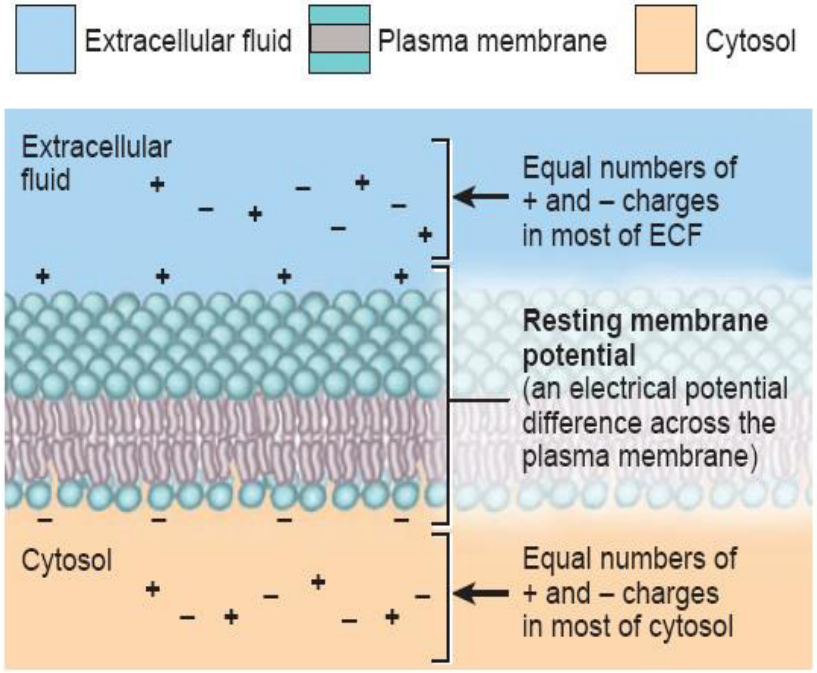
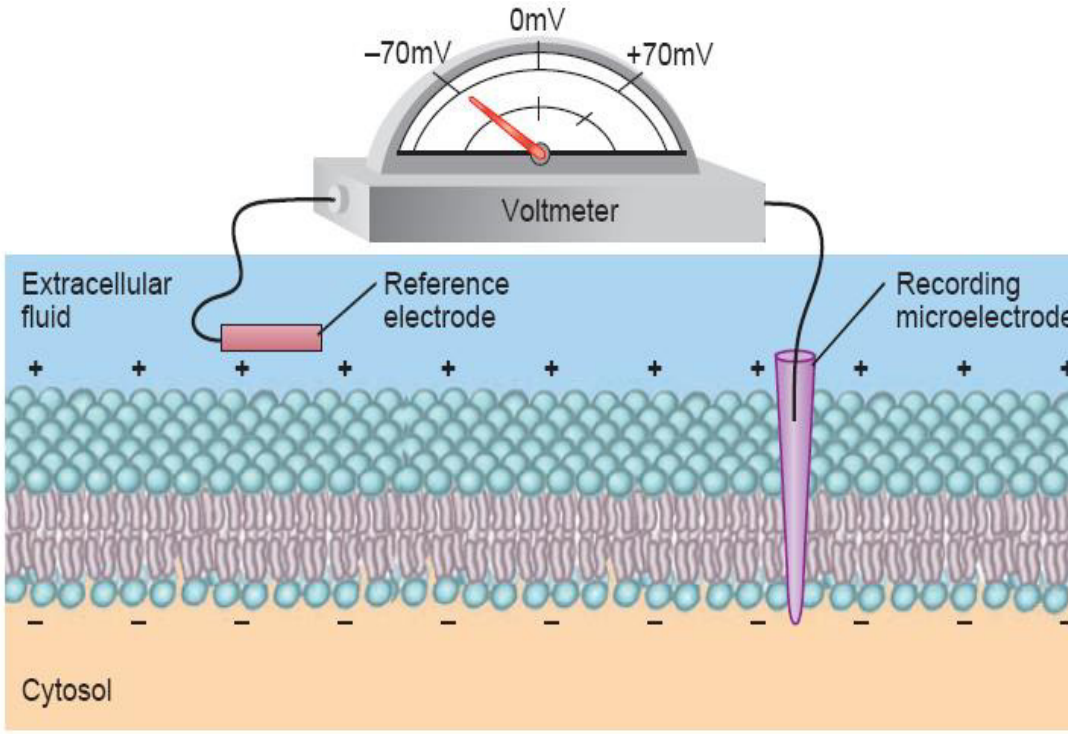
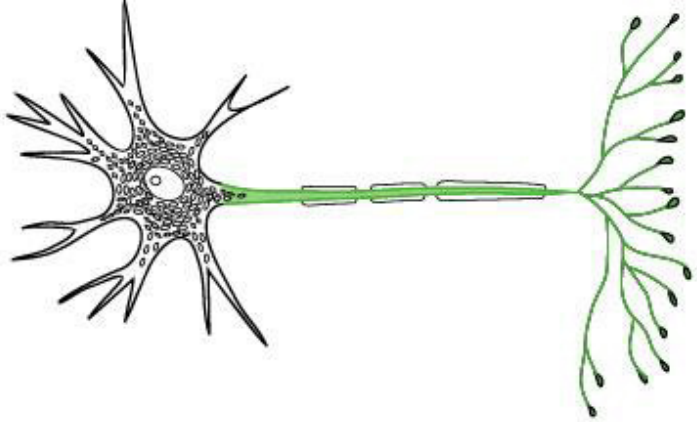
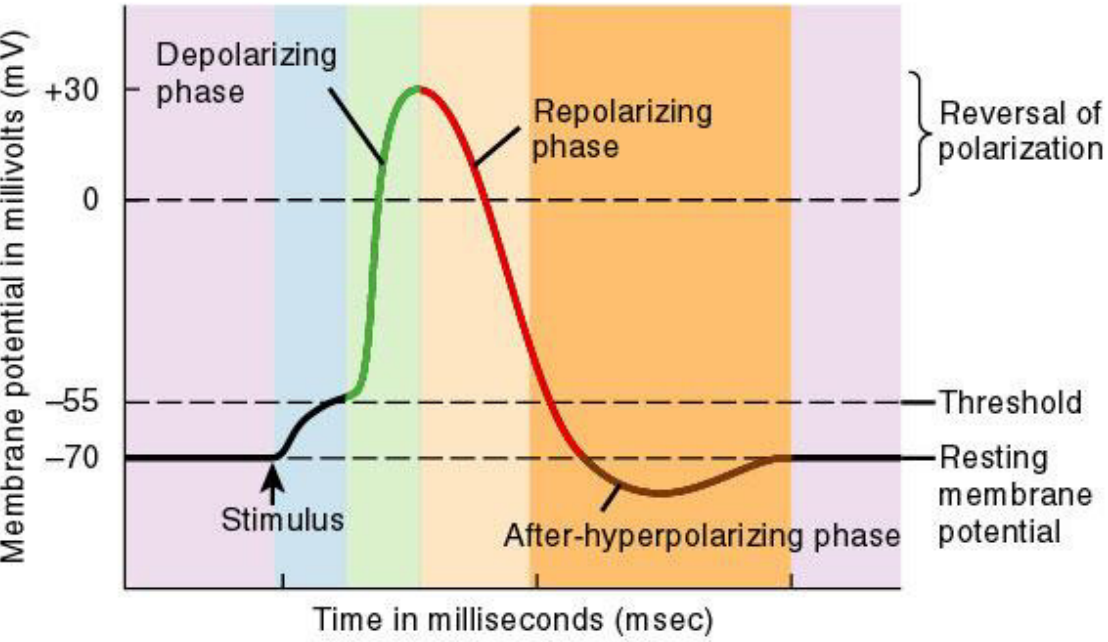
Resting Membrane Potential









