HISTORICAL DEVELOPMENT OF MICROBIOLOGY AND THE EFFECTS ON HEALTH

The term microbiology was given by French chemist **Louis Pasteur (1822-95)**. Microbiology is the study of living organisms of microscopic size (too small to be observed by the naked eye) called microbes. The term microbe was first used by **Sedillot (1878)**. The discipline focuses on the structure, function, and classification of these organisms and looks for ways to exploit and control their activities. Microbiology is said to have its roots in the great expansion and development of the biological sciences that took place after 1850. The divesity of microbes is truly staggering, yet all these microbes can be grouped into six major types: **Viruses, Bacteria, Archaea, Fungi, Protists, and Protozoa**.

Daily life is interwoven inextricably with microorganisms. In addition to populating both the inner and outer surfaces of the human body, microbes abound in the soil, in the seas, and in the air. Abundant, although usually unnoticed, microorganisms provide ample evidence of their presence—sometimes unfavourably, as when they cause decay of materials or spread diseases, and sometimes favourably, as when they ferment sugar to wine and beer, cause bread to rise, flavour cheeses, and produce valued products such as antibiotics and insulin. Microorganisms are of incalculable value to Earth's ecology, disintegrating animal and plant remains and converting them to simpler substances that can be recycled in other organisms.

Microbes are important in a plethora of industrial, physiological and pathological functions, including to;

- ferment foods
- treat sewage
- produce fuel, enzymes, and other bioactive compounds
- use as essential tools in biology as model organisms
- use in biological warfare and bioterrorism.
- Microbes are a vital component of fertile soil.
- In the human body, microorganisms make up the human microbiota, including the essential gut flora.
- The pathogens responsible for many infectious diseases are microbes

THE STUDY OF MICROORGANISMS

As is the case in many sciences, the study of microorganisms can be divided into two generalized and sometimes overlapping categories. Whereas **basic microbiology** addresses questions regarding the biology of microorganisms, **applied microbiology** refers to the use of microorganisms to accomplish specific objectives.

Fields of Microbiology

- Mycology: The study of fungi.
- Bacteriology: The study of bacteria.
- Virology: The study of viruses.
- Protozoology: The study of protozoa.
- Protistology: The study of protists
- Phycology/algology: The study of algae

IMPORTANT FIGURES OF MICROBIOLOGY

HISTORY OF MICROBIOLOGY

Spontaneous generation versus biotic generation of life

Until about the 1880s, people still believed that life could form out of thin air and that sickness was caused by sins or bad odors. The early Greeks believed that living things could originate from nonliving matter (abiogenesis) and that the goddess Gea could create life from stones. Aristotle discarded this notion, but he still held that animals could arise spontaneously from dissimilar organisms or from soil. His influence regarding this concept of spontaneous generation was still felt as late as the 17th century, but toward the end of that century a chain of observations, experiments, and arguments began that eventually refuted the idea. This advance in understanding was hard fought by individuals and schools of thoughts alike.

Varo and Columella in the first century BC postulated that diseases were caused by invisible beings (Animalia minuta) inhaled or ingested. **Fracastorius of Verona (1546)** proposed a contagium vivum as a possible cause of infections disease and **Von Plenciz (1762)** suggested that each disease was caused by a separate agent.

TIMELINE OF MICROBIOLOGY DEVELOPMENT

THE DISCOVERY ERA

- **Robert Hooke,** a 17th-century English scientist, was the first to use a lens to observe the smallest unit of tissues he called “cells.” Soon after, the Dutch amateur biologist **Anton van Leeuwenhoek** observed what he called “animalcules” with the use of his homemade microscopes.
- **Antonie van Leeuwenhoek (1632-1723)** of Delft, Holland (Netherland) was the first person to observe and accurately describe microorganisms (bacteria and protozoa) called ‘animalcules’ (little animals) in 1676 using a microscope he made himself. He is considered as the “Father of microbiology” because of this extraordinary contribution to microbiology. Leeuwenhoek is also considered to be the father of bacteriology and protozoology (protistology).

