KHULNA UNIVERSITY

Learn, Lead and Live

OBE OUTCOME BASED EDUCATION

2021-22
and onwards

Undergraduate Curriculum

Biotechnology and Genetic Engineering Discipline

Life Science School

OUTCOME-BASED CURRICULUM

BACHELOR OF SCIENCE IN BIOTECHNOLOGY AND GENETIC ENGINEERING

Biotechnology and Genetic Engineering Discipline
Khulna University
September 2022

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OUTCOME BASED EDUCATION

01 Title of the Academic Program

Bachelor of Science in Biotechnology and Genetic Engineering

Program Overview

Degree	Bachelor of Science in Biotechnology and Genetic Engineering
Abbreviated form of the Degree	B. Sc. in Biotechnology and Genetic Engineering
Discipline/Program Offering Entity (POE)	Biotechnology and Genetic Engineering Discipline
School	Life Science School
Awarding Institution	Khulna University
Location	Khulna, Bangladesh
Bangladesh National Qualifications Framework (BNQF) Level	7
International Standard Classification of Education (ISCED) Code	0512
Mode of Study	Full Time
Language of Study	English
Applicable Session	2021-22 and onwards

02 Name of the University

Khulna University

03 Vision of the University

Creation of global leaders who will contribute to make knowledge-based just society through accelerating inclusive and transformative growth of Bangladesh and the world. The university aims to achieve this vision through scholarly enquiry and contribution to the global knowledge pool.

04 Mission of the University

University Mission & Details

UM1	Explore human potential to the fullest extent and produce self-motivated, aspiring leaders to work for the betterment of the humankind based on wisdom, free thinking, creativity and unhindered intellectual exercises.
UM2	Ensure a transformative educational experience that enables creative learning, entrepreneurship and inquisitiveness among the students.
UM3	Create an inclusive research environment that enables graduates to make demonstrable economic and social impacts through translating knowledge and innovation into practice driven by moral values and professional ethics.

UM = University Mission

05 Name of the Discipline/Program Offering Entity (POE)

Biotechnology and Genetic Engineering Discipline

06 Vision of the Discipline/POE

Providing state-of-the art knowledge and skills in the field of Biotechnology and Genetic Engineering for sustainable development of society and environment.

07 Mission of the Discipline/POE

Discipline Mission & Details

M1	To impart quality education and training by experienced and high profile faculty members for producing skilled and competent graduates to contribute in different sectors including agriculture, healthcare, industry and environment.
M2	To facilitate the development of scientists, entrepreneurs, and policy makers towards nation building programs.
M3	To disseminate knowledge and skills for the betterment of the society and promote meaningful collaboration with academia, industry and research organization across the globe.
M4	To motivate and train students for higher studies, industrial practices, lifelong learning skills and entrepreneurship.
M5	To make professional leaders, academicians and researchers with high moral values and ethics.

M = Mission of the Discipline/POE

08 Objectives of the Discipline/POE

Discipline Objectives & Details

O1	To offer quality education and to maintain the highest academic standard in line with the international standard of education.
O2	To produce enthusiastic competent graduates having moral values and professional ethics for fulfilling the national and global demands.
O3	Imparting need-based state-of-the-art education and research to foster entrepreneurship among students in various application areas of Biotechnology for sustainable development.
O4	To provide solution based education with cutting edge knowledge in Biotechnology and Genetic Engineering in order to harness the latest techniques, technologies and methodologies for the graduates in the field of Agricultural (Plant and Animal) Biotechnology, Medical and Pharmaceutical Biotechnology, Microbial Biotechnology, Food Biotechnology, Industrial (bioprocess) Biotechnology and Environmental Biotechnology.
O5	Dissemination of knowledge, research findings and innovative appropriate technology to various stakeholders of the society for national development.

O = Objective of the Discipline/POE

09 Name of the Degree

Bachelor of Science in Biotechnology and Genetic Engineering

10 Description of the Program

The Bachelor degree program offered by the Biotechnology and Genetic Engineering Discipline at Khulna University is a multidisciplinary applied biological science which deals with the use of series of biological processes or enabling technologies that uses biological systems or living organisms or their sub-cellular components to make or modify products, to improve plants and animals or to improve microbes for specific uses and services for sustainable agriculture, livestock, fisheries, forestry, clean environment and energy. This includes recombinant DNA technology, transgenic crops and animals, genetically modified foods, biopharmaceuticals, bioremediation, and more. It is often used, to refer to Genetic Engineering technology in the 21st century; however, the term encompasses a wider range and history of procedures for modifying biological organisms according to the needs of humanity, going back to the initial modifications of native plants into improved food crops through artificial selection and hybridization. Modern Biotechnology includes the use of gene technology and other methods in molecular biology to produce knowledge and useful products for application in research, medicine, agriculture and industry. It combines disciplines like genetics, molecular biology, biochemistry, embryology and cell biology, which are in turn linked to practical disciplines like chemical engineering, information technology and nanotechnology. Students gain the knowledge and core set of skills that span across basic sciences, technology, engineering, and mathematics (STEM) education. Khulna University started Biotechnology education at undergraduate level in 1995 which was the first of its kind in Bangladesh. Later on, the Discipline was renamed as Biotechnology and Genetic Engineering Discipline in 2003. At present the Discipline offers four years Bachelor of Science (B.Sc.) and MS in Biotechnology and Genetic Engineering degrees. MS degree is being offered in three modes viz. One year MS (Taught course), 1.5 years MS (Mixed mode: Theory + Sessional course + Thesis/Project) and 2.0 years (Only Research) from 2022-2023 session. The course curriculum is focused on the development needs and covers multidisciplinary subject areas to create appropriate knowledge base to cope with fast paced technological advancements. The research activities at the Discipline are focused on various aspects of animal, plant, microbial, environmental, food, medical, process engineering and industrial biotechnology which encompass both basic and applied research. The Discipline has established 10 modern laboratories including one field laboratory for providing state-of-the-art and applied knowledge through hands on practical education. Twenty three experienced teachers including 14 Professors are involved in teaching and research work in this Discipline.

The Discipline has signed MOU with (1) Triticae Research Institute of Sichuan Agricultural University, China (2) East-West Seed (Bangladesh) Ltd. (Now renamed as "Lal Teer Seed Co. Ltd.) and National Institute of Biotechnology (NIB), Savar, Dhaka for collaborative research in various fields of biotechnology and genetic engineering.

The students get the opportunity to learn the state-of-the-art recent developed methodologies, techniques and technologies. Subsequently, the graduates get their way into higher studies and research across the globe. As progression of the career, they are effectively contributing into Biotechnology-oriented academia, research and industrial organizations.

A good number of pioneer BGE graduates have acquired faculty positions in many public and private universities viz. KU, JUST, JU, MBSTU, IU, SUST, MIST, NSTU, JnU, BSMRMU, NSU, BRAC, etc. and contributing to develop human capital for achieving 4th industrial revolution. Graduates are also doing job at various ministries as BCS cadre, research institutes (NIB, BCSIR, BAEC, ICDDR'B, BJRI), pharmaceutical companies, BRAC, RDA, IFC/World Bank, Bangladesh Bank and other government and private banks, and NGOs.

After completion of PhD degree from various reputed universities, more than 100 BGE graduates are engaged in teaching and/or Post-Doc researcher/scientists positions in many countries like USA, UK, Canada, Australia, Japan, Germany, Sweden, France, Finland, Norway, Netherlands, Spain, New Zealand, South Korea, China, India, Nepal, Malaysia etc. Moreover, about 60 BGE graduates are now studying in Master's and PhD degree in above mentioned countries.

11 Graduate Attributes

	Graduate Attributes	Domain
GA1	Academic Proficiency	Fundamental
GA2	Knowledge acquisition and application	Fundamental
GA3	Advanced digital literacy	Fundamental
GA4	Scientific communication	Social
GA5	Presentation skills & public speaking	Social
GA6	Teamwork	Social
GA7	Creative and critical thinking ability	Thinking
GA8	Problem-solving ability	Thinking
GA9	Entrepreneurship	Thinking
GA10	Self-motivated and sincere	Personal
GA11	Personality & leadership	Personal
GA12	Professionalism	Personal
GA13	Morality, ethics and civic	Personal
GA14	Research Skills	Personal
GA15	Innovativeness	Personal

GA = Graduate Attributes

12 Program Educational Objectives (PEOs)

Recognizing the need to strengthen undergraduate education that fosters cross-disciplinary training and collaborative interactions, the Bachelor Program of Biotechnology and Genetic Engineering Discipline fosters quality education to graduates fulfilling the following objectives:

	Program Educational Objectives	Domain
PEO 1	Graduates capable for set foot in a wide variety of postgraduate paths, including professional training programs and/ or entry-level jobs in academia, R &D sectors, industry, service sectors etc. in national and international echelons.	Fundamental
PEO 2	Graduates achieve good communication skills in order to able to fit in the job and R&D sectors and efficiently disseminate biotechnological innovations in the national and international arena.	Social
PEO 3	Graduates skilled in solving problems in their workplace (academia, R &D, service sectors) through a scientific approach by observing, analyzing the situations, reasoning and skeptical enquiry.	Thinking
PEO 4	Graduates are able to work in a team in Lab & Field and demonstrate basic research methods, including experimental designs, data collection, analysis and interpretation and able to communicate research findings to the expert and non-expert people.	Personal
PEO 5	Graduates able to demonstrate knowledge and basic laboratory skills in multidisciplinary areas of biotechnology and genetic engineering appropriate for employment, entrepreneurship, product development, service and pursuing innovative research.	Personal
PEO 6	Self-motivated graduates able to demonstrate professionalism, zeal for life-long state-of-the-art global knowledge, entrepreneur skills, moral values & ethical standards, and significantly contribute to society.	Personal

PEO = Program Educational Objective

13 Program Learning Outcomes (PLOs)

After successful completion of the degree, the learner will be able to:

A. Fundamental Skills

PLO1	Knowledge: Explain major theories, laws and concepts of various basic and applied courses and demonstrate various laboratory techniques /skills use in various fields of Biotechnology and genetic engineering.
PLO2	Comprehension: Interpret the gained theories and practices towards deeper understanding of the fundamental principles related to BGE through sustainable innovation.
PLO3	Application: Apply the acquired knowledge and skills in various application areas of BGE for human welfare.
PLO4	Analysis : Analyze biotechnological knowledge and skills for the development of goods, products and services.
PLO5	Synthesis: Integrate biotechnological innovative ideas into sustainable transformative and interdisciplinary solutions for better world.
PLO6	Evaluation: Appraise gained knowledge and skills towards logical applications of biotechnology.

B. Social Skills

PLO7	Communicate and interact efficiently and clearly the ideas, information, problems, solutions and experimental outcomes to peers, biotech experts and interdisciplinary non-experts / professionals in both Bangla and English.
PLO8	Demonstrate proficiency in science communication.

C. Thinking Skills

PLO9	Think critically to analyze the scientific and recent technological trends in the area of biotechnology to real life problems

D. Personal Skills

PLO10	Develop independence and leadership skills to implement a given task efficiently and accurately.
PLO11	Exhibit ethical practices in environmental, professional and social life.

PLO = Program Learning Outcome

14 Mapping Mission of the University with PEOs

PEOs \ Missions	UM1	UM2	UM3
PEO 1	3	1	2
PEO 2	3	3	2
PEO 3	1	2	1
PEO 4	3	3	1
PEO 5	3	2	3
PEO 6	3	2	1

Level of association: 3=High, 2=Medium, 1=Low

15 Mapping PLOs with PEOs

Program Learning Outcomes (PLOs)		Program Educational Objectives (PEOs)					
		PEO 1	PEO 2	PEO 3	PEO 4	PEO 5	PEO 6
Fundamental Domain	PLO1	●			●	●	
	PLO2	●			●	●	
	PLO3	●		●	●	●	
	PLO4				●	●	
	PLO5				●	●	●
	PLO6			●	●	●	
Social Domain	PLO7	●	●	●			●
	PLO8	●	●	●			●
Thinking Domain	PLO9	●		●		●	
Personal Domain	PLO10		●		●		●
	PLO11	●	●			●	●

16 Mapping Courses with PLOs

Course Code and Course Title	Program Learning Outcomes (PLOs)										
	Fundamental Domain						Social Domain		Thinking Domain	Personal Domain	
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
First Year First Term											
0512 07 BGE 1101: Introduction to Biotechnology and Genetic Engineering	●	●	●	●	●	●					●
0512 07 BGE 1103: Cell Biology	●	●	●	●	●	●	●				
0512 07 BGE 1104: Cell Biology Sessional	●		●	●	●	●	●	●			
0512 07 BGE 1105: Plant Physiology	●	●		●	●	●	●	●	●	●	
0512 07 Bot 1151: Evolutionary and Functional Botany	●	●	●	●	●	●	●		●		
0512 07 Bot 1152: Evolutionary and Functional Botany Sessional & Field Work	●	●		●	●	●	●	●	●		
0541 07 Math 1153: Mathematics	●	●	●	●	●	●	●		●		
0531 07 Chem 1155: Inorganic and Biophysical Chemistry	●	●	●		●	●	●		●		●
0531 07 Chem 1156: Inorganic and Biophysical Chemistry Sessional	●		●	●	●	●	●		●		●
First Year Second Term											
0512 07 BGE 1201: Microbiology	●	●	●	●	●	●	●	●	●		●
0512 07 BGE 1202: Microbiology Sessional & Field Work	●	●	●	●	●	●	●			●	●
0512 07 BGE 1203: Principles of Genetics		●	●			●		●	●	●	
0512 07 BGE 1204: Principles of Genetics Sessional & Field Work	●			●	●		●	●		●	●
0512 07 BGE 1205: Biomolecules	●	●	●		●		●		●	●	●
0512 07 BGE 1206: Biomolecules Sessional		●		●		●		●			●
0531 07 Chem 1257: Organic Chemistry and Spectroscopy			●	●	●	●	●	●	●		
0531 07 Chem 1258: Organic Chemistry and Spectroscopy Sessional	●	●	●	●	●	●	●	●	●		
0511 07 Zoo 1259: Evolutionary and Functional Zoology	●	●	●	●			●				●
0511 07 Zoo 1260: Evolutionary and Functional Zoology Sessional & Field Work	●	●		●	●	●					●
0231 07 Eng 1261: Communicative English			●	●	●	●	●	●	●	●	
0533 07 Phy 1263: Physics	●	●	●			●	●		●		
0533 07 Phy 1264: Physics Sessional	●	●	●	●	●				●		

Course Code and Course Title	Program Learning Outcomes (PLOs)										
	Fundamental Domain						Social Domain		Thinking Domain	Personal Domain	
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
Second Year First Term											
0512 07 BGE 2101: Molecular Biology	●	●	●	●	●	●	●	●	●	●	●
0512 07 BGE 2103: Bioenergetics and Metabolic Regulation	●	●		●	●	●	●		●	●	
0512 07 BGE 2105: Plant Breeding	●	●	●			●		●	●		●
0512 07 BGE 2106: Plant Breeding Sessional & Field Work	●		●	●	●		●	●		●	●
0512 07 BGE 2107: Algal and Fungal Biology		●	●		●	●	●		●		●
0512 07 BGE 2108: Algal and Fungal Biology Sessional & Field Work	●	●	●	●		●	●	●		●	●
0512 07 BGE 2109: Animal Physiology and Reproduction	●		●		●			●	●	●	●
0512 07 BGE 2110: Animal Physiology and Reproduction Sessional & Field Work		●		●		●	●	●	●		
0314 07 Soc 2165: Principles of Sociology	●	●	●	●	●			●		●	●
0821 07 Ecol 2167: Ecology	●		●	●	●	●	●		●		●
0821 07 Eco 2168: Ecology Sessional & Field Work	●	●		●	●	●	●		●	●	●
0611 07 CSE 2170: Fundamental in Computer and IT Sessional	●	●	●	●	●	●	●		●	●	
Second Year Second Term											
0512 07 BGE 2201: Plant Cell and Tissue Culture	●	●	●		●	●		●	●	●	●
0512 07 BGE 2202: Plant Cell and Tissue Culture Sessional & Field Work	●		●	●		●	●	●		●	●
0512 07 BGE 2203: Metabolism	●		●	●	●	●	●				●
0512 07 BGE 2205: Animal Genetics and Breeding		●		●	●	●		●	●		●
0512 07 BGE 2206: Animal Genetics and Breeding Sessional & Field Work	●	●	●	●		●	●	●	●	●	
0512 07 BGE 2207: Bioprocess Engineering	●	●	●		●	●			●		●
0512 07 BGE 2208: Bioprocess Engineering Sessional			●	●	●	●	●	●	●	●	●
0512 07 BGE 2209: Microbial Genetics	●		●	●		●			●	●	
0512 07 BGE 2210: Microbial Genetics Sessional	●	●		●	●		●	●		●	●
0512 07 BGE 2211: Developmental Biology		●	●		●		●	●	●		●
0512 07 BGE 2213: Human Physiology	●	●	●		●	●		●	●		
0613 07 CSE 2271: Computer Programming	●			●		●	●		●	●	
0613 07 CSE 2272: Computer Programming Sessional	●	●	●		●		●	●	●	●	●

Course Code and Course Title	Program Learning Outcomes (PLOs)										
	Fundamental Domain						Social Domain		Thinking Domain	Personal Domain	
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
Third Year First Term											
0512 07 BGE 3101: Immunology	●	●		●		●	●	●	●		●
0512 07 BGE 3102: Immunology Sessional	●		●	●		●	●	●	●		●
0512 07 BGE 3103: Molecular Genetics		●			●				●		●
0512 07 BGE 3105: Animal Cell Culture	●	●		●		●	●	●			●
0512 07 BGE 3106: Animal Cell Culture Sessional	●		●	●		●					●
0512 07 BGE 3107: Enzyme Technology		●	●	●			●	●	●		●
0512 07 BGE 3109: Biofertilizer Production Technology	●	●			●				●	●	
0512 07 BGE 3110: Biofertilizer Production Technology Sessional & Field Work	●		●	●	●	●	●			●	
0512 07 BGE 3111: Nutrition and Functional Food		●	●		●		●		●		●
0512 07 BGE 3113: Introduction to Biosafety and Bioethics	●	●	●	●		●	●	●	●	●	●
0512 07 Stat 3173: Biostatistics	●			●	●			●		●	●
0512 07 Stat 3174: Biostatistics Sessional & Field Work		●			●		●	●	●	●	
0917 07 Pharm 3175: Pharmacognosy	●	●				●		●			●
0811 07 Agr 3177: Plant Pathology	●		●	●	●		●	●	●		●
0811 07 Agr 3178: Plant Pathology Sessional & Field Work		●	●	●		●		●	●		●
Third Year Second Term											
0512 07 BGE 3201: Fermentation and Bioreactor Design	●	●			●	●	●		●	●	
0111 07 BGE 3203: Technology Transfer	●		●	●	●		●	●		●	●
0111 07 BGE 3204: Technology Transfer Sessional & Field Work		●	●	●		●		●	●		●
0512 07 BGE 3205: Bioinformatics	●	●	●		●	●		●		●	
0512 07 BGE 3206: Bioinformatics Sessional	●			●	●		●		●		●
0512 07 BGE 3207: Medical and Pharmaceutical Biotechnology		●	●	●		●	●	●		●	
0512 07 BGE 3208: Medical and Pharmaceutical Biotechnology Sessional & Field Work	●	●	●		●		●	●	●		●
0512 07 BGE 3209: Biopharmaceutical Chemistry		●	●	●		●			●	●	●
0512 07 BGE 3211: Molecular Breeding	●	●		●	●		●	●			
0512 07 BGE 3213: Biomass and Renewable Energy	●	●	●		●		●		●	●	●
0512 07 BGE 3214: Biomass and Renewable Energy Sessional & Field Work		●	●	●		●				●	
0512 07 BGE 3216: Techniques in Molecular Biology Sessional	●	●		●	●	●		●	●	●	●

Course Code and Course Title	Program Learning Outcomes (PLOs)										
	Fundamental Domain						Social Domain		Thinking Domain	Personal Domain	
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
Fourth Year First Term											
0512 07 BGE 4101: Plant Biotechnology and Genetic Engineering	●	●	●		●	●		●	●	●	
0512 07 BGE 4102: Plant Biotechnology and Genetic Engineering Sessional & Field Work	●		●	●		●	●		●		●
0512 07 BGE 4103: Animal Biotechnology and Genetic Engineering		●		●	●		●	●		●	●
0512 07 BGE 4104: Animal Biotechnology and Genetic Engineering Sessional & Field Work	●	●	●	●		●	●		●	●	
0512 07 BGE 4105: Microbial Biotechnology and Genetic Engineering	●		●		●	●		●	●		●
0512 07 BGE 4106: Microbial Biotechnology and Genetic Engineering Sessional & Field Work	●	●		●	●	●	●	●		●	●
0512 07 BGE 4107: Downstream Processing		●	●	●		●		●		●	●
0512 07 BGE 4108 : Central Viva	●		●		●		●		●	●	
0512 07 RM 4109: Research Methodology	●	●		●		●			●		●
0512 07 BGE 4111: Bionanoscience	●	●	●		●	●	●	●		●	
0512 07 BGE 4113: Molecular Medicine			●	●	●		●	●	●		●
0311 07 Econ 4179: Production Economics	●	●		●	●		●	●	●		●
Second Year Second Term											
0512 07 BGE 4201: Food Biotechnology	●	●	●		●	●	●		●	●	
0512 07 BGE 4202: Food Biotechnology Sessional & Field Work	●		●	●		●	●	●		●	●
0512 07 BGE 4203: Environmental Biotechnology	●	●		●	●		●	●	●		●
0512 07 BGE 4204: Environmental Biotechnology Sessional & Field Work	●	●	●		●	●		●	●	●	
0512 07 BGE 4205:Genomics and Proteomics	●	●		●	●	●	●		●		●
0512 07 BGE 4206:Thesis*	●	●	●	●		●	●	●		●	●
0512 07 BGE 4208: Review Report**	●	●	●	●		●	●	●		●	●
0512 07 BGE 4209: Industrial Biotechnology	●	●		●	●		●	●		●	
0512 07 BGE 4211: Instrumentation in Biotechnology and Genetic Engineering	●	●		●	●		●	●	●	●	

*A student must register for 0512 07 BGE 4206: Thesis or 0512 07 BGE 4208: Review Report for fulfilling the partial requirements of the B.Sc. in Biotechnology and Genetic Engineering degree.

** A student, who registers for the course 0512 07 BGE 4208: Review Report must register for an additional course of a minimum of two credits.

17 Structure of the Curriculum

a) Duration of the Program	04 Years	08 Terms
b) Admission Requirements	The Science group applicant must possess GPA 3.5 in both SSC and HSC examinations separately and total score should be at least 8.0 and studied "Biology" subject for applying admission test in Life Science School of Khulna University.	
c1) Graduating Credits / Total Minimum Credit Requirement to Complete the Program	160	
c2) Available Credits	205	
d) Total Class Weeks in a Term*	14	
e) Minimum CGPA Requirements for Graduation	2.50	
f) Maximum Academic Years of Completion	7	

* The Discipline needs to offer the optional courses so that each student can register for at least one optional course in each term.

*Term Duration

Teaching and Learning	Preparatory Leave	Term Final Examination	Term Break	Total
14 Weeks	2 Weeks	4 Weeks	2 Weeks	22 Weeks

g1) Area-wise Credit Distribution

Area	Course Type	Number of Courses	Credits	Total Credits
General Education (GED) Courses**	Theory	16	39	51
	Sessional	11	12	
Core/Compulsory Courses	Theory	32	96	118
	Sessional	22	22	
Optional/Elective Courses	Theory	10	27	30
	Sessional	2	3	
Capstone Courses***	Sessional	2	6	6
	Total	96	205	205

*25.24% from GED courses; **Mentioned in GED Courses and *** Thesis, project, internship etc. courses.

g2) Category of Courses

Area	Course Type	Course Title	Credits
General Education (GED) Courses	Theory	01. Evolutionary and Functional Botany 02. Mathematics 03. Inorganic and Biophysical Chemistry 04. Organic Chemistry and Spectroscopy 05. Evolutionary and Functional Zoology 06. Communicative English 07. Physics 08. Principles of Sociology 09. Ecology 10. Computer Programming 11. Biostatistics 12. Pharmacognosy 13. Plant Pathology 14. Technology Transfer 15. Research Methodology 16. Production Economics	39

Area	Course Type	Course Title	Credits
General Education (GED) Courses	Sessional	01. Evolutionary and Functional Botany Sessional & Field Work 02. Inorganic and Biophysical Chemistry Sessional 03. Organic Chemistry and Spectroscopy Sessional 04. Evolutionary and Functional Zoology Sessional & Field Work 05. Physics Sessional 06. Fundamental in Computer and IT Sessional 07. Ecology Sessional & Field Work 08. Computer Programming Sessional 09. Biostatistics Sessional & Field Work 10. Plant Pathology Sessional & Field Work 11. Technology Transfer Sessional & Field Work	12
Core/ Compulsory Courses	Theory	01. Introduction to Biotechnology and Genetic Engineering 02. Cell Biology 03. Plant Physiology 04. Microbiology 05. Principles of Genetics 06. Biomolecules 07. Molecular Biology 08. Bioenergetics and Metabolic Regulation 09. Plant Breeding 10. Algal and Fungal Biology 11. Animal Physiology and Reproduction 12. Plant Cell and Tissue Culture 13. Metabolism 14. Animal Genetics and Breeding 15. Bioprocess Engineering 16. Microbial Genetics 17. Immunology 18. Molecular Genetics 19. Animal Cell Culture 20. Enzyme Technology 21. Biofertilizer Production Technology 22. Fermentation and Bioreactor Design 23. Bioinformatics 24. Medical and Pharmaceutical Biotechnology 25. Biopharmaceutical Chemistry 26. Plant Biotechnology and Genetic Engineering 27. Animal Biotechnology and Genetic Engineering 28. Microbial Biotechnology and Genetic Engineering 29. Downstream Processing 30. Food Biotechnology 31. Environmental Biotechnology 32. Genomics and Proteomics	96
	Sessional	01. Cell Biology Sessional 02. Microbiology Sessional & Field Work 03. Principles of Genetics Sessional & Field Work 04. Biomolecules Sessional 05. Plant Breeding Sessional & Field Work 06. Algal and Fungal Biology Sessional & Field Work 07. Animal Physiology and Reproduction Sessional & Field Work 08. Plant Cell and Tissue Culture Sessional & Field Work 09. Animal Genetics and Breeding Sessional & Field Work 10. Bioprocess Engineering Sessional 11. Microbial Genetics Sessional	22

Area	Course Type	Course Title	Credits
Core/ Compulsory Courses	Sessional	12. Immunology Sessional 13. Animal Cell Culture Sessional 14. Biofertilizer Production Technology Sessional & Field Work 15. Bioinformatics Sessional 16. Medical and Pharmaceutical Biotechnology Sessional & Field Work 17. Plant Biotechnology and Genetic Engineering Sessional & Field Work 18. Animal Biotechnology and Genetic Engineering Sessional & Field Work 19. Microbial Biotechnology and Genetic Engineering Sessional & Field Work 20. Central Viva 21. Food Biotechnology Sessional & Field Work 22. Environmental Biotechnology Sessional & Field Work	
Optional/ Elective Courses	Theory	01. Developmental Biology 02. Human Physiology 03. Nutrition and Functional Food 04. Introduction to Biosafety and Bioethics 05. Molecular Breeding 06. Biomass and Renewable Energy 07. Bionanoscience 08. Molecular Medicine 09. Industrial Biotechnology 10. Instrumentation in Biotechnology and Genetic Engineering	27
	Sessional	01. Biomass and Renewable Energy Sessional & Field Work 02. Techniques in Molecular Biology Sessional	3
Capstone Courses	Sessional	01. Thesis 02. Review Report	6
		Total	205

18 Year/Term-wise Distribution of Courses

Course Code	Course Title	Course Status	Contact Hours/Week		Credits	Prerequisites
			Theory	Sessional		
First Year First Term						
0512 07 BGE 1101	Introduction to Biotechnology and Genetic Engineering	Core	3.0	-	3.0	None
0512 07 BGE 1103	Cell Biology	Core	3.0	-	3.0	None
0512 07 BGE 1104	Cell Biology Sessional	Core	-	1.5	1.0	None
0512 07 BGE 1105	Plant Physiology	Core	3.0	-	3.0	None
0512 07 Bot 1151	Evolutionary and Functional Botany	Optional	3.0	-	3.0	None
0512 07 Bot 1152	Evolutionary and Functional Botany Sessional & Field Work	Optional	-	1.5	1.0	None
0541 07 Math 1153	Mathematics	Optional	2.0	-	2.0	None
0531 07 Chem 1155	Inorganic and Biophysical Chemistry	Optional	2.0	-	2.0	None
0531 07 Chem 1156	Inorganic and Biophysical Chemistry Sessional	Optional	-	1.5	1.0	None
Total	Theory (Core: 03, Optional: 03) Sessional (Core: 01 Optional: 02)		16.0	4.5	19.0	
			20.5			
First Year Second Term						
0512 07 BGE 1201	Microbiology	Core	3.0	-	3.0	None
0512 07 BGE 1202	Microbiology Sessional & Field Work	Core	-	1.5	1.0	None
0512 07 BGE 1203	Principles of Genetics	Core	3.0	-	3.0	None
0512 07 BGE 1204	Principles of Genetics Sessional & Field Work	Core	-	1.5	1.0	None
0512 07 BGE 1205	Biomolecules	Core	3.0	-	3.0	None
0512 07 BGE 1206	Biomolecules Sessional	Core	-	1.5	1.0	None
0531 07 Chem 1257	Organic Chemistry and Spectroscopy	Core	2.0	-	2.0	None
0531 07 Chem 1258	Organic Chemistry and Spectroscopy Sessional	Core	-	1.5	1.0	None
0511 07 Zoo 1259	Evolutionary and Functional Zoology	Optional	2.0	-	2.0	None
0511 07 Zoo 1260	Evolutionary and Functional Zoology Sessional & Field Work	Optional	-	1.5	1.0	None
0231 07 Eng 1261	Communicative English	Optional	2.0	-	2.0	None
0533 07 Phy 1263	Physics	Optional	2.0	-	2.0	None
0533 07 Phy 1264	Physics Sessional	Optional	-	1.5	1.0	None
Total	Theory (Core: 04, Optional: 03) Sessional (Core: 04 Optional: 02)		17.0	9.0	23.0	
			26.0			

* Non-credit core sessional course

Course Code	Course Title	Course Status	Contact Hours/Week		Credits	Prerequisites
			Theory	Sessional		
Second Year First Term						
0512 07 BGE 2101	Molecular Biology	Core	3.0	-	3.0	None
0512 07 BGE 2103	Bioenergetics and Metabolic Regulation	Core	3.0	-	3.0	None
0512 07 BGE 2105	Plant Breeding	Core	3.0	-	3.0	None
0512 07 BGE 2106	Plant Breeding Sessional & Field Work	Core	-	1.5	1.0	None
0512 07 BGE 2107	Algal and Fungal Biology	Core	3.0	-	3.0	None
0512 07 BGE 2108	Algal and Fungal Biology Sessional & Field Work	Core	-	1.5	1.0	None
0512 07 BGE 2109	Animal Physiology and Reproduction	Core	3.0	-	3.0	None
0512 07 BGE 2110	Animal Physiology and Reproduction Sessional & Field Work	Core	-	1.5	1.0	None
0314 07 Soc 2165	Principles of Sociology	Optional	2.0	-	2.0	None
0821 07 Eco 2167	Ecology	Optional	2.0	-	2.0	None
0821 07 Eco 2168	Ecology Sessional & Field Work	Optional	-	1.5	1.0	None
0611 07 CSE 2170	Fundamental in Computer and IT Sessional	Optional	-	3.0	2.0	None
Total	Theory (Core: 05, Optional: 02) Sessional (Core: 03 Optional: 02)		19.0	9.0	25.0	
			28.0			
Second Year Second Term						
0512 07 BGE 2201	Plant Cell and Tissue Culture	Core	3.0	-	3.0	None
0512 07 BGE 2202	Plant Cell and Tissue Culture Sessional & Field Work	Core	-	1.5	1.0	None
0512 07 BGE 2203	Metabolism	Core	3.0	-	3.0	None
0512 07 BGE 2205	Animal Genetics and Breeding	Core	3.0	-	3.0	None
0512 07 BGE 2206	Animal Genetics and Breeding Sessional & Field Work	Core	-	1.5	1.0	None
0512 07 BGE 2207	Bioprocess Engineering	Core	3.0	-	3.0	None
0512 07 BGE 2208	Bioprocess Engineering Sessional	Core	-	1.5	1.0	None
0512 07 BGE 2209	Microbial Genetics	Core	3.0	-	3.0	None
0512 07 BGE 2210	Microbial Genetics Sessional	Core	-	1.5	1.0	None
0512 07 BGE 2211	Developmental Biology	Optional	3.0	-	3.0	None
0512 07 BGE 2213	Human Physiology	Optional	3.0	-	3.0	None
0613 07 CSE 2271	Computer Programming	Optional	2.0	-	2.0	None
0613 07 CSE 2272	Computer Programming Sessional	Optional	-	1.5	1.0	None
Total	Theory (Core: 05, Optional: 03) Sessional (Core: 04 Optional: 01)		23.0	7.5	28.0	
			30.5			

* Non-credit core sessional course

Course Code	Course Title	Course Status	Contact Hours/Week		Credits	Prerequisites
			Theory	Sessional		
Third Year First Term						
0512 07 BGE 3101	Immunology	Core	3.0	-	3.0	None
0512 07 BGE 3102	Immunology Sessional	Core	-	1.5	1.0	None
0512 07 BGE 3103	Molecular Genetics	Core	3.0	-	3.0	None
0512 07 BGE 3105	Animal Cell Culture	Core	3.0	-	3.0	None
0512 07 BGE 3106	Animal Cell Culture Sessional	Core	-	1.5	1.0	None
0512 07 BGE 3107	Enzyme Technology	Core	3.0	-	3.0	None
0512 07 BGE 3109	Biofertilizer Production Technology	Core	3.0	-	3.0	None
0512 07 BGE 3110	Biofertilizer Production Technology Sessional & Field Work	Core	-	1.5	1.0	None
0512 07 BGE 3111	Nutrition and Functional Food	Optional	3.0	-	3.0	None
0512 07 BGE 3113	Introduction to Biosafety and Bioethics	Optional	2.0	-	2.0	None
0542 07 Stat 3173	Biostatistics	Core	3.0	-	3.0	None
0542 07 Stat 3174	Biostatistics Sessional & Field Work	Core	-	1.5	1.0	None
0917 07 Pharm 3175	Pharmacognosy	Optional	3.0	-	3.0	None
0811 07 Agr 3177	Plant Pathology	Optional	3.0	-	3.0	None
0811 07 Agr 3178	Plant Pathology Sessional & Field Work	Optional	-	1.5	1.0	None
Total	Theory (Core: 06, Optional: 04) Sessional (Core: 04 Optional: 01)		29.0 36.5.0	7.5	34.0	
Third Year Second Term						
0512 07 BGE 3201	Fermentation and Bioreactor Design	Core	3.0	-	3.0	None
0111 07 BGE 3203	Technology Transfer	Core	3.0	-	3.0	None
0111 07 BGE 3204	Technology Transfer Sessional & Field Work	Core	-	1.5	1.0	None
0512 07 BGE 3205	Bioinformatics	Core	3.0	-	3.0	None
0512 07 BGE 3206	Bioinformatics Sessional	Core	-	1.5	1.0	None
0512 07 BGE 3207	Medical and Pharmaceutical Biotechnology	Core	3.0	-	3.0	None
0512 07 BGE 3208	Medical and Pharmaceutical Biotechnology Sessional & Field Work	Core	-	1.5	1.0	None
0512 07 BGE 3209	Biopharmaceutical Chemistry	Core	3.0	-	3.0	None
0512 07 BGE 3211	Molecular Breeding	Optional	3.0	-	3.0	None
0512 07 BGE 3213	Biomass and Renewable Energy	Optional	3.0	-	3.0	None
0512 07 BGE 3214	Biomass and Renewable Energy Sessional & Field Work	Optional	-	1.5	1.0	None
0512 07 BGE 3216	Techniques in Molecular Biology Sessional	Optional	-	3.0	2.0	None
Total	Theory (Core: 05, Optional: 02) Sessional (Core: 03 Optional: 02)		21.0 30.0	9.0	27.0	

* Non-credit core sessional course

Course Code	Course Title	Course Status	Contact Hours/Week		Credits	Prerequisites
			Theory	Sessional		
Fourth Year First Term						
0512 07 BGE 4101	Plant Biotechnology and Genetic Engineering	Core	3.0	-	3.0	None
0512 07 BGE 4102	Plant Biotechnology and Genetic Engineering Sessional & Field Work	Core	-	1.5	1.0	None
0512 07 BGE 4103	Animal Biotechnology and Genetic Engineering	Core	3.0	-	3.0	None
0512 07 BGE 4104	Animal Biotechnology and Genetic Engineering Sessional & Field Work	Core	-	1.5	1.0	None
0512 07 BGE 4105	Microbial Biotechnology and Genetic Engineering	Core	3.0	-	3.0	None
0512 07 BGE 4106	Microbial Biotechnology and Genetic Engineering Sessional & Field Work	Core	-	1.5	1.0	None
0512 07 BGE 4107	Downstream Processing	Core	3.0	-	3.0	None
0512 07 BGE 4108	Central Viva	Core	-	1.5	1.0	None
0588 07 RM 4109	Research Methodology	Optional	3.0	-	3.0	None
0512 07 BGE 4111	Bionanoscience	Optional	2.0	-	2.0	None
0512 07 BGE 4113	Molecular Medicine	Optional	3.0	-	3.0	None
0311 07 Econ 4179	Production Economics	Optional	3.0	-	3.0	None
Total	Theory (Core: 04, Optional: 04) Sessional (Core: 04 Optional: 0)		23.0	6.0	27.0	
			29.0			
Fourth Year Second Term						
0512 07 BGE 4201	Food Biotechnology	Core	3.0	-	3.0	None
0512 07 BGE 4202	Food Biotechnology Sessional & Field Work	Core	-	1.5	1.0	None
0512 07 BGE 4203	Environmental Biotechnology	Core	3.0	-	3.0	None
0512 07 BGE 4204	Environmental Biotechnology Sessional & Field Work	Core	-	1.5	1.0	None
0512 07 BGE 4205	Genomics and Proteomics	Core	3.0	-	3.0	None
0512 07 BGE 4206	Thesis*	Optional	-	6.0	4.0	0588 07 RM 4109
0512 07 BGE 4208	Review Report**	Optional	-	3.0	2.0	0588 07 RM 4109
0512 07 BGE 4209	Industrial Biotechnology	Optional	3.0	-	3.0	None
0512 07 BGE 4211	Instrumentation in Biotechnology and Genetic Engineering	Optional	2.0	-	2.0	None
Total	Theory (Core: 03, Optional: 02) Sessional (Core: 02 Optional: 02)		14.0	12.0	22.0	
			26.0			

* A student should register for and pass either 0512 07 BGE 4206: Thesis or 0512 07 BGE 4208: Review report course for fulfilling partial requirements for Bachelor of Science (B.Sc.) in Biotechnology and Genetic Engineering degree.

** A student, who registers for the course 0512 07 BGE 4208: Review report should register for an additional course of a minimum of two credits.

* Non-credit core sessional course

19 Course Description

First Year First Term			
Course Code: 0512 07 BGE 1101		Year: First	Term: First
Course Title	Introduction to Biotechnology and Genetic Engineering		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide the fundamental concepts of Biotechnology and Genetic Engineering (BGE) and its scope of application in various fields of biological sciences.		
Course Objectives	• To provide basic concepts in Biotechnology and Genetic Engineering • To acquire understanding of sector-wise application of BGE • To get acquainted with safety concerns in Biotechnological applications		

	Course Content	CLOs
	Section A	
1	Introduction: Definition; multidisciplinary nature of biotechnology, biotechnology tree, brief historical development, Colour of biotechnology; Major areas and applications of biotechnology and genetic engineering; Biotechnological interventions in developing countries.	1, 2
2	Genetic Engineering: Definition; Concept of recombinant DNA technology and its applications; Recombinants; genome editing tools.	1, 2
3	Biotechnology and Genetic Engineering in Agriculture: Biotechnological tools used in crop, animal and fish production; List of different products obtained from agricultural sector; plant tissue culture, genetically modified organism (GMO); transgenic organism; bio-control of pathogens, insects and pests.	1, 2, 3
4	Biotechnology and Genetic Engineering in Food Production and Processing: Use of microorganism in food production and processing; fermentation; list of different fermented food products; single cell protein (SCP).	1, 2, 3
	Section B	CLOs
5	Biotechnology and Genetic Engineering in Enzyme Production: Definition of enzyme, enzymology and enzyme technology, the nature of enzymes, the application of enzymes, the technology of enzyme production, immobilized enzymes.	1, 2, 3
6	Biotechnology and Genetic Engineering in Medicine: Introduction, regulatory proteins, blood products, antibiotics, vaccines and monoclonal antibodies.	1, 2, 3
7	Biotechnology and Genetic Engineering in Biological Fuel Generation: Photosynthesis - the ultimate energy resource, sources of biomass, ethanol from biomass, methane from biomass, biogas production.	1, 2, 4
8	Biotechnology and Genetic Engineering in Environment: Oil pollution, microbes and geological environment, pesticides and herbicides pollution, heavy metal pollution and sewage disposal.	1, 2, 4
9	Safety in Biotechnology and Genetic Engineering: Problems of organisms, pathogenicity, problems of biologically active biotechnological products.	1, 3

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Know the fundamentals of recombinant DNA technology	1, 2, 3, 4, 5, 10
	CLO2	Explain the applications of Biotechnology	3
	CLO3	Understand basic Biotechnological tools for clonal propagation, animal production, drug development, plant tissue culture, enzyme technology and safety management in laboratory.	1, 2, 3, 7, 10
	CLO4	Know renewable energy resources and sustenance of the environment.	1, 2, 3, 4, 5, 6, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Continuous assessment
CLO2	Lecture and presentation	Continuous assessment and assignment
CLO3	Lecture and presentation	Continuous assessment, assignment and term final exam.
CLO4	Lecture and group discussion	Term final exam.

Learning Materials

Recommended Readings	Dubey, R. C. (1993). *A textbook of biotechnology*. S. Chand & Company Ltd. New Delhi,India. Price, N.C., & Stevens, L. (1999). *Fundamentals of enzymology: The cell and molecular biology of catalytic proteins* (3rd ed.). Oxford University Press, UK. Smith, J. E. (2009). *Biotechnology* (5th ed.). Cambridge University Press, UK. Waites, M. J., Morgan, N. L., Rockey, J. S., & Higton, G. (2009). *Industrial microbiology: An introduction*. Wiley –Blackwell, USA.
Supplementary Readings	Kumar, P., & Mina, U. (2015). *Biotechnology: A problem approache* (4th ed.). Pathfinder Publication, India. Natesh, S. (Ed.). (1987). *Biotechnology in agriculture*. South Asia Books, India. Saltzman, W. M. (2015). *Biomedical engineering: Bridging medicine and technology* (2nd ed.). Cambridge University Press, UK.

Course Code: 0512 07 BGE 1103		Year: First	Term: First
Course Title	Cell Biology		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to understand basic components of prokaryotic and eukaryotic cells, especially macromolecules, membranes, and organelles		
Course Objectives	• To know how cellular components are used to generate and utilize energy in cells • To know cellular components underlying mitotic cell division. • To understand the cell's response to signals from their environment, including other cells.		

	Course Content	CLOs
	Section A	
1	Introduction: Historical perspective of major discoveries. Definition of cell and protoplasm theories.	1
2	Cell Type: Eukaryotic and Prokaryotic cells. Differences between the two types of organism with examples from each.	1
3	Cell Division A: Introduction to mitosis and meiosis. The important differences between the two processes. Abnormalities in mitosis and meiosis, causes & its significance.	2, 3
4	Cell Division B: The phases of the cell cycle, cell cycle check point: types & its significance and cell death. Mechanism of cell division. Cell signalling. Nuclear organization, chromosome replication and cell separation.	2, 3, 4
5	Cell Structure: Introduction to typical eukaryotic cells, description and labeled diagram of cellular structure.	1
	Section B	CLOs
6	Cellular Organelles: Description of the structure and function of the major cellular organelles and cytoplasmic inclusions of the eukaryotic cell including: Biological membrane: Components, structure and its role, plasma membrane, cell wall composition & structure; nucleus, endoplasmic reticulum: smooth/agranular and rough/granular. Golgi apparatus, mitochondria and chloroplast. Ribosome, lysosome, Cytoskeletal structures: microfilaments, microtubules; nuclear proteins, chromosome folding.	1, 2
7	Chromosomes: Morphological structure & architecture and chemical organization of eukaryotic chromosomes and their nomenclature, prokaryotic chromosomes and their characteristics, allocycle and heteropycnosis. Special type of chromosomes: polytene, lampbrush, sex, isochromosomes and diplochromosomes. Primary effect of different types of physical and chemical agents on chromosome morphology.	2, 4
8	Karyotype: Definition, characteristics, constancy, variation and significance.	2, 3

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Identify and distinguish various components of the cell and their functions.	1, 2, 3, 4, 5, 6, 9
	CLO2	Understand inheritance components and mechanism	1, 2, 3, 4, 5, 6, 9
	CLO3	Comprehend regulation of nuclear and cell division	1, 2, 3, 4, 6, 8
	CLO4	Compare how cells conduct and coordinate with other cells and environment	1, 2, 3, 4, 6, 7, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Quiz / continuous assessment
CLO2	Lecture / presentation	Continuous assessment / assignment / term final exam.
CLO3	Lecture / presentation	Continuous assessment / assignment / term final exam.
CLO4	Lecture / group discussion	Term final exam.

Learning Materials

Recommended Readings	De Robertis, E. D. P., & De Robertis, Jr. E. M. F. (2006). *Cell and molecular biology* (8th ed.). Lippincott William & Wilkins, NY, USA. Smith, C., & Wood, Ed. (1996). *Cell biology* (2nd ed.). Chapman and Hall, UK. Thain, M., Hickman, M., Abercrombie, M., Hickman, C. J., & Johnson, N.I. (2004). *The penguin dictionary of biology* (11th ed.). Penguin Books Ltd. UK.
Supplementary Readings	Alberts, B., Heald, R., Hopkin, K., Johnson, A., Morgan, D., Roberts, K., & Walter, P. (2019). *Essential cell biology* (5th ed.).WW Norton & Co. NY, USA. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry*. (7th ed.). WH Freeman & Co. USA.

Course Code: 0512 07 BGE 1104		Year: First	Term: First
Course Title	Cell Biology Sessional		
Course Status	Core		
Credit	1.0		
Prerequisite(s)	None		
Rationale	The course is designed to pursue the education about cell and cellular components.		
Course Objectives	The aim of this course are: • To prepare slides for microscopy. • To identify the parts of a plant cell, observe plant cells in different stages of mitosis and meiosis. • To understand various cytological and cytochemical techniques.		

	Course Content	CLOs
1	Cytological and cytochemical techniques.	1, 2
2	Introduction to the microscope. Use and care of the microscope and its development.	1, 2
3	Different types of microscope available and the various types of microscopy that may be used in cytology. How each type of microscope may be utilized?	1, 2
4	Preparation of tissue for microscopy. The sequential steps necessary for routine tissue preparation prior to light microscopy and electron microscopy. Variation that may be encountered in tissue preparation when using specialized techniques. Stationing for light and electron microscopy.	1, 2
5	Study of different stages of mitosis and meiosis.	2, 3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Operate microscope	1, 2, 3, 4, 6, 8, 9, 10
	CLO2	Prepare tissue for microscopy	1, 2, 3, 4, 5, 6, 8, 9, 10
	CLO3	Recognize different stages of mitosis and meiosis in plant cell.	1, 2, 3, 4, 5, 6, 8, 9, 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture / demonstration / group discussion	Lab work evaluation, lab report evaluation, lab final exam.
CLO2	Lecture / demonstration / group discussion	Lab work evaluation, lab report evaluation, lab final exam.
CLO3	Lecture / demonstration / group discussion	Viva voce, lab final exam.

Learning Materials

Recommended Readings	Davey, J., & Lord, J.M.(Eds.). (2003). *Essential cell biology: A practical approach* (Vol. 1): Cell structure (1st ed.). Oxford University Press, UK. De Robertis, E. D. P., & De Robertis, Jr. E. M. F. (2006). *Cell and molecular biology* (8th ed.). Lippincott William & Wilkins, NY, USA. Gupta, A., & Sati, B.K. (2019). *Practical cell biology manual-Cell biology*. Lambert academic Publisher, Jawale, C., & Dama, L. (2016). *Practical handbook of cytology: Protocols in cell biology*. LAP Lambert Academic Publisher, Germany. Smith, C., & Wood, Ed. (1996). *Cell biology* (2nd ed.). Chapman and Hall, UK. Thain, M., Hickman, M., Abercrombie, M., Hickman, C. J., & Johnson, N.I. (2004). *The penguin dictionary of biology* (11th ed.). Penguin Books Ltd. UK.
Supplementary Readings	Alberts, B., Heald, R., Hopkin, K., Johnson, A., Morgan, D., Roberts, K., & Walter, P. (2019). *Essential cell biology* (5th ed.).WW Norton & Co. NY, USA. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry*. (7th ed.). WH Freeman & Co. USA.

Course Code: 0512 07 BGE 1105	Year: First	Term: First
Course Title	Plant Physiology	
Course Status	Core	
Credit	3.0	
Prerequisite(s)	None	
Rationale	Plant physiology focuses a wide range of processes and functions that plants use to live and survive, including respiration, metabolism, transpiration, plant hormones, environmental response and transport processes. The course will help students to gain a solid foundation in fundamental concepts of plant physiology.	
Course Objectives	• To familiarize the students at the molecular interactions of photosynthesis, respiration and transportation of minerals and nutrients. • To familiarize the processes of plant development, seasonality, flowering time, responses of plants to environmental factors and stresses.	

