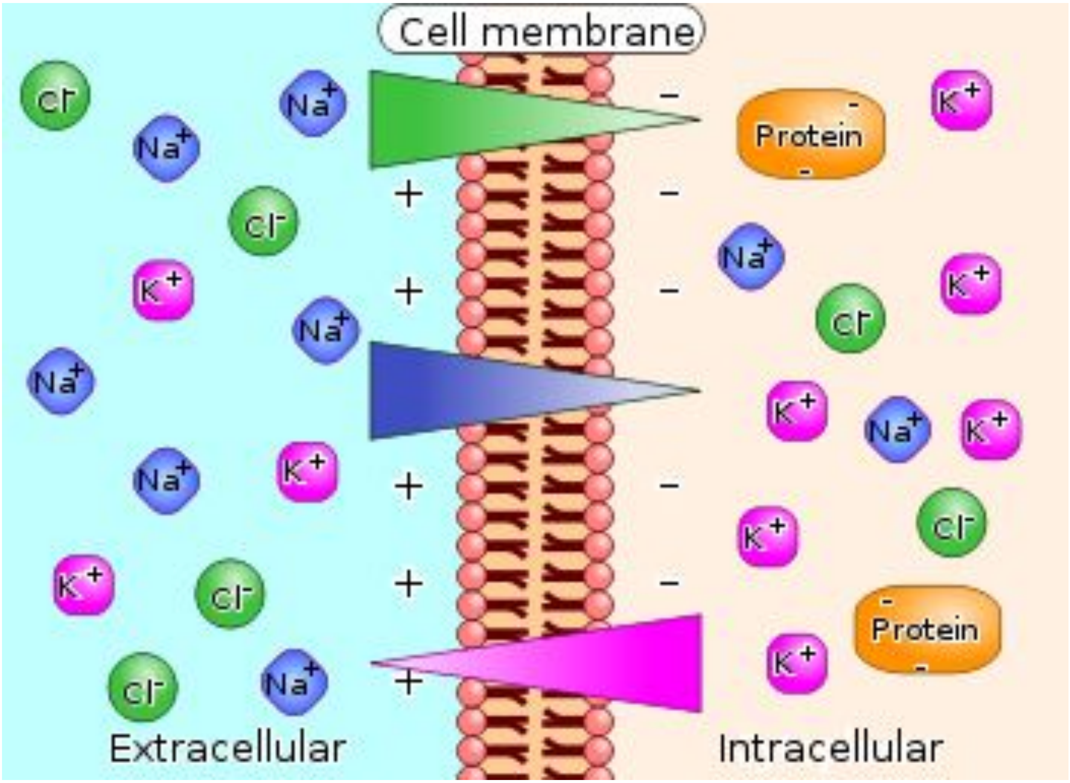
RESTING MEMBRANE POTENTIAL REVIEW

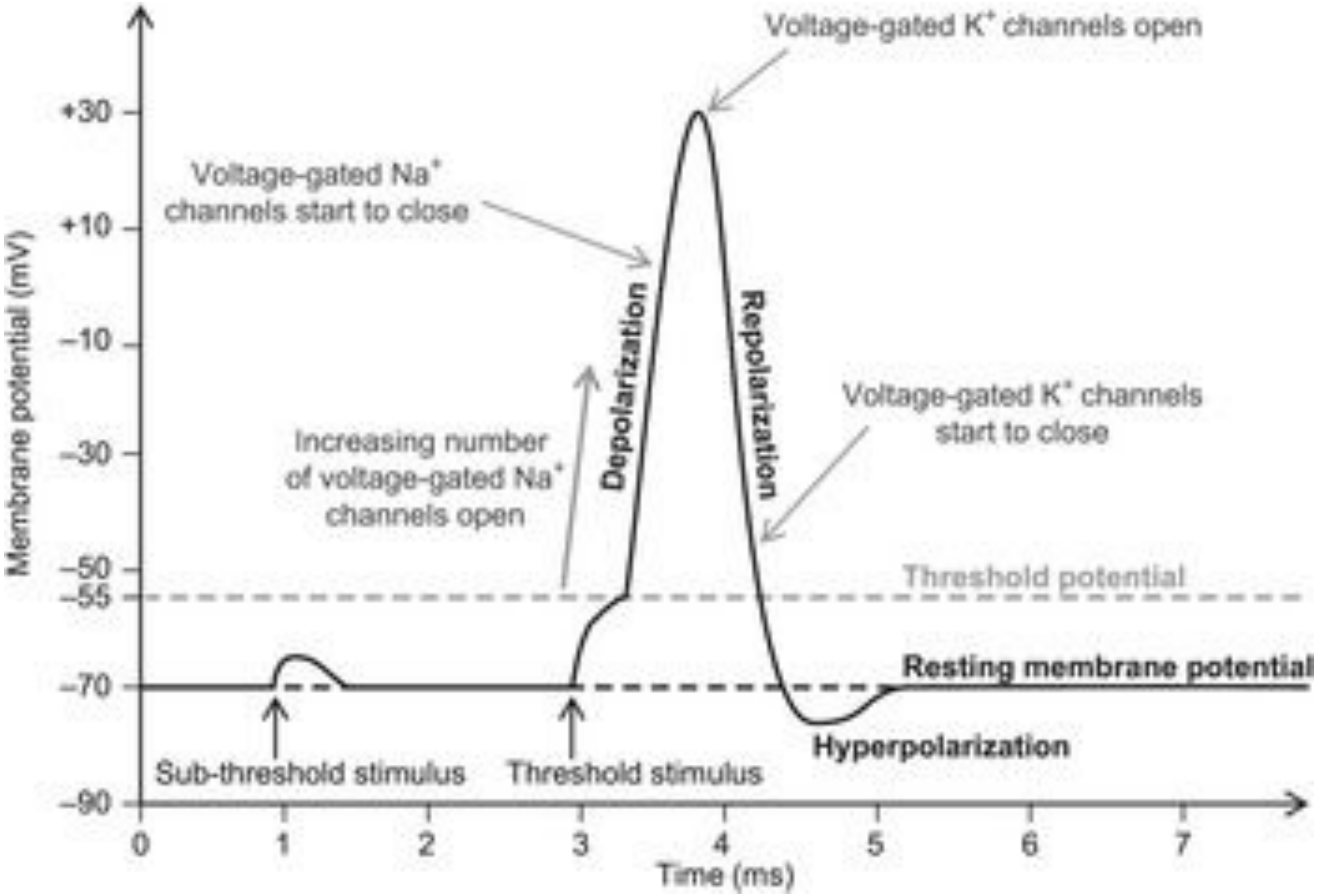
- When a neuron is at rest, there are:
  - More sodium ions outside the cell
  - More potassium ions inside the cell
- Ions can NOT move freely across the membrane



