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UNIT-III

- Microbial Evolution and Diversity
  - Endosymbiotic theory.
- Binomial nomenclature of Microbes
- Classification –
  - Five Kingdom concept
  - Eight Kingdom concept (Cavalier Smith).

MICROBIAL EVOLUTION & DIVERSITY

Introduction

- Microbial evolution refers to the genetically driven changes that occur in microorganisms and that are retained over time.
- Some microbial changes can be in response to a selective pressure.
    - The best examples of this are the various changes that can occur in bacteria in response to the **presence of antibiotics**.
    - These changes can make an individual bacterium **less susceptible** or **completely resistant** to the killing action of one or more antibiotics.

        e.g., Multi-drug resistant bacteria

History and Scientific Foundations

- Darwinian evolution can be depicted as a tree, with the original organism at the base of the trunk and the myriad evolutionary changes that occur over time generating the branches and even smaller twigs at their tips. Put another way, this route of evolution is vertical, with genetic changes transferred from one generation of a species to succeeding generations.
- This wider, interspecies transfer is called **horizontal transfer**. It is one route by which a bacterium can become resistant to one or more antibiotics. A bacterium that carries the genetic determinants for resistance to an antibiotic may be able to transfer the gene to another, unrelated bacterium, which then also becomes resistant to the antibiotic.

ORIGIN OF LIFE: First Cells

- The first living cells used RNAs as genetic material.
- Gradually, DNA replaced RNA as the hereditary macromolecule of living cells.
- Then the three-part system - DNA, RNA, and protein - became universal among cells.
- Earth is approx. 4.6 billion years old.
- Life on earth originated between 3.5 to 4 billion years ago.
- First originated organism on earth is prokaryotes (Bacterial cells)
- Discovered in Stromatolites - (Fossilized rocks consists of layers of filamentous prokaryotes and trapped mineral sediment)
- Initially, living organisms were Anaerobes
    - Thermophiles - uses organic and sulfur compounds as energy source
- Photosynthesis developed around 3 billion years ago with photosystem I (not evolve oxygen)

- Photosystem II evolved- which splits water and produces oxygen

MICROBIAL BIODIVERSITY

- Great biodiversity of Microbial world has yet to be discovered.

a) Bacterial Biodiversity
b) Archaeal Biodiversity
c) Eucaryal Biodiversity

a) BACTERIAL DIVERSITY

Domain: Bacteria / Eubacteria

- Eubacteria is a bacterium of a large group typically having simple cells with rigid cell walls and often flagella for movement. The group comprises the 'true' bacteria and cyanobacteria, as distinct from archaea.
- Bacteria constitute a large domain of prokaryotic microorganisms.
- Typically a few micrometres in length, bacteria have a number of shapes, ranging from spheres to rods and spirals.
- Bacteria were among the first life forms to appear on Earth, and are present in most of its habitats.
- Bacteria inhabit soil, water, acidic hot springs, radioactive waste, and the deep portions of Earth's crust. Bacteria also live in symbiotic and parasitic relationships with plants and animals. They are also known to have flourished in manned spacecraft.

b) ARCHAEAL DIVERSITY

Domain: Archaea

- The Archaea constitute a domain or kingdom of single-celled microorganisms.
- These microbes are prokaryotes, meaning that they have no cell nucleus or any other membrane-bound organelles in their cells.
- Archaea were initially classified as bacteria, receiving the name archaebacteria (in the Kingdom Monera), but this classification is outdated.
- Archaeal cells have unique properties separating them from the other two domains of life: Bacteria and Eukaryota.

- Cytoplasmic membrane- branched hydrocarbons and ether linkages
  (Other contains – straight chain fatty acids and ester linkages)
- Cell walls – Proteins and Glycoproteins
  others (Peptidoglycan)

Methanogens

- Methanogens are microorganisms that produce methane as a metabolic byproduct in anoxic conditions. They are classified as **archaea**, a domain distinct from bacteria.
- They are common in wetlands, where they are responsible for marsh gas, and in the digestive tracts of animals such as ruminants and humans, where they are responsible for the methane content of belching in ruminants and flatulence in humans.

c) EUKARYAL DIVERSITY

Domain: Eukarya

- First evolutionary branch in Eukarya is **Archeozoa**
    - *Giardia, Trichomonas,* etc
        - Lack Mitochondria, ER and Golgi apparatus
        - also lacks sexual reproduction
        - have 70S ribosomes
- Next branch is **Protozoa** includes variety of groups such as *Physarum, Entamoeba, Dictyostelium, Euglena, Trypanosma* etc and slime molds.
- Acquired organelles through **Endosymbiosis**
- Evolved the capacity of sexual reproduction- which allows genetic recombination.
- Leads to greater diversification of species includes- Fungi, algae , plants and animals
- As a result of evolutionary process, the extent of microbial diversity is much more greater and much of which yet to be explored.
- Only 1% of the existing bacteria are explored i.e. only 4200 sp .

