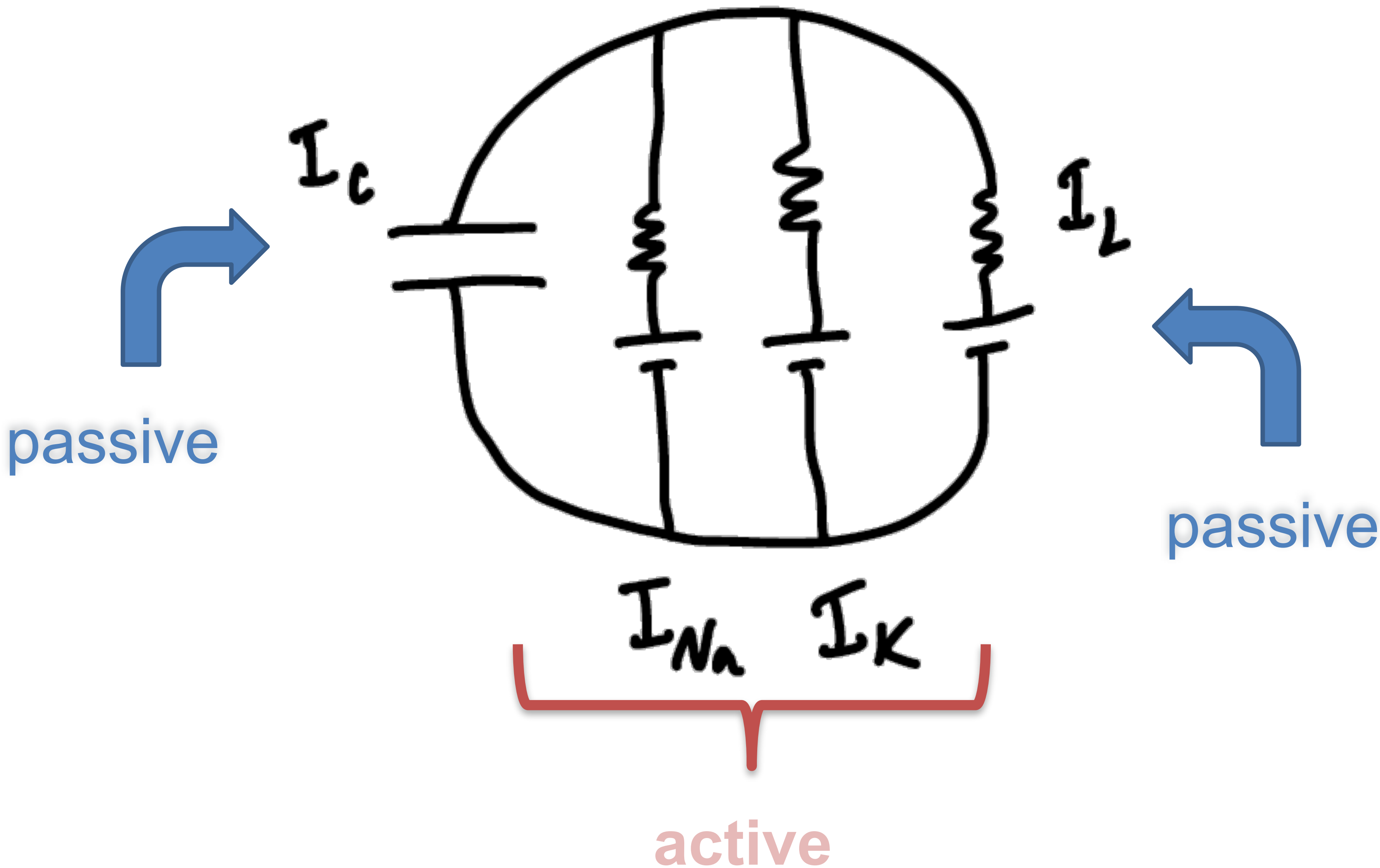
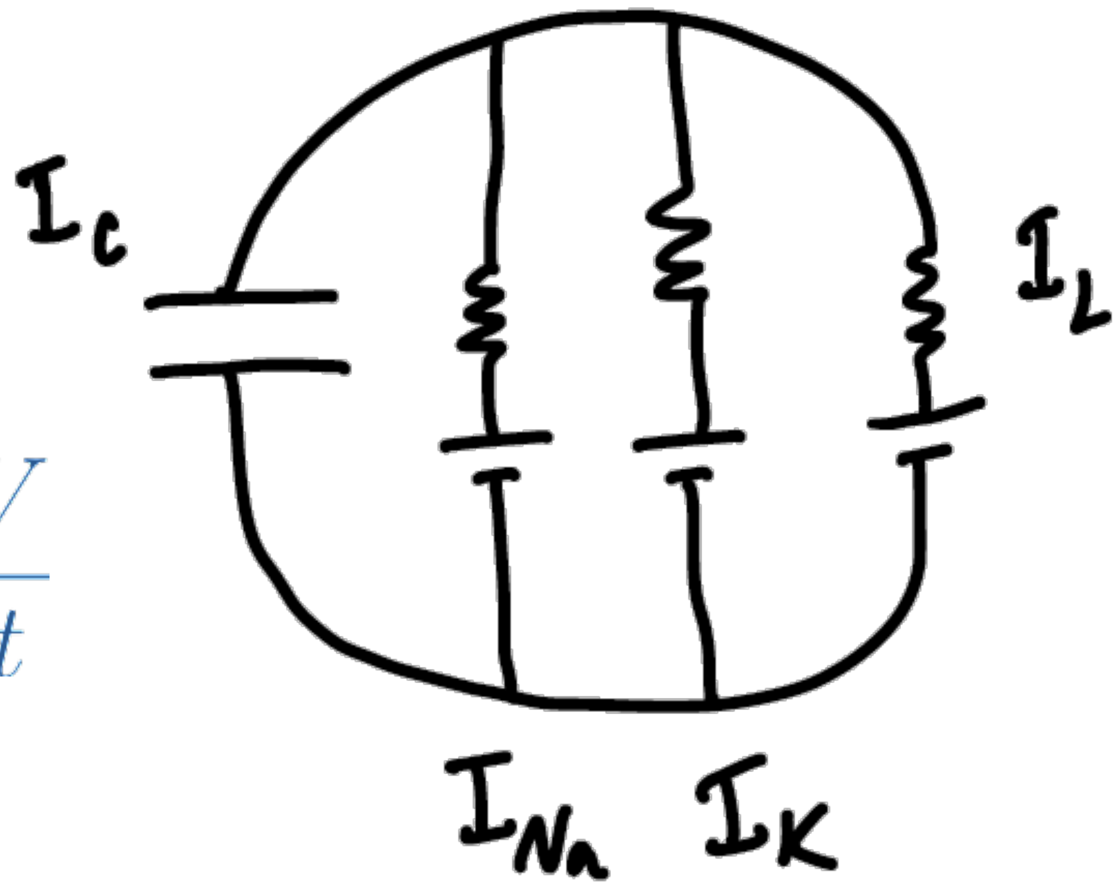
Thank you! Many slides by
Drs. Gabrielle Guiterrez
and
Adrienne Fairhall

