- *Cell Theory*
  - *Discovered by Robert Hooke ~ coined the term 'cell'.*
  - *Arises only from pre-existing cells.*
  - *Cells are an organisms basic unit of structure and function.*
  - *The cell is the lowest level of organisation that can perform all activities required for life.*
    - *Single cell (bacteria, protozoa)*
    - *Multi-cellular (animals, plants)*
  - *All enclosed by a membrane.*
  - *DNA – Genetic information.*
  - *Division of cells ~ basis of reproduction, growth and repair.*
  - *Cell size is limited ~ as size increases, it takes longer for material to diffuse from the cell membrane to the interior of the cell.*
  - *SA:V Ratio ~ Cell increases in size, volume increases 10x faster than SA.*
- *Certain structures in common*
  1) *Genetic material*
     - *Information storage ~ DNA*
     - *Duplicator of information ~ DNA replication enzymes*
     - *Information translator ~ ribosome*
  2) *Cytoplasm – Semifluid matrix.*
  3) *Plasma membrane – phospholipid bilayer*
- *Grouping Species*

Taxonomy – classifies species into groups of increasing breadth.

- *Domain Bacteria*
- *Domain Archaea*
- *Domain Eukarya*

- *Types of Cells*

PROKARYOTES

EUKARYOTES

- *Prokaryotes*

These cells thrive almost everywhere, e.g. too acidic, salty, cold or hot.

Mostly microscopic – More in a handful of fertile soil than the number of people who have ever lived.

Structural and functional adaptations contribute to prokaryotic success:

- *Unicellular.*
- *Variety of shapes:*
  - *Spheres (cocci)*
  - *Rods (bacilli)*
  - *Spirals (spirillium)*

- Curved (vibrio)

- Two types of prokaryotes
  1) Bacteria
  2) Archaea

Cell surface structures:

- Cell wall maintains shape, provides physical protection, and prevents the cell from bursting in a hypotonic environment.
- Made of cellulose (chitin).
- Bacterial cell walls contain peptidoglycan (sugar polymers cross-linked by polypeptides).
- Archaea contain polysaccharides and protein but lack peptidoglycan.
- Gram stain – used to classify bacterial species into gram-positive and gram negative groups based on cell wall composition.
  - Gram negative – Less peptidoglycan, outer membrane can be toxic, antibiotic resistant.
  - Gram positive –
- Some prokaryotes have fimbriae – allows them to stick to substrate or other individuals.
- Sex pili are longer than fimbriae and allow DNA exchange.

Reproduction and Adaptation:

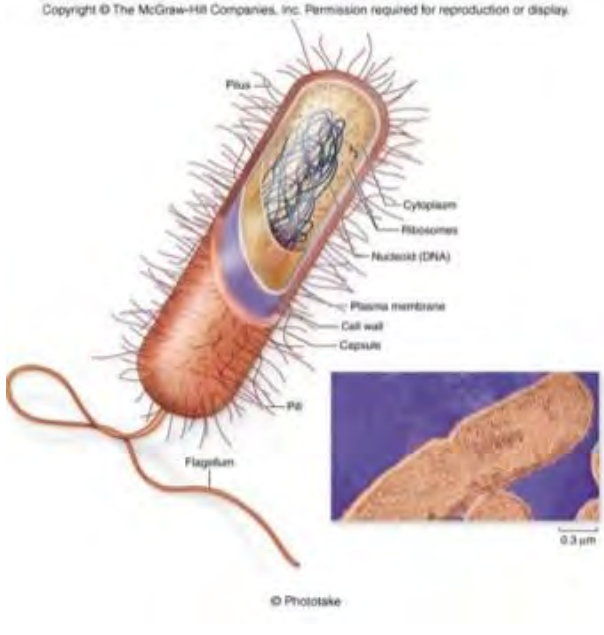
- Reproduce through Binary fission.
- Form endospores, which can remain viable in harsh conditions.
- They do have sex.

Motility (movement):

- Propel themselves by flagella.
- Heterogeneous environment = exhibit taxis, move toward/away from stimuli.

