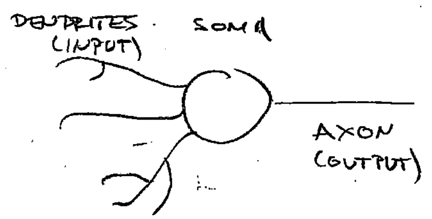
NEURON ~ $100 \cdot 10^9$ IN 1 BRAIN



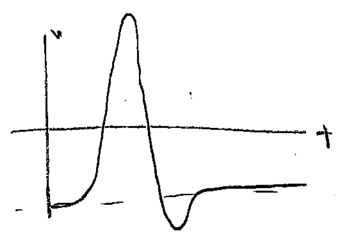
ELECTRICALLY ACTIVE

ACTION POTENTIAL

CELL MEMBRANE


$V_m = V_{IN} - V_{OUT}$

SPIKE / ACTION POTENTIAL



DEPOLARIZATION : $V_m \uparrow$

HYPERPOLARIZATION: $V_m \downarrow$

SYNAPSE: CONNECTION FROM ONE NEURON'S AXON TO ANOTHER'S DENDRITE

what's computational neuroscience about?

5-ish different levels of understanding/scale

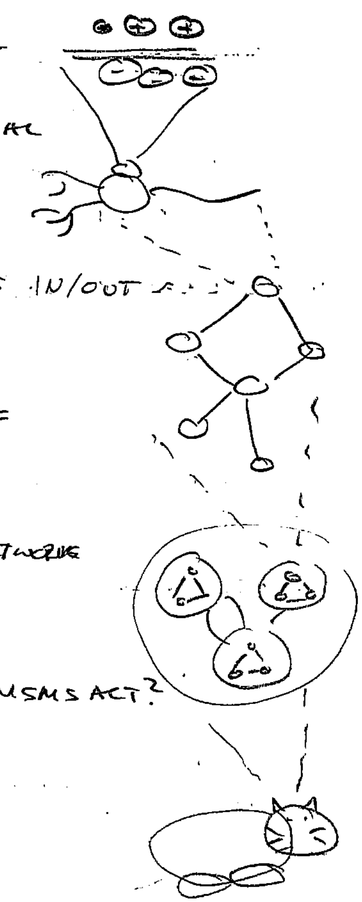
1. MOLECULAR/BIOPHYSICAL
   HOW PROTEINS/IONS ~~TREAT~~ GENERATE ELECTRICAL ACTIVITY

2. SINGLE NEURONS:
   HOW TO TREAT NEURONS AS IN/OUT SYSTEMS

3. NETWORKS: HOW GROUPS OF NEURONS INTERACT

4. MACRO CIRCUITS: HOW NETWORKS INTERACT

5. BEHAVIORAL: HOW DO ORGANISMS ACT?



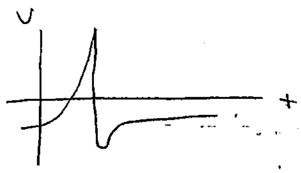
3 KINDS OF QUESTION:

DESCRIPTIVE : WHAT?

MECHANISTIC : HOW?

INTERPRETIVE : WHY?

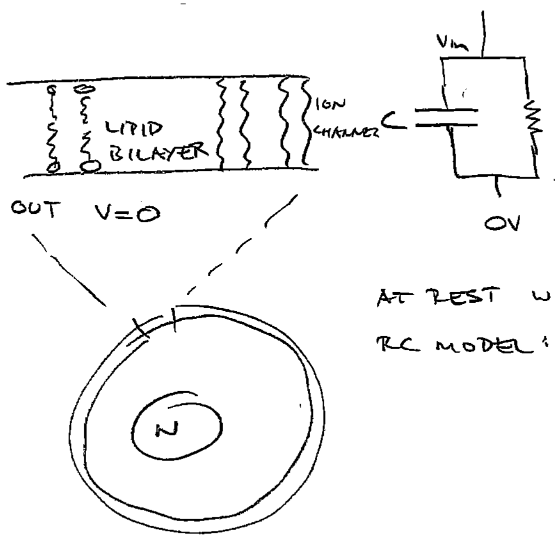
ACTION POTENTIALS (MOLECULAR LEVEL)