Intrinsic neuron currents



Intrinsic neuron currents

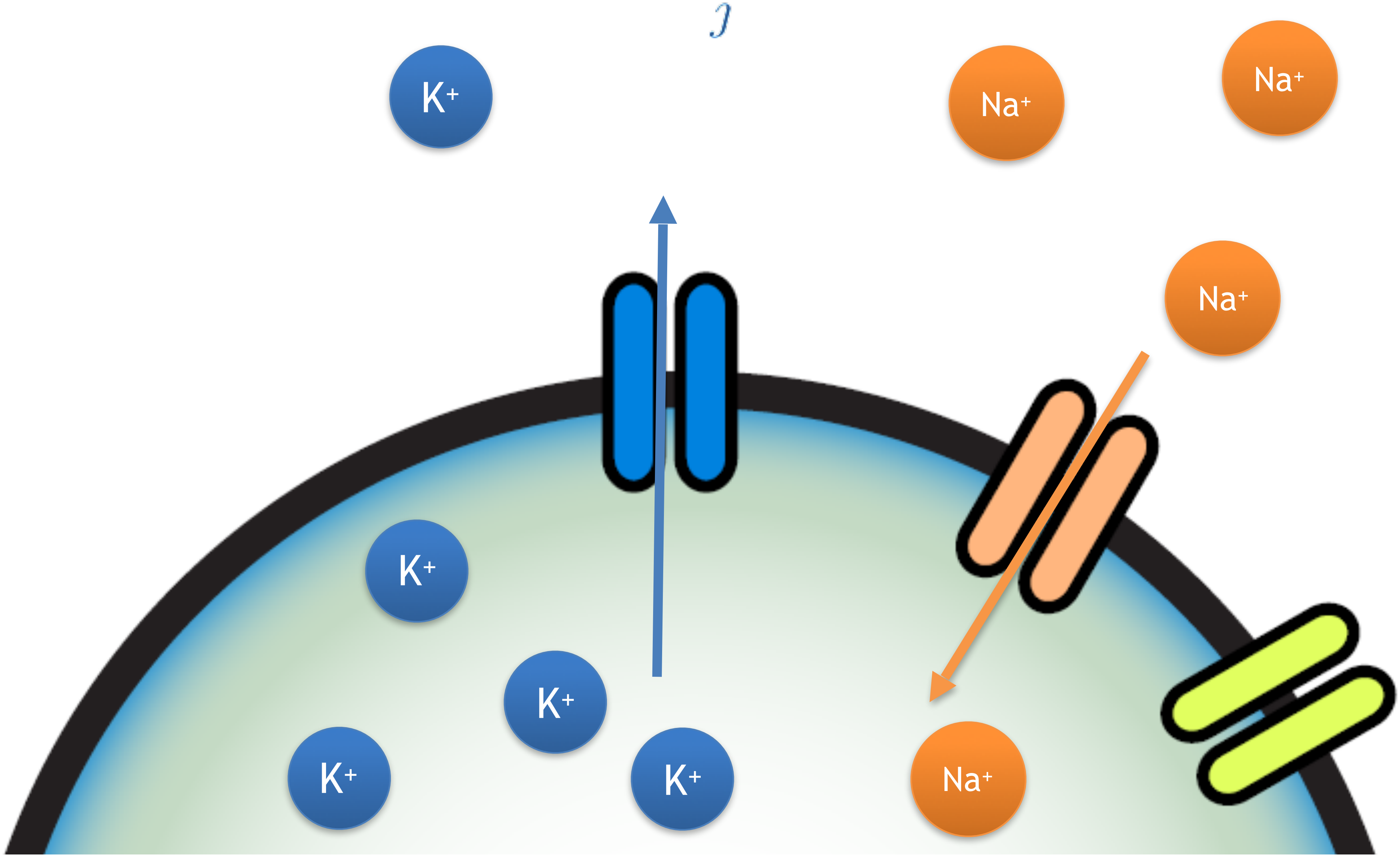


$$I_C = C\frac{dV}{dt}$$

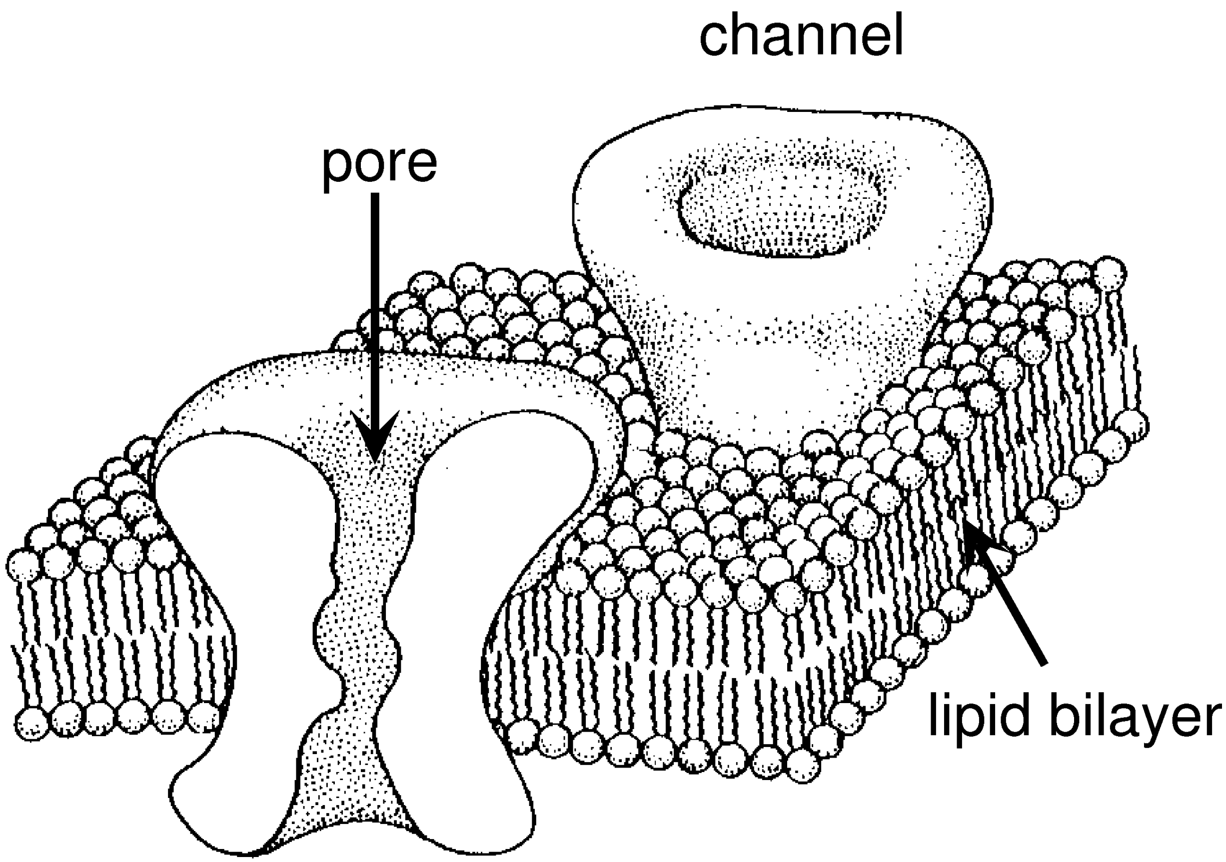
$$i_m = \sum_j g_j(V - E_j)$$

Driving force via E_j; conductance g_j

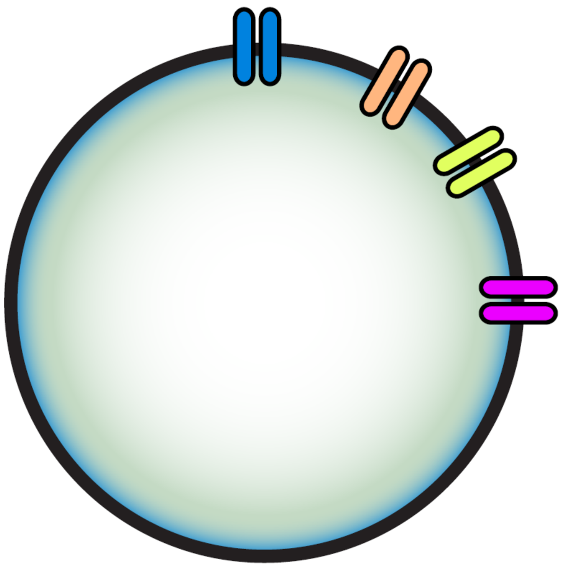
$$i_m = \sum_j g_j (V - E_j)$$



Membrane patch

