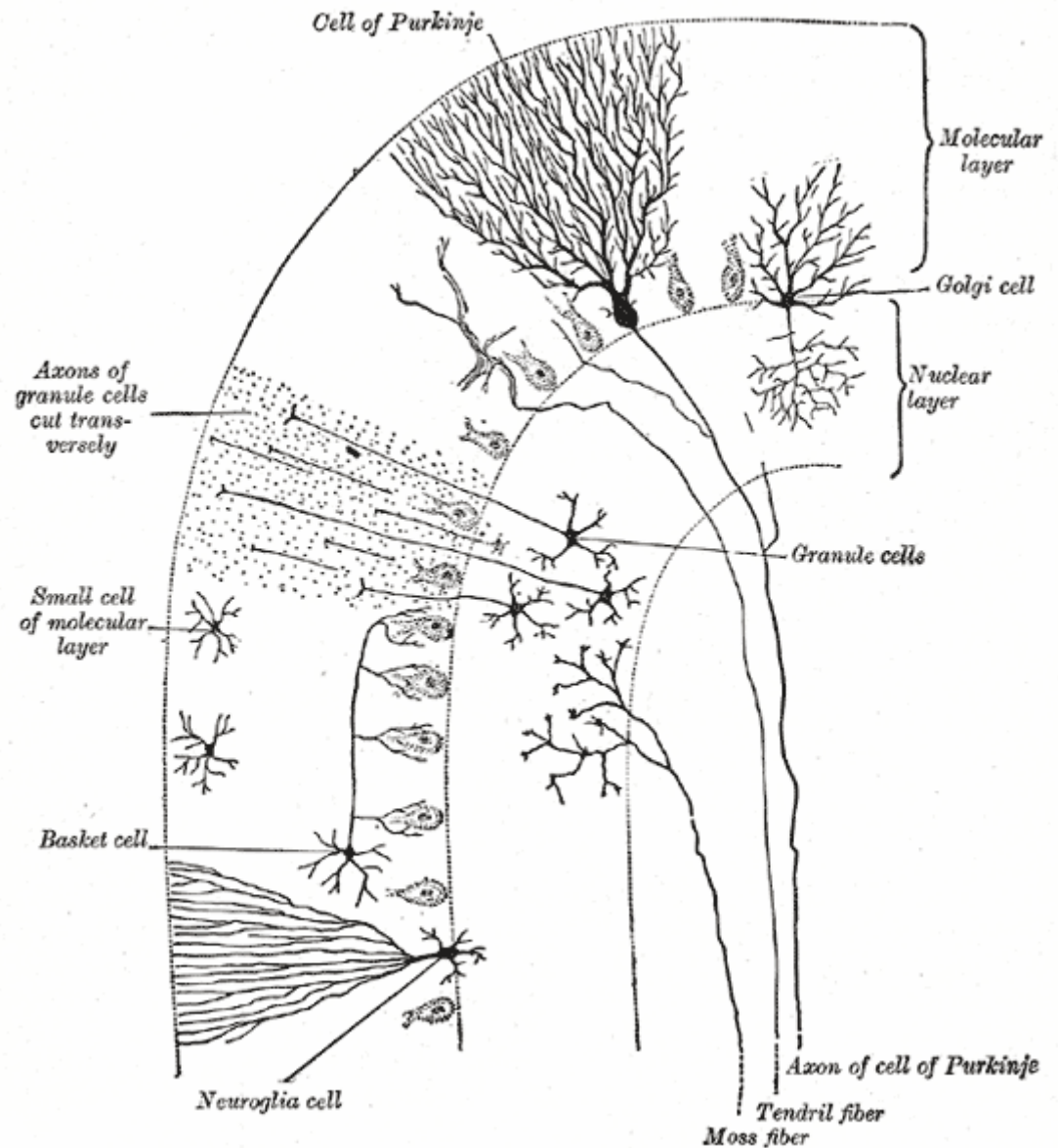
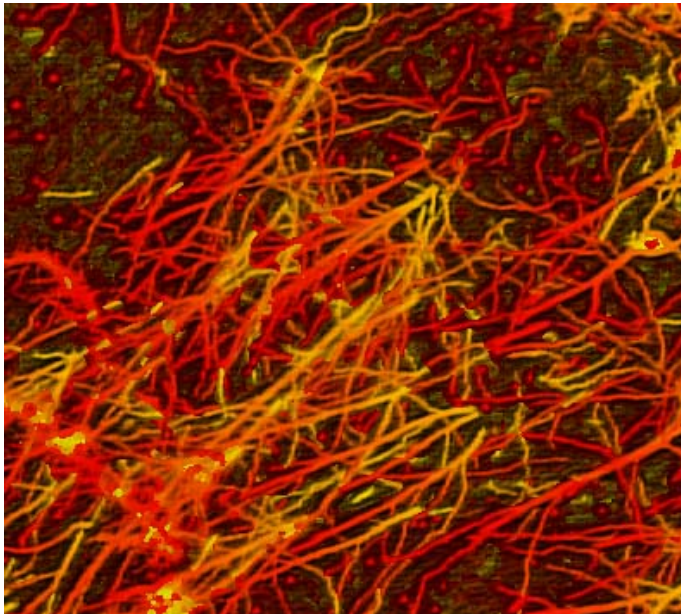


2. The neuron



Transverse section of a cerebellar folium.

