Al Muthanna University
Pharmacy College

Medical Microbiology

212

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	Title of the course: *Medical Microbiology* Course number: 212 Credit hours: **Theory 3 hours** **Laboratory 1 hour** Reference text: *1.Medical Microbiology, seventeenth edition E .Jawetz, J.L. Melnick, E.A. Adel 1987 & 2. Principles of microbiology by Roland M.*		
	Medical Microbiology I	Introduction: Importance of microbiology, History of microbiology	2
		Anatomy of bacteria: Surface appendages, Capsule, Cell wall of G.+ve & G –ve bacteria, Cytoplasmic membrane.	2
		Bacterial physiology: Physical and chemical growth determinate, growth and growth curves, bacterial reproduction.	3
		Genetics: Definition, genetic, element, mutation (spontaneous, Gene transfer, transformation, conjugation, and gene transduction).	2
		Recombinant DNA biotechnology.	1
		Sporulation and germination.	1
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		Chemotherapy and sensitivity test	3
		Staphylococci species	3
		Streptococcus species	3
		Aerobic Spore-forming bacteria Bacillus species (*B. anthracis, B. subtilis, B. cereus*).	2
		Clostridium perfringens; Clostridium tetani; Clostridium botulinum	3
		Corynebacterium diphtheriae	2
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		Mycobacterium tuberculosis; M. leprae	2
		Enterobacteriaceae: (*E. coli; Klebsiella spp.; Citrobacter , Serratia, Salmonella, Shigella*)	6
		, Vibrio, Pseudomonas, Helicobacter pylori, Neisseria spp., Brucella, Proteus,	6

Introduction:

Medical microbiology, the large subset of microbiology that is applied to medicine, is a branch of medical science concerned with the prevention, diagnosis and treatment of infectious diseases. In addition, this field of science studies various clinical applications of microbes for the improvement of health. There are four kinds of microorganisms that cause infectious disease: bacteria, fungi, parasites and viruses, and one type of infectious protein called prion..

Bacteria: are Unicellular free living organisms, They constitute a large domain of prokaryotic microorganisms. Bacteria inhabit soil, water, acidic hot springs, radioactive waste, and the deep biosphere of Earth's crust. It consist of non-pathogenic and pathogenic types.

Fungi: is any member of the group of eukaryotic organisms that includes microorganisms such as yeasts and molds, as well as the more familiar mushrooms. These organisms are classified as a kingdom. A characteristic that places fungi in a different kingdom from plants, bacteria, and some protists is chitin in their cell walls. Fungi, like animals, are heterotrophs; they acquire their food by absorbing dissolved molecules, typically by secreting digestive enzymes into their environment. Fungi do not photosynthesize. Growth is their means of mobility, except for spores (a few of which are flagellated), which may travel through the air or water. Fungi are the principal decomposers in ecological systems

Parasites: include single-celled protozoans such as the agents of malaria, sleeping sickness, and amoebic dysentery; animals such as hookworms, lice, mosquitoes, agents like a ring worm.

Virus: is a submicroscopic infectious agent that replicates only inside the living cells of an organism. Viruses infect all life forms, from animals and plants to microorganisms, including bacteria and archaea. When infected, a host cell is often forced to rapidly produce thousands of copies of the original virus. When not inside an infected cell or in the process of infecting a cell, viruses exist in the form of independent particles, or ***virions***, consisting of (i) the genetic material, i.e., long molecules of DNA or RNA that encode the structure of the proteins by which the virus acts; (ii) a protein coat, the *capsid*, which surrounds and protects the genetic material; and in some cases (iii) an outside envelope of lipids. The shapes of these virus particles range from simple helical and icosahedral forms to more complex structures. Most virus species have virions too small to be seen with an optical microscope and are one-hundredth the size of most bacteria.

Prion: are misfolded proteins that have the ability to transmit their misfolded shape onto normal variants of the same protein. They characterize several fatal and transmissible neurodegenerative diseases in humans and many other animals. Prion isoforms of the prion protein (PrP), whose specific function is uncertain, are hypothesized as the cause of transmissible spongiform encephalopathies (TSEs),[7]

including scrapie in sheep, chronic wasting disease (CWD) in deer, bovine spongiform encephalopathy (BSE) in cattle (commonly known as "mad cow disease") and Creutzfeldt–Jakob disease (CJD) in humans.

Epidemiology, the study of the patterns, causes, and effects of health and disease conditions in populations, is an important part of medical microbiology, although the clinical aspect of the field primarily focuses on the presence and growth of microbial infections in individuals, their effects on the human body, and the methods of treating those infections.

History:

In 1676, Anton van Leeuwenhoek observed bacteria and other microorganisms, using a single-lens microscope of his own design.

In 1796, Edward Jenner developed a method using cowpox to successfully immunize a child against smallpox. The same principles are used for developing vaccines today.

Following on from this, in 1857 Louis Pasteur also designed vaccines against several diseases such as anthrax, fowl cholera and rabies as well as pasteurization for food preservation.

In 1867 Joseph Lister is considered to be the father of antiseptic surgery. By sterilizing the instruments with diluted carbolic acid and using it to clean wounds, post-operative infections were reduced, making surgery safer for patients.

Louis Pasteur demonstrated in 1859 that the growth of microorganisms causes the fermentation process, and that this growth is not due to spontaneous generation (yeasts and molds, commonly associated with fermentation, are not bacteria, but rather fungi). Along with his contemporary Robert Koch, Pasteur was an early advocate of the germ theory of disease.Before them, Ignaz Semmelweis and Joseph Lister had realised the importance of sanitized hands in medical work. Semmelweis ideas was rejected and his book on the topic condemned by the medical community, but after Lister doctors started sanitizing their hands in the 1870s. While Semmelweis who started with rules about handwashing in his hospital in the 1840s predated the spread of the ideas about germs themselves and attributed diseases to "decomposing animal organic matter", Lister was active later.

In the years between 1876 and 1884 Robert Koch provided much insight into infectious diseases. He was one of the first scientists to focus on the isolation of bacteria in pure culture. This gave rise to the germ theory, a certain microorganism being responsible for a certain disease. He developed a series of criteria around this that have become known as the Koch's postulates.

Koch's postulates are the following:

1. The microorganism must be found in abundance in all organisms suffering from the disease, but should not be found in healthy organisms.
2. The microorganism must be isolated from a diseased organism and grown in pure culture.
3. The cultured microorganism should cause disease when introduced into a healthy organism.
4. The microorganism must be reisolated from the inoculated, diseased experimental host and identified as being identical to the original specific causative agent.

A major milestone in medical microbiology is the Gram stain. In 1884 Hans Christian Gram developed the method of staining bacteria to make them more visible and differentiated under a microscope. This technique is widely used today.

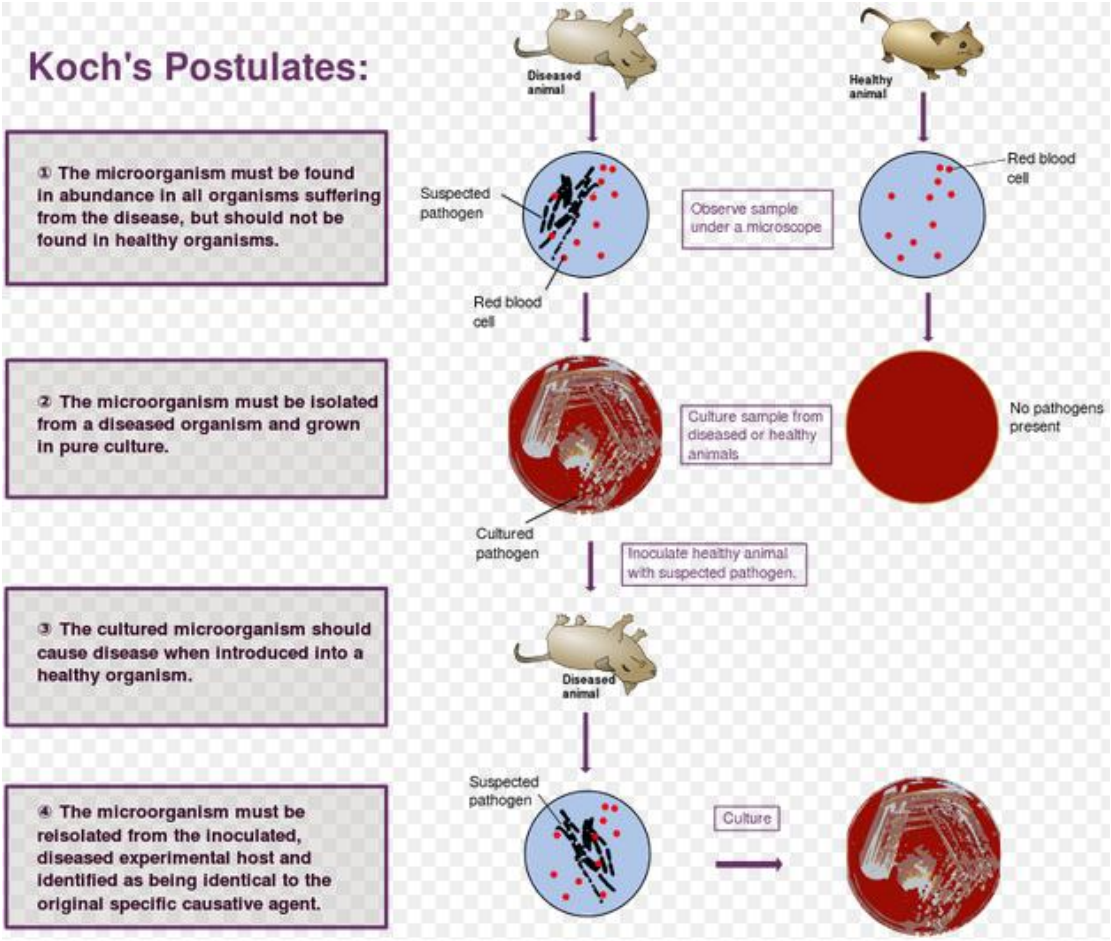
In 1910 Paul Ehrlich tested multiple combinations of arsenic based chemicals on infected rabbits with syphilis. Ehrlich then found that arsphenamine was found effective against syphilis spirochetes. The arsphenamines was then made available in 1910, known as Salvarsan.[5]

