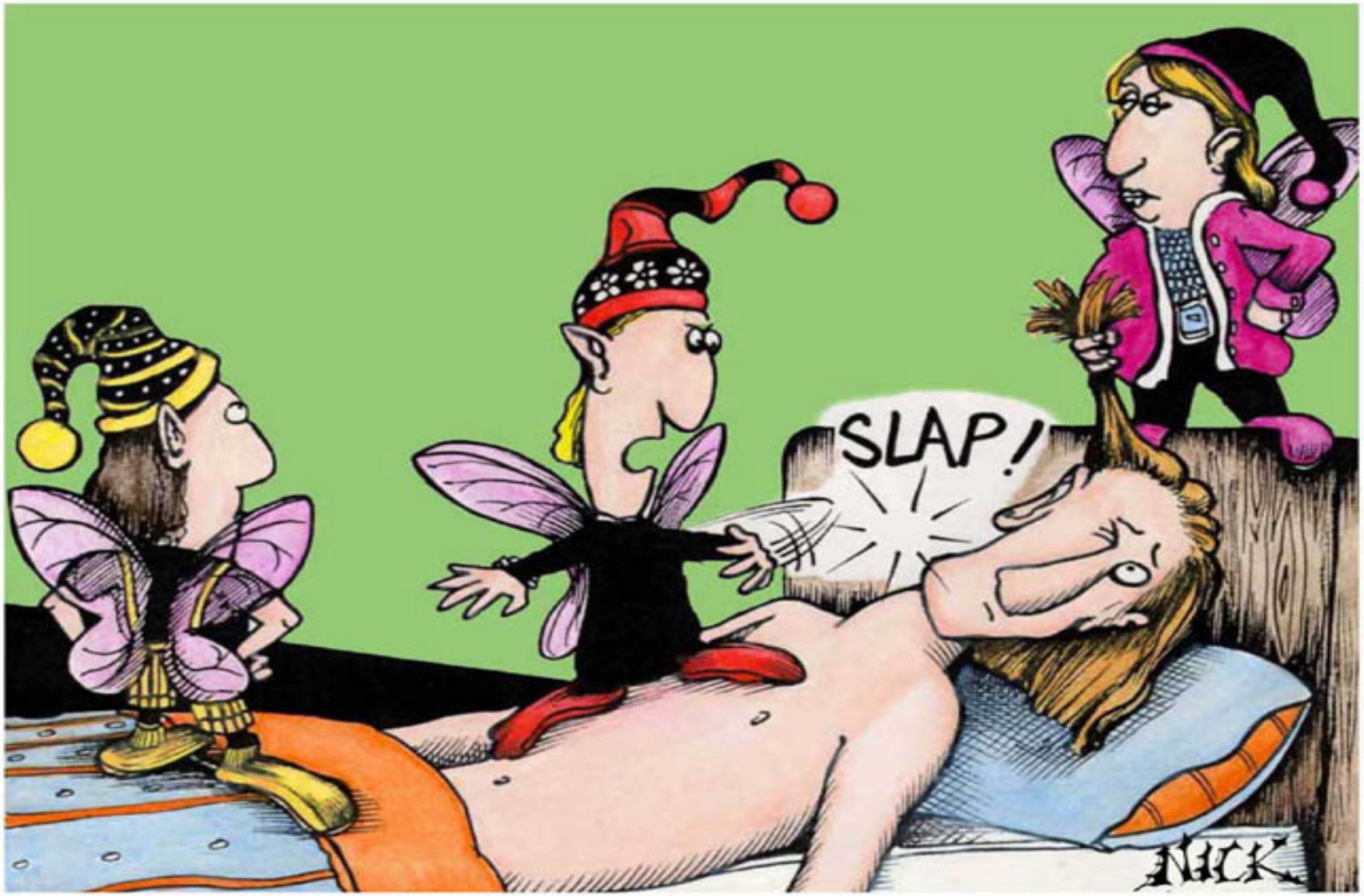
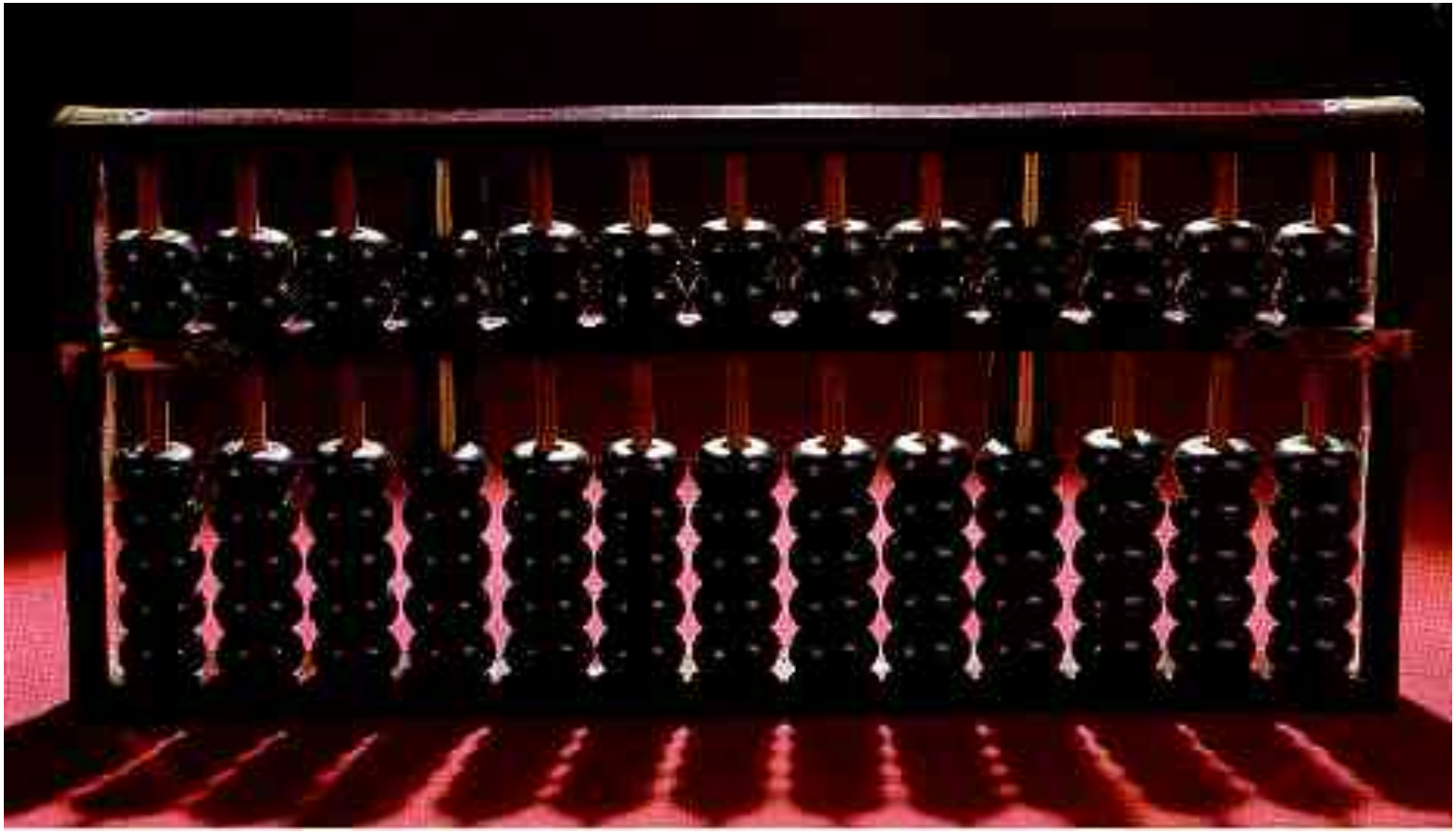


"For goodness sake, man, SNAP OUT OF IT..!!! We're NOT Aliens from outer space!! We're PIXIES! Pixies from your GARDEN! IS THAT SO DIFFICULT TO UNDERSTAND..?!?"

