Lecture 1

General physiology of the excitable tissues.

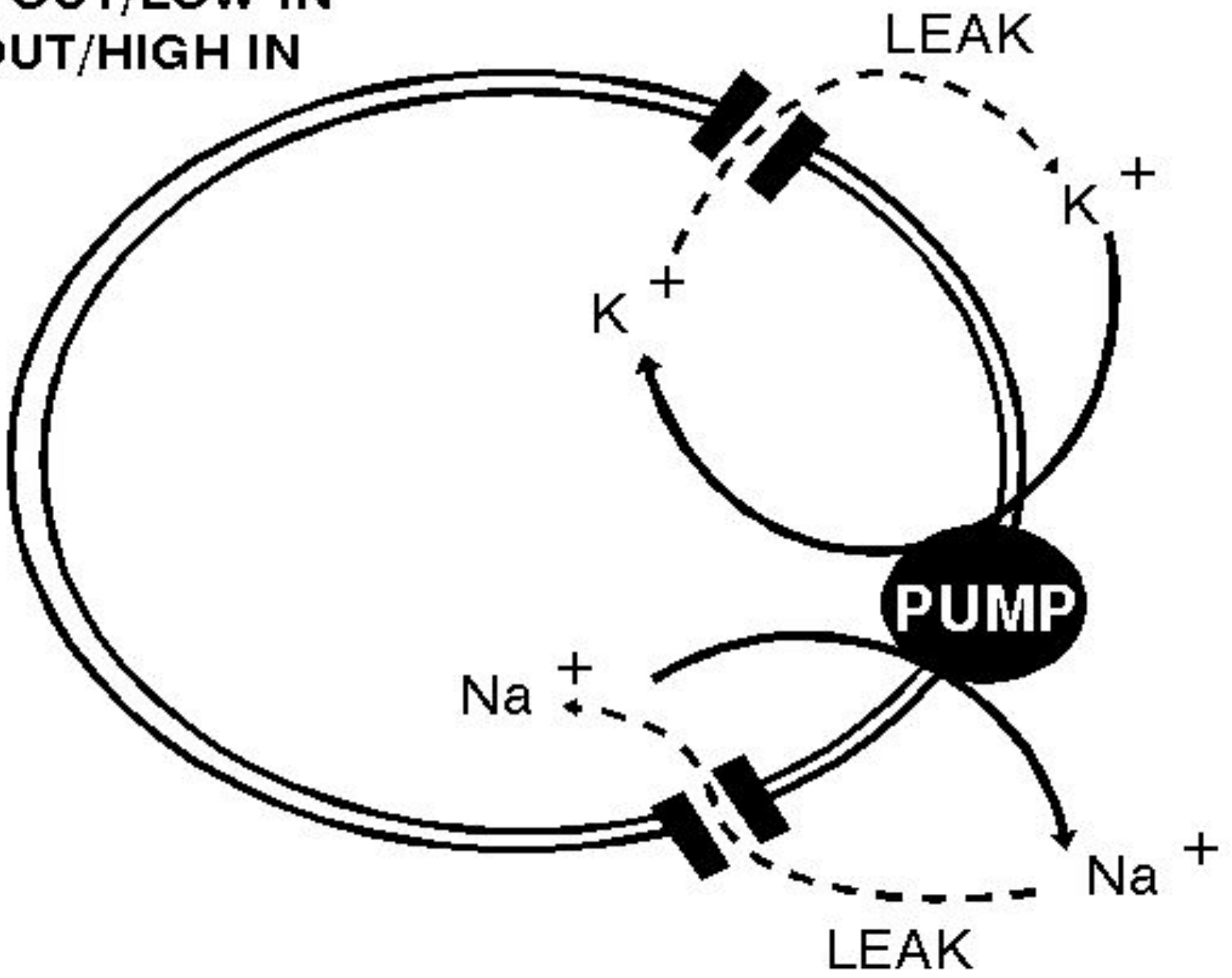
THE RESTING CELL

- HIGH POTASSIUM
- LOW SODIUM
- NA/K ATPASE PUMP
- RESTING POTENTIAL ABOUT 90 - 120 MV
- OSMOTICALLY BALANCED (CONSTANT VOLUME)

HOMEOSTATIC STEADY STATE OF RESTING CELL

Na-HIGH OUT/LOW IN

K-LOW OUT/HIGH IN



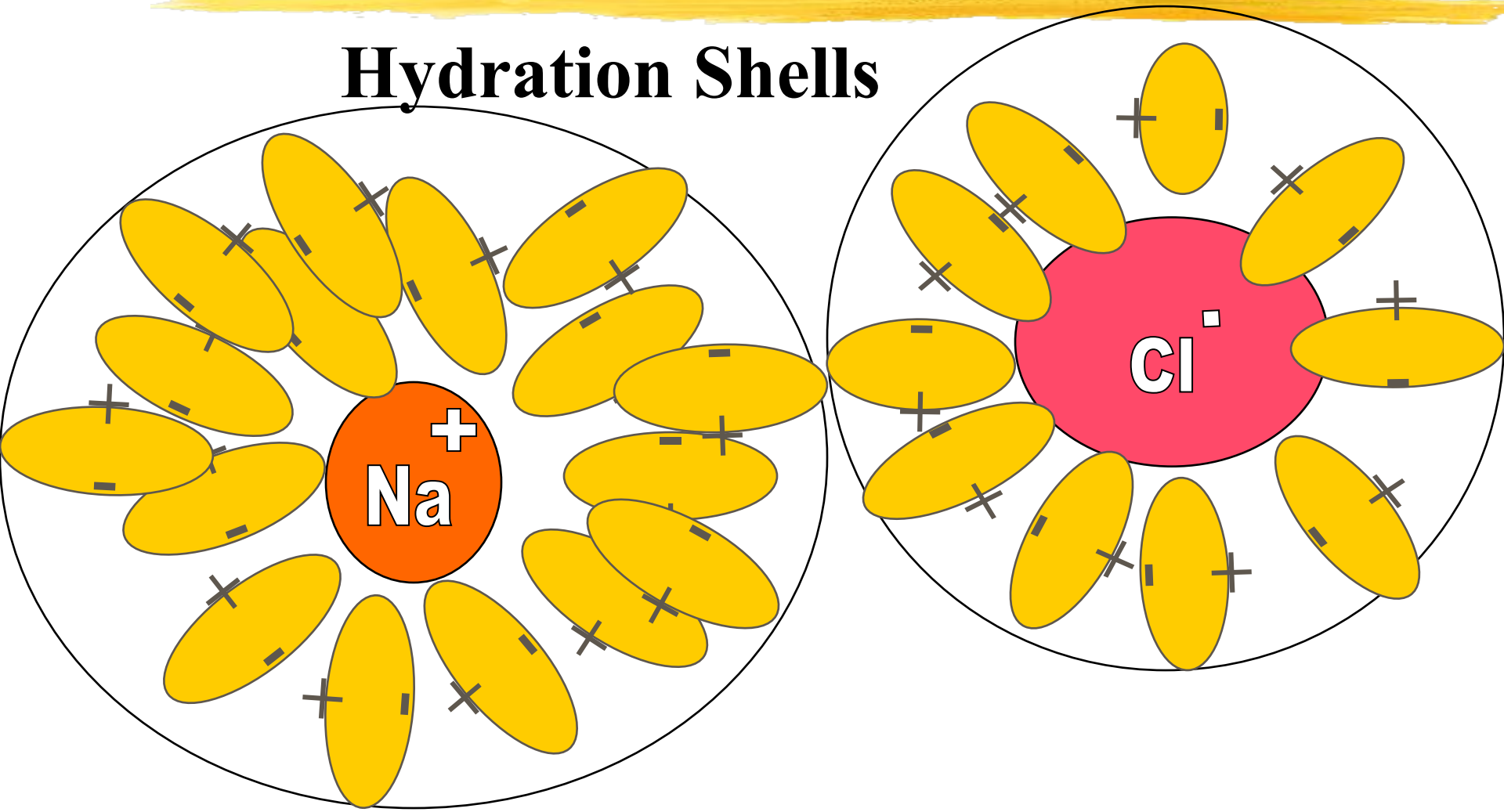
BIOELECTRICITY

THE ORIGIN OF THE MEMBRANE POTENTIAL

MOBILITY OF IONS DEPENDS ON HYDRATED SIZE

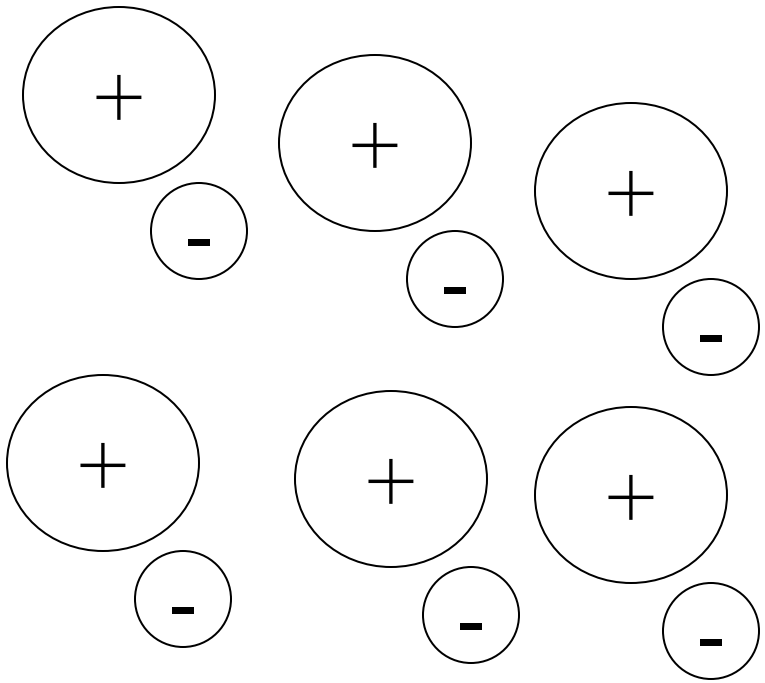
- IONS WITH SMALLER CRYSTAL RADIUS HAVE A HIGHER CHARGE DENSITY
- THE HIGHER CHARGE DENSITY ATTRACTS MORE WATER OF HYDRATION
- THUS THE SMALLER THE CRYSTAL RADIUS, THE LOWER THE MOBILITY IN WATER

