Microorganisms: An Introduction

M**icroorganisms**, or **microbes**, are living organisms that cannot be seen with the naked eye. The study of these tiny organisms is known as **microbiology**. This field of study is important, as microbes form the foundation for all segments of life; without them, the nature and capacity of life would be greatly diminished.

Learning about these microorganisms is the fundamental step to understanding life in its entirety. For approximately 3 billion years, microbes were the only living organisms that occupied Earth. Humans and other life forms are believed to have evolved from these early microbe populations. Still at present-day, microorganisms encompass a large portion of all living things on Earth. With such an abundance, microorganisms are separated into characterized groups to better define their existence.

Thus, this chapter will further define the subject of microorganisms and briefly introduce the main classifications of microorganisms - archaea, bacteria, protozoa, algae, and fungi.

**1.1 Characteristics of Microorganisms**

As previously mentioned, microorganisms are microscopic organisms that cannot be seen with the unaided eye. The vast majority of microbes are smaller than 0.1 mm in diameter, making them the smallest life form. As a result, most microbes are only visible through a microscope.

Relative to their size, microorganisms are mostly **unicellular**, which are organisms that reside in a single cell. Single-celled microbes can be further subdivided into two common cell groups: prokaryotes and eukaryotes. Although not as common, microbes can also be **multicellular** in which they are composed of several cells. These microbes are distinguished from more complex, multicellular organisms by their lack of well differentiated tissues. In contrast to unicellular microbes, multicellular organisms are only categorized into one cell group: eukaryotes. In an immense comparison, both cell types undergo the same natural cell functions and chemical processes to maintain life. However, the discrepancy between these two cell types is primarily based on cell size and complexity.

**Prokaryotes**

Prokaryotic microbes are characterized as having a comparably simple morphology. **Prokaryotes** are unicellular organisms that do not contain any membrane-delimited organelles or a formalized nucleus. Alternatively, prokaryotes possess a **nucleoid**, which is an internal structure that houses a single chromosome with circular, double-stranded DNA. Even though these single-celled organisms lack such organelles, evolutionary history suggests that modern organelles (e.g. nucleus and mitochondria) emerged from early prokaryotic cells.

Additionally, prokaryotes can be further differentiated into two inherent groups: archaea and bacteria. The divergence of these domains is based on differences in cell wall structures. Further distinction between these two classifications is discussed in Section 1.2.

**Eukaryotes**

**Eukaryotes** are large and morphologically complex organisms that are unicellular and multicellular. They possess an arrangement of internal structures that differentiates them from prokaryotes. This arrangement is defined by membranes that subdivide the cell’s cytoplasm into various membrane-bound organelles, one of which is the nucleus. The **nucleus** is an organelle that houses the genetic material of organisms in multiple chromosomes. It is suggested that these distinctive features of eukaryotic cells evolved from predation upon prokaryotes. Evolution predicts that this predator activity led to the increase in cell volume and complexity of eukaryotes.

Furthermore, the eukaryotic domain can be divided into more specific groups of microorganism: algae, protozoa, and fungi. These groups are examined in greater depth in Section 1.2.

**1.2 Classifying Microorganisms**

Prokaryotes and eukaryotes are the two cell types among all living things. Prokaryotes can specifically be divided into two separate domains, while eukaryotes form another. Accordingly, we are presented with the three domains of life: Archaea, Bacteria, and Eukarya. From these domains, we are able to classify the five types of microorganisms: archaea, bacteria, algae, protozoa, and fungi.

**Archaea**

**Archaea** are unicellular, prokaryotic organism. These microorganisms are distinguished by their ability to survive in severe environmental conditions. Archaea can be divided among each other based on their preferred habitat. The four types of archaea are defined as methanogens, halophiles, thermophiles, and psychrophiles. Methanogens are archaea organisms that produce methane. Halophiles are archaea organisms that live in salty environments. Thermophiles are archaea organisms that live in extreme heat, whereas, psychrophiles live in extreme cold.