RESTING MEMBRANE POTENTIAL REVIEW

- Stimuli excite neurons to generate a nerve impulse, called the action potential.
- The events of an action potential involve **changes in the membrane permeability to ions**, which causes changes in the **membrane potential**.

- There are 6 steps in an action potential:
  1. **Resting Membrane Potential**
  2. **Depolarization**
  3. **Action Potential**
  4. **Repolarization**
  5. **Hyperpolarization**
  6. **Return to Resting Potential**

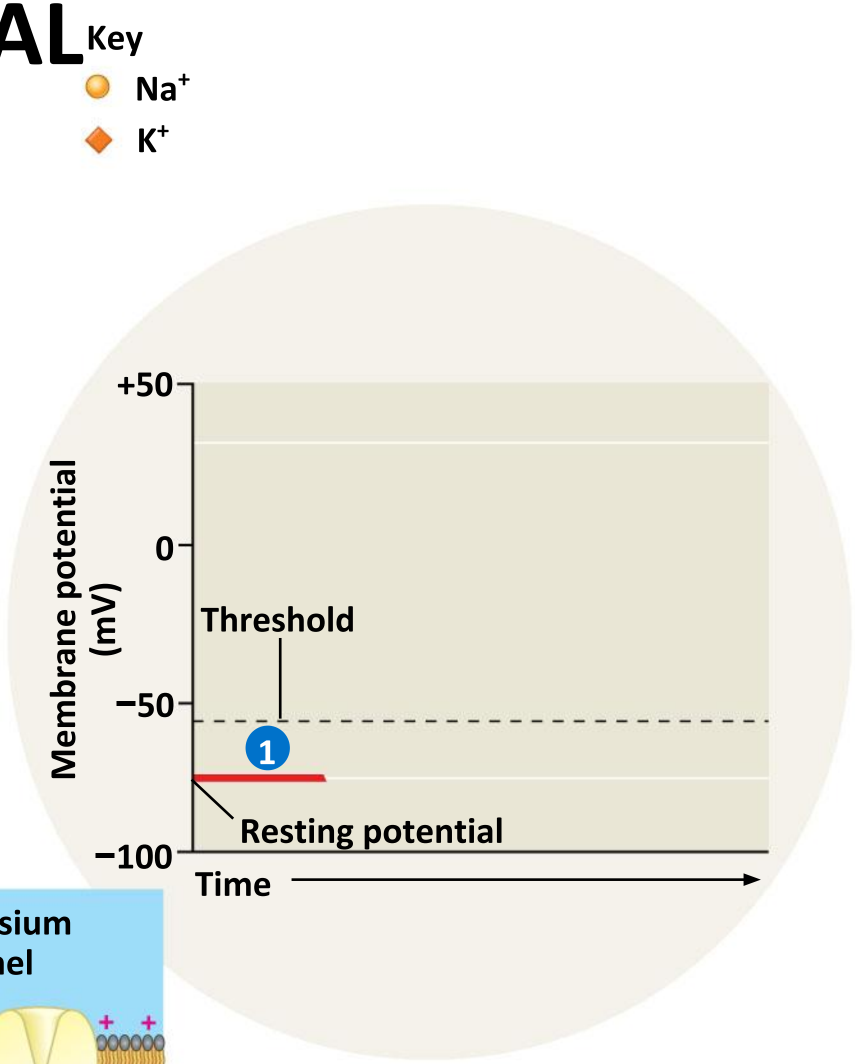


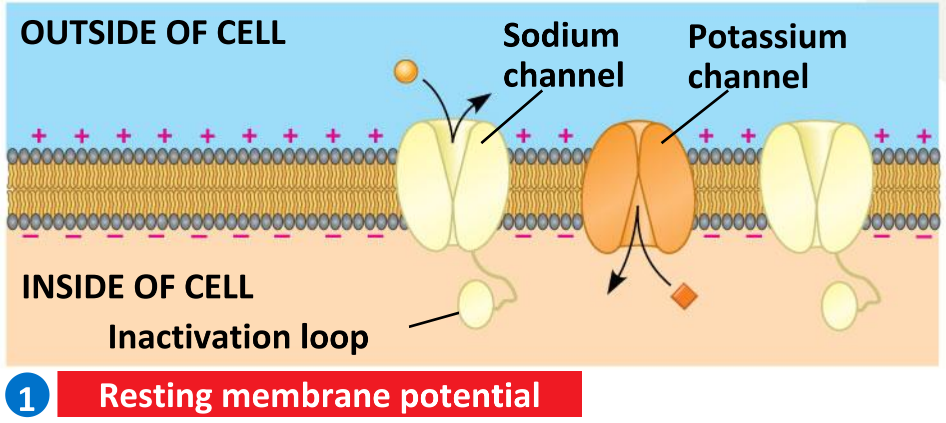
Voltage-gated K⁺ channels open
+30
+10
−10
−30
−50
−55
−70
−90
Membrane potential (mV)
