Assist. Prof. MUNA.A. ABDULLAH

Bacteria:

Are bacteria living things?

Bacteria are individual living cells. Bacteria cells are similar to your cells in many ways; yet, they also have distinct differences. Bacteria have many unique adaptations allowing them to live in many different environments.

Characteristics of Bacteria

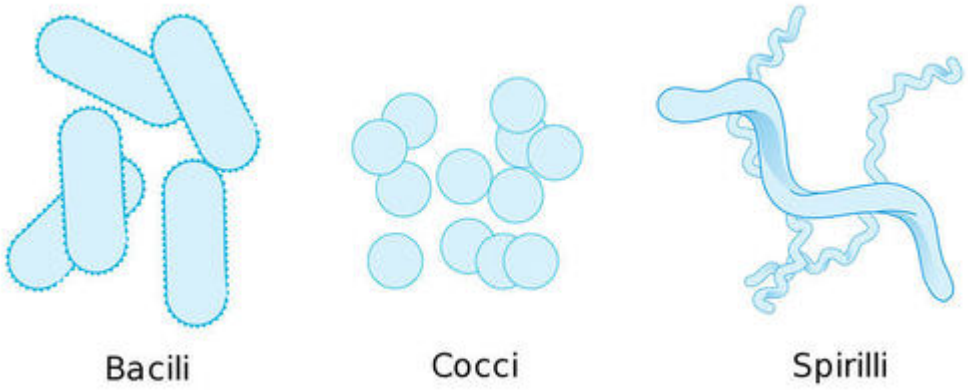
Bacteria are the most successful organisms on the planet. They lived on this planet for two billion years before the first eukaryotes and, during that time, evolved into millions of different species.

Size and Shape

Bacteria are so small that they can only be seen with a microscope. When viewed under the microscope, they have three distinct shapes (Figurebelow). Bacteria can be identified and classified by their shape:

1. Bacilli are rod-shaped.
2. Cocci are sphere-shaped.

3. Spirilli are spiral-shaped.

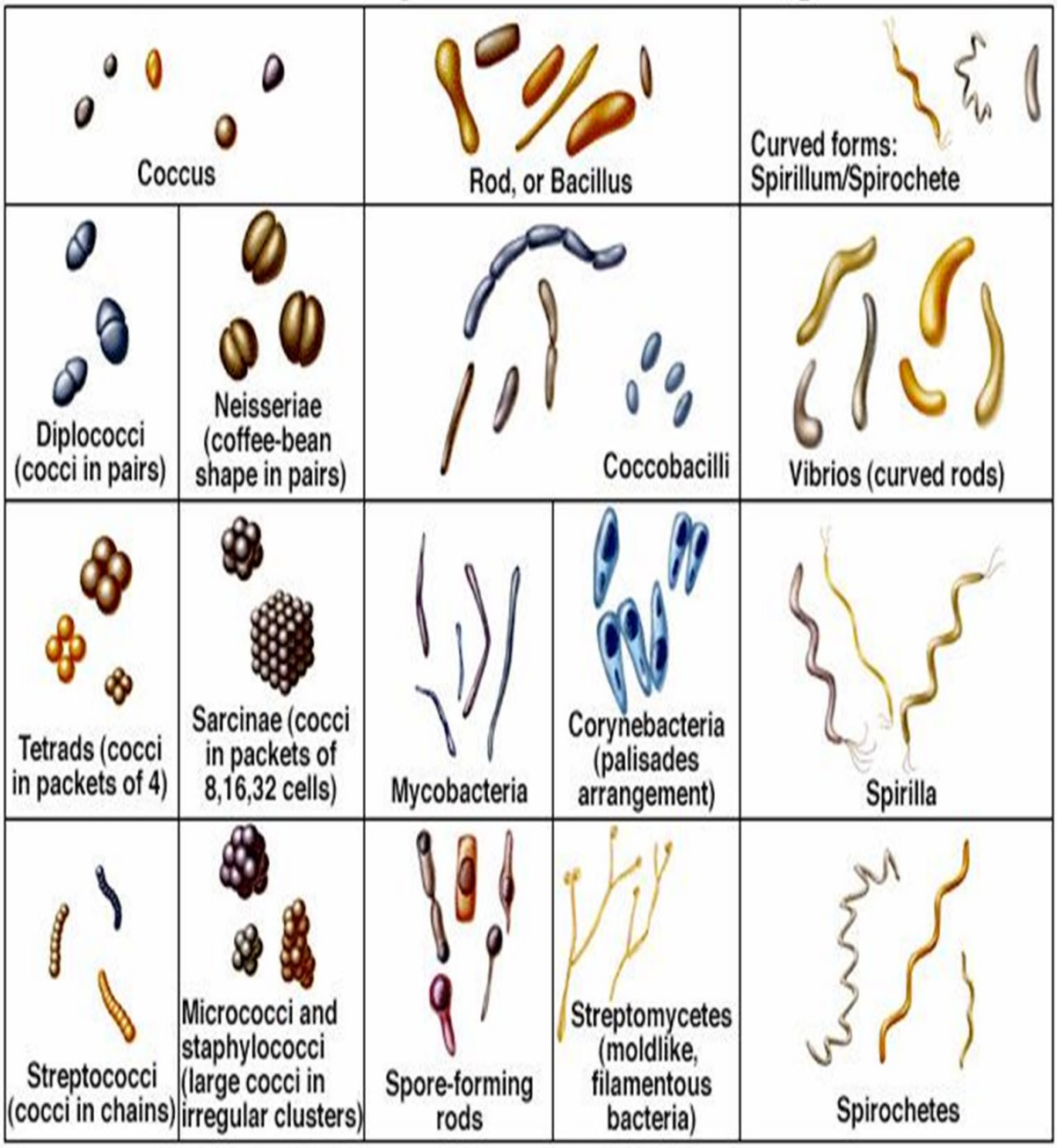


General characteristics of bacteria:

1- bacteria are unicellular free living organisms without chlorophyll, having both DNA and RNA.
2- They are able of performing all essential process of life e.g. growth, metabolism &reproduction.
3- They have rigid cell wall containing muramic acid.
4- Most bacteria are so small that their size is measure in terms of micron. Generally cocci 1M in diameter & bacilli are 2-10 M in length and 0.2-0.5 M in width.
5- The major form of bacteria are spheres, rods, curved rod, and spiral.

a- bacilli b- cocci c- curved d- cocci in pair
e-bacili in chain f- cocci in chain i-cocci in cluster

Bacterial shapes and arrangements



Similarities to Eukaryotes

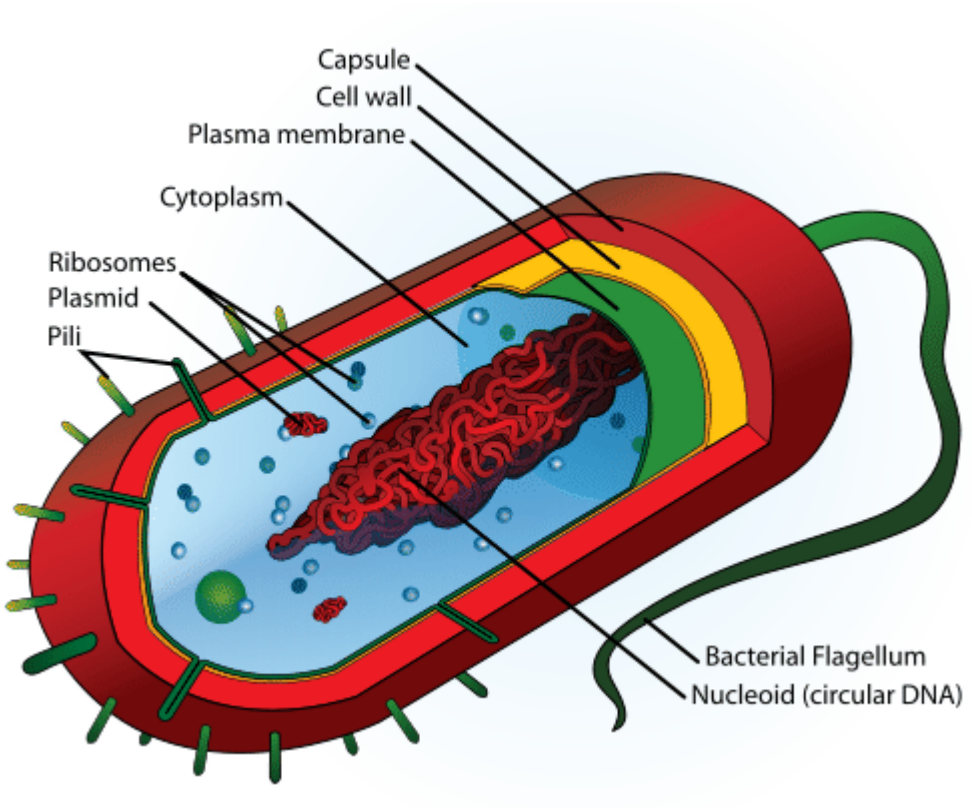
Like eukaryotic cells, bacterial cells have:

1. Cytoplasm, the fluid inside the cell.
2. A plasma or cell membrane, which acts as a barrier around the cell.
3. Ribosomes, in which proteins are put together.
4. DNA. By contrast though, bacterial DNA is contained in a large, circular strand. This single chromosome is located in a region of the cell called the nucleoid. The nucleoid is not an organelle, but a region within the cytoplasm. Many bacteria also have additional small rings of DNA known as plasmids.

The features of a bacterial cell are pictured below (Figurebelow)

The structure of a bacterial cell is distinctive from a eukaryotic cell because of features such as an outer cell wall, the circular DNA of the nucleoid, and the lack of membrane-bound

organelles.



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Unique Features

Bacteria lack many of the structures that eukaryotic cells contain. For example, they don't have a nucleus. They also lack membrane-bound organelles, such as mitochondria or chloroplasts. The DNA of a bacterial cell is also different from a eukaryotic cell. Bacterial DNA is contained in one circular chromosome, located in the cytoplasm. Eukaryotes have several linear chromosomes. Bacteria also have two additional unique features: a cell wall and flagella. Some bacteria also have a capsule outside the cell wall.

Bacterial structures

capsule: is the kind of hydrophilic gel surround many bacterial cells. Most capsule are polysaccharides and a few are proteins.

Functions

1- Capsule can protect bacteria

2- Role capsule in adherence & colonization e.g. The ability of streptococcus salivarius cells to adhere to the surface of teeth.

Cell wall: Internal to the capsule, rigid wall surround all bacteria cells.

Functions

1-Cell wall protect the cell from mechanical disruption and from being burst by the turgor pressure

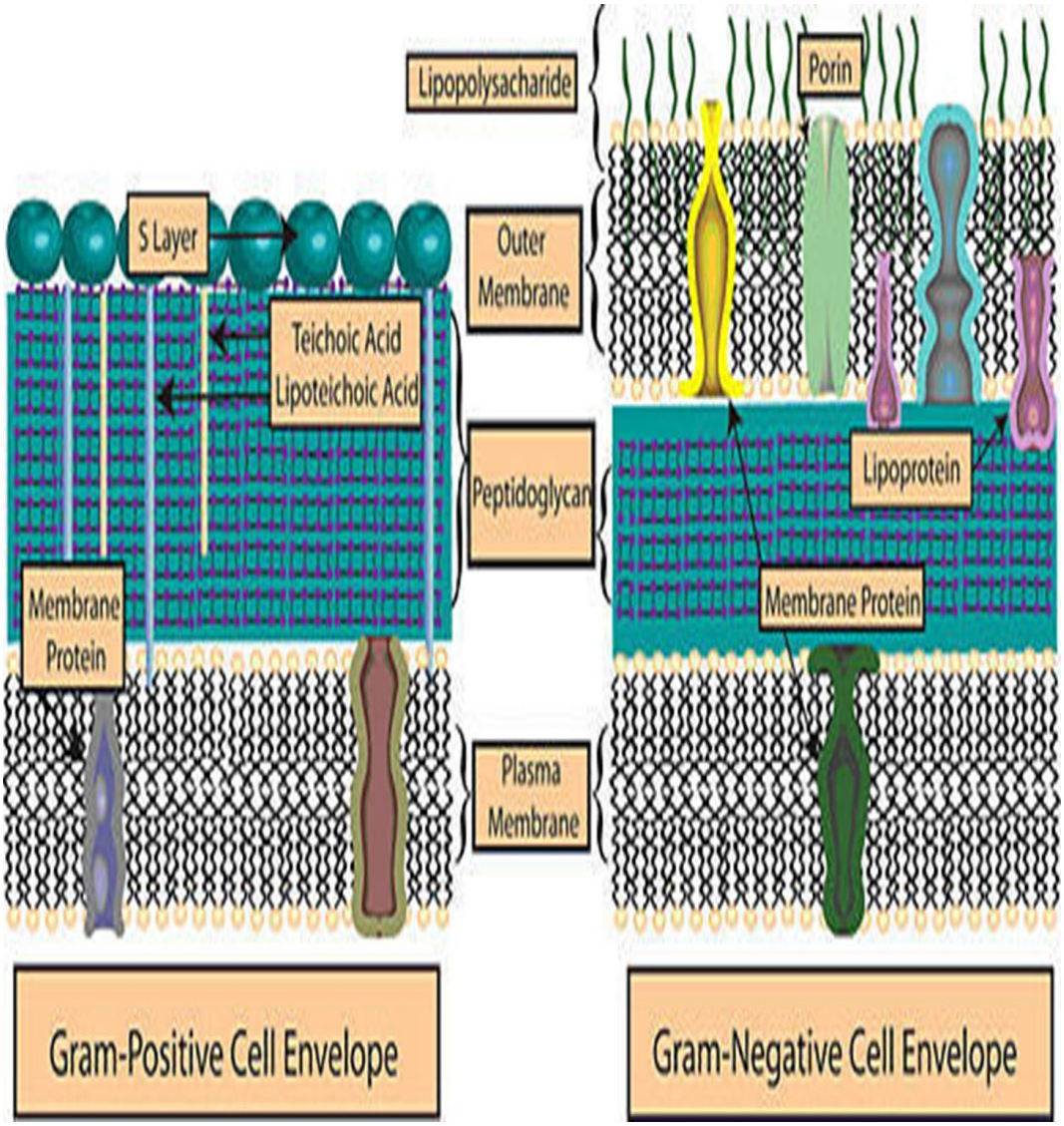
2-Provides a barrier against toxic chemical & biological agents.

3-Cell wall is responsible for the shape of the cell.

Bacteria could be divided into two groups depending on their reaction to a particular stain procedure put by Christian Gram. It is depended on the differential ability of ethanol or ethanol acetone mixtures to extract iodine crystal violet complexes, from bacteria cells. These complexes are readily extracted from one group of bacteria termed (Gram negative) , they are retained by the other termed (Gram positive). Gram positive wall contain a large amount of peptidoglycan compared to Gram negative wall.

Peptidoglycan (also known as murein) is made up of a polysaccharide backbone consisting of alternating N-Acetylmuramic acid (NAM) and N-acetylglucosamine (NAG) residues in equal amounts.

Cell wall	**Gram positive**	**Gram negative**
Thickness	15- 23 nm	10-15 nm
Variety	Few	Several
Aromatic&sulfur-containing-amino acid	Absent	Present
Lipid	Low	High 15- 20 %
Techoic acide	Present	Absent



G+ bacteria (cell wall) G- bacteria

Cell membrane : Cell membrane of bacteria is containing phospholipids& proteins. The bacterial cell membrane is rich in proteins (up to 70 % of its weight) & does not contain sterols.

Functions:

1- The bacterial chromosome is attached to the cell membrane, which play a role in segregation of daughter chromosomes at cell division , like to the role of mitotic apparatus of eukaryotes
2- The membrane is the site of DNA synthesis , cell wall polymers and membrane lipid.
3- Contain the entire electron transport system in the cell (like to the mitochondria)
4- Contains recipto proteins that function in chemotaxis
5- Involved in secretion to the exterior of proteins (exoproteins), including exotoxins & enzymes involved in the pathogenesis of disease.

Flagella : are organelles of motility found in many species of bacteria (G+ &G-) . Flagella are helical organs of locomotion . consist entirely of protein, encoded in genes called Fla (for flagella).

Functions

1- Motility
2- Chemotaxis

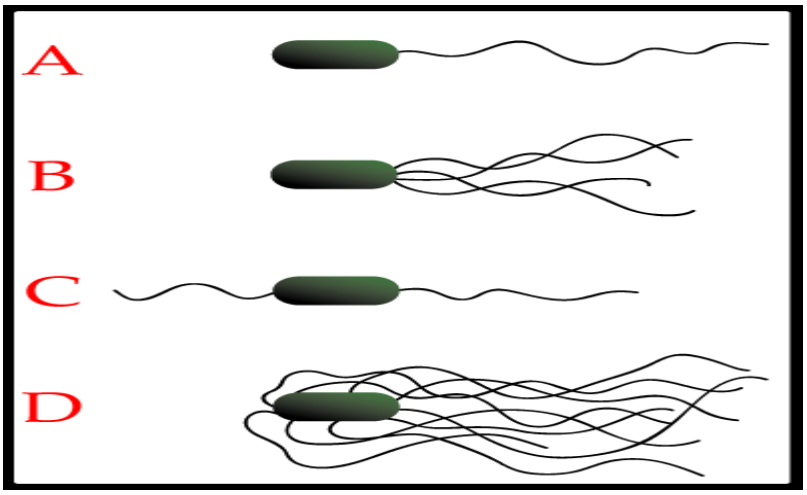
Common forms include:

A-Monotrichous - Single flagellum

B-Lophotrichous - A tuft of flagella found at one of the cell pole

C-Amphitrichous - Single flagellum found at each of two opposite poles

D-Peritrichous – Multiple flagella found at several locations about the Cell.



Pili: are molecular found on the surface of cells of many G+ &G- species. They are composed of molecules of proteins called pilin arranged to form a tube with a minute , hollow core.

There are two general classes.

1- Common pili : cover the membrane of the cell.

2- Sex pili : diagnostic of a male bacterium. There is only one per cell , and the sex pili is longer and thicken than a common pili.

Function:

There are, adhesions, which are responsible for the ability of bacteria to colonization.

Fimbriae - are protein tubes that extend out from the outer membrane They are generally short in length and present in high numbers about the entire bacterial cell surface. Fimbriae usually function to facilitate the attachment of a bacterium to a surface.

Cytosol: is bounded by the cell membrane. It appears granular because its contain ribosomes. Each ribosome is a ribonucleoprotien.

Functions

1- All of the metabolic reaction of the cell take place in the cytosol

2- Major location of a great fraction of the 2000-3000 different enzymes of the cell

3-Contain nutritional storage granules. The most consist glycogen or polymetaphosphate.

Ribosomes - Cell structures responsible for protein production.

Nucleoid

The bacterial have a single chromosome and typically consist of a bout 4000 genes encoded in o, large, circular molecule of double strand DNA. Each region contains chromosomes coated by polyamines & some specialized DNA binding proteins, but not with the structure of eukaryotic chromosome. Because it is not surrounded by a membrane, it is not called a nucleus.

The absence of nuclear membrane in prokaryotic cell a great advantage for rapid growth in changing environment.

Function

Contain the genes that responsible of the structure and activity of the cell.

Plasmids: Are small, circular, conveniently closed, double strand DNA molecules separate from the chromosome and found in many bacterial cells. More than one type of plasmid or several copies of a single plasmid may be present in the cell.

Function

1- Carry genes coding for the production of enzymes that protect the cell from toxic substances e.g. antibiotic resistance is often plasmid determination.

2- Many virulence factors, such as production of some pili& some exotoxins, are also determinate by plasmid genes.

3- Some plasmids code for production of a sex pili.

Spores: Endospore are small, dehydrated, metabolically quiescent form that are produced by some bacteria in response to nutrient limitation.

Very few bacteria produce spores ,such as

1- clostridium tetani, which grow in absence of O2

2- Bacillus subtilis, which grow in presence of O2

Some sporing bacteria are importance in medicine, causing disease such as (anthrax, tetanus, gas gangrene, and botulism). The bacterial spore is not reproductive structure. One cell forms one spore (the process is called sporulation). The spores may persist for a long time and then, on the normal condition ,give a single bacteria cell (germination).

Function

They make survival of organism possible under un-favorable condition like dry state. Spores are resistant to heat, drying, freezing, and toxic chemicals

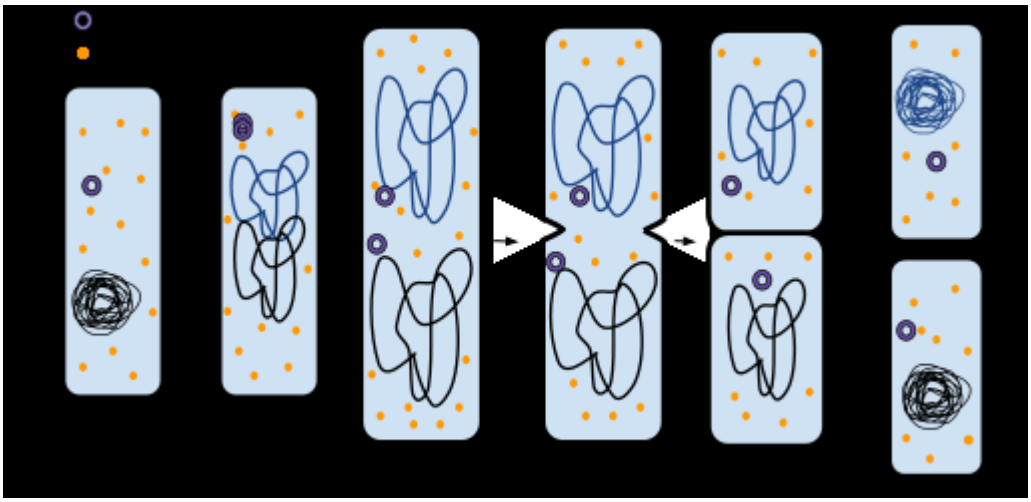
Bacterial reproduction

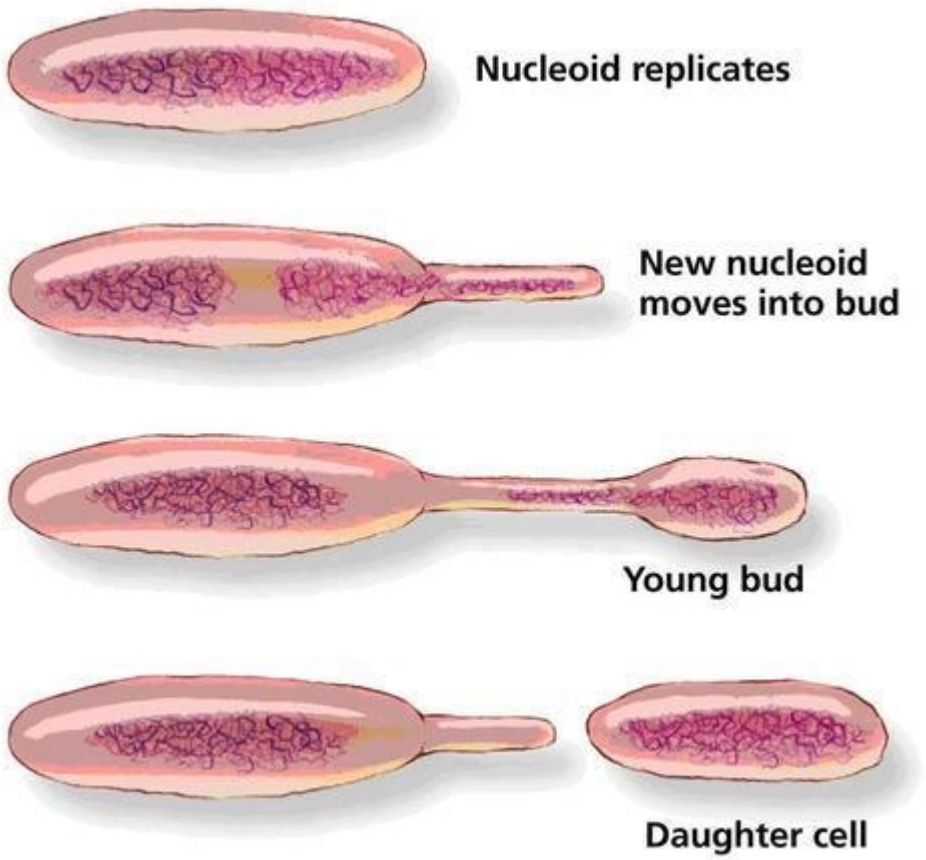
-Bacterial reproduction most commonly occurs by a kind of cell division called **simple binary fission**. Binary fission results in the formation of two bacterial cells that are genetically identical.

-**Budding:** external buds from the parent cell

Binary fission in a prokaryote

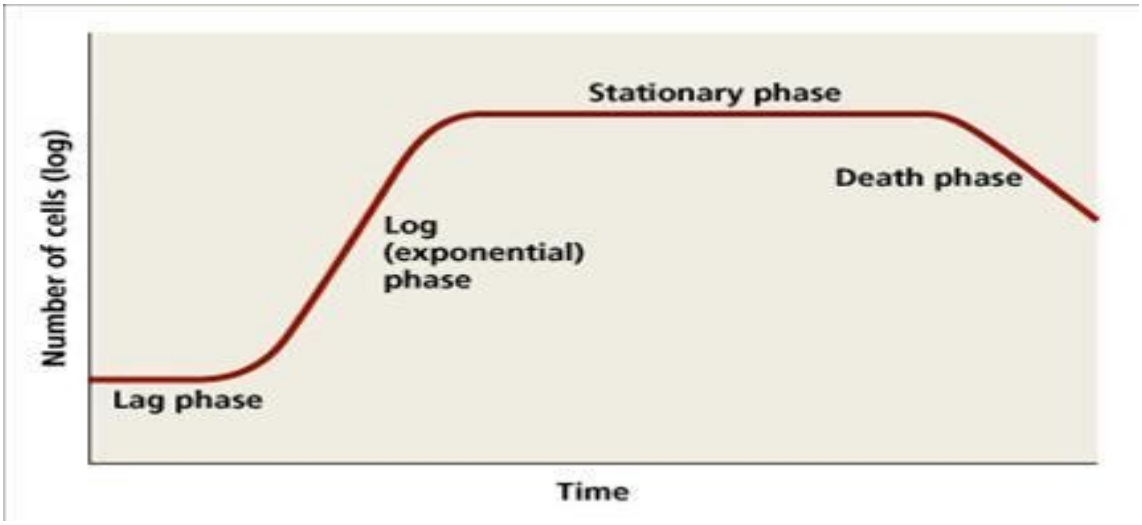
1. The bacterium before binary fission is when the DNA is tightly coiled.
2. The DNA of the bacterium has uncoiled and replicated.
3. The DNA is pulled to the separate poles of the bacterium as it increases size to prepare for splitting.
4. The growth of a new cell wall begins to separate the bacterium.
5. The new cell wall fully develops, resulting in the complete split of the bacterium.





Bacterial growth

Bacterial growth follows four phases. When a population of bacteria first enters a high-nutrient environment that allows growth, the cells need to adapt to their new environment. The first phase of growth is the **lag phase,** a period of slow growth when the cells are adapting to the high-nutrient environment and preparing for fast growth. The lag phase has high biosynthesis rates, as proteins necessary for rapid growth are produced. The second phase of growth is the **log phase,** also known as the exponential phase. The log phase is marked by rapid exponential growth. The rate at which cells grow during this phase is known as the growth rate (k), and the time it takes the cells to double is known as the generation time (g). During log phase, nutrients are metabolised at maximum speed until one of the nutrients is depleted and starts limiting growth. The third phase of growth is the **stationary phase** and is caused by depleted nutrients. The cells reduce their metabolic activity and consume non-essential cellular proteins. The stationary phase is a transition from rapid growth to a stress response state The final phase is the **dealing death phase** where the bacteria run out of nutrients and die.


Stationary phase
Death phase
Log
(exponential)
phase
Lag phase
Number of cells (log)
Time

By Assistant. prof Muna. A. Abdullah

Cell cycle and Cell Division

The cell cycle is a series of events that include growth, DNA synthesis, and cell division. The cell cycle in prokaryotes is quite simple: the cell grows, its DNA replicates, and the cell divides. In eukaryotes, the cell cycle is more complicated. The cell cycle comprises three coordinated processes of cell division, DNA replication, and cell growth. The first stages of the cell cycle involve cell growth, then synthesis of DNA. The single strand of DNA that makes up each chromosome produces an exact copy of itself. The cell undergoes a type of cell division called mitosis.

The main difference between cell cycle and cell division is that:

The Cell Cycle:

Cell division: is the process in which one cell, called the parent cell, divides to form two new cells, referred to as daughter cells. How this happens depends on whether the cell is prokaryotic or eukaryotic.

Cell division

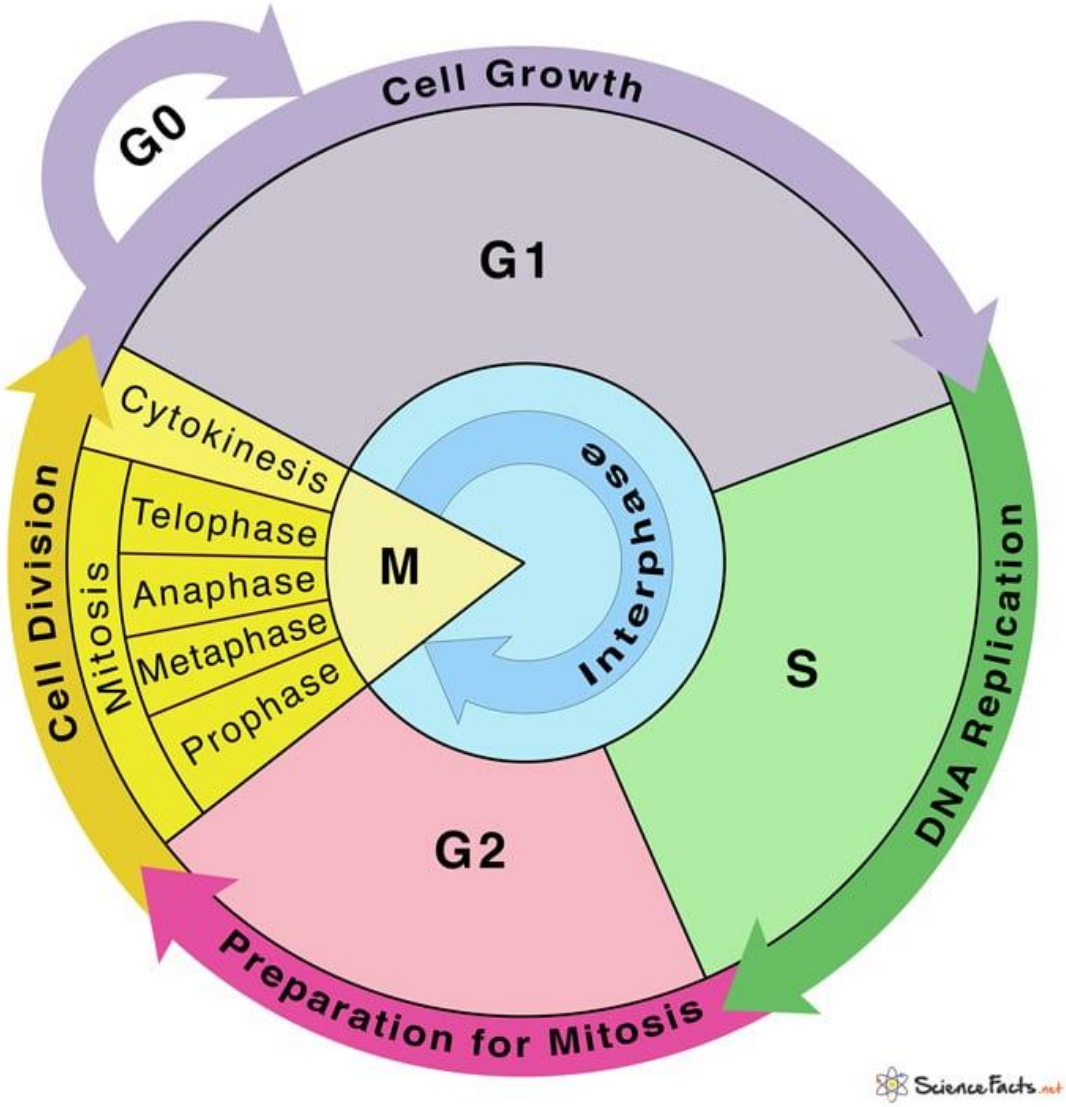
is simpler in prokaryotes than eukaryotes because prokaryotic cells themselves are simpler. Prokaryotic cells have a single circular chromosome

, no nucleus, and few other organelles. Eukaryotic cells, in contrast, have multiple chromosomes contained within a nucleus and many other organelles. All of these cell parts must be duplicated and then separated when the cell divides.

Cell division: is just one of several stages that a cell goes through during its lifetime.

The cell cycle: is a repeating series of events that include growth, DNA synthesis, and cell division. The cell cycle in prokaryotes is quite simple. the cell grows, its DNA replicates, and the cell divides. This form of division in prokaryotes is called asexual reproduction. In eukaryotes, the cell cycle is more complicated.

Cell Cycle


G0
Cell Growth
G1
Cytokinesis
Telophase
Anaphase
Metaphase
Prophase
Mitosis
Cell Division
M
Interphase
S
DNA Replication
G2
Preparation for Mitosis
ScienceFacts.net

V

BINARY FISSION	MITOSIS	MEIOSIS	SIMILARITIES BETWEEN ALL THREE
• Occurs in single celled organisms, like bacteria • Creates identical cells, or clones, and begins with DNA replication. • The number of chromosomes is preserved or stays the same. • Binary fission serves the purpose of reproduction for bacteria and creates entirely new living organisms.	• Occurs in multicellular organisms, such as plants, animals, and humans. • Creates identical cells, or clones, and begins with DNA replication. • Produces diploid cells, which are cells with a full set of DNA • Serves the purpose of growth and healing in multicellular organisms • Occurs in somatic cells • Includes steps prophase, metaphase, anaphase, telophase	• Occurs in multicellular organisms, such as plants, animals, and humans. • Creates gametes, or sex cells (pollen, seed, sperm, egg) • Begins with DNA replication • The number of chromosomes is reduced by half. • Meiosis produces haploid cells, which are cells with only half the original the DNA of the original parent cell. • Serves the purpose of reproduction in multicellular organisms. • Includes steps prophase 1, metaphase 1, anaphase 1, telophase 1, prophase 2, metaphase 2, anaphase 2, telophase 2	• Produces new cells • Replicates DNA • Plays an important role in the life cycle of the cell

Cell division takes place in one of three processes. These are known as binary fusion, meiosis and mitosis. Some living organisms utilize both meiosis and mitosis for different types of cells. Cell division is driven by the genetic coding encrypted in the DNA of the organism and is essential for the continuation and evolution of species and genetic variation.

1-Binary Fission

Binary fission is the process in which almost all prokaryotes use. The process of binary fusion functions as an asexual reproductive method for organisms such as bacteria or cyanobacteria. Literally this term means division in half and is used to clone pretty much the entire single cell organism.

2-Mitosis

Mitosis is a process of cell division for eukaryotes which produces two identical daughter cells. It begins by having chromosomes split in the cell nucleus into two identical diploid cells. This process is used primarily to replace cells that make up an organism for regenerative purposes as opposed to sexual reproduction.

3-Meiosis

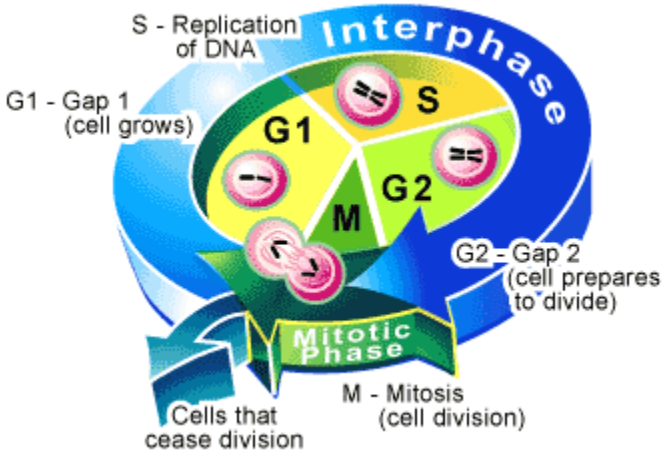
Meiosis is the form of cell division that governs sexual reproduction in eukaryotes. This is done through spores in the fungi and Plantae domain and gametes in animals and some plants. The process of meiosis does not reproduce two identical daughter cells but instead undergoes the recombination of chromosomes between two parent cells, typically derived from two individual organisms. This is the process in which genetic variation is born.

For unicellular organisms (single celled organisms) cell division is the process of reproduction for the colony. Organisms like bacteria reproduce asexually and therefore do not have the genetic variation that more complex organisms possess.

For more complex organisms cell division serves additional functions. Replacing cells is an essential part of growth and life in organisms. In humans for example, skin cells are constantly being replaced to allow our growth along with providing regeneration for damaged cells. Additionally reproduction is a process of cell division which mixes the chromosomes of two parent cells to produce a unique daughter cell with genetic variation.

Interphase: Interphase, which appears to the eye to be a resting stage between cell divisions, is actually a period of diverse activities. Those interphase activities are indispensable in making the next mitosis possible. Interphase generally lasts at

least 12 to 24 hours in mammalian tissue. During this period, the cell is constantly synthesizing RNA, producing protein and growing in size. By studying molecular events in cells, scientists have determined that interphase can be divided into 4 steps: **Gap 0 (G0), Gap 1 (G1), S (synthesis) phase, Gap 2 (G2).**



Gap 0 (G0): There are times when a cell will leave the cycle and quit dividing. This may be a temporary resting period or more permanent. An example of the latter is a cell that has reached an end stage of development and will no longer divide (e.g. neuron).

Gap 1 (G1): Cells increase in size in Gap 1, produce RNA and synthesize protein. An important cell cycle control mechanism activated during this period (G1 Checkpoint) ensures that everything is ready for DNA synthesis. (Click on the Checkpoints animation, above.)

S Phase: To produce two similar daughter cells, the complete DNA instructions in the cell must be duplicated. DNA replication occurs during this S (synthesis) phase.

Gap 2 (G2): During the gap between DNA synthesis and mitosis, the cell will continue to grow and produce new proteins. At the end of this gap is another control checkpoint (G2 Checkpoint) to determine if the cell can now proceed to enter M (mitosis) and divide.

Mitosis or M Phase: Cell growth and protein production stop at this stage in the cell cycle. All of the cell's energy is focused on the complex and orderly division

into two similar daughter cells. Mitosis is much shorter than interphase, lasting perhaps only one to two hours. As in both G1 and G2, there is a Checkpoint in the middle of mitosis (Metaphase Checkpoint) that ensures the cell is ready to complete cell division. Actual stages of mitosis can be viewed at Animal Cell Mitosis.

Cancer cells reproduce relatively quickly in culture. In the Cancer Cell CAM compare the length of time these cells spend in interphase to that for mitosis to occur.

