



**HKU  
Med**

LKS Faculty of Medicine  
School of Biomedical Sciences  
香港大學生物醫學學院

# Coordination and Response

**Enrichment Course in Biology**

**Dr Denny CW Ma**



**Leonardo da Vinci  
(1452 – 1519)**

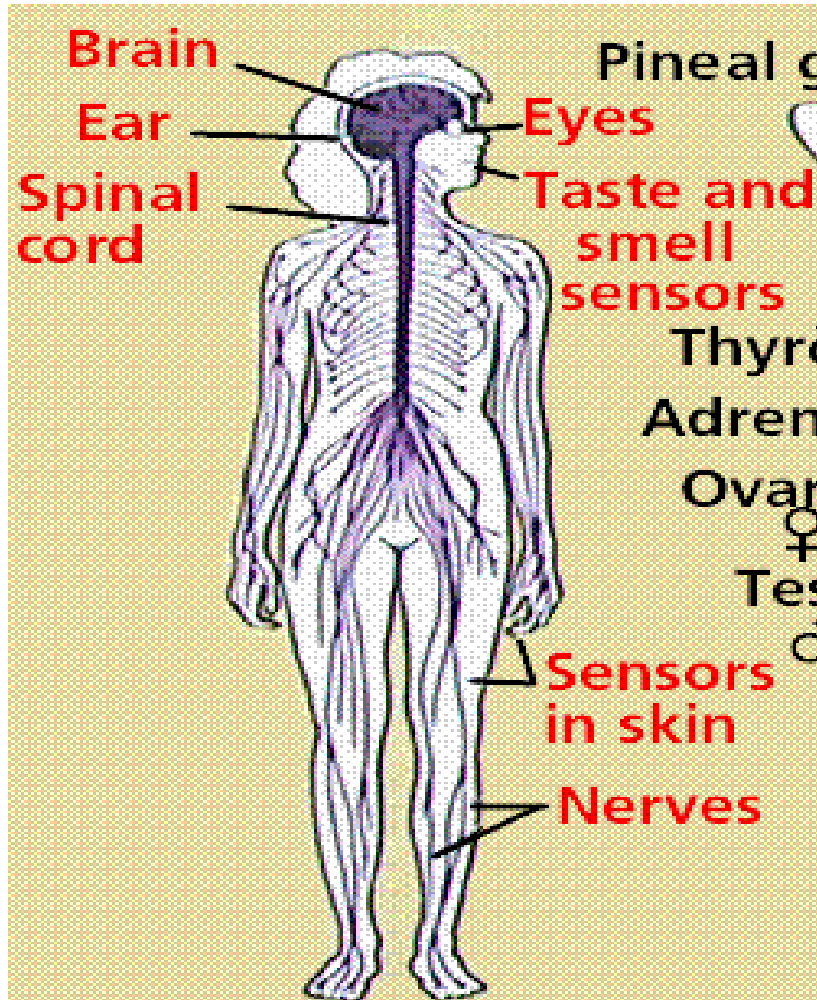


**Nervous System**

# Systems for Coordination

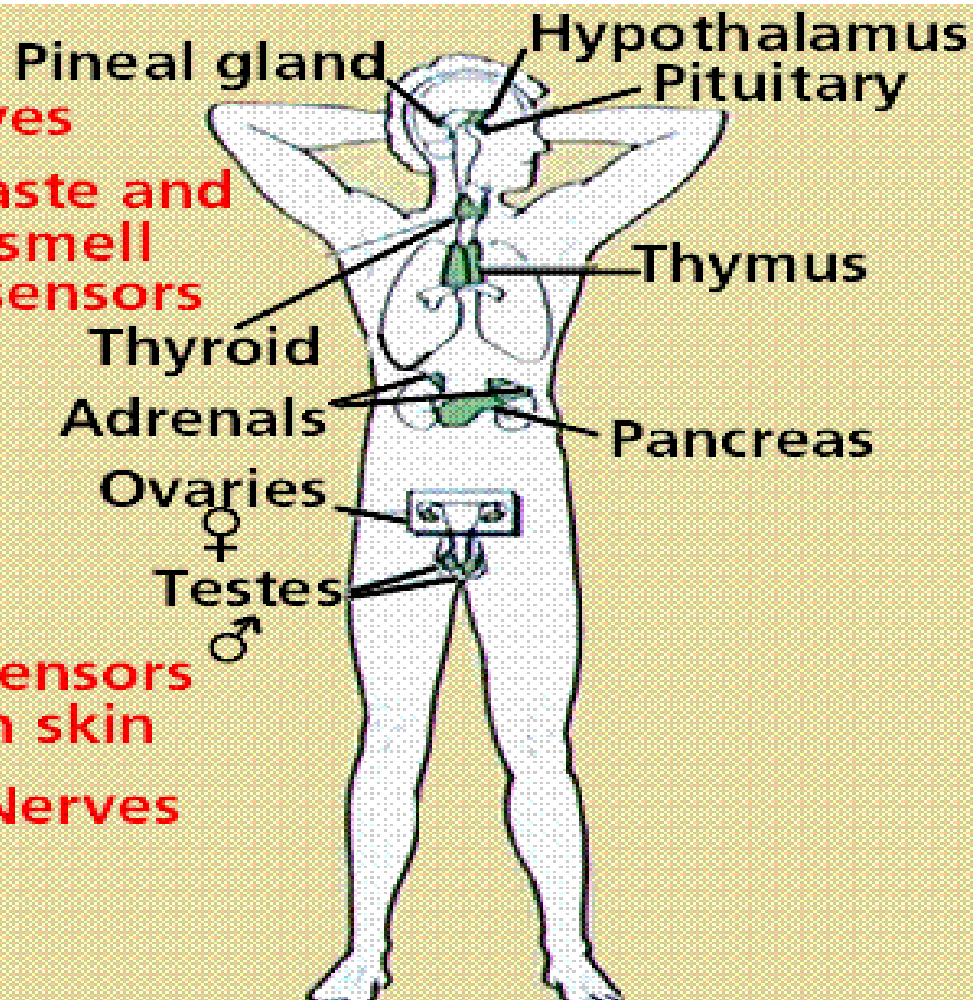
## Nervous System

**Faster**  
(electrical activity in nerves,  
neurotransmitters at synapses)



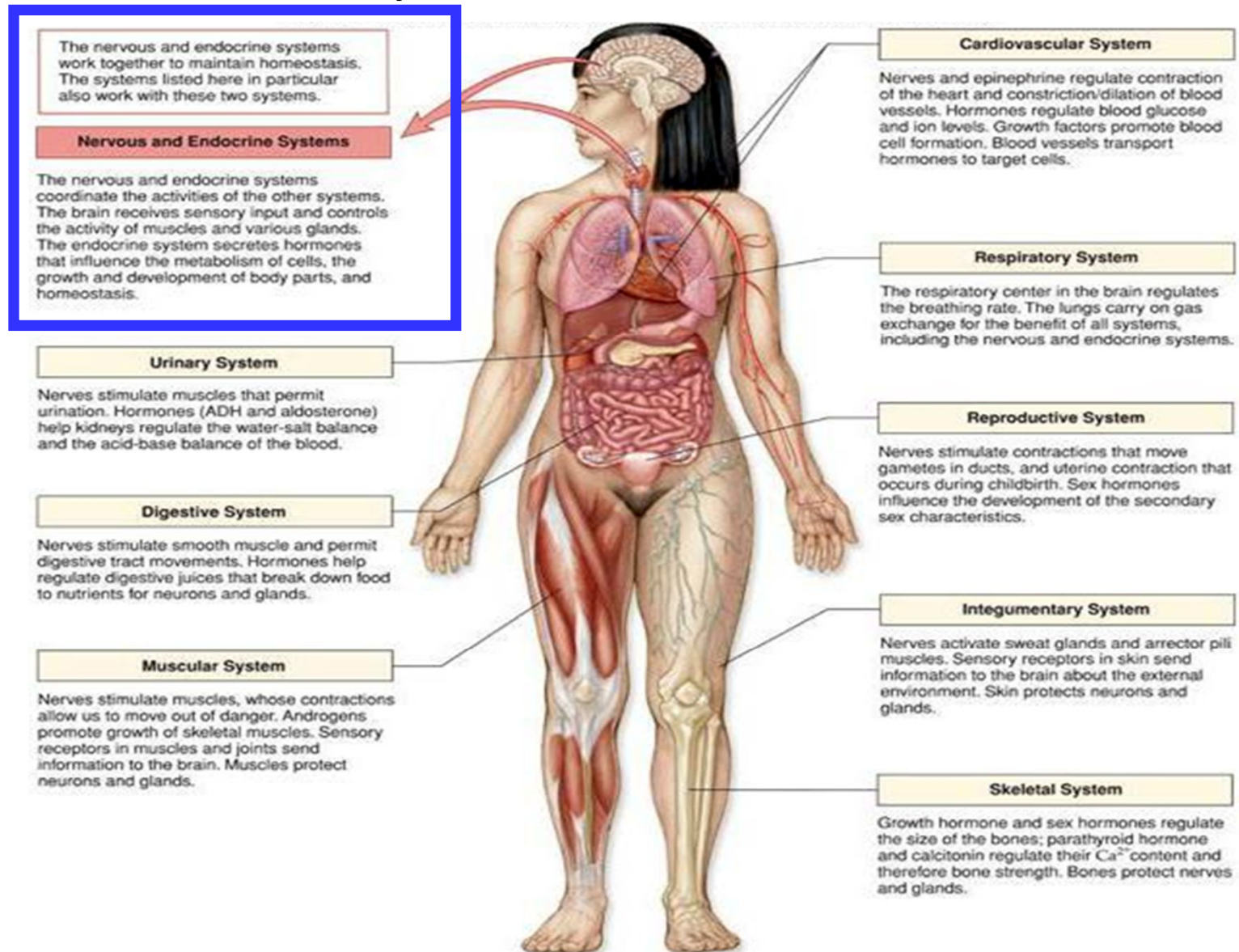
## Endocrine System

**Slower**  
(hormones in blood)



# Systems for Coordination

The **nervous** & **endocrine** systems coordinate the activities of the other system.

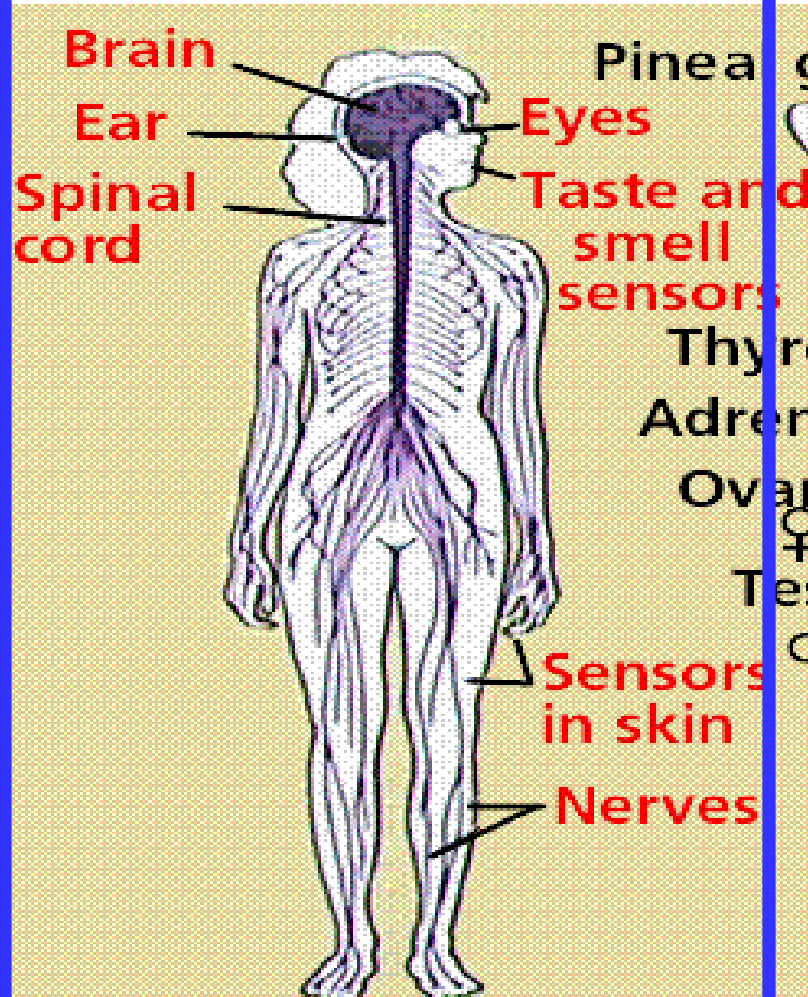




# Systems for Coordination

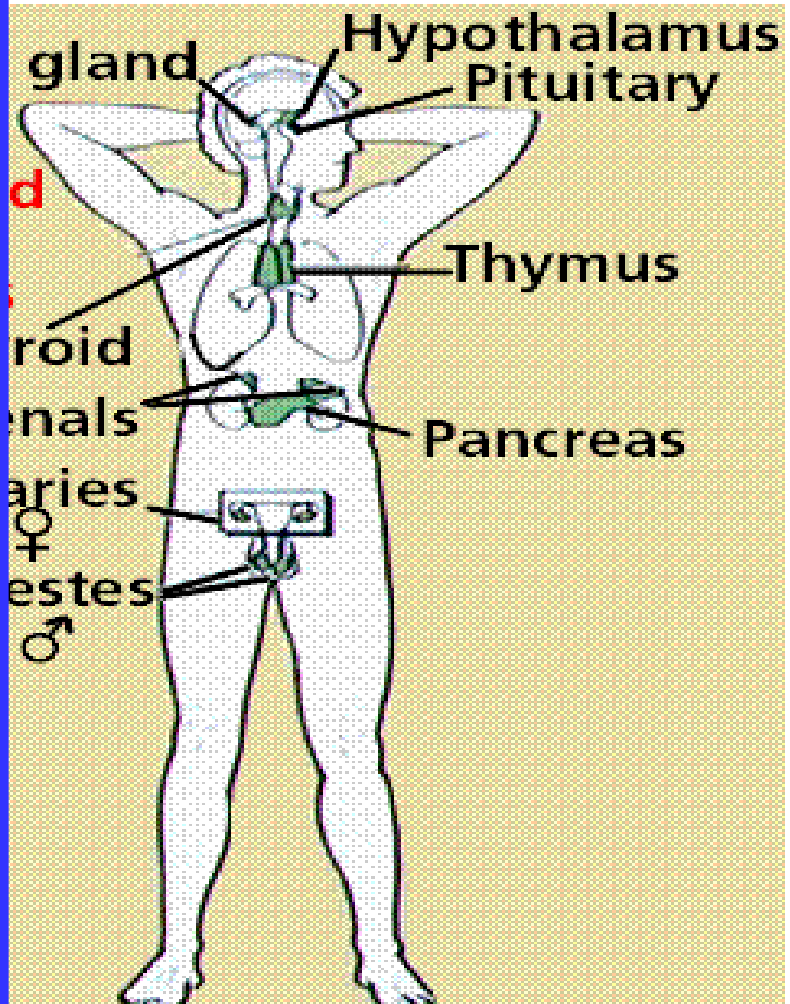
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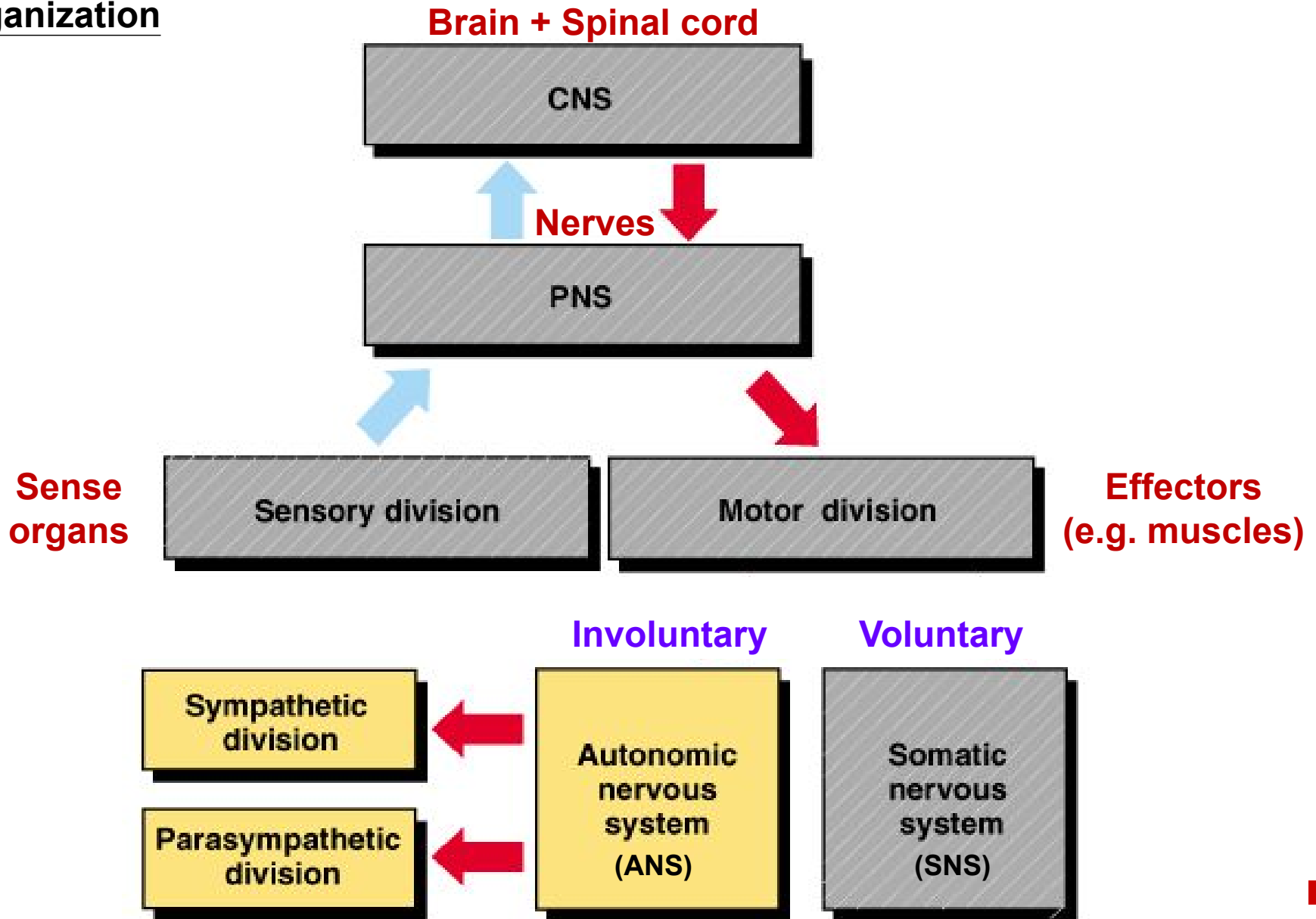
## Endocrine System

