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DEPARTMENT OF BIOLOGICAL SCIENCES

GENERAL BIOLOGY II

(BIO 102)

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BIO 102: GENERAL BIOLOGY II

COURSE OUTLINE

- Basic characteristics, identification and classification of bacteria
- Basic characteristics, identification and classification of fungi
- Basic characteristics, identification and classification of viruses
- Generalized survey of the plant and animal kingdoms based mainly on the study of similarities and differences in the external features.
- Ecological adaptations.
- Briefs on physiology to include nutrition, respiration, circulatory systems, excretion, reproduction, growth and development.

INTRODUCTION TO MICRO ORGANISMS

Microbiology is the study of microorganisms. These are organisms too small to be seen clearly by the unaided eyes. E.g. bacteria, fungi, virus, algae and protozoa

Classification Systems for Microorganisms

The five-kingdom system was established to classify organisms based on cell type and mode of nutrition. It includes Monera, Protista, Fungi, Plantae, and Animalia. Microorganisms except for viruses, which are acellular and have their own classification system, were placed in the first three kingdoms.

The Three Domains System of Classification

Presently, through advances in cell biology, biochemistry and genetics, microorganisms are now placed into three domains, namely:

i. Domain Bacteria (prokaryotic/true bacteria)
ii. Domain Archaea (prokaryotic /ancient bacteria)
iii. Domain Eucarya (eukaryotic)

Domain Bacteria

i. They are prokaryotic.
ii. They are single-celled organisms.
iii. They lack membrane bound nucleus and organelles.
iv. Most have cell wall that contains peptidoglycan.
v. They are found in the soil, water and air and on other living organisms.
vi. Some are harmful while others are beneficial to man.

Domain Archaea

i. They were formerly known as archaeobacteria.
ii. They are prokaryotic.
iii. They are single-celled organisms.
iv. They lack membrane bound nucleus and organelles.
v. They lack peptidoglycan in their cell walls.
vi. They have unique membrane lipids.
vii. Some have unusual metabolic characteristics, e.g. methanogens which generate methane gas.
viii. Many are found in extreme environments.

Domain Eucarya

i. They are simple organisms.

ii. Mostly unicellular.

iii. They are photosynthetic together with cyanobacteria.

iv. They produce about 75% of the plant's oxygen.

v. Commonly found in the aquatic environment.

vi. They are primary producers in food chains in aquatic habitat. E.g. protists and fungi

HISTORY OF MICROBIOLOGY

The development of the microscope enabled the study of microorganisms. Early microscopes, crafted from ground glass lenses, provided magnified views of these previously unseen entities. Pioneers in this exploration of the invisible microbial realm included Robert Hooke and Anthony Van Leeuwenhoek.

1. Robert Hooke (1635-1703), an English mathematician and natural historian.

- He coined the term "cells" to describe the "little boxes" he observed in examining cork slices with a compound microscope.
- He was the first to make a known description of microorganisms.
- He made microscopic observation and the earliest description of many fungi.
- Various species of fungi were clearly identified in his drawing and recorded in his book Micrographia.

2. Anthony Van Leeuwenhoek (1632-1723)

- He is known as the father of bacteriology and the first person to publish extensive and accurate observations of microorganisms
- He learned lens grinding as a hobby and made over 100 simple microscopes each capable of magnifying an image about 300 times.
- By using simple microscopes, he observed microscopic organisms which he called 'animalcules'.
- He discovered bacteria in 1676 while studying pepper water infusion and reported his observations in a series of letters to Royal Society of London which published them in 1684 in English translation.
- He made sketches of the different shapes of bacteria.

3. Francesco Redi (1626-1697)

He carried out a series of experiments on decaying meat and its ability to produce maggot spontaneously.

- He placed meat in three different containers, one was not covered, and the second was covered with fine gauze to exclude flies.
- Flies laid eggs on the uncovered meat and maggots developed.
- The two other slices of meat did not produce maggots.
- Spontaneously, flies were attracted to the gauze-covered container and laid their eggs on the gauze, these later produced maggots.
- Hence, it become evident that the generation of maggots resulted from the presence of fly eggs and that meat (a non-living matter) did not spontaneously generate maggots as previously believed.

Other scientists are: Louis Jablot (1670), John Needham (1713-1781), Lazzaro Spallanzani (1729-1799), Louis Pasteur (1822-1895).

Era of Molecular Microbiology (1970s)

- Advancement in the knowledge of bacterial physiology, biochemistry and genetics.
- Genetic manipulation which involves the transfer of DNA from one organism into another or a bacterium and the proteins encoded by the DNA harvested led to the development of the field of Biotechnology.
- DNA sequencing revealed the phylogenetic (evolutionary) relationships among bacteria which led to revolutionary new concepts in microbial systematic.
- Genomics.

BASIC ASPECTS OF MICROBIOLOGY

The basic branch of microbiology is concerned with the study of the biology of microorganisms. Fields of study in microorganisms includes:

i. Bacteriology: This is the study of bacteria.

ii. Mycology: The study of fungi such as yeasts, molds, and mushrooms.

iii. Algology: The study of algae.

iv. Protozoology: The study of protozoa; a branch of protozoology called parasitology deals exclusively with the parasite or disease producing protozoa and other parasitic micro and macro organisms.

v. Microbial Cytology: Studies the structures of microbial cells.

vi. Microbial Physiology: Studies of the nutrients that microorganisms require for metabolism and growth and the products that they make from nutrients.

vii. Microbial Genetics: Focuses on the nature of genetic information in microorganisms in microorganisms and how it regulates the development and functions of cells and organisms.

viii. Microbial Ecology: The study of microorganisms in their natural environment. It also studies the global and local contribution to nutrient cycling. In addition, it employs microorganisms in bioremediation to reduce pollution.