Internal and genomic Organisation:

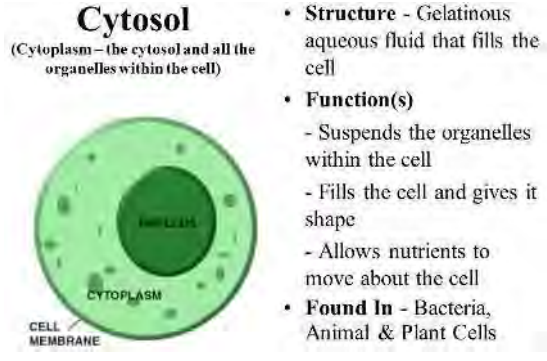
- Lack complex compartmentalisation.
- Some have specialised membranes that perform metabolic functions.
- Genome has less DNA than eukaryote genome.
- Genome consists mainly of circular chromosome.
- Genome = 1000-4000 genes.



- Eukaryotes

Possess a membrane bound nucleus.
Compartmentalize many cellular functions within organelles and the endomembrane system.
Possess a cytoskeleton for support and to maintain cellular structure.
Cytosol:

- *Part of the cytoplasm that is not held by any of the organelles in the cell.*
- *Functions:*
  - ➢ *Location of specific chemical reactions.*
  - ➢ *Storage of fat, carbohydrates as inclusions.*
  - ➢ *Storage of secretory vesicles.*
- *Cytoplasm: Cytosol and organelles.*

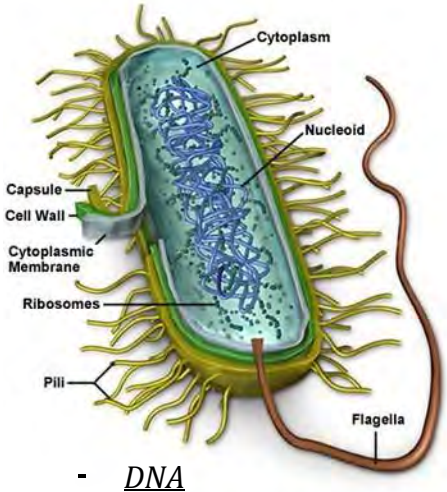


Plasma Membrane:

- *Surrounds cytoplasm, acts as a physical barrier.*
- *Site of attachment of cytoskeleton and membrane associated structures.*
- *Regulates movement of material in/out of cell, thus whole internal environment.*
- *Such materials include oxygen, waste, nutrients.*
- *Double layer of phospholipids = structure.*

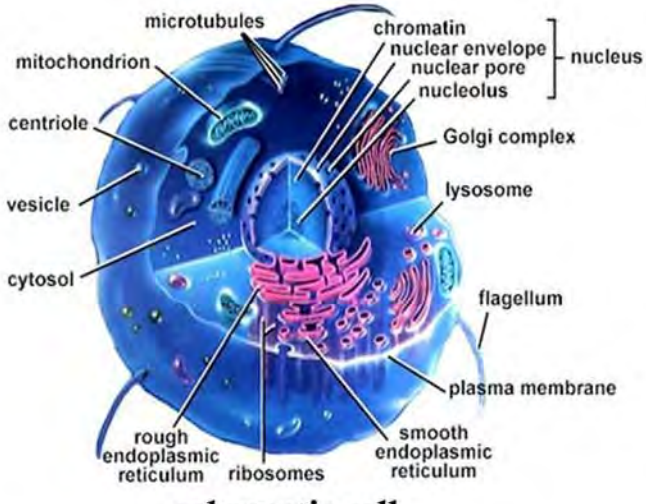
Nucleus of eukaryotes:

- *Contains most of the genes.*
- *Nuclear envelope ~ seperates from cytoplasm.*
- *Nuclear membrane ~ Double membrane (each consists of lipid bilayer).*
- *Pores regulate entry and exit of molecules.*
- *Shape maintained ~ nuclear lamina (composed of protein).*



- *DNA*

prokaryotic cell (bacteria)



eukaryotic cell (protists, fungi, animals, plants)

Transmission and expression of genetic information.

