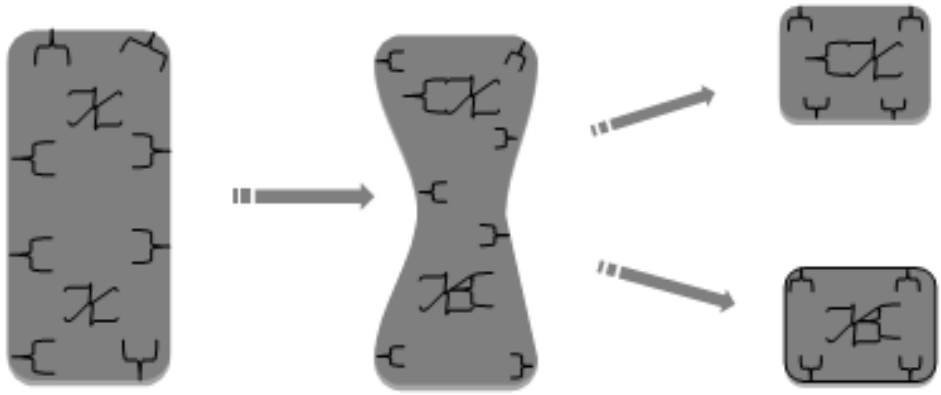
DIVERSITY OF MONERA



Contents

Topic: Diversity of Monera

Objectives

In this lecture we will learn the following:

- Need to be knowledgeable about the bacteria diversity
- Characters that separate bacteria from other living organisms
- Confident in identifying different forms of bacteria in culture
- Importance of bacteria
- Contributions of bacteria to our health

Reading Assignment

In addition to the discussion in this lecture students should read current textbooks e-books on bacteria in the OOU library and visit: ilearn.bupoyesiku.net ; Oyesiku.olubukunola@oouagoiwoye.edu.ng for the online lecture.

Lecture

Nothing less than 5 million of diversity of living organisms share the earth. Nevertheless, we humans are unique from other organisms in two ways; the degree of our curiosity and our power of speech. Based on these two attributes, we make enquiries about other living organisms and exchange information about them.

In today's lecture, we shall be discussing the kingdom Monera, which consists of mainly non-photosynthetic and photosynthetic bacteria. For those of you that are going to major in Microbiology, Plant Pathology, as well as those needing the knowledge in their various field of study, you will gain more knowledge from the diversity of bacteria and their contributions to our ecosystems, particularly their importance in our lives.

Introduction

Bacteriology is the study of bacteria. They form the decomposers (saprobe/ heterotroph) of aquatic and terrestrial food chain and web in a typical ecosystem. It is also important for you to know that water and soil odors are associated with metabolic process by heterotrophic organisms (bacteria and fungi). Another fact is that of bacteria bloom, which is characterized by murky white (white cloud) appearance of water bodies. Conversely, If the color is green it is an algae bloom, which is caused by excessive richness of nutrients (phosphorous and nitrate) in a lake or other body of water (eutrophication) in direct sunlight. It will interest you to learn that bacteria like algae also consume oxygen, if bacteria die off as a result of lack of oxygen you may experience increased ammonia odor in your environment. Despite the negative impacts, the positive impacts are equally important. Bacteria are beneficial to our lives. They help in decomposition of organic matter and recycling of the breakdown elements through plants. Although it cannot be overemphasize that bacteria and algae consume more oxygen than all the plants in the world.

Main Content

Background of Monera

Bacteria belong to the kingdom Monera. They are the smallest (<1 to 30 µm long) and the most abundant organisms on earth, which exceeds total weight of all other living organisms put together. Bacteria are the only form of life that exists on earth 3.5 billion years ago. Metabolically, bacteria are divided into two; photosynthetic bacteria (Cyanobacteria or blue-green algae) and non-photosynthetic (true bacteria). Bacteria differ from other living organisms because they are prokaryotic. The cell is composed of naked nucleus, simple chromosomes, muramic acid in the cell wall. Other characters include genetic recombination mode of reproduction. Bacteria occur in all habitats because of their unusual metabolic capability.

