

BIO 101

INTRODUCTORY BIOLOGY I

THE CELL

A cell may be defined as the standard unit of biological activity bounded by a membrane, and able to reproduce itself independently of any other living system. All living organisms, large and small, plant and animal, fish and fowl, man and microbe, are made up of cells. All cells are basically similar to each other, having many structural features in common. Organisms may be composed of only one cell, when we describe them as being unicellular, or of many cells when we say they are multicellular. With the exception of eggs, which are the largest cells (in volume) known, cells are small and mostly invisible to the unaided eye. Consequently, our understanding of cells paralleled technical advances in the resolving power of microscopes. Englishman Robert Hooke first saw the remains of dead cells in 1665 in a piece of cork as he was using his newly invented microscope and he coined the word "cell" to describe the tiny structures, thinking that they resembled the unadorned cells occupied by the monks. In 1838 Matthias Schleiden, a German botanist, announced that all plant tissues were composed of cells. A year later one of his countrymen, Theodor Schwann, described animal cells as being similar to plant cells. Schleiden and Schwann are thus credited with the unifying cell theory. Some 20 years after the announcements of Schleiden and Schwann, Rudolf Virchow, a great German physician, made another important generalization, cells come only from pre-existing cells.

Cells are separated from their external environment by an interface or plasma membrane. Everything inside the plasma membrane is sometimes referred to as protoplasm, consisting of the jelly like cytoplasm (cyto-cell, plasma thing) and various structures collectively known as organelles, including the membrane, bound nucleus. Each organelle represents a highly specialized compartment or submodule in which particular functions of the cell are localized.

(diagram)

STRUCTURE AND FUNCTIONS

The Plasma membrane: Typically the eukaryotic cell is enclosed within a thin, sturdy, differentially permeable plasma membrane. This structure regulates the flow of materials between the cell and its surroundings. In some cells, such as nerve cells, the plasma membrane also is involved in intercellular communication. In other cells, such as intestinal epithelium, the plasma membrane is modified into numerous, small, finger-like projections called microvilli that increase the surface area of the cell. Chemically, the membrane consists of lipid (fatty material) and protein.

Endoplasmic reticulum and ribosomes: transport, storage and synthesis: The endoplasmic reticulum is visible in great detail with the electron microscope and consists of an extensive network of membrane-enclosed spaces. The space is referred to as the cisterna. The membranes of the endoplasmic reticulum may appear smooth along their outer surface. However, sometimes the outer surface is studded with small particles called ribosomes, and in this case the endoplasmic reticulum has a coarse appearance and is spoken of as rough. The R.E.R. is found with greater frequency and abundance in cells which are actively synthesizing protein. The manufacture of proteins in the cell is associated with the ribosomes, which are dense particles containing protein and ribonucleic acid (RNA).

The E.R. by virtue of its extensive branching, functions in transport, the cisterna of the E.R. apparently function as roots for transport of certain substances within the cell. In some cases, the ER accumulates large masses of protein and acts in a storage capacity.

The Golgi complex: is a stack of smooth, membraneous cisternae that functions in the storage, modification and packaging of protein products, especially secretory products. It does not synthesize protein but may add polysaccharide to the complex. As its products mature, the ends of the cisterna pinch off and become membrane-bound vesicles in the cytoplasm. The contents of some of these secretory products destined to be exported from a glandular cell. Others may contain digestive enzymes that remain in the cell that produce them. Such vesicles are called Lysosomes (literally "loosening body", a body capable of causing lysis, or disintegration). The enzymes they contain are involved in the breakdown of foreign materials, including bacteria engulfed

by the cells. Lysosomes are also capable of breaking down injured or diseased cells and worn-out cellular components, since the enzymes they contain are so powerful that they kill the cell that formed them if the lysosomes membrane ruptures. In normal cells the enzymes remain safely enclosed within the protective membrane.

**Mitochondria:** These organelles are conspicuous organelles present in nearly all eukaryotic cells. They are diverse in size, number and shape, some are rodlike, and others are more or less spherical. They may be scattered uniformly the cytoplasm, or they may be localized near cell surfaces and other regions where there is unusual metabolic activity. The mitochondrion is composed of a double membrane. The outer membrane is smooth, whereas the inner membrane is folded into numerous platelike projections called cristae. These characteristics features make mitochondria easy to identify among the organelles. They are often called “powerhouse of the cell” because enzymes located on the cristae carry out the energy-yielding steps of aerobic metabolism. ATP, the most important energy storage molecule of the cells, is produced in the organelle. Mitochondria are self-replicating.

**Chloroplasts:** The food we eat and the oxygen we breath are produced by organelles called chloroplasts. They are found in green plants. They are disc-shaped bodies containing a green pigment called chlorophyll. The complex chemical processes of photosynthesis take place in the chloroplast where the energy of sunlight is trapped and utilized for the synthesis of complex organic materials from simple inorganic molecules. Each chloroplast is surrounded by two membranes that enclosed its contents and separate it from the cytoplasm. The internal portion of the chloroplast consists mainly of two parts: a fluid matrix (stroma) surrounding a complex membrane. The membrane system generally consists of a series of multilayered fluid-fluid discs (grana) resembling a stack of coins and a system of closed flat sacs (lamellae) extending throughout the chloroplast and connecting the grana.