**Slower**  
(hormones in blood)

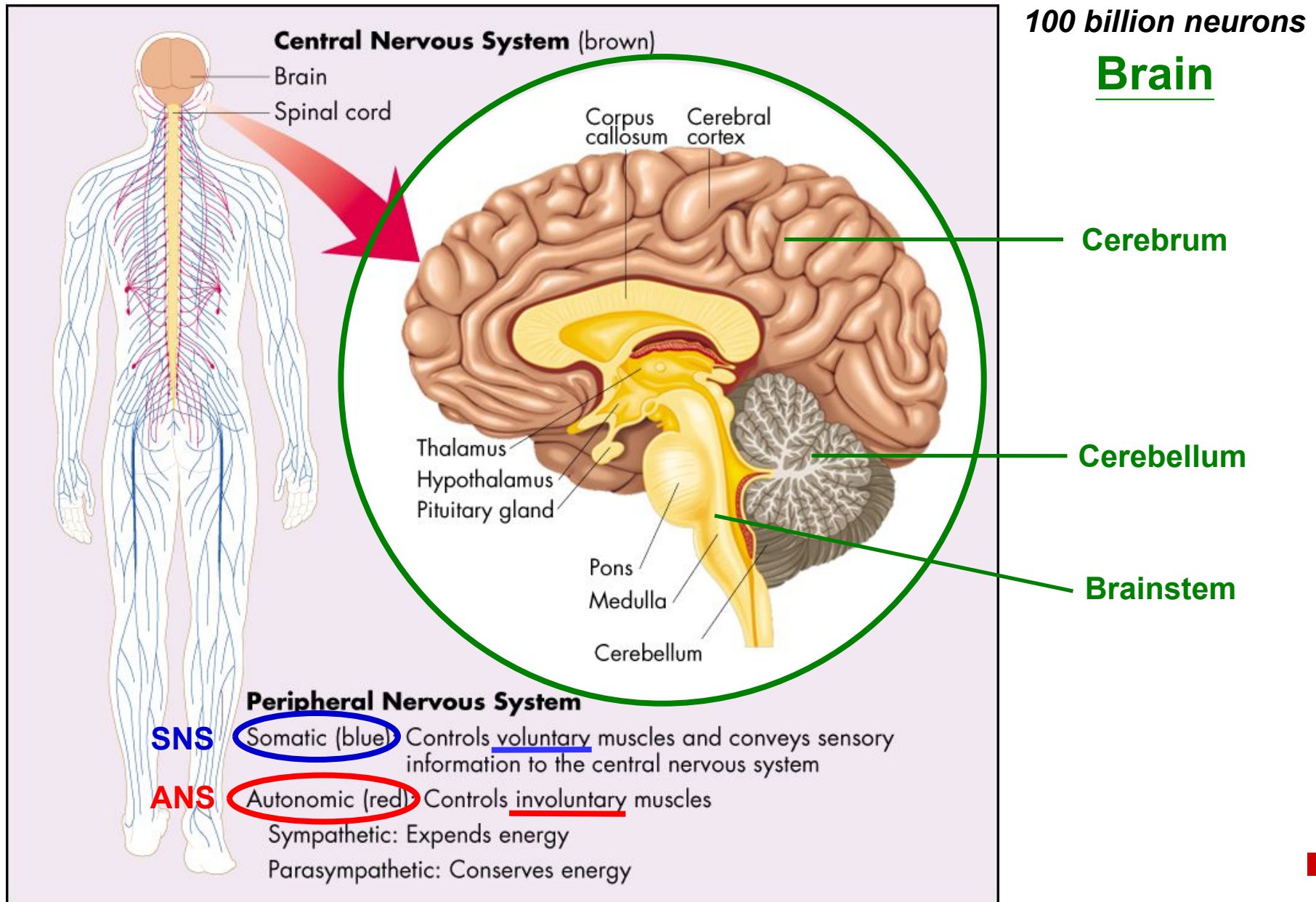


# Nervous System

## Organization



# Nervous System



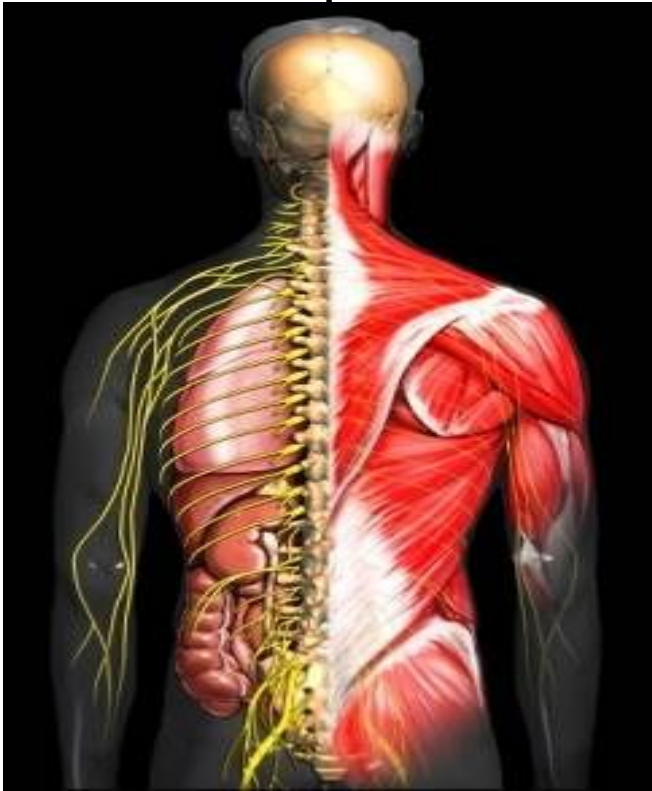
# Coordination & Response

**Nerves**

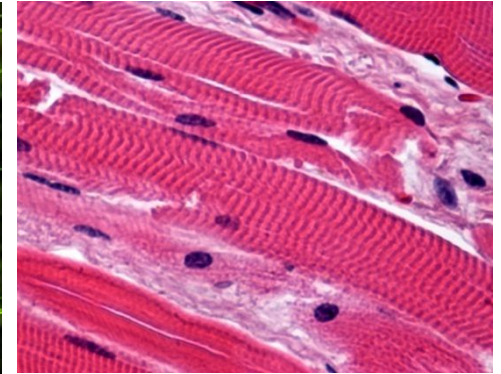
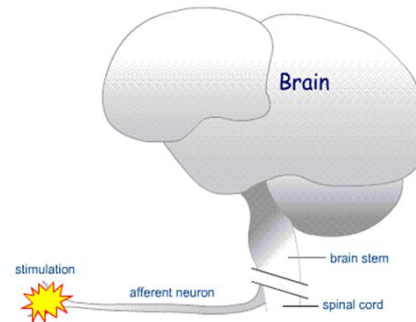
**Muscles**

**Neurons**

**Myocytes**



**Signal transmission  
& processing**

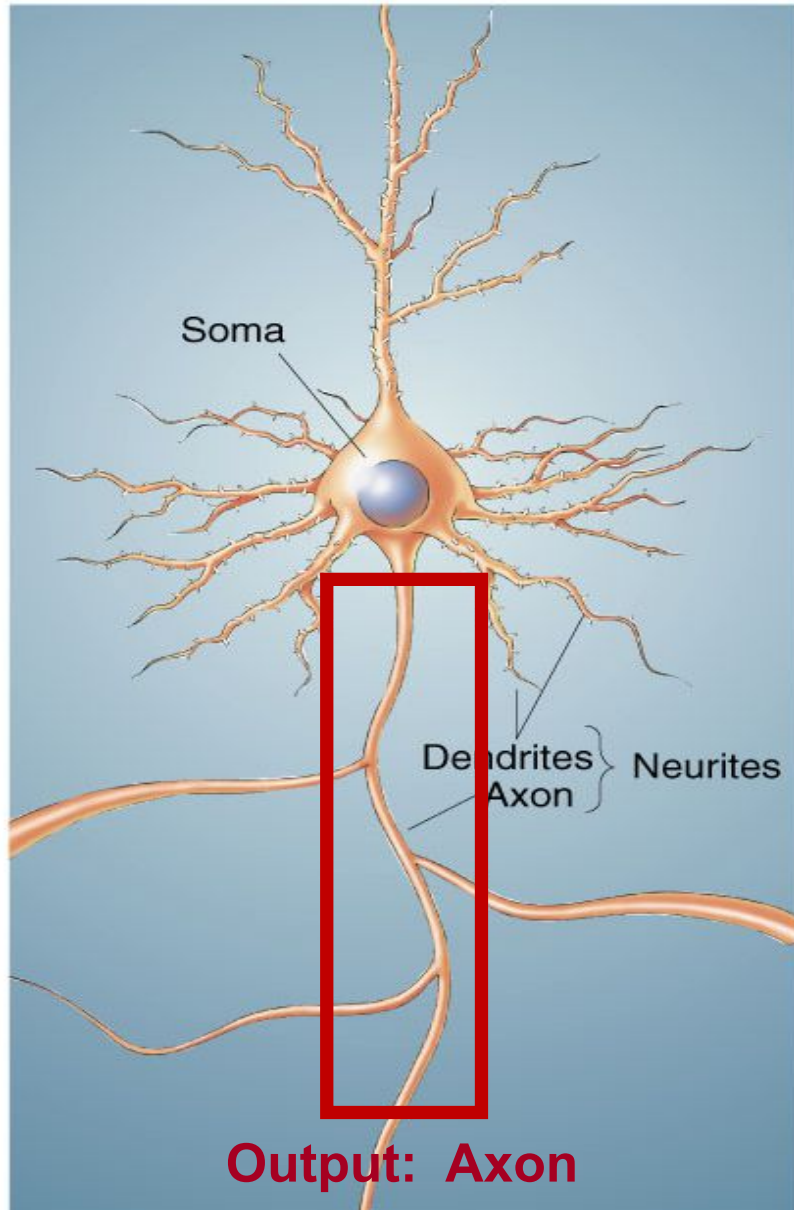


**Movement**





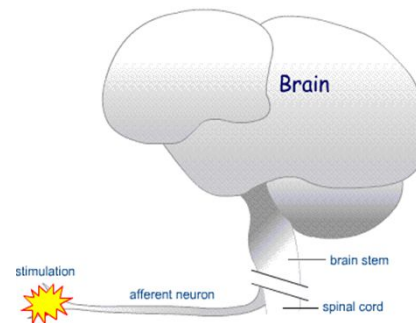
# Neurons



## Neurons



## Signal transmission & processing

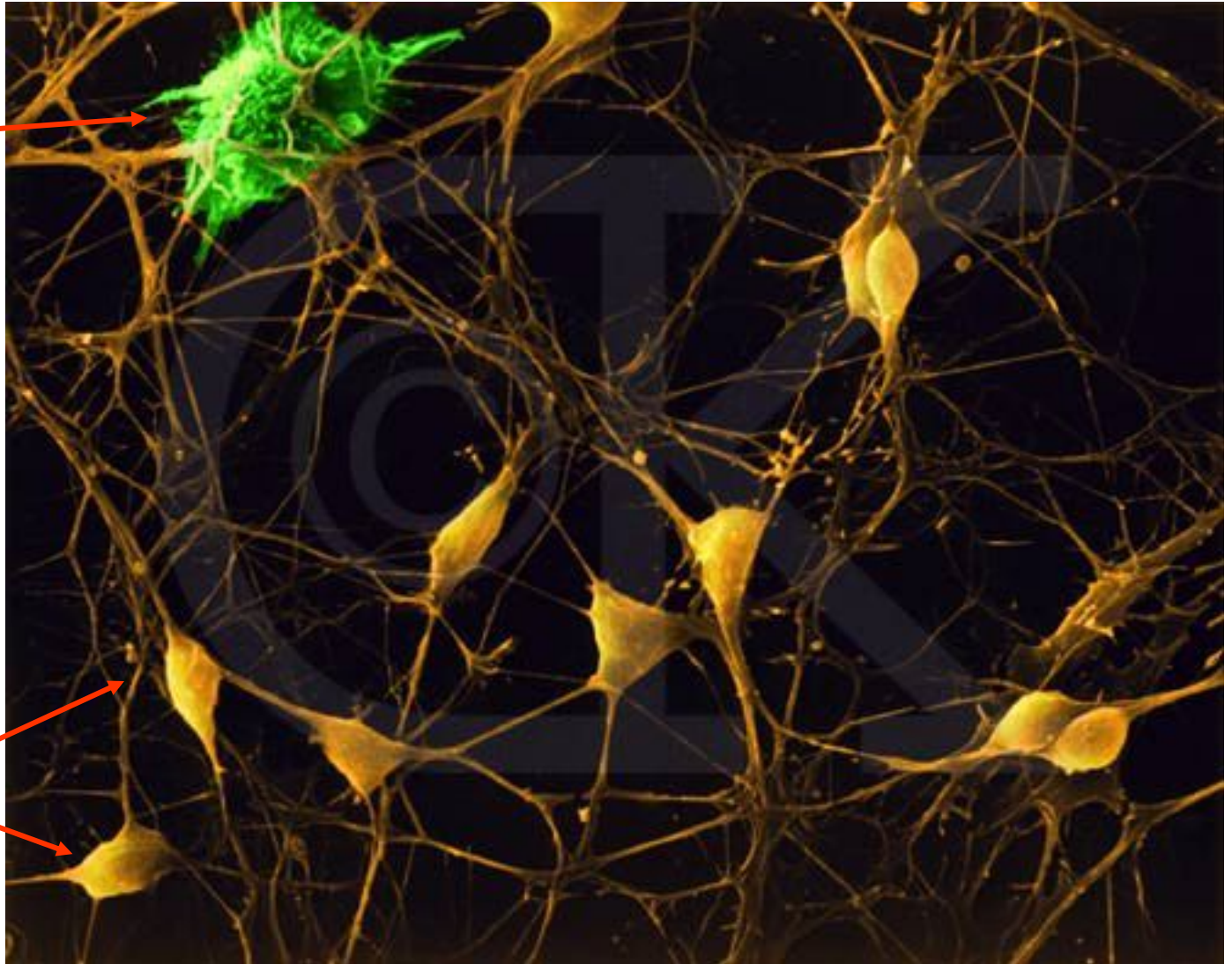


# Neurons vs. Glia

**Glia**

(supporting cells)

Non-excitable

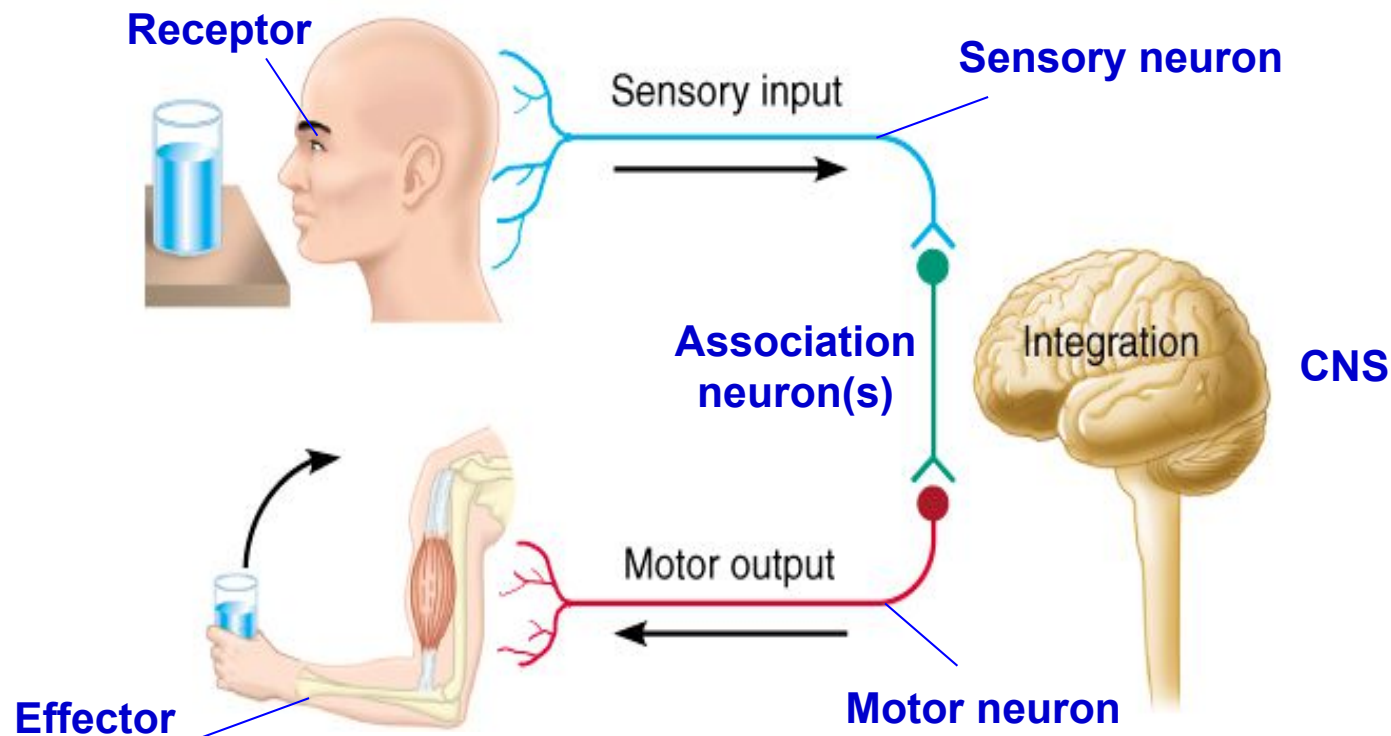


**Neurons**  
(nerve cells)

Excitable

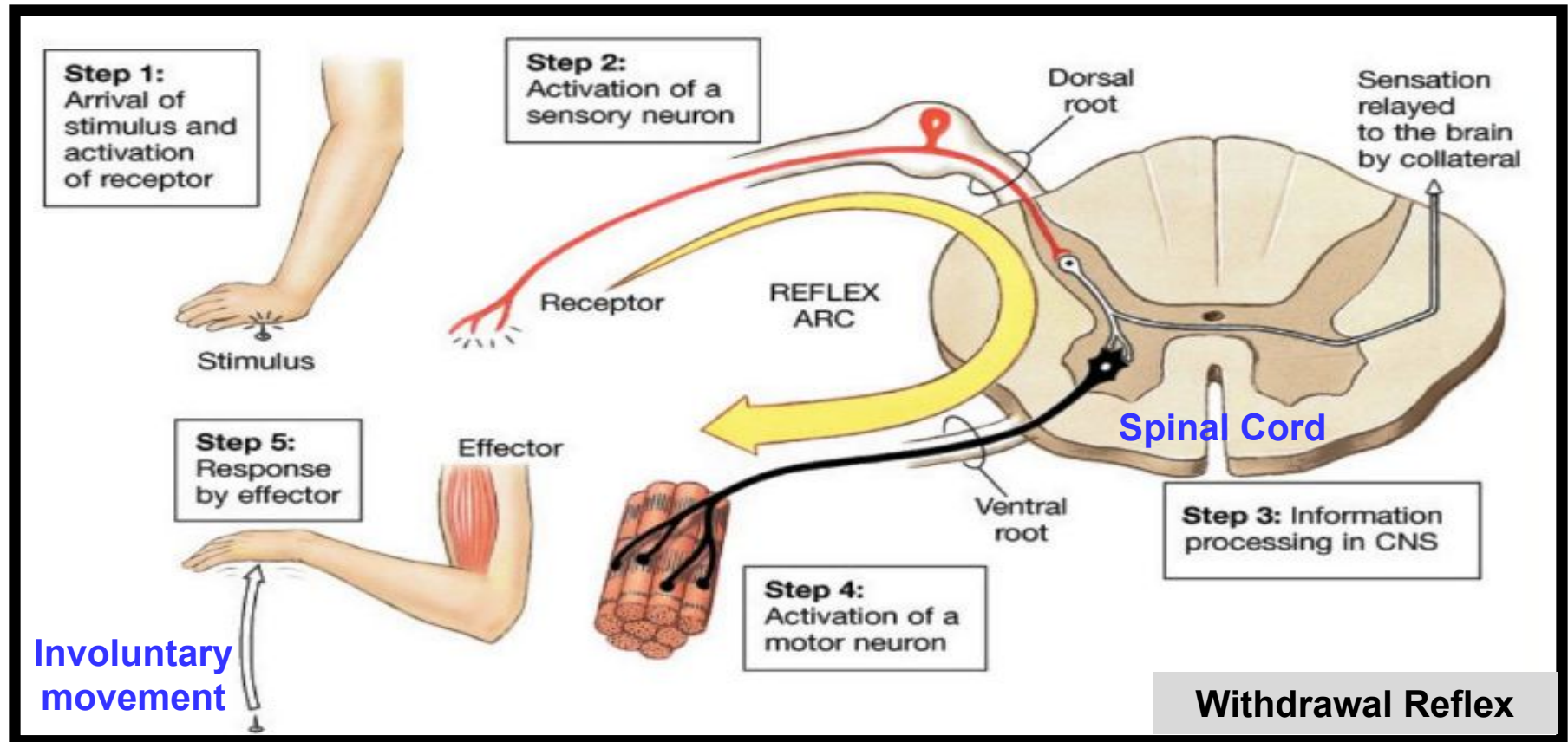
# Neural Pathways

- **Sensory input** – monitoring stimuli occurring inside & outside the body (detected by receptors)
- **Integration** – interpretation of sensory input
- **Motor output** – response to stimuli by activating effector organs (e.g. muscle)



