Introduction of Cells (2)

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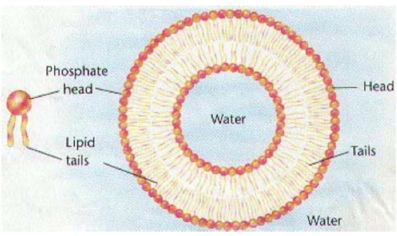
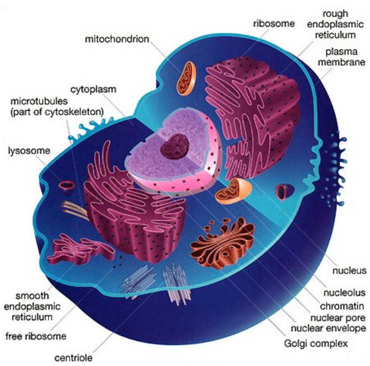
Cell Construction

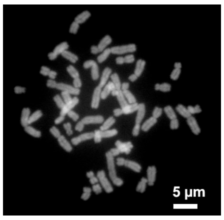
- The structures that make up a Eukaryotic cell are determined by the specific functions carried out by the cell. Thus, there is no typical Eukaryotic cell. Nevertheless, Eukaryotic cells generally have three main components:
  - A Cell Membrane
  - A Nucleus
  - A variety of other Organelles





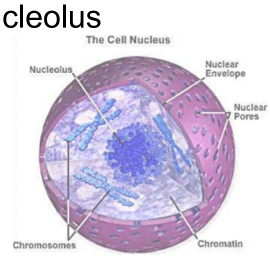
Nucleus (Nuclei)

- The nucleus is normally the largest organelle within a Eukaryotic cell.
- The nucleus contains the cell's chromosomes (human: 46, fruit fly: 6, fern: 1260), which are normally uncoiled to form a chromatinic network, which contain both linear DNA and proteins, known as histones.
- These proteins coil up (dehydrate) at the start of nuclear division, when the chromosomes first become visible.



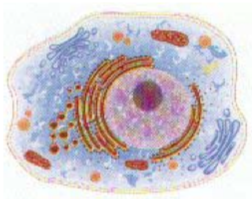
Nucleus (Nuclei)

- The nucleus is surrounded by a double membrane called nucleus envelop, which has many nuclear pores through which mRNA, and proteins can pass. These dimples make it look like a golf ball.
- Most nuclei contain at least one **nucleolus** (nucleoli). The nucleoli are where **ribosomes** (translate mRNA into proteins) are sythesised.
- When a nucleus prepares to divide, the nucleolus disappears.



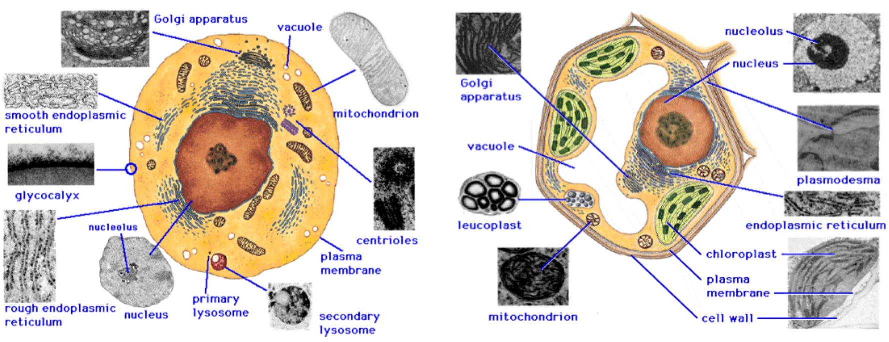
Cytoplasm

- Everything within the cell membrane which is not the nucleus is known as **cytoplasm**.
- **Cytoplasm** = **Cytosol** + **Organelles**
- **Cytosol** is the jelly-like mixture in which the other organelles are suspended
- **Organelles** carry out specific functions within the cell. In Eukaryotic cells, most organelles are surrounded by a membrane, but in Prokaryotic cells there are no membrane-bounded organelles.



