Lecture No.2

Branches of Biology

Microbiology

This division of biology deals with the study of microorganisms such as bacteria, viruses, fungi etc.

Hydrobiology

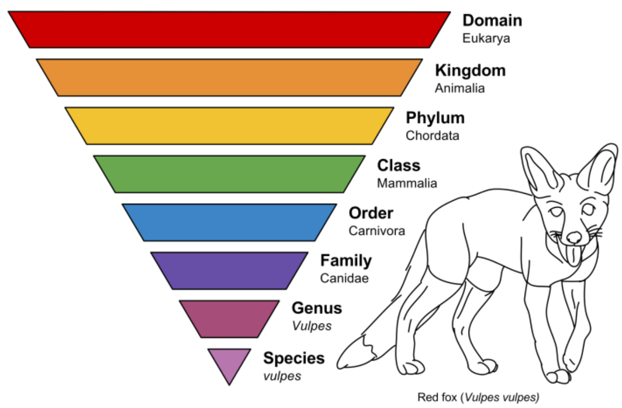
The study of life in water environment.

Cell Biology

The study of structures and functions of cells and cell organelles is called cell biology. This branch also deals with the study of cell division.

Taxonomy

Taxonomy is the science of naming, describing and classifying organisms and includes all plants, animals and microorganisms of the world.



Paleontology

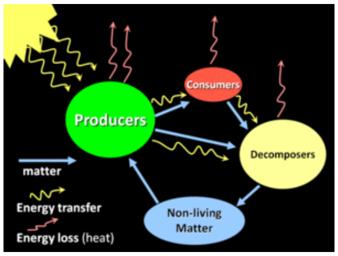
It is the study of fossils, which are the remains of extinct organisms.

Botany

This division of biology deals with the study of plants .The study of plants is vital because they underpin almost all animal life on Earth. They generate a large proportion of the oxygen and food.

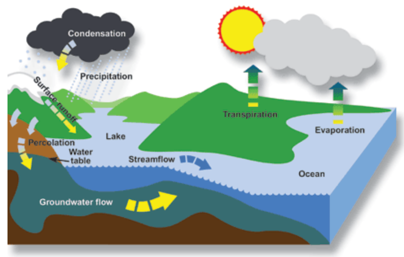
Ecology

Ecology is the study of the relationships between living organisms, including humans, and their physical environment; it seeks to understand the vital connections between plants and animals and the world around them. Ecology also provides information about the benefits of ecosystems and how we can use Earth's resources in ways that leave the environment healthy for future generations.



Limnology

Limnology **i**s the study of inland waters - lakes (both freshwater and saline), reservoirs, rivers, streams, wetlands, and groundwater - as ecological systems interacting with their drainage basins and the atmosphere. The limnological discipline integrates the functional relationships of growth, adaptation, nutrient cycles, and biological productivity with species composition, and describes and evaluates how physical, chemical, and biological environments regulate these relationships.



Marine Biology

Marine biology is the scientific study of organisms in the *ocean* or other marine or brackish bodies of water.

Zoology

Zoology is basically the branch of biology that deals with the scientific study of animals.

Entomology

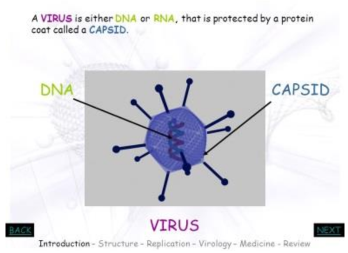
Entomology is the study of insects and their relationship to humans, the environment, and other organisms. Entomologists make great contributions to such diverse fields as agriculture, chemistry, biology, human/animal health, molecular science, criminology, and forensics.

Bacteriology

The science and study of bacteria and their relation to medicine and to other areas such as agriculture (e.g., farm animals) and industry. Bacteria are single-celled microorganisms which can live as independent organisms or, dependently, as parasites.

Virology

Virology is a branch of the sciences which focuses on the study of viruses and organisms which behave like viruses, such as prions and viroids.



Mycology

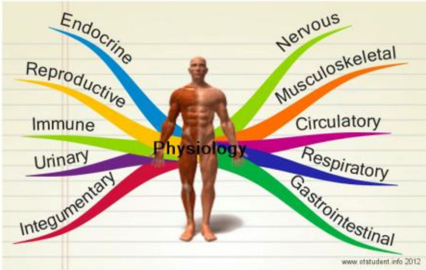
Mycology is the branch of biology concerned with the study of fungi, including their genetic and biochemical properties, their taxonomy and their use to humans as a source for tinder, medicine, food, and entheogens, as well as their dangers, such as poisoning or infection**.**

Parasitology

Parasitology is the study of parasites, their hosts, and the relationship between them.

Physiology

This branch deals with the study of the functions of different parts of living organisms.



Genetics

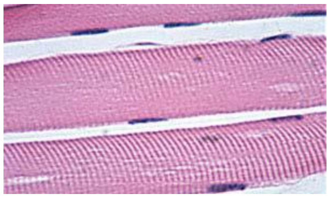
The study of genes and their roles in inheritance is called genetics. Inheritance means the transmission of characters from one generation to another.

Biotechnology

It deals with the practical application of living organisms for make substances for the welfare of mankind.

Histology

Histology is the study of the microscopic anatomy of Cells and tissues of plants and animals.

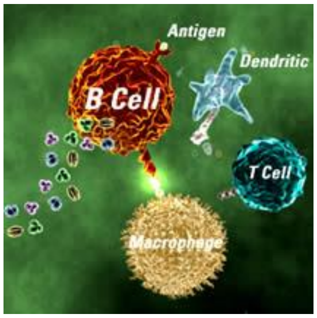


Pharmacology

It is the study of drugs and their effects on the systems of human body.

Immunology

It is the study of immune system of animals, which defend the body again invading organisms. It deals with the physiological functioning of the immune system in states of both health and diseases.



Lecture 4

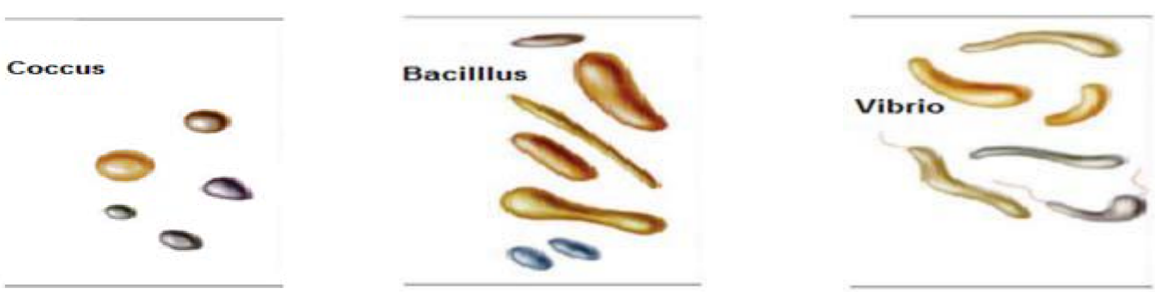
Bacteria and their Structure

Introduction of bacteria

Bacteria are single celled prokaryotic unicellular microorganisms, usually a few micrometers in length that normally exist together in millions. The cell wall of bacteria usually contains peptidoglycan and multiplies by binary fission. The cell structure is simpler than that of other organisms as there is no nucleus or membrane bound organelles. Instead their control Centre containing the genetic information is contained in a single loop of DNA. Some bacteria have an extra circle of genetic material called a plasmid. The plasmid often contains genes that give the bacterium some advantage over other bacteria. For example it may contain a gene that makes the bacterium resistant to a certain antibiotic.

Shapes of bacteria

Most bacteria are 0.2 um in diameter and 2-8 um in length. The three basic bacterial shapes are coccus (spherical), bacillus (rod-shaped), and spiral (vibrio twisted), however pleomorphic bacteria can assume several shapes.



Characteristic Groups

These bacteria can give themselves higher Level structural organizations such as

Cocci

Cocci may be oval, elongated, or flattened on one side. Cocci may remain attached after cell division. These group characteristics are often used to help identify certain cocci.

1) Cocci that remain in pairs after dividing are called diplococci.

2) Cocci that remain in chains after dividing are called streptococci.

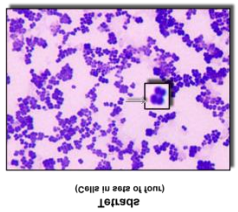
3) Cocci that divide in two planes and remain in groups of four are called tetrads.

4) Cocci that divide in three planes and remain in groups cube like groups of eight are called sarcinae.

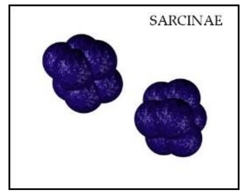
5) Cocci that divide in multiple planes and form grape like clusters or sheets are called staphylococci.

Diplococci

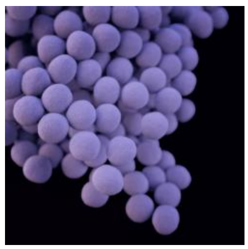
Streptococci



Tetrads



Sarcinae



Staphylococci

Bacilli

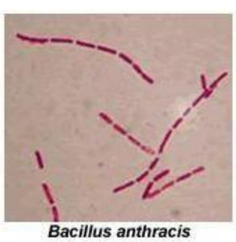
Bacilli only divide across their short axis there are fewer groupings. Bacillus is a shape (rod shaped) but there is also a genus of bacteria with the name *Bacillus*.

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

2) Streptobacilli appear in chains after division.

3) Some bacilli are so short and fat that they look like cocci and are referred to as coccobacilli.

Diplobacilli



Streptobacilli

Coccobaciili

Spiral bacteria

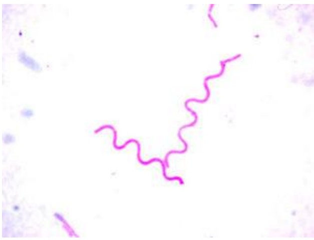
Spiral bacteria have one or more twists.

1) Vibrios look like curved rods.

2) Spirilla have a helical shape and fairly rigid bodies.

3) Spirochetes have a helical shape and flexible bodies. Spirochetes move by means of axial filaments, which look like flagella contained beneath a flexible external sheath.

Vibrio's



Spirilum

Spirochetes

Structure of bacteria

The bacterial structure is composed of following components. These are

1) Cell wall
2) Plasma membrane
3) Cytoplasm
4) Ribosomes
5) Plasmid
6) Flagella
7) Pilli
8) Capsule

1) Cell wall

Cell walls of bacteria are made up of glycoprotein murein.The main function of cell wall is it helps in providing support, mechanical strength and rigidity to cell. It protects cell from bursting in a hypotonic medium.

Two distinct structural types of cell wall known as:

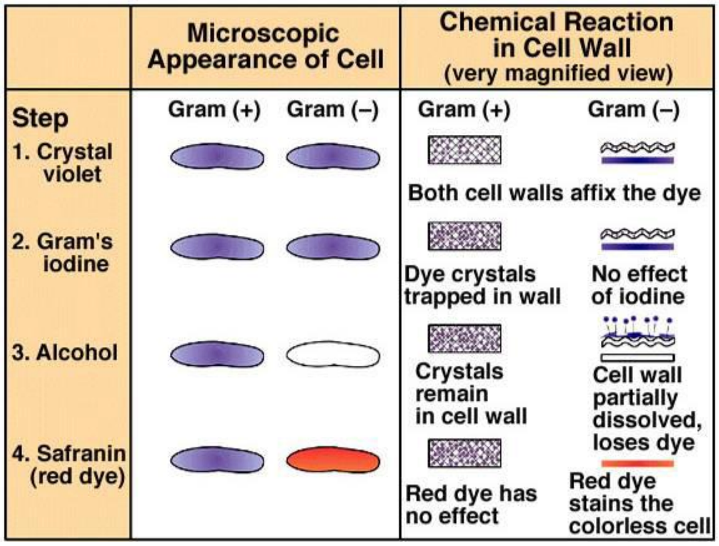
- Gram-negatives
- Gram-positives

Gram negative cell wall

Gram-negative cell walls are thin and unlike the gram-positive cell walls, they contain a thin peptidoglycan layer adjacent to the cytoplasmic membrane. Gram-negative bacteria are stained as pink colour. The chemical structure of the outer membrane's lipopolysaccharides is often unique to specific bacterial sub-species and is responsible for many of the antigenic properties of these strains**.**

Gram positive cell wall

Gram-positive cell walls are thick and the peptidoglycan (also known as *murein*) layer constitutes almost 95% of the cell wall in some gram-positive bacteria and as little as 5-10% of the cell wall in gram-negative bacteria. The gram-positive bacteria take up the crystal violet dye and are stained purple**.**



2) Plasma membrane

It is also known as cytoplasmic membrane (or) cell membrane. It is composed of phospholipids, proteins and carbohydrates, forming a fluid-mosaic. It helps in transportation of substances including removal of wastes from the body .It helps in providing a mechanical barrier to the cell. Plasma membrane acts as a semi permeable membrane, which allows only selected material to move inside and outside of the cell.

3) Cytoplasm

Helps in cellular growth, metabolism and replication. Cytoplasm is the store houses of all the chemicals and components that are used to sustain the life of a bacterium.

4) Ribosome

A tiny granule made up of RNA and proteins .They is the site of protein synthesis. They are freely floating structures that help in transferring the genetic code.

5) Plasmid

Plasmids are small circle of DNA. Bacterial cells have many plasmids. Plasmids are used to exchange DNA between the bacterial cells.

6) Flagella

This is a rigid rotating tail. It helps the cell to move in clockwise and anticlockwise, forward and also helps the cell to spin. The rotation is powered by H+ gradient across the cell membrane. Common forms include:

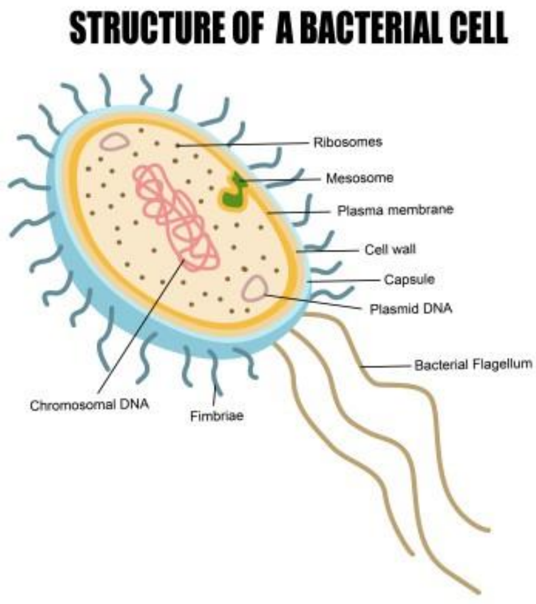
- **Polar *Monotrichous***
  A single flagellum at one or both ends of the cell
- ***Amphitrichous***
  Two or several flagella at one or both ends of the cell
- **Bipolar**
  One flagellum arises predominantly from the both pole of the cell
- ***Monotrichous***
  One flagellum from the each of the cellular pole
- **Peritrichous**
  Random, haphazard arrangement of flagella scattered around the bacterial cell

7) Pilli

Pilli are protein tubes that extend out from the outer membrane in many members of the *Proteobacteria*. 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 (e.g. to form a biofilm) or to other cells (e.g. animal cells during pathogenesis).

8) **Capsule**

Capsule is a kind of slime layer, which covers the outside of the cell wall. They are composed of a thick polysaccharide. It is used to stick cells together and works as a food reserve. It protects the cell from dryness and from chemicals.



Lecture 5

Bacterial Taxonomy

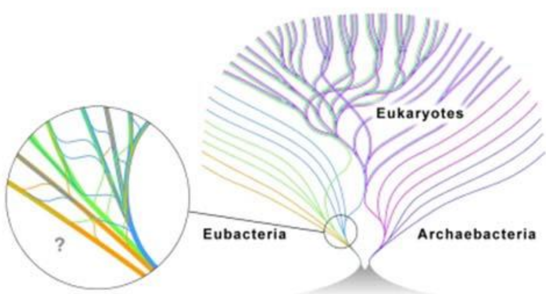
Bacterial Taxonomy

The classification, nomenclature, and identification of bacteria; sometimes used as a term to indicate the theory of classification. The bacteria are members of the kingdom Prokaryote, which is defined in terms of the unique structural and biochemical properties of their cells; Formal system originated by Carl von Linnaeus (1701-1778). Each organism placed into a specific cluster based on selected criteria.

Phenetic based Classification

In the past, the classification scheme has been based mostly on characteristics such as:

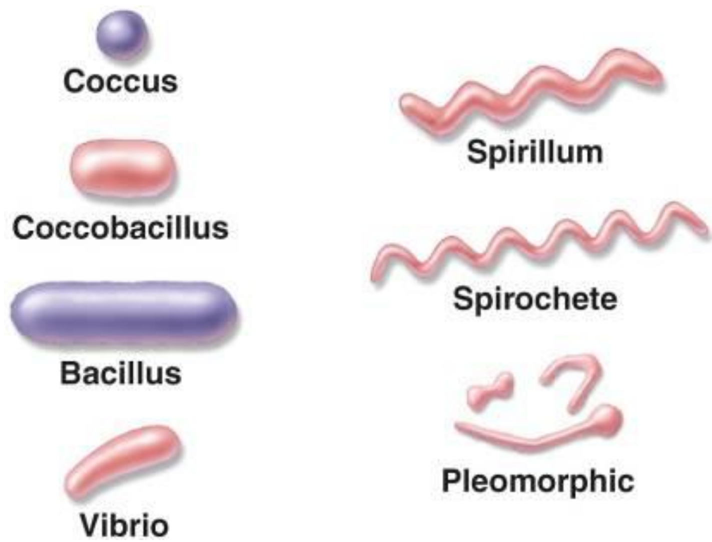
- Structural features
- Staining characteristics
- Gram Staining
- Acid Fast Staining
- Metabolic properties



Classification based upon structural Features

Shapes of bacteria

Most bacteria are 0.2 um in diameter and 2-8 um in length. The three basic bacterial shapes are coccus (spherical), bacillus (rod-shaped), and spirillum (vibrio twisted, spirochete), however pleomorphic bacteria can assume several shapes.



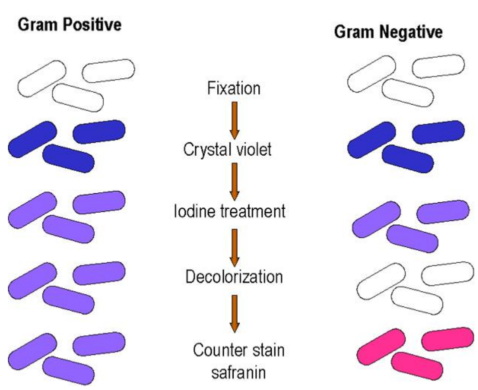
Using Staining procedure to Identify Prokaryotes

Gram Stain

The Gram stain is a differential stain that distinguishes between Gram-positive and Gram-negative bacteria. This relatively rapid test narrows the possible identities of an organism by excluding numerous others and provides suggestive information that can be helpful in the identification process.

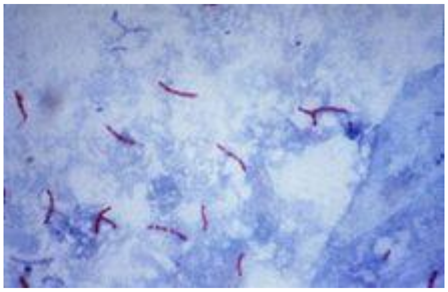
- **Gram-positive** bacteria tend to obtain blue color while don't survive with antibiotics. E.g. *Actinobacteria.* Gram-positive cell walls are thick and the peptidoglycan (also known as *murein*) layer constitutes almost 95% of the cell wall in some gram-positive bacteria and as little as 5-10% of the cell wall in gram-negative bacteria

- **Gram-negative** bacteria stained red and are more resistant to antibiotics. E.g. *proteobacteria.* The chemical structure of the outer membrane's lipopolysaccharides is often unique to specific bacterial sub-species and is responsible for many of the antigenic properties of these strains**.**



Differential Stains: Acid-Fast Stain

Acid-fast organisms are difficult to characterize using standard microbiological techniques. For example gram stain. Acid fast organisms like Mycobacterium contain large amounts of lipid substances within their cell walls called mycolic acids. These acids resist staining by ordinary methods such as a Gram stains. It can also be used to stain a few other bacteria, such as Nocardia. The reagents used are Ziehl–Neelsen carbol fuchsin, acid alcohol, and methylene blue. Acid-fast bacilli will be bright red after staining.



Classification based upon Metabolism

- **Heterotrophic**
  Saprobes
  Parasites
- **Autotrophic**
  Photosynthetic bacteria
  Cyanobacteria
  Purple sulfur bacteria
- **Chemoautotrophic**

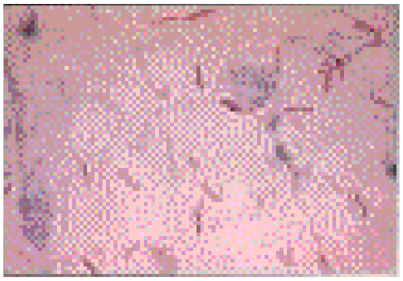
Nutrition of bacteria

They exhibits different modes of nutrition level such as-

- **Autotrophic bacteria*:*** These bacteria are able to synthesize their own food. For e.g.: Photosynthetic bacteria use a special type of chlorophyll called bacteriochlorophyll. E.g. *Rhodospirillum* O2 is not released in bacterial photosynthesis.

- **Heterotrophic bacteria*:*** These bacteria are unable to synthesize their own food, hence they depends on other organic materials.

- May feed on the remains of dead plants and animals called **Saprobes**.
- Those live on or in the organism and cause disease are called **Parasites**. For example, *Mycobacterium tuberculosis.*



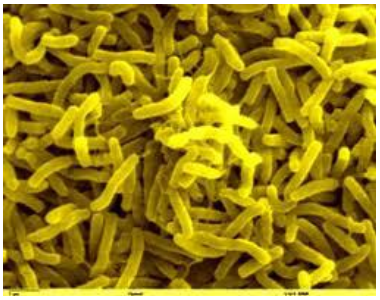
- **Symbiotic bacteria*:*** These bacteria have a mutual benefit from other organisms. For e.g.: nitrogen fixing bacteria (or) rhizobium.

- **Parasitic bacteria*:*** These bacteria are present in plants, animals and human beings. These bacteria feeds on host cells and causes harm to the host.

Chemoautotrophs

Chemoautotroph – an organism that uses the energy of environmentally available chemical reactions to fix raw materials into energy rich compounds.

Bacteria that produce organic matter by the use of energy obtained by oxidation of certain chemicals with carbon dioxide as the carbon source.



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Lecture 6

Structure of Viruses

Viruses

A virus is a small infectious agent that replicates only inside the living cells of other organisms. Viruses can infect all types of life forms, from animals and plants to microorganisms, including bacteria and archaea.

Virology

Virology is the study of viruses – submicroscopic, parasitic particles of genetic material contained in a protein coat.

Virologists

Virologists study viruses that affect humans, animals, insects, bacteria, fungi, and plants in community, clinical, agricultural, and natural environments.

Viruses as Living

Living characteristics of viruses

1) Viruses have genetic material (DNA or RNA).

2) They can be mutated.

3) They can be transmitted from one host to another.

4) They are capable of multiplication within a host.

5) They are able to infect and cause disease to living beings.

6) The DNA and proteins of viruses are similar in composition and structure to those of higher organisms.

Viruses as Non-living

Nonliving characteristics of viruses

1) Viruses can replicate and multiply inside the host but cannot grow.
2) Viral replication is different from reproduction of other living organisms.
3) There is no cell wall, membrane or cytoplasm.
4) There are no cell organelles and there is no metabolism.
5) They use the host cell's metabolic machinery.

General Features of viruses

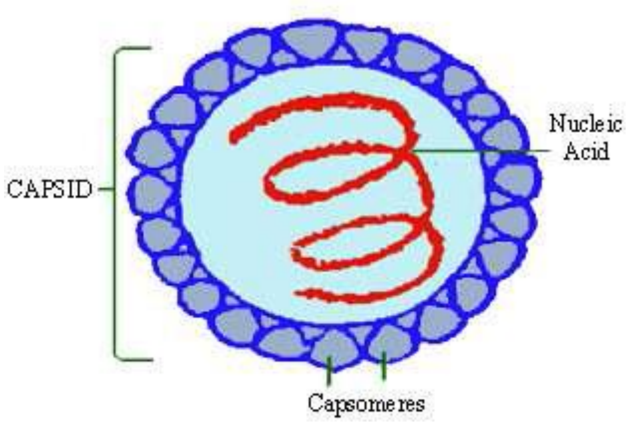
1) Obligate intracellular parasite.

2) Contain either DNA or RNA never both.

3) Can affect humans, animals, insects, bacteria and plants.

4) They do not respond to antibiotic.

5) Some viruses also surrounded by a membrane-like envelope



Structure of Viruses

Viruses come in an amazing variety of shapes and sizes. They are very small and are measured in nanometers, which is one-billionth of a meter. Viruses can range in the size between 20to750nm, which is 45,000times smaller than the width of a human hair. The majority of viruses cannot be seen with a light microscope because the resolution of a light microscope is limited to about 200nm, so a scanning electron microscope is required to view most viruses.

The three major viral components are

1. Nucleic acid **2.Capsid** **3.Viral Envelope**

1. Nucleic acid

The viral nucleic acid carries the genetic information in either DNA or RNA which is considered as the finger prints of the virus.

2. **Capsid (Protein coat)**

Capsid is the protein shells which enclose the nucleic acid. It is formed of small unis called capsomeres. Capsomeres are arranged in a precise and highly repetitive pattern around the nucleic acid. A single type of capsomeres or several chemically distinct types may make up the capsid. The combination of genome and capsid is called the viral nucleocapsid**.**

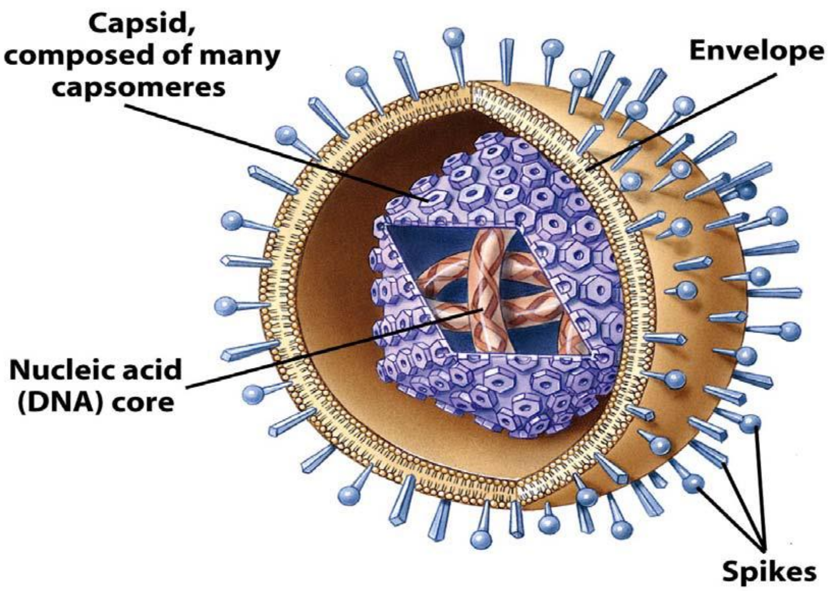
Functions of the capsid

1) Protects the viral genome against extracellular environments.

2) It carries he viral attachment proteins (VAP) which are glycoproteins that attach the virus to a specific receptor on the target cell.

3) Determine the antigenic characters of the virus.

4) It is responsible for the symmetry of the virus

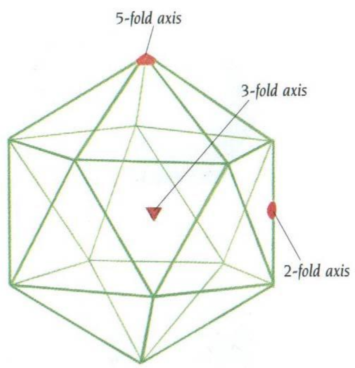


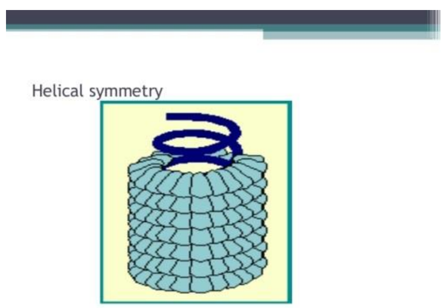
3. Viral Envelopes

A number of kinds of viruses contain envelopes. An envelope is a membrane like structure that encloses the nucleocapsid and is obtained from a host cell during the replication process. The envelope contains viral-specified proteins that make it unique. Among the envelope viruses are those of herpes simplex, chickenpox, and infectious mononucleosis.

The nucleocapsids of viruses are constructed according to certain symmetrical patterns. The virus that causes tobacco mosaic disease, for example, has helical symmetry**.** In this case, the nucleocapsid is wound like a tightly coiled spiral. The rabies virus also has helical symmetry. Other viruses take the shape of an icosahedron, and they are said to have icosahedral symmetry**.**

In an icosahedron, the capsid is composed of 20 faces, each shaped as an equilateral triangle 12 vertices, 5-3-2 symmetry axes, 60 identical subunits in identical environments can form icosahedral shell.





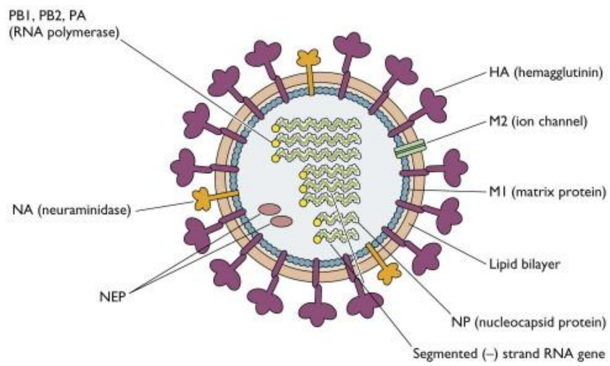
Icosahedral symmetry **helical symmetry**

Envelope Glycoproteins

Found in the envelope bilayer. This is aided by domains of host membrane proteins called *spanners.* They can generate spikes or other structures on the outside of the virion to anchor a host cell.

4. Influenza virus

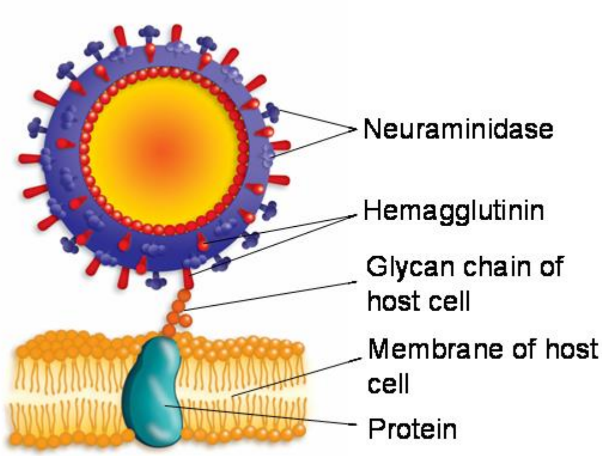
The influenza virion (as the infectious particle is called) is roughly spherical. It is an enveloped virus – that is, the outer layer is a lipid membrane which is taken from the host cell in which the virus multiplies. Inserted into the lipid membrane are ‘spikes’, which are proteins – actually glycoproteins, because they consist of protein linked to sugars – known as HA (hemagglutinin) and NA (neuraminidase). These are the proteins that determine the subtype of influenza virus.



Influenza Hemagglutinin

Hemagglutinin (BE) is an antigenic glycoprotein found on the surface of the influenza viruses. It is responsible for binding the virus to the cell that is being infected. The name "hemagglutinin" comes from the protein's ability to cause red blood cells (erythrocytes) to clump together ("agglutinate") in vitro. The process is like this: Hemagglutinin (HA) binds to the monosaccharide sialic acid which is present on the surface of its target host cells. The cell membrane then engulfs the virus through endocytosis and forms endosome. The cell then attempts to begin digesting the contents of the endosome by acidifying its interior and transforming it into a lysosome. The HA spikes extend like a spring during infection.

Influenza A virus infects a host cell



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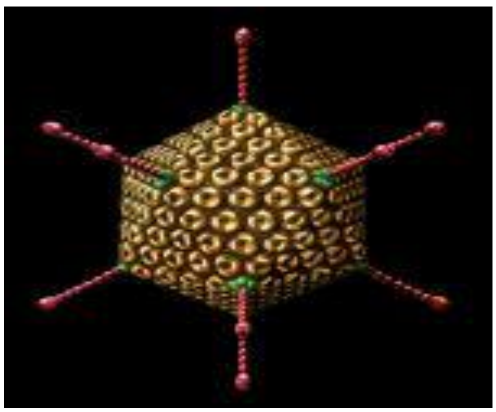
Lecture 7

Introduction to Viruses

Introduction

Virus, parasite with a noncellular structure composed mainly of nucleic acid within a protein coat. Most viruses are too small (100–2,000 Angstrom units) to be seen with the light microscope and thus must be studied by electron microscopes. In one stage of their life cycle, in which they are free and infectious, virus particles do not carry out the functions of living cells, such as respiration and growth; in the other stage, however, viruses enter living plant, animal, or bacterial cells and make use of the host cell's chemical energy and its protein- and nucleic acid–synthesizing ability to replicate themselves. Over 5,000 species of viruses have been discovered.



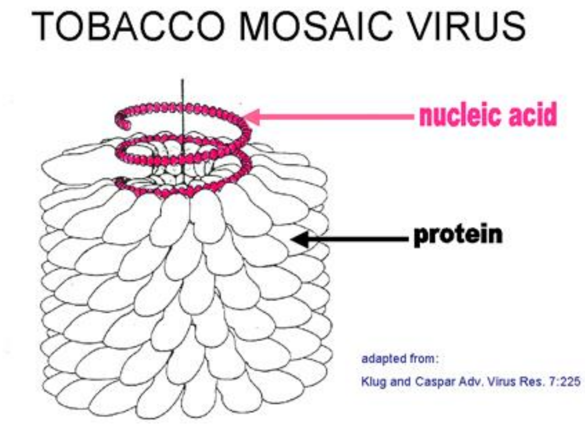
Discovery of Viruses

In 1884 the French microbiologist Charles Chamberland invented a filter, known today as the Chamberland filter or Chamberland–Pasteur filter that has pores smaller than bacteria. Thus he could pass a solution containing bacteria through the filter and completely remove them from the solution. In the early 1890s the Russian biologist Dmitri Ivanovsky used this filter to study what became known as the tobacco mosaic virus. His experiments showed that extracts from the crushed leaves of infected tobacco plants remain infectious after filtration.

At the same time several other scientists proved that, although these agents (later called *viruses*) were different from bacteria, they could still cause disease, and they were about one hundredth the size of bacteria. In 1899 the Dutch microbiologist Martinus Beijerinck observed that the agent multiplied only in dividing cells. Having failed to demonstrate its particulate nature he called it a "*contagium vivum fluidum*", a "soluble living germ".

Tobacco Mosaic Virus

Wendell Stanley (1935) crystallized sap from diseased tobacco plants. TMV is made up of a piece of nucleic acid (ribonucleic acid; RNA) and a surrounding protein coat. The complete virus is a submicroscopic, rigid, rod-shaped particle. Once inside the plant cell, the protein coat falls away and nucleic acid portion directs the plant cell to produce more virus nucleic acid and virus protein, disrupting the normal activity of the cell. TMV can multiply only inside a living cell but it can survive in a dormant state in dead tissue, retaining its ability to infect growing plants for years after the infected plant part died. Most other viruses die when the plant tissue dies.



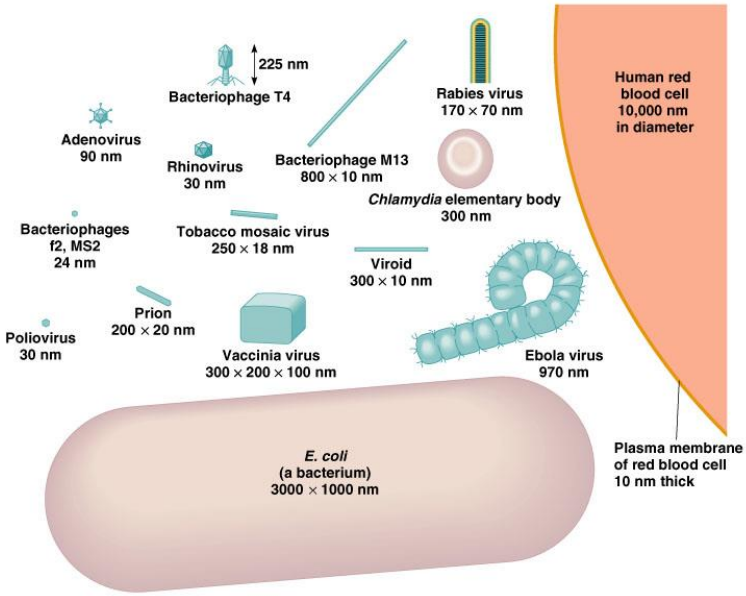
Smallpox disease

Smallpox was an infectious disease caused by either of two virus variants, *Variola major* and *Variola minor*. The disease is also known by the Latin names *Variola* or *Variola Vera*, derived from *various* ("spotted") or *varus* ("pimple"). The disease was originally known in English as the "pox" or "red plague" the term "smallpox" was first used in Britain in the 15th century to distinguish Variola from the "great pox" (syphilis).The last naturally occurring case of smallpox (*Variola minor*) was diagnosed on 26 October 1977. Vaccine was developed against smallpox by Edward Jenner (1796).

Size

Viruses are among the smallest infectious agents, and most of them can only be seen by electron microscopy. Most viruses cannot be seen by light microscopy (in other words, they are sub-microscopic their sizes range from 20 to 300 nm. They are so small that it would take 30,000 to 750,000 of them, side by side, to stretch to one cm. By contrast bacterial sizes are typically around 1 micrometer (1000 nm) in diameter and the cells of higher organisms a few tens of micrometers.

Range of Viral Size



Viral diseases

Some viruses cause disease such as:

Disease	Agnet involved
–Smallpox	By *Variola major* and *Variola minor*
–Measles	By *paramyxovirus* of the genus *Morbillivirus*
–Mononucleosis	By the Epstein–Barr virus
–Influenza	By the family Orthomyxoviridae, the influenza viruses
–Colds	By rhinovirus
–Warts	By one of the types of human papillomavirus (HPV)
–AIDS	By HIV
–Ebola	Caused by an ebolavirus

Taxonomy of viruses

Virus classification is the process of naming viruses and placing them into a taxonomic system. Viruses are mainly classified by phenotypic characteristics, such as morphology, nucleic acid type, and mode of replication, host organisms, and the type of disease they cause. Currently there are two main schemes used for the classification of viruses: 1. The International Committee on Taxonomy of Viruses (ICTV) system and 2. Baltimore classification system, which places viruses into one of seven groups. Accompanying this broad method of classification are specific naming conventions and further classification guidelines set out by the ICTV.

- Viridae used as *Family* names
- Virus is used as *Genus* names

Some Examples

- Herpesviridae
- Herpesvirus
- Human herpes virus 1, HHV 2, HHV 3
- Retroviridae
- Lentivir
- Human Immunodeficiency Virus 1, HIV 2

Prions

A prion is an infectious agent thought to be the cause of the transmissible spongiform encephalopathy (TSEs). It is composed entirely of protein material, called PrP (short for prion protein), that can fold in multiple, structurally distinct ways, at least one of which is transmissible to other prion proteins, leading to disease that is similar to viral infection. Prions Causes neuronal degeneration. Mad cow disease is an example of prions.

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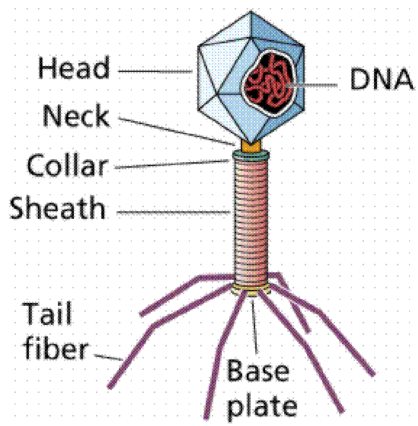
Lecture 8

Bacteriophages

Bacteriophages, also known as phages, are viruses that infect bacteria. These phages also require a bacterial host in order to replicate themselves. Bacterial viruses, as these are also often called, are made up of proteins that coat an inner core of nucleic acid – either DNA (deoxyribonucleic acid) or RNA (ribonucleic acid). Phages also vary in structure, ranging from the simple to the more elaborate and complex.

T-phages have

- Icosahedral heads
- Double-stranded DNA
- Tails

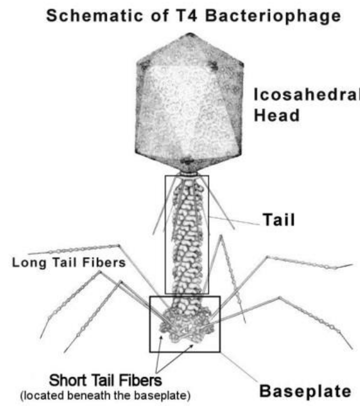


T-phages

T-phages are a specific class of bacteriophages with icosahedral heads, double-stranded DNA, and tails. The most commonly studied T-phages are T4 and T7, both of whom infect E. coli, everybody's favorite laboratory bacterium. They resemble microscopic arthropods, with a head composed of 20 triangular surfaces, a tail, and limb-like tail fibers.

T-4 Bacteriophage Structure

T-4 bacteriophage is a relatively large phage, at approximately 90 nm wide and 200 nm long (most phages range from 25 to 200 nm in length). The DNA genome is held in an icosahedral head, also known as a capsid. The T4's tail is hollow so that it can pass its nucleic acid into the cell it is infecting after attachment.



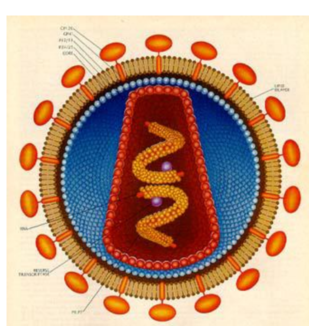
Retroviruses

Characteristics of Retroviruses

A retrovirus is a single-stranded positive-sense RNA virus with a DNA intermediate and, as an obligate parasite, targets a host cell. Once inside the host cell cytoplasm, the virus uses its own reverse transcriptase enzyme to produce DNA from its RNA genome — the reverse of the usual pattern, thus *retro* (backwards). This new DNA is then incorporated into the host cell genome by an integrase enzyme, at which point the retroviral DNA is referred to as a provirus. Retroviridae is a family of enveloped viruses that replicate in a host cell through the process of reverse transcription.

Enzyme Reverse Transcriptase

Reverse transcriptases are enzymes encoded in retroviruses viral genome. The enzyme is responsible for transcription of the viral RNA to produce a dsDNA that can be inserted into the host genome. Viral RNA is used as a template.



Retroviruses Examples

- HIV, the AIDS virus, is a retrovirus.
- Feline Leukemia Virus is also a retrovirus.

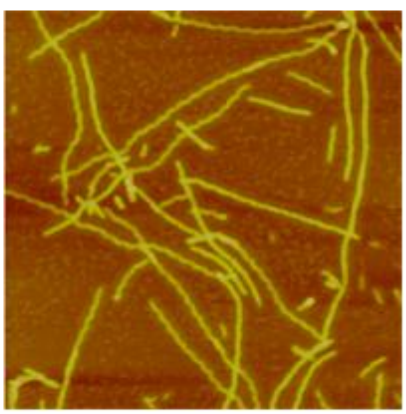
Viroids & Prions

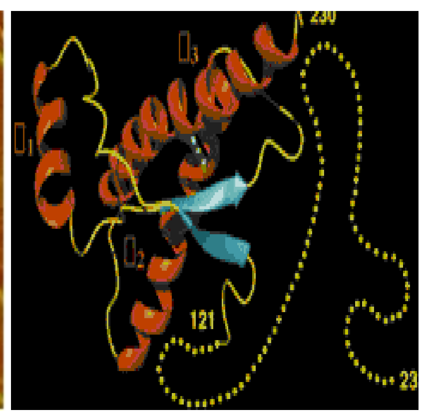
Viroids

Viroids are among the smallest infectious pathogens known, larger only than prions, which are misfolded proteins. Viroids consist solely of short strands of circular, single-stranded RNA without protein coats. They are mostly plant pathogens, some of which are of economic importance. Viroid genomes are extremely small in size, ranging from 246 to 467 nucleobases.

Prions

Prions are infectious proteins cause of the transmissible spongiform encephalopathies (TSEs). They are normal body proteins that undergo an altered configuration by contact with other prion proteins. They have no DNA or RNA. The protein involved in mammals prion diseases is called "PrP,





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Lecture 9

Viral Replication

Viral replication is the formation of biological viruses during the infection process in the target host cells. Viruses must first get into the cell before viral replication can occur. From the perspective of the virus, the purpose of viral replication is to allow production and survival of its kind. By generating abundant copies of its genome and packaging these copies into viruses, the virus is able to continue infecting new hosts. Replication between viruses is greatly varied and depends on the type of genes involved in them. Most DNA viruses assemble in the nucleus while most RNA viruses develop solely in cytoplasm.

Lytic cycle

The lytic cycle involves the reproduction of viruses using a host cell to manufacture more viruses; the viruses then burst out of the cell. The normal process of viral reproduction involving penetration of the cell membrane, nucleic acid synthesis, and lysis of the host cell. Lytic cycle is one of the two alternative life cycles of a virus inside a host cell, whereby the virus that has entered a cell takes over the cell's replication mechanism, makes viral DNA and viral proteins, and then lyses (breaks open) the cell, allowing the newly produced viruses to leave the now disintegrated host cell to infect other cells.

Process

Viruses of the lytic cycle are called virulent viruses. The lytic cycle is a five-stage cycle.

1) Attachment

The virus first attaches itself to a specific host cell. In the case of the T4 phage, a commonly studied bacteriophage that infects the bacterium *Escherichia coli,* this attachment is done by the tail fibers of the virus having proteins that have an affinity with the host cell wall.

2) Penetration

To infect a cell, a virus must first enter the cell through the plasma membrane and (if present) the cell wall. It then releases its genetic material (either single- or double-stranded RNA or DNA) into the cell. In the case of the T4 phage, after attachment to the host cell, the virus first releases an enzyme that weakens a spot in the cell wall of the host.

3) Replication

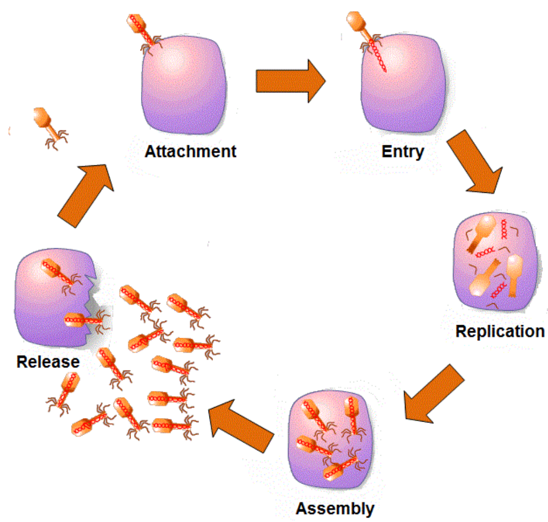
The virus' nucleic acid uses the host cell’s machinery to make large amounts of viral components, both the viral genetic material (DNA or RNA) and the viral proteins that comprise the structural parts of the virus. In the case of DNA viruses, the DNA transcribes itself into messenger RNA (mRNA) molecules that are then used to direct the cell's ribosomes. One of the first polypeptides to be translated is one that destroys the hosts' DNA.

4) Assembly

After many copies of viral components are made, they are assembled into complete viruses. In the case of the T4 phage, proteins coded for by the phage DNA act as enzymes for construction of the new phages (Towle 1989). The entire host metabolism is directed toward this assembly, resulting in a cell filled with new viruses.

5) Lysis

After assembly of the new virus particles, an enzyme is produced that breaks down the bacteria cell wall from within and allows fluid to enter. The cell eventually becomes filled with viruses (typically 100-200) and liquid, and bursts, or lyses thus giving the lytic cycle its name. The new viruses are then free to infect other cells and start the process again.



Steps of lytic cycle

Latent Phase in Viruses

• Some viruses are capable to dormant inside the host cell are called latent viruses.
• They might be inactive for long time (years).
• They may re-activate to lytic phase in response to some external signal.
• HIV and Herpes viruses are such examples.

Lysogenic Cycle

The lysogenic cycle involves the incorporation of the viral into genome the host cell genome, infecting it from within. A form of viral reproduction involving the fusion of the nucleic acid of a bacteriophage with that of a host, followed by proliferation of the resulting prophage.

Following steps involves in the lysogenic cycle.

1) Adsorption

Attachment of adsorption of tail fibers of the phage on to a specific receptor site on the bacterial cell wall.

2) Injection

Injection of viral genome into the host through the hollow tubes of the tail.

3) Integration of viral genome to the host genome

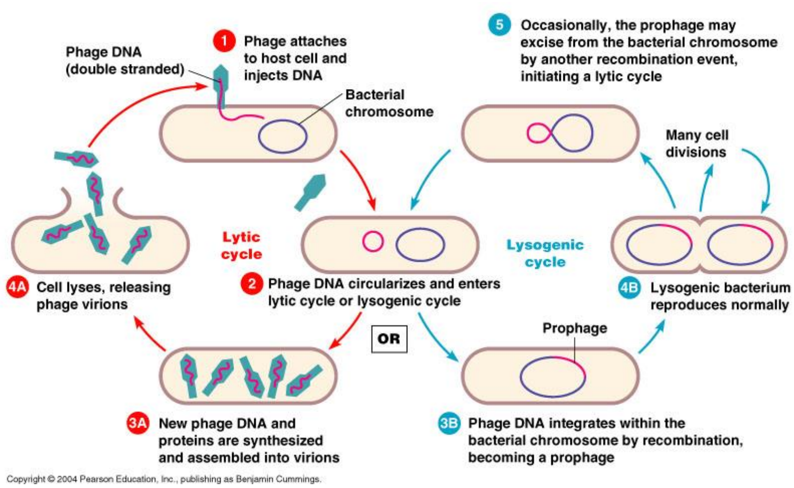
After the entry of viral genome, it gets integrated into the bacterial genome of the host. The viral genome integrated to the bacterial genome is termed prophage

4) Viral genome synthesis

Viral genome replicates along with the bacterial genome replication and Pass on to the daughter cells.

5) Induction of lytic cycle

Occasionally, integrated viral genome detaches and released into the bacterial cytoplasm**.** This dissociation is called induction and lytic cycle is followed releasing mature lysogenic phages. Induction can be induced artificially using ultraviolet rays or heat treatment.



Lysogenic cycle

Herpes Viruses

Herpes simplex virus is a common viral infection that presents with localized blistering. It affects most people on one or more occasions during their lives. Herpes simplex is commonly referred to as cold sores or fever blisters, as recurrences are often triggered by a febrile illness, such as a cold. • They can also become latent in the nervous system. A herpes infection persists for a person's lifetime.

Examples of herpes virus

- Genital herpes (Herpes Simplex 2)
- Cold sores or fever blisters (Herpes Simplex1)

Vaccination

Vaccination is the administration of antigenic material (a vaccine) to stimulate an individual's immune system to develop adaptive immunity to a pathogen. Vaccines can prevent or ameliorate morbidity from infection. An attenuated virus is a less vigorous and weakened virus. Attenuate" refers to experimental mechanism by which one weakens an agent of disease (heating). A vaccine against a viral disease can be made from less virulent strain of the virus. Attenuated by heating a virus is capable of stimulating an immune response and creating immunity, but not causing illness.

Other Viral Treatments

Interferon is naturally occurring proteins synthesized by cell itself to fight against viruses.
Following drugs are used for the treatment of virus

- Genetic altering of viruses
(Attenuated viruses)
- Antiviral drugs (AZT)
- Protease inhibitors

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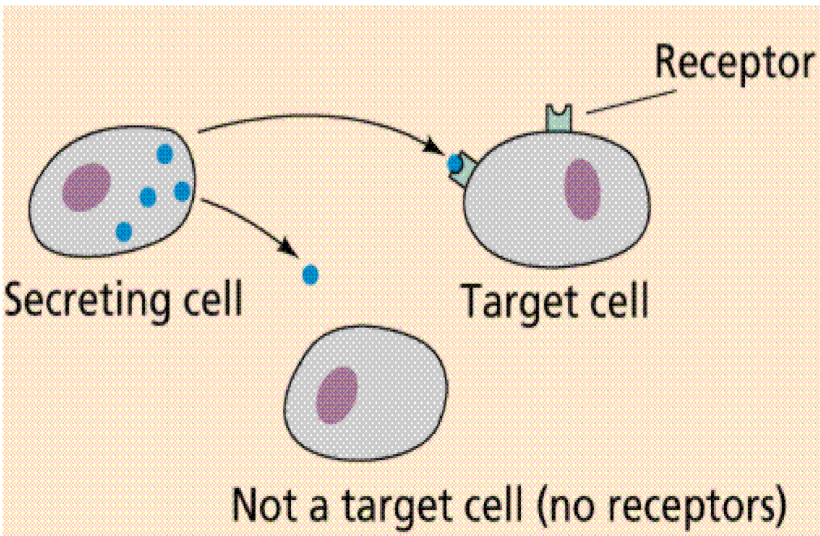
Lecture 10

Hormones

Hormones are chemical messengers that are secreted directly into the blood, which carries them to organs and tissues of the body to exert their functions. There are many types of hormones that act on different aspects of bodily functions and processes. Some of these include:

- Development and growth
- Metabolism of food items
- Sexual function and reproductive growth and health
- Cognitive function and mood



Endocrine vs. Nervous System

1) The nervous system and endocrine system interact and operate together in order to help the body achieve homeostasis. Despite both systems having the same goal to achieve a stable internal environment within the organism they exhibit differences in terms of how they operate.

2) In the nervous system the speed of the transmission is relatively fast, as the message only needs to be transmitted across minor synaptic distances. Conversely, in the endocrine system the speed of hormonal signals are generally slower. This is because the message is usually transmitted over long distances and the hormone needs to find its appropriate receptor to bind and initiate a response.

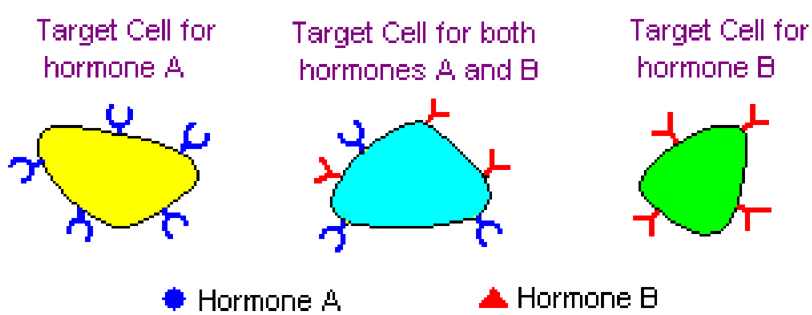
3) In the nervous system the duration of the response is relatively short. Once a neural impulse has been sent the neurotransmitter at the synapse has been inactivated relatively quickly and nothing further happens once the signal is transmitted. In contrast, in the endocrine system, hormones are typically longer sustaining responses.

Hormonal Actions

Hormones are secreted by the glands of the endocrine system and they serve to maintain homeostasis and to regulate reproduction and development. Glands of the endocrine system secrete hormones directly into the extracellular environment. The hormones then diffuse to the bloodstream via capillaries and are transported to the target cells. Hormones are molecules that generally exert effects at sites other than that from which they were produced and secreted. In the case of endocrine messages, cells must bear a *receptor* for the hormone being broadcast in order toresponse.

Hormonal Mechanism

• Most hormones circulate in blood, coming into contact with essentially all cells.
• However, a given hormone usually affects only a limited number of cells, which are called target cells.
• A target cell responds to a hormone because it bears receptors for the hormone.



Principal Functions

1) Hormones serve as chemical messengers in the body and help maintain homeostasis.
2) Hormones are released into bodily fluids, like blood, which carry them to target cells.
3) Target cells respond to a hormone when they express a specific receptor for that hormone.
4) Hormones also play a role in the regulation of cell death, the immune system, reproductive development, mood swings, and hunger cravings.
5) Maintenance of the internal environment in the body.
6) Integration and regulation of growth and development.

Types of Hormones

Endocrine hormones

Endocrine hormones are to secrete hormones directly into the bloodstream. Hormones are chemical substances that affect the activity of another part of the body (target site). In essence, hormones serve as messengers, controlling and coordinating activities throughout the body.

Neurohormones

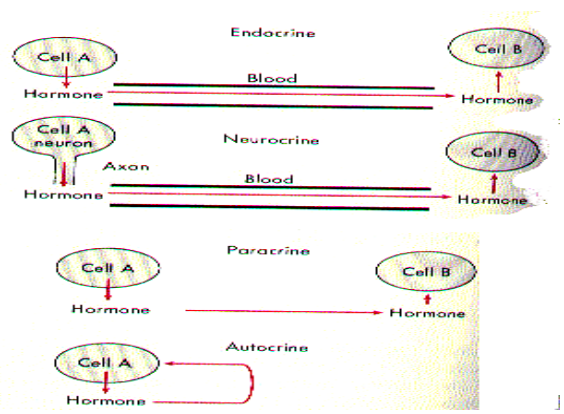
Neurohormones are any hormone produced and released by neuroendocrine cells (also called neurosecretory cells) into the blood stream. Neurohormones, they are secreted into the circulation for systemic effect, but they can also have a role of neurotransmitter or other roles such as autocrine (self) or paracrine (local) messenger.

Paracrine hormones

Paracrine hormones act on adjacent cells and autocrine. Hormones are released and act on the cell that secreted them.

Intracrine hormones

Intracrine refers to a hormone that acts inside a cell, regulating intracellular events. Steroid hormones act through intracellular (mostly nuclear) receptors and, thus, may be considered to be intracrines. In contrast, peptide or protein hormones, in general, act as endocrines, autocrines, or paracrines by binding to their receptors present on the cell surface.



Response Actions

Endocrine action

The hormone is distributed in blood and binds to distant target cells.

Paracrine action

The hormone acts locally by diffusing from its source to target cells in the neighborhood.

Autocrine action

The hormone acts on the same cell that produced.

Major Hormones and Systems

The endocrine system refers to the collection of glands of an organism that secrete hormones directly into the circulatory system to be carried towards distant target organs. The major endocrine glands include the pineal gland, pituitary gland, pancreas, ovaries, testes, thyroid gland, parathyroid gland, hypothalamus, gastrointestinal tract and adrenal glands. The endocrine system is in contrast to the exocrine system, which secretes its hormones to the outside of the body using ducts.

- Hypothalamus produces releasing factors that stimulate production of anterior pituitary hormone They act on peripheral endocrine gland to stimulate release of third hormone
- Posterior pituitary hormones are synthesized in neuronal cell bodies in the hypothalamus.
- They are released via synapses in posterior pituitary.

  Example: Oxytocin and antidiuretic hormone (ADH)

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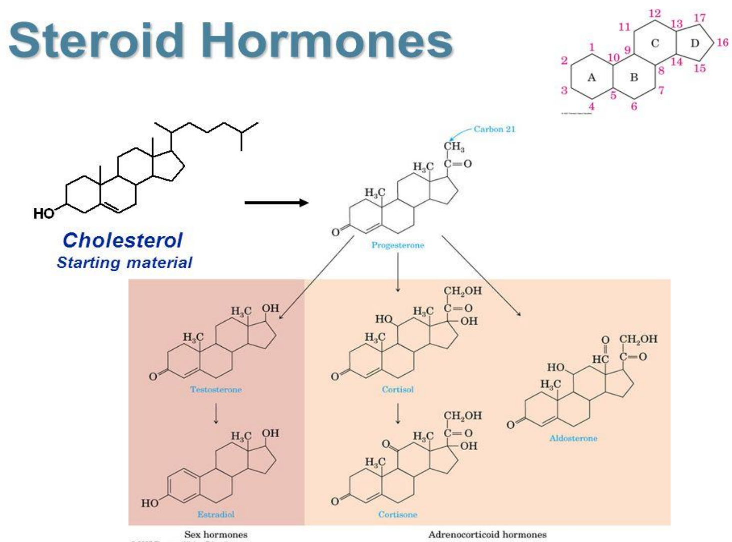
Lecture 11

Steroids

Steroid hormones

Steroid hormone**,** any of a group of hormones that belong to the class of chemical compounds known as steroids; they are secreted by three "steroid glands"—the adrenal cortex, testes, and ovaries—and during pregnancy by the placenta. All steroid hormones are derived from cholesterol. They are transported through the bloodstream to the cells of various target organs where they carry out the regulation of a wide range of physiological functions.

These hormones often are classified according to the organs that synthesize them: the adrenal steroids are so called because they are secreted by the adrenal cortex, and the sex hormones are those produced by the ovaries and testes.



Types of steroid hormones

Glucocorticoids

Glucocorticoids are a class of steroid hormone that regulate carbohydrate metabolism. Cortisol is the major representative in most mammals.

Mineralocorticoids

Mineralocorticoids are a class of steroid hormone that regulates the body levels of sodium and potassium.

Androgens

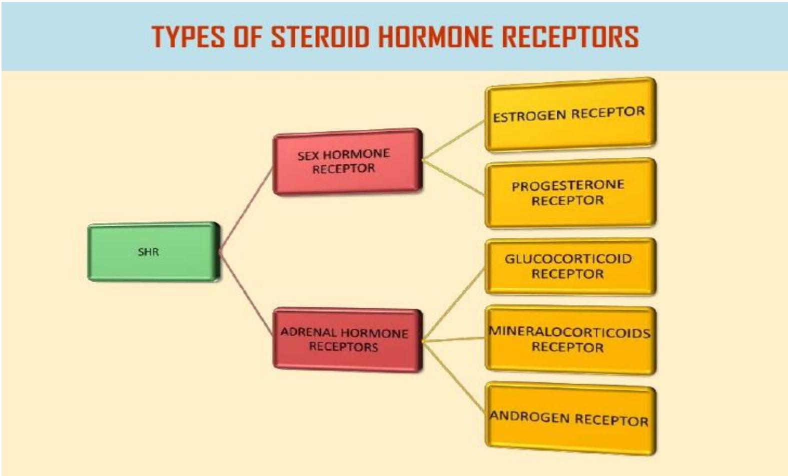
Androgens are a class of steroid hormone produced by the adrenal cortex whose actions are similar to that of steroids produced by the male gonads.

Estrogens

Estrogen is the primary female sex hormone and is responsible for development and regulation of the female reproductive system and secondary sex characteristics. Estrogen may also refer to any substance, natural or synthetic, that mimics the effects of the natural hormone

Progestogens

Progestogens are a class of steroid hormones that bind to and activate the progesterone receptor (PR). The most important progestogen in the body is progesterone (P4).



Origin of Steroid Hormones

Steroid Hormones are not packaged, but synthesized and immediately released. These hormones are all derived from the same parent compound known as cholesterol. Enzymes synthesizing them from cholesterol are located in mitochondria and smooth ER. Steroids are lipid soluble and thus are freely permeable to membranes. So they are not stored in cells.

Properties of Steroid hormones

1) Steroid hormone is not water soluble.
2) So have to be carried in the blood complexed to specific binding globulins.
3) Corticosteroid binding globulin carries cortisol.
4) Sex steroid binding globulin carries testosterone and estradiol.
5) Sometimes, a steroid is secreted by one cell and converted to its active form by the target cell.
6) An example is androgen which secreted by the gonad and converted into estrogen in the brain.

Steroid hormone synthesis

The natural steroid hormones are generally synthesized from cholesterol in the gonads and adrenal glands. These forms of hormones are lipids. They can pass through the cell membrane as they are fat-soluble, and then bind to steroid hormone receptors (which may be nuclear or cytosolic depending on the steroid hormone) to bring about changes within the cell. Steroid hormones are generally carried in the blood, bound to specific carrier proteins such as sex hormone-binding globulin or corticosteroid-binding globulin.

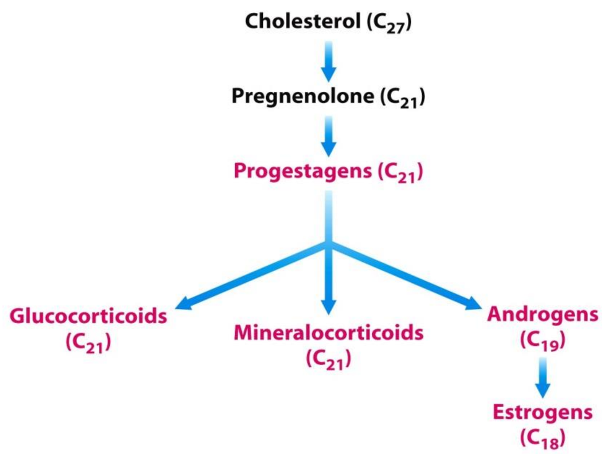


Figure 26.27
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Fatty Acid Derivatives Eicosanoids

Eicosanoids are a large group of molecules derived from polyunsaturated fatty acids.
The principal groups of hormones of this class are

1) Prostaglandins
2) Prostacyclins
3) Leukotrienes
4) Thromboxanes

Regulation of Hormone Secretion

The rate of hormone biosynthesis and secretion is often regulated by a negative feedback control mechanism. Such a mechanism depends on factors that influence the metabolism and exertion of hormones. Thus, higher hormone concentration alone cannot trigger the negative feedback mechanism. Negative feedback must be triggered by overproduction of an "effect" of the hormone.