Archaea are also unique based on how they acquire energy. They are able to use hydrogen gas, Sulphur, and carbon dioxide as sources of energy. Some species are able to absorb sunlight through their membrane using a pigment called bacteriorhodopsin that is only found in archaea.

**Bacteria**

Like archaea, **bacteria** are unicellular, prokaryotic organisms. However, they are differentiated from archaea and other microorganisms primarily by their cell wall structure. Most bacterial species contain cell walls with peptidoglycan. Depending upon the thickness of the peptidoglycan layer, bacterial species are classified as either gram-positive or gram-negative. Gram-positive bacteria have greater amounts of peptidoglycan in their cell wall, whereas, gram-negative bacteria have a reduced amount of peptidoglycan.

Additionally, bacteria can also be classified in several other ways. For example, classifications can be based on how they acquire energy, and/or by their shape. In terms of acquiring energy, they can be defined as either heterotrophs or autotrophs. Lastly, bacteria can be further characterized by shape: rod-shaped (bacillus), spherical-shaped (coccus), spiral-shaped (spirilla), and curve-shaped (vibrio).

**Algae**

**Algae** are eukaryotes that are unicellular and multicellular organisms. They are usually found in aquatic environments. Algae is differentiated from other microorganisms based on their ability to conduct photosynthesis. Due to this ability, evolution suggests that modern green plants evolved from early algae species. Similar to plants, algae contain plastids that control photosynthesis. These plastids classify algae species based on color: red, brown, and green. Red algae possess a pigment called carotenoids in their plastids that project a red color. Brown algae contain phycobiliproteins in their plastids that resembles a brown color. Green algae contain chlorophyll in their plastids, or chloroplast that reflects a green color under light.

**Protozoa**

**Protozoa** are unicellular, eukaryotes. These microorganisms make up the largest group of organisms. Protozoa are distinguishable among other microorganisms by the presence of cellulose in their cell walls. However, similar to bacteria, protozoa can also be classified as heterotrophs or autotrophs. Species among this group of microorganisms, can be specifically divided into groups based on their modes of movement: flagellates, ciliates, amoeboids, or sporozoans. Flagellates are protozoans that used whip-like anatomy to project forward. Ciliates contain tiny hairs that churn to enable movement. Amoeboids have pseudopodia, also known as false feet, to facilitate movement. Unlike the other categories, sporozoans are protozoans that are lack any movement.

**Fungi**

**Fungi** are multicellular, eukaryotic organisms. Fungi can also be identified among other microorganisms based on the cell wall composition. These microorganisms are characterized as having chitin in their cell walls. These microorganisms can be further classified into four specific groups based on shape and reproduction: Chytridiomycota, Zygomycota, Ascomycota, and Basidiomycota. Chytridiomycota fungi are characterized by their production of zoospores, which are motile asexual spores. Zygomycota are fungi that produce zygotes. They produce spores in a round-shaped structure known as a sporangium. Ascomycota, also known as sac fungi, produce spore sacs that are in the shape of a cup. The Basidiomycota, also called a club fungi, have spores that project from a club shaped encasing. Basidiomycota include the modern mushroom.

**Summary**

Microorganisms set the foundation for all life forms. These were the first organisms to occupy earth and, ultimately, gave rise to all other organisms on Earth. At present-day, microorganisms still occupy a huge portion of Earth’s living species. In order to describe this large abundance of species, we first classified these organisms into two cell types: prokaryotes and eukaryotes. Prokaryotes were defined and unicellular organisms that lack membrane-bound organelles, specifically a nucleus. Whereas, eukaryotes are organisms that possess a defined nucleus and other membrane-bound organelles.

Next, these cell types were more specifically divided into five microbial classifications: archaea, bacteria, algae, protozoa, and fungi. All five groups have unique properties that differentiated them from the others. Archaea have the ability to survive in extreme environmental conditions. Bacteria have peptidoglycan present in their cell walls. Algae have the ability to conduct photosynthesis. Protozoa contain cellulose in their cell walls and fungi have chitin within their cell walls.

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