

5.2 Excitable cells and muscle

Name: _____ Class: _____ Date: _____

Total: 23 marks

KEY WORDS refractory period

Objective

Compute rate ceilings from refractory periods and trace spike-to-force coupling.

1 Key knowledge and worked examples

■ The sentence

Rest -70 mV; Na^+ upstroke $+30$ mV (positive feedback); K^+ repolarisation; refractory ~ 1 ms (nerve) $\rightarrow$ rate $\leq \sim 1000/\text{s}$; myelin $\rightarrow$ saltatory, ~ 100 m/s.

■ Worked example: tetanus arithmetic

Twitch 100 ms vs refractory 2 ms in skeletal muscle: 20/s summation gives tetanus ✓; cardiac refractory ~ 200 ms forbids it ✓.

2 Practice

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]

3 Exam-style questions

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]

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]

Solutions

2.1

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

2.2

- Na^+ in (upstroke), then K^+ out (repolarisation).

2.3

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

3.1

- Unmyelinated: 1 s for 1 m ; myelinated: $\sim 17 \text{ ms}$ ✓.
- 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).

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.