# Neural Pathways

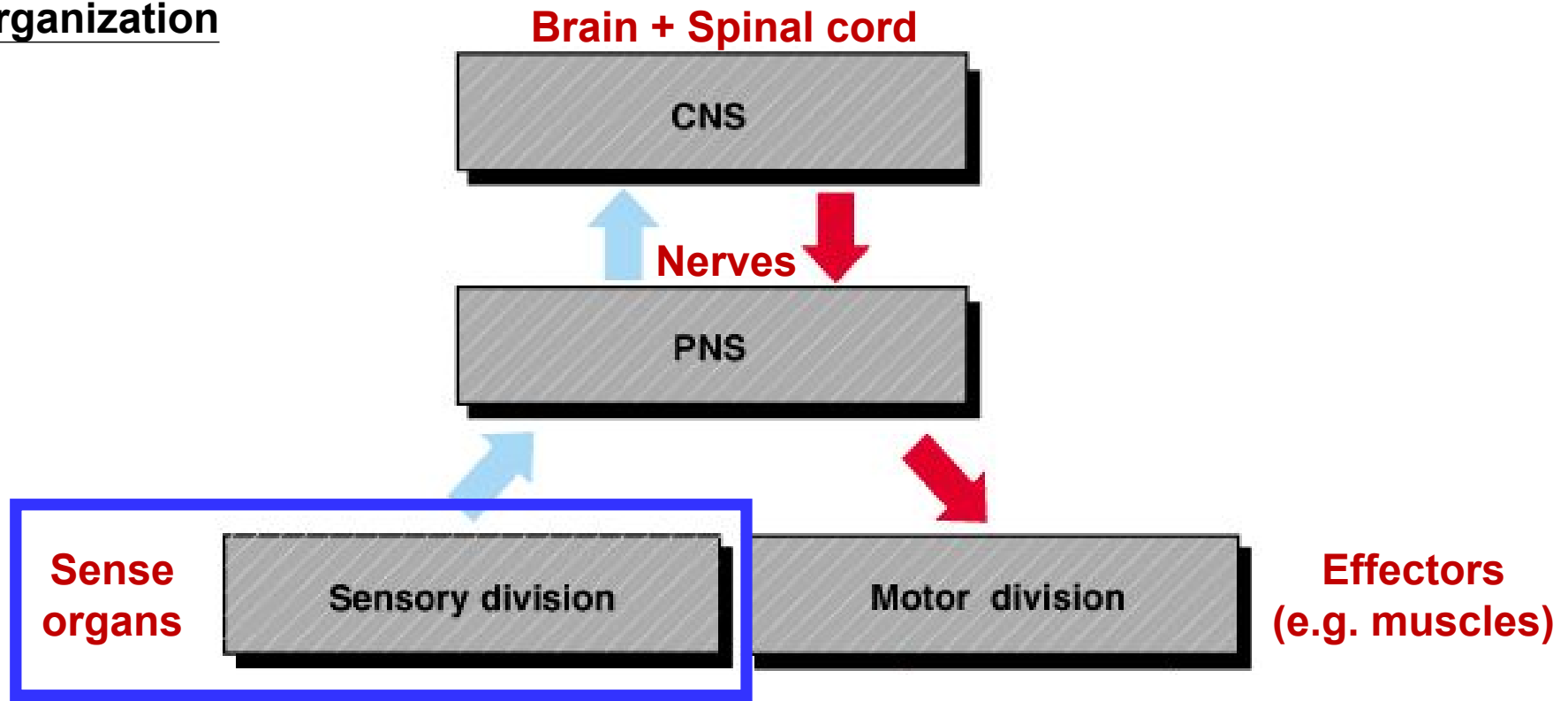
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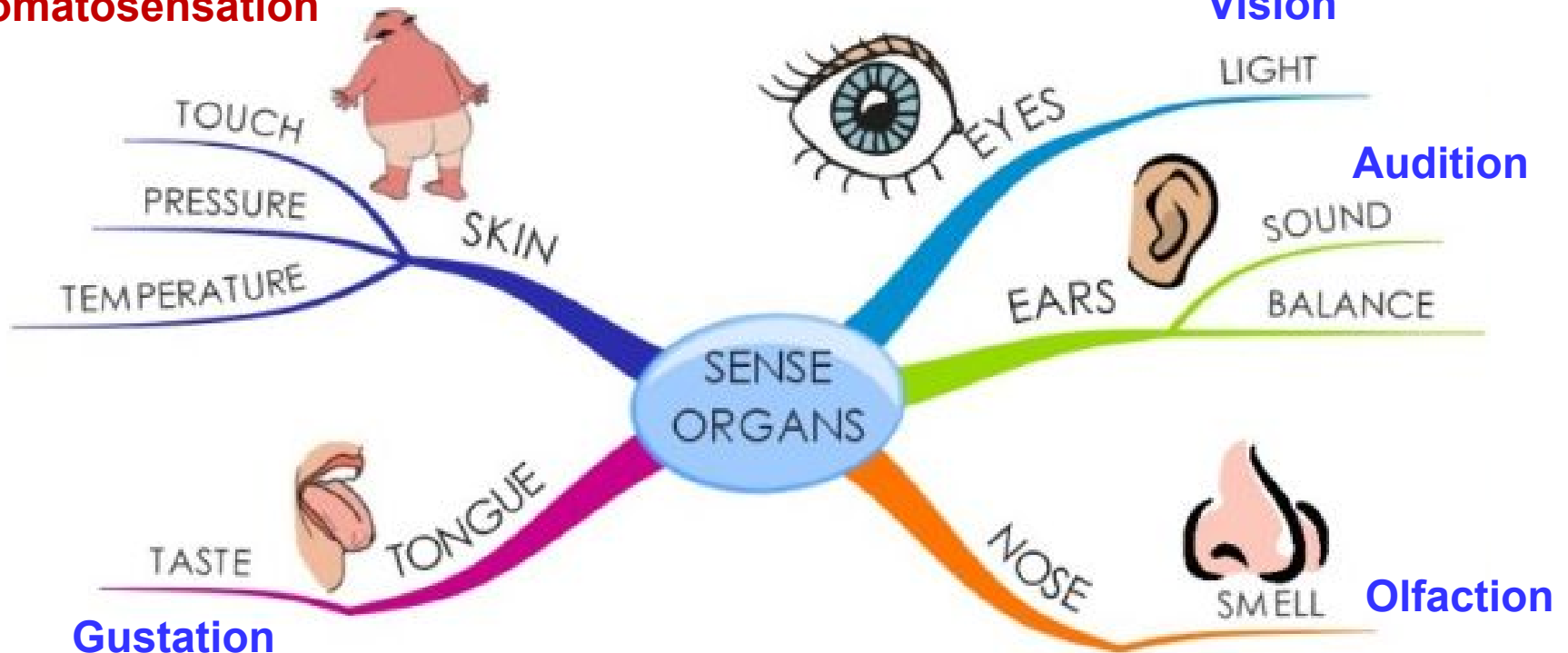
# Nervous System

## Organization



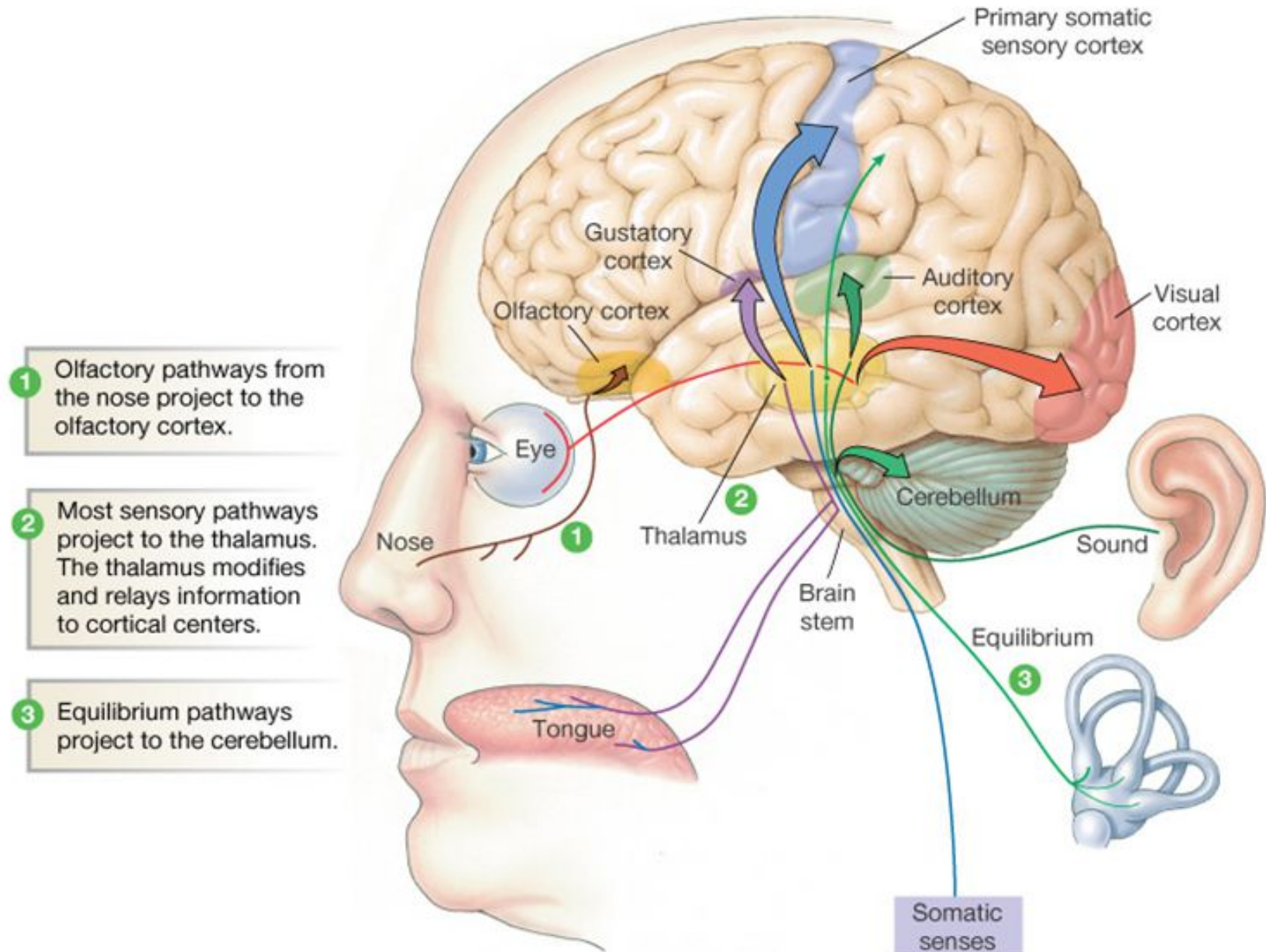
# Senses

## Somatosensation



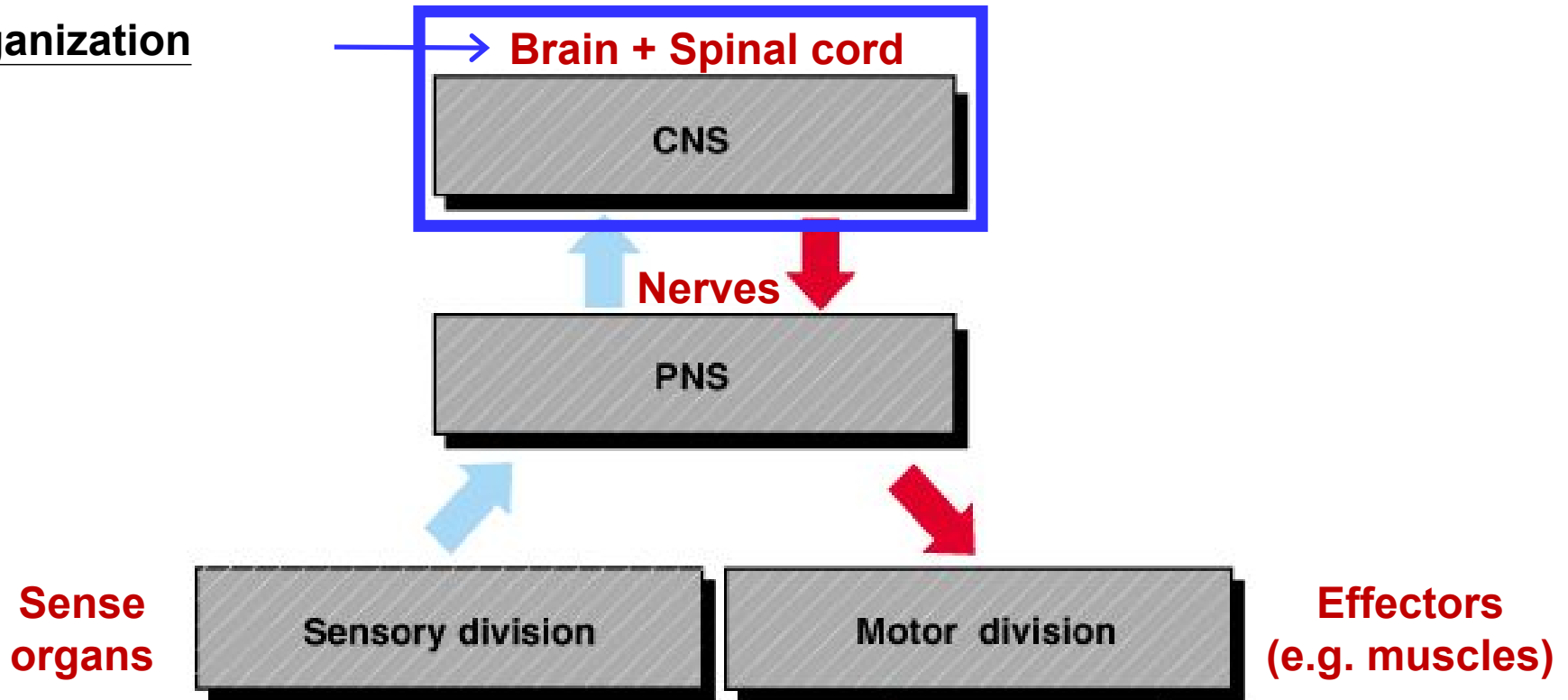
**General senses** vs. **Special senses**

