



**NATIONAL UNIVERSITY OF LIFE AND
ENVIROMENTAL SCIENSES OF UKRAINE**

Department of General Ecology, Radiobiology and Life Safety

“CONFIRMED”
Dean of Faculty of Plant Protection,
Biotechnology and Ecology

Julija KOLOMIJETS
«18» May 2023, protocol № 9

“APPROVED”
at the meeting of the department of General Ecology
Radiobiology and Life Safety
Protocol № 9 dated «19» 04 2023
Head of Department

Alla KLEPKO

“REVIEWED”
Program Coordinator of
educational-professional program «Ecology»
Program Coordinator

Volodymyr BOGOLJUBOV

CURRICULUM WORKING PROGRAM

“RADIOBIOLOGY AND RADIOECOLOGY”

Specialty:	162 - Biotechnology and bioengineering
Educational program:	«Biotechnology and bioengineering»
Faculty:	Plant protection, biotechnology and ecology
Developers:	Volodymyr Illienko , PhD in Biology, senior lecturer of General Ecology, Radiobiology and Life Safety Department
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1. Description of academic discipline

Radiobiology and Radioecology

(name)

Direction, speciality, educational program and qualification level		
Educational and qualification level	<i>Bachelor</i>	
Speciality	<i>162 - Biotechnology and bioengineering</i>	
Educational program	<i>" Biotechnology and bioengineering"</i>	
Characteristics of academic discipline		
Mode	Selective	
Total number of hours	120	
Number of credits ECTS	4	
Number of meaningful modules	2	
Form of control	<i>exam</i>	
Indicators of academic discipline for full-time and part-time forms of education		
	full-time education	part-time education
Year of study (course)	3	-
Semester	6	-
Lectures	<i>15 hours</i>	<i>- hours</i>
Practical and seminar lessons	<i>15 hours</i>	<i>- hours</i>
Laboratory practical	<i>- hours</i>	<i>- hours</i>
Self-dependent work	<i>90 hours</i>	<i>- hours</i>
Individual work	<i>- hours</i>	<i>hours</i>
Week hours for full-time education	<i>2 hours</i>	

2. PURPOSE AND OBJECTIVE OF THE DISCIPLINE

Radiobiology, or radiation biology, is a science about effects of ionizing radiations on living organisms and their groups.

During the last decades in a radiobiology next to such traditional directions as a medical radiobiology, animal radiobiology, plant radiobiology, agricultural radiobiology, radiation ecology, et al some new directions was expressly selected. They are molecular radiobiology, radiation biochemistry, radiation cytology, radiation genetics. That means that the objects of study of radiobiology are not only living organisms and their groups, but also molecules, cells and cell populations, separate processes of metabolism. And *new determination of radiobiology* appears. Now it is *the science about effects of ionizing radiations on the living systems of all of levels of organization*. This formulation is not alternative to the first are they both correct.

A basic task of radiobiology is a study of mechanism of effects of ionizing radiations on a living organism with the purpose of search of possibilities of management organisms reactions on this factor, mainly, diminishing of harmful effects. Main tasks of agricultural radiobiology as a direction which is accented in agrarian educational establishments, are: study of sensitiveness of agricultural plants and animals to the ionizing radiations, development of facilities of their protecting from a radiation defeat, search of ways of the use of ionizing radiations for an agricultural production, research of ways of migration and biological effects of the radionuclides incorporated plants and animals. However, the last task is basic for the separate section of radiobiology - radioecology.

Radioecology, or radiation ecology, is the section of radiobiology, which arose up on the joint of it with ecology. *Radioecology studies concentrations and migration of radionuclides in the environment and ionizing radiation influence on living organisms and their groups.*

Basic tasks of radioecology are: discovery of territories, contaminated by radionuclides, and determination of their concentrations; a study of migration of radionuclides in the objects of environment and ways, which they get in plants, organism of animals and man; a study of biological effects of incorporated ionizing

radioactive elements radiations on living organisms; elaboration of bases of the rational use of territories contaminated by radionuclides, in particular case agricultural lands, taking into account the specific of contamination and ground-climatic terms of regions; research of other anthropogenic factors influence which are introduced into agrosystem (ameliorator, mineral and organic fertilizers, physiological active matters, heavy metals, acid rains et al), on passing of radionuclides to the products of agricultural production, food stuffs et al; development of the scientifically grounded system of separate branches conduction which provide the permanent diminishing of level of radiocontaminant of this products.

A primary aim of these tasks is diminishing of radionuclides receipt to the organism of man by a food chain soil-plants-animals- plant-grower and animal production-man by interrupting or abatement of ecological connections on any area of this chain and decline of dose of internal radiation.