IONS MOVE WITH THEIR HYDRATION SHELLS

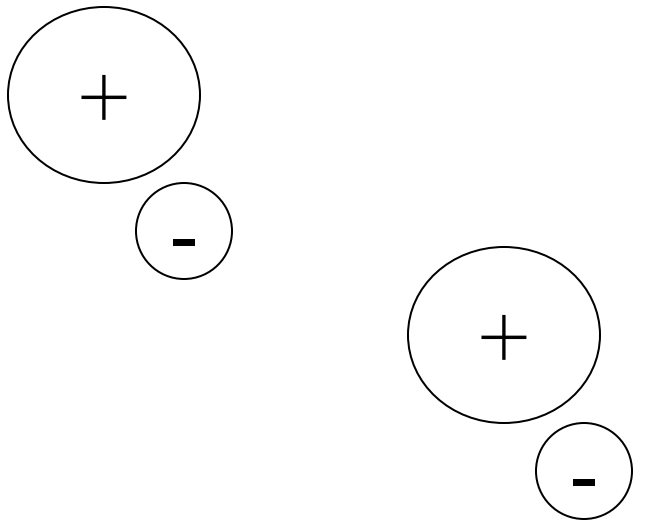


ELECTRONEUTRAL DIFFUSSION

HIGH SALT CONCEMTRATION

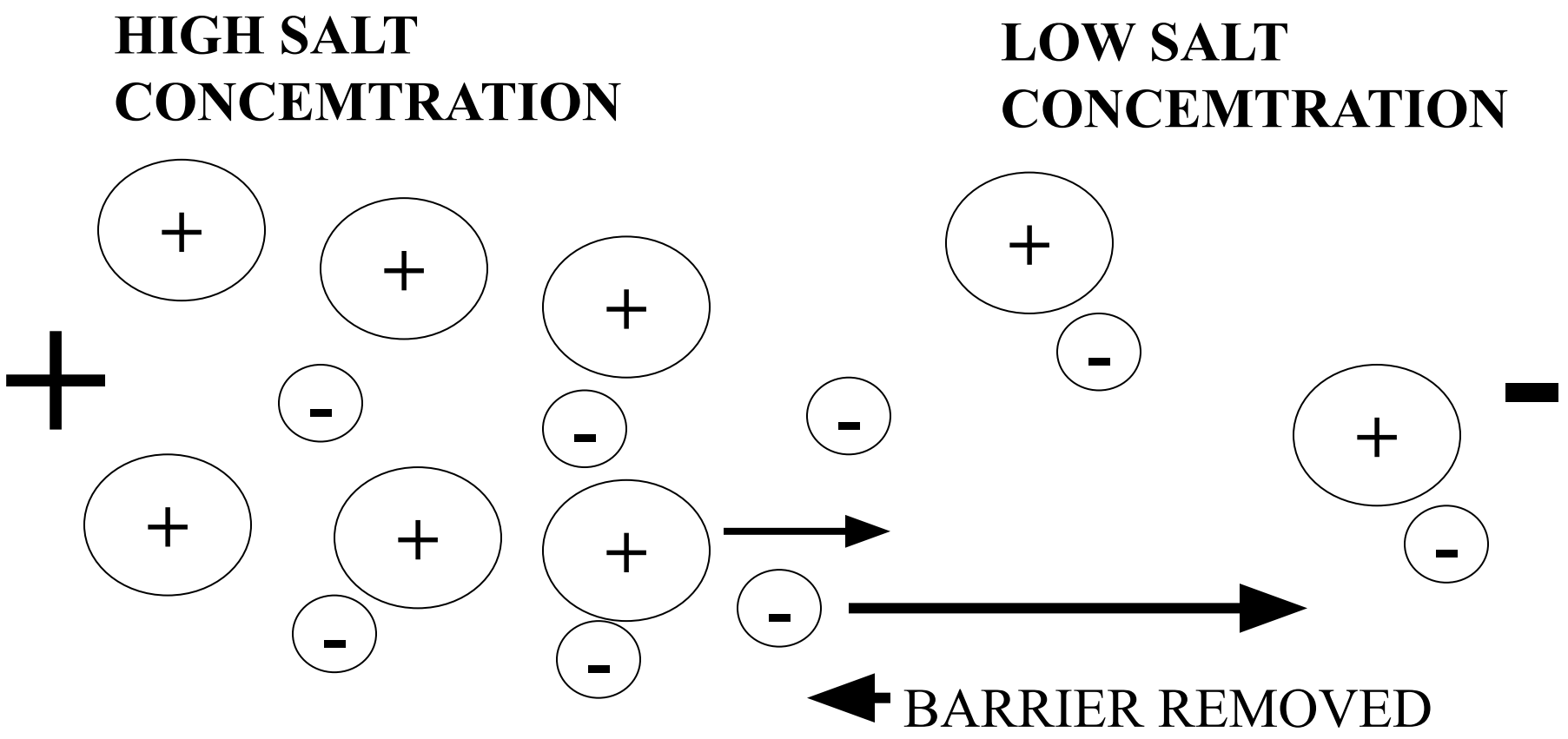


LOW SALT CONCEMTRATION



BARRIER SEPARATES THE TWO SOLUTIONS

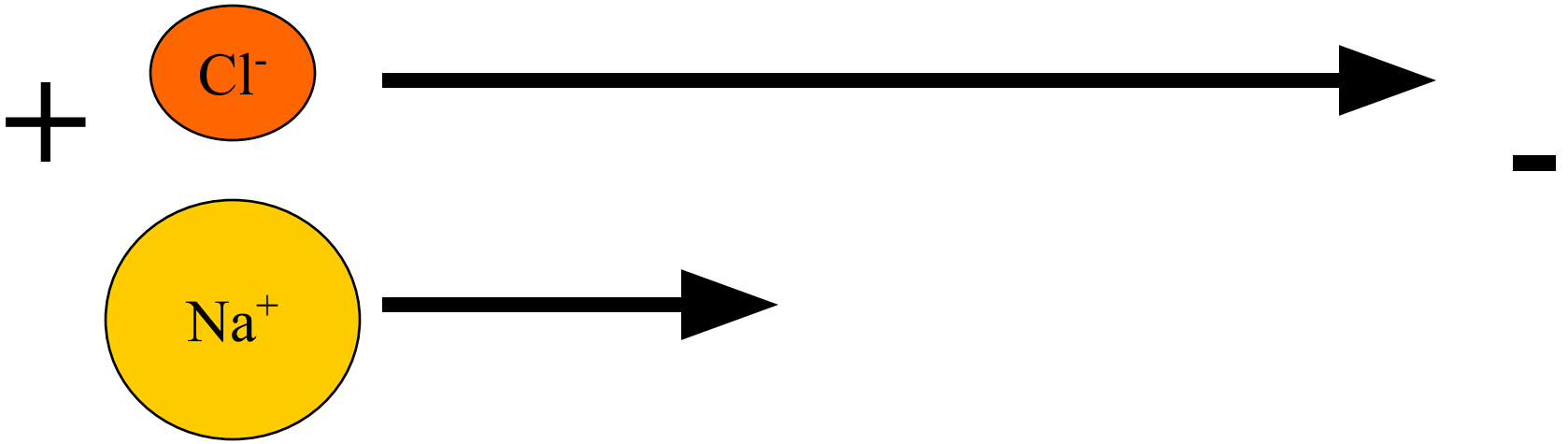
ELECTRONEUTRAL DIFFUSSION



CHARGE SEPARATION = ELECTRICAL POTENTIAL

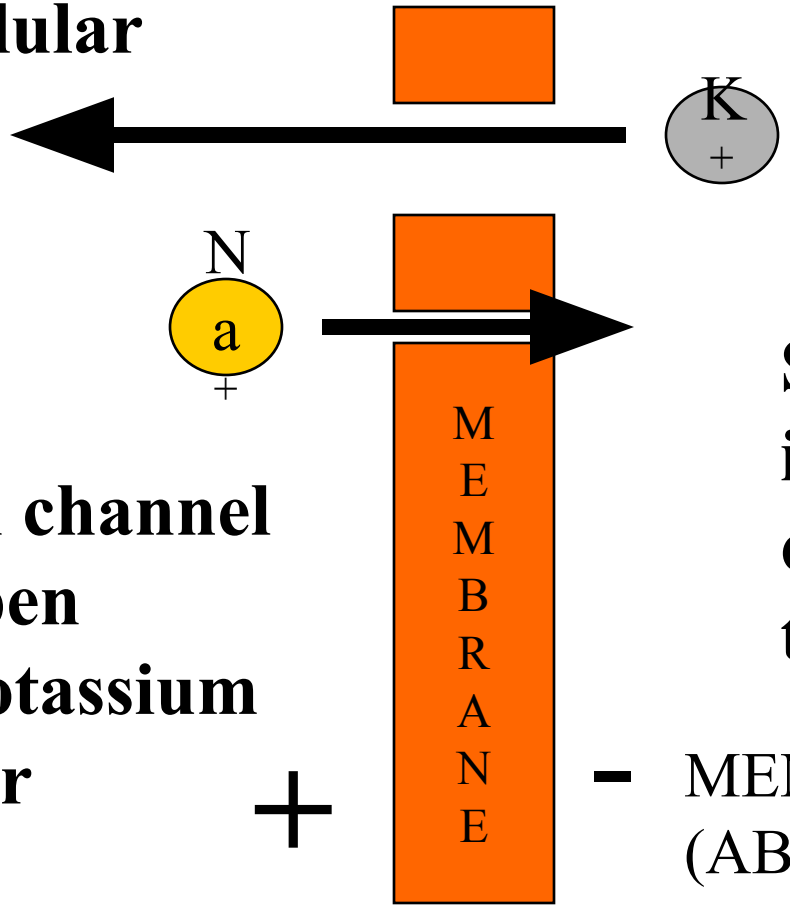
ELECTRICAL POTENTIAL=CHARGE SEPARATION

In water, without a membrane hydrated Chloride is smaller than hydrated Sodium, therefore faster:



The resulting separation of charge is called an ELECTRICAL POTENTIAL

THE MEMBRANE POTENTIAL



THE ORIGIN OF BIOELECTRICITY

- POTASSIUM CHANNELS ALLOW HIGH MOBILITY
- SODIUM CHANNELS LESS OPEN
- CHARGE SEPARATION OCCURS UNTIL BOTH MOVE AT SAME SPEED
- STEADY STEADY IS ACHIEVED WITH A CONSTANT MEMBRANE POTENTIAL

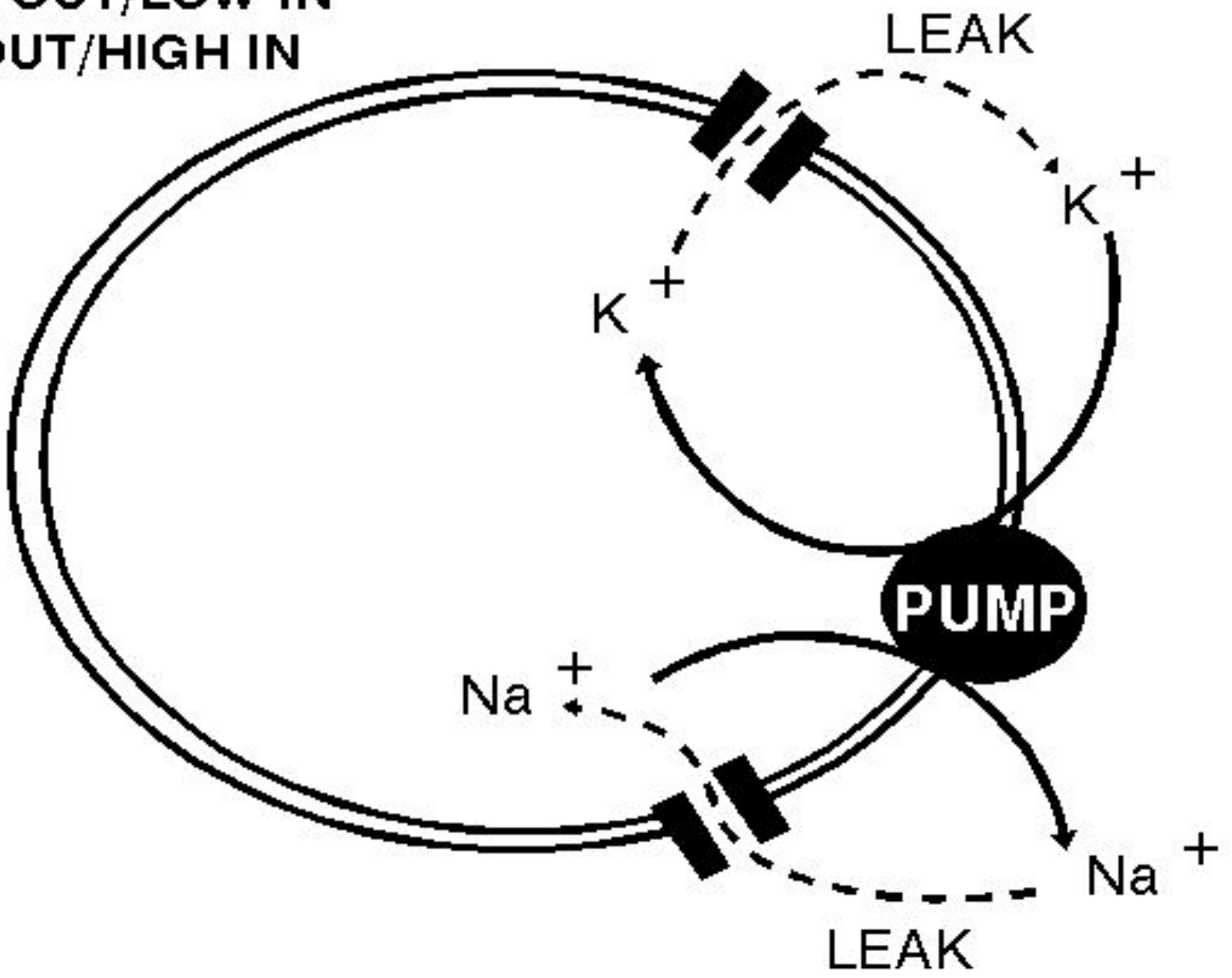
THE RESTING CELL

- HIGH POTASSIUM
- LOW SODIUM
- NA/K ATPASE PUMP
- RESTING POTENTIAL ABOUT 90 - 120 MV
- OSMOTICALLY BALANCED (CONSTANT VOLUME)

