UNIT 1

THE WORLD OF MICROBES

A. MICROBES: THE FACTORY OF EVERYTHING

MICROBES AND MAN

Despite their small size, microbes are certainly of immense importance to man; they cause disease, provide us with various foods and medicines, and dispose of our wastes.

Mankind has made use of microorganisms, or their biochemical activities, since long before he even knew of their existence. We know that in 6000 BC the ancient Babylonians and Sumerians were brewing beer as we do today and that the Egyptians were baking leaven bread 2000 years later. Despite the antiquity of these microbiological practices, the first documentations of the structure of microorganisms did not occur until the advent of the first microscopes in the seventeenth century.

We live in a time when microbiology has come of age. Industrial microbiologists produce microbial products on a huge scale. We use microbes to make beer, wine, cheese, yoghurt, sauerkraut, soya sauce, antibiotics, pesticides, gels and many other products. Microbiological reactions are used to process sewage, transform the chemical structures of drugs, clean clothes and even to extract precious metals such as copper and uranium from their mineral ores. Within the last decades new technologies have been developed, such as gene cloning, which will use microbes as factory cells for the synthesis of valuable pharmaceutical products such as human insulin, hormones, antiviral drugs and vaccines.

Despite the dramatic advances in medical microbiology since the time of Robert Koch, microorganisms will continue to be a major problem in medicine and in diseases of plants. There is still no cure for the common cold or any of the most serious viral diseases of man.

It would be grossly misleading to create the impression that microorganisms such as bacteria are by their very nature pathogenic. A normal healthy human body harbours on its surface and within its alimentary canal ten times as many microbial cells than it has cells of its own kind. Many of these are of positive benefit to the digestive process and the rest are mostly harmless passengers which we never notice.

Our relationship with the microbes is and will continue to be dichotomous – they are our deadliest adversaries but also our closest allies.

(From: J.F. Wilkinson, *Introduction to Microbiology*, Blackwell Scientific Publications)

1 *What do these personal adjectives and pronouns underlined in* Microbes and man *refer to?*

a. he *refers to* .....

b. their *refers to* .....

c. their *refers to* .....

d. their *refers to* .....

e. its *refers to* .....

f. these *refers to* .....

g. they *refers to* .....

2 *Find in* Microbes and Man*:*

a. two foods made by using microorganisms: .....

b. two beverages made by using microorganisms: .....

c. two pharmaceuticals made by using microorganisms: .....

3 *Say whether these statements are true or false and correct the false ones.*

a. All microorganisms are pathogens. .....

b. Man has always known about the existence of microorganisms. .....

c. Microorganisms have been used for making food and alcoholic beverages for many thousands years. .....

d. Microbes are used for making pharmaceuticals. .....

e. Microbial products can now be produced in large quantities. .....

4 *Choose the correct option among the words in italics in the sentences below.*

1. The brewing of beer dates back *a) 4000 b) 6000 c) 8000* years.
2. The Egyptians could make leaven bread in *a) 6000 BC b) 4000 BC c) 2000 AD.*
3. The first microscope was invented in *a) 1600 b) 1700 c) 1800.*
4. Microorganisms *a) have never been b) are no longer c) are still* a problem in medicine.
5. *a) No b) Some c) All* viral diseases can be successfully treated.

5 *Use the nouns below to complete the passage* What is microbiology?

acid, alkali, biosphere, compound, ecosystem, microorganisms, oceans, plants and animals, plastics, pressures, salts, sight, specializations, springs, temperatures, waste

Microbiology is the study of (1) ....., that is organisms which are of microscopic dimensions. The striking diversity of microorganisms lies in their ecological and physiological (2) ..... There are microbes which are adapted for life in the coldest (3) .... and in hot water (4) ..... where (5) ..... approach boiling point. Others are capable of growing in saturated (6) ....., at high (7) ...., in (8) ..... at pH 0.2 or (9) ..... at pH 12.5. The terrestrial (10) ..... depends on the activities of bacteria and fungi to dispose of the organic (11) ..... that would otherwise accumulate and consume the land. To this end, there are microbes that are capable of degrading every natural organic (12) ..... and all but a few man-made organic materials such as certain (13) ....., dioxins, etc. Microorganisms also form a range of associations with other microbes and with higher (14) ..... They can be pathogens, parasites, symbionts, commensals and saprophytes. The microbiological world may be hidden from (15) ..... but it is a microcosm whose activities are of central importance to the structure of the (16) .....