The Applied Aspects of Microbiology includes:

i. Medical Microbiology
ii. Agricultural Microbiology
iii. Industrial Microbiology
iv. Immunology
v. Food and Dairy Microbiology, etc

MICRO ORGANISMS AS FRIENDS AND FOES

Microorganisms are abundant in most natural environments and instigate numerous alterations. While some are advantageous, others are detrimental, impacting human well-being in various ways. Many microorganisms are beneficial, often termed as 'friends' and conversely, some microorganisms, considered 'foes', pose risks.

MICROORGANISMS AS FRIENDS

1. Many microorganisms are used to produce many of the foods and beverages we consume.
2. Production of Pharmaceuticals such as antibiotics, steroids vitamins, hormones, etc.
3. Production of Organic Acids e.g. Gluconic Acid, etc.
4. Microorganisms and the Environment: It can be used to clean up pollution created by human activities in a process called bioremediation.

MICROORGANISMS AS FOES

1. Microorganisms as Disease Agents e.g. Tuberculosis caused by a bacterium, mycobacterium tuberculosis, Cholera caused by a bacteria Vibrio cholera.
2. Microorganisms as Agents of Warfare and Terrorism

BASIC CHARACTERISTICS, IDENTIFICATION AND CLASSIFICATION OF BACTERIA

INTRODUCTION

Bacteria are distinguished by their cell shape, size, structure, arrangement, presence of specialized structures, developmental forms, staining reactions, and motility, including flagella arrangement. Additionally, bacterial characterization extends to factors such as cell wall composition, Gram stain reaction, cellular respiration, and nutritional mode. This unit explores the overarching characteristics of bacteria, encompassing their various shapes, forms, and both external and internal structures, among other aspects.

General Characteristics of Bacteria

i. They are simple prokaryotic cells.

ii. Bacteria are very small, 0.5 to 1.0µm in diameter. Because of their small size, they have high surface area/volume ratio which results in a high growth and metabolism rate.

iii. They are single celled organisms.

iv. They have distinctive cell wall which contain peptidoglycan

v. They are measured in micrometer

vi. Bacteria lack a true nucleus but have a region called the nucleroid region, i.e. DNA is free floating

vii. They may have additional DNA called a plasmid

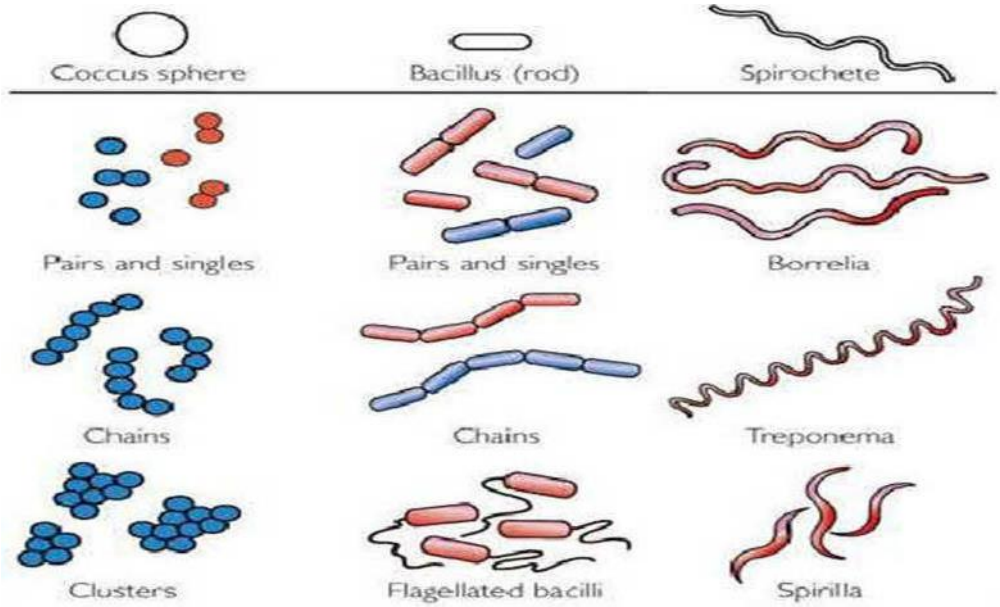
viii. Their reproduction is by binary fission

ix. They are ubiquitous.

x. The shape of a bacterium is governed by its rigid cell wall which gives it a definite shape.

Typical shapes of bacteria are:

- Cocci (round, oval or spherical), e.g. *Staphylococcus*
- Bacilli (rods) (Singular: rod, bacillus), e.g. *Bacillus subtilis*
- Vibrios (slightly curved rods, or comma shaped) e.g. *Vibrio cholerae.*
- Spirilla (helical bacteria, small, regularly coiled) e.g. *Spirillum minus.*
- Spirochaetes (helical, (complete twist), flexible, coiled) e.g. *Treponema pallidum*



Common Shapes of Bacteria **(Source:** Microorganisms in our World by Atlas (1995)

Other shapes include:

- Pear Shaped cells, e.g. *Pasteuri*
- Lobed Spheres, e.g. *Sulfolobus*
- Rods with squared ends, e.g. *Bacillus anthracis*
- Disk arranged stacks of coins, e.g. caryophanon
- Rods with helically sculptured surfaces, e.g. seliberia and many others.

The shape of a cell affects its survival and activity in the environment.

Structure of Bacteria

Examination of a bacterial cell will reveal several components and structures.

External structure of bacteria

1. Flagella
2. Pili/fimbriae which serves as the path of entry of genetic material during bacterial mating.
3. Capsules, Promoting attachment of bacteria to surfaces.
4. Sheaths: They facilitate moderate change of position.
5. Prosthecae: They increase surface area of the cell for nutrient absorption.
6. Stalks: They aid in attachment of the cells to surfaces.
7. Cell Wall: This provides structural rigidity and forms barrier against the outside environment. It has a high tensile strength conferred on it by a layer composed of a substance called peptidoglycan (murein)

Internal Structures of bacteria

1. Cytoplasmic Membranes
2. The Cytoplasm
3. Nuclear Material
4. Spores and Cysts

NUTRITION IN BACTERIA

The nutrition requirements of bacteria vary widely.