Inside the Cell

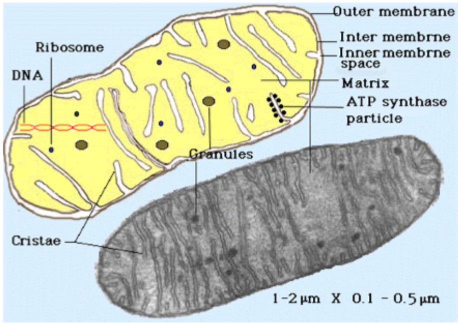
- Inside an animal cell and a plant cell:



An animal cell *A plant cell*

Mitochondria

- Mitochondria are found scattered throughout the cytosol, and are relatively large organelles.
- Mitochondria are the sites of aerobic respiration, in which energy from organic compounds is transferred to ATP. For this reason they are referred to as the **"Powerhouse"** of the cell.



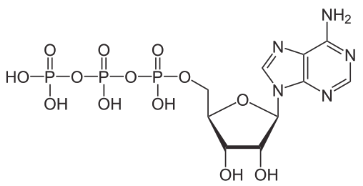
Mitochondria

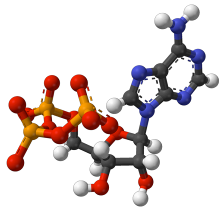
- Mitochondria are more numerous in cells that have a high energy requirement – muscle cells contain a large number of mitochondria, as do liver, heart, and sperm cells.
- Mitochondria are surrounded by two membranes:
  - The smooth outer membrane serves as a boundary between the mitochondria and the cytosol.
  - The inner membrane has many long folds, known as **cristae**, which greatly increase the surface area of the inner membrane, providing more space for ATP sythesis to occur.

Adenosine triphosphate (ATP)

- ATP transports chemical energy within cells for meabolism.
- ATP was discovered in 1929 by Karl Lohmann, but its correct structure was not determined until some years later. It was proposed to be the main energy-transfer molecule in the cell by Frits Albert Lipmann in 1941.

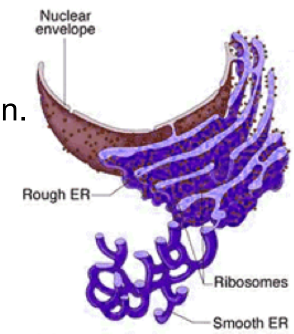
$$ATP + H_2O \rightarrow ADP + P_i \quad \Delta G^\circ = -30.5 \text{ kJ/mol } (-7.3 \text{ kcal/mol})$$
$$ATP + H_2O \rightarrow AMP + PP_i \quad \Delta G^\circ = -45.6 \text{ kJ/mol } (-10.9 \text{ kcal/mol})$$





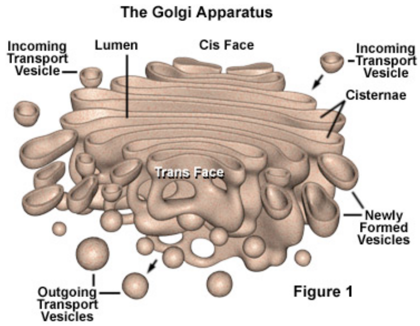
Endoplasmic Reticulum (ER)

- The primary function of the ER is to act as an internal transport system, allowing molecules to move from one part of the cell to another.
- Rough ER is the site of protein synthesis.
- Smooth ER is where polypeptides are converted into functional proteins and where proteins are prepared for secretion. Is is also involved in the regulation of calcium levels in muscle cells, and the breakdown of toxins by liver cells.
- Both types of ER transport materials throughout the cell.



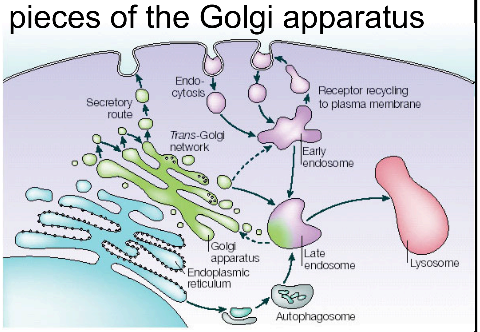
Golgi Apparatus (GA)

- The Golgi Apparatus is the processing, packaging and secreting organelle of the cell.
- The Golgi apparatus is a system of membranes, made of flattened sac-like structures called **cisternae**.
- It works closely with the smooth ER, to modify proteins for export by the cell.