Hormone secretion can be stimulated and inhibited by:

- Other hormones (stimulating- or releasing -hormones)
- Plasma concentrations of ions or nutrients, as well as binding globulins

- Neuron and mental activity
- Environmental changes, e.g., of light or temperature

Control of Endocrine Activity

1) Rate of production

Synthesis and secretion of hormones are the most highly regulated aspect of endocrine control.

2) Rate of delivery

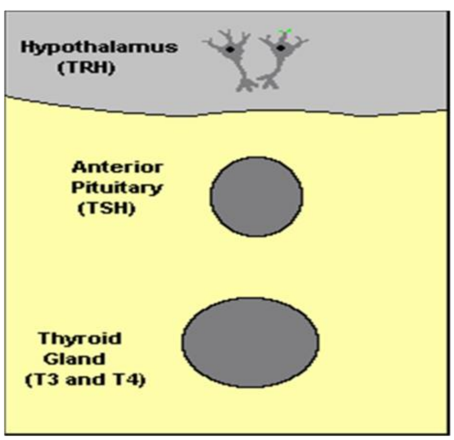
An example of this effect is blood flow to a target organ or group of target cells - high blood flow delivers more hormone than low blood flow

3) Rate of degradation and elimination

Hormones, like all biomolecules, have characteristic rates of decay, and are metabolized and excreted from the body through several routes.

Feedback Control of Hormone Production

Feedback loops are used extensively to regulate secretion of hormones in the hypothalamic-pituitary axis. An important example of a negative feedback loop is seen in control of thyroid hormone secretion.



Negative Feedback

• When blood concentrations of thyroid hormones increase above a certain threshold.
• TRH-secreting neurons in the hypothalamus are inhibited and stop secreting TRH.
• This is an example of "negative feedback".

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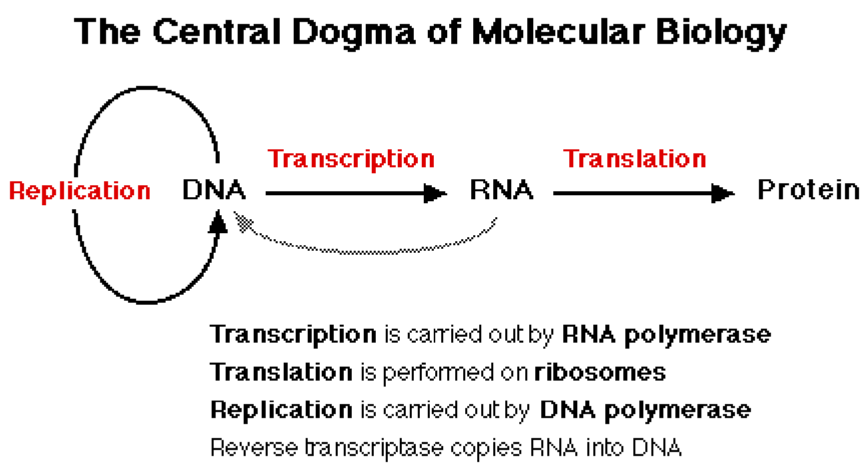
Lecture 15

Transcription and Translation

Central Dogma

The 'Central Dogma' is the process by which the instructions in DNA are converted into a functional product. It was first proposed in 1958 by Francis Crick, discoverer of the structure of DNA. The central dogma of molecular biology explains the flow of genetic information, from DNA to RNA, to make a functional product, protein. The central dogma suggests that DNA contains the information needed to make all of our proteins, and that RNA is a messenger that carries this information to the ribosome. The ribosomes serve as factories in the cell where the information is 'translated' from a code into the functional product.



Reverse Transcription

The synthesis of DNA from an RNA template, via reverse transcription, produces complementary DNA (cDNA). Reverse transcriptases (RTs) use an RNA template and a short primer complementary to the 3' end of the RNA to direct the synthesis of the first strand cDNA, which can be used directly as a template for the Polymerase Chain Reaction (PCR). Some RNA viruses, called "retroviruses" do Reverse Transcription.

RNA

RNA stands for ribonucleic acid. It is an important molecule with long chains of nucleotides. A nucleotide contains a nitrogenous base, a ribose sugar, and a phosphate. Just like DNA, RNA is vital for living beings. RNA can both store information (like DNA) and catalyze chemical reactions (like proteins). RNA/protein hybrid structures are involved in protein synthesis (ribosome). Recently it has been found that very small RNA molecules are involves in gene regulation.

RNA role in Protein Synthesis

1) Messenger RNA (mRNA)

Messenger RNA (mRNA) carries the genetic information copied from DNA in the form of a series of three-base code "words," each of which specifies a particular amino acid.

2) Transfer RNA (tRNA)

Transfer RNA (tRNA**)** is the key to deciphering the code words in mRNA. Each type of amino acid has its own type of tRNA, which binds it and carries it to the growing end of a polypeptide chain if the next code word on mRNA calls for it. The correct tRNA with its attached amino acid is selected at each step because each specific tRNA molecule contains a three-base sequence that cans base-pair with its complementary code word in the mRNA.

3) Ribosomal RNA (rRNA)

Ribosomal RNA (rRNA) associates with a set of proteins to form ribosomes. These complex structures, which physically move along an mRNA molecule, catalyze the assembly of amino acids into protein chains. They also bind tRNAs and various accessory molecules necessary for protein synthesis. Ribosomes are composed of a large and small subunit, each of which contains its own rRNA molecule

RNA vs DNA

1) RNA contains the sugar ribose.	**1)** DNA contains deoxyribose.
2) RNA contains the base uracil.	**2)** DNA contains thymine instead.
3) RNA is usually single stranded.	**3)** DNA is usually double stranded.
4) RNA is short: one gene long at most	**4)** DNA is long, containing many genes.

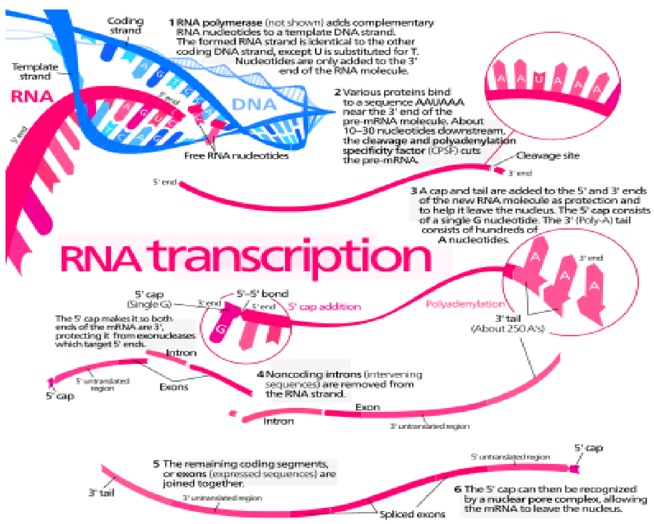
Transcription

Transcription is the first step of gene expression, in which a particular segment of DNA is copied into RNA (mRNA) by the enzyme RNA polymerase.

Both RNA and DNA are nucleic acids, which use base pairs of nucleotides as a complementary language. The two can be converted back and forth from DNA to RNA by the action of the correct enzymes. During transcription, a DNA sequence is read by an RNA polymerase, which produces a complementary, antiparallel RNA strand called a primary transcript.

Transcription proceeds in the following general steps.

1. One or more sigma factor protein binds to the RNA polymerase holoenzyme, allowing it to bind to promoter DNA.
2. RNA polymerase creates a transcription bubble, which separates the two strands of the DNA helix. This is done by breaking the hydrogen bonds between complementary DNA nucleotides.
3. RNA polymerase adds matching RNA nucleotides to the complementary nucleotides of one DNA strand.
4. RNA sugar-phosphate backbone forms with assistance from RNA polymerase to form an RNA strand.
5. Hydrogen bonds of the untwisted RNA–DNA helix break, freeing the newly synthesized RNA strand.
6. If the cell has a nucleus, the RNA may be further processed. This may include polyadenylation, capping, and splicing.
7. The RNA may remain in the nucleus or exit to the cytoplasm through the nuclear pore complex.



After Transcription

• In prokaryotes, translation starts before transcription is finished.
• In eukaryotes, the primary RNA transcript of a gene needs “RNA processing” before it can be translated.
• Also, it needs to be transported out of the nucleus into the cytoplasm.
• Steps in RNA processing:
1. Add a cap to the 5’ end
2. Add a poly-A tail to the 3’ end
3. Splice out introns.

5’ and 3’ Modification

• RNA is inherently unstable, especially at the ends.
• The ends are modified to protect it.
• At the 5’ end, a slightly modified guanine (7-methyl G) is attached.
• At the 3’ end, the primary transcript RNA is cut at a specific site.

• 100-200 adenines are attached to 3'.
• These A's are not coded in the DNA of the gene.

Introns

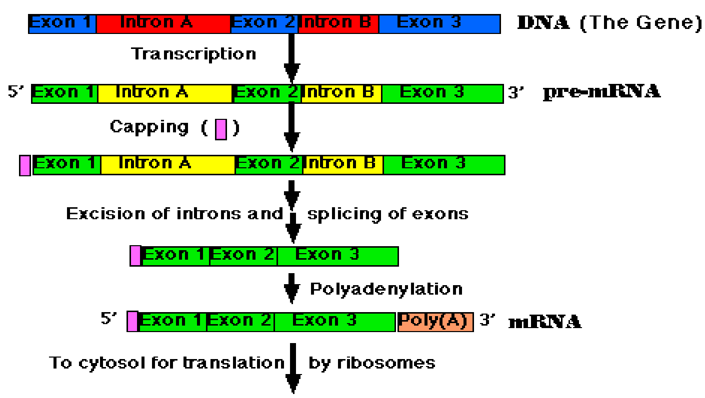
In some genes, not all of the DNA sequence is used to make protein. Introns are noncoding sections of an RNA transcript, or the DNA encoding it, that are spliced out before the RNA molecule is translated into a protein. The sections of DNA (or RNA) that code for proteins are called exons. Following transcription, new, immature strands of messenger RNA, called pre-mRNA, may contain both introns and exons.

Intron Splicing

RNA sequences between exons that are removed by splicing. Introns have been found in eukaryotic mRNA, tRNA and rRNA, as well as chloroplast, mitochondrial and a phage of *E. coli*. Eubacteria are the only species in which introns have not been found. In general, genes that are related by evolution have related organizations with conservation of the position at least some introns.

Summary of RNA processing

• RNA polymerase produces a primary transcript.
• A cap is put on the 5' end.
• The RNA is terminated and poly-A is added to the 3' end.
• All introns are spliced out to messenger RNA.
• It is then transported out of the nucleus
• In the cytoplasm, it is translated.

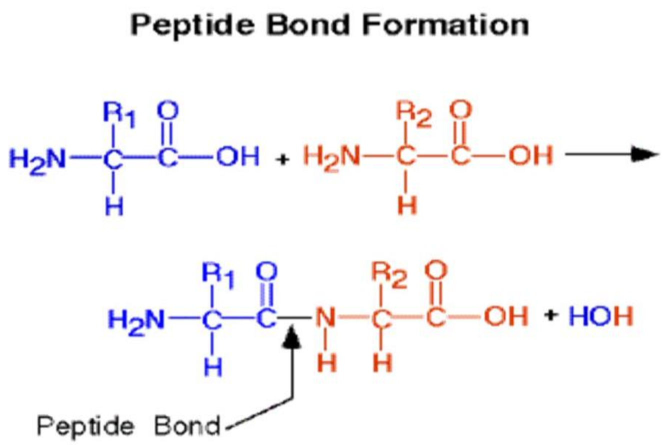


Proteins

Proteins are large biomolecules, or macromolecules, consisting of one or more long chains of amino acid residues. A linear chain of amino acid residues is called a polypeptide. A protein contains at least one long polypeptide. Short polypeptides, containing less than 20-30 residues, are rarely considered to be proteins and are commonly called peptides. The individual amino acid residues are bonded together by peptide bonds and adjacent amino acid residues.

Amino Acids and Peptide Bonds

• There are 20 different amino acids coded in DNA.
• They have an (-NH2) group on one end, and (-COOH) group on the other end.
• They attached to the central carbon is an R group.
• Two amino acids attach to each other by forming a peptide bond.



Amino Acids Classification

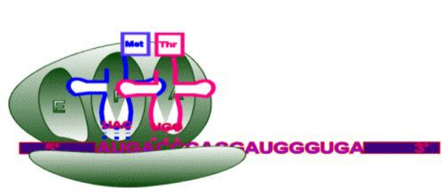
Translation

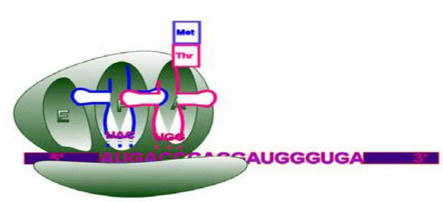
Translation is the process in which cellular ribosomes create proteins. In translation, messenger RNA (mRNA) produced by transcription from DNA is decoded by a ribosome to produce a specific amino acid chain, or polypeptide. The polypeptide later folds into an active protein and performs its functions in the cell. The ribosome facilitates decoding by inducing the binding of complementary tRNA anticodon sequences to mRNA codons. The tRNAs carry specific amino acids that are chained together into a polypeptide as the mRNA passes through and is "read" by the ribosome. The entire process is a part of gene expression.

Translation proceeds in three phases:

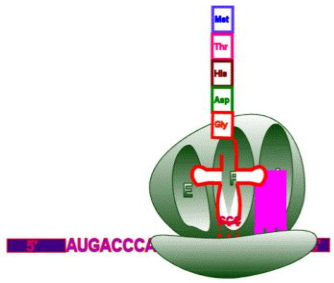
1) Initiation: The ribosome assembles around the target mRNA. The first tRNA is attached at the start codon.

2) Elongation: The tRNA transfers an amino acid to the tRNA corresponding to the next codon. The ribosome then moves (*translocates)* to the next mRNA codon to continue the process, creating an amino acid chain.





3) Termination: When a stop codon is reached, the ribosome releases the polypeptide.



The Genetic Code

• Each group of 3 nucleotides on the mRNA is a codon.

• Since there are 4 bases, there are 43 = 64 possible codons, which must code for 20 different amino acids.

• More than one codon is used for most amino acids: the genetic code is degenerate.

• AUG is used as the start codon.

• All proteins are initially translated with methionine in the first position.

• Proteins end in a stop codon, which codes for no amino acid.

Eg Stop codons are UGA, UAA and UAG

Codon table

Second letter

First letter	U	C	A	G	Third letter
U	UUU UUC Phenyl-alanine	UCU UCC UCA UCG Serine	UAU UAC Tyrosine	UGU UGC Cysteine	U C
	UUA UUG Leucine		UAA Stop codon UAG Stop codon	UGA Stop codon UGG Tryptophan	A G
C	CUU CUC CUA CUG Leucine	CCU CCC CCA CCG Proline	CAU CAC Histidine	CGU CGC CGA CGG Arginine	U C
			CAA CAG Glutamine		A G
A	AUU AUC AUA Isoleucine	ACU ACC ACA ACG Threonine	AAU AAC Asparagine	AGU AGC Serine	U C
	AUG Methionine; start codon		AAA AAG Lysine	AGA AGG Arginine	A G
G	GUU GUC GUA GUG Valine	GCU GCC GCA GCG Alanine	GAU GAC Aspartate	GGU GGC GGA GGG Glycine	U C
			GAA GAG Glutamate		A G

Ref:
http://www.yourgenome.org/facts/what-is-the-central-dogma
https://www.neb.com/applications/cloning-and-synthetic-biology/dna-preparation/reversetranscription-cdna-synthesis
http://www.news-medical.net/life-sciences/What-is-RNA.aspx
http://www.ncbi.nlm.nih.gov/books/NBK216/
https://en.wikipedia.org/wiki/Transcription_%28genetics%29
http://www.nature.com/scitable/definition/intron-introns-67
https://www.ndsu.edu/pubweb/~mcclean/plsc731/transcript/transcript4.htm
https://en.wikipedia.org/wiki/Protein
https://en.wikipedia.org/wiki/Translation_%28biology%29

Lecture 26

Introduction to Animal Biology

Characteristics of Animals

1. Eukaryotic
A eukaryote is any organism whose cells contain a nucleus and other organelles enclosed within membranes.

2. Multicellular
Composed of several or many cells.

3. Heterotrophic
An organism that cannot manufacture its own food and instead obtains its food and energy by taking in organic substances, usually plant or animal matter.

4. Move at some point in life

Migrate from one place to another when risk to their survival

5. Digest food to get nutrients

Proper digestive system is present to break down food

6. Lack cell walls
Their cell contains only plasma membrane and cell wall is not present in them.

Animal Development

1. Cell specialization
With the passage of time cells are later on specialized to perform their specific functions according to cellular requirements.
2. Cephalization
Development of complex brain to respond body signals.
3. Early development
Development of main body parts in the beginning e.g. brain, heart etc.
4. Body symmetry
Proper body shapes are developed during developmental processes.
5. Body cavity formation
Coelom formation begins in the gastrula stage. The developing digestive tube of an embryo.

Tissue Development

Cells form tissues

- **Epithelial**
  Skin, lining of cavities
- **Connective**
  Bone, blood
- **Muscular**
  Heart, biceps
- **Nervous**
  Brain, nerves

Nervous System

The nervous system is the part of an animal's body that coordinates its voluntary and involuntary actions and transmits signals to and from different parts of body. Concentration of sense organs and nerve cells lie at front end of body.

Development at Early Stages

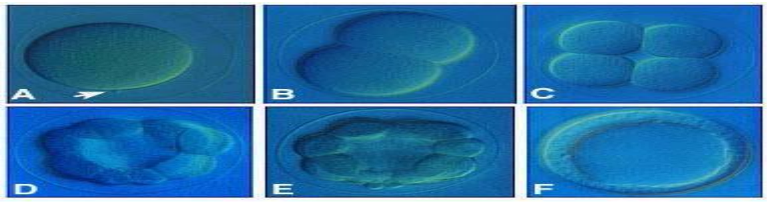
Fertilization leads to a zygote formation

1. Blastula

The early developmental stage of an animal, following the morula stage and consisting of a single, spherical layer of cells enclosing a hollow, central cavity.

2. Gastrula

An embryo at the stage following the blastula, after the movement of cells results in the formation of the three germ layers, ectoderm, mesoderm, and endoderm.



Germ Layers

1. Ectoderm

The ectoderm generates the outer layer of the embryo, and it forms from the embryo's epiblast. The ectoderm develops into the surface ectoderm, neural crest, and the neural tube.

2. Endoderm

The endoderm is one of the germ layers formed during animal embryogenesis. Cells migrating inward along the archenteron form the inner layer of the gastrula, which develops into the endoderm.

3. Mesoderm

The mesoderm germ layer forms in the embryos of triploblastic animals. During gastrulation, some of the cells migrating inward contribute to the mesoderm, an additional layer between the endoderm and the ectoderm.

Developmental Types

1. Deuterostomes

Any animal in which the initial pore formed during gastrulation becomes the anus, and the second pore becomes the mouth**.**

2. Protostomes

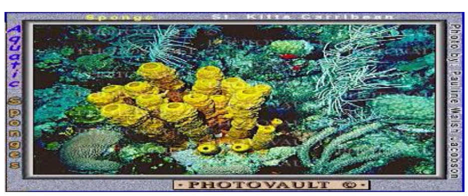
Any of numerous invertebrate animals of the group Protostomia, in which the mouth develops from the first opening in the embryo and the anus develops later, and including the mollusks, annelids, and arthropods.

Symmetry of Body

Symmetry of animal body is divided into three types

1. **Asymmetry**

Sponges are very simple animals. They are sessile, which means they do not move on their own, and live in ocean environments. Sponges are unique from all other animals and have no true tissues or organs. Most sponges have a type of symmetry referred to as asymmetry.

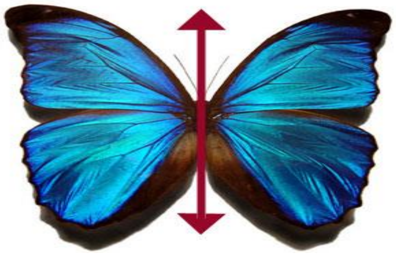


2. Radial Symmetry

An animal with radial symmetry has a body shape that radiates outward from a center point. If you think about a bike wheel, it has a center point from which all of the spokes radiate outward. Animals with this type of symmetry have a similar form**.**

3. Bilateral Symmetry

As animals evolved over time they developed bilateral symmetry. Animals with this type of symmetry have a left side, right side, top, and bottom, as well as a head and rear end. Over time, the head end developed more complex sensory processing abilities.



1. Acoelomatic Body Plans

Any organism that lacks a cavity between the body wall and the digestive tract, including the flatworms, nemertines, and sea anemones.

2. Pseudocoelomatic Body Plans

Pseudocoelomate animals have a “false cavity”, which is a fully functional body cavity. Tissue derived from mesoderm only partly lines the fluid filled body cavity of these animals. Thus, although organs are held in place loosely, they are not as well organized as in a coelomate.

3. Coelomatic Plans

Coelomates (also known as eucoelomates—"true coelom") have a fluid-filled body cavity called a coelom with a complete lining called peritoneum derived from mesoderm (one of the three primary tissue layers).

1. Feeding of Herbivores

Herbivores

A herbivor*e* is an animal anatomically and physiologically adapted to eating plant material.

Examples

Cow, Goat, sheep etc.

2. Feeding of Carnivores

Carnivores

A carnivore derives its energy and nutrient requirements from animal tissue. It may be through predation or scavenging.

Examples

Cat, Dog

3. Feeding of Omnivores

Omnivores

An omnivore is an animal that can derive its energy and nutrients from different sources. These sources may be plants, animals, algae, fungi and bacteria.

Example

Crow

4. Feeding of Filter Feeders

Filter Feeders

Filter feeders are animals that feed by straining suspended matter and food particles from water. For this purpose they pass through the water over a specialized filtering structure.

Examples

Baleen whales

5. Feeding of Parasites

Parasites

Feed on living organisms usually harmful the host organism.

Example: Lice

https://en.wikipedia.org/wiki/Eukaryote
https://en.wikipedia.org/wiki/Nervous_system
http://www.dictionary.com/browse/blastula
https://en.wikipedia.org/wiki/Germ_layer
https://en.wiktionary.org/wiki/deuterostome
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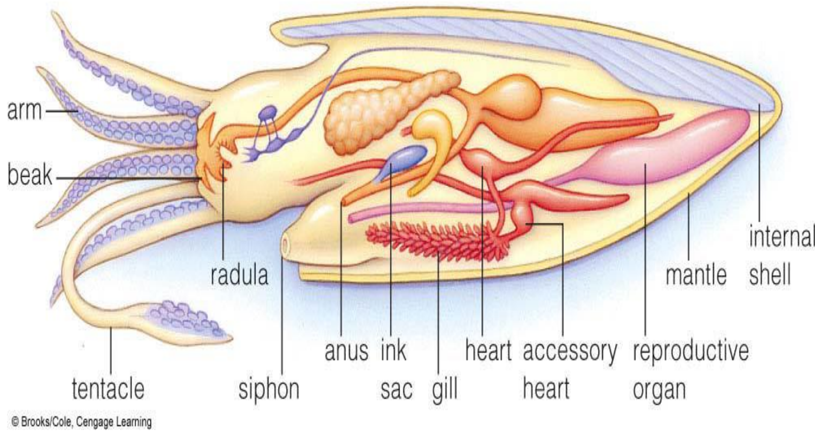
http://www.newworldencyclopedia.org/entry/Body_cavity

Lecture 27

Cephalopoda and Arthropoda

Phylum Cephalopoda

The cephalopods are considered to be the most highly advanced of the molluscs. All are marine, and the foot is modified to form a series of tentacles and a head. In some the shell is external, but in the most familiar cephalopods the shell is internal or absent. Cephalopods have very prominent and sophisticated eyes, which are remarkably similar to those of vertebrates. Include the fastest (squids), biggest (giant squid), and smartest (octopuses) invertebrates.

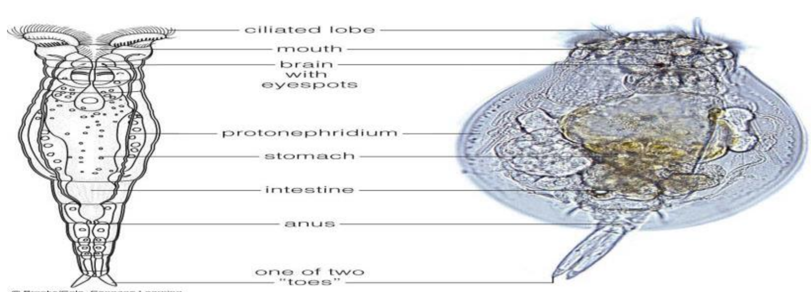


A Cephalopod's Body Plan

Rotifers and Tardigrades

Rotifers

Rotifers (phylum rotifera) live in fresh water and in damp land habitats. Most are less than one millimeter long. The group name is Latin for wheel bearer. It refers to the constantly moving cilia to the head, which direct food to the mouth and look like turning wheels. These are excretory organs (protonephridia) and a complete digestive system cut no circulatory or respiratory organ.

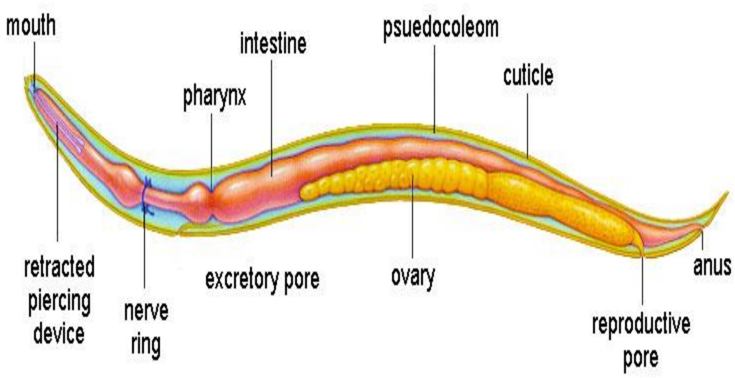


Tardigrades

Tardigrades (phylum Tardigrada) are similarly tiny animals that often live beside rotifers in damped moss and temporary ponds. Commonly called water bears they waddle about on four pairs of stubby legs. Tardigrada means slow walker. Most suck juices from plant and algae. Some including is in predators. They eat roundworms, rotifers and one another.

Phylum Nematoda

Phylum Nematoda consists of the nematodes, or roundworms. They are unsegmented, pseudocoelomate worms with a secreted cuticle that is molted. Nematodes were once classified with a very large and heterogeneous cluster of animals grouped together on the basis of their overall worm-like appearance, simple structure of an internal body cavity called a pseudocoelom, and the lack of features such as cilia and a well-defined head that are found in most animals.



Phylum Arthropoda

1. Arthropods

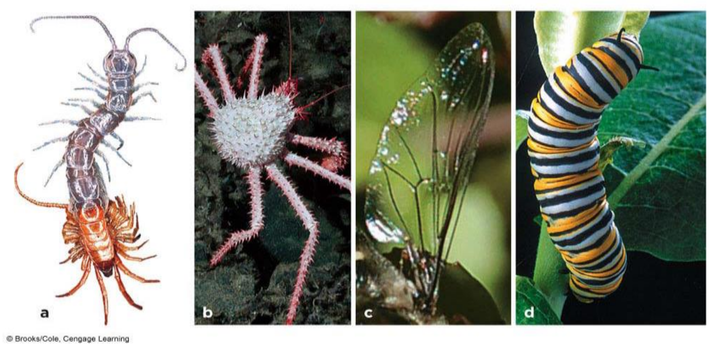
Arthropod, any member of the phylum Arthropoda, the largest phylum in the animal kingdom, which includes such familiar forms as lobsters, crabs, spiders, mites, insects, centipedes, and millipedes. About 84 percent of all known species of animals are members of this phylum. Arthropods are represented in every habitat on Earth and show a great variety of adaptations. Several types live in aquatic environments, and others reside in terrestrial ones; some groups are even adapted for flight.

Arthropod Characteristics

1. They possess a chitinous exoskeleton that must be shed during growth.
2. The paired appendages (e.g., legs, antennae) are jointed.
3. The segmented bodies are arranged into regions, called tagmata (e.g., head, thorax, and abdomen)
4. They have bilateral symmetry.
5. The nervous system is ventral (belly) and the circulatory system is open and dorsal (back).

Arthropod Adaptations

Arthropods have many adaptations that allow it to survive in their environment. The first adaptation is that the arthropods have an outer body covering called and exoskeleton. The exoskeleton is made of a special material called chitin. This material is hard and thick so it protects it from predators. Another adaptation arthropods have is that they have special mouth parts. A mosquito (arthropod) has a special mouth which allows it to break through humans skin and suck our blood. The next adaptations arthropods have are their jointed legs. These jointed legs help them so much. With them they can move really fast because their legs are flexible, or jointed, so they can get away from prey or catch prey.



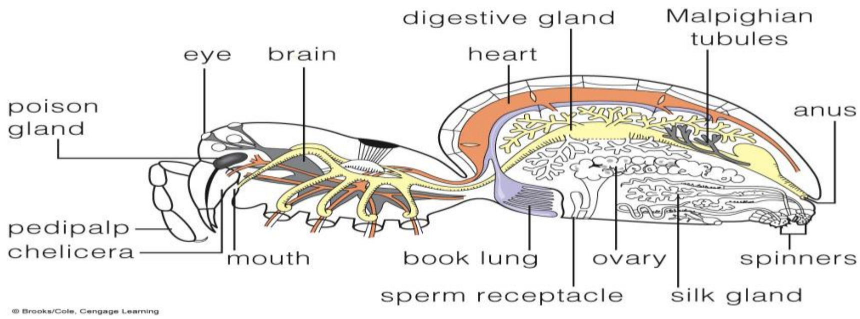
Chelicerates

The subphylum Chelicerates is one of the five subdivisions of the phylum Arthropoda, with members characterized by the absence of antennae and mandibles (jaws) and the presence of chelicerae (a pincer-like mouthpart as the anterior appendage, composed of a base segment and a fang portion). Extant Chelicerates include spiders, scorpions, ticks, and mites (class Arachnida), horseshoe crabs (class Xiphosura or Merostomata), and sea spiders (class Pycnogonida).

The Spiders

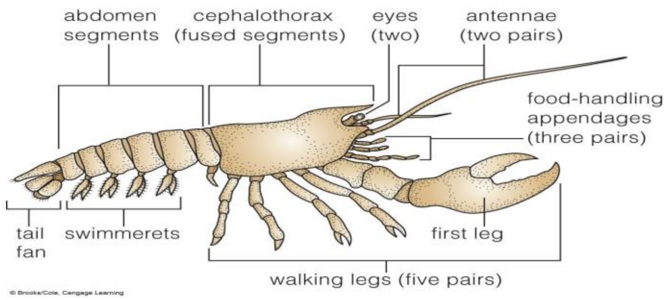
Spiders are predatory, invertebrate animals with two body segments, eight legs, no chewing mouth parts, and no wings. All spiders produce silk, a thin, strong protein strand extruded by the spider from spinnerets most commonly found on the end of the abdomen. Many species use it to trap insects in webs, although there are many species that hunt freely.

Body plan of spider



Crustaceans

Crustaceans form a very large group of arthropods, usually treated as a subphylum, which includes such familiar animals as crabs, lobsters, crayfish, shrimp, krill and barnacles. Like other arthropods, crustaceans have an exoskeleton, which they moult to grow. They are distinguished from other groups of arthropods, such as insects, myriapods and chelicerates by the possession of biramous (two-parted) limbs, and by their larval forms, such as the nauplius stage of branchiopods and copepods.



Myriapods

Myriapods (Myriapoda) are a group of arthropods that includes millipedes, centipedes, pauropods, and symphylans. There are about 15,000 species of myriapods alive today. As their name implies, myriapods are noted for their having many legs. The number of legs a myriapod has varies from species to species and there is a wide range. Some species have fewer than a dozen legs, while others have many hundreds of legs.

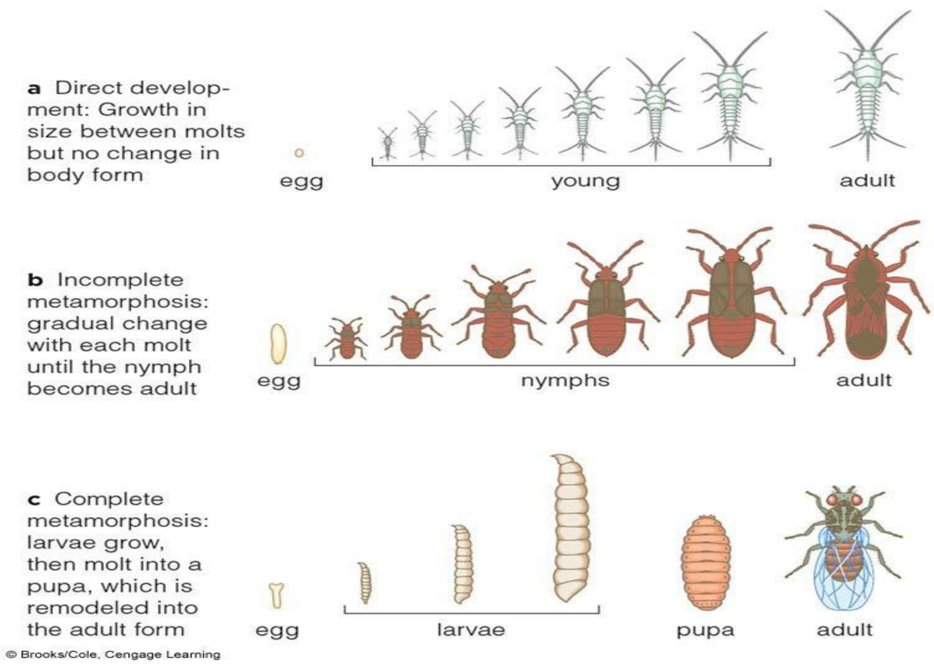
The Insects

Insects are a class of invertebrates within the arthropod phylum that have a chitinous exoskeleton, a three-part body (head, thorax and abdomen), three pairs of jointed legs, compound eyes and one pair of antennae. They are the most diverse group of animals on the planet, including more than a million described species and representing more than half of all known living organisms.

Insects are Most Successful Animals

Insects are most numerous & successful creatures on Earth. Their species richness or diversity surpasses any other group of organisms. Throughout the insect evolution, several factors have combined to make insects the most successful of all species on this planet. There are several reasons for their success, mainly their ability to fly and reproduce quickly, their generally small size, and their protective cuticle (external exoskeleton), their insulated central nervous system and their unusual wing folding mechanism. Development may be direct, or through incomplete or complete metamorphosis.

Insect Development



Ref:

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http://www.ucmp.berkeley.edu/phyla/ecdysozoa/nematoda.html
http://www.britannica.com/animal/arthropod
https://7salemanimalkingdom.wikispaces.com/Arthropods
http://www.newworldencyclopedia.org/entry/Chelicerata
http://www.newworldencyclopedia.org/entry/Spider
https://en.wikipedia.org/wiki/Crustacean
http://animals.about.com/od/arthropods/fl/myriapods.htm
https://en.wikipedia.org/wiki/Insect

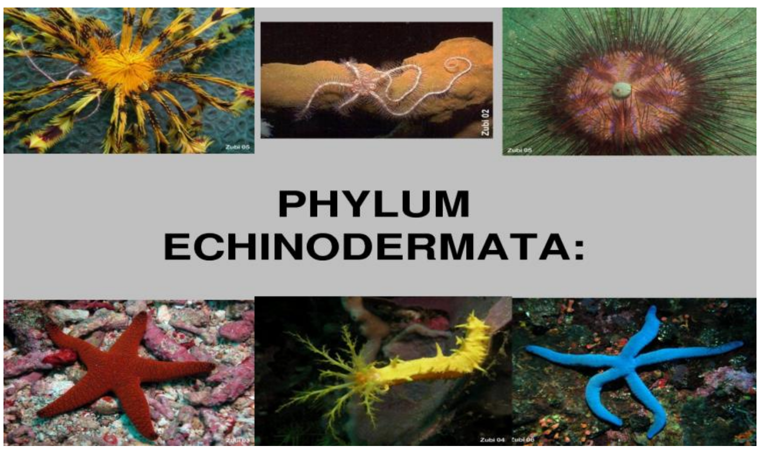
Lecture 28
Echinodermata and Chordata

Phylum Echinodermata

1. Echinoderms include common seashore animals such as seastars (also known as "starfish"), sand dollars and sea urchins, along with hundreds of more exotic forms. Their basic body plan is very different from other animals, but their closest living relatives are the Phylum Chordata (which includes the vertebrates).

2. Echinoderms are exclusively marine, and most are benthic. They are present in virtually all marine environments of normal salinity, from the shallow intertidal to the abyssal zone. Many echinoderms are suspension feeders, while others are predators, scavengers and herbivores. A few are deposit feeders.

3. Although the phylum is quite diverse, echinoderm physiology and their body plan display a surprising uniformity. They are characterized by an internal skeleton (endoskeleton) composed of calcitic plates (ossicles), and a water vascular system. The ossicles have a porous microstructure that is distinctive.

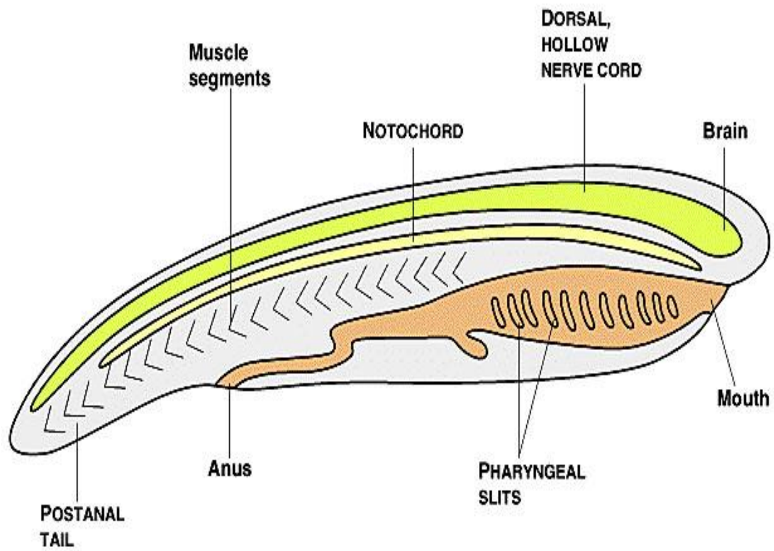


Phylum Chordata

The Phylum Chordata includes the well-known vertebrates (fishes, amphibians, reptiles, birds, mammals). The vertebrates and hagfishes together comprise the taxon Craniata. The remaining chordates are the tunicates (Urochordata), lancelets (Cephalochordata), and, possibly, some odd extinct groups. With few exceptions, chordates are active animals with bilaterally symmetric bodies that are longitudinally differentiated into head, trunk and tail. The most distinctive morphological features of chordates are the notochord, nerve cord, and visceral clefts and arches. Members of the phylum Chordata are bilaterally symmetric, deuterostome coelomates, and the vertebrate chordates display segmentation.

Characteristics of the Chordates

1. Single, hollow nerve cord beneath dorsal surface; in vertebrates, it differentiates into brain and spinal cord
2. Notochord: flexible rod on the dorsal side of gut, present at one stage in all chordates; displaced in vertebrates by vertebral column that forms around the nerve cord
3. Pharyngeal slits (pouches) connect pharynx (between mouth and esophagus) with outside Gills in sharks, fish; present in terrestrial animal embryos but disappear later except Eustachian tube (connecting throat and middle ear)
4. Postanal tail extends beyond anus; present at least in embryo; regresses into tail bone in humans
5. Segmentation: reflected in arrangement of muscles (somites) and in vertebral column (both mesoderm)



A Chordate Anatomy

Invertebrate Chordates

Sub-phylum Urochordata

The tunicates are marine, filter-feeding animals. The most prominent tunicates are the sea squirts (class Ascidiacea), which show affinities to other chordates only in the juvenile stage. Adult sea

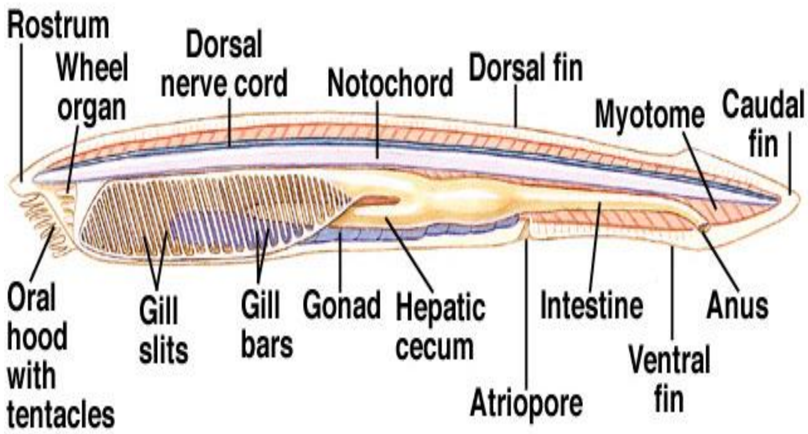
Squirts are sessile (attached), globular or tubular animals, often with prominent incurrent and excurrent siphons; many kinds grow in colonies. Most of the body of the adult is occupied by a very large pharynx with numerous gill slits that act as a sieve for food. Water taken into the incurrent siphon enters the pharynx and passes out through the gill slits, leaving food particles trapped in the pharynx. A groove in the pharynx called the endostyle secretes mucus that traps the particles and conveys them into the digestive tract; the movement of the mucus is caused by the action of cilia. Water leaves the atrium, a sac surrounding the pharynx, by way of the excurrent siphon. Thus the gill slits in tunicates serve a feeding function, not a respiratory function.

Chordate Metamerism

The repetition of organs and tissues at intervals along the body of an animal, thus dividing the body into a linear series of similar parts or segments (metameres). It is most strikingly seen in Annelida. Essentially, metameric segmentation is an internal, mesodermal phenomenon, the body musculature and coelom being the primary segmental divisions; this internal segmentation imposes a corresponding segmentation on the nerves, blood vessels, and excretory organs. In some metameric animals the segmentation is visible externally but in others (e.g. Chordata) external segmentation has been lost and internal segmentation is best seen in the embryo. Metameric segmentation is thought to have arisen as an adaptation to more efficient locomotion.

Sub-phylum Cephalochordata

This class includes the several species of lancelets, or amphioxi, small, fishlike, filter-feeding animals found in shallow water. A lancelet has a long body, pointed at both ends, with a large notochord that extends almost from tip to tip and is present throughout life. At one end is a mouth surrounded by prominent bristles and leading into a pharynx. The pharynx has gill slits, an endostyle similar to that of a sea squirt, and an atrium surrounding the pharynx. Water enters the mouth and leaves through the gill slits, and food is trapped in the pharynx. The dorsal, tubular nerve cord is slightly enlarged in the anterior region, forming a rudimentary brain. Nerves extend from the nerve chord to other parts of the body. The muscles, as in fishes, are a series of cone-shaped blocks that fit into each other like stacked paper cups.



<u>Sub-phylum Vertebrata</u>

General Characteristics

• Usually well cephalized, including a number of anterior sensory structures.
• Brain is in a skull.
• Mostly, the embryonic notochord is replaced by a *vertebral column***.**
• Possess a distinctive endoskeleton consisting of vertebral column, limb girdles, two pairs of jointed appendages, and a head skeleton
• Muscles are attached to the skeleton to provide movement
• Closed circulatory system with a well-developed muscular heart.
• Blood is oxygenated as it flows through vascularized skin, gills or lungs.

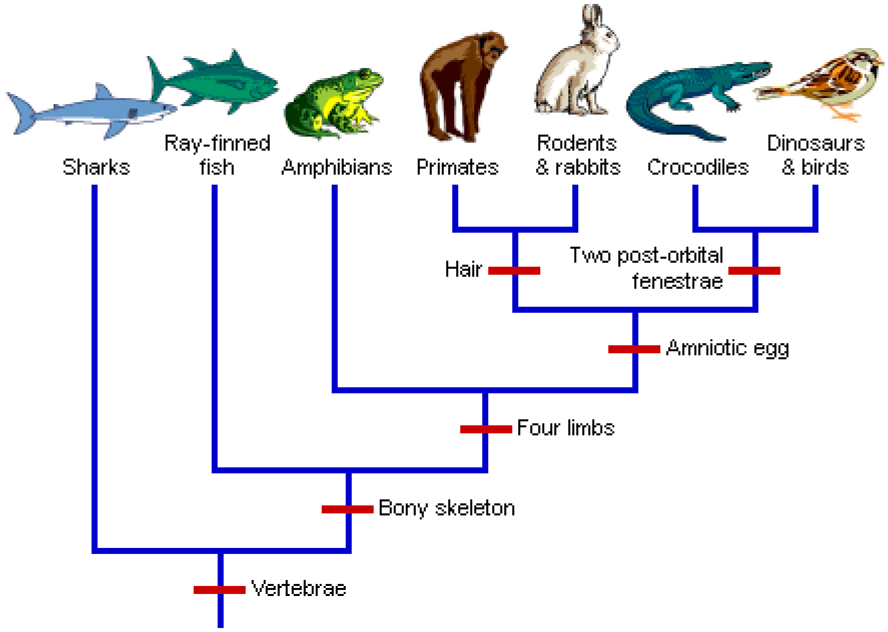
Evolutionary Relationships of Vertebrates

1) Vertebrate animals have come a long way since their tiny, translucent ancestors swam the world's seas over 500 million years ago.

2) The major vertebrate animal groups, ranging from fish to amphibians to mammals, with some notable extinct reptile lineages (including archosaurs, dinosaurs and pterosaurs) in between.

3) This idea is supported by the discovery of a fossilized mid-Cambrain invertebrate chordate from the Burgess Shale formation – *Pikaia*

4) A ribbon shaped, somewhat fish-like creature about 5 cm in length
5) It possessed a notochord and the V-shaped myomeres.
6) Resembles Amphioxus, and may very well be an early cephalochordate.



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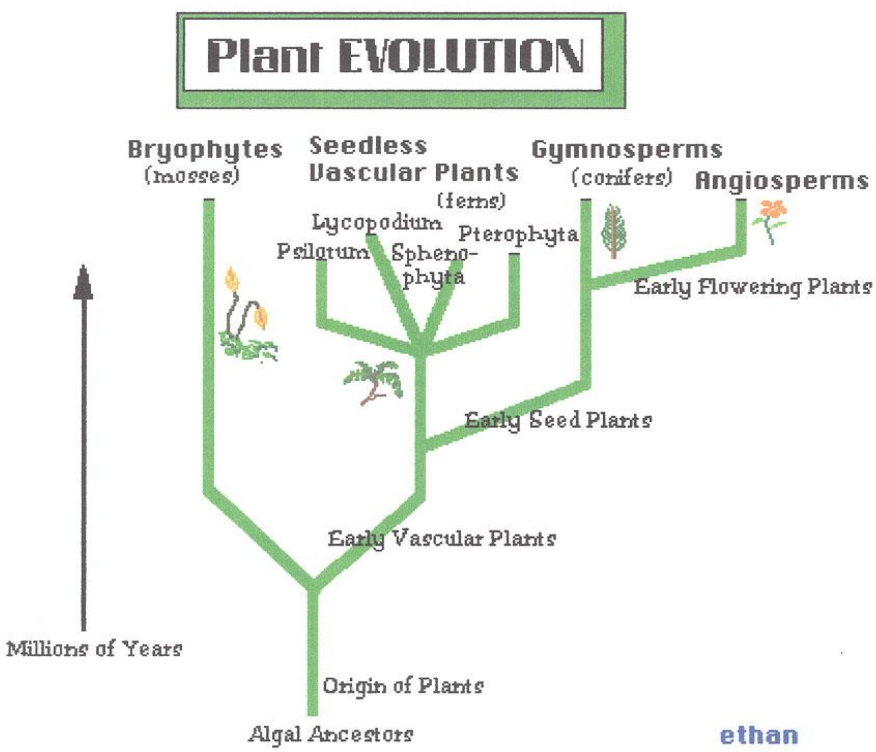
Lecture 29

Introduction to Kingdom Plantae

Fundamental Features

1. Most of the plants are eukaryotic and chlorophyll containing organisms.
Cell walls of plant cells are comprised of cellulose.
2. They have an ability to grow by cell division.
3. In life cycle of plant cells, the interchanges occur from the embryos and are supported by other tissues and self-produce.
4. Plants have both organs and organ systems.
5. They obtain their energy from sun through photosynthesis.
6. Plants reproduce both by sexual and asexual.
7. Plants develop a self-defense mechanism to protect them from being destroyed by animals, fungi and other plants.
8. Organisms within Kingdom Plantae are multicellular, eukaryotic and autotrophic.

Historical Background



Roots Function

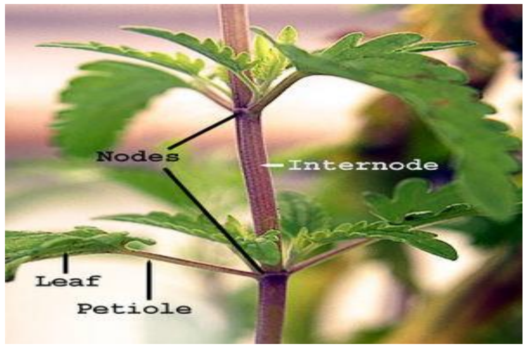
Roots anchor the plant to the ground. The roots absorb Necessary nutrients, water from the soil for photosynthesis. A root undergoes vegetative reproduction and competition with other plant

Function of Leaves

Leaves extend the surface area to capture sunlight. Photosynthesis occurs inside the chloroplasts. Chloroplasts are present in the cells present in leaves. The preparation of food material takes place out of water and carbon dioxide obtained from the soil and the air respectively.

Function of Stems

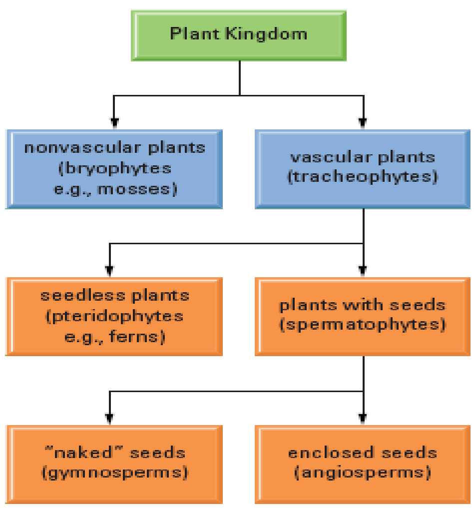
Stems are composed of rigid tissue. They provide support to leaves. It helps to maintain integrity of plants. Stems also transport materials. Transport occurs from the roots to leaves and vice versa. Plant stems always have nodes (points of attachments for leaves, roots, and flowers) and internodes (regions between nodes).The petiole is the stalk that extends from the stem to the base of the leaf.



Plant Taxonomy

Plant taxonomy is the science that finds, identifies, describes, classifies, and names plants. Thus making it one of the main branches of taxonomy (the science that finds, describes, classifies, and names living things).Plant taxonomy is closely allied to plant systematics, and there is no sharp boundary between the two. In practice, "Plant systematics" involves relationships between plants and their evolution, especially at the higher levels, whereas "plant taxonomy" deals with the actual handling of plant specimens.

Divisions of Kingdom Plantae



Bryophytes

Bryophytes are small, herbaceous plants that grow closely packed together in mats or cushions on rocks, soil, or as epiphytes on the trunks and leaves of forest trees. Bryophytes are Non-vascular land plants do not contain any conducting tissues. Such plants are often referred to as bryophytes. These plants are small, grow near the ground surface. Examples include *mosses* and
Liverworts.

Seedless Vascular Plants

Seedless vascular plants are plants that contain vascular tissue, but do not produce flowers or seeds. In seedless vascular plants, such as ferns and horsetails, the plants reproduce using haploid, unicellular spores instead of seeds. The spores are very lightweight (unlike many seeds), which allows for their easy dispersion in the wind and for the plants to spread to new habitats.

Seeded Vascular Plants

Vascular seed plants, which include conifers and flowering plants, have transport tissues and produce seeds. Seed plants evolved more than 300 million years ago. Plants that reproduce by means of seeds do not necessarily require abundant moisture in order to complete their life cycle. These are divided into two further categories.

1) Angiosperms
2) Gymnosperms

Gymnosperms

Gymnosperms are nonflowering plants. Their seeds that do not develop within an enclosed structure. Examples are conifers, cycads, Ginkgo, and Gnetales. Gymnosperm seeds develop either on the surface of scale or a leaf-like appendage of cones or at the end of short stalks.

Angiosperms

Angiosperms are seed-producing plants; they are distinguished from gymnosperms by characteristics including flowers, endosperm within the seeds, and the production of fruits that contain the seeds. Magnoliophyta are the most diverse group of plants.
Seeds produced from seeded plants are of two types

- Monocots
- Dicots

Monocots

A monocot is a type of flowering plant that is characterized by having a single cotyledon, trimerous flowers, and parallel leaf veins. Monocots have only one seed leaf inside the seed coat. It is often only a thin leaf, because the endosperm to feed the new plant is not inside the seed leaf.

Dicots

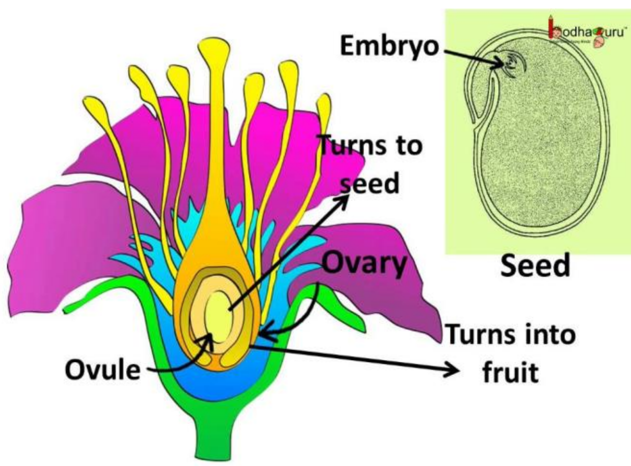
A dicot is a type of flowering plant that is characterized by having a two cotyledon, multiple flowers, and no parallel leaf veins. Dicots have two seed leaves inside the seed coat. They are usually rounded and fat, because they contain the endosperm to feed the embryo plant.

Sexual Reproduction in Plants

Plants carry out sexual reproduction. Sexual reproduction in flowering plants centers on the flower. Within a flower, there are usually structures that produce both male gametes and female gametes.

Development of the ovule and female gamete

Inside the ovary there may develop one or more ovules. Each ovule begins life as a small projection into the cavity of the ovary. As it grows and develops it begins to bend but remains attached to the ovary wall by a placenta. At the start, the ovule is a group of similar cells called the nucleus. As it develops, the mass of cells differentiates to form an inner and an outer integument, surrounding and protecting the nucellus within, but leaving a small opening called the micropyle. After fertilization the zygote develops in the seed where it can remain dormant for long periods of time and Survive drought, freezing and even fire.



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Lecture 30

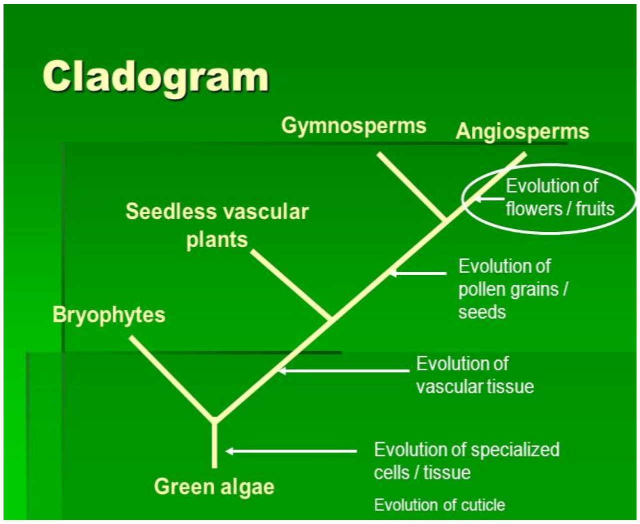
Gymnosperms and Angiosperms

Gymnosperms

Gymnosperms means “naked seed” and are are nonflowering plants. Their seeds that do not develop within an enclosed structure. Examples are conifers, cycads, Ginkgo, and Gnetales. Gymnosperm seeds develop either on the surface of scale or a leaf-like appendage of cones or at the end of short stalks.

Evolution of gymnosperms

Seed ferns were the first seed plants, protecting their reproductive parts in structures called capsules. Seed ferns gave rise to the gymnosperms during the Paleozoic Era, about 390 million years ago. Gymnosperms include the gingkoes and conifers and inhabit many, ecosystem such as the taiga and the alpine forests, because they are well adapted for cold weather. True seed plants became more numerous and diverse during the Carboniferous period around 319 million years ago; an explosion that appears to be due to a whole genome duplication event. Gymnosperms do not depend on water for fertilization (have air-borne pollen).

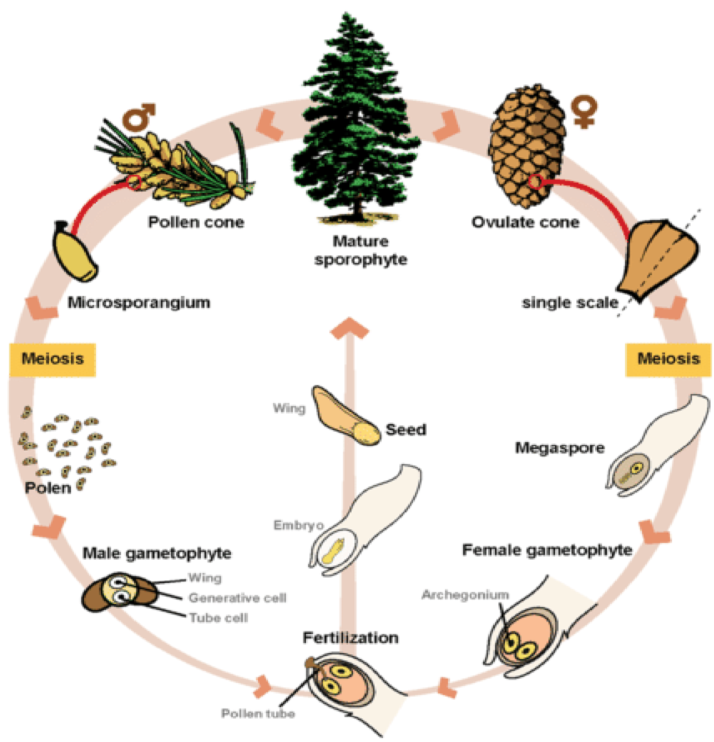


Life Cycle of Gymnosperms

1. Gymnosperms are vascular plants that produce seeds in cones. Examples include conifers such as pine and spruce trees. The gymnosperm life cycle has a dominant sporophyte generation. Both gametophytes and the next generation's new sporophytes develop on the sporophyte parent plant.

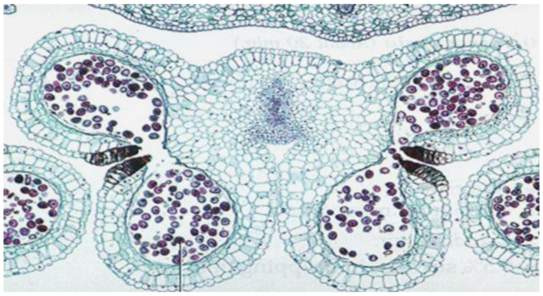
2. Cones form on a mature sporophyte plant. Inside male cones, male spores develop into male gametophytes. Each male gametophyte consists of several cells enclosed within a grain of pollen. Inside female cones, female spores develop into female gametophytes. Each female gametophyte produces an egg inside an ovule.

3. Pollination occurs when pollen is transferred from a male to female cone. If sperm then travel from the pollen to an egg so fertilization can occur, a diploid zygote results. The zygote develops into an embryo within a seed, which forms from the ovule inside the female cone. If the seed germinates, it may grow into a mature sporophyte tree, which repeats the cycle.



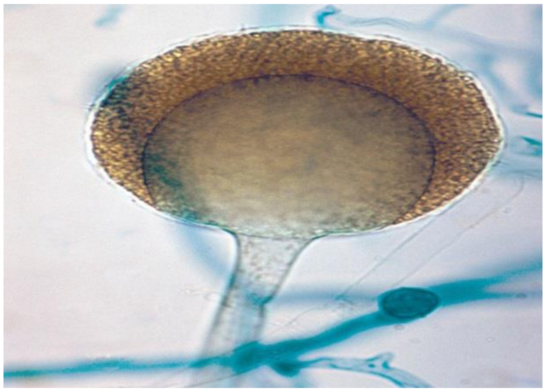
Sporophyte Generation
Sporophyte produces spores of two categories are termed as heterosporous generation.

1) Megasporangium
Megasporangium which undergoes meiosis to produce megaspores that is female gametophyte. It corresponds to the ovule or nucleus of seed plant.



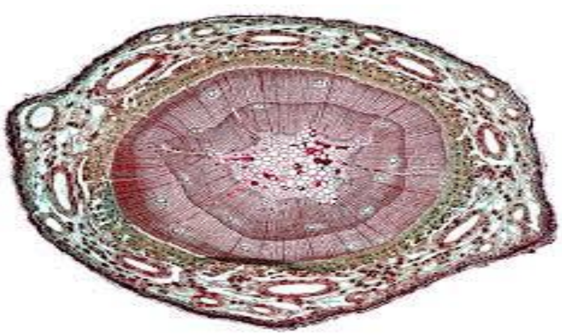
2) Sporangium

Sporangium is a structure in certain plants and other organisms that is charged with making and storing spores. Spores are haploid structures created in organisms that help to germinate and form new organisms.



Wood Manufactured by Gymnosperms

The wood is simpler than that of angiosperms; it consists primarily of elongated tracheids (water- and mineral-conducting cells) in the xylem and vascular rays in the phloem that store materials and provide for lateral conduction. The wood of gymnosperms is often called softwood to differentiate it from the hardwood angiosperms. The growth tissue of the stem and branches, known as the vascular cambium, contributes more xylem each growing season, forming concentric growth rings in the wood. Wood is formed from secondary growth.



Primary and Secondary Growth

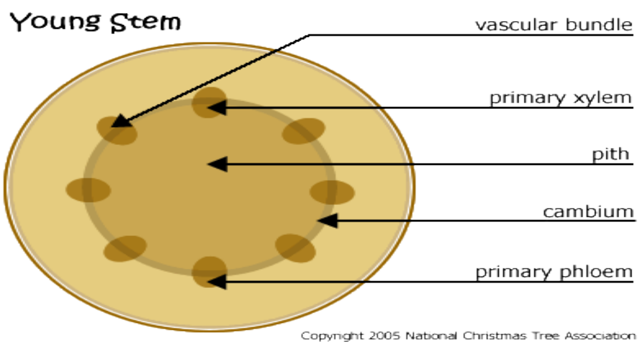
1) Primary growth

Growth in vascular plants resulting from the production of primary tissues by an apical meristem. The plant body grows lengthwise chiefly by the enlargement of cells produced by the apical meristem (rather than by cell division). Because they lack secondary tissues, most monocots and herbaceous plants grow solely by primary growth until they reach maturity, when growth stops.

2) Secondary Growth

Growth in vascular plants resulting from the production of layers of secondary tissue by a lateral meristem (the cork cambium or the vascular cambium). The new tissue accumulates and results in thicker branches and stems. Secondary growth occurs in gymnosperms, most eudicots, and woody magnoliids (such as the magnolia). Most monocots and herbaceous plants undergo little or no secondary growth but simply stop growing when their primary tissues mature.

Vascular tissue in Trees
Vascular tissue is a complex conducting tissue, formed of more than one cell type, found in vascular plants. The primary components of vascular tissue are the xylem and phloem. These two tissues transport fluid and nutrients internally. There are also two meristems associated with vascular tissue: the vascular cambium and the cork cambium. All the vascular tissues within a particular plant together constitute the vascular tissue system of that plant. Vascular tissue is present on the outer layers of the tree.



Conifers Adaptations
Conifer trees live in cold climates. This kind of cold weather can easily kill humans and other animals during prolonged exposure. Conifer trees are specially adapted to protect themselves from freezing.
One of the most notable adaptations of conifer trees is the presence of needle-like leaves. These leaves are adapted to survive in harsher and colder conditions compared to broad leaves. The needle leaf design is very similar to that of broad leaves, except everything is much more tightly packed, protecting the central vein of the leaf containing the vascular tissue. The central vein is surrounded by a sheath for protection.

Important Gymnosperms

Cycads

Cycads look like ferns and palms, but they're not really related to either of these plants. Cycads are more closely related to pine trees, and other cone-bearing plants. As mature plants, cycads bear cones, and are architectural plants that can look like living sculptures.