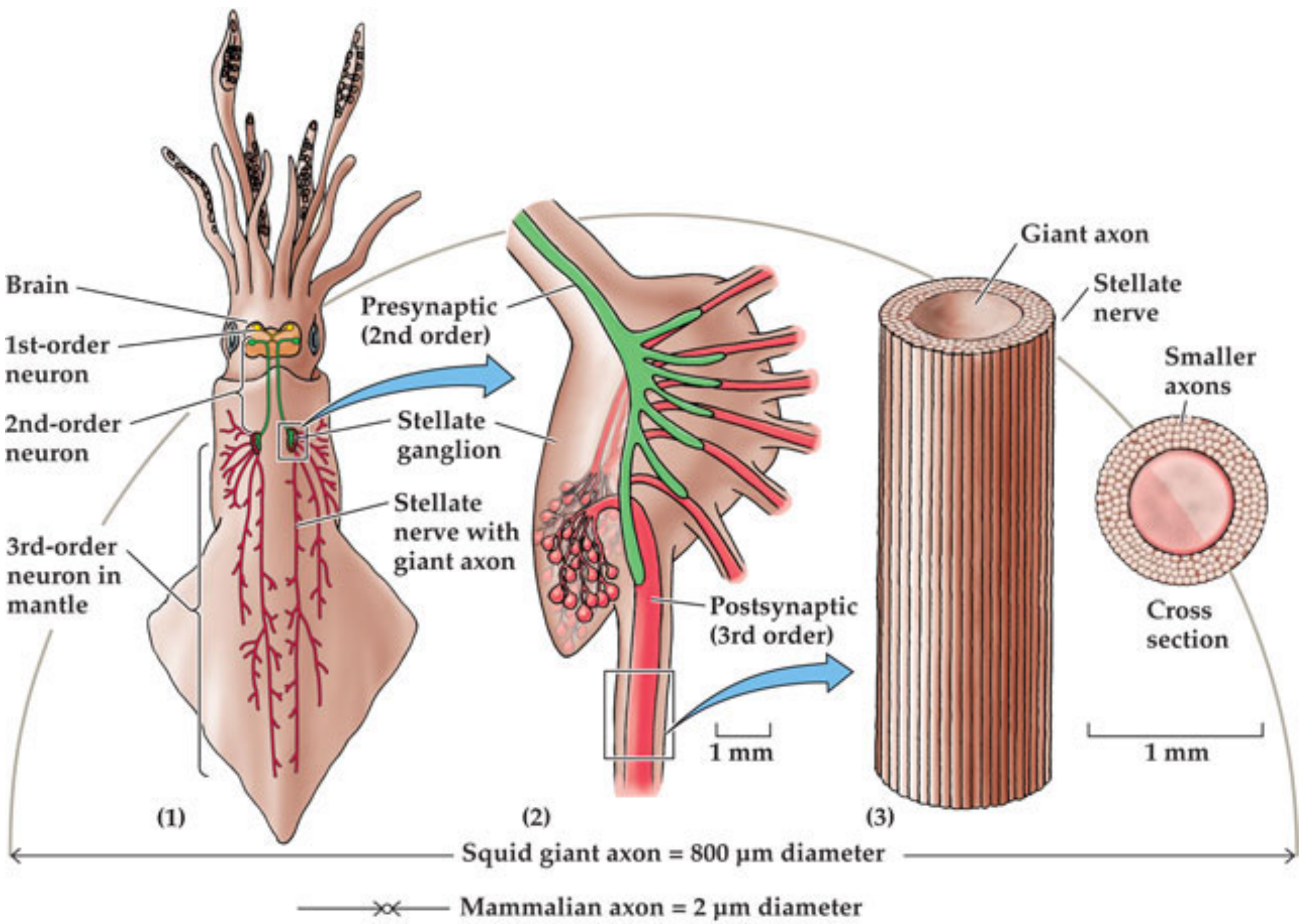


The Hodgkin-Huxley model

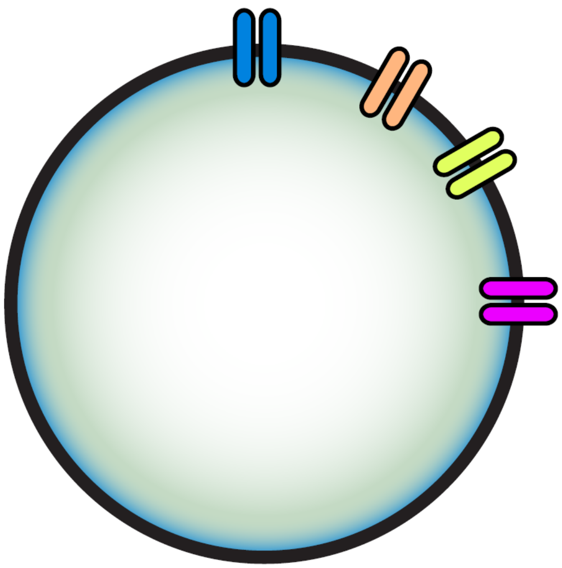


$$C_m \frac{dV}{dt} = -[I_L + I_K + I_{Na}]$$

The Hodgkin-Huxley model



The Hodgkin-Huxley model



$$g_K = \bar{g}_K n^4 \qquad g_{Na} = \bar{g}_{Na} m^3 h$$

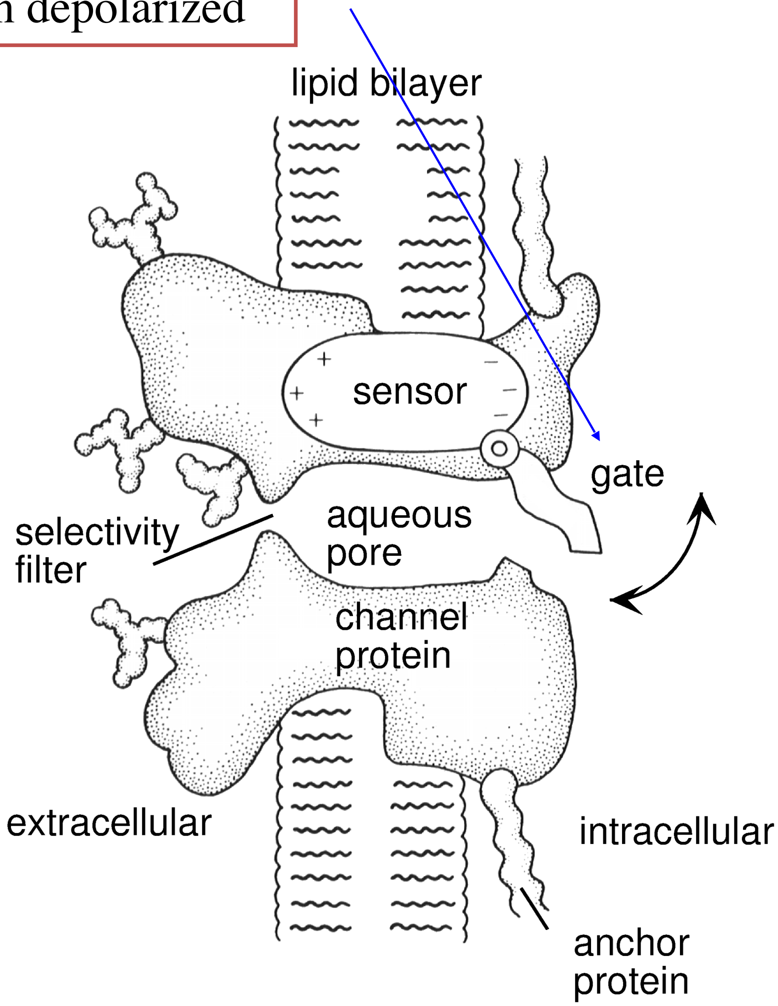
Maximal conductances