	Course Content	CLOs
	Section A	
1	Introduction: Importance, scope and application of plant physiology. Seasonal and cultural practices influencing on crop physiology.	1
2	Mineral Nutrition: The sources, chemical composition and classification of plant nutrients, deficiency symptoms and physiological role of macro and micronutrients. Hydroponics and its significance.	1, 2
3	Photosynthesis: Photosynthetic apparatus and pigment system, transformation of light energy into chemical energy, factors affecting photosynthesis, C3, C4 and CAM pathways. Significance of photosynthesis. Source and sink relationship.	2, 3, 4
4	Respiration: Types, respiratory substrates, respiratory quotients, glycolysis, Krebs Cycle, and electron transport system (ETS). Hexose-monophosphate pathway (HMP), photorespiration and its significance.	2, 3, 4
	Section B	CLOs
5	Plant Growth Regulators: Occurrence, classification; physiological & biochemical role of different kinds of growth regulators. Uses of phytohormones in agriculture and plant tissue culture.	1, 3, 4
6	Physiology of Flowering: Mechanism of flowering, florigen and its role in flowering, light image and flowering, photoperiodism and vernalization; factors, mechanism of flower induction and importance.	2, 3, 4
7	Growth and Development: Definition and measurement, factors influencing growth and development, vegetative and reproductive growth, shoot growth patterns, life processes of plants. Concept of leaf area index (LAI), Absolute growth rate and relative growth rate.	1, 2, 3, 4
8	Dormancy and Germination of Seeds: Definition of dormancy, germination and seed viability. Types and causes of dormancy, artificial breaking of dormancy. Types of germination, process of germination and germination tests. Causes of losses of seed viability, parts of monocot and dicot seedlings.	2, 3, 4
9	Stress Physiology: Biotic and abiotic stresses in plants and their effects on plant physiological activity & productivity, mechanism of salt tolerance and drought tolerance.	2, 3, 4

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Describe how plants acquire the resources needed for growth.	1, 2, 9
	CLO2	Differentiate between different mechanisms for resource acquisition.	1, 2, 3, 4, 6, 7, 8, 9
	CLO3	Recognize the general system of signal perception, transduction and response in plants.	1, 4, 5, 6, 7, 9, 10
	CLO4	Interpret experimental evidence relating to plant physiology.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, tutorial and presentation	Quiz, continuous assessment, assignment, presentation and term final exam.
CLO2	Lecture, discussion, tutorial and presentation	Quiz, continuous assessment, assignment, presentation and term final exam.
CLO3	Lecture, discussion, tutorial and presentation	Quiz, continuous assessment, assignment, presentation and term final exam.
CLO4	Lecture, discussion, tutorial and presentation	Quiz, continuous assessment, assignment, presentation and term final exam.

Learning Materials

Recommended Readings	Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.) (2015). *Biochemistry and molecular biology of plants* (2nd ed.). John Wiley & Sons, USA. Datta, S. C. (2008). *Plant physiology*. New Age International Pvt. Ltd. India. Malik, C. P. (1982). *Textbook of plant physiology*. Kalyani Publishers, India. Salisbury, F. B., & Ross, C. W. (1991). *Plant physiology* (4th ed.). CBS Publishers and Distributors, New Delhi, India.
Supplementary Readings	Berg, J. M., Tymoczko, J. L., Gatto, Jr., & Stryer, L. (2015). *Biochemistry* (8th ed.). W.H. Freeman & Company, NY. USA. Buchanan, B. B., Gruissem, W., & Jones, R. L. (Eds.). (2015). *Biochemistry and molecular biology of plants* (2nd ed.). John Wiley & Sons, New Jersey, USA. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry*. (7th ed.). WH Freeman & Co. USA. Taiz, L., & Zeiger, E. (2006). *Plant physiology* (4th ed.). Sinauer Associates, Inc., Sunderland, USA.

Course Code: 0512 07 Bot 1151		Year: First	Term: First
Course Title	Evolutionary and Functional Botany		
Course Status	Optional		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to offer modern concepts in origin of life, diversities and functional aspects of plants for welfare of human and nature.		
Course Objectives	• To know the origin of earth, life as well as plants. • To understand the diversities and its causes in plant kingdom. • To realize biology and role of plants in nature. • To utilize properties of plants in Biotechnology. • To understand plant diseases and control of it.		

	Course Content	CLOs
	Section A	
1	Origin of Plants on the Earth: Matter, energy and life. Origin of earth and its primitive atmosphere. Chemical and biological evolution of life. Endosymbiosis - origin and evolution of plants.	1
2	Diversities in Plant Kingdom: Diversities and causes of diversities in plants. Floristic region of Bangladesh. Structural variability of leaves including leaf structures of C3, C4 and CAM plants.	2
3	Plant Taxonomy: Scope and importance, study of families: Cucurbitaceae and Orchidaceae. Applications-IUCN red list, uses of chromosomes, secondary metabolites, proteins, nucleic acids in plant taxonomy. Phylogenomics as the modern trend in plant taxonomy. Role of taxonomy in the conservation of biodiversity.	1, 2
4	Plant Ecology: Concept of ecology and ecosystem. biomass production and productivity. Ecological factors. mangrove ecosystem. role of green plants in nature. green house effects. concept and applications of molecular plant ecology.	1, 2
	Section B	CLOs
5	Plant Cell and Tissue: Ultra-structure of plant cell. Tissue and tissue systems-concept and classification; characteristics features, functions and distribution of tissues in plant. Importance of studying tissue and tissue systems in Biotechnology and Genetic Engineering.	1, 3
6	Microsporogenesis, Megasporogenesis and Embryogenesis: Anther differentiation, pollen differentiation, development and maturation, male sterility, gametogenesis, mega and micro-sporogenesis, embryogenesis; endosperm, embryo, storage protein of the endosperm and embryo, pollen Biotechnology for crop production and improvement.	1, 3
7	Plant Products for Human Welfare: Methods of phytochemical screening. General chemistry and therapeutic properties of the following: a) alkaloids- Datura, Belladona, Rauwolfia, Chincona. b) glycosides- Digitalis, Aloe, c) steroids- Diascorea. d) phenolics- Capsicum. e) volatile oils- Coriandum, Lemon, Ginger, Clove. A brief account on common medicinal, fibers, oil, fruits, spices and beverage yielding plants in Bangladesh.	1, 4
8	Plant Diseases: Definitions, classification, symptoms, importance and control measures against plant diseases with giving emphasis on Biotechnology & Genetic Engineering.	1, 5

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Understand the basic concepts and theories of botany and life on the earth.	1
	CLO2	Realize the diversities of plant kingdom and the causes behind it.	1
	CLO3	Understand systematics, tissues and reproductions of plants.	1, 2, 5, 8, 9
	CLO4	Recognize functional properties of plants and its Biotechnological utilizations.	1, 2, 3, 4, 5, 7, 8
	CLO5	Identify diseases of plants and its control measures, and Biotechnological implications.	1, 2, 3, 4, 5, 7, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Continuous assessment
CLO2	Lecture and group assignment	Continuous assessment, term final exam.
CLO3	Lecture and/or presentation	Assignment and presentation
CLO4	Lecture and/or group discussion	Term final exam.
CLO5	Lecture and/or field visit	Term final exam.

Learning Materials

Recommended Readings	Bilgrami, K. S., Srivastava, L. M., & Shreemali, J. L. (1992). *Fundamentals of botany* (2nd ed.). Vikas Publishing House, India. Dutta, A. C. (1996). *Botany for degree students* (6th ed.). Oxford University Press, UK. Esau, K. (1977). *Anatomy of seed plants* (2nd ed.). John Wiley & Sons, New Jersey, USA. Gupta, R. K. (1981). *Textbook of systematic botany* (3rd ed.). Atma Ram & Sons, New Delhi, India.
Supplementary Readings	Gulzar, B., Mujib, A., Malik, M. Q., Sayeed, R., Mamgain, J., & Ejaz, B. (2020). Genes, proteins and other networks regulating somatic embryogenesis in plants. *Journal of genetic engineering and biotechnology*, (18), 1-15. Schulze, E. D., Beck, E., & Buchmann, N. et al.(2019). *Plant ecology*. Springer, USA.

Course Code: 0512 07 Bot 1152		Year: First	Term: First
Course Title	Evolutionary and Functional Botany Sessional & Field Work		
Course Status	Optional		
Credit	1.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide practical knowledge on biology, diversities, functional properties, and diseases of plants.		
Course Objectives	• To recognize biology and diversities in plants. • To know functional properties of plants. • To have practical knowledge of plant disease identification & control.		

	Course Content	CLOs
1	Study of diversities of plants including mangroves.	1, 2
2	Herbarium-collection and preservation of medicinal plants.	1, 2
3	Microscopic study of plant cells, stomata, tissues and its components.	3
4	Study of microsporangium and megasporangium.	4
5	Study of important plant diseases.	5

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Recognize diversified plant population.	1, 11
	CLO2	Distinguish adaptive features of plants in different ecosystems.	1, 10, 11
	CLO3	Prepare plant samples for microscopic observation.	1, 10, 11
	CLO4	Understand functional properties of plants and their uses.	1, 3, 4, 6, 8, 11
	CLO5	Identify different plant diseases and discuss the bio-control of it.	1, 3, 6, 8, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and/or physical observation	Final exam.
CLO2	Lecture and/or physical observation	Lab report assessment and final exam.
CLO3	Lecture and/or physical observation	Lab report assessment and final exam.
CLO4	Lecture and/or group discussion	Lab final exam. and viva voce
CLO5	Lecture and field visit	Lab final exam. and viva voce

Learning Materials

Recommended Readings	Bilgrami, K. S., Srivastava, L. M., & Shreemali, J. L. (1992). *Fundamentals of botany* (2nd ed.). Vikas Publishing House, India. Dutta, A. C. (1996). *Botany for degree students* (6th ed.). Oxford University Press, UK. Esau, K. (1977). *Anatomy of seed plants* (2nd ed.). John Wiley & Sons, New Jersey, USA. Foster, A. S. (1958). *Practical plant anatomy* (2nd ed.). D. van Nostrand Co. USA. Shravan, G. (2014). *Handbook of practical botany for degree students*. LAP Lambert Academic Publishing.
Supplementary Readings	Hepler, P. K., & Gunning, B.E.S.(1998)..Confocal fluorescence microscopy of plant cells. *Protoplasma*, (201), 121-157. Maden, K. (2004). Plant collection and herbarium techniques. *Our nature*, 2(1), 53-57.

Course Code: 0541 07 Math 1153		Year: First	Term: First
Course Title	Mathematics		
Course Status	Optional		
Credit	2.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide fundamental knowledge in Mathematics relevant to biological science.		
Course Objectives	• To introduce fundamental theories of mathematical problems. • To know different ways of solving mathematical problems.		

	Course Content	CLOs
	Section A	
1	Functions- Understanding the geometric behavior of elementary functions and families of curves- y=mx+c, y=xn, y=(1/x)n, y=ex, y=logax etc.	1, 2
2	Basic concepts of limit, continuity.	1, 2
3	Differentiation of different types of functions e.g. parametric, explicit etc. Differentials, differentiability and physical meaning of differentiation, applications of differentiation.	1, 2
4	Successive and partial differentiation.	1, 2
5	Expansion of Functions: Rolle's theorem, mean value and Taylor's theorem.	1, 2
6	Maxima and Minima: Single variable and it's applications.	1, 2
7	Tangent and normal.	1, 2
8	Indeterminate forms.	1, 2
	Section B	CLOs
9	Basics of Integration: Definite and indefinite, proper and improper integrals, antiderivative and physical meaning of integration.	1, 3
10	Integration by method of substitution.	1, 3
11	Integration by parts.	1, 3
12	Special trigonometric functions.	1, 2
13	Definite Integrals: Fundamental theorem and properties of integrals.	1, 3
14	Application of Definite Integral in Geometry Science and Engineering: Area between two curves, volumes by slicing, solids of revolution, area of a surface of revolution, length of a curve.	1, 3
15	Beta and gamma functions.	1, 2

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Acquire deep knowledge of mathematics in relation to technologies used in biology.	1, 2, 3, 8, 9
	CLO2	Learn the basic ideas, tools and techniques of mathematical analysis.	1, 2, 3, 7, 8, 9
	CLO3	Employ deferential and integral calculus to solve problems from real-life applications.	1, 8, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and group task	Quiz, assignments
CLO2	Lecture and presentation	Class test, term final exam.
CLO3	Lecture and presentation	Assignments, term final exam.

Learning Materials

Recommended Readings	Das, B. C., & Mukherjee, B. N. (2018). *Integral calculus* (54th ed.). UN Dhur & Sons (Pvt) Ltd. West Bengal, India. Das, B. C., & Mukherjee, B. N. (1993). *Differential calculus* (55th ed.). UN Dhur & Sons (Pvt) Ltd. India. Khanna, M. L. (1993). *Matrices* (12th ed.). Jaiprakash Nath & Co.India. Sattar, S. A. (1992). *A text book of higher trigonometry* (6th ed.). Ali Publications. Dhaka.
Supplementary Readings	Blair, J., Tobey, J., Slater, J., & Crawford, J. (2016). *Prealgebra* (6th ed.). Pearson, England, UK. Karsai, I., & Kampis, G. (2010). The crossroads between biology and mathematics: The scientific method as the basics of scientific literacy. *BioScience*, (60) (8), 632-638. Tiwari, M. (2012). Mathematical applications into the cells. *Journal of natural science, biology and medicine*, (3) (1), 19.

Course Code: 0531 07 Chem 1155		Year: First	Term: First
Course Title	Inorganic and Biophysical Chemistry		
Course Status	Optional		
Credit	2.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide basic concepts and organizing principles of inorganic chemistry and valuable insights in analytical and biophysical chemistry.		
Course Objectives	• To describe the evolution of atomic theory from earlier models of the atom to the modern-day quantum mechanical view of an atom. • To demonstrate an understanding of the quantum mechanical model of the atom and explain how this model accounts for the arrangement of the elements in the periodic table and the observed trends in the atomic properties of these elements. • To describe the various models of chemical bonding and use these bonding models to predict the geometry and properties of molecules. • To explain the principles and theories in the area of "Biophysical Chemistry" with relation to biological examples.		

	Course Content	CLOs
	Section A	
1	Chemistry: Definition, scope, objectives of the study of chemistry in Biotechnology and Genetic Engineering.	1
2	Atomic Structure and Periodic Table: Early views about atomic structure, introduction to quantum theory; photoelectric effect, Bohr's theory, wave mechanical approach about atomic structure, Quantum number, electronic configuration, periodic relationship among the elements; periodic variation in physical and chemical properties.	1
3	Chemical Bonding: Definition, types, covalent vs. ionic bond, coordinate covalent bonding; bonding in transition metal complex, molecular geometry and molecular orbits, chemical bonding and structural theory, intermolecular and intramolecular forces, acidity and basic properties.	1
4	Chemistry of Elements: Chemistry of metal, nonmetallic elements and their compounds, transition metal chemistry and coordination compounds; chemistry of iron and copper.	1
	Section B	CLOs
5	Thermodynamics: Open, closed and isolated systems; 1st Law of thermodynamics, enthalpy; biological application and 2nd law of thermodynamics; entropy and physiological steady-state; Gibb's free energy; biological applications.	2
6	Ionization and Electrolysis: Ionization and colligative properties, solubility product, common ion effect, electrolysis and electrolytic conductance, dielectric constant, dilution and conductance.	3
7	Hydrogen Ion Concentration: Protolysis of water, acids, bases and salts; buffers; buffer capacity; biological relevance and effects of pH; measurement of pH; maintenance of pH, electrode potential; potentiometric titration.	3
8	Colloids and Surface Phenomena: Colloids, dialysis, electrodialysis and ultrafiltration; electrophoresis, surface tension and interfacial tension, Gibbs-Donnan membrane equilibrium, adsorption, chromatography, biological membrane potential, macromolecules.	3

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Apply scientific data, concepts and different models of inorganic chemistry.	1, 2, 3
	CLO2	Understand system, various laws of thermodynamics and their uses in biological systems.	1, 2
	CLO3	Learn various topics of biophysical chemistry like, electrolysis, colligative properties, protolysis of water, acid, bases and buffers, buffering in human body. Colloids and surface phenomena etc.	1, 2, 3

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and presentation	Continuous assessment and term final examination
CLO2	Lecture and presentation	Continuous assessment and term final examination
CLO3	Lecture, presentation and group discussion	Continuous assessment, assignment and term final examination

Learning Materials

Recommended Readings	Chang, R., & Goldsby, K.A. (2012). *Chemistry* (11th ed.). McGraw Hill Education, NY, USA. Das, D. (1982). *Biophysics & biophysical chemistry* (6th ed.). Academic Publishers, Cambridge, UK. Klostermeier, D., & Rudolph, M. G. (2020). *Biophysical chemistry* (1st ed.). CRC Press, Florida, USA. Lee, J. D. (1999). *Concise inorganic chemistry* (5th ed.). Wiley- Blackwell, New Jersey, USA.
Supplementary Readings	Allen, J. P. (2008). *Biophysical chemistry*. Wiley-Blackwell, New Jersey, USA. Kalidas, C., & Sangaranarayanan, M. V. (2020). *Biophysical chemistry: Techniques and applications*. Ane Books Pvt. Ltd. India.

Course Code: 0531 07 Chem 1156		Year: First	Term: First
Course Title	Inorganic and Biophysical Chemistry Sessional		
Course Status	Optional		
Credit	1.0		
Prerequisite(s)	None		
Rationale	Students need hands on training in preparation of standard solutions and volumetric analysis through different titrations. This course will also help the students to learn physico-chemical principles underlying biological processes.		
Course Objectives	• Graduates will be able to understand the objective of their chemical experiments, properly carry out the experiments, and appropriately record and analyse the results. • Will be able to use standard laboratory equipment, modern instrumentation and classical techniques to carry out experiments. • Will know and follow the proper procedures and regulations for safe handling and use of chemicals. • Graduates will be able to communicate the concepts and results of their laboratory experiments through effective writing and oral communication skills.		

	Course Content	CLOs
1	Maintenance of chemistry laboratory.	1
2	Preparation of standard solutions.	1, 2
3	3. Volumetric analysis: a) Acid-base titration: Determination of the strength of the acid/base. b) Oxidation-reduction titration: Determination of the amount of iron by standard KMnO4. c) Iodometric titration: Determination of the amount of copper by standard Na2S2O3. d) Precipitation titration: Determination of chloride by standard AgNO3 solution. e) Complexometric titration: Determination of Ca and Mg by EDTA titration.	1, 2
4	Measurement and maintenance of pH.	1, 2

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Acquainted with the basic laboratory instruments and understand the principles of measurements used in inorganic and biophysical chemistry.	1, 2, 3, 4, 6
	CLO2	Understand fundamental concepts and application of physico-chemical principles underlying biological processes.	1, 2, 3, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and/or physical observation	Lab report assessment and final exam.
CLO2	Lecture and/or physical observation / group discussion	Lab final exam. and viva voce

Learning Materials

Recommended Readings	Khaleque, A. (1999). *A text book of practical chemistry*. Ideal Library, Dhaka. Marshal, A. G. (1978). *Biophysical chemistry: Principles, techniques and applications*. Wiley- Blackwell, USA. Mendham, J., Denney, R. C., Barnes, J.D., Thomas, M., & Sivasankar, B. (2009). *Vogel's textbook of quantitative chemical analysis* (6th ed.). Pearson education, London, UK.
Supplementary Readings	Lee, J. D. (1999). *Concise inorganic chemistry* (5th ed.). Wiley- Blackwell, New Jersey, USA. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry*. (7th ed.). WH Freeman & Co. USA. Pass, G. (1979). *Practical inorganic chemistry: Preparations, reactions and instrumental methods* (2nd ed.). Springer, NY, USA.

First Year Second Term			
Course Code: 0512 07 BGE 1201		Year: First	Term: Second
Course Title	Microbiology		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course will provide basic knowledge on microorganisms with giving emphasize on bacteria. This course will help to familiarize with the fundamental scientific concepts and basic skills utilized in microbiology to enable students to expand their knowledge of the microscopic world in general, or for taking more advanced courses in related fields.		
Course Objectives	• Demonstrate an understanding of microbiological principles and methods. • Deliver basic skills on microscopy. • Provide scope and applications of microorganisms in biotechnology.		

	Course Content	CLOs
	Section A	
1	Introduction to Microbiology: Microorganisms in the living world; germ theory of disease; major areas of microbiology.	1
2	Microscopic Examination of Microorganisms: Microscope and microscopy, types, preparations for light-microscopic examinations.	1, 3
3	Characterization, Classification and Identification of Microorganisms: Major characteristics of microorganisms; microbial classification and identification.	1, 2
4	Virus: General Characteristics; morphology, structure and components; isolation, cultivation, identification and classification of viruses; replication- lytic and lysogenic cycles; a brief account on common viral diseases of plants, animals and humans.	1, 2, 4
5	Bacteria: Morphology, size, shape and arrangement of bacterial cells; structures, chemical compositions and functions of flagella, pili, capsules, and cell wall; structures internal to the cell wall.	1, 2
6	Special Groups of Microorganisms: Structure, characteristics, reproduction and importance of Prions, Viroids, Spirochaetes, Rickettsiae, Mycoplasma, and Actinomycetes.	1, 2
	Section B	CLOs
7	Growth, Cultivation and Preservation of Bacteria: Modes of cell division; normal growth cycle (growth curve) of bacteria, nutritional requirements and nutritional types of bacteria; bacteriological media, physical condition required for growth; quantitative measurement of bacterial growth, methods of maintenance and preservation of bacteria.	1, 2, 4
8	Control of Microorganisms: Fundamentals of control; the control of microorganisms by physical and chemical agents.	1, 4, 5
9	Bacterial Diseases: A brief account on common bacterial diseases of plants, animals and/or humans in relation to *Pseudomonas, Salmonella, Shigella, Vibrio, Clostridium, Xanthomonas* & *Corynebacterium*.	1, 5
10	Microbes in Biotechnology: A general account of products and functions of microorganisms used in Biotechnology.	6

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Understand microbial world.	1, 2, 3, 4, 5, 6, 10, 11
	CLO2	Characterize and classify microorganisms.	1, 2, 3, 4, 6, 10, 11
	CLO3	Learn different types of microscope and microscopy.	1, 2, 3, 4, 6
	CLO4	Recognize the methods of studying microorganisms.	1, 2, 3, 4, 6, 9
	CLO5	Explain microbial diseases and their control	1, 2, 3, 6, 7, 8, 9, 10, 11
	CLO6	Explore microorganisms in biotechnology.	1, 2, 3, 4, 5, 6, 9, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, presentation, discussion	Quiz, assignment, exam.
CLO2	Lecture, presentation, training	Quiz, assignment, exam.
CLO3	Lecture, training	Term final exam.
CLO4	Lecture, training	Term final exam.
CLO5	Lecture, presentation, discussion	Assignment, exam.
CLO6	Lecture, presentation, discussion	Assignment, exam.

Learning Materials

Recommended Readings	Chowdhury, M. R. (1990). *Modern medical microbiology* (5th ed.). Bishaw Parichay. Dhaka, Bangladesh. Clarke, S. C. (2003). *Modern medical microbiology: The fundamentals* (1st ed.). Hodder Education Publishers, London, UK. Kreig, N. R., Chan, E. C. S., & Pelczar, M. J. Jr. (1993). *Microbiology: Concepts and applications*. McGraw-Hill Education, NY, USA. Madigan, M. T., Bender, K. S., Buckley, D. H., Sattley, W.M., & Stahl, D.A. (2020). *Brock biology of microorganisms*. (16th ed.). Pearson Education, London, UK. Tortora, G. J., Funke, B. R., Case, C. L., Bair, W.B., & Weber, D. (2023). *Microbiology: An introduction* (14th ed.). Pearson, London, UK.
Supplementary Readings	Burdass, D., Grainger, J., & Hurst, J. (2016). *Basic practical microbiology: A manual*. Microbiology Society, London, UK. Dubey, R. C., & Maheshwari, D. K. (2002). *Practical microbiology* (4th ed.). S. Chand Publishing, India.

Course Code: 0512 07 BGE 1202		Year: First	Term: Second
Course Title	Microbiology Sessional & Field Work		
Course Status	Core		
Credit	1.0		
Prerequisite(s)	None		
Rationale	This course is designed to provide practical knowledge on basic methods and techniques in microbiology and microscopy. It will explain the classical methods in bacteriology for the exploitation of bacterial traits and metabolites in biotechnology.		
Course Objectives	• To demonstrate the basic methods and techniques in studying bacteria. • To provide practical hands on detecting important traits and metabolites.		

	Course Content	CLOs
1	Isolation, pure culture preparation and characterization of bacteria.	1, 4
2	Microscopic examination of bacteria- wet mount preparation, hanging drop technique, simple staining, gram staining, and acid-fast staining.	1, 2
3	Measurement of bacterial growth and construction of growth curve.	1, 3
4	Susceptibility of microbes against antibiotics, antibacterial drugs and natural compounds.	1, 4
5	Determination of Minimum Inhibition Concentration (MIC) of antibiotics against isolated bacteria.	1

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Understand the basic methods and techniques used for studying bacteria.	1, 2, 3, 9, 10, 11
	CLO2	Familiar with the use and care of microscope	1, 3, 10, 11
	CLO3	Explain bacterial growth.	1, 2, 3, 4, 5, 6, 7, 8, 10, 11
	CLO4	Explore bacterial traits and metabolites.	1, 2, 3, 4, 5, 6, 9, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, presentation, hands on training	Quiz, assignment, exam., viva voce
CLO2	Lecture, hands on training	Assignment, exam., viva voce
CLO3	Lecture, presentation, hands on training	Final exam., viva voce
CLO4	Lecture, hands on training	Lab final exam., viva voce

Learning Materials

Recommended Readings	Burdass, D., Grainger, J., & Hurst, J. (2016). *Basic practical microbiology: A manual*. Microbiology Society, London, UK. Dubey, R. C., & Maheshwari, D. K. (2002). *Practical microbiology* (4th ed.). S. Chand Publishing, India. Saravanan, R., Dhachinamoorthi, D., & Rao, C.M.M. P. (2019). *A handbook of practical microbiology*. LAP Lambert Academic Publishing, Germany.
Supplementary Readings	Chowdhury, R. (1990). *Modern medical microbiology*. Bishaw Parichay, Dhaka. Stanier R. Y., Adelberg E. A., & Ingraham I. J. (1999). *General microbiology* (4th ed.). Macmillan Publisher, London, UK. Tortora, G. J., Funke, B. R., Case, C. L., Bair, W.B., & Weber, D. (2023). *Microbiology: An introduction* (14th ed.). Pearson, London, UK..

Course Code: 0512 07 BGE 1203		Year: First	Term: Second
Course Title	Principles of Genetics		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide basic concepts in heredity, inheritance patterns in plants, animals and microbes, nature of genetic materials and their transmission pattern, sex determinations mechanisms in various organisms, mutations and implications in living organisms as well as in society.		
Course Objectives	To learn and understand basic principles of genetics, laws of inheritance at the cellular, individual and population level as well as basic molecular mechanisms by which genes control growth, development and morphology.		

Course Content		CLOs
Section A		
1	Introduction: Definition, history, scope and branches of genetics. Importance of genetics in human society. Heredity and its physical basis, chromosome theory of heredity, genetic materials, Brief account of the structure and function of gene. The evaluation of science of genetics leading to the modern Biotechnology and Genetic Engineering.	1, 2
2	Variation: Concept, type and significance of variation in biological world, natural sources of variation, causes of genetic variation in asexually reproducing organism (Bacteria, fungi,); Sexual reproductive cycle (Gametogenesis) of yeast, Drosophila and mammals.	2, 3
3	Mendelism: History and Mendel's experiments with pea plants. Mendelian Principles I & II and relevant terminology, the physical basis of law of segregation and law of random assortment. Mendelian heredity in human and animal.	2, 3, 4
4	Beyond the Mendelian Genetics: Introduction, types of interactions and discussion of different kinds of allelic and non-allelic interactions of genes. Modifiers, expressivity, heterosis, transgressive segregation. Multiple factors, xenia, multiple allelism and cytoplasmic inheritance.	3, 5
Section B		CLOs
5	Crossing Over: Definition, types and importance of crossing over. Genetical consequences of crossing over. Theories on the mechanisms of crossing over. Generalized mechanism of crossing over. Factors affecting recombination frequencies.	1, 2
6	Linkage and Mapping: Definition, types and importance of linkage. History and different hypotheses of linkage, detection of linkage. Inheritance pattern of linked genes. Genetic and cytological mapping of chromosomes: Concepts, methods of determining cytological and genetic mapping.	3, 5
7	Sex Chromosomes and Sex Determination: Discovery of sex chromosomes, different mechanism of sex determination.	3, 5, 6
8	Chromosomal Aberrations: Types of structural and numerical changes of chromosomes and mechanisms, consequences of changing chromosome structure and number.	3, 4
9	Gene Mutation: Definition, types, causes & effects of gene mutation and mechanisms. Mutagens and its types.	5, 6

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Demonstrate sound understanding of basic concepts, history, scope, application, .gene, genomics, structure and functions of gene, gene expression and regulation, sex determination mechanism, gene linkage, mapping, mutation and theories of genetics.	1, 2
	CLO2	Explain and interpret Mendelian and non-Mendelian theories of genetics, gene interactions etc.	2
	CLO3	Apply gained knowledge of genetics in their personal life, family, society and various application areas to develop products e.g animal breeds, fishes, and improved crop varieties.	3, 6
	CLO4	Integrate various concepts and theories of genetics into solutions.	3, 5, 10
	CLO5	Communicate effectively and interact with peers, society about genetical phenomena relevant to social development.	1, 2, 5, 6, 7, 8, 10
	CLO6	Think critically to analyze various genetical phenomena, innovations and recent discoveries and practice ethical issues.	4, 6, 9, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, presentation	Assignment, class test
CLO2	Lecture, presentation, group discussion	Assignment, class test
CLO3	Lecture, presentation, field demonstration	Class test
CLO4	Lecture, presentation, group work	Term final exam.
CLO5	Lecture, presentation	Term final exam.
CLO6	Lecture, presentation	Term final exam.

Learning Materials

Recommended Readings	Gardner, E.J., Simmons, M. J., & Snustad, D. P. (1991). *Principles of genetics* (8th ed.). Wiley & Sons, New Jersey, USA. Gelbert, W. M., Lewontin, R.C., Wessler, S.R., Suzuki, D. T., Miller, J.H., & Griffiths, J.F. (2004). *Introduction to genetic analysis*. (8th ed.). W. H. Freeman & Co. Ltd. Islam, A. S (1973). *Fundamentals of genetics*. Humaira Islam, Dhaka. Lewin, B. (2007). *Genes IX* (9th ed.). Jones and Bartlett Publishers, MA, USA. Russel, J. P. (1986). *Genetics*. Little, Brown and Co. Boston, USA. Strickberger, M. W. (2015). *Genetics* (3rd ed.). Pearson, India.
Supplementary Readings	Finkeldey, R., & Hattemer, H.H. (2006). *Tropical forest genetics*. Springer Science & Business Media. Hartl, D. L. (2022). *Essential genetics and genomics* (7th ed.). Jones & Bartlett Publishers. Hurston, Z. N. (2008). *Mules and men*. Amistad Publication, USA. Ohno, S. (2013). *Evolution by gene duplication*. Springer Science & Business Media. Ottenheimer, M. (1996). *Forbidden relatives: The american myth of cousin marriage* (1st ed.). University of Illinois Press, Illinois, USA.

Course Code: 0512 07 BGE 1204		Year: First	Term: Second
Course Title	Principles of Genetics Sessional & Field Work		
Course Status	Core		
Credit	1.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide fundamental concepts and practical implications of genetics, inheritance patterns and sex determination mechanisms in animals and plants		
Course Objectives	• To apply learned genetical principles in plants like maize, pea plants, tomatoes and laboratory animals like insects (Drosophila spp., honey bee), poultry birds, pigeon, fish, and humans. • Solving conceptual and experimental genetic problems. • To construct pedigree chart. • To construct genetic linkage map.		

	Course Content	CLOs
1	Working out the problems on Mendelian inheritance pattern.	1, 2, 3
2	Working out the problems on modified Mendelian inheritance ratios.	1, 2, 3
3	Working out the problems on two and three point testcross for linkage and crossing over.	2, 3, 4
4	Working out the problems on linked genes and blood group inheritance.	3, 4
5	Study of pea and corn genetics: Dominant-recessive characters, observing recombination and segregation pattern of traits after crossing different corn types.	4, 5, 6
6	Study of human genetic traits: PTC taste test and survey of human phenotypic characteristics like-holandric gene effect, fingerprint, iris color, colorblindness, albinism and thalassemia	3, 4, 5, 6

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Explain and interpret Mendelian and Non-Mendelian inheritance pattern	1, 2, 9
	CLO2	Apply acquired genetic principles and theories in various fields	3, 9
	CLO3	Analyse and solve various problems related to transmission genetic (Mendelian, non-Mendelian and geneinteractions, Sex-linkage etc.) traits using learned genetic principles.	3, 4, 9, 10
	CLO4	Construct pedigree chart, genetic and linkage maps.	3
	CLO5	Genetic counselling in the families and societies to eradicate wrong concepts like sole responsibility of the mother for giving birth of female children only, and some genetic diseases like thalassemia, Down's syndrome, albinism and consanguineous marriage etc.	3
	CLO6	Demonstrate ethical issues of human genetics in our society	10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Presentation, group discussion	Quiz
CLO2	Presentation and practical work	Lab report evaluation
CLO3	Presentation and practical work	Evaluation of solution of given problems
CLO4	Presentation and practical work	Evaluation of prepared pedigree chart
CLO5	Presentation, field survey	Field survey report evaluation
CLO6	Presentation, group discussion	Lab final exam. and viva voce

Learning Materials

Recommended Readings	Islam, A. S. (1973). *Fundamentals of genetics*. Humaira Islam, Dhaka. Bedis, M.R. (2014). *Practical approaches on principles of genetics*. Universal Prakashan, India. Clarke, A. (1994). *Genetic counseling: Practice and principles* (1st ed.). Routledge, London, UK. Jones, R.N. (1991). *Practical genetics*. Open University Press Lewis, R. (2017). *Human genetics* (12th ed.).McGraw Hill Education, UK. Griffiths, A. J. F., Wessler, S. R., Lewontin, R. C., Gelbart, W. M., Suzuki, D.T., & Miller, J. H. (2005). *Introduction to genetic analysis* (8th ed.). WH Freeman & Co. NY, USA.
Supplementary Readings	Arner, G.B.L. (2013). *Consanguineous marriages in the American population*. Tredition Classics Publisher. MacFarlane, I., & Veach, P.M. (2014). *Genetic counseling research: A practical guide*. Oxford University Press, UK. Sharma, P.P., & Dashora, A. (2023). *Practical fundamentals of genetics*. Wiley. Shaw, A., & Raz, A. (2015). *Cousin marriages: Between tradition, genetic risk and cultural change*. Berghahn Book. Sheppard, P. M. (1973). *Practical genetics*. Wiley.

Course Code: 0512 07 BGE 1205	Year: First	Term: Second
Course Title	Biomolecules	
Course Status	Core	
Credit	3.0	
Prerequisite(s)	None	
Rationale	The course is designed to provide the basic concepts on the chemistry of biomolecules. Furthermore, the course offers introductory knowledge on the four major classes of biomolecules, namely carbohydrate, lipid, protein and nucleic acid.	
Course Objectives	• To introduce the basic concepts of biomolecules. • To demonstrate how fundamental organic chemistry defines the structure and thereby the function of these biological macromolecules.	

	Course Content	CLOs
	Section A	
1	Introduction: Basic concepts of Biomolecules.	1, 2
2	Stereoisomerism: Introduction, enantiomers, chiral centre, configuration, specification of configuration: R and S, Diastereomers, Meso compound, Conformational isomers.	1, 2
3	Carbohydrates: Nomenclature, classification, optical properties, structures and general reactions, mono and polysaccharides, aminosugars and other important saccharides. Sources and biological functions of major carbohydrates.	1, 2
4	Lipids: Nomenclature, classification and general reactions of fats, fatty acids and sterols; structure and biological functions of acylglycerols, wax, phospholipids, terpenes, steroids and eicosanoids.	1, 2
	Section B	CLOs
5	Amino acids and peptides: Structural features, optical activity and classification of amino acids, ionization of amino acids in solutions, titration curve of amino acids, isoelectric properties, and general reactions of amino acids. Peptides of biological interest.	1, 2
6	Proteins: General introduction; classification based on shape, structure and biological function; sequence determination of protein; preliminary concept on secondary, tertiary and quaternary structure of proteins; fibrous proteins: α and β-keratins. Globular proteins: structure of myoglobin, oligomeric proteins and quaternary structure of hemoglobin, oxygen binding curve of hemoglobin and myoglobin.	1, 2
7	Nucleotides and nucleic acids: Occurrence, structure and physico-chemical properties.	1, 2

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Explain the basic of biological macromolecules and their properties	1, 6, 7
	CLO2	Apply and analyze results from methods used to analyze different classes of biomolecules	2, 3

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, presentation, group discussion	Written test, assignment, quiz
CLO2	Lecture, presentation, group discussion	Written test, assignment, term final exam.

Learning Materials

Recommended Readings	Bahl, A., & Bahl, B. S.. (2021). *Textbook of organic chemistry* (22nd ed.). S. Chand & Company Ltd. Lehninger, A. L. (1975). Biochemistry: *The molecular basis of cell structure and function* (2nd ed.). Worth Publishers. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry* (7th ed.). WH Freeman & Co.
Supplementary Readings	Morrison, R. T., & Boyd, R. N. (2007). *Organic chemistry* (6th ed.). Prentice Hall of India. Raymond, C., & Overby, J. (2018). *Chemistry* (13th ed.). Mc Graw-Hill, Inc. USA. Streitwieser, J. A., & Healthcock, I.C.H. (1981). *Introduction to organic chemistry* (2nd ed.). Memillan Publishing Co. Tewari, K. S., & Vishnoi, N. K. (2017). *A text book of organic chemistry* (4th ed.). Vikas Publishing House Pvt. Ltd. India.

Course Code: 0512 07 BGE 1206		Year: First	Term: Second
Course Title	Biomolecules Sessional		
Course Status	Core		
Credit	1.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide the basic laboratory concepts and skills on the chemistry of biomolecules. This is the first Sessional course in the BSc. in Biotechnology program where students will deal with the biomolecules in isolation as well as in the living system towards the aim to analyze them on the basis of their fundamental features.		
Course Objectives	• To introduce the basic laboratory practices and skill needed to handle biomolecules. • To demonstrate the fundamental analytical techniques appropriate for the different classes of biomolecules.		

	Course Content	CLOs
1	Preparation of Buffer solution	1, 2, 3, 4
2	Color tests for Carbohydrates: (i) Molisch's test (ii) Benedict test.	1, 2, 3, 4
3	Estimation of sugar content of blood by Nelson-Somogyi method.	1, 2, 3, 4
4	Determination of protein content of blood by Biuret method and calculation of A/C ratio.	1, 2, 3, 4
5	Determination of iodine number of lipid.	1, 2, 3, 4
6	Chromatographic techniques	1, 2, 3, 4

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Handle necessary tools and equipment in a reproducible manner.	2, 6, 7
	CLO2	Make dilution series and measure these spectrophotometrically.	2, 3
	CLO3	Demonstrate knowledge about different separation techniques used for biomolecules.	7
	CLO4	Outline the principles in spectrophotometrical measurements, be familiar with using a spectrophotometer in biochemical studies.	2, 3

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, demonstration, presentation, group discussion, laboratory hands on training, fieldwork	Written test, assignment, viva voce
CLO2	Lecture, demonstration, presentation, group discussion, laboratory hands on training, fieldwork	Written test, assignment, viva voce
CLO3	Lecture, demonstration, presentation, group discussion, laboratory hands on training, fieldwork	Lab work evaluation, viva voce
CLO4	Lecture, demonstration, presentation, group discussion, laboratory hands on training, fieldwork	Lab report evaluation, final exam., viva voce

Learning Materials

Recommended Readings	Bahl, A., & Bahl, B.S. (2021). *Textbook of organic chemistry* (22nd ed.). S. Chand & Company Ltd. India. Geethak, D. (2016). *Practical biochemistry* (2nd ed.). Jaypee Pub. India. Lehninger, A. L., Nelson, D. L., & Cox, M. M. (1993). *Principles of biochemistry* (2nd ed.). CBS Publishers and Distributors, India. Lehninger, A. L. (1978). *Biochemistry* (2nd ed.). Worth Publishers. Stryer, L. (1995). *Biochemistry* (4th ed.). W H Freeman & Co. NY, USA.
Supplementary Readings	Morrison, R. T., & Boyd, R. N. (2007). *Organic chemistry* (6th ed.). Prentice Hall of India.

Course Code: 0531 07 Chem 1257	Year: First	Term: Second
Course Title	Organic Chemistry and Spectroscopy	
Course Status	Core	
Credit	2.0	
Prerequisite(s)	None	
Rationale	The course will provide basic knowledge on Organic Chemistry relevant to understanding more advanced courses in Biotechnology	
Course Objectives	Provide basic knowledge on Fundamentals of organic chemistry and spectroscopy with applications relevant to Biotechnology.	

	Course Content	CLOs
	Section A	
1	Structure and Properties of Organic Molecules: Chemical bonding and structural theory, concept of hybridization; hybrid orbitals, shape of organic molecules, single bond (σ), double bond (π), rotation of single bond vs. rigidity of double bond, cis-trans isomer, geometric isomers, E-Z isomers.	1, 2
2	Characteristic Chemical Reactions and Organic Reaction Mechanism with Particular Reference to the Functional Groups: Free radical reaction, nucleophilic substitution reaction, nucleophilic addition reaction, elimination reaction, electrophilic substitution reaction and electrophilic addition reaction.	1, 2
3	Role of Solvent and Secondary Bonding: Solubility, non-ionic and ionic, the SN1 and SN2 reactions; role of solvent, Solvolysis, medium; concept of conjugation and resonance.	1, 2
4	Some important organic reactions: Friedel-Crafts alkylation and acylation, aldol condensation reaction, Reimer-Tiemann reaction, Kolbe reaction.	1, 2
	Section B	CLOs
5	Determination of Structure: Spectroscopic methods, electromagnetic spectrum, absorption of electromagnetic radiation by organic molecules, spectrophotometer and absorption spectrum.	2, 3
6	Ultraviolet and Visible Spectroscopy: Electronic transitions, definition of some terms and designations of UV absorption bands, general applications of Ultraviolet spectroscopy, λmax, WoodWard-Fieser rules.	2, 3
7	Infrared Spectroscopy: Absorption in the Infrared region, molecular vibrations and calculation of vibrational frequencies, Interpretation of infrared spectra-characterization of functional groups, application of infrared spectra.	2, 3
8	Nuclear Magnetic Resonance (NMR): Theory of NMR spectroscopy, chemical shift, spin-spin coupling, coupling constant, carbon-13 NMR (CMR) spectroscopy, application of NMR spectroscopy, mass spectroscopy.	2, 3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Understand the relationship between structure and function of molecules	1, 2, 3, 4, 5, 6, 8
	CLO2	Evaluate the major classes of reactions, reaction energetics and mechanisms.	1, 2, 3, 4, 5, 6, 8, 9
	CLO3	Apply and analyse various spectroscopic techniques to determine structure and synthesis of organic compounds.	1, 2, 3, 4, 5, 6, 8, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, presentation, group discussion	Written test, assignment
CLO2	Lecture, presentation, group discussion	Written test, assignment
CLO3	Lecture, presentation, group discussion	Written test, assignment, term final exam.

Learning Materials

Recommended Readings	Bahl, A., & Bahl, B.S. (2021). *Textbook of organic chemistry* (22nd ed.). S. Chand & Company Ltd. India. Delgado, J.N., & Remors, W. A. (1991). *Wilson and Gisvold's textbook of organic medical and pharmaceutical chemistry* (9th ed.). J. B. Lippincott Company. Finar, I. L. (2012). *Organic chemistry* (Vol-I)) (6th ed.). Pearson, India. Kalsi, P.S. (2006). *Spectroscopy of organic compounds.* New Age International Ltd. Pub. India.
Supplementary Readings	Morrison, R. T., & Boyd, R. N. (1992). *Organic Chemistry* (6th ed.). Prentice-Hall. Raymond, C. (1981). *Chemistry* (5th ed.). Mc Graw-Hill, Inc. Streitwieser, J. A., & Healthcock, .C.H. (1981). *Introduction to organic chemistry* (2nd ed.). Memillan Publishing Co. Tewari, K. S., Mehrotra, S. N., & Vishnoi, N. K. (1994). *A text book of organic chemistry*. Vikas Publishing House Pvt. Ltd.

Course Code: 0531 07 Chem 1258	Year: First	Term: Second
Course Title	Organic Chemistry and Spectroscopy Sessional	
Course Status	Core	
Credit	1.0	
Prerequisite(s)	None	
Rationale	This course is designed to provide a fundamental overview of organic chemistry and spectroscopy to students relevant to understand more advanced courses in Biotechnology	
Course Objectives	Provide basic knowledge on fundamentals of organic chemistry and spectroscopy with applications relevant to Biotechnology	

	Course Content	CLOs
1	Experimental techniques.	1
2	Investigation and characterization of organic compounds: a) Preliminary examinations b) The study of solubility behaviour c) Detection of elements present d) Functional group identification	2, 3
3	Spectroscopic study of organic compounds e.g. λmax determination, IR spectrum of functional group.	2, 4

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Characterize the organic compounds; their solubility behavior.	1, 2, 3, 4, 5, 6, 9, 10
	CLO2	Detect the types of chemical compounds present in their samples.	1, 2, 3, 4, 5, 6, 8, 9, 10
	CLO3	Determine the functional group identification	1, 2, 3, 4, 5, 6, 8, 9, 10
	CLO4	Perform spectrometric absorption of different organic compounds and chromatographic techniques	1, 2, 3, 4, 5, 6, 7, 8, 9, 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture / demonstration / group discussion	Lab report assessment / assignment / final exam.
CLO2	Lecture / demonstration / group discussion	Lab report assessment /assignment / final exam.
CLO3	Lecture / demonstration / group discussion	Lab work evaluation / assignment / final exam.
CLO4	Lecture / demonstration / group discussion	Viva voce / lab final exam.

Learning Materials

Recommended Readings	Bahl, A., & Bahl, B.S. (2021). *Textbook of organic chemistry* (22nd ed.). S. Chand & Company Ltd. India. Delgado, J.N., & Remors, W. A. (1991). *Wilson and Gisvold's textbook of organic medical and pharmaceutical chemistry* (9th ed.). J. B. Lippincott Company. Finar, I. L. (1990). *Organic Chemistry* (Vol-I and II) (6th ed.). English Language Book Society. Kalsi, P.S. (1996). *Spectroscopy.* New Age International Ltd. Pub. Leonard, J., Barry, L., & Garry, P. (2013). *Advanced practical organic chemistry* (3rd ed.). CRC, USA. Richards, S.A., & Hollerton, J.C. (2023). *Essential practical NMR for organic chemistry* (2nd ed.). Wiley & Sons, USA.
Supplementary Readings	Morrison, R. T., & Boyd R. N. (1992). *Organic chemistry* (6th ed.). Prentice-Hall of India Pvt. Ltd. Raymond, C. (1981). *Chemistry* (5th ed.). Mc Graw-Hill, Inc. Streitwieser, J. A, & Healthcock, I.C.H. (1981). *Introduction to organic chemistry* (2nd ed.). Macmillan Publishing co. NY, USA.

Course Code: 0511 07 Zoo 1259		Year: First	Term: Second
Course Title	Evolutionary and Functional Zoology		
Course Status	Optional		
Credit	2.0		
Prerequisite(s)	None		
Rationale	The course begins with the relationship between structure and function. Concepts of phylogeny will be introduced and the enormous diversity of animals will be examined in a phylogenetic framework. The biology of the vertebrates will follow groups from fishes to terrestrial vertebrates, including the amphibians, reptiles, birds and mammals.		
Course Objectives	• To show how the form, function and behaviour of animals become adapted to the environment through evolution. • To elucidate general biological principles through the study of specialized or experimentally tractable systems. • To familiarize students for knowledge of zoology at the systems and organismal levels. • To develop students' practical scientific skills.		

	Course Content	CLOs
	Section A	
1	Introduction: Definition, importance.	1
2	Evolution: Theories and their criticism; evidences with example and factors.	1
3	Ecology: Definition, types and fields, importance, habitat, community and ecological factors.	1
4	Ecosystem: Definition Structure and functioning, types, energy flow, food chains and webs.	1, 2
5	Reproduction: Definition, types and description of reproduction of Annelids, Mollusca, Chordates and Arthropods with their advantages and disadvantages.	1, 2, 3
	Section B	CLOs
6	Study of the following with special reference to Biotechnological significance: i) Protozoa; ii) Annelida; iii) Mollusca; iv) Chordata; v) Arthropoda - introduction; brief classification; role of insects, spiders and mites; concept of insect pests, pesticides; pest control strategies with comparative merits and demerits; definition of bio-agents: predator, parasitoid and vector; criteria for good bio-agents; predaceous, parasitic and disease transmitting insects and spiders; means and ways of utilizing biological agents in biological control of pests; conservation and augmentation of bio-agents.	1, 2, 3
7	Diseases of Annelids, Mollusca, Chordates and Arthropods: Definition, classification; of diseases, factors of diseases; utilization of bio-agents or their products in disease control.	1, 3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Understand the basic theories, diversity and evolutionary relationships among animals.	1
	CLO2	Explain the structure and function of different groups of invertebrates and vertebrates and its Biotechnological utilizations.	1, 2, 4, 8
	CLO3	Understand systematics, skeleton, reproductions and disease of animals.	8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Continuous assessment, quiz
CLO2	Lecture and/or Group discussion	Term final exam., assignment
CLO3	Lecture and/or Presentation	Term final exam.

