Scope and Nature of Microbiology

Lesson Aim

Discuss the nature and scope of microbiology and its potential application to human life and society.

Microbiology is the study of tiny living things that cannot be seen by the unaided human eye. This includes both helpful and unhelpful organisms, small animals and plants, bacteria, fungi, viruses and algae. It includes organisms that contribute in a very positive way to our health and wellbeing, and others that can kill us.

Microorganisms are found everywhere - inside and outside of the human body, and within all other animals and plants.

Some microorganisms are very simple, single celled organisms; but others are multicellular organisms.

WHY STUDY MICROORGANISMS?

- They impact directly upon our health and wellbeing.
- They impact upon the quality of physical world we live in.
- They impact upon the other living organisms we depend upon: everything from crops and farm animals to our pets.
- Studying them can give us insights into all life.

Types

Microorganisms include:

- Bacteria
- Archaea (bacteria lookalikes)
- Fungi
- Viruses
- Protozoa
- Other multicellular organisms

A HUGE TOPIC - WHERE DO YOU BEGIN?

Given the scope and nature of microbiology, this course cannot hope to teach you about every type of microorganism. There are in fact so many different microorganisms that microbiology experts don't know even a fraction of what is to be learnt.

This is however such an important subject because microorganisms have a huge impact upon both us and the world around us.

The starting point is to become aware of the scope and nature of these organisms, to understand how they can be examined and the general characteristics of different types of microorganisms. The bulk of this course focuses on giving you that broad foundation, with a particular focus on some of the more significant types. Toward the end of the course you will explore some of the practical applications for microbiology.

Bacteria

Bacteria are one of the smallest living things, being just single-celled organisms (though they are slightly larger than viruses). They enter plants through wounds or natural openings such as stomata (tiny epidermal pores on the surface of leaves or stem) or water pores (hydathodes). Most cannot break directly through the cell walls of the 'surface' of a plant though some, e.g. potato scab, can enter through thin tuber walls. Some penetrate through root hairs e.g. root nodule bacteria of legumes. Others enter through specialised cells that produce nectar during flowering, e.g. apple, pear, and quince blight. Bacterial invasion can cause rots, blights, spots, galls, scabs and other symptoms (note: fungi can also cause many of these).

Although bacteria often join together to form a mass of cells, each one is independent of the others. They multiply by cell division and this can occur at a rapid rate with cell division occurring several times in an hour under favourable conditions. Due to their relatively large surface area and the large number of cells produced they are able to attack plant tissue rapidly if the conditions are right.

Bacteria which feed on dead plant (or animal) tissue are known as 'saprophytes'. Disease causing bacteria are known as ‘parasites’. Many bacteria can live as both parasites and saprophytes. They will often survive on dead plant material until a new plant or crop becomes available, e.g. they can over-winter on dead tissue.

Some species of pathogenic bacteria have external hair-like appendages known as 'flagella' which can be vibrated to enable them to move small distances in water and plant juices. Those without flagella can still be relocated through the splashing of water or wind-blown droplets, for instance. They can also be spread by movement of soil from one location to another.

Once bacteria have entered the plant tissue they may move about in the plant juices within or between cells, or they can be transported within the sap stream. Usually bacteria are found between the cells at the onset of disease but as the cell walls become damaged they are able to penetrate the cells.

The symptoms produced by a plant in response to bacterial invasion are often indicative of the disease e.g. galls, wilts, spots etc. These symptoms and their effects are similar to those of fungal infections. Galls normally only affect one part of the plant, wilts affect the whole plant, and rots may affect one part or the whole plant. Bacterial infections are very difficult to treat because very few chemicals or fungicides can control them.

Actinomycetes

These organisms are somewhat similar to bacteria but they are not motile (capable of independent or spontaneous movement). The only species of importance to plant pathology are the *Streptomycetes spp*. known to cause common potato scab. Acid scab (*Streptomyces acidiscabies)* of potatoes for example most frequently occurs in very acid soil conditions i.e. a pH under 5.2 (producing the typical superficial lesions on the surface of the potato known as scab). The second pathogen (that occurs on less acidic through to alkaline soils) is *S. scabiei,* this produces raised lumps and raised lesions on the surface of the potato.

Fungi

Fungi are members of the 'thallophyte' group of plants and do not produce chlorophyll. Since fungi do not generate their own energy from photosynthesis, they must feed off other organic material. Like bacteria, they are either usually parasites or saprophytes, but most can alternate between the two states. There are over 15,000 species known, with estimates of more than 100,000 in existence, and many are responsible for major plant diseases. They are thread-like organisms which grow amongst the tissue they derive their nutrition from, and the individual threads or 'hyphae' are collectively known as 'mycelium'. To reproduce, they grow fruiting bodies from a mass of mycelia and spores are produced in these fruiting bodies. Fruiting bodies serve as a useful form of identification.

Mycelia are microscopic and therefore many fungal diseases have to be diagnosed by symptoms rather than the presence of the organism. However, in some species where the mycelia come together to form bracket fungi or toadstools for example, identification is easier.