HOMEOSTATIC STEADY STATE OF RESTING CELL

Na-HIGH OUT/LOW IN

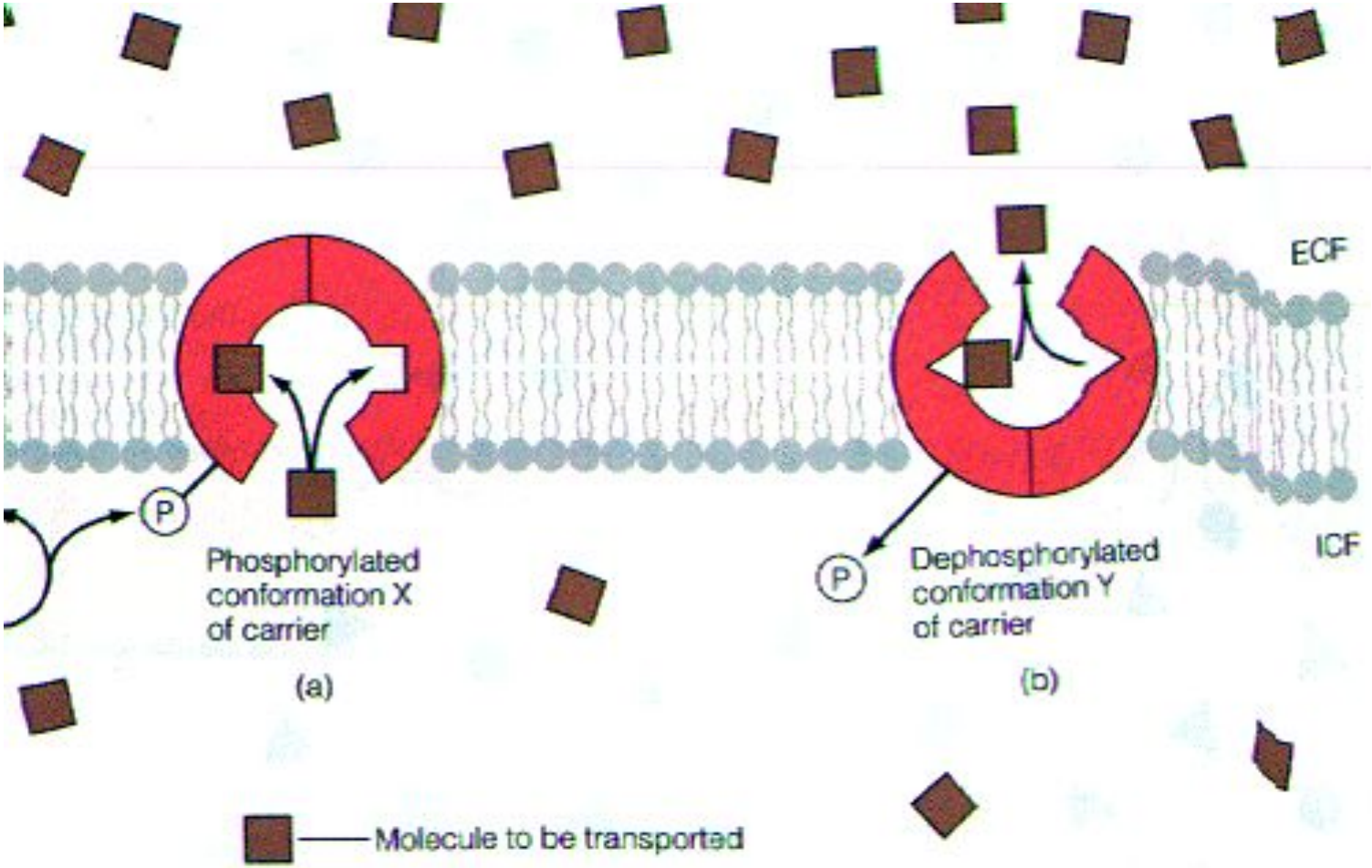
K-LOW OUT/HIGH IN



ACTIVE TRANSPORT

ADP

ATP



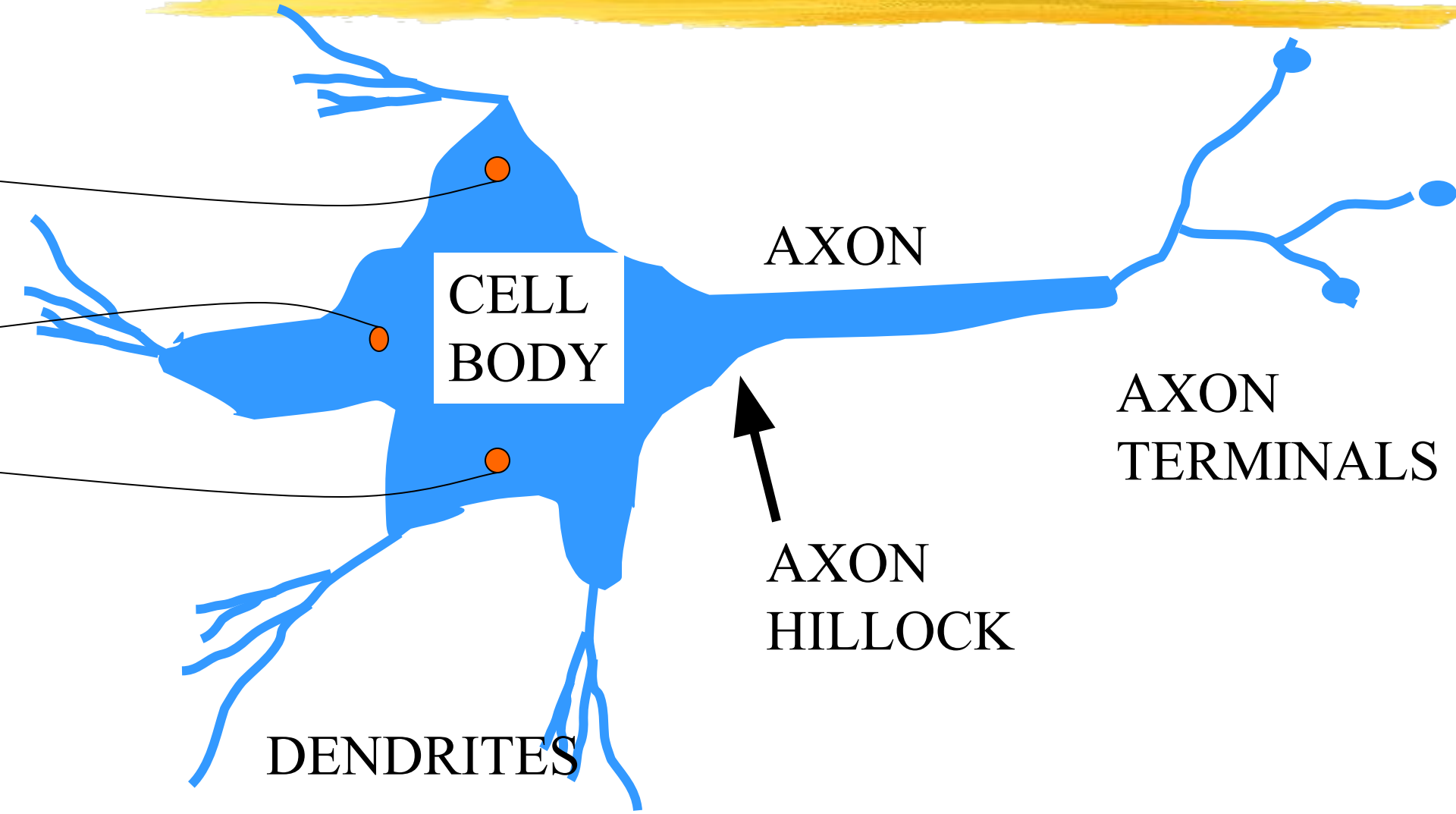
ACTIVE TRANSPORT REQUIRES AN INPUT OF ENERGY

- USUALLY IN THE FORM OF ATP
- ATPase IS INVOLVED
- SOME ASYMMETRY IS NECESSARY
- CAN PUMP UPHILL

EXCITABLE TISSUES

- NERVE AND MUSCLE
- VOLTAGE GATED CHANNELS
- DEPOLARIZATION LESS THAN THRESHOLD IS GRADED
- DEPOLARIZATION BEYOND THRESHOLD LEADS TO ACTION POTENTIAL
- ACTION POTENTIAL IS ALL OR NONE

THE NERVE CELL



EXCITABLE TISSUES:THE ACTION POTENTIAL

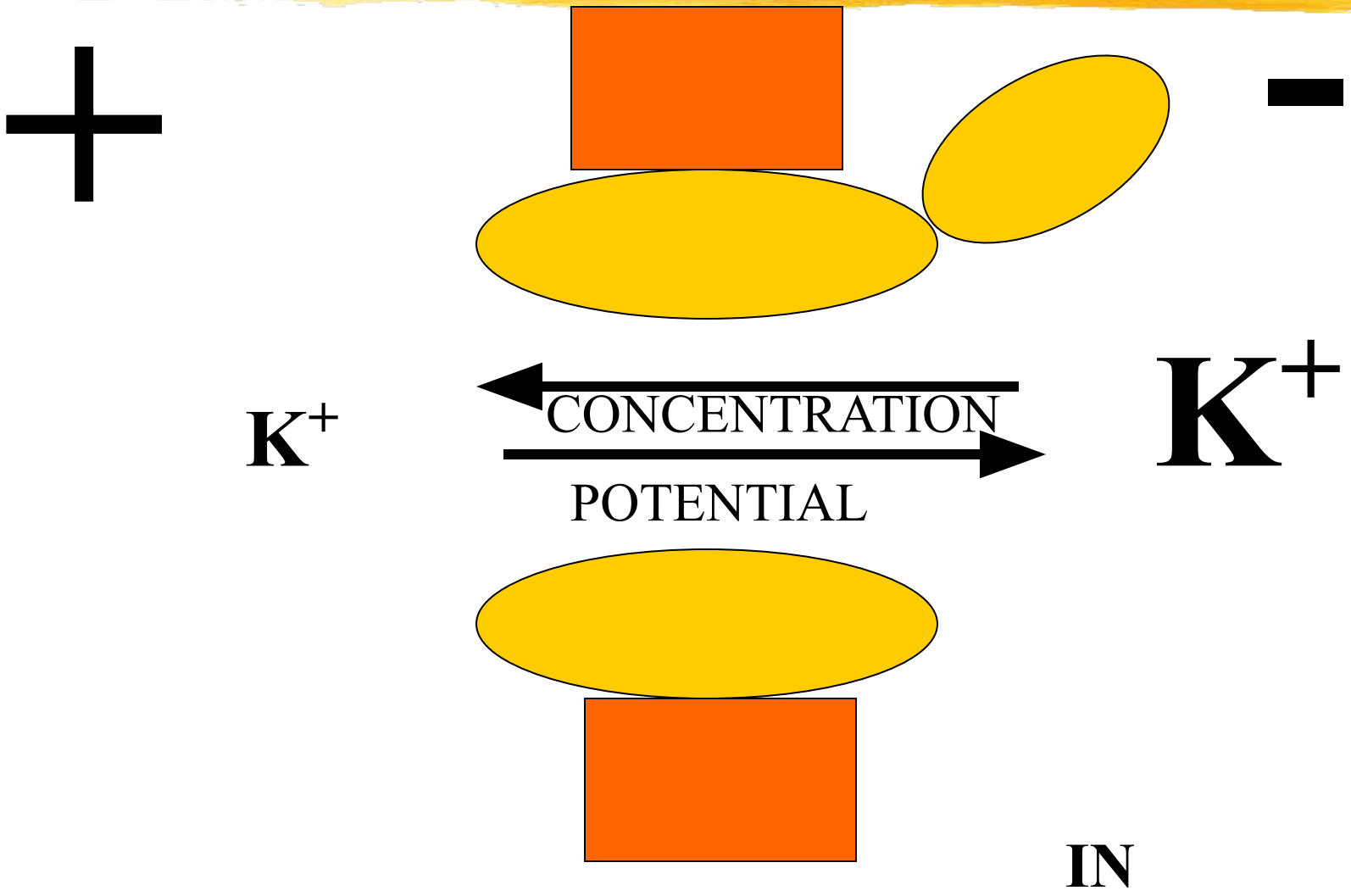
- THE MEMBRANE USES VOLTAGE GATED CHANNELS TO SWITCH FROM A POTASSIUM DOMINATED TO A SODIUM DOMINATED POTENTIAL
- IT THEN INACTIVATES AND RETURNS TO THE RESTING STATE
- THE RESPONSE IS "ALL OR NONE"

EQUILIBRIUM POTENTIALS FOR IONS

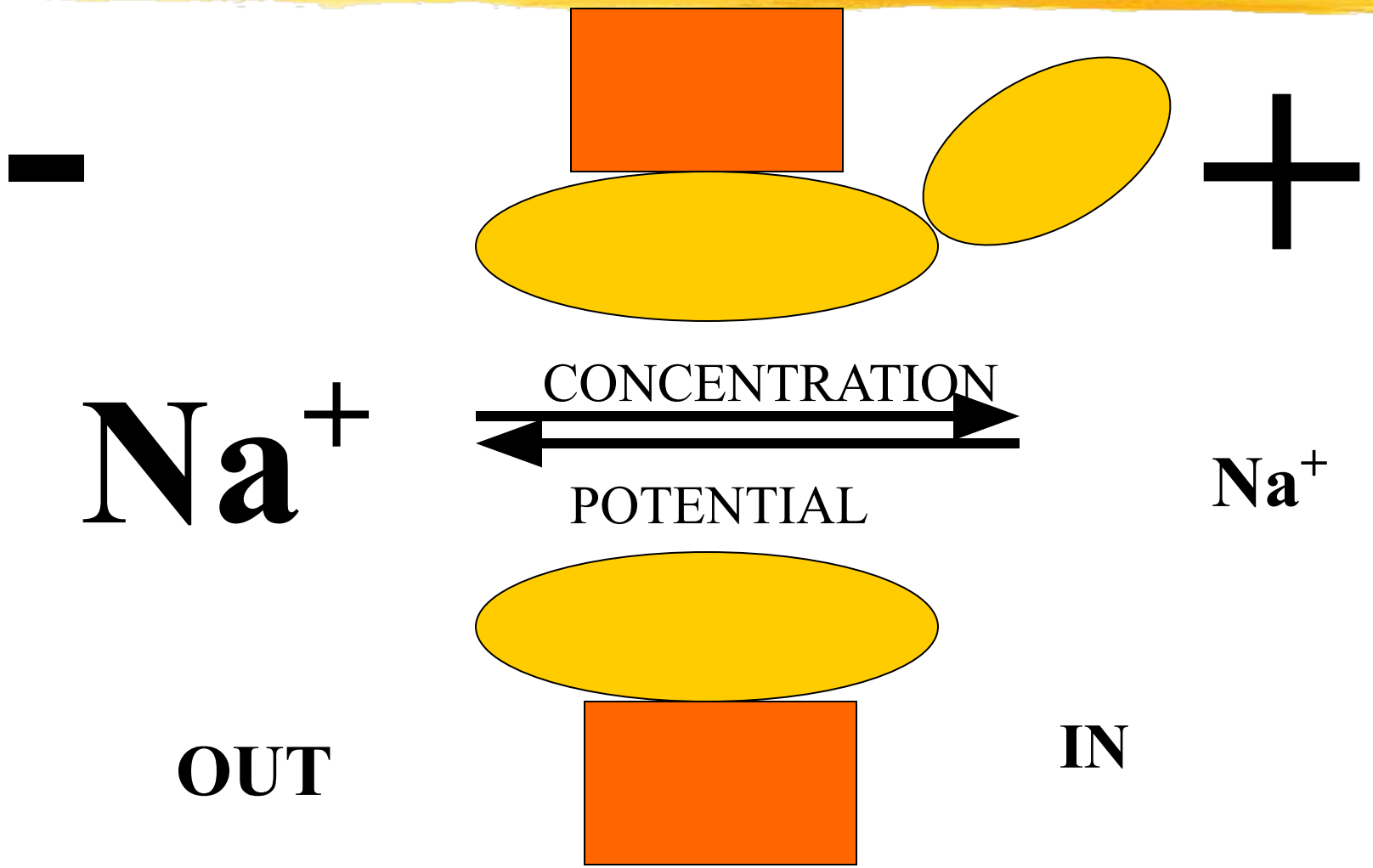
FOR EACH CONCENTRATION DIFFERENCE ACROSS THE MEMBRANE THERE IS AN ELECTRIC POTENTIAL DIFFERENCE WHICH WILL PRODUCE EQUILIBRIUM.

AT EQUILIBRIUM NO NET ION FLOW OCCURS

THE EQUILIBRIUM MEMBRANE POTENTIAL FOR POTASSIUM IS -90 mV



THE EQUILIBRIUM MEMBRANE POTENTIAL FOR SODIUM IS + 60 mV



THE RESTING POTENTIAL IS NEAR THE POTASSIUM EQUILIBRIUM POTENTIAL

- AT REST THE POTASSIUM CHANNELS ARE MORE OPEN AND THE POTASSIUM IONS MAKE THE INSIDE OF THE CELL NEGATIVE
- THE SODIUM CHANNELS ARE MORE CLOSED AND THE SODIUM MOVES SLOWER

