2

The regulatory role of nervous system

Cellular base of nervous system

What is nervous system good for?

The regulatory role of nervous system

Unicellular organism

Multicellular organism

The regulatory role of nervous system

Unicellular organism

- One cell has to do everything- lower effectivity
- Total dependence on environment

Multicellular organism

- Functional specialization of particular cells – higher effectivity
- Inner environment – homeostasis

The regulatory role of nervous system

Unicellular organism

- One cell has to do everything- lower effectivity
- Total dependence on environment
- High level of stress
- Short life time

Multicellular organism

- Functional specialization of particular cells – higher effectivity
- Inner environment – homeostasis
- Lower level of stress
- Longer life time

The role of nervous system

- Essentials for survival of multicellular organism
  - To maintain homeostatis
  - To coordinate bodily functions

The role of nervous system

- Essentials for survival of multicellular organism
  - To maintain homeostatis
  - To coordinate bodily functions

- Maintaining homeostasis
  - The composition of inner environment
  - The integrity of organ/ bodily barriers

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- Esseantials for coordination of bodily functions
  - To receive signals from outer and inner environment
  - To process this information
  - To respond in a coordinate manner to these stimuli

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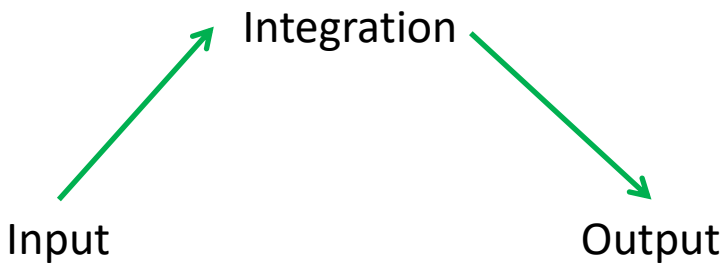

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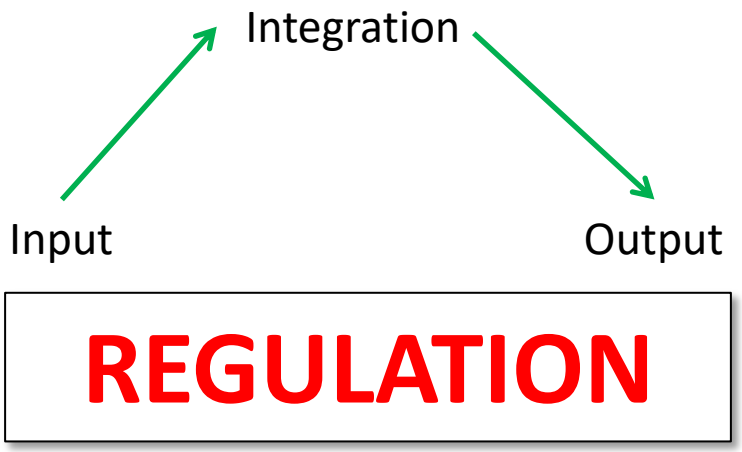

The role of nervous system

- Regulation
  - Nervous
  - Humoral

The role of nervous system

- Regulation
  - Nervous
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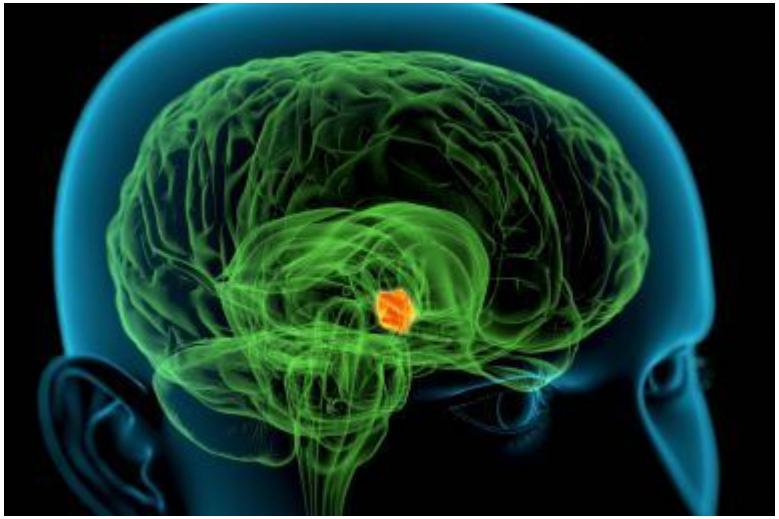


http://biology.about.com/od/anatomy/p/Hypothalamus.htm

Central nervous systém control/influence all the types of regulations

The role of nervous system

Humoral regulations

- Chemical compounds
- Non-specific channel of conduction (blood stream)
- Target site defined by specific receptor

Nervous regylations

- Neurtransmitters
- Specific channel of conduction
- Target site defined by infrastructure

The role of nervous system

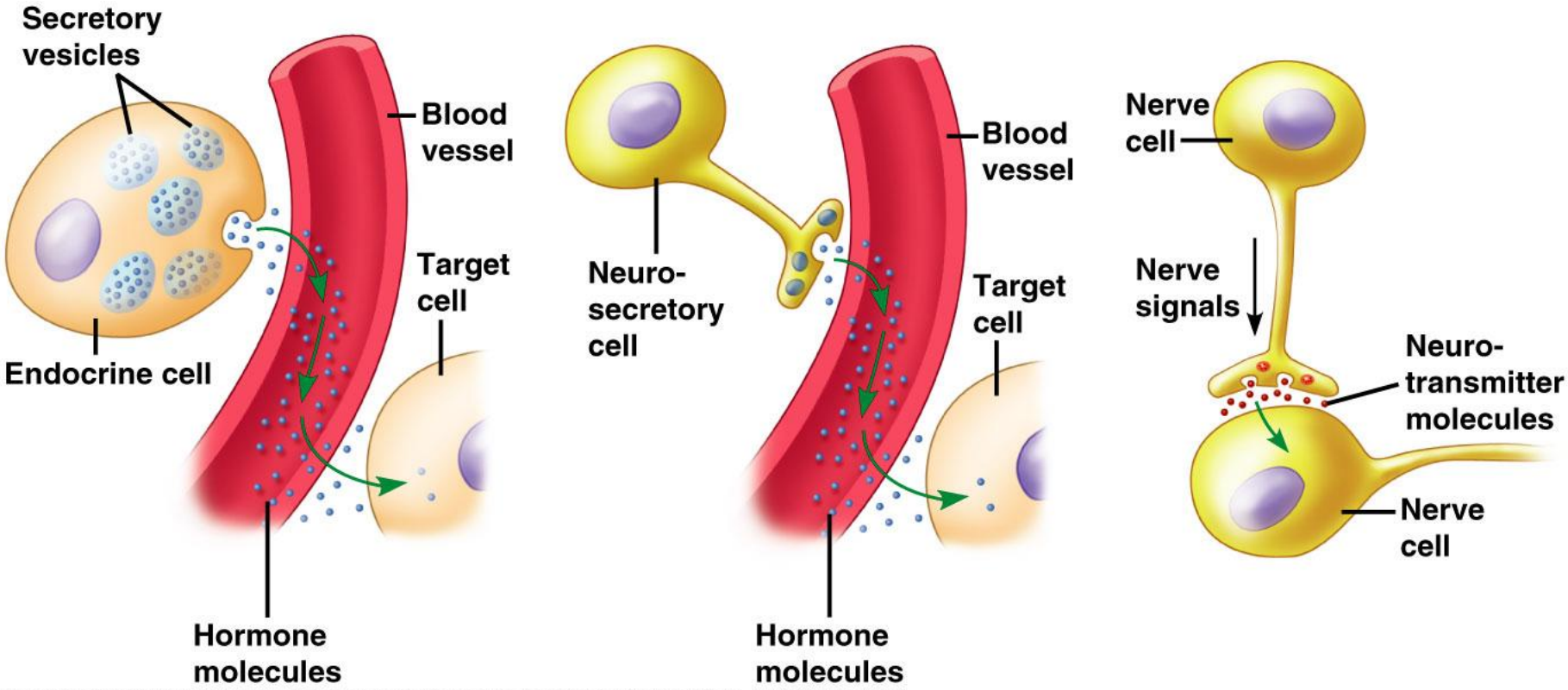
Humoral regulations

- Chemical compounds
- Non-specific channel of conduction (blood stream)
- Target site defined by specific receptor
- Low energetical demands
- Slow speed
- Long duration

Nervous regylations

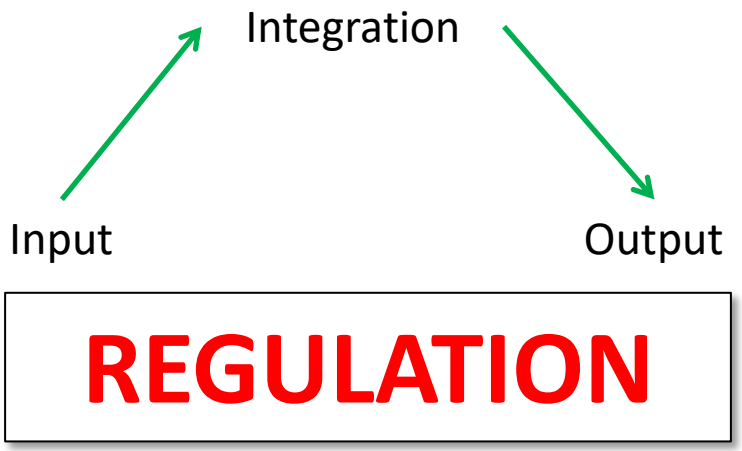
- Neurtransmitters
- Specific channel of conduction
- Target site defined by infrastructure
- High energetical demands
- Fast speed
- Short duration