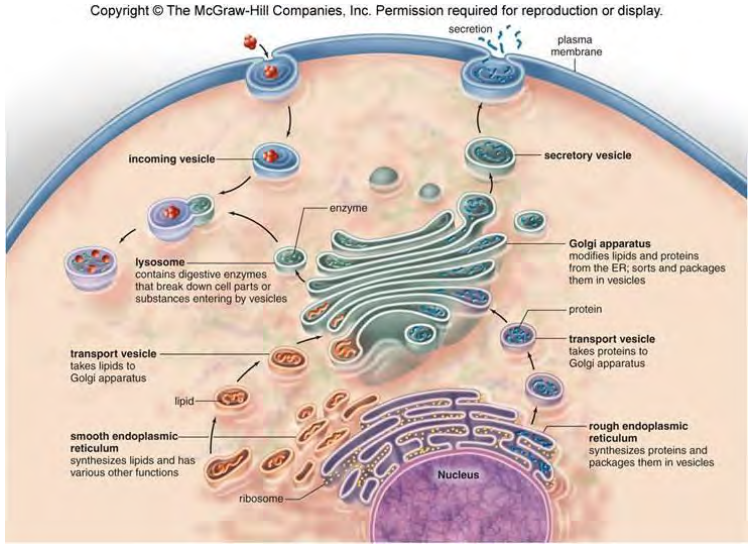
- *Chromosomes consist of DNA and associated proteins – store genetic code. Chromatin is the non-condensed form.*
- *DNA transcribed into RNA (mRNA) – necessary to express code.*
- *Each gene is the DNA code for a particular protein. When cells divide the DNA condenses into chromosomes.*
- *Ribosomes*

Particles made of ribosomal RNA and protein (found in cytosol of cytoplasm).

- *Carries out protein synthesis in 2 locations:*
  1) *Cytosol (free ribosomes).*
  2) *Nuclear envelope or outside of endoplasmic reticulum (bound ribosomes).*
- *Endomembrane System*

Divides cells into compartments where different cellular functions occur.
A series of membranes throughout the cytoplasm.
Components:

- *Endoplasmic reticulum*
- *Golgi Apparatus*
- *Lysosomes*
- *Nuclear envelope*
- *Vacuoles*
- *Plasma membrane*



Endoplasmic Reticulum

- *Continuous with the nuclear envelope.*
- *Two regions:*
  1) *Smooth ER: Synthesis of membrane lipids, calcium storage, detoxification of foreign substances.*
  2) *Rough ER: Membranes, ribosomes attached to membrane. Synthesis of proteins (glycoproteins) and distributed in transport vesicles.*

Golgi Apparatus

- *Flattened stacks of interconnected membranes.*
- *Synthesis of cell wall components.*
- *Functions:*
  - ➢ *Modification of ER products.*
  - ➢ *Manufacture of certain macromolecules.*
  - ➢ *Packaging materials into transport vesicles.*

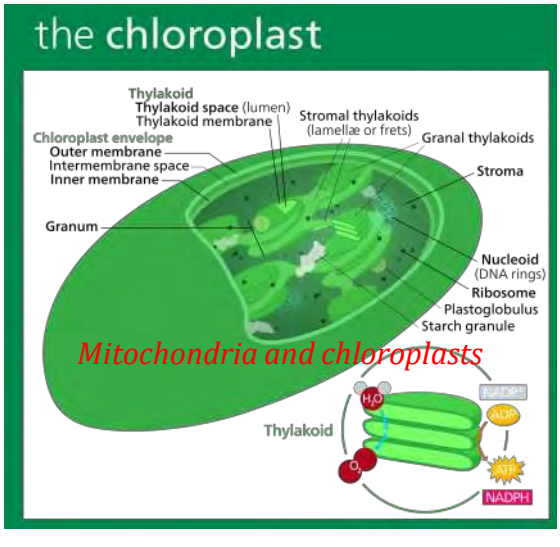
Lysosomes

- *Membrane-bound vesicles containing digestive (hydrolytic) enzymes to break down macromolecules (proteins, fats, polysaccharides and nucleic acids).*
- *Destroy cells or foreign matter that the cell has engulfed by phagocytosis.*