Ginkgo biloba

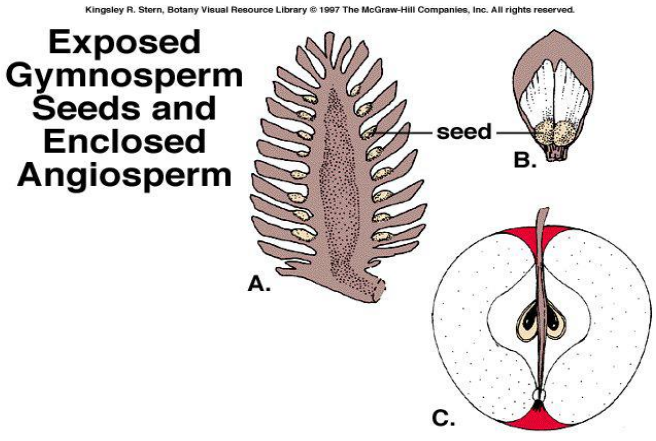
Ginkgo (*Ginkgo biloba*) is one of the oldest living tree species. It is also one of the best-selling herbal supplements in the United States and Europe. Ginkgo has a long history of use in treating blood disorders and memory issues. It is best known today as way to potentially keep your memory sharp.

Angiosperms

The angiosperms are one of the major groups of extant seed plants and arguably the most diverse major extant plant group on the planet, with at least 260,000 living species classified in 453 families. They occupy every habitat on Earth except extreme environments such as the highest mountaintops, the regions immediately surrounding the poles, and the deepest oceans. They live as epiphytes (i.e., living on other plants), as floating and rooted aquatics in both freshwater and marine habitats, and as terrestrial plants that vary tremendously in size, longevity, and overall form. They can be small herbs, parasitic plants, shrubs, vines, lianas, or giant trees. Angiosperms are the most successful and advanced plants on earth.

Evolutionary History of Angiosperms

Angiosperms evolved during the late Cretaceous Period, about 125-100 million years ago. Angiosperms have developed flowers and fruit as ways to attract pollinators and protect their seeds, respectively. Flowers have a wide array of colors, shapes, and smells, all of which are for the purpose of attracting pollinators. Once the egg is fertilized, it grows into a seed that is protected by a fleshy fruit. As angiosperms evolved in the Cretaceous period, many modern groups of insects also appeared, including pollinating insects that drove the evolution of angiosperms; in many instances, flowers and their pollinators have coevolved. Angiosperms did not evolve from gymnosperms, but instead evolved in parallel with the gymnosperms; however, it is unclear as to what type of plant actually gave rise to angiosperms.



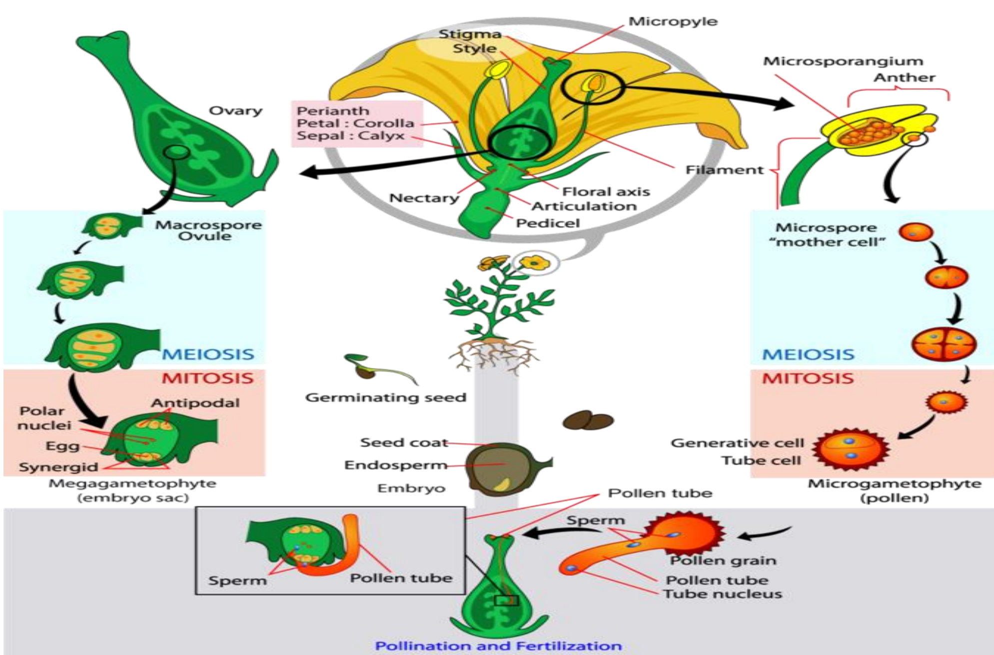
Life Cycle of Angiosperm

1. The adult, or sporophyte, phase is the main phase of an angiosperm's life cycle. As with gymnosperms, angiosperms are heterosporous. Therefore, they generate microspores, which will produce pollen grains as the male gametophytes, and megaspores, which will form an ovule that contains female gametophytes. Inside the anthers' microsporangia, male gametophytes divide by meiosis to generate haploid microspores, which, in turn, undergo mitosis and give rise to pollen grains. Each pollen grain contains two cells: one generative cell that will divide into two sperm and a second cell that will become the pollen tube cell.

2. The ovule, sheltered within the ovary of the carpel, contains the Megasporangium protected by two layers of integuments and the ovary wall. Within each megasporangium, a megasporocyte undergoes meiosis, generating four megaspores: three small and one large. Only the large megaspore survives; it produces the female gametophyte referred to as the embryo sac. The megaspore divides three times to form an eight-cell stage. Four of these cells migrate to each pole of the embryo sac; two come to the equator and will eventually fuse to form a 2n polar nucleus. The three cells away from the egg form antipodals while the two cells closest to the egg become the synergids.

3. The mature embryo sac contains one egg cell, two synergids ("helper" cells), three antipodal cells, and two polar nuclei in a central cell. When a pollen grain reaches the stigma, a pollen tube extends from the grain, grows down the style, and enters through the micropyle, an opening in the integuments of the ovule.

4. A double fertilization event then occurs. One sperm and the egg combine, forming a diploid zygote, the future embryo. The other sperm fuses with the 2n polar nuclei, forming a triploid cell that will develop into the endosperm, which is tissue that serves as a food reserve. The zygote develops into an embryo with a radicle, or small root, and one (monocot) or two (dicot) leaf-like organs called cotyledons.



Comparison of Monocotyledonous and Dicotyledonous plants

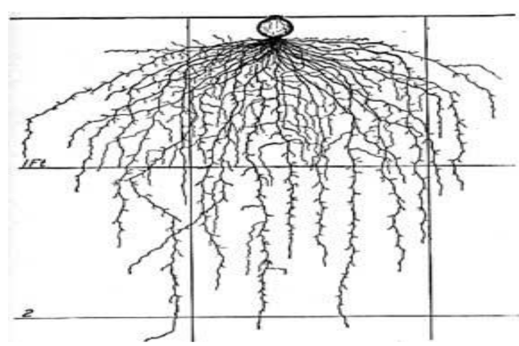
Angiosperms are divided into Monocotyledonous plants and Dicotyledonous plants.

Monocotyledonous plants vs Dicotyledonous plants

Monocotyledonous plants	Dicotyledonous plants
Seeds have a single cotyledon.	Seeds have two cotyledons
Adventitious root system present.	Tap root system present
Leaves have parallel venation.	Leaves have net venation or reticulate venation.
Flowers usually incomplete and trimerous (Floral parts are in the number of threes).	Flowers usually complete and pentamerous (floral parts in the number of fives).
Vascular bundles in stem are numerous and scattered.	Vascular bundles in stem are fewer and arranged in circles or rings.
No cambium, no secondary growth in stem.	Cambium is present, secondary growth occurs.
Stem usually hollow.	Stem usually solid
Seed germination normally hypogeal	Seed germination either hypogeal or epigeal.

Monocots

A monocot is a type of flowering plant that is characterized by having a single cotyledon, trimerous flowers, parallel leaf veins, Scattered, Herbaceous. Monocots have only one seed leaf inside the seed coat. It is often only a thin leaf, because the endosperm to feed the new plant is not inside the seed leaf. Examples (corn, lily, fibrous root etc).



Dicots

A dicot is a type of flowering plant that is characterized by having a two cotyledon, multiple flowers, and no parallel leaf veins. Dicots have two seed leaves inside the seed coat. They are usually rounded and fat, because they contain the endosperm to feed the embryo plant. Examples (bean, oak, tap root etc).

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Lecture 33-34

Biotechnology

The DNA Toolbox:

Sequencing of the genomes of more than 7,000 species was under way since 2010. DNA sequencing has depended on advancements in technology, starting with making recombinant DNA. In recombinant DNA, nucleotide sequences from two different sources, often two species, are combined in vitro into the same DNA molecule.

Recombinant DNA Technology:

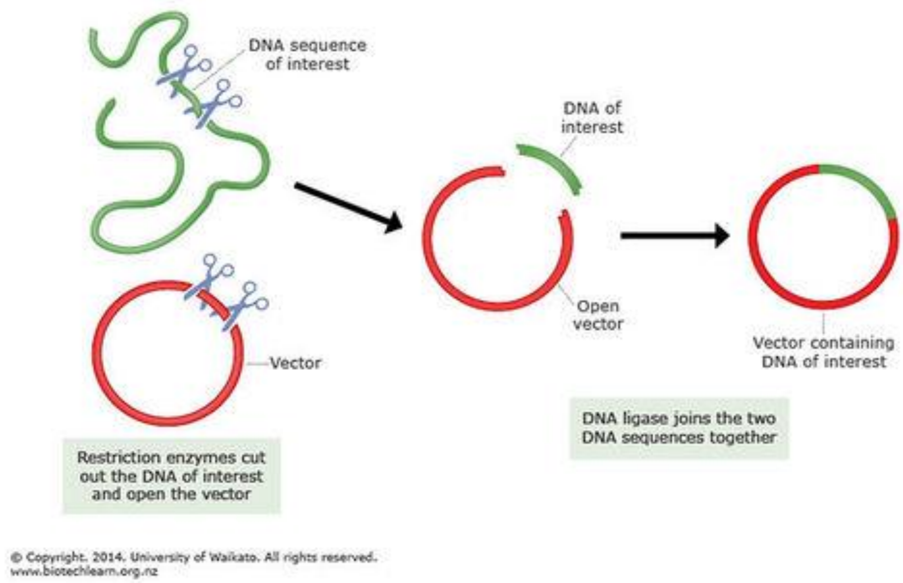
Joining together of DNA molecules from two different species that are inserted into a host organism to produce new genetic combinations that value to science, medicine, agriculture, and industry. Methods for making recombinant DNA are central to genetic engineering, the direct manipulation of genes for practical purposes. DNA technology has revolutionized biotechnology, the manipulation of organisms or their genetic components. An example of DNA technology is the microarray, a measurement of gene expression.

DNA Cloning:

The production of exact copies (clones) of a particular gene or DNA sequence using genetic engineering techniques. To work directly with specific genes, scientists prepare well-defined segments of DNA in identical copies, a process called DNA cloning. Bacterial plasmids are just small, circular DNA molecules that copy themselves separately from the other bacterial DNA material. Plasmids are ideal to use in cloning for two reasons: they are very versatile and can carry just about any gene, but they also get passed from one generation of bacteria to the next so they carry that gene on down the line.

After isolation, the scientist will treat both the plasmid and the gene of interest with an enzyme that cuts the DNA, called a restriction enzyme. These enzymes get their name from their role in nature - to restrict invading DNA from entering bacterial cells by cutting up the foreign DNA. This invading DNA may come from other organisms or even viruses, so it's important to keep them out.
The restriction enzyme cuts the plasmid in one place so that it creates an area that the target DNA can bind to. The target gene is cut out of its original DNA strand so that just the gene of interest is attached to the plasmid for cloning. After cutting both the target DNA and the plasmid, the two are linked together with an enzyme called DNA ligase. This pasting process results in a recombinant DNA plasmid, which is a single DNA molecule combined from two different sources of DNA. It is literally 'recombined,' hence the name 'recombinant.'
After the two DNA pieces have been pasted together, the plasmid is inserted into a bacterial cell,

which will allow the bacteria to replicate and produce plasmid 'babies' that are identical to the 'parent' plasmid.



Transformation:

Genetic modification of a cell by the uptake and incorporation of exogenous DNA is called transformation. Transformation occurs naturally in some species of bacteria, but it can also be affected by artificial means in other cells.
Before transformation, bacteria are treated with a chemical called calcium chloride, which causes water to enter into the cells and makes them swell. These swollen bacteria are then known as competent bacteria.
Next, plasmid DNA (containing the foreign DNA) is mixed with the competent bacteria and the solution is heated. The plasmid DNA enters the bacteria through small pores created in the cell membranes. Once in the host cell, the plasmid DNA is copied many times by the bacteria's own DNA replicating machinery.

Gene Cloning in a Bacterial Plasmid:

In gene cloning, the original plasmid is called a cloning vector. A DNA molecule that carries foreign DNA into a host cell, replicates inside a bacterial (or yeast) cell and produces many copies of itself and the foreign DNA is a cloning vector. The following three features are common in all clones.

1. Sequences that permit the propagation of itself in bacteria or yeast.
2. A cloning site to insert foreign DNA; the most versatile vectors contain a site that can be cut by many restriction enzymes.

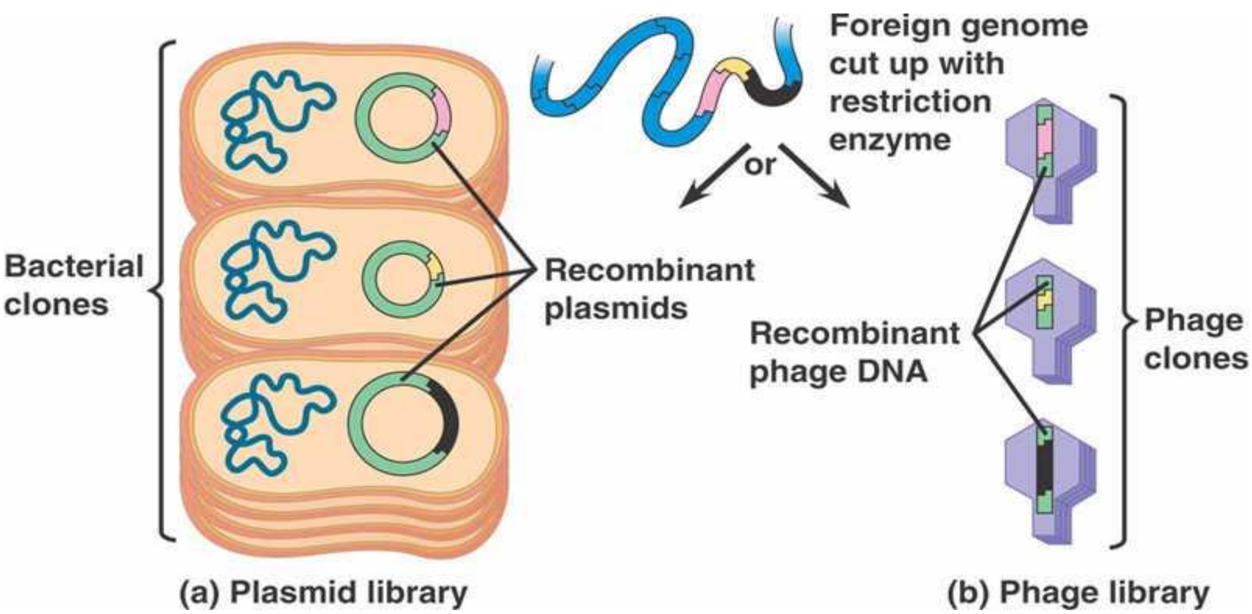
3. A method of selecting for bacteria yeast containing a vector with foreign DNA. Usually accomplished by selectable markers for drug resistance.

Producing Competent Cells:

Several steps are required to clone the hummingbird β-globin gene in a bacterial plasmid. The humming bird genomic DNA and a bacterial plasmid are isolated. Both humming bird genomic DNA and bacterial plasmids are cut with the same restriction enzyme. The fragments are mixed, and DNA ligase is added to bond the fragment sticky ends. Some recombinant plasmids now contain humming bird DNA. The DNA mixture is added to bacteria that have been genetically engineered to accept it. The bacteria are plated on a type of agar that selects for the bacteria with recombinant plasmids. This results in the cloning of many hummingbird DNA fragments, including the β-globin gene.

Preparing Genomic Libraries:

A genomic library is a collection of the total genomic DNA from a single organism. The DNA is stored in a population of identical vectors, each containing a different insert of DNA. In order to construct a genomic library, the organism's DNA is extracted from cells and then digested with a restriction enzyme to cut the DNA into fragments of a specific size. The fragments are then inserted into the vector using DNA ligase. Then the vector DNA can be taken up by a host organism. A genomic library that is made using bacteria is the collection of recombinant vector clones. A genomic library that is made using bacteriophages is stored as a collection of phage clones.



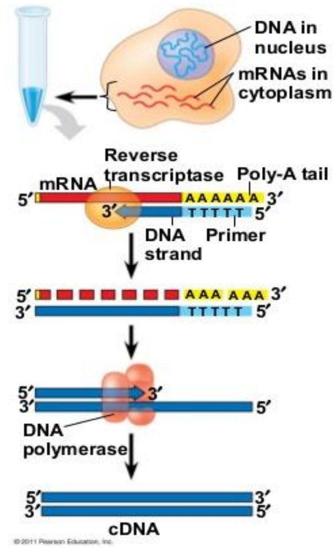
Bacterial Artificial Chromosome:

A bacterial artificial chromosome (BAC) is an engineered DNA molecule used to clone DNA sequences in bacterial cells for example, E. coli. BACs are often used in connection with DNA sequencing. Segments of an organism's DNA, ranging from 100,000 to about 300,000 base pairs, can be inserted into BACs. The BACs, with their inserted DNA, are then taken up by bacterial cells. As the bacterial cells grow and divide, they amplify the BAC DNA, which can then be isolated and used in sequencing DNA. BACs are another type of vector used in DNA library construction.

Making complementary DNA

1. CDNA refers to complementary DNA. CDNA is known to be synthesized, or manufactured from an mRNA or messenger RNA template. It is synthesized in a reaction that is catalyzed by the reverse transcriptase and DNA polymerase enzymes. Essential to note is that cDNA is usually used to clone eukaryotic genes in prokaryotes.
2. Scientists usually use cDNA when they want to express s certain protein in a cell that does not normally express such a protein. This process is referred to as heterologous expression. The expression of such a protein will be done by transferring the cDNA that codes for that protein to the recipient cell. Also, essential to note is that cDNA can also be produced by retroviruses like Simian Immunodeficiency Virus, HIV-1 and HIV-2 among others. Once the cDNA is created from such viruses, it is integrated into the genome of the host, where it goes on to create a provirus.
3. Research shows that when a protein is being synthesized, a gene's DNA is transcribed into an mRNA, which is then translated into a protein. Genes are usually divided into eukaryotic and prokaryotic genes. The only difference between these genes is that the eukaryotic genes contain introns instead of extrons that are contained in the prokaryotic genes.
4. Introns are not coding sequences, while extrons are DNA coding systems. During the transcription of the proteins, all intron RNA are cut from the primary RNA and the remaining piece is sliced back to become an mRNA. In other words, the mRNA is formed after all introns are removed from the primary RNA. Once formed, the mRNA is then translated into an amino acid and comprises a newly formed protein.

Figure 20.6 Making complementary DNA (cDNA) from eukaryotic genes.

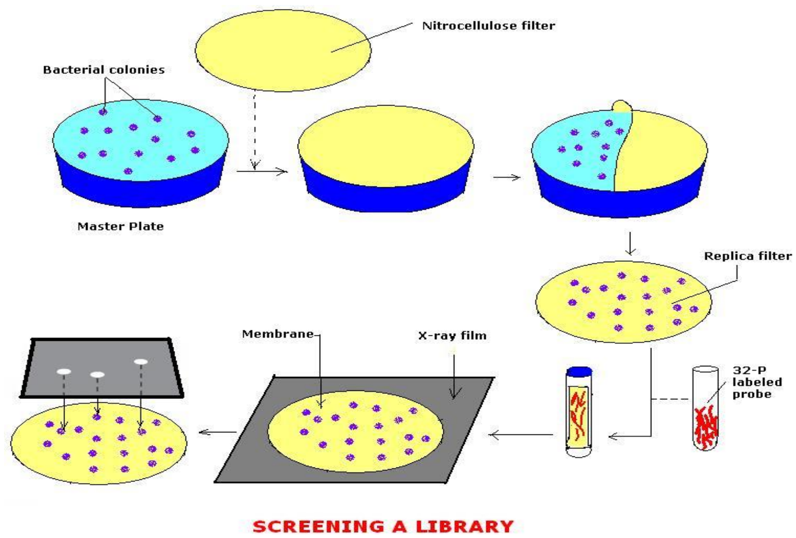


Screening a Library

One of the key elements required to identify a gene during cloning is a probe. A probe is normally a cloned piece of DNA that contains a portion of the sequence for which you are searching. You typically will make the probe radioactive and add it to a solution. Filters containing immobilized clones are then bathed in the solution. The principal behind this step is that the probe will bind to any clone containing sequences similar to those found on the probe. This binding step is called hybridization.

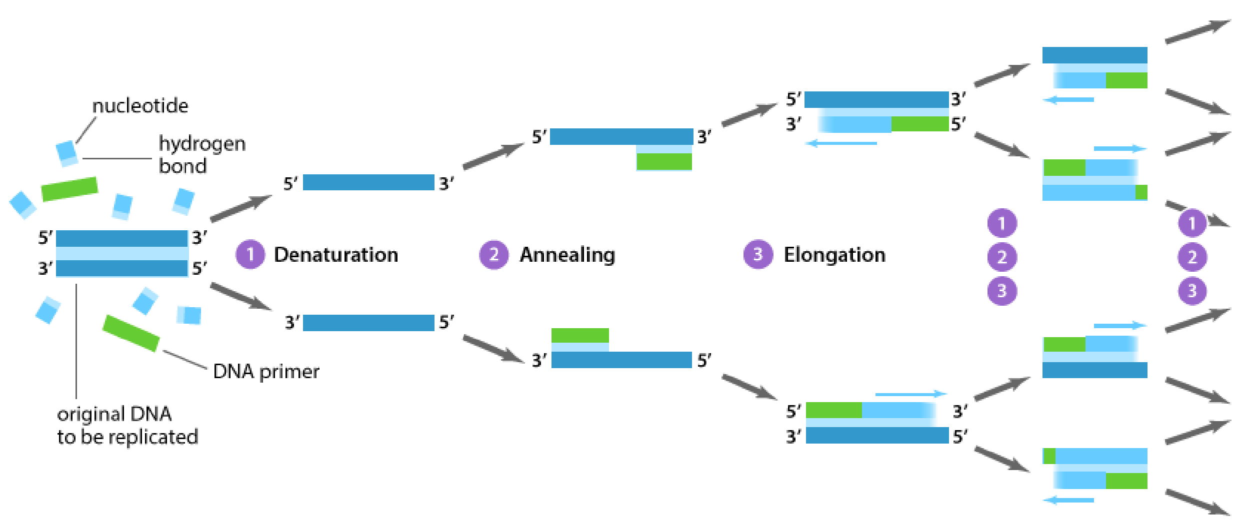
Following steps involved for screening a library.

1. Immobilize members of the library onto a nylon membrane and denature them so that they are single-stranded.
2. Prepare a radiolabelled probe and denature it to make it single-stranded.
3. Hybridize the probe to the library of clones.
4. Wash the excess probe and expose an X-ray film.
5. Isolate the positive clone and analyze.



Polymerase Chain Reaction

The polymerase chain reaction (PCR) can produce many copies of a specific target segment of DNA.A three step cycle heating, cooling, and replication brings about a chain reaction that produces an exponentially growing population of identical DNA molecules The key to PCR is an unusual, heat-stable DNA polymerase called Taq-polymerase.



DNA Sequencing

DNA Sequencing determining the order of the four chemical building blocks - called "bases" - that makes up the DNA molecule. The sequence tells scientists the kind of genetic information that is carried in a particular DNA segment. For example, scientists can use sequence information to determine which stretches of DNA contain genes and which stretches carry regulatory instructions, turning genes on or off. In addition, and importantly, sequence data can highlight changes in a gene that may cause disease.

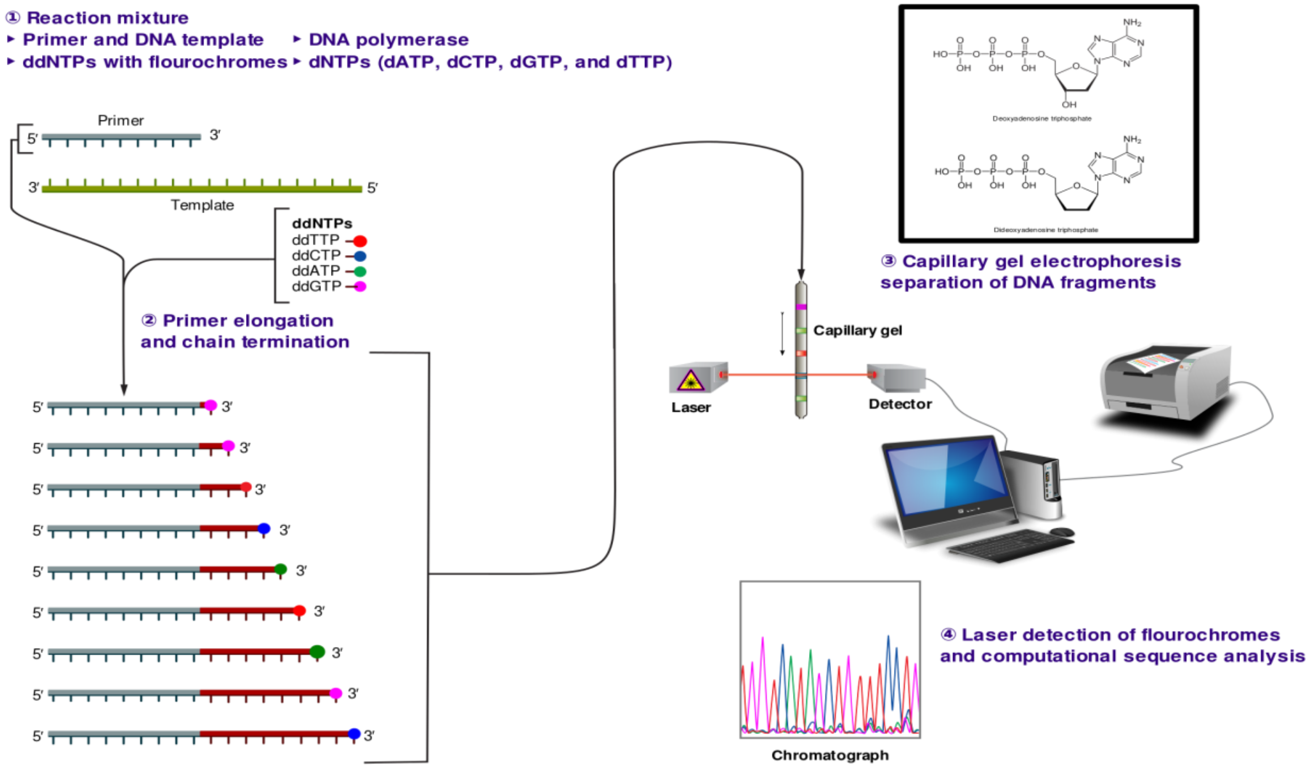
In the DNA double helix, the four chemical bases always bond with the same partner to form "base pairs." Adenine (A) always pairs with thymine (T); cytosine (C) always pairs with guanine (G). This pairing is the basis for the mechanism by which DNA molecules are copied when cells divide, and the pairing also underlies the methods by which most DNA sequencing experiments are done. The human genome contains about 3 billion base pairs that spell out the instructions for making and maintaining a human being.

Sanger sequencing

1. Sanger sequencing is a method of DNA sequencing based on the selective incorporation of chain-terminating dideoxynucleotides by DNA polymerase during in vitro DNA replication. The classical chain-termination method requires a single-stranded DNA template, a DNA primer, a DNA polymerase, normal deoxynucleosidetriphosphates (dNTPs), and modified di-deoxynucleosidetriphosphates (ddNTPs), the latter of which terminate DNA strand elongation. These chain-terminating nucleotides lack a 3'-OH group required for the formation of a phosphodiester bond between two nucleotides, causing DNA polymerase to cease extension of DNA when a modified dNTP is incorporated. The ddNTPs may be radioactively or fluorescently labeled for detection in automated sequencing machines.

2. The DNA sample is divided into four separate sequencing reactions, containing all four of the standard deoxynucleotides (dATP, dGTP, dCTP and dTTP) and the DNA polymerase. To each reaction is added only one of the four dideoxynucleotides (ddATP, ddGTP, ddCTP, or ddTTP), while the other added nucleotides are ordinary ones.

3. The dideoxynucleotide is added to be approximately 100-fold lower in concentration than the corresponding dinucleotide (e.g. 0.005mM ddATP: 0.5mM dATP) allowing for enough fragments to be produced while still transcribing the complete sequence. Putting it in a more sensible order, four separate reactions are needed in this process to test all four ddNTPs. Following rounds of template DNA extension from the bound primer, the resulting DNA fragments are heat denatured and separated by size using gel electrophoresis. In the original publication of 1977, the formation of base-paired loops of ssDNA was a cause of serious difficulty in resolving bands at some locations. This is frequently performed using a denaturing polyacrylamide-urea gel with each of the four reactions run in one of four individual lanes (lanes A, T, G, and C). The DNA bands may then be visualized by autoradiography or UV light and the DNA sequence can be directly read off the X-ray film or gel image.



Applications

Diagnosis and Treatment of Diseases

Scientists can diagnose many human genetic disorders using PCR and sequence-specific primers.

1. Then amplified product is sequenced to look for the
Disease-causing mutation.
2. SNPs may be associated with a disease-causing mutation
3. SNPs may also be correlated with increased risks for conditions such as heart disease or certain types of cancer.

Forensic Evidence and Genetic Profiles

1. An individual's unique DNA sequence, or genetic profile, can be obtained by analysis of tissue or body fluids.
2. DNA testing can identify individuals with a high degree of certainty.
3. Genetic profiles can be analyzed using RFLP analysis by Southern blotting.

Short Tandem Repeats

Even more sensitive is the use of genetic markers called short tandem repeats (STRs).
1. These are variations in the number of repeats of specific DNA sequences
2. PCR and gel electrophoresis are used to amplify and then identify STRs of different lengths
3. The probability that two people who are not identical twins have the same STR markers is Exceptionally small.

Agricultural Applications

1 .DNA technology is being used to improve agricultural productivity and food quality
2. Genetic engineering of transgenic animals speeds up the selective breeding process.
3. Beneficial genes can be transferred between varieties or species.

Genetically Modified Organisms

1. Most public concern about possible hazards centers on genetically modified (GM) organisms Used as food.
2. Some are concerned about the creation of "super weeds" from the transfer of genes from GM crops to their wild relatives.
3. Other worries include the possibility that transgenic protein products might cause allergic Reactions.

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Lecture 35

Transgenic Animals

Introduction

Transgenic animals are animals (most commonly mice) that have had a foreign gene deliberately inserted into their genome. Such animals are most commonly created by the micro-injection of DNA into the pronuclei of a fertilized egg which is subsequently implanted into the oviduct of a pseudopregnant surrogate mother. This results in the recipient animal giving birth to genetically modified offspring. The progeny are then bred with other transgenic offspring to establish a transgenic line. Transgenic animals can also be created by inserting DNA into embryonic stem cells which are then micro-injected into an embryo which has developed for five or six days after fertilization, or infecting an embryo with viruses that carry a DNA of interest. This final method is commonly used to manipulate a single gene; in most cases this involves removing or 'knocking out' a target gene. The end result is what is known as a ‘knockout’ animal.

Transgenic Techniques

The three principal methods used for the creation of transgenic animals are DNA microinjection, embryonic stem cell-mediated gene transfer and retrovirus-mediated gene transfer.

1. Embryonic stem cell-mediated gene transfer

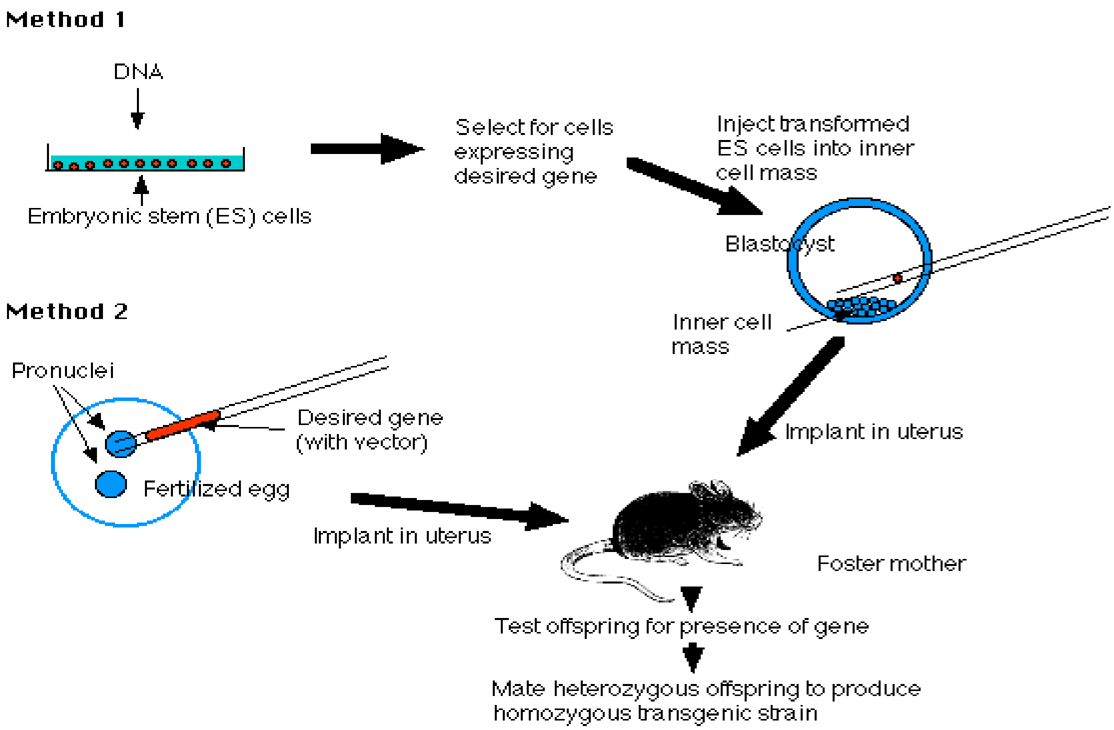
in this technique, the foreign DNA is inserted into the embryonic stem cells culture in in vitro environment by homologous recombination. Stem cells are the cells other than the sex cells which have the ability to differentiate into different types of cells giving rise to a complete organism. If the study of the genetic control is concerned then this technique is of significance and it is best used mice. It is also able to target the mutations in the genes by homologous recombination.

2. DNA Microinjection

DNA microinjection is concerned with the insertion of a single gene or group of gene into the pronucleus of a fertilized ovum. The genes of interest are taken either from the same species or from different species. This method is best used in mammals where it introduces new DNA. The introduction of new DNA may lead to the expression of either certain genes within the mammal or the expression of those genes which are newly added into the animal's genome. There is also this possibility that the gene inserted may not reach the desired site in the genome. The genetically modified ovum is then transferred into the recipient female. This method can be applied in various species.

3. Retrovirus-mediated gene transfer

Sometimes the new genes are added into the genome of the animals to increase the expression. To insert new genes, retroviruses are used as vectors which are responsible for taking the genetic material into the organism's genome. The genes inserted through this method are not expressed in all the cells. If the retrovirus succeeds to enter the germ cells of the organism, it is possible that the transgenes will be expressed in all the cells in the next generation.



Applications of Transgenic Animals

1) Can use gene transfer to improve the productivity of livestock.
2) Introduce genes for faster growth rates or leaner growth patterns.
3) A model substituting the normal gene for hemoglobin to replace sickle cell anemia gene.

Genetic Engineering

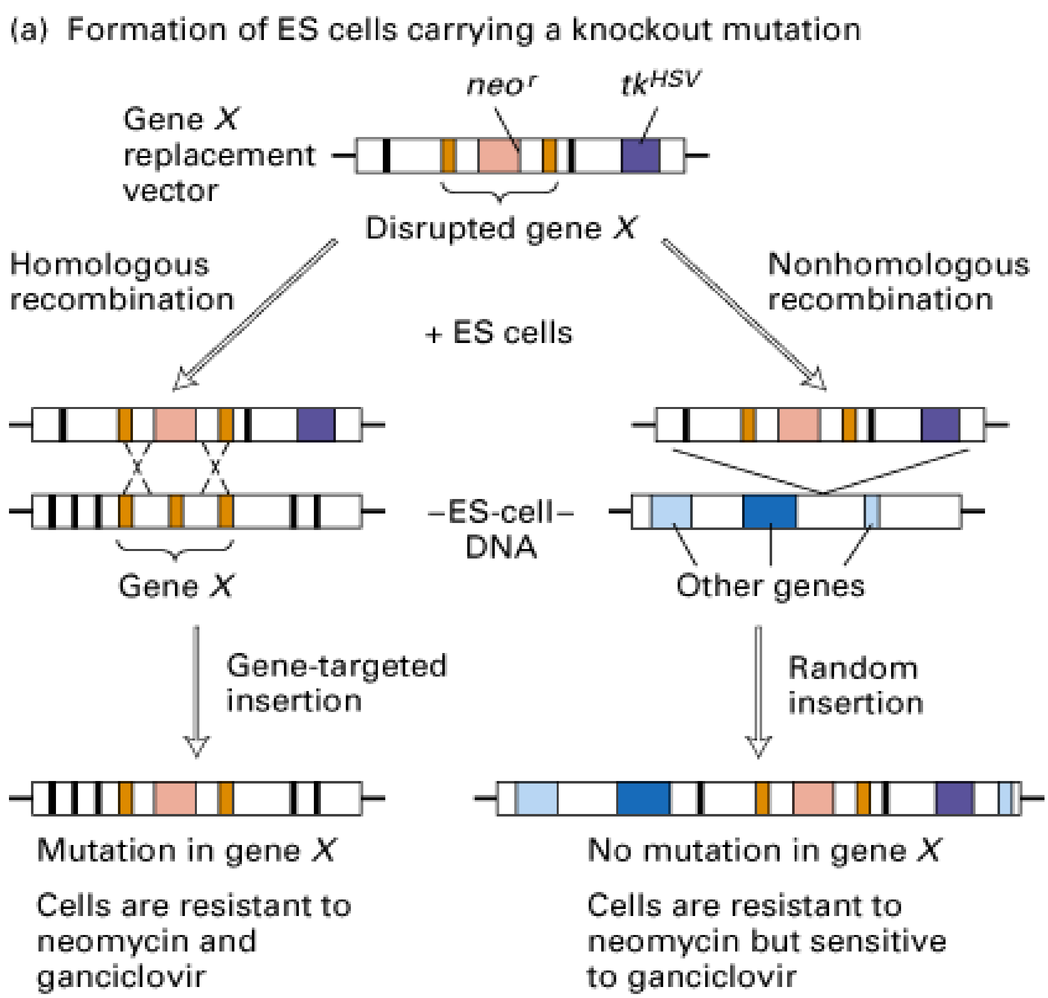
Genetic engineering alters the genetic make-up of an organism using techniques that remove heritable material or that introduces DNA prepared outside the organism either directly into the host or into a cell that is then fused or hybridized with the host.

Process

1) The first step is to choose and isolate the gene that will be inserted into the genetically modified organism. The gene can be isolated using restriction enzymes to cut DNA into fragments and gel electrophoresis to separate them out according to length. Polymerase chain reaction (PCR) can also be used to amplify up a gene segment, which can then be isolated through gel electrophoresis. If the chosen gene or the donor organism's genome has been well studied it may be present in a genetic library. If the DNA sequence is known, but no copies of the gene are available, it can be artificially synthesized.

2) The gene to be inserted into the genetically modified organism must be combined with other genetic elements in order for it to work properly. The gene can also be modified at this stage for better expression or effectiveness. As well as the gene to be inserted most constructs contain a promoter and terminator region as well as a selectable marker gene. The promoter region initiates transcription of the gene and can be used to control the location and level of gene expression, while the terminator region ends transcription.

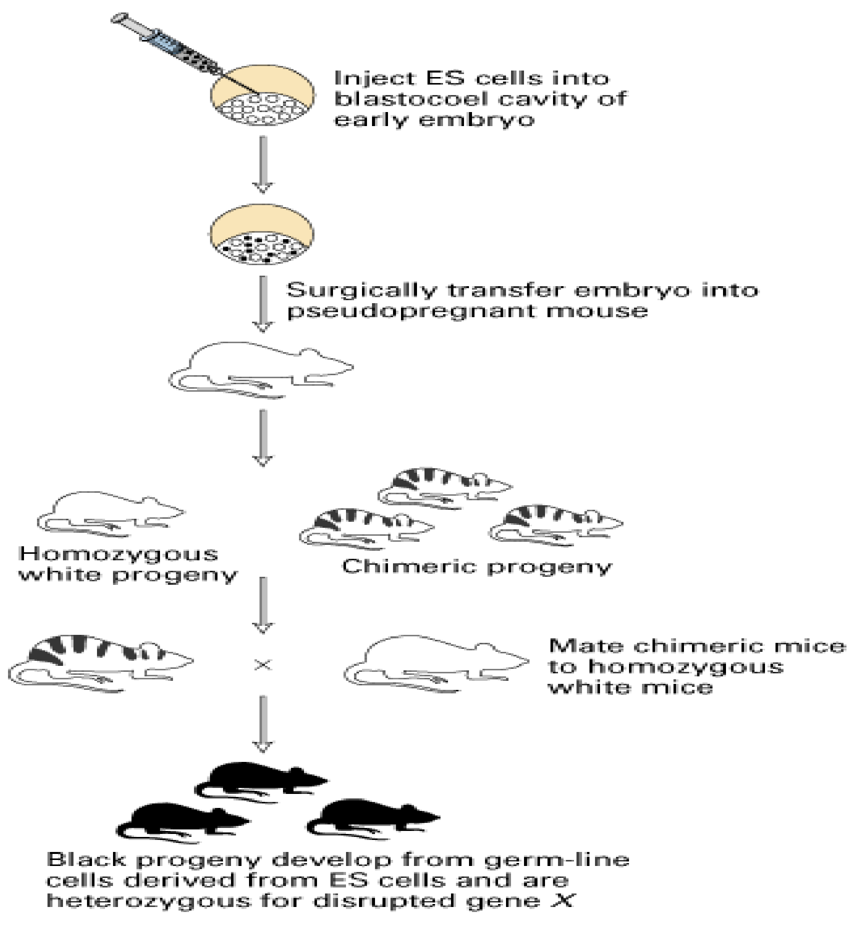
3) The most common form of genetic engineering involves inserting new genetic material randomly within the host genome. Other techniques allow new genetic material to be inserted at a specific location in the host genome or generate mutations at desired genomic loci capable of knocking out endogenous genes. The technique of gene targeting uses homologous recombination to target desired changes to a specific endogenous gene. This tends to occur at a relatively low frequency in plants and animals and generally requires the use of selectable markers. In addition to enhancing gene targeting, engineered nucleases can also be used to introduce mutations at endogenous genes that generate a gene knockout.



Transformation

1) The first step is to choose and isolate the gene that will be inserted into the genetically modified organism. The gene can be isolated using restriction enzymes to cut DNA into fragments and gel electrophoreses to separate them out according to length. Polymerase chain reaction (PCR) can also be used to amplify up a gene segment, which can then be isolated through gel electrophoresis. If the chosen gene or the donor organism's genome has been well studied it may be present in a genetic library. If the DNA sequence is known, but no copies of the gene are available, it can be artificially synthesized.

2) The gene to be inserted into the genetically modified organism must be combined with other genetic elements in order for it to work properly. The gene can also be modified at this stage for better expression or effectiveness. As well as the gene to be inserted most constructs contain a promoter and terminator\ region as well as a selectable marker gene. The promoter region initiates transcription of the gene and can be used to control the location and level of gene expression, while the terminator region ends transcription. The selectable marker, which in most cases confers antibiotic resistance to the organism it is expressed in, is needed to determine which cells are transformed with the new gene. The constructs are made using recombinant DNA techniques, such as restriction digests, ligations and molecular cloning The manipulation of the DNA generally occurs within a plasmid.



Benefits of Transgenic Animals

The benefits of these animals to human welfare can be grouped into areas:

1. Agriculture

2. Medicine

3. Industry

1. Agricultural Applications

a) Breeding

Farmers have always used selective breeding to produce animals that exhibit desired traits (e.g., increased milk production, high growth rate) Traditional breeding is a time-consuming, difficult task. When technology using molecular biology was developed, it became possible to develop traits in animals in a shorter time and with more precision. In addition, it offers the farmer an easy way to increase yields.

b) Quality

Transgenic cows exist that produce more milk or milk with less lactose or cholesterol, pigs and cattle that have more meat on them, and sheep that grow more wool. In the past, farmers used growth hormones to spur the development of animals but this technique was problematic, especially since residue of the hormones remained in the animal product.

2. Medical Application

a) Xenotransplantation

Patients die every year for lack of a replacement heart, liver, or kidney. For example, about 5,000 organs are needed each year in the United Kingdom alone. Transgenic pigs may provide the transplant organs needed to alleviate the shortfall currently, xenotransplantation is hampered by a pig protein that can cause donor rejection but research is underway to remove the pig protein and replace it with a human protein.

b) Human gene therapy

Human gene therapy involves adding a normal copy of a gene (transgene) to the genome of a person carrying defective copies of the gene. The potential for treatments for the 5,000 named genetic diseases is huge and transgenic animals could play a role. For example, the A. I. Virtanen Institute in Finland produced a calf with a gene that makes the substance that promotes the growth of red cells in humans.

3. Industrial Applications

In 2001, two scientists at Nexia Biotechnologies in Canada spliced spider genes into the cells of lactating goats. The goats began to manufacture silk along with their milk and secrete tiny silk strands from their body by the bucketful. By extracting polymer strands from the milk and weaving them into thread, the scientists can create a light, tough, flexible material that could be used in such applications as military uniforms, medical microsutures, and tennis racket strings.

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Lecture 37

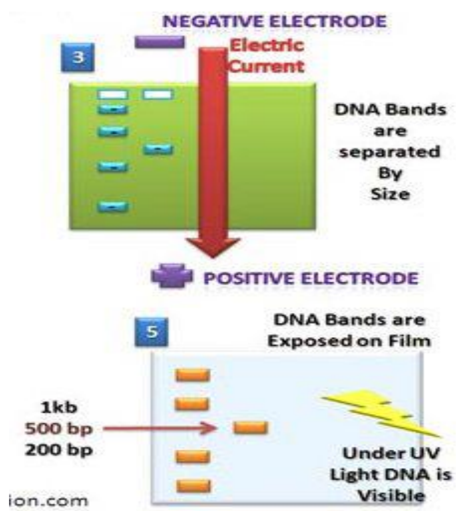
Tools in Molecular Biology

Gel electrophoresis

1. Gel electrophoresis is a laboratory method used to separate mixtures of DNA, RNA, or proteins according to molecular size. In gel electrophoresis, the molecules to be separated are pushed by an electrical field through a gel that contains small pores. The molecules travel through the pores in the gel at a speed that is inversely related to their lengths. This means that a small DNA molecule will travel a greater distance through the gel than will a larger DNA molecule.

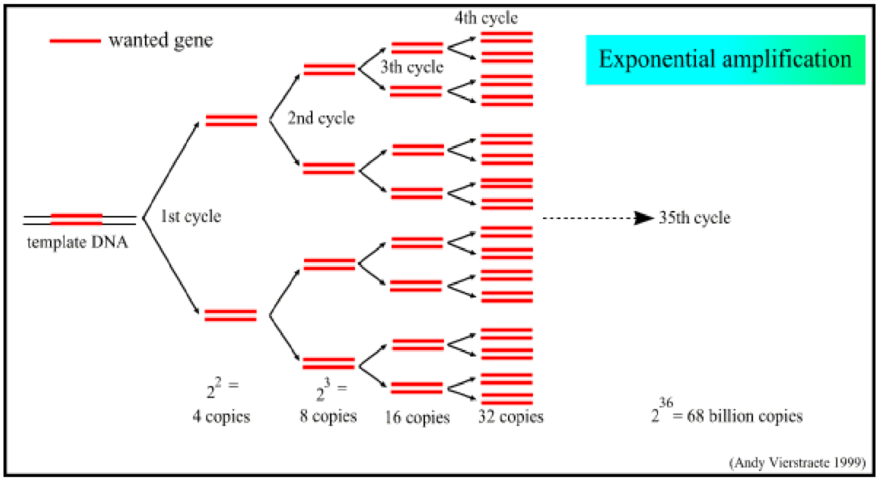
2. Gel electrophoresis involves an electrical field; in particular, this field is applied such that one end of the gel has a positive charge and the other end has a negative charge. Because DNA and RNA are negatively charged molecules, they will be pulled toward the positively charged end of the gel.

3. Proteins, however, are not negatively charged; thus, when researchers want to separate proteins using gel electrophoresis, they must first mix the proteins with a detergent called sodium dodecyl sulfate. Finally, after the DNA, RNA, or protein molecules have been separated using gel electrophoresis, bands representing molecules of different sizes can be detected.



Polymerase chain reaction (PCR)

Polymerase chain reaction, or PCR, is a laboratory technique used to make multiple copies of a segment of DNA. PCR is very precise and can be used to amplify, or copy, a specific DNA target from a mixture of DNA molecules. First, two short DNA sequences called primers are designed to bind to the start and end of the DNA target. Then, to perform PCR, the DNA template that contains the target is added to a tube that contains primers, free nucleotides, and an enzyme called DNA polymerase, and the mixture is placed in a PCR machine. The PCR machine increases and decreases the temperature of the sample in automatic, programmed steps. Initially, the mixture is heated to denature, or separate, the double-stranded DNA template into single strands. The mixture is then cooled so that the primers anneal, or bind, to the DNA template. At this point, the DNA polymerase begins to synthesize new strands of DNA starting from the primers. Following synthesis and at the end of the first cycle, each double-stranded DNA molecule consists of one new and one old DNA strand. PCR then continues with additional cycles that repeat the mentioned steps. The newly synthesized DNA segments serve as templates in later cycles, which allow the DNA target to be exponentially amplified millions of times.



Applications of PCR

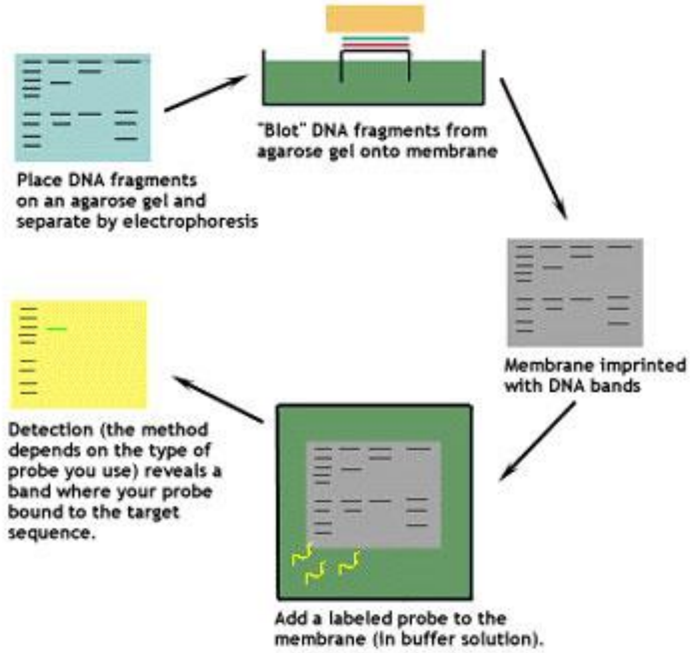
1. The first application of PCR was for genetic testing, where a sample of DNA is analyzed for the presence of genetic disease mutations. Prospective parents can be tested for being genetic carriers, or their children might be tested for actually being affected by a disease. DNA samples for prenatal testing can be obtained by amniocentesis, chorionic villus sampling, or even by the analysis of rare fetal cells circulating in the mother's bloodstream. PCR analysis is also essential to preimplantation genetic diagnosis, where individual cells of a developing embryo are tested for mutations.

2. PCR can also be used as part of a sensitive test for tissue typing, vital to organ transplantation. As of 2008, there is even a proposal to replace the traditional antibody-based tests for blood type with PCR-based tests.

3. Many forms of cancer involve alterations to oncogenes. By using PCR-based tests to study these mutations, therapy regimens can sometimes be individually customized to a patient.

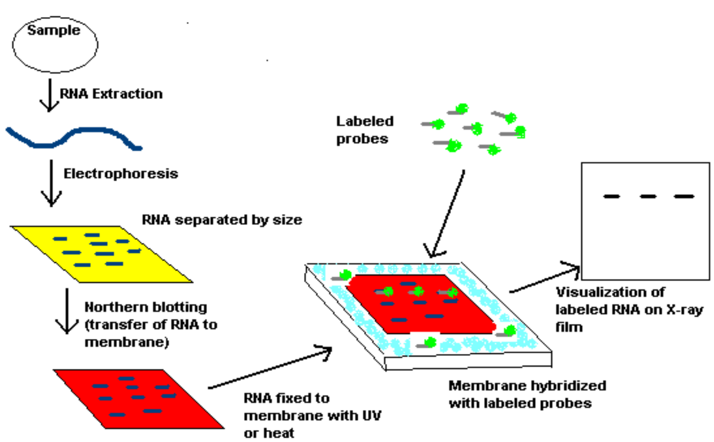
Southern blotting

A Southern blot is a method used in molecular biology for detection of a specific DNA sequence in DNA samples. Southern blotting combines transfer of electrophoresis-separated DNA fragments to a filter membrane and subsequent fragment detection by probe hybridization. The membrane is then exposed to a labeled DNA probe. The amount of DNA needed for this technique is dependent on the size and specific activity of the probe. Short probes tend to be more specific. Under optimal conditions, you can expect to detect 0.1 pg of the DNA for which you are probing.



Northern blotting

A northern blot is a laboratory method used to detect specific RNA molecules among a mixture of RNA. Northern blotting can be used to analyze a sample of RNA from a particular tissue or cell type in order to measure the RNA expression of particular genes. RNA is separated based on size and transferred to a membrane .It is probed with a labeled complement of a sequence of Interest. The results may be visualized depending on the label used. Most result in the revelation of bands representing the sizes of the RNA detected in sample. The band intensity is related to the amount of the target RNA.



Western blotting

Western blot is often used in research to separate and identify proteins. In this technique a mixture of proteins is separated based on molecular weight, and thus by type, through gel electrophoresis. These results are then transferred to a membrane producing a band for each protein. The membrane is then incubated with labels antibodies specific to the protein of interest. The unbound antibody is washed off leaving only the bound antibody to the protein of interest. The bound antibodies are then detected by developing the film. As the antibodies only bind to the protein of interest, only one band should be visible. The thickness of the band corresponds to the amount of protein present; thus doing a standard can indicate the amount of protein present.

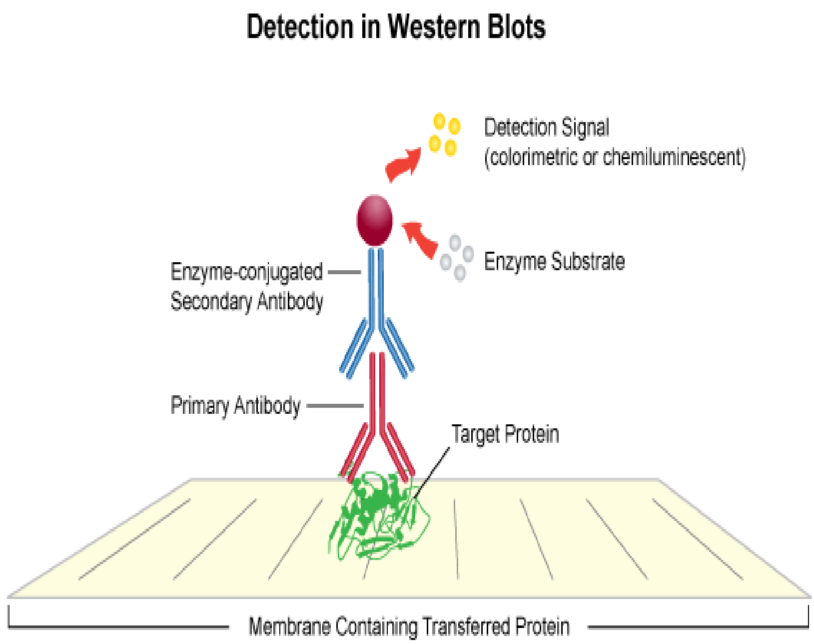


Diagram 2: *Illustration of detection in Western Blots.*

Principles of DNA Isolation and Purification
Sources of DNA include

- Blood
- Buccal cells
- Cultured cells (plant and animal)
- Bacteria
- Biopsies
- Forensic samples i.e. body fluids, hair follicles bone and teeth roots.

Basic steps in DNA Extraction

There are three four steps involved in a DNA extraction.

1. Breaking cells open to release the DNA

The cells in a sample are separated from each other, often by a physical means such as grinding put into a solution containing salt. The positively charged sodium ions in the salt help protect the negatively charged phosphate groups that run along the backbone of the DNA.

2. Separating DNA from proteins and other cellular debris

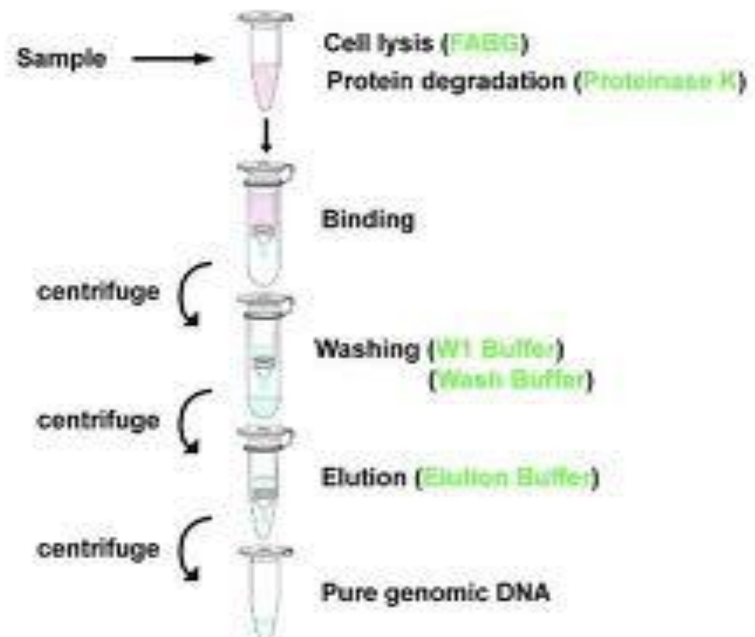
To get a clean sample of DNA, it's necessary to remove as much of the cellular debris as possible. This can be done by a variety of methods. Often a protease (protein enzyme) is added to degrade DNA-associated proteins and other cellular proteins. Alternatively, some of the cellular debris can be removed by filtering the sample.

3. Precipitating the DNA with an alcohol

Finally, ice-cold alcohol (either ethanol or isopropanol) is carefully added to the DNA sample. DNA is soluble in water but insoluble in the presence of salt and alcohol. By gently stirring the alcohol layer with a sterile pipette, a precipitate becomes visible and can be spooled out. If there is lots of DNA, you may see a stringy, white precipitate.

4. Cleaning the DNA

The DNA sample can now be further purified (cleaned). It is then resuspended in a slightly alkaline buffer and ready to use. A pellet is formed upon centrifugation. This step also removes alcohol soluble salt.



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Lecture 38

Basic Genetics

Introduction to genetics

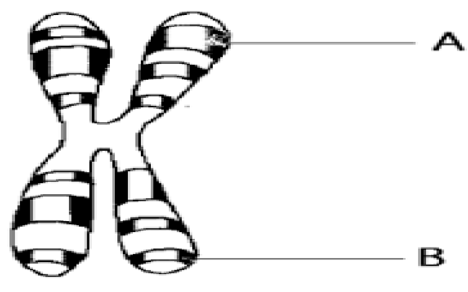
Genetics is the study of heredity, the process in which a parent transfers genes onto their children. In genetics, a feature of an organism is called a "trait". Some traits are features of an organism's physical appearance; for example, a person's eye-color, height or weight. There are many other trait types, and these range from aspects of behavior to resistance to disease. Traits are often inherited, for example tall and thin people tend to have tall and thin children. Other traits come from the interaction between inherited features and the environment. For example a child might inherit the tendency to be tall, but if little food is available and the child is poorly nourished, it will still be short. The way genetics and environment interact to produce a trait can be complicated: for example, the chances of somebody dying of cancer or heart disease seem to depend on both their family history and their lifestyle.

Characterizing Genes

Use library resources to define the following words and write their definitions using your own words.

Allele

An allele is an alternative form of a gene (one member of a pair) that is located at a specific position on a specific chromosome. These DNA coding determine distinct traits that can be passed on from parents to offspring through sexual reproduction.



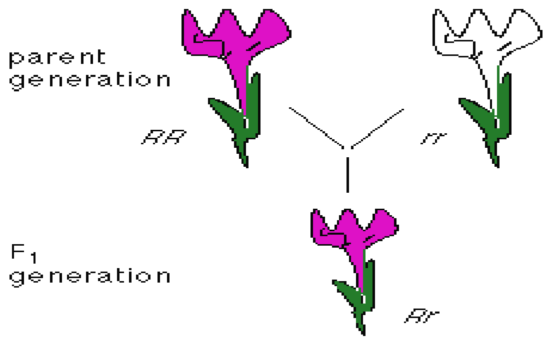
Alleles

Genes

Genes are the working subunits of DNA. Each gene contains a particular set of instructions, usually coding for a particular protein or for a particular function.

Dominant

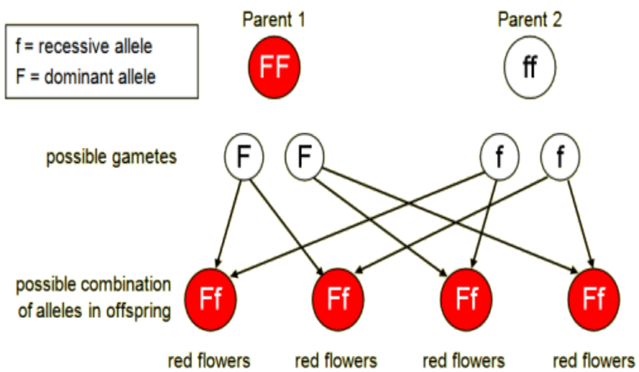
A dominant allele produces a dominant phenotype in individuals who have one copy of the allele, which can come from just one parent.



Genetic Terms

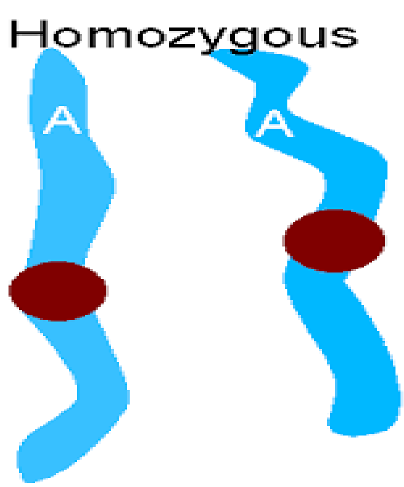
Recessive

Two copies of a mutant gene, one copy from each parent are received. Its appearance is masked when dominant allele is transmitted from parents.



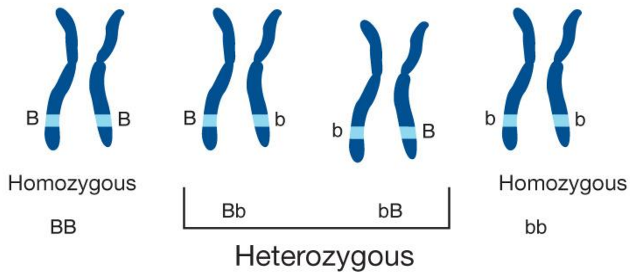
Homozygous

A cell is said to be homozygous for a particular gene when identical alleles of the gene are present on both homologous chromosomes.



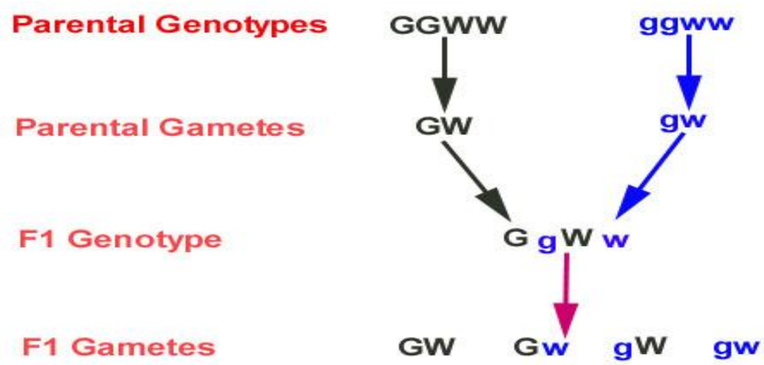
Heterozygous

A diploid organism is heterozygous at a gene locus when its cells contain two different alleles of a gene.