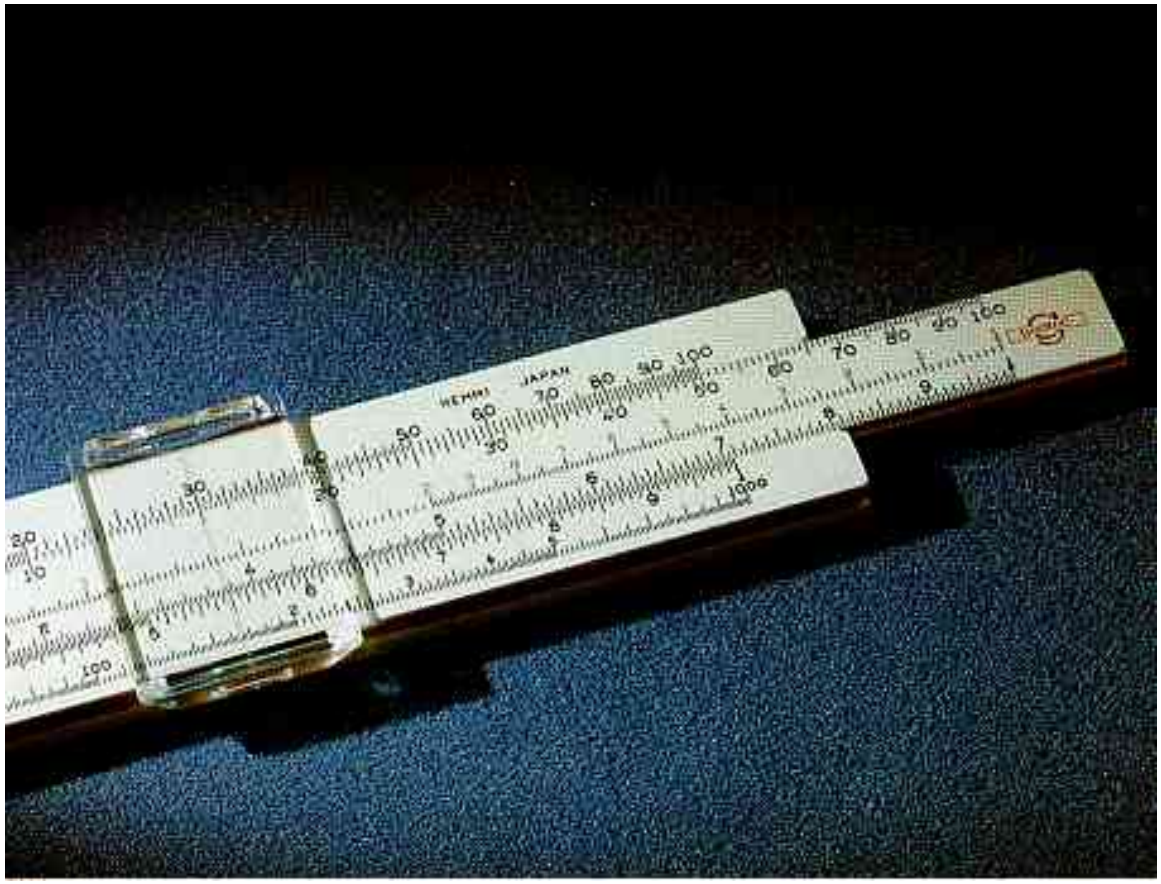
Brains

875 Abacus



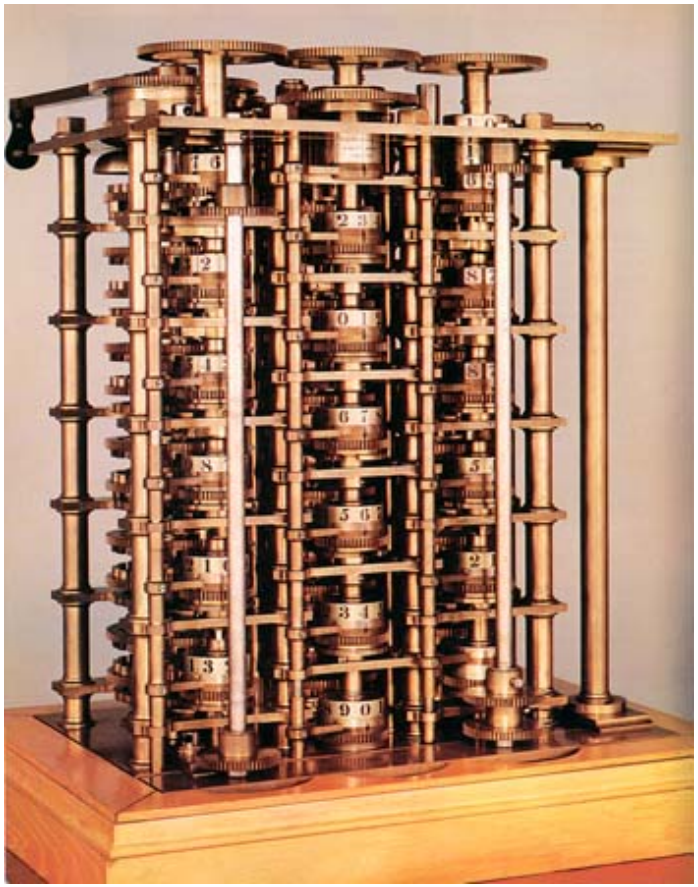
Brains

1600 Slide Rule - Oughtred



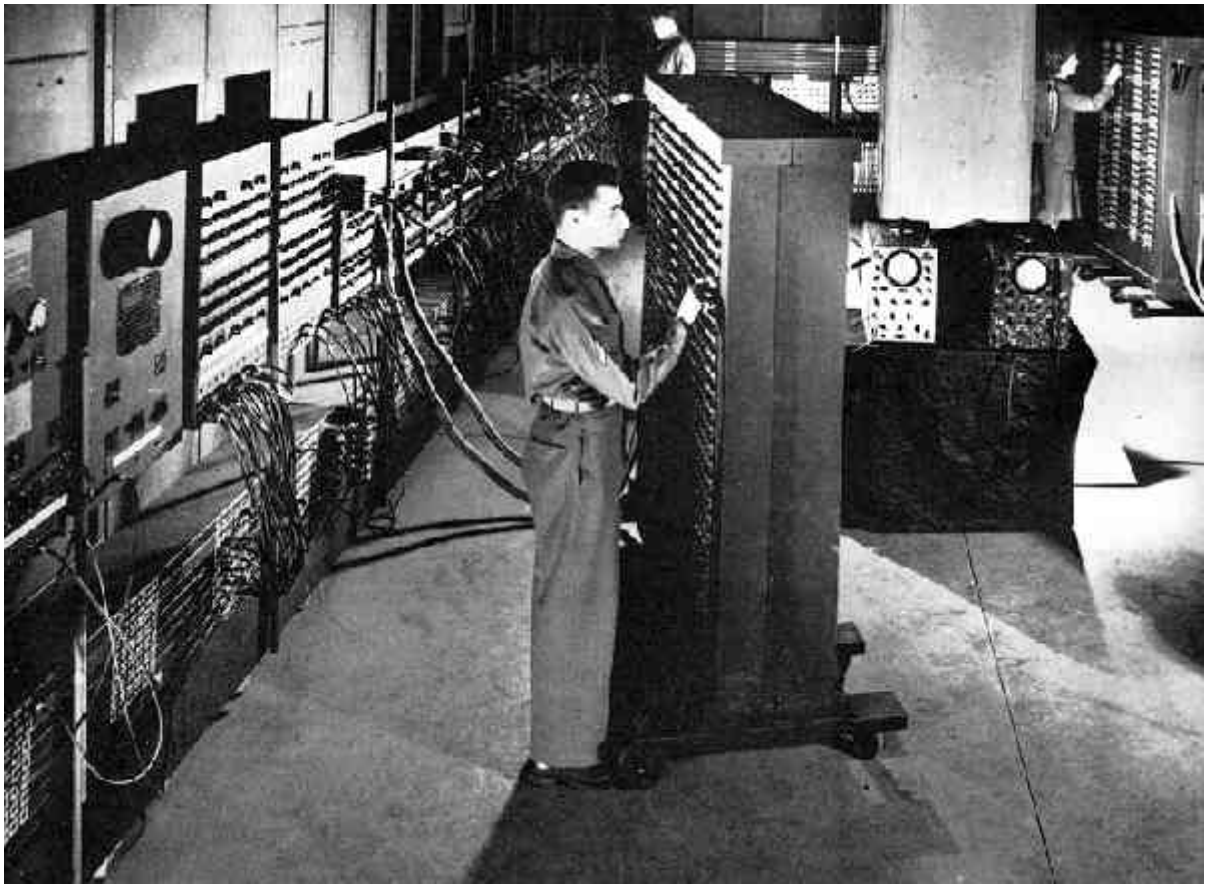
Brains

1822 multi function calculator - Babbage



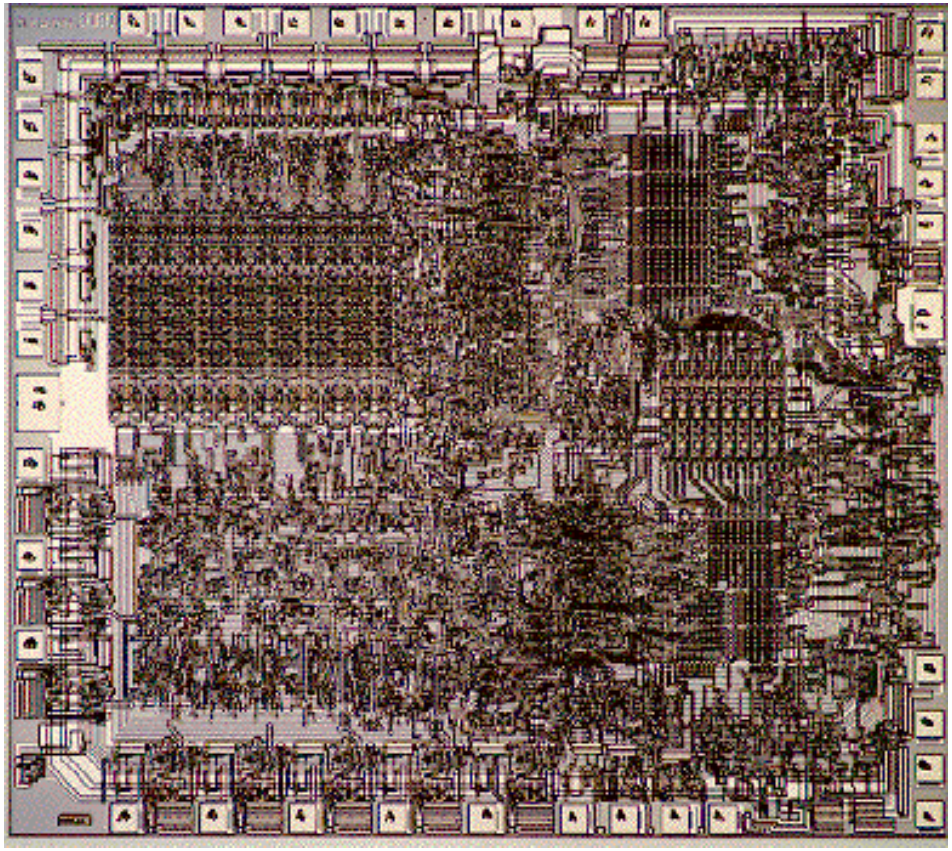
Brains

1946 ENIAC - U.S. Army



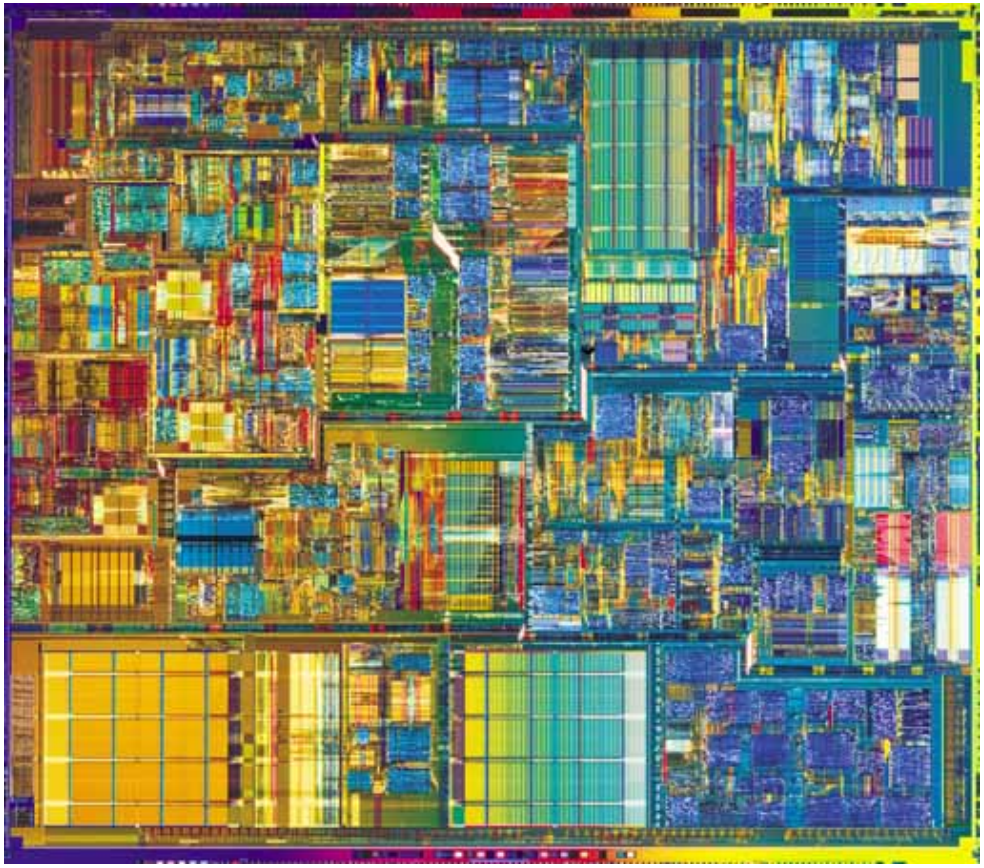
Brains

1971 Microprocessor Intel

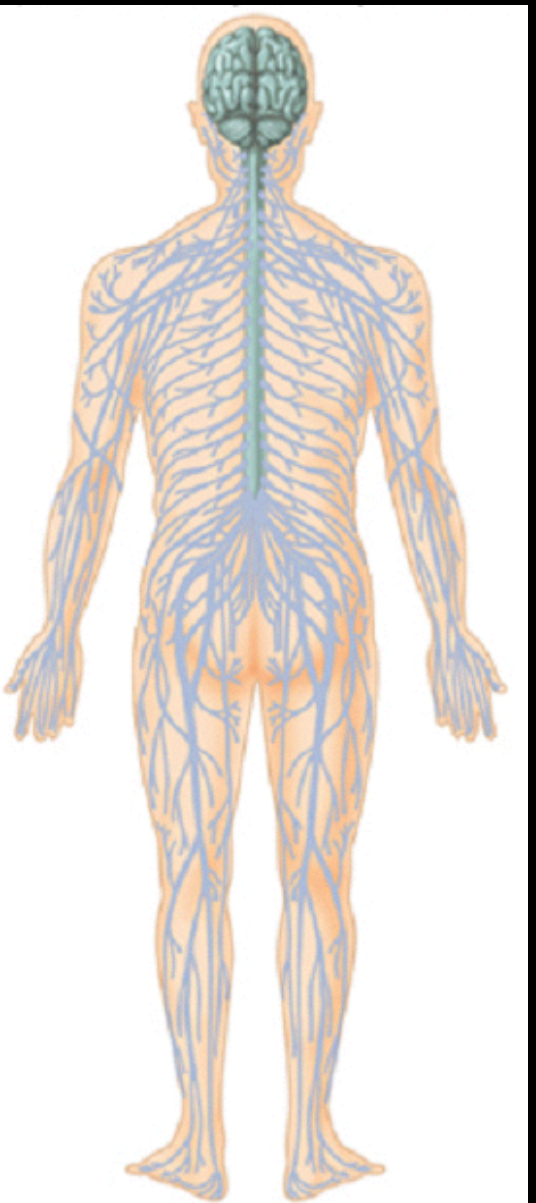


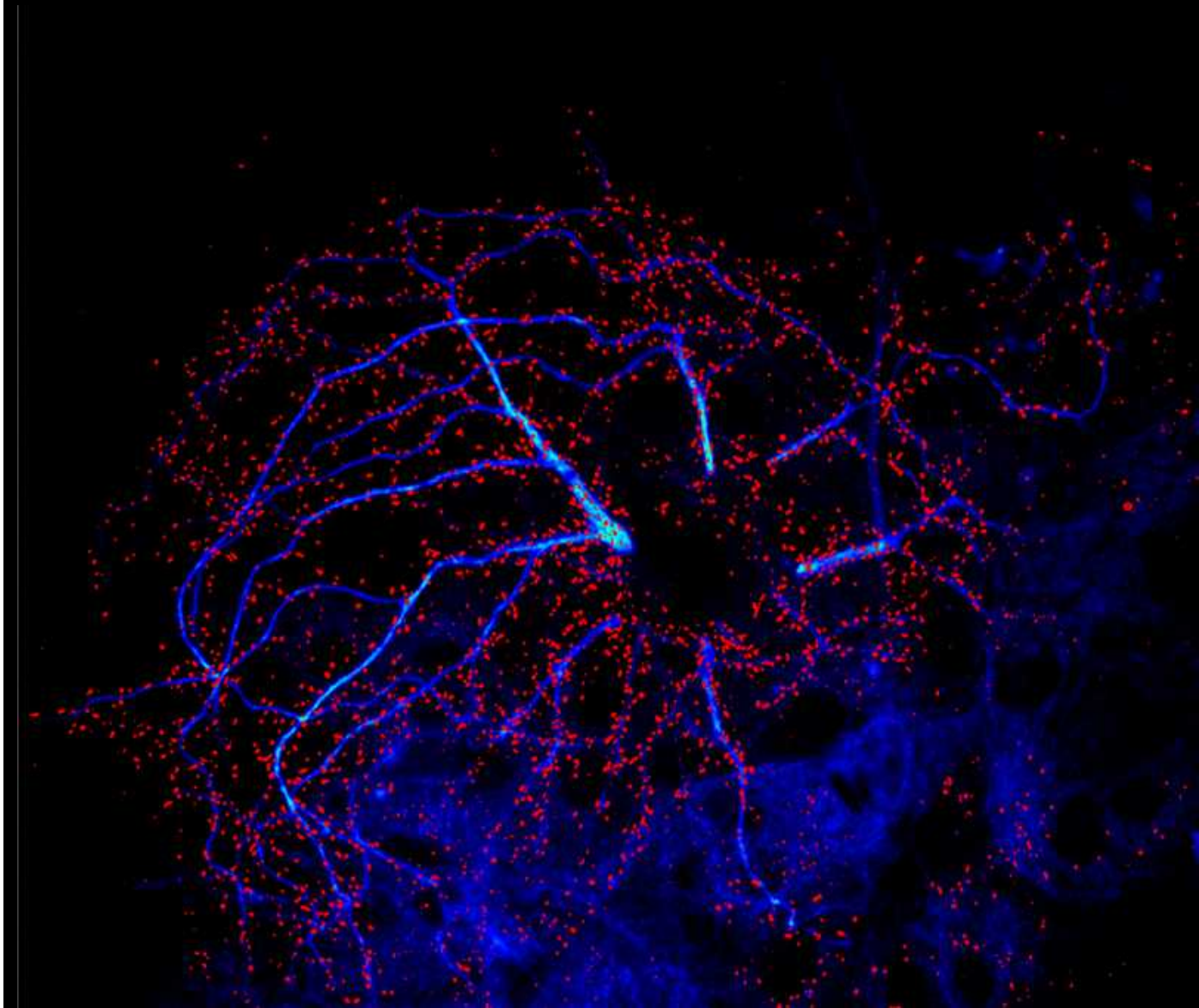
Brains

2000 Pentium IV Intel



The Nervous System





Any physical or biophysical mechanism instantiating an information processing system that needs to survive in the real world must obey several constraints

