Exocytosis and Endocytosis

Exocytosis and Endocytosis are the two important functions performed by the cell membrane. Exocytosis concerned with the moving out of material from within a cell and endocytosis is the movement of material just in opposite direction, i.e. from outside of a cell to inside.

Exocytosis

In exocytosis a variety of proteins are exported from both animal and plant cells . Animal cell secret peptide and protein hormones, mucus, milk proteins and digestive enzymes by this way. The basic steps of the exocytosis process can be describe briefly in the following steps-

i) The vesicles containing molecules are transported from within the cell to the cell membrane.
ii) The vesicle membrane attaches to the cell membrane. The Fusion of the vesicle membrane with the cell membrane releases the vesicle contents to the exterior of the cell.
iii) The membrane of the vesicle become integrated to the plasma membrane; with the inner surface of the vesicle become the outer surface of the plasma membrane.

iv) Glycoproteins and the Glycolipids that remain anchored to the plasma membrane then face the extracellular space.

Fig -1

There are three common pathways of exocytosis.

i) C**onstitutive exocytosis**, involves the regular secretion of molecules. This action is performed by all cells. This exocytosis functions to deliver membrane proteins and lipids to the exterior of cell.
ii) **Regulated exocytosis** -It occurs commonly in secretory cells. Secretory cells store products such as hormones, neurotransmitters, and digestive enzymes that are released only when triggered by extracellular signals. Secretory vesicles are not incorporated into the cell membrane. Once the delivery has been made, the vesicles reform and return to the cytoplasm.

iii) A third pathway for exocytosis in cells involves the fusion of vesicles with **lysosomes**. These organelles contain acid hydrolase enzymes that break down waste materials, microbes, and cellular debris. Lysosomes carry their digested material to the cell membrane where they fuse with the membrane and release their contents into the extracellular matrix.

Fig -2

The role of calcium in triggering exocytosis-

The fusion of regulated secretory vesicle is generally triggered by a specific extracellular signal. In most cases the signal is a hormone or neurotransmitter that bind to specific receptor on the cell surface and trigger the synthesis or release of a second messenger within the cell. During regulated secretion a transient elevation of the intracellular concentration of calcium ions often appears to be an essential step in the signal cascade leading from the receptor on the cell surface to exocytosis. Although the role of calcium ion is not yet clear, but it appears that elevated calcium level leads to the activation of protein kinases whose target proteins are components of either the vesicle menbrane or the plasma membrane.

Physiological role-

Exocytosis serves several important functions as it allows cells to secrete waste substances and molecules, such as hormones and proteins. It is also important for chemical signal messaging and cell to cell communication. In addition, exocytosis is used to rebuild the cell membrane by fusing lipids and proteins removed through endocytosis back into the membrane.

Polarised secretion- In many cases, exocytosis of specific protein is limited to a specific surface of the cell. For eg. The secretary cells that line the intestine release digestive enzyme only on the side of the cell that face the interior of the intestine. On the opposite side of the cell, a completely different set of proteins is secreted. This phenomenon is called **polarised secretion**. It is also seen in the nerve cells, which secret neurotransmitter molecule only at junctions with other verve cells.

Endocytosis

Endocytosis is a cellular process in which substances are brought into the cell. The material to be internalized is surrounded by an area of plasma membrane, which then buds off inside the cell to form a vesicle containing the ingested material.

The basic steps of the endocytosis process occur in the following steps-

i) A small segment of the plasma membrane progressively folds inward and then it pinched off to form an endocytic vesicle containing ingested substance or particles.
ii) As a result of this, materials that were previously outside the cell are brought into the cell.
iii) A part of plasma membrane that encircle the ingested vesicle, withdrawn from the plasma membrane of the cell.

In terms of membrane flow, exocytosis and endocytosis clearly have opposite role. Exocytosis adds lipids and proteins to the plasma membrane as vesicle fuse to it; on the other hand endocytic vesicles pinched off from the plasma membrane and thereby subtract part of plasma membrane. Thus, exocytosis and endocytosis steady-state composition of plasma membrane.

Types of endocytosis-Depending on the nature of material ingested and the mechanism employed endocytosis is of two basic types – i) **Phaocytosis** (cellular eating) and ii) **Pinocytosis** (cellular drinking)

i) Phagocytosis-

The ingestion of large particle (> 0.5μm diameter), including aggregates of macromolecules, part of other cell and even microorganism is known as phagocytosis. For many single celled eukaryotes such as amoeba and ciliated protozoa, phagocytosis is a routine way for acquiring food. Same is also found in primitive animals like flatworms, coelenterates and sponges as a means of obtaining nutrition. In complex organisms phagocytosis is usually restricted to some specialised cells called **phagocytes**. For eg. in mammal two classes of WBCs that routinely exhibit phagocytosis are *neutrophils* and *macrophages*.

The process of phagocytosis has been extensively studied in amoeba. Amoeba can ingest a bacterium or so by producing a **phagocytic vacuole or phagosome** and after ingestion ,it can fuse with a primary lysosome to form secondary lysosome.

ii) **Pinocytosis-**

When the cell engulfs fluid material through endocytic vesicle , the process is called **Pinocytosis.** Depending on the cell type**,** mammalian cell can ingest hormones, growth factors, enzymes, serum proteins, antibodies even some viral and bacterial toxins by his mechanism. Pinocytosis can be divided into – ***Receptor- mediated endocytosis*** or clathrin-dependent endocytosis and ***Clatherin- independent endocytosis***.

Receptor- mediated endocytosis- it is a pathway for concentrating and ingesting extracellular molecules by means of specific receptors on the outer surface of the plasma membrane. i) The process begin with the binding of liagnd molecules to their respective receptor on the outer surface of the plasma membrane .ii)As the receptor-ligand diffuses laterally in the membrane they encounter specialised membrane region, called coated pits that serve as sites for the collection and internalization of such complexes. iii) The coated pit occupy about 20% of the total surface area of the plasma membrane. Accumulation of receptor- ligand complexes within the coated pit triggers accumulation of additional proteins – including adaptor protein, clathrin, and dynamin – that are required for promoting membrane curvature and invagination of the pit. iv) These proteins are found in the inner surface of the plasma membrane. Invagination continues until the pit pinched off from the plasma membrane, forming a coated vesicle. V) The clathrin oat is released, leaving an uncoated vesicle.vi) the coated proteins and dynamin are then recycled to the plasma membrane, where they become available for forming new vesicles, while the endocytic vesicle is free to fuse with an early endosome.vii) the speed and scope of receptor- mediated endocytosis are impressive. For eg. 2500 such coated pits invaginate per minute in a cultured fibroblast cells.

Fig - 3

Clatherin- independent endocytosis- It is a pathway of non specific internalization of extracellular fluid. Here the cell engulfs fluid without a mechanism for collecting or excluding particular molecule. It can be a means for controlling cell's volume and surface area.