# Structure and function of eukaryotic cell

**Eukaryotic** have evolved ways to partition off different functions to various locations in the cell. In fact, specialized compartments called organelles exist within eukaryotic cells for this purpose. Different organelles play different roles in the cell. Nearly all eukaryotic organelles are separated from the rest of the cellular space by a membrane.

## The nucleus

The nucleus houses the **genetic material** within eukaryotic chromosomes. Each chromosome contains one long DNA molecule associated with many proteins. The complex of DNA and proteins making up chromosomes is called chromatin. It contains chromatin in a semifluid matrix called the nucleoplasm. Chromatin condenses into chromosomes, just before the cell divides. Each eukaryotic species has a characteristic number of chromosomes.

It is separated from the cytoplasm by a **double membrane** (nuclear envelope). The two membranes, each a lipid bilayer with associated proteins, are separated by a space of 20–40 nm. The nuclear side of the envelope is lined by the nuclear lamina, a netlike array of protein filaments that maintains the shape of the nucleus by mechanically supporting the nuclear envelope. The nuclear envelope has nuclear pores to permit the passage of ribosomal subunits and mRNA out of the nucleus and the passage of proteins from the cytoplasm into the nucleus. At the lip of each pore, the inner and outer membranes of the nuclear envelope are continuous.

A prominent structure within the nondividing nucleus is the **nucleolus**. Here a type of RNA called **ribosomal RNA** (rRNA) is synthesized from instructions in the DNA. Also in the nucleolus, proteins imported from the cytoplasm are assembled with rRNA into large and small subunits of ribosomes. These subunits then exit the nucleus through the nuclear pores to the cytoplasm, where a large and a small subunit can assemble into a ribosome. Sometimes there are two or more nucleoli; the number depends on the species and the stage in the cell’s reproductive cycle.

The nucleus directs protein synthesis by synthesizing **messenger RNA** (mRNA) according to instructions provided by the DNA. The mRNA is then transported to the cytoplasm via the nuclear pores. Once the mRNA molecule reaches the cytoplasm, ribosomes translate the mRNA’s genetic message into the primary structure of a specific polypeptide.

## Ribosomes

Ribosomes are complexes made of **ribosomal RNA** and **protein**. They are the cellular components that carry out **protein synthesis**. They are consist of 2 subunits. Each subunit has its own mix of proteins and rRNA. Free ribosomes are suspended in the cytosol, while bound ribosomes are attached to the outside of the endoplasmic reticulum. Most of the proteins made on free ribosomes function within the cytosol. Bound ribosomes generally make proteins that are destined for insertion into membranes, for packaging within certain organelles, or for export from the cell (secretion) -> Only if the protein being synthesized by a ribosome begins with a sequence of amino acids called a signal peptide. The signal peptide binds a particle SRP (signal recognition particle), which then binds to a receptor on the endoplasmic reticulum.

## Endoplasmic reticulum

The endoplasmic reticulum is consisting of a complicated system of **membranous cannes and sacules**. It is physically continuous with the nuclear envelope. It forms vesicles that transport molecules to other parts of the cell, notably the Golgi apparatus. The ER membrane separates the internal compartment of the ER, called the ER lumen (cavity) or cisternal space, from the cytosol. And because the ER membrane is continuous with the nuclear envelope, the space between the two membranes of the envelope is continuous with the lumen of the ER.

**Rough endoplasmic reticulum** is studded with **ribosomes**. It has the capacity to produce **proteins**. Inside its lumen, rough ER contains enzymes that can add carbohydrate chains to proteins. Many cells secrete proteins that are produced by ribosomes attached to rough ER. In addition to making secretory proteins, rough ER is a membrane factory for the cell; it grows in place by adding membrane proteins and phospholipids to its own membrane. As polypeptides destined to be membrane proteins grow from the ribosomes, they are inserted into the ER membrane itself and anchored there by their hydrophobic portions. Like the smooth ER, the rough ER also makes membrane phospholipids; enzymes built into the ER membrane assemble phospholipids from precursors in the cytosol. The ER membrane expands, and portions of it are transferred in the form of transport vesicles to other components of the endomembrane system.

**Smooth ER**, which is continuous with rough ER, does not have attached ribosomes. The smooth ER functions in diverse **metabolic processes**, which vary with cell type. These processes include synthesis of lipids, metabolism of carbohydrates, detoxification of drugs and poisons, and storage of calcium ions. Enzymes of the smooth ER are important in the synthesis of lipids, including oils, steroids, and new membrane phospholipids. Other enzymes of the smooth ER help detoxify drugs and poisons, especially in liver cells. Detoxification usually involves adding hydroxyl groups to drug molecules, making them more soluble and easier to flush from the body. The smooth ER also stores calcium ions. In muscle cells, for example, the smooth ER membrane pumps calcium ions from the cytosol into the ER lumen. When a muscle cell is stimulated by a nerve impulse, calcium ions rush back across the ER membrane into the cytosol and trigger contraction of the muscle cell. In other cell types, calcium ion release from the smooth ER triggers different responses, such as secretion of vesicles carrying newly synthesized proteins.

## The Golgi apparatus

The GA sorts the modified molecules and packges them into vesicles that depart from the outer face. It is a stack of flattened saccules. One side of the stack (cis) is directed toward the ER, and the other side (trans) is directed toward the plasma membrane. Protein-filled vesicles that bud from the rough ER and lipid-filled vesicles that bud from the smooth ER are received by the GA at its inner face. The GA alters these substances as they move through its saccules.

