Lec 1 : Introduction to biology and its definition

Biology :Is the science of living things

Biology com from the Greek bios means life and Logos means word or knowledge ,Biology includes the study of evolutionary relationships among organisms and the diversity of life on earth , Cells the basic structural functional and biological unit of all living organisms

* Term cell com from Latin cella meaning ‘’small room ‘’

Cell Theory

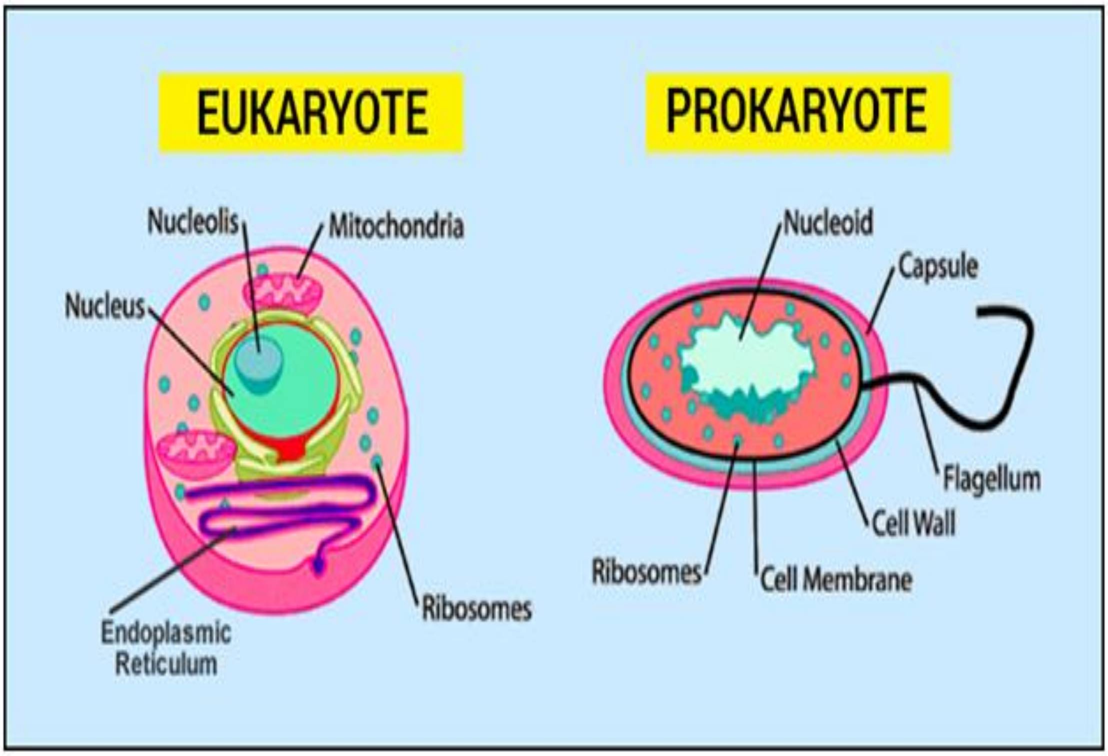
Credit for the formation of this theory to Theodor Schwann ,Matthias Schleiden , and Rudolph Virchow
The cell Theory states

- All form of life contain one or more cells
- All cells come from pre-existing cells
- All functions that make life possible occure within the cells
- All cells have genetic material required to regulate cell functions and replicate ,passing this genetic information to new cell

Prokaryotic and Eukaryotic

Prokaryotic : are organisms without a cell nucleus or any other membrane-bound organelles, such as Archaea and Bacteria

Eukaryotic :Eukaryotic cells are cells that contain a nucleus and organelles, and are enclosed by a plasma membrane. Organisms that have eukaryotic cells include protozoa, fungi, plants and animals. These organisms are grouped into the biological domain Eukaryota. Eukaryotic cells are larger and more complex than prokaryotic cells



prokaryotic have a larger surface area to volume ratio giving them a higher metabolic rate a higher growth rate and consequently a shorter generation time compared to Eukaryotes .

Unicellular organisms : organisms that have only one cell such as Amoeba

Multicellular organisms : organisms that have many cells this cell form the tissue and organs

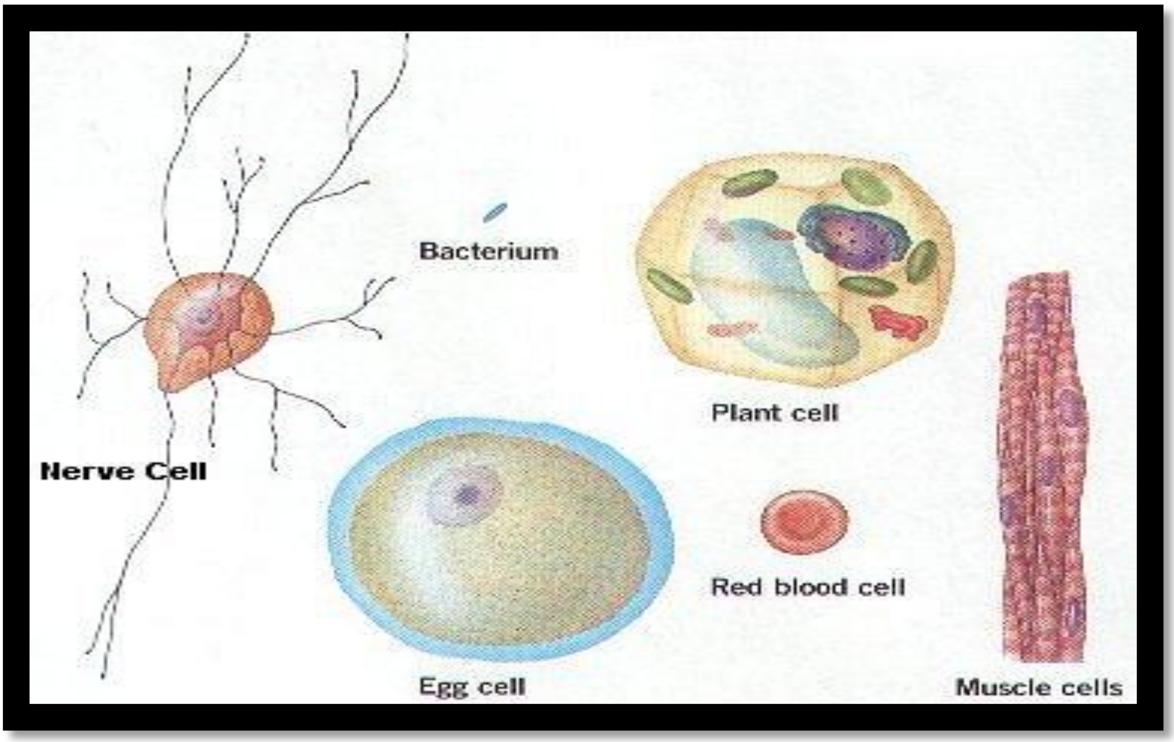
Cell are typically composed of

1. Cell membrane (Plasma membrane)
2. Cytoplasm and its organelles such as (mitochondria, endoplasmic reticulum , Ribosome's, Golgi complex etc,.
3. True nucleus

Cell shape:

There is no typical shape ,but generally the cells are rounded or spherical , oval, cuboidal ,cylindrical ,flat etc,.

the shape of cells depending mainly on functional adaptation and partly on the surface tension and viscosity of cytoplasim,the mechanical action of adjoining cells and rigidity of the cell membrane .



Cell Number

- Some organisms like protozoans are single cell and others are multicellular The body of human being is composed of about 26 trillions of cells in human blood the number of erythrocytes is about five million per cubic ml of blood .and about 10 billion neurons constitute the nerves system in human being

Cell size

The size of different cells ranges within broad limits ,some plant and animals cells are visible to the naked eye , such as eggs ,but the majority of cells are visible only under microscope .the size of human RBC is 7-8 µ in diameter

Cell structure

Cells are typically composed of

1- cell membrane (Plasma membrane)
2- Cytoplasm and its organelles
3- True nucleus

Cell Membrane Function and Structure

The cell membrane (plasma membrane) is a thin semi-permeable membrane that surrounds the cytoplasm of a cell. Its function is to protect the integrity of the interior of the cell by allowing certain substances into the cell, while keeping other substances out.

It also serves as a base of attachment for the cytoskeleton in some organisms and the cell wall in others.

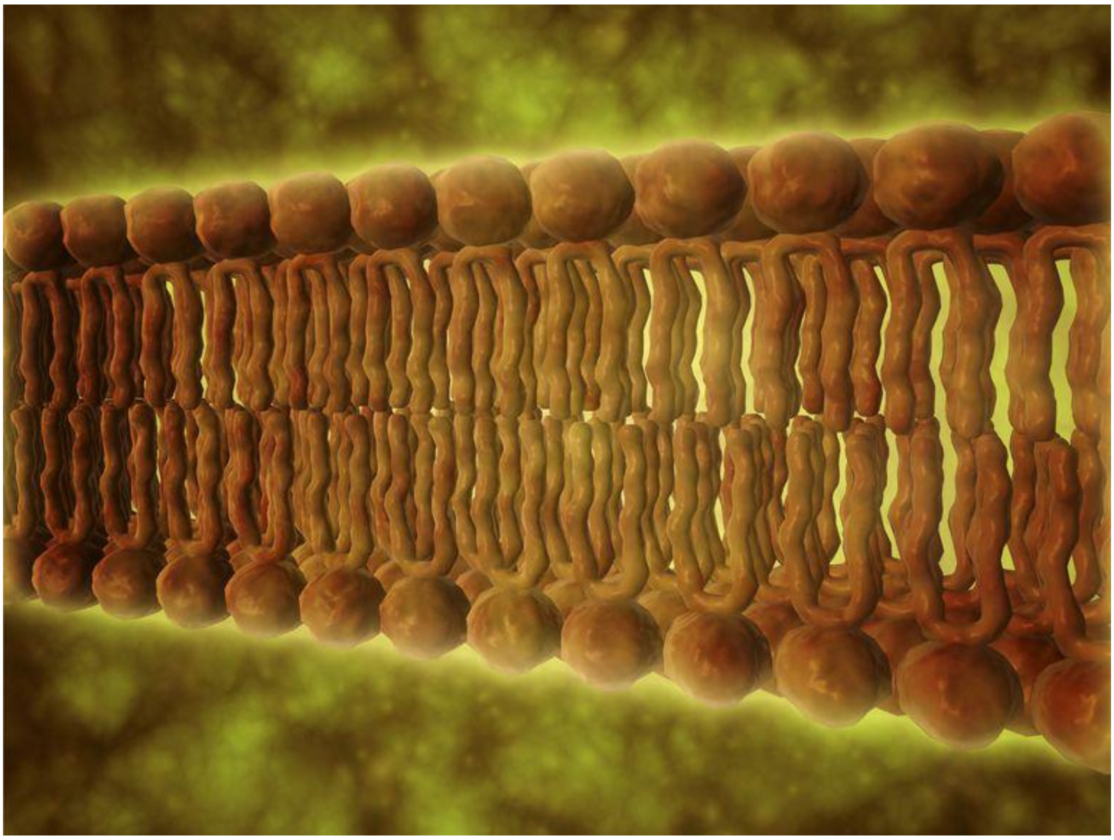
Thus the cell membrane also serves to help support the cell and help maintain its shape. Another function of the membrane is to regulate cell growth through the balance of endocytosis and exocytosis.

In endocytosis, lipids and proteins are removed from the cell membrane as substances are internalized. In exocytosis, vesicles containing lipids and proteins fuse with the cell membrane increasing cell size.

Animal cells, plant cells, prokaryotic cells, and fungal cells have plasma membranes. Internal organelles are also encased by membranes.

Cell Membrane Structure

The cell membrane is primarily composed of a mix of proteins and lipids. Depending on the membrane's location and role in the body, lipids can make up anywhere from 20 to 80 percent of the membrane, with the remainder being proteins. While lipids help to give membranes their flexibility, proteins monitor and maintain the cell's chemical climate and assist in the transfer of molecules across the membrane.



Cell Membrane Structure

Organelles and their function

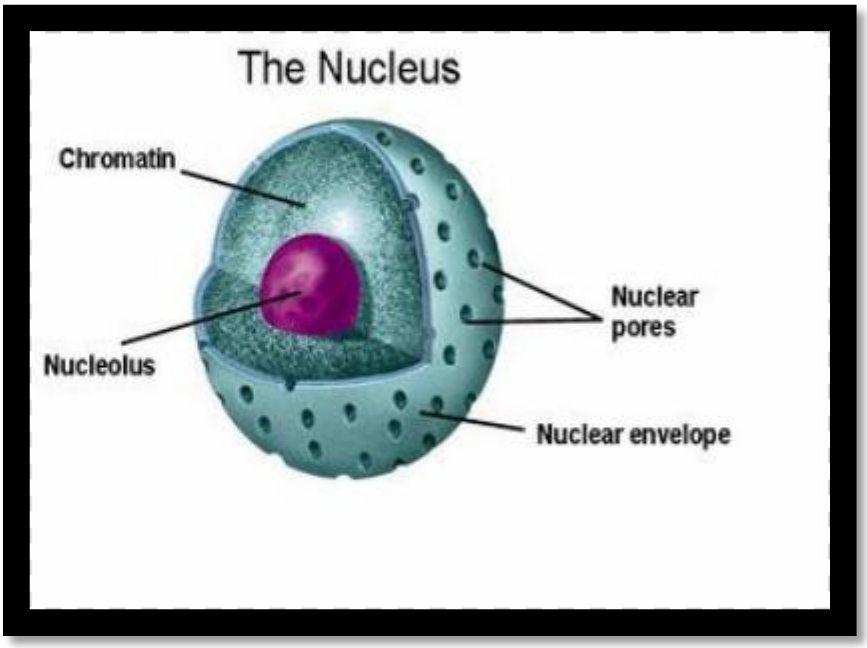
1- Nucleus:

Nucleus is a large organelle that store the cell's DNA (deoxyribonucleic acid) .

The nucleus control all of the cells activities such as growth and metabolism ,using the DNAs genetic information .

Structure of Nucleus :

a)Nuclear membrane
b)Nucleoplasm.
c) Chromatin network.
d) Nucleolus.



NUCLEUS STRUCTURE

Function of Nucleus:

1)Nucleus plays a major role in the general metabolism of the cell .
2) it is helpful in the synthesis of the Ribosomes .
3) it is helpful in the synthesis of RNA .
4) it controls the synthesis of protein.
5) it is the seat of heredity.

Within the nucleus is a smaller structure called the nucleolus ,which house the RNA (ribonucleic acid) . RNA help convey the DNAs orders to the rest of the cell and serves as template for protein synthesis ,this space forms near the part of DNA with instructions for making ribosomes ,the molecules responsible for making proteins . Ribosomes are assembled in the nucleolus ,and exit the nucleus with nuclear pores .

2- Ribosomes:

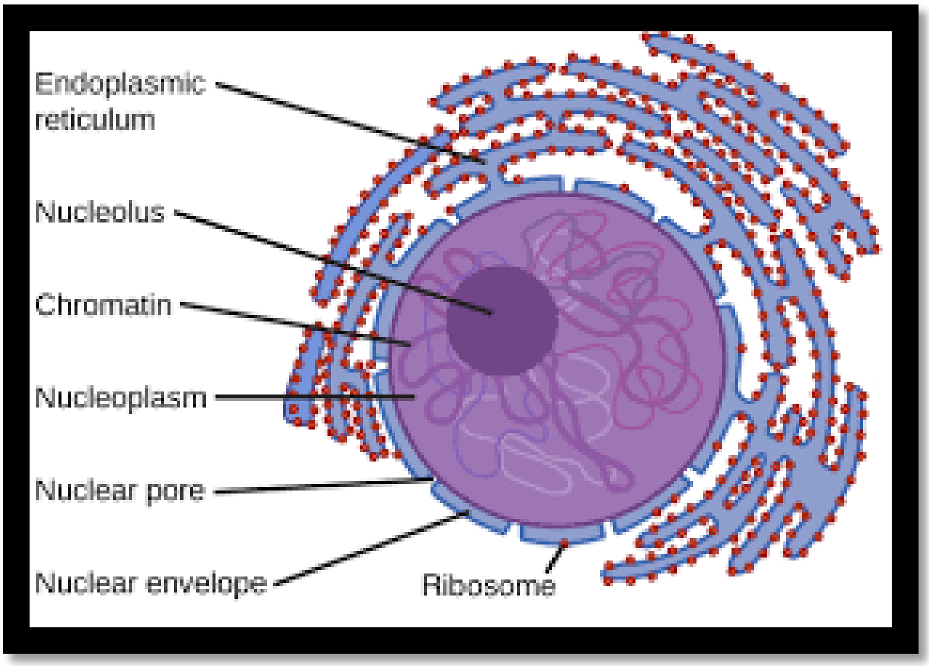
Ribosomes are the protein factories of the cell. Composed of two subunits , they can be found floating freely in the cells cytoplasm or embedded within endoplasmic reticulum .

A ribosomes formed from two subunits locking together ,functions to :

(1) Translate encoded information from the cell nucleus provided by messenger ribonucleic acid (mRNA)

(2) Link together amino acid selected and collected from the cytoplasm by transfer ribonucleic acid (t RNA)

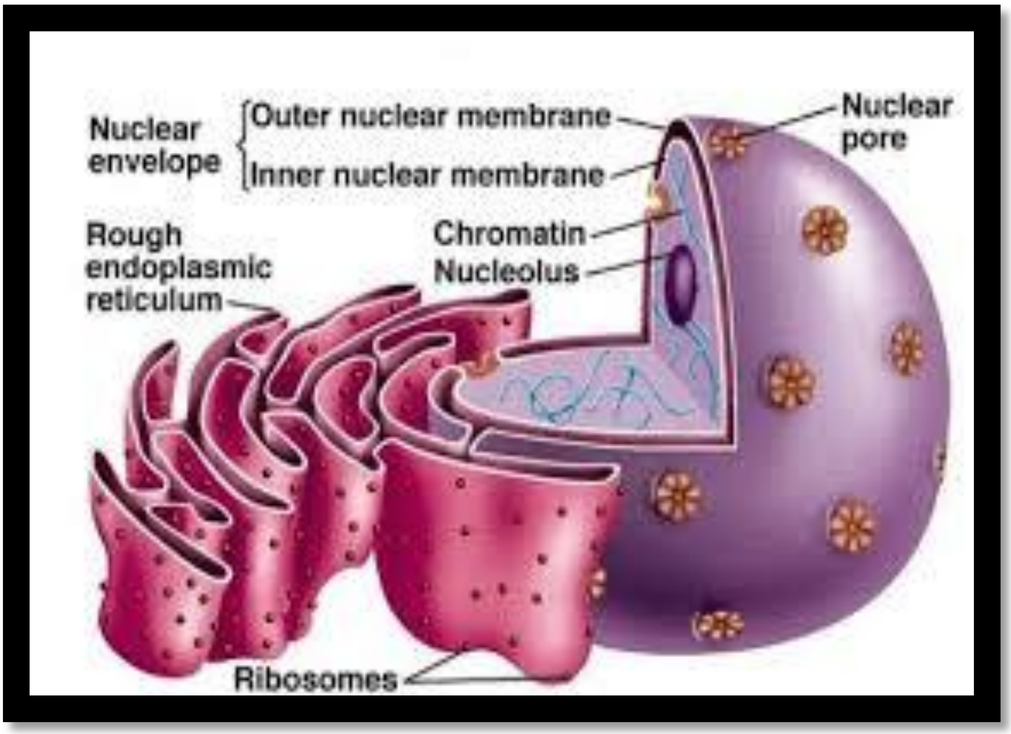
(3) Export the polypeptide produced to the cytoplasm where it will form a functional protein .



3- Endoplasmic reticulum:

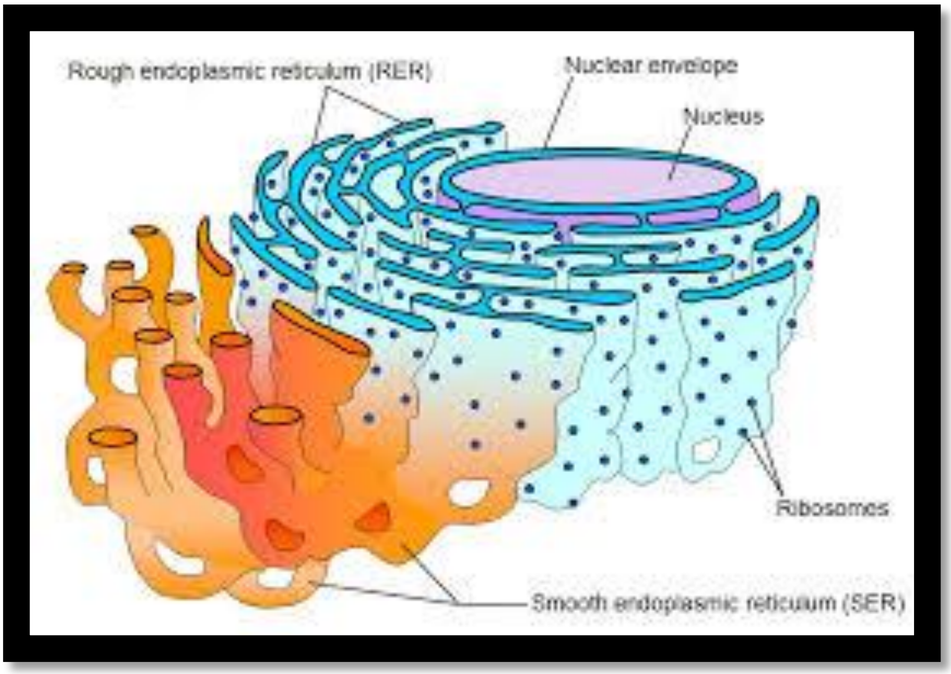
The endoplasmic reticulum (ER) is a membranous organelle that shares part of its membrane with that of nucleus .some portion of ER ,known as the rouge ER ,are studded with ribosomes and are involved with protein manufacture .the rest of the organelle is referred to as the smooth ER and serves to produce vital lipids (fats).

Booth the smooth and rough endoplasmic reticulum help in the production and storage of protein.
The main difference is that one contains ribosomes on it and the others does not .
The rough endoplasmic reticulum (RER) has ribosomes on its surface .this is what give the RER rough appearance .rough ER synthesizes (makes) and package proteins. The RER is attached to the nuclear membrane .the Golgi apparatus tend to be on the other side of the RER .



ROUGY ENDOPLASMIC RETICULUM

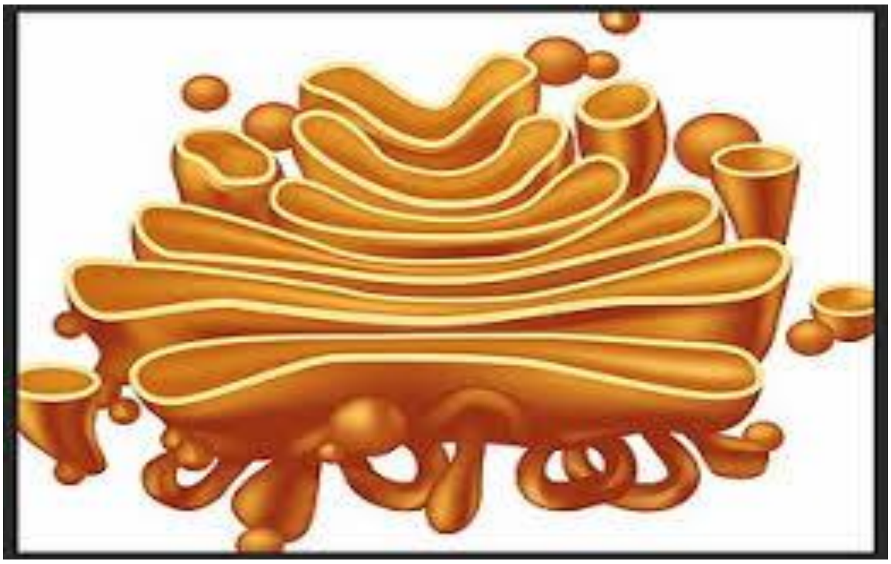
The smooth endoplasmic reticulum (SER) does not contain ribosomes .The SER helps in the storage of protein and lipids .Cells that produce oils have a higher rate of SERs than do other cells .The smooth endoplasmic reticulum can be found dispersed throughout the cytoplasmic of the cell.



SMOOTH ENDOPLASMIC RETICULUM

4- Golgi apparatus :

If the protein from the rough ER require further modification , They are transported to the Golgi apparatus (or Golgi complex) .Like the ER ,the Golgi apparatus is composed of folded membranes . it searches the proteins amino acid sequences for specialized "codes" and modifies them accordingly .these processed protein are then stored in the Golgi or packed in vesicles to be shaped elsewhere in the cell.



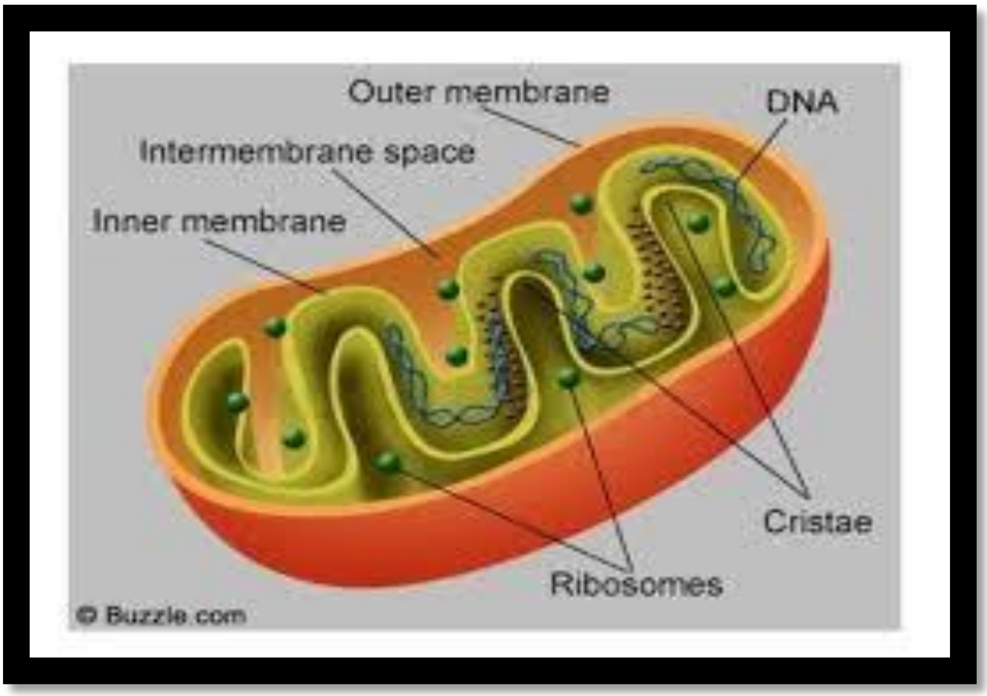
GOLGI APPARATUS

5- Chloroplast:

Plant and some algae , organelles know as chloroplast serve as the site of photosynthesis .chloroplast contain a pigment known as chlorophyll, which capture the suns energy to transform water and carbon dioxide into glucose for food .Chloroplasts allow autotrophic organisms to meet their energy needs without consuming other organisms .