Vacuoles

- **Central vacuoles** *hold organic compounds and water.*
- **Contractile vacuoles** *found in many freshwater protists, pump excess water out of cells.*
- **Food vacuoles** *formed by phagocytosis.*

- *Microbodies*
  - *Membrane bound vesicles.*
  - *Contain enzymes.*
  - *Not part of the endomembrane system.*
  - *Glyoxysomes in plants contain enzymes for converting fats to carbs.*
  - *Peroxisomes contain oxidative enzymes and catalase – produce hydrogen peroxide and convert it to water.*
- *Mitochondria*
  - *Contain oxidative metabolism enzymes for transferring the energy within macromolecules to ATP.*
  - *Surrounded by 2 membranes*
    1) *Smooth outer*
    2) *Folded inner with layers of cristae.*
  - *Matrix = within inner membrane.*
  - *Intermembrane space = Between 2 membranes.*
  - *Contain their own DNA.*
- *Chloroplasts*
  - *Work to convert light energy into sugars that can be used by cells. Depends on the green chlorophyll molecules in each chloroplast.*
  - *Contain chlorophyll for photosynthesis.*
  - *Surrounded by 2 membranes.*
  - *Thylakoids are membranous sacs within inner membrane of chloroplast.*
  - *Grana are stacks of thylakoids.*



Mitochondria and chloroplasts

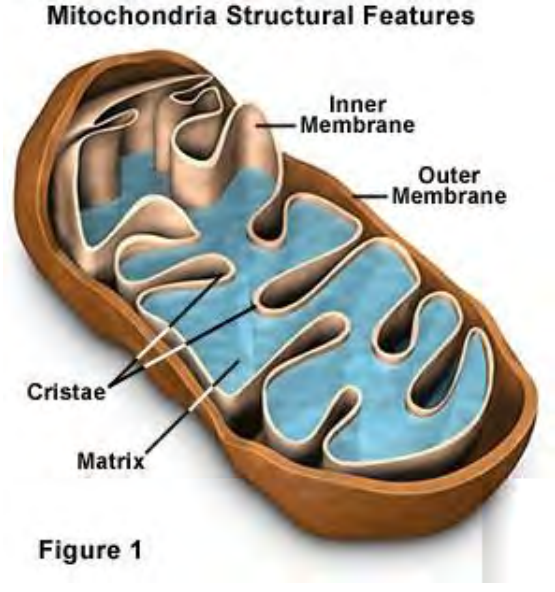


Figure 1

- *Thought to have evolved through the process of* **Endosymbiosis** *~ one cell engulfed a second cell and a symbiotic relationship developed.*
- *Such evidence:*
  - *Both have 2 membranes.*
  - *Possess DNA and ribosomes.*
  - *Size of a prokaryotic cell.*
  - *Divide by a process similar to bacteria.*

- *Cytoskeleton*
  - *Network of protein fibres found in all eukaryotic cells.*
  - *Supports shape of cell.*
  - *Keeps organelles in fixed locations.*
  - *Helps move materials within the cell.*
  - *Functions:*
    - *Mechanical support and structure.*
    - *Intracellular transport for materials.*
    - *Suspension of organelles.*
    - *Contraction.*
    - *Cell motility. (Cilia and flagella: motile extensions of the plasma membrane with a core of microtubules)*

- *Filaments of cytoskeleton*

Microfilaments (common type – ***Actin****)*
- *Muscle contraction*
- *Amoeboid-like movements*
- *Separation of cytoplasm during cell division*
- *Structural support for cell projections*

Intermediate filaments
- *Vimentin (support cellular membranes and keep some organelles in fixed place within cytoplasm)*
- *Keratin (found in skin and hair)*