GOAL: MODEL MEMBRANE AS ELECTRICAL CIRCUITS

OHM'S LAW $V = IR$, $R = 1/G$, $I = GV$

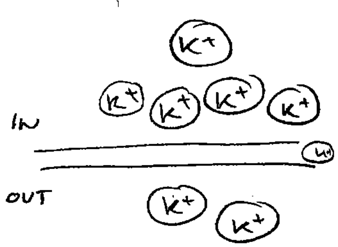
IN (CONDUCTOR)



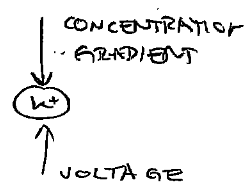
AT REST WITH

RC MODEL: $V_m = 0$

IN REAL CELL, RESTING $V_m \approx -70$ mV

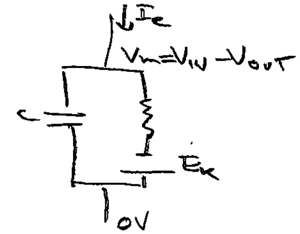


IN BALANCED STATE:



REVERSAL POTENTIAL = POTENTIAL AT WHICH THE ELECTRICAL PUSH BALANCES CONCENTRATION PUSH

$E_K \approx -80$ mV



GOAL: $V_m(t) = ?$

1. KIRCHHOFF:

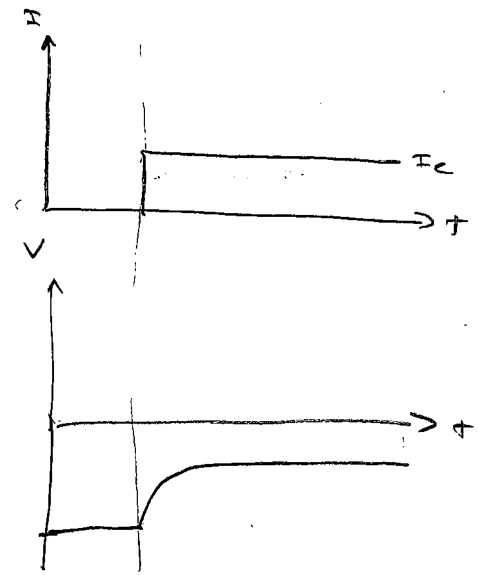
$I_e = I_C + I_R$

2. OHM'S LAW:

$I_R = g(V_m - E_K)$

3. $C = Q/V \Rightarrow I_C = C\frac{dV_m}{dt}$

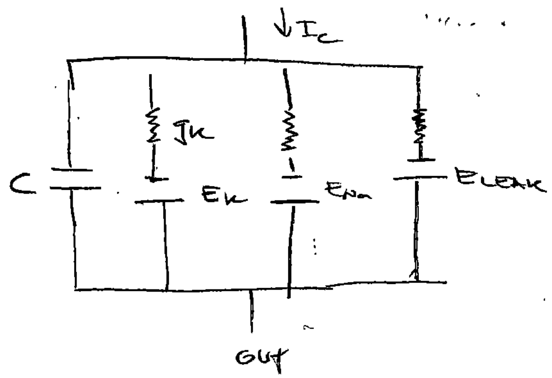
$$I_e = C\frac{dV_m}{dt} + g(V_m - E_K)$$



$$V_m(t) = E_K + \frac{I_e}{g}\left(1 - e^{-t/\tau}\right) \qquad \tau = RC$$

+ MULTIPLE CHARGE CARRIERS : K^+, Na^+, LEAK

MORE Na^+ OUTSIDE: $E_{Na} = 50mV$



$\underline{I_e} = I_c + I_K + I_{Na} + I_{LEAK}$

$$= C\frac{dV_m}{dt} + g_K(V_m - E_K) + g_{Na}(V_m - E_{Na}) + g_L(V_m - E_{LEAK})$$

