**MEMBRANES AND RECEPTORS - SESSION 3**

**THE RESTING CELL MEMBRANE**

**LECTURE 3.1 - THE RESTING MEMBRANE POTENTIAL**

**AIMS**

The aims of this session are:

to develop an understanding of the membrane potential in cells

to outline how they are set up and how they may be changed by mechanisms involved in cellular signalling.

**LEARNING OUTCOMES**

By this session you should be able to:

describe the ionic basis of membrane potential and the differences in ionic

composition of intra- and extra-cellular fluids

understand what is meant by membrane depolarization or hyperpolarization and

the roles of the major ion-specific channels in the plasma membrane

**PRIVATE STUDY**

Private study time should be used to:

complete the work sheet associated with this session in preparation for the

tutorial in Session 5.

to research the basis of the action potential and nerve impulse conduction in

preparation for Lectures 4.1 and 4.2 is Session 4.

Start thinking about your presentations for Sessions 6 and 7. See Assignment

Presentation booklet. 58

**MEMBRANES AND RECEPTORS - SESSION 3**

**THE RESTING CELL MEMBRANE**

**LECTURE 3.1 - THE RESTING MEMBRANE POTENTIAL**

**AIMS**

This session should develop your understanding of the membrane potential of cells;

how they are set up and may be changed by mechanisms involved in cell signalling.

By the end of the session you should be able to:

outline what a membrane potential is, how the resting potential of a cell may be

measured, and the range of values found

understand the concept of selective permeability, and explain how the selective

permeability of cell membranes arises

describe how the resting potential is set up given the distribution of ions across

cell membranes.

understand the term equilibrium potential for an ion, and calculate its value form the ionic concentrations on either side of the membrane.

define depolarization and hyperpolarization, and explain the mechanisms that may lead to each of these

explain how changes in ion channel activity can lead to changes in membrane

potential, and outline some of the roles of the membrane potential in signalling within and between cells.

outline how ligand-gated channels can give rise to synaptic potentials. 59

**THE RESTING MEMBRANE POTENTIAL**

All cells have an electrical potential difference across their plasma membrane.

Changes in this membrane potential underlie the basis of signal transmission in the

nervous system and in many other cells.

**Measuring the Membrane Potential**

Membrane potentials can be measured using a very fine micropipette - a

microelectrode - that will penetrate the cell membrane.

**Selective Permeability of the Cell Membrane**

Membrane potentials are set up because the membrane is selectively permeable to

different ions. The permeability of the membrane to ions occurs by way of channel proteins; membrane-spanning transport proteins that allow ions to permeate. 60

These **ion channels** are characterized by:

1. Selectivity: the channel lets through only one (or a few) ion species. Channels

selective for Na+, K+, Ca2+ , Cl- , and with non-selective cation permeability are

known.

2. Gating: the channel can be open or closed by a conformational change in the protein

molecule.

3. A high rate of ion flow that is always down the electrochemical gradient for the ion.

So, depending on which types of channel are open, the resting membrane can be

selectively permeable to certain ion species.

**Setting up the Resting Potential** 61

At rest the membrane has open K+ channels, so is selectively permeable to K+ . K+

will begin to diffuse out of the cell down its concentration gradient. Since anions cannot follow, the cell will become negatively charged inside. This membrane potential will oppose the outward movement of K+, and the system will come into equilibrium.

**The Equilibrium Potential for K+**

How big will the membrane potential be for given K+ concentrations on either side?

Imagine a model system, in which a membrane perfectly selective for K+ ions separates two solutions with different K+ concentrations (in each case balanced by an anion A- that cannot pass through the membrane). 62

The system will rapidly come into equilibrium so that the electrical (dotted line) and

diffusional (solid line) forces balance one another and there is no net movement of K+. The membrane potential at which this occurs is called the **potassium equilibrium potential** or **EK**. It can be calculated from the **Nernst equation:**

where V is the membrane potential, R is the gas constant, T is the temperature in o K,

Z the valency of K+ (+1), F is Faraday's number, and [K+]o and [K+]i are the outside and inside concentrations of K+. It is common to work out the constants and convert the natural logarithm to log10, giving, at 37oC: 63

The Nernst equation may be written for other ions as well, e.g. Na+, Ca2+, Cl-

**The living cell**

For the concentrations above, EK works out at -95 mV. Open K+ channels dominate the resting permeability of many cells, so the resting membrane potential (RP) is quite close to EK. The membrane is not perfectly selective, however, mainly because other types of channel are also open, and so the RP is rather less negative than EK. In skeletal muscle, the resting membrane is highly permeable to Cl- as well as K+, and resting potential lies close to both EK and ECl.

The dependence of the RP on K+ permeability means that changing EK will change

the RP. Increasing [K+]o makes EK more positive and so changes the membrane potential in the same direction.