## Lysosomes

They are membrane bounded vesicles produced by the Golgi apparatus. They have a very low pH and store powerful hydrolytic-digestive enzymes. Lysosomes assist in digesting material taken into the cell, and they destroy nonfunctional organelles and portions of cytoplasm.

## Peroxisomes

Peroxisomes are membrane-bounded vesicles that enclose enzymes. The enzymes in peroxisomes are synthesized by free ribosomes and transported into a peroxisome from the cytoplasm. They are prevalent in cells that are synthesizing and breaking down lipids. Some peroxisomes use oxygen to break fatty acids down into smaller molecules that are transported to mitochondria and used as fuel for cellular respiration. Peroxisomes in the liver detoxify alcohol and other harmful compounds by transferring hydrogen from the poisons to oxygen. Peroxisomes contain enzymes that remove hydrogen atoms from various substrates and transfer them to oxygen (O2), producing hydrogen peroxide (H2O2) as a by-products. The H2O2 formed by peroxisomes is itself toxic, but the organelle also contains an enzyme that converts H2O2 to water.

## Vacuoles

They are membranous sacs. They usually store substances. Plants have central vacuole which maintains hydrostatic pressure or turgor pressure in plant cells. It functions in storage of other nutrients and waste products. It can have also lysosomal-like function.

## Chloroplasts

Chloroplasts use **solar energy** to **sythesize carbohydrates**. They are bounded by a **double membrane**, which includes an outer membrane and inner membrane. The double membrane encloses the semifluid stroma, which contains enzymes and thylakoids. The thylakoids are disklike sacs formed from a third chloroplas membrane. Chlorophyll and the other pigments that capture solar energy are located in the thylakoid membrane, and the enzymes that synthesize carbohydrates are located outside the thylakoid in the fluid of the stroma. Their shape is changeable. They can grow and occasionally pinch in two, reproducing themselves. They are mobile and move around the cell along tracks of the cytoskeleton.

They are derived from a photosynthetic bacterium that was engulfed by a eukaryotic cell. Chloroplasts have their **own prokaryotic-type chromosome and ribosomes**.

## Mitochondria

Mitochondria have **two membranes**, the outer membrane and the inner membrane. The inner membrane is highly convoluted into cristae that project into the matrix. The inner membrane encloses a semifluid matrix, which contains mitochondrial DNA and ribosomes. They produce most of the ATP utilized by the cell. They are place of cellular respiration. Mitochondria can moving, changing their shapes, and fusing or dividing in two. Early ancestor of eukaryotic cells engulfed an oxygen-using nonphotosynthetic prokaryotic cell. The engulfed cell formed a relationship with the host cell in which it was enclosed, becoming an endosymbiont. Over the course of evolution, the host cell and its endosymbiont merged into a single organism, a eukaryotic cell with a mitochondrion.

## Cytoskeleton

Cytoskeleton contains actin filaments,intermediate filaments and microtubules. It maintains cell shape and allow the cell and its organelles to move. It is very dynamic part of the cell.

Actin filaments are long, extremely thin, flexible fibers that occur in bundles or meshlike networks. Each actin filament contains two chains of globular actin monomers twisted about one another in a helical manner. They play a structural role. They interact with motor molecules. Intermediate filaments are ropelike assembly of fibrous polypeptides. Some intermediate filaments support the nuclear envelope, whereas others support the plasma membrane. They are also highly dynamic and will disassemble when phosphate is added to them by a kinase. Microtubules are made of a globular protein called tubulin, which is of two types called α and β. When assembly occurs, α and β tubulin molecules come together as dimers, and the dimers arrange themselves in rows. Microtubules have 13 rows of tubulin dimers, surrounding empty central core. The regulation of microtubule assembly is under the control of a microtubule organizing center (MTOC). In most eukaryotic cells, the main MTOC is in the centrosome. Microtubules radiate from the centrosome, helping to maintain the shape of the cell and acting as tracks along which organelles can move. The motor molecules kinesin and dynein are associated with microtubules. Before a cell divides, microtubules disassemble and then reassemble into a structure called a spindle.

## Plasma Membrane

The membrane is composed of a phospholipid bilayer in which proteins are embedded (integral proteins) or also occur on the cytoplasmic side (peripheral proteins). The two sides of the plasma membrane are not identical. The hydrophobic tails of phospholipids make up the interior of the membrane and the hydrophilic polar heads naturally face the outside and inside of the cell. In the animal plasma membrane is found also cholesterol, which helps modify the fluidity of the membrane. The plasma membrane is differentially permeable (certain substances can move across the membrane while others cannot). Small, noncharged molecules ($CO_2$, $O_2$, glycerol, alcohol) can freely cross the membrane (follow their concentration gradient).

## Cell wall

The cell wall is an extracellular structure of plant cells that maintains cell’s shape and protects cell from mechanical damage. All plant cells have a primary cell wall. The primary cell wall contains cellulose fibrils in which microfibrils are held together by noncellulose substances. Pectins allow the wall to stretch when the cell is growing, and noncellulose polysaccharides harden the wall when the cell is mature. Between primary walls of adjacent cells is the middle lamella, a thin layer rich in pectins. The middle lamella glues adjacent cells together. Some cells in woody plants have a secondary wall that forms inside the primary cell wall. The secondary wall has a greater quantity of cellulose fibrils than the primary wall. Lignin is a common ingredient of secondary cell walls in woody plants and it adds strength. Plant cell walls are usually perforated by channels between adjacent cells called plasmodesmata.