Learning Materials

Recommended Readings	Barrington, E. J. W. (1982). *Invertebrate structure and function.* Van Nostrand Reinhold Inc. USA. Bhamrah, H. S., & K. Junjea. (1993). *Cytology and evolution.* Anmol Publications Pvt. Ltd. Bhuiyan, A. H., & R. W. Timn (1974). *A textbook of biology.* Mullick Brother, Dhaka. Jardan, E. I., & P. S. Verma (1978). *Invertebrate zoology.* S. Chand and Co. Ltd. Parker, T. J., and Haswell, W.A. (2018). *A text book of zoology* (Vol. I). Sagwan Press.
Supplementary Readings	Berasategui, A., Shukla, S., Salem, H., & Kaltenpoth, M. (2016) Potential applications of insect symbionts in biotechnology. *Applied microbiology and biotechnology,* (100), 1567-1577. Cock, M.J.W., Murphy, S.T., Kairo, M.T.K., Thompson, E., Murphy, R.J., & Francis, A.W. (2016) Trends in the classical biological control of insect pests by insects: An update of the BIOCAT database. *BioControl*, 61(4), McKelvey, M. (1996). *Evolutionary innovations: The business of biotechnology.* Oxford University Press.

Course Code: 0511 07 Zoo 1260		Year: First	Term: Second
Course Title	Evolutionary and Functional Zoology Sessional & Field Work		
Course Status	Optional		
Credit	1.0		
Prerequisite(s)	None		
Rationale	The prime focus of the course Zoology Sessional/practical is to impart knowledge about major areas of Zoology and teach different methods of exploration, investigation, organization of data and its utilization in practical life.		
Course Objectives	• Provide students with a clear sense of how science works. • Provide students with an understanding of evolutionary mechanisms and patterns. • Provide students with an overview of animal physiological and anatomical diversity. • Provide students with an overview of animal diversity. • Provide hands on experience to reinforce concepts introduced in theory lectures.		

	Course Content	CLOs
1	Study of the characters and classification of the important representatives of different groups of animals; beneficial and harmful Arthropods of major groups.	1
2	Dissection of the followings: Cockroach/grasshopper-digestive, nervous, reproductive systems, mouthparts; placemen-digestive and nervous systems.	2
3	Care and maintenance of bee hive, silk worms and lac insects	1
4	Collection and preservation of different kinds of animals.	3

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Understand basic approaches to testing scientific hypotheses.	1, 3
	CLO2	Learn the diversity of animal anatomy and physiology.	1
	CLO3	Learn animal classification and phylogenies	2, 3, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and/or group task	Exam and assignments
CLO2	Lecture and Physical observation	Exam and viva voce
CLO3	Lecture and/or group task	Exam, assignments and viva voce

Learning Materials

Recommended Readings	Parker, T. J. & Haswell, W. A. (1990). *A Textbook of Zoology* (Vol. I & II). Low Price Publication. Poonia, P., & Gaur, L. (2021). *Practical book of zoology.* Associated Book Co. India. Storer, T. I. (1957). *General zoology.* McGraw Hill Publishing Company.
Supplementary Readings	Aslam, M., Chalfant, R. B., & Herzog G. A. (1998) Naturally occurring arthropods on cotton strains grown under different levels of pest management. *Pakistan Journal of Arid Agriculture*, 1, 61-67. Bell, W. J. (2012) *The laboratory cockroach: Experiments in cockroach anatomy, physiology and behavior*. Springer Science & Business Media. Pisani, G. R. (1973) *A guide to preservation techniques for amphibians and reptiles.* Society for the Study of Amphibians and Reptiles. Pomeroy, N., & Plowright, R. C. (1980) Maintenance of bumble bee colonies in observation hives (Hymenoptera: Apidae). *The Canadian Entomologist,* 112, 321-326.

Course Code: 0231 07 Eng 1261		Year: First	Term: Second
Course Title	Communicative English		
Course Status	Optional		
Credit	2.0		
Prerequisite(s)	None		
Rationale	Competence in language skills is essential for effective communication. The course offers the students an opportunity to know the skills of English Language and their proper uses.		
Course Objectives	• To learn about the major skills of English language and their proper applications in everyday life. • To develop students' communicative competence.		

	Course Content	CLOs
	Section A	
1	Development of Vocabulary: Processes of word formation and transformation; proper use of parts of speech.	1
2	Sentence Structure: Structures of basic sentences, identification of clauses and phrases, joining sentences, transformation of sentences, framing W/H questions.	1
3	Reading and Understanding: Perspectives on reading comprehension; elements of reading: vocabulary, syntax and meaning; reading strategies: intensive and extensive reading; scanning and skimming; prediction and inference; reader's expectation and interpretation; contextual understanding and understanding the whole text; effective note-taking.	1, 2
	Section B	CLOs
4	Development of Speaking Skills: Art of good speaking, notions and functions, speaker-listener rapport, intonation and stress.	4
5	Development of Writing Skills: Process of writing, understanding academic writing: features and elements, mechanics in writing: capitalization and punctuation; generating ideas for a writing task; drafting and supporting ideas with evidence; integrating data and graphics in texts; modes of writing, writing tasks: paragraph, essay, summary, précis, report, abstract, letter of application, assignment, examination paper.	3
6	Development of Listening Skills: Guide lines for developing listening skills, role of a good listener, listening comprehension.	5

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Acquire basic knowledge of sentence making and suitability of vocabulary uses.	1, 6, 7, 8
	CLO2	Develop the skill of reading by employing different reading strategies with different elements.	1, 7, 8
	CLO3	Employ the knowledge of writing process and mechanics.	1, 7, 8
	CLO4	Accomplish the task of speaking.	1, 6, 7, 8
	CLO5	Improve personal listening skill.	1, 7, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Quiz, continuous assessment
CLO2	Lecture and/or group discussion	Continuous assessment, assignment and term final exam.
CLO3	Lecture and/or presentation	Continuous assessment, assignment and term final exam.
CLO4	Lecture and/or group discussion	Quiz
CLO5	Lecture and/or group discussion	Term final exam.

Learning Materials

Recommended Readings	Hornby, A. S. (1970). *A guide to patterns and usage in English.* Oxford University Press, UK. McCarthy, M., & O'Dell, F. (2002). *English vocabulary in use advanced* (1st ed.). Cambridge University Press, UK. Murphy, R. (2012). *Intermediate English grammar in use: a self-study reference and practice book for intermediate learners of English* (4th ed.). Cambridge University Press, UK. Pyle, M. A., & Munoz, M. E. (1995). *Cliff's TOEFL Preparation Guide* (5th ed.). Hungry Minds Inc, USA.
Supplementary Readings	Chambers, H. E. (2000). *Effective communication skills for scientific and technical professionals.* Basic Books, NY, USA. Koneru, A. (2017). *Professional communication* (1st ed.). McGraw Hill Pub. India. Karakoc, A.I., (2018). *Integrating Reading, Writing, Listening, and Speaking with Visuals.* In English Teaching Forum (56) (2),30-33. US Department of State. Bureau of Educational and Cultural Affairs, Office of English Language Programs, SA-5, 2200 C Street NW 4th Floor, Washington, DC 20037. Martha, M. D. (1985). *Integrating listening, speaking, reading, and writing in the classroom.* Language Arts Journal of Michigan, 1(1), Mishra, R.K. (2012). *Personality development: Transform yourself.* Rupa Publications, India.

Course Code: 0533 07 Phy 1263		Year: First	Term: Second
Course Title	Physics		
Course Status	Optional		
Credit	2.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide fundamental and basic concepts, theories, and principles of physics and how these are related to physical world.		
Course Objectives	• To introduce the core theories and principles of classical and modern physics. • To Provide basic knowledge on the scope and application of physics with regards to Biotechnology. • To explain the nature of physical phenomena and fundamental mechanisms in the biological world.		

	Course Content	CLOs
	Section A	
1	Gravitation: Kepler's and Newton's Law, gravitational attraction of sphere, the acceleration of gravity, gravitational effect of spherical distribution of matter, mass and density of the earth.	1
2	Hydrostatics and Surface Tension: Hydrostatic pressure, change of pressure with elevation; equilibrium of floating bodies; pressure gauges; forces against dam; surface tension and energy; factor affecting surface tension capillarity.	1
3	Hydrodynamics and Viscosity: Lines and tubes of flow, equation of continuity; Bernoulli's equation and its application; Flow in curved duct; viscosity, co-efficient of viscosity of liquids and gases; variation of viscosity with temperature.	1, 2
4	Oscillations: Harmonic motion; Simple harmonic oscillations, its amplitude, frequency, time period and energy.	1, 2
5	Rotational Kinematics: Rotational motion; rotation with constant angular acceleration; relation between linear and angular kinematics of a particle in circular motion.	1, 2
6	Basic Electronics: Overview of vacuum tube technology, solid-state electronics devices and their applications, diodes, transistors and amplifiers, oscillators, introduction to operational amplifiers, integrated circuits, digital electronics, special electronics, special electronic devices like photocells, photomultipliers, cathode-ray tubes.	1, 2, 3
	Section B	CLOs
7	Transfer of Heat: Conduction, thermal conductivity of thermal diffusivity; radial flow of heat in a sphere of cylinder; experimental measurements of thermal conductivity, convection. Newton's law of cooling.	1, 3
8	Kinds of Gases and their characteristics: Kinetic theory of gas, fundamental assumption in the kinetic theory; pressure exerted by a perfect gas; Brownian movement; molecular and atomic specific heat; mean free path.	1, 3
9	Thermodynamics: First and second laws of thermodynamics, Carnot's cycle.	1, 2, 3, 4
10	Radiation: Black body radiation; emissive power and absorption power, different laws of radiation, application of radiation laws, adsorption, scattering and dispersion.	1, 2, 3
11	Laser Emission and Absorption: Types and applications of laser.	1, 2, 3, 4
12	Atomic and Nuclear Physics: Determination of the charge and mass of an electron, the photoelectric effect, De Broglie waves, the Heisenberg uncertainty principles, electron microscopy, nuclear atom model, the Bohr model for the hydrogen atom, quantum mechanics, different kinds of rays like x-ray, gamma ray, UV ray and their characteristics and their applications, x-ray diffraction, absorption spectra, and color vision, radiation effect in biology, radiation dosage, diagnostic use of X-ray.	1, 2, 3, 4

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Demonstrate a rigorous understanding of the core theories and principles of physics.	1, 2, 3, 5, 8
	CLO2	Apply critical reasoning skills to model and solve physics related problems.	1, 9, 10
	CLO3	Demonstrate proficiency in the collection, analysis and interpretation of data.	6, 10
	CLO4	Communicate scientific information in oral, written, and graphical formats.	1, 7, 8, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Quiz, continuous assessment
CLO2	Lecture and/or group discussion	Continuous assessment, assignment and term final exam.
CLO3	Lecture and/or presentation and data collection	Continuous Assessment, Assignment and term final exam.
CLO4	Lecture and/or group discussion	Term final exam.

Learning Materials

Recommended Readings	Felder, G.N., & Felder, K.M. (2022). *Modern physics*. Cambridge University Press, UK. Mathur, D. S. (2010). *Elements of properties of matter.* S. Chand Publishing, New Delhi, India. Resnick, R., & Halliday, D. (1977). *Physics,* Part-I (3rd ed.). John Wiley & Sons Inc. USA. Teraja, B. L. (1993). *Modern physics* (5th ed.). S. Chand & Co. Ltd. New Delhi, India. Wark, K. & Richards, D. (1983). *Thermodynamics* (4th ed.). McGraw-Hill Book Co. NY, USA.
Supplementary Readings	De Cuyper, M., & Bulte, J.W. M. (Eds.) (2014). *Physics and chemistry basis of biotechnology.* Springer, NY, USA. Robinson, M.T. (1994). Basic physics of radiation damage production. *Journal of Nuclear Materials*, 216,1-28.

Course Code: 0533 07 Phy 1264	Year: First	Term: Second
Course Title	Physics Sessional	
Course Status	Optional	
Credit	1.0	
Prerequisite(s)	None	
Rationale	The course is designed to provide practical knowledge on solving problems related to physics.	
Course Objectives	Development of practical skills of the students with regards to measurement, design and problem solving of different types of physical states of matter.	

	Course Content	CLOs
1	Determination of surface tension of water.	1
2	Study of the variation of surface tension of a liquid with temperature.	1
3	Variation study of viscosity of water with temperature.	1
4	Determination of specific heat of a liquid by cooling method.	2
5	Use of resistance thermometer to determine the boiling point of a liquid.	2
6	Construction and calibration of a direct reading thermoelectric and measurement of boiling point of a saturated brine solution.	2
7	Thermal conductivity of bad and good conductors.	3
8	Specific rotation of a solution using a polarimeter.	3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Calculate and solve the basic problems of hydrodynamics and viscosity.	1, 2, 3, 10
	CLO2	Design and use different thermoelectric equipment.	1, 3, 6, 7, 10
	CLO3	Measure the properties of the equipment with regards to heat transfer.	1, 7, 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and group task	Quiz, assignments
CLO2	Lecture and lab work	Assessment, lab final exam., viva voce
CLO3	Lecture and lab work	Assessment, lab final exam., viva voce

Learning Materials

Recommended Readings	Felder, G.N., & Felder, K.M. (2022). *Modern physics*. Cambridge University Press, UK. Mathur, D. S. (2010). *Elements of properties of matter.* S. Chand Publishing, New Delhi, India. Resnick, R., & Halliday, D. (1977). *Physics* Part-I (3rd ed.). John Wiley & Sons Inc. USA. Squires, G.L. (2008). *Practical physics* (4th ed.). Cambridge University Press, UK. Teraja, B. L. (1993). *Modern physics* (5th ed.). S. Chand & Co. Ltd. New Delhi, India. Wark, K. & Richards, D. (1983). *Termodynamics* (4th ed.). McGraw-Hill Book Co. NY, USA.
Supplementary Readings	Hauner, I.M., Deblais, A. M., Beattie, J.K., Kellay, H.K., & Bonn, D.(2017). The dynamic surface tension of water. *The Journal of Physical Chemistry Letters,* 8(7),1599-1603. Holmes, M.J., Parker, N.G., & Povey, M.J.W. (2011).Temperature dependence of bulk viscosity in water using acoustic spectroscopy. *Journal of Physics Conference Series,* 269, 012011.

Second Year First Term			
Course Code: 0512 07 BGE 2101		Year: Second	Term: First
Course Title	Molecular Biology		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide the basic concepts on the structure, function and synthesis of nucleic acids and proteins mainly in prokaryotic systems.		
Course Objectives	• To introduce the basic concepts of biology at molecular level. • To appreciate that molecular biology is a dynamic and ever-changing experimental science. Understand how molecular machines are constructed and regulated so that they can accurately copy, repair, and interpret genomic information.		

	Course Content	CLOs
	Section A	
1	Chemistry of Nucleosides, Nucleotides and Nucleic Acids: Structure and physico-chemical properties of nucleotides and nucleosides; structure and chemistry of nucleic acids; molecular weight determination of nucleic acids; structures of RNAs, structure of DNA, physico-chemical properties- tm value, Cot curve, hybridization kinetics; homoduplex; different conformations of cruciform structure. Properties of A, B, and Z DNA.	1, 2
2	DNA Replication: Mode of replication, DNA polymerases, mechanism and control of DNA synthesis.	1, 2, 3
3	Damage, Mutability and Repair of DNA: Mutagenic agents, gene and chromosomal mutations, mechanisms involved in repair of DNA damage and mutations.	1, 2
4	Supercoiling and Packaging of DNA: Topology of DNA supercoiling, function of topoisomerases. Organization of nucleosomes in chromatin, constitution of the prokaryotic genome, organization of histone octamer. Formation of higher order structures.	1, 3
	Section B	CLOs
5	Transcription: Fine structure of prokaryotic gene, prokaryotic RNA polymerase, mechanism of transcription, regulation of transcription-operon models, reverse transcriptase.	1, 2
6	Translation: Structure of mRNA, tRNA and rRNA; molecular detail of ribosome, the translation process of prokaryotes, regulation of translation by antibiotics.	1, 2
7	The Genetic Code: Mathematical derivation of tri-nucleotide as codon, deciphering the genetic code, nature and characteristics of genetic code, collinearity of gene and protein structure.	1, 2, 3
8	Protein Trafficking and Degradation: Overview of secretory pathway, co-translational transport and post-translational transport; protein degradation- ubiquitin-proteasome pathway, lysosomal proteolysis.	1, 2, 3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Demonstrate knowledge and understanding of the molecular machinery of living system.	1, 2, 3, 6, 8, 9, 10
	CLO2	Understand the way of expression of genetic information.	1, 2, 3, 6, 8, 9, 10
	CLO3	Distinguish between different molecular biology techniques that are used to isolate, separate, and probe for specific proteins, nucleic acids and their interactions.	1, 2, 3, 6, 8, 9, 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Class lecture, group discussion	Quiz, continuous assessment
CLO2	Class lecture, presentation	Written test/ assignment
CLO3	Class lecture	Written test/ assignment, term final exam.

Learning Materials

Recommended Readings	Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). M*olecular biology of the cell* (6th ed.). Garland Science. Krebs, J. E., Lewin, B., Goldstein, E. S., & Kilpatrick, S. T. (2013). *Lewin's genes XI*. Jones & Bartlett Learning. Lewin, B. (2003). *Genes VIII*. Benjamin Cummings. Nelson D. L., & Cox, M. M. (2012). *Lehninger principles of biochemistry* (6th ed.). W. H. Freeman. Russell, P. J. (2009). *iGenetics: A molecular approach* (3rd ed.). Pearson. Watson, J. D., Baker, T. A., Bell, S. P., Gann, A., Levine, M., & Losick, R. (2013). *Molecular biology of the gene* (7th ed). Pearson.
Supplementary Readings	Ahern, K. (2019). *Biochemistry and molecular biology:* How life works. The Teaching Company. Alberts, B., Johnson, A., Lewis, J., Morgan, D., Raff, M., Roberts, K., & Walter, P. (2014). *Molecular biology of the cell* (6th ed.). Garland Science, USA. Clark, D. P., Pazdernik, N. J., & McGehee, M. R. (2018). *Molecular biology.* Academic Press. Lodish, H., Berk, A., Kaiser, C. A., Krieger, M., Bretscher, A., Ploegh, H., Amon, A., & Martin, K. C. (2016). *Molecular cell biology.* W. H. Freeman. Michal, G., & Schomburg, D. (2012). *Biochemical pathways: An atlas of biochemistry and molecular Biology* (2nd ed.). Wiley Press.

Course Code: 0512 07 BGE 2103		Year: Second	Term: First
Course Title	Bioenergetics and Metabolic Regulation		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide basic knowledge on bioenergetics and regulation processes of metabolism.		
Course Objectives	To explore how living organisms store chemical energy for their use in various purposes. To know how living organisms regulate their metabolic pathways according to the environmental conditions.		

	Course Content	CLOs
	Section A	
1	Principles of Bioenergetics: Bioenergetics & thermodynamics, high and low energy compounds, structure and properties of ATP, special role of ATP in biological energy exchange, structural basis of the high phosphoryl transfer potential of ATP, other biological high energy compounds.	1
2	Biological Oxidation-Reduction Reactions: Electron affinity; reduction potential.	1
3	Proton-Motive Force and ATP Synthesis: Structure of ATP synthase, proton path through membrane, binding-change mechanism of ATP synthase.	1, 2
4	Oxidative Phosphorylation: Biochemical anatomy of mitochondrion, enzyme localization in mitochondrion, respiratory chain and electron carriers, mitochondrial electron flow, chemiosmotic hypothesis.	2
5	Photophosphorylation: Harvesting light energy, structure of chloroplast, organization of photo-system components in thylakoid membrane, light driven electron flow, coupling ATP synthesis to light driven electron flow.	2
	Section B	CLOs
6	Regulation of Enzyme Activity: Enzyme availability, alteration of catalytic efficiency of enzyme activity.	3
7	Hormones: Classification and chemistry of hormones, hormone receptor and mechanism of hormone action, feedback control, communication among cells and tissues.	3
8	Hormonal Regulation of Fuel Metabolism: Epinephrine signal, glucagon signal, insulin signal, metabolism shift during starvation.	3
9	Signal Transduction: Types of signal transduction, molecular mechanism of signal transduction, insulin receptor, regulation of gene expression by insulin, activation of glycogen synthase by insulin, epinephrine cascade and glycogen breakdown, second messenger, role of G protein in production of second messenger, epinephrine-β-adrenergic receptor complex, cAMP as second messenger, diacylglycerol and inositol triphosphate as second messengers, Ca ion as second messenger, central role of protein phosphorylation and dephosphorylation in cellular control, interference of signal transduction by toxins, oncogenes and tumor promoters, metabolic integration, regulation of metabolism in liver, muscle and adipose tissue.	2, 3
10	Regulation of Bacterial Metabolism: Environmental stimuli-catabolite repression, carbon flow control, nutrient starvation, nitrogen limitation; global regulators-cAMP, rpoN; operon models.	3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Know how living organisms store chemical energy.	1, 2, 3
	CLO2	Understand the transduction of chemical energy into thermal, mechanical and light energy.	1, 2, 3
	CLO3	Explain regulation of anabolic and catabolic pathways of living organisms according to the environmental condition they live in.	1, 2, 3, 4, 7, 8, 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and presentation	Continuous assessment and term final examination
CLO2	Lecture and presentation	Continuous assessment and term final examination
CLO3	Lecture, presentation and group discussion	Continuous assessment, assignment and term final examination

Learning Materials

Recommended Readings	Guyton, A. C., & Hall, J. E. (1996). *Textbook of medical physiology* (9th ed.) W. B. Saunders Company. Lehninger, A. L., Nelson, D. L., & Cox, M. M. (1993). *Principles of biochemistry* (2nd ed.). CBS Publishers and Distributors. Martin, B. R. (1988). *Metabolic regulation*. Blackwell Scientific Publications. Murray, R. K., Granner, D. K., Mayes, P. A., & Rodwell, V. W. (1997). *Herper's biochemistry* (24th ed.). Prentice-Hall International Inc. Stryer, L. (1998). *Biochemistry* (3rd ed.). W. H. Freeman and Company.
Supplementary Readings	Ganong, W. F. (1998). *Review of medical physiology* (18th ed.). Prentice Hall International Inc.

Course Code: 0512 07 BGE 2105		Year: Second	Term: First
Course Title	Plant Breeding		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to make students familiar and introduce them with fundamental and applied principles and strategies of crop improvement to meet the demand of farmers, consumers and entrepreneurs in the changing environments.		
Course Objectives	To impart knowledge and technology to the students for exploitation of genetic and Biotechnological principles for the development of improve (Modern/HYV) crop varieties useful to fulfill the needs of the society		

Course Content		CLOs
Section A		
1	Introduction to Plant Breeding: Definition, nature, scope and history & objectives of plant breeding. What should a plant breeder know? Variation: the basis of crop improvement. Some important achievements and prospects of plant breeding, national and international institutes engaged in crop improvement: Their nature of work.	1
2	Mode of Reproduction and Pollination Control: Relevance of mode of reproduction to plant breeding. Modes and methods of reproduction, modes of pollination, antithesis, mechanisms and genetic significance of pollination control method. Self-incompatibility and male sterility.	2
3	Qualitative and Quantitative Characters and Their Inheritance pattern: Polygenic inheritance and continuous variation. Concept of yield and yield contributing characters of some important crops.	2, 3
4	Breeding Methods and Selection Strategies: Introduction. Selection strategies: Pure line, mass, pedigree, recurrent, single seed descent and clonal selection. Population: double haploids (DH); recombinant inbred lines (RILs); near-isogenic lines (NILs). Factors affecting the choice of breeding strategy; The environments and their interactions with the genotypes; Concept of genetic gain, population size and selection intensity.	4
5	Hybridization Techniques and Consequences: Definition, objectives, types, prerequisites, advantages and disadvantages of hybridization. Selfing and crossing techniques, difficulties and precautions, combine ability, GCA, SCA, top cross, raising of the F1 generation, and techniques in field trails.	2, 5, 7
6	Heterosis and Inbreeding Depression: Inbreeding depression: genetic effects, degree & practical application (in plants, animals, human and fishes) of inbreeding depression, outbreeding, crossbreeding. Heterosis- Types, historical background, estimation, and theories of heterosis. Heterosis in self & cross-pollinated crops and its application. Genetic basis of heterosis and inbreeding depression.	3, 4, 6
7	Breeding of Self-pollinated crops: Rice, wheat, brinjal, pulses etc.	7, 8
Section B		CLOs
8	Methods of Breeding of Cross-Pollinated Crops: Maize & cucurbits and asexually propagated crops- potato, sugarcane.	1, 2
9	Methods of Ploidy and Mutation Breeding of Crops: Introduction, Selection of mutants. Breeding of self-pollinated, cross-pollinated and clonally propagated crops using mutagens and changing of ploidy level, application and achievement of induced mutation.	1, 4
10	Breeding for Insect and Disease Resistant Crops: Improvement of crops resistant to insects, pests and diseases. Transfer of Bt and other genes from GMO.	2
11	Germplasm/ Plant Genetic Resources (PGR) and Germplasm Conservation: Definition, classification, exploration, characterization, evaluation and various methods of conservation of germplasm/ (PGR), biodiversity, and genetic diversity and its significance, genetic erosion: causes, implication & possible dangers from genetic erosion.	3, 4
12	Distant Hybridization in Plant Breeding: Concept, objectives and techniques of production of distant hybrids, applications and limitations in crop improvement. Barriers to the production of distant hybrids.	5, 6

	Section B	CLOs
13	Improved Seeds: Classes of improved seeds, their production practices, release and evaluation of new varieties, requirements of seed certification, quality seed production and processing, IPR, plant breeders and farmers right, maintenance of improved seeds/parents (A-line, B-line and R-lines) of hybrids/GM (Bt eggplant) varieties. Distribution of improved seeds in Bangladesh.	4, 8
14	Biotechnology in Crop Improvement: Brief introduction and application of different techniques.	6, 7, 8

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Demonstrate understanding basic concepts of plant breeding, its activities, objectives, applications, mode of reproduction and pollination, conventional and modern breeding techniques, field trials, distant hybridizations, biotechnological tools of variety development, variety release and seed production etc.	1, 10
	CLO2	Identify sources of variation, self- and cross pollinated crops, parents for hybridizations, segregation generations etc.	3, 9, 10
	CLO3	Compare and contrast among various breeding techniques, materials and identify the best one.	1, 2, 3, 9, 10
	CLO4	Evaluate, analyze and interpret various breeding materials and methodologies.	2, 4, 6, 9, 10
	CLO5	Develop superior inbreed line/s and hybrid varieties by exploiting hybrid vigor.	3, 5, 9, 10
	CLO6	Disseminate gained knowledge of breeding especially hybrid variety development and use, pure seed production of op variety, inbred variety, isolation distance, inbreeding depression of cross pollinated crops etc.	3, 7, 8, 10
	CLO7	Critically investigate various breeding techniques, modes of creating variation and selection procedures and their utilizations.	2, 9, 10
	CLO8	Perform emasculation and crossing, characterize crop germplasm, conduct field experiments, collect data & perform statistical analysis and interpretation	3, 6, 7, 9, 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture / presentation	Class test, assignment
CLO2	Lecture / presentation	Class test, continuous assessment
CLO3	Lecture / presentation	Term final exam.
CLO4	Lecture / presentation	Term final exam.
CLO5	Lecture / presentation	Class test
CLO6	Lecture / presentation	Class test
CLO7	Lecture / presentation	Term final exam.
CLO8	Lecture / presentation	Term final exam.

Learning Materials

Recommended Readings	Allard, R. W. (1960). *Principles of plant breeding*. John Wiley & Sons Inc. Chopra, V. L. (1989). Plant breeding. Oxford & IBH Publishing Co. Pvt. ltd. Frey, K. J. (1982). *Plant breeding I & II*. Kalayni Publishers, India. Poehlman, J. M. & Borthakur, D. (1969). *Breeding Asian field crops*. Oxford & IBH Publishing Co. Pvt. Ltd. India. Simmonds, N.W. (1979). *Principles of crop improvement*. Longman Group Ltd. UK.
Supplementary Readings	Al-Khayri, J. M., Jain, S. M., & Johnson, D. V. (2015). *Advances in plant breeding strategies: Breeding, biotechnology and molecular tools* (Vol. 1). Springer. Blum, A. (1988). *Plant breeding for stress environments*. CRC Press Inc. Blum, A. (2011). *Plant breeding for water limited environments*. Springer

Course Code: 0512 07 BGE 2106	Year: Second	Term: First
Course Title	Plant Breeding Sessional & Fieldwork	
Course Status	Core	
Credit	1.0	
Prerequisite(s)	None	
Rationale	The course is designed to make students familiar and introduce them with techniques of hybridization of several important crops, estimation of heterosis and field trial/screening techniques.	
Course Objectives	To provide hands–on-training about parents selection, emasculation, crossing / hybridization and field trial/disease screening techniques.	

	Course Content	CLOs
1	Techniques of Hybridization: Parent selection, emasculation pollination, bagging and labelling of rice, wheat, maize and plants of Cucurbitaceae family.	1, 2
2	Harvesting of F1 seeds and recording data.	1, 2
3	Handling of F1 hybrids, germinating F1 seeds and growing of F1 plants.	1, 2
4	Study of different types of field trial (Observation Trial, PYT, AYT, and ZYT): Selection of AEZ, season, land/soil, soil fertility, field layout, managing trials: agronomic practices, data collection.	4
5	Germplasm evaluation and experimental hybrid evaluation techniques.	3, 4
6	Estimation of heterosis and heritability.	4
7	Pollen viability testing, pollen germination and pollen tube growth testing.	1
8	Self- incompatibility and male sterility testing.	2, 5
9	Handling of plants in the F2 generation: Growing of F2 plants for particular characters to be studied.	5
10	Determination of probable number of genes controlling the characters under study.	4, 6
11	Practice of induction of polyploidy (e.g. triploidy) by colchicine treatment.	5
12	Preparation of report on visit to research institution, BADC, SCA, private seed companies.	6

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Demonstrate understanding basic concepts of flower biology, mode of reproduction and pollination, parent selection, conventional and modern breeding techniques, field trials, distant hybridizations, biotechnological tools of variety development, variety release and seed production practices etc.	1, 10
	CLO2	Demonstrate the ability to identify, evaluate and select phenotype, parents for hybridization (Inbred parent, A-line, B-line, R-line) modes of pollination, appropriate stage of flower for emasculation and pollination and apply it for hybrid variety development.	3, 5, 6, 9, 10
	CLO3	Demonstrate the ability to develop and evaluate inbred lines from OP population and use in hybrid varieties of cross pollinated crops viz. corn & gourds.	1, 3, 4, 6, 9, 10
	CLO4	Demonstrate the ability to select suitable parents for crossing/hybridization, and harvesting of F1 hybrids and handle successive generations.	1, 3, 4, 6, 9, 10
	CLO5	Demonstrate the ability to apply the knowledge and skills to produce pure seed production of OP variety and inbred variety.	3, 5, 10
	CLO6	Demonstrate the ability to conduct field experiment and calculate hereosis, analyze and interpret the field trial data and communicate the experiments findings effectively.	2, 3, 4, 5, 6, 7, 9, 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture / presentation	Assignment / lab quiz
CLO2	Presentation / field & lab demonstration	Evaluation of given task
CLO3	Presentation / hands on training	Evaluation of given task
CLO4	Lecture / field demonstration	Evaluation of given task
CLO5	Lecture / field demonstration	Lab report evaluation of given task
CLO6	Presentation / hands on training, visit to research institutes, BADC	Sessional tour report evaluation / sessional final exam., viva voce

Learning Materials

Recommended Readings	Gupta, S.K. (2005). *Practical plant breeding* (2nd ed.). Agrobios Publication, India. Lucht, J.M. et al. (Eds.). (2016). *Practical plant breeding*. Intelliz Press, LLC Lawrence, W.J.C. (1948). *Practical plant breeding*. George Allen Publisher. Prajapat, R.K., Sain, R.S., Sharma, S.K., Shubra, S. & Baba, A.Y. (2021). *Practical manual on fundamentals of plant breeding*. New Century Publications, India. Poehlman, J. M. & Borthakur, D. (1969). *Breeding Asian field crops*. Oxford & IBH Publishing Co. Pvt. Ltd. Simmonds, N.W. (1979). *Principles of crop improvement*. Longman Group Ltd.
Supplementary Readings	Al-Khayri, J. M., Jain, S. M., & Johnson, D. V. (2015). *Advances in plant breeding strategies: Breeding, biotechnology and molecular tools* (Vol. 1). Springer. Deppe, C. (2000). *Breed your own vegetable varieties: The gardener's and farmer's Guide to plant breeding and seed saving* (2nd ed.). Chelsea Green Publishing. Spears, A. (2019).*Crop breeding: Strategies for crop improvement*. CALLISTO REFERENCE.

Course Code: 0512 07 BGE 2107		Year: Second	Term: First
Course Title	Algal and Fungal Biology		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course provides a strong grounding in fundamental aspects of biology of algae and fungi with giving emphasis on their scope and applications in foods, medicine, industries and environment.		
Course Objectives	Demonstrate the biology of algae and fungi. Provide biotechnological uses of important species of cyanobacteria, algae and fungi.		

	Course Content	CLOs
	Section A	
1	General Characteristics: Habitats; habit; comparison of algae with fungi and other groups of plants; reproduction; pigments, plastids and chromatophore; range of thallus organization.	1, 2
2	Cyanophyceae: Characteristics; Range of structure; fine structure; reproduction; heterocyst- types, fine structure, functions; structure, occurrence and biotechnological importance of *Nostoc*, *Spirulina*, *Anabaena* and *Gloeotrichia*; Chlorophyceae: Characteristics; structure, reproduction, and biotechnological importance of Chlorella; characteristics and importance of Xanthophyceae, Bacillariophyceae, Dinophyceae, Euglenophyceae, Phaeophyceae, and Rhodophyceae.	1, 2, 3
3	Isolation, Culture and Cultivation of Economically Important Freshwater and Marine Algae; Algal Biotechnology to produce food, fodder, bio-fuels, biofertilizers, polysaccharides, mucilage, medicines, antibiotics, polyphenols, antioxidants, carotenoids, food supplements, single cell proteins; algae in relation to agriculture, diatomite, water purification, sewage disposal, land reclamation, space research, water pollution, and toxin production.	2, 3, 4, 5
	Section B	CLOs
4	Introduction to Fungi: General characteristics; habitats; habit; classification; vegetative structures- unicellular, mycelia; reproduction- vegetative, asexual, sexual; fruiting bodies; importance; comparisons with other kingdoms.	1, 2
5	Myxomycotina (Pseudo-fungi or the Slime Moulds)- Characteristics, vegetative body, types of plasmodium; Eumycotina-true lower fungi- characteristics, reproduction, and importance, a brief account on Synchytrium, Phytophthora and Mucor; Ascomycetes- characteristics, occurrence, structure, reproduction and importance; a brief account on *Saccharomyces, Aspergillus*, and *Penicillium*; Basidiomycetes- characteristics, structure, reproduction and importance; a brief account on Puccinia, Ustilago; Deuteromycetes- characteristics, discussion on *Cercospora* and *Colletotrichum*.	1, 2, 3
6	Isolation, Culture and Cultivation of Economically Important Fungi; Fungal biotechnology for mushroom, mycorrhizae, yeasts; fungal bio-prospecting; secondary metabolites; industrial significance; fungi in food processing; production of fungal enzymes, alcohols, antibiotics; use of fungi in green chemistry and bio-nanotechnological applications; medical mycology- medicine, mycoses, immune-deficiency, fungal toxins.	2, 3, 4, 5

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Understand the biology of algae and fungi.	1, 2, 6, 10, 11
	CLO2	Characterize and classify algae and fungi.	1, 2, 6, 10, 11
	CLO3	Recognize the methods of studying algae and fungi.	1, 2
	CLO4	Explain importance of algae and fungi in industries and environment.	1, 2, 3, 5, 7, 8, 10, 11
	CLO5	Explore algae and fungi in biotechnology.	1, 3, 5, 6, 8, 9, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, presentation, discussion	Quiz, assignment
CLO2	Lecture, presentation, training	Assignment, countinuous assessment
CLO3	Lecture, training	Class test
CLO4	Lecture, presentation	Assignment, term final exam.
CLO5	Lecture, presentation, discussion	Assignment, term final exam.

Learning Materials

Recommended Readings	Alexopoulos, C. J., Mims, C. W., Blackwell, M. M., & Dabağyan, L.P. (2007). *Introductory mycology* (4th ed.). Wiley. Chowdhury, R. (1990). *Modern medical microbiology*. Bishaw Parichay, Dhaka. Kumar, H. D., & Singh, H. N. (1979). *A textbook on algae*. The Macmillan Press Ltd. Dube, H. C. (2015). *An introduction to fungi.* Scientific Publishers Pelczar, M.J., Reid, R.D., & Chan, E.C.S. (1993). *Microbiology* (4th ed.) McGraw-Hill Publishing Company Limited. Reiss, E., Shadomy, H. J., & Lyon, G. M. (2012). *Fundamental medical mycology*. Wiley-Blackwell Sangeetha, J., Thangadurai, D., Elumalai, S., & Thimmappa, S. C. (2021). *Phycobiotechnology: Biodiversity and biotechnology of algae and algal products for food, feed, and fuel*. Apple Academic Press. Waites, M. J., Morgan, N. L., Rockey, J. S., & Higton, G. (2001). *Industrial microbiology: An introduction*. Blackwell Science Ltd.
Supplementary Readings	Germain, St. G. (2010). *Identifying fungi: A clinical laboratory handbook*. Star Publishing Company. Rajan, S. S. (2000). *Practical manual of algae*. Anmol Publications, India. Sivakumar, K. (2016). *Algae: A practical approach*. MJP Publisher.

Course Code: 0512 07 BGE 2108	Year: Second	Term: First
Course Title	Algal and Fungal Biology Sessional & Field Work	
Course Status	Core	
Credit	1.0	
Prerequisite(s)	None	
Rationale	The course provides fundamental & practical knowledge on isolation, cultivation, pure culture preparation and identification of economically important algae and fungi.	
Course Objectives	Demonstrate the basic methods and techniques in studying algae and fungi. Provide practical hands on pure culture preparation of algae and fungi. Distinguish important biotechnological traits and metabolites in algae and fungi.	

	Course Content	CLOs
1	Collection, preservation and identification of common algae and fungi used in biotechnology.	1, 2
2	Preparation of algal and fungal culture media.	1
3	Isolation and uni-algal culture preparations.	1
4	Isolation and pure culture preparations of *Saccharomyces, Aspergillus, Penicillium* etc.	1, 2
5	Study on heterocyst.	1
6	Study on mushroom.	1
7	Study on asci, ascocarp, ascospores, basidia, basidiocarp and basidiospores.	1
8	Fermentation experiment using yeast.	3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Understand the basic methods and techniques used for studying algae and fungi.	1, 2, 4, 5, 6, 10, 11
	CLO2	Identify common algae and fungi.	1, 2, 3, 4, 5, 6, 9, 10, 11
	CLO3	Explore biotechnological traits in algae and fungi.	1, 2, 3, 4, 5, 6

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, hands on training	Assignment, exam., viva voce
CLO2	Lecture, presentation, hands on training	Lab report evaluation, assignment, exam., viva voce
CLO3	Lecture, hands on training	Lab final exam., viva voce

Learning Materials

Recommended Readings	Germain, St. G. (2010). *Identifying fungi: A clinical laboratory handbook*. Star Publishing Company. Rajan, S. S. (2000). *Practical manual of algae*. Anmol Publications, India. Sivakumar, K. (2016). *Algae: A practical approach*. MJP Publisher, India. Vanhoutte, K. (2021). *Algae revolution: Practical micro-algae technologies*. Koen Vanhoutte Publication.
Supplementary Readings	Alexopoulos, C. J., Mims, C. W., & Blackwell, M. M. (2007). *Introductory mycology*. Wiley. Chowdhury, R. (1990). *Modern Medical Microbiology*. Bishaw Parichay. Kumar, H. D. and Singh, H. N. (1979). *A textbook on algae*. The Macmillan Press Ltd. Reiss, E., Shadomy, H. J., & Lyon, G. M. (2012). *Fundamental medical mycology*. Wiley-Blackwell Sangeetha, J., Thangadurai, D., Elumalai, S., & Thimmappa, S. C. (2021). *Phycobiotechnology: Biodiversity and biotechnology of algae and algal products for food, feed, and fuel*. Apple Academic Press Stephenson, S.L. (2010). *The kingdom fungi: The biology of mushrooms, molds, and lichens*.(1st ed.). Timber Press

Course Code: 0512 07 BGE 2109		Year: Second	Term: First
Course Title	Animal Physiology and Reproduction		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course will provide a conceptual physiological framework for understanding the lives of farm animals at every level of organization. The course illustrates how the major physiological systems of farm animals function and integrate to sustain the lives of animals.		
Course Objectives	• To know the physiological basis of growth, puberty, lactation and digestion of farm animals. • To understand the endocrine system, reproduction and embryology of livestock. • To familiarize with reproductive behaviors, sperm capacitation, fertilization, pregnancy and parturition.		

	Course Content	CLOs
	Section A	
1	Introduction: Introduction to anatomy of male and female reproductive systems of farm animals.	1
2	Physiology of Reproductive Tract of Farm Animals: The major male and female reproductive organs including the external genitalia of cattle, buffalo, goat, sheep, swine and deer.	1
3	Physiological Basis for Growth and Development of Farm Animals: Embryo development: from zygote to embryo, pre-implantation of embryo, implantation, early embryogenesis.	1
4	Lactation and Milk Let Down in Farm Animals: Anatomical arrangements of the udder for milk let down; Oxytocin: the hormone involved in milk let down; milking related release of other hormones; stimulation of the milk let down reflex; stimuli other than milking such as feeding during milking; inhibition of milk let down.	1
5	Hormonal Systems of Farm Animals: Pituitary gland, adrenal glands, thyroid gland, parathyroid glands, pancreas, testes, ovaries, and placenta of domesticated farm animal species.	1
6	Nutrition and Physiology of Digestion of Farm Animals: Anatomy of the digestive system. Importance of nutrition and digestion for animal growth; classes and sources of nutrients; concentrates vs. roughages; nutrient requirements for farm animals; physiology of digestion of farm animals.	2
	Section B	CLOs
7	Introduction to Reproduction: The material of reproductive and genetic differences, genetic improvement of cattle: limitations to progress, control of reproduction in animal.	3
8	Female Reproductive Cycles: Reproductive behaviors that lead to oocyte and sperm meeting, hormones that regulate reproductive cycle, periods of the cycle, time sequences, ovarian and tubular changes, oogenesis & ovulation, transport of ovum, clinical ovarian dysfunction.	3
9	Spermatogenesis, Sperm Capacitation and Fertilization: Spermatocytogenesis, spermiogenesis, endocrine control, spermatozoa transport and survival of spermatozoa in the female tract, interaction between semen and female reproductive tract, transport of ova, formation and fusion of pronuclei.	3
10	Early Comparative Embryology and Maternal Recognition: Preparation of the reproductive tract, prenatal periods, fetal nutrition and metabolism, factors affecting fetal growth.	3
11	Placentation, Endocrinology of Pregnancy and Parturition: Placenta, classification, function, transplacental transfer of immunoglobulins, hormones in pregnancy, theories on the initiation of parturition, stages of parturition, involution of the uterus.	4
12	Physiology of the Newborn Animal and Puberty: Characteristics of the newborn, postnatal adaptation, sexual maturity, breeding season, pheromones.	5

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Understand the core concepts of animal growth, reproduction and milk letdown mechanism.	1, 2
	CLO2	Estimate basic nutrition requirements and understand physiology of digestion.	1, 2
	CLO3	Demonstrate reproductive cycles of farm animals and the process of spermatogenesis and oogenesis.	1, 2, 3
	CLO4	Understand endocrinology of pregnancy and parturition.	1, 2, 3
	CLO5	Acquire knowledge about newborn physiology and puberty.	1, 2

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and presentation	Continuous assessment and term final examination
CLO2	Lecture and presentation	Continuous assessment, assignment and term final examination
CLO3	Lecture and presentation	Continuous assessment, assignment and term final examination
CLO4	Lecture and presentation	Continuous assessment and term final examination
CLO5	Lecture and presentation	Continuous assessment and term final examination

Learning Materials

Recommended Readings	Colville, T. P., & Bassert, J. M. (2007). *Clinical anatomy & physiology for veterinary technicians*. Mosby. Frandson, R. D., Wike, W. L., & Fails, A. D. (2009). Anatomy and physiology of farm animals. Wiley-Blackwell. Reece, W. O. (2009). *Functional anatomy and physiology of domestic animals*. Wiley-Blackwell. Wesley, M. (1889). *A text-book of animal physiology*. Caxton House.
Supplementary Readings	Cupps, P. T. (2016). *Reproduction in domestic animals* (4th ed.). Academic Press. Sjaastad, O.V., Sand, O., & Hove, K. (2013). *Physiology of domestic animals*. Scandinavian Veterinary Press.

Course Code: 0512 07 BGE 2110	Year: Second	Term: First
Course Title	Animal Physiology and Reproduction Sessional & Field Work	
Course Status	Core	
Credit	1.0	
Prerequisite(s)	None	
Rationale	The graduates develop highly skilled professionals in the application of scientific principles and new technologies in animal physiology and reproductive techniques for the changing circumstances in the livestock industry.	
Course Objectives	• To know the physiological basis of growth, puberty, lactation and digestion of farm animals. • To understand the endocrine system, reproduction and embryology of livestock. • To familiarize with reproductive behaviors, sperm capacitation, fertilization, pregnancy and parturition.	

	Course Content	CLOs
1	Gross anatomy of male and female reproductive tracts of farm animals; anatomy of the digestive tracts of farm animals.	1
2	Histology of the testis, ductus deferens, ampullae, epididymis and vesicular glands. Histology of the ovary, oviduct, uterus and cervix.	1
3	Ooestrus detection in cow, buffalo, ewe and doe.	2
4	Pregnancy diagnosis in cow, ewe and doe by laboratory tests and by rectal palpation method.	2
5	Ration formulation.	3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Get acquainted with reproductive organs of farm animals in the laboratory.	1, 2
	CLO2	Identify the time of ooestrus and conduct AI.	1, 2, 3, 9
	CLO3	Formulate ration for different stages of growth of animals.	1, 2

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and group discussion, hands on training	Lab report, viva voce and final examination
CLO2	Lecture, Experiments and group discussion	Lab report, viva voce and final examination
CLO3	Lecture, Experiments and group discussion	Lab report, viva voce and final examination

Learning Materials

Recommended Readings	Akhtar, M.S. (2012). *Practical manual of veterinary obstetrics: Bovine obstetrics*. LAP Lambert Academic Publication. Colville, T. P., & Bassert, J. M. (2007). *Clinical anatomy & physiology for veterinary technicians*. Mosby. Frandson, R. D., Wike, W. L., & Fails, A. D. (2009). *Anatomy and physiology of farm animals*. Wiley-Blackwell. Wesley, M. (1889). *A text-book of animal physiology*. Caxton House.
Supplementary Readings	Mali, R.P. (2015). *A practical manual on innovative animal physiology*. Oxford Book Co. Reece, W. O. (2009). *Functional anatomy and physiology of domestic animals*. Wiley-Blackwell. Sjaastad, O.V., Sand, O., & Hove, K. (2013). *Physiology of domestic animals*. Scandinavian Veterinary Press.

Course Code: 0314 07 Soc 2165		Year: Second	Term: First
Course Title	Principles of Sociology		
Course Status	Optional		
Credit	2.0		
Prerequisite(s)	None		
Rationale	Studying the sociology and behavioral sciences develops the capacity for critical and analytical thinking about human behavior, community dynamics and social policies in terms of cultural and cross-cultural contexts. Those who study the psychology and sociology often go on to careers in social work, social/human services and the professional pastorate.		
Course Objectives	• To prepare students who are interested in careers in which they can apply an under- standing of human behaviour. • To prepare students for graduate study. • To model and encourage a global perspective for understanding human behaviour.		

	Course Content	CLOs
	Section A	
1	Understanding Sociology: Definition, nature and scope of sociology, development of sociology, major theoretical perspectives of sociology, research in sociology, and necessity of studying sociology.	1
2	Basic Concepts of Sociology: Society, community, association, institution, group, norms, values, social process.	1
3	Culture and Social Structure: Meaning and elements of culture, development of culture around the world, culture and civilization; definition and elements of social structure, social structure in global perspective.	1, 2
4	Socialization and Institutions: Meaning, theories and agents of socialization; major institutions-family, marriage, kinship, property, division of labor, religion, education, state.	1, 2, 3
5	Social Stratification and Inequality: Definition and theories of social stratification, determinants and forms of social stratification; meaning, determinants and dimensions of social inequality.	1, 2, 3
	Section B	CLOs
6	Social Mobility and Changing World: Types of society; social change; theories of social change, resistance to social change, technology and social change, urbanization, industrialization and social change.	1, 2
7	Mass Media, Communication and Collective Behavior: Meaning and sociological perspectives of mass media and communication; forms and theories of collective behavior, new communication technology and collective behavior.	1, 4
8	Deviance, Crime and Social Control: Meaning and theories of deviance and crime, juvenile delinquency; definition and agents of social control.	1, 4, 5
9	Population and Environment: Theories on population, basic demographic processes, population and environment.	1, 5
10	Changing Society of Bangladesh: Social structure of colonial Bangladesh, changing political system and social problems of Bangladesh.	1, 2, 4, 5

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Exhibit basic knowledge and theories of sociology.	1, 7
	CLO2	Understand culture and civilization, elements of social structures and social laws.	1, 7
	CLO3	Demonstrate an understanding of race, class, and gender inequality.	1
	CLO4	Analyze the influence of individual values, beliefs, and traditions on the larger society.	1, 9
	CLO5	Develop and express interpretation and analysis of sociological principles.	4, 5, 7, 8, 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and/or group discussion	Quiz, assessment
CLO2	Lecture and case studies	Assignment
CLO3	Lecture and/or presentation	Term final exam.
CLO4	Lecture and/or group discussion	Term final exam.
CLO5	Lecture and/or survey	Term final exam. /survey report evaluation

Learning Materials

Recommended Readings	Desai, A. R. (1976). *The social background of Indian nationalism*. Popular Prakash. Giddens, A. (2009). Sociology. Polity Press. Karim, A. K. N. (1996). *Changing society in India*, Pakistan and Bangladesh. Nawroze Kitabistan. Schaefer, R. T. (2012). *Sociology*. McGraw-Hill. Smelser, N. J. (1994). *Sociology*. Prentice Hall. Stewart, E. W. & Glynn, J. A. (1988). *Introduction to Sociology*. McGraw-Hill Company.
Supplementary Readings	Zastrow, C., Kirst-Ashman, K.K., & Hassenauer, S.L. (2018). *Understanding human behavior and the sociale environment* (11th ed.). Cengage Learning.