6- Mitochondria :

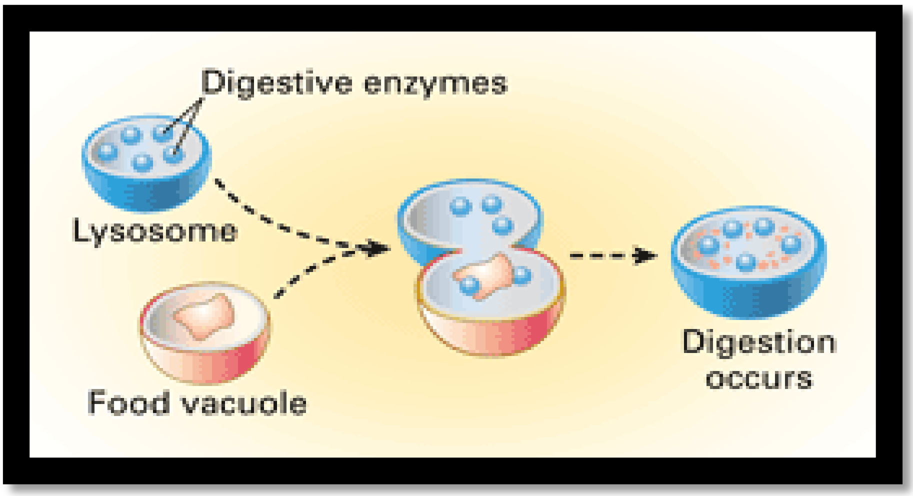
Mitochondria are oval –shaped organelles found in most eukaryotic cells. As the site of cellular respiration ,mitochondria serve to transform molecules such as glucose into an energy molecule known as ATP (adenosine triphosphate) .ATP fuels cellular process by breaking its high-energy chemical bonds. Mitochondria are most plentiful in cells that require significant amounts of energy to function. Such as Liver muscle cells .



MITOCHONDRIA STRUCTURE

7- Lysosomes:

The lysosome is the cells recycling center .there organelles are spheres full of enzymes ready to hydrolyze whatever substance crosses the membrane .so the cell can reuse the raw material .these disposal enzymes only function properly in environments with a PH of 5 ,two orders of magnitude more acidic than the cells internal PH of 7 . Lysosomal protein only being active in an acidic environment acts as safety mechanism for the rest of the cell ,if the lysosome were to somehow leak or burst , the degradative enzymes would in activate before they chopped up proteins the cell still needed .



DIGESTION BY LYSOSOMES

8- Peroxisome:

Like the lysosome .the peroxisome is a spherical organelle responsible for destroying its contents. Un like the lysosome .which mostly degrades proteins ,the peroxisome is the site of fatty acid breakdown .it also protect the cell from reactive oxygen species (ROS)molecules which could seriously damage the cell.

ROSs are molecules like oxygen ions or peroxides that are created as a byproduct or normal cellular metabolism .but also by radiation ,tobacco ,and drugs . they cause what is known as oxidative stress in the cell by reacting with and damaging DNA and lipid-based molecules like cell membranes .these ROSs are the reason we need antioxidants in our diet.

9- Cytoskeleton :

Within the cytoplasm there is network of protein fibers known as the cytoskeleton .this structure is responsible for both cell movement and stability . The major components of the cytoskeleton are microtubules ,intermediate filaments ,and microfilaments.

1- Microtubules:

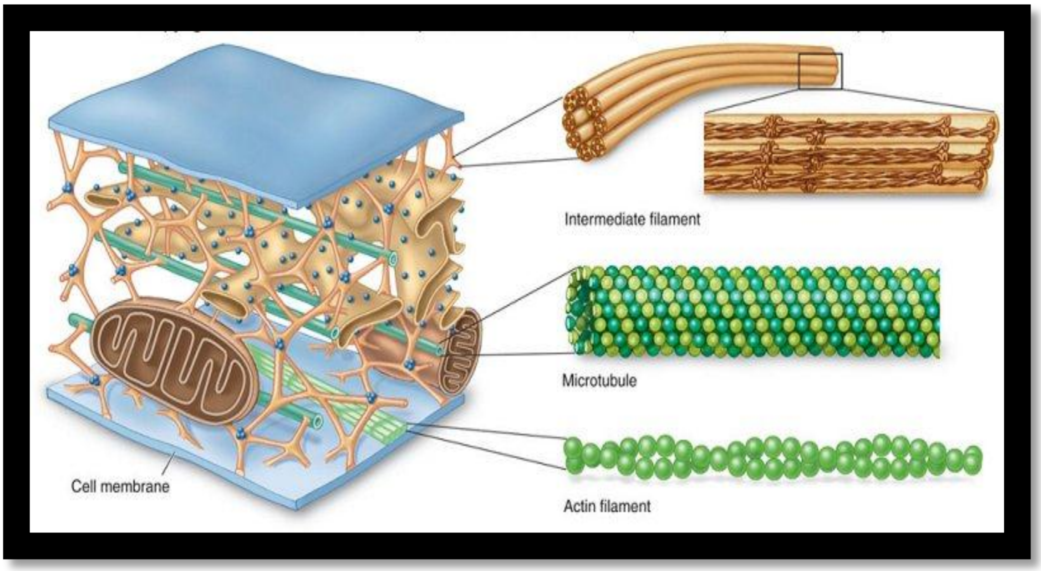
Microtubules are small tubes made from the protein tubulin .these tubules are found in cilia and flagella ,structures involved in cell movement .they also help provide pathways for secretory vesicles to move through the cell ,and are even involved in cell division as they are a part of the mitotic spindle ,which pulls homologous chromosomes apart.

2-Intermediate filaments:

Smaller than the microtubules. But larger than the microfilaments .the intermediate filaments are made of a variety of proteins such as keratin and /or neurofilament .they are very stable .and help provide structure to the nuclear envelope and another organelles.

3- Microfilaments:

Microfilaments are the thinnest part of the cytoskeleton ,and are made of actin (a highly-conserved protein that is actually the most abundant protein in most eukaryotic cells) . Actin is both flexible and strong .making it a useful protein in cell movement.



CYTOSKELETON STRUCTURE

Lec 3 the cell cycle and mitosis

the cell cycle

The **cell cycle** can be thought of as the life cycle of a cell. In other words, it is the series of growth and development steps a cell undergoes between its “birth”—formation by the division of a mother cell—and reproduction—division to make two new daughter cells.

Stages of the cell cycle

To divide, a cell must complete several important tasks: it must grow, copy its genetic material (DNA), and physically split into two daughter cells. Cells perform these tasks in an organized, predictable series of steps that make up the cell cycle. The cell cycle is a cycle, rather than a linear pathway, because at the end of each go-round, the two daughter cells can start the exact same process over again from the beginning.
In eukaryotic cells, or cells with a nucleus, the stages of the cell cycle are divided into two major phases: **interphase** and the **cell division (mitosis and meiosis)**

Interphase

Before a dividing cell enters mitosis, it undergoes a period of growth called interphase. Some 90 percent of a cell's time in the normal cellular cycle may be spent in interphase.

- **G1 phase:** The period prior to the synthesis of DNA. In this phase, the cell increases in mass in preparation for cell division. Note that the G in G1 represents gap and the 1 represents first, so the G1 phase is the first gap phase.
- **S phase:** The period during which DNA is synthesized. In most cells, there is a narrow window of time during which DNA is synthesized. Note that the S represents synthesis.
- **G2 phase:** The period after DNA synthesis has occurred but prior to the start of prophase. The cell synthesizes proteins and continues to increase in size. Note that the G in G2 represents gap and the 2 represents second, so the G2 phase is the second gap phase.
- In the latter part of interphase, the cell still has nucleoli present.
- The nucleus is bounded by a nuclear envelope and the cell's chromosomes have duplicated but are in the form of chromatin.

- In animal cells, two pair of centrioles formed from the replication of one pair are located outside of the nucleus.

Cell division

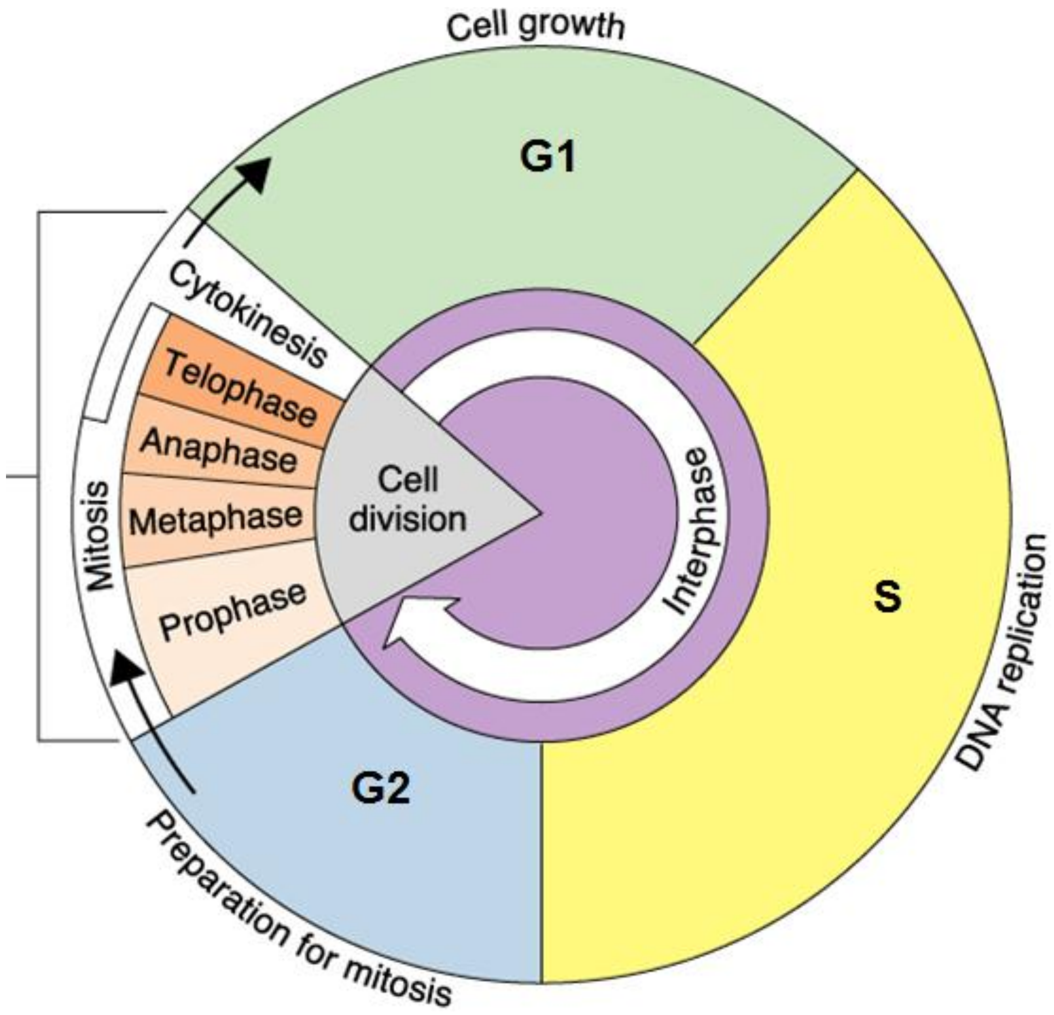
Depending on the type of cell, there are two ways cells divide—mitosis and meiosis. Each of these methods of cell division has special characteristics. One of the key differences in mitosis is a single cell divides into two cells that are replicas of each other and have the same number of chromosomes. This type of cell division is good for basic growth, repair, and maintenance. In meiosis a cell divides into two cells that have half the number of chromosomes. Reducing the number of chromosomes by half is important for sexual reproduction and provides for genetic diversity

Stages of the cell cycle

The stages of the cell cycle are divided into two major phases:

1- **Interphase** include **(**two gap phases G1 , G2 ; and S for synthesis phase**)**

2- **cell division** include
  - nuclear division (mitosis and meiosis)
  - cytoplasm division (cytokinesis)



The Stage of the cell cycle

1-Mitosis

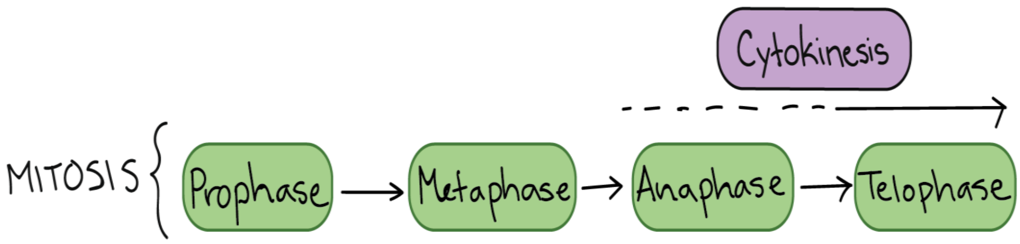
Mitosis is a type of cell division in which one cell (the **mother**) divides to produce two new cells (the **daughters**) that are genetically identical to itself. In the context of the cell cycle, mitosis is the part of the division process in which the DNA of the cell's nucleus is split into two equal sets of chromosomes.

The great majority of the cell divisions that happen in your body involve mitosis. During development and growth, mitosis populates an organism’s body with cells, and throughout an organism’s life, it replaces old, worn-out cells with new ones. For single-celled eukaryotes like yeast, mitotic divisions are actually a form of reproduction, adding new individuals to the population.

In all of these cases, the "goal" of mitosis is to make sure that each daughter cell gets a perfect, full set of chromosomes. Cells with too few or too many chromosomes usually don't function well: they may not survive, or they may even cause cancer. So, when cells undergo mitosis, they don't just divide their DNA at random and toss it into piles for the two daughter cells. Instead, they split up their duplicated chromosomes in a carefully organized series of steps.

Phases of mitosis

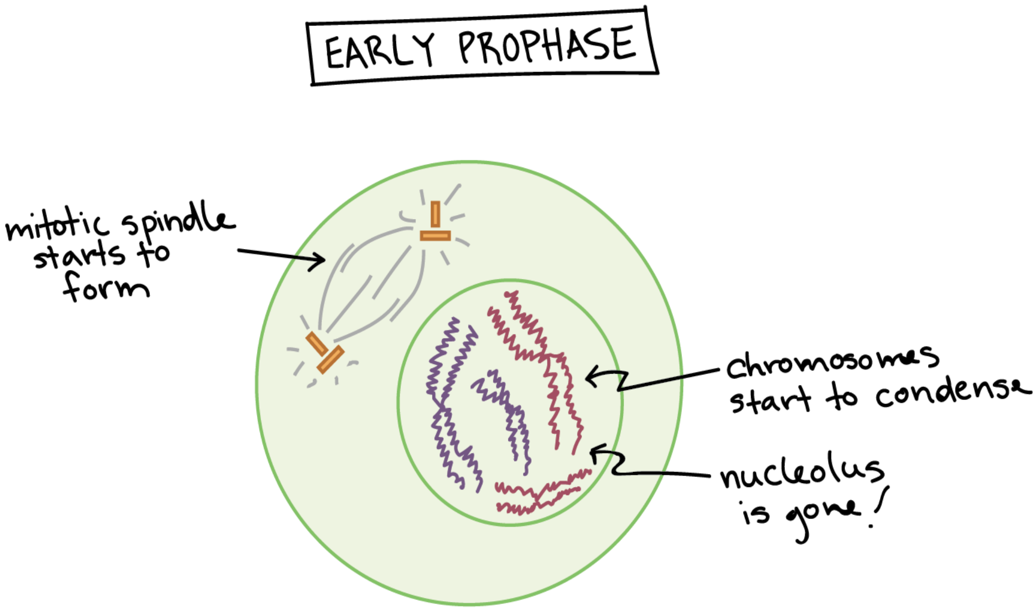
Mitosis consists of four basic phases: **prophase, metaphase, anaphase, and telophase**. Some textbooks list five, breaking prophase into an **early phase** (called **prophase**) and a **late phase** (called **prometaphase**). These phases occur in strict sequential order, and **cytokinesis** - the process of dividing the cell contents to make two new cells - starts in anaphase or telophase.



1-1 Prophase

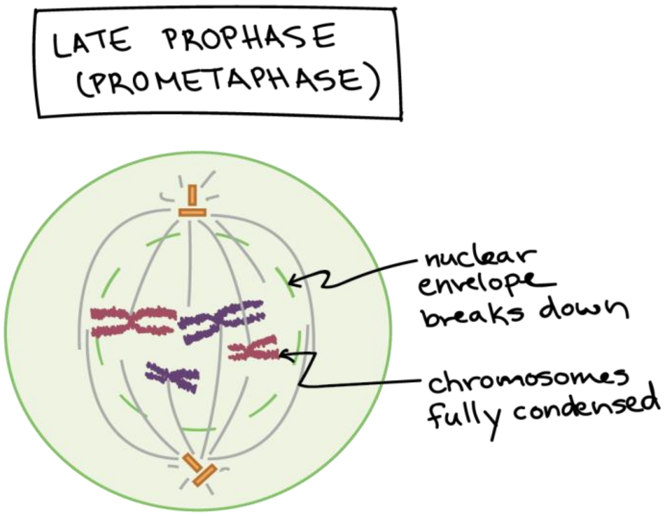
In early **prophase**, the cell starts to break down some structures and build others up, setting the stage for division of the chromosomes.

- The chromosomes start to condense (making them easier to pull apart later on).
- The **mitotic spindle** begins to form. The spindle is a structure made of microtubules, strong fibers that are part of the cell's "skeleton." Its job is to organize the chromosomes and move them around during mitosis. The spindle grows between the centrosomes as they move apart.
- The **nucleolus** (or nucleoli, plural), a part of the nucleus where ribosomes are made, disappears. This is a sign that the nucleus is getting ready to break down.



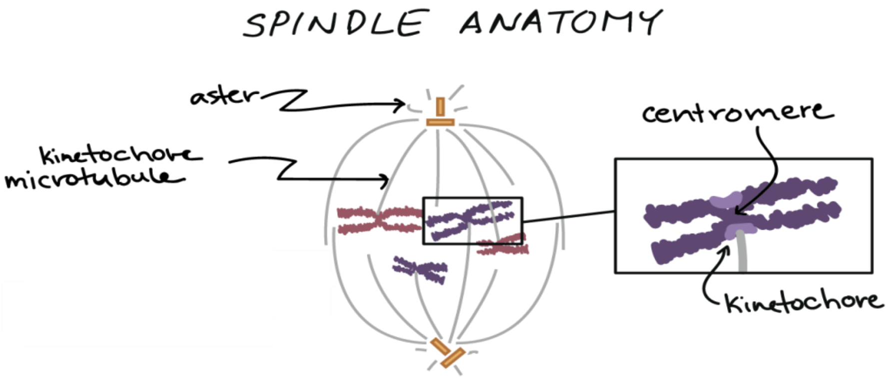
In late prophase (sometimes also called **prometaphase**), the mitotic spindle begins to capture and organize the chromosomes.

- The chromosomes finish condensing, so they are very compact.
- The nuclear envelope breaks down, releasing the chromosomes.
- The mitotic spindle grows more, and some of the microtubules start to "capture" chromosomes.



Microtubules can bind to chromosomes at the **kinetochore**, a patch of protein found on the centromere of each sister chromatid. (**Centromeres** are the regions of DNA where the sister chromatids are most tightly connected.)

Microtubules that bind a chromosome are called **kinetochore microtubules**. Microtubules that don't bind to kinetochores can grab on to microtubules from the opposite pole, stabilizing the spindle. More microtubules extend from each centrosome towards the edge of the cell, forming a structure called the **aster**.

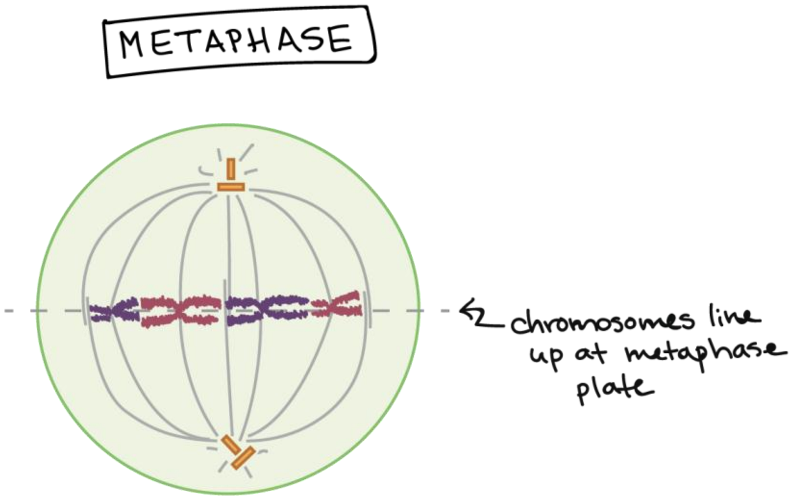


1-2 Metaphase

In **metaphase**, the spindle has captured all the chromosomes and lined them up at the middle of the cell, ready to divide.

- All the chromosomes align at the **metaphase plate** (not a physical structure, just a term for the plane where the chromosomes line up).
- At this stage, the two kinetochores of each chromosome should be attached to microtubules from opposite spindle poles.

Before proceeding to anaphase, the cell will check to make sure that all the chromosomes are at the metaphase plate with their kinetochores correctly attached to microtubules. This is called the **spindle checkpoint** and helps ensure that the sister chromatids will split evenly between the two daughter cells when they separate in the next step. If a chromosome is not properly aligned or attached, the cell will halt division until the problem is fixed

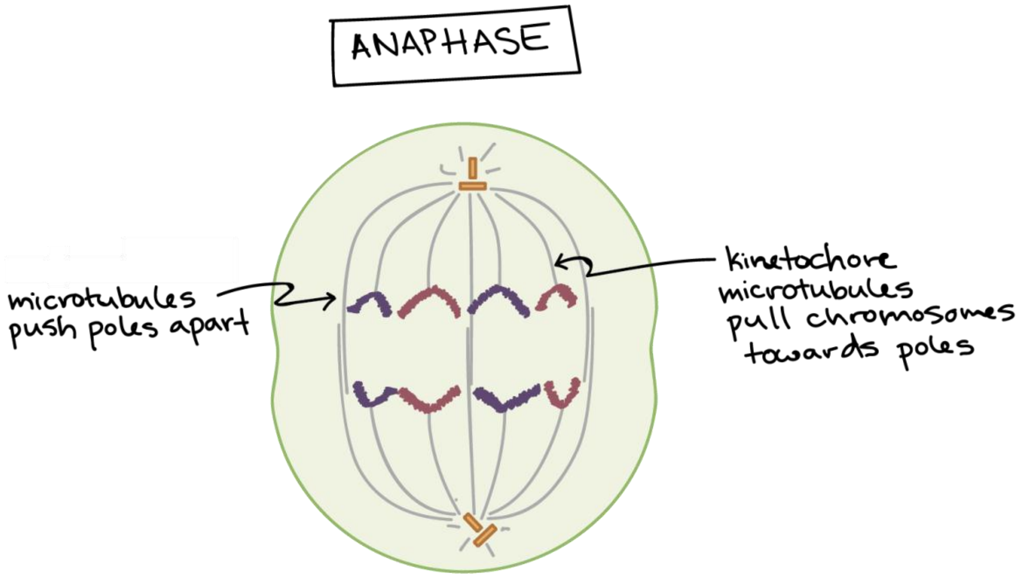


1-3 Anaphase

In **anaphase**, the sister chromatids separate from each other and are pulled towards opposite ends of the cell.

- The protein “glue” that holds the sister chromatids together is broken down, allowing them to separate. Each is now its own chromosome. The chromosomes of each pair are pulled towards opposite ends of the cell.
- Microtubules not attached to chromosomes elongate and push apart, separating the poles and making the cell longer.

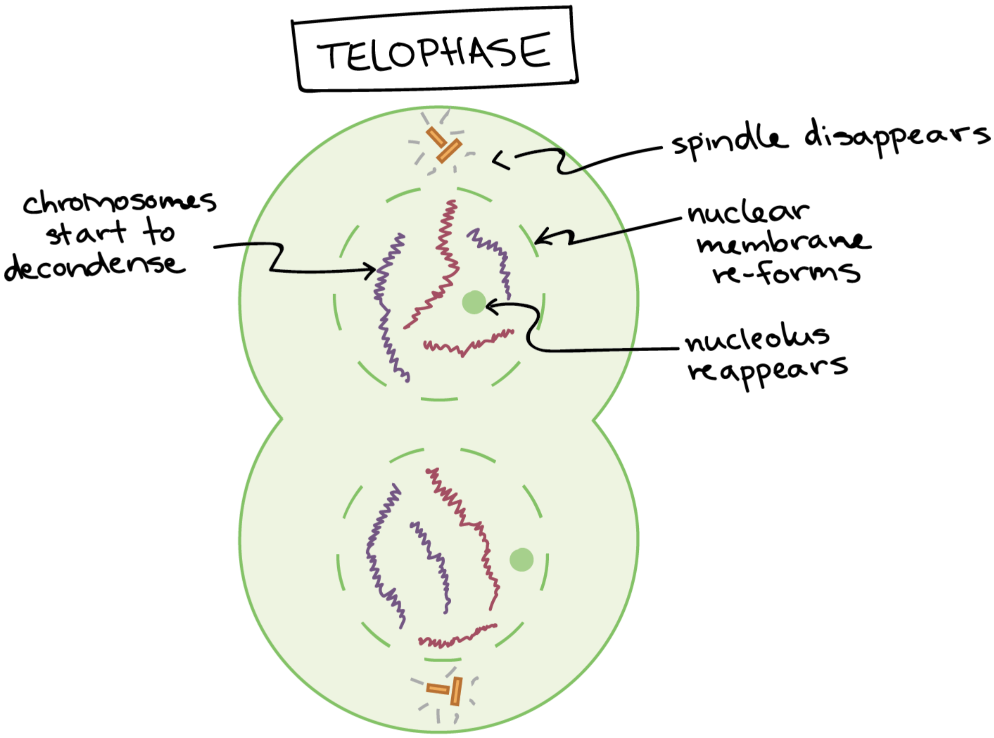
All of these processes are driven by **motor proteins**, molecular machines that can “walk” along microtubule tracks and carry a cargo. In mitosis, motor proteins carry chromosomes or other microtubules as they walk.



1-4 Telophase,

In **telophase**, the cell is nearly done dividing, and it starts to re-establish its normal structures as cytokinesis (division of the cell contents) takes place.

- The mitotic spindle is broken down into its building blocks.
- Two new nuclei form, one for each set of chromosomes. Nuclear membranes and nucleoli reappear.
- The chromosomes begin to decondense and return to their "stringy" form.