# Sensory Pathways



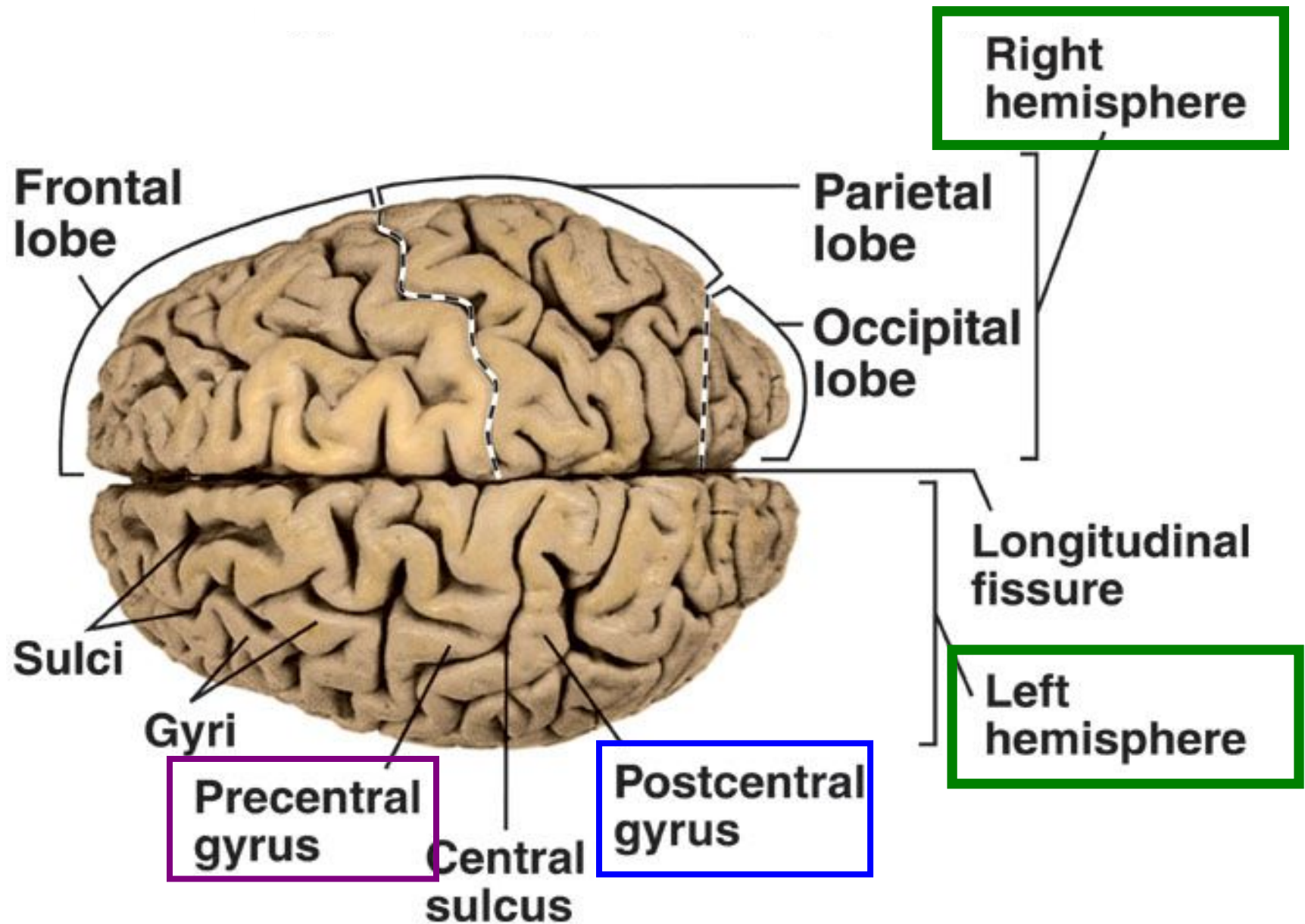
# Nervous System

## Organization

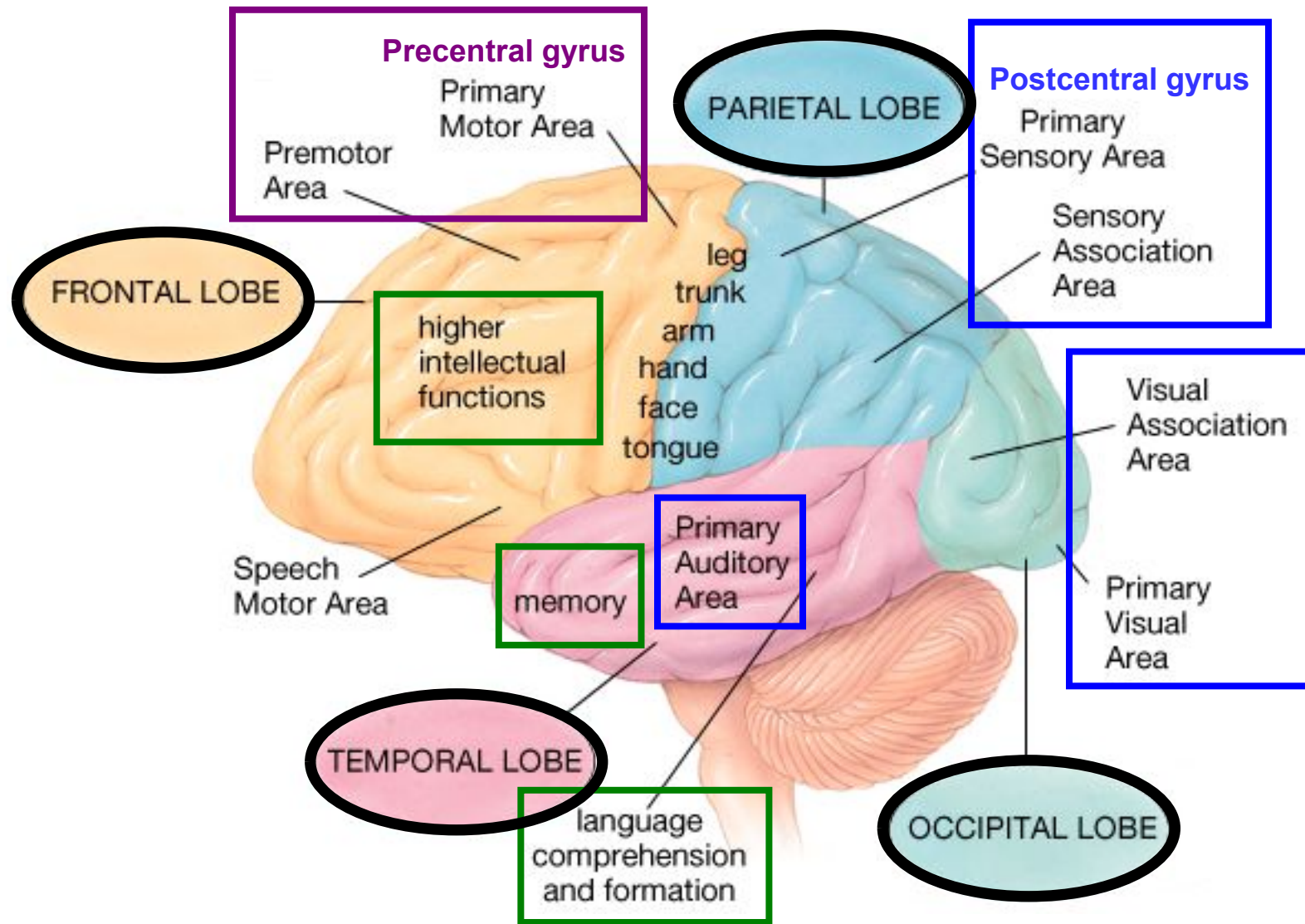




# Cerebrum

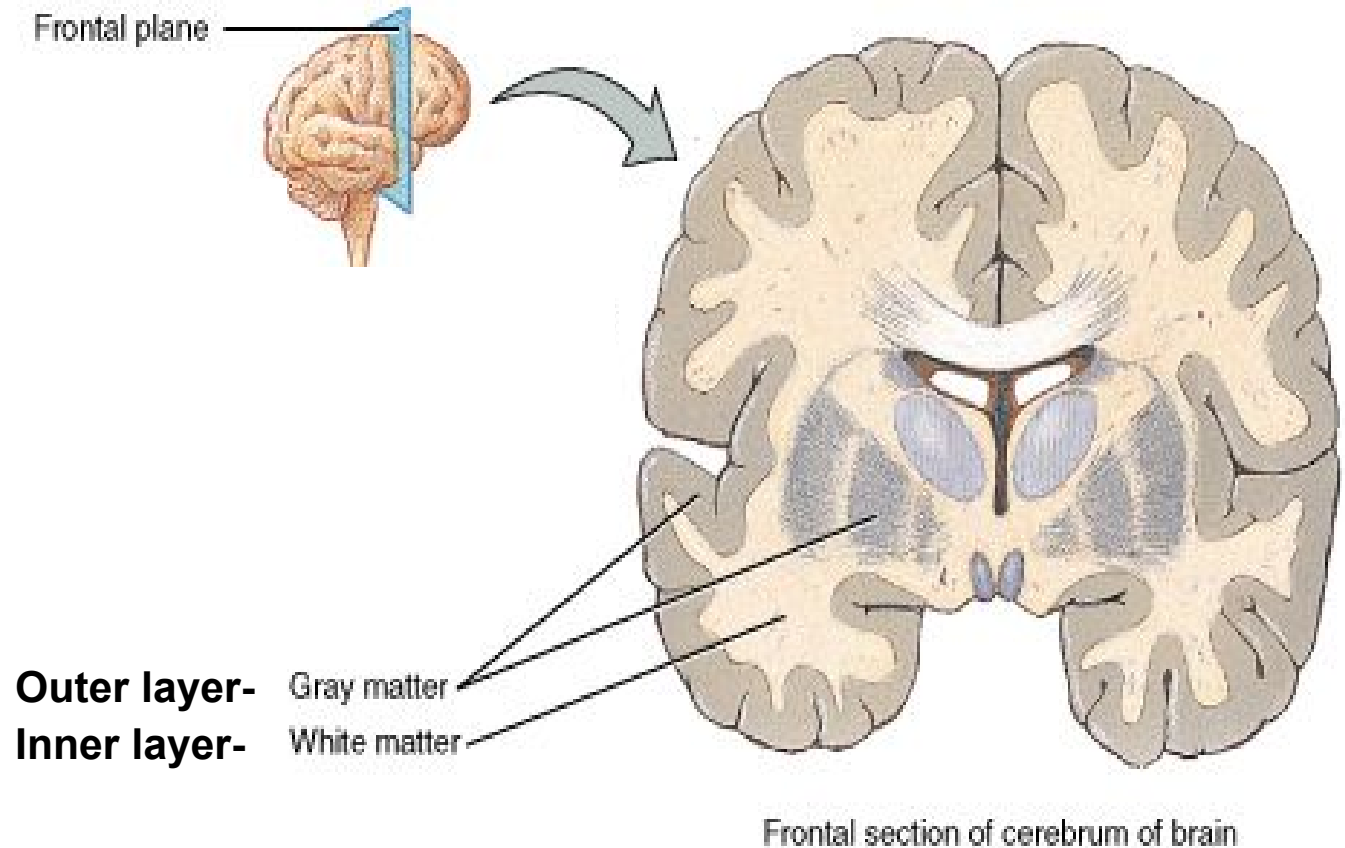


# Cerebrum



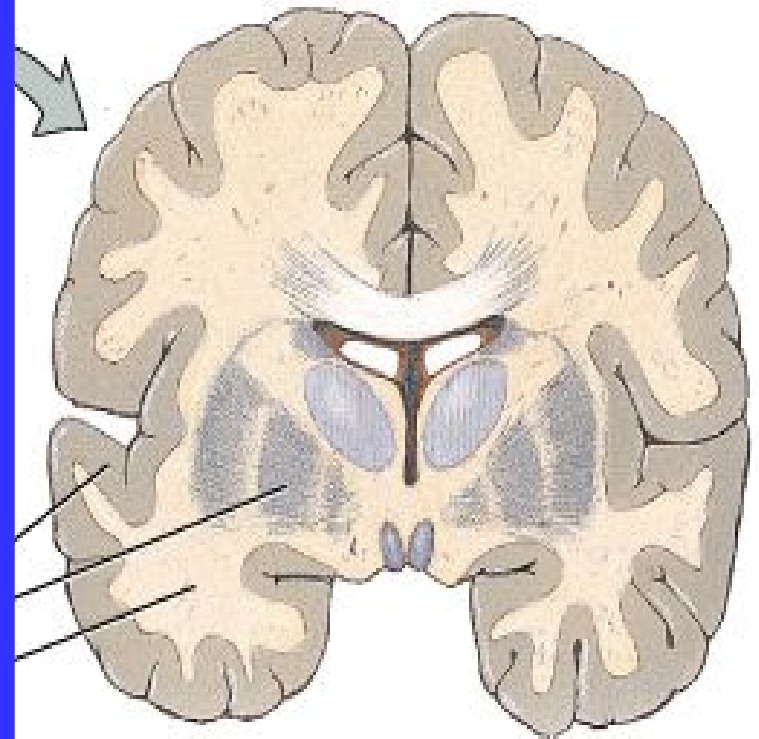
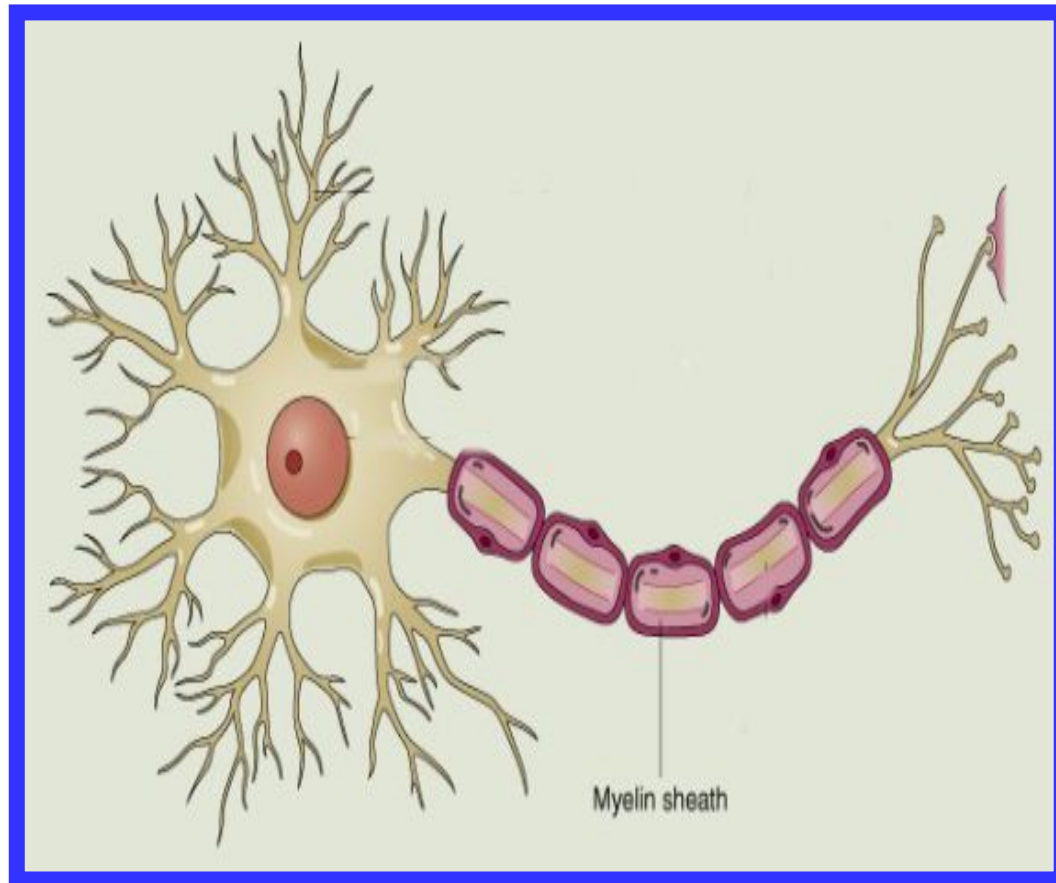
Enables **sensation**, **communication**, **memory**, **understanding**, & **voluntary movements**

# Gray Matter & White Matter



- **Gray matter** formed by neuron cell bodies
- **White matter** consists of axons covered in myelin

# Gray Matter & White Matter

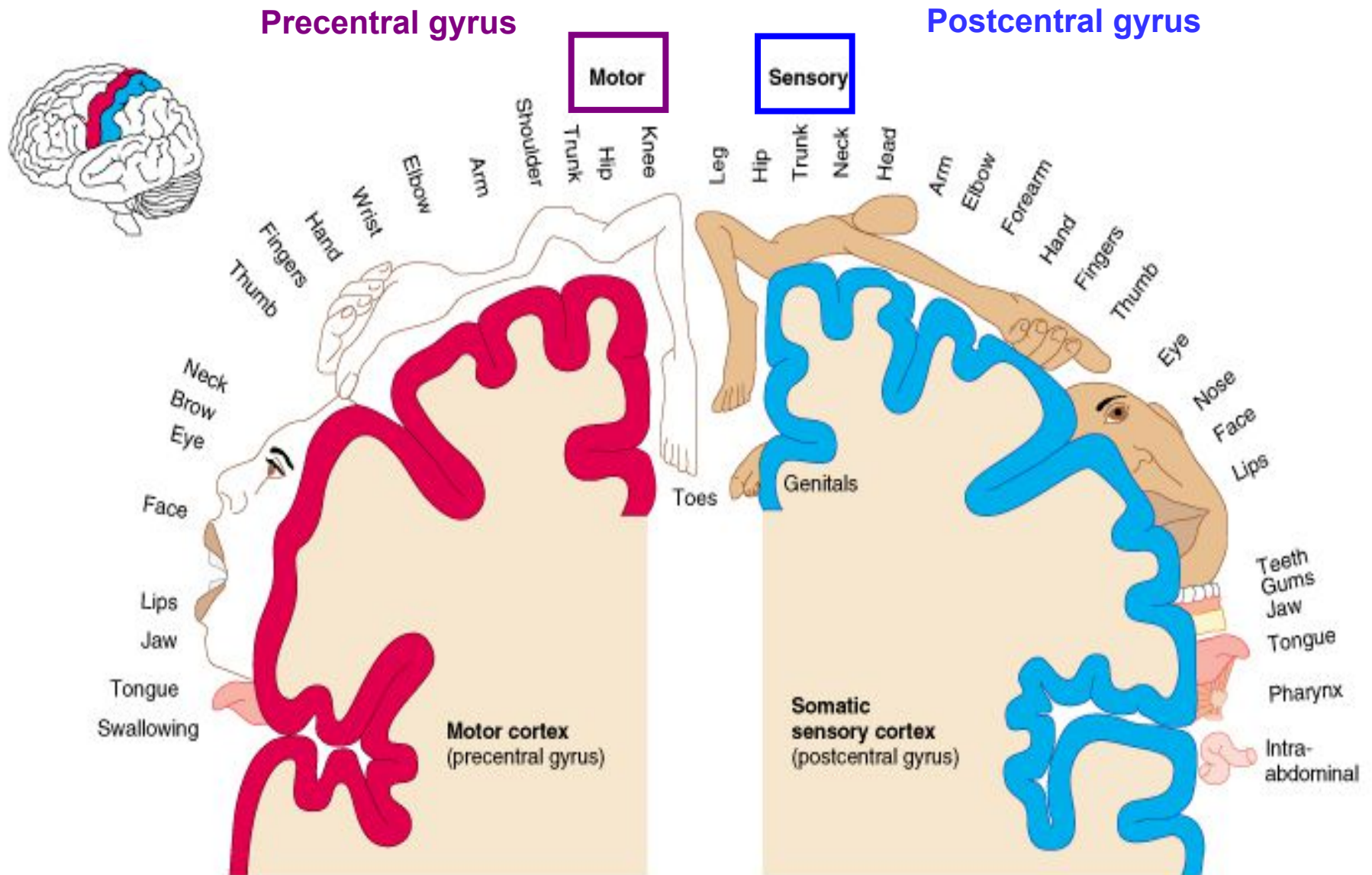


Frontal section of cerebrum of brain

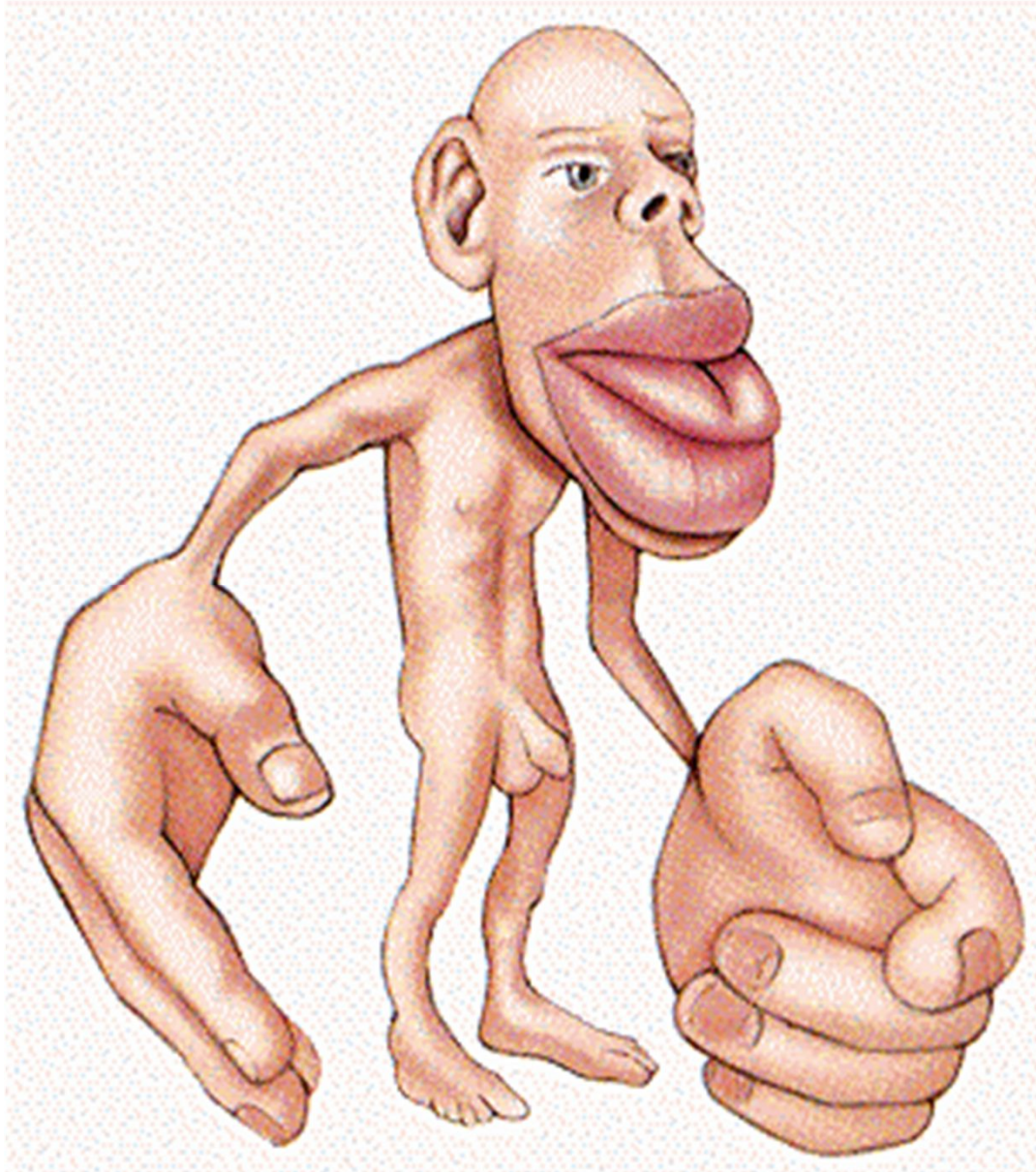
- **Gray matter** formed by neuron cell bodies
- **White matter** consists of axons covered in myelin



# Homunculus



# Homunculus



Distortions :

**Area of sensory (or motor) cortex** devoted to a particular body region

is proportional not to the region's absolute size,

but to the no. of sensory receptors it contains (or the no. of motor neurons innervation).

# Cerebellum

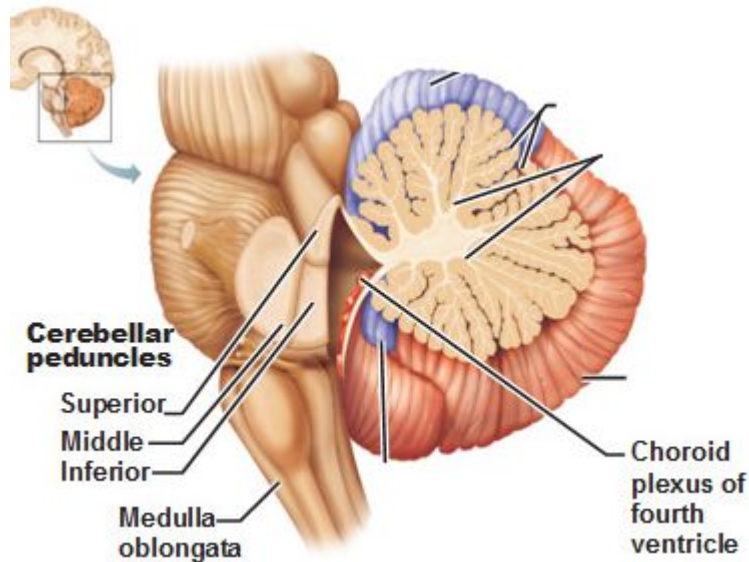
## Functions:

1. Adjustment in **postural muscles** of the body

→ Maintains **balance**

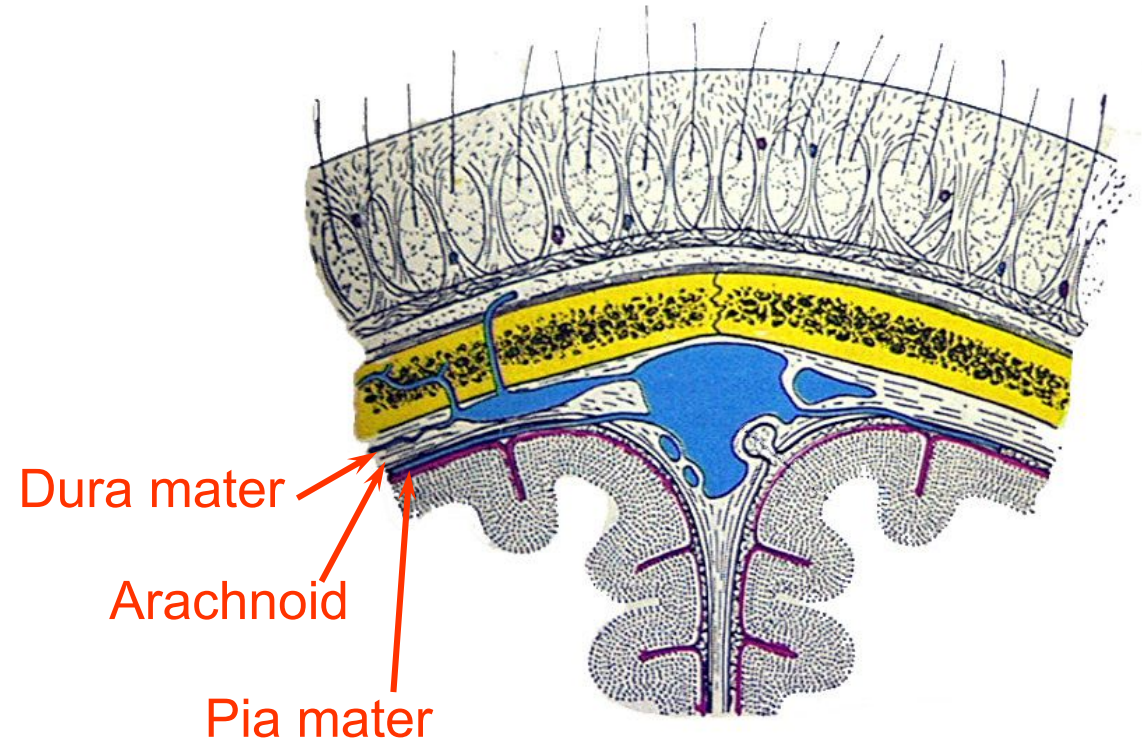
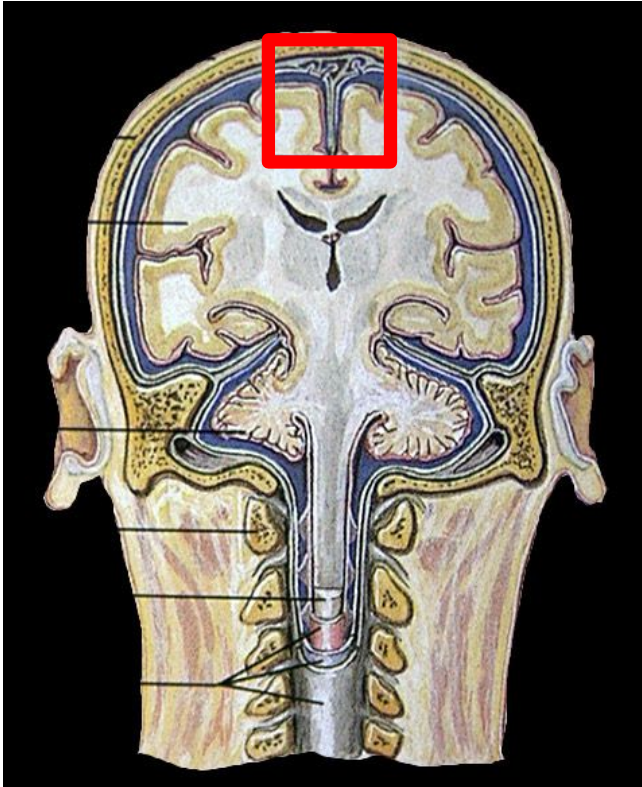
2. Programming & fine-tuning of movements

→ **Refines learned movement** patterns (to make the movement smooth)





