KHULNA UNIVERSITY

Learn, Lead and Live

OBE OUTCOME BASED EDUCATION

MS Curriculum

Biotechnology and Genetic Engineering Discipline

Life Science School

2021-22

and onwards

Outcome-based Curriculum of

Master of Science
in
Biotechnology and Genetic Engineering

Biotechnology and Genetic Engineering Discipline
Khulna University

September 2022

Table of Content

01. Title of the Academic Program

Master of Science in Biotechnology and Genetic Engineering (MS in BGE)

Program Overview	
Degree	**Master of Science in Biotechnology and Genetic Engineering**
Abbreviated form of the Degree	MS in BGE
Mode	Three independent modes namely- i. MS in BGE (Coursework) ii. MS in BGE (Mixed Mode) iii. MS in BGE (by Research)
Major (only applicable in Mixed Mode)	Animal Biotechnology Plant Biotechnology Environmental Biotechnology Microbial Biotechnology Food Biotechnology Medical and Pharmaceutical Biotechnology Industrial Biotechnology Computational Biology
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	9
International Standard Classification of Education (ISCED) Code	0512
Mode of Study	Full Time
Language of Study	English
Applicable Session	2022-23 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

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, freethinking, 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-art knowledge and skills in the field of Biotechnology and Genetic Engineering for sustainable development of society and the environment

07. Mission of the Discipline/POE

M1	To provide quality education for producing competent graduates in Biotechnology and Genetic Engineering to contribute to different sectors including agriculture, healthcare, industry and the environment
M2	To facilitate the development of scientists, entrepreneurs and policymakers towards a nation-building program
M3	To disseminate knowledge and skills for the betterment of the society and promote meaningful collaboration with academia, industry and research organizations across the globe

M = Mission of the Discipline/POE

08. Objectives of the Discipline/POE

O1	To attract and retain outstanding students, faculty and staff
O2	To provide students with the fundamental tools and practical skills required to generate competent and highly qualified graduates

O3	To equip students with the necessary critical theoretical background, and develop the analytical, and basic research skills that will help students to pursue higher education in reputed institutes at both national and international levels
O4	To develop students' ability to apply knowledge and skills to solve theoretical and practical problems in biology and biotechnology
O5	To affirm the concept of teamwork and communication skills among students for graduate employment in the field of biotechnology
O6	To provide students with the basis for lifelong self-learning in an attempt to keep up with the continuous quick changes in the field of biotechnology
O7	To foster entrepreneurship among students in areas pertinent to biotechnology
O8	To acquaint the students with the principles of biosafety and ethical perspectives of biotechnological systems
O9	To organize and participate in meetings, conferences, symposiums, workshops, interaction and collaboration between researchers and academic institutions nationally and internationally
O10	To establish a strong reliable infrastructure and facilities to implement the current advanced applications in biotechnology focusing on humans, plants, microbiology and the environment

O = Objective of the Discipline/POE

09. Name of the Degree

Master of Science in Biotechnology and Genetic Engineering

10. Description of the Program

Biotechnology is a series of enabling technologies which use biological processes, organisms, or systems to produce/manufacture goods, products and services intended to improve the quality of life. The interdisciplinary nature of this branch of science encompasses a wide range of disciplines for the study of animals, plants and microorganisms to harness the activities for wellbeing. It is rapidly gaining significance and opportunities for the students, faculty members and graduates who want to explore the new frontiers of science are simply immense. Keeping the pivotal importance of Biotechnology, the government of Bangladesh has prioritized investing to meet the challenges of the millennium through biotechnology education and research. As a part of this initiative, Khulna University took the leading role in introducing the biotechnology program at the tertiary level in 1995. Later, this discipline was named Biotechnology and Genetic Engineering. Biotechnology and Genetic Engineering Discipline has attracted a number of highly qualified faculties, firmly committed to making the Discipline lead Biotechnology not only in the country but also to raise it up to international standards. This is visible from its various research programs in collaboration with different universities in Bangladesh and across the globe. The prime objective of this Discipline is to achieve excellence in academia and research by investigating innovative spheres in Biotechnology, for the creation of goods and services for society at large.

Bearing in mind the vision, mission and objective of Khulna University as well as the Biotechnology and Genetic Engineering Discipline, the discipline is going to offer Master of Science in Biotechnology (MS BGE) program in the following three (03) different modes-

(i) Master of Science in Biotechnology and Genetic Engineering (Coursework) program offered by the Biotechnology and Genetic Engineering Discipline at Khulna University is of 12 months in duration and consists of two (02) terms. This program is particularly designed

to produce qualified professionals intended to serve the biotechnology-oriented industries and organizations and who aspire to pursue their career in different sectors of biotechnology.

(ii)Master of Science in Biotechnology and Genetic Engineering (Mixed Mode) program offered by the Biotechnology and Genetic Engineering Discipline at Khulna University is of 18 months in duration and consists of three terms. This hybrid mode program is consist of both coursework and research work. The program is specially designed to produce competent professionals who are able to think critically and lead in biotechnology development with its different fields of specialization. Since its inception, the discipline has produced a large number of quality biotechnology professionals. Graduates of this discipline have already acquired fame in professional arenas as well as in non-professional job markets. They are competent to meet the future challenges of agriculture, healthcare, food and environmental issues of the country and the globe as a whole. A student enrolled in the MS BGE (mixed mode) program will have the option to choose a generalized degree (Master of Science in Biotechnology and Genetic Engineering) or can opt for a specialized degree mentioning a major area. In such specialized degrees, there are eight (08) major areas to choose from, namely Major in Animal Biotechnology, Major in Plant Biotechnology, Major in Environmental Biotechnology, Major in Microbial Biotechnology, Major in Food Biotechnology, Major in Industrial Biotechnology, Major in Medical and Pharmaceutical Biotechnology and Major in Computational Biology. A student deciding to undertake a generalized MS BGE program must obtain a minimum of twelve (12) credits from the offered courses belonging to at least two major areas out of eight majors during the second term of the program. A student opting for a specialized degree must obtain a minimum of twelve (12) credits from a single major area during the second term of the program.

(iii)Master of Science in Biotechnology and Genetic Engineering (by Research) program offered by the Biotechnology and Genetic Engineering Discipline at Khulna University is of 24 months in duration and consists of four (04) terms. The program is specially designed to produce proficient researchers and academicians who are capable to delve deeper on a particular research topic and are able to study design and conduct research projects independently.

11. Graduate Attributes

Attribute No	Description of Attribute(s)	Corresponding Domain
GA1	Critical, creative and evidence-based thinking to conceive innovative responses to future challenges	Thinking domain
GA2	Intellectual integrity and the ethics of scholarship	Fundamental domain
GA3	In-depth knowledge of their specialist discipline(s)	Fundamental domain
GA4	High level of achievement in writing, project activities, problem-solving and communication	Fundamental domain
GA5	An aptitude for continued self-directed learning	Personal domain
GA6	Flexible and transferable skills for different types of employment	Personal domain

GA7	Capable of initiating and implementing constructive change in their communities, including professions and workplaces	Social domain

GA = Graduate Attributes

12. Program Educational Objectives (PEOs)

Sl. No.	Objective	Domain
PEO1	To demonstrate comprehensive knowledge and interdisciplinary skills in different fields of biotechnology and relevant specialisations	Fundamental domain
PEO2	To use knowledge and skills in the different fields of biotechnology and relevant field of specialisations to identify research questions to formulate new products, and services and evaluate them	Fundamental domain
PEO3	To apply critical, creative and evidence-based thinking in areas related to biotechnology to design and develop new products for solving problems	Thinking domain
PEO4	To communicate scientific results and research outcomes to the general public and experts in effective and meaningful ways	Personal and social domain
PEO5	To manifest knowledge and transferable skills in multidisciplinary areas of biotechnology suitable for employment, consultancy, business development and entrepreneurship	Personal domain

PEO = Program Educational Objective

13. Program Learning Outcomes (PLOs)

(i) PLOs for MS Coursework

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

A. Fundamental Skills	
PLO1	Demonstrate comprehensive knowledge and interdisciplinary skills
PLO2	Test hypothesis, design experiments, and interpret the data to solve various problems in different areas of biotechnology
B. Social Skills	
PLO3	Manifest moral values, ethics, professionalism and societal values for personal, organizational and social development
C. Thinking Skills	
PLO4	Sense the scientific and technological trends in different academic and industry settings, identify the pertinent questions to be addressed, build hypotheses, and design experimental strategies to solve the scientific problems
PLO5	Analyse biotechnological approaches for multidisciplinary and interdisciplinary problems and address them effectively for sustainable development
D. Personal Skills	
PLO6	Demonstrate conceptual learning through systematic thinking and self-study and lifelong learning that helps to solve scientific problems with well-defined solutions

PLO = Program Learning Outcome

(ii) PLOs for MS Mixed Mode

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

A. Fundamental Skills	
PLO1	Demonstrate comprehensive knowledge and interdisciplinary skills
PLO2	Test hypothesis, design experiments, and interpret the data to solve various problems in different areas of biotechnology
B. Social Skills	
PLO3	Exhibit the ability to work on research projects and assignments in the teams of students coming from different academic disciplines, diverse cultures and ethnicities
PLO4	Demonstrate the ability to take initiative, set direction, design strategy, and build social cohesion not only in research labs but also in social contexts
PLO5	Express moral values, ethics, professionalism and societal values for personal, organizational and social development
C. Thinking Skills	
PLO6	Demonstrate the ability to sense the scientific and technological trends in different academic and industry settings, identify the pertinent questions to be addressed, build hypotheses, and design experimental strategies to solve the scientific problems
PLO7	Analyse biotechnological approaches for multidisciplinary and interdisciplinary problems and address them effectively for sustainable development
D. Personal Skills	
PLO8	Demonstrate conceptual learning through systematic thinking and self-study and lifelong learning that helps to solve scientific problems with well-defined solutions
PLO9	Exhibit communication skills, scientific writing and data recording abilities in all the fields of biotechnology

PLO = Program Learning Outcome

(iii) PLOs for MS by Research

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

A. Fundamental Skills	
PLO1	Demonstrate comprehensive knowledge and interdisciplinary skills
PLO2	Test hypothesis, design experiments, and interpret the data to solve various problems in different areas of biotechnology
B. Social Skills	
PLO3	Exhibit the ability to take initiative, set direction, design strategy, and build social cohesion not only in research labs but also in social contexts
PLO4	demonstrate moral values, ethics, professionalism and societal values for personal, organizational and social development
C. Thinking Skills	
PLO5	Demonstrate the ability to sense the scientific and technological trends in different academic and industry settings, identify the pertinent questions to be addressed, build hypotheses, and design experimental strategies to solve the scientific problems
PLO6	Analyse biotechnological approaches for multidisciplinary and interdisciplinary problems and address them effectively for sustainable development
D. Personal Skills	
PLO7	Demonstrate communication skills, scientific writing and data recording abilities in all the fields of biotechnology

PLO = Program Learning Outcome

14. Mapping Mission of the University with PEOs

Missions / PEOs	UM1	UM2	UM3
PEO1	3	2	3
PEO2	3	3	2
PEO3	3	3	2
PEO4	2	2	3
PEO5	2	3	3

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

15. Mapping PLOs with PEOs

(i) Mapping PLOs of MS in BGE (Coursework) with PEOs

Program Learning Outcomes (PLOs)		Program Educational Objectives (PEOs)				
		PEO1	PEO2	PEO3	PEO4	PEO5
A. Fundamental Domain	PLO1	●	●	●	●	●
	PLO2	●	●	●	●	
	PLO3		●	●	●	●
C. Thinking Domain	PLO4		●	●		●
	PLO5		●	●		●
D. Personal Domain	PLO6	●	●	●	●	●

(ii) Mapping PLOs of MS in BGE (Mixed Mode) with PEOs

Program Learning Outcomes (PLOs)		Program Educational Objectives (PEOs)				
		PEO1	PEO2	PEO3	PEO4	PEO5
A. Fundamental Domain	PLO1	●	●	●	●	●
	PLO2	●	●	●	●	
B. Social Domain	PLO3		●	●	●	●
	PLO4	●	●	●		●
	PLO5		●	●	●	●
C. Thinking Domain	PLO6		●	●		●
	PLO7		●	●		●
D. Personal Domain	PLO8	●	●	●	●	●
	PLO9	●	●	●	●	●

(iii) Mapping PLOs of MS in BGE (by Research) with PEOs

Program Learning Outcomes (PLOs)		Program Educational Objectives (PEOs)				
		PEO1	PEO2	PEO3	PEO4	PEO5
A. Fundamental Domain	PLO1	●	●	●	●	●
	PLO2	●	●	●	●	
	PLO3	●	●	●		●
	PLO4		●	●	●	●
C. Thinking Domain	PLO5		●	●		●
	PLO6		●	●		●
	PLO7	●	●	●	●	●

16. Mapping Courses with PLOs

(i) Mapping Courses with PLOs of MS in BGE (Coursework)

Course Code and Course Title	PLOs					
	Fundamental Domain		Social Domain	Thinking Domain		Personal Domain
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
MS First Year First Term						
0512 07 BGE 5101 Molecular Biosciences	●	●	●	●	●	
0512 07 BGE 5103 Bioanalytical Techniques	●	●		●		●
0512 07 BGE 5106 Skills in Biosciences Sessional	●	●		●	●	●
0417 07 BA 5107 Bio-business and Entrepreneurship	●	●	●		●	●
1022 07 ES 5109 Biosafety, Bioethics and Intellectual Property Rights	●	●	●	●	●	●
0512 07 BGE 5111 Biotechnology: Concepts and Applications	●	●	●	●		●
0512 07 BGE 5114 Seminar I	●	●	●	●	●	●
0512 07 BGE 5116 Viva Voce I	●	●	●	●	●	●

Course Code and Course Title	PLOs					
	Fundamental Domain		Social Domain	Thinking Domain		Personal Domain
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6
MS First Year Second Term						
0512 07 AB 5203 Biotechnology in Animal Production	●	●	●	●	●	●
0512 07 PB 5203 Molecular Breeding and Hybrid Seed Technology	●		●	●	●	●
0512 07 PB 5204 Molecular Breeding and Hybrid Seed Technology Sessional and Fieldwork	●	●			●	●
0512 07 MB 5205 Industrial Microbiology and Fermentation	●	●	●	●	●	
0512 07 MB 5206 Industrial Microbiology and Fermentation Sessional and Fieldwork	●	●		●	●	●
0512 07 FB 5203 Advanced Food Biotechnology	●	●		●	●	●
0512 07 FB 5204 Advanced Food Biotechnology Sessional and Fieldwork	●	●		●	●	●
0512 07 MPB 5203 Regulatory Framework in Pharmaceutical Industry	●	●	●	●		●
0512 07 MPB 5204 Regulatory Framework in Pharmaceutical Industry Sessional and Fieldwork	●	●		●	●	●
0512 07 CB 5211 Computational Drug Discovery	●	●		●	●	
0512 07 BGE 5214 Seminar II	●	●	●	●	●	●
0512 07 BGE 5216 Viva voce II	●	●	●	●	●	●

(ii) Mapping Courses with PLOs of MS Mixed Mode

Course Code and Course Title	PLOs								
	Fundamental Domain		Social Domain			Thinking Domain		Personal Domain	
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
MS First Year First Term									
0512 07 BGE 5101 Molecular Biosciences	●	●		●	●	●		●	●
0512 07 BGE 5103 Bioanalytical Techniques	●		●	●		●	●		●
0512 07 BGE 5106 Skills in Biosciences Sessional	●	●	●			●	●	●	●
0417 07 BA 5107 Bio-business and Entrepreneurship	●	●	●	●	●	●	●	●	●
1022 07 ES 5109 Biosafety, Bioethics and Intellectual Property Rights	●	●			●	●	●	●	●
0512 07 BGE 5116 Viva Voce I	●	●	●	●	●	●	●	●	●

Major in Animal Biotechnology									
Course Code and Course Title	PLOs								
	Fundamental Domain		Social Domain			Thinking Domain		Personal Domain	
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
MS First Year Second Term									
0512 07 AB 5201 Molecular Animal Physiology	●	●	●		●	●	●	●	●
0512 07 AB 5202 Molecular Animal Physiology Sessional and Fieldwork	●	●	●	●		●	●		●
0512 07 AB 5203 Biotechnology in Animal Production	●	●	●		●	●	●	●	●
0512 07 AB 5205 Feed Biotechnology	●	●		●		●	●	●	
0512 07 AB 5206 Feed Biotechnology Sessional and Fieldwork	●	●	●		●	●		●	●
0512 07 BGE 5216 Viva voce II	●	●	●	●	●	●	●	●	●
0512 07 BGE 5218 Dissertation Part-I-M	●	●	●	●	●	●	●	●	●
OPTIONAL									
0512 07 AB 5207 Disease Diagnosis and Therapeutics	●	●	●		●	●	●	●	
0512 07 AB 5209 Animal Functional Genomics	●	●		●	●	●	●		●
0512 07 AB 5211 Reproductive Biotechnology	●		●	●	●		●	●	

Major in Plant Biotechnology									
Course Code and Course Title	**PLOs**								
	Fundamental Domain		**Social Domain**			**Thinking Domain**		**Personal Domain**	
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
MS First Year Second Term									
0512 07 PB 5201 Molecular Plant Physiology	●	●		●		●	●	●	
0512 07 PB 5203 Molecular Breeding and Hybrid Seed Technology	●	●	●		●	●		●	●
0512 07 PB 5204 Molecular Breeding and Hybrid Seed Technology Sessional and Fieldwork	●	●		●		●	●	●	●
0512 07 PB 5205 Plant Protection	●	●	●		●		●	●	●
0512 07 PB 5206 Plant Protection Sessional and Fieldwork	●	●		●		●	●	●	●
0512 07 BGE 5216 Viva voce II	●	●	●	●	●	●	●		●
0512 07 BGE 5218 Dissertation Part-I-M	●	●	●	●	●	●	●	●	●
OPTIONAL									
0512 07 PB 5207 Plant-Microbe Interaction	●	●	●	●		●	●	●	
0512 07 PB 5209 Plant Functional Genomics	●			●	●	●	●	●	●
0512 07 PB 5211 Circular Agriculture and Artificial Intelligence	●		●	●	●	●	●		●

Major in Environmental Biotechnology									
Course Code and Course Title	**PLOs**								
	Fundamental Domain		**Social Domain**			**Thinking Domain**		**Personal Domain**	
	PLO1	PLO2	PLO 3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
MS First Year Second Term									
0512 07 EB 5201 Environmental Microbiology	●	●	●	●		●	●		●
0512 07 EB 5202 Environmental Microbiology Sessional and Fieldwork	●	●	●	●		●	●	●	●
0512 07 EB 5203 Waste Treatment and Management	●	●			●	●	●	●	
0512 07 EB 5204 Waste Treatment and Management Sessional and Fieldwork	●	●		●	●		●	●	●
0512 07 EB 5205 Environmental Toxicology	●		●		●	●		●	●
0512 07 BGE 5216 Viva voce II	●	●	●	●	●	●		●	●
0512 07 BGE 5218 Dissertation Part-I-M	●	●	●	●	●	●	●	●	●
OPTIONAL									
0512 07 EB 5207 Environmental Chemistry	●	●	●		●	●	●		●
0512 07 EB 5209 Biodiversity and Bioprospecting	●		●	●	●		●	●	

0512 07 EB 5211 Biotechnology for Sustainable Environment	●		●	●		●	●		●

Major in Microbial Biotechnology									
Course Code and Course Title	**PLOs**								
	Fundamental Domain		**Social Domain**			**Thinking Domain**		**Personal Domain**	
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
MS First Year Second Term									
0512 07 MB 5201 Microbial Diversity and Bioprospecting	●	●	●	●	●	●	●		●
0512 07 MB 5202 Microbial Diversity and Bioprospecting Sessional and Fieldwork	●	●	●	●		●	●		●
0512 07 MB 5203 Microbial Expression Systems	●	●		●		●	●	●	●
0512 07 MB 5205 Industrial Microbiology and Fermentation	●	●		●	●	●	●	●	●
0512 07 MB 5206 Industrial Microbiology and Fermentation Sessional and Fieldwork	●	●	●		●		●	●	●
0512 07 BGE 5216 Viva voce II	●	●	●	●	●	●	●	●	●
0512 07 BGE 5218 Dissertation Part-I-M	●	●	●	●	●	●	●	●	●
OPTIONAL									
0512 07 MPB 5201 Infection, Immunity and Control	●		●	●	●		●	●	●
0512 07 MPB 5205 Vaccine Technology and Biopharmaceuticals	●	●	●		●	●	●		●
0512 07 MPB 5209 Virology and Oncology	●	●		●		●		●	●

Major in Food and Nutritional Biotechnology									
Course Code and Course Title	**PLOs**								
	Fundamental Domain		**Social Domain**			**Thinking Domain**		**Personal Domain**	
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
MS First Year Second Term									
0512 07 FB 5201 Food Chemistry and Microbiology	●	●	●		●	●	●		●
0512 07 FB 5202 Food Chemistry and Microbiology Sessional and Fieldwork	●	●	●	●		●	●	●	●
0512 07 FB 5203 Advanced Food Biotechnology	●	●	●		●	●	●	●	
0512 07 FB 5204 Advanced Food Biotechnology Sessional and Fieldwork	●	●	●		●	●	●	●	●

0512 07 FB 5205 Food Processing Technology	●	●		●	●	●	●		●
0512 07 BGE 5216 Viva voce II	●	●	●	●	●	●	●	●	●
0512 07 BGE 5218 Dissertation Part-I-M	●	●	●	●	●	●	●	●	●
OPTIONAL									
0512 07 MB 5205 Industrial Microbiology and Fermentation	●	●	●	●	●		●	●	
0512 07 FB 5209 Food Safety	●		●	●		●	●	●	●
0512 07 FB 5211 Nutrition and Dietetics	●		●	●	●			●	
0512 07 FB 5213 Nutritional Biotechnology	●	●			●	●	●	●	●

Major in Industrial Biotechnology									
Course Code and Course Title	**PLOs**								
	Fundamental Domain		**Social Domain**			**Thinking Domain**		**Personal Domain**	
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
MS First Year Second Term									
0512 07 IB 5201 Industrial Microbiology	●	●	●	●	●	●	●		●
0512 07 IB 5202 Industrial Microbiology Sessional and Fieldwork	●	●		●		●	●	●	●
0512 07 IB 5203 Biochemical Engineering	●	●	●		●	●		●	●
0512 07 IB 5204 Biochemical Engineering Sessional	●	●	●		●		●	●	●
0512 07 IB 5205 Industrial Bioprocess	●		●	●		●	●	●	
0512 07 BGE 5216 Viva voce II	●	●	●	●	●	●	●	●	●
0512 07 BGE 5218 Dissertation Part-I-M	●	●	●	●	●	●	●	●	●
OPTIONAL									
0512 07 MPB 5205 Vaccine Technology and Biopharmaceuticals	●		●	●	●	●	●	●	
0512 07 IB5207 Biomolecular Engineering and Synthetic Biology	●	●	●		●	●	●	●	●
0512 07 PB5211 Circular Agriculture and Artificial Intelligence	●	●		●	●		●		●

Major in Medical and Pharmaceutical Biotechnology									
Course Code and Course Title	**PLOs**								
	Fundamental Domain		**Social Domain**			**Thinking Domain**		**Personal Domain**	
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
MS First Year Second Term									
0512 07 MPB 5201 Infection, Immunity and Control	●	●	●		●	●	●		●
0512 07 MPB 5202 Infection, Immunity and Control Sessional	●	●		●		●	●	●	●
0512 07 MPB 5203 Regulatory Framework in Pharmaceutical Industry	●	●		●	●	●	●	●	
0512 07 MPB 5204 Regulatory Framework in Pharmaceutical Industry Sessional and Fieldwork	●	●	●		●	●		●	●
0512 07 MPB 5205 Vaccine Technology and Biopharmaceuticals	●		●		●	●	●		●
0512 07 BGE 5216 Viva voce II	●	●	●	●	●	●	●	●	●
0512 07 BGE 5218 Dissertation Part-I-M	●	●	●	●	●	●	●	●	●
OPTIONAL									
0512 07 MPB 5207 Experimental Medicine	●		●		●	●	●		●
0512 07 MPB 5209 Virology and Oncology	●	●		●	●		●	●	
0512 07 MPB 5211 Epigenetics and Gene Regulation	●		●	●		●	●	●	●
0512 07 MPB 5213 Bionanotechnology in Therapeutics and Diagnostics	●				●	●	●		●
0512 07 MPB 5215 Biosensor Technology	●	●	●	●		●	●	●	●

Major in Computational Biology									
Course Code and Course Title	**PLOs**								
	Fundamental Domain		**Social Domain**			**Thinking Domain**		**Personal Domain**	
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
MS First Year Second Term									
0512 07 CB 5201 Programming Languages in Life Sciences	●		●	●		●	●		●
0512 07 CB 5202 Programming Languages in Life Sciences Sessional	●	●	●			●	●	●	
0512 07 CB 5203 Big Data in Life Sciences	●		●	●		●	●		●
0512 07 CB 5204 Big Data in Life Sciences Sessional and Fieldwork	●	●	●		●		●	●	●
0512 07 CB 5205 Computational Genomics	●		●	●		●	●	●	
0512 07 BGE 5216 Viva voce II	●	●	●	●	●	●	●	●	●

0512 07 BGE 5218 Dissertation Part-I-M	●	●	●	●	●	●	●	●	●
OPTIONAL									
0512 07 CB 5207 Systems Biology	●		●	●		●	●		●
0512 07 CB 5209 Machine Learning	●	●		●	●		●		●
0512 07 CB 5211 Computational Drug Discovery	●	●	●			●	●	●	●

MS in BGE (Mixed Mode)- Dissertation

Course Code and Course Title	**PLOs**								
	Fundamental Domain		**Social Domain**			**Thinking Domain**		**Personal Domain**	
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
MS Second Year First Term (Dissertation under Mixed Mode)									
0512 07 BGE 6102 Dissertation Part II-M	●	●	●	●	●	●	●	●	●

MS in BGE (Mixed Mode)- Project/Internship

Course Code and Course Title	**PLOs**								
	Fundamental Domain		**Social Domain**			**Thinking Domain**		**Personal Domain**	
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9
MS Second Year First Term (Project/Internship under Mixed Mode)									
0512 07 BGE 5111 Biotechnology: Concepts and Applications	●	●	●		●	●	●	●	●
0512 07 BGE 5114 Seminar I	●	●	●	●	●	●	●	●	●
0512 07 BGE 6104 Project/ Internship	●	●	●	●	●	●	●	●	●

(iii) Mapping Courses with PLOs of MS in BGE (by Research)

Course Code and Course Title	**PLOs**						
	Fundamental Domain		**Social Domain**		**Thinking Domain**		**Personal Domain**
	PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7
MS First Year First Term							
0512 07 BGE 5120 Dissertation Part I-R	●	●	●	●	●	●	●
MS First Year Second Term							
0512 07 BGE 5220 Dissertation Part II-R	●	●	●	●	●	●	●
MS Second Year First Term							
0512 07 BGE 6120 Dissertation Part III-R	●	●	●	●	●	●	●
MS Second Year Second Term							
0512 07 BGE 6220 Dissertation Part IV-R	●	●	●	●	●	●	●

17. Structure of the Curriculum

(i) Structure of MS in BGE (Coursework) Curriculum

a) Duration of the Program	1.0 year	2 terms
b) Admission Requirements	Candidates seeking admission into a MS in BGE (Coursework) program must possess a four year Bachelor degree in Biotechnology/ allied sciences from any a recognized university and a minimum CGPA (2.5 out of 4.0). Students having Appeared Certificate of Bachelor degree may be admitted in the Master's program. But he/she has to submit the original Transcript, Provisional Certificate/ Certificate/ Migration Certificate of Bachelor degree within two months of admission. Otherwise his/her admission will be cancelled. Other terms and conditions are set or revised periodically by the appropriate authority.	
c1) Graduating Credits / Total Minimum Credit Requirement to Complete the Program[i]	40	
c2) Available Credits	40 (A student enrolled in the coursework mode program might choose additional optional courses from mixed mode program and thus could avail further credits; however, such credits are not mentioned in this column)	
d) Total Class Weeks in a Term[ii]	14	
e) Minimum CGPA Requirements for Graduation	2.50	
f) Maximum Academic Years of Completion	3 years	

(ii) Structure of MS in BGE (Mixed Mode) Curriculum

a) Duration of the Program	Minimum 1.5 years (Minimum 03 terms)- Full time mode Minimum 02 years (Minimum 04 terms)- Part time mode
b) Admission Requirements	Candidates seeking admission into a MS (Mixed Mode) program must possess a four year Bachelor degree in Biotechnology/ allied sciences from any a recognized university and a minimum CGPA (2.5 out of 4.0). Students having Appeared Certificate of Bachelor degree may be

	admitted in the Master's program. But he/she has to submit the original Transcript, Provisional Certificate/ Certificate/ Migration Certificate of Bachelor degree within two months of admission. Otherwise his/her admission will be cancelled. Other terms and conditions are set or revised periodically by the appropriate authority.
c1) Graduating Credits / Total Minimum Credit Requirement to Complete the Program[i]	40
c2) Available Credits	MS BGE (Mixed mode, General)- 50 MS BGE (Mixed mode) Major in Animal Biotechnology-44 MS BGE (Mixed mode) Major in Plant Biotechnology-44 MS BGE (Mixed mode) Major in Environmental Biotechnology-44 MS BGE (Mixed mode) Major in Microbial Biotechnology-44 MS BGE (Mixed mode) Major in Food and Nutritional Biotechnology-46 MS BGE (Mixed mode) Major in Industrial Biotechnology-44 MS BGE (Mixed mode) Major in Medical and Pharmaceutical Biotechnology-48 MS BGE (Mixed mode) Major in Computational Biology-44
d) Total Class Weeks in a Term[ii]	14
e) Minimum CGPA Requirements for Graduation	2.50
f) Program Mode	Full time or Part time If a student decides to register for a part time mode, he/she has to complete the program in a minimum duration of 02 years instead of 1.5 years in a full time mode. The interchange between full time and part time mode can be permitted once for the entire program.
g) Maximum Academic Years of Completion	3 years

(iii) Structure of MS in BGE (by Research) Curriculum

a) Duration of the Program	Minimum 02 years (Minimum 04 terms)- Full time mode Minimum 2.5 years (Minimum 05 terms)- Part time mode
b) Admission Requirements	Candidates seeking admission into the MS (by Research) program must possess a four-year bachelor's degree in biotechnology/ allied sciences from any a recognized university with a minimum CGPA of 2.5 out of 4.0. Candidate seeking admission into the MS (by Research) program must have either (i) dissertation or similar type of course at the bachelor level, or (ii) published at least one article in a reputed journal as the first author.

	Students having Appeared Certificate of Bachelor degree may be admitted in the Master's program. But he/she has to submit the original Transcript, Provisional Certificate/ Certificate/ Migration Certificate of Bachelor degree within two months of admission. Otherwise his/her admission will be cancelled. Other terms and conditions are set or revised periodically by the appropriate authority would be applicable.
c1) Graduating Credits / Total Minimum Credit Requirement to Complete the Program[i]	50
c2) Available Credits	50 (A student enrolled in the research mode program might choose additional optional courses from mixed mode program and thus could avail further credits; however, such credits are not mentioned in this column)
d) Total Class Weeks in a term[ii]	14
e) Minimum CGPA Requirements for Graduation	2.50
f) Program Mode	Full time or Part time If a student decides to register for a part time mode, he/she has to complete the program in a minimum duration of 2.5 years instead of 02 years in a full time mode. The interchange between full time and part time mode can be permitted once for the entire program.
g) Maximum Academic Years of Completion	3 years

Program type	**Credit Distribution**			
	Coursework (Min.)	Dissertation (Min.)	Dissertation (Max.)	Min. from Major Area
MS in BGE (Coursework)	40	-	-	-

Program type	**Credit Distribution**		
	Coursework (Min.)	Dissertation/Project/Internship	Min. from Major Area
MS in BGE (Mixed mode): Dissertation	25	15	12
MS in BGE (Mixed mode): Project	34	6	12

MS in BGE (Mixed mode): Internship	34	6	12

Program type	**Credit Distribution**			
	Coursework (Min.)	Dissertation (Min.)	Dissertation (Max.)	Min. from Major Area
MS in BGE (by Research)	-	50	50	-

* For achieving a Master's degree with a major in a specified field under a mixed-mode or 'Master's by Research' scheme, the concerned dissertation must be directly linked with the 'major area' under consideration.