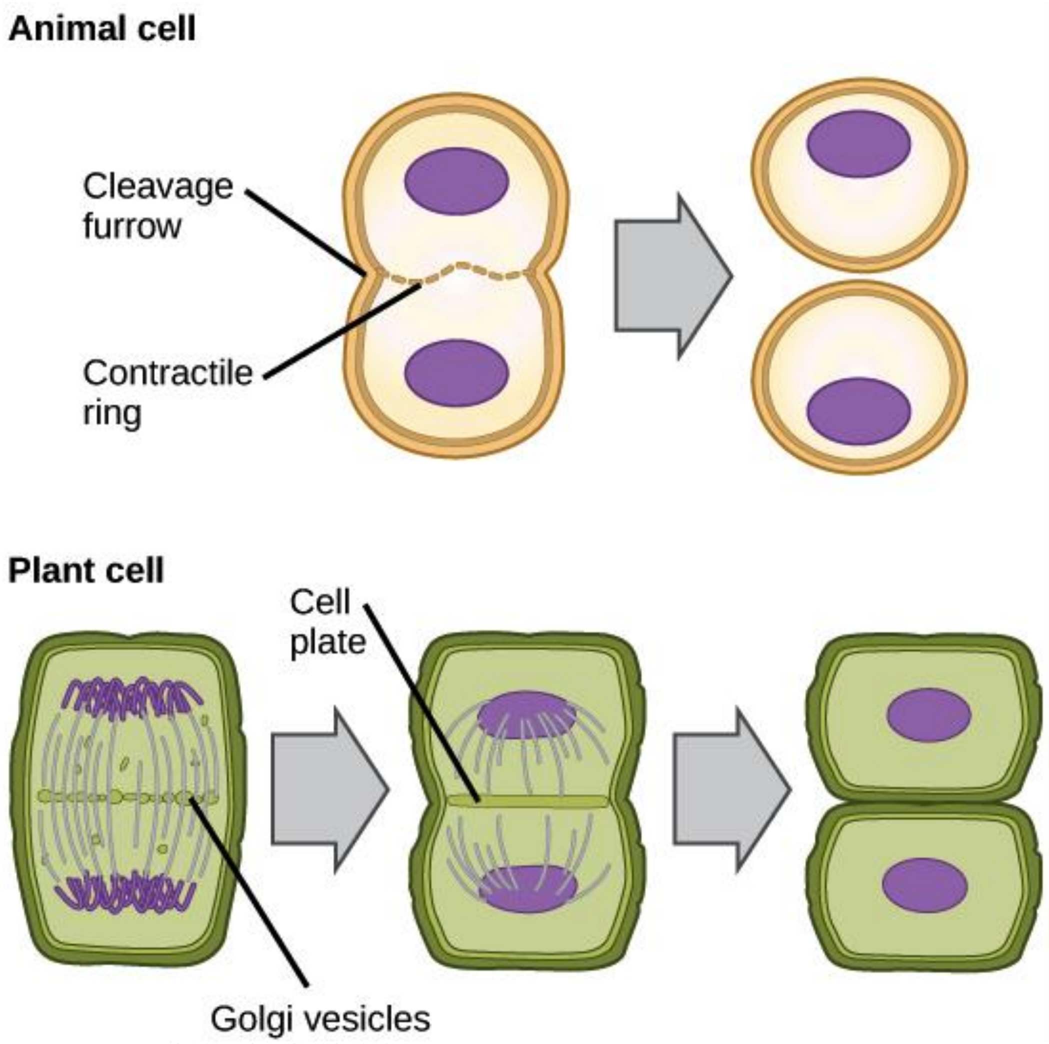


Cytokinesis

The division of the cytoplasm to form two new cells, overlaps with the final stages of mitosis. It may start in either anaphase or telophase, depending on the cell, and finishes shortly after telophase.

* **In animals**, cell division occurs when a band of cytoskeletal fibers called the **contractile ring** contracts inward and pinches the cell in two, a process called contractile cytokinesis. The indentation produced as the ring contracts inward is called the **cleavage furrow**. Animal cells can be pinched in two because they're relatively soft and squishy.

* **Plant cells** are much stiffer than animal cells; they're surrounded by a rigid cell wall and have high internal pressure. Because of this, plant cells divide in two by building a new structure down the middle of the cell. This structure, known as the **cell plate**, is made up of plasma membrane and cell wall components delivered in vesicles, and it partitions the cell in two.



Cell cycle exit and G0

What happens to the two daughter cells produced in one round of the cell cycle? This depends on what type of cells they are. Some types of cells divide rapidly, and in these cases, the daughter cells may immediately undergo another round of cell division. For instance, many cell types in an early embryo divide rapidly, and so do cells in a tumor.
Other types of cells divide slowly or not at all. These cells may exit the **G1 phase** and enter a resting state called **G0 phase**. In G0 , a cell is not actively preparing to divide, it’s just doing its job. For instance, it might conduct signals as a neuron (like the one in the drawing below) or store carbohydrates as a liver cell. G0 is a permanent state for some cells, while others may re-start division if they get the right signals.

Lec 4 meiosis

The concept of meiosis

The purpose of meiosis is to make haploid gametes. In order to explain the difference between mitosis and meiosis quickly and easily, consider the following analogy: You own a restaurant, and you keep 46 cookbooks on hand, to store all the recipes you need to make the food you sell. If you opened a new restaurant that you wanted to make the same food as the one that already exists, what would you do? Copy all 46 cookbooks, and take them to the new restaurant. That's like what happens in *mitosis*. Consider that the cookbooks are chromosomes, each containing lots of recipes that cells use to make "dishes," called proteins. When cell division occurs, each cell wants to ensure that each new cell can make the same proteins as the original. So each of the chromosomes are copied and evenly distributed to both new cells—both cells get a copy of each "cookbook."
Meiosis is different. Whereas as mitosis makes a new cell with the same number of chromosomes, meiosis is a *reductive* type of cell division: it results in cells with fewer chromosomes.

Phases of meiosis

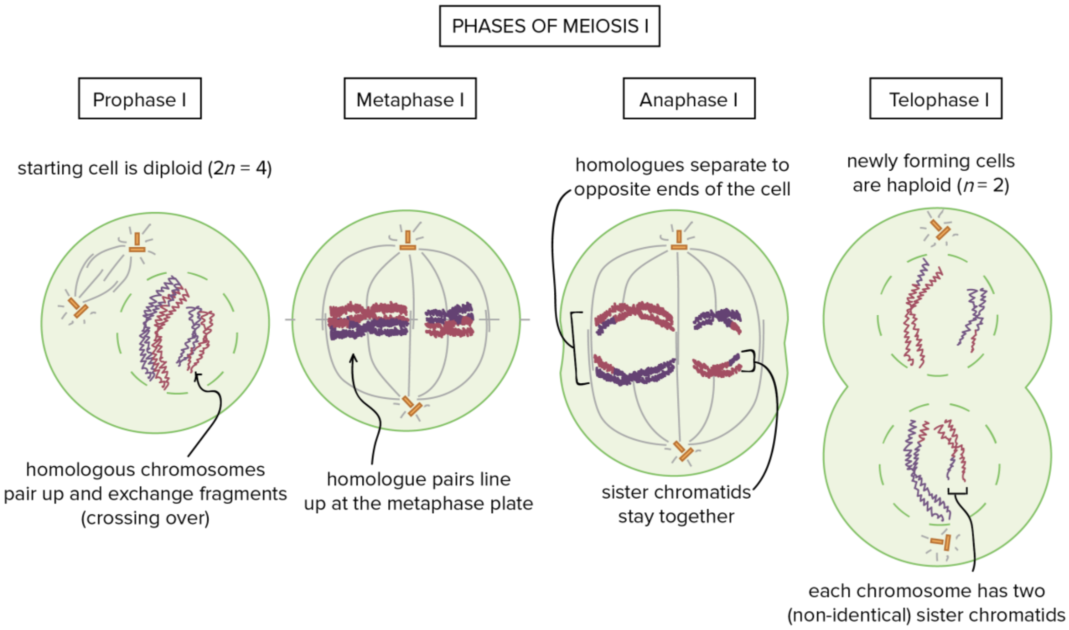
In many ways, meiosis is a lot like mitosis. The cell goes through similar stages and uses similar strategies to organize and separate chromosomes. In meiosis, however, the cell has a more complex task. It still needs to separate **sister chromatids** (the two halves of a duplicated chromosome), as in mitosis. But it must also separate **homologous chromosomes**, the similar but non identical chromosome pairs an organism receives from its two parents.
These goals are accomplished in meiosis using a two-step division process. Homologue pairs separate during a first round of cell division, called **meiosis I**. Sister chromatids separate during a second round, called **meiosis II**.
Since cell division occurs twice during meiosis, one starting cell can produce four gametes (eggs or sperm). In each round of division, cells go through four stages: prophase, metaphase, anaphase, and telophase.

Meiosis

Meiosis is the form of eukaryotic cell division that produces **haploid** sex cells or gametes (which contain a single copy of each chromosome) from **diploid** cells (which contain two copies of each chromosome). The process takes the form of one DNA replication followed by two successive nuclear and cellular divisions (Meiosis I and Meiosis II). As in mitosis, meiosis is preceded by a process of DNA replication that converts each chromosome into two sister chromatids.

Meiosis I

Before entering meiosis I, a cell must first go through interphase. As in mitosis, the cell grows during G1 phase, copies all of its chromosomes during S phase, and prepares for division during G2 phase



In Meiosis I a special cell division reduces the cell from diploid to haploid.

Prophase I

The homologous chromosomes pair and exchange DNA to form recombinant chromosomes. For instance, in the image below, the letters A, B, and C represent genes found at particular spots on the chromosome, with capital and lowercase letters for different forms, or alleles, of each gene. The DNA is broken at the same spot on each homologue—here, between genes B and C—and reconnected in a criss-cross pattern so that the homologues exchange part of their DNA.

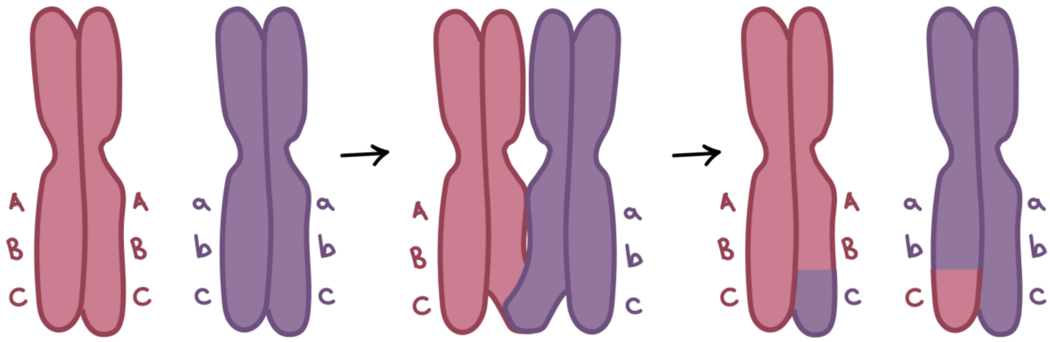


Image of crossing over

This process, in which homologous chromosomes trade parts, is called **crossing over**. It's helped along by a protein structure called the **synaptonemal complex** that holds the homologues together. The chromosomes would actually be positioned one on top of the other—as in the image below—throughout crossing over; they're only shown side-by-side in the image above so that it's easier to see the exchange of genetic material.

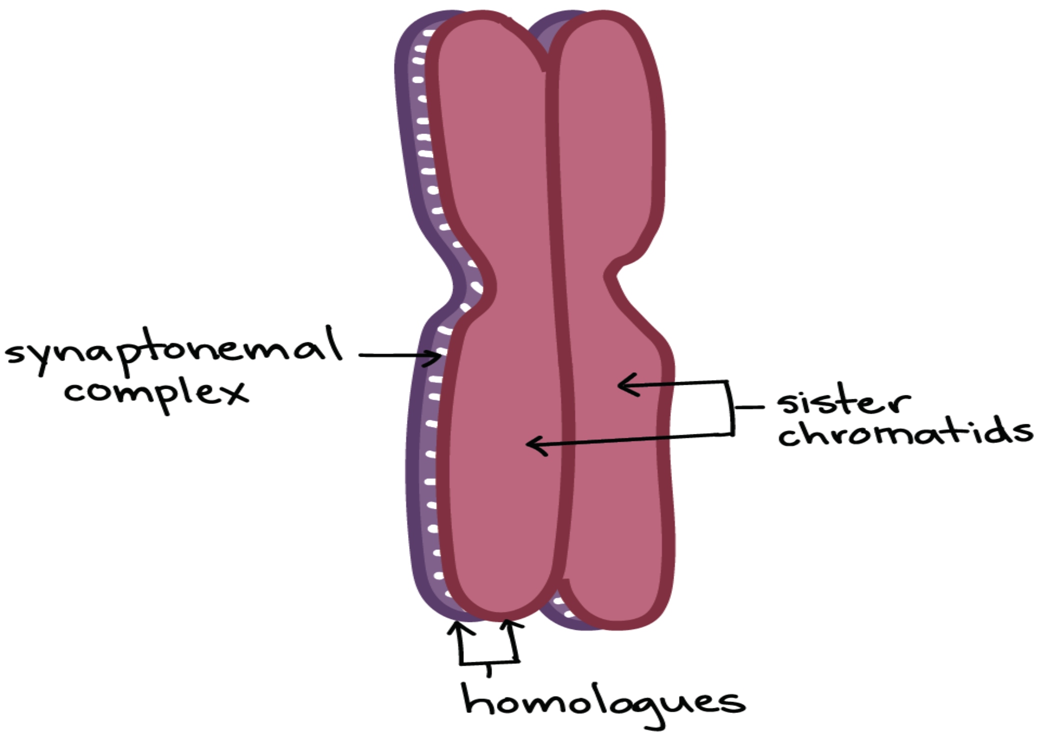


Image of two homologous chromosomes, positioned one on top of the other and held together by the synaptonemal complex

Prophase I is divided into five phases:

- **Leptotene**: chromosomes start to condense.
- **Zygotene**: homologous chromosomes become closely associated (synapsis) to form pairs of chromosomes (bivalents) consisting of four chromatids (tetrads).
- **Pachytene**: crossing over between pairs of homologous chromosomes to form chiasmata (sing. chiasma).
- **Diplotene**: homologous chromosomes start to separate but remain attached by chiasmata.
- **Diakinesis**: homologous chromosomes continue to separate, Spindle apparatus formed, and chromosomes attached to spindle fibres by kinetochores.

Metaphase I

Homologous pairs of chromosomes (bivalents) arranged as a double row along the metaphase plate. The arrangement of the paired chromosomes with respect to the poles of the spindle apparatus is random along the metaphase plate. (This is a source of genetic variation through random assortment, as the paternal and maternal chromosomes in a homologous pair are similar but not identical. The number of possible arrangements is 2^n, where n is the number of chromosomes in a haploid set. Human beings have 23 different chromosomes, so the number of possible combinations is 2^{23}, which is over 8 million.)

Anaphase I

The homologous chromosomes in each bivalent are separated and move to the opposite poles of the cell

Telophase I

The chromosomes become diffuse and the nuclear membrane reforms.

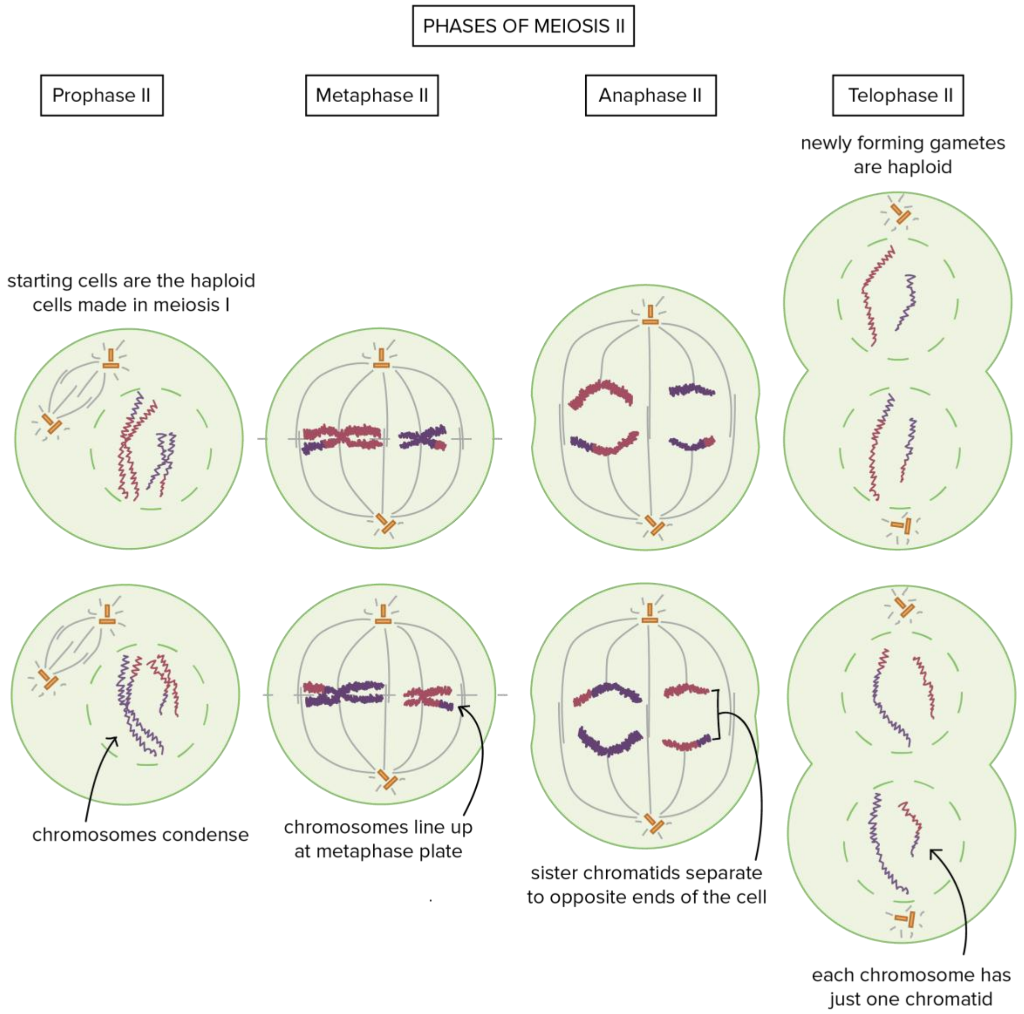
Cytokinesis

The final cellular division to form two new cells, followed by Meiosis II. Meiosis I is a reduction division: the original diploid cell had two copies of each chromosome; the newly formed haploid cells have one copy of each chromosome.

Meiosis II

Cells move from meiosis I to meiosis II without copying their DNA. Meiosis II is a shorter and simpler process than meiosis I, and you may find it helpful to think of meiosis II as “mitosis for haploid cells."

The cells that enter meiosis II are the ones made in meiosis I. These cells are haploid—have just one chromosome from each homologue pair—but their chromosomes still consist of two sister chromatids. In meiosis II, the sister chromatids separate, making haploid cells with non-duplicated chromosomes.



Phases of meiosis II

Prophase II: Starting cells are the haploid cells made in meiosis I. Chromosomes condense.
Metaphase II: Chromosomes line up at the metaphase plate.
Anaphase II: Sister chromatids separate to opposite ends of the cell.
Telophase II: Newly forming gametes are haploid, and each chromosome now has just one chromatid.
During **prophase II**, chromosomes condense and the nuclear envelope breaks down, if needed. The centrosomes move apart, the spindle forms between them, and the spindle microtubules begin to capture chromosomes.
In some organisms, the centrosomes duplicate between meiosis I and II, even though DNA is not copied during this period. For instance, the centrosomes duplicate between meiosis I and II during spermatogenesis, sperm production, in humans

The diagram above, which shows two
centrosomes at the start of meiosis II, assumes that the centrosomes were duplicated between meiosis I and II.
In other organisms, however, the centrosomes do not duplicate at all between meiosis I and II. Instead, the two centrioles that make up a single centrosome separate, and each acts as a separate spindle pole during meiosis II. This pattern of centriole separation is seen in insect spermatogenesis .
The two sister chromatids of each chromosome are captured by microtubules from opposite spindle poles. In **metaphase II**, the chromosomes line up individually along the metaphase plate. In **anaphase II**, the sister chromatids separate and are pulled towards opposite poles of the cell.
In **telophase II**, nuclear membranes form around each set of chromosomes, and the chromosomes decondense. Cytokinesis splits the chromosome sets into new cells, forming the final products of meiosis: four haploid cells in which each chromosome has just one chromatid. In humans, the products of meiosis are sperm or egg cells.
. In some cases, meiosis does produce four functional gametes: for instance, meiosis during spermatogenesis, or sperm production, in human males yields four sperm cells.

However, when meiosis takes place during oogenesis, egg cell production, in human females, only one functional egg cell is made. At the end of meiosis I, only one of the two daughter cells continues down the egg cell pathway, while the other becomes a non-egg cell called a **polar body**. Similarly, of the two products of meiosis II, one will become a functional egg cell, while the other will become a second polar body.

The polar bodies are not normally fertilized by sperm cells, and they typically undergo programmed cell death, or apoptosis, within 24 hours of being produced .

The events of Meiosis II are analogous to those of a mitotic division, although the number of chromosomes involved has been halved

Meiosis generates genetic diversity through:

- the exchange of genetic material between homologous chromosomes during Meiosis I
- the random alignment of maternal and paternal chromosomes in Meiosis I
- the random alignment of the sister chromatids at Meiosis II

Lec 5 cell differentiation

Cell Differentiation

What is Cell Differentiation?

Living organisms can be made of a single cell, such as bacteria and protists, or they can be multicellular, like plants, animals, and fungi. Unicellular organisms, like bacteria, are able to perform all life functions within one single cell. They can transport molecules, metabolize nutrients, and reproduce within this one cell.

Multicellular organisms need many different types of cells to carry out the same life processes. Each of these special types of cells has a different structure that helps it perform a specific function. Humans have many different types of cells with different jobs, such as blood cells that carry oxygen and nerve cells that transmit signals to all parts of the body. Cell differentiation is the process by which cells become specialized in order to perform different functions

Multicellular organisms begin as just one single cell—a fertilized egg. Growing from one single cell to trillions of specialized cells that perform different functions is a process that happens with the regulation of DNA and RNA.

Stem Cells

A **stem cell** is an unspecialized cell that can divide without limit as needed and can, under specific conditions, differentiate into specialized cells. Stem cells are divided into several categories according to their potential to differentiate.

The first embryonic cells that arise from the division of the zygote are the ultimate stem cells; these stems cells are described as **totipotent** because they have the potential to differentiate into any of the cells needed to enable an organism to grow and develop.

The embryonic cells that develop from totipotent stem cells and are precursors to the fundamental tissue layers of the embryo are classified as pluripotent. A **pluripotent** stem cell is one that has the potential to differentiate into any type of human tissue but cannot support the full development of an organism. These cells then become slightly more specialized, and are referred to as multipotent cells.

A **multipotent** stem cell has the potential to differentiate into different types of cells within a given cell lineage or small number of lineages, such as a red blood cell or white blood cell.

Finally, multipotent cells can become further specialized oligopotent cells. An **oligopotent** stem cell is limited to becoming one of a few different cell types. In contrast, a **unipotent** cell is fully specialized and can only reproduce to generate more of its own specific cell type.

Stem cells are unique in that they can also continually divide and regenerate new stem cells instead of further specializing. There are different stem cells present at different stages of a human's life. They include the embryonic stem cells of the embryo, fetal stem cells of the fetus, and adult stem cells in the adult

. One type of adult stem cell is the

epithelial stem cell: which gives rise to the keratinocytes in the multiple layers of epithelial cells in the epidermis of skin.

hematopoietic stem cells, which give rise to red blood cells, white blood cells, and platelets

endothelial stem cells: which give rise to the endothelial cell types that line blood and lymph vessels

mesenchymal stem cells : which give rise to the different types of muscle cells.

Roles of DNA and RNA in Cell Differentiation

DNA controls the way cells function. It also determines what type of specialized cells will be made. Stem cells are cells that have the ability to become any type of specialized cell in the body. After an egg cell and sperm cell unite to begin forming a new organism, all of the DNA in each cell of that organism will be virtually identical. If every part of the DNA in each cell is the same, then how do cells become different types of cells? Let's look more closely at DNA to find out.

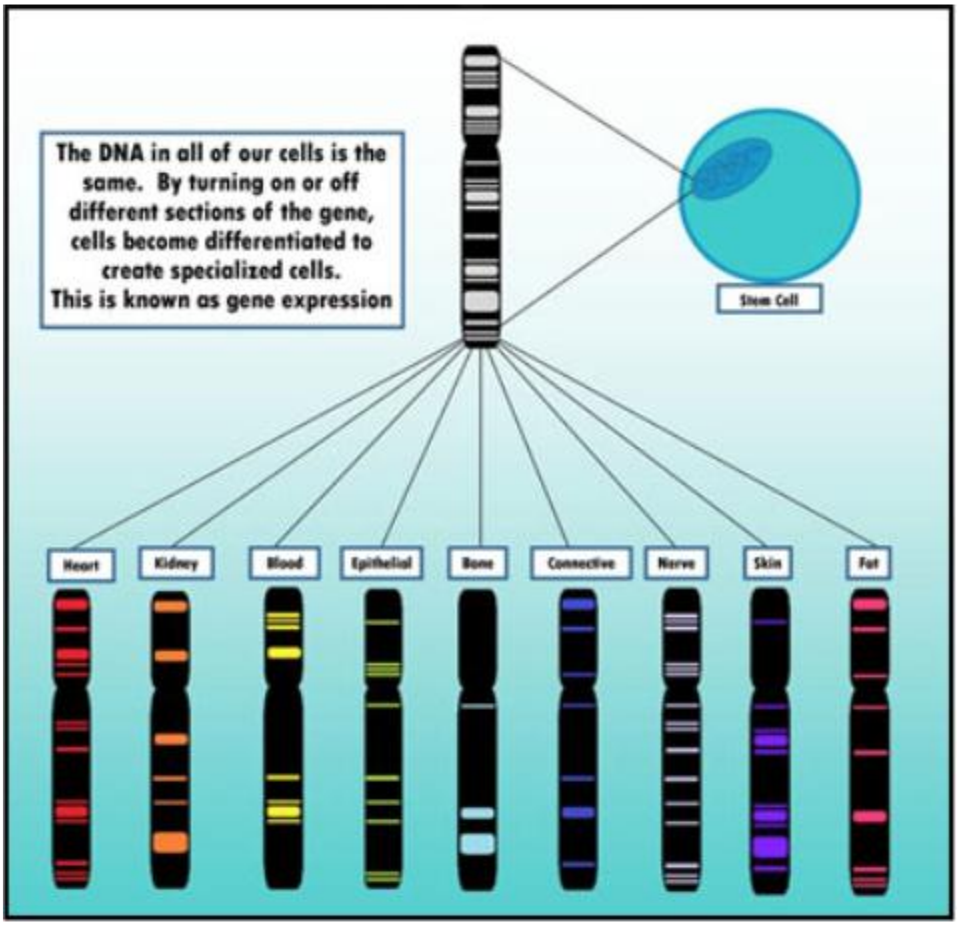


Figure (1) gene expression

DNA is wound tightly into chromosomes. Different regions of the chromosome code for every different function and cell type. Not all sections of a chromosome are turned on, or expressed, at the same time. Only the regions that are needed to perform a specific function are expressed in each cell. These regions are often depicted as bands or stripes on a drawing of a chromosome. These bands are called genes, and whether or not a gene is expressed determines what type of cell will be created. For example, genes that are expressed (turned on) in a nerve cell are different from the genes that are expressed in a muscle cell. Both cells have the same DNA, but expressing different genes generates different cell types.

This process by which information from a gene is used to make the structures of a cell is called gene expression. Since RNA translates and transcribes the DNA code into proteins (the structures of a cell), it also plays a role in cell differentiation.