ENDOSYMBIOTIC THEORY

- It is thought that life arose on earth around four billion years ago.
- The endosymbiotic theory states that some of the organelles in today's eukaryotic cells were once prokaryotic microbes.
- In this theory, the first eukaryotic cell was probably an amoeba-like cell that got nutrients by phagocytosis and contained a nucleus that formed when a piece of the cytoplasmic membrane pinched off around the chromosomes.
- Some of these amoeba-like organisms ingested prokaryotic cells that then survived within the organism and developed a symbiotic relationship.

- Mitochondria formed when bacteria capable of aerobic respiration were ingested;
- chloroplasts formed when photosynthetic bacteria were ingested.
- They eventually lost their cell wall and much of their DNA because they were not of benefit within the host cell. Mitochondria and chloroplasts cannot grow outside their host cell.

- Evidence for this is based on the following:
  i. Chloroplasts are the same size as prokaryotic cells, divide by binary fission, and, like bacteria, have Fts proteins at their division plane. The mitochondria are the same size as prokaryotic cells, divide by binary fission, and the mitochondria of some protists have Fts homologs at their division plane.
  ii. Mitochondria and chloroplasts have their own DNA that is circular, not linear.
  iii. Mitochondria and chloroplasts have their own ribosomes that have 30S and 50S subunits, not 40S and 60S.
  iv. Several more primitive eukaryotic microbes, such as Giardia and Trichomonas have a nuclear membrane but no mitochondria.
  v. Although evidence is less convincing, it is also possible that flagella and cilia may have come from spirochetes.

REFERENCES

http://www.authorstream.com/Presentation/harini123456-1149007-microbial-evolution-and-diversity/
https://www.slideshare.net/majid4uonly/biodiversity-and-microbial-biodiversity
https://bio.libretexts.org/Bookshelves/Microbiology/Book%3A_Microbiology_(Boundless)/8%3A_Microbial_Evolution_Phylogeny_and_Diversity/8.16%3A_Eukaryotic_Microbial_Diversity/8.16D%3A_Endosymbiotic_Theory_and_the_Evolution_of_Eukaryotes
https://www2.slideshare.net/phylogenomics/bis2c-biodiversity-and-the-tree-of-life-2014-l7-intro-to-microbial-diversity?qid=9babcb7b-cf55-4151-b90e-a50e345c210b&v=&b=&from_search=5

BINOMIAL NOMENCLATURE OF MICROBES

Nomenclature of Microorganisms

The Origin of Names

- The Greek philosopher Aristotle attempted to classify all living things as either Plant or Animal. He grouped animals into Land Dwellers, Water Dwellers, and Air Dwellers. Although this system made sense to Aristotle, we would have a difficult time in grouping elephants and earthworms, whales and water striders, flies and falcons together.
- Subsequent scientists later tried to classify living creatures by means of locomotion, grouping butterflies and bats (flying), barnacles and barley (both rooted in place). This system of classification was obviously flawed as well.

Today, microorganism names originate from four different sources:

1. Descriptive

e.g.,

Staphylococcus aureus (grape-like cluster of spheres, golden in color),

Streptococcus viridans (chains of spheres, green in colony color),

2. Scientist's names

e.g.,

Escherichia coli (Theodor Esherich),

Erlichia (Paul Erlich),

Nessieria (Albert Neisser),

Listeria (Joseph Lister),

3. Geographic places

e.g.,

Legionella longbeachiae (Long Beach, California),

Pasturella tularensis (Tulare County, California),

Pseudomonas fairmontensis (Fairmount Park, Pennsylvania),

4. Organizations

e.g.,

Legionella (American Legion),

Afipia felis (Air Force Institute of Pathology),

Taxonomy

Kingdom (American system has six: Animalia, Plantae, Fungi, Protista, Archaea, Bacteria)

Phylum (there are 23+ bacterial phyla)

Class

Order

Family

Genus (aka, generic name)

Species (aka, specific name, specific epithet)

Subspecies

For example, the bacteria used in yogurt production would be classified as follows…

Kingdom: Bacteria

Phylum: Firmicutes

Class: Bacilli

Order: Lactobacillales

Family: Lactobacillaceae

Genus: Lactobacillus

Species: L. delbrueckii

Subspecies: L. d. bulgaricus

Rules of Nomenclature

1. Use Binary Names

- Binary names (invented by Linnaeus), consisting of a generic name and a species epithet (e.g., Escherichia coli), must be used for all microorganisms. Names of categories at or above the genus level may be used alone, but species and subspecies names (species names) may not. In other words…never use a species name alone.

