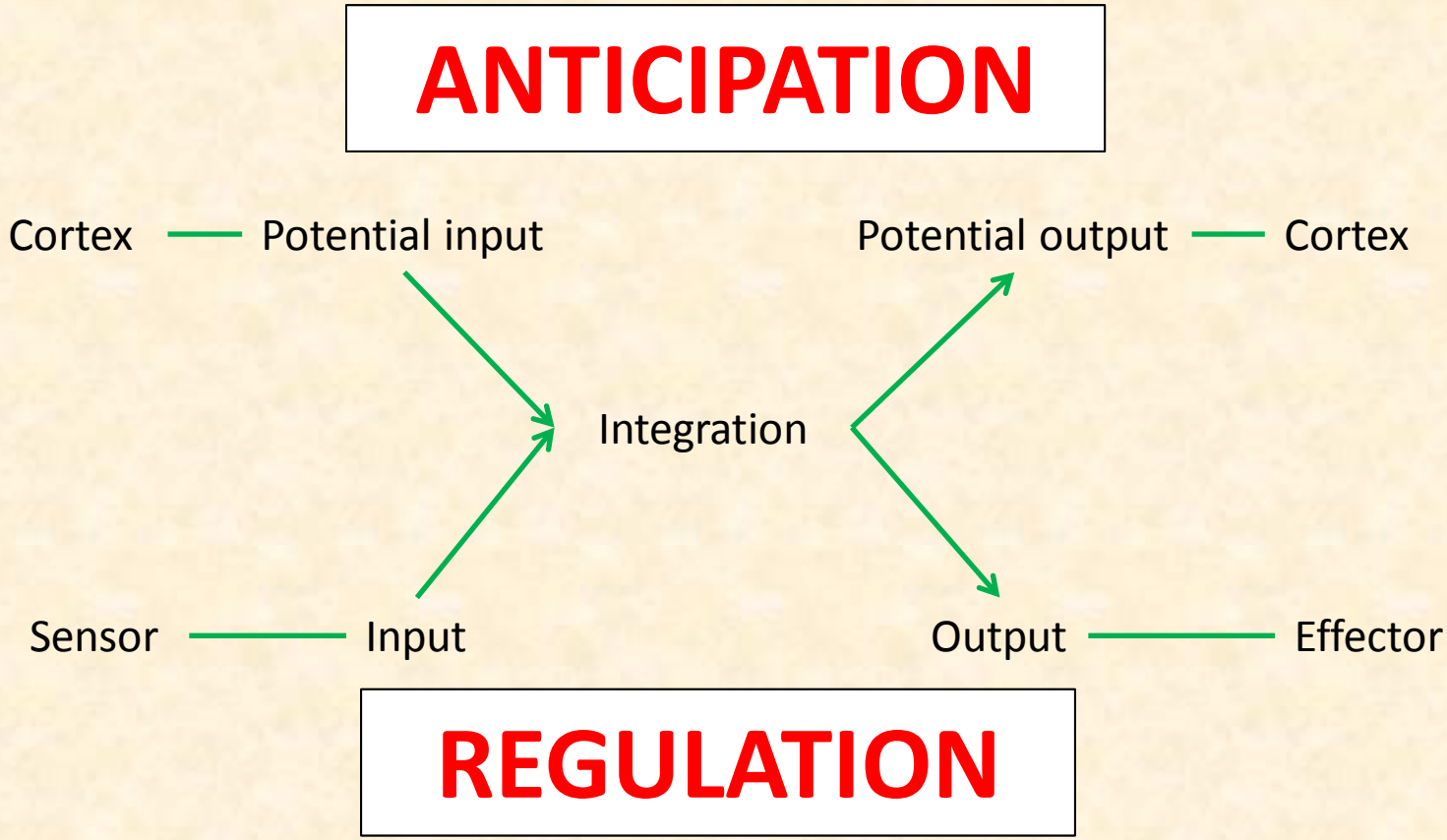
# Regulation

# in cardiovascular system

# The role of nervous system



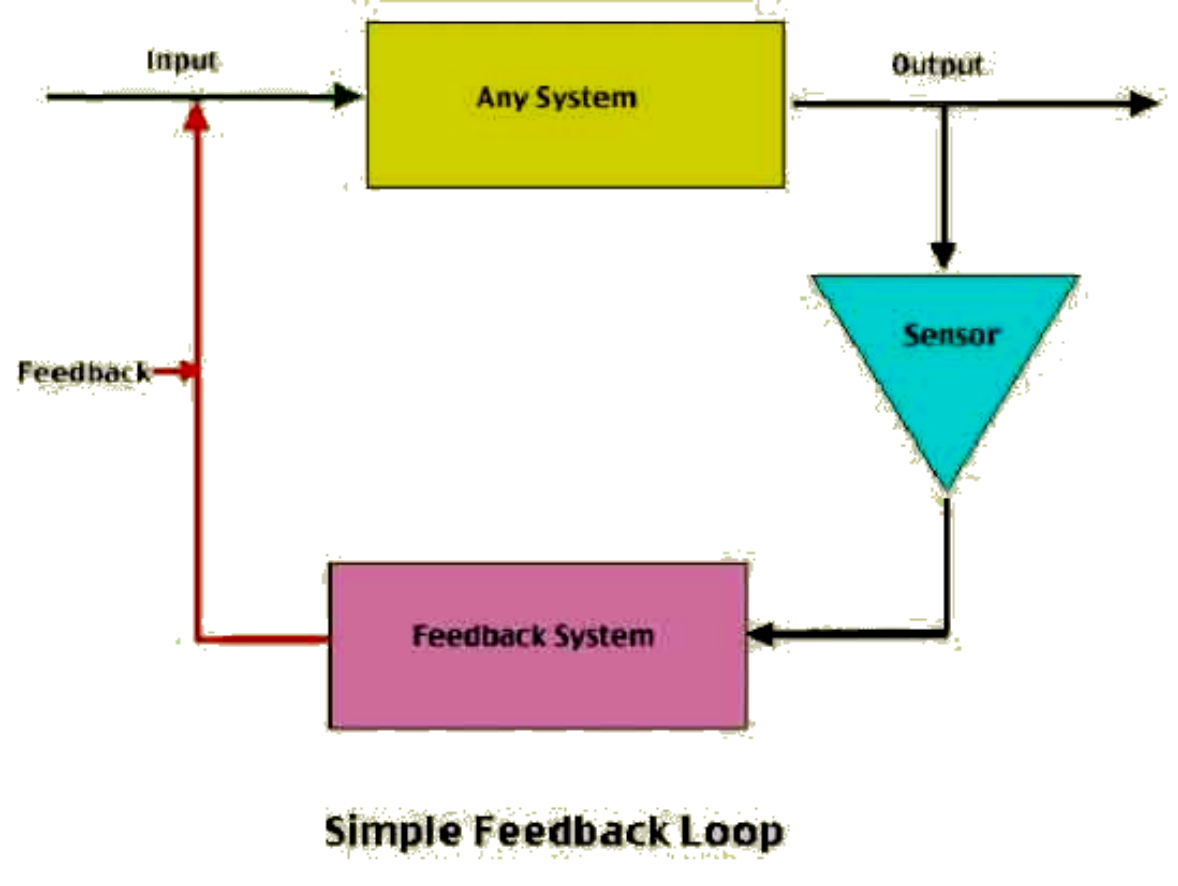
# Types of regulation - general view

2 basic types:

- ✓ Nervous regulation
- ✓ Humoral regulation
  - ✓ Feedback control - negative
  - ✓ - positive

autoregulation – local regulation – system regulation

# Feedback regulation




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

# REGULATION IN CARDIOVASCULAR SYSTEM

Main function:

- keep relatively constantaneous arterial blood pressure
- Keep perfusion of tissues

# Regulation of vessels tone

- Tone of the vessels = basic tension of the smooth muscle inside of the wall

  (vasoconstriction x vasodilatation)

- Regulation - local autoregulation

  - system regulation

# Autoregulation

Autoregulation – the capacity of tissues to regulate their own blood flow

**Myogenic theory** – Bayliss phenomenon (as the pressure rises, the blood vessels are distended and the vascular smooth muscle fibres that surround the vessels contract; the wall tension is proportional to the distending pressure times the radius of the vessels – law of Laplace)

# Autoregulation

- **Metabolic theory** – vasodilator substances tend to accumulate in active tissue, and these metabolites also contribute to autoregulation
  - ending products of energetic metabolism – $CO_2$, lactate acid, $K^+$
  - effect of hypoxia (circulation: vasodilatation x pulmonary circulation: vasoconstriction)
  - Adenosin – coronary circulation: vasodilatation

# Autoregulation

- **by substances which releasing from:**
  - endothelium
  - tissues

## Substances secreted by the ENDOTHELIUM

***Vasodilatation:***

Nitric oxide (NO) from endothelial cells
(originally called: EDRF)
Prostacyclin is produced by endothelial cells

