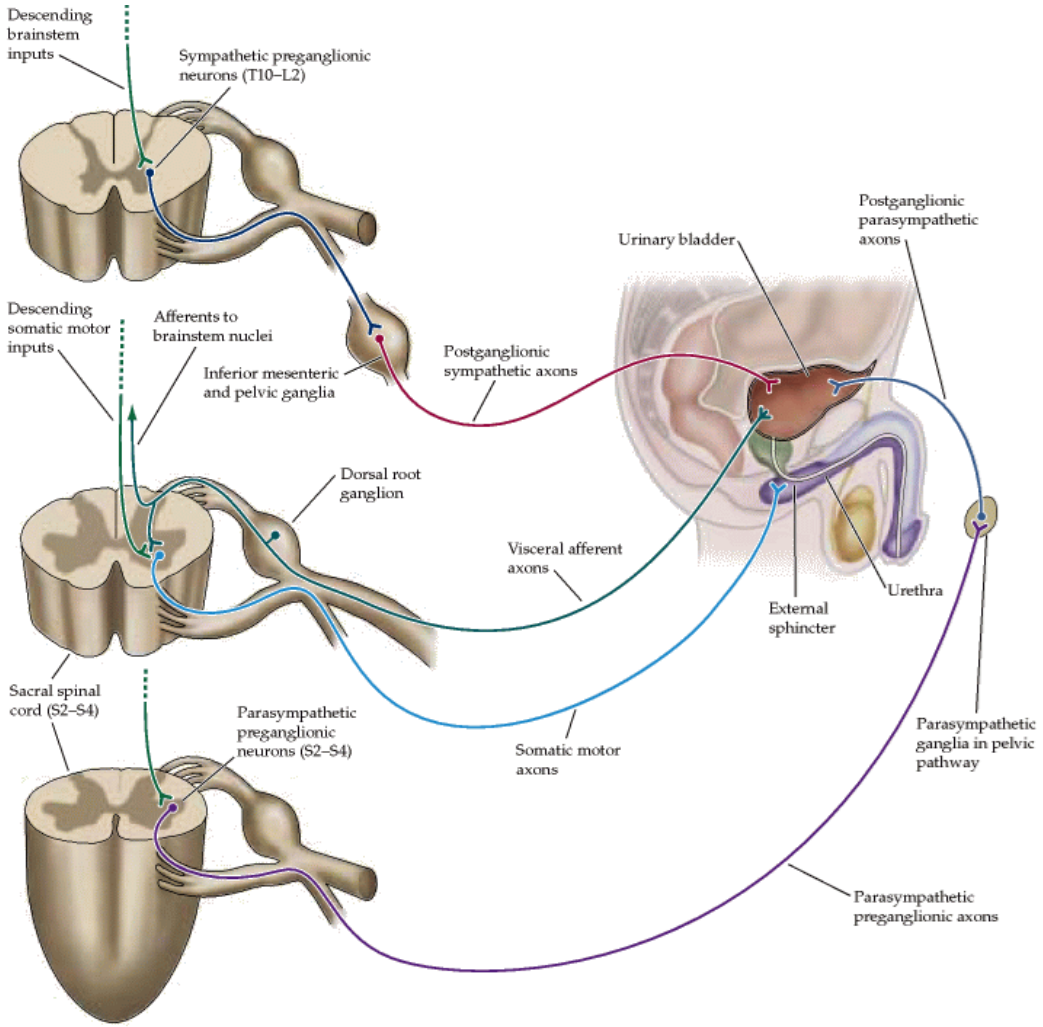
Baroreflex



MUNI MED

ANS and urinary bladder

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

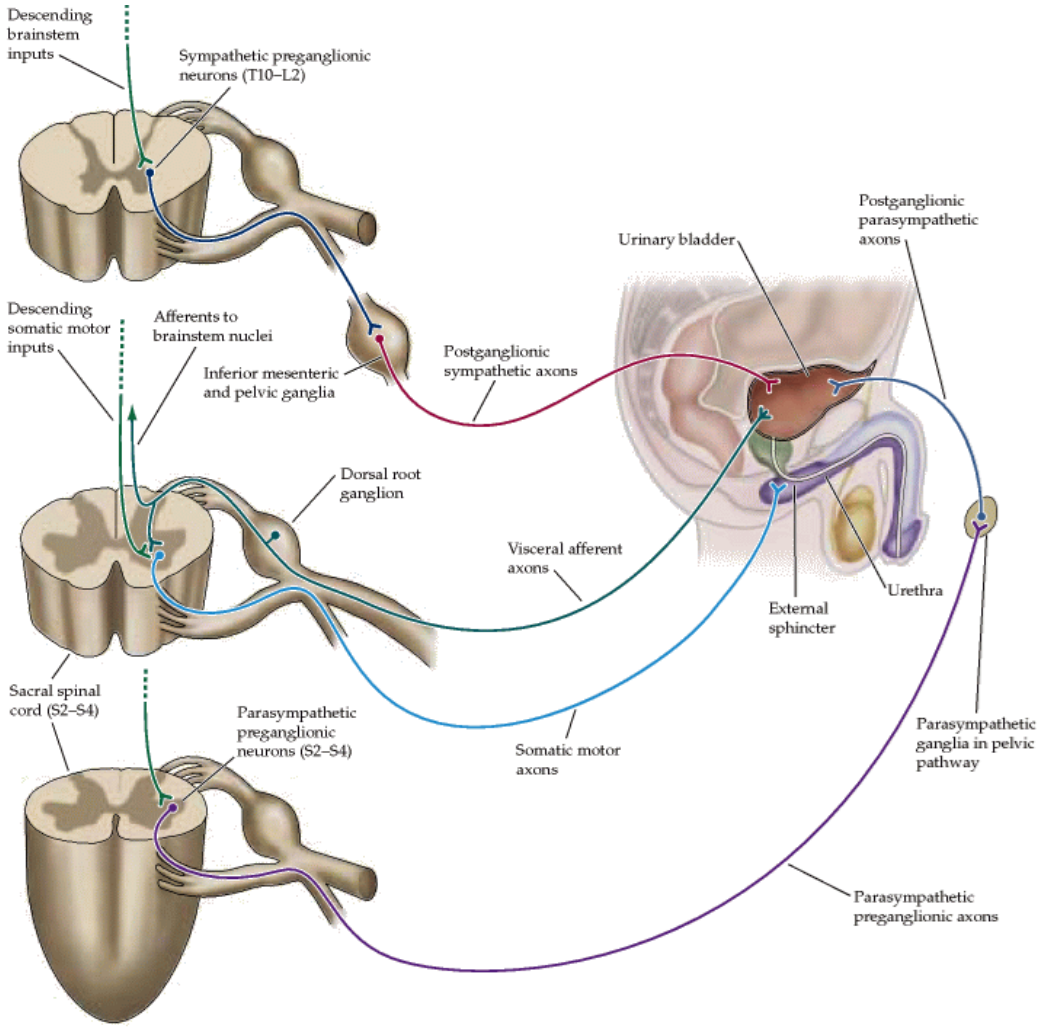


http://www.slideshare.net/drpsdeb/presentations

MUNI MED

ANS and male reproductive system

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



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

MUNI MED

ANS and female reproductive system