B. PROKARYOTES vs. EUKARYOTES

HOW EUKARYOTES ARE DIFFERENT FROM PROKARYOTES

Around two billion years ago, when all cells still lived in the ocean, a few of the earliest cells, or prokaryotes, evolved into more complicated cells called eukaryotes. They seem to have done this by enclosing several different kinds of prokaryotes inside another prokaryote. At first this happened by chance, probably because one cell was trying to eat another cell. But it turned out that this whole group of prokaryotes could then all work together, cooperating to increase everyone's chance of survival and reproduction. The cells that are part of your body, and that are part of trees and other plants and animals, all still work this way.

One kind of prokaryote that evolved to live inside another cell was a chloroplast. A chloroplast is basically a prokaryote that can photosynthesize and instead of just producing energy for itself, it produces energy for a larger cell, and in exchange the bigger cell keeps the smaller one safe inside it. All plant cells have lots of chloroplasts inside them. Chloroplasts still have their own DNA molecule separate from the cell they live in.

Another kind of prokaryote that evolved to live inside another cell was a mitochondrion. Mitochondria use oxygen to break down the sugars that the cell eats in order to make energy for the cell. Mitochondria could not evolve until about two billion years ago, because that was the first time that there was enough oxygen in the atmosphere for them to use.

Most eukaryote cells also have other specialized pieces inside them that help them. These other pieces seem to have evolved gradually inside the cells. Some of these pieces are the nucleus, vacuoles, the endoplasmic reticulum, Golgi bodies and lysosomes. Eukaryote cells are about ten times as big as prokaryote cells, so they can hold all these pieces.

Most eukaryote cells still live independently, as one-celled creatures like yeast. But starting about 600 billion years ago, a few eukaryotes evolved into multi-celled creatures, beginning with small simple animals and ending up with complicated creatures like people. Other eukaryotes live on or in animals. Some of these are helpful - you need bacteria in your intestines to help you digest your food. Others are harmful. Usually the harmful bacteria are just newcomers, and they gradually evolve into a more helpful role.

6 *Choose the correct statement.*

1. **a.** Prokaryotes appeared on the Earth around two billion years ago. **b.** Prokaryotes appeared on the Earth earlier than two billion years ago. **c.** Prokaryotes appeared on the Earth later than billion years ago.
2. **a.** Eukaryotes are less ancient and less complicated cells than prokaryotes. **b.** Eukaryotes are more ancient and more complicated cells than prokaryotes. **c.** Eukaryotes are more complicated cells than prokaryotes but prokaryotes are more ancient.
3. **a.** Prokaryotes cooperated to reproduce more easily and to survive longer. **b.** Prokaryotes cooperated to reduce their chance of survival and reproduction. **c.** Prokaryotes did not work together to reproduce more easily and to survive longer.
4. **a.** Chloroplasts are prokaryotes able to photosynthesize.**b.** Chloroplast evolved to live inside other cells. **c.** Both a. and b. are true.
5. **a.** Mitochondria started evolving about two billion years ago. **b.** Mitochondria need oxygen to live. **c.** Both a. and b. are true.
6. **a.** Eukaryotes are a bit larger than prokaryotes. **b.** Eukaryotes are much larger than prokaryotes. **c.** Eukaryotes are much smaller than prokaryotes.
7. **a.** Most eukaryotes are single-celled. **b.** Most eukaryotes are multi-cellular. **c.** All eukaryotes are helpful.