Higher plants contain a variety of intracellular bodies called plastids. Usually there are two types; the chromoplasts (coloured bodies) and leucoplasts (white or colourless

bodies). Chloroplasts belong to the chromoplasts group. Other kinds of chromoplasts give many flowers and leaves their colours or yellow, orange or red. Leucoplasts serve as food storage deposits for the cell and contain oil, starch grains and protein.

**Vacuoles: inner space:** The cell may contain fluid filled spaces surrounded by a membrane, called vacuoles. Plant cells have more prominent vacuoles in young plant cells the vacuoles are many and they are rather small, but as the plant ages (gets older), these vacuoles fuse to form a large, conspicuous central vacuole. The hydrostatic (fluid) pressure of the vacuole forces the cytoplasm to the periphery of the cell, and there it remains as a thin layer closely pressed against the plasma membrane. The vacuole of plant cells contains primarily water and a watery of other substances together called cell sap, because cell sap has a higher osmotic pressure than the external medium, water moves into the cell and the cell becomes turgid. It does not burst because it is surrounded by a rigid cell wall. The turgid nature of the plant cell contribute to the strength of certain plant stems and the crispness of vegetables such as celery and lettuce.

The plant cell stores a number of important substances in the variety fluids of the vacuole, and these include amino acids, proteins, salts, sugars and the red pigment anthocyanin. The red colour of roses, and red onions is due to the presence of anthocyanins in their vacuolar fluid. Vacuoles are formed in animal cells during the processes of pinocytosis and phagocytosis.

**Microtubules and microfilament:** Cellular movements involve two kinds of rodlike structures: microtubules and microfilaments. Microtubules are capable of rapid assembly and disassembly and are primarily composed of the protein tubulin. Microtubules are the structural framework of cilia and flagella; in the mitotic spindle, microtubules act to move the chromosomes during cell division.

The threadlike microfilaments are smaller in diameter than microtubules and do not contain tubulin. They are often associated with the inner surface of the plasma membrane where they occur in bundles and sheets. The muscle-like contractions of

microfilaments are involved in cell movement and changes of cell shape and in cytoplasmic streaming.

Centrioles, cilia and flagella: The centriole ("central body") is a dark central body just outside the nucleus. This densely stained granule plays an important role in the division of animal cells. Centrioles are not indispensable during cell division, however, the cells of higher plants contain no centrioles, and yet are still capable of dividing properly. The centrioles under the electron microscope consist of a circlet of nine microtubules, each of which is further subdivided into three smaller tubules. Centrioles are self-replicating.

The surfaces of many cells have short hair like or long whiplike appendages that move fluid across the surface of the cell. If the cell is free to move on its own, the appendages can propel the cell in a watery medium. The hairlike appendages are called cilia and the whiplike appendages are called flagella. The cells of the fallopian tubes of the female (human) reproductive system and the cells of the trachea are lined with cilia. Spermatozoa produced in the testes of the human male are motile because of the activity of their lashing tails, which are really flagella.

In cells that bear cilia and flagella, the centriole replicates itself, and the copies migrate to the cell surface, where they become basal bodies that in turn give rise to the cilia and flagella. Every cilium and every flagellum has the same structure when viewed with the electron microscope. Each cilium and flagellum is covered by the plasma membrane, and internal to this is a ring of nine pairs of microtubules surrounding two central tubules. The basic structure of these organelles is often referred to as a nine-plus-two arrangement of tubules. Only the cylinder of nine tubules continues below the cell surface and there it forms the basal body, which appears structurally identical to the centriole. The ability to move rhythmically or to beat is an inherent property of cilia and flagella, and even when detached from the cell, they can be made to move.

Nucleus: The most conspicuous feature of a cell viewed with a microscope is the nucleus. The nucleus is a relatively large structure, spherical or avoid in shape and separated from the cytoplasm by a nuclear membrane. The electron microscope

reveals that the nuclear envelope really consists of two membranes and that the membranes have pores that appear to connect the inside of the nucleus (nucleoplasm) with the cytoplasm. The nucleus contains chromatin and one or more dense, granular structures called nucleoli (nucleolus). The chromatin is a complex of DNA and histone and nonhistone protein and carries the genetic information of the cell. Nucleoli are specialized parts of certain chromosomes that carry multiple copies of the DNA information to synthesize ribosomal RNA. After transcription from the nucleolar DNA, the ribosomal RNA combines with several different proteins to form a ribosome. The ribosome detaches from the nucleolus, and passes through nuclear pores to the cytoplasm. The nucleolus may be thought of as the cell's peacemaker since any change in the activity of the nucleolus will result in a change in the growth rate of the cell.

#### Prokaryotic and Eukaryotic cells

There are two general classes of cells: the prokaryotic cell typical of bacteria and blue-green algae (cyanobacteria) and the eukaryotic cell found in all other organisms, plant and animal.