http://en.wikipedia.org/wiki/Purkinje_cell

Brain cells: neurons and glial cells

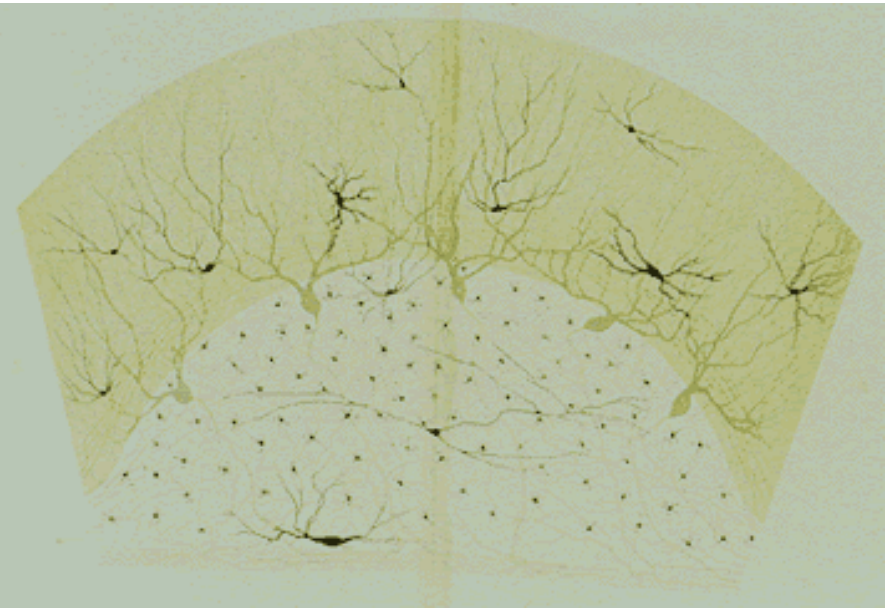
Neurons: the functional cells of the nervous system. See below.

Glial cells (neuroglia): make up 90% of the brain cells

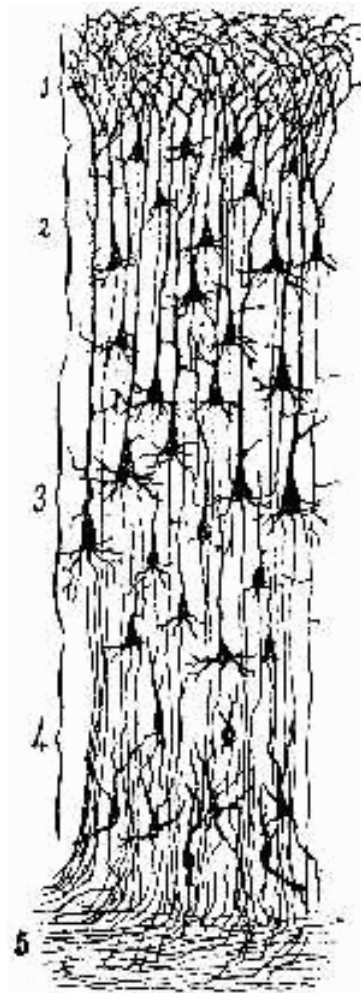
- a) **astrocytes** - these cells anchor neurons to blood vessels, regulate the micro-environment of neurons, and regulate transport of nutrients and wastes to and from neurons.
- b) **microglia** - these cells are phagocytic to defend against pathogens. They may also monitor the condition of neurons.
- c) **ependymal** cells - these cells line the fluid-filled cavities of the brain and spinal cord. They play a role in production, transport, and circulation of the cerebrospinal fluid.
- d) **oligodendrocyte** - produce the myelin sheath in the CNS which insulates and protects axons.
- e) **Schwann cells** - produce the myelin sheath in the PNS. The myelin sheath protects and insulates axons, maintains their micro-environment, and enables them to regenerate and re-establish connection with receptors or effectors.
- f) **satellite cells** - surround cell bodies of neurons in ganglia. Their role is to maintain the micro-environment and provide insulation for the ganglion cells.

http://webanatomy.net/anatomy/neuro_notes.htm

Camillo Golgi (1843-1926)



Santiago Ramón y Cajal (1852-1934)



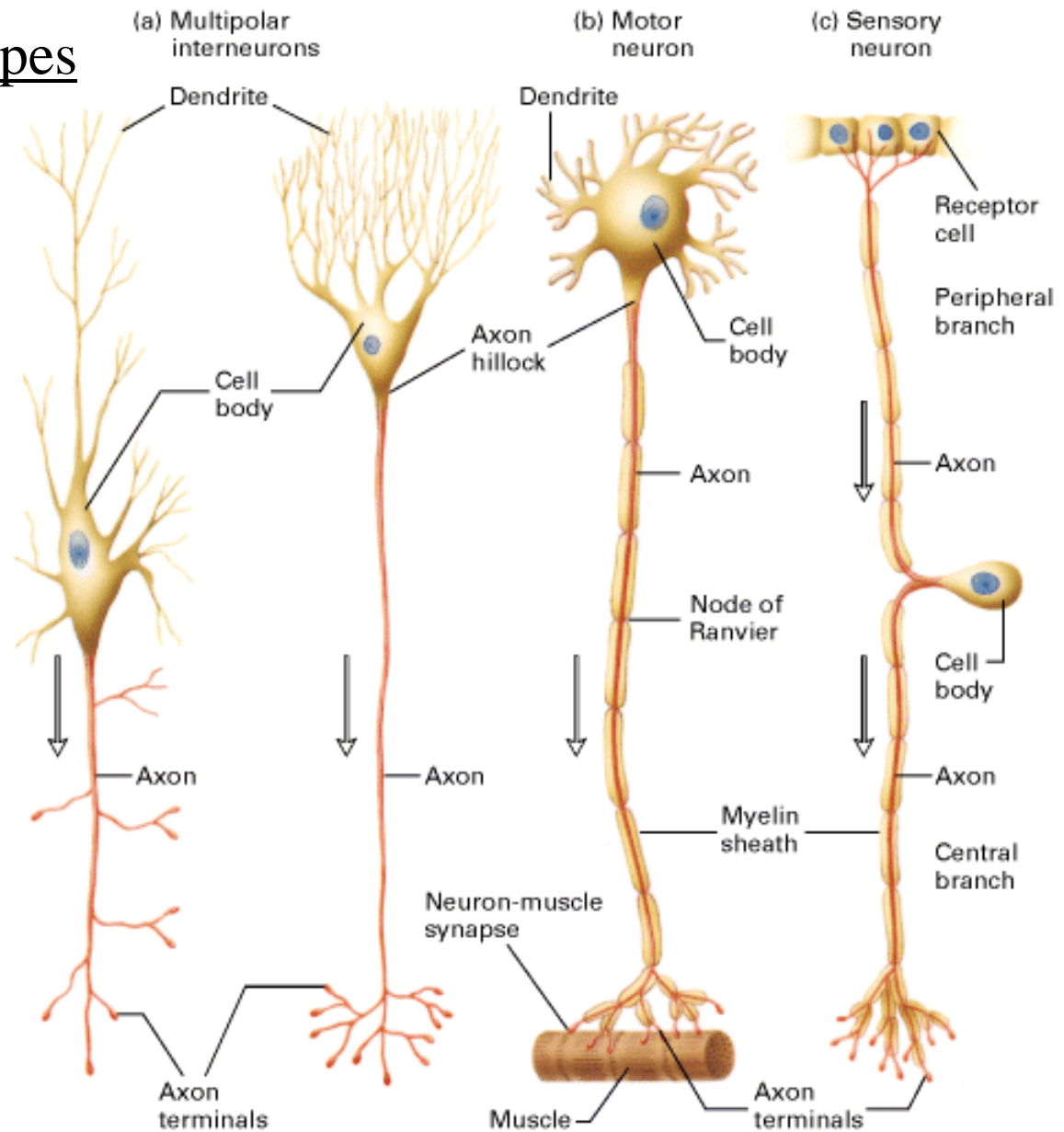
independent neurons, or nerve cells, are the building blocks of the central nervous system