Term Duration[ii]				
Teaching and Learning	Preparatory Leave	Term Final Examination	Term Break	Total
14 Weeks	2 Weeks	4 Weeks	2 Weeks	22 Weeks

g1-1) Area-wise Credit Distribution: Coursework Mode

Area	**Course Type**		**Number of Courses**	**Credits**	**Total Credits**
General Education (GED) Courses**	Theory		2	6	6
Core/Compulsory Courses	Theory		9	21	34
	Sessional		9	13	
Capstone Courses***			-	-	-
Total					40

g1-2-1) Area-wise Credit Distribution: Mixed Mode-Dissertation

Area	**Course Type**		**Number of Courses**	**Credits**	**Total Credits**
General Education (GED) Courses**	Theory		2	06	06
	Sessional		-	-	
Core/Compulsory Courses	Theory	**Major in Animal Biotechnology**	5	12	17
		Major in Plant Biotechnology	5	12	
		Major in Environmental Biotechnology	5	12	
		Major in Microbial Biotechnology	5	12	
		Major in Food Biotechnology	5	12	
		Major in Industrial Biotechnology	5	12	
		Major in Medical and Pharmaceutical Biotechnology	5	12	
		Major in Computational Biology	5	12	
	Sessional	**Major in Animal Biotechnology**	5	5	
		Major in Plant Biotechnology	5	5	
		Major in Environmental Biotechnology	5	5	
		Major Microbial Biotechnology	5	5	
		Major Food and Nutritional Biotechnology	5	5	
		Major Industrial Biotechnology	5	5	

		Major in Medical and Pharmaceutical Biotechnology	5	5	
		Major in Computational Biology	5	5	
Optional/Elective Courses	Theory	**Major in Animal Biotechnology**	3	6	06/08/10
		Major in Plant Biotechnology	3	6	
		Major in Environmental Biotechnology	3	6	
		Major Microbial Biotechnology	3	6	
		Major Food and Nutritional Biotechnology	4	8	
		Major Industrial Biotechnology	3	6	
		Major in Medical and Pharmaceutical Biotechnology	5	10	
		Major in Computational Biology	3	6	
	Sessional	**-**	-	-	
Capstone Courses***	Dissertation I and II		02	15	15
Total					**44/46/48**

g1-2-2) Area-wise Credit Distribution: Mixed Mode- Project/Internship

Area	Course Type		Number of Courses	Credits	Total Credits
General Education (GED) Courses**	Theory		2	06	06
	Sessional		-	-	
Core/Compulsory Courses	Theory • (A student enrolled in a Mixed Mode MS Program undertaking project or internship would not be considered for a major/specialization degree. • During the First year Second Term of the study period, such a student have to obtain 14.0 credits. from at least two major areas out of the 8 major areas mentioned in this document. In such cases, a student must have to register 0512 07 BGE 5216 Viva Voce II consisting of 1.0 credit and fulfil the rest 13.0 credits by registering courses from at least two major areas out of the 8 major areas mentioned in this document)	**Major in Animal Biotechnology**	6	15	23
		Major in Plant Biotechnology	6	15	
		Major in Environmental Biotechnology	6	15	
		Major in Microbial Biotechnology	6	15	
		Major in Food and Nutritional Biotechnology	6	15	
		Major in Industrial Biotechnology	6	15	
		Major in Medical and Pharmaceutical Biotechnology	6	15	
		Major in Computational Biology	6	15	
	Sessional	**Major in Animal Biotechnology**	6	8	
		Major in Plant Biotechnology	6	8	
		Major in Environmental Biotechnology	6	8	

		Major Microbial Biotechnology	6	8	
		Major Food and Nutritional Biotechnology	6	8	
		Major Industrial Biotechnology	6	8	
		Major in Medical and Pharmaceutical Biotechnology	6	8	
		Major in Computational Biology	6	8	
Optional/Elective Courses	Theory	**Major in Animal Biotechnology**	3	6	06/08/10
		Major in Plant Biotechnology	3	6	
		Major in Environmental Biotechnology	3	6	
		Major Microbial Biotechnology	3	6	
		Major Food and Nutritional Biotechnology	4	8	
		Major Industrial Biotechnology	3	6	
		Major in Medical and Pharmaceutical Biotechnology	5	10	
		Major in Computational Biology	3	6	
	Sessional	-	-	-	
Capstone Courses***	Project/Internship		01	06	06
Total					**41/43/45**

g1-3) Area-wise Credit Distribution: Research Mode

Area	Course Type		Number of Courses	Credits	Total Credits
Capstone Courses***	Dissertation I, II, III and IV		4	50	50
Total					**50**

g2-1) Category of Courses- MS Coursework

Area	Course Type	Course Title	Credits
General Education (GED) Courses	Theory	1. Bio-business and Entrepreneurship 2. Biosafety, Bioethics and Intellectual Property Rights	06
	Sessional	-	-
Core/ Compulsory Courses	Theory	1. Molecular Biosciences 2. Bioanalytical Techniques 3. Biotechnology: Concepts and Applications 4. Molecular Breeding and Hybrid Seed Technology 5. Biotechnology in Animal Production 6. Industrial Microbiology and Fermentation 7. Advanced Food Biotechnology 8. Regulatory Framework in Pharmaceutical Industry 9. Computational Drug Discovery and Development	21
	Sessional	1. Skills in Biosciences Sessional 2. Seminar I 3. Viva voce I 4. Molecular Breeding and Hybrid Seed Technology Sessional and Fieldwork 5. Industrial Microbiology and Fermentation Sessional and Fieldwork	13

		6. Advanced Food Biotechnology Sessional and Fieldwork 7. Regulatory Framework in Pharmaceutical Industry Sessional and Fieldwork 8. Seminar II 9. Viva voce II	
Capstone Courses		-	-
Total			**40**

g2-2-1) Category of Courses- Mixed Mode: Dissertation			
Area	Course Type	Course Title	Credits
General Education (GED) Courses	Theory	1. Bio-business and Entrepreneurship 2. Biosafety, Bioethics and Intellectual Property Rights	06
	Sessional		-
Core/ Compulsory Courses	Theory	**Major in Animal Biotechnology** 1. Molecular Biosciences 2. Bioanalytical Techniques 3. Molecular Animal Physiology 4. Biotechnology in Animal Production 5. Feed Biotechnology	12
		Major in Plant Biotechnology 1. Molecular Biosciences 2. Bioanalytical Techniques 3. Molecular Plant Physiology 4. Molecular Breeding and Hybrid Seed Technology 5. Plant Protection	12
		Major in Environmental Biotechnology 1. Molecular Biosciences 2. Bioanalytical Techniques 3. Environmental Microbiology 4. Waste Treatment and Management **5.** Environmental Pollution and Toxicology	12
		Major in Microbial Biotechnology 1. Molecular Biosciences 2. Bioanalytical Techniques 3. Microbial Diversity and Bioprospecting 4. Microbial Expression Systems 5. Industrial Microbiology and Fermentation	12
		Major in Food and Nutritional Biotechnology 1. Molecular Biosciences 2. Bioanalytical Techniques 3. Food Chemistry and Microbiology 4. Advanced Food Biotechnology **5.** Food Processing Technology	12
		Major in Industrial Biotechnology 1. Molecular Biosciences	12

		2. Bioanalytical Techniques 3. Industrial Microbiology and Bioprospecting 4. Biochemical Engineering **5.** Industrial Bioprocess	
		Major in Medical and Pharmaceutical Biotechnology 1. Molecular Biosciences 2. Bioanalytical Techniques 3. Infection, Immunity and Control 4. Regulatory Framework in Pharmaceutical Industry **5.** Experimental Medicine	12
		Major in Computational Biology 1. Molecular Biosciences 2. Bioanalytical Techniques 3. Programming Languages in Life Sciences 4. Big Data in Life Sciences 5. Computation Genomics	12
	Sessional	**Major in Animal Biotechnology** 1. Skills in Bioscience Sessional 2. Viva Voce I 3. Molecular Animal Physiology Sessional and Fieldwork 4. Feed Biotechnology Sessional and Fieldwork 5. Viva Voce II	05
		Major in Plant Biotechnology 1. Skills in Bioscience Sessional 2. Viva Voce I 3. Molecular Breeding and Hybrid Seed Technology Sessional and Fieldwork **4.** Plant Protection Sessional and Field Work **5.** Viva Voce II	05
		Major in Environmental Biotechnology 1. Skills in Bioscience Sessional 2. Viva Voce I 3. Environmental Microbiology Sessional and Fieldwork 4. Waste Treatment and Management Sessional and Fieldwork **5.** Viva Voce II	05
		Major in Microbial Biotechnology 1. Skills in Bioscience Sessional 2. Viva Voce I 3. Microbial Diversity and Bioprospecting Sessional and Fieldwork **4.** Industrial Microbiology and Fermentation Sessional and Fieldwork **5.** Viva Voce II	05
		Major in Food and Nutritional Biotechnology 1. Skills in Bioscience Sessional 2. Viva Voce I	05

		3. Food Chemistry and Microbiology Sessional and Fieldwork 4. Advanced Food Biotechnology Sessional and Fieldwork **5.** Viva Voce II	
		Major in Industrial Biotechnology 1. Skills in Bioscience Sessional 2. Viva Voce I 3. Industrial Microbiology and Bioprospecting Sessional and Fieldwork **4.** Biochemical Engineering Sessional **5.** Viva Voce II	05
		Major in Medical and Pharmaceutical Biotechnology 1. Skills in Bioscience Sessional 2. Viva Voce I 3. Infection, Immunity and Control Sessional **4.** Regulatory Framework in Pharmaceutical Industry Sessional and Fieldwork **5.** Viva Voce II	05
		Major in Computational Biology 1. Skills in Bioscience Sessional 2. Viva Voce I 3. Programming Languages in Life Sciences Sessional **4.** Big Data in Life Sciences Sessional and Fieldwork **5.** Viva Voce II	05
Optional/ Elective Courses	Theory	**Major in Animal Biotechnology** 01. Disease Diagnosis and Therapeutics 02. Animal Functional Genomics 03. Reproductive Biotechnology **Major in Plant Biotechnology** 01. Plant-Microbe Interaction 02. Plant Functional Genomics 03. Circular Agriculture and Artificial Intelligence **Major in Environmental Biotechnology** 01. Environmental Chemistry 02. Biodiversity and Bioprospecting 03. Biotechnology for Sustainable Environment **Major Microbial Biotechnology** 01. Vaccine Technology and Biopharmaceuticals 02. Virology and Oncology 03. Infection, Immunity and Control **Major Food and Nutritional Biotechnology** 01. Food Safety 02. Industrial Fermentation 03. Nutrition and Dietetics 04. Nutritional Biotechnology	06.0/08.0/10.0

		Major Industrial Biotechnology 01. Biomolecular Engineering and Synthetic Biology 02. Vaccine Technology and Biopharmaceuticals 03. Circular Agriculture and Artificial Intelligence **Major in Medical and Pharmaceutical Biotechnology** 01. Vaccine Technology and Biopharmaceuticals 02. Epigenetics and Gene Regulation 03. Bionanotechnology in Therapeutics and Diagnostics 04. Virology and Oncology 05. Biosensor Technology **Major in Computational Biology** 01. Systems Biology and Network Analysis 02. Machine Learning 03. Computational Drug Discovery and Development	
	Sessional	-	-
Capstone Courses	Dissertation	Dissertation Part I (03) Dissertation Part II (12)	15
Total			**Minimum 40; Maximum 44/48**

g2-2-2) Category of Courses- Mixed Mode: Project/Internship			
Area	Course Type	Course Title	Credits
General Education (GED) Courses	Theory	1. Bio-business and Entrepreneurship 2. Biosafety, Bioethics and Intellectual Property Rights	06
	Sessional		-
Core/ Compulsory Courses	Theory	**Major in Animal Biotechnology** 1. Biotechnology: Concepts and Applications 2. Molecular Biosciences 3. Bioanalytical Techniques 4. Molecular Animal Physiology 5. Biotechnology in Animal Production 6. Feed Biotechnology	15
		Major in Plant Biotechnology 1. Biotechnology: Concepts and Applications 2. Molecular Biosciences 3. Bioanalytical Techniques 4. Molecular Plant Physiology 5. Molecular Breeding and Hybrid Seed Technology 6. Plant Protection	15
		Major in Environmental Biotechnology 1. Biotechnology: Concepts and Applications 2. Molecular Biosciences 3. Bioanalytical Techniques 4. Environmental Microbiology 5. Waste Treatment and Management	15

		6. Environmental Pollution and Toxicology	
		Major in Microbial Biotechnology 1. Biotechnology: Concepts and Applications 2. Molecular Biosciences 3. Bioanalytical Techniques 4. Microbial Diversity and Bioprospecting 5. Microbial Expression Systems 6. Industrial Microbiology and Fermentation	15
		Major in Food and Nutritional Biotechnology 1. Biotechnology: Concepts and Applications 2. Molecular Biosciences 3. Bioanalytical Techniques 4. Food Chemistry and Microbiology 5. Advanced Food Biotechnology **6.** Food Processing Technology	15
		Major in Industrial Biotechnology 1. Biotechnology: Concepts and Applications 2. Molecular Biosciences 3. Bioanalytical Techniques 4. Industrial Microbiology and Bioprospecting 5. Biochemical Engineering **6.** Industrial Bioprocess	15
		Major in Medical and Pharmaceutical Biotechnology 1. Biotechnology: Concepts and Applications 2. Molecular Biosciences 3. Bioanalytical Techniques 4. Infection, Immunity and Control 5. Regulatory Framework in Pharmaceutical Industry **6.** Experimental Medicine	15
		Major in Computational Biology 1. Biotechnology: Concepts and Applications 2. Molecular Biosciences 3. Bioanalytical Techniques 4. Programming Languages in Life Sciences 5. Big Data in Life Sciences 6. Computation Genomics	15
	Sessional	**Major in Animal Biotechnology** 1. Skills in Bioscience Sessional 2. Viva Voce I 3. Molecular Animal Physiology Sessional and Fieldwork 4. Feed Biotechnology Sessional and Fieldwork 5. Viva Voce II 6. Seminar I	08
		Major in Plant Biotechnology 1. Skills in Bioscience Sessional 2. Viva Voce I 3. Molecular Breeding and Hybrid Seed Technology Sessional and Fieldwork	08

		4. Plant Protection Sessional and Field Work 5. Viva Voce II **6.** Seminar I	
		Major in Environmental Biotechnology 1. Skills in Bioscience Sessional 2. Viva Voce I 3. Environmental Microbiology Sessional and Fieldwork 4. Waste Treatment and Management Sessional and Fieldwork **5.** Viva Voce II **6.** Seminar I	08
		Major in Microbial Biotechnology 1. Skills in Bioscience Sessional 2. Viva Voce I 3. Microbial Diversity and Bioprospecting Sessional and Fieldwork 4. Industrial Microbiology and Fermentation Sessional and Fieldwork **5.** Viva Voce II **6.** Seminar I	08
		Major in Food and Nutritional Biotechnology 1. Skills in Bioscience Sessional 2. Viva Voce I 3. Food Chemistry and Microbiology Sessional and Fieldwork 4. Advanced Food Biotechnology Sessional and Fieldwork **5.** Viva Voce II **6.** Seminar I	08
		Major in Industrial Biotechnology 1. Skills in Bioscience Sessional 2. Viva Voce I 3. Industrial Microbiology and Bioprospecting Sessional and Fieldwork **4.** Biochemical Engineering Sessional **5.** Viva Voce II **6.** Seminar I	08
		Major in Medical and Pharmaceutical Biotechnology 1. Skills in Bioscience Sessional 2. Viva Voce I 3. Infection, Immunity and Control Sessional **4.** Regulatory Framework in Pharmaceutical Industry Sessional and Fieldwork **5.** Viva Voce II **6.** Seminar I	08
		Major in Computational Biology 1. Skills in Bioscience Sessional 2. Viva Voce I 3. Programming Languages in Life Sciences Sessional	08

		4. Big Data in Life Sciences Sessional and Fieldwork **5.** Viva Voce II **6.** Seminar I	
Optional/ Elective Courses	Theory	**Major in Animal Biotechnology** 01. Disease Diagnosis and Therapeutics 02. Animal Functional Genomics 03. Reproductive Biotechnology **Major in Plant Biotechnology** 01. Plant-Microbe Interaction 02. Plant Functional Genomics 03. Circular Agriculture and Artificial Intelligence **Major in Environmental Biotechnology** 01. Environmental Chemistry 02. Biodiversity and Bioprospecting 03. Biotechnology for Sustainable Environment **Major Microbial Biotechnology** 01. Experimental Medicine 02. Virology and Oncology 03. Infection, Immunity and Control **Major Food and Nutritional Biotechnology** 01. Food Safety 02. Industrial Fermentation 03. Nutrition and Dietetics 04. Nutritional Biotechnology **Major Industrial Biotechnology** 01. Biomolecular Engineering and Synthetic Biology 02. Vaccine Technology and Biopharmaceuticals 03. Circular Agriculture and Artificial Intelligence **Major in Medical and Pharmaceutical Biotechnology** 01. Vaccine Technology and Biopharmaceuticals 02. Epigenetics and Gene Regulation 03. Bionanotechnology in Therapeutics and Diagnostics 04. Virology and Oncology 05. Biosensor Technology **Major in Computational Biology** 01. Systems Biology and Network Analysis 02. Machine Learning 03. Computational Drug Discovery and Development	06.0/08.0/10.0
	Sessional	-	-
	Project/Internship	• A student enrolled in a Mixed Mode MS Program undertaking project or internship would not be considered for a major/specialization degree. • During the First year Second Term of the study period, such a student have to obtain 14.0 credits from at least two major areas out of the 8 major areas mentioned in this document. In such cases, a student must have to register 0512 07 BGE 5216 Viva Voce II consisting of 1.0 credit and fulfil the rest 13.0 credits by registering courses from at least	06

		two major areas out of the 8 major areas mentioned in this document.	
Total			**41/43/45**

18. Year/Term-wise Distribution of Courses
18.1 MS in BGE (Coursework)

First Year First Term (Coursework)						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0512 07 BGE 5101	Molecular Biosciences	Core	3.0	-	3.0	None
0512 07 BGE 5103	Bioanalytical Techniques	Core	3.0	-	3.0	None
0512 07 BGE 5106	Skills in Biosciences Sessional	Core	-	1.5	1.0	None
0417 07 BA 5107	Bio-business and Entrepreneurship	Core	3.0	-	3.0	None
1022 07 ES 5109	Biosafety, Bioethics and Intellectual Property Rights	Core	3.0	-	3.0	None
0512 07 BGE 5111	Biotechnology Concept and Application	Core	3.0	-	3.0	None
0512 07 BGE 5114	Seminar I	Core	-	4.5	3.0	None
0512 07 BGE 5116	Viva voce I	Core	-	1.5	1.0	None
Total	Core Courses:8, Optional Courses: 0.0, Theory Courses: 5, Sessional Courses: 3		15.0	7.5	20.0	-
			22.5			

A student enrolled in the coursework mode program might choose additional optional courses from mixed mode program and thus could avail further credits; however, such credits are not mentioned in this column.

First Year Second Term (Coursework)						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0512 07 AB 5203	Biotechnology in Animal Production	Core	2.0	-	2.0	None
0512 07 PB 5203	Molecular Breeding and Hybrid Seed Technology	Core	2.0	-	2.0	None
0512 07 PB 5204	Molecular Breeding and Hybrid Seed Technology Sessional and Fieldwork	Core	-	1.5	1.0	None
0512 07 MB 5205	Industrial Microbiology and Fermentation	Core	2.0	-	2.0	None
0512 07 MB 5206	Industrial Microbiology and Fermentation Sessional and Fieldwork	Core	-	1.5	1.0	None
0512 07 FB 5203	Advanced Food Biotechnology	Core	2.0	-	2.0	None
0512 07 FB 5204	Advanced Food Biotechnology Sessional and Fieldwork	Core	-	1.5	1.0	None
0512 07 MPB 5203	Regulatory Framework in Pharmaceutical Industry	Core	2.0	-	2.0	None
0512 07 MPB 5204	Regulatory Framework in Pharmaceutical Industry Sessional and Fieldwork	Core	-	1.5	1.0	None
0512 07 CB 5211	Computational Drug Discovery	Core	2.0	-	2.0	None
0512 07 BGE 5214	Seminar II	Core	-	4.5	3.0	None
0512 07 BGE 5216	Viva voce II	Core	-	1.5	1.0	None
Total	Core Courses:12, Optional Courses:0.0 , Theory Courses: 6, Sessional Courses: 6		12.0	12.0	20.0	-
			24.0			

A student enrolled in the coursework mode program might choose additional optional courses from mixed mode program and thus could avail further credits; however, such credits are not mentioned in this column.

18.2 MS in BGE (Mixed Mode)

First Year First Term (Mixed Mode)						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0512 07 BGE 5101	Molecular Biosciences	Core	3.0	-	3.0	None
0512 07 BGE 5103	Bioanalytical Techniques	Core	3.0	-	3.0	None
0512 07 BGE 5106	Skills in Biosciences Sessional	Core	-	1.5	1.0	None
0417 07 BA 5107	Bio-business and Entrepreneurship	Core	3.0	-	3.0	None
1022 07 ES 5109	Biosafety, Bioethics and Intellectual Property Rights	Core	3.0	-	3.0	None
0512 07 BGE 5116	Viva voce I	Core	-	1.5	1.0	None
Total	Core Courses:6, Optional Courses: 0, Theory Courses: 4, Sessional Courses: 2		12.0	3.0	14.0	-
			15.0			

First Year Second Term (Generalized BGE) (Mixed Mode)

A student enrolled in the MS BGE (mixed mode) program will have the option to choose a generalized degree (MS BGE) or can opt for specialized major degree. In such specialized major degrees, there are eight (08) major areas to choose from namely Animal Biotechnology, Plant Biotechnology, Environmental Biotechnology, Microbial Biotechnology, Food and Nutritional Biotechnology, Medical and Pharmaceutical Biotechnology, Industrial Biotechnology, and Computational Biology.

A student opting for a generalized MS BGE (mixed mode) must obtain a minimum of fourteen (14) credits from the offered courses belonging to the above mentioned eight major areas during the second term of the program. BGE academic committee will decide the list of courses to be offered before the start of MS term II course registration. However, a maximum of two courses could be offered from each major area.

First Year Second Term (Major in Animal Biotechnology) (Mixed Mode)						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0512 07 AB 5201	Molecular Animal Physiology	Core	2.0	-	2.0	None
0512 07 AB 5202	Molecular Animal Physiology Sessional and Fieldwork	Core	-	1.5	1.0	None
0512 07 AB 5203	Biotechnology in Animal Production	Core	2.0	-	2.0	None
0512 07 AB 5205	Feed Biotechnology	Core	2.0	-	2.0	None
0512 07 AB 5206	Feed Biotechnology Sessional and Fieldwork	Core	-	1.5	1.0	None
0512 07 AB 5207	Disease Diagnosis and Therapeutics	Optional	2.0	-	2.0	None
0512 07 AB 5209	Animal Functional Genomics	Optional	2.0	-	2.0	None
0512 07 AB 5211	Reproductive Biotechnology	Optional	2.0	-	2.0	None
0512 07 BGE 5216	Viva voce II	Core	-	1.5	1.0	None
0512 07 BGE 5218	Dissertation Part I-M	Core	-	4.5	3.0	None
Total	Core Courses:7, Optional Courses:3, Theory Courses: 6, Sessional Courses: 4		12.0	9.0	18.0	-
			21.0			

First Year Second Term (Major in Plant Biotechnology) (Mixed Mode)						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0512 07 PB 5201	Molecular Plant Physiology	Core	2.0	-	2.0	None
0512 07 PB 5203	Molecular Breeding and Hybrid Seed Technology	Core	2.0	-	2.0	None
0512 07 PB 5204	Molecular Breeding and Hybrid Seed Technology Sessional and Fieldwork	Core	-	1.5	1.0	None
0512 07 PB 5205	Plant Protection	Core	2.0	-	2.0	None
0512 07 PB 5206	Plant Protection Sessional and Field Work	Core	-	1.5	1.0	None
0512 07 PB 5207	Plant-Microbe Interaction	Optional	2.0	-	2.0	None
0512 07 PB 5209	Plant Functional Genomics	Optional	2.0	-	2.0	None
0512 07 PB 5211	Circular Agriculture and Artificial Intelligence	Optional	2.0	-	2.0	None
0512 07 BGE 5216	Viva voce II	Core	-	1.5	1.0	None
0512 07 BGE 5218	Dissertation Part I-M	Core	-	4.5	3.0	None
Total	Core Courses:7, Optional Courses:3, Theory Courses: 6, Sessional Courses: 4		12.0	9.0	18.0	-
			21.0			

First Year Second Term (Major in Environmental Biotechnology) (Mixed Mode)						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0512 07 EB 5201	Environmental Microbiology	Core	2.0	-	2.0	None
0512 07 EB 5202	Environmental Microbiology Sessional and Fieldwork	Core	-	1.5	1.0	None
0512 07 EB 5203	Waste Treatment and Management	Core	2.0	-	2.0	None
0512 07 EB 5204	Waste Treatment and Management Sessional and Fieldwork	Core	-	1.5	1.0	None
0512 07 EB 5205	Environmental Pollution and Toxicology	Core	2.0	-	2.0	None
0512 07 EB 5207	Environmental Chemistry	Optional	2.0	-	2.0	None
0512 07 EB 5209	Biodiversity and Bioprospecting	Optional	2.0	-	2.0	None
0512 07 EB 5211	Biotechnology for Sustainable Environment	Optional	2.0	-	2.0	None
0512 07 BGE 5216	Viva voce II	Core	-	1.5	1.0	None
0512 07 BGE 5218	Dissertation Part I-M	Core	-	4.5	3.0	None
Total	Core Courses:7, Optional Courses:3, Theory Courses: 6, Sessional Courses: 4		12.0	9.0	18.0	-
			21.0			

First Year Second Term (Major in Microbial Biotechnology) (Mixed Mode)						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0512 07 MB 5201	Microbial Diversity and Bioprospecting	Core	2.0	-	2.0	None
0512 07 MB 5202	Microbial Diversity and Bioprospecting Sessional and Fieldwork	Core	-	1.5	-	None

0512 07 MB 5203	Microbial Expression Systems	Core	2.0	-	2.0	None
0512 07 MB 5205	Industrial Microbiology and Fermentation	Core	2.0	-	2.0	None
0512 07 MB 5206	Industrial Microbiology and Fermentation Sessional and Fieldwork	Core	-	1.5	1.0	None
0512 07 MPB 5201	Infection, Immunity and Control	Optional	2.0	-	2.0	None
0512 07 MPB 5205	Vaccine Technology and Biopharmaceuticals	Optional	2.0	-	2.0	None
0512 07 MPB 5209	Virology and Oncology	Optional	2.0	-	2.0	None
0512 07 BGE 5216	Viva voce II	Core	-	1.5	1.0	None
0512 07 BGE 5218	Dissertation Part I-M	Core	-	4.5	3.0	None
Total	Core Courses:7, Optional Courses:3, Theory Courses: 6, Sessional Courses: 4		12.0	9.0	18.0	-
			21.0			

First Year Second Term (Major in Food and Nutritional Biotechnology) (Mixed Mode)

Course Code	Course Title	Course Status	Contact Hours/Week		Credits	Prerequisites
			Theory	Sessional		
0512 07 FB 5201	Food Chemistry and Microbiology	Core	2.0	-	2.0	None
0512 07 FB 5202	Food Chemistry and Microbiology Sessional and Fieldwork	Core	-	1.5	1.0	None
0512 07 FB 5203	Advanced Food Biotechnology	Core	2.0	-	2.0	None
0512 07 FB 5204	Advanced Food Biotechnology Sessional and Fieldwork	Core	-	1.5	1.0	None
0512 07 FB 5205	Food Processing Technology	Core	2.0	-	2.0	None
0512 07 MB 5205	Industrial Microbiology and Fermentation	Optional	2.0	-	2.0	None
0512 07 FB 5209	Food Safety	Optional	2.0	-	2.0	None
0512 07 FB 5211	Nutrition and Dietetics	Optional	2.0	-	2.0	None
0512 07 FB 5213	Nutritional Biotechnology	Optional	2.0	-	2.0	None
0512 07 BGE 5216	Viva voce II	Core	-	1.5	1.0	None
0512 07 BGE 5218	Dissertation Part I-M	Core	-	4.5	3.0	None
Total	Core Courses:7, Optional Courses:4, Theory Courses: 7, Sessional Courses: 4		14.0	9.0	20.0	-
			23.0			

First Year Second Term (Major in Industrial Biotechnology) (Mixed Mode)

Course Code	Course Title	Course Status	Contact Hours/Week		Credits	Prerequisites
			Theory	Sessional		
0512 07 IB 5201	Industrial Microbiology	Core	2.0	-	2.0	None
0512 07 IB 5202	Industrial Microbiology Sessional and Fieldwork	Core	-	1.5	1.0	None
0512 07 IB 5203	Biochemical Engineering	Core	2.0	-	2.0	None
0512 07 IB 5204	Biochemical Engineering Sessional	Core	-	1.5	1.0	None
0512 07 IB 5205	Industrial Bioprocess	Core	2.0	-	2.0	None
0512 07 IB 5207	Biomolecular Engineering and Synthetic Biology	Optional	2.0	-	2.0	None

0512 07 MPB 5205	Vaccine Technology and Biopharmaceuticals	Optional	2.0	-	2.0	None
0512 07 PB 5211	Circular Agriculture and Artificial Intelligence	Optional	2.0	-	2.0	None
0512 07 BGE 5216	Viva voce II	Core	-	1.5	1.0	None
0512 07 BGE 5218	Dissertation Part I-M	Core	-	4.5	3.0	None
Total	Core Courses:7, Optional Courses: 3, Theory Courses: 6, Sessional Courses: 4		12.0	9.0	18.0	-
			21.0			

First Year Second Term (Major in Medical and Pharmaceutical Biotechnology) (Mixed Mode)

Course Code	Course Title	Course Status	Contact Hours/Week		Credits	Prerequisites
			Theory	Sessional		
0512 07 MPB 5201	Infection, Immunity and Control	Core	2.0	-	2.0	None
0512 07 MPB 5202	Infection, Immunity and Control Sessional	Core	-	1.5	1.0	None
0512 07 MPB 5203	Regulatory Framework in Pharmaceutical Industry	Core	2.0	-	2.0	None
0512 07 MPB 5204	Regulatory Framework in Pharmaceutical Industry Sessional and Fieldwork	Core	-	1.5	1.0	None
0512 07 MPB 5205	Vaccine Technology and Biopharmaceuticals	Core	2.0	-	2.0	None
0512 07 MPB 5207	Experimental Medicine	Optional	2.0	-	2.0	None
0512 07 MPB 5209	Virology and Oncology	Optional	2.0	-	2.0	None
0512 07 MPB 5211	Epigenetics and Gene Regulation	Optional	2.0	-	2.0	None
0512 07 MPB 5213	Bionanotechnology in Therapeutics and Diagnostics	Optional	2.0	-	2.0	None
0512 07 MPB 5215	Biosensor Technology	Optional	2.0	-	2.0	None
0512 07 BGE 5216	Viva voce II	Core	-	1.5	1.0	None
0512 07 BGE 5218	Dissertation Part I-M	Core	-	4.5	3.0	None
Total	Core Courses: 7, Optional Courses: 5, Theory Courses: 8, Sessional Courses:4		16.0	9.0	22.0	-
			25.0			

First Year Second Term (Major in Computational Biology) (Mixed Mode)

Course Code	Course Title	Course Status	Contact Hours/Week		Credits	Prerequisites
			Theory	Sessional		
0512 07 CB 5201	Programming Languages in Life Sciences	Core	2.0	-	2.0	None
0512 07 CB 5202	Programming Languages in Life Sciences Sessional	Core	-	1.5	1.0	None
0512 07 CB 5203	Big Data in Life Sciences	Core	2.0	-	2.0	None
0512 07 CB 5204	Big Data in Life Sciences Sessional and Fieldwork	Core	-	1.5	1.0	None
0512 07 CB 5205	Computational Genomics	Core	2.0	-	2.0	None
0512 07 CB 5207	Systems Biology and Network Analysis	Optional	2.0	-	2.0	None
0512 07 CB 5209	Machine Learning	Optional	2.0	-	2.0	None
0512 07 CB 5211	Computational Drug Discovery	Optional	2.0	-	2.0	None
0512 07 BGE 5216	Viva voce II	Core	-	1.5	1.0	None
0512 07 BGE 5218	Dissertation Part I-M	Core	-	4.5	3.0	None
Total	Core Courses:7, Optional Courses:3, Theory Courses: 6, Sessional Courses: 4		12.0	9.0	18.0	-
			21.0			

Second Year First Term (Dissertation under Mixed Mode)						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0512 07 BGE 6102	Dissertation Part II-M	Core	-	18.0	12.0	None
Total	Core Courses:1, Optional Courses: 0, Theory Courses: 0, Sessional Courses: 0, Capstone Course: 1		-	18.0	12.0	-

Second Year First Term (Project/ Internship under Mixed Mode)						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0512 07 BGE 5111	Biotechnology Concept and Application	Core	3.0	-	3.0	None
0512 07 BGE 5114	Seminar I	Core	-	4.5	3.0	None
0512 07 BGE 6104	Project/ Internship	Core	-	9.0	6.0	None
Total	Core Courses:3, Optional Courses: 0.0, Theory Courses: 1, Sessional Courses: 1, Capstone Course: 1		3.0	13.5	12.0	-
			16.5			

- A student enrolled in a Mixed Mode MS Program undertaking project or internship would not be considered for a major/specialization degree.
- During the First year Second Term of the study period, such a student have to obtain 14.0 credits. from at least two major areas out of the 8 major areas mentioned in this document. In such cases, a student must have to register 0512 07 BGE 5216 Viva Voce II consisting of 1.0 credit and fulfil the rest 13.0 credits by registering courses from at least two major areas out of the 8 major areas mentioned in this document.

18.3 MS in BGE (by Research)

First Year First Term (MS by Research)						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0512 07 BGE 5120	Dissertation Part I-R	Core	-	20.0	10.0	None
Total	Core Courses:1, Optional Courses: 0, Theory Courses: 0, Sessional Courses: 0, Capstone Course: 01		15.0		10.0	-

First Year Second Term (MS by Research)						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0512 07 BGE 5220	Dissertation Part II-R	Core	-	20.0	10.0	-
Total	Core Courses:1, Optional Courses: 0, Theory Courses: 0, Sessional Courses: 0, Capstone Course: 01		15.0		10.0	

Second Year First Term (MS by Research)						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0512 07 BGE 6120	Dissertation Part III-R	Core	-	22.5	15.0	-
Total	Core Courses:1, Optional Courses: 0, Theory Courses: 0, Sessional Courses: 0, Capstone Course: 01		22.5		15.0	

Second Year Second Term (MS by Research)						
Course Code	**Course Title**	**Course Status**	**Contact Hours/Week**		**Credits**	**Prerequisites**
			Theory	**Sessional**		
0512 07 BGE 6220	Dissertation Part IV-R	Core	-	22.5	15.0	-
Total	Core Courses:1, Optional Courses: 0, Theory Courses: 0, Sessional Courses: 0, Capstone Course: 01		22.5		15.0	

19. Course Description

Course Code: 0512 07 BGE 5101		Year: MS First	**Term:** First
Course Title: Molecular Biosciences			
Course Status: Core			
Credit: 3.0			
Prerequisite(s): None			
Rationale	Molecular Bioscience provides the understanding of how molecular machines are constructed and regulated so that they can accurately copy, repair, and interpret genomic information in prokaryotes and eukaryotic cells. Further, it appreciates the subject of molecular biology as a dynamic and ever-changing experimental science with the knowledge of underlying principles.		
Course Objectives	The objectives of the course are to acquire fundamental knowledge in molecular biosciences, different techniques and their applications in the field.		

Course Contents		**CLOs**
Section A		
1	**Introduction to Molecular Biosciences:** Introduction; history; insight into the nature of hereditary material; the central dogma of molecular biology; structure of DNA; DNA double helix; structure of RNA; protein structure and folding	1, 2, 3
2	**DNA Replication and Repair:** Insight into the mode of DNA replication; bacterial and eukaryotic replisome; alternative mode of circular DNA replication; the role of telomerase in DNA replication, aging and cancer; mutation and DNA damage; classification and description of various DNA repair mechanisms	1, 2, 3
3	**Transcription, RNA Processing, Post-transcriptional Gene Regulation and Epigenetic Regulation:** Transcription in bacteria; transcription in eukaryotes; methylation, splicing and polyadenylation of pre-mRNA; post-transcriptional gene regulation by RNAi; epigenetic markers; genomic imprinting; X chromosomal inactivation; epigenetic control of transposable elements; epigenetics and nutritional legacy	1, 2, 3
4	**Translation, Trafficking and Degradation of Protein:** Introduction; ribosome structure and assembly; the process of translation; post-translational control; co- and post-translational transport; signal peptide; different modes of protein degradation	1, 2, 3
Section B		**CLOs**
5	**Recombinant DNA Technology and Genetically Modified Organisms (GMOs):** Introduction; cutting and joining of DNA; molecular cloning; library screening and probes; GMO methodology and applications	1, 2, 3
6	**Tools for Analyzing Gene Organization, Expression and Function:** DNA typing; Sequencing of DNA; whole genome sequencing; reporter genes; analysis of RNA expression and localization; analysis of protein expression and localization; nucleic acid-protein interaction; protein-protein interaction	1, 2, 3

7	**OMICS Technologies:** Background; genomics, transcriptomics, proteomics, metabolomics, other omics; omics and system biology; omics-driven bioengineering and systems biology; application	1, 2, 3

Mapping of CLOs with PLOs (MS Coursework)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Understand the basic concepts in molecular biosciences	1,2,4,5,6
	CLO2	Recognize the usage of the tools of molecular biosciences	1,2,6
	CLO3	Choose, analyze and illustrate techniques employed for genetic manipulation and gene expression analysis	2,4,6

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Understand the basic concepts in molecular biosciences	1,2,6,7,8,9
	CLO2	Recognize the usage of the tools of molecular biosciences	1,2,3,4,8
	CLO3	Choose, analyze and illustrate techniques employed for genetic manipulation and gene expression analysis	2,4,6,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture, presentation, group discussion	Written test, assignment, viva voce
CLO2	Lecture, presentation, group discussion	Written test, assignment, viva voce
CLO3	Lecture, presentation, group discussion	Written test, assignment, viva voce

Learning Materials

Recommended Readings	1. David P. Clark, Nanette Pazdernik, Michelle McGehee (2018) Molecular Biology, 3rd Edition, Academic Cell 2. Bruce Alberts, Rebecca Heald, Alexander Johnson, David Morgan, Martin Raff, Keith Roberts, Peter Walter, John Wilson (2022) Molecular Biology of the Cell, Seventh edition W. W. Norton & Company

	3. Preeti Arivaradarajan, Gauri Misra (2018) Omics Approaches, Technologies And Applications: Integrative Approaches For Understanding OMICS Data, 1st edition, Springer.
Supplementary Readings	1. Debmalya Barh, Vasco Azevedo (2017) Omics Technologies and Bio-engineering: Volume 1: Towards Improving Quality of Life, 1st Edition, Academic Press

Course Code: 0512 07 BGE 5103		Year: MS First	**Term:** First
Course Title: Bioanalytical Techniques			
Course Status: Core			
Credit: 3.0			
Prerequisite(s): None			
Rationale	This course presents the concepts, tools and common instrumental techniques employed in modern bioanalytical chemistry for the quantitative analysis of important biomolecules likes drugs, metabolites, toxins, environmental contaminants, biomarkers, proteins, biotherapeutics and/or DNA in biological samples. The applications discussed will encompass food, pharmaceuticals and biopharmaceuticals, toxicology, forensics, clinical sciences, environmental analysis and biotechnology.		
Course Objectives	1. To provide the students with an ability to understand the principles of instrumentation 2. To impart the knowledge of different techniques and methods in biotechnology 3. To improve the understanding of applications of techniques in the field of biotechnology		

Course Contents		**CLOs**
Section A		
1	**Analytical Techniques in Biosciences:** Introduction, biological sample description, basic notions regarding biological sample collection, handling, processing and storage, application of bioanalytical techniques in industry	1, 2, 3
2	**Chromatography:** Introduction; distribution coefficient; various classification schemes of chromatography; contemporary chromatographic techniques- HPLC, GC	1, 2, 3
3	**Electrophoresis:** Principles of electrophoresis; modes of electrophoresis; electrophoresis of DNA and RNA; electrophoresis of proteins	1, 2, 3
4	**Spectroscopy:** Atomic spectra; electron transition in a molecule; absorption, emission and scattering; law of absorption of light; electromagnetic radiation; UV-Vis spectroscopy; fluorescence spectroscopy; AAS; NMR	1, 2, 3
Section B		**CLOs**
5	**Mass spectrometry:** MS, GC-MS/MS, LC-MS/MS, Principle of mass spectrometry; instrumentation- ionization techniques, mass analyzer, detector; hyphenated techniques- GC-MS/MS; LC-MS/MS; application	1, 2, 3
6	**Analytical Techniques in Molecular Biology:** Principle and application of contemporary molecular analytical techniques- PCR, RT-PCR, Protein-DNA interaction analysis, microarray, sequencing and NGS	1, 2, 3
7	**Immuno-analytical Techniques:** Immunochemistry; principle, methodology and application of ELISA, EMSA etc.	1, 2, 3

8	**Electro-analytical Techniques:** Electrochemistry; electrochemical cell and cell potential measurement; reference electrodes; microelectrodes, electrochemical sensors; components and characteristics of biosensors; bioreceptor molecules and biosensing techniques	1, 2, 3

Mapping of CLOs with PLOs (MS Coursework)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Illustrate the different methods of analytical techniques for quantitative analysis	1,2,5
	CLO2	Explain the importance of biological sample preparation and chromatography as analytical techniques	1,4,6
	CLO3	Appraise various analytical approaches and infer their utility	1,2,5

Mapping of CLOs with PLOs (MS Mixed Mode)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Illustrate the different methods of analytical techniques for quantitative analysis	1,2,3,4,7,9
	CLO2	Explain the importance of biological sample preparation and chromatography as analytical techniques	1,2,3,8
	CLO3	Appraise various analytical approaches and infer their utility	1,2,4,7,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture, presentation, group discussion	Written test, assignment, viva voce
CLO2	Lecture, presentation, group discussion	Written test, assignment, viva voce
CLO3	Lecture, presentation, group discussion	Written test, assignment, viva voce

Learning Materials

Recommended Readings	1. Chukwuebuka Egbuna, Kingsley C. Patrick-Iwuanyanwu, Muhammad Ajmal Shah, Jonathan C. Ifemeje, Azhar Rasul (2021) Analytical Techniques in Biosciences: From Basics to Applications, Academic Press

	2. James Robinson (2020) Instrumental Analytical Chemistry: An Introduction by, CRC Press 3. Friedrich Lottspeich, Joachim W. Engels (2018) Bioanalytics: Analytical Methods and Concepts in Biochemistry and Molecular Biology, 1st Edition, Wiley-VCH 4. Sekhar Talluri (2012) Bioanalytical Techniques, IK International Publishing House 5. Sabari Ghosal (2018) Fundamentals of Bioanalytical Techniques and Instrumentation, 2nd Edition, PHI Learning. 6. Willard and Merrit (2002) Instrumental Methods and Analysis, 6th Edition, CBS Publishers & Distributors.
Supplementary Readings	1. Gurdeep R. Chatwal and Sham K. Anand (2012) Instrumental Methods of Chemical Analysis. 5th Edition. Himalaya Publishing House, India. 2. B K Sharma (2014) Instrumental Methods of Chemical Analysis. 24th revised and enlarged edition., GOEL Publishing House, India. 3. Keith Wilson and John Walker (2010) Principles and Techniques of Practical Biochemistry and Molecular Biology. 7th Edition. Cambridge University Press, UK. 4. Douglas A. Skoog, F. James Holler and Stanley R. Crough (2007) Instrumental Analysis. 6th Edition, Brooks Cole Publishing Company, USA. 5. Avinash Upadhyay, Kakoli Upadhyay and Nirmalendu Nath (2014) Biophysical Chemistry: Principles and Techniques. Himalaya Publsihing House Pvt. Ltd., India.

Course Code: 0512 07 BGE 5106		Year: MS First	**Term:** First
Course Title: Skills in Biosciences Sessional and Field Work			
Course Status: Core			
Credit: 1.0			
Prerequisite(s): None			
Rationale	Skill development is the process of identification of the skills gap in graduates and providing skilling training and increase employment opportunities. Only academic excellence is not enough for successful graduates. Soft skills are as vital as hard skills. Lack of soft skills is now a global problem among fresh graduates. Soft skills are important just like other academic qualifications. Graduates who have both hard and soft skills can be successful in their higher studies, research and other professions. Graduates are hired for their technical skills but fired for the lack of soft skills. Harvard study shows that soft skills contribute up to 85% in graduate career success while technical skills only contribute 15%. Now a day, employers prefer positive attributes and soft skills from job seekers to academic excellence and technical skills.		
Course Objectives	• To train graduates for soft skills development. • To increase employment opportunities. • To improve the quality of graduates.		

	Course Contents	CLOs
1	**Introduction:** Concept of skills, importance, types: soft and hard skills, skills vs. education, metacognitive skills, critical thinking (CT) skills, ways of developing CT and complex problem solving, negotiation and persuasion skills, team management skills, leadership qualities, Lab. manager skills, project manager skills and qualifications. Human resource management skills, educational leadership, computer skills and proficiency, interpersonal skills, etc.	1
2	**Research Design, Experimentation, Data Collection and Analysis:** Research, characteristics of research, criteria of good research, 6Ps for research framework, types of research, research process, formulating research problem, searching research gap and researchable problem, selection of research topic, key elements of research proposal, thesis/dissertation proposal preparation, research question and hypothesis, experimental design, types, basic principles, scientific paths, data collection (experimental and survey), processing, and analysis using various software's, Online data collection and analysis tools, data visualization and presentation.	1,2,6
3	**Project Management:** Concept of project, types, phases of project management, 6 sigma, project planning, development, execution, management, implementation and evaluation. Project cycle; grant hunting project preparation, Budgeting and Gantt chart preparation. Procurement of	1,2

	office equipment, furniture, machinery, Lab. equipment, chemicals, glassware, plasticware, consumable items etc. Public procurement rule 2006 and e-tender.	
4	**Communicating Science:** Importance: Importance, mode of scientific communications-written, oral and visual. Written: Thesis/dissertation writing, formatting, paraphrasing of abstract, plagiarism, referencing, Scientific paper writing, editing, reviewing, popular article, annual report, project report, executive summary writing. Oral: Presentation skills, public speaking tips, criteria of good power point, lectures, presentation in seminar, conference, 3MT, zoom meeting, round table debate/meeting, international networking and team work. Visual: Academic and Popular poster designing, preparation and display, photography of experimental results/ items, video,	2,3,4,5
5	**Scientific Ethics:** Plagiarism, photocopying the printed materials.	2,6

Mapping of CLOs with PLOs (MS Coursework)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Improve soft skills & solve complex problems through team management, good leadership negotiation etc.	1,2,4,5,6
	CLO2	Develop effective communication skills (spoken and written).	1,2,5,6
	CLO3	Develop effective presentation skills.	1,2,4,5,6
	CLO4	Efficiently and smartly present scientific work in three minutes (3MT).	1,2,4,5,6
	CLO5	Prepare and present a good poster.	1,2,4,5,6
	CLO6	Organize workshops, training programs and conferences efficiently	1,2,4,5,6

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Improve soft skills & solve complex problems through team management, good leadership negotiation etc.	1,2,3,4,6,7,8,9
	CLO2	Develop effective communication skills (spoken and written).	1,2,3,4,7,8,9
	CLO3	Develop effective presentation skills.	1,2,3,4,6,7,8,9
	CLO4	Efficiently and smartly present scientific work in three minutes (3MT).	1,2,3,4,6,7,8,9
	CLO5	Prepare and present a good poster.	1,2,3,4,6,7,8,9

	CLO6	Organize workshops, training programs and conferences efficiently	1,2,3,4,6,7,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture + Presentation + Problem solving exercise & Teamwork	Individual student performance evaluation & team work evaluation
CLO2	Lecture + Demonstration	Seminar , and popular & scientific article evaluation
CLO3	Lecture + Presentation	Presentation evaluation
CLO4	Lecture + Demonstration	3MT evaluation,
CLO5	Lecture + Presentation	Academic & Popular poster evaluation
CLO6	Lecture + Presentation + Practice	Written Exam. & Performance evaluation as organizer of a workshop/seminar

Learning Materials

Recommended Readings	1. Federick H. Wentz (2012) Soft Skills Training: A Workbook to Develop Skills for Employment. CreateSpace Independent Publishing Platform. 2. Bruce Tulgan (2022) Bridging the Soft skills Gap, 2nd Edition, John Wiley and Sons Inc. 3. Zina O'Leary (2004) The Essential Guide to Doing Research, SAGE Publications. 4. John W. Creswell and J. David Creswell (2017) Research Design, 5th Edition, SAGE Publications. 5. Stephen Barker (2008) Brilliant Project Management. Pearson Education.
Supplementary Readings	1. Meenu Wats and Rakesh Kumar Wats (2009) Developing Soft Skills in Students, The International Journal of Learning Annual Review 15(12):1-10. 2. Mastering Soft Skills for Workplace Success accessed at https://www.dol.gov/sites/dolgov/files/odep/topics/youth/softskills/softskills.pdf.

Course Code: 0417 07 BA 5107		Year: MS First	**Term:** First
Course Title: Bio-business and Entrepreneurship			
Course Status: Core			
Credit: 3.0			
Prerequisite(s): None			
Rationale	Research and business belong together and both are needed. In a rapidly developing life science industry, there is an urgent need for people who combine business knowledge with an understanding of science and technology. Bio-business and entrepreneurship, an interdisciplinary course, revolves around the central theme of how to manage and develop life science companies and projects.		
Course Objectives	The objectives of this course are to teach students about concepts of entrepreneurship including identifying a winning business opportunity, gathering funding and launching a business, growing and nurturing the organization and harvesting the rewards.		

	Course Contents	**CLOs**
	Section A	
1	**Innovation and entrepreneurship in bio-business:** Introduction and scope in Bio-entrepreneurship, Types of bio-industries and competitive dynamics between the sub-industries of the bio-sector (e.g., pharmaceuticals vs. Industrial biotech), Strategy and operations of bio-sector firms: Factors shaping opportunities for innovation and entrepreneurship in bio-sectors, and the business implications of those opportunities, Alternatives faced by emerging bio-firms and the relevant tools for strategic decisions, Entrepreneurship development programs of public and private agencies, strategic dimensions of patenting & commercialization strategies.	1, 2
2	**Bio markets:** Negotiating the road from lab to the market (strategies and processes of negotiation with financiers, government and regulatory authorities), Pricing strategy, Challenges in marketing in bio business (market conditions & segments; developing distribution channels, the nature, analysis and management of customer needs), Basic contract principles, different types of agreement and contract terms typically found in the joint venture and development agreements, Dispute resolution skills.	1, 2, 3
3	**Business Strategy:** Entry and exit strategy; pricing strategy; negotiations with financers, bankers, government and law enforcement authorities; dispute resolution skills; external environment/ changes; avoiding/managing crisis; broader vision–global thinking; mergers & acquisitions.	1, 2
4	**Marketing**: Market conditions, segments, prediction of market changes; identifying needs of customers; Market linkages, branding issues; developing distribution channels - franchising; policies, promotion, advertising; branding and market linkages for 'virtual start-up company	3, 4

Section B		CLOs
5	**Basics of bioentrepreneurship:** Importance of entrepreneurship; advantages of being an entrepreneur-freedom to operate; introduction to bio entrepreneurship-biotechnology on a global scale; Scope in bioentrepreneurship; types of bio-industries – biopharma, bioagri, bioservices and bioindustrial; innovation – types, out of box thinking; skills for successful entrepreneur– creativity, leadership, managerial, team building, decision making; patent landscape, IP protection & commercialization strategies	1, 2, 3
6	**Finance and accounting:** Business plan preparation including statutory and legal requirements, Business feasibility study, financial management issues of procurement of capital and management of costs, Collaborations & partnership, Information technology	1, 3
7	**Technology Management:** Technology – assessment, development & upgradation, managing technology transfer, Quality control & transfer of foreign technologies, Knowledge centers and Technology transfer agencies, Understanding of regulatory compliances and procedures (CDSCO, NBA, GCP, GLA, GMP)	1, 2

Mapping of CLOs with PLOs (MS Coursework)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Gain entrepreneurial skills	1,2,5
	CLO2	Understand the various operations involved in venture creation	1,5,6
	CLO3	Identify the scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centres and various agencies.	3,5,6
	CLO4	Build up a strong network within the industry with the knowledge pertaining to management.	1,6

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Gain entrepreneurial skills	1,2,7,9
	CLO2	Understand the various operations involved in venture creation	1,3,7,8
	CLO3	Identify the scope for entrepreneurship in biosciences and utilize the schemes promoted through knowledge centres and various agencies.	5,7,8

	CLO4	Build up a strong network within the industry with the knowledge pertaining to management.	1,3,8,9

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 Final Exam.
CLO3	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO4	Lecture and Group Discussion	Viva voce and Final Exam.

Learning Materials

Recommended Readings	1. D J Adams and JC Sparrow (2008) Enterprise for Life Scientists: Developing 2. C D Shimasaki (2014) Biotechnology Entrepreneurship: Starting, Managing, and Leading Biotech Companies. Amsterdam: Elsevier. Academic Press is an imprint of Elsevier.
Supplementary Readings	1. A Onetti and A Zucchella (2018) Business Modeling for Life Science and Biotech Companies: Creating Value and Competitive Advantage with the Milestone Bridge. Routledge. 2. JF Jordan (2014) Innovation, Commercialization, and Start-Ups in Life Sciences, London: CRC Press. 3. V Desai (2009) The Dynamics of Entrepreneurial Development and Management, New Delhi: Himalaya Pub. House

Course Code: 1022 07 ES 5109		Year: MS First	**Term:** First
Course Title: Biosafety, Bioethics and Intellectual Property Rights			
Course Status: Core			
Credit: 3.0			
Prerequisite(s): None			
Rationale	The course is expected to introduce the concept of biosafety, bioethics, intellectual property rights and patenting. It will also impart the commitment towards professional and stakeholders through the implementation of patent laws vide patent licensing and agreement. Moreover, the course would be able to discharge ethical responsibilities as a social endeavor to bring harmony with nature.		
Course Objectives	To learn biosafety and risk assessment of products derived from biotechnology and regulation of such products. To become familiar with ethical issues in biological research. To provide basic knowledge on intellectual property rights and their implications in biological research and product development.		

Course Contents		**CLOs**
Section A		
1	**Biosafety and Biosecurity:** Definition and necessity of biosafety, biosecurity and bioethics**;** General principles and consideration relevant to risk assessment and management; Biological safety cabinets; primary containment for biohazards; biosafety levels; GRAS organisms, biosafety levels of specific microorganisms; recommended biosafety levels for infectious agents and infected animals. Environmental risk assessment and food and feed safety assessment.	1
2	**National and International Regulations:** Biosafety guidelines and/regulations of Bangladesh and some other countries; National Committee on Biosafety (NCB), Biosafety Core Committee (BCC), Institutional Biosafety Committee (IBC) and Field Level Biosafety Committee (FBC). Cartagena protocol, OECD consensus documents and Codex Alimentarius. General principles of risk assessment, methodology of risk assessment, criteria for risk assessment, use of GMOs and LMOs in the field, foreign GMOs and LMOs into the environment, industrial use of GMOs.	1, 3
3	**Bioethics:** Introduction, ethical conflicts in biological sciences - interference with nature, bioethics in health care - "DNA Act 2014" of Bangladesh, patient confidentiality, informed consent, euthanasia, artificial reproductive technologies, prenatal diagnosis, genetic screening, gene therapy, transplantation. Bioethics in research – cloning and stem cell research, Human and animal experimentation, animal rights/welfare, Agricultural biotechnology – Genetically engineered food, environmental risk, labelling and public opinion. Sharing benefits and protecting future generations - Protection of environment and biodiversity – biopiracy.	2, 3

Section B		CLOs
4	**Introduction to IPR:** Introduction to intellectual property; types of IP: patents, trademarks, copyright & related rights, industrial design, traditional knowledge, geographical indications, protection of new GMOs; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to biotechnology and few case studies; introduction to history of GATT, WTO, WIPO and TRIPS; plant variety protection and farmers rights act; concept of 'prior art': invention in context of "prior art"; patent databases - country-wise patent searches (USPTO, EPO); analysis and report formation.	2
5	**Patents, Patent Laws and Management:** Types of patent**s,** Patent Cooperation Treaty (PCT) and implications; procedure for filing a PCT application. Time frame and cost, status of the patent applications, precautions while patenting, disclosure/nondisclosure, financial assistance for patenting, introduction to existing schemes. Patent licensing and agreement. Basic, principles and general requirements of patent law. Biotechnological inventions and patent law. Patent infringement- meaning, scope, litigation, case studies. and examples.	2, 3
6	**Organs Transplantation:** Organs transplantation in human beings, ethics in xenotransplantation, bioethical issues.	3

Mapping of CLOs with PLOs (MS Coursework)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of genetically modified organisms.	1,2,3,6
	CLO2	Understand the rationale for and against IPR and especially patents.	1,2,4,5,6
	CLO3	Understand ethical aspects related to biological, biomedical, health care and biotechnology research.	1,3,4,5,6

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Gain knowledge of biosafety and risk assessment of products derived from recombinant DNA research and environmental release of genetically modified organisms.	1,2,5,8,9
	CLO2	Understand the rationale for and against IPR and especially patents.	1,2,6,7,8

	CLO3	Understand ethical aspects related to biological, biomedical, health care and biotechnology research.	1,5,6,7,8,9

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, Assignment and Final Exam
CLO3	Lecture and Group Discussion	Viva Voce and Final Exam.

Learning Materials

Recommended Readings	1. Complete Reference to Intellectual Property Rights Laws. (2007). Snow White Publication. 2. Ganguli, P. (2001). Intellectual Property Rights: Unleashing the Knowledge Economy. New Delhi: Tata McGraw-Hill Pub. 3. International Union for the Protection of New Varieties of Plants. http://www.upov.int 4. Karen F. Greif and Jon F. Merz, Current Controversies in the Biological Sciences-Case Studies of Policy Challenges from New Technologies, MIT Press 5. Kuhse, H. (2010). Bioethics: An Anthology. Malden, MA: Blackwell. 6. National IPR Policy, Department of Industrial Policy & Promotion, Ministry of Commerce, GoI 7. World Intellectual Property Organisation. http://www.wipo.int 8. World Trade Organisation. http://www.wto.org
Supplementary Readings	1. National Biodiversity Authority. http://www.nbaindia.org 2. Recombinant DNA Safety Guidelines, 1990 Department of Biotechnology, Ministry of Science and Technology, Govt. of India. Retrieved from http://www.envfor.nic.in/ divisions/csurv/geac/annex-5.pdf 3. J D Wolt, P Keese, A Raybould, J W Fitzpatrick, M Burachik, A Gray, F Wu (2009). Problem Formulation in the Environmental Risk Assessment for Genetically Modified Plants. Transgenic Research, 19(3), 425-436. doi:10.1007/s11248-009-9321-9 4. W Craig, M Tepfer, G Degrassi and D Ripandelli (2008). An Overview of General Features of Risk Assessments of Genetically Modified Crops. Euphytica, 164(3), 853-880. doi:10.1007/s10681-007-9643-8

	5. Guidelines for Safety Assessment of Foods Derived from Genetically Engineered Plants. 2008.

Course Code: 0512 07 BGE 5111		Year: MS First	**Term:** First
Course Title: Biotechnology: Concepts and Applications			
Course Status: Core			
Credit: 3.0			
Prerequisite(s): None			
Rationale	This course is designed to give students both a theoretical background and a working knowledge of the principle, techniques and instrumentation employed in biotechnology. Emphasis will be placed on the biotechnology innovations. Enabling technologies in contemporary biotechnology will be highlighted with relevant examples.		
Course Objectives	• To gain familiarity with basic approaches to biotechnology research and development, and the wide range of biotechnology applications • To understand ethics and societal issues relevant to applications of biotechnology		

	Course Contents	**CLOs**
	Section A	
1	**Introduction to Biotechnology:** Definition, history, multidisciplinary nature, scope and avenues of biotechnology, discourse on biotechnology controversy	1, 2, 3
2	**Recombinant DNA and "omics" technology:** Recombinant DNA technology, cloning, expression, genomics, transcriptomics, proteomics, metabolomics, application of omics	1, 2, 3
3	**Microbial biotechnology:** Microbes as a tool, microbial fermentation and fermented products, microbial biotechnology in industry, bioterrorism	1, 2, 3
4	**Medical and pharmaceutical biotechnology:** Animal models of human diseases, biotechnology-enabled diagnosis approaches, biopharmaceuticals, gene therapy and regenerative medicine, vaccine technology	1, 2, 3
	Section B	**CLOs**
5	**Agricultural biotechnology:** Use of biotechnology in selective breeding, plant tissue culture, genetic engineering of plants, biofertilizer, biopharming, animal cloning, animal cell culture, transgenic animals	1, 2, 3
6	**Environmental Biotechnology**: Biotechnology and environment, bioremediation, bioleaching, biotransformation, wastewater treatment, biopesticide, environmental risk of biotechnology	1, 2, 3
7	**Entrepreneurship in Biotechnology:** Innovation, the fourth industrial revolution, intellectual property right, capital management, biobusiness, biobusiness incubator, entrepreneurship concepts	1, 2, 3
8	**Ethical and safety issues in biotechnology:** Ethics, crosstalk of biotechnology with ethics, biosafety and biosecurity, ethics and safety in the age of omics	1, 2, 3

Mapping of CLOs with PLOs (MS Coursework)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	An understanding of the multidisciplinary nature of biotechnology and the associated role that has been played by enabling technologies in the development of biotechnology	1,2,6,7
	CLO2	Appraisal of the national and global significance of biotechnology and its resultant industries	1,2,6,7
	CLO3	Awareness of some of the current and future issues surrounding the relationship between biotechnology and government, investors, the environment and consumers and the impact of these on the development of future biotechnology enterprises	1,2,6,7

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture, presentation, group discussion	Written test, assignment, viva voce
CLO2	Lecture, presentation, group discussion	Written test, assignment, viva voce
CLO3	Lecture, presentation, group discussion	Written test, assignment, viva voce

Learning Materials

Recommended Readings	1. William Thieman (2019) Introduction to Biotechnology, 4th edition, Pearson Education 2. Bernard R. Glick and Cheryl L Patten (2017) Molecular Biotechnology: Principles and Applications of Recombinant DNA (ASM Books) 5th Edition, ASM Press 3. Carolyn A. Dehlinger (2014) Molecular Biotechnology, Jones & Bartlett Learning
Supplementary Readings	1. Mark Warner (2019) Industrial Biotechnology Commercialization Handbook: How to make proteins without animals and fuels or chemicals without crude oil

Course Code: 0512 07 BGE 5114	Year: MS First	**Term:** First
Course Title: Seminar I		
Course Status: Core		
Credit: 3.0		
Prerequisite(s): None		

Rationale	This course shall ensure that the students are able to present their academic knowledge and research skills to the panel of academics in the most effective way.
Course Objectives	• To train the students to evaluate research papers. • To enhance the communication skill of students to present their knowledge and research skills.

	Course Contents	CLOs
1	Every week, each student will have to present a research paper. They should choose research paper with the most recent scientific findings.	1, 2

Mapping of CLOs with PLOs (MS Coursework)

			Mapping with PLOs
Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		
	CLO1	Critically analyse the research papers on various topics.	1,6,7,8
	CLO2	Understand the weaknesses and strengths of a research paper and what experiments are needed to strengthen the research design.	1,6,7,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1		Presentation and Viva voce
CLO2		Presentation and Viva voce

Learning Materials

Recommended Readings	1. Bowles P, Marenah K, Ricketts D, Rogers B (2013) How to prepare for and present at a journal club. Br J Hosp Med. 74 Suppl 10:C150-2.
Supplementary Readings	1. Bhattacharya S (2017) Journal club and post-graduate medical education. Indian J Plast Surg. 50(3):302-305.

Course Code: 0512 07 BGE 5116	Year: MS First	**Term:** First
Course Title: Viva Voce I		
Course Status: Core		
Credit: 1.0		
Prerequisite(s): None		
Rationale	This course shall ensure that the students are able to present the knowledge, skills and practical that they undertake in an ongoing term to be presented to the panel of academics in the most effective way.	
Course Objectives	• To equip the students with analytical and evaluation abilities to to respond to impromptu questions • To enhance the communication skill of students in order to present the knowledge, skills and problems in efficient way	

	Course Contents	CLOs
1	The comprehensive viva voce is based on the theoretical knowledge, skills and the practices which the students have undergone in a single term of the MS program in Biotechnology and Genetic Engineering.	1, 2, 3

Mapping of CLOs with PLOs (MS Coursework)

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Demonstrate the application of the knowledge acquired in the term to solve the problems	1,2,4,5
	CLO2	Able to make effective presentation of different topics learnt	1,2,4,5
	CLO3	Communicate meaningfully and effectively	1,2,3,4,5

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Demonstrate the application of the knowledge acquired in the term to solve the problems	1,2,3,6,7,9
	CLO2	Able to make effective presentation of different topics learnt	1,2,3,4,5,6,7,9
	CLO3	Communicate meaningfully and effectively	1,2,3,4,5

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1		Viva voce
CLO2		Viva voce
CLO3		Viva voce

Learning Materials

Recommended Readings	1. Hassan, Shahizan. (2004) How to survive your viva: A practical Guide
Supplementary Readings	1. Peter Smith (2014) The PhD Viva: How to Prepare for Your Oral Examination (Bloomsbury Research Skills), Bloomsbury Academic,1st Edition

Major
in
Animal Biotechnology

Course Code: 0512 07 AB 5201		Year: MS First	**Term:** Second
Course Title: Molecular Animal Physiology			
Course Status: Core			
Credit: 2.0			
Prerequisite(s): None			
Rationale	The course will provide students a concept on animal nutrition, animal immunity and disease for managing animal health and to increase animal production. This course is designed to teach students how to apply what they have learned about animal husbandry and how to generate revenue from it.		
Course Objectives	This course explores a combination of conventional and biotechnology-based livestock rearing techniques. And also- • To understand control of reproduction cycle of economic importance • To familiarize with animal feed metabolism process, uptake and conversion of feed nutrients • To know regulation of immune function and oxidative stress management • To recognize role of probiotics and gut microbial regulation		

	Course Contents	**CLOs**
	Section A	
1	**Introductory Concepts**: Definitions, Historical overview of mile stones in research; Scope and Applications	1
2	**Reproduction and Gender Determination in Animals**; X-chromosome inactivation; Gender-dependent hormonal differences; Role of endocrine and paracrine factors in gonadogenesis, gonadal steroidogenesis and gametogenesis, Control of reproduction cycles in animals of economic importance	3
3	**Animal Development**: Molecular and cellular control mechanisms during early embryogenesis, Programmed cell death, Regeneration and ageing, Stem cells and differentiation, Signal transduction, cellular communication and gene expression processes	1
4	**Discussion of Recent Case Studies and Publications** in reproductive and developmental animal physiology.	1,2,3,4
	Section B	**CLOs**
5	**Animal Micro- and Macromolecule Metabolism:** Feed metabolism processes, Uptake and conversion of glucose, lipid and protein, Small molecules and vitamin metabolism, Cellular recycling of metabolites and autophagy	2
6	**Animal Immunity and Inflammation:** Role of oxidative stress and inflammatory processes in animal physiology, Pro-inflammatory signaling mechanisms and disease response, Immune cell function and diversity, Regulation of immune function and anti-inflammatory processes in animal health	3

7	**Gut Microbial Regulation of Animal Physiology and Metabolism**: Gut microbiome of animals, Intercellular communication and functions of Proteobacteria, Firmicutes and Bacteroidetes, Roles and prospects of probiotic treatment	2
8	**Molecular Ecology and Epigenetics**: Environment and development, Macroevolution and development (molecular evo-devo aspects) of selected animal cells and processes	4
9	**Discussion of Recent Case Studies and Publications** in advanced molecular animal physiology.	1,2,3,4

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Learn the animal environment, macroevolution and development of animal cells and process	1,7,8
	CLO2	Understand the importance of micro and macro nutrients, metabolism and uptake process in animal production	1,7,8
	CLO3	Gain knowledge on hormone and cellular and molecular control reproduction cycle	1,2,6,7,8,9
	CLO4	Visualize environment specific animal selection and development	

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, Viva voce and Final Exam.
CLO2	Lecture, Discussion, Tutorial and Presentation	Quiz, Continuous Assessment, Assignment, Presentation, Viva voce and Final Exam.
CLO3	Lecture, Discussion, Tutorial and Presentation	Quiz, Continuous Assessment, Assignment, Presentation, Viva voce and Final Exam.
CLO4	Lecture, Discussion, Tutorial and Presentation	Quiz, Continuous Assessment, Assignment, Presentation, Viva voce and Final Exam.

Learning Materials

Recommended Readings	1. Animal Physiology, 4th Edition, Richard W. Hill, Gordon A. Wyse & Margaret Anderson 2. Introduction to Animal Physiology and Physiological Genetics, 1st Edition, EM Pantelouris

	3. Animal Physiology: From Genes to Organisms, 2nd Edition, Lauralee Sherwood, Hillar Klandorf & Paul Yancey 4. Animal Physiology, 1st Edition, R.C. Sobti 5. Principles of Animal Physiology, 3rd Edition, Christopher Moyes & Patricia Schulte
Supplementary Readings	

Course Code: 0512 07 AB 5202	Year: MS First	**Term:** Second
Course Title: Molecular Animal Physiology Sessional and Fieldwork		
Course Status: Core		
Credit: 1.0		
Prerequisite(s): None		

Rationale	This course is designed to provide in-depth knowledge of various experimental work on molecular animal physiology.
Course Objectives	• To familiarize with the cutting-edge approaches and techniques of molecular animal physiology. • To appraise the skills necessary for animal physiology ranging from molecular to organismal level

Course Contents		CLOs
1	Gender Determination of different Animals	1,2
2	Study of various animal gene expression level	1,2
3	Different staining techniques of animal cells and tissues.	1,2
4	Biochemical analysis of different feed formulation	1,2
5	Identification of different inflammatory biomarkers of domesticated animals.	1,2
6	Microscopic, biochemical and molecular study of Proteobacteria, Firmicutes, Bacteroidetes and Probiotics.	1,2
7	Study of Animal Epigenetics	1,2

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Gain, develop, engage and merge a range of technical, and laboratory skills relevant for animal biochemistry and physiology	1,2,3,4,5,6,7,8,9
	CLO2	Document and describe their routine wise experimental work and actively present their scientific work	1,2,3,4,6,7,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture, Presentation, hands on training and field work/ laboratory visit	Reports, written examination, Viva voce, presentation.
CLO2	Lecture, Presentation, hands on training and field work/ laboratory visit	Reports, written examination, Viva voce, presentation.

