MINISTRY OF SCIENCE AND HIGHER EDUCATION OF RUSSIAN FEDERATION
Federal State Autonomous Educational Institution of Higher Education
Far Eastern Federal University
(FEFU)
SCHOOL OF BIOMEDICINE

AGREED
Head of OP
_____
(Signed) (Full name)

CLAIM
Director of the Department of Medical Biology and Biotechnology
_____
(Signed) (Acting Name)
December 30, 2021

WORK PROGRAM OF THE DISCIPLINE
Synergetics
Direction of training 06.04.01 Biology
Educational program in the profile "Molecular and Cell Biology (in English)"

Course 1 semester 2
Lectures – 6 hours
Practical classes – 18 hours.
Seminar classes – not provided
Including with the use of MAE - pr.18 h.
The total hours of classroom load are 36 hours.
Including with the use of MAE 18 hours.
Independent work – 72 hours.
Abstract works are provided
Coursework is not provided
Credit 2 semester

The work program is drawn up in accordance with the requirements of the Federal State Educational Standard in the direction of training 06.04.01 Biology, approved by the order of the Ministry of Education and Science of Russia dated 11.08.2020 No. 934

The work program was discussed at the meeting of the Department of Medical Biology and Biotechnology Protocol dated December 30, 2021 No. 5

Director of the Department of Implementing Structural Unit Ph.D., Associate Professor Kumeiko V.V.

Vladivostok
2021

Reverse side of the RPD cover page

1. The work program was revised at the meeting of the Department / department / department (implementing the discipline) and approved at the meeting of the Department / department / department (issuing structural unit), the protocol from "_____ __ № _____

2.The work program was revised at the meeting of the Department / department / department (implementing the discipline) and approved at the meeting of the Department / department / department (issuing structural unit), the protocol from "__ № _____

3.The work program was revised at the meeting of the Department / Department / Department (implementing the discipline) and approved at the meeting of the Department / Department / Department (issuing structural unit), the protocol from "____ № _____

4.The work program was revised at the meeting of the Department / Department / Department (implementing the discipline) and approved at the meeting of the Department / Department / Department (issuing structural unit), the protocol from "_____ __ № _____

5.The work program was revised at the meeting of the Department / Department / Department (implementing the discipline) and approved at the meeting of the Department / Department / Department (issuing structural unit), the protocol from "_____ __ № _____

Abstract of the work program of the discipline «Synergetics»

The working program of the academic discipline B1.O.02 "Synergetics" is compiled for students in the educational program of the magistracy 06.04.01 Biology "Molecular and cell biology (together with the NSCMB FEB RAS)" in accordance with the requirements of the Federal State Educational Standard in the direction of training 06.04.01 Biology, approved by the order of the Ministry of Education and Science of Russia dated 11.08.2020 No. 934.

Discipline B1.O.02 "Synergetics" is compiled for students in the educational program of the magistracy 06.04.01 Biology, is included in the basic part of the compulsory disciplines of the master's program "Molecular and Cell Biology (together with the NSCMB FEB RAS)".

The total labor intensity of mastering the discipline is 3 credit units (108 hours). The curriculum provides for lectures (18 hours), practical classes (18 hours) and independent work (72 hours). Evaluation of learning outcomes: credit.

The discipline "Synergetics" is a basic biological discipline. Requirements for the "input" knowledge, skills and readiness of the student, necessary when mastering this discipline, include an understanding of all levels of organization and functioning of living systems, from molecular to population, given by a number of previously read disciplines: from biochemistry to ecology inclusive. Basic knowledge of physics, chemistry, mathematics, and computer science is also important for mastering the discipline.

Unlike most other disciplines, Synergetics emphasizes a synthetic rather than an analytical research methodology, describes living systems as complex, emergent, systems, the dynamics of development of which can be understood, considering them as a whole, not reducible to the sum of their constituent components. In addition, this course examines a whole range of open, nonlinear, dynamic self-organizing systems, from physical to social, on the example of which the general principles of self-organization can be traced, it is proved that without a synthetic consideration of such systems as a whole, it is impossible to adequately describe and predict their behavior. This approach is consistent with the understanding of synergetics as an interdisciplinary area of research, and allows us to consider the facts presented in a number of disciplines studied earlier by students from the point of view of a synergetic paradigm, without which it is impossible to describe and model processes in complex multicomponent dynamical systems, such as ecological systems, developing living organisms or cyclic autocatalytic chemical reactions.

The discipline is ideological, generally descriptive in nature, and is not overloaded with a mathematical apparatus, which distinguishes it from similar courses taught in physical and mathematical specialties.

The purpose of the discipline: to acquaint the student with the basic concepts of a synergetic worldview, with the general laws of self-organization of both inanimate and living systems, as well as the basics of the methodology for studying chaos and self-organization in dynamical systems.

Objectives of the discipline:

As a result of mastering the discipline, the student must:

To know:

− the subject, tasks and methods of synergetics, its fundamental sections necessary for a common understanding of the synergetic paradigm;

− the concepts of self-organization and deterministic chaos, including in application to living systems of all levels of organization;

− methodology for the study of self-organizing systems, including the concepts of strange attractors in phase space, catastrophes and the Feigenbaum sequence;

− principles of modeling the dynamics of biosystems;

− basic concepts of fractal geometry;

− connection of fractal geometry with the processes of self-organization;

− the use of fractal geometry in the description of the structure and dynamics of living systems.

can:

− apply knowledge of synergetics to a more in-depth, integrated consideration of general biological and specific issues and challenges related to multicomponent developing systems;

− to see behind the particular laws of individual disciplines the general conceptual phenomena of the development of open, dynamic, evolving systems.

possess:

− methodology of research of open systems, description of them in the language of fractal geometry.

Universal competencies of graduates and indicators of their achievement:

Name of the category (group) of universal competencies	Code and name of the universal competence (the result of mastery)	Code and name of the competency achievement indicator
	UK-1 Is able to carry out critical analysis of problem situations on the basis of a systematic	UK-1.1 Analyzes the problem situation using a systematic approach and modern natural science knowledge, using reliable data and reliable sources of information.

	approach, to develop an action strategy.	UK-1.2 Develops and substantively argues possible strategies for solving the problem situation on the basis of systematic and interdisciplinary approaches, taking into account the parameters of the level of health of the population. UK-1.3 Develops a scenario for the implementation of the optimal strategy for solving a problem situation, taking into account the necessary resources, achievable results, possible risks and consequences.

General professionalcompetencies of graduates and indicators of their achievement:

Name of the category (group) of general professional competencies	Code and name of general professional competence (the result of mastery)	Code and name of the competency achievement indicator
	OPK-1 Is able to use and apply fundamental biological concepts and modern methodological approaches to pose and solve new non-standard tasks in the field of professional activity.	OPK-1.1 Monitors current topical problems, main discoveries and methodological developments in the field of biological and related sciences. OPK-1.2 Analyzes trends in the development of scientific research and practical developments in the selected field of professional activity, formulates innovative proposals for solving non-standard problems, using in-depth general scientific and methodological special training. OPK-1.3 Applies modern methodological approaches and methods for setting and solving new non-standard tasks in the field of professional activity.