C. BACTERIA & CO.

7 *Read* Prokaryotic organisms *and decide which is the right meaning of the words underlined in the phrases below.*

a. with the aid of the microscope (**1.** *encouragement* **2.** *help*)
b. stained films of bacteria (**1.** *blotted movies* **2.** *dyed layers*)
c. regardless of their individual cell shape (**1.** despite **2.** rudely)
d. cytoplasm throughout which (**1.** *from the beginning to the end of* **2.** *all over*)
e. the cell membrane controls the entry and exit of all substances (**1.** *going in and going out* **2.** *way in and way out*)
f. a very small pin head colony (**1.** *a colony on the head of a pin* **2.** *a colony having the size of a pin head*)

C.1 PROKARYOTIC ORGANISMS

These are simple single celled organisms which occur widely. Bacteria occur in the soil, on plants, in air, in water and also in animals and humans.
Bacteria are of simple shape and can only be seen individually with the aid of the microscope. When stained films of bacteria are looked at under the microscope many bacterial cells are seen at the same time, and it is sometimes a means of making a preliminary identification if the arrangement of the cells is observed.
Regardless of their individual cell shape all bacteria have the same internal structures. The cell consists of cytoplasm throughout which small units, the ribosomes (the sites of protein synthesis), and diffuse areas of staining (the nuclear material of DNA and RNA) exist attached to the membrane system. The cell membrane controls the entry and exit of all substances. Many Gram positive bacteria have a mesosome. The outer cell layer is a strong cell wall whose function is to retain the characteristic shape of the organism, and act as a barrier to certain compounds.
The Gram's staining technique is important in differentiating bacteria into two groups – Gram positive cells and Gram negative cells. The test relies on fundamental differences in cell wall biochemistry and morphology. The cell walls of Gram negative bacteria are more complex than those of Gram positive organisms. Bacteria sometimes possess additional structures. A flagellum is a whip-like appendage attached to the cell membrane by a complex basal structure which rotates it. Flagella are responsible for motility in bacteria.
Some bacteria have a capsule, a layer of gelatinous material which seems to protect the bacterium against destruction. Endospores, more commonly referred to as spores, are structures produced by the groups of bacteria genus Bacillus and genus Clostridium. Other groups of bacteria also produce endospores. A mature spore can exist in a dormant state for a long period, being resistant to the adverse effects of severe heat (such as cooking), cold (such as refrigeration and freezing) and to chemicals (such as disinfectants and sterilents). A spore can survive in dust, on vegetation and in soil for weeks, months or even years, or until it eventually finds itself in an environment suitable for reproducing the vegetative cell.
Bacteria reproduce by a process known as 'binary fission', a process of one cell dividing into two parts. This process can lead to a rapid increase in cell numbers. Large numbers of bacteria grouped together form colonies which, when the numbers have reached several million cells, may be visible to the naked eye as a very small pin head colony. Species forming larger colonies may be identified to some extent if the colonies develop into characteristic shapes.

(from: Parry – Pawsey, *Principles of Microbiology for students of food technology*, Stanley Thornes (Publishers) Ltd)

8 *Answer these questions about* Prokaryotic organisms.

a. What does a bacterial cell consist of? • **b.** What is the function of the cell membrane? • **c.** What is the function of the cell wall? • **d.** How are bacteria grouped? • **e.** What are flagella and what is their function? • **f.** What is the capsule and what is its function? • **g.** What are endospores? • **h.** How long can spores survive? • **i.** How do bacteria reproduce?

9 *Say whether these statements are true or false and correct them if necessary.*

a. Bacteria are multicellular organisms. .....

b. Bacteria are ubiquitous. .....

c. Bacteria can be seen with the naked eye. .....

d. Observing the arrangement of bacterial cells and the shape of bacterial colonies helps identifying bacteria. .....

e. All bacteria differ in shape and in internal structures. .....

f. Gram+ bacteria have more complex cell walls than Gram– bacteria. .....

g. Spores can survive extremes of temperature and hostile environments. .....

