Course Syllabus

The BIO306 course contains 4 main units divided by exams

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. Structure and of *E. coli* and the "thrombone" model. 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.

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. 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 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.