MICROBIOLOGY 2024

Lecture course by Alex Lyakhovich, Office: FENS 1043,
Tel. 9506 email: alex.lyakhovich@sabanciuniv.edu
TAs: Zülal Muganlı and Cemile Uslu

Name: **Microbiology**

Codes: **BIO306 and BIO306L**

When/Where: #**Tuesday 12.40PM - 2.30PM Lecture: FENS L035**

Thursday 11.40AM - 12.30AM Lecture: FENS L065

Wednesday 9.40AM - 1:30PM Lab: FENS G049/50

Aim(s): The course intends to provide an up-to-date overview of the microbiology. It covers the essentials of microorganisms, molecular, cellular, biochemical principles operated among bacteria, archaea and smaller eukaryotic cells, interactions between microbes and the human host, their characteristics, pathogenicity and modes of transmission, key aspects of food chemistry, novel bioproducts (green chemistry, new types of food), health and social benefits resulted from the development of medical microbiology. Laboratory instruction includes a study of aseptic technique as well as, culturing and staining of bacteria.

Course Outcomes: 1. Students will be able to describe the key steps of development microbiology from ancient times to present days. They will be able to identify the major bacterial, viral, fungal, protozoan and helminthic pathogens with an understanding of taxonomy, transmission, pathogenesis, epidemiology and treatment. 2. Students will be able to describe DNA replication, protein synthesis, gene expression, mutation and mechanisms of drug resistance in bacteria, archaea and unicellular eukaryotes. 3. Students will be able to describe and analyze major metabolic pathways of microorganisms. 4. Students will be able to understand basic principles of food microbiology and sustainable development of modern society, be familiarized with healthy issues linking microbes and important human diseases and see the perspectives of microbiology for the 21st century.

Format: This course consists of approximately 23+ lectures separated by 4 tests. Students will be required to read and analyze some complimentary papers in top journals for some lectures and come to class prepared to discuss them.

Prerequisites: A basic level understanding of biology, molecular and cell biology, biochemistry and statistics is a highly prerequisite.

Attendance and participation: Required in at least 70% of the lectures. Students are expected to apply concepts that they have learned in other science disciplines to this course and be able to express themselves orally and in written form. Scientific reasoning and the application of the scientific method in the lab approach should be emphasized.

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Scoring and Evaluation criteria:

Theoretical part – **60%** (Quizzes – 12%, T1- 12%, T2-12%, T3-12%, T4- 12%);

Lab Practice (BIO306L) – mandatory – **40%**

Letter Grade Criteria for Earning Grade

A 100 – 90 %

A - 89 – 85 %

B+ 84 – 80 %

B 79 – 75 %

B - 74 – 70 %

C+ 69 – 65 %

C 64 – 60 %

C - 59 – 55 %

D+ 54 – 50 %

F Less than 49 %

Additional: Bonus question system (for the theoretical part) - sometimes I ask bonus questions (also projected on slides). If you want to get an extra point, send me your answer by e-mail **before** the next lecture when the answer is announced.

Disability Accommodations

If you need disability-related accommodations for this course, please contact the Disable Students Support Unit Center of Individual and Academic Development (CIAD) address: Orhanlı, Tuzla, 34956, Istanbul, Turkey, e-mail: specialneeds@sabanciuniv.edu telephone: + 90 216 483 9448 website: http://ciad.sabanciuniv.edu/en/disabled-students-services

How to communicate with me ?

Drop by my office or drop me an e-mail or whatsup/Telegram me (+34 600 79 84 27), or leave a message via SUcourse, where all announcements and amendments will be placed.

Important notes: - Life is full of the unexpected, and sometimes we are faced with unavoidable situations such as illness, urgent household needs, or off-campus events (such as spot competitions or student conferences). All of these issues are handled on a case-by-

case basis. For example, illness and inability to attend lectures must be accompanied by an appropriate report from the medical center; off-campus duty usually happens once, and those who are required to participate must provide me with a letter from your supervisor.

The **BIO306 theoretical course** contains **4 main parts** divided by tests

Part A. Basic Principles of Microbiology

The biological language of our lives. Carl Richard Wiese and his system of all living organisms. The phylogenetic tree of microorganisms. Taxonomy system - three domains - Bacteria, Archaea and Eukarya. LUCA. Viruses, viroids and other extracellular life forms.

Microbes around us and how to study them. Microscopy and the history of microorganisms. Pasteur's experiments and Koch's postulates.

Bacteria. Unicellular microorganisms. Morphological differences. Basic elements of bacterial cells, structure of cell walls and membranes. Hans Gram's test. Peptidoglycans with teichoic acids. Gram-positive and gram-negative bacteria and their resistance to antibiotics. Pathogenicity. Growth and reproduction of bacterial cells.

Archaea and Eukarya. Structure of bacteria and archaea. Extremophiles. Optical isomerism and division of our biological world into L- and D-molecules. Eukaryotic cells and their difference from bacteria and archaea. Major organelles and their functions. Adaptation for survival among three domains.

Acellular life forms. Viruses. Comparison of biological and computer viruses. Reproduction and genetic code. Phages. Prions, viroids, circulating DNA and RNA, and exosomes.

Part B. Molecular biology of microorganisms.

Cell genetic material. DNA, RNA. The most important experiments performed to understand the structure and function of these molecules. Basic dogmas of molecular biology and the three basic processes in the cell: replication, transcription and translation.

Replication in bacteria. Semi-conservative mechanism of DNA and chromosome replication. Study of enzymatic system of DNA synthesis based on the structure and catalytic activity of E. coli DNA polymerase I. Verification of complementarity and antiparallelism of replication. Characterization of *E. coli* DNA polymerase I, DNA polymerase II and DNA polymerase III. Kornberg, Cairns and Okazaki replication schemes. Mechanism of DNA ligase operation and replication topological problems.