Learning Materials

Recommended Readings	1. Animal Physiology, 4th Edition, Richard W. Hill, Gordon A. Wyse & Margaret Anderson 2. Introduction to Animal Physiology and Physiological Genetics, 1st Edition, EM Pantelouris 3. Animal Physiology: From Genes to Organisms, 2nd Edition, Lauralee Sherwood, Hillar Klandorf & Paul Yancey 4. Animal Physiology, 1st Edition, R.C. Sobti 5. Principles of Animal Physiology, 3rd Edition, Christopher Moyes & Patricia Schulte
Supplementary Readings	

Course Code: 0512 07 AB 5203	Year: MS First	**Term:** Second
Course Title: Biotechnology in Animal Production		
Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		
Rationale	Biotechnology in Animal Production course is expected to impart innovative techniques for the production of improved healthy and sustainable livestock resources. The course would be able to employ recent interventions for the production of elite livestock and subsequently will assist to open up the avenue for obtaining suitable career and trade opportunities among the concerned stake holders. It will also create the insight knowledge in regard to education and research.	
Course Objectives	The course will make the students knowledgeable and skilled in regard to transgenesis, stem cells, nutrition, animal health, reproduction, gene transfer and post-harvest technology of animal products.	

Course Contents		**CLOs**
Section A		
1	**Artificial Animal Breeding and Transgenic Technology:** Artificial insemination, transplantation, *in vitro* fertilization and embryo transfer, advantages of cell manipulation, nuclear transplantation and cell cloning. Molecular DNA markers to characterize and conserve animal genetic resources, selective animal breeding and their potential production, applications of functional genomics and discovery of new genes. Animal welfare and human health.	1, 3
2	**Stem Cells and its Applications:** Source and isolation of stem cells, embryonic and adult stem cells. Generation and manipulation of mouse and human embryonic stem cells. Bone transplant and reconstitution of hematopoietic system. Stem cells and therapeutics. Novel sources of multipotent stem cells. Science policies and ethics in stem cell research.	2
3	**Applications of Animal Biotechnology:** Improvement of cattle, buffalo, sheep, goat, swine, rabbit, poultry and fishery. Detection of genetic disorders. Gene and cell therapy and tissue transplantations. Production of interferon, interleukins and hormones. Industrial applications of metabolites, bio control agents and enzymes.	3, 4
4	**Gene Transfer Technology in Animals**: Viral and non-viral methods. Production and status of transgenic animals, molecular pharming. Animal and Human cloning: Techniques, relevance and ethical issues.	
Section B		**CLOs**
5	**Nutrition:** Natural range management in tropical areas, new or more effective uses of local biomass and feedstuff residues such as aquatic weeds, cereal stalks, and grain milling by-products and ensilage. Feeding strategies for local	1, 4

	areas. Methods to identify chemical inhibitors in plants to permit more efficient use of indigenous fodder species. Strategies for providing balanced/sufficient feeds to improve overall nutritional efficiency.	
6	**Animal Health:** Use of better diagnostic techniques through monoclonal antibodies, introduction of better preventive and treatment measures including improved vaccines against susceptible parasitic, viral and bacterial diseases.	4
7	**Reproduction:** For males, methods of production, collection, processing, Cryo-preservation and use of semen from proven male partners. Regarding females, methods of superovulation, collection, manipulation and cryo-preservation of ova and embryos. Sex determination and production of identical multiplets.	1, 3
8	**Post-harvest Technology:** Postharvest technology and marketing of animal Products, improved systems of delivering and storing animal products for consumers.	4

Mapping of CLOs with PLOs (MS Coursework)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Learn the techniques of animal breeding and transgenic technology	1,2,3,4,5,6
	CLO2	Understand the stem cell technology, bone transplantation and stem cell therapeutics	1,2,3,4,5,6
	CLO3	Learn the techniques of gene transfer in farm animals	1,2,3,4,5,6
	CLO4	Familiarize and learn the reproductive techniques, nutritional management, disease diagnostic, prevention and treatment measures and post-harvest technology of animal products of domesticated animals	1,2,4,5,6

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Learn the techniques of animal breeding and transgenic technology	1,2,3,4,5,6,7,8,9
	CLO2	Understand the stem cell technology, bone transplantation and stem cell therapeutics	1,2,5,6,7,8,9
	CLO3	Learn the techniques of gene transfer in farm animals	1,2,3,4,5,6,7,8,9
	CLO4	Familiarize and learn the reproductive techniques, nutritional management, disease diagnostic, prevention and treatment measures	1,2,3,4,6,7,8,9

		and post-harvest technology of animal products of domesticated animals	

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, Assignment and Final Exam
CLO3	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam
CLO4	Lecture and Group Discussion	Viva Voce and Final Exam.

Learning Materials

Recommended Readings	1. Butler. M (1991). Mammalian Cell Biotechnology: A Practical Approach (Practical Approach Series, 76). 2. Gordon (2005). Reproductive Techniques in Farm Animals, Oxford CAB International. 3. Hafez, B. and Hafez, E.S.E. (2010). Reproduction in Farm Animals, 7th Edition, Wiley- Blackwell. 4. Houdebine, L.M. (2010). Transgenic Animals: Generation and Use, 1st Edition, CRC Press.
Supplementary Readings	1. Ricki Lewis (2019). Human Genetics: Concepts and Applications, 12th Edition (Colour Edition), Mc Graw Hill. 2. Robert Lanza, Helen Blau, John Gearhart, Brigid Hogan, Douglas Melton, Malcolm Moore, Roger Pedersen, E. Donnall Thomas, James Thomson, Catherine Verfaillie, Irving Weissman, Michael West, Editors (2004). Handbook of Stem Cells: Embryonic/Adult and Fetal Stem cells (Vol. 1 & 2). Academic Press. 3. Sandy B. Primrose and Richard Twyman (2013). Principles of Gene Manipulation and Genomics, 7th Edition.

Course Code: 0512 07 AB 5205		Year: MS First	**Term:** Second
Course Title: Feed Biotechnology			
Course Status: Core			
Credit: 2.0			
Prerequisite(s): None			
Rationale	Feed Biotechnology imparts the concepts in feed technology, feed manufacturing, feed analysis and quality control, clinical animal nutrition, toxic constituents in animal feed stuffs, biotechnological concepts in feeding of ruminants & monogastrics, microbial feed additives & probiotics for ruminants, rumen fermentation and roles of macro & micronutrients. The course would be able to open up the avenue for obtaining brilliant career and entrepreneurship opportunities among the concerned stake holders.		
Course Objectives	The course will make the students knowledgeable and skilled in regard to feed formulation, biotechnological techniques for feed and fodder processing, use of non-conventional feed resources, detoxification of toxin feeds, bio-availability of macro and micro nutrients, microbial feed additives & probiotics for ruminants, protected proteins and amino acids for ruminants and biotechnology for the treatment of animal manure.		

Course Contents		**CLOs**
Section A		
1	**Introduction:** Importance of feed biotechnology in relation to animal productivity. The integrated biological, chemical and physical basis for evaluating the inherent nutritional quality of feed ingredients and feeds.	1
2	**Feed Formulation:** The formulation of concentrate mixtures, premixes and rations using computer. Feed formulation of large and small ruminants for different physiological stages. Introduction of microbial feed additives & probiotics and protected proteins & amino acids for ruminants. Limiting nutrients and strategic feeding of high yielding ruminants. Concept of by-pass nutrients and their impact on production, reproduction and immune status. Laws and regulation of feed manufacturing industry, Codex alimentarius, HACCP.	1, 4
3	**Feed Ingredients:** Identification of feed ingredients and their specifications, as well as compound feed for different categories of livestock and poultry. Feed microscopy and formulating premixes. Introduction to Pulverisers, pelletisers. Experiential learning at the feed plant for preparing feed, urea molasses mineral blocks, mineral mixtures etc. Merits and demerits of automated feed plants.	1, 2
4	**Feed and Fodder Processing:** Biotechnological interventions for feed and fodder processing and preservation techniques, their merits and demerits. Particle size reduction, bulk density, processing of grains & oil seeds, and processing of roughages. Ensiling the green fodders and preparation of hay.	2, 3

	Biotechnological upgradation of feed and feed components. Procurement, planning and purchase procedures, traditional and modern farm level storage structures. Feed storage and godown management, estimation of storage capacity and stack plan.	
Section B		**CLOs**
5	**Use of Non-Conventional Feed Resources:** Formulation of concentrates and premixes in rations. By-products of agricultural, industrial, food processing units and forest by-products. Improvement of nutritive value of poor quality roughages and liquid feed supplements. Solid state fermentation (SSF) technology. Evaluation by chemical and biological methods. Formulation of economical rations. Biotechnology for the treatment of animal manure.	3
6	**Toxic Feeds:** Toxic principles in animal feedstuffs. Chemical-Physical properties of various toxins. Effect of toxins on biological system and nutrients utilization in different species of livestock. Detoxification of toxin principles by various physical, chemical and biotechnological techniques. Insecticide and pesticide residue detection.	4
7	**Vitamins and Minerals: V**itamin and mineral requirements for growth, reproduction and lactation. Identification and correction of deficiencies and toxicities of minerals in farm animals.	1, 3
8	**Bio-availability of Macro and Micro nutrients:** Factors affecting the bio-availability of minerals, bio-marker concept for mineral requirements for correction of deficiencies and toxicity of minerals.	4

Mapping of CLOs with PLOs (MS Mixed Mode)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Learn the techniques of animal feed formulation	1,2,5,6,7,8,9
	CLO2	Understand the feed and fodder processing techniques	1,2,5,6,7,8,9
	CLO3	Learn the techniques of use of microbial feed additives, probiotics & protected proteins and amino acids for ruminants, use of non-conventional feed resources and biotechnology for the treatment of animal manure	1,2,3,4,5,6,7,8,9
	CLO4	Familiarize and learn the methods of detoxification of toxin feeds and to know the status of bio-availability of macro and micro nutrients in ration	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	Continuous Assessment and Quiz
CLO2	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam
CLO3	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam
CLO4	Lecture and Group Discussion	Viva Voce and Final Exam.

Learning Materials

Recommended Readings	1. Banerjee G.C. (2015). Feeds and Principles of Animal Nutrition. Oxford & IBH. 2. Givens DI., E. Owen, R.F.E. Axford, and H.M. Omed (2000). Forage Evaluation in Ruminant Nutrition, University of Wales Bangor, UK, CABI Publishing. 3. Lohan OP, Chahal SM & Kishore N. (2010). Feed Quality Evaluation Techniques. CCS Haryana Agricultural Univ. Press. 4. McEllihnery, Robert R. (1994). Feed Manufacturing Technology. The American Feed Industry Assoc., 4th Edition.
Supplementary Readings	1. Peter R.C. (2005). Applied Animal Nutrition Feeds and Feeding. Pearson Prentice Hall. 2. Ponds WG, Church DC, Pond KR & Schoknecht PA (2005). Basic Animal Nutrition and Feeding. Wiley Dreamtech, India. 3. Richard O Kellems; D C Church (2010). Livestock feeds and feeding, Boston, Prentice Hall.

Course Code: 0512 07 AB 5206	Year: MS First	**Term:** Second
Course Title: Feed Biotechnology Sessional and Fieldwork		
Course Status: Core		
Credit: 1.0		
Prerequisite(s): None		

Rationale	The course will provide hands on training towards the students regarding biotechnology in animal nutrition, role of biotechnology to improve fibrous feeds and gut microbes, biotechnology products for feed additives, introduction of probiotics and prebiotics based animal feeds, genetically modified rumen microbes, protection of protein & amino acids, improving nutritive value of cereals fodders and conserved feeds, modifying the digestive function through development of transgenic animals and so on. They will also get the opportunity to be placed at different feed manufacturing industries to conduct field research.
Course Objectives	The course will make the students knowledgeable and skilled in regard to feed formulation, biotechnological techniques for feed and fodder processing, use of non-conventional feed resources, detoxification of toxin feeds, bio-availability of macro and micro nutrients, microbial feed additives & probiotics for ruminants, protected proteins and amino acids for ruminants and biotechnology for the treatment of animal manure. The course will also provide the opportunity for the students for field trips to visit modern feed processing industries.

	Course Contents	**CLOs**
1.	Techniques to improve fibrous feeds and gut microbes.	1, 3
2.	Ration formulation for domesticated animals.	1
3.	Development of probiotics and prebiotics based animal feeds.	3
4.	Biotechnological techniques for feed and fodder processing.	2
5.	Improvement of nutritive value of cereals fodders and conserved feeds.	2, 3
6.	Detoxification of toxin feeds.	4
7.	Field Trips to visit concerned Research Institutes and Modern Feed Processing Industries.	4

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Learn the techniques of animal feed formulation	1,2,5,6,7,8,9
	CLO2	Understand the feed and fodder processing techniques	1,2,5,6,7,8,9
	CLO3	Learn the techniques of use of microbial feed additives, probiotics & protected proteins and	

		amino acids for ruminants, use of non-conventional feed resources and biotechnology for the treatment of animal manure	1,2,3,4,5,6,7,8,9
	CLO4	Familiarize and learn the methods of detoxification of toxin feeds and to know the status of bio-availability of macro and micro nutrients in ration. Field trips to visit modern feed processing industries.	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	Laboratory Sessional/hands on training	Quiz
CLO2	Practical Demonstration	Presentation
CLO3	Laboratory Sessional/Field Demonstration	Final Examination
CLO4	Field trips at modern food processing industries	Report writing

Learning Materials

Recommended Readings	1. Banerjee G.C. (2015). Feeds and Principles of Animal Nutrition. Oxford & IBH. 2. Givens DI., E. Owen, R.F.E. Axford, and H.M. Omed (2000). Forage Evaluation in Ruminant Nutrition, University of Wales Bangor, UK, CABI Publishing. 3. Lohan OP, Chahal SM & Kishore N. (2010). Feed Quality Evaluation Techniques. CCS Haryana Agricultural Univ. Press. 4. McEllihnery, Robert R. (1994). Feed Manufacturing Technology. The American Feed Industry Assoc., 4th Edition.
Supplementary Readings	1. Peter R.C. (2005). Applied Animal Nutrition Feeds and Feeding. Pearson Prentice Hall. 2. Ponds WG, Church DC, Pond KR & Schoknecht PA (2005). Basic Animal Nutrition and Feeding. Wiley Dreamtech, India. 3. Richard O Kellems; D C Church (2010). Livestock feeds and feeding, Boston, Prentice Hall.

Course Code: 0512 07 AB 5207	Year: MS First	**Term:** Second
Course Title: Disease Diagnosis and Therapeutics		
Course Status: Optional		
Credit: 2.0		
Prerequisite(s): None		

Rationale	Animal is one of the core components of environment like human being. Animal, specially domesticated animal such as cattle, goat, sheep, play role in our health and nutrition by providing meat, milk, skin, wool etc. and have a significant role in economy. Like human animal also faces different internal and external causes of diseases. A disease caused by a pathogen can be fatal for a herd resulting great economic loss for a farm or individual farmer level. Thus, knowledge about disease, its diagnosis, and treatment is a prerequisite for animal farming. Proper diagnosis and treatment is therefore very much necessary for farming in large scale and also for individual farmer level. This course will give the students the insight of animal diseases, its diagnostic methods, and therapeutic applications. It will provide knowledge to the students to follow further courses of animal biotechnology and to play role to work with new and advanced tools for disease diagnosis and development of vaccine and drug for therapeutic applications.
Course Objectives	• To know the principle and insights of animal disease. • To know the diagnosis principle, techniques, and the therapeutics available for the diseases. • To appraise sate of the art technologies regarding disease diagnosis and therapeutics.

Course Contents		**CLOs**
Section A		
1	**Introductory:** The animal medical history, physical examination of the herd, clinical examination and making a diagnosis, prognosis and therapeutic decision making.	1, 2
2	**General Systemic States:** The vital sign, Hypothermia, Hyperthermia, fever, septicemia/viremia, toxemia and endotoxemia, allergy and anaphylaxis, electrolytes and acid base balance, pain, colocalized infection, disturbance in appetite.	1, 2
3	**Diseases of Newborn:** perinatal and postnatal diseases, congenital defect, diseases of cloned offspring, clinical assessment and care of critically ill newborn.	1, 3
4	Diseases of alimentary tract I and II, alimentary tract dysfunction, examination, principles of treatment of alimentary tract diseases.	1, 2

5	Diseases of Liver and Pancreas: Principles of hepatic dysfunction, manifestation of hepatic and biliary diseases, special examination of lever, principle of treatment.	1, 2
Section B		**CLOs**
6	**Diseases of Cardiovascular System:** principles of circulatory failure, manifestation of circulatory failure and heart diseases, special examination of diseases, diseases of blood vessel, treatment of heart diseases.	1, 2
7	**Diseases of Nervous System and Mammary Gland:** Principles of nervous dysfunction and clinical manifestation of diseases, special examination and principles of treatment, bovine mastitis, common pathogen of cattle mastitis, control of bovine mastitis. Retroviral gene delivery system as a therapy of neurodegenerative diseases.	1, 2
8	Diseases associated with bacteria, virus, chlamydia, fungi, protozoa and helminthic parasites. Diseases characterized by chromosomal abnormalities, inherited defects of different organs.	1, 2
9	**Molecular Tools in Animal Diseases Diagnosis:** Hybridization techniques, PCR, diagnosis of microbial infection, neoplasia, inherited genetic disorder, and immune techniques in diseases diagnosis.	1, 2, 3
10	Advances in animal diseases diagnosis and therapeutics.	1, 2, 3

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Achieve knowledge of different diseases of animal, their diagnosis, tools and methods, and therapeutics.	1,6,7,8,9
	CLO2	Identify skills necessary for animal disease diagnosis and treatment.	1,2,3,4,6,7,8,9
	CLO3	Appraise the social, legal and ethical issues in animal disease diagnosis and treatment.	2,3,4,5,6,7,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Class lecture, group discussion	Class test
CLO2	Class lecture, presentation	Class test, Assignment
CLO3	Class lecture, presentation, group discussion	Class test

Learning Materials

Recommended Readings	1. Veterinary medicine: A text book of the diseases of cattle, horses, sheep, pigs and goats (10th edition). By Otto M, Radostits, Clive C, Hay et al 2007Givens DI., E. Owen, R.F.E. Axford, and H.M.

	Omed (2000). Forage Evaluation in Ruminant Nutrition, University of Wales Bangor, UK, CABI Publishing. 2. Text book of veterinary internal medicine (8th edition) By Stephen J Ettinger, Edward C Feldman.
Supplementary Readings	1. Joseph B Crisner, Russel D Cohen (2011) Inflammatory Bowel Disease: Diagnosis and therapeutics, 2nd ed, Humana Press.Ponds WG, Church DC, Pond KR & Schoknecht PA (2005). Basic Animal Nutrition and Feeding. Wiley Dreamtech, India. 2. Maxine A, Stephen J (2021) Current Medical Diagnosis and Treatment

Course Code: 0512 07 AB 5209		Year: MS First	**Term:** Second
Course Title: Animal Functional Genomics			
Course Status: Optional			
Credit: 2.0			
Prerequisite(s): None			
Rationale	The course aims to provide knowledge in animal functional genomics for BGE discipline students'. Also, the course is outline to give animal advanced genomics area including transcriptome epigenomics and ethics.		
Course Objectives	• To organize and analysis the large amount of gene sequencing and Next Generation Sequencing and its application • To organize and analysis the large amount of RNA sequencing and uses tools for transcriptomics • To enhance students' understanding of transcriptome sequencing, microarray-based genotyping, and modern bioinformatics approaches • To learn modern - omics i.e., structural, functional, comparative and epigenomics approaches in animals • To aware students for ethic in animal functional genomics research.		

	Course Contents	**CLOs**
	Section A	
1	Main advantages and limitations of the most common technologies used for functional genome analysis, variant detection to functional genome analysis, bioinformatics in animal genomics	1,2
2	New technique for functional genomics and recombinant DNA techniques, including DNA isolation, PCR, T-vector cloning, automated DNA sequencing, OLA-based genotyping, RNA isolation, real-time RT-PCR and reporter gene analysis in transgenic organisms.	1,2
3	Functional analysis for epigenetic modifications, DNA methylation and histone modifications use methylation-dependent restriction enzymes (MDRE), methylation-specific PCR, sequencing, bead array, etc. Detection of histone modifications for chromatin immunoprecipitation (ChIP) based microarray analysis (ChIPchip), sequencing (ChIP-seq), or quantitative PCR.	1,2,3
4	Microarray-based technologies for studies of RNA expression (transcriptomics)	1,2,3
	Section B	**CLOs**
5	Proteomics and interactomics: Define proteomics and interactomics use genomics, epigenomics, and transcriptomics, immunoassays, enzyme-linked immunosorbent assay (ELISA), one-dimensional protein separation method, two-dimensional gel electrophoresis (2-DE), quantification is mass spectrometry (MS), mass spectrometric immunoassay (MSIA), characterization of the protein function uses two-hybrid system (Y2H).	1,2

6	Functional genomics integrating model systems: Animal models applied in investigation of biological and pathogenically mechanisms and drug discovery, CRISPR-Cas9 in animal research.	1,2,3
7	Ethic in animal functional genomics: Socio-ethical aspects and public perception for functional genomics, issues and policies in animal functional genomics.	4

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Account for how all stages in a genome sequencing project are carried out and describe current large-scale DNA-sequencing technologies and describe the overall structure and organisation of the genome in animals	1,2,3,4,6,7,8,9
	CLO2	Differentiate between genomic, and other large-scale analyses, at different levels, including genomics, transcriptomics, proteomics, metabolomics, metagenomics and systems biology.	1,2,3,4,6,7,8,9
	CLO3	Describe and explain a broad spectrum of large-scale functional genomics methods, as well as current technical developments, suggest and outline solutions to theoretical and experimental problems within the genomics and functional genomics fields. within the genomics and functional genomics fields.	1,2,6,7,8,9
	CLO4	Plan and carry out a small functional genomics project, both theoretically and experimentally, handle and analyse large-scale experimental datasets, and present results and interpretations in a scientifically stringent manner and critically examine research reports.	1,2,3,4,6,7,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture	Quiz, Continuous Assessment, Assignment and Final Exam
CLO2	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam
CLO3	Lecture and/or Group discussion	Continuous Assessment, Assignment and Final Exam
CLO4	Lecture and Presentation	Continuous Assessment, Assignment and

		Final Exam, Viva voice

Learning Materials

Recommended Readings	1. Lesk, Arthur M. (2007) Introduction to genomics, Oxford and New York: Oxford University Press. Text book of veterinary internal medicine (8th edition) By Stephen J Ettinger, Edward C Feldman. 2. Gibson G, Muse SV (2009) A primer of genome science, Ed 3rd., Sinauer Associates, Sunderland, Mass. 3. Pevsner J (2009) Bioinformatics and functional genomics, Ed 2nd., Wiley-Blackwell, Hoboken, N.J. 4. Sukanta Mondal, Ram Lakhan Singh (2020) Advances in Animal Genomics, 1st Edition, eBook ISBN: 9780128206126
Supplementary Readings	1. Animal Genetics and Genomics, MDPI (ISSN 2076-2615), https://www.mdpi.com/journal/animals/sectioneditors/Animal_Genetics_and_Genomics 2. Caird Rexroad1 , Angelica Van Goor2 , Lakshmi Kumar Matukumalli2 , and Jeffrey Vallet1 (2019) An Executive Summary of "Genome to Phenome: Improving Animal Health, Production, and Well-Being – A New USDA Blueprint for Animal Genome Research 2018–2027." Frontiers in Genetics Vol 10:327 doi: 10.3389/fgene.2019.00327

Course Code: 0512 07 AB 5211		Year: MS First	**Term:** Second
Course Title: Reproductive Biotechnology			
Course Status: Optional			
Credit:2.0			
Prerequisite(s): None			
Rationale	The course will provide an insight of the advanced techniques used in animal reproduction to achieve maximum output from the farm animal and also to meet the food requirements of the world. The course also illustrate how the major diseases of the farm animal will diagnose and manage keeping constant animal production.		
Course Objectives	This course's main purpose is to teach students about applied biotechnology in animal production and development. • To know the advanced animal reproductive technologies • Understanding safe and ethical issue related to animal reproductive biology • Enhance knowledge of bioinformatics on animal disease diagnosis and for molecular drug development in commercial level • Identify current trends in livestock reproductive biotechnology		

	Course Contents	CLOs
	Section A	
1	**Introduction to Animal Reproductive Biotechnology:** Definitions, Historical overview of mile stones in research; Scope and Applications	1
2	**Molecular Physiology and Cell Biology of Animal Production:** Valuable animal genes and genomes, Gene expression and regulation, Stem cell rejuvenation and iPSCs, Growth endocrinology, Cellular and development processes involved in animal reproduction	3
3	**Classical Reproductive Biotechnology Techniques:** Overview of animal reproductive physiology, Artificial Insemination, Embryo Transfer Technology, IVF, IVM, Embryo sexing, cryopreservation, Advantages and limitations of classical reproductive biotechnology techniques	1
4	**Biosafety and Bioethics:** Established protocols and guidelines for safe and ethical animal reproduction biotechnology	2
5	Discussion of Recent Case Studies and Publications in animal production and classical reproductive biotechnology	1,2,3
	Section B	**CLOs**
6	**Transgenesis and Molecular Biotechnology**: Gene transfer methods for mammalian cells and animal transgenics; Nuclear transfer, germ cells and animal cloning; Recombinant DNA technology, Gene editing methods for reproduction	3

7	**Omics Technologies in Animal Production**: Multiomics technologies in animal reproduction, Functional genomics, Proteomics and lipidomics in animal reproductive trait monitoring and breeding Metabolomics and metabonomics of animal reproduction, Regulation of animal reproductive genes by siRNA, miRNA and lncRNA	1,3
8	**Molecular Diagnostics and Medicine**: Applications of molecular technologies in disease detection, treatment and management in animal reproduction, DNA sequencing and bioinformatic applications in animal disease diagnosis and treatment, Animal immunobiologicals and molecular drug development strategies	3
9	**Discussion of Recent Case Studies and Publications** in molecular techniques used in reproductive biotechnology	1,2,3

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Understand various advanced reproductive technologies to increase animal's product quality and quantity	1,2,3,4,5,6,7,8,9
	CLO2	Know the ethical aspects for handling and for using technologies	1,2,5,6,7,8,9
	CLO3	Detect various diseases and manage them in molecular level by identifying genes and by developing new drugs	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, Assignment, Presentation, Viva voce and Final Exam.
CLO2	Lecture, Discussion, Tutorial and Presentation	Quiz, Continuous Assessment, Assignment, Presentation, Viva voce and Final Exam.
CLO3	Lecture, Discussion, Tutorial and Presentation	Quiz, Continuous Assessment, Assignment, Presentation, Viva voce and Final Exam.
CLO4	Lecture, Discussion, Tutorial and Presentation	Quiz, Continuous Assessment, Assignment, Presentation, Viva voce and Final Exam.

Learning Materials

Recommended Readings	1. Animal Biotechnology: Models in Discovery and Translation, 2nd Edition, Ashish Verma & Anchal Singh 2. Essential Reproduction, 8th Edition, Martin H. Johnson 3. Animal Biotechnology 1: Reproductive Biotechnologies, 2nd Edition, Heiner Niemann & Christine Wrenzycki 4. Reproductive Technologies in Animals, 1st Edition, Giorgio Presicce
Supplementary Readings	1. Biotechnologies Applied to Animal Reproduction, 1st Edition, Juan Carlos Gardón & Katy Satué

Major
in
Plant Biotechnology

Course Code: 0512 07 PB 5201		Year: MS First	**Term:** Second
Course Title: Molecular Plant Physiology			
Course Status: Core			
Credit: 2.0			
Prerequisite(s): None			
Rationale	The principal focus of the existent course is on the molecular aspects of the physiological and metabolic processes in plants. Preliminary knowledge of plant physiology and metabolism would be imparted. Critical knowledge of phytohormone biosynthesis, mode and mechanism of action will be highlighted. Students will be oriented toward developing a molecular understanding of the principles of photosynthesis, photomorphogenesis, molecular basis of nutrient uptake and utilization with emphasis on plant stress physiology and pathology.		
Course Objectives	• To illustrates knowledge of stress adaptations in biological systems. • To deliver molecular understanding of primary and secondary metabolic process. • To present perspectives of the current tools for application in biological system for biotechnological research. • To demonstrate the concept using different activities for building capacity.		

Course Contents		**CLOs**
Section A		
1	**Introduction:** *Arabidopsis thaliana* as a model species in molecular plant physiology. The physiology, germination, and genetic map of Arabidopsis thaliana. Natural variation of *Arabidopsis thaliana* to understand its molecular mechanism and Complex transcriptional networks underlie the development of Arabidopsis thaliana.	1
2	**Mineral nutrition, assimilation, and translocation:** Essential nutrients for plant development. Mycorrhizae and their role in plant root development, Strategies of nutrient absorption in grasses versus dicots and non-grass monocots. Nitrogen: deficiency and excess absorption and reduction of nitrate to ammonium. Assimilation of ammonium (GS-GOGAT). translocation of minerals and solutes, translocation of minerals through plants and translocation of organic solutes in phloem.	1
3	**Signaling and transport:** Hormonal signaling: ABA signaling and their molecular role. Plant water relations which are necessary for plant development. Movement of water through flowering plants. Transpiration and movement of water through the leaf and ascent of water in the xylem. The mechanisms for the uptake of water by roots, the uptake of mineral salts and their transport across roots.	1

4	**Photosynthesis:** Introduction of C3 to C4 photosynthesis. The transition from the C3 to C4 photosynthesis pathway. The development of kranz anatomy. The establishment of the C4 cycle and alterations at the gene expression level. Change of C3 crops into C4 photosynthesis.	1
Section B		**CLOs**
5	**Respiration:** An overview of plant respiration. Glycolysis in plant physiology. The TCA cycle in plant physiology. The branched respiratory electron chain of plant mitochondria. Gaseous exchange in flowering plants. Control of plant cell respiration and the change of respiration due to global climate change.	1
6	**Photomorphogenesis and the circadian clock:** Skoto-morphogenesis and photo-morphogenesis. Classes of plant photoreceptors. Phytochrome: molecular structure, photoconversion, absorption spectrum, photo-stationary state, action spectrum. Nuclear translocation of Pfr and modification of gene expression. Family of PHY genes and multiplicity of responses. Cryptochromes: structure and function. Role of cryptochromes in de-etiolation and hypocotyl elongation. The roles of Phototropin in plants. The mechanisms of biological clock in plant physiology.	2
7	**Stress Physiology:** Biotic interactions: plant-plant (allelopathy), plant-herbivore, plant-pathogen; molecular mechanisms of the interaction and the defense response. Interactions between plants and their surrounding environment.	2
8	**Current advances in plant physiology:** Effect of wastewater irrigation on crop health. *Arabidopsis thaliana*: Super-molecular organization of photosynthetic complexes. Control of microbiogenesis and its action in plants. Mechanisms of metalloid uptake, transport, toxicity, and tolerance in plants. Signal transduction in plants with response to heavy metal toxicity.	2

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Have a complete understanding on the kingdoms of biomolecules, metabolites and pathways that are the prerequisites and consequences of physiological phenomenon for further manipulations	1,2,5,6,7,8,9
	CLO2	Have an acquaintance with mechanistic view on the plant environment interactions and finally, development of integrative approach for visions in biological problems.	1,2,5,6,7,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Presentation	Continuous Assessment and Final Examination
CLO2	Lecture, Presentation and Assignment	Continuous Assessment, Assignment and Final Examination

Learning Materials

Recommended Readings	1. Taiz, L., Zeiger, E., Møller, I. M. and Murphy, A. 2014. Plant Physiology and Development (6 th Edition). Sinauer Associates, inc.Or Taiz, L. and Zeiger, E. 2010. Plant Physiology (5th Edition) Sinauer Associates, Inc. 2. Urry, L. A., Cain, M. L., Wasserman, S. A., Minorsky, P. V. and Reece, J.B. 2016. Campbell Biology (11th Edition). Pearson. 3. Berg, J. M., GattoJr.,G. J., Tymoczko, J. L. and Stryer, L. Biochemistry (8th Edition). 2015. W. H. Freeman
Supplementary Readings	1. Biochemistry & Molecular Biology of Plants. Authors: Buchanan BB, Gruissem W and Jones RL (2000), American Society of Plant Physiologists. 2. Lehninger Principles of Biochemistry, Authors: David L. Nelson and Michael M.Cox. 3. Plant Physiology. Authors: Taiz L, and Zeizer E, (2006), Sinauer Associates, Inc. 4. Biochemistry. Authors: Berg JM, Tymoczko, JL, and Stryer L (2006). W. H. Freeman. 5. Plant Pathology. Authors: Agrios GN 5 ed; 2005, Elsevier Academic Press, 2005.

Course Code: 0512 07 PB 5203		Year: MS First	**Term:** Second
Course Title: Molecular Breeding and Hybrid Seed Technology			
Course Status: Core			
Credit: 2.0			
Prerequisite(s): None			
Rationale	This course is designed to provide knowledge on the principles of molecular breeding and hybrid variety development of crops and seed production processing technology. In addition to this, genetic recombination as a tool for genetic map construction, theory, and application of DNA markers for mapping and selection, including pros, cons, and their special characteristics are discussed.		
Course Objectives	• To study the structure of plant population and the importance of genetic variation and covariation among traits • To impart knowledge about recent advances in population genetic theory and application in plant breeding • To impart knowledge and technology to the students to exploit genetic and Biotechnological principles for developing improved (Modern/HYV) crop varieties useful to fulfill the needs of society.		

