MODELS OF NEURONS AND NEURONAL NETWORK

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NEURON

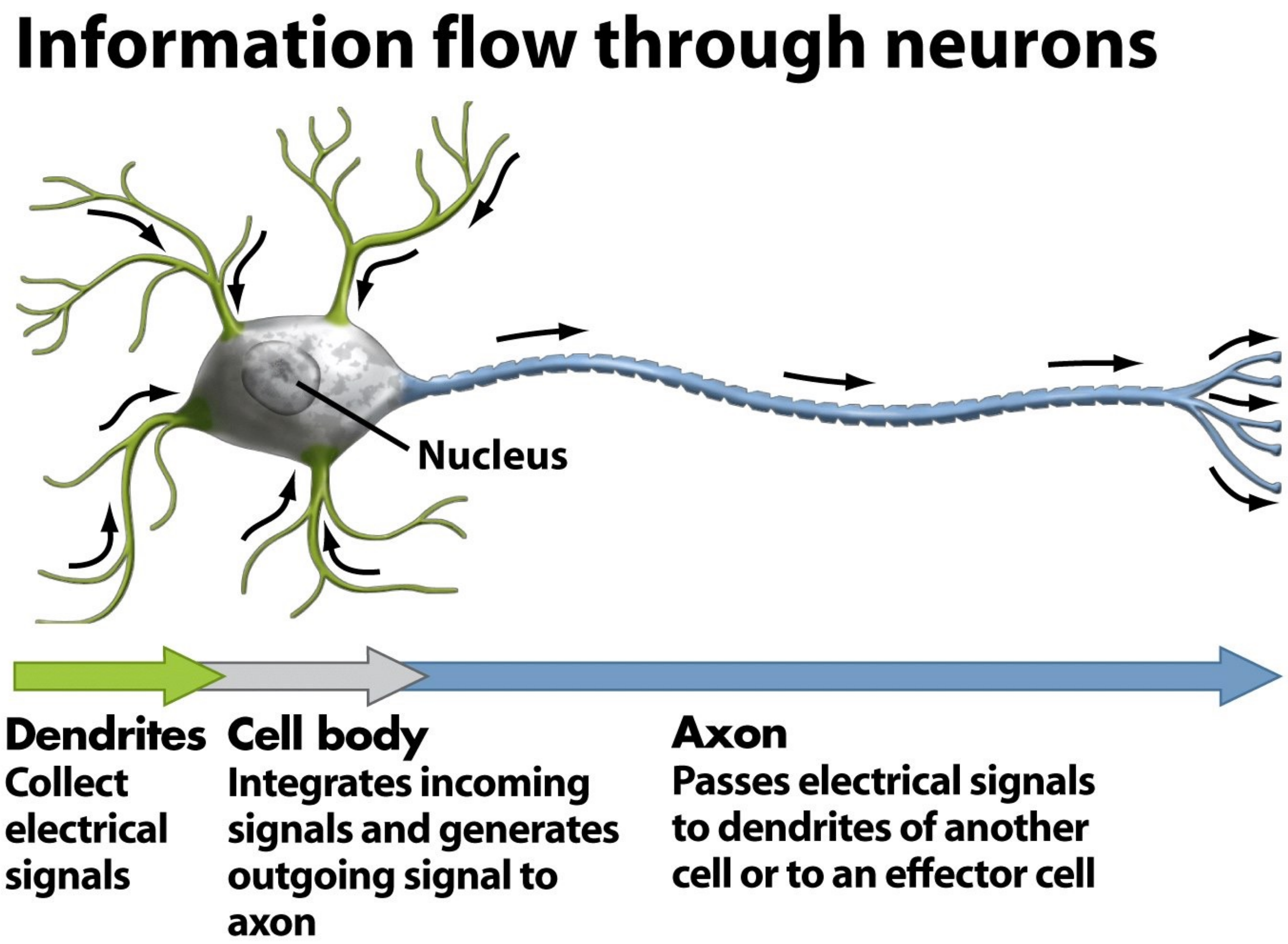
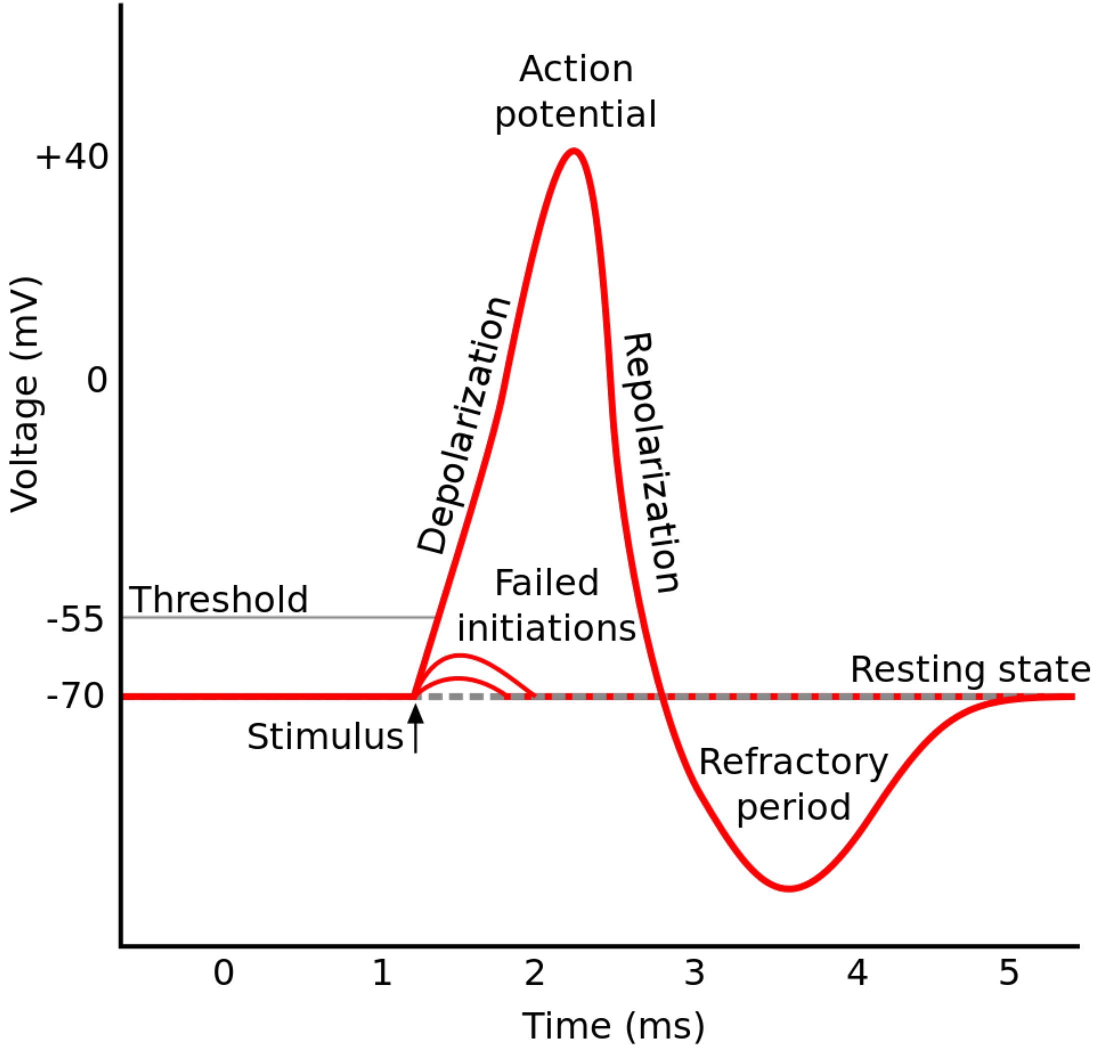