Neurons: 3 basic types

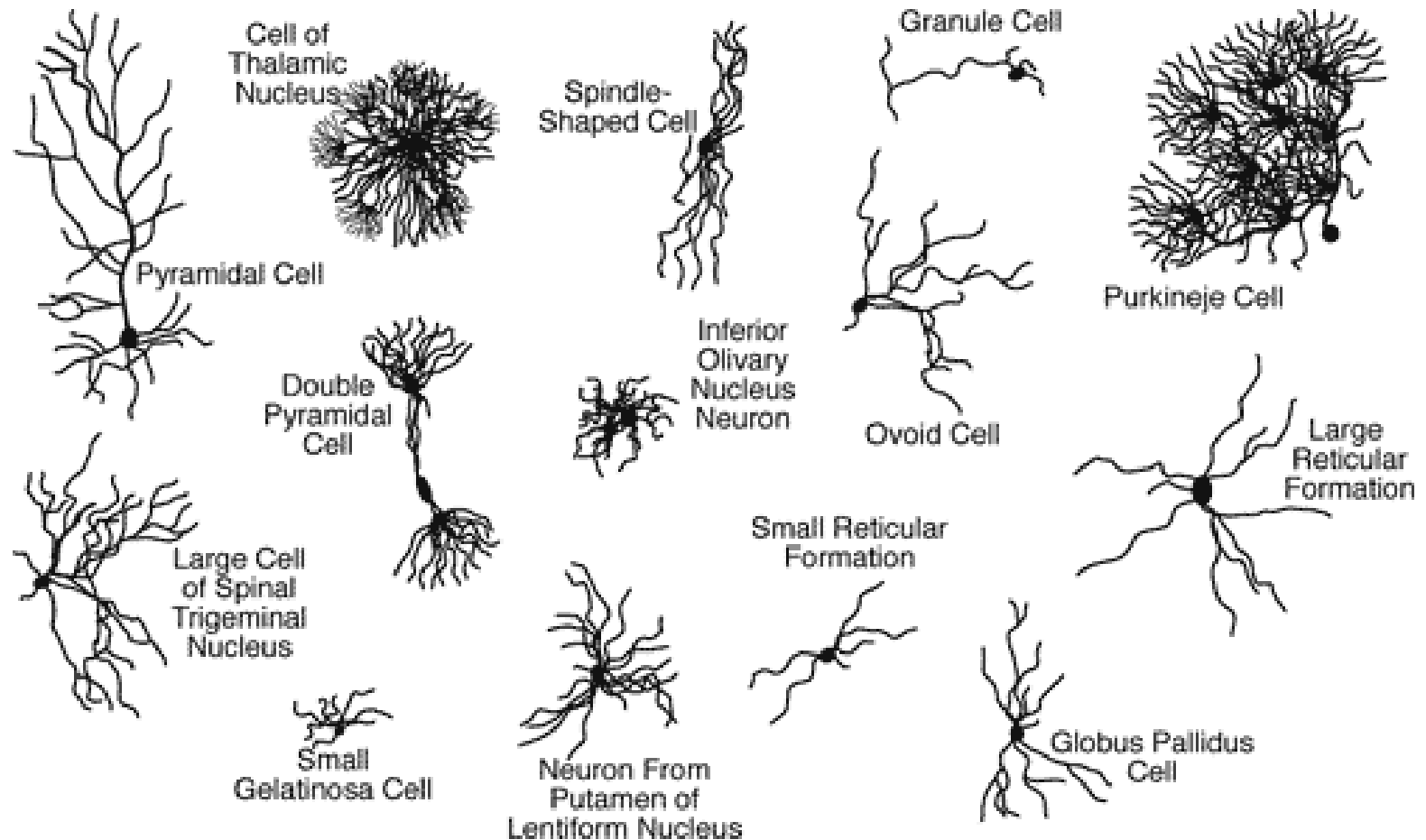
Interneuron

Motor neuron

Sensory neuron

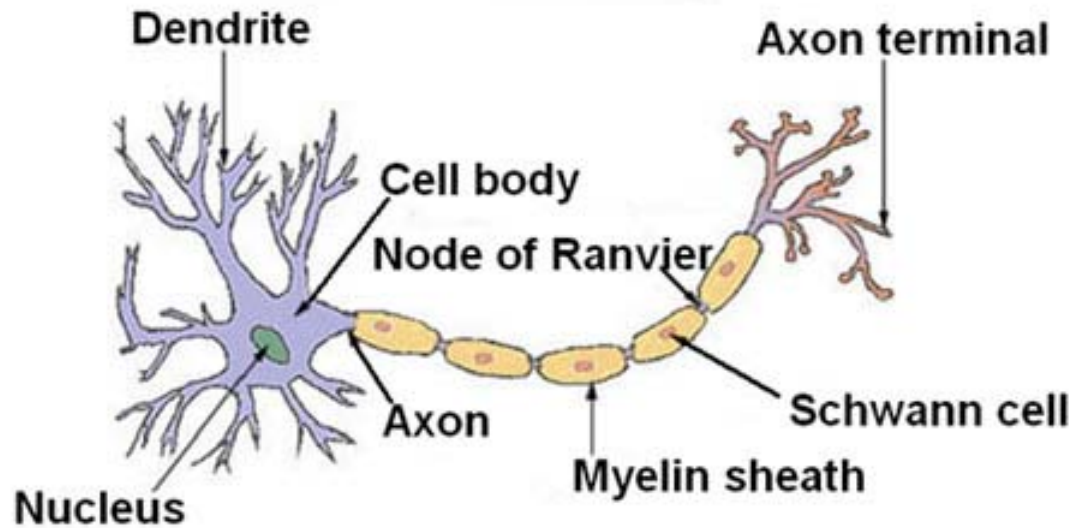


10,000 specific types of neurons in the human CNS
various shapes and sizes
100-200 billion neurons in a brain



The drawings made by Cajal

Structure of a Typical Neuron



Diameter: 4 – 100 μm

Length: an inch to several feet

Active Conduction

Unmyelinated Axons

many voltage gated Na^+ channels in proximity

