Molecular Biology for

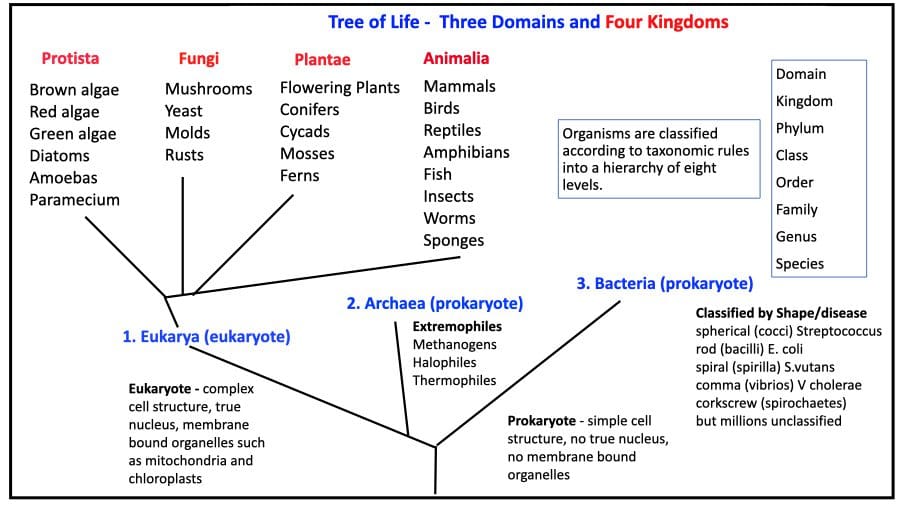
Computer Scientists

Notes

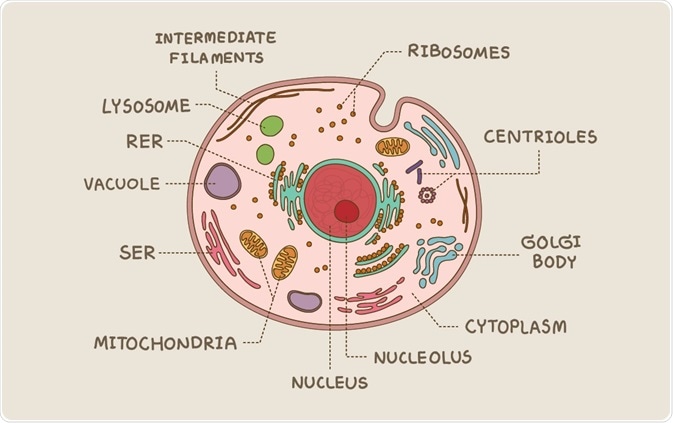
Chapter1:Introduction

All living things are made of cells

Cell 🡪 membrane-enclosed sacks of chemicals carrying out finely tuned sequences of reactions called metabolic pathways



Eukarya

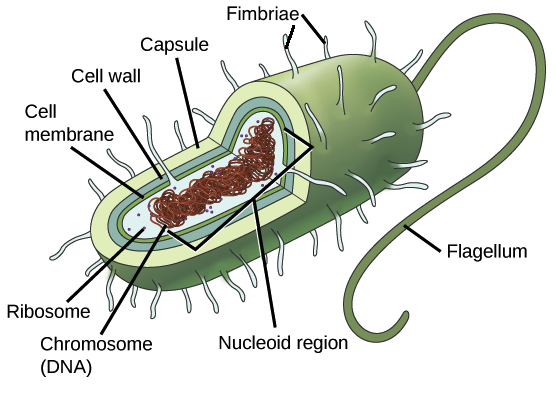


* Contains nucleus to hold genetic information
* Multi-chromosomal
* Contains organelles like
  + Mitochondria – powerhouse of the cell
  + Chloroplast – capture energy from sunlight

Fungi vs Green Plants

* Fungi do not photosynthesize

Prokarya



* No nucleus so genetic information in cytoplasm
* Single-chromosome
* Unicellular organism

Archaea

* Prokaryotic organism that lives in superheated Sulphur vents in the deep sea
* Do not require oxygen

Viruses

* Zombies
* Parasites – Relies on the biochemical machinery of the host organism to survive i.e. parasitic relationship
* Virus inject their genetic information (often stored in their RNA) into the living organisms. When this organism cells multiply then the virus also replicates.

