



Controlled synthesis of metabolites

Work program of the discipline (Syllabus)

Details of the discipline

Level of higher education	<i>Third (educational and scientific)</i>
Branch of knowledge	<i>16 «Chemical and bioengineering»</i>
Specialty	<i>162 – Biotechnology and bioengineering</i>
Educational program	<i>Biotechnology</i>
Discipline status	<i>Selective</i>
Form of study	<i>part-time</i>
Year of preparation, semester	<i>2nd year, spring semester</i>
The scope of discipline	<i>5 ECTS credits</i>
Semester control / control measures	<i>Exam / CW</i>
Schedule	<i>Lectures: 6 hour / 2 hour / week according to the schedule</i>
Language	<i>English</i>
Information about course head / teachers	<i>Lecturer: Doctor of Biology Sciences, prof. Galkin Olexandr Yurievich alexftb@gmail.com; (Telegram)</i> <i>Practice: Doctor of Biology Sciences, prof. Galkin Olexandr Yurievich</i>
Course placement	Google classroom. https://www.sikorsky-distance.org/g-suite-for-education/%D1%84%D0%B1%D1%82/ Code xcefsi

Curriculum of the discipline

1. Description of the discipline, its purpose, subject of study and learning outcomes

The relevance of the discipline "Controlled synthesis of metabolites" is the ability to create specified products as a result of changes in the metabolism of microorganisms under the influence of physical and chemical environmental factors, which will allow the introduction of new effective biotechnologies or improve existing ones. This approach will build the graduate student's ability to solve complex problems in the field of biotechnology and bioengineering, perform original research, generate new ideas, critically evaluate the results, leading to the development of new and improvement of existing biotechnologies. This discipline should acquaint the student with the basics of the action of physical and chemical environmental factors on cell metabolism, modern approaches to obtaining the target product, to promote the formation of a scientific worldview.

The aim of the discipline is to form students' abilities to: solve complex problems in the field of biotechnology and bioengineering, which involves a deep rethinking of existing and creation of new holistic knowledge and professional practice based on analysis of ways to change the metabolism of microorganisms for increased biosynthesis of certain substances; perform original research, achieve scientific results that create new knowledge in the field of biotechnology and bioengineering and related interdisciplinary areas; develop new and improve existing biotechnologies based on an understanding of modern scientific facts, concepts, theories, principles and methods used in biotechnology and bioengineering and natural sciences.

The main tasks of the discipline -

selection of methods, techniques and equipment for the cultivation of microorganisms in order to obtain new target products or increase the yield of existing technologies. According to the

requirements of the curriculum, students after mastering the credit module must demonstrate the following learning outcomes:

Knowledge:

- the action of chemical and physical factors used to change the metabolism in cells and leads to the formation of new products of biosynthesis and increase the content of metabolites in cells and extracellular;
- mechanisms of formation of metabolites in cells;
- methods of analysis of the target product (on the example of the components of the lipid fraction);

Skills:

- choose the most suitable object for research and production in the field of biotechnology;
- use modern approaches to regulate biochemical processes and improve biological agents;
- carry out laboratory and production procedures with biological objects;
- apply modern physical methods of influencing the metabolism of microorganisms; to carry out the analysis of the received target products;
- to develop new and improve existing biotechnologies for obtaining products for various purposes and environmental biotechnologies.

2. Prerequisites and postrequisites of the discipline (place in the structural and logical scheme of education according to the relevant educational program)

It is based on the knowledge received by students at studying of disciplines: Biochemistry, Biophysics, General biotechnology, Biochemical and physical methods of the analysis in biotechnology, Integration and differentiation of modern scientific knowledge in biotechnology; Problematic issues of ecobiotechnology and bioenergy and foreign language skills not lower than A2 level and information technology at the user level.

It is used in the development of technological solutions to increase product yield or create a new type of product, to increase the efficiency of processing of various types of waste, as well as in the performance of research work in research institutions, laboratories and research institutes.

4. The content of the discipline

Section 1. Influence of nutrients on the development of microorganisms

Topic 1.1. The use of microorganisms in industries. Consideration of the specifics of approaches to the use of microorganisms for the biosynthesis of the target product and processing of waste of different origins. The effect of inhibitors on cell development.

