

Ministry of Education and Science of Ukraine  
Ivan Franko National University of Lviv  
Faculty of Biology  
Department of Microbiology

**“APPROVE”**

Dean of the Faculty of Biology

\_\_\_\_\_ ass. prof. Khamar I. S.

\_\_\_\_\_ “\_\_\_\_\_” 2018

(Resolved by the Scientific Council  
of the Faculty of Biology

\_\_\_\_\_ "\_\_\_\_", 2018,  
minutes N \_\_\_\_)

**«MICROBIOLOGY»**

**PROGRAM**  
**of the mandatory educational discipline**

**Field of knowledge 09 «Biology»**

**Speciality 091 «Biology»**

**Language of study: Ukrainian**

**(PP 01.20)**

Lviv – 2018

DEVELOPED by: Ivan Franko National University of Lviv

DEVELOPER OF THE PROGRAM:

head of the Department of Microbiology Svitlana Hnatush

Program approved at the meeting of the Department of Microbiology

Minutes N 1 from August "28", 2018.

Head of the Department of Microbiology

\_\_\_\_\_/prof. Hnatush S. O./  
(signature)

August "28", 2018.

Approved by the Methodical Council of the Faculty of Biology

Minutes N 1 from " " , 2018.

" " \_\_\_\_\_2018 Head \_\_\_\_\_/ass. prof. Honcharenko V. I./  
(signature)

## INTRODUCTION

Program of the educational discipline "Microbiology" is developed according to the educational-professional program of the training of bachelor by the field of knowledge 09 "Biology" and speciality 091 "Biology".

**The subject** of the educational discipline is the structure of microorganisms, ways of reproduction and methods of cultivation, particularities of organization of genetic information, metabolism of microorganisms, types of interactions of microorganisms with the cells of plants, human, animals and bacteria, and also their practical usage.

**Interdisciplinary connections:** Biochemistry, Virology, Genetics, Molecular Biology, Biotechnology, Botany, Human Physiology, Zoology, Immunology, Mycology.

Program of the educational discipline consists of such subject modules:

1. History of research and cytology of microorganisms
2. Physiology and systematics of microorganisms
3. Genetics and biochemistry of microorganisms
4. Ecology of microorganisms and their practical usage

### 1. Aim and tasks of the educational discipline

**1.1. The aim** of the educational discipline "Microbiology" is to acquaint students with the world of microorganisms, their structure, physiological and biochemical properties. To study the questions of modern systematics and characterize main groups of microorganisms. To get acquainted with theoretical and practical aspects of obtaining the accumulative and pure cultures, considering their type of nutrition and effects of environmental factors. To elucidate the particularities of energetic and constructive metabolism in microorganisms, the questions of the regulation of metabolism. To represent the required information about the organization of genome of microorganisms, exchange of the genetic information, selection of mutants, main principles of genetic engineering research. To acquaint students with the practical usage of microorganisms in different fields of economy and their significance in the cycles of elements.

**1.2. The main tasks** of the discipline "Microbiology" are the formation of the system of skills in students which enable them to work with microorganisms.

1.3. According to the requirements of the educational-professional program students have to:

#### **know:**

- structure, physiological and biochemical properties of microorganisms;
- types of nutrition and effects of environmental factors to the cells of microorganisms;
- main groups of bacteria;
- theoretical and practical aspects of the obtaining the accumulatory and pure cultures;
- particularities of catabolism and anabolism;

- genome organization in prokaryotes and exchange of genetic information;
- principles of metabolism regulation in prokaryotes;
- practical usage of microorganisms.