Thromboxane A2 promotes platelet aggregation
(important prostacyclin – thromboxan balance)

***Vazoconstriction:***

Endothelins (polypeptids – 21peptides)
three isopeptides: ET 1, ET 2 , ET 3

## Substances secreted by the tissues:

**Histamine – primarily tissue hormones**.

General affect: vasodilatation - decrease periphery resistence, blood pressure

**KININS: 2 related vasodilated peptides**

**Bradykinin + lysylbradykinin (kallidin)**.

Sweat glands, salivary glands

10x strongers than histamine

Relaxation of smooth muscle, decrease blood pressure

# Systemic regulation

**By hormones**

Catecholamines – epinephrine, norepinephrine - effect as activation of sympathetic system

RAAS - stress situation

ADH - general vasoconstriction

Natriuretic hormones - vasodilatation

# Neural regulatory mechanism

**Autonomic nervous system**

***Sympathetic: vasoconstriction***

All blood vessels except capillaries and venules contain smooth muscle and receive motor nerve fibers from sympathetic division of ANS (noradrenergic fibers)

- Regulation of tissue blood flow
- Regulation of blood pressure

***Parasympathetic part: vasodilatation***

Only sacral parasympathetic cholinergic fibres (Ach) inervated arteriols from external sex organs

## Sympathetic nervous system

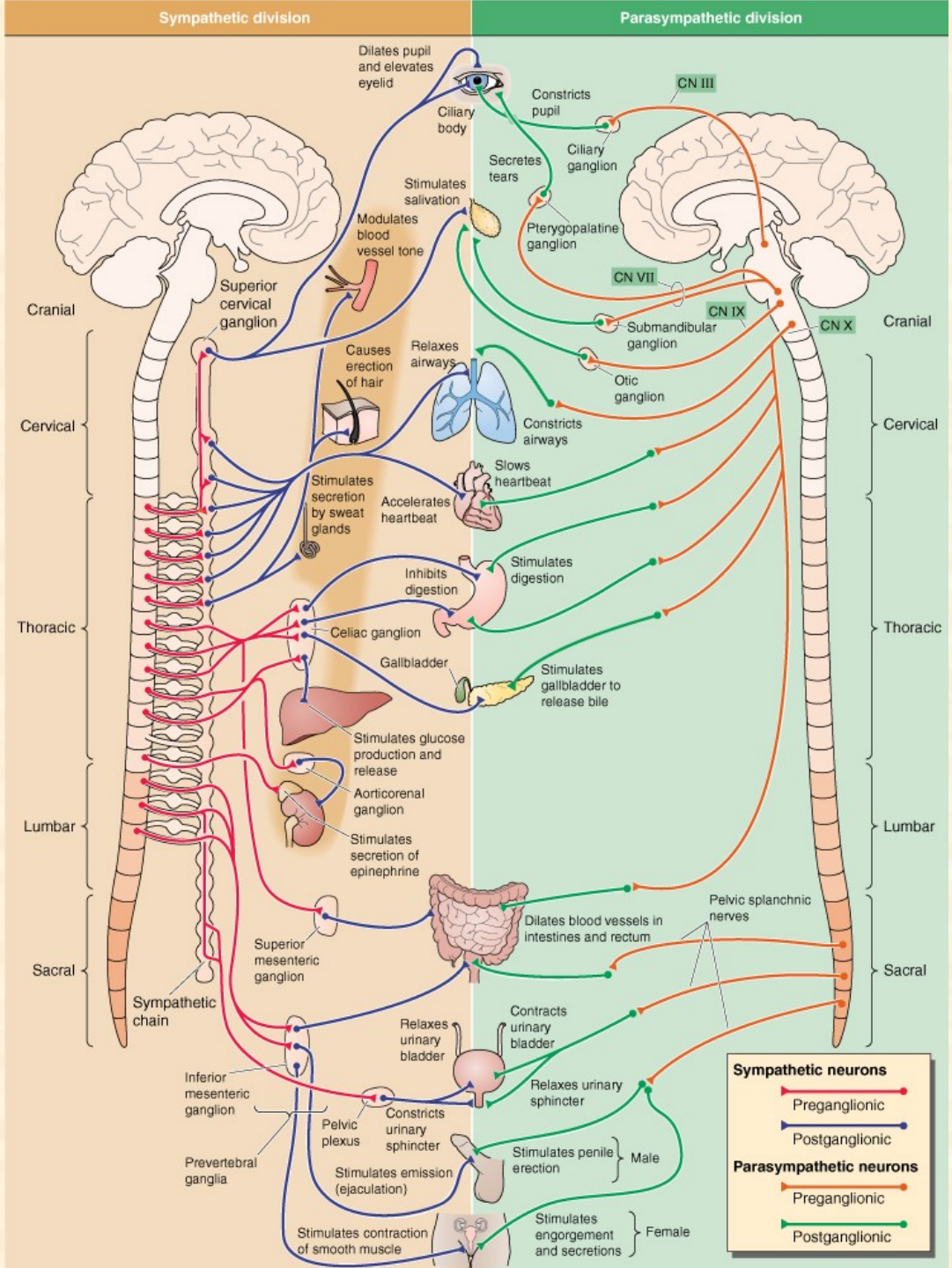
Fight or flight response

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/en. store production

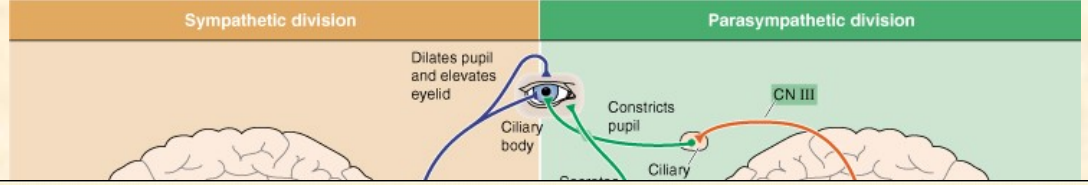
Preganglionic neuron
– Brain stem and spinal cord
– cranio-sacral system

