I. Introduction and History (Chapter 1)

A. Introduction to the course (syllabus)

1. overall goals
   a. general knowledge of microbiology
   b. integration/explanation of fundamental biological processes
   c. knowledge applicable to everyday life
   d. improved critical thinking, problem solving, scientific literacy

2. general background
   a. ubiquitous, wherever life = microbes
      (1) 1E8/g soil, 200 - 500 lb/acre fertile soil
      (2) about as much biomass as plant
      (3) only microbe-free living environment is inside healthy tissues
   b. layman associates bacteria (germs) with disease
      (1) all over skin surfaces (10^{13} body cells vs 10^{14} microbes)
      (2) all food not sterilized or freshly cooked
      (3) drinks, soil, dust, air, etc
      (4) majority are harmless, many beneficial, pathogens in the minority, except where sickness is prevalent
   c. life as we know it could not exist without microbes
      (1) evolution
      (2) photosynthesis, oxygen production
      (3) elemental cycles (C, N, O, S, metals)/waste degradation
      (4) nutrition

3. why study microbiology
   a. basic biological science
      (1) accessible research tools for investigating life processes
      (2) deepest understanding of living processes due to studies with microbes
   b. role in the biosphere
      (1) important in food chains
      (2) mineral cycling
   c. applied biological science
      (1) impact on medicine, agriculture, industry
      (2) many diseases (especially communicable)
         (a) disease major cause of death at turn of century, better sanitation and health practices have lowered risk tremendously
         (b) microbial disease still a major cause of death in many developing countries
      (3) soil fertility and animal production
         (a) N_2 fixation
         (b) rumen microbiology
         (c) nutrient cycling
      (4) food microbiology
         (a) preservation (antimicrobial)
         (b) fermented foodstuffs (dairy, grain, vegetables)
         (c) chemical production (fructose from corn syrup, amino acids for
aspartame, citric acid for soft drinks)
(5) biotechnology (especially pharmaceuticals, stock chemicals, genetic engineering)
(6) sanitation (food treatment, landfills, sewage treatment)
   (a) wastes carried away with flowing water (pipelines) over 4000 years ago
   (b) today, 15,000,000 children die each year from poor sanitation and lack of immunization and simple medical treatment

B. Overview of Microbiology and Cell Biology
1. Classes of microorganisms
   a. bacteria
      (1) prokaryotes = cells that lack a true, membrane-enclosed nucleus, having genetic material in a nucleoid instead
      (2) Archaea = archaebacteria
      (3) Bacteria = eubacteria
   b. algae
      (1) eucaryotic = cells that have a membrane-delimited nucleus
      (2) photosynthetic = convert light to energy (via chloroplasts)
      (3) lack roots, stems, and leaves, but have chlorophyll, like other plants
      (4) microscopic (e.g. Euglena) to macroscopic (e.g. brown kelp)
      (5) phycology or algology is the study of algae
   c. fungi
      (1) "eucaryotic, spore-bearing organism that has absorptive nutrition and lacks chlorophyll; that reproduces asexually, sexually, or by both methods; and that normally has filamentous hyphae surrounded by cell walls, which usually contain chitin" (Prescott)
      (2) important as decomposers
      (3) molds, yeasts, mushrooms (toadstools, truffles)
   d. protozoa
      (1) eucaryotic, animal-like, usually motile, unicellular
      (2) important in food chains; many are animal parasites; some have become useful in molecular biology
   e. viruses
      (1) simple, acellular entities consisting of DNA or RNA enclosed in a protein coat
      (2) obligate intracellular parasites
      (3) specific viruses infect bacterial, plant, animal cells

C. Early history
1. health-related
   a. Mosaic law (over 5000 years ago) included hygienic practices
   b. other cultures (e.g., Greek, Roman) also had hints of microbiology
2. bubonic plague (Black Death) decimated Europe and Asia (in waves) from about 500 - 1700 AD
   a. caused by a bacterial agent spread by ticks that live on rats
   b. strong influence on culture
      (1) ring around the rosy
D. History of early microbiology

1. Francesco Redi demonstrated that maggots do not arise from spontaneous generation
   a. meat was left uncovered or covered with gauze or paper
   b. maggots developed in uncovered meat
   c. maggots did not develop in meat covered with paper
   d. flies laid eggs on gauze where they developed into maggots, meat was not infested
   e. important toward development of scientific method (reproducible, controls)

2. microorganisms first seen and described by Antony van Leeuwenhoek (1676)
   a. simple, single lens microscopes (50 - 300x magnification)
   b. huge curiosity, observed anything he could
   (1) animalcules (intestinal organisms, including Giardia)
   (2) bacteria from overnight pepper infusions
   (3) seeds and plant embryos
   (4) small invertebrates
   (5) spermatozoa
   (6) red blood cells
   (7) essentially all main unicellular organisms we know today
       (a) yeasts
       (b) protozoa
       (c) algae
       (d) bacteria
   c. "I have had several gentlewomen in my house, who were keen on seeing the little eels in vinegar; but some of them were so disgusted at the spectacle, that they vowed they'd never use vinegar again. But what if one should tell such people in the future that there are more animals living in the scum on the teeth in a man's mouth, than there are in a whole kingdom?"
   d. superior observation skills but did not allow others to copy his techniques and verify his results
   e. compound microscopes, at that time, provided higher magnification, but quality of dual lenses was lower than Leeuwenhoek's single lens
   f. renewed argument for spontaneous generation
      (1) animalcules formed spontaneously
      (2) arose from "seeds" or "germs" of animalcules always present in air
      (3) difficult to prove a negative