Hormonal and nervous regulations

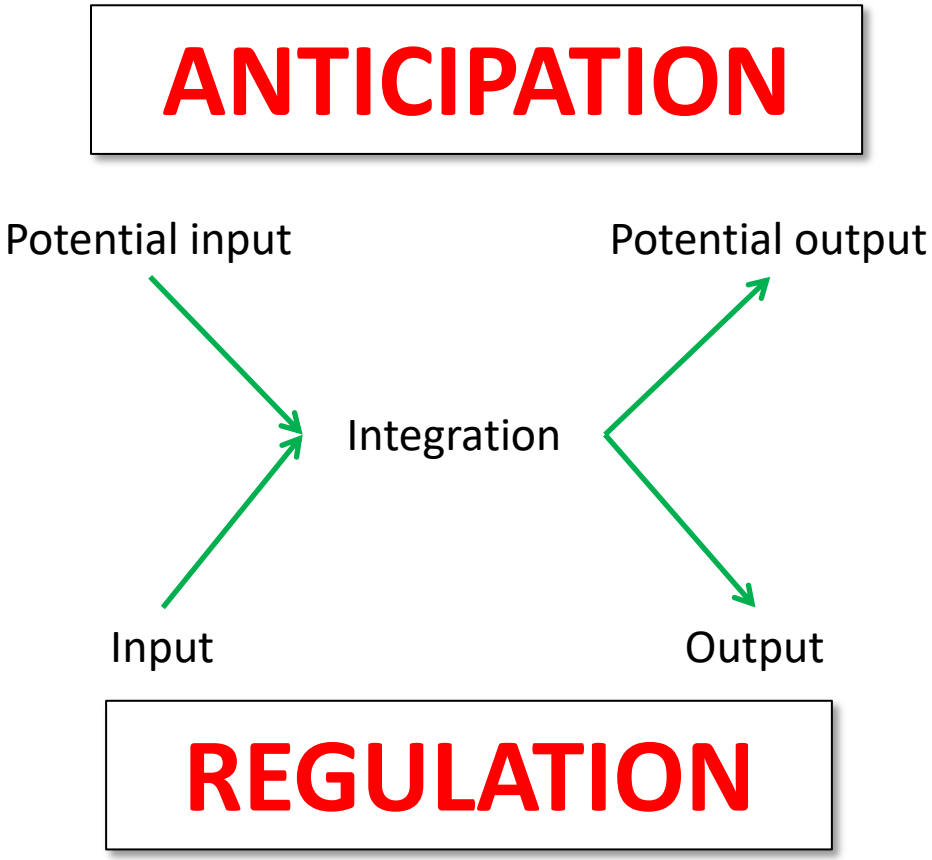


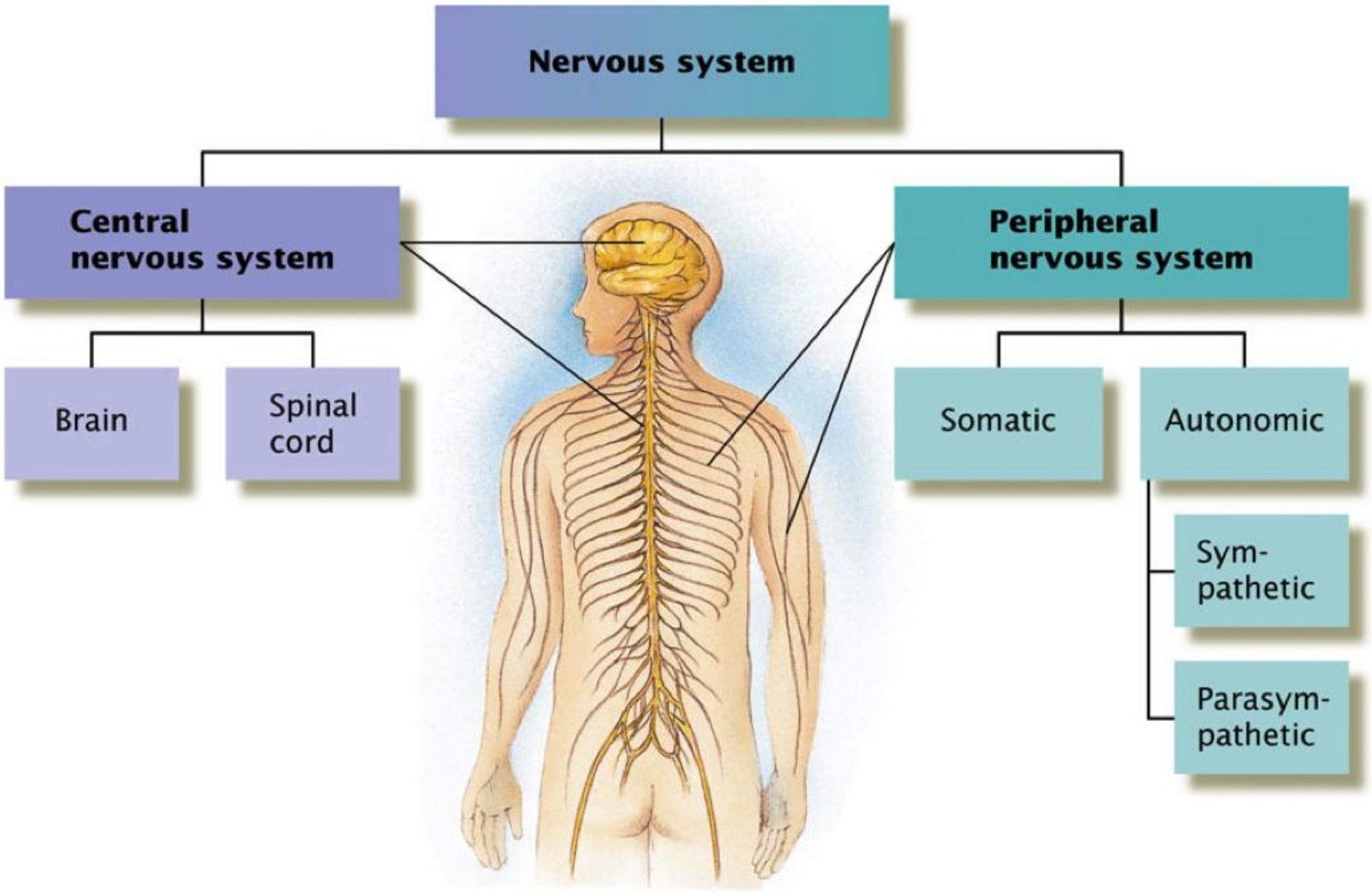
http://www.austincc.edu/

The role of nervous system



The role of nervous system





https://userscontent2.emaze.com/images/be175f0a-afae-4d7c-944c-f6376cf09fba/60c3e8a3-a6b9-4a3d-943d-1841136a9ccf.png

Compartmentalization

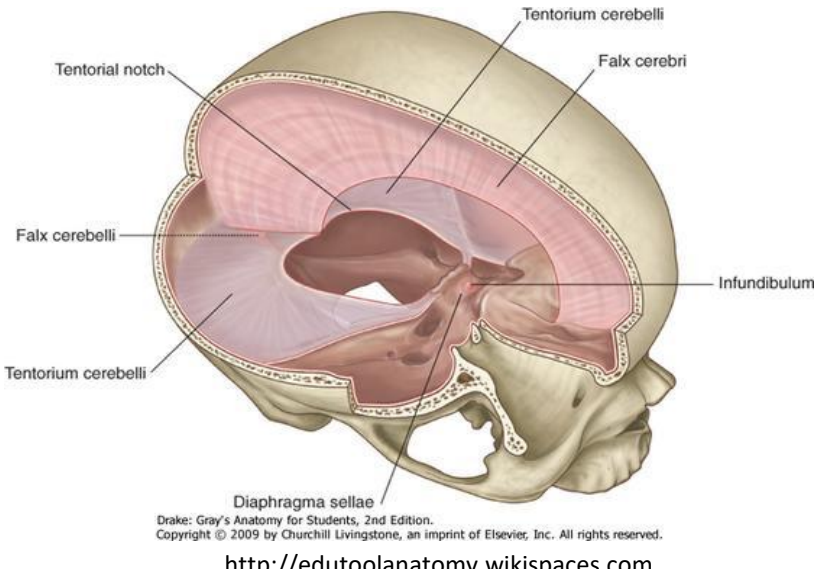
- Cellular specialization leads to compartmentalization on several levels
  - Tissue level
  - Organ level
  - Organ system level

Compartmentalization

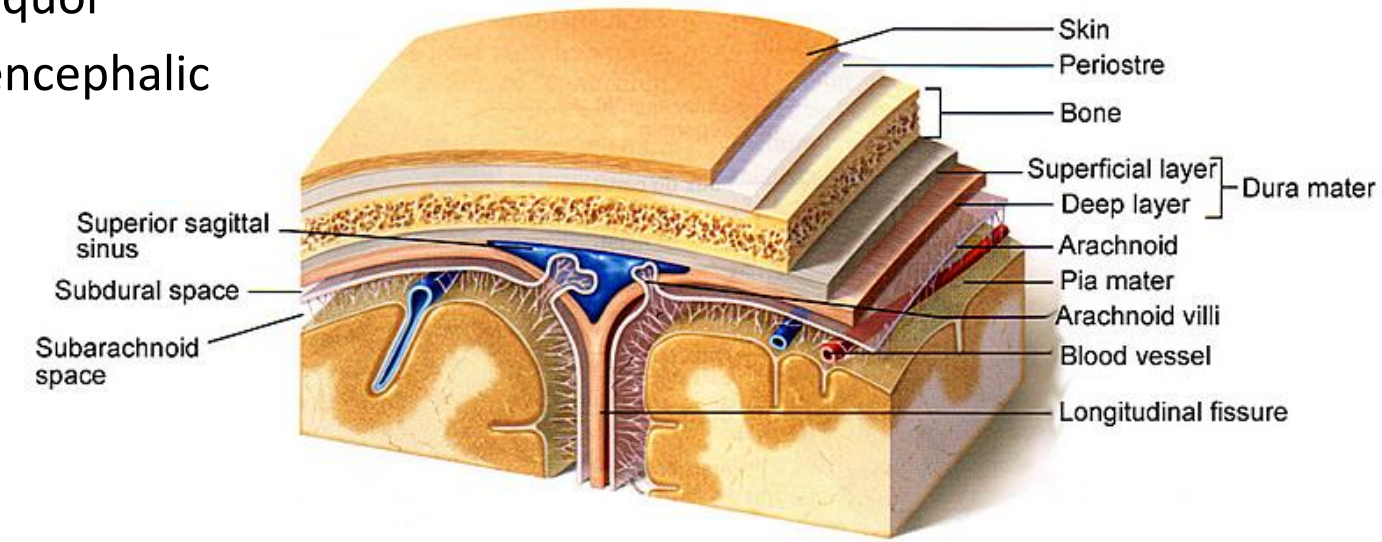
- Cellular specialization leads to compartmentalization on several levels
  - Tissue level
  - Organ level
  - Organ system level
- There are barriers in between compartments
- Properties/content may vary among different compartments