action potential and passive conduction of the depolarizing current

opening of the nearby Na^+ channels to generate another action potential

repeated until the action potential reaches the terminal

Myelinated Axons

jumping of action potentials from node to node called saltatory conduction

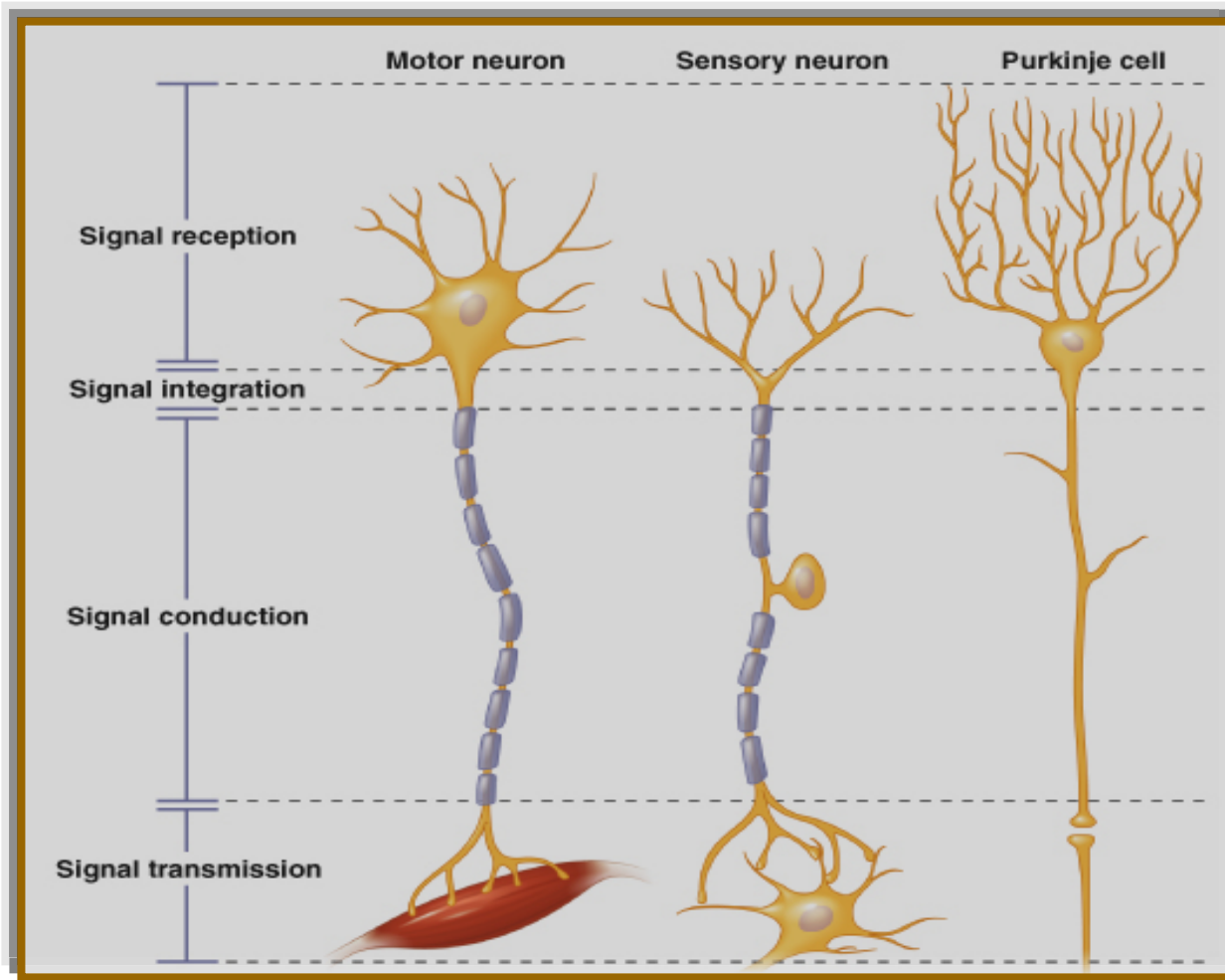
axons covered with myelin sheath

(in the form of Schwann cells in the PNS or oligodendrocytes in the CNS)