Reproduction in Bacteria

Bacteria do not reproduce by mitosis and meiosis as can be found in higher organisms instead they adopted methods such as fission and genetic recombination.

Asexual method

The major mode of reproduction in bacteria is by asexual method. The expansion of bacterial cells follow by splitting into two parts by a process known as fission (Fig 1.1).

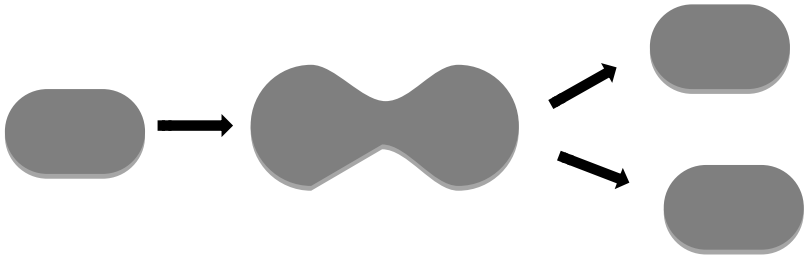


Fig1.1 Asexual reproduction in a bacteria cell by fission process

Sexual methods

Sexual reproduction takes place by three methods, conjugation, transduction and transformation. The three methods are based on genetic recombination, which involve transfer of genetic materials (pro-DNA) between two different strains of bacteria.

Conjugation

Conjugation is described as recombination of genetic material (DNA), which takes place through a conjugation tube (Fig 1.2), developed between two mating haploid bacterial cells (*Escherichia coli*). One bacterial cell is a donor (-) and the other is a recipient cell (+).

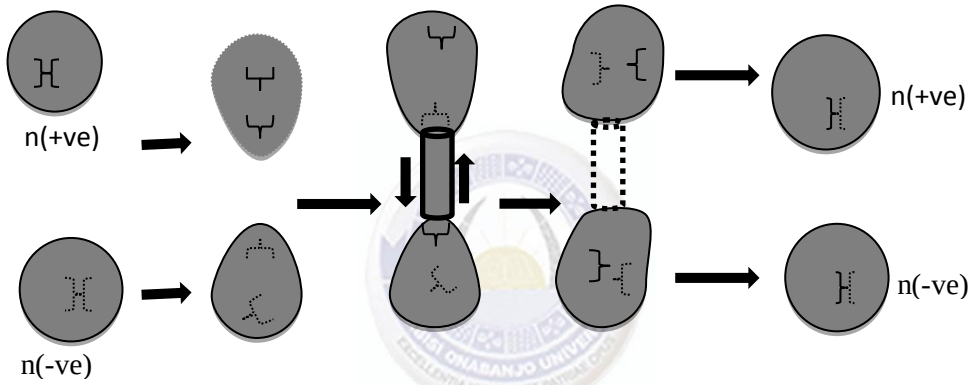


Fig 1.2 Sexual reproduction in bacterial cells by conjugation method. n=haploid, -ve=negative

Transduction

Transduction is described as unilateral recombination in bacteria. In this method, the genetic recombination is effected by bacterial virus known as bacteriophage, living in the protoplasm of the host bacteria. Occasionally the genetic material (DNA) of the bacteriophage cells combine with that of bacteria cells, resulting in a new and strange daughter cells .

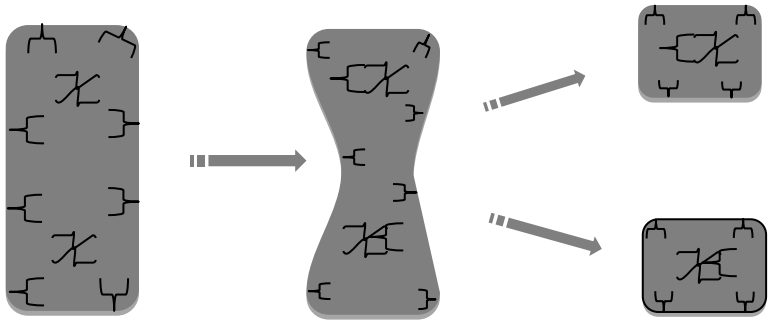


Fig 1.3 Sexual reproduction in bacterial cells by transduction method. Bacteriophage DNA {
bacterial DNA , bacterial daughter cell DNA

Transformation

Transformation method differs from transduction. In the formal method the genetic transfer is effected by transformation of non-capsulated (harmless) into capsulated pathogenic cells. It has been observed that when extracts of both capsulated and non-capsulated bacteria are mixed in a culture, the non-capsulated cells automatically acquire the capacity to transform themselves into capsulated type. This concept is called transformation.