$$C\frac{dV}{dt} = -\bar{g}_L(V - E_L) - \bar{g}_K n^4 (V - E_K) - \bar{g}_{Na} m^3 h (V - E_{Na})$$

Gating variables

The ion channel is a cool molecular machine

K channel: open probability increases when depolarized



$P_K \sim n^4$

Persistent conductance

n describes a subunit

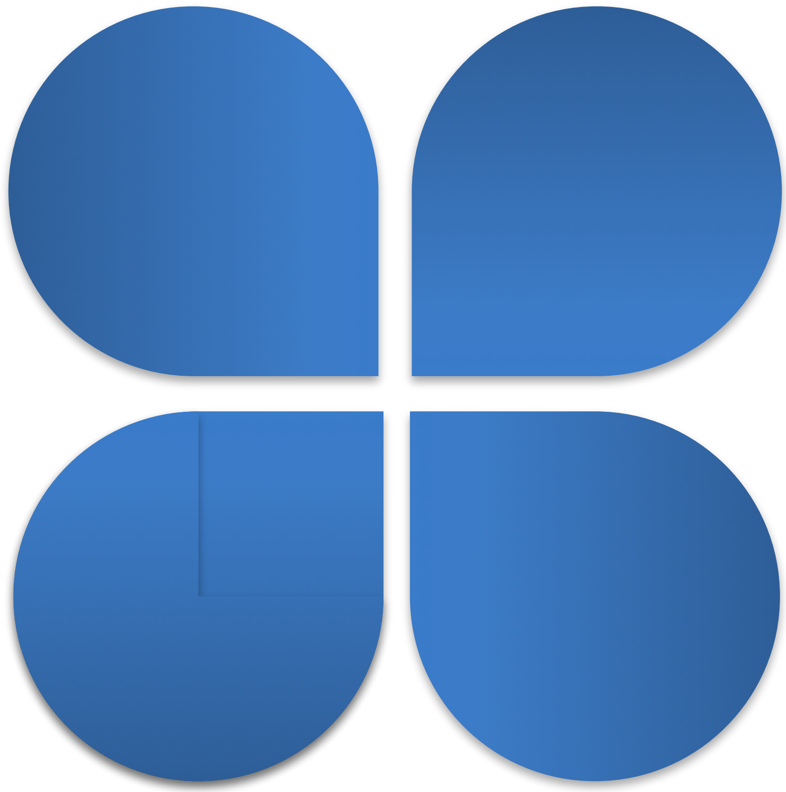
n	is open probability
$1 - n$	is closed probability