Symbiotic relationship

* Bacteria in our guts
* We eat food. Some of it digested. The remaining undigested food (like starch) is digested by the bacteria in our guts
* The opposite of parasitic relationship

Phage Medicine

* Utilizes bacteriophages (viruses that infect and kill bacteria) to treat bacterial infections
* Infect bacteria with virus to counter other bacteria

Multicellular organisms

Why

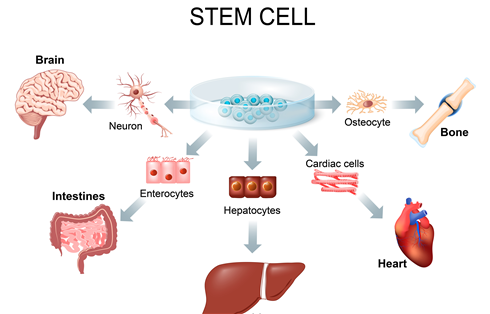
* Multicellular organisms can have cells that are far apart in distance. These cells can exchange matter, energy or information for their mutual benefit
* For example, in plants, cells in the root of the plant supply energy to the cells in the leaves and vice versa.

Property

* All multicellular organisms begin from a single fertilized egg called a zygote.
* Multicellular organisms separate cells for reproduction called germ cells and other tasks called somatic cells
* For example, sperm and eggs are germ cells

Cell differentiation

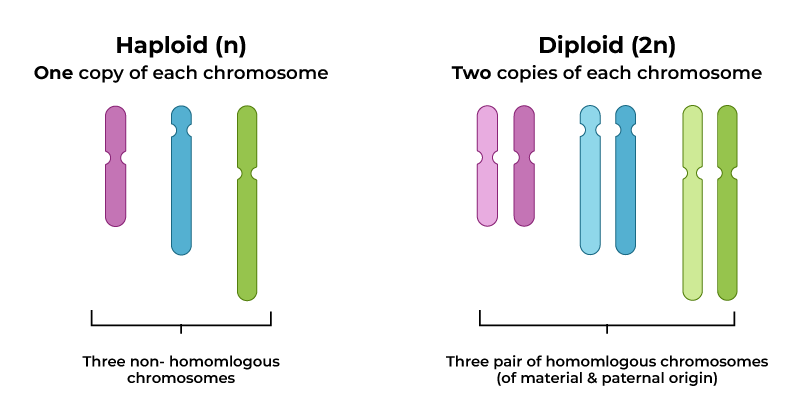
* Somatic cells undergo differentiation where they specialize for a particular task.
* Cell specialization allows multicellular organisms to divide up complex tasks
* Not every cell needs to extract nutrients, protect itself, move itself, reproduce itself etc.
* For example, skin cells, nerve cells, blood cells, tissue and organ cells etc.



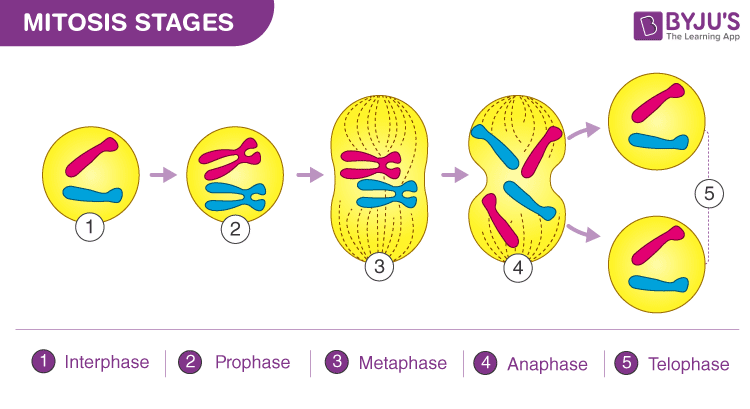
* Once differentiated, cells cannot change
* All cells have the same genetic code. The difference is the expression like the gene product or the amount of product produced.