Course Code: 0821 07 Eco 2167	Year: Second	Term: First
Course Title	Ecology	
Course Status	Optional	
Credit	2.0	
Prerequisite(s)	None	
Rationale	The course is designed to provide a grounding concept on ecological factors, components, structures and dynamics as well as anthropogenic impacts, which bring forth changes in the environment.	
Course Objectives	• To know actions, reactions and interactions among the components in ecology. • To recognize dynamics of ecological systems. • To distinguish between plants, animals, human and microbial ecology. • To understand physiological and community ecology.	

	Course Content	CLOs
	Section A	
1	Ecology and Environment: Definitions, history, scope, types, branches and organizational levels.	1
2	Factors Controlling the Distribution of Flora and Fauna: Biotic and abiotic factors; biotic- intra specific and inter specific relationship.	1, 2
3	Ecosystem: Definitions; characteristics; types, structure, components and functions of ecosystem. Trophic level, trophic structure and energy flow in ecosystem. Food chain, food web, ecological pyramids, ecological niche; ecological efficiency; dynamics of aquatic and terrestrial ecosystems; structure and dynamics of the Sundarbans' ecosystem. Eutrophication- eutrophic ecosystems, causes, indication and control measures.	2
4	Nutrient cycling and Biogeochemical Cycles: Concept, types; carbon, oxygen, nitrogen, phosphorus, and water cycles.	2
	Section B	CLOs
5	Physiological and Community Ecology: Effects of climatological and physiological factors on physiological functions of plants, animals and microbes; metabolic aspects of stress tolerant plants. Structure and function of communities; trophic structure; species diversity, individualistic and functional aspect of communities.	4
6	Climate Change and precautions: Global warming, greenhouse effect, energy balance and flow, effects on plants, animal and humans; prevention and control measures: renewable energy, bioremediation, ecotourism, environmental sustainability.	4
7	Molecular Ecology: Concept, applications and recent advancement.	3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Acquire knowledge about the fundamentals of ecology.	1
	CLO2	Be familiar with ecological factors, components, structures, dynamics and apply knowledge to balance between ecosystem and environment.	1, 2, 3, 5, 6
	CLO3	Develop skills to analyze, interpret and management of ecological data and provide solution for critical problems.	2, 4, 5, 6, 8, 9
	CLO4	Distinguish ways to achieve sustainable environment.	2, 3, 5, 6

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Continuous assessment
CLO2	Lecture	Continuous assessment
CLO3	Problem-based learning and presentation	Assignment
CLO4	Lecture and group discussion	Quiz test, continuous assessment and term final exam.

Learning Materials

Recommended Readings	Agarwal, S. K. (1998). *Fundamentals of ecology*. Ashish Publication House. Colinvaux, P. (1993). *Ecology*. John Wiley & Sons. Kerbs, C.J. (2001). *Ecology* (3rd ed.). Harper Collins Pub. Kormond, E. J. (2017). *Concepts of ecology* (4th ed.). Prentice Hall. Smith, G. (1983). *Studies in ecology* (Vol. 9). Blackwell Scientific India Ltd.
Supplementary Readings	Kumar, P. & Mina, U. (2021). *Fundamentals of ecology and environment* (3rd ed.). Pathfinder Publication. Miller, G. T., & Spoolman, S. E. (2011). *Essentials of ecology* (6th ed.). Yolanda Cossio Pub.

Course Code: 0821 07 Eco 2168	Year: Second	Term: First
Course Title	Ecology Sessional & Field Work	
Course Status	Optional	
Credit	1.0	
Prerequisite(s)	None	
Rationale	The course is designed to provide a practical concept on ecological components, ecosystems, and pollutants.	
Course Objectives	• To be familiar with different ecosystems in Bangladesh. • To distinguish differences in components of ecosystems. • To understand energy flow in an ecosystem. • To determine metal pollutants in water and air.	

	Course Content	CLOs
1	Study of physicochemical and biological components of different ecosystems in Bangladesh.	1
2	Comparative study on flora and fauna of aquatic and terrestrial ecosystems.	1, 2
3	Study of ecological features of plants in different ecosystems.	2
4	Study of nutrient budgets.	3
5	Study of the Sundarbans' ecosystem.	4
6	Study on biogeography.	4
7	Study on Environmental Protection Act.	4

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Acquire basic knowledge of ecosystem in Bangladesh.	1
	CLO2	Develop skills in ecosystem management.	1, 2, 3, 4, 5, 6, 7, 11
	CLO3	Analyze and interpret quantitative ecological data.	2, 4, 5, 6, 8, 9
	CLO4	Balance between ecology system and nature.	2, 3, 5, 6, 8, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Quiz test
CLO2	Lecture	Quiz test and assignment
CLO3	Presentation	Assignment and final exam.
CLO4	Lecture, group discussion and field visit	Viva voce, field tour report, evaluation and lab final exam.

Learning Materials

Recommended Readings	Agarwal, S. K. (1998). *Fundamentals of ecology*. Ashish pub. House. Cook, P.A., Bell, J. R., & Wheater, C. P. (2011) *Practical field ecology: A project guide* (1st ed.). Wiley . Colinvaux, P. (1993). *Ecology*. John Wiley & Sons. Henderson, P.A. (2003). *Practical methods in ecology* (1st ed.).Wiley-Blackwell. Kerbs, C.J. (2001). *Ecology* (3rd ed.). Harper Collins Pub. Kormond, E. J. (2017). *Concepts of ecology* (4th ed.). Prentice Hall.
Supplementary Readings	Kumar, P. & Mina, U. (2021). *Fundamentals of ecology and environment* (3rd ed.). Pathfinder Pub. Miller, G. T., & Spoolman, S. E. (2011). *Essentials of ecology* (6th ed.). Yolanda Cossio Pub. Neogi, S. B., Dey, M., Kabir, S. M. L., Masum, S. J. H., Kopprio, G., Yamasaki, S., & Lara, R. (2016). Sundarban mangroves: Diversity, ecosystem services and climate change impacts. *Asian J. Med. Biol.* 2 (4), 488-507.

Course Code: 0611 07 CSE 2170	Year: Second	Term: First
Course Title	Fundamental in Computer and IT Sessional	
Course Status	Optional	
Credit	2.0	
Prerequisite(s)	None	
Rationale	The course is designed to provide fundamental knowledge in Computer Science and Engineering.	
Course Objectives	The aim of this course is to: • Hardware and software management practices. • Familiarization of ways in approaching computer networking. • PowerPoint presentation.	

	Course Content	CLOs
1	Introduction: Types of computers, application areas, concept of CPU, keyboard, mouse, floppy disk, hard disk, windows and the peripheral, working principles of computer systems.	1
2	Hardware and Software: Organization and architecture, motherboard and microprocessor system, memory and devices, classification of software, importance, components, basic functions. DOS, WINDOWS, UNIX/LINUX etc.	1, 2
3	File Management and Word Processing: Concept of file and folder, creation of file, saving of file, deleting file, editing document/file variable, file copy, file move, layout, formatting, page setup and printing, tables and graphs etc.	1, 3
4	Spread Sheet Analysis: Mathematical and statistical function: frequency, standard deviation, variance, mean, median, line, bar, pie graph, correlation, regression, etc., creating and formatting chart, printing sheet, problem solving using formulas, data consolidation.	1, 3
5	PowerPoint Presentation: Preparation of slides, tables, graphs, editing, copying.	1, 4
6	Database: I. Concept of field, record, table, database and database management system. Ii. Creating and adding information to a database. Iii. Editing and viewing the data. Iv. Designing and viewing/printing reports. V. Understanding sorting and indexing.	1, 2
7	Introduction to IT: Computer networking, basic concept of LAN, MAN and WAN; e-mail and the WWW.	1, 2, 3
8	Maintenance of Computer: Power supply, stability, grounding, handling and protection, computer viruses and troubleshooting.	1, 2

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Understand different part of a computer and their importance.	1, 2, 3, 8, 9
	CLO2	Organize both hardware and software and their basic functions and importance.	1, 2, 3, 8, 9
	CLO3	Know how to prepare spread sheets, data analysis for their thesis and other applications.	1, 7, 8, 9, 10
	CLO4	Understand how to prepare slides for PowerPoint presentations.	1, 7, 8, 9, 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment strategy
CLO1	Lecture and/or presentation	Quiz, assignment
CLO2	Lecture and hand-hand introduction	Exam., lab work assessment
CLO3	Lecture and group work	Lab final exam., assignment evaluation
CLO4	Lecture and/or presentation	Lab final exam., assignment and viva voce

Learning Materials

Recommended Readings	Montgomery, J. (1995). *Troubleshooting your multimedia pc*. Addison-Wesley-Wesley Publishing Company. Norton, P. (2002). *Introduction to computers*. Career Education. Perry, G. M., Wethington, A., & Perry, G. (1999). *SAMS Teach Yourself Microsoft Office 2000*.Techmedia Rajaraman, V. (1999). *Fundamentals of computers* (3rd ed.). Prentice-Hall.
Supplementary Readings	Evans G.(1993). *Windows on education: A skills-referenced perspective*. New Horizons in Education. (88):14-27. Hahnel, C., Goldhammer, F., Naumann, J., & Kröhne, U. (2016). Effects of linear reading, basic computer skills, evaluating online information, and navigation on reading digital text. *Computers in Human Behavior.* (55), 486-500.

Second Year Second Term			
Course Code: 0512 07 BGE 2201		Year: Second	Term: Second
Course Title	Plant Cell and Tissue Culture		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide a key Knowledge on in vitro techniques of plant cell and tissue culture. Different plant breeding programs have been used to produce commercially important crop varieties; however, this requires a long time to release a new variety. In this regard, plant cell and tissue culture provide a new insight to produce commercially important variety within a very short period through the culture of cells or tissue/organs under aseptic conditions. In addition, different commercially important secondary metabolites can be produced on a large scale through the in vitro culture of plant cell and tissue. Students will study media preparation, sterilization, explants selection, preparation & sterilization techniques, micropropagation, callus culture, organogenesis, embryogenesis, somatic embryogenesis, doubled haploids production, interspecific hybrids, protoplast fusion, and environmental conditions required.		
Course Objectives	• To give a clear knowledge of micropropagation of different plant parts like protoplast, somatic embryo, ovule, pollen, and anther, etc. for the production of the important commercial variety. • To provide a basic concept on secondary metabolites production, cryopreservation of endangered plants, somaclonal and gametoclonal variation, and their application in agriculture. • Finally, to develop the graduates' capabilities of knowledgeability, comprehension, and applications of plants in cell and tissue culture systems and how cell and tissue culture contribute to global sustainability.		

	Course Content	CLOs
	Section A	
1	Introduction to Plant Tissue Culture: Definition, types of culture and historical development, purposes of cell, tissue and organ culture, cellular totipotency, cell and tissue growth process, characteristics and measurement methods, laboratory organization.	1, 2
2	Culture Media: Components, composition, functions of components, preparation of media. Solidification, media selection and maintenance of media.	1, 2, 3
3	Aseptic Techniques: Plant tissues, chemicals, instruments, glassware and personal hygiene	2, 3
4	Micropropagation: Concept, purpose, steps, merits, demerits, comparison with clonal/seed propagation, commercial prospects (national and international), Selection, collection and preparation of explants, mode of plant regeneration: organogenesis and morphogenesis, direct and indirect methods of micro propagation: Meristem, shoot tip, bud, node culture of potato, banana, orchid and strawberry. Transfer, storage and maintenance of cultures, factors affecting shooting and rooting, commercial tissue culture, precautions and troubleshooting during plant tissue culture.	5
5	Protoplast: Isolation, purification and culture of protoplast, development and application of somatic hybrids and cybrids.	5
6	Production of Disease-free Plants: Methods of virus elimination, virus indexing, eradication of pathogens other than virus, application and limitations.	4
	Section B	CLOs
7	Somatic Embryo Production: Initiation of somatic embryo: callus and suspension culture, maintenance of callus and suspension culture, production and management of somatic embryo and its application, plant formation from somatic embryo.	2, 3
8	Culture of anther/pollen, ovule, embryo, endosperm and their usages: Rice, wheat, barley, maize, brinjal.	2, 3
9	*In vitro* Pollination and Fertilization: Methods and applications.	1, 2, 3
10	Production and Selection of Somaclonal and Gametoclonal Variation: Utilization of somaclone and gametoclone in agriculture, *in vitro* selection of disease resistant and stress tolerant plants.	5

	Section B	CLOs
11	*In vitro* Conservation of Plant Materials: Methods and factors affecting *in vitro* conservation, maintenance of frozen culture.	4
12	Industrial Application of Plant Tissue Culture: Secondary metabolites derived from plants and their uses. Techniques of selecting cell lines for high production of secondary products. Mass cultivation of plant cells, scale-up, isolation, immobilization & purification and limiting factors.	6

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Students will interpret the basic concepts and terminology used in plant tissue culture.	1, 2, 3, 4, 5, 6
	CLO2	Formulate and prepare various culture media and perform *in vitro* propagation of different plant parts in a sterile condition.	1, 2, 3, 4, 5, 6, 9
	CLO3	Students will interpret the basic techniques to establish different types of *in vitro* cultures by themselves due to hand on training in the subject.	1, 2, 3, 4, 5, 6, 9
	CLO4	Demonstrate knowledge of producing disease-free plants and *in vitro* conservation methods of plant materials.	1, 3, 4, 5, 9
	CLO5	Demonstrate knowledge and experience in, current methodologies in Plant Biotechnology	1, 3, 5, 6
	CLO6	Demonstrate an interpreting of the major classes and roles of secondary plant products and their production processes.	1, 2, 3, 4, 5, 6

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and presentation	MCQ, continuous assessment
CLO2	Lecture and presentation	MCQ, continuous assessment
CLO3	Lecture and presentation	Continuous assessment
CLO4	Lecture and presentation	Continuous assessment
CLO5	Lecture and presentation	Continuous assessment
CLO6	Lecture and presentation	Continuous assessment, term final exam.

Learning Materials

Recommended Readings	Bhojwani, S. S. (Ed.). (2012). *Plant tissue culture: applications and limitations*. Elsevier Science, Netherlands. Gamborg, O. L., & Phillips, G. C. (2004). *Plant cell, tissue and organ culture: Fundamental methods*. Narosa Publishing House. Razdan, M. K. (1993). *An introduction to plant tissue culture*. Oxford & IBH Publishing Co. Pvt. Ltd. Reinert, J., & Bajaj, Y. P. S.(Eds.). (2013). *Applied and fundamental aspects of plant cell, tissue, and organ culture.* Springer Pub. Vasil, I. K. & Thorpe. T. A. (Eds.). (1994). *Plant cell and tissue culture.* Kluwer Academic Publishers.
Supplementary Readings	Bajaj, Y.P.S. (2010). *Somaclonal variation in crop improvement I (Biotechnology in agriculture and Forestry 11)*. Springer Bhojwani, S. S., & Dantu, P. K. (2013). *Plant tissue culture: An introductory text.* Springer. Bhojwani, S.S and Razdan. M.K. (2009). *Plant tissue culture-Theory and practice.* Elsevier India Pvt. Ltd. Cassells, A. C., and Peter, B. G. (2006). *Dictionary of plant tissue culture.* Food Products Press, an Imprint of the Haworth Press, Inc.

Course Code: 0512 07 BGE 2202		Year: Second	Term: Second
Course Title	Plant Cell and Tissue Culture Sessional & Field Work		
Course Status	Core		
Credit	1.0		
Prerequisite(s)	None		
Rationale	Plant tissue culture is the science of growing plant cells, tissues, or organs isolated from the mother plants on artificial media. It includes techniques and methods used to research many botanical disciplines and has several practical objectives. The purpose of this course is to give students a practical experience in techniques used in plant tissue culture.		
Course Objectives	• This course seeks to familiarize students with the basic principles of plant tissue culture and applications. • To provide hands-on experience of the most common of these techniques in labs and demonstrations of more advanced or uncommon techniques. • To Interpret a procedure that is often used to propagate many plants of the same genetic background. • To Interpret the importance of sterile techniques.		

	Course Content	CLOs
1	Laboratory, personal safety, precaution, and uses/operation of instruments available in the laboratory.	1, 2, 3
2	Sterilization techniques of glassware, instruments, media, and explants.	1, 2, 3
3	Techniques of media preparation and their stock solutions.	1, 2, 3
4	Selection and pre-treatment of different kinds of explants.	3, 4
5	Detection of contamination of media and cultures.	6
6	Initiation of callus and regeneration.	2, 3, 4
7	Microscopic analysis of callus for cytodifferentiation.	3, 4
8	Determination of appropriate stages of anther and pollen.	5
9	Exploration, selection, collection, and growing of donor/mother plants: Banana, orchids, strawberry, gerbera, rice, barley, maize, etc.	2, 3, 4
10	Hardening techniques of plantlets.	6

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Prepare culture medium from reagent-grade chemicals and stock solutions, routinely transfer cultures without contamination, and analyze the usefulness of the information available from the scientific literature that deals with plant tissue culture.	1, 3
	CLO2	Sterilize instruments, lab wares, culture media, and explants.	1, 2, 3, 4, 5, 6, 9
	CLO3	Design and prepare various culture media, stock solutions of inorganic salts, and growth regulators.	1, 2, 3, 4, 5, 6, 9
	CLO4	Identify appropriate explant and learn inoculation techniques into suitable culture media under sterile conditions.	1, 2, 3, 4, 5, 6, 9
	CLO5	Determination of appropriate stages of anther and pollen useful for anther/pollen culture.	1, 2, 3, 4, 5, 6, 9
	CLO6	Identify contaminated media and culture.	1, 2, 3, 4, 5, 6, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and presentation	MCQ, lab work evaluation
CLO2	Lecture, presentation, and laboratory work	Lab work evaluation and viva voce
CLO3	Lecture, presentation, and laboratory work	Lab work evaluation and viva voce
CLO4	Lecture, presentation, and laboratory work	Lab work evaluation and viva voce
CLO5	Lecture, presentation and laboratory work	Lab report evaluation and viva voce
CLO6	Lecture, presentation, visit to plant tissue culture labs, and fields of public / private research institutes / organizations	Tour report evaluation, lab final examination and viva voce

Learning Materials

Recommended Readings	Gamborg, O. L., & Phillips, G. C. (2004). *Plant cell, tissue and organ culture: Fundamental methods.* Narosa Publishing House. Razdan, M. K. (1993). *An introduction to plant tissue culture.* Oxford & IBH Publishing Co. Pvt. Ltd. Reinert, J., & Bajaj, Y. P. S. (1995). *Plant tissue and organ culture: Applied and fundamental aspects.* Narosa Publishing House. Smith, R. H. (2012). *Plant tissue culture: Techniques and experiments* (3rd ed.). Academic Press. Sherathiya, H. (2013). *Practical manual for plant tissue culture: Basic techniques of plant tissue culture and molecular biology.* Grin Verlag. Vasil, I. K. & Thorpe. T. A. (1994). *Plant cell and tissue culture*. Kluwer Academic Publishers.
Supplementary Readings	Bhojwani, S.S and Razdan. M.K. (2009). *Plant tissue culture-Theory and practice.* Elsevier India Pvt. Ltd. Santosh, N., & Madhavi, A. (2010). *Practical biotechnology and plant tissue culture.* S. Chand & Company.

Course Code: 0512 07 BGE 2203		Year: Second	Term: Second
Course Title	Metabolism		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide basic Knowledge on metabolism.		
Course Objectives	Objective of this course is to explain the basic biochemical reactions which take place in all living organisms.		

	Course Content	CLOs
	Section A	
1	General Aspects of Metabolism: Overall metabolic pathway, concept of catabolism and anabolism, energy relationship between anabolic and catabolic pathways.	1
2	Glycolysis and Catabolism of Hexoses: Phases of glycolysis, catalytic mechanism of triose phosphate isomerase, catalytic mechanism of glyceraldehyde-3-phosphate dehydrogenase, catalytic mechanism of phosphoglyceratemutase, fates of pyruvate under aerobic and anaerobic condition, feeder pathways for glycolysis.	1, 2
3	The Citric Acid Cycle and Glyoxylate Cycle: Formation of acetyl-CoA from pyruvate, catalytic mechanism of pyruvate dehydrogenase complex, reactions of the citric acid cycle, catalytic mechanism of citrate synthase, catalytic mechanism of succinyl-CoA synthetase, reactions of the glyoxylate cycle.	1, 2
4	Oxidation of Lipid: Hormone-induced fatty acid mobilization in adipocyte, activation of fatty acid, transport of acyl-CoA into mitochondrial matrix, acyl-carnitine/carnitine transporter, reaction sequence of β-oxidation, oxidation of odd chain fatty acid, oxidation of mono unsaturated fatty acid, oxidation of poly unsaturated fatty acid, formation of ketone bodies, fate of glycerol of triacylglycerol.	1, 2, 3
5	Amino Acid Oxidation and Urea Cycle: Metabolic fate of amino group, transamination and oxidative deamination, glutamine as ammonia carrier, glucose-alanine cycle, nitrogen excretion and urea cycle, Krebs cycle, degradative pathways of amino acids.	1, 2, 3
	Section B	CLOs
6	Carbohydrate Biosynthesis: Gluconeogenesis, role of biotin in pyruvate carboxylase reaction, biosynthesis of glycogen, regulation of glycogen biosynthesis, photosynthetic synthesis of carbohydrate, regulation of carbohydrate metabolism in plants, reciprocal regulation of gluconeogenesis and glycolysis, reciprocal regulation of glycogenesis and glycogenolysis.	1, 2
7	Lipid Biosynthesis: Biosynthesis of fatty acid, catalytic mechanism of acetyl-CoA carboxylase reaction, catalytic mechanism of fatty acid synthase complex, acetate shuttle, regulation of fatty acid biosynthesis, biosynthesis of triacyl glycerol, regulation of triacyl glycerol biosynthesis, biosynthesis of membrane phospholipids, biosynthesis of cholesterol, regulation of cholesterol biosynthesis, biosynthesis of steroid hormones.	1, 2
8	Biosynthesis of Amino Acids: Overview of nitrogen metabolism, incorporation of ammonia, regulation of nitrogen metabolism, reactions of the biosynthetic pathways of amino acids.	1, 2
9	Biosynthesis of Nucleotides: De novo purine synthesis, feedback control of purine biosynthesis, biosynthetic pathways of pyrimidines, feedback control of pyrimidine biosynthesis, salvage pathway.	1, 2

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Acquire basic knowledge on cellular metabolism and its significance.	1, 2, 8, 9, 10
	CLO2	Recognize the pathways of biomolecule synthesis in living organisms.	1, 2, 8, 9, 10
	CLO3	Interpret the use of various organic compounds to provide energy.	1, 2, 8, 9, 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and/or presentation	Quiz, assignment
CLO2	Lecture and/or group discussion	Final exam., continuous assessment
CLO3	Lecture and/or presentation	Term final exam.

Learning Materials

Recommended Readings	Champe, P. C., & Harvey, R. A. (1987). *Lippincott's illustrated reviews: Biochemistry* (2nd ed.). J. B. Company. Clark, J. M., & Switzer, R. L. (1984). *Experimental biochemistry* (2nd ed.). WH. Freeman & Company. Conn, E. E. & Stumpt, P. K. (1976). *Outlines of biochemistry* (4th ed.). John Wiley & Sons Kennelly, P., Botham, K., McGuinness, O., Rodwell, V., & Well, P. A. (2022). *Harper's illustrated biochemistry* (32nd ed.). Prentice Hall International. Nelson, D. L., & Cox, M. M. (2017). *Lehninger principles of biochemistry* (7th ed.). WH Freeman
Supplementary Readings	Dixon, M., MacDonald, A., White, F., & Stafford, J. (2015). *Disorders of amino acid metabolism, organic acidaemias and urea cycle disorders. Shaw, V. (Ed), Clinical paediatric dietetics* (4th ed.). Wliley Blackwell Sonnenburg, J. L., & Bäckhed, F. (2016). Diet–microbiota interactions as moderators of human metabolism. *Nature*. 535(7610),56-64..

Course Code: 0512 07 BGE 2205	Year: Second	Term: Second
Course Title	Animal Genetics and Breeding	
Course Status	Core	
Credit	3.0	
Prerequisite(s)	None	
Rationale	The course will assist to develop Knowledgeable and skilled graduates to employ the scientific principles and new technologies in the field of animal breeding for subsequent improvement of the livestock industry.	
Course Objectives	• To interpret gene and genotype frequency, correlations, heritability and repeatability. • To learn selection and breeding plan for improvement of goat, sheep, buffalo and dairy cattle. • To familiarize with artificial insemination, synchronization, super ovulation and pregnancy diagnosis of farm animals.	

	Course Content	CLOs
	Section A	
1	Introduction: Concept of animal genetics and breeding taxonomy and terminology. Domestication of animals, Need of animal products. Qualitative and quantitative traits. Breeds of dairy cattle, beef cattle, dairy buffaloes, sheep, goat, swine and poultry.	1
2	Classical Genetics: Mendelian and Non-Mendelian mode of inheritance. Sex determination and differentiation, sex chromosome and sex-linked, sex-limited, sex-influenced characters in domestic animals.	1, 3
3	Genes- Their Functions and Role in Animal Genetics: Nature of genes, control of gene function, the concept of gene frequencies, genotype frequency, features modifying gene frequency, detrimental and lethal alleles in farm animals. Phenotypic expression of genes, non-additive gene action, additive gene action, genes vary in their expression, non-genetic defects, hereditary diseases and defects, conjoined individuals, identification of genetic and non-genetic defects.	2
4	Principles of Selection: Indirect selection and correlated response, methods of selection, animal diversity variation, importance of G×E, epigenetic principles of heritability and repeatability.	2
5	Molecular and Quantitative Animal Genetics: Genetic and phenotypic parameters- their methods of estimation, uses, possible biases and precision. Scale effects and threshold traits. Quantitative genetics- gene effects, population mean and variance and its partitioning, biometric relations between relatives.	2
	Section B	CLOs
6	Principles of Breeding in Farm Animals: Inbreeding, outbreeding, crossbreeding, grading, heterosis and species hybridization. Guidelines in the use of biotechnology in development of breeding programs including gene mapping and parentage testing. Breeding plans for farm animals in developing countries.	4
7	Artificial Insemination (AI): History and advantages of AI; collection, evaluation, dilution, and preservation of semen; factors influencing the quality and quantity of semen. Advantages and transportation of frozen semen. Insemination techniques and significance of AI in animal breeding.	4
8	Factors Influencing Fertility: Infections, anatomical, functional, management, genetic and environmental factors affecting cattle fertility; recommended practices for improving cattle fertility.	2, 4
9	Artificial Control of Ooestrus: Synchronization and super ovulation. Concepts regarding embryo transfer technology, *in vitro* fertilization and cloning. Pregnancy diagnosis of cattle.	5

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Identify traits of economic importance of various farm animals which can be used for selection and breeding purposes.	1, 2, 3, 4
	CLO2	Determine the frequency of a particular gene in a population and compute the relationships between the genetic parameters.	1, 2, 3
	CLO3	Familiarize with sex determination and differentiation, sex chromosome and sex-linked, sex-limited and sex-influenced characters in domestic animals.	1, 2, 3, 4
	CLO4	Learn the techniques of collection, processing, evaluation and preservation of semen of farm animals.	1, 2, 3, 9
	CLO5	Learn the techniques of synchronization, super ovulation, artificial insemination and pregnancy diagnosis.	1, 2, 3

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, presentation and group discussion	Continuous assessment and term final examination
CLO2	Lecture and presentation	Continuous assessment and term final examination
CLO3	Lecture and presentation	Continuous assessment, assignment and term final examination
CLO4	Lecture, presentation and group discussion	Continuous assessment and term final examination
CLO5	Lecture and presentation	Continuous assessment and term final examination

Learning Materials

Recommended Readings	Banerjee, G. C. (2010). *A text book of animal husbandry.* Oxford and IBH Publishing Company. Dalton, D. C. (1998). *An introduction to practical animal breeding.* English Language Book Society Collins. FAO. (2007). *Global plan of action for animal genetic resources and the interlaken declaration.* FAO, Rome. FAO. (2010). *Breeding strategies for sustainable management of animal genetic resources. FAO animal production and health guidelines.* No. 3. Rome. Hutt, F. B. (1982). *Animal genetics.* John Wiley & Sons Co.
Supplementary Readings	Landweber, L. F., & Dobson, A. P. (1999). *Genetics and the extinction of species.* Princeton University Press. Nicholas, F. W. (2009). *Introduction to veterinary genetics* (3rd ed.). Wiley-Blackwell. Willis, M. B., (1998). *Dalton's introduction to practical animal breeding* (4th ed.). Wiley-Blackwell.

Course Code: 0512 07 BGE 2206	Year: Second	Term: Second
Course Title	Animal Genetics and Breeding Sessional & Field Work	
Course Status	Core	
Credit	1.0	
Prerequisite(s)	None	
Rationale	This course is designed to demonstrate the modern principles and technologies of animal genetics and breeding.	
Course Objectives	• To obtain practical Knowledge regarding special types of chromosome, cell division and Mendelian genetics in farm animals. • To learn physical traits, gene and genotypic frequency in a population. • To demonstrate collection, processing and evaluation of semen of domesticated animals.	

	Course Content	CLOs
1	Handling and study of life cycle of laboratory animals.	1
2	Study on the polytene chromosome of *Drosophila melanogaster* and haploid and diploid chromosomes of farm animals.	1
3	Study of the cell division and Mendelian genetics in farm animals.	1
4	Study of physical traits of farm animals.	1, 3
5	Study of artificial and natural selection, culling.	2, 3
6	Practical breeding plans of dairy cattle, beef cattle, dual-purpose cattle, sheep, dual-purpose sheep and goat.	2
7	Practical demonstration on collection, preservation and evaluation of bull semen.	4
8	Learning of artificial insemination (AI) technique.	4

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Apply the concept of Mendelian and population genetics in animal breeding programs.	1, 2, 3, 4
	CLO2	Determine the frequency of a particular gene and effective breeding programs for trait improvement in a herd.	1, 2, 3, 4, 9
	CLO3	Characterize genetic and phenotypic traits of farm animals.	1, 2, 4
	CLO4	Learn the techniques of collection, evaluation, processing, preservation of semen and artificial insemination (AI) of farm animals.	1, 2, 3, 4, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and group discussion	Lab report, viva voce and lab final examination
CLO2	Lecture, experiments and group discussion	Lab report, viva voce and lab final examination
CLO3	Lecture, experiments and group discussion	Lab report, viva voce and lab final examination
CLO4	Lecture, experiments and group discussion	Lab report, viva voce and lab final examination

Learning Materials

Recommended Readings	FAO. (2007). *Global plan of action for animal genetic resources and the interlaken declaration,* Rome. FAO. (2010). *Breeding strategies for sustainable management of animal genetic resources.* FAO animal production and health guidelines. No. 3. Rome. Gordon, I. R. (1983). *Controlled breeding in farm animals*, Pergamon Press. Harper, M.W. (2018). *Manual of farm animals: A practical guide to the choosing, breeding, and keep of horses, cattle, sheep, and swine.* Forgotten Books, Megahed, M. (2013). *Handbook of animal breeding and genetics: Practical handbook for genetic improvement of animals.* LAP Lambert Academic Publishing Willis, M.B. (1998). *Dalton's introduction to practical animal breeding* (4th ed.).Wiley-Blackwell .
Supplementary Readings	Dalton, C. (1985). *Introduction to practical animal breeding* (2nd ed.). Blackwell Science Ltd. Nicholas, F. W. (2009). *Introduction to veterinary genetics* (3rd ed.). Wiley-Blackwell.

Course Code: 0512 07 BGE 2207		Year: Second	Term: Second
Course Title	Bioprocess Engineering		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide detailed basic and applied knowledge and insights in the area of Bioprocess Engineering which is the basis of Industrial Biotechnology.		
Course Objectives	• To describe detailed aspects of the various areas of Bioprocess Engineering, the basis of "Industrial Biotechnology". • To explain the principles and theories that deal with static and dynamic fluid properties • To demonstrate various principles and theories in heat transfer required in industrial production. • To develop the analytical and problem solving skills of the students of Biotechnology and Genetic Engineering.		

Course Content		CLOs
Section A		
1	Introduction: Importance of bioprocess engineering in Biotechnology, state of matter, dimensions and dimensional analysis, units and unit conversions.	1, 2, 5, 6
2	Fluid Statics & Manometer: Static fluid properties, pressure and pressure gauge, measurement of fluid pressure.	1, 3, 5, 6
3	Basic Equations of Fluid Flow: Equation of continuity, mechanical energy balance, roughness and friction factor flow through pipes, expansion, contraction and fitting losses.	1, 3, 5, 6
4	Agitation & Mixing of Liquids: Introduction, equipment, standard turbine design.	1, 5
Section B		CLOs
5	Mode of Heat Transfer: Conduction, convection and radiation.	1, 4, 5, 6
6	Conduction: Fourier's law, thermal conductivity, multilayer heat conduction, resistances in series, heat flow through cylindrical systems, overall heat transfer coefficient, critical thickness of insulation.	1, 4, 5, 6
7	Convection: Natural and forced convection, overall heat transfer coefficients, boiling heat transfer.	1, 4, 5, 6
8	Evaporation: Heat transfer in evaporators, classification and application of evaporators, multiple effect evaporators.	1, 4, 5, 6
9	Heat Exchangers: Double pipe heat exchangers, shell and tube heat exchangers.	1, 4, 5, 6

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Acquire detailed basic Knowledge on various areas of Bioprocess Engineering which is the basis of Industrial Biotechnology.	1, 2, 3, 4, 7, 9
	CLO2	Get a clear idea about dimension, dimensional analysis, unit and unit conversions that are the key areas of industrial production.	1, 2, 3, 4, 5, 6, 9
	CLO3	Recognize various theories and principles of static and dynamic fluid properties.	1, 2, 3, 4, 5, 9
	CLO4	Interpret basic theories in heat transfer.	1, 2, 3, 4, 5, 9
	CLO5	Apply Knowledge of heat transfer in industrial production.	1, 2, 3, 4, 5, 6, 7, 9
	CLO6	Develop analytical ability and problem-solving skills in the area of Biotechnology.	1, 2, 3, 4, 5, 6, 9, 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and group work	Continuous assessment and term final exam
CLO2	Lecture and Q-A sessions	Continuous assessment and term final exam
CLO3	Lecture and group work	Continuous assessment and term final exam
CLO4	Lecture and group work	Continuous assessment and term final exam
CLO5	Lecture and group work	Continuous assessment and term final exam
CLO6	Lecture and group work	Continuous assessment and term final exam

Learning Materials

Recommended Readings	Fox, R. W., & McDonald, A. L. (1995). *Introduction to fluid mechanics* (4th ed.). John Wiley & Sons. Holman, J. P. (1996). *Heat transfer* (7th ed.). McGraw-Hill Book Co. McCabe, W., Smith, J., & Harriot, P. (2004). *Unit operations of chemical engineering* (7th ed.). McGraw-Hill Inc. Streeter, V. L., & Wylie, E. B. *Fluid mechanics* (15th ed.). S. Chand, Co. Ltd.
Supplementary Readings	Doran, P. M. (1995). *Bioprocess engineering principles*. Elsevier. Ladisch, M. (2004). The role of bioprocess engineering in biotechnology. *The Bridge,* 34(3),26-32.

Course Code: 0512 07 BGE 2208	Year: Second	Term: Second
Course Title	Bioprocess Engineering Sessional	
Course Status	Core	
Credit	1.0	
Prerequisite(s)	None	
Rationale	The course is designed to provide Knowledge on hands-on training and insights in the area of Bioprocess Engineering.	
Course Objectives	• To explain few areas of Bioprocess engineering through hands on training. • To learn proper methods of writing a scientific report.	

	Course Content	CLOs
1	Measurement of mass, volume and density of different fluids	1
2	Verification of Bernoulli's theorem with the help of a Bernoulli's apparatus.	2
3	Measurement of heat transfer using various modes.	3
4	Fluid pumps and motors, fluid viscosity.	4

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Learn basic measurement technique	1, 2, 3, 4, 5, 6, 8, 9, 10
	CLO2	Prove Bernoulli's theorem through experiment and use this Knowledge in problem solving.	1, 2, 3, 4, 5, 6, 8, 9, 10
	CLO3	Calculate heat transfer using different fluids.	1, 2, 3, 4, 5, 6, 8, 10, 11
	CLO4	Learn principles and uses of pumps and motors and gain Knowledge in viscosity.	1, 2, 3, 4, 5, 6, 8, 9, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and hands on training	Quiz, oral exam. and lab report evaluation
CLO2	Lecture and hands on training	Quiz, oral exam. and lab report evaluation
CLO3	Lecture and hands on training	Quiz, oral exam. and lab report evaluation
CLO4	Lecture	Quiz, oral exam. and lab report evaluation

Learning Materials

Recommended Readings	Holman, J. P. (1996). *Heat transfer* (7th ed.). McGraw-Hill Book Co. Lydersen, B.K., D'Elia, N.A., & Nelson, K. L.(2010). *Bioprocess engineering: Systems, equipment and facilities* (1st ed.). Wiley, India. McCabe, W. L., Smith, J. C., & Harriot, P. (1993). *Unit operations of chemical engineering* (5th ed.). McGraw-Hill Inc. Streeter, V. L., & Wylie, E. B. *Fluid mechanics* (15th ed.). S. Chand, Co. Ltd.
Supplementary Readings	Mishra, S. K., Agarwal, P. K., & Verma, A. (2008). *Experiment no. 1 - Verification of Bernoullis theorem.* Uttarakhand Board of Technical Education Xuan, Y., & Li, Q. (2000). Heat transfer enhancement of nanofluids. *International Journal of Heat and Fluid Flow,* 21(1), 58-64.

Course Code: 0512 07 BGE 2209		Year: Second	Term: Second
Course Title	Microbial Genetics		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	This course is designed to introduce different aspects of microbial genetics. It starts with the basic mechanisms of microbial and phage genetics which extends to their particular applications.		
Course Objectives	• To familiarize with fundamental organization and processes of the microbial genome, plasmids and gene transfer. • To introduce phage genetics and applied microbial genetics in practice.		

	Course Content	CLOs
	Section A	
1	Bacterial Chromosome: Introduction, structure and replication.	1
2	Plasmid: Introduction, structure and replication, replication of Col E1, R6k and conjugative plasmid, control of plasmid replication, plasmid curing, R-plasmid and antibiotic resistance, mechanism of antibiotic resistance.	1, 4
3	Conjugation: F+ and F- like plasmids, tra-operon, sex pili, formation of hfr strain, gene mapping by conjugation analysis, transfer of non-conjugative plasmid by a conjugative plasmid, plasmid mobilization, and chromosome transfer by cultures of *E. coli* K-12. Conjugation and chromosome transfer in other bacteria, conjugal transfer of R-plasmid.	1, 4
4	Transformation and Electroporation: Competence, uptake of DNA, transfection. Artificially induced competence. DNA transfer by electroporation.	1, 4
5	Transduction: Generalized transduction, experimental evidence, the origin of generalized transducing phage, genetic mapping by different transduction classes. Specialized transduction, experimental evidence, and the origin of the specialized transducing phage particle.	1, 2
	Section B	CLOs
6	Phage genetics: Phage T4 life cycle (lytic vs. lysogenic), genetic recombination in T4 phage, genetic fine structure, unit of function. Phage ΦX 174- life cycle, genetic organization.	2
7	Transposon and Insertion Sequences: Transposable elements, the mechanism of transposition. Transposon mutagenesis.	3
8	Molecular Cloning: Restriction endonuclease and digestion of DNA. Ligases; blunt-ended ligation, linker. Homopolymer tailing. Cloning vector; use of bacterial plasmid, λ DNA, cosmid, and yeast plasmid as cloning vector. Gene libraries.	4
9	Yeast Genetics: Mating type genetics of yeast, yeast plasmid, mitochondrial inheritance in yeast.	2, 3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Learn about the microbial and viral genome, plasmids, and gene transfer processes e.g. conjugation, transduction and transformation.	1, 2, 6
	CLO2	Familiarize with yeast and phage genetics, temperate lifestyle, and other phages.	1, 2, 3, 6
	CLO3	Explain the transposon, mechanism of transposition and also transposons mutagenesis.	1, 2
	CLO4	Interpret the biological vector systems in molecular cloning and their roles in genetic transformation.	1, 2

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Continuous assessment and term final examination
CLO2	Lecture and presentation	Quiz and term final examination
CLO3	Lecture and presentation	Continuous assessment and term final examination
CLO4	Lecture and presentation	Quiz and term final examination

Learning Materials

Recommended Readings	Chaudhury, K. (2012). *Textbook of microbial genetics.* Tata Energy Research Institute. Dale, J. W., & Park, S.F. (2010). *Molecular genetics of bacteria* (5th ed.). Wiley & Sons Gardner, E.J., Snustad, D.P., & Simmons, M.J. (1991). *Principles of genetics.* John Wiley & Sons. Snyder, L., Peters, J. E., Henkin, T. M., & Champness, W. (2013). *Molecular genetics of bacteria* (4th ed.). Wiley. Strickberger, M. W. (1990). *Genetics*. Macmillan Pub. Co. Suzuki, D. T., Griffiths, A. J. F., Miller, J. H., & Lewontin, R. C. (1986). *Introduction to genetic analysis.* W. H. Freeman and Co. Tortora, G., Funke, B., & Case, C. (1998). *Microbiology- An introduction.* Wiley.
Supplementary Readings	Streips, U. N., & Yasbin, R. E. (2002). *Modern microbial genetics* (2nd ed.). Wiley-Liss, Inc. Glazer, A. N., & Nikaido, H. (2007). *Microbial biotechnology: Fundamentals of applied microbiology* (2nd ed.). Cambridge University Press.

Course Code: 0512 07 BGE 2210	Year: Second	Term: Second
Course Title	Microbial Genetics Sessional	
Course Status	Core	
Credit	1.0	
Prerequisite(s)	None	
Rationale	This course is designed to learn practical skills related to microbial genetics. It covers laboratory strategies for gene transfer.	
Course Objectives	• To work with bacterial plasmids e.g. isolation and curing. • To learn gene transfer processes e.g. transformation and conjugation.	

	Course Content	CLOs
1	Conjugal transfer of R-Plasmid.	1, 2, 3, 4
2	Plasmid isolation and curing.	1, 2, 3, 4
3	Transformation of *E. coli* K-12 with plasmid DNA.	1, 2, 3, 4
4	Transduction experiment with available temperate phage and lysogenic bacteria.	1, 2, 3, 4

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Explain the complication of microbial genetics on the basis of facts, principles and earned Knowledge of the procedures conferred during the course.	1
	CLO2	Interpret to set up of experiments, employing a personal responsibility, scientifically proper and systematic approach.	1, 10
	CLO3	Organize laboratory data, make complete observations, acquire the Knowledge of using laboratory equipment and conduct the techniques with safety and reliability.	1, 3, 10
	CLO4	Show the ability to interpret data, analyze results and report writing.	1, 3, 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Practical/tutorials and lectures	Quiz, practical work including a report, final examination
CLO2	Practical/tutorials and lectures	Quiz, practical work including a report, final examination
CLO3	Practical/tutorials and lectures	Quiz, practical work including a report, final examination
CLO4	Practical/tutorials and lectures	Quiz, practical work including a report, lab final examination and viva voce

Learning Materials

Recommended Readings	Miller, J. R. (1992). *A short course in bacterial genetics: Lab manual*. Cold Spring Harbor Laboratory Press. Suzuki, D. T., Griffiths, A. J. F., Miller, J. H., & Lewontin, R. C. (1986). *Introduction to genetic analysis*. W. H. Freeman and Co.
Supplementary Readings	Primrose, S. B., & Twyman, R. M. (2006, 2012). *Principles of gene manipulation and genomics*. Blackwell.

Course Code: 0512 07 BGE 2211	Year: Second	Term: Second
Course Title	Developmental Biology	
Course Status	Optional	
Credit	3.0	
Prerequisite(s)	None	
Rationale	This course introduces the molecular and cellular principles behind how a single cell becomes a multicellular organism with specialized tissues and organs.	
Course Objectives	• To Interpret the underlying mechanisms of development. • To explore how alterations in some aspects of development can result in human developmental disorders. • To develop the ability to formulate hypotheses about the mechanistic bases for biological phenomena.	

	Course Content	CLOs
	Section A	
1	Introduction to Developmental Biology: Cellular basis of morphogenesis, differentiation and morphogenesis, developmental dynamics of cell specification, cell-cell communication and signaling.	1
2	Mammalian Embryonic Development: Trimester-wise embryonic development, axis formation, sex determination, germline development, neural tube and crest development, organ development, post-embryonic development.	1, 2
3	Differential Gene Expression: The biological origin of gene theory, zygotic genome activation, epigenetic gene regulation during mammalian development, developmental trajectory differences between humans and other mammalians.	1, 2
	Section B	CLOs
4	Stem Cells and Regeneration: Stem cells and their regenerative properties, source of stem cells, iPSCs and its uses, genetic regulation of iPSCs.	1, 2, 3
5	Development and Disease: Infertility, developmental disorders, teratogenesis, environmental toxicity and development.	1, 2
6	Developmental Biology and Medicine: Impact of developmental biology on medicine, current topics on developmental biology.	1, 2, 3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Describe the developmental dynamics of cell specification.	1, 2, 3, 9
	CLO2	Apply knowledge on the genetic, cellular and molecular mechanism that underlies animal development.	1, 2, 3, 4, 9
	CLO3	Predict and explain the implications to organism development following alterations in gene expression or environmental changes.	1, 2, 3, 4, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and presentation	Quiz, assignment
CLO2	Lecture, group task	Term final exam.
CLO3	Lecture and/or presentation	Assignment, term final exam.

Learning Materials

Recommended Readings	Gilbert, S. F., & Barresi, M. J. F. (2016). *Developmental biology* (11th ed.). Sinauer Associates. Slack, J. (2012). *Essential developmental biology* (3rd ed.). Wiley-Blackwell. Wolpert, L., Beddington, R., Jessell, T., Lawrence, P., Meyerowitz, E, and Smith, J. (2002). *Principles of development* (2nd ed.). Oxford University Press.
Supplementary Readings	Beyer, T. A., Narimatsu, M., Weiss, A., David, L., & Wrana, J. L. (2013). The tgfβ superfamily in stem cell biology and early mammalian embryonic development. *Biochimica et Biophysica Acta* (BBA)-General Subjects, 1830(2), 2268-79. Evered, D., Marsh, J., (Eds) (2008). *Cellular basis of morphogenesis.* John Wiley & Sons. Honein, M. A., Gilboa, S. M., & Broussard, C. S. (2013). The need for safer medication use in pregnancy. *Expert Review of clinical Pharmacology,* 6(5), 453-455. Malik, N., & Rao, M.S. (2013). A review of the methods for human iPSC derivation. *Pluripotent Stem Cells*. 23-33

Course Code: 0512 07 BGE 2213		Year: Second	Term: Second
Course Title	Human Physiology		
Course Status	Optional		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to Interpret how the vast arrays of molecular and cellular events successfully integrate to define the phenomenon of human existence.		
Course Objectives	This course will make the students apply their Knowledge for exploring the basics of human physiology. Hence, the course will focus on the followings: • Physiological basis for growth and development of human. • Hormonal systems of human. • Integrate the regulation of organ system functions in a whole human to explain homeostasis. • Structure-function relationships of different organs and systems. Focus on the structure, biochemistry, and function of mammalian hormones and endocrine glands. • To develop the ability to formulate hypotheses about the mechanistic bases for biological phenomena.		