Transitions between states occur at voltage dependent rates

$\alpha_n(V)$	C → O
$\beta_n(V)$	O → C

$$\frac{dn}{dt} = \alpha_n(V)(1-n) - \beta_n(V)n$$

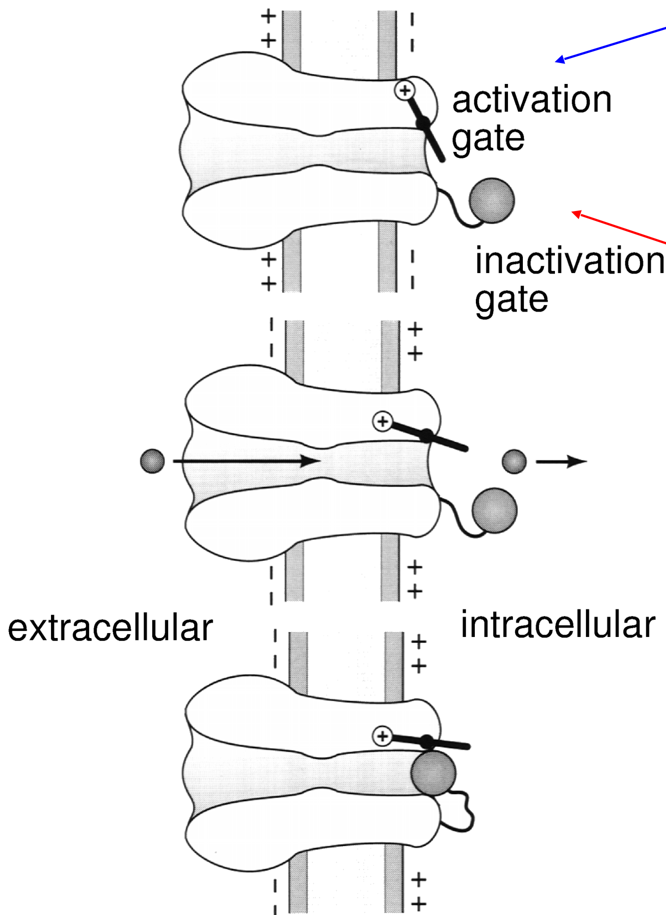
There are 4 "independent" subunits in the K channel



$$proba(\text{ 1 subunit open}) = n$$

$$proba(\text{ all 4 subunits, and hence channel open}) = n^4$$

Transient conductances



Gate acts as in previous case

Additional gate can block channel when open

$P_{Na} \sim m^3h$

m is activation variable
h is inactivation variable

m and *h* have opposite voltage dependences:

depolarization increases *m*, activation
hyperpolarization increases *h*, deinactivation

Dynamics of activation and inactivation

$$\frac{dn}{dt} = \alpha_n(V)(1-n) - \beta_n(V)n$$

$$\frac{dm}{dt} = \alpha_m(V)(1-m) - \beta_m(V)m$$

$$\frac{dh}{dt} = \alpha_h(V)(1-h) - \beta_h(V)h$$

We can rewrite:

