Course BIOLUMINESCENT BIOTECHNOLOGIES

Basic Information

This is a course, which contributes to MSc award in Biology

Title of the Academic Program	Master's Degree Programs in English "Biological Engineering"
Type of the course	core /mandatory
Course period	From February 1st till June 1st, 1 semester (18 weeks)
Study credits	4 ECTS credits
Duration	144 hours
Language of instruction	English
Academic requirements	- BSc degree in Biology, Physics, Biophysics, Chemistry, Biochemistry, Environmental Sciences or equivalent (transcript of records), - good command of English (certificate or another official document

Course Description

The course is designed to provide students with the most recent and updated knowledge of basic as well as applied research in the field of bioluminescence. The interdisciplinary nature of the subject "Bioluminescent biotechnologies (BB)" provides ample opportunities for students of different backgrounds to learn, experiment and design new biosensing strategies applicable in the area of environmental monitoring, food safety and biomedical sciences.

Special Features of the Course

The course covers the key foundations of BB including: fundamental principles of bioluminescent enzymes, stabilization techniques and their potential applications in environmental monitoring, food safety and health.

Course Aim

The course aims to introduce students the general aspects and interdisciplinary nature of BB, acquaint them with recent trends in the area of biosensor research and provide with understanding of fundamental principles related to biosensing design.

Course Objectives

The course is designed to:

- provide students with thorough knowledge of various bioluminescent systems and their application in biosensor research;
- equip students with practical and applied skills of bioluminescence based biosensing agents for their application in food safety, health and environmental monitoring;
- make students familiar with fundamentals of immobilization and bioconjugate chemistry;
- give knowledge of designing bioluminescence based novel biosensing strategies.

Learning Outcomes of the Course

A successful completion of this course will enable students to:

- apply basic skills of luciferase enzyme purification and stabilization;
- synthesize different types of nanomaterials and characterize them;
- demonstrate basic microbiological techniques;
- generate and modify bioconjugation techniques for their wide usage in biosensor design;
- create biochips and microfluidic platforms.

Course (module) Structure

Learning Activities	Hours
Lectures	14
Practice sessions / Seminars,	14
Self-study Assignments	80
Final Exam (including preparation)	36
Total study hours	**144**

Course Outline

Week	Lectures	Practical work / Assignments	Hours
1-3	Module 1 «Bioluminescence in nature: an overview of different enzyme systems and applications» • Responsive lecture «Different Bioluminescent enzyme systems» • Lecture « Potential applications of bacteria»	• Problem set № 1 • Home assignment № 1 • Lab «Optimization of cultivation media for bioluminescent luciferase enzyme systems»	4
4-5	Module 2 «Bacterial bioluminescence: Diversity, lux gene cassette and biotechnological potentials»		

	• Lecture «Bacterial bioluminescence: diversity and lux gene cassette» • Lecture «Biotechnological applications of bacterial bioluminescence system»	• Problem set № 2 • Home assignment № 2 • Lab «Whole cell immobilization and metal inhibition assays»	4
6-7	Module 3 «Luminescent beetles: diversity and potential applications»		
	• Lecture «Diversity of luminescent beetles» • Lecture «Application of ATP bioluminescence system»	• Problem set № 3 • Home assignment № 3 • Lab «Stability studies of firefly luciferase»	**4**
	Module 4 «Introduction to coelenterazine system and BRET/FRET based applications»		
8-9	• Lecture «Introduction to Coelenterazine system» • Lecture «Fluorescent proteins and FRET/BRET based assay application»	• Problem set № 4 • Home assignment № 4 • Lab «Fluorescent proteins: Isolation and characterization»	4
	Module 5 «Other bioluminescent systems and their commercial viability»		
10-11	• Lecture «Other bioluminescent systems» • Lecture «Commercial potential of luciferases»	• Problem set № 5 • Home assignment № 5 • Lab «Extraction of bacterial luciferase»	4
	Module 6 «Functional nanomaterials and their scope in bioluminescence research»		
12-13	• Lecture «Functional nanomaterials» • Lecture «Interaction of nanomaterials with bioluminescent enzyme systems»	• Problem set № 6 • Home assignment № 6 • Lab « Synthesis of nanomaterials» • Lab «Interaction of nanomaterials with bioluminescent	4

		proteins»	
	Module 7 «Functional nanomaterials and their scope in bioluminescence research»		
14-16	• Lecture «Recent research investigations in bioluminescence: A» • Lecture «Recent research investigations in bioluminescence: B»	• Problem set № 7 • Home assignment № 7 • Lab «Immobilization of luciferase enzyme on microfluidic chip»	4
	• Final Exam		

Assessment

The overall course percentage grade will consist of the final test results (40%) and the combined grades of 7 modules assignments (60%).

The score for each module is the sum of the following assignments:

• Module 1-6 (8% each):

Home assignments and class participation (3%)

Lab work (2%)

Problem set (1%)

Attendance (2%)

• Module 7 (12%):

Home assignments and class participation (6%)

Lab work (2%)

Problem set (2%)

Attendance (2%)

The overall course percentage grade will be converted into a letter grade as follows:

A = 91-100%

B = 81-90%

C = 71-80%

D = 61-70%

E = less than 61%.

Attendance Policy

It is advised to attend the classes regularly since lab work, home assignments and class participation requires physical presence of the students. Attendance of at least 75% is mandatory.

