Neurons and Glial Cells
Introduction

• vertebrate nervous systems
  • the central nervous system (CNS) - brain and spinal cord
  • the peripheral nervous system (PNS) - nerves

• two kinds of cells
  • neurons - the information processing cells
  • glial cells - support cells

• three functionally different kinds of neurons
  • sensory neurons - input from sensory receptors
  • interneurons - “central” processing
  • motor neurons - output to effectors (muscles and glands)
Basic Structure of Neurons

- soma (cell body)
- dendrites (with spines)
- axon
- collaterals
- terminal arborizations
- terminal buttons
- myelin sheath
myelin sheath
Demyelinating Diseases

- multiple sclerosis (MS) - demyelination of motor and sensory pathways (usually “idiopathic”)
- vitamin B12 deficiency
- tabes dorsalis - demyelination of the dorsal column sensory paths (touch sense) due to untreated syphilis
- progressive multifocal leucoencephalopathy - a viral inflammation (encephalitis) of white matter of the brain, almost always in people with severe immune deficiencies
- optic neuritis - inflammation and destruction of the myelin sheath of the optic nerve leading to progressive loss of vision, usually the result of multiple sclerosis
axons can be six feet long!
pyramidal neuron in the cortex
(axon not visible)
Polarization and Synaptic Connections

[Diagram of neurons showing synapses, cell bodies, dendrites, axons, and myelin sheaths]
Detail of a Synapse

Myelin sheath

Axon initial segment

Nucleus

Soma

Dendrites

Terminal arborizations

Direction of conduction

Axon

Terminal buttons

Detail of the Synapse

Terminal potential

Presynaptic membrane

Vesicle

Synaptic cleft

Postsynaptic membrane

Neurotransmitter

Postsynaptic receptors
SYNAPTIC TERMINAL occupies most of this electron micrograph made by John E. Heuser of the University of California School of Medicine in San Francisco and Thomas S. Reese of the National Institutes of Health. The cleft separating the presynaptic membrane from the postsynaptic one undulates across the lower part of the picture. The large dark structures are mitochondria. The many round bodies are vesicles that hold transmitter. The fuzzy dark thickenings along the cleft are thought to be principal sites of transmitter release.
Release of Neurotransmitter

SYNAPTIC VESICLES are clustered near the presynaptic membrane. The diagram shows the probable steps in exocytosis. Filled vesicles move up to synaptic cleft, fuse with the membrane, discharge their contents and are reclaimed, re-formed and refilled with transmitter.
TRANSMITTER IS DISCHARGED into the synaptic cleft at the synaptic junctions between neurons by vesicles that open up after they fuse with the axon’s presynaptic membrane, a process called exocytosis. This electron micrograph made by Heuser has caught the vesicles in the terminal of an axon in the act of discharging acetylcholine into the neuromuscular junction of a frog. The structures that appear in the micrograph are enlarged some 115,000 diameters.
FREEZE-FRACTURE REPLICA S of the presynaptic membrane of the frog neuromuscular junction were made by Heuser. The upper micrograph shows the membrane three milliseconds after the muscle had been stimulated. Running across the axon membrane is a double row of particles: membrane proteins that may be calcium channels or structural proteins to which vesicles attach. The lower micrograph shows the membrane five milliseconds after stimulation. The stimulation has caused synaptic vesicles to fuse with presynaptic membrane and form pits.
excitatory and inhibitory synapses
when inhibition goes wrong

(some people think)
Bipolar and Unipolar Neurons

mostly sensory in function

(Interneurons and motor neurons are multipolar in vertebrate nervous systems.)
Glial (and Schwann) Cells

- formation of the myelin sheath
- oligodendrocytes in the CNS
- Schwann cells in the PNS
- notice the myelin is not continuous
- nodes of Ranvier
Nerves and Tracts

- In the PNS, a bundle of axons is called a nerve. In the CNS, it is called a tract.

- If a nerve is severed, it will usually regenerate. A tract will not.

- This is due to a difference in the properties of the myelin-generating cells.

Cross section of the sciatic nerve in the hip and leg, from anatomyatlases.com.
• Blue dye injected into the general circulation will stain every part of the body except the brain and spinal cord.

• In part, this is due to the structure of the capillaries.

• To get into the brain, chemicals have to diffuse through the cell membrane or be taken up by special transporters.

• Astrocytes and the BBB.
Neurons are Electrical Devices

- **membrane potential** - the voltage measured across a cell membrane
- **resting potential** - the voltage measured across a cell membrane when the cell is resting (inactive); approx. -70 mV
- **graded potential** - a relatively slow, small, and variable change in the membrane potential (quickly die out)
- **action potential** - a very brief, large, all-or-none voltage change across the membrane that provides the basis for neural conduction along the entire length of the axon
Cell Membrane: Ions, Channels, and Pumps

Action Potentials
Ion Channel Poisons

TTX is a substance found in the Japanese puffer fish, as well as other animals, that blocks Na+ channels by binding to the channel protein.

Once a molecule of TTX binds to the channel, sodium ions cannot pass through. This prevents the formation of action potentials on axons.
A Neural Network: The Nervous System Doing Something
More Complicated Networks

retina
More Complicated Networks

visual system