Membrane Potential and Nerve Impulse Transmission

The Main Concepts

- Resting neurons maintain a difference in electrical charge across their cell membranes.
- The inside of the resting neuron is negatively charged, the outside is positively charged.
- When a neuron is stimulated this polarity is reversed, these reversals are called action potentials.
- Nerve impulses are conducted along the neuron by a wave of membrane polarity reversals(action potentials).
- Chemical messengers(neurotransmitters) carry nervous impulses from one neuron to another across the synapse.

The Neuron Membrane at Rest

The neuron maintains a *resting membrane potential* of about -70 millivolts across the cell membrane.

Sodium(Na^+) and potassium(K^+) are the main ions involved.

Na^+ and K^+ cannot pass through the lipid bilayer membrane.

These ions move through the membrane by using membrane proteins.

The membrane proteins do several things:

Some "leak" ions all the time.

Some "leak" ions only when the cell has been stimulated(ion "gates").

Some "pump" ions by active transport.

The *sodium-potassium pumps*(membrane proteins) actively transport sodium out of the cell and potassium in. (Three Na^+ are pumped out for every two K^+ pumped in. The cell has more Na^+ on the outside and more K^+ on the inside.)

The pumping of Na^+ out makes the outside more positive and the inside of the cell more negative.

The Stimulated Neuron

Nerve cells are unique in their ability to carry a signal using membrane potential changes.

Stimulation of a neuron opens some of the membrane proteins(a.k.a. Na^+ gates) and allows Na^+ to pass freely into the cells.

This free flow of Na^+ into the cell causes a reversal of membrane polarity. This polarity reversal is called the *action potential*.

This reversal of polarity(action potential) moves along the cell like a wave. This is how the impulse is conducted along the cell.

The membrane restores the resting potential very quickly (in less than 7 milliseconds). The cell can be stimulated again.

All-or-none Aspect of Nerve Stimulation

Nerve cell stimulation is a classic example of the all-or-none phenomenon.

All-or-none refers to the idea that once a *threshold limit* is reached any stronger stimulus will not increase the cell's response. A stimulus below the threshold also will not stimulate the neuron.

Note the graph in your text book showing the membrane potential plotted against time to see the threshold limit and action potential.

Neuron to Neuron Communication: The Synapse

Most neurons communicate across the *synapse* by using chemical messengers called neurotransmitters

There is a space, the *synaptic cleft*, between adjacent neurons.

There are many neurotransmitters, some act to inhibit neurons and some excite neurons.

Neurotransmitters are found in vesicles in the cytoplasm beneath the membrane at the synaptic nob.

When the action potential arrives at the synaptic nob the vesicle fuse with the cell membrane and the neurotransmitters are dumped into the synaptic cleft.

The neurotransmitters diffuse across the synaptic cleft and attach to receptors on the adjacent membrane.

The attachment of the neurotransmitters to this membrane causes ion channels to open and generate an action potential.

Examples of neurotransmitters are: acetylcholine, endorphins, dopamine, GABA, seratonin and epinephrine.

Neurotransmitters are involved in many diseases and drug addiction.

Prepared by P. Vanderschaegen Date: March 22, 1997