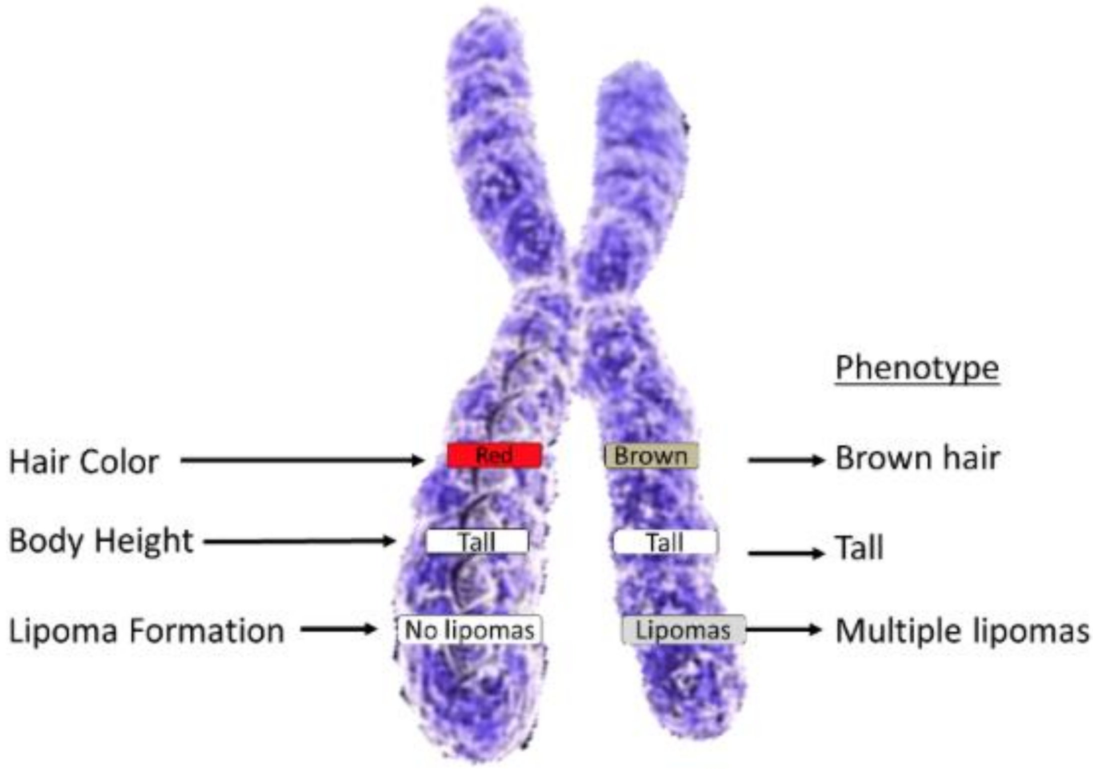


Figure (2) Images of chromosomes

Images of chromosomes, like the one to the left, usually look a bit like an ‘X’. That is because chromosomes come in pairs—one from each of our parents. Chromosomes in a pair contain the same genes (like genes for hair color, body height, and lipoma formation). The genes we receive from each parent might be the same (as shown for body height), or or they might be different (as shown for hair color). The alternative forms of a gene that are found at the same place on a chromosome are called alleles.

Lec 6 Animals Tissue (Epithelia and Glandular Tissue)

Animals Tissue

The term **tissue** is used to describe a group of cells found together in the body. The cells within a tissue share a common embryonic origin. Microscopic observation reveals that the cells in a tissue share morphological features and are arranged in an orderly pattern that achieves the tissue's functions.

Although there are many types of cells in the human body, they are organized into four broad categories of tissues: epithelial, connective, muscle, and nervous. Each of these categories is characterized by specific functions that contribute to the overall health and maintenance of the body. A disruption of the structure is a sign of injury or disease. Such changes can be detected through **histology**, the microscopic study of tissue appearance, organization, and function.

Embryonic Origin of Tissues

The zygote, or fertilized egg, is a single cell formed by the fusion of an egg and sperm. After fertilization the zygote gives rise to rapid mitotic cycles, generating many cells to form the embryo. The first embryonic cells generated have the ability to differentiate into any type of cell in the body and, as such, are called **totipotent**, meaning each has the capacity to divide, differentiate, and develop into a new organism. As cell proliferation progresses, three major cell lineages are established within the embryo. Each of these lineages of embryonic cells forms the distinct germ layers from which all the tissues and organs of the human body eventually form. Each germ layer is identified by its relative position: **ectoderm** (ecto- = "outer"), **mesoderm** (meso- = "middle"), and **endoderm** (endo- = "inner") Epithelial cells derive from all three major embryonic layers. The epithelia lining the skin, parts of the mouth and nose, and the anus develop from the ectoderm. Cells lining the airways and most of the digestive system originate in the endoderm. The epithelium that lines vessels in the lymphatic and cardiovascular system derives from the mesoderm and is called an endothelium, whereas nervous tissue derives primarily from the ectoderm and muscle tissue from mesoderm.

Epithelial tissues

Most epithelial tissues are essentially large sheets of cells covering all the surfaces of the body exposed to the outside world and lining the outside of organs. Epithelium also forms much of the glandular tissue of the body

Functions of the Epithelium

Epithelia tissue forms boundaries between different environments, and nearly all substances must pass through the epithelium. In its role as an interface tissue, epithelium accomplishes many functions, including:

1. Protection for the underlying tissues from radiation, toxins, and physical trauma.
2. Absorption of substances in the digestive tract lining with distinct modifications.
3. Regulation and excretion of chemicals between the underlying tissues and the body cavity.
4. The secretion of hormones into the blood vascular system. The secretion of sweat, mucus, enzymes, and other products that are delivered by ducts come from the glandular epithelium.
5. The detection of sensation.

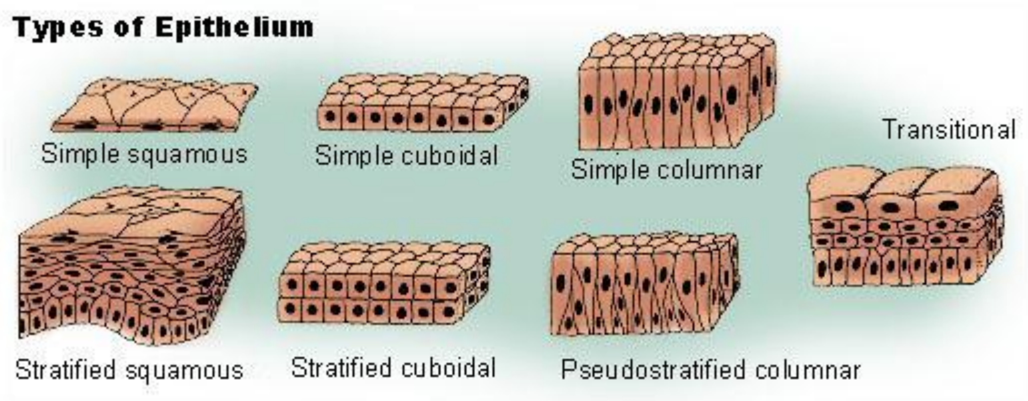
Characteristics of Epithelial Layers

Epithelial tissue is composed of cells laid out in sheets with strong cell-to-cell attachments. These protein connections hold the cells together to form a tightly connected layer that is avascular but innervated in nature.The epithelial cells are nourished by substances diffusing from blood vessels in the underlying connective tissue. One side of the epithelial cell is oriented towards the surface of the tissue, body cavity, or external environment and the other surface is joined to a basement membrane. The basement layer is non-cellular in nature and helps to cement the epithelial tissue to the underlying structures.

Types of Epithelial Tissue

Epithelium has two names. The first name indicates the number of cell layers, the second describes the shape of its cell. Based on the number of cell layers, epithelia can either be simple or stratified.

- **Simple epithelia**– consist of a single cell layer (found where absorption, secretion, and filtration occur).
- **Stratified epithelia**– are composed of two or more cell layers stacked on top of each other (typically found in high abrasion areas where protection is needed).



Simple Epithelia

Simple epithelium consists of a single layer of cells. They are typically where absorption, secretion and filtration occur. The thinness of the epithelial barrier facilitates these processes.

Simple epithelial tissues are generally classified by the shape of their cells. The four major classes of simple epithelium are: 1) simple squamous; 2) simple cuboidal; 3) simple columnar; and 4) pseudostratified.

Simple Squamous

Simple squamous epithelium cells are flat in shape and arranged in a single layer. This single layer is thin enough to form a membrane that compounds can move through via passive diffusion . Two simple squamous epithelium in the body have special names reflecting their location.

1. **Endothelium**– provides a friction-reducing lining in lymphatic vessels and all hollow organs of the cardiovascular system (heart, blood vessels, capillaries).
2. **Mesothelium**– is the epithelium found in serous membranes (membranes lining the ventral body cavity and covering the organs within it).

Simple Cuboidal

Simple cuboidal epithelium consists of a single layer cells that are as tall as they are wide. The important functions of the simple cuboidal epithelium are secretion and absorption. This epithelial type is found in the small collecting ducts of the kidneys, pancreas, and salivary glands.

Simple Columnar

Simple columnar epithelium is a single row of tall, closely packed cells, aligned in a row. These cells are found in areas with high secretory function (such as the wall of the stomach), or absorptive areas (as in small intestine). They possess cellular extensions (e.g., microvilli in the small intestine, or the cilia found almost exclusively in the female reproductive tract).

Pseudostratified

These are simple columnar epithelial cells whose nuclei appear at different heights, giving the misleading (hence pseudo) impression that the epithelium is stratified when the cells are viewed in cross section.

Pseudostratified epithelium can also possess fine hair-like extensions of their apical (luminal) membrane called cilia. In this case, the epithelium is described as ciliated pseudostratified epithelium. Ciliated epithelium is found in the airways (nose, bronchi), but is also found in the uterus and fallopian tubes of females, where the cilia propel the ovum to the uterus.

Stratified Epithelium

Stratified epithelium differs from simple epithelium by being multilayered. It is therefore found where body linings have to withstand mechanical or chemical insults.

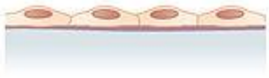
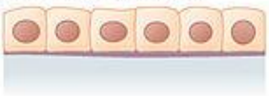
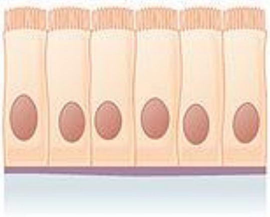
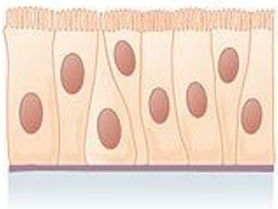
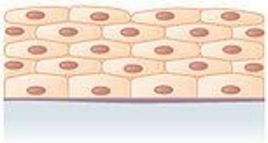
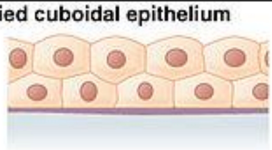
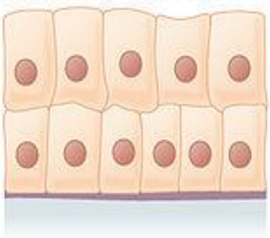
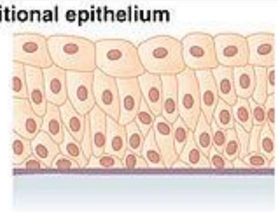
Stratified epithelia are more durable and protection is one their major functions. Since stratified epithelium consists of two or more layers, the basal cells divide and push towards the apex, and in the process flatten the apical cells.

Stratified squamous epithelium– is the most widespread stratified epithelia. It’s composed of several layers and is perfect for its protective role. Its apical surface cells are squamous and cells of the deeper layer are either cuboidal or columnar. Stratified squamous forms the external part of the skin and extends into every body opening that’s continuous with the skin. The outer layer of the skin (epidermis) is *keratinized* (contains *keratin*, a protective protein). Other stratified squamous in the body is nonkeratinized.

Stratified cuboidal epithelium– is somewhat rare in the human body. It's mainly found in the ducts of glands (sweat glands, mammary glands) and is typically has two layers of cuboidal cells.

Stratified columnar epithelium– is also rare in the human body. Small amounts are found in the pharynx, male urethra, and lining of some glandular ducts. Stratified columnar epithelium occurs in transition areas (junctions) between other epithial types.

Transitional epithelium– forms the lining of hollow urinary organs, which stretch as they fill with urine. Cells in the basal layer are cuboidal or columnar. Cells by the apical surface vary in appearance depending if the organ is stretched at the time. Transitional cells have the ability to change their shape which allows more urine to flow through.

Cells	Location	Function
Simple squamous epithelium 	Air sacs of lungs and the lining of the heart, blood vessels, and lymphatic vessels	Allows materials to pass through by diffusion and filtration, and secretes lubricating substance
Simple cuboidal epithelium 	In ducts and secretory portions of small glands and in kidney tubules	Secretes and absorbs
Simple columnar epithelium 	Ciliated tissues are in bronchi, uterine tubes, and uterus; smooth (nonciliated tissues) are in the digestive tract, bladder	Absorbs; it also secretes mucous and enzymes
Pseudostratified columnar epithelium 	Ciliated tissue lines the trachea and much of the upper respiratory tract	Secretes mucus; ciliated tissue moves mucus
Stratified squamous epithelium 	Lines the esophagus, mouth, and vagina	Protects against abrasion
Stratified cuboidal epithelium 	Sweat glands, salivary glands, and the mammary glands	Protective tissue
Stratified columnar epithelium 	The male urethra and the ducts of some glands	Secretes and protects
Transitional epithelium 	Lines the bladder, uretha, and the ureters	Allows the urinary organs to expand and stretch

Glandular Epithelium

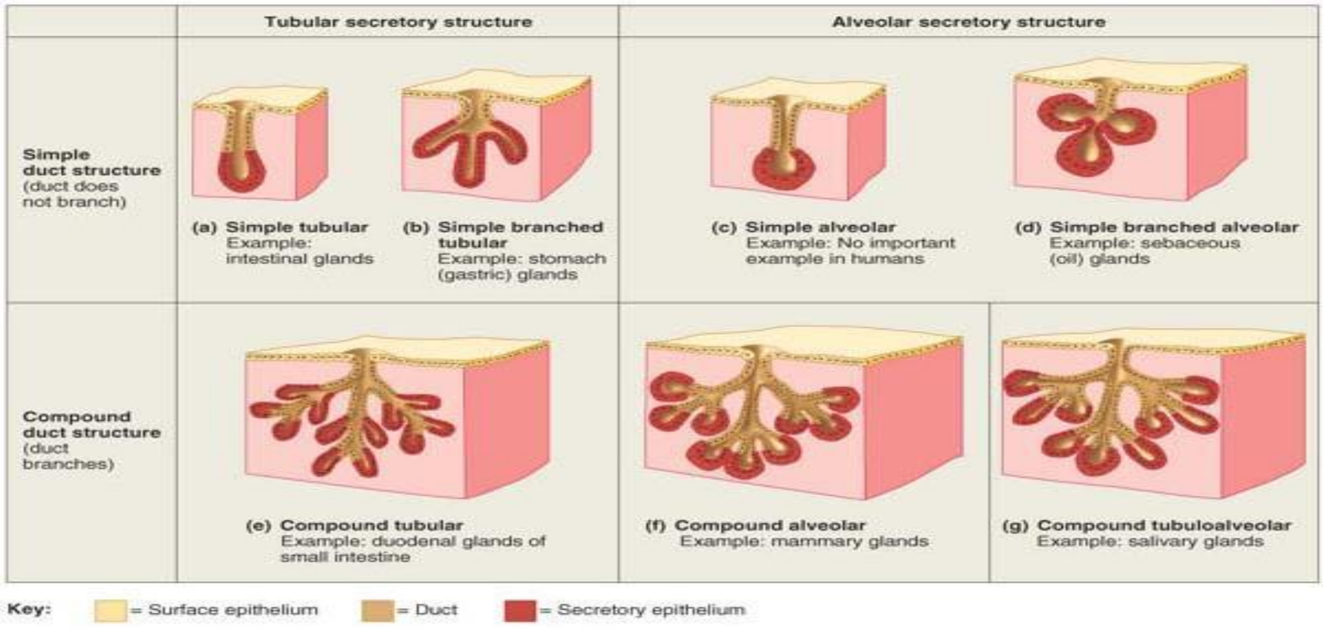
A **gland** is one or more cells that produce and secrete a specific product. The product is always a water-based fluid (aqueous) and usually contains proteins (the product is referred to as a **secretion**). Secretion is considered an active process. Glandular cells obtain substances needed from blood and transform them (chemically) into a product that's discharged from the cell.

Glands are classified into two groups based on characteristics:

1. Where they release their product- glands can be *endocrine* (secrete internally) or *exocrine* (secrete externally),or mixed gland (secrete internally and externally)
2. The number of cells they contain- glands can be *unicellular* (one-celled) or *multicellular* (more than one cell).

Endocrine Glands

Endocrine glands are also called *ductless glands* because eventually, they lose their ducts. They produce **hormones** (chemical messengers) and secrete them by exocytosis into the extracellular space. After entering the extracellular space, they enter the blood or lymphatic fluid and travel to specific organs. Each hormone makes its target organ respond in a specific way. For instance, hormones produced by intestinal cells cause the pancreas to release enzymes that aid in digestion.



Hormones secreted by endocrine glands vary. For instance, one gland might secrete an amino acid while another secretes glycoproteins or steroids.

Exocrine Glands

Exocrine glands secrete their products onto the skin or into body cavities. Unicellular exocrine glands do this directly by exocytosis, while multicellular glands transport their product through a duct on the epithelial surface. Products secreted by exocrine glands include sweat, oil, mucous, bile, and more.

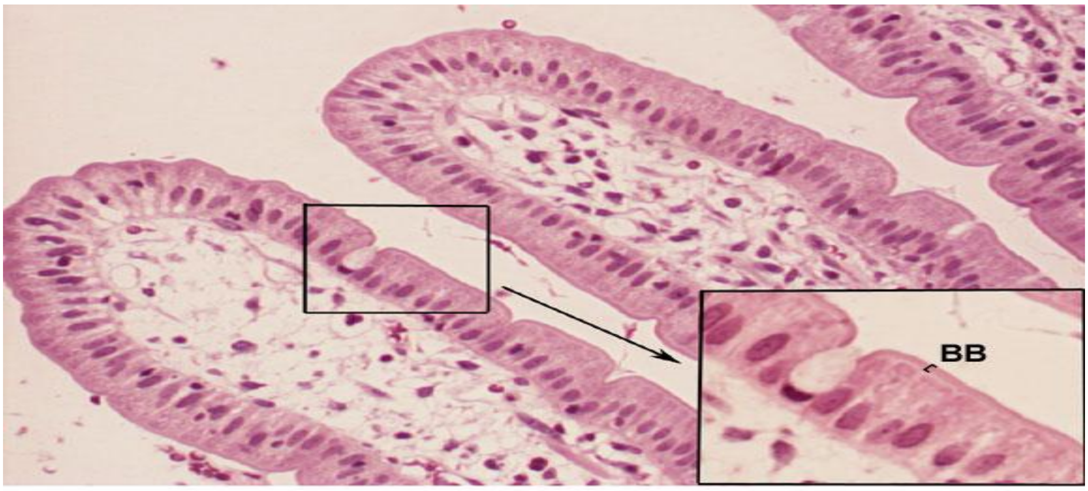
Unicellular exocrine glands

Important examples of **unicellular glands** include *goblet cells* (looks like a goblet) and *mucous cells*. Unicellular glands can be found within the epithelial linings of the intestinal and respiratory tracts.

In humans, unicellular exocrine glands produce **mucin,** a complex glycoprotein that dissolves in water. When the mucin is dissolved, it forms mucous (which protects and lubricates surfaces).

Multicellular exocrine glands

Structurally, **multicellular exocrine glands** are more complex than their unicellular neighbors. They have two main parts: an *epithelium-derived duct* and a *secretory unit* (made of secretory cells). In almost all cases, the secretory unit is surrounded by connective tissue. The connective tissue supplies the secretory unit with blood vessels and nerve fibers . It also forms a *fibrous capsule* that extends into the gland and divides it into *lobes*. Multicellular exocrine glands are classified by structure and secretion (type).



Observe simple columnar epithelium. 20x Insert shows a closeup of a goblet cell and has brush border (BB) labeled.

Image of a unicellular exocrine gland (goblet cell).

Structural classification

Multicellular exocrine glands are structurally classified depending on the structure of their duct.

- **Simple glands**– have an unbranched duct
- **Compound glands**– have a branched duct

The glands can be further categorized by their secretory units as:

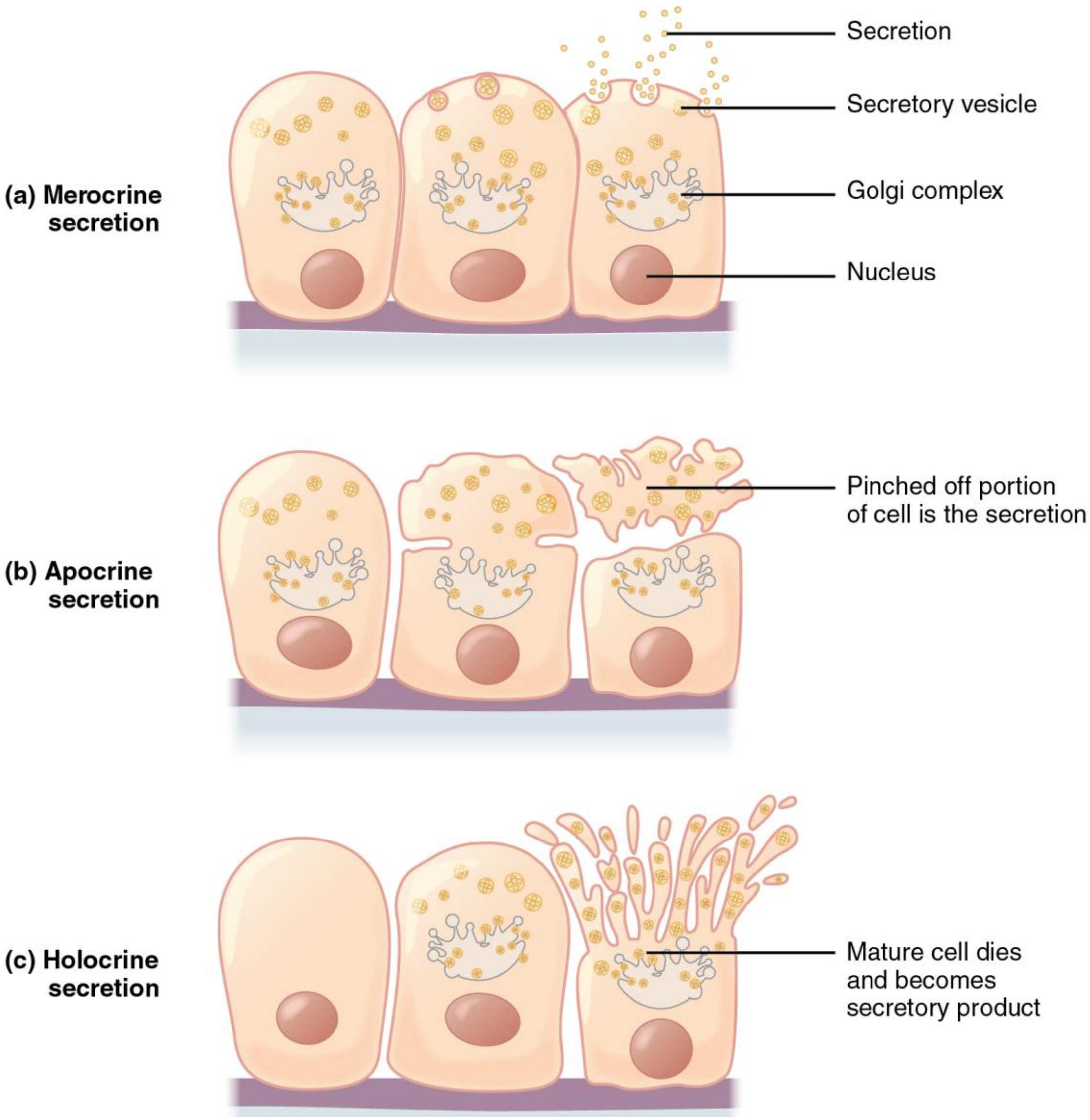
- **Tubular**– if the secretory cells form tubes
- **Alveolar**– if the secretory cells form small sacs
- **Tubuloalveolar**– if they have both tubular and alveolar secretory units

Methods and Types of Secretion

Exocrine glands can be classified by their mode of secretion and the nature of the substances released, as well as by the structure of the glands and shape of ducts **Merocrine secretion** is the most common type of exocrine secretion. The secretions are enclosed in vesicles that move to the apical surface of the cell where the contents are released by exocytosis. For example, watery mucous containing the glycoprotein mucin, a lubricant that offers some pathogen protection is a merocrine secretion.

Apocrine secretion accumulates near the apical portion of the cell. That portion of the cell and its secretory contents pinch off from the cell and are released. The sweat glands of the armpit are classified as apocrine glands. Both merocrine and apocrine glands continue to produce and secrete their contents with little damage caused to the cell because the nucleus and golgi regions remain intact after secretion.

In contrast, the process of **holocrine secretion** involves the rupture and destruction of the entire gland cell. The cell accumulates its secretory products and releases them only when it bursts. New gland cells differentiate from cells in the surrounding tissue to replace those lost by secretion. The sebaceous glands that produce the oils on the skin and hair are holocrine glands/cells



Lec 7 Connective tissue

Connective tissue

connective tissue serves a connecting function. It supports and binds other tissues in the body. Unlike epithelial tissue, which has cells that are closely packed together, connective tissue typically has cells scattered throughout an extracellular matrix of fibrous proteins and glycoproteins attached to a basement membrane. The primary elements of connective tissue include a ground substance, fibers, and cells.

Function of Connective Tissue

The major functions of connective tissue include:

1) establishing a structural framwork for the body.
2) transporting fluids and dissolved materials from in body.
3) provides protection for delicate organs.
4) supports, surrounds, and interconnects other tissue types.
5) stores energy reserves (especially lipids).
6) defends the body from invasion.

Structure of Connective Tissue

Connective tissue has three main components:

1. **Ground substance**
2. **Fibers**
3. **Cells**

Together the ground substance and fibers make up the extracellular matrix. The composition of these three elements vary tremendously from one organ to the other. This offers great diversity in the types of connective tissue.

Ground substance is a clear, colorless, viscous fluid that fills the space between the cells and fibers. It is composed of proteoglycans and cell adhesion proteins that allow the connective tissue to act as glue for the cells to attach to the matrix. The ground substance functions as a molecular sieve for substances to travel between blood capillaries and cells.

Connective tissue fibers provide support. Three types of fibers are found in connective tissue:

1. **Collagen fibers**
2. **Elastic fibers**
3. **Reticular fibers**

Collagen Fibers are the strongest and most abundant of all the connective tissue fibers.Collagen fibers are fibrous proteins and are secreted into the extracellular space . White fiber is soft, flexible and inelastic that gives the tissue strength. We can see in dermis.

Elastic Fibers are long, thin fibers that form branching network in the extracellular matrix. They help the connective tissue to stretch and recoil.