myelin prevents current leakage by increasing resistance in the axon

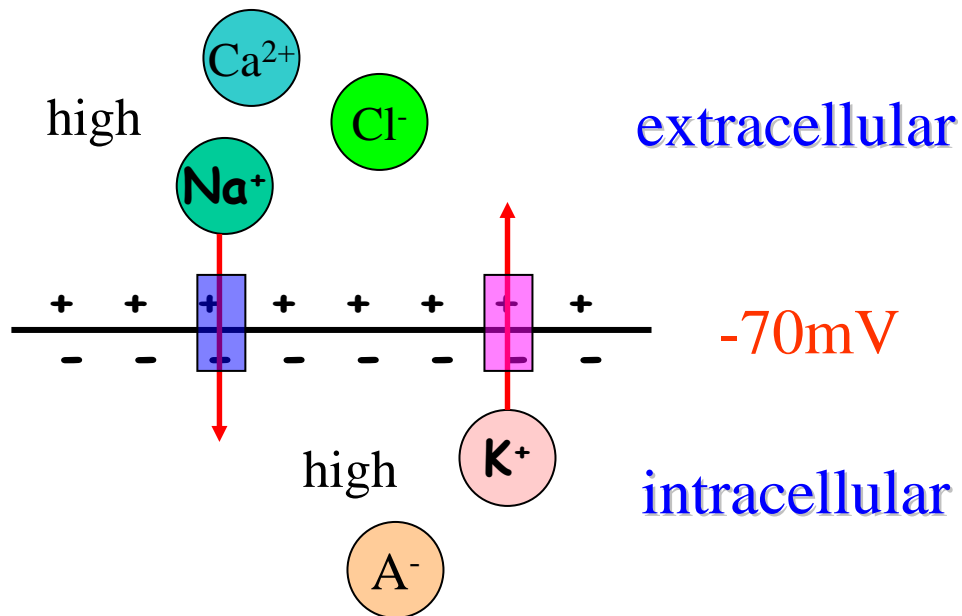
passive current to the gaps between the myelin sheaths (Nodes of Ranvier)

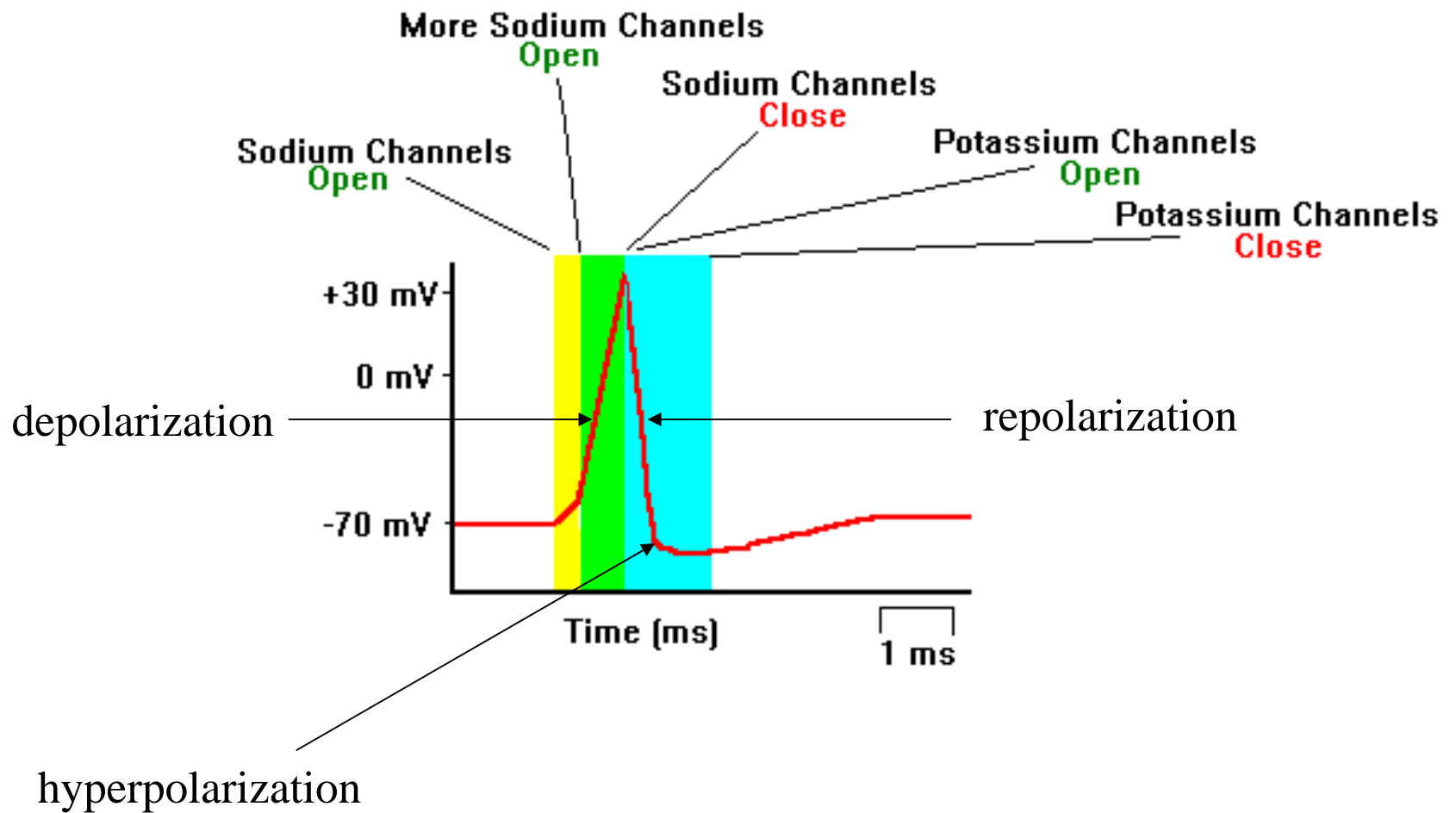
The Nodes of Ranvier contains Na^+ channels, which fire another action potential upon depolarization from the passive current