**to be able to:**

- Prepare the nutrition medium for particular group of microorganisms, using data about the prescribing.
- Perform the sterilization of the laboratory utensils and nutrition media for the cultivation of microorganisms, using systemized data about the principles of sterilization.
  - Establish the morphological type of microorganism by the systemized data about the particularities of microbial cell, using the microscope and cytochemical stains.
  - Prepare the preparations of surface structures, using special methods of microbiological research for the particular bacterial culture.
  - Isolate pure culture of microorganisms from the represented substrate, using generally recognized methods (Dryhalskyi method, Shukevych method, method of the heating of bacterial suspension for the isolation of spore-forming bacteria).
  - Determine the conditions of cultivation of particular group of microorganisms, considering data about the particularities of metabolism.
  - Perform the determination of quantitative composition of microbiota of fermented-milk products, using the information about the industrial usage of microorganisms.
    - Establish the quantity of microorganisms in the natural substrate, using special methods of their isolation.
    - Determine the number of *Escherichia coli* cells in substrate, using differentially diagnostic nutrition media.
    - Determine the factors of pathogenicity for the particular group of microorganisms on the basis of information about the pathogenicity and pathogenic process.
    - Determine the condition of human microbiota in the microbiological laboratory using recognized methodics.
    - Determine the presence of modificational variability in the particular group of microorganisms in microbiological laboratory, using the methodics of assessment the sensitivity of bacteria to antibiotics, determine the sensitivity of particular strain of bacteria to antibiotics.
    - Determine the systematic position of the given culture of microorganisms on the level of group, using the complex of morphological, cultural, physiological and biochemical properties.
    - Determine the duration of phases of growth of microbial population in the periodical culture in microbiological laboratory, using data about the number of microbial cells in the culture and considering information about the growth and reproduction of microbial population.

- Determine the types of differentiation in microbiological laboratory, considering data about the differentiation at the level of cellular organization of prokaryotes, using cytological methods of microbiological research.
- Detect significant for identification Gram staining of microbiological objects in the conditions of laboratory, using data about the composition and structure of the cell wall, using information about the system of diagnostic biochemical properties.
- Detect the ability of microorganisms to bind molecular nitrogen in microbiological laboratory, using cultural methods.

120 hours / 4 ECTS credits are given for the study of educational discipline.

## **2. Information content of the educational discipline**

### **Subject module 1. History of research and cytology of microorganisms**

**History of microbiology.** Introduction. Subject, methods and tasks of microbiology, its place and role in modern science, economy and medicine. History of microbiology. Discovery of microorganisms by A. Leeuwenhoek. Role of L. Pasteur in the formation of modern microbiology. Significance of works by R. Koch, M. Beijerinck, A. Kluyver, A. Fleming. Development of microbiology in Ukraine. Works by D. Samoylovych, S. Winogradsky, I. Mechnikov, M. Hamaliya, V. Omelyansky, D. Zabolotny. Works in microbiology by Lviv scientists (research by J. Kamensky, Kshemieniewski family, R. Weigl, Y. Badian, G. Shavlovsky).

Main courses of development of modern microbiology: general, industrial, soil, water, geological, medical, sanitary, agricultural microbiology.

**Yeasts.** Morphology, structure, chemical composition of cell. Functions of its components. Cell wall, membrane structures, nucleus, ribosomes, endoplasmic reticulum, Golgi apparatus, lysosomes, peroxisomes, glyoxysomes, mitochondria. Reserve substances. Ways of replication. Life cycles of haploid and diploid yeasts. Usage in the economic activity of human.

**Moulds.** Morphology, structure, chemical composition of cells. Ways of reproduction. Life cycles. Usage in the economic activity of human.

**Structure of the prokaryotic cell.** Morphology, sizes, chemical composition of bacterial cells. Cell wall. Gram staining. Particularities of Gram-positive and Gram-negative bacteria structure. Spheroplasts, protoplasts, L-forms, mycoplasmas.

Extracellular structures of prokaryotes: mucous layers, capsules, sheathes. Organelles of motility: pili, flagella. Structure, number, arrangement, mechanism of motility, types of motility. Taxes in microorganisms. Gas vacuoles (airsomes), phycobilisomes, chlorosomes. Reserve nutrients.

**Reproduction and ways of differentiation of prokaryotes.** Reproduction of bacteria. Life cycles. Differentiation in prokaryotes. Resting forms and specialized cells. Formation of spores in bacteria.

### **Subject module 2. Physiology and systematics of prokaryotes.**

**Effects of environmental factors.** Effects of temperature to microorganisms. Psychrophyls, mesophyls, thermophyls. Thermostability. Response of microorganisms to molecular oxygen: aerobes and anaerobes (obligatory,

facultative), aerotolerant microorganisms. Effects of hydrostatic pressure. Growth of microorganisms depending on the content of water. Tolerance of cultures to drying. Lyophilization. Osmotic pressure. Particularities of halophiles and osmophiles. Low, medium and extreme halophiles. Halotolerant microorganisms. pH of medium and its effects to cultures. Alkaliphilic, acidophilic, tolerant to acid microorganisms. Effects of different types of radiation to microorganisms. Resistance of cultures to UV- and ionizing radiation. Photoreactivation. Microbocycle and microbostatic effects. Significant chemotherapeutic preparations.