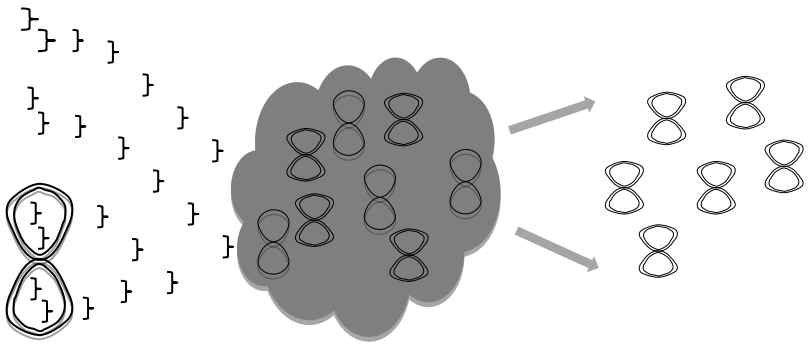


Fig 1.4 Sexual reproduction by transformation method in bacteria. Capsulated bacteria non-capsulated bacteria, DNA

Example, oval shaped Pneumococcal (*Diplococcus pneumonia*), which causes pneumonia when it is capsulated while non-capsulated Pneumococcal could not cause pneumonia.

It is important for you to know that genetic recombination by transformation is accountable for the spread of pathogenic bacteria that resist antibiotic drug treatments. Most particularly when bacterial cells are broken down (extracted) by chemical or heat, "naked" fragments of DNA (plasmid) are released and could pass into other cells by transformation.

Classification of Monera

Monera can be classified into three groups according to their mode of nutrition, chemotrophic, heterotrophic and phototrophic. Five groups of photosynthetic bacteria are discussed in this lecture. They include; cyanobacteria, green-Sulphur bacteria, purple-Sulphur bacteria, purple non-Sulphur bacteria and prochloron.

Chemotrophic bacteria

At this point it may interest you to know that chemotrophic bacteria obtain energy from oxidation of inorganic molecules in the dark. The reduced inorganic compounds are substitute for light function in the dark. The inorganic molecules participating in chemosynthetic process are sulphur, iron and gaseous hydrogen. For example reaction of carbon dioxide (CO_2) and hydrogen sulphide (H_2S) in the dark produce Carbohydrate (chemical energy). Interestingly, chemosynthetic bacteria produce energy for the whole

community of organisms dwelling in complete darkness of the deep-sea at a temperature of about 360 ^{O}C.

Archaebacteria

Archaebacteria is a group of chemotrophic bacteria that is responsible for production of methane gas. It is strictly anaerobic bacteria, which lives in the digestive tracks of cattle and ruminants, sewage treatment plants and in deep-seas. Archaebacteria unlike all other bacteria they lack muramic acid in their cell walls. Additionally, they are metabolically differs from all other bacteria and capable of fixing atmospheric nitrogen. They shares number of characters with Halobacteria (purple non-Sulphur bacteria).

Heterotrophic bacteria

Bacteria in this group of metabolic process obtain energy from dead organic matter and they are called saprobes. It is important to know that both saprobic bacteria and fungi cause the decay and recycling of organic materials in the soil. Soil odor is therefore, associated with metabolic process by heterotrophic microbes (bacteria and fungi).

