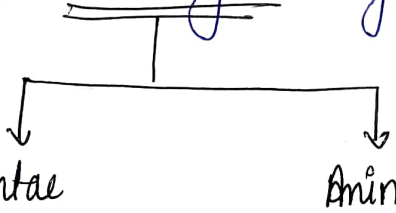
# Biological Classification

- Aristotle was the earliest to attempt a more scientific basis for classification.
- He used simple morphological characters to classify plants into trees, shrubs and herbs.
- He also divided animals into two groups, those which have red blood and those that did not.
- In Linnaeus time a two Kingdom system of classification

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- included all plants and animals respectively.
- did not distinguish b/w prokaryotes and eukaryotes, unicellular and multicellular organisms and photosynthetic (green algae) and non-photosynthetic (fungi) organisms.
- This classification was easily done and was easy to understand but a large number of organisms did not fall into either category.

- Hence, 2 Kingdom classification was found inadequate.

- Classification systems for the living organisms have hence, undergone several changes over the time.
- Though plant and animal kingdoms have been a constant under all different systems, the understanding of what groups / organisms be included under these kingdoms have been changing.
- The number and nature of other kingdoms have also been understood differently by different scientists over the time.
- R. H. Whittaker (1969) proposed a five kingdom classification
- Kingdoms defined by him were named Monera, Protista, Fungi, Plantae and Animalia.
- Main criteria for classification used by him include cell structure, body organisation, mode of nutrition, reproduction and phylogenetic relationships.

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Amrita Rawal Ma'am

# Characteristics of the Five Kingdoms.

| Characters | Five Kingdoms | | | | |
|---|---|---|---|---|---|
| | Monera | Protista | Fungi | Plantae | Animalia |
| Cell type | Prokaryotic | Eukaryotic | Eukaryotic | Eukaryotic | Eukaryotic |
| Cell wall | Noncellulosic (Polysaccharaide + amino acid) | Present in some | Present with chitin | Present (Cellulose) | Absent |
| Nuclear membrane | Absent | Present | Present | Present | Present |
| Body organisation | Cellular | Cellular | Multicellular/ loose tissue | Tissue/ organ | Tissue/ organ/ organ system |
| Mode of Nutrition | Autotrophic (Chemosynthetic and photosynthetic and Heterotrophic (saprophytic/parasitic) | Autotrophic (photosynthetic) and Heterotrophic | Heterotrophic (saprophytic/ parasitic) | Autotrophic (Photosynthetic) | Heterotrophic (Holozoic/ saprophytic etc.) |

- The three domain system has also been proposed that divides the Kingdom Monera into two domains, leaving the remaining eukaryotic Kingdoms in the three domain and thereby a six Kingdom classification.

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- Let us look at five kingdom classification to understand the issues and considerations that influenced the classification system.
- Earlier classification systems included bacteria, blue green algae, fungi, mosses, ferns, gymnosperms and the angiosperms under 'Plants'.
- Character that unified this whole kingdom was that, all organisms had a cell wall in their cells.
- This placed together groups which widely differed in other characteristics.
- It brought together the prokaryotic bacteria and the blue green algae (cyanobacteria) with others which were eukaryotic.
- Also grouped together the unicellular organisms and the multicellular ones.

  Example Chlamydomonas and Spirogyra → placed together under algae.

- The classification did not differentiate between the hetero-trophic group – fungi and the autotrophic green plants.

  fungi → had chitin in cell walls

  Characteristic difference

  green plants → had a cellulosic cell wall

  when such characteristics were considered, fungi were placed in separate kingdom → Kingdom Fungi

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- All prokaryotic organisms were grouped together under Kingdom Monera.

- Unicellular eukaryotic organisms under - Kingdom Protista

- Kingdom Protista has brought together Chlamydomonas, Chlorella (earlier placed in algae within Plants and both having cell wall) with Paramoecium and Amoeba (which were earlier placed in the animal Kingdom which lack cell wall).

- This has put together organisms which, in earlier classifications, were placed in different Kingdoms.

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This happens, because the criteria for classification changed.

- Over time, an attempt has been made to evolve a classificatio system which reflects not only the morphological, physiologica and reproductive similarities, but is also phylogenetic i.e. based on evolutionary relationships.

- Characteristics of Kingdoms Monera, Protista and Fungi of the Whittaker system. The Kingdoms Plantae and Animalia.