Reticular Fibers are short, fine collagenous fibers that can branch extensively to form a delicate network.

Connective tissue cells

- **Fibroblasts -** secrete the proteins needed for fiber synthesis and components of the extracellular matrix
- **Adipose** or **fat cells** (**adipocytes**). Common in some tissues (dermis of skin); rare in some (cartilage)
- **Mast cells**. Common beneath membranes; along small blood vessels. Can release heparin, histamine, and proteolytic enzymes in response to injury.
- **Leukocytes (WBC's)**. Respond to injury or infection
- **Macrophages**. Derived from monocytes (a WBC). Phagocytic; provide protection
- **Chondroblasts -** form cartilage
- **Osteoblasts -** form bone
- **Hematopoietic stem cells** - form blood cells
- **Undifferentiated mesenchyme** (stem cells). Have potential to differentiate into adult cell types.

Types of connective tissue

1-proper connective tissue
2-Special connective tissue

Connective tissue proper has two subclasses: **loose** and **dense**.

Loose connective tissue is divided into

1) areolar connective tissue
2) adipose connective tissue

3)reticular connective tissue

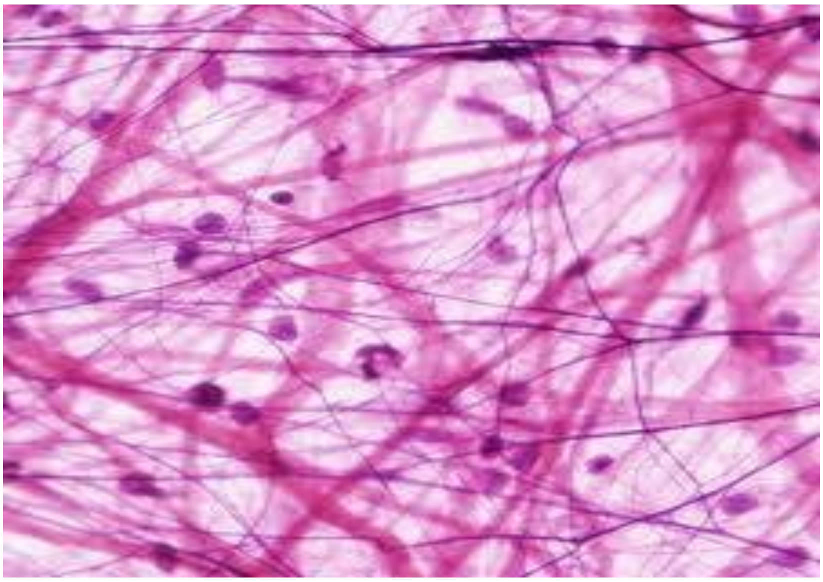
Dense connective tissue is divided into
1) dense regular connective tissue
2) dense irregular connective tissue
3) elastic connective tissue

proper connective tissue

Areolar Connective Tissue

These tissues are widely distributed and serve as a universal packing material between other tissues. The ground substance is semisolid which contain yellow and white fibers and little of reticular fibers. The cells which the most common in this tissue are: fibroblast, mast cell, macrophage, and plasma cell.The functions of areolar connective tissue include the support and binding of other tissues.

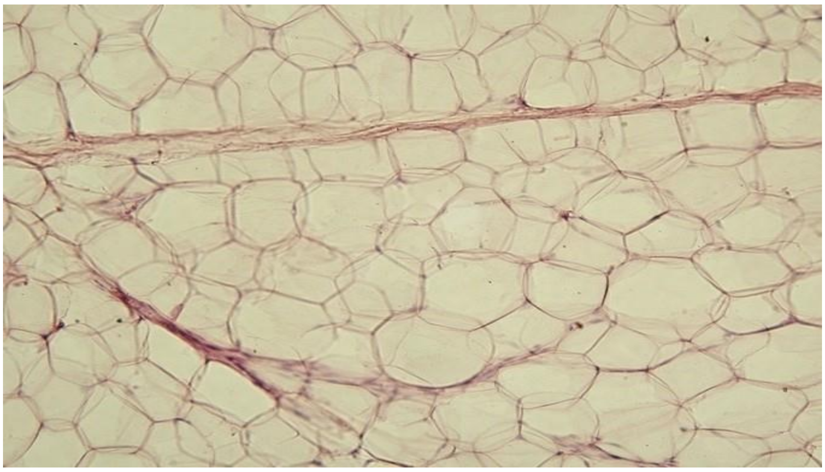
It also helps in defending against infection. When a body region is inflamed, the areolar tissue in the area soaks up the excess fluid as a sponge and the affected area swells and becomes puffy, a condition called edema.



Adipose Tissue

This is loose connective tissue composed of adipocytes. It is technically composed of roughly only 80% fat. Its main role is to store energy in the form of lipids, although it also cushions and insulates the body.

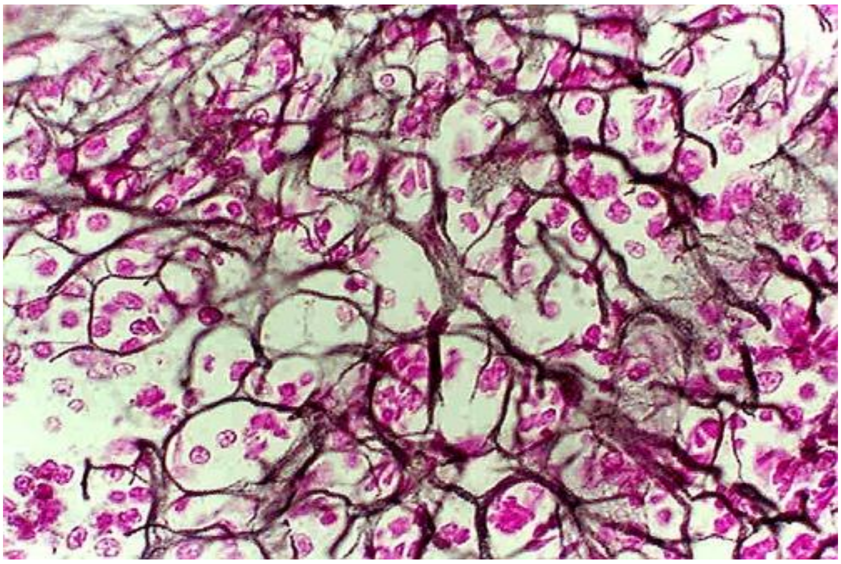
The two types of adipose tissue are white adipose tissue (WAT) and brown adipose tissue (BAT). Adipose tissue is found in specific locations ,referred to as adipose depots.



Adipose Tissue

Reticular Connective Tissue

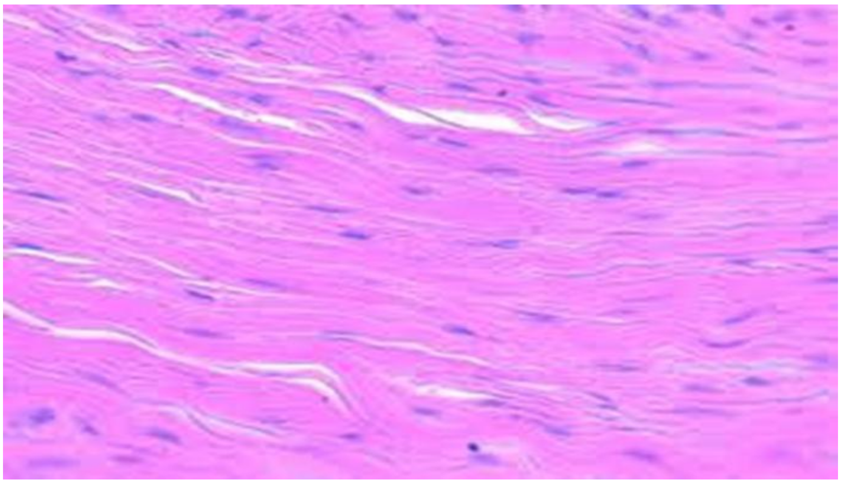
This tissue resembles areolar connective tissue, but the only fibers in its matrix are the reticular fibers, which form a delicate network. The reticular tissue is limited to certain sites in the body, such as internal frameworks that can support lymph nodes, spleen, and bone marrow.



Dense Regular Connective Tissue

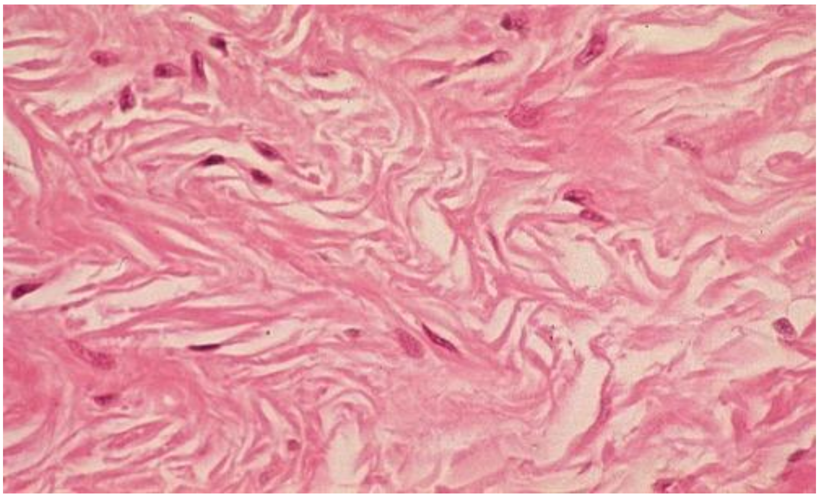
This consists of closely packed bundles of collagen fibers running in the same direction. These collagen fibers are slightly wavy and can stretch a little bit.

With the tensile strength of collagen, this tissue forms tendons, and ligaments. This tissue forms the fascia, which is a fibrous membrane that wraps around the muscles, blood vessels, and nerves.



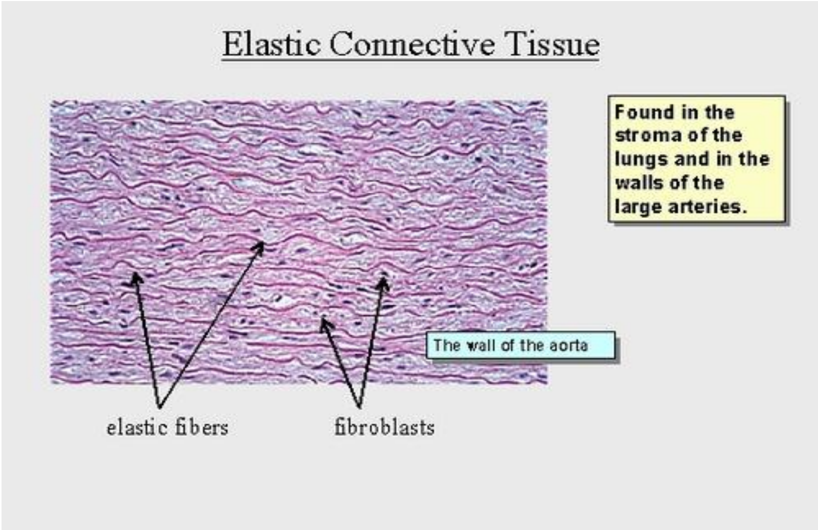
Dense Irregular Tissue

This has the same structural elements as dense regular tissue, but the bundles of collagen fibers are much thicker and arranged irregularly. This tissue is found in areas where tension is exerted from many different directions. It is part of the skin dermis area and in the joint capsules of the limbs.



Elastic Connective Tissue

The main fibers that form this tissue are elastic in nature. These fibers allow the tissues to recoil after stretching. This is especially seen in the arterial blood vessels and walls of the bronchial tubes.



Classification of Connective Tissue

Type	Cells and Matrix	Function	Location
Loose (areolar)	Fibroblasts, mast cells; Collagenous fibers, elastin	Binding; protection, nourishment; holds fluids	Deep to skin; around muscles, vessels, organs
Dense fibrous	Fibroblasts; Densely packed collagenous fibers	Strong, flexible	Tendon, ligament
Elastic	Fibroblasts; Elastin fibers	Flexibility, distensibility	Arteries, larynx, trachea, bronchi
Reticular	Phagocytes; Reticular fibers in jellylike matrix	Phagocytic function	Liver, spleen, lymph nodes, bone marrow
Adipose	Adipocytes; very little matrix	Stores lipids	Hypodermis, around organs
Cartilage Hyaline Fibrocartilage Elastic	Chondrocytes; Collagenous fibers, elastin in elastic cartilage	Support, strength and flexibility	Joints, trachea, nose, outer ear, larynx
Bone Spongy bone Compact bone	Osteocytes; Collagenous fibers, calcium carbonate	Strong support	Bones
Blood	Erythrocytes; leukocytes, thrombocytes (platelets);	Conduction of nutrients and wastes	Circulatory system

Lec 8 Special connective tissue

Special connective tissue

Specialized connective tissues include a number of different tissues with specialized cells and unique ground substances. Some of these tissues are solid and strong, while others are fluid and flexible.

1- Cartilage

Cartilage is a flexible connective tissue that differs from bone in several ways. For one, the primary cell types are chondrocytes as opposed to osteocytes. Chondrocytes are first chondroblast cells that produce the collagen extracellular matrix (ECM) and then get caught in the matrix. They lie in spaces called lacunae with up to eight chondrocytes located in each.

Chondrocytes rely on diffusion to obtain nutrients as, unlike bone, cartilage is avascular, meaning there are no vessels to carry blood to cartilage tissue. This lack of blood supply causes cartilage to heal very slowly compared with bone.

The base substance of cartilage is chondroitin sulfate, and the microarchitecture is substantially less organized than in bone. The cartilage fibrous sheath is called the perichondrium.

Articular cartilage function is dependent on the molecular composition of its ECM, which consists mainly of proteoglycans and collagens. This connective tissue found in many areas in the bodies of humans and other animals, including the joints between bones, the rib cage, the ear, the nose, the knee, the bronchial tubes, and the intervertebral discs.

Types of Cartilage

There are three major types of cartilage: hyaline cartilage, fibrocartilage, and elastic cartilage.

Hyaline Cartilage

Hyaline cartilage is the most widespread cartilage type and, in adults, it forms the articular surfaces of long bones, the rib tips, the rings of the trachea, and parts of the skull. This type of cartilage is predominately collagen (yet with few collagen fibers), and its name refers to its glassy appearance.

In the embryo, bones form first as hyaline cartilage before ossifying as development progresses. Hyaline cartilage is covered externally by a fibrous membrane, called the perichondrium, except at the articular ends of bones; it also occurs under the skin (for instance, ears and nose).

Hyaline cartilage is found on many joint surfaces. It contains no nerves or blood vessels, and its structure is relatively simple.

Fibrocartilage

Fibrous cartilage has lots of collagen fibers (Type I and Type II), and it tends to grade into dense tendon and ligament tissue. White fibrocartilage consists of a mixture of white fibrous tissue and cartilaginous tissue in various proportions.

It owes its flexibility and toughness to the fibrous tissue, and its elasticity to the cartilaginous tissue. It is the only type of cartilage that contains type I collagen in addition to the normal type II.

Fibrocartilage is found in vertebral discs, discs of knee joint

Elastic Cartilage

Elastic or yellow cartilage contains elastic fiber networks and collagen fibers. The principal protein is elastin.

Elastic cartilage is histologically similar to hyaline cartilage but contains many yellow elastic fibers lying in a solid matrix. These fibers form bundles that appear dark under a microscope. They give elastic cartilage great flexibility so it can withstand repeated bending.

Chondrocytes lie between the fibers. Elastic cartilage is found in the epiglottis (part of the larynx) and the pinnae (the external ear flaps of many mammals, including humans).

2-Bone

Bone tissue is a type of connective tissue that contains lots of calcium and phosphorous salts. About **25%** of bone tissue is water, another **25%** is made up of protein fibers like collagen. The other **50%** of bone tissue is a mixture of mineral salts, primarily calcium and phosphorous.

Function of Bone Tissue

1-Support ,The skeleton serves as a structural framework to support the organs of the body.
2- Protection ,Critically important organs need protection from everyday bumps and bruises.
The brain is particularly sensitive and is completely encased in an armored container known as the skull.
The heart and lungs also require protection. They are surrounded by a cage of bone known as the rib cage.
3-Movement ,Muscles work with the bones of the skeletal system to move body parts around.

4-Energy storage ,Energy is stored in fat cells or **adipose tissue** in the yellow bone marrow. This tissue is found inside the hollow core of bones, particularly long bones.

5-Blood cell production ,Blood cells are produced in the red marrow. The production of blood cells is called **hemopoesis**.

6-Mineral "Bank" Bone tissue contains a large amount of certain ions, (calcium, phosphorous) which help make the tissue so strong and durable.

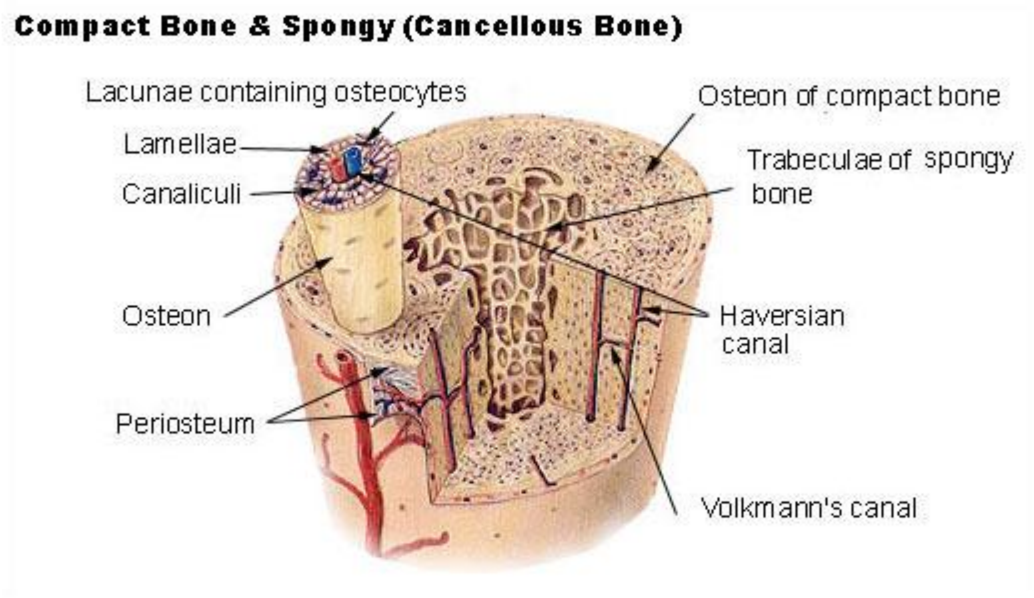
This large deposit of ions can also be used to maintain blood levels of these ions by either adding or removing them from the bloodstream and storing them in bone tissue.

Structure of Bone Tissue

There are two types of bone tissue: compact and spongy. The names imply that the two types differ in density, or how tightly the tissue is packed together. There are three types of cells that contribute to bone homeostasis. Osteoblasts are bone-forming cell, osteoclasts resorb or break down bone, and osteocytes are mature bone cells. An equilibrium between osteoblasts and osteoclasts maintains bone tissue.

A-Compact Bone

Compact bone consists of closely packed osteons or haversian systems. The osteon consists of a central canal called the osteonic (haversian) canal, which is surrounded by concentric rings (lamellae) of matrix. Between the rings of matrix, the bone cells (osteocytes) are located in spaces called lacunae. Small channels (canaliculi) radiate from the lacunae to the osteonic (haversian) canal to provide passageways through the hard matrix. In compact bone, the haversian systems are packed tightly together to form what appears to be a solid mass. The osteonic canals contain blood vessels that are parallel to the long axis of the bone. These blood vessels interconnect, by way of perforating canals, with vessels on the surface of the bone.



B- Spongy (Cancellous) Bone

Spongy (cancellous) bone is lighter and less dense than compact bone. Spongy bone consists of plates (trabeculae) and bars of bone adjacent to small, irregular cavities that contain red bone marrow. The canaliculi connect to the adjacent cavities, instead of a central haversian canal, to receive their blood supply. It may appear that the trabeculae are arranged in a haphazard manner, but they are organized to provide maximum strength similar to braces that are used to support a building.

3- Blood and Lymph

Blood

This is considered a specialized form of connective tissue. Blood is a bodily fluid in animals that delivers necessary substances, such as nutrients and oxygen, to the cells and transports metabolic waste products away from those same cells. The matrix consists of the plasma with **erythrocytes or** red blood cells, **leukocytes or** white blood cells, and platelets suspended in the plasma . Blood has three main functions: **transport, protection and regulation.**

Composition of blood

Blood is classified as a connective tissue and consists of two main components:

1. Plasma, which is a clear extracellular fluid
2. Formed elements, which are made up of the blood cells and platelets

The formed elements are so named because they are enclosed in a plasma membrane and have a definite structure and shape. All formed elements are cells except for the platelets, which are tiny fragments of bone marrow cells. Formed elements are:

- Erythrocytes, also known as red blood cells (RBCs)
- Leukocytes, also known as white blood cells (WBCs)
- Platelets

Red blood cells

Red blood cells (RBCs), also known as erythrocytes, have two main functions:

1. To pick up oxygen from the lungs and deliver it to tissues elsewhere
2. To pick up carbon dioxide from other tissues and unload it in the lungs

An erythrocyte is a disc-shaped cell with a thick rim and a thin sunken centre. . Red blood cells contain a protein called Haemoglobin. This combines with oxygen to form Oxyhaemoglobin. Each red blood cell has a lifespan of approximately 120 days before it gets broken down by the spleen. New cells are manufactured in the bone marrow of most bones. There are approximately 4.5-5 million red cells per micro-litre of blood

White blood cells

White blood cells (WBCs) are also known as leukocytes. They can be divided into granulocytes and agranulocytes. The former have cytoplasms that contain organelles that appear as coloured granules through light microscopy,

Granulocytes

1. **Neutrophils:** These contain very fine cytoplasmic granules that can be seen under a light microscope. Neutrophils are also called polymorphonuclear (PMN) because they have a variety of nuclear shapes. They play roles in the destruction of bacteria and the release of chemicals that kill or inhibit the growth of bacteria.
2. **Eosinophils:** These have large granules and a prominent nucleus that is divided into two lobes. They function in the destruction of allergens and inflammatory chemicals, and release enzymes that disable parasites.
3. **Basophils:** They have a pale nucleus that is usually hidden by granules. They secrete histamine which increases tissue blood flow via dilating the blood vessels, and also secrete heparin which is an anticoagulant that promotes mobility of other WBCs by preventing clotting.

Agranulocytes

1. **Lymphocytes:** These are usually classified as small, medium or large. Medium and large lymphocytes are generally seen mainly in fibrous connective tissue and only occasionally in the circulation bloodstream. Lymphocytes function in destroying cancer cells, cells infected by viruses, and foreign invading cells. In addition, they present antigens to activate other cells of the immune system. They also coordinate the actions of other immune cells, secrete antibodies .
2. **Monocytes:** They are the largest of the formed elements. Their cytoplasm tends to be abundant and relatively clear. They function in differentiating into macrophages, which are large phagocytic cells, and digest pathogens, dead neutrophils, and the debris of dead cells. Like lymphocytes, they also present antigens to activate other immune cells.

Platelets : are fragments of cytoplasm detached from Megakaryocytes in the bone marrow. They aggregate together during the process of blood coagulation and clotting. Platelets are small (2-5 um), have no nucleus and are ovoid shaped.

Blood plasma ,Blood plasma is a mixture of proteins, enzymes, nutrients, wastes, hormones and gases.

Proteins ,These are the most abundant substance in plasma by weight and play a part in a variety of roles including clotting, defense and transport There are three major categories of plasma proteins

1. **Albumins**
2. **Globulins**
3. **Fibrinogen**

Lymph

Lymph ,pale fluid that bathes the tissues of an organism, maintaining fluid balance, and removes bacteria from tissues; it enters the blood system by way of lymphatic channels and ducts.Prominent among the constituents of lymph are lymphocytes and macrophages, the primary cells of the immune system with which the body defends itself from invasion by foreign microorganisms. Lymph is conveyed from the tissues to the venous bloodstream via the lymphatic vessels. On the way, it is filtered through the lymphatic organs (spleen and thymus) and lymph nodes.

Bacteria and other particles that find their way into body tissues are taken up by the lymph and carried into the lymph nodes ,Lymphocytes proliferate in response to the foreign invader, some cells remaining in the node and others migrating to other nodes elsewhere in the body. Some of these cells produce antibodies against the invading bacteria, while others take part in a direct attack on the foreign material, surrounding and engulfing it. Although the primary function of the lymphatic system is to return proteins and fluids to the blood.

4-Hematopoietic tissue

Hematopoietic tissue is where new blood cells are formed in the body, and where hematopoietic stem cells are located. Hematopoietic stem cells are found in larger quantities within the bones located in the pelvis, femur and sternum. The hematopoietic stem cell appearance is small in size compared to other blood cells and round in shape .

Hemopoiesis: is the continual production of new blood cells. There are two kinds of hemopoietic tissue: (1) **myeloid tissue** or bone marrow where RBCs, granular WBCs, platelets, monocytes are produced and (2) **lymphatic tissue -** thymus, spleen, lymph nodes, where lymphocytes are made.

Myeloid tissue

Myeloid tissue generally refers to the red bone marrow, especially in the formation of red blood cells (erythropoiesis).

In the adult, **red bone marrow** is found in portions of the vertebrae, sternum, ribs, skull, scapulae, pelvis, and proximal limb bones, collectively known as flat and irregular bones.

Other marrow areas contain a fatty tissue known as **yellow marrow**. Yellow marrow is found in the hollow center of the diaphysis (the long shaft of the bone) known as the *medullary cavity*. Normally, yellow marrow does not have any blood-producing function. However, under certain conditions, as a hemorrhage, yellow marrow can be converted to red marrow and assume the responsibility of producing blood cells.

During infancy and early childhood, all bone marrow is red; but as one grows older and less blood cell production is needed, the fat content of the marrow increases, forming more yellow and less red. This means that the elderly are more prone to infections and cancers because there are fewer lymphocytes being produced since the red bone marrow is decreasing.

The hematopoietic elements are present between the bone spicules. The marrow has a rich vascular supply, as well as sinusoids. The primordial cell that gives rise to all hematopoietic elements, as well as lymphoid cells, is the pluripotential stem cell. A few of these cells circulate, but their job is to home in on marrow and establish cell lines for blood cell production. This pleuripotential stem cell gives rise to two cell lines:

- Uncommitted lymphoid stem cell: this in turn give rise to the B stem cells and the T stem cells that establish populations of B lymphocytes and T lymphocytes.
- Hematopoietic stem cell: from this line arise three additional subpopulations: the granulocyte-monocyte line, the megakaryocytic line, and the erythroid line. The granulocyte-monocyte line further differentiates into cell lines producing monocytes and granulocytes.

(2) Lymphatic tissue: A part of the body's immune system that helps protect it from bacteria and other foreign entities.

Lymphatic tissue is rich in lymphocytes (and accessory cells such as macrophages and reticular cells). The lymphatic tissue includes the lymph nodes, spleen, thymus (an organ in the chest that is particularly large during infancy).

