CASE

There is a 43-year-old man with epigastric pain who visits the doctor's clinic. The patient is diagnosed with peptic ulcer disease after a thorough workup. His stomach's "proton pump" is inhibited by a medication.

- A proton pump is referred to above. What is it?
- Which type of cell membrane transport would this medication block?
- How does a cell membrane transport four other types of information?

ANSWERS TO CASE 1: MEMBRANE PHYSIOLOGY

Summary : The pron pump inhibitor is prescribed to a 43-year-old man with peptic ulcer disease.

- Pump of proton: H+-K+-ATPase (adenosine triphosphatase).
- Primary active transport is a type of cell membrane transport.
- Other types of transport: Simple diffusion, restricted diffusion, facilitated diffusion, secondary active transport (cotransport and countertransport).

CLINICAL CORRELATION

Primary care physicians often see patients with peptic ulcer disease. Midepigastric pain is typically gnawing or burning and is relieved with antacids or food several hours after meals. An upper gastrointestinal (GI) bleed may be the only symptom of ulcerative disease in some patients.Alcohol, nonsteroidal anti-inflammatory drugs (NSAIDs), tobacco, and physiologic stress (sepsis, trauma) are risk factors for peptic ulcer disease.Helicobacter pylori infection plays a significant role in ulcer formation and must be treated when discovered. Peptic ulcer disease patients must also control acidity within their stomachs. The parietal cells in the stomach contain the proton pump H+-K+-ATPase, which is blocked by omeprazole.

APPROACH TO MEMBRANE PHYSIOLOGY

Objectives

1. Understand the structure and components of a cell membrane.

2. Learn about different types and examples of cell membrane transport.

3. Know what diffusion and equilibrium potentials are.

Definitions

Diffusion: The movement of molecules across membranes caused by a concentration gradient (uncharged molecules) or an electrochemical gradient (charged molecules).

Active transport: In a membrane, molecules move against a gradient of chemical or electrochemical potential.In order to perform this type of transfer, energy must be input.

DISCUSSION

The intracellular membrane maintains the concentration gradients required for cell metabolism through compartmentalization of cell components. The cell membrane preserves the intracellular composition, which is different from the extracellular composition, by marking cell boundaries. It is essential for a cell to function, however, that inorganic and organic molecules can pass through the membrane.A lipid core forms when the hydrophilic components of phospholipids meet the hydrophilic parts of the aqueous intracellular and extracellular fluids and their hydrophobic parts interact. Cholesterol and proteins are contained within and/or associated with this bilayer.Integral proteins can span the entire bilayer or peripheral proteins can adhere to one surface or the other. Cell types differ in the number and types of proteins, and polarized cells, such as epithelia, have proteins in the basolateral membrane that differ from those in the apical.Membrane-bound proteins serve a variety of functions, including transporting molecules across the cell membrane, especially water-soluble molecules.

Diffusion and active transport are the two main methods of transport across membranes. Simple diffusion, restricted diffusion, and/or facilitated diffusion are different forms of diffusion. Below are descriptions of each of these processes.

Different concentrations of molecules inside and outside the cell cause many molecules to move across membranes. Diffusion is a term used to describe such movement. Net diffusion is induced by molecular movement and greater repulsion of molecules in more concentrated solutions. An equation can be used to describe movement rate (J):

$$J = P\Delta C$$

P is the permeability coefficient of the membrane in question, and C is the concentration gradient across it. Lipid solubility and concentration determine the rate of diffusion of lipid-soluble substances.It doesn't seem to matter how big the molecule is. In simple diffusion, lipids dissolving and appearing on the other side of the membrane result in simple diffusion. In order for water-soluble solutes to permeate a membrane, both their concentration and hydration size are crucial. In membranes, restricted diffusion occurs through proteinaceous pores or channels.

Considering only the chemical gradient and permeability will suffice if the solute is uncharged (e.g., urea, glucose, water, lipids). As a result, the rate of diffusion depends on the electrochemical gradient, which is the difference between the actual membrane potential and the equilibrium potential (E) for any specific set of intracellular and extracellular concentrations, if the solute is charged (e.g., sodium and chloride ions). The Nernst equation can be used to calculate E in millivolts:

$$E = [60/z] \log C_o/C_i$$

A solute's valence is represented by z, while its concentrations are represented by Co, Ci, and Co'.In order to express the rate of diffusion (J), the membrane potential (V) can be measured and expressed as follows:

$$J = G\ (V - E)$$

The conductance of a membrane is G if an ion is conducted there. When V is equal to E, there will be no net movement of the ion if its movement is by passive diffusion; however, changes in concentration and/or changes in V will result in diffusion until electrochemical equilibrium is restored. In addition, the size of the channel and the charge of the amino acids lining it determine the selectivity of restricted diffusion.

Structure plays a crucial role in the diffusion of larger water-soluble solutes such as glucose. Facilitated diffusion involves proteins called carriers and is called facilitated diffusion. In contrast to restricted diffusion, facilitated diffusion exhibits a high degree of structural specificity and saturation kinetics. In other words, as the concentration gradient increases, the diffusion rate will plateau.

Diffusion can account for the movement of many solutes across cell membranes, but many others are transported against chemical or electrochemical gradients.In active transport, energy is inputted into the process. In active transport, adenosine triphosphate (ATP) brings about conformational changes that lead to the transport of a solute from a lower chemical/electrochemical concentration to a higher concentration. Primary active transport occurs when the protein complex involved in the transport is also involved in the ATP split.In almost all cells, there is a primary active transport process that transports sodium out of the cell and potassium into it (the sodium pump). With respect to the extracellular fluid, it maintains low intracellular sodium and high potassium concentrations. There are also those that transport calcium out of most cells and hydrogen ions out of parietal cells into the gastric lumen.

Most cells, especially specialized epithelial cells, do not have an ATPase activity on the carrier involved in active transport. The carrier's ability to transport one solute against a chemical/electrochemical gradient is coupled with the ability of another solute to flow down an electrochemical gradient, typically sodium.In turn, the sodium gradient is maintained by the sodium pump. Sodium can power a solute's entry against a gradient by coupling it with sodium.This type of cotransport is how glucose is absorbed by cells in the proximal tubules of the intestinal and renal epithelia. Sodium, on the other hand, can be used to extrude another solute through its entry. Calcium is removed from myocardial cells by such countertransport.