- **Kingdom Monera**: Bacteria are the sole members of this kingdom.
- are the most abundant micro-organisms.
- also live in extreme habitats such as hot springs, deserts, snow and deep oceans.
- Many of them live in or on other organisms as parasites.
- Bacteria are grouped under four categories based on their shape.
  - (i) the spherical cocus
  - (ii) the rod-shaped Bacillus
  - (iii) the comma-shaped vibrum
  - (iv) the spiral spirillum.

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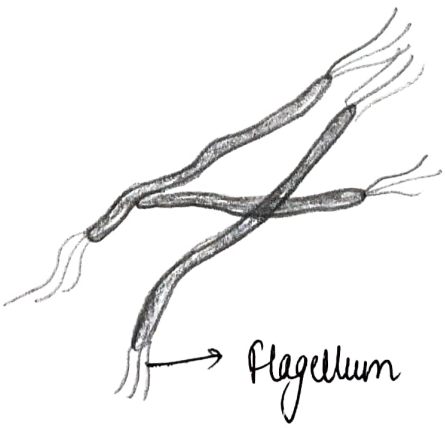
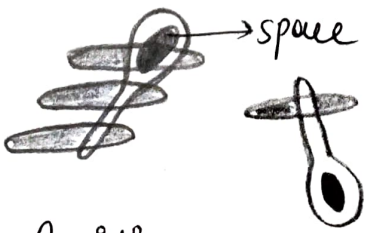
Cocci




Spirilla

Vibrio




Bacilli

Fig: Bacteria of different shapes

- Bacterial structure is very simple, they are very complex in behaviour.

- Compared to others, bacteria as a group show the most extensive metabolic diversity.

- Some are autotrophic : synthesis own food from inorganic substance.

- may be photosynthetic autotrophic or chemosynthetic autotrophic.

- Vast majority of bacteria are heterotrophs → depend on other organisms or on dead organic matter for food.

- Archaebacteria : These bacteria are special since they live in some of the most harsh habitats.

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→ such as extreme salty areas (halophiles)

→ hot springs (thermoacidophiles)

→ marshy areas (methanogens)

- Archaebacteria differ from other bacteria in having a different cell wall structure. (responsible for their survival in extreme conditions)

- Methanogens are present in the gut of several ruminant animals such as cows and buffaloes.

- Methanogens are responsible for the production of methane (biogas) from dung of cows and buffaloes.

- Eubacteria : There are thousands of different eubacteria or true bacteria.
  - Characterised by the presence of a rigid cell wall and if motile, a flagellum.
  - The cyanobacteria (also referred to as blue-green algae) have chlorophyll a similar to green plants and are photosynthetic autotrophs.

- Cyanobacteria are unicellular, colonial or filamentous, freshwater / marine or terrestial algae.
- Colonies are generally surrounded by gelatinous sheath.
- Often form blooms in polluted water bodies.
- Some can fix atmospheric nitrogen in specialised cells called heterocysts

Example : Nostoc and Anabaena.

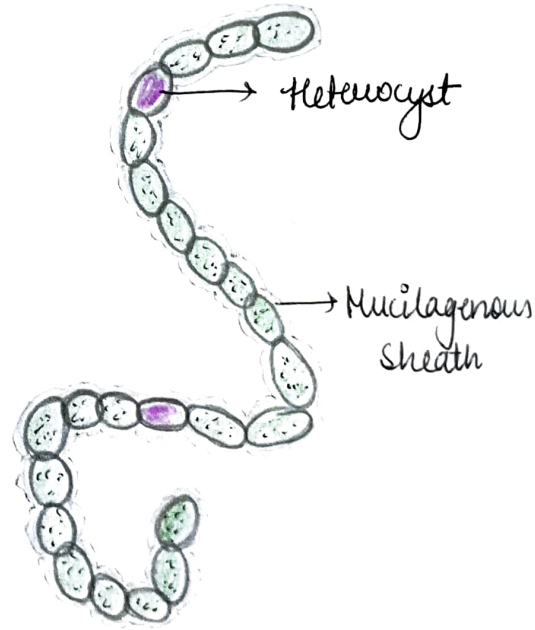


Fig: A filamentous blue-green algae - Nostoc

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- Chemosynthetic autotrophic bacteria oxidise various inorganic substances such as nitrates, nitrites and ammonia.

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use the released energy for ATP production

- Play a great role in recycling nutrients like nitrogen, phosphorous, iron and sulphur.