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 |

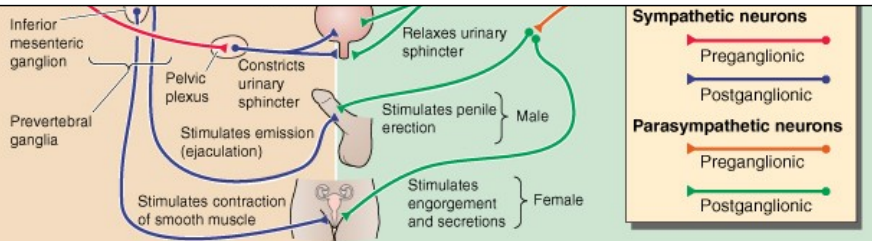
Fight c … digest
resp … se

Energy … y
consu … n/energ
… duction

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

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

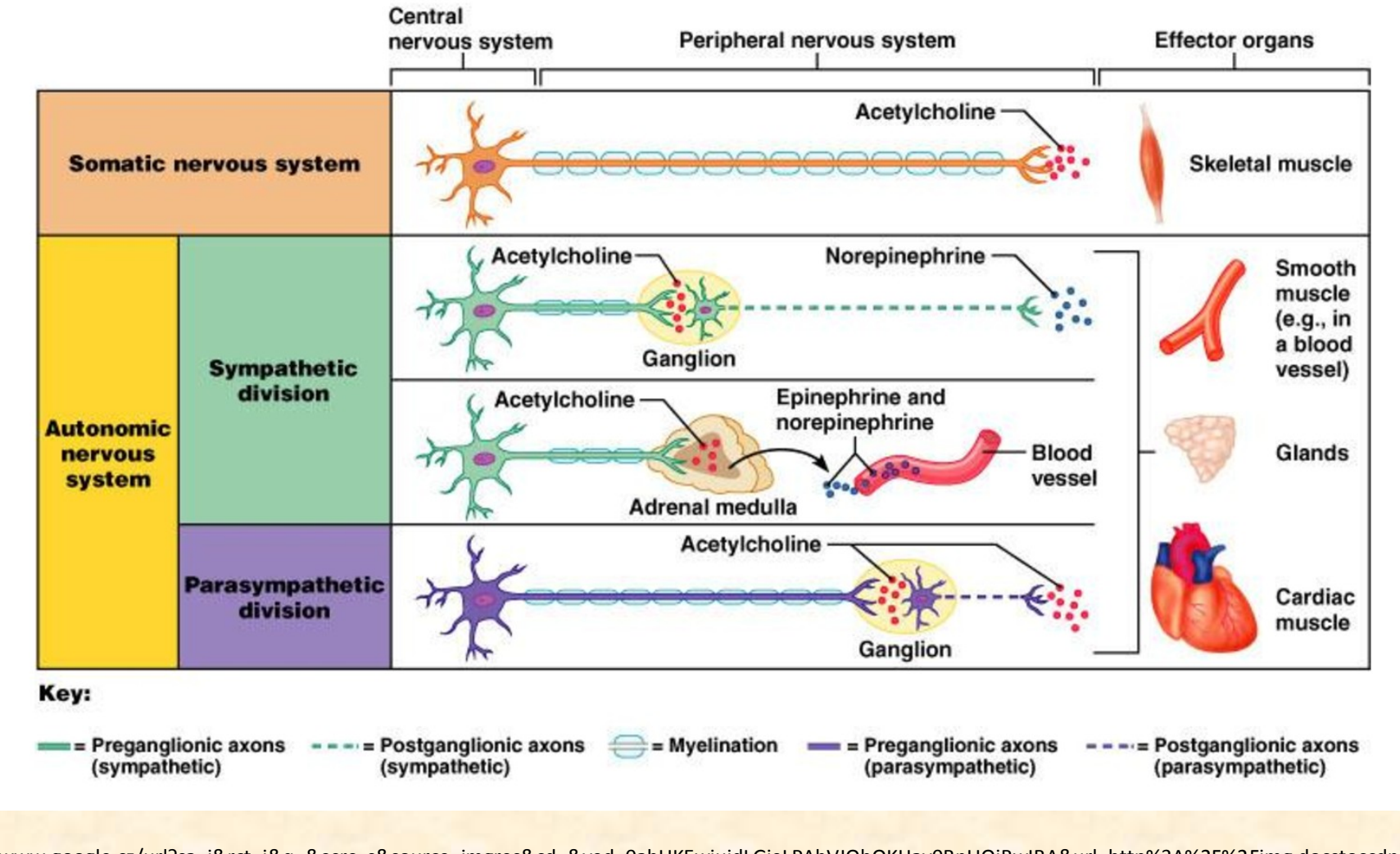
-Plexus aorticus




Mostly diffuse effect

Mostly local effect