Web page of the course

The webpage of the course «Bioluminescent Biotechnologies» is available through E-learning SibFU web site: www.e.sfu-kras.ru . You must be logged in to access this course. Course Guide and all accompanying materials are also available at the course web-page.

Core reading

1. Coursebook.

2. Esimbekova EN, Kratasyuk VA, Torgashina IG. Disk-shaped immobilized

multicomponent reagent for bioluminescent analyses: correlation between activity and composition. Enzyme and microbial technology. 2007 Jan 4;40(2):343-6.

3. Ranjan R, Esimbekova EN, Kratasyuk VA. Rapid biosensing tools for cancer biomarkers. Biosensors and Bioelectronics. 2017 Jan 15;87:918-30.

4. Ranjan R, Rastogi NK, Thakur MS. Development of immobilized biophotonic beads consisting of Photobacterium leiognathi for the detection of heavy metals and pesticide. Journal of hazardous materials. 2012 Jul 30;225:114-23.

5. Ranjan R, Priyanka BS, Thakur MS. ATPase inhibitor based luciferase assay for prolonged and enhanced ATP pool measurement as an efficient fish freshness indicator. Analytical and bioanalytical chemistry. 2014 Jul 1;406(18):4541-9

6. Abhijith KS, Sharma R, Ranjan R, Thakur MS. Facile synthesis of gold–silver alloy nanoparticles for application in metal enhanced bioluminescence. Photochemical & Photobiological Sciences. 2014;13(7):986-91.

7. Shimomura O. Bioluminescence: chemical principles and methods. World Scientific; 2006.

8. Haddock SH, Moline MA, Case JF. Bioluminescence in the sea. Annual Review of Marine Science. 2010 Jan 15;2:443-93.

9. Rich P.B., Douillet C. (Eds.) Bioluminescence: Methods and Protocols. In Humana Press Inc. 2009. BIOLUMINESCENT BIOTECHNOLOGIES. Syllabus

510. Pfleger KD, Eidne KA. Illuminating insights into protein-protein interactions using bioluminescence resonance energy transfer (BRET). Nature methods. 2006 Mar 1;3(3):165-74.

11. Meighen EA. Molecular biology of bacterial bioluminescence. Microbiological reviews. 1991 Mar 1;55(1):123-42

12. Esimbekova, E., Kratasyuk, V. and Shimomura, O., 2014. Application of enzyme bioluminescence in ecology. In Bioluminescence: Fundamentals and Applications in Biotechnology-Volume 1 (pp. 67- 109). Springer Berlin Heidelberg.

13. Thakur, M.S., Ranjan, R., Vinayaka, A.C., Abhijith, K.S. and Sharma, R., 2013. Nanoparticles and biophotonics as efficient tools in resonance energy transfer-based biosensing for monitoring food toxins and pesticides. In Advances in applied nanotechnology for agriculture (pp. 55-84). American Chemical Society.

14. Roda A, Guardigli M. Analytical chemiluminescence and bioluminescence: latest achievements and new horizons. Analytical and bioanalytical chemistry. 2012 Jan 1;402(1):69-76.

15. England CG, Ehlerding EB, Cai W. NanoLuc: a small luciferase is brightening up the field of bioluminescence. Bioconjugate chemistry. 2016 Apr 19;27(5):1175-87.

16. Kuchimaru T, Iwano S, Kiyama M, Mitsumata S, Kadonosono T, Niwa H, Maki S, Kizaka-Kondoh S. A luciferin analogue generating near-infrared bioluminescence achieves highly sensitive deep-tissue imaging. Nature communications. 2016 Jun 14;7.

17. Rosselló GA, Rodríguez MP, Grande MS, Domingo AO, Pérez MÁ. A two-hour antibiotic susceptibility test by ATP-bioluminescence. Enfermedades Infecciosas y Microbiología Clínica. 2016 Jul 31;34(6):334-9.

18. Smirnova DV, Samsonova JV, Ugarova NN. The bioluminescence resonance energy transfer from firefly luciferase to a synthetic dye and its application for the rapid homogeneous immunoassay of progesterone. Photochemistry and photobiology. 2016 Jan 1;92(1):158-65.

19. Magalhães CM, Esteves da Silva JC, Pinto da Silva L. Chemiluminescence and Bioluminescence as an Excitation Source in the Photodynamic Therapy of Cancer: A Critical Review. ChemPhysChem. 2016 Aug 4;17(15):2286-94.

Additional reading:

1. Malhotra, B.D. and Turner, A. eds., 2003. Advances in biosensors: Perspectives in biosensors (Vol. 5). Elsevier.

2. Rogers, K.R. and Mulchandani, A. eds., 1998. Affinity biosensors: techniques and protocols (Vol. 7). Totowa, NJ, USA:: Humana Press.

3. Hermanson, G.T., 2013. Bioconjugate techniques. Academic press.

4. Li, P.C., 2005. Microfluidic lab-on-a-chip for chemical and biological analysis and discovery. CRC press.

Course Instructor Contact information

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Facilities, Equipment and Software

The laboratory of bioluminescent biotechnologies is equipped with high-end and modern scientific tools for research in the area of enzymology, microbiology, nanotechnology and molecular biology. Biological Engineering offers training to students in above mentioned areas of research.