Topic 1.2. Biologically active substances produced by microorganisms. Proteins, vitamins, hormones, lipids, carbohydrates, biologically active substances, etc.

Section 2. The effect of nutrients on the metabolism of microorganisms

Topic 1. Changes in the metabolism of cells of microorganisms under the influence of chemical factors. Relationship of nutrients with metabolic processes in microorganisms of different classes. The influence of the source of carbon, nitrogen, iron and other elements on the yield of the desired product. Change in cell metabolism under the simultaneous action of elevated concentrations of elements. The action of mutagenic compounds to obtain overproduces.

Section 3. The effect of physical factors on the development of microalgae

Topic 1. Changes in the metabolism of microalgae cells under the influence of physical factors. The effect of irradiation with different wavelengths, lighting, temperature on the growth of biomass and biosynthesis of lipids, fatty acids, carotenoids, chlorophylls, vitamins, carbohydrates in microalgae and increase the efficiency of waste processing of different origins. The combined effect of physical and chemical factors on changes in cell metabolism.

4. Training materials and resources

Recommended Books

Basic

1. Sandeep Telkar, M. Nalina, H. T. Sowmya, Prakash M. Navale Basic Concept of Biotechnology https://www.researchgate.net/publication/271908784_Basic_Concept_of_Biotechnology
2. A Closer Look at Biodiesel Production, Chapter 3 *The Influence of Raw Material on Biodiesel Production* / L.L. Diaz-munoz, H.E. Reynel-Avila, D.I. Mendoza-Castillo, A. Bonilla-Petriciolet/ Series: Renewable Energy: Research, Development and Policies, Nova science publishing. – 2019. 317 p.
3. Physical Factors' Influence on Chlorella vulgaris Microalgae Development and Lipid Biosynthesis/ N.B. Golub, I.I. Levtun //Series: Renewable Energy: Research, Development and Policies, Nova science publishing. – 2019. 317 p.
4. Golub N.B. Impact of sound irradiation on Chlorella vulgaris cell metabolism / N.B. Golub, I.I. Levtun // Eastern-European journal of enterprise technologies. – 2016, – Vol. 80, – № 2. 27–31 p.
5. Kong W. The characteristics of biomass production, lipid accumulation and chlorophyll biosynthesis of *Chlorella vulgaris* under mixotrophic cultivation / W. Kong, H. Song, Y. Cao, H. Yan [at al.] // African J. Biotechnol. – 2011. – V. 10. – № 55. – P. 11620 – 11630.

Additional

1. Ameyalli M Rodríguez-Cano. / Ameyalli M Rodríguez-Cano, Claudia C Calzada-Mendoza, Guadalupe Estrada-Gutierrez, Jonatan A Mendoza-Ortega, Otilia Perichart-Perera// Nutrients 2020. – 2020. 12(7). 2166 p.
2. Scott Hayes. Interaction of Light and Temperature Signalling in Plants / Scott Hayes // John Wiley & Sons, Inc. eLS. – 2020. 1-8 p.
3. Golub N.B. Influence of light energy wavelength on cultivation of Chlorella vulgaris / N.B. Golub, I.I. Levtun // Вісник Національного університету «Львівська політехніка», серія «Хімія, технологія речовин та їх застосування». –2016. – Вип. 841. 138–144 p.

Informational resources

1. <https://www.pharmencyclopedia.com.ua>
2. <https://dspace.ltsu.org/bitstream/123456789/3126/2/Matsayi.pdf>
3. <https://nuczu.edu.ua/sciencearchive/Articles/gornostal/vajinskii%20posibnyk.pdf>
4. r.nmu.org.ua/bitstream/handle/123456789/2622/HTБ453689.pdf
5. <https://nmcbook.com.ua/Arhiw1/atlasrosl/Biotehnologia.pdf>

Educational content

5. Methods of mastering the discipline (educational component)

Lectures

Strategies for active and collective learning are used, which are determined by the following methods and technologies: problem-based learning methods (problem-based presentation, part-search (heuristic conversation); information and communication technologies that provide problem-based research and activation of students' independent work) for lectures, use of audio, video support of educational classes, development and application on the basis of computer and multimedia means of creative tasks, etc.).

