CELLS – THE UNITS OF LIFE

Cells, the smallest structures capable of maintaining life and reproducing, compose all living things, from single-celled plants to multibillion-celled animals. The human body contains more than ten trillion cells; a result of multiple cycles of division after conception from one newly fertilised cell. This process of cellular renewal continues throughout life, where old and weak cells are replaced by new and strong ones.

Ideas about cell structure have changed considerably over the years. Early biologists saw cells as simple membranous sacs containing fluid and a few floating particles. Today's biologists know that cells are infinitely more complex than this. There are many different types, sizes, and shapes of cells in the body. To effectively describe a cell, we can introduce the concept of a "generalised cell". This generalised cell includes features from all cell types. A cell consists of three parts: the cell membrane, the nucleus, and between the two, the cytoplasm. Within the cytoplasm lie intricate arrangements of fine fibres and hundreds or even thousands of miniscule but distinct structures called organelles. The shapes of cells are quite varied with some, such as neurons, being longer than they are wide and others, such as parenchyma (a common type of plant cell) and erythrocytes (red blood cells) being equi-dimensional. Some cells are encased in a rigid wall, which constrains their shape, while others have a flexible cell membrane (and no rigid cell wall). The size of cells is also related to their function. Eggs (*ova*) are very large, often being the largest cells an organism produces. The size of ova is related to the process of development occurring after fertilisation; the contents of the egg (now termed a zygote) are used in a rapid series of cellular divisions, each requiring tremendous amounts of energy that is available in the zygote cells.

GENERAL ASPECTS OF CELL STRUCTURES AND THEIR RESPECTIVE FUNCTIONS

Cell Membrane

Every cell in the body is enclosed by a cell (plasma) membrane. The cell membrane separates extra cellular material from intracellular material. It maintains the integrity of a cell and controls passage of material into and out of the cell. The cell membrane functions as a semi-permeable barrier, allowing few molecules across it while fencing the majority of organically produced chemicals within the cell. Electron microscopic examinations of cell membranes have led to the development of the lipid bilayer model (also referred to as the fluid-mosaic model). The most common molecule in the model is the phospholipid, which has a polar (hydrophilic) head and two non-polar (hydrophobic) tails. These phospholipids are aligned tail to tail so the non-polar areas form a hydrophobic region between the hydrophilic heads on the inner and outer surfaces of the membrane. This layering is termed a bilayer since an electron microscopic technique known as freeze-fracturing is able to split the bilayer. Cholesterol is another important component of cell membranes embedded in the hydrophobic areas of the inner (tail-tail) region. Most bacterial cell membranes do not contain cholesterol. Proteins in the cell membrane provide structural support, form channels for the passage of materials, act as receptor sites, function as carrier molecules, and provide identification markers. Proteins are suspended in the inner layer, although the more hydrophilic areas of these proteins "stick out" into the cells interior and out of the cell's exterior. Known as gateway proteins, these integral molecules function as gateways that will, in exchange for a price, allow certain molecules to cross into and out of the cell. The outer surface of the plasma membrane will tend to be rich in glycolipids, with their hydrophobic tails embedded in the hydrophobic region of the membrane.

The contents (both chemical and organelles) of a cell are termed protoplasm, and are further subdivided into cytoplasm (all of the protoplasm except the contents of the nucleus) and nucleoplasm (all of the material, plasma and DNA etc. within the nucleus).

Cell Wall

The cell wall is a component that not all cells of living things contain (i.e. animals and many of the more animal-like protistans). Located outside the plasma membrane, bacteria have cell walls containing peptidoglycan. Plant cells have a variety of chemicals incorporated in their cell walls. Cellulose is the most common chemical in the primary cell wall of a plant cell. Some plant cells also have lignin and other chemicals embedded in their secondary walls. Chemical cell-to-cell communication through thick cell walls is conducted through connections known as plasmodesmata. Fungi and many protists have cell walls: not containing cellulose, but rather a variety of chemicals (chitin for fungi).

Nucleus

Formed by a nuclear membrane around a fluid nucleoplasm, the nucleus is the control centre of the cell. The nucleus can lie in the most varied positions within a cell – most frequently located in the centre. The nucleus determines the basic structure and function of a given cell, and is also responsible for the transfer of nucleolar substances to the cytoplasm. The nucleus occurs only in eukaryotic cells, and is the location of the majority of different types of nucleic acids. Deoxyribonucleic acid (DNA) is the genetic material for all living organisms, and contains information that is essential for heredity. DNA is what makes each individual different from the next. With the exception of plastid (cpDNA) and mitochondrial DNA (mDNA), all DNA is restricted to the nucleus. In every cell there are highly specific ribonucleic acids - RNA - the composition of which is dependant upon DNA. RNA is formed in the nucleus by utilising DNA as a template for synthesis. RNA then moves out into the cytoplasm and directs the manufacture of proteins as well as cellular reproduction, which is accomplished by RNA functioning in a template like fashion. Consequently, the cell divides, producing daughter cells identical to the parent.

