Diffusion processes in the brain

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Contents

The Central Nervous System

- All invertebrates except sponges and radially symmetric animals have one.
- Consist of spinal cord and brain in vertebrates.
- Tasked with gathering and processing information.

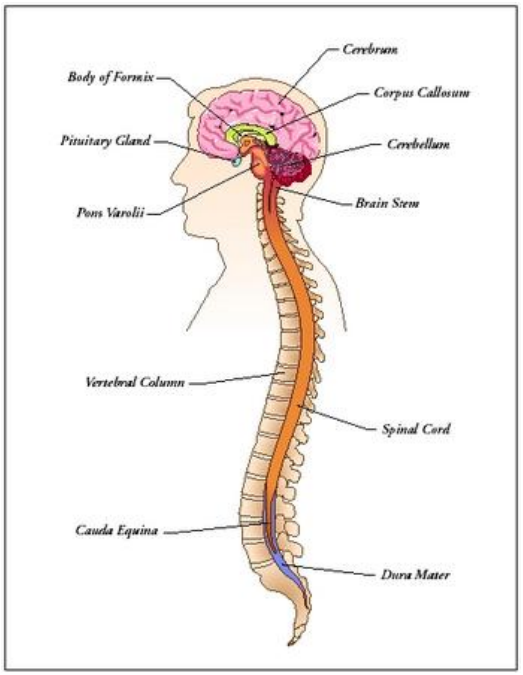


Figure: Human CNS

Some words about the brain

- Labeled the most complex object in the universe.
- $\sim$ 200 billion neurons with $\sim$ 125 trillion connections in neocortex alone.
- Different parts associated with different tasks.
- Many underlying processes are very inefficient.

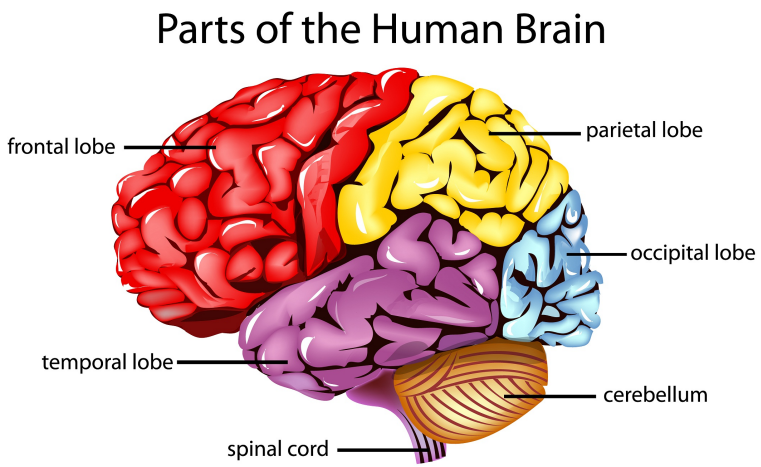
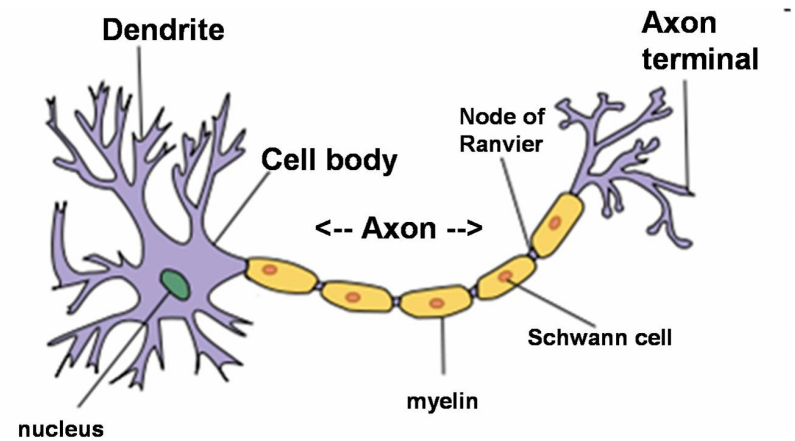


Figure: Human brain with labels

Cells in the brain

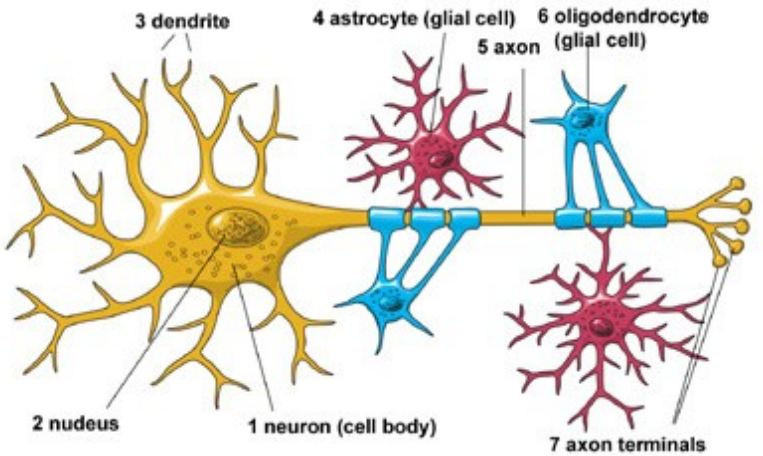
Neurons:

- Signal processing



Neuroglia:

- Janitorial tasks



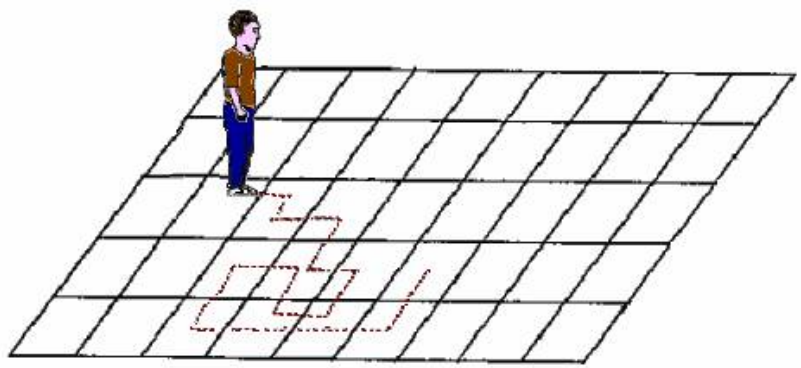
Normal diffusion

- Process of net movement due to a difference in concentration.
- Formulated in 1855 by Adolf Fick in the modern way.
- Widely used across many diciplines like social studies, economics and biology.

$$\frac{\partial C}{\partial t} = D\nabla^2 C$$

Random walks

- Also widely used in many diciplines.
- "Endless" possibilities for added complexity.
- Conceptually not that difficult.
- Recreates diffusion



Diffusion across synapses

- Two types of synapses connect neurons - electrical and chemical.
- Action potentials triggers release of neurotransmitter into synaptic cleft.
- Receiving end passes input on to cell body.
- Diffusion across synaptic cleft takes $\sim \mu$s or less.

Figure: Chemical synapse with dendritic spine.

PKCγ diffusion into spines

- PKCγ is an enzyme associated with learning.
- Released from cell body and diffuses through dendrite into spines.
- Very low concentrations could require multi scale modeling.

Thank you!

Firing in auditory nervous system

Cells with specific tasks

Visual cortex