Photosynthetic bacteria

All chlorophylls in bacteria have the basic structure as that of higher plants except chlorophyll-***a***, which is special***.***

Group-1: Cyanobacteria

Cyanobacteria are photosynthetic bacteria with blue-green pigmentation and they were formally classified as member of algae. Photosynthesis process in cyanobacteria is similar to that of all eukaryotic organisms. Cyanobacteria produce carbohydrate, which is stored as glycogen in the cell walls. Common examples of cyanobacteria in the vicinity of the main campus of Olabisi Onabanjo University include *Anabaena*, *Oscillatoria* and *Nostoc*

Group-2, 3, 4: Green-Sulphur bacteria, purple-Sulphur bacteria, and non-Sulphur bacteria. These three groups of bacteria are distinguished by accessory pigments (green and purple). In addition, sulphur plays similar role of water as in organisms that contain common chlorophyll-***a***.

Halobacteria halobium is an example of group-4, non-Sulphur bacterium. You can identify them by patches of a purple pigment on the plasma membrane. They are motile and

sensitive to violet light. Photosynthetically, they convert sunlight into chemical energy. They are common found in full sun saline environment (salt pools or lakes).

Group-5: Prochloron

Prochloron group of bacteria lives in association with colonial marine animals (sea-squirts, coral shells) dwelling along sea shores. Prochloron shares similar chloroplast with cyanobacteria and green algae.

Photosynthetic equations:

$$CO_2 + 2H_2O \xrightarrow{Light} (CH_2O) + H_2O + 2O_{gas} \text{ (Cyanobacteria)}$$

$$CO_2 + H_2S \xrightarrow{Light} (CH_2O) + H_2O + 2S_{gas} (\textbf{Sulphur bacteria})$$

$$CO_2 + CH_2OH \xrightarrow{Light} (2CH_2O) + H_2O \ (\textbf{non - Sulphur bacteria})$$

$$CO_2 + 2H_2A \xrightarrow{Light} (CH_2O) + H_2O + 2A \ (\textbf{Generalized hydrogen donor equation})$$

Where A may be H_2O, H_2S keto acid, alcohol, fatty acids, serving as electron (hydrogen) donors for process of photosynthesis

Characteristics of Monera

Fossil records

As already mentioned in the background earlier in this lecture you will recollect that all Monera are prokaryotes. Fossil and chemical evidences have shown that atmosphere was anaerobically rich on CO_2 and H_2 about 3 billion years ago (BYA).

Therefore fossil bacteria are about 3.5 billion years old (BYO). These records gave an indication that Cyanobacteria and other photosynthetic bacteria were in existence between 3.3 and 3.2 BYA as compared with the oldest eukaryote, which exists 1.5 BYA.

Gram-negative bacteria cell wall consists of molecules of peptidoglycan about 10 nm in thickness. A coat of lipopolysaccharide molecules protect the thin outer layer of the cell walls from the attack of antibiotics (as penicillin). In addition, lipopolysaccharide prevents

the cell walls from taking the stain (purple/violet), which suggests the reason for resistance of gram-negative bacteria to antibiotics treatment.

Gram-positive bacteria cell wall consists of a single macromolecule of peptidoglycan ranging between 15 nm and 80 nm thick. Unlike gram-negative they lack lipopolysaccharide and that is why they readily takes up stain (purple/violet) making the cell walls vulnerable to attacking antibiotics (as penicillin).

Cytoplasm in bacteria, like all other living organisms is housed within a plasma membrane and coated with group of enzymes on the inner surface (Fig 1.5). Cytoplasm inclusions include ribosome, DNA, plasmid and other granular organelles.

Flagella are locomotors attached to the outer surface of cell wall in many ways. In our example here a cluster of flagella is restricted to a particular location (Fig 1.5). Flagella are slender, rigid and helical in form that is only seen by electron microscope. Their cells are often longer than the cells to which they are attached. Rotary motion is unique to all bacteria. Flagella beat rapidly with rotary movement that carries the bacteria from one place to another. The rotary motion has never been reported in eukaryotic living organisms.

In addition, Pilli are shorter and straighter than flagella and they distinguished gram-negative bacteria from gram-positive. The exact function of pilus is not known. It has been speculated that they serve as bridge for the transfer of DNA, or help bacteria find a partner and attach themselves during conjugation as discussed earlier in this lecture.