Somatic Cells vs Germ Cells

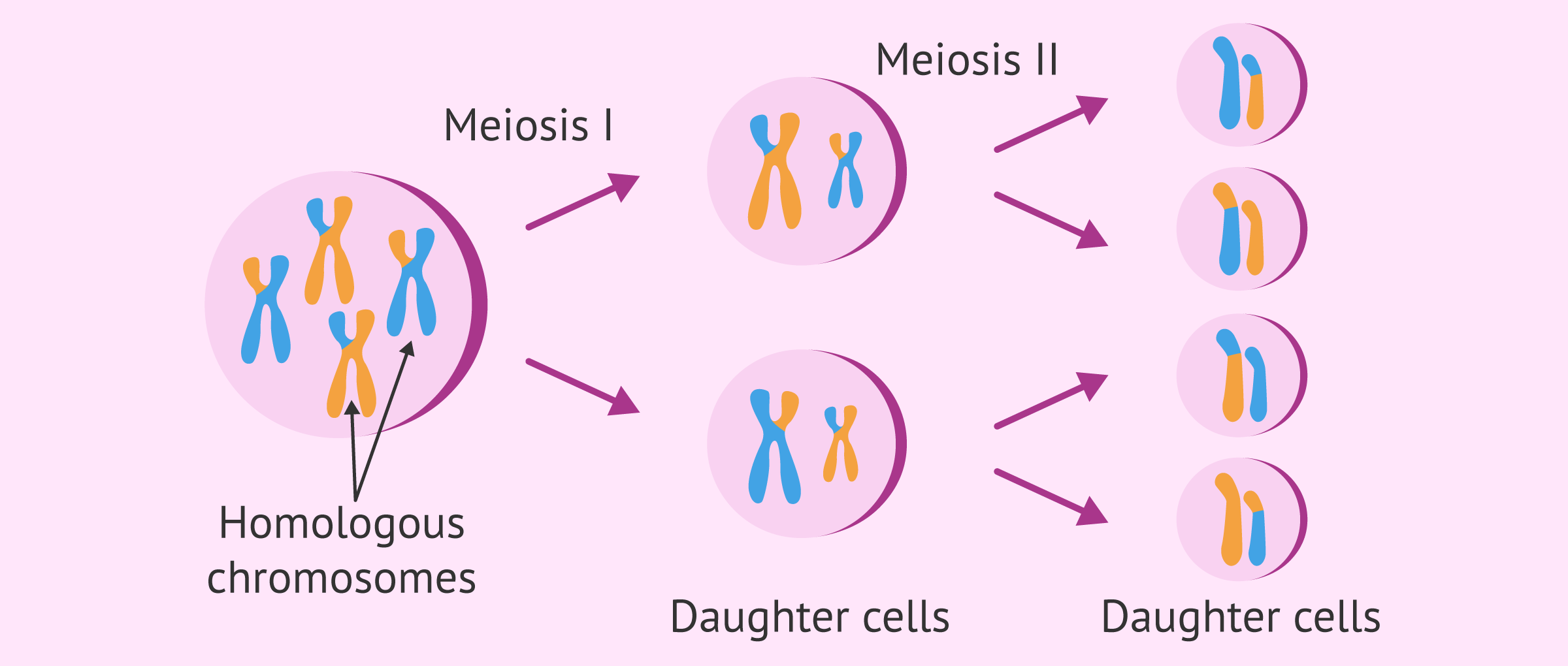
* Somatic cells are diploid, meaning they contain two complete sets of chromosomes (one maternal and one paternal) while Mature germ cells (gametes) are haploid, containing a single set of chromosomes.



* Somatic cells undergo mitosis



* Germ cells undergo Meiosis



* Variation in somatic cells does not affect descendants while variation in germ cells does affect

Chapter2:

Living Parts: Tissue, Cells, Compartments and Organelles

Tissue 🡪 group of cells specialized for a particular function

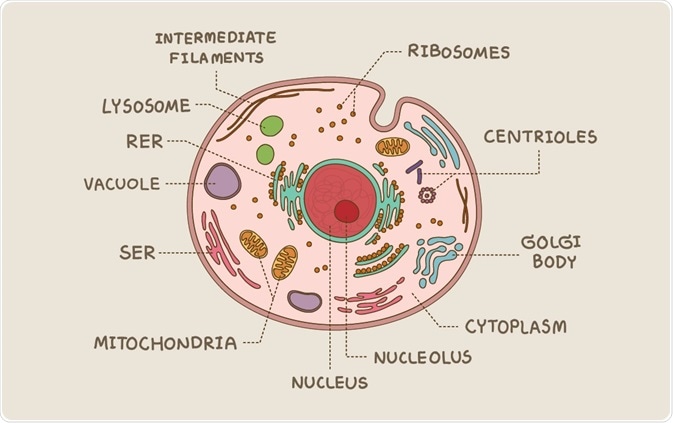
Examples are:

