UNIVERSITY OF MEDICAL SCIENCES, ONDO

DEPARTMENT OF PHYSIOLOGY

PHS 211

TRANSPORT MECHANISM

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OUTLINE

- Introduction

- Basic mechanisms
  - Passive transport
  - Active transport

INTRODUCTION

- Body cells need essential substances (nutrients, water, electrolytes etc) and must get rid of unwanted substances (waste materials, carbon dioxide etc) to function optimally.

- Transport mechanisms across cell membrane will help to achieve these.

- Cell membranes either allow all substances to pass (permeable membrane) or may be restrictive allowing only small solvent molecules to pass (semi-permeable membrane).

- Lipids and proteins of cell membrane play important role for substances to be transported between ECF and ICF.

BASIC MECHANISMS

- Passive transport mechanism

- Active transport mechanism

PASSIVE TRANSPORT MECHANISM

- Transport of substances along concentration gradient or electrical gradient or both.
- It is also known as diffusion or downhill movement. It requires no energy.
- The energy involved is the energy of the normal kinetic motion of matter.
- Substances move from region of higher concentration to region of lower concentration through a permeable membrane.

TYPES OF DIFFUSION

- Diffusion is of two types

  - Simple diffusion

  - Facilitated (carrier mediated) diffusion

SIMPLE DIFFUSION

- Occurs either through lipid layer or protein layer of cell membrane.
- Through lipid layer: the lipid layer is permeable to lipid soluble substances alone e.g. oxygen, carbon dioxide and alcohol.
- Diffusion through this lipid layer is directly proportional to the solubility of the substances in lipids.
- Through protein layer: The protein layer is permeable to water soluble substances e.g. many electrolytes diffuse through the protein layer.

FACILITATED OR CARRIER MEDIATED DIFFUSION

- Occurs with the aid of carrier proteins of the cell membrane.
- Water soluble substances with larger molecules are transported through the cell membrane with the help of a carrier protein.
- Transport of substances are faster than in simple diffusion.
- Glucose and amino acids are examples of substances transported by this means.

FACTORS AFFECTING RATE OF DIFFUSION

- Permeability of the cell membrane.
- Temperature of the body.
- Concentration or electrical gradient of the substance across the cell membrane.
- Solubility of the substance. e.g. oxygen is highly soluble in lipid and diffuses rapidly through lipid layer.
- Thickness of the cell membrane.
- Size of the molecules.
- Size of ions.
- Charge on the ions

SPECIAL TYPES OF PASSIVE TRANSPORT

- Bulk flow
- Filtration
- Osmosis

- Bulk flow: diffusion of large amount of substances from a region of high pressure to region of low pressure.

- E.g. The exchange of gases across the respiratory membrane in the lungs.

- Partial pressure of oxygen is greater in the alveolar air than in the alveolar capillary blood.

- Oxygen moves from alveolar air into the blood through the respiratory membrane.

- Reverse is the case for carbon dioxide.

- Filtration: movement of water or solute from an area of high hydrostatic pressure to an area of low hydrostatic pressure.

- Hydrostatic pressure is developed by the weight of the fluid.

- Example is seen at the arterial end of the capillaries where movement of fluid occurs along with dissolved substances from blood into the interstitial fluid.

- Osmosis: A special type of diffusion.
- Defined as the movement of water or solvent from an area of lower concentration to an area of higher concentration of a solute through a semi-permeable membrane.
- The semi-permeable membrane permits the passage of only water or other solvents but not the solutes.
- It occurs when there is a difference in the solute concentration on both sides of the membrane.
- Osmosis depends upon osmotic pressure.
- Osmosis across the cell membrane is of two types
  - Endosmosis: movement of water into the cell.
  - Exosmosis: movement of water out of the cell.

ACTIVE TRANSPORT

- Movement of substances against the chemical, electrical or electrochemical gradient.
- It is also called uphill transport.
- It requires energy which is obtained majorly from the breakdown of high energy compounds e.g. ATP.

CARRIER PROTEINS OF ACTIVE TRANSPORT

➢Carrier proteins involved in active transport are two types.

- Uniport
- Symport or antiport.

- Uniport: carrier protein that carries a single substance in one direction. It is also called uniport pump.

- Symport or antiport: carrier protein that transport two substances at a time.

- Symport transports two different substances in the same direction, it is also known as symport pump.

- Antiport transports two substances in opposite direction, it is also called antiport pump.

TYPES OF ACTIVE TRANSPORT

- Primary
- Secondary

- Primary active transport: energy is directly liberated from the breakdown of ATP.

- Substances like sodium, potassium, calcium, hydrogen and chloride are transported across the cell membrane.

- Secondary active transport: This is the transport of a substance with sodium ion by the help of a common carrier protein.

- The movement is either in the same direction or in the opposite direction.

- Secondary active transport may be co-transport or counter-transport.
- Sodium co-transport: Sodium is transported along side another substance by the same carrier protein called symport.
- Energy needed for transport of sodium is derived from the breakdown of ATP.
- Energy released by the transport of sodiun is used to transport the other substance.
- Glucose and amino acids are transported by this process.
- Sodium counter-transport: Substances are transported across cell membrane in exchange for sodium ion by carrier protein called antiport. E.g. sodium-hydrogen counter transport

SPECIAL TYPES OF ACTIVE TRANSPORT

- Endocytosis
- Exocytosis
- Transcytosis

- Endocytosis: Macromolecules (substances with larger molecules) enter the cell.

- Macromolecules cannot pass through the cell membrane by both passive and active transport, hence they are transported by endocytosis.

- It is an energy-dependent movement of molecules across cell membrane.

- Portion of the membrane protrudes, surrounds the substance and engulfs it, then bring it into the cell.

➢Endocytosis is divided into three

- Pinocytosis
- Phagocytosis
- Receptor-mediated endocytosis.

- Pinocytosis: Macromolecules in form of fluid droplets, bacteria and antigen are taken into the cell. It is also called cell drinking.

- Phagocytosis: Particles larger than macromolecules like larger bacteria and larger antigen are engulfed into the cells. It is also called cell eating.

- Receptor-mediated endocytosis: Macromolecules are transported with the help of a receptor protein. The surface of cell membrane has some pits which contain receptor proteins called clathrin. Chemical or ligand binds to a receptor in the membrane and is enclosed in a vesicle to be graded.

- Exocytosis: Process by which substances are expelled or removed from the cell.

- Substances are extruded from cell without passing through the cell membrane e.g. the release of peptide hormones from endocrine glands or transfer of fats from intestinal cell into the lacteal.

- Transcytosis: This is a transport mechanism in which an extracellular macromolecule enter through one side of the cell, migrate across the cytoplasm of the cell and exits through the other side of the cell.