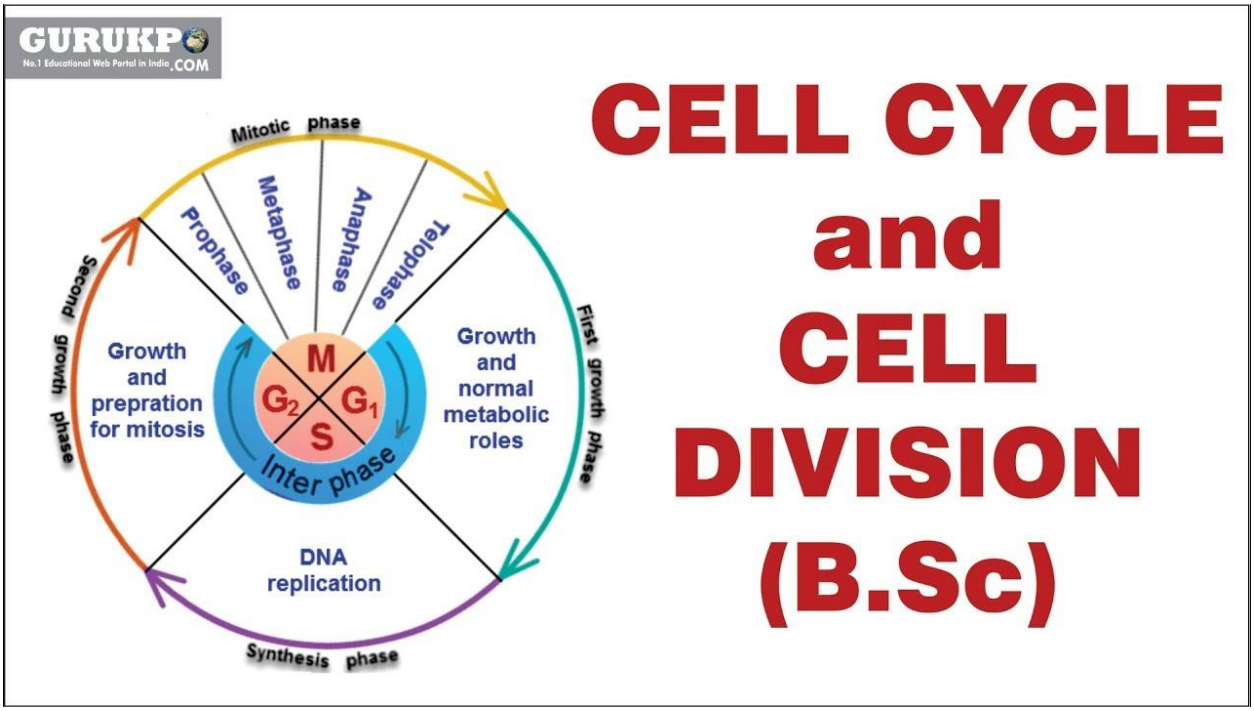
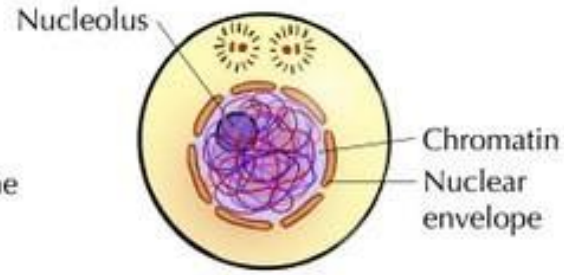


TABLE (1): Cell division at different rate.

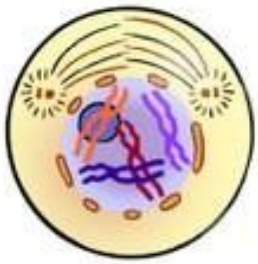
Cell type	Approximate life span
Skin cell	2 weeks
RBC	4 months
Liver cell	300-400 days
Intestine	4-5 days
Muscle and other tissues	16 years

	Mitosis	Meiosis
(i)	It occurs in all somatic cells and may continue throughout life.	It occurs in reproductive cells and at specific times.
(ii)	It involves a single division, resulting in two daughter cells only.	It involves two successive divisions, resulting in four daughter cells.
(iii)	Subsequent mitotic divisions are similar to the earlier ones.	Two meiotic divisions are dissimilar, first is reductional while the second is equational.
(iv)	Prophase is relatively short and simple.	Prophase I is very long and elaborate, comprising 5 subphases.
(v)	There is no pairing of homologous chromosomes.	Homologous chromosomes pair and often undergo crossing over in prophase I.
(vi)	Chromatids are genetically similar to chromosomes they arise from.	Chromatids may differ genetically from the chromosomes they arise from due to crossing over.
(vii)	No synaptonemal complex forms.	Synaptonemal complex forms between synapsed homologous chromosomes.
(viii)	Chromosomes do not unfold, and no transcription and protein synthesis occur in prophase.	Chromosomes unfold, and transcription and protein synthesis may occur in diplotene of prophase I (oocytes of certain animals).
(ix)	Daughter cells have diploid number (2N) of chromosomes like the parent cell.	Daughter cells have haploid number (N) of chromosomes unlike the parent cell.

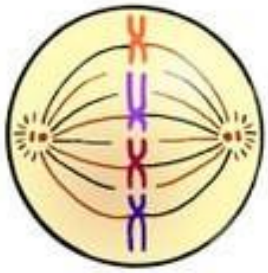
Interphase
The nucleolus and the nuclear envelope are distinct and the chromosomes are in the form of threadlike chromatin.



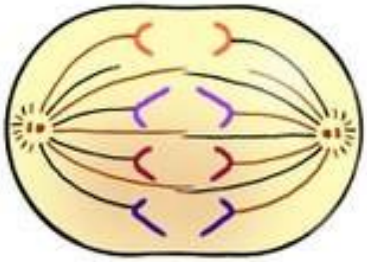
Prophase
The chromosomes appear condensed, and the nuclear envelope in not apparent.



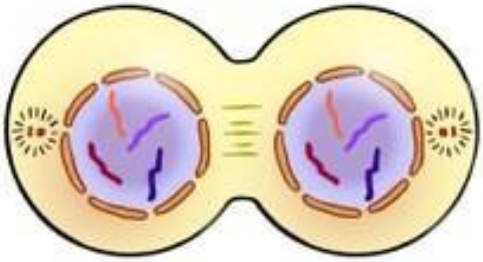
Metaphase
Thick, coiled chromosomes, each with two chromatids, are lined up on the metaphase plate.



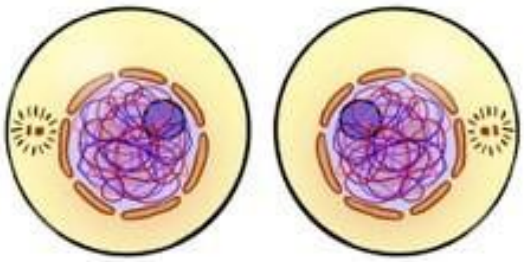
Anaphase
The chromatids of each chromosome have separated and are moving toward the poles.



Telophase
The chromosomes are at the poles, and are becoming more diffuse. The nuclear envelope is reforming. The cytoplasm may be dividing.



Cytokinesis (part of telophase)
Division into two daughter cells is completed.



V

Assistant.Prof. MUNA.A. ABDULLAH

Genetics

Genetics, study of heredity in general and of genes in particular. Genetics forms one of the central pillars of biology and overlaps with many other areas, such as agriculture, medicine, and biotechnology.

Father of genetics is **Gregor Mendel**, Mendel studied 'trait inheritance', patterns in the way traits were handed down from parents to offspring. He observed that organisms (pea plants) inherit traits by way of discrete "units of inheritance". This term, still used today, is a somewhat ambiguous definition of what is referred to as a **gene.**

Genetics as a scientific discipline stemmed from the work of Gregor Mendel in the middle of the 19th century. Mendel

suspected that traits were inherited as discrete units, and, although he knew nothing of the physical or chemical nature of genes at the time, his units became the basis for the development of the present understanding of heredity. All present research in genetics can be traced back to Mendel's discovery of the laws governing the inheritance of traits. The word *genetics* was introduced in 1905 by English biologist William Bateson, who was one of the discoverers of Mendel's work and who became a champion of Mendel's principles of inheritance.

Genetics arose out of the identification of genes, the fundamental units responsible for heredity. Genetics may be defined as the study of genes at all levels, including the ways in which they act in the cell and the ways in which they are transmitted from parents to offspring. Modern genetics focuses on the chemical substance that genes are made of, called deoxyribonucleic acid, or DNA, and the ways in which it affects

the chemical reactions that constitute the living processes within the cell. Gene action depends on interaction with the environment. Green plants, for example, have genes containing the information necessary to synthesize the photosynthetic pigment chlorophyll that gives them their green colour. Chlorophyll is synthesized in an environment containing light because the gene for chlorophyll is expressed only when it interacts with light. If a plant is placed in a dark environment, chlorophyll synthesis stops because the gene is no longer expressed.

A gene: is the **basic physical and functional unit of heredity**. Genes are made up of DNA and occupy a fixed position (locus) on a chromosome. Some genes act as instructions to make molecules called proteins, while many genes do not code for proteins. Genes vary in size from a few hundred DNA bases to more than 2 million bases in humans.

The modern working definition of **a gene is a portion or sequence of DNA that codes for a known cellular function or process (e.g. the function "make melanin molecules").**

The amino acids in a protein determine how it folds into its unique three-dimensional shape, a structure that is ultimately responsible for the protein's function. Proteins carry out many of the functions needed for cells to live. **A change to the DNA in a gene** can alter a protein's amino acid sequence, thereby changing its shape and function and rendering the protein ineffective or

even malignant (e.g. sickle cell anemia**). Changes to genes are called mutations.**

Mutations:

Mutation, an alteration in the genetic material (the genome) of a cell of a living organism or of a virus that is more or less permanent and that can be transmitted to the cell's or the virus's descendants. (The genomes of organisms are all composed of DNA, whereas viral genomes can be of DNA or RNA; see heredity: The physical basis of heredity.) Mutation in the DNA of a body cell of a multicellular organism (somatic mutation) may be transmitted to descendant cells by DNA replication and hence result in a sector or patch of cells having abnormal function, an example being cancer. Mutations in egg or sperm cells (germinal mutations) may result in an individual

offspring all of whose cells carry the mutation, which often confers some serious malfunction, as in the case of a human genetic disease such as cystic fibrosis. Mutations result either from accidents during the normal chemical transactions of DNA, often during replication, or from exposure to high-energy electromagnetic radiation (e.g., ultraviolet light or X-rays) or particle radiation or to highly reactive chemicals in the environment. Because mutations are random changes, they are expected to be mostly deleterious, but some may be beneficial in certain environments. In general, mutation is the main source of genetic variation, which is the raw material for evolution by natural selection.

Mendel's laws of genetics are as follows:

Law of Segregation: There are dominant and recessive traits passed on randomly from parents to offspring.

Law of Independent Assortment: Traits are passed on independently of other traits from parent to offspring.

Law of Dominance: A dominant gene will express itself over the recessive gene.

Organisms have discrete factors that determine their features (these ‘factors’ are now recognized as genes).

Mechanisms of genetics include:

-Gene expression steps, starting with the production of an mRNA (transcription), followed by its processing and localization, and continuing to protein synthesis (translation).

-Mutation, which is a mechanism of genetic change for DNA viruses that use the host DNA synthesis machinery for replicating their genomes.

-Chromatin accessibility, transcription, and RNA processing, which are mechanisms of eukaryotic gene expression regulation.

All animals have a set of DNA coding for genes present on chromosomes. In humans, most mammals, and some other species, two of the chromosomes, called the X chromosome and Y chromosome, code for sex. In these species, one or more genes present on their Y-chromosome that determine maleness.

In humans, sex-determining region Y (SRY) protein, is a DNA-binding protein (also known as gene-regulatory

protein/transcription factor) encoded by the SRY gene that is responsible for the initiation of male sex determination in humans. Once SRY is activated, cells create testosterone and anti-Mullerian hormone to turn the genderless sex organs into male. With females, their cells excrete estrogen, driving the body down the female pathway. **In animals** this is often accompanied by chromosomal differences, generally through combinations of XY, ZW, XO, ZO chromosomes.

In other cases, sex is determined by environmental variables (such as temperature) or social variables (e.g. the size of an organism relative to other members of its population).

Environmental sex determination preceded the genetically determined systems of birds and mammals; it is thought that a temperature-dependent amniotes was the common ancestor of

amniotes with sex chromosomes. **Some species do not have a fixed sex,** and instead change sex based on certain cues.

Chromosomal crossover and Genetic linkage

Chromosomal crossover and gene linkage are two important concepts in genetics.

Gene linkage refers to the tendency of related genes in a chromosome to be inherited together.

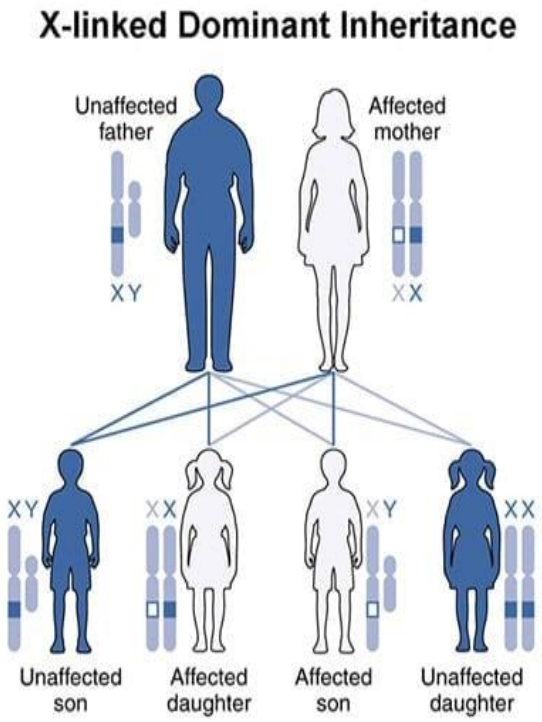
Chromosomal crossover refers to the exchange of segments of a pair of chromosomes during reduction division, which results in the separation of linked genes and recombination. The chances of a pair of genes getting inherited together are inversely proportional to the distance between them in the chromosome. **This process of chromosomal crossover** generally occurs during meiosis, a series of cell divisions that creates haploid cells.

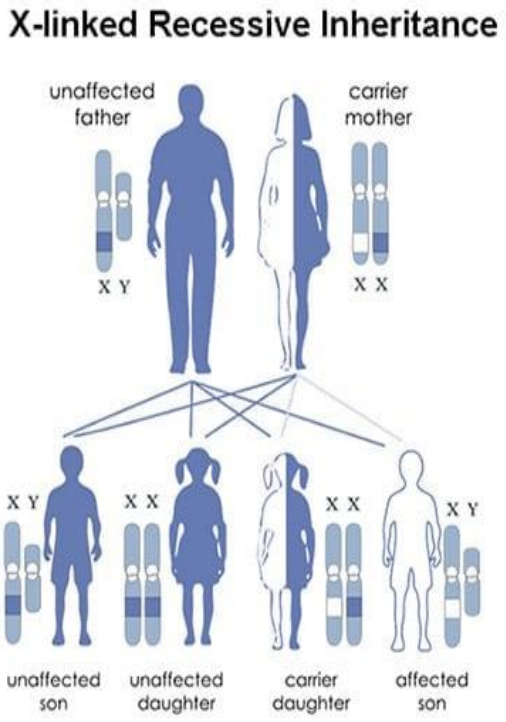
The probability of chromosomal crossover occurring between two given points on the chromosome is related to the distance between the points. For an arbitrarily long distance, the probability of crossover is high enough that the inheritance of the genes is effectively uncorrelated. For genes that are closer together, however, the lower probability of crossover means that the genes demonstrate genetic linkage; alleles for the two genes tend to be inherited together.

Genetic linkage is the tendency of alleles that are located close together on a chromosome to be inherited together during meiosis. Genes whose loci are nearer to each other are less likely to be separated onto different chromatids during chromosomal crossover, and are therefore said to be genetically linked. In other words, the nearer two genes are on a chromosome, the lower is the chance of a swap occurring

between them, and the more likely they are to be inherited together.

- **Sex-Linked Genes**
- Genes located on the X chromosomes (some cause diseases).
- The Y is much smaller, contains few genes.





Sex-linked disorders

Sex-linked disorders are traits that are found on either one of the sex chromosomes, X or Y. Examples of sex-linked disorders include:

- **Hemophilia**
- **Red-green color blindness**
- **Congenital night blindness**
- **Some high blood pressure genes**
- **Duchenne muscular dystrophy**
- **Fragile X syndrome**

Sex-linked disorders are inherited in a dominant or recessive pattern. Dominant inheritance occurs when an abnormal gene from one parent can cause a disease, even though a matching gene from the other parent is normal. The abnormal gene dominates the gene pair.

Color blindness is a sex linked disorder

Color blindness genetic problem:

15.2 Daily activity, sex-linked genes, critical thinking

Cross a normal (normal means the individual does not carry the allele for color blindness) man with a carrier female (X^BX^b x X^BY).

What is the probability of an offspring being color blind?

What is the probability of a female offspring being color blind?

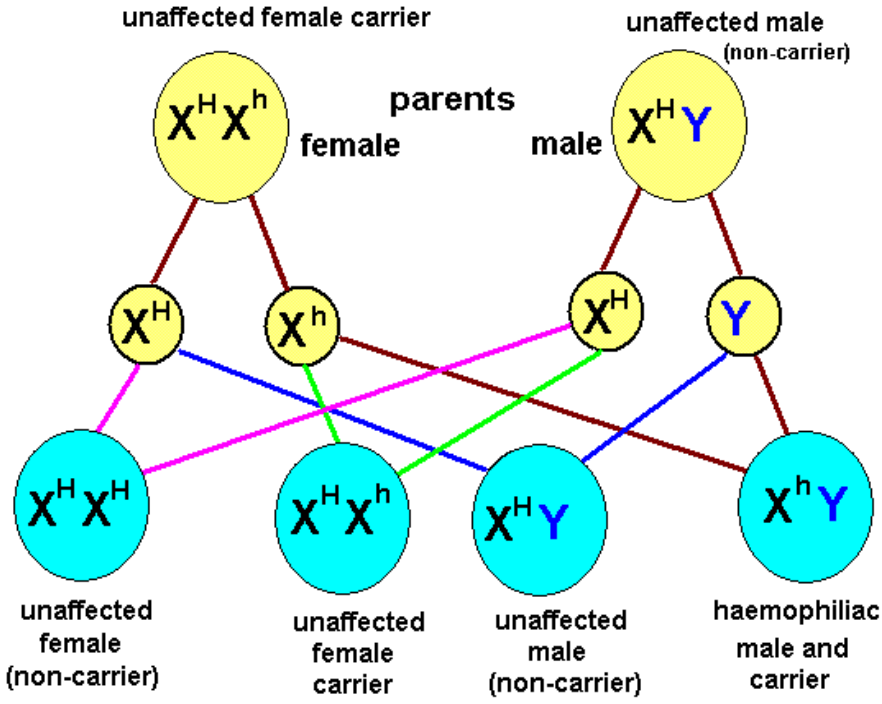
Does this suggest that sex-linked disorders more common in males, why?

Red-Green Color Blindness

- Recessive X-Linked disorder
  - X^N shows the normal trait on the X chromosome
  - X^C shows the trait for color blindness on the X chromosome
  - Y chromosome is normal

	X^C	X^C
X^N	$X^N X^C$	$X^N X^C$
Y	$X^C Y$	$X^C Y$

A genetic diagram for the the inheritance of haemophilia



parents phenotypes

parents genotypes

gamete genotypes

offsprings genotypes

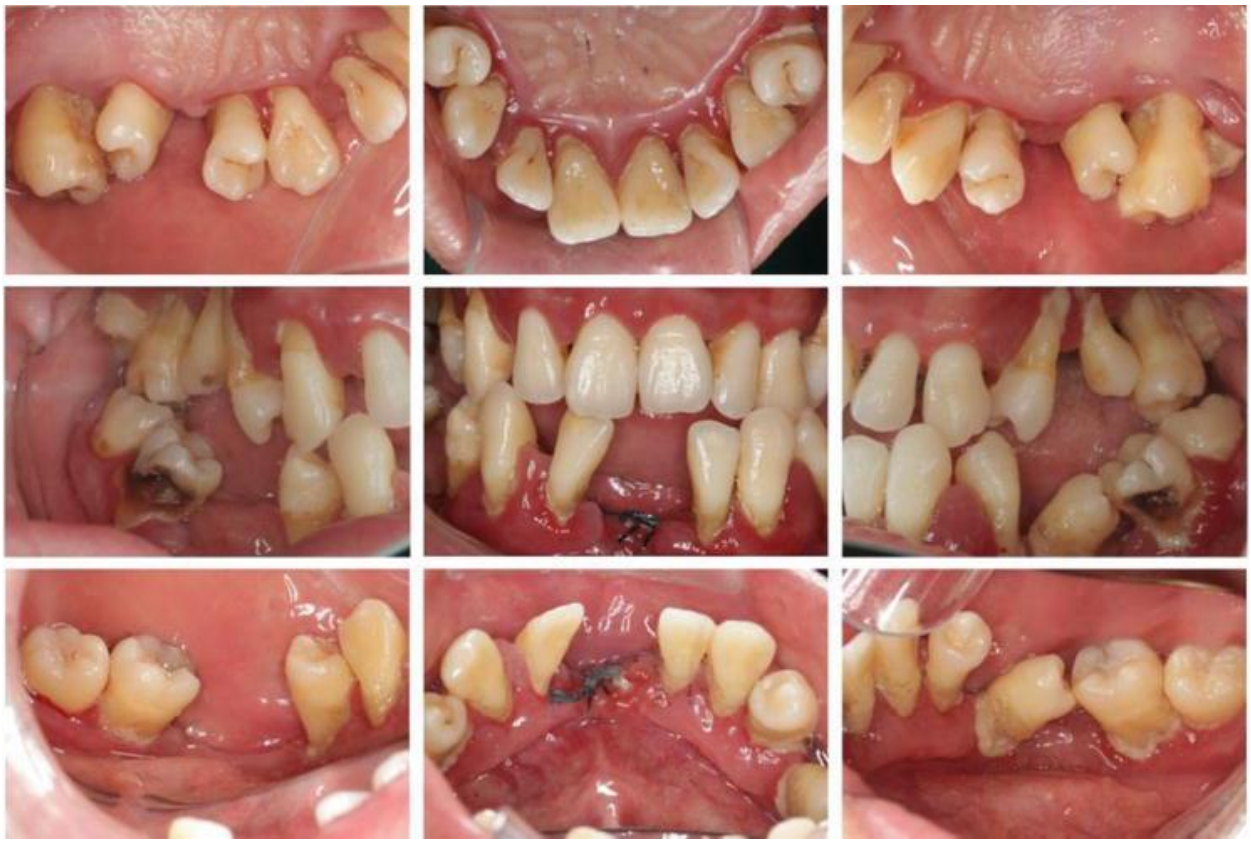
offsprings phenotypes

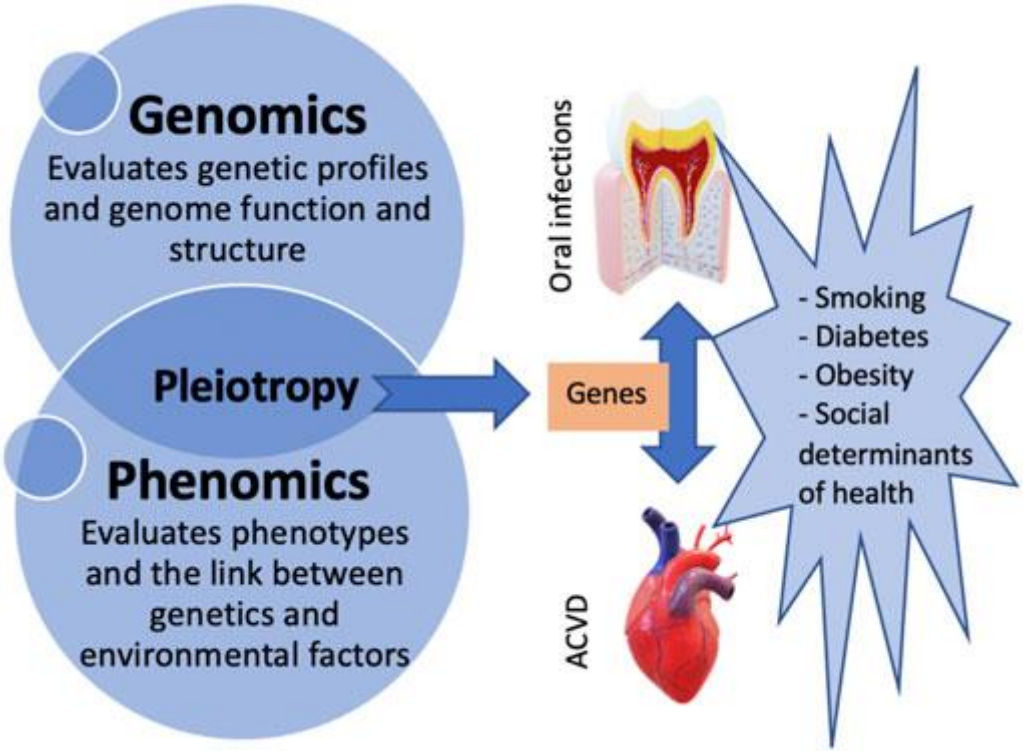
H is the normal blood clotting allele h is the faulty recessive blood clotting allele

Genetics and oral disease:

Oral disease genetics is the study of how defective genes can cause problems, dysfunctions and diseases of oral tissues and dentition. Some oral conditions, such as dental caries and gum disease, are complex diseases with multiple genetic and environmental risk factors. There are no genetic tests for these diseases . Other oral conditions, such as dental anomalies, are linked to inherited traits and defects, or result from spontaneous genetic mutations. There are many genetic syndromes that cause dental anomalies.

Periodontal Disease Associated with Genetic Disorders




Genomics
Evaluates genetic profiles and genome function and structure
Pleiotropy
Phenomics
Evaluates phenotypes and the link between genetics and environmental factors
Genes
Oral infections
ACVD
- Smoking
- Diabetes
- Obesity
- Social determinants of health

Genetic Dental Abnormalities: Types and Symptoms:

Genetic mouth/dental abnormalities (anomalies) are problems, dysfunctions and diseases of oral tissues and dentition caused by defective genes. Many genetic dental/oral abnormalities indicate more complex disorders and are linked to inherited traits and defects, or result from spontaneous genetic mutations.

Types of Genetic Oral/Dental Abnormalities

Cleft Lip & Cleft Palate: The most common craniofacial deformity is clefting of the lip and palate. Clefting, the incomplete fusion of the lip and/or palate, can appear alone or as part of a hereditary syndrome. Family history of clefting increases the chances of inheriting the disorder.

Cleft lip with or without a cleft palate occurs most frequently among Asians. Seen more often in boys than girls, cleft lip or "harelip" usually appears on one side, most often on the left. A bilateral or two-sided cleft is less common. An incomplete cleft stops short of the nostril; a complete cleft goes into the nostril. Both cleft types often involve the palate. A typical patient with

cleft palate/cleft ridge has defects in the roof of the palate, with an opening into the nasal cavity.

Anodontia/Hypodontia: Anodontia, also called congenitally missing teeth, is a hereditary condition in which one or more permanent teeth do not develop, though primary (baby) teeth usually erupt. Anodontia may involve the absence of all (total anodontia) or only some (hypodontia) teeth. Hypodontia – which alters bone development of the upper and lower jaws, resulting in spacing problems – is more common in males; incidence varies among populations. Third molars, maxillary (upper) lateral incisors, and maxillary and mandibular (lower) second premolars (bicuspids) are the teeth that most frequently fail to appear.

Dental genetics is the study of how genes affect our oral health and the development of our teeth, jaw, and mouth. Some genetic factors can influence the risk of tooth decay, gum disease, oral cancer, and other oral conditions. However, environmental factors, such as diet, hygiene, smoking, and diabetes, also play a significant role in oral health. There is no single gene that determines the outcome of oral health, but rather a complex interaction of multiple genes and environmental factors.

Genes control how teeth develop naturally. Some dental conditions are caused by defective genes, while others are not. Dental caries and periodontitis share certain genetic signatures with characteristics such as smoking, education, personality traits, and cardiovascular and metabolic measures. There is no direct genetic link that predisposes you to

cavities, but your enamel and dentin structure, immune system response, the content and amount of your saliva, and your natural oral bacteria all affect cavity development.

How many genes are linked to dental caries?

Dental caries is a **complex disease with multiple genetic and environmental risk factors**. No gene has been identified that has as large an impact on dental caries as do environmental influences, such as smoking or diabetes. There are many genetic factors that likely contribute to caries risk and resistance, such as taste preference, salivary factors, immune response, tooth morphology, enamel composition and structure, and behavior. Genetic processes that contribute to dental caries may also affect cardiovascular and metabolic health.

Table 16.1 Inherited genetic disorders and their associated periodontal findings.

Disease	Defect	Inheritance	Type of periodontal disease
Papillon-Lefèvre syndrome	Cathepsin C	Autosomal recessive	Early-onset periodontitis, premature loss of teeth in both dentitions.
Haim-Munk syndrome	Cathepsin C	Autosomal recessive	
Ehlers-Danlos syndrome type IV	Collagen	Autosomal dominant	Early-onset periodontitis.
Ehlers-Danlos syndrome	Collagen	Autosomal dominant	
Hypophosphatasia	Tissue-non-specific alkaline phosphatase (TNSALP)		Premature loss of deciduous dentition.
Cyclic neutropenia	Neutrophil elastase	Autosomal dominant	
Chronic familial neutropenia	Defect unknown	Autosomal dominant	Severe periodontitis (rapidly progressive), loss of teeth in both dentitions .
Chediak-Higashi syndrome	Lysosomal trafficking regulator gene	Autosomal recessive	Early-onset periodontitis, premature loss of teeth in both dentitions.
Weary-Kindler syndrome	Defected expression of Type VII collagen		Early-onset periodontitis.
Leukocyte adhesion deficiency type I	Leukocyte chain adhesion molecule Cd18	Autosomal recessive	Homozygous form manifests as generalized Grade C periodontitis whereas heterozygous may have normal prepubertal status.
Leukocyte adhesion deficiency type II	Glucose diphosphate fucose transporter-1	Autosomal recessive	Severe periodontitis.
Hyper-IgE (Job's syndrome, HIE)	Marked elevation of IgE		Periodontitis with oral ulcerations.

Medical Biology

Assist. Prof. MUNA.A. ABDULLAH

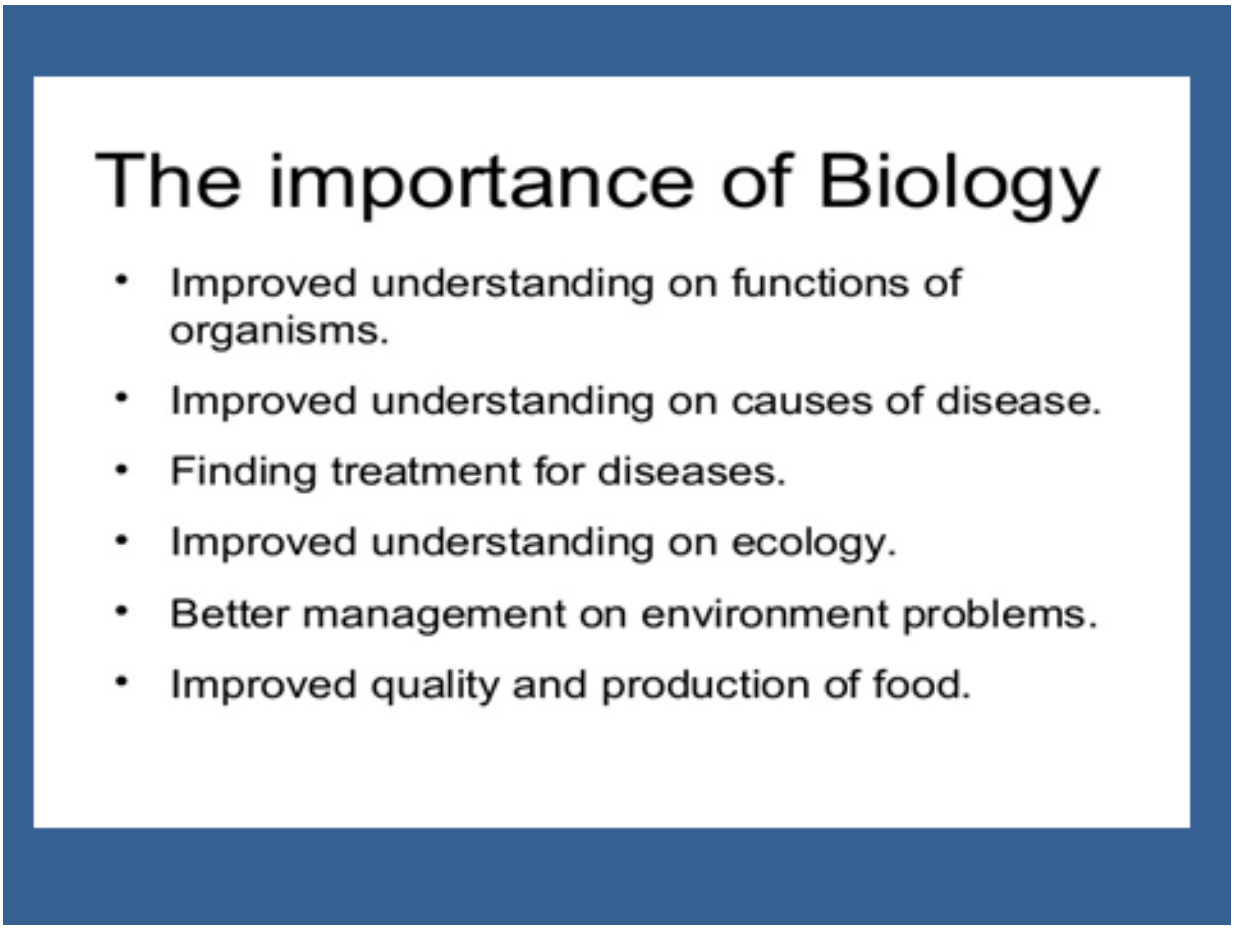
MEDICAL BIOLOGY

Lecture:1

Introduction to Medical and oral Biology Definition of Biology:

Biology: The science of biology is the study of life in all its aspects. including their structure, function, growth, evolution, distribution, and taxonomy. The word biology is derived from Greek origin: Bios means life and logos means science or the study of living things.

Importance of Biology



The general characteristics of living organisms:

1- Protoplasm.

2- Metabolism.

3- Growth.

4- Irritability and movement.

5- Reproduction.

Protoplasm: All living organism are composed of this substance, which has been termed (living matter). Protoplasm is a complex system in which there is a constant interchange of materials between the different components.

Metabolism: A living organism can be distinguished from a non-living things by its ability to show spontaneous activity, to do work. In the process of metabolism the energy obtained by the living organism. The source of energy in a living organism is that contained in some of the chemical compounds, such as carbohydrates and proteins. The molecules of these compounds contain energy, which can be released by a series of exothermic reaction, called "respiration".
The ultimate source of energy is the sun. plants alone have power of obtaining energy from sun light, since plants can synthesize organic substances like carbohydrates from inorganic compounds, CO_2 and H_2O by the process of "photosynthesis".

Growth: as a result of nutrition more substances are produced by the organism under normal condition that is used up in respiration. In this way a definite increase in the amount of protoplasm occurs, with the result that organism grows.

Irritability and Movement: All living organism exhibit irritability, that is, they respond to external stimuli. This response generally takes the form of movement. In animals, movement is highly developed, for it is necessary as a mean of obtaining food.

Reproduction: The power of reproduction is common in all living organisms. It consists in the formation of new individuals similar to these of previous generation.

Branches of Biology

Biology is divided into two sub-sciences

1- **Zoology:** deals with animals

2- **Botany:** deals with plants

Some important terms in biology:

a- Morphology: is the study of external form.

b- Anatomy: is the study of internal structure.

c- Physiology: is the study of function.

d- Embryology: is the study of development.

e- Taxonomy: is the study of classification.

f- Ecology: is the study of the relationship between organism and their habitats.

g- Cell biology – the study of cell at the microscopic or at the molecular level. It includes studying the cells' physiological properties, structures, organelles, interactions with their environment, life cycle, division and apoptosis.

h- Microbiology - the branch of biology that deals with microorganisms and their effects on other living organisms

i- Molecular Biology – the branch of biology that deals with the formation, structure, and function of macromolecules essential to life, such as nucleic acids and proteins, and especially with their role in cell replication and the transmission of genetic information.

j- Mycology - the study of fungi.

k- Parasitology - the study of parasites and parasitism.

l- Pathology - the study of the nature of disease and its causes, processes, development, and consequences

m- Pharmacology - the study of preparation and use of drugs and synthetic medicines.

Cell structure

All living organisms are made from cells, it's a fundamental unit of life, whether, the organism is a single cell or with trillions of cells.

There are two different forms of cells:

Prokaryotic

- 1-10µm (bacteria) which relatively simple cells
- lack nuclear membrane and many organelles.

Eukaryotic

- 10-100 µm
- For example: plants, animals, fungus and etc….
- more complex cells, have a nucleus and many organelles.

A prokaryotic: cell is a type of cell that does not have a true nucleus or membrane-bound organelles. Organisms within the domains Bacteria and Archaea are based on the prokaryotic cell, while all other forms of life are eukaryotic. A prokaryotic cell consists of a single membrane and therefore, all the reactions occur within the cytoplasm. They can be free-living or parasites.

Characteristics of Prokaryotic Cell:

Prokaryotic cells have different characteristic features. The characteristics of the prokaryotic cells are mentioned below

1. They lack a nuclear membrane.
2. Mitochondria, Golgi bodies, chloroplast, and lysosomes are absent.
3. The genetic material is present on a single chromosome.
4. The histone proteins, the important constituents of eukaryotic chromosomes, are lacking in them.
5. The cell wall is made up of carbohydrates and amino acids.
6. The plasma membrane acts as the mitochondrial membrane carrying respiratory enzymes.
7. They divide asexually by binary fission. The sexual mode of reproduction involves conjugation.

Eukaryotic Cell Definition

“Eukaryotic cells are the cells that contain a membrane bound nucleus and organelles.

What is a Eukaryotic Cell?

Eukaryotic cells have a nucleus enclosed within the nuclear membrane and form large and complex organisms. Protozoa, fungi, plants, and animals all have eukaryotic cells. They are classified under the kingdom Eukaryotes.

They can maintain different environments in a single cell that allows them to carry out various metabolic reactions. This helps them grow many times larger than the prokaryotic cells.

Characteristics of Eukaryotic Cells

The features of eukaryotic cells are as follows:

1. Eukaryotic cells have the nucleus enclosed within the nuclear membrane.
2. The cell has mitochondria.
3. Flagella and cilia are the locomotory organs in a eukaryotic cell.
4. A cell wall is the outermost layer of the eukaryotic cells.
5. The cells divide by a process called mitosis.
6. The eukaryotic cells contain a cytoskeletal structure.
7. The nucleus contains a single, linear DNA, which carries all the genetic information.