	Course Content	CLOs
	Section A	
1	General Physiology: Introduction to human physiology, homeostasis, cell structure, membrane transport, cell membrane potential, action potential, excitation rhythmical.	1
2	Blood: Composition, origin, functions and functions in general; properties of plasma proteins, erythrocytes-morphology, function, developmental fate, leukocytes-morphology, function, classification, properties, development; thrombocytes-morphology, function, development; hemoglobin-synthesis, structure, function, fate; homeostasis and coagulation-concept of coagulation, anti-coagulation; Blood groups- ABO system; Rh factor, lymph-function circulation.	1, 2
3	Cardiovascular System: Structure and properties of cardiac muscle, generation and conduction of cardiac impulse, electro physiology of cardiac muscle (ECG); events of cardiac cycle and cardiac outputs, heart rate, factors affecting heart rate, hemodynamic, blood pressure and its regulation.	1, 2
4	Respiratory System: Introduction of respiratory apparatus and pulmonary circulating, mechanism of respiration, pulmonary ventilating, pulmonary volume, alveolar ventilation, capacities, gaseous exchange, ventilation-perfusion relationship, oxygen transport, oxygen dissociation and saturation curve, carbon-dioxide transport, oxygen carriage, regulation of respiration-nervous and chemical.	1, 2
5	Urinary System: Structure and function of kidney, renal circulation, urine formation-filtration, re-absorptions of different components of tubular fluid, secretion of substances by the kidney, concentration of urine, concept of plasma clearance. Acidification of urine.	1, 2
	Section B	CLOs
6	Nervous System: Organization of the nervous system, neuron, glial cells, nerve impulse, synapse. Synaptic and neuron-muscular transmission, Neuro transmitters.	1, 3
7	Reproductive System: Introduction to reproductive organs, puberty, menarche and menopause. a) Female Reproductive Organ: Structure and functional aspects of ovary and ovarian cycle, menstrual cycle, b) Male Reproductive Organ: Structure of testes, spermatogenesis steps and control, fertility, fertility control and sterility.	1, 3
8	Ooestrous cycle: Marshall phases of ooestrous cycle, follicular phase and luteal phase, length of ooestrous cycle, duration of Ooestrus and time of ovulation, survivability of sperm and egg in female reproductive tract,	1, 3
9	Pregnancy and Parturition: Physiology of pregnancy, stages of ovum, embryo and fetus, changes in uterus and its contents and mammary gland during pregnancy, placenta and its functions. Various stages of parturition and evolution of the uterus, normal and abnormal presentation of fetus.	1, 3

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Interpret function of mammalian systems with regards to homeostasis, metabolism, growth and normal physiological processes as well as some pathophysiological situations and physiological adaptability to various environmental situations	1, 2, 3, 6, 7, 9, 11
	CLO2	Acquire knowledge in reproductive endocrinology and hormones.	1, 2, 3, 6, 7, 9, 11
	CLO3	Describe the process of spermatogenesis and oogenesis.	1, 2, 3, 6, 7, 9, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Class lecture	Written test, continuous assessment
CLO2	Class lecture, presentation	Written test/assignment
CLO3	Class lecture, group discussion	Term final exam.

Learning Materials

Recommended Readings	Bijlani, R. L. (1995). *Interpreting medical physiology: A text book of medical students.* Jaypee Brothers Medical Publishers Pvt. Ltd. Chaudhuri, S. K. (1997). *Concise medical physiology.* New Central book Agency Pvt. Ltd. Ganong, W. F. (1997). *Review of medical physiology* (18th ed.). Appleton and Lange. Guyton, A. C. and Hall, J. E. (1995). *Textbook of medical physiology.* W. B. Saunders Co.
Supplementary Readings	Rogers, K. (2010). The Eye: *The Physiology of human perception (the human body).* Britannica Educational Publication. Sherwood, L. (2014). Human Physiology: *From cells to systems*. Cengage Learning USA.

Course Code: 0613 07 CSE 2271	Year: Second	Term: Second
Course Title	Computer Programming	
Course Status	Optional	
Credit	2.0	
Prerequisite(s)	None	
Rationale	This is an entry level programming course designed to teach students the basic concepts of computer programming. The course includes different operating systems and designing, coding, debugging, testing, and documenting programs using a high-level programming language.	
Course Objectives	This course will make the students apply their Knowledge for exploring the basics of human physiology. Hence, the course will focus on the followings: • To develop fundamental computational concepts underlying most programming languages. • To gain skills in a range of problem-solving techniques using computers. • To acquire Knowledge in different bioinformatics software and to create expertise in mathematical & biological modeling and system biology.	

Course Content		CLOs
Section A		
1	Programming with Visual Tools: Basic concept, object, method, event, event-driven programming, the BVIDE, working with forms, basic active control: text box control, list box control, comb box control, file control, command button, MSFlex grid control. Visual basic language, variable, constants, arrays, dynamic arrays, collections, procedures: subroutines, functions, calling procedures, arguments, control flow statements: if..then, if..then..else, select case. Loop statements: Do loop, for..next, nested control structures, the exit statement.	1, 2
2	Programming with C/C++: Constants, variables, data types, operators, expression, input and output operations, branching, looping, arrays, pointer, functions, structures and union, files, dynamic memory allocation.	1, 2, 3
Section B		CLOs
3	Database Programming, Database, DBMS, relational concepts, keys, referential integrity, introduction to SQL, basic structure, joins, attaching queries to a database, the data control, advanced data bound controls, the ADO data control, entering data, accessing fields in record sets.	1, 3, 5
4	HTML and Font page.	1, 3
5	Applications: Introduction and applications of Agrobase, WINBOT, BLAST, PDB, Perl and Linux programs.	1, 3
6	Retrieving information using internet and CD-ROM.	1, 4

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Develop basic computational concepts and elementary data structures.	1, 8, 9, 10
	CLO2	Gain knowledge in different operating system	1, 7, 8, 9, 10
	CLO3	Recognize the fundamentals of computer programing.	1, 2, 3, 7, 8, 9, 10
	CLO4	Amend existing programs to adjust or correct their functionality.	1, 8
	CLO5	Interpret different biological modelling and perform different bioinformatics software.	1, 2, 3, 7, 8, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and/or group task	Quiz, assignments
CLO2	Lecture and presentation	Assessment of assignments
CLO3	Lecture and/or hand to hand teaching	Term final exam.
CLO4	Lecture and presentation	Term final exam., assignments
CLO5	Lecture and presentation	Term final exam.

Learning Materials

Recommended Readings	Deborah, S. & Roy, E.S. (2003). *Mastering HTML.* Wily Interscience. Korth, H. F. & Silberschartz, A. (2003). *Database system concepts.* Wiley Interscience, Inc. Kerninghan, B.W. & Dennis, M. (2002). *Programming language*. McGraw Hill. Peroutsos, E. (2001). *Mastering visual basic 6.0*. McGraw Hill Book Inc. Silberschatz, K. S. (2002). *Database system concepts.* McGraw Hill.
Supplementary Readings	Cowell, J. ADO Data *Control Events. InEssential Visual Basic 6.0 fast 2000* (pp. 183-189). Springer. Johnson, M., Zaretskaya, I., Raytselis, Y., Merezhuk, Y., McGinnis, S., & Madden, T. L. (2008). NCBI BLAST: *a better web interface.* Nucleic acids Research. 36 (suppl.-2), W5-W9. Josuttis, N. M.. *The C++ standard library: a tutorial and reference.* Saeed, M. S., Saeed, A., Iqbal, M., & Adnan, M. (2020). Utilization of bioinformatics in the field of biotechnology-A review. *International Journal of Recent Biotechnology*, 8(4), 16-18.

Course Code: 0613 07 CSE 2272	Year: Second	Term: Second
Course Title	Computer Programming Sessional	
Course Status	Optional	
Credit	1.0	
Prerequisite(s)	None	
Rationale	This is an entry level programming course designed to teach students the basic concepts of computer programming.	
Course Objectives	• To develop fundamental computational concepts and underlying most programming languages. • Hands-on training on programming.	

	Course Content	CLOs
1	Laboratory work based on Computer Programming (CSE-2151)	1, 2, 3, 4
2	Student will complete projects with proper documentation as assigned by the course teacher.	1, 2, 3, 4

		Upon successful completion of the course, the students will be able to:	Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Develop basic computational concept.	1, 8
	CLO2	Recognize the fundamentals of computer programming	1, 8
	CLO3	Translate well-structured plans into working programs.	1, 9
	CLO4	Use the error messages of the compiler to identify and correct mistakes in program syntax.	1, 2, 8, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and/or Group Discussion	Quiz, final exam.
CLO2	Lecture and/or Group Presentation	Lab final exam., assignment evaluation
CLO3	Hand-hand working	Project evaluation
CLO4	Hand-hand working	Project evaluation, viva voce

Learning Materials

Recommended Readings	Deborah, S., & Roy, E.S. (2003). *Mastering HTML*. Wily Interscience. Kerninghan, B.W. & Dennis, M. (2002). *Programming language*. McGraw Hill Book Inc. Korth, H. F. & Silberschartz, A. (2003). *Database system concepts.* Wiley Interscience, Inc. Peroutsos, E. (2001). *Mastering visual basic 6.0.* McGraw Hill Book Inc. Silberschatz, K. S. (2002). *Database system concepts.* McGraw Hill Book Inc.
Supplementary Readings	Campbell, J., Gries, P., Montojo, J., & Wilson, G. (2009). *Science using Python (Pragmatic Programmers)* (1st ed.). Pragmatic Bookshelf. Gries, P., Campbell, J., & Montojo, J. (2013. *Practical Programming: An Introduction to Computer Science Using Python 3 (Pragmatic Programmers)* (2nd ed.).Pragmatic Bookshelf.

Third Year First Term			
Course Code: 0512 07 BGE 3101		Year: Third	Term: First
Course Title	Immunology		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The Immunology course is designed to provide a foundation in the basic concepts and terminology of immunology.		
Course Objectives	• To introduce the concepts of immune system, their integral components and the interplay among towards host immunity. • To deliver the Knowledge of fine coordination of immune components, absence of it and therapeutic approaches. • To overview different immunopathological states and the techniques of deciphering immunological reactions.		

	Course Content	CLOs
	Section A	
1	Introduction to Immune System: Adaptive and innate immunity, cells of the immune system, soluble mediators of immunity, cytokine, antigens, haptens and carriers, immune responses, inflammation, opsonization, chemotaxis, phagocytosis, defense against intracellular and extracellular pathogens.	1
2	Cells Involved in Immune Responses: Lymphocytes (T-cells, B cells, NK cells), mononuclear phagocytes, polymorphonuclear granulocytes, mast cells, platelets, antigen presenting cell, primary and secondary clonal expansion of lymphocytes.	1, 2
3	The Lymphoid System: Primary and secondary lymphoid tissue, primary lymphoid organs, secondary lymphoid organs, lymphocyte traffic.	1, 2
4	Antigen Receptor Molecules: Immunoglobulins (class, structure, physicochemical properties, biological roles), antibody variants, membrane and secreted immunoglobulins, production of immunoglobulins, T-cell antigen receptors, major histocompatibility complex (class, structure, function.	1, 3
5	Antibody Diversity and T-cell Receptor: Theories of antibody formation, immunoglobulin variability, immunoglobulin genes, light chain gene recombination, heavy chain gene recombination, variable recombination and additional diversity, somatic mutation, heavy chain constant region genes, class switching, T-cell receptor genes.	1, 2, 3
	Section B	CLOs
6	Antigen Recognition: Antigen-antibody binding, antibody affinity and avidity, antibody specificity and cross reactivity, antigen processing and presentation, T-cell antigen recognition	1, 2
7	Cell Cooperation in the Antibody Response: Cooperation between different cell types, cell activation, antigen specific triggering of lymphocyte, antibody responses in vivo, affinity maturation, immunological memory.	1, 2
8	Cell Mediated Immune Reactions: T-cell-independent cell mediated defense mechanism, T-cell dependent cell mediated responses, mechanism of cell mediated cytotoxicity, ¬lymphokine-mediated activation of macrophages, cytokine network	1, 2, 3
9	Complement System: Introduction, classical and alternative pathways of complement activation, regulation of classical and alternative pathway, amplification loop, membrane attack complex, complement receptor, biological effects of complement.	1, 2
10	Immunopathology and Psychoneuroimmunology: Immunodeficiency (AIDS), hypersensitivity, autoimmune disease, immune-neuroendocrine network, endocrine-immune modulation, neuro-immune modulation, neuroendocrine and immune effect of psychosocial stress, effect of psychosocial stress on infection, allergy, cancer, AIDS and autoimmunity, immune activity and psychopathology, immune function enhancement.	1, 2, 3

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Acquire a fundamental working knowledge of the basic principles of immunology;	1, 2, 6, 9
	CLO2	Begin to interpret how these principles apply to the process of immune function;	1, 2, 3, 6, 7, 9
	CLO3	Develop the ability to solve problems in clinical immunology by making use of the available resources and communicating with colleagues.	1, 2, 3, 6, 7, 9, 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Class lecture	Written test/quiz
CLO2	Class lecture, group discussion	Written test
CLO3	Class lecture, presentation	Written test/assignment, term final exam.

Learning Materials

Recommended Readings	Abbas, A. K., Lichtman, A. H., & Pillai, S. (2021). *Cellular and molecular immunology* (10th ed.). Elsevier, Amsterdam, Netherlands. Kindt,T. J., Goldsby, R. A., & Osborne, B.A. (2000). *Kuby immunology* (4th ed.). W.H. Freeman and Company, New York. Roitt, I. M. (1994). *Essential immunology* (8th ed.). Wiley-Blackwell Scientific, Oxford, UK.
Supplementary Readings	Cochet O., Teillaud, J. L., & Sautes, C. (Eds.). (1998). *Immunological techniques made easy.* John Wiley & Sons, New Jersey, USA. Koenig, H. G., & Cohen, H. J. (Eds.). (2002). *The link between religion and health: Psychoneuroimmunology and the faith factor*. Oxford University Press. UK. Schedlowsky, M., & Tewes, U. (Eds.) (1999). *Psychoneuroimmunology: An interdisciplinary introduction.* (1st ed). Springer.

Course Code: 0512 07 BGE 3102		Year: Third	Term: First
Course Title	Immunology Sessional		
Course Status	Core		
Credit	1.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide hand-on training to the students specially on various immunological techniques and assays		
Course Objectives	• To Recognize antigen-antibody interactions • To Interpret immune assay techniques viz. immunofluorescence, radioimmuno, complements and enzyme-linked assay.		

	Course Content	CLOs
1	Antigen-Antibody Interactions	1
2	Precipitation reaction in gels.	1, 2
3	Haemagglutination and haemagglutination fixation test.	2
4	Complement fixation.	2
5	Direct and indirect immunofluorescence	3
6	Radioimmunoassay	2
7	Enzyme-linked immunosorbent assay.	1, 2
8	Immunoblotting and immunoprecipitations.	1, 2
9	Isolation of pure antibodies.	2, 3
10	Assay for complements	2, 3
11	Isolation of lymphocyte population.	2, 3
12	Effectors' cell assay	3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Interpret antigen antibody interaction and precipitation reaction in gel and to Explain the procedure of haemagglutination fixation and complement fixation test	1, 2, 8, 6, 7, 9, 10
	CLO2	Perform various assay techniques such as radioimmunoassay, enzyme-linked immunosorbent assay and effectors' cell assay	1, 2, 3, 6, 7, 9, 10
	CLO3	Isolate pure antibodies and lymphocyte population.	1, 2, 3, 6, 7, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Class lecture, experimentation	Laboratory experimentation, viva voce
CLO2	Class lecture, experimentation	Lab report/ evaluation, viva voce
CLO3	Class lecture, experimentation	Lab report/ evaluation, lab final exam. and viva voce

Learning Materials

Recommended Readings	Cochet O., Teillaud, J. L., & Sautes, C. (Eds.). (1998). *Immunological techniques made easy*. John Wiley & Sons, New Jersey, USA. Harbeck, R. J., & Giclas, P.C. (1991). *Diagnostic immunology laboratory manual.* Raven Press, South Africa. Hay, F.C., & Westwood, O.M.R. (1980). *Practical immunology* (2nd ed.). Wiley Blackwell, USA. Male, D., Brostoff, J., Roth, D., & Roitt, I. (Eds.). (2012). *Immunology* (8th ed.). Elsevier, NY. USA.
Supplementary Readings	Delves, P.J., Martin, S.J. Burton, D.R., Roitt, I.M. (2017), *Roitt's essential immunology* (13th ed.) Wiley-Blackewll, USA

Course Code: 0512 07 BGE 3103		Year: Third	Term: First
Course Title	Molecular Genetics		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	This course is designed to increase appreciation of the molecular basis of modern genetics. It covers the more traditional life sciences such as genetics, biochemistry, microbiology, and cell biology. The course is to explain classical and advanced genetics in the molecular fundamentals.		
Course Objectives	• To explain how genes are transmitted between generations, and how and when errors can arise; • To introduce the basic concept of the molecular control of development; • To demonstrate the theoretical aspects of Genetic Engineering.		

	Course Content	CLOs
	Section A	
1	Fine Structure and Transcription of Eukaryotic Gene: Promoters, proximal and distal regulatory sequences; eukaryotic RNA polymerases, transcription initiation, elongation and termination.	1, 2
2	RNA Processing: Capping, splicing and polyadenylation of nascent mRNA; transcription and processing of ribosomal RNA genes.	1, 2
3	Gene Cloning: Cloning host, cloning and shuttle vectors, important enzymes in cloning- restriction endonuclease and DNA ligase.	4, 5
4	Construction of Gene Libraries: Construction, rationale and importance of genomic and cDNA libraries.	4, 5
5	Analysis of Gene and Gene Products: Analysis of DNA by Southern Blotting Hybridization, analysis of RNA by Northern Blotting and RT-PCR, protein analysis by Western Blotting.	4, 7
6	Gene Silencing: Concept, mechanisms, and their roles.	2
	Section B	CLOs
7	Genomic Organization: Structure and gene content of mitochondrial, nuclear and plastid gene expression, and cytoplasmic male sterility (CMS).	2, 3
8	Molecular Control of Development: Discovery, types and occurrence of transposable elements/transposons of eukaryotes, transposon tagging and genetic significance of transposons chromosome walking and subtractive hybridization.	4
9	Genes in Development: Genes action during development and differentiation, nuclear and cytoplasmic factors in development, turning genes on and off, development of model organisms (*Drosophila* and *Arabidopsis thaliana*).	4
10	Mutagenesis: Molecular basis of mutation, targeted mutagenesis, *in vitro* site-specific mutagenesis, DNA damage and repair mechanisms.	5, 6
11	Regulation of Plant Gene Expression: Signal transduction pathway, signaling for self-incompatibility in the plant, DNA methylation, trans-acting factors. Post-transcriptional control of gene expression.	3, 4
12	Nature's Genetic Engineer: Development of crown gall, *Agrobacterium spp.* classification of gall based on opines, organization of Ti and Ri plasmid, virulence operon, and molecular mechanism of T-DNA transfer.	6

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Explain the mechanisms of DNA replication, RNA processing, protein synthesis, and also theoretical aspects of Genetic Engineering.	1, 2
	CLO2	Explain the fundamental molecular processes of the cell, including DNA replication, transcription, translation and analyze genes and gene products.	2, 3
	CLO3	Describe gene expression and regulation at the transcriptional and post-transcriptional levels	2, 5, 8
	COL4	Illustrate the use of information from mutations to infer the role(s) of gene products and get the idea of cloning the mutant genes cloning and repair	4, 6, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Continuous assessment, and term final examination
CLO2	Lecture and presentation	Quiz and term final examination
CLO3	Lecture and presentation	Continuous assessment and term final examination
CLO4	Lecture and presentation	Quiz and term final examination

Learning Materials

Recommended Readings	Brown, T. A. (1995). *Gene cloning: An introduction* (3rd ed.). Chapman & Hall, UK. Gardner E.J. Simmons, M. J., & Snustad, D. P. (2006). *Principles of genetics* (8th ed.). John Willey & Sons Inc. NY, USA. Krebs, J. (2012). *Lewin's genes XI* (11th ed.). Jones & Bartlett Learning, MA, USA.
Supplementary Readings	Kornberg, R. D. (2001). The eukaryotic gene transcription machinery. *Bio Chem.* 382(8),1103-7. Venters, B. J., & Pugh, B. F. (2009). How eukaryotic genes are transcribed. *Critical reviews in biochemistry and molecular biology*. 44(2-3),117-41.

Course Code: 0512 07 BGE 3105		Year: Third	Term: First
Course Title	Animal Cell Culture		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide concepts and principles in Animal Cell Culture and related technologies for cell culture and cell culture products for therapeutics and commercial interest.		
Course Objectives	• To describe the basic principle and concepts about mammalian cell culture and cell culture technologies. • To comprehend the practical applications of animal cell culture and production of therapeutics for human and animal.		

	Course Content	CLOs
	Section A	
1	Introduction: Animal cell culture, organ culture and histotypic culture. Applications, advantages and disadvantages of animal cell culture. Products of animal cell culture.	1, 2, 3
2	Cell Culture Techniques and Cell Lines: Initiation of cell culture, cell types, disaggregation of tissues, primary culture, subculture, cell lines, tests for cell line identification, culture of specific cell types.	1, 2, 3
3	Stem Cells: Definition, classification, potential applications, totipotency, pluripotency and multipotency, embryonic and adult stem cells, patterns of stem cell division.	1, 2, 3
4	Genetic Engineering of Animal Cells in Culture: DNA-mediated transformation into mammalian cells. Methods of transfer of 'naked' DNA, DNA transfer using viruses, advantages and disadvantages of different methods for introducing DNA into cultured animal cells, selection and amplification the genes of transfected cells, transient and stable gene expression.	1, 2, 3
5	Tissue Engineering and Organ Transplantation: Principles, biomaterials, method of harvesting of cells from patients, guided tissue repair, autotransplants, allotransplants, xenotransplants, Apligraf, sources of organs for transplantation, complications of organ transplantation, new direction for organ transplantation.	1, 2, 3
	Section B	CLOs
6	Preparation and Maintenance of Cell Line: Isolation of different types of animal tissue; fibroblast, liver, kidney, bone marrow and their uses. Routine observation and maintenance; cloning and selection of specific cell-types.	1, 2, 3
7	Quantitation and Experimental Design: Selection of cell line; experimental design; growth phase; cell counting, preparation of samples for enzyme assay and immune assay. Preparation of samples for extraction of DNA and RNA.	1, 2, 3
8	Specialized Techniques of cell culture: Mass cell culture technique, lymphocyte preparation. Auto radiography, cell synchrony, culture of amniocytes.	1, 2, 3
9	Expression of Recombinant Biomedical Products from Continuous Mammalian Cell Lines: Production of Monoclonal Antibodies, genetic modification to expressed gene, expression vectors, transfection, selection, amplification and purification of recombinant proteins.	1, 2, 3
10	Risk Assessment and Regulatory Aspects: Risk assessment of cell culture procedure, standardization of cell culture procedure. Good laboratory practice for cell culture procedures, good manufacturing practice for cell culture processing, regulatory framework.	1, 2, 3

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Recognize the fundamentals of animal cell culture and the technologies used for cell culture.	1, 2, 3, 6, 7, 9
	CLO2	Familiarize with different cell cultures and cell lines.	1, 2, 3, 6, 7, 9
	CLO3	Choose the cell line for expression of recombinant proteins for commercial and therapeutic applications.	1, 2, 3, 6, 7, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, presentation, assignment	Continuous assessment, quiz and term final exam.
CLO2	Lecture, presentation, assignment	Continuous assessment, quiz and term final exam.
CLO3	Lecture, presentation, assignment	Continuous assessment, quiz and term final exam.

Learning Materials

Recommended Readings	Butler, M. (2004). *Animal cell culture and technology: The basics* (2nd ed.). Taylor & Francis, UK. Freshney, R. I. (2016). *Culture of animal cells: A manual of basic technique and specialized applications* (7th ed.). Wiley-Blackwell, New Jersey, USA. Stacey, G.N., & Davis, J. (Eds.). (2007). *Medicines from animal cell culture* (1st ed.). Wiley & Sons, USA.
Supplementary Readings	Castilho, L., Moraes, A., Augusto, E., & Butler, M.(Eds.). (2007). *Animal cell technology*: From *biopharmaceuticals to gene therapy* (1st ed.). (2008). Taylor & Francis, UK. Davis, J. M. (Ed.). (2011). *Animal cell culture: Essential methods* ((1st ed.). Wiley and Blackwell Publishers, USA.

Course Code: 0512 07 BGE 3106		Year: Third	Term: First
Course Title	Animal Cell Culture Sessional		
Course Status	Core		
Credit	1.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide concepts and principles and practical Knowledge in Animal Cell Culture and related technologies for cell culture.		
Course Objectives	• Orientation with cell culture laboratory and to learn the basic principle and concepts about the preparation of cell culture media and different cell lines. • To learn the different assay techniques used in the cell culture.		

	Course Content	CLOs
1	Design, layout and laboratory requirements.	1, 2, 3
2	Techniques of sterilization.	1, 2, 3
3	Preparation of media.	1, 2, 3
4	Preparation of primary cell lines.	1, 2, 3
5	Maintenance of primary and permanent cell lines.	1, 2, 3
6	Cultivation of virus.	1, 2, 3
7	Virus assay techniques: TCID 50, Plaque assay, Immunofluorescence technique, Haemagglutination and Haemagglutination inhibition test, Enzyme linked Immuno-sorbent assay (ELISA), Agar Gel Immuno-diffusion test, Agglutination test, Complement fixation test, Serum Neutralization test (SWI).	1, 2, 3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Prepare the cell line and subculture of cell line.	1, 2, 8, 6, 7, 9, 10
	CLO2	Maintain the cell line.	1, 2, 3, 6, 7, 9, 10
	CLO3	Perform the assay techniques used in cell culture.	1, 2, 3, 6, 7, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Experiment and presentation	Quiz, report and lab final exam.
CLO2	Experiment and presentation	Quiz, report and lab final exam.
CLO3	Experiment and presentation	Quiz, report and lab final exam., viva voce

Learning Materials

Recommended Readings	Castiho, L., Moraes, A., Augusto, E., & Butler, M. (Eds.). (2007). *Animal cell technology: From biopharmaceuticals to gene therapy* (1st ed.). Taylor & Francis Group, NY, USA. Davis, J.M. (2012). *Animal cell culture: Essential methods* (1st ed). Wiley-Blackwell Publishers. Freshney, R.I. (2016). *Culture of animal cells: A manual of basic technique and specialized applications* (7th ed.). Wiley-Blackwell. Masters, J.R.W. (Ed.). (2000). *Animal cell culture: A practical approach* (3rd ed.). Oxford University Press.
Supplementary Readings	Twyman, R. (2004). Gene *transfer to animal cells: Advanced methods* (1st ed.). Taylor & Francis.

Course Code: 0512 07 BGE 3107		Year: Third	Term: First
Course Title	Enzyme Technology		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide basic concepts and valuable insights of enzyme, kinetics, inhibition and regulation, and its structure determination. Students will also learn applications of enzyme technology in food, medical, and diagnostic industries and related issues.		
Course Objectives	• To discuss various aspects on characteristics and properties of enzymes • To explain the concept and applications of enzymes in Biotechnology-related industries. • To illustrate the process of large-scale production of enzymes for Biotechnology-related industries		

Course Content		CLOs
Section A		
1	Introduction to Enzymes: Definition, classification of enzymes, factors affecting enzyme activity; active site, ground state, standard free energy change, transition state, activation energy, rate-limiting step, equilibrium constant, rate constant, rate law, binding energy, interaction between enzyme and substrate.	1
2	Enzyme Kinetics: Basic reaction kinetics, Michaelis- Menten equation, double reciprocal plot or Lineweaver-Burk equation kinetics of enzymatic reaction having two or more substrates.	1, 2
3	Enzyme Inhibition: Reversible and irreversible inhibition, competitive noncompetitive and uncompetitive inhibition.	1, 2
4	Regulatory Enzyme: Allosteric enzyme, kinetic behavior of allosteric enzyme, mechanism of regulatory activity of allosteric enzyme, covalent modification of enzyme, covalent activation of zymogen; isozyme.	1, 2
Section B		CLOs
5	Application of Enzymes in Biotechnology: Advantages of using enzymes for manufacturing products; application of amylolytic, cellulytic, pectolytic and other industrial enzymes.	3
6	Enzyme Isolation, Purification and Assay: Introduction, objectives and strategies in enzyme purification; primary clarification of the soluble enzyme; methods of concentrating enzymes; various chromatographic methods for enzyme purification; examples of purification procedure; techniques of enzyme assay.	3, 4
7	Industrial Production of Enzymes: Selection of microbial system, large scale production system, production and purification, industrial application.	3, 5
8	Immobilized Enzymes: Isolated enzymes vs. immobilized enzymes, immobilized whole cell vs. immobilized enzymes. Methods of enzyme immobilization, application of immobilized enzyme.	3, 6

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Gather basic in-depth Knowledge on enzymes and their various characteristics.	1, 2, 3, 4, 5, 6, 8
	CLO2	Obtain clear conception about enzyme kinetics, enzyme inhibition and regulation.	1, 2, 3, 4, 5, 6, 8, 9
	CLO3	Recognize the uses of enzymes in the different fields of biotechnology.	1, 2, 3, 4, 5, 6, 8, 9
	CLO4	Acquire knowledge on various enzyme assay techniques.	1, 2, 4, 5, 9, 10, 11
	CLO5	Learn production and purification schemes of large scale protein production.	1, 2, 3, 4, 5, 9, 10
	CLO6	Get a clear view on enzyme immobilization.	1, 2, 3, 4, 5, 6, 7, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and Q-A session	Continuous assessment and term final exam.
CLO2	Lecture and group works	Continuous assessment and term final exam.
CLO3	Lecture and Q-A session	Continuous assessment and term final exam.
CLO4	Lecture and group works	Continuous assessment and term final exam.
CLO5	Lecture	Continuous assessment and term final exam.
CLO6	Lecture	Continuous assessment and term final exam.

Learning Materials

Recommended Readings	Conn, E. E., Stumpf, P.K., Bruening, G., & Doi, R.H. (2006). *Outlines of biochemistry* (5th ed.). Wiley. Nelson, D.L., & Cox, M. M. (2017). *Lehninger principles of biochemistry* (7th ed.). WH Freeman Macmillan West, V. B., Todd, W.R., & Mason, H.S. (1966). *Textbook of biochemistry* (4th ed.). Macmillan Publishers, London, UK. Wiseman, A. (1990). *Principles of biotechnology* (2nd ed.). Springer, NY, USA.
Supplementary Readings	Watson, J. D., Gilman, M., Witkowski, J. A., & Zoller, M. (1992). *Recombinant DNA* (2nd ed.). W. H. Freeman & Co. USA.

Course Code: 0512 07 BGE 3109	Year: Third	Term: First
Course Title	Biofertilizer Production Technology	
Course Status	Core	
Credit	3.0	
Prerequisite(s)	None	
Rationale	The course is designed to teach students the scientific basis of biological nitrogen fixation and biofertilizers. The course also provides microbial technologies for the production and application of biofertilizers to increase soil fertility and crop productivity.	
Course Objectives	• To recognize the biology, enzymology and genetics of nitrogen fixation. • To distinguish microorganism's potential as biofertilizers. • To recognize the techniques of mass production of bacterial, fungal and algal biofertilizers. • To prepare carrier-based inocula and its applications in crop production. • To recognize the different ways of manure production.	

	Course Content	CLOs
	Section A	
1	Introduction: History, soil fertility, concept of biofertilizers, scope and importance of biofertilizers, types of biofertilizers, sources of nutrients in soil, N and P-cycles.	1, 2
2	Nitrogen Fixation: Methods- discharge of electricity, activity of symbionts, activity of free fixers, and manufacture of synthetic nitrogen. Mechanism of penetration of *Rhizobium* into roots, signal exchange before cell infection, interaction at the root hair surface infection, infection thread development and nodulation; function of the nodule; measurement of fixed N_2. Factors affecting nodule development, amount of nitrogen-fixed. Factors affecting nitrogen fixation.	1, 2
3	Nitrogenase: Discovery, nature and mode of action and mechanism of nitrogen-fixation, assimilation of fixed nitrogen, ammonia assimilation.	1, 2
4	The nif Genes: nif+ and nif-; genetics of nif in *Klebsiella pneumoniae*; structure and regulation of nif genes in *K. pneumoniae, Rhizobium* and *Anabeana.*	1, 2
5	Production of Bacterial Biofertilizers: *Rhizobium, Azotobacter*, phosphorus-solubilizing bacteria, plant growth promoting Rhizobacteria.	1, 2, 3, 4
	Section B	CLOs
6	Blue Green Algae (BGA): Nitrogen transformation in a low land rice ecosystem, heterocyst mode of nitrogen fixation in BGA and mass cultivation of BGA.	1, 2
7	Next Generation Novel Biofertilizer: Microbial bioformulations, bionanobiofertilizer, nano-biofertilizers.	2, 4
8	Production and application: *Azolla*, green manure, organic matter composting, *Azospirillium, Frankia* and Mycorrhizae.	2, 3, 4
9	Advances in microorganisms-based biofertilizers: Major mechanisms and applications.	1, 2, 3, 4
10	Present scenario: Biofertilizer production and marketing around the globe.	2, 3, 4

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Recognize the fundamentals of biological nitrogen fixation.	1, 2, 3, 4, 5, 6, 8
	CLO2	Be familiar with microorganisms associated with biological nitrogen fixation and biofertilizers.	1, 2, 3, 4, 5, 6, 8, 9
	CLO3	Produce mass biofertilizers and interpret their application.	1, 2, 3, 4, 5, 6, 8, 9
	CLO4	Produce different types of biological manures.	1, 2, 4, 5, 9, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Continuous assessment
CLO2	Lecture and presentation	Continuous assessment and assignment
CLO3	Lecture and presentation	Continuous assessment, assignment and term final exam.
CLO4	Lecture and group discussion	Term final exam.

Learning Materials

Recommended Readings	Postagate, J. R. (1998). *The fundamentals of nitrogen fixation* (3rd ed.). Cambridge University Press, UK. Rakshit, A., Meena, V.S., Parihar, M., Singh, H.B., & Singh, A.K. (2021). *Biofertilizers: Volume 1: Advances in bio-inoculants* (1st ed.). Woodhead Publishing, Cambridge, UK. Stacey, G., Burris, R. H., & Evans, H. J. (Eds.). (1992). *Biological nitrogen fixation* (1992nd ed.). Springer, NY, USA. Surajit De, M., & Ajit, K. P. (2021). *Recent advancement in microbial biotechnology* (1st ed.). Academic Press.
Supplementary Readings	Itelima, J. U., Bang, W. J., Onyimba, I. A., et al. (2018). A review: biofertilizer- a key player in enhancing soil fertility and crop productivity. *Journal of Microbiology and Biotechnology Reports*. 2(1), 22-28. Swapnil, R., & Nidhi, S. (2020). *Biofertilizer an alternative of synthetic fertilizers*. Plant Archives (20), Supplement 2, 1374-1379. Uddin, I., Ahamed, M. I. ., Boddula, R., & Rezakazemi, M. (Eds.). (2021). *Biofertilizers: Study and impact* (1st ed.). Wiley-Scrivener. Yunus, M.U., Silas, K., Yaumi, A. L., & Kwaji, B.H. (2022). A review of biofertilizer production: bioreactor, feedstocks and kinetics, *International Journal of Recent Engineering Science* (9) 1, 39-50.

Course Code: 0512 07 BGE 3110		Year: Third	Term: First
Course Title	Biofertilizer Production Technology Sessional & Field Work		
Course Status	Core		
Credit	1.0		
Prerequisite(s)	None		
Rationale	The course provides practical Knowledge on nitrogen-fixing microorganisms used as biofertilizers and their industrial production process.		
Course Objectives	• To Recognize the techniques of isolation, characterization and identification of microbial biofertilizers. • To Recognize the techniques of algalization. • To recognize different types of manure production.		

	Course Content	CLOs
1	Isolation, Characterization and Identification of the following microorganisms: Rhizobium, spp., *Azotobacter* spp., and blue green algae.	1, 2, 3
2	Nodulation experiments.	1, 2, 3
3	Study on algalization technique.	2, 3
4	Study on *Azolla* spp.	2, 3
5	Organic matter composting processes.	2, 3, 4

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Recognize the fundamentals of biological nitrogen fixation.	1, 2, 5, 6
	CLO2	Be familiar with microorganisms associated with biological nitrogen fixation and biofertilizers.	1, 2
	CLO3	Produce mass biofertilizers and Interpret their application.	3, 7, 8, 9, 10, 11
	CLO4	Produce different types of biological manures	1, 3, 7, 8, 9, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and group discussion	Lab report evaluation and viva voce
CLO2	Lecture and Lab experiment	Lab final exam. and viva voce
CLO3	Lab experiment	Lab final exam. and viva voce
CLO4	Lab experiment	Lab final exam. and viva voce

Learning Materials

Recommended Readings	Postagate, J. R. (1998). *The fundamentals of nitrogen fixation* (3rd ed.). Cambridge University Press, UK. Stacey, G., Burris, R.H., & Evans, H. J. (Eds.) (1992). *Biological nitrogen fixation* (1992nd ed.). Springer Yadav, A. N. (2021). *Production technology for bioagents and biofertilizers*- A laboratory manual. Eternal University, Himachal Pradesh, India,
Supplementary Readings	Amitava, R., Meena, V. S., Parihar, M., Singh, H. B., & Singh, A. K. (Eds.) (2021). *Biofertilizers:Volume Advances in bio-inoculants* (1st ed.). Woodhead Publishing, Mandal, S. De., & Passari, A. K. (Eds.) (2021). *Recent advancement in microbial biotechnology: Agriculture and industrial approach* (1st ed.). Academic Press.

Course Code: 0512 07 BGE 3111	Year: Third	Term: First
Course Title	Nutrition and Functional Food	
Course Status	Optional	
Credit	3.0	
Prerequisite(s)	None	
Rationale	The course will provide emphasis the study of nutrition involving various disciplines such as chemistry, biochemistry, nutrition and engineering to teach students how diet and nutrition affects the health of individuals, and also the technologies for creating new food products, and designing new processes to improve the safety and quality of foods. Moreover, it will also provide emphasis on the health benefits of specific functional foods viz. crops, fruits & vegetables, milk and milk products and fishes.	
Course Objectives	This course will help the students to apply their Knowledge for- Importance of food science and nutrition. Characteristics of different food items. Constituents of food stuffs. Biochemistry of principal foods. Nutritive value of food components and nutritional requirements of different functional foods as medicine.	

	Course Content	CLOs
	Section A	
1	Introduction: Food, nutrition and health. Good nutrition, nutrient and food guides for health promotion, relation between food and nutrition. Digestion, absorption and assimilation of foods.	1
2	Constituents of Food Stuff: Composition of food stuff, analytical & nutritional values, simple carbohydrate and derived products, polysaccharide based food stuff, lipid & protein based food staff, vitamin & mineral based food stuff, water and pigment based food stuff.	1, 2
3	Diet therapy: Diet and diet therapy for gastrointestinal disorders, liver diseases, cardiovascular diseases, diabetes mellitus, kidney diseases, cancers, osteoporosis and disabling diseases.	1, 2
4	Food Combining: Importance, number of possible combinations, the choice of foods, the effects of food combining, good combinations, bad combinations, problematical combinations.	1, 2
	Section B	CLOs
5	Introduction: Functional foods and their health implications.	1
6	Soybean as Functional Food: Bioactive compounds in soybean, role of soybean components in specific disease conditions viz. cardiovascular, renal, cancer, bone health, menopause and non-alcoholic fatty liver disease.	1, 2
7	Fruits and Vegetables as Functional Food: Ellagic acid and cancer, ellagic acid and cardiovascular health. Raspberries, cherries, grape seed, blueberries, strawberry and black berry: plant product viz. spices and honey as functional foods and their cardiovascular, anti-inflammatory, anticancer and antidiabetic effects.	1, 2
8	Milk and Milk Products as Functional Food: Whey protein and anticarcinogic effects; benefits of lactoferrin & colostrum; effects of immunoglobulins and growth factors; effects of milk glycoprotein & sugars; and role of milk fatty acids in cardiovascular diseases.	1, 2, 3
9	Fish as Functional Food: Role of different fish components in specific disease conditions viz. cardiovascular, cancer, diabetes, obesity, kidney disease and diseases on digestive track systems, brain and immune system.	1, 2, 3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Learn the basic knowledge of design, formulation, production and packaging of foods with specific functional and nutritional properties.	1, 2, 3, 8, 10
	CLO2	Interpret the importance of developing a sustainable, nutritious and healthy food supply.	1, 2, 3, 6, 8, 10
	CLO3	Develop the placement skill in the food industry or a nutrition/health related organization.	1, 2, 3, 6, 8, 9, 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and/or presentation	Quiz, continuous assessment
CLO2	Lecture and/or group task	Exam. assignment
CLO3	Lecture and/or field visit	Term final exam.

Learning Materials

Recommended Readings	Dries,J., & Dries, I. (1998). *The complete book of food combining: A new approach to healthy eating.* Element Books Ltd. Boston, MA, USA. Nix, S. (2016). *Williams' basic nutrition & diet therapy* (1st ed.). Elsevier, India. Paul, S. (2021). *A text book of bio-nutrition: Curing diseases through diet.* CBS Publishers and Distributors, New Delhi, India. Rotimi, E.A. (2012). *Functional foods and nutraceuticalsI (2012th ed.)*. Springer, NY, USA.
Supplementary Readings	Monteiro, C. A. (2009). Nutrition and health: The issue is not food, nor nutrients, so much as processing. *Public Health Nutrition* (12) 5,729-731.

Course Code: 0512 07 BGE 3113		Year: Third	Term: First
Course Title	Introduction to Biosafety and Bioethics		
Course Status	Optional		
Credit	2.0		
Prerequisite(s)	None		
Rationale	This course is outlined to give basic ideas of social and ethical issues in Biotechnology and Genetic Engineering. This course will also provide the biological risk assessment and management practices in the Lab , field and market.		
Course Objectives	• To provide biosafety and ethical issues concerning Biotechnology and Genetic Engineering. • To provide good laboratory practices regarding biohazards and its management. • To Recognize the risk assessment and management practices.		

Course Content		CLOs
	Section A	
1	Introduction to Biosafety and Bioethics: Definition, concept, importance, necessity of biosafety, biosecurity and bioethics. General principles and consideration relevant to risk assessment and management. Biosafety for human health and environment, uses and abuses of genetic information, social and ethical issues in Biotechnology and Genetic Engineering.	1
2	General principles for the laboratory and environmental biosafety, good laboratory practices (GLP), SOPs, health aspects, toxicology, allergen city, antibiotic resistance, etc.	1, 2
3	Biological Risk Assessment: Hazardous characteristics of an agent and laboratory procedures, work practices.	2
4	Principles of Biosafety: Laboratory practices and technique, safety equipment, safety equipment, facility safeguards and facility design.	3
5	Laboratory Biosafety Level criteria: Physical containment levels, biological containment, selecting physical containment levels	3
6	Principles of Laboratory Biosecurity: Biosafety and biosecurity, risk management, developing biosecurity program.	3
	Section B	CLOs
7	Primary Containment for Biohazards: Selection, Installation and use of biological safety cabinets, decontamination and disinfection of hazardous agents and materials.	4
8	Biosafety Guidelines of Bangladesh and some other countries (brief account of biosafety regulations of USA, The Philippines, India, and Canada). Biosafety committees, composition, powers, functions and responsibilities of various committees (NCB, BCC, IBC), Biological safety Officers- functions and responsibilities.	5
9	Risk Assessment and Management: Use of risk assessment, risk of modern Biotechnology, risk assessment criteria, procedure and permission for work, import, introduce, trans-boundary movement, transport, packaging, field trials or release of GMOs/LMOs, principles and methodology of risk assessment.	2
10	Standard Operating Procedures (SOPs) for confined field trials, and transport of GMOs/GM crops, post-harvest management of field trial sites of GM crops (Bt eggplant).	2, 3, 5
11	Bioethics of human cloning, animal cloning, alien gene transfer to different organisms, gene therapy, genetic modification, genome sequencing, disclosing personal genetic information of individuals.	1, 5
12	DNA law of Bangladesh.	5

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Interpret biosafety for human health & environment and ethical issues in Biotechnology and Genetic Engineering.	1, 2, 7, 8, 9, 10, 11
	CLO2	Recognize principles of laboratory and environmental biosafety, risk assessment and management.	1, 2, 3, 5, 7, 8, 9, 10, 11
	CLO3	Explain principles of laboratory biosecurity & biosafety and laboratory biosafety level criteria.	1, 3, 6, 7, 9, 10, 11
	CLO4	Discuss primary containments for biohazard	1, 2, 3, 5, 6, 7, 9, 10, 11
	CLO5	Interpret various guidelines and laws of biosafety and bioethics.	1, 3, 9, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion and presentation	Quiz, continuous assessment, assignment, presentation
CLO2	Lecture, discussion, tutorial and presentation	Quiz, continuous assessment, assignment, presentation,
CLO3	Lecture, discussion and presentation	Quiz, continuous assessment, assignment, presentation and final exam.
CLO4	Lecture, discussion and presentation	Quiz, continuous assessment, assignment, presentation and term final exam.
CLO5	Lecture, presentation, group work	Continuous assessment, term final exam.

Learning Materials

Recommended Readings	Ministry of Environment, Forest and Climate Change (MoEFCC). (2007). *Biosafety guidelines of Bangladesh.* Sreekrishna, V. (2007). *Bioethics and biosafety in biotechnology* (1st ed.). New Age International Pvt. Ltd. New Delhi, India. U.S. Department of Health and Human Services. (2016). *Biosafety in microbiological and biomedical laboratories* (5th ed.). CDC. HHS Publication No. (CDC) 21-1112.
Supplementary Readings	Craig, W. M., Tepfer, G. D., & Ripandelli, D. (2008). *An overview of general features of risk assessments of genetically modified crops. Euphytica,* 164(3),853-880. Indian Council of Medical Research (2008). *Guidelines for safety assessment of foods derived from genetically engineered plants,* New Delhi, India. Kuhse, H., Klenk, U.S., & Singer, P. (Eds.) (2015). *Bioethics 3e: An Anthology* (3rd ed.). Wiley-Blackwell.

Course Code: 0542 07 Stat 3173		Year: Third	Term: First
Course Title	Biostatistics		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide basic concepts in statistics and biostatistics useful for advanced course on "Biostatistics" and research methodology.		
Course Objectives	• To Introduce the students to the basic concepts of statistics like data collection from lab And field experiments, survey, data processing, data analysis and interpretation. • To provide theoretical Knowledge about correlation & regression, hypotheses formulations and testing, various design of experiments and analysis of variance.		

	Course Content	CLOs
	Section A	
1	Introduction: Definition, division of statistics and scope of biometry.	1
2	Basic Concepts: Variables- definition and classification of variables; population and sample and data; sampling procedure, use of random number, data classification, sources of data and collection procedure, accuracy and precision of data, presentation of data principle in construction of table. Frequency distribution and construction of frequency distribution table; graphical presentation frequency distribution and curve.	1, 2
3	Measures of Location: Introduction, characteristics of ideal measures of location, different kinds of measures of location: arithmetic, geometric and harmonic mean, median and mode. Empirical relationship among arithmetic, geometric and harmonic means and also with mode and median.	1, 2, 3
4	Measures of Dispersion: Introduction, characteristics of ideal measures of dispersion, different kinds of measures of dispersion, empirical relationship among quartile deviation standard deviation and mean deviation, moments, skewness and kurtosis.	2, 4, 5
5	Probability: Basic concepts, definition, laws of probability and its application in biological sciences, binary and Position distribution.	2, 4, 5
	Section B	CLOs
6	Correlation and Regression: Introduction to correlation and regression, rank, types of correlation, simple, multiple and partial correlation, simple linear and multiple regression.	6
7	Test of Hypothesis: Introduction to hypothesis and experiment, normal test, t-test, chi-square test, and F-test.	7
8	Design of Experiment and Analysis of Variance: Introduction, some basic terms in experimental design, Principles and types of design, important steps in design of experiments, field plot and laboratory technique, determination of number of Latin square, split plot and Factorial design, test of significance.	8, 9
9	Data Transformation: Introduction, significance of data transformation, square root, logarithmic and arcsine transformation.	10

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Demonstrate a sound interpreting of the basic concepts and theory underlying the main areas of descriptive and inferential biostatistics.	1
	CLO2	Collect, summarize and calculate descriptive and inferential statistical tests independently related to biological sciences.	3, 4, 10, 11
	CLO3	Explain fundamental concepts in the design and analysis of biotechnological studies.	1, 2, 9
	CLO4	Analyze statistical data and test hypotheses.	3, 4, 9, 10
	CLO5	Interpret results of commonly used statistical analyses.	2, 10, 11
	CLO6	Apply statistical Knowledge in sampling, designing and conducting experiments.	3, 4, 10, 11
	CLO7	Create various graphs/charts to display analyzed data using various software.	3, 7, 8, 10
	CLO8	Communicate and interact effectively and efficiently the outcome of experiments to a range of audiences.	7, 8, 10
	CLO9	Think critically to answer research questions in the field of biosciences.	9
	CLO10	Exhibit ethical rules of collection, analysis, display and documentation of data.	7, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, presentation	Assignment/continuous assessment
CLO2	Lecture, hands on practice	Class test, problem solving exam.
CLO3	Lecture, presentation	Continuous assessment
CLO4	Lecture, hands on practice	Class test, problem solving exam.
CLO5	Lecture, hands on practice	Assignment, problem solving exam.
CLO6	Lecture, presentation	Term final exam.
CLO7	Lecture, presentation, demonstration	Term final exam.
CLO8	Lecture, presentation	Term final exam.
CLO9	Lecture, presentation	Term final exam.
CLO10	Lecture, presentation	Term final examination

Learning Materials

Recommended Readings	Cochran, W. G., & Cox, G. M. (1992). *Experimental designs* (2nd ed.). Wiley & Sons, USA. Cochran, W. G. (1963). *Sampling techniques* (2nd ed.). Wiley & Sons,USA. Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research* (2nd ed.). Wiley & Sons, USA. Mian, M. A., & Miyan, A. M. (1974). *An introduction to statistics* (3rd ed.). Ideal Library, Dhaka, Bangladesh. Zaman, S. M. H., Rahim, K., & Howlader, M. (1992). *Simple lessons from biometry.* Bangladesh Rice Research Institute, Gazipur, Bangladesh.
Supplementary Readings	Leps, J., & Smilauer, P. (2020). *Biostatistics with R: An introductory guide for field biologists* (1st ed.). Cambridge University Press, UK. Motulsky, H. (2015). *Essential biostatistics: A nonmathematical approach.* Oxford University Press, Oxford, UK. Pezzullo, P. (2013). *Biostatistics for dummies* (1st ed.). Wiley & Sons, USA.

Course Code: 0542 07 Stat 3174		Year: Third	Term: First
Course Title	Biostatistics Sessional & Field Work		
Course Status	Core		
Credit	1.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide basic practical concepts in statistics and biostatistics useful for conducting research in final year, advanced course on "Biostatistics" and research methodology as well.		
Course Objectives	• To introduce the students about the applied concepts of statistics like data collection from lab And field experiments, survey, data processing, data presentation techniques, data analysis and interpretation. • To provide practical/applied Knowledge about computation of basic descriptive statistics related to central location, dispersion, correlation & regression, hypotheses formulations and testing, choosing and formulating various design of experiments and analysis of variances.		