* Epithelial tissue (like skin),
* Connective tissue (like bone or blood),
* Muscle tissue
* Nervous tissue

Cells 🡪 structural unity of life

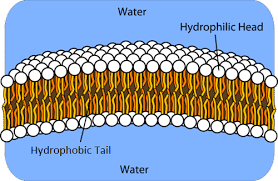
* Blob of chemicals in a state of equilibrium
* Requires energy for replication. In animals this comes from food while in plants from sunlight
* Respond to external stimulus
* Cells can evolve
* Cells can self-regulate (turn on/off part of their DNA)
* All cells contain the genetic material and cytoplasm

Components of Eukarya cells



Cell membrane 🡪 boundary between cell and the outside

* Contains two layers of phospholipids
* The phosphate group is hydrophilic and the lipids end is hydrophobic



Protein 🡪 performs the function of the cell

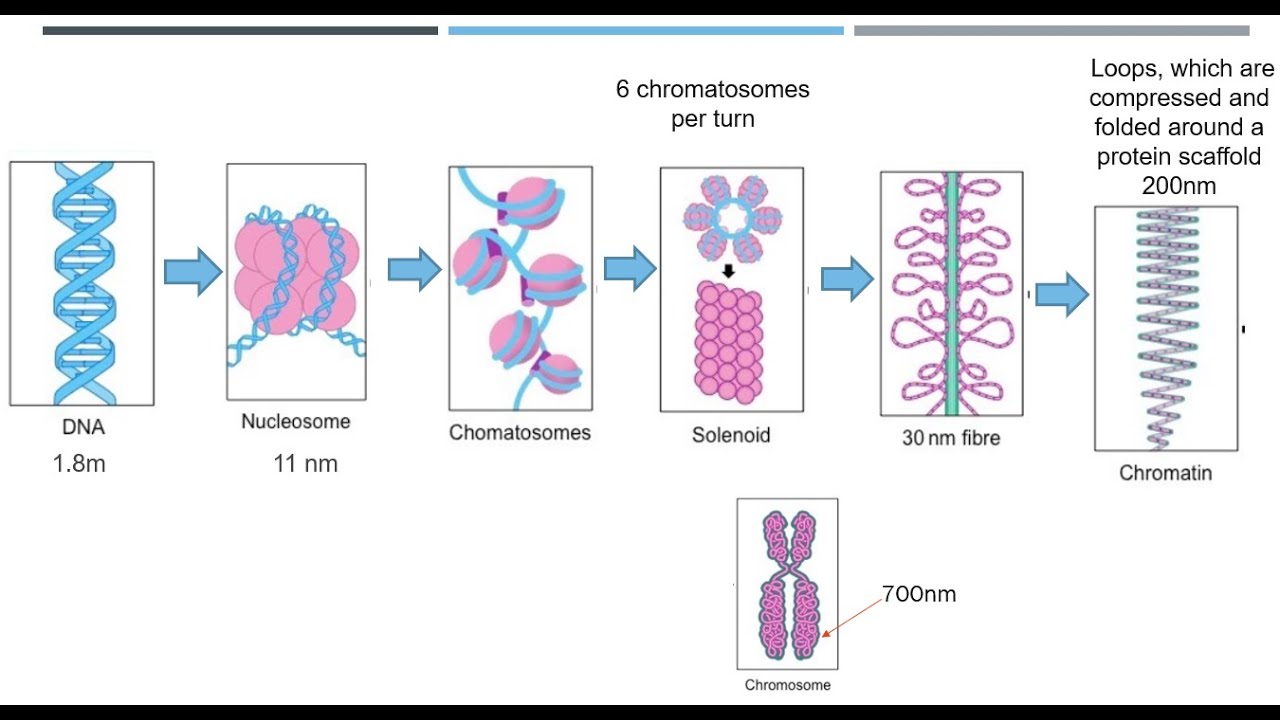
* Polymer of peptide chain = polypeptide
* Peptide chain is made of amino acids. There are 20 naturally occurring amino acids
* The 3D structure of a protein depends on the peptide chain
* Its functionality depends on its structure
* If the 3D structure is distorted, the protein cannot function properly
* Some proteins bind to prosthetic groups in order for them to function. Example, the haem is a prosthetic group which bonds with the oxygen in the globin protein to form haemoglobin