Cell component	Prokaryotes	Eukaryotes
Nucleus	no membrane, single circular chromosome	membrane bound, a number of individual chromosomes.
Extra-chromosomal DNA	present in form of plasmid	Present as mitochondrial DNA
Organelles in cytoplasm	Non	Mitochondria and chloroplast in photosynthetic organisms
Cytoplasmic membrane	Contain enzyme of respiration, sit of phospholipids and DNA synthesis	Semi-permeable layer not possessing function
Cell wall	Rigid layer of peptidoglycan	No peptidoglycan
Sterols	Absent	Present
Ribosome	70 S in cytoplasm	80 S in cytoplasmic reticulum

Differences Between Plant Cell and Animal Cell

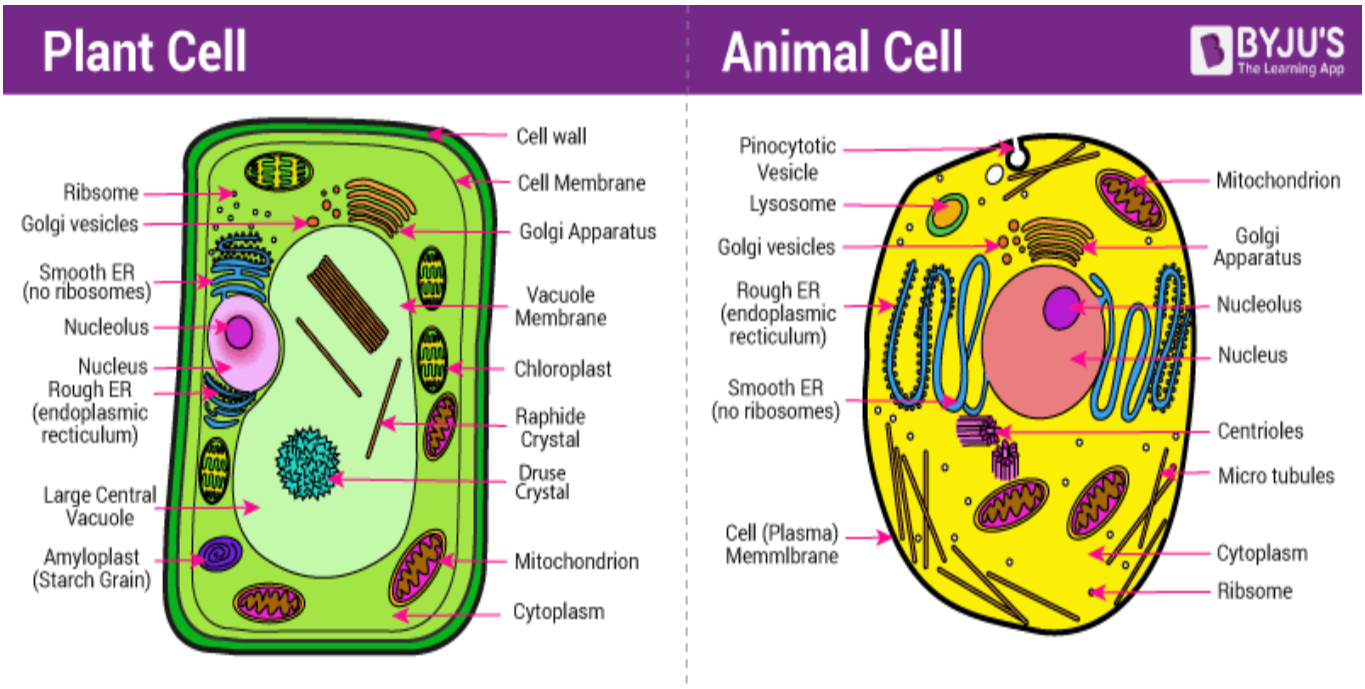


Diagram showing the Difference between Plant cell and Animal cell

As stated above, both plant and animal cells share a few common cell organelles, as both are eukaryotes. The function of all these organelles is said to be very much similar. However, there are major differences between plant and animal cells.

The major differences between the plant cell and animal cell are mentioned below:

Micro-organism: Are those organisms which are invisible to the naked eye.

Functions:

1- Play role in the nitrogen and carbon cycles.

2- Contribute to maintaining the atmosphere oxygen level.

Microorganisms include:

1- Fungi.

2- Protozoa

3- Bacteria

4- Viruses

Cell biology is the study of cell structure and function, and it revolves around the concept that the cell is the fundamental unit of life. cell biology focuses on the structure and function of a cell, from the most general properties shared by all cells, to the unique, highly intricate functions particular to specialized cells.

The cell is the basic structural and functional unit of life because it is the smallest units of living material capable of carrying on all the activities necessary for life. The cell is as complete metabolic unit, because it has all of the chemical and physical components needed for its own maintenance and growth.

Inside the cell

The cell interior consisted of a homogeneous jelly that they called **protoplasm**. The portion of the cell outside the nucleus is called **cytoplasm**, and the material within the nucleus is called **nucleoplasm**. The intracellular fluid, called **cytosol**, consists mainly of water, in which are dissolved amino acids, sugars, and other substances needed to manufacture large molecules. Also present are structural proteins, enzymes used in cellular metabolism.

Most of the subcellular organelles are enclosed by membranes. These membrane- bound organelles effectively partition the cytoplasm into different compartments.

Cell structures and functions

Nucleus

One or more per cell, Spherical shape, Denser than surrounding cytoplasm

1- Chromosomes-

Usually in the form of chromatin, contains genetic information, Composed of DNA**,** thicken for cellular division**,** Set number per species (i.e. 23 pairs for human)

2-Nuclear membrane

Surrounds nucleus, Composed of two layers, Numerous openings for nuclear traffic.

3-Nucleolus

Spherical shape, Visible when cell is not dividing, Contains RNA for protein manufacture

Cytoplasm

Collective term for cytosol and organelles contained within, Colloidal suspension, Cytosol mainly composed of water with free-floating molecules, Viscosity constantly changes.

1-Centrioles

Paired cylindrical organelles near nucleus, composed of nine tubes, each with three tubules, involved in cellular division, Lie at right angles to each other

2-Chloroplasts

A plastid usually found in plant cells, contain green chlorophyll where photosynthesis takes place

3-Cytoskeleton

Composed of microtubules, supports cell and provides shape, aids movement of materials in and out of cells.

4-Endoplasmic reticulum

Tubular network fused to nuclear membrane, goes through cytoplasm onto cell membrane, Stores, separates, and serves as cell's transport system, Smooth type: lacks ribosomes, rough type: ribosomes embedded in surface.

5-Golgi apparatus

Protein packaging, A membrane structure found near nucleus, composed of numerous layers forming a sac.

6-Lysosome

Digestive 'plant' for proteins, lipids, and carbohydrates, Transports undigested material to cell membrane for removal, Vary in shape depending on process being carried out, Cell breaks down if lysosome explodes.

7-Mitochondria

Second largest organelle with unique genetic structure, Double-layered outer membrane with inner folds called cristae, Energy-producing chemical reactions take place on cristae, Controls level of water and other materials in cell, Recycles and decomposes proteins, fats, and carbohydrates, and forms urea.

8-Ribosomes

Each cell contains thousands, Miniature 'protein factories', Composes 25% of cell's mass, Stationary type: embedded in rough endoplasmic reticulum, Mobile type: injects proteins directly into cytoplasm.

9-Vacuoles

Membrane-bound sacs for storage, digestion, and waste removal, Contains water solution

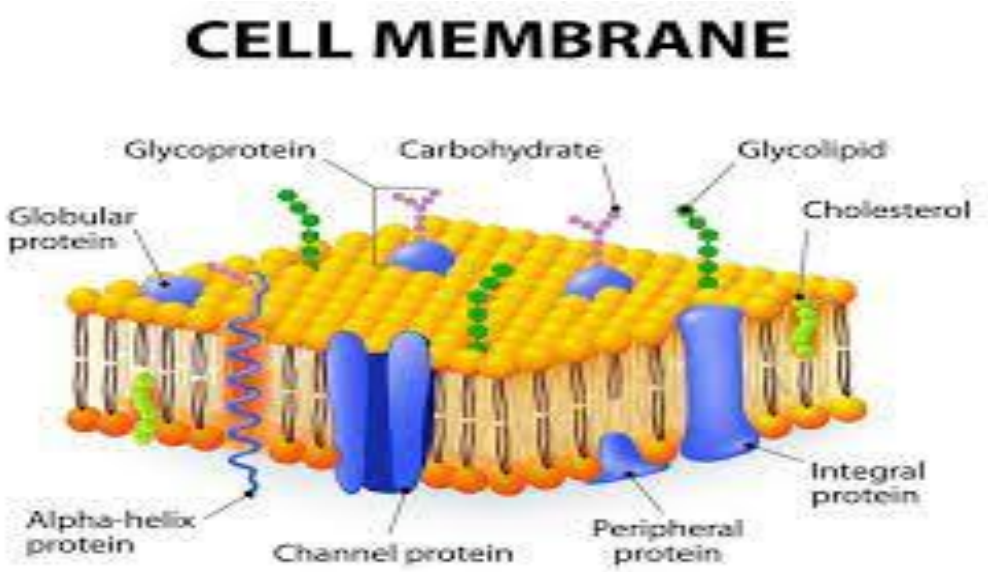
, Contractile vacuoles for water removal (in unicellular organisms)

Surface

1-Cell wall

Most commonly found in plant cells, controls turgid, Extracellular structure surrounding plasma membrane, Primary cell wall: extremely elastic, Secondary cell wall: forms around primary cell wall after growth is complete.

2-Plasma membrane: A cell membrane consists of two phospholipid layers with proteins. The phospholipid molecule has a polar head and nonpolar tails, the polar heads are charged, they are hydrophilic (water-loving) and face outward, where they are likely to encounter a watery environment. The nonpolar tails are hydrophobic (water fearing) and face inward. This makes it easier for small, neutrally-charged molecules to pass through the cell membrane as opposed to charged and larger molecules. Protein channels float through the phospholipids, and, collectively, this model is known as the fluid mosaic model.



♣ The types of protein in cell membrane including: integral protein and peripheral protein, addition to other certain proteins in the outer surface of cell membranes (Globular protein).

♣ Carbohydrate molecules are found on the surface of the cell membrane. There are two types, glycoproteins and glycolipids.

The main function of the cell membrane is ¬

To protect the cell from its surrounding substances.

¬ regulate cell growth through the balance of endocytosis and exocytosis (selective permeable to ions and organic molecules).

¬ consider as location of cell markers, cell receptors, cell adhesion and cell signaling.

Nucleus ♣ The nucleus (plural: nuclei) is of primary importance because it stores the genetic information that determines the characteristics of the body's cells and the metabolic functioning (protein synthesis, cell division, growth and differentiation).

♣ Nucleus different in shape and size. some of them are spherical, oval, elongated, disc, irregular shaped depending on the type of cell. Nucleus is present in all eukaryotic cells, but they may be absent in few cells like the mammalian RBCs. Nucleus has chromatin which contains DNA and much protein, as well as some RNA.

Nucleus is composed of four parts:

1-Nuclear Envelope (nuclear membrane)

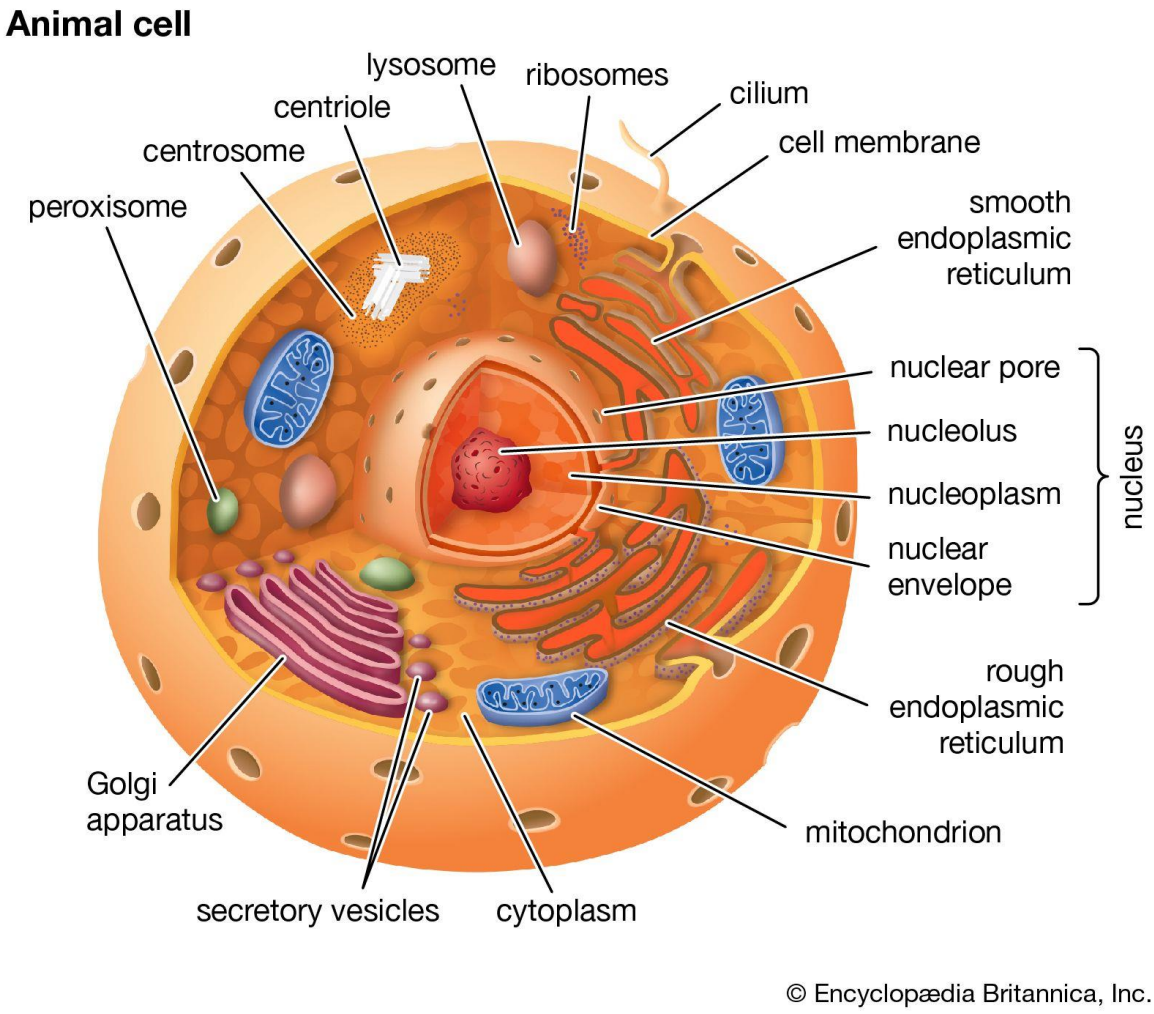
2- Nucleoplasm (Nuclear sap)

3- Nucleolus

4- Chromatin

-Nuclear Envelope (nuclear membrane) :

• It is made up of two lipid bilayer membranes, an outer membrane and an inner membrane. The outer membrane of the nucleus is continuous with the membrane of the rough endoplasmic reticulum. • The space between these layers is known as the perinuclear space.

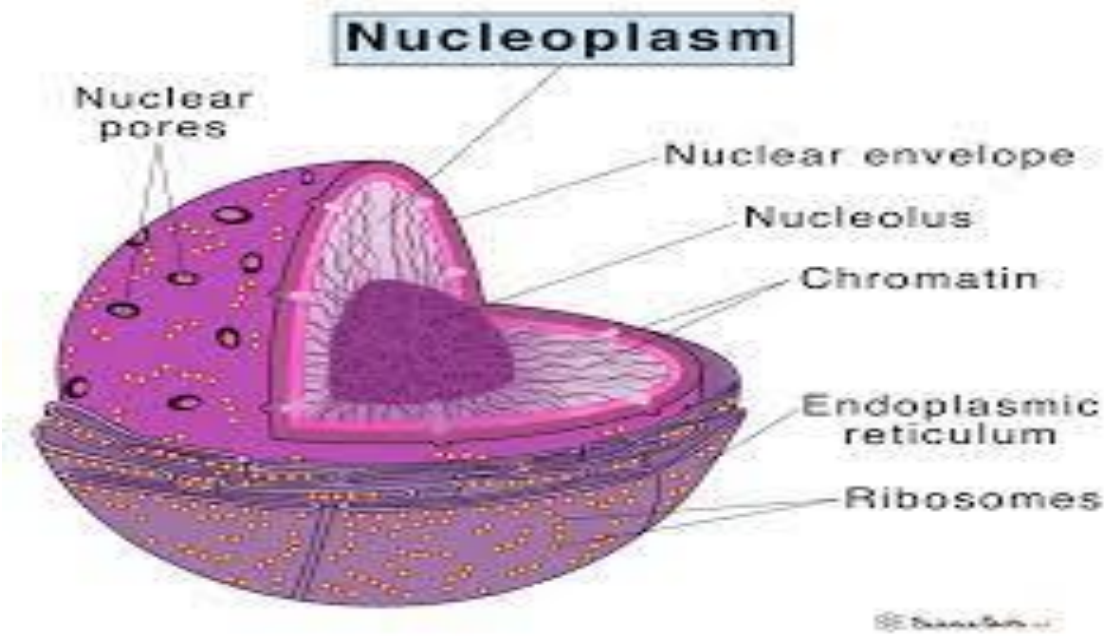


• The nuclear envelope encloses the nucleus and separates the genetic material of the cell from the cytoplasm of the cell and serves as a barrier to prevent passage of macro-molecules freely between the nucleoplasm and the cytoplasm

• The nuclear envelope is perforated with numerous pores called nuclear pores. They are composed of many proteins known as nucleoproteins which act as molecular channels, permitting certain molecules to pass into and out of the nucleus.

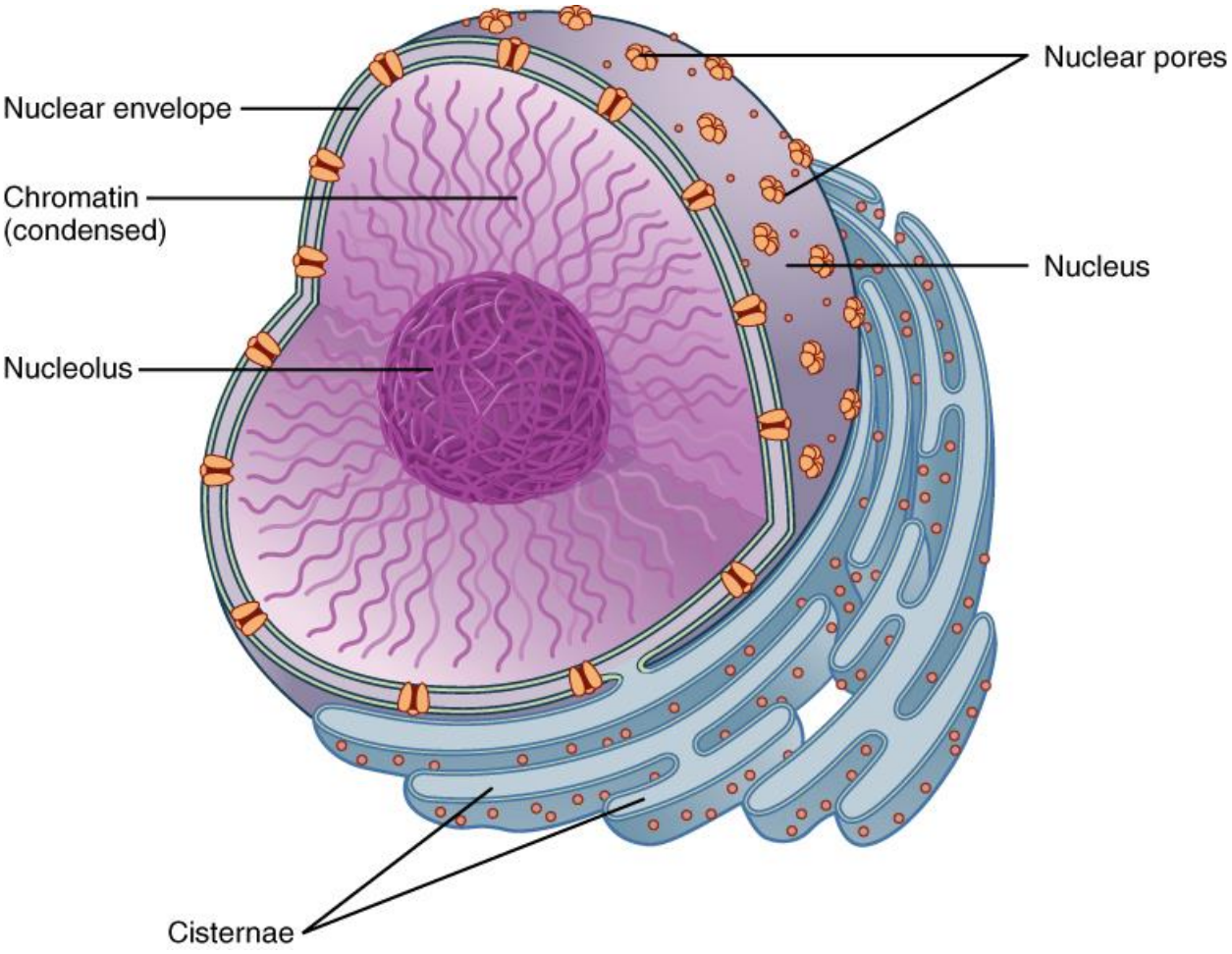
2- Nucleoplasm (Nuclear sap)

It colorless fluid which contain nucleic acid, protein and inorganic acid (Mg and Ca), it act as substance reservoir for protein synthesis.



3- Nucleolus

- It is a densely stained and spherical structure found in the nucleus and surrounded by a membrane.
- It composed of protein and RNA.
- During early stage of cell division, the nucleolus disappears and reappear during final stages of division.



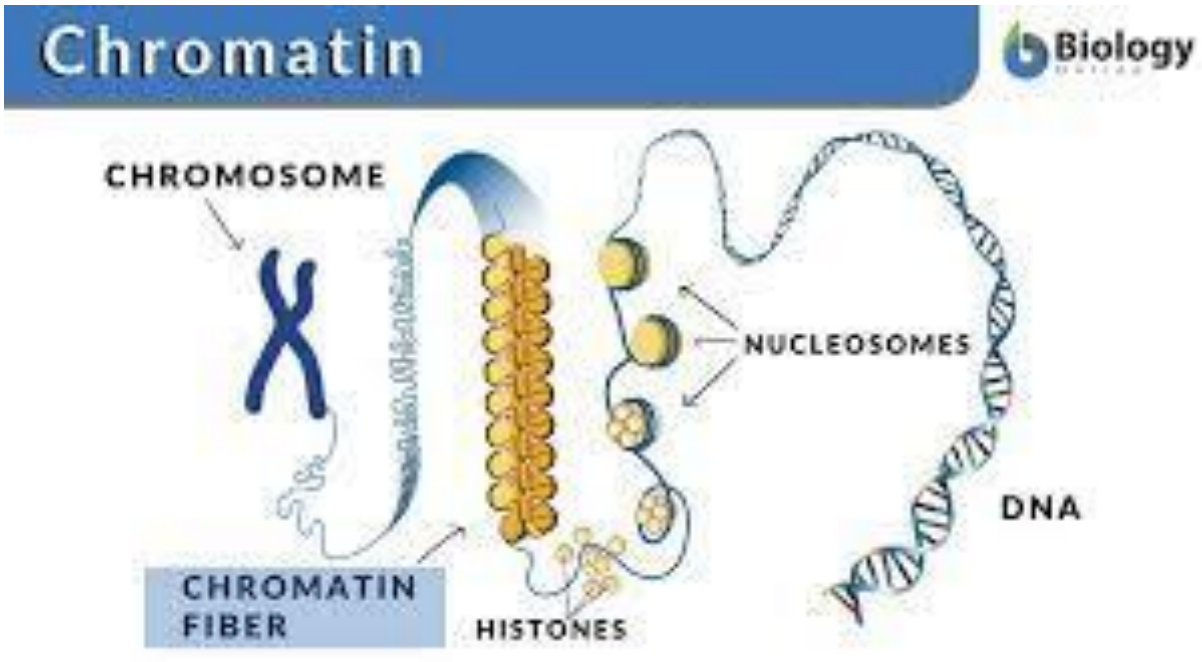
4- Chromatin

• DNA is organized into structures called chromosomes and each chromosome is composed of a pair of sister chromatids which links by centromere.

• DNA wraps around proteins called histones. The resulting DNA protein complex is called chromatin

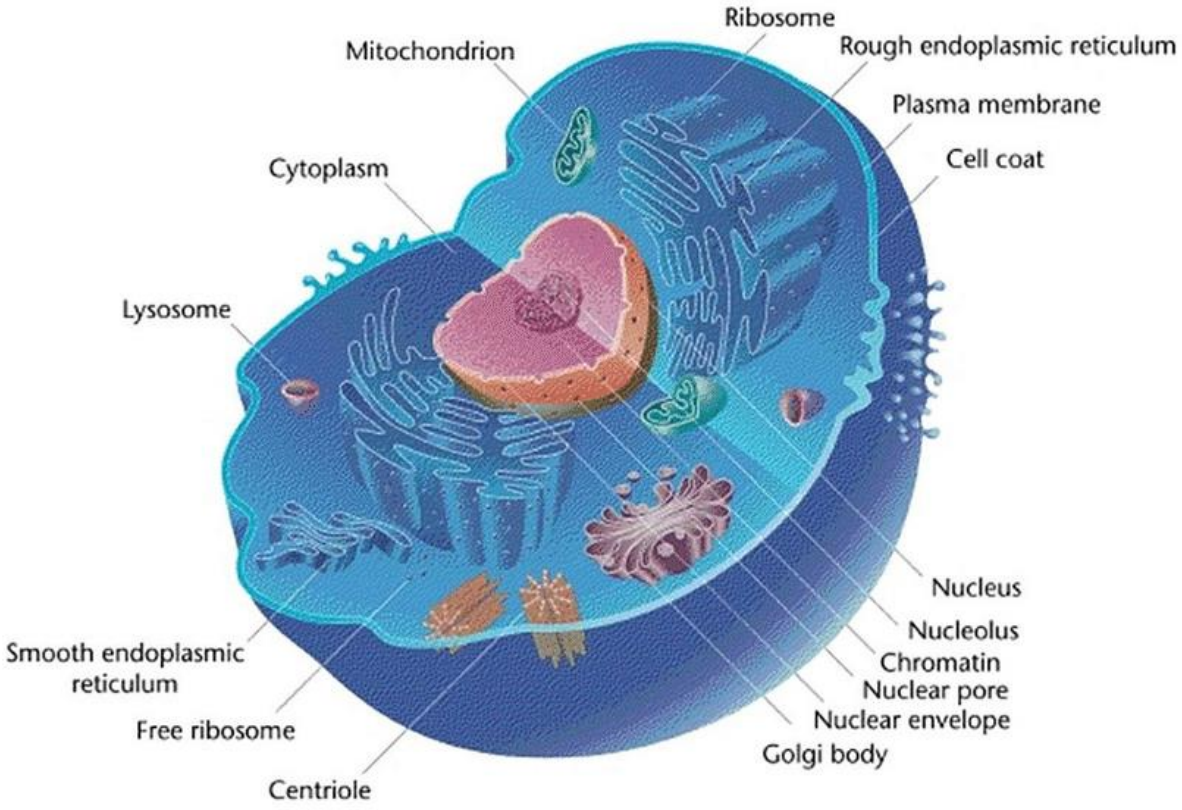
•In prokaryotic cells, chromosomes are circular, whereas in eukaryotic cells, they are linear strands.

• Different organisms have different numbers of chromosomes: human cells usually have 46.



Cytoplasm and cytoplasmic organelles:

Cytoplasm is the space inside the cell membrane but outside the nucleus, it gel-like fluid and contains water, salts, proteins and other organic particles. Cytosol is part of the cytoplasm but does not contain membranes, organelles or the nucleus.



Mitochondria

¬ Mitochondria (singular: mitochondrion) play a critical role in the generation of metabolic energy in eukaryotic cells.

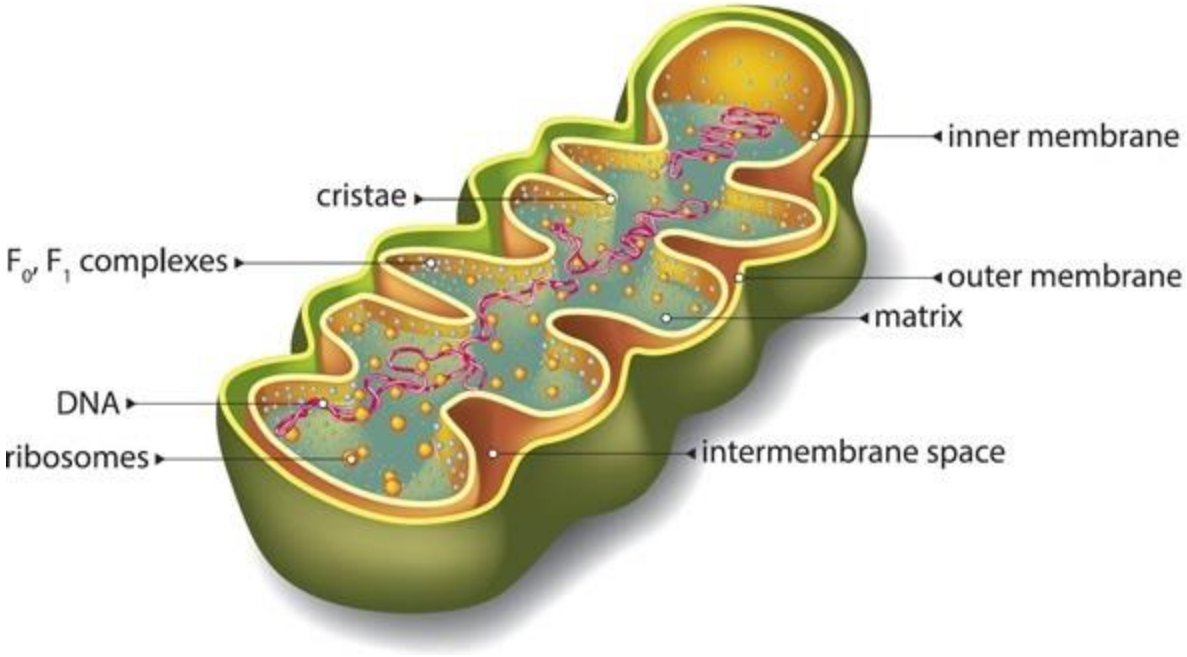
¬ They are responsible for most of the useful energy derived from the breakdown of carbohydrates and fatty acids, which is converted to ATP by the process which called aerobic respiration.

¬ Mitochondria are rod-shaped organelles and bounded by double membranes, the outer membrane is smooth and derived from the endoplasmic reticulum of the cell, while the inner one is folded into many folds called cristae. and the space between them, is called the inter membrane space, while the internal fluid is called matrix.

¬ The protein which carry out oxidative metabolism are submerged within the membranes or located on the surfaces of these membranes.

Mitochondria have their own genome (DNA) which carry several genes that produce some of proteins which essential in respiration. ¬ The mitochondria can divide by simple fission like in bacteria but with participation of DNA. ¬ The cells have 100-300 mitochondria depending on the activity of the cell in producing energy, for example, muscles and liver cells have a large number of mitochondria while the mature mammalian red blood cells are lack them.

MITOCHONDRIA



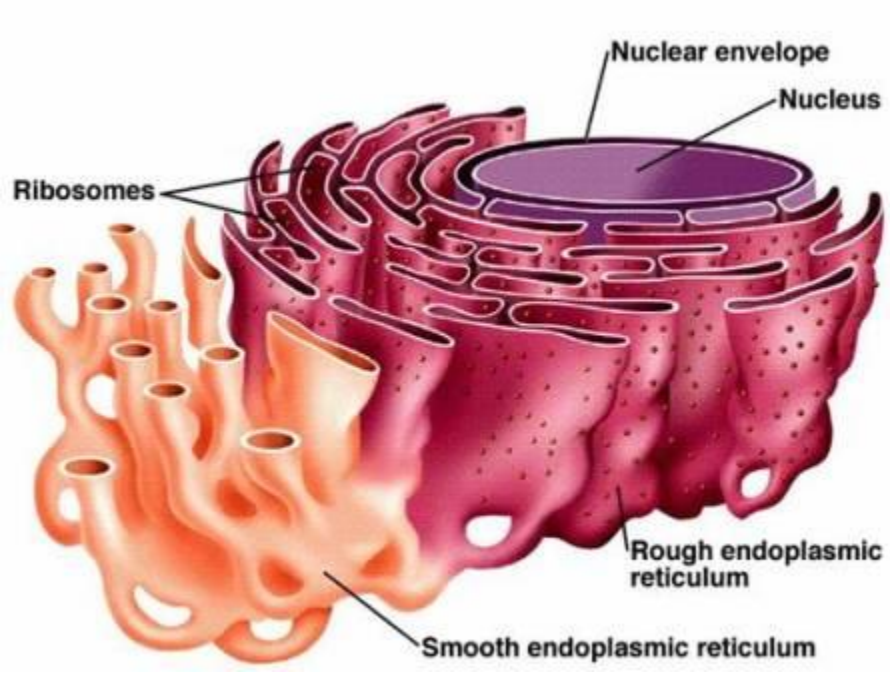
Endoplasmic reticulum (ER)

¬ It is a continuous membrane system that forms a series of flattened sacs within the cytoplasm of eukaryotic cells and serves as synthesis, folding, modification, and transport of proteins and lipids.

¬ There are two types of ER, rough ER and smooth ER.

1- Rough endoplasmic reticulum (RER): which coated with ribosomes, they are site of protein synthesis.

2- Smooth endoplasmic reticulum (SER): which lacked ribosomes, they are site of lipids synthesis.

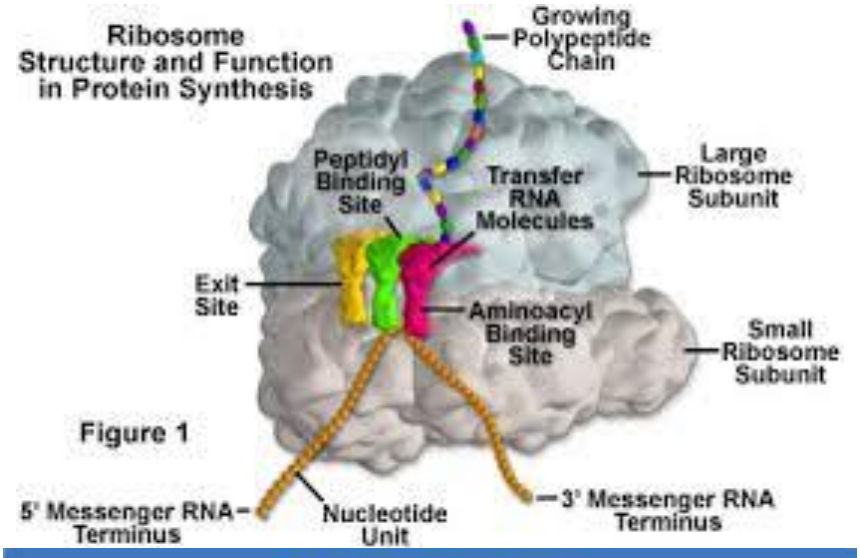


Ribosomes

¬ The ribosome is a complex molecule made of ribosomal RNA molecules and proteins that form a factory for protein synthesis in cells.

¬ The ribosome is responsible for translating encoded messages from messenger RNA molecules to synthesize proteins from amino acids.

¬ The ribosome translates each codon (set of three nucleotides), of the mRNA template and matches it with the appropriate amino acid in a process called translation.



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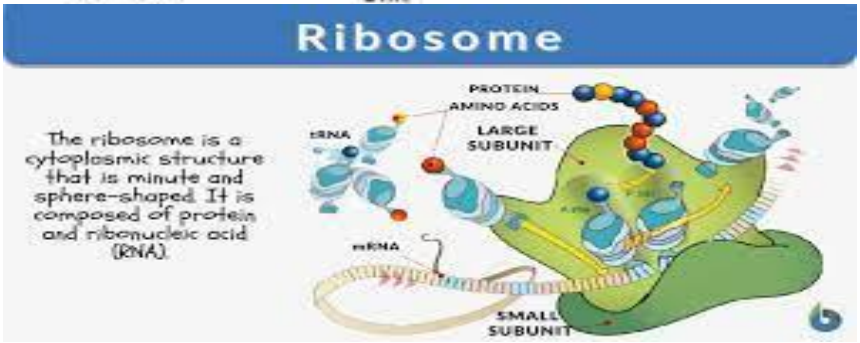
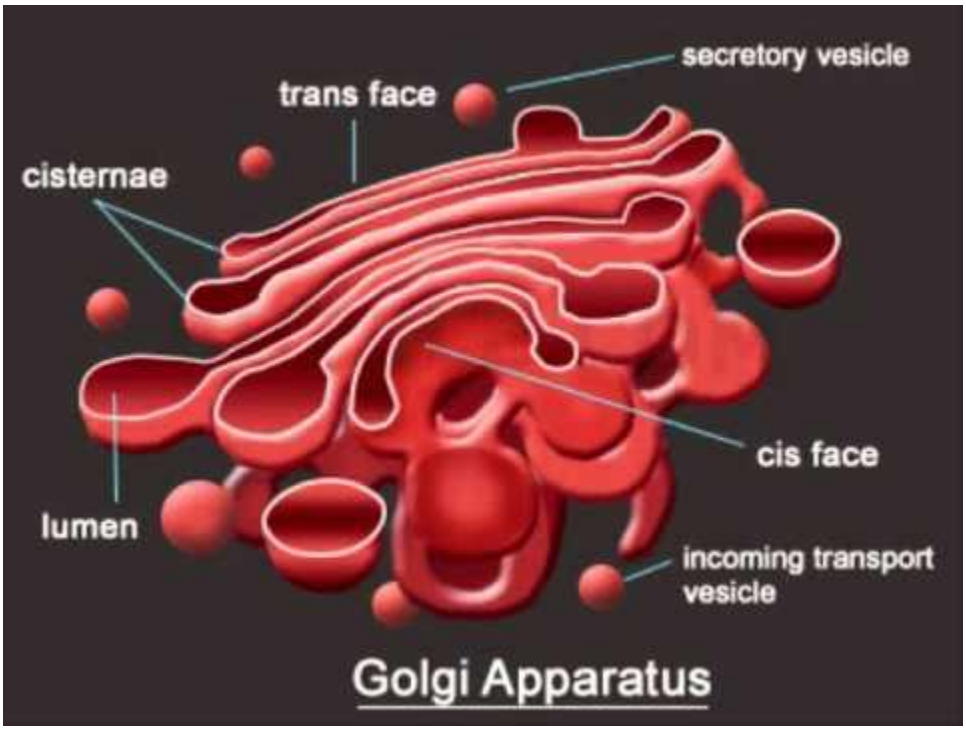


¬ The amino acid is provided by a transfer RNA (tRNA) molecule. Each newly translated amino acid is then added to the growing protein chain until the ribosome completes the process of protein synthesis.
¬ Eukaryotes have 80S ribosomes, each consisting of a small (40S) and large (60S) subunit.

Golgi apparatus (Golgi complex)

¬ It is a collection of stacked, flattened, cup-shaped sacs situated in the cytoplasm of cells near the nucleus and have membranous vesicles, present in most living cells, that stores and modifies proteins and other macromolecules, then, transports them within the cell (by vesicles) or excretes them from the cell.
¬ The apparatus is thought to have a storage role as well as enabling the assembly of simple molecules into more complex ones, for example, the packaging of carbohydrates and proteins into glycoprotein.



¬ The modified products are stored in vesicles (such as lysosomes) for later use or transported by vesicles to the plasma membrane, where they are excreted from the cell.

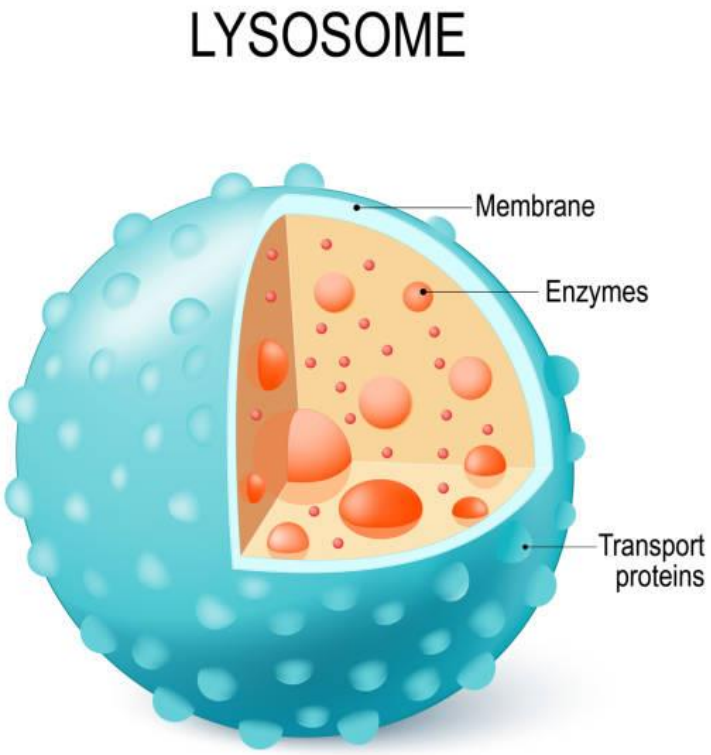
Lysosomes

¬ A lysosome is a membrane-bound organelle found in nearly all animal cells.

