# Cellular interaction

Cellular interaction د. أسامة الموسوي

- Cell–cell interaction refers to the direct interactions between cell

surfaces that play important role in the development and function of multicellular organisms.

- These interactions allow cells to communicate with each other in response to changes in their microenvironment, also to send and receive signals is essential for the survival of the cell. Interactions between cells can be stable such as those made through cell junctions which can involve in the communication and organization of cells within a particular tissue. Or transient (temporary) such as those between cells of the immune system or the interactions involved in tissue inflammation. These types of intercellular interactions are distinguished from other types such as those between cells and the extracellular matrix.The loss of communication between cells can result in uncontrollable cell growth and cancer.

**Tight junctions**, also known as occluding junctions or zonulae occludentes, are the closely associated areas of two cells whose membranes join together forming a virtually impermeable barrier to fluid. It is a type of junctional complex present only in vertebrates. Tight junctions are composed of a branching network of sealing strands, each strand acting independently from the others. Therefore, the efficiency of the junction in preventing ion passage increases exponentially with the number of strands. Each strand is formed from a row of trans membrane proteins embedded in both plasma membranes.

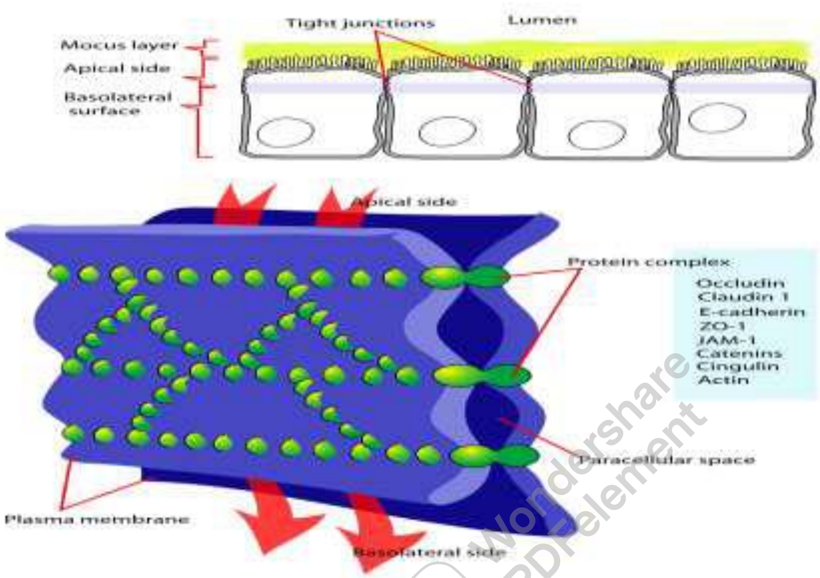
The main functions of tight junction:

- They hold cells together.
- Barrier function, which can be further subdivided into protective barriers

and functional barriers serving purposes such as material transport and maintenance of osmotic balance.

Tight Junctions help to maintain the polarity of cells by preventing the lateral diffusion of integral membrane proteins between the apical and lateral/basal surfaces, this makes sure that the proper endocytosis and exocytosis processes occur in both sides.Tight Junctions prevent the passage of molecules and ions through the space between plasma membranes of adjacent cells.

Tight junction found in epithelial of lung, intestine, stomach and bladder






- Gap junctions

Is a specialized cell junction that directly connects the cytoplasm of two cells. A gap junction channel is composed of two connexin protein, also known as hemichannels that line up across the intercellular space.