Voltage-gated Na⁺ channels start to close
Depolarization
Repolarization
Voltage-gated K⁺ channels start to close
Increasing number of voltage-gated Na⁺ channels open
Threshold potential
Resting membrane potential
Hyperpolarization
Sub-threshold stimulus
Threshold stimulus
0
1
2
3
4
5
6
7
Time (ms)

1. RESTING MEMBRANE POTENTIAL

- When the membrane is at rest there are more negative charges inside the cell relative to outside the cell, resulting in a negative membrane potential.

- Resting potential = -70 mV





2. DEPOLARIZATION

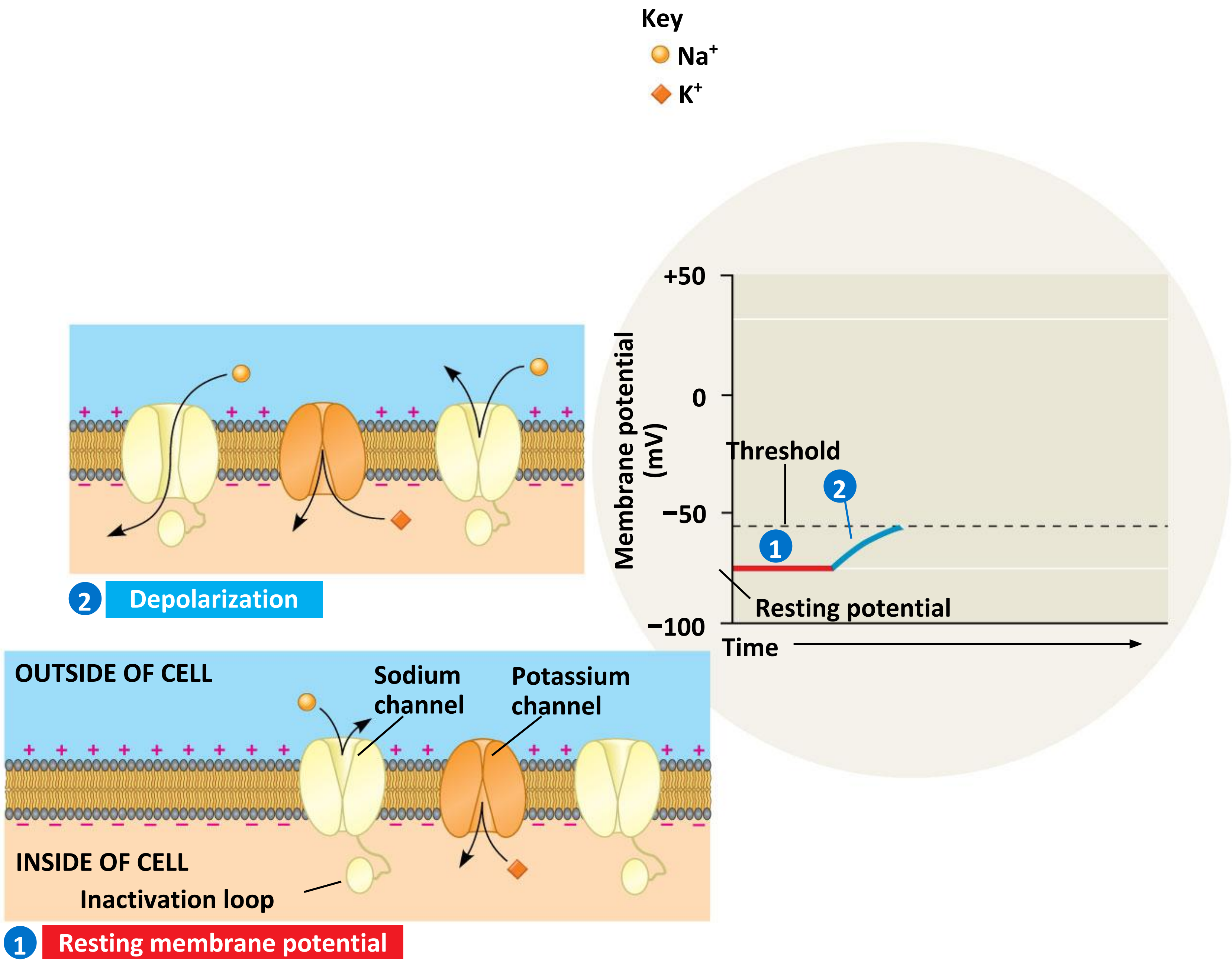
- When a neuron receives a stimulus, **positive charged ions flow into the cell body.**