Its functions include but not limited:

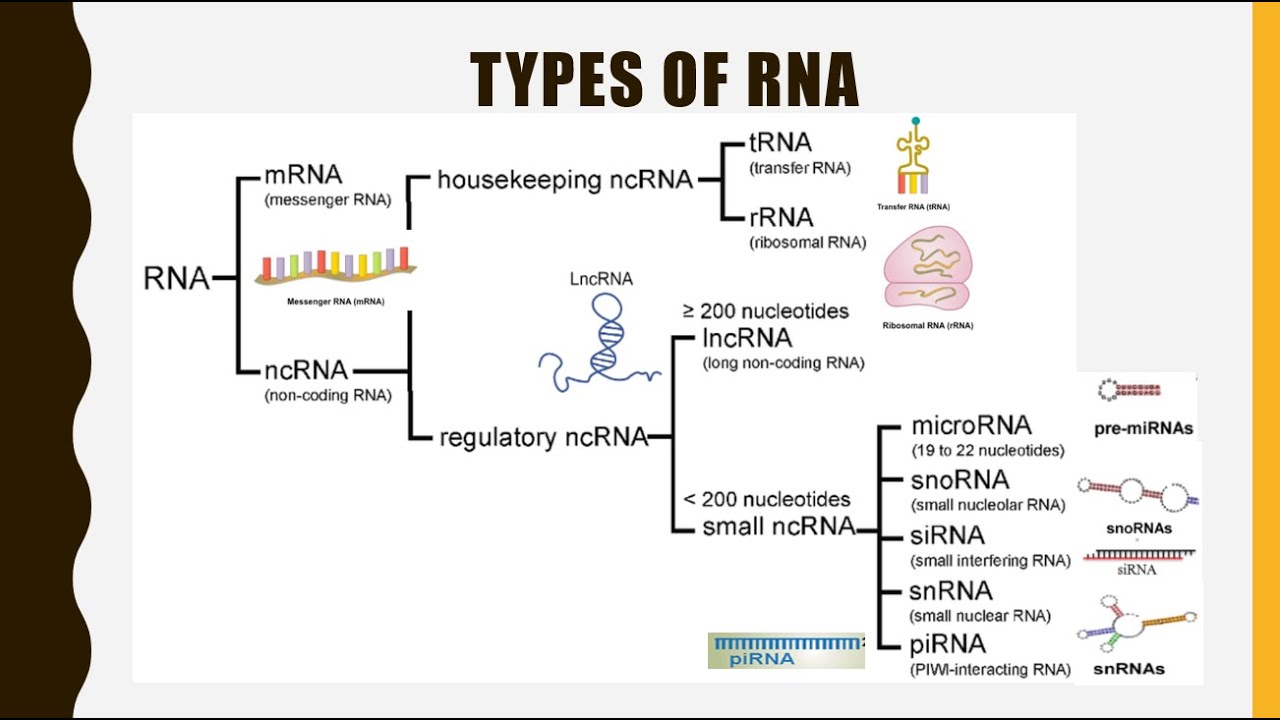
* Sensors that see, taste, smell etc.
* Enzymes that catalyse reactions with substrates
* Structure of the cell
* Regulatory function like turn on/off gene
* Provides mechanism for transforming energy into physical work in the muscles

Genetic Material 🡪 contains the blue print for all the proteins the cell can produce.