¬ They are spherical vesicles which contain hydrolytic enzymes that can break down many kinds of biomolecules like proteins, nucleic acids, carbohydrates, and lipids.

¬ Lysosomes function as the digestive system of the cell, serving both to degrade material taken up from outside the cell (Heterophagy) and to digest obsolete components of the cell itself (Autophagy).

¬ Lysosome enzymes are made by proteins from the endoplasmic reticulum and enclosed within vesicles by the Golgi apparatus. Lysosomes are formed by budding from the Golgi complex.



Peroxisomes

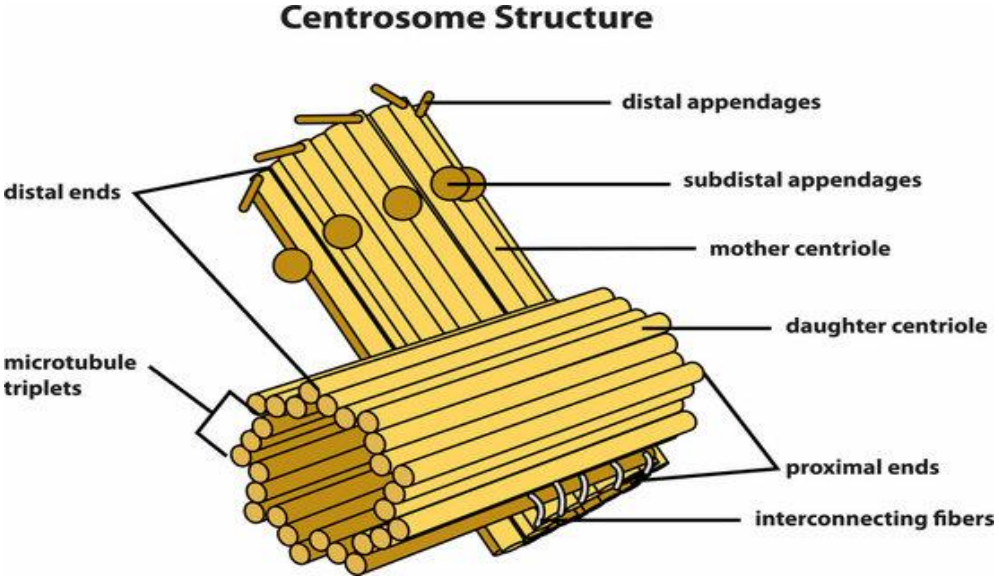
¬ Peroxisomes or microbodies are membrane bound organelles contain at least about 50 different enzymes, it similar in structure to lysosomes but they are smaller.

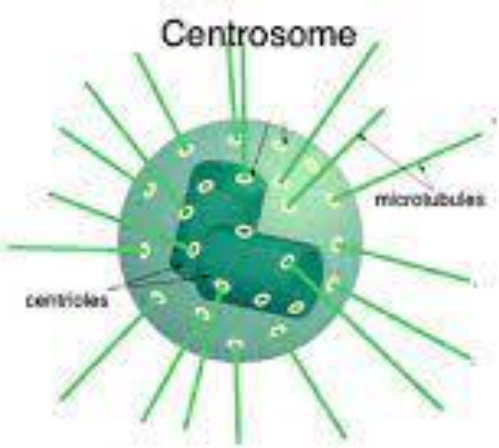
¬ Peroxisomes contain enzymes that oxidize certain molecules normally found in the cell. Those oxidation reactions produce hydrogen peroxide (H2O2), which is the basis of the name peroxisome. However, hydrogen peroxide is potentially toxic to the cell, because it has the ability to react with many other molecules.

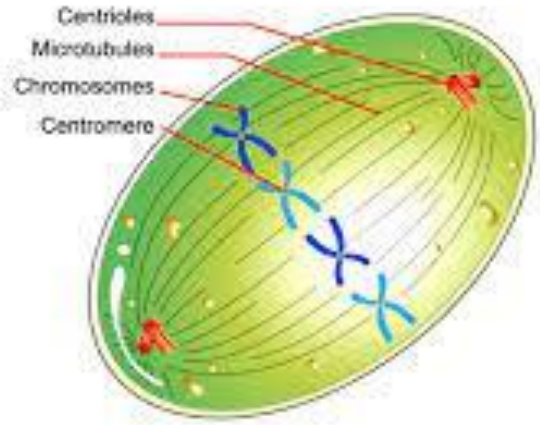
¬ Therefore, peroxisomes also contain enzymes such as catalase that convert hydrogen peroxide to water and oxygen.
¬ Also, the peroxisome enzymes function to detoxify drugs, alcohol, and other potential toxins.
¬ The liver and kidneys contain large numbers of peroxisomes because these organs help to cleanse the blood. Hence, the peroxisomes provide a safe location for the oxidative metabolism of certain molecules.

Centrosomes and centrioles

¬ A centrosome is an organelle that is found close to the nucleus within the cytoplasm of cells.
¬ Centrosomes are made of from arrangement of two-barrel shaped clusters of microtubules called centrioles and a complex of proteins that help in microtubules formation. These proteins allow the centrosomes to start and stop the formation of microtubule proteins, then, they allow them to control the formation of mitotic spindle fibers that are required during metaphase of mitosis.







Centrioles

¬ The centrioles are two cellular organelles as cylindrical shaped. They are found in most of the eukaryotic cells.

¬ The centrioles are made of groups of microtubules, these microtubules are arranged in a pattern of 9+3, they are located near the nucleus.

¬ In animal cells the centrioles play a major role in cell division (mitosis and meiosis), centrioles have major role in formation of cilia and flagella structure.

Cytoskeleton of cells

The cytoskeleton is a network of fibers, these fibers consist of a complex mesh of protein filaments and motor proteins that aid in cell movement and stabilize the cell. The cytoskeleton is composed of at least three different types of fibers: microtubules, microfilaments and intermediate filaments.

- Microtubules: are hollow rods functioning primarily to help support and shape the cell and as "routes" along which organelles can move. Microtubules are consisting of tubulin protein. They vary in length and measure.
- Microfilaments: or actin filaments are thin, solid rods that are active in muscle contraction, and consist of globular actin protein. They also participate in organelle movement.

Intermediate filaments: they are providing support for microfilaments and microtubules by holding them in place. These filaments form keratins found in epithelial cells and neurofilaments in neurons.

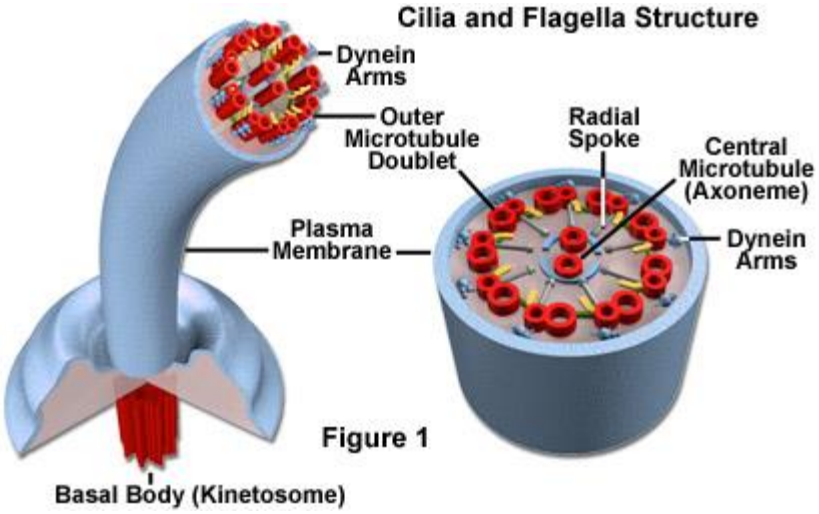
- **Motor Proteins**: A number of motor proteins are found in the cytoskeleton; these proteins actively move cytoskeleton fibers. As a result, molecules and organelles are transported around the cell.

Motor proteins are powered by ATP, which is generated through cellular respiration.

Cilia and flagella

¬ They are cell organelles that are structurally similar (composed of microtubules) but are differentiated based on their function and length.

¬ Cilia are short and there are usually many (hundreds) cilia per cell, while the flagella are longer and their fewer flagella per cell (usually one to eight).



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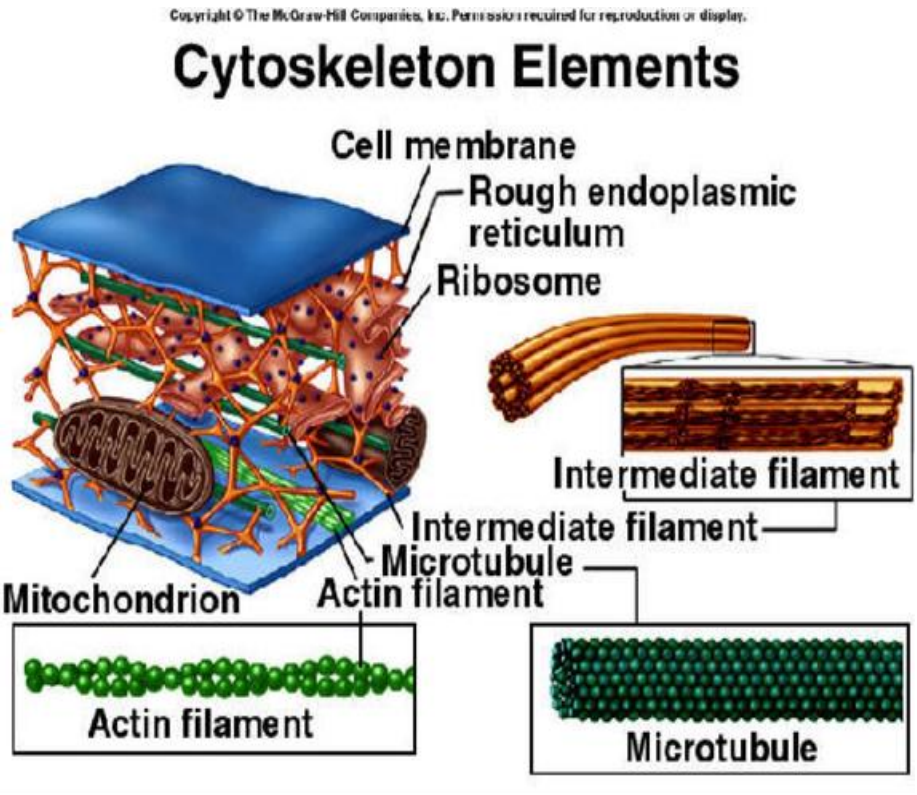
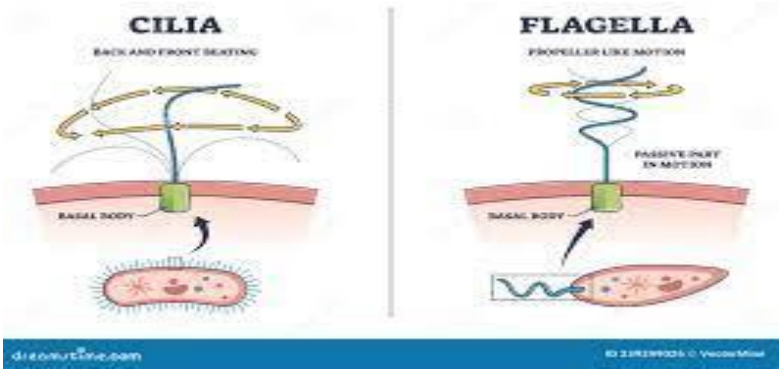


The motion of flagella is often undulating (wave-like) and slow movement compared to cilia, whereas the motile of cilia are more complicated, rotational (like a motor), very fast moving with a power.



Proteins

Proteins are very important molecules in cells. Proteins are the major component of the dry weight of cells. They can be used for a variety of functions from cellular support to cellular locomotion. While proteins have many diverse functions, all are typically constructed from one set of 20 amino acids and have distinct three-dimensional shapes. Below is a list of several types of proteins and their functions.

Protein Structure

There are two general classes of protein molecules: globular proteins and fibrous proteins. Globular proteins are generally compact, soluble, and spherical in shape. Fibrous proteins are typically elongated and insoluble. Globular and fibrous proteins may exhibit one or more of four types of protein structure. The four structure types are primary, secondary, tertiary, and quaternary structure. A protein's structure determines its function. For instance, structural proteins such as collagen and keratin are fibrous and stringy. Globular proteins like hemoglobin, on the other hand, are folded and compact. Hemoglobin, found in red blood cells, is an iron containing protein that binds oxygen molecules. Its compact structure is ideal for traveling through narrow blood vessels.

Protein Functions

1-Antibodies - are specialized proteins involved in defending the body from antigens (foreign invaders). They can travel through the blood stream and are utilized by the immune system to identify and defend against bacteria, viruses, and other foreign intruders. One way antibodies counteract antigens is by immobilizing them so that they can be destroyed by white blood cells .

2-Contractile Proteins - are responsible for movement. Examples include actin and myosin. These proteins are involved in muscle contraction and movement .

3-Enzymes - are proteins that facilitate biochemical reactions. They are often referred to as catalysts because they speed up chemical reactions. Examples include the enzymes lactase and pepsin. Lactase breaks down the sugar lactose found in milk. Pepsin is a digestive enzyme that works in the stomach to break down proteins in food .

4-Hormonal Proteins - are messenger proteins which help to coordinate certain bodily activities. Examples include insulin, and somatotropin. Insulin regulates glucose metabolism by controlling the blood-sugar concentration. Somatotropin is a growth hormone that stimulates protein production in muscle cells .

5-Structural Proteins - are fibrous and stringy and provide support. Examples include keratin, collagen, and elastin. Keratins strengthen protective coverings such as hair, quills, horns, and beaks. Collagens and elastin provide support for connective tissues such as tendons and ligaments.

6-Storage Proteins - store amino acids. Examples include ovalbumin and casein. Ovalbumin is found in egg whites and casein is a milk-based protein.

7-Transport Proteins - are carrier proteins which move molecules from one place to another around the body. Examples include hemoglobin and cytochromes. Hemoglobin transports oxygen through the blood. Cytochromes operate in the electron transport chain as electron carrier proteins.

Amino Acids

Most amino acids have the following structural properties :

A carbon (the alpha carbon) bonded to four different groups:
1-A hydrogen atom (H)
2-A Carboxyl group (-COO)
3-An Amino group (-NH2)
4-A "variable" group

Of the 20 amino acids that typically make up proteins, the "variable" group determines the differences among the amino acids. All amino acids have the hydrogen atom, carboxyl group and amino group bonds.

Nucleic Acids

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Nucleic acid, naturally occurring chemical compound that is capable of being broken down to yield phosphoric acid, sugars, and a mixture of organic bases (purines and pyrimidines). Nucleic acids are the main information-carrying molecules of the cell, and, by directing the process of protein synthesis, they determine the inherited characteristics of every living thing. The two main classes of nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). DNA is the master blueprint for life and constitutes the genetic material in all free-living organisms and most viruses. RNA is the genetic material of certain viruses, but it is also found in all living cells, where it plays an important role in certain processes such as the making of proteins.

Nucleotides: building blocks of nucleic acids

Basic structure

Nucleic acids are polynucleotides—that is, long chainlike molecules composed of a series of nearly identical building blocks called nucleotides. Each nucleotide consists of a nitrogen-containing aromatic base attached to a pentose (five-carbon) sugar, which is in turn attached to a phosphate group. Each nucleic acid contains four of five possible nitrogen-containing bases: adenine (A), guanine (G), cytosine (C), thymine (T), and uracil (U). A and G are categorized as purines, and C, T, and U are collectively called pyrimidines. All nucleic acids contain the bases A, C, and G; T, however, is found only in DNA, while U is found in RNA. The pentose sugar in DNA (2′-deoxyribose) differs from the sugar in RNA (ribose) by the absence of a hydroxyl group (—OH) on the 2′ carbon of the sugar ring. Without an attached phosphate group, the

sugar attached to one of the bases is known as a nucleoside. The phosphate group connects successive sugar residues by bridging the 5′-hydroxyl group on one sugar to the 3′-hydroxyl group of the next sugar in the chain. These nucleoside linkages are called phosphodiester bonds and are the same in RNA and DNA.

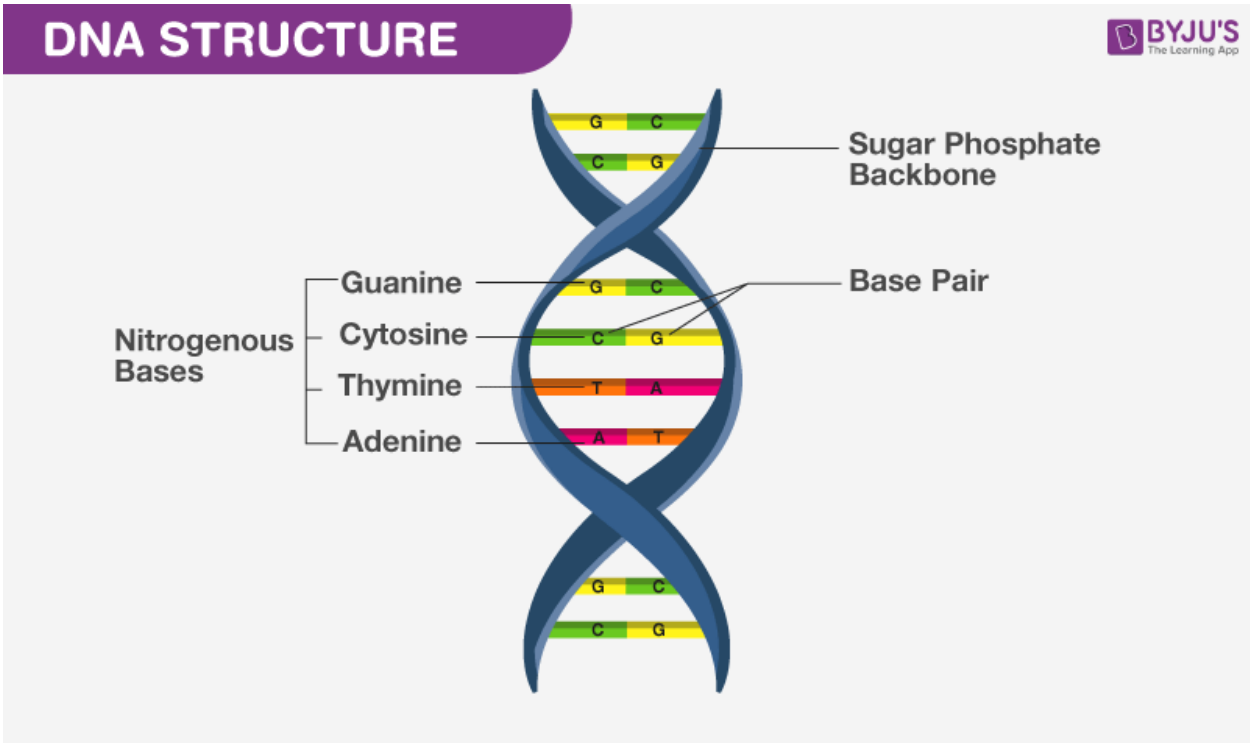
Functions of nucleic acids

Nucleic acids, including DNA and RNA, play **essential roles in all cells and viruses**. Some of the functions of nucleic acids in the body include

- Carrying hereditary information
- Making other nucleic acids and proteins
- Supporting cell division
- Controlling cell metabolism
- Stimulating apoptosis
- Designing the proteins
- Encoding the information cells need to make proteins.

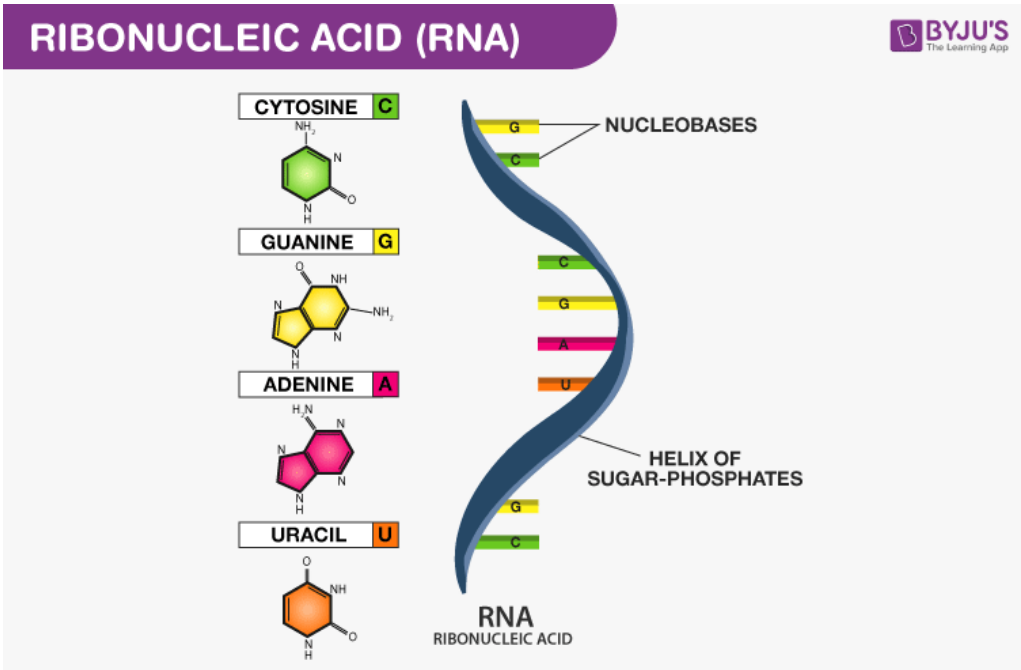
WHAT IS THE DNA?

DNA, or deoxyribonucleic acid, is **a molecule that contains the genetic code or instructions that determine the traits of living organisms**. It is made of units called nucleotides, which have bases that form a double helix structure. DNA is usually the basis of heredity, as it is passed from parents to offspring during reproduction. In most organisms, DNA is found inside the cell nucleus, where it is tightly packaged.



What is the RNA?

RNA, complex compound of high molecular weight that functions in cellular protein synthesis and replaces DNA (deoxyribonucleic acid) as a carrier of genetic codes in some viruses. RNA consists of ribose nucleotides (nitrogenous bases appended to a ribose sugar) attached by phosphodiester bonds, forming strands of varying lengths. The nitrogenous bases in RNA are adenine, guanine, cytosine, and uracil, which replaces thymine in DNA.

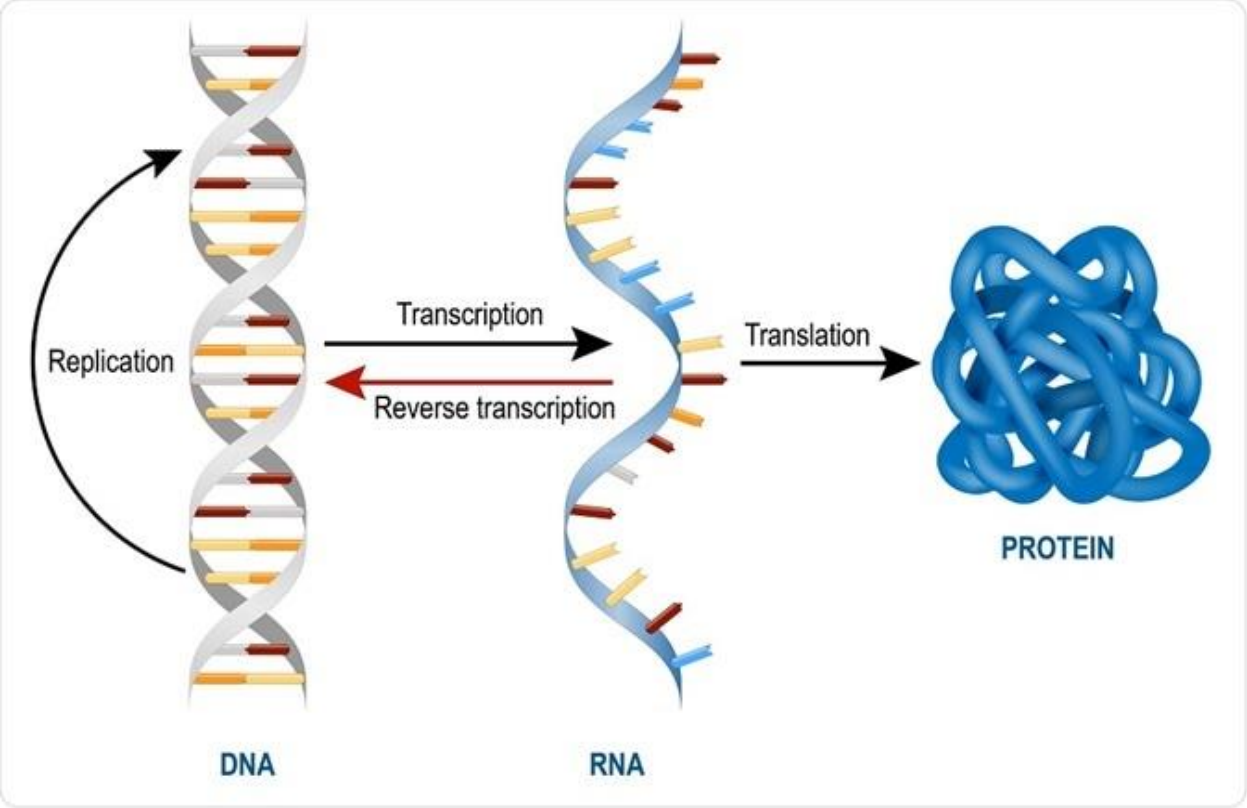


Difference between DNA & RNA

While both **DNA** and **RNA** are used to store genetic information, there are clear **differences between** them. **The main differences between DNA and RNA are**:

- DNA is double-stranded and RNA is single-stranded.
- DNA stores genetic information and RNA transfers genetic codes for protein synthesis.
- DNA has a deoxyribose sugar phosphate backbone and RNA has a ribose sugar phosphate backbone.

- DNA has the bases adenine, thymine, cytosine, and guanine and RNA has the bases adenine, uracil, cytosine, and guanine.



Nutrition in Bacteria:

By: **Assistant. Prof Muna. A. Abdullah**

Metabolism - How do bacteria feed themselves?

Bacteria exhibit different modes of nutrition. On this basis, broadly two types of bacteria can be recognized autotrophic bacteria and heterotrophic bacteria.

1- Autotrophic Bacteria

These are bacteria which are able to synthesize their own organic food from inorganic substances. They use carbon dioxide for obtaining carbon and utilize hydrogen sulphide (H2S) or ammonia (NH3) or hydrogen (H2) as the source of hydrogen to reduce carbon. These bacteria can be distinguished further into two types as follows:

a- Photoautotrophic Bacteria

The photoautotrophic bacteria possess photosynthetic pigments in membrane bound lamellae (or thylakoids) and utilize solar energy. The bacterial photosynthesis is different from that of green plants since here water is not used as a hydrogen donor. Hence oxygen is not released as a byproduct. For this reason, the process is described as un oxygenic photosynthesis.

b- Chemosynthetic Bacteria

These are bacteria which manufacture organic compounds from inorganic raw materials utilising energy liberated from the oxidation of

inorganic substances. Following are the common types of chemo autotrophic bacteria.

1. Nitrifying bacteria which derive energy by oxidizing ammonia into nitrates. Eg: Nitrosomonas, Nitrobacter.
2. Sulphur bacteria which derive energy by oxidising hydrogen sulphide to sulphur. Eg: Thiobacillus, Beggiatoa.

3. Iron Bacteria which derive energy by oxidising ferrous ions into ferric form. Eg: Ferrobacillus, Gallionella.

2- Heterotrophic Bacteria

These are bacteria which are unable to manufacture their own organic food and hence are dependent on external source. These bacteria can be distinguished into three groups as follows:

a- Saprophytic Bacteria: These bacteria obtain their nutritional requirements from dead organic matter. They breakdown the complex organic matter into simple soluble form by secreting exogenous enzymes. Subsequently they absorb the simple nutrients and assimilate them, during which they release energy. These bacteria have a significant role in the ecosystem, functioning as decomposers.

b- Aerobic and Anaerobic bacteria: the aerobic breakdown of organic matter is called as **decay or decomposition**. It is usually complete and not accompanied by the release of foul gases. Anaerobic breakdown of organic matter is called **fermentation**. It

is usually incomplete and is always accompanied by the release of foul gases. Anaerobic breakdown of proteins is called putrefaction.

c- **Industrial bacteria:** The property of decomposition of organic compounds is employed in several industrial processes such as ripening of cheese, in the retting of fibers and in the curing of tobacco.

Symbiotic Bacteria

These are bacteria which occur in the body of animals and plants, obtaining their organic food from there. Most of these bacteria are pathogenic, causing serious diseases in the host organisms either by exploiting them or by releasing poisonous secretions called toxins.

GENE TRANSFER MECHANISMS IN BACTERIA

INTRODUCTION

In bacterial populations mutations are constantly arising due to errors made during replication. If there is any selective advantage for a particular mutation (e.g. antibiotic resistance), the mutant will quickly become the major component of the population due to the rapid growth rate of bacteria. Thus, mutations in bacterial populations can pose a problem in the treatment of bacterial infections. Not only are mutations a problem, bacteria have mechanisms by which genes can be transferred to other bacteria. Thus, a mutation arising in one cell can be passed on to other cells.

Gene transfer in bacteria is unidirectional from a donor cell to a recipient cell and the donor usually gives only a small part of its DNA to the recipient. Bacterial genes are usually transferred to members of the same species but occasionally transfer to other species can also occur.

Three common mechanisms of lateral gene exchange :

1– Transformation (extracellular DNA uptake)

2– Transduction (viral mediated gene exchange)

3– Conjugation (bacterial mating systems)

1. Transformation

Transformation is gene transfer resulting from the uptake by a recipient cell of naked DNA from a donor cell. Certain bacteria (e.g. Bacillus, Haemophilus, Neisseria, Pneumococcus) can take up DNA from the environment and the DNA that is taken up can be incorporated into the recipient's chromosome.

Factors affecting transformation

a. DNA size state

Double stranded DNA of at least 5 X 10^5 daltons works best. Thus, transformation is sensitive to nucleases in the environment.

b. Competence of the recipient

Some bacteria are able to take up DNA naturally. However, these bacteria only take up DNA a particular time in their growth cycle when they produce a specific protein called a competence factor. At this stage the bacteria are said to be competent. Other bacteria are not able to take up DNA naturally. However, in these bacteria competence can be induced in vitro by treatment with chemicals (e.g. CaCl2).

Significance

Transformation occurs in nature and it can lead to increased virulence. In addition transformation is widely used in recombinant DNA technology.

2. Transduction

Transduction is the transfer of genetic information from a donor to a recipient by way of a bacteriophage. The phage coat protects the DNA in the environment so that transduction, unlike transformation, is not affected by nucleases in the environment. Not all phages can mediate transduction. In most cases gene transfer is between members of the same bacterial species. However, if a particular phage has a wide host range then transfer between species can occur. The ability of a phage to mediated transduction is related to the life cycle of the phage.

Significance

Lysogenic (phage) conversion occurs in nature and is the source of virulent strains of bacteria.

3. Conjugation

Transfer of DNA from a donor to a recipient by direct physical contact between the cells. In bacteria there are two mating types a donor (male) and a recipient (female) and the direction of transfer of genetic material is one way; DNA is transferred from a donor to a recipient.

Mating types in bacteria

a. Donor

The ability of a bacterium to be a donor is a consequence of the presence in the cell of an extra piece of DNA called the F factor or fertility factor or sex factor. The F factor is a circular piece of DNA that can replicate autonomously in the cell; it is an independent replicon. Extrachromosomal pieces of DNA that can replicate autonomously are given the general name of plasmids. The F factor has genes on it that are needed for its replication and for its ability to transfer DNA to a recipient. One of the things the F factor codes for is the ability to produce a sex pilus (F pilus) on the surface of the bacterium. This pilus is important in the conjugation process.

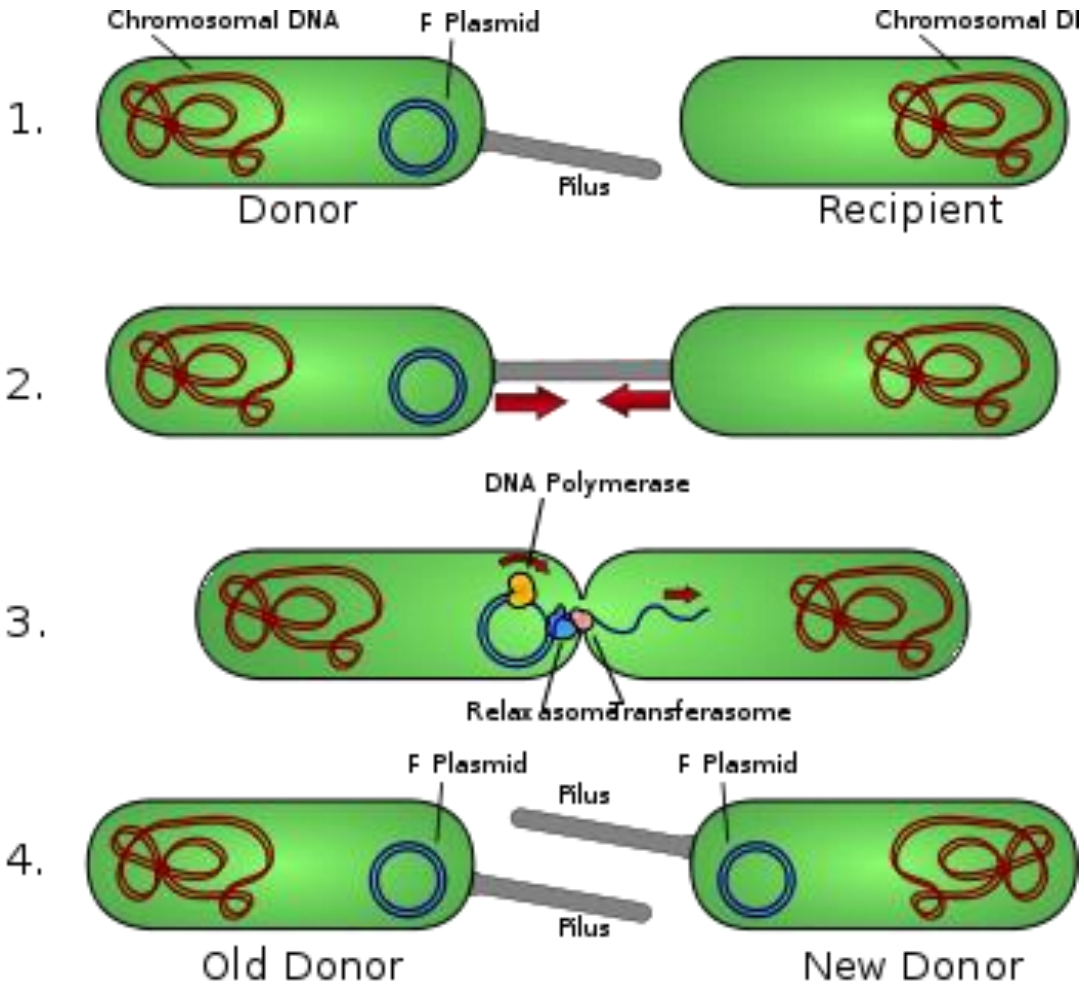
b. Recipient

The ability to act as a recipient is a consequence of the lack of the F factor.

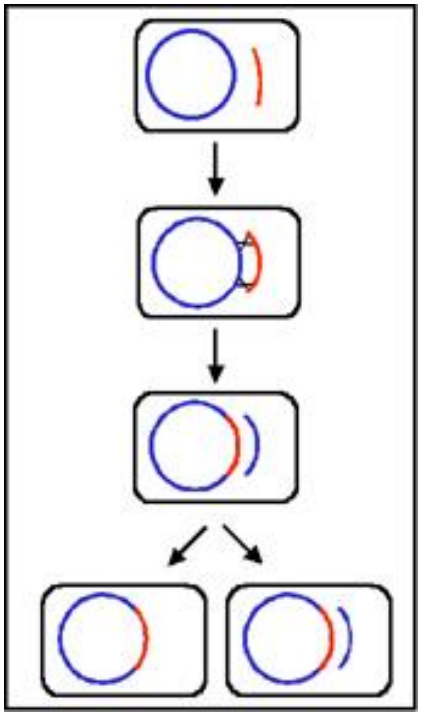
Significance

Among the Gram-negative bacteria this is the major way that bacterial genes are transferred. Transfer can occur between different species of bacteria. Transfer of multiple antibiotic resistance by conjugation has become a major problem in the treatment of certain bacterial diseases. Since the recipient cell becomes a donor after transfer of a plasmid it is easy to see why an antibiotic resistance gene carried on a plasmid can quickly convert a sensitive population of cells to a resistant one.

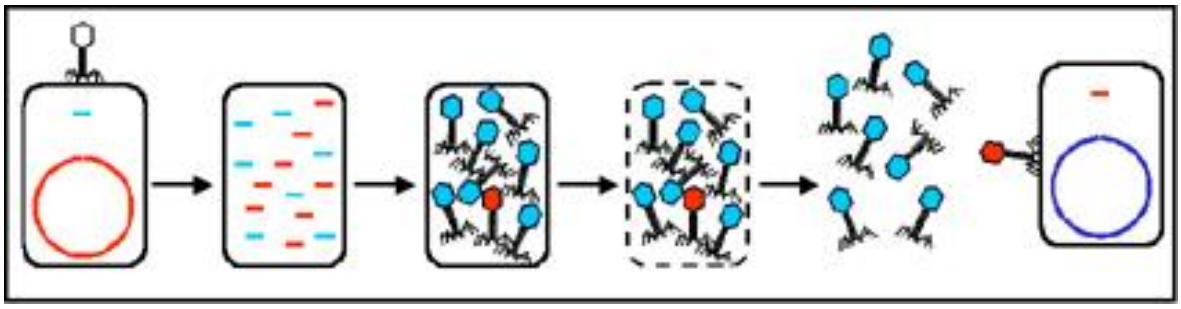
Gram positive bacteria also have plasmids that carry multiple antibiotic resistance genes, in some cases these plasmids are transferred by conjugation while in others they are transferred by transduction. The mechanism of conjugation in Gram + bacteria is different than that for Gram -. In Gram + bacteria the donor makes an adhesive material which causes aggregation with the recipient and the DNA is transferred.



Schematic drawing of bacterial conjugation. Conjugation diagram 1- Donor cell produces pilus. 2- Pilus attaches to recipient cell and brings the two cells together. 3- The mobile plasmid is nicked and a single strand of DNA is then transferred to the recipient cell. 4- Both cells synthesize a complementary strand to produce a double stranded circular plasmid and also reproduce pili; both cells are now viable donors.



General recombination. Donor DNA is shown in red and recipient DNA in blue



Mechanism of generalized transduction

Bacteria and disease

Human and animals have abounded microbial normal flora. A diverse microbial flora is associated with the skin and mucous membranes, oral and Upper Respiratory Tract, Gastrointestinal Tract, Urogenital, and Conjunctive Flora of every human being from shortly after birth until death. Most bacteria do not produce disease but achieve a balance with the host that ensure the survival, growth, and propagation of both the bacteria and host. Sometimes bacteria that are clearly pathogens (e.g Salmonella typhi) are present, but infection remains latent subclinical and the host is a “carrier” of the bacteria.

Koch's postulates

Koch's postulates are four criteria designed to establish a causal relationship between a causative microbe and a disease. The postulates were formulated by Robert Koch and Friedrich Loeffler in 1884 and refined and published by Koch in 1890. Koch’s postulates are summarized as follows:

1. The microorganism must be found in abundance in all organisms with the infectious disease but not found in healthy ones.
2. The microorganism must be isolated from an organism with the infectious disease and grown in pure culture in vitro for several generation.
3. The microorganism isolated in pure culture must initiate disease when re-inoculated into susceptible animals.
4. The microorganism should be re-isolated from the experimentally infected animals.