Nucleolus

The nucleolus is an area of the nucleus (usually 2 nucleoli per nucleus) that is the site of ribosome assembly. It consists of RNA, proteins, DNA and ribosomes in different synthesis stages. Each cell's nucleus typically contains one or more nucleoli, which appear as irregularly shaped, dense areas of fibres and granules. Ribosomes are small particles composed of RNA that are the foundation for synthesis of proteins. Ribosomes can be found in clusters along the membranes of the nuclear envelope and endoplasmic reticulum (smooth and rough). They can also be found in the cytoplasm as dark granules. Genetic information for ribosomal proteins, found in the nucleus, is copied into a specific type of messenger RNA (mRNA). The mRNA then travels out of the nucleus into the cell's cytoplasm where this information is translated into ribosomal proteins. The new proteins enter the nucleolus and combine with RNA to create large and small ribosomal structures. These ribosomal structures exit the nucleus and enter the cytoplasm where they are able to make a complete ribosome. It takes about an hour for the nucleolus to make a single ribosome, but thousands are made by each nucleolus at the same time.

Cytoplasm

Involved in protein synthesis, the cytoplasm is the material between the cell membrane and the nuclear envelope. It consists of a solid plasma-gel (ectoplasm) and a fluid plasma-gel (endoplasm). If a cell's organelles (nucleus, mitochondria, Golgi apparatus, centrosomes, microsomes, ergastoplasm) are removed from the cell, the cytoplasm remains. Fibrous proteins in the cytoplasm, referred to as the cytoskeleton maintain the shape of the cell as well as anchoring organelles, moving the cell and controlling internal movement of structures.

Vacuoles

Vesicular structures of varying size can often be seen in the nucleoli and cytoplasm of living cells. Known as vacuoles, they are single-membrane organelles that are essentially part of the outside that is located within the cell. Many organisms will use vacuoles as storage areas. Vacuoles also serve the purpose of transporting material into and out of a cell.

Ribosomes

Ribosomes are the sites of protein synthesis. They are not membrane-bound and thus occur in both prokaryotes and eukaryotes. Eukaryotic ribosomes are slightly larger than prokaryotic ones. Structurally the ribosome consists of a small and larger subunit. Bio-chemically, the ribosome consists of ribosomal RNA (rRNA) and some 50 structural proteins. Often ribosomes cluster on the endoplasmic reticulum, in which case they resemble a series of factories adjoining a railroad line.

Endoplasmic Reticulum

The endoplasmic reticulum is a mesh of interconnected membranes whose function involves protein synthesis and transport. The rough endoplasmic reticulum (rough ER) has a rough appearance due to the numerous ribosomes that occur along it. The rough ER connects to the nuclear envelope through which messenger RNA (mRNA); the blueprint for proteins; travels to ribosomes. The smooth ER lacks the ribosome characteristic of the rough ER and is thought to be involved in transport and a variety of other functions.

Golgi Apparatus and Dictyosomes

Golgi Complexes are flattened stacks of membrane-bound sacs. They function as a packaging plant, modifying vesicles from the rough ER. New membrane material is assembled in various cisternae of the Golgi apparatus.

Mitochondria

Mitochondria contain their own DNA (mDNA) and are thought to represent bacteria-like organisms over 700 million years ago (perhaps even as far back as 1.5 billion years ago). They function as the sites of energy release (following glycolysis) and adenosine tri-phosphate (ATP) formation. The mitochondrion has been termed the powerhouse of the cell. Mitochondria are bound by two membranes. The inner membrane folds into a series of cristae, which are the surfaces on which ATP is generated. During the 1980s, the theory of endosymbiosis was proposed to explain the origin of mitochondria and chloroplasts from prokaryotes. According to this idea, a larger prokaryote (or early eukaryote) engulfed a smaller prokaryote about 1.5 billion to 700 million years ago. Instead of digesting the smaller organism, the large organism and the smaller became mutualistic, a type of symbiosis where both organisms benefit and neither is harmed. The larger organism gained excess ATP provided by the "protomitochondrion" and excess sugar provided by the "protochloroplast", while providing a stable environment and the raw materials the endosymbionts required. Eukaryotic cells cannot survive without mitochondria (likewise photosynthetic eukaryotes cannot survive without chloroplasts), and endosymbionts are unable to survive outside their hosts. Nearly all eukaryotes have mitochondria.

Cell Movement

Cell movement is both internal and external, referred to as cytoplasmic streaming motility respectively. Cytoplasmic streaming of organelles is governed by actin filaments. These filaments make an area in which organelles such as chloroplasts can move. Internal movement is known as cytoplasmic streaming. Motility is determined by organelles that specialise in locomotion.

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