Course Contents		**CLOs**
Section A		
1	**The Dynamic Plant Genomes:** Genome Organization: Nuclear and organellar genomes; C-Value paradox, Unique and repeat DNA sequences; Classification of Repeat elements: Tandem, Interspersed, Micro-satellites, Minisatellites, hyper-variability of VNTRs.	1
2	**Forward Mapping for Gene Discovery and Functional Genomics:** Traits (simple and complex; continuous and discontinuous variation), Construction of genetic linkage maps; Linkage mapping software packages and interfaces; Trait Mapping; Map-based cloning/ positional cloning for gene discovery, Navigating from genetic to physical map (methodologies and challenges).	1, 2
3	**Genotyping Tools as Plant Variety Protection:**Marker Assisted Selection (MAS), gene/QTL introgression and pyramiding, Foreground and background selection for introgression of QTL by SSR markers, DNA bar-coding technology, hybrid purity tests, diagnostics (transgenics), establishing clonal fidelity, Fingerprinting for BAC assembly for physical maps. Genomics platforms for genome-wide analysis: DARTseq, GBS (genotyping by sequencing) and other third-generation sequencing platforms, GEBVs (Genomics estimated breeding values), GWAS (Genome-wide association studies).	3, 4
Section B		**CLO s**
4	**Hybrid Breeding and Related Concept:** Heterosis and hybrid vigor phenomenon in crop plants; cytoplasmic and molecular basis for the	5

	expression of heterosis. CMS: Concept, types, sources, and transfer of CMS genes, development of A-line, maintenance of B-line and genetic control of CMS, and self-incompatibility.	
5	**Hybrid Breeding Program using Biotechnological Approaches:** Various types of hybrids and their importance, a. Development, evaluation, and maintenance of parental lines. Purification and improvement of parental lines. b. Use of various breeding techniques: CMS, GMS, Self-incompatibility, apomixes, and chemicals.	6
6	**Development of Hybrid Varieties in Crop Plants:** Development of hybrid varieties of important field crops viz. tomato, brinjal, rice, maize, okra, watermelon, cucumber, sweet gourd, bottle gourd, bitter gourd, ribbed gourd; hybrid seed production of rice, maize, and vegetables.	6
7	**Seed Production and Processing Technology:** Basic requirements for seed production, physiology of crops related to seed production procedures, manipulations of physiological processes of crops by the environment for better production, and some basic techniques on seed processing, storage, and transportation.	7

Mapping of CLOs with PLOs (MS Coursework)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Demonstrate advanced knowledge and understanding of plant genomes and regulation of gene expression	1,2,4,5,6
	CLO2	Analyze information from plant molecular biology research and recognize its potential applications in crop and hybrid seed improvement	1,2,4,5,6
	CLO3	Synthesize information from plant molecular biology and plant breeding to design plant molecular breeding strategies	1,2,4,5,6
	CLO4	Evaluate the relative merits of plant transformation, marker-assisted breeding and conventional phenotypic selection for particular situations	1,2,4,5,6
	CLO5	Demonstrate emerging technologies and the ability to apply these principles to a specified field	1,2,4,5,6
	CLO6	Demonstrate hybrid variety development in different crops	
	CLO7	Evaluate the parental lines of hybrids and various methods of breeding	

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Demonstrate advanced knowledge and understanding of plant genomes and regulation of gene expression	1,2,6,7,8,9
	CLO2	Analyze information from plant molecular biology research and recognize its potential applications in crop and hybrid seed improvement	1,2,3,4,6,7,8,9
	CLO3	Synthesize information from plant molecular biology and plant breeding to design plant molecular breeding strategies	1,2,3,4,6,7,8,9
	CLO4	Evaluate the relative merits of plant transformation, marker-assisted breeding and conventional phenotypic selection for particular situations	1,2,3,4,6,7,8,9
	CLO5	Demonstrate emerging technologies and the ability to apply these principles to a specified field	1,2,3,4,6,7,8,9
	CLO6	Demonstrate hybrid variety development in different crops	2,3,4,5,6,7,8,9
	CLO7	Evaluate the parental lines of hybrids and various methods of breeding	2,3,4,6,7,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLO	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture, presentation, group discussion	Quiz, Continuous Assessment, Assignment, Presentation, Viva voce and Final Exam
CLO2	Lecture, presentation, group discussion	Quiz, Continuous Assessment, Assignment, Presentation, Viva voce and Final Exam
CLO3	Lecture, presentation, group discussion	Quiz, Continuous Assessment, Assignment, Presentation, Viva voce and Final Exam
CLO4	Lecture, presentation, group discussion	Quiz, Continuous Assessment, Assignment, Presentation, Viva voce and Final Exam
CLO5	Lecture, presentation, group discussion	Quiz, Continuous Assessment, Assignment, Presentation, Viva voce and Final Exam

CLO6	Lecture, presentation, group discussion	Quiz, Continuous Assessment, Assignment, Presentation, Viva voce and Final Exam
CLO7	Lecture, presentation, group discussion	Quiz, Continuous Assessment, Assignment, Presentation, Viva voce and Final Exam

Learning Materials

Recommended Readings	1. Yunbi Xu (2010) Molecular Plant Breeding, CABI. 2. H. John Newbury (2009) Plant Molecular Breeding, Wiley Blackwell Publications. 3. Pradip Chandra Deka (2020) Molecular Plant Breeding and Genome Editing Tools for Crop Improvement. 4. Rattan Lal Agrawal (2018) Seed Technology, oxford and IBH Publications.
Supplementary Readings	1. Snustad, D. P. and Simmons M.J. (2015). Principles of Genetics, 7th Ed. John Wiley & Sons. 2. Strickberger, M.W. (2015). Genetics. 3rd ed. Pearson. 3. Singh, B.D. (2015). Plant Breeding. Principles and Methods. Kalyani publishers. 4. Allard, R.W. (1981). Principles of Plant Breeding, John Wiley & Sons 5. Klug, W. S., Cummings, M. R., Spencer, C. A., & Palladino, M. A. (2016). Concepts of Genetics (10th ed.). Pearson. 6. David Allen Sleper, John Milton Poehlman (2006), Breeding Field Crops, 5th Edition, Wiley-Blackwell.

Course Code: 0512 07 PB 5204	Year: MS First	**Term:** Second
Course Title: Molecular Breeding and Hybrid Seed Technology Sessional and Fieldwork		
Course Status: Core		
Credit: 1.0		
Prerequisite(s): None		

Rationale	This course is designed to provide knowledge on the principles of molecular breeding and hybrid variety development of crops and seed production processing technology.
Course Objectives	• To impart knowledge about recent advances in molecular breeding and application in plant breeding • To impart knowledge and technology to the students to exploit genetic and Biotechnological principles for developing improved (Modern/HYV) crop varieties useful to fulfil the needs of society.

	Course Contents	**CLOs**
1.	Extraction, purification, and quantification of plant DNA samples.	1
2.	Performing PCR and DNA Separation by agarose gel electrophoresis.	1
3.	Study of floral biology: Rice, Maize, Okra, Sweet gourd, Bottle gourd, Cucumber, Watermelon, Brinjal, Tomato, etc.	2
4.	Techniques of hybridization: Rice, Maize, Okra, Sweet gourd, Bottle gourd, Cucumber, Watermelon, Brinjal, Tomato, etc.	2
5.	Test of pollen viability and/or sterility.	3
6.	Hybridity and varietal purity testing in laboratory and in field using molecular markers and GOT test.	3
7.	Seed quality testing: Seed purity, moisture, seed viability (germination and tetrazolium test) and vigour test.	3
8.	Visit to research institutes/organizations, BADC and seed companies related to hybrid seed development research and production and submission of field trip report.	4

Mapping of CLOs with PLOs (MS Coursework)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Demonstrate DNA extraction, purification, PCR and DNA fragment separation by gel electrophoresis	2,4,5,6, 7, 8, 9
	CLO2	Demonstrate floral biology and hybridization techniques in various crops	2,5,6, 7, 8, 9
	CLO3	Demonstrate pollen viability testing, hybridity, varietal purity and seed quality testing	2,4,5,6

	CLO4	Demonstrate hybrid seed production and processing technique	2,5,6

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Demonstrate DNA extraction, purification, quantification, and separation	2,3,4,6,7,8,9
	CLO2	Demonstrate floral biology and hybridization techniques in crops	2,3,4,7,8,9
	CLO3	Demonstrate pollen viability testing	2,3,4,6,7,8,9
	CLO4	Demonstrate hybrid seed production and processing technique	2,3,4,7,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture, Lab. demonstration and presentation	Lab. work & report evaluation, final examination, viva voce
CLO2	Presentation and demonstration of floral biology of various crops.	Lab. work & report evaluation, final examination, viva voce
CLO3	Lecture, Lab. demonstration and presentation.	Lab. work & report evaluation, final examination, viva voce
CLO4	Field visit of research institutes, BADC, farmer's field, and seed companies.	Field visit reports evaluation, and viva voce.

Learning Materials

Recommended Readings	1. Yunbi Xu (2010) Molecular Plant Breeding, CABI. 2. H. John Newbury (2009) Plant Molecular Breeding, Wiley Blackwell Publications. 3. Pradip Chandra Deka (2020) Molecular Plant Breeding and Genome Editing Tools for Crop Improvement. 4. Rattan Lal Agrawal (2018) Seed Technology, oxford and IBH Publications.
Supplementary Readings	1. Snustad, D. P. and Simmons M.J. (2015). Principles of Genetics, 7th Ed. John Wiley & Sons. 2. Strickberger, M.W. (2015). Genetics. 3rd ed. Pearson. 3. Singh, B.D. (2015). Plant Breeding. Principles and Methods. Kalyani publishers. 4. Allard, R.W. (1981). Principles of Plant Breeding, John Wiley & Sons

	5. Klug, W. S., Cummings, M. R., Spencer, C. A., & Palladino, M. A. (2016). Concepts of Genetics (10th ed.). Pearson. 6. David Allen Sleper, John Milton Poehlman (2006), Breeding Field Crops, 5th Edition, Wiley-Blackwell.

Course Code: 0512 07 PB 5205	Year: MS First	**Term:** Second
Course Title: Plant Protection		
Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		
Rationale	Agriculture is the backbone of Bangladesh. The most important goal in agriculture is to achieve higher productivity and production to meet the ever-increasing demand of food commodities. About 20-30% of agricultural produce is lost annually due to insect pests, diseases, weeds and rodents. Plant protection technology occupies an important position in agricultural crop production. Most often, losses due to pests are the major limiting factor for sustaining the increase in crop productivity and production. To keep pace with the demand for food commodities, adoption of appropriate strategies that include effective, economical, safe and environmentally sound plant protection technology in sustainable agriculture is a critical requirement.	
Course Objectives	• To acquaint the students with the agents that causes crop damages and economic loss to the farmers. • To acquaint the students with the basics of plant protection. • To apprise and familiarize the students about pest and disease management strategies of crops to ensure sustainable food and nutrition security.	

Course Contents		**CLOs**
Section A		
1	Introduction: Enemies of crop plants, concept of various pests and pesticides, losses due to attack of pests, damages caused by insects, mites, pathogens, vertebrate animals, and weeds. Taxonomy of insect pests, mouth parts of insects, life cycle of insects. Diagnostic characteristics of insects, mites, spiders of agricultural importance.	1,2
2	Insect Physiology and Ecology: Insect nutrition, Endocrine glands and hormones, types & their functions, metamorphosis, moulting, reproductive	1,2

	systems and types of reproduction. Ecological niche and habitat, agro-ecosystem, factors of insect population, insect population estimation, insect scouting and sampling, and crop loss assessment.	
3	Pest management strategy: Concept of pest control and management, economic injury and threshold levels, principles of pest management: conventional methods - cultural, mechanical, physical, legal and chemical methods, biotechnological methods- biocontrol, biopesticides insect sterility, behavioral control- attractants, repellents, antifeedants and pheromones, types of pesticides, formulation, safety category, pesticide labelling, pre-harvest interval, their mode of action, hazards, 3R (Residue, Resistance and resurgence), application techniques and safety during spraying and equipment. IPM, IPM triangle, components, strategies, limitation and implementation.	1,2,3
4	Weed and weed management: Introduction to monocot and dicot weeds, losses due to weed infestation. Weeds of major crops, nature of damages and their control strategies Integrated weed management, conventional and biotechnological. Concept of herbicides, their types, advantages and disadvantages.	1,2,3
Section B		**CLOs**
5	Plant Disease: Concept of plant disease, causal agents of disease, disease triangle, losses due to disease, epidemics due to disease, host-pathogen interaction, parasitism & pathogenicity, virulence, races of pathogens, stages of disease development, disease cycle, symptoms and sign of diseases, host defences against pathogen (structural and biochemical), effect of pathogens on plant physiological function. Plant virology: Plant virus, types, transmission, losses due to attack of virus, virus isolation and purification.	1,2,3
6	Host resistance and virulence of pathogen: Concept of host resistance & types, immunity & resistance, mechanism of variation in plant pathogens and its significance , anatomical and biochemical features of host resistance, genetic control of host resistance and virulence, gene for gene theory.	1
7	Diseases of selected cereal, vegetable, fruit, oil & pulses and ornamental crops: Causal agents, mode of transmissions, symptoms and disease cycle of rice, wheat, maize, jute, cotton, mustards, lentils, grams, green gram, potato, tomato, chilli, brinjal, cabbage, cauliflower, tea, sugarcane, mango, papaya, banana. Seed borne diseases of crops: causal agents, symptoms and signs and control strategy- seed treatment.	1,2,3
8	Plant Disease control: Plant disease management strategies: Cultural, mechanical, physical, legal, biological and chemical. Types of chemicals-fungicides, bactericides, nematicides, mode of action of fungicides, evaluation of fungicides. Use of resistant host varieties, types of resistance, trap crop and antagonistic plants. Control of diseases of major crops.	2,3

	Formulation of fungicides and application methods, sprayers & modern techniques.	
9	Molecular diagnosis of pathogens, insects, mites, nematodes and viruses.	1

Mapping of CLOs with PLOs (MS Mixed Mode)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Demonstrate comprehensive knowledge and skills of biology regard to insects and pathogens, disease triangle, epidemics, forecasting and various aspects of plant protection.	1,5,6,8
	CLO2	Demonstrate ability to identify and explain plant pests (insects, mites, pathogens & vertebrate animals, weeds etc.) and disorders and estimate crop damages.	1,2, 6,7,8
	CLO3	Demonstrate the ability to analyse and apply various basic knowledge and tools of IPM and IDM to crop protection.	1,2,5,6,7,8
	CLO4	Demonstrate the ability to develop and disseminate integrated management program for insect pests, diseases, and weeds in the field and explain the benefits and limitations of its components.	1,3,6,7,8
	CLO5	Demonstrate the ability to communicate plant protection related information effectively following safety and ethical considerations through various modes (oral and written).	1,3,4,5,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture + Presentation	Class Test
CLO2	Lecture + Presentation + Field visit	Field report evaluation + group work
CLO3	Lecture + Presentation + Field work	Class Test + Field work evaluation
CLO4	Lecture + Presentation	Term Final exam.
CLO5	Lecture + Presentation	Term final examination

Learning Materials

Recommended Readings	1. Agrios, GN. 1990. Plant Pathology, Academic Press, London, UK. 2. Campbel, R. 1989. Biological Control of Microbial Plant Pathogens, Cambridge University Press, London, Uk.

	3. Neergaard, P. 1980. Seed Pathology (Vol. 1 &2), Academic Press, London, UL. 4. Singh, RS. 1980. Plant Diseases. Oxford & IBH Publishing Co. New Delhi, India. 5. Crop Protection Compendium (CPC), 2003. CABI 6. Robert L. Metcalf and W. H. Luckman, 2015. Introduction to Insect Pest Management, 3rd Ed. Wiley
Supplementary Readings	1. Bhutta, A.R. 2010.Text book of introductory seed pathology, HEC., Islamabad. 2. Atwal, A. S and G. S, Dhaliwal.2005. Agricultural Pests of South Asia and their Management, 5th ed. Kalyani Publishers, Ludhiana 3. Agrios, G. N. 2005. Plant Pathology, 5th ed. Elsevier Academic Press Inc., New York. 4. Shah, H. A. and Saleem, M. A. 2005. Applied Entomology. 3rd ed. B. Z. University Press, Multan. 5. Ahmad, I. and Bhutta, A. R. 2004. Text book of Introductory Plant Pathology. Pub. National Book Foundation, Islamabad, Pakistan. 6. Oudejans, J.H.1991.Agro-Pesticides: Properties and functions in integrated crop protection. United Nation Pub. Bangkok. Thailand.

Course Code: 0512 07 PB 5206		**Year:** MS First	**Term:** Second
Course Title: Plant Protection Sessional and Fieldwork			
Course Status: Core			
Credit: 1.0			
Prerequisite(s): None			
Rationale	Besides human, many living organisms e.g. animals, insects, rodents and mites, fungi, bacteria etc. uses plants as a source of food. Crop losses occur due to attack of biotic factors like insects, mites, rodents, pathogens etc. Exploiting highest potential of crop plants on a limited cultivated land area is a challenging job. It is estimated that weeds, insect pest and pathogens currently destroy 45% potential yield of world crops. Practical hands on training of graduates are very much essential to combat theses enemies and to protect our crops from damage. Training on IPM and IDM are also indispensable that encourages minimum uses of chemical pesticides and maximum uses of cultural, mechanical and biological methods of pest management for safe food production.		
Course Objectives	• To introduce the basic knowledge of IPM and IDM. • To focus on various tools of IPM - Cultural, Mechanical, Physical, Biological, Legal and Chemical. • To make students familiar with Components of IDM. • To estimate crop losses due to attack of insects, pathogens and weeds.		

	Course Contents	**CLOs**
1	1. Demonstration of various types of symptoms of diseases of crop plants: Cereals, oilseeds, pulses, fibers, vegetables, fruits and ornamental crops. 2. Isolation and detection of fungi and bacteria from diseases plant materials. 3. Preparation & sterilization culture media and culture of pathogens. 4. Identification of plant pathogens using microscope, biochemical and molecular techniques. 5. Seed health testing 6. Study of insect mouth parts and feeding habits.	1,2,3,4,5

	7. Field identification of major insects, mites, viral vectors of cereal, oilseeds, pulses, vegetables fruit crops and their nature of damage and pest management strategies. 8. Sampling techniques for the estimation of insect population, insect pest damage and damage due to plant diseases. 9. Pest surveillance (through light traps, pheromone traps and field scouting.) and forecasting of pest incidence. 10. Crop loss assessment (Loss due to insects, rodents, diseases and weeds). 11. Study of sprayers, pesticides formulations, calculation of doses and compatibility of pesticides with other agro-chemicals. 12. Study of Pest management strategies: IPM practices, integrated disease management and principles of GAP for safe food production. 13. Visit of farmers' fields and Research Institutes for identification and collection of insects, mites, viral vectors and plant diseases and submitting the field visit report.	

Mapping of CLOs with PLOs (MS Mixed Mode)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Demonstrate comprehensive knowledge and skills to identify biotic factors that threaten crop plants and strategies for pest monitoring and forecasting.	1,2,6,7,8
	CLO2	Understand, analyse and apply various basic knowledge and tools of IPM and IDM.	1,2,3,6,7,8
	CLO3	Differentiate between various insects, mites, plant pathogens and weed control options.	1,6,8
	CLO4	Estimate crop losses due to attack of insects, rodents, pathogens weeds, etc.	1,2,6,8
	CLO5	Evaluate how different methods of control can be intergraded to achieve the goals of crop protection.	1,2,5,6,7,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture+ Presentation+ Field & Lab. Demonstration	Lab. Report evaluation, supplied Specimen identification & labelling
CLO2	Lecture+ Presentation+ Field & Lab. Demonstration	Lab. Exam.
CLO3	Lecture + Presentation	Lab. Report evaluation + Lab. Exam.

CLO4	Lecture + Field demonstration+ Group field work for crop loss assessment	Lab. Report evaluation + Lab. Exam
CLO5	Lecture + Presentation	Viva –voce + Lab. Final exam.

Learning Materials	
Recommended Readings	1. Rangaswami, G., 1972. Diseases of crop Plants in India. Prentice Hall of India Private Ltd. 2. Singh, R. S. 1973. Plant Diseases. 3rd ed. Oxford & IBH. 3. Stakman, E. C. and J. C. Harrar, 1957. Principles of Plant Pathology. The Ronald Press Company, New York. 4. Flint MC & Bosch RV. 1981. Introduction to Integrated Pest Management.1st Ed., Springer, New York. 5. Dhwaliwal GS and Ramesh Arora .2001.Integrated Pest Management-Concepts and Approaches: Kalyanai Publishers, Ludhiana.
Supplementary Readings	1. Corbett, J. K. and H. D. Sister (Ed) 1964. Plant Virology. University of Florida Press. Gainsville, USA 2. Metcalf RL and Luckman WH .1982.Introduction to Insect Pest Management. Wiley Inter Science Publishing, New York. 3. Steinhaus EA . 1949. Principles of Insect Pathology; McGraw Hill Book Co., New York. 4. Labrada, R.; Caseley, J.C. and Parker, C. 1994. Weed Management for developing countries. Published by FAO,Rome, Italy. 5. Alteri, M.A. and Liebman, M. 1988. Weed Management in Agroecosystem : Ecological Approaches, CRC Press,Inc. Boca Raton Florida, U.S.A.

Course Code: 0512 07 PB 5207		Year: MS First	**Term:** Second
Course Title: Plant-microbe Interaction			
Course Status: Optional			
Credit:2.0			
Prerequisite(s):			
Rationale	Plants and microbes interact in many different ways. In this course, interactions between plants and microbes are discussed on a general and detailed level for both pathogenic and symbiotic interactions. Infection mechanisms, the establishment of symbiotic relations, plant defence, resistance and stress responses.		
Course Objectives	• Students will be introduced to key concepts, tools and techniques for studying plant-microbe interactions, and specific beneficial, pathogenic interactions involving viruses, bacteria, and fungi. • Provide knowledge about mechanisms of pathogen attack and defence and resistance to the plant.		

	Course Contents	**CLOs**
	Section A	
1	Colonization by Beneficial Bacteria: Introduction, Attraction, Nutrition, Colonization, General effects, and plant growth-promoting bacteria	1,3
2	Plant-microbe interactions: Types of interactions, rhizosphere and rhizoplane, phyllosphere and phylloplane, mycorrhizae; Impact of interactions on agricultural ecosystems, and nitrogen fixation	2, 4
3	Plant virus: Plant virus movement, Plant defense responses against viruses, Plant virus transmission	4,5
4	Molecular mechanisms of plant-microbe interactions: Plants' perception of microbial signals, signal transduction pathways, and associated defense mechanisms.	2, 4
	Section B	**CLOs**
5	Role and function of molecules of interest (salicylic ac., fatty acids, ethylene, active oxygen species, phytoalexins, jasmonates, nitric oxide) in plant resistance to pathogens.	1, 2

6	Plant-Microbe Interaction and Recent Trends in Biotechnology for Secondary Metabolites Production in Plants.	3
7	Mechanisms of pathogen attack and defense in the interactions between plants and pathogens. Genetic analysis of interactions.	4,5
8	Induction of Plant resistance: Mechanisms of RNAi involved in plant-pathogen interaction. Interaction gene to gene, structure, and function of gene R.	2,3,4

Mapping of CLOs with PLOs (MS Mixed Mode)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Comprehensively discuss the pathogenic and symbiotic plant-microbe interactions.	1,2,7,8
	CLO2	Clarify the physiological and biochemical processes hidden in the best-characterized plant-microbe interactions.	1,6,8
	CLO3	Draw a link between the biology of plant-microbe relationships and their impact on the Ecosystem.	1,2,4,7
	CLO4	Comprehensively discuss interactions between plants and pathogenic fungi, bacteria and viruses as well as the defence reactions of the host plant (biotic stress).	1,2,3

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Presentation	Quiz, Continuous Assessment and Final Examination
CLO2	Lecture and Presentation	Continuous Assessment and Final Examination
CLO3	Lecture and Presentation	Continuous Assessment, and Final Examination
CLO4	Lecture and Group Discussion	Continuous Assessment, and Final Examination

Learning Materials	
Recommended Readings	1. Ben Lugtenberg, Principles of Plant-Microbe Interactions: Microbes for Sustainable Agriculture, ISBN-13 : 978-3319085746

	2. Plant–Microbe Interactions for Sustainable Agriculture: Fundamentals and Recent Advances, Publisher: Springer New Delhi Heidelberg New York Dordrecht London 3. Vidhyasekaran, P. Fungal Pathogenesis in Plants and Crops: Molecular Biology and Host Defence. Mercle Dekker Inc, New York.
Supplementary Readings	1. Jan Schirawski and Michael H. Perlin,Plant Microbe Interaction, ISBN 978-3-03897-328-7

Course Code: 0512 07 PB 5209	Year: MS First	**Term:** Second
Course Title: Plant Functional Genomics		
Course Status: Optional		
Credit: 2.0		
Prerequisite(s): Plant physiology, Molecular Genetics		
Rationale	Plant functional genomics is an area of biological science and relevant to conventional biological sciences like plant physiology, genetics, biochemistry, pathology and plant breeding, etc. Plant functional genomics focuses on the structure, function and evolution of whole plant genomes. as well as individual genes, their interaction and network. Functional genomics is the cornerstone of genomics and helps understand the reproduction, adaptation and evolution of living organisms.	
Course Objectives	This course will teach students to understand, evaluate, and apply next-generation molecular techniques used in the study of biological systems. Subjects will include linkage analysis and genetic and association mappings, proteomics, NextGen genome and transcriptome sequencing, as well as the informatics associated with these technologies. Lectures will encompass the fundamentals of the technologies, their applications and challenges associated with the techniques and data interpretation. In-class tutorials and homework assignments will introduce example datasets and software tools.	

Course Contents		**CLOs**
	Section A	
1	**Plant Genomes and Genes**: Plant genetic material, The shifting genomic landscape, Transposable elements,	1,2
2	**Forward And Reverse Genetics**: Targeted Plant Genome Editing via the CRISPR/Cas9 Technology; QTL Mapping Using High-Throughput Sequencing; Genome-Wide Association Mapping; Tilling by Sequencing.	1,2,3
3	**RNA Interference**: Introduction; Methods and Protocols; Applications; Targeting Transgenes in Arabidopsis using RNAi; Tissue-Specific RNA Silencing; Advantages of Using RNAi in Plant Functional Genomics.	1,2

4	**Expression profiling**: DNA microarrays for expression analysis; Counting RNA Molecules (ESTs, SAGE and MPSS^{TM}); Proteomics	1,2
Section B		**CLOs**
5	**New Frontiers in Plant Functional Genomics**: Introduction; Library Generation; Emulsion PCR; Sequencing by Ligation; Base Calling; Potential Applications	1,2,3
6	**Next Generation Tools for Functional Genomics**: Introduction; Methods and Protocols; Data Analysis; Applications.	1,2
7	**Structural, Functional, and Comparative Annotation of Plant Genomes**: Introduction; Structural Annotation; Functional Annotation; Comparative Annotation; Perspectives.	1,2

Mapping of CLOs with PLOs (MS Mixed Mode)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Use critical thinking skills to understand the advanced technology in plant genomics, create hypotheses and describe the approaches to test these hypotheses in genomics.	1,7,8
	CLO2	Understand the knowledge of plant genomics that promotes agriculture and benefits society.	4,5,6,7,8,9
	CLO3	Engage in solving social problems and understand social concerns about new technology.	1,5,6,7,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	The course will be taught using a hybrid of lectures, group presentations, class discussions,	Quiz, Continuous Assessment and final examination
CLO2	Lecture, presentation	Quiz, Continuous Assessment and final examination
CLO3	Lecture, Presentation and Discussion	Quiz, Continuous Assessment and final examination

Learning Materials	
Recommended Readings	1. Erich Grotewold, Joseph Chappell, Elizabeth A. Kellogg, 2015. Plant Genes, Genomes and Genetics. John Wiley & Sons, Inc., publication. 2. Christopher A. Cullis, 2004. Plant Genomics and Proteomics. John Wiley & Sons, Inc., publication.

	3. Gunter Kahl and Khalid Meksem, 2005. The Handbook of Plant Functional Genomics. WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim.
Supplementary Readings	

Course Code: 0512 07 PB 5211	**Year:** MS First	**Term:** Second
Course Title: Circular Agriculture and Artificial Intelligence		
Course Status: Optional		
Credit: 2.0		
Prerequisite(s): None		

Rationale	This course is intended to provide an interdisciplinary, integrated overview of the most recent developments in the fields of circular agriculture and artificial intelligence, as well as the potential uses of these technologies in the agricultural farming industry.
Course Objectives	• To explain the basic principles of circular agriculture • To understand how AI is being used in the current agricultural sector • To know the detailed description of the latest tools and technologies for the farming industry • To acquire the most-needed solutions to dealing with the planetary emergency

Course Contents		**CLOs**
Section A		
1	**Introduction:** Fundamental concept and key principles of circular agriculture. Purpose and need for circularity in agri-food production. Problems of the traditional farming industry, Opportunities, barriers, andboundaries towards the circular system. Policies to promote circular agriculture.	1,3
2	**Approaches and Practices:** Circular approaches in small-scale food production. Circular agricultural practices; mixed farming, urban farming, organic farming, regenerative agriculture, carbon farming, precision farming, climate-smart farming, permaculture, hydroponics, agroforestry, etc. Circular agriculture in low and middle-income countries	2

3	**Strategies and Design:** Strategies to achieve circular agriculture, System requirements, and design for circular farming in crops, microbes, livestock, poultry, pig, and aquaculture sector.	2
4	**Waste Management and Circular Economy:** Modern concept of farm waste management. Optimal use of waste streams. Nutrients recycling, water recycling, and wastewater reuse. AgroCycle: developing a circular economy in agriculture. Biological and technical cycles in the circular economy. Blue-bioeconomy. Biocircular business model. Contribution of agriculture to the circular economy and sustainable development.	3
Section B		**CLOs**
5	**AI in Agriculture:** IoT, Big data, and AI in Agriculture 5.0. Challenges while adopting AI. Present and future prospects, market size, the demand for Al in smart farms and agri-food industries; Ethics, regulations, safety concerns of AI technologies.	4
6	**IoT, Sensor and Remote Sensing:** Types, advantages, and limitations of sensors. Remote sensing: soil health monitoring, crop yield prediction, crop health monitoring, rainfall, weather forecasting, and so on. Data-driven agriculture 4.0; net production and consumption, real-time data on agricultural market and network, import-export volume details, etc.	2,4
7	**Robotic Farming Industry:** Major components of robots. Types and functions of farm robots; crop harvest robot, weeding robot, robotic greenhouse, etc. Need for robots in the farming industry. Application and benefits of robotic farming. Agricultural robot companies.	4
8	**Farm Imaging & Automation:** Types & functions of different drones; seed planting, imaginary aerial drones, sprayer drones, etc. Significance of drones in the farming industry. Image-based insight generation; identifying the readiness of crops, smart irrigation, fertilization & field management system etc. Intelligent farm machinery.	4

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Understand the fundamental concept and key principles of circular agriculture.	1,2,3,4,6,7,8,9
	CLO2	Elucidates various types of approaches, designs and tools available for intelligent farming.	1,2,6,7,8,9
	CLO3	Provide quality food by recycling nutrients within agriculture to feed not only humans but also the soil, its microbes, and other living species on this planet.	1,2,3,4,6,7,8,9
	CLO4	Acquire information about different types of regulations and policies made all over the	1,2,5,6,7,8,9

		world that motivate farmers and innovators to invest and adopt the AI-enabled tools and farming systems for sustainable circular food production.	

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, Viva voce and Final Exam.
CLO2	Lecture, Discussion, Tutorial and Presentation	Quiz, Continuous Assessment, Assignment, Viva voce and Final Exam.
CLO3	Lecture, Discussion, Tutorial and Presentation	Quiz, Continuous Assessment, Assignment, Presentation and Final Exam..
CLO4	Lecture, Discussion, Tutorial and Presentation	Quiz, Continuous Assessment, Assignment, Presentation, Viva voce and Final Exam.

Learning Materials	
Recommended Readings	1. Food in a Planetary Emergency by Dora Marinova, Diana Bogueva 2. Artificial Intelligence, IoT and Machine Learning By Latief Ahmad, Firasath Nabi
Supplementary Readings	

Major
in
Environmental Biotechnology

Course Code: 0512 07 EB 5201	Year: MS First	Term: Second
Course Title: Environmental Microbiology		
1Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		
Rationale	This course describes microorganisms and their role in the environment. The dynamic activities of microorganisms in nature bringing froth continuous changes in our surroundings. These phenomenon of microorganisms can be utilized to make valuable products, goods and services.	
Course Objectives	• To understand dynamisms of microorganisms in nature and its utilization in biotechnology.	

Course Contents		**CLOs**
Section A		
1	Introduction to environmental microbiology; classification of microorganisms; microbial habitats- aero-microbiology, soil microbiology, aquatic microbiology, and microbiology of extreme environment.	1,2
2	Microorganisms in key biogeochemical events- carbon, nitrogen, phosphorus sulphur and iron cycles.	1
3	Action of microorganisms on organic and metal pollutants; mechanisms- biodegradation, bioremediation, biotransformation	1, 3
Section B		**CLOs**
4	Environmentally transmitted pathogens; water-borne pathogen- control and detection- total coliforms, faecal coliforms and *Escherichia coli*. Use of microorganisms in assessment of chemical pollutants.	3
5	Municipal wastewater treatment- the nature of wastewater; treatment of liquid wastes; treatment of solid wastes.	1,3

6	Metagenomics, ecogenomics, proteomics, metabolomics for environmental microbiology. Special and applied topics in environmental microbiology.	3,4

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	1	Understand the relationship of microorganisms to environmental processes.	1,2,3,4,6,7,8,9
	2	Assess microorganisms in different environment.	1,2,3,4,6,7,8,9
	3	Learn about the utilization of microorganisms in pollutants removal.	1,2,3,4,6,7,8,9
	4	Recognize the ways of identifying environmental microorganisms	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, presentation	Quiz, assignment, viva
CLO2	Lecture, presentation, hands on training	Assignment, final exam.
CLO3	Lecture, presentation, hands on training	Assignment, final exam.
CLO4	Lecture	Final exam., viva

Learning Materials

Recommended Readings	1. Pepper, I. L., Gerba, C. P. and Gentry, T. J. 2015. Environmental Microbiology. 3rd edition, Academic Press. 2. Madigan, M. T. and Martinko, J. M. 2006. Brock's biology of microorganisms. 11th edition. Pearson Education Inc. 3. Pelczar, M. J. Jr., Chan, E. C. S. and Krieg, N. R. 1993. Microbiology, 5th Edition, TataMacGraw Hill Press.
Supplementary Readings	1. Lammert, J. M. 2006. *Techniques for Microbiology: A Student Handbook*. Benjamin Cummings. 2. Dubey, R. C. and Maheswari, D. K. 2002. *Practical Microbiology*. 2nd Edition, S. Chand & Co., New Delhi

Course Code: 0512 07 EB 5202	**Year:** MS First	**Term:** Second
Course Title: Environmental Microbiology Sessional and Fieldwork		
Course Status: Core		
Credit: 1.0		
Prerequisite(s): None		
Rationale	The course provides hands on training in environmental microorganisms, their assessment, identification and utilization.	
Course Objectives	• To assess environmental microorganisms and their utilization.	