EVENTS DURING EXCITATION

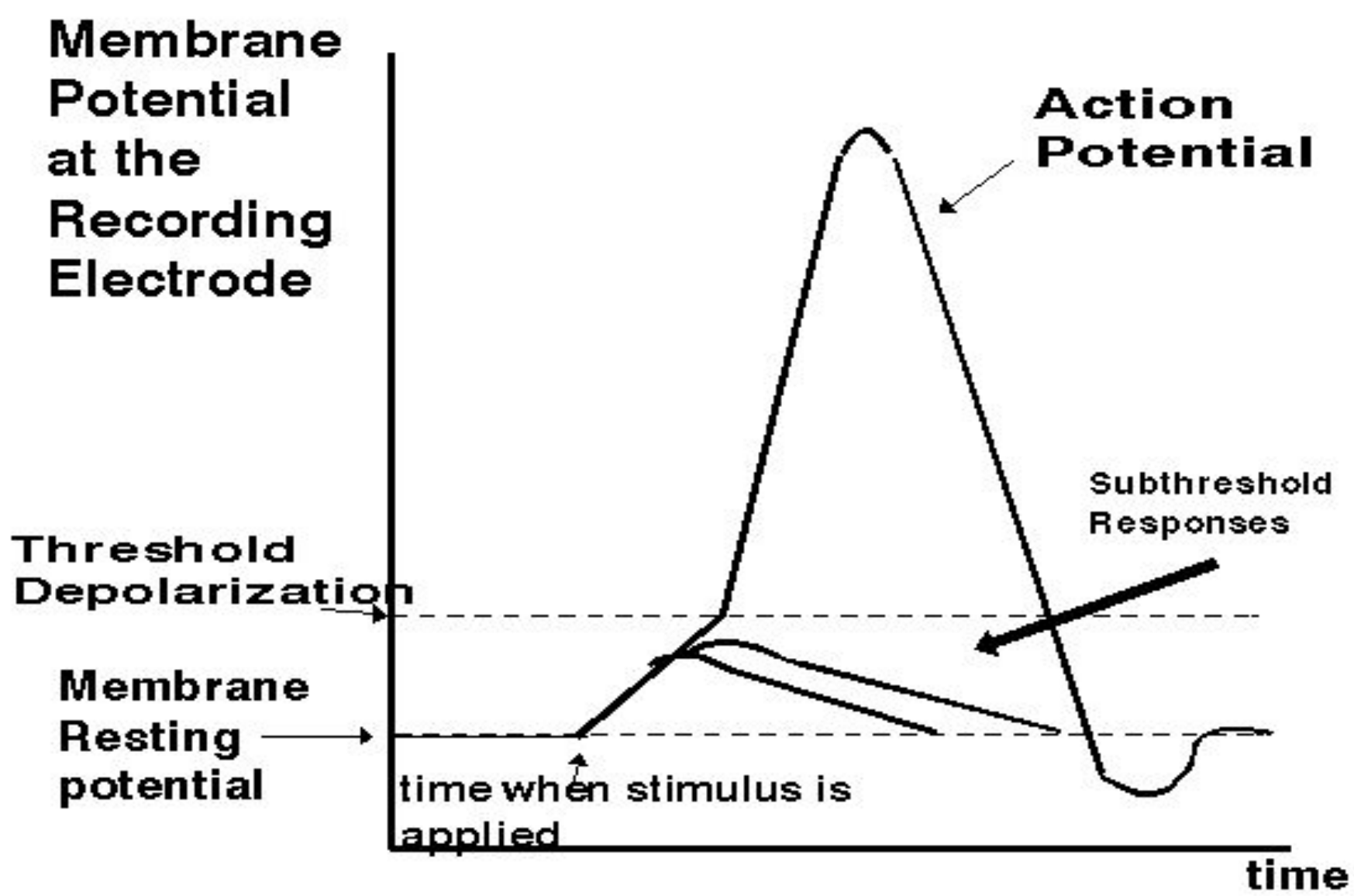
- DEPOLARIZATION EXCEEDS THRESHOLD
- SODIUM CHANNELS OPEN
- MEMBRANE POTENTIAL SHIFTS FROM POTASSIUM CONTROLLED (-90 MV) TO SODIUM CONTROLLED (+60 MV)
- AS MEMBRANE POTENTIAL REACHES THE SODIUM POTENTIAL, THE SODIUM CHANNELS CLOSE AND ARE INACTIVATED
- POTASSIUM CHANNELS OPEN TO REPOLARIZE THE MEMBRANE

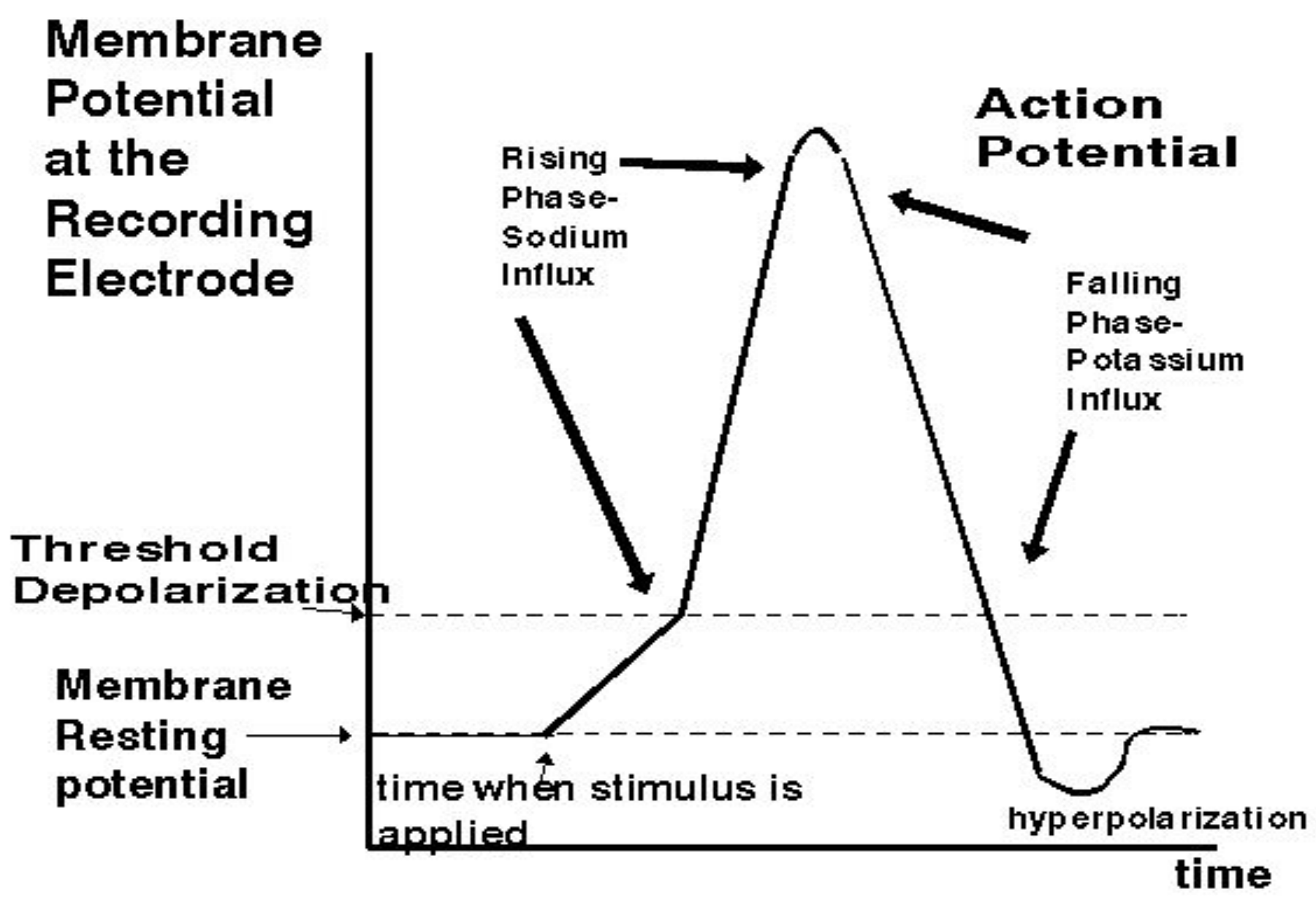
OPENING THE SODIUM CHANNELS ALLOWS SODIUM TO RUSH IN

- THE MEMBRANE DEPOLARIZES AND THEN THE MEMBRANE POTENTIAL APPROACHES THE SODIUM EQUILIBRIUM POTENTIAL
- THIS RADICAL CHANGE IN MEMBRANE POTENTIAL CAUSES THE SODIUM CHANNELS TO CLOSE (INACTIVATION) AND THE POTASSIUM CHANNELS TO OPEN REPOLARIZING THE MEMBRANE
- THERE IS A SLIGHT OVERSHOOT (HYPERPOLARIZATION) DUE TO THE POTASSIUM CHANNELS BEING MORE OPEN

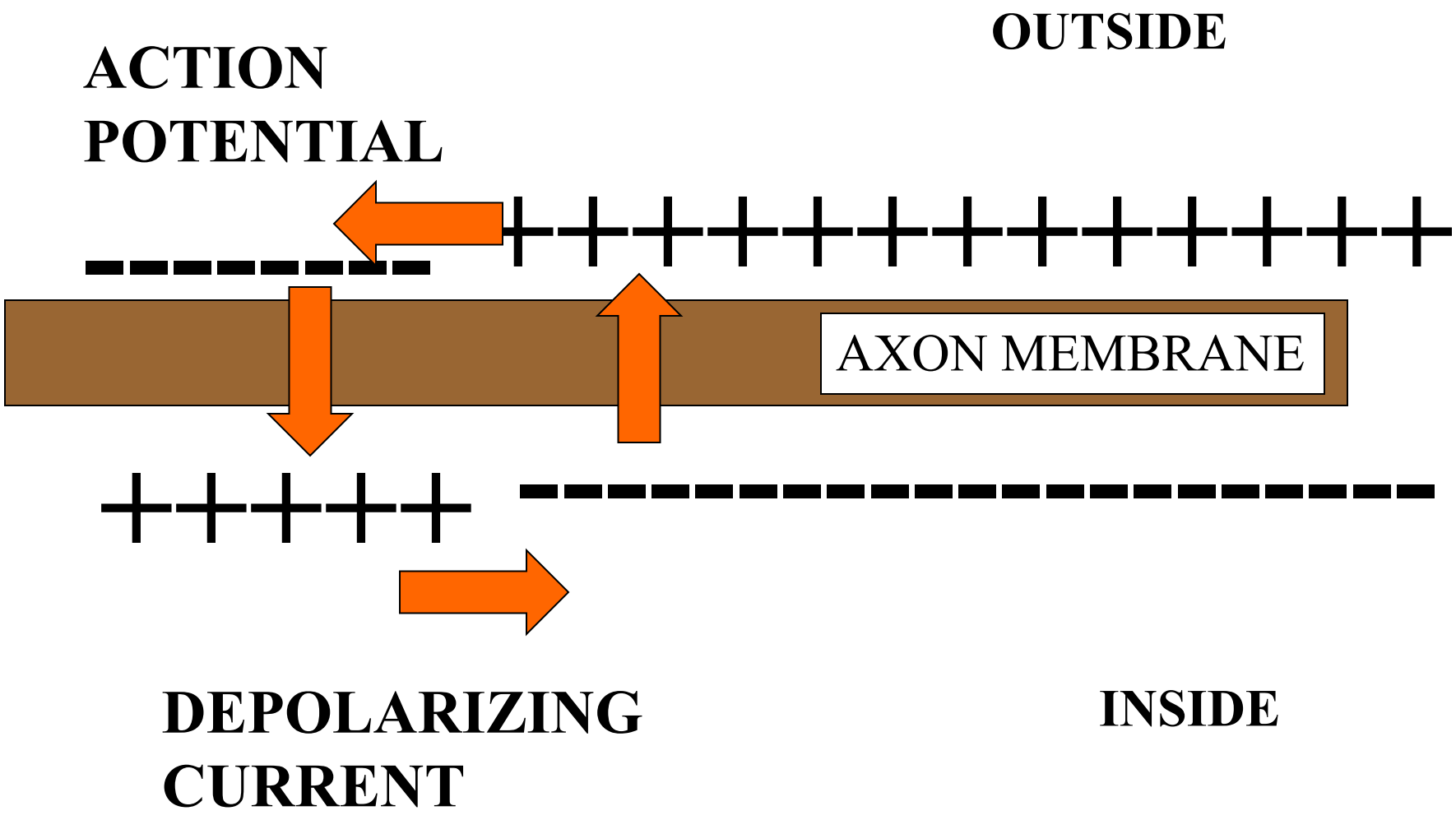
GRADED VS ALL OR NONE

- A RECEPTOR'S RESPONSE TO A STIMULUS IS GRADED
- IF THRESHOLD IS EXCEEDED, THE ACTION POTENTIAL RESULTING IS ALL OR NONE

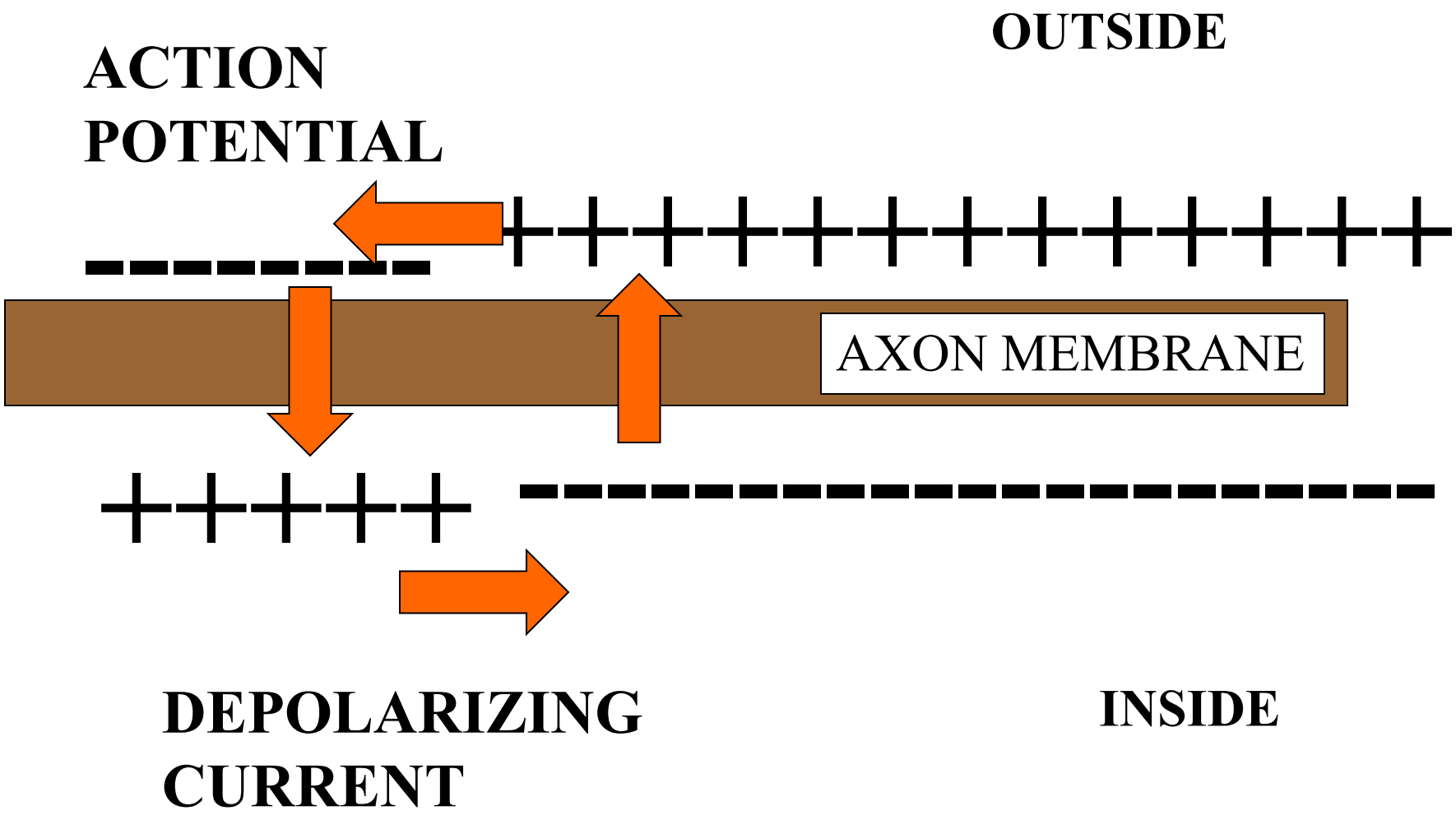

Membrane Potential at the Recording Electrode
Action Potential
Subthreshold Responses
Threshold Depolarization
Membrane Resting potential
time when stimulus is applied
time