Intracranial compartment

- Brain
- Cerebrospinal fluid
- Blood (intravasculary)
- Barriers
  - Meningeal
  - Hematoliquor
  - Hematoencephalic

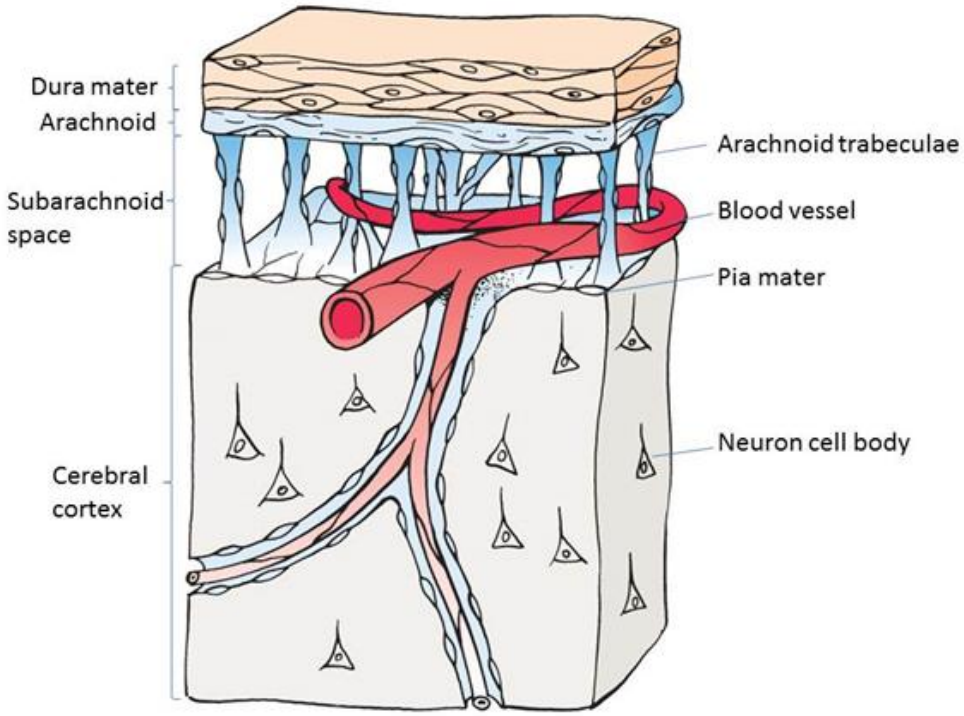


http://edutoolanatomy.wikispaces.com



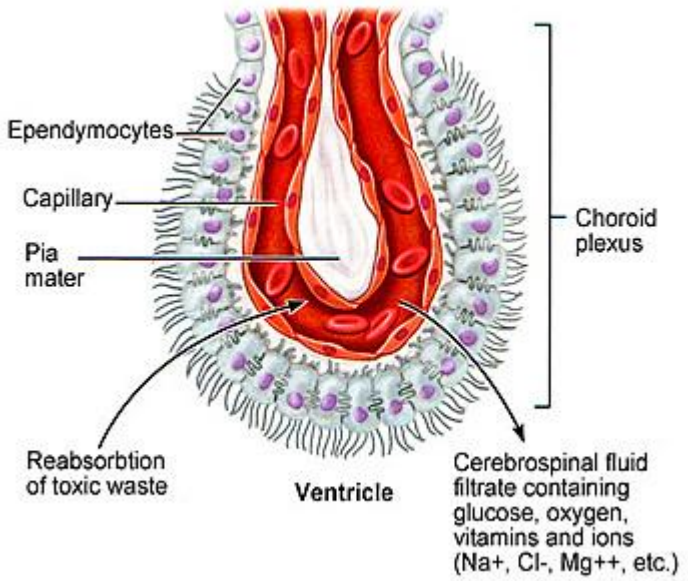
http://www.corpshumain.ca/en/Cerveau3_en.php

Meningeal and hematoliquor barrier



Adopted from: M.H.Ross and W. Pawlina. Histology: a text and atlas, *Lippincott Williams & Wilkins*, 2011

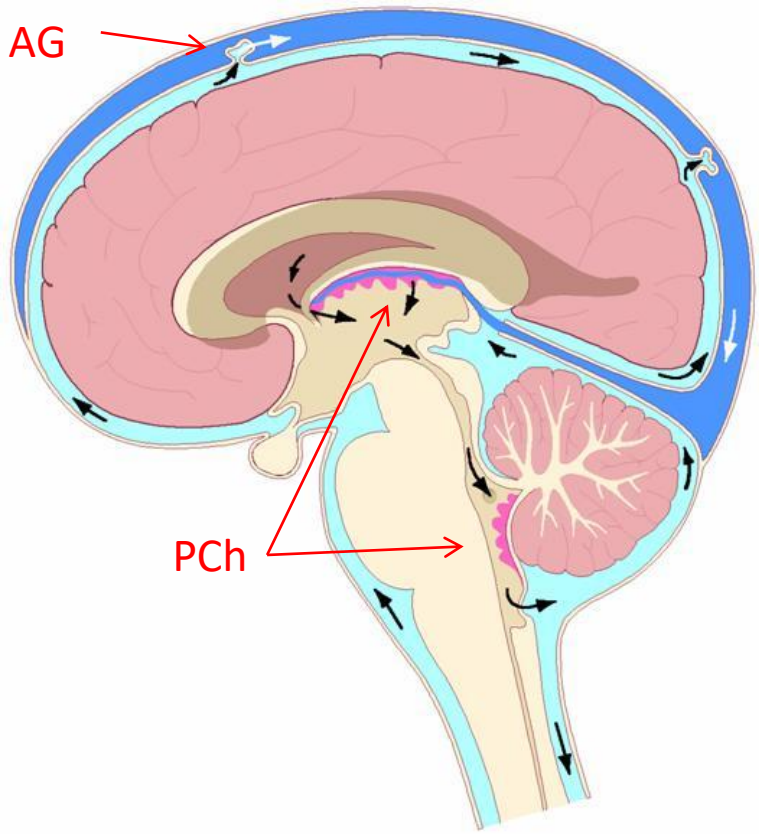
https://sisu.ut.ee/histology/meninges



https://sisu.ut.ee/histology/meninges

Cerebrospinal fluid

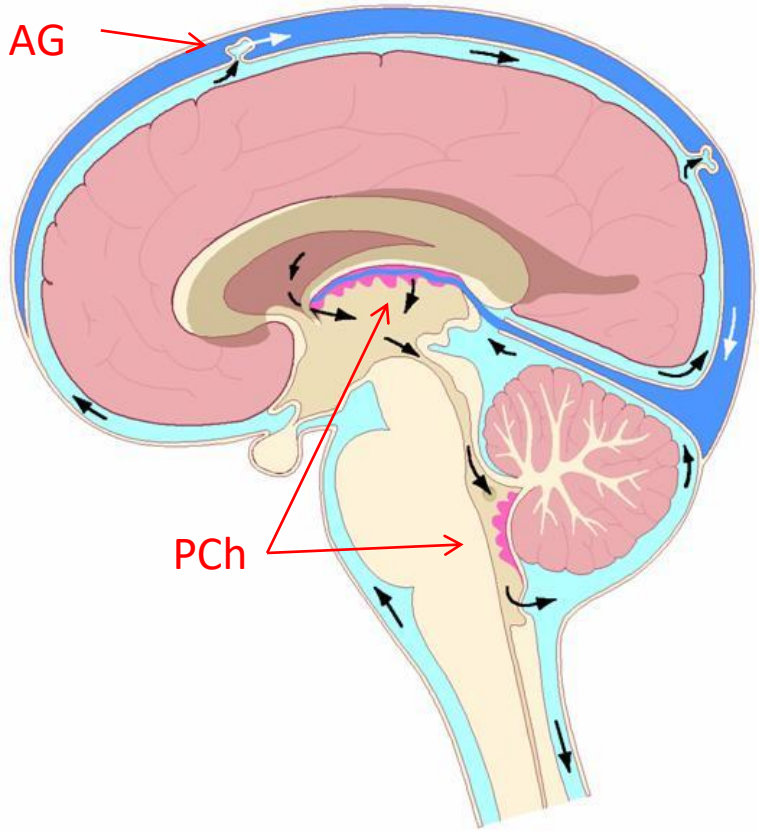
- Clear fluid produced by active secretion
- Liquor space
  - lined by ependymal cells
  - 150-250 ml