- The positive ions cause **the membrane potential to depolarize.**

- **If the membrane potential reaches -55 mV, the voltage-gated Na^+ channels will open.**

- This potential is the **threshold** that initiates the **action potential**.

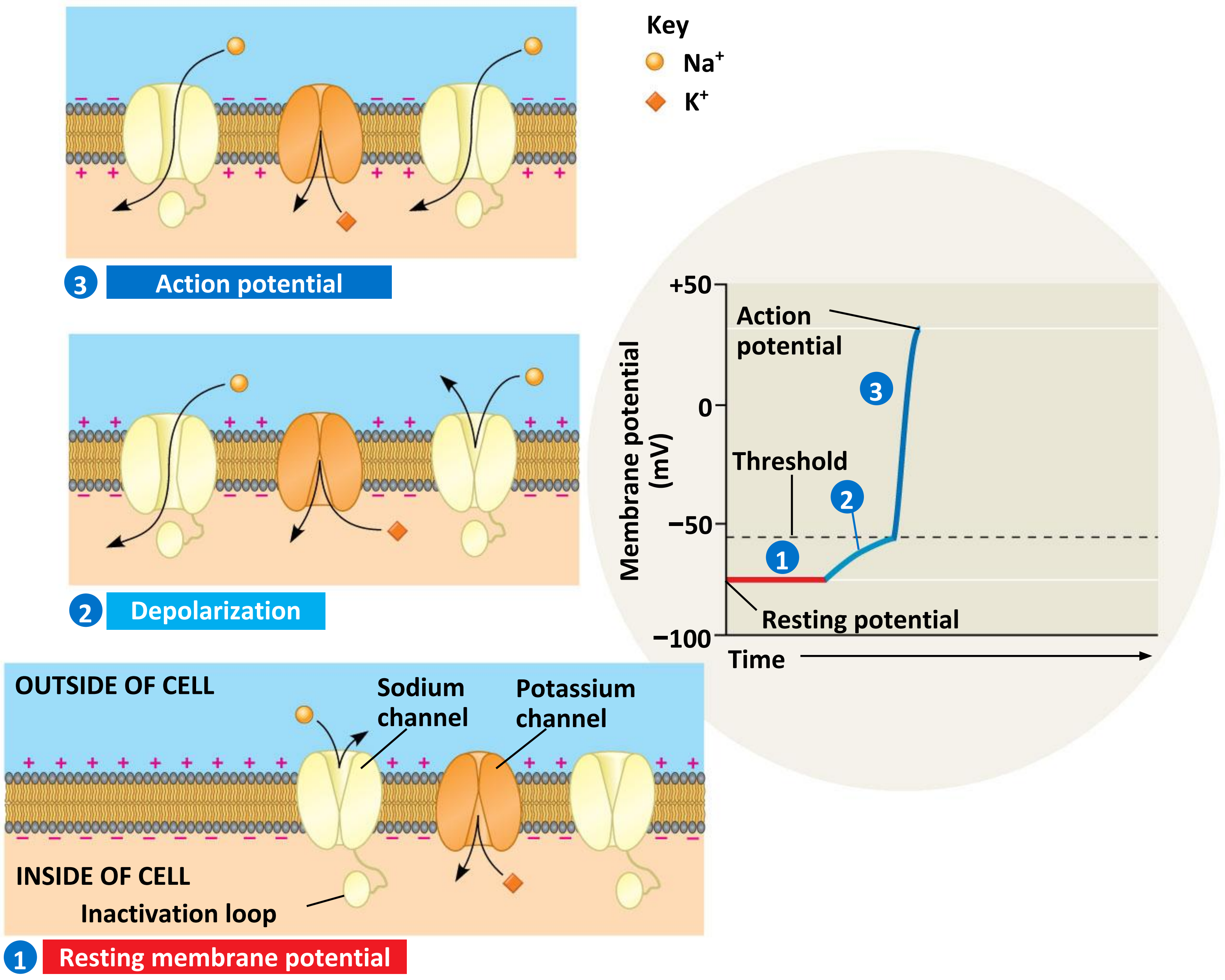
- An action potential is an **all-or-none response.**