Key:

- Resting membrane potential: Voltage-gated Na^+ channels are in the resting state and voltage-gated K^+ channels are closed
- Stimulus causes depolarization to threshold
- Voltage-gated Na^+ channel activation gates are open
- Voltage-gated K^+ channels are open; Na^+ channels are inactivating

} Absolute refractory period

- Voltage-gated K^+ channels are still open; Na^+ channels are in the resting state

} Relative refractory period

12.11

Resting Membrane Potential & Goldman Equation

$$V_m = \frac{RT}{F} \log \frac{P_K[K^+]_o + P_{Na}[Na^+]_o + P_{cl}[Cl^-]_o}{P_K[K^+]_i + P_{Na}[Na^+]_i + P_{cl}[Cl^-]_i}$$

- P = permeability
- at rest: P_K: P_{Na}: P_{Cl} = 1.0 : 0.04 : 0.45 –
- Net potential movement for all ions
- known V_m:Can predict direction of movement of any ion ~

Effect of K Ions on the RMP

Effect of K Ions on the RMP

- hyperkalemia :
- weakness, ascending paralysis,
- If untreated cardiac arrhythmias
- Hypokalemia : serum K+ <3.5 mEq/L

Myopathies (**Myotonia**)

weakness, fatigue, paralysis

Effect of K Ions on the RMP

- hyperkalemia : serum K+ >5 mEq/L, moderate (6 to 7 mEq/L) and severe (>7 mEq/L)

- Hypokalemia :

Weakness , fatigue, motor paralysis

Myopathies (**Myotonia**)

Effect of Na Ions on the RMP

Effect of Na Ions on the RMP

- **Hyponatremia**

Effect of Na Ions on the RMP

- **Hyponatremia**
- lethergy, confusion, weakness and muscle cramps, nausea and vomiting >>>> coma >>>>seizures
- Tt
- only 1 mlmol/L/hour
- Osmotic demyelination syndrome (central pontine myelinolysis)

Effect of Na Ions on the RMP

- **Hyponatremia**
- lethergy, confusion, weakness and muscle cramps, nausea and vomiting >>>> coma >>>>>seizures
- Tt
- only 1 mlmol/L/hour or (8 mmol/L of Na/day)
- Osmotic demyelination syndrome (central pontine myelinolysis)

Effect of Na Ions on the RMP

Effect of Na Ions on the RMP

- **Hypernatremia**

Effect of Na Ions on the RMP

- **Hypernatremia**
- nausea, and vomiting, altered mental status, confusion, neuromuscular excitability and hyperreflexia, irritability, seizures, and even coma or death.
- Tt
- 0.45% sodium chloride
- brain edema or hemorrhage, potentially seizures, permanent brain damage, or death

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Effect of Ca Ions on the RMP

Effect of Ca Ions on the RMP

- **Hypercalcemia**

Effect of Ca Ions on the RMP

- **Hypercalcemia**

Headache, and lethargy. anxiety, depression, and cognitive dysfunction, insomnia, coma

Effect of Ca Ions on the RMP

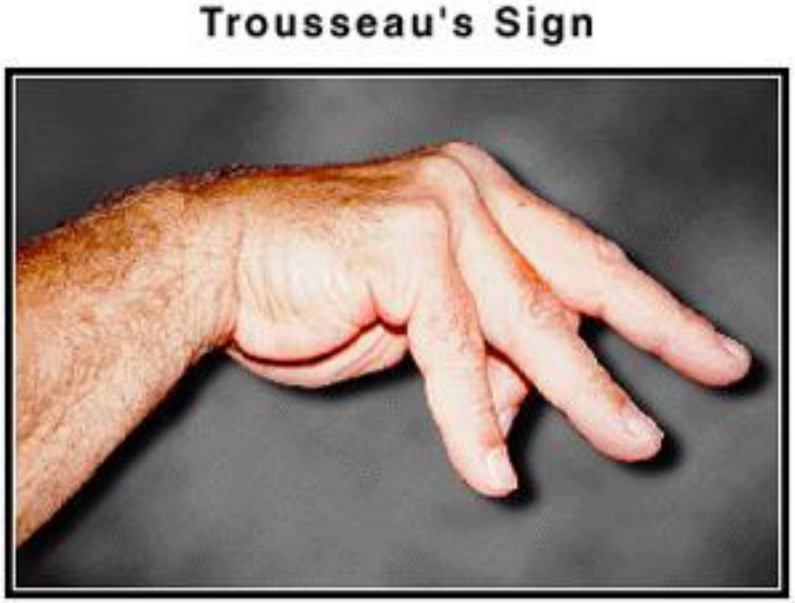
- **Hypocalcemia**

Effect of Ca Ions on the RMP

- **Hypocalcemia**

- The hallmark is neuromuscular irritability and tetany

(Trousseau's sign & Chvostek's sign)



- Irritability , hyperreflexia, Seizures, psychosis and hallucination

Effect of Ca Ions on the RMP

- **Hypocalcemia**

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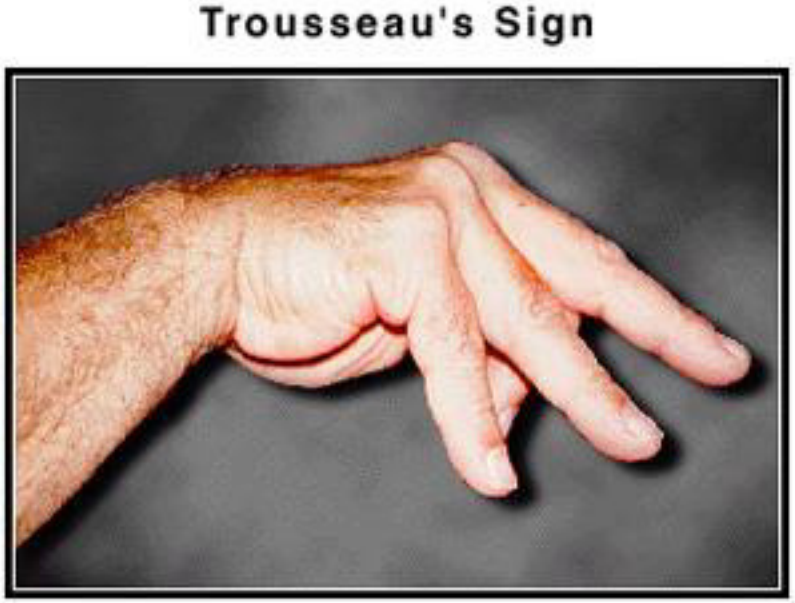