Code and name of the competency achievement indicator	**Stages of competence formation**
OPK-1.1 Monitors current topical problems, main discoveries and methodological developments in the field of biological and related sciences.	Knows modern actual problems, discoveries, developments in the field of biology and related sciences Able to find information, analyze, monitor modern topical problems, main discoveries and methodological developments in the field of biological and related sciences Possess the skill of searching for information
OPK-1.2 Analyzes trends in the development of scientific research and practical developments in the selected field of professional	Knows the current trends in the development of scientific research and practical development in his field of knowledge Able to formulate innovative proposals for solving non-standard tasks

activity, formulates innovative proposals for solving non-standard problems, using in-depth general scientific and methodological special training.	Possess the skill of using in-depth general scientific and methodological information, set goals, objectives, interpret the data obtained.
OPK-1.3 Applies modern methodological approaches and methods for setting and solving new non-standard tasks in the field of professional activity.	Knows current problems in his professional activities Able to apply modern methodological approaches and methods for setting and solving new non-standard tasks Possess the skill to solve new non-standard tasks in the field of professional activity

To form the above competencies within the discipline "Synergetics", the following methods of active / interactive learning are used: lecture classes (collective discussion, lecture-conversation) and practical exercises (seminar-discussion).

1. Labor intensity of discipline and types of training sessions in the discipline

The total labor intensity of the discipline is 3 credit units (108 academic hours), (1 credit unit corresponds to 36 academic hours).

Types of training sessions and work of the student in the discipline are:

Designation	Types of training sessions and work of the student
Lek	Lecture
Ave	Practical exercises
WED	Independent work of the student during the period of theoretical training
including control	Independent work of the student and contact work of the student with the teacher during the period of intermediate certification

Structure of the discipline:

The form of training is full-time.

№	Name of the section Discipline	Semester	Number of hours by types of training sessions and work of the student						Intermediate attestation forms
			Lek	Lab	Ave	OK	WED	Control	
1	Medical and geographical analysis of natural landscapes	2	6		6		24		UO-1; PR-6, Pr-12

2	Medical-geographical analysis of natural-anthropogenic complexes	2	6		6		24		UO-1; PR-6, Pr-12
3	Assessment of the quality of the environment according to medical and geographical criteria. Regional health and environmental monitoring	2	6		6		24		UO-1; PR-6, Pr-12
	Total:	2	18	0	18		72		Credit

I. STRUCTURE AND CONTENT OF THE THEORETICAL PART OF THE COURSE

Lectures (18 hours)

Topic 1. Introduction (1 h)

A change in the scientific paradigm over the past two or three decades.

Field of research of nonlinear science and the theory of self-organization (synergetics).

A brief history of the formation and origins of modern nonlinear science:

- from classical to nonlinear thermodynamics;
- from topological theory of features to catastrophe theory;
- From the determinism of Laplace and Einstein to the theory of dynamic (deterministic) chaos.

Topic 2. Deterministic chaos (3 h)

Entropy as a measure of chaos. The Modern Understanding of Chaos.

Order and chaos; determinism and unpredictability.

E. Lorenz (1963): the fundamental impossibility of long-term forecasting.

Strange (chaotic) attractors; trajectories in phase space.

Dynamic chaos and the limits of predictability.

Chaos theory as a modern stochastic theory.

Strange attractors in physical, climatic, astronomical and biological systems.

Transition from an ordered mode to a chaotic one.

Synchronization in Biological Systems: The Transition from Chaos to Orderliness.

Transitional chaos.

Chaos in the physiology and morphology of the body: neural ensembles, ECG.

Adaptability of a partially chaotic mode.

Topic 3. Catastrophe theory (3 h)

Whitney's Theory of Topological Features.

René Thom's Catastrophe Theory.

Popularization of catastrophe theory: I. Stewart, W.I. Arnold.

Disaster as bifurcation.

The area of predictability and unpredictability in bifurcation diagrams.

Different scenarios and modes of bifurcation.

Cascade of bifurcations. Feigenbaum sequence.

The concept of self-organized criticality.

Scenario of doubling the period of the Verhulst process: the transition from an ordered regime to a chaotic one.

Population growth.

Applicability of catastrophe theory to other areas of biology.

Topic 4. Fractal geometry (3 h)

Predecessors of modern fractal geometry: Weierstrass, Hausdorf, Cantor, Julia.

Koch, Sierpiński; the first graphic images of fractals, L-system.

Fractal geometry of B. Mandelbrot; Mandelbrot set, his algorithm; other computer nonlinear fractals.

The main properties of fractals: scale invariance, fractional dimension.

Linear and nonlinear fractals.

Deterministic and chaotic fractals.

Fractal trees (L-systems).

Virtual landscapes.

Physical fractal clusters.

Aggregation model limited by diffusion; its applicability to biological objects.

Topic 5. Quasi-fractality of biosystems (3 h)

Examples of fractal structures in biology; simulation fractal models.

The ratio of orderliness and chaos in the structural organization of biological objects, revealed using fractal models.

Quasi-fractality of biosystem morphology:

- at the subcellular and cellular levels;

- at the organismal level, quasi-fractality of color, structure of organs and body systems;

- At the population level.

Quasi-fractality in the dynamics of the physiology of organisms.

Advantages of quasi-fractal organization.

Topic 6. Theory of self-organization (3 h)

Mathematical proof of spontaneous symmetry breaking and the occurrence of heterogeneity in an initially homogeneous system (Turing).

Nonlinear thermodynamics and dissipative structures: I. Prigogine.

Synergetics (Haken) as an interdisciplinary science of self-organization.

Classic examples of dissipative structures: Benard cells, Belousov-Jabotinsky reaction, laser, aggregation of myxomycetes amoebas, etc.

The concept of emergence.

Prigozhin's Brussels.

Topic 7. Modeling in biology (2 h)

Continuum and discrete models of self-organization, imitation of real processes and structures of inanimate and living nature.

Limited diffusion aggregation model.

Model of cellular automata.

Reaction-diffuse models of self-organization: meinhardt and Walpert models.

Modeling and self-learning of neural networks.

Modeling of the processes of evolution.

II. STRUCTURE AND CONTENT OF THE PRACTICAL PART OF THE COURSE

Practical (seminar) classes (18 h)

Session 1. Change of scientific paradigms (2 h)

1. Content, scope of application and methodology of science of the classical period.
2. Content, scope of application and methodology of science of modern times.
3. Laplace's philosophy and Poincaré's philosophy.
4. Evolutionary principle in science. Time scale.
5. Concept, history and methodology of synergetics

Session 2. Deterministic chaos. Bifurcations and disasters (2 h)

1. Concepts of chaos, order, deterministic chaos.
2. Bifurcation, bifurcation point, 3 types of equilibrium.
3. Feigenbaum sequence.
4. Deterministic chaos in the functioning of living systems.

Session 3. Self-organization (2 h)

1. The concept of self-organization.
2. Phase transitions in static systems.
3. Dynamical systems. Benard cells, laser, Eigen hypercycles.
4. Belousov–Jabotinsky reaction.

5. Self-organization in the development of the body, in the work of organs and systems.

6. Processes of self-organization in biopopulations and in society.

Session 4. Strange attractors (2 h)

1. Methodology of research of chaotic processes.

2. Attractor, strange attractor, phase space, phase trajectories.

3. Topology and studies of the strange attractor.

4. N. Lorenz and his climate model. Lorentz attractor.

5. Strange attractor in the description of physiological processes. Chaos in the norm and pathology.

6. Ennon attractor, Poincaré cross section.

Session 5. Modeling in biology (2 h)

1. Discrete models: DLA model, cellular automata.

2. Continuum models: reactionary-diffuse models, Walpert's "French Flag" model, Meinhard's models.

3. Modeling of self-organization in the morphogenesis of the organism.

4. Modeling of evolution.

5. Artificial neural network, self-learning.

3. Genetic algorithm.

Session 6. Fractal geometry (3 h)

1. Benoît Mandelbrot and Fractal Geometry of Nature.

2. Basic concepts. Definition and properties of fractal.

3. Linear, nonlinear and chaotic fractals. Fractal clusters.

4. Quasi-fractality in inanimate nature.

5. Fractal dimensions.

6. Fractality and processes of self-organization.

Session 7. Fractality of living systems (3 h)

1. Quasi-fractality of subcellular, cellular, organismal organization of living systems.

2. The cell as a fractal cluster. The cell as a percolation cluster.

3. Study of quasi-fractality of morphology on the example of the gastrovascular system of jellyfish.

4. Fractality of sedentary and mobile organisms.

5. Fractality and development of the organism.

6. The main directions and advantages of the use of quasi-fractal structures by living organisms.

7. Study of quasi-fractality in the dynamics of living systems.

Session 8. Final Seminar (2 hours)

At the last seminar, we will discuss the penetration of the synergetic approach into all areas of technology, fundamental science, contemporary art, the transformation of the scientific worldview as a whole. In particular, we will touch upon such issues as modeling evolutionary processes, fuzzy logic, genetic learning algorithms, self-organization of computer networks, self-assembly in nanotechnology, etc. By the seminar, it is necessary to own all the basic synergetic concepts given in this course, to understand the methodology of this science, to understand the principles of self-organization of complex systems.

