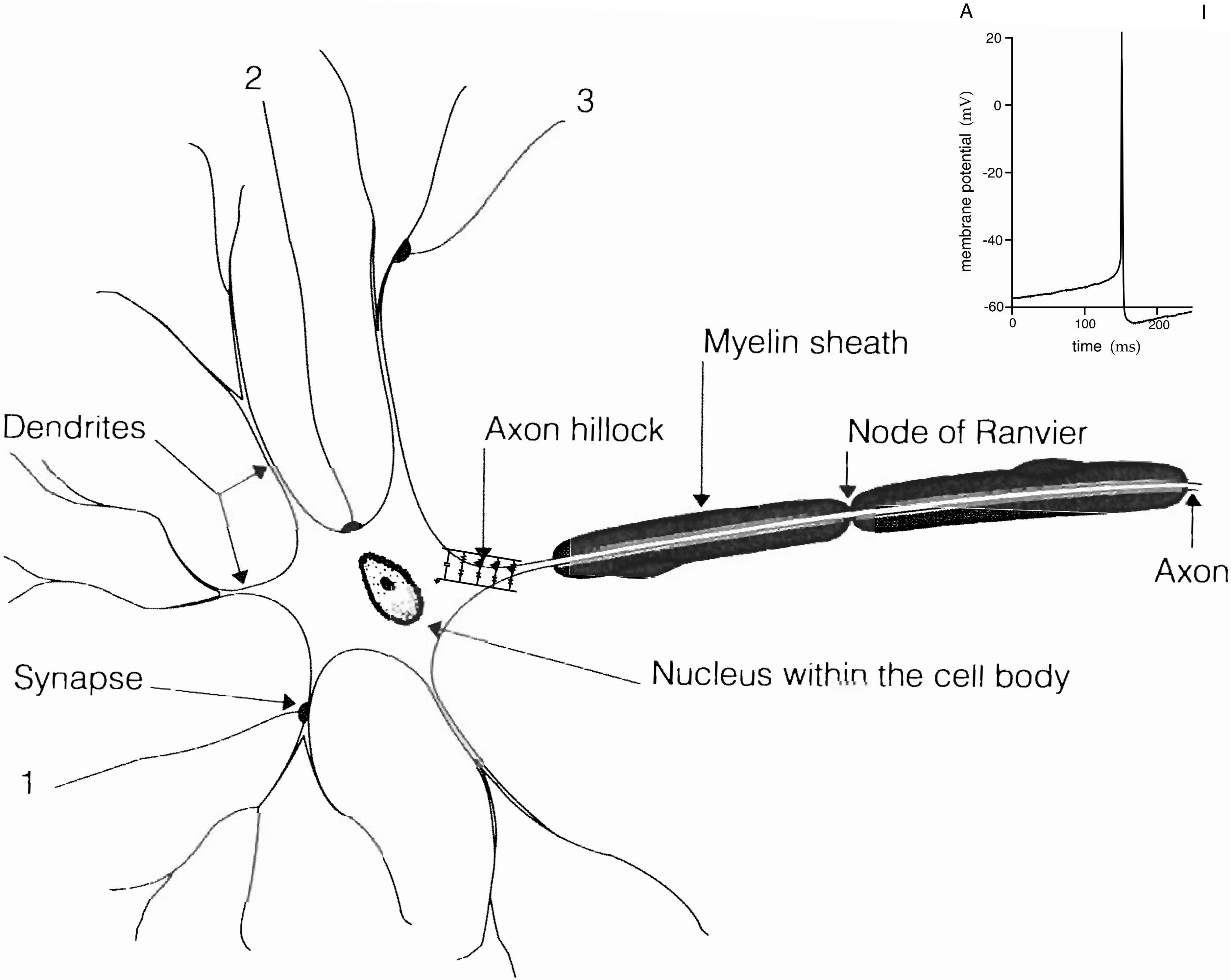
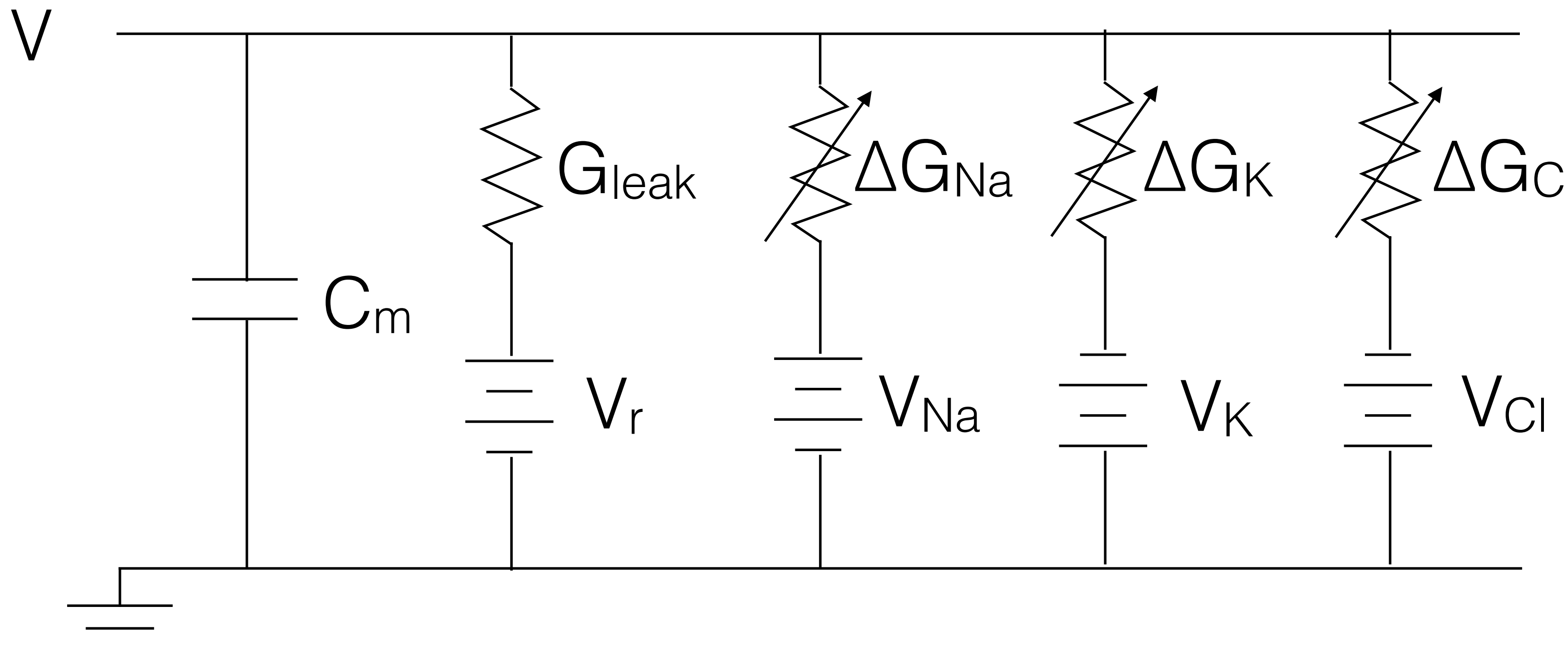
Spikes