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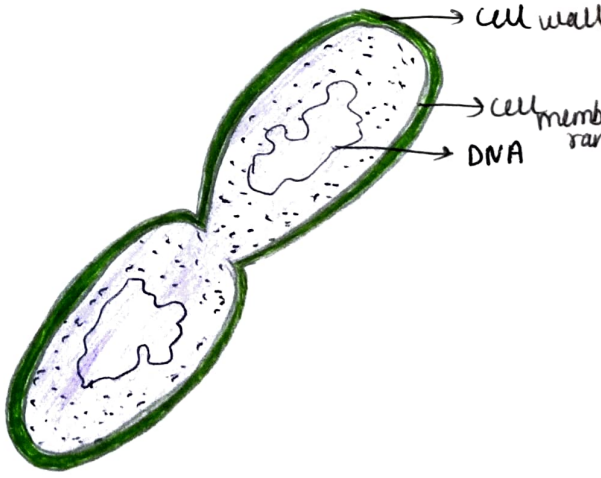
- Heterotrophic bacteria: most abundant in nature.
  - majority are important decomposers.
  - many have a significant impact on human affairs.
  - helpful in making curd from milk, production of antibiotics, fixing nitrogen in legume roots etc.
  - Some are pathogens causing damage to human beings, crops, farm animals and pets.
  - Cholera, typhoid, tetanus, citrus canker are well known diseases caused by different bacteria.




A dividing bacterium

- Bacteria reproduce mainly by fission.

- Sometimes, under unfavourable conditions, they produce spores.
- also reproduce by a sort of sexual reproduction by adopting a primitive type of DNA transfer from on bacterium to the other.

- **Mycoplasma** :
  - organisms that completely lack a cell wall.
  - are the smallest living cell known.
  - can survive without oxygen.
  - many are pathogenic in animals and plants.

- **Kingdom Protista** : single-celled eukaryotes are placed under protista, but boundaries of this Kingdom are not well defined.

- We include Chrysophytes, Dinoflagellates, Euglenoids, Slime moulds and Protozoans under protista.



- Members are primarily acquatic.
- Being, eukaryotes, the protistan cell body contains a well defined nucleus and other membrane bound organelles.
- Some have flagella or cilia.
- reproduce asexually and sexually by a process involving cell fusion and zygote formation.

- Chrysophytes : includes diatoms and golden algae (desmids)
- found in fresh water as well as in marine environments.
- are microscopic and float passively in water currents (plankton).
- Most of them are photosynthetic.
- In diatoms → cell wall forms 2 overlapping shells
  ↓
  fit together as in a soap box
- walls are embedded with silica, thus walls are indestructible
- diatoms have left behind large amount of cell wall deposits in their habitat.
  ↓
  Accumulations over billions of years is referred to as "diatomaceous earth." (used in polishing, filtration of oils and syrups)
- Diatoms are the chief producers in oceans

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- Dinoflagellates : organisms are mostly marine and photosynthetic.
- appear yellow, green, brown, blue or red depending upon the main pigment present in their cells.
- cell wall has stiff cellulose plates on the outer surface.

- most of them have 2 flagella one lies - longitudinally and other - transversely b/w the wall plates.

- Very often, red dinoflagellates Ex. Gonyaulax
  ↓
  undergo rapid multiplication
  ↓
  make the sea appear red (red tide)

Dinoflagellates

- Toxins released by such large numbers may even kill other marine animals such as fishes.

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- Euglenoids : majority are fresh water organism found in stagnant water

- Instead of cell wall, they have protein rich layer called pellicle (makes body flexible)

- have 2 flagella a short and a long one.

- photosynthetic in the presence of sunlight, when deprived of sunlight they behave like heterotrophs. Pigment of euglenoids are identical to higher plants.

Example : Euglena

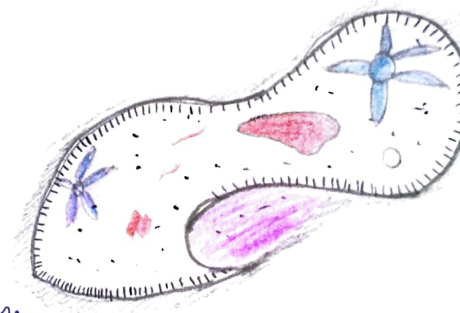
Euglena

- **Slime Moulds**: are saprophytic protists.
- body moves along decaying twigs and leaves engulfing organic material.
- Under suitable conditions, they form an aggregation called plasmodium → may grow and spread over several feet.
- During unfavourable conditions, plasmodium → differentiates → forms fruiting bodies bearing spores at their tips.