TRANSITION PERIOD

When microorganisms were known to exist, most scientists believed that such simple life forms could surely arise through **spontaneous generation**. That is to say life was thought to spring spontaneously from mud and lakes or anywhere with sufficient nutrients. This concept was so compelling that it persisted **until late into the 19th century**. The main aspects were to solve the controversy over spontaneous generation which includes experimentations mainly of **Francesco Redi, John Needham, Lazzaro Spallanzani** and **Nicolas Appert** etc and to know the disease transmission which mainly includes the work of **Ignaz Semmelweis** and **John Snow**. **Darwin (1859)** in his book, ‘Origin of the Species’ showed that the human body

could be conceived as a creature susceptible to the laws of nature. He was of the opinion that disease may be a biological phenomenon, rather than any magic.

THE GOLDEN AGE

The Golden age of microbiology began with the work of Louis Pasteur and Robert Koch who had their own research institute. During this period, we see the real beginning of microbiology as a discipline of biology.

- The concept of spontaneous generation was finally put to rest by the French chemist **Louis Pasteur** in an inspired set of experiments involving a goosenecked flask. When he boiled broth in a flask with a straight neck and left it exposed to air, organisms grew. When he did this with his goose-necked flask, nothing grew. The S-shape of this second flask trapped dust particles from the air, preventing them from reaching the broth. By showing that he could allow air to get into the flask but not the particles in the air, Pasteur proved that it was the organisms in the dust that were growing in the broth. Pasteur, thus in 1858 finally resolved the controversy of spontaneous generation versus **biogenesis** and proved that microorganisms are not spontaneously generated from inanimate matter but arise from other microorganisms.
  He also found that fermentation of fruits and grains, resulting in alcohol, was brought about by microbes and also determined that bacteria were responsible for the spoilage of wine during fermentation. Pasteur in 1862 suggested that mild heating at 62.8°C (145°F) for 30 minutes rather than boiling was enough to destroy the undesirable organisms without ruining the taste of the product, the process was called ***Pasteurization***. His work led to the development of the germ theory of disease. **Louis Pasteur is known as the "Father of Modern Microbiology / Father of Bacteriology.**
- **John Tyndall (1820 – 1893):** An English physicist, deal a final blow to spontaneous generation in 1877. He conducted experiments in an aseptically designed box to prove that dust indeed carried the germs. He demonstrated that if no dust was present, sterile broth remained free of microbial growth for indefinite period even if it was directly exposed to air. He discovered highly resistant bacterial structure, later known as endospore, in the infusion of hay. Prolonged boiling or intermittent heating was necessary to kill these spores, to make the infusion completely sterilized, a process known as ***Tyndallisation.***
- Around the same time that Pasteur was doing his experiments, a doctor named **Robert Koch** was working on finding the causes of some grave animal diseases (first anthrax, and then tuberculosis). He gave the first direct demonstration of the role of bacteria in causing disease. He was a german physician who first of all isolated anthrax bacillus (*Bacillus anthracis*, the cause of anthrax) in 1876. He perfected the technique of isolating bacteria in pure culture. He also introduced the use of solid culture media in 1881 by using gelatin as a solidifying agent. In 1882, he discovered *Mycobacterium tuberculosis*. He proposed Koch postulate which were published in 1884 and are the corner stone of the germ theory of diseases and are still in use today to prove the etiology (specific cause) of an infectious disease.

Koch's four postulates are:

- The organism causing the disease can be found in sick individuals but not in healthy ones.
- The organism can be isolated and grown in pure culture.
- The organism must cause the disease when it is introduced into a healthy animal.
- The organism must be recovered from the infected animal and shown to be the same as the organism that was introduced.

- The combined efforts of many scientists and most importantly Louis Pasteur and Robert Koch established the **Germ theory of disease**. The idea that invisible microorganisms are the cause of disease is called **germ theory**. This was another of the important contributions of Pasteur to microbiology. It emerged not only from his experiments disproving spontaneous generation but also from his search for the infectious organism (typhoid) that caused the deaths of three of his daughters.
- **Fanne Eilshemius Hesse (1850 – 1934)** one of Koch's assistant first proposed the use of agar in culture media. Agar was superior to gelatin because of its higher melting (i.e. 96°C) and solidifying (i.e. 40-45°C) points than gelatin and was not attacked by most bacteria. Koch's another assistant Richard Petri in 1887 developed the Petri dish (plate), a container used for solid culture media. Thus contribution of Robert Koch, Fannie Hesse and Richard Petri made possible the isolation of pure cultures of microorganisms and directly stimulated progress in all areas of microbiology.

