Physiological Dynamics in Animals & Plants – Lecture 8 – Cell-to-cell signaling

I. Cells "communicate" through a process called cell signaling.

A. Signaling cell = cell sending signal (if signal is cellular in origin)

B. Cell which detects signal = target cell

1. Signal is usually detected by a receptor protein

C. Conversion of the information in a signal from one form to another = signal transduction

1. Example: Conversion of a chemical signal (neurotransmitter) to an electrical signal (change in membrane electric potential) during conduction of a nerve impulse.

II. Signals can act over long or short distances.

A. Some type of signal molecules = amino acids, peptides, proteins, nucleotides, fatty acid derivatives, and dissolved gases.

B. Physical signals may include: heat, cold, light quantity or quality, etc.

C. Forms of cell signaling

1. Endocrine secretion of animal hormones; hormone secretion in plants

2. Paracrine signaling by secretion of local mediators; e.g. inflammatory response of the animal immune system

3. Neuronal signaling using neurotransmitters

4. Contact-dependent signaling – e.g. delta/Notch system in developing neurons

III. Each cell responds to a limited set of signals based on the complement of receptors its posseses for a variety of signal molecules.

A. Each cell type has a unique collection of different receptors.

B. A single type of signal molecule binding to one type of receptor can trigger a variety of effects in a single cell – e.g., a change in metabolism, gene expression, cell shape, etc.

1. Some effects are fast, others are slow.

C. The effects of multiple signals may be interactive.

IV. Binding of a signaling molecule to a receptor triggers a "signaling cascade" in which information is passed from the primary receptor from one "intracellular signaling molecule" to another.

A. Functions of signaling cascades

1. Transfer of signal to response machinery of cell

2. Transformation of signal into a molecular form that can evoke the desired response

3. Amplification of the signal

4. Distribution of the signal to divergent response mechanisms

5. Capacity for modulation by internal or external factors

V. In general, there are two classes of signal molecules – those that can cross the plasma membrane and those that can't.

A. Large hydrophilic signaling molecules bind to receptors in the plasma membrane.

1. The signal must be relayed across the membrane, often by a "second messenger"

    a. Second messengers: 3',5' cyclic AMP (cAMP); 3'5' cyclic GMP; 1,2-Diacylglycerol (DAG); inositol 1,4,5-triphosphate (IP_3); calcium ion

B. Hydrophobic signaling molecules often cross the plasma membrane and bind to intracellular receptors.

1. Steroid hormones are good examples

C. Nitric oxide (NO) can enter cells to activate enzymes directly.

1. NO causes relaxation of smooth muscle.

VI. There are three main classes of cell surface receptors for large, hydrophilic signaling molecules.

A. Ion-channel-linked receptors

B. G-protein-linked receptors

C. Enzyme-linked receptors