No	The title of the lecture topic and a list of key issues
1	Lecture 1. <u>The specifics of the use of microorganisms for the biosynthesis of the target product and the processing of waste of various origins.</u> Tasks that are set to increase the yield of a product with specified properties. Obtaining the target product using strains of microorganisms. Obtaining the target product using associations of microorganisms.

	Influence of power supply on the use of a biological object. The effect of inhibitors on cell development. <i>References: [1]</i>
2	Lecture 2. Influence of light and temperature on cell metabolism. Dependence of biomass yield and biosynthesis of organic compounds depending on light intensity. Influence of the wavelength spectrum of the visible range on the production of organic compounds by microorganisms. Biosynthesis of chlorophylls and carotenoids depending on the combination of light diodes. Changes in the metabolism of different classes of microorganisms depending on temperature conditions. The yield of metabolic products depending on the cultivation temperature, which differs from the optimal conditions. <i>References: [3]</i>
3	Lecture 3. Influence of irradiation on the development of microorganisms and production of the target product. The effect of ultrasonic radiation on the development of microalgae cells, the yield of the lipid fraction and the component composition of fatty acids. Influence of sound irradiation on the growth of microalgae. Changing the efficiency of waste processing processes when irradiating the association of microorganisms. <i>References: [3]</i>

Seminars

1. *The main objectives of the series of seminars on the subject "Controlled synthesis of metabolites" is the formation of students' ability to choose the most suitable for research and production in the field of biotechnology object; use modern approaches to improve biological agents and regulate biochemical processes; carry out laboratory and production procedures with biological objects;*

Strategies of active and collective learning are applied, which are determined by the following methods and technologies: personality-oriented (developing) technologies based on active forms and methods of learning (discussion, express conference, educational debates, application of creative tasks based on computer and multimedia means.)

No	Topic of the lesson
1	Mechanisms to increase product yield. The effect of simultaneous action of altered concentrations of batteries on product yield. Influence of the increased concentration of one element on receipt of another. Techniques used. Consideration of postgraduate students' proposals on mechanisms to increase the yield of products under study <i>References: [2,5]</i>

6. Individual work of a graduate student

The graduate student's independent work in the discipline includes preparation for classroom classes (6 hours), control (4 hours), preparation for the exam (30 hours) and independent study of certain topics, the list of which is given below (110 hours).

No	Names of topics and questions submitted for self-study and references to educational literature	Number of hours
1	<u>The use of microorganisms in industries.</u> Biologically active substances produced by microorganisms. Pharmaceutical industry - production of	8

	enzymes, vitamins, antibiotics and other biologically active substances. Food industry - obtaining fragrant substances, producers of necessary products for fermentation, etc., Energy - obtaining methane, hydrogen, biodiesel. Agriculture - obtaining pesticides and herbicides of natural origin. <i>References: [1]</i>	
2	<u>Dependence of the formation of organic compounds on the content and shape of the carbon source.</u> Effect of inorganic and organic substances: glucose, pyruvate, mannose, fructose, glyceryl, ethyl alcohol, etc. on the growth of biomass and component composition of cells. Mixotrophic cultivation. <i>References: [1]</i>	8
3	<u>The relationship of nutrients with metabolic processes in microorganisms of different classes.</u> Changes in cell metabolism under the action of various compounds and nitrogen concentrations. Influence of alkali metal ions on the development of microorganisms. <i>References: [9 chapters 1 and 2, 13 chapters 3]</i>	8
4	<u>The influence of metals on cell development. Dependence of biomass production on the form of compounds and the concentration of iron ions.</u> The relationship between the course of enzymatic reactions and the form and number of iron compounds. Accumulation of metal ions by cells for disease prevention. The influence of some metals on the accumulation of others. <i>References: [10 chapters 1-3]</i>	8
5	<u>Influence of halogens and chalcogens on the development of microorganisms.</u> Change in the metabolism of microorganisms under the action of compounds of non-metallic elements. Influence of concentrations of different elements on assimilation of elements and production of various biologically active substances. <i>References: [11 chapters 2 and 3]</i>	8
6	<u>Obtaining effective producers.</u> The effect of mutagenic inorganic and organic compounds on the production of overproduces. Obtaining genetically modified plants. <i>References: [12 chapters 1 and 2]</i>	8
7	Components of microorganism structures: lipids, fatty acids, carotenoids, chlorophylls, vitamins, carbohydrates. The specific composition of cells depending on the class of microorganisms. <i>Literature: additional literature and information sources from the list</i>	2 4
8	Prepare a proposal for possible methods of obtaining a product in your research work and suggest methods for its analysis. To analyze the disadvantages and advantages of the proposed methods and techniques. Prepare a presentation <i>Literature: additional literature and information sources from the list</i>	14
9	Prepare a proposal for methods to increase product yield in your research paper. Consider the action of inhibitors that may be formed during the	14

