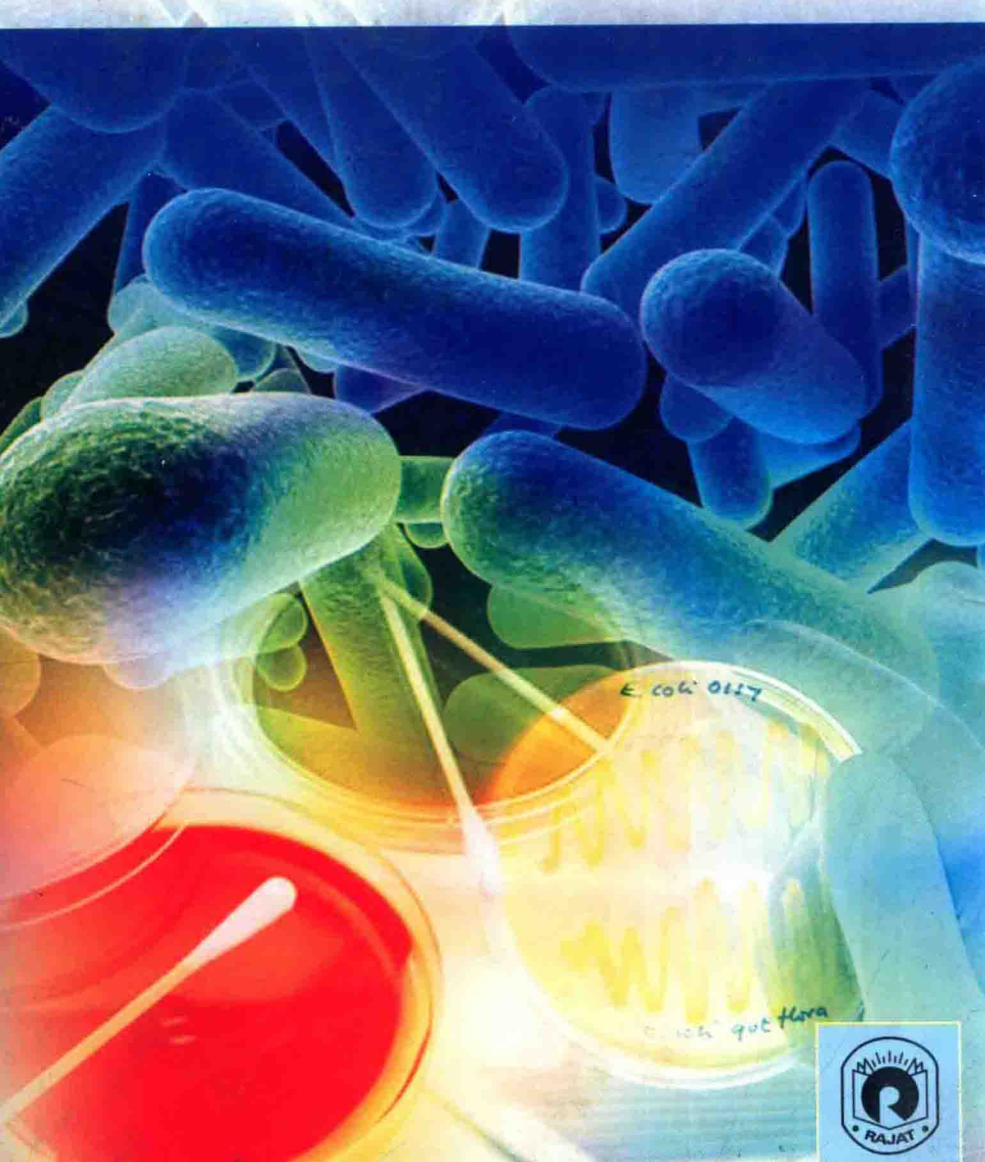
ADVANCES IN MICROBIOLOGY

Amrita Rohilla



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Preface

The purpose of the present book is to introduce the students of the Microbiology, an understanding of which will assist in evaluating biological principles found throughout the world of life. This introductory text contains adequate material to acquaint the student with fundamentals but omit unessential. It should serve to orient the thinking and broaden the horizons of students who pursue biological studies. Microbiology is one of the fastest emerging fields as it comprises of multidisciplinary subjects like medicine, agriculture and environment. The purpose of this book is to organize our knowledge into something that can be comprehended in a relatively short time and still convey a reasonably complete picture of the microorganisms and the diseases caused by them.

Amrita Rohilla

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Introduction

WHAT IS MICROBIOLOGY?