Koch's postulates remain a mainstay of microbiology however, since the late 19 century, many microorganisms that do not meet the criteria of the postdates have been shown to cause disease. For example, Treponema pallidum and Mycobacterium leprae cannot be grown in the vitro. In an other example; Neisseria gonorrhoeae there is no animal model of infection.

The infectious process

1-The bacteria must enter and establish themselves within the host. The most frequent portals of entry are the respiratory (mouth and nose), gastrointestinal, and genitourinary tract. Abnormal areas of mucosa membranes and skin (e.g. cuts, burn, and other injuries) are also frequent sites of entry.

2- Once in the body, bacteria must attach to host cell usually epithelial cells.

3- After the bacteria have established, they multiply and spread. Infection can spread directly through tissues or by the lymphatic system to the blood steam. Blood steam infection (Bacteremia) allows bacteria to spread widely in the body and permits them to reach tissues particular suitable for their multiplication.

Bacterial virulence factors

1- Adherence factors (e.g. pili), hair-like appendages that extend from the bacteria cell surface and help mediate adherence of the bacteria to host cell surfaces. For example, some E. coli strains.

2- Exotoxins: such as

a- Diphtheria by Corynebacterium diphtheria

b- Tetanus by Clostridium tetani

c- Botulism by Clostridium Botulinum

d- Gas gangrene by Clostridium perfringens

3-Endotoxins of gram negative bacteria: The Endotoxins of G- bacteria are complex lipopolysaccharide derived from bacterial cell walls and are often liberated when the bacteria lysed.

4- Enzymes: a- Coagulase b-Collagenase c- Streptokinase

5- Antiphagocytic factors.

Definition in bacteriology

Adherence (adhesion, attachment) The process by which bacteria stick to the surface of host cells

Carrier: a person or animal with asymptomatic infection that can be transmitted to another susceptible person or animal.

Infection: Multiplication of an infectious agent within the body. Multiplication of the bacteria that are part of the normal flora of the gastrointestinal tract, skin, etc. Is generally not consider an infection, on other hand, multiplication of pathogenic bacteria (e.g. salmonella species) even if the person is asymptomatic is deemed an infection.

Invasion: The process where by bacteria, animal, parasites, fungi, and viruses enter host cells or tissues and spread in the body.

Non- pathogen: A microorganisms that does not cause disease; may be part of the normal flora.

Opportunistic pathogen; An agent capable of causing disease only when the host's resistance is impaired (e.g. The patient is "immunocompromised"

.

Pathogen: A microorganisms capable of causing disease.

Pathogenicity: The ability of an infectious agent to cause disease.

Toxigenic: The ability of a microorganisms to produce a toxin that contributes to the development of disease.

Virulence: The quantitative ability of an agent to cause disease. Virulence agent cause disease when introduced into the host in small number. Virulence involves invasions and toxigenic.

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passage of material across cell membrane

Cell membranes are semi-permeable membranes that allow small molecules such as oxygen, water, and carbon dioxide to pass through but do not allow larger molecules like glucose, sucrose, proteins, and starch to enter the cell directly. Here are some examples of materials that can pass through the cell membrane:

- Small, nonpolar molecules (e.g. oxygen and carbon dioxide)
- Small, polar molecules (e.g. water)
- Other lipids
- Alcohol

Transport Across cell membrane:

Cell membrane is a phospholipid bilayer that regulates the entry and exit of molecules. Diffusion, osmosis and active transport are some forms of transport seen across the cell membrane.

- **Movement of Substances Across Cell Membrane:**

The contents of a cell are completely surrounded by its cell membrane or plasma membrane. Thus, any communication between the cell and the extracellular medium is mediated by the cell membranes. These cell membranes serve two important functions:

1. It must retain the dissolved materials of the cell so that they do not simply leak out into the environment.
2. It should also allow the necessary exchange of materials into and out of the cell.

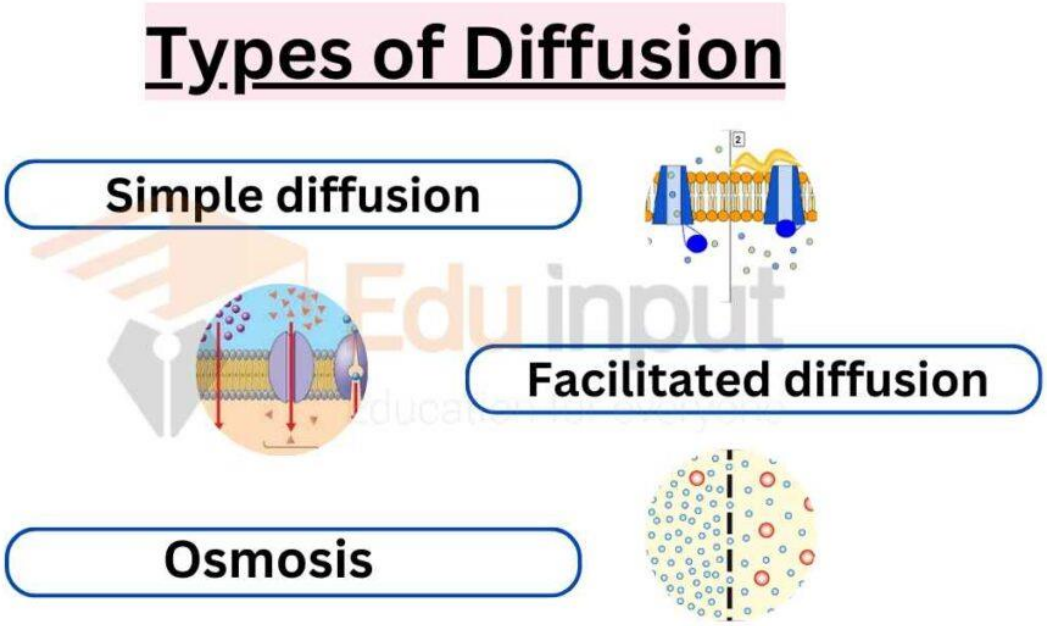
There are two major methods for moving molecules across a membrane, and it is related to whether or not cell energy is used. Passive mechanisms, such as diffusion, require no energy to

function, whereas active transport does. In passive transport, an ion or molecule crosses the membrane and moves down its concentration or electrochemical gradient. The different types of transport mechanisms across cell membranes are as follows:

1. Simple diffusion
2. Facilitated diffusion
3. Osmosis

- **Diffusion:**

Diffusion is a spontaneous process in which a substance moves from a region of high concentration to a region of low concentration, eventually eliminating the concentration difference between the two regions.



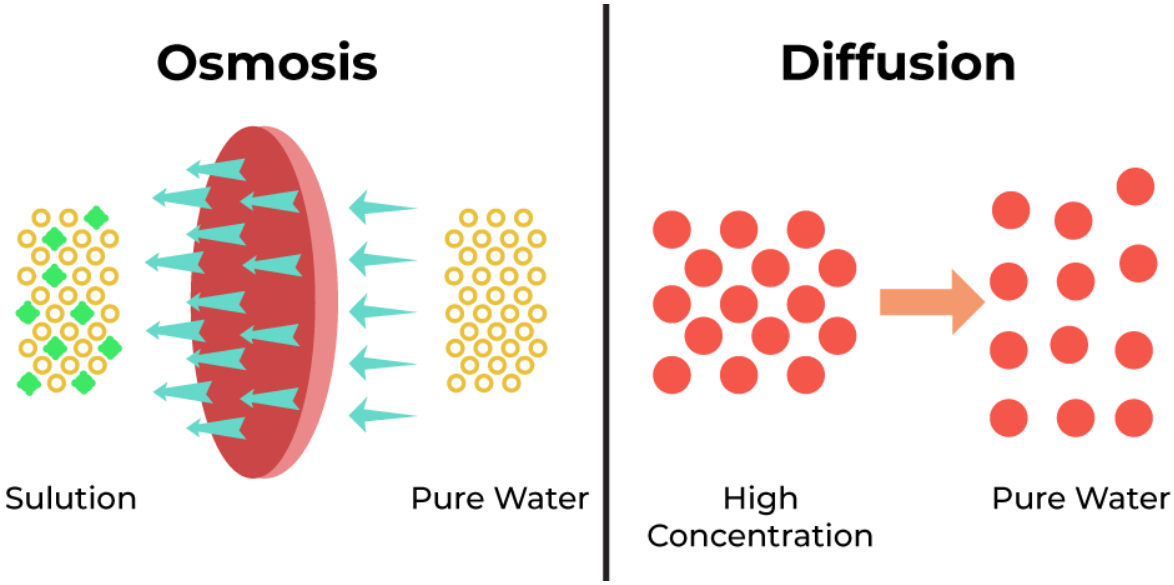
Simple Diffusion

Transport across the plasma membrane occurs unaided in simple diffusion, i.e., molecules of gases such as carbon dioxide and oxygen, as well as small molecules like ethanol, enter the cell by crossing the cell membrane without the assistance of any permease. A small molecule in an aqueous solution dissolve into the phospholipid bilayer, crosses it, and then dissolves into the aqueous solution on the opposite side during simple diffusion. The relative rate of molecule diffusion across the phospholipid bilayer is proportional to the concentration gradient across the membrane.

Facilitated Diffusion

This is a type of passive transport in which molecules that cross the cell membrane move quickly due to the presence of specific permeases in the membrane. Facilitated diffusion occurs only in the direction of a concentration gradient and does not require metabolic energy. It is distinguished by the following characteristics:

- The rate of molecule transport across the membrane is much faster than would be expected from simple diffusion.
- This is a specific process; each facilitated diffusion protein transports only one type of molecule.
- There is a maximum rate of transport, which means that when the concentration gradient of molecules across the membrane is low, increasing the concentration gradient results in an increase in the rate of transport.

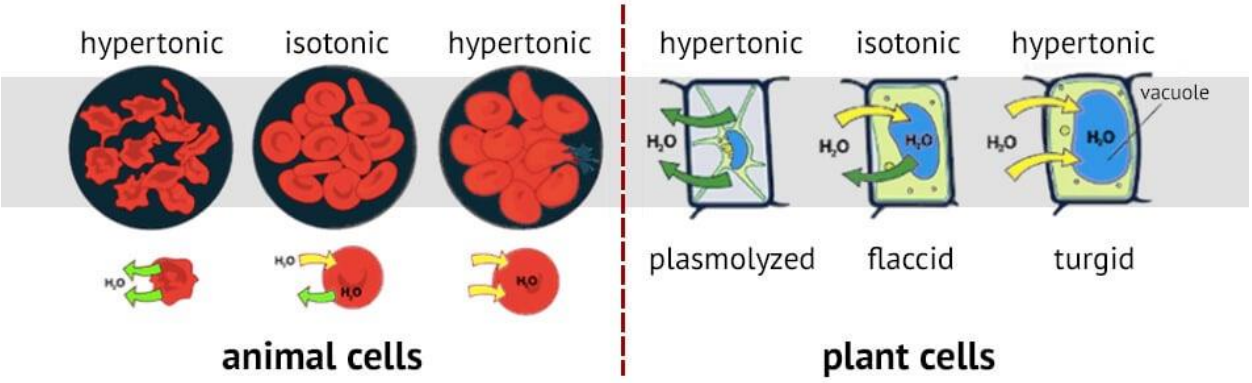

Osmosis
Diffusion
Sulution
Pure Water
High Concentration
Pure Water

- **Osmosis:**

Water molecules can transport through the cell membrane. The movement of water molecules through the cell membrane is caused by differences in the concentration of the solute on its two sides. Osmosis is the process by which water molecules pass through a membrane from a region of higher water concentration to a region of lower water concentration.

- The process by which water molecules enter the cell is known as **endosmosis**, whereas the process by which water molecules exit the cell is known as **exosmosis**.
- Excessive exosmosis causes the cytoplasm and cell membrane in plant cells to shrink away from the cell wall. This is known as **plasmolysis**. It is due to plasmolysis that a plant loses its support and wilts.
- When two compartments of different solute concentrations are separated by a semipermeable membrane, the compartment with higher solute concentration is called **hypertonic** relative to the compartment of lower solute concentration, which is described as **hypotonic**.

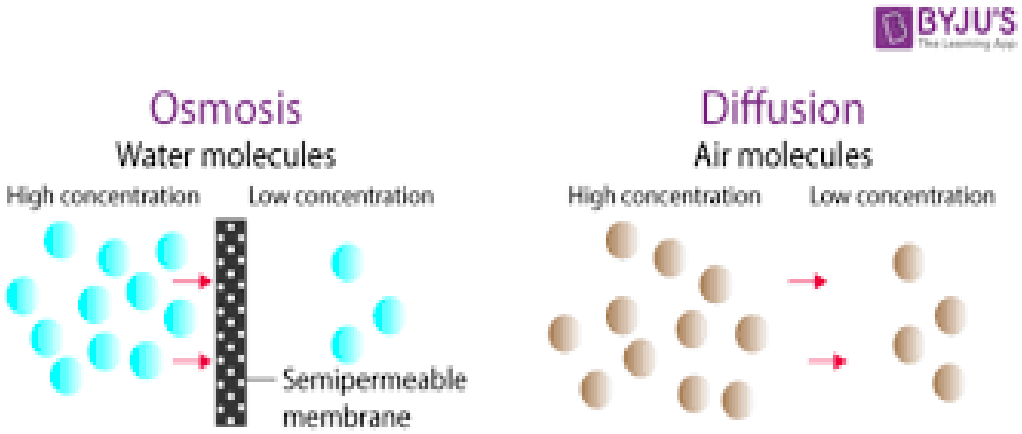
- If a cell is placed in a hypotonic solution, it rapidly gains water by osmosis and swells. Conversely, a cell placed into a hypertonic solution rapidly loses water by osmosis and shrinks.
- When the internal solute concentration equals the external solute concentration, it is said to be **isotonic**. Here, no net movement of water in or out of the cells occurs.
- The amount of water contained within the cell creates a pressure termed hydrostatic pressure (osmotic pressure). The cell membrane regulates the osmotic pressures of intracellular and intercellular fluids

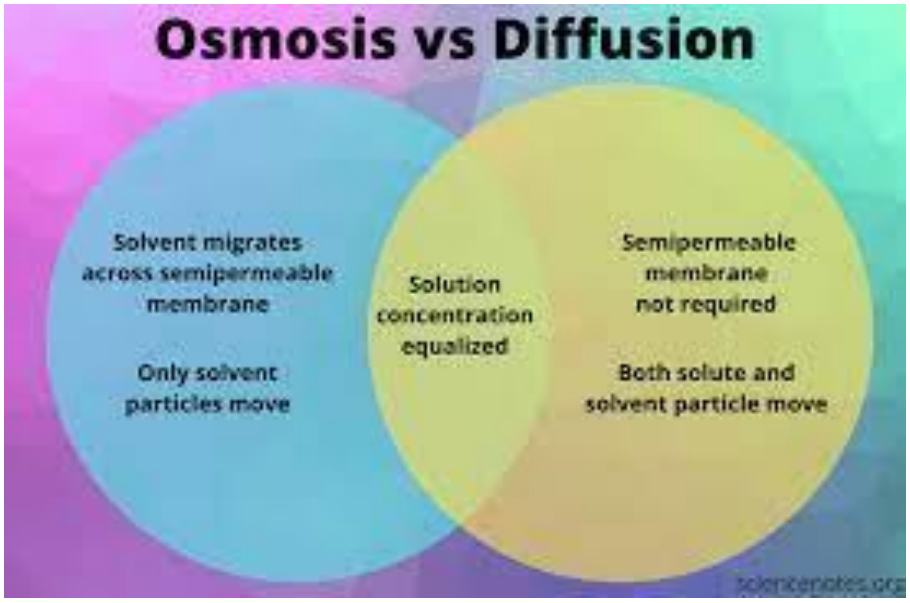


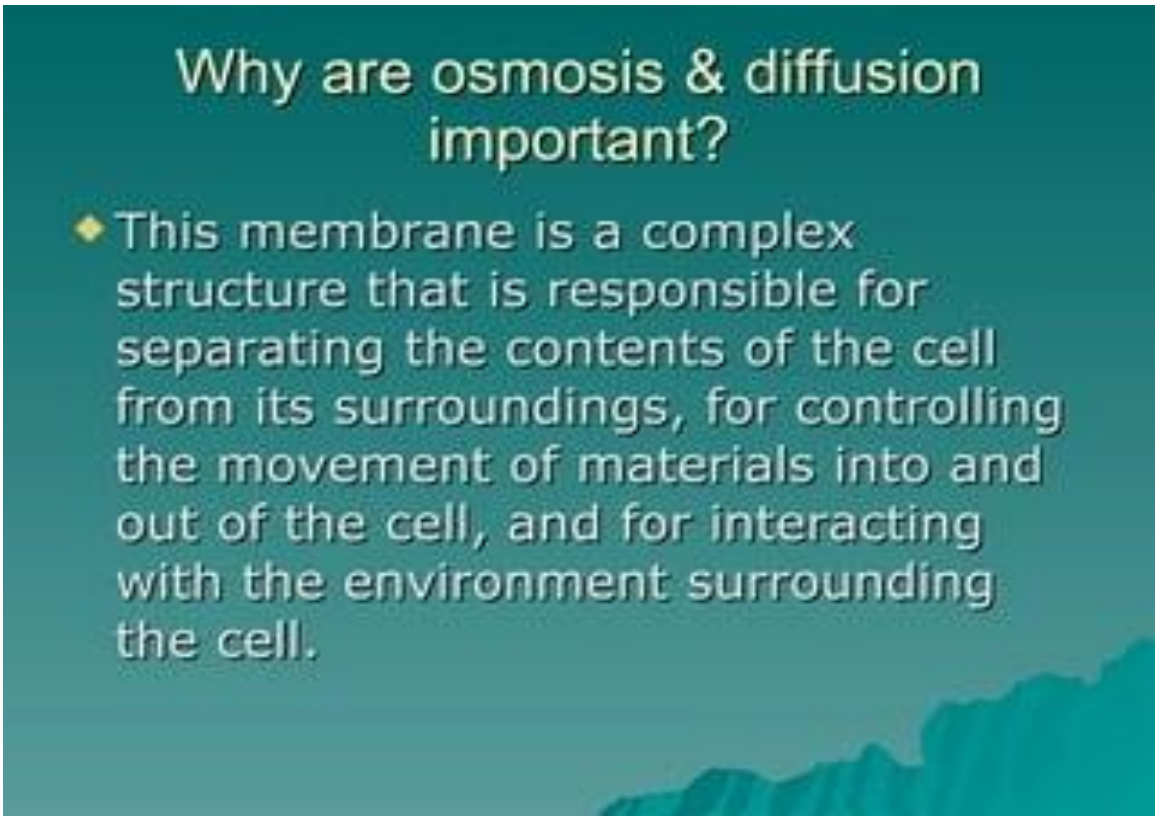
Difference between Diffusion and Osmosis:

Osmosis	Diffusion
It is limited only to the liquid medium.	Occurs in liquid, gas and even solids.
Requires a semipermeable membrane.	Does not require a semipermeable membrane.
Depends on the number of solute particles dissolved in the solvent.	Depends on the presence of other particles.
Requires water for the movement of particles.	Does not require water for the movement of particles.
Only the solvent molecules can diffuse.	Both the molecules of solute and solvent can diffuse.
The flow of particles occurs only in one direction.	The flow of particles occurs in all the directions.
The entire process can either be stopped or reversed by applying additional pressure on the solution side.	This process can neither be stopped nor reversed.
Occurs only between similar types of solutions.	Occurs between the similar and dissimilar types of solutions.
It involves the movement of only solvent molecules from one side to the other.	It involves the movement of all the particles from one region to the other.
The concentration of the solvent does not become	The concentration of the diffusion substance

equal on both sides of the membrane.	equalises to fill the available space.
Depends on solute potential.	Does not depend on solute potential, pressure potential, or water potential.
Only water or another solvent moves from a region of its high concentration to a region of its lower concentration.	Any type of substance moves from area of highest energy or concentration to region of lowest energy or concentration.
Not associated with uptake of minerals and nutrients.	It helps in the uptake of minerals and nutrients.







- **Active Transport:**

Active transport is a kind of cellular transport in which substances like amino acids, glucose and ions are transported across cell membranes to a region that already has a high concentration of such substances. As a result, active transport employs chemical energy like ATP to move substances against their concentration gradient. This type of transport is commonly found in the small intestine wall and root hair cells. Active transport is performed by a special type of protein molecules of the cell membrane called the transport proteins or pumps. They consume energy in the form of ATP molecules.

Primary Active Transport

Photon energy and redox energy are two sources of energy for primary active transport. The mitochondrial electron transport chain, which uses the reduction energy of NADH to transport protons across the inner membrane of mitochondria against their concentration gradient, is an example of primary active transport using redox energy. The proteins involved in photosynthesis are an example of primary active transport using photon or light energy.

Primary active transport is demonstrated by glucose uptake in the human intestine.

Secondary Active Transport

Secondary active transport allows one solute to move downward (along its electrochemical potential gradient) in order to generate enough

entropic energy to drive the transport of the other solute upward (from a low concentration region to a high concentration region). This is also known as coupled transport. There are two types of coupled transport – antiport and symport. Antiport transport involves the movement of two ion or other solute species in opposite directions across a membrane, whereas symport transport involves the movement of two species in the same direction.

Differences between Diffusion, Osmosis and Active transport

Process	Movement of	Condition	Additional requirements
Diffusion	Molecules/ ions	High conc. to low conc.	Down a conc. gradient
Osmosis	Water molecules	High water potential to low water potential	Across a partially permeable membrane
Active transport	Particles of substances	Low conc. to high conc.	Against a conc. Gradient; Energy required

Definitions

- **Osmosis**: Osmosis is the movement of solvent particles across a semipermeable membrane from a dilute solution

into a concentrated solution. The solvent moves to dilute the concentrated solution and equalize the concentration on both sides of the membrane.

- **Diffusion**: Diffusion is the movement of particles from an area of higher concentration to lower concentration. The overall effect is to equalize concentration throughout the medium.

Examples:

- **Examples of Osmosis:** Examples include red blood cells swelling up when exposed to freshwater and plant root hairs taking up water. To see an easy demonstration of osmosis, soak gummy candies in water. The gel of the candies acts as a semipermeable membrane.
-
- **Examples of Diffusion:** Examples of diffusion include the scent of perfume filling a whole room and the movement of small molecules across a cell membrane. One of the simplest demonstrations of diffusion is adding a drop of food coloring to water. Although other transport processes do occur, diffusion is the key player.

Similarities

Osmosis and diffusion are related processes that display similarities:

- Both osmosis and diffusion equalize the concentration of two solutions.
- Both diffusion and osmosis are passive transport processes, which means they do not require any input of extra energy to occur. In both diffusion and osmosis, particles move from an area of higher concentration to one of lower concentration.

Differences

Here's how they are different:

- Diffusion can occur in any mixture, including one that includes a semipermeable membrane, while osmosis always occurs across a semipermeable membrane.
- When people discuss osmosis in biology, it always refers to the movement of water. In chemistry, it's possible for other solvents to be involved. In biology, this is a difference between the two processes.
- One big difference between osmosis and diffusion is that both solvent and solute particles are free to move in diffusion, but in osmosis, only the solvent molecules (water molecules) cross the membrane. This can be confusing because while the solvent particles are moving from higher to lower **solvent** concentration across the membrane, they are moving from lower to higher **solute** concentration, or from a more dilute solution to a region of more concentrated solution. This occurs naturally because the system seeks balance or equilibrium. If the solute particles can't cross a barrier, the only way to equalize

concentration on both sides of the membrane is for the solvent particles to move in. **You can consider osmosis to be a special case of diffusion in which diffusion occurs across a semipermeable membrane and only the water or other solvent moves.**

Thanks

Release of the energy

A fascinating parallel between plant and animal life is in the use of tiny energy factories within the cells to handle the energy transformation processes necessary for life. In plants, these energy factories are called chloroplasts. They collect energy from the sun and use carbon dioxide and water in the process called photosynthesis to produce sugars. Animals can make use of the sugars provided by the plants in their own cellular energy factories, the mitochondria. These produce a versatile energy currency in the form of adenosine triphosphate (ATP). This high-energy molecule stores the energy we need to do just about everything we do.

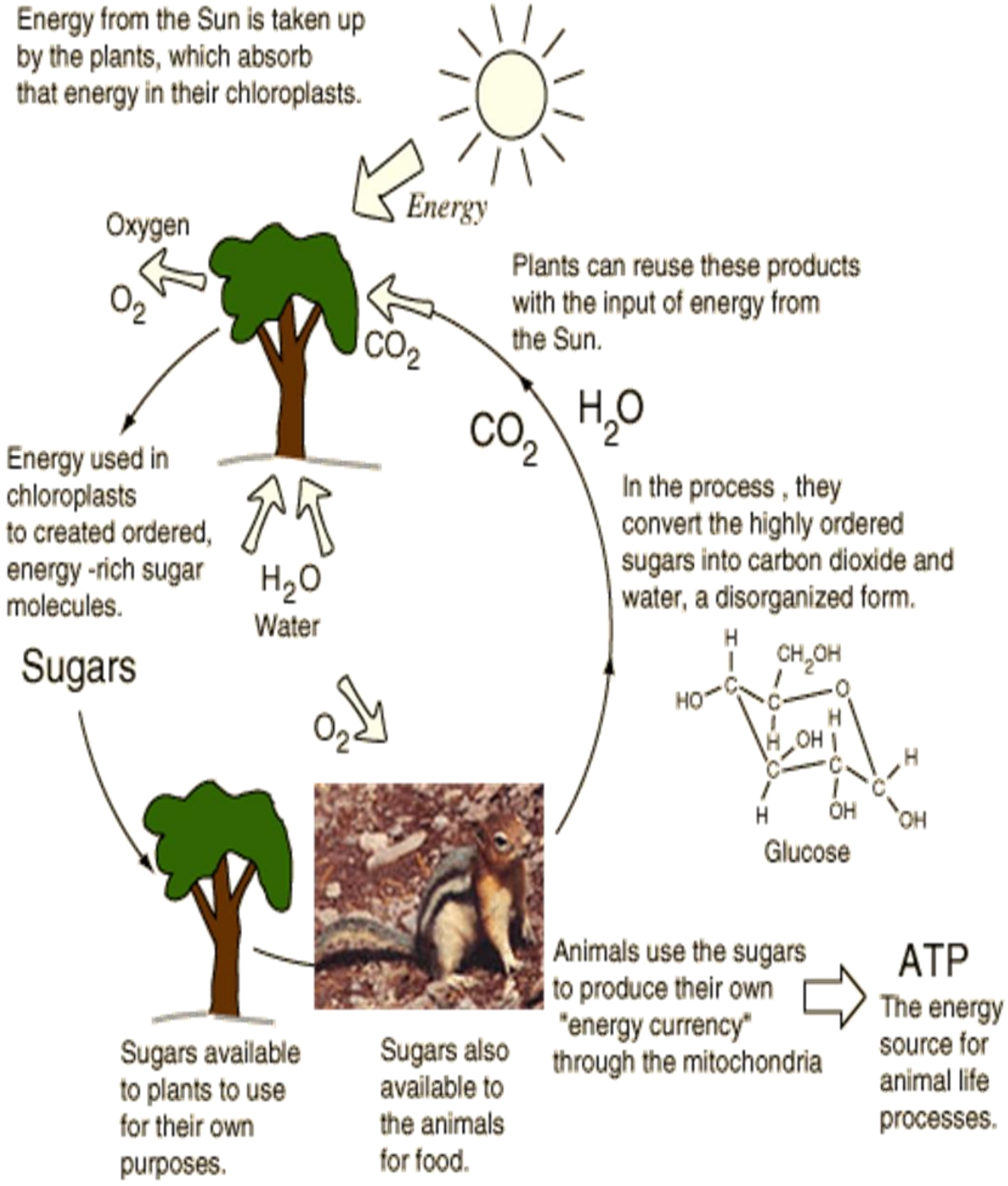
The energy cycle for life is fueled by the Sun. The main end product for plants and animals is the production of highly energetic molecules like ATP . These molecules store enough immediately available energy to allow plants and animals to do their necessary work.

There are a number of energy transformations in plants and animals which are essential to life. These processes will be described as the "work" of living things, Some of the general kinds of processes involved in the energy cycle are:

Synthetic Work: Both plants and animals must make the complex molecules necessary for life. One example is the production of DNA - your genetic material. If you don't make extra copies of DNA, you will have no information to pass on to your offspring. Every time one of your cells makes a copy of itself, it has to make a new copy of the DNA. That synthesis process requires a lot of ATP. The process of growth requires a lot of synthetic work to create the new cells and enlarge the structures.

Electrical Work: you may not think of yourself as an electrically operated machine, but you are. Each of our cells has an electric potential associated with it. This potential, or voltage, helps to control the migration of ions across the cell membranes. A major example of electrical work is in the operation of the nerves. When your nerves fire, they generate an electrical impulse called an action potential which can communicate information to your brain, or carry a signal from your brain to a muscle to initiate its movement. Electrical energy transformation is essential for sensing your environment as well as for reacting to that environment in any way.

Mechanical Work: Most easily visualized is the mechanical work associated with the moving of our muscles. This muscle movement is very important and requires a lot of energy. The source of that energy is ATP.
to



Helminthes

Helminths (worm), which are metazoan, are larger, multicellular organisms, normally visible to the naked eye in their adult form. They reproduce sexually, usually within the host, and have pre-adult stages (ova, larvae) which live externally or in other hosts.

Morphology and Classification of Helminths

1. Worms are elongated, bilaterally symmetric organisms that vary in length from less than 1 mm to a meter or more.
2. The body wall is covered with a tough a cellular cuticle, which may be smooth or possess ridges, spines, and tubercles.
3. At the anterior end there are often suckers, hooks, teeth, or plates used for the purpose of attachment.
4. Some have alimentary tracts, none possess a circulatory system.

The common helminthic parasites of humans can be placed in one of three classes:

1. Trematoda (Flukes)
2. Cestodes (Tapeworms)
3. Nematoda (roundworms).

Trematoda (Flukes)

General characteristics of Trematodes

1. Trematodes, often have flat, leaf shaped bodies ranging in length from few millimeters to 8 cm.
2. Two suckers, one serve as attachment organs: an oral sucker, and the other a ventral sucker.
3. Particulate waste is regurgitated through the mouth.
4. The body surface of adult trematodes is covered by a cellular tegument through which substances can be absorbed from the environment.
5. Most species are hermaphroditic, only the schistosomes have separate sexes.
6. Snails are the first intermediate hosts; some species require arthropods or fish as second intermediate hosts.

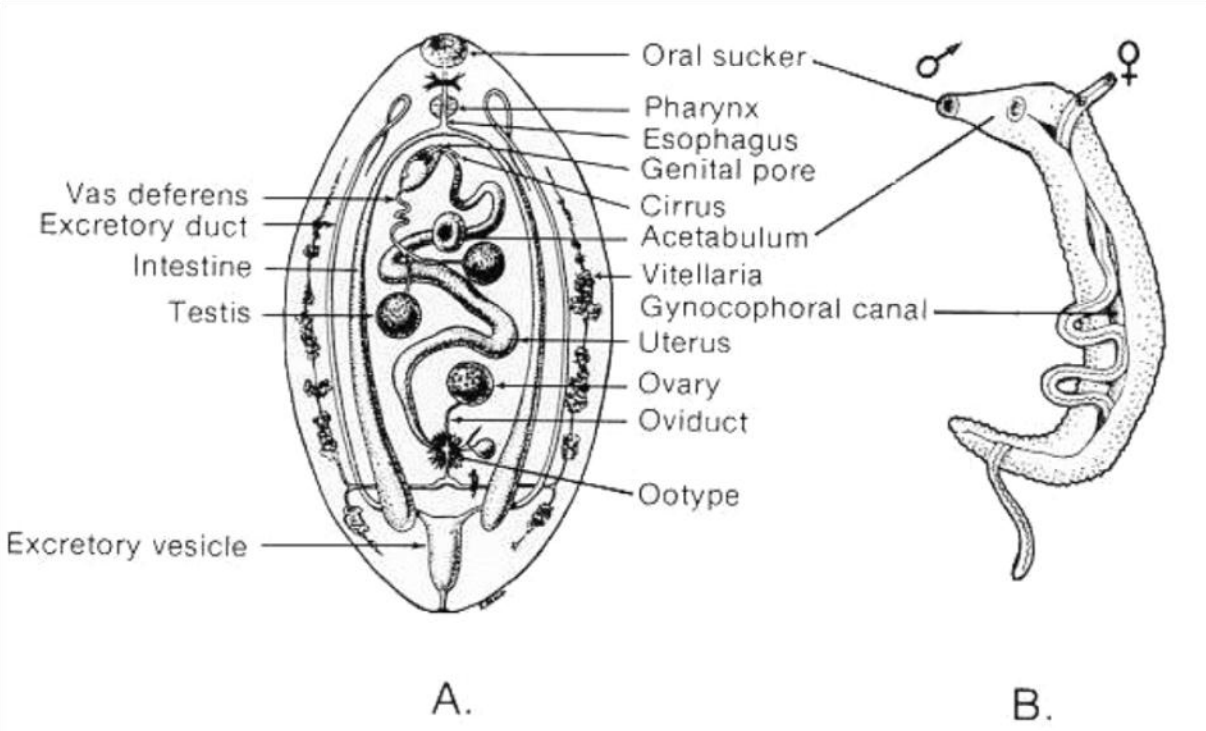


Figure 1: Structure of flukes. A- Hermaphroditic fluke B- Bisexual fluke

Schistosoma (Blood Flukes)

The General Characteristics of Schistosomes

1. Schistosomes are elongated and cylindrical, perhaps as an adaptation to living in vascular channels. They have oral and ventral suckers.

2. They differ from other trematodes in that they have separate sexes.

3. The adult schistosomes live as worm pairs (male and female) within the human vasculature.

4. They require definitive and intermediate hosts (freshwater snails) to complete their life cycle.

5. The schistosomes differ from other trematodes in that infection is acquired by penetration of cercaria through the skin. It is the eggs and not the adult worms which are responsible for the pathology associated infections.

6. The most important sources of energy for the parasites are carbohydrates and incompletely degraded organic acids, such as lactic, acetic and propionic acids. Adult schistosomes also digest red blood cells, which they break down using a unique hemoglobinase.

Figure 2: The threadlike female is enclosed in a groove in the body of the male.

Schistosomosis

- Human schistosomiasis is caused by five species of schistosomes: ***S. japonicum S. mansoni S. haematobium S. intercalatum S. mekongi*** each with its own unique epidemiology and geographic range. ***Schistosoma haematobium*** causes urinary schistosomosis**;** ***S. mansoni, S. japonicum, S. intercalatum, and S. mekongi*** are the causative agents of intestinal schistosomosis and other forms of the disease.

Life cycle of Schistosoma

Eggs are eliminated with feces or urine (1). Under optimal conditions the eggs hatch and release miracidia (2), which swim and penetrate specific snail intermediate hosts (3). The stages in the snail include 2 generations of sporocysts (4) and the production of cercariae (5). Upon release from the snail, the infective cercariae swim, penetrate the skin of the human host (6), and shed their forked tail, becoming schistosomulae (7). The schistosomulae migrate through several tissues and stages to their residence in the veins ((8), (9)). Adult worms in humans reside in the mesenteric venules in various locations, depending on the species (10). For instance, *S. japonicum* is more frequently found in the superior mesenteric veins draining the small intestine (A), and *S. mansoni* occurs more often in the superior mesenteric veins draining the large intestine (B). However, both species can occupy either location, and they are capable of moving between sites, so it is not possible to state unequivocally that one species only occurs in one location. *S. haematobium* most often occurs in the venous plexus of bladder (C), but it can also be found in the rectal venules. The females (size 7 to 20 mm; males slightly shorter) deposit eggs in the small venules of the portal and perivesical systems. The eggs are moved progressively toward the lumen of the intestine (*S. mansoni* and *S. japonicum*) and of the bladder and ureters (*S. haematobium*), and are eliminated with feces or urine, respectively (1)

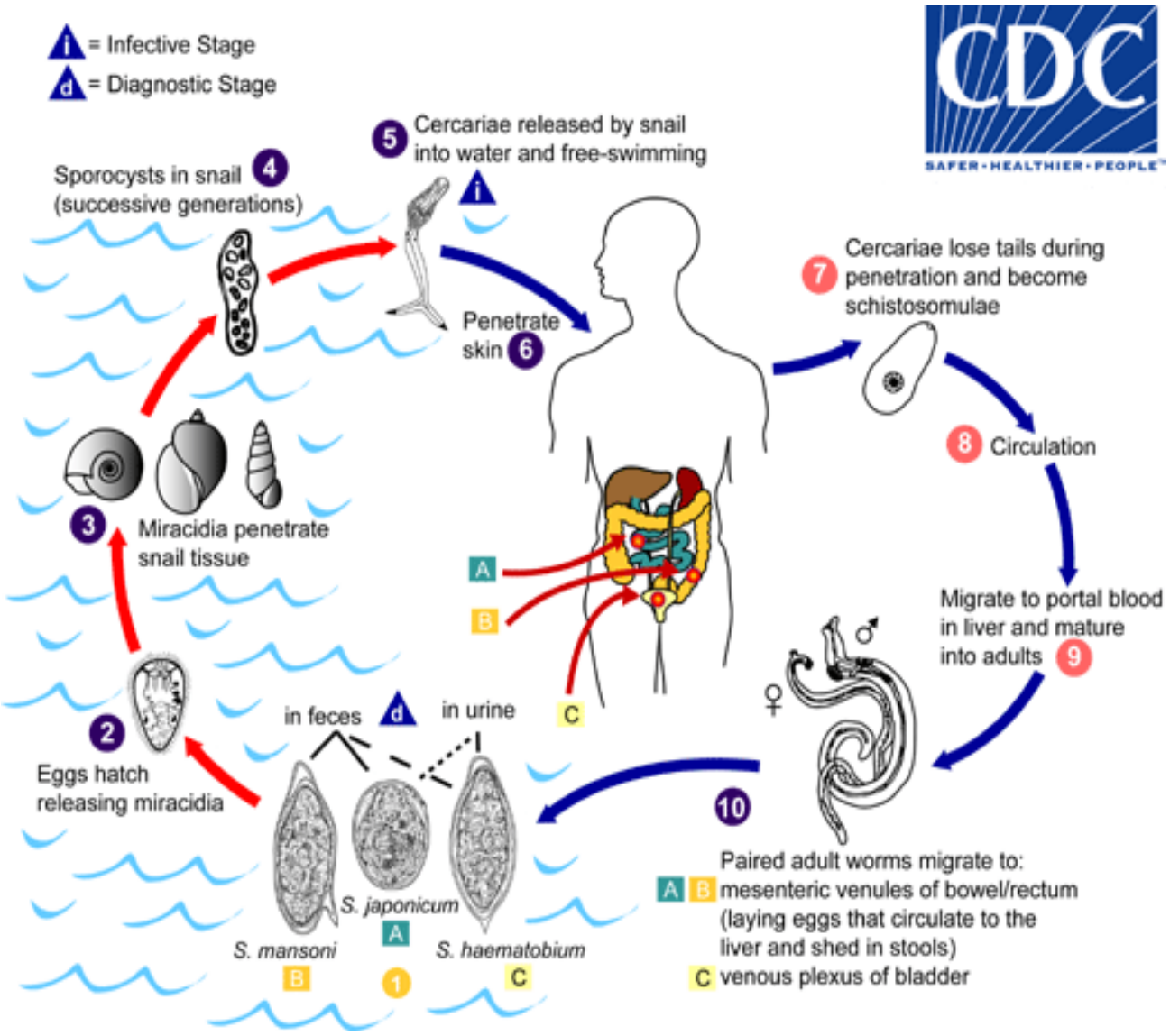


Figure 4: The life-cycle of schistosomes.