III. CHEBNO-METHODICAL SUPPORT OF INDEPENDENT WORK OF STUDENTS

Educational and methodological support for the independent work of students in the discipline "Synergetics" is presented in Appendix 1 and includes:

- a schedule for the implementation of independent work in the discipline, including approximate norms of time for each task;
- characteristics of tasks for independent work of students and methodological recommendations for their implementation;
- requirements for the presentation and design of the results of independent work;
- criteria for evaluating the performance of independent work.

Independent work of the student includes:

1) library or homework with educational literature and lecture notes;

2) preparation for testing and control (final) interview;

3) study of the main information sites on the Internet related to the issues of human biology and health.

The order of performing independent work is determined by students themselves, guided by the calendar-thematic plan of the discipline, in which the sequence of lectures, practical classes and tests on the topics of the course is established.

Calendar-thematic plan of the discipline "Synergetics"

Week	Date	Lecture	Practical exercises
1		Topic 1. Introduction (1 h) A change in the scientific paradigm over the past two or three decades. Field of research of nonlinear science and the theory of self-organization (synergetics). A brief history of the formation and origins of modern nonlinear science: - from classical to nonlinear thermodynamics; - from topological theory of features to catastrophe theory;	-

		- From the determinism of Laplace and Einstein to the theory of dynamic (deterministic) chaos.	
2		Topic 2. Deterministic chaos (3 h) Entropy as a measure of chaos. The Modern Understanding of Chaos. Order and chaos; determinism and unpredictability. E. Lorenz (1963): the fundamental impossibility of long-term forecasting. Strange (chaotic) attractors; trajectories in phase space. Dynamic chaos and the limits of predictability. Chaos theory as a modern stochastic theory. Strange attractors in physical, climatic, astronomical and biological systems. Transition from an ordered mode to a chaotic one. Synchronization in Biological Systems: The Transition from Chaos to Orderliness. Transitional chaos. Chaos in the physiology and morphology of the body: neural ensembles, ECG. Adaptability of a partially chaotic mode.	Session 1. Change of scientific paradigms (2 h) 1. Content, scope of application and methodology of science of the classical period. 2. Content, scope of application and methodology of science of modern times. 3. Laplace's philosophy and Poincaré's philosophy. 4. Evolutionary principle in science. Time scale. 5. Concept, history and methodology of synergetics.
3		Topic 3. Catastrophe theory (3 h) Whitney's Theory of Topological Features. René Thom's Catastrophe Theory. Popularization of catastrophe theory: I. Stewart, W.I. Arnold. Disaster as bifurcation. The area of predictability and unpredictability in bifurcation diagrams. Different scenarios and modes of bifurcation. Cascade of bifurcations. Feigenbaum sequence. The concept of self-organized criticality. Scenario of doubling the period of the Verhulst process: the transition from an ordered regime to a chaotic one. Population growth. Applicability of catastrophe theory to other areas of biology.	Session 2. Deterministic chaos. Bifurcations and disasters (2 h) 1. Concepts of chaos, order, deterministic chaos. 2. Bifurcation, bifurcation point, 3 types of equilibrium. 3. Feigenbaum sequence. 4. Deterministic chaos in the functioning of living systems.
4		Topic 4. Fractal geometry (3 h) Predecessors of modern fractal geometry: Weierstrass, Hausdorf, Cantor, Julia. Koch, Sierpiński; the first graphic images of fractals, L-system. Fractal geometry of B. Mandelbrot; Mandelbrot set, his algorithm; other computer nonlinear fractals. The main properties of fractals: scale	Session 3. Self-organization (2 h) 1. The concept of self-organization. 2. Phase transitions in static systems. 3. Dynamical systems. Benard cells, laser, Eigen hypercycles. 4. Belousov–Jabotinsky reaction. 5. Self-organization in the development of the body, in the work of organs and systems.

		invariance, fractional dimension. Linear and nonlinear fractals. Deterministic and chaotic fractals. Fractal trees (L-systems). Virtual landscapes. Physical fractal clusters. Aggregation model limited by diffusion; its applicability to biological objects.	6. Processes of self-organization in biopopulations and in society. Testing on Topic 1.
5		Topic 5. Quasi-fractality of biosystems (3 h) Examples of fractal structures in biology; simulation fractal models. The ratio of orderliness and chaos in the structural organization of biological objects, revealed using fractal models. Quasi-fractality of biosystem morphology: - at the subcellular and cellular levels; - at the organismal level, quasi-fractality of color, structure of organs and body systems; - At the population level. Quasi-fractality in the dynamics of the physiology of organisms. Advantages of quasi-fractal organization.	Session 4. Strange attractors (2 h) 1. Methodology of research of chaotic processes. 2. Attractor, strange attractor, phase space, phase trajectories. 3. Topology and studies of the strange attractor. 4. N. Lorenz and his climate model. Lorentz attractor. 5. Strange attractor in the description of physiological processes. Chaos in the norm and pathology. 6. Ennon attractor, Poincaré cross section.
6		Topic 6. Theory of self-organization (3 h) Mathematical proof of spontaneous symmetry breaking and the occurrence of heterogeneity in an initially homogeneous system (Turing). Nonlinear thermodynamics and dissipative structures: I. Prigogine. Synergetics (Haken) as an interdisciplinary science of self-organization. Classic examples of dissipative structures: Benard cells, Belousov-Jabotinsky reaction, laser, aggregation of myxomycetes amoebas, etc. The concept of emergence. Prigozhin's Brussels.	Session 5. Modeling in biology (2 h) 1. Discrete models: DLA model, cellular automata. 2. Continuum models: reactionary-diffuse models, Walpert's "French Flag" model, Meinhard's models. 3. Modeling of self-organization in the morphogenesis of the organism. 4. Modeling of evolution. 5. Artificial neural network, self-learning. 3. Genetic algorithm.
7		Topic 7. Modeling in biology (2 h) Continuum and discrete models of self-organization, imitation of real processes and structures of inanimate and living nature. Limited diffusion aggregation model. Model of cellular automata. Reaction-diffuse models of self-organization: meinhardt and Walpert models. Modeling and self-learning of neural networks. Modeling of the processes of evolution.	Session 6. Fractal geometry (3 h) 1. Benoît Mandelbrot and Fractal Geometry of Nature. 2. Basic concepts. Definition and properties of fractal. 3. Linear, nonlinear and chaotic fractals. Fractal clusters. 4. Quasi-fractality in inanimate nature. 5. Fractal dimensions. 6. Fractality and processes of self-organization.