2. When to Capitalize

- The genus name (and above) is always capitalized, the species name is never capitalized, e.g. Bacillus anthracis

3. When to Italicize

- Names of all taxa (kingdoms, phyla, classes, orders, families, genera, species, and subspecies) are printed in italics and should be underlined if handwritten; strain designations and numbers are not. If all the surrounding text is italic, then the binary name would be non-italic (Roman typeface) or underlined (e.g. A common cause of diarrhea is E. coli 0157, a gram negative bacillus).

4. When to use Initials

- A specific epithet must be preceded by a generic name, written out in full the first time it is used in a paper. Thereafter, the generic name should be abbreviated to the initial capital letter (e.g., E. coli), provided there can be no confusion with other genera used in the paper. Be careful with the "S" words; Salmonella, Shigella, Serratia, Staphylococcus, Streptococcus, etc.

5. Plural Forms

Plural of genus is genera

Plural of species (sp.) is species (spp.)

Plural of medium is media (never say "this culture media")

Plural of fungus is fungi

Plural of streptococcus is streptococci (staphylococcus - staphylococci; enterococcus - enterococci, etc)

Plural of bacillus is bacilli

Plural of bacterium is bacteria

Plural of alga is algae

Plural of protozoan is protozoa

http://www.hardydiagnostics.com/wp-content/uploads/2016/05/nomenclature-of-microorganisms.pdf

CLASSIFICATION OF ORGANISMS

KINGDOM SYSTEM / CONCEPT

The following points highlight the top six concepts of the kingdom system of organisms classification. The concepts are:

1. Two Kingdom Systems (Lennaeus' Concept):
2. Three Kingdom System (Haeckel's Concept):
3. Four Kingdom Systems (Copeland's Concept):
4. Five Kingdom Systems (Whittakar's Concept)
5. Six Kingdom System (Grey and Doolittle's Concept):
6. Eight Kingdom System (Cavalier-Smith's Concept):

EIGHT KINGDOM SYSTEM OF CLASSIFICATION

(Cavalier-Smith's Concept)

- The Kingdom Protista was still too diverse to be taxonomically useful.
- Many attempts have been made to divide protists into better-defined Kingdoms and in this regard, an eight-Kingdom system (Fig. 2.7) was given by Cavalier-Smith (1987).
- Cavalier-Smith, using ultra-structural characteristics as well as rRNA sequences, divides all organisms into
    a) two Empires and
    b) eight kingdoms.

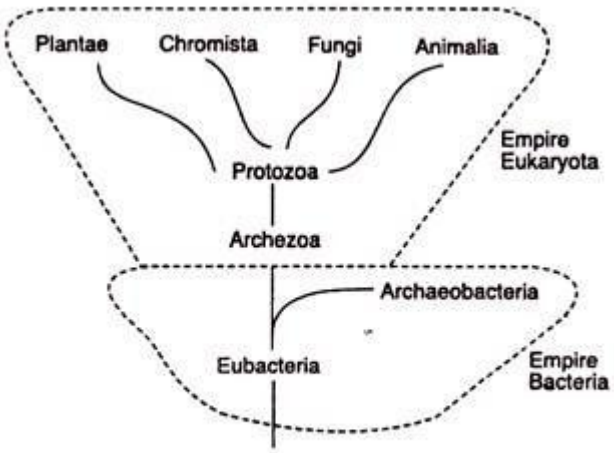

FIG. 2.7. Eight kingdom system. (Cavalier-Smith, 1987)

- The Empire Bacteria consists of two Kingdoms,

i. the Eubacteria and
ii. the Archaeobacteria

- The Empire Eukaryota contains six Kingdoms of eukaryotes

i. Archezoa,
ii. Protozoa,
iii. Chromista,
iv. Fungi,
v. Plantae and
vi. Animalia;

- Archezoa and Chromista are the two new Kingdoms of eukaryotes.
- The Kingdom Archezoa consists of primitive eukaryotic unicellular micro-organisms (e.g. *Giardia*) that possess 70S ribosomes and lack cell organelles like golgi apparatus, mitochondria, chloroplasts and peroxisomes.
- The Kingdom Chromista is represented by diatoms, brown algae, crypto-monads and oomycetes; mainly the photosynthetic micro-organisms that have their chloroplasts within the lumen of the rough ER rather than in the cytoplasmic matrix (as is found in the members of kingdom Plantae).
- The four Kingdoms Plantae, Fungi, Animalia and Protozoa are retained but their boundaries have been adjusted to better define each kingdom and differentiate it from the others.