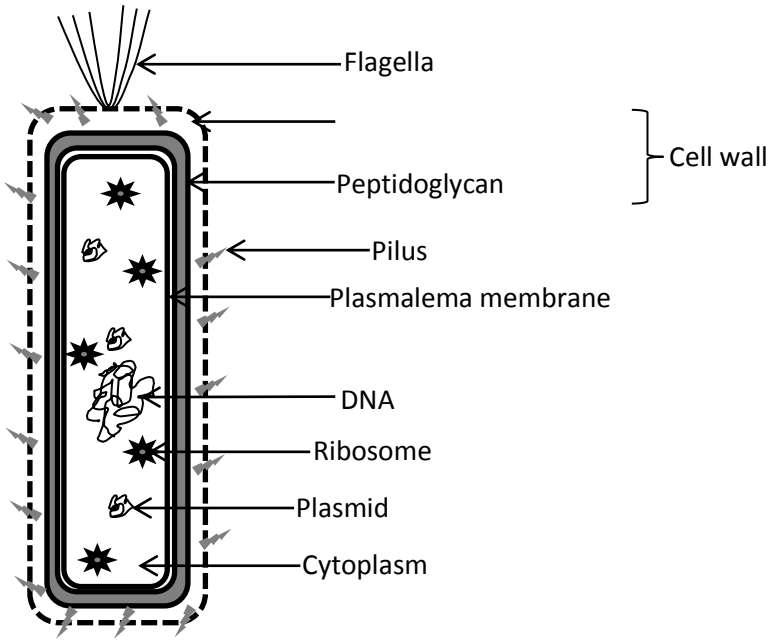


Fig 1.5 Structure of a typical gram-negative bacterium

Diversity of Forms in Monera

Moneran can be conveniently be grouped into three basic types of shapes rod, spherical and spiral. Diverse forms occur in gelatinous matrix of different shapes in which each cell is independent of another. At this level you should know that cells in gelatinous matrix include colonies, chains and threads.

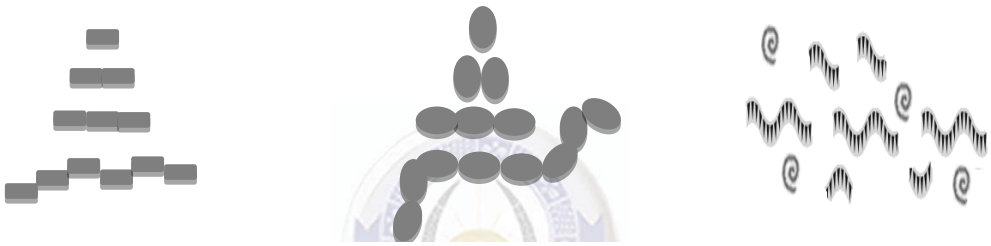


Fig 1.6 Diversity of forms in bacteria. Bacillus ( ), spherical ( ), spiral ( )

Habitats of Monera

Habitat with large quantity of decaying organic matter is characterized by rotten egg odor produce by photosynthetic purple-Sulphur bacteria. It is important to remember that total weight of all bacteria in the world is estimated to exceed the entire population of other living organism. Bacteria are native of the whole world because of their unusual metabolic characteristics. They are found growing in great diverse habitats where oxygen play important limiting factor. Two common members of bacteria occupy habitats with more or less oxygen supply. They include obligate anaerobes and facultative anaerobes. Obligate anaerobes survive only in habitat devoid of oxygen, example is Streptococcal bacteria. Facultative anaerobes live in habitat either with or without oxygen, but they prefer oxygenated habitat. This is because respiration yields more energy than fermentation. It is important you know the role of oxygen in energy production by an organism. Process of fermentation extracts energy from organic molecules in the absence of oxygen while respiration extracts energy from organic molecules in the presence of oxygen. And several bacteria are found in oxygen rich habitat.