Action potential

<http://faculty.washington.edu/chudler/ap.html>





Signal intensity

Repeated action potential: normally 30-100 Hertz or up to 500

Signal speed

axon diameter

myelin sheath

up to 220 miles/h

Synapse

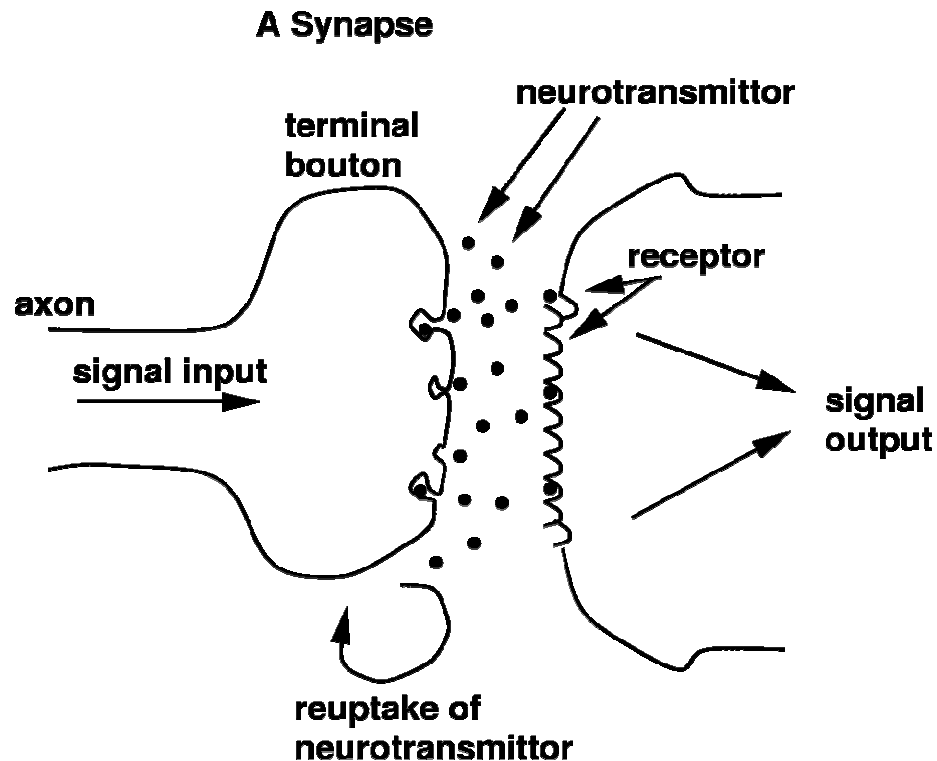
A gap between neurons (axon terminal and dendrite)

Suggested by Cajal

Demonstrated by EM in 1950s

How the signal is transmitted?

translation of electrical signal to chemical signal



Chemical provides nerve communication

Curare: nerve toxin suggested by Claud Barnard
acetylcholine receptor blocker
muscle contraction is inhibited

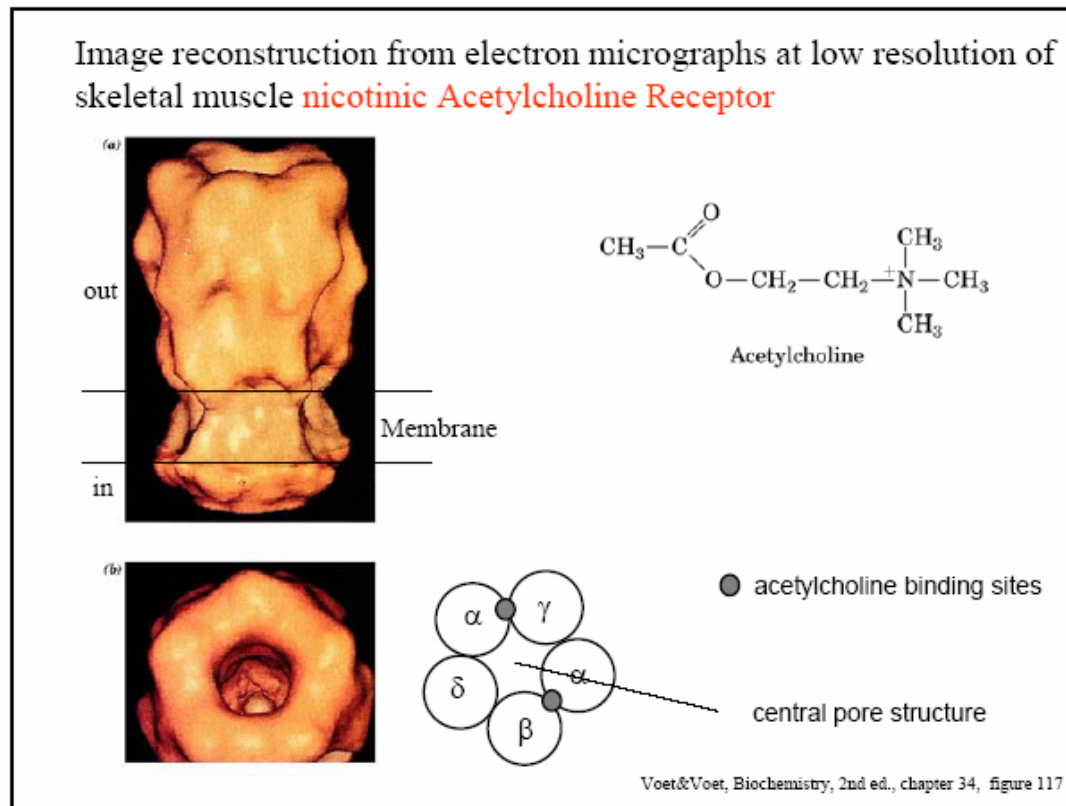
Discovery of the first neurotransmitter by Otto Loewi in 1929

<http://faculty.washington.edu/chudler/chnt1.html>

acetylcholine

Release of acetylcholine into the synapse
the higher the signal the more acetylcholine released

Specific receptor molecules
Opening of ion channel



How many synapses?