During the **Golden Age of Microbiology,** many agents of different infectious diseases were identified. Many of the etiologic agents of microbial disease were discovered during that period, leading to the ability to halt epidemics by interrupting the spread of microorganisms. Despite the advances in microbiology, it was rarely possible to render life-saving therapy to an infected patient. Then, after World War II, the **antibiotics** were introduced to medicine. The incidence of pneumonia, tuberculosis, meningitis, syphilis, and many other diseases declined with the use of antibiotics. Work with viruses could not be effectively performed until instruments were developed to help scientists see these disease agents. In the 1940s, the **electron microscope** was developed and perfected. In that decade, cultivation methods for viruses were also introduced, and the knowledge of viruses developed rapidly. With the development of vaccines in the 1950s and 1960s, such viral diseases as polio, measles, mumps, and rubella came under control.

MODERN ERA - Progress in the 20th century

Since the 1940s microbiology has experienced an extremely productive period during which many disease-causing microbes have been identified and methods to control them developed. Microorganisms have also been effectively utilized in industry; their activities have been channeled to the extent that valuable products are now both vital and commonplace. The study of microorganisms has also advanced the knowledge of all living things. Microbes are easy to work with and thus provide a simple vehicle for studying the complex processes of life; as such they have become a powerful tool for studies in genetics and metabolism at the molecular level. This intensive probing into the functions of microbes has resulted in numerous and often unexpected dividends.

MEDICAL AND PUBLIC HEALTH MICROBIOLOGY

Following the establishment of the germ theory of disease in the mid-1880s and the development of laboratory techniques for the isolation of microorganisms (particularly bacteria), the causative agents of many common diseases were discovered in rapid succession. Some common diseases and the date of discovery of their causative agent illustrate this point: anthrax (1876), gonorrhea (1879), typhoid fever (1880), malaria (1880), tuberculosis (1882), diphtheria (1883), cholera (1884), and tetanus (1884). Some of the most notable successes of medical microbiology include the development of vaccines beginning in the 1790s, antibiotics during the mid-20th century, and the global eradication of smallpox by 1977.

Despite such great advances in identifying and controlling agents of disease and in devising methods for their control, the world still faces the threat of diseases such as AIDS and hantavirus pulmonary syndrome (HPS), the reemergence of old scourges such as tuberculosis, cholera, and diphtheria, and the increasing resistance of microbes to antibiotics. (See also public health; human disease; antibiotic resistance.)

MICROBES AND DISEASE

A few harmful microbes, for example **less than 1% of bacteria, can invade our body (the host) and make us ill**. Microorganisms are the causative agents (pathogens) in many infectious diseases. The organisms involved include pathogenic bacteria, causing diseases such as plague, tuberculosis and anthrax; protozoan parasites, causing diseases such as malaria, sleeping sickness, dysentery and toxoplasmosis; and also fungi causing diseases such as ringworm, candidiasis or histoplasmosis. However, other diseases such as influenza, yellow fever or AIDS are caused by pathogenic viruses, which are not usually classified as living organisms and are not, therefore, microorganisms by the strict definition.

There is also strong evidence that microbes may contribute to many non–infectious chronic diseases such as some forms of cancer and coronary heart disease. Different diseases are caused by different types of micro-organisms. **Microbes that cause disease are called pathogens.**

Infectious disease	Microbe that causes the disease	Type of microbe
Cold	Rhinovirus	Virus
Chickenpox	*Varicella zoster*	Virus
German measles	Rubella	Virus
Whooping cough	*Bordatella pertussis*	Bacterium
Bubonic plague	*Yersinia pestis*	Bacterium
TB (Tuberculosis)	*Mycobacterium tuberculosis*	Bacterium
Malaria	*Plasmodium falciparum*	Protozoan
Ringworm	*Trichophyton rubrum*	Fungus
Athletes’ foot	*Trichophyton mentagrophytes*	Fungus

IMPORTANT DEFINITIONS

- A **pathogen** is a micro-organism that has the potential to cause disease.
- An **infection** is the invasion and multiplication of pathogenic microbes in an individual or population.

- **Disease** is when the infection causes damage to the individual's vital functions or systems, with resultant physiological signs and symptoms. An infection **does not** always result in disease!
- To cause an infection, microbes must enter our bodies. The site at which they enter is known as the **portal of entry.**

Microbes capable of causing disease—or pathogens can enter the body through the four sites listed below:

- Respiratory tract (mouth and nose) e.g. influenza virus which causes the flu.
- Gastrointestinal tract (mouth oral cavity) e.g. Vibrio cholerae which causes cholera.
- Urogenital tract e.g. Escherichia coli which causes cystitis.
- Breaks in the skin surface - through wounds or bites that breach the skin barrier e.g. Clostridium tetani which causes tetanus.