8			Session 7. Fractality of living systems (3 h) 1. Quasi-fractality of subcellular, cellular, organismal organization of living systems. 2. The cell as a fractal cluster. The cell as a percolation cluster. 3. Study of quasi-fractality of morphology on the example of the gastrovascular system of jellyfish. 4. Fractality of sedentary and mobile organisms. 5. Fractality and development of the organism. 6. The main directions and advantages of the use of quasi-fractal structures by living organisms. 7. Study of quasi-fractality in the dynamics of living systems.
9			Session 8. Final Seminar (2 hours) At the last seminar, we will discuss the penetration of the synergetic approach into all areas of technology, fundamental science, contemporary art, the transformation of the scientific worldview as a whole. In particular, we will touch upon such issues as modeling evolutionary processes, fuzzy logic, genetic learning algorithms, self-organization of computer networks, self-assembly in nanotechnology, etc. By the seminar, it is necessary to own all the basic synergetic concepts given in this course, to understand the methodology of this science, to understand the principles of self-organization of complex systems.
10			Final interview. Testing (2 hours)

Schedule for the implementation of independent work in the discipline "Synergetics"

№ p/n	**Due Date/Deadlines**	**Type of independent work**	**Approximate norms of execution time**	**Form of control**
1	1 week	Work with literature and lecture notes. Preparation for practical exercises.	8 hours	Self-control.
2	Week 2	Work with literature and lecture notes. Preparation for practical exercises.	8 hours	Work in a practical lesson.

3	Week 3	Work with literature and lecture notes. Preparation for practical exercises.	8 hours	Work in a practical lesson.
4	Week 4	Work with literature and lecture notes. Preparation for practical exercises.	8 hours	Work in a practical lesson.
5	Week 5	Work with literature and lecture notes. Preparation for practical exercises.	8 hours	Work in a practical lesson.
6	Week 6	Work with literature and lecture notes. Test Preparation 1.	8 hours	Work in a practical lesson.
7	Week 7	Work with literature and lecture notes. Preparation for practical exercises.	8 hours	Testing 1.
8	Week 8	Work with literature and lecture notes. Preparation for the final interview.	8 hours	Work in a practical lesson.
9	Week 9	Work with literature and lecture notes.	8 hours	Final interview.
		TOTAL	72 hours	

Current monitoring of the results of independent work is carried out during practical exercises and tests on topics. Intermediate (semester) certification is carried out in the form of an oral interview (offset). Based on these results, the student receives current grades, according to which the final grade is derived.

Guidelines for preparation for seminars

Since the seminar is a collective form of consideration and consolidation of educational material, all students should prepare for it, although not all will have reports. For each seminar, the topic and the list of questions are announced in advance for the preparation of abstracts and relevant oral reports (messages) - for 5-7 minutes for each question. It is necessary to work out the relevant material from the textbook, lecture notes, additional literature and Internet sources to the report. It is necessary to think in advance about the schemes for illustration on the board or prepare them in the form of a computer presentation. In the report, it is necessary to use terms and keywords on this topic. After the report, a brief discussion is held with additions, amendments in the form of questions - answers or additional speeches. Both the quality of the report and the activity of the participants in the discussion are evaluated.

Seminars are held in the form of a discussion.

Guidelines for preparing for testing by topic

The student should prepare for the test especially carefully, since the grades obtained are one of the leading sources of the student's final assessment. It is necessary to repeat the lecture material once again, read the necessary section in the textbook, remember the discussions at lectures and practical classes. Try to use more additional material, including from Internet sources, for better assimilation of the material. In many topics, it will be necessary to refer to sources (textbooks) in other disciplines. Do not neglect such sources, be sure to use them when preparing. In this case, the material will be absorbed more easily.

Methodical instructions for working with literature

Decide on the list of references available to you. The basis may be the list of references recommended in the work program of the course. For the convenience of work, you can make your own file cabinet of selected sources (surname of the authors, title, characteristics of the publication) in the form of a working file in the computer. Such a file cabinet has an advantage, because it allows you to add sources, replace one with another if necessary, remove those that turned out not to correspond to the topic. The initial list of references can be supplemented using the electronic catalog of the FEFU library, while not hesitate to seek help from the library staff.

Working with literature on a particular topic, it is necessary not only to read, but also to learn the method of its study: make a brief summary, an algorithm, a scheme of the material read, which allows you to quickly understand it, remember it. It is not recommended to rewrite the text verbatim.

When studying materials on synergetics, try to use both electronic resources and numerous sites on science news to assimilate up-to-date information on various topics of the course.

IV. MONITORING THE ACHIEVEMENT OF COURSE OBJECTIVES

The following assessment tools are used for monitoring:

UO-1 – oral interview, mainly on credit;

UO-4 – discussion;

PR-1 – written (or computer) test

No p/n	Controlled modules /partitions / topics of discipline	Codes and stages of competence formation		Valuation tools - name	
				current control	Intermediate certification
1	Session 1. Changing scientific paradigms	UK-1.1; UK-1.2; UK-1.3	Knowledge Ability	UO-4 PR-1	UO-1

			Possession		
		OPK-1.1; OPK-1.2; OPK-1.3	Knowledge Ability Possession	UO-4 PR-1	UO-1
2	Session 2. Deterministic chaos. Bifurcations and disasters	UK-1.1; UK-1.2; UK-1.3	Knowledge Skill Mastery	UO-4 PR-1	UO-1
		OPK-1.1; OPK-1.2; OPK-1.3	Knowledge Ability Possession	UO-4 PR-1	UO-1
3	Session 3. Self-organization	UK-1.1; UK-1.2; UK-1.3	Knowledge Ability Possession	UO-4 PR-1	UO-1
		OPK-1.1; OPK-1.2; OPK-1.3	Knowledge Ability Possession	UO-4 PR-1	UO-1
4	Session 4. Strange attractors	UK-1.1; UK-1.2; UK-1.3	Knowledge Ability Possession	UO-4 PR-1	UO-1
		OPK-1.1; OPK-1.2; OPK-1.3	Knowledge Ability Possession	UO-4 PR-1	UO-1
5	Session 5. Modeling in Biology	UK-1.1; UK-1.2; UK-1.3	Knowledge Skill Mastery	UO-4 PR-1	UO-1
		OPK-1.1; OPK-1.2; OPK-1.3	Knowledge Ability Possession	UO-4 PR-1	UO-1
6	Session 6. Fractal geometry	UK-1.1; UK-1.2; UK-1.3	Knowledge Ability Possession	UO-4 PR-1	UO-1
		OPK-1.1; OPK-1.2; OPK-1.3	Knowledge Ability Possession	UO-4 PR-1	UO-1
7	Session 7. Fractality of living systems	UK-1.1; UK-1.2; UK-1.3	Knowledge Ability Possession	UO-4 PR-1	UO-1
		OPK-1.1; OPK-1.2; OPK-1.3	Knowledge Ability Possession	UO-4 PR-1	UO-1
8	Session 8. Final Seminar	UK-1.1; UK-1.2; UK-1.3	Knowledge Skill Mastery	UO-4 PR-1	UO-1
		OPK-1.1; OPK-1.2; OPK-1.3	Knowledge Ability Possession	UO-4 PR-1	UO-1

V. LIST OF EDUCATIONAL LITERATURE AND INFORMATION SUPPORT OF THE DISCIPLINE

Main literature

(electronic and printed publications)

1. Karetin Yu.A. Synergetics for biologists. Course of lectures. Vladivostok: DVGU, 2009. http://lib.dvfu.ru:8080/lib/item?id=chamo:262992&theme=FEFU

2. Riznichenko G. Y. Lectures on mathematical models in biology / G. Y. Riznichenko. - Moscow Izhevsk : Regular and chaotic dynamics, 2011. – 558 p. http://lib.dvfu.ru:8080/lib/item?id=chamo:821122&theme=FEFU

3. Synergetics and self-organization. Sotsial'naya psikhologiya / V. P. MilovanovMoscow : URSS, : [Librocom], [2013] 179 p http://lib.dvfu.ru:8080/lib/item?id=chamo:779715&theme=FEFU