In 1929 Alexander Fleming developed the most commonly used antibiotic substance both at the time and now: penicillin.

In 1939 Gerhard Domagk found Prontosil red protected mice from pathogenic streptococci and staphylococci without toxicity. Domagk received the Nobel Prize in physiology, or medicine, for the discovery of the sulfa drug.

DNA sequencing, a method developed by Walter Gilbert and Frederick Sanger in 1977, caused a rapid change the development of vaccines, medical treatments and diagnostic methods. Some of these include synthetic insulin which was produced in 1979 using recombinant DNA and the first genetically engineered vaccine was created in 1986 for hepatitis B.

In 1995 a team at The Institute for Genomic Research sequenced the first bacterial genome; *Haemophilus influenzae*. A few months later, the first eukaryotic genome was completed. This would prove invaluable for diagnostic techniques.



Importanc

Humans and most other animals carry millions of bacteria. Most are in the gut, and there are many on the skin. Most of the bacteria in and on the body are harmless or rendered so by the protective effects of the immune system, and many are beneficial,[2] particularly the ones in the gut. However, several species of bacteria are pathogenic and cause infectious diseases, including cholera, syphilis, anthrax, leprosy, tuberculosis, tetanus and bubonic plague. The most common fatal bacterial diseases are respiratory infections. Antibiotics are used to treat bacterial infections and are also used in farming, making antibiotic resistance a growing problem. Bacteria are important in sewage treatment and the breakdown of oil spills, the production of cheese and yogurt through fermentation, the recovery of gold, palladium, copper and other metals in the mining sector, as well as in biotechnology, and the manufacture of antibiotics and other chemicals.

Microorganisms contribute to the world in myriads of ways. Apart from some that cause harm, there are others who have immense importance . in our ecosystem and health system. Some of these benefits are explained below.

- **Agriculture:** Microbes help plants take required nutrients by breaking down complex compounds into simpler forms. They also make the soil rich in nutrients and minerals (like nitrates) that enhance crop yield. . Microbes help plants fix nitrogen, and some of them are used as biofertilizers, thus contributing to a better and higher output.
- **Biotechnology and genetic engineering:** Microbial studies have allowed scientists to understand their working mechanisms and engineer them in a way that helps in the increased production of medicinal compounds. It is believed that the insertion of foreign genes in some bacterial species might lead to creating a bacterial strain that can provide solutions to myriads of challenges, including pollution, food and energy shortages, and the treatment and control of the disease.
- **Producing certain compounds:** Bacteria are used in industries to make new products from the provided raw materials. They can perform a metabolic reaction rapidly on a large scale that meets the population's demand for medicines, food materials, or other chemical compounds, such as insulin and other growth hormones.
- **Combating diseases:** The study of microbes has unraveled their potential in treating several deadly conditions. For example, several bacterial species are used to isolate medicinal compounds, like antibiotics and develop vaccines.
- **Keep the planet healthy:** Microbes play an essential role in recycling minerals like nitrogen and carbon for easy availability to other organisms, keeping the environment oxygenated, and actively degrading organic matter.
- **Food processing:** The study of microbiology has enlightened us on the application of microbes as an essential source of nutrients. For example, some algal and fungal species are part of people's meal, such as mushroom, *Chlorella*, *Spirulina*, and certain microbes are also used in food processing, fermentation, baking, and producing livestock feed.