100-200 billion neurons in a brain

Each connected to 5000 and 200000 other neurons
(trees in the Amazon jungle and leaves in the trees)

Rapid removal of released neurotransmitters
transporters and degrading enzymes

Chemical synapse & electrical synapse
electrical synapse has an advantage of time and energy
but the majority are chemical synapse

Any advantage of chemical synapse?

Variable and diverse inputs

- different concentrations (different extents)

- different chemicals (different actions)

- different times

- even more subtle role in communication

- neuromodulation: excitatory or inhibitory

<http://serendip.brynmawr.edu/bb/neuro/neuro98/202s98-paper2/Casasanto2.html>

Enormous flexibility and versatility in the brain

- using different combinations of transmitter chemicals

Brain & Computer

Chemical system & electrical system

Changing chemical composition & unchanging hardware

Novel response through learning to the same command

Thinking & logic (programmed)

Brain chemicals

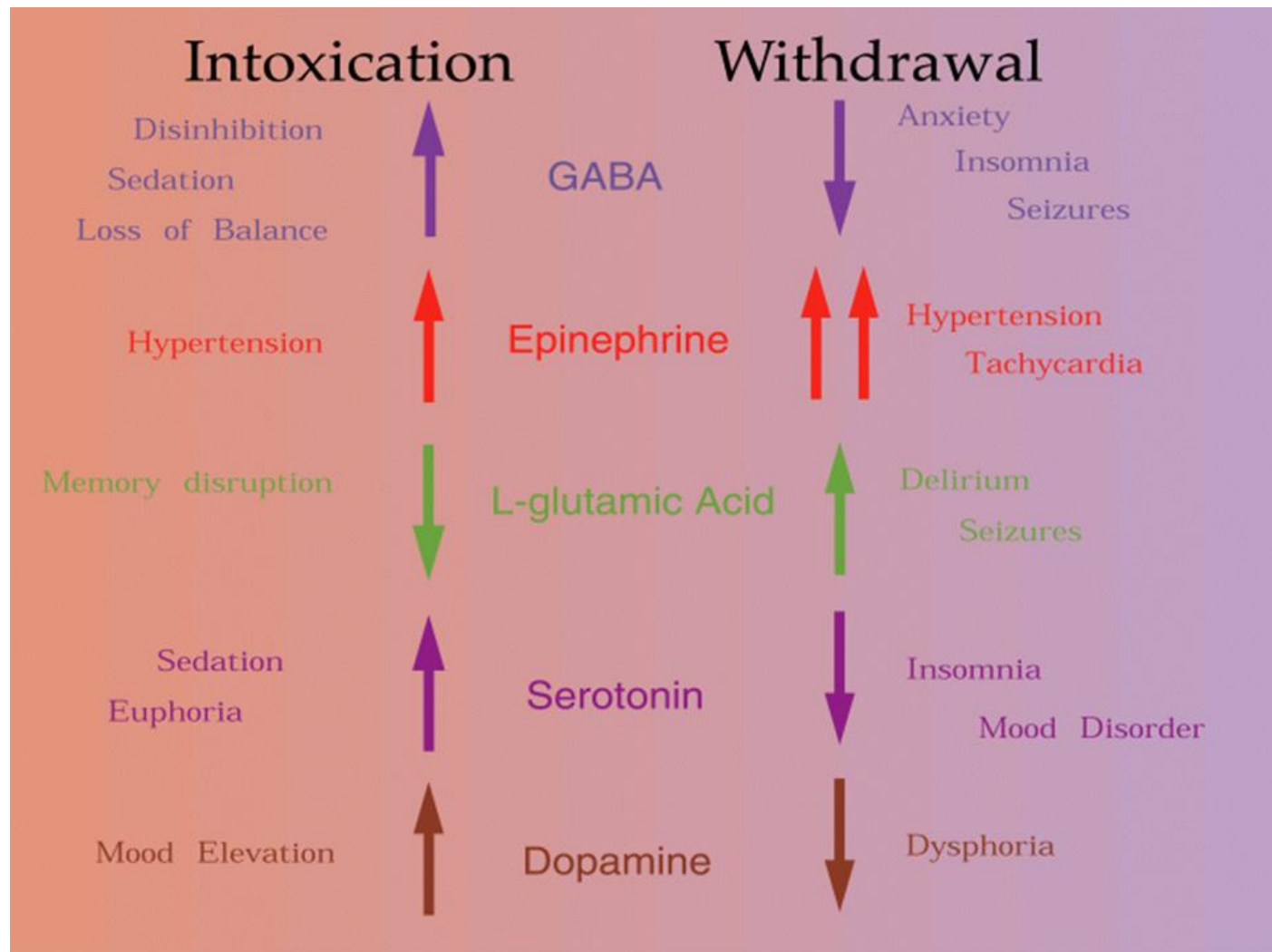
Many brain chemicals

Highly specific targets and highly diverse ways of action

Common Neurotransmitters

Neurotransmitter	Action	Receptor Subtypes
Acetylcholine (ACh)	+/-	Nicotinic, Muscarinic
Norepinephrine (NE)	+	α_1 , α_2 , β_1 , β_2 , β_3
Dopamine (DA)	+/-	D ₁ , D ₂ (D ₃ , D ₄)
Serotonin (5-HT) (5 Hydroxytryptamine)	+/-	5-HT _{1A} , etc.
Glutamate (Glu)	+	NMDA, AMPA
GABA (Gamma-aminobutyric acid)	-	GABA _A , GABA _B
Enkephalins (Enk)	-	μ , κ , δ