Key
Na+
K+
+50
0
−50
−100
Membrane potential (mV)
Threshold
Resting potential
Time
1
2
2 Depolarization
OUTSIDE OF CELL
Sodium channel
Potassium channel
INSIDE OF CELL
Inactivation loop
1 Resting membrane potential

3. ACTION POTENTIAL

- Once the threshold has been reached, **the voltage-gated Na^+ channels open and Na^+ ions flow into the cell along their concentration gradient toward the negative interior of the cell.**

- **This flow of positive ions causes the inside of the cell to become more and more positive.**



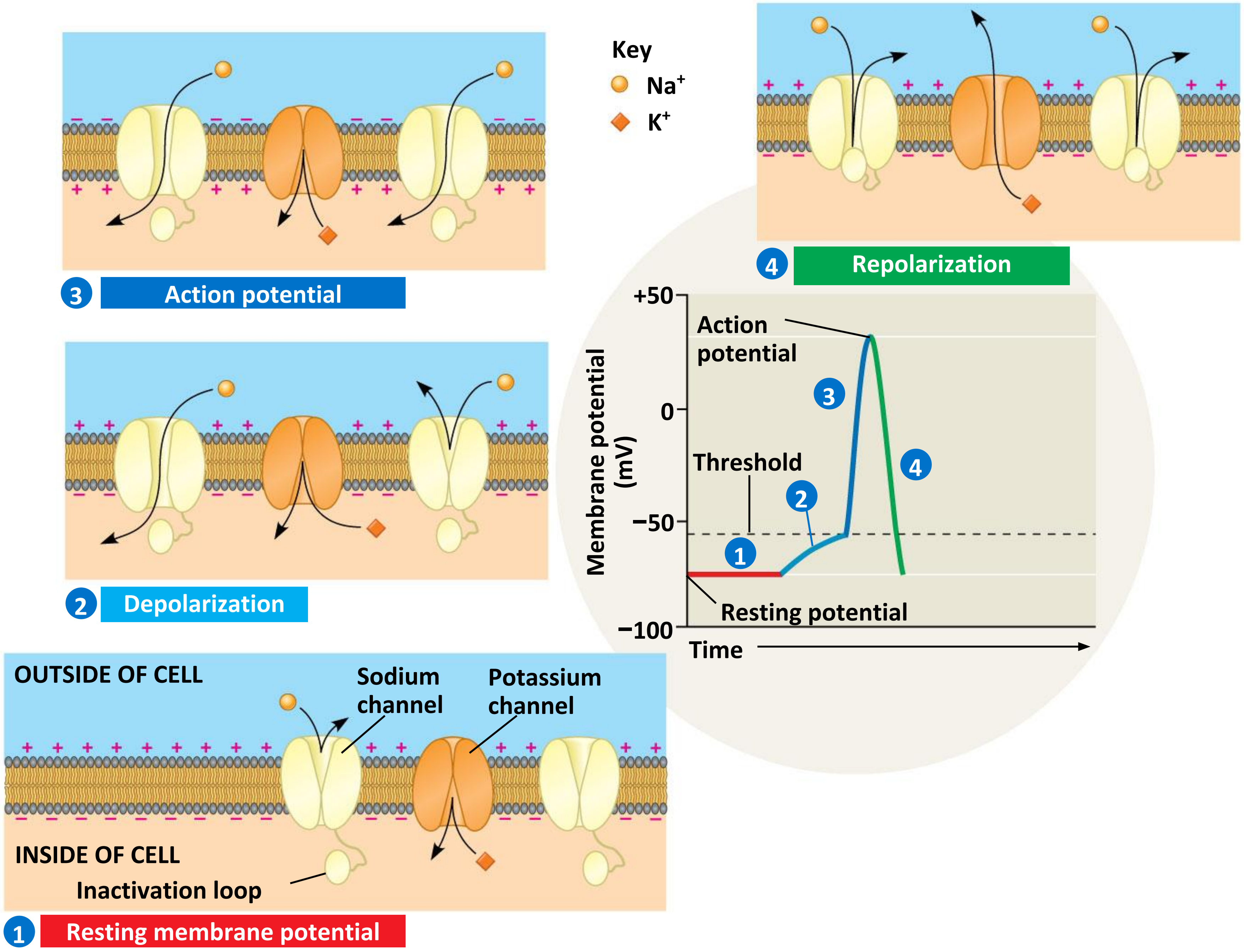
Key
Na+
K+
3 Action potential
2 Depolarization
OUTSIDE OF CELL
Sodium channel
Potassium channel
INSIDE OF CELL
Inactivation loop
1 Resting membrane potential
+50
0
−50
−100
Membrane potential (mV)
Action potential
Threshold
Resting potential
Time