A
I
20
0
-20
-40
-60
membrane potential (mV)
0
100
200
time (ms)
2
3
Myelin sheath
Dendrites
Axon hillock
Node of Ranvier
Axon
Nucleus within the cell body
Synapse
1

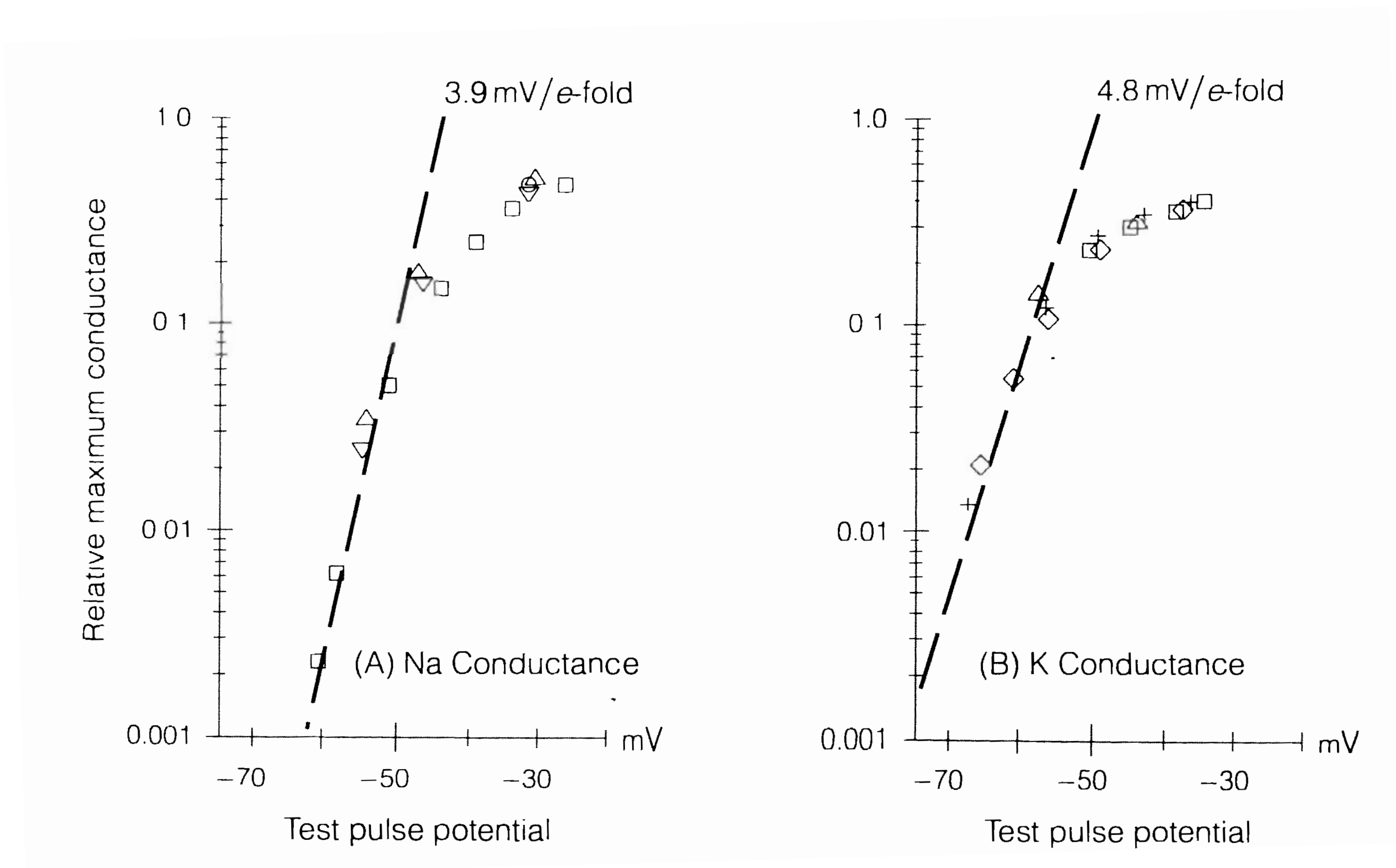
Membrane with synaptic inputs



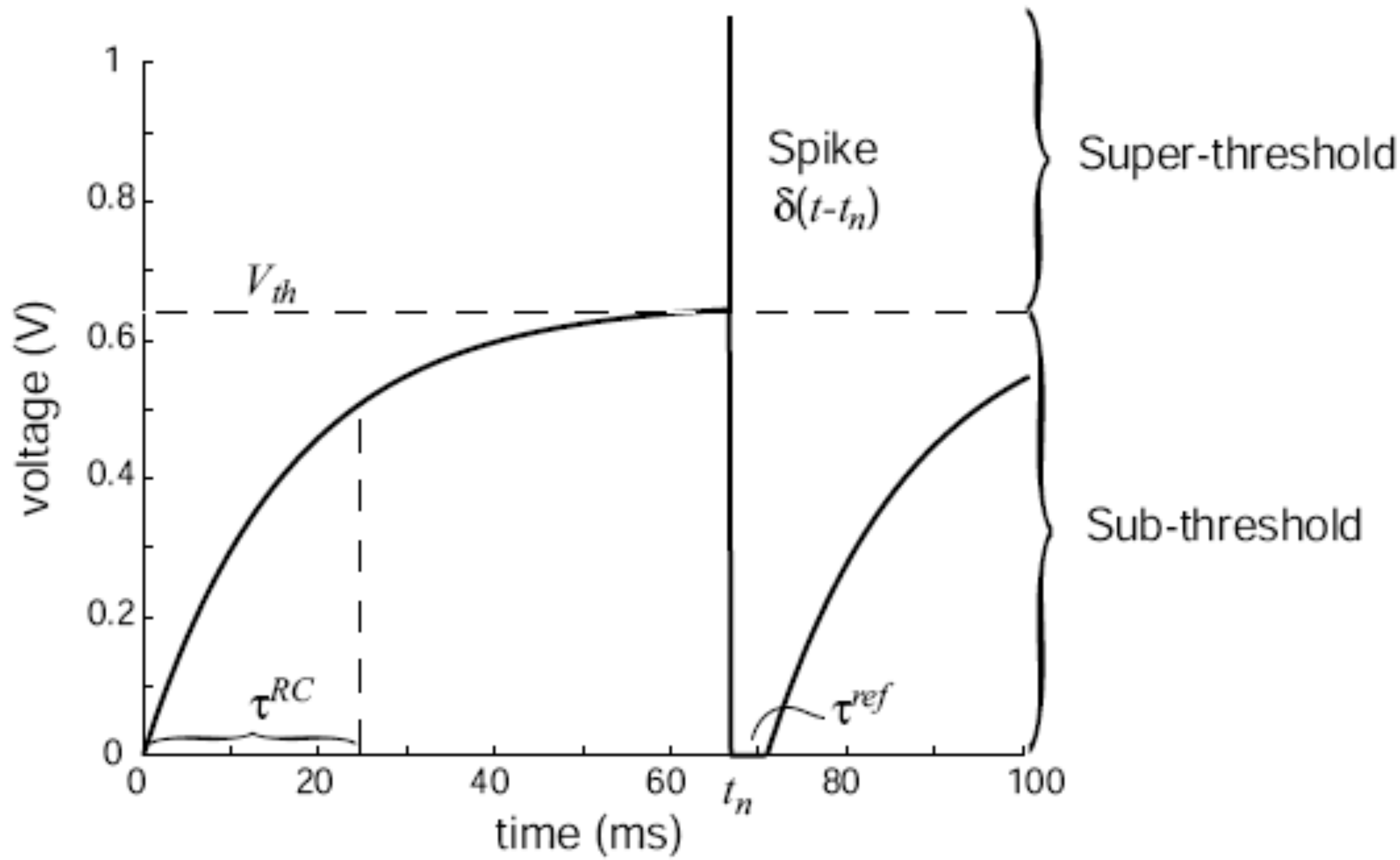
$$\tau \frac{dV}{dt} + V = \frac{V_r \, G_{\text{leak}} + V_{Na} \, \Delta G_{Na} + V_K \, \Delta G_K + V_{Cl} \, \Delta G_{Cl}}{G_{\text{total}}}$$

$$G_{\text{total}} = G_{\text{leak}} + \Delta G_{Na} + \Delta G_K + \Delta G_{Cl} \qquad \tau = \frac{C_m}{G_{\text{total}}}$$