https://www.biologydiscussion.com/organism/the-kingdom-system-of-organisms-classification-top-6-concepts/54667

FIVE KINGDOM SYSTEM OF CLASSIFICATION

Features and Limitations

- Taxonomy refers to the science of classification of living organisms.
- According to Bergey's Manual of Systematic Bacteriology, taxonomy consists of three separate but interrelated areas: classification, nomenclature, and identification.
- Classification is the arrangement of organisms into taxonomic groups known as taxa on the basis of similarities or relationships.
- Taxa include kingdoms or domains, divisions or phyla, classes, orders, families, genera, and species.

The Five Kingdom System of Classification

- Very early on, scientists began grouping the living organisms under different categories.
- Some biologists classified organisms into plants and animals.
- Ernst Haeckel, Robert Whittaker, and Carl Woese are some biologists who attempted a broader system of classification.

Features of Five Kingdom System of Classification

- Whitaker proposed that organisms should be broadly divided into kingdoms, based on certain characters like the structure of the cell, mode of nutrition, the source of nutrition, interrelationship, body organization, and reproduction.
- The kingdoms include:
    a) Bacteria and archaea are in the Kingdom Prokaryotae (or Monera)
    b) Algae and protozoa are in the Kingdom Protista (organisms in this kingdom are referred to as protists)
    c) Fungi are in the Kingdom Fungi
    d) Plants are in the Kingdom Plantae
    e) Animals are in the Kingdom Animalia

Kingdom Monera

- These organisms are prokaryotic and unicellular.
- They do not have a well-defined nucleus and also lack cell organelles.
- Examples include Bacteria, Cyanobacteria, and Mycoplasma.

Kingdom Protista

- Organisms grouped under Kingdom Protista are all unicellular, but eukaryotic organisms.

- These are the simplest forms of eukaryotes that exhibit either autotrophic or heterotrophic mode of nutrition.
- Some organisms have appendages such as cilia or flagella or pseudopodia to move around.
- Some examples are Diatoms, Protozoans like Amoeba, Paramecium

Kingdom Fungi

- Heterotrophic, Multicellular and Eukaryotic organisms are grouped under Kingdom Fungi.
- Their mode of nutrition is saprophytic as they use decaying organic matter as food.
- They have cell walls, which are made up of a substance called Chitin.
- Yeast, Mushroom, Aspergillus are examples of Fungi.

Kingdom Plantae

- These are Eukaryotic, Multicellular organisms with a cell wall that is made up of cellulose.
- They are autotrophs and synthesize their own food through the process of photosynthesis. This kingdom includes all plants.
- Examples are Spirogyra, Ferns, Pines, and Mango Plant etc.

Kingdom Animalia

- This Kingdom includes organisms that are Multicellular, Eukaryotic, without the presence of cell wall.
- They have a heterotrophic mode of nutrition.
- Some of the phyla are Porifera, Coelenterata, Arthropoda, Echinodermata, Chordata etc. Examples – Hydra, Starfish, Earthworms, Monkeys, Birds etc.
- Viruses are not included in the Five-Kingdom System of Classification because they are not living cells; they are acellular.
- Four of the five kingdoms consist of eukaryotic organisms.
- In some cases, species are subdivided into subspecies, their names consisting of a genus, a specific epithet, and a subspecific epithet (abbreviated "ssp.")

- An example would be *H. influenzae* ssp. *aegyptius*, the most common cause of "pinkeye."

Limitations or Objections to the Five Kingdom System of Classification

- Some scientists do not agree that algae and protozoa should be placed into the same kingdom.
- In some classification schemes, protozoa are placed into a subkingdom of the Animal Kingdom.

- A distinction between unicellular and multicellular organisms is not possible in case of algae in this system of classification.
- Each group has so many diversities that it is difficult to keep them together. For example, monera and Protista contain both walled and wall-less organisms. Photosynthetic and non-photosynthetic organisms, cellular or filamentous organism.
- Virus has not been included in this kingdom.
- Archaebacteria differ from other bacteria in structure, composition and physiology.
- Mycoplasma are quite different form bacteria where they have been placed along with prokaryotes.
- Symbiotic associations are not considered in this classification system. For example, lichens are organisms which are formed by the symbiotic association between fungi and algae.

https://microbenotes.com/five-kingdom-system-of-classification-features-and-limitations/