

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_{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

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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_v

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)

AMPA

Structure

Gating

Kinetics and subunit composition

Genetic dissection of AMPAR subunits

AMPA trafficking

NMDA

Subunits and properties

Developmental switch in subunits

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Scaffolds

Adhesion Proteins

Plasticity (Nicoll)

Taxonomy of memory systems

Hippocampal LTP

Induction of LTP/LTD

Associativity

AMPA, 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

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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