Very complicated.....

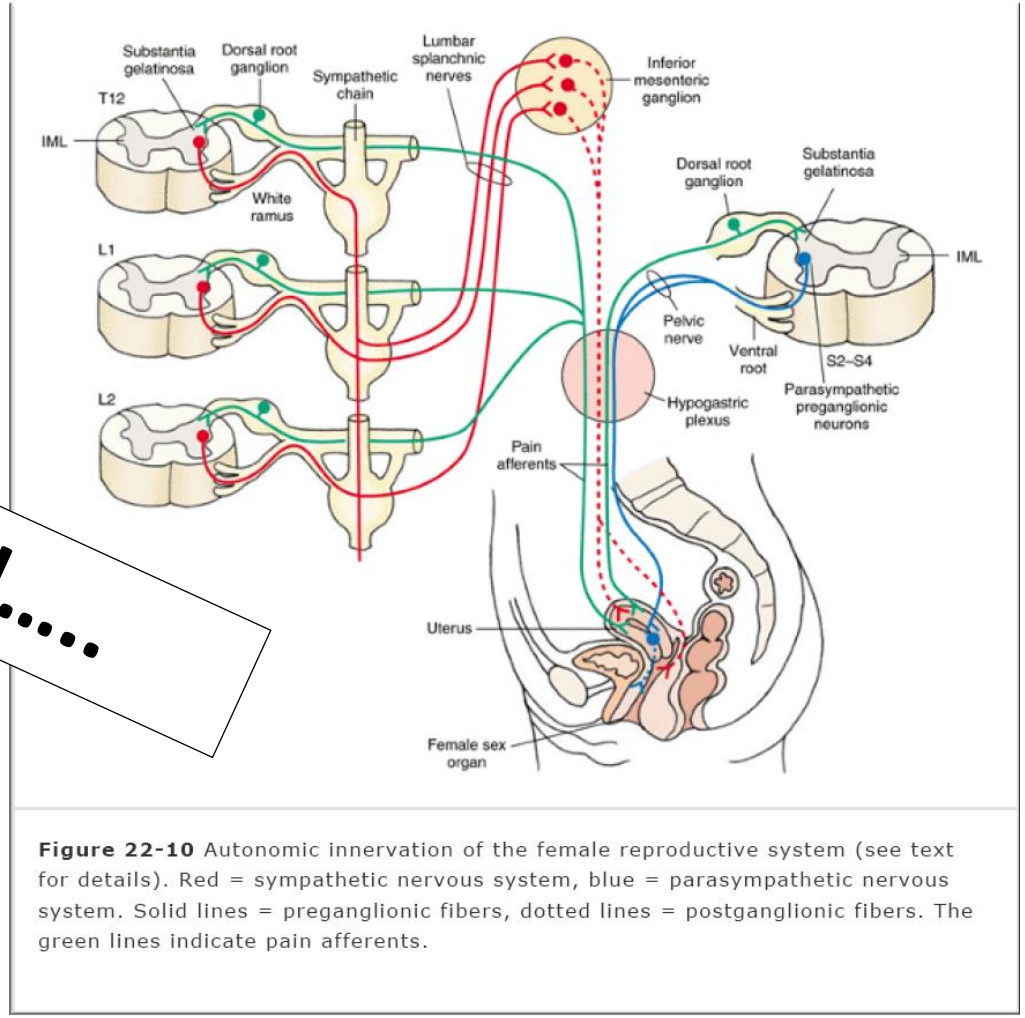


Figure 22-10 Autonomic innervation of the female reproductive system (see text for details). Red = sympathetic nervous system, blue = parasympathetic nervous system. Solid lines = preganglionic fibers, dotted lines = postganglionic fibers. The green lines indicate pain afferents.

MUNI MED

MUNI
MED

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

MUNI
MED