Program of course «Radiobiology and radioecology» foresees the deep study of sections of common radiobiology, including plant, animal, man, radiobiology especially related to antirad action protecting of products of agriculture from a radiocontaminant, to radiation safety in separate industries of production. Part, related to the study of radioecology is given in more generalized kind, taking into account that in subsequent students will study a separate course «Agricultural radioecology».

Primary purpose of study of discipline “Radiobiology and radioecology» is a capture thorough knowledge about influence of ionizing radiations on living organisms, mastering of the applied aspects of specialty, related to radiation safety, and also practical application of knowledge, for the solving of research and applied tasks.

As a result of radiobiology study student are:

to know: sources of ionizing radiations in the environment, mechanisms of radiations influence on living organisms, radiosensitivity of basic types of plants and animals, principles of defense of living organisms, from radiations, ways of ionizing radiations use in different spheres production, including agrarian production, theoretical bases of radionuclides application in scientific researches.

To be able: to estimate a radiation situation by the dosimetric devices of the different systems, to develop the system of radioprotective measures of radionuclides radiation defeat and contamination warning of agrocenosis, to apply radionuclides in scientific researches.

A student are to master:

1) general information about physical nature, ionization of matter under influence of physical factors, nature of corpuscular and electromagnetic radiations which are studied in the courses of «Physics» and „Biophysics”;

2) chemical elements and their basic isotopes, including radioactive, types of their co-operation one with other, compounds which appear here, that studied are in courses «General chemistry» and other chemical disciplines;

3) bases of ecology, especially sections about migration of anthropogenic origin pollutants in the objects of environment and agriculture, which are studied in courses «General ecology», «Agroecology» and other ecological disciplines;

4) systems of tillage, methods of growing and storage of agricultural cultures, basis of stock-raising, geneticists, which are studied in courses «Agriculture», „Plant-growing”, „Soil Science”, „Agricultural Chemistry”; «Bases of stock-raising», «Genetics».

Acquisition of competences as a result of studying the discipline:

general competences (CG):

ZK5. Ability to learn and master modern knowledge.

ZK 6. Skills of performing safe activities.

ZK7. The desire to preserve the environment.

ZK9. The ability to preserve and multiply moral, cultural, scientific values and achievements of society based on understanding the history and patterns of development of the subject area, its place in the general system of knowledge about nature and society and in the development of society, technology and technologies, to use various types and forms of motor activity for active recreation and leading a healthy lifestyle.

Program learning outcomes (PRN):

PRN22. Be able to take into account social, ecological, ethical, economic aspects, requirements of labor protection, industrial sanitation and fire safety during the formation of technical solutions. To be able to use different types and forms of motor activity for active recreation and leading a healthy lifestyle.

3. DISCIPLINE CONTENT AND TYPES OF EDUCATIONAL WORK
4. CONTENTS OF DISCIPLINE MODULES AND TYPES TO WORK

№	Topic	The topic content, recommended literature	Types of educational activity, hours.		
			lectures	practical work	independent work

Module 1. Introduction. Physical basics of radiobiology and radioecology

1.1.	Introduction to radiobiology. History	Definition of radiobiology (radiation biology) and radioecology (radiation ecology). Radioecology as a component of radiobiology. Radiobiology objects of studying. Organizational structure of radiobiology. A place of radiobiology among the allied science. Directions of radiobiology development. Tasks of radiobiology and radioecology. History of radiobiology and radioecology development. A role of achievements of nuclear physics is at the end of a 19 th century in an origin and development of radiobiology. Stages of radiobiology and radioecology development. Development of radiobiology and radioecology in Ukraine. Modern problems of radiobiology and radioecology: specific of influence on the living organisms of small doses of ionizing radiations, features of influence on the living organisms of chronic irradiation, prophylaxis and therapy of sharp and chronic radiation defeats, radiation dysimmunity, remote consequences of irradiation, general influence on the organism of ionizing radiations and other factors, migration of natural and artificial radionuclides in the objects of environment, features of influence on the organism of the incorporated radionuclides, in plants, organisms of animals and man, blocking of receipt of radionuclides, in plants, organism of animals and man, leading out of radionuclide from an organism. Theoretical and practical value of radiobiology. Necessity of wide propaganda of radiobiological knowledge.	1	2	10
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Literature: 1, 8-12