Voltage-gated channels

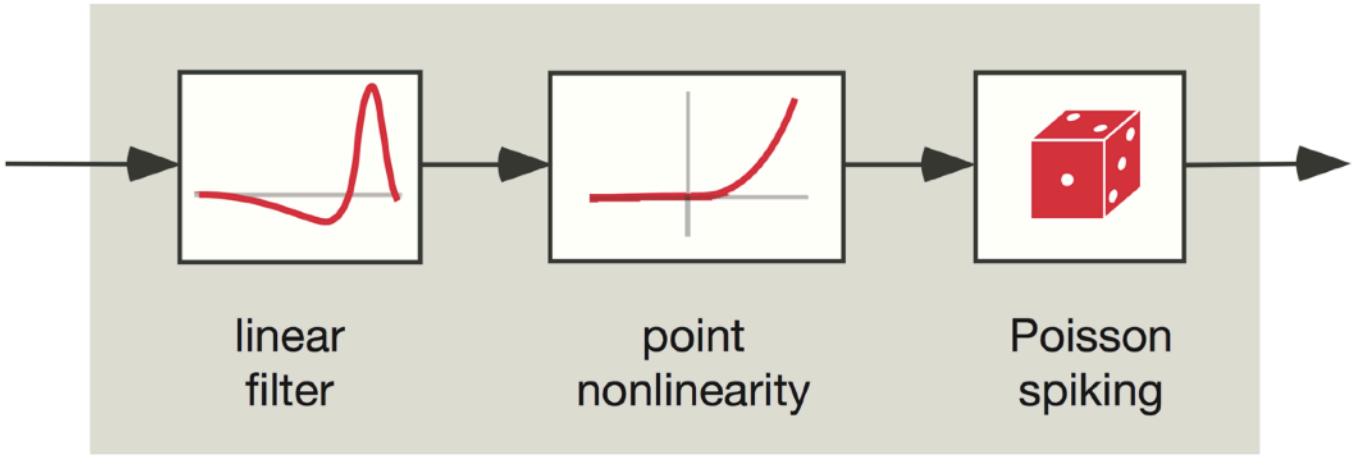


Leaky integrate-and-fire neuron



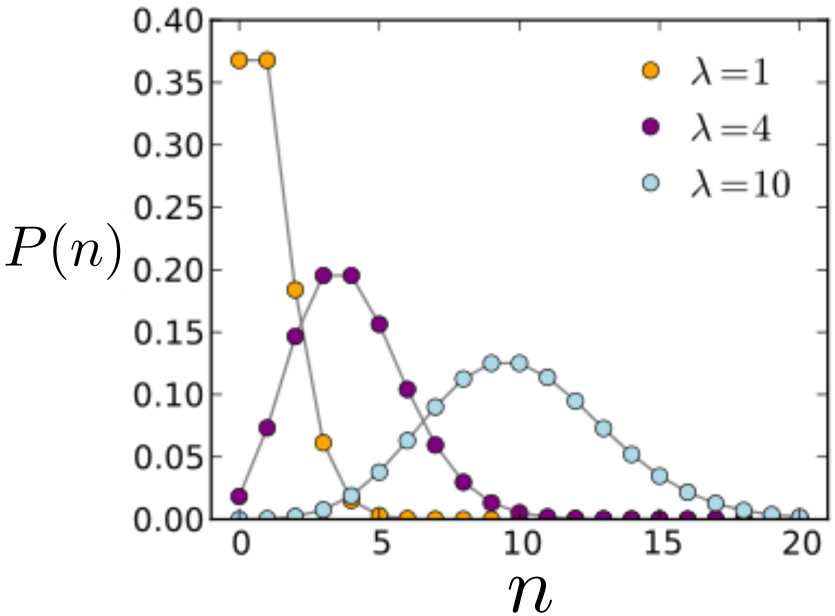
Linear - non-linear - Poisson (LNP) model