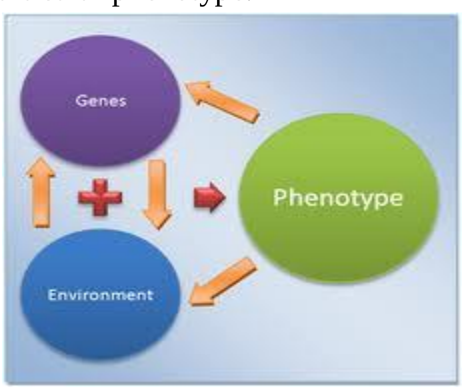
Genotype

The genotype is the genetic makeup of a cell, an organism, or an individual usually with reference to a specific characteristic under consideration.



Phenotype

The observable physical or biochemical characteristics of an organism, as determined by both genetic makeup and environmental influences. The expression of a specific trait, such as stature or blood type, based on genetic and environmental influences. An individual or group of organisms exhibiting a particular phenotype.



Mendelian Inheritance

An analysis of genetic crosses depends upon an understanding of Mendel's two laws:

1. The principle of segregation

The two members of a gene pair (alleles) segregate (separate) from each other in the formation of gametes. Half the gametes carry one allele, and the other half carries the other allele.

2. The principle of independent assortment

The Principle of Independent Assortment describes how different genes independently separate from one another when reproductive cells develop. Genes for different traits assort independently of one another in the formation of gametes.

Features

1. The inherited traits are determined by genes that are passed from parents to children.

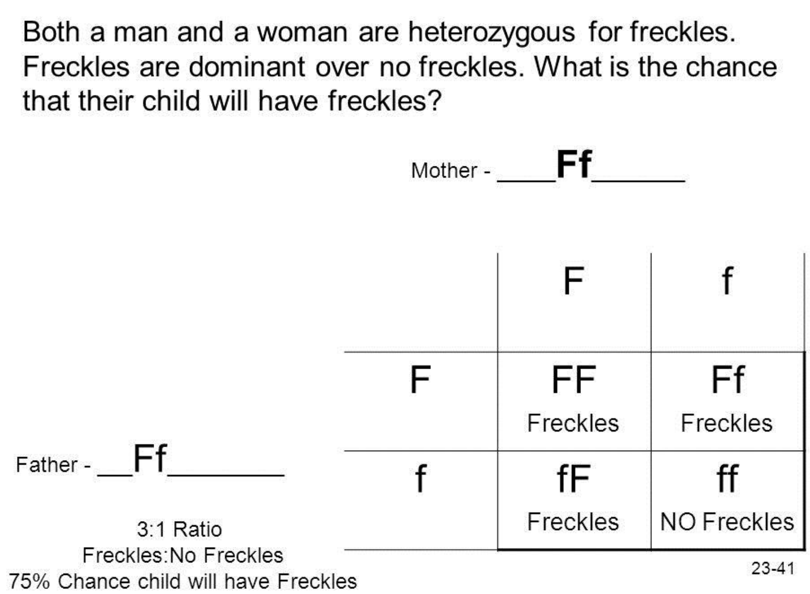
2. A child inherits two sets of genes, one from each parent.

3. A trait may not be observable, but its gene can be passed to the next generation.

4. Each person has 2 copies of every. These copies may come in different variations, known as alleles that express different traits.

For example, 2 alleles in the gene for freckles are inherited from mom and dad:

- Allele from mom = has freckles (F)
- Allele from dad = no freckles (f)
- Child has the inherited gene pair of alleles, **Ff** (F allele from mom and f allele from dad).



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Lecture 39

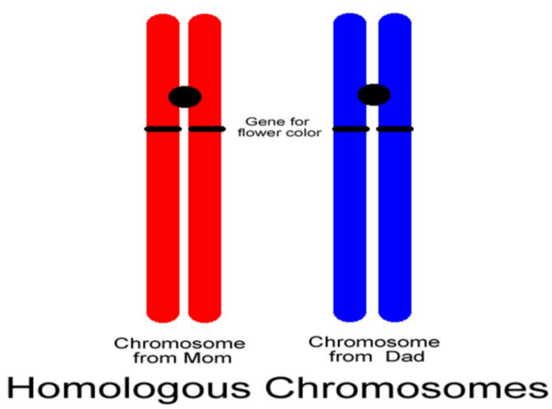
Genetics

Introduction

Humans, like every other organism, are made up of cells. We all start off as just one cell at the time of fertilization. This cell contains two sets of genes, one from our mother and one from our father. For ease of storage and access, the genes are packaged up into 46 protein parcels called chromosomes. As the single cell divides, the genes are copied so that every new cell possesses the full complement of genetic material. This mechanism of copying the genes is quite remarkable considering that the human body contains approximately 10 trillion cells. Genes are made of a chemical called DNA. Information of organism development is contained in its DNA.

Genes as a Functional heredity Unit

Chromosomes occur in pairs called homologous chromosomes. Chromosomes are made up of genes that control traits. Some traits are influenced by many genes are called as polygenic Eg height in humans. A gene is found at a specific location or locus on a chromosome.

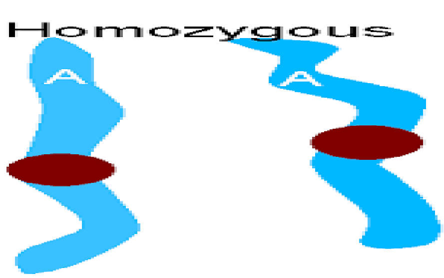


Homozygous & Heterozygous

Human has two sets of chromosomes; it will have two copies of each gene. These two copies may be the same allele, or they may be different.

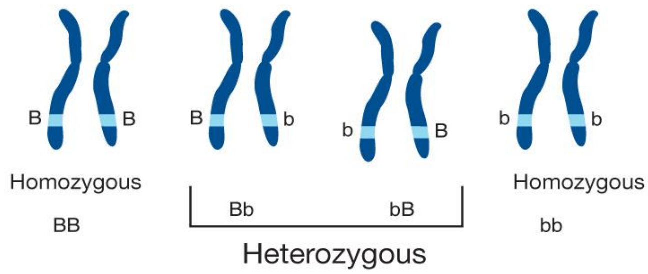
1) Homozygous

A cell is said to be homozygous for a particular gene when identical alleles of the gene are present on both homologous chromosomes.



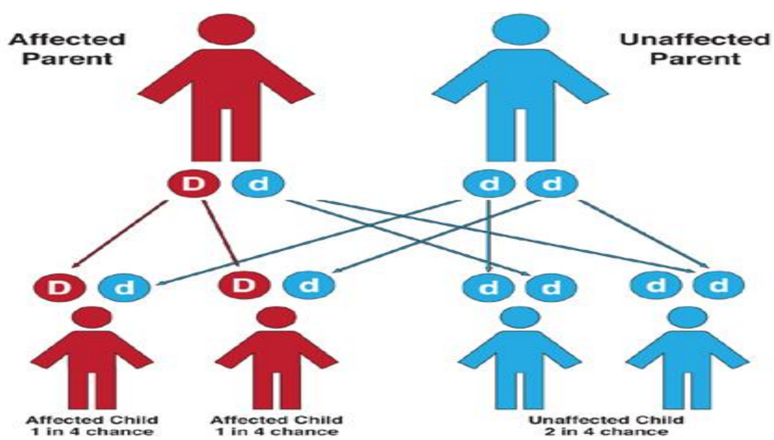
2) Heterozygous

A diploid organism is heterozygous at a gene locus when its cells contain two different alleles of a gene.



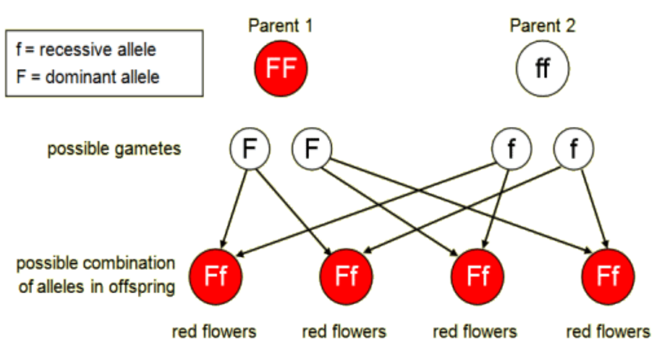
Dominant Inheritance

When a trait is dominant, only one allele is required for the trait to be observed. A dominant allele will mask a recessive allele, if present. A dominant allele is denoted by a capital letter (A versus a). Since each parent provides one allele, the possible combinations are: AA, Aa, and aa.



Recessive Inheritance

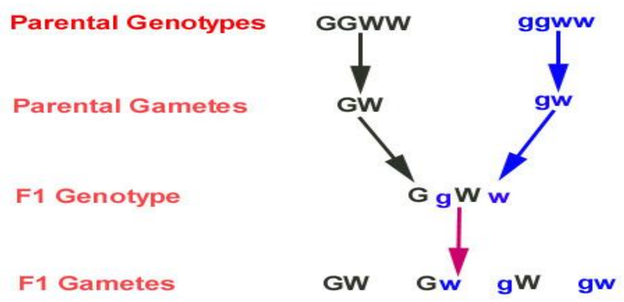
Recessive if it is masked by dominant allele in heterozygous condition. If two parents are both carriers of a genetic condition with a recessive inheritance pattern, there is a one-in-four chance that each child will be affected. So on average, one-quarter of their children will be affected. Pp Two white flower alleles (homozygous).



Genotype & Phenotype

Genotype

The genotype is the genetic makeup of a cell, an organism, or an individual usually with reference to a specific characteristic under consideration.



Phenotype

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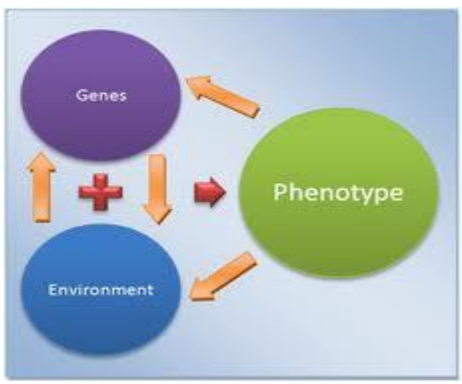


Heredity

One or two traits are passed from one generation to another. A rule *Punnett square* explains this transfer efficiently.

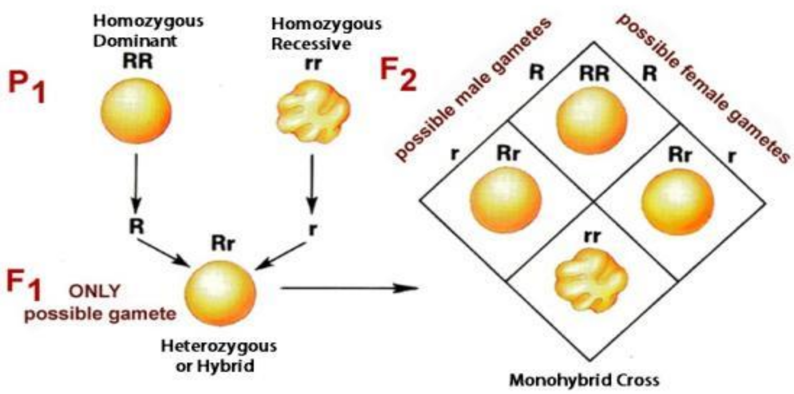
1. Albino
• A simple recessive trait
2. Pinstripe
• A dominant pattern mutation

Albino Trait

Albino Trait is an inherited condition present at birth, characterized by a lack of pigment that normally gives color to the skin, hair, and eyes. Many types of albinism exist, all of which involve lack of pigment in varying degrees. The condition, which is found in all races, may be accompanied by eye problems and may lead to skin cancer later in life.

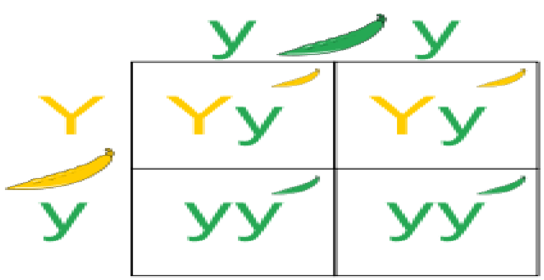
Monohybrid Cross

A monohybrid cross is a mating between two individuals with different alleles at one genetic locus of interest. The character(s) being studied in a monohybrid cross are governed by two or multiple alleles for a single locus.



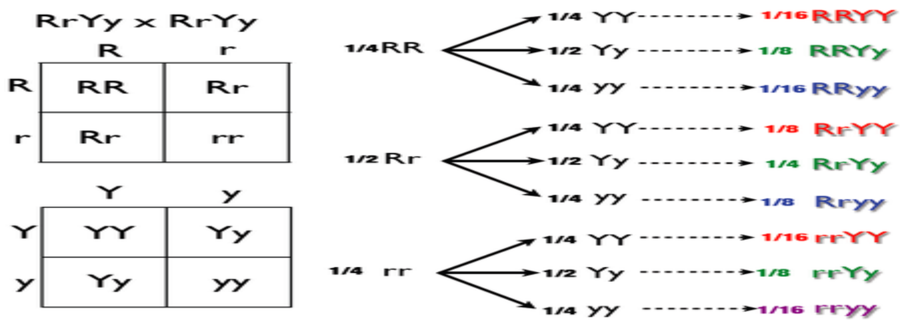
Punnett Square with one Trait

The Punnett square is a useful tool for predicting the genotypes and phenotypes of offspring in a genetic cross involving Mendelian traits. To draw a square, write all possible allele combinations one parent can contribute to its gametes across the top of a box and all possible allele combinations from the other parent down the left side. The allele combinations along the top and sides become labels for rows and columns within the square. Complete the genotypes in the square by filling it in with the alleles from each parent. Since all allele combinations are equally likely to occur, a Punnett Square predicts the probability of a cross producing each genotype.



Dihybrid Cross Genotypes

Dihybrid cross is a cross between two different lines (varieties, strains) that differ in two observed traits. In the Mendelian sense, between the alleles of both these loci there is a relationship of complete dominance - recessive. In the example pictured to the right, RRYY/rryy parents result in F_1 offspring that are heterozygous for both R and Y (RrYy). The Dihybrid cross is easy to visualize using a Punnett square of dimensions 4 x 4. The Punnett square gives us the *genotypes* that result from the cross.



Dihybrid Cross Phenotypes

In a cross, each parent plant contributes one allele for each gene, and every parental allele has an equal chance of being given to the offspring. The *phenotypes* would be:

– 9 Pinstripe (*A_P_*)

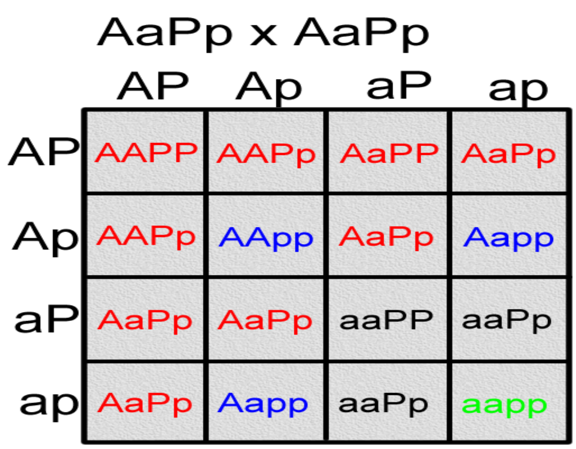
– 3 Normal (*A_pp*)

– 3 Albino pinstripe (aaP_)

– 1 Albino (*aapp*)

• Albino is a recessive trait, while pinstripe is a dominant trait.

• The 9:3:3:1 phenotypic ratio is characteristic of a dihybrid cross.



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Lecture 40

Role of Biology in Medicine

Insects of Medical Importance

1) Medical entomologists work in the public health arena, dealing with insects (and other arthropods) that parasitize people, bite, sting, and/or vector disease.
2) Some personal pests of May vector pathogens: Lice, Fleas, Bedbugs, Ticks, Scabies mites**.**

The Housefly

The housefly is a very common and cosmopolitan species which transmits diseases to man. The organisms of both amoebic and bacillary dysenteries are picked up by flies from the faeces of infected people and transferred to clean food either on the fly's hairs or by the fly vomiting during feeding. Typhoid germs may be deposited on food with the fly's faeces.

The Cockroach

Cockroaches carry disease-causing organisms (typically gastroenteritis) as they forage. Cockroach excrement and cast skins also contain a number of allergens causing responses such as, watery eyes, skin rashes, congestion of nasal passages and asthma.

Biting insects

Biting insects are Mosquitoes, Biting Midges, Sandflies, Black flies, Horse Flies, Stable flies. Pathogen infection transmitted by insect or other arthropod vectors.

Pharmaceutically Important Insects

1) Venom is extracted from insects that sting.
2) So that they may test people for allergies.
3) Moreover to treat allergies in a series of small injections.

Apitherapy

Apitherapy is a branch of alternative medicine that uses honey bee products including honey, pollen, bee bread, propolis, royal jelly and bee venom. Proponents of apitherapy make many wide-ranging claims for its health benefits which are not supported by medical evidence. It helps to treat inflammation in case of Rheumatoid Arthritis, Multiple Sclerosis and Melittin blocks the expression of inflammatory genes.

Maggot Debridement Therapy

Maggot therapy is the controlled, therapeutic use of live blow fly larvae ("maggots") to treat skin and soft tissue wounds. Maggot Debridement Therapy is used to treat for removing dead tissue from wound, preventing infection and speeding healing process.

Beetle Juice Therapies

Cantharidin

Cantharidin is a substance derived from the blister beetle *Cantharis vesicatoria*. The Chinese have used this ancient medicine for thousands of years for a number of maladies. Cantharidine is a vesicant that causes a blister to form on the wart or growth. This action lifts the wart off the skin and after a few days when the blister has dried the wart will come off. The action of Cantharidin does not go beyond the epidermal cells, the basal layer remains intact hence no scarring.

Plant-Derived Medicines

All plants produce chemical compounds as part of their normal metabolic activities. These phytochemicals are divided into primary metabolites such as sugars and fats, which are found in all plants; and secondary metabolites compounds which are found in a smaller range of plants, serving a more specific function. For example, some secondary metabolites are toxins used to deter predation and others are pheromones used to attract insects for pollination. Major classes of compounds are

1) Steroids

2) Alkaloids

Steroids

A steroid is an organic compound with four rings arranged in a specific configuration. Examples include the dietary lipid cholesterol, the sex hormones estradil and testosterone and the anti-inflammatory drug dexamethasone. Steroids have two principal biological functions: certain steroids (such as cholesterol) are important components of cell membranes which alter membrane fluidity, and many steroids are signaling molecules which activate steroid hormone receptors.

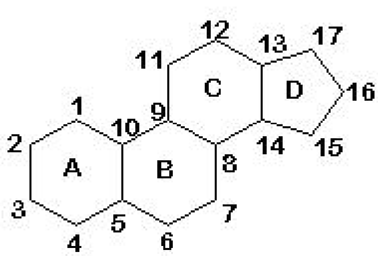
Structure

1. Steroids basic structure consists of 3 6-membered rings (e.g. Containing 6 carbon atoms each) and a fourth rings that contain 5 carbons.

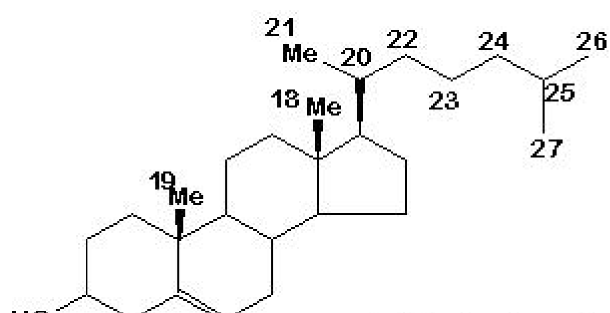
2. Different steroids exist based on added chemical substituents at the molecule.

3. For example, the structure of a common and important steroid, cholesterol, is shown.

4. Cholesterol is produced only by animals.



4 Steroid ring system



5 (Cholesterol)

Alkaloids

Alkaloids are a group of naturally occurring chemical compounds that contain mostly basic nitrogen atoms. This group also includes some related compounds with neutral and even weakly acidic properties. Some synthetic compounds of similar structure are also termed alkaloids.

Structure

1. Plants produce a large number of alkaloids, many of which have important applications.
2. Coniine and strychnine (upper left and lower right) are two highly poisonous compounds.
3. Reserpine and vinblastine are two alkaloids that are poisonous in large quantities
4. They have been determined to be highly effective medicines when used at the proper concentrations and conditions

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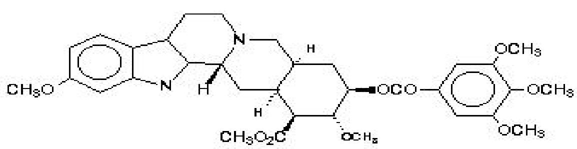
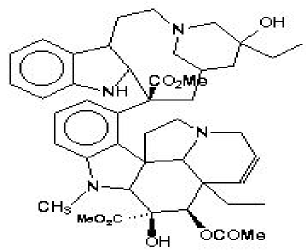
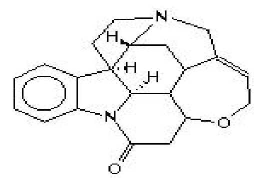


Reserpine



Vinblastine



Strychnine

Examples of Plant Medicines

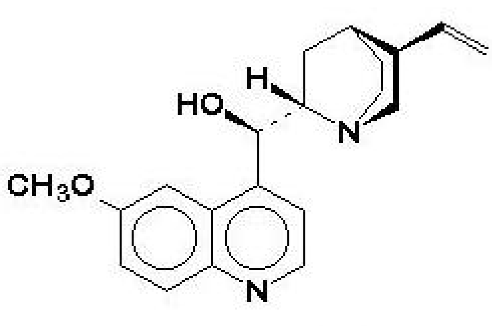
1 Anasthetics
2 Analgesics
3 Heart medicines
4 Laxatives
5 Muscle relaxants

Chaulmoogra Oil - Hydnocarpus

Chaulmoogra is a tree in the Achariaceae family. The oil from its seeds has been widely used in Indian medicine and Chinese traditional medicine for the treatment of leprosy. It entered early Western medicine in the nineteenth century before the era of sulfones and antibiotics for the treatment of several skin diseases and leprosy.

Malaria Cure from *Cinchona*

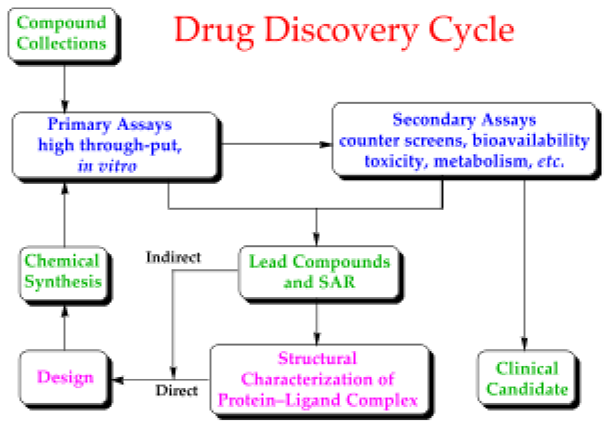
Cinchona is a genus of flowering plants in the family Rubiaceae containing at least 23 species of trees and shrubs. They are native to the tropical Andean forests of western South America. The disease is caused by a protozoan. The medicine quinine was the first effective treatment. Quinine is a medication used to prevent and treat malaria and to treat babesiosis. It was obtained from extracting the bark of a shrub. This includes the treatment of malaria due to Plasmodium falciparum that is resistant to chloroquine when artesunate is not available.



Quinine

New Drug Development

Drug development is the process of bringing a new pharmaceutical drug to the market once a lead compound has been identified through the process of drug discovery. It includes pre-clinical research on microorganisms and animals, filing for regulatory status, such as via the United States Food and Drug Administration for an investigational new drug to initiate clinical trials on humans, and may include the step of obtaining regulatory approval with a new drug application to market the drug.



Regenerative Medicine from stem cells

Regenerative medicine is an interdisciplinary approach that seeks to repair or replace damaged or diseased human cells or tissues to restore normal function, which holds the promise of revolutionizing patient care in the 21st century. It may involve the transplantation of stem cells, progenitor cells or tissue, stimulation of the body's own repair processes, or the use of cells as delivery-vehicles for therapeutic agents such as genes and cytokines. Develop methods to prepare patients for transplants with minimal toxic agents.

Cure of Neural Diseases

Neurology is a medical specialty dealing with disorders of the nervous system. Specifically, it deals with the diagnosis and treatment of all categories of disease involving the central, peripheral, and autonomic nervous systems, including their coverings, blood vessels, and all effected tissue, such as muscles.

There are over 600 known neurological disorders and conditions that affect the human nervous system and for many of them treatment options are extremely limited.

Neurological disorders are health conditions involving the nervous system.

A neurological disorder is a disease or injury of the central nervous system that causes paralysis of any part of the body.

1. Sometimes physical injury to the brain, spinal cord, or nerves can be the cause of neurological disorders.

2. Sometimes they can result from biochemical causes.

3. Other times, the cause may be unknown and only the effects are seen.

These disorders include

1. Lysosomal storage diseases (Battens, Gauchers, etc)
2. Brain cancers
3. Spinal cord contusion with demyelination
4. Strokes

5. ALS
6. Parkinsons
7. Alzheimers
8. Huntington’s
9. Cerebral palsy

The product is CNS stem cells that regenerate for life; not a drug.

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Lecture 41

Pharmacology

Definitions

1) Pharmacokinetics

The process by which a drug is absorbed, distributed, metabolized and eliminated by the body.

Pharmacokinetic properties of drugs may be affected by elements such as the site of administration and the dose of administered drug. These may affect the absorption rate.

2) Pharmacodynamics

The interactions of a drug and the receptors responsible for its action in the body. Pharmacodynamics places particular emphasis on dose-response relationships i.e. the relationship between drug concentration and effect. These effects can include those manifested within mammals (including humans), microorganisms, or combinations of organisms (e.g. malaria infection).

The Life Cycle of a Drug

1. Absorption

The process of a substance entering the blood circulation.

2. Distribution

The dispersion or dissemination of substances throughout the fluids of the body.

3. Degradation

The change of a chemical compound into a less complex compound.

4. Excretion

The removal of the substances from the body. In rare cases, some drugs irreversibly accumulate in body tissue.

Absorption

Absorption involves several phases. First, the drug needs to be introduced via some route of administration (oral, topical-dermal, *etc*.) and in a specific dosage form such as a tablet, capsule, solution and so on.

In other situations, such as intravenous therapy, intramuscular injection, enteral nutrition and others, absorption is even more straightforward and there is less variability in absorption and bioavailability is often near 100%. It is considered that intravascular administration (e.g. IV) does not involve absorption, and there is no loss of drug. The fastest route of absorption is inhalation, and not as mistakenly considered the intravenous administration

Faster Absorption

Parenterally (injection)

1. Intravenous (IV)

The infusion of liquid substances directly into a vein.

2. Intramuscular (IM)

The injection of a substance directly into a muscle.

3. Subcutaneous (SC)

A subcutaneous injection is administered as a bolus into the subcutis.

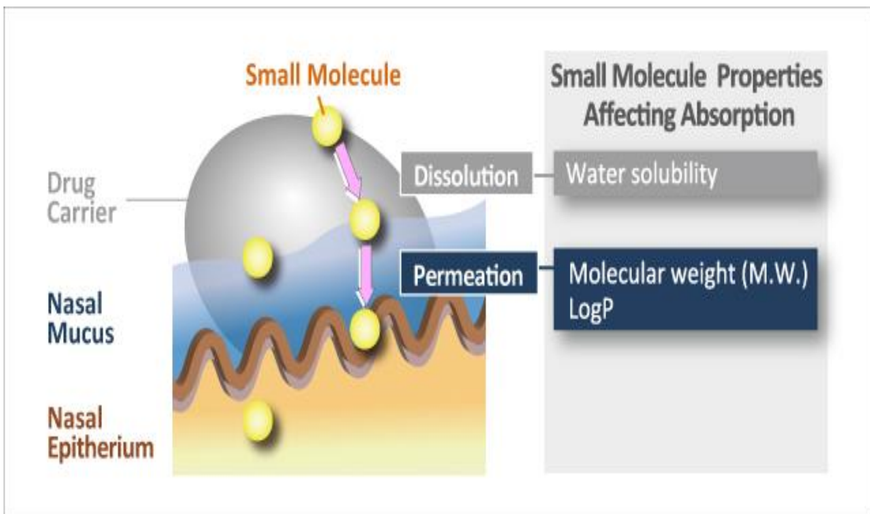
4. Intraperitoneal (IP)

The injection of a substance into the peritoneum (body cavity).eg Inhaled (through lungs).

Absorption and Solubility

The gastrointestinal tract is lined with epithelial cells. Drugs must pass or permeate through these cells in order to be absorbed into the circulatory system. One particular cellular barrier that may prevent absorption of a given drug is the cell membrane. Cell membranes are essentially lipid bilayers which form a semipermeable membrane. Pure lipid bilayers are generally permeable only to small, uncharged solutes. Hence, whether or not a molecule is ionized will affect its absorption, since ionic molecules are charged. Solubility favors charged species, and permeability favors neutral species. Some molecules have special exchange proteins and channels to facilitate movement from the lumen into the circulation.

The Henderson-Hasselbalch equation offers a way to determine the proportion of a substance that is ionized at a given pH. In the stomach, drugs that are weak acids (such as aspirin) will be present mainly in their non-ionic form, and weak bases will be in their ionic form. Since non-ionic species diffuse more readily through cell membranes, weak acids will have a higher absorption in the highly acidic stomach.

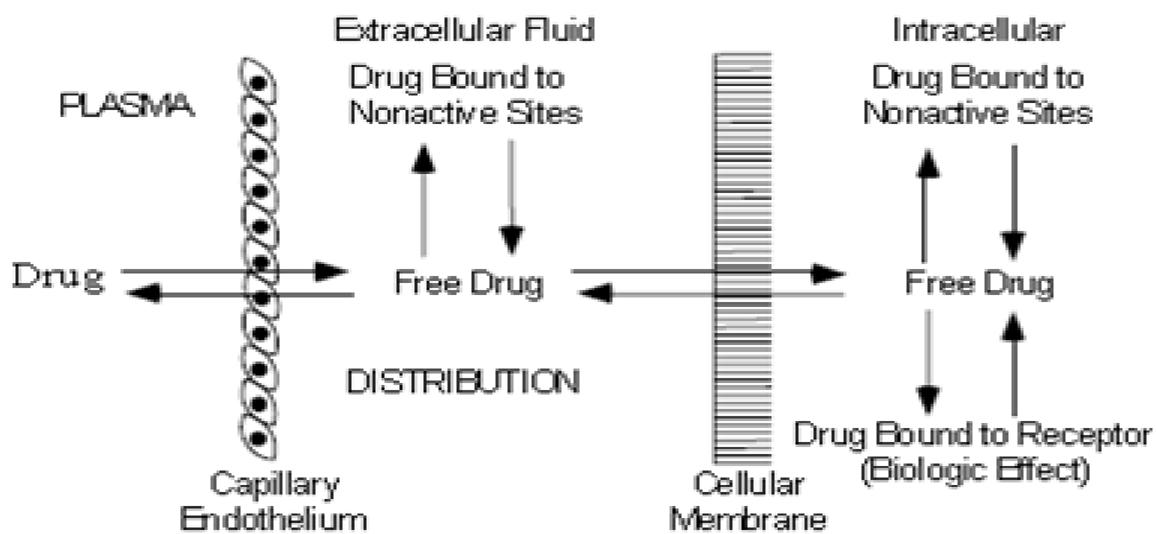


Distribution

1. Distribution in pharmacology is a branch of pharmacokinetics which describes the reversible transfer of drug from one location to another within the body.

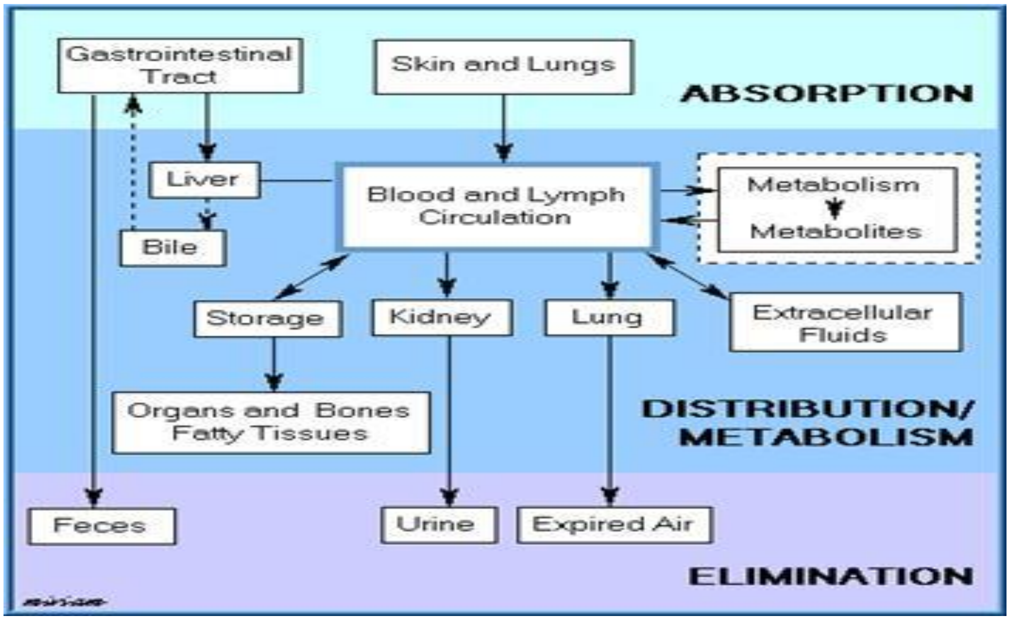
2. Once a drug enters into systemic circulation by absorption or direct administration, it must be distributed into interstitial and intracellular fluids. Each organ or tissue can receive different

doses of the drug and the drug can remain in the different organs or tissues for a varying amount of time. The distribution of a drug between tissues is dependent on vascular permeability, regional blood flow, cardiac output and perfusion rate of the tissue and the ability of the drug to bind tissue and plasma proteins and its lipid solubility. PH partition plays a major role as well. The drug is easily distributed in highly perfused organs such as the liver, heart and kidney. It is distributed in small quantities through less perfused tissues like muscle, fat and peripheral organs. The drug can be moved from the plasma to the tissue until the equilibrium is established (for unbound drug present in plasma).



Excretion

In pharmacology the elimination or excretion of a drug is understood to be any one of a number of processes by which a drug is eliminated from an organism either in an unaltered form (unbound molecules) or modified as a metabolite. The kidney is the main excretory organ although others exist such as the liver, the skin, the lungs or glandular structures, such as the salivary glands and the lacrimal glands. These organs or structures use specific routes to expel a drug from the body, these are termed elimination pathways:



Bioavailability

The fraction of an administered dose of drug that reaches the blood stream.

When the drug is administered orally the bioavailability depends on several factors:

1. Physicochemical properties of the drug and its excipients that determine its dissolution in the intestinal lumen and its absorption across the intestinal wall.
2. Decomposition of the drug in the lumen.
3. PH and perfusion of the small intestine.
4. Surface and time available for absorption.
5. Competing reactions in the lumen (for example of the drug with food).
6. Hepatic first pass effect

Depot Binding

Binding of a drug with various tissues of the body or with proteins in the blood; causes drugs to not reach their site of action.
E.g. Albumin a protein found in the blood that transports free fatty acids and can bind with some lipid-soluble drugs.
1. Can delay or prolong the effects of a drug.
2. Depot binding reduces bioavailability, slows elimination, can increase drug detection window.
3. Depot-bound drugs can be released during sudden weight loss.

Excretory Organs

The main organs responsible for drug excretion are the kidneys (renal excretion) and the liver (biliary excretion). Other organs can be involved in excretion, such as the lungs for volatile or gaseous agents. Drugs can also partially be excreted into sweat, saliva and tears. Breast milk is another pathway for drug excretion. Milk is more acidic than plasma; therefore, basic compounds can slightly concentrate in milk. This is an important factor for the estimation of the amount of drug administered to the breastfed baby.

Half Life

The plasma concentration of a drug is halved after one elimination half-life. Therefore, in each succeeding half-life, fewer drugs are eliminated. After one half-life the amount of drug remaining in the body is 50% after two half-lives 25%, etc. After 4 half-lives the amount of drug (6.25%) is considered to be negligible regarding its therapeutic effects.

The half-life of a drug depends on its clearance and volume of distribution. The elimination half-life is considered to be independent of the amount of drug in the body.

Factors affecting half-life

1. Age

2. Renal excretion

3. Liver metabolism

4.Protein binding

Drug Effectiveness

1. Drugs affect only the rate at which existing biologic functions proceed. Drugs do not change the basic nature of these functions or create new functions. For example, drugs can speed up or slow down the biochemical reactions that cause muscles to contract, kidney cells to regulate the volume of water and salts retained or eliminated by the body, glands to secrete substances (such as mucus, stomach acid, or insulin), and nerves to transmit messages.

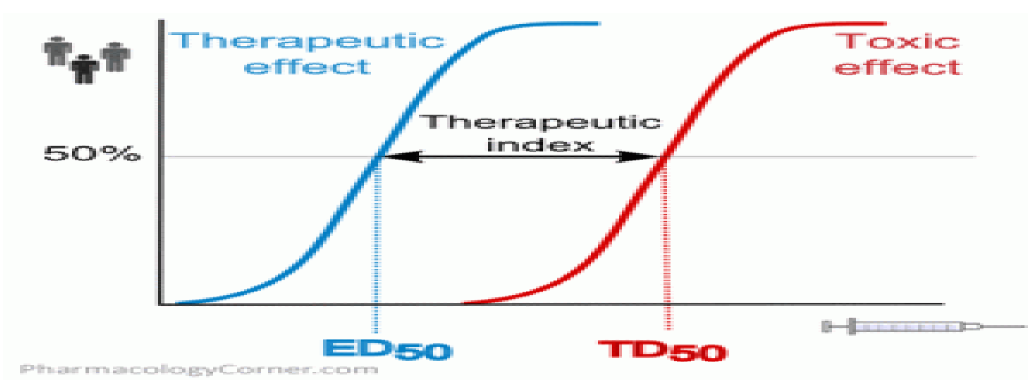
2. Drugs cannot restore structures or functions already damaged beyond repair by the body. This fundamental limitation of drug action underlies much of the current frustration in trying to treat tissue-destroying or degenerative diseases such as heart failure, arthritis, muscular dystrophy, multiple sclerosis, Parkinson disease, and Alzheimer disease. Nonetheless, some drugs can help the body repair itself. For example, by stopping an infection, antibiotics can allow the body to repair damage caused by the infection.

Therapeutic Index

The therapeutic index (TI) is a comparison of the amount of a therapeutic agent that causes the therapeutic effect to the amount that causes toxicity.

TI refers to the ratio of the dose of drug that causes adverse effects at an incidence/severity not compatible with the targeted indication (e.g. toxic dose in 50% of subjects, TD50) divided by the dose that leads to the desired pharmacological effect (e.g. efficacious dose in 50% of subjects, ED50). In contrast, in a drug development setting TI is calculated based on plasma exposure levels

$$\text{Therapeutic index} = \frac{TD_{50}}{ED_{50}}.$$



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Lecture 42

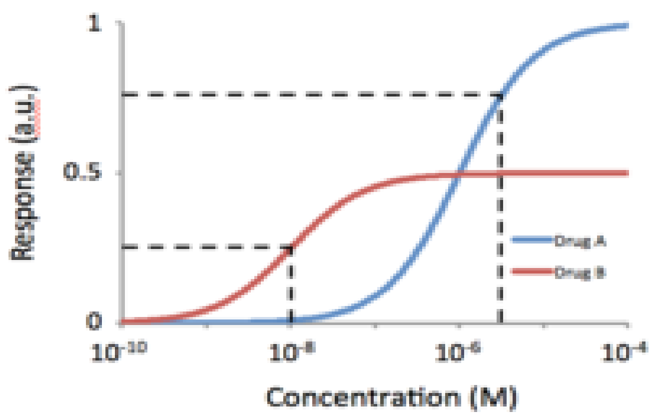
Properties of Drugs

Potency

Potency is a measure of drug activity expressed in terms of the amount required to produce an effect of given intensity. A highly potent drug (e.g., fentanyl, alprazolam, risperidone) evokes a given response at low concentrations, while a drug of lower potency (codeine, diazepam, ziprasidone) evokes the same response only at higher concentrations. The potency depends on both the affinity and efficacy.

Affinity is the ability of the drug to bind to a receptor. Efficacy is the relationship between receptor occupancy and the ability to initiate a response at the molecular, cellular, tissue or system level. The response is equal to the effect, or (E), and depends on both the drug binding and the drug-bound receptor then producing a response; thus, potency depends on both affinity and efficacy.

The E_{max} is the maximum possible effect for the agonist. The concentration of A at which E is 50% of E_{max} is termed the half maximal effective concentration and is abbreviated $[A]_{50}$, or more commonly EC_{50}. The term "potency" refers to the $[A]_{50}$ value. The lower the $[A]_{50}$, the less the concentration of a drug is required to produce 50% of maximum effect and the higher the potency.

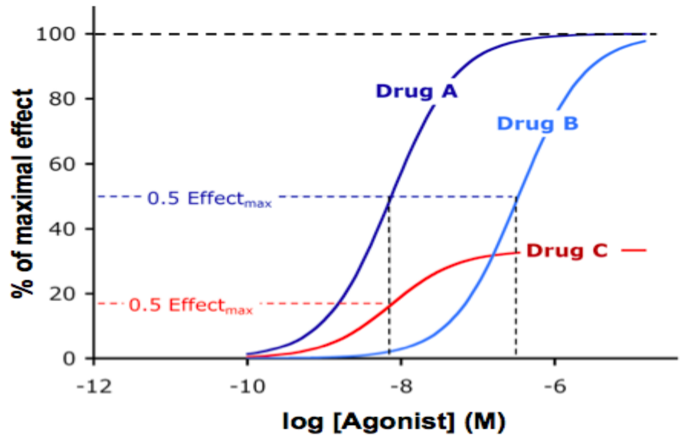


Efficacy

Efficacy (E_{max}) is the maximum response achievable from an applied or dosed agent, for instance, a small molecule drug. Intrinsic activity is a relative term that describes a drug's efficacy relative to a drug with the highest observed efficacy. It is a purely descriptive term that has little or no mechanistic interpretation.

In order for a drug to have an effect, it needs to bind to its target, and then to affect the function of this target. The target of a drug is commonly referred to as a receptor, but can in general be any chemically sensitive site on any molecule found in the body. The nature of such binding can be quantified by characterizing how tightly these molecules, the drug and its receptor, interact:

this is known as the affinity. Efficacy, on the other hand, is a measure of the action of a drug once binding has occurred. The maximum response, E_{max}, will be reduced if efficacy is sufficiently low, but any efficacy greater than 20 or so gives essentially the same maximum response.

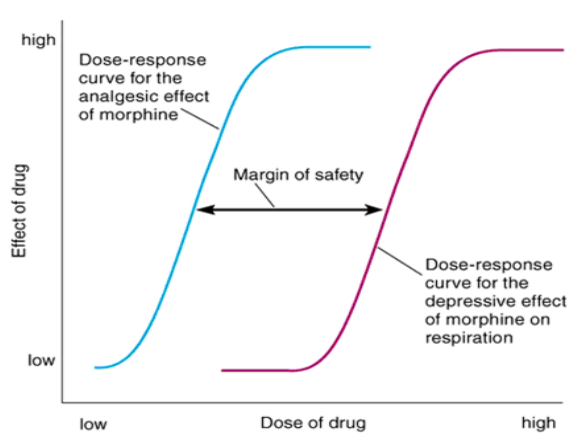


Tolerance

Tolerance describing subjects' reduced reaction to a drug following its repeated use. Increasing its dosage may re-amplify the drug's effects; however this may accelerate tolerance, further reducing the drug's effects. Drug tolerance is a contributing factor of drug addiction.

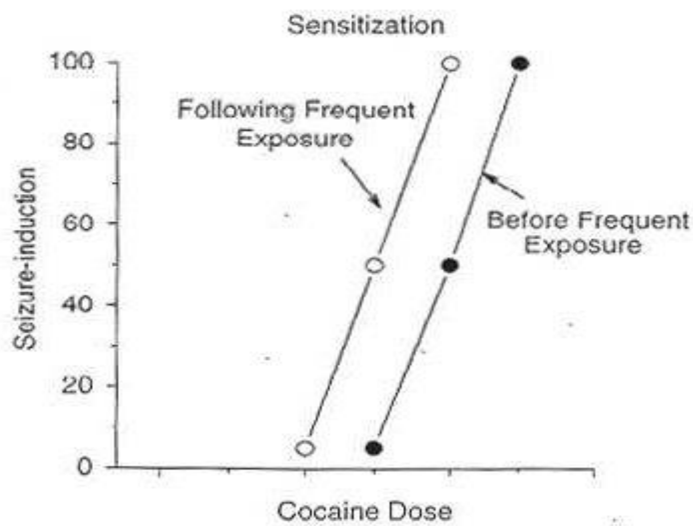
When drugs such as morphine are used repeatedly over time, tolerance may develop. Tolerance occurs when the person no longer responds to the drug in the way that person initially responded. Stated another way, it takes a higher dose of the drug to achieve the same level of response achieved initially. For example, in the case of morphine, tolerance develops rapidly to the analgesic effects of the drug.

► Dose-Response Curves for the Analgesic and Depressant Effects of Morphine



Sensitization

Sensitization is increased in a drug effect upon successive exposures to a drug or hypersensitivity to a drug in animals that were exposed to the drug in the past. For example, one unconditional effect of drugs such as amphetamine or cocaine is to produce psychomotor activation, often measured as an increase in forward locomotion. Under some circumstances repeated administration pshycostimulant drugs result in progressive increase in this drug effect whereby successive injections of the same dose produce greater and greater psychomotor activation. It is possible to develop tolerance to some side effects AND sensitization to other side effects of the same drug. Furthermore exposure to one drug eg amphetamine can also render animals hypersensitive to the locomotor activating effects of the other drugs eg cocaine or morphine.



Drug-drug Interactions

Drug-drug interactions occur when a drug interacts, or interferes, with another drug. This can alter the way one or both of the drugs act in the body, or cause unexpected side effects. The drugs involved can be prescription medications, over-the-counter medicines and even vitamins and herbal products.

In terms of efficacy, there can be several types of interactions between medications: cumulative, additive, synergistic, and antagonistic.

1. Pharmacodynamic interactions

The change in an organism's response on administration of a drug is an important factor in pharmacodynamic interactions. These changes are extraordinarily difficult to classify given the wide variety of modes of action that exist and the fact that many drugs can cause their effect through a number of different mechanism

2. Pharmacokinetic interactions

Modifications in the effect of a drug are caused by differences in the absorption, transport, distribution, metabolization or excretion of one or both of the drugs compared with the expected behaviour of each drug when taken individually.

Cumulative Effects

The condition in which repeated administration of a drug may produce effects that are more pronounced than those produced by the first dose. This is of frequent occurrence and is sometimes accidental, but is often caused deliberately by pushing a drug to its full physiologic effect. In cases in which this action occurs unexpectedly and is undesired, the drug should be immediately stopped, and not again given in doses that could cause such an effect.

Additive Effects

The effect of two chemicals is equal to the sum of the effect of the two chemicals taken separately, eg. aspirin and motrin.

Synergistic Effects

The effect of two chemicals taken together is greater than the sum of their separate effect at the same doses. E.g., alcohol and other drugs.

Antagonistic Effects

The effect of two chemicals taken together is less than the sum of their separate effect at the same doses.

Pharmacodynamics

Pharmacodynamics defined as the biochemical and physiological study of drug effects. These effects can include those manifested within mammals (including humans), microorganisms, or combinations of organisms (e.g. malaria infection). Pharmacodynamics places particular emphasis on dose-response relationships i.e. the relationship between drug concentration and effect. One dominant example is drug-receptor interactions as modeled by

$$\mathbf{L+R=L.R}$$

where *L*, *R*, and *LR* represent ligand (drug), receptor, and ligand-receptor complex concentrations, respectively.

Agonism and Antagonism

Physiological agonism describes the action of a substance which ultimately produces the same effects in the body as another substance as if they were both agonists at the same receptor without actually binding to the same receptor. Physiological antagonism describes the behavior of a substance that produces effects counteracting those of another substance (a result similar to that produced by an antagonist blocking the action of an agonist at the same receptor) using a mechanism that does not involve binding to the same receptor.

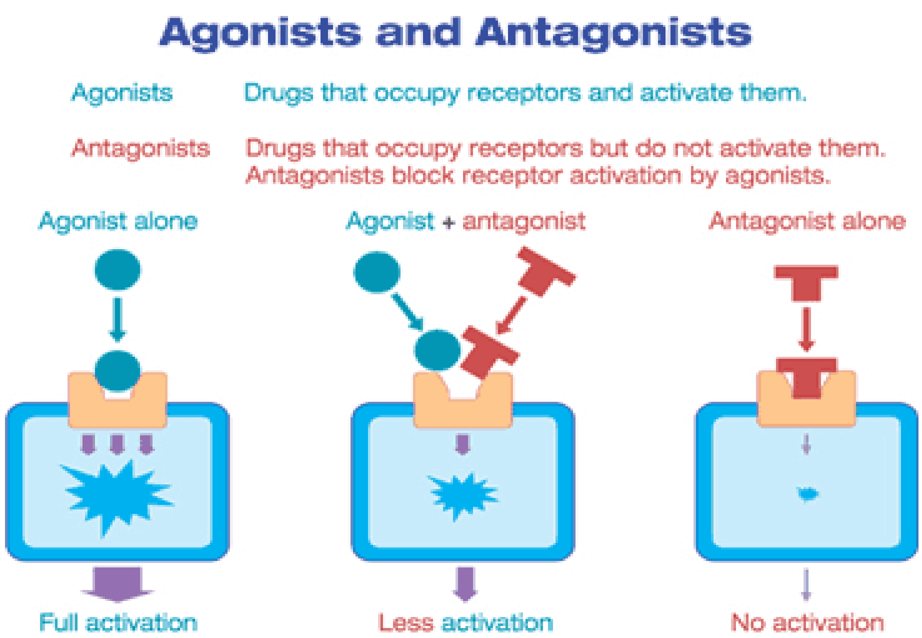
Modes of Action

1. Agonism

A compound that does the job of a natural substance. Does not affect the rate of an enzyme catalyzed reaction.

2. Antagonism

A compound inhibits an enzyme from doing its job. Slows down an enzymatically catalyzed reaction.



Law of Mass Action

A model to explain ligand-receptor binding. When a drug combines with a receptor, it does so at a rate which is dependent on the concentration of the drug and of the receptor. This model assumes that binding is reversible.

$$\text{Receptor} + \text{Ligand} \underset{Koff}{\overset{Kon}{\rightleftarrows}} \text{Receptor} \bullet \text{Ligand}$$

Binding occurs when ligand and receptor collide due to diffusion, and when the collision has the correct orientation and enough energy. The rate of association is:

Number of binding events per unit of time =[Ligand]·[Receptor]·kon.

Equilibrium is reached when the rate at which new ligand×receptor complexes are formed equals the rate at which the ligand×receptor complexes dissociate. At equilibrium:

$$[\text{Ligand}] \cdot [\text{Receptor}] \cdot k_{on} = [\text{Ligand} \cdot \text{Receptor}] \cdot k_{off}$$

Meaning of Kd

Rearrange that equation to define the equilibrium dissociation constant Kd.

$$\frac{[\text{Ligand}]\cdot[\text{Receptor}]}{[\text{Ligand}\cdot\text{Receptor}]}=\frac{k_{off}}{k_{on}}=K_d$$

The Kd has a meaning that is easy to understand. Set [Ligand] equal to Kd in the equation above. The Kd terms cancel out, and you will see that [Receptor]/ [Ligand×Receptor]=1, so [Receptor] equals [Ligand×Receptor]. Since all the receptors are either free or bound to ligand, this means that half the receptors are free and half are bound to ligand. In other words, when the concentration of ligand equals the Kd, half the receptors will be occupied at equilibrium. If the receptors have a high affinity for the ligand, the Kd will be low, as it will take a low concentration of ligand to bind half the receptors

Applications of Drug Receptor Interaction

1. Drugs can potentially alter rate of any bodily/brain function.
2. Drugs cannot impart entirely new functions to cells.
3. Drugs do not create effects, only modify ongoing ones.
4. Drugs can allow for effects outside of normal physiological range.

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Lecture 43

Evolution

The Tree of Life

The Tree of Life is an ever-evolving depiction of life's common ancestry. Scientists design the Tree of Life from careful observations and comparisons of living things. The tree shows that all organisms are related through their descent (the branches) from a common ancestor (the root). The more structural and genetic similarities that organisms share, the more closely related they are and the closer they are on the Tree of Life. We can draw a Tree of Life to show how every species is related. Evolution is the process by which one species gives rise to another and the Tree of Life grows.

Theory and Fact

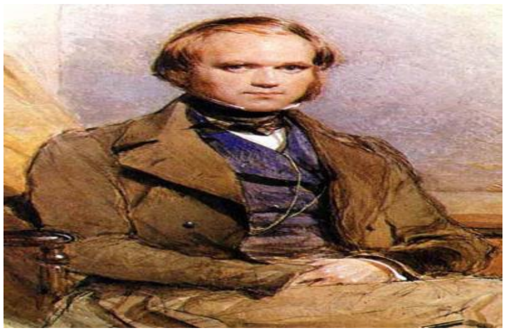
A scientific theory is a well-substantiated explanation of such facts. The facts of evolution come from observational evidence of current processes, from imperfections in organisms recording historical common descent, and from transitions in the fossil record. Theories of evolution provide a provisional explanation for these facts. Evolution means change over time, as in stellar evolution. In biology it refers to observed changes in organisms, to their descent from a common ancestor, and at a technical level to a change in gene frequency over time; it can also refer to explanatory theories (such as Charles Darwin's theory of natural selection) which explain the mechanisms of evolution. To a scientist, fact can describe a repeatable observation that all can agree on; it can refer to something that is so well established that nobody in a community disagrees with it; and it can also refer to the truth or falsity of a proposition.

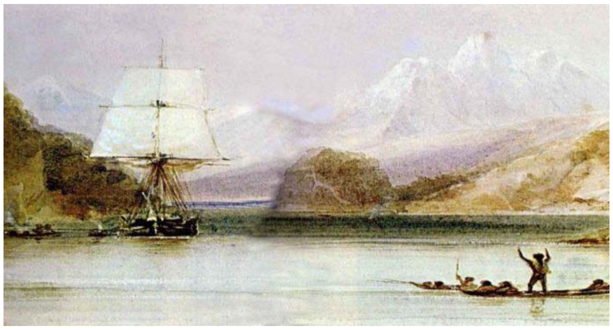
Transmutation

Jean-Baptiste Lamarck proposed a theory on the transmutation of species in Philosophie Zoologies (1809). Lamarck did not believe that all living things shared a common ancestor. Rather he believed that simple forms of life were created continuously by spontaneous generation. He also believed that an innate life force, which he sometimes described as a nervous fluid, drove species to become more complex over time, advancing up a linear ladder of complexity that was related to the great chain of being. Lamarck also recognized that species were adapted to their environment. He explained this observation by saying that the same nervous fluid driving increasing complexity, also caused the organs of an animal (or a plant) to change based on the use or disuse of that organ, just as muscles are affected by exercise. He argued that these changes would be inherited by the next generation and produce slow adaptation to the environment. Hence giraffes got their long necks to reach high branches.

Darwin's Voyage

The voyage of the *Beagle* (1831-1836) was one of the most important scientific expeditions in history. On board was the young naturalist Charles Darwin. His investigations would change science and the world forever. There was no sudden discovery on the Galapagos sparked by the finches as popular legend has it. Instead he intensively studied the geology, animals, plants and peoples of the lands visited. Along the way he made a number of striking discoveries, particularly in South America, which eventually led him to realize that living things must evolve over time. After his return home he formulated what he called "natural selection" to explain how living things adapt to a changing world.





Genetics

Gregor Mendel discovered some of the "rules" of diploid inheritance. Mendel's work was not widely known until it was rediscovered in the 1900s. Mendel demonstrated particulate inheritance, dispensing with the problems of blending inheritance. This mode of inheritance was initially used to argue against natural selection being a strong force: Since variants or mutants observed by early geneticists had discrete effects, and species differed discretely, species could have arisen by discrete, perhaps systemic changes (perhaps with a direction determined by orthogenesis or other mechanisms).

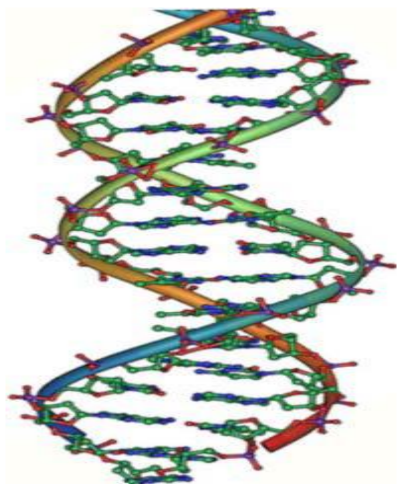
Evolutionary Principles

Charles Darwin proposed the idea of evolution in his book 'On the Origin of Species' in 1859. He called evolution 'descent with modification'. It is the process by which all life on earth has diversified from bacterial mats that existed over 3.6 billion ago. Evolution has had a long time. For a long time it was mistakenly thought that evolution was a simple linear progression, with humankind at the top of the ladder. This old view was replaced long ago as new evidence came to light. We now understand that evolution proceeds in a kind of branching pattern, with species on one branch giving rise to other branches and so on.

Genetics and Phenotype

Genotype

The genotype is the genetic makeup of a cell, an organism, or an individual usually with reference to a specific characteristic under consideration.

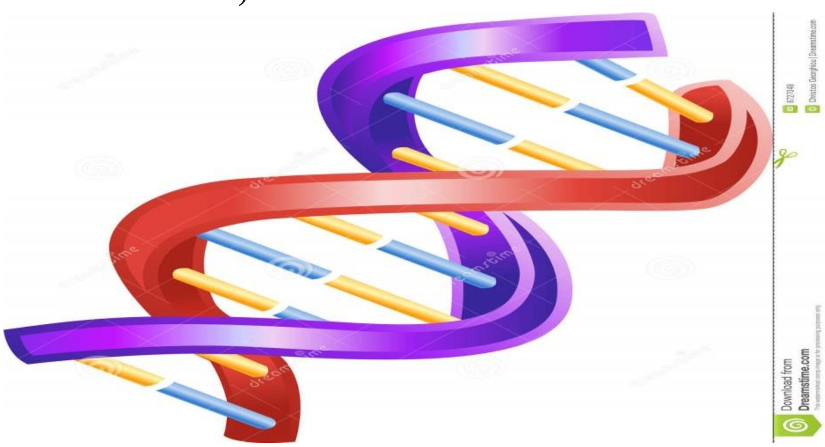


Phenotype

The observable physical or biochemical characteristics of an organism, as determined by both genetic makeup and environmental influences. The expression of a specific trait, such as stature or blood type, based on genetic and environmental influences.

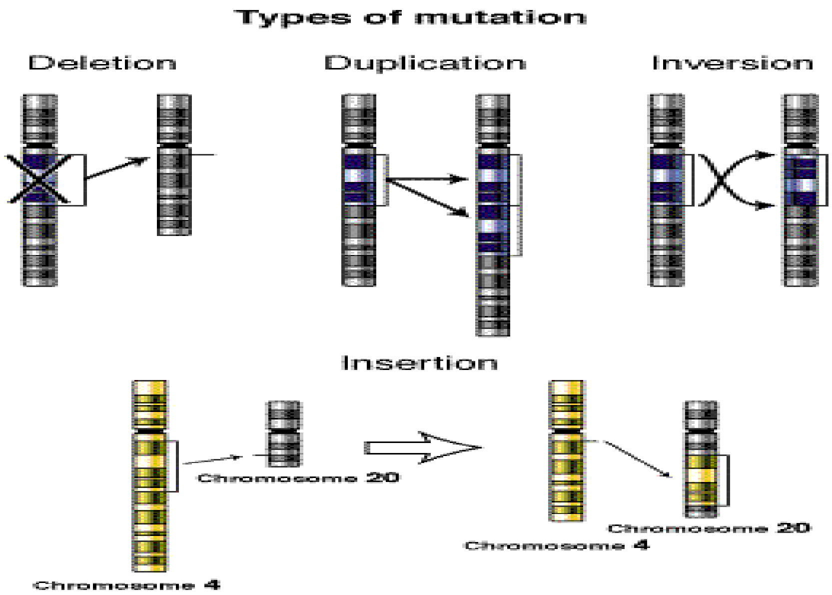
DNA

The double-helix structure of DNA was discovered in1953. DNA, or deoxyribonucleic acid, is the hereditary material in humans and almost all other organisms. Nearly every cell in a person's body has the same DNA. Most DNA is located in the cell nucleus (where it is called nuclear DNA), but a small amount of DNA can also be found in the mitochondria (where it is called mitochondrial DNA or mtDNA).



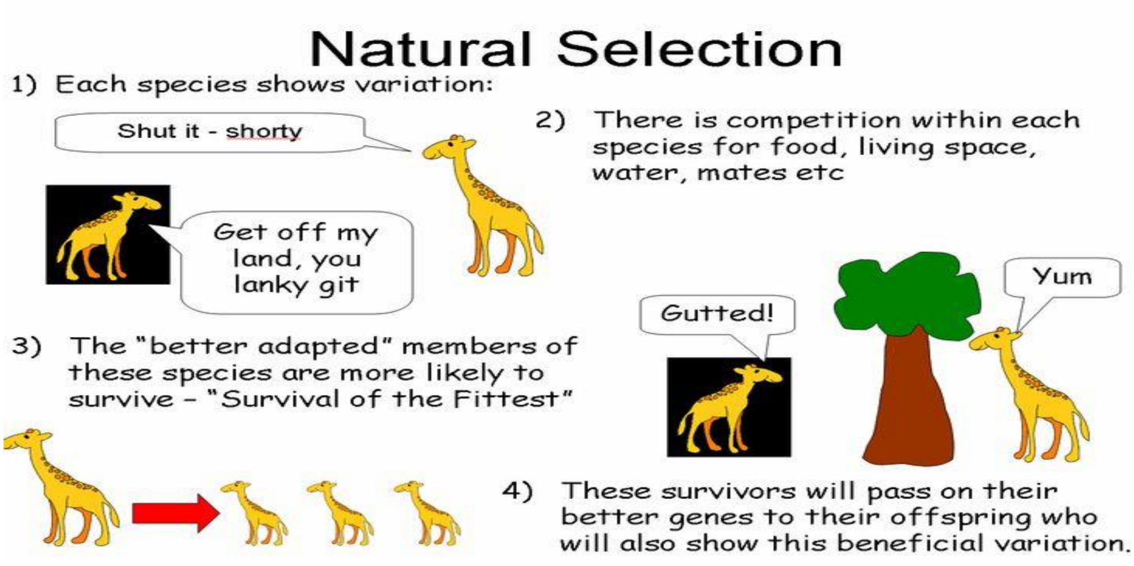
Mutation

Mutation is a natural process that changes a DNA sequence. Mutations result from damage to DNA which is not repaired, errors in the process of replication, or from the insertion or deletion of segments of DNA by mobile genetic elements. Mutations may or may not produce discernible changes in the observable characteristics (phenotype) of an organism. Mutations play a part in both normal and abnormal biological processes including: evolution, cancer, and the development of the immune system, including junctional diversity.



Natural Selection

Natural selection is the differential survival and reproduction of individuals due to differences in phenotype. It is a key mechanism of evolution, the change in heritable traits of a population over time. Variation exists within all populations of organisms. This occurs partly because random mutations arise in the genome of an individual organism, and offspring can inherit such mutations. Throughout the lives of the individuals, their genomes interact with their environments to cause variations in traits. (The environment of a genome includes the molecular biology in the cell, other cells, other individuals, populations, species, as well as the abiotic environment.) Individuals with certain variants of the trait may survive and reproduce more than individuals with other, less successful, variants. Therefore, the population evolves.

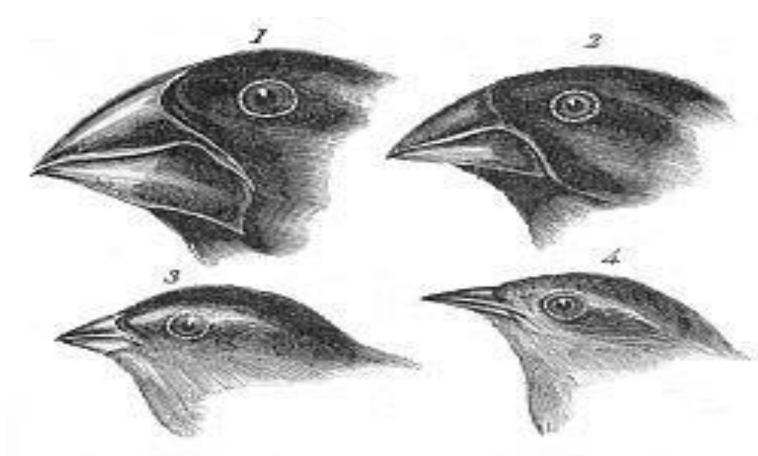


Microevolution

Microevolution is the change in allele frequencies that occurs over time within a population.]This change is due to four different processes: mutation, selection (natural and artificial), gene flow, and genetic drift. This change happens over a relatively short (in evolutionary terms) amount of time compared to the changes termed 'macroevolution' which is where greater differences in the population occur. Dogs have been artificially selected for certain characteristics for many years. Because their different breeds have different alleles. All breeds of dog belong to the same species, Canis lupus (the wolf). That is an example of Microevolution as no new species has resulted.