1.2 Physical basics of radiobiology	Phenomenon of radioactivity. Law of radioactive decay. Nature atoms and molecules of matter ionization. Definition of concept of ionizing radiations. Types of ionizing radiations: electromagnetic and corpuscular radiation. Types of electromagnetic ionizing radiations: x-ray photography, gamma- and slowing-down radiation. Physical descriptions of basic types of radiations: alpha -, beta-, proton and neutron radiations. Exposure, absorbed and equivalent doses of ionizing radiations. Power of dose. Types of irradiation depending on power of dose, factor of time and multiplicity of irradiation: sharp and prolonged (chronic), non-permanent and frequent (fractionating). Units of radioactivity and doses of ionizing radiations. Connection between radioactivity of matter and dose ionizing a radiation.	2	2	12
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Literature: 1, 2, 4, 8-11, 23

1.3 Sources of radioactive substances and ionizing radiation	Natural and artificial sources of ionizing radiations. Natural ionizing radiation. Space radiation and radiation of natural radioactive elements. Sun and galactic radiation. Radiation of radioactive elements from families of uranium, actinouranium and thorium. Payment of radiation of radon. Radiation of non-family natural radionuclides. Payment of radiation radioactive calcium. Radiation of cosmogenic radioactive elements. Radioactive hydrogen and carbon. Natural radiation background. Estimations of doses of irradiation of living organisms, predefined a natural ionizing radiation. The possible value of natural radiation in the processes of vital functions of organisms. Ionizing a radiation from artificial radionuclides. Sources of artificial radionuclides in environment. Radiation from radionuclides which appear as a result of tests of nuclear-powered weapon. «Global» nuclear fall-outs. Radiation of radionuclides which enter environment from the enterprises of nuclear energy. Radiation from sources which are used in medicine and everyday life.	2	2	10
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Literature: 1, 3, 4, 7, 8, 10-13

1.4	Physical bases of interaction of ionizing radiations with substances of cells of living organisms	Energy transfer of ionizing radiation to atoms and molecules. Ionization and excitation of atoms and molecules. Secondary electrons and their participation in the ionization and excitation of atoms and molecules. The main processes that occur during the interaction of electromagnetic ionizing radiation with matter: the photoeffect, the Compton effect, the birth of ion pairs. Features of interaction of corpuscular ionizing radiation with matter: role of mass, charge, energy. Penetrating ability of ionizing radiation. Liquid and densely ionizing radiation. Linear energy loss (LVE) of ionizing radiation. LVE and track structure. Bragg curve. Relative biological efficiency (VBE) and ionization radiation quality factor. LVE and VBE connection. Features of neutron interaction with matter. Direct and indirect effects of ionizing radiation on molecules. The essence of the target theory. The target of ionizing radiation is DNA and DNA membrane complex. Ionized atoms and molecules and the free radical state of molecules. Quantitative characteristics of radiation-chemical reactions. Radiation and chemical transformations of water. Participation of oxygen in radiation-chemical transformations of water. Radiation and chemical damage to nucleic acids. Changes in the structure of chromatin under the influence of ionizing radiation. Radiation-chemical transformations of protein molecules. Radiation chemistry of amino acids. Lipid conversion under the influence of ionizing radiation. Free radical states of lipid molecules and lipid chain oxidation. Radiation and chemical reactions of carbohydrates. Radiation damage to membranes. Hypothesis of enzyme release. Influence of radiation on separate metabolic systems: synthesis of DNA and RNA, proteins, lipids, photosynthesis, respiration, synthesis of hormones, mineral and water metabolism and others. Toxic products of radiolysis of organic compounds. Hypothesis of "radiotoxins". Structural and metabolic hypothesis of biological action of ionizing radiation.	2	2	12
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Literature: 1, 3, 8, 10-13

Module 2. Effect of ionizing radiation on living organisms and production on radionuclide-contaminated areas

2.1	Biological effects of ionizing radiation on plants and animals	Concept of radiobiology effect. Classification of radiobiology effects. Somatic and genetic radiobiology effects. Essence of radiation stimulation. Radiation stimulation of plants and animals. Basic types of morphological changes of organs of plants under ionizing radiations influence. Animal morphological changes. Essence of teratogenic influence of ionizing radiations. Concept of radiation chimera. Carcinogenic influence of radiations. Mechanisms of morphological origin changes at the influence of ionizing radiations. Radiation illness of plants. Kinds and degrees of mammal's radiation illness. Influence of ionizing radiations is on the acceleration of senescence and life-span. Death of organisms is at the high doses of irradiation. «Death under a ray». Specific of plants radiation death. «Gamma-germs». Features of ionizing radiation influence on the forest planting. Reactions of trees on an irradiation. Unspecificity of types of mutations which arise up at the influence of ionizing radiations. Thresholdless and threshold conceptions of ionizing radiation influence. Thresholdless character of carcinogenic and genetic influence of ionizing radiations. Close and remote effects of ionizing radiations . Stochastic character of remote consequences of radiation defeat. Features of influence of small doses of ionizing radiations on living organisms: stimulative, antiimmune, carcinogenic, genetic effects. Biological effects of radiotelemetrings.	2	2	10
<i>Literature: 1, 3, 9-12, 24</i>					
2.2	Radiation protection and radiosensitization	The phenomena of antagonism and synergism are at the general influence on the living organisms of ionizing radiations and other factors. Concept of modification of radiation defeat of organism. Antirad biological defense and sensibilization of radiation defeat. Physical antirad and radiosensibilization factors: composition of atmosphere, temperature, humidity, light et al. Oxygen effect. Quantitative description of oxygen effect is an oxygen amplification	2	2	12