4. REPOLARIZATION

- **At +40 mV, voltage-gated K^+ channels open and Na^+ channels close.**

- **K^+ ions will flow out of the cell along their concentration gradient and are pushed away from the positive interior of the cell.**

- **This flow of positive ions causes the inside of the cell to repolarize and become negative.**

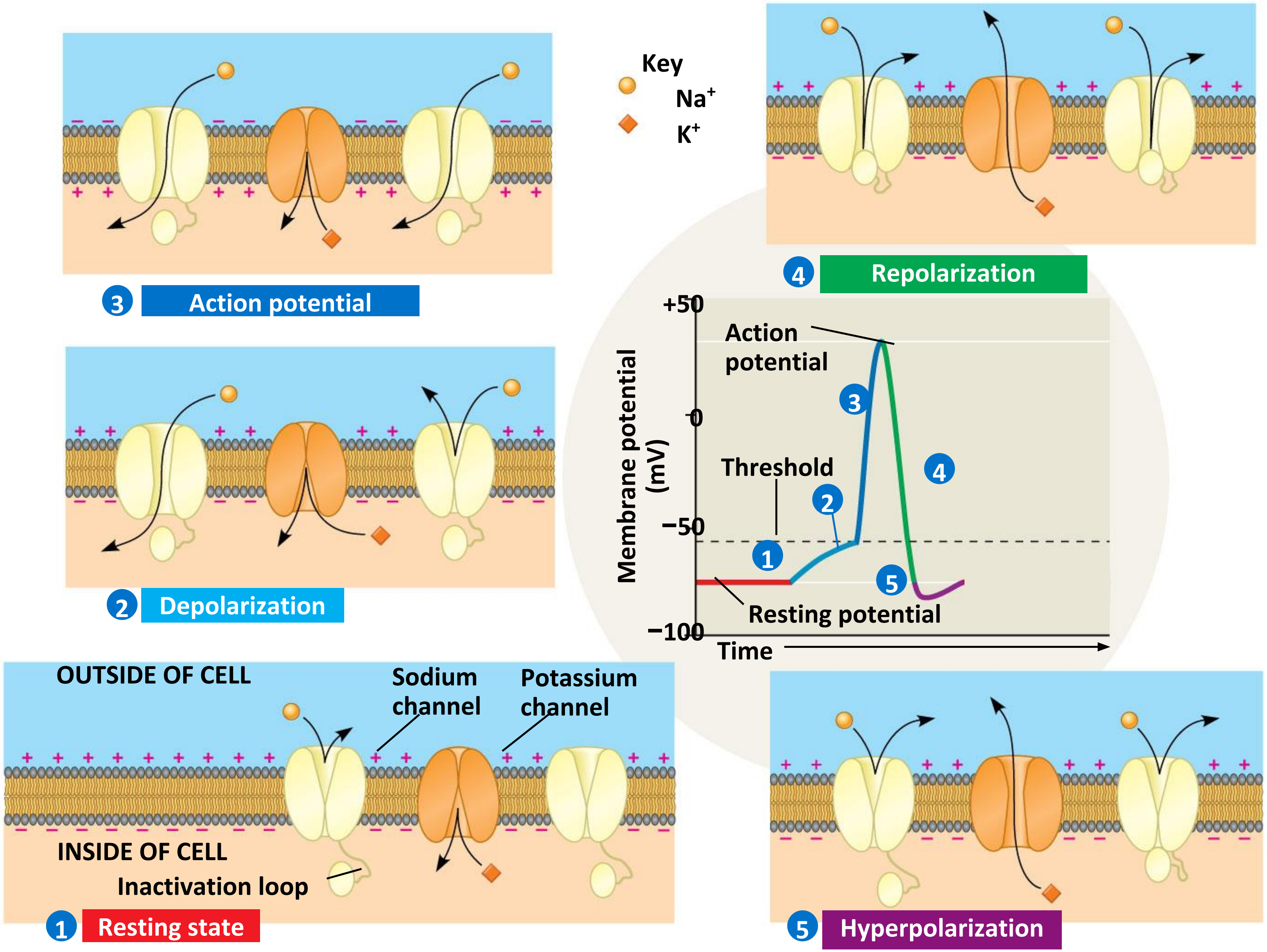


Key
Na+
K+
3 Action potential
2 Depolarization
4 Repolarization
OUTSIDE OF CELL
Sodium channel
Potassium channel
INSIDE OF CELL
Inactivation loop
1 Resting membrane potential
Membrane potential (mV)
+50
0
−50
−100
Action potential
Threshold
Resting potential
Time
1
2
3
4

