Cell and Cell Division

Chapter 2

Lecture Outline

Cell

- Cell membrane
- Nucleus: Nuclear Envelope, Nucleoplasm and Chromatin (DNA + Histones)
- Cytoplasm: Cytosol and Cell Organelles

Cell Division

- Cell Cycle
- Mitosis: division of nucleus
- Cytokinesis: division of cytoplasm

Cell Theory

4 basic concepts of cell theory are:
Cells are the units of structure (building blocks) of all organisms
Cells are the smallest unit of function in all organisms
Cells originate only from pre-existing cells by cell division.
All cells maintain homeostasis (internal conditions within limits)

Cell Membrane

All cells are covered with a thin covering of a double layer of Phospholipids and associated Proteins present here and there.
Each phospholipid has a polar (hydrophilic) head and non-polar (hydrophobic) tails. In the double layer the tails face each other forming a hydrophobic barrier which keeps water dissolved contents inside.
Proteins may be Intrinsic – embedded in the lipid double layer and Extrinsic associated outside the lipid double layer.

Cytoplasm

Cytoplasm is the living fluid part between cell membrane and nucleus. It has special structures called Cell Organelles in it.
Cytosol is the liquid part of cytoplasm formed of water having dissolved or suspended substances in it.
Cell Organelles are organ like each performing specific function/s but formed of molecules and membranes only (sub-cellular).
Double Membrane bound Organelles: Mitochondria, Chloroplasts, Endoplasmic Reticulum, Golgi Body, and *Nucleus*.
Single Membrane bound Organelles: Lysosomes, Peroxisomes, Vacuoles
Organelles lacking any membrane: Ribosomes, Centrioles, *Nucleolus*

Nucleus and Ribosomes 1

Genetic Control of the Cell

Nucleus: is the most distinct structure inside cell visible with light microscope. It has inside it DNA having all the information needed to form and run the cell. The segments of DNA are called Genes.
Nuclear Envelope: is formed of 2 membranes with a gap between them. It has a large number of Nuclear Pores usually bound by a nuclear complex. The pores are large enough to allow RNA and proteins to pass through.
Nucleoplasm: is the liquid part of nucleus and has a different composition than Cytosol.
Chromatin fibers: are very long molecules of DNA associated with proteins (Histones and other nuclear proteins). Each chromatin fiber, at the time of cell division, organizes into Chromosomes.
Nucleolus: is present in the nucleus when the cell is not dividing. No membrane bounds it. It assembles both units of Ribosomes.

The Endomembrane System 1

Manufacturing and Distributing Cellular Products

Endoplasmic Reticulum, Golgi Apparatus, Lysosomes and Vacuoles collectively form Endomembrane System.

Endoplasmic Reticulum: is a system of double membranes in the form of tubes and sacs throughout cytoplasm (in between cell membrane and nuclear envelope). ER is the main manufacturing facility. Functions include synthesis of proteins and lipids including steroids, detoxification, and cellular transportation. It transports materials inside the cell by transport vesicles.

The Endomembrane System 2

Golgi Apparatus = Golgi Body: is a stacks of flattened sacs called cisternae. A cell may have from a few to a few hundred of Golgi stacks. Golgi Apparatus receives transport vesicles from ER on one side, modifies received chemicals, can store them and packs them in secretory vesicles and releases them on shipping side.

Lysosomes: are single membrane bound organelles rich in digestive enzymes, help in breakdown of large molecules like proteins, polysaccharides, lipids and nucleic acids. Lysosomes provide a safe place for digestion of large molecules without damaging molecules of the cell. A Lysosomes joins a food vacuole to digest the materials inside vacuole. Lysosomes are absent in most plant cells.

Vacuoles: are membrane bound sacs and pinch off from ER, Golgi Apparatus and cell membrane. Functions include Endocytosis, exocytosis, maintain Turgor pressure in a plant cell, transportation.

Mitochondria

Energy Conversion

Mitochondria (sing. Mitochondrion): are the powerhouses of cells and the site for cellular respiration. Respiration is oxidation of food and chief source of energy for the cell.

