Action potentials propagate down their axon

Larger diameter axons have less resistance to ion flow

Speed of conduction is faster in large diameter axons
Saltatory conduction in myelinated axons

Myelinated axons conduct action potentials up to 10X faster

Large myelinated axons can conduct up to 150 m/sec, 330 mph
How neurons communicate

- Ionic basis for resting membrane potential
- Action potentials
- Synaptic transmission: chemical
If K channels open:
K will follow concentration gradient
Inside negative

Equil. potential when elect. potential = concentration grad.

\[ E_K = -58 \text{ mV} \]

- At rest, K permeability is much higher than Na permeability
- Resting potential is near \( E_K \)

If Na channels open:
Inside positive

\[ E_{Na} = +58 \text{ mV} \]
Ionic basis of resting membrane potential

- The inside of neurons is about -60 mV relative to the outside
  - Cell membrane is semi-permeable
  - Ionic concentrations inside and outside are different
    - $[\text{Na}]$ is high outside, low inside
    - $[\text{K}]$ is high inside, low outside
  - Sodium/potassium pump helps maintain this imbalance
    - Much of the energy (70%) of the brain is expended here
  - At rest $K$ permeability is about 40x higher than $Na$
- Resting potential: when electrical potential balances concentration gradient
Action potentials: arise from changes in Na and K permeability

At rest, K channels are open.

Na channels open briefly to produce a surge of inward Na.

K channels open again to repolarize.

Depolarization

Increase Na permeability

Increase Na current

Action potentials:

• ’All-or-none’, not graded in amplitude
• Membrane potential must be depolarized above a threshold of about -55 mV
Action potentials: neurons communicate with other neurons by electrical pulses

- They are more or less identical
- The membrane potential must be depolarized above a threshold of about -55 mV
- They are ‘all-or-none’, not graded in amplitude
- They are followed by an absolute and relative refractory period
Synaptic transmission at a chemical synapse

Action potential in presynaptic terminal triggers release of neurotransmitters from synaptic vesicles

Neurotransmitter diffuses across synaptic cleft to bind with receptors for transmitter

Activation of receptors opens ion channels leading to excitatory (EPSP) or inhibitory post-synaptic potentials (IPSP)
Excitatory depolarize (glutamate)

Inhibitory hyperpolarize (GABA)
Cell body integrates inputs

Spatial summation

Temporal summation

EPSPs can summate spatially or temporally

Bear et al., 2001
Methods of visualizing neurons

- **Golgi** method will stain a small percentage of neurons in their entirety
- **Nissl** stain reveals the shape of cell bodies
- **Weigert** stain stains the myelinated axons
- Intracellular injections of dyes or tracers can also label single neurons
Golgi stain

- Stains a small percentage of neurons in their entirety.
- Which cells get stained is not understood.

Purves et al., 2001
Nissl stain

- Stains cell body, or soma

Purves et al., 2001
Weigert stain reveals myelinated axons
Neurons aggregate together in different ways

Lateral geniculate nucleus  Cerebral cortex
Cytoarchitectonic maps of the cerebral cortex

Korbinian Brodmann (1868–1918)
Caudate nucleus
Parkinson's disease

- Loss of dopaminergic cells in SNpc
- Symptoms
  - Akinesia - lack of movement and difficulty in initiating movement
  - Resting tremor
  - Festinating gait
- Treated by increasing dopamine (l-dopa therapy)
- Can be induced by a neurotoxin (MPTP)
Symptoms of Parkinson’s Disease

- Tremor at Rest
- Shuffling Gait and Stooped Posture
- Masked Face and Rigidity
Parkinson’s Disease

Normal

PD

Substantia nigra
L-dopa therapy

The effect of a single intravenous administration of L-dopa was, in short, a complete abolition or substantial reduction of akinesia. Bedridden patients who were unable to sit up, patients who could not stand up from a sitting position, performed all these activities with ease after L-dopa. They walked around with normal associated movements and they could even run and jump. ....For short periods of time the patients were able to perform motor activities which could not be prompted by any other known drug to any comparable degree. This dopa effect reached its peak within 2-3 hours and lasted, in diminishing intensity, for 24 hours. (Hornykiewicz, about 1969).