	Course Content	CLOs
1	Condensation and graphical presentation of data.	1
2	Construction of frequency distribution table.	2
3	Calculation of measures of central values: means, mode, median, variance, standard deviation, coefficient of variation, standard error etc. kurtosis and skewness.	1, 2, 3
4	Calculation and uses of normal test, t-test, chi-square test, and F-test.	3
5	Estimation of regression coefficient and correlation coefficient and their corresponding tests.	4, 5
6	Field layout, data analysis and interpretation relevant to different designs.	4, 5

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Demonstrate and explain various descriptive statistics related to measures of location and dispersion, correlation, regression, design of experiments, hypothesis testing etc.	1
	CLO2	Perform various sampling from population, collect & summarize data and calculate descriptive and inferential statistical tests related to biological sciences and interpret independently.	2, 3, 4, 10
	CLO3	Create and display various graphs/charts of analysed data using various software.	3, 6, 7, 8, 10
	CLO4	Design lab & field experiments independently to answer research questions.	1, 3, 9, 10
	CLO5	Analyze and interpret experimental data to solve biological Sciences problems and communicate to other audiences maintaining ethical principles.	3, 4, 6, 7, 8, 9, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Presentation, practical work	Lab report, problem solution evaluation
CLO2	Presentation, fieldwork	Field work report, evaluation of given problems
CLO3	Fieldwork, hands on training	Lab report on practical work, exam.
CLO4	Presentation, practical work	Sessional final exam., viva voce
CLO5	Presentation, practical work	Sessional final exam., viva voce

Learning Materials

Recommended Readings	Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research* (2nd ed.). Wiley & Sons, USA. Mian, M. A., & Miyan, A. M. (1974). *An introduction to statistics* (3rd ed.). Ideal Library, Dhaka, Bangladesh. Suchmacher, M., & Geller, M. (2012). *Practical biostatistics: A friendly step by step approach for evidence-based medicine*. Academic Press, Cambridge, UK. Zaman, S. M. H., Rahim, K., & Howlader, M. (1992). *Simple lessons from biometry*. Bangladesh Rice Research Institute, Gazipur, Bangladesh. Twisk, J. W. R. (2019). *Applied mixed model analysis: A practical guide*. Cambridge University Press, UK.
Supplementary Readings	John, P. (2013). *Biostatistics for dummies* (1st ed.). Wiley & Sons. Leps, J., & Smilauer, P. (2020). *Biostatistics with R: An introductory guide for field Biologists* (1st ed.). Cambridge University Press, UK. Norman, T. J., & Bailey, M.A. (1995). *Statistical methods in biology* (3rd ed.). Cambridge University Press, U.K.

Course Code: 0917 07 Pharm 3175		Year: Third	Term: First
Course Title	Pharmacognosy		
Course Status	Optional		
Credit	3.0		
Prerequisite(s)	None		
Rationale	Pharmacognosy is a science which is one of the basic disciplines of pharmacy and it researches drugs derived from natural sources. The studies in this field usually focus on traditional uses of plants, medicines derived from plants, various types of organisms (bacteria, fungi etc.) and recently, marine organisms. The main topics of the pharmacognosy studies are natural product & drug discovery, biological activities of the substances obtained from natural sources, herb-drug interactions and phytotherapy.		
Course Objectives	• To develop a clear interpreting of natural products that are used therapeutically in medicine. • To emphasize the role of phytotherapy in human health improvement and treatment.		

Course Content		CLOs
Section A		
1	Background to Pharmacognosy: History of pharmacognosy, terminologies, scope of pharmacognosy, emerging areas of pharmacognosy; forensic pharmacognosy, molecular pharmacognosy, ecopharmacognosy.	1, 2, 3
2	The Plant and Animal Kingdoms as Sources of Drugs: Biological and geographical sources of drugs, taxonomic approach to the study of medicinal plants and animal derived drugs.	1, 2, 3
3	Traditional Medicines: Complementary and alternative medicine, Traditional Chinese medicine, Indian systems of medicine, African traditional medicine, traditional medicines as a source of new drug.	1, 2, 3
4	Metabolites: Basic metabolic pathways, secondary metabolites form plant, animal and microbial origin.	1, 2, 3
5	Chemistry of Major Secondary Metabolites and Their Bioactivity: Glycosides, alkaloids, flavonoids, tannins, terpenoids, lignins and vitamins, Pharmacological activities of natural products, synergy and other interactions in phytomedicines. Nonmedicinal toxic plant compounds and pesticides of natural origin.	1, 2, 3
Section B		CLOs
6	Phytochemistry: General methods associated with phytochemical investigation of natural compounds; Preparation of crude extracts from plant/animal origin. Bioassays for screening of biologically active crude extracts, Isolation and purification of biologically active compounds.	1, 2, 3
7	Drug Development and Novel Targets: Strategies and techniques in drug discovery. Disease models, target identification and target validation, examples of novel targets e.g. heart disease, infections and cancer.	1, 2, 3
8	Current Trends in Pharmacognosy Research: Natural product structure elucidation by NMR spectroscopy, metabolomics- identification, role in drug discovery and metabolic engineering, nanotechnology in pharmacognosy research.	1, 2, 3
9	Regulatory and Ethical Aspects of Pharmacognosy: Regulatory categories and frameworks, review of current regulations, the legal framework of field research with local communities, establishing ethical research partnership with local communities, ethics in laboratory research.	1, 2, 3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Interpret the origin of important drugs from natural sources.	1, 4, 9
	CLO2	Explain the role of natural products as the source of many drugs and pharmaceutical ingredients.	2, 7
	CLO3	Demonstrate appreciation of practice of herbal medicine and its contribution in the health care.	1, 4

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, presentation, group discussion	Written test, assignment
CLO2	Lecture, presentation, group discussion	Written test, assignment
CLO3	Lecture, presentation, group discussion	Written test, assignment, term final exam.

Learning Materials

Recommended Readings	Delgoda, R., & McCreath, S. B. (2016). *Pharmacognosy: Fundamentals, applications and strategies* (1st ed.). Academic Press, Cambridge, UK. Evans, W.C. (2009). *Trease and Evans' Pharmacognosy* (16th ed.). Saunders Ltd. Heinrich, M., Barnes, J., Prieto-Garcia, J., Gibbons, S., & Williamson, E. M. (2018). *Fundamentals of pharmacognosy and phytotherapy* (3rd ed.). Elsevier, Amsterdam, Netherlands.
Supplementary Readings	Robbers, J. E., Speedie, M. K., & Tyler, V. E. (1996). *Pharmacognosy and pharmacobiotechnology.* Williams & Wilkins, Philadelphia, USA.

Course Code: 0811 07 Agr 3177		Year: Third	Term: First
Course Title	Plant Pathology		
Course Status	Optional		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide Knowledge about fundamental and applied concepts in plant disease, its causes/causal agents, and mechanism of disease development, epidemiology, disease resistance mechanism and different strategies of disease control. Special emphasis will be given to provide information about Biotechnological and Genetic Engineering aspects of disease control and genetically modified crops.		
Course Objectives	• To study the causal agents of disease, pathogenicity, symptoms of disease, their dissemination, predisposing factors, factors of disease development and epidemics, and control mechanisms along with special reference to Biotechnological approaches. • Comprehend the principles of host-pathogen interaction and genetics, genetics of host resistance and origin of pathogenic race formation and mutation mechanism. • To provide Knowledge about Biotechnological methods of pathogen and disease diagnosis using the Knowledge of molecular biology. • To provide Knowledge about the strategies of plant disease management following integrated approach.		

	Course Content	CLOs
	Section A	
1	Introduction: The concept of disease in plants, causes of plant disease, classification of plant disease, importance of plant diseases, and diagnosis of plant diseases.	1
2	Parasitism and Disease Development: Parasitism and pathogenicity, stages in the development of plant disease (inoculation, infection, growth and reproduction of the pathogen, dissemination of the pathogen, overwintering and over summering of the pathogen), symptomology.	2
3	Host-Pathogen Interaction: (a) Pathogen attack of host plants: (i) Mechanical forces exerted by pathogens (ii) Chemical weapons of pathogens (Enzymes, toxins and growth regulators). (b) Host defense against pathogens: (i) Structural defense (ii) Biochemical defense. (c) Pathogens effect on plant physiological functions: (i) Effect of pathogens on photosynthesis ii) Effect of pathogens on host plant respiration iii) Effect of pathogens on translocation of water and nutrients in the host plant. (c) Host resistance and pathogen virulence: (i) Immunity and resistance (ii) Mechanisms of maintaining variation in plant pathogens and its significance (iii) Genetic control of resistance and virulence (iv) Gene for Gene Theory.	3
4	Plant Pathogenic Bacteria and Fungi: Classification and rapid detection of pathogens.	4
	Section B	CLOs
5	Plant Virology: Isolation and purification, disease symptoms, translocation and distribution of viruses in plants, rapid detection.	5
6	Selected Crop Diseases (symptoms, causal agents, disease cycle and control measures): (i) Field crops: Rice, jute, wheat, sugarcane, maize and groundnut. (ii) Fruits: Citrus, Banana and mango. (iii) Vegetable crops: Potato, tomato, cabbage and cauliflower. (iv) Miscellaneous: Tea, tobacco.	6
7	Seed-Borne Disease: (i) Seed-borne bacterial diseases (ii) Seed-borne viral diseases (iii) Seed-borne fungal diseases (iv) Control of seed-borne diseases.	7

	Section B	CLOs
8	Plant Disease Control: (i) Chemical control of plant diseases: Types of chemicals used and specification of a good fungicide, protestant versus systemic fungicides, mechanisms of action of fungicides, evaluation of fungicides in vitro. Resistance of plant pathogens of fungicides. (ii) Biological control of diseases: Use of resistant host varieties, cross protection and interference, hyper-parasites, trap crop and antagonistic plants and microorganisms.	8

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Demonstrate interpreting the concept of plant disease, pathogens, pathogenicity, host-pathogen interaction, disease symptoms, virulence, disease triangle & cycle, disease management, epidemics,	1
	CLO2	Analyze and apply Knowledge to identify/diagnose various types of plant diseases, their causal agents and symptoms etc.	3, 4, 7, 10
	CLO3	Compare and contrast between resistant and susceptible hosts, and various disease control strategies.	1, 10
	CLO4	Evaluate, explain and interpret diseases diagnosis techniques, and disease controlling methods, available fungicides etc.	1, 2, 3, 6, 9, 10
	CLO5	Formulate and propose new strategies of disease control by compiling all gained Knowledge of plant pathology	3, 5, 6, 10
	CLO6	Disseminate innovative information of integrated disease management strategies among the farmers and other stakeholders.	7, 8, 10
	CLO7	Analyze critically all plant pathological recent discoveries and innovations to give solution of emerging issues of plant diseases for food security.	4, 9, 10
	CLO8	Demonstrate ethical and eco-friendly practices of plant disease management for sustainable agriculture and safe food production.	1, 3, 5, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, presentation, field demonstration	Assignment, class test
CLO2	Lecture, presentation, field demonstration	Continuous assessment
CLO3	Lecture, presentation	Term final exam.
CLO4	Lecture, presentation, field demonstration	Term final exam.
CLO5	Lecture, group discussion	Assignment
CLO6	Lecture, presentation	Term final exam.
CLO7	Lecture, presentation	Term final exam.
CLO8	Presentation, discussion	Term final exam.

Learning Materials

Recommended Readings	Agrios, G. N. (2005). *Plant pathology* (5th ed.). Academic Press, London, UK. Campbell, R. (1989). *Biological control of microbial plant pathogens* (1st ed.). Cambridge University Press, London, UK. Neergaard, P. (1979). *Seed pathology* Vol.1. Macmillan Publishers, UK. Singh, R. S. (2017). *Plant diseases* (10th ed.). Oxford & IBH Publishing Co Pvt.Ltd, India.
Supplementary Readings	Christensen, C. M. (1965). *The molds and man: An introduction to the fungi*. University of Mennesota Press. USA. Goto, M. (2012). *Fundamentals of bacterial plant pathology.* Academic Press, Cambridge, UK. Rangaswami, G., & Mahadevan, A. (1998). *Diseases of crop plants in India* (4th ed.). Prentice Hall of India Pvt. Ltd.

Course Code: 0811 07 Agr 3178		Year: Third	Term: First
Course Title	Plant Pathology Sessional & Field Work		
Course Status	Optional		
Credit	1.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide practical Knowledge about collection, identification and control of various plant diseases, their symptoms, and management of disease and also to select appropriate methods of disease control and selection of eco- friendly bio-control agents and proper fungicides.		
Course Objectives	• To study the about the procedure of identification, collection diseased crop plants and its causal agents. • Identification of different symptoms of crop plant diseases in the field and laboratory. • To study the various practical methods of plant disease management/ control strategies.		

	Course Content	CLOs
1	Preparation and sterilization of culture media for the growth of plant pathogen.	1
2	Isolation, purification and identification of plant pathogens obtained from diseased plant parts.	2
3	Evaluation of fungicides in vitro.	3
4	Handling of equipment used for applying fungicides.	4
5	Seed health testing methods.	5
6	Collection, identification and preservation of diseased plant specimens.	6
7	Farmer's field visit and visit of research organization and report writing	7, 8

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Interpret, identify, compare and interpret various symptoms of plant diseases and pathogens, their mode of transmission, disease cycle in the field and lab	1, 2, 10
	CLO2	Conduct experiments in the isolation and culturing methods of pathogens from different sources using selective media and identify the causal agents of disease.	3, 10
	CLO3	Prescribe farmers about appropriate conventional and biotechnological tactics of disease control.	3, 6, 9, 10
	CLO4	Evaluate available fungicides, biopesticides and various disease control methods.	3, 6, 9, 10
	CLO5	Explain the mechanism of plant disease spread, epidemiology and integrated approaches of disease management among the farmers and field level officers for sustainable crop production.	1, 7, 8, 9, 10
	CLO6	Critically evaluate and analyse the available approaches of integrated disease management (IDM).	3, 5, 9, 10
	CLO7	Conduct pathological and disease screening experiments independently in the field and lab	3,10
	CLO8	Demonstrate ethical & safety practices of chemical fungicides used in vegetable, kitchen gardens, and fruit orcards.	1, 2, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Presentation, demonstration in field and lab	Lab report, quiz
CLO2	Presentation, lab demonstration	Lab report, evaluation of expt. results
CLO3	Presentation, group work	Evaluation of presentation
CLO4	Lab demonstration	Evaluation of expt.
CLO5	Presentation	Lab report, presentation evaluation
CLO6	Presentation, group discussion	Lab exam.
CLO7	Lab demonstration	Lab, field expt. evaluation
CLO8	Presentation, hands on training	Lab exam., viva voce

Learning Materials

Recommended Readings	Bhale, U., Mishra, M., Kumar, S., & Gupta, O. (2015). *Laboratory manual on plant pathology*. Satish Serial publishing House, India. Naz, H., Khan, H. H., & Singh, C.K. (2018). *Practical lab manual for microbiology and plant pathology.* AkiNik Publication, New Delhi, India. Yadav, V. (2015). *A colour handbook on practical plant pathology* (1st ed.). Nipa Publishing Agency, New Delhi, India.
Supplementary Readings	Goto, M. (1996). *Fundamental of bacterial plant pathology.* Academic Press Inc. Tokyo. Sileshi, F., Galano T., & Biri, B. (2016). *Plant disease diagnosis: Practical laboratory manual.* Institute of Biodiversity, Ethiopia.

Third Year Second Term			
Course Code: 0512 07 BGE 3201		Year: Third	Term: Second
Course Title	Fermentation and Bioreactor Design		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide detailed Knowledge in fermentation process and designing bioreactor to produce bioproducts in the area of Industrial Biotechnology.		
Course Objectives	• To describe details of a fermentation process. • To explain the principles and theories to design a bioreactor. • To explain critical aspects in bioreactor design to produce bioproducts at the industrial scale. • To disseminate the Knowledge regarding scale up, instrumentation and control mechanism that are used in design a bioreactor.		

	Course Content	CLOs
	Section A	
1	Fermentation Process: Definition of fermentation and product classification, common fermentation pathways, Component parts of a fermentation process, media preparation and sterilization, sterilization kinetics, inoculation, industrial cell lines.	1, 2
2	Biological Reaction Kinetics: The ideal batch reactor, the ideal continuous-flow stirred-tank reactor (CSTR), Monod Chemostat model, kinetic implications of endogenous and maintenance metabolism, Kinetics in cell recycling.	3, 4, 5, 9
3	Multiple Interacting Microbial Populations: Introduction, two-species Interactions, Impact of competition in Chemostat design.	3, 4
4	Biological Reactors: Mode of operation, types of bioreactors.	5, 9
	Section B	CLOs
5	Transport Phenomena in Bioprocess Systems: Introduction, gas-liquid mass transfer in cellular systems, critical oxygen concentration and oxygen uptake, determination of oxygen transfer rates, mass transfer across free surfaces, surfaces, factor affecting oxygen transfer rates, sterilization of gases and liquids by filtration.	6, 9
6	Scale Up: History, scale up criteria, equipment to be scaled up, scale up parameters.	7, 9
7	Instrumentation and Control: Introduction, process control, in-line measurements, on-line measurements, computers and interfaces.	8, 9
8	Bioprocess Economics: Stages in plant design, break even analysis, depreciation, method of calculation of depreciation, optimization, graphical and mathematical approaches of optimization.	3, 9

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Learn details of a fermentation process.	1, 2, 3, 4, 5, 6, 9
	CLO2	Interpret sterilization kinetics and aseptic operations.	1, 2, 3, 4, 5, 6, 9, 10
	CLO3	Acquire an overview of various parameters needed for bioreactor design.	1, 2, 3, 4, 5, 6, 10, 11
	CLO4	Recognize various theories and principles of designing a bioreactor for industrial production of bioproducts.	1, 2, 3, 4, 5, 6, 7, 9, 10, 11
	CLO5	Learn mode of operations and types of bioreactor.	1, 2, 3, 4, 5, 6, 7, 9, 10, 11
	CLO6	Acquire Knowledge on oxygen transfer and related issues.	1, 2, 3, 4, 5, 6, 7, 9, 10, 11
	CLO7	Get a clear view on instrumentation and controlling system of bioreactor.	1, 2, 3, 4, 5, 6, 7, 9, 10, 11
	CLO8	Demonstrate ethical & safety practices of chemical fungicides used in vegetable, kitchen gardens, and fruit orcards.	1, 2, 3, 4, 5, 6, 7, 9, 10, 11
	CLO9	Apply the knowledge obtained in designing bioreactor.	1, 2, 3, 4, 5, 6, 7, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and Q-A session	Continuous assessment and term final exam.
CLO2	Lecture	Continuous assessment and term final exam.
CLO3	Lecture	Continuous assessment and term final exam.
CLO4	Lecture and Q-A session	Continuous assessment and term final exam.
CLO5	Lecture	Continuous assessment and term final exam.
CLO6	Lecture and presentation	Continuous assessment and term final exam.
CLO7	Lecture and presentation	Continuous assessment and term final exam.
CLO8	Lecture and presentation	Continuous assessment and term final exam.
CLO9	Lecture and group work	Continuous assessment and term final exam.

Learning Materials

Recommended Readings	Aiba, S. (1973). *Biochemical engineering* (1st ed.). Academic Press. Bailey, J. E. & Ollis, D. F. (1988). *Biochemical Engineering Fundamentals* (2nd ed.). McGraw-Hill College Shuler, M., Kargi, F., & DeLisa, M. (2017). *Bioprocess engineering: Basic concepts* (3rd ed.). Pearson Stanbury, P. F., & Whitaker, A. (1984). *Principles of fermentation technology* (1st ed.). Pergamon Press, UK.
Supplementary Readings	Moo-Young, M. (2019). *Comprehensive biotechnology* (3rd ed.), Pergamon Press, UK.

Course Code: 0111 07 BGE 3203		Year: Third	Term: Second
Course Title	Technology Transfer		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide Knowledge on how Science and Technology Studies can improve our interpreting of technology transfer. How teaching-learning methods, education-communication systems could keep role in diffusion, assessment & acquisition and planning in technology transfer process. How do science and technology move from the laboratory to the market or from the university research lab to the private company? What challenges are involved in transferring technologies between different industries or countries? What ethical and policy challenges are involved with the transfer of technology? What are the different technology generating agencies in Bangladesh and their policy?		
Course Objectives	• Describe an appropriate technology, development process and acquisition with focus on using Biotechnology & Genetic Engineering tools. • Describe the learning, education, communication, teaching, adoption and diffusion processes of technology, problems and issues related to transfer of Biotechnology. • Sources and activities of technology and technology generating organizations / institutions / agencies in different sectors of Bangladesh.		

	Course Content	CLOs
	Section A	
1	Introduction: Definition, concept and objectives of technology and technology transfer. Characteristics of appropriate technology. Private technology transfer; technology transfer from government to industry; university-industry technology transfer; principles of technology transfer. Technology Transfer in developing countries: technology transfer process; competitiveness; customer relationship management; technology development challenges; road maps and key focus areas. Opportunities for Biotechnology Transfer to developing countries.	1
2	Learning: Concept, theories and laws of learning; phases of learning; Learners: common sense learners; dynamic learners; analytical learners and imaginative learners. Bloom's Taxonomy of Learning: use of Bloom's Taxonomy, three major domain(s) of Bloom's Taxonomy and its modification.	1, 2
3	Education: Definition, meanings, aims and objectives, principles, philosophy; types: formal, informal and non-formal education; education systems in Bangladesh.	1, 2
4	Communication: Definition, importance, functions, model and elements of communication; communication methods: individual, group and mass methods of communication, their types, objectives, techniques, implementation strategies, follow-up and limitations. Cultural and ethical issues in communication.	2, 4
5	Teaching: Definition, purpose, objectives, approaches and principles of teaching. Planning a teaching/training session. Methods of teaching: keys to class room excellence; different types of teaching aids which enhance the effective teaching process with their relative merits and demerits. Major constraints of teaching at the university level of Bangladesh and possible remedies.	2, 3
	Section B	CLOs
6	Adoption and Diffusion of Technology: Definition and types of innovation, characteristics of innovation, innovation decision, adoption and diffusion, diffusion of innovation process, stages of Knowledge and diffusion process, elements of diffusion, adopter categories and their salient features, adoption and innovation factors. Innovation diffusion; factors of the demand and supply of innovation. Planning extension/technology transfer campaigns, on-farm testing and verification of new technology, approach of adapting and dissemination of new technology to farmers. Adoption and diffusion of Biotechnological innovations, motivation technique for biotech products. Commercialization of biotech products.	1, 2

	Section B	CLOs
7	Technology Assessment and Acquisition: Concepts of technology assessment, characteristics, process and factors and tools of technology assessment. Process of technology development and acquisition.	1, 2
8	Technology Transfer Planning: Concept of technique, Recognize-how, planning, transfer and diffusion of technology. Strategies of communicating science, Elements, factors, problem and issues of technology transfer.	1, 2
9	Intellectual Property: Patents, trade secrets, trademarks, copy rights and masks, Transferring IP, IP control. Capacity building in IP management in Agricultural, Livestock, Fisheries and other sectors of Biotechnology. Acquiring protection for improved germplasm and inbred lines.	2, 4
10	Problems and Issues of Technology Transfer- IPR, patent and patent laws, patent application procedure, material transfer agreement (MTA) etc.	2, 4
11	Strategies of Technology Transfer of ICGEB, IRRI etc.	5

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Recognize the fundamentals of an appropriate technology.	1, 2, 3, 4, 6, 10, 11
	CLO2	Choose a proper learning, education, communication, teaching and diffusion process depending on adopter categories.	1, 2, 3, 4, 8, 9, 10, 11
	CLO3	Identify the sources of an appropriate technology and technology generating agencies in Bangladesh.	1, 2, 3, 4, 6, 9, 10, 11
	CLO4	Learn about technology transfer planning and IPR.	1, 2, 3, 4, 6, 7, 10, 11
	CLO5	Impart knowledge regarding strategies of technology transfer activities of different organizations of Bangladesh.	1, 2, 3, 4, 6, 8, 9, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Continuous assessment and quiz
CLO2	Lecture and presentation	Continuous assessment and assignment
CLO3	Lecture and presentation	Continuous assessment, assignment and demonstration
CLO4	Lecture and presentation	Continuous assessment, assignment and term final examination
CLO5	Lecture and group discussion	Term final examination

Recommended Readings	Erbisch, F.H.,& Maredia, K.(2004). *Intellectual property rights in agricultural biotechnology* (2nd ed.). CABI Fox, R. (1969). *Agricultural and technical journalism.* Prentice-Hall. Kashem, M. A. (1992). *Samprasaran bijana (Extension science).* Bangladesh Packing Press Ltd. Dhaka. Bangladesh. Khalil, T. M. (1999). *Management of technology* (1st ed.). McGraw-Hill Kumar, D. (2012). *Mass communication in agricultural extension.* Satish Serial Publishing House, India Lionberger, H. F. (2012). *Adoption of new ideas and practices*. Literary Licensing, LLC. Islam, M. N., & Haque, M.M. (1996). *Technology planning and control.* BUET, Dhaka. Bangladesh. Robertson, P. L., & Jacobson, D. (Eds.). (2011). *Knowledge transfer and technology diffusion.* Edward Elgar Publishing. Rogers, E.M. (2003). *Diffusion of innovations* (5th ed.). Free Press Singh, A. K. (2019). *Agricultural extension and farm journalism*. Bio-Green Books, India. Singhal, A., & Dearing, J.W. (Eds.). (2006). *Communication of innovations: A journey with Ev Rogers* (1st ed.). SAGE Publications India Pvt. Ltd. Speser, P.L. (2006). *The art and science of technology transfer* (1st ed.). Wiley Sullivan, N.F. (1996). *Technology transfer: Making the most of your intellectual property* (1st ed.). Cambridge University Press, UK.
Supplementary Readings	Anderson, L., Krathwohl, D., Peter Airasian, P. , Cruikshank, K., Mayer, R., Pintrich, P., Raths, J., & Wittrock, M. (2000). *Taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives* (1st ed.). Pearson. Adair, J. (2009). *Leadership and motivation: The fifty-fifty rule and the eight key principles of motivating others.* Kogan Page, USA. Porter, L.W., Bigley, G. A., & Steers, R.M. (1996). *Motivation and leadership at work.* McGraw-Hill College. Barton, J. H. (2007). *New trends in technology transfer: Implications for national and international policy.* ITCSD, Geneva. Hoekman, B. M., Maskus, K. E., & Saggi, K. (2005). *Transfer of technology to developing countries: Unilateral and multilateral policy options.* World Development, (33) 10, 1587–1602.

Course Code: 0111 07 BGE 3204		Year: Third	Term: Second
Course Title	Technology Transfer Sessional & Field Work		
Course Status	Core		
Credit	1.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide advanced concepts on different teaching and training aids as well as strategies in planning a training program for the clients of Biotechnological products. How model science & technology park and science fair could keep role to disseminate technology and the technology transfer mechanism of different developmental sectors of Bangladesh.		
Course Objectives	• Describe different teaching and training aids. • Describe preparation of posters, literature and booklets. • Observe the technology transfer activities of different research organizations, Govt. institute, private sectors and NGOs of Bangladesh.		

	Course Content	CLOs
1	Study of different teaching and training aids.	1
2	Study of strategies of communicating science and technology.	1, 2
3	Planning a training program for the clients of Biotechnological products/services.	1, 2
4	Preparation of posters, literature and booklets.	1, 2
5	Study of model science & Technology Park and science fair to disseminate technology.	2, 3
6	Study of technology transfer mechanism of different developmental sectors of Bangladesh.	3, 4
7	Visit to different research organizations, Govt. institutes, private sectors and NGOs to observe the technology transfer activities, preparation and submission of reports.	4
8	Academic poster preparation, flip chart, power point presentation and oral presentation etc.	2

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Demonstrate the ability to comprehensive knowledge of mode of learning, education, communication, teaching, teaching and training aids and innovation diffusion process.	1, 2, 3, 4, 6, 10, 11
	CLO2	Demonstrate the ability to identify, select and use the appropriate teaching and training aids essential for dissemination of science & technology in Biotechnological field.	1, 2, 3, 4, 8, 9, 10, 11
	CLO3	Demonstrate the ability to prepare booklet, academic & popular posters, plan and execute science fair, demonstration trials, a workshop/training program for communicating science effectively.	1, 2, 3, 4, 6, 9, 10, 11
	CLO4	Adapt different strategies in technology transfer mechanisms in developmental sectors of Bangladesh	1, 2, 3, 4, 6, 7, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture / demonstration / group discussion	Continuous assessment, assignment, final exam.
CLO2	Lecture / hands-on training /group discussion	Continuous assessment, assignment, final exam.
CLO3	Lecture / presentation/ demonstration / group discussion	Evaluation of poster, booklet, presentation, assignment, final exam.
CLO4	Lecture / demonstration / group discussion / visit to fields of GOs and NGOs relevant to technology transfer	Viva voce, lab final exam., field visit report evaluation

Learning Materials

Recommended Readings	Bereir, A. (2020). *Tools for better agricultural extension communication.* LAP Lambert Academic Publishing. DAE. (2018). *Agricultural extension manual.* MOA, Govt. of the People's Republic of Bangladesh. Kashem, M. A. (1992). *Samprasaran Bijana (Extension Science).* Bangladesh Packing Press Ltd. Dhaka. Bangladesh. Lionberger, H. F. (1960). *Adoption of new ideas and practices.* Ames. Iowa State University
Supplementary Readings	Khalid, S.M.N., & Sherzad, S. (Eds.) (2019). *Agricultural extension manual for extension workers.* FAO Mortiss, P.D. (1988). *Agricultural extension: A practical manual*. Dept.of Primary Industries, Queensland, Australia. Speser, P.L. ((2006). *The art and science of technology transfer.* John Wiley and Sons, USA.

Course Code: 0512 07 BGE 3205	Year: Third	Term: Second
Course Title	Bioinformatics	
Course Status	Core	
Credit	3.0	
Prerequisite(s)	None	
Rationale	The purpose of this course is to introduce the field of bioinformatics where available biological data can be interpreted using informatics. The subject covers databases, their uses and application of bioinformatics.	
Course Objectives	The aim of this course is to: • To learn the properties of different types of biological data, their annotation and preservation in databases. • To learn about the management and integration of biological data using different tools and programs	

	Course Content	CLOs
	Section A	
1	Introduction and Biological Databases: Definition, goal, scopes, applications and limitations of bioinformatics. Databases, different type of biological databases, formats and data retrieval from biological databases.	1
2	Genome Mapping and Assembly: Genome mapping; Genome sequencing; Genome sequence assembly; Comparative genomics.	2
3	Molecular Phylogeny and evolution: Basics of phylogenetics. Phylogenetic tree construction methods- Distant-based methods and character-based methods. Phylogenetic tree construction- group work.	3
4	Next-generation Sequencing (NGS): Perspectives; Considerations prior to assembly; Transcriptome assembly strategies; investigating gene expression with RNA-seq; RNA-seq Genome Annotation Assessment Project.	2
	Section B	CLOs
5	Sequence Alignment: Pairwise sequence alignment-similarity, identity, scoring matrices and statistical significance. Database similarity searching-exhaustive and heuristic database searching, BLAST and FASTA. Multiple sequence alignment-statistical models, e.g. position specific scoring matrices(PSSMs), profiles and hidden Markov models (HMMs)	2
6	Genes and Promoter Prediction: Categories of gene prediction programs, gene prediction in prokaryote and eukaryote. Prediction of promoter and regulatory elements in genome and prediction algorithms.	4
7	Protein Motifs and Domain Prediction: Motif and domain identification in aligned and unaligned sequence, motif database and sequence logo.	2
8	Structural Bioinformatics: Protein structure basics. Visualization, comparison and classification of protein structures. Secondary and tertiary structure prediction, homology modeling. RNA structure prediction.	5

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Comprehend the fundamental principles of bioinformatics	1
	CLO2	Compare and identify the differences among sequences	2, 3, 6, 7, 8, 9, 10
	CLO3	Interpret the evolutionary concepts related to biological query	1, 2, 3, 6, 7, 9
	CLO4	Recognize about theoretical background of how different biological data are analyzed.	1, 7, 9
	CLO5	Recognize the applications of bioinformatics in biotechnology, drug design and computational biology.	1, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and group discussion	Entry and exit questions
CLO2	Lecture and group discussion	Strategic questioning
CLO3	Presentation and lecture	Continuous assessment
CLO4	Lecture and group discussion	Assignment
CLO5	Presentation and lecture	Group work, term final exam.

Learning Materials

Recommended Readings	Lesk, A. (2019). *Introduction to bioinformatics* (5th ed.). Oxford University Press. Moorhouse, M., & Barry, P. (2004). *Bioinformatics biocomputing and Perl: An introduction to bioinformatics computing skills and practice* (1st ed.). Wiley and Sons Pevsner, J. (2015). *Bioinformatics and functional genomics* (3rd ed.). Wiley-Blackwell. Ramsden, J. (2015). *Bioinformatics: An introduction* (3rd ed.). Springer. Xiong, J. (2006). *Essential bioinformatics* (1st ed.). Cambridge University Press.
Supplementary Readings	Edwards, D., Stajich, J., & Hansen, D. (Eds.) (2009). *Bioinformatics: Tools and applications*. Springer. Forsdyke, D. R. (2016). *Evolutionary bioinformatics* (3rd ed.). Springer Havukkala, I. (2010). *Biodata mining and visualization:* Novel approaches (1st ed.). Wspc.

Course Code: 0512 07 BGE 3206		Year: Third	Term: Second
Course Title	Bioinformatics Sessional		
Course Status	Core		
Credit	1.0		
Prerequisite(s)	None		
Rationale	The purpose of this course is to familiarize students with several databases and online tools to retrieve process and analyse different biological data.		
Course Objectives	• To learn data organizations in different databases, formats and collection procedure. • To learn the uses of different tools and programs for particular task. • To learn the methods related to finding and retrieving information stored in vast databases.		

	Course Content	CLOs
1	Different database browsing and data collection.	1
2	Pairwise and multiple sequence alignment.	2, 3, 4
3	Genes and promoters prediction.	2, 3, 4
4	Protein motifs and domain prediction.	3, 4
5	Phylogenetic tree construction.	4
6	Homology modelling and protein docking.	2, 4
7	Basic operational skills in UNIX, LINUX and programming languages.	2
8	Differential gene and transcript expression analysis of RNA-seq.	1, 2, 4

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Search and extract different biological data from relevant databases.	2, 3, 6, 7, 9
	CLO2	Describe web-based versus command-line approaches to bioinformatics.	1, 2, 6, 7, 8, 9, 10
	CLO3	Implement different tasks, e.g. sequence alignment, gene and motif prediction etc.	2, 3, 6, 7, 9
	CLO4	Design and integrate different tools and programs to address specific research question.	2, 3, 4, 7, 8, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and group discussion	Entry and exit questions
CLO2	Lecture and group discussion	Strategic questioning
CLO3	Presentation and lecture	Lab work evaluation
CLO4	Lecture and group discussion	Assignment, lab final exam., viva voce

Learning Materials

Recommended Readings	Kasturi, K., & Lakshmi, K.S. (2018). *Bioinformatics: A practical manual.* Pharmamed Press. Keith, J.M. (2017). *Bioinformatics: Volume I: Data, sequence analysis, and evolution (Methods in molecular biology)*. Humana Press Lesk, A. (2019). *Introduction to bioinformatics* (5th ed.). Oxford University Press.
Supplementary Readings	Iftekhar, M., & Ghalib, M.R. (Eds.) (2015). *Bioinformatics practical manual.* CreateSpace Independent Publishing Platform. Low, L., & Tammi, M. (Eds.) (2017). *Bioinformatics: A practical handbook of next generation sequencing and its applications.* World Scientific Publishing Co. Marshall, C. (Ed.) (2015). *Handbook of bioinformatics* (Illustrated ed.). CALLISTO REFERENCE.

Course Code: 0512 07 BGE 3207		Year: Third	Term: Second
Course Title	Medical and Pharmaceutical Biotechnology		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide detailed Knowledge ofthe fermentation processes and designing bioreactors to produce by-products in the area of Industrial Biotechnology		
Course Objectives	The aim of this course is to: • To familiarize with fundamental processes and practices in pharmaceutical industries. • To get updated Knowledge of medical applications e.g., therapies and diagnosis of prominent disease markers. • To be aware of innovation patenting, ethics and regulations.		

	Course Content	CLOs
	Section A	
1	Concept of Good Manufacturing Practice (GMP), quality control, quality assurance &in-process control in the pharmaceutical industry.	1, 2
2	Determination of potency of antibiotic or anti-microbial preservative in pharmaceutical products. Production of Antibiotics & biopolymers by rDNA technology.	1, 2
3	Vaccine Production and Immunization: Active & passive immunity, vaccination, the effectiveness of the vaccine, antigens used as a vaccine, classification of vaccines based on antigen presentation, adjuvant, manufacture of vaccine and its quality control.	1, 2
4	Production of Bio-pharmaceuticals by Recombinant DNA Technology: Introduction to biopharmaceuticals, benefits and drawbacks of biopharmaceuticals derived by rDNA technology, production process of major biopharmaceuticals- Interferon, Insulin, Somatostatin, Human Growth Hormone, HIV therapeutic agents.	1, 2
5	Infectious and Genetic Diseases: Diagnosis of diseases by conventional and molecular techniques: Causes, factors, transmissions, detection & control/treatment of important diseases.	1, 2
	Section B	CLOs
6	Cloning of Human Disease Genes: Detection of mutations in human diseases, functional gene cloning, candidate gene cloning, and positional gene cloning, positional- candidate gene cloning.	1, 2
7	Gene Therapy: Concept of gene therapy, ex vivo &in vivo gene therapy, gene delivery systems, somatic and embryonic gene therapy, human gene therapy, ethical issues in gene therapy.	1, 2
8	DNA Fingerprinting in Forensics: Concept of DNA fingerprinting, history, Current technological platform and databases, the future of forensic DNA analysis.	1, 2
9	Regulation: Patenting Biotechnology inventions, regulations regarding rDNA technology and cloning.	1, 2, 3
10	Topics on current interest/ issue of medical & pharmaceutical Biotechnology.	3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Learn about general procedures and practices needed for pharmaceutical setup.	1, 2, 3, 6, 7, 9, 11
	CLO2	Recognize the recent advances related to therapies and diagnostic procedures.	1, 2, 3, 6, 7, 9, 10, 11
	CLO3	Interpret the ethical and patenting issues of medical and biotechnological research and innovations.	1, 2, 3, 6, 7

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Quiz and continuous assessment
CLO2	Lecture and presentation	Continuous assessment, assignment and term final exam.
CLO3	Lecture and presentation	Continuous assessment, assignment and term final exam.

Learning Materials

Recommended Readings	Crommelin, D.J.A., Sindelar, R.D., & Meibohm, B. (Eds.) (2013). *Pharmaceutical biotechnology: Fundamentals and applications* (4th ed.). Springer. Glick, B. R., & Pasternak, J. J. (1998). *Molecular biotechnology: Principles and application of recombinant DNA* (2nd ed.). ASM Press, Washington, USA. Khalid, A.M., Malik K. A., & Nasim, .A. (Eds.) (1995). *Biotechnology for sustainable development.* NIBGE, Pakistan Academy of Sciences.
Supplementary Readings	Denyer, S.P., Hodges, N. A., & Gorman, S. P. (Eds.) (2009). *Hugo and Russell's pharmaceutical microbiology* (7th ed.). Wiley India Pvt. Ltd.

Course Code: 0512 07 BGE 3208	Year: Third	Term: Second
Course Title	Medical and Pharmaceutical Biotechnology Sessional & Field Work	
Course Status	Core	
Credit	1.0	
Prerequisite(s)	None	
Rationale	This course is designed to provide small scale strategies to handle pharmaceutical products and visit of pharmaceutical industries.	
Course Objectives	• To practice and learn good manufacturing practice. • To visit pharmaceutical companies to gather experience in biopharmaceutical production processes.	

	Course Content	CLOs
1	Determination of potency of antibiotics.	1, 2
2	Screening for antibiotic producer organism from environmental sample.	1, 2
3	Determination of endotoxins in IV solution: Limulus amebocyte lysate (LAL) test.	1, 2
4	Demonstration on vaccine production and testing.	1, 2
5	Demonstration of biopharmaceuticals production and quality control process.	1, 2
6	Detection of genetically transmitted diseases of humans.	1, 2
7	Visiting of different pharmaceutical industries.	1, 2

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Conduct some small-scale experiments needed for pharmaceutical and medical production.	1, 2, 3, 6, 8, 9
	CLO2	Experience real-world pharmaceutical production systems and control mechanisms.	1, 2, 3, 6, 8, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and presentation	Quiz and lab report evaluation
CLO2	Laboratory, industry and field visit	Lab & tour reports evaluation and viva voce

Learning Materials

Recommended Readings	Dogramatzis, D. (2010). *Healthcare biotechnology: A practical guide* (1st ed.). CRC Press, USA Glick, B.R., Patten, C.L., & Delovitch, T. L. (Eds.) (2013). *Medical biotechnology: Principles and applications of recombinant DNA* (1st ed.). ASM Press, USA. Glick, B. R., & Pasternak, J. J. (1998). *Molecular biotechnology: Principles and application of recombinant DNA* (2nd ed.). ASM Press, USA. Khalid, A.M., Malik K. A., & Nasim, A. (Eds.) (1995). *Biotechnology for sustainable development.* NIBGE, Pakistan Academy of Sciences.
Supplementary Readings	Hugo, W. B., & Russell, A. D. (Eds.) (1993). *Pharmaceutical Microbiology* (6th ed.). CBS Pub. India

Course Code: 0512 07 BGE 3209	Year: Third	Term: Second
Course Title	Biopharmaceutical Chemistry	
Course Status	Core	
Credit	3.0	
Prerequisite(s)	None	
Rationale	The course will provide conceptual framework for interpreting pharmaceutical products, pharmacokinetics and pharmacokinetics of biopharmaceuticals. The course illustrates biophysical characterization, active ingredients and targeted delivery of biopharmaceuticals. This course will generate idea of drug designing and discovery of drugs.	
Course Objectives	• To study current and future prospects of biopharmaceuticals. • To acquire knowledge on pharmacokinetic and pharmacodynamics models. • To recognizing the drug designing, discovery and targeted drug delivery systems.	

Course Content		CLOs
Section A		
1	Pharmaceuticals, Biologics, Biopharmaceuticals and Biosimilars: Introduction to pharmaceutical products, biopharmaceuticals and Pharmaceutical Biotechnology, history, current status and future prospects of biopharmaceuticals, biopharmaceuticals of microbial, plant and animal origin.	1
2	Pharmacokinetics and Pharmacodynamics of Biopharmaceuticals: Basic pharmacokinetics and pharmacokinetic models, pharmacodynamics, toxicokinetics and clinical toxicology.	2
3	Absorption of Biopharmaceuticals: Introduction to drug absorption, miscellaneous routes of drug administration, nature of cell membrane, passage of drugs across the cell membrane, drug interactions, factors related to drug absorption.	3
4	Distribution and Elimination of Biopharmaceuticals: Physiological factors of distribution, protein binding of drugs, elimination and clearance.	4
Section B		CLOs
5	Biophysical Characterization of Biopharmaceuticals: The role of biophysical characterization in biopharmaceutical drug development, general consideration in analyzing the biophysical properties, challenges in biophysical measurements, standard class of biophysical tools used in biopharmaceutical industry, advances tools for biophysical analysis.	3
6	Biopharmaceutic Consideration in Drug Design: Factors and rationale for biopharmaceutical product design, biopharmaceutical product performance and stability, bioavailability and bioequivalence.	3
7	Biopharmaceutical Aspects of the Active Pharmaceutical Ingredients: Concept of active pharmaceutical ingredients (API) and pharmaceutical equivalence related to biopharmaceuticals, formulation and manufacturing.	3
8	Targeted Delivery of Biopharmaceuticals: Drug carriers and targeting, targeted drug delivery, current approaches and future prospective.	4

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Explain the biopharmaceutical products and their origin (microbial, animal and plant)	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
	CLO2	Interpret pharmacokinetic and pharmacodynamics models of biopharmaceuticals.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
	CLO3	Enumerate performance, stability and bioactivity of the products.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
	CLO4	Recognize the drug administration, drug carriers, targeted drug delivery approaches.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
	CLO5	Interpret distribution, binding and elimination and clearance of drugs.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, tutorial and presentation	Quiz, continuous assessment, presentation
CLO2	Lecture, discussion, tutorial and Presentation	Quiz, continuous assessment, assignment and presentation
CLO3	Lecture, discussion, tutorial and presentation	Quiz, continuous assessment, presentation and term final exam.
CLO4	Lecture, discussion, tutorial and presentation	Quiz, continuous assessment, assignment and presentation
CLO5	Lecture, discussion, tutorial and presentation	Quiz, continuous assessment, assignment, presentation and term final exam.

Learning Materials

Recommended Readings	Damian, H., & Steven, B. (2014). *Biophysical characterization of protein in developing biopharmaceuticals* (1st ed.). Elsevier. Shargel, L., & Yu, A. (2015). *Applied biopharmaceutics and pharmacokinetics* (7th ed.). McGraw-Hill Education/Medical, NY, USA. Walsh, G. (2003) *Biopharmaceuticals: Biochemistry and biotechnology* (2nd ed.). Wiley –Blackwell.
Supplementary Readings	Chinthaginjala, H., Chappidi, S. R., & Bhupalam, P. (2018). *Practical manual of biopharmaceutics & pharmacokinetics.* LAP Lambert Academic Publishing.

Course Code: 0512 07 BGE 3211	Year: Third	Term: Second
Course Title	Molecular Breeding	
Course Status	Optional	
Credit	3.0	
Prerequisite(s)	None	
Rationale	This course is designed to provide molecular and marker assisted breeding of various crops. It will also provide concept of population genetics, molecular dissection of complex traits, functional analysis of genes and Omics breeding.	
Course Objectives	• To study genetic structure of plant and animal population and importance of genetic variation and covariation among traits. • To impart Knowledge about recent advances in population genetic theory and application in plant and animal breeding.	

	Course Content	CLOs
	Section A	
1	Introduction: Properties and classification of population; limitations of phenotype-based plant breeding; the transgenic technology in plant breeding; notable achievements and future prospects.	1
2	Molecular Dissection of Complex Traits: Single marker-based approaches; interval mapping; composite interval mapping; multiple populations/crosses; multiple QTL; Bayesian mapping; linkage disequilibrium or association mapping; meta-analysis; *in silico* mapping.	1, 2
3	Marker Assisted Selection: Components of marker-assisted selection; marker-assisted gene introgression; marker-assisted gene pyramiding; selection for quantitative traits; long-term selection.	1, 2
4	Isolation and Functional Analysis of Genes: in silico prediction; comparative approaches for gene isolation; cloning based on cDNA sequencing; positional cloning; identification of genes by mutagenesis; other approaches for gene isolation.	1, 2
5	Omics in Plant Breeding: The post-genomics era; the Omics: Genomics, precision genomics, and RNA interference; transcriptomics and proteomics; metabolomics and physiognomics; phenomics; bioinformatics; plant databases.	3, 4
	Section B	CLOs
6	Basic Concept: Conventional versus molecular animal breeding, necessity and importance of molecular techniques in animal breeding, potentials for developing countries. Molecular information in livestock breeding: monitoring diversity between and within breeds, information for sustainable livestock production.	1, 2
7	Molecular Genetic Technologies: Marker assisted selection, PCR, DNA sequencing, transgenic& cloning technology, and their applications in animal breeding.	1, 2
8	Animal Mitochondrial Genome: Structure, gene organization, replication and transcription, genomic diversity, mitochondrial inheritance, mitochondrial genome organization.	1, 2
9	Statistical Analysis of Genetic Data: Overview, computational tools in molecular breeding, modern computational approaches.	3, 4
10	Phylogenetic Tree Construction: Concept, fundamental elements of phylogenetic models, calculation of distance and similarity matrix, tree interpretation- the importance of identifying paralogs and orthologs, phylogenetic data analysis steps.	3, 4

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Recognize various genome mapping processes of plants	1, 2, 3, 4, 5, 6, 7, 9
	CLO2	Identify various molecular markers and its application	1, 2, 3, 4, 5, 6, 7, 8, 9
	CLO3	Interpret genomics, precision genomics, and RNA interference.	1, 2, 3, 4, 5, 6, 7, 8, 9
	CLO4	Interpret metabolomics and physiognomics; phenomics; bioinformatics; plant databases.	1, 2, 3, 4, 5, 6, 7, 8, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, discussion, tutorial and presentation	Quiz, continuous assessment, presentation and term final exam.
CLO2	Lecture, discussion, tutorial and Presentation	Quiz, continuous assessment, assignment and presentation
CLO3	Lecture, discussion, tutorial and presentation	Quiz, continuous assessment, presentation and term final exam.
CLO4	Lecture, discussion, tutorial and presentation	Quiz, continuous assessment, assignment, presentation and term final exam.

Learning Materials

Recommended Readings	Barh, D., Khan, M.S., & Davies, E. (2015). *Plant omics: The omics of plant science* (1st ed.). Springer. Khatib, H. (2015). *Molecular and quantitative animal genetic*s (1st ed.). Wiley-Blackwell, USA. Lorz, H., & Wenzel, G.(Eds.). (2008). *Molecular marker systems in plant breeding and crop improvement* (Biotechnology in Agriculture and Forestry Book 55) (1st ed.). Springer, NY, USA. Russell, P. J. (2009). *iGenetics: A molecular approach* (3rd ed.). Benjamin Cummings.
Supplementary Readings	Saitou, N. (2013). *Introduction to evolutionary genomics* (Computational biology). Springer.