(i) operate at ***high speeds***

(ii) a ***rich repertoire of computational primitives*** with the ability to implement a variety of linear and nonlinear operations

(iii) ***interface with the physical world*** in the sense of being able to accurately represent sensory input pattern and translate the result of the computations into action, i.e. motor output

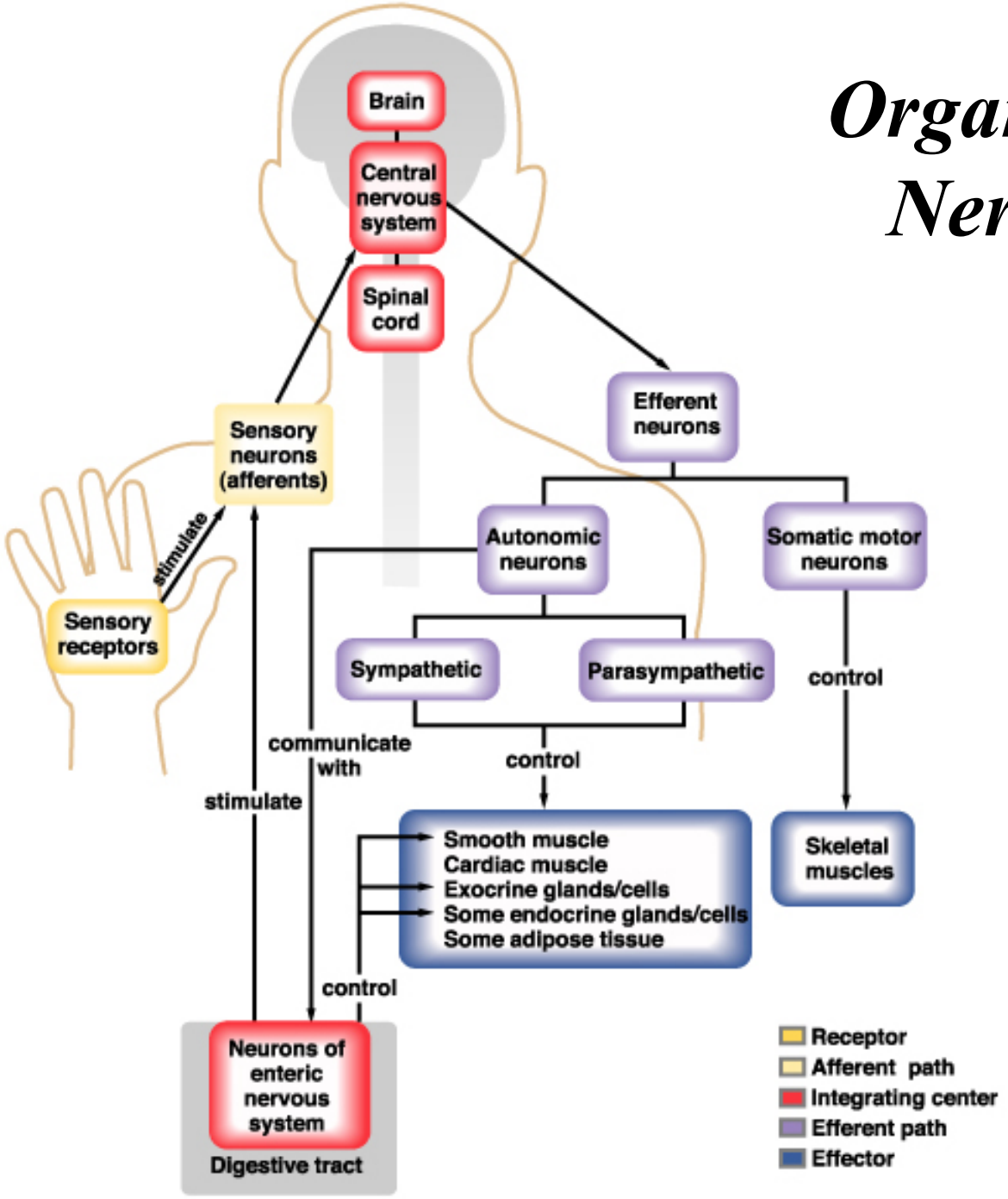
The membrane potential

- it vary rapidly over large distances

- controls a vast number of nonlinear gates – ionic channels – that provide a very rich substrate for implementing nonlinear operations.