5. HYPERPOLARIZATION

- **The cell actually repolarizes below the resting potential to -90 mV.**

- **After hyperpolarization the voltage-gated K^+ channels close.**

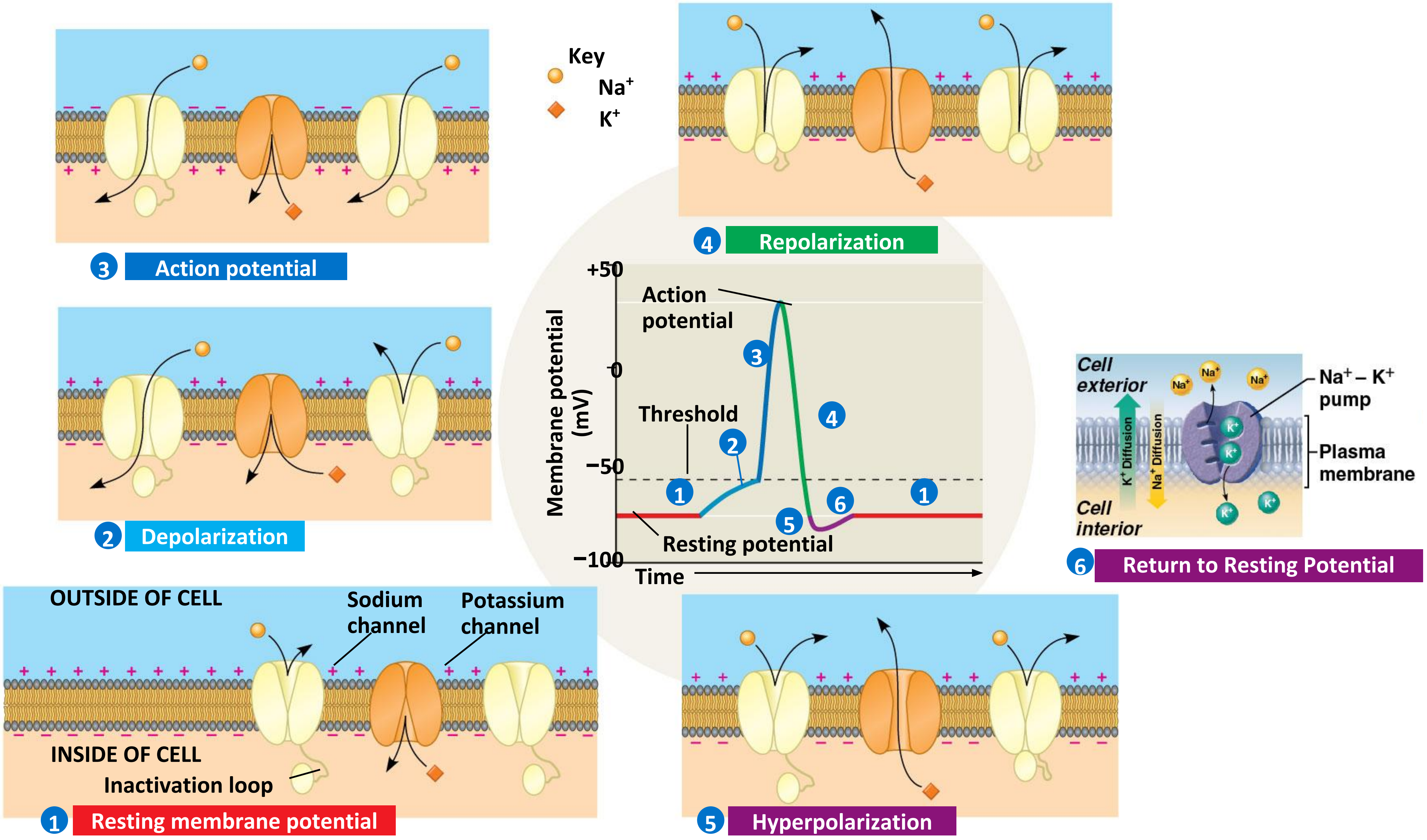


Key
Na+
K+
3 Action potential
2 Depolarization
4 Repolarization
5 Hyperpolarization
1 Resting state
OUTSIDE OF CELL
INSIDE OF CELL
Sodium channel
Potassium channel
Inactivation loop
Membrane potential (mV)
+50
0
−50
−100
Action potential
Threshold
Resting potential
Time
1
2
3
4
5