http://www.control.tfe.umu.se

Cerebrospinal fluid

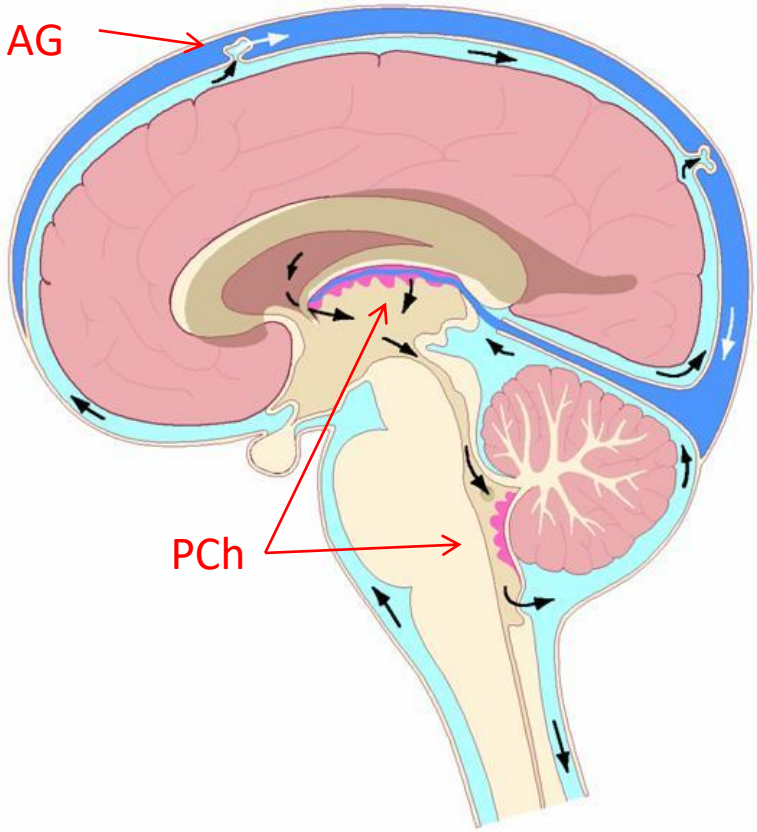
- Clear fluidproduced by active secretion
- Liquor space
  - ➢ lined by ependymal cells
  - ➢ 150-250 ml
- Production
  - ✓ Plexus choroideus (PCh) -70%
  - ✓ Cell metabolism
  - ✓ Cappilary filtration
  - ➢ 450-750 ml/day
- Resorbtion
  - ✓ Archnoid granulations (AG)



http://www.control.tfe.umu.se

Cerebrospinal fluid

- Content
  - ✓ High levels of Mg^{+} and Na^{+}
  - ✓ Low levels of K^{+} and Ca^{2+}
  - ✓ Almost no cells (max 5/ml)

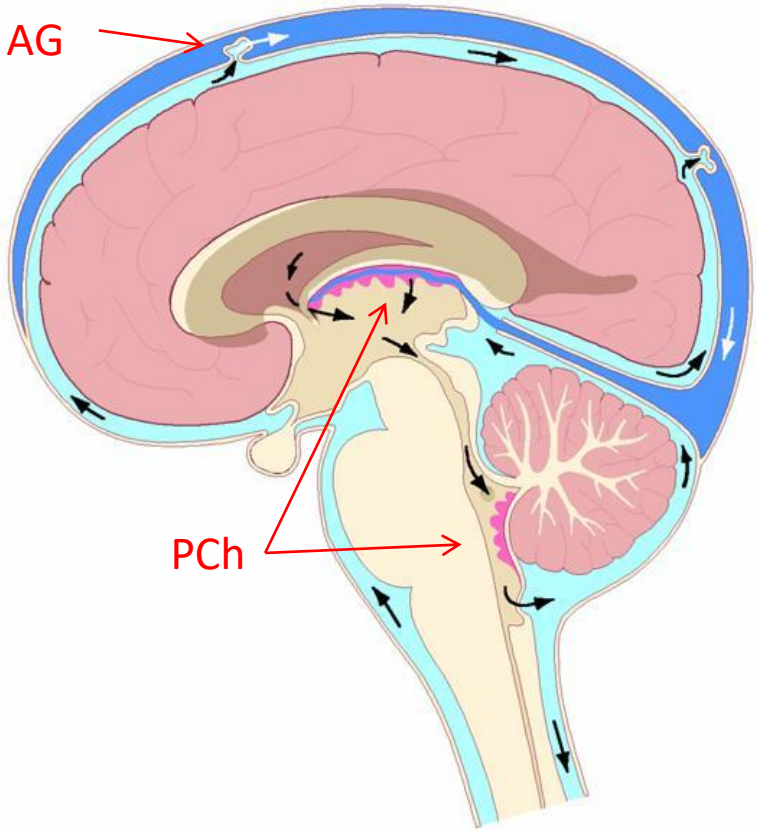


http://www.control.tfe.umu.se

Cerebrospinal fluid

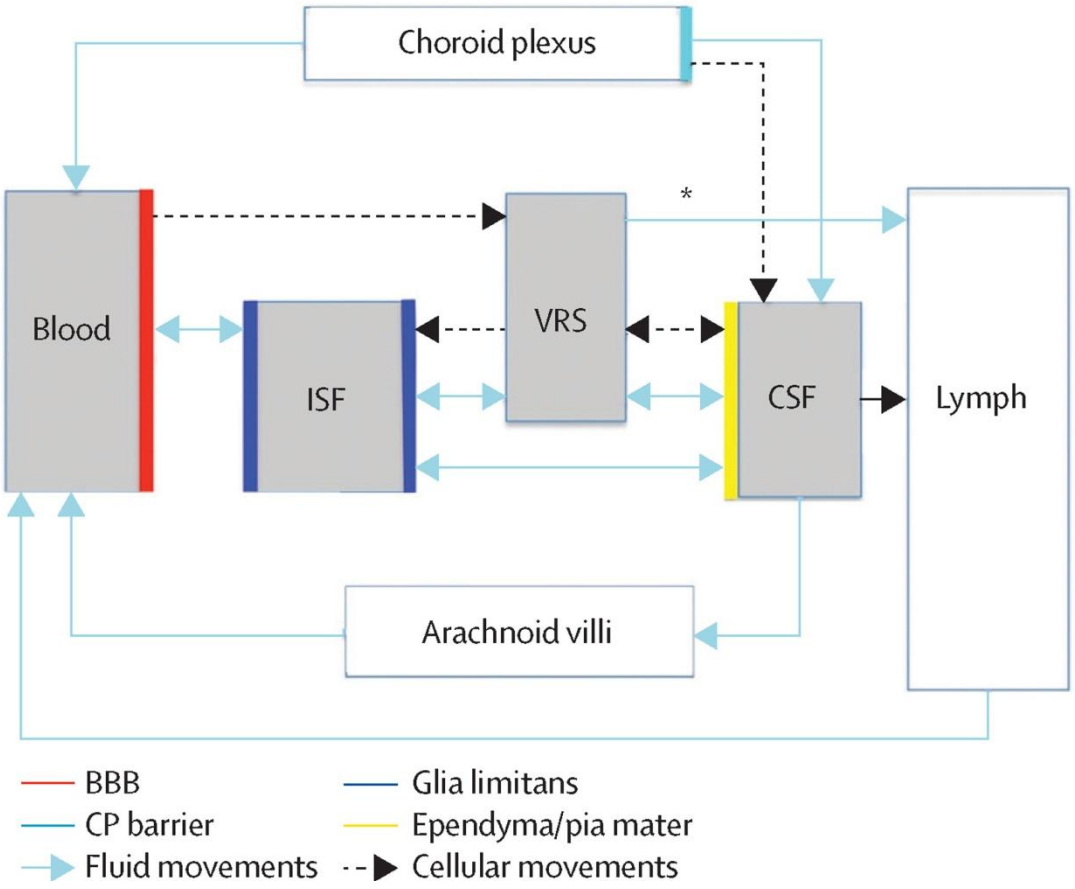
- Content
  - ✓ High levels of Mg^{+} and Na^{+}
  - ✓ Low levels of K^{+} and Ca^{2+}
  - ✓ Almost no cells (max 5/ml)

- Function
  - ✓ Protection
  - ✓ Microenvironment of neurons and glia
    - – Metabolic function
    - – Immunologic function
    - – Transport function and so on



http://www.control.tfe.umu.se

New insight into the production and resorbtion of CSF

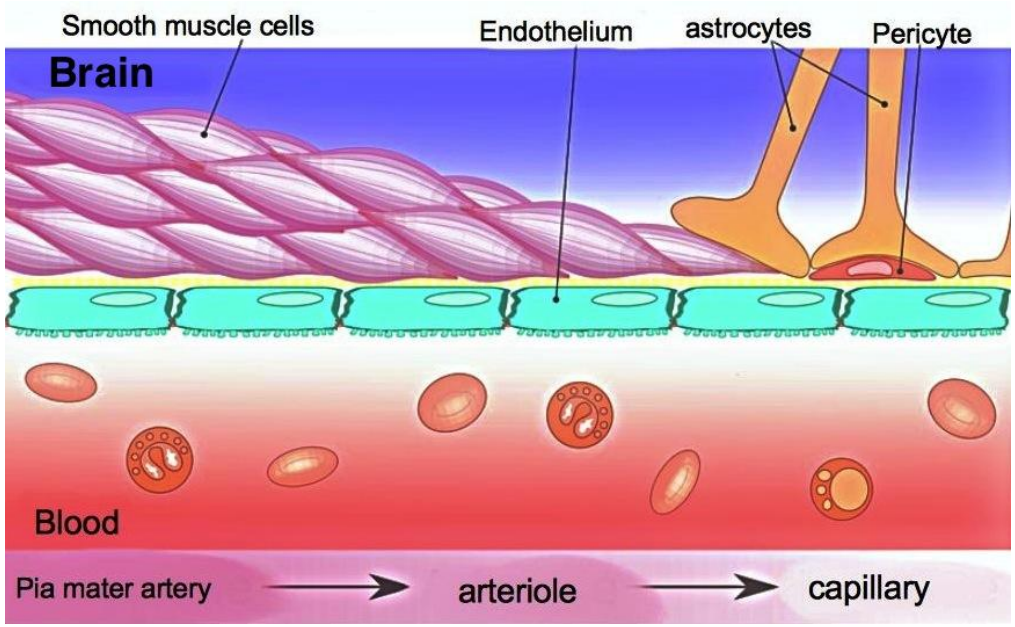


- CSF – cerebrospinal fluid
- ISF – interstitial fluid
- VRS – Virchow Robin space (space between the pia mater and an artery or a vein, but not capillaries)

Ducros A, Biousse V. Headache arising from idiopathic changes in CSF pressure. *The Lancet Neurology*. 2015;14:655–668.