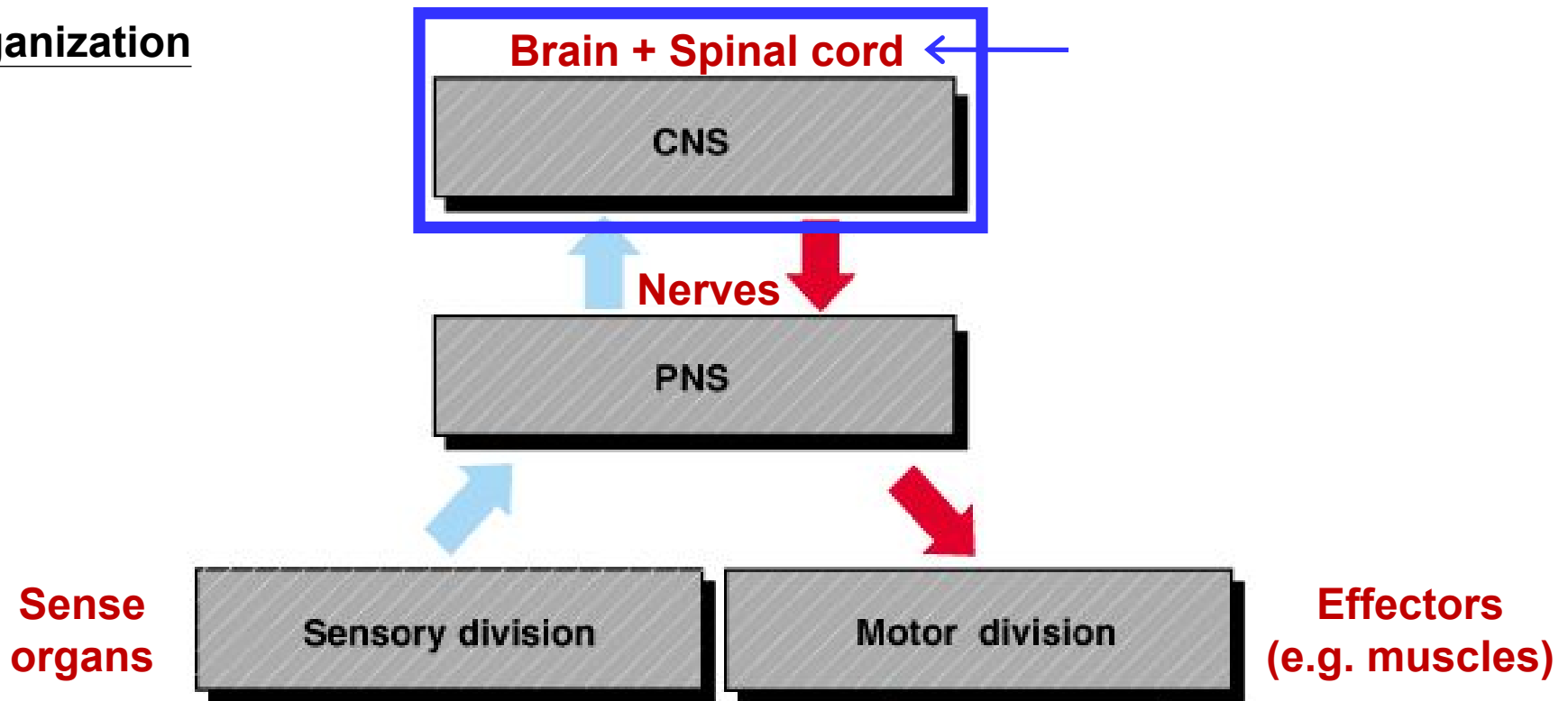
# Brain Meninges





# Nervous System

## Organization

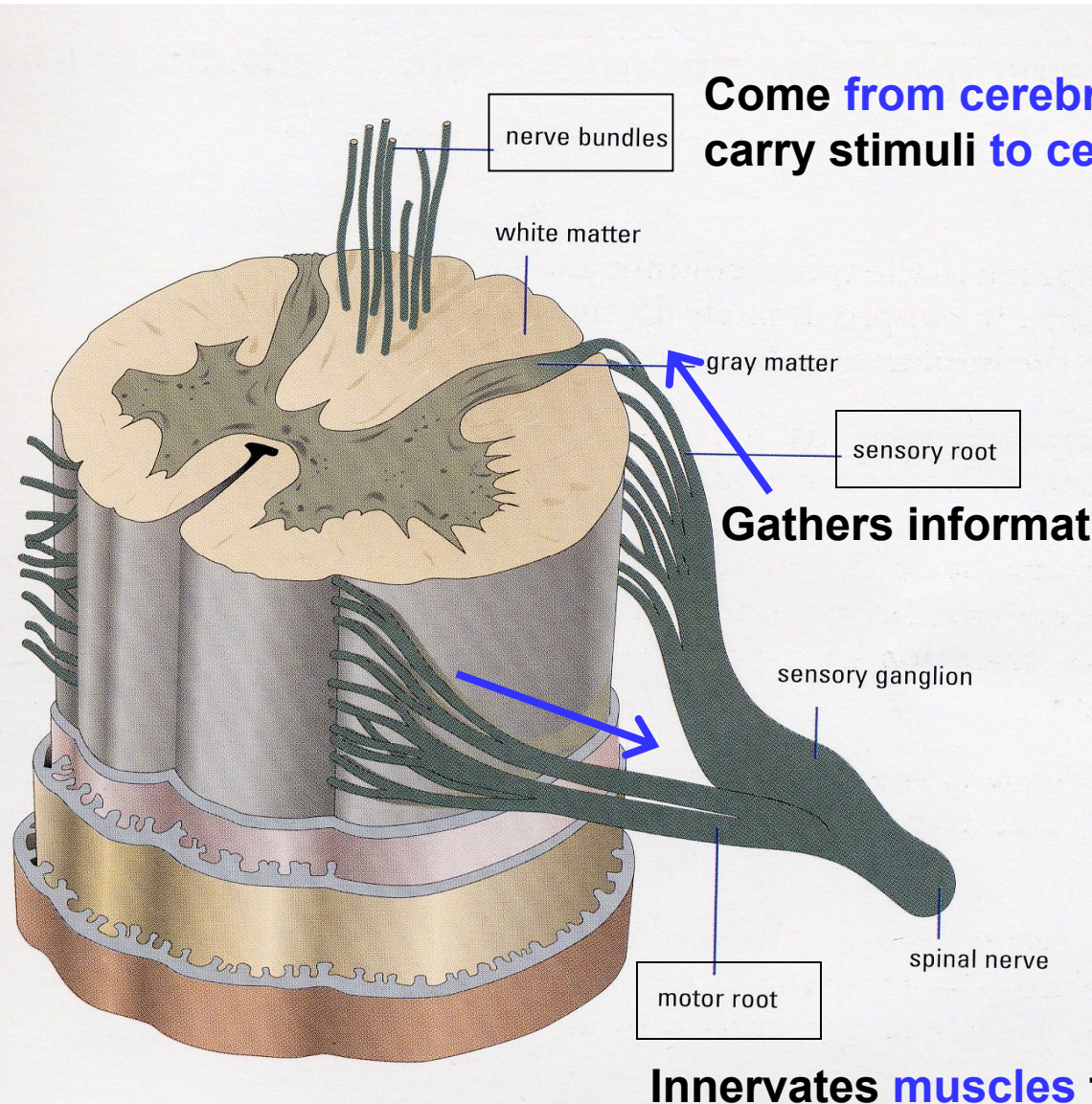


# Spinal Cord



- Passes through the **spinal canals** of the **vertebral column**
- Extends from brain stem to lower back

# Spinal Cord



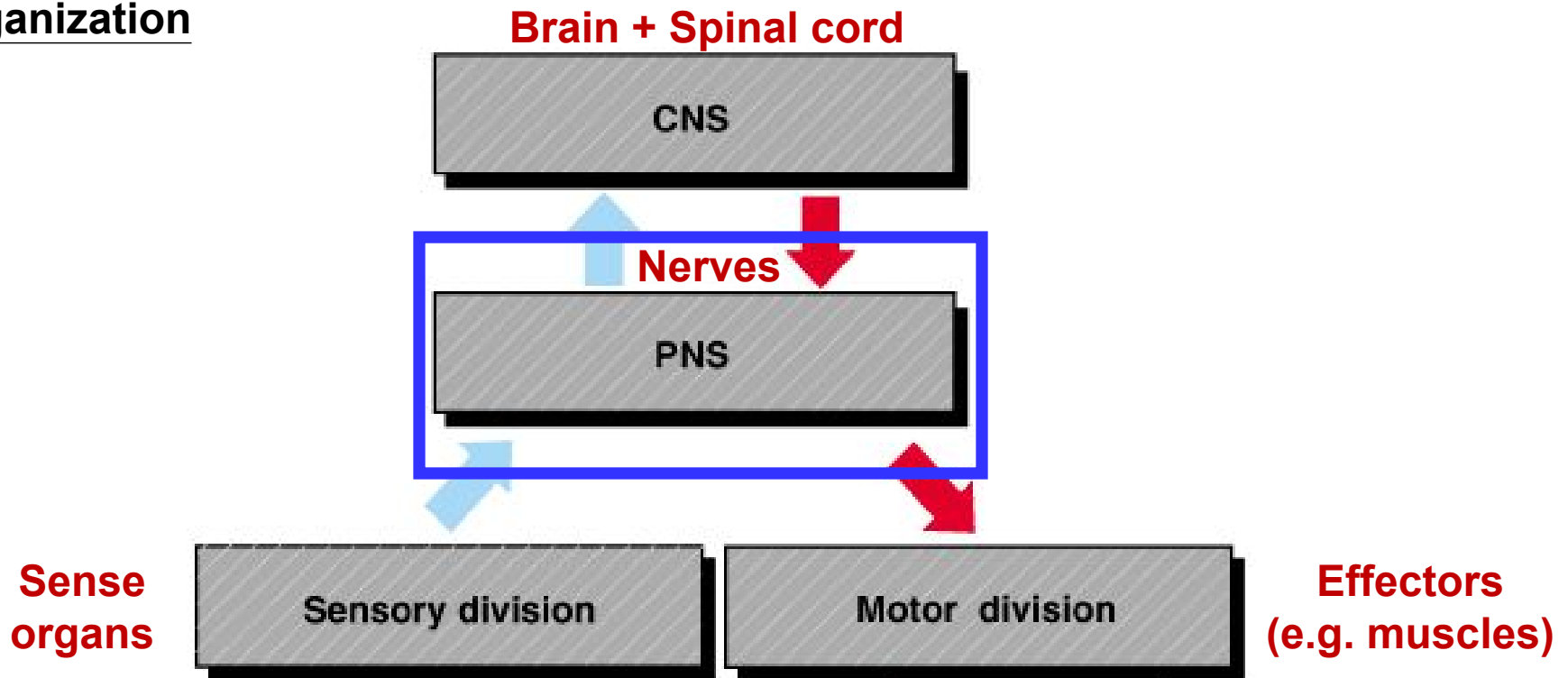
Come from cerebrum (descending fibers) or carry stimuli to cerebrum (ascending fibers)

Gathers information from peripheral receptors

Innervates muscles to produce movement

# Nervous System

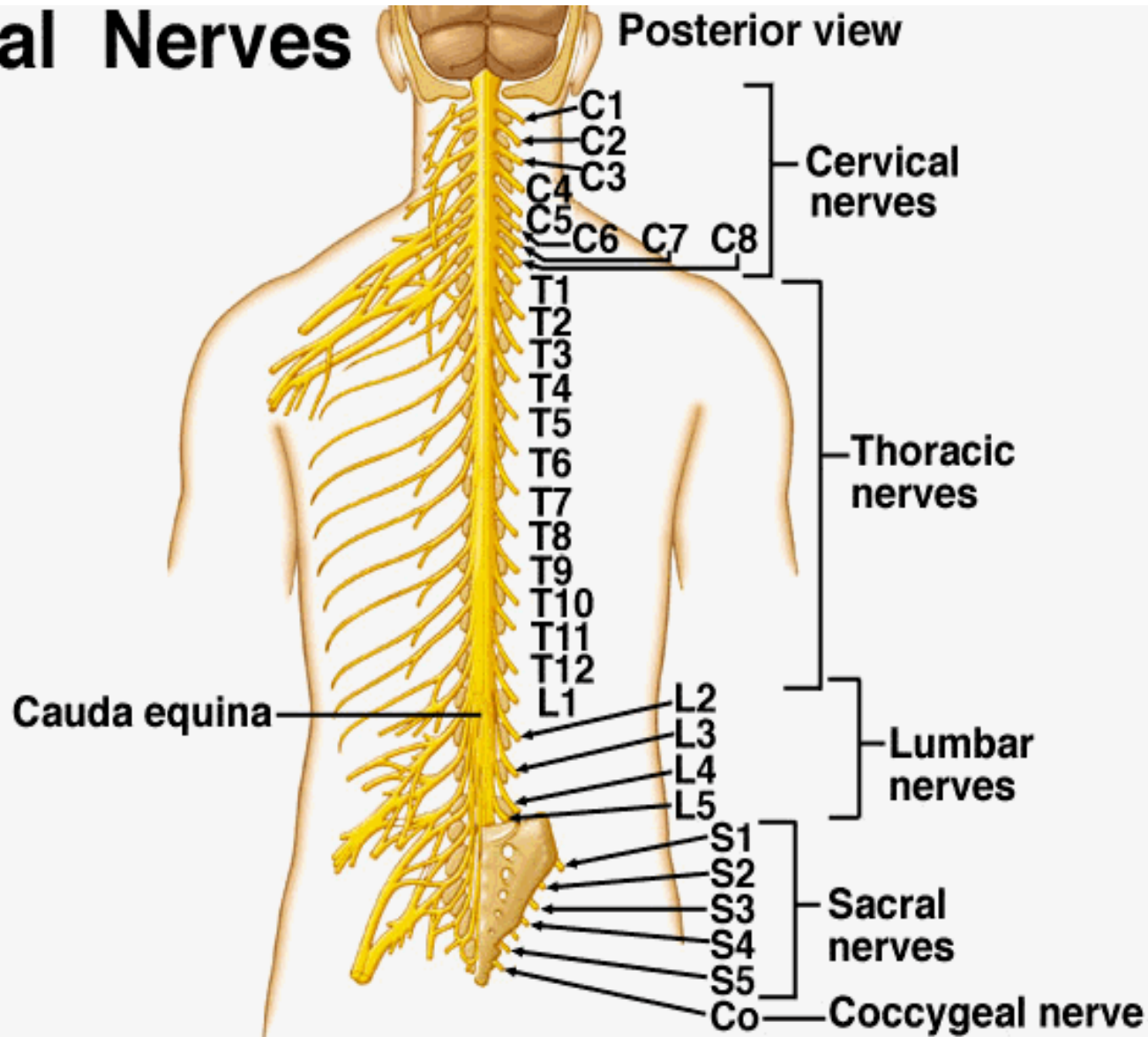
## Organization





# Spinal Nerves

## Spinal Nerves

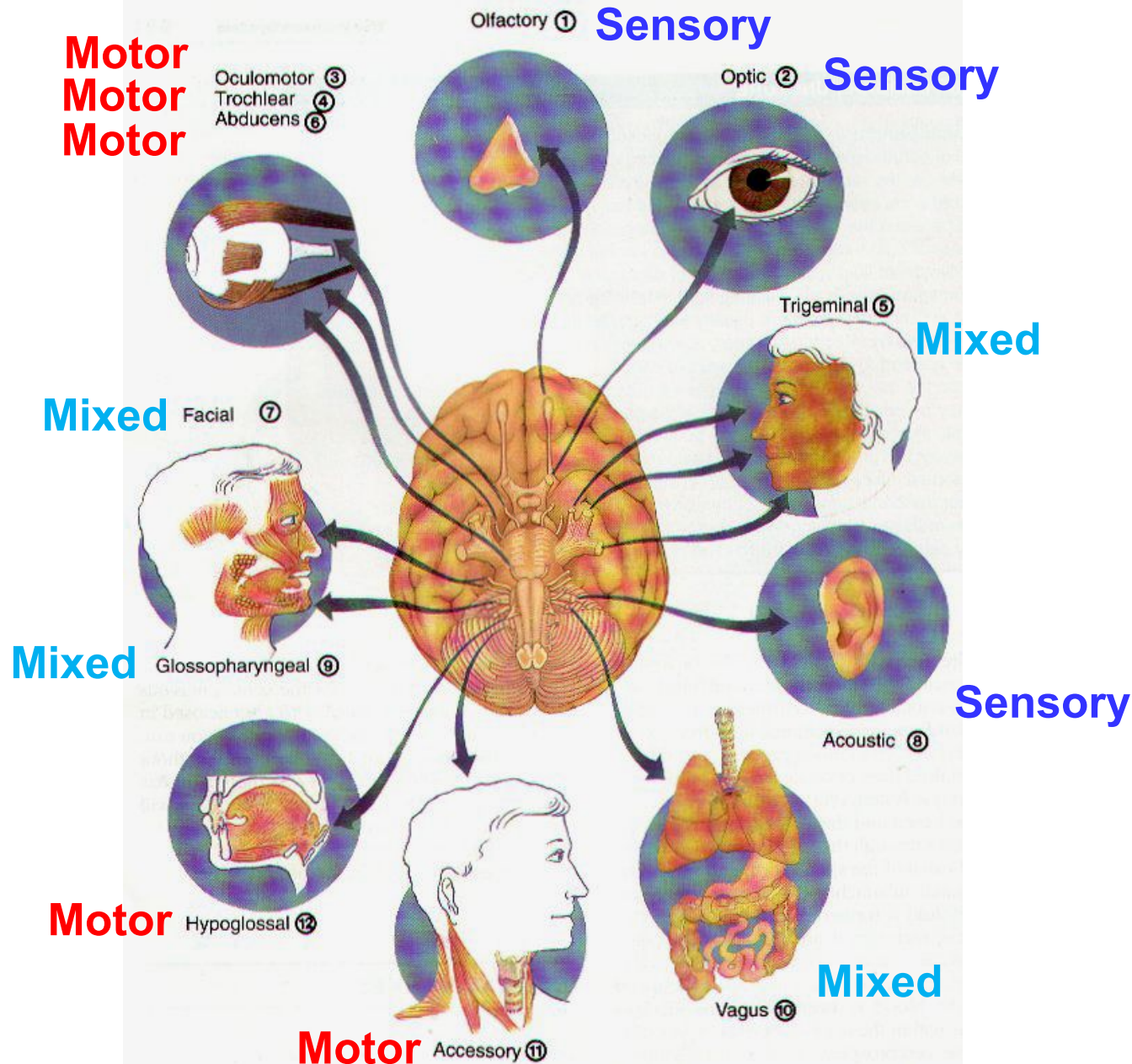


31 Pairs

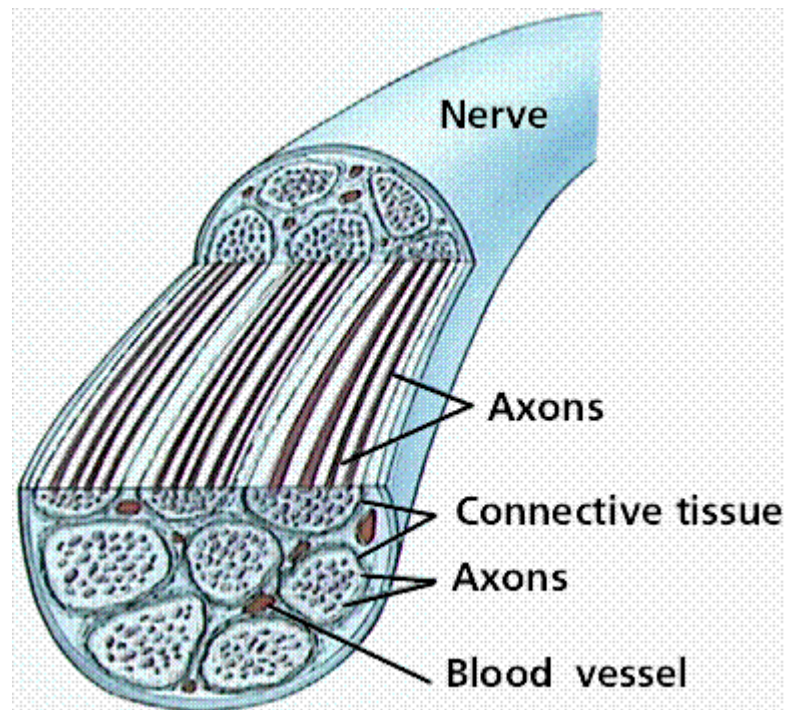
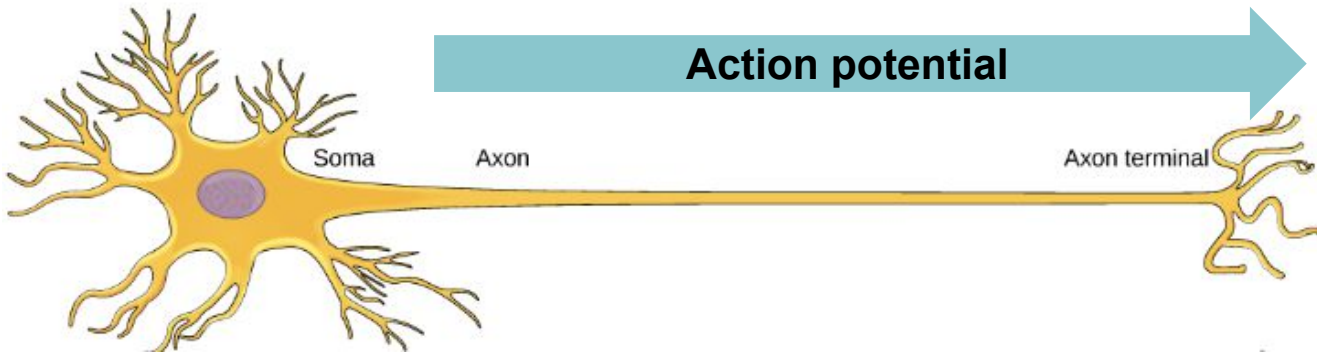