4. Bukina E.Ya., Synergetika [Electronic resource] / Bukina E.Ya. - Novosibirsk : Izd-vo NGTU, 2014. - 212 p. - ISBN 978-5-7782-2548-0 - Access mode: http://www.studentlibrary.ru/book/ISBN9785778225480.html

5. Gubarev, V. V. Kibernetika, synergetics, informatics [Elektronnyi resurs] : uchebnoe posobie / V. V. Gubarev. - Electron. text data. — Novosibirsk : Sibirskii gosudarstvennyi universitet telecommunications i informaticsii, 2009. — 38 c. — 2227-8397. – Access mode: http://www.iprbookshop.ru/54762.html

Further reading

1. Glake J. Chaos. Creation of a new science. - S-Pb. Amphora. 2001.

2. Isaeva V. V. Synergetics dlya biologov. Introductory course : textbook / V. V. Isaeva ; Far Eastern State University, Institute

Marine Biology FEB RAS, REC "Marine Biota". - Vladivostok : [Izd-vo Dalnevostochnogo universiteta], 2003. – 87 p. http://lib.dvfu.ru:8080/lib/item?id=chamo:5509&theme=FEFU

3. Isaeva V. V. Synergetika dlya biologov : introductory kurs : uchebnoe posobie / V. V. Isaeva ; [ed. by V. L. Kasyanov] ; Russian Academy of Sciences, Far Eastern Branch, Institute of Marine Biology; Far Eastern State University. - Moscow : Nauka, 2005. – 159 p. http://lib.dvfu.ru:8080/lib/item?id=chamo:247458&theme=FEFU

4. Knyazeva E.N., Kurdyumov S.P. Laws of evolution and self-organization of complex systems. M., Nauka, 1994.

5. Nikolis G., Prigozhin I. Poznanie complicatnogo. M., URSS. 2003.

6. Nikolis G. Poznanie complicatnogo : vvedenie / G. Nikolis, I. Prigozhin ; trans. with English by V. F. Pastushenko. - Moscow : Mir, 1990. – 342 p. http://lib.dvfu.ru:8080/lib/item?id=chamo:29328&theme=FEFU

7. Mandelbrot B. Fractal geometry of nature. M. IKI. 2002.

8. Prigozhin I. From existing to arising. M., URSS. 2002.

9. Prigozhin I. Ot estvennogo k arising. Time and Complexity in Physical Sciences / I. Prigogine ; trans. with English by Y. A. Danilova. - Moscow : Nauka, 1985. – 327 p. http://lib.dvfu.ru:8080/lib/item?id=chamo:51733&theme=FEFU

10. Prigozhin I., Stengers I. Order from chaos. A New Dialogue of Man with Nature : Trans. with English / I. Prigozhin, I. Stengers ; ed. V. I. Arshinov. - Moscow : Progress, 1986. – 432 p. http://lib.dvfu.ru:8080/lib/item?id=chamo:53303&theme=FEFU

11. Riznichenko, G. Y. Lectures on mathematical models in biology. Part 1 [Elektronnyi resurs] / G. Y. Riznichenko. - Electron. text data. — Moscow-Izhevsk : Regular and chaotic dynamics, Izhevsk Institute of Computer Research, 2002. — 232 p. — Access mode: http://www.iprbookshop.ru/17629.html

12. Haken G., Haken-Krell M. Secrets of perception. M. IKI. 2002.

13. Haken G. General principles of self-organization in nature and in society. On the History of Synergetics / G. Haken, P. Plath, W. Ebeling [et al.]. - Moscow Izhevsk : Institute of Computer Research, 2018. – 419 p. http://lib.dvfu.ru:8080/lib/item?id=chamo:870824&theme=FEFU

14. Gleick J. Chaos: making a new science / James Gleick. - [New York] : Penguin Books, [1988]. - 352 p. http://lib.dvfu.ru:8080/lib/item?id=chamo:834265&theme=FEFU

15. Mandelbrot B. The Fractal Geometry of Nature / Benoit B. Mandelbrot. - New York : W. H. Freeman and Company, 2000. - 468 p. http://lib.dvfu.ru:8080/lib/item?id=chamo:11351&theme=FEFU

16. Peitgen, H.-O., Hartmut, J., Saupe, D. Chaos and fractals: new frontiers of science (2nd ed.). Springer. 2004. 864 pp. – Access mode: https://yadi.sk/i/osGZ32Ipm2VgH

17. Edgar Gerald. Measure, Topology, and Fractal Geometry. Springer-Verlag New York, LLC. 2008. ISBN: 0387747486. 268 p.

List of resources of the information and telecommunication network "Internet"

1. http://www.highwire.org/lists/freeart.dtl - Library of scientific journals of Stanford University. About 700,000 full-text articles.

2. http://www.scientific-library.net/ - Huge library of scientific and technical literature. You can download electronic versions of books.

List of information technologies and software

1. In the implementation of the educational process, students use the following software: Microsoft Office (Access, Excel, PowerPoint, Word, etc.), electronic resources of the FEFU website, including FEFU EBS.

2. Scientific electronic library eLIBRARY, electronic library system of the publishing house "Lan", electronic library "Student Consultant", information system "SINGLE WINDOW" access to educational resources, access to electronic order of books in the FEFU library.

VI. METHODICAL INSTRUCTIONS FOR MASTERING THE DISCIPLINE

In the process of studying the discipline "Synergetics", a variety of methods and means of mastering the educational content are offered: lectures, practical works, testing, independent work of students.

Lecture

The lecture is the main active form of classroom classes, explanations of the fundamental theoretical sections of biology, which involves intensive mental activity of the student. The lecture is cognitive, developmental, educational and organizing in nature. Lecture notes help to assimilate the theoretical material of the discipline. When listening to the lecture, it is necessary to take notes on its rubric, terminology, keywords, definitions, formulas, graphic schemes. The summary is useful when it is is written by the student himself. You can develop your own word shortening scheme. The name of topics, paragraphs can be highlighted with colored markers.

When working at home with lecture notes, it is necessary to use the main textbook and additional literature that are recommended for this discipline. It is such a serious work of the student with the lecture material that allows him to achieve success in mastering new knowledge.

When presenting a lecture course on the discipline "Synergetics", the following are used as forms of interactive learning: lecture-conversation and collective discussion, which are based on previous knowledge gained by students in the study of related disciplines.

Lecture-conversation - is built in the form of a dialogue with the audience. At the same time, at the beginning of the lecture or in the course of the presentation of the material, the teacher puts problem questions to the audience on the topic under study and stimulates different parts of the audience to answer. At the same time, students may have their own questions, which can cause a creative discussion. This form of conducting the lesson enhances the effect of mastering the material by students, since they are directly involved in the discussion of some

questions of the topic. In addition to In addition, this form creates direct contact of the teacher with the audience.

Collective discussion. Within the framework of some of the topics that are the most pressing issues of synergetics to date, the teacher stimulates the development of discussion within the student body present at the lecture, asking burning and sometimes provocative questions. Within the framework of such a discussion, the general erudition of students, the ability to orient in the material, as well as the degree of their mastery of the material of past topics are usually well manifested.

Practical exercises

Practical exercises are a collective form of consideration and consolidation of educational material. Seminars are one of the main types of practical classes designed for in-depth study of the discipline, conducted in an interactive mode. At the classes on the topic of the seminar, issues are analyzed, and then, together with the teacher, their discussion is held, which is aimed at consolidating the material, forming the skills to conduct polemics, developing independence and critical thinking, the ability of students to navigate in large information flows, to develop and defend their own position on problematic issues of the discipline. As methods of interactive learning in seminar classes, a seminar-discussion is used.