- channels transduce stimuli into changes of the membrane potential and such voltage changes back into the release of neurotransmitter or the contraction of muscles.

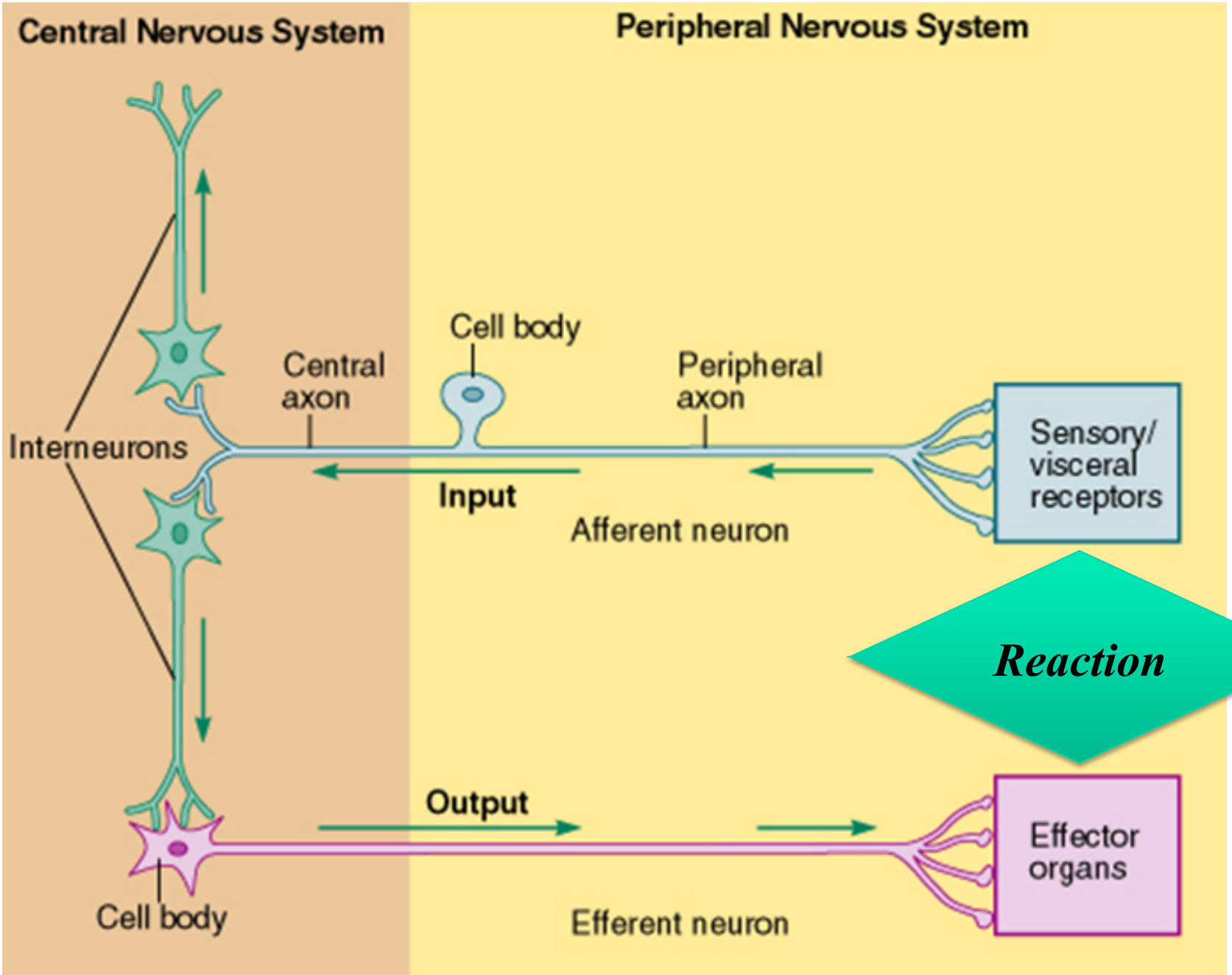
Organization of the Nervous System



Subdivisions

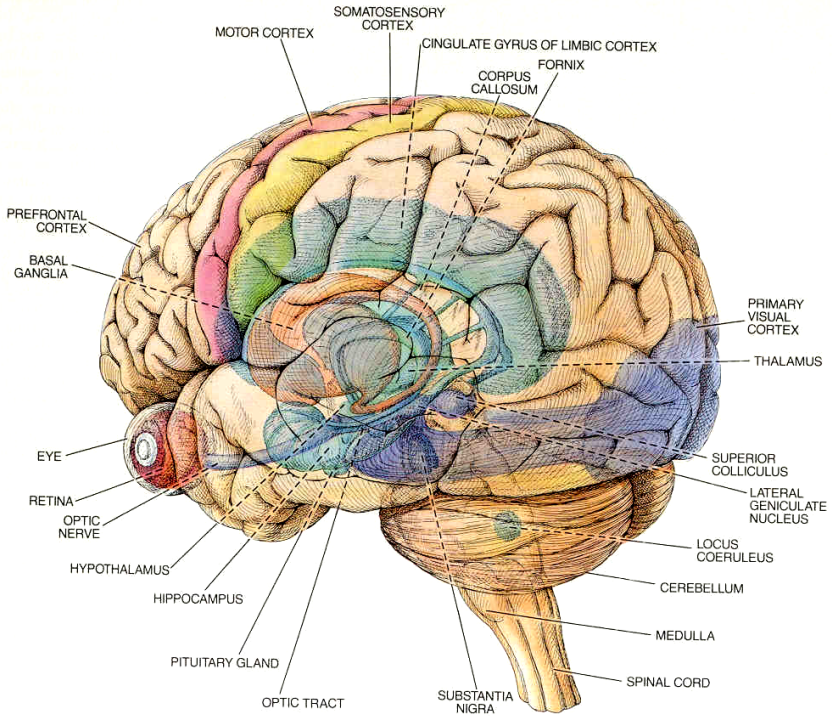
- Central nervous system (CNS)
- Peripheral nervous system (PNS)

Nervous system



A Human Brain

- mass **1 – 2** kg (in mature adult)
- about **2 %** of body weight
- uses **20%** of oxygen
- **25 %** of glucose
- **15 %** of blood flow
- Circulating blood turns over **7x/min**

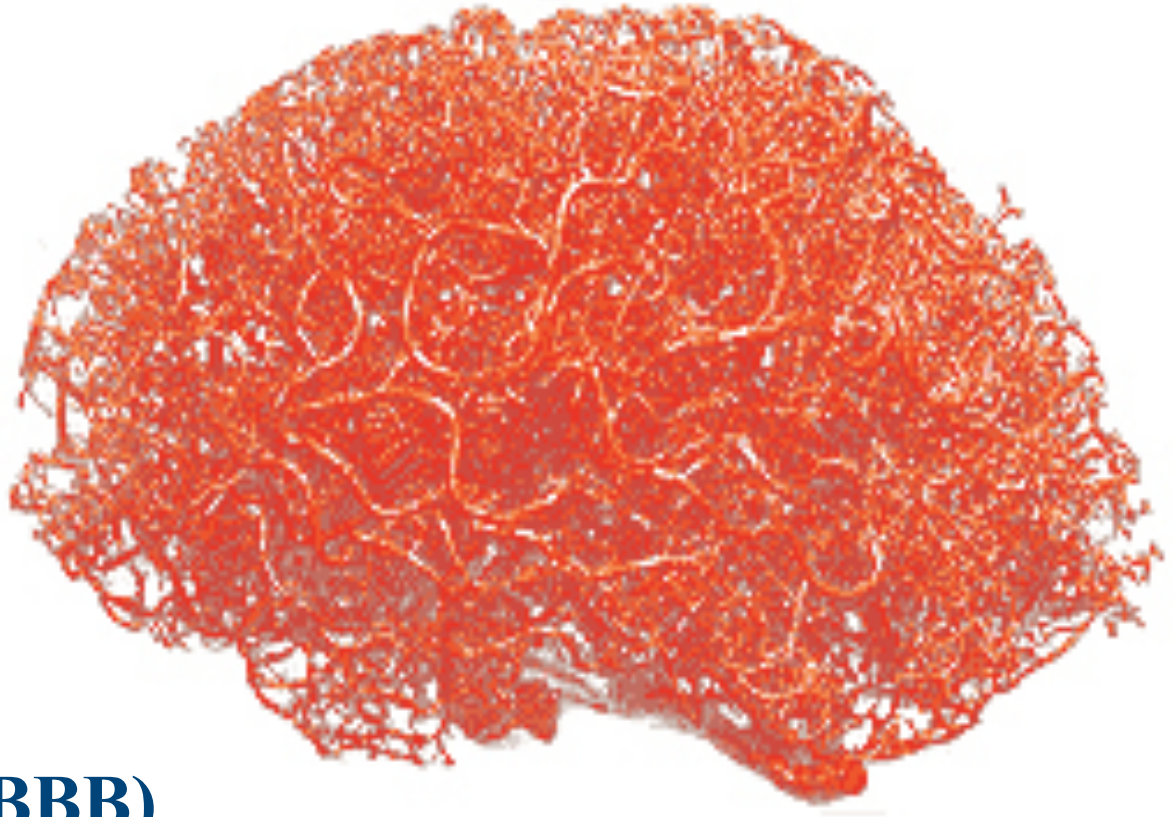


Brain deprived of blood for 20 sec – ***unconsciousness***

After 4-5 min – ***irreversible unconsciousness or death***

Mass at birth about **20 %** of final value. Mass increase is due to growth of ***axons, dendrites, synapses and myelin sheats***.