Membrane Potential at the Recording Electrode
Action Potential
Rising Phase- Sodium Influx
Falling Phase- Potassium Influx
Threshold Depolarization
Membrane Resting potential
time when stimulus is applied
hyperpolarization
time

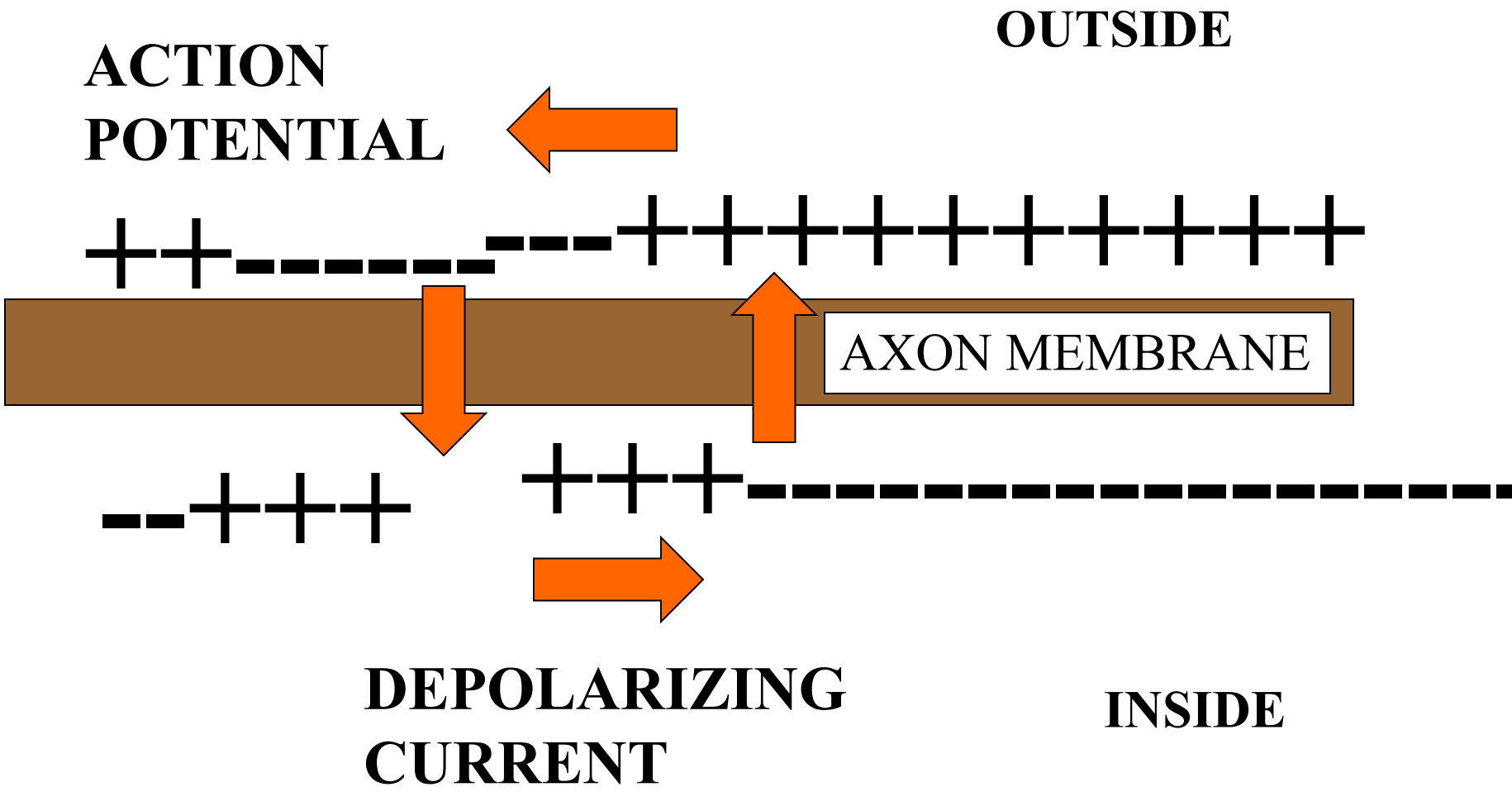
PROPAGATION OF THE ACTION POTENTIAL



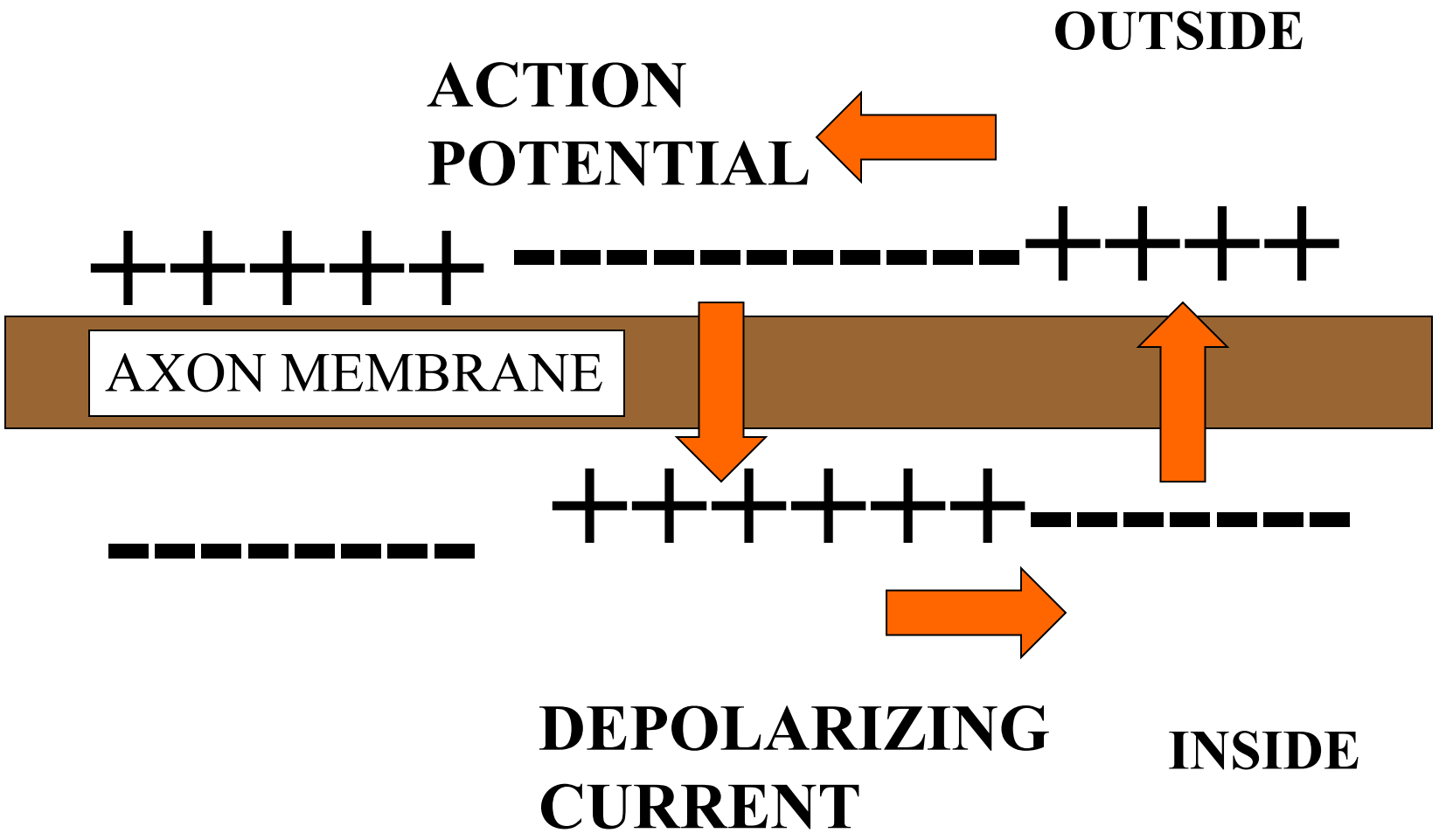
PROPAGATION OF THE ACTION POTENTIAL



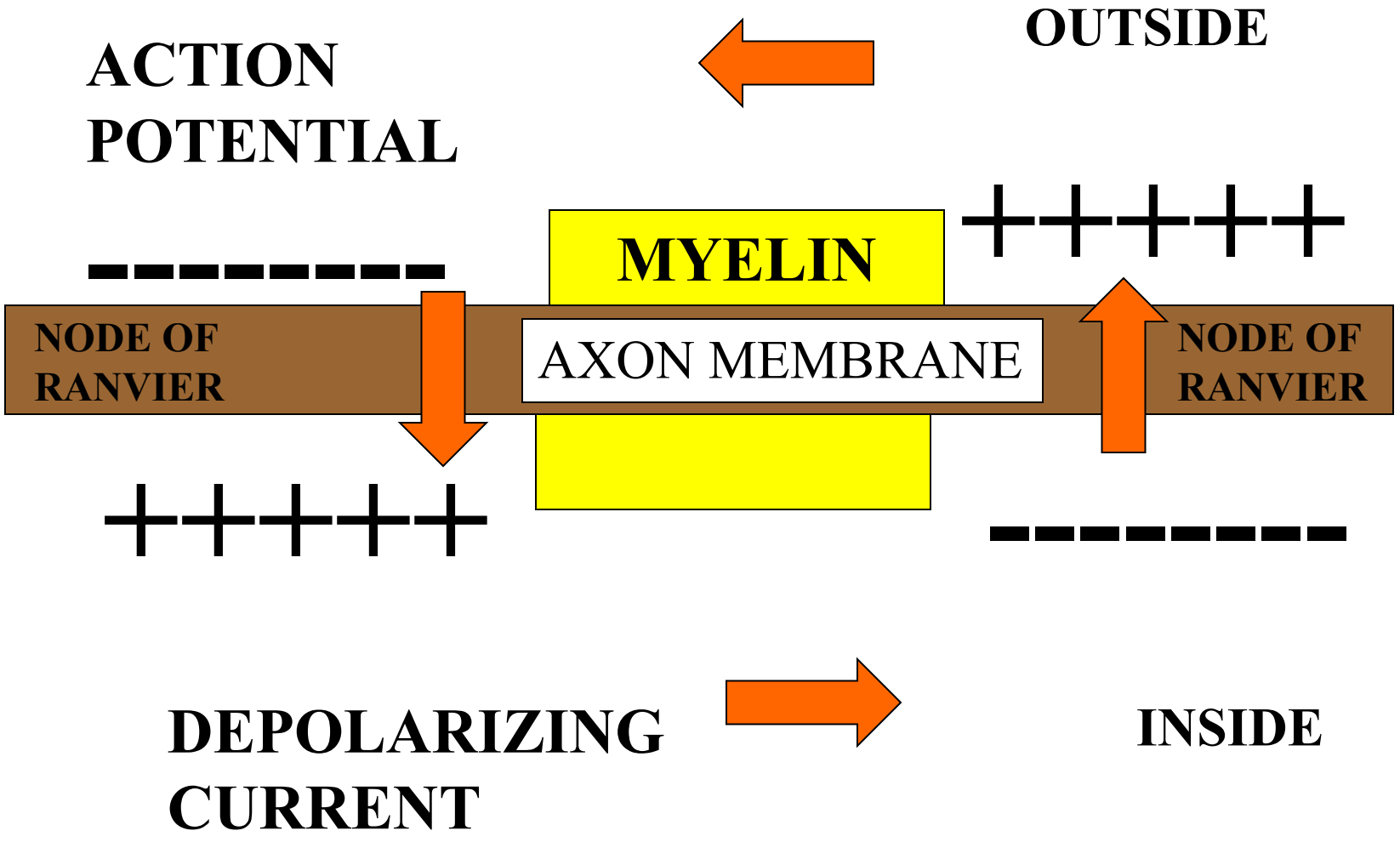
PROPAGATION OF THE ACTION POTENTIAL



PROPAGATION OF THE ACTION POTENTIAL

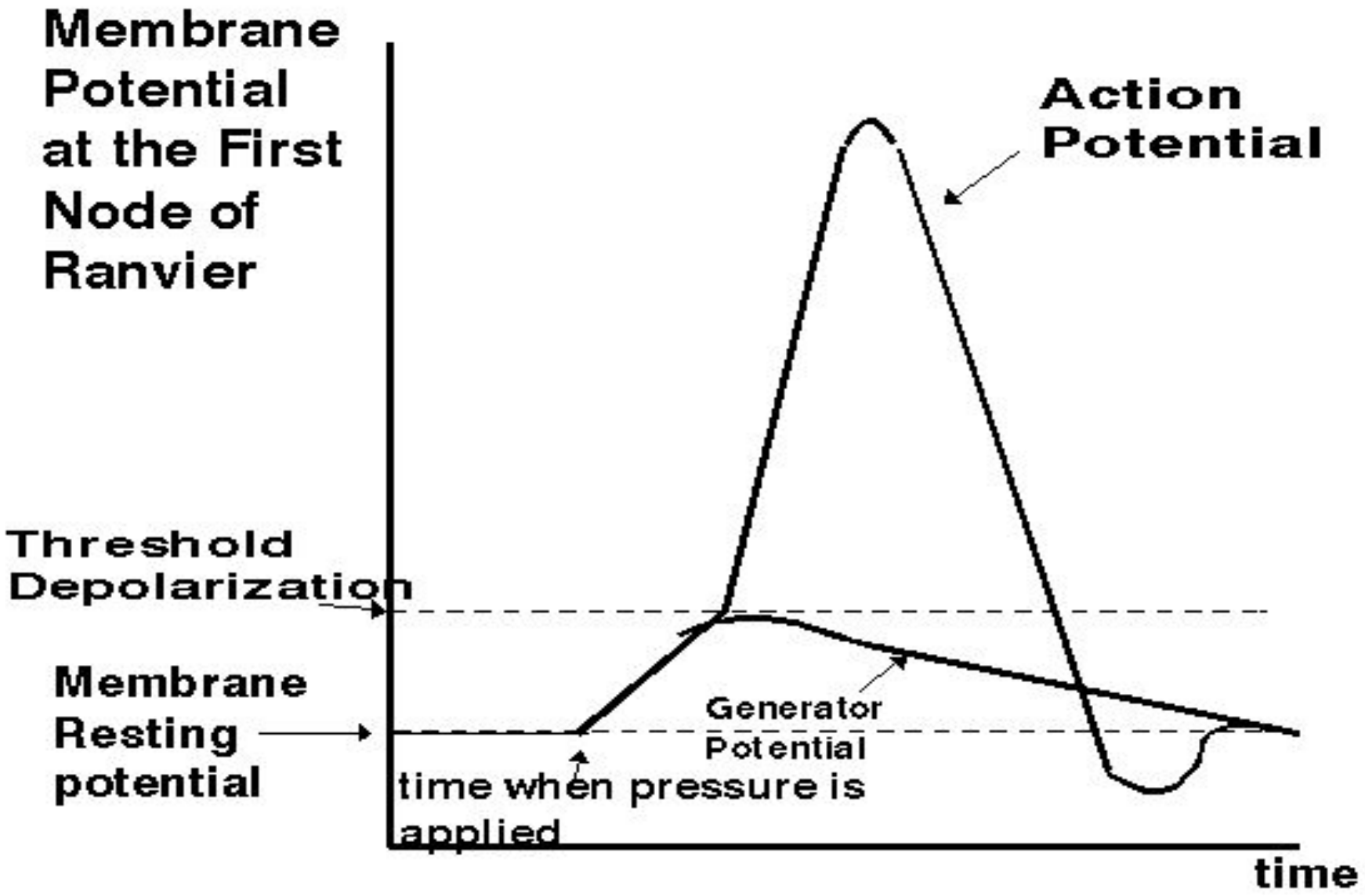


SALTATORY CONDUCTION



NORMALLY A NERVE IS EXCITED BY A SYNAPSE OR BY A RECEPTOR

