Module 1: History and Scope of Microbiology

OBJECTIVES

This section aims to carry out the following learning objectives:

- Define the science of microbiology
- Development of microscope
- Historical concept of spontaneous generation and experiments performed to disproved the theory
- Discuss how Koch postulates are used in establishing the etiological role of diseases
- Discuss on the discovery of microbial effects on organic and inorganic matter
- Discuss the importance of the field of microbiology to other areas of biology and to general human welfare.

INTRODUCTION

Microbiology is the study of microscopic life on earth. Life on earth began early in our planets history with microscopic organism or microbes. Microorganisms are too small to be seen by unaided human eye. Its subjects are viruses, bacteria, algae, fungi and protozoa. Microbial life has shaped our atmosphere, our geology and the energy cycles of all ecosystems. Even before microorganisms were seen some investigators suspected their existence and responsibility for diseases. The development of microscope and the various observations made by various scientist led to the discovery of microorganisms. Microscopes are optical instruments that serve to magnify objects so small that they cannot be seen clearly by unaided eye.

THE DISCOVERY OF MICROORGANISMS

Antony Van Leeuwenhoek (1632-1723) was the first person to observe and describe microorganisms using a microscope of his own design and made one of the most important contribution to microbiology. But the first person to observe living things was Robert Hooke. Leeuwenhoek microscope could magnify around 50-300 times. His microscope consists of spherical lens mounted between two small metal plates. He illuminated his liquid specimen by placing between two pieces of glass and shining light on them at 45ºangle to the specimen plane. This provided a form of dark field illumination. His observation was reported to the Royal Society of London in 1673 with accurate shape and detailed movement. The organisms that he observed were possibly bacteria and protozoa which he termed it as animalcules.

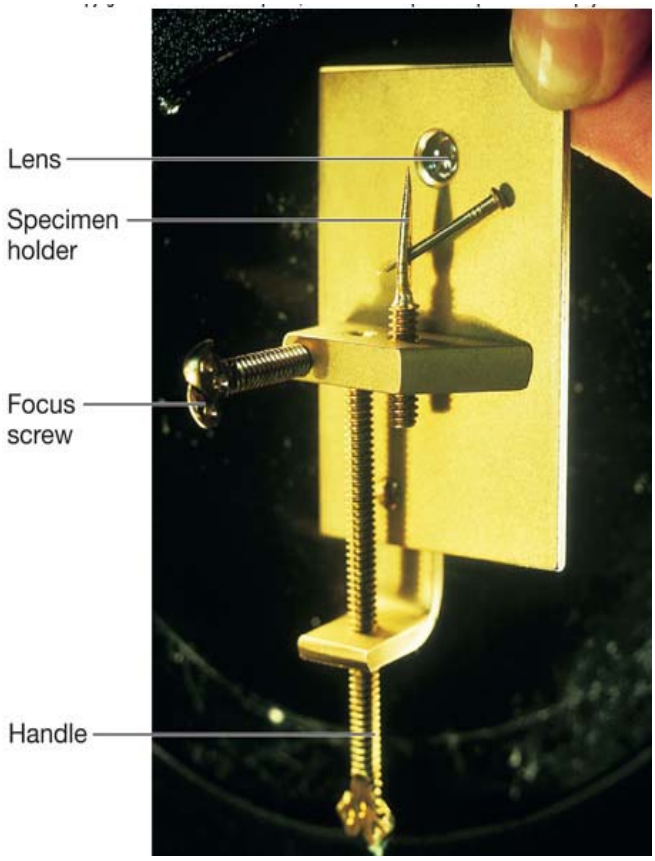

Figure1: Leeuwenhoek Microscope

CONFLICT OVER SPONTANEOUS GENERATION

The believe in the spontaneous formation of living beings from non living matter is known as the doctrine of spontaneous generation or abiogenesis. Spontaneous generation was widely held belief throughout the middle ages and into the later half of the 19th century. This view was finally challenged by the Italian Physician Francesco Redi(1626-1697) who carried out a series of experiments on decaying meat and its ability to produce maggots spontaneously.