Brain blood supply

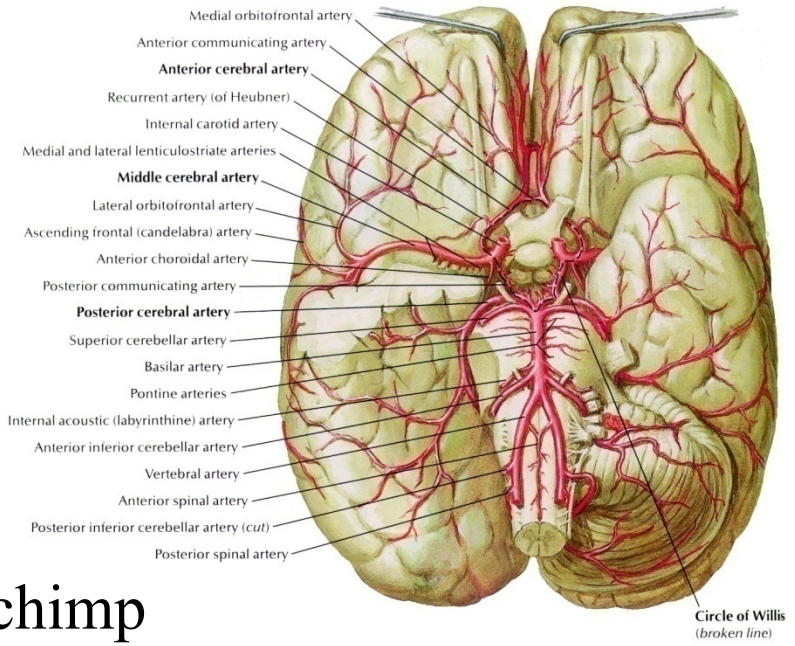


- **600 km capillaries (BBB)**
- **20 m^2**
- **distance between capillaries: 40 μm**
- **every neuron has its own capillary**

1 km blood vessel per cm^3

Cortex

Size of cortex separates humans from other species



Area

- 5 cm^2 for rat
- 5 x 10^2 cm^2 for chimp
- 2 x 10^3 cm^2 for human (extra area in human cortex obtained by folding)

Thickness of cortex 0.3 cm

> 3 x 10^{10} neurons in human cortex (1.5 x 10^7 neurons per cm^{-2})

> 10^{14} synapses in human cortex (10^3 synapses per neuron)

Genome length

4 cm for fruit fly;

1m for mouse;

1 m for human

Number of neurons

10^5 for fruit fly

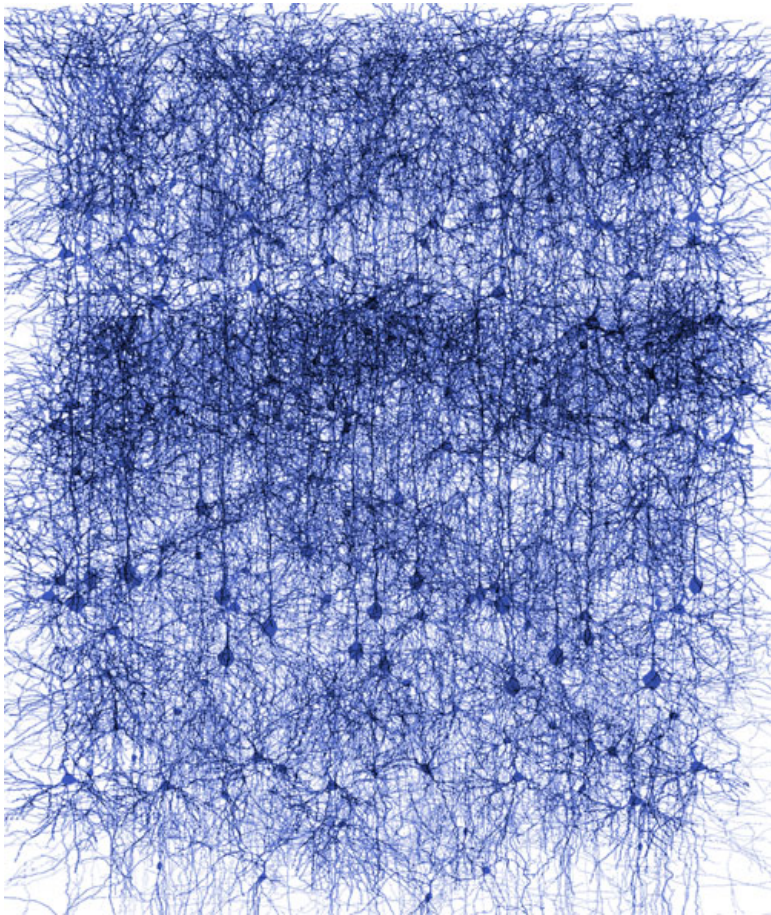
5×10^6 for mouse

10^{11} for human

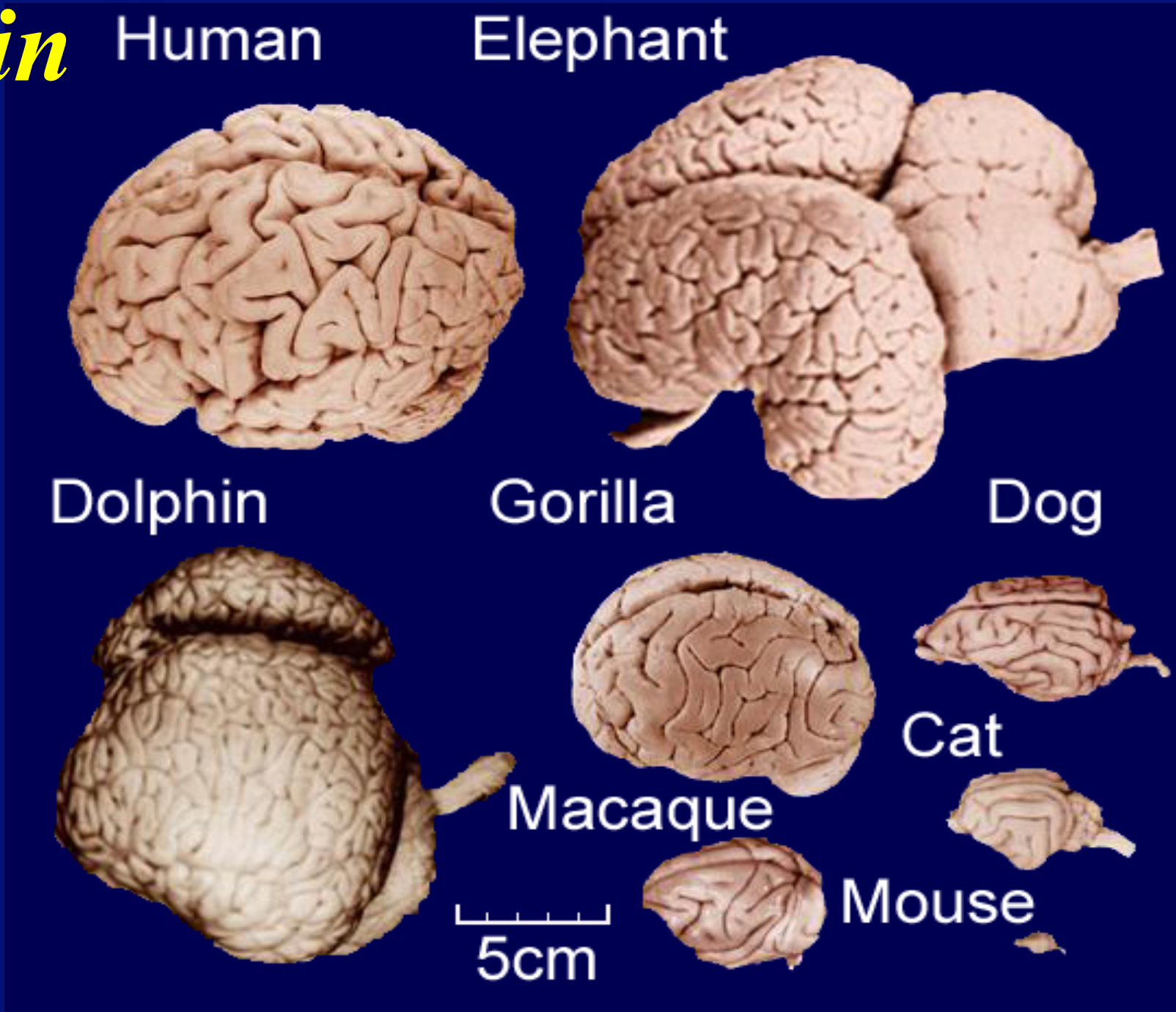
Human genome does not carry detailed wiring diagram for cortex