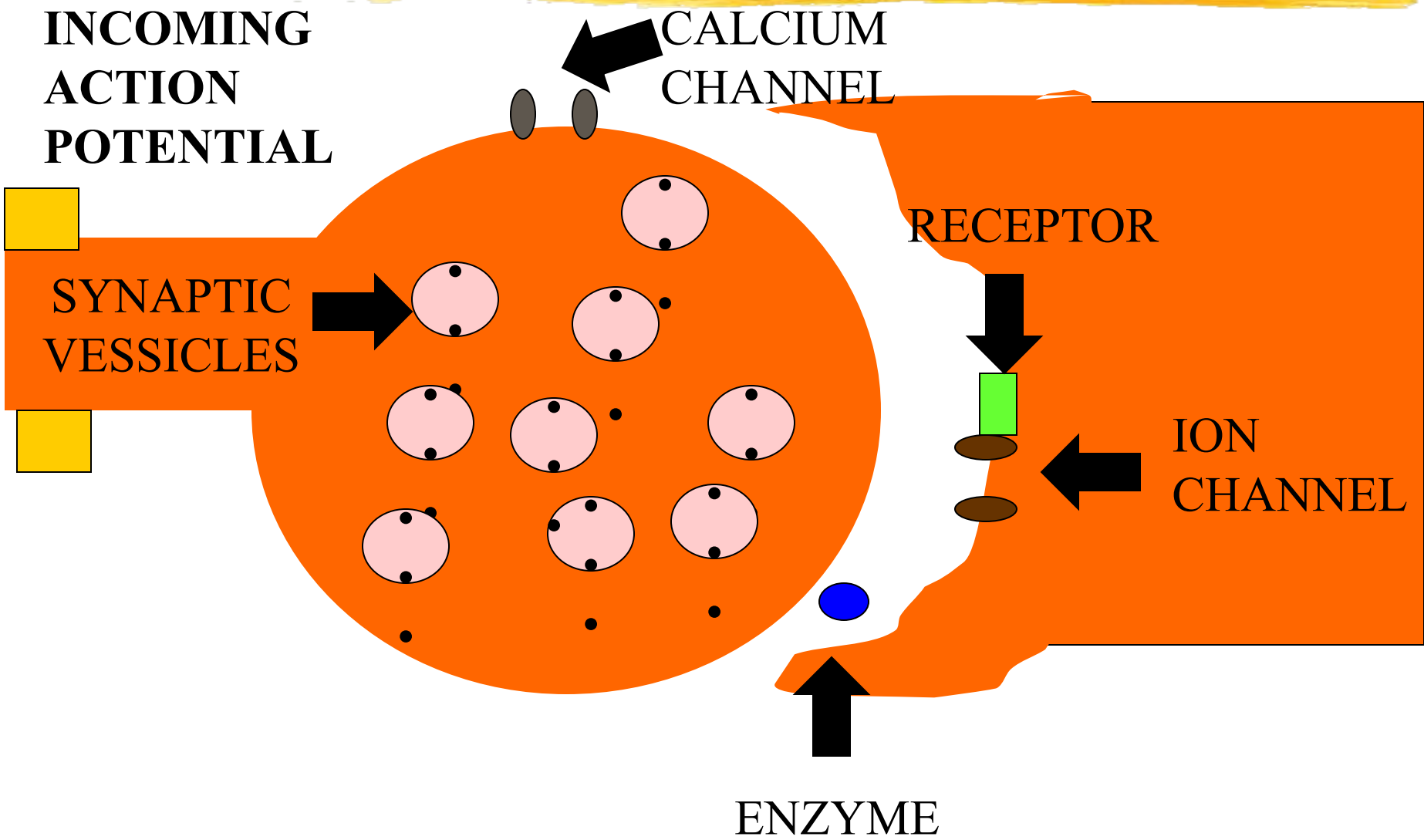
- MANY NERVES SYNAPSE ON ANY GIVEN NERVE
- RECEPTORS HAVE GENERATOR POTENTIALS WHICH ARE GRADED
- IN EITHER CASE WHEN THE NERVE IS DEPOLARIZED BEYOND THRESHOLD IT FIRE AN ALL-OR-NONE ACTION POTENTIAL AT THE FIRST NODE OF RANVIER


Membrane Potential at the First Node of Ranvier
Action Potential
Threshold Depolarization
Membrane Resting potential
Generator Potential
time when pressure is applied
time

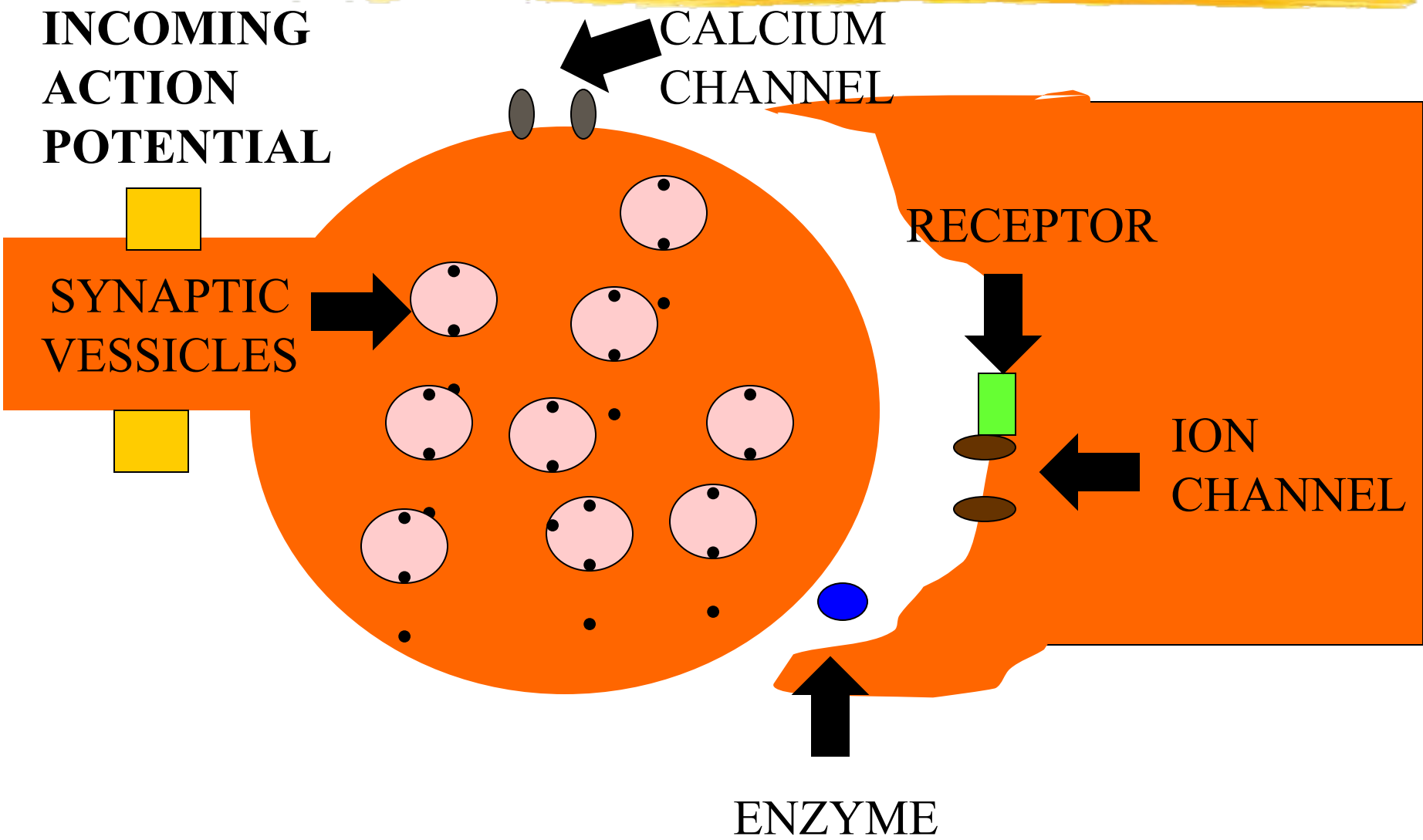
THE SYNAPSE

- JUNCTION BETWEEN TWO NEURONS
- CHEMICAL TRANSMITTER
- MAY BE 100,000 ON A SINGLE CNS NEURON
- SPATIAL AND TEMPORAL SUMMATION
- CAN BE EXCITATORY OR INHIBITORY