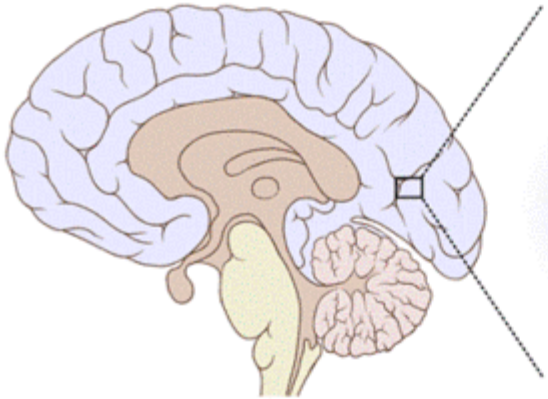
Hematoencephalic barrier

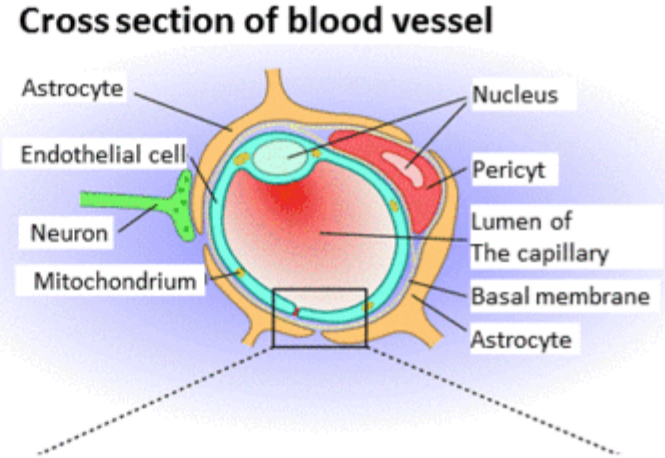
- Highly organised structure
  - Endothelial cells (low permeability thanks to zonlua occludens)
  - Lamina basalis
  - Astrocytes

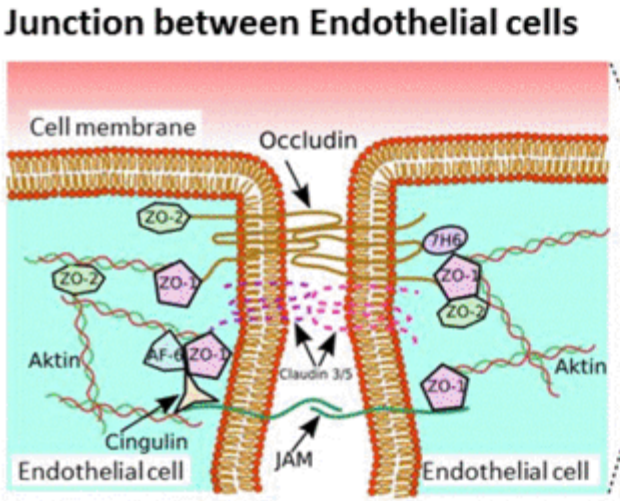


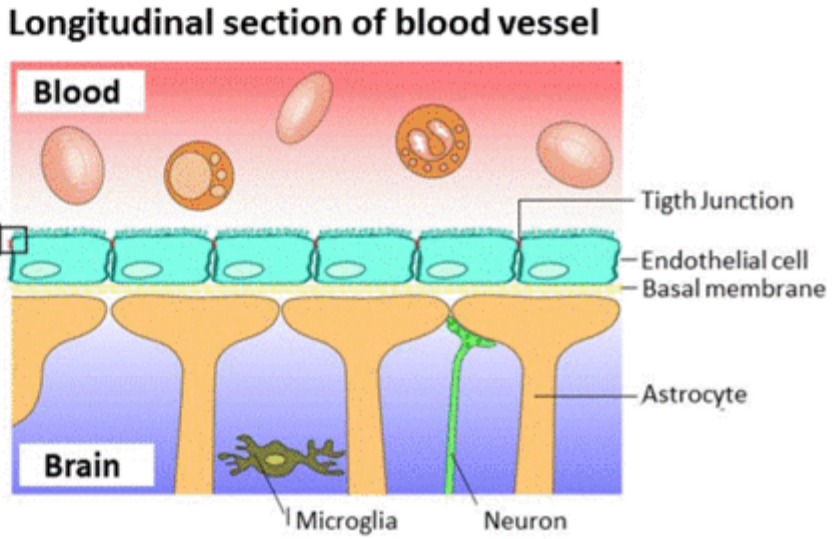
https://upload.wikimedia.org/wikipedia/commons/1/12/Blood_vessels_brain_english.jpg

Hematoencephalic barrier





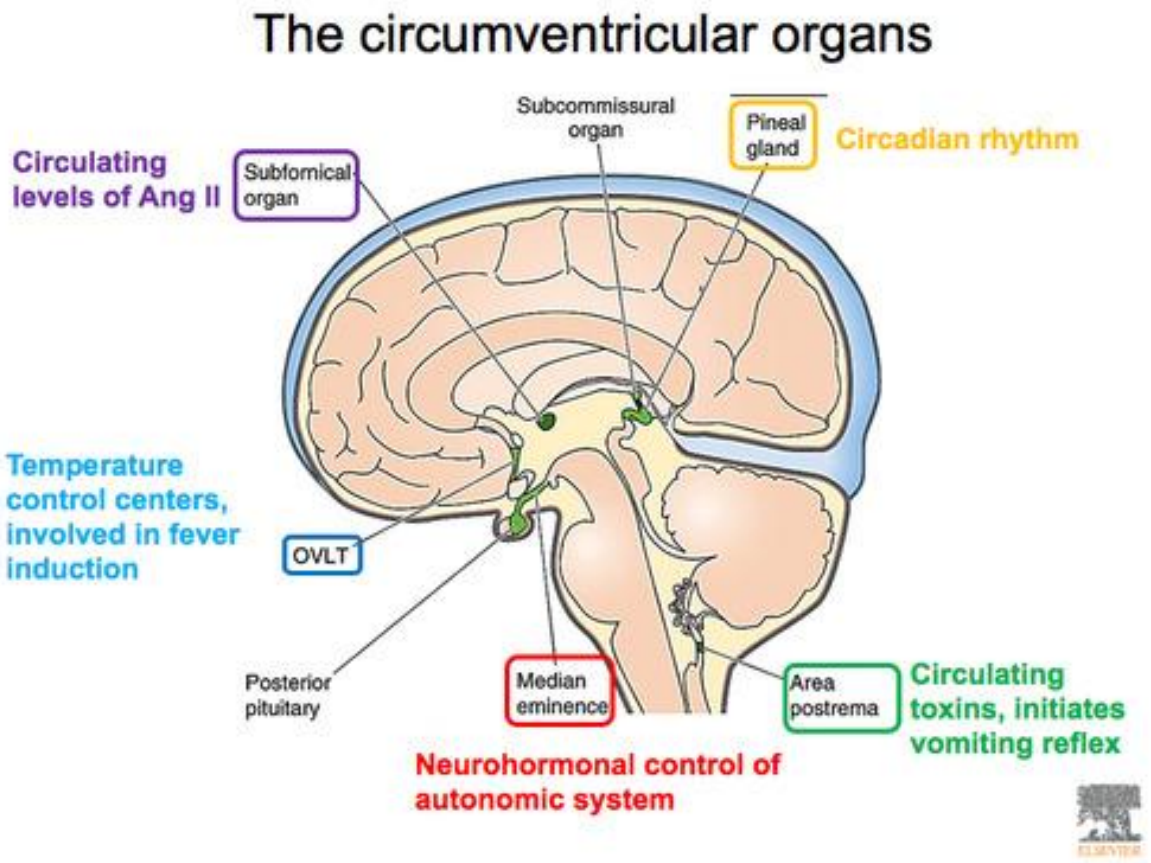




FSM (basic artwork: wikimedia commons)