$s(t)$

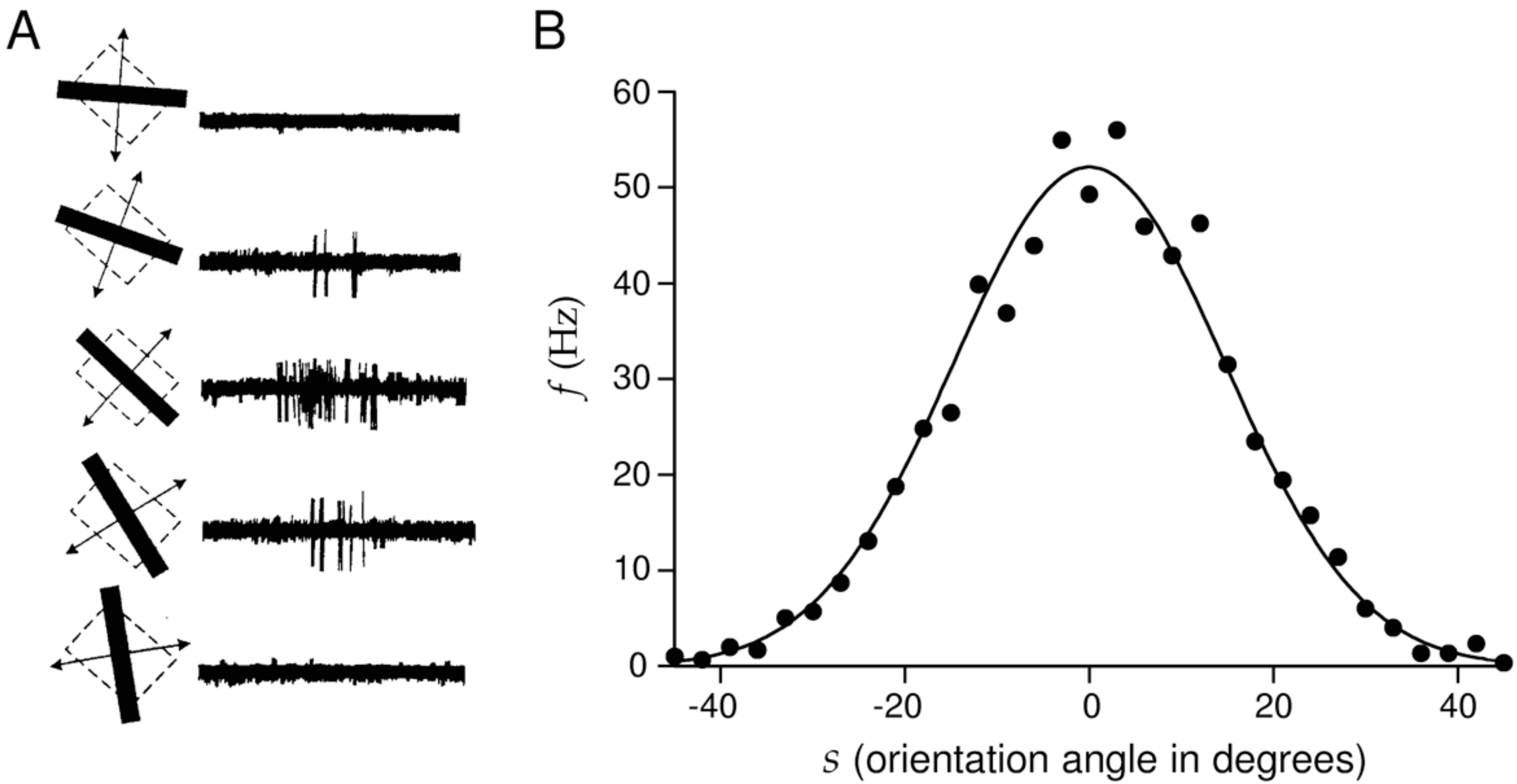


$\rho(t)$

$$P(n) = \frac{\lambda^n e^{-\lambda}}{n!}$$

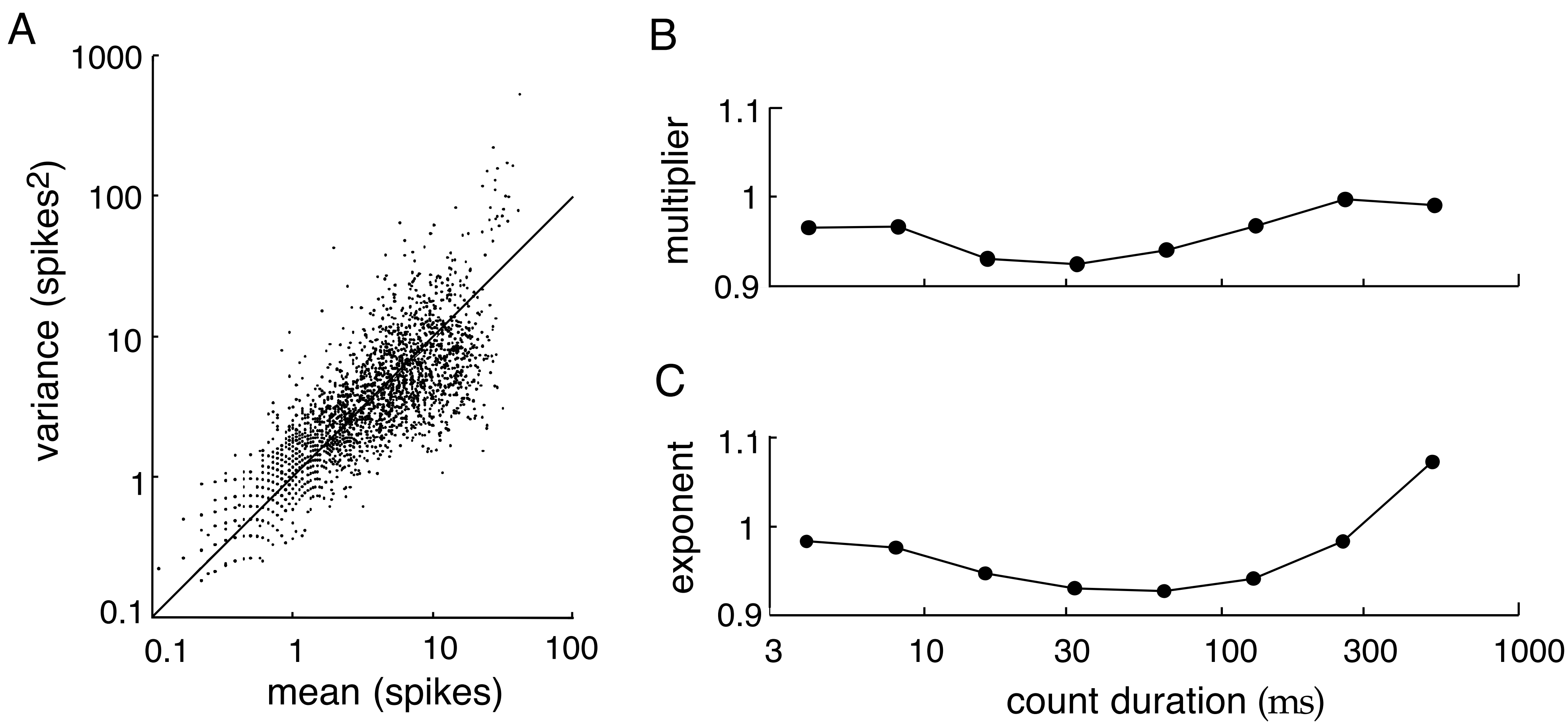


Rate coding hypothesis: the signal conveyed by a neuron is in the *rate* of spiking. Spiking irregularity is largely due to noise and does not convey information.