# Cranial Nerves

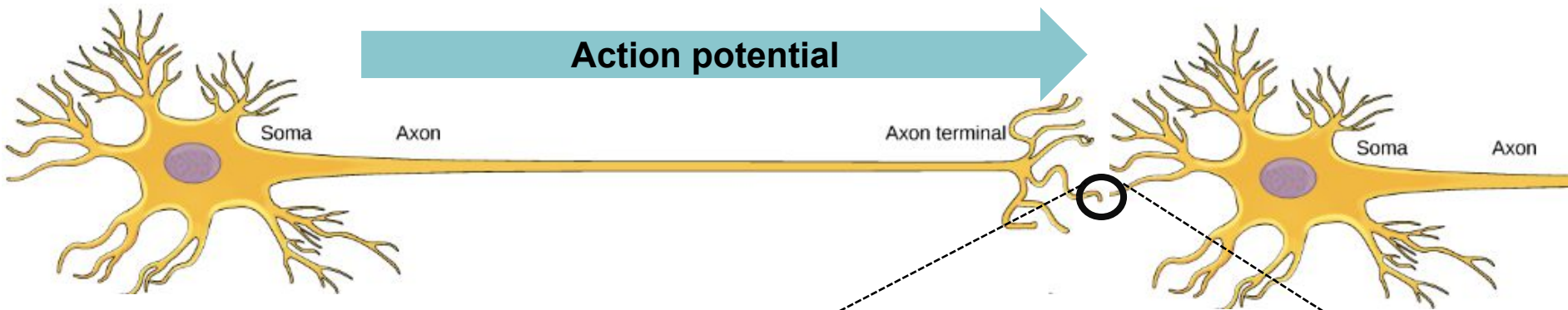
12 Pairs



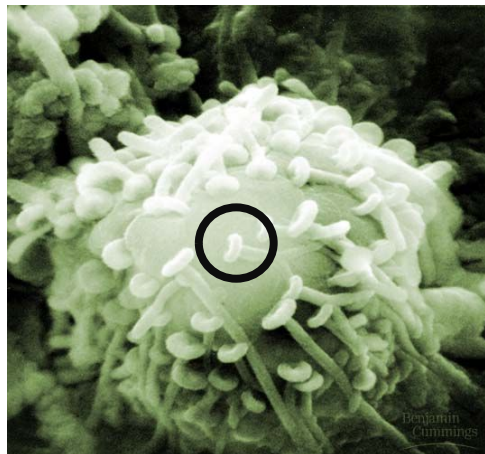
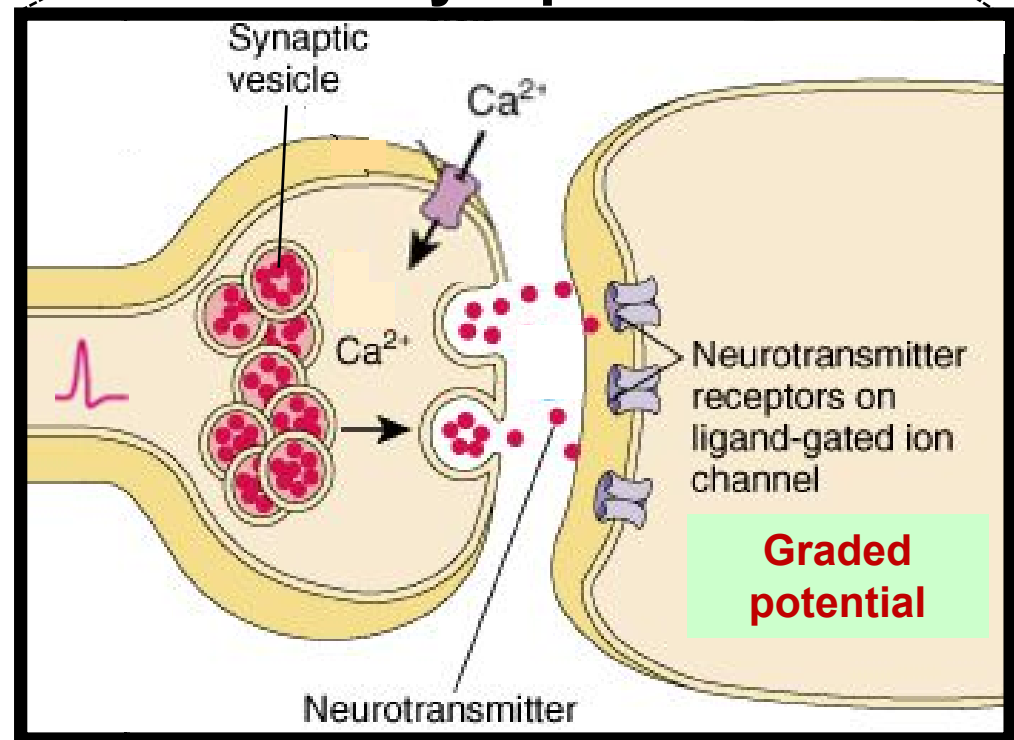
# A Nerve is a Bundle of Axons



# Synapses

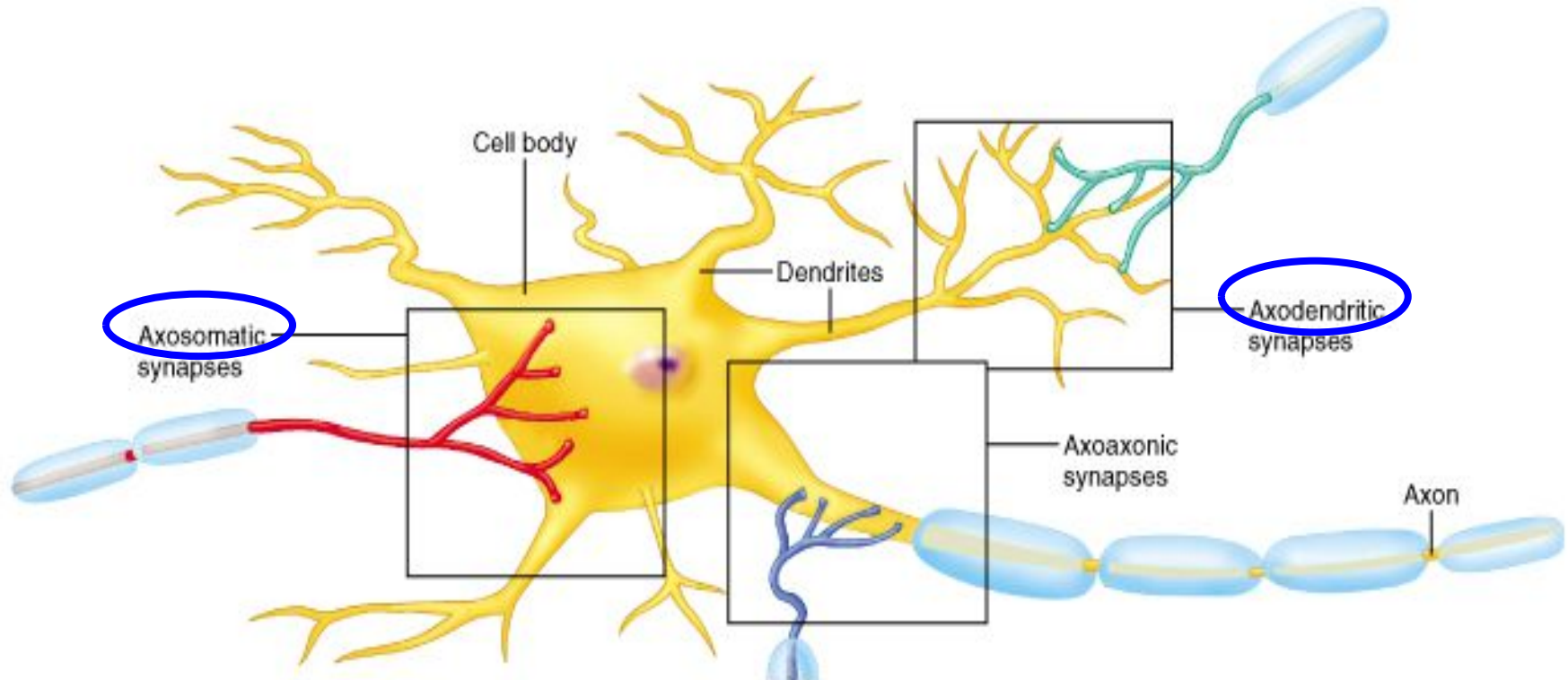


## Synapse



# Synapses

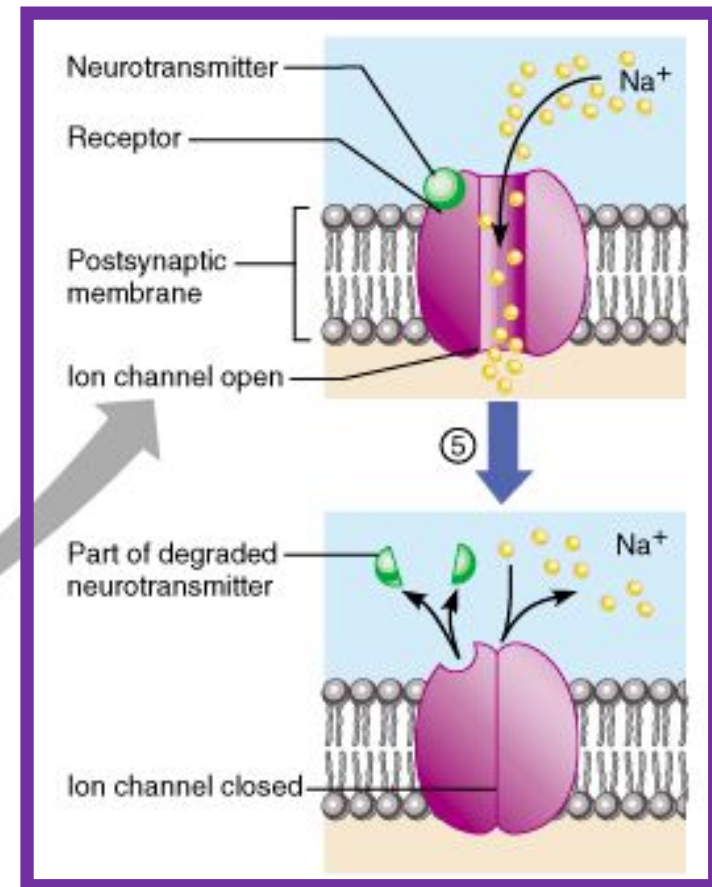
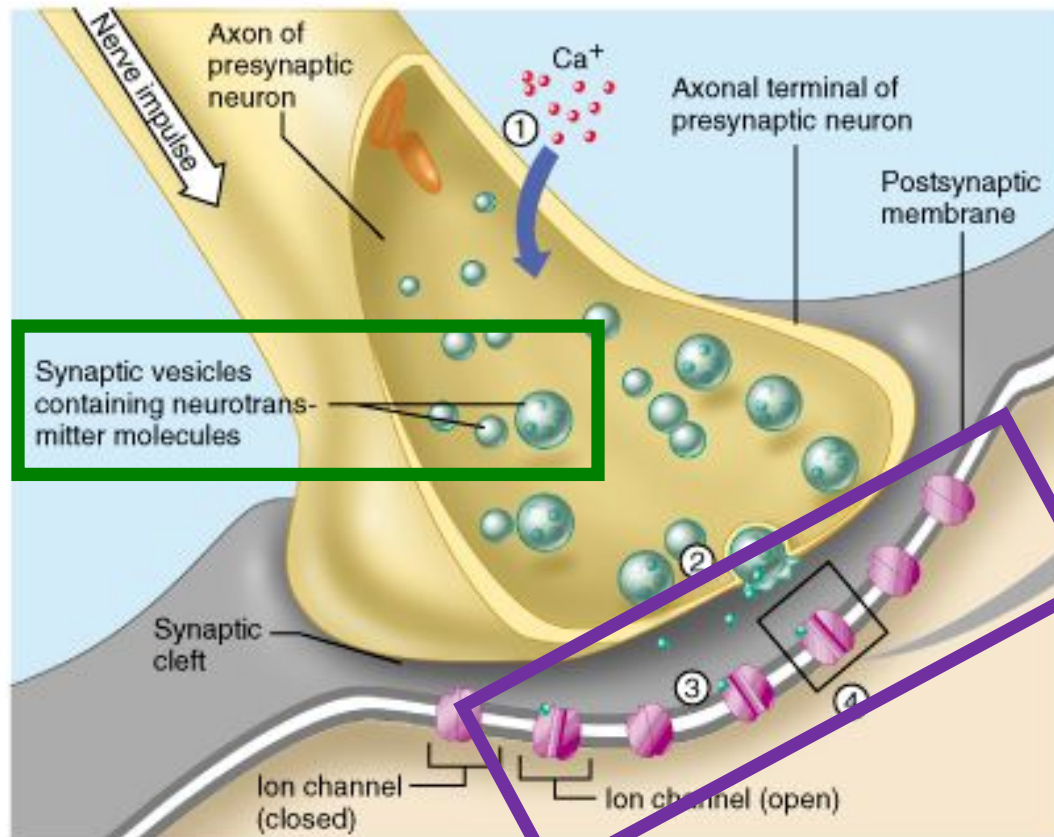
- **Junction** that mediates information transfer from one neuron:
  - to another neuron
  - to an effector cell (e.g. muscle cell)





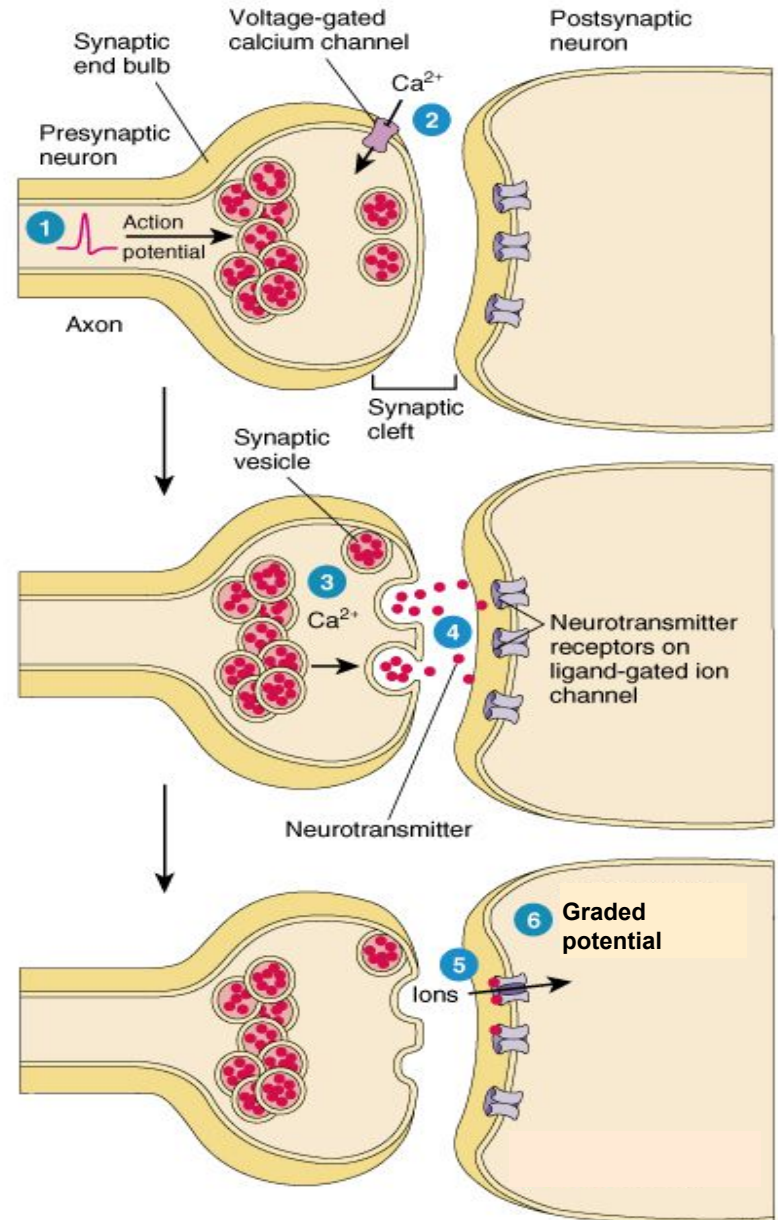
# Chemical Synapses

- **Synaptic cleft** between **presynaptic** & **postsynaptic** neurons
- Ensure **unidirectional communication** between neurons
  - Presynaptic terminal: Synaptic vesicles with neurotransmitter
  - Postsynaptic terminal: Receptors for neurotransmitter



# Information Transfer across Chemical Synapses

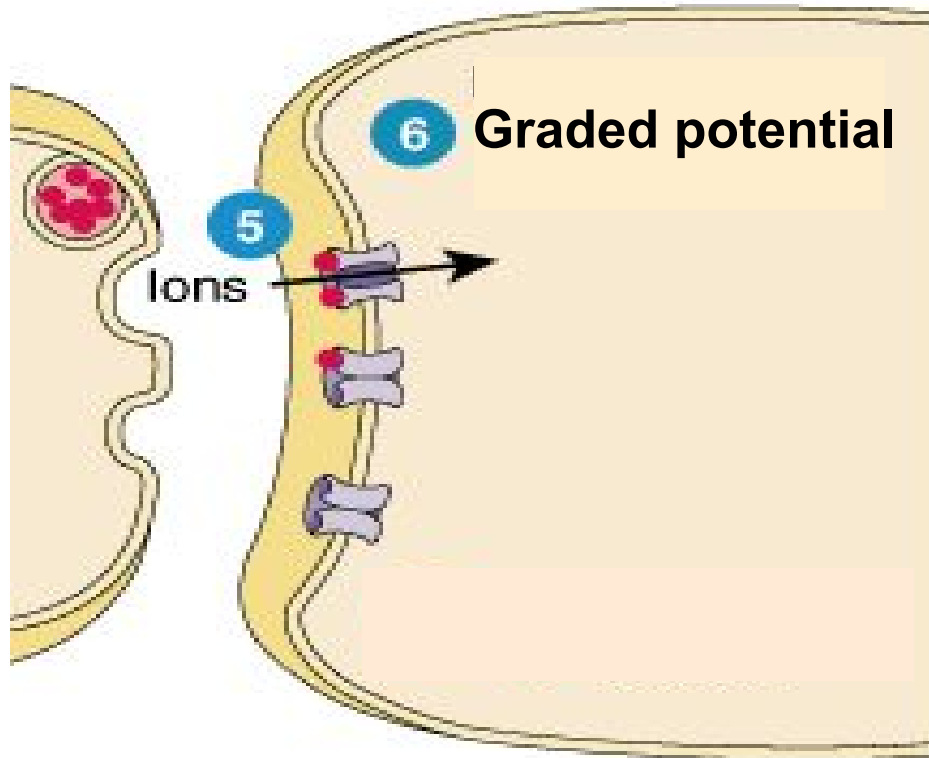
1. **Action potential** arrives at axon terminal
2. Voltage-gated  $\text{Ca}^{2+}$  channels open  $\rightarrow$   $\text{Ca}^{2+}$  influx
3.  $\text{Ca}^{2+}$  acts as a messenger
4. Neurotransmitter is released by exocytosis
5. Neurotransmitter diffuses across the synaptic cleft & binds to receptors  $\rightarrow$  Channels open  $\rightarrow$  Ion influx
6. **Graded potential** is generated



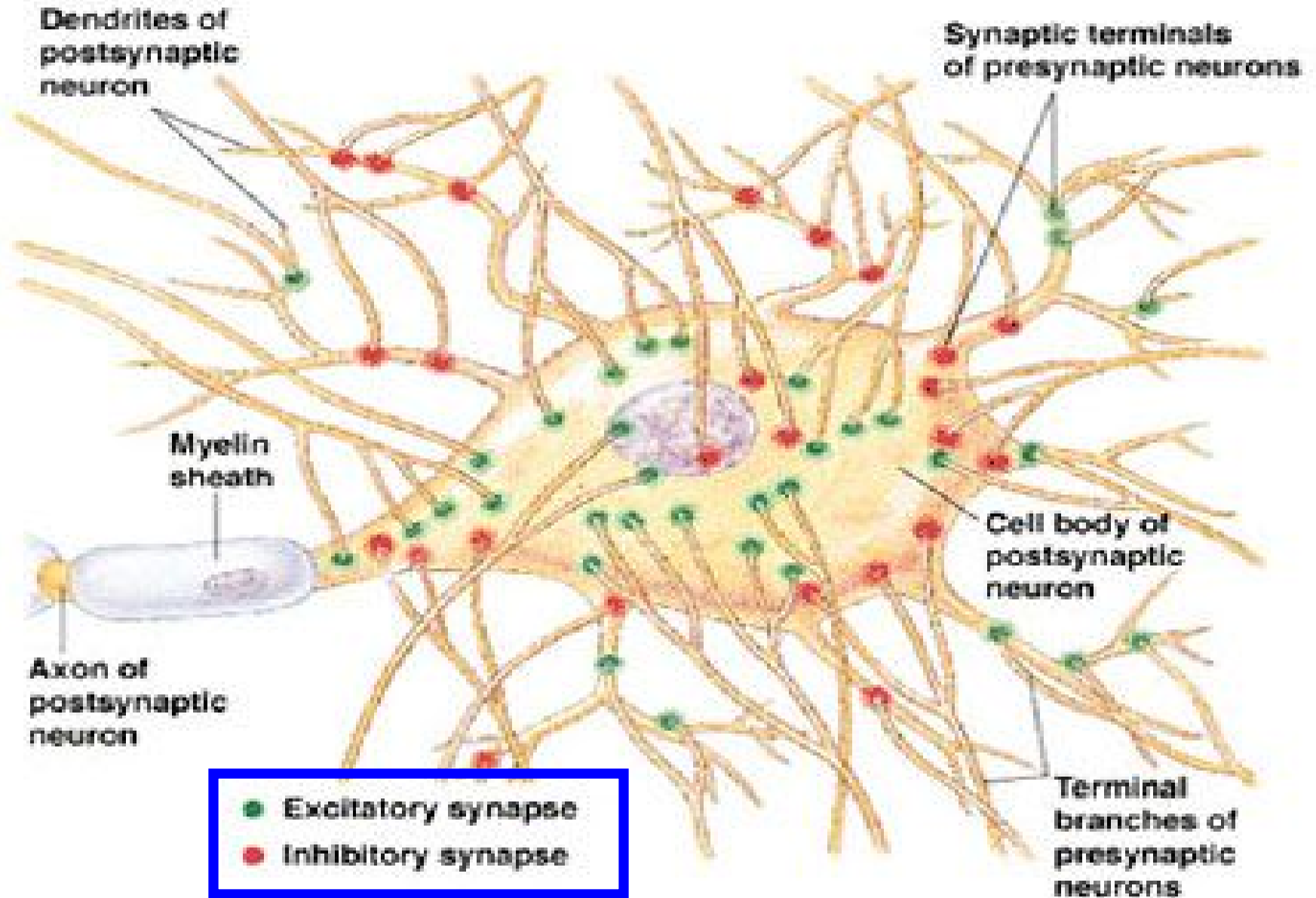
# Postsynaptic Potentials

2 types of **graded potentials**:

- **Excitatory** postsynaptic potentials (**EPSPs**)
- **Inhibitory** postsynaptic potentials (**IPSPs**)