Figure 2: Francesco Redi (1626-1697)

Redi placed meat in three containers. One was uncovered, the second was covered with papers and the third was covered with fine gauze that would exclude flies. Maggots developed in the uncovered meat from the eggs laid by the flies. The other two pieces of meat did not produced maggots spontaneously. However, flies were attracted to the gauze-covered container and laid their eggs on the gauze and produced maggots. Hence, the development of maggots resulted from the presence of flies eggs and not from the meat spontaneously.

Figure 3: Redi's experiment on spontaneous generation

The concept and debate of spontaneous generation was revived in 1748 by an English Priest John Needham. In his experiment he boiled mutton broth and then tightly stoppered the flask. Many of the flasks become turbid because of the presence of microorganisms in it. He thought that organic matter contains a vital force that could confer life on non-living matter.

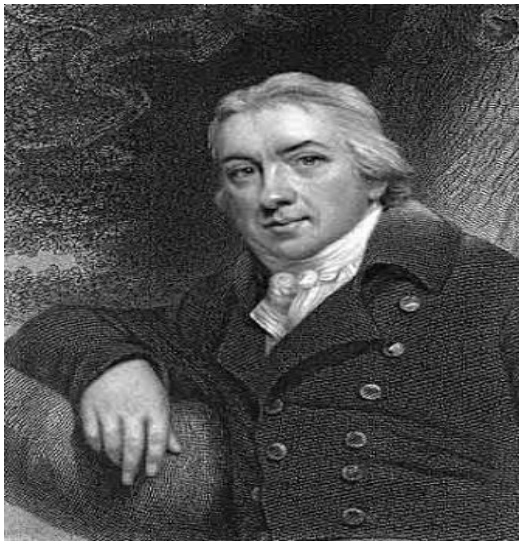

Figure 4: Lazzaro Spallanzani, (1729-1799)

Lazzaro Spallanzani, (1729-1799) an Italian Priest and naturalist improved on Needham experiment by sealing the flask that contained water and seeds and placing it on boiling water for ¾ of an hour. No growth took place as long as the flask remained sealed. He proposed that not only air carried germs to the culture medium, air is required for growth of animals already in the medium.

The controversy over spontaneous generation was resolved by a French scientist Louis Pasteur (1822-1895) in 1861.

Figure 5: Louis Pasteur (1822-1895)

In his experiment Pasteur first filtered air through cotton and found that objects resembling plant spores had been trapped. If this piece of cotton is placed in a sterile medium microbial growth appeared. In another experiment Pasteur boiled nutrient solution in a flask which have a variety of curves while keeping the ends of the necks open to the atmosphere. No growth took place when the flask is cooled even though the contents of the flask were exposed to the air. He pointed out that no growth appeared in the flask because the germs and the dust particles are trapped on the walls of the curved necks. If the necks were broken growth commenced immediately.

Figure 6: Pasteur swan neck flask

A final blow to spontaneous generation was given by an English Physicist, John Tyndall (1820-1893) in 1877 by demonstrating that dust indeed carry germs and if dust were absent, broth remained sterile even if directly exposed to air. Tyndall also provided evidence for the existence of heat resistance forms of bacteria. He then developed a method of sterilization by discontinuous heating known as tyndallisation which could kill not only the growing bacteria but also their heat resistant forms.

ROLE OF MICROBES IN DISEASES

Earlier many scientist suggested that disease were caused by invisible living creature but this idea was not accepted and people believed that diseases was due to supernatural forces.

Louis Pasteur postulated a theory known as germ theory of disease which states that infectious diseases are caused by microorganisms. But the first direct demonstration with evidence of the role of bacteria in disease was provided by Robert Koch (1843-1910) from the study of anthrax.

