Introduction

Microbiology is the study of microorganisms, a large and diverse group of microscopic organisms that exist as single cells or cell clusters; it also includes viruses, which are microscopic but not cellular.

Microorganisms have a big impact on all life and the physical and chemical makeup of our planet. They are responsible for cycling the chemical elements essential for life, including carbon, nitrogen, sulfur, hydrogen, and oxygen; more photosynthesis is carried out by microorganisms than by green plants. It has been estimated that 5 x 10^{30} microbial cells exist on earth; excluding cellulose, these cells constitute about 90% of the biomass of the entire biosphere. Humans also have an intimate relationship with microorganisms; more than 90% of the cells in our bodies are microbes.

Viruses

Viruses lack many of the properties of cells, including the ability to replicate. Only when it infects a cell does a virus acquire the key property of a living system: reproduction. Viruses are known to infect all cells, including microbial cells.

A viral particle consists of a nucleic acid molecule, either DNA or RNA, enclosed in a protein coat, or capsid (sometimes itself enclosed by an envelope of lipids, proteins, and carbohydrates).

A number of transmissible plant diseases are caused by **viroids**- small, single-stranded, covalently closed circular RNA molecules

existing as highly base-paired rod-like structures. They range in size from 246 to 375 nucleotides in length. The extracellular form of the viroid is naked RNA-there is no capsid of any kind.

Prions

A number of remarkable discoveries in the past 3 decades have led to the molecular and genetic characterization of the transmissible agent causing **scrapie**, a degenerative central nervous system disease of sheep. Studies have identified a scrapie-specific protein in preparations from scrapie-infected brains of sheep that capable of reproducing the symptoms of scrapie in previously uninfected sheep. To distinguish this agent from viruses and viroids, the term **prion** was introduced to emphasize its proteinaceous and infectious nature. The cellular form of the prion protein (PrP^c) is encoded by the host's chromosomal DNA. PrP^c is a sailoglycoprotein with a molecular weight of 33,000-35,000 and a high content of a-helical secondary structure that is sensitive to proteases and soluble in detergent. PrP^c is expressed on the surface of neurons via a glycosylphosphatidyl inositol anchor both infected and uninfected brains. An abnormal isoform of this protein (PrP^{res}) is the only known component of the perion and is associated with transmissibility. It has the same amino acid sequence as PrP^c, but differs physically from the normal cellular isoform by its high β-sheet content, its insolubility in detergents, its propensity to aggregate, and its partial resistance to proteolysis. It is believed that PrP^{res} induces PrP^c to fold or refold into the prion form.

There are additional prion diseases of importance such as Kuru, Creutzfeldt-Jakob disease (CJD), Gerstmann-Straussler-Scheinker disease, and fatal familial insomnia affect humans. Human prion diseases are unique in that they manifest as sporadic, genetic, and infectious diseases.

Prokaryotes

The primary distinguishing characteristics of the prokaryotes are their relatively small size, usually on the order of 1 μm in diameter, and the absence of a nuclear membrane. The DNA of almost all bacteria is a circle with a length of about 1 mm; this is the prokaryotic chromosome. The chromosomal DNA must be folded more than 1000-fold just to fit within the prokaryotic cell membrane. The specialized region of the cell containing DNA is termed the **nucleoid** and can be visualized by electron microscopy as well as by light microscopy after treatment of the cell make the nucleoid visible. Thus, it would be a mistake to conclude that subcellular differentiation, clearly demarcated by membranes in eukaryotes, is lacking in prokaryotes. Indeed, some prokaryotes form membrane-bound subcellular structures with specialized function such as the **chromatophores** of photosynthetic bacteria. **Bacteria** and **Archaebacteria** are the major subdivisions within the prokaryotes.

Protists

The "true nucleus" of eukaryotes is only one of their distinguishing features. The membrane-bound organelles, the

microtubules, and the microfilaments of eukaryotes form a complex intracellular structure unlike that found in prokaryotes. The agents of motility for eukaryotic cells are flagella or cilia that do not resemble the flagella of prokaryotes.

Genetic transfer among eukaryotes depends upon fusion of **haploid gametes** to form a **diploid** cell containing a full set of genes derived from each gamete. The life cycle of many eukaryotes is almost entirely in the diploid state, a form not encountered in prokaryotes.

Microbial eukaryotes-**protists**- are members of the four following major groups: algae, protozoa, fungi, and slime molds.

Algae

All organisms that produce O_2 as a product of photosynthesis. One major subgroup of these organisms-the blue-green bacteria, or **cyanobacteria**- are prokaryotic and no longer are termed algae. All algae contain chlorophyll in the photosynthetic membrane of their subcellular chloroplast. Many algal species are unicellular microorganisms. Other algae may form extremely large multicellular structures. A number of algae produce toxins that are poisonous to humans and other animals. Red tides caused by the dinoflagellate *Gonyaulax* species are serious as this organism produces neurotoxins such as **saxitoxin** and **gonyautoxins**, which accumulate in shellfish (eg, clams, mussels, scallops, and oysters) that feed on this organism. Ingestion of these shellfish by humans results in symptoms of **paralytic shellfish poisoning** and can lead to death.

Protozoa

Protozoa are unicellular nonphotosynthetic protists. The most primitive protozoa appear to be **flagellated forms** that in many respects resemble representatives of the algae.

From flagellated protozoa appear to have evolved the **ameboid** and the **ciliated** types; intermediate forms are known that have flagella at one stage in the life cycle and pseudopodia (characteristic of the ameba) at another stage. A fourth major group of protozoa, the **sporozoa**, are strict parasites that are usually immobile; most of which reproduce sexually and asexually in alternate generations by means of spores.

Fungi

The fungi are nonphotosynthetic protists growing as a mass of branching, interlacing filaments "**hyphae**" known as a **mycelium**. Although the hyphae exhibit cross walls, the cross walls are perforated and allow free passage of nuclei and cytoplasm. The entire organism is thus a **coenocyte** (a multinucleated mass of continuous cytoplasm) confined within a series of branching tubes. The mycelial forms are called **molds**; a few types, **yeast**, do not form a mycelium but are easily recognized as fungi by the nature of their sexual reproductive processes and by the presence of transitional forms.

The major subdivisions(phyla) of fungi are: **Chytridiomycota, Zygomycota, Ascomycota, Basidiomycota,** and the **Deuteromycetes** or "imperfect fungi".

Slime Molds

These organism are characterized by the presence, as a stage in their life cycle, of an ameboid multinucleate mass of cytoplasm called a **plasmodium**. The plasmodium of a slime mold is analogous to the mycelium of a true fungus. Both are coenocytic. In the latter, cytoplasmic flow is confined to the branching network of chitinous tubes, whereas in the former the cytoplasm can flow in all directions. This flow causes the plasmodium to migrate in the direction of its food source, frequently bacteria.