Slime mould



- Spores possess true walls.
- are extremely resistant and survive for many years, even under adverse conditions.
- Spores are dispersed by air currents.



Paramoecium

- **Protozoans**: are heterotrophs and live as predators or parasities.
- are believed to be primitive relatives of animals.
- There are 4 major groups of protozoans.

(a) Amoeboid protozoans : organisms live in fresh water, sea water or moist soil.

- move and capture their prey by putting out pseudopodia (false feet) as in Amoeba.
- Marine forms have silica shells on their surface.
- Some, such as Entamoeba are parasites.

(b) Flagellated protozoans : are either free-living or parasitic

- They have flagella.
- parasitic forms causes diseases such as sleeping sickness.

  Example : Trypanosoma.

(c) Ciliated protozoans : are acquatic, actively moving organisms because of the presence of thousand cilia.

- have a cavity (gullet), opens to the outside of the cell surface.
- The co-ordinated movement of rows of cilia causes the water laden with food to be steered into the gullet.

  Example: Paramoecium

- **Sporozoans:** includes diverse organisms that have an infectious spore-like stage in their life cycle.
- most notorious is Plasmodium (malarial parasite), causes malaria.

- **Kingdom Fungi:** Fungi constitute a unique Kingdom of heterotrophic organisms.
- show a great diversity in morphology and habitat.
- grows on moist bread and rotten fruits.
- mushrooms and toadstools are also fungi.
- Some unicellular fungi eg. yeast → used to make bread and beer.
- Other fungi cause diseases in plants and animals.

eg: wheat rust causing Puccinia

- Some are source of antibiotics eg: Penicillium
- Fungi are cosmopolitant, occur in air, water, soil and on animals and plants.
- prefer to grow in warm and humid places.

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- With the exception of yeast (unicellular), fungi are filamentous.
- consist of long, slender thread like structures called hyphae.
- network of hyphae is known as mycelium
- Some hyphae are continuous tubes filled with multinucleated cytoplasm — called coenocytic hyphae.
- Other have septae or cross walls in their hyphae.
- Cell walls of fungi are composed of chitin and polysaccharides.
- most fungi are heterotrophic and absorbe soluble organic matter from dead substrates, hence called Saprophytes.
- depend on living plants and animals are called parasites.
- Can also live as symbionts — in association with algae as lichens and with roots of higher plants as mycorrhiza.

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Reproduction takes place by vegetative means - fragmentation, fission and budding.

Asexual reproduction is by spores called conidia or sporangiospores or zoospores.

- sexual reproduction is by oospore, ascospores and basidiospores.
- spores are produced in fruiting bodies.
- The sexual cycle involves the three steps:
  - fusion of protoplasms between 2 motile or 2 non-motile gametes
    ↓
    called plasmogamy
  - fusion of 2 nuclei called karyogamy.
  - Meiosis in zygote resulting in haploid spores.

Notes by Amrita Raval Ma'am

- When a fungus reproduces sexually
  ↓
  two haploid hyphae of compatible type
  ↓
  come together and fuse
- In some fungi fusion of two haploid cells
  ↓
  immediately results in diploid cells (2n)
- In other fungi, (ascomycetes and basidiomycetes), an intervening dikaryotic stage (n+n) i.e two nuclei per cell occurs, called dikaryon and phase is dikaryophase of fungus.

- Later, the parental nuclei fuse and the cells become diploid.
- Fungi form fruiting bodies in which reduction division occurs, leading to formation of haploid spores.

Notes by Ameeta Rawat Ma'am

- Morphology of mycelium, mode of spore formation, fruiting bodies form the basis → for the division of kingdom into various classes.

(a) **Phycomycetes:**

- members are found in aquatic habitats and on decaying wood in moist and damp places or as obligate parasite on plants.
  - mycelium is aseptate and coenocytic
  - asexual reproduction takes place by zoospores (motile) or by aplanospores (non-motile)
  - spores are endogenously produced in sporangium.
  - zygospore is formed by fusion of two gametes.
  - gametes are similar in morphology (isogamous) or dissimilar (anisogamous or oogamous)

Example - Mucor, Rhizopus (the bread mould) and Albugo (parasitic fungi on mustard)

(b) **Ascomycetes** : commonly known as sac-fungi.