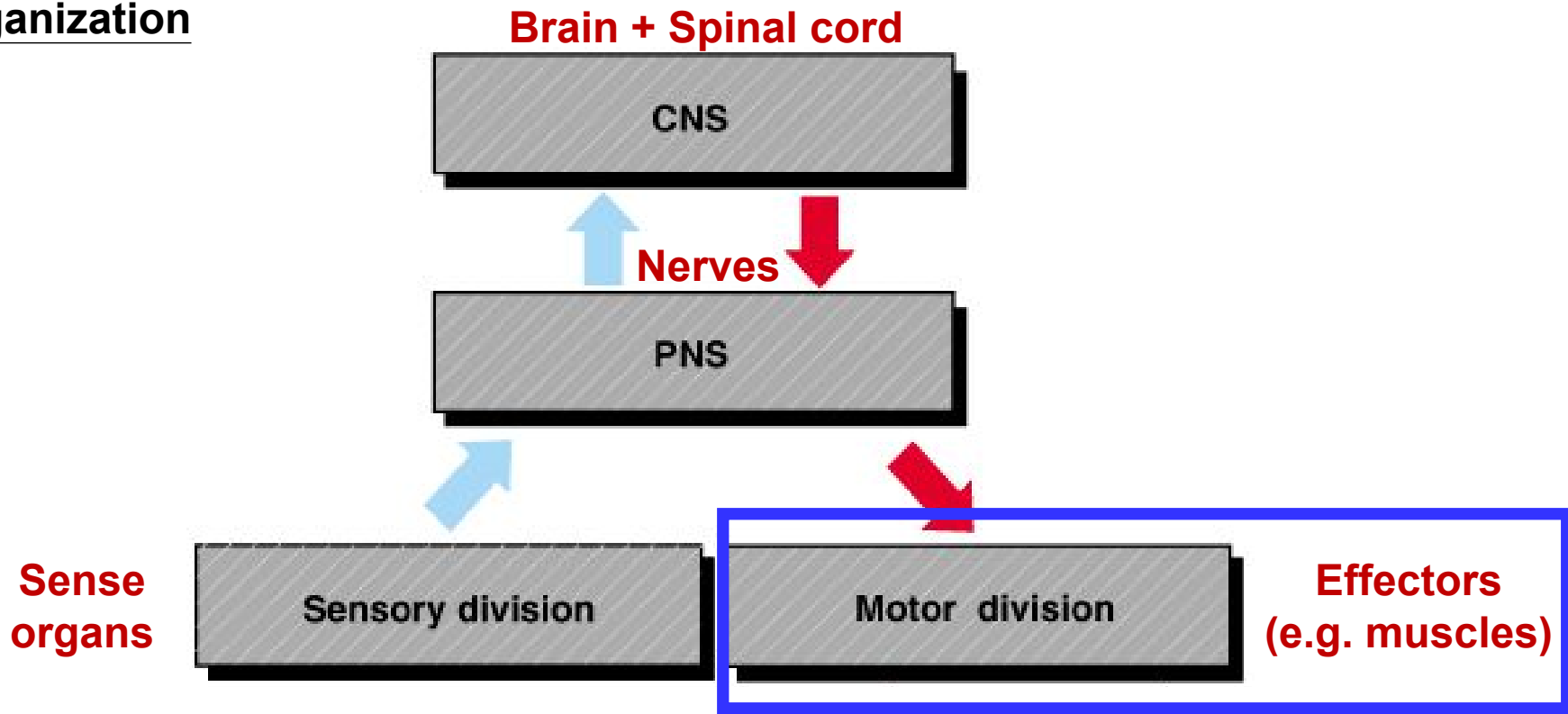
# Postsynaptic Potentials



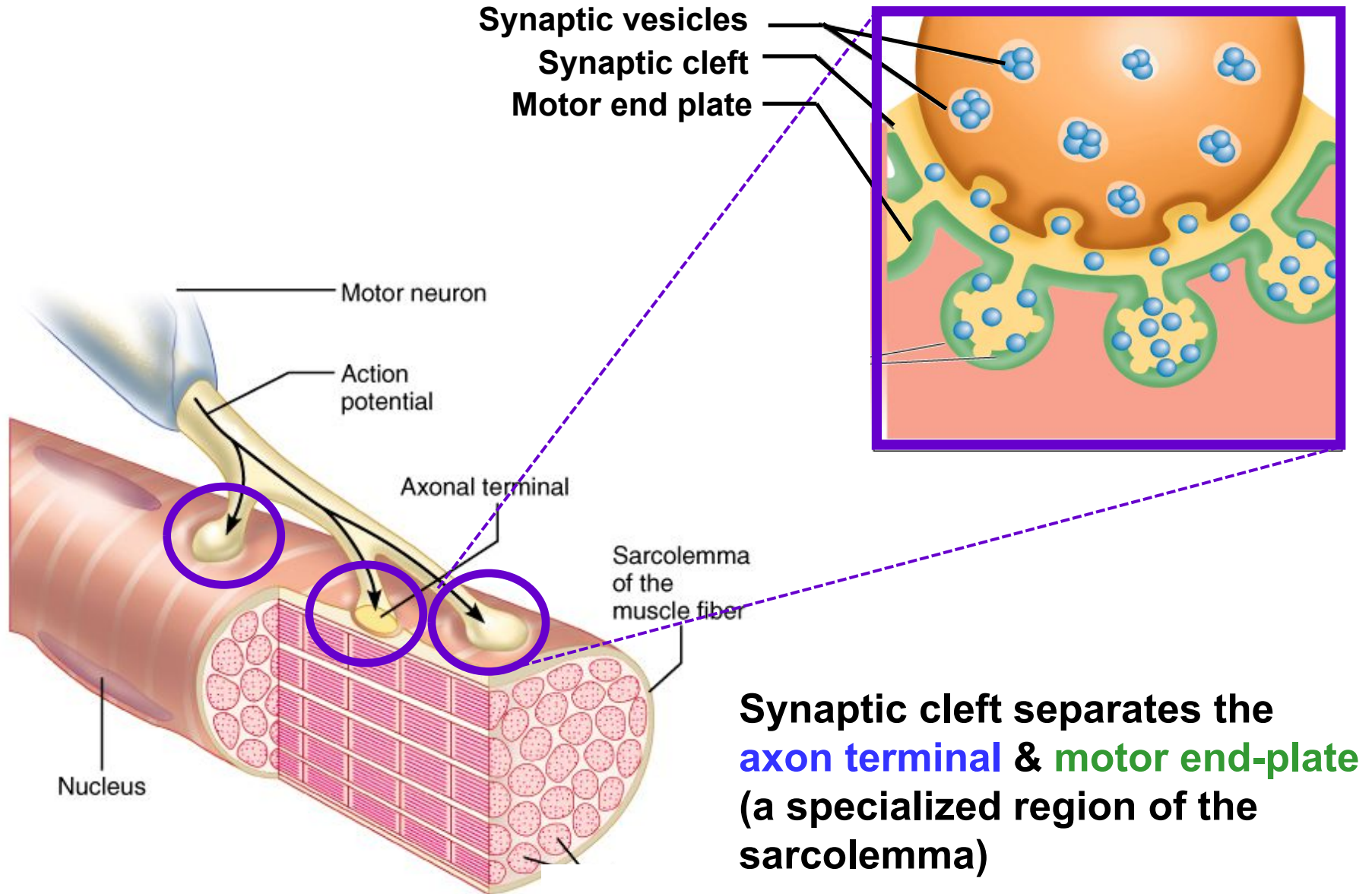


# Nervous System

## Organization



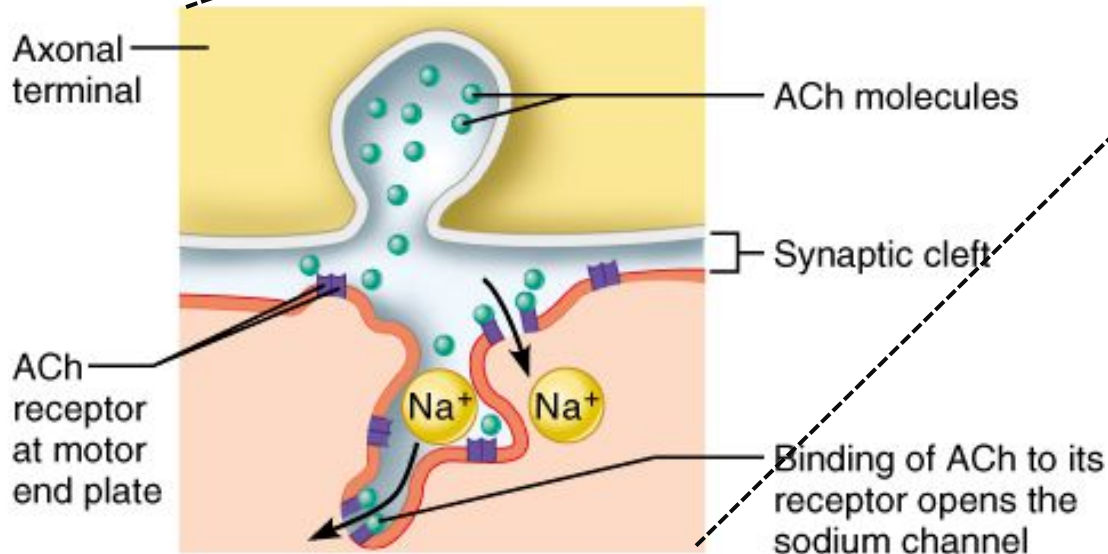
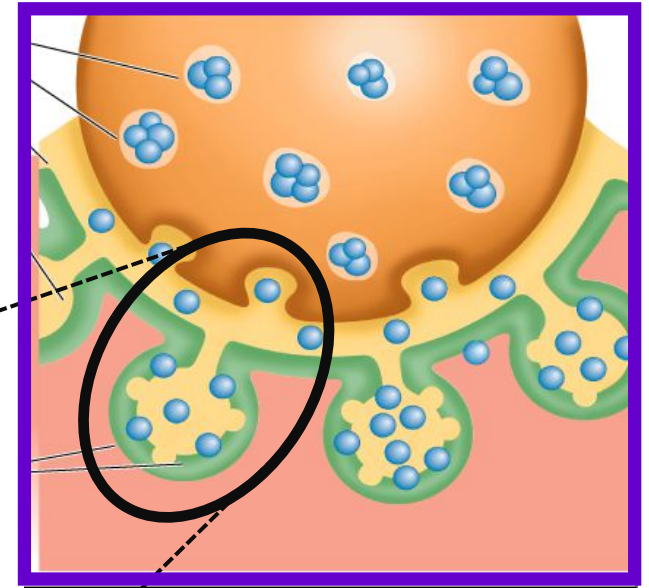
# Neuromuscular Junction



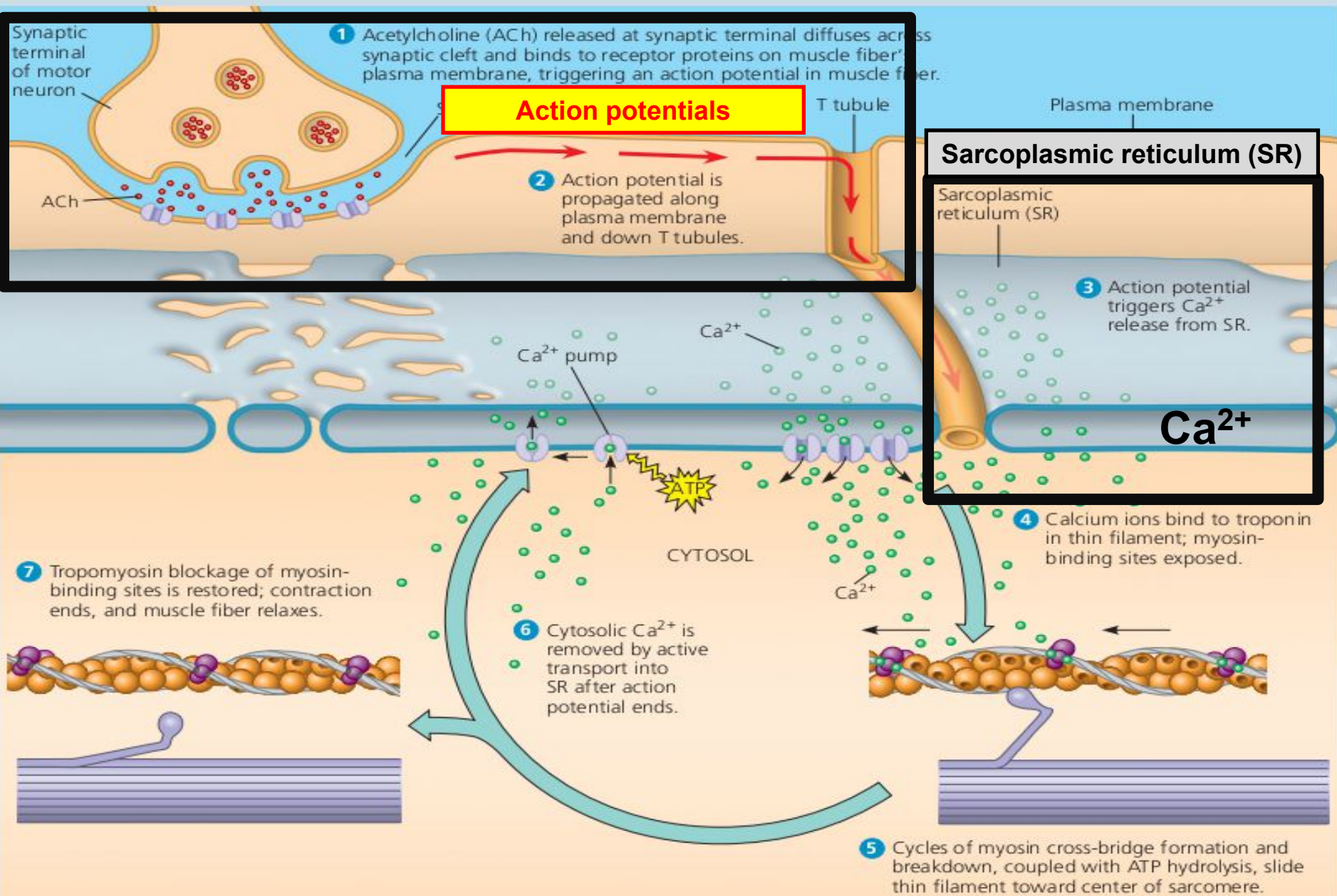
# Neuromuscular Junction

**Acetylcholine (ACh)** release from motor neuron

- Binding of ACh to **receptors** at motor end-plate
- $\text{Na}^+$  influx
- **End-plate potential** (depolarization)
- **Action potential** of muscle fiber