Symptoms and complications

Patients infected with S. haematobium suffer from terminal haematuria and painful micturition. There is inflammation of the urinary bladder (cystitis), and enlargement of spleen and liver.

Patients infected with S. mansoni suffer from cercarial dermatitis (swimmers itch) and dysentery (mucus and blood in stool with tenesmus) as well as enlargements of the spleen and liver. S. haematobium causes squamous cell carcinoma in the bladder.

. LIVER FLUKES

♦ Clonorchis sinensis: Chinese liver fluke - adult worms live in bile ducts.

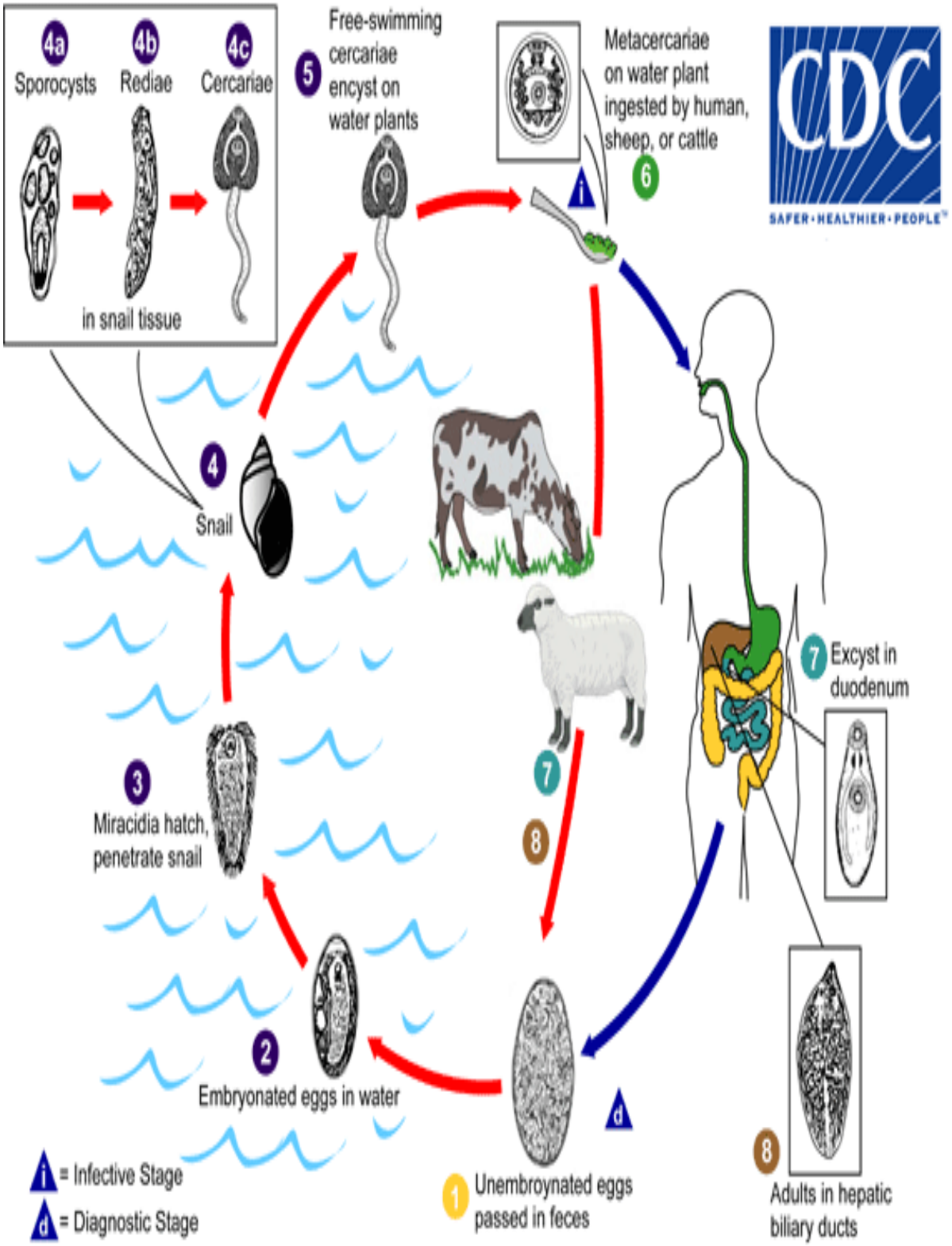
♦ Faciola hepatica: Sheep liver fluke - is a common parasite, cosmopolitan in distribution. It is large (3 cm in length).

Adult worms reside in the large biliary passages and gall bladder.

Life cycle of Fasciola hepatica and Fasciola gigantica .

Immature eggs are discharged in the biliary ducts and in the stool. (1) Eggs become embryonated in water (2), eggs release miracidia (3), which invade a suitable snail intermediate host (4), including the genera Galba, Fossaria and Pseudosuccinea. In the snail the parasites undergo several developmental stages [sporocysts (4a), rediae (4b), and cercariae (4c)]. The cercariae are released from the snail (5) and encyst as metacercariae on aquatic vegetation or other surfaces. Mammals acquire the infection by eating vegetation containing metacercariae. Humans can become infected by ingesting metacercariae-containing freshwater plants, especially watercress

(6). After ingestion, the metacercariae excyst in the duodenum (7) and migrate through the intestinal wall, the peritoneal cavity, and the liver parenchyma into the biliary ducts, where they develop into adults (8). In humans, maturation from metacercariae into adult flukes takes approximately 3 to 4 months. The adult flukes (F. hepatica: up to 30 mm by 13 mm; F. gigantica: up to 75 mm) reside in the large biliary ducts of the mammalian host. F. hepatica parasites can infect various animal species, mostly herbivores (source 1)


4a
Sporocysts
4b
Rediae
4c
Cercariae
in snail tissue
5
Free-swimming cercariae encyst on water plants
Metacercariae on water plant ingested by human, sheep, or cattle
i
6
CDC
SAFER·HEALTHIER·PEOPLE™
4
Snail
3
Miracidia hatch, penetrate snail
7
Excyst in duodenum
7
8
2
Embryonated eggs in water
d
1
Unembroynated eggs passed in feces
8
Adults in hepatic biliary ducts
i = Infective Stage
d = Diagnostic Stage

Cestodes (Tapeworms)

The General Characteristics of Cestodes

1. The cestodes or tapeworms found in humans, all have a flat, ribbon-shaped body. They inhabit the small intestine and are attached to the mucosa by means of a scolex.
2. The head, or **scolex** , has suckers for attaching to the intestinal mucosa of the definitive host.
3. The body consists of a chain of segments or proglottids. Each mature proglottid contains both male and female reproductive organs.
4. Tapeworms lack a digestive system. To obtain nutrients from the small intestine, they absorb food through their cuticle.
5. These cestode species are hermaphrodites.
6. The life cycle of tapeworms involves both an intermediate and definitive host.
7. The tapeworms which affect man are ***Taenia* species, *Diphyllobothrium latum* , *Hymenolepis nana* , *Hymenolepis diminuta*** **and** ***Echinococcus granulosus*.**
8. Humans can also be infected by larval stages of various tapeworm species (cysticerci or, metacestodes).

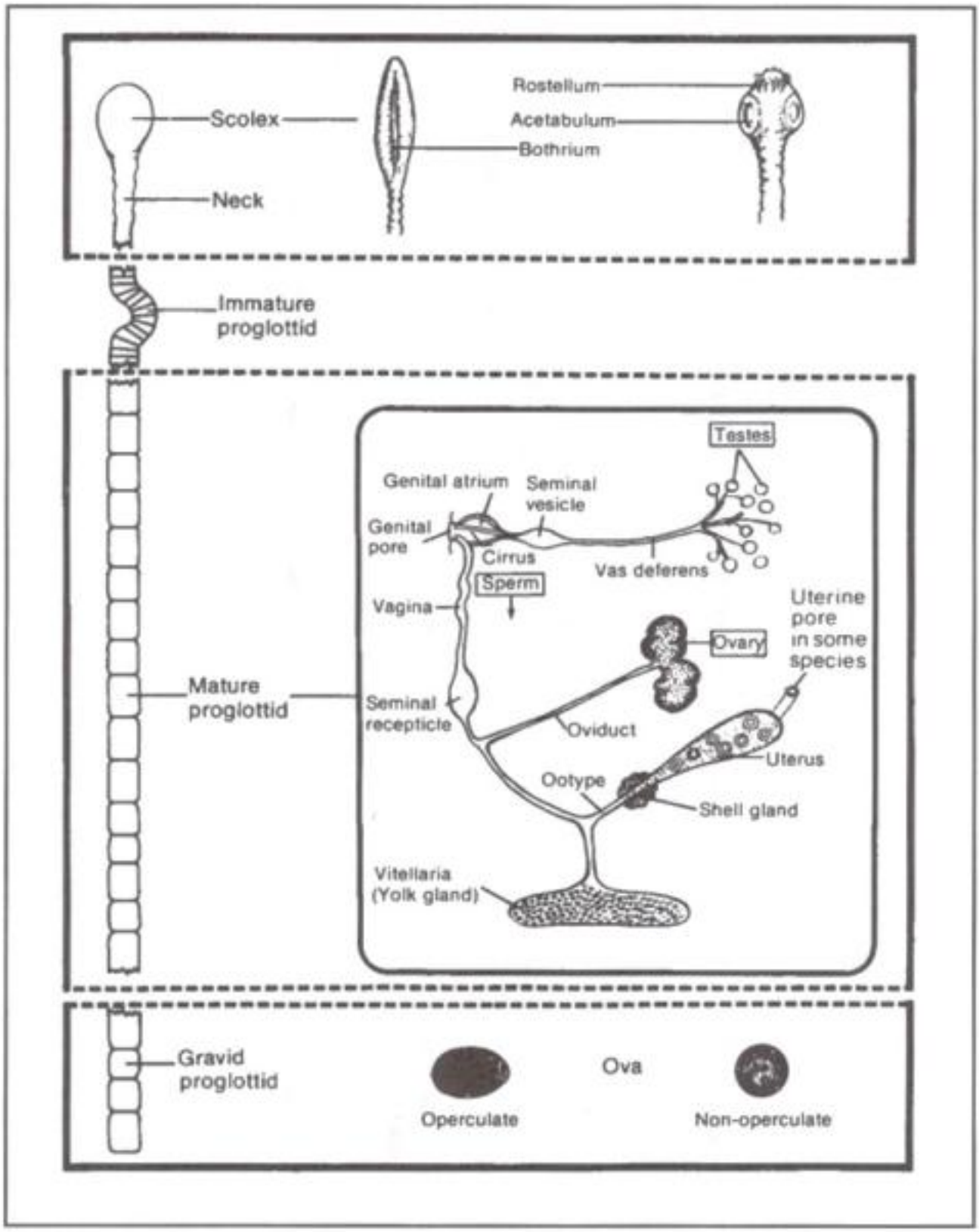

Scolex
Neck
Rostellum
Acetabulum
Bothrium
Immature proglottid
Mature proglottid
Testes
Genital atrium
Seminal vesicle
Genital pore
Cirrus
Vas deferens
Sperm
Vagina
Ovary
Uterine pore in some species
Seminal recepticle
Oviduct
Uterus
Ootype
Shell gland
Vitellaria (Yolk gland)
Gravid proglottid
Ova
Operculate
Non-operculate

Figure 5: Structure of tapeworms.

Taenia saginata (Beef Tapeworm)

- ***Taenia species*** is causative agents of taeniosis and cysticercosis.

- **Taeniosis** is a small intestine infection of humans caused by ***Taenia*** species. In the case of ***T. saginata,*** the intermediate hosts are cattle, in the musculature of which metacestodes (cysticerci) develop and can be ingested by humans who eat raw beef.

- ***T. saginata*** grows as long as 10 m and has a scolex with four suckers but a rostellum and hooks are lacking.

- The proglottids at the posterior end of the chain are longer than wide and each contains a treelike branched uterus containing 80 000–100 000 eggs (gravid segments). The eggs are small (diameter approx. 30–40 µm) and round.

Figure 2: ***Taenia saginata*** **proglottid stained to show uterine branches.**

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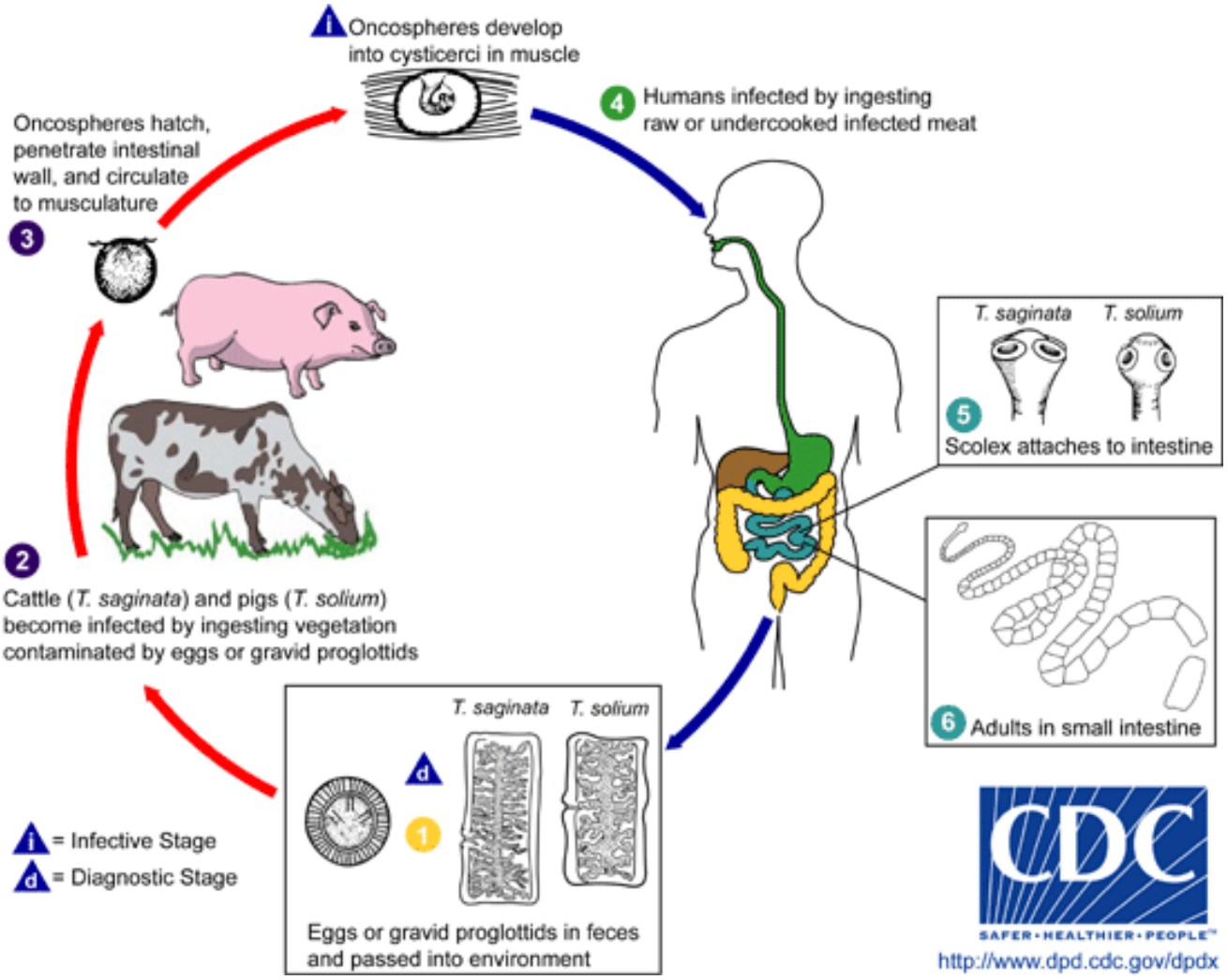
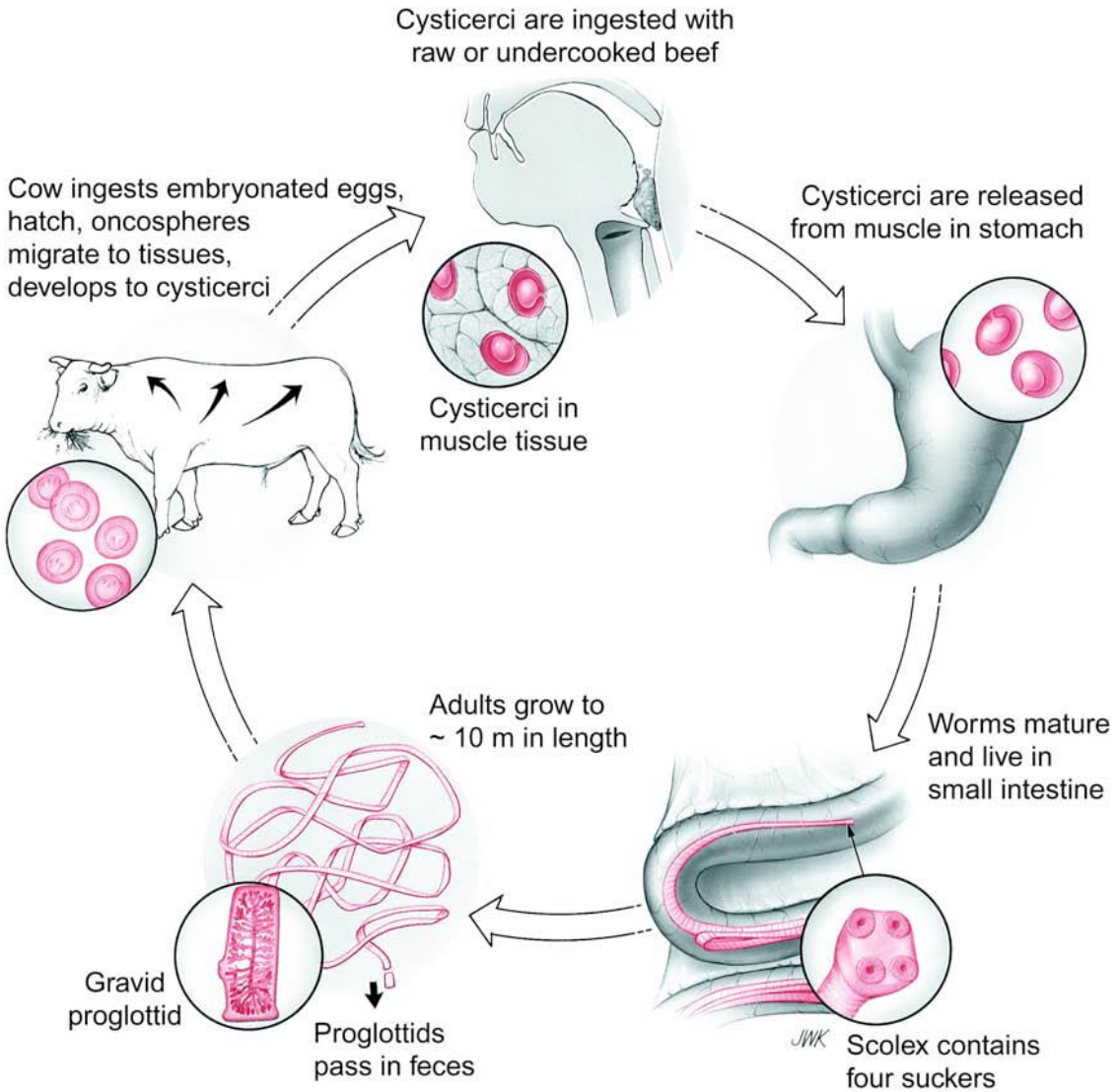


Figure 3: The Life Cycle of *T. saginata*.

Taenia saginata



Pathogenesis and Clinical Manifestation

- In some infected persons, ***T. saginata*** causes morphological changes (villus deformation, enterocyte proliferation, cellular mucosal infiltration) and functional disturbances. Blood eosinophilia may occur sometimes.

- Symptoms of infection include nausea, vomiting, upper abdominal pains, diarrhea or constipation and increased or decreased appetite.

Nematodes (Round Worms

The General Characteristics of Round Worms

1. The nematodes are threadlike, non segmented parasites, a few mm to 1m in length live in salt water, fresh water and the soil. Many of them are harmful to man as they are parasites.
2. They are cylindrical in structure and taper towards their anterior and posterior ends.
3. They possess a complex tegument and a digestive tract. The body wall is composed of an outer cuticle that has a noncellular, chemically complex structure, a thin hypodermis, and musculature.
4. They are bilaterally symmetrical.
5. Have a tubular alimentary tract that extends from the mouth of the anterior end to the anus at the posterior end.
6. The sexes are separate in most species, a few are hermaphrodite. The males are usually smaller than the females.
7. These worms divided into those that dwell within the gastrointestinal tract and those that parasite that blood and tissue of humans. Those in the gastrointestinal tract generally do not require intermediate hosts.
8. Nematode parasites of domestic animals vary greatly in size ranging from small hair-like worms (up to 2 cm long) in the Super family **Trichostrongyloidea** to large, robust worms (up to 40 cm long) in the Super family Ascaridoidea.

Ascaris lumbricoides **(Large Roundworm)**

- ***Ascaris lumbricoides*** - Causative agent of ascariosis**.** This infection is caused by the large roundworm of humans *Ascaris lumbricoides*. *A. lumbricoides* can also infect domestic and wild pigs, apes, etc.

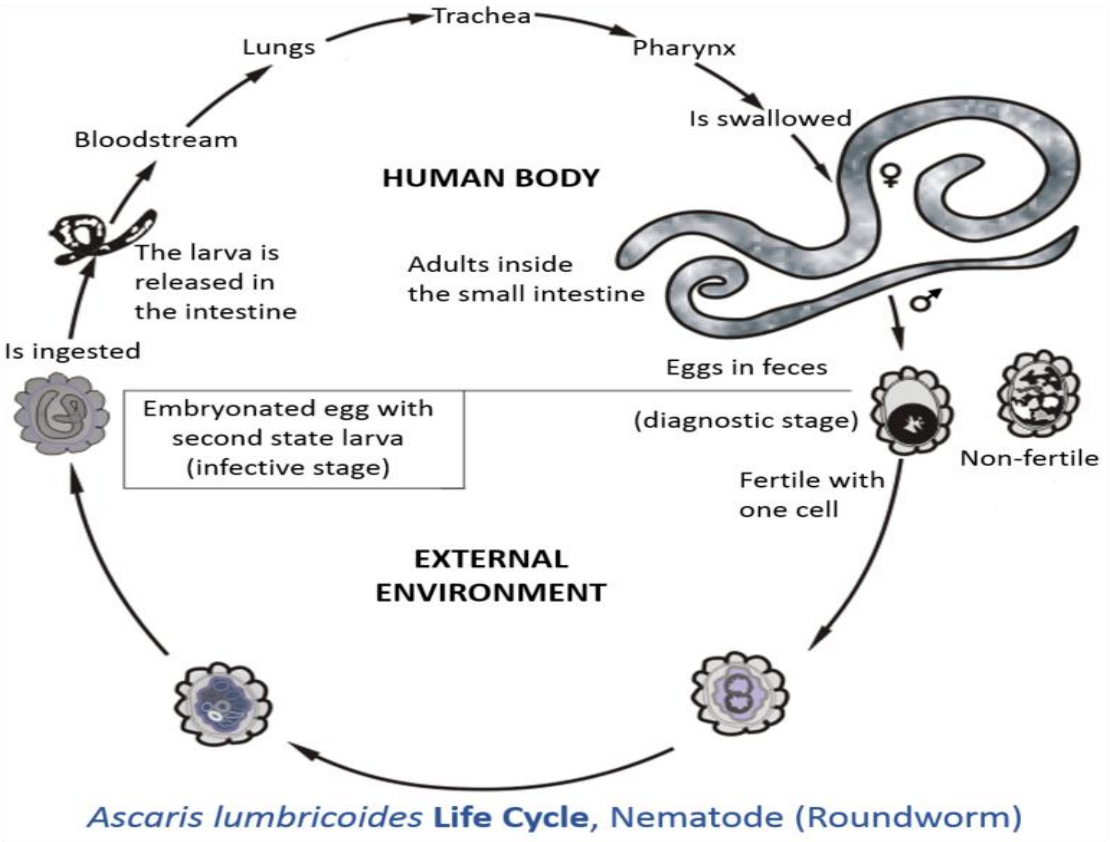
- The human large roundworm occurs worldwide. The number of infected persons is estimated at 1.38 billion (WHO, 1998). The main endemic regions include countries in Southeast Asia, Africa, and Latin America.
- Female worms reach a length of about 20-35 cm, males of 15-30 cm. Males can be distinguished by the coiled posterior end.

Figure 5: Male and female Ascaris.

Life Cycle of *Ascaris lumbricoides*

The adult ascarids living in the small intestine (ascaris: worm) are 15–40 cm in length. The sexually mature females produce as many as 200 000 eggs per day, which are shed with feces. At optimum temperatures of 20–25 C with sufficient moisture and oxygen, an infective larva in the egg develops within about three to six weeks.

Human infections result from peroral ingestion of eggs containing larvae, which hatch in the upper small intestine and penetrate into the veins of the intestinal wall. They first migrate hematogenously into the liver, and then into the lungs, where they leave the capillary network and migrate into the alveoli. Via tracheopharyngeal (the bronchus and trachea) migration they finally reach the digestive tract, where they further differentiate into adults in the small intestine.



Pathogenicity and clinical features

Adult worms in the intestine cause abdominal pain and may cause intestinal obstruction especially in children. Larvae in the lungs may cause inflammation of the lungs (Loeffler's syndrome) – pneumonia-like symptoms.

Infective stage and modes of infection:

The egg containing larva when ingested with contaminated raw vegetables causes ascariasis.

HOOK WORMS

Ancylostoma duodenale:

Grayish-white in color. The body is slightly ventrally curved. The anterior end follows the body curvature. The buccal cavity is provided ventrally with pairs of teeth and dorsally with a notched dental plate.

Distribution: This species is found in the northern part of the world including China, Japan, Europe, North Africa and Ethiopia.

Morphology

Male: The male measures 10 cm in length. The posterior end is broadened into a membraneous copulatory bursa that is provided with two long spicules.

Female: The female measures 12 cm in length. The posterior end is straight.

INTESTINAL NEMATODES WITHOUT TISSUE STAGE

ENTEROBIUS VERMICULARIS (PIN WORM OR THREAD WORM)

Enterobius vermicularis is a small white worm with thread-like appearance. The worm causes enterobiasis. Infection is common in children.

Morphology

Male: The male measures 5 cm in length. The posterior end is curved and carries a single copulatory spicule.

Female: The female measures 13 cm in length. The posterior end is straight.

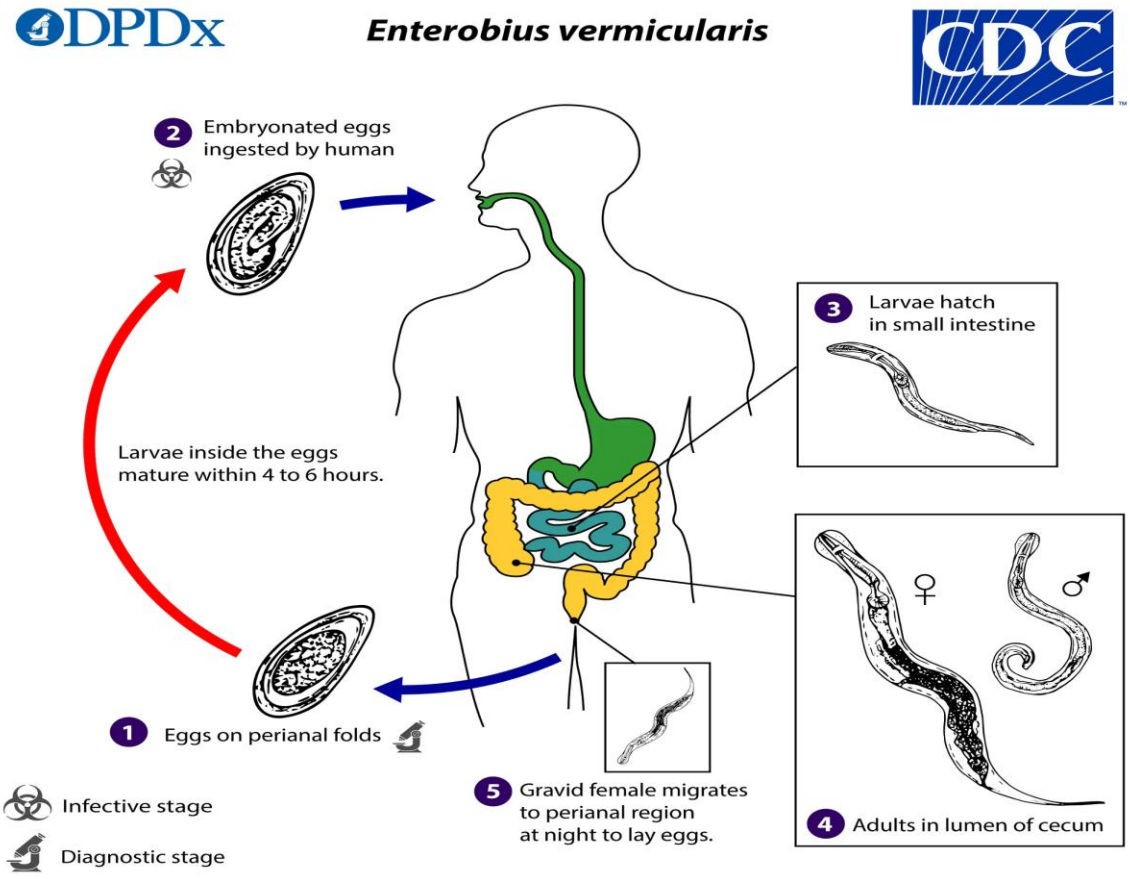
Infective stage :Infection is by ingestion of eggs containing larvae with contaminated raw vegetables.

Mode of infection:

By direct infection from a patient (Fecal-oral routeAutoinfection: the eggs are infective as soon as they are passed by the female worm. If the hands of the patient get contaminated with these eggs, he/she will infect him/herself again and again.

Aerosol inhalation from contaminated sheets and dust.

Adult worm lives in the large intestine. After fertilization, the male dies and the female moves out through the anus to glue its eggs on the peri-anal skin. This takes place by night. The egg is 50x25 microns, plano-convex and contains larva. When the eggs are swallowed, they hatch in the small intestine and the larvae migrate to the large intestine to become adult.



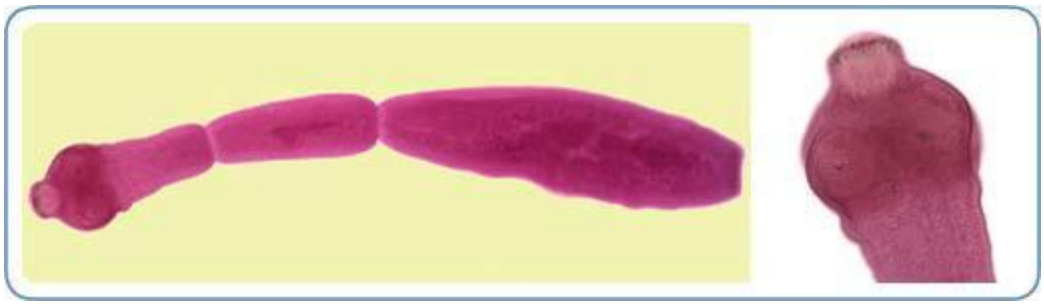
Clinical presentation

The migration of the worms causes allergic reactions around the anus and during night it causes nocturnal itching (pruritus ani) and enuresis. The worms may obstruct the appendix causing appendicitis.

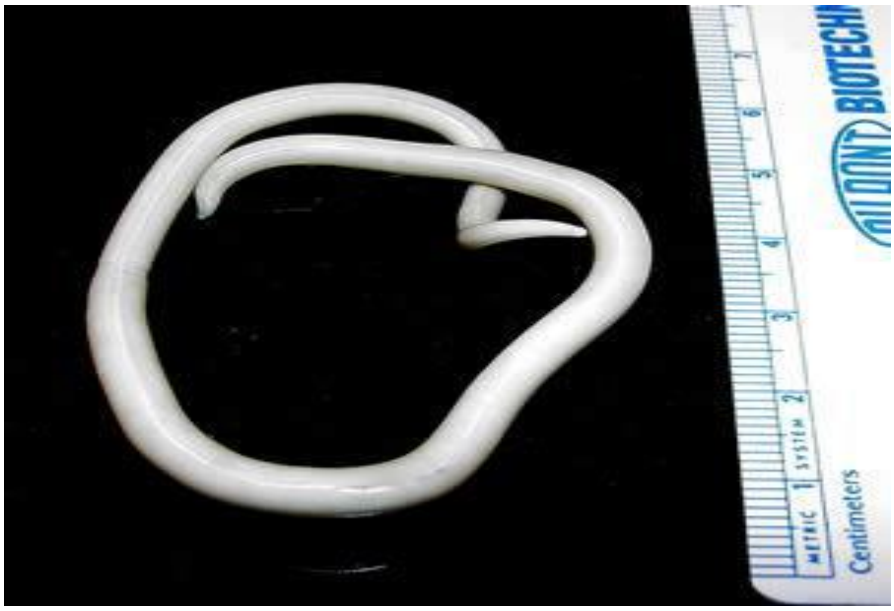
Classification and General Characters of parasites

Parasites form part of the animal kingdom which include about 800,000 identified, species categorized into 33 phyla. The most acceptable taxonomic classification of human parasites includes Endoparasites and Ectoparasites. Endoparasites are sub-classified into Helminthic parasites (multicellular organisms) and Protozoan parasites (unicellular organisms). Helminthic parasites are either flat worms (Trematodes), segmented worms (Cestodes) or cylindrical worms (Nematodes).

A Trematode worm, *Fasciola hepatica*



A Cestode worm, *Echinococcus granulosus*



A Nematode worm, *Ascaris lumbricoides*

Endoparasites

Most parasites of humans live inside the host (endo- means internal). These are helminthes (worms of various types), protozoa, or sometimes larval stages of arthropods (insects, mites, etc. Both helminthic and protozoan parasites can infect different tissues and organs of the human body. A great number of endoparasites live in the intestines, or at least pass through the intestines, having been swallowed in food or water.

Virtually any organ can be affected, however some parasites like Trichinella spp. and Toxoplasma gondii live in muscles, larvae of Echinococcus spp. and liver flukes occupy the liver, Schistosoma hematobium targets the urinary bladder and most of the protozoan parasites circulate in blood.

Ectoparasites

Human ectoparasites live on the host (ecto- means outside of). They include fleas, lice,mosquitoes, bugs, mites, ticks etc. In general, ectoparasites attach to the skin to feed and remain on the host for their entire lives. Many ectoparasites are known to be vectors of pathogens, which the parasites typically transmit to host while feeding.

Pediculus humanus capitis (male) as an example of

Life cycle

Parasitic life cycles occur in a variety of forms, all involving the exploitation of one or more hosts. Those that must infect more than one host species to complete their life cycles are said to have complex or indirect life cycles, while those that infect a single species have direct life cycles.

Life cycles differ greatly between major types of parasites and are generally classified as direct or indirect. Direct life cycles do not require an intermediate host. For direct life cycles, only a definitive host is required: the species in which the parasite reaches sexual maturity and produces progeny. Indirect life cycles may involve one or more intermediate hosts. Intermediate hosts are required by the parasite for completion of its life cycle because of the morphological and physiological changes that usually take place in the parasite within those hosts.

Infective stage of parasites

The infective stage is the part of the life cycle of the parasite, which upon its contact with the host cause the infection. The stage vary according to different parasites.These included the following stages:

1-Egg or ovum: which enters with the food or drink as in the case of some intestinal worms.

2-Larva: which enters the host through its skin as in Ancylostoma ,or blood as in Wuchsrcria,or meet as in Taenia,or vegetables as in Fasciola.

3-Cyst: which enters through the food or water as in the case of Entamoeba histolytica.

4-Adult : as in the case of lice.

Sources of infection

Is the way in which the infective stage of the parasites become in contact with the host to perform the infection.

1-**Soil**: the direct contact with the soil gives the possibility for the establishment of som parasitic infection as eggof som worms and cyst of som protozoa.

2-**Water**:water contaminated with cyst, eggs and larvae of some parasites through drinking, swimming, washing.Diseases in whichwater is considered as the source of infection are known as waterborne diseases.

3-**Food(plant and animal)**:the infective stage of many parasites are found in the food. Diseases for which food is considered as the source of infection are known as foodborne diseases.

4-Blood- sucking animals:many blood sucking insects, mites, ticks and leeches are considered as sources of infection when such animals feed on human or animals blood and hence transmit the concerned parasite.

5-**Wild and domestic animals**: cats, dogs, birds…ect.play important role in spreading the infection with many parasitic diseases through their direct or indirect contact with human. Some of wild and domestic animals act as final, intermediate, carrier, vector or reservoir hosts for many parasites.

6-**Fomites:** Hair combs and brushes,tooth brushes, cloths, vaginal specula, syringes….ect,have important role in introducing some parasites to new hosts as in case of human lice, Entamoeba gingivalis and Trichomonas vaginalis.

Entries and Exits of infection

The infective stages enter host body or leave it through one or more of the following portals**:**

1- mouth as in case of most intestinal parasites.

2-Skin as in case of bilharzial and malarial parasites.

3-Nose as in some cases of infection with the pinworm.

4-Urino-genital tract as in Trichomonas vaginalis.

5-Placenta as in the cases of Toxoplasma gondii from the infected pregnant woman to her fetus.

6-Blood transfusion and organ transplantation as in some cases of

Zoonoses

Zoonoses are the diseases, which are naturally transmitted from animals to human and vice versa.

Introduction to Parasittology

Parasitology is the science which deals with the study of parasites, their hosts, and the relationship between them. One of the largest fields in parasitology, **medical parasitology**

Medical parasitology is the subject which deals with the parasites that infect man, the diseases caused by them, clinical picture and the response generated by man against them. It's also concerned with the various methods of their diagnosis, treatment and finally their prevention & control.

Importance of parasitology

1-Public health importance: some parasites infect human and may cause death or pathological changes in the body.

2- Economic importance: some parasites infect animals and cause economic loos or may cause direct or/ and indirect harm to human.

-some parasites infect plants and cause economic loos or cause indirect harm to human.

3-Control:some parasites can be used as tools for the biological control of some harmful animals or pests.

A parasite is defined as an organisms that lives on or within another organism called the host , derives sustenance from it and is pathogenic to the host..

Types of Parasites

parasites classified according to the following criteria:

1- According to their presence within the hosts

a- Ectoparasites(external parasites):are found on the external surface of their hosts as in the presence of human lice on skin

b- Endoparasites(internal parasites):are found in viscera,coeloma ,muscles of their hosts such as in tapeworms found in small intestine

2- According to the nature of living

a- An obligatory parasite that is completely dependent on its host and can't survive without it e.g. hookworms.

b- A facultative parasite that can change its life style between free-living in the environment and parasitic according to the surrounding conditions. e.g. Strongyloides stercoralis.

c- An accidental parasite that affects an unusual host e.g. Toxocara canis (a dog parasite) in man.

3- According to their duration with their hosts

a- A temporary parasite that visits the host only for feeding and then leaves it. e.g. Bed bug visiting man for a blood meal

b- A permanent parasite that lives in or on its host without leaving it e.g. Lice.

c- An opportunistic parasite that is capable of producing disease in an immunedeficienthost (like AIDS and cancer patients). In the immuno-competent host, it is either found in a latent form or causes a self limiting disease e.g. Toxoplasma gondii.

4- According to their affinity with their hosts

a- Intraspecific parasites:both the parasites and the hosts belong to the same species such as in human fetus

b- Interspecific parasites:parasite belongs to a species and its host belongs to another species such as in the majority of parasites

c- A zoonotic parasite that primarily infects animals and is transmittable to humans.e.g. Fasciola species

Types of Hosts

Hosts are classified according to their role in the life cycle of the parasite into:

1-Definitive host (DH) that harbours the adult or sexually mature stages of the parasite or in whom sexual reproduction occurs) e.g. man is DH for Schistosoma haematobium, while female Anopheles mosquito is DH for Plasmodium species malaria parasites.