3. Louis Pasteur
   a. filtered air through guncotton
      (1) dissolved cotton in alcohol/ether and found trapped objects resembling plant spores, protozoan cysts, and other microbial cells
      (2) placing the cotton in sterile medium resulted in growth
   b. sterilized nutrient broth in open flasks with swan necks
      (1) no growth occurred
(2) if necks were broken (shortened), growth occurred immediately

4. Pasteur's studies led him to discover the existence of life forms that can live only in the absence of free oxygen
   a. microscopic observation of butyric acid bacteria showed loss of motility at margin of flattened drop
   b. cells in center (away from air) remained motile
   c. introduced the terms aerobic and anaerobic
   d. "fermentation is life without air"

5. Sterilization is killing all microorganisms in or on objects
   a. sterile = devoid of life
   b. sterilization procedures were essential to development of microbiology as a science
   c. basis of the canning preservation of many foods

6. Aseptic technique = handling of objects so as to prevent contamination

7. Pasteur termed the microbial spoilage of wine and beer "diseases"
   a. considered that microorganisms could act as agents of infectious disease
      (1) already known that fungi could cause disease in wheat and rye
      (2) a fungus was responsible for the great Potato Blight of Ireland
   b. introduction of anesthesia (1840) allowed longer, more complicated surgeries
      (1) surgical sepsis increased
      (2) bacteria in air (demonstrated by Pasteur) considered as possible cause

8. Ignaz Semmelweis improved hospital sanitary practices
   a. observed mortality rates lower with midwives than doctors
      (1) strep infection = child bed fever or puerperal sepsis
      (2) got fired
   b. friend died of P.S. from cut during autopsy of P.S. victim
   c. hypothesized an invisible agent responsible for disease
   d. sanitized hospitals by required handwashing and changing lab coats (fired again)
   e. died in insane asylum of P.S.

9. John Lister sterilized instruments with heat and used phenol on dressings and sometimes on wounds
   (1) phenol kills bacteria
   (2) less wounds became infected
   (3) indirect evidence for role of bacteria in infection

10. Direct evidence for role of bacteria in disease was by Robert Koch, working with anthrax
    (1) injected a series of 20 healthy mice with anthrax bacilli
    (2) inoculated broth with spleen from infected mouse
    (3) isolated anthrax bacilli spores
    (4) injection of spores into mice resulted in anthrax

11. Koch's Postulates
    a. The organism should be present in every case of the disease, but absent in healthy individuals
b. The suspected microorganism must be isolated and grown in pure culture
c. The disease must result when the isolated microorganism is inoculated into a healthy host
d. The same microorganism must be isolated again from the diseased host

12. Vaccination developed by Pasteur
   a. against cholera and rabies
   b. named in honor of Edward Jenner (vacca is Latin for cow)
      (1) Jenner saw that milkmaids who had cowpox were immune from smallpox
      (2) started intentional inoculation with cowpox to prevent smallpox

13. The germ theory of disease (from Pasteur’s and Koch’s work) describes the demonstration that microbes can be the agents of disease
   a. general belief was that epidemics were penalties of God
   b. greatest impetus for development of microbiology
   c. contagious diseases spread through populations by contagions
   d. after discovery of microbes, contagions = microorganisms

14. Koch developed spread plate techniques on solid nutrient surfaces
   a. started with potato slices
   b. added gelatin to nutrient fluid (e.g. blood serum)
      (1) digested by many bacteria
      (2) melted above 28°C
   c. agar suggested by Fanny Angelina Eilshemius, the wife of Walter Hesse, one of Koch’s assistants
      (1) not attacked by most bacteria
      (2) did not melt below 100°C

15. Biochemistry born when Buchner discovered that sugar added to disrupted yeast (physical grinding) was fermented
   a. key to chemical analysis of energy-yielding metabolic processes
   b. similarities later observed between glycolysis by muscle and alcohol fermentation by yeast
   c. vitamins required by animals identical to growth factors required by some bacteria and yeast

E. Microbes and human welfare
   1. microbes are critical for some of the steps in nature’s mineral cycles
   2. natural abilities of microorganisms are exploited to treat solid wastes and recycle water
   3. bacteria and fungi are used to clean up environmental pollutants (bioremediation)
   4. experiments conducted this century with microbes helped establish the science of genetics and molecular biology
      a. mechanisms of genetic transfer
      b. establishment of DNA as hereditary material
      c. biotechnology (recombinant genetics)
      d. gene therapy

F. Microbes and human disease
   1. **normal flora** are the microorganisms that co-exist on us
      a. perform functions that help us
b. protects us from invasion by pathogenic bacteria
2. microbes (bacteria, protozoa, fungi, viruses) can cause disease
3. emerging diseases are those that have come to our notice within the last two decades
   a. AIDS (HIV)
   b. mad cow disease = Creutzfeldt-Jakob in humans (spongiform encephalopathy)
   c. Ebola
   d. hantavirus