Seminar-discussion in a group has a number of advantages. It is based on reports, reports on the topics of abstracts prepared by students in advance, within the framework of each practical lesson. The discussion can be caused by the teacher during the lesson or planned in advance by him and is formed as a process of dialogic communication, during which there is a formation of practical experience in discussing theoretical and practical problems. During the polemics, students form resourcefulness, speed of mental reaction. At such a seminar, students learn to accurately express their thoughts and argue their point of view, as well as to refute opponents.

Control testing

Testing. Testing can be conducted both in the form of traditional written in a regular classroom and electronic in a computer class. Types of test tasks are different: choosing one or more correct answer options, establishing correspondence, supplementing terms, etc.

VII. MATERIAL AND TECHNICAL SUPPORT OF DISCIPLINE

1. Lecture hall with multimedia support and interactive whiteboard.
2. Auditorium for practical (seminar) classes, tests and testing.
3. Computer lab for ongoing student testing.

4. Study tables, slides, computer presentations.

Lecture hall with multimedia support and interactive whiteboard. To perform independent work, students in fefu residential buildings are provided with Wi-Fi.

Name of equipped premises and premises for independent work	List of main equipment
Classroom for practical exercises Computer class School of Biomedicine aud. M723, 15 workplaces, area 80.3 m²	Screen with electric drive 236 * 147 cm Trim Screen Line; Projector DLP, 3000 ANSI Lm, WXGA 1280x800, 2000:1 EW330U Mitsubishi; Subsystem of specialized fasteners of equipment CORSA-2007 Tuarex; Video switching subsystem: DVI DXP 44 DVI Pro Extron matrix switch; DVI twisted pair extender DVI 201 Tx/Rx Extron; Subsystem of audio switching and sound amplification; acoustic system for ceiling mounting SI 3CT LP Extron; digital audio processor DMP 44 LC Extron; extension for IPL T CR48 management controller; Wireless LANs for trainees are provided with a system based on 802.11a/b/g/n 2x2 MIMO(2SS) access points.
Reading rooms of the FEFU Scientific Library with open access to the fund (building A - level 10)	HP All-in-One 400 All-in-One 19,5 (1600x900), Core i3-4150T, 4GB DDR3-1600 (1x4GB), 1TB HDD 7200 SATA, DVD+/-RW,GigEth,Wi-Fi,WT,usb kbd/mse,Win7Pro (64-bit)+Win8.1Pro(64-bit),1-1-1 Wty Internet access speed 500 Mbps. Workplaces for people with disabilities are equipped with Braille displays and printers; equipped with: portable devices for reading flat-printed texts, scanning and reading machines with a video magnifier with the ability to regulate color spectra; magnifying electronic magnifiers and ultrasonic markers
Auditorium for independent work of students , Vladivostok, Russky Island, Ajax village, 10, Building 25.1, room M621 Area 44.5 m²	Monoblock Lenovo C360G-i34164G500UDK 19.5" Intel Core i3-4160T 4GB DDR3-1600 SODIMM (1x4GB)500GB Windows Seven Enterprise - 17 pieces; Wired LAN - Cisco 800 series; wireless LANs for students are provided with a system based on access points 802.11a / b / g / n 2x2 MIMO (2SS).
Auditorium for lecture classes , Vladivostok, Russky Island, Ajax village, 10, room M422	Multimedia audience: Monoblock Lenovo C360G-i34164G500UDK; Projection screen Projecta Elpro Electrol, 300x173 cm; Multimedia projector, Mitsubishi FD630U, 4000 ANSI Lumen, 1920x1080; Mortise interface with the system of automatic cable retraction TLS TAM 201 Stan; Document camera Avervision CP355AF; Microphone buttonhole radio system UHF range Sennheiser EW 122 G3 as part of a wireless microphone and receiver; Video conferencing codec LifeSizeExpress 220- Codeconly-Non-AES; Multipix MP-HD718 Network Video Camera; Dual 47", Full HD, LG M4716CCBA LCD Panels; Audio Switching and Amplification Subsystem; Centralized Uninterrupted Power Supply

In order to provide special conditions for the education of disabled people

and persons with disabilities at FEFU, all buildings are equipped with ramps, elevators, lifts, specialized places equipped with toilets, signs of information and navigation support.

VALUATION FUNDS
FOS Passport

Universal competencies of graduates and indicators of their achievement:

Name of the category (group) of universal competencies	Code and name of the universal competence (the result of mastery)	Code and name of the competency achievement indicator
	UK-1 Is able to carry out critical analysis of problem situations on the basis of a systematic approach, to develop an action strategy.	UK-1.1 Analyzes the problem situation using a systematic approach and modern natural science knowledge, using reliable data and reliable sources of information. UK-1.2 Develops and substantively argues possible strategies for solving the problem situation on the basis of systematic and interdisciplinary approaches, taking into account the parameters of the level of health of the population. UK-1.3 Develops a scenario for the implementation of the optimal strategy for solving a problem situation, taking into account the necessary resources, achievable results, possible risks and consequences.

Competence code and wording	**Stages of competence formation**
UK-1.1 Analyzes the problem situation using a systematic approach and modern natural science knowledge, using reliable data and reliable sources of information	Knows the basic laws of synergetics, the causes and mechanisms of self-organizational processes in nature and society, the main problems of this subject area Able to apply knowledge of the laws of synergetics to generate ideas in scientific and professional activities, ableto identify problem situations using a systematic approach and modern natural science knowledge Possesses the skills of a non-standard approach in the planning and implementation of scientific and professional activities
UK-1.2 Develops and substantively argues possible strategies for solving a problem situation on the basis of systemic and interdisciplinary approaches, taking into account the parameters of the level of health of the population	Knows all possible strategies for solving problem situations in this subject area Able to develop and argue possible strategies for solving a problem situation on the basis of systemic and interdisciplinary approaches, taking into account the parameters of the level of health of the population Possesses the skill of solving the tasks

UK-1.3 Develops a scenario for the implementation of the optimal strategy for solving a problem situation, taking into account the necessary resources, achievable results, possible risks and consequences	Know the ways to implement the optimal strategy for solving a problem situation Able towork out a scenario for the implementation of the optimal strategy for solving a problem situation, taking into account the necessary resources, achievable results, possible risks and consequences Possess

General professional competencies of graduates and indicators of their achievement:

Name of the category (group) of general professional competencies	Code and name of general professional competence (the result of mastery)	Code and name of the competency achievement indicator
	OPK-1 Is able to use and apply fundamental biological concepts and modern methodological approaches to pose and solve new non-standard tasks in the field of professional activity.	OPK-1.1 Monitors current topical problems, main discoveries and methodological developments in the field of biological and related sciences. OPK-1.2 Analyzes trends in the development of scientific research and practical developments in the selected field of professional activity, formulates innovative proposals for solving non-standard problems, using in-depth general scientific and methodological special training. OPK-1.3 Applies modern methodological approaches and methods for setting and solving new non-standard tasks in the field of professional activity.

	Stages of competence formation
OPK-1.1 Monitors current topical problems, main discoveries and methodological developments in the field of biological and related sciences.	Knows modern actual problems, discoveries, developments in the field of biology and related sciences Able to find information, analyze, monitor modern topical problems, main discoveries and methodological developments in the field of biological and related sciences Possess the skill of searching for information
OPK-1.2 Analyzes trends in the development of scientific research and practical developments in the selected field of professional activity, formulates innovative proposals for solving non-standard problems, using in-depth general scientific and methodological special training.	Knows the current trends in the development of scientific research and practical development in his field of knowledge Able to formulate innovative proposals for solving non-standard tasks Possess the skill of using in-depth general scientific and methodological information, set goals, objectives, interpret the data obtained.