Lymph nodes

Lymph nodes are small, oval, or bean-shaped bodies that occur along lymphatic vessels. They are abundant where lymphatic vessels merge to form trunks, especially in the inguinal (groin), axillary (armpit), and mammary gland areas. Lymph flows into a node through afferent lymphatic vessels that enter the convex side of a node. It exits the node at the hilus, the indented region on the opposite, concave side of the node, through efferent lymphatic vessels. Efferent vessels contain valves that restrict lymph to movement in one direction out of the lymph node. The number of efferent vessels leaving the lymph node is fewer than the number of afferent vessels entering, slowing the flow of lymph through the node.

Lymph nodes perform three functions:

- They filter the lymph, preventing the spread of microorganisms and toxins that enter interstitial fluids.
- They destroy bacteria, toxins, and particulate matter through the phagocytic action of macrophages.
- They produce antibodies through the activity of B cells.

Thymus

The thymus is a bilobed organ located in the upper chest region between the lungs, posterior to the sternum. It grows during childhood and reaches its maximum size of 40 g at puberty. It then slowly decreases in size as it is replaced by adipose and areolar connective tissue. By age 65, it weighs about 6 g.

Each lobe of the thymus is surrounded by a capsule of connective tissue. Lobules produced by trabeculae (inward extensions of the capsule) are characterized by an outer cortex and inner medulla. The following cells are present:

- Lymphocytes consist almost entirely of T cells.
- Epithelial-reticular cells resemble reticular cells, but do not form reticular fibers. Instead, these star-shaped cells form a reticular network by interlocking their slender cellular processes (extensions). These processes are held together by desmosomes, cell junctions formed by protein fibers. Epithelial-reticular cells produce thymosin and other hormones believed to promote the maturation of T cells.

Spleen

Measuring about 12 cm (5 inches) in length, the spleen is the largest lymphatic organ. It is located on the left side of the body, inferior to the diaphragm and at the left edge of the stomach. Like other lymphatic organs, the spleen is surrounded by a capsule whose extensions into the spleen form trabeculae. The splenic artery, splenic vein, nerves, and efferent lymphatic vessels pass through the hilus of the spleen located on its slightly concave, upper surface. There are two distinct areas within the spleen:

- White pulp consists of reticular fibers and lymphocytes in nodules that resemble the nodules of lymph nodes.

- Red pulp consists of venous sinuses filled with blood. Splenic cords consisting of reticular connective tissue, macrophages, and lymphocytes form a mesh between the venous sinuses and act as a filter as blood passes between arterial vessels and the sinuses.

Lec 9 Muscular Tissue

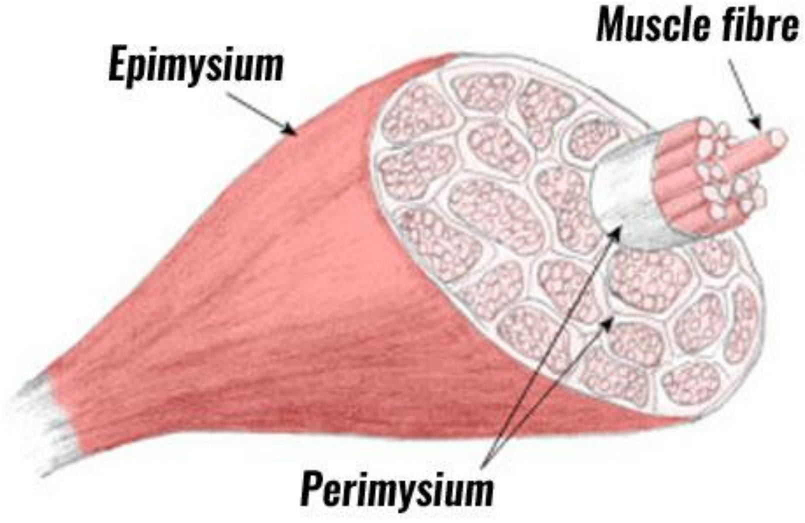
Muscle tissue

Muscle is a soft tissue that is highly specialized for the production of tension which results in the generation of force. Muscle tissue consists of fibers of muscle cells connected together in sheets and fibers. Together these sheets and fibers and known as muscles, and control the movements of an organisms as well as many other contractile functions. There are three different types of muscle found in animals, depending on their use. While these muscles differ slightly, they function in a similar way.

Functions of muscle tissue

1. **Movement:** Our body's skeleton gives enough rigidity to our body that skeletal muscles can yank and pull on it, resulting in body movements such as walking, chewing, running, lifting, manipulating objects with our hands .
2. **Maintenance of posture:** Without much conscious control, our muscles generate a constant contractile force that allows us to maintain an erect or seated position, or posture.
3. **Respiration:** Our muscular system automatically drives movement of air into and out of our body.
4. **Heat generation:** Contraction of muscle tissue generates heat, which is essential for maintenance of temperature homeostasis. For instance, if our core body temperature falls, we shiver to generate more heat.
5. **Communication:** Muscle tissue allows us to talk, gesture, write, and convey our emotional state by doing such things as smiling or frowning.
6. **Constriction of organs and blood vessels:** Nutrients move through our digestive tract, urine is passed out of the body, and secretions are propelled out of glands by contraction of smooth muscle. Constriction or relaxation of blood vessels regulates blood pressure and blood distribution throughout the body.
7. **Pumping blood:** Blood moves through the blood vessels because our heart tirelessly receives blood and delivers it to all body tissues and organs.

Structure of Skeletal Muscle



Although skeletal muscle cells come in different shapes and sizes the main structure of a skeletal muscle cell remains the same. If you were to take one whole muscle and cut through it, you would find the muscle is covered in a layer of connective muscle tissue known as the Epimysium.

The Epimysium protects the muscle from friction against other muscles and bones. It also continues at the end of the muscle to form (along with other connective tissues) the muscles tendon. Looking at the cross section of the muscle you can see bundles of fibers, known as **Fasciculi**, which are surrounded by another connective tissue, called the Perimysium. Each Fasciculi contains anywhere between 10 and 100 muscle fibres, depending on the muscle in question.

A large strong muscle, such as thoses forming your Quadriceps would have a large number of fibers within each bundle. A smaller muscle used for precision movement, such as those in the hand would contain far fewer fibres per Fasciculi.

Looking at each muscle fiber in detail, you can see they too are covered in a fibrous connective tissue, known as Endomysium which insulates each muscle fiber. Muscle fibers can range from 10 to 80 micrometers in diameter and may be up to 35cm long.

Beneath the Endomysium and surrounding the muscle fibre is the Sarcolemma which is the fibers cell membrane and beneath this is the

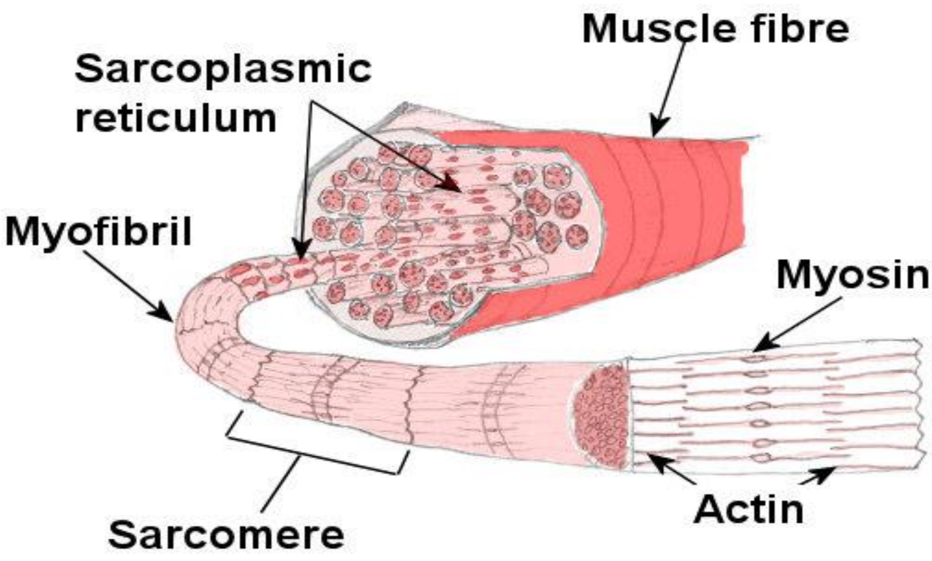
Sarcoplasm, which is the cells cytoplasm, a gelatinous fluid which fills most cells.

This contains Glycogen and Fats for energy and also Mitochondria which are the cells powerhouses, inside which the cells energy is produced.

Each muscle fiber itself contains cylindrical organelles known as Myofibrils. Each muscle fiber contains hundreds to thousands of Myofibrils. These are bundles of Actin and Myosin proteins which run the length of the muscle fiber and are important in muscle contraction.

Surrounding the Myofibril there is a network of tubules and channels called the Sarcoplasmic Reticulum in which Calcium is stored which is important in muscle contraction. Transverse tubules pass inwards from the Sacrolemma throughout the Myofibril, through which nerve impulses travel.

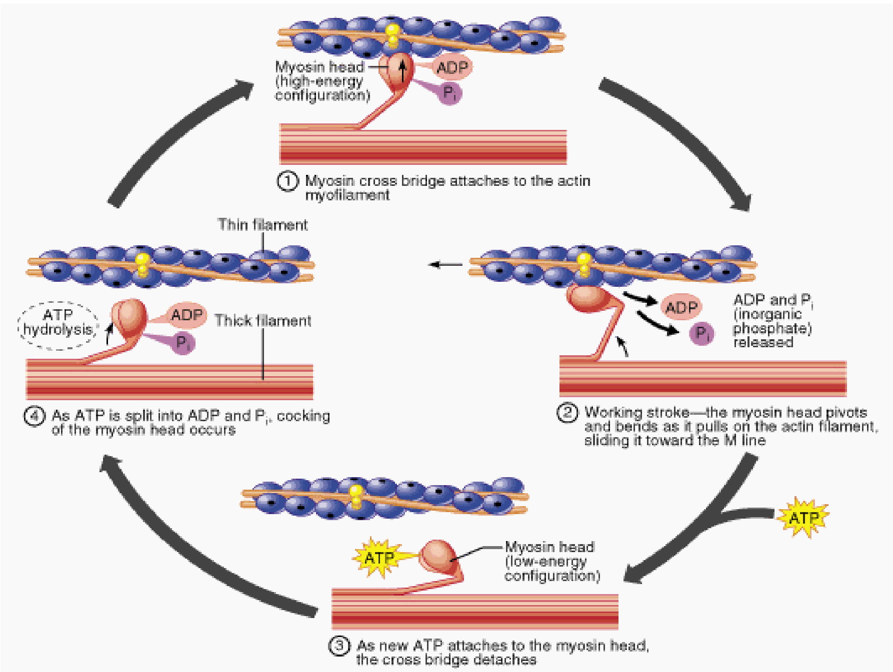
Each Myofibril can then be broken down into functional repeating segments called Sarcomeres.



The sliding filament theory of muscle contraction

There are two main muscle filaments in muscle fibers: **Actin** and **myosin filaments**. Actin filaments are thin and have **binding sites** for the globular heads of myosin filaments. Myosin filaments are thick and formed of a fibrous "tail" and globular "head". These two filaments overlap and interact to form muscle fibers. The functional unit of a muscle fiber is called a **sarcomere**.

During the contraction of a muscle fiber, **calcium** moves into the sarcomere and binds to the protein **troponin** on actin filaments **revealing** myosin head binding sites on actin filaments. Myosin heads containing **ADP** form **crossbridges** with the actin filaments by binding to the **myosin head binding site on actin**. The myosin head then **releases the ADP** molecule causing the myosin filament to move to the **cocked position**, pulling the actin fiber towards the middle of the sarcomere in a "**power stoke**" . **ATP** then attaches to the bound myosin head, breaking the myosin head - actin cross bridge. The **enzyme ATPase** then hydrolyses **ATP to ADP + inorganic phosphate (Pi)** providing **energy** for the myosin head to return to it's **original** uncocked position. As the myosin head now contains **ADP** it is ready to form another crossbridge, starting the cycle again.



Types of Muscle Tissue

Muscle tissue can be classified functionally, voluntary or involuntary and morphologically striated or non-striated. Voluntary refers to whether the muscle is under conscious control, striation refers to the presence of visible banding within myocytes which occurs due to organization of myofibrils to produce a constant direction of tension.

By applying the above classifications it is possible to describe three forms of muscle tissue which perform the wide range of functions described.

Skeletal muscle

Skeletal Muscles are those which attach to bones and have the main function of contracting to facilitate movement of our skeletons. They are also sometimes known as striated muscles due to their appearance. The cause of this 'stripy' appearance is the bands of Actin and Myosin which form the Sarcomere, found within the Myofibrils.

Skeletal muscles are also sometimes called voluntary muscles, because we have direct control over them through nervous impulses from our brains sending messages to the muscle. Contractions can vary to produce powerful, fast movements or small precision actions. Skeletal muscles also have the ability to stretch or contract and still return to their original shape. Skeletal muscle tissue can be controlled voluntarily, by the somatic nervous system. The other types of muscle are controlled mainly by the involuntary or autonomic nervous system

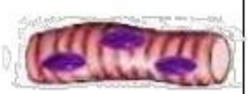
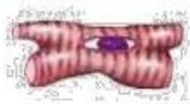
Smooth muscle

Smooth muscle is also sometimes known as Involuntary muscle due to our inability to control its movements, or unstriated as it does not have the stripy appearance of Skeletal muscle. Smooth muscle is found in the walls of hollow organs such as the Stomach, Oesophagus, Bronchi and in the walls of blood vessels. This muscle type is stimulated by involuntary neurogenic impulses and has slow, rhythmical contractions used in controlling internal organs, for example, moving food along the Oesophagus or contricting blood vessels during Vasoconstriction.

Cardiac muscle (heart muscle)

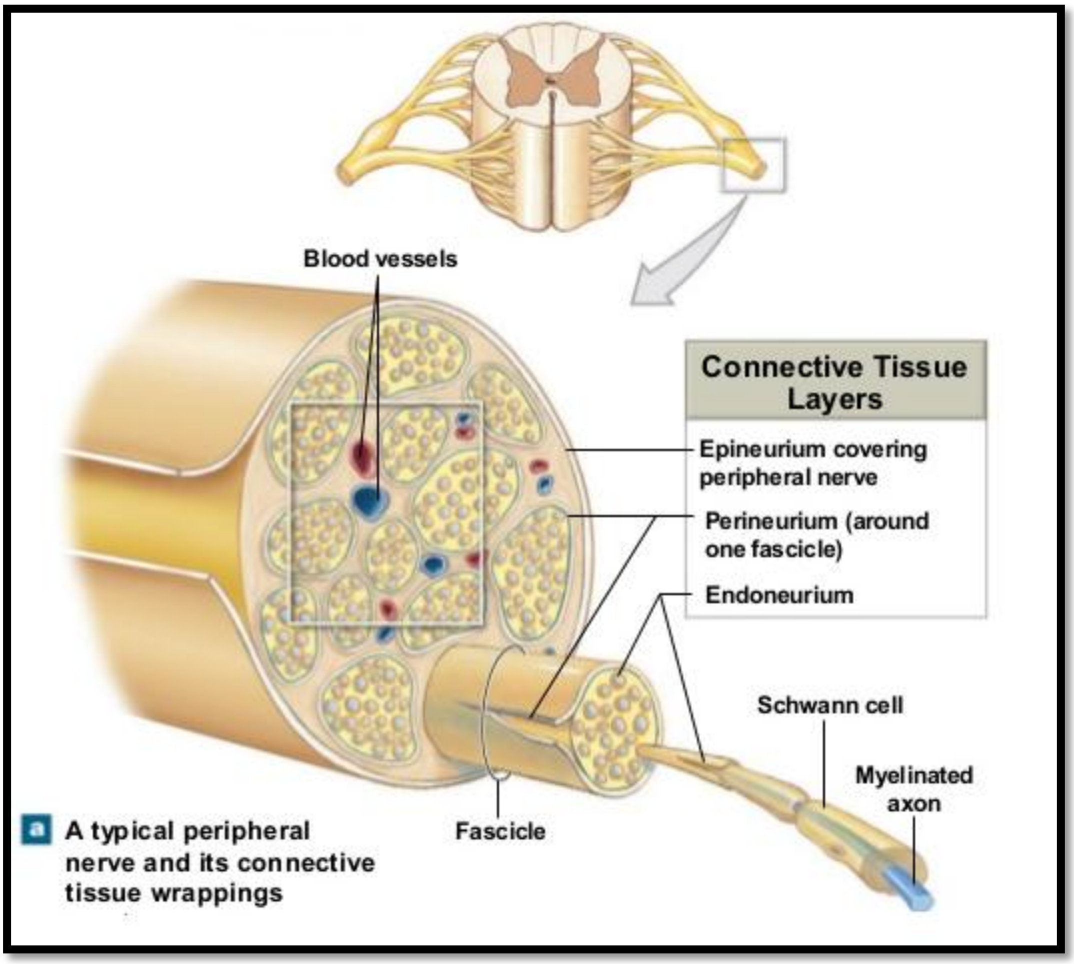
This type of muscle is found solely in the walls of the heart. It has similarities with skeletal muscles in that it is striated and with smooth muscles in that its contractions are not under conscious control. However this type of muscle is highly specialised. It is under the control of the autonomic nervous system, however, even without a nervous imput contractions can occur due to cells called pacemaker cells. Cardiac muscle is highly resistant to fatigue due to the presence of a large number of mitochondria, myoglobin and a good blood supply allowing continuous aerobic metabolism.

Comparison of Muscle Types

Muscle Type	Skeletal	Cardiac	Smooth
Location	Attached to bone	Heart	Walls of internal organs + in skin
Function	Movement of bone	Beating of heart	Movement of internal organs
Control Mode	Voluntary	Involuntary	Involuntary
Shape	Long + slender 	Branching 	Spindle shape 
Characteristics	Striated- light and dark bands Many nuclei	Striated One or two nuclei	Non-striated One nucleus (visceral)

Lec 10 Nerves Tissue

Nervous Tissue:Nervous tissue is the term for groups of organized cells in the nervous system, which is the organ system that controls the body's movements, sends and carries signals to and from the different parts of the body, and has a role in controlling bodily functions such as digestion. Nervous tissue is grouped into two main categories: neurons and neuroglia. Neurons, or nerves, transmit electrical impulses, while neuroglia do not; neuroglia have many other functions including supporting and protecting neurons. Neurons are easily stimulated and transmit impulses very rapidly. A nerve is made up of many nerve cell fibres (neurons) bound together by connective tissue. A sheath of dense connective tissue, the epineurium surrounds the nerve. This sheath penetrates the nerve to form the perineurium which surrounds bundles of nerve fibres. blood vessels of various sizes can be seen in the epineurium. The endoneurium, which consists of a thin layer of loose connective tissue, surrounds the individual nerve fibres.



Anatomy of peripheral nerve

Functions of Nerve Tissue

1. Gathers information from both inside and outside the body Sensory Function

2. Transmits information to the processing areas of the brain and spine

3. Processes the information in the brain and spine Integration Function

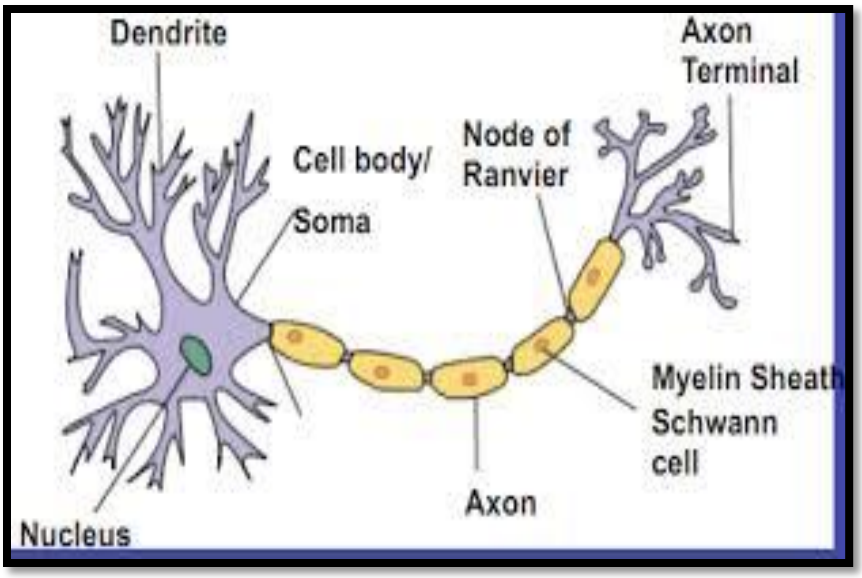
4. Sends information to the muscles, glands, and organs so they can respond appropriately Motor Function

Nerve tissue is composed of 2 main types of cells:

Neurons -nerve cells that are specialized to detect and react to stimuli, by generating and conducting nerve impulses.
Neuroglial cells- accessory cells for filling spaces and supporting neurons.

Microscopic anatomy of neurons

All neurons have a cell body called **soma** which contains a nucleus, organelles, and a modified endoplasmic reticulum called **Nissl body** Although there is DNA in the neuron, somehow DNA replication and mitosis do not occur, resulting in the neurons lack of ability to reproduce or regenerate.
Extensions of the soma form nerve such as **dendrites** which conduct nerve impulses toward the soma, and **axon** which conducts nerve impulses away from the soma (to another neuron, or to an effector organ).The number of dendrites ranges from 1 (in unipolar and bipolar neurons) to thousands (in multipolar neurons).



Anatomy of The Neuron

All neurons only contain 1 axon .Longer axons are enclosed by a lipoprotein substance called **myelin sheath** produced by type of neuralgia cell celled **schwann cell** This myelin sheath insulates the axon against depolarization, and forces action potential to occur in the gaps (**node of Ranvier**) in between the myelin sheath.

axons enclosed by myelin sheath are called myelinated axons which make up the white matter in the nervous system; while axons that have no myelin sheath are called unmyelinated axons which make up the gray matter in the nervous system.

The myelin sheath insulates the axon leaving only narrow gaps called nodes of Ranvier to allow action potential to occur. This type of nerve impulse propagation where action potential jumps from one gap to the next is referred to as "saltatory conduction" .

Synapse

A synapse is the junction between two neurons, or between a neuron and an effector organ (muscle or gland). Each synapse consists of:

Presynaptic neuron-that sends an impulse to the synapse.

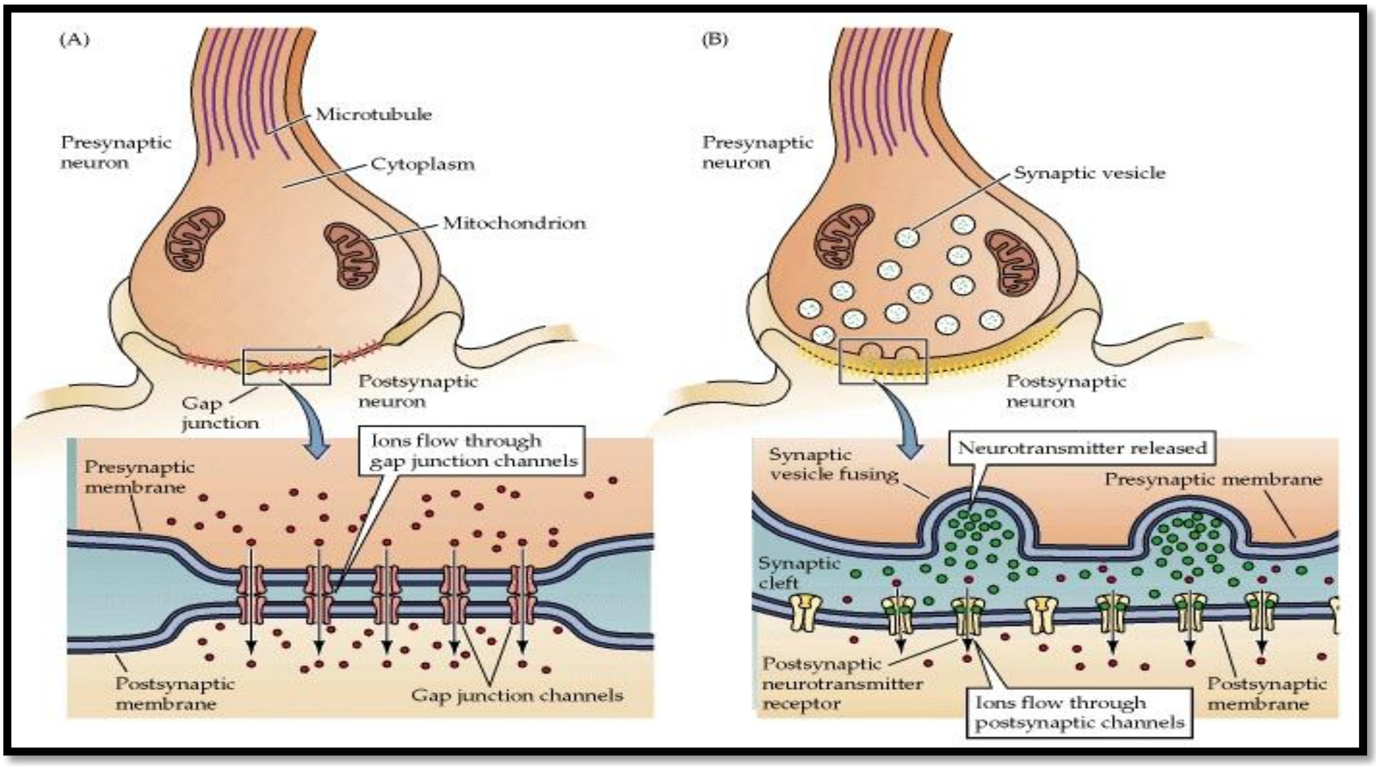
Axon–the nerve fiber extends from the presynaptic neuron, that propagates the impulse to the synapse .

Synaptic knobs -the round endings of the axon.

Synaptic vesicles -membranous sacs that contain a neurotransmitter (e.g. acetylcholine, norepinephrine, dopamine), located in the synaptic knobs.

Synaptic cleft-a gap between the two neurons in the synapse.

Dendrite–the nerve fiber that continues to propagate the nerve impulse to the second neuron (postsynaptic neuron). Receptors on this dendrite receive the neurotransmitter from the axon .
Postsynaptic neuron -the neuron that receives the nerve impulse from the presynaptic neuron, through the synapse.



Electrical vs . chemical synapses

Impulses

•**A stimulus** is a change in the environment with sufficient strength to initiate a response.
•**Excitability** is the ability of a neuron to respond to the stimulus and convert it into a nerve impulse
•**All of Nothing Rule**– The stimulus is either strong enough to start and impulse or nothing happens
•Impulses are always the same strength along a given neuron and they are self-propagation –once it starts it continues to the end of the neuron in only one direction-from dendrite to cell body to axon.
•The nerve impulse causes a movement of ions across the cell membrane of the nerve cell.