10 *Match nouns* a-j, *as they are used in* Prokaryotic organisms, *with their synonyms* 1-10. *Tip: copy the pairs in your indexed book.*

a.	means	☐	**1.** access
b.	arrangement	☐	**2.** array
c.	shape	☐	**3.** cooling
d.	site	☐	**4.** film
e.	entry	☐	**5.** form
f.	exit	☐	**6.** leaving
g.	layer	☐	**7.** method
h.	appendage	☐	**8.** place
i.	genus	☐	**9.** projection
j.	refrigeration	☐	**10.** species

11 *Match adjectives* a-j, *as they are used in* Prokaryotic organisms, *with their synonyms* 1-10. *Tip: copy the pairs in your indexed book.*

a.	preliminary	☐	**1.** appropriate
b.	individual	☐	**2.** external
c.	same	☐	**3.** identical
d.	diffuse	☐	**4.** initial
e.	outer	☐	**5.** latent
f.	characteristic	☐	**6.** scattered
g.	dormant	☐	**7.** specific
h.	adverse	☐	**8.** typical
i.	suitable	☐	**9.** unaided
j.	naked	☐	**10.** unfavourable

C.2 **12** *Read* Eukaryotic microorganisms *then answer questions* a-j.

EUKARYOTIC MICROORGANISMS

Protozoa are simple unicellular animals which live in an aqueous environment such as pond or ditch water, sea or soil water. The majority are free living and harmless to man but a few species cause diseases.

Algae are simply constructed plants, some of which are large (macroscopic), for example the large types of seaweed. Others are very tiny (microscopic) and are only visible under the microscope. All algae manufacture their own food by the process of photosynthesis.

Yeasts are single celled organisms which can only be seen individually using a microscope, although a large mass of yeast cells can easily be seen with the naked eye. A few species are pathogenic – causing skin infections in man, others cause disease in plants.

Yeasts are used in several industrial processes – in the making of beer, wines, spirits and bread – utilizing their ability to ferment sugars, to produce carbon dioxide and alcohol. Yeasts reproduce by a process known as 'budding'.

Moulds, in contrast to yeasts and bacteria, can often be seen easily with the naked eye. The typical growth that they display is fluffy. In further contrast to bacteria and yeasts, moulds are multicellular.

Moulds are saprophytic organisms which break down complex organic materials into simpler substances and in so doing contribute to the rotting of leaves and other material in the soil.

The same activity contributes to the widespread spoilage of foods, although in some cases mould growth in foods is sought, as when they are used in the ripening of cheeses such as Roquefort and Camembert. A further application of the biochemical activity of moulds is in the ability of some to produce antibiotics – notable among these is the *Penicillum* group of moulds.

A few moulds are pathogenic, causing diseases in plants and in man.

It is possible to see with the unaided eye that moulds are composed of many threads – the hyphae, the mass of which are known as the mycelium. The hyphae run over and through the medium on which the mould is growing, obtaining nourishment from it, although parts of some hyphae are primarily concerned with reproduction rather than feeding.

Moulds reproduce by the production of spores by asexual methods of by a mating process (sexual reproduction).

(from: Parry-Pawsey, *Principles of Microbiology for students of food technology*, ST(P))

a. Where do protozoa live? • **b.** How do algae manufacture their food? • **c.** What are some industrial processes which rely on the activity of yeasts? • **d.** What is budding? • **e.** When are moulds environmentally useful? • **f.** Is mould activity in foods always harmful? If not, when is it useful? • **g.** How are moulds employed by the pharmaceutical industry? • **h.** What are hyphae? • **i.** What is the mycelium? • **j.** How do moulds reproduce?