# Mediators of somatic and autonomic nervous system

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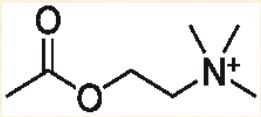
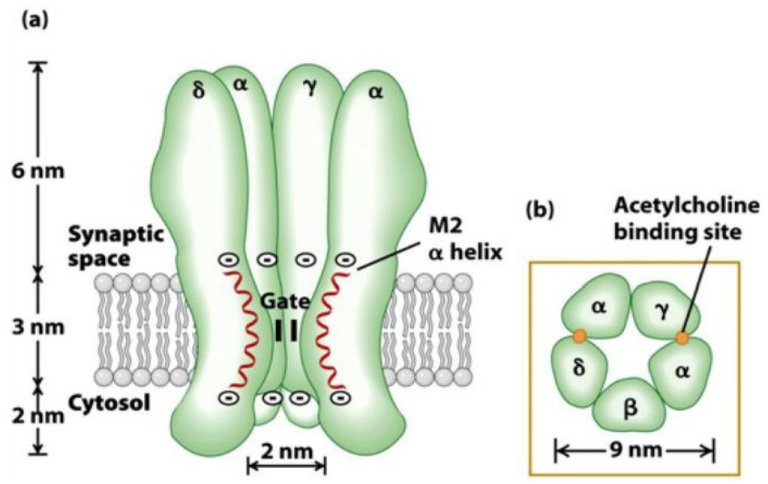


# Acetylcholine

## Preganglionic fibers

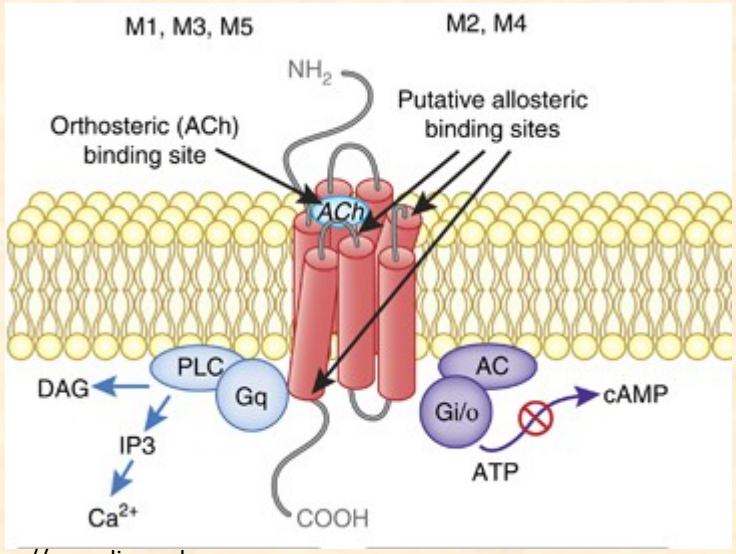
- Sympathetic
- Parasympathetic
- ✓ Nicotinic receptor
  - Ligand-gated ion channels
  - Na+, K+, Ca2+
  - Neuronal ($N_N$) and muscle ($N_M$) type
  - Excitatory