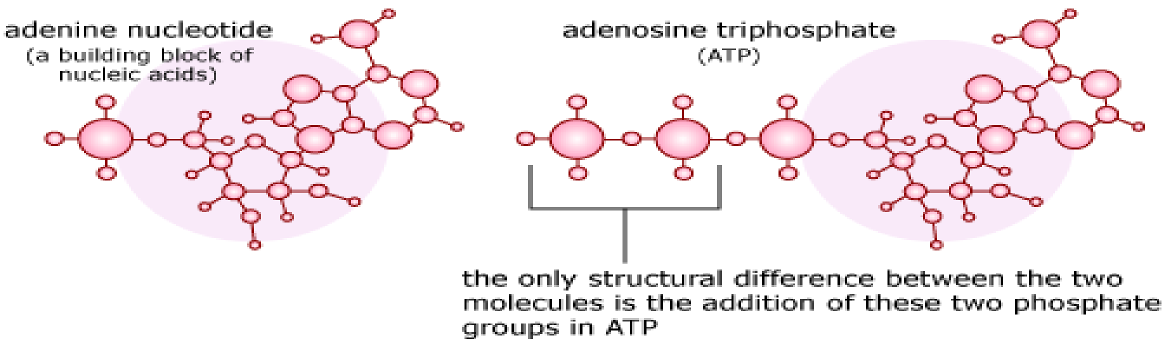
Macroevolution

Macroevolution is evolution on a scale of separated gene pools.Macroevolutionary studies focus on change that occurs at or above the level of species, in contrast with microevolution,which refers to smaller evolutionary changes (typically described as changes in allele frequencies) within a species or population. If the two populations can no longer interbreed, new species are born. This is called Macroevolution. Darwin’s Galapagos finches are an example of this process in action.



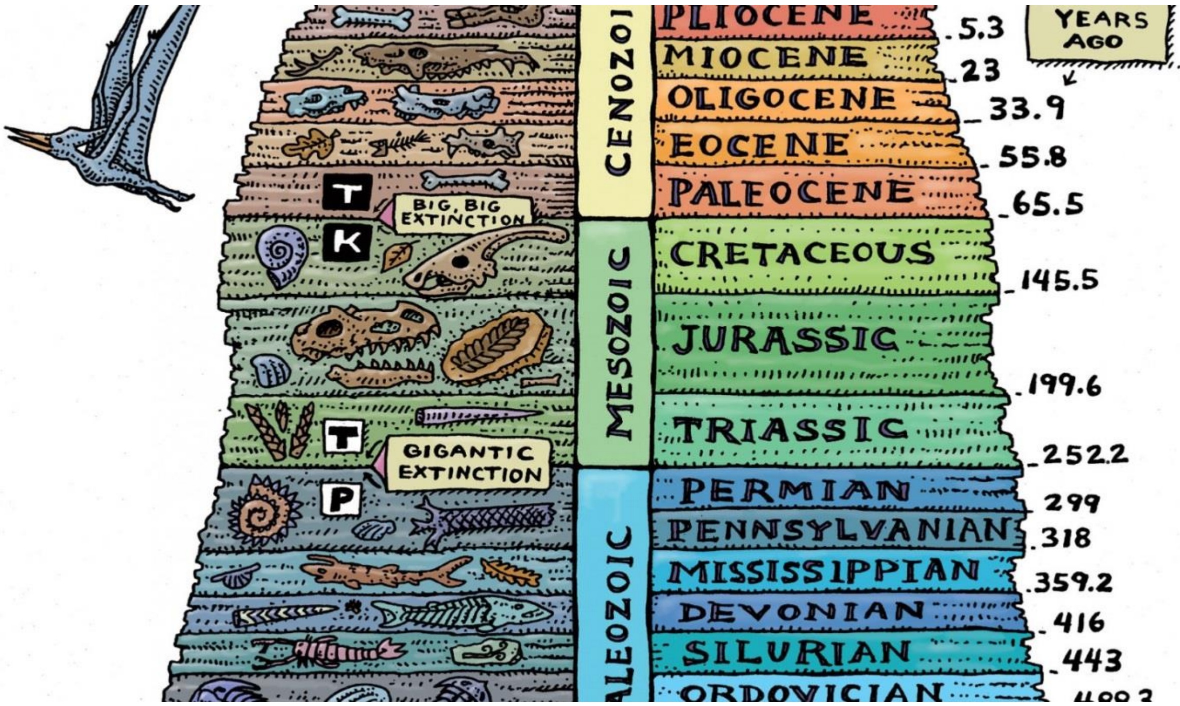
Evidence using Biochemistry

We can begin to piece together how biochemical systems evolved near the root of the tree of life. However, up until the early 1980s, biologists were stumped by a "chicken and egg" problem: in all modern organisms, nucleic acids (DNA and RNA) are necessary to build proteins, and proteins are necessary to build nucleic acids - so which came first, the nucleic acid or the protein. This problem was solved when a new property of RNA was discovered: some kinds of RNA can catalyze chemical reactions and that means that RNA can both store genetic information and cause the chemical reactions necessary to copy it. This breakthrough tentatively solved the chicken and egg problem: nucleic acids (and specifically, RNA) came first and later on, life switched to DNA-based inheritance.



Fossil Record

The fossil record is life's evolutionary epic that unfolded over four billion years as environmental conditions and genetic potential interacted in accordance with natural selection. It could be likened to a movie recording the history of life across nearly four billion years of geological time. Fossils provide a unique view into the history of life by showing the forms and features of life in the past. Fossils tell us how species have changed across long periods of the Earth's history. For instance, in 1998, scientists found a fossil showing an animal at the transition from sea creature to land creature. This tetrapod had a hand-like fin, confirming a prediction of evolutionary biology. The fossil record is a remarkable gift for the study of nature.



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Lecture no.45

Study of Flowers

Definition

The part of a seed plant comprising the reproductive organs and their envelopes if any, especially when such envelopes are more or less conspicuous in form and color.

Physiological Function

A flower, sometimes known as a bloom or blossom, is the reproductive structure found in plants that are floral (plants of the division Magnoliophyta, also called angiosperms). The biological function of a flower is to effect reproduction, usually by providing a mechanism for the union of sperm with eggs.

Composing of Flower

The essential parts of a flower can be considered in two parts: the vegetative part, consisting of petals and associated structures in the perianth, and the reproductive or sexual parts. A stereotypical flower consists of four kinds of structures attached to the tip of a short stalk. Each of these kinds of parts is arranged in a whorl on the receptacle.

Vegetative (Perianth)

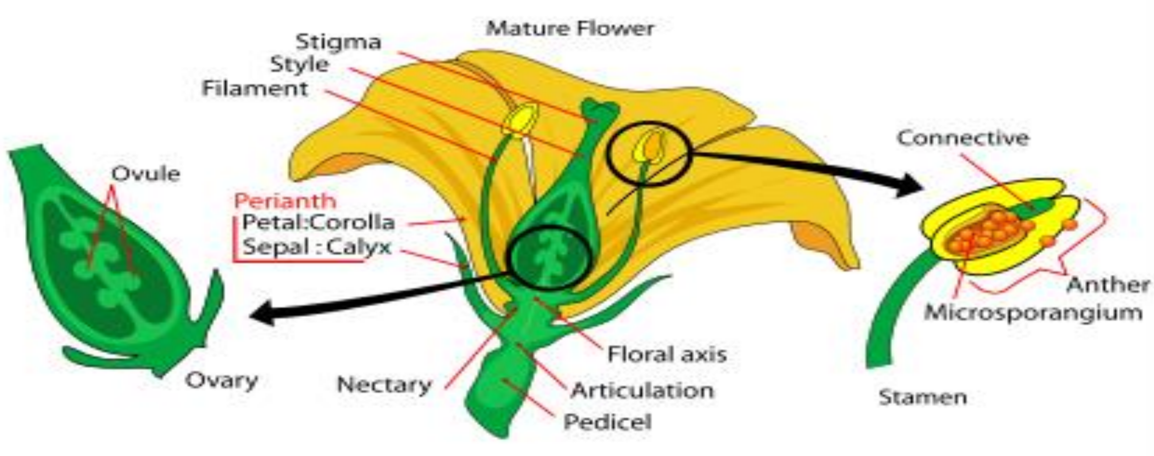
Collectively the calyx and corolla form the perianth.

Calyx

The outermost whorl consisting of units called sepals these are typically green and enclose the rest of the flower in the bud stage; however, they can be absent or prominent and petal-like in some species.

Corolla

The next whorl toward the apex, composed of units called petals, which are typically thin, soft and colored to attract animals that help the process of pollination.



Reproductive

Androecium

The next whorl (sometimes multiplied into several whorls), consisting of units called stamens. Stamens consist of two parts: a stalk called a filament, topped by an anther where pollen is produced by meiosis and eventually dispersed.

Type of Stamen

1. Monadelphous stamen
2. Diadelphous stamen
3. Didynamous stamen
4. Tetradynamous stamen
5. Polyadelphous stamen
6. Syngenesious stamen

1. Monadelphous
Fused into a single, compound structure

2. Diadelphous
Joined partially into two androecial structures.

3. Didynamous
Occurring in two pairs, a long pair and a shorter pair

4. Tetradynamous

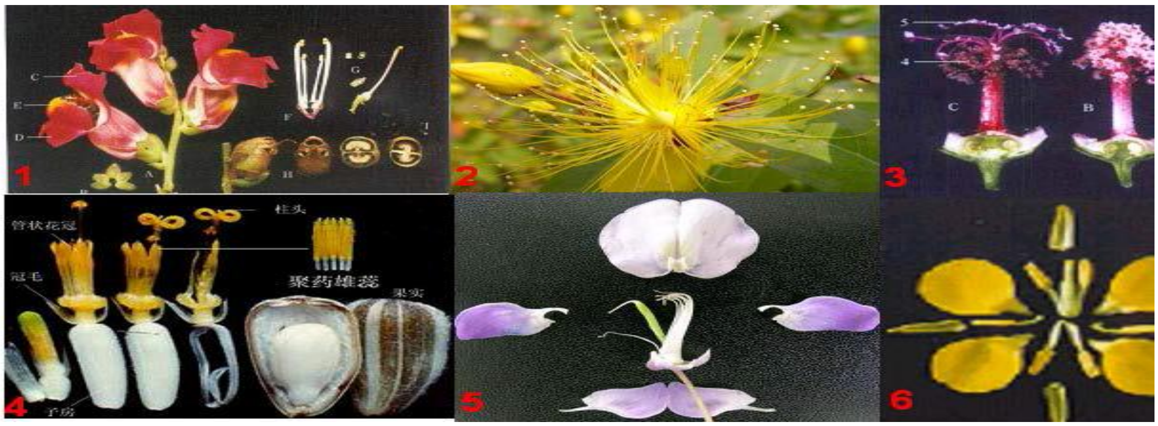
Occurring as a set of six stamens with four long and two shorter ones

5. Polyadelphous

Having united filaments so that they are arranging in three or more groups.

6. Syngenesious

Having the stamens united by the anthers; of or pertaining to the Syngenes



Gynoecium

The innermost whorl of a flower, consisting of one or more units called carpels. The carpel or multiple fused carpels form a hollow structure called an ovary, which produces ovules internally. Ovules are megasporangia and they in turn produce megaspores by meiosis which develops into female gametophytes. These give rise to egg cells. The gynoecium of a flower is also described using an alternative terminology wherein the structure one sees in the innermost whorl (consisting of an ovary, style and stigma) is called a pistil. A pistil may consist of a single carpel or a number of carpels fused together.

Types of pistil

1. Simple pistil

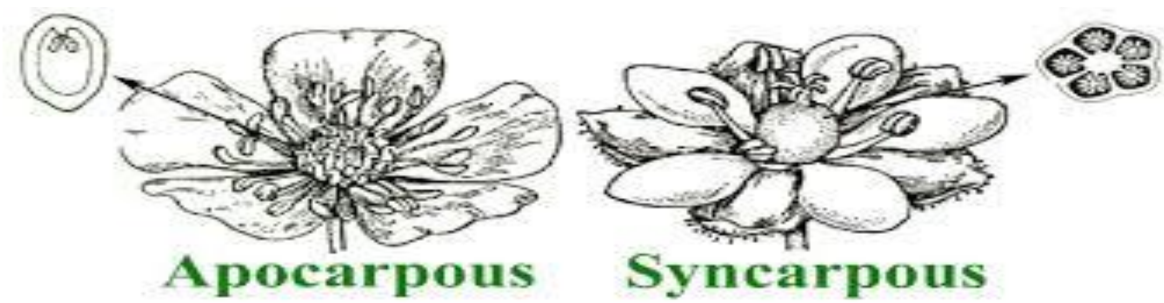
The female ovule-bearing part of a flower composed of ovary and style and stigma.

2. Syncarpous pistil

Syncarpous (fruit or pistil), composed of several carpels consolidated into one.

3. Apocarpous pistil

Having carpels that are free from one another. Used of a single flower with two or more separate pistils as in roses.



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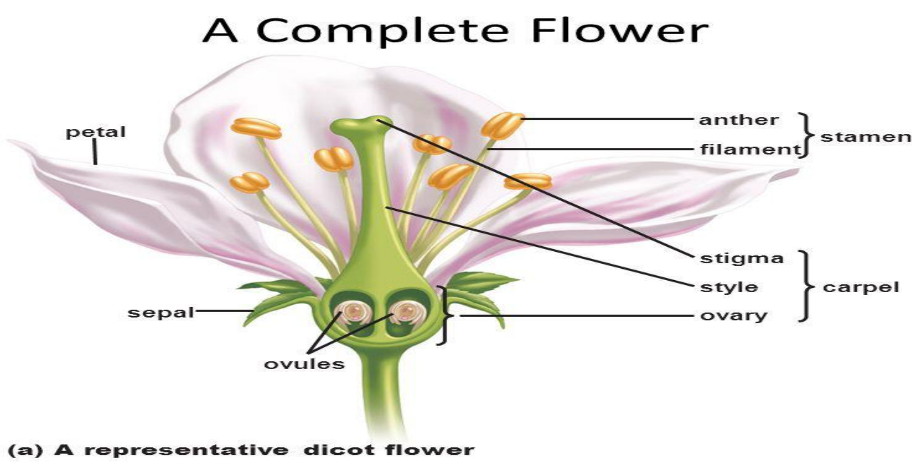
Type of Flower

Complete flower

A flower having all four floral parts: sepals, petals, stamens, and carpels.

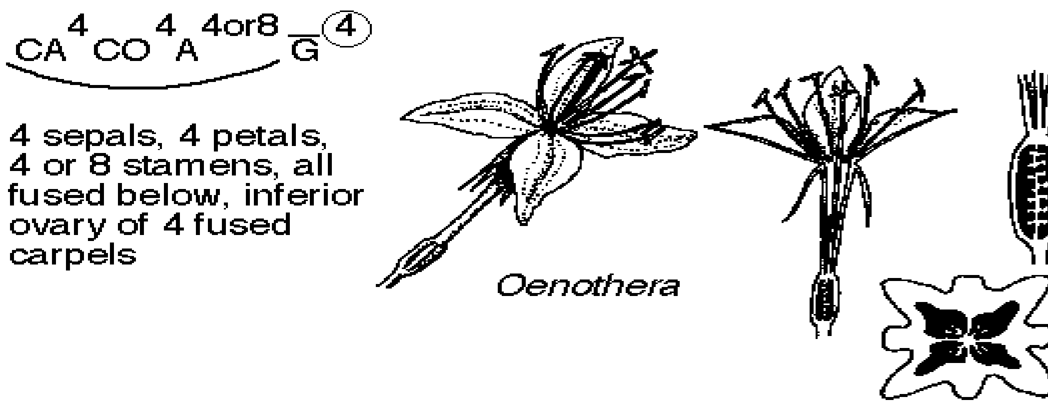


2. Incomplete flower

A flower without one or more of the normal parts, as carpels, sepals, petals, pistils, or stamens.

Flower Formula

Flower Formula is a means to represent the structure of a flower using numbers, letters and various symbols, presenting substantial information about the flower in a compact form. It can represent particular species, or can be generalized to characterize higher taxa, usually giving ranges of organ numbers.



Inflorescence

An inflorescence is a group or cluster of flowers arranged on a stem that is composed of a main branch or a complicated arrangement of branches. Morphologically, it is the part of the shoot of seed plants where flowers are formed and which is accordingly modified. The modifications can involve the length and the nature of the internodes and the phyllotaxis, as well as variations in the proportions, compressions, swellings, adnations, connations and reduction of main and secondary axes.

Type of Inflorescence

1. Spike - an elongate, unbranched, indeterminate inflorescence with sessile flowers.

2. Spikelet - a small spike, characteristic of grasses and sedges.

3. Raceme - an elongate, unbranched, indeterminate inflorescence with pedicelled flowers.

4. Panicle - a branched raceme.

5. Corymb - a flat-topped raceme with elongate pedicels reaching the same level.

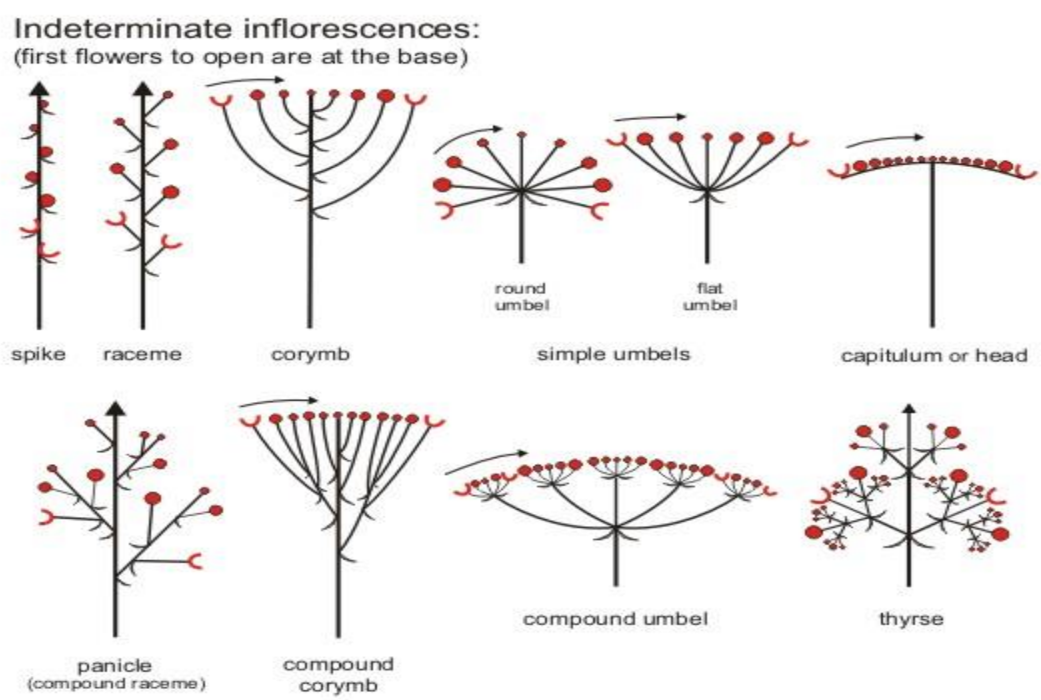
6. Compound Corymb - a branched corymb.

7. Umbel - a flat-topped or rounded inflorescence with the pedicels originating from a common point. Umbels can be determinate or indeterminate.

8. Compound Umbel - a branched umbel, with primary rays arising from a common point, and secondary umbels arising from the tip of the primary rays.

9. Capitulum (or head) - a dense vertically compressed inflorescence with sessile flowers on a receptacle and subtended by an involucre of phyllaries, characteristic of the Asteraceae. Heads can be determinate or indeterminate.

10. Thyrse - a many-flowered inflorescence with an indeterminate central axis and many opposite, lateral dichasia; a mixed inflorescence, with determinate and indeterminate shoots.



Definite inflorescence

A type of flowering shoot) in which the first-formed flower develops from the growing region at the top of the flower stalk. Thus no new flower buds can be produced at the tip and other flowers are produced from lateral buds beneath.

Type of Definite Inflorescence

1. Solitary cyme

When the apical or the axillary bud forms a single flower it does not form a real 'inflorescence' but this type is better included within the 'definite' group as further development is limited.

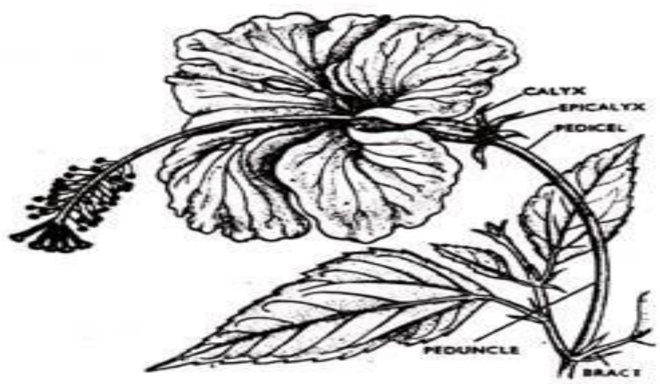


FIG. 283. Solitary flower of *Hibiscus rosa-sinensis*.

2. Cyathium cyme

The common garden Poinsettia (Euphorbia) pulcherrima shows this specialized cymose inflorescence which is covered by a cup-shaped green involucre formed by the union of bracts. The extremely reduced florets are placed on a convex receptacle.

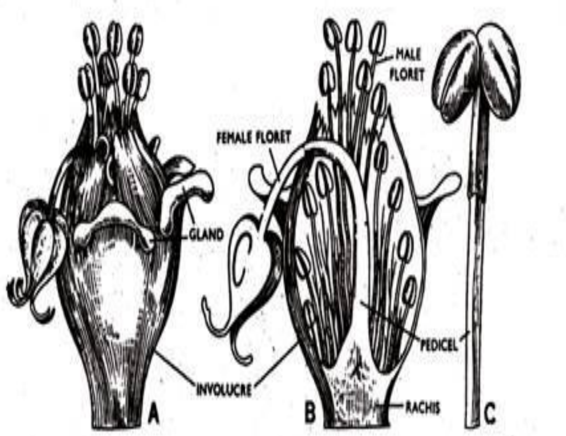


FIG. 290. Cyathium of *Poinsettia* (*Euphorbia*) *pulcherrima*. A. External view. B. L.s. showing male and female florets with bracteoles in between. C. A male floret formed of a single stamen.

3. Dichasium

This is the more normal cymose type where- two lateral branches develop on the two sides of the terminal apical (oldest) flower. The lateral branches may again branch similarly after the manner of biparous cymose branching

4. Polychasium

These branches as in the multiparous cyme, there being more than two lateral branches from the base of the apical flower. An example may be found in Calotropis of Asclepiadaceae of Caprifoliaceae.

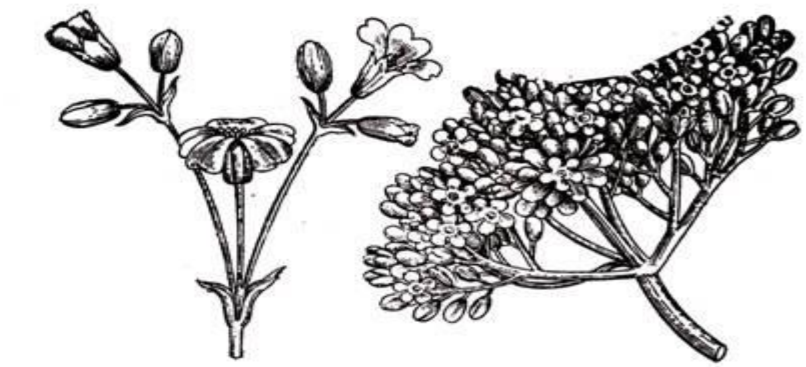


FIG. 286 FIG. 287

FIG. 286. Dichasium of *Dianthus chinensis*. FIG. 287. Polychasium of *Viburnum tinus*.

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Biology lecture # 1

Levels of Life

(From Atom to Biosphere)

WHAT IS LIFE?

Anything is living if:

- It can acquire energy from the environment, e.g., plants acquire energy using sunlight and carbon dioxide and animals gain energy by eating plants like goats eat plants.
- It is capable of reproducing itself, e.g., all animals produce young ones like lions produce cubs. Plants also reproduce seeds to give rise to new plants.
- Mutating / changing itself: all organisms have a property of mutations, i.e., their heredity material – DNA changes itself during division or other times and the result is change in any characteristic of the organism. This characteristic may be beneficial or harmful; organisms survive better if mutation is beneficial and may die if it is harmful.

BIOLOGY – THE STUDY OF LIFE

Biology (Bio – life; logos – study, reasoning); biology is hence the study of life or living organisms. Biology is about exploring the living part of the world, e.g., studying about animals, plants and even microorganisms is biology.

Biology have many subdivisions; for example, anatomy – the study of structures, physiology – the study of functions, microbiology – the study of microorganisms and many more.

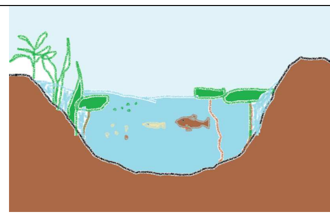
The exploration of life helps in understanding the phenomena of nature and effective utilization and management of natural resources. We can find solutions to various problems for example treatment for various diseases could be discovered, methods for energy production from biological materials may be found, e.g., few bacteria can produce fuel from grasses.

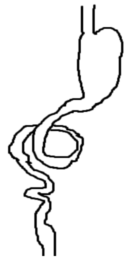
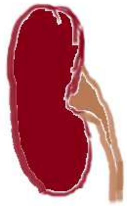
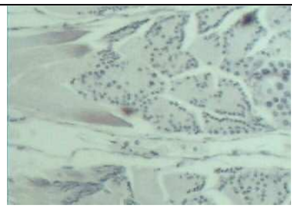
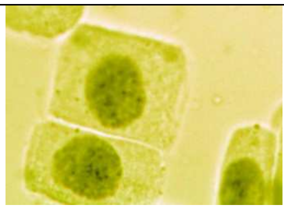
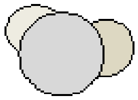
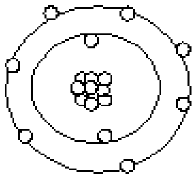
LEVELS OF ORGANIZATION IN LIFE

- Atoms
- Molecules
  - Micromolecules
  - Macromolecules

- Cells
- Tissues
- Organs
- Organ-systems
- Organisms
- Populations
- Communities
- Ecosystems
- Biosphere

Diagram below:

Biosphere	
Ecosystem	
Community	
Population	
Organisms	

Organ systems	
Organs	
Tissues	
Cells	
Molecules	
Atoms	

LEVELS OF ORGANIZATION IN LIFE – MORE DETAILS

Atoms

Greek: a, not; tom, to cut: The smallest component of an element that have all the properties of that element. In nature, 92 kinds of elements are present, out of which only 16 make the living organisms, called **bioelements**. Bioelements are Oxygen (O), Carbon (C), Hydrogen

(H), Nitrogen (N), Calcium (Ca), and Phosphorus (P). These elements make 99% of living mass. Others ten elements make 1 % of total living mass named Potassium (K), Sulfur (S), Chloride (Cl), Sodium (Na), Magnesium (Mg), Iron (Fe), Copper (Cu), Manganese (Mn), Zinc (Nz), and Iodine (I).

Atoms

All living things consist of atoms, like all other forms of matter. Atoms consist of “subatomic particles”; charged or not charged. These include electrons which are negatively charged particles, protons which are positively charged and neutrons which have no charge. Protons and neutrons are present inside the center and the electrons revolve around these in orbits.

Atoms do not live in isolation but join together to make molecules (compounds).

Molecules

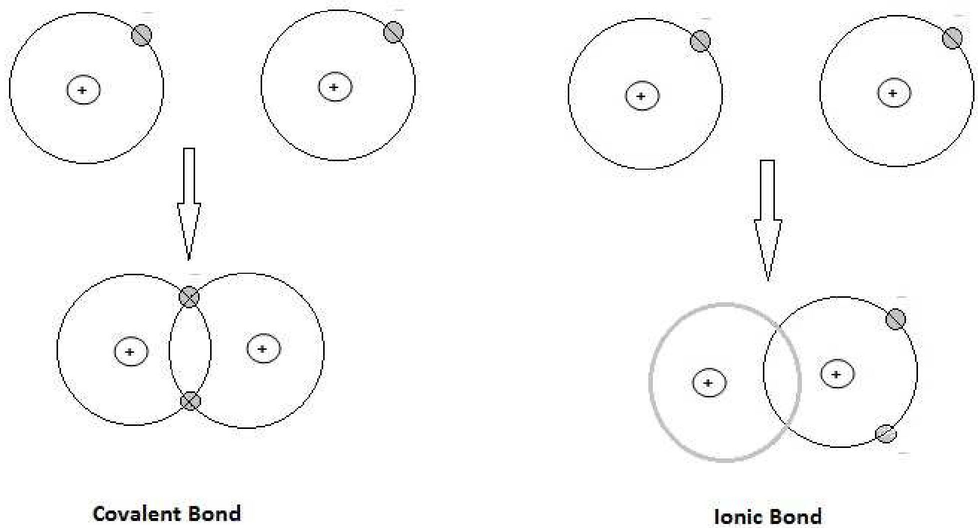
Atoms join together by a process called “bonding” to each other to construct molecules. Bonding is of two types.

- ionic bonds
- covalent bonds

In **inonic bonding** one atom gives one or more of its electron to the other atom which is called a donor and the other receive the electron called recipient. The donor atom then becomes positively charged and the recipient becomes negatively charged. In **covalent bonding**, however, the atoms share one or more of their electrons and these electrons revolve in the orbit of both atoms. Covalent bonding is more strong form of bonding.

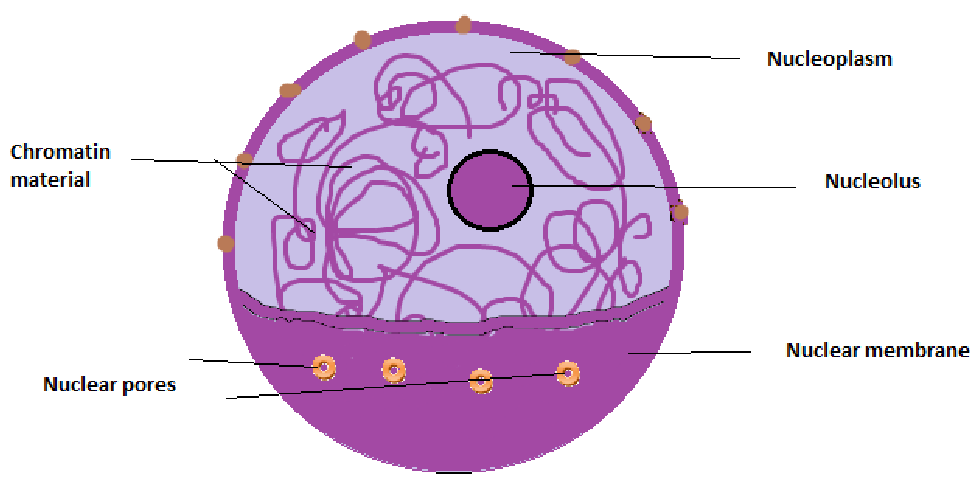
On the bsis of their size molecules are categorized into micromolecules and macromolecules. Micromolecules are the molecules with low molecular weight, e.g., glucose, water. Macromolecules are the molecules with high molecular weight, e.g., proteins, carbohydrates and lipids.

An organism consists of enormous number of biomolecules different types. Though some organisms are unicellular, i.e., consist of one cell only. Many other organisms are multicellular, i.e., these consist of many cells.



Organelles

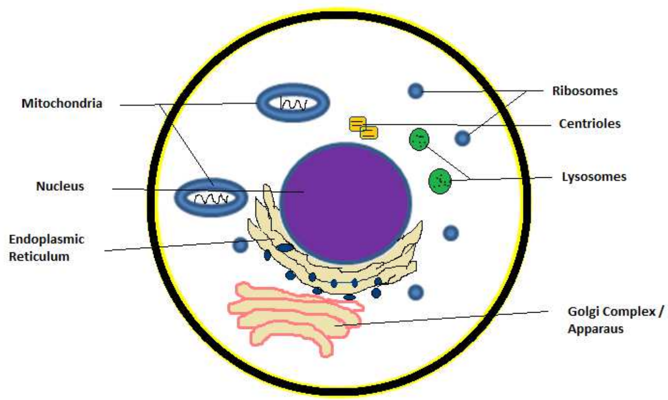
Molecules make organelles. Organelles are sub-cellular structures, assemble together to make cells – the units of life, e.g., mitochondria, lysosomes, Golgi bodies, nucleus. For example, mitochondria of a cell (Singular: mitochondrion) is called "powerhouse" of the cell. This organelle is present in the cytoplasm of the cells and makes energy for the cells hence called "power house". These are found in both plants and animals. Another example is nucleus present in almost all cells.



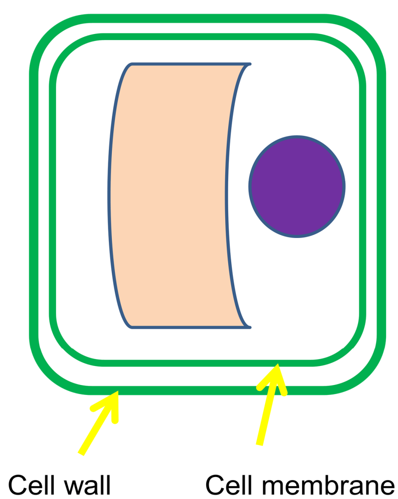
Organelle: nucleus.

Cells – the basic unit of life

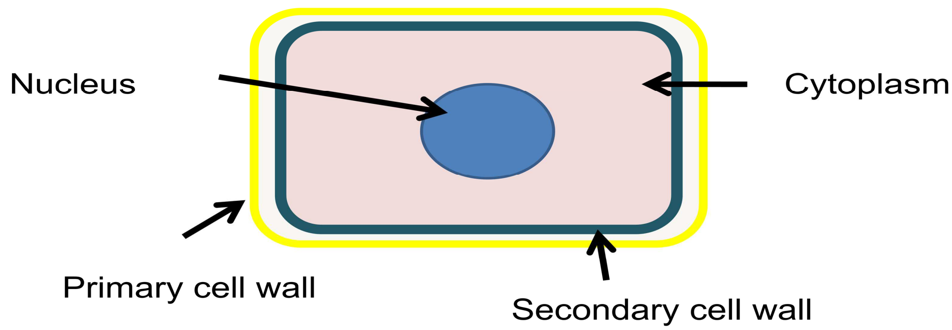
All the living organisms consist of cells. Cells are called the basic units of life. Cells are specialized in their structure and functions. There are different types of cells present in the bodies of multicellular organisms. But some organisms like amoeba consist of only one cell. Cells are categorized based upon the placement of their nuclear material into prokaryotic and eukaryotic cells. Prkaryotic (Pro: old, Karyotic: related to nucleus) cells are those cells that do not have a true nucleus – it means that their nuclear material is not covered by a membrane. While eukaryotic cells have a true nucleus, i.e., their nuclear material is covered by a membrane called nuclear membrane. Sometimes a cell makes a whole unicellular organism, like Prokaryotes and Protists. A variety of cells makes a single, multi-cellular organism.



Animals Cell



Plant Cell



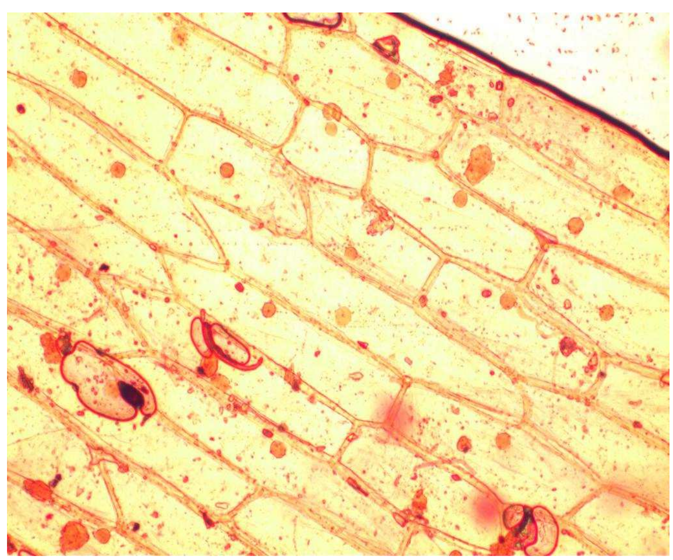
Bacterial Cell

Stem Cells

These are the undifferentiated cells in which most of the genes are switched on and these have a potential to make almost all cells of the body. These cells are present in a few places in adult organism or present in the embryos. These are useful for human beings because these can be used in making organs of any type which may be damaged by for example a disease.

Tissues

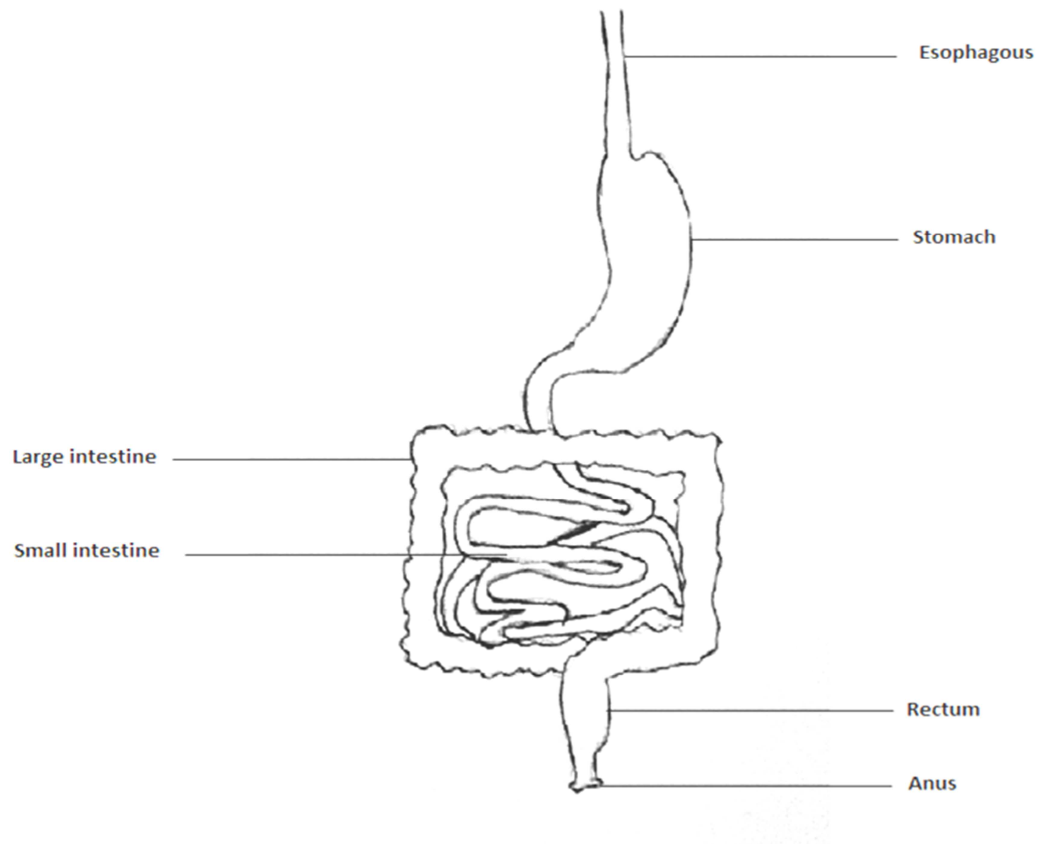
These are the groups of similar kind of cells which perform a same function. The tissues perform a common function, specialized to the tissue. For example, epithelial tissue that makes the skin.



Onion Epidermis (tissue)

Organs and organ systems

Tissues group and work together to make a unit called organ. Different tissues in an organ work differently to perform collective function of the organ. For example in stomach, there are muscle tissues that contract and relax for grinding and there are secretory cells which secrete gastric juices to digest the food. Collective action is the secretion of gastric juices and its mixing.



Digestive system in humans

In the simple to complex organisms, many organ-systems are present, for example, in humans digestive system, cardiovascular system, respiratory system and many more are present that work for a specific purpose. Digestive system consists of oral cavity, esophagus, stomach, intestine, pancreas, liver and rectum. Cardiovascular system consists of heart, vessels and blood.

Organism

Organ-systems join together to constructs organisms. In an organism, the organs and organ-systems coordinate to perform the activities of the whole organism. For example, in humans brain control the activities of most of the organs and organ-systems. If a person is running;

cardiovascular system provides it oxygen and nutrients, muscles contract and relax for movement and nervous system coordinate all of these functions.

Population

All organisms of a species living in an area at a particular time are called population, like all deer in a forest. Biologists study populations to explore the interactions between organisms. For example, interactions between male-male, female to female or else.

Ducks in a local park

Community & Ecosystem

Different populations living in an area in a particular time, for example, in a forest plants, animals, algae, fungi live together are called a **community**. Populations interact with each other and also to the abiotic factors of the area to make Ecosystem, for example, a lake ecosystem.

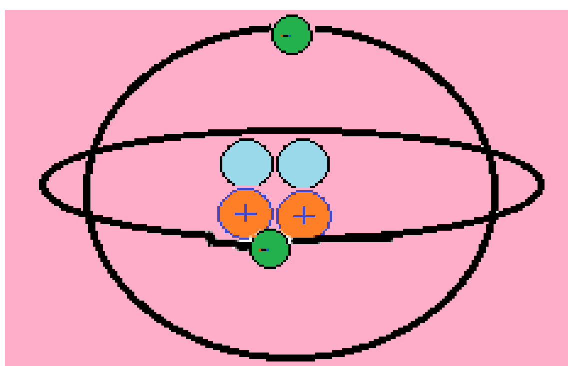
Plant community in a forest

Biosphere

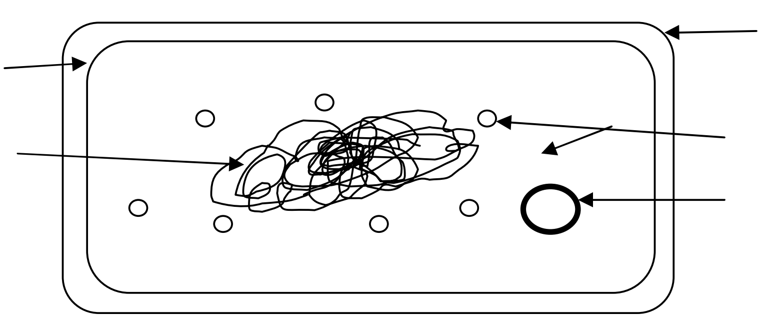
The part of the world covered or inhabited by the living organisms is called biosphere. This is also called zone of life on Earth. Biosphere includes all ecosystems, like forests, lakes, oceans and valleys where biotic components exist.

Exercise

1. Draw a flow chart to demonstrate the levels of organization in life.
2. Label various parts of atom in the following diagram:



3. Label various parts of a bacterial cell in the following diagram:



Biology lecture # 3

CELL ORGANELLES

WHAT IS CELL THEORY?

- Cell theory in its modern form states:
  - All living organisms are composed of one or more cells.
  - Cells are the smallest living things, the basic unit of all living organisms.
  - Cells arise only by division in pre-existing cells.

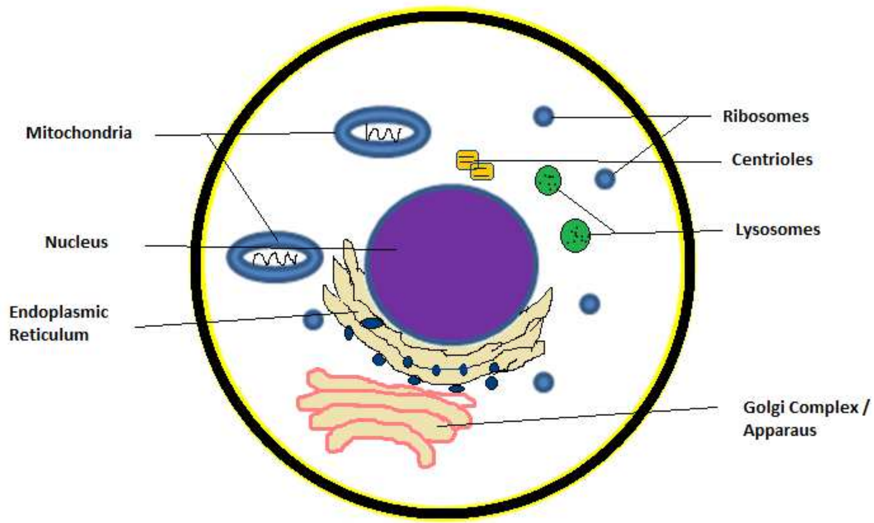
HOW CELL THEORY DEVELOPED?

- Cells were first described by Robert Hooke (Curator for instruments of Royal Society of London) in 1665.
- Leeuwenhoek (Textile Merchant) observed tiny organisms in pond’s water, called them animalcules.
- In 1809, de-Lamark proposed that nobody can have life if its parts are not cellular tissues.
- Robert Brown discovered nucleus in the cell.
- In 1838, Schleiden stated that all plants are aggregates of individual cells.
- In 1839, Schwann stated that all animal tissues consist of cells.
- In 1855, Virchow proposed that cells arise from pre-existing cells.
- In 1862, Pasteur provided experimental proof for the above.

CELLULAR COMPONENTS

Cells consist of several components. Some important and common ones are discussed below:

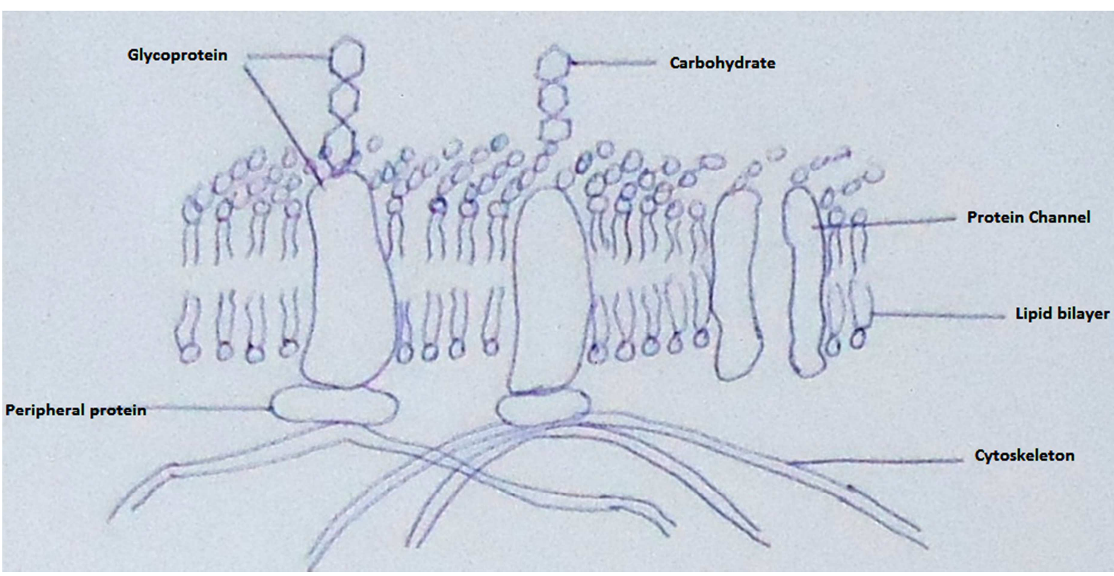
- Cell membrane
- Cell wall
- Cytoplasm
- Cytoskeleton
- Organelles (e.g. nucleus, ribosomes)



A typical animal cell

Cell Membrane

- Cell membrane is the external most layer that covers the cell from outside.
- Functions of the cell membrane are:
    - It acts as a barrier, i.e., it separates the cell from environment.
    - It provides protection to the inner parts of the cells including all the organelles.
    - Another important function of cell membrane is transport of materials. Cell membrane manages the transport in and out of the cell.



Structure of plasma membrane

Structure and Functions of Cell Membrane

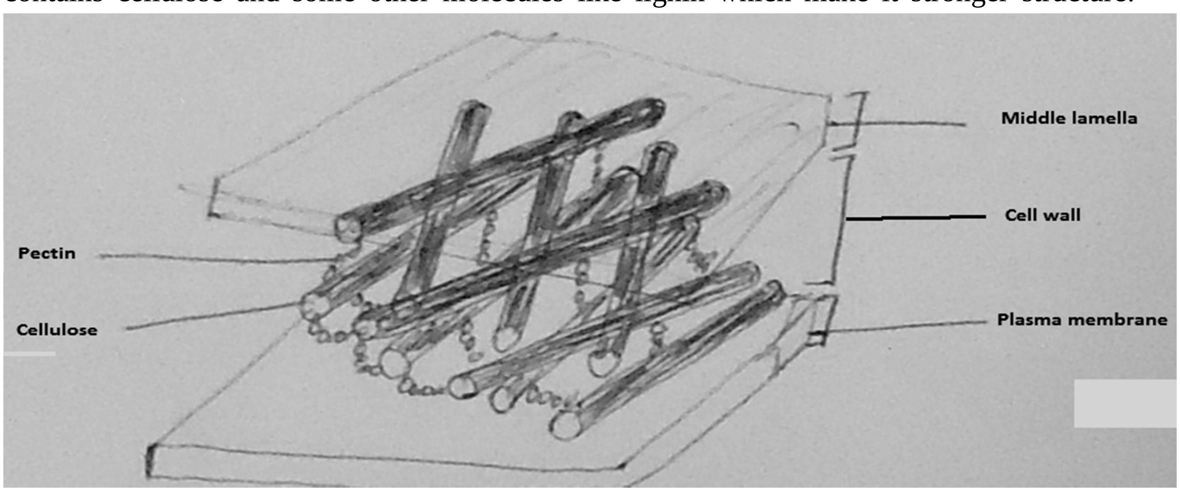
Structure of cell membrane is described by Fluid Mosaic Modal. It consists of lipid bilayer, proteins and carbohydrates. Lipid bilayer provides it with fluidity, flexibility and transport of lipid like substances. Proteins are integrated inside the membrane or present on its peripheries called **integrated proteins** and **peripheral proteins**, respectively. Some proteins are transmembrane, i.e., these are integrated and their ends (domains) are exposed from both intracellular and extracellular side of the membrane. These make channels for transport of materials, e.g., aquaporins are the protein channels for transport of water. Proteins and glycoproteins (carbohydrates attached to proteins) make receptors for message transmission. Cells carry out their message transmission with other cells or environment with the help of these glycoproteins mostly, we call these **receptors**.

Movements across Cell Membrane

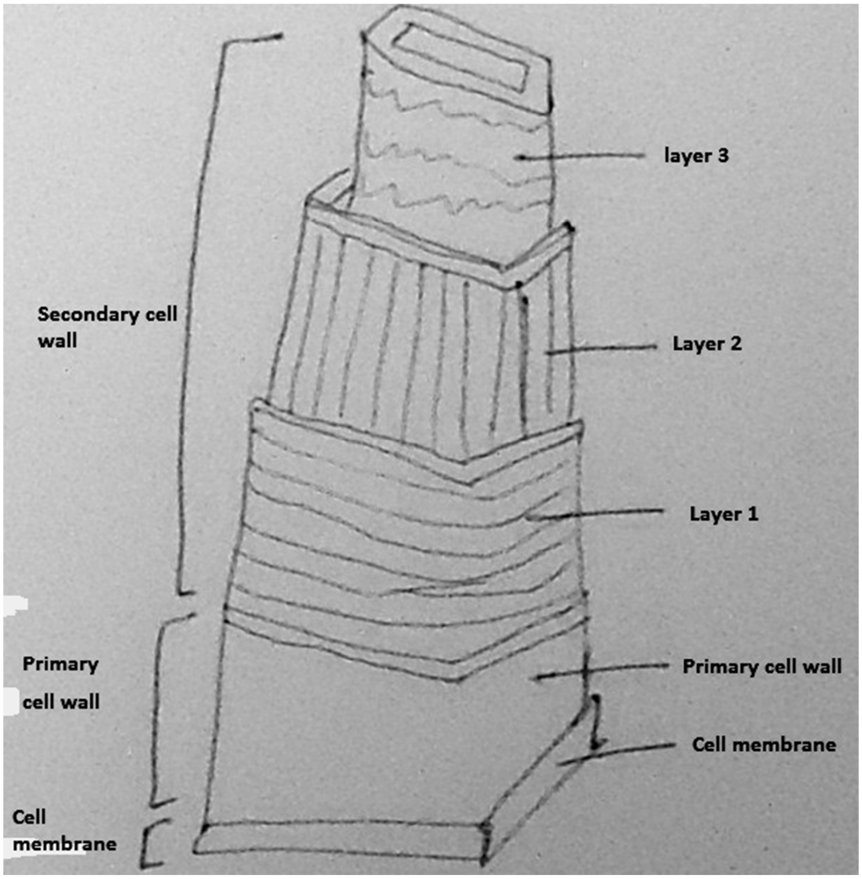
- Some molecules can pass directly e.g. few lipids.
- Other molecules need channels to pass through; channels are made up of proteins.
- There are different types of channels for different molecules like water channels and ion channels (Sodium channels, Calcium channels).

Cell Wall

It is the outermost covering in many organisms surrounding the cell membrane. Prokaryotic cells, fungi and plant cells have a cell wall around their cell membrane. Cell wall makes the outermost covering in these organisms. Cell wall is tough in comparison to cell membrane; it is a rigid structure. Cell wall in plants consists of **cellulose**, **hemicellulose**, and **pectin**. Fungal cell walls consist of a long polymer called, **chitin**. Prokaryotic cell wall consists of a polymer, called **peptidoglycan**. Functions of the cell wall are protection, shape, strength and support. Plant cells have 2 types of cell wall, primary cell wall and secondary cell wall. Primary wall consists of mainly cellulose, hemicellulose and pectin. Secondary cell wall contains cellulose and some other molecules like lignin which make it stronger structure.



Primary cell wall



Secondary cell wall

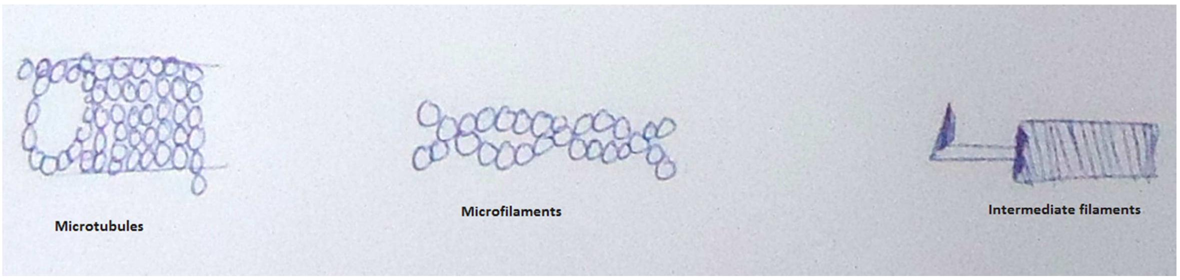
Cytoplasm

Cytoplasm is a semi transparent substance present between plasma membrane and the nucleus. It contains water in which organic (e.g. proteins, carbohydrates) and inorganic materials (e.g. salts), which are partially or fully dissolved in this solution. Cytoplasm provides space for metabolic reactions (e.g. glycolysis). It also provides space for functioning of organelles and metabolic reactions.

Cytoskeleton

Cytoskeleton is the skeletal framework of the cell – a network of filaments and tubules. There are three types of cytoskeletal elements called microfilaments, intermediate filaments and microtubules.

Microfilaments are the smallest in their diameter. These help in movement of organelles and the cell. These consist of helical chains of a protein called actin e.g. in muscle cells these are highly modified. **Intermediate filaments** are intermediate in size. These consis of different proteins belong to a protein family called keratins. These filaments help in maintaining shape and placement of the cell and its various parts. These also provide protection to various parts of the cell particularly to the nucleus. **Microtubules** are largest in diameter, these filaments consist of a protein called tubulin which makes dimers and then long and large hollow tubes. These help in movement of the organelles inside the cells and also in movement of the cell itself. Cilia and flagella consist of microtubules. These filaments help in maintaining shapes of organelles and cell. For example these make the nuclear lamina, a layer that maintain the shape of the nucleus and give it support.



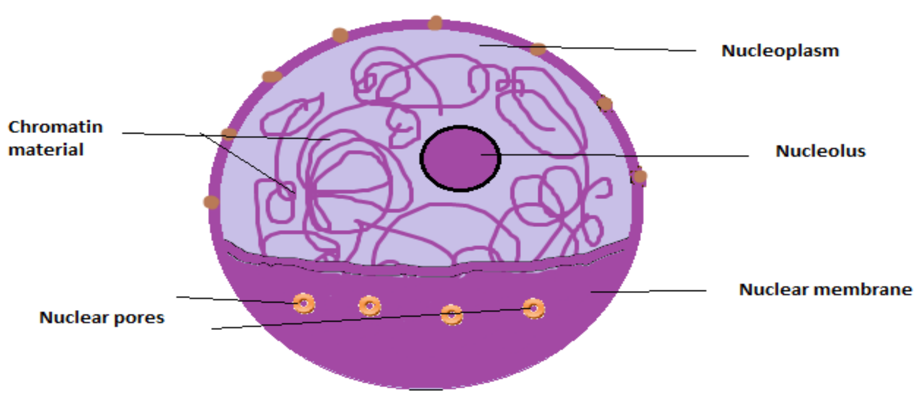
Cytoskeletal fibers

Cell Organelles

These are sub-cellular structures that perform a particular function. These include nucleus, mitochondria, endoplasmic reticulum and many more.

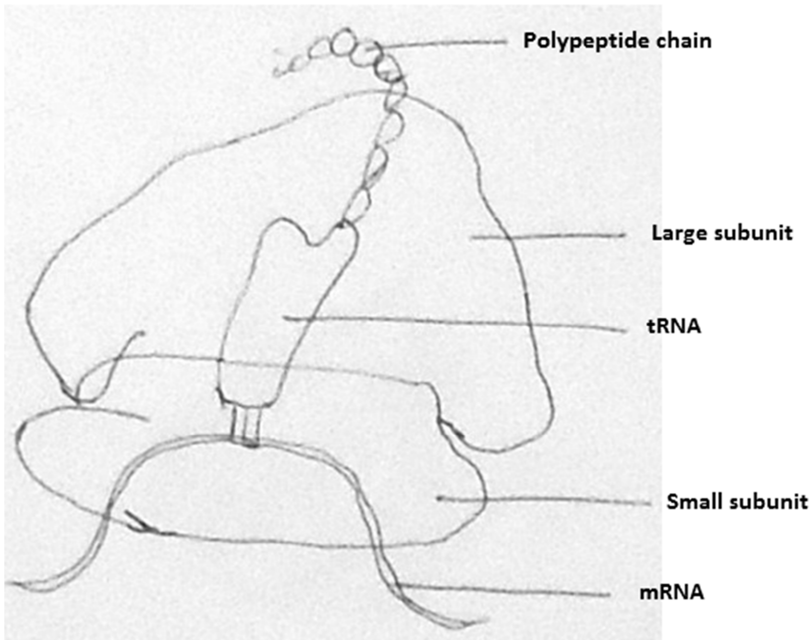
Nucleus

It is the organelle that contains genetic material. It is present in the center in animal cells usually. In plant cells, it is present on a side due to presence of a large vacuole. Nucleus is covered by nuclear membrane with nuclear pores. It is filled with a fluid called nucleoplasm. It also contains a denser body called nucleolus which is involved in ribosomal RNA production. Genetic material is present inside the nucleus in most of the eukaryotic cells, though, some cells have extranuclear DNA. DNA is present in the form of chromosomes, which are visible during cell division.



Ribosomes

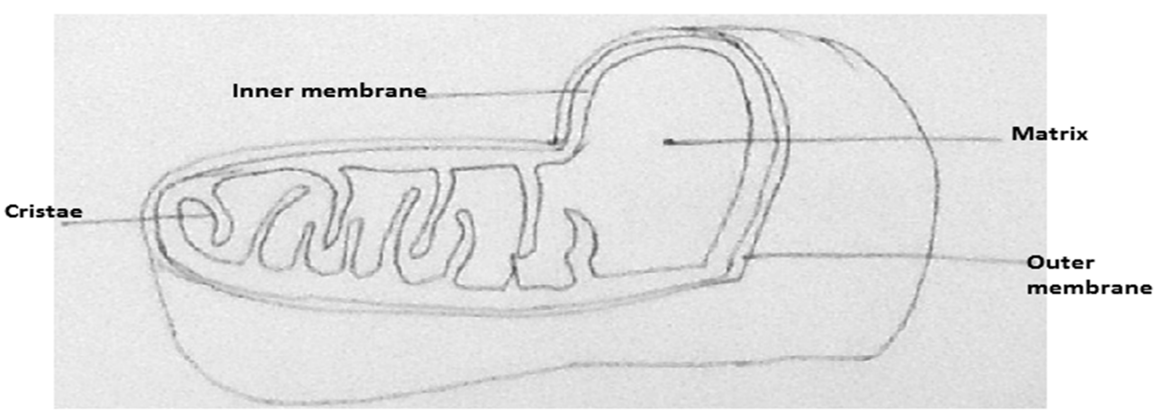
Ribosomes are the protein making machinery of the cells. These are present free in cytoplasm or attached to endoplasmic reticulum. A large number of ribosomes are present in cells. Eukaryotic ribosomes are slightly different than prokaryotic ones in their size.



Structure of a ribosome

Mitochondria

Mitochondria are called power house of the cell. These make energy for the cells in the form of ATP (Adenosine Tri Phosphate). ATP is the biological or chemical form of energy. Mitochondria have a double membrane, one is called outer and the other is inner membrane. Mitochondria are filled with matrix containing circular DNA molecule and other molecules including the enzymes. Mitochondria are self replicating organelles.



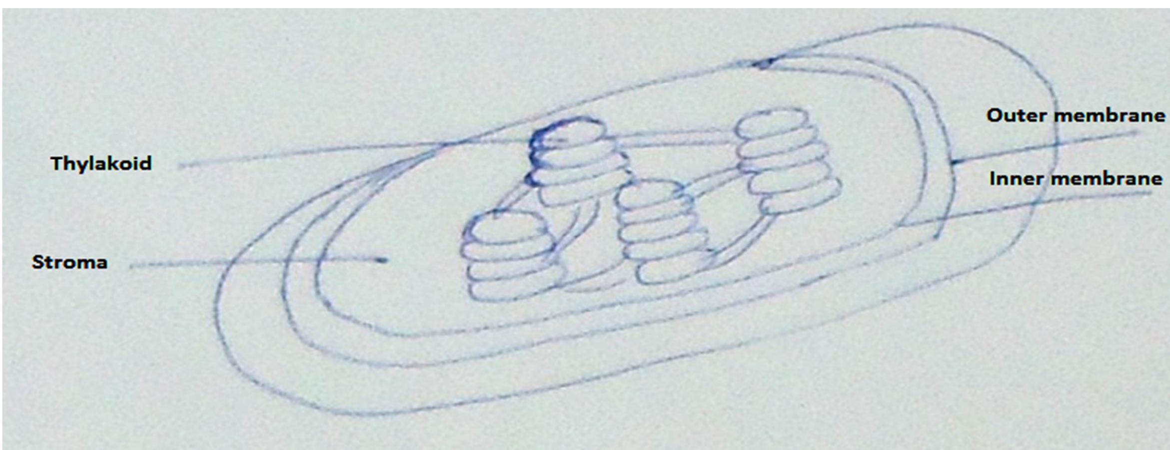
Mitochondria

Plastids

Plastids are the double membrane bound organelles, present in plants and in the other organisms which are producers such as algae. These are of three main types:

- Chloroplasts are present in the green parts of plants. These are green in color and their color is due to chlorophyll, the green pigment. These help in photosynthesis.
- Chromoplasts are the organelles present in the fruits and flowers of the plants. Beautiful colors of fruits and flowers are due to presence of Chromoplasts which contain red, yellow, orange and more colored pigments.
- Lecuoplasts are the plastids present in the roots and tubers. These are colorless pigments and their function is to store various materials in the roots and tubers, e.g., potatoes.

