

The Subcellular Structure

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The unit of life, the cell, is an unbelievable highly organized institute of factories. The biological world has two types of cells:

The Prokaryotic Cells

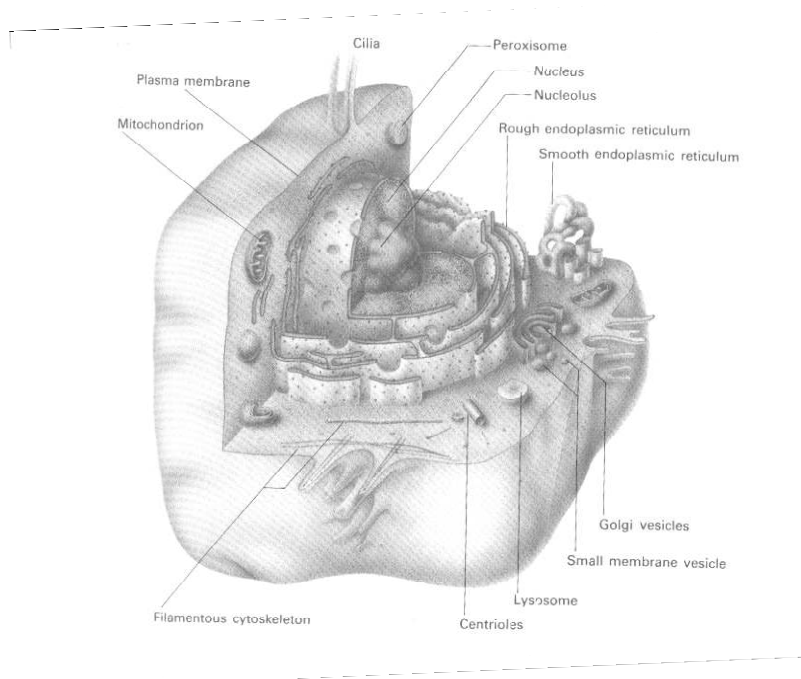
These anuclear cells have no internal compartments and therefore there is a seamless coupling of their gene function and other events in the cells.

The Eukaryotic Cells

Which are those containing a nucleus and other intracellular compartments and thus with more complicated modes of gene regulation.

The eukaryotic cell is an institute with well timed, well organized chemical processes occurring in highly specialized factories, which are the intracellular compartments that are connected

Figure 1. The structure of the cell and its different



organelles.

together by a set of channels.

The fence of our institute is the **plasma**

membrane which is a semipermeable barrier surrounding the outer perimeter of the cell separating the cell cytoplasm from the extracellular medium. This plasma membrane can allow nutrients to enter the cell, can keep out unwanted materials in the extracellular milieu, can transport metabolic wastes out into the extracellular fluid, can prevent needed metabolites and ions from leaving the cell and at last can maintain the proper ionic composition and osmotic pressure of the cytosol, specialized areas of the plasma membrane contain proteins that make contact with other cells to strengthen tissues and to allow the exchange of metabolites between cells.

The head of all the composing factories of the institute is the largest organelle which is the **nucleus**. The major physiological function of the nucleus is synthesis of RNA. In a nucleus that is not during cell division, the chromosomes are dispersed and are only about 25 nm thick. They can't be observed by the light microscope. However a suborganelle of the nucleus, the **nucleolus**, is easily recognized under the light microscope. Most of the cell's Ribosomal RNA is synthesized in the nucleolus, some ribosomal

proteins are added to ribosomal RNAs within the

nucleus as well. The finished or partly finished ribosomal subunit passes through a nuclear pore to the cytosol.

In the nucleus, the non-nucleolar regions is called the **nucleoplasm**. It contains areas of high DNA concentration often closely associated with the nuclear membrane.

The nucleus is actually surrounded by two membranes. Each one is a phospholipids bilayer containing many different types of proteins. The inner nuclear membrane defines the nucleus itself. In many cells the outer nuclear membrane is continuous with rough endoplasmic reticulum, and the space between the inner and outer nuclear membranes is continuous with the lumen or the inner cavity of the rough endoplasmic reticulum.

The **cytosol** is the fluid region of the cell cytoplasm that lies outside the organelles. The cytosol of eukaryotic cells contains a cytoskeleton composed of at least three classes of fibers-tubulin-containing microtubules (20 nm in diameter), actin microfilaments (7 nm in diameter) and intermediate fibers (10 nm in diameter) which contains at least five different subtypes made of different types of proteins.

The **endoplasmic reticulum** is an interconnected network of internal membranes that plays an important role in the synthesis of many membrane lipids and proteins. The smooth endoplasmic reticulum is smooth because it lacks ribosomes while the rough endoplasmic reticulum is studded with ribosomes.

The **smooth endoplasmic reticulum** is the site of synthesis and metabolism of fatty acids and phospholipids. They can also help in modification or detoxification of chemicals.