- wiring diagram would require **$>10^{14}$** bits of information

- genome carries about **5×10^9** bits of information



Brain

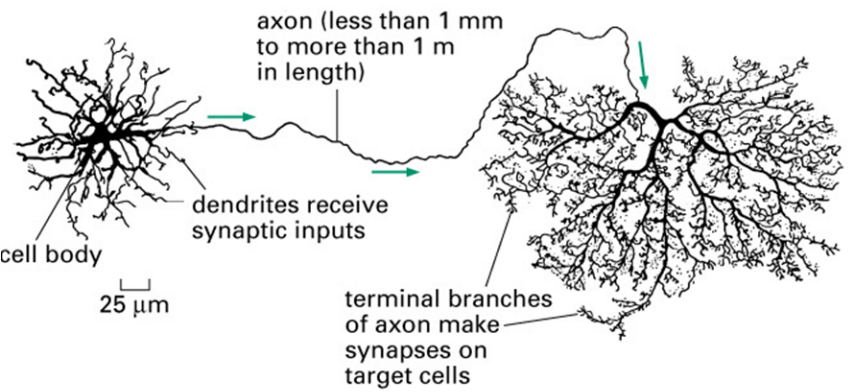


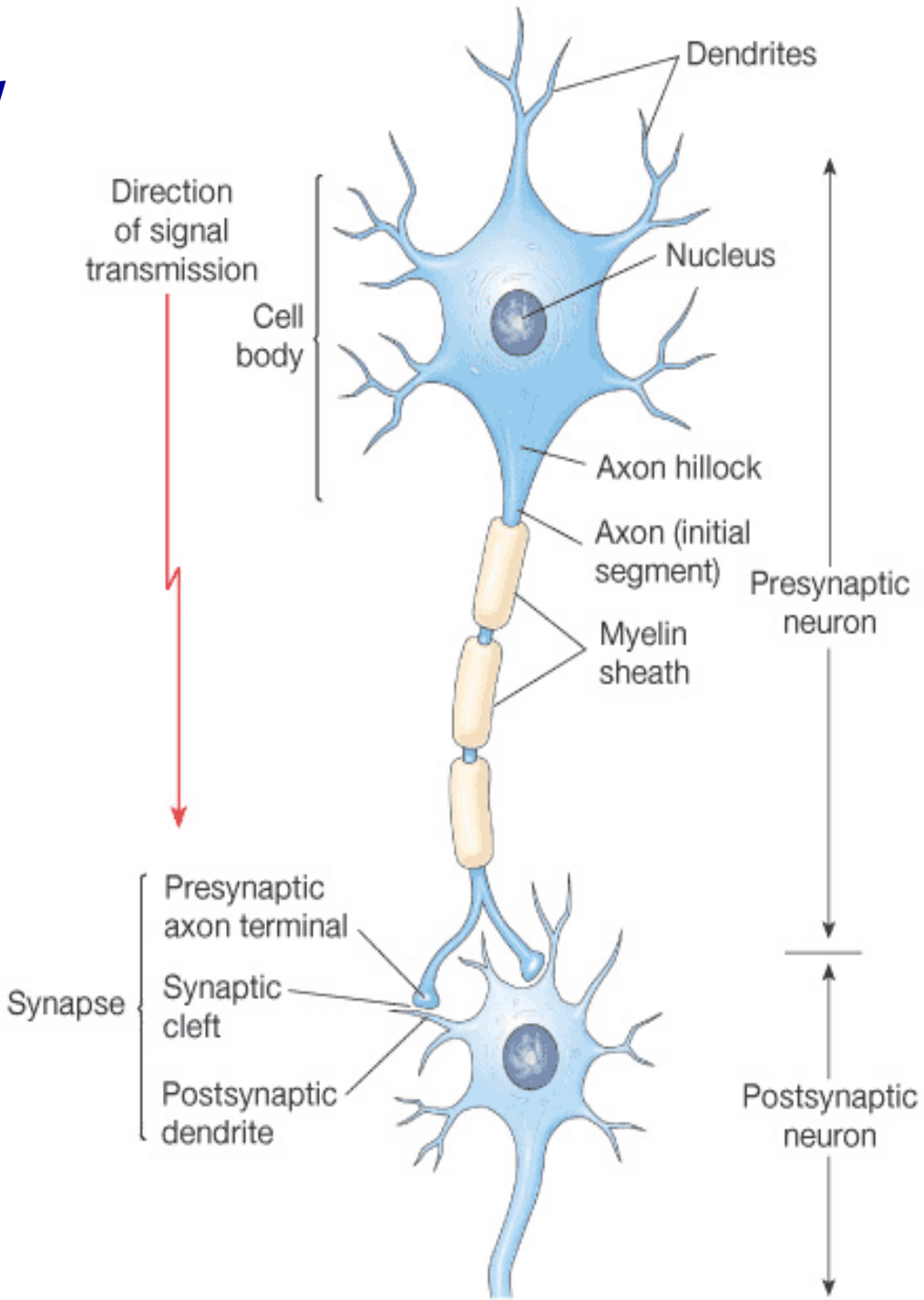
Neuron or nerve cell

Receive stimuli and
transmit action potentials.

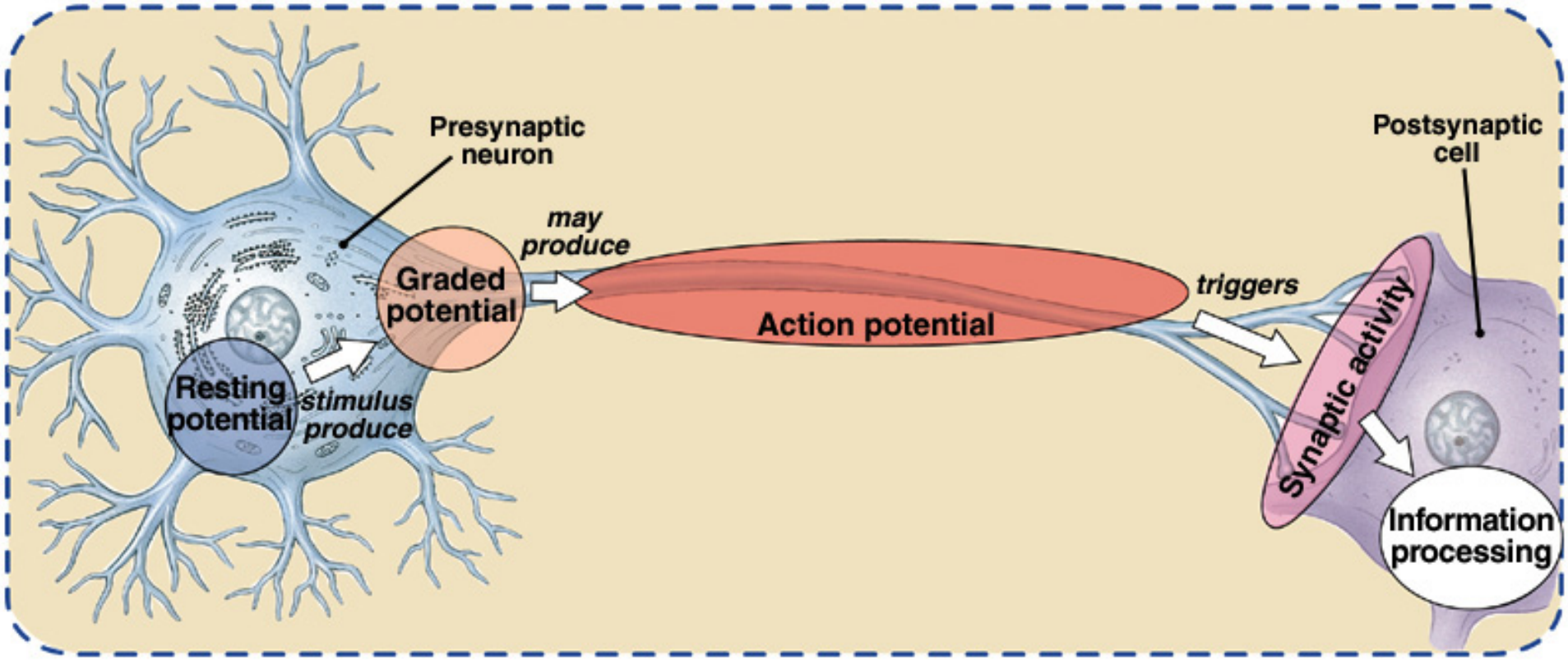
Dendrites are input devices
(electrically passive)

Axons are output devices
(actively propagate signals)



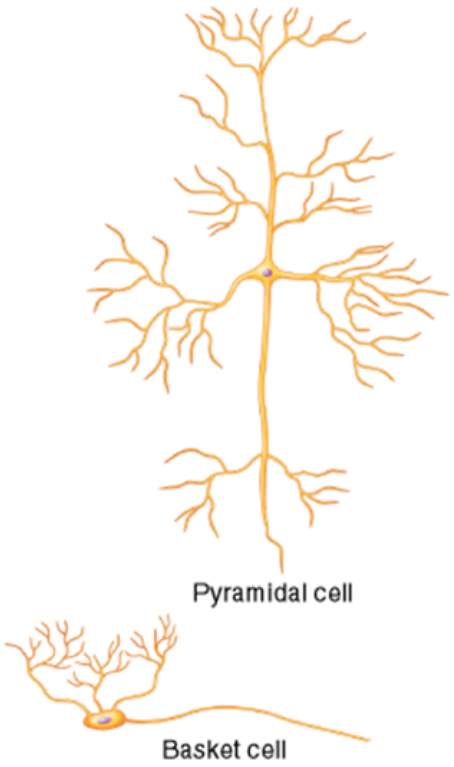


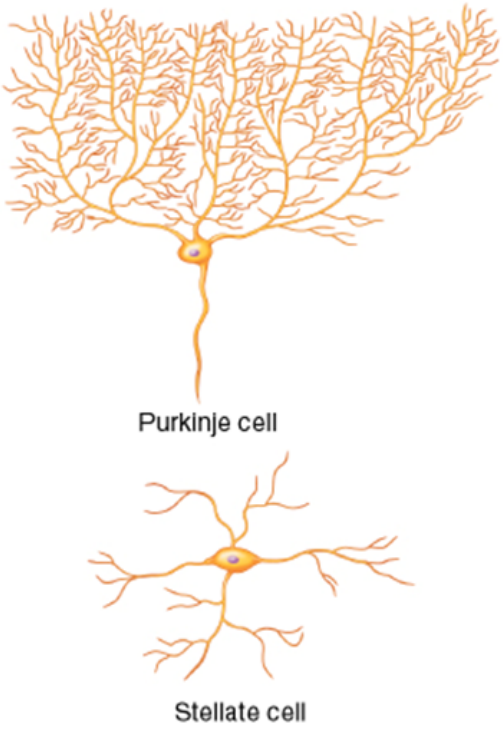
Four Basic Components of Signal Movement Through Neuron