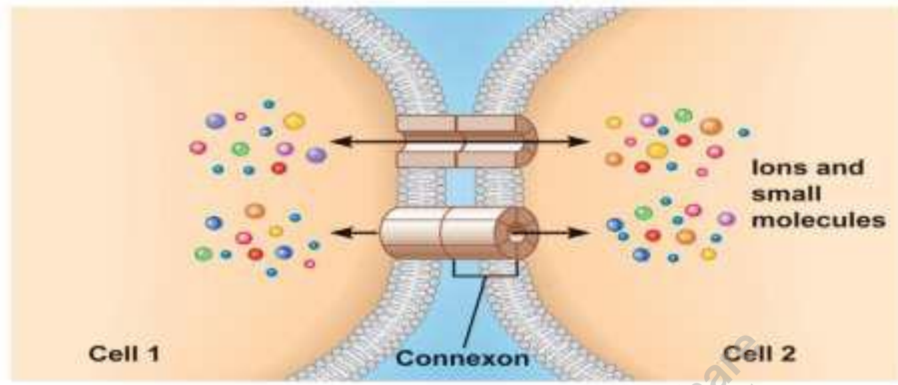
The main functions of gap junction:

 Gap junctions allow the exchange of ions, second messengers, and small metabolites between adjacent cells.

 The primary regulators of gap junction permeability are pH and cytosolic $Ca^{2+}$ concentration as.

 Regulated the extracellular signals including neurotransmitters like dopamine.

Gap junctions are found in many places throughout the body. This includes epithelia, which are the coverings of body surfaces, as well as nerves, cardiac (heart) muscle, and smooth muscle , skeletal muscle and mobile cell types such as sperm or erythrocytes




(a) Direct communication through gap junctions





•Desmosomes

A desmosome also known as a macula adhaerens, is a cell structure specialized for cellto- cell adhesion. They are localized spot-like adhesions randomly arranged on the lateral sides of plasma membranes. Desmosomes are molecular complexes of cell adhesion proteins and linking proteins that attach the cell surface adhesion proteins to intracellular keratin cytoskeletal filaments.

The main functions of desmosomes:

 Desmosomes form links between cells

 Provide a connection between intermediate filaments of the cell cytoskeletons of adjacent cells. This structure gives strength to tissues.

Desmosomes are found in simple, stratified squamous epithelium and muscle tissue where they bind muscle cells to one another.

•Transient interaction

Transient interaction is occurring by the following:

 In immune system, when the movement of leukocyte into tissues by (extravasation) for fight infections, these cell-cell interactions are mediated mainly by a group of Cell Adhesion Molecules (CAM).

 T helper cells, central to the immune system, interact with other leukocytes by releasing signals known as cytokines which activate and stimulate the proliferation of B cells and T cells.

 T helper cells also directly interact with macrophages, cells that engulf foreign matter and display antigens on its surface.

 In coagulation, when the platelets are interacting and stick to the exposed connective tissue through specific cell-surface receptors, then, it activation and aggregation to fibrin formation and blood clotting.

Pathological implications

 In normal cells and when loss of cell-cell interaction, because the growth is controlled by contact inhibition, contact inhibition is lost and results in uncontrolled growth or proliferation, tumor formation, and metastasis.

 Cell–cell interactions are highly specific and are tightly regulated. Genetic defects and dysregulation of these interactions can cause many different disease that leads to leukocyte migration into healthy tissues and cause conditions such as acute respiratory distress syndrome , some types of arthritis and the autoimmune disease.

 Bacterial cells can bind to many host cell surface structures such as glycolipids and glycoproteins which serve as attachment receptors. Once attached, the bacteria begin to interact with the host to disrupt its normal functioning and disrupt or rearrange its cytoskeleton

**Cellular metabolism**

**•Catabolism and anabolism**

Anabolism and catabolism are the two broad types of biochemical reactions that make up metabolism. Anabolism builds complex molecules from simpler ones, while catabolism breaks large molecules into smaller ones. Most people think of metabolism in the context of weight loss and bodybuilding, but metabolic pathways are important for every cell and tissue in an organism. Metabolism is how a cell gets energy and removes waste. Vitamins, minerals, and cofactors aid the reactions.

