I ♥ Microbes
The Relationship Between the Microbial World and Us

What are microorganisms?

- Microorganisms=microbes
- Do not include just prokaryotes.
- Microorganisms include bacteria, fungi, protozoa, microscopic algae, viruses, and anything that cannot be seen by the unaided eye.
- A little free word association…

Microbes are easy *and* difficult to study

- Reproduce rapidly, large populations can be grown in the laboratory
- Can't be seen directly, must be analyzed through indirect methods in addition to using microscopes

Scope of Microbiology

- Medical microbiology
- Immunology
- Public health microbiology & epidemiology
- Food, dairy and aquatic microbiology
- Agricultural microbiology
- Industrial microbiology
- Genetic engineering & recombinant DNA technology

Importance of Microbiology

- Early life forms
  - Single-celled organisms arose 3.5 billion years ago and were the only living inhabitants until ~2.9 billion years ago
- Photosynthesis and decomposition
- Human use of microorganisms
- Infectious diseases

Things to Do, Places to See

- Microbes account for over 70% of the earth's photosynthesis- contributing the majority of the oxygen to the atmosphere

Decomposition:

- Breakdown of dead matter and wastes
- Accomplished by bacteria and fungi

Microbial Involvement in Shaping Our Planet

- Microbes are the main forces that drive the structure and content of soil, water, and atmosphere
  - Gas production by microbes
  - Microbes living within the earth's crust
  - Bacteria and fungi living in complex associations with plants and animals

Human Use of Microorganisms

- Humans have been using microorganisms for thousands of years to improve life and even shape civilizations

Biotechnology

- Manipulation of microorganisms to make products in an industrial setting

Genetic Engineering

- Manipulates the genetics of microbes, plants, and animals for the purpose of creating new products and genetically modified organisms (GMOs)

Recombinant DNA technology:

- Techniques that allow the transfer of genetic material from one organism to another and deliberately alter DNA

Bioremediation:

- Introduction of microbes into the environment to restore stability or to clean up toxic pollutants

So Many Different Hats…

- The popular idea is that microbes cause disease or sickness.
- However, microbes are crucial components in the environment.
- They're even in your intestines…but what can they do?

- The food industry has also benefited from microbes.
- Microbes have been used to produce cheese, wine, and even soy sauce.
- Despite all of this, the popular idea still remains the popular one. Why?

Nomenclature

- A binomial system of nomenclature was established in 1735.
- Each name consists of a Genus and a Species name (or specific epithet).
- A scientific name can describe an organism, identify the habitat from which it is found, or it can be used to honor a researcher or person who found (isolated) the organism.

Types of Microorganisms

- Bacteria, Archaea, fungi, protozoa, algae, viruses, and multicellular animal parasites.
- Of these, two are prokaryotic, four are eukaryotic, and one is…

Bacteria

- Do not have membrane bound organelles.
- They are enclosed in cell walls composed primarily of peptidoglycan.
- Remember Carl Woese?
- It was he, who proposed the three domain system that currently includes this domain.
- It consists of only one kingdom of the same name.

Archaea

- They were identified in 1977 by Carl Woese and George Fox based on their separation from other prokaryotes on 16S rRNA phylogenetic trees.
- Similar to bacteria, however they have differences in their cell walls.
- They have the ability to survive in extreme environments.

Fungi

- Eukaryotic
- Can be found as unicellular or multicellular organisms.
- May reproduce sexually or asexually.
- They may look like plants, however cannot photosynthesize.
- Yeasts are examples of unicellular fungi.

Protozoa

- Eukaryotic
- Unicellular microbes
- May use flagella, cilia or pseudopodia as means of locomotion.
- Many protozoa are parasites
- May reproduce sexually or asexually.

Algae

- Eukaryotic
- Photosynthetic organisms
- They are abundant in fresh and salt water.
- Cell walls are mostly composed of cellulose (like plants).

Viruses

- Acellular
- So small that they can only be seen with an electron microscope.
- Simple structure-contains a core of genetic material.
- Use host's cellular machinery to replicate.
- Not considered living organisms.

Multicellular Animal Parasites

- These are not always microorganisms.
- Helminths consist of roundworms and flatworms.
- At some point in their life cycle, they are microscopic.

A little microbiological history…

- Remember Van Leeuwenhoek?
- If not, he was the first to make bacterial observations.
- Some form of microbiological treatment was practiced by many people, throughout the two hundred year period after Hooke and van Leeuwenhoek, but this was with very little understanding of the microbial processes involved.