The prokaryotes, meaning literally "before the nucleus" are the simplest cell known. As a rule, these cells are small in dimension: from 0.1 to 0.25cm (micrometers) among the mycoplasmas, the smallest cells known, a few micrometer in length and somewhat less in width among the bacteria, and a bit larger in the blue-green algae. The living portion of the cells of bacteria and blue-green is limited externally by a plasma membrane, outside of which a more or less rigid cell wall and a jellylike, mucilaginous capsule or sheath are present. They contain a single chromosome comprised of a single, large molecule of DNA not located in a membrane-bound nucleus, but found in a nuclear region, or nucleoid. The DNA is not complexed with histone proteins, and prokaryotes lack membraneous organelles such as mitochondria, plastids, golgi apparatus, and endoplasmic reticulum. During cell division, the nucleoid divides without visible chromosomes, never by true chromosome (mitotic) division.

Then eukaryotes ("true nucleus") is a far more elaborate structured and partitioned unit than is the prokaryotic cell from which it is presumably division. An internal division of

labour has taken place, accomplished by the use of membranes. The exterior of the cell is bounded by a plasma membrane, to which, in the case of plant cells, an outer wall of cellulose and other materials have been added. The hereditary material is enclosed in a membrane-bound nucleus and is segmented into complex nucleoprotein bodies or chromosomes, the number of which is characteristic for each species.

Table : The Table below summarizes the existing differences between prokaryotic and eukaryotic cells

Features	Prokaryotes	Eukaryotes
Cell size	Mostly small (1-10cm)	Mostly large (10-100cm)
Plasma membrane	Present	Present
Nuclear membrane	Absent	Present
Genetic system	DNA with some non histone, protein simple, circular chromosome in nucleus, nucleus not membrane bound	DNA complexed with histone and nonhistone; proteins is complex; chromosomes within the nucleus; nucleus with membraneous envelope
Cell division	Direct by binary fission or budding. No mitosis	Some form of mitosis occur; centrioles many, mitotic spindle present
Sexual system	Absent in most; highly modified if present	Present in most; there are male and female partners; gametes that fuse other
Nutrition	Absorption by most, photosynthesis by some	Absorption, ingestion, photosynthesis by some
Intracellular movement	None	Cytoplasmic streaming, phagocytosis, pinocytosis
Mitochondria	Absent	Present
Endoplasmic	Absent	Present

reticulum		
Golgi apparatus	Absent	Present
Ribosomes	Present	Present
Cell wall	Present, composed of amino acids and muramic acid	Lacking in animals, present in plants, with cellulose a major component
Vacuoles	Absent	Present (particularly in plants)

Table 2:

### PLANT KINGDOM

CRYPTOGAMS (Non-flowering plants)

PHANEROGAMS (flowering plants)

Thallophyta

Bryophyta

Pteridophyta

Gymnosperms

Angiosperms

Liverworts  
mosses

-naked ovule

-enclosed ovule

-flowers without

-flowers with

Whorls

whorls

Algae Fungi Lichens

Simplified classification



## 1. OLD CLASSIFICATION

### PLANT KINGDOM

#### DIVISION:

- |                                 |  |
|---------------------------------|--|
| Cryptogams                      | Spermatophyta  |
| Flowerless plants<br>(seedless) | Flowering plants<br>(Seed Plants)                            |
| -Thallophyta                    | - Gymnospermae<br>(naked seed plants) Cycads, conifers, etc. |
| -Byrophyta                      | -Angiospermae<br>(closed – seed plants) monocots & dicots    |
| -Pteridophyta                   |  |

## 2. MODERN CLASSIFICATION

### KINGDOM PLANTAE

#### (A) SUB KINGDOM – Thallophyta (plants not forming standard embryo)

##### DIVISIONS – 1. Algae (phycophyta) 6 classes

- (Cyanophyta) Blue green
- (Euglenophyta) Euglenoids
- Classes - (Bacillarophyta) Diatoms
- (Chlorophyta) Green algae
- (Phacophyta) Brown algae
- (Rodophyta) Red algae

#### II. Fungi (Mycophyta) 6 classes

- (Schizomycophyta) – Bacteria
- (Myxomycophyta) – Slime fungi
- (Eumycophyta) – true fungi
- Classes - (Phycomycetes) - algalike fungi
- (Ascomycetes) – sac fungi
- (Basidiomycetes) – club fungi

(B) SUB KINGDOM: Embryophyta (Plants forming embryo)

DIVISIONS

- I. Bryophyta (Plants with vascular tissues)  
Liverworts, mosses
- II. Tracheophyta (plants with vascular tissues)
  - (a) Pteridophytes, ferns etc.
  - (b) Spermatophyta (i) Gymnosperm (with naked ovules)  
(ii) Angiosperm

Dicots 2 cotyledon embryo

Primary root not persist and give rise to tap root system

- Reticulate venation
- Flower with petalmerous systems
- Vascular bundles arranged in ring

Monocot

- 1 cotyledon embryo