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

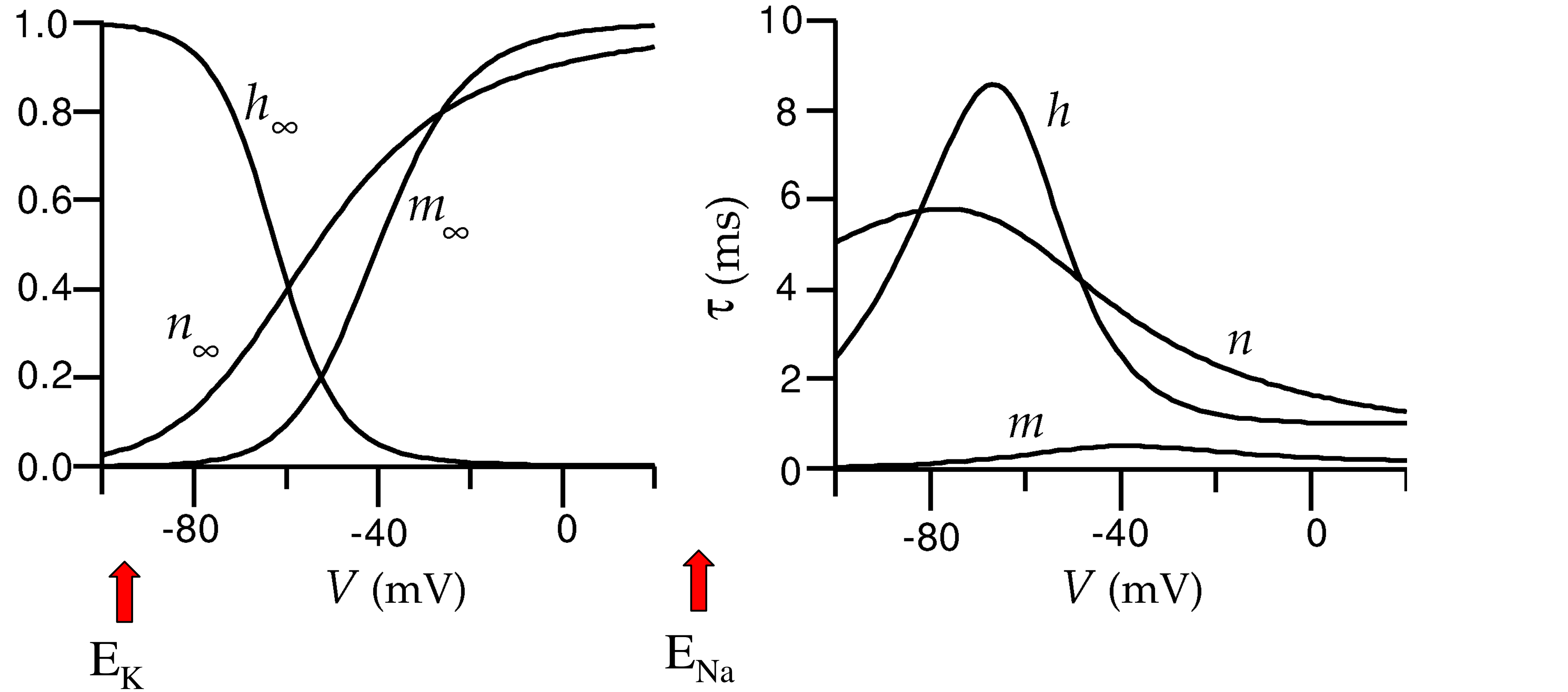
where

$$\tau_n(V) = \frac{1}{\alpha_n(V) + \beta_n(V)}$$

$$n_\infty(V) = \frac{\alpha_n(V)}{\alpha_n(V) + \beta_n(V)}$$

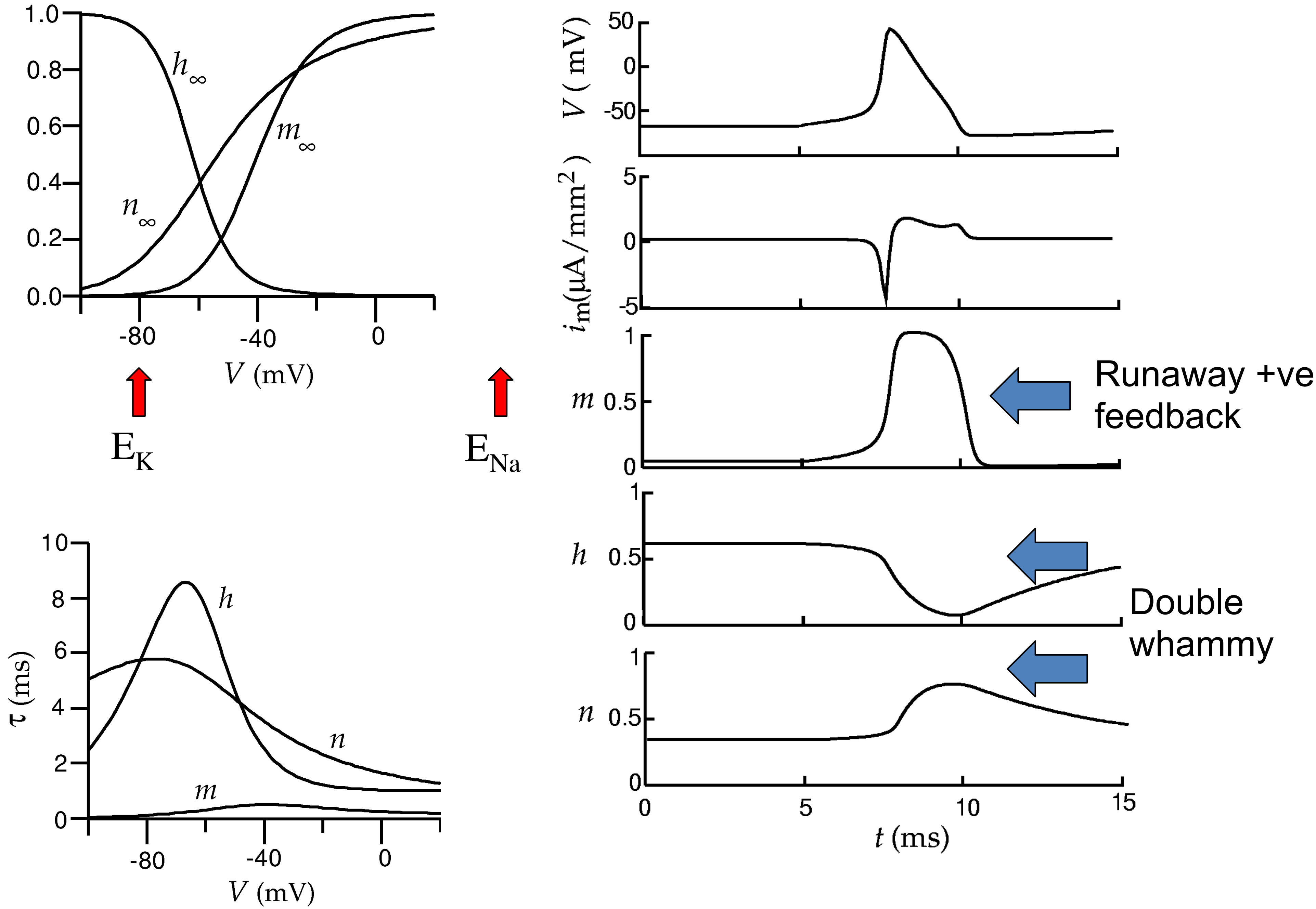
Anatomy of a spike

$$C\frac{dV}{dt} = -\bar{g}_L(V - E_L) - \bar{g}_K n^4(V - E_K) - \bar{g}_{Na} m^3 h(V - E_{Na})$$