# Excitation-Contraction Coupling

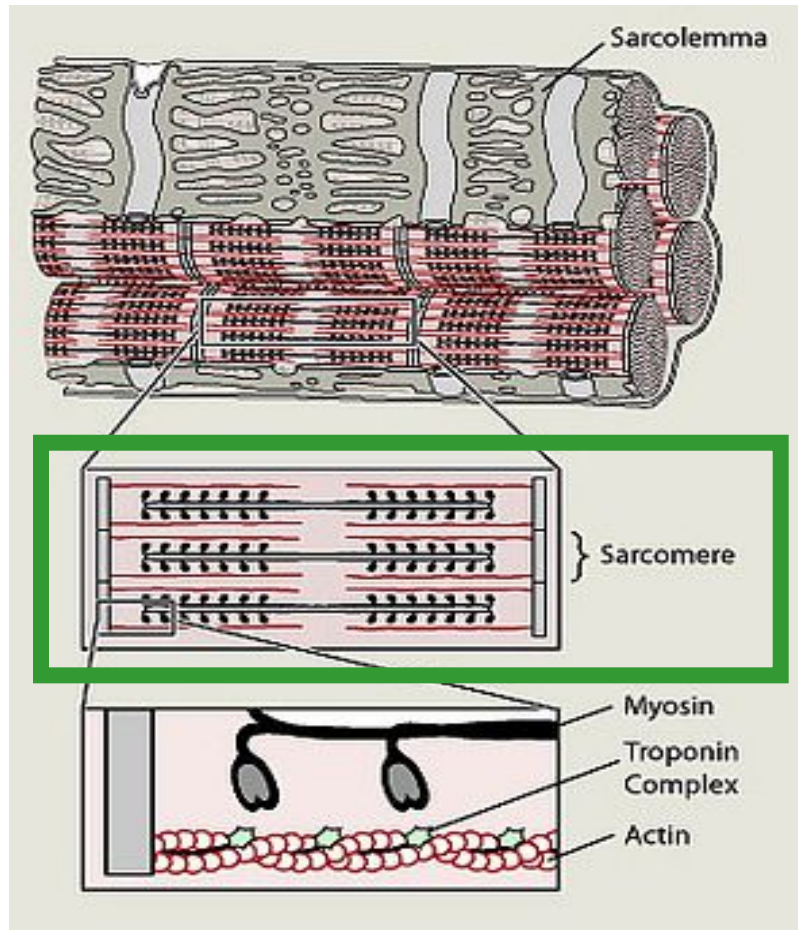




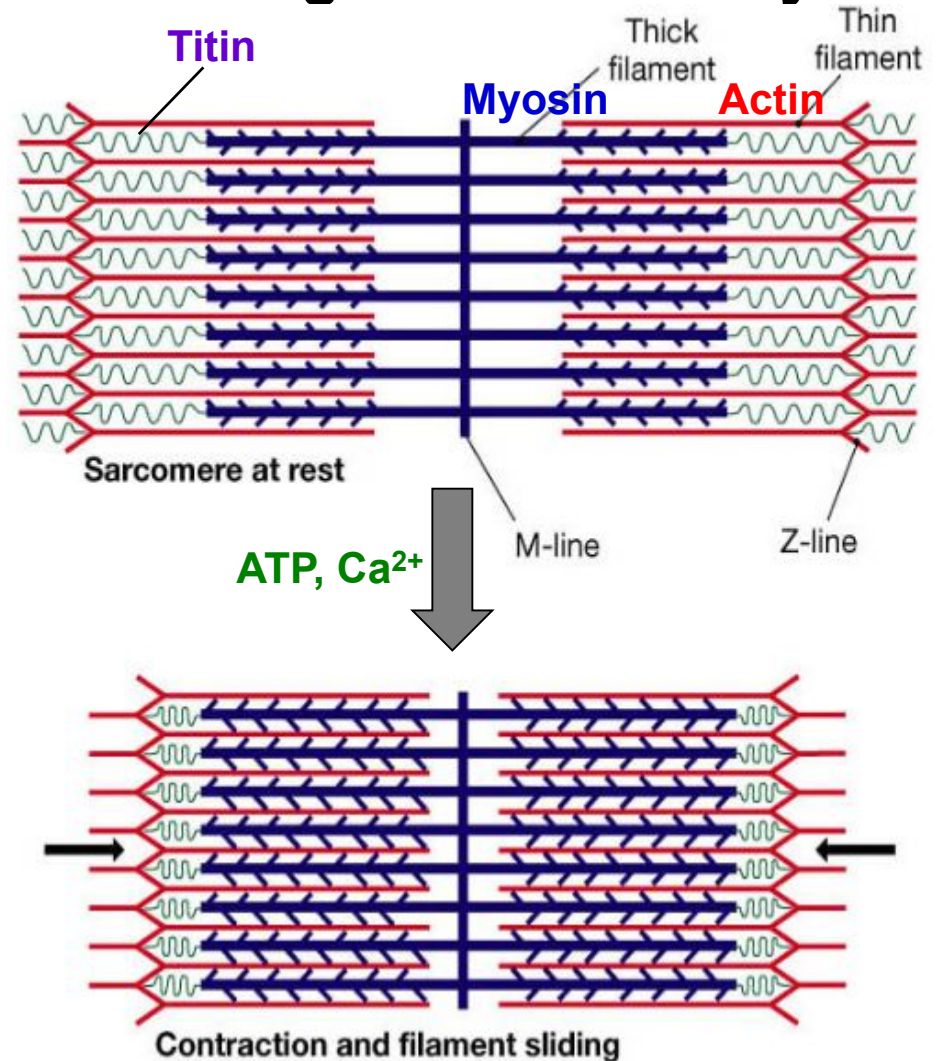
# Mechanism of Muscle Contraction

## Sarcomere:

Basic unit of a muscle



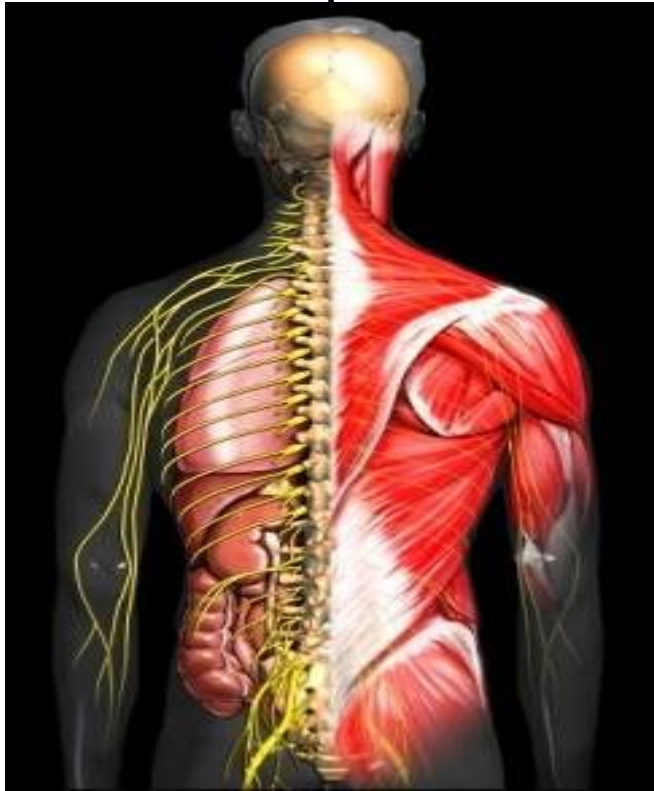
## Sliding filament theory



# Coordination & Response

**Nerves**

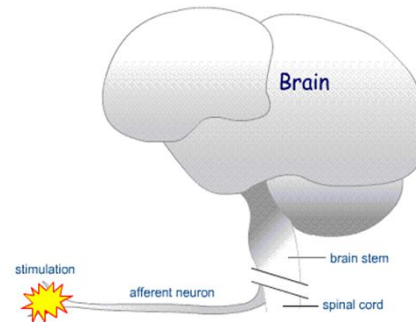
**Muscles**



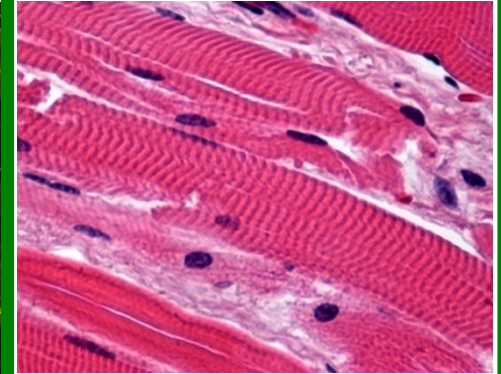
**Neurons**



**Signal transmission  
& processing**



**Myocytes**



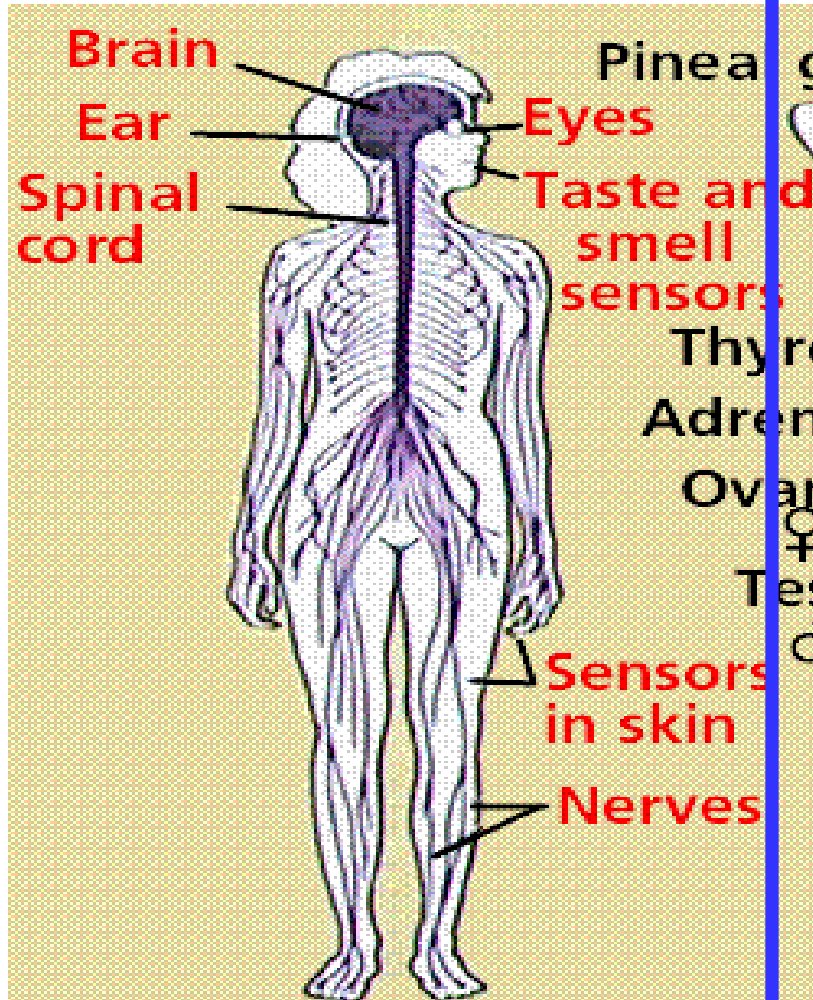
**Movement**



# Systems for Coordination

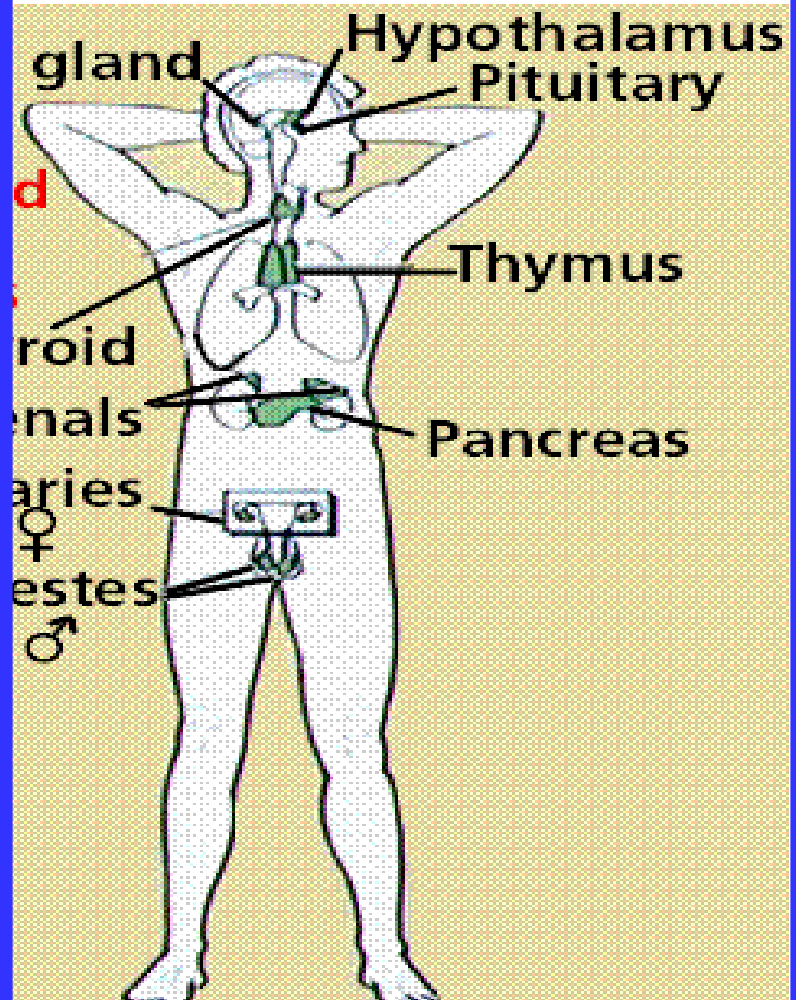
## Nervous System

**Faster**  
(electrical activity in nerves,  
neurotransmitters at synapses)



## Endocrine System

**Slower**  
(hormones in blood)



# Endocrine System

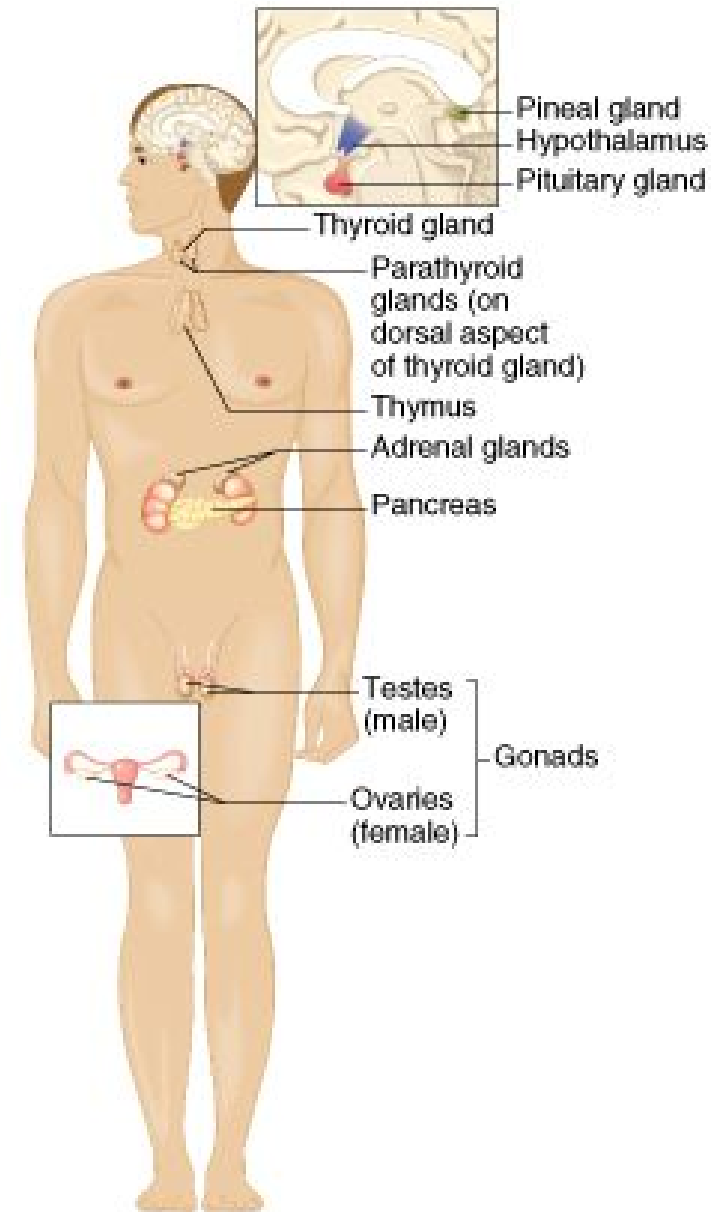
- Endocrine system influences metabolic activities of cells by means of hormones



# Endocrine Glands

## Major endocrine glands:

- Hypothalamus & pituitary
- Thyroid & parathyroid
- Adrenal glands & pancreas
- Pineal gland
- Gonads
  - Testes (male)
  - Ovaries (female)



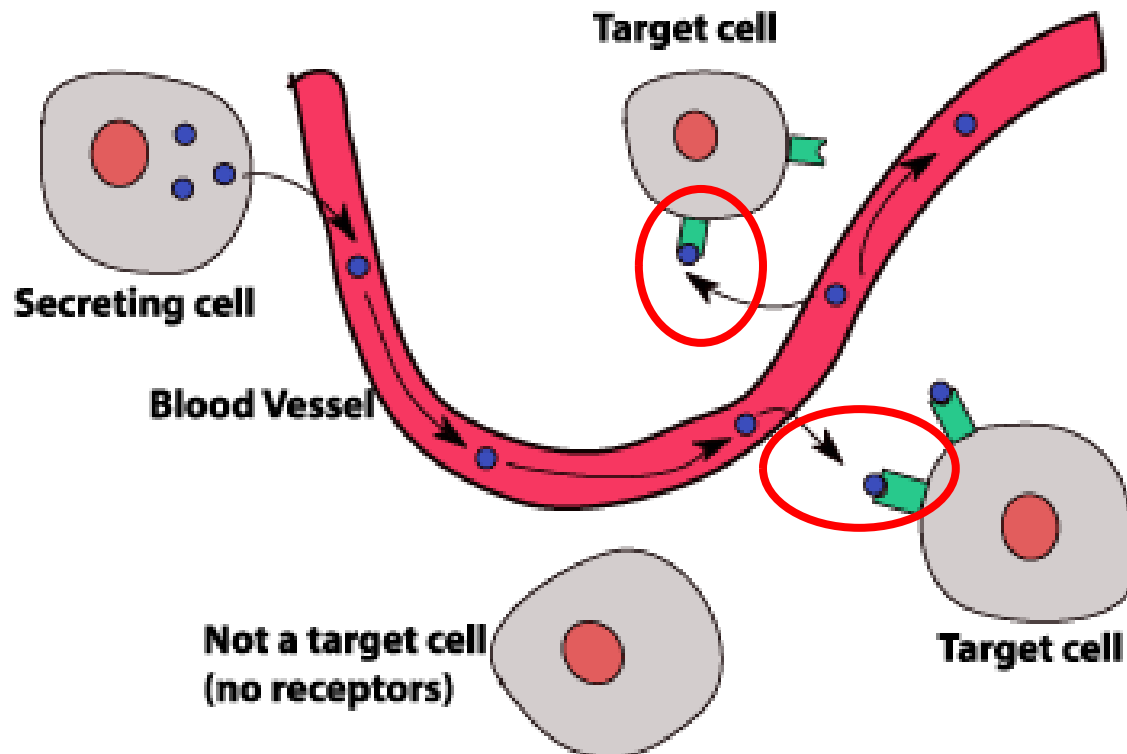
# Other Sites of Hormone Production

Other tissues & organs that produce hormones:

- Adipose cells (leptin)
- Small intestine (secretin, cholecystokinin)
- Stomach (gastrin)
- Kidneys (erythropoietin)
- Heart (atrial natriuretic peptide)

# Hormones

- Chemical substances **secreted by living cells**
- Released in small quantities **into blood** & delivered by circulation to a **specific site** of action
- **Regulate reactions** that elicit a typical **response**



# Mechanisms of Hormone Actions

Hormones produce one or more of following cellular changes:

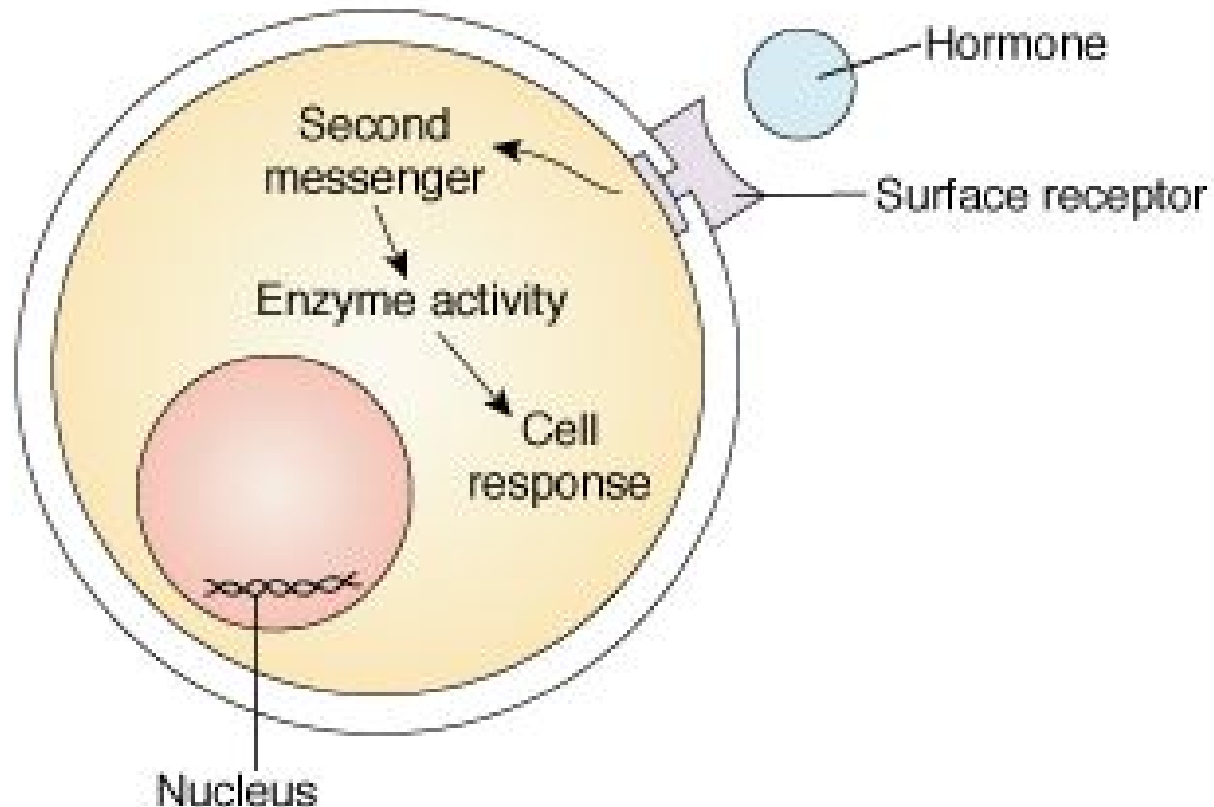
- Alter plasma membrane permeability
- Stimulate protein synthesis
- Activate or deactivate enzyme systems
- Induce secretory activity
- Stimulate mitosis



# Mechanisms of Hormone Actions

## Amino Acid–Based Hormone Action

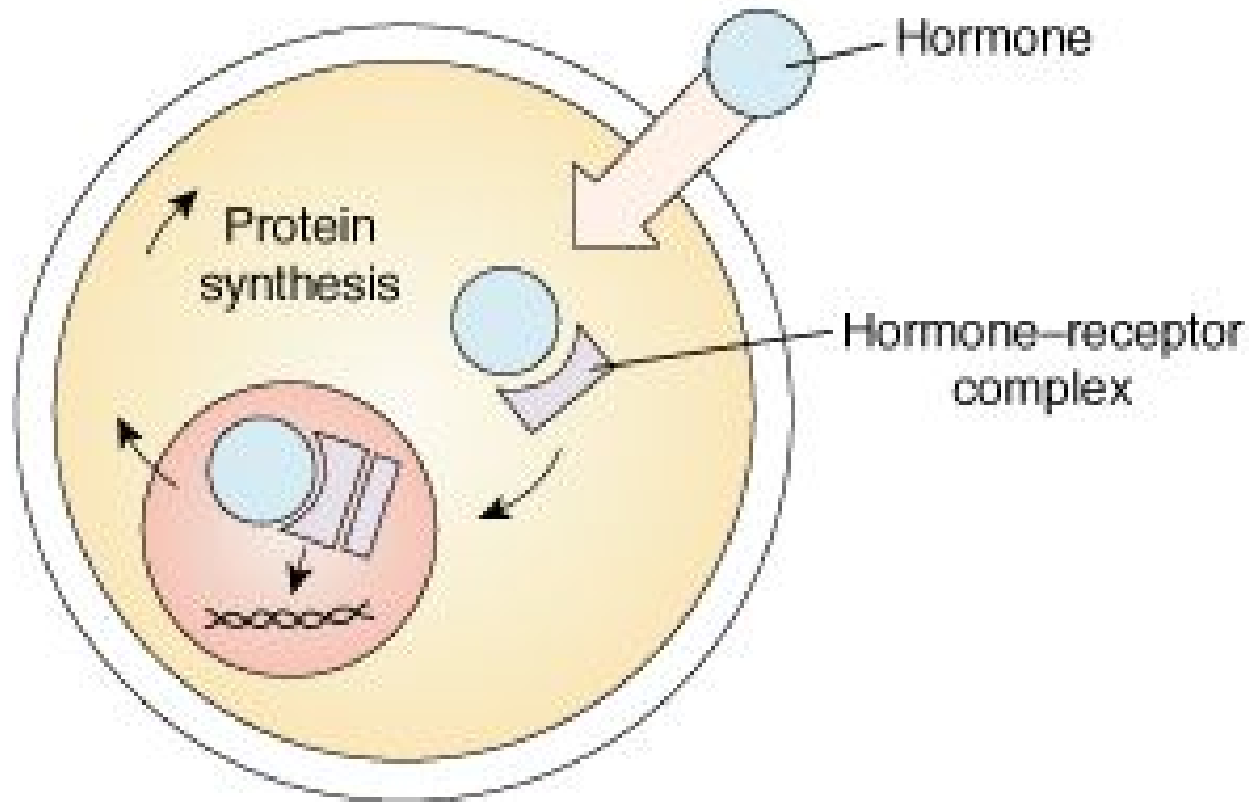
- Bind to a specific membrane receptor of cells to elicits specific cellular response (via second messengers)



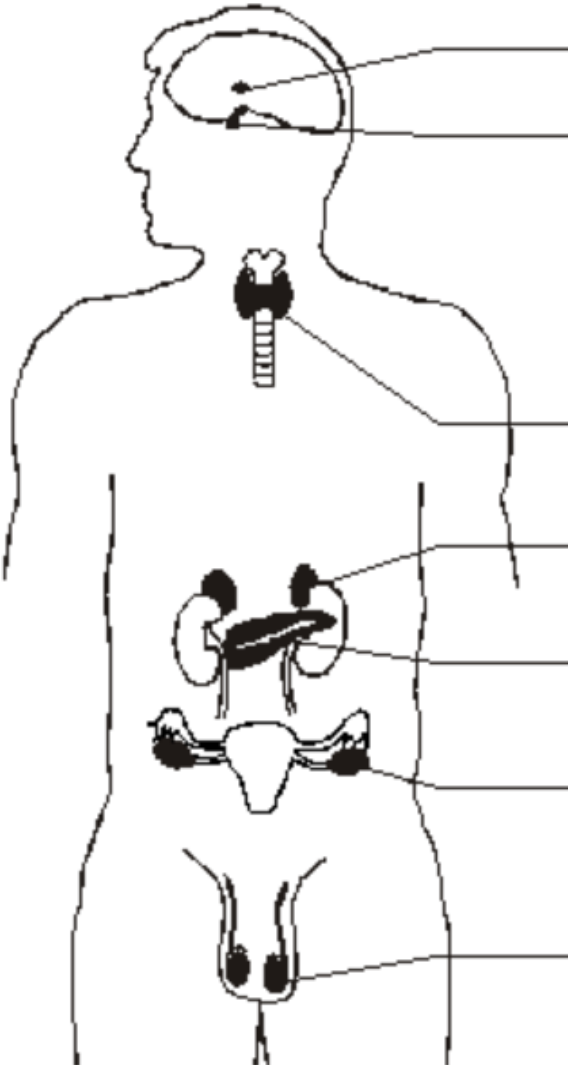
# Mechanisms of Hormone Actions

## Steroid Hormone Action

- Enter the cell & activate genes, leading to formation of intracellular proteins that initiate specific functions



# Functions of Major Endocrine Glands



Gland	Hormone	Target organ	Function
Pineal gland	melatonin	many	biological clock
Pituitary gland	FSH LH ADH growth hormone oxytocin prolactin	ovaries ovaries kidneys many uterus mammary glands	menstrual cycle menstrual cycle water homeostasis stimulates cell division birth contractions milk production
Thyroid gland	thyroxine	liver	metabolic rate
Adrenal glands	adrenaline cortisol	many many	fight or flight anti-stress
Pancreas	insulin glucagon	liver liver	glucose homeostasis glucose homeostasis
Ovaries	oestrogen progesterone	uterus uterus	menstrual cycle menstrual cycle
Testes	testosterone	many	male characteristics



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