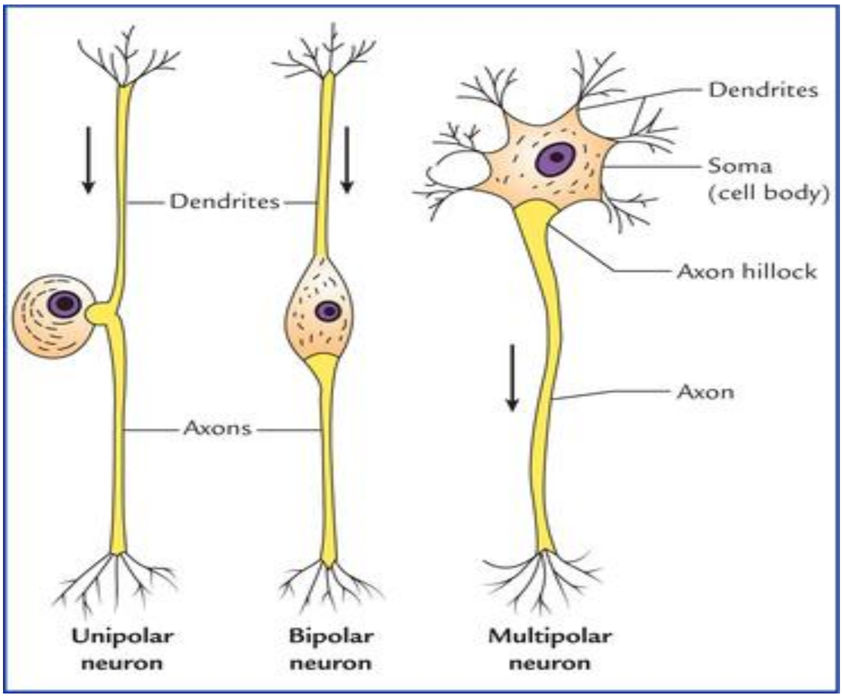
Neurotransmitters

Neurotransmitters–Chemicals in the junction which allow impulses to be started in the second neuron

Classification of neurons

Classification based on structure:

A) unipolar neuron- a single nerve fiber is extended from the soma, and it divides into a dendrite and an axon (sensory neurons that conduct reflexes or detect various stimuli).
B) bipolar neuron- a dendrite and an axon extend from the soma independently (sensory neurons involved in special senses such as vision, olfaction, and hearing).
C) multiple neuron- one axon and many dendrites extend from the soma (interneurons located inside the brain and spinal cord).



Classification based on function:

A) sensory or afferent neuron
-conducts nerve impulses from the body to the brain or spinal cord.
-endings of its dendrite may be modified to become nerve receptors.
-usually unipolar in structure.
B) interneuron:
- relays nerve impulse from sensory neuron to motor neuron .
-located totally inside the tissues of the brain or spinal cord.

-involved in the processing and integration in the nervous system.
-usually multipolar in structure.

C) motor or efferent neuron:

- conducts nerve impulses from the brain or spinal cord to the Effector organ (muscles or glands).
- usually multipolar in structure.
- accelerator motor neurons cause an increase of activity in the Effector organ; while inhibitory motor neurons cause a decrease of activity in the effector organ.

The Neuroglia

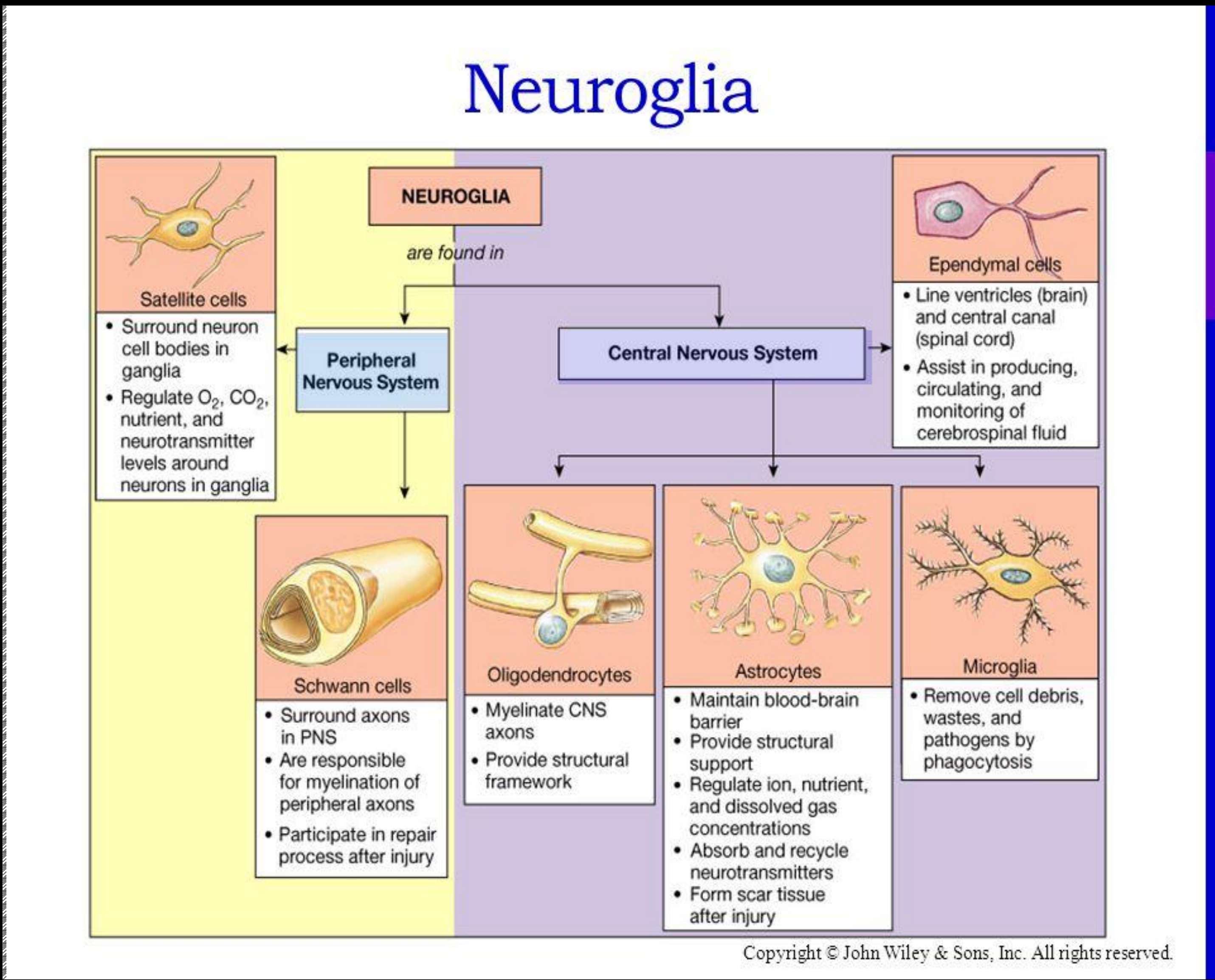
Supporting cells in the Central Nervous System(CNS) are grouped together as Neuroglia ,Neuroglia literally means “nerve glue” The function of neuroglia is to support, insulate ,and protect the delicate neurons of the brain, In H & E staining, only their nuclei can be seen. Neuroglia is Capable of multiplying in mature nervous tissue , but Cannot generate or transmit the impulse.

Types of Neuroglia in CNS

1- Astrocytes: star shaped cells found between neurons and blood vessels. They are the most abundant glial cells.
2- Microglial cells: small ovoid cells.
3- Ependymal cells: cuboidal or columnar shaped cells.
4- Oligodendrocytes: resemble astrocytes but have less processes and arranged in rows along nerve fibers.

Types of Neuroglia in PNS

1-Satellite cells : Surround the nerve cells of ganglia, satellite cells are Flattened cells with prominent nuclei.
2-Schwann cells: Flattened cells with flattened nucleus.



Divisions of the Nervous System

The human nervous system consists of the :

1- **Central Nervous System (CNS)**
2- **Peripheral Nervous System (PNS)**

1-Central Nervous System (CNS)

The **central nervous system (CNS)** is the processing center for the nervous system. It receives information from and sends information to the **peripheral nervous system**.(CNS) is composed of the brain (located in the cranial cavity) and the spinal cord (located in the vertebral cavity), which serve as the main control centers for all body activities . The brain processes and interprets sensory information sent from the spinal cord.

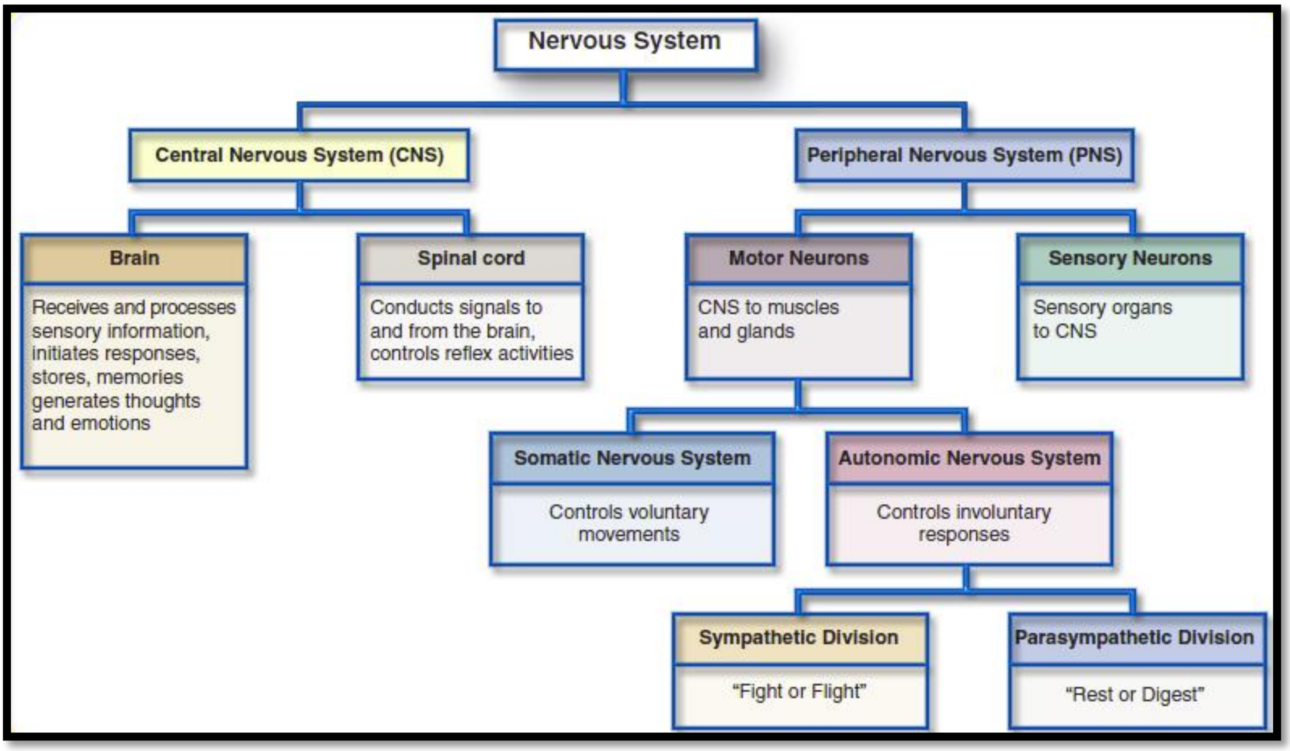
Both the brain and spinal cord are protected by a three-layered covering of connective tissue called the **meninges**.

2. Peripheral Nervous System (PNS)

is composed of nerves derived from the brain and spinal cord (12 pairs of cranial nerves and 31 pairs of spinal nerves),which serve as linkage between the CNS and the body. PNS can be subdivided into Sensory(afferent) nerves and Motor(efferent) nerves. Sensory nerves send nerve impulse from the body to CNS, while motor nerves send impulse from CNS to effector organs.

Motor nerves are divided into the Somatic Nervous system (SNS) which regulates the voluntary contraction of skeletal muscles and autonomic nervous system (ANS) which regulates the involuntary control of smooth, cardiac muscles and glands**.**

Finally, the ANS can be divided into Sympathetic and Parasympathetic branches where in general sympathetic nerves stimulate activities of the effector organs (except digestive organs), and parasympathetic nerves inhibit activities of the effector organs (except digestive organs).



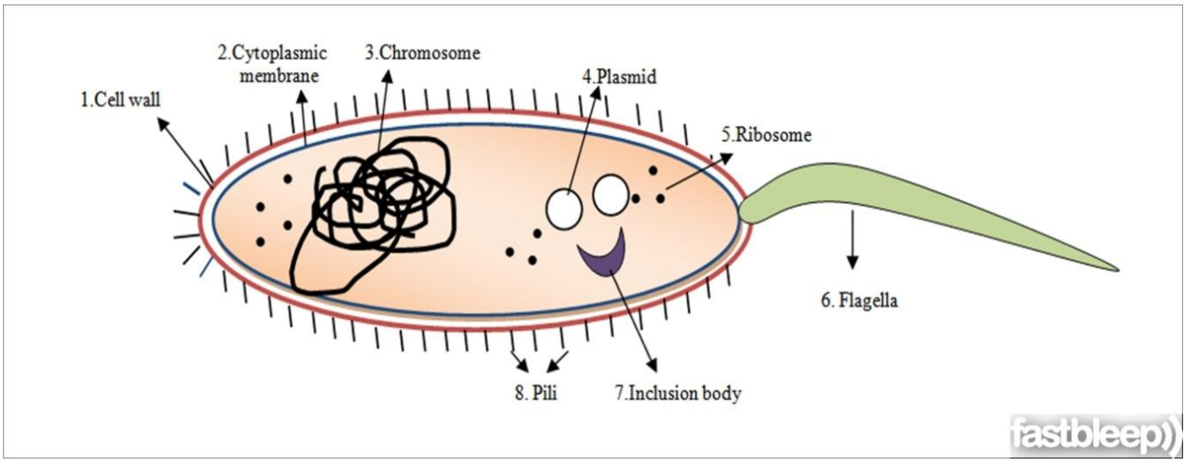
Lec 11 Bacteria define its general properties ,shape & arrangement.

Bacteria

Bacteria are prokaryotic, unicellular microorganisms, The cell structure is simpler than that of other organisms as there is no nucleus or membrane bound organelles.

Due to the presence of a rigid cell wall, bacteria maintain a definite shape, though they vary as shape, size and structure.

Bacterial cell structure



Structures of cells

1. **Cell wall**
2. **Cytoplasmic membrane**
3. **Chromosome**
4. **Plasmid**
5. **Ribosome**
6. **Flagella**
7. **Inclusion body**
8. **Pili**
9. **Endospore**

Unique & Distinguishing Characteristics of bacteria

1- No nucleus: Unlike other eukaryotic cell, bacterial cell is the only cell which lacks prominent nucleus within. This feature has lead to the scientists to consider bacteria as primitive organisms , earliest forms of life on earth

2. **Presence of Cell wall**: Bacteria has a cell wall which is distinct from other cells having cell wall. The wall is made of different substances like glycoproteins, lipopolysacharides and lipoproteins ther are two main types of bacteria cell walls, those of Gram –positive bacteria and those of Gram –negative bacteria , which are differentiated by their Gram staining characteristics.

3- Cell membrane: This is present immediately below the cell wall. This has a small variation with that of plants and animals cell membranes. In plants and animals, it is mostly a single or double layer (bi-layer) of lipids. But bacteria especially the gram negative ones have an extra membrane i.e. an outer membrane called periplasm which lies bellow cell wall but above cell membrane.

4-Pilli: These are small and tube like projections from bacterial surface. They are the organelles of sexual reproduction and are involved in exchange of genetic material as part of reproduction between two bacteria.

5- Food dependence: All the organisms either live by their own or on other resources. But bacteria have different modes of food procurement. Some of them synthesize their own food like plants by use of sunlight**(Autotrophic bacteria).**

Other derive food energy from chemical sources around them **(chemotrops).** Sulfur bacteria, hydrogen bacteria, iron bacteria etc.

Few of them are parasites which live on alive plants and animals. They cause diseases to the host in doing so **(Parasitic bacteria).**

While others are**(symbiotic bacteria).** They live in a give and take relationships with other animals. Ex: rhizobium in roots, E-coli in intestine.

6- Reproduction: Most organism have one or two methods of reproduction. But bacteria have many.

A). Asexual reproduction: The bacteria cell undergoes to produce two bacteria by Binary fission and also by endospores.

B) Sexual reproduction: It is also by three distinct methods like transformation, conjugation and transduction. In transformation, one bacteria releases naked DNA strand into the surroundings. The other bacteria takes t up and incorporate into their genome. Transduction happens due to virus.

7. Spore formation: When the environmental conditions around are harsh, the bacteria converts to a hard spore form. This spore is highly resistant to heat, chemicals and drought conditions, When the conditions are favorable, these spores break open and release the bacteria.

Spore forming rod shaped bacteria

8-Ribosomes: The protein making machinery has 70S ribosome which is of two sub-units as 50S and 30S. While in other animals and plants, it is 80S ribosome consisting of two sub-units 60S and 40S.

9- Absence of Cell organelles: Other cell organelles like mitochondria, golgi bodies, endoplasmic reticulum are absent in a bacterial cell.

10-Flagella presence: Some of the bacteria are motile. They, especially the bacilli type have flagella. These are the organs of locomotion. They are long filamentous organs originating from cell membrane.

11. Cosmopolitan distribution: Bacteria are the only organisms which show cosmopolitan distribution. They are present in air, water, soil, snow etc. They are present at very cold (minus degree) temperature regions and also very high temperature regions. They can live in acidic environment (helico bacter pyroli) and even basic environment (iron bacteria).

12. Resistance and tolerance: Some of the bacteria are highly resistant to adverse environments. Even they get tolerance to harsh chemical and other stuff which destroy them. Hence irrational use of antibiotics. THis has become so severe that World Health Organization warns of rampant prevalence of resistant bacteria which can be incurable by currently available drugs.

Types of Bacteria

The cell wall also makes Gram staining possible. Gram staining is a method of staining bacteria involving crystal violet dye, iodine, and the counterstain safranin. Many bacteria can be classified into one of two types: gram-positive, which show the stain and appear violet in color under a microscope, and gram-negative, which only show the counterstain, and appear red. Gram-positive bacteria appear violet because they have thick cell walls that trap the crystal violet-iodine complex. The thin cell walls of gram-negative bacteria cannot hold the violet-iodine complex, but they can hold safranin. This makes gram-negative bacteria appear red under a microscope . Gram staining is used for general identification of bacteria or to detect the presence of certain bacteria; it cannot be used to identify bacteria in any specific way, such as at a species level. Examples of gram-positive bacteria include the genera *Listeria, Streptococcus, and Bacillus*, while gram-negative bacteria include Proteobacteria, green sulfur bacteria, and cyanobacteria.

Shape of Bacterial Cell

The three basic bacterial shapes are coccus (spherical), bacillus (rod-shaped), and spiral (twisted), however pleomorphic bacteria can assume several shapes.

1-Cocci (or coccus for a single cell) are round cells, sometimes slightly flattened when they are adjacent to one another.

2-Bacilli (or bacillus for a single cell) are rod-shaped bacteria.

3-Spirilla (or spirillum for a single cell) are curved bacteria which can range from a gently curved shape to a corkscrew-like spiral. Many spirilla are rigid and capable of movement. A special group of spirilla known as spirochetes are long, slender, and flexible

Arrangement of Cocci

Cocci bacteria can exist singly, in pairs (as diplococci), in groups of four (as tetrads), in chains (as streptococci), in clusters (as stapylococci), or in cubes consisting of eight cells (as sarcinae). Cocci may be oval, elongated, or flattened on one side. Cocci may remain attached after cell division. These group characteristics are often used to help identify certain cocci.

1. Diplococci

The cocci are arranged in pairs. Examples: *Streptococcus pneumonia*

2. Streptococci

The cocci are arranged in chains, as the cells divide in one plane.
Examples: *Streptococcus pyogenes*

3. Tetrads

The cocci are arranged in packets of four cells, as the cells divide in two plains.Examples: *Aerococcus*

4. Sarcinae

The cocci are arranged in a cuboidal manner, as the cells are formed by regular cell divisions in three planes. Cocci that divide in three planes and remain in groups cube like groups of eight. Examples: *Sarcina ureae,*

5. Staphylococci

The cocci are arranged in grape-like clusters formed by irregular cell divisions in three plains. Examples: *Staphylococcus aureus*

Arrangement of Bacilli

The cylindrical or rod-shaped bacteria are called ‘bacillus’ (plural: bacilli).

1. Diplobacilli

Most bacilli appear as single rods. Diplobacilli appear in pairs after division.

Example of Single Rod: *Bacillus cereus*
Examples of Diplobacilli: *Coxiella burnetii,*

2. Streptobacilli

The bacilli are arranged in chains, as the cells divide in one plane.

Examples: *Streptobacillus moniliformis*

3. Coccobacilli

These are so short and stumpy that they appear ovoid. They look like coccus and bacillus. Examples: *Haemophilus influenzae*,

4. Palisades

The bacilli bend at the points of division following the cell divisions, resulting in a palisade arrangement resembling a picket fence and angular patterns that look like Chinese letters. Example: *Corynebacterium diphtheria*

Arrangement of Spiral Bacteria

Spirilla (or spirillum for a single cell) are curved bacteria which can range from a gently curved shape to a corkscrew-like spiral. Many spirilla are rigid and capable of movement. A special group of spirilla known as spirochetes are long, slender, and flexible.

1. Vibrio

They are comma-shaped bacteria with less than one complete turn or twist in the cell.Example: *Vibrio cholerae*

2. Spirilla

They have rigid spiral structure. Spirillum with many turns can superficially resemble spirochetes. They do not have outer sheath and endoflagella, but have typical bacterial flagella.

Example: *Helicobacter pylori*

3. Spirochetes

Spirochetes have a helical shape and flexible bodies. Spirochetes move by means of axial filaments, which look like flagella contained beneath a flexible external sheath but lack typical bacterial flagella. Examples: *Leptospira* species

Others Shapes and Arrangements of Bacteria

1. Filamentous Bacteria

They are very long thin filament-shaped bacteria. Some of them form branching filaments resulting in a network of filaments called ‘mycelium’. Example: *Candidatus* Savagella

2. Star Shaped Bacteria

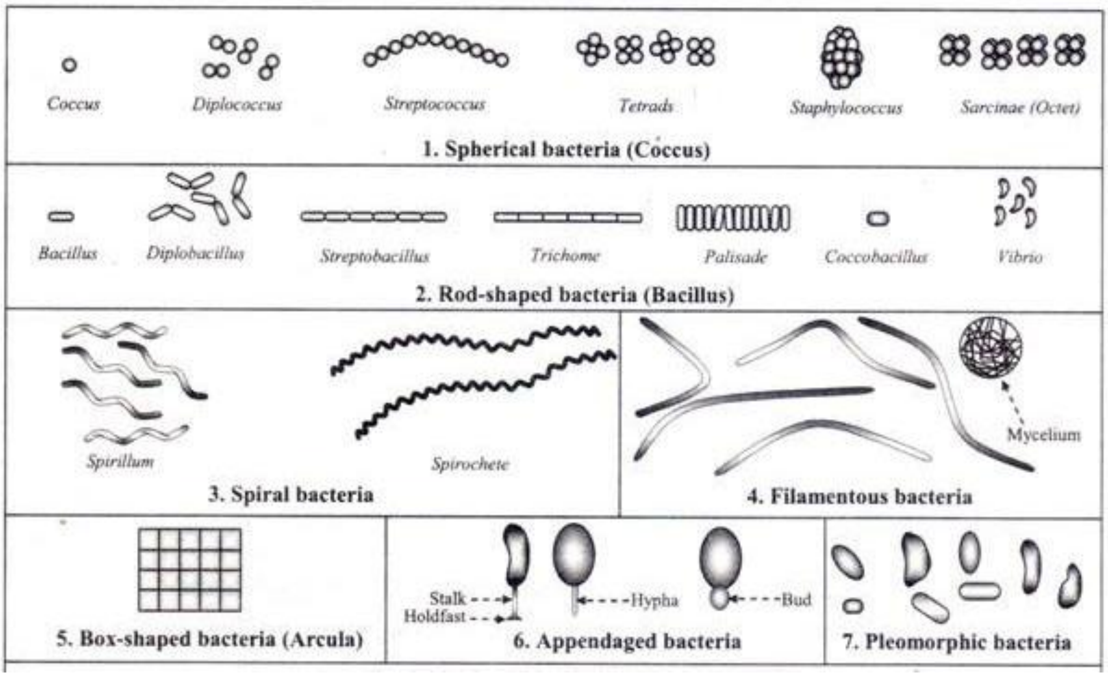
Example: *Stella*

3. Rectangular Bacteria

Examples: *Haloarcula* spp

4. Pleomorphic Bacteria

These bacteria do not have any characteristic shape unlike all others described above. They can change their shape. In pure cultures, they can be observed to have different shapes.
Examples: *Mycoplasma pneumoniae*,



Lec12 Sterilization and disinfection

Introduction

Microbes are ubiquitous and many microorganisms are associated with undesirable consequences, such as food spoilage and disease. Therefore, it is essential to kill a wide variety of microorganisms or inhibit their growth to minimize their destructive effects. The goal is twofold: (a) to destroy pathogens and prevent their transmission and (b) to reduce or eliminate microorganisms responsible for the contamination of water ،food, and other substances.

Sterilizationis defined as a process by which an article, surface, or medium is freed of all living microorganisms either in the vegetative or in the spore state. Any material that has been subjected to this process is said to be **sterile**. These terms should be used only in the absolute sense. An object cannot be slightly sterile or almost sterile; it is either sterile or not sterile .Although most sterilization is performed with a physical agent ،such as heat, a few chemicals called **sterilants** can be classified as sterilizing agents because of their ability to destroy spores.**A germicide,** also called a **microbicide**, is any chemical agent that kills pathogenic microorganisms. A germicide can be used on inanimate (nonliving) materials or on living tissue, but it ordinarily cannot kill resistant microbial cells. Any physical or chemical agent that kills "germs" is said to have germicidal properties

Mode of action

1- **Damage of protein**
2- **Damage of nucleic acid**
3- **Inhibition of metabolism**
4- **Alteration of cell membrane permeability**

Sterilization

Methods of sterilization can be broadly classified as:
1 .Physical methods of sterilization, and
2. Chemical methods of sterilization

Physical Methods of Sterilization

Physical methods of sterilization include the following:
1 .Sunlight
2 .Heat

3 .Filtration
4 .Radiation
5- Sound (sonic) waves

Sunlight

Direct sunlight is a natural method of sterilization of water in tanks, rivers, and lakes. Direct sunlight has an active germicidal effect due to its content of ultraviolet and heat rays. Bacteria present in natural water sources are rapidly destroyed by exposure to sunlight.

Heat

Heat is the most dependable method of sterilization and is usually the method of choice unless contraindicated. As a rule ،higher temperatures (exceeding the maximum) are microbicidal ،whereas lower temperatures (below the minimum) tend to have inhibitory or microbistaticeffects. Two types of physical heat are used in sterilization—moist and dry heat.