The **rough endoplasmic reticulum (ER)** has ribosomes bound to it which synthesize certain membrane and organelle proteins and virtually all proteins to be secreted from the cell. The **ribosomes** that fabricate secretory proteins are bound to rough endoplasmic reticulum by the nascent polypeptide chain of the protein. As the growing secretory polypeptide emerges from the ribosome, it passes through the rough ER membrane, with the help of specific proteins in the membrane the newly made secretory proteins accumulate in the lumen (inner cavity) of the rough endoplasmic reticulum before being transported to their next destination.

Several minutes after their synthesis, most proteins leave the rough endoplasmic reticulum within small membrane-bounded transport vesicles that bud off from regions of the rough endoplasmic reticulum not coated with ribosomes. These vesicles carry the proteins to the luminal cavity of another membrane-limited organelle, the **Golgi complex**, a series of vesicles located near the nucleus in many cells.

The Golgi complex is composed of a series of flattened membrane vesicles or sacs, surrounded by a number of more or less spherical membrane vesicles. The stack of flattened golgi vesicles has three defined regions. The *cis*, the medial and the *trans*. The transfer vesicles from the rough endoplasmic reticulum fuse with the *cis* region of the Golgi complex, where they deposit their proteins. These proteins then progress from the *cis* to the medial to the *trans* region, within each region are different enzymes that modify secretory and membrane proteins differently, depending on their structures and their final destinations. After secretory proteins are modified in the Golgi vesicles, they are transported out of the complex by a set of transport vesicles, which seem to bud off the *trans* side of the Golgi complex.

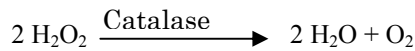
In many cells, the membranes of the secretory transport - vesicles quickly fuse with the plasma membrane releasing their secretory protein contents into the extracellular space - a process termed "exocytosis". In other cells, the secretory transport vesicles fuse with similar vesicles, forming intracellular membrane - limited storage reservoirs for their secretory proteins. These reservoirs do not release their contents into the extracellular fluid until an appropriate signal stimulates the cell to fuse its storage vesicles with the plasma membrane.

No part of a cell is immortal; even in growing cells. The **lysosomes**, membrane-limited organelles found in animal cells, degrade many membranes and organelles that have out lined their usefulness to the cell; they also degrade proteins and particles that are taken up by the cell.

These lysosomes vary in size and shape primary lysosomes are roughly spherical and don't contain obvious particulate or membrane debris Secondary lysosomes are larger and irregularly shaped and do contain particles or membranes that are being digested.

The **peroxisomes** are a class of small, membrane limited organelles found in the

cytoplasm of all animal cells and many plant cells, for a longtime, they were believed to be lysosomes because their morphology resembles that of lysosomes. However, peroxisomes were found to contain enzymes that degrade fatty acids and amino acids, a product of this reaction is H₂O₂ a corrosive substance. Peroxisomes also contain copious amounts of the enzyme catalase which degrades H₂O₂.



The high energy molecules; the ATPase the usual source of chemical energy for cellular growth and metabolism, and the principal sources of ATP in non photosynthetic cells are fatty acids and glucose. The complete aerobic degradation of a glucose molecule is coupled with the production of 32 ATP molecules. The initial stages of glucose degradation occur in the cytosol where two ATP molecules are produced and then the rest of the process is completed within the **mitochondria** where about 30 ATP molecules are produced. Also the oxidation of fatty acids to CO₂ is coupled with ATP production and this also occurs inside the mitochondria.

These mitochondria are regarded as the "power plant" of the cell. They have 2 very different membranes an outer and an inner one. The outer membrane is composed of about half lipid and half protein. It contains proteins that render the membrane permeable to molecules having molecular weight as high as 10,000. In this respect they resemble gram negative bacteria. The inner membrane is much less permeable and about 20% lipid and 80% protein. The surface area of the inner membrane is greatly increased by a large number of infoldings, or cristae, that protrude into the matrix or central space.

The matrix and cristae are sites of the enzymes that catalyze the final oxidation of sugars and lipids and the synthesis of ATP. Mitochondria have their own DNA, which is located in the matrix.

The surfaces of some eukaryotic cells often contain a number of protuberances and extensions that serve specific and important functions. Bunches of microtubules that are structurally similar to the microtubules that compose the mitotic spindle run the length of the central core of **cilia and flagella** the cilia beat backward and forward, while the flagella which are longer than the cilia undulate in a whip like manner and both motions can propel a cell.

The **centrioles** are small cylindrical particles constructed of microtubules, play a key role in organizing the network of microtubules during the prophase and metaphase stages of cell division. During the beginning of mitosis, the two centrioles move apart and microtubules radiate from each centriole in all directions, forming a star. The two centrioles end up at opposite ends of the cells termed the poles of the cells. These radiating microtubules together with associated proteins are called the mitotic spindle. Some of the microtubules connect.

The centrioles with the kinetochores which are granular regions in the centromeres of the chromatids. These microtubules play a role in orienting the chromosomes in the center of the mitotic spindle prior to completion of the process of cell division.

Further Reading

1. Turnpenny PD and Ellard S. Emery's Elements of Medical Genetics. Elsevier, Churchill Livingstone, 2005. 12th Edition.
2. Russell PJ. Genetics. HarperCollins College Publishers, New York, 1996. 14th Edition.