Anabolism Definition

Anabolism or biosynthesis is the set of biochemical reactions that construct molecules from smaller components. Anabolic reactions are endergonic, meaning they require an input of energy to progress and are not spontaneous. Typically, anabolic and catabolic reactions are coupled, with catabolism providing the activation energy for anabolism. The hydrolysis of adenosine triphosphate (ATP) powers many anabolic processes. In general, condensation and reduction reactions are the mechanisms behind anabolism.



**Anabolism Examples**

Anabolic reactions are those that build complex molecules from simple ones. Cells use these processes to make polymers, grow tissue, and repair damage.Anabolic hormones stimulate anabolic processes. Examples of anabolic hormones include insulin, which promotes glucose absorption, and anabolic steroids, which stimulate muscle growth. Anabolic exercise is anaerobic exercise, such as weightlifting, which also builds muscle strength and mass.

### Catabolism Definition

Catabolism is the set of biochemical reactions that break down complex molecules into simpler ones. Catabolic processes are thermodynamically favorable and spontaneous, so cells use them to generate energy or to fuel anabolism. Catabolism is exergonic, meaning it releases heat and works via hydrolysis and oxidation. Cells can store useful raw materials in complex molecules, use catabolism to break them down, and recover the smaller molecules to build new products. For example, catabolism of proteins, lipids, nucleic acids, and polysaccharides generates amino acids, fatty acids, nucleotides, and monosaccharides, respectively. Sometimes waste products are generated, including carbon dioxide, urea, ammonia, acetic acid, and lactic acid.

### Catabolism Examples

Catabolic processes are the reverse of anabolic processes. They are used to generate energy for anabolism, release small molecules for other purposes, detoxify chemicals, and regulate metabolic pathways.



### Classification of organism according to respiration

Cellular Respiration: Definition

All living things use cellular respiration to turn organic molecules into energy. **Cellular respiration** is the chemical process of breaking down food molecules in order to create energy in the form of adenosine triphosphate (ATP). This process makes energy from food molecules available for the organism to carry out life processes.

Cellular respiration usually occurs in the presence of oxygen. This is called **aerobic respiration**. When oxygen is not present or present in very low amounts, **anaerobic respiration** takes place.

For some organisms, including many bacteria, anaerobic respiration is a way of life. Fermentation is a specific type of anaerobic respiration that is used by yeast and some bacteria.

Cellular Respiration: Equation

Cellular respiration can be represented by the equation:

$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + ATP$

The **cellular respiration equation** represents the process through which glucose molecules react with oxygen, creating energy in the form of ATP as well as carbon dioxide and water as byproducts.

Cellular respiration is a series of smaller chemical reactions that can vary depending on the type of organism; however, the cellular respiration equation represents the main components of this process that are common among most organisms.

Types of Cells That Undergo Cellular Respiration

Living organisms can be grouped into two categories: eukaryotes and prokaryotes. **Eukaryotes** are organisms whose cells have a nucleus and membrane-bound organelles. **Prokaryotes** are organisms whose cells lack a nucleus.

Eukaryotes carry out cellular respiration with the help of mitochondria. **Mitochondria** are organelles that produce the enzymes necessary to catalyze the series of reactions that produce ATP. Mitochondria are required to carry out cellular respiration in eukaryotic organisms. Types of organisms with eukaryotic cells include animals, plants, fungi and protists.

Prokaryotes do not have mitochondria and produce the enzymes for cellular respiration using their cell membrane. Although they lack mitochondria, these types of cells can still undergo a form of cellular respiration to turn their food molecules into usable energy in the form of ATP.

Two Types of Organisms

There are two main types of organisms that use cellular respiration: autotrophs and heterotrophs.

**Autotrophs** are organisms that can make their own food. The types of organisms that are autotrophs include plants as well as some bacteria and protists (such as algae).

**Heterotrophs** are organisms that cannot make their own food. The types of organisms that are heterotrophs include animals, fungi, some protists and bacteria.

Autotrophs: Organisms That Can Make Their Own Food

Autotrophs, also known as **producers**, can be grouped into two main categories: photoautotrophs and chemoautotrophs.