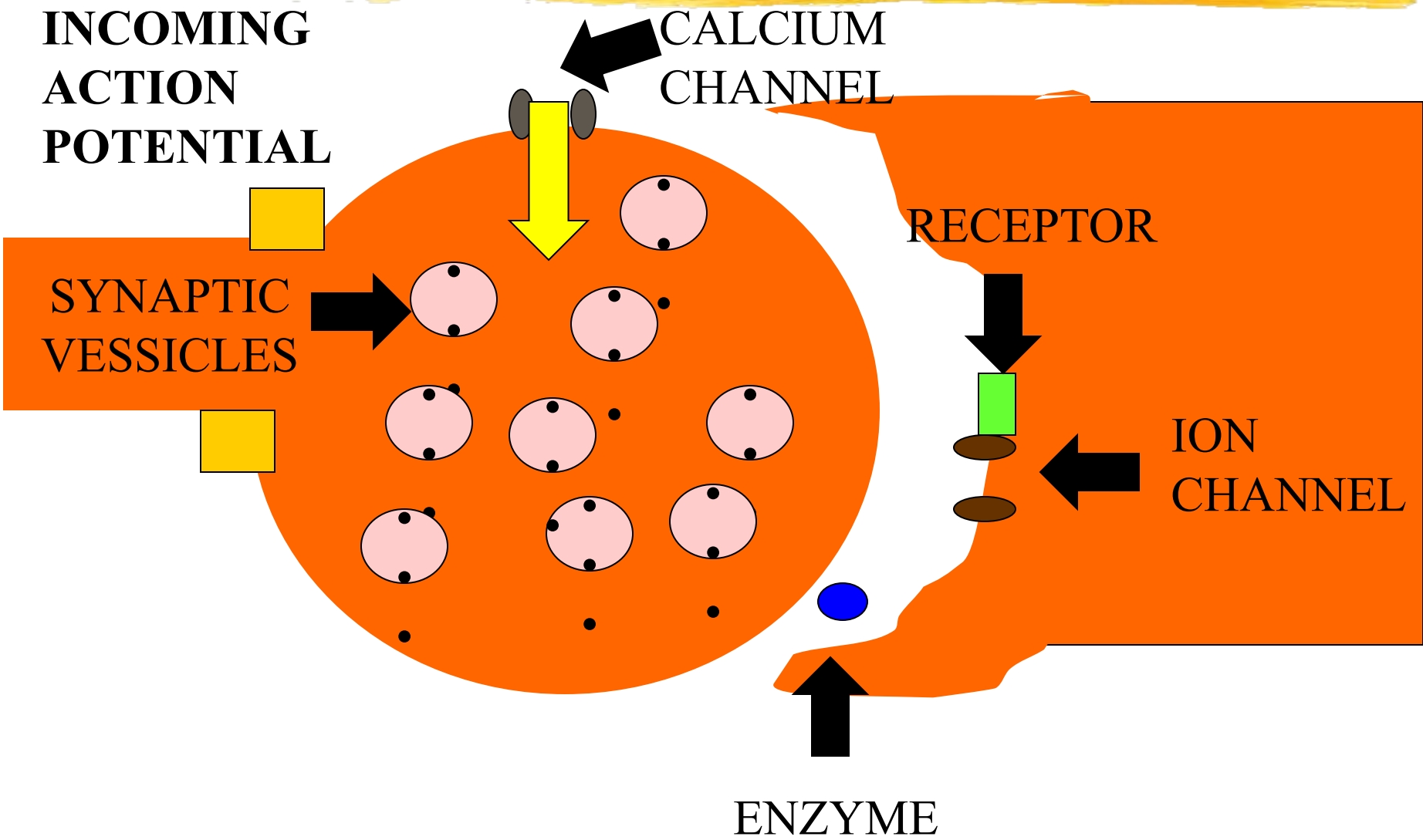
THE SYNAPSE


INCOMING
ACTION
POTENTIAL
CALCIUM
CHANNEL
RECEPTOR
SYNAPTIC
VESSICLES
ION
CHANNEL
ENZYME

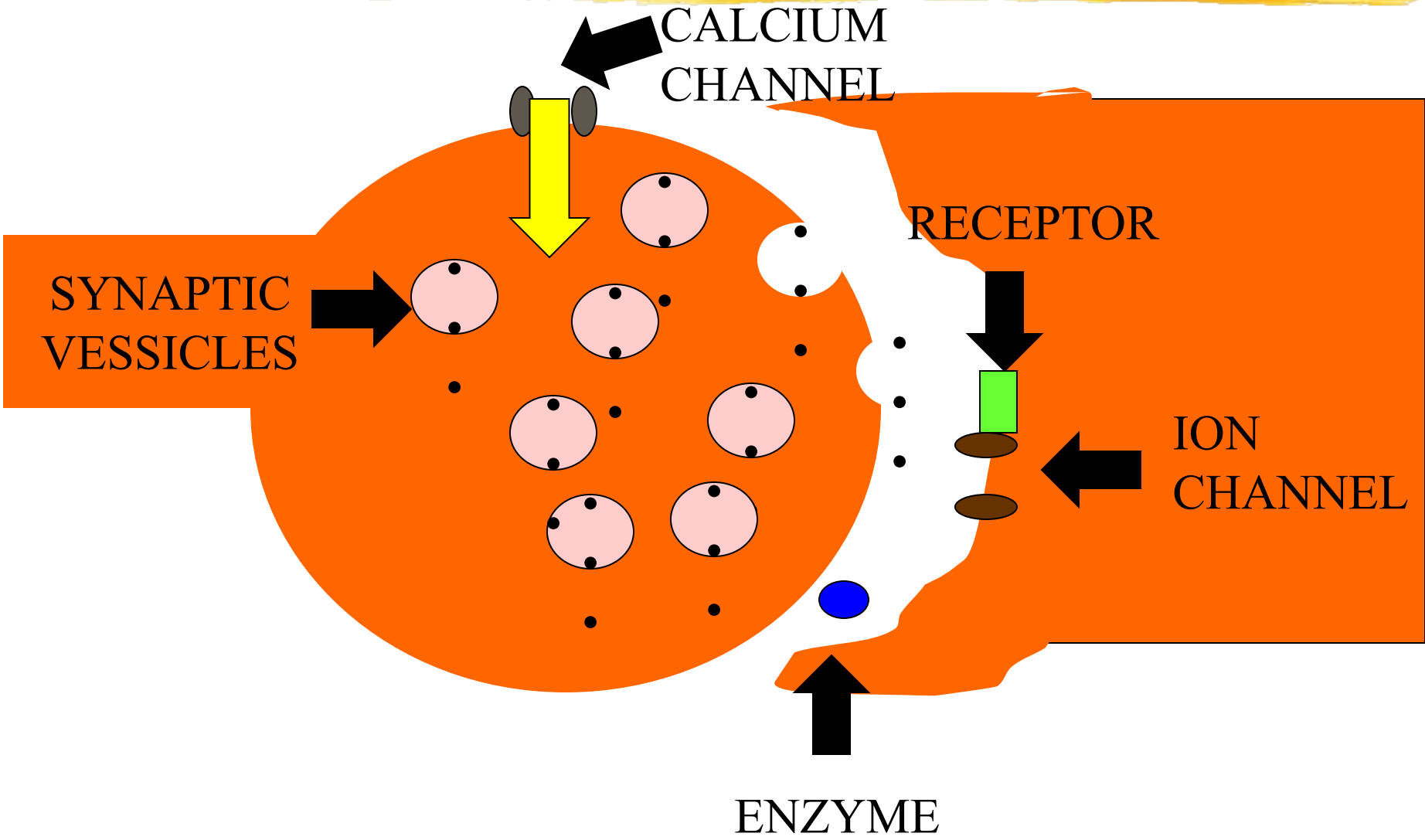
THE SYNAPSE


INCOMING
ACTION
POTENTIAL
CALCIUM
CHANNEL
RECEPTOR
SYNAPTIC
VESSICLES
ION
CHANNEL
ENZYME

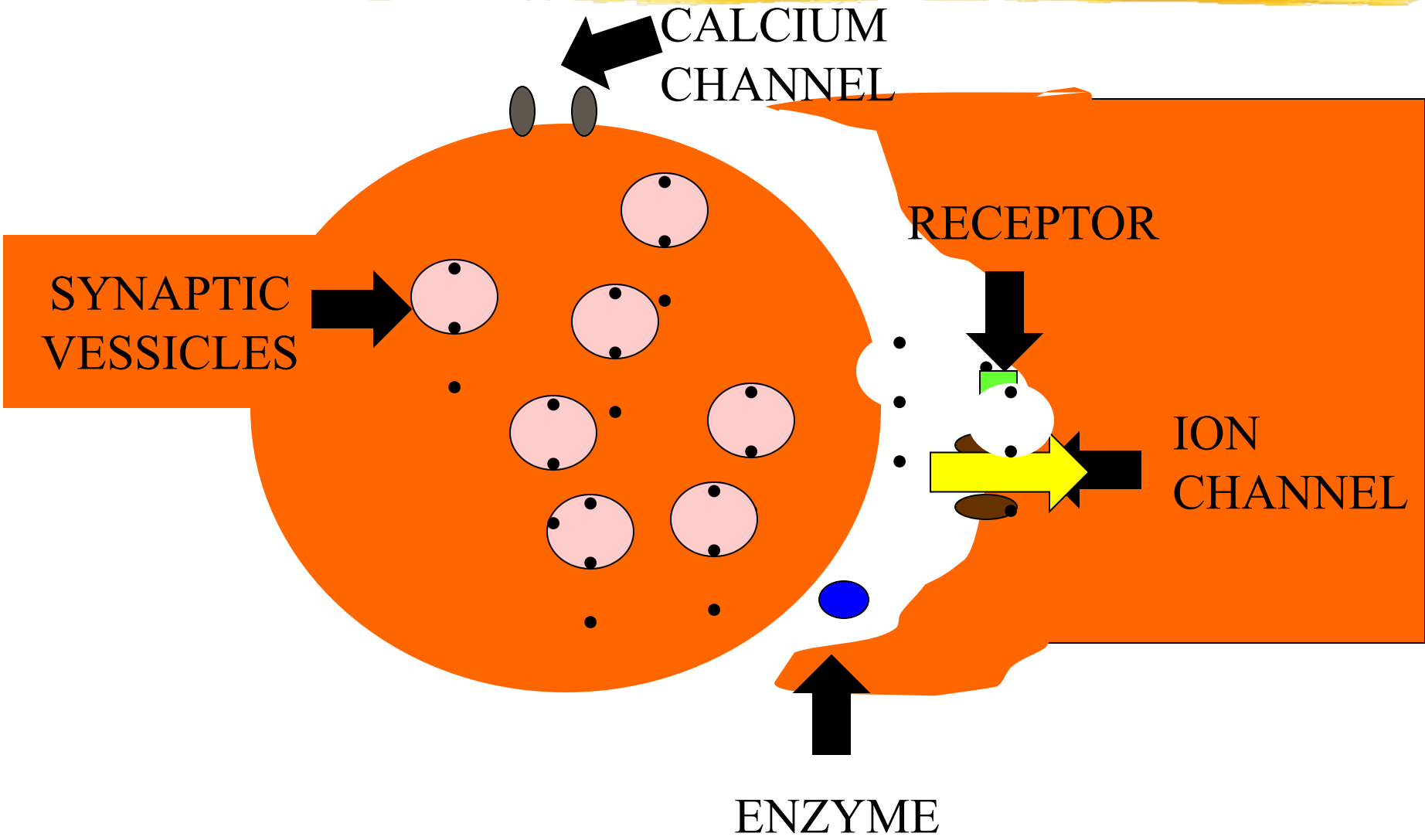
THE SYNAPSE


INCOMING
ACTION
POTENTIAL
CALCIUM
CHANNEL
RECEPTOR
SYNAPTIC
VESSICLES
ION
CHANNEL
ENZYME

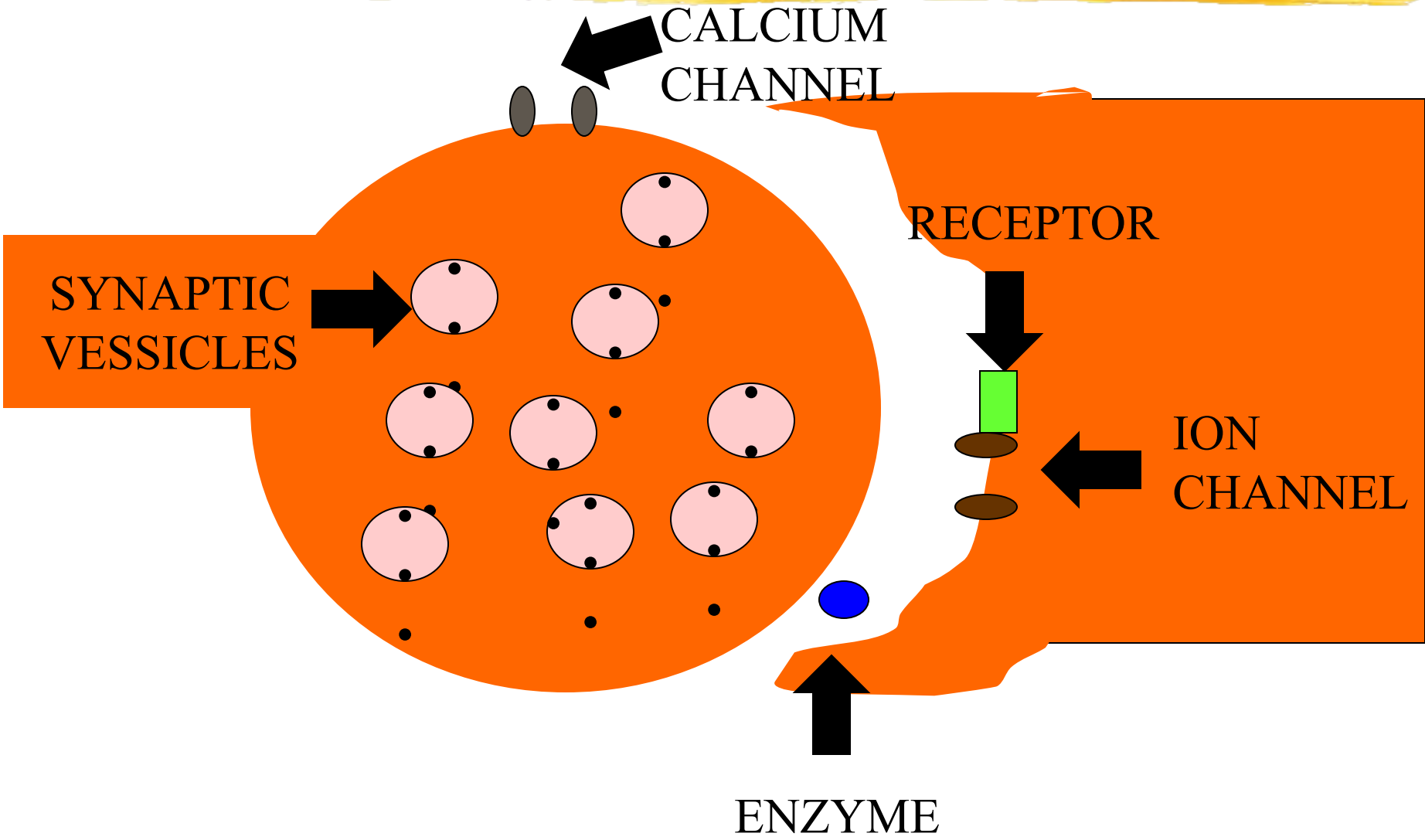
THE SYNAPSE


CALCIUM
CHANNEL
RECEPTOR
SYNAPTIC
VESSICLES
ION
CHANNEL
ENZYME

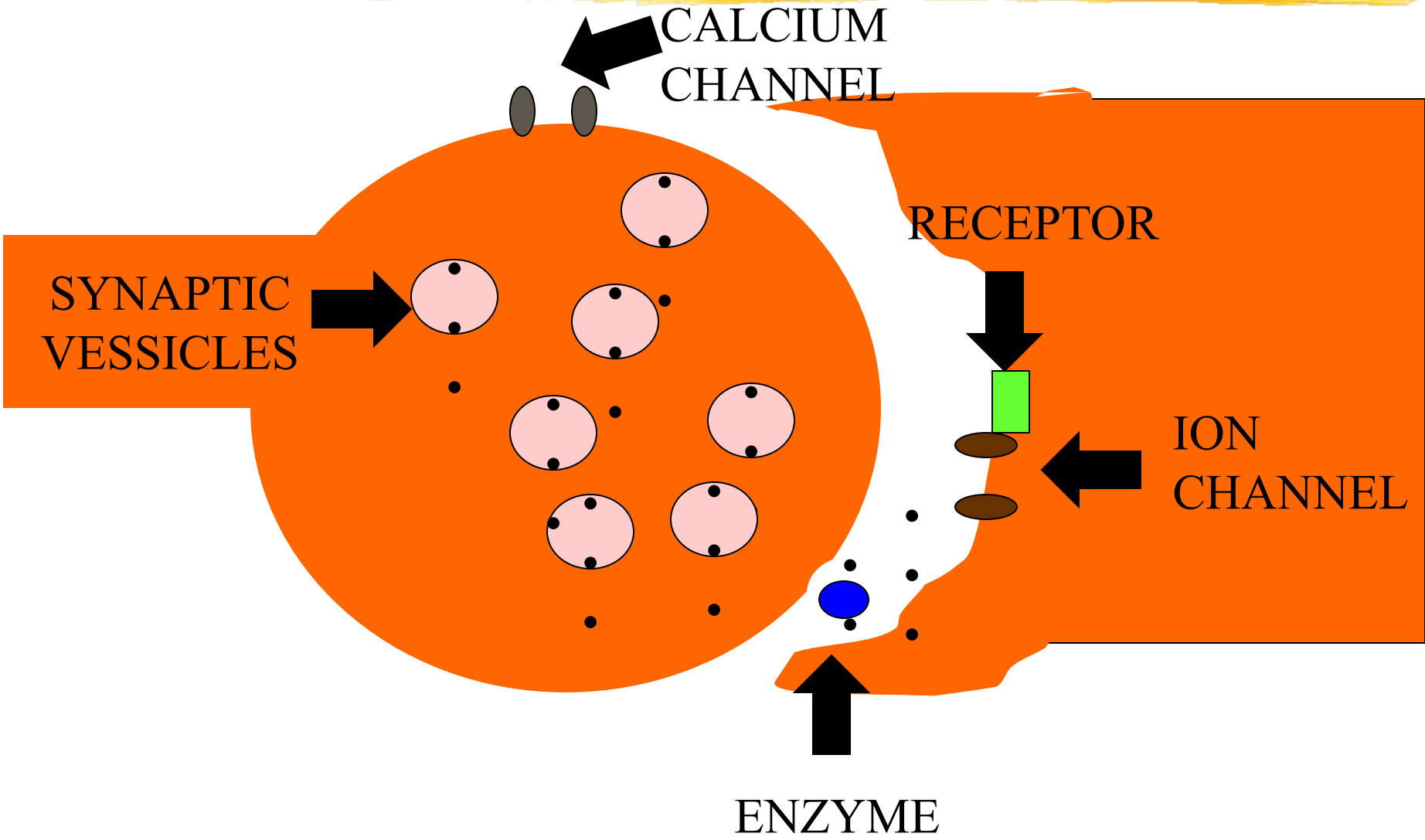
THE SYNAPSE


CALCIUM
CHANNEL
RECEPTOR
SYNAPTIC
VESSICLES
ION
CHANNEL
ENZYME

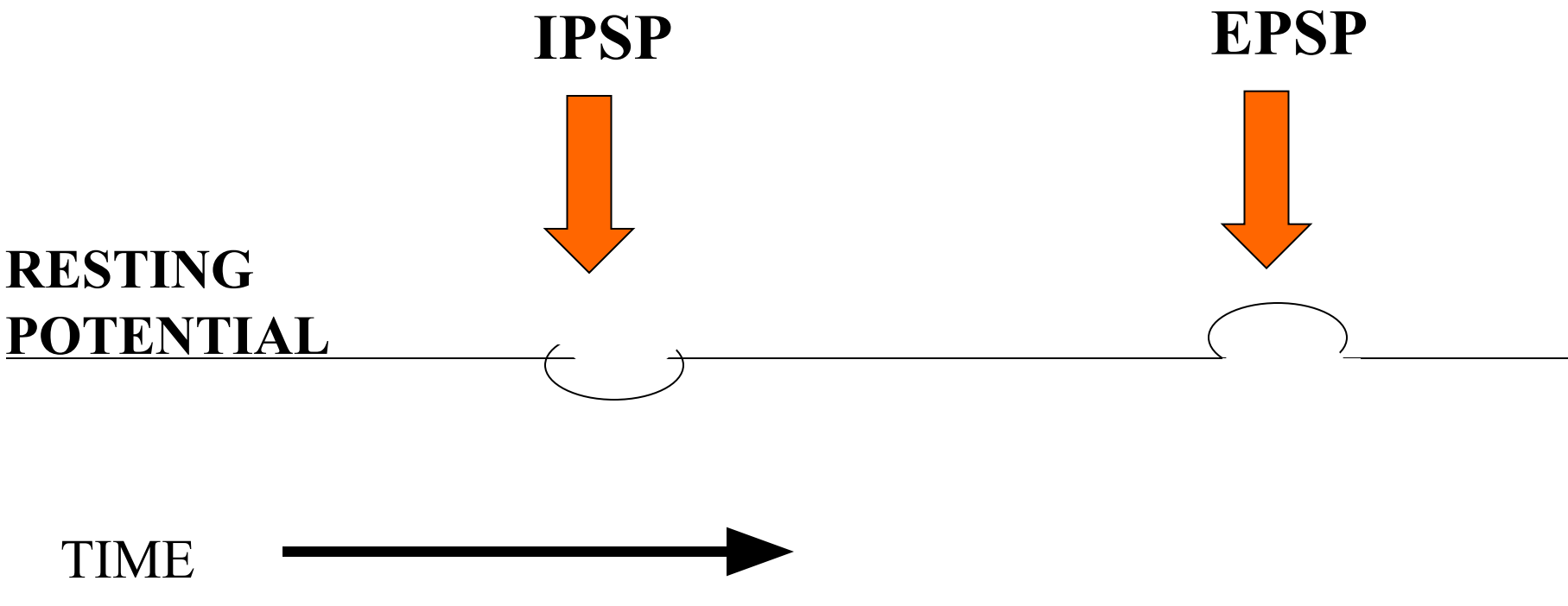
THE SYNAPSE


CALCIUM
CHANNEL
RECEPTOR
