Membrane biophysics (Sargent)

Neurophysiology Primer
- Properties of resistors, capacitors in series/in parallel
- Kirchoff’s current law/Kirchoff’s voltage law/Ohm’s law
- Properties of RC circuits
- Biological membranes as parallel RC elements
- Neuronal geometry and the passive electrical properties of excitable cells

Determinants of Membrane Potential
- Model cells permeable to one ion
- The Nernst Equation - equilibrium
- Model cells permeable to more than one ion – steady state
- Current, conductance, and driving force (Ohm’s law)
- The Goldman/GHK equation
- Contribution of pumps to membrane potential
- Leak channels and the resting potential

Action Potentials
- Voltage clamp; HH analysis
- Modeling
- IV curves
- Threshold
- Refractory period
- Gating current
- Propagating action potentials

Single Channels
- Noise
- Patch Clamp
- \( P_{\text{open}} \)
- Two state transitions; deriving rate constants from dwell times

Ion Channel Structure and Function (Kirichok, Jan L)

Ion channel classes by selectivity
K channels
- \( K_V \) channel structure
  - Selectivity filter
  - Gating
  - Voltage sensor
  - Inactivation
- Kir channels
  - Structure
Na channels
- \( Na_V \) channels
Ca channels
- \( Ca_V \) channels
Selectivity

Auxiliary subunits

Non-selective cation channels
CNG channels, HCN channels
Nicotinic acetylcholine receptor
  Structure
  Permeation
  Gating

Synaptic Transmission (Sargent)

Electrical Synapses
Ionotropic Receptors
  Role of ionotropic receptors in fast chemical transmission
  Determinants of the time course of synaptic current
  Ionic basis of excitatory and inhibitory synaptic transmission
  Reversal potential
  Inhibition by shunting

Transmitter Release
  Role of calcium
  Fate of released transmitter
  Direct and indirect methods for measuring transmitter release
  Spontaneous and evoked transmitter release
  Synchronous and asynchronous release
  The quantal hypothesis
  The vesicle hypothesis
  Statistical methods
    Use of binomial/poisson statistics to measure changes in p,
    Estimating N, P, and Q from variance-mean analysis
  Univesicular and multivesicular release
    Linearity/nonlinearity of synapses
  Short-term Facilitation/depression

Glutamate Receptors and Plasticity (Nicoll)

Glutamate Receptors (Nicoll)
  Classification
  Expression cloning
  The postsynaptic density (PSD)
  AMPARs
    Structure
    Gating
    Kinetics and subunit composition
    Genetic dissection of AMPAR subunits
    AMPAR trafficking
  NMDARs
    Subunits and properties
    Developmental switch in subunits
Scaffolds
Adhesion Proteins

Plasticity (Nicoll)
Taxonomy of memory systems
Hippocampal LTP
Induction of LTP/LTD
Associativity
AMPARs, NMDARs
Expressions Mechanisms of LTP/LTD
“Quantal Analysis” and LTP
Silent Synapses
CaMKII
Receptor Centric Model vs PSD centric Model

Integration (Bender)
Cable theory
Role of capacitance in filtering
Neuronal exploitation of passive cable properties
Fast integration
Time difference coding
Sublinear integration
Passive integration in dendrites
Orthodromic and antidromic spike propagation
Active properties of dendrites
Importance of synaptic location, EPSPs vs IPSPs
Synapses onto spines and shafts; what are spines good for?
Axonal integration
Analog vs. digital components of action potential induced release
Determinants of AP initiation
Modification of integration

Neurotransmitter transport (Edwards)
Synaptic Vesicles
Purification
Proteins associated with synaptic vesicles
Transport of synaptic vesicles
Molecular basis of synaptic vesicle docking and priming
Molecular basis of calcium-dependency of exocytosis
Molecular constituents of the active zone
Peptidergic vesicles

Neurotransmitter transport
Endocytosis
Clathrin
Adapters
BAR domain proteins
Uncoating
Models for exocytosis/encocytosis
Synaptic vesicle pools
Are spontaneous and evoked vesicles different

Receptor Pharmacology (Whistler)
Ionotropic and metabotropic receptors
G protein mediated signaling
Primer on pharmacological terms (ligand, agonist, antagonist)
Ligand affinity
Efficacy
Ligand potency and selectivity
Allosteric modulators
Receptor oligomerization
Receptor desensitization/downregulation
Biased agonism