Microbiology is the study of micro-organisms which include bacteria, viruses, protozoa, algae and fungi. These organisms are extremely important in our everyday lives. Some are responsible for a significant proportion of the diseases affecting not only humankind but also plants and animals; others are vitally important in the maintenance and modification of our environment; still others play an essential role in industry, where their unique properties have been harnessed in the production of food, beverages and antibiotics. More recently, scientists have learnt how to exploit micro-organisms in the field of molecular biology, a science which is making an enormous impact both industrially and medically. Microbiology also encompasses the study of the body's ability to mount defences against infectious microbes.

Microbes are microscopic organisms, which range in size from the lower fungi and algae through bacteria to the smallest organisms of all, the viruses. Microbiology is the study of the properties of these organisms and the roles they play in health and disease, industrial processes as well as in the environment.

Microbiology in addition to the study of microbes also encompasses a wide range of research fields; from immunology, which sets out to study how the body's immune system protects the host from infectious disease, to microbial genetics, including the recently-developed field of recombinant DNA. Knowledge gained from the study of how bacteria carrying specially engineered DNA can economically produce new enzymes, pharmaceuticals and industrial processes is already revolutionising biotechnology industries. Microbiologists also study how to diagnose, prevent and treatinfectious diseases—important skills in this era of emerging diseases and antibiotic resistance.

Microbiology can be applied in fields as diverse as medicine and brewing, food spoilage and space science and in this regard, knowledge of microbiology is essential for understanding and causing problems arising from pollution of the environment by detergents, insecticides, hydrocarbons, etc. Novel sources of food and new processes in mining and other industries make use of bacteria.

Knowledge of microbiology is thus useful for people pursuing careers in health, engineering, food science and the environment and the human environment as well as for those intending to pursue careers in microbiology.

Microbiology, one of the fastest growing areas of science, is the study of organisms so small that they must be viewed with a microscope. These organisms are primarily bacteria, yeasts, molds, and viruses. Many of the most important scientific discoveries of recent years have been made by microbiologists: since 1910, one-third of the Nobel Prizes in medicine and physiology have been awarded to microbiologists. They are concerned with the welfare of humankind, concentrating not only on aspects of host-microbial interactions influencing disease and immunity, but also on ecological concerns impacting food production and the environment. There is a great demand for microbiologists. Graduates with a concentration in Microbiology find positions in the areas of medical, agricultural, food, industrial, or pharmaceutical microbiology, or microbial genetics or physiology. They may become teachers, science writers, technical librarians, or managers of scientific companies. Some of these professions require advanced degrees. The concentration in Microbiology is designed to furnish necessary experience in academic and practical skills to prepare graduates for immediate entry into the job market or for continuing graduate education in pure or applied biological sciences.

Microbiology is the branch of science dealing with microorganisms. It is one of the most relevant, dynamic and exciting disciplines in the biological sciences. Microorganisms benefit society by cycling inorganic and organic matter into molecules needed for life and detoxifying discarded wastes. Historically, they have served as microscopic factories for the production of cheeses, alcohol and antibiotics. Microorganisms have also been engineered to produce a wide variety of products for our benefit through the emergence of biotechnology. Microorganisms have, however, also inflicted great distress to human, animal and plant populations through disease, spoilage of crops, foods and the fouling and degradation of man-made structures. More recently, microorganisms have been used as terrorist weapons.

Microbiology has become an umbrella term that encompasses many sub disciplines or fields of study. These include:

- Bacteriology : The study of Bacteria
- Mycology : The study of Fungi
- Protozoology : The study of Protozoa
- Phycology : The study of Algae
- Parasitology : The study of Parasites
- Virology : The study of Viruses

An understanding of these various life forms in the environment has created other sub disciplines of: microbial ecology, microbial physiology, microbial genetics and molecular biology. Our need to control infectious diseases has brought about the fields of pathology and immunology. Bioinformatics, the in silico research, is a new area of research in microbiology which analyses the genomes of life forms.

Microbiology is the study of microscopically small, living organisms, such as fungi, algae, protozoa and bacteria, which require a light microscope for observation, and viruses which are visible only under an electron microscope at more than 20

000x magnification, to increase scientific knowledge and develop medical, veterinary, industrial, environmental and other practical applications. Basic characteristics of the microorganisms, including their form, structure, physiology, growth, reproduction and genetics are studied in courses on mycology, yeast biology, bacteriology and the molecular biology of bacteria, viruses and yeasts. Other courses deal with the composition, activities, ecology, practical importance and control of microbial populations of soil, water, food, plants, human and animal bodies, including disease-producing organisms, as well as industrial microbial fermentations.