Few bacteria occupy habitats with extremely high temperatures. Such include *Thermoanaerobacter ethanolicus* (produce ethanol) in hot springs at a temperature close to 80 ^{O}C. Chemosynthetic bacteria occupy the ocean floor with ambient temperature close to 360 ^{O}C. Other includes bacteria that could remain in a state of suspended animation for a longer period of time at ambient temperature range of -7 ^{O}C to -14 ^{O}C. Such habitats include greater depth of rock and ice berg (*ca*. 450 m).

Ecology of Monera

Monera are important key species in the world ecosystems. They occupy the base of ecological food chain (or web). Almost all living plants depend upon them for their nutritional elements. An autotrophic *Spirulina* (a genus in Cyanobacteria) is an important source of protein. It will be of interest to you to know that many genera of cyanobacteria are harmful to humans. *Spirulina*, however, are unique not only in that they are edible, but also because they provide many health benefits.

Nitrogen fixing bacteria (actinomycetes) fix nitrogen in nodules of legume roots and enhance soil fertility balance. In addition heterotrophic bacteria are known to be potential

decomposers like fungi. They could help in decomposing synthetic materials such as dyes, herbicides, nylon. For instance *Flavobacterium* decomposed the first manufactured nylon (in 1939), pesticides, petroleum, and they are capable of extracting oil from rock.

Bacteria have been used as possible indicators of existence in other planets. For example, Jupiter planet known to have extreme atmospheric alkalinity (pH >12) cannot support survival of bacteria. But another school of thought observed that Venus planet give possible survivability to bacteria given to its atmospheric pH of 11.5 and high concentration of ammonia.

Economic uses of Monera

Monerans have a great economic value to humans, animals and plants. The current trend in the use of monerans have step up our interest in the field of criminology. Researchers have found that our unique finger prints have unique bacteria that can be used as personal identifiers, even in identical twins. These bacteria are left behind on any material our fingers touched. Through the genetic sequencing process, specific bacteria found on a material can be matched to the hand that touched the material.

Bacteria are used in production of cheese by fermentation of lactose into lactic acid (coagulation of milk protein). Acetic acid, vinegar, amino acids and enzymes produced by bacteria are sources of commercial preservatives. *Spirulina* is another source of commercial protein as a supplement in human foods or animal feeds. It is important you know that protein produced by *Spirulina* is ten times that of wheat and soy beans.

Group of bacteria called actinomycetes could be responsible for the production of 75% of antibiotics registered by NAFDAC in Nigeria. Examples of such antibiotics are Streptomycin, Aureomycin Neomycin and Tetracycline. Others include Tryrothricin, Bacitracin and Subtilin.

Nevertheless; certain bacteria are of negative impact as sources of diseases in other organisms. For example, *Mycobacterium tuberculosis* (actinomycete) is responsible for tuberculosis in humans. Other diseases in humans caused by bacteria include cholera, anthrax, gonorrhea, tetanus and diphtheria. Fire blight disease is caused by plant pathogens.

Conclusion

You must have learnt how to recognize bacteria and their habitats. The current trend in research as to the commercial use of bacteria cannot be over emphasized. Over 2500 species of bacteria have been identified, if serious research is embraced and directed towards identification of more wild bacteria out there in the wild, it could contributes to ecological and economic benefits to humans, animals and plants.

Summary

Having study this lecture, you should:

- Have some understanding of types of monerans
- Have a better idea of the characters that separate them from other groups of plants
- Be ready to look around your environment for the common monerans
- Better aware of the ecological and economic benefits

References/Further readings/Links

Test Yourself Questions (TYQ)

Matric No	Department	Attendance Code	Session/Student's Level
		AC_____	

Question	TRUE	FALSE
1. All monera are multicellular prokaryotes		
2. All monera are photosynthetic organisms		
3. Streptococcus is a rod-shaped bacteria		
4. Bacteria is an indicator of existence of life in a planet		
5. Facultative anaerobic bacteria survive only in absence of oxygen		
6. Gram positive bacteria is protected with lipopolysaccharide		
7. Gram negative bacteria do take up stain		
8. Transformation is a genetic recombination involving bacteriophage		
9. Cyanobacteria are examples of sulphur producing bacteria		
10. Atmosphere is anaerobically rich in CO_2 and H_2 3 BYA		

Comment: