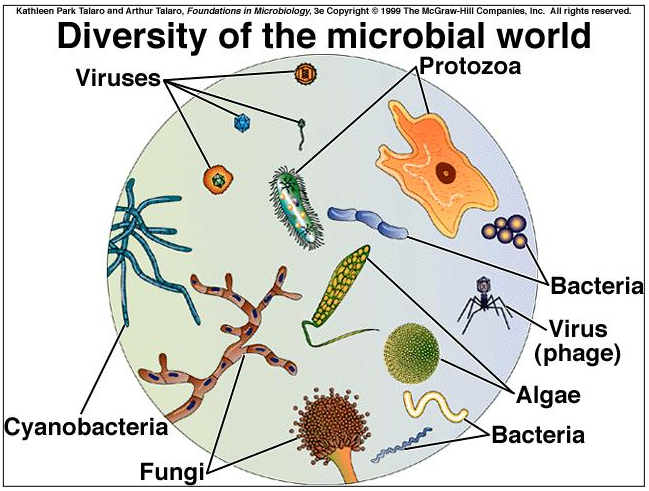
Unit 1 Lecture 1

Introduction

Microbiology is the study of living organisms too small to be seen with the naked eye. Unusual agents and organisms included in microbiology are viruses (they are not living), certain helminthes (large enough to be seen), and some insects that carry other infectious agents. A few of the divisions of microbiology include:

1. Bacteriology: study of bacteria
2. Mycology: study of fungi and yeast
3. Protozoology: study of protozoans
4. Virology: study of viruses
5. Parasitology: study of helminthes worms, pathogenic protozoa, certain insects
6. Immunology: study of the host defenses that protect against infection
7. Serology: study of the products of immune reactions (antigens and antibodies)



Why is microbiology important? Microbes play an important role in medicine (disease), environmental science, food and drink production, agriculture, pharmaceutical industry, and in genetic engineering. Microbes also play a very important role in cleaning up (bioremediation) the environmental mess that humans have created. Microbes have been around for over 3.5 billion years. These prokaryotic cells developed the cellular mechanisms that enabled higher living cells to evolve. If a particular mechanism was not compatible with life, the organism did not survive. Microbes also play an important role in making the Earth a "living planet" from their role in photosynthesis to decomposition.

Some of the significant historical events that have occurred in the field of microbiology are listed below.

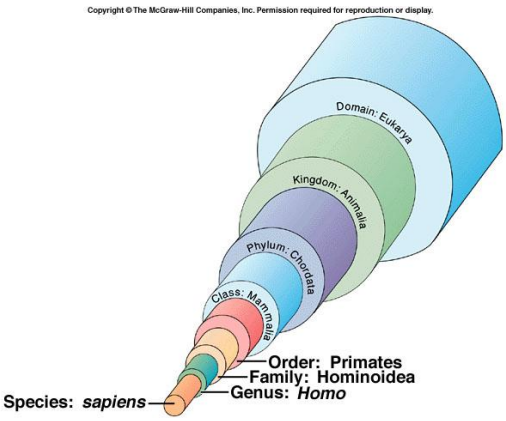
- 1676: van Leeuwenhoek opened the eyes of the world to the field of microorganisms by designing a simple microscope which he used to view and describe microbes
- 1796: Edward Jenner introduces a vaccination for smallpox
- 1839: Schleiden and Schwann develop cell theory

- 1865-1890: Pasteur (Father of microbiology) discovers many pathogens, invents pasteurization, rabies and anthrax vaccinations and disproves theory of spontaneous generation
- 1867: Lister publishes paper on antiseptic surgery
- 1876-1886: Koch's proof of infectious process, discovery of the TB organism, and Koch's Postulates
- 1884: Metchnikoff discovered human phagocytosis
- 1908: Ehrlich first chemotheraputic agent "magic bullet"
- 1929: Fleming discovered penicillin
- 1935: Domagk developed first sulfa drug
- 1953: Watson and Crick defined the structure of DNA

Rise of the Scientific Method

In an effort to support natural phenomena other than a mixture of belief, superstition, and argument a method had to be developed that was not based on prejudice. Two types of reasoning are applied; an inductive approach whereby the scientist accumulates data and then **formulates a hypothesis** to account for those facts; and a **deductive approach** whereby the scientist constructs a hypothesis, tests its validity outlining particular events that are predicted by the hypothesis, and then performs experiments to test for those events. In time hypothesis gives rise to a theory (a collection of statements or concepts that explains a natural phenomenon). For validity, experiments need to contain controls. At some point in time a theory becomes a law.

Taxonomy



Taxonomy is the organizing, classifying and naming of organisms (nomenclature); in this subject – Microorganisms. The basis of biological classification is morphology and reproduction patterns, physiology (chemistry), and DNA relatedness. Genetic relatedness is now the primary basis. Scientific nomenclature is a result of the work of Linnaeus who grouped organisms as plant or animal and set the rules for nomenclature. Subsequent taxonomists added other categories as more knowledge was obtained: Kingdom - Phylum or Division - Class - Order - Family -Genus - Species. Strains are organisms within species that vary in a given quality (for example, MRSA is a strain of *S. aureus)* and Serotypes are organisms within species that vary immunologically *(E. coli* O157:H7).

Kingdom are the most inclusive of groupings, have the widest variety of organisms, and compared to other groups have fewest restrictions for "belonging." Species on the other hand are the most exclusive of groupings,

have the least variation of organisms compared to other groups, and have the most requirements for "belonging". Most microbes are discussed at the genus and species level although sometimes we will talk about the families they belong to.

Binomial nomenclature uses both genus and species names for identification. All living organisms named in this manner. Each genus-species represents only one organism.

The rules are:

1. Genus name given first, species name given second.
2. Genus name is capitalized, species name isn't.
3. Source for nomenclature is Latin or Greek
4. Both parts of the name are italicized, underlined, or both, i.e. Escherichia coli or *Escherichia coli.*

A classification scheme with five Kingdoms according to Whittaker is:

Monera which exhibit a **Prokaryotic** cell structure, live unicellular or colonial, are Heterotrophic (deriving energy from complex organic substances) or autotrophic (deriving energy from simple inorganic substances), and possess cell walls of peptidoglycan. Significant groups include Bacteria, blue-green algae (cyanobacteria) and Archaea (extremeophiles).

Protista exhibit a **eukaryotic** cell structure, live unicellular or colonial, are mostly heterotrophic, and can either possess or lack cell walls. Significant groups are the Protozoans and unicellular algae.

Mycetae (fungi) have a eukaryotic cell structure, are mostly multicellular, heterotrophic, and possess incomplete cell walls of chitin. Significant groups include molds, yeasts, and mushrooms.

The **Plantae** have a eukaryotic cell structure, are multicellular, autotrophic, and possess cell walls of cellulose. Significant groups include flowers, trees, ferns, grasses, mosses, and multicellular algae.

Animalia always have a eukaryotic cell structure, are multicellular, heterotrophic, and most importantly lack cell walls.

Carl Woese and subsequent taxonomists developed a newer system based on the ribosomal DNA found. They established three different cell types and assign organisms to the Eukarya, Bacteria, and Archaea. The later two have a prokaryotic cell structure. Regardless of cellular type, living organisms all share the same characteristics of life: growth (increase in size), reproduction (increase in number), responsiveness (ability to react to an external

stimulus), metabolism (controlled chemical reactions of the organism), and a cellular structure where all of the above occur.

Chemistry of Biology

There are four major groups of **biomolecules** or ORGANIC compounds, which all contain carbon, hydrogen, and oxygen. ORGANIC compounds present in the cell include carbohydrates (which are the most numerous and serve as energy sources), lipids (which are the most diverse), proteins (the building blocks of the cell) and nucleotides. Proteins are made from amino acids. The amino acid sequence determines the proteins conformation which in turn determines its function. Proteins are the most versatile biomolecule. Globular proteins are soluble and act as carriers, messengers, defense molecules and enzymes. Enzymes are catalysts in a living system. They speed up chemical reactions without being consumed. Proteins, lipids and carbohydrates combine to form glycoproteins, glycolipids, or lipoproteins. Nucleotides are important in the storage and transmission of information. Small nucleotides include ATP, ADP, and cyclic AMP. Nucleotide polymers are nucleic acids DNA and RNA.