	Course Contents	CLOs
1	Cultivation and counting of bacteria in soil, air and water.	1
2	Isolation of thermophilic, acidophilic and alkaliphilic bacteria.	2
3	Cultural method for rapid detection of *E. coli*.	2
4	Removal of pollutants from contaminated water using microorganisms.	3
5	DNA extraction, amplification of 16S rRNA genes of bacteria.	4

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	1	Count bacterial load in soil, air and water	1,2,3,4,6,7,8,9
	2	Recognize different types of bacteria	1,2,3,4,6,7,8,9
	3	Demonstrate removal of pollutants using microorganisms.	1,2,3,4,6,7,8,9
	4	Identify bacteria in molecular ways.	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, lab., hands on training	Quiz, assignment, exam. viva
CLO2	Lecture, lab., hands on training	Quiz, exam., viva
CLO3	Lecture, lab., hands on training	Quiz, exam.
CLO4	Lecture, lab., hands on training	Quiz, assignment, exam. viva

Learning Materials

Recommended Readings	1. Lammert, J. M. 2006. *Techniques for Microbiology: A Student Handbook*. BenjaminCummings. 2. Dubey, R. C. and Maheswari, D. K. 2002. *Practical Microbiology*. 2nd Edition, S. Chand & Co., New Delhi.
Supplementary Readings	1. Pepper, I. L., Gerba, C. P. and Gentry, T. J. 2015. Environmental Microbiology. 3rd edition, Academic Press. 2. Madigan, M. T. and Martinko, J. M. 2006. Brock's biology of microorganisms. 11th edition. Pearson Education Inc. 3. Pelczar, M. J. Jr., Chan, E. C. S. and Krieg, N. R. 1993. Microbiology, 5th Edition, TataMacGraw Hill Press.

Course Code: 0512 07 EB 5203	**Year:** MS First	**Term:** Second
Course Title: Waste Treatment and Management		
Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		
Rationale	Waste treatment management is important as it saves the environment from the toxic effects of inorganic and biodegradable element present in waste. course will provide students a basic understanding of the types of waste generated by industry and the impacts they can have on the environment. Furthermore, students will get acquainted with various types of treatment and management approaches. The knowledge gained in this course will thus help graduates to understand the role that they can play in processing and managing waste at work.	
Course Objectives	The objectives of the course are to acquire fundamental knowledge on wastes generated from household, agriculture, industrial etc sectors coming from both rural and urban settings; identify and analyze different methodologies of waste treatment; and appraise the classical and modern waste management practices.	

Course Contents		**CLOs**
Section A		
1	**Introduction to Waste Treatment:** Definition and classification of waste; Waste treatment processes; controlling factors of biological processes;	1, 2, 3
2	**Wastewater treatment:** Introduction, types of water contaminants, wastewater microbiology, wastewater treatment processes, mass balance (solid-liquid separation)	1, 2, 3
3	**Solid waste:** Introduction, categories of solid wastes, treatment, processing and disposal of municipal solid waste, hazardous and medical waste, agricultural and food waste,	1, 2, 3
4	**Biotechnology in waste processing:** Bioconversion of organic waste,	1, 2, 3

	bioconversion technologies: microbial anaerobic digestion, enzymatic hydrolysis, insect and worm farming, waste valorization processes and conversion to value-added products	
Section B		**CLOs**
5	**Introduction to waste management:** Waste generation and management in modern societies; impact of waste on health and environment; waste management and integrated waste management, waste management hierarchy, sustainability and circular economy considerations	1, 2, 3
6	**Emerging wastes requiring multilevel management:** Medical waste; microplastic; laboratory waste; nuclear waste; implication of biotechnology on emerging waste	1, 2, 3
7	**Regulation of waste**: Introduction; the growth of environmental legislations; solid and hazardous waste legislation; water quality legislation	1, 2, 3
8	**Best practices in waste management:** Waste governance; waste management accountability;	1, 2, 3

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	1	Understand the knowledge-base of current and futuristic waste treatment and management approaches.	1,2,4,5,6,7,8,9
	2	Analyze and assess usage of the tools of waste treatment and management.	1,2,3,4,5,6,7,9
	3	Appraise the social and ethical perspectives of waste management	1,2,5,6,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture, presentation, group discussion	Written test, assignment, viva voce
CLO2	Lecture, presentation, group discussion	Written test, assignment, viva voce
CLO3	Lecture, presentation, group discussion	Written test, assignment, viva voce

Learning Materials

Recommended Readings	1. Jonathan Wong, et al (2020) Current Developments in Biotechnology and Bioengineering: Sustainable Food Waste Management: Resource Recovery and Treatment, 1st Edition, Elsevier 2. Trevor M. Letcher, Daniel Vallero (2019) Waste: A Handbook for Management, 2nd Edition, Academic Press

	3. John Pichtel (2014) Waste Management Practices: Municipal, Hazardous, and Industrial, Second Edition, 2nd Edition, CRC Press 4. Rumana Riffat (2019) Fundamentals of Wastewater Treatment and Engineering, 1st Edition, CRC Press
Supplementary Readings	1. Saleh S. Al Arni, Mahmoud M. Elwaheidi (2020) Concise Handbook of Waste Treatment Technologies, CRC Press 2. Frank Kreith, George Tchobanoglous (2002) Handbook of Solid Waste Management, 2nd Edition, McGraw Hill

Course Code: 0512 07 EB 5204	**Year:** MS First	**Term:** Second
Course Title: Waste Treatment and Management Sessional and Fieldwork		
Course Status: Core		
Credit: 1.0		
Prerequisite(s): None		
Rationale	Treatment, processing and management of waste has become a burning issue from villages to cities. Only a small quantity of solid waste is collected and a miniscule of it is properly segregated and reused. Thus waste are either seen littered along streets or end up in landfills, creating lot of health issues for the people in the society. One of the reasons for not recovering wealth from waste is non-availability of people trained in managing wastes. Biotechnology is historically contributing to the waste processing and have a major role to play in coming future. Therefore, practical skills on waste treatment and management is deemed essential for biotechnology graduates.	
Course Objectives	• To provide knowledge and skill regarding technological, organizational and legislative developments and practices on waste treatment and management.	

	Course Contents	**CLOs**
1	Composition of Solid Waste	1, 2
2	Properties of solid waste: Physical, chemical and biological properties	1, 2
3	Various methods of waste treatment and resource recovery	1, 2
4	Waste management practices including legislative issues	3

Course Learning	Upon completion of this course the students will be able to:	**Mapping with PLOs**

Outcomes (CLOs)	1	Understand the techniques and approaches of waste treatment and management.	1,3,4,7,8,9
	2	Analyze and identify suitable treatment process and management strategy	2,3,6,7,8,
	3	Appraise the social and legal implication of waste management	2,4,5,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture, presentation, group discussion, field trip, hands on training	Written test, assignment, viva voce
CLO2	Lecture, presentation, group discussion, field trip, hands on training	Written test, assignment, viva voce
CLO3	Lecture, presentation, group discussion, field trip, hands on training	Written test, assignment, viva voce

Learning Materials

Recommended Readings	1. George Tchobanoglous, Kilary Theisen, Samuel Vigil, "Integrated Solid Waste Management", Mcgraw-Hilllnc, International Edition. 2. Howard Peavy, Donald Rowe, George Tchobanoglous, "Environmental Engineering", Mcgraw Hill Inc, International Edition. 3. Frank Kreeith, "Handbook of Solid Waste Management", Mcgraw Hill Inc
Supplementary Readings	1. NPC / IUCN National Conservation Strategy Implementation Program 2. Integrated Resource Recovery in Municipal Solid Waste Management, The World Bank

Course Code: 0512 07 EB 5205	**Year:** MS First	**Term:** Second
Course Title: Environmental Toxicology		
Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		

Rationale	This course is designed to provide in depth knowledge on environmental toxicants and their consequences on humans, animals and the environment.
Course Objectives	• To provide knowledge on environmental pollutants and their effects. • To learn effective control measures of hazardous pollutions. • To give basic knowledge on toxicology. • To acquire information of molecular insights into toxicity.

	Course Contents	**CLOs**
	Section A	
1	**Introduction to Toxicology:** History of poisons and evolution of toxicology; Toxicants and their sources; Routes of exposure; Dose-response relationship; Heavy metal toxicity.	1
2	**Measurement of Toxicity:** LD50 and LC50; Bioassay methods of ecotoxicity assessment; Biosensors for environmental toxicity assessment.	1,2,3
3	**Specialized Toxicology and Case Studies:** The instructor will provide a number of case studies related to environmental toxicity before the beginning of the course.	1,2,3
	Section B	**CLOs**
4	**Molecular Insights into Toxicity:** Effects of toxicants on kinases, phosphatases and endocrine signalings; Overview of reproductive and developmental toxicology; Environmental impacts on gut microbiota.	1,2

5	**Developmental and Reproductive Toxicity:** Concept of male and female reproductive toxicity; Teratogenecity; Mechanism of different teratogens during development; Assessment of developmental abnormalities.	1,2,3
6	**Toxicogenomics:** Genotoxic substances; Various aspects of genetic and epigenetic toxicology.	1,3
7	**Recent Trends on Environmental Pollutants and Toxicology**: Students will have to prepare presentations and discuss related topics in toxicology (to be provided by instructors short before the beginning of the course).	1,2,3

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	1	Acquire advanced information in environmental pollutants and its toxicity.	1,2,5,7,8,9
	2	Have knowledge to control environmental pollutions	1,2,3,4,5,6,7,8,9
	3	Discuss the new areas within of environmental toxicology.	1,3,4,6,7,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and/or tutorial	Quiz, Continuous Assessment
CLO2	Lecture and/or tutorial and/or Group discussion	Continuous Assessment, Assignment and Final Exam
CLO3	Lecture and/or presentation and/or Group discussion	Continuous Assessment, Assignment and Final Exam. Viva voce

Learning Materials

Recommended Readings	1. Klaassen, C., L.J. Casarett, and J. Doull, Casarett & Doull's Toxicology: The Basic Science of Poisons, Eighth Edition. 2013: McGraw-Hill Education. 2. Ernest Hodgson, Ed A Textbook of Modern Toxicology, Fourth Edition Hoboken, NJ: John Wiley & Sons, Inc, 2010. ISBN: 978-0-470-46206-5. 3. Wright and Welbourn, Environmental Toxicology. Cambridge University Press, NY. 4. Patricia Frank and M. Alice Ottoboni, The Dose Makes the Poison, 3rd Edition, John Wiley and Sons, Inc., ISBN: 978-0-470-91844-9. 5. Online recourses and peer reviewed journal articles.

Supplementary Readings	1. Guo HR, Hashim Z, Su SB, Bundschuh J. Environmental toxicology in addressing public health challenges in East Asia. BioMed research international. 2015 Apr 29; 2015. 2. Keikotlhaile BM, Spanoghe P, Steurbaut W. Effects of food processing on pesticide residues in fruits and vegetables: a meta-analysis approach. Food and Chemical Toxicology. 2010 Jan 1;48(1):1-6. 3. Wegner C, Nau H. Alteration of embryonic folate metabolism by valproic acid during organogenesis: implications for mechanism of teratogenesis. Neurology. 1992 Apr 1;42(4 Suppl 5):17-24. 4. Honein MA, Gilboa SM, Broussard CS. The need for safer medication use in pregnancy. Expert review of clinical pharmacology. 2013 Sep 1;6(5):453-5.

Course Code: 0512 07 EB 5207	**Year:** MS First	**Term:** Second
Course Title: Environmental Chemistry		
Course Status: Optional		
Credit: 2.0		
Prerequisite(s): None		
Rationale	Environmental Chemistry is an application of chemical principles to the study of the environment. It includes natural processes and pollution problems related to air, water, and soil. Students will learn about the chemistry of organic and inorganic compounds, whether they are produced on purpose or generated as by-products of industrial processes, and about their reactivity and their interactions with living systems. Well-developed interdisciplinary skills and a high level of analytical understanding provided by the Environmental Chemistry course would enable the biotechnology graduates toward excellent job prospects.	
Course Objectives	• To provide knowledge on atmospheric chemistry. • To enable students with contemporary and futuristic concepts of pollution, toxicity and climate change. • To train students with the analytical approaches regarding environmental chemistry.	

Course Contents		**CLOs**
Section A		
1	**Introduction to Environmental Chemistry :** Environmental chemistry; environmental composition; chemical processes; anthropogenic effects	1, 2

2	**Atmospheric Chemistry :** Stratospheric chemistry; the ozone layer; the chemistry of ground level air pollution; environmental and health consequences of polluted air	1, 2
3	**Hydrospheric Chemistry:** The chemistry of water; water pollution; water purification; aquatic microbial biochemistry	1, 2
4	**Geosphere and Geochemistry:** The geosphere; geochemistry and weathering; effect of human activities; geosphere as a waste repository	1, 2
Section B		**CLOs**
5	**Toxicological Chemistry :** Introduction to toxicology and toxicological chemistry; dose-response relationship; reversibility and sensitivity; xenobiotic and endogenous substances; teratogenic, mutagenic and carcinogenic toxic substances; toxic elements and elemental forms; toxic inorganic compounds; toxic organic compounds; chemical analysis in environmental and toxicological chemistry	2
6	**Energy and Climate Change :** The greenhouse effect; fossil fuels; global climate change; biofuels and other alternative fuels; renewable energy technologies	2, 3
7	**Industrial Ecology and Green Chemistry :** Industrial ecology; components of industrial ecosystem; the Kalundborg industrial ecosystem; environmental impact of industrial ecology; green chemistry; waste prevention and green chemistry; green chemistry and synthetic chemistry; feedstocks, reagents, media and solvents	1, 2, 3

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	1	Explain and demonstrate knowledge of concepts and assumptions related to the processes impacting earth's chemical processes.	1,2,3,6,7,8
	2	Synthesize and evaluate scientific information about the pollution, toxicity and climate change.	1,2,3,4,,6,7,8,9
	3	Discuss the new areas within of environmental toxicology.	1,2,4,5,6,7,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture, presentation, case study, assignment, group discussion	Written exam, viva voce, presentation
CLO2	Lecture, presentation, case study, assignment, group discussion	Written exam, viva voce, presentation

CLO3	Lecture, presentation, case study, assignment, group discussion	Written exam, viva voce, presentation

Learning Materials

Recommended Readings	1. Gary W vanLoon and Stephen J Duffy (2018) Environmental Chemistry: A Global Perspective, Oxford University Press, 4th Edition 2. Colin Baird and Michael Cann (2012) Environmental Chemistry, WH Freeman, 5th edition 3. Stanley E Manahan (2022) Environmental Chemistry, CRC Press, 11th edition

Course Code: 0512 07 EB 5209	**Year:** MS First	**Term:** Second
Course Title: Biodiversity and Bioprospecting		
Course Status: Optional		
Credit: 2.0		
Prerequisite(s): None		
Rationale	The course provides insight into diversity in plants, animals and microorganisms, their conservation and utilization. It also deals with the transformation of traditional knowledge in bio-resources into modern products and services manufacturing.	
Course Objectives	• To impart knowledge in biodiversity, and bioprospecting aspects related to natural product production.	

Course Contents		**CLOs**
Section A		
1	**Biodiversity:** Interpretation, importance; diversities in plants, animals and microorganisms. Biodiversity in Bangladesh. Factors controlling distribution of biodiversity. Methods used in research on biodiversity and ecosystem function.	1
2	**Chemical prospecting, bionic prospecting and gene prospecting.** Bio-resources mapping, inventorisation and monitoring of biological diversity. Conservation biology, endangered species; the convention on biological diversity; conservation for sustainable development.	1

3	**Drugs derived from plants:** Antitumor agents- etoposide, colchicine, taxol, vinblastine, vincristine; cardiotonic- convallatoxin, acetyldigoxin, adoniside; anti-inflammatory- aescin, bromelain; choleretic- curcumin; antimalarial-quinine- cinchona; analgesic- morphine- opium. Volatile, pigments and terpenes, phenols, flavonoids.	1,2
Section B		**CLOs**
4	**Drugs derived from microorganisms:** Screening for bioactivity; antimicrobials; pharmacologically active agents; industrial enzymes; plant growth promoting agents; antifoulants and anti-biofilm agents.	1,2
5	**Drug discovery and product development:** Discovery from traditional medicine; modern tools in drug discovery; role of chromatography in drug analysis including HPLC, GC and LC and GC; mass spectrometry, FT-IR, -NMR their principles and merits. Product development procedures and policies.	1,3
6	**Regulatory legislation and convention in bioprospecting:** Rules and regulations in patenting of products and process development and various conventions pertaining to bioprospecting of products from microorganism, plant and animal products. Bioprospecting policies. Approval and IPR, protection policies of bioprospecting.	4

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	1	Familiarize the students in major areas of biodiversity and bioprospecting.	1,3,4,6,7,8,9
	2	Obtain a comprehensive knowledge about natural products from bioresources	1,2,3,4,5,6,7,8,9
	3	Gain knowledge on drug discovery and related modern tools.	1,2,3,4,5,6,7,8,9
	4	Familiar with regulatory legislation and convention in bioprospecting for commercialization.	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, presentation, group work	Quiz, Assignment, continuous assessment
CLO2	Lecture, presentation	Assignment, viva, final exam.
CLO3	Lecture, presentation	Assignment, viva, final exam.
CLO4	Lecture, presentation, group work	Assignment, viva, final exam.

Learning Materials

Recommended Readings	1. Pullin A. S. 2002. *Conservation Biology*. Cambridge University Press, Cambridge, UK. 2. Magurran A. E. 2004. *Measuring Biological Diversity* .Blackwell Publishing, MA, USA. 3. Paterson R. and Lima N. (Editors). 2017. Bioprospecting: success, potential and constraints (topics in biodiversity and conservation). Springer
Supplementary Readings	1. Scheppler J. A. Cassin P. E. and Gambier R. M. 2014. Biotechnology explorations: applying the fundamentals. Wiley.

Course Code: 0512 07 EB 5211	**Year:** MS First	**Term:** Second
Course Title: Biotechnology for Sustainable Environment		
Course Status: Optional		
Credit: 2.0		
Prerequisite(s): None		
Rationale	Biotechnological processes, products and services significantly contribute sustainable development through overcome the challenges created by the climate change. The course focuses on biotechnological ways to prevent environmental pollution for optimizing needs of present and the future also.	
Course Objectives	• To familiarize students with modern biotechnological tools that contribute to pollution free sustainable development.	

Course Contents		**CLOs**
Section A		
1	**Introduction:** biotechnology, environment and sustainable development; environmental biotechnology for sustainable future; environmental problems; contamination; pollution- types; biotechnology to control soil, water and air pollutions.	1, 5
2	**Biopesticides-** types, production and applications; biofertilizers- types, production and application; biofuel- methanogenic archaea- characteristics and applications.	2,3, 4, 5

3	**Bioremediation-** types, nano-bioremediation, bioremediation strategies and their significance, bioremediation of metal and polycyclic hydrocarbons.	2, 3, 5
Section B		**CLOs**
4	**Biodegradation-** types, degradation of xenobiotic, microorganisms involved in phenols and bisphenol A biodegradation, degradation pathway.	2, 3, 5
5	**Bioconversion of tannery wastes-** synthetic dye decolourization and degradation; hexavalent chromium reduction and removal; biotransformation of chrome shavings waste into valuable products.	2,3, 4,5
6	Biological wastewater treatment; bioleaching and biohydrometallurgy; Bioreactors, biosensors and nanotechnology for sustainable environment.	2, 3,4,5

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	1	Understand the relationship between biotechnology and sustainable development..	1,3,4,5,6,7,8
	2	Grasp common environmental-friendly ways of pollution control	1,2,3,4,5,6,7,8,9
	3	Demonstrate reduction of pollutants from the environment.	1,2,3,4,5,6,7,8,9
	4	Familiar with regulatory legislation and convention in bioprospecting for commercialization..	1,2,3,4,6,7,8,9
	5	Express the ways to achieve sustainable development	1,4,7,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture, group discussion	Quiz, continuous assessment
CLO2	Lecture, presentation	Assignment, final exam
CLO3	Lecture, presentation	Assignment, final exam
CLO4	Lecture, presentation	Assignment, final exam
CLO5	Lecture, group discussion	Quiz, assignment, continuous assessment

Learning Materials

Recommended Readings	1. Joshi et al. (2021). Biotechnology for Sustainable Environment. Springer 2. Popoola et al. (2022). Bioenergy and Environmental Biotechnology for Sustainable Development. CRC press. 3. Singh R. L. (2016). Principles and Applications of Environmental Biotechnology for a Sustainable Future. Springer

Supplementary Readings	1. Sobti R. C. (2019). Environmental Biotechnology: For Sustainable Future. Springer

Major

in
Microbial Biotechnology

Course Code: 0512 07 MB 5201		Year: MS First	**Term:** Second
Course Title: Microbial Diversity and Bioprospecting			
Course Status: Core			
Credit: 2.0			
Prerequisite(s): None			
Rationale	Microorganisms represent the vast majority of Earth's biodiversity, but are the least-studied organisms in almost every ecosystem. Critically important as pathogens, parasites, mutualists, decomposers, nutrient cyclers, bioremediators, and model systems, microbes represent many unique and remarkable branches on the tree of life. This course is designed for undergraduate students interested in understanding the biodiversity of microbes and their often cryptic but important roles in ecology at scales ranging from individual cells to the planet as a whole. The study of microbial diversity is perhaps more exciting now than ever before – new tools, new methods, and new interdisciplinary approaches are setting the stage for rapid growth, and for applications of material covered in this course to medicine, industry, agriculture, and evolutionary biology.		
Course Objectives	• To offer students with an interest in the remarkable genetic, species-level, physiological, phylogenetic, functional, and ecological diversity of acellular, prokaryotic, and eukaryotic microorganisms.		

Course Contents		CLOs
Section A		
1	Major groups of microorganisms; morphological, biochemical, molecular and ecological characteristics of the major groups of microorganisms; concept of microbial species.	1, 4
2	Diversities in viruses, bacteria, fungi, algae and protozoa & their classification.	1, 4
3	Microscopic, cultural, molecular and genomic methods for studying microbial diversity; phylogenetic analysis.	3
Section B		**CLOs**
4	Microbial assisted production of bioethanol, biogas, bio-glycerol, amino acids, and single-cell protein.	2, 4
5	Microbial biofertilizers- N_2-fixing, P-solubilizing, plant growth promoting; microbial fuel cell- wastewater treatment and bioelectricity production; bioremediation, biodegradation etc.	2, 4
6	Microbial products as novel therapeutics- Prophylactic and therapeutic vaccines, virotherapy, antibiotics and enzymes; biologics; neutrceuticals etc.	2, 4

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Possess a strong grasp of the diversity of microbes from multiple perspectives	1,2,3,4,5,6,7,8,9
	CLO2	Describe the primary roles and importance of major microbial groups	1,2,3,4,5,6,7,8,9
	CLO3	Understand phylogenetic trees and molecular analyses relevant to discovering and understanding microbial diversity	1,2,3,4,5,6,7,8,9
	CLO4	Gain a broad understanding of the importance of microbes in all aspects of human- and ecosystem function	1,4,5,6,7,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture, presentation, discussion	Quiz, assignment, continuous assessment
CLO2	Lecture, presentation	Assignment, final exam.
CLO3	Lecture, presentation	Assignment, final exam.
CLO4	Lecture, presentation, discussion	Quiz, assignment, continuous assessment

Learning Materials	
Recommended Readings	1. Bull, A.T. (Editor) 2004. Microbial Diversity and Bioprospecting. Washington, DC: American Society for Microbiology Press.ISBN 1-555811-267-8. 2. Madigan, M., Martinko, J., Buckley, D. and Stahl, D. 2014. *Brock Biology of Microorganisms*, 14th Edition. Benjamin Cummings, New York. 3. Tortora, G. J., Funke, B. R. and Case, C. L. 2012. *Microbiology: An Introduction*. 11th Edition. Pearson education Pvt. Ltd. Singapore. 4. Colwell, R.R., U.Simidu, and K. Ohwada (Editors). 1996. Microbial diversity in time and space. New York: Plenum Press, c1996. ISBN 0306451948.
Supplementary Readings	1. Margulis et al (2000) Handbook of Protoctista: The structure, cultivation, habitats and life histories of the eukaryotic microorganisms and their descendants exclusive of animals, plants and fungi. Academic Press, New York.

Course Code: 0512 07 MB 5202	Year: MS First	**Term:** Second
Course Title: Microbial Diversity and Bioprospecting Sessional and Fieldwork		
Course Status: Core		
Credit: 1.0		
Prerequisite(s): None		
Rationale	The course provide diversities of microorganisms and its utilization in biotechnology.	
Course Objectives	To have practical knowledge on microbial diversities and its product preparation.	

	Course Contents	CLOs
1	Study on diversities in major groups of microorganisms.	1
2	Isolation and characterization of microbial biofertilizers (*Rhizobium*, *Azotobacter*, BGA), biopesticides (*Bacillus thuringiensis*) and pesticides degrading microorganisms.	2,3
3	Uses of microbial diversities for production of biotechnological products-bioethanol, antibiotics, enzymes etc.	2,3

Mapping of CLOs with PLOs (MS Mixed Mode)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Recognize different groups of microorganisms and its diversities	1,2,3,4,7,8,9
	CLO2	Demonstrate production of important microbial products	2,3,4,5,6,7,8,9
	CLO3	Utilize microorganisms in different purposes	1,2,6,7,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture, hands-on training	Assignment, exam., viva
CLO2	Hands-on training, presentation	Assignment, exam., viva
CLO3	Hands-on training, presentation	Assignment, exam., viva

Learning Materials	
Recommended Readings	1. Collins and Lyne's (1995). Microbiological Methods. 7th Edition, Hodder Education Publishers 2. Colwell, R.R., U.Simidu, and K. Ohwada (Editors). 1996. Microbial diversity in time and space. New York: Plenum Press, c1996. ISBN 0306451948.
Supplementary Readings	1. Bull, A.T. (Editor) 2004. Microbial Diversity and Bioprospecting. Washington, DC: American Society for Microbiology Press.ISBN 1-555811-267-8. 2. Madigan, M., Martinko, J., Buckley, D. and Stahl, D. 2014. *Brock Biology of Microorganisms*, 14th Edition. Benjamin Cummings, New York.

Course Code: 0512 07 MB 5203		Year: MS First	**Term:** Second
Course Title: Microbial Expression Systems			
Course Status: Core			
Credit: 2.0			
Prerequisite(s): None			
Rationale	Expression host systems are employed for the production of recombinant proteins both for therapy and research. Industrial production depends on the use of inexpensive media components and high anticipated economic yield from the product. Besides, the quality of the product is very essential, especially in medicine where production of human pharmaceuticals is regulated under strict safety aspects. Thus, suitable host system needs to be selected depending on the purpose.		
Course Objectives	The objectives of this course are to introduce students to developments/advances made in field of microbial expression systems for application in production of both industrial and therapeutic protein.		

Course Contents		**CLOs**
Section A		
1	**Prokaryotic expression hosts:** Major aspects of *Escherichia coli, Bacillus subtilis, Bacillus megaterium, Pseudomonas, Corynebacterium, Lactococcus lactis* and *Ralstonia eutropha.*	1,2

2	**Eukaryotic expression hosts:** Major aspects of Yeast, Fungus and Insect systems.	1,2
3	**Choice of host organism:** The intelligent choice of a host organism, Cloning strategies envisioned by an "in silico" multistep cloning, Promoter strength and induction, Copy number and silencing problems in heterologous hosts.	1,2,3
Section B		**CLOs**
4	**Selection of expression vector:** Choice of, and placement of purification tags, Secretion of proteins and signal trapping, Post-translational modifications in different host organisms, Inclusion bodies and folding of proteins, Expression of membrane proteins compared to soluble proteins.	1,2,3
5	**Heterologous expression of recombinant proteins:** Heterologous expression for production of antibodies, Expression of toxic proteins, Transient expression and Optimisation of expression level.	1,2,3,4
6	Recent development of heterologous gene expression in different expression hosts.	1,4

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Develop deeper understanding about the main features of different microbial protein expression systems.	1,2,3,4,6,7,8
	CLO2	Design an appropriate strategy for the expression of target protein in selectively designed expression host.	1,2,3,4,5,6,7,8,9
	CLO3	Create an optimal genetically modified expression host.	1,2,3,4,5,6,7,8,9
	CLO4	Apply their expertise in both industrial and therapeutic protein production industry.	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	Continuous Assessment
CLO2	Lecture and Presentation	Continuous Assessment and Assignment.
CLO3	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO4	Lecture and Group Discussion	Viva voce and Final Exam.

Learning Materials	
Recommended Readings	1. (2016) Heterologous Expression of Membrane Proteins: Methods and Protocols (Methods in Molecular Biology), Humana Press,

	Second Edi., 2016, Esabelle Mus-Veteau. https://link.springer.com/book/9781071623671 2. (2016) Kraševec, N., Benčina, M. Gene Expression in Filamentous Fungi: Advantages and Disadvantages Compared to Other Systems. In: Schmoll, M., Dattenböck, C. (eds) Gene Expression Systems in Fungi: Advancements and Applications. Fungal Biology. Springer, Cham. https://doi.org/10.1007/978-3-319-27951-0_8. 3. (2009) Heterologous Expression. In: Binder M.D., Hirokawa N., Windhorst U. (eds) Encyclopedia of Neuroscience. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-29678-2_2190. 4. (2009) Heterologous Expression System. In: Binder M.D., Hirokawa N., Windhorst U. (eds) Encyclopedia of Neuroscience. Springer, Berlin, Heidelberg. https://doi.org/10.1007/978-3-540-29678-2_2191
Supplementary Readings	1. Rader.R.A.(2008). Biopharmaceutical Expression Systemsand Genetic Engineering Technologies: Current and Future Manufacturing Platforms, Bioplan Associates Inc., ISBN1-934106-14-3, Rockville. 2. Vermasvuori, R., Koskinen, J., Salonen,K., Sirén, N., Weegar, J., Dahlbacka, J., Kalkkinen, N., vanWeymarn, N.(2009). Production of Recombinant HIV-1 Nef Protein Using Different Expression Host Systems: A Techno-Economical Comparison, *Biotechnology Progress,* 25(1),pp.95-102. 3. Hans-Peter Meyer and Diego R. Schmidhalter (2012). Microbial Expression Systems and Manufacturing from a Market and Economic Perspective, Innovations in Biotechnology, Dr. Eddy C. Agbo (Ed.), ISBN: 978-953-51-0096-6, InTech, Available from:http://www.intechopen.com/books/innovations-in-biotechnology/microbial-expression

Course Code: 0512 07 MB 5205	**Year:** MS First	**Term:** Second
Course Title: Industrial Microbiology and Fermentation		
Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		

Rationale	The course is designed to provide detailed knowledge on the application of microbiology in the area of fermentation and related product development.
Course Objectives	• To understand detailed area of application of microbiology in industrial production processes. • To explain the principles and theories in various bioprocess operation and fermenter development. • To discuss various aspects on large-scale bioprocess.

	Course Contents	**CLOs**
	Section A	
1	**Introduction:** Microbial growth curve and metabolite production. Industrially important microbes.	1
2	**Industrial microbes handling:** Types of culture, preparation of industrial culture, characteristics.	2
3	**Industrial media:** Types of media, media preparation, media sterilization, sterilization kinetics.	2

4	**Inocula development:** Inocula development for bacteria, Inocula for yeasts.	2
Section B		**CLOs**
5	**Fermentation:** Basic fermentation process, fermenter hardware, aeration system, mode of operation, process kinetics and design, maintaining aseptic conditions.	1, 3
6	**Process control:** Process variables, Instrumentation and control system.	4
7	**Separation techniques:** Importance, cell removal and cell disruption techniques, separation steps, separation processes.	5
8	**Waste water treatment:** Waste water characteristics, treatment strategies.	6

Mapping of CLOs with PLOs (MS Coursework)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Learn industrial importance of microbiology and know about different bioprocesses	1,3,5,6
	CLO2	Gather knowledge on basic and applied knowledge on industrial fermentation process.	1
	CLO3	Learn critical issues of bioreactor and its operation	1,3,4,5,6
	CLO4	Understand instrumentation and control of bioreactors	1,3,4,5,6
	CLO5	Understand various separation and purification processes of bioproducts.	1,3,4,5,6
	CLO6	Know waste water treatment process.	1,3,5,6

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Learn industrial importance of microbiology and know about different bioprocesses	1,5,7,8
	CLO2	Gather knowledge on basic and applied knowledge on industrial fermentation process.	1,3,9
	CLO3	Learn critical issues of bioreactor and its operation	1,5,6,7,8
	CLO4	Understand instrumentation and control of bioreactors	1,5,6,7,8
	CLO5	Understand various separation and purification processes of bioproducts.	1,5,6,7,8
	CLO6	Know waste water treatment process.	1,3,5,7,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**

CLO1	Lecture, Q-A session	Continuous Assessment and Final Exam.
CLO2	Lecture	Continuous Assessment and Final Exam.
CLO3	Lecture, group discussion	Continuous Assessment and Final Exam.
CLO4	Lecture, group discussion	Continuous Assessment and Final Exam.
CLO5	Lecture, group discussion	Continuous Assessment and Final Exam.
CLO6	Lecture	Continuous Assessment and/or Final Exam.

Learning Materials	
Recommended Readings	1. P. F. Stanbury, A. Whitaker and S. J. Hall. Principles of Fermentation Technology, 2nd edition, Butterworth-Heinmann, UK. 2. Bailey and Ollis. Biochemical Engineering Fundamentals, McGraw–Hill, New York 3. Roger Harrison et al. Bioseparation Science and Engineering, Oxford University Press, 2003. 4. Harrison, Todd, Rudge. Bioseparation Science and Engineering, Oxford Press 2003. 5. Pauline Doran. Bioprocess engineering principles, Academic Press, 1995.
Supplementary Readings	

1. Murray-Moo-Young. Comprehensive Biotechnology, V-2, Pergamon Press Ltd, Oxford, England.
2. Atkinson Bernard, Ferda Mevituna. Biochemical Engineering and Biotechnology Handbook, 2nd edition, Stockton Press, USA.