Ferdinand Cohn

- One of the most notable scientists of the time was Ferdinand J. Cohn who in 1875 effectively founded the science of bacteriology (a branch of microbiology which studies bacteria).
- He showed that the protoplasm was almost identical in plant and animal cells. He founded the science of bacteriology with a three volume treatise published in 1872 which classified bacteria into genera and species. Cohn also encouraged Koch and gave him a position in his lab.

Robert Koch

- Robert Koch was a medical doctor, who was influenced by Virchow at one point, also made a very big discovery.
- During his time, anthrax was rampant.
- The bacillus that caused anthrax had already been characterized but little was still known about it.
- Koch set out to prove that this bacillus was in fact the causative agent of the anthrax disease.

- His work caught the eye of Cohn, who let him into his lab.
- Here he started to make giant progress in his work.
- Eventually, after moving on to the Imperial Health Bureau, he proved his theory and developed a set of postulates which were used to determine if an organism was pathogenic.

Louis Pasteur

- The germ theory of disease, also called the pathogenic theory of disease, is a scientific theory that suggests that instead of genetics being the proximal cause of many diseases that the environment plays a significant factor in the form of pathogenic microorganisms such as bacteria or viruses.
- Pasteur used a swan-necked flask setup in 1862 to disprove spontaneous generation and to cement his Germ Theory.

Spontaneous generation

Early belief that some forms of life could arise from vital forces present in nonliving or decomposing matter. (flies from manure, etc)

- Louis Pasteur showed microbes caused fermentation & spoilage, and disproved spontaneous generation.

Joseph Lister

- People were dying after surgeries were performed.
- The thought at the time was that the moist tissue being exposed to oxygen caused it to explode.
- However, after making a connection with Pasteur's work, Lister figured that the causative agents were bacteria found in the air.

- This led to the use of chemicals to kill bacteria in the air and the birth of aseptic technique.

- He used carbolic acid in the room before performing surgeries (1867-1870).

Edward Jenner

- Edward Jenner was a country doctor who had studied nature and his natural surroundings since childhood.
- He had always been fascinated by the rural old wives tale that milkmaids could not get smallpox.
- He believed that there was a connection between the fact that milkmaids only got a weak version of smallpox the non-life threatening cowpox but did not get smallpox itself.

- A milkmaid who caught cowpox got blisters on her hands and Jenner concluded that it must be the pus in the blisters that somehow protected the milkmaids.
- Jenner decided to try out a theory he had developed.
- A young boy called James Phipps would be his guinea pig. He took some pus from cowpox blisters found on the hand of a milkmaid called Sarah.

- She had milked a cow called Blossom and had developed the tell-tale blisters.
- Jenner injected some of the pus into James. This process he repeated over a number of days gradually increasing the amount of pus he put into the boy.
- He then deliberately injected Phipps with smallpox. James became ill but after a few days made a full recovery with no side effects. It seemed that Jenner had made a brilliant discovery.

- This discovery was that of the vaccine.
- While many scientists of the eighteenth and nineteenth century studied plant and animal structures under the microscope, the real science of microbiology only began in the latter half of the nineteenth century, when high-magnification microscopes of good optical quality became more widely available.

Ignaz Philipp Semmelweis

- He was a Hungarian obstetrician who discovered the causative agent of puerperal fever.
- Semmelweis concerned himself with the problem of puerperal fever, a problem of 19th century European birth clinics.
- Most women at the time delivered at home, but those who had to take to the hospitals, due to poverty, illegitimacy, or birth complications, suffered a mortality of 25-30 percent.

- Some physicians believed the infection to be caused by crowdedness, poor ventilation, beginning lactation, or miasma.
- Despite strong resistance from his superior, who had accepted the disease as non-preventable, Semmelweis commenced his work on finding the causes of this disease.

- During a short vacation in Venice, the tragic death of his friend Jakob Kolletschka, professor of forensic medicine at Vienna, occurred after his finger was accidentally cut with a knife during a postmortem examination.
- Interestingly, Kolletschka's own autopsy revealed a pathological situation similar to that of the women who were dying from puerperal fever.

- Semmelweis made a crucial association. He promptly connected the idea of cadaveric contamination with puerperal fever, and made a detailed study of the mortality statistics of both obstetrical clinics.
- He concluded that he and the students carried the infecting particles on their hands from the autopsy room to the patients they examined during labor.

- This startling hypothesis led Semmelweis to devise a novel system of prophylaxis in May 1847.
- Realizing that the cadaveric smell emanating from the hands of the dissectors reflected the presence of the incriminated poisonous matter, he instituted the use of a solution of chlorinated lime for washing hands between autopsy work and examination of patients.
- Mortality rates due to the fever dropped, and an era of GLP started.