**Cultivation of microorganisms.** Accumulative cultures and principle of selectivity. Pure cultures of microorganisms, methods of their obtaining. Clone, strain. Needs of microorganisms in the nutrients. Media for their cultivation. Cultivation of aerobic and anaerobic microorganisms. Surface and abyssal cultivation. Periodic and continuous cultivation.

Main parameters of growth of cultures: time of generation, specific rate of growth, yield, economic coefficient. Methods of determination of growth of microorganisms. Detection of number of living and dead cells. Balanced and disbalanced growth. Limitation of growth and death of microorganisms, growth curve, particularities of phases. Growth of cultures during the continuous cultivation. Systems of chemostat and turbidostat. Significance of continuous cultivation for the study of properties of microorganisms, practical usage. Synchronous cultures: ways to obtain, significance. Mixed cultures.

**Nutrition and transport.** Types of nutrition of microorganisms. Phototrophy, chemotrophy. Autotrophy, heterotrophy, organotrophy, lithotrophy. Transport of nutrients to microbial cells.

**Systematics of bacteria.** Principles of classification of bacteria. Bases of systematics and nomenclature. Modern systematics of bacteria. Characteristics of categories. Characteristics of main groups. Characteristic representatives.

Causative agents of human, animals and plants diseases. Pathogenicity, virulence as the measure of pathogenicity. Factors of pathogenicity. Formation of toxins by microorganisms. Exo- and endotoxins.

### **Subject module 3. Genetics and biochemistry of microorganisms**

**Organization, functioning of genetic apparatus in microorganisms.** Sizes of genome. Phenotype and genotype variability. Mutagenesis (spontaneous, induced). Nature of mutations. Selection of mutants.

Transformation, transduction, conjugation. Recombination in prokaryotes and eukaryotic microorganisms. Principles of genetic engineering construction of microorganisms.

**Destruction of natural polymers** by microorganisms: proteins, nucleic acids, lipids, cellulose, starch, pectin, chitin.

**Energetic metabolism.** General characteristics. Obtaining of energy by microorganisms depending on the types of nutrition. First reactions of metabolism of carbohydrates. Embden-Mejergoff-Parnas, Entner-Dudorov, Khoreker-Dikkens pathways.

Fermentation. Ways of fermenting the carbohydrates. Alcoholic fermentation. Homofermentative and heterofermentative lactic fermentation, propionic, butyric, formic, acetone-butylic fermentation. Effects of environmental

factors on the process of fermentation. Characteristics of microorganisms – causative agents of different types of fermentation.

Obtaining of energy of aerobes. Oxidation of carbohydrates by microorganisms. Full and partial oxidation. Functioning of TCA cycle in microorganisms. Respiratory chain. Synthesis of ATP. Obtaining of energy by chemolithotrophs: sulfur bacteria, nitrifying, thionic, hydrogen, ferrum bacteria.

**Anaerobic respiration.** Electron donors and acceptors at the anaerobic respiration of microorganisms. Microorganisms that reduce nitrates and other nitrogen compounds. Dissimilatory nitrate reduction and denitrification. Sulfate- and sulfur-reducing bacteria. Dissimilatory sulfate reduction. Substrates of oxidation. Methanogenic bacteria, their particularities. Production of methane by microorganisms. Carbonate respiration.

**Bacterial photosynthesis.** Characteristics of photosynthetic bacteria. Mechanism of bacterial photosynthesis.

**Nitrogen fixation.** Mechanism of the process, nitrogen-fixing microorganisms (free-living, symbiotic).

**Assimilatory metabolism.** Sources of carbon and nitrogen for the constructive metabolism. Assimilation of carbon dioxide by heterotrophs and autotrophs. Ribulobisphosphate cycle. Functioning of ribulobisphosphate and serine cycles. Assimilation of nitrogen compounds. Assimilatory nitrate reduction. Pathways of ammonium assimilation and amino acids production. Synthesis of main biopolymers by microorganisms (nucleic acids, proteins, lipids, carbohydrates, porphyrins). Secondary metabolites.

