9.09J/7.29J - Cellular Neurobiology, Spring 2005
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Review Session 3/14/04

- Na^+K^+ pump - can run many APs after turn off pump "Nernst battery
  - Nernst equilibrium: concentration gradient, electrical gradient give you battery

somatotopic - eg retinotopic cat on retina → cat on visual cortex
local neighborhood relationships preserved (adjacent cells on retina project to adjacent cells in visual cortex)
eg tickle cells close together on body → cells close together stimulated in brain

Nernst equation: $V = \frac{RT}{zF} \times \ln \frac{[I]_o}{[I]_i}$
$= 58 \log \frac{[I]_o}{[I]_i}$ (at room temperature)
- good for any ions (takes care of its own sign)
- (in Goldman equation, negative ions have $[I]_i/[I]_o$, so can use same z for all terms)
- Goldman equation not covered enough to use on test

weighted-average equation: used for all H&H models
derived from Ohm's Law for Membranes
$I = g_{Na}(V_m - E_{Na}) + g_K(V_m - E_K)$
$0 = g_{Na}(V_m - E_{Na}) + g_K(V_m - E_K)$
$V_m = \frac{g_{Na}E_{Na} + g_K E_K}{g_{Na} + g_K}$ (weighted by relative conductances)
- if only conductive to K^+, $V_m \sim E_K$
- if only conductive to Na^+, $V_m \sim E_{Na}$
  ↳ approximated by top of AP
- when conductances equal, becomes "average" equation:
  g_{tot} $E_{Na} + E_K / 2$
- comes directly from equivalent circuit model

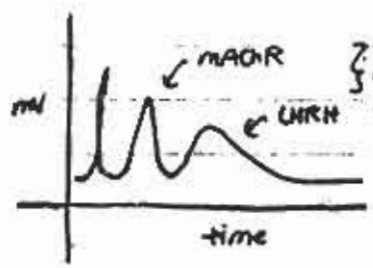
what is difference from Erev?
- E_{rev} when channel conducts 2 ions will also use this equation (eg AChR)

#4b from 2003: [voltage clamp

- put electrode in cell, inject current to pull away from resting, fire synapse, see if V goes up or down (which way current injected)
- or, patch-clamp, put on GABA

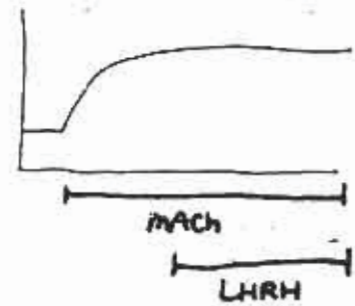
- know list of drugs for nAChR & mAChR; α-adrenergic, β-adrenergic
  - don't need to know particular names for these drugs
  - if not covered in class, don't need to know

occlusion experiments



} both metabotropic (evidence: slow onset, slow offset) both close K^+ M channel (this is atypical of CNS)

- eg in sympathetic ganglion, w/ fast, slow, late slow EPSPs
- do slow & late slow signaling events represent convergent pathways?
  - yes, b/c affect same K^+ M channel
  - how do we find out? iontophorese for drug substance, record postsynaptically
    - eg iontophorese muscarine; at some point during depolarization, iontophorese LHRH
      - if no response, response to muscarine "occludes" response to LHRH
      - then do in other order, to show that there is LHRH response (just no additional response)



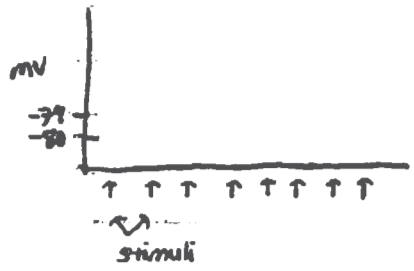
equation for discharging capacitor: not for AP

- know equations for charging & discharging (need to know to solve * on Problem Set #1)

* will probably get questions w/ differentiated definition of capacitance: $\frac{dV}{dt} = -\frac{I}{C}$

- flow of positive charge inward = negative current, but depolarizing, so gives positive ΔV (that's why negative sign there)
- find slope, figure out current, area of capacitor (this type of question)

quantal assay analysis - bathe in low $[Ca^{2+}]$ solution to get inefficient transmission



- stimulate over & over, get eg 1mV deflections

2 pieces of information:

1. transmission quantized
2. statistically wobbly (1, 2, 3.

- if you get eg 5 out of 10 failures (lack of postsynaptic response), $P_0 = 50\%$
- Poisson distribution based on assumption of lots & lots of vesicles (like NMJ); however, CNS synapses have much fewer synapses (in this case, use binomial distribution instead)
  - eg 4 vesicles at CNS synapse each w/ 50% probability of release, $P_0 = \frac{1}{2}$ (Poisson only true if many vesicles)
- if increase probability of vesicle being released, increase m, decrease P_0 (always inversely related; m shows presynaptic event)
  - quantal analysis: look for change in P_0 for presynaptic effect

channels: [α-helices (no prolines) (hydrophobic A.As (eg valine, isoleucine))

1. voltage-gated: 6 TM, 4th (S4) not α-helix: every 3rd A.A positively charged
   - this is what moves in response to voltage change
   - by crystallography, S4 turns out not to be α-helix; rather, is paddle out in membrane that flips outward w/ depolarization (4 S4s per channel)
2. ligand-gated
3. 2nd messenger

H & H vot problems:

- spatial changes in voltage (solve w/ space clamp so every patch of membrane at same V): gives you membrane AP (each patch goes off at same time: velocity of propagation infinite)
- need voltage clamp to avoid changes in conductance
- need way to separate I_{Na} & I_K (drugs) (or bath-changing experiments)
  ↳ used all the time by physiologists
  changes gradients / resting potential, so eg can see effect of ion on resting potential, overshoot, E_{rev}, etc

- at Nernst equilibrium, energy lost by going down concentration gradient compensated by energy gained by going up voltage gradient

- effect of changing $[Cl^-]$?
  - Cl^- not pumped (in class examples, anyway) so does not have effect on resting V_m
    $V_{Cl} = -58mV \log [Cl]_o/[Cl]_i$
    - if adjusts itself passively, V_{Cl} will be resting V_m
      ↑ so V_{Cl} is constrained; what you solve for is $[Cl]_o/[Cl]_i$
    (look like silent synapses but are inhibitory)

- drugs that change both m & $\bar{v}_i$? not in scope of course (but eg drill pores in membranes)

- dendrites poor in voltage-gated K^+ & Na^+ channels; no regenerative positive feedback response (this is why synaptic potentials graded while APs not)

permeability vs. conductance:

- don't need to know about permeability
- permeability is purely property of membrane; conductance is property of whole circuit

- net flow of ions at resting V_m; so slight leakage of K^+ outward, tiny leakage of Na^+ inward: these are equal, so steady V
  - would run down if not for Na^+ K^+ pump (this counteracts)

advantages of Aplysia: big cells, reproducible networks

- know habituation, sensitization
  - ↳ mimicked by 5-HT application (upstream of PKA)

- know capicitative current in voltage clamp
  - ~~change~~ changing of V a whole lot; if $\frac{dV}{dt}$ big, I is big

collagenase - lets you pull presynaptic & postsynaptic sides apart
  - degrades collagen

Morris water maze - need hippocampus to perform well
  (knock out both short-term & long-term memory)

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