Circumventricular organs

- Rich vascularisation
- Modified hematoencephalic barrier
- Sensors
- Secretion



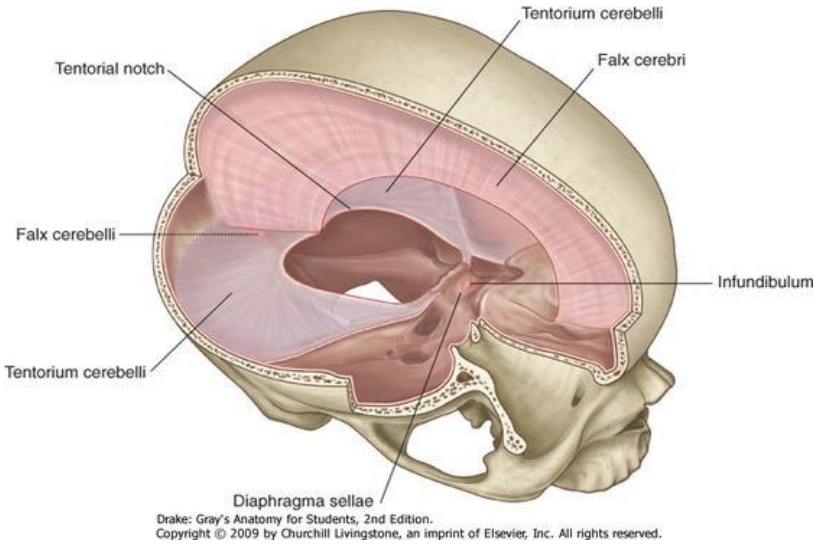
http://www.neuros.org/index.php?option=com_photos&view=photos&oid=hafizbilal

Intracranial compartment

- Brain
- Cerebrospinal fluid
- Blood (intravasculary)

- Intracranial pressure (ICP)

- Cerebral perfusion pressure (CPP) pressure gradient driving blood flow intracranialy



http://edutoolanatomy.wikispaces.com

CPP = MAP - ICP

Cerebral perfusion pressure

Mean arterial pressure

Intracranial pressure

Cellular base of nervous system

- Neuronal cells
  - Reception, integration and propagation of information

- Neuroglial cells
  - Support for neuronal cells

Cellular base of nervous system

- Neuronal cells
  - Reception, integration and propagation of information
- Neuroglial cells
  - Support for neuronal cells
- The total amount of neuronal cells - 100 billions
- Neruon/glia ratio
  - 1/10 - 50 (Principles of Neural Science, 4th ed., 2012)
  - 1/1 (Nolte´s Human Brain, 7th ed., 2015)

Cellular base of nervous system

The brain homeostasis is maintained within a narrow range thanks to hematoencephalic barrier and astrocyte activity

Cellular base of nervous system

The brain homeostasis is maintained within a narrow range thanks to hematoencephalic barrier and astrocyte activity

This allows neuronal cells to live for the entire life of the individual

Neuroglial cells

Central nervous system

- Astrocytes
  - Hematoencephalic b.
  - Homeostasis maintaining
  - Metabolism of neurotransmitters
  - Important during brain development

Neuroglial cells

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- Microglia
  - Immune funtion

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  - Myelin sheat
- Microglia
  - Immune funtion
- Ependymal cells
  - Choroid plexus
  - (hemato-liquor barrier)
  - Ventricular lining

    (liquro-encephalic barrier)

Neuroglial cells

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Peripheral nervous system

- Satelite cells
  - Support functions in PNS

Neuroglial cells

Central nervous system

- Astrocytes
  - Hematoencephalic b.
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    (liquro-encephalic barrier)

Peripheral nervous system

- Satelite cells
  - Support functions in PNS
- Schwan cells
  - Myelin sheat

Neuron

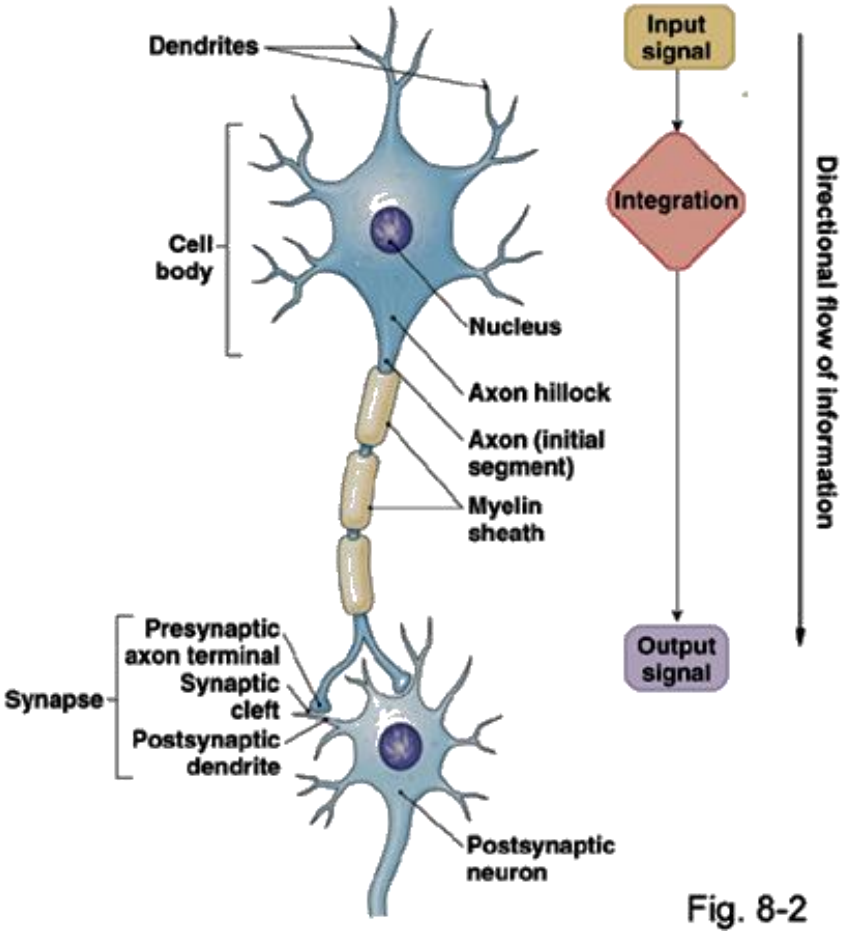
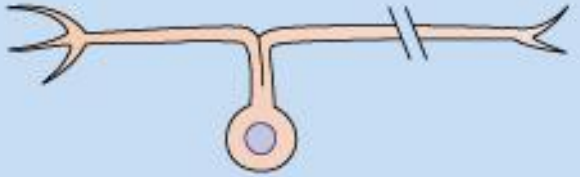


Fig. 8-2

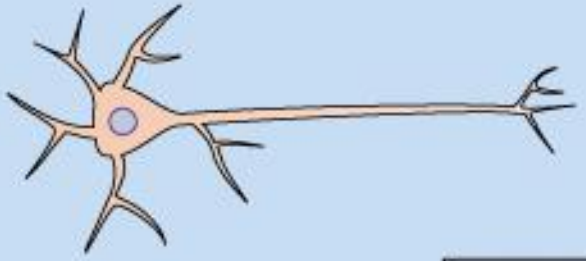
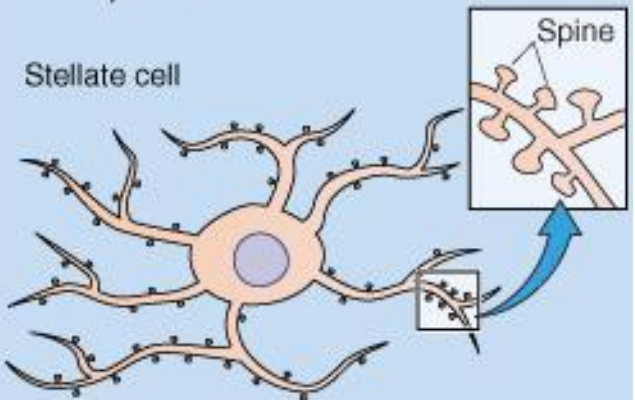
http://www.slideshare.net/drpsdeb/presentations

Neuronal classification

Basis for classification	Example	Functional implication	Structure
1. Axonal projection			
Goes to a distant brain area	Projection neuron or Principal neuron or Golgi type I cell (cortical motor neuron)	Affects different brain areas	Dorsal root ganglion cell 
Stays in a local brain area	Intrinsic neuron or Interneuron or Golgi type II cell (cortical inhibitory neuron)	Affects only nearby neurons	Retinal bipolar cell 

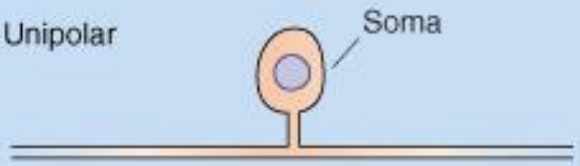
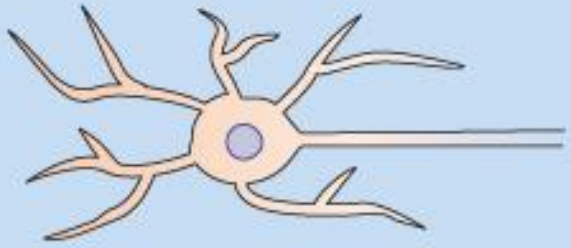
http://www.slideshare.net/CsillaEgri/presentations

Neuronal classification

Basis for classification	Example	Functional implication	Structure
2. Dendritic pattern			Pyramidal cell
Pyramid-shaped spread of dendrites	Pyramidal cell (hippocampal pyramidal neuron)	Large area for receiving synaptic input; determines the pattern of incoming axons that can interact with the cell (i.e., pyramid-shaped)	
Radial-shaped spread of dendrites	Stellate cell (cortical stellate cell)	Large area for receiving synaptic input; determines pattern of incoming axons that can interact with the cell (i.e., star-shaped)	Stellate cell 