Course Code: 0512 07 BGE 3213	Year: Third	Term: Second
Course Title	Biomass and Renewable Energy	
Course Status	Optional	
Credit	3.0	
Prerequisite(s)	None	
Rationale	The course is designed to provide basic and detailed Knowledge and insights in the area of Biomass and Renewable energy.	
Course Objectives	• To describe various energy sources. • To explain the principles and theories regarding formation and processing of energy from renewable sources.	

	Course Content	CLOs
	Section A	
1	Introduction: The ultimate energy source, energy cycle, types of energy: solar energy, wind energy, geothermal energy, tidal energy, biomass energy, fossil fuel, History and international politics on renewable energy.	1
2	Important Terminologies: Combustion and combustion products, calorific value, fuel density, flammability, other fuel properties.	1, 2
3	Solar Energy and Carbon Cycle: Energy spectrum, carbon cycle, Greenhouse gases, application of solar energy, solar heating systems, solar panels, business issues.	1, 3
4	Biomass and Biomass Energy: Production of biomass from different sources, conversion of biomass to biofuels, dedicated bioenergy crops, production of biodiesel and biofuel, biodiesel properties and characteristics.	1, 5
5	Biogas and Anaerobic Digestion: Introduction, utilization and importance of biogas, mechanism of anaerobic digestion, critical issues, solid waste management.	1, 3, 4
	Section B	CLOs
6	Densification: Introduction, application, hot and high-pressure densification, cold and low-pressure densification.	3, 4
7	Gasification: Definition, gasification processes, fixed bed and fluidized bed gasification, other examples.	1, 3, 4
8	Pyrolysis: Introduction, types of reactors, reactor mechanism, charcoal making process, charcoal kiln, factors influencing yield.	1, 3, 4
9	Fuel Cell Technology: History, types of fuel cells (proton exchange, alkaline electrolyte, phosphoric acid, molten carbonate, solid oxide and direct methanol fuel cells), principle and operation of Proton Exchange Membrane fuel cell, materials and fabrication methods for fuel cell technology, micro fuel cell power sources.	1, 3, 4
10	Environmental Issues: Environmental regulations and ethics, regulatory bodies and policies, environmental impacts and remedies.	6

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Recognize existing energy systems of the universe in details.	1, 7, 8, 9
	CLO2	Interpret various concepts and principles of energy.	1, 2, 7, 8
	CLO3	Learn formation and uses of renewable and non-renewable energy sources.	1, 7, 8
	CLO4	Gather basic in-depth Knowledge on energy production from biomass.	1, 2, 3, 7, 9
	CLO5	Learn various mechanisms in energy production processes using biomass and other renewable sources.	1, 2, 3, 4, 5, 6, 8, 11
	CLO6	Gain knowledge on environmental issues behind energy production and usage.	1, 2, 5, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Continuous assessment, quiz
CLO2	Lecture and Q-A session	Continuous assessment and term final exam.
CLO3	Lecture and presentation	Continuous assessment and term final exam.
CLO4	Lecture and presentation	Continuous assessment and term final exam.
CLO5	Lecture and presentation	Continuous assessment and term final exam.
CLO6	Lecture and group discussion	Continuous assessment and term final exam.

Learning Materials

Recommended Readings	Bhatia, S. C., & Gupta, R. K. (2019). *Textbook of renewable energy* (1st ed.). Woodhead Publishing, India. Kanoglu, M. Cengel, Y., & Cimbala, J. (2019). *Fundamentals and applications of renewable energy* (1st ed.). McGraw-Hill Education, NY, USA.
Supplementary Readings	Maleka, P. T. (1990). *Systems modelling approach to drought management strategies in the lake kariba district of Zambia*. [Doctor of Philosophy thesis, University of Wollongong, Australia.]

Course Code: 0512 07 BGE 3214		Year: Third	Term: Second
Course Title	Biomass and Renewable Energy Sessional & Field Work		
Course Status	Optional		
Credit	1.0		
Prerequisite(s)	None		
Rationale	This course will introduce fundamental principles and practical applications of biomass-to-renewable energy processes, biofuel production from plant sources, and thermo-conversion of biomass.		
Course Objectives	• To provide the students with an overview over biomass and renewable energy resources and to introduce students to current and emerging technologies to exploit renewable energy resources. • To introduce available or projected technologies for generation of fuel and energy or to satisfy primary energy demand from renewable resources.		

	Course Content	CLOs
1	Biomass Energy basics: Biomass energy and sources, importance.	1, 2
2	Anaerobic Digestion for Biogas Production: Anaerobic microorganisms, anaerobic process for biogas production, anaerobic process for hydrogen production, gas purification processes.	1, 2
3	Biofuel Production Process: Bioethanol production, biodiesel production.	1, 2
4	Thermochemical Conversion Processes: Combustion, gasification, pyrolysis	1, 2

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Gain an interpreting of the physical principle of the origin and conversion potential of the individual resources.	1, 2, 3, 4, 5, 6, 8, 9, 10
	CLO2	Gain an interpreting and hands-on experience of the principles and current technologies of energy extraction, conversion, and integration.	1, 2, 3, 4, 5, 6, 8, 9, 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Quiz, oral exam. and lab report
CLO2	Lecture and hands on training	Quiz, oral exam., lab report, evaluation and final exam.

Learning Materials

Recommended Readings	Kumar, K. L. (2010). *Engineering fluid mechanics.* S. Chand & Co. ltd., India. McCabe, W., Smith, J., & Harriot, P. (2004). *Unit operations of chemical engineering* (7th ed.). McGraw-Hill Education, Singapore. Rajput, R.K. (1998). *Text book of fluid mechanics.* S. Chand Publication, India. Streeter,V. L. & Wylie, E. B. (1984). *Fluid mechanics* (15th ed.). S. Chand, Co. Ltd. India.
Supplementary Readings	Holman, J. P. (2009). *Heat transfer* (10th ed.). McGraw-Hill Education. Singapore,

Course Code: 0512 07 BGE 3216		Year: Third	Term: Second
Course Title	Techniques in Molecular Biology Sessional		
Course Status	Optional		
Credit	2.0		
Prerequisite(s)	None		
Rationale	A comprehensive study of molecular biology applications and techniques as they relate to Biotechnology. The topics covered in this course include RNA isolation and Northern blotting, gene cloning, mutation of DNA, real-time quantitative PCR, and Bioinformatics.		
Course Objectives	• To demonstrate proficiency in advanced molecular biology techniques, • To interpret and comply with standards of professional ethics, • To fully interpret lab safety issues associated with toxic chemicals, radioisotopes, infectious agents, and manipulation of DNA, • To be able to correctly, completely and accurately maintain a laboratory notebook suitable for laboratory use and legal records		

	Course Content	CLOs
1	Isolation & purification of DNA and RNA.	1, 2, 3, 4
2	Quantitation of nucleic acids by UV absorbance spectrometry.	1, 2, 3, 4, 5
3	Agarose gel electrophoresis of DNA.	1, 2, 3, 4, 5
4	Polyacrylamide gel electrophoresis of protein.	1, 2, 3, 4, 5
5	Virus detection.	1, 2, 3, 4, 5
6	Two-dimensional gel electrophoresis of protein.	1, 2, 3, 4, 5
7	Marker detection. (RAPD, PCR-RFLP, microsatellite marker, SNP)	1, 2, 3, 4, 5
8	Thin Layer Chromatography (TLC) of extracts from different sources.	1, 2, 3, 4, 5

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Maintain records correctly and accurately of laboratory procedures, techniques and exercises.	1, 6
	CLO2	Perform experiments and evaluate data collected from advanced DNA processing and manipulation techniques in molecular biology.	1, 10
	CLO3	Show professional, industrial and research laboratory quality scientific write-ups.	1, 3, 10
	CLO4	Interpret to set up of experiments, employing a personal responsibility, scientifically proper and systematic approach.	1, 3, 10
	CLO5	Organize laboratory data, make complete observations, acquire the knowledge of using laboratory equipment and conduct the techniques with safety and reliability.	1, 3, 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Practical/tutorials and lectures	Quiz, practical work including a report, lab final exam.
CLO2	Practical/tutorials and lectures	Quiz, practical work including a report, lab final exam.
CLO3	Practical/tutorials and lectures	Quiz, practical work including a report, lab final exam.
COL4	Practical/tutorials and lectures	Quiz, practical work including a report, lab final exam.
COL5	Practical/tutorials and lectures	Quiz, practical work, lab report evaluation, lab final exam. and viva voce

Learning Materials

Recommended Readings	Green, M. R., & Sambrook, J. (2012). *Molecular cloning: A laboratory manual.* (4th ed.). Cold Spring Harbor Laboratory, USA. Primrose, S. B., & Twyman, R. (2006). *Principles of gene manipulation and genomics* (7th ed.). Wiley-Blackwell Publishing, New Jersey, USA.
Supplementary Readings	Kale, P., Shingote, P., & Mirajkar, S. (2017). *A practical manual for basic techniques in molecular biology.* LAP Lambert Publishing.

Fourth Year First Term			
Course Code: 0512 07 BGE 4101		Year: Fourth	Term: First
Course Title	Plant Biotechnology and Genetic Engineering		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None*		
Rationale	This course presents is designed to give an outline related to molecular and biotechnological tools. An overview of the techniques and underlying theory of Plant Biotechnology and Genetic Engineering, PCR amplification and genetic transformation in plants, research and commercial applications, and issues/challenges in the area of Plant Biotechnology and Genetic Engineering.		
Course Objectives	To provide knowledge and interpreting of plant Biotechnology and Genetic Engineering, basic principles of recombinant DNA technology, gene manipulation & genetic transformation of plants, their application to plant improvement & their conservation.		

* Students should have fundamental Knowledge of plant pests especially insects, mites and pathogens, their biology, crop damages pattern, resistance mechanism and protection strategies and nutrition to comprehend & application of recombinant DNA Technology and genome editing.

	Course Content	CLOs
	Section A	
1	Introduction: Concept, the historical development of agricultural Biotechnology and Genetic Engineering, the scope of improvement through Biotechnology and Genetic Engineering; sustainable development and Biotechnology: Green Revolution, Biotechnology for small scale agriculture and agroforestry, present farming systems of Bangladesh and Asian countries.	1
2	Apomixis: Introduction; types of apomixis and definitions, characters of apomictic plants, the genetic basis of apomixes, environmental influence; breeding apomictic crops, introducing apomixis in amphimictic crops, perspectives.	1
3	Synthetic Seeds: Concepts, merits, demerits & commercial production.	1
4	In vitro Ploidy Manipulation: Introduction, gene pools, diploid species, polyploidy species, gene transfers involving chromosomes or chromosome segments, future prospects; implications on agriculture.	1
5	Biological Control of Insects, Pathogens, Nematodes and Weeds; biocontrol agents; application of Biotechnology and integrated pest management. Biotechnology and new diagnostics applied in agriculture, detection of GM crops.	1
6	Biotechnology and Biodiversity: Concept, components, interactions, level, hierarchical pattern and scales of biodiversity, genetic diversity and implication, losses and conservation of biodiversity. Biodiversity and agriculture; causes of erosion of genetic resources. Biotechnology and use of plant genetic resources in the industry, application of Biotechnology in biodiversity utilization, genetic diversity analysis using morphological, biochemical and molecular markers.	1
7	Patents and intellectual property rights (IPR), Cartagena protocol on biosafety, plant variety protection (PVP) and farmer's right.	1
	Section B	CLOs
8	Mechanism of insect, disease and stress resistance in plants.	1
9	Basic Tools of Gene Manipulation: Restriction and DNA modification enzymes, prerequisites in Plant Genetic Engineering.	1, 2
10	Gene Cloning and Identification: Vector types, structures, characteristics of good cloning vectors, creation of recombinant molecule, selection of transformants.	1, 2
11	Development of Transgenic Plants: Steps, vector preparation, gene transfer methods, gene and genome editing technology: CRISPR cas-9, mechanisms, relative advantages and disadvantages of physical and biological methods, foreign gene expression in plants, strategies of stable transformation.	1, 2

	Section B	CLOs
12	Marker Assisted Breeding: Techniques of plant variety identification, selection of segregating populations, selection of quantitative traits, QTL mapping, genome wide association (GWA), marker –assisted gene introgression & gene pyramiding and estimation of genetic variation using a Biotechnological approach and molecular farming.	1, 2
13	PCR-based cloning.	1, 2

		Upon successful completion of the course, the students will be able to:	Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Display a broad interpreting of Plant Biotechnology and Genetic Engineering	1, 2, 3, 4, 5, 6, 9
	CLO2	Explain concepts including recombinant DNA technology and CRISPR-cas9 techniques	1, 2, 3, 4, 5, 6, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and presentation	Continuous assessment, assignment, class test
CLO2	Lecture and presentation	Continuous assessment, term final exam.

Learning Materials

Recommended Readings	Callow, J. A., Ford-Lloyd, B. V., & Newbury, H. J. (1997). *Biotechnology and plant genetic resources: Conservation and use. Biotechnology in agriculture series no. 19.* CABI, UK. Chect, I. (1993). *Biotechnology in plant disease control.* Wiley-Liss Pub. Singapore. Khush, G. S & Toenniessen, G. H. (Eds.). (1991). *Rice biotechnology (Biotechnology in agriculture series no. 6)*. CABI in association with IRRI, UK. Gelvin, S. B., Schilperoort, R. A., & Verma, D. P. S. (Eds.). (1989). *Plant molecular biology manual*. Springer, Dordrecht. Prersely. G. J. (1997). *Agricultural biotechnology: Country case studies*. CABI, UK. Ravindhran, R., Ganesan, G., & Vinoth, A. (2019). *Crop genome editing using CRISPR/Cas9*: *Theory and practice.* Academic Press.
Supplementary Readings	Chawla, H. S. (2009). *Introduction to plant biotechnology* (3rd ed.). Science Publishers, Plymouth, UK. Glick, B. R., & Pattten, C.L. (2022). *Molecular biotechnology: Principles and applications of recombinant DNA* (6th ed.). ASM Press, Washington, USA. Primrose, S. B., & Twyman, R. (2007). *Principles of gene manipulation and genomics* (7th ed.). Wiley-Blackwell, UK. Slater, A., Scott, N., & Fowler, M. (2008). *Plant Biotechnology: The genetic manipulation of plants* (2nd ed.). Oxford University Press, UK.

Course Code: 0512 07 BGE 4102	Year: Fourth	Term: First
Course Title	Plant Biotechnology and Genetic Engineering Sessional & Fieldwork	
Course Status	Core	
Credit	1.0	
Prerequisite(s)	None	
Rationale	This course presents hands-on training related to molecular and Biotechnological tools. An overview of the techniques and underlying theory of Plant Biotechnology and Genetic Engineering, PCR amplification and genetic transformation in plants, research and commercial applications, and issues/challenges in the area of Plant Biotechnology and Genetic Engineering.	
Course Objectives	• Develop the basic laboratory techniques of Biotechnology and Genetic Engineering. • Encourage teamwork and accountability among the students which will help the students working in a research group in the sophisticated laboratories abroad. • Develop multitasking skills for encouraging students to take charge of their learning. • Develop multitasking skills for encouraging students to take charge of their learning.	

	Course Content	CLOs
1	Plant DNA extraction from leaf tissue, purification, quantification of the extracted DNA sample.	1
2	Demonstration of polymerase chain reaction (PCR) of extracted DNA using RAPD/SSR primers.	1
3	Agarose gel electrophoresis and separation of DNA.	1
4	Preparation of vector DNA and transformation of competent E. coli.	2
5	Culturing of *Agrobacterium tumefaciens* and *A. tumefaciens* mediated transformation of plants and their bioassay.	2
6	Protoplast isolation and fusion with PEG.	2
7	Direct DNA transfer to protoplast and plant regeneration from protoplast.	2
8	Encapsulation of somatic embryo and testing of synthetic seed.	2
9	ELISA testing of viral plant pathogens in potato, tomato and brinjal	2
10	Virus (Potato & other crops) testing using Loop mediated isothermal amplification (LAMP) technique.	1
11	Visit to research institutes and private seed companies.	2

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Isolate DNA, DNA amplification, gel preparation, and other basic molecular techniques.	1, 2, 3, 4, 5, 6, 7
	CLO2	Interpret techniques for crop improvement through recombinant technology and genetic manipulation and transformation.	1, 2, 3, 4, 5, 6, 7, 9, 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, presentation, and laboratory work	Lab work evaluation, lab final examination and viva voce
CLO2	Lecture, presentation, and laboratory work	Lab & tour reports evaluation, lab final exam. and viva voce

Recommended Readings	Chect, I. (1993). *Biotechnology in plant disease control*. Wiley-Liss Pub. Singapore. Chourasia, H.K., & Sah, P.K. (2015). *Plant disease diagnosis: Recent advances and future perspective.* LAP Lambert Academic Publishing. Dounda, J., & Mali, P. (Eds.) (2016). *CRISPR-Cas: A laboratory manual.* Cold Spring Harbor Laboratory Press. Foster, G. D., & Twell, D. (Eds.) (1996). *Plant gene isolation: Principles and practice* (1st ed.). Wiley & Sons. Gelvin, S. B., Schilperoort, R. A., & Verma, D. P. S. (Eds.) (2000). *Plant molecular biology manual* (2nd ed.). Springer, Netherlands. Giri, C.C., & Giri, A. (2007). *Plant biotechnology: Practical manual*. IK International Publishing House, India. Kale, P., Shingote, P., & Miraikar, S. (2017). *A practical manual for basic techniques in molecular biology.* LAP Lambert Academic Publishing, Germany. Mitra, S. (2014). *Genetic engineering: Principles and practice* (2nd ed.). McGraw Hill Education Pvt. Ltd. India. Parekh, S.R. (Ed.) (2004). *The GMO handbook: Genetically modified animals, microbes and plants in biotechnology.* Humana Press.
Supplementary Readings	Arencibia, A.D. (Ed.) (2011). *Plant genetic engineering: Towards the third millennium.* Elsevier Science. Brown, T. A. (Ed.). (2000). *Essential molecular biology: A practical approach,* Vol. I (2nd ed.). Oxford University Press, UK. Primrose, S. B., & Twyman, R. (2007). *Principles of gene manipulation and genomics* (7th ed.). Wiley-Blackwell, UK. Shaw, C. H. (Ed.). (1988). *Plant molecular biology: A practical approach*. Oxford University Press, UK

Course Code: 0512 07 BGE 4103		Year: Fourth	Term: First
Course Title	Animal Biotechnology and Genetic Engineering		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course focuses on the vast array of applications in animal Biotechnology and Genetic Engineering. Lectures will cover embryo transfer in domestic animals, in vitro fertilization in ruminants, genetic manipulation, micromanipulation of farm animal embryos, cloning and techniques for Genetic Engineering. The importance of animal Biotechnology in these Areas will be explored through examples such as gene transfer and animal transgenesis.		
Course Objectives	• Develop an interpreting of current techniques used in Biotechnology and their applications to animal agriculture and the biomedical field. • Develop an interpreting of the gene transfer methods. • Develop an interpreting of embryo transfer and IVF techniques. • Develop an interpreting of transgenic animals. • Develop an interpreting of the cloning of animals. • Interpret and discuss how Genetic Engineering has benefited the producer & consumer.		

	Course Content	CLOs
	Section A	
1	Introduction: Application of Biotechnology for animal production.	1
2	Embryo Transfer Technology in Domestic Animals: Definition, history, advantages and applications of embryo transfer. Steps in embryo transfer technique: selection and management of donor and recipients; superovulation; Oestrus synchronization; Oestrus detection; insemination of the donor; preparation of culture media; a collection of embryos using surgical and non-surgical methods. Handling of embryos: identification of embryos; evaluation of embryos; cryopreservation of embryos; transfer of embryos; limitations of embryo transfer techniques.	1
3	Biotechnological Utilization of Female Reproductive Potential: *In vitro* fertilization (IVF) in ruminants; potential uses of IVF. Mechanisms involved in IVF: harvesting and maturation of oocytes; collection and capacitating of sperm; fertilization and development of embryos to a transferable stage.	2
4	Metabolomics and Metabonomics in Animal Biotechnology: Definition, promising areas of applications of metabolomics in livestock production systems. Metabonomics and the impact of dietary components on gene expression and production of metabolites.	4
	Section B	CLOs
5	Transgenic Animal Production and Applications: Methods of transgenic animal production; advantages and limitations of methods; transgenic animal as human disease model; applications of transgenic models and transgenic livestock.	4
6	Cloning: Definition; history of animal cloning; cloning of mammals.	3
7	Manipulation of Gametes and Embryos: Evaluation of chromosomes of ova; separation of X and Y chromosome; embryos and zona pellucida; manipulation of gametes. Anatomy and physiology of embryos in relation to micromanipulation; culture methods; dividing embryos. Combining embryonic cells; intracellular manipulation and conservation of manipulated embryos.	3
8	Peptides in Animal Health: Synthetic peptide production and applications in animal therapeutics; production and applications of monoclonal and polyclonal antibodies.	5
9	Animal Vaccine Production by Recombinant DNA Technology: Subunit vaccines, attenuated vaccines and vector vaccines for animals' viral and bacterial diseases.	5

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Interpret the IVF techniques in ruminants.	1, 2, 3, 4, 6, 8, 11
	CLO2	Learn micromanipulation of farm animal embryos, cloning and techniques for gene transfer in domesticated animals.	1, 2, 3, 4, 7, 10, 11
	CLO3	Acquaint with techniques to produce transgenic animals and learn about metabolomics and metabonomic in animal biotechnology.	1, 2, 3, 4, 6, 8, 11
	CLO4	Impart Knowledge regarding animal vaccine production by recombinant DNA technology and maintenance of animal health.	1, 2, 3, 4, 6, 9, 10

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and presentation	Continuous assessment and assignment
CLO2	Lecture and presentation	Continuous assessment, assignment and demonstration
CLO3	Lecture and presentation	Continuous assessment, assignment and term final examination
CLO4	Lecture and group discussion	Term final examination

Learning Materials

Recommended Readings	Brackett, B.G., Seidel, G.E., & Seidel, S.M. (Eds.). (1982). *New technologies in animal breeding* (1st ed.). Academic Press, NY. Glick, B.R., Pasternak, J. J., & Patten, C.L. (2010). *Molecular biotechnology: Principles and applications in recombinant DNA* (3rd ed.). ASM Press, Washington DC, USA. Gordon, I. (1983). *Controlled breeding in farm animals* (1st ed.). Elsevier, Amsterdam, Netherlands. Hafez, E.S.E., & Hafez, B. (2013). *Reproduction in farm animals* (7th ed.). Wiley- Blackwell, USA. Verma, A.S., & Singh, A. (Eds.) (2019). *Animal biotechnology: Models in discovery and translation* (2nd ed.). Academic Press, USA.
Supplementary Readings	Gjerris, M., Olsson, A., & Sandøe, P. (2006). *Animal biotechnology and animal welfare*. In Animal welfare (pp. 89-110). Council of Europe. Ethical eye Singh, B., Gautam, S.K., Chauhan, M.S., & Singla, S.K. (2015). *Text book of animal biotechnology.* New Delhi:TERI. Smith, J. E. (2009). *Biotechnology* (5th ed.). Cambridge University Press, UK.

Course Code: 0512 07 BGE 4104	Year: Fourth	Term: First
Course Title	Animal Biotechnology and Genetic Engineering Sessional & Field Work	
Course Status	Core	
Credit	1.0	
Prerequisite(s)	None	
Rationale	The practical course will provide training on selection of donor and recipient animals; synchronization of oestrus; detection of oestrus; super ovulation and artificial insemination, different techniques of embryo collection & transfer and *in vitro* fertilization (IVF) in farm animals.	
Course Objectives	• Demonstration on the basic laboratory techniques of embryo transfer technology in domestic animals. • Demonstration on mechanisms involved in *in vitro* fertilization (IVF).	

	Course Content	CLOs
1	Selection of donor and recipient animals.	1
2	Synchronization and detection of oestrus of donor animals.	2
3	Superovulation and artificial insemination of donors.	2
4	Collection and evaluation of embryos from donor animals.	3
5	Transfer of embryos to recipient animals.	4
6	Demonstration on mechanisms involved in *in vitro* fertilization (IVF) in ruminants and animal transgenesis.	5

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Learn how to select donor and recipient animals.	1, 2, 3, 4, 5, 6, 8, 10, 11
	CLO2	Demonstrate the techniques how to perform synchronization of oestrus; superovulation & artificial insemination of farm animals.	1, 2, 5, 6, 8, 9, 10, 11
	CLO3	Demonstrate the method of collection and evaluation of farm animals' embryos.	1, 4, 5, 6, 7, 9, 11
	CLO4	Gain practical exposure and skills in the transfer of embryos.	1, 2, 3, 4, 5, 6, 11
	CLO5	Demonstrate mechanisms involved *in vitro* fertilization (IVF) and transgenesis	1, 2, 3, 4, 6, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Laboratory sessional/hands on training	Quiz
CLO2	Practical demonstration	Presentation
CLO3	Laboratory sessional/field demonstration	Partial sessional evaluation
CLO4	Field trips at food industries	Lab report evaluation
CLO5	Laboratory sessional	Viva voce, lab final examination

Learning Materials

Recommended Readings	Bhattacharya, T.K., & Kumar, P. (2017). *Animal biotechnology: A practical guide* (1st ed.). Kalyani Publisher, India. Brackett, B.G. (1982). *New technologies in animal breeding* (1st ed.). Academic Press, Cambridge, London, UK. Gordon, I. R. (1983). *Controlled breeding in farm animals* (1st ed.). Pergamon Press, Oxford, UK.
Supplementary Readings	Gjerris, M., Olsson, A., & Sandøe, P. (2006). *Animal biotechnology and animal welfare. In:Ethical Eye: Animal Welfare*. Strasbourg: Council of Europe, pp. 89-110. Lopez Jr., D. S. (2010). *Buddhism and science: A guide for the perplexed.* The University of Chicago Press, UK. Singh, B., Gautam, S.K., Chauhan, M.S., & Singla, S.K.(2015). *Textbook of animal biotechnology.* The Energy and Resources Institute (TERI), India.

Course Code: 0512 07 BGE 4105		Year: Fourth	Term: First
Course Title	Microbial Biotechnology and Genetic Engineering		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide advanced concepts in microbial Biotechnology and Genetic Engineering and related practices as well as strategies in the production of microbial, human and animal proteins and their products of commercial interest in microbial systems.		
Course Objectives	• Describe the current state of Microbial Biotechnology, with a focus on industrial practices in the development of new products, from renewable energy to solvents and pharmaceutics. • Comprehend the principles of microbial genetics and metabolic engineering in the age of genomics and systems biology.		

Course Content		CLOs
Section A		
1	Introduction: Biotechnological applications of microorganisms in agriculture, food, medicine, pharmaceuticals, environment and industry.	1
2	Microbial Protein Production: Production of single-cell proteins for use in food or feed; bacterial, fungal, yeast and algal proteins; therapeutic and health benefit.	1, 2
3	Genetic Engineering of Microorganisms: Restriction endonucleases, plasmid cloning vector, creating and screening a library, cloning DNA sequences, vectors for cloning, genetic transformation.	2, 3
4	Production of Commercial Products by Microorganisms: Enzymes, organic acids, indigo, amino acids, biopolymers, polysaccharides, alginate, foods and beverages.	2, 3
5	Antibiotics Production: Introduction, strain improvement and scale-up; cloning of antibiotic biosynthesis genes; production of penicillin, cephalosporins, tetracyclines etc. Searching of new antibiotics.	2, 3
Section B		CLOs
6	Bacterial Cell Engineering by Protoplast Fusion: Introduction to microbial protoplast fusion, methods and applications, molecular breeding by genome shuffling.	2, 4
7	Heterologous Expression in Microbial System: Introduction, rationale, vector system, host, fusion protein, approaches for downstream processing	3
8	Microbial Production of Therapeutic Agents: Viral gene delivery system.	3, 4
9	Immobilization and Co-Immobilization of Microorganism: Rationale, methodology and application.	1, 2
10	Engineering Enzymes for Clinical Diagnosis: Enzymes in clinical diagnosis, enzyme engineering approaches, case study.	1, 3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Recognize the fundamentals of microbial biotechnology.	1, 2, 3, 4, 6
	CLO2	Choose a proper microbial system to produce valuable compounds.	1
	CLO3	Propose different strategies for homologous and heterologous compounds of industrial interest exploiting microbial systems.	1, 2
	CLO4	Develop the industrial bacterial strains through molecular techniques.	1, 6, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Quiz, continuous assessment, and final examination
CLO2	Lecture and presentation	Quiz and term final examination
CLO3	Lecture and presentation	Continuous assessment and term final examination
CLO4	Lecture and presentation	Quiz and term final examination

Learning Materials

Recommended Readings	Brown, T. A. (1995). *Gene cloning: An introduction* (3rd ed.). Chapman & Hall Co. Ltd. UK. Gardner, E. J., Simmons, M. J., & Snustad, D. P. (1997). *Principles of genetics* (8th ed.). John Willey & Sons Inc. Singapore, NY. Krebs J.E., Goldstein E.S., & Kilpatrick, S.T. (2017). *Lewin's Genes XII* (12th ed.) Jones & Bartlett Learning, MA. USA. Lee, Y. K. (2003). *Microbial biotechnology*: *Principles and applications* (3rd ed.) World Scientific Publishing Company, Singapore. Singh, J.,Vyas, A., Wang, S., & Prasad, R. (Eds.) (2020).*Microbial biotechnology: Basic research and applications.* Springer Nature Pte Ltd. Singapore.
Supplementary Readings	Glazer, A. N., & Nikaido, H. (2007). *Microbial biotechnology: Fundamentals of applied microbiology* (2nd ed.).Cambridge University Press, UK.

Course Code: 0512 07 BGE 4106		Year: Fourth	Term: First
Course Title	Microbial Biotechnology and Genetic Engineering Sessional & Field Work		
Course Status	Core		
Credit	1.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide practical Knowledge on various techniques and methodologies related to Microbial Biotechnology and Genetic Engineering.		
Course Objectives	• Familiarize the students with different techniques and methodologies in planning and devising experiments in Microbial Biotechnology • Provide hands-on training to the students so that they can be able to deal with practicalities in the laboratory.		

	Course Content	CLOs
1	Culture of Single Cell Protein (SCP) in the laboratory.	1, 2, 3
2	Protoplast fusion of microorganisms.	1, 2, 3
3	Genetic manipulation of microorganisms.	1, 2, 3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Explain how microbiology is applied to manufacturing in industrial settings.	1, 2, 3, 4, 5, 6, 9, 10, 11
	CLO2	Relate quality control to the manufacturing process.	1, 2, 3, 4, 5, 6, 9, 10, 11
	CLO3	Describe the production methods for pharmaceuticals of microbial origin such as antibiotics and vaccines.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, hands-on training	Quiz, assignment, exam., viva voce
CLO2	Lecture, hands-on training, discussion	Assignment, exam., viva voce
CLO3	Lecture, hands-on training, discussion	Assignment, lab final exam., viva voce

Learning Materials

Recommended Readings	Diwakar, R.P. (2020). *Practical handbook on microbial biotechnology.* LAP Lambert Academic Publishing. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2010). *Molecular biotechnology: Principles and applications of recombinant DNA* (6th ed.). ASM Press, Washington DC, USA. Hui, Y. H., & Khachatourians, G. G. (Eds.). (1996). *Food biotechnology: Microorganism* (1st ed.). Wiley- VCH, New York, USA. Malik, V.S., & Sridhar, P. (1992). *Industrial biotechnology.* Oxford and IBH Publishing Co. Pvt. Ltd. India.
Supplementary Readings	Dlugonski, J. (Ed.). (2023). *Microbial biotechnology in the laboratory and practice: Theory, exercises and specialist laboratories.* Jagiellonian University Press.

Course Code: 0512 07 BGE 4107	Year: Fourth	Term: First
Course Title	Downstream Processing	
Course Status	Core	
Credit	3.0	
Prerequisite(s)	None	
Rationale	The course is designed to provide detailed Knowledge in separation and purification of bioproducts in the area of industrial Biotechnology.	
Course Objectives	• To describe detailed processes for bioproduct separation and purification techniques used in Biotechnology focusing on real industrial products. • To explain the principles and theories of various bio-separation processes to solve the real problems in industrial processes.	

	Course Content	CLOs
	Section A	
1	Introduction: Bioproducts, definition, selection criteria, basis of separation, broth characteristics, operational stages.	1, 3
2	Filtration: Introduction, classification, pre-treatment, theory and problems.	1, 2, 3, 4
3	Centrifugation: Principle, classification, centrifuge design, equipment, problem solving.	1, 2, 3
4	Disruption of Microbial Cell: Introduction, composition and structure of different cell walls analysis of disruption, laboratory-scale and large-scale disruption techniques.	2, 3
5	Extraction: Introduction, principle and chemistry of extraction, extraction methods.	2, 3, 4
	Section B	CLOs
6	Adsorption: Introduction, theory of adsorption, classification, adsorption processes.	2, 3, 4
7	Chromatography: Introduction, chromatographic process, classification, yield and purity.	2, 3, 4
8	Precipitation: Concept of solubility, theory and classification of precipitation, problem solving.	2, 3, 4
9	Ultrafiltration: Definition, osmosis and osmotic pressure, UF theory, membrane characteristics, preparation of membrane, development of semi-permeable membrane, methods of preparation, membrane characteristics and performances, membrane fouling and treatment, UF equipment and processes.	2, 3, 4
10	Crystallization: Basic concepts, saturation, nucleation, crystal growth.	2, 3, 4

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Have an overview of bioproduct separation and purification techniques.	1, 2, 3, 4, 6
	CLO2	Recognize various theories and principles of various bio-separation processes.	1
	CLO3	Learn critical aspects in operating various downstream techniques.	1, 2
	CLO4	Improve their skills in problem solving with respect to designing separation and purification processes.	1, 6, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Continuous assessment and term final exam.
CLO2	Lecture and group work	Continuous assessment and term final exam.
CLO3	Lecture and group work	Continuous assessment and term final exam.
CLO4	Lecture and group work	Continuous assessment and term final exam.

Learning Materials

Recommended Readings	Bailey, J. & Ollis, D. (2017). *Biochemical engineering fundamentals* (2nd ed.). McGraw Hill Education, NY, USA. Belter, P. A., Cussler, E. L., & Hu, W. (1988). *Bioseparations: Downstream processing for biotechnology* (1st ed.). Wiley-Interscience, USA. Shuler, M., Kargi, F., & DeLisa, M. P. (2017). *Bioprocess engineering: Basic concepts* (3rd ed.). Pearson Education, Inc. London, UK. Stanbury, P. F., Whitaker, A., & Hall, S. J. (2016). *Principles of fermentation technology* (3rd ed.). Pergamon Press, Oxford, UK.
Supplementary Readings	Moo-Young, M. (Ed.). (2019). *Comprehensive biotechnology* Vol. 2 &3 (3rd ed.). Pergamon Press, UK.

Course Code: 0512 07 BGE 4108	Year: Fourth	Term: First
Course Title	Central Viva	
Course Status	Core	
Credit	1.0	
Prerequisite(s)	All offered courses	
Rationale	A Central viva voce or oral exam. is an important learning practice in education in which questions are asked to the students in verbal form and the student has to answer the questions to demonstrate sufficient knowledge of the subject matter.	
Course Objectives	To face viva voce confidently and answer the questions accurately.	

	Course Content	CLOs
1	The Concerned "Examination Committee" of 4th year First term will conduct the viva and assess the students' performance.	1
2	Members of "Examination Committee" will test the depth of basic knowledge regarding the relevant subjects learnt so far in various terms.	2
3	Questions will be asked on personal views on various issues relevant to various areas of Biotechnology and Genetic Engineering and its contemporary issues.	3
4	Members of "Examination Committee" will exchange views on professional etiquette suitable for career progression.	4

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Demonstrate basic level of interpreting on relevant subjects learnt so far.	1
	CLO2	Demonstrate self-confidence in facing a jury board for oral examination in general.	6
	CLO3	Present his/her views convincingly and precisely.	9, 10
	CLO4	Exhibit professional etiquette suitable for career progression.	2, 7

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and team teaching	Viva voce
CLO2	Lecture and group riscussion	Viva voce
CLO3	Lecture and team teaching	Viva voce
CLO4	Lecture and group discussion	Viva voce

Learning Materials

Recommended Readings	Listed references of all the previously taught theory and sessional courses.

Course Code: 0588 07 RM 4109		Year: Fourth	Term: First
Course Title	Research Methodology		
Course Status	Optional		
Credit	3.0		
Prerequisite(s)	None		
Rationale	This course is designed to help undergraduate students to grasp what research is, how it is conducted and its place in academic disciplines. The focus will be on assisting students in developing practical research skills and strategies to enhance academic and professional success in the field of biosciences. Another focus will be on assisting students with developing the ability to effectively prepare a research proposal, perform research effectively, manipulate data and manage research. Other course topics include research law, research ethics, experimental and non-experimental research, and acquiring electronic and non-electronic information resources for research purposes. It also helps the students to gain Knowledge on the writing of the thesis and research reports.		
Course Objectives	• To recognize about different types of research. • To interpret research formulation. • To develop the ability to effectively prepare a research proposal. • To recognize about research designs and methodology. • To learn about presentations, thesis and research report writing.		

Course Content		CLOs
Section A		
1	Introduction: Definition, scope, goals, objectives and approaches of research. Research methods versus methodology. Areas and types of research; research process, characteristics, qualities and criteria of good research. Evaluation of a research proposal.	1
2	Research Problem: Meaning, selecting the problem, necessity and technique in defining the problem.	2, 3
3	Research Design: Meaning, need, features and properties of research design. Non-experimental and experimental studies; experimental research design. Research questions and hypothesis.	1, 2, 3, 4, 5
4	Sampling and Sample Design: Concepts and importance of sampling. Non-probability and probability sampling.	1, 2, 3, 4
5	Data Collection: Personal interview method; self-administered questionnaire method; telephone interviewing; computer-assisted personal interviewing; qualitative data collection technique; data quality check; construction of questionnaire and its qualities; considerations in designing a questionnaire.	5, 6, 8
6	Techniques of Preparing a Research Proposal: Project title, introduction, justification, statement of the problem and setting the objectives, hypothesis, methodology, recruitment and training of project personnel, data collection, management and analysis, research team, work plan, budget, references.	5, 6, 7
7	Techniques and Styles of Writing a Thesis: Guidelines for writing a thesis, format of a thesis, cover and inside the title, approval sheet, declaration sheet, acknowledgement, abstract, table of contents, list of table and figures, list of acronyms and abbreviations, introduction along with justification and objectives, review of literature, materials and methods, results and discussion, summary and conclusions, references, appendixes.	7
Section B		CLOs
8	Rapid Rural Appraisal (RRA), Participatory Rural Appraisal (PRA) and Rapid Rural System Appraisal (RRSA). Organization and differences among RRA, PRA and RRSA.	1, 2, 3
9	Ex-ante Analysis: Ex-ante analysis of research design and critical path method for planning and management of the project.	1, 2, 3, 4
10	Research Law, Monitoring and Evaluation: International and national laws and legislation; objectives, monitoring and evaluation process, typology of evaluation, planning and designing a monitoring and evaluation system, monitoring and evaluation of training programs, writing an evaluation report, term of references, program performance indicators and plan for dissemination of evaluation report.	7
11	Literature Review: Purpose and types/sources of review; preparation of index card for reviewing and abstracting; review of scientific reports.	6

	Section B	CLOs
12	Validity, Reliability and Ethics in Research: Definition, differences between validity and reliability, factors resulting in poor reliability and improvement measures, internal and external validity. Necessities of ethical clearance and its monitoring.	7
13	Annual Reports and Interpretation: Concept, techniques and significance and precautions of interpretation. Types, purpose, format, steps, significance and precautions of writing the research report, salient features of research highlights and executive summary.	8
14	Research systems and its coordination in different sectors of Bangladesh (Agriculture, health, industry, fisheries, livestock and universities).	7

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Describe the various types of research.	1, 9, 10, 11
	CLO2	Justify the importance of doing research in different contexts.	2, 9
	CLO3	Construct a framework to demonstrate the relationship between the different components of the research process.	1, 2, 6, 7, 9, 10, 11
	CLO4	Distinguish between experimental and non-experimental research in terms of definitions, assumptions, and procedures.	1, 2, 3, 7, 10, 11
	CLO5	Select appropriate research methods for the research problem.	1, 6, 7
	CLO6	Search the literature using electronic and non-electronic resources to retrieve appropriate information related to research.	1, 2, 6, 7, 9, 10, 11
	CLO7	Abide by standard law and ethical guidelines during all stages of the research process.	1, 2, 6, 9
	CLO8	Write a well designed research proposal, thesis and research report.	1, 2, 4, 7, 8, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Quiz and continuous assessment
CLO2	Lecture and presentation	Continuous assessment, assignment and term final exam.
CLO3	Lecture and presentation	Continuous assessment, assignment and term final exam.
CLO4	Lecture and presentation	Continuous assessment, assignment and term final exam.
CLO5	Lecture and presentation	Continuous assessment, assignment and term final exam.
CLO6	Lecture and presentation	Continuous assessment, assignment and term final exam.
CLO7	Lecture and presentation	Continuous assessment, assignment and term final exam.
CLO8	Lecture and presentation	Continuous assessment, assignment and term final exam.

Learning Materials

Recommended Readings	Abedin, Z. (1996). *A handbook of research for the fellows of M. Phil and PhD programs* (1st ed.). Book Syndicate, Dhaka, Bangladesh. BARI/BARC (1990). *Resource manual of research planning and evaluation training course.* BARI, Joydebpur, Gazipur-1701. Holmes, D., Moody, P., & Dine, D. (2010). *Research methods for the biosciences* (2nd ed.). Oxford University Press Inc., UK. Islam, M.N. (2015). *An introduction to research methods* (3rd ed.). Mullick and Brothers, Dhaka, Bangladesh.
Supplementary Readings	Kothari, C. R., & Garg, G. (2016). *Research methodology: Methods and techniques* (3rd ed.). New Age International Ltd., New Delhi, India Singh, A. K. (2015). *Tests, measurements and research methods in behavioral sciences.* Tata McGraw-Hill Pub. Co. New Delhi, India.

Course Code: 0512 07 BGE 4111	Year: Fourth	Term: First
Course Title	Bionanoscience	
Course Status	Optional	
Credit	2.0	
Prerequisite(s)	None	
Rationale	Familiarization with Bionanoscience is essential to Interpret the inherent properties of the nano world within biological systems. The course is designed to help students in interpreting and comprehending the materials, devices, systems and application on nanoscience and its connection with Biotechnology.	
Course Objectives	Students will be able to learn the structure, formation, observation and application of nano objects present in biological system.	

Course Content		CLOs
Section A		
1	Introduction: Concept of "Nanos", context and motivation of nanoscience, from traditional world to quantum world, nanoscience and biotechnology.	1
2	Natural Biological Assembly at the Nano-Scale: Nano-assembly of viruses, membranes and proteins.	1
3	Nanomaterials: Nanofiber, nanorod, nanoparticle and graphene-based material.	2
4	Nanodevices: Electronic, magnetic, optical and mechanical devices.	2
Section B		CLOs
5	Nanofacture: Top-down, bottom-up and molecular manufacturing of nanomachines.	2
6	Nanometrology: Observation and measurement at nanoscale, imaging with photon and electron, SEM, AFM.	2
7	Application of Bionanoscience in medical and diagnostics.	1, 2
8	Current Progress and Future Perspective: Recent articles in bionanoscience	1, 2

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Recognize what bionanoscience.	1, 2
	CLO2	Learn the nanomaterial and devices, their manufacturing and imaging procedures and medical and diagnostic uses.	1, 2, 3, 6, 9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and presentation	Continuous assessment and term final examination
CLO2	Lecture and presentation	Continuous assessment, assignment and term final examination

Learning Materials

Recommended Readings	Anand, R. (2017). *Essentials of nanotechnology* (1st ed.). Medtech Publishing Co. USA. India. Nouailhat, A. (2007). *An introduction to nanoscience and nanotechnology*. Wiley-ISTE, London, UK. Ramsden, G. (2009). *Essentials of nanotechnology.* Geremy Ramsden and Ventus publishing,
Supplementary Readings	Gazit, E. (2007). *Plenty of room for biology at the bottom: An introduction to bionanotechnology.* Emperial College Press, London, UK.

Course Code: 0512 07 BGE 4113		Year: Fourth	Term: First
Course Title	Molecular Medicine		
Course Status	Optional		
Credit	3.0		
Prerequisite(s)	None		
Rationale	This course is outlined to provide Knowledge in molecular medicine. This course will also enhance the knowledge of the students in the area of DNA polymorphism, RNAi, therapeutic enzymes and recombinant vaccines, drug-metabolizing enzymes, alteration of the microbiome to improve health and legal & social issues of bioethics.		
Course Objectives	• To enhance students' interpreting of molecular medicine theory and its applications. • To expose students to gene therapy, pharmacogenetics/pharmacogenomics, molecular diagnosis etc. • To enable students to interpret the challenges and opportunities of achieving regarding personalized medicine, ethical, legal and social issues molecular medicine		

	Course Content	CLOs
	Section A	
1	History of Molecular Medicine: Technological development, mutation analysis, genetic therapies, DNA polymorphism, RNAi, Human genome project.	1
2	Classes of Recombinant Protein Drugs: Production of recombinant proteins using different expression systems. Classes of recombinant drugs; Monoclonal Antibodies, hormones, growth factors, fusion proteins, cytokines, blood coagulation factors, therapeutic enzymes and recombinant vaccines.	1, 2
3	Gene Therapy: Types of gene therapy. Methods of gene transfer; retroviral, adenoviral, adeno-associated virus vector, non-viral gene transfer, tissue specificity of gene transfer and gene expression, monogenic and polygenic disorder and gene therapy.	2, 3
4	Pharmacogenetics/Pharmacogenomics: Uptake and transport of drugs, drug metabolism; cytochrome P 450 enzymes and other drug-metabolizing enzymes. Drug targeting, drug toxicity and hypersensitivity, drug development and individual pharmacotherapy modern drug delivery.	2, 3
	Section B	CLOs
5	Molecular Diagnosis: Identification of aberrant/malfunction gene, DNA and RNA hybridization techniques, Microarray, next generation sequencing.	2, 4
6	Antisense, Ribozyme and RNA interference strategies: Antisense oligonucleotides; mechanism of action of antisense oligonucleotides, development and stabilization of antisense oligonucleotides, clinical applications, ribozyme; classification of ribozymes, development of ribozymes for medical applications, clinical applications of ribozymes, RNA interference; mechanism of RNA interference, non-specific side effects, delivery and pre-clinical applications, antisense therapeutics for hypertension, antisense strategies for treatment of heart failure, antisense therapy in clinical oncology, biology of micro-RNAs, micro-RNAs and diseases.	3
7	Aptamers: Basics of aptamers, selection and modification of aptamers, clinical development of aptamers.	3, 4
8	Personalized Medicine: Personalized medicine, personal factors that impact our health, transcriptome, proteome and metabolome to analyze a person, personal microbiome; microbiome in personal health, effects of diet on the microbiome, alteration of the microbiome to improve health.	1, 2
9	Ethical, legal and social issues.	1, 3

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Recognize the fundamentals of molecular medicine.	1, 3, 6
	CLO2	Interpret uptake and transport of drugs, enzymes and drug-metabolizing enzyme.	1, 7, 8
	CLO3	Identify aberrant/malfunction gene.	1, 2, 6
	CLO4	Learn DNA and RNA hybridization techniques, microarray, next generation sequencing.	1, 2, 5, 6, 8, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO 1	Lecture	Quiz, continuous assessment and term final exam.
CLO 2	Lecture and presentation	Quiz and term final exam.
CLO 3	Lecture and presentation	Continuous assessment and term final exam.
CLO 4	Lecture and presentation	Quiz and term final exam.

Learning Materials

Recommended Readings	Kurreck, J. & Stein, Cy. A. (2016). *Molecular medicine: An introduction* (1st ed.). Wiley-Blackwell, USA. Phillips, M. I. (Ed.). (2005). *Antisense therapeutics: Methods in molecular medicine* (2nd ed.). Humana Press, New Jersey, USA. Trent, R. J. (2005). *Molecular medicine: An introductory text* (3rd Ed.). Churchill Livingstone , London, UK.
Supplementary Readings	Snyder, M. (2016). *Genomics and personalized medicine: What everyone needs to know* (1st ed.). Oxford University Press, Oxford, UK.

Course Code: 0311 07 Econ 4179		Year: Fourth	Term: First
Course Title	Production Economics		
Course Status	Optional		
Credit	3.0		
Prerequisite(s)	None		
Rationale	This course aims to provide students an overview of these tools: Theory of the firm; technology, production sets and input requirement sets; cost, profit, and supply functions of the firm; cost minimization and profit maximization, using the profit function to estimate supply and factor demand; linear programming (LP) and the theory of production; and of the insights that can be obtained with them, concentrating on those most relevant to production economics.		
Course Objectives	• To enhance students' interpreting of production economics theory and its applications; • To expose students to the practical applications of production theory to agricultural problems, rural development and environment; • To enable students to interpret the challenges and opportunities of achieving agricultural productivity growth in Bangladesh; • To facilitate students to apply production economics theory and methods in agricultural research and management.		