1. Based on their source of energy
2. Based on the source of carbon which is the major source of nutrient for all cells
3. Based on whether they need oxygen to survive or not

REPRODUCTION IN BACTERIA

Bacteria reproduce mainly by asexual method which most of the time is transverse binary fission.

STAINING OF BACTERIA

This staining technique makes use of properties in the cell wall of the bacteria i.e. the peptidoglycan content in the cell wall. Bacteria are classified as Gram +ve or Gram –ve according to their response to Gram staining procedure i.e based on the propensity of their cell wall to hold fast to the primary dye (crystal violet) or otherwise when exposed to a decolorizing agent such as acetone or 95% alcohol.

BASIC CHARACTERISTICS, IDENTIFICATION AND CLASSIFICATION OF FUNGI

Fungi are large, diverse and widespread group of organisms, the molds, mushrooms and yeasts. Fungi are better able to withstand certain extreme environments than other microorganisms. They can tolerate more acidic conditions than other microbes. Some types of yeasts are facultative; they can grow under both aerobic and anaerobic conditions. Molds and many types of yeast are usually aerobic microorganisms. Fungi grow over a wide range of temperature. The optimum temperature for most saprobic species is 22 to 30^0C, while pathogenic fungi have a higher temperature optimum of 30 to 37^0C. Some fungi will grow at or near 0^0C and thus can cause spoilage of meat and/or vegetables in cold storage.

STRUCTURE AND FORMS OF FUNGI

The body or vegetative structure of a fungus is called a thallus (plural thalli). It varies in complexity and size ranging from the single cell microscopic yeasts to multicellular moulds and mushrooms. The fungal cell is usually enclosed in a cell wall of chitin.

DISTINGUISHING CHARACTERISTICS OF FUNGI

1. Eukaryotic cells: Fungi are eukaryotic, meaning their cells have a true nucleus and other membrane bound organelles.
2. Heterotrophic: Fungi are heterotrophic, meaning they obtain their nutrients by decomposing organic matter or by forming symbiotic relationships with other organisms.
3. Cell walls: Fungal cells have cell walls made of chitin, a polysaccharide.
4. Reproduce by spores: Fungi reproduce by producing spores, which are similar to the seeds of plants.
5. Non-motile: Fungi are non-motile, meaning they cannot move on their own.
6. Multicellular: Most fungi are multicellular, meaning they are composed of many cells.
7. Thread-like structures: Fungi have thread-like structures called hyphae, which make up their mycelium (vegetative part of the fungus).
8. Symbiotic relationships: Fungi can form symbiotic relationships with other organisms, such as plants (mycorrhizae) and animals (lichens).
9. Decomposers: Fungi are important decomposers, breaking down organic matter and recycling nutrients.
10. Important in food chain: Fungi play a crucial role in the food chain, serving as a food source for many animals.
12. Produce secondary metabolites: Fungi produce secondary metabolites, such as antibiotics, toxins, and pigments.

IDENTIFICATION OF FUNGI

1. Morphology: Fungi come in a variety of shapes and sizes, including mushrooms, molds, and yeasts.
2. Spore print: The color and shape of the spores can be used to identify different species of fungi.
3. Chemical tests: Chemical tests, such as the KOH test, can be used to identify fungi based on their chemical composition.

CLASSIFICATION

Fungi are classified into several groups, including:

1. Ascomycota (sac fungi): This group includes morels, truffles, and cup fungi.
2. Basidiomycota (club fungi): This group includes mushrooms, puffballs, and bracket fungi.
3. Zygomycota (conjugated fungi): This group includes bread mold and Rhizopus.
4. Chytridiomycota (chytrid fungi): This group includes aquatic fungi that are important decomposers.
5. Deuteromycota (imperfect fungi): This group includes fungi that do not produce spores, such as yeasts and molds.

REPRODUCTION IN FUNGI

Fungi reproduces both sexually and asexually.

Asexual reproduction:

- Fungi reproduce asexually by fragmentation, budding, or producing spores.

- Asexual spores are genetically identical to the parent and may be released either outside or within a special reproductive sac called a sporangium.

- Adverse environmental conditions often cause sexual reproduction in fungi.

Sexual reproduction:

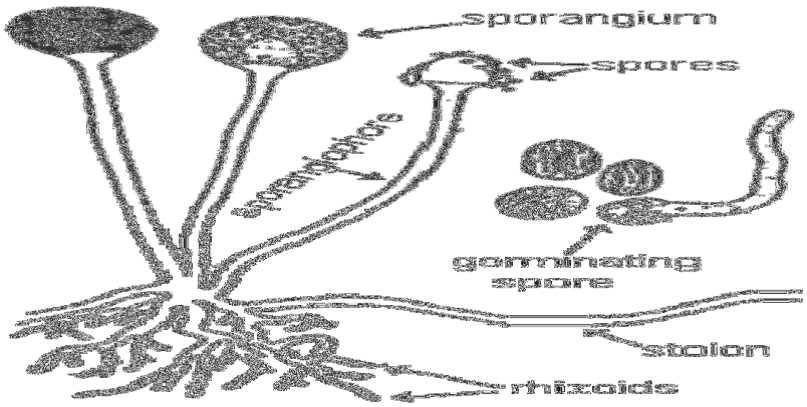
- Sexual reproduction introduces genetic variation into a population of fungi.

- Sexual reproduction includes the following three stages: plasmogamy, karyogamy, and gametangia.

- Plasmogamy occurs when two haploid cells fuse, leading to a dikaryotic stage where two haploid nuclei coexist in a single cell.

- Karyogamy occurs when the haploid nuclei fuse to form a diploid zygote nucleus.