MT neurons
Alert macaque monkey
256 ms window

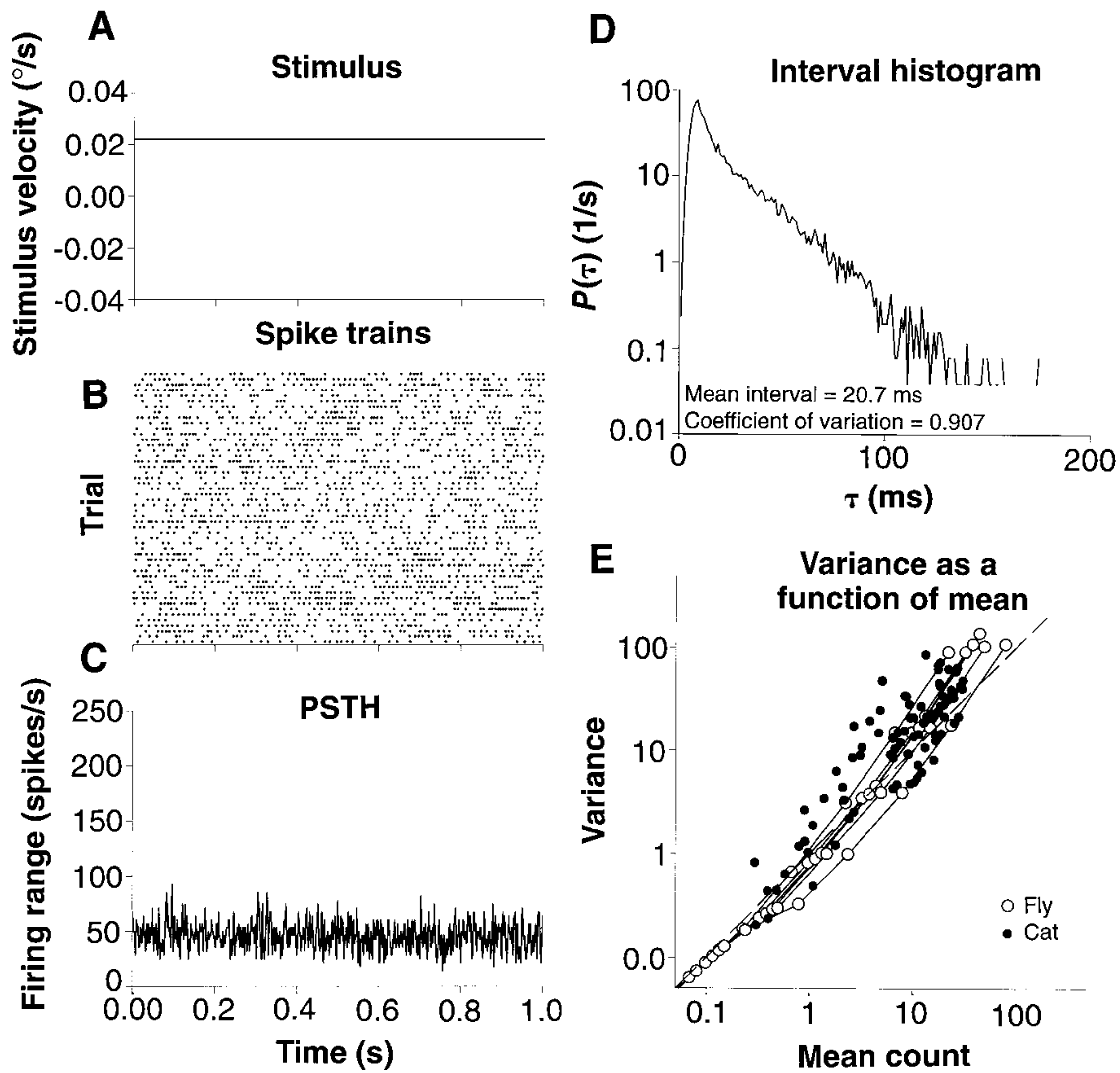
Fit of $\sigma^2(n) = A\,\langle n \rangle^B$