Course Code: 0512 07 MB 5206	**Year:** MS First	**Term:** Second
Course Title: Industrial Microbiology and Fermentation Sessional and Fieldwork		
Course Status: Core		
Credit: 01		
Prerequisite(s): None		
Rationale	The course is designed to provide knowledge on few fermentation processes as well as studying a laboratory fermenter.	
Course Objectives	• To familiarize students with various parts and operating modes of a fermenter. • To provide the students hands on training on few important fermentation process.	

	Course Contents	CLOs
	Section A	
1	Study of a fermenter	1
2	Study and preparation of medium and sterilization	2, 3
3	Carbohydrate fermentation process.	1, 2, 3
4	Fruit juice fermentation	1, 2, 3
5	Lactic acid fermentation	1, 2, 3

Mapping of CLOs with PLOs (MS Coursework)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Understand salient features of a fermenter	1,2,4,5
	CLO2	Have the knowledge on the basics of a fermentation process	1,2,4,5,6
	CLO3	Get hands on training on few important fermentation processes.	1,2,3,4,5,6

Mapping of CLOs with PLOs (MS Mixed Mode)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Understand salient features of a fermenter	1,2,3,6,7,9
	CLO2	Have the knowledge on the basics of a fermentation process	1,2,3,6,7,8,9
	CLO3	Get hands on training on few important fermentation processes.	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 and Demonstration	Quiz, Oral exam and Report writing
CLO2	Demonstration and Hands on Training	Quiz, Oral exam and Report writing
CLO3	Demonstration and Hands on Training	Quiz, Oral exam and Report writing

Learning Materials	
Recommended Readings	1. P. F. Stanbury, A. Whitaker and S. J. Hall. Principles of Fermentation Technology, 2nd edition, Butterworth-Heinmann, UK. 2. J.E. Bailey and D.F.Ollis. Biochemical Engineering Fundamentals, McGraw –Hill Book Co., New York.
Supplementary Readings	1. Atkinson Bernard, Ferda Mevituna. Biochemical Engineering and Biotechnology Hand book, 2nd edition, Stockton Press, USA.

Major

in
Food and Nutritional Biotechnology

Course Code: 0512 07 FB 5201	**Year:** MS First	**Term:** Second
Course Title: Food Chemistry and Microbiology		
Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		
Rationale	Food is the first priority concern for living being including human being. The survival and healthy living of human need nutrition with safe food. There are numerous technological applications in food production, processing, preservation, distribution and consumption of food. The knowledge about food is a prerequisite for technological applications and consumption of food. Food chemistry deals with different constituents of different food and the structural and biochemical organizations, different kind of bonding and biochemical interactions lies between and among the constituents, microbial contamination, spoilage and preservation of food, toxicological and safety issues of food and food products. As, food is a major area of biotechnology especially food biotechnology, students of biotechnology need to know the food science particularly food chemistry and microbiology for its safe, economic and technological applications.	

Course Objectives	The main focus of this course is as follows- • To know the different biomolecules, constituents and their structural and biochemical organization and interactions lies in different food and food products. • The microbial populations and their interactions and role in food production, microbial contamination risk, Food spoilage and economic loss for ensuring safety of food and different processed food products.

	Course Contents	
	Section A	
1	Food Polysaccharides: Starch, Pectin, sweetened Polysaccharides, hemicellulose and Fiber, Gums.	1, 2
2	Food Lipids: Fatty acids, Triglycerides and Polar Lipids in food and food products, fatty acid profile of different edible oil and animal fat.	1, 2
3	Food Proteins: Amino acids, Food protein systems; milk, cheese, egg, meat, fish, bread. Myoglobin and free radicals, Food enzymes.	1, 2
4	Vitamins and minerals from food, Food colors, Flavors, Emulsifier and Preservatives. Endogenous and exogenous toxin in food and food products. Toxic metal and agricultural residue in food.	1, 2,3
	Section B	
5	Microorganism and food material: Microorganism of soil and water origin, Microorganism of plant and animal origin, growth and survival of microorganism in food.	1, 2
6	Microbiology of primary food commodities: Micro flora of raw milk, Microbial spoilage of dairy, meat, fish, cereal and fruits products.	1, 2
7	Fermented and microbial food: microbes and their role in fermented milk, cheese, fermented plant, meat and fish products.	1, 2
8	Food hazards and food bore illness, bacterial and non-bacterial agents of food borne illness.	1, 2,3

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Acquired knowledge about chemical interactions and processes of different food substances and the knowledge of microbial association, food spoilage, preservation, health risk associated with unsafe food and economic loss and benefit.	1,2,3,4,5,6,7,8,9
	CLO2	Take decision and play role in technological applications in food processing, preservation, safe consumption of food and food products.	1,2,3,4,5,6,7,8,9

	CLO3	Prepare themselves for learning of further advance courses of food biotechnology and appraise social, ethical and legal issues.	1,3,4,5,6,7,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Class lecture	Class test
CLO2	Class lecture, presentation	Class test, assignment
CLO3	Class lecture, group discussion	Report, assignment

Learning Materials	
Recommended Readings	1. Food chemistry of its components (6th edition) By Tom Coultate, April 2018 2. Food Chemistr (4th edition) By T.D. Belitz, Werner GroschPeter Schiebarta, December 2008 3. Food Microbiology (4th edition) By Martin and Adams, December 2018 4. Food Microbiology: An Introduction By Kalmia E, Kneil, Thomas J, Montiville et al., April 2017
Supplementary Readings	1. Food flavours and chemistry advances of the new millennium Ellena Tratras Contis, Cynthia Mussinan, Thomas H Parliment, Chi-Tang Ho, Arthur M Spanier, Fereidoon Shahidi, 2011 ACS Food Chemistry Division, Royal society of Chemistry 2. Case Studies in Food Microbiology for Food Safety and Quality R K Pawsey 2002, Royal society of Chemistry

Course Code: 0512 07 FB 5202		Year: MS First	**Term:** Second
Course Title: Food Chemistry and Microbiology Sessional and Fieldwork			
Course Status: Core			
Credit: 1.0			
Prerequisite(s): None			
Rationale	Food chemistry deals with the chemical, physical and functional properties of food constituents and the chemical changes these constituents undergo during handling, processing and storage including those that limit food shelf life. Food chemistry is an interdisciplinary subject in which the chemical, biological, and physical sciences are used to study the nature of foods, the causes of deterioration, the principles underlying food processing, and the improvement of foods from a consumer and sustainability perspective. The aim of the course is to provide the students with a deep understanding of how food components contributes to overall quality of foods; and to enable students to analyze and explain how the highly complex nature of food may result in a multitude of desired and undesired reactions which are controlled by a variety of parameters.		
Course Objectives	• To provide knowledge and skills regarding chemical and microbiological perspectives of food; physical, chemical and		

	biochemical reactions and the impact of these reactions on food quality during postharvest processing, storage and utilization

Course Contents		CLOs
1	Proximate analysis of food samples: Determination of moisture, ash, carbohydrate, protein, fat and fiber content.	1, 2, 3
2.	Chromatography of food pigments	1, 2
3.	Microbial examination of foods	2
4.	Isolation and identification of common food borne pathogens	1, 2
5.	Good manufacturing practices of food	1, 2, 3
6.	Chemical and microbiological food preservation techniques	3

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Describe the relationship between the chemical composition of food and food quality	1,3,4,7
	CLO2	Explain why certain ingredients are used in foods	1,2,3,7
	CLO3	Explain the rationale for certain food processes	2,4,5,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture, presentation, laboratory work, group discussion, field trip	Written test, assignment, viva voce
CLO2	Lecture, presentation, group discussion, field trip, hands on training	Written test, assignment, viva voce
CLO3	Lecture, presentation, group discussion, field trip, hands on training	Written test, assignment, viva voce

Learning Materials	
Recommended Readings	1. Bruce R. D'Arcy and Geoff Hawes (2003) Chemical food analysis: A practical manual, Queensland University Press 2. Rashida Rajuva and Joy PP (2014) A food technology lab manual, Kerala Agricultural University
Supplementary Readings	1. Neelima Garg, K L Garg & K.G. Mukerji (2013) Laboratory manual of food microbiology, IK International Pvt Ltd.

Course Code: 0512 07 FB 5203	**Year:** MS First	**Term:** Second
Course Title: Advanced Food Biotechnology		
Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		
Rationale	Advanced Food Biotechnology is concerned with finding effective and efficient ways of food production, processing and preservation through the applications of innovative techniques of biotechnology. It is a perfect career field for those wanting to revolutionise the ways food products have been made and also being manufactured. Through this course, it would be possible to delve into what the field of Food Biotechnology entails for the scope of brilliant careers.	
Course Objectives	• The course will provide a broad grounding in concepts, techniques and issues involved in food production, processing and their preservation on the basis of food biotechnological aspects.	

Course Contents	
Section A	

1	**Food Biotechnology:** Introduction, importance, recent advances, trends and techniques. Genetically modified foods, functional foods, natural and organic foods, biofortification.	1, 3
2	**Dairy Products:** Microbiology of raw and processed milk, starter cultures, development of industrially important fermented dairy food products. Heat treatment of milk and milk products, utilization of milk components. Implications of probiotic, prebiotic and symbiotic based foods on human and animal health.	2, 3
3	**Meat Products:** Implications of biotechnology on meat quality and value, carcass composition and meat tenderness, muscle morphology. Development of functional meat products, cold storage and food freezing of meat, quality control and sanitation, sensory analysis of meat, new developments in decontaminating raw meat.	1, 2, 3
4	**Beverage Products:** Composition, principles and techniques of manufacturing & preservation of carbonated, non-carbonated and alcoholic beverages**.** Cleaning, disinfection and beverage plant sanitation, CIP for beverage plants.	2, 4
	Section B	
5	Metabolic Engineering of bacteria for food ingredients, technologies used for microbial production of food ingredients, production of amino acids, acetic acids, and carotenoids. Bacterial strain improvement for food enzymes. Metabolic engineering of plant for enhanced starch synthesis. Pathway engineering in animal for enhanced glycogen reserve.	1, 3, 4
6	Applications of enzymes in baking, dairy, fruit processing, meat, fish processing, and brewing industries. Production of natural color, flavors, preservatives from bacterial, plant and animal sources. Health hazards of synthetic food additives.	2, 3, 4
7	Aseptic processing and packaging, general hygienic and control consideration, marketing of food products.	3, 4
8	Food safety and regulation, Food borne illness, national and international regulatory system. Natural toxin in food stuffs, food contaminants from industrial waste, toxicants of food processing.	4

Mapping of CLOs with PLOs (MS Coursework)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Identify the biotechnological techniques involved in the improvement of food qualities.	1,2,3,4,5,6
	CLO2	Understand the principles involving food production, processing and preservation.	1,2,3,4,5,6
	CLO3	Understand the principles that make a food product safe for consumption.	1,3,4,5,6

	CLO4	Demonstrate knowledge of major scientific concepts, social, economic and ethical implications in Food Biotechnology.	1,2,3,4,5,6

Mapping of CLOs with PLOs (MS Mixed Mode)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Identify the biotechnological techniques involved in the improvement of food qualities.	1,2,3,4,5,6,7,8,9
	CLO2	Understand the principles involving food production, processing and preservation.	1,2,3,5,6,7,8,9
	CLO3	Understand the principles that make a food product safe for consumption.	1,3,4,5,6,7,8,9
	CLO4	Demonstrate knowledge of major scientific concepts, social, economic and ethical implications in Food Biotechnology.	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	Continuous Assessment and Quiz
CLO2	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam
CLO3	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam
CLO4	Lecture and Group Discussion	Viva Voce and Final Exam.

Learning Materials	
Recommended Readings	1. Alexandru Mihai Grumezescu and AlinaMaria Halban (2018). Advances in Biotechnology for Food Industry. London, Academic Press. 2. Capuccino, J.G., & Sherman, N. (1996). Microbiology and Laboratory Manual. New York: The Benjamin Cummings Pub. Co. 3. Lee, B.H. (2015). Fundamentals of Food Biotechnology. New Jersey: Wiley Blackwell Publishers. 4. Montel, D., & Ramesh, C. R. (2016). Fermented Foods, Part I: Biochemistry and Biotechnology. London: Taylor and Francis 5. Puniya, A.K. (2015). Fermented Milk and Dairy Products. Florida: Taylor and Francis Group. 6. Rai, R. (2016). Advances in Food Biotechnology. London: Wiley-Blackwell.

	7. Ray, R.C. & Didier, M. (2017). Fermented Foods, Part II: Technological Interventions. Florida: CRC Press, Talor and Francis Group. 8. S. Bielecki, J. Polak, J. Tramper (2000). Food Biotechnology. 1st Edition, eBook ISBN: 9780080531816 9. Venema, K. & Carmo, A. P. (2015). Probiotics and Prebiotics: Current Research and Future Trends. Norfolk: Caister academic press.
Supplementary Readings	1. Flickinger MC & Drew SW. 1999. Encyclopedia of BioprocessTechnology. A Wiley-Inter Science Publication. 2. Kruger JE. et al. 1987. Enzymes and their Role in Cereal Technology. American Association of Cereal Chemists Inc. 3. Nagodawithana T & Reed G. 1993. Enzymes in Food Processing.Academic Press 4. Tucker GA & Woods LFJ. 1991. Enzymes in Food Processing. Whitehurst R & Law B. 2002. Enzymes in Food Technology. Blackwell Publ. 5. Kalidas Shetty, Gopinath Paliyath, Anthony Pometto and Robert E, Levin, Food Biotechnology- Second Edition, CRC Press, 2005. 6. Journal of Food Biosciences, www.journals.elsevier.com/food-bioscience 7. Debasis Bagchi , Francis C. Lau and Manashi Bagchi, Application of Genomics and Bioinformatics Analysis in Exploratory Study of Functional Food, Wiley-Blackwell, Oxford, UK. doi: 10.1002/9780813821474.ch6

Course Code: 0512 07 FB 5204	Year: MS First	**Term:** Second
Course Title: Advanced Food Biotechnology Sessional and Fieldwork		
Course Status: Core		
Credit: 1.0		
Prerequisite(s): None		

Rationale	The course will provide hands on training towards the students regarding food production, processing and preservation through the applications of innovative techniques of food biotechnology. Students will also get the opportunity to be placed at different food manufacturing industries to train up themselves. It would also be possible to delve into what the field of Food Biotechnology entails for the scope of brilliant careers for the graduates.
Course Objectives	The course will make the students knowledgeable and skilled in regard to modern food production, processing and preservation. The course will also provide the opportunity for the students to visit modern food processing industries.

Course Contents	**CLOs**

1.	Methods of heat treatment of milk and milk products.	1, 3
2.	Physical, chemical and microbiological quality analysis of dairy, beverage, meat and bakery & confectioneries products.	2, 4, 3
3.	Development of probiotic food products.	2
4.	Techniques of enzymatic processing of food and food products.	5, 6
5.	Learning of food safety, ethical implications and national & international food regulatory systems.	2, 3
6.	Field Trips to visit concerned Educational/Research Institutes and Modern Food Processing Industries.	6, 7

Mapping of CLOs with PLOs (MS Coursework)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Learn the techniques of food production, processing and preservation.	1,2,3,4,5,6
	CLO2	Understand the techniques involved in the improvement of food qualities.	1,2,3,4,5,6
	CLO3	Learn the techniques that make a food product safe for consumption.	1,3,4,5,6
	CLO4	Familiarize and learn the methods of scientific, social, economic and ethical implications of Food Biotechnology.	1,2,3,4,5,6

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Learn the techniques of food production, processing and preservation.	1,2,3,4,5,6,7,8,9
	CLO2	Understand the techniques involved in the improvement of food qualities.	1,2,3,5,6,7,8,9
	CLO3	Learn the techniques that make a food product safe for consumption.	1,3,4,5,6,7,8,9
	CLO4	Familiarize and learn the methods of scientific, social, economic and ethical implications of Food Biotechnology.	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	Laboratory Sessional/hands on training	Quiz

CLO2	Practical Demonstration	Presentation
CLO3	Laboratory Sessional/Field Demonstration	Final Examination
CLO4	Field trips at modern food processing industries	Report writing

Learning Materials	
Recommended Readings	1. Alexandru Mihai Grumezescu and AlinaMaria Halban (2018). Advances in Biotechnology for Food Industry. London, Academic Press. 2. Capuccino, J.G., & Sherman, N. (1996). Microbiology and Laboratory Manual. New York: The Benjamin Cummings Pub. Co. 3. Lee, B.H. (2015). Fundamentals of Food Biotechnology. New Jersey: Wiley Blackwell Publishers. 4. Montel, D., & Ramesh, C. R. (2016). Fermented Foods, Part I: Biochemistry and Biotechnology. London: Taylor and Francis 5. Puniya, A.K. (2015). Fermented Milk and Dairy Products. Florida: Taylor and Francis Group. 6. Rai, R. (2016). Advances in Food Biotechnology. London: Wiley-Blackwell. 7. Ray, R.C. & Didier, M. (2017). Fermented Foods, Part II: Technological Interventions. Florida: CRC Press, Talor and Francis Group. 8. S. Bielecki, J. Polak, J. Tramper (2000). Food Biotechnology. 1st Edition, eBook ISBN: 9780080531816 9. Venema, K. & Carmo, A. P. (2015). Probiotics and Prebiotics: Current Research and Future Trends. Norfolk: Caister academic press.
Supplementary Readings	1. Flickinger MC & Drew SW. 1999. Encyclopedia of BioprocessTechnology. A Wiley-Inter Science Publication. 2. Kruger JE. et al. 1987. Enzymes and their Role in Cereal Technology. American Association of Cereal Chemists Inc. 3. Nagodawithana T & Reed G. 1993. Enzymes in Food Processing.Academic Press 4. Tucker GA & Woods LFJ. 1991. Enzymes in Food Processing. Whitehurst R & Law B. 2002. Enzymes in Food Technology. Blackwell Publ. 5. Kalidas Shetty, Gopinath Paliyath, Anthony Pometto and Robert E, Levin, Food Biotechnology- Second Edition, CRC Press, 2005. 6. Journal of Food Biosciences, www.journals.elsevier.com/food-bioscience

	7. Debasis Bagchi , Francis C. Lau and Manashi Bagchi, Application of Genomics and Bioinformatics Analysis in Exploratory Study of Functional Food, Wiley-Blackwell, Oxford, UK. doi: 10.1002/9780813821474.ch6

Course Code: 0512 07 FB 5205		**Year:** MS First	**Term:** Second
Course Title: Food Processing Technology			
Course Status: Core			
Credit: 2.0			
Prerequisite(s): None			
Rationale	The course is designed to provide concepts and valuable insights in food processing technology which will be helpful to understand food production process.		
Course Objectives	• To describe detailed area in food processing principles • To explain the principles and theories in various food product and process development • To discuss various aspects on large-scale food processing		

Course Contents		
Section A		
1	Introduction: Dimension and Units, Unit conversation, Density, moisture content, water activity, Viscosity, mass balance.	1

2	Microwave and radiation: Principle of heating, radiation process and classification.	1
3	Refrigeration: Introduction, refrigerant selection, modern refrigeration process.	1, 2
4	Freezing: Introduction, freezing principle, factors affecting food.	2, 5
Section B		
5	Evaporation: boiling point elevation, types of evaporators, design of evaporator.	1, 3
6	Psychrometrics: Introduction, properties of air and water vapor, important terms, chart construction.	1
7	Dehydration: Principle of drying, drying systems.	3, 5
8	Enzymes in food processing: Principles of enzyme actions on starch, types of enzymes, types of applications.	4, 5

Mapping of CLOs with PLOs (MS Mixed Mode)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Learn basic and updated knowledge required for food processing and food preservation	1,2,3,4,5,6,7,8,9
	CLO2	Understand principle and techniques on low temperature preservation processes	1,5,8
	CLO3	Gain knowledge on high temperature processing technologies.	1,3,5,6,7,8
	CLO4	Learn regarding enzymes used in different food processing operations	1,4,5,6,7,8,9
	CLO5	Able to communicate and work with others and to provide advice, guidance, and knowledge transfer on food processing	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, group discussion	Continuous Assessment and Final Exam.
CLO2	Lecture, group discussion	Continuous Assessment and Final Exam.
CLO3	Lecture, Q-A session	Continuous Assessment and Final Exam.
CLO4	Lecture, group discussion	Continuous Assessment and Final Exam.
CLO5	Lecture, group discussion	Continuous Assessment and Final Exam.

Learning Materials	
Recommended Readings	1. R. Paul Singh, Dennis R. Heldman, Introduction to Food Engineering, Fourth Edition, Academic Press 2. P.J. Fellows, Food Processing Technology. Principles and Practice. 5th Edition.

Supplementary Readings	

Course Code: 051207 FB 5209	Year: MS First	**Term:** Second
Course Title: Food Safety		
Course Status: Optional		
Credit: 2.0		
Prerequisite(s): None		
Rationale	Food is an essential constituent in human life. Food safety is a global issue affecting billions of people who suffer from diseases caused by contaminated food. Access to sufficient amounts of safe and nutritious food is key to sustaining life and promoting good health. Nonetheless, some foods can be detrimental to a person's health by causing life-threatening diseases link to food safety (WHO, 2000). Food can transmit disease from individual to individual, and also serves as a growth medium for bacteria that can cause food poisoning. It has been estimated that each year 1.8 million people die as a result of diarrheal disease and most of these cases can be attributed to contaminated food or water. More than 200 known diseases are transmitted through food. Almost 1 in 10 people in the world – fall ill after	

	eating contaminated food and 420 000 die every year, resulting in the loss of 33 million healthy life years (DALYs). Approximately, 30 million people are suffering from food borne illness each year in Bangladesh. Food borne disease is an economic burden to public health of many countries of the world. Foodborne diseases impede socioeconomic development by straining health care systems and harming national economies, tourism and trade. FAO is advocating a "farm to table" approach that addresses that how food is growing to how it is collected, transported, processed, packaged, sold and consumed. Food borne diseases can be prevented or even reduced by providing proper food safety education, training and also creating awareness.
Course Objectives	• To improve food safety knowledge and skills to prevent food borne illness. • To provide an understanding of principles of food safety and how to apply knowledge to control hazards and prevent food poisoning. • To minimize and improve public health through the application of acquired knowledge of food safety.

Course Contents		**CLOs**
Section A		
1	**Introduction:** Concept of safe food and its importance, quality food, food safety standards, Microbiological standard of safe food, 4 C's in food safety, good food hygiene, food safety issues in food chain. Five keys to safe food. Ten golden rules for safe food preparation.	1
2	**Food Contaminants in primary production:** Biological, chemical and physical, risk assessment. Personal hygiene of food handlers, general cleanliness and hygiene, Major health hazards of fast foods.	1,2,3,4
3	**Food Allergens and food borne illness:** Causes, symptoms, diagnosis and remedies. Preventing food borne illness, preventing cross-contamination, hygienic procedure, temperature danger zone, relationship of time and temperature to food safety.	1,2,3,4
4	**Food Poisoning:** Causes, symptoms and remedies, preventing food poisoning. Food safety systems in Bangladesh.	1,2,3,4
Section B		**CLOs**
5	**Food safety auditing system and practice:** Food safety emergency response, surveillance and risk management.	1,2,3,4
6	**Food safety regulations and standards:** CODEX Alimentarius, ISO 22000-2005 FSMS, Pure food law, Safe Food Act 2013 & safe Food act - 2018 (additional) of Bangladesh. Food Adulteration: Criteria of pure food, adulterant used in food items in Bangladesh, identification of residue of veterinary and fishery drugs, microbial, fertilizers, insecticides, pesticides, heavy metals, food additives, preservatives, mycotoxins, antibiotics, growth promoters of animals and plants etc. Prohibited	3,4,6,7

	poisonous elements used in food production, processing, packaging, supply chain and storage.	
7	**Food safety management systems in primary production:** Good Agriculture Practices (GAP, GTP, GSP, COC); Good Kitchen practices (GKP), safe feed production, Good Hygiene Practices (GHP), Good Manufacturing Practices (GMP) and HACCP: purpose and benefits, principles and pre-requisites, steps, hazard identification table and control.	1,3,4,5,6,7

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Demonstrate comprehensive knowledge of fundamental areas of food safety viz. food contamination, cross-contamination, food poisoning, adulterants, identification of contaminants, its sources and prevention methods, personal hygiene, food handling, storage, food laws, food management systems etc.	1,6,8
	CLO2	Identify food hazard contaminants (Biological, Physical, Chemical, and Allergens), adulterants, its sources, and cross-contamination and temperature danger zone.	1,6,7,8
	CLO3	Distinguish safe and unsafe foods and apply knowledge and expertise for preventing food contamination, adulteration through proper handling, processing, transportation and storage.	1,2,6,7,8
	CLO4	Demonstrate and explain various types of food contamination sources, cross-contamination, illness due to contaminant foods, their prevention systems and various food management systems, safe handling and storage etc. procedures in academic and non-academic sections of a society.	1,2,3,4,6,7,8
	CLO5	Demonstrate and implement knowledge of food safety management systems (GAP, GHP, GVP, GTP, GSP, GMP, HACCP etc.) for primary production of foods.	1,2,6,8
	CLO6	Evaluate food safety management systems and recommend the preventive measures.	1,2,5,7,8

	CLO7	Demonstrate moral values and ethics of food production, handling, processing and storage.	3,5,6,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture + Presentation	Class Test
CLO2	Lecture + Presentation + Field/market visit	Assignment/ Class Test
CLO3	Lecture+ presentation+ Group work	Class Test/assignment
CLO4	Presentation+ Group discussion	Term Final Exam.
CLO5	Lecture + Presentation	Term Final Exam.
CLO6	Lecture + Presentation	Term Final Exam.
CLO7	Presentation + Motivational work	Term Final Exam.

Learning Materials	
Recommended Readings	1. Nina E. Redman (2007). Food Safety: A Reference Handbook, 3rd Edition, ABC CLIO 2. Robert W. Kapp. Food Safety and Human Health, 1st Edition. 3. World Bank, Food Safety Hand Book, IPC 4. Margret Will and Doris Guenther. 2007. Food Quality and Safety Standards: A Practitioner's Reference Book, GTZ, Germany.
Supplementary Readings	1. Vaclavik, V. and Christian, EW. 2014. Essentials of Food Science 4th ed. New York: Springer 2. Marriott, NG and Gravani, RB. 1985. Principles of Food Sanitation, 5th Ed. Springer. 3. Rai VR and Bai JA. 2018. Food Safety and Protection, 1st Ed 4. Haard, NF and Simpson, BK. 2000. Sea Food Enzymes: Utilization and Influence on Post-harvest Sea Food Quality, 1st Ed.Tailor & Francis Group, Routledge.

Course Code: 0512 07 FB 5213		**Year:** 2nd	**Term:** II
Course Title: Nutritional Biotechnology			
Course Status: Optional			
Credit: 2.0			
Prerequisite(s): None			
Rationale	Nutritional Biotechnology imparts the concepts of food science that deals with the production, preservation, quality control and research and development of the food products using techniques of food biotechnology.		
Course Objectives	The programme will be of particular interest to graduates with an interest in developing knowledge and skills in subjects such as food and nutritional biotechnology, food management and techniques currently used in the food industries. It is also suitable to develop skills in these concerned areas.		

Course Contents		
Section A		
1	**Introduction:** Impact of biotechnology on nutrients, food production, food processing, food preservation, quality control and food safety.	1

2	**Nutrients:** Definition of food, nutrition, nutrients and diets. Classification, types and functions of nutrients. Functions of different categories of Genetically Modified (GM) foods.	1
3	**Dietary Requirements and Allowances of Food and Nutrients:** Nutritional requirement of macro and micro nutrients and their health aspects.	2
4	**Protective and Regulatory Foods:** Role in growth and cellular differentiation; integrity of epithelial tissues; role in immune response; role as antioxidant; bones and nerves; role in protein metabolism and growth; role in the synthesis of mucoproteins and macro polysaccharides; and role in reproduction.	3
	Section B	
5	**Development of Foods through Modern Biotechnology:** GM crops for food production; innovative techniques for livestock and fish production; microorganisms as foods; food ingredients, processing aids and dietary supplements derived from GM microorganisms.	3
6	**Use of Biotechnology to Improve Food Production by Plants**: extent of use of GM crops; modification of non-staple crops; improved lipid composition of selected plants; Golden Rice with improved nutrient contents;	3
7	**Use of Biotechnology to Improve Food Production by Animals:** Modifications of digestive tract microorganisms to improve efficiency of food production by animals; production of low-lactose milk; gene farming with cloned animals; use of recombinant somatotropin for production of dairy foods and meat production.	4
8	**Science and Technology for Food Availability and Security:** Food Availability: science and technology to improve agricultural productivity; Food Access: Technologies for food accessibility; Food use and Utilization: science for nutrition; Food Stability: new ways to combat acute and chronic food insecurity.	4

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Have an idea of nutrients and their constituents.	1,6,8,9
	CLO2	Understand about dietary requirements and allowances of food and nutrients.	1,6,7,8
	CLO3	Learn the scope and prospects of nutritional biotechnology at different food industries and consumer levels.	1,2,3,4,6,7,8,9
	CLO4	Familiarize and learn the methods of production, preservation and quality control of biotech food and food products.	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 and Presentations	Continuous Assessment and Final Exam.
CLO2	Lecture and Presentations	Continuous Assessment and Final Exam.
CLO3	Lecture and Presentations	Continuous Assessment and Final Exam.
CLO4	Lecture, Presentation and Group Discussion	Continuous Assessment, Assignment and Final Exam.

Learning Materials	
Recommended Readings	1. Agbios (2005). GM database [online database]. Agbios, Merrickville, Ontario, Canada, http://www.agbios.com/dbase.php?action=ShowForm. 2. Arundel A (2012). GM Field Trials: Relevance to Developing Countries. United Nations University Institute for New Technologies (UNU-INTECH), Maastricht, The Netherlands, Technology Policy Briefs. 3. Board on Agriculture and Natural Resources (2002) Animal biotechnology: science based concerns. National Academies Press; Washington, DC. 4. Chataway J, Tait J, Wield D (2010). From Life Sciences to a New Agro-Industry. Technology Policy Briefs, Volume 1, Issue 2. United Nations University Institute for New Technologies (UNU-INTECH), Maastricht, The Netherlands. 5. Dunham RA, Warr GW, Nichols A, Duncan PL, Argue B, Middleton D, Kucuktas H (2011). Enhanced bacterial disease resistance of transgenic channel catfish *Ictalurus punctatus* possessing cecropin genes. Marine Biotechnology. 6. Givens DI., E. Owen, R.F.E. Axford, and H.M. Omed (2012). Use of Biotechnology to Increase Food Production and Nutritional Value Forage Evaluation in Ruminant Nutrition, University of Wales Bangor, UK, CABI Publishing. 7. Huang J, Pray C, Rozelle S (2002a). Enhancing the crops to feed the poor. Nature, 418, 678–684. 8. James C (2004a). Global area of Biotech Crops, Million Hectares (1996 to 2004). Background document from the International Service for the Acquisition of Agri-biotech Applications (ISAAA), SEAsia Center, Manila, The Philippines. 9. Nuffield Council on Bioethics (2003). The use of genetically modified crops in developing countries: a follow-up discussion paper. Nuffield Council on Bioethics, London. 10. Paarlberg RL (2002). Governance and food security in an age of globalization. Food, Agriculture and the Environment Discussion

	Paper 36. International Food Policy Research Institute (IFPRI), Washington, DC, http://www.ifpri.org/2020/dp/2020dp36.pdf. 11. Salyers AA, Gupta A, Wang Y (2004). Human Intestinal Bacteria as Reservoirs for Antibiotic Resistance Genes. Trends in Microbiology, 12, 412–416. 12. Unnevehr LJ (2001). Food Safety and Food Quality. 2020 Focus 8 (Shaping globalization for poverty alleviation and food security). International Food Policy Research Institute, Washington, DC, www.ifpri.org/2020/focus/focus08/focus08_07.htm.
Supplementary Readings	1. Paarlberg RL (2002). Governance and food security in an age of globalization. Food, Agriculture and the Environment Discussion Paper 36. International Food Policy Research Institute (IFPRI), Washington, DC, http://www.ifpri.org/2020/dp/2020dp36.pdf. 2. Salyers AA, Gupta A, Wang Y (2004). Human Intestinal Bacteria as Reservoirs for Antibiotic Resistance Genes. Trends in Microbiology, 12, 412–416. 3. Unnevehr LJ (2001). Food Safety and Food Quality. 2020 Focus 8 (Shaping globalization for poverty alleviation and food security). International Food Policy Research Institute, Washington, DC, www.ifpri.org/2020/focus/focus08/focus08_07.htm.

Major

in
Industrial Biotechnology

Course Code:0512 07 IB 5201	**Year:** MS First	**Term:** Second
Course Title: Industrial Microbiology		
Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		
Rationale	The course will provide knowledge about fundamental and applied concepts in industrially important microorganisms; its screening, improvement to product development. Special emphasis is given on fermentation and related products.	
Course Objectives	• To provide basic and applied concepts on industrial microorganisms, and its utilization for production of valuable products.	

Course Contents		**CLOs**
Section A		
1	Definition and characteristics of industrial microbiology. Scope of industrial microbiology. Microbial nutrition and nutritional classification; growth and growth curve; screening of industrially important microorganisms and their characteristics.	1

2	Preservation and storage of important microorganisms; fermentation- homo and hetero-lactic acid fermentation; fermentation media, formulation of media; industrial sterilization- batch and continuous sterilization;	1,2
3	Molecular biology and bioinformatics in industrial microbiology and biotechnology. Strain improvement- mutation, recombination and protoplast fusion.	1,2
Section B		**CLOs**
4	Generation of industrial microbial products- acetic acid, lactic acid, single cell proteins, protease, amylase, lipase and antibiotics.	3,4
5	Production of biofuel- hydrogen, methane; bioelectricity; bio-pigments; biohydrometallurgy; beverages- beer and wine etc.	3,4
6	Vaccines and bioactive microbial products. Processes for overproduction of microbial metabolites.	3, 4

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	1	Understand important industrial microorganisms.	1,2,3,4,6,7,8,9
	2	Recognize culture media, screening, sterilization and fermentation techniques.	1,2,3,4,5,6,7,8,9
	3	Gain knowledge on drug discovery and related modern tools	1,2,3,4,6,7,8,9
	4	Recognize culture media, screening, sterilization and fermentation techniques.	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, group discussion	Quiz, assignment, continuous assessment
CLO2	Lecture, presentation	Assignment, final exam.
CLO3	Lecture, presentation	Assignment, final exam.
CLO4	Lecture, presentation, group discussion	Assignment, final exam.