Figure 45-2b Biological Science, 2/e

NEURON SPIKE

$$I(t) = C_{\mathrm{m}} \frac{dV_{\mathrm{m}}(t)}{dt}$$



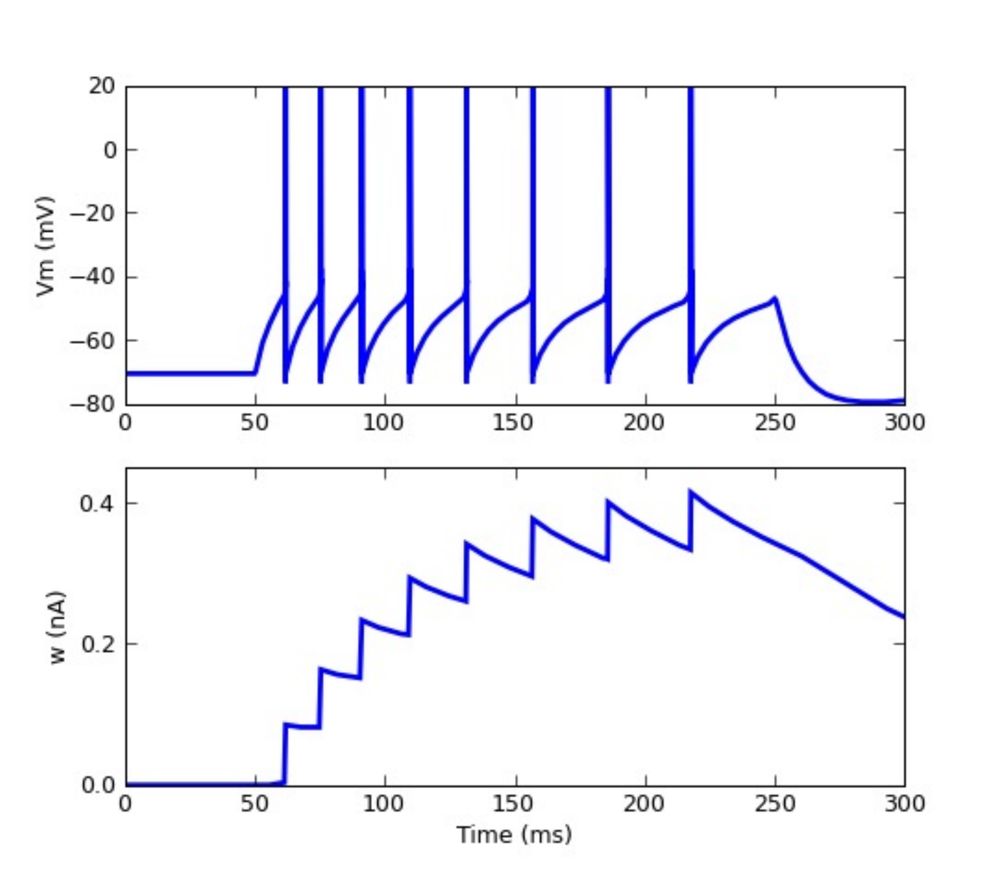
ADAPTIVE EXPONENTIAL INTEGRATE-AND-FIRE MODEL

$$C\frac{dv}{dt} = -g_L(v - E_L) + g_L\Delta_T \exp\left(\frac{v - v_{thres}}{\Delta_T}\right) - w + I$$

$$\tau_w \frac{dw}{dt} = a(v - E_L) - w$$

$$\text{if } v > v_{thres}, \text{ then } \begin{cases} v \leftarrow E_L \\ w \leftarrow w + b \end{cases}$$

Parameter	Description	Value
C	Membrane Capacitance	$281pF$
g_L	Leak Conductance	$30nS$
E_L	Leak reversal potential	$-70.6mV$
v_{thres}	Firing threshold	$-50.4mV$
Δ_T	Slope factor	$1mV$
τ_w	Adaptation time constant	$144ms$
a	Sub-threshold adaptation parameter	$4ns$
b	Spike triggered adaptation parameter	$0.0805nA$