OPK-1.3 Applies modern methodological approaches and methods for setting and solving new non-standard tasks in the field of professional activity.	Knows current problems in his professional activities Able to apply modern methodological approaches and methods for setting and solving new non-standard tasks Possess the skill to solve new non-standard tasks in the field of professional activity

To form the above competencies within the discipline "Synergetics", the following methods of active / interactive learning are used: lecture classes (collective discussion, lecture-conversation) and practical exercises (seminar-discussion).

No p/n	Controlled modules /partitions / topics of discipline	Codes and stages of competence formation		Valuation tools - name	
				current control	Intermediate certification
1	Session 1. Changing scientific paradigms	OK-5 AboutPK-6	Knowledge Ability Possession	UO-4 PR-1	UO-1
		OPK-3 AboutPC-3	Knowledge Ability Possession	UO-4 PR-1	UO-1
2	Session 2. Deterministic chaos. Bifurcations and disasters	OK-5 AboutPK-6	Knowledge Skill Mastery	UO-4 PR-1	UO-1
		OPK-3 AboutPC-3	Knowledge Ability Possession	UO-4 PR-1	UO-1
3	Session 3. Self-organization	OK-5 AboutPK-6	Knowledge Ability Possession	UO-4 PR-1	UO-1
		OPK-3 AboutPC-3	Knowledge Ability Possession	UO-4 PR-1	UO-1
4	Session 4. Strange attractors	OK-5 AboutPK-6	Knowledge Ability Possession	UO-4 PR-1	UO-1
		OPK-3 AboutPC-3	Knowledge Ability Possession	UO-4 PR-1	UO-1
5	Session 5. Modeling in Biology	OK-5 AboutPK-6	Knowledge Skill Mastery	UO-4 PR-1	UO-1
		OPK-3 AboutPC-3	Knowledge Ability Possession	UO-4 PR-1	UO-1
6	Session 6. Fractal geometry	OK-5 AboutPK-6	Knowledge Ability Possession	UO-4 PR-1	UO-1

		OPK-3 AboutPC-3	Knowledge Ability Possession	UO-4 PR-1	UO-1
7	Session 7. Fractality of living systems	OK-5 AboutPK-6	Knowledge Ability Possession	UO-4 PR-1	UO-1
		OPK-3 AboutPC-3	Knowledge Ability Possession	UO-4 PR-1	UO-1
8	Session 8. Final Seminar	OK-5 AboutPK-6	Knowledge Skill Mastery	UO-4 PR-1	UO-1
		OPK-3 AboutPC-3	Knowledge Ability Possession	UO-4 PR-1	UO-1

Methodological recommendations that determine the procedures for assessing the results of mastering the discipline

According to the discipline under study, the following are used for current control and intermediate (semester) certification

VALUATION TOOLS :

UO-1 – individual interview;

PR-1 – written (or computer) test;

PR-2 – control works.

Oral questioning is the most common method of monitoring students' knowledge. Oral questioning establishes direct contact between the teacher and students, during which the teacher receives ample opportunities to study the individual possibilities of students' assimilation of educational material. It is the most common and adequate form of monitoring students' knowledge. Includes an interview on credit.

Criteria for evaluating an oral response:

"5 points" are given to the student if he gives the right answers to the questions under discussion, which are distinguished by the depth and completeness of the disclosure of the topic, is able to draw conclusions and generalizations, give reasoned answers that are logical and consistent.

"4 points" is given to the student if he gives the right answers to the questions under discussion, which differ in the depth and completeness of the disclosure of the topic, is able to draw conclusions and generalizations, but one or two errors in the answers are allowed.

"3 points" are given to the student if he gives answers to the discussed questions that do not fully disclose it, there is no logical construction of the answer, makes several mistakes.

"2 points" are given to the student if he gives answers to the questions under discussion, which show that he does not own the material of the topic, cannot give reasoned answers, serious errors are made in the content of the answer.

A seminar session can serve as a form not only of testing, but also of increasing the knowledge of students. At colloquia, all or individual topics, issues of the course being studied can be discussed.

The criteria for evaluating speeches (reports) at seminars and practical classes are the same as for oral response.

The test is a written or computer form of control aimed at checking the possession of the terminological apparatus and specific (accurate) knowledge in the field of fundamental and applied disciplines.

Test evaluation criteria:

5 points are given to the student if he answered 86-100% of all questions.

4 points are given for the correct answer to 76-85% of all questions.

3 points are given for the correct answer to 61-75% of all questions.

2 points are given for the correct answer to 50-61% of all questions.

1 point is given for the correct answer on less than 50% of all questions.

A test work is a written or electronic form of control over the current assimilation of material on a large section (topic) of the discipline, evaluates the assimilation of terms, basic concepts, methods, the ability to solve practical problems.

Criteria for assessing the control work:

Test works are estimated by the share of work performed from the volume of the entire task.

5 points are given to a student if he has completed 86-100% of the total amount of the task.

4 points are given for the completion of 76-85% of the total volume of the task.

3 points are given for the completion of 61-75% of the total volume of the task.

2 points are given for the completion of 50-61% of the total volume of the task.

1 point is given for completing less than 50% of the total amount of the task.

Tests and tests are carried out during the hours allotted for practical exercises.

Assessment tools for intermediate attestation

As the final stage of the intermediate (semester) certification in the discipline "Bioinformatics" **, credit is provided**.

Guidelines for passing the test

At the exam, as an assessment tool, an interview is used on the questions of tickets drawn up by the leading teacher and signed by the head of the department. Exams are taken by the lead teacher or his assistant.

During the exam, students can use the working program of the discipline. If a student uses cheating funds, the examiner has the right to remove the student from the exam and put an unsatisfactory grade on the exam sheet.

When appearing for the exam, students are required to have a record book with them. The teacher fills in the appropriate columns of the student's gradebook: the name of the discipline in accordance with the curriculum, its laboriousness, the name of the teacher, grade, date, signature.

To take the oral exam, 5-6 students are invited to the audience at the same time. Students are not allowed to leave the classroom while preparing for answers without the permission of the examiner. The time given to the student to prepare for the answer in the oral exam is 30 minutes.

When conducting an exam, the exam card is chosen by the student himself. When taking the oral exam, the examiner may ask additional questions. If a student finds it difficult to answer one question of the selected ticket, then he can be offered to take another ticket, while the score is reduced by a point.

During the intermediate certification, grades are established: on the exams "excellent", "good", "satisfactory" and "unsatisfactory", on the tests - "credited" and "not credited".

If a student fails to appear for the exam without a valid reason, an entry "did not appear" is made in the statement.

The grades given by the examiner on the basis of the results of the examinations are not subject to revision. A student who does not agree with the grade has the right to submit an application addressed to the Director of the School. If the application is justified, the Director of the School shall establish a commission consisting of three teachers for the relevant department. The grade obtained by the student during the retake of the commission exam is final.

Criteria for scoring on the test

The "credit" grade is given when the student is fluent in the theoretical material of the discipline being studied, does not make mistakes when answering the questions asked, using visual tables, or admits some inaccuracies in the answers, but quickly corrects errors when asking him leading questions. In addition, the student is guided in the collection of histological preparations in their determination.

The grade "not counted" is given when the student does not own the materials of the discipline being studied, does not answer additional questions of the teacher and does not navigate the collection of histological preparations when determining them.