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

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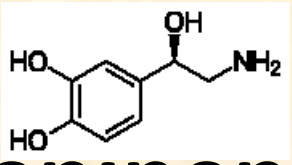
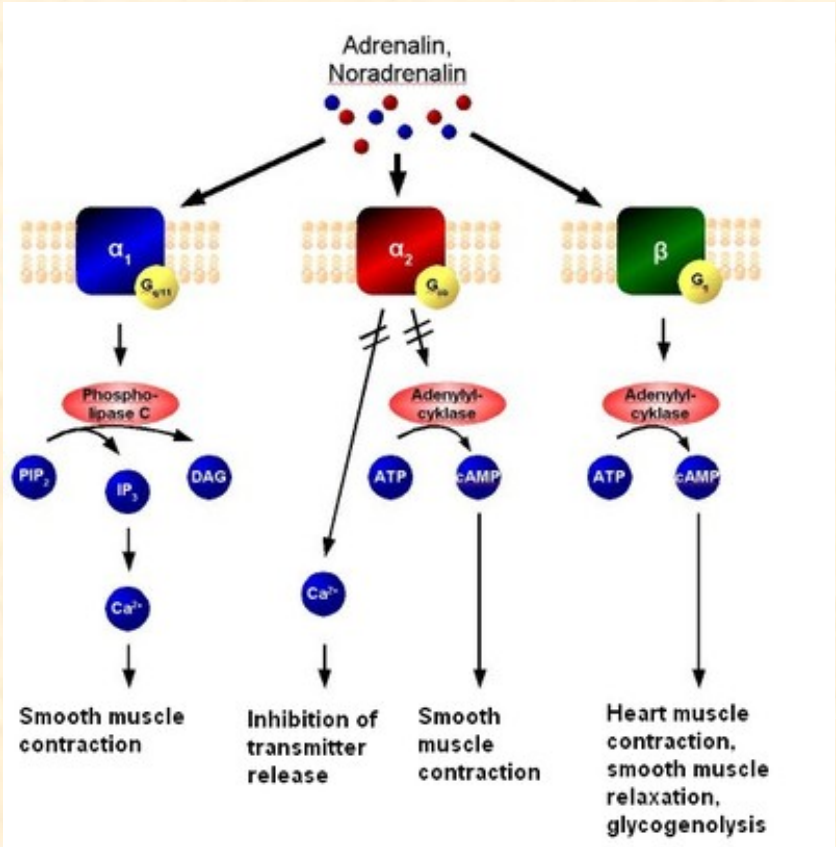


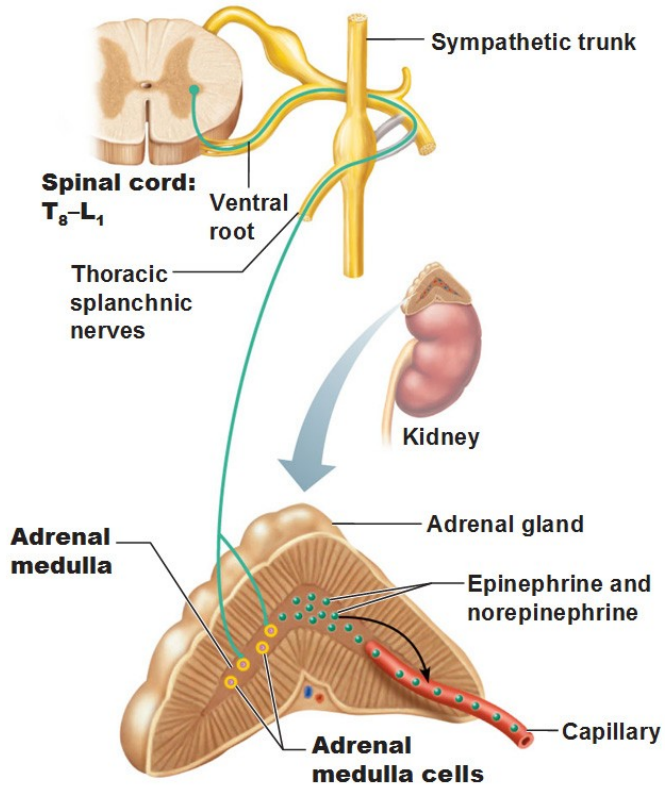

# Norepinephrine

- Postganglionic sympathetic fibers
- Adrenergic receptor
  - G-coupled
  - α type– generally excitatory (contraction)
  - 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