These are bound with double membrane, outer smooth and inner folded. Mitochondria have enzymes for breakdown glucose derivatives, fatty acids and amino acids.

Mitochondria have Electron-Transport-System that generates ATP molecules by using the energy contained in H's produced during breakdown of glucose.

Mitochondria are found in plants, animals, fungi and protists.

The Cytoskeleton

Cell Shape and Movement

Maintaining Cell Shape: The shape of the cell is maintained by Intermediate Filaments, the thick ropes of twisted protein fibers; Microtubules, the hollow organelles and Microfilaments the solid thinner organelles. These maintain the shape of cells and keep in position the nucleus. The framework of support is highly dynamic that can organize and dismantle really fast.

Transport of organelles and molecules: Microtubules are the freeways used by organelles like lysosomes to move from one part of cell to another. Microfilaments are the roads/streets used by smaller things.

Cell Division

Passes on Genes from Cells to Cells

Results in growth and repair of Organisms

Genes – DNA – Chromatin fiber – Chromosomes

Genes, the segments of DNA, are part of chromatin fiber found in nucleus.

Chromatin fiber is formed of nucleic acid DNA and Histone proteins.

Mostly the chromatin fibers exist as a diffuse network (not visible even under electron microscope). However, when the cell starts to divide the chromatin fibers organize into compact threads called Chromosomes.

Each species has a fixed # of chromosomes – 46 in most human cells.

Chromosome – DNA – Gene

Almost all genes (about 20000 in humans) are found in the chromosomes. Some genes are present in

Mitochondria.
DNA associates with small proteins Histones and coil to form chromatin. Chromatin packs into thicker and thicker threads. The thickest threads are Chromatids. A chromosome has 1 or 2 Chromatids in it.
A chromosome with 1 chromatid divides to form a chromosome with 2 Chromatids (sister). One chromatid is passed on to each daughter cell.

Cell Cycle

A cell is either dividing or preparing to divide.
Interphase: is a phase between 2 successive cell divisions. Cell grows in size and DNA is replicated. Cell is now ready to divide.
Mitosis is division of nucleus and Cytokinesis is division of cytoplasm.
Mitosis is the division of growth and replacement of lost or damaged cells.
Mitosis has 4 distinct phases Prophase, Metaphase, Anaphase and Telophase. *Memory aid: P-MAT*

Mitosis – Prophase
pro = first

Prophase: is the phase that prepares the cell for mitosis.
Centrosomes start moving to opposite ends and spindle formation starts.
Chromosomes coil and pack into thick threads and get distinct.
In late prophase nuclear envelope degenerates and chromosomes are released in cytoplasm.
Spindle fibers either join a spindle fiber from the opposite centrosome or connect to the centromere of a chromosome.

Mitosis – Metaphase
meta = after

Metaphase: The spindle is fully formed now.
The chromosome pack further and get most distinct.
Chromosomes arrange on an imaginary disc = equatorial plate at the middle. The centromeres of chromosomes lie at the plate.
Each centromere is joined through spindle fibers to both centrosomes.

Mitosis – Anaphase
ana = apart

Anaphase: is the movement of young chromosomes from the middle towards respective poles (centrosomes).
It starts suddenly when the centromeres divide. Each chromosome is formed only of 1 chromatid.
The motor proteins at centromeres move the chromosomes on the microtubules of spindle fibers.

Telophase
telo = end

Telophase begins when the 2 groups of chromosomes reach the poles.
This phase is the reverse of prophase.
Chromosomes unpack to diffuse network.
Nuclear envelope is reorganized from Endoplasmic Reticulum.
Spindle fibers disappear.
One nucleus is completely divided into 2 genetically similar daughter nuclei.

Cytokinesis
kinesis = motion

Cytokinesis takes place along Telophase.
In an animal cell cleavage furrow appears at the middle and divides the cytoplasm into 2 equal halves, each with a nucleus.
In a plant cell a cell-plate is formed at the middle to complete the Cytokinesis.
Most plant cells lack centrioles in them and centrosomes organize spindle formation.