SYNAPTIC
VESSICLES
ION
CHANNEL
ENZYME

THE SYNAPSE

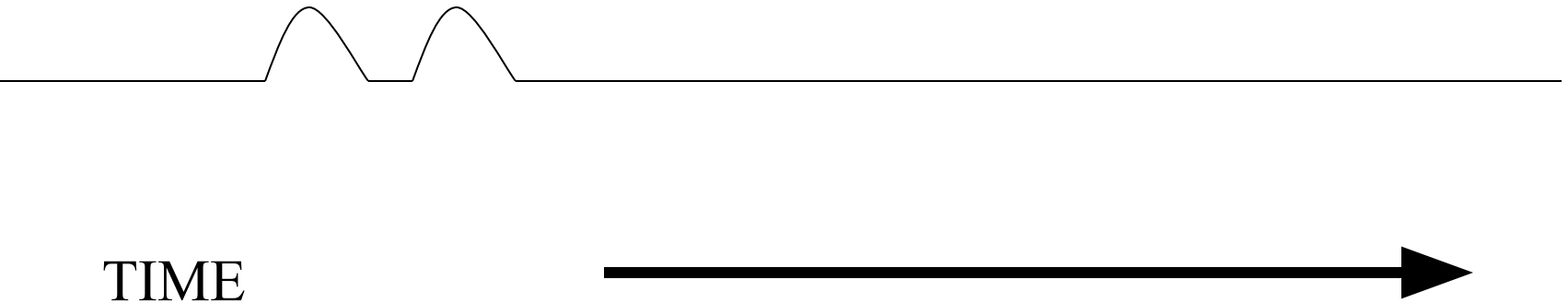

CALCIUM
CHANNEL
RECEPTOR
SYNAPTIC
VESSICLES
ION
CHANNEL
ENZYME

POSTSYNAPTIC POTENTIALS



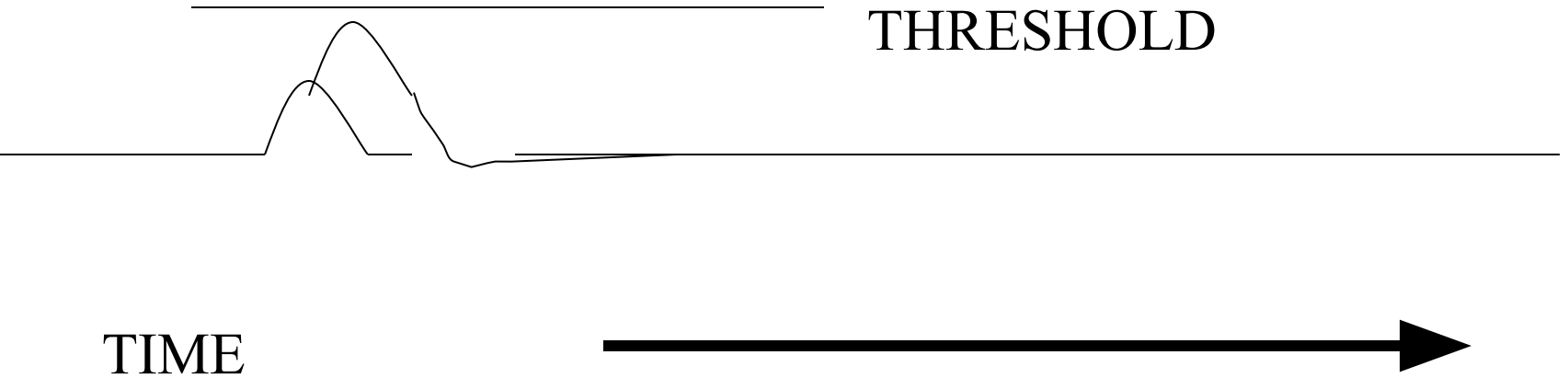
TEMPORAL SUMMATION

TOO FAR APART IN TIME:
NO SUMMATION



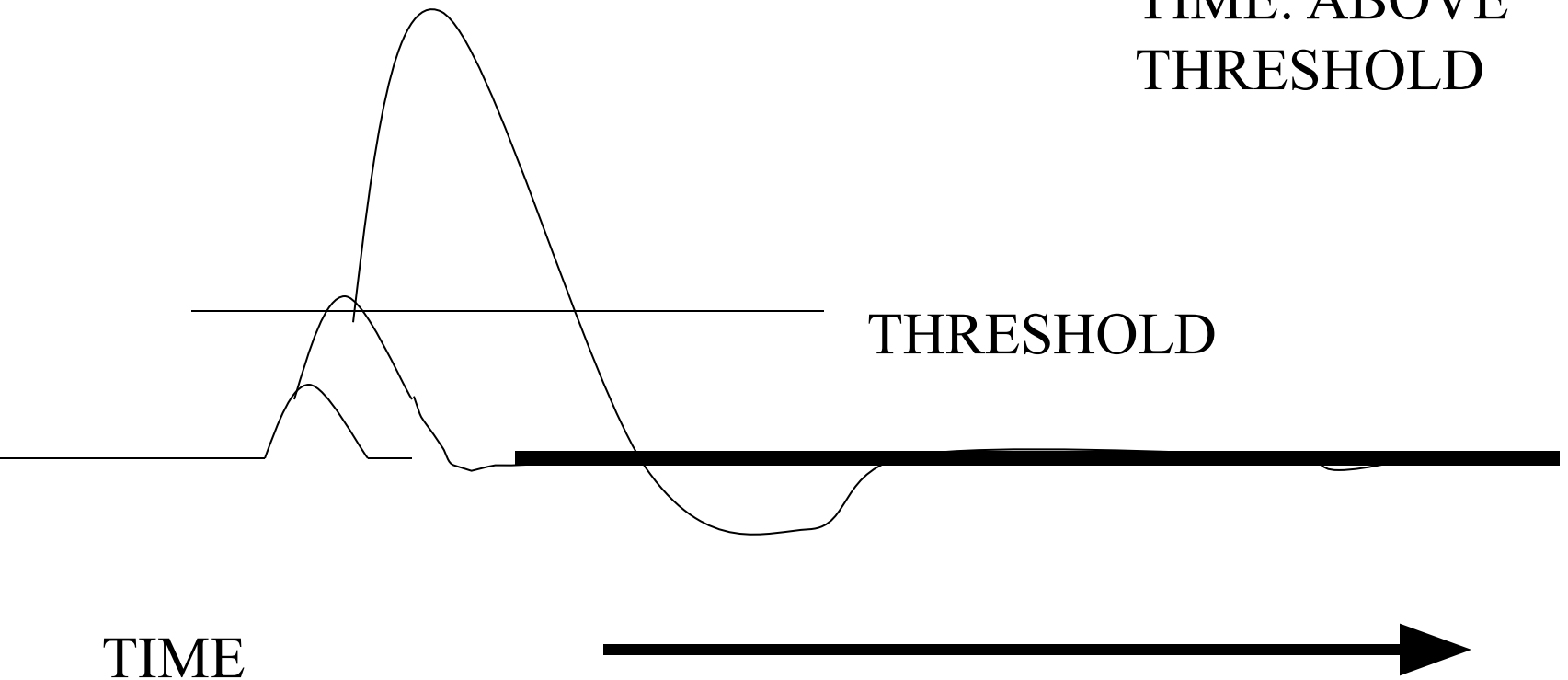
TEMPORAL SUMMATION

CLOSER IN TIME:
SUMMATION BUT
BELOW THRESHOLD



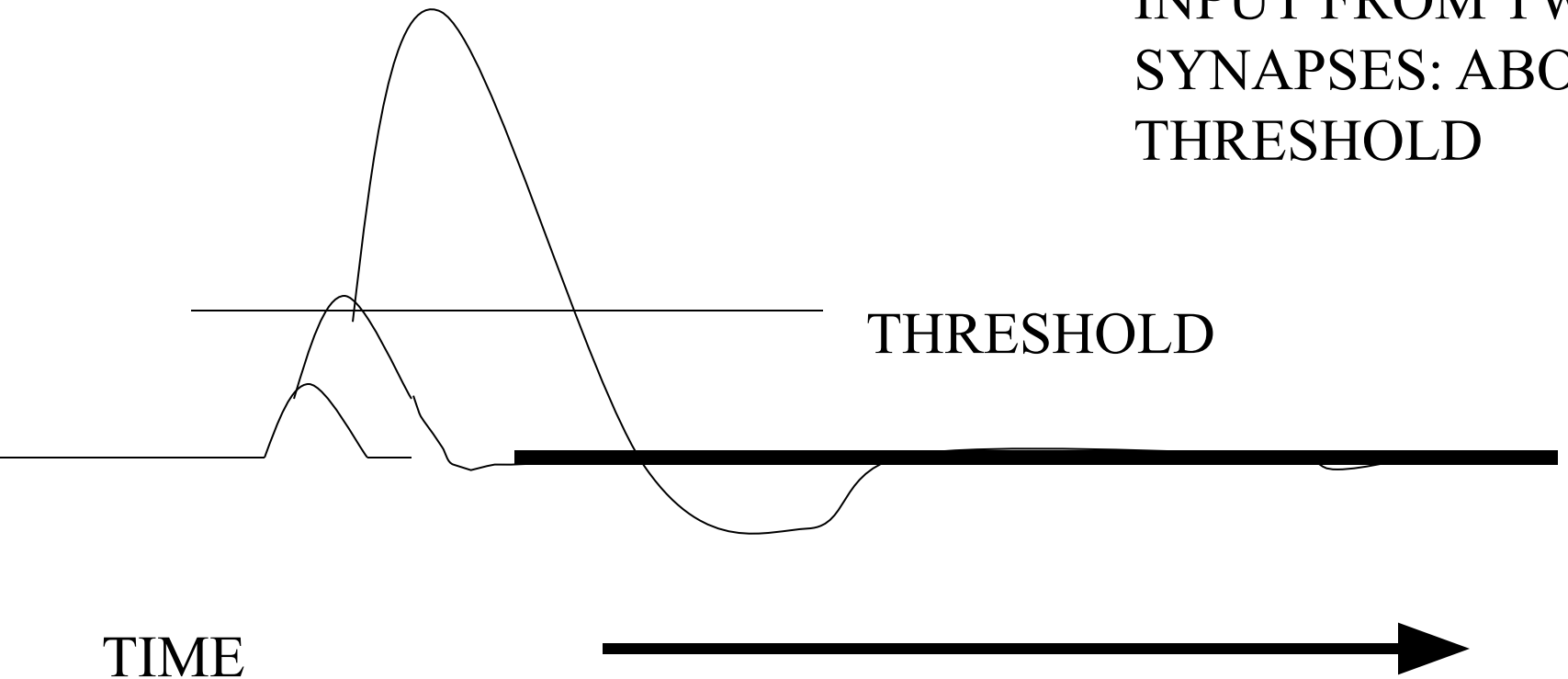
TEMPORAL SUMMATION

STILL CLOSER IN TIME: ABOVE THRESHOLD



SPATIAL SUMMATION

SIMULTANEOUS INPUT FROM TWO SYNAPSES: ABOVE THRESHOLD



EPSP-IPSP CANCELLATION

NEURO TRANSMITTERS

- ACETYL CHOLINE
- DOPAMINE
- NOREPINEPHRINE
- EPINEPHRINE
- SEROTONIN
- HISTAMINE
- GLYCINE
- GLUTAMINE
- GAMMA-AMINOBU TYRIC ACID (GABA)