2- Intermediate host (IH) that harbours larval or sexually immature stages of the parasite (or in whom asexual reproduction occurs) e.g. man is IH of malaria parasites. tapeworms and other parasitic flatworms have complex life-cycles, in which specific developmental stages are completed in a sequence of several different hosts.

3- Carrier host is a person or animal with asymptomatic infection that can be transmitted to another susceptible person or animal .

4-Reservoir host (RH) refers to a living (human, animal, insect, or plant) or non-living (soil, water) entity where a disease-causing organism can

normally live and multiply. It maintains the life cycle of the parasite in nature and is therefore, a source of infection for man. e.g. sheep are RH for Fasciola hepatica. Hosts often do not get the disease carried by the pathogen.

5- Transport host in whom the parasite does not undergo any development but remains alive and infective to another host. Paratenic hosts bridge gap between the intermediate and definitive hosts. For example, dogs and pigs may carry hookworm eggs from one place to another, but the eggs do not hatch or pass through any development in these animals.

6-Vector host is an arthropod that transmits parasites from one host to another, e.g. female sand fly transmits Leishmania parasites.

Host-Parasite Relationship

The term refers to the relationship between the host and the parasite and the competition for supremacy that takes place between them.

Types of Symbiotic Association:

•**Mutualism** is a relationship in which both partners benefit from the association. Mutualism is usually obligatory, since in most cases physiological dependence has evolved to such a degree that one mutual cannot survive without the other Blood-sucking leeches cannot digest blood, and overcome that by harbouring certain intestinal bacterial species to do the digestion for their hosts. At least 20% of insect species، as well as many mites, spiders, crustaceans, and nematodes, are mutually.

•**Commensalism**: in which one partner benefits from the association، but the host is neither helped nor harmed. Commensalism may be facultative, in the sense that the commensal may not be required to participate in an

association to survive Humans harbor several species of commensal protozoans, that colonize in the intestinal tract such as *Entamoeba dispar*, *Entamoeba hartmanni*.

•**Parasitism**: is a relationship between two different organisms where one of the organisms actually harms the other through the relationship. The organism that is harming the other one is called a parasite. parasites are different from predators in that the host of a parasite is not necessarily killed. Fleas or ticks that live on dogs and cats are parasites. They are living off of the blood of the host animal.. However, in some cases, then impact of parasites on a host is great enough to cause disease, and in extreme cases, the death of the host may also occur.

Human amoebas, *E. histolytica , E coli, E gingivalis*

1-Entamoeba histolytica

The Morphology and physiological properties of *E. histolytica* are:

1. The trophozoites are microaerophilic dwell in the lumen or wall of the colon.
2. Feed on bacteria and tissue cells.
3. *Entamoeba histolytica* is the most causative agent of the worldwide occurring amoebiasis, a disease particularly prevalent in warmer countries. The infection is transmitted from one human to another by:
    - Contaminated food and water with infective stage (mature cysts).
    - Carrier (Asymptomatic cyst passers), especially those working in food handling and processing.

Life cycle

The *E. histolytica* life-cycle is relatively simple and consists of an infective cyst and an invasive trophozoite form.

- The trophozoite of *E. histolytica* is 10–60 μm in diameter, granular, vacuolated endoplasm, clear ectoplasm with finger like pseudopods, and containing a single nucleus with a central karyosome.

- The cyst of *E. histolytica* contains a single nucleus, a glycogen vacuole, and one or more large, cigar-shape ribosomal clusters known as chromatoid bars or bodies. The mature cyst is 10–15 μm in diameter and contains four or fewer nuclei. The quadrinucleate cyst that is excreted with feces.

- Following oral ingestion of *E. histolytica* cyst, excystation of the cyst occurs in the intestine where the cyst undergoes nuclear and cytoplasmic division to form eight uninucleate trophozoites. The trophozoites can then colonize or invade the large intestine mucosa or lumen, and penetrate into the intestinal wall and invade the liver and other organs hematogenously to produce clinical forms of amoebiasis, as shown in figure 2.

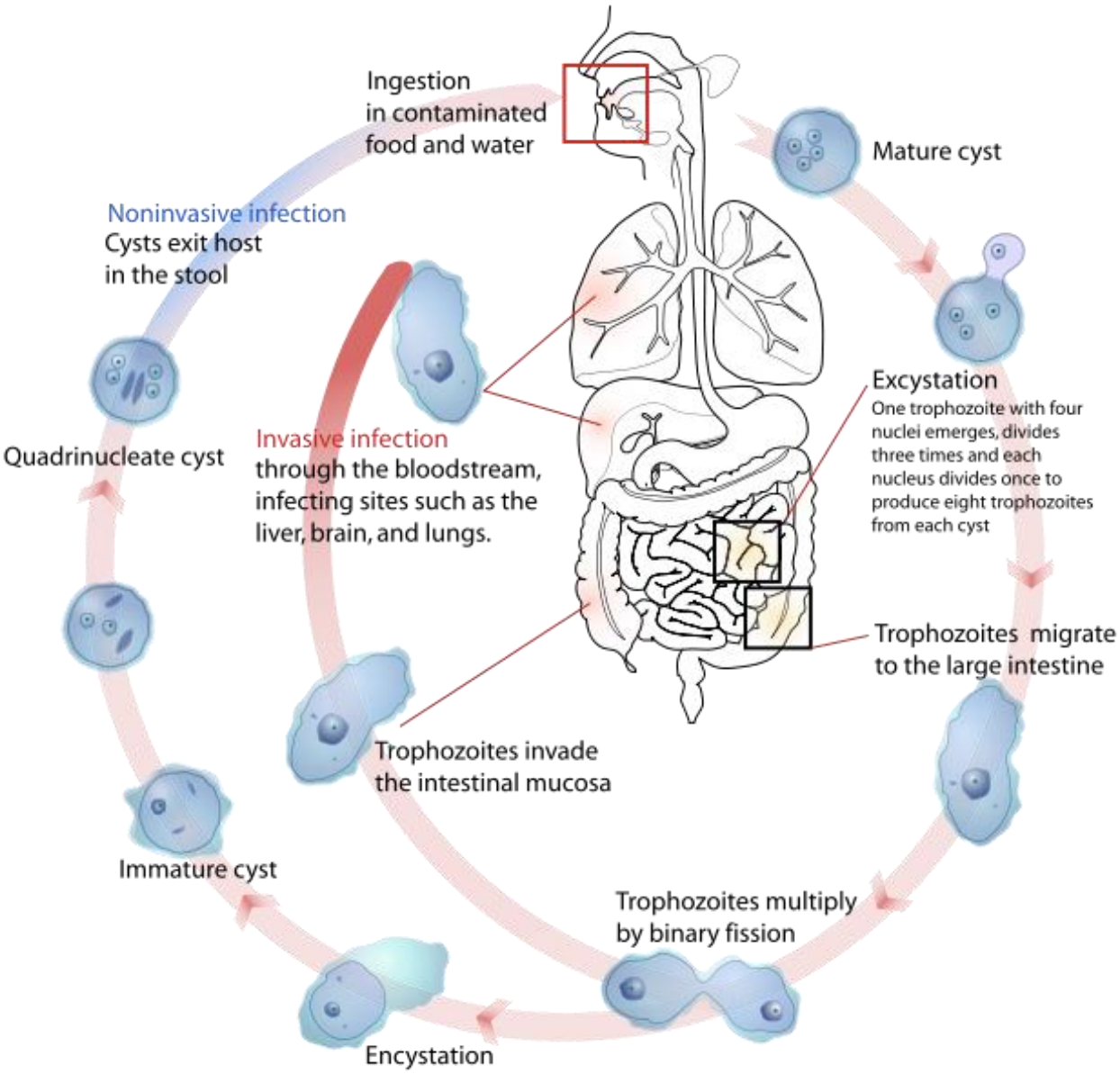


Figure 2 : The life cycle of *E. histolytica*

Pathogenicity and Symptoms

Infections of *E. histolytica* vary in intensity from asymptomatic to severe or fatal invasions.

1- Intestinal amoebiasis: The trophozoites come in contact with mucosa, secrete proteolysis enzyme, which enable them to penetrate the epithelium and begin moving deeper. The intestinal lesion spreads in the intestinal wall as a duct like ulcer. Through these ulcers, blood escapes to the intestine lumen to demonstrate the important sign of amoebiasis. Trophozoite carried out by blood and lymph to form secondary lesion throughout the body

2- Extracellular amoebiasis: Invasive forms cause secondary lesion mainly in liver (hepatic or liver amoebiasis) ,in lung(pulmonary or lung amoebiasis),in brain, spleen. If trophozoites penetrate the intestinal wall, serious problems can occur, including liver abscesses, or spread to the lungs and brain, usually resulting in death.

Signs and symptoms

Only about 10% to 20% of people infected with *E. histolytica* become ill. Even then, symptoms are often mild. They can include diarrhea, stomach pain, and stomach cramping. **A severe form of amoebiasis** called amebic dysentery can cause stomach pain, bloody poop, and fever.

Prevention

To prevent spreading the infection to others, one should take care of personal hygiene. Always wash your hands with soap and water after using the toilet and before eating or preparing food.

2. Entamoeba coli

1. *Entamoeba coli* is a non-pathogenic species of *Entamoeba*.

2. The life-cycle of *E. coli* is identical to that of *E. histolytica*, and the two organisms are found concurrently in 10– 30% of patients in an endemic area.

3. Cysts of *E. coli* are rounded, 10 - 35 μm in diameter with 1 - 8 nuclei. Whereas *E. histolytica* cysts usually have fewer than five nuclei and are 10–15 μm in diameter.

4. Trophpozoits of *E. coli* are less active than *E. histolytica* trophpzoites with short, wide pseudopodia, and 15 - 50 μm in diameter, ectoplasm is not differerntiated from endoplasm. Karyosome is slightly large eccentric.

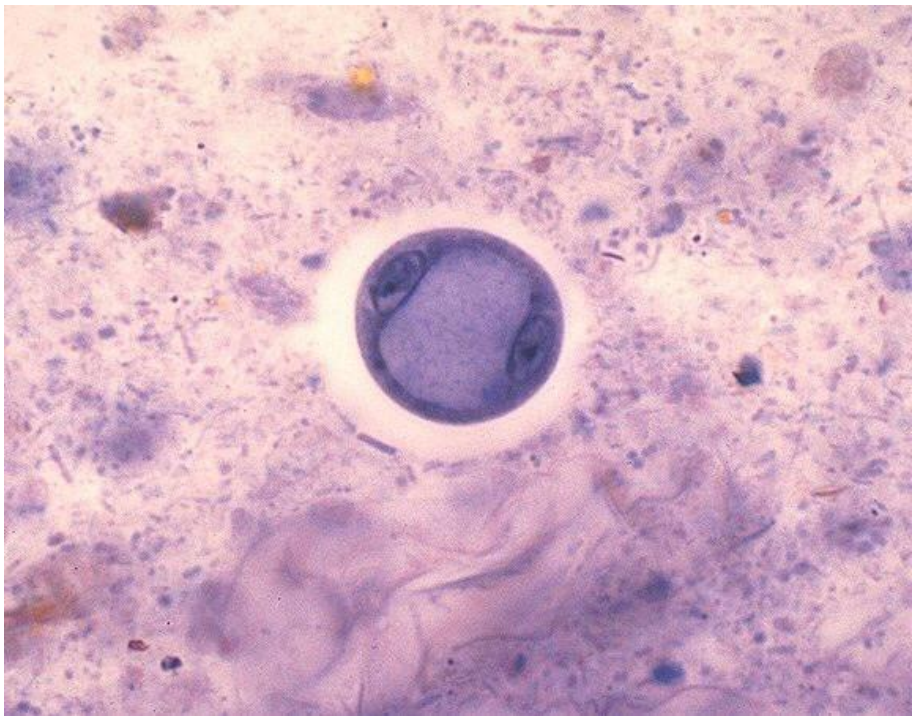


Figure 3: ***Entamoeba coli***

Entamoeba gingivalis

1- *Entamoeba gingivalis* is a non-pathogenic protozoa and is known to be the first amoeba in humans to be described. It is found only in the mouth between the gingival pockets and near the base of the teeth.

2- *Entamoeba gingivalis* is found in 95% of people with gum disease and in 50% of people with healthy gums.

3- The cyst formation is not present, therefore transmission is occurs through the droplets of saliva, direct from one person to another by kissing, or by sharing eating utensils.

4- Only the trophozoites are formed and the size is usually 10 micrometer to 20 micrometer in diameter and morphologically resembles that of E. histolytica.

5- *Entamoeba gingivalis* trophozoites have active motility by numerous pseudopods. The single nucleus contains a central karyosome surrounded by peripheral chromatine. Ectoplasm differentiated from endoplasm. Endoplasm contain many food vacuoles, some of them contain ingested white blood cells and epithelia cells. It is non-pathogenic and isolated from healthy mouth but mainly it is isolated from diseased mouth with oral abscesses dental carries and other inflammatory conditions in the mouth. In addition, the *E. gingivalis* trophozoites have been known to inhabit the tonsillar crypts and the bronchial mucus.

Flagellates-Protozoan

Mostly unicellular organisms, that possess, at some time in the life cycle, one to many flagella for locomotion and sensation. (A flagellum is a hair like structure capable of whip like lashing movements that furnish locomotion(.Mastigophora (the flagellates): Inhabit the mouth، bloodstream، gastrointestinal، or urogenital tracts.

Morphological Characteristics

1- Flagellum(ae) - organelles of locomotion; anextension of ectoplasm; moves with a whip-like motion.
2- Axostyle - a supporting mechanism, a rod-shaped structure; not all flagellates have these.
3- Undulating membrane - a protoplasmic membrane with a flagellar rim extending out like a fin along the outer edge of the body of some flagellates.
4- Costa - a thin, firm rod-like structure running along the base of the undulating membrane. Cytosome – a rudimentary mouth; also referred to as a gullet

Identification of a flagellate is based upon:

1- Size.
2- Shape.
3- Motility.
4- Number and morphology of nuclei.
5- Number and location of flagella.
6- Location in the body of the host.

Flagellates are classified according to their occurrence in their vertebrate host body

1- intestinal and atrial flagellates which live in the alimentary canal and the urinogenital tract.
2- Blood and tissue flagellates which live in the blood, lymph and tissue of the host.

Intestinal and atrial flagellates

•Giardia intestinalis (G.lamblia)

1- Is a flagellate protozoan, that colonizes and reproduces in the small intestine, causing giardiasis. common to human and several other mammalian species such as dogs, cats, bovines .

2- The life cycle includes trophozoite and cyst phases. The trophozoite is pear shaped, with a broad anterior and much attenuated posterior. It is 10-12µm long and 5-7µm wide, bilaterally symmetrical, and has two nuclei. It is also relatively flattened, with a large sucking disk on the anterior ventral side, which serves as the parasite's method of attachment to the mucosa of the host. The trophozoite also has two median bodies and four pairs of flagella anterior, caudal, posterior and ventral.
3- The G. intestinalis cyst is egg-shaped, and Measures 8-14 µm by 7- 10 µm. After encystation, each organelles duplicates, so each cyst contains four nuclei, four median bodies, eight pairs of flagella--although these organelles are not arranged in any clear pattern. Upon excystation, each cyst produces two trophozoites.

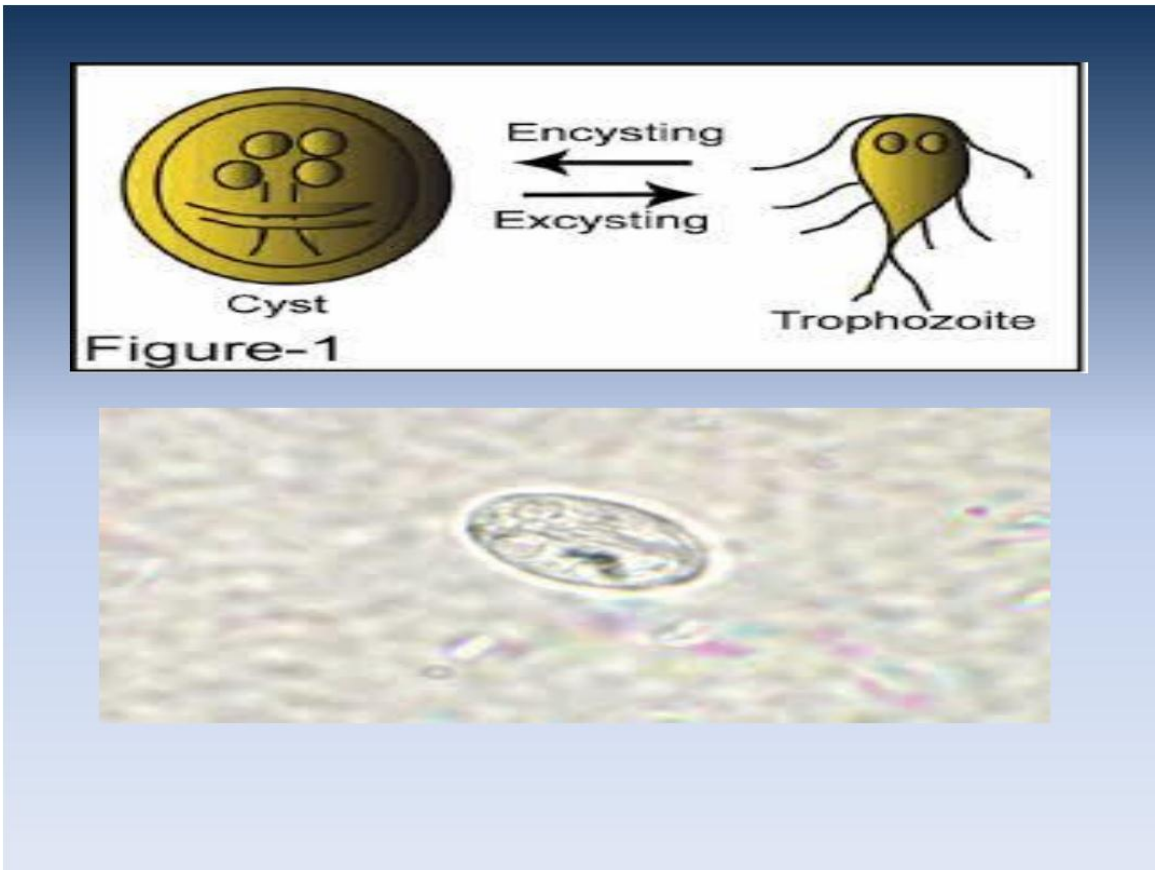


Figure-1

Life cycle

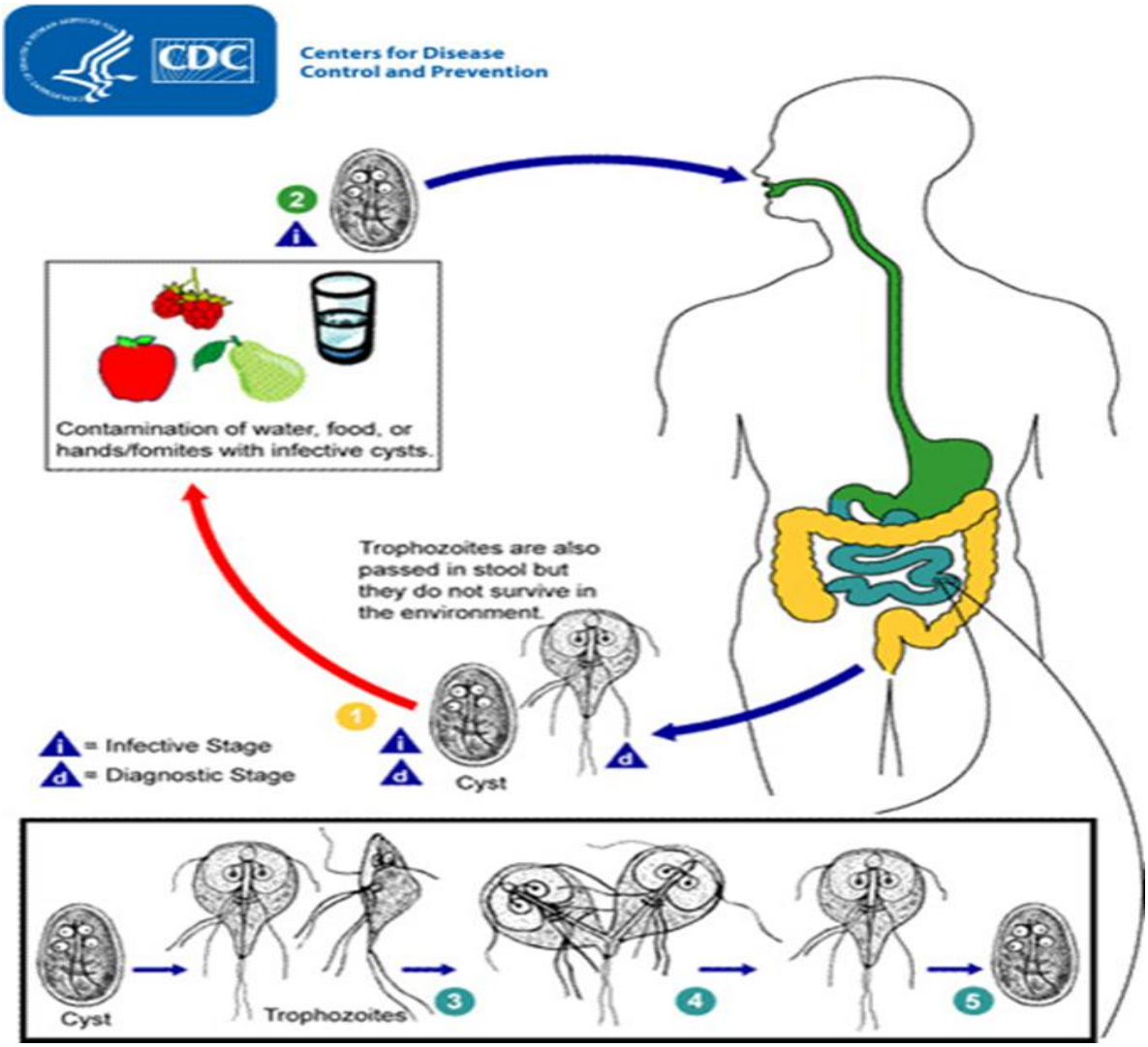
Trophozoites multiply by binary fission.Then the trophozoites encysted when the intestine contents leave the jejunum and begin to lose moisture.The encysted trophozoites undergoes another division and thus the mature cyst contain 4 nuclei.The cyst(infective stage) is passed to the environment with the feces, it is very resistant to environmental factors and can be survive more than 2 months in water at 8 C0 and about 1 month at 21 C0 and it is resistant to chlorinated ,disinfectants.

• The cyst is repeated when ingests by new host, the parasite frees it self from the cyst in the duodenum and emerges as a tetranucleate trophozoite that quickly divides into two binucleate trophozoite.

Pathogenecity

1- Infection with Giardia intestinalis can range from asymptomatic to severe diarrhea(greasy, mucous, watery but not bloody diarrhea).

2- The parasite may enter the bile duct, and the gall bladder which can cause jaundice and colic.



Trichomonas

1- Members of this genus are known as trophozoites only.

2- Trophozoite is ovoid or pear-shaped, with 3-5 anterior flagella and another flagellum curving back along the margin of undulating membrane، which is supported at its base by a flexible structure known as costa.

3- One nucleus is present in the anterior part of the body. One axostyle arise from the anterior end and extends from the posterior end as a hard spine.

Three species of Trichomonas lives in human body.

Trichomonas tenax:

1- Oral trichomonas, is a species of trichomonas found in the oral cavity of humans, dogs and cats.

2- Routine hygiene is generally not sufficient to eliminate the parasite. The parasite is frequently encountered in periodontal infections, affecting more than 50% of the population in some areas, but it is usually considered insignificant..

3- However, it is not found on healthy gums. It presence in necrotizing ulcerative gingivitis (GUN) and necrotizing ulcerative periodontitis (PUN) make it a possible pathogen worsening periodontal disease. This parasite is also present in some chronic lung diseases.

4- It is the smallest of the three Trichomonas, 6-8 µm long and 5-6 µm wide, and has a long axostyle and tail, 4 anterior flagella and a recurrent flagellum raising an undulating membrane to two third of the body.

5- It feeds on microorganisms and cellular debris.

6- Transmission is direct, usually by kissing or common use of eating and drinking utensils.

Trichomonas hominas

1- T. hominis has no cystic stage. The trophozoite measures from 5-15μm in length by 7-10μm in width. The shape is pyriform and has an axostyle which runs from the nucleus down the center of the body and extends from the end of the body and undulating membrane which extends the entire length of the body and projects from the body like a free flagellum.
2- It has 4 free flagella with a recurrent fifth one and a single nucleus at the anterior end. .It lives in the large intestine and caecum. .
3- Transmission occurs by ingestion of the trophozoite with contaminated water and food.

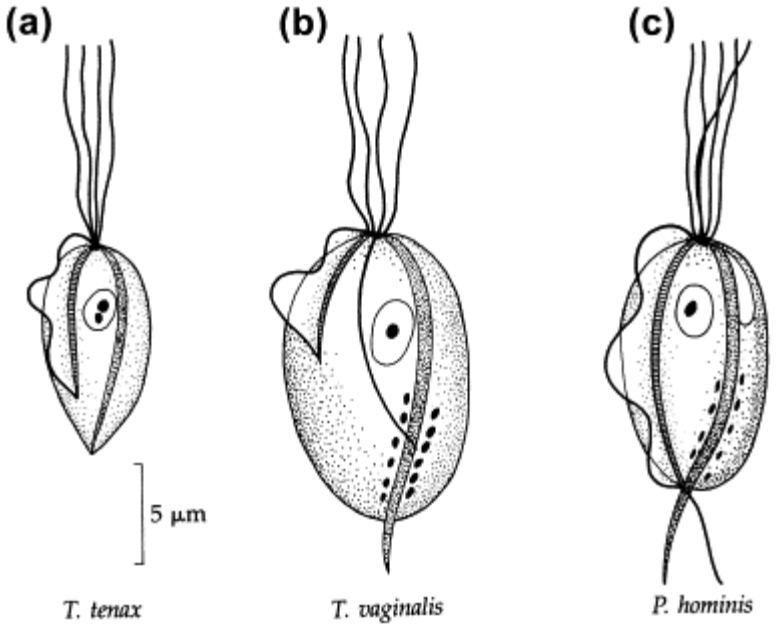
Tricomonas vaginalis

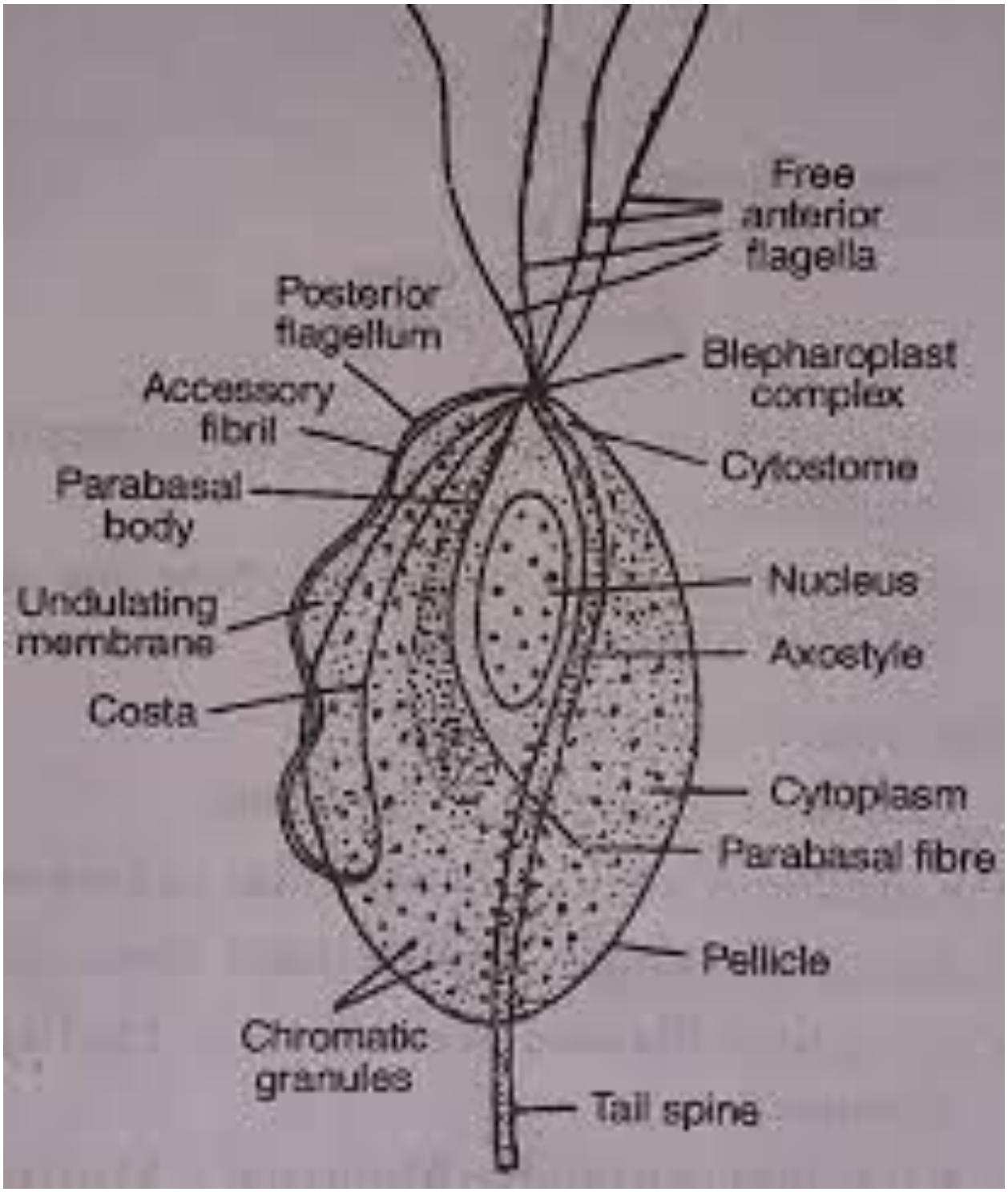
1- It is cause tricomonas vaginitis in women.
2- Both men and women are infected, the infection has spread from the vagina to other parts of the urogenital system and men remain asymptomatic.
3- T.vaginalis (pear-shaped) ranges in size from 4-32mm in length and 2-7 μm in width. It has four anterior flagella and a recurrent flagellum attached to the body by undulating membrane**.**

• Clinical signs:

• cause an inflammation of the epithelium leads to tenderness, pain, itching and excessive production of mucus, also can infect parts of the urogenital system and has been found in the bladder, ureters and kidneys.

• Men usually remain asymptomatic, but infrequently there is inflammation of the urethra and the prostate gland.


(a)
(b)
(c)
5 μm
T. tenax
T. vaginalis
P. hominis


Free anterior flagella
Posterior flagellum
Blepharoplast complex
Accessory fibril
Cytostome
Parabasal body
Nucleus
Undulating membrane
Axostyle
Costa
Cytoplasm
Parabasal fibre
Pellicle
Chromatic granules
Tail spine

Blood and tissue flagellates

Members of this group live in the blood، lymph and tissues of vertebrate hosts and complete their life cycles in the gut of blood- sucking insects and other invertebrates. They are also known as haemoflagellates. They occur in four morphological forms.

Two genera within hemoflagellates infect human which are:

• Genus Leishmania

• Genus Trypanosoma

Genus Leishmania

General characters of genus Leishmania

1- Life cycle is indirect and completed in tow hosts, vertebrate (human, dog, rodent) as a final host and invertebrate; blood sucking insect (female of sand fly) as an intermediate host (vector).

2- Tow developmental forms are found, amastigote and promastigote ,amastigote in the final host (human) and promastigote in the vector (sand fly).

3- The vector is sand fly of genus Phlebotomus.

4- Promastigote is the infective stage to final host (man) and amastigote is infective stage to sand fly (vector).

5- The parasite infects the reticuloendothelial cells of skin, mucus membrane or viscera (as liver, spleen and bone marrow) of the final host (man).

6- The parasite multiplies by binary fission (asexual).

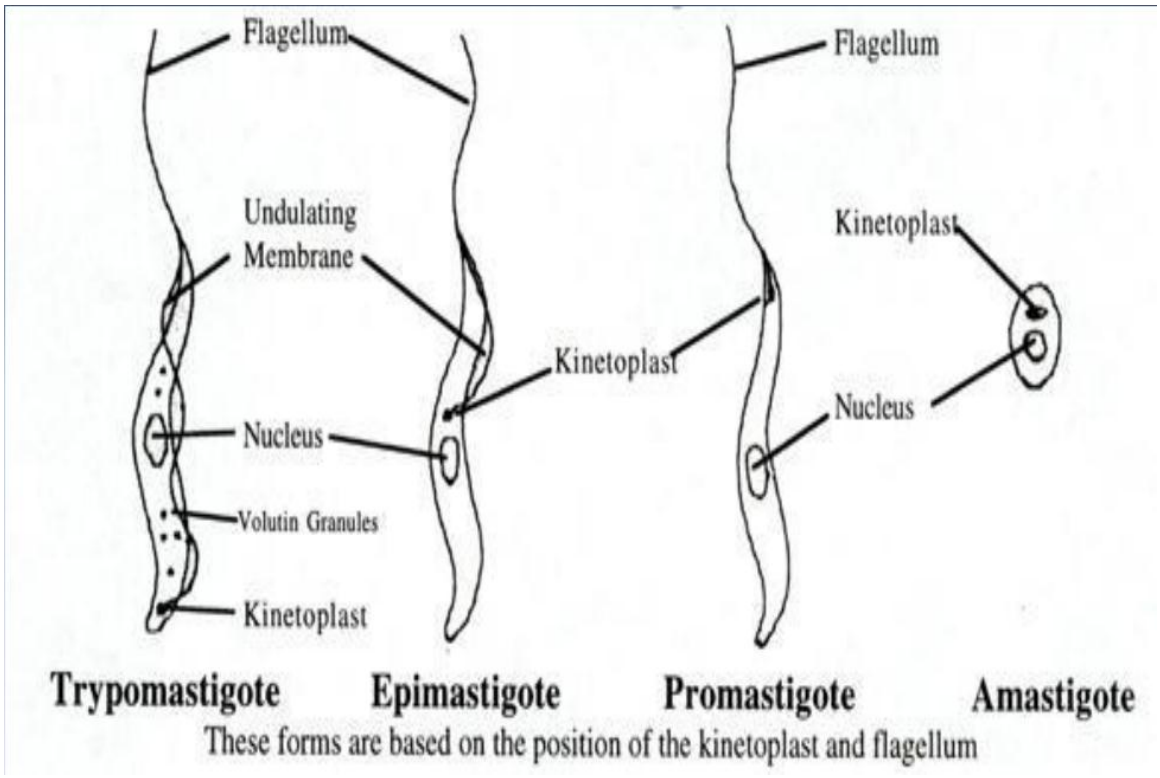
Leishmania includes parasites cause three diseases in human:

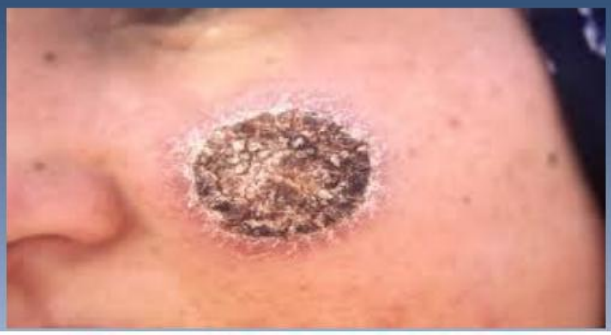
1- Leishmania tropica infects the skin and cause Cutaneous Leishmaniasis or oriented sore, Delhi boil,

Baghdad boil.(CL)

2- Lieshmania donovani infects spleen,liver , bone marrow and cause Visceral Leishmaniasis or Kala-azar black fever, and Dumdum fever (VL)

3- Leishmania braziliensis infects mucous membrane of the mouth,nose,pharynx and cause mucocutaneous Leishmaniasis(MCL).