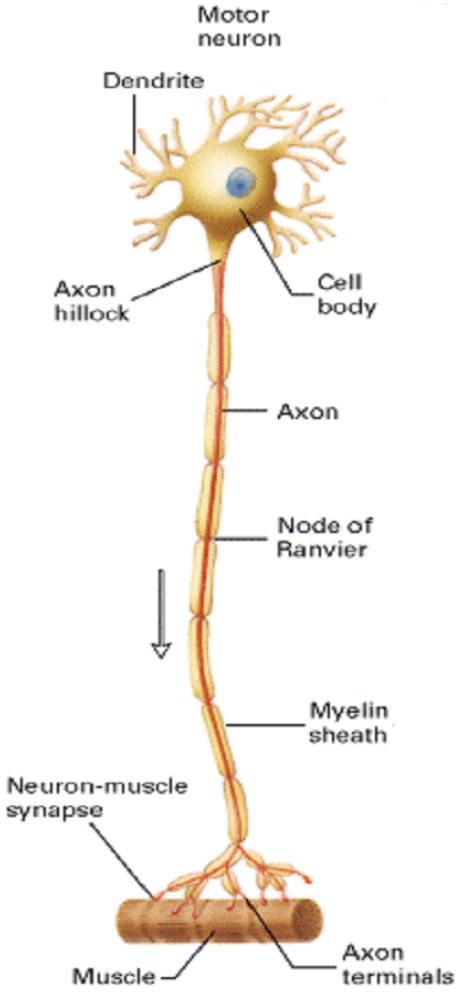


Types of Neurons – functional classification

Motor or efferent: action potentials away from CNS



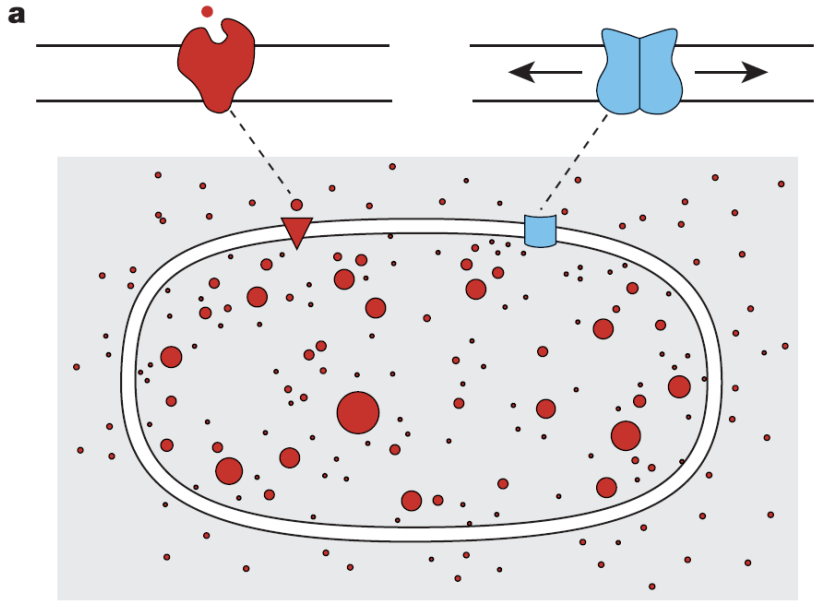




Interneurons or association neurons: within CNS from one neuron to another

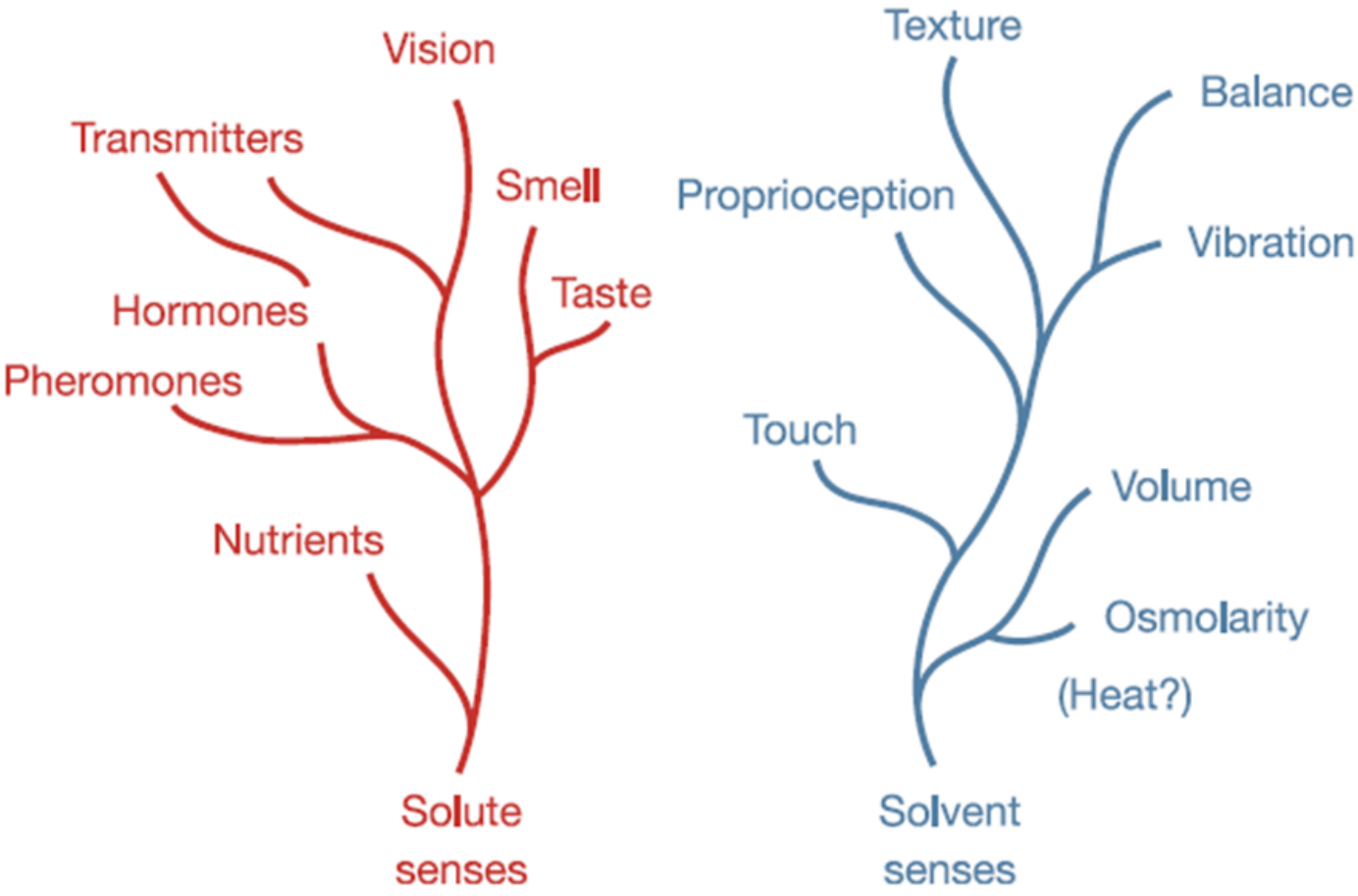
Sensory Physiology

An imaginary cell equipped with two types of receptors that are required to sense solutes and solvents - the two ingredients of life's chemistry.

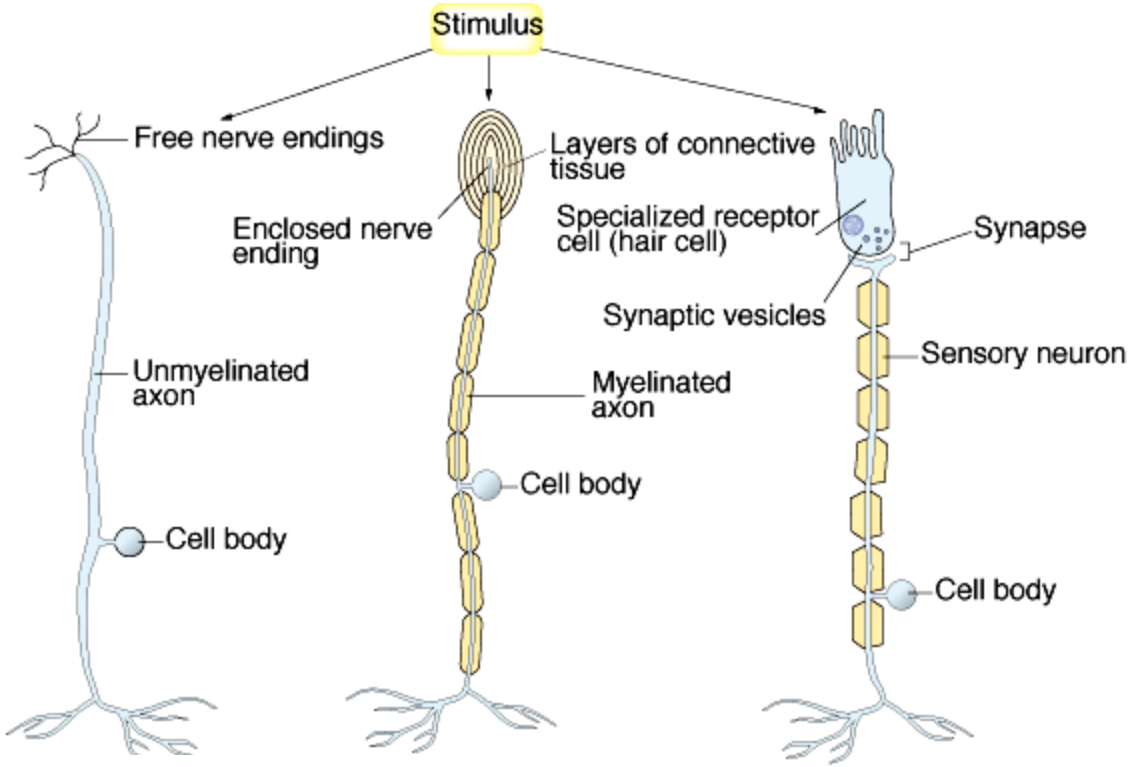


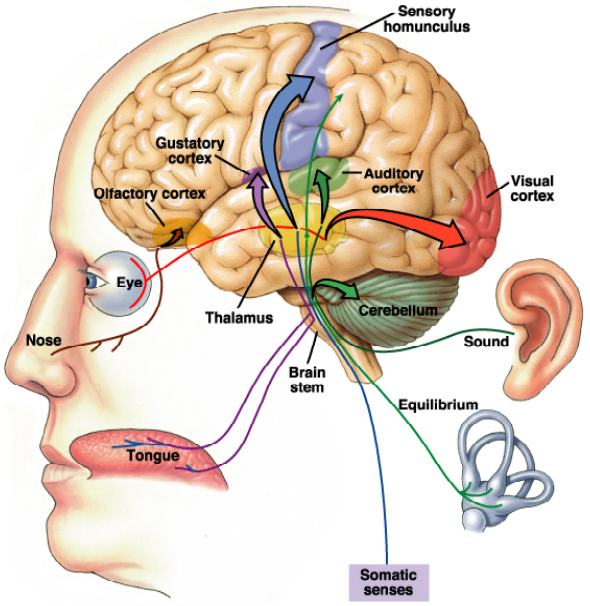
Both the lock-and-key type of receptors (red) for different solutes (ligands), as well as the turgor sensors (blue) for water (the solvent), are needed for a cell to survive.

A hypothetical diagram on the grouping of various senses that emphasizes the discrete separations of the lock-and-key type of sensing of the solutes (red) from the force-from-bilayer type of sensing of the solvent (blue).