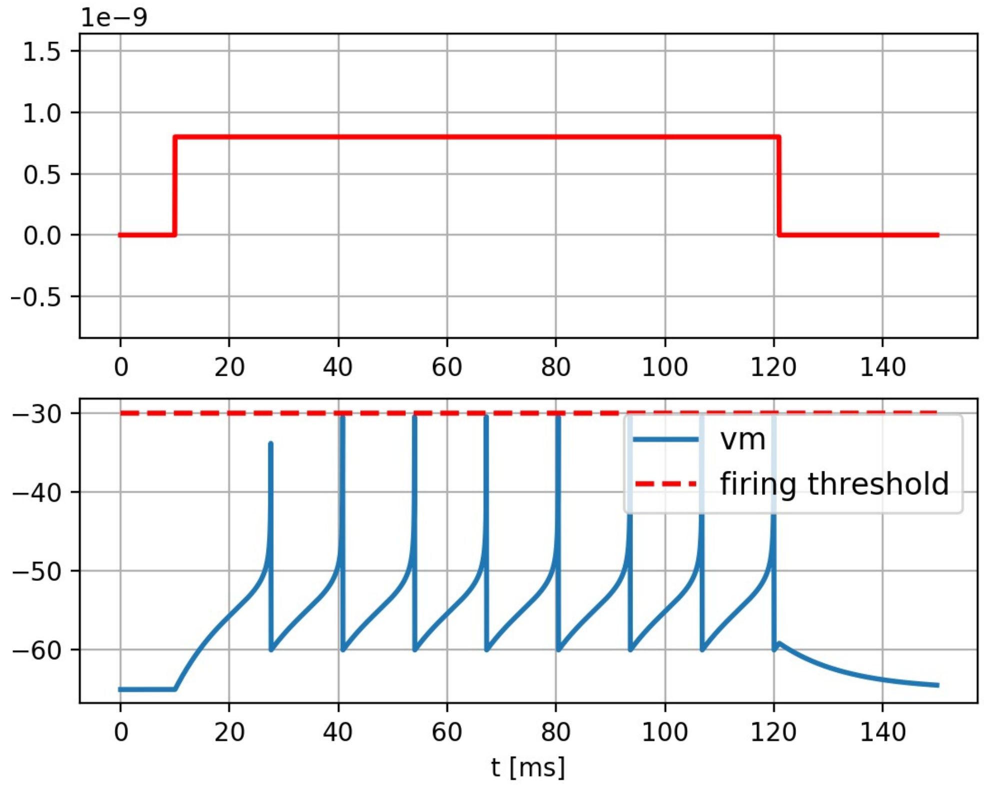


QUADRATIC INTEGRATE-AND-FIRE MODEL

$$\tau_m \frac{dv}{dt} = v^2(t) + RI(t),$$

$$\text{if } v > v_{thres}, \text{ then } v \leftarrow v_{reset}$$

Parameter	Description	Value
v_{thres}	Firing threshold	$-30mV$
v_{reset}	Reset voltage	$-65mV$