- Finally, meiosis takes place in the gametangia, in which gametes of different mating types are generated



Rhizopus stolonifer

Source: Retrieved from the Backyard Nature Website at File://G:\Bread Mold Fungus, Rhizopus Stolonifer.htm.

NUTRITION IN FUNGI

Fungi are heterotrophic, they rely solely on carbon obtained from other organisms for their metabolism and nutrition. They get their nutrients by absorbing organic compounds from the environment, and they can obtain nutrients in three different ways:

1. Decomposition of dead organic matter: Saprotrophic fungi play a very important role as recyclers in ecosystem energy flow and biogeochemical cycles.
2. Feeding on living hosts: Parasitic fungi use enzymes to break down living tissue, which may cause illness in the host.
3. Living mutualistically with other organisms: Mutualistic fungi live harmlessly with other living organisms.

BASIC CHARACTERISTICS, IDENTIFICATION AND CLASSIFICATION OF VIRUSES

Introduction

Viruses are diverse entities: They vary in structure, methods of replication, and the hosts they infect. Nearly all forms of life—from prokaryotic bacteria and archaeans, to eukaryotes such as plants, animals, and fungi—have viruses that infect them. While most biological diversity can be understood through evolutionary history (such as how species have adapted to changing environmental conditions and how different species are related to one another through common descent), much about virus origins and evolution remains unknown.

The Study of Viruses

Microscopically small infectious organisms known as viruses can only replicate inside the cells of their hosts. Biologically speaking, viruses cannot be categorized as either living things or non-living things. A virus is a type of infectious agent that can only reproduce inside of its host organism. This is because they have specific distinguishing characteristics of both living and non-living things. A virus, in its simplest form, is an infectious, non-cellular organism consisting of genetic material and protein that can only enter and reproduce inside the living cells of bacteria, plants, and animals. For example, a virus is unable to replicate outside of the host cell. This is due to the absence of the necessary cellular machinery in viruses. As a result, it enters and binds to a particular host cell, injects its genetic material, reproduces using the genetic material of the host, and then the host cell ruptures, releasing the new viruses. Additionally, viruses can crystallize, something that no other living thing can achieve. These elements are what cause viruses to be categorized as existing in a gray area between living things and non-living things.

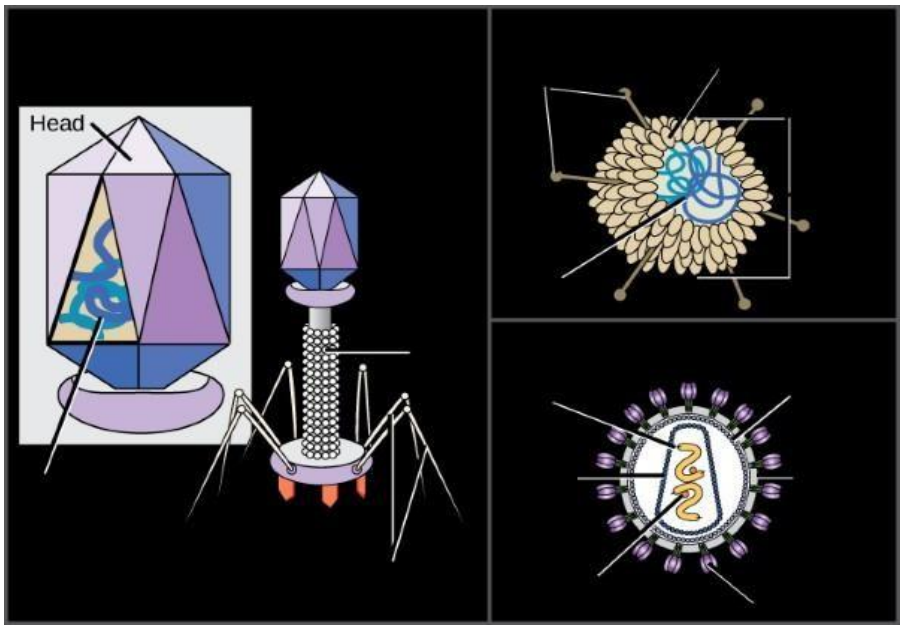
Basic Characteristics of Viruses

1. A **virus** is nothing more than some DNA or RNA surrounded by a coat of proteins.
2. A virus is not a cell.
3. A virus cannot use energy, respond to stimuli, grow, or maintain homeostasis.
4. A virus cannot reproduce on its own. However, a virus can reproduce by infecting the cell of a living host. Inside the host cell, the virus uses the cell's structures, materials, and energy to make copies of itself.
5. Because they have genetic material and can reproduce, viruses can evolve. Their DNA or RNA can change through time. The ability to evolve is a very lifelike attribute.

Based on their characteristics, many scientists think that viruses should not be classified as living things because they lack most of the defining traits of living things. Other scientists aren't so sure. They think that the ability of viruses to evolve and interact with living cells earns them special consideration. Perhaps a new category of life should be created for viruses. What do you think?

Structure of a Virus

Viruses are extremely small, with sizes between 30 and 50 nm. In contrast to having no cells and frequently having no cell wall, viruses are encased in a layer of protective protein called a capsid. It has a genetic component and is distinguished by the coevolution of the host and the virus. The genetic material in them is either DNA or RNA. In order to spread, viruses primarily rely on hosts to provide the sophisticated metabolic machinery of prokaryotic or eukaryotic cells. The virus's primary function is to deliver its DNA or RNA genome to the host cell, where the host cell can then transpose it. A symmetric protein that has been capsuled contains the viral genome structure. The protein associated with nucleic acid (also known as nucleoprotein) produces the nucleocapsid with the genome.