Organisms can spread, or be transmitted, by several routes.

Droplets spread by sneezes, coughs, or simply talking can transmit disease if they come in contact with mucous membranes of the eye, mouth, or nose of another person.

Contact: Some diseases spread via direct contact with infected skin, mucous membranes, or body fluids. Diseases transmitted this way include cold sores (herpes simplex virus type 1) and sexually transmitted diseases such as AIDS. Pathogens can also be spread by indirect contact when an infected person touches a surface such as a doorknob, countertop, or faucet handle, leaving behind microbes that are then transferred to another person who touches that surface and then touches his or her eye(s), mouth, or nose. Droplets spread by sneezes, coughs, or simply talking can transmit infection if one person comes in contact with the mucous membranes of the eye(s), mouth, or nose of another person. Influenza is spread by airborne droplet transmission but more commonly by indirect contact on surfaces.

Common vehicles: Contaminated food, water, blood, or other vehicles may spread pathogens. Microorganisms like *E. coli* and Salmonella enter the digestive system in this manner.

Vectors: Creatures such as fleas, mites, and ticks—called vectors—can also transmit disease. The most common vector for human infection is the mosquito, which transmits malaria, West Nile virus, chikungunya, dengue fever, yellow fever, and Zika.

Airborne transmission: Pathogens can also spread when residue from evaporated droplets or dust particles containing microorganisms is suspended in air for long periods of time. Diseases spread by airborne transmission include tuberculosis, measles, hantavirus pulmonary syndrome, and Legionnaires' disease.

HUMAN GUT FLORA

Microorganisms can form an endosymbiotic relationship with other, larger organisms. For example, microbial symbiosis plays a crucial role in the immune system. The microorganisms that make up the gut flora in the gastrointestinal tract contribute to gut immunity, synthesize vitamins such as folic acid and biotin, and ferment complex indigestible carbohydrates. Some microorganisms that are seen

to be beneficial to health are termed probiotics and are available as dietary supplements, or food additives.

HYGIENE

Even though microorganisms, especially bacteria, are found virtually everywhere, harmful microorganisms may be reduced to acceptable levels rather than actually eliminated. In food preparation, microorganisms are reduced by preservation methods such as cooking, cleanliness of utensils, short storage periods, or by low temperatures. If complete sterility is needed, as with surgical equipment, an autoclave is used to kill microorganisms with heat and pressure.

Methods of reducing microbial population include;

- Decontamination reduces the microbial contamination of materials or surfaces and is accomplished through the use of a chemical disinfectant.

- Disinfection refers to the elimination of virtually all pathogenic organisms on inanimate objects and surfaces thereby reducing the level of microbial contamination to an acceptably safe level. Disinfection is accomplished through the use of chemical disinfectants. Some common laboratory disinfectants include freshly prepared10% bleach and 70% ethanol.

- In contrast, sterilization refers to the destruction of all microbial life. Methods used in sterilization procedures include heat, ethylene oxide gas, hydrogen peroxide gas, plasma, ozone, and radiation.

- Antisepsis is the application of a liquid antimicrobial chemical to skin or living tissue to inhibit or destroy microorganisms. It includes swabbing an injection site on a person or animal and hand washing with germicidal solutions.

Nosocomial infections also referred to as healthcare-associated infections (HAI), are infection(s) acquired during the process of receiving health care that was not present during the time of admission. They may occur in different areas of healthcare delivery, such as in hospitals, long-term care facilities, and ambulatory settings, and may also appear after discharge. To be considered nosocomial, the infection cannot be present at admission; rather, it must develop at least 48 hours after admission. These infections can lead to serious problems like sepsis and even death. HAIs also include occupational infections that may affect staff. Infection occurs when pathogen(s) spread to a susceptible patient host. HAI is the most common adverse event in health care that affects patient safety.

Often, nosocomial infections are caused by multidrug-resistant pathogens acquired via invasive procedures, excessive or improper antibiotic use, and not following infection control and prevention procedures. In fact, many nosocomial infections are preventable through guidance issued by national public health institutes such as the Centers for Disease Control and Prevention (CDC).

LINKS

https://ehs.mit.edu/biological-program/decontamination-and-disinfection/

https://www.osmosis.org/answers/nosocomial-infection