τ_m	Membrane time constant	$12ms$
R	Membrane resistance	$20\text{M}\Omega$
I	Injected current	$1nA$



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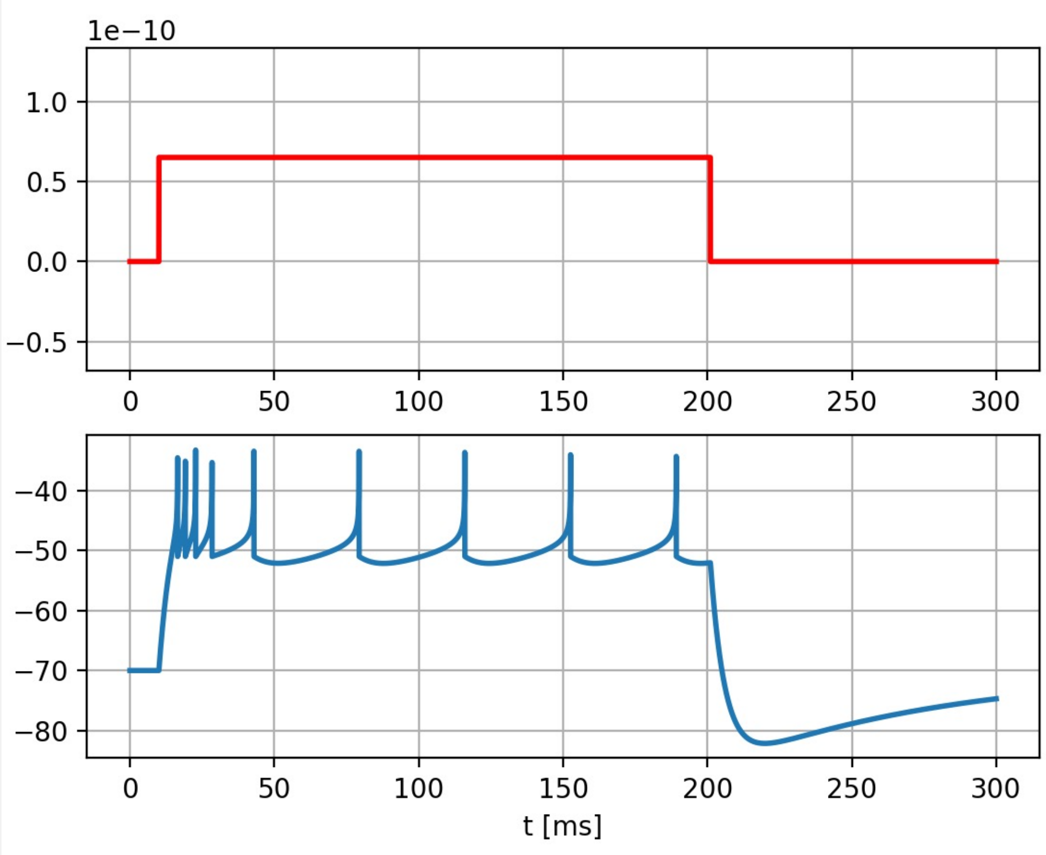
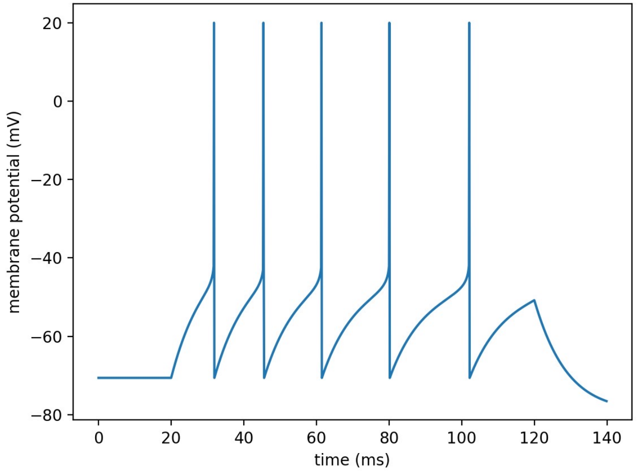
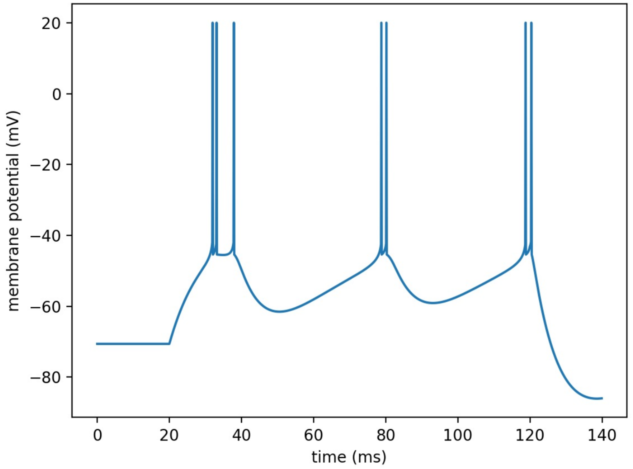


