

Exercise walk-through

5.2

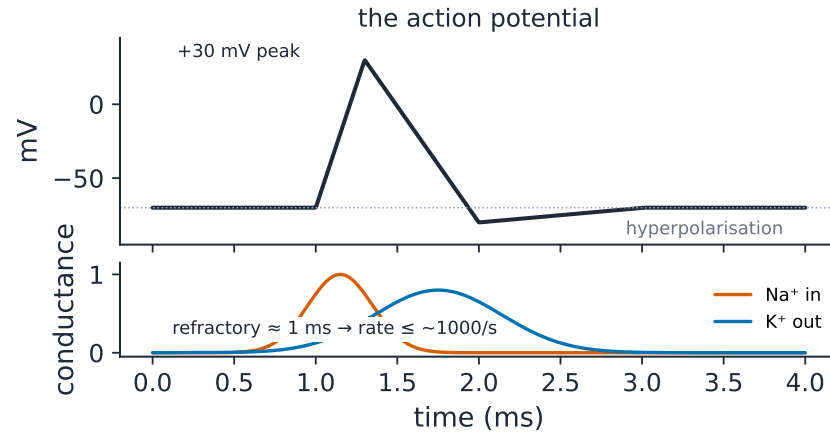
Excitable cells and muscle

University Medicine

Excitable cells: one sentence of electricity

- 1 **Spike** Rest -70 mV (K^+); Na^+ upstroke ($+30$, positive feedback); K^+ repolarisation; brief hyperpolarisation.
- 2 **Limits** Refractory ~ 1 ms caps firing $\sim 1000/s$; myelin $\rightarrow$ **saltatory conduction** up to ~ 100 m/s.
- 3 **Muscle** Spike $\rightarrow Ca^{2+} \rightarrow$ sarcomere: twitch 100 ms vs refractory 2 ms, so $20/s$ gives **tetanus** - never in the heart.

The action potential



One sodium upstroke, one potassium repolarisation, one refractory gap.

Exercises 2.1-2.3

2.1 What sets the maximum firing rate of a neurone? [3]

2.2 Name the two conductances of the action potential in order. [3]

2.3 Why cannot the heart tetanise? [3]

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2.1 What sets the maximum firing rate of a neurone? [3]

2.1

- The refractory period ($\sim 1 \text{ ms} \rightarrow \sim 1000/\text{s}$).
-

2.2 Name the two conductances of the action potential in order. [3]

2.2

- Na^+ in (upstroke), then K^+ out (repolarisation).
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2.3 Why cannot the heart tetanise? [3]

2.3

- Cardiac refractory ($\sim 200 \text{ ms}$) lasts as long as the twitch: no summation window.

Exercise 3.1

3.1 Two axons: unmyelinated (1 m/s) and myelinated (60 m/s).

Compute the travel time over 1 m for each. Explain the mechanism of the speed difference.
Predict the effect of demyelination on the fast axon. [7]

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3.1

- Unmyelinated: 1 s for 1 m; myelinated: ~17 ms ✓.
- Myelin insulates and channels cluster at nodes: the spike jumps (saltatory) instead of regenerating continuously.
- Demyelination strips the insulation: conduction slows, then blocks (the safety factor fails).

Exercise 3.2

3.2 A myopathy shows a serum potassium of 2.8 mmol/L after a carbohydrate meal (fictional).

Explain the Nernst consequence for the muscle resting potential. Predict the effect on threshold reachability. State why the weakness is episodic. [7]

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3.2

- Low ECF K^+ hyperpolarises: the K^+ equilibrium potential becomes more negative, dragging rest further from threshold.
- A larger depolarisation is now needed: spikes fail, so contraction fails.
- Episodic because the trigger (insulin after meals, driving K^+ in) wanes with the glucose.