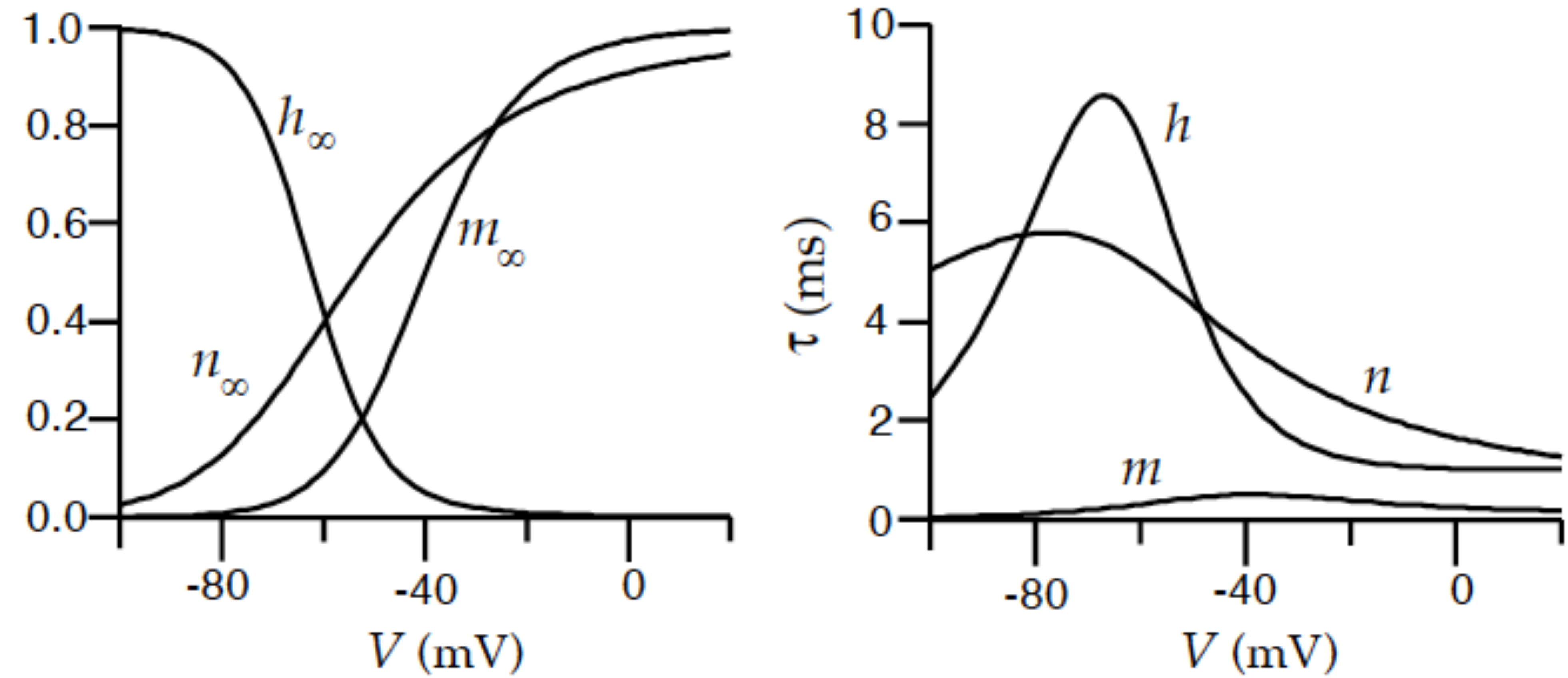
$g_{Na} \sim m^3h$ $g_K \sim n^4$

$$C\frac{dV}{dt} = -\bar{g}_L(V - E_L) - \bar{g}_K n^4(V - E_K) - \bar{g}_{Na} m^3 h(V - E_{Na})$$



Gating Variables

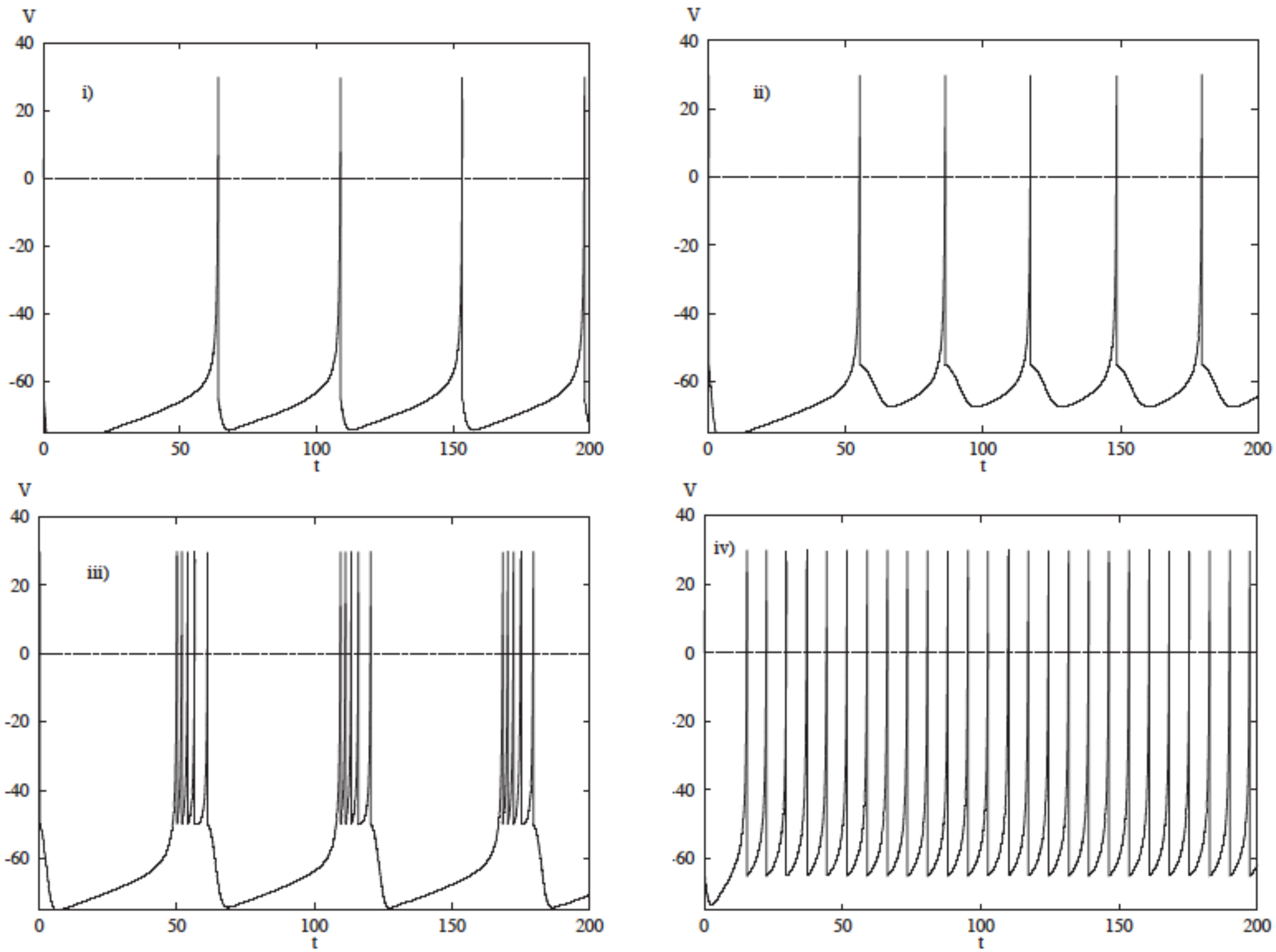
$$\tau_n(V)\frac{dn}{dt} = n_\infty(V) - n$$