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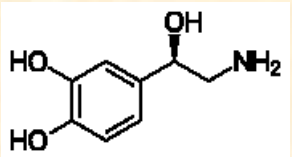


# Norepinephrine

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  - Modified sympathetic g
  - Tra

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

Epi, epinephrine; NE, norepinephrine; Iso, isoproterenol

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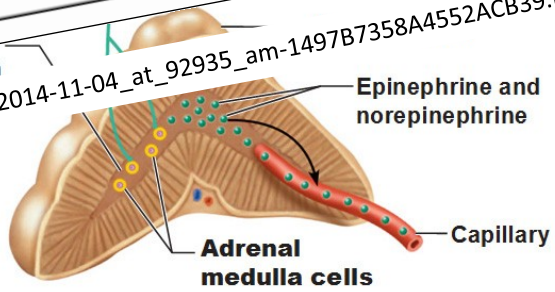


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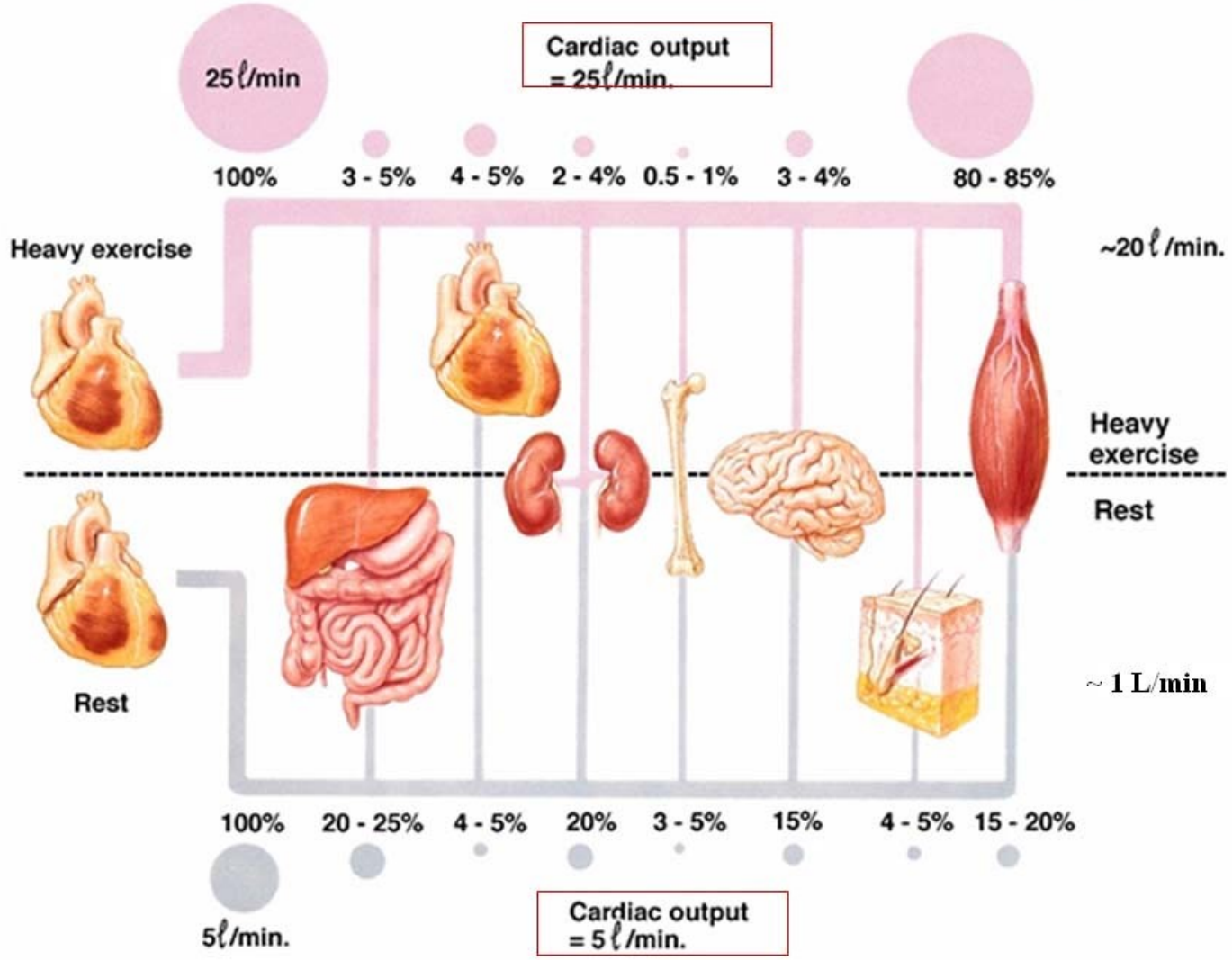
contraction, smooth muscle relaxation, glycogenolysis