Dayan & Abbott, Figure 1.14

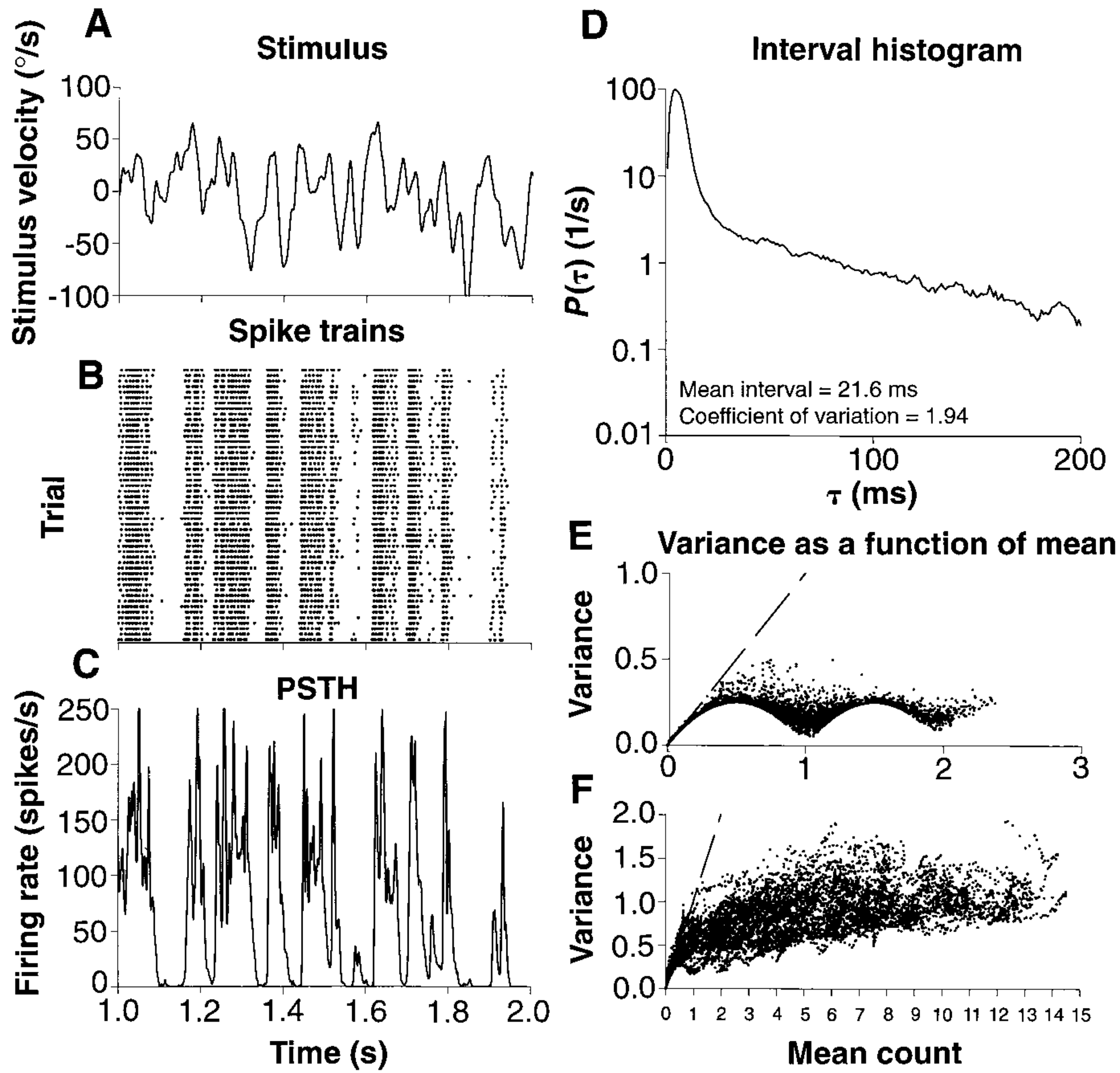
Fly H1 neuron - constant stimulus

(de Ruyter et al., 1997)



Fly H1 neuron - time-varying stimulus

(de Ruyter et al., 1997)