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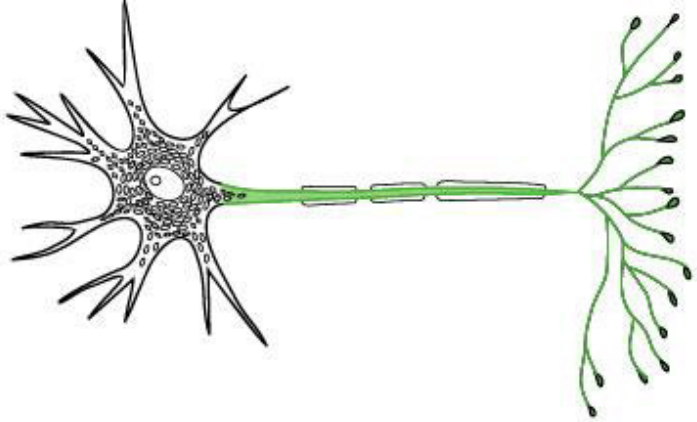

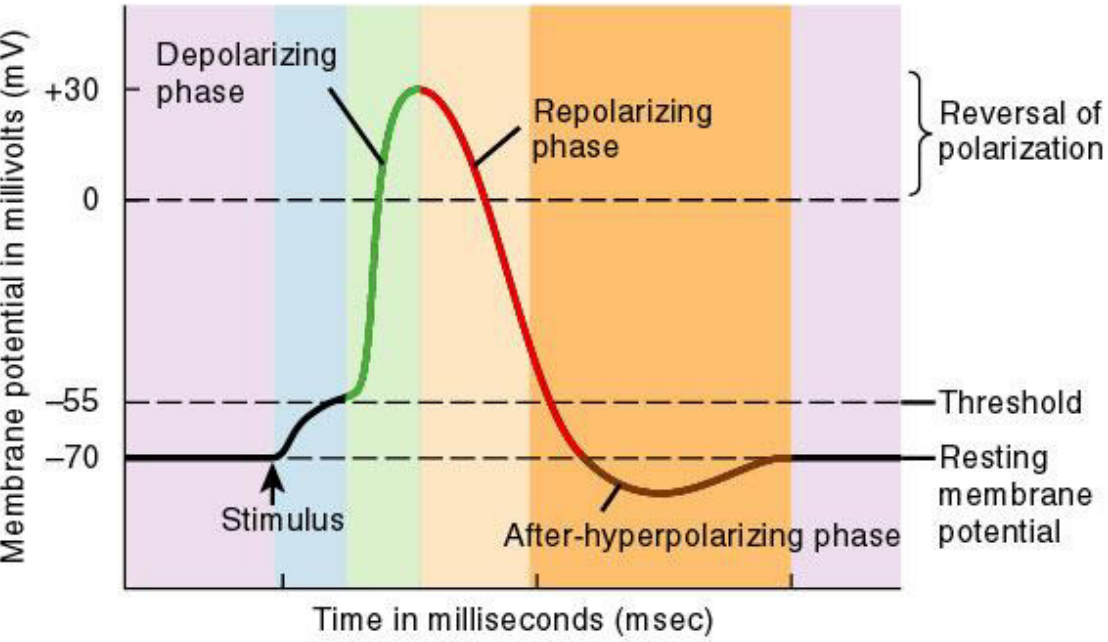

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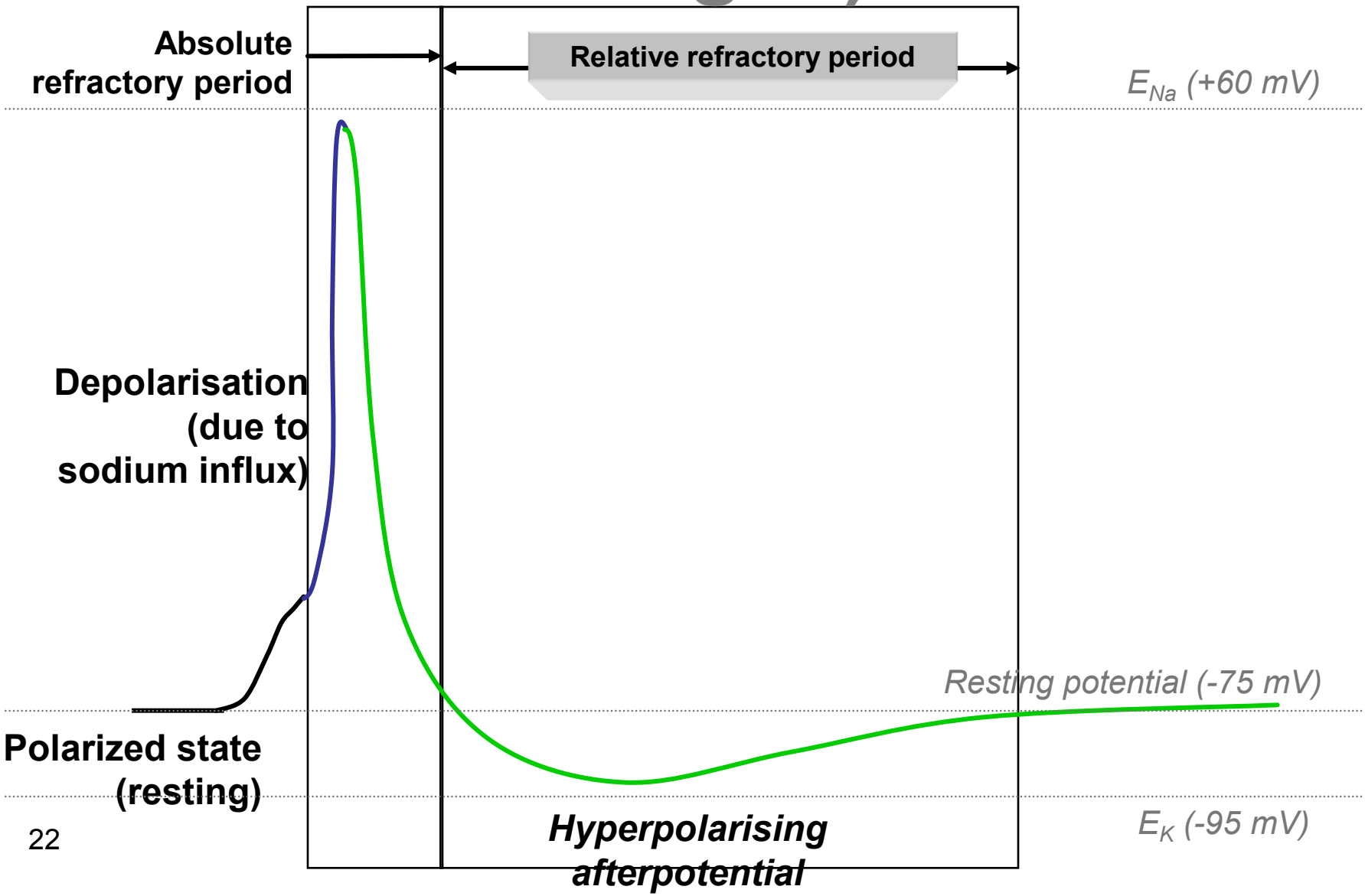