Notes by Amrita Rawal Mahan

- are mostly multicellular eg: Penicillium
- rarely unicellular eg: yeast (Saccharomyces)
- are saprophytic, decomposers, parasitic or coprophilous (growing on dung)
- Mycelium is branched and septate.
- asexual spores are conidia produced exogenously on special mycelium called conidiophores
- Conidia on germination produce mycelium.
- Sexual spores are called ascospores produced endogenously in sac like asci (singular ascus)
- asci are arranged in different types of fruiting bodies called ascocarps.

Example Aspergillus, claviceps and Neurospora. (used extensively in biochemical and genetic work.)

- Many members, morels and truffles are edible.

(c) **Basidiomycetes** : known forms are mushrooms, bracket fungi or puffballs.

- grow in soil, on logs and tree stumps and in living plant bodies as parasites eg. rusts and smuts.
- mycelium is branched and septate.
- asexual spores are generally not found, but vegetative reproduction by fragmentation is common.
- sex organs are absent, but plasmogamy is brought about fusion of two vegetative or somatic cells of different strains.
- resultant structure is dikaryotic → give rise to basidium.
- basidia are arranged in fruiting bodies called basidiocarps.

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Example Agaricus (mushroom), Ustilago (smut) and Puccinia (rust fungus)

Agaricus

(d) Deuteromycetes : comonly known as imperfect fungi because only asexual or vegetative phases of these fungi are known.

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- Once sexual stage of members of deuteromycetes were discovered they often moved to ascomycetes and basidiomycetes.
- deuteromycetes reproduce only by asexual spores known as conidia.
- mycelium is septate and branched.
- some members are saprophytes or parasites.
- large number of them are decomposers of litter, help in mineral recycling.

Example Alternaria, Colletotrichum and Trichoderma.

Kingdom Plantae : includes all eukaryotic chlorophyll - containing organisms commonly called plants.

- few members are partially heterotrophic such as the insectivorous plants or parasites.

- Bladderwort and Venus fly trap → examples of insectivorous plants.
- Cuscuta — parasite.
- plant cells have an eukaryotic structure with prominent chloroplasts.
- Cell wall mainly made of cellulose.
- Life cycle of plants has two distinct phases
  - diploid Sporophytic
  - haploid gametophytic
- Length of diploid and haploid phases, whether these phases are free living or dependent on other → vary among different groups in plants.
- This phenomenon is called alternation of generation

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Kingdom Animalia : Characterised by heterotrophic eukaryotic organisms

- Are multicellular and cells lack cell walls.

- directly or indirectly depend on plants for food.
- digest their food in an internal cavity and store food reserves as glycogen or fat. Mode of nutrition is holozoic – ingestion of food.
- follow a definite growth pattern and grow into adults that have a definite shape and size.
- Higher forms show elaborate sensory and neuromotor mechanism.
- Most of them are capable of locomotion.
- Sexual reproduction is by copulation of male and female followed by embryonic development.