Microbiology is the study of all microscopic organisms, principally bacteria, fungi and viruses. Microbiology is one of the foundation biological sciences. Through study of microorganisms has come fundamental understanding of how a cell works. It is also an applied science, helping health and medicine, agriculture and maintenance of the environment, as well as the biotechnology industries. We study microorganisms at the level of the community (ecology and epidemiology), at the level of the cell (cell biology and physiology), at the level of protein and gene (molecular biology). The fusion of these elements is Microbiology.

Microbiology today is an integral part of molecular biology, the study of cellular information, which applies to all of biology. Apparently simple organisms, bacteria and viruses are very important to us. They cause a variety of diseases in humans, animals, and plants. Microbiology has benefited us tremendously in improved health care and agriculture. Through the efforts of microbiologists, diagnosis and treatment of bacterial and viral infections have become effective for most diseases. Bacteria and viruses are also an essential part of genetic engineering which has universal application in biological research and in biotechnology. Bacteria are widely used to produce antibiotics and other chemicals, to generate energy from biomass, and to detoxify environmental pollutants. The Microbiology Option offers a strong science foundation and advanced courses in molecular biology of microorganisms, in microbial diversity, in immunochemistry, and in pathogenic and food microbiology. Many microbiology students graduate with a minor in chemistry although a minor is not required. An in-depth education in microbiology prepares you for academic and industrial research and development in many areas of biology as well as for investigations which focus on specific microorganisms or cellular systems. It also prepares you for advanced study in medicine and clinical microbiology and for graduate study in biology.

Microbiology is the study of microorganisms - specifically, disease-causing microorganisms. Microbiology is responsible for identifying infectious agents in blood, urine, sputum, feces, cerebrospinal fluid, and other body fluids. The infectious agents are then tested for sensitivity to certain antibiotics used to treat infections.

Bacteria are absolutely necessary for all life on this planet - for every known ecosystem - including the human ecosystem! Without bacteria, there would be no life, as we call life, on the earth. However, it is a good thing that most bacteria die-out. Here is why: bacteria are single-cell organisms, that produce more of their kind by cell-division, alone. So, if one begins with a single bacterial cell like E. coli, in 20 minutes there will be two, and 20 minutes later, four, etc., E. coli cells. At this rate, even though most bacteria are several hundred-times smaller than we can see with our naked eye, in only 43 hours, from that one cell at the beginning, there would be enough E. coli to occupy the entire volume of the earth (1,090,000,000,000,000,000,000 cubic meters)! In only about two additional hours, these bacteria would weigh as much as the earth - 6,600,000,000,000,000,000,000 tons! Bummer! Luckily for us, most bacterial cells die because of the enormous competition for food, and because of other tiny organisms which produce substances (antibiotics) that kill them - you know, like penicillin, which is made by a particular fungus, the mold - Penicillium). Thank goodness for that one, huh? Actually, many antibiotics are made by certain bacteria too, and, we get many of our necessary vitamins and nutrients from bacteria by allowing the bacteria to multiply in number, and isolating the things that they make, that we cannot make. Amino acid supplements are available ("enriched" bread simply means that the amino acid, lysine, which we absolutely need, but cannot make ourselves, is added to the flour used to make the bread), to provide one additional source which most people will eat. This amino acid is produced by certain bacteria grown in huge vats (can be 20,000 liters at one time - that's about 1,500 gallons!), and purified for our use. Antibiotic production is similarly done.

With the advent of molecular genetics and recombinant DNA technology, bacteria now play a very important role as producers of human substances. Since we have learned how genes function, we are able to introduce a human gene into a bacterium and have the product of the human gene expressed. Consequently, a hormone called erythropoietin, which is absloutely necessary for the proper development of red blood cells (erythrocytes), but very, very, difficult to isolate, is now available in high quantity. People who do not have kidneys cannot make this hormone; however, because the hormone has been cloned into bacteria, plenty of this hormone can be made, purified, and given to these people. Human insulin can be similarly made. These are only two examples of the many substances now available to treat human disorders because of our understanding of bacteria.