Questions for credit

in the discipline "Synergetics"

1. What is the mechanism of building a fractal structure? (A fractal is not a form, a fractal is an iterative process, you need to keep that in mind.)
2. What is a fractal? (Give either a rigorous mathematical or alternative definition.)
3. Who coined the term "Fractal"? (The name of the scientist, his profession, place of work.)
4. What is fractal dimension?
5. What was the first practical application of fractal dimension measurement and why was it needed?
6. Algorithm for calculating fractal dimension box-counting method. Write a formula and decipher it.
7. Algorithm for constructing the Cantor set. Write a formula for calculating the fractal dimension of a given set.
8. Algorithm for constructing the Sierpiński triangle. Write a formula for calculating the fractal dimension of a given set.
9. What is a quasiphractal?
10. Julie and Mandelbrot sets. The construction algorithm.
11. Explain the statement: "Fractal geometry is the geometry of nature." Who is the author of this statement?
12. What is entropy?
13. Dynamic (deterministic) chaos. Define.
14. What is the difference between dynamic (deterministic) chaos and chaos in the traditional sense?
15. What is a nonlinear system? (Define: Properties of nonlinear systems.)
16. What is a dynamic system? (Define: Properties of dynamical systems.)
17. What is an open system? (Define: Properties of open systems.)
18. Give examples of deterministic chaos in the real world: in physics, in economics, in chemistry, in biology.
19. Phase space – definition. What can serve as coordinate axes of phase space?
20. Self-similarity, definition.
21. Advantages of the use of fractality by living organisms in the morphology of organs, systems, tissues, and the organism as a whole.

22. The cell as a percolation cluster. Features of functioning, advantages.

23. Intracellular self-organization, give at least 2 examples.

24. The cell as a quasiphractal. To describe the advantages of fractal organization of living matter at the cellular (subcellular) level of organization.

25. Methods for calculating fractal dimension, describe at least 4 methods.

26. Lacunarity: clarification, definition, use.

27. Box-counting fractal dimension. Describe the method of calculation.

28. Ruler fractal dimension. Describe the method of calculation.

29. Model of the "world of daisies". In what states can this system stabilize?

30. Write an equation of the dynamics of the population of Malthus, leading to a cascade of bifurcations with an increase in r.

31. Model objects for studying chaos in the morphogenesis of multicellular, give at least 2 examples.

32. Chaos and fractality in the evolution of life.

33. What properties of fractals are useful for the external or internal structures of living organisms? 34. Prove the universality of synergistic principles. (Synergetics was originally formed and is developing as an interdisciplinary field of research, think about why this happened).

35. In what areas of knowledge is synergetic methodology used and why is it necessary there?

36. What happens to the entropy of closed, open and living systems?

37. Describe the process of self-organization of the wave zug in the laser.

38. Mitchell Feigenbaum – the significance of his works for synergetics.

39. Reductionism in Biology. What is its essence and historical perspective?

40. 2 main types of models in biology and their differences.

41. Examples of discrete models in biology. (Name and briefly describe 2 models).

42. Cyclic cellular automaton. Describe the rules for generating patterns by this model and give at least 2 examples of real systems, the dynamics of which are reproduced by this model.

43. Model of the "French Flag" by L. Wolpert. Give a brief description and scope of use.

44. Reaction-diffuse model. Describe the rules for pattern formation in this model, I will give at least 2 examples of real systems whose dynamics can be described using this model.

Assessment tools for the current attestation

Questions to prepare for hands-on labs

in the discipline "Synergetics"

Topic 1.

1. What are the prerequisites, and what are the prerequisites for the change in the scientific paradigm that led to the emergence of synergetics? (What goals did scientists of different eras set for themselves, what are the practical applications of old and new science. Analysis and synthesis in science. Births of the evolutionary principle in science.)

2. The world of Laplace and the world of Poincaré, what is the difference between them?

3. What is the order parameter? (Why the behavior of a system element is excellent inside and outside the system, why the system is not equal only to the sum of its constituent elements)

4. Why is the knowledge of biological life impossible without a synergistic approach, but only the study of its individual elements?

5. What does nonlinear science include?

6. Why is synergetics such an interdisciplinary area of research?

7. What traditional field of physics has studied processes that have a time scale that are irreversible, and how did its postulates diverge from evolutionary ideas?

8. What are open systems and what is nonlinear behavior?

9. What is chaos, order and entropy?

Topic 2.

1. What is a phase transition?

2. Give examples of phase transitions in static systems.

3. Give examples of phase transitions in dynamical systems.

4. Describe the occurrence of the Benard cell in the heated liquid.

5. Do you think the amount of information in the system has increased or decreased since the appearance of Benard cells?

6. What are the general patterns of phase transitions?

7. What is self-organization?

8. What is the relationship between self-organization and phase transition?

9. What other examples of self-organization processes can you give?

10. How to reconcile the processes of self-organization with the second law of thermodynamics?

Topic 3.

1. Why is the winter of 1961 considered the birth time of chaos science?

2. Give examples of very simple model systems with unpredictable behavior.

3. What is phase space?

4. What is an attractor?

5. How will the attractor of a fading and unquenchable pendulum be represented in phase space?

6. What is a strange attractor?

7. How many measurements can the space of a strange attractor have?

8. Describe a few important properties of the strange attractor.

9. Which systems are described by the strange attractor?

10. Robert May's bifurcation cascade: what is interesting about its discovery?

11. What is deterministic chaos and how is it different from classical chaos?

12. The "world of daisies" model: what stable states can this system accept? Are there any transitions between them?

13. Give examples of self-organization at the subcellular, supracellular, organismal, population levels.

14. Give examples of non-chaotic and chaotic dynamics of the body in norm and pathology.

15. What is the fundamental difference between a living organism and artificial systems created today by man?

16. Prove the presence of self-organization processes in the development and functioning of the human brain.

17. Describe the development of the organism as a process of self-organization.

18. Describe the process of evolution as a self-organizing process.

25. What modern technologies do you know that use or try to use the principle of self-organization?

Topic 4.

1. The scientific activity of Benoit Mandelbrot and its importance for the development of fractal geometry.

2. What is a fractal, what are its properties?

3. Give examples of algorithms for constructing linear fractals.

4. What are L graphics?

5. What are nonlinear fractals? Name a couple of famous ones.

6. Is there a fundamental relationship between the attractor and the nonlinear fractal?

7. What is a fractal cluster?

8. Is there a connection between deterministic chaos and fractal structure?

9. What is meant by "fractal dimension"?

10. What other nonlinear parameters besides fractal dimensions do you know?

11. Give examples of quasi-fractal forms in inanimate nature.

12. Why did Mandelbrot call fractal geometry "the geometry of nature"?

13. What properties of fractals do living systems use?

14. Give examples of quasi-fractality in the dynamics of the functioning of living systems.

Testing on the topics covered is carried out on paper forms or in a computer lab. An example of the test is given below.

Intermediate Attestation Test Example

Subject of testing: «Synergetics»

1. What is a fractal? (Give either a strict mathematical or alternative definition; the alternative definition should mention at least 2 features of a fractal structure)

2. Who coined the term "fractal"?

a. Mandelbrot

b. Haken

v. Serpinsky

Prigozhin

e. Peano

3. Describe 3 methods for calculating fractal dimension, name them.

4. What type of fractals does the Mandelbrot set belong to:

a. Chaotic fractals

b. Linear fractals

c. Nonlinear fractals

5. In which systems is self-organization possible? (Multiple answers can be selected)

a. Open

b. closed

c. stationary

d. nonlinear

e. dynamic

e. static

6. How many measurements can the phase space have (Multiple answers can be selected)

a. 1

b. 2

c. 3

d. 4.

7. Please provide a couple of properties of the strange attractor.

8. The scientist meteorologist who created the first strange attractor as a model of the dynamics of deterministic-chaotic systems:

a. Feigenbaum

b. Mandelbrot

c. Haken

Lorenz

Prigozhin village

9. Emergence is:

a. the non-compliance of the properties of the system with the sum of the properties of its elements

b. the correspondence of the properties of the system to the sum of the properties of its elements

c. changing the properties of a system by one of its elements

d. changing the properties of a system when it is open

10. At what level of organization can the self-organization of living systems be observed:

a. Subcellular level

b. Cellular level

c. organismal level

d. population level

e. at all levels of the organization

e. self-organization does not occur in living systems