# Redistribution of Blood Flow During Exercise

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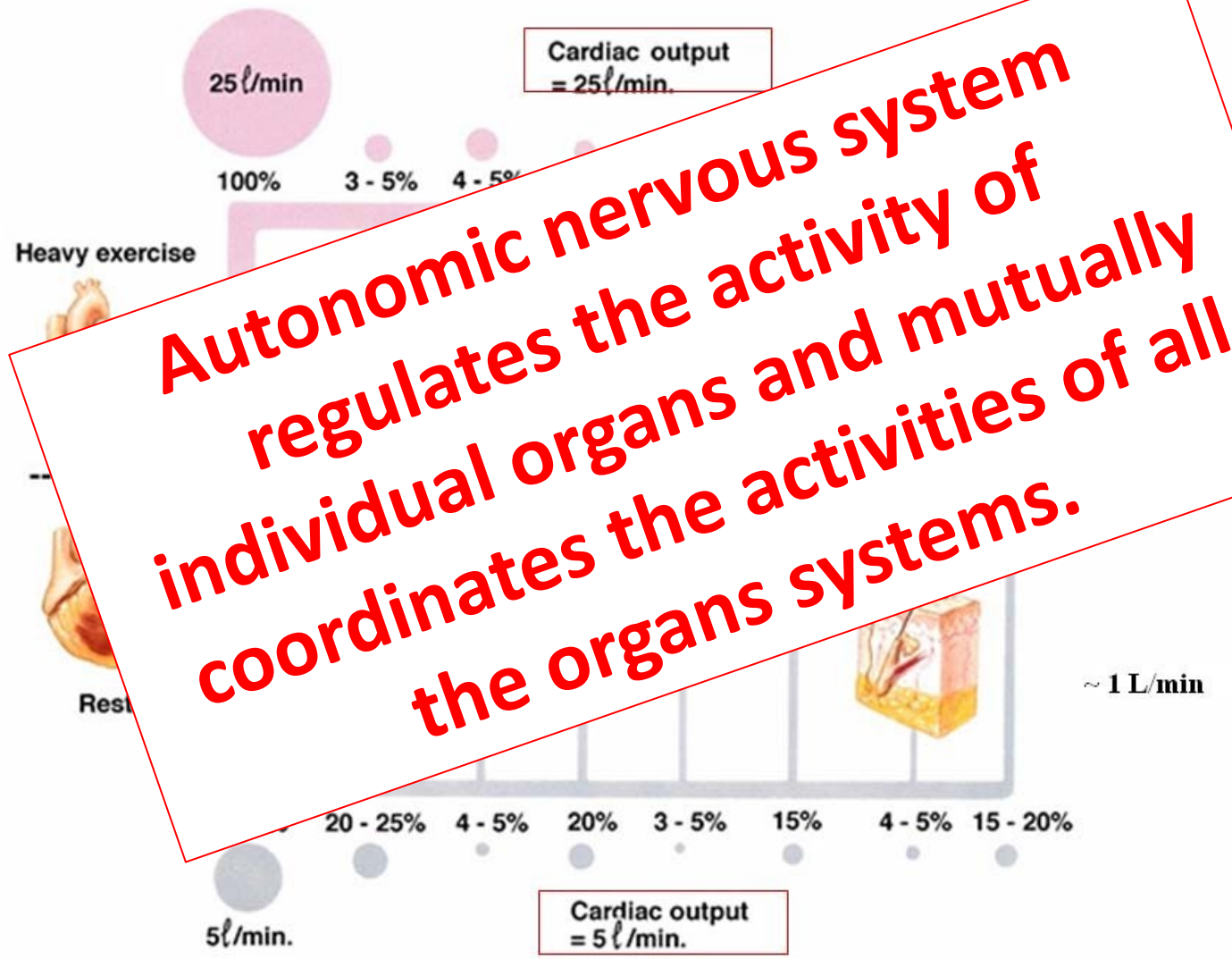


**Autonomic nervous system regulates the activity of individual organs and mutually coordinates the activities of all the organs systems.**

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