Scientists use two names to describe each kind of bacteria. The first is the genus name and second is the species name. The genus name usually refers to the group to which the bacterium belongs, somewhat like our human family names, except it is listed first. Many times the genus and species names are selected to describe some general feature of the bacterium. The word used to describe the genus name, Streptococcus, tells us that it is a sphere-shaped cell and that it occurs in chains. The species name is more specific and usually refers to the activity or habit of the organism. The species name lactis tells us that is associated with milk. To illustrate, then, we have the most common bacterium in dairy work: Streptococcus lactis. Once one becomes familiar with the various types of bacteria important to your work, "nicknames" are often used to describe the species of bacteria. Streptococcus lactis becomes "Strept. lactis". If you want to refer to more than one species of bacteria that have some common characteristics, you can use another nickname, like Streps, referring to those several species of bacteria with characteristics like those found in the genus Streptococcus. One nickname commonly used in the dairy industry is E. coli which is short for Escherichia coli. With sometimes difficult names to pronounce, it is no wonder that people prefer bacterial nicknames!

HOW SMALL ARE MICROORGANISMS?

One of the most important things to remember about bacteria is their extreme smallness. The fact that they cannot be seen with the unaided eye is one of the chief reasons they are not given the prime consideration they should by people in the dairy and food industries. The average bacterial cell is 1/25,000 of an inch in length and even smaller in diameter. In other words, one could place 25,000 bacteria cells, side by side, on an inch-long line. By contrast, if 25,000 people were lined up shoulder to shoulder, they would make a line over 18 miles long. For us to see these incredibly small living things, a microscope with a magnification of over 800 power or more is needed. In contrast, most binoculars used to observe sporting evens magnify objects about 7 to 10 power. So if these bacteria are too small to see with the eye, how does one know they are present in a food? The process we use is to plate the food being examined to determine if bacteria are present. One takes a sample of food being examined and places a small portion of it on an agar that contains food on which bacteria will grow. The agar, a gelatin-like substance containing the bacterial food, is actually placed in a Petri plate, a shallow round dish with a cover. A small portion of the food being examined is spread over the surface of the agar. The amount of food being "plated" depending on the suspected number of bacteria in the food. For foods containing only a few bacteria, up to one gram (g) or milliliter (ml) will be "plated". For foods heavily contaminated with bacteria, one-millionth or a gram or ml of the food would be plated. The food is diluted with sterile water to achieve this small amount on the agar in the Petri plate. If bacteria are present they grow rapidly producing offspring that within 12 to 48 hours will produce a "mound" of bacteria in one spot. We can see this mound and call it a colony. The assumption is that each colony originated from one bacterial cell 12 to 36 hours ago. If this assumption is true—sometimes it is not-likely one can calculate the number of bacteria in the original food placed on the agar in the Petri dish by knowing how much food was placed on the plate originally.

An individual bacterium is very tiny. They are usually one or two micrometers across. Since micro means 1/000,000 (one-millionth), they are commonly one millionth of a meter in diameter. A meter is 39.37 inches (3.33 inches longer than a yard). How many bacteria lying snugly side-by-side would it take to reach one meter? Since they are one to two micrometers wide, it would take about one million lying side by side to reach one meter, or 500,000 if they were 2 micrometers wide.

Is bacteria the same thing as a virus? Bacteria are very small one-celled organisms. There are many different kinds & they live all around us...on your computer keyboard, on the table, on your face, and in your body! Most of them are not harmful. Some, however, can cause illness in our bodies. If you get sick from bacteria, your doctor may prescribe antibiotics, a medicine made from fungus, a natural enemy of bacteria, to kill the bacterial infection.

Viruses are much smaller and are unlike any other living thing on earth. In fact, scientists disagree as to whether viruses are "living" at all. When a tiny virus comes into contact with the type of cell that it likes to attack, the virus sticks to the cell & injects it with instructions. These instructions replace the natural instructions in the cells nucleus. The cell gets confused and begins to follow the new (wrong) instructions, and uses its energy to make more viruses instead of what it was doing before. When the cell is full of new viruses, it explodes & the viruses float off to find more cells. Our immune system makes white blood cells that kill viruses, but sometimes it takes time.

Once your white blood cells figure out how to kill the virus, they never forget. If that type of virus ever attacks your body again, your white blood cells will kill it instantly.

Bacteria are very small. They do big things. If a three micron long bacterium were enlarged to the size of a six-foot, tall person, and then the person was enlarged the same way, the person would be about 700 miles tall. Yes, bacteria are small. Bacteria often live in tunnels left behind as hyphae of soil fungi die. Amoebae are not able to attack the bacteria in the minute- diameter tunnels.