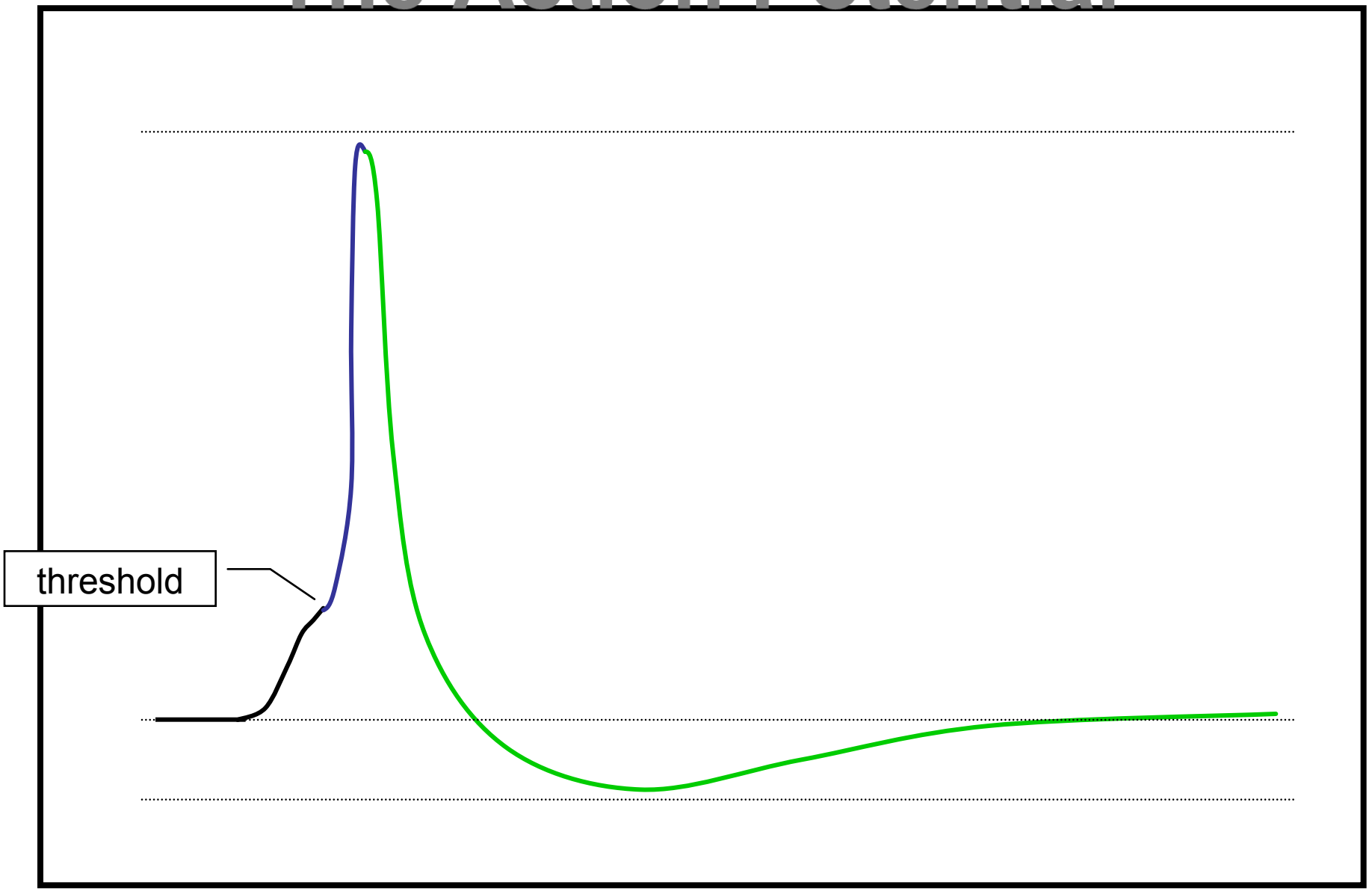
The Action Potential (excitability changes)



The Action Potential



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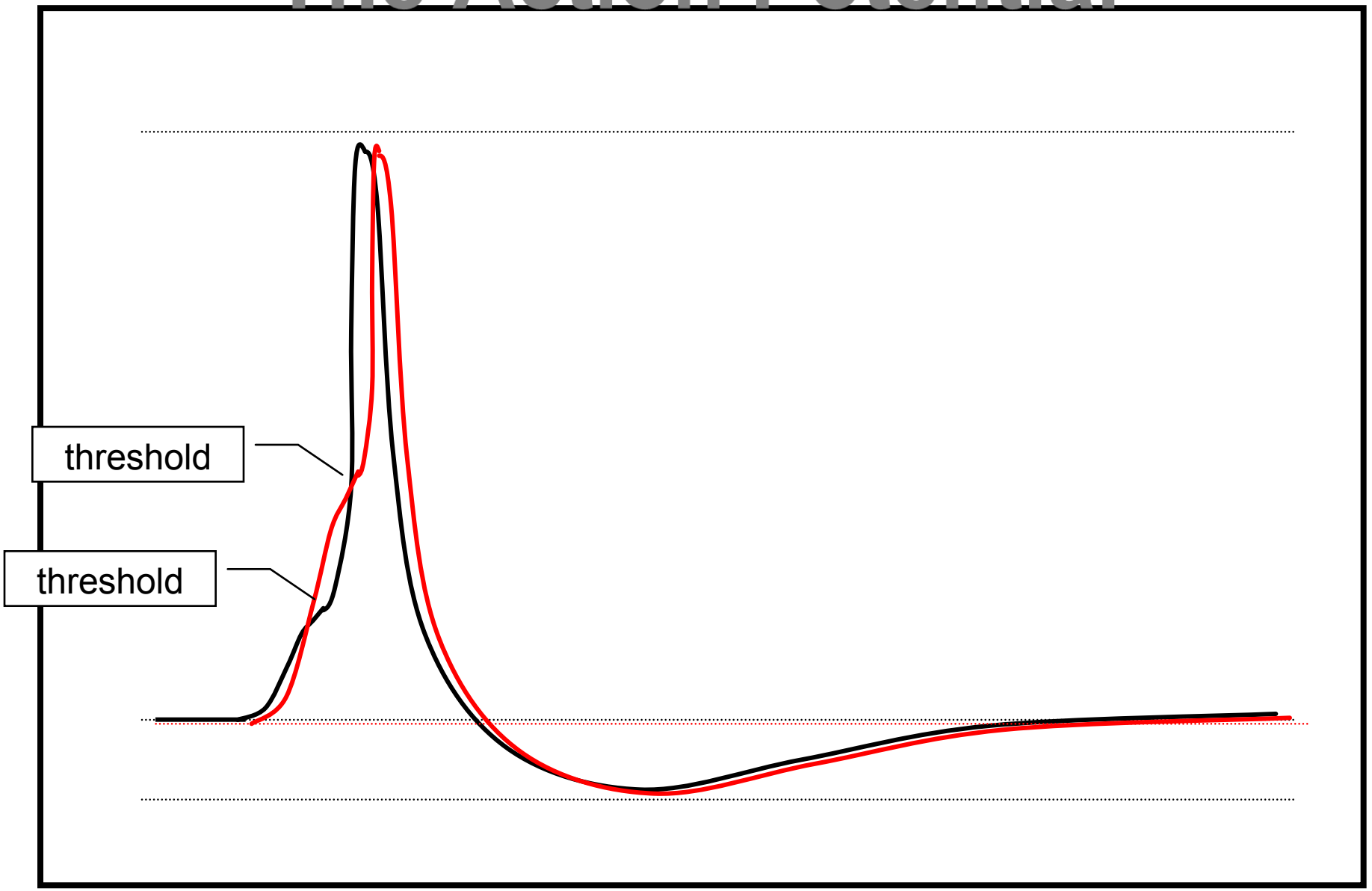