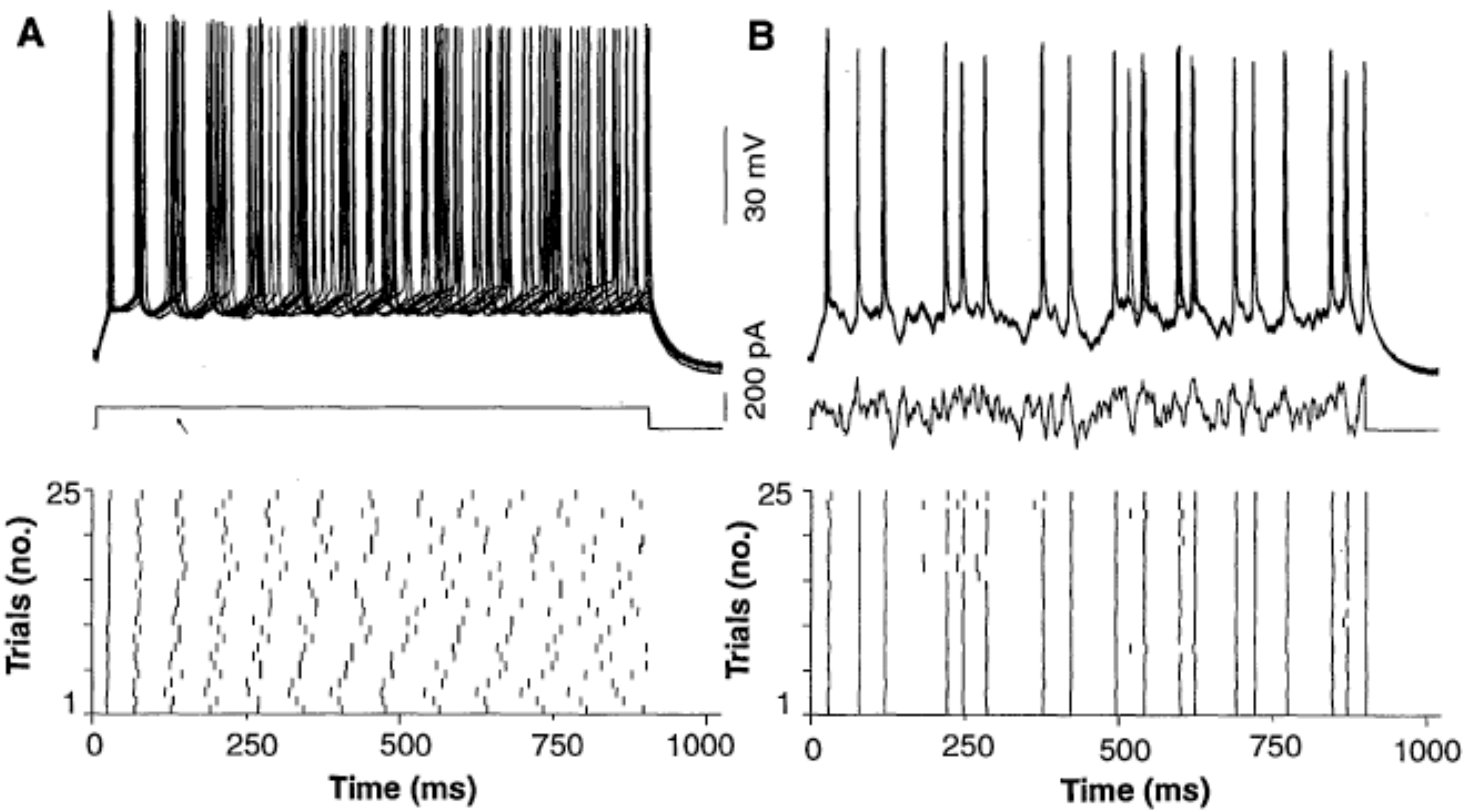


10 ms window

100 ms window

Spike timing can be very precise in response to *time-varying* signals

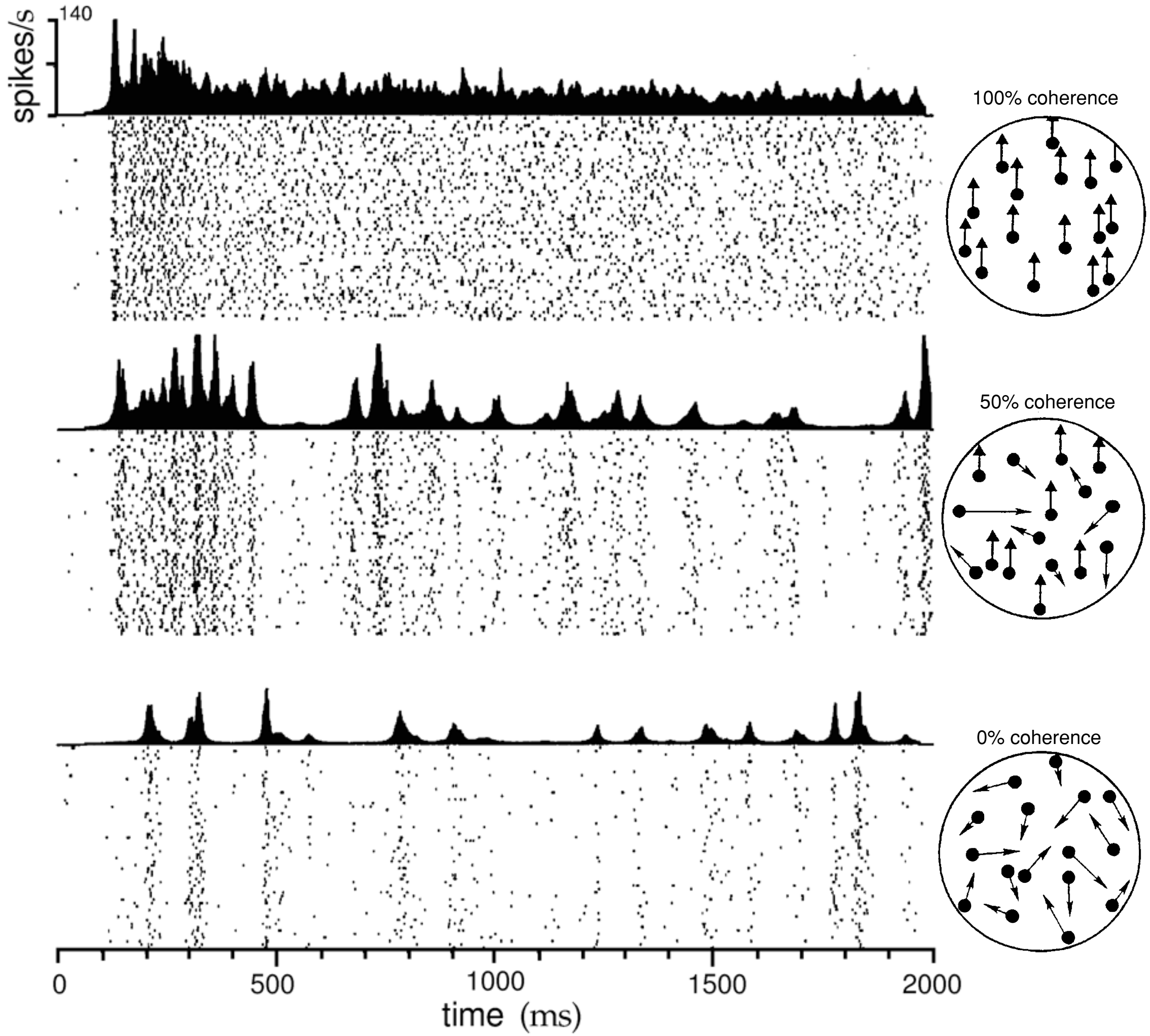
Mainen & Sejnowski (1995)



Spike timing can be *very precise* in response to time-varying signals

MT neuron response to stochastic moving dot stimuli at different levels of coherence (Newsom lab)

Analysis by Bair & Koch (1996)
“This suggests that temporal dynamics of a higher order than those found in rigid translation are necessary to induce a specific and unique time course in the spike discharge pattern.”



Cat V1 - natural movies (J. Baker, S.C. Yen, C.M. Gray, MSU Bozeman)