When you lookat the biomolecules, be sure to note their biochemical makeup. That is carbohydrates are composed of carbon, hydrogen, and oxygen Proteins are made of carbon, hydrogen, oxygen and nitrogen and ten folded into different configurations. Lipids are like carbohydrates in that they are made of carbon, hydrogen, and oxygen but are composed of fatty acids and triglycerides. Membrane lipids also have phosphorus and are called phospholipids.

Another concept related to chemistry is acidity, alkalinity and pH. To make a substance more acid add more H ions; to make it more alkaline add more OH ions. A pH less than 7.0 is considered acidic. A pH greater than 7.0 is considered alkaline and a pH of 7.0 is considered neutral. We use pH in the determination of microbial utilization of the biomolecules based on the product formed when the microbe uses the biomolecule. Nucleic acids are complex molecules composed of an acid (ribose or deoxyribose), a nucleotide (adenine, thymine or uracil, guanine, cytosine), and a phosphate group.

ORGANIC MOLECULE	FUNCTION
CARBOHYDRATES	Mostly used as energy sources for cellular metabolism. Ex: glucose, glycogen
LIPIDS	Energy source, chemical messengers between cells, membrane component.
PROTEINS	Structure, communication between cells, membrane transport, catalysis, recognition and protection, movement, and cell adhesion
NUCLEOTIDES	Energy source for the cell (ATP), specifies protein structure and replicates itself exactly (DNA), and

	facilitates protein production (RNA).

Concepts of Microscopy

Microbes are small. To observe them, one needs a tool to magnify or enlarge their image. Often stains are used to help visualize the organism.

Refraction: When a beam or ray of light transmitted through air strikes and passes through a convex surface, it experiences some degree of refraction (bending of the light ray). The greater the difference in composition of two substances, the greater is the degree of refraction. This is the basis for lens design. Convex lenses are most important in magnified images.

Magnification: Determined by the power of the objective times the power of the ocular equals the total magnification. For example:

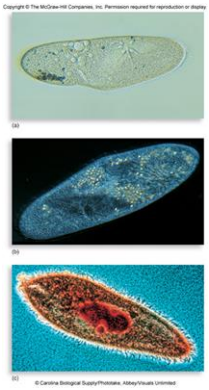
10X low power objective X 10X ocular = 100X magnification.

Resolution: Distinguishing magnified objects clearly. This is the factor that most limits the clarity of microscopic images. It is the capacity of an optical system to distinguish two adjacent objects or points from one another and is limited by the wavelength of light used. The maximum resolution can be determined using the formula = ½ wavelength of light used (1/2 λ). The best resolution for the type of microscope is listed below.

- Light microscope = 0.2 microns (0.2μm)
- Ultraviolet microscope = 0.2 microns (0.2μm)
- Electron microscope = 0.5 – 10 nm

Types of Microscopes See Table 3.5 in the text to compare the different types of microscopes used in microbiology.

A **Brightfield** microscope uses light, which is transmitted through thin objects into the lens system (Fig a). This microscope is the most often used type of microscope and one that we will be using in lab. When using a stain, organisms are killed.



A **Darkfield** microscope uses light that is reflected by the object into the lens system. It is used on very thin living specimens often to detect mobility. (Fig b) Organisms are living and moving in darkfield preps.

The **Phase-contrast** microscope contains a special condenser that exaggerates different densities within lining cells. (Fig c)

Some materials to be observed are stained (attaches dyes by using specific antibodies) with dyes that fluoresce under ultraviolet light resulting in higher resolution and are visualized using the **Fluorescent** microscope.

An **Electron** microscope sends transmitted (TEM – highest magnification) or reflected (SEM) electron beam to a television screen for viewing or photography.

Finally, a **Simple** microscope has only one magnifying lens whereas a **Compound** has two magnifying lenses.