V_m MOVES TOWARDS THE REVERSAL POTENTIAL ~~WITH THE~~ OF THE ION W/ THE LARGEST CONDUCTANCE

PROB. OF A SUBUNIT OF CHANNEL BEING OPEN

$$g_K(t,V) = \bar{g}_K n(t,V)^4$$

$$\boxed{\tau_n(V)\frac{dn}{dt} = n_\infty(V) - n}$$

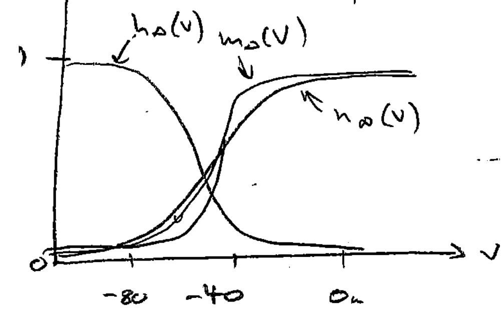
$$g_{Na} = \bar{g}_{Na} m^3(t,V)h$$

$$\boxed{\tau_h(V)\frac{dh}{dt} = h_\infty - h}$$

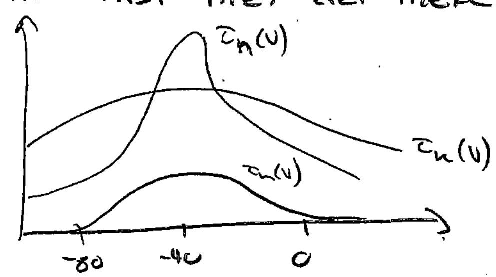
$$\boxed{\tau_m(V)\frac{dm}{dt} = m_\infty - m}$$

HODGKIN
HUXLEY
EQUATIONS

WHERE n, m, h ARE HEADED



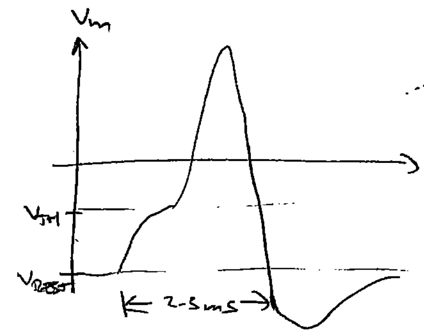
HOW FAST THEY GET THERE



1st → m INCREASES, $V_m \to E_{Na}$

2nd → n INCREASES, $V_m \to E_K$

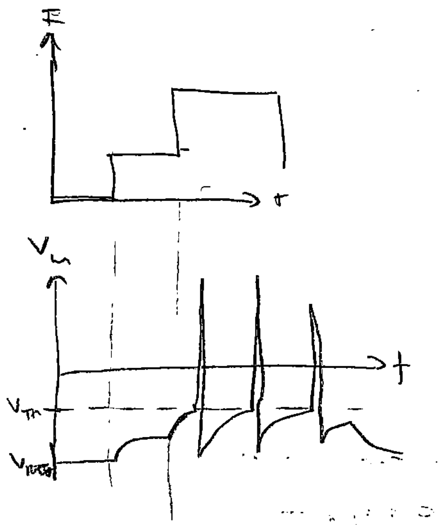
h DECREASES, $V_m \to E_K$



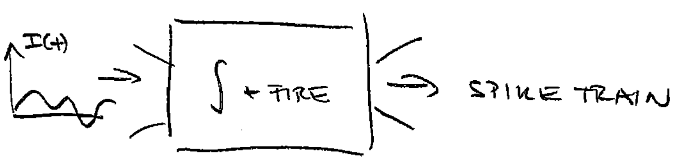
1. IF $V < V_{TH}$ THEN : $V_m \sim$ RC CIRCUIT