Three relatively complex virions (the bacteriophage T4, with its DNA-containing head group and tail fibers that attach to host cells)

Source: **http://library.open.oregonstate.edu/microbiology/**

These microorganisms belong to the virus genus and the viridae family. Because they essentially exist in a state beyond living entities and inanimate objects, viruses cannot be sorted into any of the established kingdoms. The term "virus" was coined by Dutch microbiologist Martinus Willem Beijerinck in 1897. Its etymology traces back to Latin, where it signifies a toxic or harmful substance. Following infection of a

susceptible cell, a virus can activate the cell's mechanisms to generate additional virus particles. Viruses consist of a DNA or RNA core enveloped by a protein coat. Their dimensions range from 20 nanometers to 250 nanometers, an extraordinarily minute scale. Detection typically requires an electron microscope due to their size. Numerous viruses possess either DNA or RNA as their genetic material, often in single or double strands.

A complete infectious virus, known as a virion, comprises genetic material and an outer protein shell. The complexity of viruses varies, with the simplest encoding around four proteins in their DNA or RNA, while the most intricate viruses encode 100 to 200 proteins. The study of virus is known as virology.

Classification of Viruses

The primary elements utilized for the classification of viruses encompass their observable characteristics, core composition, chemical constitution, capsid structure, size, shape, replication mechanisms, and other structures within their genetic makeup. The Baltimore classification system is the predominant method employed for studying virus classification. This system was formulated by American biologist David Baltimore during the 1970s, leading to his receipt of the Nobel Prize. The subsequent content delves into the categorization of viruses according to diverse criteria.

The conventional methods devised by scientists for categorizing prokaryotic and eukaryotic cells prove to be of limited utility since viruses are likely to have originated from varied sources. Genomic or protein analysis also holds minimal value if viruses are remnants of other life forms. This is due to the absence of a shared genomic sequence across all viruses. For instance, the commonly employed 16S rRNA sequence in constructing prokaryotic phylogenies becomes irrelevant for entities lacking ribosomes, like viruses. Biologists have employed multiple classification systems in the past. Initially, viruses were grouped based on shared morphology. Subsequently, different subsets of viruses were categorized based on the presence of DNA or RNA, as well as the single-stranded or double-stranded nature of their nucleic acids. Yet, these older classification schemes divided viruses into separate groups due to reliance on diverse virus characteristics. The Baltimore classification system, currently the predominant approach, hinges on how messenger RNA (mRNA) is generated in distinct types of viruses.

1. **Classification based on the presence of nucleic acid**
    a. **DNA**: The virus, having DNA as its genetic material. There are two different types of DNA virus. Single-stranded (ss) DNA virus: e.g. Picornaviruses, Parvovirus etc. Double-stranded (ds) DNA virus: e.g. Adenovirus, Herpes virus, etc.
    b. **RNA virus:** The virus, having RNA as its genetic material. There are two different types of RNA virus. Double-stranded (ds) RNA virus: e.g. Reovirus, etc. Single-stranded (ss) RNA virus. It is further classified into two Positive sense RNA (+RNA) and negative sense RNA (-RNA).

Poliovirus, Hepatitis A, Rabies virus, Influenza virus are examples of single-stranded RNA virus.

2. Classification based on the structure or symmetry

Viruses come in different shapes, from basic helical and icosahedral shapes to more intricate ones. The classification based on different shapes and symmetry of viruses are as follows:

a. Complex virus. E.g Poxvirus
b. Radial symmetry virus. E.g.Bacteriophage
c. Cubical or icosahedral symmetry shaped virus. E.g. Reovirus, Picornavirus
d. Rod or Spiral shaped or helical symmetry virus. E.g. Paramyxovirus, orthomyxovirus

3. Classification based on the replication properties and site of replication

Here, viruses invade into the host cell, where it replicates and assembly within the cell organelles.

a. Replication within the cytoplasm of the host cell. E.g. All RNA viruses except the Influenza virus.
b. Replication within the nucleus and the cytoplasm of the host cell. E.g. Influenza virus, Poxvirus, etc.
c. Replication within the nucleus of the host cell. All DNA viruses except Pox virus.
d. Replication of the virus through the double-stranded DNA intermediate. E.g. All DNA viruses, Retrovirus and some tumour causing RNA virus.
e. Replication of the virus through a single-stranded RNA intermediate. E.g. All RNA viruses except Reovirus and tumour-causing RNA viruses.

4. Classification based on the host range

Based on the type of host, there are four different types of viruses:

a. Animal viruses

These viruses infect by invading the cells of animals, including humans. Prominent examples of animal viruses include the influenza virus, mumps virus, rabies virus, poliovirus, Herpes virus, etc.

b. Plant viruses

These viruses infect plants by invading the **plant cells.** Replication of plant viruses is obligate and does not happen without a host. Well- known examples of plant virus include the potato virus, tobacco mosaic virus (TMV), beet yellow virus, and turnip yellow virus, cauliflower mosaic

virus, etc.

c. Bacteriophage

The virus which infects bacterial cells is known as bacteriophage. There are many varieties of bacteriophages, such as DNA virus, MV-11, RNA virus, λ page, etc.

d. Insect virus

The virus which infects insects is known as Insect virus, also called the viral pathogen of insects. These viruses are considered as a powerful biocontrol agent in the landscape of modern agriculture. Ascovirus virions and Entomopox virus, are best examples for insect virus.

5. **Classification based on the mode of transmission**

a. Airborne infections – Transmission of the virus through the air into the respiratory tract. E.g. Swine flu, and Rhinovirus.
b. Fecal oral route – Transmission of the virus through the contaminated water or food. E.g. Hepatitis A virus, Poliovirus, Rotavirus.
c. Sexually transmitted diseases – Transmission of the virus through sexual contacts with the infected person. E.g. Retrovirus, human papillomavirus, etc.
d. Transfusion-transmitted infections- Transmission of the virus through the blood transfusion. E.g. Hepatitis B virus, Human Immunodeficiency Virus, etc.
e. Zoonoses -Transmission of the virus through the biting of infected animals, birds, and insects to human. E.g. Rabies virus, Alpha virus, Flavivirus, Ebola virus, etc.