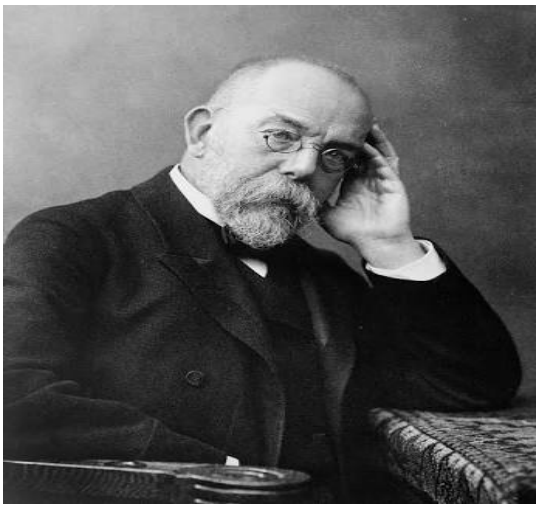

Figure 7: Robert Koch (1843-1910)

He established the etiological role of bacteria in anthrax and proposed a set of rules in the establishment of etiology. The procedures made by Koch is known as Koch postulates. Koch postulates states that –

1. The microorganism must be present in every case of the disease but absent from healthy organism
2. The suspected microorganism must be isolated and grown in a pure culture.
3. The same disease must result when the isolated microorganism is inoculated into a healthy host.
4. The same microorganism must be isolated again from the diseased host.

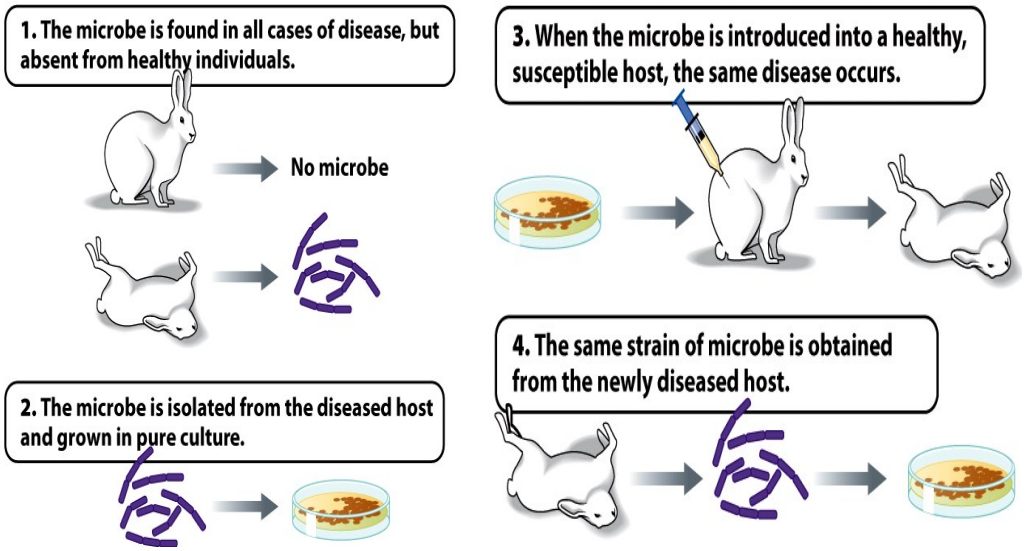

Figure 8: Koch postulate

Koch also developed media suitable for growing bacteria isolated from the body. This resulted in the development of nutrient broth and nutrient agar.

Vaccines against rabies and anthrax were developed by Pasteur. During his studies on chicken cholera he discovered that culture lost their ability to cause disease when incubated for long intervals. If the chickens were injected with these attenuated cultures, they remained healthy but developed the ability to resist the disease. Such attenuated culture is termed as vaccine.

Joseph Lister (1872-1912) developed a system of surgery designed to prevent microorganism from contaminating wounds. He implemented the use of sterile surgical instrument and used carbolic acid (phenol) during surgery and wound dressing.