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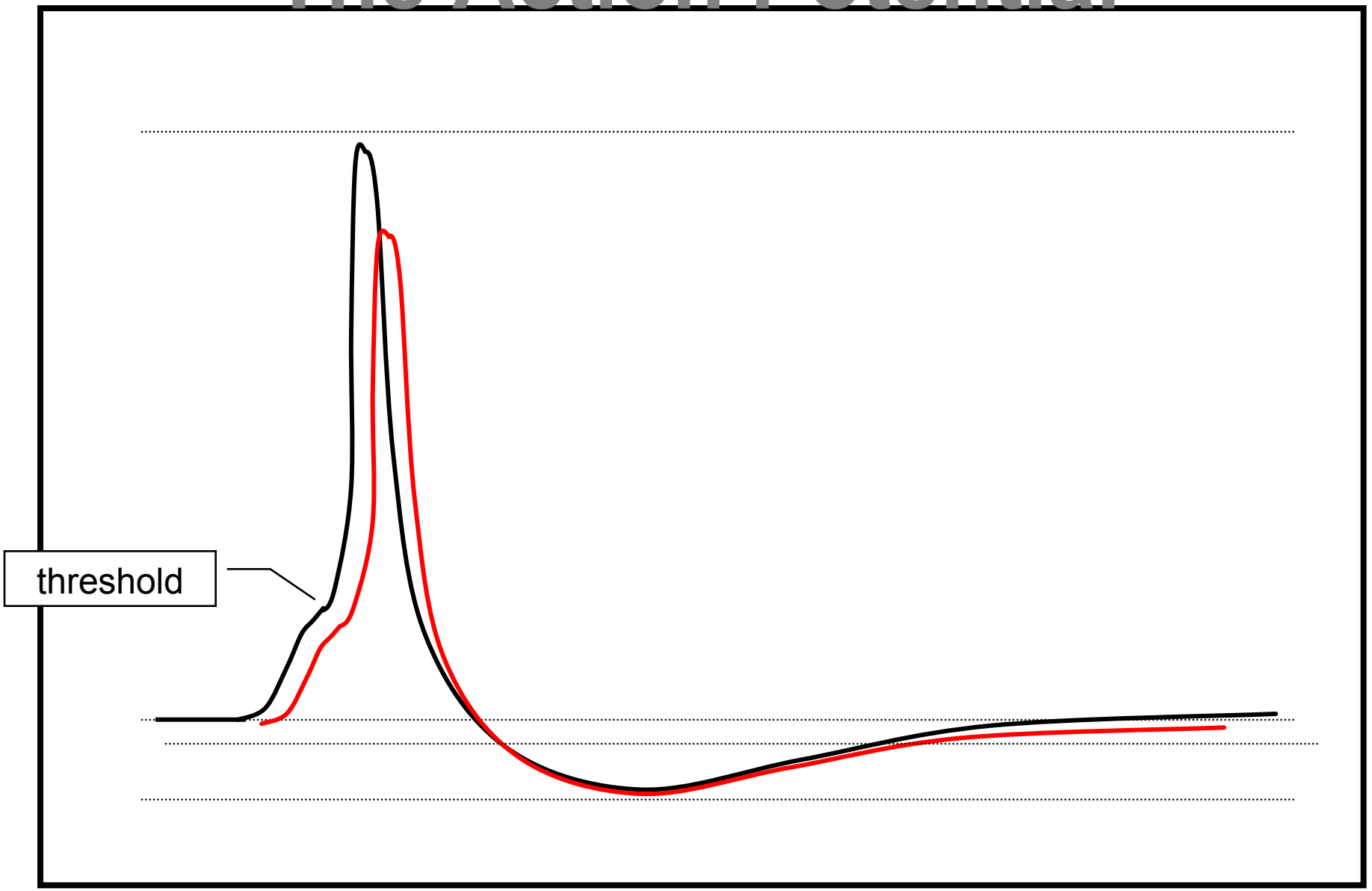
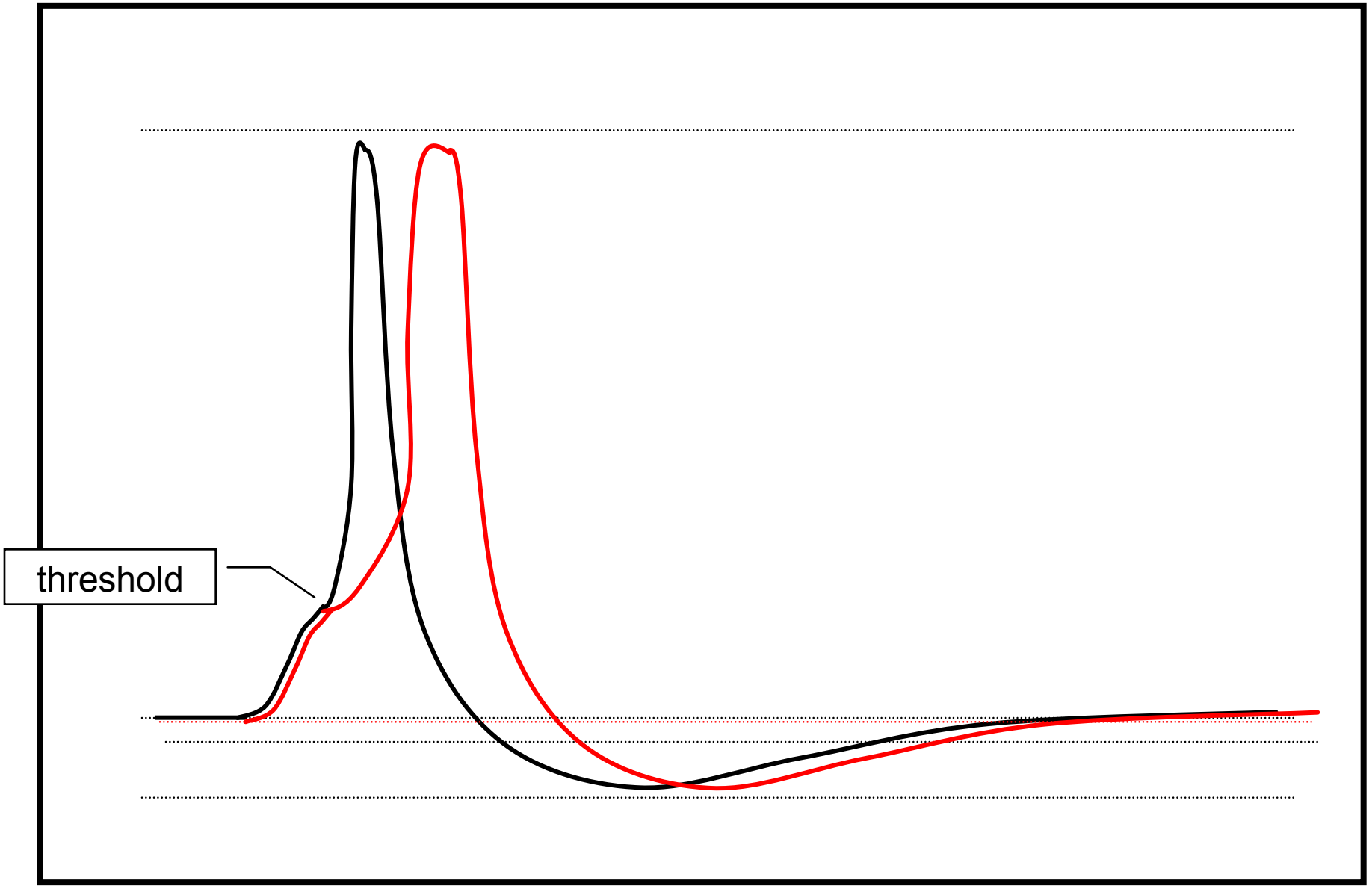