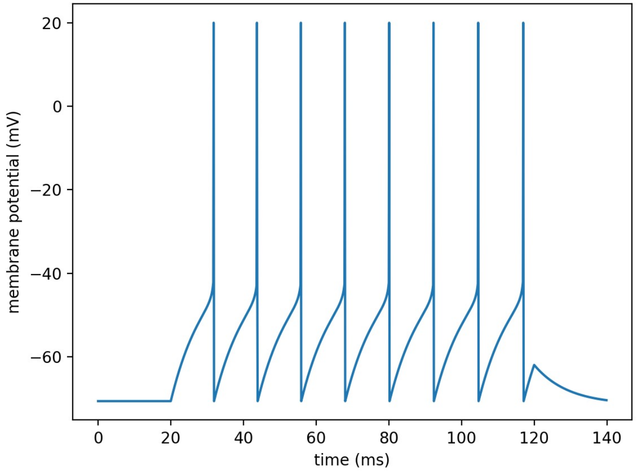
SIMULATION OF FIRING PATTERNS



Regular Spiking



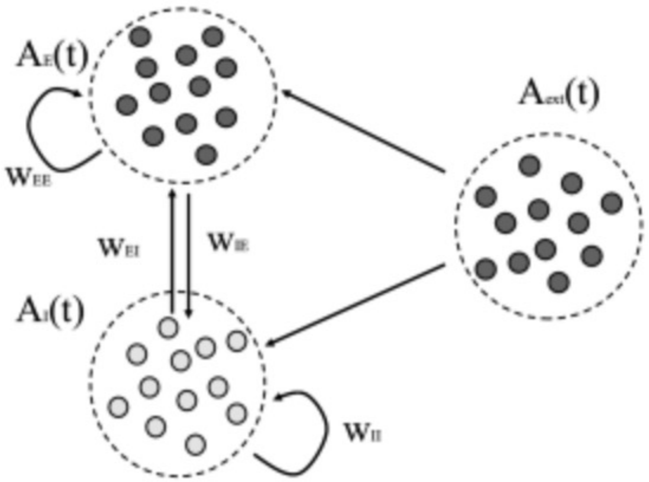
Bursting



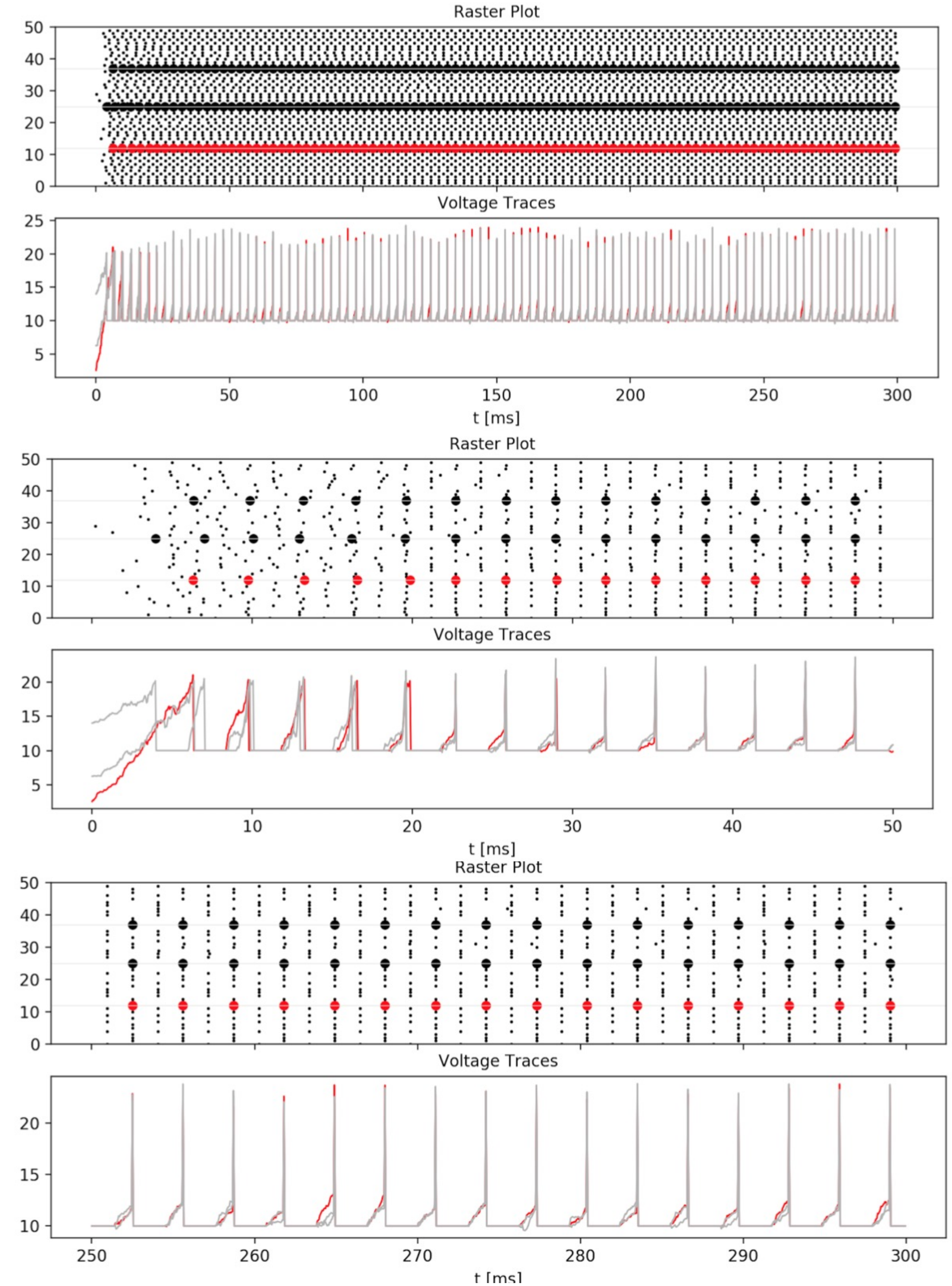
Fast Spiking

Type	C (pF)	g_L (nS)	τ_w (ms)	a (nS)	b (nA)	v_{reset} (mV)
Tonic	200	10	30	2	0	-58
Adapting	200	12	300	2	0.06	-58
Initial Burst	130	18	150	4	0.12	-50
Bursting	200	10	120	2	0.1	-46
Irregular	100	12	130	-11	0.030	-48
Transient	100	10	90	-10	0.030	-47
Delayed Burst	200	12	300	-6	0	-58