13 *Say whether these statements are true or false and correct them if necessary.*

a. Some protozoa are pathogenic. .....

b. Algae can only be seen using a microscope. .....

c. Individual yeast cells can be seen with the naked eye. .....

d. Most yeasts are useful, some are harmful. .....

e. Moulds are single celled organisms. .....

f. Moulds of the *Penicillum* group are used in cheese making and in antibiotic production. .....

.....

g. Hyphae have both nutritive and reproductive functions. .....

C3 **14** *Read* Viruses *and choose the right meaning of these words underlined in the passage.*

a. enslave: **1.** make a slave of ; **2.** subjugate
b. resolved: **1.** determined; **2.** seen distinctively
c. light microscope: **1.** microscope of little weight; **2.** microscope that uses light to make a specimen visible
d. core: **1.** centre; **2.** essence
e. coat: **1.** external layer; **2.** outer garment
f. envelope: **1.** enclosing covering; **2.** paper wrapper
g. host: **1.** guest entertainer; **2.** organism where a virus reproduces

VIRUSES

Viruses are a group of microscopic infectious agents which are distinct from the two basic forms of cellular life. They are non-cellular and have no associated metabolism so they enslave the cells they infect in order to replicate themselves. All viruses are obligate parasites of cellular organisms.

A few of the largest viruses are bigger than the smallest bacteria, although most are very much smaller and cannot be resolved using a light microscope.

The usual method of naming viruses is to describe the host and often the symptoms of the disease caused.

As soon as it became possible to view viruses in the electron microscope, three generalizations emerged.

1. A wide variety of different shapes and sizes occurred.
2. The individual particles of a particular virus were identical in size and shape.
3. Each virus particle (virion) consists of a core of nucleic acid enclosed by a coat or capsid. The capsid is in some cases surrounded by an envelope of lipid and protein.

There are two basic chemical components in viruses: protein and nucleic acid

The system that has been generally used to study the reproduction of viruses is the attack of a bacterium by a bacteriophage (or phase, for short).

The multiplication of a phage can be considered in three phases:

1. Adsorption and penetration of the host.
2. Synthesis and assembly of new phage within the host.
3. Lysis and liberation from the host.

The majority of prokaryotes can be attacked by a suitable virus. Viruses also attack blue-green bacteria but they do not commonly attack yeasts since such infections would almost certainly have been observed as a result of the widespread use of yeast in industry.

(from: J.F. Wilkinson, *Introduction to Microbiology*, Blackwell Scientific Publications)

15 *Answer these questions about* Viruses.

a. What are viruses? • **b.** What size are viruses? • **c.** How are viruses named? • **d.** Are all viruses the same shape and size? • **e.** What do virus particles consist of? • **f.** What are the basic chemical components of viruses? • **g.** What are the three phases of the multiplication of a phage? • **h.** Which microorganisms can viruses attack?

D. GROWTH REQUIREMENTS FOR MICRO-ORGANISMS

16 The ecology of microorganisms *mentions some groups of microorganisms capable of living in different environmental conditions. Try to match the names of the microorganisms with the descriptions, then read the passage and check if you were right.*

a. barophiles	**1.** organisms capable of growing at a moderate temperature
b. halophiles	**2.** organisms capable of growing at a low temperature
c. mesophiles	**3.** organisms capable of growing at a high temperature
d. osmophiles	**4.** organisms capable of growing in a salty environment
e. psycrophiles	**5.** organisms capable of growing under high environmental pressure
f. thermophiles	**6.** organisms capable of growing under high osmotic pressure

THE ECOLOGY OF MICROORGANISMS

Microorganisms are ubiquitous and make up a significant percentage of the total biomass on the earth. One of the most important factors affecting the rate of microbial growth is the environmental temperature. There is a minimum temperature below which growth will not occur. Above an optimum temperature there is a rapid drop in the rate of growth.