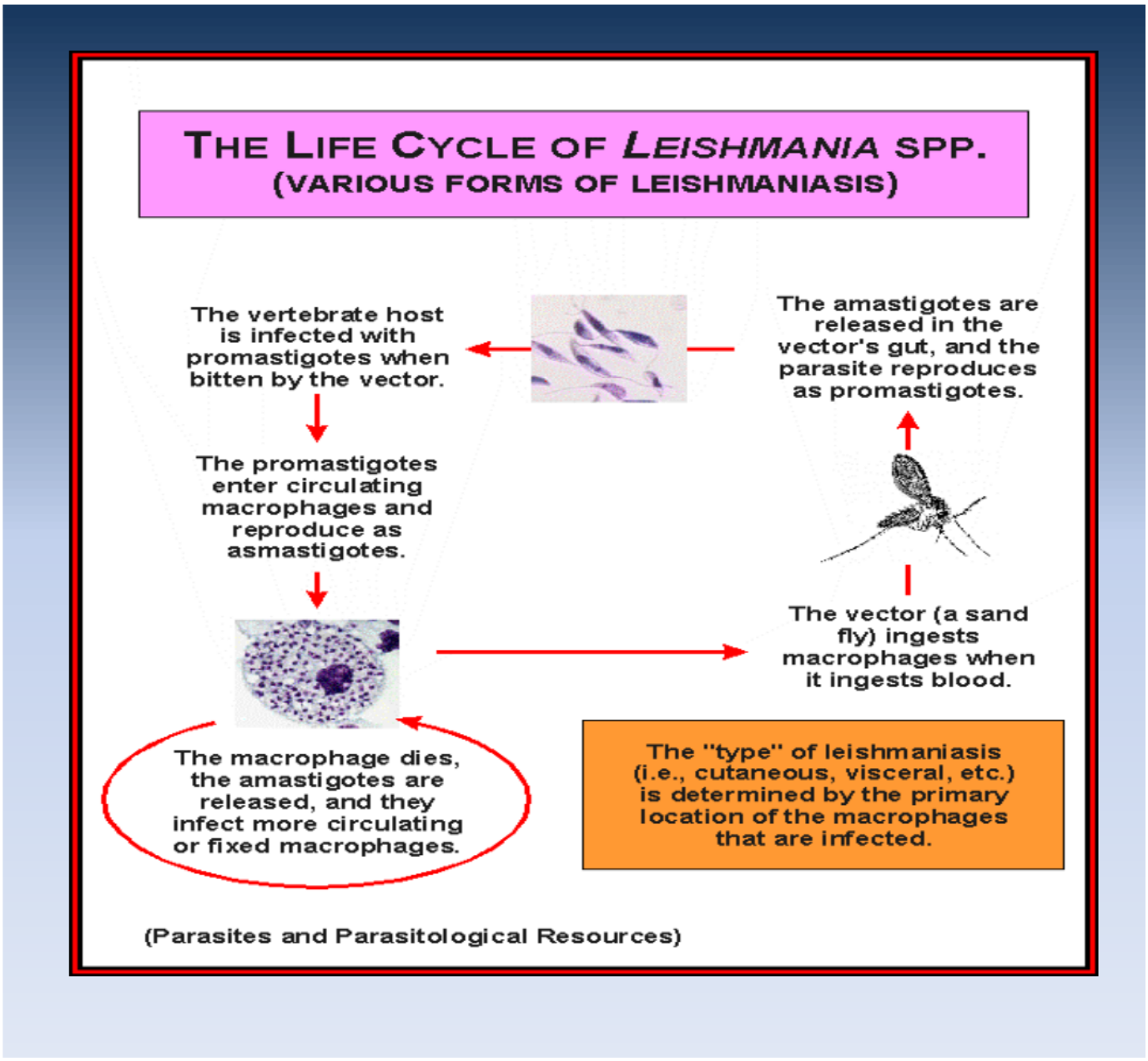


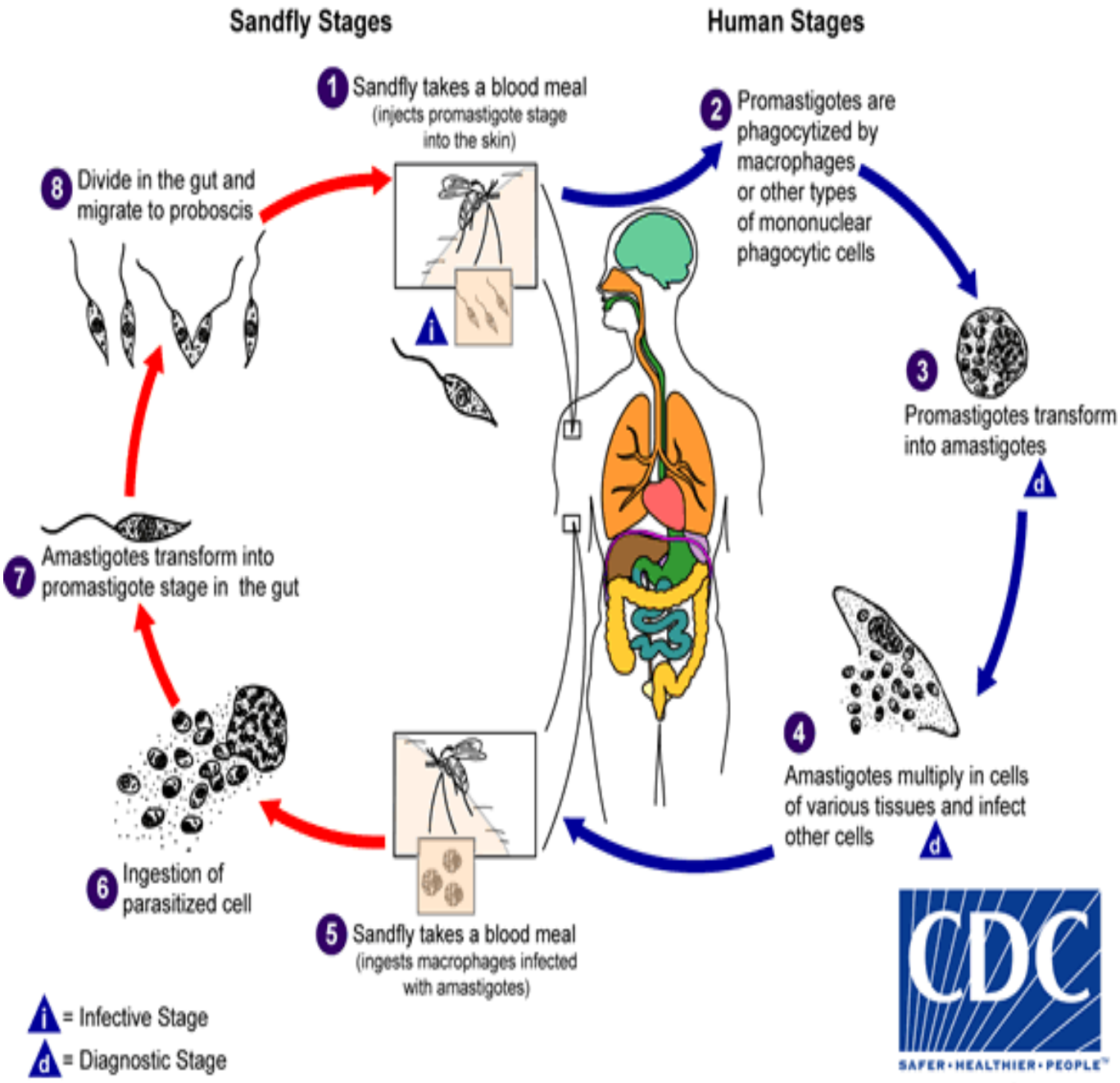
Leishmania Parasites and Diseases

SPECIES	Disease
*Leishmania tropica** *Leishmania major** *Leishmania aethiopica* *Leishmania mexicana*	Cutaneous leishmaniasis
Leishmania braziliensis	Mucocutaneous leishmaniasis
*Leishmania donovani** *Leishmania infantum** *Leishmania chagasi*	Visceral leishmaniasis

Transmission

VL is transmitted through the bite of an infected female phlebotomine sand fly, although congenital and parenteral transmission (through blood transfusions and needle sharing) have been reported.


THE LIFE CYCLE OF LEISHMANIA SPP.
(VARIOUS FORMS OF LEISHMANIASIS)
The vertebrate host is infected with promastigotes when bitten by the vector.
The promastigotes enter circulating macrophages and reproduce as asmastigotes.
The macrophage dies, the amastigotes are released, and they infect more circulating or fixed macrophages.
The amastigotes are released in the vector's gut, and the parasite reproduces as promastigotes.
The vector (a sand fly) ingests macrophages when it ingests blood.
The "type" of leishmaniasis (i.e., cutaneous, visceral, etc.) is determined by the primary location of the macrophages that are infected.
(Parasites and Parasitological Resources)


Sandfly Stages
Human Stages
1 Sandfly takes a blood meal
(injects promastigote stage
into the skin)
2 Promastigotes are
phagocytized by
macrophages
or other types
of mononuclear
phagocytic cells
3 Promastigotes transform
into amastigotes
4 Amastigotes multiply in cells
of various tissues and infect
other cells
5 Sandfly takes a blood meal
(ingests macrophages infected
with amastigotes)
6 Ingestion of
parasitized cell
7 Amastigotes transform into
promastigote stage in the gut
8 Divide in the gut and
migrate to proboscis
i = Infective Stage
d = Diagnostic Stage
CDC
SAFER·HEALTHIER·PEOPLE™

Sporozoa

The Sporozoa are parasitic protozoans that lack locomotion organs. They have no cilia, no flagella, no pseudopods, with most species presenting only glidingmotility, except for male gametes in the sexual phase,which have a flagellated stage of They are usually intracellular parasites. All species are parasitic and have indirect life cycles, often requiring more than one host. The life cycle include asexual generation(reproduces by simple or multiple fission or internal budding) alternating with sexual generation(reproduces by gametes).

Plasmodium

Four species of Plasmodium cause human malaria : **Plasmodium vivax, P.ovale, P.malaria, P.falciparum**

The final host: female Anopheles mosquito

The intermediate host: vertebrate (human)

Disease: Malaria

Infective stage: sporozoites

Mode of infection: insect biting

Life cycle

Life cycle is indirect includes two stages

A-Sexual in Anopheles

B-asexual in human

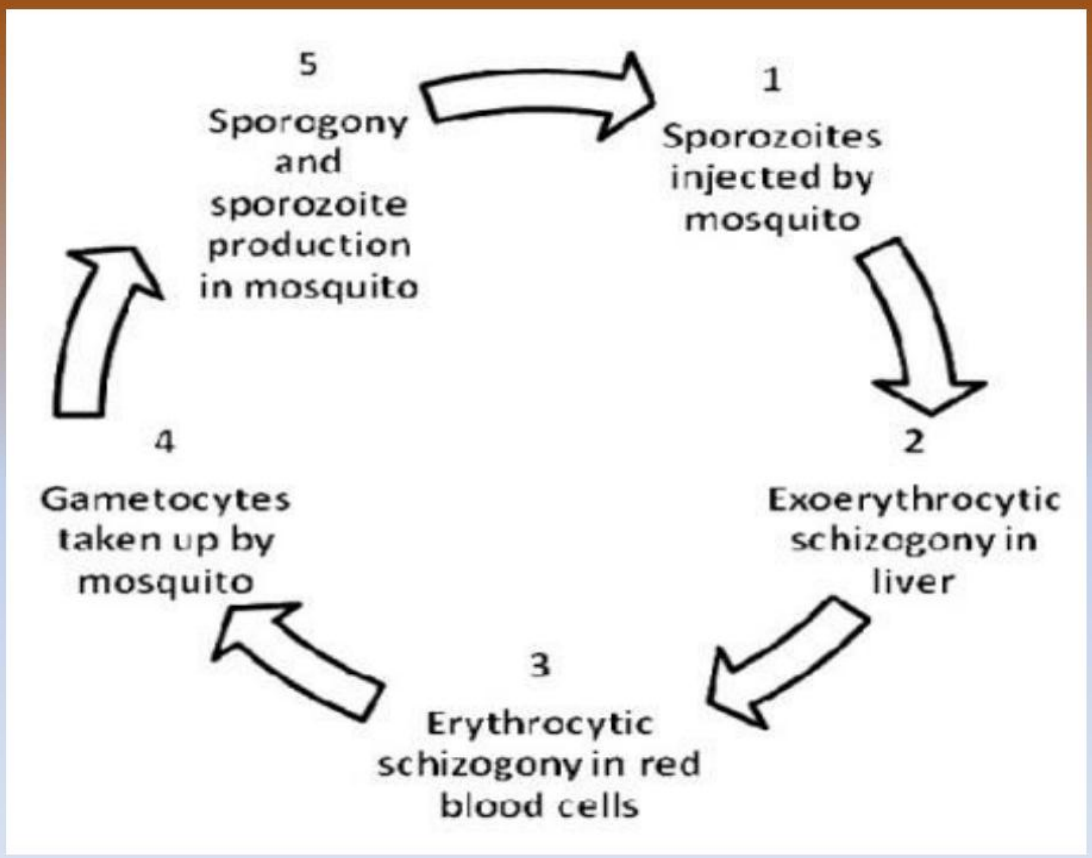
1- exoerythrocytic cycle (liver stage)

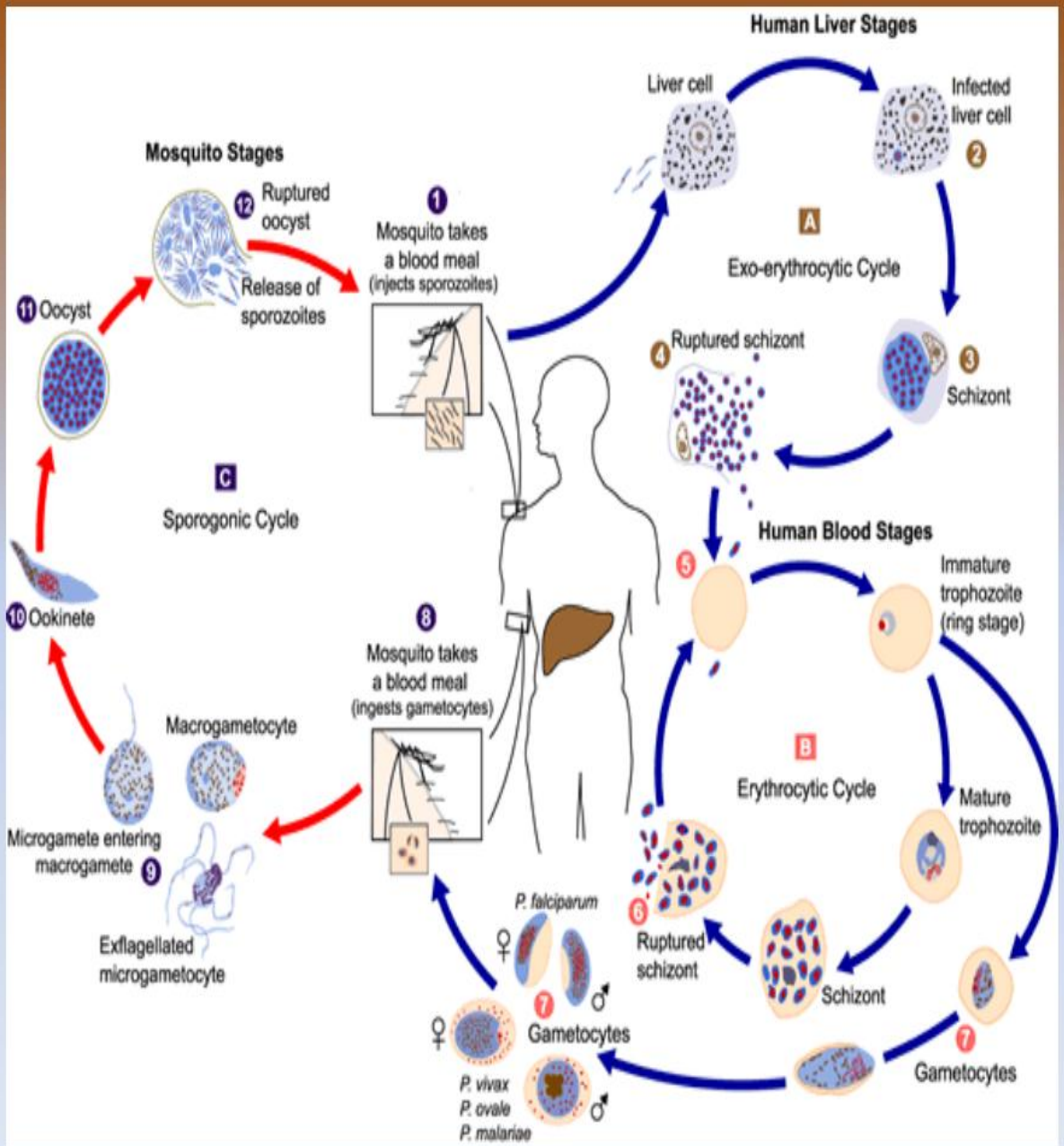
2-erythrocytic cycle in R.B.C

The infection is initiated when sporozoites are injected with the saliva of a feeding mosquito. Sporozoites are carried by the circulatory system to the liver and invade hepatocytes (1). The intracellular parasite undergoes an asexual replication known as schizogony within the hepatocyte (2-4). schizogony culminates in the production of merozoites which are released into the bloodstream (5). A proportion of the liver-stage parasites from P. vivax and P. ovale go through a dormant period instead of immediately undergoing asexual replication. These hypnozoites will reactivate several weeks to months (or years) after the primary infection and are responsible for relapses. Merozoites invade erythrocytes (6) and undergo a trophic period in which the parasite enlarges (7-8). The early trophozoite is often referred to as 'ring form' because of its morphology. Trophozoite enlargement is accompanied by an active metabolism including the ingestion of host cytoplasm and the proteolysis of hemoglobin into amino acids. The end of the trophic period is manifested by resulting a schizont (9). Merozoites are released following rupture of the infected erythrocyte (11).
Invasion of erythrocytes reinitiates another round of the blood-stage replicative cycle (6-11). The blood stage is responsible for the pathology associated with malaria .. As an alternative to the asexual replicative cycle, the parasite can differentiate into sexual forms known as macro- or microgametocytes (12).

gametocytes are taken up with the blood and mature in the mosquito gut. The male and female gametocytes fuse and form an ookinete—a fertilized, motile zygote which penetrates the gut epithelial cells and develops into an oocyst .The oocyst undergoes multiple rounds of asexual replication resulting in the production of sporozoites .

Rupture of the mature oocyst releases the sporozoites into the hemocoel (i.e., body cavity) of the mosquito .The sporozoites migrate to and invade the salivary glands, thus completing the life cycle.In summary, malaria parasites undergo three distinct asexual replicative stages (exoerythrocytic schizogony, blood stage schizogony, and sporogony) resulting in the production of invasive forms (merozoites and sporozoites).
A sexual reproduction occurs with the switch from vertebrate to invertebrate host and leads to the formation of the invasive ookinete.




Human Liver Stages
Liver cell
Infected liver cell
2
A
Exo-erythrocytic Cycle
Ruptured schizont
4
3
Schizont
Mosquito Stages
12 Ruptured oocyst
1
Mosquito takes a blood meal (injects sporozoites)
Release of sporozoites
11 Oocyst
C
Sporogonic Cycle
Human Blood Stages
5
Immature trophozoite (ring stage)
10 Ookinete
8
Mosquito takes a blood meal (ingests gametocytes)
Macrogametocyte
B
Erythrocytic Cycle
Mature trophozoite
Microgamete entering macrogamete 9
Exflagellated microgametocyte
P. falciparum
6
Ruptured schizont
Schizont
7
Gametocytes
7
Gametocytes
P. vivax
P. ovale
P. malariae

Pathogenesis

All of the pathology of malaria is due to parasites multiplying in erythrocytes. The primary attack of malaria begins with headache, fever, anorexia, malaise, and myalgia. This is followed by chills, fever, and sweating. There may be nausea, vomiting, and diarrhea. Then, depending on the species, the paroxysms tend to assume a characteristic periodicity. In P. vivax, P. ovale and P. falciparum the periodicity is 48hr and for P. malariae the periodicity is 72 hours.

Toxoplasma gondii

Final host: feline family (cats)

Intermediate host: mammals including human

Infective stage:oocyst contains sporozoites or

tissue cyst containing bradyzoites

Disease: Toxoplasmosis

Mode of infection:contaminated food and water And congenital transmission

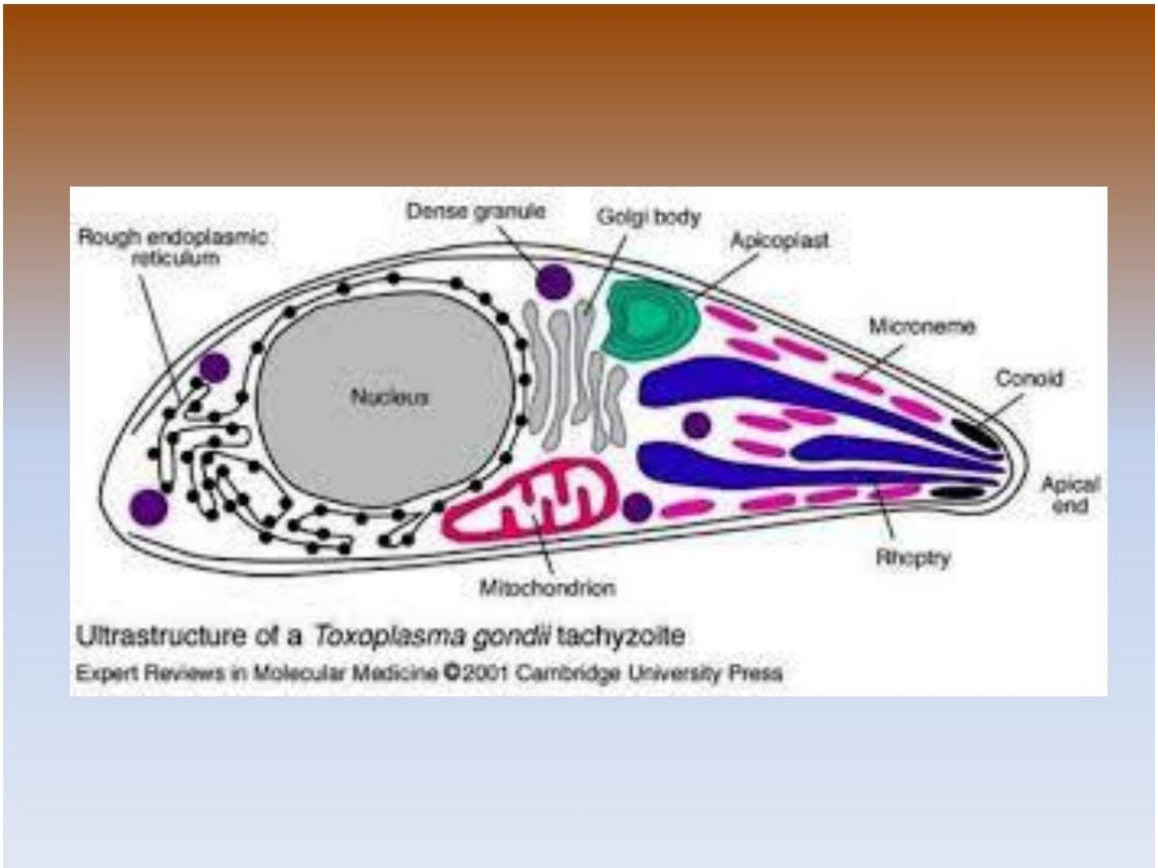
Toxoplasma gondii

Cellular stages

During different periods of its lifecycle, individual parasites convert into various cellular stages, with each stage characterized by a distinct cellular morphology, biochemistry and behavior. These stages include the tachyzoites, merozoites, bradyzoites (found in tissue cysts), and sporozoites (found in oocysts).

Tachyzoites

Tachyzoites are Motile, and quickly multiplying, responsible for expanding the population of the parasite in the host. When a host consumes a tissue cyst (containing bradyzoites) or an oocyst (containing sporozoites), the bradyzoites or sporozoites stage-convert into tachyzoites upon infecting the intestinal epithelium of the host. During the initial, acute period of infection, tachyzoites spread throughout the body via the blood stream. During the later, latent (chronic) stages of infection, tachyzoites stage-convert to bradyzoites to form tissue cysts.

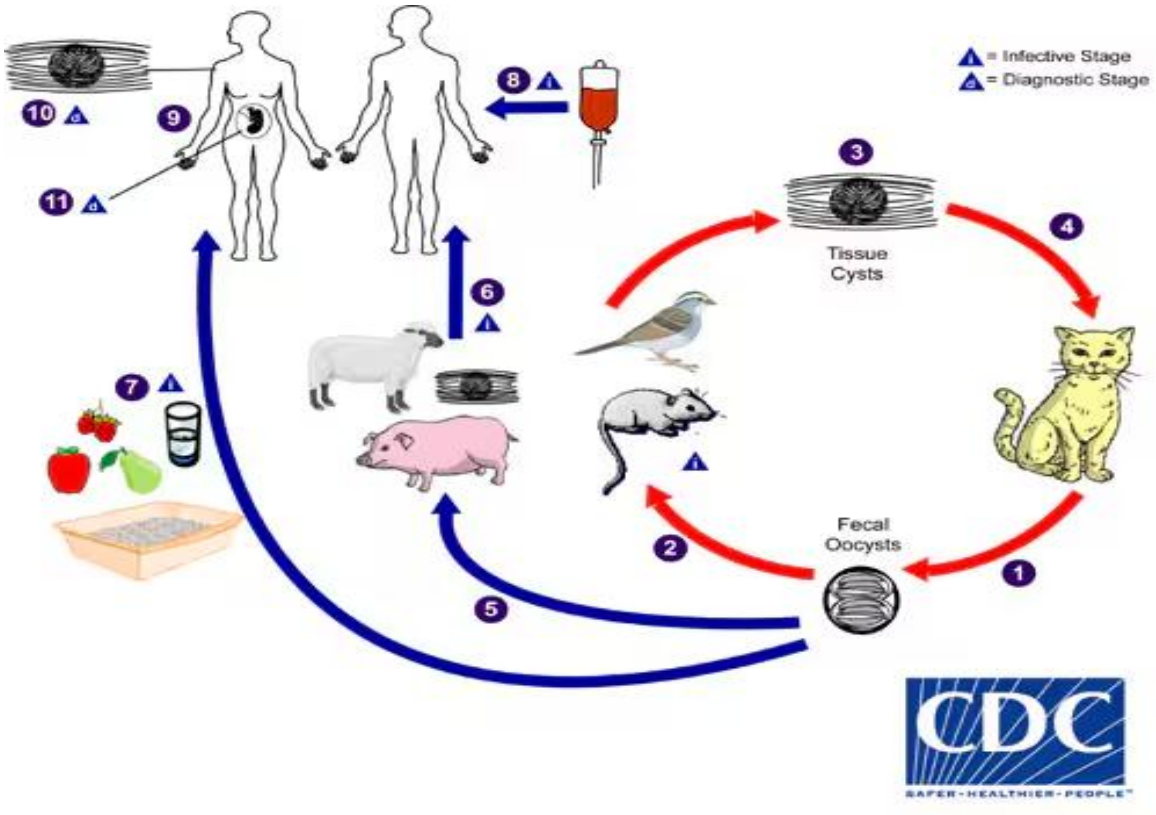


Ultrastructure of a *Toxoplasma gondii* tachyzoite

Bradyzoites

Bradyzoites are the slowly dividing stage of the parasite that make up tissue cysts. When an uninfected host consumes a tissue cyst, bradyzoites released from the cyst infect intestinal epithelial cells converting to the

tachyzoite stage. Following the initial period of proliferation throughout the host body, tachyzoites then convert back to bradyzoites, which reproduce inside host cells to form tissue cysts in the new host..



Life cycle of Toxoplasma gondii

The only known definitive hosts for Toxoplasma gondii are members of family Felidae (domestic cats and their relatives). Unsporulated oocysts are shed in the cat's feces . Although oocysts are usually only shed for 1–3 weeks, large numbers may be shed. Oocysts take 1–5 days to sporulate in the environment and become infective. Intermediate hosts in nature (including birds and rodents) become infected after ingesting soil, water or plant material contaminated with oocysts .

Oocysts transform into tachyzoites shortly after ingestion. These tachyzoites localize in neural and muscle tissue and develop into tissue cyst

bradyzoites. Cats become infected after consuming intermediate hosts harboring tissue cysts. Cats may also become infected directly by ingestion of sporulated oocysts. Animals bred for human consumption and wild game may also become infected with tissue cysts after ingestion of sporulated oocysts in the environment . Humans can become infected by any of several routes:

1-Eating undercooked meat of animals harboring tissue cysts .

2-Consuming food or water contaminated with cat feces or by contaminated

3-environmental samples (such as fecal-contaminated soil or changing the litter box of a pet cat) .

4-Blood transfusion or organ transplantation .

5-Transplacentally from mother to fetus .

In the human host, the parasites form tissue cysts, most commonly in skeletal muscle, myocardium, brain, and eyes; these cysts may remain throughout the life of the host. Diagnosis is usually achieved by serology, although tissue cysts may be observed in stained biopsy specimens . Diagnosis of congenital infections can be achieved by detecting T. gondii DNA in amniotic fluid using molecular methods such as PCR .

Pathogenesis

• Infection with Toxoplasma gondii is usually asymptomatic in healthy individuals. • About 10-20% of those with an acute infection will have enlarged lymph nodes as well as flu-like symptoms (fever, headache, muscle pain).

• The infection is generally self-limited and the symptoms usually resolve in a few months.

• Immunocomprimised persons often show involvement of the central nervous system but may also have heart and lung complications. In persons with AIDS, toxoplasmic encephalitis and brain lesions may occur.

•Congenital infection occurs if the mother is infected during pregnancy. Toxoplasma gondii tachyzoites are thought to cross the placenta to the fetus which may lead to stillbirths or severe birth defects.

•Early diagnosis and treatment of the mother may reduce the probability of congenital infection.

• Chronic infections may also lead to blindness over time as cysts in the eye develop and rupture the infected cells.

Ciliates

• Ciliates are single-celled organisms that, at some stage in their life cycle, possess cilia, short hairlike organelles used for locomotion and food gathering.

• Ciliates have one or more macronuclei and from one to several micronuclei. The macronuclei control metabolic and developmental functions; the micronuclei are necessary for reproduction .

•Reproduction is typically asexual, although sexual exchange occurs as well. Asexual replication is usually by binary fission or by budding. Sexual phenomena include conjugation (genetic exchange between individuals)

• Although most ciliates are free-living and aquatic, such as the Paramicium, some, such as the dysentery-causing Balantidium are parasitic.

Balantidium coli

• Balantidium coli is an intestinal protozoan parasite that can infect humans. It is responsible for the disease Balantidiasis .

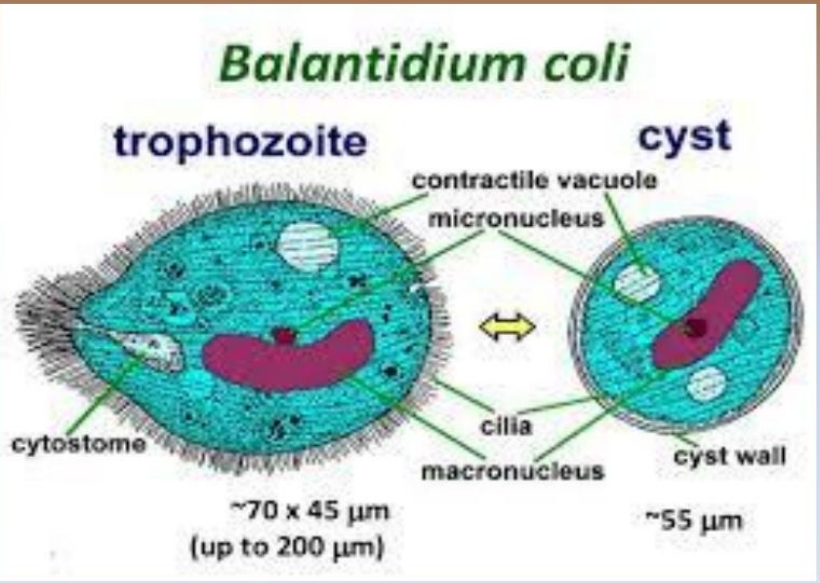
These parasites can be transmitted through the fecal-oral route by contaminated food and water. Balantidium coli infection is mostly asymptomatic, but people with other serious illnesses can experience persistent diarrhea, abdominal pain, and sometimes a perforated colon.

• Balantidium coli has two developmental stages called the trophozoite stage (reproductive stage) and the cyst stage (infectious stage).

In the trophozoite stage, Balantidium coli can measure between 50-130 µm long by 20-70 µm wide. When observing Balantidium coli unstained, it has a short ciliary covering and has spiraling motility. The two nuclei of

Balantidium coli are clearly visible, the macronucleus is a long, kidney-shaped structure while the micronucleus is spherical. The peristome, which is an opening at the anterior end of cell, is also visible. The peristome leads to the cytostome (cell mouth).

• The cyst is the infective stage, Cysts are smaller than trophozoites, measuring 40-60 □m across. Cysts are round and have a tough, heavy cyst wall made of one or two layers. Usually only the macronucleus and perhaps cilia and contractile vacuoles are visible in the cyst.



• cyst is ingested via feces-contaminated food or water, it passes through the host digestive system. The tough cyst wall allows the cyst to resist degradation in the acidic environment of the stomach and the basic

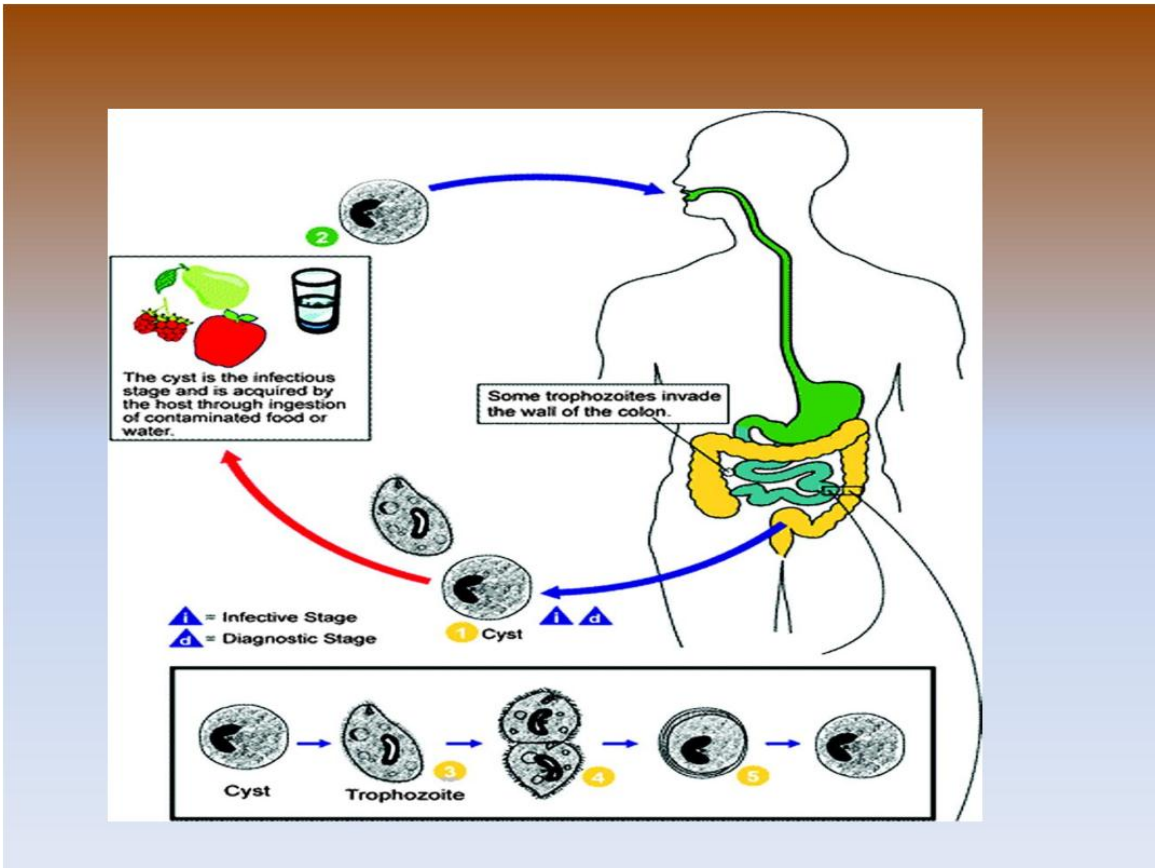
environment of the small intestine until it reaches the large intestine. There, excystation takes place. Excystation produces a trophozoite from the cyst stage.

• The motile trophozoite then resides in the lumen of the large intestine, feeding on intestinal bacterial flora and intestinal nutrients.

•Trophozoites multiply by asexual binary fission or sexual conjugation (with the exchange of nuclear material).

•The trophozoite may become invasive and penetrate the mucosa of the large intestine. Trophozoites are released with the feces, and encyst to form new cysts.

• Encystation takes place in the rectum of the host as feces are dehydrated or soon after the feces have been excreted.



General and oral Protozoa

Protozoa are eukaryotic, single-celled microorganisms with specialized organelles that enable the animals to purchase all its functions as multicellular animals metazoan do with the aid of their organs.

Structure of protozoa

1- nucleus: usually only one is present

2- Cytoplasm: which differentiated into outer cytoplasm (ectoplasm) and Inner cytoplasm (endoplasm)

Nutrition of protozoa

1- Holozoic protozoa: utilize preformed food material derived from living animals or plants, such as Amoeba

2- Saprozoic protozoa: absorb nutrients. means that

certain protozoa absorb predigested or soluble nutrients through their cell membrane

3- Holophytic protozoa :like plants(chlorophyll).

•Locomotion of protozoa

Protozoa can be move by: pseudopodia, flagella, cilia and gliding

Reproduction of protozoa

1- Sexual reproduction

a- Conjugation: two organisms exchange nuclear material during a temporary union (e.g., ciliated protozoans), and then separate.

b-Syngamy: two gametes fuse together to form zygotes (microgametes +macrogametes).

2- Asexual reproduction

a- Binary fission: the nucleus divide then the cytoplasm (1,2,4,8.16,……)

b- Multiple fission: the nucleus divide several times then the cytoplasm does.

C-Budding: two or many daughter forms are produced from the parent cell.

d-Sporogony: occurs after the sexual reproduct (syngame),a process of multiple fission ,number of sporozoites are formed within the wall of a cyst.

Four main groups of protozoa are recognized on the basis of their locomotion using specialized subcellular and cytoskeletal features

• **Amoebae** use pseudopodia (singular: pseudopodium) to creep or crawl over solid substrates. Pseudopodia (or 'false feet') are temporary thread-like or balloon-like extensions of the cell membrane into which the protoplasm streams. Similar amoeboid motion has been observed in cells of many life-forms, especially phagocytic cells (e.g. human macrophages).

Flagellates use elongate flagella singular: (flagellum) which undulates to propel the cell through liquid environments. Flagella are 'hairlike structure' extensions of the cell membrane constructed of basal body, hook and filament with an inner core of microtubules arranged in a specific 2 9 configuration (2 single central microtubules surrounded by 9 peripheral microtubules). The coordinated sliding of these microtubules confers movement. Many organisms produce flagellated cells (e.g. human spermatozoa).

Ciliates use numerous small cilia (singular: cilium) which undulate in waves allowing cells to swim in fluids. Cilia are 'hair-like' extensions of the cell membrane similar in construction to flagella but shorter and present in much

larger numbers. Ciliated cells are found in specialized tissues and organs in many other higher life- forms (e.g. human bronchial epithelial cells).

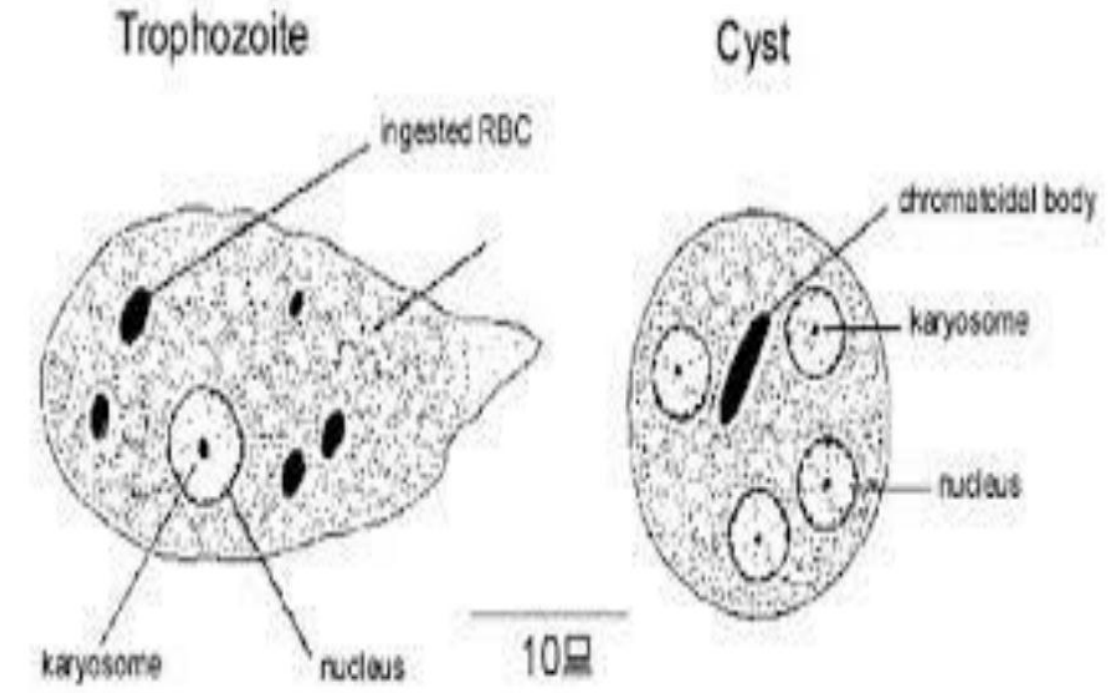
Sporozoa spore-formers(’ were originally recognized not on the basis of their locomotion‹ but because they all formed non-motile spores as transmission stages. Recent studies, however‹ have shown that many pre-spore stages move using tiny undulating waves in the cell membrane imparting a forward gliding motion‹ but the actual mechanisms involved are not yet known.

Intestinal Protozoa: Amoebas

Amoebas are unicellular organisms common in the environment: many are parasites of vertebrates and invertebrates.

General Characteristics of Amoebas

1. Amoebas are the most primitive of the protozoa.
2. Relatively few species inhabit the human intestine and produce human diseases, such as.
    1. *Entamoeba histolytica* that live in alimentary canal and able to invade tissues.
    - *Entamoeba coli*, *Entamoeba gingivalis*, *Entamoeba nana*, *Iodamoeba butschlii*, and *Dientamoeba fragilis* which unable to invade tissues, but *dwell in the canal lumen and are obligate parasites of GIT*.
    - *Naegleria fowleri* that infects human brain while swimming in contaminated waters.
3. Move by cytoplasmic organelles called pseudopodia.
4. Amoebas cysts surrounded by a chitinous and may survive for prolonged periods (for at least 12 days) under conditions that would rapidly destroy the motile trophozoite.


Trophozoite
Cyst
ingested RBC
chromatoidal body
karyosome
nucleus
karyosome
nucleus
10㎛