PART I BASIC BACTERIOLOGY

CHAPTER 1

Bacteria Compared with Other Microorganisms

CHAPTER CONTENTS

MICROBES THAT CAUSE INFECTIOUS DISEASES

The agents of human infectious diseases belong to five major groups of organisms: bacteria, fungi, protozoa, helminths, and viruses. Bacteria belong to the prokaryote kingdom, fungi (yeasts and molds) belong to the kingdom of fungi, and protozoa are members of the kingdom of protists. Helminths (worms) are classified in the animal kingdom (Table 1–1). Protists and fungi are distinguished from animals and plants by being either unicellular or relatively simple multicellular organisms. In contrast, helminths are complex multicellular organisms. Taken together, the helminths and the protozoa are commonly called parasites. Viruses are quite distinct from other organisms—they are not cells but can replicate only within cells.

IMPORTANT FEATURES OF MICROBES

Many of the essential characteristics of these organisms are described in Table 1–2. One salient feature is that bacteria, fungi, protozoa, and helminths are cellular, whereas viruses are not. This distinction is based primarily on three criteria:

(1) **Structure.** Cells have a nucleus or nucleoid (see below), which contains DNA; this is surrounded by cytoplasm, within which proteins are synthesized and energy is generated. Viruses have an inner core of genetic material (either DNA or RNA) but no cytoplasm, and so they depend on host cells to provide the machinery for protein synthesis and energy generation.

TABLE 1–1 Biologic Relationships of Pathogenic Microorganisms

Kingdom	Pathogenic Microorganisms	Type of Cells
Animal	Helminths (worms)	Eukaryotic
Protists	Protozoa	Eukaryotic
Fungi	Fungi (yeasts and molds)	Eukaryotic
Prokaryote	Bacteria Viruses	Prokaryotic Noncellular

TABLE 1–2 Comparison of Medically Important Organisms

Characteristic	Viruses	Bacteria	Fungi	Protozoa and Helminths
Cells	No	Yes	Yes	Yes
Approximate diameter (μm)[1]	0.02–0.2	1–5	3–10 (yeasts)	15–25 (trophozoites)
Nucleic acid	Either DNA or RNA	Both DNA and RNA	Both DNA and RNA	Both DNA and RNA
Type of nucleus	None	Prokaryotic	Eukaryotic	Eukaryotic
Ribosomes	Absent	70S	80S	80S
Mitochondria	Absent	Absent	Present	Present
Nature of outer surface	Protein capsid and lipoprotein envelope	Rigid wall containing peptidoglycan	Rigid wall containing chitin	Flexible membrane
Motility	None	Some	None	Most
Method of replication	Not binary fission	Binary fission	Budding or mitosis[2]	Mitosis[3]

[1]For comparison, a human red blood cell has a diameter of 7 μm.

[2]Yeasts divide by budding, whereas molds divide by mitosis.

[3]Helminth cells divide by mitosis, but the organism reproduces itself by complex, sexual life cycles.

(2) **Method of replication.** Cells replicate either by binary fission or by mitosis, during which one parent cell divides to make two progeny cells while retaining its cellular structure. Prokaryotic cells (e.g., bacteria) replicate by binary fission, whereas eukaryotic cells replicate by mitosis. In contrast, viruses disassemble, produce many copies of their nucleic acid and protein, and then reassemble into multiple progeny viruses. Furthermore, viruses must replicate within host cells because, as mentioned previously, they lack protein-synthesizing and energy-generating systems. With the exception of rickettsiae and chlamydiae, which also require living host cells for growth, bacteria can replicate extracellularly.

(3) **Nature of the nucleic acid.** Cells contain both DNA and RNA, whereas viruses contain either DNA or RNA, but not both.

EUKARYOTES & PROKARYOTES

Cells have evolved into two fundamentally different types, **eukaryotic** and **prokaryotic**, which can be distinguished on the basis of their structure and the complexity of their organization. Fungi, protozoa, and helminths are eukaryotic, whereas bacteria are prokaryotic.

(1) The eukaryotic cell has a true **nucleus** with multiple chromosomes surrounded by a nuclear membrane and uses a mitotic apparatus to ensure equal allocation of the chromosomes to progeny cells.