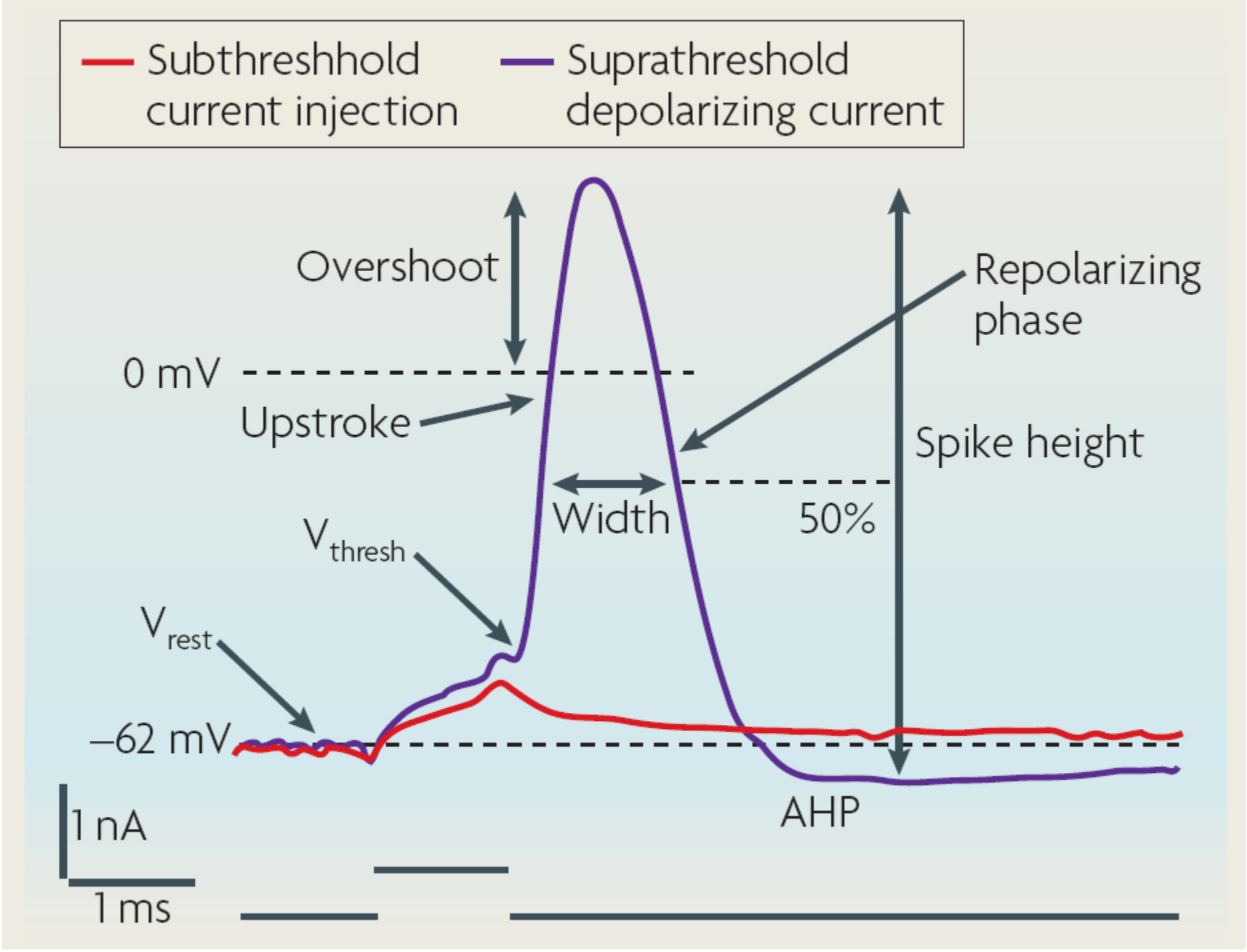
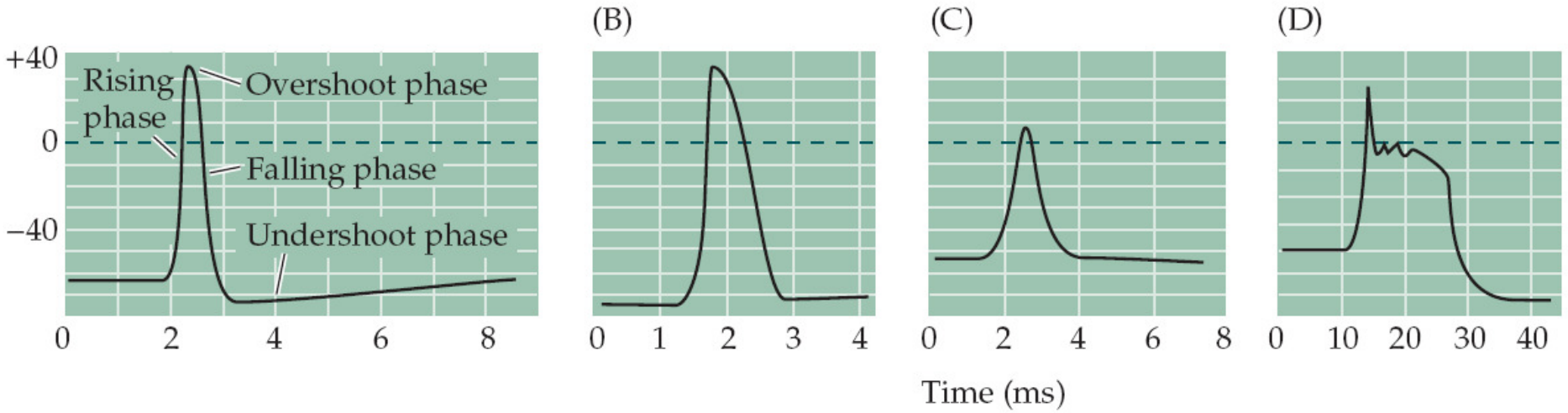
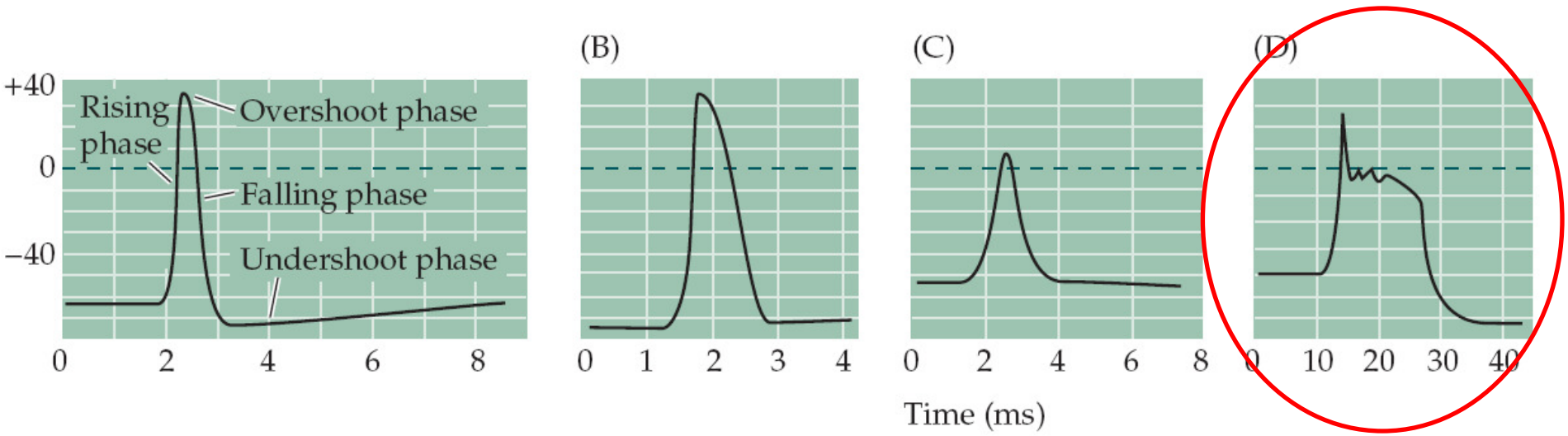