**Regulation of metabolism.** Constitutive and inducible enzymes. Regulation of enzymes synthesis (induction, repression). Principle of the operon organization of genome. Catabolite regulation. Role of cAMP. Diauxy. Regulation of branched biosynthetic processes.

Regulation of enzymes activity. Properties of allosteric enzymes. Chemical modification of enzymes.

#### **Subject module 4. Ecology of microorganisms and their practical usage**

**Ecology of microorganisms.** Microorganisms of soil, air, waters. Human microbiota. Participation of microorganisms in carbon, nitrogen, sulfur and other elements cycles. Role of microorganisms in soil-forming processes and providing the fertility of soil. Significance of microorganisms in the primary production of waters and mineralization of compounds. Role of microorganisms in the formation of mineral resources. Participation of microorganisms in the transformation of wastes and detoxification of poisons.

**Types of interactions.** Symbiosis. Types of symbiosis. Commensalism, metabiosis. Facultative and obligatory symbionts. Symbiotic associations of microorganisms, their diversity and significance.

Rhizosphere. Epiphytic microbiota. Mycorrhiza. Phytopathogenic microorganisms. Microorganisms of rumen of ruminants, their activity. Symbionts of insects and other invertebrates. Pathogenic for animals and plants microorganisms. Antagonism. Antibiotics.

**Practical usage of microorganisms.** Usage of microorganisms for the obtaining of nutritional and fodder products, chemical and pharmaceutical

preparations. Usage of microorganisms in agriculture, in the biohydrometallurgy, wastes purification. Obtaining of fuel.

### 3. Recommended literature

#### Basic

1. *Hudz S. P., Hnatush S. O., Bilinska I. S.* Microbiology. – Ed. center of Ivan Franko LNU, 2009. – 359 p. [in Ukrainian]
2. *Hudz S. P., Hnatush S. O., Bilinska I. S.* Microbiology: practice, tests. – Ed. center of Ivan Franko LNU, 2012. – 228 p. [in Ukrainian]
3. *Yavorska H. V., Hudz S. P., Hnatush S. O.* Industrial microbiology. Ed. center of Ivan Franko LNU, 2009. – 253 p. [in Ukrainian]
4. *Hudz S. P., Hnatush S. O., Bilinska I. S.* Practice in Microbiology. – Lviv: Ed. center of Ivan Franko LNU, 2003. – 77 p. [in Ukrainian]
5. *Pyroh T. P.* General microbiology: a handbook. – K.: NUKhT, 2004. – 471 p. [in Ukrainian]
6. *Serhiichuk M. H., Pozur V. K., Vinnikov A. I., Furzikova T. M., Zhdanova N. M., Dombrovska I. V., Shvets Y. V.* Microbiology. – Kyiv VPC University, 2005. – 375 p. [in Ukrainian]
7. *Borisov L. B.* Medical microbiology, virology and immunology. – M.: Med. Infom. Agency ltd, 2002. 736 p. [in Russian]
8. *Bergey's manual on systematic bacteriology* / ed. by J. Hoult, R. Krig, P. Snit et al. – M.: Mir, 1997. – V. 1–2. [in Russian]
9. *Modern microbiology: prokaryotes: in 2 vol.* / ed. by J Lengeler, G. Drevs, G. Shlegel. – M.: Mir, 2005. – V. 1. – 656 p., V. 2. – 496 p. [in Russian]

#### Additional

1. *Vozianova Zh. I.* Infectious and parasitary diseases: in 3 vol. – K.: Zdorovia, 2002, 2003. [in Ukrainian]
2. *Serhiichuk M. H.* Structure of bacterial cell and methods of its research. – K.: phytosociocenter, 2001. – 232 p. [in Ukrainian]
3. *Shlehel G.* History of microbial,ogy. – M.: Mir, 2002. – 302 p. [in Russian]

### 4. Form of the final control of the success of education

Final control – exam.

### 5. Methods of control

Control of students' knowledge is performed by the 100-point scale.

The highest number of points during the control of students' skills on the discipline with exam is 50 points for the current progress and 50 points during the exam.



**Scale: of the instiotution, national and ECTS**

ECTS	Points	National scale	
A	90 – 100	5	Excellent
B	81-89	4	Good
C	71-80		
D	61-70	3	Satisfactory
E	51-60		
FX	21–50		Not satisfactory
F	0–20		

Author \_\_\_\_\_(Hnatush S. O.)