Sterilization by moist heat

Moist heat occurs in the form of hot water, boiling water, or steam (vaporized water). In practice, the temperature of moist heat usually ranges from 60 to 135°C. Adjustment of pressure in a closed container can regulate the temperature of steam . Moist heat kills microorganisms by denaturation and coagulation of proteins. Sterilization by moist heat can be classified as follows:

1 Sterilization at a temperature <100°C
2 .Sterilization at a temperature of 100°C
3 .Sterilization at a temperature> 100°C
4. Intermittent sterilization

1.Sterilization at a temperature < 100°C:
Pasteurization is an example of sterilisation at a temperature < 100°C
Pasteurization:Fresh beverages (such as milk, fruit juices ،beer, and wine) are easily contaminated during collection and processing. Because microbes have potential for spoiling these foods or causing illness, heat is frequently used to reduce the microbial load and to destroy pathogens .Pasteurization is a technique in which heat is applied to liquids to kill potential agents of infection and spoilage, while at the same time retaining the liquid's flavor and food value.This technique is named after Louis Pasteur who devised this method.

2 Sterilization at a temperature of 100°C:

Sterilsation at a temperature of 100ºC includes (a) boiling and (b) steam sterilizer at 100°C.

Boiling:Simple boiling of water for 10–30 minutes kills most of the vegetative forms of bacteria but not bacterial spores

Steam sterilizer at 100°C: is used for heat-labile substances that tend to degrade at higher temperatures and pressure, . These substances are exposed to steam at atmospheric pressure for 90 minutes during which most vegetative forms of the bacteria .except for the thermophiles are killed by the moist heat

3. Sterilization at a temperature >100 C

Autoclaving is one of the most common methods of sterilization. Principle: In this method sterilization is done by steam under pressure. Steaming at temperature higher than 100°C is used in autoclaving. The temperature of boiling depends on the surrounding atmospheric pressure. A higher temperature of steaming is obtained by employing a higher pressure. When the autoclave is closed and made air-tight, and water starts boiling, the inside pressures increases and now the water boils above 100°C. At 15 pounds per square inch (psi) , 121°C temperatures is obtained. This is kept for 15 minutes for sterilization to kill spores. It works like a pressure cooker.

4**.Intermittent sterilization**:

Certain heat-labile substances(e.g., serum, sugar, egg, etc.) that cannot withstand the high temperature of the autoclave can be sterilized by a process of intermittent sterilization, known as tyndallization.Tyndallizationis carried out over a period of 3 days and requires a chamber to hold the materials and a reservoir for boiling water. Items to be sterilized are kept in the chamber and are exposed to free-flowing steam at 100°C for 20 minutes, for each of the three consecutive days. On the first day, the temperature is adequate to kill all the vegetative forms of the bacteria, yeasts, and molds but not sufficient to kill spores. The surviving spores are allowed to germinate to vegetative forms on the second day and are killed on re-exposure to steam. The third day re-ensures killing of all the spores by their germination to vegetative forms . Intermittent sterilization is used most often to sterilize heat-sensitive culture media, such as those containing serum (e.g., Loeffl er's serum slope), egg (e.g., Lowenstein–Jensen's medium), or carbohydrates (e.g., serum sugars) and some canned foods .

Sterilization by dry heat

Mechanisms. (1) Protein denaturation, (2) Oxidative damage, (3) Toxic effect of elevated electrolyte (in absence of water).
Dry heat at 160°C (holding temperature for one hour is required to kill the most resistant spores). The articles remain dry. It is unsuitable for clothing which may be spoiled. Sterilization by dry heat includes sterilization by (a) flaming (b) incineration , and (c) hot air oven

A-Flaming:Sterilization of inoculating loop or wire, the tip of forceps, searing spatulas, etc., is carried out by holding them in the flame of the Bunsen burner till they become red hot. Glass slides, scalpels, and mouths of culture tubes are sterilized by passing them through the Bunsen flame without allowing them to become red hot.

B- Incineration:Incineration is an excellent method for safely destroying infective materials by burning them to ashes. It has many uses :

■Incinerators are used to carry out this process and are regularly employed in hospitals and research labs to destroy hospital and laboratory wastes.

■The method is used for complete destruction and disposal of infectious material, such as syringes, needles ،culture material, dressings, bandages, bedding, animal carcasses, and pathology samples.
C-Hot Air Oven (Sterilizer). Glass wares, swab sticks, all-glass syringes, powder and oily substances are sterilized in hot air oven. For sterilization, a temperature of 160°C is maintained (holding) for one hour. Spores are killed at this temperature. It leads to sterilization.

Filtration

Filtration is an excellent way to reduce the microbial population in solutions of heat-labile material by use of a variety of filters. Filters are used to sterilize these heat-labile solutions .Filters simply remove contaminating microorganisms from solutions rather than directly destroying them

Radiations

The ionizing and nonionizing radiations are the two types of radiation used for sterilization
1 .**Ionizing radiations**: Ionizing radiation is an excellent sterilizing agent with very high penetrating power .These radiations penetrate deep into objects and destroy bacterial endospores and vegetative cells, both prokaryotic and eukaryotic. These are,

however, not that effective against viruses. Ionizing radiations include (a) X-rays ،(b) gamma rays

2. Nonionizing radiations: Nonionizing radiations include infrared and ultraviolet radiations.

■Infrared radiationsare used for rapid and mass sterilization of disposable syringes and catheters.

■Ultraviolet (UV) radiationwith wavelength of 240–280 nm is quite lethal and has a marked bactericidal activity. It acts by denaturation of bacterial protein and also interferes with replication of bacterial DNA.

Sound (sonic) waves

High-frequency sound (sonic) waves beyond the sensitivity of the human ear are known to disrupt cells

Chemical Methods of Sterilization

Several chemical agents are used as antiseptics as well as disinfectants. All these chemical agents (e.g., alcohols, aldehydesetc.) are described later in detail under disinfection

Disinfection

Disinfection is the process of inactivating microorganisms by direct exposure to chemical or physical agents.

■**Disinfectants** are products or biocides that destroy or inhibit the growth of microorganisms on inanimate objects or surfaces. Disinfectants can be sporistatic but are not necessarily sporicidal .

■**Antiseptics** are biocides or products that destroy or inhibit the growth of microorganisms in or on living tissue.Antiseptics and disinfectants are used extensively in hospitals for a variety of topical and hard surface applications. They are an essential part of infection control practices and aid in the prevention of nosocomial infections.

Action of Disinfectants

Disinfectants act in many ways as discussed below.

1 .They produce damage to the cell wall and alter permeability of the cell membrane, resulting in exposure, damage, or loss of the cellular contents
2 .They alter proteins and form protein salts or cause coagulation of proteins.
3 .They inhibit enzyme action and inhibit nucleic acid synthesis or alter nucleic acid molecules.
4. They cause oxidation or hydrolysis

Factors Influencing Activity of Disinfectants

Various conditions influencing the efficiency of disinfectant are as follows:

■**Temperature**:Increase in temperature increases the efficiency of disinfectants.
■**Type of microorganism:**Vegetative cells are more susceptible than spores. Spores may be resistant to the action of disinfectants.
■**Physiological state of the cell**:Young and metabolically active cells are more sensitive than old dormant cells .Nongrowing cells may not be affected
■ **Environment**:The physical or chemical properties of the medium or substance influence rate as well as efficiency of disinfectants, e.g., pH of the medium and presence of extraneous materials

Types and Classes of Chemical Agents as Disinfectants

ALCOHOLS

-Ethyl or isopropyl at a concentration of 50-70% are used for some surfaces where a rapid evaporation of the chemical and leaving no residue may be important, such as on laboratory equipment, etc. Alcohols are low in sporocidal activity and must remain wet on the surface for several minutes to achieve any reasonabledisinfection.

ALDEHYDES

-Formaldehyde or more usually glutaraldehyde are used as instrument and catheter disinfectants. The glutaraldehyde is the basic chemical for various trademarks, such as Cidex, or Sonacide and newer ones such as Sporocidin or Glutacide or Totacide, etc. These are used for disinfectants or sterilization of instruments and catheters but not for environmental surfaces. They may also be used for pipettes and clinical thermometers, etc.

DETERGENTS

-The term detergent refers to a removal of soil or dirt and various types of detergents are available. The anionic detergent such as soap and sodium lauryl sulfate and its close chemical relative which are the ingredients in the various dish and laundry detergents have very low level in antimicrobial activity and work by the removal of dirt
and microorganisms and rinsing them down the drain.

GASEOUS AGENTS

-Ethylene oxide as a gaseous agent may best be used as a sterilant,
but has been used in liquids for antimicrobial action. The use of formaldehyde as a liquid at the 8% level in alcohol (for many hours) may have sterilizing capability as well as 20%   aqueous formal
in and formaldehyde with low temperature steam (75 C).

HALOGENS

-Chlorine and iodine are the usual halogens used as antimicrobial
chemicals. The chlorine is used as a gas for disinfection of water and swimming pools. (It is used as the hypochlorite (Clorox) for sanitizing.) Chlorine dioxide has been utilized for disinfection and is a rapid oxidizing sterilant when used under certain conditions. Iodine as the tincture is probably the best of the skin antiseptics, but is more frequently used asthe iodophor which is a so-called tamed iodine which releases iodine slowly to the environmental surfaces. It is used as a sanitizer in food preparation areas and also as a skin antiseptic, a surgical scrub, etc.

HEAVY METALS

-The mercurial salts and other heavy metal preparations have lost favor in the laboratory and hospital scene since they are more bacteriostatic than bactericidal and may be extremely toxic. This would include trademark names such asMercurochrome, Merthiolate (Thiomerosal), Merbak, Metaphen and others.

PEROXIDES

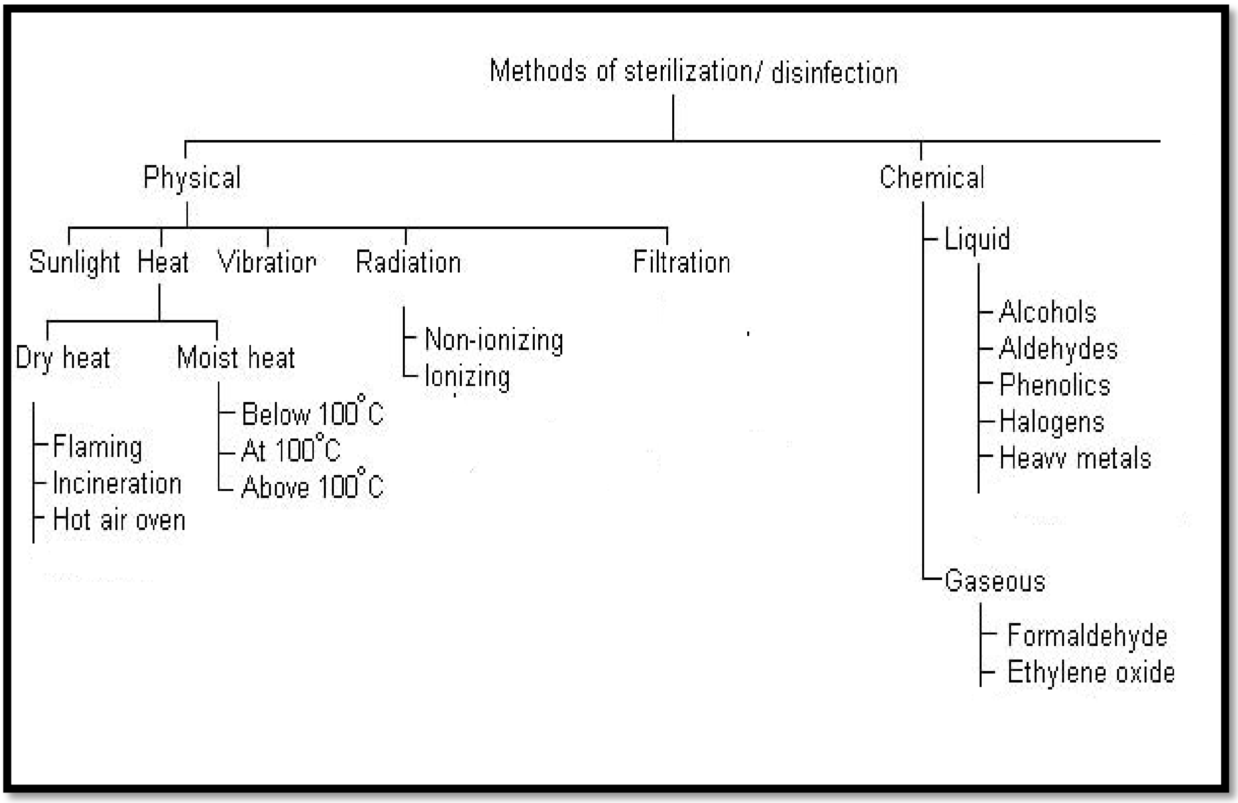
-The use of weak peroxides on skin wounds of various small area has negligible antimicrobial activity and its effect probably due to a washing away of extraneous dirt and microorganisms. A newer, highly concentrated peroxide at a low pH has been proposed as a disinfectant-sterilant, under the trademark of Sterisyl and may disinfect very rapidly

PHENOLICS

-The chemicals based on phenol, i.e., a benzene ring with hydroxyl (OH)group are among the more common disinfectants for environmental surfaces. Instead of phenol or cresol, today it is more common to use a mixture of highly substituted phenolics (such as orthophenylphenol) which may be diluted out further (1:128-1:256) to achieve their bactericidal activity.

OTHER CHEMICALS

-Various dyes, acetic acid, carbonates , bicarbonates, chlorites,
essential oils, etc., have been used with more or less success, (usually less success) as antimicrobial chemicals and should give way to the more effective ones noted above.



Common antiseptics and disinfectants

Chemical	Action	Uses
Ethanol (50-70%)	Denatures proteins and solubilizes lipids	Antiseptic used on skin
Isopropanol (50-70%)	Denatures proteins and solubilizes lipids	Antiseptic used on skin
Formaldehyde (8%)	Reacts with NH_2, SH and COOH groups	Disinfectant, kills endospores
Tincture of Iodine (2% in 70% alcohol)	Inactivates proteins	Antiseptic used on skin
Chlorine (Cl_2) gas	Forms HClO, a strong oxidizing agent	Disinfect drinking water; general disinfectant
Silver nitrate ($AgNO_3$)	Precipitates proteins	Antiseptic and used in the eyes of newborns
Mercuric chloride	Inactivates proteins by reacting with SH groups	Disinfectant, occasionally used as an antiseptic on skin
Detergents (e.g. quaternary ammonium compounds)	Disrupts cell membranes	Skin antiseptics and disinfectants
Phenolic compounds (e.g. lysol, hexylresorcinol, hexachlorophene)	Denature proteins and disrupt cell membranes	Antiseptics at low concentrations; disinfectants at high concentrations
Ethylene oxide gas	Alkylating agent	Disinfectant used to sterilize heat-sensitive objects (plastics)

Differences between sterilization and disinfection

	Sterilization	Disinfection
Definition	Freeing an article, surface, or medium from all living organisms including viruses, bacteria and their spores, and fungi and their spores	Process that reduces the number of contaminating microorganisms, liable to cause infection to a level which is deemed no longer harmful to health. Spores are not killed
Uses	Objects or instruments coming in direct contact with a break in skin or mucous membrane or entering a sterile body area	Objects or instruments coming in direct contact with mucous membrane but tissue is intact or via intact skin
Examples	Surgical instruments, needles ، syringes, parenteral fluid ، arthroscopes, media, reagents and equipments in laboratory use	Endotracheal tubes, aspirators ، bedpans, urinals, etc

Lec 13 Viruses , Structure , morphology ,pathogenicity

A virus: is a small parasite that cannot reproduce by itself. Once it infects a susceptible cell, however, a virus can direct the cell machinery to produce more viruses. Most viruses have either RNA or DNA as their genetic material. The nucleic acid may be single- or double-stranded. The entire infectious virus particle, called a virion, consists of the nucleic acid and an outer shell of protein. The simplest viruses contain only enough RNA or DNA to encode four proteins. The most complex can encode 100 – 200 proteins.

Properties of virus

1- They do not have cellular organization.
2- They contain only one type of nucleic acid either DNA or RNA but never both
3- They are obligate intracellular parasites.
4- They lack the enzymes necessary for protein and nucleic acid synthesis and are dependent for replication on the machinery of host cells
5- They multiply by a complex process and not by binary fission.
6- They are unaffected by antibacterial antibiotics.

Virus structure

viruses contain the following components: 1) a **nucleic acid genome** and 2) a **protein capsid** that covers the genome. Together this is called the **nucleocapsid**. In addition, many animal viruses contain a 3) **lipid envelope**. The entire intact virus is called the **virion**. The structure and composition of these components can vary widely.

A: Viral Genomes: While the genomes of all known cells are comprised of double stranded DNA, the genomes of viruses can be comprised of single or double stranded from DNA or RNA. The known structures of viral genomes are summarized below.

DNA: Double Stranded - linear or circular

Single Stranded - linear or circular

Other Structures - gapped circles

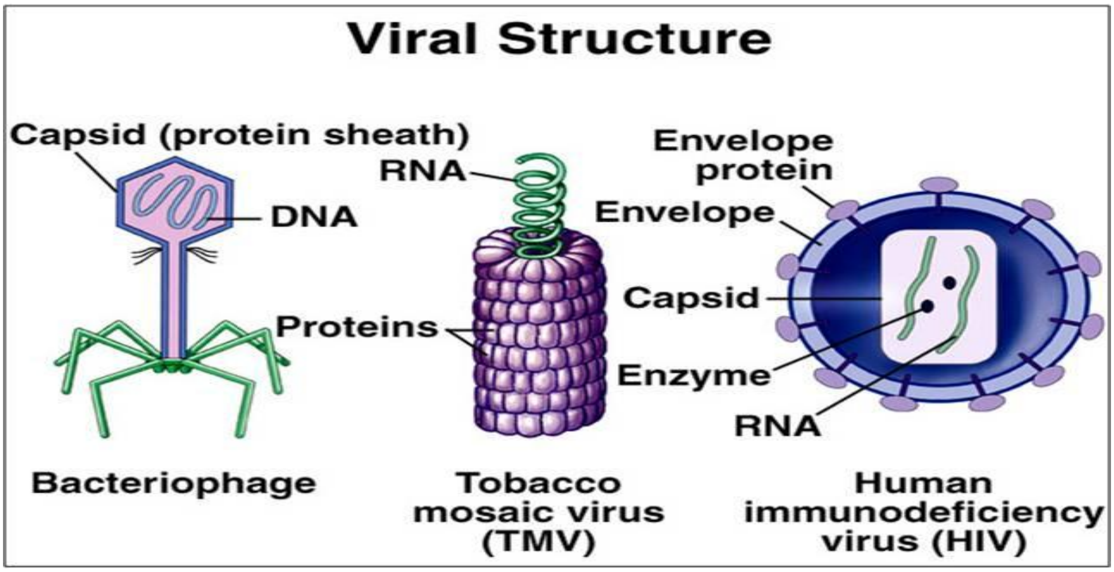
RNA: Double Stranded - linear

Single Stranded - linear :

The genome of some RNA viruses is segmented, meaning that a virus particle contains several different molecules of RNA, like different chromosomes.

B: Protein Capsid

Viral genomes are surrounded by protein shells known as capsids. A capsid is almost always made up of repeating structural subunits that are arranged in one of two symmetrical structures, a **helix** or an **icosahedron**. In the simplest case, these "subunits" consist of a single polypeptide. In many cases, however, these **structural subunits (also called protomers)** are made up of several polypeptides.



Protein Capsid Function

1- It protects the viral genome from physical destruction and enzymatic inactivation by nucleases in biological material.

2-It provides the binding site which enable the virus to attach to specific site on the host cell.

3-it facilitates the assembly and packaging of viral genetic informataion.

4-It serves as a vehicle of transmission from host to another.

5- It provides the structural symmetry to the virus particle.

Viral architecture can be grouped into three types based on the arrangement of morphological subunits.

Icosahedral:

These viruses appear spherical in shape, but a closer look actually reveals they are icosahedral. The icosahedron is made up of equilateral triangles fused together in a spherical shape. This is the most optimal way of forming a closed shell using identical protein sub-units. The genetic material is fully enclosed inside of the capsid. Viruses with icosahedral structures are released into the environment when the cell dies, breaks down and lyses, thus releasing the virions. Examples of viruses with an icosahedral structure are the poliovirus, rhinovirus, and adenovirus.

Helical :

This virus structure has a capsid with a central cavity or hollow tube that is made by proteins arranged in a circular fashion, creating a disc like shape. The disc shapes are attached helically (like a toy slinky) creating a tube with room for the nucleic acid in the middle. All filamentous viruses are helical in shape. They are usually 15-19nm wide and range in length from 300 to 500nm depending on the genome size. An example of a virus with a helical symmetry is the tobacco mosaic virus.

Complex :

These virus structures have a combination of icosahedral and helical shape and may have a complex outer wall or head-tail morphology. The head-tail morphology structure is unique to viruses that only infect bacteria and are known as bacteriophages. The head of the virus has an icosahedral shape with a helical shaped tail. The bacteriophage uses its tail to attach to the bacterium, creates a hole in the cell wall, and then inserts its DNA into the cell using the tail as a channel. The Poxvirus is one of the largest viruses in size and has a complex structure with a unique outer wall and capsid. One of the most famous types of poxviruses is the variola virus which causes smallpox

C: Viral Envelope

In some animal viruses, the nucleocapsid is surrounded by a membrane, also called an envelope. This envelope is made up of a lipid bilayer, and is comprised of host-cell lipids. It also contains virally encoded proteins, often glycoproteins which are trans-membrane proteins. These viral proteins serve many purposes, such as binding to receptors on the host cell, playing a role in membrane fusion and cell entry, etc. They can also form channels in the viral membrane.

Many enveloped viruses also contain matrix proteins, which are internal proteins that link the nucleocapsid to the envelope.

Enveloped viruses are formed by budding through cellular membranes, usually the plasma membrane but sometimes an internal membrane such as the ER, golgi, or nucleus. In these cases, the assembly of viral components (genome, capsid, matrix) occurs on the inside face of the membrane, the envelope glycoproteins cluster in that region of the membrane, and the virus buds out. This ability to bud allows the virus to exit the host cell without lysing, or killing the host. In contrast, non-enveloped viruses, and some enveloped viruses, kill the host cell in order to escape.

D: Virus Classification

Viruses are classified using a combination of characteristics, including the following

1) Morphology: size, shape, presence of envelope, etc.
2) Physicochemical properties: thermal stability, detergent stability, molecular mass, etc.
3) Genome: size, type of nucleic acid, , etc. 4) Proteins: number, size, sequence, etc.
5) Lipids: content, character, etc.
6) Carbohydrates: content, character, etc.
7) Antigenic properties: serological relationships.
8) Biological properties: Host range, mode of transmission, pathogenicity, tissue tropisms, geographic distribution, etc.

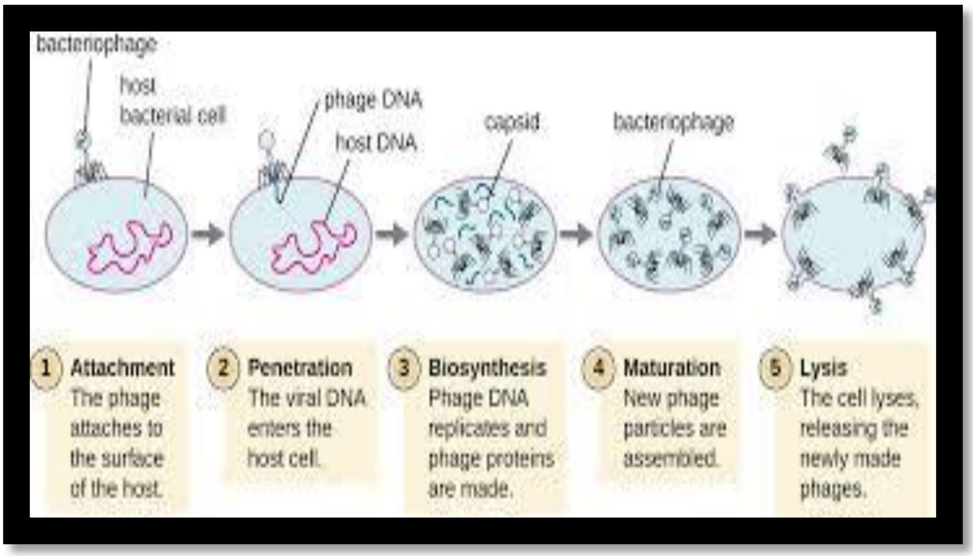
General step in viral replication cycles

1-Atachment

2- penetration

3-viral genome replication

4-mutration
5-Release



Pathogenesis

Pathogenesis is the process by which an infection leads to disease. Pathogenic mechanisms of viral disease include (1) implantation of virus at the portal of entry, (2) local replication, (3) spread to target organs (disease sites), and (4) spread to sites of shedding of virus into the environment. Factors that affect pathogenic mechanisms are (1) accessibility of virus to tissue, (2) cell susceptibility to virus multiplication, and (3) virus susceptibility to host defenses. Natural selection favors the dominance of low-virulence virus strains.

Cellular Pathogenesis

Direct cell damage and death from viral infection may result from (1) diversion of the cell's energy, (2) shutoff of cell macromolecular synthesis, (3) competition of viral mRNA for cellular ribosomes, (4) competition of viral promoters and transcriptional enhancers for cellular transcriptional factors such as RNA polymerases, and inhibition of the interferon defense mechanisms. Indirect cell damage can result from , induction of mutations in the host genome, inflammation, and the host immune response.

There are several mechanisms that must occur for a viral disease to develop:

1- **Implantation at Portal of Entry**: The virus must implant at the entry portal into the body. Implantation is the earliest stage of pathogenesis. Implantation frequency is at its greatest where viruses directly contact living cells. Viruses usually implant on cells of respiratory, gastrointestinal, skin and genital tissues. Some viruses are capable of implanting in a fetus through infected germ cells at the time of fertilization.

2- **Local Replication and Local Spread**: Local replication and spread of the virus follows implantation. Replicated virus from the initially infected cell has the capability to disperse to neighboring extracellular fluids or cells. Spread occurs by the neighboring cell being infected or the virus being released into extracellular fluid.

3- **Replication**: The invading virus must reproduce itself in large numbers. It usually does this intracellularly.

4- **Dispersal**: The replicated viruses must spread to target organs (disease sites) throughout the body. The most common route of spread from the portal of entry is the circulatory system, which the virus reaches via the lymphatic system. Viruses can access target organs from the blood capillaries by multiplying inside endothelial cells, moving through gaps, or by being carried inside the organ on leukocytes. Some viruses, such as Herpes , rabies and polio viruses, can also disseminate via nerves.

5- **Shedding**: The viruses must spread to sites where shedding into the environment can occur. The respiratory, alimentary and urogenital tracts and the blood are the most frequent sites of shedding.

bacteria and viruses.

	Bacterium	Virus
Living Attributes	Living	Opinions differ on whether a virus is a form of life or organic structure that interacts with living organisms.
Cell Number	Unicellular (one cell)	No cells; not living?
Structures	DNA, RNA, cell wall, cell membrane	DNA or RNA enclosed inside a coat of protein
Ribosomes	Present	Absent
Enzymes	Yes	Yes – in some
Nucleus	No	No
May Cause Disease	Yes	Yes
Treatment	Antibiotics	Vaccines-prevent the spread and antiviral meds help to slow reproduction but cannot stop it completely.
Beneficial	Some beneficial – certain bacteria produce vitamins in gut; used to make yogurt , cheese	Specific viruses may be able to destroy tumors and may be useful in genetic engineering.
Reproduction	Fission –form of asexual reproduction	Invades host cell and takes over the cell causing it to make copies of the viral DNA or RNA. Destroys the host cell