Lysosomes

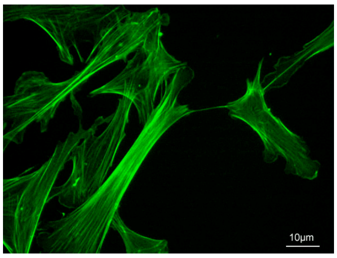
- Lysosomes are small spherical organelles that enclose hydrolytic enzymes within a single membrane.
- Lysosomes are the site of protein digestion – thus allowing enzymes to be re-cycled when they are longer required. They are also the site of food digestion in the cell.
- Lysosomes are formed from pieces of the Golgi apparatus that break off.



Cytoskeleton

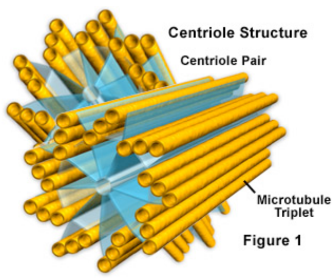
- Just as a human body depends on a skeleton to maintain its shape and size, so a cell needs structures to maintain its shape and size.
- In animal cells, which have no cell wall, an internal framework called the cytoskeleton maintains the shape of the cell, and helps the cells to move.
- The cytoskeleton consists of two structures

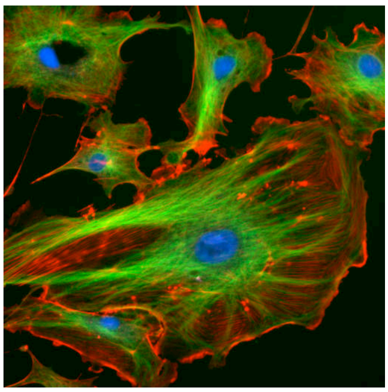
  - **Microfilments** (contractile). They are made of actin, and are common in motile cells.
  - **Microtubules** (rigid, hollow tubes – made of tubulin)



Cytoskeleton - Microtubules

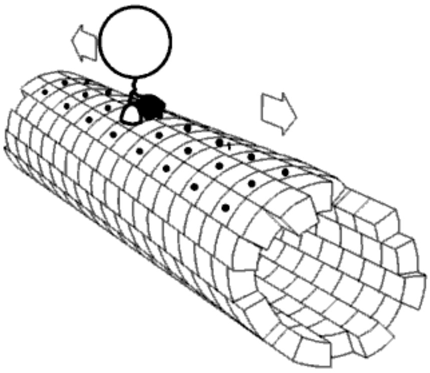
- Microtubules have three functions:
  - To maintain the shape of the cell
  - To serve as tracks for organelles to move along within the cell.
  - They form **centriole**.

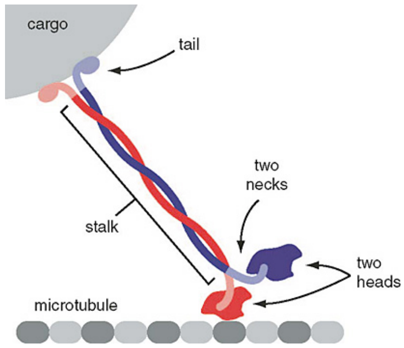




Microtubules and Kinesin

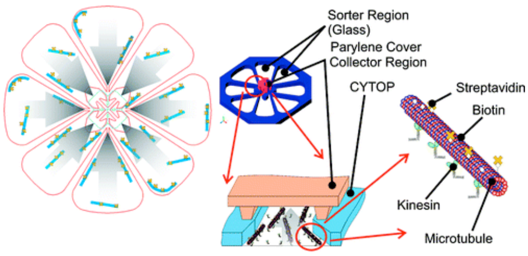
- A **kinesin** is a protein belonging to a class of motor proteins found in eukaryotic cells. Kinesins move along microtubule filaments, and are powered by the hydrolysis of ATP.

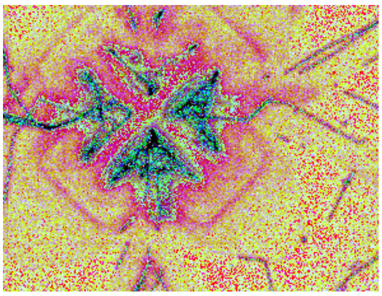


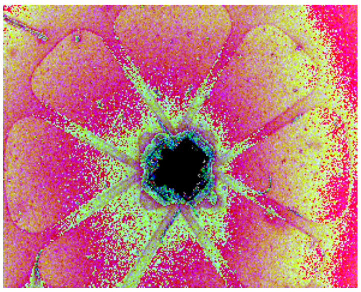


Microtubules and Kinesin

Self-contained, biomolecular motor-driven protein sorting and concentrating in an ultrasensitive microfluidic chip.