NETWORK OF NEURONS



SYNCHRONISATION



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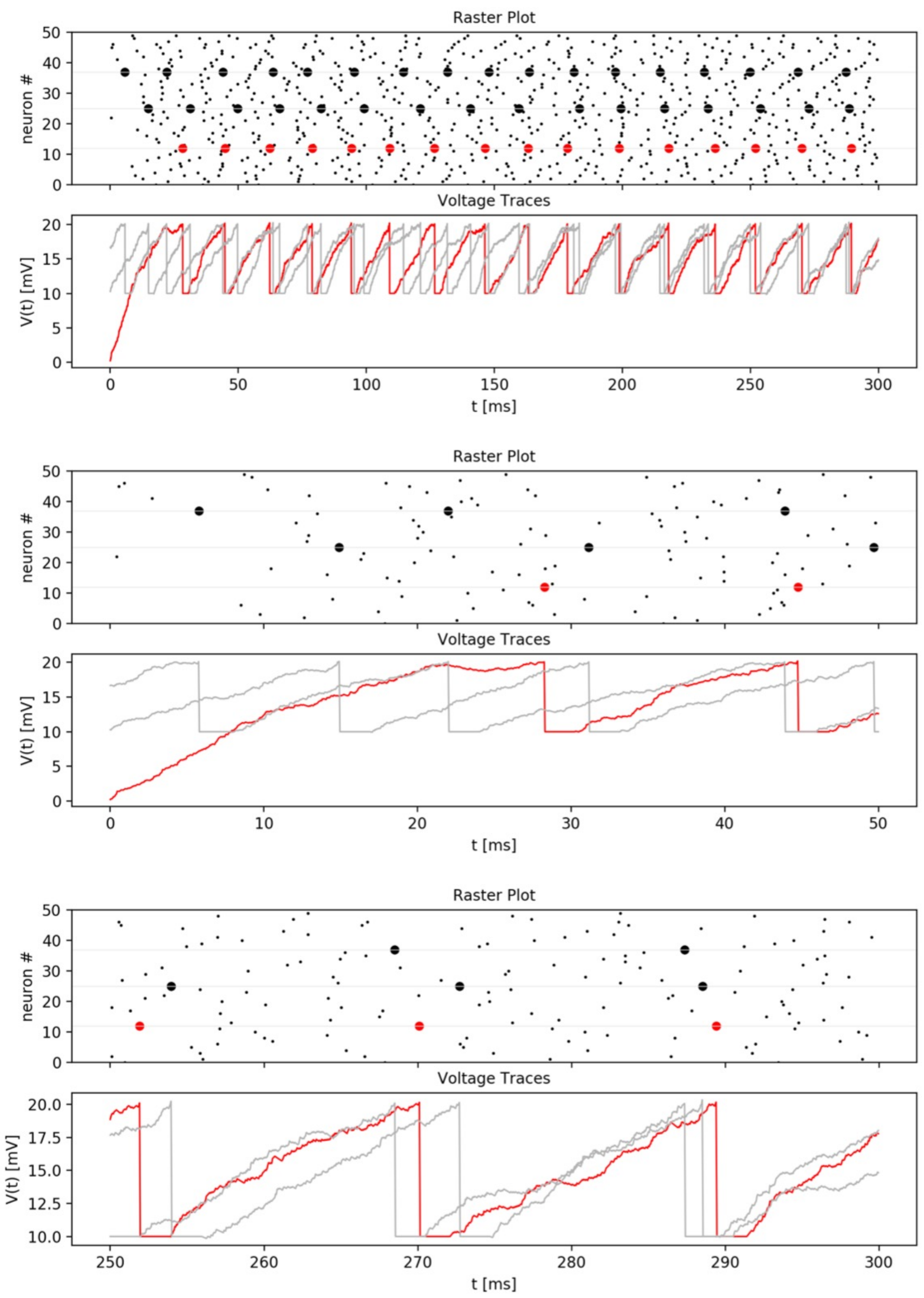

CONCLUSION

PERSONAL ACHIEVEMENTS

- Simulated a network of interacting populations of spiking neurons
- Wrote 1500 lines of Python codes.
- Read in excess of 20 research papers and technical books.
- Implemented a GUI simulator for testing.