(2) The **nucleoid** of a prokaryotic cell consists of a single circular molecule of loosely organized DNA, lacking a nuclear membrane and mitotic apparatus (Table 1–3).

In addition to the different types of nuclei, the two classes of cells are distinguished by several other characteristics:

(1) Eukaryotic cells contain **organelles**, such as mitochondria and lysosomes, and larger (80S) ribosomes, whereas prokaryotes contain no organelles and smaller (70S) ribosomes.

(2) Most prokaryotes have a rigid external cell wall that contains **peptidoglycan**, a polymer of amino acids and sugars, as its unique structural component. Eukaryotes, on

TABLE 1–3 Characteristics of Prokaryotic and Eukaryotic Cells

Characteristic	Prokaryotic Bacterial Cells	Eukaryotic Human Cells
DNA within a nuclear membrane	No	Yes
Mitotic division	No	Yes
DNA associated with histones	No	Yes
Chromosome number	One	More than one
Membrane-bound organelles, such as mitochondria and lysosomes	No	Yes
Size of ribosome	70S	80S
Cell wall containing peptidoglycan	Yes	No

the other hand, do not contain peptidoglycan. Either they are bound by a flexible cell membrane, or, in the case of fungi, they have a rigid cell wall with chitin, a homopolymer of *N*-acetylglucosamine, typically forming the framework.

(3) The eukaryotic cell membrane contains **sterols**, whereas no prokaryote, except the wall-less *Mycoplasma*, has sterols in its membranes.

Motility is another characteristic by which these organisms can be distinguished. Most protozoa and some bacteria are motile, whereas fungi and viruses are nonmotile. The protozoa are a heterogeneous group that possess three different organs of locomotion: flagella, cilia, and pseudopods. The motile bacteria move only by means of flagella.

TERMINOLOGY

Bacteria, fungi, protozoa, and helminths are named according to the binomial Linnean system that uses genus and species, but viruses are not so named. For example, regarding the name of the well-known bacteria *Escherichia coli*, *Escherichia* is the genus and *coli* is the species name. Similarly, the name of the yeast *Candida albicans* consists of *Candida* as the genus and *albicans* as the species. But viruses typically have a single name, such as poliovirus, measles virus, or rabies virus. Some viruses have names with two words, such as herpes simplex virus, but those do not represent genus and species.

PEARLS

- The agents of human infectious diseases are **bacteria, fungi (yeasts and molds), protozoa, helminths (worms),** and **viruses.**
- Bacterial cells have a **prokaryotic** nucleus, whereas human, fungal, protozoan, and helminth cells have a **eukaryotic** nucleus. Viruses are not cells and do not have a nucleus.
- All cells contain both DNA and RNA, whereas viruses contain either DNA or RNA, but not both.
- Bacterial and fungal cells are surrounded by a rigid cell wall, whereas human, protozoan, and helminth cells have a flexible cell membrane.
- The bacterial cell wall contains **peptidoglycan**, whereas the fungal cell wall contains chitin.

SELF-ASSESSMENT QUESTIONS

1. You're watching a television program that is discussing viruses called bacteriophages that can kill bacteria. Your roommate says, "Wow, maybe viruses can be used to kill the bacteria that infect people! You're taking the Microbiology course now; what's the difference between viruses and bacteria?" Which one of the following would be the most accurate statement to make?

(A) Viruses do not have mitochondria, whereas bacteria do.
(B) Viruses do not have a nucleolus, whereas bacteria do.
(C) Viruses do not have ribosomes, whereas bacteria do.
(D) Viruses replicate by binary fission, whereas bacteria replicate by mitosis.
(E) Viruses are prokaryotic, whereas bacteria are eukaryotic.

2. Bacteria, fungi (yeasts and molds), viruses, and protozoa are important causes of human disease. Which one of the following microbes contains either DNA or RNA but not both?

(A) Bacteria
(B) Molds
(C) Protozoa
(D) Viruses
(E) Yeasts

3. Which one of the following contains DNA that is not surrounded by a nuclear membrane?

(A) Bacteria
(B) Molds
(C) Protozoa
(D) Yeasts

ANSWERS

(1) (**C**)
(2) (**D**)
(3) (**A**)

PRACTICE QUESTIONS: USMLE & COURSE EXAMINATIONS

Questions on the topics discussed in this chapter can be found in the Basic Bacteriology section of Part XIII: USMLE (National Board) Practice Questions starting on page 709. Also see Part XIV: USMLE (National Board) Practice Examination starting on page 751.