factor (K_{OA}). Chemical radioprotective matters and radiosensitizers. Determination of radioprotectors, radioblocators and radiodcopyrants concepts. The basic requirements to a description of radioprotective matters. Factor of changing dose (FCD) and its definition Quantitative descriptions of antirad influence. Basic classes of radioprotectors. Natural and artificial radioprotectors. Native radioprotectors of cells. Antioxidants as radioprotectors. Radioprotectors of the prolonged action. Mechanisms of action of radioprotectors: induction of the hypoxic state, «interception» of the free radicals states, formation of mixed disulfides, hypothesis of «biochemical shock». Chemical radiosensibilization matters. Mechanisms of influence of radiosensibilizers.

Literature: 1, 7-12, 19

2.3	Migration of radionuclides in the environment and objects of agriculture	of General ways of migration of radionuclides in the objects of environment and agriculture. Trophic, or food, chain. Sources of receipt of radionuclides in atmosphere. Ways of receipt of radionuclides in soil. A role of physical and chemical and agricultural chemistry properties of radionuclides in their migration in soil. Vertical and horizontal migration. Influence of weather-climatic terms on migration of radionuclides in soil.	2	2	12
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Literature: 1-3, 7, 10, 13, 17

2.4	Measures to reduce the accumulation of radionuclides into crop and livestock products	to Basic principles of receptions application on transition of radionuclides diminishing from soil in agricultural plants. Generally accepted and special receptions of soil tilling, which reduce entering of radionuclides plants: cultivating and ploughing, deep ploughing, is by a trencher plough, removal of epiphase of soil, filing up of muddy layer by clean soil. Agricultural chemistry facilities of diminishing of receipt of radionuclides to plants: liming and gypsuming, application of megascopic norms of phosphoric and potassium fertilizers, use of oligoelements, organic fertilizers. Selection of agricultural cultures, as a measure on diminishing of maintenance of radionuclides in plants. A management of	2	1	12
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irrigation regime is an effective measure of decline of receipt of radionuclides in agricultural cultures. Application of the special chemical matters and connections is for diminishing of piling up of radionuclides in plants. Phytodezactivation of soils. Land-of radionuclides contaminated meadows and pastures as a mean of diminishing of maintenance of radionuclides in sterns. Aerophare control of forages and products of stock-raising. Influence of changing of the regim of feeding and will make rations, to maintenance in the ration of alkali-earth elements and other factors on the transition of radionuclides from forages to milk, meat, eggs and other products of stock-raising. tothe rations of mineral additions and preparations which prevent the transition of radionuclides from forages to the organism of animals and acceleration of their leadingout. Radioblocators and radiodecorporants. Organizational measures. Cleaning of products of plant-grower from radionuclides washing off external contamination, receipt of oil, exception of carbonhydratess, receipt of alcohol, receipt of forage and food albumen, cleaning of grain, exception of pharmacological, bioactive and other connection, culinary treatment. Cleaning of products of stock-raising is from radionuclides: processing of milk, washing of milk products, cleaning of milk, by ion-exchanging connections and electrodialysis, culinary treatment of meat, fat and other products. Coefficient of cleaning of products.

Literature: 1, 7, 9-12

Total:

15

15

90

5. STUDENT RATINGS

5.1 Criteria for calculating the maximum number of points in conditions of rating by hours:

Lectures - for each hour of listened and recapitulated lecture – 1 point.

Practical works - for every hour of completed and assigned task of practical classes - 1 point.

Independent work - for every hour of self-prepared and assigned task - 0.5 points.