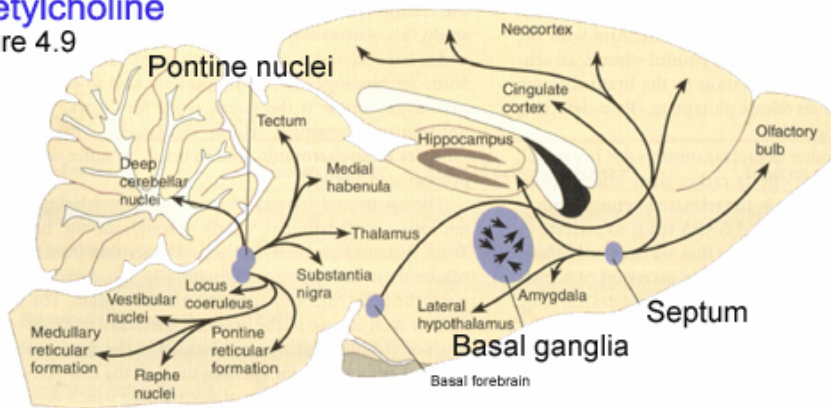
<http://www.colorado.edu/intphys/Class/IPHY3730/06neurotransmitters.html>



Major Brain Pathways

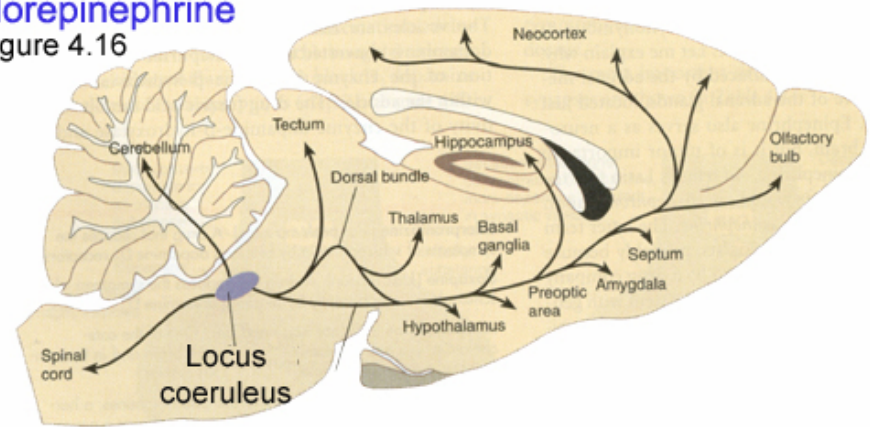
Acetylcholine

Figure 4.9



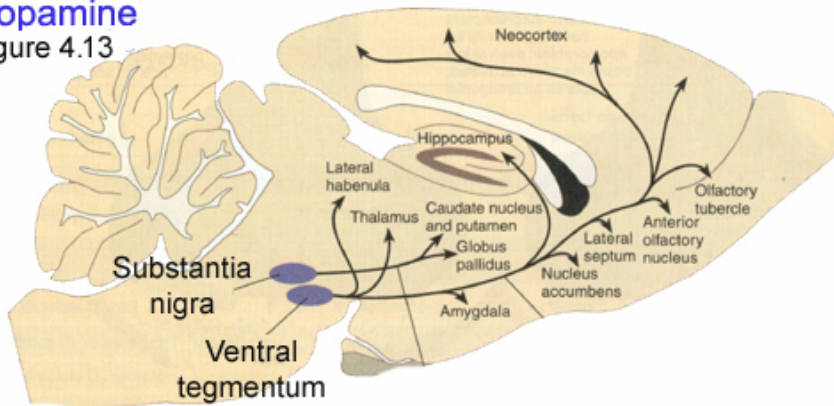
Norepinephrine

Figure 4.16



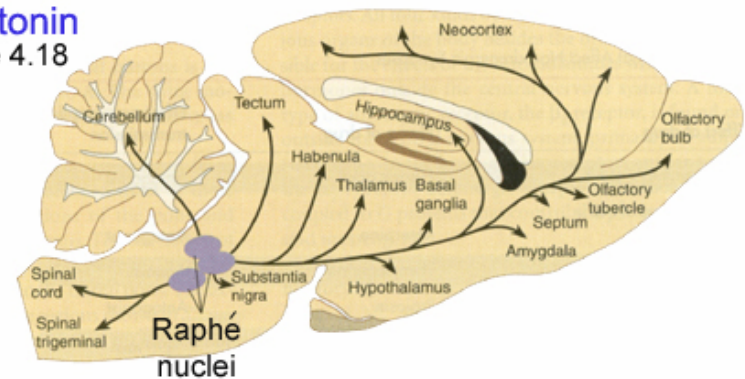
Dopamine

Figure 4.13



Serotonin

Figure 4.18



Drugs

influence on behavior by changing chemical communication

nicotine, morphine, cocaine, ecstasy

Nicotine

Agonist action on acetylcholine receptor

Stimulation is far higher than with acetylcholine

long-term effects on brain: receptors become less sensitive and habituated

need for the higher amounts: chemical basis of addiction

Nicotine works on one receptor type: one-sided effect

Body in alerted condition

Morphine

Heroin: chemically modified form of morphine

Effect on brain stem and slow down breathing

Relief from pain

feel pain but not bothered

Mimic natural transmitters (opioid peptides): enkephalin, endorphin, dynorphin

Enkephalin blocker (naloxone) worsens pain & analgesic effects of acupuncture

Opioid peptide act locally but morphine or heroin acts on all brain

The excessive activation of receptors is similar to nicotine addiction

Cocaine and crack: smoking & snorting

Blocks noradrenaline removal

Sustained effects

Puts body into a false stress situation

Amphetamine (speed)

excess release of noradrenaline & dopamine

prevent their reabsorption

Dopamine, noradrenaline, acetylcholine: brain stem

Ecstasy

Excessive release of serotonin

Hallucinogen

Euphoria

Long-term use results in depression and suicide

Death of the clump of neurons (the raphe nuclei) in the brain stem

Prozac

The link between

the known molecular/cellular change and the change in the way we actually feel

Biochemical action within hours

but therapeutic action after some ten days

The link between
the known molecular/cellular change and
the change in the way we actually feel

Biochemical action within hours
but therapeutic action after some ten days