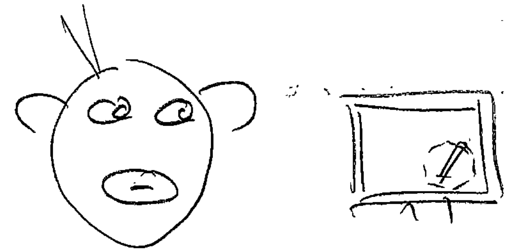
ELSE V_m TO LARGE VALUE

V_m RESETS

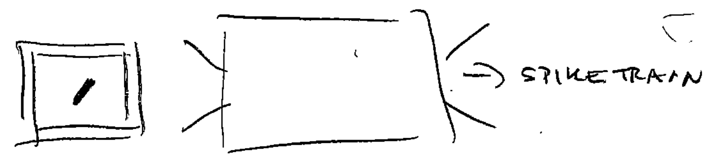


INTEGRATE + FIRE MODEL

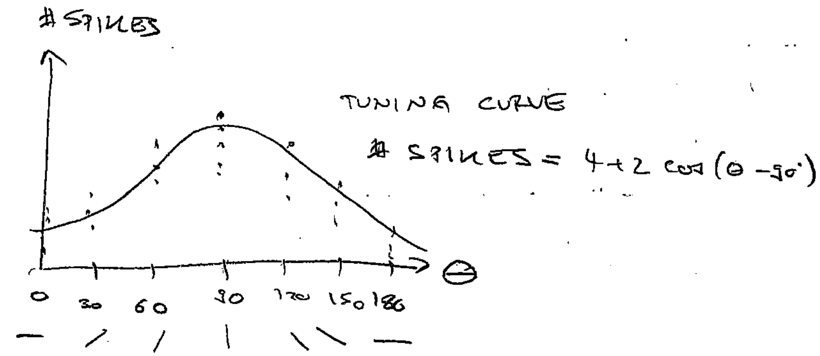


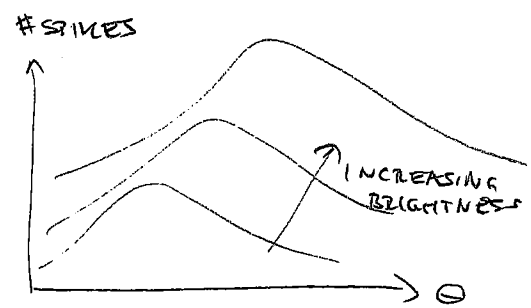


STIMULUS RESPONSE SYSTEM



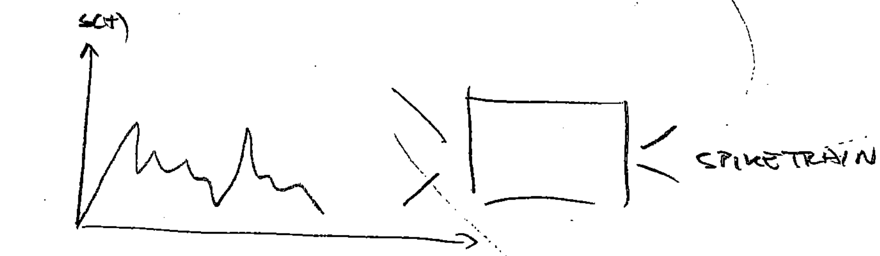
EXPT. : SHOW IMAGE ON SCREEN FOR 1S, COUNT # SPIKES IN 1S

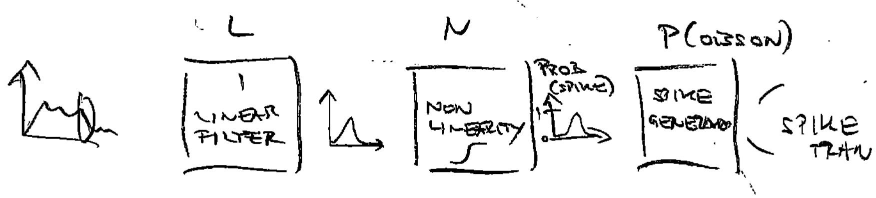




2D TUNING CURVE

TIME VARYING STIMULUS RESPONSE





SUMMARY

NEUROBIO ⇒ NEURONS ELECTRICALLY ACTIVE

⇒ ACTION POTENTIALS ⇒ BIOPHYSICAL MODEL (HODGKIN HUXLEY) ⇒ SIMPLIFIED NEURONS

⇒ STIMULUS/RESPONSE SYSTEM