threshold


Subthreshhold current injection
Suprathreshold depolarizing current
Overshoot
Repolarizing phase
0 mV
Upstroke
Spike height
Width
50%
V_{thresh}
V_{rest}
–62 mV
AHP
1 nA
1 ms


+40
0
−40
Rising phase
Overshoot phase
Falling phase
Undershoot phase
0 2 4 6 8
(B)
0 1 2 3 4
(C)
0 2 4 6 8
(D)
0 10 20 30 40
Time (ms)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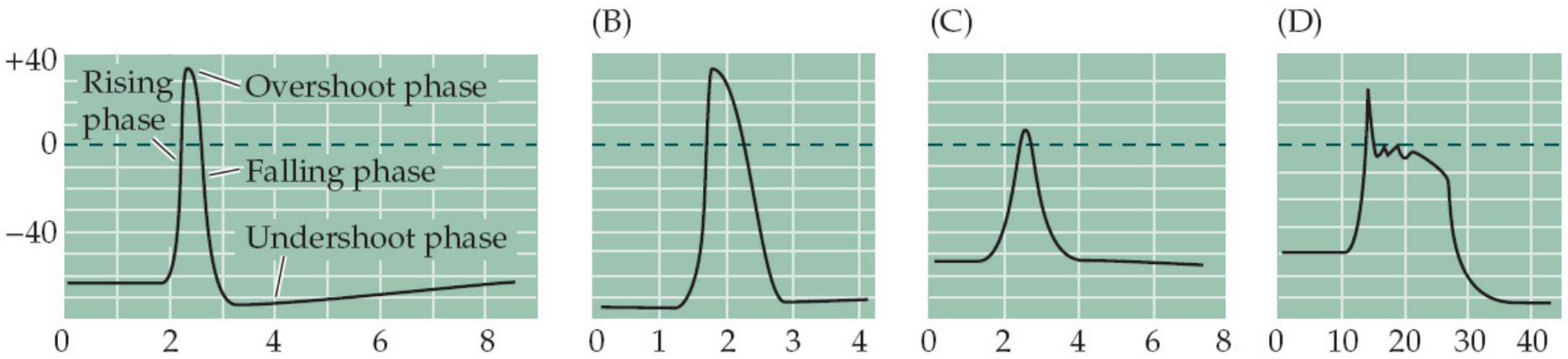