	biosynthesis of the product and use as a nutrient medium for waste. Prepare a presentation <i>Literature: additional literature and information sources from the list</i>	
10	Prepare a reasonable mechanism of action of several elements simultaneously with a concentration outside the optimal values to increase the yield of products offered in your research <i>Literature: additional literature and information sources from the list</i>	10
11	Analyze the impact of different forms of carbon supply on the yield of products you get in the work <i>Literature: additional literature and information sources from the list</i>	4
12	Consider the impact of different classes of organic waste on the production of the target product <i>Literature: additional literature and information sources from the list</i>	4
13	Consider the change in the metabolism of the association of microorganisms in the disposal of waste depending on the conditions of the process (change in temperature, pH, mass transfer processes, etc.) <i>Literature: additional literature and information sources from the list</i>	4

Policy and control

7. Course policy (educational component)

Deadline and Recompilation Policy: Entries that fail to meet deadlines without good reason are rated lower. Rearrangement of topics (modules) occurs for good reasons.

The policy and principles of academic integrity are set out in Section 3 of the Code of Honor

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Igor Sikorsky ». Details: <https://kpi.ua/code>. The use of additional sources of information when assessing knowledge is prohibited (including mobile devices). Mobile devices may only be used during online testing and calculations.

Norms of ethical behavior: Norms of ethical behavior of students and employees are defined in section 2 of the Code of Honor of the National Technical University of Ukraine "Kyiv Polytechnic Institute named after Igor Sikorsky". Details: <https://kpi.ua/code>.

Attendance policy: Attendance at lectures, practical classes, as well as absence from them, is not evaluated. However, students are encouraged to attend classes because they teach theoretical material and develop the skills needed to develop the competencies defined by the standard of education. The assessment system is focused on obtaining points for student activity, as well as performing tasks that are able to develop practical skills and abilities. For objective reasons (eg illness, employment, international internship, etc.), training can take place online in consultation with the course head.

8. Types of control and rating system for assessing learning outcomes (RSO)

Current control: survey on the topic of practical training (10 points), CW (20 points), presentation on topics made on the VTS (20 points). The total amount of points for the semester work is 50 points. More detailed information on the current control and evaluation criteria is given in the RSO on the subject. (Appendix 1)

Calendar control: conducted twice a semester as a monitoring of the current state of compliance with the requirements of the syllabus.

Semester control: exam. The total amount of points on the exam is 50 points. More detailed information on the conduct and evaluation is provided in the RSO in the discipline.

Conditions of admission to the semester control: semester rating from 30 to 50 points, writing MCW and presentation on one of the topics made by the VTS.

Appendix 1

Rating system for assessing student performance

in the discipline "Controlled synthesis of metabolites" for the specialty 162 Biotechnology and Bioengineering
Faculty of Biotechnology and Biotechnics
(third level doctor of philosophy, full-time)

Distribution of study time by types of classes and tasks in the discipline according to the working curriculum

Semester	Training time		Distribution of teaching hours				Control measures		
	Credits	Academic hours	Lectures	Seminars	Lab work	VTS	MCW	abstract	Semester control
4	5	150	6	2		114	1		Exam

The student's rating consists of the points he receives for:

1. Answers on the seminar;
2. control work (CW);
3. exam.

System of rating (weight) points of classes and rating assessments by types of control for the year

№	type of control	score	amount	Sum
	Seminars			
	Weight score	10	1	10
	Answer	0-10		
2.	Modular control work			
	Weight score	20	1	20
	Quality**	0-20		
3.	Presentation on VTC topic			
	Quality	0-10		
	Weight score	10	2	20
4	Total			50

*** - Answer at seminars:**

correctly proposed solution and its justification - 10 points;
complete answer to the questions with some shortcomings – 8-9 points;
incomplete answer – 6-7 points;
unsatisfactory answer - 0-5 points.