Complexity Range of Receptors





Simple neural receptor

Complex neural receptor

Special senses receptor

Specialized receptor cell:

Amount of NT released ∝ stimulus strength

Receptor is part of neuron:

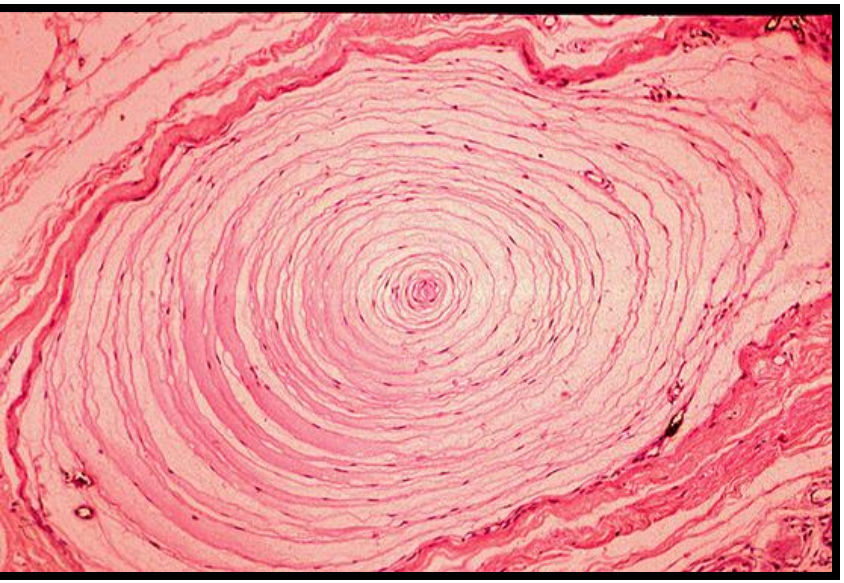
AP triggered if receptor potential above threshold

Touch receptors

Free or encapsulated dendritic endings

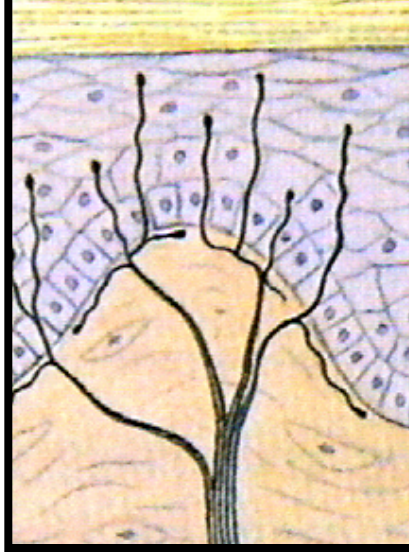
In skin and deep organs, *e.g.*: Parcinian corpuscles

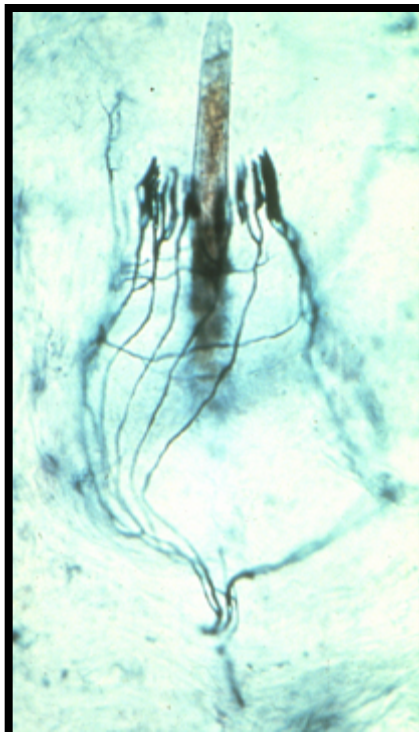
- concentric layers of c.t. ⇒ large receptive field
  detect vibration



opens mechanically gated ion channel

rapid adaptation





The central nervous system consists of neurons and glial cells.

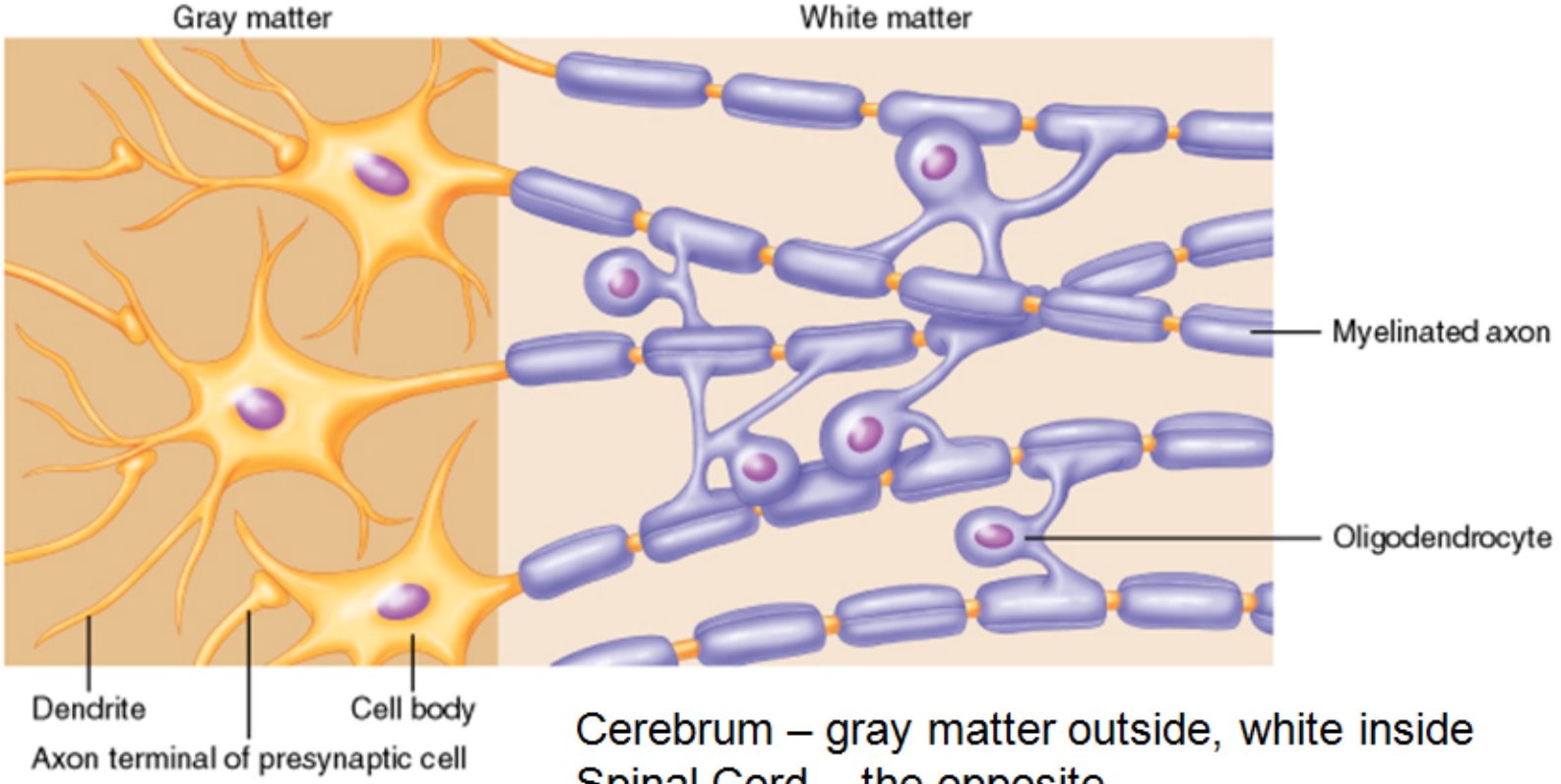
Neurons constitue about half the volume of the CNS and glial cells make up the rest.

Glial cells provide support and protection for neurons.

Main functions of glial cells are:

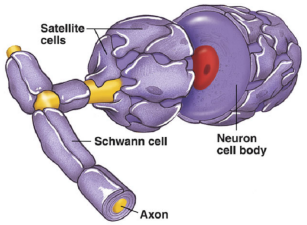
- to surround neurons and hold them in place
- to supply nutrients and oxygen to neurons
- to insulate one neuron from another
- to destroy and remove the carcasses of dead neurons (clean up)

Difference between Gray and White Matter



Cerebrum – gray matter outside, white inside
Spinal Cord – the opposite

Non-excitable cells of the nervous system

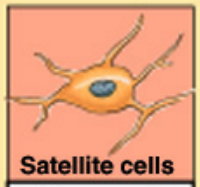


NEUROGLIA

are found in

Peripheral Nervous System

Central Nervous System

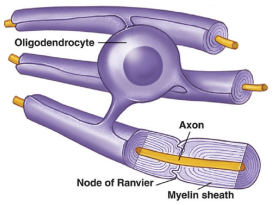


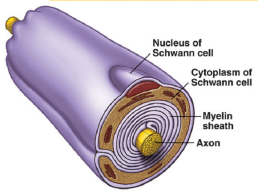
Satellite cells

Surround neuron cell bodies in ganglia; regulate; O_2, CO_2, nutrient,and neuro-transmitter levels around neurons in ganglia

Schwann cells

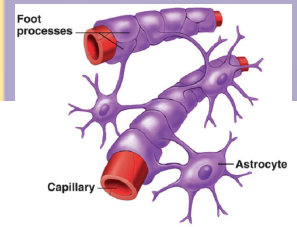
Surround all axons in PNS; responsible for myelination of peripheral axons; participate in repair process after injury

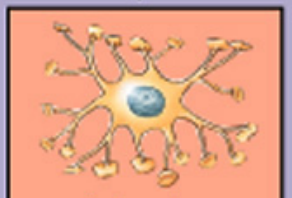




Oligodendrocytes

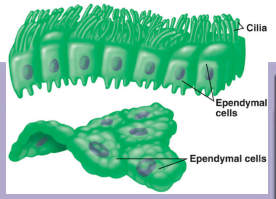
Myelinate CNS axons; provide structural framework





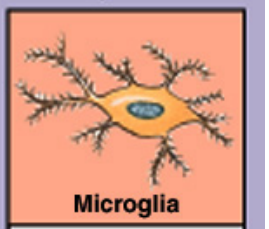
Astrocytes

Maintain blood–brain barrier; provide structural support; regulate ion, nutrient, and dissolved gas concentrations; absorb and recycle neurotransmitters; form scar tissue after injury



Ependymal cells

Line ventricles (brain) and central canal (spinal cord); assist in producing, circulating, and monitoring of cerebrospinal fluid



Microglia

Remove cell debris, wastes, and pathogens by phagocytosis