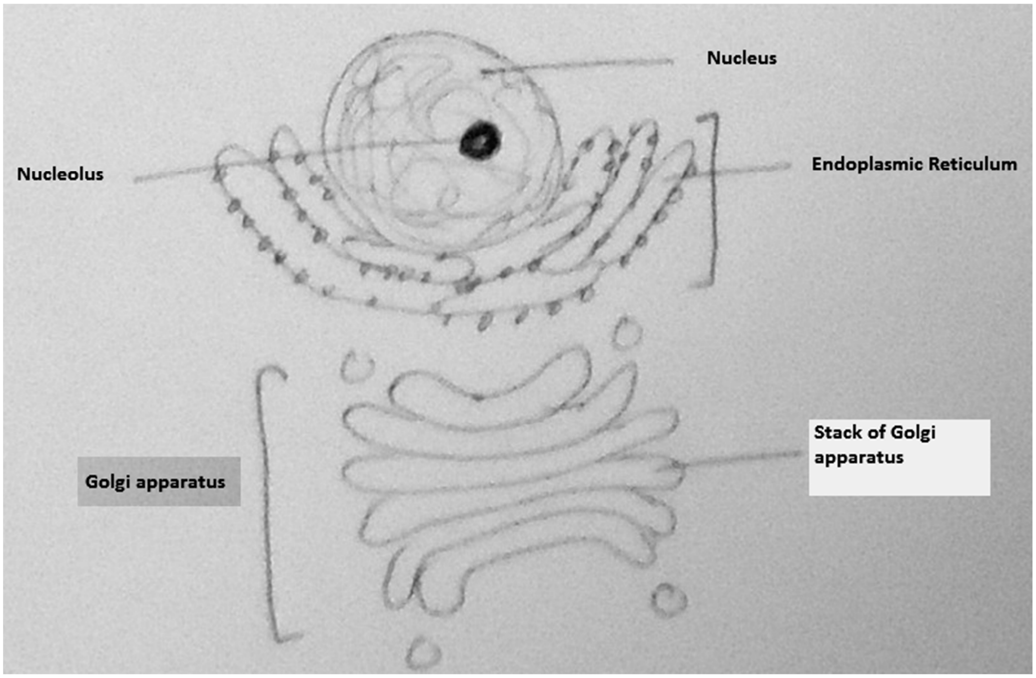
Plastids have a double membrane system. Their membranes are called outer membrane and inner membrane. They have a membrane system called thylakoid. Stacks thylakoids are called grana. They have a matrix inside inner membrane which is called stroma. These organelles like mitochondria have their own circular DNA. These are self replicating organelles.



Structure of a chloroplast (a kind of plastid)

Endoplasmic Reticulum

Endoplasmic reticulum (ER) is a network of interconnected channels present inside the cells. This is of two types: Rough ER and Smooth ER. Rough endoplasmic reticulum is the rough due to the ribosomes present on its surface. This type is involved in protein modification. The other type is free of ribosomes so that shape of this one is smooth giving it its name. SER is involved in metabolism of lipids and carbohydrates.



Endoplasmic reticulum and Golgi apparatus

Golgi Apparatus

This is also called Golgi bodies or Golgi complex. This is also very important organelle of the cells. It was discovered by Camillo Golgi. Golgi apparatus consist of flattened disks called cisternae which are associated with endoplasmic reticulum. These are called the post office of the cell because these pack materials in the form of vesicles. For example the proteins formed by the ribosomes and modified by the endoplasmic reticulum enter in the cisternae and here these are packed in the vesicles and transferred to the part of the cell where these are required or secreted out of cells.

Centrioles

These are hollow and cylindrical bodies present near the nucleus of the animal cells. It is also present in some lower plants. A pair of Centrioles is collectively called centrosome. Their function is during cell division. These make the spindle fiber during cell division in animal cells.

Vacuoles

Vacuoles are membrane bound organelles present in most of the cells. Their major function is storage of various materials including food materials to waste materials. If these store food then these are called food vacuoles. Their size is from small to very large in different cells according to the requirements of the cells. In mature plant cells a single large vacuole is present. Contractile vacuole in unicellular fresh water organisms helps in removal of water from the body.

Lysosomes

Lysosomes are membranous sacs filled with enzymes. Lysosomes are spherical bag like structures that are bound by a single layer membrane. These are found in all eukaryotic cells and act as 'garbage disposal' or the 'digester' of the cell. These act as disposal system of the cell. They break down complex proteins, carbohydrates, lipids and other macromolecules into simpler compounds. These simple compounds are returned to the cytoplasm and are used as new cell building materials. They are used for digestion of cellular waste products, dead cells or extracellular material such as bacteria.

Exercise

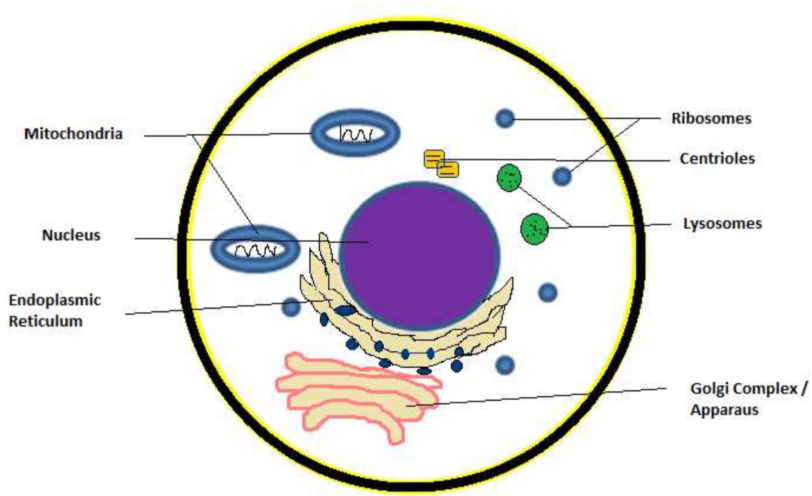
1. Draw the structure of an animal cell.
2. Draw structure of a plant cell.
3. Compare mitochondria with chloroplast.

Biology lecture # 3

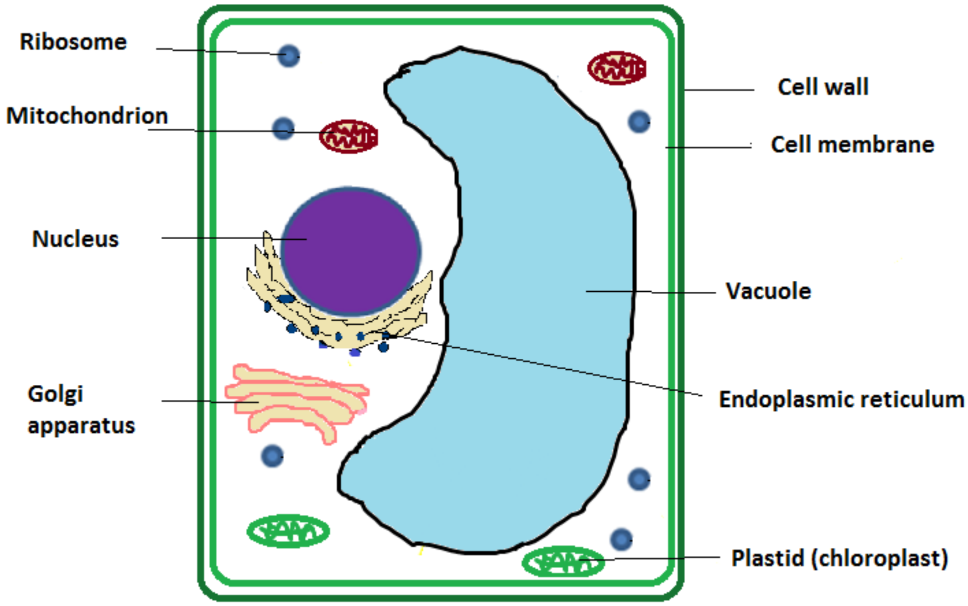
Diversity of Cells and Mitosis

Animal Cell Vs Plant Cell

Animal Cell	**Plant Cell**
▪ Cell membrane is outer most layer ▪ *Many small vacuoles* ▪ Nucleus in the center ▪ *Roughly round and/or have variable shapes* ▪ Plastids are absent ▪ *Cilia present* ▪ Centrioles present	▪ Cell wall is present outside the cell membrane ▪ *Have a large central vacuole* ▪ Nucleus on a side ▪ *Roughly rectangular shape due to presence of cell wall* ▪ Plastids are present ▪ *Cilia rarely present* ▪ Centrioles absent in most of the plants



A typical animal cell



A typical plant cell

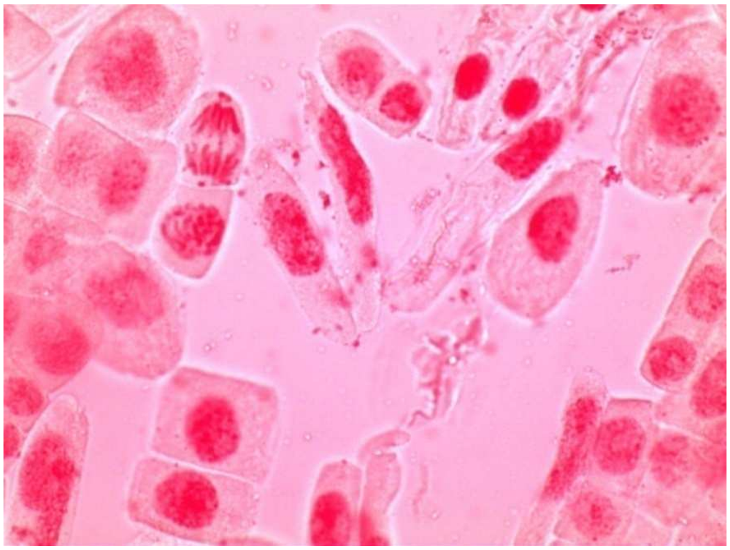
Prokaryotic Cell Vs Eukaryotic Cell

Prokaryotic Cells	**Eukaryotic Cells**
▪ No defined nucleus but a nucleoid region ▪ No membrane bound organelles ▪ Small in size (e.g. 1-2 microns in bacteria) ▪ Cell wall consist of peptidoglycan (a polymer of amino acids and sugars)	▪ Defined nucleus with nuclear membrane ▪ Membrane bound organelles are present ▪ Larger than prokaryotic cells on average (20 microns of animal cells) ▪ Cell wall consist of cellulose (plants) and chitin (fungi)

CELL DIVISION

Division is the property of cells. Cells have to divide for various purposes, for reproduction or for growth and repair of the tissues. There are two types of the cells called somatic cells and germ line cells. Somatic cells are those which make all the tissues of the body except for some cells which are involved in reproduction. Few cells involved in reproduction and are meant for making gametes for reproduction.

There are two types of the cell divisions called Mitosis and Meiosis. Mitosis is the division of the somatic cells and also serves as means of asexual reproduction. Meiosis is however involved in division of the germ line cells.



Stages of mitosis in onion root tip cells

CELL CYCLE

Cells go through a cyclic process in which they pass by various phases over time. These phases include a phase of rest, high metabolic activity and division. It is also defined as the sequence of events or a cyclic process between divisions of the cell. The cell cycle consists of the following phases:

- Interphase (consist of Gap 1 phase, Synthesis Phase, Gap 2 phase)
- M Phase (Mitosis or Division Phase)
- Resting or G0 Phase (Gap 0, read as Gap not)

Interphase

Interpahse consist of following phases. This is normally called as rest phase but actually it is a phase of high metabolic activity.

Gap 1

Cells increase in size in Gap 1. They produce materials required for DNA synthesis. The *G_1 checkpoint* control mechanism ensures that everything is ready for DNA synthesis.

Synthesis phase

DNA replication occurs during this phase. An S phase check point checks that whether the synthesis of DNA is correctly done or not. If everything is correct cell continue to the next phase and if not then cell wither have to die or correct its errors.s

Gap 2

During the gap between DNA synthesis and mitosis, the cell will continue to grow. Cell prepares all the materials required for division, e.g. microtubule proteins. *The G_2 checkpoint control mechanism ensures that everything is ready to enter the M (mitosis) phase and divide.*

Cell Division or M- Mitosis Phase

Cell growth stops at this stage and cellular energy is focused on the orderly division into two daughter cells. A checkpoint in the middle of mitosis (called *Metaphase Checkpoint*) ensures that the cell is ready to complete cell division.

Resting or G_0 (Gap 0)

A resting phase in which the cell has leaves the cycle and has stopped dividing. G0 starts from G1 and cell may sustain in G0 may be for years.

Mitosis

Mitosis is the cell division that results in two daughter cells which are like each other. Though, mitosis is a term that is used to describe the nuclear division.

Cell division consists of following phases:

Karyokineses – division of nucleus

- Divided into Prophase, Metaphase, Anaphase and Telophase

Cytokinesis – division of cell

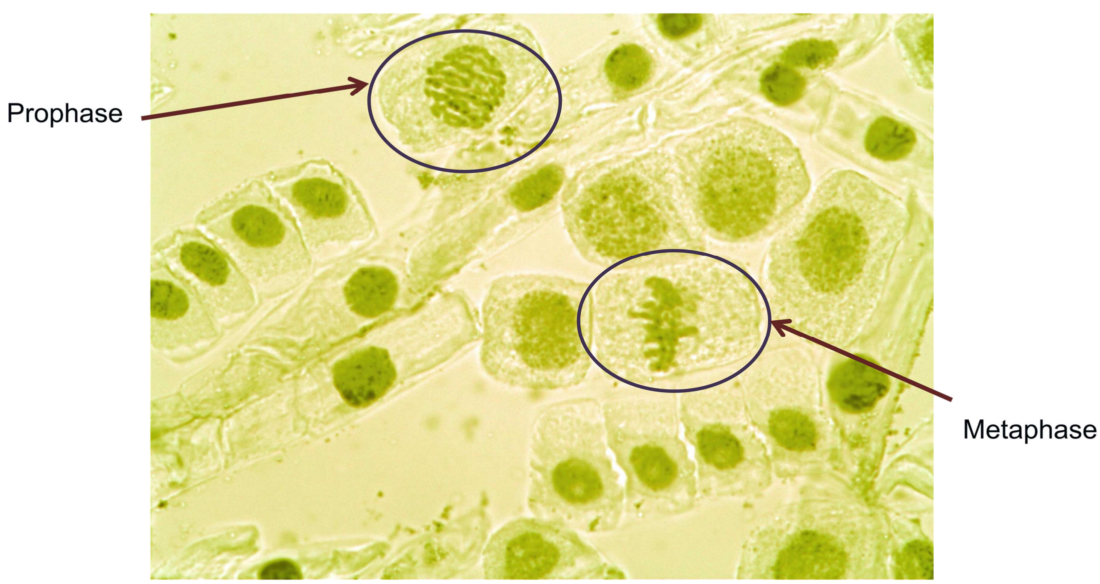
- Different in animal and plant cells

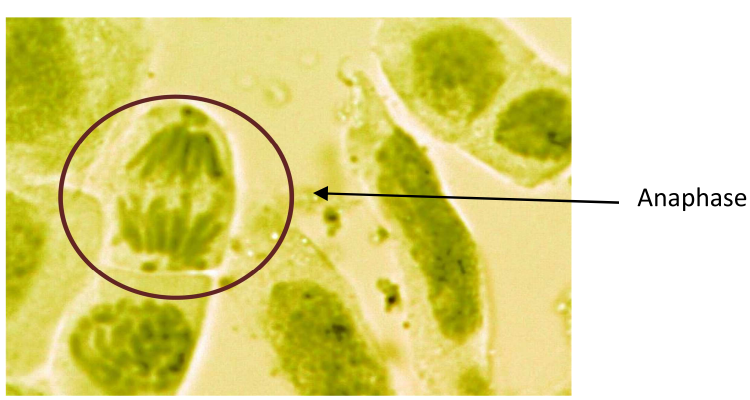
<u>Karyokinesis</u>

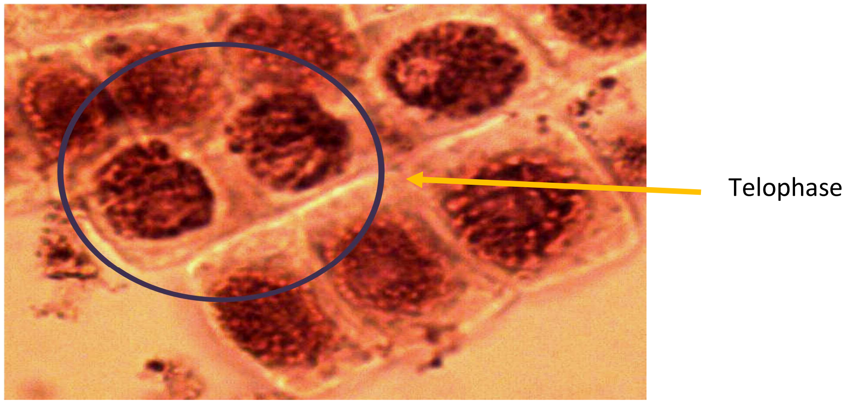
1. ***Prophase***
    - Chromatin material condenses and chromosomes becomes visible
    - Each chromosome is replicated (duplicated) and consist of two sister chromatids
    - At the end of the stage nuclear membrane disappear
    - Centrioles move towards poles of the cell and microtubules starts forming

2. **Metaphase**
   - Chromosomes arrange themselves at the equator
   - Kinetochores are attached to the microtubules
3. **Anaphase**
   - Chromosomes starts moving towards the poles
   - The sister chromatids separate from each other, so each sister chromatid move towards a pole
4. **Telophase**
   - Chromosomes (sister chromatids) reaches at the poles
   - Nuclear material starts ***de-condensing*** again
   - Nuclear membrane starts forming

The nuclear division is complete, next is the **Cytokinesis or division of the cell.**



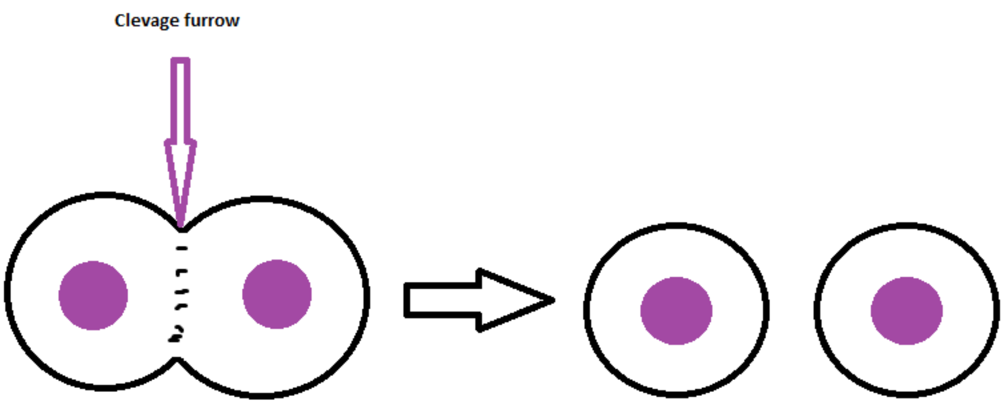




Cytokinesis

Cytokinesis in plant and animal cells is different from each other. In plant cells, a **cell plate** starts forming in the center of the cell and moves towards sides. The cell plate divides the cell into two cells. The cell plate consists of material produced by Golgi bodies in vesicles. This material contains the cell membrane and cell wall components.

Cytokinesis in animal cells occurs in a different way. In animal cells a cleavage furrow is formed by invagination of cell membrane. This process occur with the help of cytoskeleton (microfilaments particularly). The furrows divide the cell into 2 daughter cells.



Cleavage in animal cells

Importance of Mitosis

Mitosis is the cell division which helps in development and growth processes of the cells and hence the tissues. Development of new cells is a requirement in many parts of the body like epithelia usually keep growing. Replacement of cells and wound healing is another requirement of the organisms which also need new cells. Regeneration is a capability of some organisms. They came make their lost parts. This process also needs mitosis. Mitosis also serves as a means of asexual reproduction in various organisms.

Errors in Mitosis

Cells divide correctly most of the times because of many check points at various phases but sometimes it may go wrong. If it happens due to any reason the result is usually serious problems. Uncontrolled division of the cells may result into abnormal tissue growth and cancer.

Exercise

1. Draw various steps of mitosis.
2. Demonstrate the process of cytokinesis in animal cells.
3. Give any two examples of regeneration in animals.
4. Show the process of cytokinesis in plant cells with the help of a diagram.

Biology lecture # 4

CELL DIVISION – MEIOSIS

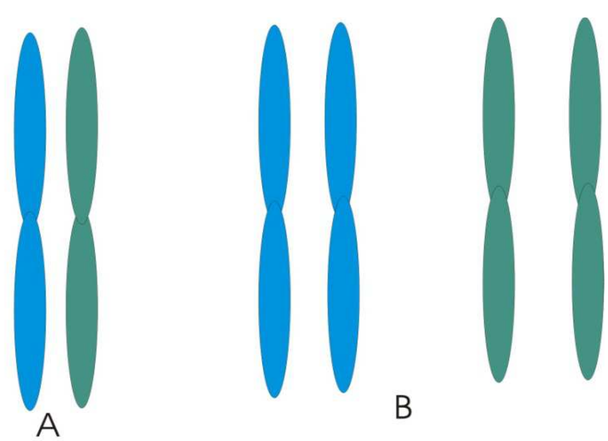
Reduction Division

MEIOSIS - CONSIST OF TWO DIVISIONS

Meiosis occur in germ line cells to make gametes, gametes are formed for sexual reproduction. Meiosis is also called reduction division because it results in four daughter cells which are haploid. We know that chromosomes occur in pairs e.g. human have 46 chromosomes in 23 pairs which is called a diploid number. The chromosomes in each pair are called homologous because these are like each other and are complementary to each other. Meiosis makes cells that have a half number of the chromosomes in each daughter cell called a haploid number also.

Diploidy and Polyploidy

The condition of having two sets of chromosomes is called diploidy (2N number of chromosomes). The gametes formed by meiosis, hence, are called haploid (N number of chromosomes). For example, in humans 2N is 46 and N is 23 in each gamete, when gametes combine in fertilization the chromosome number is retained to 2N. Some plants have more than two sets of chromosomes and are called polyploids. This characteristic is called polyploidy.



Homologous chromosomes (A. before replication; B. After replication

Phases of Meiosis

- Meiosis I
    - The reduction division
    - Chromosome number becomes half in each daughter cell (N)

- Cytokinesis I
- Meiosis II
    - Just like mitosis
    - Chromosome number remains same in daughter cells

- Cytokinesis II

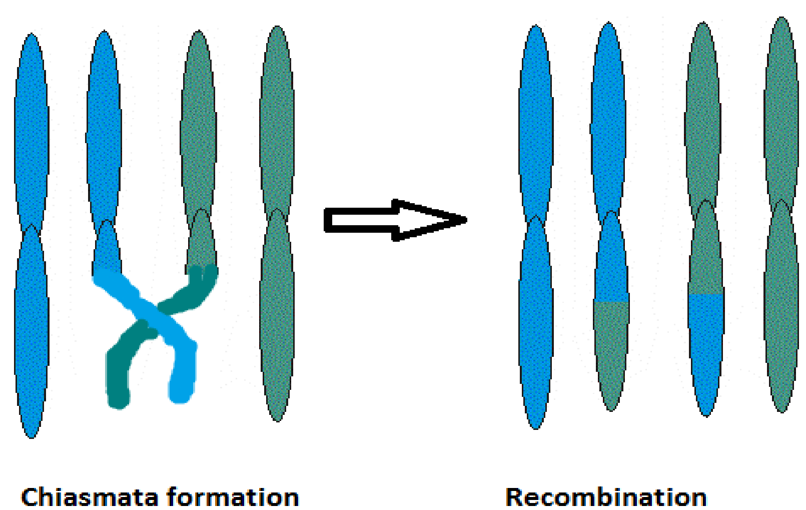
Meiosis I

- **Meiosis I consist of following phases:**
    - Prophase I
    - Metaphase I
    - Anaphase I
    - Telophase I

Stages of Meiosis I

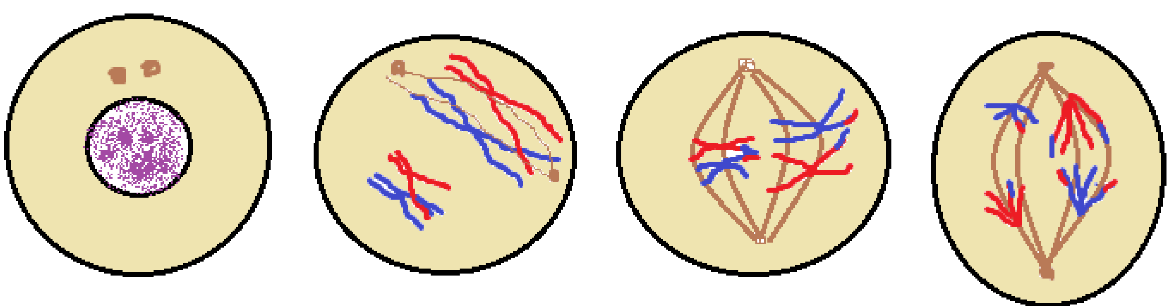
- ***Prophase I*** is a long phase in meiosis. It consist of following stages:

    - It is marked by the pairing of homologous chromosomes (synapses) and recombination (exchange of the parts of chromosomes.
    - Paired chromosomes are called **Bivalents or Tetrads.**



Homologous chromosomes carry out recombination during meiosis.

- **Metaphase I**
    - Chromosomes attach to the spindle fibers by kinetochore, one kinetochore per a chromosome and not per chromatid.
    - One homologue on each side so there is a 50-50 chance to get each parents chromosome.
- **Anaphase I**
    - The chromosomes move towards the poles.
    - A homologue, consist of two chromatids moves and sister chromatids do not separate.
    - The result is half number of chromosomes towards each pole.
- **Telophase I and Cytokinesis**
    - Chromosomes reach at poles, half on each side.
    - Cell divides and then starts meiosis II.



Chaismata formation

Prophase I

Metaphase I

Anaphase I

Events of Meiosis II

- Karyokinesis
    - Prophase II
    - Metaphase II
    - Anaphase II
    - Telophase II
- Cytokinesis
    - Each cell divides into two cells.

At the end of meiosis each cell divides into **4 haploid cells.**

This division is different in males and females.

In females, after first meiotic division (meiosis I), cytoplasm is unequally distributed and one large and other small cell are produced. The small cell is called a polar body. Then both of these cells carry out meiosis II. Polar body divides into 2 polar bodies. The large cell however is divided into one ovum (large) and another polar body. So that meiosis results into 1 ovum and 3 polar bodies.

In males, both meiotic divisions results into equal sized cells called sperms.

Comparison of Mitosis and Meiosis

Mitosis	Meiosis
• Cell divides into 2 daughter cells • Alike in males and females • Chromosome number remains equal (2N) in daughter cells	• One cell divides into 4 daughter cells • Different in males and females • Chromosome number becomes half (N) in daughter cells

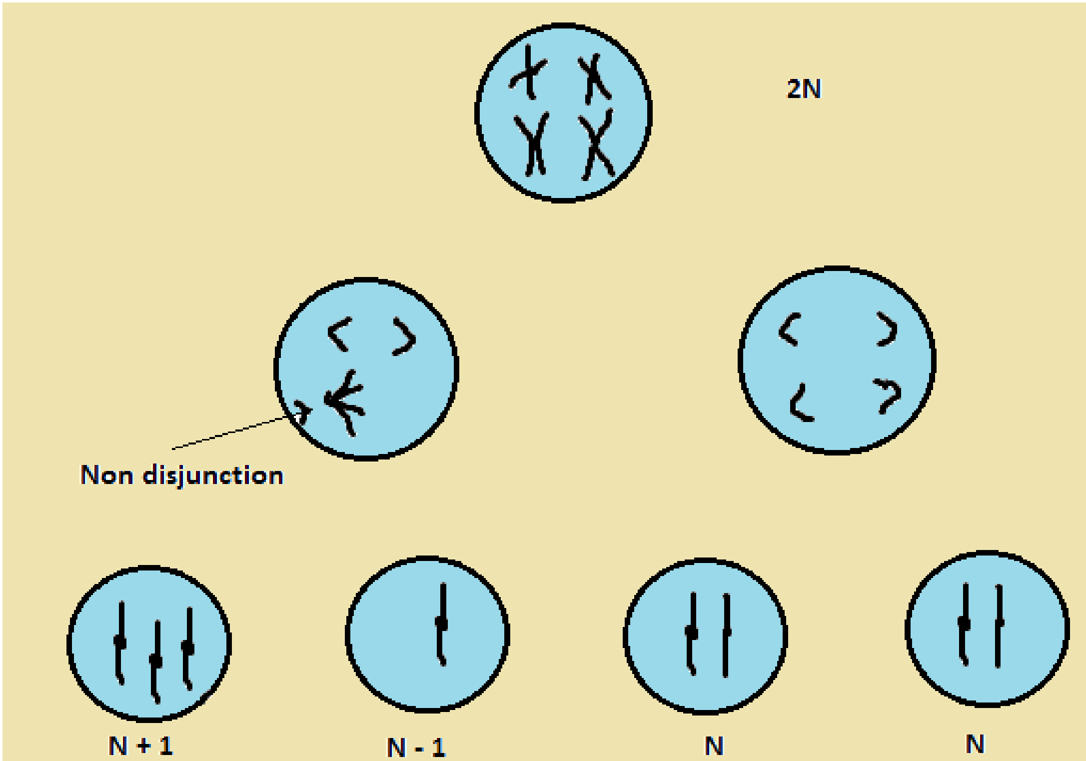
Importance of Meiosis

Major advantage of meiosis is the genetic variations by recombination (crossing over). During prophase I of the meiosis crossing over takes place which result in genetic recombination. When gametes combine to make a zygote, more variations arise. This variation assures new combinations resulting in increase in adaptability of the organism.

Errors in Meiosis

Meiosis is a well regulated process but sometimes errors may arise which may lead to mostly serious disorders. The common cause of disorders in non-disjunction of the homologous pairs of chromosome abnormally. This may results into unequally distributed chromosomes in the gametes and when these fertilize, they give rise to individuals with disorders.

For example, in Down's syndrome the affected individual have 3 homologues in the 21^{st} pair of chromosomes.



Non-disjunction results into abnormal gametes, e.g., in above diagram N and N are normal and N +1 or N -1 are abnormal gemetes

Twins

There are two types of twins.

- ***Fraternal twins***
    - These are produced by separate eggs (also called dizygotic twins)/ These are produced if two eggs are released and fertilized.
    - These are genetically different from each other and may be both males, females or both male and female.

- ***Identical twins***
    - These are produced by division in the same egg (also called monozygotic twins). These are produced by division in the zygote.
    - These are genetically same / identical and have same characteristics. Both of these are either males or females.

Environment and twins

Environment may affect even the identical twins. Identical twins may also have different characteristics if they are brought up in different environments. We know that the genes interact with environment to produce various characteristics. This characteristic also affects the twins.

Exercise

1. Draw various steps of meiosis I.
2. Demonstrate difference between the meiosis in females and males.
3. What are the effects of non-disjunction? Describe with the help of a diagram.

Biology lecture # 5

Chromosomes, DNA and Genes

Heredity Information Flow

Reproducing itself is a property of life. Transferring characteristics to next generation is a property of living organisms. Heredity information flow in living organisms is carried out by the genes. The "Chromosome theory of heredity" states that the genes are present on chromosomes and are responsible for the transfer of characteristics from generation to generation. Genes are present in the form of DNA molecules, organized in a structure called chromosome (chromatin material).

Chromatin - the Genetic Material

Genetic material is present in the nucleus of the cell in eukaryotes and in the nucleoid region in prokaryotes. These are called chromatin material. Chromatin material is not visible during interphase (non-dividing state) of the cell. These become visible during cell division due to condensation of chromosomes.

Functions of Genetic Material

There are some important properties of genetic material, which are following:

- It replicates itself.
- It regulates the growth and development of the organism.
- It allows the organism to adapt to the environmental changes.

Chromosomes - DNA – Genes

Chromosomes consist of DNA molecule associated with proteins. In chromosomes, DNA is wrapped around proteins. Few of these proteins are called histones and few others. DNA is associated with histone and non-histone proteins in a chromosome.

Introduction of DNA and Gene

DNA is a macromolecule (large molecule) organized in structure chromosome. In prokaryotes DNA is a circular molecule. In eukaryotes it is a long linear molecule. Mitochondria and chloroplast also have their own circular DNA molecules.

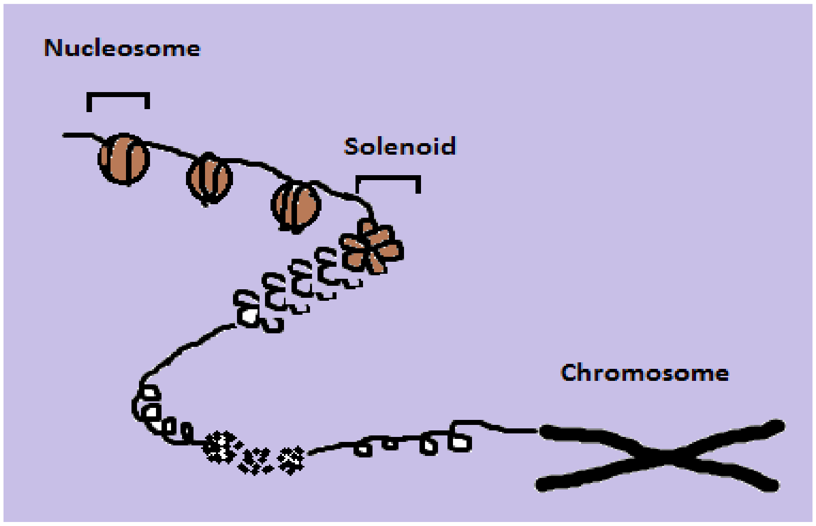
Gene is a length of DNA that codes for a peptide or protein. So that gene is a part or length of DNA.

Condensation of Genetic Material

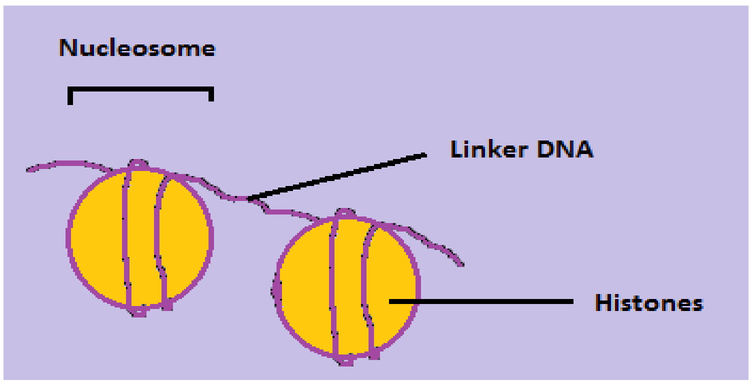
Chromatin material condenses during prophase of mitosis in the form of chromosomes. Chemical analysis shows that chromosome consist of DNA and proteins. DNA is a long molecule about 2nm thick running continuously within each chromosome. Chemical analysis shows that DNA is acidic in nature.

The Structure of Chromosomes

Chromosome consists of a DNA molecule wound around proteins. DNA in human cell (all chromosomes) is about 6 feet long, packed in a microscopic nucleus of a cell. In one human chromosome, it is 1.7-8.5 cm long. How is this possible? The answer is “coiling” and “super-coiling”. The chromosome consists of highly condensed structure. If we can open this like a thread, then the long thread will appear like a flower like structure called solenoid which consists of many smaller units. These small units are called “nucleosomes”. A nucleosome is a length of DNA coiled around a set of proteins. The DNA coils around histones twice, which is up to 200 base pairs long. Two nucleosomes are connected to each other by a length of DNA, which is called “linker DNA” (up to 80 base pairs long).



Chromosome coiling and nucleosome



Two nucleosomes

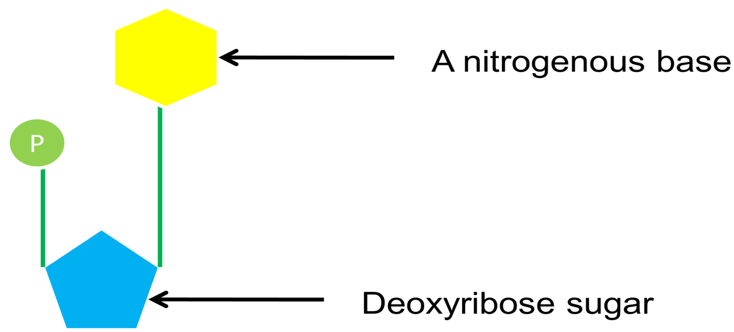
Chemical Composition of DNA

DNA is a complex macromolecule (large molecule). DNA stands for Deoxyribose Nucleic Acid. The smallest unit of DNA is called a "nucleotide"; nucleotides join to make polynucleotide. We can say that DNA consists of nucleotides joined together.

Nucleotides

Each nucleotide consists of:

1. Deoxyribose sugar
2. Phosphate group
3. Nitrogenous base



Structure of a nucleotide

There are four nucleotides based upon four different nitrogenous bases attached to them. Nitrogenous bases are of two types: purines and pyrimidine. Purines include two bases Adenine and Guanine which have a double ringed structure. Pyrimidine bases include the other ones called Thymine and Cytosine that have single ringed structure.

Mechanism of Gene Action

Genes express themselves by making proteins. Making the proteins by DNA occur by two processes called transcription and translation. **Transcription** is formation of a form of RNA from DNA called messenger RNA (mRNA). mRNA is formed inside the nucleus in eukaryotes and in nucleoid region in prokaryotes. The next process is **translation**, which is formation of a protein or peptide by mRNA with the help of another organelle called ribosome.

Replication is another function of DNA. It is doubling of DNA molecule to make two copies of itself. Replication occurs before cell division to make copies of DNA for the daughter cells.

Genetic code is a term used for the parts of DNA that code for proteins. A codon is a 3 nucleotides code for an amino acid, i.e., codon is a 3 nucleotide set of DNA molecule that codes for a protein.

Transcription and Translation

- Transcription = DNA $\longrightarrow$ mRNA
- Translation = mRNA $\longrightarrow$ Protein
- *The following scheme is called the central dogma of molecular biology / genetics*

DNA $\longrightarrow$ RNA $\longrightarrow$ Protein

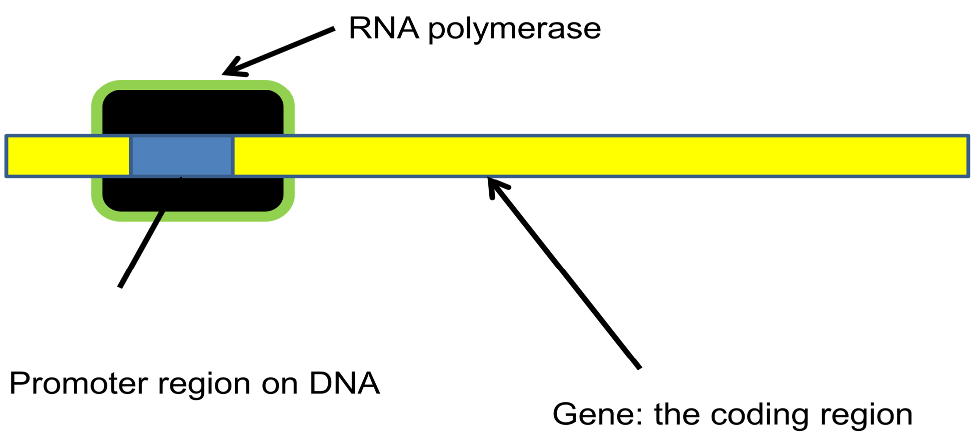
Transcription

- DNA $\longrightarrow$ mRNA

The process of transcription involves an enzyme called RNA polymerase. One strand of DNA act as the template strand which is actually coded into the mRNA.

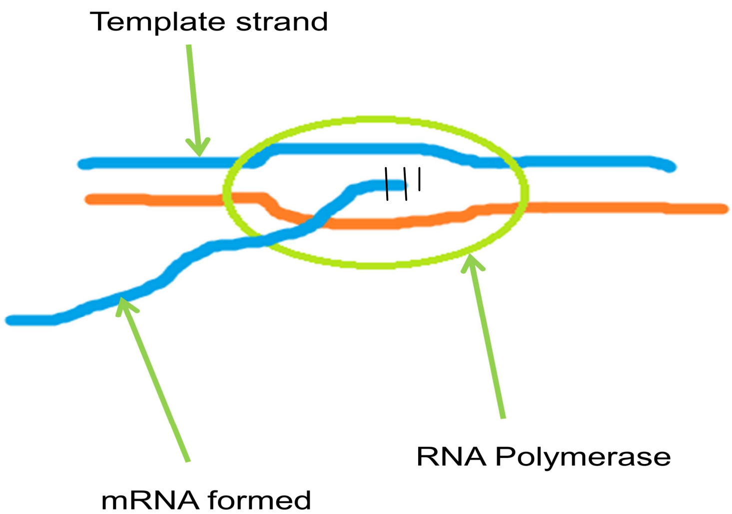
- ***Steps of transcription***

    - RNA polymerase identifies and attaches to a region called promoter on the DNA *upstream* the gene.
    - RNA polymerase open the double helix chain which results in the formation of transcription bubble.



Transcription Process

- RNA polymerase moves on the gene, the helix unwinds and make a complementary strand of RNA. This strand of mRNA protrudes out of transcription bubble.
- At end of the gene there is a stop sequence. Usually it is a series of GC base pairs followed by a series of AT base pairs.
- These sequences make a hair pin loop like structure which stops RNA polymerase from transcribing.
- Thymine is coded as uracil in mRNA.

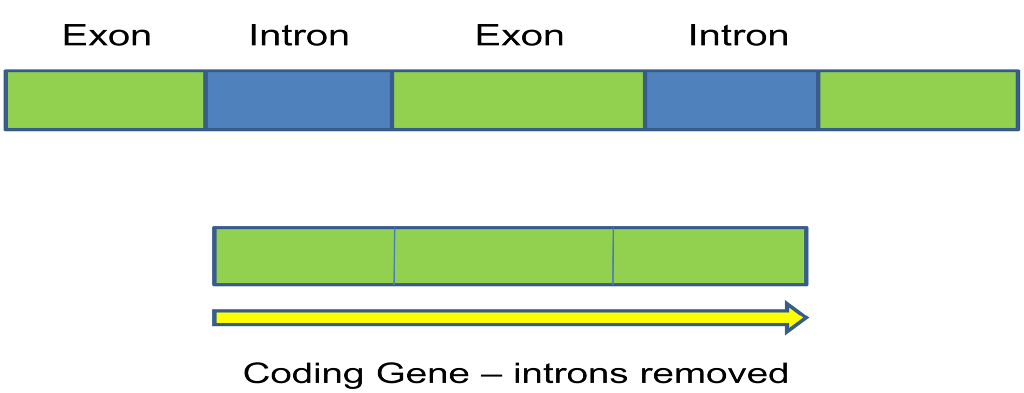


Transcription in Prokaryotes and Eukaryotes

In prokaryotes, the mRNA directly moves into cytoplasm and its translation starts because there is no nuclear membrane, nucleoid region is continuous with cytoplasm. In eukaryotes, mRNA formed moves out of nucleus through nuclear pores and then it is translated in the cytoplasm with the help of ribosomes.

Modification of mRNA in eukaryotes

mRNA in eukaryotes has to travel from nucleus to cytoplasm, to protect it from the action of nucleases (the DNA cutting enzymes) and proteases (protein cutting enzymes), it is modified. On its 5' end a cap of 7 methyl GTP is added; while on the 3' end a poly A tail is added. Introns are also removed. Introns are DNA sequences in the eukaryotes which are non coding and should be removed from the mRNA. The coding regions are called exons.



mRNA in eukaryotes have regions – exons and introns

Translation

- mRNA ------- Protein

The process of translation consists of three major steps: initiation, elongation, and termination.

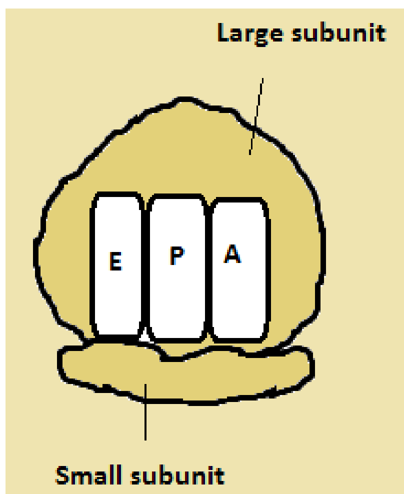
Steps of Transcription

- In prokaryotes, translation starts while transcription is going on because there is no barrier between nucleoid and cytoplasm.
- In eukaryote, first introns are removed.

Process of Translation

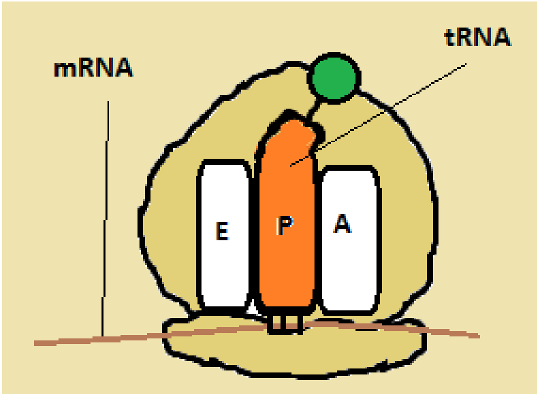
Initiation:

- The mRNA binds to the small unit of ribosome.
- The large ribosomal subunit has 3 binding sites called E (Exit), P (Peptidyl), and A (Aminocyl).
- When the first codon (triplet code) is aligned at the P site then the large ribosomal subunit attaches to the small subunit.



A ribosome

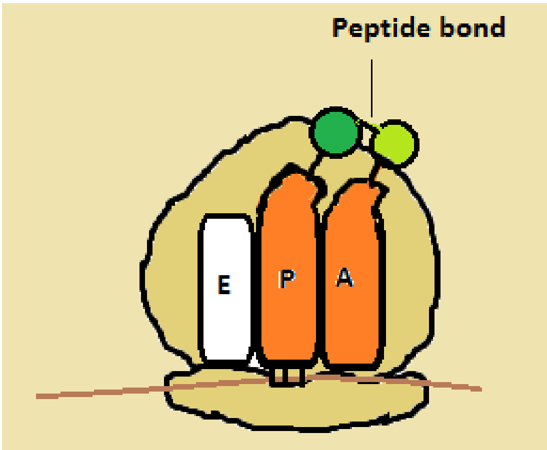
- A tRNA carrying the amino acid methionine attaches to the start codon (AUG) on the messenger RNA.



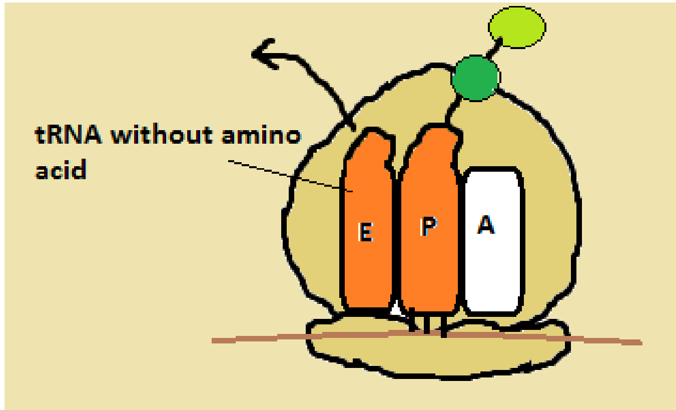
A tRNA with an amino acid on the P site

Elongation:

- A tRNA with its amino acid attaches to the A binding site.
- Peptide bond formation occurs between the methionine and the amino acid carried at the A binding site.
- Ribosome moves in the 3' direction down the messenger RNA by three bases, shifting the tRNA and polypeptide chain to the P Binding site.
- The A binding site is open and a vacant tRNA (without amino acid) is in the E binding site.
- Now, the next tRNA brings another amino acid and bind to A site.
- A peptide bond is formed between the second and this new (thirs) amino acid.
- Ribosome moves in 3’ direction and the vacant tRNA is released from the E site.
- This process continues until a stop codon arrives on mRNA.
- A Releasing factor comes and binds to the A site in place of stop codon. The polypeptide chain separates from tRNA and ribosome. Then ribosomal units disassemble again. mRNA molecule also released which has been coded.



Peptide bond is formed between the amino acids brought by tRNAs present on P and A sites.



Growing polypeptide is present on P site and empty amino acid on E site. New tRNA with an amino acid will come and attach on A site.

Exercise

1. Explain the process of transcription with the help of diagram.
2. Explain the process of translation with the help of diagrams.
3. Differentiate between the transcription and translation processes of prokaryotes and eukaryotes.

Biology lecture # 6

DIGESTIVE SYSTEM

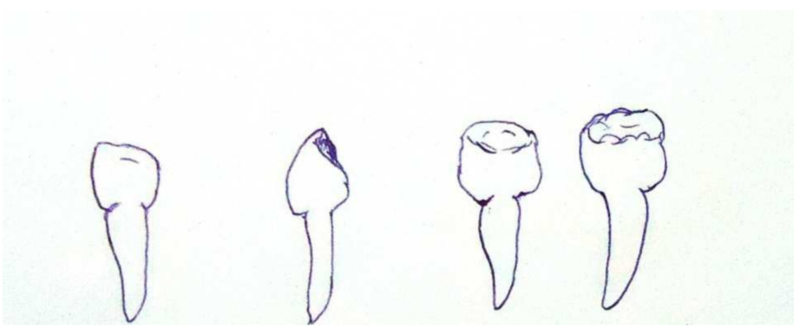
Nutrition

Acquiring energy from environment is one essential property of life. Plants acquire energy from sunlight and prepare their food. We call them producers. Animals, however, acquire energy from either plants or other animals or organic materials. We call the consumers or decomposers.

Common Modes of Nutrition in Animals

- Herbivores
    - Plant eaters, e.g. goat
- Carnivores
    - Flesh, meat eaters, e.g. lion
- Omnivores
    - Mixed food, e.g., bear, crows
- Detritivores
    - Dead organic matter, e.g. earthworms

Dentition is according to the mode of nutrition



Dentition in animals; incisor, canine, premolar and molar teeth

Mouth Parts also are also according to the mode of nutrition

Animals have different types of tongues according to their mode of nutrition. For example, frogs have forked, inverted and sticky tongue to catch insects. Tongue of chameleon is also sticky and very long. Beaks of birds make another example. Birds have a variety of beaks; long, small, curves and many other. All of these are present in birds according to their mode of nutrition for example parrots have long curves beak for cutting and breaking nuts. Pelican have a very long and wide for catching fish from water. Snouts in mammals make another example. Mammals have different snouts according to their food.

A parrot: observe the long and curved beak.

Nutrition, Ingestion, Digestion, Absorption, Assimilation, Elimination

- After acquiring food and ingestion, animals have to digest it.
- Digestion is actually, breaking down food into small ingredients. For example, carbohydrates to glucose.
- Absorption is movement of food into blood after digestion.
- Assimilation is utilizing those broken small molecules for getting energy for organisms functions.
- Elimination is removal of the undigested matter from the body.

Nutrition and Digestion in Human beings

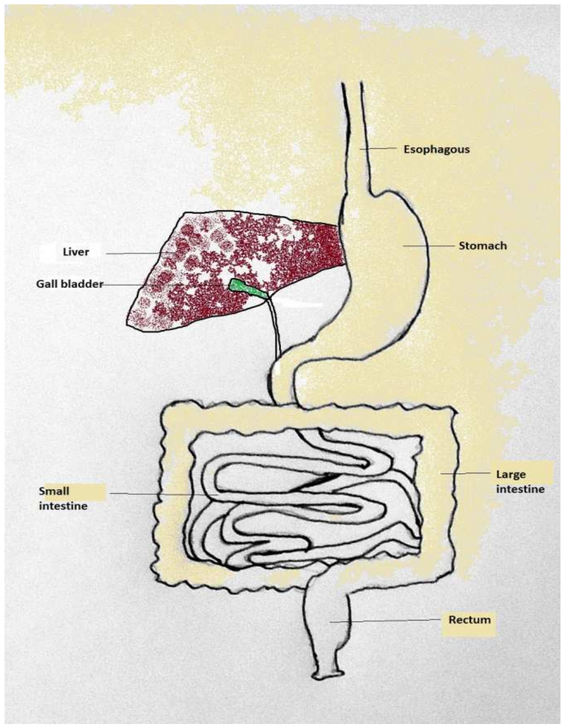
Humans are omnivores, i.e., we eat plants (vegetables) and meat (chicken, beef). Digestive system of humans hence is adapted accordingly.

Basic Components of Human Digestive System

- Alimentary canal
  - From mouth to anus
- Alimentary canal in humans consist of following parts:

- Oral cavity
- Pharynx
- Esophagus
- Stomach
- Intestine (small and large)
  Rectum and anus

- Accessory glands
  - Liver, Pancreas



Digestive system in human beings

Sensing the Food

We look at the food and smell when we get a food. These are called sensory qualities of food. This is the first part of food selection and foods which are improper are rejected. If the food looks inappropriate or it smells bad, it is rejected. This is a human adaptation just like other animals.

Alimentary Canal - From mouth to anus

The Oral Cavity

Food selection is one function of the oral cavity. Oral cavity has **tongue** with taste buds. Food selection takes place by taste buds if food tastes bad it is rejected. Tongue converts the ground food mass to a bolus. Grinding the food is the other important function of oral cavity.

Oral cavity contains teeth for this purpose. **Dentition** is according the food types. Teeth are of four types; incisors, canine, premolars and molars. Human have all four types of teeth; few animals have others. **Lubrication** and **chemical digestion** is another function of the oral cavity. Salivary glands secrete saliva which contains amylase for digestion of starch. It also contains mucous for lubrication of food.

Pharynx

Pharynx is a part of digestive system. It lies just behind the mouth and nasal cavity and above the esophagous and larynx. Food bolus passes through pharynx to enter the esophagus. Pharynx helps swallowing by closing the trachea and nasal cavity pathways.

Esophagus

It is a long tube starts from pharynx and enters stomach. From pharynx, food enters esophagus. In esophagus, food moves down to stomach by a series of muscular contractions called “peristalsis”. Bolus moves down by alternate contraction and relaxation of muscles of esophagus. Sometimes an antiparistalsis occur, i.e., movement from stomach to mouth that result in vomiting.

Stomach

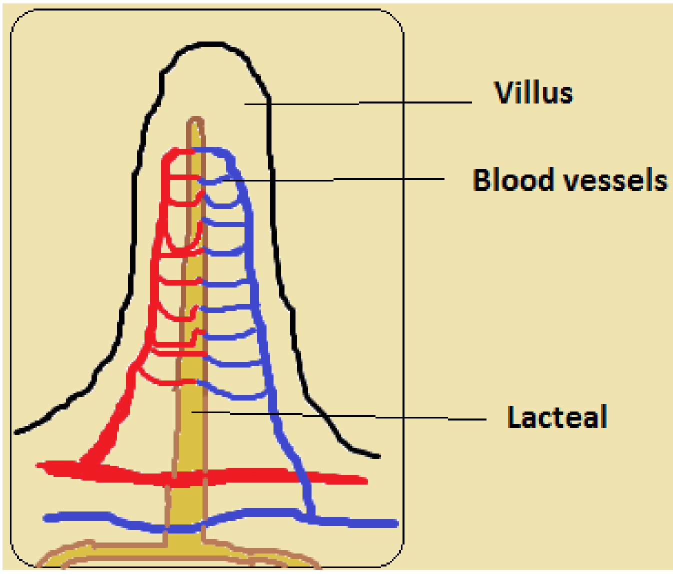
Stomach is mainly a storage organ. It also helps in digestion of proteins. Stomach has guarded openings on either side. There is a sphincter (group of muscles) which is pyloric sphincter that controls movement of food from stomach to intestine. The other sphincter is present where esophagus meets stomach. Gastric glands in stomach produces gastric juice, which contain mucus, hydrochloric acid and an enzyme called pepsinogen. Pepsinogen is converted into pepsin which is its activated form. Pepsin converts proteins to peptides. Protection of the stomach walls from the acid particularly is important, mucus secreted by the stomach walls cover the stomach lining to protect it from acidic damage.

Stomach is also designed to mix up the food with enzymes and acid. Churning movements of stomach walls thoroughly mixes the food with gastric juice. Churning converts food to chyme, small part of which enters the small intestine by pyloric sphincter.

Small Intestine

It consist of three parts; duodenum, jejunum and ilium. Duodenum (first 25 cm of intestine) is the first part where most of the digestion occurs. *Bile* enter here from liver and helps emulsification and digestion of lipids. *Pancreatic juice* from pancreas also enters here, which contains trypsin, pancreatic amaylase and lipase fordigestion of protein, carbohydrates and lipids. *Intestinal juice* is also released, which help in digestion of all foods.

Jejunum is the next 2.4 m of the small intestine; remaining digestion takes place here. Ilium is the last 3.5 m long part where absorption takes place. Its lumen is highly folded. It have extensions of the epithelium called villi and microvilli, which increases the surface area to a greater extent to increase absorption.



A single villus in smalle intestine

Large Intestine

Undigested food comes in the large intestine. It consists of various parts including caecum, colon, and rectum. Absorption of water from the undigested matter occurs in colon. Water is returned to blood vascular system. Remaining semi solid mass is called feces that are are stored in rectum, when rectum is full it give rise to a reflex for defecation and feces are excreted out.

Intestinal Motility is an important factor. If the motility in large intestine is increased then there is less water reabsorption and result is a situation called **diarrhea**. On the other hand if motility is decreased then **constipation** is the result which means that feces will have less than normal water.

Liver and Pancreas

Liver produces a secretion called bile which helps in fat digestion and emulsification. Bile is stored in gall bladder and is released by its contraction. Liver perform various functions called deamination, converting ammonia to urea, destroys old blood cells and manufactures fibrinogen, which is blood clotting factor.

Exercise

1. Diagrammatically show various parts of human digestive system.
2. How human beings find out the quality of foods?
3. List various functions of small intestine.
4. List various functions of liver and pancreas.

Biology lecture # 7

Transport System and Blood – the Circulatory Fluid

Why transport systems?

Organisms have to exchange materials with the environment. They also need to distribute nutrients, gases and metabolic products within their body.

Living organisms …

- acquire energy or food from the environment; they have to distribute energy and food within the body.
- need an intake of oxygen and removal of carbon dioxide from their bodies.
- need to remove toxic materials and waste products from their bodies.
- have to distribute hormones and other materials in the body.
- have to exchange materials with the environment

For all that, they require a Transport System.

Transport systems in organisms

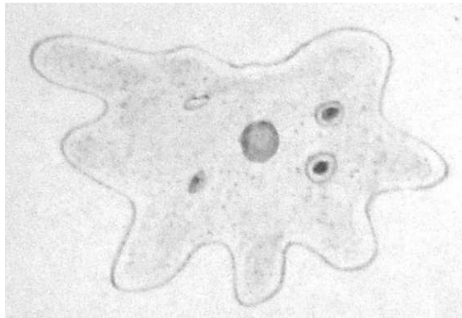
A transport system should fulfill the requirements of the organism for all of the above functions like nutrient distribution or gas exchange.

We take some examples here:

- Unicellular organisms
    - e.g. amoeba
- Simple multicellular organisms
    - Small organisms; e.g. sponges, hydra
- Plants and animals
    - Plants
    - Animals

Unicellular organisms

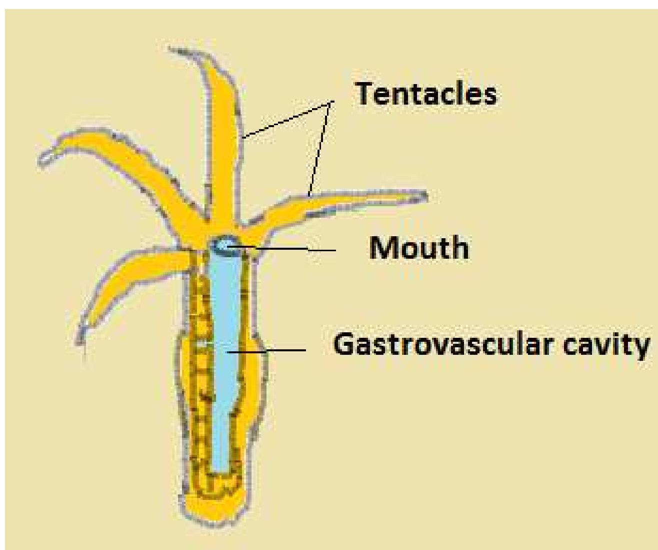
Unicellular organisms have a simple body, just one cell. Their requirements are also few. For example amoeba performs the transport via cytoplasmic streaming which is the movement of their cytoplasm and few organelles. Food vacuoles distribute the food in the body. Contractile vacuoles removes the water fro the body. Cytoskeleton helps in the movement of all the above parts.



Amoeba

Simple multicellular organisms

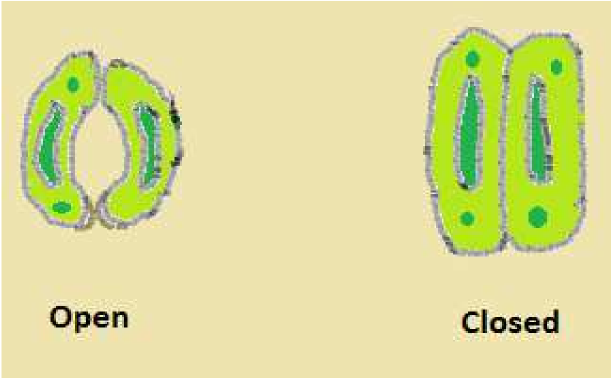
Simple multicellular organisms transport materials by simple methods. Like hydra have a mouth and a body cavity; water enters through mouth and transport of materials takes place in the body cavity. Body wall also exchange materials with the water outside as organism is aquatic. Hence, water act as a medium of transport. Few cells help in transport, which are present inside the body towards body cavity.



Hydra: transport system.

Transport in plants

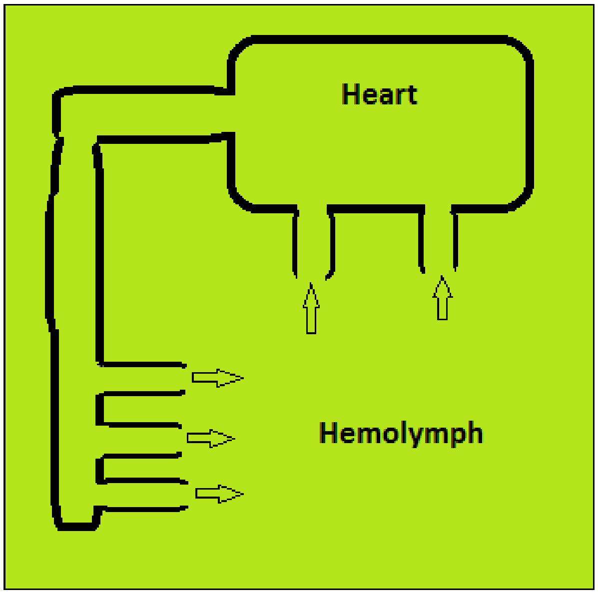
Transport in plants occurs by roots and conducting tissues called phloem and xylem. Roots absorb water and materials from soil. Plants remove water through a process of transpiration. The leave has guarded openings called stomata, which open and close to remove water.



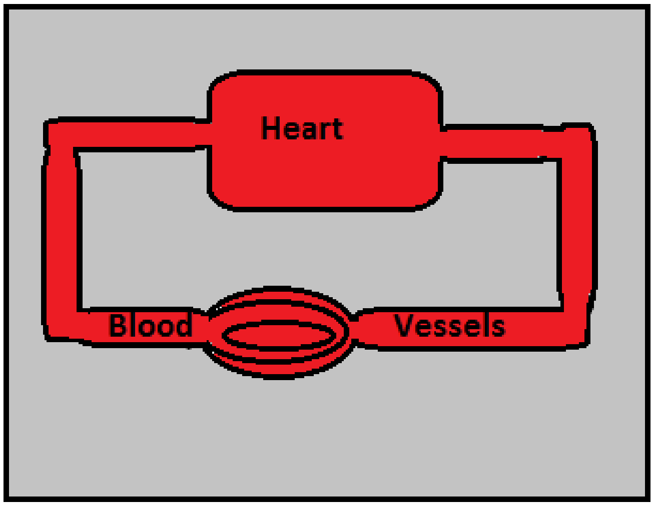
Stomata: opened and closed.

Transport in animals

Animals have a system called circulatory system for transport. There are two kinds of this system called an open circulatory system and closed circulatory system. In an **open circulatory system**, the circulatory fluid is freely moving in the body cavity bathing tissues and there is/are pumping heart/s but these only send blood to some vessels which are then connected to body cavity. In **closed circulatory system**, the blood never leaves vessels and heart and is always present inside the vessels.