Viruses

Viruses are very small microscopic particles composed of nucleic acid and protein. They are more similar to chemicals than living organisms and represent the greatest cause for concern of all the pathogens. They exhibit

many, but not all, characteristics of living organisms and, as such, are sometimes called a life form. Mostly, they are not considered a life form. Viruses can only replicate inside a living host cell.

Viruses only contain only one kind of nucleic acid, either DNA or RNA. This nucleic acid may be single- or double-stranded, and is enclosed by a protein coat called a capsid. Some viruses also contain enzymes, and some are surrounded by a bilayer membrane called an envelope.

Viruses can mutate. They cause many serious diseases and frequently cause variegation or mottling of leaf colour. Some viruses are considered beneficial because of the variations they provide in leaf colour – this is how we have come by many of our variegated-leaf plants. To retain the leaf variegation though, plants have to be propagated vegetatively, as seed grown plants will revert back to the appearance of the parent plant. Whether considered beneficial or not, viruses cause a general weakening of the plants they infect, making the plant more susceptible to other problems and often stunting growth to some degree.

Viruses are able to multiply rapidly in plant material. Most are introduced to plants by the action of insect pests, such as aphids. These act as vectors, carrying and spreading the virus. Some viruses may be spread by pollen or seeds. Others may enter wounds caused by mechanical damage, e.g. foot traffic or strong winds or by an infected plant coming into contact with a non-infected one.

Typically, viruses invade all the cells of an infected plant which makes the virus incurable. In both horticulture and agriculture these infected plants have to be destroyed by burning.

Another pathogen, referred to as 'mycoplasmas' are somewhere between the size of viruses and bacteria. These are transmitted by pests such as mites and leafhoppers and again, infected plants usually have to be destroyed.

Other multicellular organisms

Other multicellular organisms include a whole range of tiny living things from nematodes to mites. These are generally impossible to see with the naked eye, but can be far larger and more complex than bacteria, viruses and protozoa.

Nematodes

Nematodes are worms. They live in water (fresh or salt water) or on the land (from Polar Regions to deserts and even in hot springs). Some can be visible to the naked eye, but most are tiny (e.g. a handful of soil may contain thousands of nematodes). Several species of nematodes also spread plant viruses they do this by feeding on the tissue of infected plant roots and then move on to healthy plants infecting them as a result. Those that transmit viruses in plants fall mainly within the families:

> Longidorus (needle nematodes): accumulate around and under roots tips of plants causing damage to plants and crops e.g. cause damage to corn and mint etc. also spreads tobacco, tomato and raspberry ringspot viruses some species.
>
> Trichidorus (stubby root nematode): soil dwellers that feed on plants; diseases include pea early browning virus.
>
> Xiphinema (dagger nematode): feed on the roots of plants and crops and also spreads viral mosaic and wilting diseases and spreads tobacco, tomato and raspberry ringspot viruses.

Mites

Mites are tiny insects related to spiders (but distinct from spiders) and include ticks. Some are too small for the naked eye to see. Although highly variable in appearance they have four pairs of legs and two body segments and are usually without eyes (but may also have from 1 to 5 eyes depending on the species) and without wings.

There are some 50,000 species of mites which may be useful or destructive; they live on every single continent in the world and in any environment: within the soil, on surfaces, on people, animals, on plants, in water in household furnishings including mattresses, curtains, carpet and bedding etc. Mites can cause skin and other allergies and respiratory problems in humans (about 65 known species) and other animals.

Mites are also significant part of the ecosystem they help to decay dead plant materials, other organic matter and algae, bacteria, fungi, mosses and yeasts. Although mites (e.g. spider mites) are a significant pest on plants

and agricultural crops some species (e.g. phytoseiid mites) have symbiotic associations with certain plant species (on which they live) making them useful in biological pest control of other mites.

Around 6,000 species of mites, within several families (world-wide), are phytophagous i.e. mites that feed on plants. Some attack plants causing plant damage and as a result reduce photosynthesis capabilities (i.e. due to holes and other damage on plant leaves).

The majority of this 6,000 species (within around 11 families) of plant feeding mites falls within the following families:

Eriophyoidae (super family) - includes bud mites, erinose mites, gall mites and rust mites. Several viruses are spread by Eriophydae mites e.g. fig mosaic, peach mosaic and wheat streak mosaic viruses; these are obligate plant feeders (feed only on plants).

Tetranychoidae - includes some 1200 species within several sub-families and include spider mites and false spider mites; these are obligate plant feeders (feed only on plants).

SET TASK

Activity 1

Find and look at a range of products or services that people use in their daily life which are related to microbiology. Photograph several products or brochures/signs of services you discovered.

You may find these in your home, workplace, or by visiting places such as a health food shop, chemist, supermarket, pet barn, nursery suppliers, etc.

Try to visit at least one place outside of your home or workplace though.

Products or services may be such things as:

Antibiotic medicines

Yeast used for food preparations

Probiotics

Antifungal medicines

Vaccine treatments

Soil inoculant

Equipment for food preserving or brewing

Microbiological plant protection products

Microbiology in plant growth (e.g. VAM)

Choose two products or services. Determine how an understanding of microbiology is significant to provision of this product or service to a user. Make sure you have a digital photo of each.