Most microorganisms are capable of growth in a temperature range of 20-30°C. Most microorganisms have a growth optimum between 20 and 40°C and are called mesophilic. However, those inhabiting cold environments such as polar areas can grow at much lower temperatures. These microorganisms are called psychrophilic and may cause trouble in food stored in refrigerators over a long period. Other microorganisms called thermophiles can grow at temperatures as high as 80-100°C, when the great majority of living organisms would rapidly die. In fact, it seems that microorganisms can grow at any temperature as long as water is in a liquid state. A distinction must be drawn between growth and survival. Although most microorganisms are rapidly killed above their maximum growth temperature, they are not necessarily killed below their minimum growth temperature.

As with temperature, the pH range at which a microorganism will grow varies considerably. Most organisms grow best at pH near neutrality, bacteria usually slightly on the alkaline side and algae and fungi on the acid side. However, some microbes can grow at extreme values of low or high environmental pH.

The presence or absence of oxygen divides organisms into three main classes: strict aerobes require oxygen, facultative anaerobes can obtain their energy in the absence of oxygen, strict anaerobes have an energy-producing system which does not require oxygen, and in addition, they are actually poisoned by oxygen. The aerobic or anaerobic nature of a microorganism is related to the normal natural environment of that organism.

Most microbes are capable of growing within a fairly wide range of environmental osmotic pressure. However, the colonization of such environments as salt lakes, salt pans, and the oceans requires specialized organisms called osmophiles or halophiles.

The only natural environments with hydrostatic pressures high enough to inhibit the growth of most microorganisms are the depths of the oceans. Here we find colonization by specialized barophiles.

Most microorganisms are killed by high doses of electromagnetic radiation, particularly in the ultraviolet range, and by smaller doses of ionizing radiations. Death occurs mainly by damage to DNA. Visible light is essential to the growth of photosynthetic microorganisms since it provides their energy source.

(from: J.F. Wilkinson, *Introduction to Microbiology*, Blackwell Scientific Publications)

17 *Say whether these statements are true or false and correct them when necessary.*

a. Microorganisms live everywhere on the earth. .....

b. Microorganisms can grow neither at very low nor at very high temperatures. .....

.....

c. Psychrophilic microorganisms live at very high temperatures. .....

d. Microorganisms live in liquid water, in ice and in water vapour. .....

e. High temperatures are lethal for most microorganisms. .....

f. Facultative aerobes need oxygen to obtain energy. .....

g. Strict anaerobes cannot live in the presence of oxygen. .....

h. Most microorganisms can live at any level of osmotic pressure. .....

i. Prokaryotes can live over a wider range of environmental conditions than eukaryotes. .....

.....

j. Microorganisms can degrade any synthetic compound. .....

18 *Choose the correct alternative among the words in italics.*

a. The rate of growth of microorganisms *decreases / increases* at temperatures above the optimum.

b. Psychrophilic microorganisms live at *higher / lower* temperatures than mesophilic microorganisms.

c. The range of temperature at which microorganisms can survive is *narrower / wider* than that at which they can grow.

d. High temperatures are *less / more* lethal to microorganisms than low temperatures.

e. Bacteria grow at a more *acid / alkaline* pH than algae and fungi.

f. Osmophiles can grow at a very *high / low* level of osmotic pressure.

g. *Higher / Lower* doses of ionizing radiations than of electromagnetic radiations are needed to kill microorganisms.

h. Visible light has *negative / positive* effects on photosynthetic microorganisms.

19 *Answer these questions about* The ecology of microorganisms.

a. What is the best temperature for mesophilic microorganisms?

b. What kind of microorganisms can grow in refrigerated foods?

c. What is the maximum temperature at which thermophiles can grow?

d. What is the ideal pH value for most microorganisms?

e. What do aerobes need to obtain energy?

f. What microorganisms can live in the deep waters of the oceans at very high hydrostatic pressure?

g. Why are most microorganisms killed by high doses of radiations?

h. What do photosynthetic microorganisms need for living?