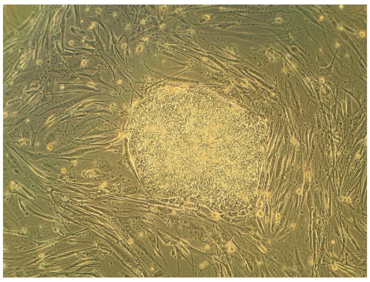






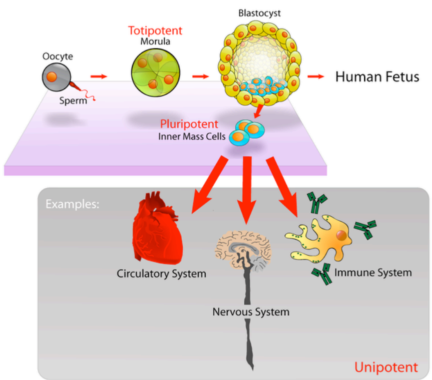
Stem Cell

- Research on stem cells is advancing knowledge about how an organism develops from a single cell and how healthy cells replace damaged cells in adult organisms. This promising area of science is also leading scientists to investigate the possibility of cell-based therapies to treat disease, which is often referred to as **regenerative or reparative medicine.**



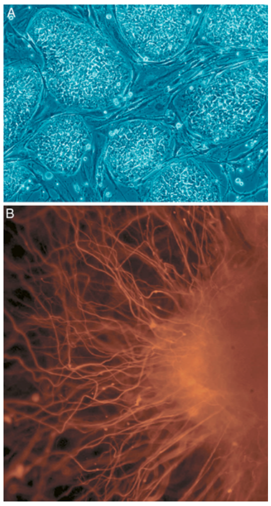
Stem Cell

- The two properties of stem cells:
  - ***Self-renewal***: the ability to go through numerous cycles of cell division while maintaining the undifferentiated state**.**
  - ***Potency***: the capacity to differentiate into specialized cell types. In the strictest sense, this requires stem cells to be either totipotent or pluripotent—to be able to give rise to any mature cell type.



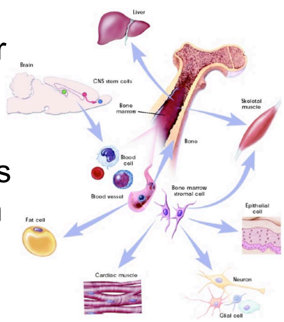
Embryonic Stem Cell

- **Embryonic stem cells**, as their name suggests, are derived from embryos.
- The embryos are typically four or five days old and are a hollow microscopic ball of cells called the **blastocyst**.
- The blastocyst includes three structures: the trophoblast, which is the layer of cells that surrounds the blastocyst; the blastocoel, which is the hollow cavity inside the blastocyst; and the inner cell mass, which is a group of approximately 30 cells at one end of the blastocoel.



Adult Stem Cell

- An adult stem cell is an undifferentiated cell found among differentiated cells in a tissue or organ, can renew itself, and can differentiate to yield the major specialized cell types of the tissue or organ.
- The primary roles of adult stem cells in a living organism are to maintain and repair the tissue in which they are found.
- Unlike embryonic stem cells, which are defined by their origin (the inner cell mass of the blastocyst), the origin of adult stem cells in mature tissues is unknown.



iPS Cells

- iPS cells are typically derived by transfection of certain stem cell-associated genes into non-pluripotent cells, such as adult fibroblasts.
- Transfection is typically achieved through viral vectors.
- Transfected genes include the master transcriptional regulators Oct-3/4 (Pou5f1) and Sox2, although it is suggested that other genes enhance the efficiency of induction.
- After 3–4 weeks, small numbers of transfected cells begin to become morphologically and biochemically similar to pluripotent stem cells, and are typically isolated through morphological selection, doubling time, or through a reporter gene and antibiotic selection.

iPS Cells