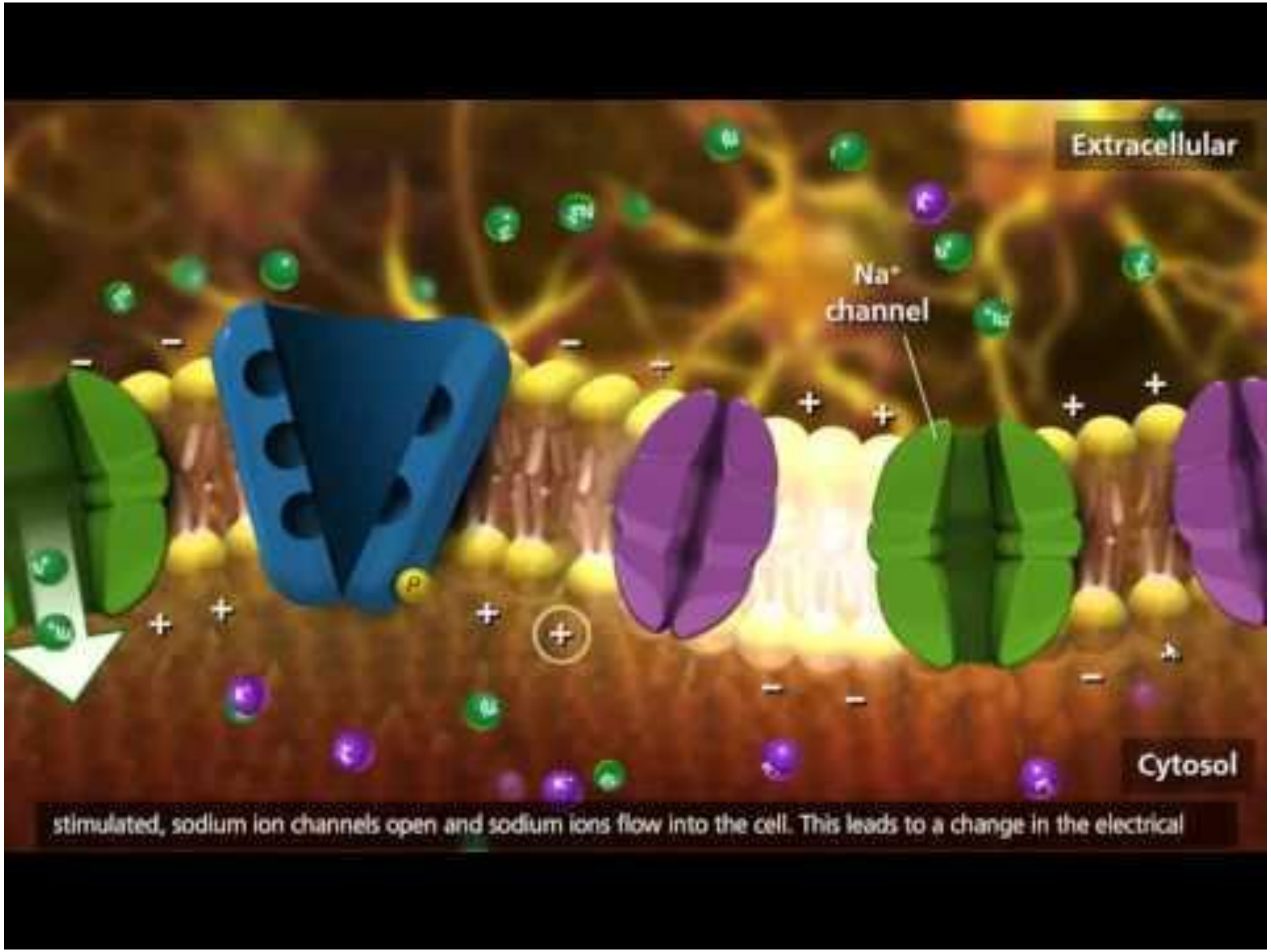
6. RETURN TO RESTING POTENTIAL

- **With both voltage-gated ion channels closed, the Na^+-K^+ pumps returns the axon to its resting membrane potential by pumping Na^+ ions out of the cell and K^+ ions into the cell.**

- **For every 3 Na^+ ions pumped out of the cell, 2 K^+ ions are pumped into the cell.**



Key
Na+
K+
3 Action potential
2 Depolarization
OUTSIDE OF CELL
Sodium channel
Potassium channel
INSIDE OF CELL
Inactivation loop
1 Resting membrane potential
4 Repolarization
+50
0
−50
−100
Membrane potential (mV)
Action potential
Threshold
Resting potential
Time
5 Hyperpolarization
Cell exterior
Cell interior
Na+ – K+ pump
Plasma membrane
K+ Diffusion
Na+ Diffusion
6 Return to Resting Potential


Extracellular
Na+ channel
Cytosol
stimulated, sodium ion channels open and sodium ions flow into the cell. This leads to a change in the electrical