DNA denaturation during replication. Helicases and their role. Mechanisms of action of type I and type II topoisomerases. Regulation of *E. coli* replication by methylation.

Replication of eukaryotic DNA. Eukaryotic DNA polymerases, their structure and differences in their polymerizing activity. Role of different eukaryotic DNA polymerases in replication and repair, structure of replicative complex in eukaryotes, replicative fork. The problem of insufficient replication of linear DNA molecules. Telomerase.

Principles of transcription and structure of bacterial RNA polymerase. Different variants of prokaryotic promoters. Closed and open enzyme-matrix transcription complexes. Recognition and binding stage, initiation stage, elongation stage, and termination stage. Negative and positive induction as well as negative and positive repression in transcription. Attenuation and insulators.

Transcription in the eukaryotic system. Diversity of eukaryotic RNA polymerases. Proximal and distal cis-elements of transcription. TATA-containing promoters and promoters without a TATA box. Basal transcription factors. Enhancers and silencers. Processing of gRNAs and tRNAs in pro- and eukaryotes. Stages of mRNA processing in eukaryotes. Capping and its role. Polyadenylation and its role. RNA-protein complexes (RNPs). The concept of splicing. A variety of splicing mechanisms. Alternative splicing. Editing.

Splicing in bacteria. Deciphering triplet genetic code and its properties. Coding information using binary code. Structure of tRNA, ribosomes, ribosomal active centers. Formation of translation initiation complex, elongation and completion of protein synthesis.

Translation in eukaryotic systems. Basic differences between translation in prokaryotes and eukaryotes. Comparison of replication, transcription and translation in bacteria, archaea and eukaryotes.

Replication, transcription and assembly of viral particles. Viruses and their reproduction cycle. Retrovirus and its structure. Functions of reverse transcriptase. Mechanisms of viral integration. Examples of other viruses including SARS-2.

Part C. Biochemistry of Microorganisms

Introduction to the biochemistry of bacterial, archaeal, and eukaryotic cells. Three major events - metabolism, catabolism and anabolism. Bioenergetic pathways in microorganisms, function of the universal energy currency, ATP, where and how it is produced, electron transport chains (ETC).

Catabolism. Types of nutrition and energy source for microorganisms. Aerobic respiration, glycolytic pathway, TCA cycle and oxidative phosphorylation (OXPHOS).

Mitochondria. Symbiotic theory, role of pra-alpha proteo-bacteria. Mitochondrial dysfunction and related diseases.

Anabolism. Utilization of carbon, hydrogen, oxygen, nitrogen, phosphorus and sulfur by cell. Synthesis of carbohydrates, amino acids, purines, pyrimidines, nucleotides and lipids. Heterotrophs, autotrophs, and their biochemistry.

Part D. Medical Microbiology

The microbiota is the community of microorganisms present in our intestines, skin, and other parts of the body. Why people study microbiomes. Ecological niches and healthy issues.

We are not the host of the microbiome, but the microbiome agrees to live in us. Amensalism and commensalism. Aseptic conditions and antiseptics.

The era of antibiotics. Sustainable development of modern society. History of antibiotics that revolutionized medicine. The major classes of these compounds and their mechanisms of action. Resistance to antibiotics and methods to combat it. Modern methods of searching for new antibiotics. Superbugs. WHO list of drugs.

Antifungal and antiviral drugs. How to develop new drugs and what targets to use. Fungi, viruses, their weaknesses and strengths. What to expect from microbiology in the 21st century?

What is a disease? Pathogenic and nonpathogenic microbes. What makes a microbe pathogenic? Infectious and non-infectious diseases. ID50, LD50, contagiousness, prevalence, incidence. Infectious and noninfectious diseases. Primary and opportunistic pathogens. Stages of the disease process: adhesion, invasion, infection, and transmission. Virulence factors and their differences in viruses, bacteria and protozoa.

Fundamentals of epidemiological research. Retrospective and prospective studies.

Food microbiology. Differences in pathogen development in food and host cells. Measures to protect food from spoilage. Industrial microbiology. Artificial food production and flavor microbiology.

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BIO 306Laboratory syllabus – our Tas will update you with the new version. The old one:

Week 1 - Introduction to Lab Sessions (Sterilization, autoclave, disinfection etc.) - How to write lab reports. Lab rules and Grading parameters

Week 2 - Microscopy and Its importance for Microbiology

Week 3 - Spread Plate Technique

Week 4 - Streak plate and Pour plate Technique

Week 5 - Bacterial Growth Curve analysis

Week 6 - Analysis of ambient growth condition for different species

Week 7 - LAB MIDTERM-I

Week 8 - Staining Techniques: Gram and acid-fast staining technique

Week 9 - Antibiotics & Antibiotic sensitivity Test

Week 10 - Sterilization & Disinfection: Filter Paper Disk method

Week11 - Overall Discussion of Lab Sessions

Week 12 - LAB MIDTERM-II

FİNAL and Grading

Outcomes from BIO306L

Students will be able to identify the major bacterial, viral, fungal, protozoan and helminthic pathogens with an understanding of taxonomy, transmission, pathogenesis, epidemiology and treatment. 4. Quizzes and exams. Understanding the interactions between host and pathogen and how various etiological agents cause unique symptomology. 5. Students will learn the importance of sterility, aseptic techniques, and safety when handling microorganisms.

Reference Letters

Some students decide to continue their MSc./Ph.D. program nationally or internationally and letters of recommendation are requested. I can provide such letters of recommendation to those who are successful (75% or higher) in my class.