	Course Content	CLOs
	Section A	
1	Introduction: Nature, scope and importance of production economics; assumptions, advantages and limitations of static production economics.	1, 2
2	Factor Product Analysis: Physical product functions and related concepts; features of a typical production process; stages of production in factor-product analysis; forms of production function and their relative advantages.	1, 2
3	Factor Analysis: Isoquants and their characteristics; isoclines and ridge lines; stages of production in factor-factor analysis; partial elasticity of production and function coefficients; changes in factor proportions and changes in the scale.	1, 2
4	Product Analysis: Derivation of production possibility curves; vertical and horizontal combinations of enterprises.	1, 2
	Section B	CLOs
5	Optimum Input Use: Value product functions and their relationships; profit maximization and determination of optimum input use in factor-product, factor-factor and product-product analyses.	1, 3
6	Profit Maximizing Output: Cost and revenue functions, equilibrium of the firm; determination of profit maximizing output under various market conditions; derivations of supply functions.	1, 3, 4
7	Linear Programming: Components and assumptions of linear programming; solution of a simple linear programming problem.	1, 2

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Acquire basic knowledge and production theories of economics.	1, 4, 7, 8, 9
	CLO2	Apply production theory to practical problems related to biotechnology.	2, 3, 4, 7, 9
	CLO3	Interpret and apply production and cost functions and implications for profit maximization in the short and long run.	3, 9, 10
	CLO4	Analyse market structure and implications for profit maximization.	1, 2, 5, 6, 8

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO 1	Lecture and/or group discussion	Quiz, continuous assessment
CLO 2	Lecture and/or case studies	Term final exam.
CLO 3	Lecture and/or presentation	Assignment
CLO 4	Lecture and group task	Term final exam.

Learning Materials

Recommended Readings	Bishop, W.D., & Toussaint, C.E. (1958). *Introduction to agricultural economic analysis.* John Wiley & Sons, Inc. NY, USA. Bradford, L. A., Johnson, G. L., & Johnson, G. L. (1953). *Farm management analysis.* John Wiley & Sons, USA. Dillon, J. L., & Anderson, J.R. (1990). *The analysis of response in crop and livestock production.* Pergamon Press, Oxford, UK. Dillon, J. L. and Hardaker, J. B. (1993). *Farm management research for small farmer development*: FAO farm system management series; FAO, Rome. Doll, J. P., & Orazem, F. (1992). *Production economics: Theory with applications* (2nd ed.). Wiley & Sons, USA.
Supplementary Readings	Debertin, D.L. (2012). *Agricultural production economics*: *The art of production theory.* University of Kentucky UKnowledge.

Fourth Year Second Term			
Course Code: 0512 07 BGE 4201		Year: Fourth	Term: Second
Course Title	Food Biotechnology		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	Food Biotechnology course will emphasize on the study of a coherent and systematic body of knowledge and interpreting of the nature and composition of food, their selection, processing, genetic modification and preservation using living organisms or parts thereof through the application of appropriate technology and the environmental management and marketing of the finished/desired food and food products. The course will ensure to meet the needs of consumers for safe, wholesome, nutritious, functional and attractive foods.		
Course Objectives	• Knowledgeable of the chemical, physical, microbiological and sensory aspects and functional properties of bioactive food constituents that provide health benefits. • To promote food Biotechnology for efficient utilization of agricultural foods resources. • To acquaint with the role of microorganisms in food and food industry. • To familiarize the students about the processing and preservation techniques of different food and food products. • To emphasize the importance of food safety & security, food quality, food laws & regulations, food engineering and packaging in food industry.		

	Course Content	CLOs
	Section A	
1	Introduction: Microorganisms important in food Biotechnology- bacteria yeasts and molds, their importance, characteristics and relevance to food Biotechnology.	1
2	Transgenic Biotechnology in Food production: Biotechnological interventions for important agronomic traits. Production of leaner meats, modified proteins, foods with improved nutrition and processing from ruminants, poultry, fish and other mammals. Use of GMO/LMO for production of GM foods. Advantages and controversy of GM foods.	2
3	Dairy Biotechnology: Milk and its food value; type A1 and A2 milk, pasteurization, homogenization and fortification of milk and milk products, starter culture, production technology of cheese; butter; fermented dairy products; evaporated, condensed and powder milk and ice cream. Adulteration of milk and dairy products.	2
4	Fermented Food and Beverage Production: Principles of Production of carbonated beverage, alcoholic beverage, amino acids, vitamin and single cell protein.	1, 2
5	Probiotic Food Products: History and probiotic concept, sources of probiotic microorganisms, established effects of probiotics, advantages of probiotics; effects of probiotics on: pathogenic bacteria; cancer, hepatic diseases and pregnancy; probiotic strains currently being used; concepts of prebiotic, synbiotic, functional, natural and organic foods.	3
	Section B	CLOs
6	Enzymes in Food Industry: Industrial enzymes and their applications. enzymes in food processing and production; bakery and confectionary, meat, fish, fruit, vegetables and brewing, baby foods and nutraceuticals	3
7	Food Spoilage and Preservation: Causes of food spoilage, technology of food preservation; food additives: Anti-oxidants, antimicrobial agents, acidulants, anticaking agents, emulsifier and stabilizers, firming and crisping agents, food colors, flavours, flavour enhancer or potentiator, sweeteners, nutrient supplements and sequestrants etc.	1, 4
8	Fortification of Processed Food and Food Products: Methods, elements of fortification, advantages and disadvantages/health effects.	1, 5

	Section B	CLOs
9	Food Toxicology: Natural toxins in animal food stuffs, food contaminants from industrial wastes, toxicants formed during food processing; health risk of processed food products.	4
10	Commercialization of Food and Food Products: Food packaging, storage, transportation and merchandising of various food products with added value.	5
11	Food Security, Safety and Regulation: Global perspective of food security, nature and cost of food borne illness, legislative perspectives; international food standards, national and international regulatory systems.	5

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Familiarize the scope and prospects food biotechnology. Learn the role of microorganisms in food production, processing and preservation.	1, 5, 6, 10, 11
	CLO2	Demonstrate knowledge and skills in the fields of transgenic & dairy biotechnology and fermented food products and their processing and preservation.	1, 2, 3, 4, 8, 9, 10, 11
	CLO3	Gain knowledge and skills regarding probiotic food products and use of enzymes in food industries.	1, 3, 4, 6, 9, 10, 11
	CLO4	Learn about food spoilage and food toxicity.	1, 3, 4, 6, 7, 10, 11
	CLO5	Impart knowledge regarding commercialization of food and food products, food security, safety and regulation.	1, 3, 4, 6, 7, 8, 9, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Continuous assessment and quiz
CLO2	Lecture and presentation	Continuous assessment and assignment
CLO3	Lecture and presentation	Continuous assessment, assignment and demonstration
CLO4	Lecture and presentation	Continuous assessment, assignment and term final examination
CLO5	Lecture and group discussion	Term final examination

Learning Materials

Recommended Readings	Andrews, S. (2017). *Food and beverage services: A training manual* (3rd ed.). McGraw-Hill Education Pvt. Ltd, New Delhi, India. Eckles, C.H., Combs, W.B., & Macy, H. (1943). *Milk and milk products* (3rd ed.). Tata McGraw-Hill Book Company, NY, USA. Eskin, N. A. M., & Shahidi, F. (2012). *Biochemistry of foods* (3rd ed.). Academic Press, Cambridge, UK.
Supplementary Readings	Bhatia, S.C., Foster, G.N., & Bhatia, S.C. (2020). *Food biotechnology.* CBS Publishers, India. Hasler, C.M. (Ed.) (2005). *Regulation of functional foods and nutraceuticals: A global perspective* (1st ed.). Wiley-Blackwell. Kosikowski, F. V. (1997). *Cheese and fermented milk foods* (2nd ed.). Edwards Brothers, Inc. Smith, J., & Charter, E. (2010). *Functional food product development* (1st ed.). Blackwell Publishing Ltd.

Course Code: 0512 07 BGE 4202	Year: Fourth	Term: Second
Course Title	Food Biotechnology Sessional & Field Work	
Course Status	Core	
Credit	1.0	
Prerequisite(s)	None	
Rationale	The course will provide hands on train towards the students regarding sampling, physical, chemical and microbiological taste/tests of milk and other dairy products. The students will be skilled in the areas of manufacturing processes and quality tests of dairy, bakery & confectionery products, fruits and vegetable products, meat and meat products, beverage and fermented product. They will also get the opportunity to be placed at different food manufacturing and food processing industries at home, abroad and the globe as a whole.	
Course Objectives	The course will make the student to practically apply their knowledge for sampling procedures of different food items, determination of their food values, familiarity with the manufacturing methods, processing, preservation, transportation and marketing of different food items, learning the techniques of quality control of foods and gather applied knowledge through field trips to modern dairy plants, beverage industries, confectionery, bakery and food processing industries.	

	Course Content	CLOs
1	Qualitative and quantitative analysis of milk and dairy products: organoleptic taste, clot-on-boiling test, alcohol test, fat, acidity, specific gravity, Solids-Non-Fat (SNF) and Total Solids (TS).	1
2	Detection of adulteration in food and dairy products.	3, 5
3	Microbiological analysis of food and dairy products.	5
4	Manufacturing and processing of selected food and dairy products.	2
5	Field trips to modern dairy plants, beverage, confectionery and other food manufacturing and processing industries.	4

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Learn how to perform physical, chemical and microbiological analysis of different food items	1, 2, 5, 6, 9, 11
	CLO2	Demonstrate the techniques how foods being manufactured and methods of quality control of foods.	1, 2, 5, 6, 8, 9, 10, 11
	CLO3	Familiarize regarding applications of food rules and regulations for safe, nutritious and wholesome foods.	1, 4, 5, 6, 7, 9, 11
	CLO4	Gain practical exposures and skills of different food items at industrial levels.	1, 2, 4, 6, 8, 10, 11
	CLO5	Learn the social, economic and ethical implications of Food Biotechnology.	1, 3, 4, 6, 8, 9, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Laboratory sessional/hands on training	Quiz
CLO2	Practical demonstration	Presentation
CLO3	Laboratory sessional/field demonstration	Partial sessional evaluation
CLO4	Field trips at food industries	Lab report evaluation
CLO5	Laboratory sessional	Lab final examination, viva voce

Learning Materials

Recommended Readings	Andrews, S. (2013). *Food and beverage service training manual.* Tata McGraw-Hill Education Pvt. Ltd. India. Eckles, C.H., Combs, W.B., & Macy, H., (1943). *Milk and milk products* (4th ed.). Tata McGraw-Hill Book Company Ltd. India. Eskin, N.A.M. (2012). *Biochemistry of foods* (3rd ed.). Academic Press. Fortin, N.D. (2016) *Food regulation: Law, science, policy and practice* (2nd ed.). Wiley USA.
Supplementary Readings	Hasler, C.M. (Ed.) (2005). *Regulation of functional foods and nutraceuticals: A global perspective* (1st ed.). Wiley-Blackwell. Kosikowski, F. V. (1997). *Cheese and fermented milk foods* (2nd ed.). Edwards Brothers, Inc. Smith, J., & Charter, E. (2010). *Functional food product development* (1st ed.). Blackwell Publishing Ltd. WHO (2015). *Modern food biotechnology, human health & development: An evidence-based study.* Food Safety Department, WHO.

Course Code: 0512 07 BGE 4203	Year: Fourth	Term: Second
Course Title	Environmental Biotechnology	
Course Status	Core	
Credit	3.0	
Prerequisite(s)	None	
Rationale	The course provides modern concepts on biotechnology to build a sustainable environment. It deals with the technologies using microorganisms or components of biological origin to create a pollution free high productive environment.	
Course Objectives	• Demonstrate an interpreting of the environment, pollution and sustainable development. • Deliver biotechnological approaches to build a pollution-free environment. • Provide skills in environment-friendly technologies to produce value-added products from wastes.	

	Course Content	CLOs
	Section A	
1	Introduction: Environment & sustainable development, biogeochemical transformations of C, N, S and P.	1
2	Environmental Pollution : Définition, nature of pollutants. types of pollution: origin, effects & control systems.	1
3	Biodegradation: Microbial degradation of cellulose, pesticides, aromatics and hydrocarbons.	2, 4
4	Biopesticides Production: Fungi (*Trichoderma* spp. and *Glycladium* sp.), bacteria (*Bacillus* sp.), baculoviruses and neem.	2, 4
5	Bioleaching, Biosorption and Fossil Fuel Processing: Concepts and application.	2, 4
6	Bioremediation: Pollution control of heavy metals; Zinc, lead, mercury, copper and cadmium, arsenic pollution, its effects and possible remedies.	2. 4
7	Biodeterioration: Prevention of biodeterioration of valuable materials.	4
	Section B	CLOs
8	Water supply and treatment: Introduction, softening, coagulation & flocculation, sedimentation, filtration; water pollutant and their sources; water quality and standards; water quality management techniques; rapid detection of water borne pathogens and risk assessment of chemicals.	3
9	Waste Water Treatment: Waste water microbiology. Waste water characteristics of different sources. Pretreatment, primary treatment and secondary treatment. Sludge treatment and disposal.	2, 3, 4
10	Scientific aspects of biological waste treatment for biofuel production.	2, 3, 4
11	Isolation and identification of microorganisms from environmental samples: classical and modern approaches, case study.	2
12	Environmental risks of Biotechnology: Reducing biotechnological risks towards the environment.	4

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Interpret the environment, pollution and sustainable development.	1, 2, 3, 5, 6, 10, 11
	CLO2	Recognize potential bio-resources for use in environmental biotechnology.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
	CLO3	Distinguish the techniques used for the treatment of waste.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
	CLO4	Utilize the techniques to build a pollution-free environment.	1, 2, 3, 4, 5, 6, 7, 9, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, presentation, discussion	Quiz, assignment, exam.
CLO2	Lecture, presentation, training	Assignment, class test
CLO3	Lecture, presentation, discussion	Assignment, exam.
CLO4	Lecture, presentation, discussion	Assignment, term final exam.

Learning Materials

Recommended Readings	Bhattacharyya, B. C., & Banerjee, R. (2008). *Environmental biotechnology* (1st ed.). Oxford University Press, UK. Jördening, H-J., & Winter, J. (Eds.) (2005). *Environmental biotechnology: Concepts and applications* (1st ed.). Wiley-Blackwell Publishing, USA. Vallero, D. A. (2015). *Environmental biotechnology :A biosystems approach* (2nd ed.). Academic Press, Cambridge, UK.
Supplementary Readings	Evans G. M., & Furlong, J. C. (2012). *Environmental biotechnology: Theory and application* (2nd ed.). Wiley India Pvt. Ltd.

Course Code: 0512 07 BGE 4204		Year: Fourth	Term: Second
Course Title	Environmental Biotechnology Sessional & Field Work		
Course Status	Core		
Credit	1.0		
Prerequisite(s)	None		
Rationale	The course is designed to provide practical Knowledge on environmental pollutants, indicator organisms, degradation of pollutants and waste utilization		
Course Objectives	• Distinguish Physico-chemical parameters of water pollution. • Provide biotechnological ways to remove pollutants from a contaminated site. • Demonstrate rapid detection of pathogenic microorganisms in drinking water.		

	Course Content	CLOs
1	Determination of dissolved oxygen (DO).	1
2	Measurement of turbidity.	2
3	Determination of total dissolved solids.	1
4	Determination of metals in water.	2
5	Study on the basis of applications of biological agents for biotechnological control of environmental pollution: biosorption, bioaccumulation and precipitation of metals; hazardous materials degradation; biocontrol of pest and rapid detection of the pathogen.	3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Determine physico-chemical parameters of water pollution.	1, 2, 3, 4, 5, 6, 9, 10, 11
	CLO2	Demonstrate removal of pollutants from contaminated water.	1, 2, 3, 4, 5, 6, 9, 10, 11
	CLO3	Detect coliforms in water.to build a pollution-free environment.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture, hands-on training	Quiz, assignment, exam., viva voce
CLO2	Lecture, hands-on training, discussion	Assignment, exam., viva voce
CLO3	Lecture, hands-on training, discussion	Assignment, lab final exam., viva voce

Learning Materials

Recommended Readings	Patra, J. K., Das, G., Das, S. K., & Thatoi, H. (2020). *A practical guide to environmental biotechnology* (1st ed.). Springer, NY, USA. Sangeetha, J., Thangadurai, D., David, M., & Abdullah, M. A. (Eds.). (2016). *Environmental biotechnology: Biodegradation, bioremediation, and bioconversion of xenobiotics for sustainable development* (1st ed.). Apple Academic Press, USA.
Supplementary Readings	Pepper, I., Gerba,, C. P., & Gentry, T. (Eds.).(2014). *Environmental microbiology* (3rd ed.). Academic Press, Cambridge, UK.

Course Code: 0512 07 BGE 4205		Year: Fourth	Term: Second
Course Title	Genomics and Proteomics		
Course Status	Core		
Credit	3.0		
Prerequisite(s)	None		
Rationale	Genomics and proteomics deals with a rapidly evolving scientific area that introduces students into genomes, proteomes and databases that store various data about genes, proteins, genomes and proteomes. The information obtained during the course should be helpful to those students who want to work in core facilities and commercial biological laboratories as well as in postgraduate studies.		
Course Objectives	To organize the large amount of information about genomics, proteomics and bioinformatics and offer basic Knowledge of genome sequencing, Major differences between prokaryotic and eukaryotic genomes, basic proteomics and its applications, basics in bioinformatics, comparative and evolutionary genomics and applications.		

	Course Content	CLOs
	Section A	
1	DNA copying and mutation, DNA sequencing, fragment assembly, restriction mapping and PCR techniques. Size and structure of genome of different organisms.	1, 3
2	Recognizing coding regions and annulating genes.	1
3	Human Genome Project (HGP): Structure, functions and evolution of the human genome, human disease genes.	1, 3
4	Genomic Data Bases: Finding and browsing genome maps on the webs, ensemble and map viewer, web interferences to genomic analyses, Align DNA to protein.	1, 2, 3
5	Phylogenetics: Distance measure, neighbor-joining and parsimony, statistical inference principles, maximum likelihood inferences, Bayesian inferences.	1, 2
6	Microarray: Definition, types, cancer and genomic microarrays, improving health care with DNA microarrays.	1, 2
	Section B	CLOs
7	Proteomics: Definition, scope, tools of proteomics, flow scheme of proteomic pathway, application of proteomics.	1
8	Separation Strategy for Proteomics: Introduction, goal, principles of 2D gel electrophoresis, strength and weakness, principle of capillary electrophoresis.	1, 2, 3
9	Protein Identification in Proteomic Scale: Introduction, inappropriateness of classical identification approaches, concept, component and application mass spectrometry, protein identification by data from mass spectrometry.	1, 2, 3
10	Structural Proteomics: Concept of structural levels of protein structure, concordance and non-concordance of protein sequence and structure, structural prediction in global proteomic scale.	1, 2, 3
11	Interaction Proteomics: Introduction, library-based methods for the analysis of binary, standard expression library, phage interaction library and yeast two protein-protein interaction hybrid screening, modification of yeast two-hybrid assay, proteome interaction map.	1, 2, 3
12	Application of proteomics in pharmaceutical, medical, agriculture and other avenues.	2, 3

Course Learning Outcomes (CLOs)	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
	CLO1	Gain basic and applied knowledge of functional genomics and proteomics.	1, 2, 3, 4, 7, 8, 9, 10, 11
	CLO2	Develop their skills by recognizing technical details of modern technologies used in genomic and proteomic studies.	1, 2, 3, 4, 5, 7, 8, 9, 10
	CLO3	Interpret and discuss the ethics of applying genomics and proteomics to human health.	1, 7, 8, 9, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lectures and/or presentations	Quiz, continuous assessment
CLO2	Lecture and/or group task	Term final exam., assignments
CLO3	Lecture and/or presentation	Class test, assignment and term final exam.

Learning Materials

Recommended Readings	Busch, W. (2017). Plant genomics: *Methods and protocols* (1st ed.). Humana Press, USA. Carlson, D.B., & Choudhuri, S. (2009). *Genomics: Fundamentals and applications* (1st ed.). Routledge, NY, USA. Haga, S.B. (2022). *The book of genes and genomes*. Springer, NY, USA. Glick, B. R., Pasternak, J. J., & Patten, C. L. (2009). *Molecular Biotechnology: Principles and applications of recombinant DNA* (4th ed.). ASM Press, Washington, USA. Morot-Gaudry, J.F., P Lea, P., & Briat, J. F. (2007). *Functional plant genomics*. CRC Press, Florida, USA. Twyman, R. M. (2013). *Principles of proteomics* (2nd ed.). Garland Science, NY, USA.
Supplementary Readings	Rao, V.S., Srinivas, K., Sujini, G.N., & Kumar, G.N. (2014). *Protein-protein interaction detection: Methods and analysis.* International Journal of Proteomics. 2014:147648 Yates, J. R. 3rd. (2000). Mass spectrometry: From genomics to proteomics. *Trends in genetics.* 16(1), 5-8.

Course Code: 0512 07 BGE 4206		Year: Fourth	Term: Second
Course Title	Thesis		
Course Status	Optional*		
Credit	4.0		
Prerequisite(s)	None		
Rationale	The thesis is designed for the students to learn how a research project/ review are implemented.		
Course Objectives	• Learn fundamental aspects of research, research design, experimentation, literature review, data collection, analysis and interpretation and finally summarizing for write-up for specific as well as a broader audience. • Familiarize with the effective techniques of research communication.		

*A student must register for and pass either 0512 07 BGE 4206: Thesis or 0512 07 BGE 4208: Review Report course for fulfilling partial requirements for B.Sc. in Biotechnology and Genetic Engineering degree.

	Course Content	CLOs
1	Introduction	1
2	Review of relevant research	1, 2
3	Methods	2, 3
4	Findings (Results/analysis)	2, 3
5	Discussion (e.g., Interpretation, connection to existing research, implications, limitations of the study)	2, 3
6	Conclusion	2

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Acquire a basic interpreting of the scientific method.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
	CLO2	Practice thinking critically and analytically and reason logically using current information and past experiences.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
	CLO3	Assess basic sources of information and how to evaluate and use this information.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Experiment	Supervision of research works
CLO2	Data Analysis	Thesis defense and/or oral exam.
CLO3	Review of literature and citation	Thesis evaluation

Learning Materials

Recommended Readings	Felix, M.S., & Smith, I. (2019). *A practical guide to dissertation and thesis writing* (1st ed.). Cambridge Scholars Publishing, UK. Friedland, A., & Folt, C.L. (2009). *Writing successful science proposals* (2nd ed.). Yale University Press, USA. Turabian, K. L., Booth, W. C., Colomb, G. G., Williams, J. M., Bizup, W.J., & FitzGerald, W.T. (2007). *A manual for writers of research papers, theses, and dissertations* (7th ed.). University of Chicago Press, CA, USA.
Supplementary Readings	Booth, W.C., Colomb, G.G., Williams, J. M., Bizup, J., & FitzGerald, W.T. (2016).*The craft of research* (4th ed.). University of Chicago Press, USA. Montello, D. R., & Sutton, P. (2013). *An introduction to scientific research methods in geography and environmental studies* (2nd ed.). SAGE Publications Ltd. USA.

Course Code: 0512 07 BGE 4208	Year: Fourth	Term: Second
Course Title	Review Report	
Course Status	Optional*	
Credit	2.0	
Prerequisite(s)	None	
Rationale	The review work is designed for the students to identify the problems, Interpret the objectives, scopes and project goals & benefits.	
Course Objectives	• Learn fundamental aspects of a project, literature review, data collection, analysis and interpretation, and summarizing for the write-up for specific and broader audiences. • Familiarize with the effective techniques of research communication.	

* A student should register for and pass either 0512 07 BGE 4206 thesis or 0512 07 BGE 4208: Review Report for fulfilling partial requirements for Bachelor of Science (B.Sc.) in Biotechnology and Genetic Engineering degree.

A student, who registers for the course 0512 07 BGE 4208: Review Report, should register for an additional course of a minimum of two credits.

	Course Content	CLOs
1	Introduction	1
2	Problem identification, goals & benefits	1, 2
3	Review of literature	2, 3
4	Findings (Results/analysis)	2, 3
5	Discussion (e.g., Interpretation, connection to existing research, implications, limitations of the study)	2, 3
6	Conclusion	2

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Identify the organizational strategy; the need for the project within an organizational context.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
	CLO2	Practice thinking critically and analytically and reason logically using current information and past experiences.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11
	CLO3	Assess basic sources of information and how to evaluate and use this information.	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Experiment / study / review of literature	Supervision of review works
CLO2	Data analysis	Defense and/or oral exam.
CLO3	Review of literature and citation	Review report evaluation

Learning Materials

Recommended Readings	Friedland, A., & Folt, C.L. (2009). *Writing successful science proposals* (2nd ed.). Yale University Press, USA. Turabian, K. L., Booth, W. C., Colomb, G. G., Williams, J. M., Bizup, W.J., & Gerald, W.T.F. (2007). *A manual for writers of research papers, theses, and dissertations* (7th ed.). University of Chicago Press, UK.
Supplementary Readings	Booth, W.C., Colomb, G.G., Williams, J. M., Bizup, J., & FitzGerald, W.T. (2016). *The craft of research* (4th ed.). University of Chicago Press, USA. Montello, D. R., & Sutton, P. (2013). *An introduction to scientific research methods in geography and environmental studies* (2nd ed.). SAGE Publications Ltd. USA.

Course Code: 0512 07 BGE 4209	Year: Fourth	Term: Second
Course Title	Industrial Biotechnology	
Course Status	Optional	
Credit	3.0	
Prerequisite(s)	None	
Rationale	The course is designed to provide critical knowledge in industrial Biotechnology in relation to bioeconomy and management.	
Course Objectives	• To describe various aspects of industrialization in Biotechnology. • To explain the principles and theories of bioeconomic development and their management.	

	Course Content	CLOs
	Section A	
1	Introduction: History of the fermentation process, Industrial application of biotechnological products, steps of bioprocess production.	1
2	Bioeconomy: Introduction, concept and components, influencing factors and impacts of the bioeconomy, the framework for the bioeconomy, present status, critical issues and challenges.	1, 2
3	Instrumentation for upstream and downstream processes.	1, 2
4	Entrepreneurship: Definition and classification, characteristics, challenges and growth.	1, 2
5	Bioengineering of gaseous fuel, biomethane and biohydrogen; microbial fuel cells; liquid fuels-bioethanol, biodiesel.	1, 3
	Section B	CLOs
6	Legal and Environmental Issues: GMP and global issues, international politics.	2, 3
7	Industry Management: Science, technology, and business, financial management, industrial procurement, quality management, risk management, R&D management, market and market analysis.	2, 3
8	Intellectual Property: Overview- innovation and patenting, patent copyright & trademark, patentable and non-patentable, patent application, intellectual property rights for Biotechnology.	3
9	Biotechnology Policy: Definition, Bangladesh policy, EU policy and US policy.	2, 3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Describe the fundamental biological and engineering principles for the production of proteins, metabolites and cells, devices and apparatuses.	1, 2, 3, 7, 8, 10
	CLO2	Interpret the principles for engineering, design of key unit operation and other functional operations such as bioreactor cultivation and chromatographic separation of bioproducts and analytical instruments.	1, 2, 3
	CLO3	Carry out engineering computations and simulation of bioprocesses based on physical, chemical and biological fundamentals, units, mathematical equations and models.	1, 2, 3, 4

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture and presentation	Continuous assessment and term final examination
CLO2	Lecture and presentation	Continuous assessment and term final examination
CLO3	Lecture, presentation and group discussion	Continuous assessment, assignment and term final examination

Learning Materials

Recommended Readings	Belter, P. A., Cussler, E. L., & Hu, W-S., (1988). *Bioseparations: Downstream processing for biotechnology.* Wiley-Blackwell, New Jersey, USA. Moo-Young, M. (Ed.). (2019). *Comprehensive biotechnology* (Vol. 2 & 3)(3rd ed.). Pergamon Press, Oxford, UK. OECD (2009). T*he bioeconomy to 2030: Designing a policy agenda* (1st ed.). OECD Publishing, Paris, France. Stanbury, P. F., Whitaker, A., & Hall, S.J. (2016). *Principles of fermentation technology* (3rd ed.). Butterworth-Heinemann, Oxford, UK.
Supplementary Readings	Boer, F. P. (1999). *The valuation of technology: Business and financial issues in R&D* (1st ed.). John Wiley & Sons Inc. NY, USA.

Course Code: 0512 07 BGE 4211		Year: Fourth	Term: Second
Course Title	Instrumentation in Biotechnology and Genetic Engineering		
Course Status	Optional		
Credit	2.0		
Prerequisite(s)	None		
Rationale	This instrumentation technology course is designed for undergraduate students to provide concepts on principle instrumentation in Biotechnology and Genetic Engineering. The students would also grasp the concept of selection and maintenance of common equipment.		
Course Objectives	• To interpret the equipment used in molecular biology, and food and beverage industries. • To interpret current loops and recognize the common output devices. • To provide knowledge about the working principles of instruments used in a modern laboratory		

Course Content		CLOs
Section A		
1	Introduction: Implications of instruments in Biotechnological research, historical development, list of instruments used in Biotechnological research.	1, 2, 3
2	Selection of instruments and their models.	1, 2, 3
3	Maintenance of common laboratory equipment.	1, 2, 3
4	Types, main component parts, working principles and method of handling of balances, water stills, freezers, shakers, de-ionizers, pH meter and water baths. Electron microscope, fluorescence microscope.	1, 2, 3
Section B		CLOs
5	Types, main component parts, working principles and methods of handling different types of ovens, incubators, centrifuges and laminar hood cabinets.	1, 2, 3
6	Types, main components, working principles and method of handling of different types of electrophoresis machines, PCR machines and spectrophotometers.	1, 2, 3
7	Types, main components, working principles and method of handling of chromatography instruments, mass spectrometry, protein and DNA sequencer.	1, 2, 3

	Upon successful completion of the course, the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Demonstrate sound theoretical knowledge in the operation and maintenance of the automated process.	1, 2, 3, 4, 6
	CLO2	Interpret control and measurement systems used in the production of various Biotechnological commodities.	1, 7
	CLO3	Learn the theories on the maintenance of common laboratory equipment.	1, 2

Mapping CLOs with the Teaching-Learning and Assessment Strategy

CLOs	Teaching-Learning Strategy	Assessment Strategy
CLO1	Lecture	Quiz, continuous assessment, and term final examination
CLO2	Lecture and presentation	Quiz and term final examination
CLO3	Lecture and presentation	Continuous assessment and term final examination

Learning Materials

Recommended Readings	Bisen, P.S. & Sharma, A. (2012). *Introduction to instrumentation in life sciences*. CRC Press, NY, USA. Hamilton, R. & Sewell, P. A. (1982). *Introduction to high performance liquid chromatography, vol. 10* (2nd ed.). Springer, Netherlands. Reed. R., Holmes, D., Weyers, J., & Jones, A. (2003). *Practical skills in biomolecular sciences* (2nd ed.). Benjamin Cummings, San Francisco, USA.
Supplementary Readings	Fleming, I. & Williams, D. (2019). *Spectroscopic methods in organic chemistry* (7th ed.). Springer, Netherlands.

20 Grading and Evaluation

20.1 Grading Scale

a) Letter Grades and corresponding Grade Points will be awarded following provisions shown below:

Numerical Grade	Letter Grade	Grade Point
80% or above	A+ (A plus)	4.00
75 to less than 80%	A (A regular)	3.75
70 to less than 75%	A- (A minus)	3.50
65 to less than 70%	B+ (B plus)	3.25
60 to less than 65%	B (B regular)	3.00
55 to less than 60%	B- (B minus)	2.75
50 to less than 55%	C+ (C plus)	2.50
45 to less than 50%	C (regular)	2.25
40 to less than 45%	D	2.00
Less than 40%	F	00
Incomplete	I	
Withdrawn	W	
Continuation (for the project, thesis design, etc. course)	X	

20.1.1 Evaluation of Theory Courses

a) All theory courses will be evaluated out of 100 marks, the distribution of which is given below:

Sl. No.	Items	Marks
1	Attendance and Class Participation	10
2	Continuous Assessments	30
3	Term Final Examination	60
	Total	100

b) The basis for awarding marks for class attendance and participation will be as follows:

Attendance & Participation	Marks
90% or above	10
85 to below 90%	9
80 to below 85%	8
75 to below 80%	7
70 to below 75%	6
65 to below 70%	5
60 to below 65%	4
Below 60%	0

c) The continuous assessments of the theory courses may be conducted in the form of class tests, assignments, homework, presentation, quiz, viva voce, etc. The course teacher(s) will evaluate every continuous assessment and share the result with the students within 2(two) weeks of conducting that continuous assessment.

d) The duration of a class test may be 20-45 minutes, and it will preferably be given during class hours.

e) If a student does not attend the class test for reasons satisfactory enough to the course teacher, the course teacher may allow the student one more chance for such assessment during the term; however, it must be held before the term final examinations. A student who has been absent for a short period, up to a maximum of three weeks due to illness, should approach the course teacher(s) or Coordinator(s) for make-up of quizzes/class tests or assignments, etc.,

immediately on returning to the classes. Such request should be supported by a medical certificate endorsed by the Chief Medical Officer of the University. The medical certificate issued by a registered medical practitioner (with the registration number shown explicitly on the certificate) and endorsed by the Chief Medical Officer of the University will also be acceptable only when the student has valid reasons for his/her absence from the University.

f) The number of Continuous Assessments (CAs) in each course will be as follows:

No. of credit(s)	Total no. of CA required	CAs to be consideredfor grading
3 – 4	4 (2 in each section)	Section best assessments shall be averaged for grading
1.5 – 2	3 (at least one in each section)	

g) If two teachers teach a course, both the teachers will conduct continuous assessments individually.

h) Answer scripts of the continuous assessment may be shown to the students to identify their strengths and weaknesses, but those would not be returned to them. The concerned teacher would submit the evaluated continuous assessment answer scripts and attendance register to the Head of the Discipline/Program Offering Entity (POE). The final score of attendance and class participation (out of 10) and continuous assessment (out of 30) should be displayed on the Discipline's notice board/ Discipline website/ Course web page before starting the term final examination.

i) The course teachers must submit the continuous assessment mark sheets to the Chair of the Examination Committee before the starting of the term final examination.

j) The Term Final Examination will carry 60 marks. There will be two separate answer scripts for Section A and Section B in the Term Final Examination.

k) When a student repeats a course in which he/she previously obtained an F grade, he/she will be given just an immediate lower grade that he/she obtained in the repeated course. However, in case he/she obtains a D grade, that will be maintained, and this grade will be shown in the transcript. If a student has to repeat a course due to punishment on him/her, the grade obtained will be maintained. If a student obtains a grade other than an F in a course, he/she will not be allowed to repeat the course for grade improvement.

l) If a student obtains an 'F' grade in any Core course in any term, this 'F' grade will not be counted for Grade Point Average (GPA) but will be shown on the grade sheet, and in such case, he/she will have to retake the course for grade improvement.

m) While registering for a retake/re-retake theoretical course, a student must be given an option to decide whether s/he intends to sit for continuous assessment of the course. If s/he opts to sit for continuous assessments, his/her fresh mark will be counted to prepare the result. However, the class attendance and participation marks will be taken from the previous record.

n) A student has to register for the backlog/retake/re-retake core courses first followed by the fresh courses offered by the Discipline for the term s/he is going to enrol subject to the compliance with: (i) completion of prerequisite courses (if any) and (ii) maximum registration limit of 25 credits per term. However, s/he may not choose to register the optional backlog/retake/re-retake courses first.

o) In addition, a student may be allowed to register for advance course(s) in a term subject to: (i) his/her all backlog/retake/re-retake and offered core courses are either clear or registered, (ii) his/her current terms' offered all core courses are registered, (iii) completion of corresponding prerequisite courses (if any), (iv) compliance with a maximum registration limit of 25 credits per term, and (v) the desired advance courses are offered by the Discipline/POE in the current term. However, such advance course registration option will not be applicable for capstone courses like Thesis/Project/ Internship/ Research study/ Monograph/ Portfolio, and so on.

p) A Special Term may be offered for the final year students who have retake/re-retake course(s). In this case, the maximum credit limit for a student will be 15 credits. This will be a Non-Taught Term. The Examination of Special Term will start 4 (four) weeks after publishing 4th-year 2nd Term results and will continue not more than 2 (two) weeks. The continuous assessment marks (40%) will be carried over from previously registered theory course(s), and Special Term Final Examination will carry the remaining (60%) marks. Final Year Term Thesis/Dissertation/Design or Core Sessional(s) supervisor(s)/course teacher(s) in consultation with the Head may allow the student(s) to re-submit the Thesis/

Dissertation Design or Core Sessional(s) within the Special Term schedule. However, it must be within the allowed limits of the Special Term credits.

20.1.2 Evaluation of Sessional Courses

a) All sessional courses will be evaluated out of 100 marks, the distribution of which is given below:

Sl. No.	Items	Marks
1	Attendance/Class Participation/Contact with teachers	10
2	Sessional Evaluation/Internal criticism/Observation	60
3	viva voce/ Final Jury	30
	Total	100

b) Sessional evaluation would be done through a laboratory test, class test, quiz, assignment, assigned project, report, oral test, performance/behaviour of the students, etc. The course teacher(s) will complete every sessional evaluation and share the result with the students within 2(two) weeks of conducting that item. Attendance and sessional evaluation mark sheets (out of 10+60=70) will be displayed on the Discipline's notice board/Discipline website/Course web page before starting the term final examination.

c) viva voce of each sessional course will usually be conducted by the course teacher(s). The senior most among the course teachers (if any) will be the Chair of the viva board. However, such viva voce/final assessment of a sessional course can also be done through jury board in applicable cases. The jury board will be headed by the Head of the Discipline or any other senior teacher of the Discipline/POE not below the rank of Assistant Professor. The Chairman of the viva/jury board may appoint other teacher(s) as a board member if necessary. A student must attend a sessional evaluation and viva voce. In case of absence in any component, he/she will get an F grade in that course.

d) The course teachers must submit the continuous assessment mark sheets to the Chair of the Examination Committee before the starting of the term final examination.

e) A student may register sessional courses as retake/re-retake (if applicable) on the Discipline Head's written approval. For retake/re-retake sessional courses, no previous records/marks will be counted.

20.1.3 Evaluation of Capstone Courses

a) The distribution of marks for a Capstone (Thesis/ Monograph/ project paper/ etc.) course will be as follows:

Sl. No.	Description	Marks
1	Contact/Discussion/Communication with the Supervisor	10
2	Evaluation	60
3	Oral presentation and/or viva voce	30
	Total	100

b) There will be two examiners (including the Supervisor) to examine the Thesis. Each examiner will evaluate the Thesis separately, and the average marks will be considered for grading. However, if the marks given by the First and Second Examiners vary 20% or more, a Third Examiner to be appointed by the concerned Examination Committee from the outside the University will evaluate the Thesis Monograph/Project paper. Among these numbers, the average of the closest two numbers will be considered for grading. However, if the marks given by the Third Examiner happen to stand at the middle of the marks given by the first two Examiners, the average of the three marks will be considered for grading.

c) For the thesis/dissertation/final project/other projects like the thesis of the final year students, there will be a presentation and defense session before the defense board. If deemed necessary to the concerned defense board, these sessions might be arranged online. A three-member defense board will evaluate the presentation and defense session. The Supervisor of the thesis/ project/ internship/ research study/ monograph/ portfolio courses will normally be the Chairman of the board while the second examiner and one member nominated by the Head of the Discipline/POE will be the members of the defense board. Every member of the defense board will evaluate individually and the final marks will be calculated by averaging all the marks given by the three members. The defense board members will be remunerated individually as per the approved rate of the university. For Jury board or in other special circumstances, the Head of the Discipline/POE might include additional member(s) in the board for justifiable reasons.

d) A Discipline might allow some students to register for an Internship program/ Project paper/ Monograph/ Research study according to the course curriculum of the respective Discipline. Such an internship program/ Project paper/Research study course might be considered as the substitute of Thesis for those students. The evaluation and related activities of such Internship program/ Project paper/ Research study courses will be similar to Thesis. Usually, a Thesis will carry double weight in terms of credit compared to other alternatives like Project/ Internship/ Research study/ Monograph/ Portfolio and so on.

e) A Discipline might allow splitting the thesis/similar course into more than one term. 'X' grade may be assigned for continuing the same course in multiple terms to assign a complete grade in the last term. Alternatively, multiple courses under thesis/similar course might be assessed by providing complete grades at the end of each term. The curriculum of the concerned Discipline/Entity will clarify all such issues.

20.1.4 Evaluation of viva voce

a) There might be a grand viva voce in each term. A student will not usually be allowed to register for more than one course of this type bearing 01 (one) credit in a term. The concerned Examination Committee of that Term will conduct the viva and assess the students. The distribution of marks for viva voce will be as follows:

Description	Marks
viva voce	100

20.2 Grades

Grade related issues are reported in section 20.1.

20.3 Grade Point Average (GPA) and Cumulative Grade Point Average (CGPA)

a) Grade Point Average (GPA) is the weighted average of Grade Points obtained in all the courses passed/completed by a student. For example, if a student has passed/completed five courses in a term having credits of C1, C2, C3, C4, and C5 and his/her points in these courses are G1, G2, G3, G4, and G5, respectively, then,

$$GPA = \sum CiGi/\sum Ci$$

b) A Numerical Example: Suppose a student has completed five courses in a term and obtained the following grades:

Course	Credit	Grade	Grade Point
A	3	A+	4.00
B	3	C+	3.00
C	3	A	3.75
D	2	B	3.25
E	1	B+	3.50

Then his/her GPA for the term will be computed as follows:
GPA= 3(4.0) + 3(3.0) + 3(3.75) + 2(3.25) + 1(3.5) /(3 + 3 + 3 + 2 + 1) = 3.52

c) A student's performance will be evaluated in terms of three indices- Term Grade Point Average (TGPA), Yearly Grade Point Average (YGPA), and Cumulative Grade Point Average (CGPA). The TGPA is computed by dividing the total points earned in a Term by the number of credits taken in the Term. The YGPA is computed by dividing the total grade points earned in two Terms in a year by dividing the number of credits taken in that year. The CGPA is computed by dividing the total grade points accumulated till date by the total completed credits. Thus a student who has earned 275 grad points in attempting 100 credits of courses would have an overall CGPA of 2.75.

20.4 Course Withdrawal

a) 'W' is the corresponding grade for withdrawn of a course, as mentioned in section 20.1.

b) If any student cannot complete the Term Final Examination due to severe illness or serious accident, he/she may apply to the Dean through the Head of the concerned Discipline for total withdrawal from the Term within eight working days after the Term Final Examination. However, he/she may choose not to withdraw from any sessional course if the grade obtained in such a course is C or better. A medical certificate endorsed by the Chief Medical Officer of the University must support the application. The Dean of the concerned School will decide on such an application and inform the Academic Council. If a student is allowed to withdraw from a Term, he/she will have to register as fresh from the Term he/she has withdrawn. However, he/she may be allowed to register for backlog courses, if offered.

20.5 Incomplete (I) Courses

'I' is the corresponding grade for an incomplete course, as mentioned in section 20.1.

20.6 Retake

Retake related issues are reported in sections 20.1.1 and 20.1.2.

20.7 Grade Improvement

Grade improvement related issues are reported in section 20.1.1.

20.8 Dropout/Cancellation of Studentship

a) A first-year first term student's admission will stand cancelled if he/she fails to complete course registration by ten working days from the beginning of the classes.

b) A first-year first term student's admission will stand cancelled if he/she fails to attend at least 50 percent of classes during ten working days from the beginning of the classes. However, in case of severe illness/accident this provision may be relaxed subject to submission of a medical certificate issued by a registered medical practitioner (with the registration number shown explicitly on the certificate) and endorsed by the Chief Medical Officer of the University.

c) A student's studentship will stand cancelled if he/she fails to comply with registration of minimum credit requirements under article 12.2 of the latest (July 2022) 'Ordinance for Undergraduate Program' of Khulna University. According to that article, a student must register for at least 15 credits per term and may be allowed to register for up to a maximum of 25 credits if recommended by his/her Discipline Head. The Discipline/POE might offer less than, greater than or equal to 25 credits per term as per the approved curriculum. The student will enjoy the option of choosing backlog, re-take, re-retake, advance courses (subject to compliance with applicable requirements/restrictions, as reported in other articles of the Ordinance) in addition to fresh courses to comply with the restriction of maximum 25 credits per term. If any student fails to register, in any way, for minimum credits (15 credits), his/her studentship at the University will stand cancelled. This minimum 15-credit registration limit may be relaxed if: (i) the student requires less than 15-credit to complete his/her graduation, or (ii) the sum of applicable (for the student) credits offered by the Discipline is less than 15-credit in the corresponding term for any valid reason.

d) A student's studentship will stand cancelled if he/she fails to earn minimum credits under article 12.5.2 of the latest (July 2022) 'Ordinance for Undergraduate Program' of Khulna University. According to that article, when a student is going to register for his/her courses in the 3rd year 2nd term, his/her earned credits up to 2nd year 2nd term must be at least 36. Otherwise, his/her studentship at the University will stand cancelled.

Approval Records	
Approving Authority	Date of Approval
Curriculum Committee of the Discipline	July 28, 2022
Executive Committee of the School	September 11, 2022
BOAS (if applicable)	-
Academic Council	October 12, 2022
Syndicate (if applicable)	October 20, 2022

Appendix 01: Summary of Major Changes in the OBE Format Curriculum

Program : Bachelor of Science in Biotechnology and Genetic Engineering
Discipline : Biotechnology and Genetic Engineering Discipline
School : Life Science School

Sl. No.	Criteria	Existing Curriculum	OBE Curriculum
1	Duration of the Program (in Year)	4	4
2	Total Available Credits	198	204
3	Minimum Credit Requirement to Complete the Degree	160	160
4	Available Credits from GED Courses	23	55
5	Credits from GED Courses (% of Total Credits)	11.62	25.49
6	Credits from GED Courses (% of Required Credits)	14.38	32.50
7	Available Credits from Core Theory Courses*	115	105
8	Available Credits from Core Sessional Courses*	29	25
9	Available Credits from Optional Theory Courses*	43	58
10	Available Credits from Optional Sessional Courses*	11	16
11	Available Credits from Capstone Courses	-	4
12	Term Duration (in week)	14	14
13	Credits from Newly Introduced Courses (Theory + Sessional)	-	12
14	Number of Newly Introduced Courses (Theory + Sessional)	-	6
15	Number of Omitted Courses	-	5
16	Change in Course Title (Number of Courses)	-	7
17	Change in Course Status (Number of Courses)	-	15
18	Inter-term Shift (Number of Courses)	-	6
19	Change in Course Contents (Number of Courses)	-	12
20	Name of Majors (if Applicable)	NA	NA
21	Name of Modes (if Applicable)	NA	NA

* including GED

- More GED courses are incorporated in the current curriculum;
- PLOs are revised according to Bloom's taxonomy;
- Few new courses are considered in the current curriculum as per suggestions of the stakeholders;
- Course contents and CLOs are updated;
- PEOs are mapped with the missions of Khulna University;
- PLOs of this curriculum are mapped with the PEOs and CLOs of each course.

Appendix 02: Concerned Committee of the Discipline/POE

Sl. No.	Name	Affiliation	Designation
1	Dr. Md. Raihan Ali	Professor, BGE Discipline, KU	Convener
2	Dr. Ahsan Habib	Professor, BGE Discipline, KU	Member
3	Dr. Chanchal Mondal	Assistant Professor, BGE Discipline, KU	Member
4	Shaila Siddiqua	Assistant Professor, BGE Discipline, KU	Member
5	Dr. S.M. Mahbubur Rahman	Professor, BGE Discipline, KU	Member Secretary

Appendix 03: PSAC of the Discipline

Sl. No.	Name	Affiliation	Designation
1	Dr. Sheikh Julfikar Hossain	Professor & Head, BGE Discipline, KU	Chairman
2	Dr. Md. Morsaline Billah	Professor, BGE Discipline, KU	Member
3	Dr. Ahsan Habib	Professor, BGE Discipline, KU	Member

Appendix 04: Acknowledgements

Biotechnology and Genetic Engineering Discipline would like to thanks all the stakeholders and participants in the workshop for their valuable comments and suggestions on the Outcome-based Education (OBE) Curriculum of the discipline. We also want to express our heartfelt gratitude to Professor Dr. Md. Mizanur Rahman of Jessore University of Science and Technology for his opinions that assist us for finalizing the curriculum accordingly.

References

BAC (2021). *Bangladesh Accreditation Council (BAC) Standards for Accreditation of Academic Program*. BAC, Dhaka. pp.1-8.

Economics Discipline (2016). *Curriculum for BSS (Hons) in Economics Program*. Economics Discipline, Khulna University. pp. 1-190.

FWT Discipline (2022). *Outcome Based Curriculum for Bachelor of Science (Hon's.) in Forestry*. Forestry and Wood Technology (FWT) Discipline, Khulna University

IQAC (2022). *Template of Outcome-based Curriculum, Institutional Quality Assurance Cell (IQAC)*. Khulna University. pp. 1-18.

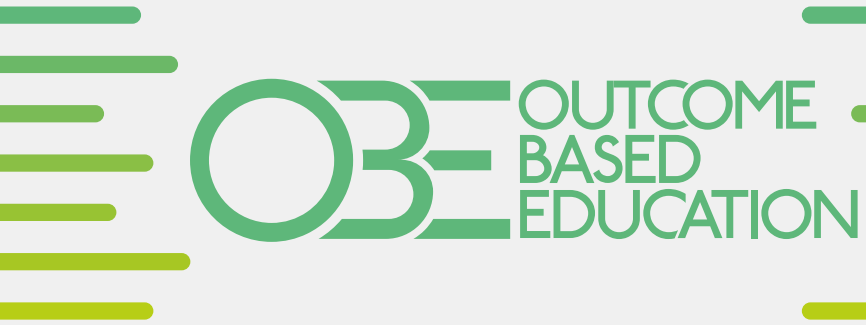
KU (2022a). *Ordinance for Undergraduate Examination*. Khulna University. pp. 1-13.

KU (2022b). *Ordinance for Undergraduate Program*. Khulna University. pp. 1-16.

Law Discipline (2021). *Program Specification and Curriculum of Bachelor of Laws (LLB Hons.)*. Law Discipline, Khulna University. pp. 1-120.

UGC (2020). *Template of Outcome Based Education (OBE) Curriculum (Revised)*. pp. 1-8.

UGC (2021). *Bangladesh National Qualifications Framework (BNQF) Part B: Higher Education (level 7-10)*. pp. 1-29.



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