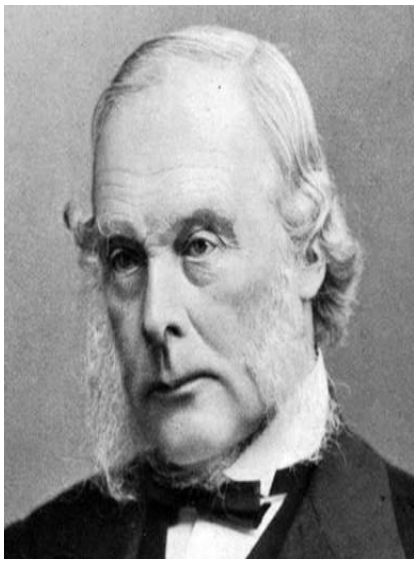

Figure 9: Joseph Lister (1872-1912)

MICROBIAL EFFECTS ON ORGANIC AND INORGANIC MATTER

Earlier people believed that fermentation was due to the chemical instability that degrades sugar to alcohol although Theodore Schwann and others proposed in 1837 that alcoholic fermentation was carried out by yeast cells. It was Pasteur who demonstrated that all fermentations were due to the activities of specific yeast and bacteria.

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow{\text{Zymase in yeast}} \underset{\text{Ethanol}}{2C_2H_5OH} + \underset{\text{Carbon dioxide}}{2CO_2}$$

His discovery came from the work of wine souring which resulted in the decline of alcohol yield. Pasteur showed that fermentation was failing because the yeast normally responsible for alcohol formation had been replaced by microorganism producing lactic acid rather than ethanol. His discovery on fermentation not only led to the study of wine diseases but also developed a technique known as pasteurization for the storage of wine.

SCOPE OF MICROBIOLOGY

Microbes were the first living organism on our planet and are more numerous then any other kind of organism. From among the five kingdom classification proposed by R.H.Whittaker (1969) microbes include three of the kingdoms i.e. Monera, Prostita and Fungi. Microbiology deals with five major groups of microorganisms – viruses, bacteria, fungi, algae and protozoa. Microbiology has a great impact on medicine, agriculture, food science, ecology, genetics, biochemistry and other fields. Microbiology has two main branches –

1. Basic Microbiology

2. Applied Microbiology

The basic branch of microbiology is the study of biology of microorganisms which include –

1. Bacteriology (study of bacteria)
2. Mycology (study of fungi)
3. Algology (study of algae)
4. Protozoology (study of protozoa)
5. Microbial cytology (study of microbial cell structure)
6. Microbial physiology (study of microbial metabolism and growth)
7. Microbial genetics (study of genetic information of microorganisms and their regulation and function).
8. Microbial Ecology (study of microorganisms in their natural environment)
9. Microbial Taxonomy (study of microbial classification)
10. Biochemistry (study of microbial enzymes and their chemical reactions)

The applied aspect of microbiology deals with practical application of microorganism to solve problems related to diseases, water and waste water treatment, food spoilage and food production.

CONCLUSION

The science of microbiology involved microorganisms that are very small and cannot be seen by naked eye. Microbiology developed only after the invention of microscope. Antony Van Leeuwenhoek shown microorganisms which he referred to as animalcules to the world for the first time. Simple organisms are developed by spontaneous generation was universally accepted prior to the introduction of microscope. This view was challenged and disproved by experiments of Francesco Redi, Pasteur and many others. The idea of spontaneous generation was displaced by the germ theory of diseases. The tremendous strides made by infectious diseases research since the days of Robert Koch have led to great expectations of infectious disease control community.

GLOSSARY

Attenuated: A procedure that reduces or abolishes the virulence of a pathogen without altering its immunogenicity.

Etiology: A branch of science concerned with the causes and origin of diseases

Fermentation : An energy yielding process in which organic molecules serves as both electron donors as well as acceptors.