Identification of Viruses

Regardless of the method of cultivation, once a virus has been introduced into a whole host organism, embryo, or tissue-culture cell, a sample can be prepared from the infected host, embryo, or cell line for further analysis under a brightfield, electron, or fluorescent microscope. Methods in identification of plant viruses.

1. Viruses are inoculated into indicator plants which develop typical symptoms when infected by specific viruses and in virus assay.
2. Serological tests are carried out using antisera of known viruses.

3. Transmission aspects of the virus are considered: whether by sap inoculation, and the vectors, if any, involved; whether the virus is persistent or non-persistent in the vector; whether stylet borne, circulative or propagative, and other aspects of its transmission.
4. Such properties as the thermal inactivation point, the dilution end point, and survival outside the plant can be used to characterize viruses.
5. Interaction with other viruses is considered, notably cross- protection.
6. Host range and symptoms are studied.
7. Study of morphology and chemical constitution of the virus particle.

Cultivation of Viruses

Viruses cannot be grown in standard microbiological culture: e.g. broth and agar - They need to be cultured in the presence of a suitable host such as: prokaryotes (easiest to grow in the lab), plants and animals because they are unable to reproduce independently of living cells. Methods used include the following: - Use of embryonated eggs - Tissue culture - Culturing viruses in plants and animals - Culturing viruses in bacteria.

1. Culturing Viruses in Bacteria

Viruses can be grown in cultures maintained in either liquid or agar plates - Bacteria and phages are mixed with warm nutrient agar and poured on a thin layer on the surface of an agar plate

a. During incubation: - Bacterial cells infected by phages are lysed and release new phages that infect the nearby bacterial cells - The uninfected bacterial cells grow and reproduce normally
b. Appearance of plate after incubation: - The plate has a uniform bacterial lawn interrupted by clear zones - The clear zones are known as plaques
c. Estimation of phage numbers - This is done by using the plaque assay - Each plaque corresponds to a single phage in the original bacterium or virus mixture

2. Cell Culture

Cell culture is aseptically removing tissue fragments in order to cultivate multicellular eukaryotic cells, particularly animal cells. It is a helpful technique for growing clinical samples that may include viruses. It aids in the laboratory detection, characterisation, and identification of viruses. Because cell material is always available, cell lines make it easy to study viruses. Treatment of the tissues with an enzyme that dissolves the intracellular cement causes the tissues to become dissociated. A flat surface, such as the bottom of a culture flask or a Petri dish, is used to disperse the resulting suspension. A monolayer is the term used to describe the thin layer of cells that eventually appears on the plate's surface. This is incubated at the appropriate temperature and covered with an appropriate culture medium. Some cell cultures can be

maintained as permanent cell lines and cultivated indefinitely. However, a culture won't always continue to grow indefinitely; instead, it may exist for a few days. These cultures are referred to as primary cell lines. Despite the necessity to occasionally prepare new viruses from different sources, these cells may still be useful for developing viruses.

Procedure

1. A layer of animal cells is covered with a virus inoculums and viruses are allowed time to settle and attach to the cells
2. Plates are usually incubated at 37°C in the presence of 5%CO2
3. Localised areas of destruction and lysis called plaques are often formed and may be detected if stained with dyes such as tryptan blue or neutral red that are used to distinguish live cells from dead ones
4. In some cases virus growth may cause microscopic or macroscopic degenerative changes or abnormalities in host cells and tissues known as cytopathic effects
5. Cytopathic effects may be lethal

Disadvantages

1. Expensive and time consuming method used to cultivate viruses
2. Cells are grown under controlled conditions outside their natural environment

Components of medium used in tissue culture

1. Amino acids, vitamins, salts, glucose, bicarbonate buffer system
2. Blood serum is usually added to obtain best growth
3. Antibiotics are added to prevent bacterial and fungal contamination
3. Use of whole organs or part of organs of animals

In some cases, whole organs or pieces of animal organs may be used for successful replication of viruses - Involves use of less-controlled laboratory environment because part of animal is used - Animals used include: monkeys, rabbits, guinea pigs, rats, hamsters, and mice - Live inoculation of human volunteers was first used for the of yellow fever.

4. Culturing viruses in embryonated chicken eggs

1. Inexpensive method to culture viruses
2. The yolk is nourishing and this is a suitable environment for viruses to grow in
3. Fertilized chicken eggs incubated for 6-8 days after laying are used

Procedure

1. The egg shell surface is disinfected with iodine and a small sterile drill is used to create a hole.
2. Viruses are then inoculated into the embryo either on the chloriallantoic membrane or on the allantoic cavity (these are the sites often used to grow animal viruses)

3. The hole is then sealed with gelatine and the eggs are incubated.
4. Viruses may be able to reproduce only in certain parts of the embryo and thus should be injected onto the proper region.
5. Examples of viruses grown in this manner include: mumps virus (prefers the allantoic cavity), myxoma virus (prefers chloriallantoic membrane).
6. Infection may be characterised by local tissue lesion known as a pock whose appearance often is characteristic of the virus

5. Cultivation of plant viruses

a) Cultivated in a variety of ways o Use of plant tissue culture o or Cultures of separated cells o or cultures of protoplasts o or use of Whole plants

b) Leaves are mechanically inoculated when rubbed with a mixture of viruses and an abrasive such as carborandum

c) When the cell walls are broken by an abrasive, viruses directly contact the plasma membrane and infect the exposed host cells

d) Insects may also fill the role of an abrasive by sucking or crushing the plant leaves and thus transmitting viruses

e) A localized necrotic lesion often develops due to rapid death of cells in the infected area

f) Infected plants may show symptoms such as changes in pigmentation or leaf shape

g) Some plant viruses can be transmitted only if a diseased part is grafted onto a healthy plant