* DNA or RNA
* Bacteria store the genetic material in a circular DNA
* Eukarya store the genetic material in a linear DNA
* Virus store the genetic material in a RNA



* DNA on its own has a double helix structure
* During cell division, DNA packaged into chromosomes. Naturally, it exists in the form of chromatin.
* Chromosomes are made up of chromatin, which exists in two forms:
  + **Euchromatin**
    - Lightly packed form of chromatin
    - Transcriptionally active (genes are accessible for transcription)
  + **Heterochromatin**
    - Densely packed form of chromatin
    - **Constitutive heterochromatin:** Always inactive (e.g. centromeres, telomeres)
    - **Facultative heterochromatin:** Can become active or inactive depending on conditions (e.g. Barr body in females)



* RNA exists as single strand
* There are many different forms of RNA with various functions

Examples:

* mRNA – Messenger RNA: Carries the message (instructions) from DNA to make proteins.
* tRNA – Transfer RNA: Brings the correct amino acid to the ribosome to build the protein.
* rRNA – Ribosomal RNA: Makes up the ribosome, which is the machine that builds proteins.
* snRNA – Small Nuclear RNA: Helps in splicing, which means removing the unwanted parts (introns) from mRNA.
* miRNA – Micro RNA: Regulates gene expression by blocking or destroying mRNA.
* siRNA – Small Interfering RNA: Also blocks mRNA, used in gene silencing (often in research or defense).

Nuclei 🡪 The nucleus contains the genetic material (DNA) of a eukaryotic organism in the form of chromatin.

* Chromatin is a complex of DNA and nuclear proteins, mainly histones, in which DNA is tightly folded and packaged inside the nucleus
* Nucleus separated from the cell by a nuclear membrane.

Cytoplasm 🡪 gel-like collection of substances inside a cell

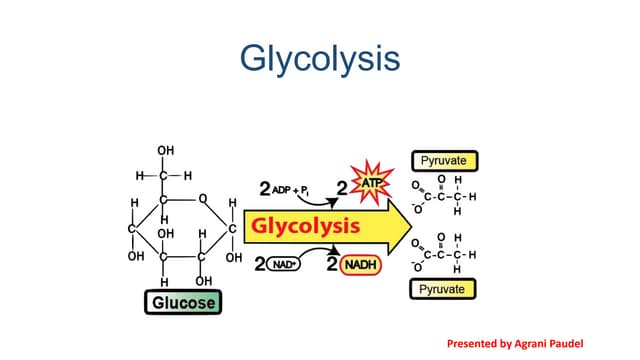
* Prokaryotes genetic material exists in the cytoplasm

Ribosomes 🡪 large molecular complexes made up of proteins and RNA

* Factory of the cell which assembles the proteins

Cellular Organelles

* Mitochondria: Powerhouse of the cell
  + They convert glucose (food) and oxygen into ATP (adenosine triphosphate) — the main energy currency of the cell.
  + This process called cellular respiration.
  + Mitochondria has its own genetic material which is maternally inherited i.e. inherited via the cytoplasm of the egg
* Chloroplast: Exists in plants, chloroplasts capture sunlight and use it to make glucose (food) through a process called photosynthesis.
  + This process uses carbon dioxide (CO₂) and water (H₂O) to produce glucose (C₆H₁₂O₆) and oxygen (O₂).
  + sunlight + CO₂ + H₂O → glucose + O₂
  + Chloroplasts contain a green pigment called chlorophyll, which absorbs light



* Prokaryotes get energy only through glycolysis (glycol = sugar, lysis = destruction) as they do not have mitochondria
  + Glycolysis is the process of breaking down glucose into pyruvate. It happens in the cytoplasm
  + Produces:
    - 2 ATP (a small amount of energy)
    - 2 NADH (electron carriers)
    - 2 pyruvate (can be used further)
  + If oxygen is available (aerobic bacteria):
    - Pyruvate can go into a process similar to the Krebs cycle and electron transport chain — even without mitochondria.
    - Result: Up to ~38 ATP per glucose — similar to eukaryotes!
  + If oxygen is not available (anaerobic bacteria):
    - Use anaerobic respiration or fermentation.
    - Only two ATP per glucose — much less efficient but it is faster, and works without oxygen.
* Endoplasmic Reticulum: The Endoplasmic Reticulum (ER) is an organelle in eukaryotic cells only.
  + It helps produce important components of the cell membrane, such as:
    - Lipids (main part of the membrane)
    - Proteins (for membrane structure and function)
* Golgi apparatus: The Golgi apparatus is made of stacked, flattened membrane sacs.
  + It modifies, sorts, and packages proteins and lipids received from the endoplasmic reticulum (ER).
  + It prepares materials to be:
    - Exported out of the cell (exocytosis)
    - Sent to specific locations inside the cell (like lysosomes or the plasma membrane)