HH code

- Please download HH.m and allied codes from folder on our website

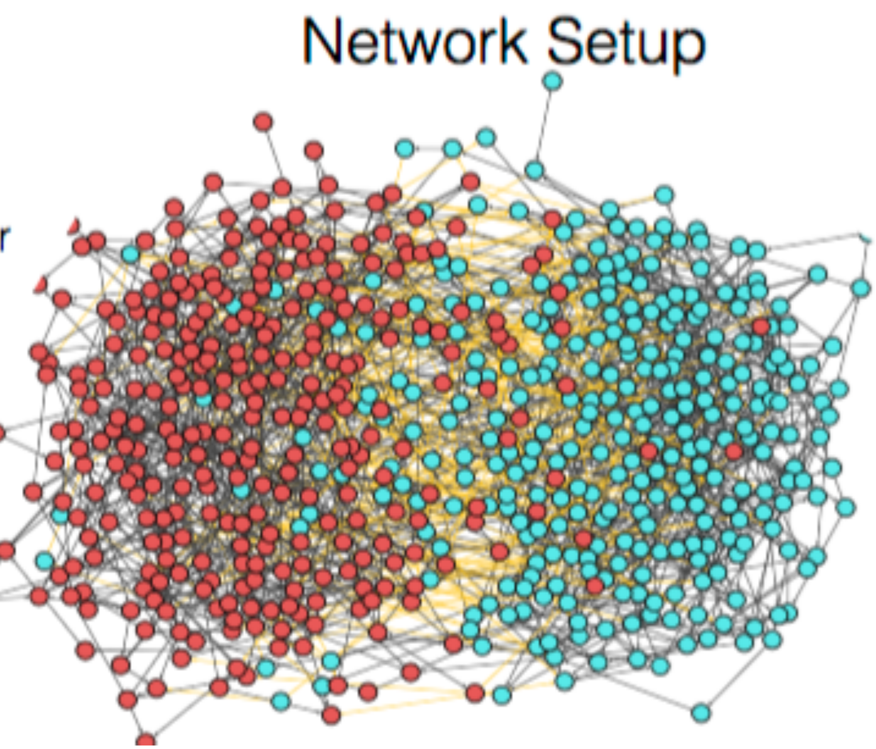
Ion channel types, what are they good for?



DOI: 10.1016/j.physd.2011.05.012

Who cares about bursting?

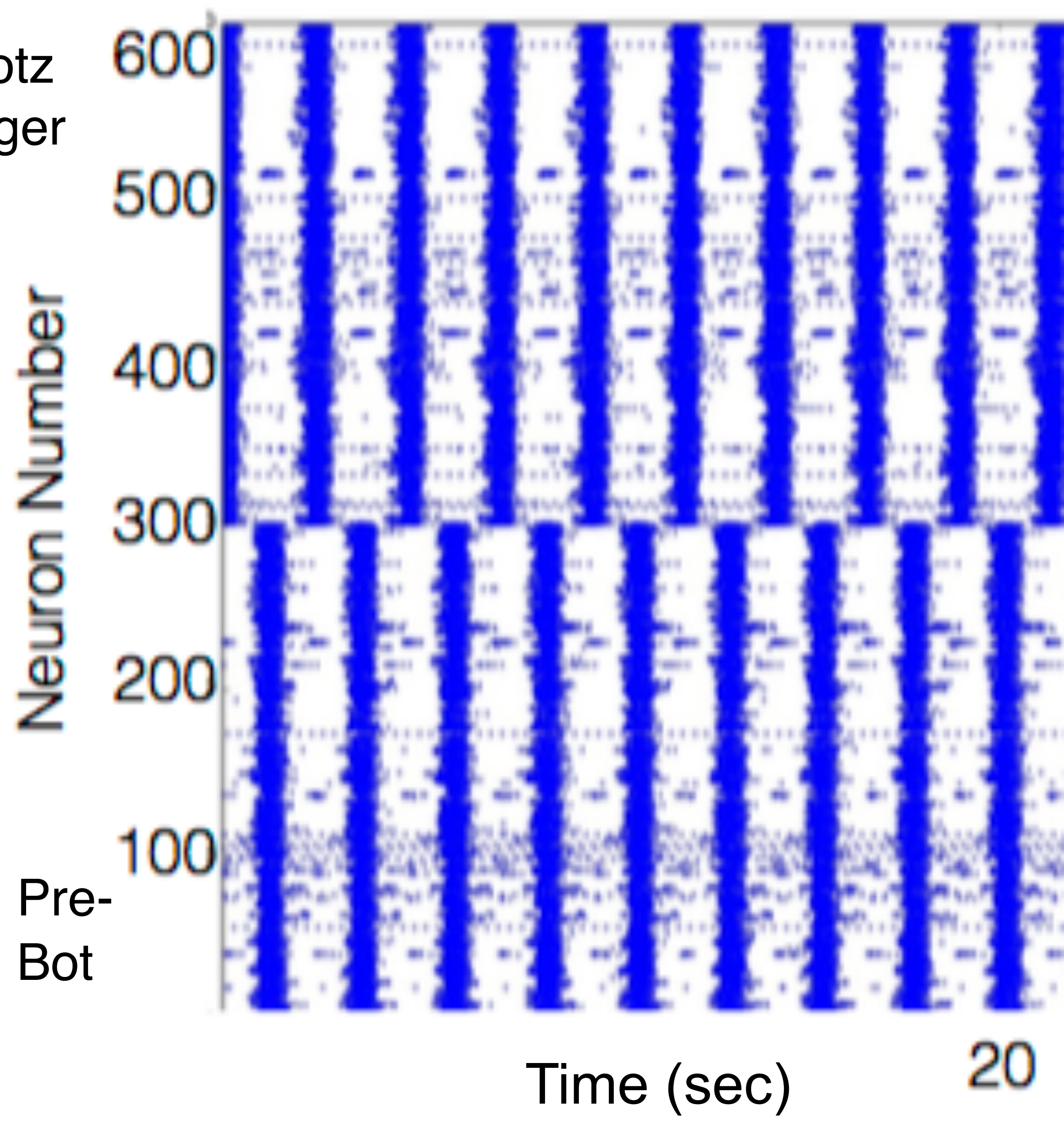
Bursting rhythms drive breathing:



Botzinger complex (expiration)

Pre-Botzinger complex (inspration)

Botz inger



Pre-Bot

J. Mendoza, UW Hon.Thesis ‘15