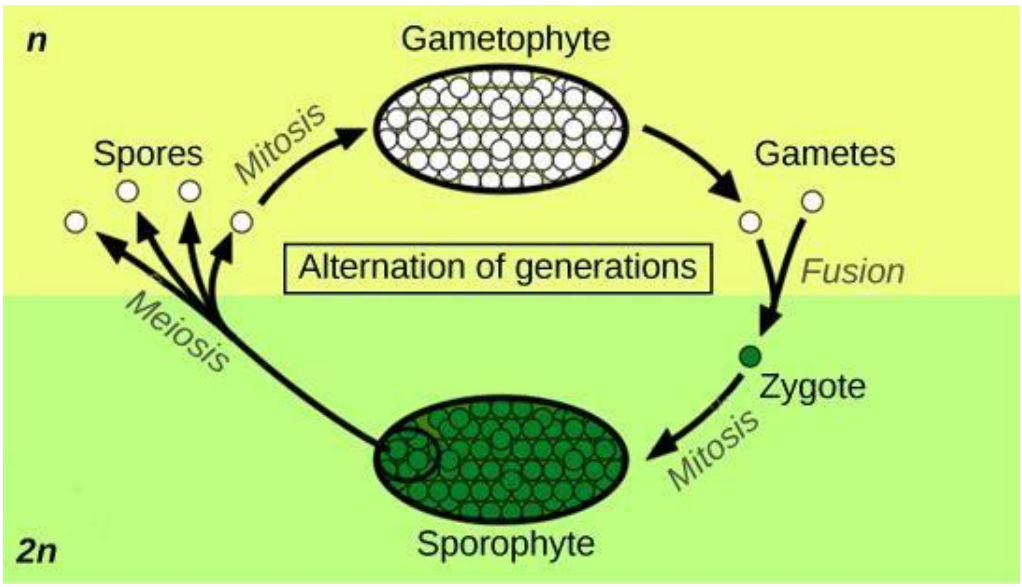
A GENERALIZED SURVEY OF THE PLANT KINGDOM

Introduction

Plants comprise a diverse and extensive array of organisms, with nearly 300,000 species identified and catalogued. Among these, approximately 260,000 are seedproducing plants. Included within the plant kingdom are mosses, ferns, conifers, and flowering plants. Predominantly, plants are photosynthetic organisms, although some are chemosynthetic or parasitic. Plants are characterized by cell walls composed of cellulose. While sexual reproduction is common among plants, they also employ various methods of asexual reproduction.

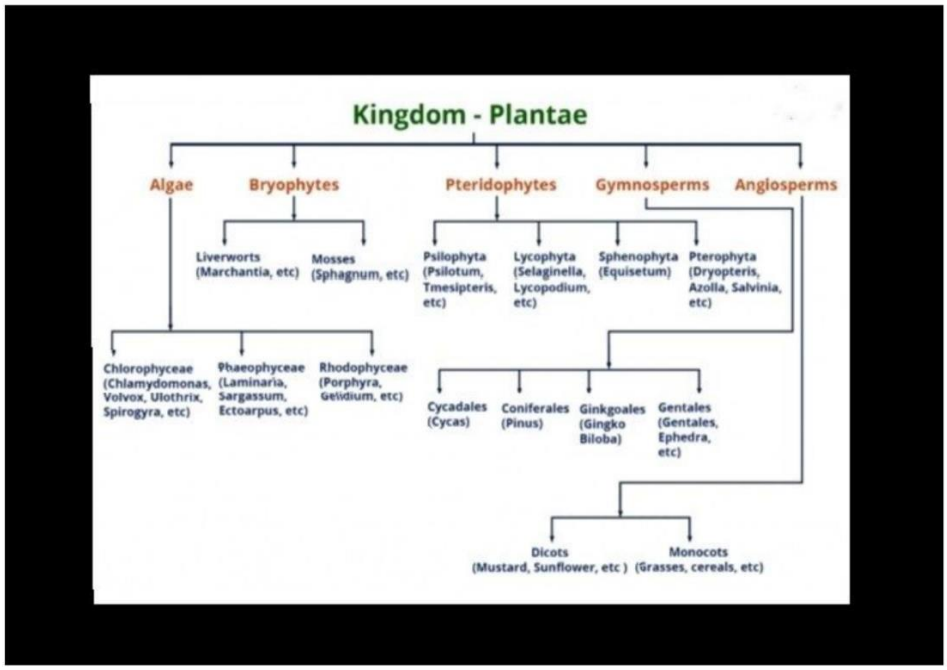
CHARACTERISTICS

1. **Multicellular Organization**: Plants are multicellular organisms composed of different types of cells organized into tissues, organs, and organ systems.
2. **Cell Wall**: Plant cells have rigid cell walls primarily composed of cellulose, providing structural support and protection.
3. **Chloroplasts** and Photosynthesis: Plants contain chloroplasts, which are organelles responsible for photosynthesis. They capture sunlight and convert it into chemical energy, producing glucose and releasing oxygen as a byproduct.
4. **Alternation of Generations**: Most plants undergo an alternation of generations life cycle, alternating between a multicellular haploid gametophyte phase and a multicellular diploid sporophyte phase.



Alternation of generations between the 1n gametophyte and 2n sporophyte.
Source: https://openstax.org/books/concepts-biology/pages/14-1-the-plant- kingdom

5. **Reproduction**: Plants reproduce sexually through the production of gametes (sperm and egg cells) and fertilization. They also reproduce asexually through various methods such as fragmentation, budding, or the production of specialized structures like runners or rhizomes.
6. **Plant Adaptations to Life on Land**: As plants adapt to life on land, they have to contend with several challenges in the terrestrial environment. In terrestrial ecosystems, four major adaptations are found which are:
    i. Alternation of generations,
    ii. A sporangium in which spores are formed,
    iii. A gametangium that produces haploid cells, and,
    iv. Apical meristem tissue in roots and shoots (in vascular plants).