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

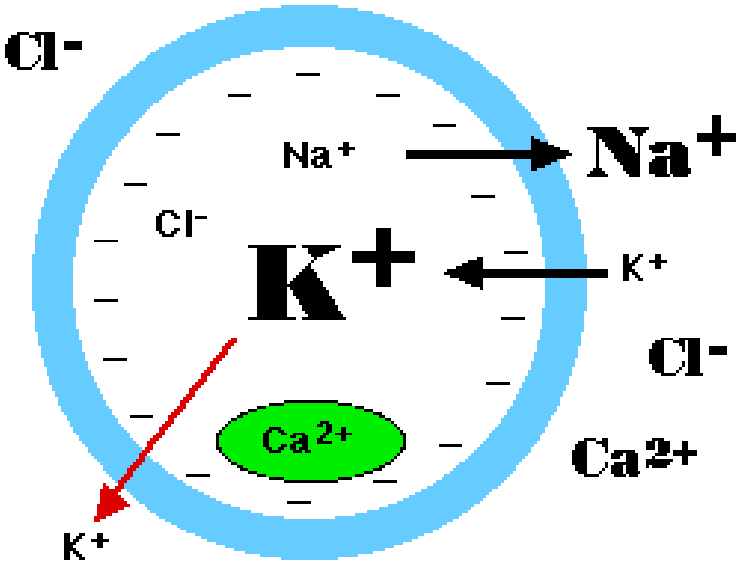
Neuronal classification

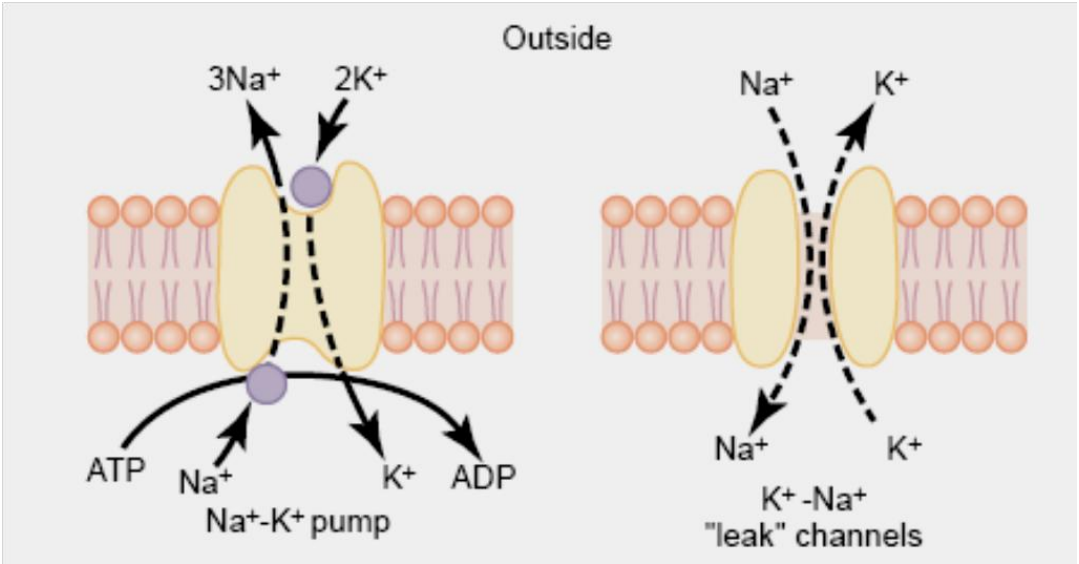
Basis for classification	Example	Functional implication	Structure
3. Number of processes			
One process exits the cell body	Unipolar neuron (dorsal root ganglion cell)	Small area for receiving synaptic input: highly specialized function	Unipolar 
Two processes exit the cell body	Bipolar neuron (retinal bipolar cell)	Small area for receiving synaptic input: highly specialized function	Bipolar 
Many processes exit the cell body	Multipolar neuron (spinal motor neuron)	Large area for receiving synaptic input; determines the pattern of incoming axons that can interact with the cell	Multipolar 

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

Membrane potential

- Due to differences in the concentrations of ions on opposite sides of a cellular membrane





Resting membrane potential of a neuron

http://assassinscreed.ubi.com

- Highly instable state of membrane
- Why? – Speed!
- Brain sonsumption
  - ✓Oxygen - 20% of total body consumption
  - ✓Glucose – 25% of total body consumption

Action potential

- Quick voltage change on the membrane
- Spreads along the axon
- All or nothing principle

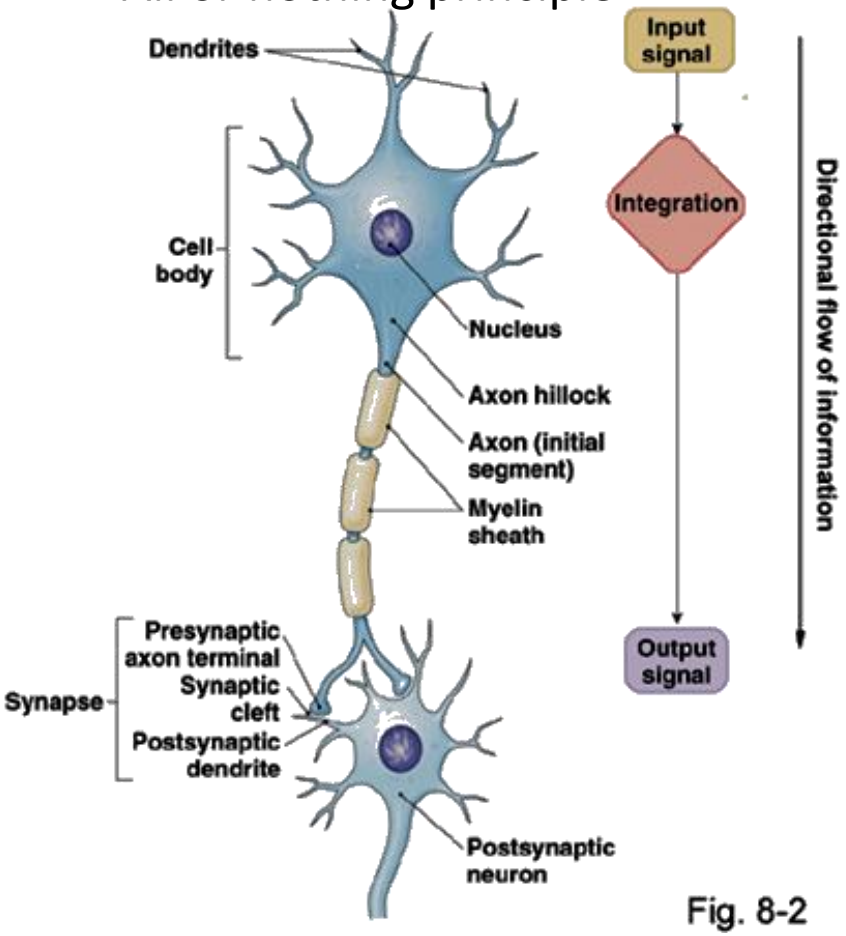
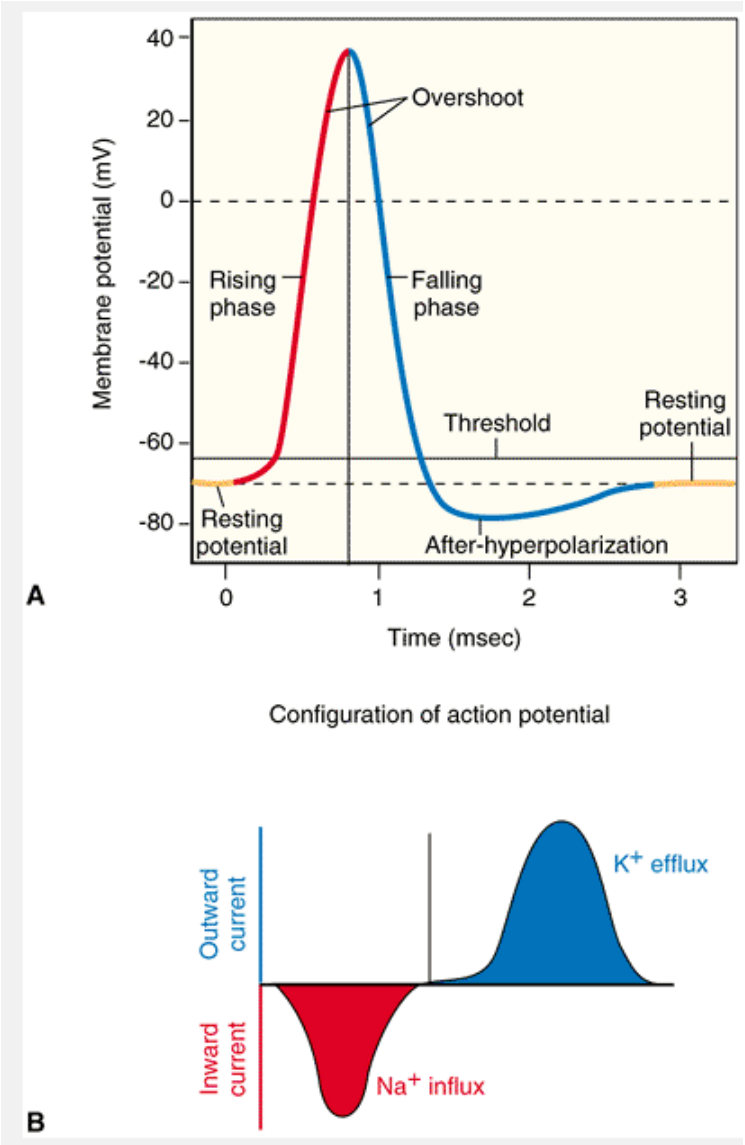
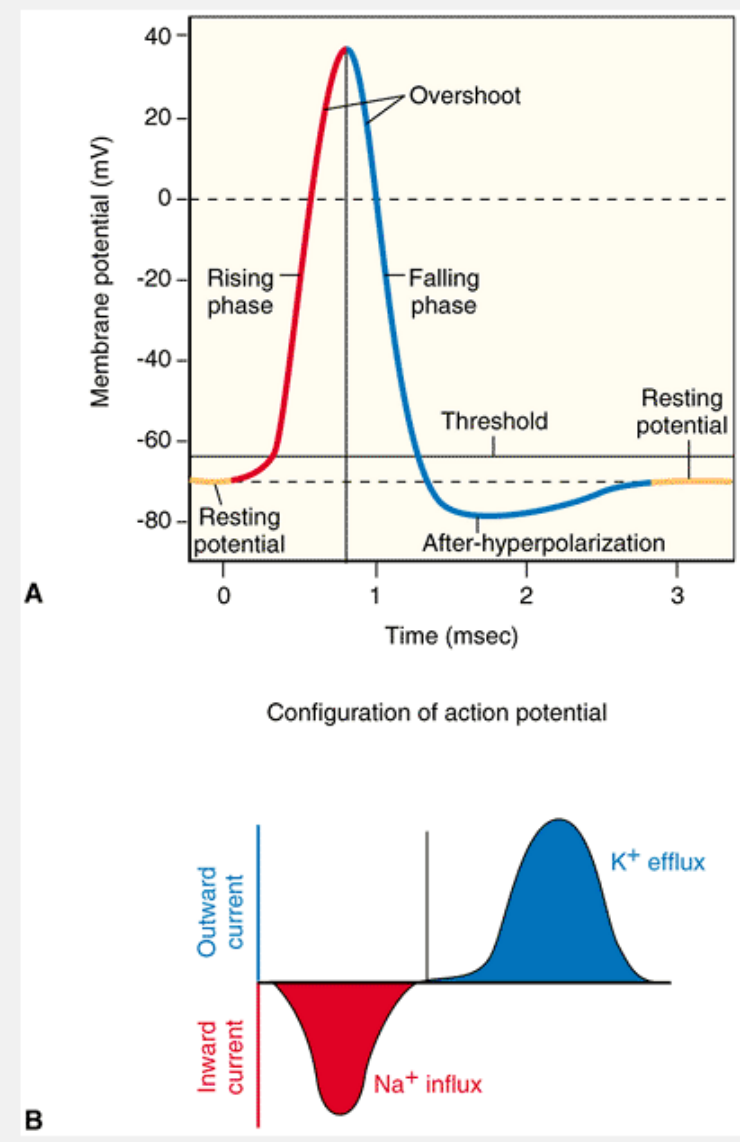
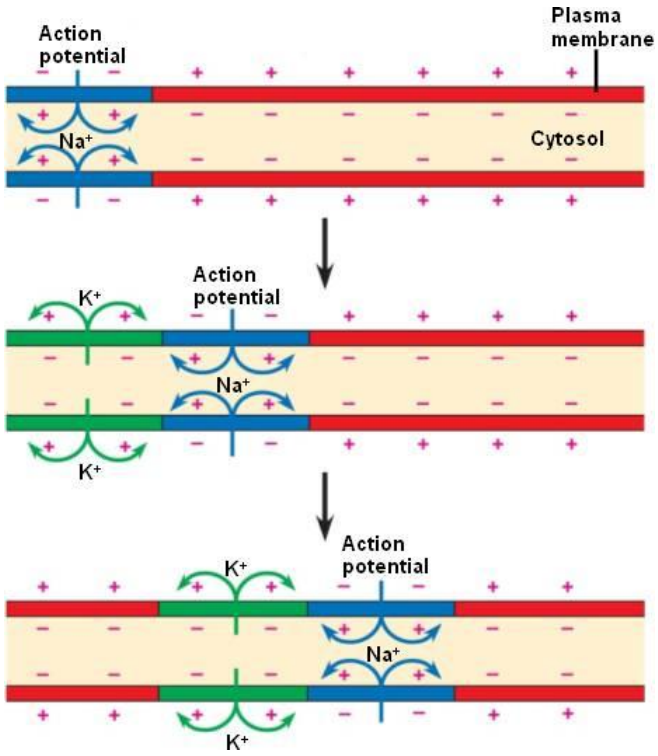