Media: A substance either solid or liquid used for the cultivation of microorganism

Microorganism: An organism that is too small to be seen by naked eye.

Microscope: An optical instrument used for viewing very small objects

Pasteurization: The process of heating milk and other liquids to destroy microorganisms that can cause spoilage or disease

Sterilization: The process by which all living cells, viable spores, viruses and viriods are either destroyed or removed from an object or habitat.

Tyndallisation: A sterilization process in which the container is heated at 90-100ºC for 30 minutes.

Vaccine: A preparation of either killed or weakened microorganism administered to induced immune response.

FAQs:

1. State the Koch postulates.

Answer: Koch postulates state that –

1. The microorganism must be present in every case of the disease but absent from healthy organism
2. The suspected microorganism must be isolated and grown in a pure culture.
3. The same disease must result when the isolated microorganism is inoculated into a healthy host.
4. The same microorganism must be isolated again from the diseased host.

2. Define microbiology.

Answer: Microbiology is the study that deals with the study of organism too small to be seen by the naked eye.

3. How did Louis Pasteur resolved the controversy over spontaneous generation?

Answer: Louis Pasteur resolved the controversy over spontaneous generation in 1861. In his experiment Pasteur first filtered air through cotton and found that objects resembling plant spores had been trapped. If this piece of cotton is placed in a sterile medium microbial growth appeared. In another experiment Pasteur boiled nutrient solution in a flask which have a variety of curves while keeping the ends of the necks open to the atmosphere. No growth took place when the flask is cooled even though the contents of the flask were exposed to the air. He pointed out that no growth appeared in the flask because the germs and the dust particles are trapped on the walls of the curved necks. If the necks were broken growth commenced immediately.

4. State the spontaneous generation theory

Answer: The spontaneous formation of living beings from non living matter is known as the spontaneous generation theory.

5. Discuss the contribution of Joseph Lister and Louis Pasteur to the treatment or prevention of disease.

Answer: Joseph Lister (1872-1912) developed a system of surgery designed to prevent microorganism from contaminating wounds. He implemented the use of sterile surgical instrument and used carbolic acid (phenol) during surgery and wound dressing.

Vaccines against rabies and anthrax were developed by Pasteur. During his studies on chicken cholera he discovered that culture lost their ability to cause disease when incubated for long intervals. If the chickens were injected with these attenuated cultures, they remained healthy but developed the ability to resist the disease. Such attenuated culture is termed as vaccine.

6. Differentiate between basic and applied microbiology.

Answer: The basic branch of microbiology is the study of biology of microorganisms whereas the applied aspect of microbiology deals with practical application of

microorganism to solve problems related to diseases, water and waste water treatment, food spoilage and food production.

7. Briefly describe the experiment conducted by Francesco Redi to disproved the spontaneous generation theory.

Answer: To disprove the spontaneous generation theory Francesco Redi experiments on decaying meat and its ability to produce maggots spontaneously. Redi placed meat in three containers. One was uncovered, the second was covered with papers and the third was covered with fine gauze that would exclude flies. Maggots developed in the uncovered meat from the eggs laid by the flies. The other two pieces of meat did not produced maggots spontaneously. However, flies were attracted to the gauze-covered container and laid their eggs on the gauze and produced maggots. Hence, the development of maggots resulted from the presence of flies eggs and not from the meat spontaneously.

8. Describe the contribution of John Tyndall in microbiology.

Answer: John Tyndall finally resolved the spontaneous generation theory in 1877 by demonstrating that dust indeed carry germs and if dust were absent, broth remained sterile even if directly exposed to air. Tyndall also provided evidence for the existence of heat resistance forms of bacteria. He then developed a method of sterilization by discontinuous heating known as tyndallisation which could kill not only the growing bacteria but also their heat resistant forms.

9. What are animalcules?

Answer: Antony Van Leeuwenhoektermed the organism that he observed under his microscope for the first time as animalcules.

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