While some bacteria are small spheres, others are shaped like tiny hotdogs (frankfurters, or sausages). Some species of bacteria hang together in chains like a chain of sausages. Often these chains contain only a few cells, but some form chains of hundreds of cells. The hotdog shaped bacteria are usually 2 or 3 times as long as wide, but some are very long in comparison to width. Some individual cells are long shaped like a needle.

Many species of bacteria reproduce by a wall forming across the cell dividing the original cell into two daughter cells having the same shape and genetic composition. Since the cells are growing, by the time division (fission) is completed each of the daughters may be as large as the mother cell was before it began fission (splitting).

Bacteria are very small (microscopic) unicellular procaryotes, mostly without chlorophyll. (All other organisms are eucaryotic – having DNA surrounded by a nuclear membrane.

With the exception of few very interesting photosynthetic bacteria and others that are chemosynthetic, bacteria are poor synthesizers. Most are saprophytic heterotrops and are valuable decomposers in soil and water; but of course, some decomposers of food and plant fibers are pests and a few species cause very serious animal and plant diseases.

To familiarize yourself with the three types of bacteria, look first at the stained slide of the "type bacteria". The cocci are spherical, the bacilli are rod-shaped, the spirilli are spiral-shaped. Sometimes the cells are single, sometimes they are joined together in chains or groups. For instance, cocci in chains are streptococci, in pairs: diplococci, in irregular groups: staphylococci, in regular cubes:

Bacteria are very small living organisms made of only one cell. They are present just about everywhere: the air, the soil, and the skin. Many of them are microbes that cause diseases, but others are very helpful to humans. Bacteria in the intestine help digestion and we often use bacteria to make food products.

Bacteria are very small, single-celled living things. Their cell walls differ from those of other living things – they are made from a different material and the nuclei and organelles are not enclosed in membranes. Bacteria are very successfully adapted to an immense range of habitats. While most need oxygen for respiration, others use sulphate and nitrates instead of oxygen.

Bacteria are very small micro organisms that can not be seen with a naked eye. So we can not see them swimming in water. The other problem is that often millions of bacteria are condensed in a small spot.

To see bacteria, you grow them in a nutrient agar plate so each bacteria will become a colony of thousands of bacteria. Then we can see them as a bacteria colony.

Bacteria are very small - they cannot be detected by the naked eye - up to 3 million can fit on the end of a pin. Some bacteria are essential to life and are naturally present in the human gut and help in the digestion of food. Bacteria which are harmful to man are called Pathogens and it is these that cause food poisoning and other illnesses. Many of these bacteria are destroyed during cooking, however some of them may produce spores and toxins which can survive very high temperatures, and are therefore able to re-contaminate food as it cools.

As an aside not all bacteria are very small i.e a few microns, there are some species that are fractions of a millimetre in diameter. The largest found to date, a bacterium 0.75mm across, was recently reported in the press and is thus just visible to the naked eye. Bacteria are very small, yet they show a surprising degree of complexity in their structures. Bacteria causing disease (pathogens) have various properties that make them have a better ability to create illnesses. One important property is the ability to attach to the victim. Many bacteria are capable of movement in their environment by gliding motility. Bacteria have a long, flexible, spiral shaped structure, the flagellum, that helps to push the microbe through solution. As a microbe grows, it has to synthesize most of its self.

Bacteria are very small creatures that can only be seen with a microscope.

Bacteria are very small (<1 to 5 microns) and can only be seen adequately by electron microscopy. Fungi and protozoa are much larger (12 to 200 microns or even larger) and can be seen with a light microsope at x 400 magnification.

Bacteria multiply by splitting into halves, a process called binary fission. Under the most favourable conditions one bacterial cell will divide into two cells in about 20 to 30 minutes. Twenty minutes later, these two cells will elongate and split into four cells. Then after 20 more minutes, each of the four cells will divide into eight cells and so on. It's called a logarithmic progression ("log growth", as the bacteriologist call it). 1 cell ' 2 cells ' 4 cells ' 8 cells ' 16 cells ' 32 cells ' 64 cells ' 128 cells ' 256 cells ' 512 cells ' 1024 cells, etc. In the previous examples one bacterial cell, multiplying about every 20 minutes, increases it's number in less than 3 hours to around 1020 cells. In 36 hours of continuous, unrestricted growth, there would be enough bacteria to fill 200 five-ton trucks! Obviously, bacteria do not multiply indefinitely, so what does control bacterial growth? One factor is temperature.

Nanobacteria have exceptional properties. Firstly, nanobacteria can be cultured in cell culture media for mammalian cells. However this organism does not need mammalian cells at all. It grows under conditions similar or