Diversity of Kingdom Plantae

Source: https://www.studocu.com/

CLASSIFICATION

1. **Non-Vascular Plants (Bryophytes):** These are the simplest plants and include mosses, liverworts, and hornworts. They lack vascular tissues for water and nutrient transport and are typically found in moist environments.
2. **Vascular Plants:**

a. **Seedless Vascular Plants (Pteridophytes):** These include ferns, horsetails, and clubmosses. They have vascular tissues (xylem and phloem) for efficient water and nutrient transport but reproduce via spores rather than seeds.

b. Seed Producing Plants (Spermatophytes):

i. **Gymnosperms**: Gymnosperms produce naked seeds that are not enclosed within a fruit. They include conifers (pines, spruces, firs), cycads, ginkgoes, and gnetophytes.

ii. **Angiosperms**: Angiosperms produce seeds enclosed within fruits. They are the most diverse group of plants and include trees, shrubs, herbs, and grasses.

ECOLOGICAL IMPORTANCE

1. Primary Producers: Plants are the primary producers in terrestrial ecosystems, converting solar energy into organic compounds through photosynthesis and forming the base of food chains.

2. Habitat and Food Source: Plants provide habitat and food for a wide range of organisms, including insects, birds, mammals, and other plants.
3. Oxygen Production: Through photosynthesis, plants release oxygen into the atmosphere, playing a critical role in maintaining the balance of atmospheric gases.
4. Soil Formation and Stabilization: Plants contribute to soil formation through the decomposition of organic matter and help stabilize soil with their root systems, preventing erosion.

A GENERALIZED SURVEY OF THE ANIMAL KINGDOM

The animal kingdom, also known as Animalia, comprises a vast array of organisms, ranging from microscopic invertebrates to massive mammals.

CLASSIFICATION

The animal kingdom is classified into several hierarchical levels:

Phylum: The kingdom Animalia is divided into various phyla, such as Chordata (which includes vertebrates), Arthropoda (insects, arachnids, etc.), Mollusca (snails, octopuses, etc.), and many others.

Class: Each phylum is further divided into classes. For example, the class Mammalia includes animals that have mammary glands and hair/fur.

Order, Family, Genus, Species: Further subdivisions within classes are based on increasingly specific characteristics. For example, within the class Mammalia, there are orders like Carnivora (carnivores) and Primates (including humans).

CHARACTERISTICS

Animals share several key characteristics that distinguish them from other kingdoms (such as plants, fungi, and bacteria):

1. **Multicellularity**: Animals are multicellular organisms, meaning they are composed of more than one cell.

2. **Heterotrophy**: Unlike plants, which can produce their own food through photosynthesis, animals are heterotrophic, meaning they must ingest organic material for sustenance.

3. **Mobility**: Most animals are capable of movement at some stage of their life cycle, whether it's locomotion for hunting, migration, or other purposes.

4. **Nervous System**: Animals have a nervous system that allows them to respond to stimuli in their environment, enabling them to adapt and survive.

5. **Reproduction**: Animals typically reproduce sexually, although some species also reproduce asexually. Sexual reproduction involves the fusion of gametes (sperm and egg) from two parents to produce offspring with genetic variation.

6. **Developmental stages**: Many animals undergo distinct stages of development from birth (or hatching) to adulthood, which may include larval stages, metamorphosis, or other transformations.

7. Animals are classified based on body symmetry and developmental traits. Symmetry, such as radial or bilateral, categorizes animals into groups like Parazoa, Placozoa, Cnidaria, and Bilateria. Radial symmetry, seen in jellyfish, has body parts arranged around a central axis. Bilateral symmetry, like in butterflies, divides animals into equal halves. Ctenophores exhibit rotational symmetry. Each symmetry type suits the lifestyle of the animal.

DIVERSITY OF THE ANIMAL KINGDOM

The animal kingdom is incredibly diverse, with millions of known species and potentially many more yet to be discovered. Some major groups within the animal kingdom include:

1. Phylum Porifera (Sponges):

- Simple, multicellular organisms with porous bodies.
- Lack true tissues and organs.
- Filter feeders that pump water through their bodies to obtain food and oxygen.

2. Phylum Cnidaria (Cnidarians):

- Include jellyfish, corals, sea anemones, and hydras.
- Possess radial symmetry and specialized stinging cells called cnidocytes.
- Some exist as polyps (sessile) while others are medusae (free-swimming).

3. Phylum Platyhelminthes (Flatworms):

- Flat-bodied, unsegmented worms.
- Includes planarians, flukes, and tapeworms.
- Many are parasitic, while others are free-living.

4. Phylum Nematoda (Roundworms):

- Unsegmented worms with cylindrical bodies.
- Found in diverse habitats including soil, water, and animals.
- Many are parasitic, causing diseases in plants, animals, and humans.

5. Phylum Annelida (Segmented Worms):

- Segmented worms with bodies divided into repeated segments.
- Includes earthworms, leeches, and marine polychaetes.

- Exhibit diverse lifestyles, from burrowing in soil to swimming in oceans.

6. Phylum Mollusca (Mollusks):

- Soft-bodied animals often protected by a hard shell.

- Divided into classes such as Gastropoda (snails, slugs), Bivalvia (clams, oysters), and Cephalopoda (squids, octopuses).

- Many have a radula, a feeding structure used for scraping food.

7. Phylum Arthropoda (Arthropods):

- Largest phylum, characterized by jointed appendages and a segmented body.

- Includes insects, arachnids, crustaceans, and myriapods.

- Exhibit remarkable diversity in size, habitat, and behavior.

8. Phylum Echinodermata (Echinoderms):

- Marine animals with spiny skin and a unique water vascular system.

- Include starfish, sea urchins, sand dollars, sea cucumbers, and brittle stars.

- Exhibit radial symmetry as adults.

9. Phylum Chordata (Chordates):

- Possess a notochord, dorsal nerve cord, pharyngeal gill slits, and a post-anal tail at some stage in their life cycle.

- Divided into subphyla including Vertebrata (vertebrates) and Urochordata (tunicates).

- Vertebrates include fish, amphibians, reptiles, birds, and mammals.