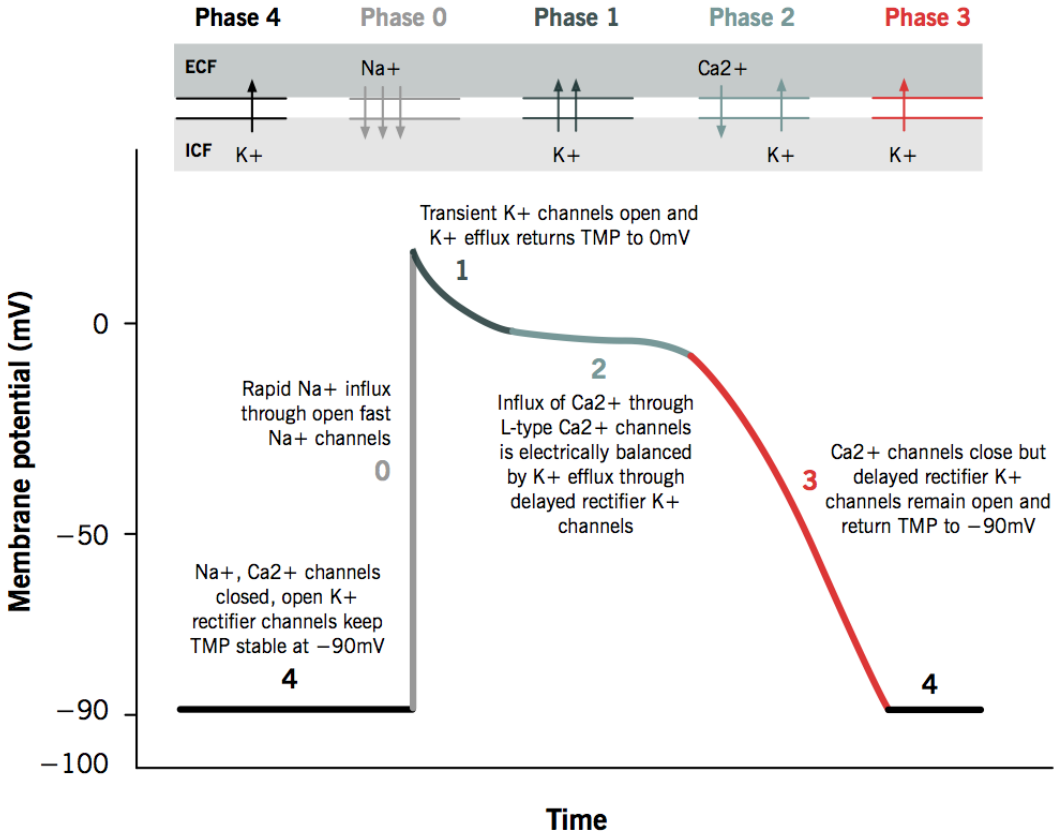
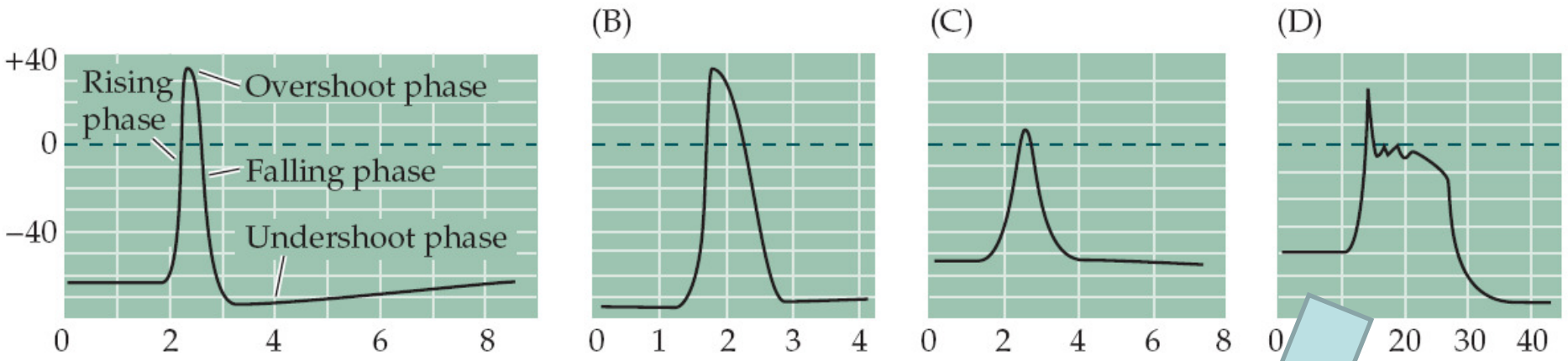


Action potential of cardiac muscles

Grigoriy Ikonnikov and Eric Wong





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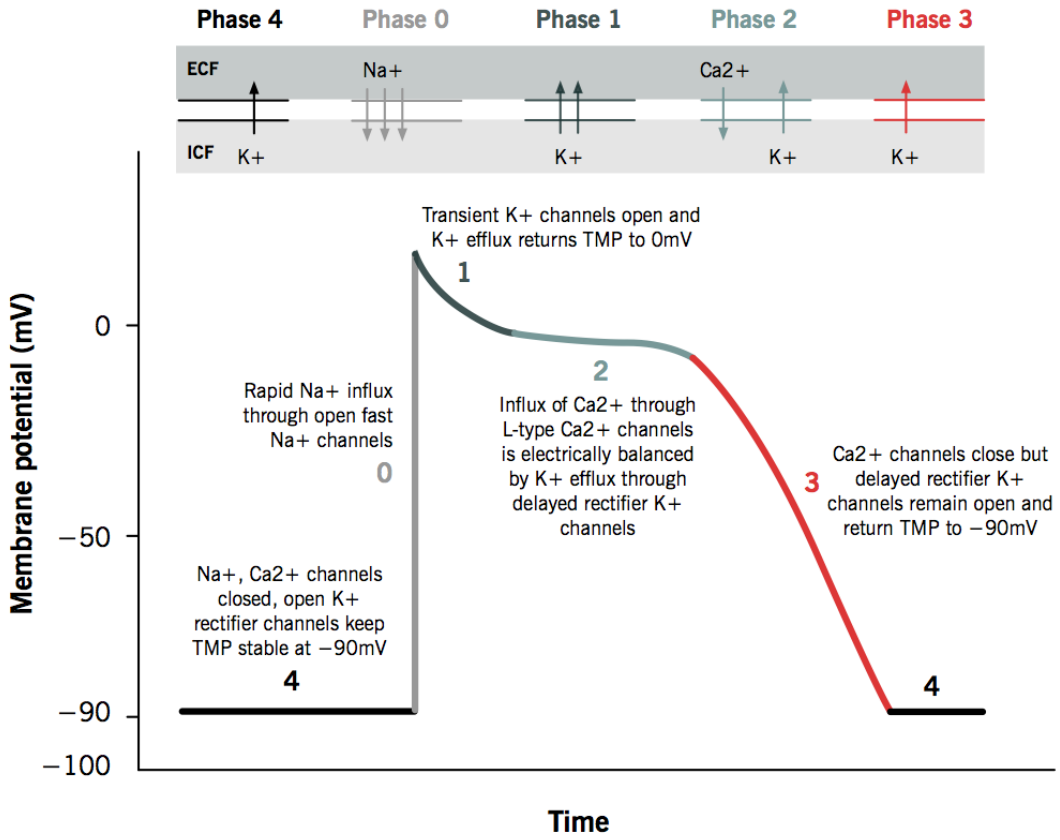

neuron from the inferior olive

Channelopathies

- Pages 84 & 85 in

  Neuroscience 3rd edition by Dale *Purves*

Ion Channel Neurotoxins