Diagrammatic presentation of an open circulatory system. In this system circulatory fluid (e.g. Hemolymph moves into body cavity and from here to back to heart



Diagrammatic presentation of closed circulatory system. I this system, blood never leaves vessels

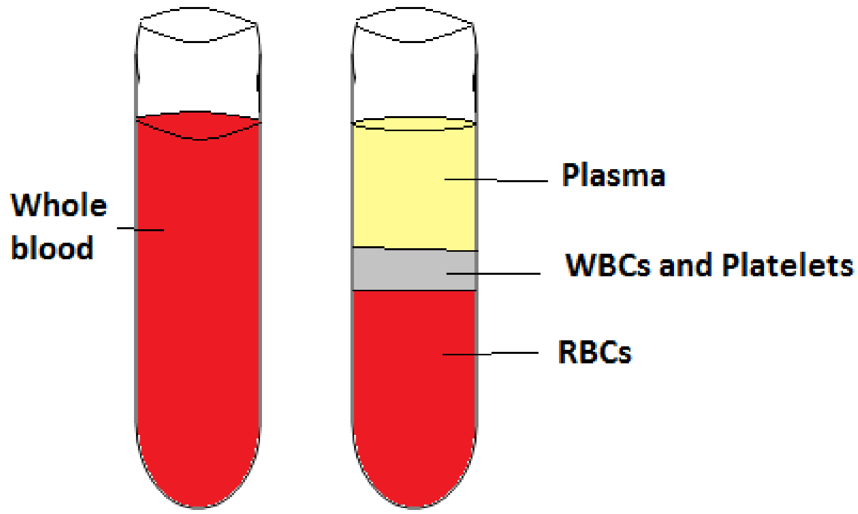
Basic components of human circulatory system

Blood is the circulatory fluid which is the medium for transport. Blood vessels are the tubular system for transport of blood within the body. Heart is the pumping organ that pumps the blood toward the body.

Composition of blood

Human blood consists of plasma (fluid) and cellular content (cells). Plasma is the fluid with dissolved and un-dissolved materials. It consists mainly of water, which have many inorganic and organic materials dissolved in it. Cellular content consist of Red Blood Cells (RBCs), White Blood Cells (WBCs) and Platelets. Red blood cells are also called erythrocytes and white blood cells are also called leukocytes. Plasma consists of 55% of the blood. Cells constitute 45% of the blood Average human body has about 5liters of blood.

Blood contents could be separated based upon their densities and weights by various methods including centrifugation and sedimentation.



Components of blood

Functions of the main components of blood

Blood plasma

Plasma consist of 55% of the blood, It consist of 92% water. 0.9% of it consists of salts – NaCl, Mg, Zn ions etc. The salts maintain the pH of the blood. Plasma has 7-9% part consist of proteins. Important proteins include antibodies, fibrinogen and albumin. Plasma also contains digested food, nitrogenous wastes, hormones, respiratory gases etc.

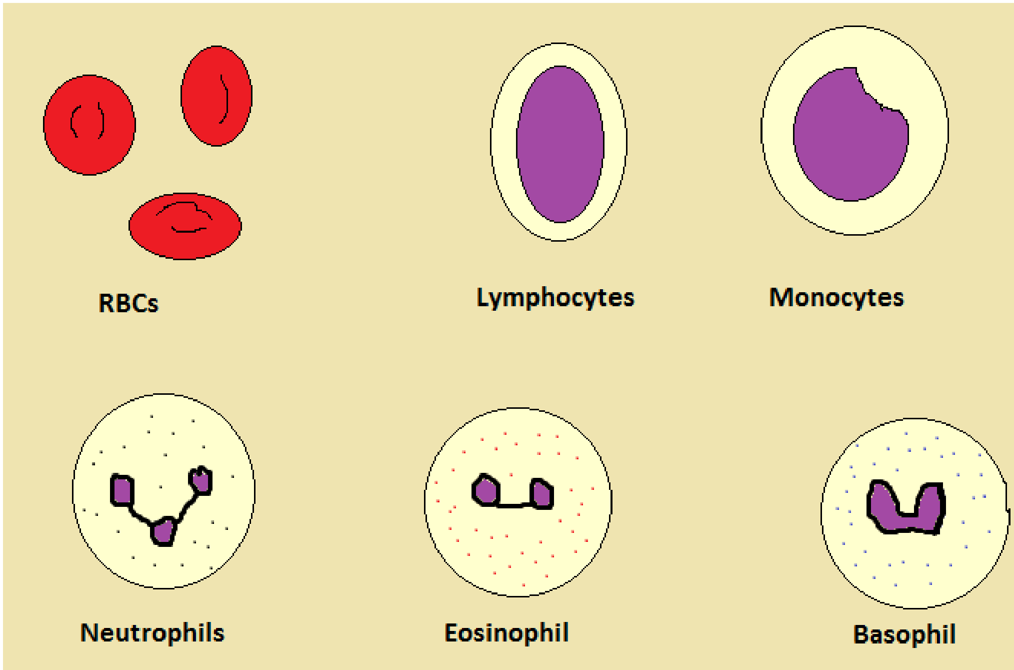
Blood cells and cell-like bodies

Cellular components of blood consist of erythrocytes, leucocytes, thrombocytes. Erythrocytes – Red Blood Cells carry oxygen with the help of a protein called haemoglobin. In men 5-5.5 million cells/mm^3 RBCs are present. This number is 4- 4.5 million/mm^3 in women. Men have usually larger bodies and more muscle mass, so that heir demand for oxygen is more than women.

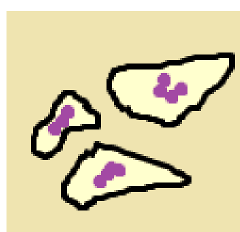
Leukocytes – White Blood Cells are categorized in to two kinds: *Agranulocytes* and *granulocytes.*

Agranulocytes are theose white blood cells which have nongranulated cytoplasm, these include monocytes and lymphocytes. Granulocytes are those WBCs, which have granulated cytoplasm. These include basophils, eosinophils and neutrophils. Platelets are the third type of cells or we can call these, cell like bodies. These are formed by fragmentation of a single cell called megakaryocyte.

Erythrocytes (RBCs) do not have a nucleus at maturity. That is why these look concave under microscope.



Blood cells include RBCs and WBCs (lymphocytes, monocytes, neutrophils, eosinophils, and basophils).



Platelets

Blood groups in human beings and blood transfusion

Blood cells have some specific protein present on their surfaces called antigens, which are meant for the identification of the blood cells. About 29 blood groups are identified. The most important blood group systems are, however, two named as **ABO** and **Rh blood group systems**. There are four main types of blood groups present in human beings according to ABO blood group system. These blood groups are based upon presence or absence of two antigens on surface of RBCs called antigen A and antigen B (Table 1). Other important blood group is based upon presence or absence of Rh antigens on the surface of RBCs. The people have Rh antigen on the surface of their RBCs are called Rh positive and those who do not have it are called Rh negative. ABO system works with the help of Rh system. So that we talk of the blood groups based upon ABO system with Rh positive or negative. For example, A +ive means that the person have an A blood type with Rh antigens present.

Table 1: Blood groups, antigens and antibodies

Blood Group	**Antigen A**	**Antigen B**	**Antibody A**	**Antibody B**
A	Present	Absent	Absent	Present
B	Absent	Present	Present	Absent
AB	Present	Present	Absent	Absent
O	Absent	Absent	Present	Present

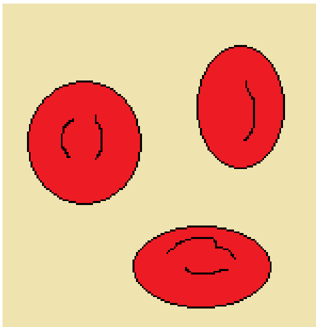
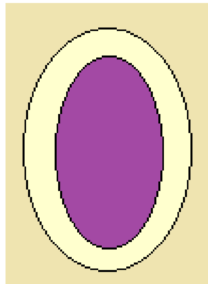
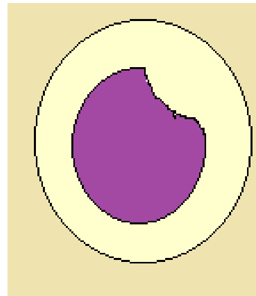
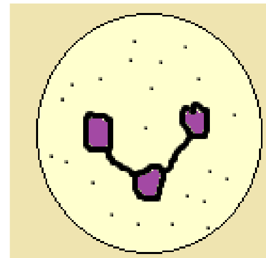
Blood transfusion

Blood transfusion is required in case of some diseases, surgery or in case of injuries. Blood groups of donor and recipient should match, otherwise could cause agglutination reactions leading to even death of the patient. Blood groups are matched using antigen antibody reactions. A blood group O -ive is called Universal donor because it has not antigens, hence, it cannot react with any of the antibodies in recipient’s blood. Universal acceptor is AB+ blood group which has all antigens.

Exercise

1. What are the ABO blood groups and how these are important in transfusion?
2. Describe various transportation systems in unicellular and small multicelluar organisms with the help of diagrams.
3. What are various components of blood and how can we separate them?
4. Describe important functions of white blood cells.
5. Identify the following:

Diagrams of blood cells

a. _____________________ b. _______________ c. _______________ d. _______________

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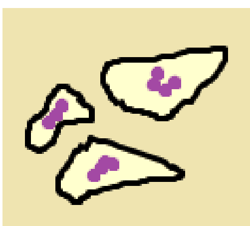 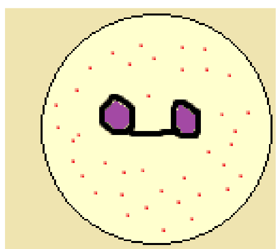 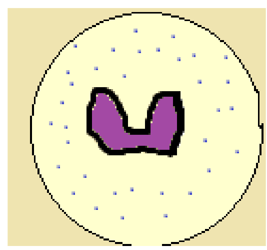

e. _____________________ f. _________________ g. _______________

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6. List various functions of red blood cells.

Biology lecture # 8

Circulatory System in Humans - Blood Vessels and Heart

Circulatory System in Humans

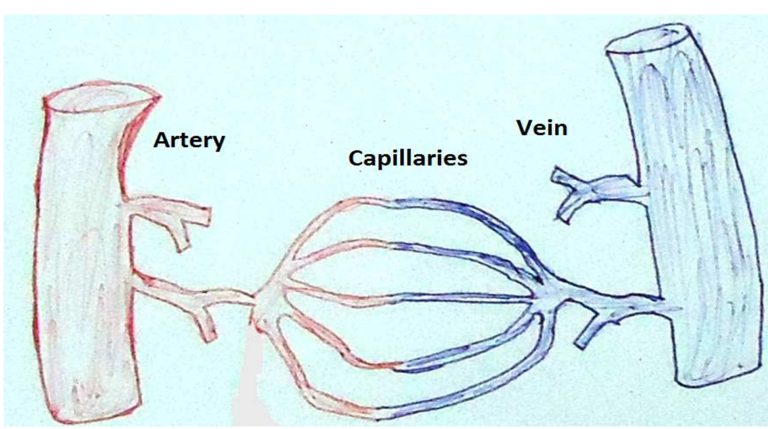
Circulatory system in humans consists of blood, vessels and heart. Blood is the circulatory fluid. We can call it a **liquid tissue**. Blood consist of plasma – the watery fluid and cells – the cellular content. **Blood** has been described in detail in last lecture. Here we talk about heart and blood vessels. **Heart** is a pumping organ and is highly muscular. Function of the heart is to pump blood with pressure towards lungs and body. **Vessels** are of three main types; arteries, veins and capillaries. Arteries carry blood from the heart to body. Veins return blood from body to heart. Capillaries connect arteries to veins. Function of the capillaries is the exchange of materials.

Structure and functions of blood vessels

Arteries and veins are elastic in their structure. These also have a layers of muscles. These consist of 3 layers:

- External layer - connective tissues layer
- Middle layer, consist of smooth muscles
- Inner layer, consist of endothelium

Lumen of both of these is meant for blood flow. Arteries have a lumen smaller in diameter and veins have large.



Artery, vein and capillaries

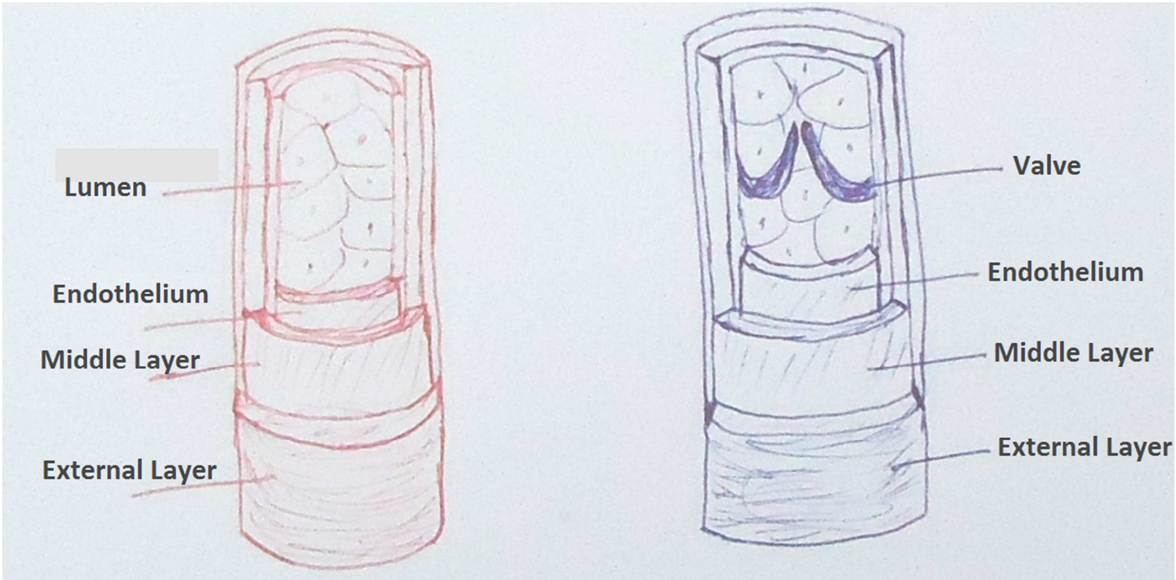
Comparison of Arteries, Veins and Capillaries

	Arteries	**Veins**	**Capillaries**
Carries blood	From heart to body; one exception pulmonary artery	From body to heart; one exception is pulmonary vein	From arteries to tissues to veins
Stat of blood	Oxygenated	Deoxygenated	Oxygenated to deoxygenated
Layers	3	3	1
Walls	Thick	Thin in comparison to arteries	Very thin; one cell thick only called endothelium
Pressure	High	Low	Medium
Valves	Absent	Present	Absent

Arteries carry blood from heart to body. These face maximum pressure. Their function is to distribute blood to all the body tissues. Blood is pumped in the arteries by the heart with very high pressure that is why arteries are thick walled to withstand high pressure.

Veins have to collect blood from the body and return it to the heart. Veins face less pressure, pressure almost negligible in major veins. Blood flow in major veins against gravitational pull and with low pressure so that veins have valves that prevent backflow of blood. In many parts of the body like arms and legs there are muscles that contract and relax to move the blood towards heart.

Capillaries have to exchange materials with tissues; these originate from arteries and pass from tissues then joins to make veins. Capillaries have to carry out exchange of materials with the tissues that is why their walls are just one celled thick. Capillaries when enters tissues makes branches, where they branch groups of muscles are present which may open or close to increase or decrease the blood flow towards tissues.



Comparison of an artery and a vein

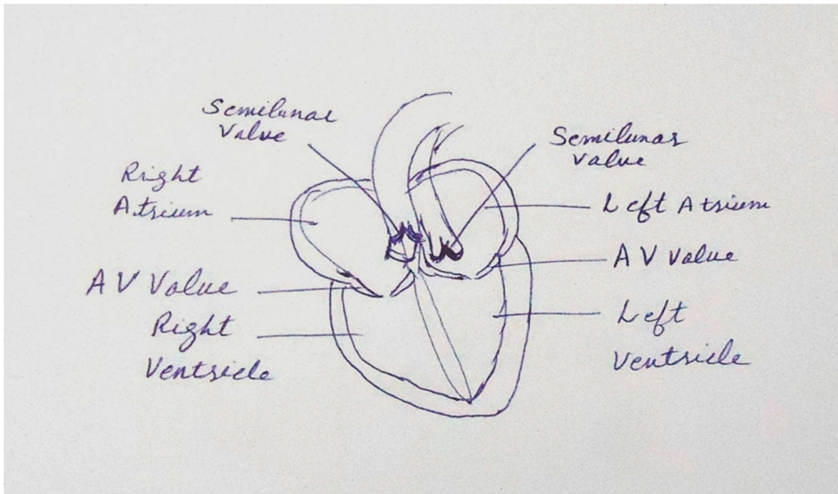
Main arteries and veins in human arterial and venous systems

- head, shoulders, arms
- other body organs like kidneys, gonads, liver etc.

Structure of human heart

Heart in human beings is a muscular pump to push blood towards body and lungs. Heart in humans is of the size of a clenched fist. Heart consists of four chambers including 2 atria and 2 ventricles. Atria receive blood from body and lungs. Ventricles push blood from heart to body and lungs. These chambers (atria and ventricles) are connected to each other. At their junction valves are present, which are responsible to prevent backflow of blood.

Left side of the heart, particularly ventricle is stronger because it has to push blood to the whole body in comparison to right side.



Structure of human heart

Double pumping action of heart and role of valves

Deoxygenated blood from body enters the heart through major veins (vena cava) to right atrium. When right atrium contract, blood enters the right ventricle. There is a valve called **tricuspid valve** that prevents backflow of blood. On the other side, oxygenated blood from lungs enters the left atrium and when left atrium contract it enters the left ventricle. At the junction of left atrium and ventricle another valve is present called **bicuspid valve** that prevents backflow of blood. **Tricuspid** and **bicuspid valves** are collectively called **atrioventricular vales**.

In fact, both atria are filled at the same time and also contract at the same time to push blood in the ventricles. Both ventricles also contract at the same time to push blood toward body (left one) and lungs (right side). **Right ventricle** pushes blood in the **pulmonary artery** towards lungs. At this junction a valve is present called **pulmonary valve** that prevent backflow of blood from pulmonary arteries to right ventricle. **Left ventricle** pushes blood towards **aorta**, which is the main artery distributing blood the body. This junction is also guarded by a valve called **aortic valve**, which prevents backflow of heart from the aorta to left ventricle. **Pulmonary** and aortic **valves** are collectively called as **semilunar valves**.

Self-excitatory system of the heart

Heart has self-excitatory system. Heart has s group of muscles called **sinoatrial node** which produces impulse (electrical activity) that spread in the heart to contract its various chambers systematically. Impulse spread toward atria first and causes the atria to contract. Then it enters another node called **atrioventricular node** where its magnitude is increased and then it enters the ventricles and the ventricles contract. The self-excitatory group of muscles of the heart is called **pace maker**.

Cardiac Cycle

Cardiac cycle is the time period from when the blood enters the heart to the time when blood is pushed by the heart. We can also say that it is the time period from artial and ventricular diastole to ventricular systole.

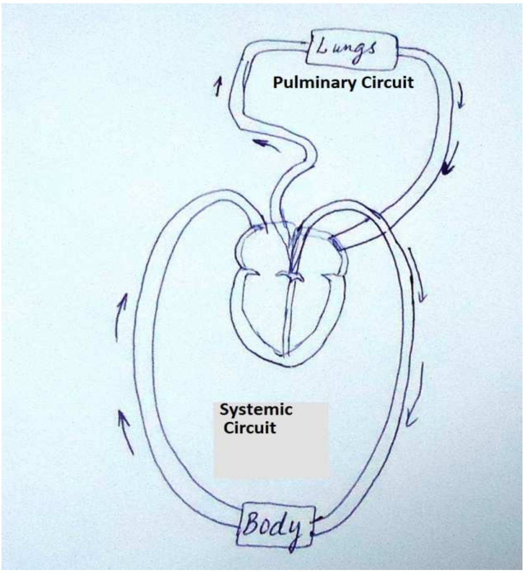
Cardiac cycle consists of following steps:

1. Both atria and ventricles are relaxed. This is the time when both atria are filled with blood from body and lungs. All heart muscles are relaxed, which means that these are at diastole.
2. Then both atria contract and blood is pushed into ventricles. This is called atrial systole. At this time, both AV valves are open and both semilunar valves are closed.
3. Then the ventricles contract and push blood into aorta and pulmonary artery. This is called ventricular systole. With this, a **cardiac cycle** is complete.
4. Then again, both atria and ventricles are relaxed, i.e., come back to the initial state.

Double Circulation

Human circulatory system is called a double circulatory system because heart receives and sends blood from and to lungs (**pulmonary circuit**) and body (**systemic circuit**). Look at the diagram below for a detailed view.

- Systemic circulation
    - From heart to body and vice versa
    - Head, shoulders and arms
    - Lower body organs
- Pulmonary circulation
    - From heart to lungs and vice versa



Double circulation in humans

Exercise

1. Draw the structural diagram of human heart.
2. Differentiate between arteries and veins using diagrams.
3. Draw the structure of a capillary. Also describe the functions of capillaries.
4. Explain the significance of valves in preventing backflow of blood in heart.

Biology lecture # 9

Respiratory System

Lecture Outline

Why respiration?

- Living organisms needs energy for their activities.
- Energy is extracted by complex metabolic processes from food or photosynthesis.
- Respiration is the process of exchange of gases to produce energy in biological form.

What is respiration?

Respiration consist of processes involves exchange of gases in living organisms or metabolic reaction to produce energy. Respiration is one of the most important metabolic activities. It is of two types:

- **Organismic respiration** consists of breathing or ventilation, i.e., inhalation and exhalation movements and gas exchange.
- **Cellular respiration** consist of metabolic reactions to produce energy by utilization of oxygen, production of carbon dioxide and extracting and conserving energy from food molecules in biological form, such as ATP.

Cellular respiration

Cellular respiration is of two types:

- Aerobic, in which oxygen is utilized to produce energy.
    - Example is electron transport chain in mitochondria.

- Anaerobic, in which oxygen is not involved but energy is produced using other molecules.
    - Example is fermentation in some bacteria.

Organismic respiration

Organismic respiration is the ventilation or breathing, i.e., the movements which causes inhalation and exhalation. Air contains gases and exchange of gases occurs in the specialized organs, for example, lungs in humans.

Difference between cellular and organismic respiration

- Cellular respiration is a series of events of metabolic reactions for production of energy.
- Organismic respiration is the process of coordinated movements of body that results in inhalation and exhalation of air. *We also call it breathing or ventilation.*

Respiration in air and water

Respiration in air is easier in comparison to water because air is lighter and water is denser. Also, air is much more saturated with oxygen than water. So that gas exchange in air is easier in the water than in water.

Respiration in plants

Gas exchange in plants occurs by stomata in mesophyll cells. Stomata are openings guarded by guard cells; these are used for transpiration in plants through water vapors. Roots of land plants get the oxygen required by the plants from air present in soil. Aquatic plants acquire their oxygen from oxygen dissolved in water.

Respiration in animals

In animals, respiration occurs by means of specialized organs, for example gills in fishes and lungs in terrestrial animals. The most important property of the respiratory organs is respiratory surfaces that support and facilitate the process of repiration.

Properties of Respiratory surfaces

Properties of Respiratory surfaces include a large and moist surface area, a thin epithelium, ventilation (air availability) and a capillary network.

Respiration in some small animals

In small animals, respiration occurs by means of general body surface or specialized systems. Hydra is an aquatic organism, which have a mouth and body cavity through which water moves in and out. Cells of the inner body wall exchange gases with that water. Cells of the epidermal layer exchange gases with the water.

In some other organisms like earthworms which have a closed circulatory system the exchange of gases takes place by the capillaries, which are present in closed vicinity with the body wall.

In the arthropods, especially insects like cockroach a very special system of gas exchange exist called the **tracheal system**. Tracheal system is a system of tubes which are extensions of the body wall and makes a network of tubes called **tracheae**, **tracheoles** and **air sacs** in the body. These have openings to the exterior called **spiracles**. Air enters in through spiracles and enters the trachea and tracheoles, which are present close to the tissues. Gas exchange is easier because in trachea only air is present, which is a very lighter medium. Tracheal system is a very efficient system of respiration.

Respiration in fish, frog and birds

Fishes

Fishes are aquatic animals; these have respiratory organs called **gills**. Water enters through mouth into the gills where gas exchange occurs and then water move out from gills. Heart is fishes is called a single circuit heart, which pumps blood towards gills where gas exchange occurs and then blood moves towards body.

Frogs

Frogs are called a transition between aquatic and land animals. These live in water and land both. These have three different types of respiratory system at different stages of life. When a frog is hatched for an egg and becomes a larva, it lives in water and respires through gills. When it becomes an adult frog it respires by lungs and skin. Frog's skin has a network of blood capillaries so that gas exchange may occur there.

Birds

Birds have a very efficient system of respiration. Birds respire through lungs. They also have air sacs in their in their body and bones, which also helps in capturing air and hence efficiency of gas exchange is improved.

Respiratory organs

Land animals have their respiratory organs named lungs. In aquatic animals, gills are the organs for gas exchange.

Respiratory system in humans

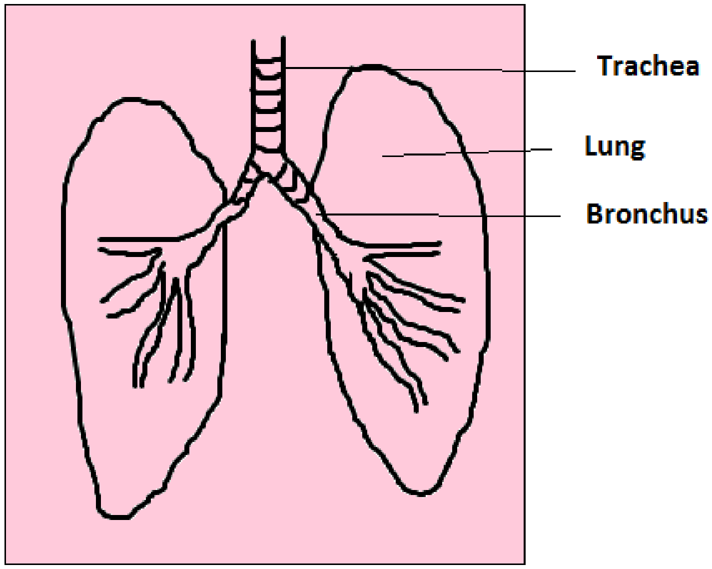
Respiration in human beings occurs by lungs and associated air passageways. Human respiratory system consists of:

Air passageways in humans

- Nostril and nasal cavity
- Pharynx
- Larynx
- Trachea
- Bronchi
- Bronchioles

Lungs in humans

- Pleural cavity
- Body of lungs
- Alveoli – the smallest units



Lungs inhuman beings

Structure and functions of various parts of air passageways

Nose and nasal cavity

Nose is the part for inhalation. Nose and nasal cavity is lined with ciliated epithelium and its surface is covered with mucus. The ciliated and moist surface traps dirt and other particles. The air, which enters inside is filtered, moist and warm.

Pharynx

It is a small muscular passage, which is lined with mucous membrane. Air moves down to larynx through pharynx.

Larynx: the voice box

Larynx is a complex cartilaginous structure, through which air moves down to trachea. Its opening is ciliated and covered with mucous. Mucus membrane is stretched across into thin edged fibrous bands called *vocal cords*. Vocal cords help in voice production.

Trachea (windpipe)

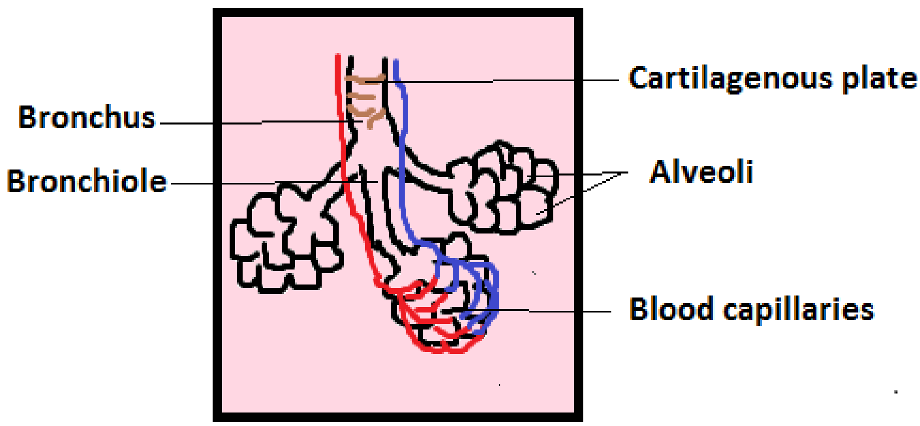
Trachea is a long tube stretched from larynx to lungs. It has a tubular structures and it lies ventral to the esphagous. It has C-shaped cartilaginous rings which are supporting structure and prevent tracheal collapse. Trachea extends through the chest cavity or thorax. In thorax, it divides into 2 tubes called *bronchi* one entering each lung.

Bronchi, bronchioles and alveoli

Trachea divides to form *bronchi* in thorax region. Bronchi enter the lungs and divide further to make *bronchioles* (when they attain a diameter of 1mm or less). Bronchi have same cartilaginous rings but these become irregularly distributed plates when reaches at the end of bronchioles.

Alveoli

Brochioles keep dividing further and enter deep into the lungs to give rise to *air sacs*. Air sac is the functional unit of lungs. Air sacs consist of several microscopic structures called *alveoli*. Alveoli and air sacs are covered by a network of capillaries. This network is the site of gas exchange.



Functional units of lungs

Structure of lungs

There is a pair of lungs, one is right and other is left. These are present in chest cavity. Lungs are protected by ribs and pleural cavity (double membrane fluid filled cavity). Lungs are spongy in structure because of the presence of millions of alveoli. Below lungs a muscular floor of the chest is present, which is called *diaphragm*.

Breathing

Breathing is the process of inhalation and exhalation. Lungs are spongy, cannot pull or push air themselves. Breathing movements occurs with the help of pressure and movements of diaphragm. Diaphragm is dome-like structure present as the floor of chest cavity. When it is contracted, it becomes less dome-like, which results in expansion of chest and inhalation of air. When it is relaxed then it becomes more dome-like and pressure in the chest is decreased, which results in exhalation of air. When muscles between the ribs contract, the rib cage is elevated; and when relax, ribs settle down. This movement also helps in the process of breathing.

Exchange of gases in alveoli

Gases are exchanged against a pressure difference in the blood and lungs (alveoli). Blood capillaries are distributed around alveoli in very thin layers. Blood cells and alveolar air are very close for exchange of gases. Gases are exchanged at the alveoli.

Hemoglobin (Hb) in blood cells help in exchange of oxygen against the concentration difference.

$Hb + O_2 \longrightarrow HbO_2$ (reversible if pressure of gases in air is changed)

Transport of CO_2

Carbon dioxide is more soluble and dissolves in tissue fluids. From here it enters into blood capillaries. Carbon dioxide is transported in blood as:

- 20 % as carboxyhemoglobin
- 5% by few plasma proteins
- About 70 % as bicarbonate ions combined with sodium.
- CO2 + H2O –Carbonic anhydrase- H_2CO_3
- $H_2CO_3 \longrightarrow$ H+ + HCO^{3-}

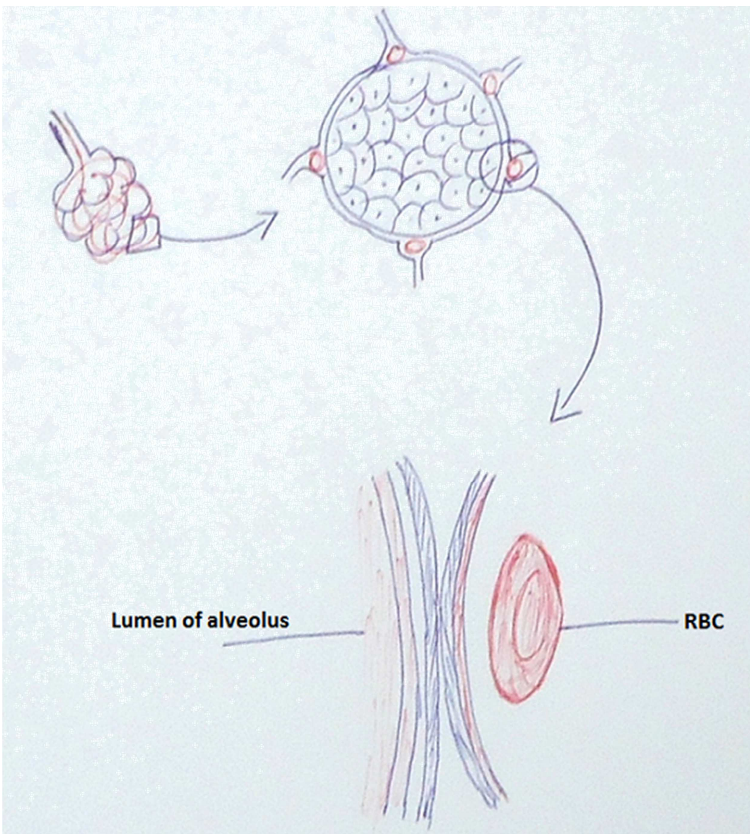


Figure showing association of the alveoli with blood capillaries in lungs.

Factors affecting gas exchange

- Carbon dioxide
    - If CO_2 increases then O_2 tension decreases. The result is that capacity of hemoglobin for O_2 is reduced.
- Temperature
    - Rise in temperature decreases the oxygen carrying capacity of hemoglobin.
- pH
    - If pH declines then oxygen carrying capacity declines.

- H+ ions bind to hemoglobin to decrease oxygen carrying capacity.

Lung capacity and effect of exercise on breathing rate

In humans, fully inflated lungs have a capacity of 5 liters. Normally, at rest or sleep exchange is half a liter. During exercise, it may increase up to 3.5 liters. It means that there is a 1.5 L residual volume that cannot be expelled. Inhalation per minute is 15-20 times; during exercise it may be up to 30 times to fulfill the needs of exercising muscles.

Changes in composition of breathed air

Gas	**Inhaled air**	**Exhaled air**
Oxygen	21 %	16%
Carbon dioxide	0.04%	4%
Nitrogen	79%	79%
Water vapors	Variable	Saturated

Exercise

1. Differentiate between cellular and organismic respiration.
2. Draw the structure of human lungs.
3. What are characteristics of a respiratory surface?
4. How exercise affects the breathing process?

Biology lecture # 10

Excretory System

Introduction and need of excretion

Living organisms have to metabolize which consist of anabolism and catabolism. Anabolism consists of all reactions for formation of compounds. Catabolism is break down of various compounds including glucose, proteins and lipids for the formation of energy.

Catabolism of carbohydrates, proteins and lipids

$$\text{carbohydrates + oxygen} \longrightarrow CO_2 + H_2O + \text{energy}$$

$$\text{proteins + oxygen} \longrightarrow CO_2 + H_2O + NH3 + \text{energy}$$

$$\text{lipids + oxygen} \longrightarrow CO_2 + H_2O + \text{energy}$$

Metabolic wastes

We can see in the reactions above that metabolic waste products are carbon dioxide, water and ammonia. These are waste and surplus materials. These have to be removed. Ammonia is highly toxic for the tissues. Water and CO_2 are dangerous for the body if these are present in excess. Rise in CO_2 may result in decrease in pH in blood which is dangerous. Ammonia is highly toxic and has to be converted into less toxic form. But those forms also need to be removed. Changes in water concentration in tissue fluids also create problems. Higher concentration may cause *dropsy*, which is accumulation of water in tissues. Decrease in water concentration may lead to dehydration. For all of these reasons an excretory system is required.

Excretion in Vertebrates

Major waste products in vertebrates

- Carbon dioxide
- Mineral salts
- Urea
- Creatinine
- Uric acid
- Excess water

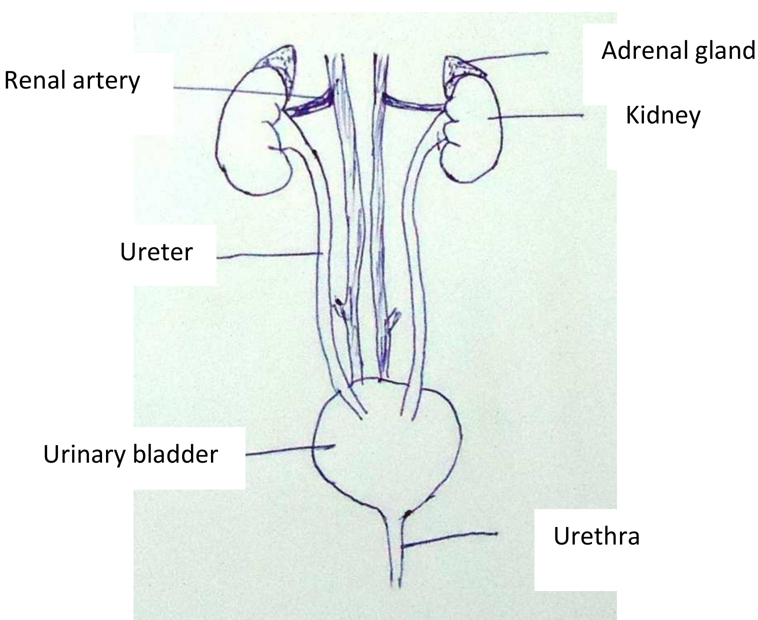
Excretion in animals

- Unicellular organisms
- Small animals
- Large animals
- Adaptations to habitat
    - water - fresh and brackish e.g. marine
    - desert
    - terrestrial

Excretory Organs

- Skin acts as excretory structure
- Salt glands are present in some marine or brackish water inhabiting organisms
- Intestine sometimes act as excretory organ
- Kidney
    - Major organ for excretion in vertebrates
    - Help also in osmoregulation
- Structure of kidney is different in organisms living in fresh and marine waters. Kidneys in fresh water organisms is modified to produce dilute urine while kidneys of marine or brackish water inhabiting animals are designed to produce concentrated urine.

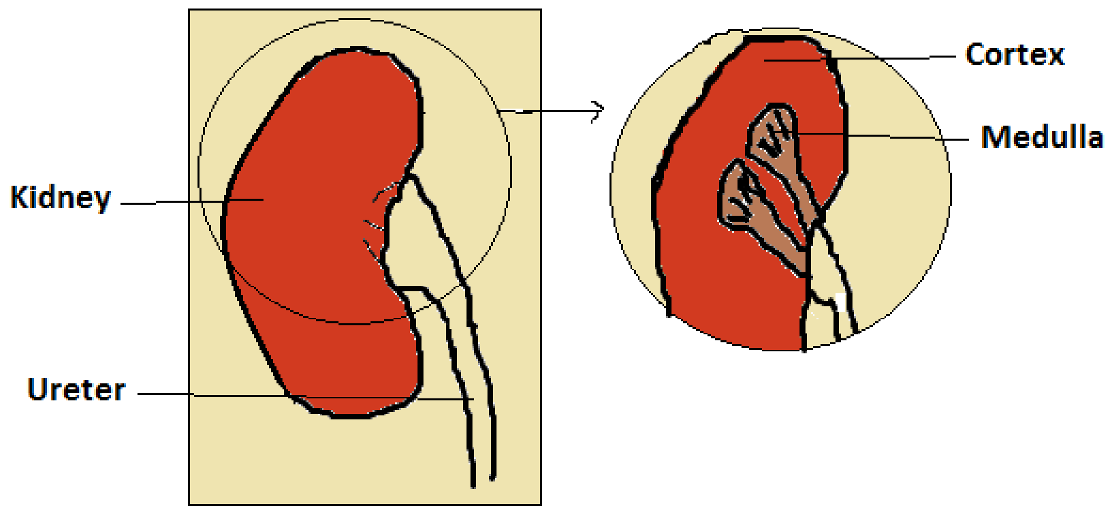
Basic components of human excretory system: kidneys and accessory parts



Various parts of human excretory system

External and internal structure of kidney

Kidney is a bean shaped structure. A pair of kidneys is present in abdominal cavity attached to dorsal body wall. The concave part of kidney lies towards vertebral column. There is a depression present towards the vertebral column which is called *hilus*. The concave part provides space for entrance and exit of renal artery, vein and nerves. A thin tube *ureter* arises out of the concave part of kidney.



Structure of a kidney

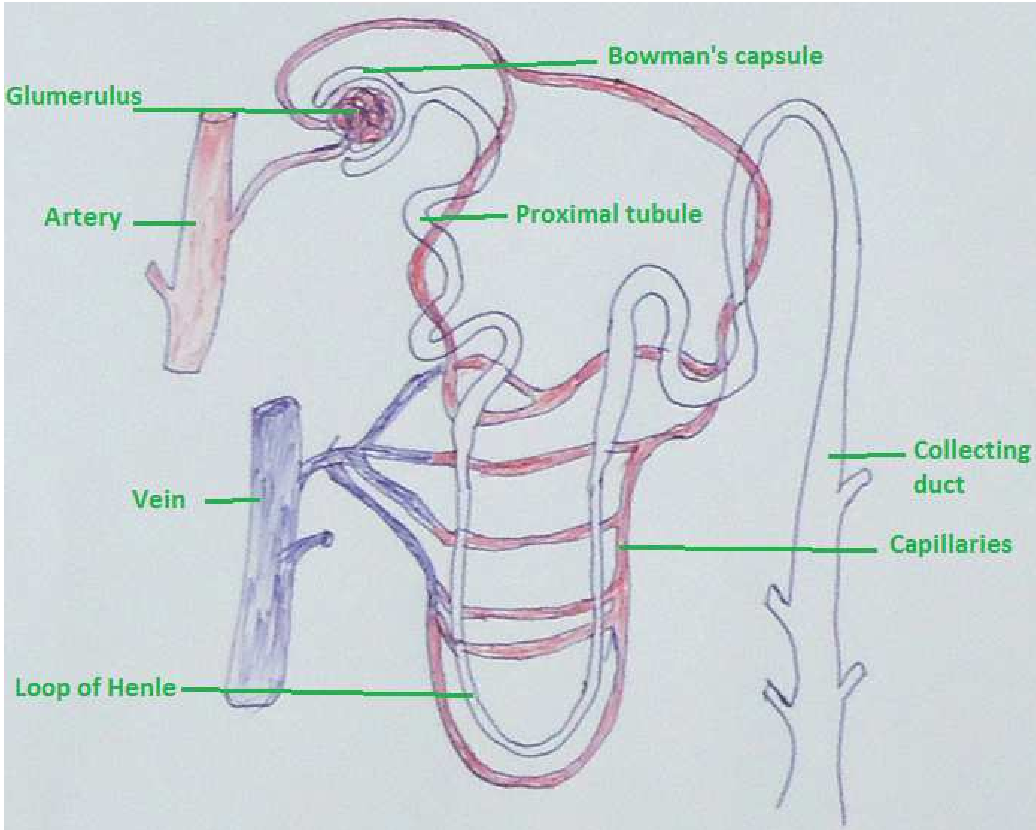
Renal cortex and renal medulla

If we look at a section of a kidney, then the outermost layer, reddish in color is called *cortex*. After cortex the second layer consists of structure like pyramids occur. This region is called *medulla.* A funnel shaped cavity is present towards inside that receives urine called *renal pelvis*.

Nephron

Nephron is the functional unit of kidney. Kidneys have many small structures present in cortex and medulla called nephrons. Function of the nephron is to produce urine. Nephron consists of following structures:

- Glomerulus, which is a capillary network.
- Bowman's capsule (Glumerular capsule) is the capsule like structure in which the glumerulus is present.
- Convoluted tubule
- Loop of Henle
- Collecting duct



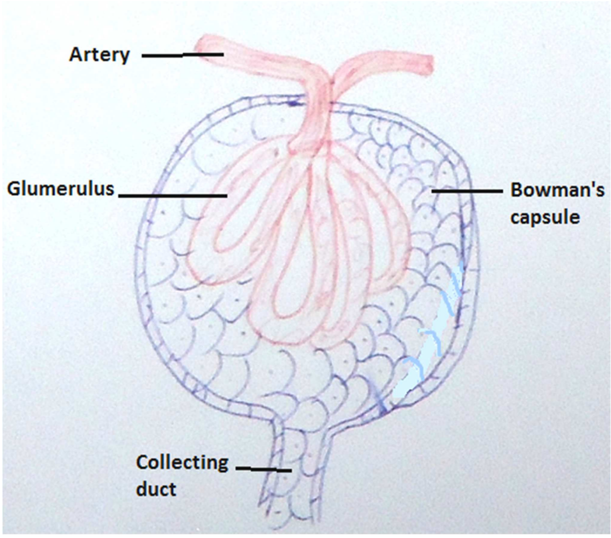
Structure of a nephron

Functioning of the kidney: Urine formation

Function of the kidney is to produce urine. Kidney produces urine by following mechanism.

Pressure Filtration

- Pressure filtration in the renal corpuscle occurs due to blood pressure in renal artery. Molecules other than RBCs and plasma are filtered, i.e., these enter into the renal capsule.
- It is called Bowman's filtrate
- It consist of salts, glucose, urea and uric acid



Filtration apparatus: Bowman's capsule and glumerulus.

Reabsorption

The filtrate moves down the tubular system. Next step is called reabsorption. Reabsorption means that those compounds which are useful for the body return back to the blood and the remaining part of filtrate in the tubules makes urine consist of water and nitrogenous wastes. Reabsorption occurs through the network of capillaries surrounding the tubules. Reabsorption is selective process. Glucose, water and salts are reabsorbed.

In the last step, only nitrogenous wastes remain inside the urine. This urine now goes down to pelvis and uretes. Through ureters it enters the urinary bladder for temporary storage. When bladder is full, there is a reflex for urination through urethra. Urination is not under conscious control in infants. In adults, however, this is under the conscious control through a sphincter present on the junction of urinary bladder and urethera.

Osmoregulation

Kidneys help in osmoregulation. This also helps in the maintenance of blood pressure. In case of increased blood pressure dilute urine is produced to temporarily reduce the quantity of water. In case of decreased blood pressure concentrated urine is produced and water is reabsorbed to compensate for fluid loss like in case of too much perspiration. Thirst is also a reflex in response to decreased quantity of water in blood.

Exercise

1. Draw a labeled diagram of human kidney.
2. Describe the structure of human excretory system with the help of diagram.
3. Describe the process of urine formation.
4. Describe the role of kidneys in osmoregulation.

Biology lecture # 11

Reproductive System

Introduction of reproduction

Reproduction is one of the basic characteristics of life. It is a biological process by which the organisms produce their young ones which are similar to their parents. This ability also allows organisms to adapt itself to the changing environment.

Types of Reproduction

There are two types of reproduction, asexual and sexual. In *asexual reproduction*, offspring are produced by simple cell division. No gametes are involved and offspring have same characteristics as their parents. In *sexual reproduction*, two organisms are involved in reproduction and offspring have characteristics which are combination of their parents and some new. Gametes are involved in this kind of reproduction. Sexual reproduction has advantage of increase in genetic variability. Gametes are formed by a process called meiosis in which alterations in genetic material takes place. As two organisms are involved, mixing of their characteristics takes place that increase more genetic variability. Genetic variability leads towards more adaptability to the environment.

Types of asexual reproduction

Asexual reproduction involves no gametes. There are many methods of asexual reproduction in organisms including:

- Binary fission
- Multiple fission
- Budding
- Regeneration
- Vegetative propagation in plants

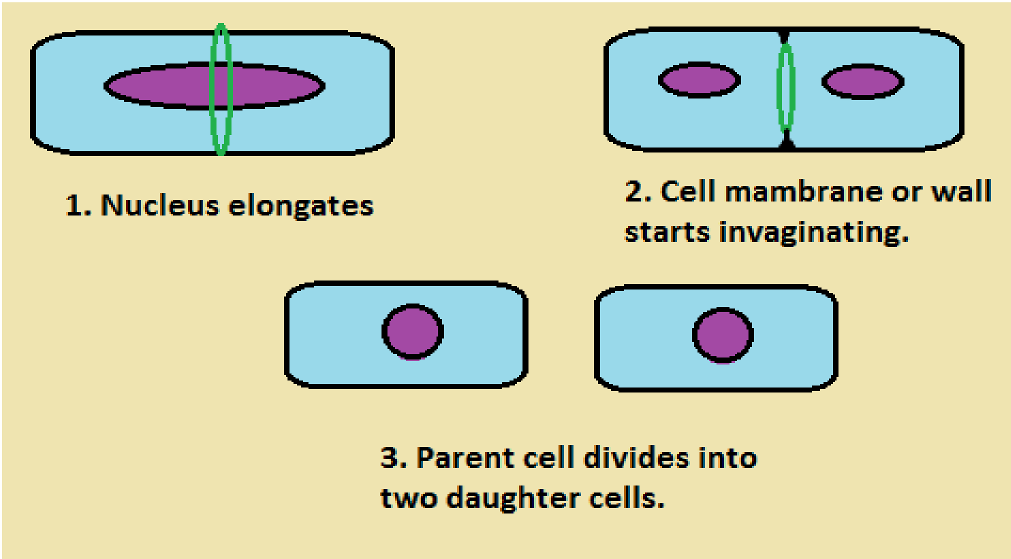
Binary fission

This is a type of asexual reproduction in which one unicellular organism divides into two by simple division. In bacteria, for example, binary fission takes place:

1. Replication of single chromosome takes place.
2. Daughter chromosomes move towards opposite poles.
3. Cell membrane invaginates and meets in the center.
4. Cell wall follows the cell membrane and cell divides into two.

Binary fission also takes place in unicellular organisms like amoeba and paramecium. In these organisms:

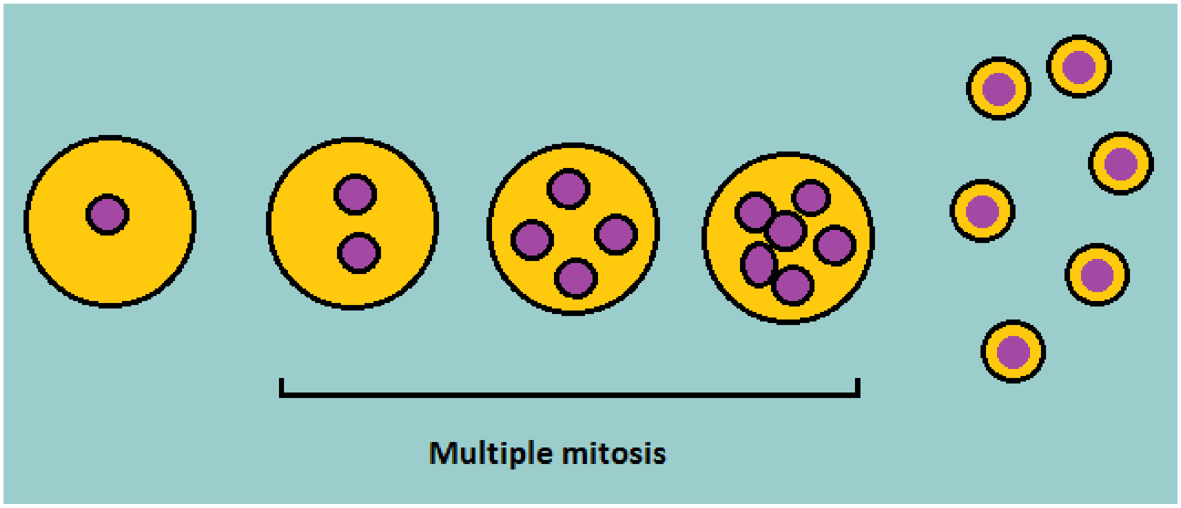
1. nucleus elongates and divide into two
2. Cytoplasm also divides and cell divides into two



Process of binary fission

Multiple fission

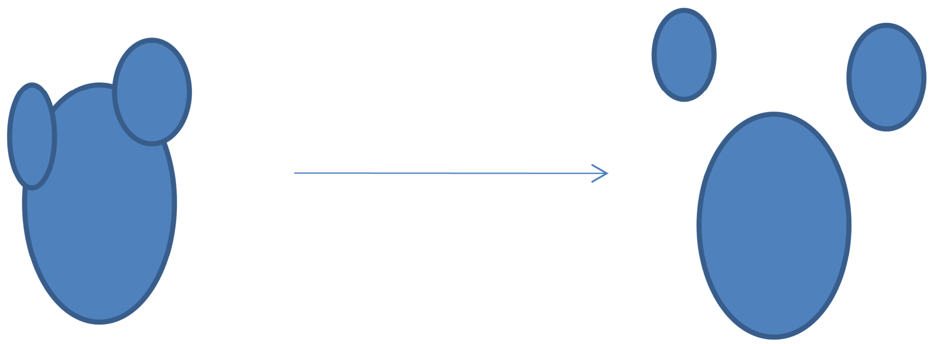
This is a process in which a single cell divides into many cells. For example amoeba makes a cyst in unfavorable conditions. Its nucleus divides into many nuclei and every part is surrounded by some cytoplasm. When favorable conditions come, the cyst split into many cells, each one a new amoeba.



Multiple Fission results in production of many daughter cells.

Budding

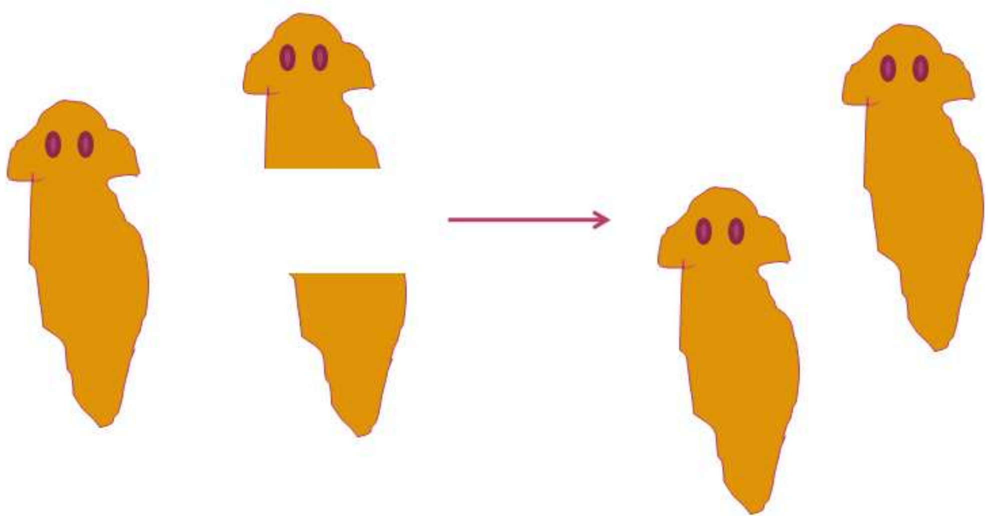
In this process an outgrowth (called bud) appears on the surface of an animal and may separate later on to develop into a new organism. Examples are yeast, hydra.



Budding in yeast

Regeneration

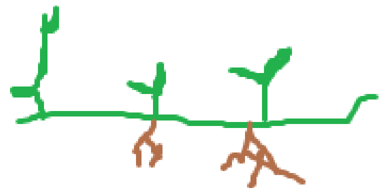
Regeneration is the formation of lost part of the body. Examples are starfish and planaria. If their one body part is lost then they have ability to grow it again. In star fish an arm is lost then the arm grows again.



Regeneration in planaira

Vegetative propagation in plants

It is a process that involves the vegetative propagation of some plant part such as stem or leaves. Examples are runners, suckers. Runners like grasses and strawberry and suckers like banana and mint.



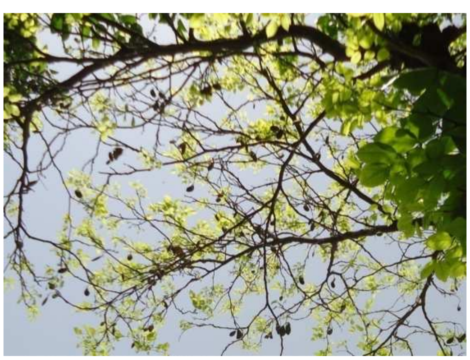
Adventitious roots are means of vegetative propagation.

Sexual reproduction in Plants

Flowering plants reproduce by sexual reproduction. Flowers have male and female parts called stamen and carpel. Fertilization occurs with the help of a process called pollination, i.e., transfer of pollen grains from anthers of stamen to carpel and then ovary. Pollination is of two types: self-pollination and cross pollination.

Formation of seed and fruit

- Seed is formed from the zygote. It consists of embryo and its food.
- When the seed are formed then the wall of ovary becomes fleshy or scaly and forms fruit wall.
- The floral parts (sepals, petals etc.) fall off.
- The ripened ovary is called fruit.



Sexual reproduction in Animals

In animals, it occurs through fertilization of gametes (sperms and ova). Gametes are produced by meiosis which is the reduction division. These have half a number of chromosomes. Females and males are different in only one pair of chromosomes. Males have a chromosome different called a Y chromosome in one pair. So females have an XX pair while males have XY.

Example of Frogs

- Frogs carry out sexual reproduction.
- Female frog lays a large amount of ova in water and male release sperms on these.
- Sperms and ova fertilize to produce zygote.
- Zygote the divide by mitosis to develop a larva which lives in water for a specific period of time and then by a process called morphogenesis develops into adult frog.

Reproductive system in humans

Humans reproduce sexually by fertilization of gametes called sperms and ova. Gametes are produced by specialized organs called testes and ovaries. Gametes have a haploid number of chromosomes, i.e., 23 chromosomes. 22 of these pairs are alike but 23^{rd} pair is different in males and females. Females have X chromosomes in their gamete while males have an X or Y. Gender of the child is hence determined by the sperm, X or Y. Female always contribute an X in gamete. If male gamete has a Y then a male child will be produced. If sperm have an X then female child will be produced.

Basic components of male reproductive system

Human male reproductive system consists of a pair of gonads called testes, and a system of accessory tubes. (testis: sing.; testes: plural). Testes are paired which produces sperms. Testes lie outside the body in the sac called scrotum. From testes, sperms are transferred to main duct called vas deferns. Vas deferns makes a complex system of ducts called epididymis. From epididymis, sperms pass through the urinogenital tract and discharged.

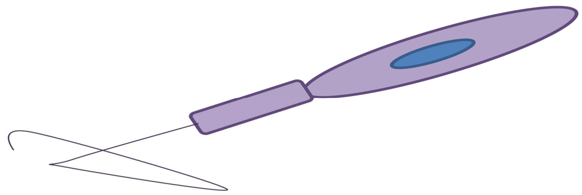
Function of testes

Function of testes is to produce sperms and the male hormone testosterone. Testis consists of a system of tubules called seminiferous tubules.

Process of Spermatogenesis

1. In the seminiferous tubules, germinal epithelium produces the cells called spermatogonia.
2. Spermatogonia divide into primary spermatocytes (2N).
3. Primary spermatocytes undergo meiosis to produce secondary spermatocytes (N).
4. Secondary spermatocytes divide further to make 4 haploid cells called spermatids.
5. Spermatids are converted to sperms by morphological changes.

Testis also has some large cells in seminiferous tubules called sertoli cells. These cells provide support and nourishment to the developing sperms.



Mature sperm

Basic components of female reproductive system

Female reproductive system consists of a pair of ovaries and an associated system of tubes. A pair of ovaries lies inside the female body cavity which produces ova. Ovaries leads to the tubes called oviducts also called fallopian tubes. Oviduct opens into uterus. Ovum is fertilized in the oviducts then it passes to the uterus where it is implanted. A placenta is established between the uterine and fetal tissues for the exchange of materials. Uterus is connected to the vagina through cervix.

Function of ovaries

Function of ovaries is to produce ova and female hormones estrogen and progesterone. Germ cells in ovary produce many cells called oogonia.

Process of Oogenesis

1. Oogonia produce primary oocyte (2N) by mitosis.
2. The primary oocyte divides by meiosis into secondary oocyte (N) and a polar body.
3. The secondary oocyte divides to form one ovum and a polar body.
4. The first polar body also divides to form 2 polar bodies.
5. Hence from secondary oocyte, one ovum and three polar bodies are produced.

Usually ovary releases one ovum at a time, this is called ovulation. Sometimes it releases more which may result into fraternal (non-identical) twins.

Exercise

1. Draw the process of spermatogenesis.
2. Draw the process of binary fission in bacteria.
3. Draw the process of multiple fission in amoeba.
4. Differentiate the process of meiosis in males and females.

Biology lecture # 12

Ecology I

Ecology is the study of interactions among organisms and their environment.

Environment

The physical surroundings of an organism including air, water, soil etc. Organisms have to interact with environment. Environment provides organisms everything required to live. Environment is always changing, may be supportive or hostile. Organisms living in an environment are "best fit" for that particular environment.

Environment consist of biotic and abiotic factors

- Biotic factors
  - Animals, plants, fungi, algae, bacteria

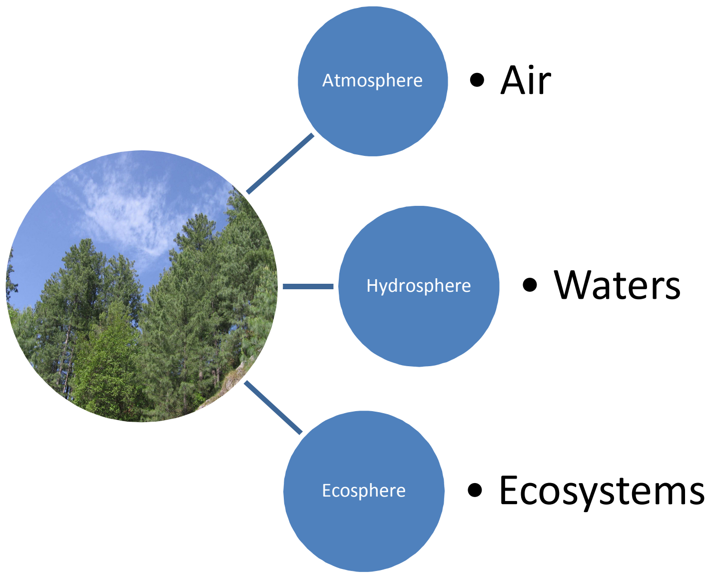
- Abiotic factors
  - Air, water, soil

What is Ecology?

- The study of interactions between organisms with each other and their environment.
- Biosphere and environment.
  - Surface of Earth's crust
  - Water bodies on Earth's surface
- Atmosphere that surrounds Earth

Soil support life

Rain helps in water availability



Levels of Organization in an Ecosystem

- Species
- Population
- Community
- Ecosystem

Then comes:

- Biome
- Biosphere

Species: male and female Golden Pheasants

Population is the group of organisms of same species living in an area.

Ecosystem

Ecosystem is the area where organisms live in interaction with non-living factors.

Organisms and their environment

Organisms live in specific locations or areas suitable for them. *Habitat* is the term used for physical location of organism. Another term is *niche*. Niche is defined as ecological role of organisms. Organisms interact with their surroundings; their interaction is termed as niche.

Organisms and their environment

Biotic and Abiotic Components

- Living / Biotic Components of an Environment
    - Animals, plants; Interactions between organisms.

- Non-living / Abiotic Components of an Environment:
    - Air, water; Interactions between organisms and their environment.

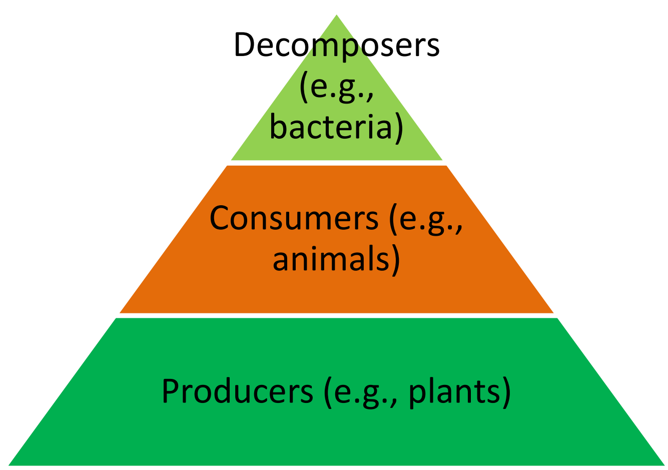
Energy Flow in Ecology

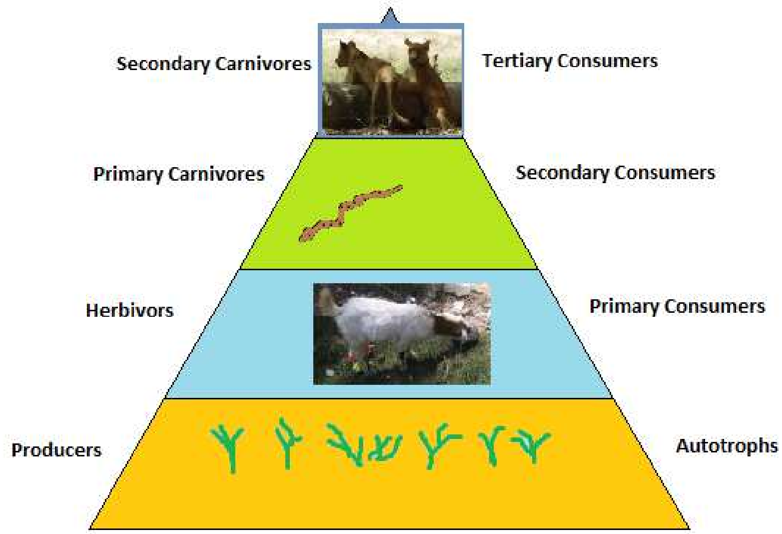
Main source of energy in an ecosystem is "Sunlight". Autotrophs (producers) are the organisms which utilize the energy stored in inorganic compounds and use sunlight to make their food. These organisms carry out "photosynthesis" and use this energy to convert "carbon dioxide and water into oxygen and glucose". The other type of autotrophs makes carbohydrates using chemical energy e.g., many bacteria. These are called chemoautotroph. Heterotrophs (consumers) are the organisms that cannot make their own food and depends upon organic source.