Rating (maximum) of the student by modules considering hours as a criterion

Module	R _{e.w.}	Credits	Lectures	Practical works	Independent work	Total
1	M ₁	1.5	7 · 1 = 7	8 · 1 = 8	30 · 0.5 = 15	30
2	M ₂	1.5	8 · 1 = 8	7 · 1 = 7	30 · 0.5 = 15	30
	Total	3.0	15	15	30	60

Rating of educational work **R_{e.w.}** = 70 %, and rating of exam **R_{exam}** = 30 % from the total number of points (according to the Regulations).

In case of 100% mastering of discipline the student can get **R_{e.w.}** - 42 points, and **R_{exam}** - 18 points.

5.2 Rating of attestation for discipline

National score	ECTS	Definition ECTS	R _{dis.} , points	R _{dis.} , actual points for discipline
Excellent	A	Excellent - perfectly performance, with only a small number of errors.	$(0.9 - 1.0) \cdot R_{dis.}$	54 – 60
Good	B	Very good - above average level with several mistakes	$(0.82 - 0.89) \cdot R_{dis.}$	49 – 53
	C	Good - generally correct with some mistakes	$(0.75 - 0.82) \cdot R_{dis.}$	45 – 48

Satisfactory	D	Satisfactory - not bad, but with a significant number of shortcomings	$(0.66 - 0.74) \cdot R_{\text{dis.}}$	40 - 44
	E	Enough - execution satisfies the minimum criteria	$(0.60 - 0.65) \cdot R_{\text{dis.}}$	36 - 39
Unsatisfactory	FX	Unsatisfactory - you need to work before getting a score (positive rating)	$(0.35 - 0.59) \cdot R_{\text{dis.}}$	21 - 35
	F	Unsatisfactory - serious further work is needed	$(0.01 - 0.34) \cdot R_{\text{dis.}}$	1 - 20

5.3 Discipline rating

$$R_{\text{dis.}} = R_{\text{e.w.}} + R_{\text{exam}} + R_{\text{add.w.}} - R_{\text{penal}}$$

Assume that the student scored only 45 points, which is 75% of 3.0 credits or $R_{\text{dis.}}$ of student is 2.25 credit.

6. EXAMPLE OF CONTROL TASKS

National University of Life and Environmental Sciences of Ukraine			
Bachelor 3rd year study Specialty 162 - Biotechnology and Bioengineering	General Ecology, Radiobiology and Life Safety Department 2020/2021 study year	Test № 1 from the course Radiobiology and Radioecology	Approved Head of department
Questions			
1. Factors affecting the migration of radionuclides in the atmosphere.			
2. Definition of oxygen effect concept.			
Tests			
1.	Water has _____ action a) Radiosensitizing; b) Radioprotective; c) Both; d) There is no correct answer		
2.	What element has an antagonist with Cs? a) Sr; b) Ca; c) K; d) Pb		
3.	What phase of cell cycle is the most radiosensitive? a) S; b) G ₁ ; c) M; d) G ₂		
4.	Arrange the correct links on types of radionuclides distribution in animals (few radionuclide can respond to one type)		
	1	bone	a
	2	diffuse	b
	3	reticuloendothelial	c
			d
			e
5.	Critical tissue in plants are: a) phloem; b) xylem; c) meristem; d) parenchyma		
6.	Which of the natural potassium isotopes is radioactive? a) ³⁹ K; b) ⁴⁰ K; c) ⁴¹ K; d) ⁴² K		
7.	Among vertebrate animals, the highest radioresistance have: a) fishes; b) birds; c) mammals; d) reptile		
8.	A critical organ to ¹⁴ C is: a) eye lens; b) bone tissue; c) spleen; d) fatty tissue		
9.	To construct the survival curve is carried out: a) experiments in vacuum conditions; b) experiments on the neutralization of ionizing radiation; c) experiments with irradiation in different doses; d) experiments on irradiation in stimulating doses		
10.	What statements are correct for α-particles:		

a) Have '2-' charge; b) Consists of 2 protons and 2 neutrons; c) Is a nuclei of helium d) Is the most harmful for organism
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7. RECOMMENDED LITERATURE

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4. Climate change and nuclear power. International Atomic Energy Agency, VIENNA, 2005, 112 p.
5. Natural and induced radioactivity in food. International Atomic Energy Agency, VIENNA, 2002, 136 p.
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18. Паренюк О.Ю., Ілленко В.В., Гудков І.М. Мікрофлора забруднених радіонуклідами ґрунтів. – К.: Вид-во НУБіП України, 2018. – 198 с.

19. Бондар О.І., Фещенко В.П., Гудков І.М., Гуреля В.В. Радіоекологічний термінологічний словник (україно-англійсько-російський). – Житомир: ПП Експертний центр Укреколбіокон, 2018. – 254 с.
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