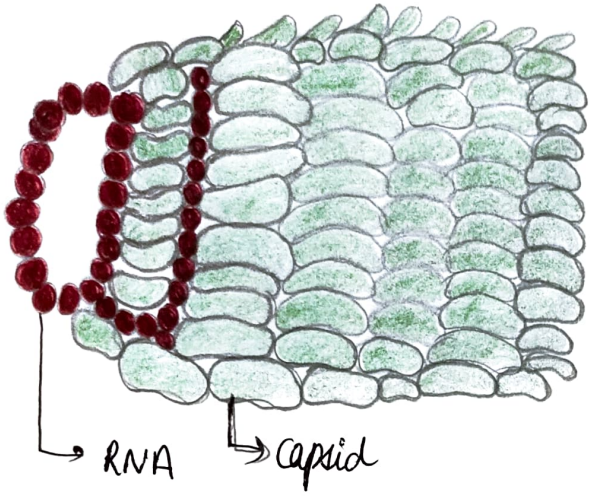
Notes by
Amrita Rawal ma'am

## Viruses, Viroids, Prions And Lichens

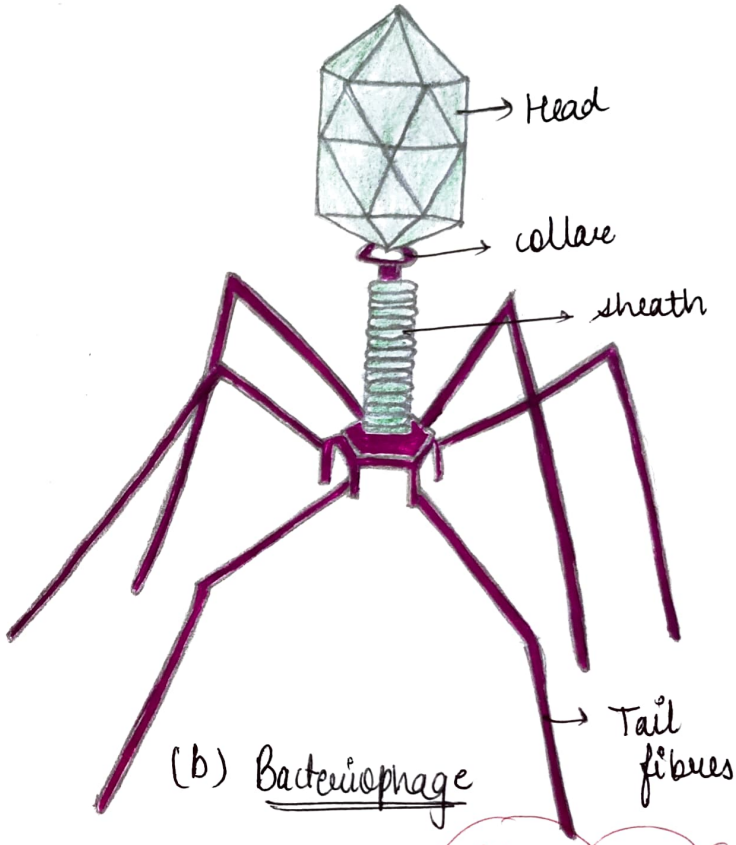
- In five Kingdom classification, there is no mention of lichens and some acellular organisms like viruses, viroids and prions.
- all the ill effects of common cold or 'flu' are the effects of viruses on us.
- Viruses did not find a place in classification since they are not considered as truly living.
- Viruses are non-cellular organisms, characterised by having inert,

Crystalline structure outside the living cell.

- Once, they infect a cell they take over the machinery of the host cell to replicate themselves, killing the most.




(a) Tobacco Mosaic Virus (TMV)




(b) Bacteriophage

Notes by Amrita Kaur Malan

- Name virus means venom or poisnous fluid - Given by Dmitri Ivanowsky (1892)
- He recognised certain microbes as causative organism of the mosaic disease of tobacco.
- They found to be smaller than bacteria, because they passed through bacteria-proof filters.

- M.W. Beijerinck (1898) - demonstrated that the extract of the infected plants of tobacco could cause infection in healthy plants and called the fluid as Contagium vivum fluidum (infectious living fluid)

- W.M Stanley (1935) showed that viruses could be crystallised and crystals consist largely of proteins.

Notes by Amrita Rawal Ma'am

- They are inert outside their specific host cell.
- Viruses are obligate parasites.

- Addition to protein, viruses also contain genetic material, could be either RNA or DNA.

- No virus contains both RNA and DNA.
- A virus is a nucleoprotein and the genetic material is infectious.
- In general, viruses that infect plant have single stranded RNA and that infect animals have either single or double stranded RNA or double stranded DNA.

- Bacterial viruses or bacteriophages (viruses that infect bacteria) are usually double stranded DNA viruses.
- The protein coat called capsid made of small subunits called capsomeres protects the nucleic acid.

- Capsomeres are arranged in helical or polyhedral geometric forms
- Viruses cause diseases like mumps, small pox, herpes and influenza.
- AIDS in humans is also caused by a virus.
- In plants, the symptoms can be mosaic formation, leaf rolling, and curling, yellowing and vein clearing, dwarfing and stunted growth.

**Viroids:** In 1971 T.O. Diener discovered a new infectious agent that was smaller than viruses and caused potato spindle tuber disease.

- was found to be a free RNA. (low molecular weight)
- lacked the protein coat that is found in viruses, hence the name viroid.

**Prions:** In modern medicine certain infectious neurological diseases were found to be transmitted by an agent consisting abnormally folded protein.

- agent was similar in size to virus, called prions.
- caused bovine spongiform encephalopathy (BSE) commonly called mad cow disease in cattle and its analogous variant Cr-Jacob disease (CJD) in humans.

- **Lichens**: symbiotic associations i,e mutually useful associations, between algae and fungi.

  algae → K/as phycobiont → autotrophic

  fungi → K/as mycobiont → heterotrophic

Notes by Amrita Rawal Ma'am

- Algae prepare food for fungi and fungi provide shelter and absorb mineral nutrients and water for its partner.
- Lichens are very good pollution indicators → they do not grow in polluted areas.