Microtubules (composed of tubulin – hollow tubes of spherical protein)
- *Strength for cytoskeleton*
- *Determine overall shape of cell and distribution of cellular organelles*
- *Mitotic spindle involved in chromosome distribution during cell division*

- *Extracellular structures*

Most cells synthesise and secrete materials that are external to the plasma membrane.
Include:
- *Cell walls of plants, fungi, and some protists.*
- *Extracellular matrix surrounding animal cells.*
- *Intercellular junctions.*

- *Bacteria have several extracellular structures.*

Cell Walls

- *The carbohydrates present in the cell wall vary depending on the cell type.*
  - ➢ *Plant/protist – cellulose*
  - ➢ *Fungi – Chitin*
- *The cell wall distinguishes plant cells from animal cells.*
- *Maintains shape, protects and prevents excessive uptake of water.*

Extracellular Matrix

- *Surrounds animal cells.*
- *Composition ~ glycoproteins and fibrous proteins such as collagen.*
- *May be connected to cytoplasm via integrin proteins in plasma membrane.*

Intercellular Junctions

- *Plasmodesmata are channels that perforate plant cell walls. Water and small solutes pass through this.*
- *Tight junctions, membranes of neighbouring cells are pressed together preventing leakage of extracellular fluid.*
- *Desomsomes fasten cells together into strong sheets.*
- *Gap junctions provide cytoplasmic channels between adjacent cells.*

Lecture 2 – Intro to Chemical Compounds

- *Chemical Bonds*

Ionic Bonds

- *Involves the transfer of an electron from one element to another.*
- *Not common in biology.*
- *One element becomes positive, one becomes negative.*

Covalent Bonds

- *Sharing of electrons to make a molecule.*
- *Common in biology.*
- *Carbon compounds use covalent bonding.*

Polarity

- *Unequal sharing of electrons.*
- *Slightly negative, slightly positive.*
- *E.g. Water = Oxygen (positive), Hydrogen (negative)*
- *Polarity of water is essential for life.*
- *Because oxygen is more electronegative than hydrogen, shared electrons are pulled more toward oxygen.*

Polarity and H^+ Bonds

- *Hydrogen bonds are weak.*
- *Slightly negative and positive attracted towards each other.*
- *They are weak because the molecules need to be close together for an attraction to occur.*

- *Repulsion – if two slightly negative ends of molecules come close together, they will repel each other.*

Interaction with water

- *Loads of hydrogen bonds.*
- *70% water = Earth.*
- *60% water = Humans.*
- *Aqueous environment.*
- *Elements in the human body need to interact with water (ions, compounds, molecules).*
- *Compounds need to dissolve in water.*
- *Molecules try to keep their polar regions (charged) on the outside of the molecule – it can interact with water.*
- *Hydrophobic (non-polar) do not dissolve in water.*
- *Compounds that are hydrophilic do.*

Carbon Compounds

- *Carbon has 4 valence electrons – huge capacity to make a variety of compounds.*
- *Can be single bonds (rotate), double bonds (don't rotate) or triple bonds (for carbon).*
- *Can combine to itself or to other elements such as oxygen or hydrogen.*
- *Isomers – A compound that has the same molecular formula but a different arrangement of those elements in 3D space.*
    - *Structural – form of isomerism in which molecules with the same molecular formula have bonded together in different orders, as opposed to stereoisomerism*
    - *Geometric – each of two or more compounds which differ from each other in the arrangement of groups with respect to a double bond, ring, or other rigid structure.*
    - *Enantiomers – are chiral molecules that are mirror images of one another. Furthermore, the molecules are non-superimposable on one another. This means that the molecules cannot be placed on top of one another and give the same molecule.*
    - *Stereoisomer – Stereoisomers are isomeric molecules that have the same molecular formula and sequence of bonded atoms (constitution), but differ in the three-dimensional orientations of their atoms in space.*

Functional Groups

- *Also known as R-groups.*
- *Different groups of elements with different chemical properties.*