- Herbivores (the organisms that eat plants, i.e., producers; also called primary consumers)
- Carnivores (the organisms that eat herbivores or other carnivore animals)
- Omnivores (the organisms that eat upon plants and animals both)

Pyramids in Ecology

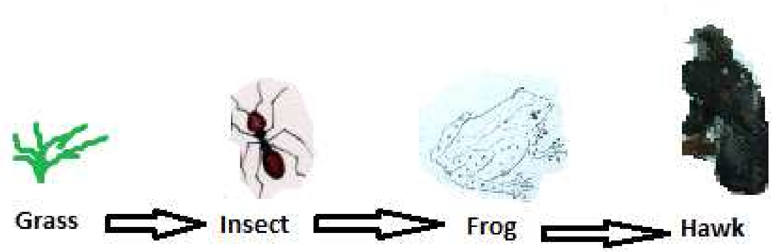
- Decomposers (these are the organisms which break down the dead organic matter)
- Consumers (the organisms which feed upon producers or other consumers)
- Producers (the organisms which makes their own food by either using sunlight or inorganic chemicasl)

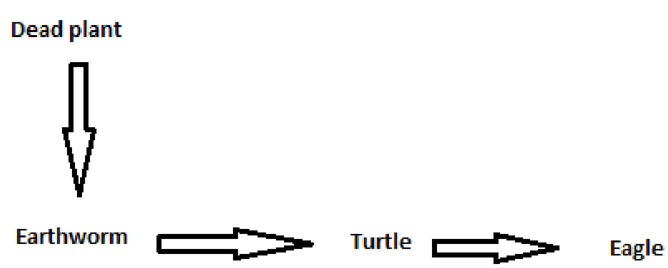




An example of ecological Pyramid

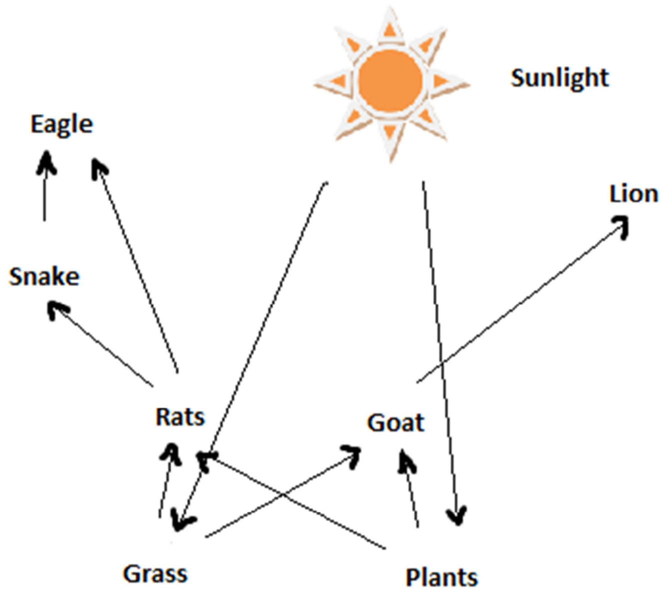
Food Chains are straight energy flow relationships in an ecosystem.





Food Webs

Food webs are complex energy flow pathways and relationships in an ecysystem.



An example of a terrestrial food web

Introduction of the factors that affect the quality of environment

Factors that Affect Environment

- Air currents
- Temperature
- Soil
- Water
- Light

Human interference

Industrial effluents

Industrial growth results in the production of more and more effluents. Industries produce effluents which may be solid or liquid. These may contain heavy metals, toxic chemicals. These are disastrous for the biodiversity. These should be treated well. The solution is treatment plants for removal of dangerous materials.

Deforestation

Forests are cut down for wood; wood may be used in buildings, furniture etc. Forests are also cut for making towns. This result in destruction of habitats of organisms which may leads to extinction of many organisms. As organisms are related, results may be increase or decrease of number of other organisms, e.g., if sparrows are decreased then insect pests may increase and destroy crops in that area.

Human interference: littering by the tourists.

Urban spread

As populations are increasing there is an increasing need of towns and cities. Urban spread requires the cutting of forests or other type of habitat destruction.

Construction of dams, waterways

Dams and water ways etc are constructed on water bodies. These may result in habitat destruction of fish and other aquatic animals. Loss of biodiversity results in instability of ecosystem.

Agriculture

Agriculture also affect environment. In grasslands keeping too many animals may result into loss of grass and destruction of ecosystem. In crop growing fields fertilizer use and growing exhaustive crops (the crops that uses much of soil's resources) may result in damage to the ecosystem.

Natural factors

Natural disasters like floods, earthquakes etc. may lead towards total or partial habitat destruction. Both biotic and abiotic factors are affected. The whole structure of ecosystem may change.

Importance of environment for the healthy living of organisms

Organisms have to live in environment

Organisms need food, shelter and other resources. If the balance of environment is changed by extinction of an organism or some other factor then many organism in the food chain or web are disturbed. A balanced ecosystem is required for healthy living of organisms.

Exercise

1. Differentiate between niche and habitat.
2. Describe the effects of human interference on ecosystems.
3. Define the following:
   a. Population
   b. Community
   c. Ecosystem
   d. Biosphere
4. Describe some abiotic and biotic factors of an ecosystem.
5. Draw a typical water ecosystem.
6. Draw a typical example of terrestrial ecosystem.

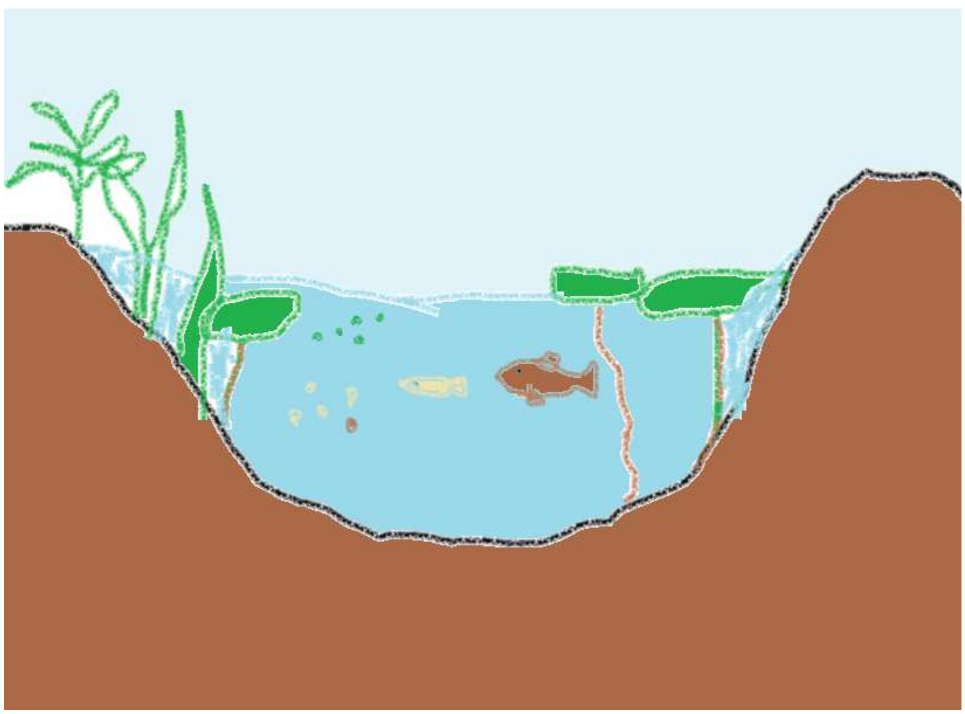
Biology lecture # 13

Ecology II - Ecosystems

Ecosystems - An Introduction

Ecosystem is an area where the organisms are living in an area in interactions with each other and their physical surroundings. There are many types of ecosystems, mainly divided into two categories:

- Aquatic ecosystems (ecosystem in water)
- Terrestrial ecosystems (ecosystem on land)



An aquatic ecosystem

Basic components of an ecosystem; and their roles / significance

Ecosystem consists of:

- Abiotic factors
    - Air, water, soil
    - Temperature, pH, humidity

- Biotic factors
    - Animals, plants, protists, bacteria

Biotic components

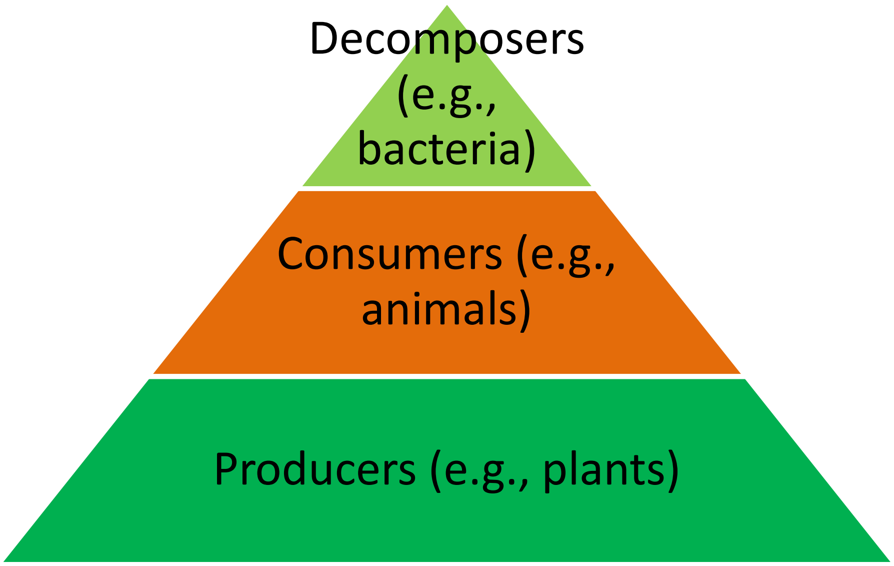
- Producers
    - Plants, algae

- Consumers
    - Animals

- Decomposers
    - Fungi, bacteria

Pyramids in Ecosystems

Ecological relationships are also shown in the form of pyramids in ecology. These are called ecological pyramids or trophic levels. On the base come producers, then consumers and then decomposers.



A pyramid

Producers

The living organisms which make their own food are called producers. Examples include plants, bacteria and algae. They carry out photosynthesis, carbon dioxide and sunlight to water and oxygen. They synthesize carbohydrate by a process called Calvin's cycle. Entry point of energy in the ecosystem is producers.

Consumers

These are the organisms that uses organic carbon source. These use carbohydrates produced by plants. Types include primary, secondary and tertiary consumers. Consumers include herbivores, carnivores and omnivores.

Consumers

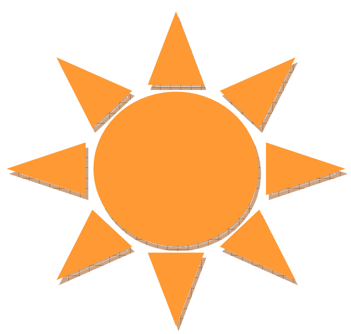
Decomposers

These organisms feed upon dead organic matter. These include fungi and bacteria.

Abiotic components of Ecosystem

Water, Light, Air and Soil

- Water is a limiting factor in an ecosystem. It is required by living organisms. Organisms have to adapt according to the availability of water.
- Sun light is the primary source of energy, e.g. zones of a lake.
- Air manages temperature and other things.
- Soil supports life.



ECOSYSTEMS – EXAMPLES

Climate and weather affect the ecosystem. There are various ecosystems in the world and in Pakistan according to the climate of the area.

Aquatic Ecosystems

Water is a liquid medium to support life. Aquatic ecosystems may be of fresh water or marine; a lake or a sea.

Water has some properties

- It changes its temperature slowly; more appropriate for life.
- It absorb considerable amount of energy (sunlight) but at depths its level decreases for photosynthesis.
- Nutrients are concentrated at bottom.
- Water is abundantly available in this ecosystem.

Fresh water lakes

- Lakes vary in nutrient, physical conditions and depths.
- Life also varies according to the conditions.
- Lakes have three zones:
    - Littoral – shallow water, photosynthesis occur, most diverse, anchored plants, submerged plants, phyto and zooplankton and fishes.
    - Limnetic – upper layer of deep water, have good light penetration, photosynthesis occur, cynobacteria – protozoans – crustaceans and fishes.

- Profundal – bottom layer of deep part, almost no light for photosynthesis, high nutrients on bottom, bacteria – decomposers.

Human interference

Wastes comes from different areas and results in eutrophication. Excessive growth of cyanobacteria creates a scum on the surface; result is that plants and animals die. Decomposer bacteria further decompose result in more organic matter. Ultimately habitat destruction is the result.

Terrestrial Ecosystems

Plants and animals adapts to the changes from water to land habitat. Supporting tissue developed for the purpose; animals have skeleton and plants have vascular bundles to support these organisms on land. Water conservation is another adaptation to conserve water.

Types of Terrestrial Ecosystems

Divided into four main types:

  - Forest ecosystems
    - Tropical rain forests
    - Temperate deciduous forests
    - Coniferous alpine and boreal forests
  - Grassland ecosystems
  - Desert ecosystems
- Tundra ecosystems

Major ecosystems in Pakistan

- Pakistan has a variety of climate and seasons.
- Have these main ecosystems:
  - Temperate deciduous forests – Shogran and Neelum valley
  - Coniferous alpine and boreal forests – Kaghan, Malam Jabba, Dir and Chillas
  - Grassland ecosystems – Gilgit, Kashmir, Waziristan, Chitral and Kallat
  - Desert ecosystem – Mianwali, Bahawal Nagaar, Bahawalpur and more, Thal, Thar and Cholistan
  - Tundra ecosystem – mountains of Karakoram and Hindukash

Temperate deciduous forest

- Present in Southeast Asia, India, North America, China, Japan etc.
- Have moderate temperature – 4 – 30°C
- Rain fall 750 to 1500 mm
- Plants – Taxus, Pinus, Berberis, ferns, grasses, herbacious; shed their leaves in dry season

- Animals – Rehesus monkeys, leopard, black bears
- Soil - very fertile and rich in nutrients
- Humans hunt animals and cut wood

Coniferous alpine and boreal forest

- Eurasia, North America, Canada
- Low temperature – freezing to 10C
- Snow cover is present
- Harsh climate – less suitable for life
- Highly adapted species lives here, Marco polo sheep, bisons, wolf, black bear
- Plants – Pinus species grow; have long waxy needle like leaves to survive cold
- Human disturbs less because less accessible

Grassland ecosystem

- Pakistan, Eurasian countries, North America
- Two types – Prairies, Savana
- Rain fall 250-750 mm, water is a crucial factor
- Plants are grasses – tall and short, legumes, herbs, mosses, lichens
- Animals are reptiles, amphibians, mammals
- Decomposers are fungi, bacteria
- Human impact – agriculture and live stock

Desert ecosystem

- Rain fall – 25-50 mm
- Perennial plants, cacti, succulent leaves and stems
- Animals adapt to little water, kangroo rats, reptiles, birds
- Human impact – desertification

Tundra ecosystem

- Very cold, snowy
- Small perennial flowers
- Mosquitoes grow well, birds feed upon these (geese, ducks)
- White bears, foxes, snow owls are present
- Human interference can produce long lasting effects because plants grow slowly but this interference is low due to harsh weather

A monkey in Ayubia National Park

Monkeys in Ayubia National park, you can see the solid wastes behind these.

Black bear which was once found in the Ayubia National Park

A beautiful ecosystem.

Exercise

1. What is an ecosystem? Name some areas of Pakistan that have desert ecosystems.
2. With the help of a drawing show the grassland ecosystem.
3. Describe various components of an aquatic ecosystem with the help of a diagram.
4. List some effects of human interference on ecosystems.

Biology lecture # 14

Food Chains and Food Webs

Ecosystem

An area where the organisms are living in interactions with each other and their physical surroundings is called an ecosystem. There are many types of ecosystems, mainly divided into two categories:

- Aquatic ecosystems (water ecosystems)
- Terrestrial ecosystems (land ecosystems)

Ecosystem

Ecosystem consist of biotic (living) and abiotic (non living) components.

- Biotic factors:
  - Producers, Consumers, decomposers
  - Plants, animals, fungi / bacteria

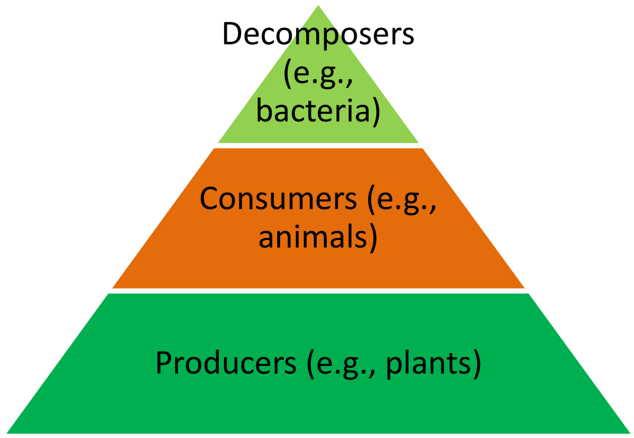
Biotic factors are in relationship with each other in an ecosystem. These also interact with abiotic factors present in their surroundings like air, water, sunlight.

Trophic levels

Trophic levels or feeding levels in an ecosystem define roles of the groups of organisms.

- Producers
  - Plants, algae
  - Consumers
  - Animals
  - Decomposers
- Decomposers
  - Fungi, bacteria

Pyramids in Ecosystems



Autotrophs – Producers

These are the organisms that make their own food using sunlight as an energy source. These convert carbon dioxide and water into carbohydrates. Producers are the only source for all organic food in the planet Earth; this is the entry point of energy. These provide food to all other life forms. Examples include plants, algae.

Chemotrophs

These are the organisms, which uses inorganic chemicals as energy source and makes carbohydrates. These lives in deep oceans, where there is no light source. Examples are some bacteria and deep sea worms.

Heterotrophs – Consumers

Organisms that do not make their own food and get food from other organisms are called *consumers*. They get energy by eating either plants or other animals. Their source of food hence is organic compounds produced by producers. Examples are small and large animals.

Types of Consumers

Consumers are divided into three classes:

- Primary consumers – herbivores (plant eaters)
  - e.g., goats, cows
- Secondary consumers – primary carnivores (meat eaters that eat herbivores)
  - e.g., frogs, snakes
- Tertiary consumers – secondary carnivores (meat eaters that eat other meat eaters)
  - e.g., eagle, hawk

Goat – herbivore **Squirrel - herbivore**

Cat - carnivore

Decomposers

These are the organisms that eat dead organic matter. These feed upon animals and plants – their fallen parts or dead organisms. These recycle food in the ecosystem, convert non available organic matter into available matter for producers.

Food chains

What is a food chain?

Food chain is a one-way flow of energy in an ecosystem.

Producers to consumers to decomposers

In an ecosystem different food chains exist. This is a relationship of eating and being eaten.

Phytoplankton ⇒ Fish Herbivore ⇒ Fish Carnivore ⇒ Fish Eater Bird

Example of a food chain from land (grassland) ecosystem

Grassland ecosystem has following characteristics:

- Rain fall 250-750 mm, water is a crucial factor
- Plants are grasses – tall and short, legumes, herbs, mosses, lichens
- Animals are reptiles, amphibians, mammals
- Decomposers are fungi, bacteria

Sunlight → **Grass** → **Primary consumer (Rat/Mole)**

↓

Tertiary Consumer (Hawk) ← **Secondary Consumer (snake)**

A grassland ecosystem food chain

Example of a food chain from aquatic ecosystem

- Aquatic ecosystem is marked by:
  - Water, which is a liquid medium to support life.
  - May be fresh water or marine; a lake or a sea.
- Light, temperature penetration is important for biodiversity.

A Simple Food Chain in a Lake

Phytoplankton → Crustaceans → Fishes → Fishes

Arctic ecosystem

Algae → Shrimp → Arctic cod (fish) → Seal → Polar bear

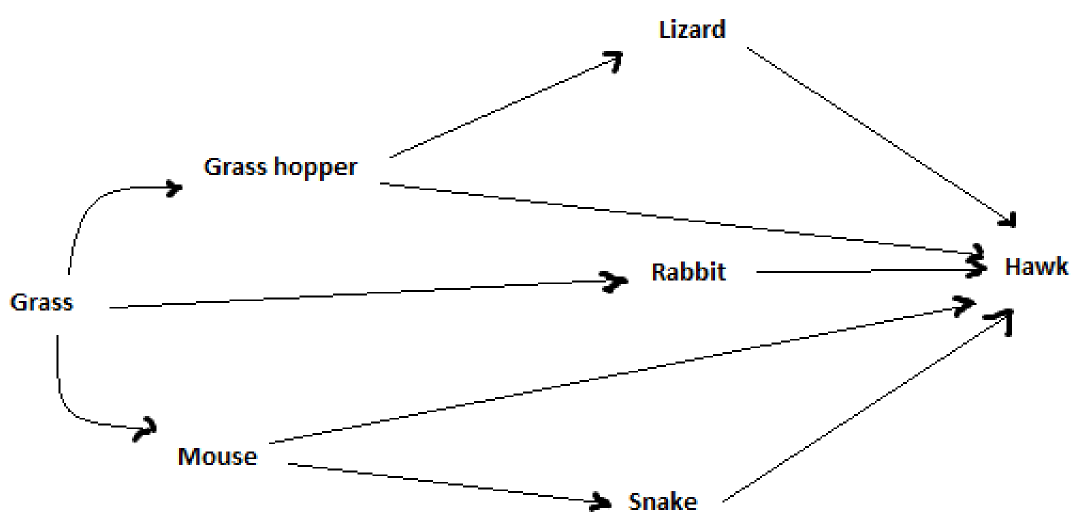
Food web

What is a food web?

- A network of eating and being eaten.
- Feeding relationships between organisms are not as simple as food chains.
- There is a diversity of organisms and one organism may be eaten by more than one other organisms.
- Example is grass is eaten by cows, buffaloes

Example of a food web from land (grassland) ecosystem

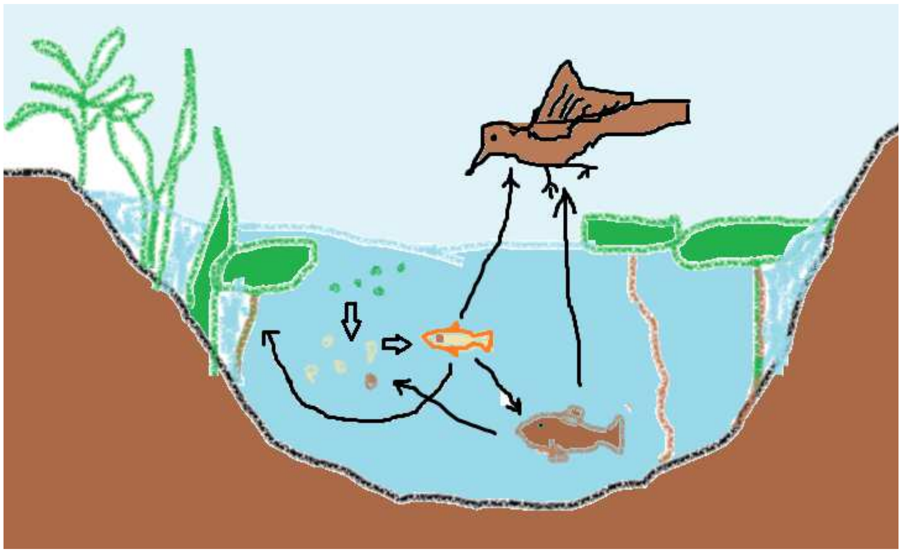
- Grassland ecosystem have small plants, reptiles, amphibians and mammals.
- Grass is eaten by most of the herbivores.
- Herbivores are eaten by more than one carnivores.



A food web of Grassland Ecosystem

Example of a food web from aquatic ecosystem

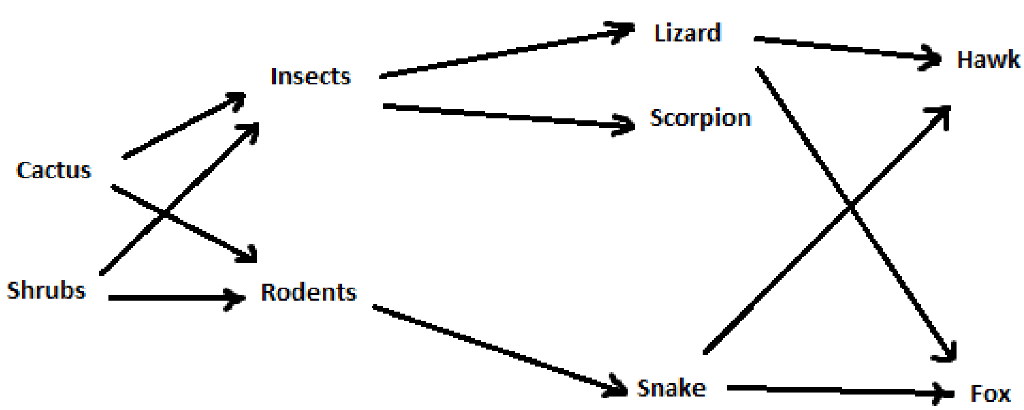
Aquatic ecosystem has phytoplanktons, zooplanktons, plants, animals and decomposers. Food webs may be simple or complex starting from producers.



A food web in an aquatic ecosystem

Desert Ecosystem

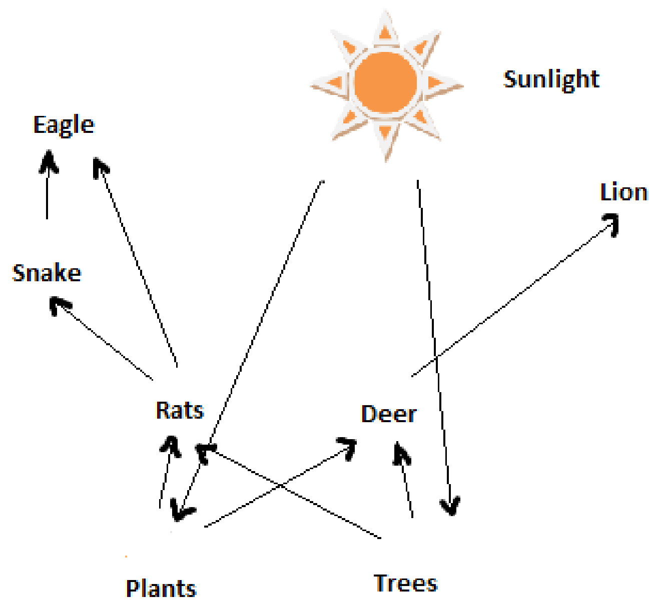
- Dry and hot environment.
- Few specific plants.
- Well adapted animals.



A desert food web

Forest Ecosystem

- Dense vegetation, animal diversity is high
- Simple to complex food webs



Exercise

1. Draw a food chain in a grassland ecosystem.
2. Draw a food chain in an aquatic ecosystem.
3. Draw a food web in a forest ecosystem.
4. Draw a food web in a lake ecosystem.

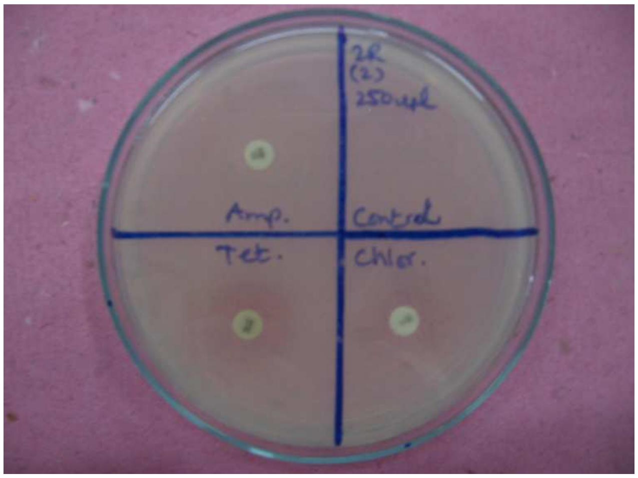
Biology lecture # 15

Algae and Fungi

Algae are:

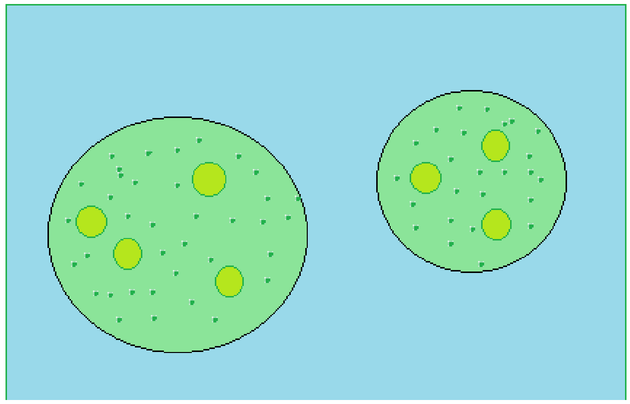
The organisms range in size from microscopic unicellular to large sea weeds, demonstrate following characteristics:

- Major producers of oxygen
- Provide food for animals in various food chains
- Source of chemicals with pharmaceutical value
- Utilize carbon dioxide to reduce the greenhouse effect
- Source of valuable materials including biofuels, food and agar (part of media for microbial growth)
- Thrived for 1.5 billion years, are an integral part of the global ecosystem



Distinguishing characteristics of algae, with examples

- Photosynthetic, autotrophic
- Eukaryotic, have cell wall consist of cellulose
- Classified by their:
  - energy storage products
  - cell walls
  - colour (due to types and abundance of pigments their plastids)
  - cellular organization
  - Reproduce both asexually and sexually
  - Asexually by mitosis
  - Sexually when there is environmental stress
  - Plus and minus gametes fuse to form zygospore which give rise to new organism e.g. chlamydomonas
  - Some reproduce by conjugation like spyrogyra



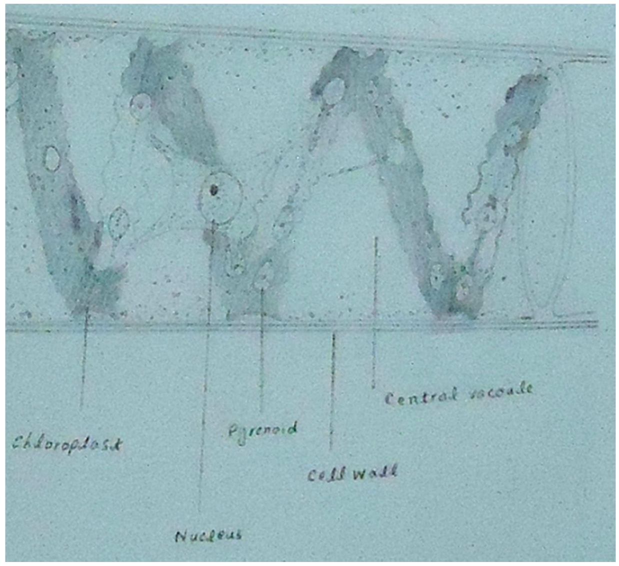
Volvox is algae consist of rounded colonies

Types of Algae based upon the pigments

- Green algae (chlorophyll, soluble in organic solvents only, such as alcohol), 7000 species
- Red algae (have “phycobilins” water soluble pigment) 4000 species, cosmeics, gelatin etc
- Brown algae 1500 species, weeds
- Golden brown algae (formation of petroleum products)
- Carotenoids are also algal pigments soluble in organic solvents
- Euglenoids, both plant and animal like characteristics

Algae could be distinguished by cellular organization:

- **Unicellular** algae: species occur as single, unattached cells that may or may not be motile. For example, Chlamydomonas, Euglena.
- **Filamentous** algal species occur as chains of cells attached end to end. These filaments may be few to many cells long and may be unbranched or branched in various patterns. For example, Spirogyra.
- **Colonial** algae occur as groups of cells attached to each other in a nonfilamentous manner. For example, a colony may include several cells adhering to each other as a sphere, flat sheet, or other three-dimensional shape. For example, Volvox.



Spirogyra

Distribution and Significance of algae

Algae are widely distributed in various areas of the world in small to large water bodies. These are present in small ponds to huge oceans. Green algae are found almost everywhere. Red algae and brown algae are mostly marine organisms. Euglenoids are fresh water inhabitants. When algae grow a lot covering large area of water it is called algal blooms.

Important producers of the planet Earth

Algae are producers in many food chains particularly in aquatic ecosystems. These convert sunlight into energy and carbon dioxide into carbohydrates. These help in reducing the Greenhouse effect by absorbing carbon dioxide.

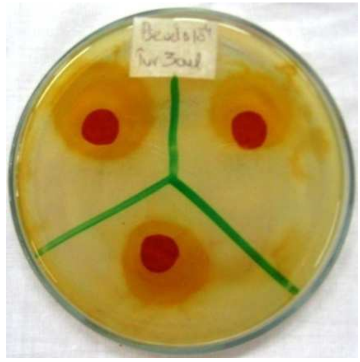
Algae as human diet alternatives

Agar is used in the place of gelatin to make gels in many foods. Weeds are part of the salads and other materials for making various kinds of salads and desserts. Some are used in making ice creams.

Production of Agar

These are also used in production of Agar which is material extracted from sea weeds and help in solidifying bacterial growth media.

- Agar is very important in scientific research
- Used to culture microorganisms on solid surface
- A plentiful and cheap source for growing microorganisms
- Used in almost all microbiology research laboratories, for example in clinical laboratory



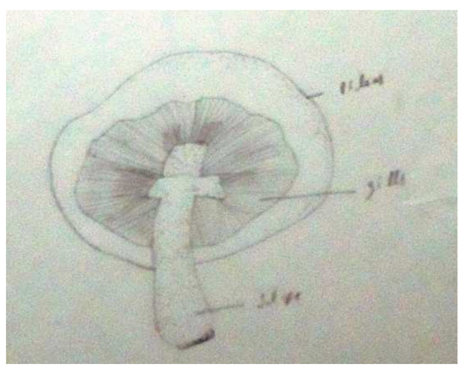
Agar medium to test bacterial growth and effect of an antibiotic on it

Algal Biofuels

Algae can produce huge biomass. This biomass could be used to convert into fuels like ethanol. Algae are potential source of biofuels.

The Fungi

Fungi are the heterotrophs and major decomposers which feed upon decaying organic matter. These range in size from microscopic to large ones. These include heterotrophs, symbionts and parasites.



Mushroom

Distinguishing characteristics of fungi, with examples

- Unicellular to multicellular
- Eukaryotic
- Body is made of long filaments of hyphae (singular: hypha) which form a mycelium (collection of hyphae)
- Have a cell wall, made up of chitin
- Reproduce both asexually and sexually
    - Spores
    - Mating of hyphae

Some important groups of Fungi

Phylum Zygomycota = the Bread Molds

e.g. Rhizopus – black bread mold

Phylum Ascomycota = the Sac Fungi

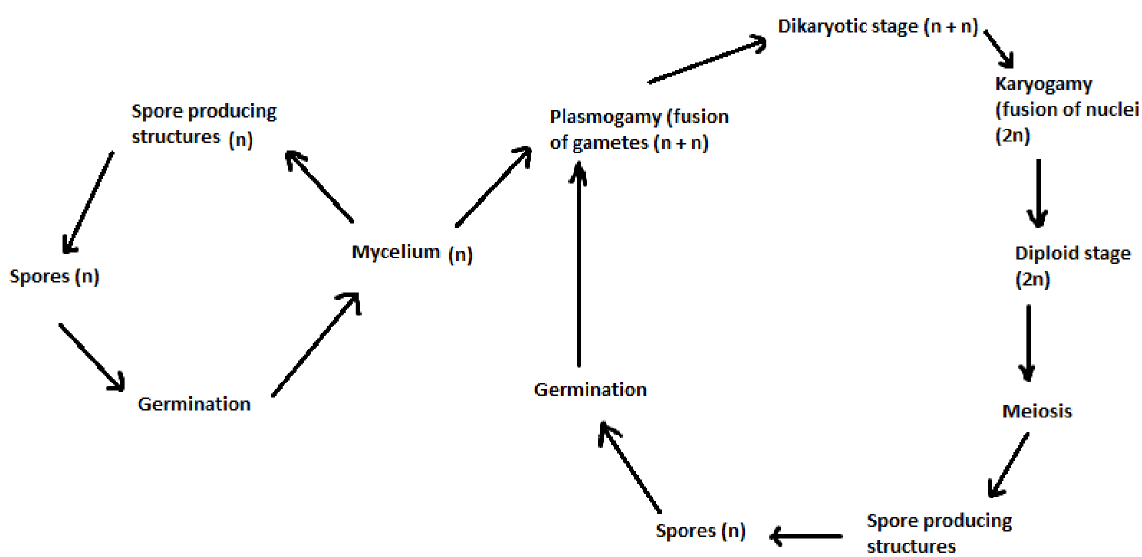
e.g. Yeast

Phylum Basidiomycota = the Club Fungi

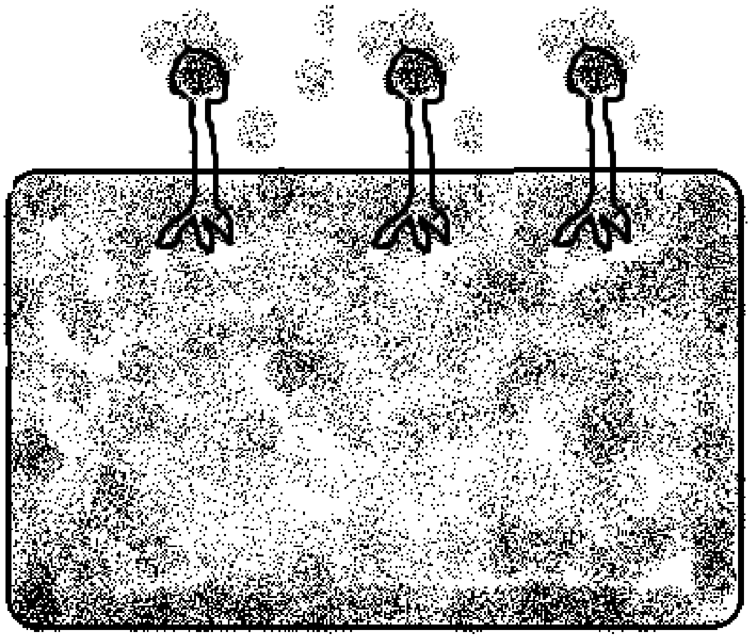
e.g. Mushrooms, puffballs, bracket fungi, rusts, smuts

Phylum Deuteromycota = the Fungi Imperfecti

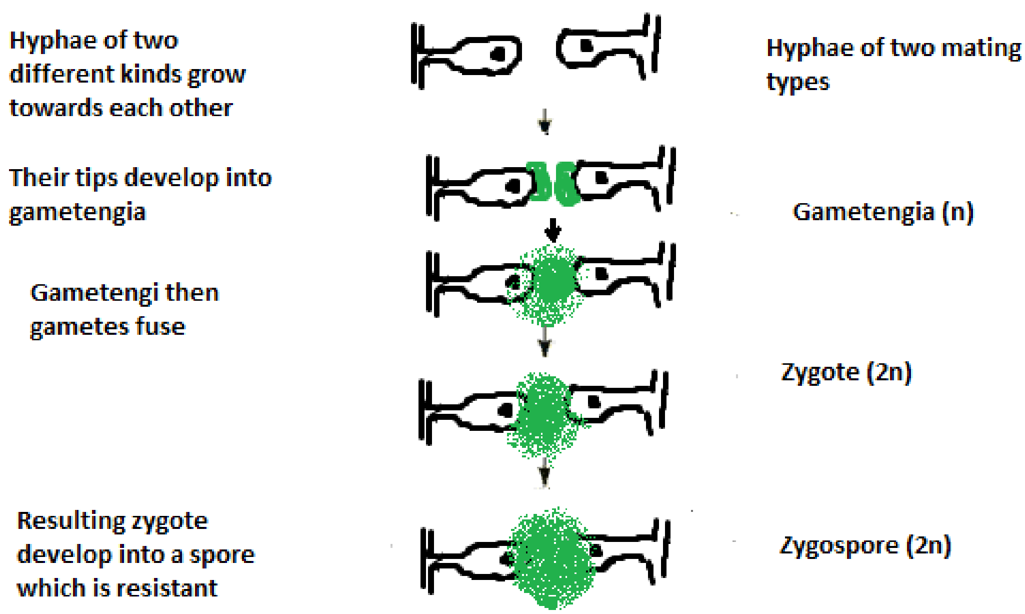
e.g. Penicillium



Life cycle of fungi



Hyphae and mycelium; Spores on the top (fruiting bodies)



Mating in fungi

Habitats and Significance of fungi

Fungi grow in almost every habitat imaginable, as long as there is some type of organic matter present and the environment is not too extreme. It is a diverse group; number of described species is somewhere between 69,000 to 100,000 (estimated 1.5 million species total). It is present in soil, water, or on foods. These may also live on animal or plant bodies. Mycorrhizae are the fungi associated with the roots of vascular plants. Lichens are the association between fungi and algae.

Lichens

Lichens consist of association between algae and fungi. It is a symbiotic association. These are usually the first inhabitants of a new ecosystem.

Fungi are important reducers / decomposers

- Feed on dead organic matter
- Convert it to less toxic form
- Convert into useable form for plant’s use

Food source and food spoilage

Many fungi are source of food and many other spoils foods.

- Mushrooms
    - Various types
    - Poisonous to edible
    - Used as food, protein source

- Some fungi cause spoilage of foods
    - Bread molds

Sources of medicines

Some fungi are sources for medicines.

- Truffles
    - Used in medicines
    - Gorw inside soil

- Penicillium
    - Source of penicillin

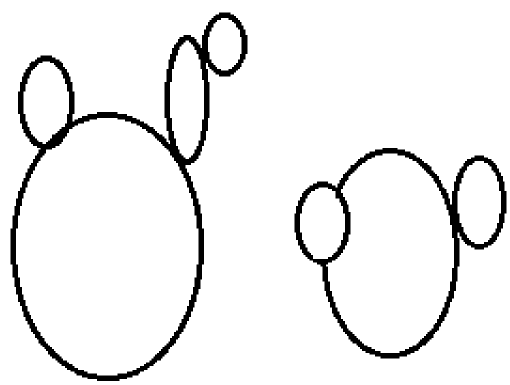
- Other drugs

Pathogenic fungi causing diseases in plants and humans

Many fungi are pathogenic and cause infections in animals, plants and human beings. These may cause skin infections, eye infections and others. Parasites can harm human beings and plant infections can damage crops.

Yeast

Yeast is a very important organism for biotechnology and food industry. It is used to make various biotechnological products. It is eukaryotic and better in making proteins in comparison to prokaryotes. It is also used in wastewater treatments because it absorbs heavy metals and converts other contaminants into less toxic form.



Structure of yeast while budding

Exercise

1. What are important characteristics of algae?
2. What are important uses of fungi?
3. What are lichens and their significance for ecosystems?

Biology lecture # 16

Animals and Their Importance

Distinguishing Characteristics of Animals, with examples

- Consist of eukaryotic cells
- Multicellular organisms, from simplest sponges to complex animals like mammals
- Highly adapted to their environments
- Widely distributed, present in all types of aquatic to terrestrial ecosystems even in air, e.g., the birds
- Important parts of food chains as consumers of different levels
- Heterotrophic, rely on organic carbon sources
- Independently living or parasitic
- Reproduce asexually or sexually
- Very important for human beings and the ecosystems

Diversity of animals

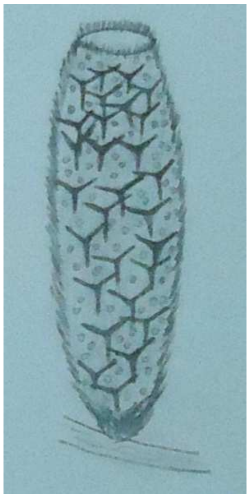
These are widely distributed and are present in almost all habitats. There are two major groups including invertebrates and vertebrates. Animals are wild if these are living in natural habitat or these are termed as domestic if these are kept for some benefit or as pets. Animals are kept in captivity or controlled habitats if there is a need in zoological gardens and safari parks.

Phyla of Invertebrates with examples

Porifera

These are simple animals with one opening as mouth and a body cavity. These are aquatic organisms.

- e.g. Sponges
- Two layered, no specific organ, porous body
- Highly specialized cells

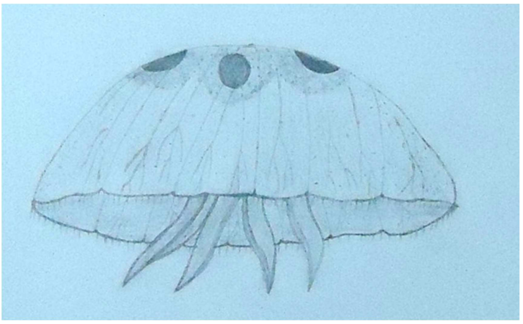


Leucosolenia

Coelenterates

The animals with 3 body layers. These have stinging cells which have a poison to paralyze or kill the prey.

- e.g. Jelly fishes which are marine
- Have simple organs
- Have stings, mouths, tentacles

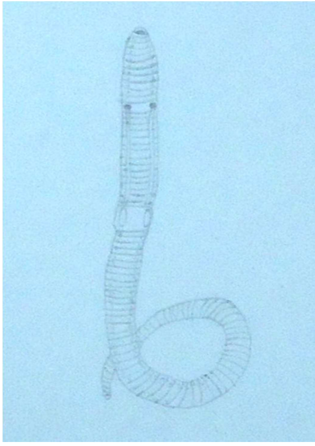


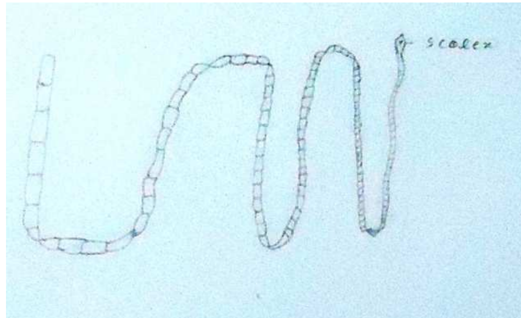
Aurelia – a jelly fish.

The worms

These are of different kinds including round worms, flat worms and earth worms.

- Regeneration: These have ability to regenerate their lost part.
- Parasites, decomposers
- Grow very long





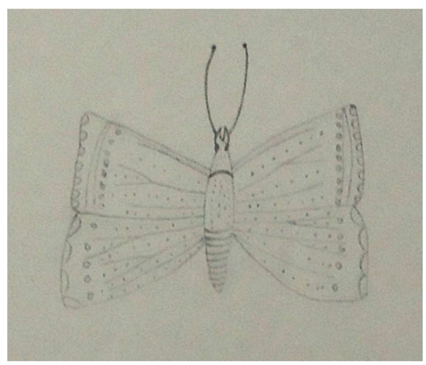
Earthworm and flat worm

Arthropods, widely distributed

These are one of the most diverse groups of animals. These organisms have an exoskeleton.

- Four major groups
  - Arachnids (spiders)
  - Crustaceans
  - Insects
  - Millipede, centipede
- Have sense organs, are segmented, have exoskeleton

House fly

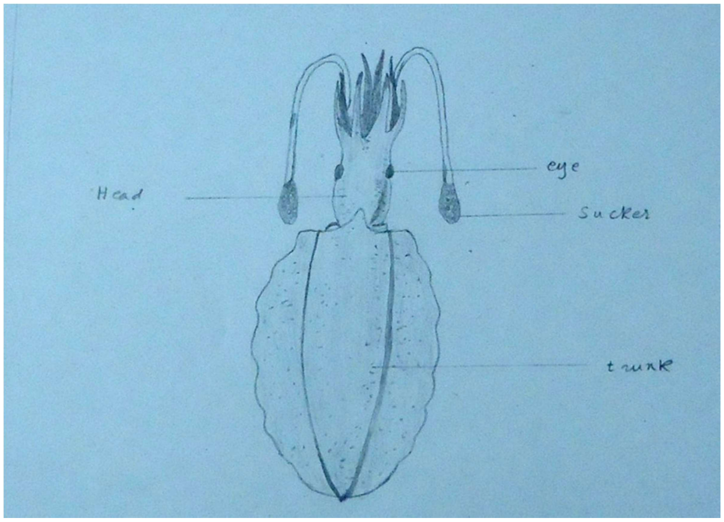


Butterfly

Molluska

These organisms are specific to have shells around their soft bodies.

- Soft bodies, hard shells
- Aquatic mostly
- Snails, lobsters
- Some of these make pearls

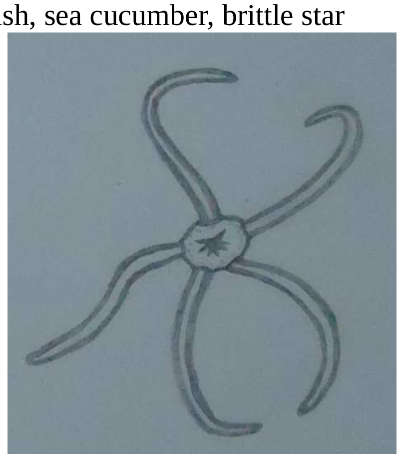


Sepia

Echinoderms

These are the animals with spiny skins hence called echinoderms (echino-spiny).

- Exclusively marine
- Have a water vascular system for the movement
- Examples are star fish, sea cucumber, brittle star



Brittle star

Importance of Invertebrates

- Invertebrates are very important part of lot of food chains hence important for stability of ecosystems
- For human use:
  - Sponges are used widely in sound proofing, washing
  - Worms are important parasites of domestic animals and human beings
  - Insects are pests of many crops, many useful insects like honey bee, lac insect
  - Lobsters makes pearls, cultured for pearls

These are components of Food Webs

- Component of aquatic food webs
- Components of terrestrial food webs
- Maintain ecosystem stability, if one becomes extinct then the whole food chain or web may become disturbed.

Role in Soil Fertility

- Some invertebrates are decomposers, e.g., Earthworm
- They feed upon dead organic matter and increase soil fertility
- When animals die their bodies become part of soil and decomposed to add nutrients to soil

Parasitic Invertebrates

These could harm the humans and also harm our domestic animals and crops. There are many treatments available for these.

- Ticks, mites, lice are ectoparasites
- Worms are endoparasites
- Leeches are ectoparasits

Major Classes of Vertebrates and their Importance

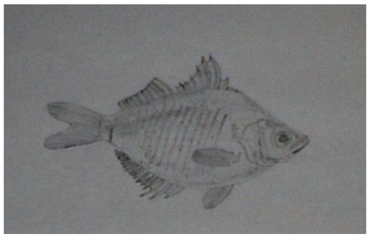
Vertebrates are the organisms with a vertebral column precisely with 3 main characteristics at any stage of their life including notochord, nerve cord and pharayngeal slits.

Vertebrates are divided into:

- Fishes
- Amphibians
- Reptiles
- Birds
- Mammals

Fishes

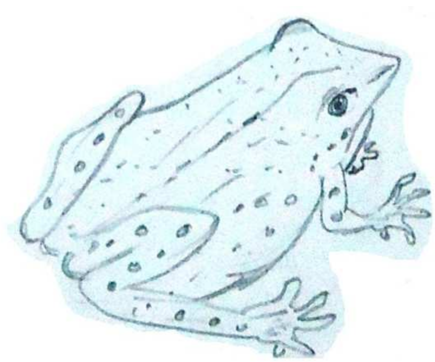
- Aquatic animals, occupies fresh water and marine habitats, widely distributed, bony or cartilaginous
- Have gills for gas exchange, 5 chambered single circuit heart
- Have streamlined and slimy body, ectotherms
- Have fins (appendages) and tail
- Cultured in ponds and caught from natural habitats, are important food source of proteins
- Cultured for ornamental purposes
- Examples are Rohu, Carps, sharks, electric rays



An ornamental fish

Amphibians

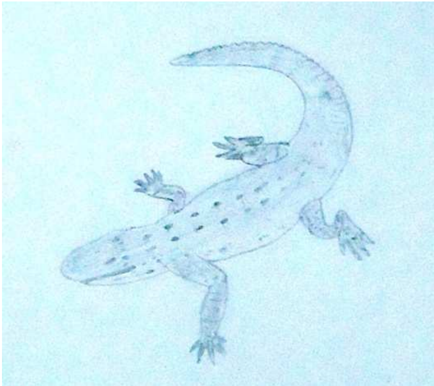
- Are transition between aquatic and land animals
- Gills, lungs and cutaneous respiration
- 5 chambered double circuit heart, mixing of blood
- Some part of the life is aquatic and some part terrestrial
- Produce large number of eggs, no parental care
- Ectotherms
- Examples are frogs, toads



A frog

Reptiles

- Of diverse types, widely distributed, aquatic and marine
- Highly adapted for hot dry habitats such as deserts
- Terrestrial animals, ectotherms
- Scaly skin, four chambered double circuit heart
- Lungs for gas exchange
- e.g. lizards, chameleon, turtles, tortoises, crocodiles, snakes, gavials



An alligator

Birds

- Arial mode of life, terrestrial life, fore arms modified into wings
- Endotherms, 4 chambered heart
- Lungs and air sacs for respiration
- Lays fewer eggs, provide parental care
- Bones light weight called hollow bones
- Grain eaters to omnivores
- e.g. parrots, pigeons, peacock, pelican, king fisher

A type of crane

Mammals

- Widely distributed, most complex, endotherms
- 4 chambered heart, lungs for gas exchange
- Highly developed brains
- Young ones are born mostly, mother feed them with milk, provide parental care
- Have hairs on their body, provide insulation
- Thick skin with skin sensory receptors
- Heterotrophs, herbivores to omnivores

A rhinoceros

Importance of Vertebrates

These are beneficial

- Important parts of food chain and webs
- Beauty and diversity of nature
- Provides protein foods to human beings, eggs, milk, meat, honey
- Furs and feathers are used for various purposes
- By products of fish industry
- Pearls, clam culture
- Lac insect and silk worm
- Snake venom for medicines

These are harmful

- Poisonous animals, e.g. frogs, snakes,
- Parasitic animals, e.g. worms, mites, ticks
- Insect pests of crops
- Other animal pests e.g. rats
- Termites damage woody structures of buildings

Exercise

1. How biology helps in dealing with parasites?
2. How can we use knowledge of biology to improve our animal keeping capability?

Biology lecture # 17

Applications of Biology

Biology – Useful for Humankind and World

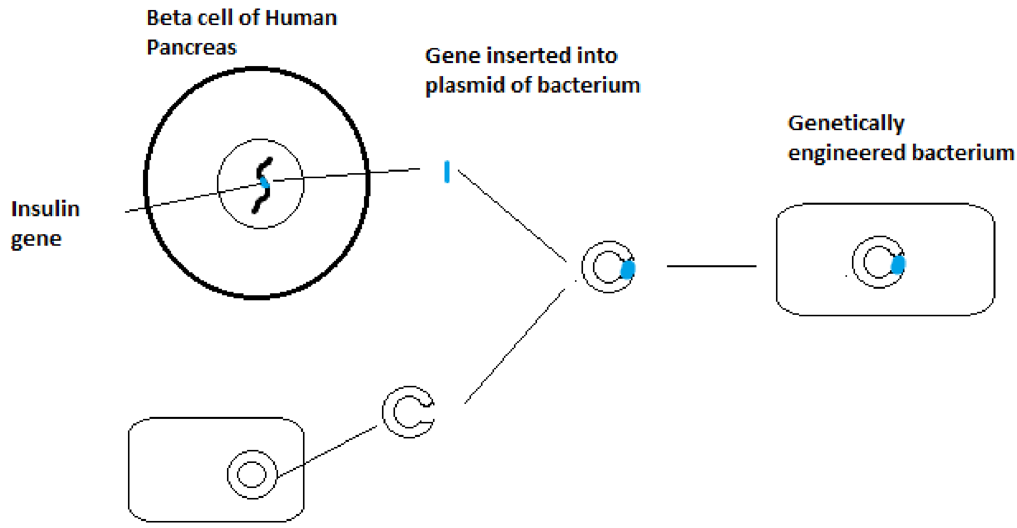
- Demands and problems are increasing with increase in population.
- Biologists investigate phenomena of nature and problem and find ways to resolve these.
- They introduced techniques and technologies to explore all biological resources to cope demands and resolve problems.

Biotechnology

- **Biotechnology** is the use and manipulation of biological processes, organisms and systems to manufacture products to improve the quality of human life.
- The term biotechnology was first used in 1970's.
- Some important applications
  - Genetic Engineering
  - Fermentation and Microorganisms

Genetic Engineering

- It is a process in which a useful gene is taken from one organism and inserted into another organism. The resulting organism is called transgenic.
- This process is carried out with the help of vectors and enzymes.
- Most common vector is bacterial plasmid.
- Most common enzymes are restriction endonucleases or restriction enzymes.



The Process of Genetic Engineering: Transgenic organisms (organisms that acquires a foreign gene)

Transgenic bacteria

- *E. coli – most commons microorganisms in biotechnology because these have many strains (types) which are non-pathogenic, i.e., these cannot produce disease.*
- *GRAS (Generally regarded as Safe) Organisms are those which are known for their non-pathogenecity.*
- Chemical industry: Acids and alcohols are produced using bacteria.
- Pharmaceutical industry
  - Formation of insulin by *E. coli* for diabetic patients
  - Formation of human growth hormone for dwarf children
  - Formation of vaccines

Transgenic Bacteria

Transgenic bacteria are used in many industries, for example:

- Food industry
  - Yogurt, Cheese, Sour creams are prepared using microorganisms
  - Breads b use of yeast
  - Beverages, drinks by yeasts or some bacteria

- Treatment of waste materials is also carried out using different form of bacteria or even yeast. The microorganisms are used to treat:
  - Solid wastes
  - Waste water
  - Oil spills
  - Nuclear wastes
- Bacteria and algae are also helpful in biofuels production (biogas, biodiesel etc).

Transgenic plants

These plants are produced to develop certain specific properties in these, for example, resistance to viruses. Some examples are following:

- Virus resistant crops (cotton)
- Insect resistant corn
- Genetically modified banana
- Pesticide resistant crops
- FOOD SAFETY AND SECURITY: This is very important in modifying food crops particularly that if we are inserting a gene of resistance or else, the plant should not develop any harmful characteristic. For this purpose, before selling any transgenic seed or other product to market, it is tested for safety. This is called *biosafety*.

Transgenic animals

- Transgenic mice as model of human disease
  - Obese rats, diabetic mice
- Genetically modified organisms to increase milk yield
- Genetically modified farm animals to produce antibodies
- FOOD SAFETY AND SECURITY: This is very important in modifying food producing animals particularly that if we are inserting a gene of interest the animal should not develop any harmful characteristic. For this purpose, before selling any transgenic product to market, it is tested for safety. This is called *biosafety*.

Fermentation Pathways

Microorganisms carryout fermentation, i.e., utilization of anaerobic pathway for production of energy. They produce many useful products for us during these pathways. These products are commercially produced by growing such organism in mass culture in very big vessels called *fermenters or bioreactors*.

Following products are obtained by this process:

- Biofuels
- Acids and alcohols
- Yogurt, cheese, sour creams
- Bread
- Beer, wine

Applications of biology in culturing Animal

Animals are traditionally cultured for their products

- Meat from fish, chicken, goats, cows
- Milk from cows, buffaloes
- Eggs from hens, ducks
- Wool from sheep
- Leather industry uses skins
- Honey from Honey bee
- Silk from silk worm


Poultry farms provide us with meat and eggs.

<u>Common types of animal cultures</u>

- Aquaculture
- Ornamental fish
- Seri culture (Silk worm)
- Dairy and Poultry
- Apiculture (honey bee)
- Biological pest control

We discuss these one by one briefly.

Aquaculture

Culturing animals in water is called aquaculture for example fish farming.

- Fish farming, Prawn culture
- Pearl oyster culture
- Other aquacultures (clams, lobsters etc.)
- Byproducts of fishing industry include many cosmetics and some animal diets.

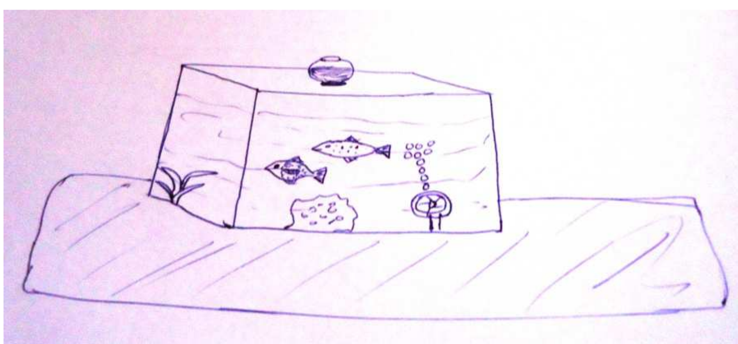
Biology helps in improvement of fish varieties and also extraction of various products from these, for example:

- Selection of fishes in a fish pond (herbivores, carnivores)
- Feed for fishes which may increase their production
- Diseases and their treatment: biology help in finding causes of diseases and their treatments.

Aquaculture for Ornamental Fish

Ornamental fishes are the beautiful usually small fishes kept in small aquaria in houses or other places like hotels. *Biology helps in:*

- Feed: which is good for their maintenance
- Diseases: how can we handle diseases
- Requirements for healthy culture in small to large aquaria



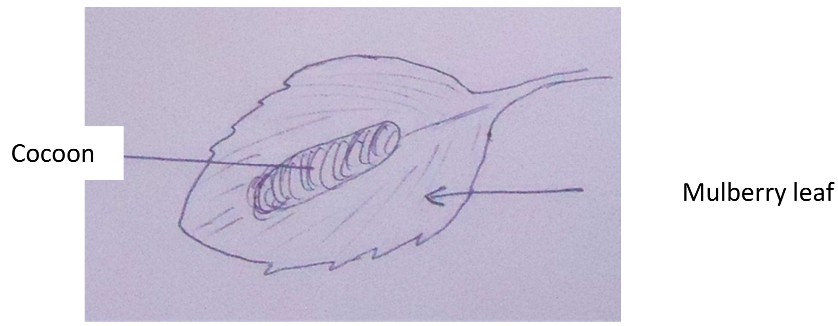
We keep aquaria at home

Sericulture

Culture of silk moth for making silk on mulberry leaves is called *sericulture*. It is a popular home industry in many parts of the world

Biology helps in improvement of this culture:

- Process of making silk
- Diseases in moth or larvae can result in huge loss
- Biology helps in making new varieties, e.g., wingless variety, varieties which completes 5-6 cycles in a year



Sericulture, a cocoon on the leaf of mulberry

Dairy and poultry

Biology plays very important roles in dairy and poultry industries. Biology helps in many ways for example:

- Improved breeding techniques and cross breeds (more vigorous and resistant).
- Improved quality and quantity yield of meat, milk, wool and eggs.
- Diagnosis and cure for diseases in farm animals.
- Biological knowledge is also helping in providing balanced food for best yield.

Apiculture (honey bee)

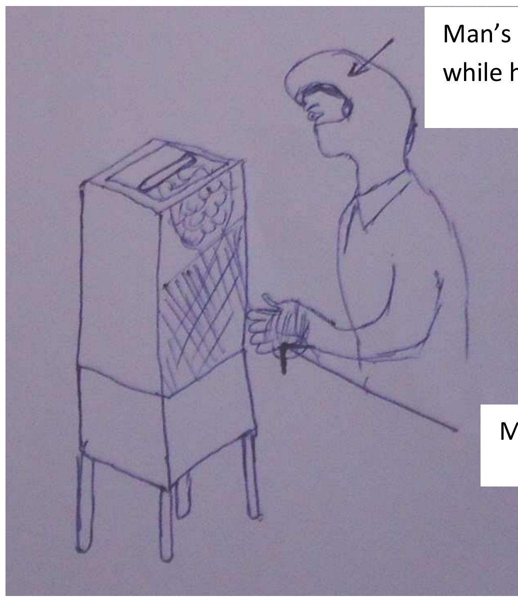
Keeping the honey bee for honey production is called Apiculture (Bee keeping). Biologists explore the phenomena behind Honey production, like knowledge of biology tells us that:

- Honey bee is a social insect and lives in large colonies
- Queen bee, drones and workers

Biology helps in understanding how this system works and can help in production of better varieties and improved system for culturing these animals to increase yield of honey.

Honey bee (small sized)

Honey bee (large sized)



A unit of honey bee keeping farm

Biological pest control

A large number of organisms damage the useful plants or animals and can cause huge losses. These are called pests, e.g., many insects damage crops.

There are few ways to control pests:

- Primary or cultural control
    - Crop rotation rather than monoculture, i.e., different crops are grown at different seasons.
- Chemical control
    - Various chemicals are used to kill insects but insects may develop resistance and chemicals are dangerous for health

- *Biological control* means that the pests are controlled or killed by living organisms.

- This is the most promising method of pest control
- The natural enemies and predators of the pests are used to kill the pests
- Lady beetles for citrus fruits
- *Bacillus thuringienesis for cotton*

Selection of biological control agent needs care. These should be ecologically safe. For example if we introduce a sparrow for eating an insect and that sparrow also start eating some plants. This will be even more harmful for crops and environment.

Advantages of biological pest control

- They do not pollute the environment.
- They do not disturb the natural ecosystem.
- A more permanent control because pest usually do not develop resistance

Applications of Biology in agriculture and plant growth

Plants are in many ways useful

- Parts of ecosystems, producers
- Food crops: crops, which makes our food like wheat, rice, vegetables.
- Many useful products like perfumes, medicines, furniture
- Beauty of the nature, ornamental plants

Biology helps in:

- Understanding the life cycles and methods of spread
- Better varieties by cross breeding or genetic engineering
- Disease mechanisms and control
- Appropriate soil, fertilizers and water availability

Exercise

1. Discuss the role of biology in apiculture.
2. Describe the process of sericulture.
3. What are important advantages of biocontrol?