**** - Quality of performance of modular control works:**

full disclosed answer -19-20 points;
error in one task or incomplete answer in two tasks -16-18 points;
error in two tasks or incomplete answer in 4 tasks - 12-15 points;
work is not credited - 0 - 11 points.

***** Quality of independent work:**

Substantiated proposals -10 points are displayed;
 Some criteria (2) -8-9 points are not taken into account;
 Make mistakes in justification and ignore criteria (3) -6-7 points;
 work is not credited - 0 - 5 points.

Calculation of the rating scale (R)

The sum of weight points of control measures during the semester is:

$R_c = 20 + 20 + 10 = 50$ points:

The examination component of the scale is equal to 50% of R, namely:

$R_e = R_c \cdot 0.5 / 0.5 = 50$;

**The rating scale of the discipline is $R = R_c + R_e$
 100 points;**

A necessary condition for admission to the exam is the enrollment of all presentations of independent work, performance on a positive assessment of the modular test. The starting rating of rc is not less than 60% of Rc, ie 30 points.

Boundary (scheduled certifications). The student must score points: 1 certification - "credited" - 12 points (24 - maximum), 2 certification - 21 points (42 - maximum).

The examination ticket consists of 5 questions, 1 question is estimated at 10 points.

The complete answer to the question - (9-10) points

Minor mistakes were made - (7-8) points

Significant errors in the answer - (6) points

The answers are not correct - (0-5) points.

Total rating:

Rating	ESTS	mark
$95 \leq R < 100$	A	Perfect
$85 \leq R < 95$	B	Good
$75 \leq R < 85$	C	Good
$65 \leq R < 75$	D	Satisfactorily
$60 \leq R < 65$	E	Satisfactorily
$R < 60$	Fx	Non satisfactorily

Exam questions

1. Media for the cultivation of microorganisms, the effect of nutrients on metabolism.
2. The relationship of nutrients with metabolic processes in microorganisms of different classes.
3. The relationship of the form of nutrients with metabolic processes in microorganisms of different classes.
4. Influence of the amount of nutrients (compounds of carbon, phosphorus, nitrogen) on the growth of microorganisms.
5. Change in metabolism when changing the nutrient medium.
6. The influence of the amount of nutrients (compounds of trace elements) on the growth of microorganisms.
7. Changes in the metabolism of microorganisms when changing the nutrient medium.
8. The effect of nutrients on the qualitative and quantitative composition of lipids in the microalgae *Chlorella vulgaris*.
9. The effect of nutrients on the yield of metabolites.
10. Increasing the yield of metabolites depending on the form of nutrient compounds.
11. Influence of physical and chemical factors (lighting, temperature, irradiation, pH) on the growth of biomass and changes in algal metabolism.
12. Change in the qualitative and quantitative composition of lipids.
13. Changes in the composition of carotenoids in phototrophic microorganisms under the action of illumination at different wavelengths.
14. Methods of isolation, purification and analysis of lipid fractions from algae (different types of chromatography).
15. Obtaining hydrogen fuel using algae.

16. Conditions of hydrogen production by algae.
17. Methods of increasing hydrogen yield.
18. Methods of obtaining various products (vitamins, antibiotics, etc.) using microalgae.
19. Use of algae in agriculture.
20. The effect of radiation on the metabolism of microorganisms.
21. Methods to increase the yield of the target product.
22. Combination of the action of physical and chemical factors on the metabolism of microorganisms.
23. Analysis of product yield depending on stress.

Work program of the discipline (syllabus):

Compiled by Doctor of Tech. Sciences, Professor of environmental biotechnology and bioenergy
Golub Nataliia Borisovna

Approved by the Department of Environmental biotechnology and bioenergy (Minutes № 12 of
12.06.20)

Approved by the Methodical Commission of the faculty (protocol № 10 from 26.06.20)