The majority of autotrophs are photoautotrophs, which are organisms that use the sun's light to do photosynthesis. Photosynthesis is the process of transforming the sun's energy to make glucose molecules.

Types of organisms that use photosynthesis are plants, some bacteria and plant-like protists.

Cellular Respiration Example: Photoautotrophs

The vast majority of plants are autotrophs and rely on photosynthesis to make their food. When plants are not undergoing photosynthesis, they use cellular respiration to transform the glucose molecules they make into energy they can use for carrying out life's processes.



Plants "breathe" in oxygen during photosynthesis and breathe out carbon dioxide during cellular respiration. This cellular respiration example has a large effect on the composition of the Earth's atmosphere.

Cellular Respiration Example: Chemoautotrophs

Chemoautotrophs are bacteria that can make their own food but use chemicals for this process instead of sunlight. Chemoautotrophs undergo cellular respiration to transform inorganic molecules into energy they can use.

This is a cellular respiration example that occurs in **extreme conditions** that are usually devoid of light and oxygen. These types of organisms transform inorganic molecules such as hydrogen sulfide, methane or ammonia into organic molecules that they can use for food.

Heterotrophs: Organisms That Cannot Make Their Own Food .Organisms that cannot make their own food are called **heterotrophs**.

Another word for heterotrophs is **consumers**. These organisms must consume organic molecules created by other organisms for their food. Heterotrophs will eat autotrophs or other heterotrophs.

Cellular Respiration Example: Heterotrophs

Heterotrophs are required to consume other organisms or parts of organisms in order to obtain their food molecules. They undergo cellular respiration in order to turn the food they eat into energy they can use. Heterotrophs rely on autotrophs that store energy from the sun as biomass that the heterotrophs can consume. Autotrophs that use photosynthesis provide over 99 percent of the energy used to support all life on Earth.

Glycolysis and Krebs cycle

| **Glycolysis** | **Krebs Cycle** |
|---|---|
| It is the first step of respiration yielding two molecules of pyruvic acid after the partial breakdown of a glucose molecule in a set of enzymatic processes | Krebs Cycle is the second step of aerobic respiration in which pyruvate is oxidised completely into inorganic substances forming carbon dioxide |
| Occurs in all the living organisms | Occurs in aerobes |
| Occurs inside the cytoplasm | Occurs inside the mitochondria |
| No carbon dioxide evolved | Carbon dioxide evolved |
| Oxygen not required for glycolysis | Oxygen is required for Krebs Cycle |
| Four ATP molecules are produced in the glycolysis for each glucose molecule | One ATP or GTP molecule is produced by substrate-level phosphorylation in each turn of the Kreb’s cycle |

| | |
|---|---|
| Consumes 2 molecules of ATP for initial phosphorylation of substance molecules | Doesn’t consume ATP |
| Net gain of two molecules of ATP and two molecules of NADH gained for every molecule of glucose broken down | Each turn of the Krebs cycle yields three molecules of NADH and two molecules of FADH2 |
| Occurs as a linear sequence | Occurs as a cyclic sequence |

Respiration is an essential process that occurs in all living beings in which oxygen is utilised and carbon dioxide is released from the body. The mechanism of cellular respiration involves the following mechanism:

- Glycolysis – Partial breakdown of Glucose to Pyruvic acid (Anaerobic)
- Krebs Cycle – Complete oxidation of Pyruvate to release Carbon dioxide (Aerobic respiration)
- Electron Transport system – Oxidation of NADH and FADH2 to generate ATP

Here, in the article, let us discuss the difference between the Krebs Cycle and glycolysis but first let us take a look at what each of these terms means.

**Glycolysis –** It is an anaerobic process, which occurs in the cytoplasm of the cell. In glycolysis, partial oxidation of glucose occurs, which yields two molecules of pyruvic acid.

**Krebs Cycle –** It is an aerobic process that takes place in the mitochondria of the cell. It gives Carbon dioxide after complete oxidation of pyruvic acid formed during glycolysis.