Fig. 8-2



Action potential spreading

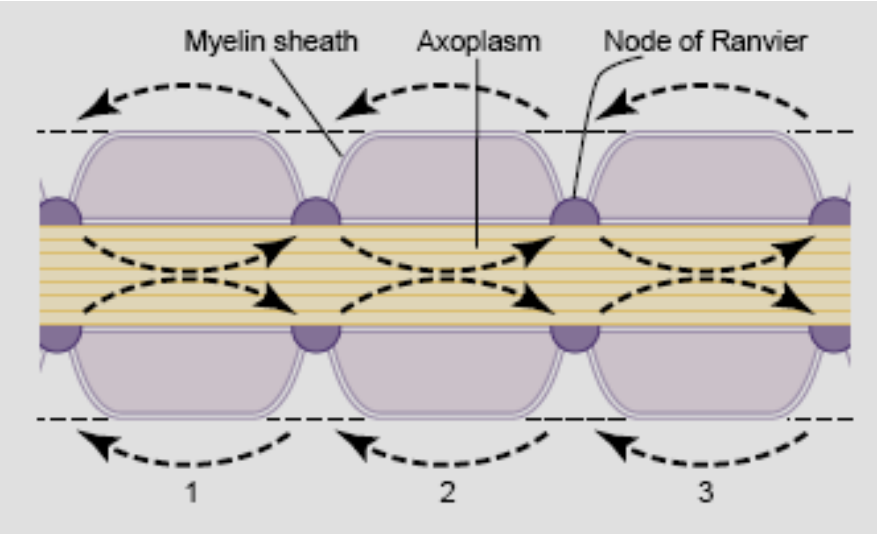




- Local currents
- Anterograde

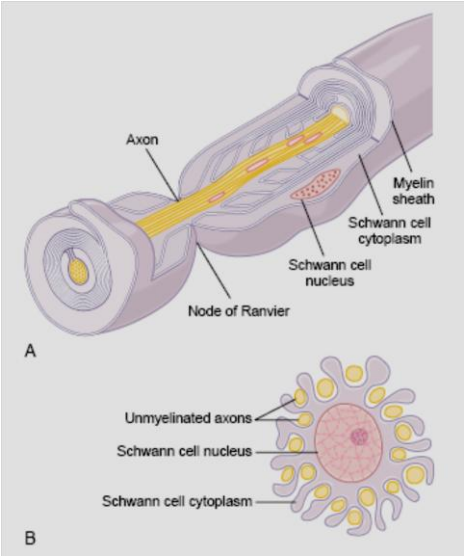
Saltatory conduction

- Myelin sheat
- Nodes of ranvier



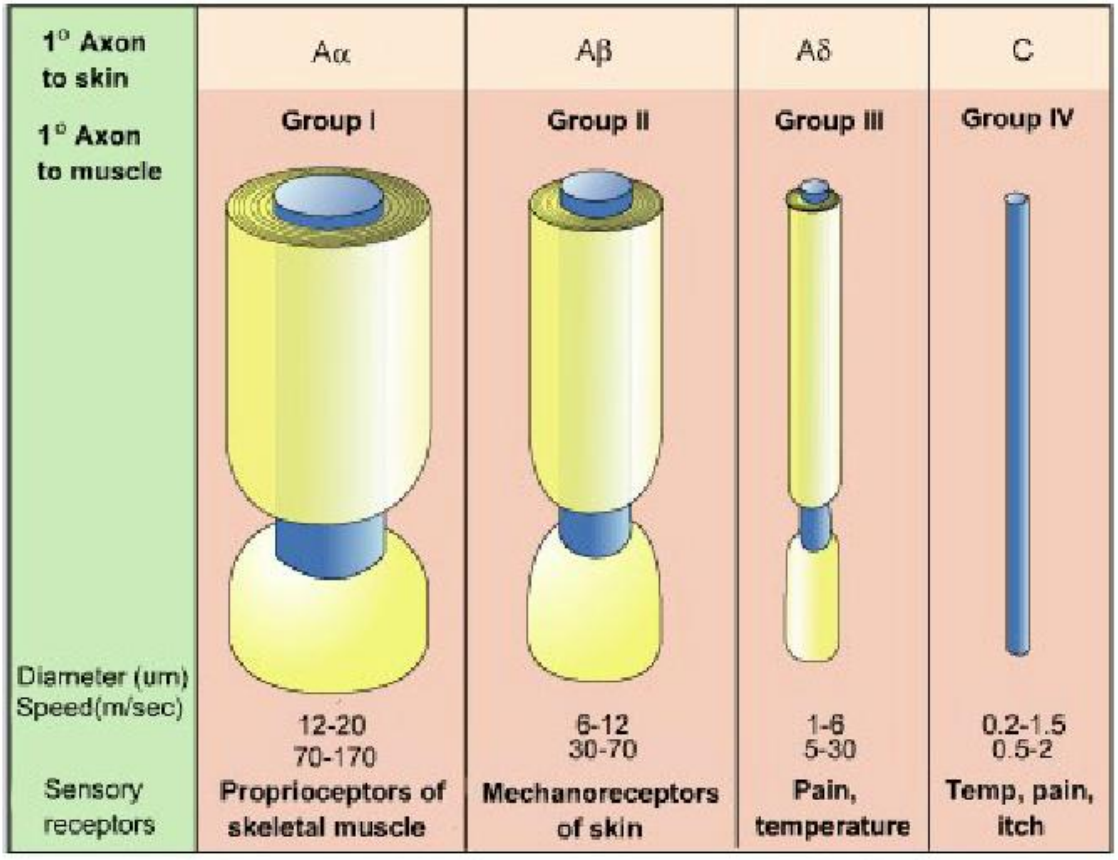
- Economy
- Speed of conduction

- Speed of conduction also dependent of nerve fibre diameter
  - the electrical resistance is inversly proportional to area of cross-section



Classification of nerve fibers

- In humans mostly myelinated
- All fibers are myelinated in CNS
- Non-myelinated are evolutionary old ones



http://neuroscience.uth.tmc.edu/s2/chapter04.html