Learning Materials

Recommended Readings	1. Waites, M. J., Morgan, N. L., Rockey, J. S. and Higton, G. 2001. Industrial Microbiology: An Introduction. Blackwell Science Ltd. 2. Madigan, M., Martinko, J., Buckley, D. and Stahl, D. 2014. Brock Biology of Microorganisms, 14th Edition. Benjamin Cummings, New York.

	3. Whitaker, A., Stanbury, P. F. and Hall, S. J. 2009. Principles of Fermentation Techniques. Elsevier 4. Okafor, N. 2007. Modern Industrial Microbiology and Biotechnology. CRC Press.
Supplementary Readings	1. Waites, M. J., Morgan, N. L., Rockey, J. S. and Higton, G. 2001. Industrial Microbiology: An Introduction. Blackwell Science Ltd. 2. Madigan, M., Martinko, J., Buckley, D. and Stahl, D. 2014. Brock Biology of Microorganisms, 14th Edition. Benjamin Cummings, New York. 3. Whitaker, A., Stanbury, P. F. and Hall, S. J. 2009. Principles of Fermentation Techniques. Elsevier 4. Okafor, N. 2007. Modern Industrial Microbiology and Biotechnology. CRC Press.

Course Code: 0512 07 IB 5202	**Year:** MS First	**Term:** Second
Course Title: Industrial Microbiology Sessional and Fieldwork		
Course Status: Core		
Credit: 1.0		
Prerequisite(s): None		
Rationale	The course will provide practical knowledge on screening and preservation of potential industrial microorganisms.	
Course Objectives	• To know the basic methods on industrial microorganisms.	

	Course Contents	CLOs
1	Screening microbial production of enzymes and antibiotics	1,2, 3
2	Preservation techniques of industrially important microorganisms	4
3	Laboratory scale production and estimation of lactic acid, indole acetic acid, and ethanol.	1,2, 3

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	1	Screen out industrial microorganisms from nature.	1,2,3,4,6,7,8,9
	2	Determine industrially important microbial products.	1,2,3,4,6,7,8,9
	3	Demonstrate potentiality of microorganisms.	1,2,3,4,6,7,8,9
	4	Maintain microbial culture.	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, experimental	Assignment, Exam., Viva
CLO2	Lecture, experimental	Assignment, Exam., Viva
CLO3	Lecture, experimental	Assignment, Exam., Viva
CLO4	Lecture, experimental	Assignment, Exam., Viva

Learning Materials	
Recommended Readings	1. Collins and Lyne's (1995). Microbiological Methods. 7th Edition, Hodder Education Publishers 2. Goldman, E. and Green, L. H. 2008. *Practical Handbook of Microbiology*. 2nd Edition. CRP Press. 3. Whitaker, A., Stanbury, P. F. and Hall, S. J. 2009. *Principles of FermentationTechniques*. Elsevier 4. Pelczar, M. J. Jr., Chan, E. C. S., Krieg, N. R. 1993. *Microbiology*. McGraw Hill Book Company**,** London.
Supplementary Readings	1. Okafor, N. 2007. Modern Industrial Microbiology and Biotechnology. CRC Press. 2. Madigan, M., Martinko, J., Buckley, D. and Stahl, D. 2014. Brock Biology of Microorganisms, 14th Edition. Benjamin Cummings, New York.

Course Code: 0512 07 IB 5203	**Year:** MS First	**Term:** Second
Course Title: Biochemical Engineering		
Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		
Rationale	The course is designed to provide detailed knowledge in biochemical engineering necessary for the production of bioproducts in the area of industrial biotechnology.	
Course Objectives	• To understand detailed area in engineering aspects in industrial biotechnology processes • To explain the principles and theories in various product and process development • To discuss various aspects on large-scale bioprocess	

	Course Contents	**CLOs**
	Section A	
1	**Basic Engineering Principles:** Unit and Unit conversion, Mass transfer and Heat transfer, Mass balance equation.	1

2	**Reaction kinetics:** Introduction, stoichiometry, classification of reaction kinetics, enzyme kinetic system.	1, 2
3	**Bioreactor Design:** Basics of bioreactor, mode of operations, reactor design, product formation design, classification of reactors.	1, 3
Section B		**CLOs**
4	**Aeration and Agitation:** Aerobic and anaerobic culture, oxygen transfer system, oxygen transfer parameters.	
5	**Scale-up:** Scale-up parameters, examples.	3, 4
6	**Instrumentation and Control:** Introduction, manual and automatic control system, classification.	3, 4
7	**Economic Evaluation of Bioprocess:** Cost evaluation, Project evaluation, Various costs, cost indexes.	1, 3, 5

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	1	Learn basics of bioprocesses and biochemical engineering.	1,3,5,6,7,8
	2	Understand the enzyme and microbial growth kinetics.	1,3,6,7,8,9
	3	Gather in-depth knowledge on process operations and bioreactor design.	1,3,6,7,8
	4	Understand instrumentation and control of bioreactors.	1,3,5,6,8
	5	Know various industrial process know how with economic aspects.	1,5,6,7,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture, group discussion	Continuous Assessment and Final Exam.
CLO2	Lecture, group discussion	Continuous Assessment and Final Exam.
CLO3	Lecture, group discussion	Continuous Assessment and Final Exam.
CLO4	Lecture, Q-A session	Continuous Assessment and Final Exam.
CLO5	Lecture, group discussion	Continuous Assessment and Final Exam.

Learning Materials	
Recommended Readings	1. J. E. Bailey and D.F.Ollis. Biochemical Engineering Fundamentals, McGraw-Hill Book Co., New York 2. Michael Shuler and Fikret Kargi. Bioprocess Engineering: Basic Concepts, 2nd Edition, Prentice Hall, and Englewood Cliffs, NJ, 2002.

	3. Roger Harrison et al. Bioseparation Science and Engineering, Oxford University Press, 2003. 4. Harrison R.G. Todd P., Rudge S.R. Bioseparation Science and Engineering, Oxford Press 2003. 5. Pauline Doran. Bioprocess engineering principles, Academic Press, 1995.

Course Code: 0512 07 IB 5204	**Year:** MS First	**Term:** Second
Course Title: Biochemical Engineering Sessional and Fieldwork		
Course Status: Core		
Credit: 1.0		
Prerequisite(s): None		
Rationale	The course is designed to provide theoretical knowledge and hands on training on biochemical engineering.	
Course Objectives	• To familiarize students with various parts and operating modes of a fermenter. • To provide the students hands on training on few important fermentation process.	

	Course Contents	CLOs
1	Study of a bioreactor.	1
2	Study and preparation of medium and sterilization.	2, 3
3	Study of enzyme kinetics.	1, 2, 3
4	Carbohydrate fermentation process.	1, 2, 3

5	Designing a bioreactor.	1, 2, 3

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	1	Understand salient features of a bioreactor.	1,2,3,6,7,9
	2	Provide knowledge and hands on training on media preparation and sterilization	1,2,3,6,7,8,9
	3	Learn enzyme kinetics and get hands on training on fermentation process.	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 and Demonstration	Quiz, Oral exam and Report writing
CLO2	Demonstration and Hands on Training	Quiz, Oral exam and Report writing
CLO3	Demonstration and Hands on Training	Quiz, Oral exam and Report writing

Learning Materials	
Recommended Readings	1. P. F. Stanbury, A. Whitaker and S. J. Hall. Principles of Fermentation Technology, 2nd edition, Butterworth-Heinmann, UK. 2. J.E. Bailey and D.F.Ollis. Biochemical Engineering Fundamentals, McGraw-Hill Book Co., New York
Supplementary Readings	1. Atkinson Bernard, Ferda Mevituna. Biochemical Engineering and Biotechnology Hand book, 2nd edition, Stockton Press, USA.

Course Code: 0512 07 IB 5205	**Year:** MS First	**Term:** Second
Course Title: Industrial Bioprocess		
Course Status: Core		
Credit: 02		
Prerequisite(s): None		
Rationale	The course is designed to provide concepts and valuable insights in industrial biotechnology to learn various biotechnology-based process and products.	
Course Objectives	• To describe basic and detailed features of industrial biotechnology processes • To explain the principles and theories in various product and process development • To discuss various aspects on specific large-scale bioprocess	

Course Contents		**CLOs**
Section A		
1	**Introduction:** Basic bioprocess, history, importance, bioproducts, classification.	1, 2

2	**Upstream processing:** Introduction, important considerations, starch preparation, malting, extraction techniques.	1, 2
3	**Downstream Processing:** Basic bioseparation criteria, cost determination, bioseparation problems, various separation processes: filtration, centrifugation, extraction, membrane separations, precipitation.	3, 4
Section B		**CLOs**
4	**Ethanol production:** Raw materials, process, specification.	1, 3, 4
5	**Antibiotic production:** Raw materials, process, specification.	1, 3, 4
6	**Enzyme production:** Raw materials, alpha amylase production process, specification.	1, 3, 4
7	**Insulin Production:** Background, raw materials, process.	1, 3, 4

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	1	Know various industrial process know how.	1,5,6,8,
	2	Understand principles and techniques for preparatory techniques	1,2,3,5,6,7,8,9
	3	Learn various primary isolation and purification methods	1,4,5,7,8,
	4	Gain theoretical views on important bio product development processes.	1,2,5,7,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture, Q-A session	Continuous Assessment and Final Exam.
CLO2	Lecture	Continuous Assessment and Final Exam.
CLO3	Lecture, group discussion	Continuous Assessment and Final Exam.
CLO4	Lecture, presentation	Continuous Assessment and Final Exam.

Learning Materials	
Recommended Readings	1. P. A. Belter, E.L. Cussler, Wei-Shou Hu. BIOSEPARATIONS Downstream Processing for Biotechnology, John Wiley & Sons, Inc., USA. 2. J. E. Bailey and D. F. Ollis. Biochemical Engineering Fundamentals, McGraw –Hill Book Co., New York. 3. M. Shuler and F. Kargi. Bioprocess Engineering: Basic Concepts, 2nd Edition, Prentice Hall, and Englewood Cliffs, NJ, 2002. 4. R. Harrison et al., Bioseparation Science and Engineering, Oxford University Press, 2003.

	5. R. G. Harrison, P. Todd, S. R. Rudge. Bioseparation Science and Engineering, Oxford Press 2003.
Supplementary Readings	1. Murray-Moo-Young. Comprehensive Biotechnology, V-2, Pergamon Press Ltd., Oxford, England. 2. A. Bernard, F. Mevituna. Biochemical Engineering and Biotechnology Handbook, 2nd edition, Stockton Press, USA.

Course Code: 0512 07 IB 5207	**Year:** MS First	**Term:** Second
Course Title: Biomolecular Engineering and Synthetic Biology		
Course Status: Optional		
Credit: 2.0		
Prerequisite(s): None		
Rationale	A broad-based course that integrates biological and chemical sciences with engineering concepts. This course will open doors to a variety of careers from Biotechnology and Genetic Engineering graduates. Furthermore, this course will offer fundamental knowledge of central technologies in Synthetic Biology, advanced tools for integration of basic synthetic units into multi component devices, and modern analytical techniques for designing and testing new systems.	
Course Objectives	• To provide fundamental understanding of biomolecular engineering and synthetic biology i.e. basic cellular processes, design and implement new cellular behaviors by applying mathematical, analytical and engineering tools for studying biological systems.	

Course Contents		CLOs
Section A		
1	**Introduction to Chemical and Biomolecular Engineering:** Definitions, Concepts, Historical overview of milestones in research; Scope and Applications	1, 2
2	**Analysis of Biomolecular Processes:** Basic mathematical concepts and statistical tools, physical laws, stoichiometric strategies, and structured programming approaches.	1, 2, 3
3	**Biomolecular Engineering Thermodynamics and Reactor Design:** Chemical and phase equilibria in multicomponent systems and control systems engineering for biological chassis including feedback and dynamic regulation, Principles of chemical kinetics, Analysis of reaction rate data.	1, 2
4	**Separation Technologies for Chemical and Biomolecular Processes:** Separations of biological molecules, and bioprocess engineering: mass transport, distillation, solid-liquid and liquid-liquid extraction, crystallization, absorption, adsorption, stripping and membrane processes.	1, 2,3
5	**Macromolecular and Cellular Engineering**: Polymers synthesis, structure, transport and dynamics of designed peptides, proteins, lipids and nanomaterials, Complex fluids in macromolecular design and production, Rational design and directed solutions for cell and protein engineering, Strategies to regenerate metabolic organs and repair structural tissues, Cell-based therapies to deliver proteins and other therapeutic drugs.	1, 2
Section B		**CLOs**
6	**Synthetic Biology Basics:** Synthetic biology – definitions and concepts; History and evolution of synthetic biology and engineering perspectives; Natural vs. Engineering systems.	3
7	**Synthetic Biology-Foundation Technologies and Standards:** Key enabling technologies in synthetic biology; BioBricks, black-box encapsulation, PoPs and RiPs; The Registry of Standard Biological Parts; Signal carrier, modularity, Abstraction hierarchy. Tools for analysing and controlling Biological Systems and simulation tools.	4
8	**DNA re-writing, devices and circuits:** Writing DNA: DNA synthesis, artificial genes, never born proteins, non-natural nucleic acids; Devices and circuits: Bacterial camera, Construction of toggle switches, logic gates, oscillators, pulse generators, time delayed circuits.	4
9	**Implications and Applications of Synthetic Biology:** Applications of synthetic biology- Bioplastics, Artemisinin, DNA origami, RNA-based designs, genome engineering, biofuel - microbial and minimal synthetic cell, Reconstructing viruses, 3D bioprinting; Directed evolution of chemical sensors.Cellular Systems: Microbial communities and factories, cell-based and cell-free synthetic systems for metabolic engineering and biosynthetic pathway prototyping.	3, 4, 5

10	**Risks and Ethical, Legal and Social issues:** Safety and Legal issues: Ethics, bio-security, Bio-safety – case studies on 1918 Spanish flu virus resurrection. Intellectual Property-Ownership and sharing regimes for biological entities: open-access to patenting, implications for systems and synthetic biology research; Major global events-iGEM competition.	6

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	1	Apply knowledge in biomolecular engineering and its underlying disciplines in a wide range of settings by identifying, formulating and solving engineering problems in the realm of biotechnology	1,2,3,4,7,8,9,
	2	Explain basic concepts, models, and statistical measures to characterize the properties of synthetic biological processes and general networks, as well as use the software tools to design and analyze empirical networks;	1,2,3,4,5,7,8
	3	Acquire knowledge and fundamental aspects that make up synthetic biology and understand how it is integrated into an interdisciplinary context;	1,2,4,5
	4	Rationalize the information from different areas and translate them into deeper understanding to relate the knowledge on design and synthesis of new elements, pathways, cells and systems;	1,2,3,4,5,7,9
	5	Gain knowledge about the construction and modelling of novel genetic circuits, modelling of metabolic pathways, engineering for biofuels and other state-of-the-art applications;	1,2,3,4,5,7,8
	6	Utilize the knowledge of biochemical engineering to use different biomolecules as templates and their	1,2,3,4,5,6,7,8,9

		subsequent modifications for differential purposes;	
	7	Be aware of bioethical and societal issues related to the inclusion of synthetic biology in differential paradigms	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	Quiz and Continuous Assessment
CLO2	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO3	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO4	Lecture and Group Discussion	Viva voce and Final Exam.
CLO5	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO6	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO7	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.

Learning Materials	
Recommended Readings	1. Freemont, P.S and Kitney, R.I. (2012). Synthetic Biology – a Primer. World Scientific Publishing Co pte Ltd 2. Singh, V and P.K. Dhar. (2015). Systems and Synthetic Biology. Springer publishing, Netherlands 3. Fu, P and Panke, S (2009). Systems Biology and Synthetic Biology. Wiley Publishing. 4. Church, G and Regis, E. (2012). Regenesis: How Synthetic Biology will Reinvent Nature and Ourselves. Basic Books. 5. Joyce, F. (2018). Biomolecular Engineering: Structures and Functions, Larsen and Keller Education
Supplementary Readings	1. Shaw, J-F. (2010) Biocatalysis and Biomolecular Engineering, Wiley.

Major
in
Medical and Pharmaceutical Biotechnology

Course Code: 0512 07 MPB 5201		Year: MS First	**Term:** Second
Course Title: Infection, Immunity and Control			
Course Status: Core			
Credit: 2.0			
Prerequisite(s): None			
Rationale	This course is designed to provide the basic concepts of the infection process, immune defence mechanism and mechanism of disease control.		
Course Objectives	• To understand the pathological basis of microbial diseases. • To familiarize with the integral components of the immune system. • To provide in-depth knowledge of the innate and adaptive immune system. • To elucidate the role of immune system in heath and diseases control.		

Course Contents	**CLOs**
Section A	

1	**Microbial Etiology of Disease**: Pathogenesis of Bacterial, Viral, Fungal and Protozoal Diseases.	1
2	**Introduction to Immune System:** Overview of Immune System; Hematopoietic Stem Cells; Differentiation of Granulocytes, Macrophages and Lymphocytes; Antibody Molecule and Immunoglobulin Domain.	2
3	**Innate and Adaptive Immunity:** Anatomical Barriers to Infection; Toll-like Receptors and Their Ligands; Complement System; Major Pathways of Complement Activation, Organization of Immunoglobulin Genes; Molecular Mechanisms to Generate Antibody Diversity; Major Histocompatibility Complex; Structure and Function of MHC Class I and MHC Class II Molecules, Organization of MHC Genes; Antigen Presentation.	3
Section B		**CLOs**
4	**Effector Responses:** T-Cell Receptor, B-Cell Receptor; Activation and Differentiation of T-Cell; Activation and Differentiation of B-Cell.	3, 4
5	**Immune System and Disease Control:** Hypersensitive Reactions; Barriers and Vectors in Infectious Diseases; Viral Defense Mechanisms; Emerging and Re-emerging Infectious Diseases; Immunity by Active and Passive Immunization, Advantages and Challenges of Various Vaccine Strategies, Meditation, Immune Boosting Strategies.	4
6	**Trends in Immunology:** Contemporary concepts of immunology research will be covered by journal articles.	5

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	1	Learn about the pathological basis of microbial diseases	1,3,4,5,6,7,8
	2	Gather knowledge about the various components of the immune system.	1,3,4,5,6,7,8
	3	Develop a perspective of how immune defence mechanisms function at cellular and molecular levels.	1,5,6,7,8,
	4	Understand how the knowledge of infection and immunity may be used for	1,2,3,4,5,6,7,8,9

		developing therapeutic strategies for disease control	
	5	Get acquainted with the contemporary concepts of immunology research.	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 and Presentation	Continuous Assessment and Final Examination
CLO2	Lecture and Presentation	Continuous Assessment and Final Examination
CLO3	Lecture and Presentation	Continuous Assessment and Final Examination
CLO4	Lecture, Presentation and Group Discussion	Continuous Assessment, Assignment and Final Examination
CLO5	Lecture, Presentation and Group Discussion	Continuous Assessment, Assignment and Final Examination

Learning Materials	
Recommended Readings	1.Shetty N, Tang JW and Andrews J (2009) Infectious Disease: Pathogenesis, Prevention, and Case Studies (1st Ed.), Wiley-Blackwell 2.Punt J, Stranford SA, Jones PP and Owen JA (2019) Kuby Immunology (8th Ed.), New York: W.H. Freeman. 3.Journal Articles and Internet Resources
Supplementary Readings	1.Sampaio CV, Lima MG and Ladeia AM (2017) Meditation, Health and Scientific Investigations: Review of the Literature. J Relig Health; 56(2):411-427. 2.Hilton L, Hempel S, Ewing BA, Apaydin E, Xenakis L, Newberry S, Colaiaco B, Maher AR, Shanman RM, Sorbero ME, Maglione MA (2017) Mindfulness Meditation for Chronic Pain: Systematic Review and Meta-analysis. Ann Behav Med; 51(2):199-213.

Course Code: 0512 07 BGE 5202		Year: MS First	**Term:** Second
Course Title: Infection, Immunity and Control Sessional and Fieldwork			
Course Status: Core			
Credit: 1.0			
Prerequisite(s): None			
Rationale	This course is designed to provide in-depth knowledge of various immunological techniques.		
Course Objectives	• To familiarize with the concepts of antigen and antibody interactions • To deliver hands-on experience on various immunological techniques		

	Course Contents	CLOs
1	Selection of animals, preparation of antigens, immunization and methods of blood collection	1
2	Immuno-electrophoresis and SDS PAGE	1
3	Antibody Detection by ELISA Method.	2
4	Detection and Quantitation of Proteins Using Western Blotting	2

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	1	Learn about sample preparation and different separation and quantitation techniques used in immunology research.	1,2,3,4,5,6,7,8,9
	2	Learn about sample preparation and different separation and quantitation techniques used in immunology research.	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, Experiments and Presentation	Reports, Viva voce and Final Examination
CLO2	Lecture, Experiments and Presentation	Reports, Viva voce and Final Examination

Learning Materials	
Recommended Readings	1. Stevens CD, Miller LE (2017) Clinical Immunology and Serology: A Laboratory Perspective (4th Ed.), F.A. Davis Company 2. Punt J, Stranford SA, Jones PP and Owen JA (2019) Kuby Immunology (8th Ed.), New York: W.H. Freeman.
Supplementary Readings	Hay FC and Westwood OMR (2008) Practical Immunology (4th Ed.) Wiley-Blackwell.

Course Code: 0512 07 MPB 5203	**Year:** MS First	**Term:** Second
Course Title: Regulatory Framework in Pharmaceutical Industry		
Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		
Rationale	The pharmaceutical industry is a highly regulated industry and all production must be carried out in accordance with good manufacturing practice. The regulatory environment tends to stifle any attempts to change the process once the development stage is over and the product and process have been licensed. However, the regulatory and business environments are now changing at a great pace. Biotechnology graduates intending to build a career in pharmaceutical sectors need to know the national and international regulatory policies and practices in a systematic way. This course is designed to provide such systematic knowledge and skill base.	
Course Objectives	• The objective of the course is to give the ability to achieve standards in the manufacture of quality products in the pharmaceutical industry and equip students with biomanufacturing principles and good manufacturing practices for the production of pharmaceuticals and biopharmaceuticals.	

Course Contents	CLOs

Section A		
1	**Introduction to QC and QA:** Good Practices in QC laboratory, Schedule L1, standardization of reagents, labelling of reagents, control samples, controls on the animal house, data generation and storage, QC documentation, LIMS Sampling Techniques, Sampling Plans, and Good warehousing practices. Pest and rodent controls; Temperature mapping and monitoring of warehouses; Good Distribution Practices, Waste disposal, disposal procedures and records, and current regulations for waste disposal.	1, 2
2	**Quality Management Models:** Total Quality Management and its importance to improving business performance; Quality models in business, Six Sigma Concept, Six Sigma tools, Continuous improvements and its applications, Lean Concept for Process improvements.	1, 2, 3
3	**Policies and guidelines:** ISO 9001/ ISO 13485 standards and their implementation, Quality-Related Guidelines, Legislations and Regulations, PIC guidelines for GMP, Schedule L1, EU guidelines for GMP, WHO GMP guidelines, Canadian GMP Guidelines, Regulatory requirements by different countries, Consumer Protection Act Environment Protection Act, Factories Act, Packaged commodities Act, Import/Export policy; Requirements for import and export of Excipients, Drug substances and Drug Products / Devices.	1, 2
4	**Product and facility design and life cycle implementation:** Designing of manufacturing facilities for Excipients, API, Drug Formulations, and Medical Devices; ISPE Baseline guidelines; Designing requirements for HVAC systems; Quality -Planning in the Product Life cycle; Product Quality Life cycle implementation (PQLI); In-process quality control on various dosage forms- Sterile and non-sterile; Packaging and labelling controls.	3, 4
5	**Current industry status and recalls:** Contract manufacturing and analysis, Present status and scope of the pharmaceutical industry in Bangladesh; Analytical Method Transfers; Complaints handling; Root cause analysis; Keppener Trego technique for investigations; Establishment of CAPA; Handling of Recall and recall procedures; Mock recalls.	5
Section B		**CLOs**
6	**Biomanufacturing principles:** Overview and design of biomanufacturing, quality by design approach, technical considerations, phases and scale up: life cycle of manufacturing, raw material considerations, compliance and quality in biomanufacturing, lean biomanufacturing; Process analytical technology (PAT) during biomanufacturing: background and need tools for data acquisitions (software in fermenters, flow filtrations, chromatography, analysis and design process analyzers, process control tools and continuous improvement and knowledge management; Standard manufacturing operating procedures of biotechnology, including upstream and downstream processing of proteins, and quality control of protein production, and final fill and finish	1, 2, 3

	of product; Case studies to be included: therapeutic proteins, monoclonal antibodies, human vaccines.	
7	**Quality System:** Introduction to quality system, main elements of a quality system; Essential of the quality system; Practical implementation of a quality system; Structure of quality manual, correlation between GMP requirements (WHO) and ISO 9001:2000.	1, 3
8	**Principles and Practice of GMP:** Personnel, Premises, Facilities and Equipment, Pharmaceutical water, Qualification, Process Validation, Cleaning Validation, Production, Sterile Production and Packaging, Documentation.	1, 2
9	**GMP in regulation:** Information, national bodies and pharmaceutical associations; Pharmacopeia; EU directives and guidelines, USA: CFR and FDA guidelines, ICH-guidelines, PIC/S guidelines, GMP of other regions, WHO guidelines.	4

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	1	Understand and implement quality assurance and quality control for particular operations during drug development	1,2,5,6,7
	2	Understand useful concepts like Six Sigma and its application in the pharmaceutical industry;	1,2,3,4,6,7,8,9
	3	Understand the drug development process and its importance in the pharmaceutical industry;	2,5,6,7,8,9
	4	Develop conceptual clarity and knowledge about systems for quality manufacturing of biotherapeutics (biopharmaceuticals, diagnostics and foods) manufactured for human use. The knowledge of GMP and GLP requirements is critical for students who opt for careers in pharmaceutical manufacturing.	1,2,3,6,7,8,9

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 Final Exam.

CLO3	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO4	Lecture and Group Discussion	Viva voce and Final Exam.

Learning Materials	
Recommended Readings	1. Introduction to Biomanufacturing, by Mark Witcher. In Encyclopedia of Industrial Biotechnology. 2. Good Manufacturing Practices for Pharmaceuticals (e-resource): a Plan for Total Quality Control. Sidney Willig and James Stoker. 3.Good Manufacturing Practices for Pharmaceuticals (e-resource): a Plant for Total Quality Control. Sidney Willig and James Stoker.
Supplementary Readings	1. Learn Biomanufacturing, 1st Edition; Author Nigel Smart; Woodhead Publishing London: CRC Press. 2.GMP manual; Publisher Maas & Peither America, Inc. GMP Publishing 3. Bentrand L. Hanser, Prabhakar M. Ghare, (1986), Quality Control & Application, Prentice Hall.

Course Code: 0512 07 MPB 5204	**Year**: MS First	**Term:** Second
Course Title: Regulatory Framework in Pharmaceutical Industry Sessional and Fieldwork		
Course Status: Core		
Credit: 1.0		
Prerequisite(s): None		
Rationale	This course deals with the various aspects of quality control and quality assurance aspects of the pharmaceutical industries. It covers important aspects like cGMP, QC tests, documentation, quality certifications, GLP and regulatory affairs	
Course Objectives	• To introduce the students to the dynamic pharmaceutical production systems and their regulatory requirements.	

Course Contents		**CLOs**
1	Analysis of pharmacopoeial compounds in bulk and in their formulations (tablet/ capsules/semisolids) by UV Vis spectrophotometer; Simultaneous estimation of multi-drug component containing formulations by UV spectrophotometry	1
2	Experiments based on HPLC and Gas Chromatography	5
3	Estimation of riboflavin/quinine sulphate by fluorimetry, Estimation of sodium/potassium by flame photometry or AAS	5

4	Case studies on a) Total Quality Management, b) Six Sigma, c) Change Management/ Change control. Deviations, d) Out of Specifications (OOS) e) Out of Trend (OOT), f) Corrective & Preventive Actions (CAPA) and g) Deviations.	1, 2, 3, 5
5	Development of stability study protocol and studying the effect of pH on the solubility of drugs	5
6	Validation of an analytical method for a drug and a processing area	4
7	Qualification of at least two analytical instruments	4
8	Case study on the application of QbD and PAT	1, 2, 3, 5

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	1	Understand the cGMP aspects in the pharmaceutical industry.	1,2,3,4,5
	2	Appreciate the importance of documentation and prepare them.	1,2,3,4,6,7,8
	3	Analyze the scope of quality certifications applicable to the pharmaceutical industry.	1,2,4,5,6,7
	4	Visualize the responsibilities of the QA & QC departments..	1,2,3,4,8,9
	5	Demonstrate the skills in conducting hands-on experiments related to pharmaceutical quality control individually and as a part of a group.	1,2,3,4,5,7,8

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and Presentation	Quiz and Viva voce
CLO2	Lecture and Presentation	Reports and Viva voce
CLO3	Supervised experiments	Reports and Viva voce
CLO4	Field visit	Reports and Viva voce
CLO5	Individual experiments	Reports, Viva voce and Final Examination

Learning Materials	
Recommended Readings	1. Good Laboratory Practice Regulations, Sandy Weinberg Vol. 69, Marcel Dekker Series. 2. Quality Assurance of Pharmaceuticals- A compendium of Guidelines and Related Materials, Vol I & II, WHO Publications. 3. How to Practice GMPs – P P Sharma, Vandana Publications, Agra.

	4. The International Pharmacopoeia – vol I, II, III, IV & V - General Methods of Analysis and Quality specification for Pharmaceutical Substances, Excipients and Dosage forms, WHO, Geneva. 5. Good Laboratory Practice Regulations – Allen F. Hirsch, Volume 38, Marcel Dekker Series. 6. ICH guidelines 7. ISO 9000 and total quality management. 8. QA Manual – D.H. Shah, 1st edition, Business Horizons.
Supplementary Readings	1. Good Manufacturing Practices for Pharmaceuticals a plan for total quality control – Sidney H. Willig, Vol. 52, Marcel Dekker Series. 2. Steinborn L. GMP/ISO Quality Audit Manual for Healthcare Manufacturers and Their Suppliers, (Volume 1 - With Checklists and Software Package), Taylor & Francis. 3. Sarker DK. Quality Systems and Controls for Pharmaceuticals, John Wiley & Sons. 4. Packaging of Pharmaceuticals.

Course Code: 0512 07 MPB 5205	**Year:** MS First	**Term:** Second
Course Title: Vaccine Technology and Biopharmaceuticals		
Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		

Rationale	New developments in biotechnology have led to a number of new approaches for the development of vaccines and biopharmaceuticals aimed at preventing and treating a multitude of diseases. Such trend thus flourished vaccine and biopharmaceutical research, development, industrial manufacturing, governance and last but not least, policy making. Therefore, Vaccine Technology and Biopharmaceuticals is deemed an indispensable course for Biotechnology graduate program.
Course Objectives	• To impart knowledge on the role of vaccination in improving the immune system. • To gain an understanding of recent developments in vaccine technology. • To make aware of the commercialization and regulatory guidelines in vaccine production

Course Contents	**CLOs**

Section A		
1	**Introduction to Vaccination:** Introduction, history and principles of vaccine development, Types of vaccines, Conventional and modern strategies for vaccine improvement, Immunization strategies: Active and Passive, Reverse vaccinology, Adjuvants: history, classification, mechanisms. Factors affecting adjuvants selection and production.	1, 2, 3 1, 2
2	**Delivery of Vaccines:** Controlled delivery system for vaccines: emulsions, microparticles, immune-stimulating complexes (ISCOMs, liposomes), and Virosomes. Application of Nanoparticles in vaccine delivery, Induction of immune responses by the nanoparticle-based vaccine. Role of polymeric nanoparticles in vaccine delivery. Transdermal vaccine delivery system.	3, 4
3	**Vaccine Design and Development:** Fundamental research to rational vaccine design. Antigen identification and delivery, T-Cell expression cloning for identification of vaccine targets for intracellular pathogens, Fundamentals of Immune recognition, implications for manipulating the T-Cell repertoire, Targeting Dendritic cells; a rational approach for Vaccine development, Cellular basis of T- Cell memory, Rational design of new vectors, CpG adjuvant activity, Transcutaneous immunization.	1, 5
4	**Commercial Production and Regulatory Guidelines:** Quality control and regulations in vaccine research, Animal testing, Rational design to clinical trials, large-scale production, Commercialization, ethics. Overview of national and international regulatory requirements/ guidance for the production of vaccines, quality control and implementation of good clinical practices.	1.5
Section B		**CLOs**
5	**Introduction to Biopharmaceuticals and Biogenerics**: Introduction to Biopharmaceuticals and pharmaceutical biotechnology, generic and branded biopharmaceuticals. Discovery of protein or peptide-based therapeutics: In-silico, pharmaco-informatics. Pre-clinical toxicity assessment, Clinical trial phases and design, clinical data management, and the concept of Pharmacovigilance.	1, 2, 3
6	**Impact of omics in Drug Discovery:** Pharmacogenetics, Pharmacogenomics and proteomics, structural, functional and comparative genomics, DNA & oligonucleotides microarrays, genetically engineered animals, Integration of personalized and systems medicines, pharmacogenomics in preclinical and clinical development of drugs.	1, 3
7	**Immunotherapeutic & Immunodiagnostics:** Overview of antibody-based therapeutics, biologics for autoimmunity and inflammation, vaccine adjuvant technology, genetically engineered vaccines. Principles of an immunodiagnostic assay based on a solid-phase system. Fluorescent ligands and radio-isotope tracers, principles and instrumentation for molecular	2, 3

	diagnostics (Time-resolved fluorescence immunoassay, light scattering principles), PCR and nucleic acid-based diagnostics, and imaging techniques.	
8	**Biopharmaceuticals Based Delivery Systems**: Novel drug delivery systems for biopharmaceuticals (rate controlled and site-specific), Nanotechnology-based miniaturization of biopharmaceuticals and therapeutics, peptides for intracellular targeting, delivery of nucleic acids and therapeutic peptides, the concept of responsive or smart drug delivery system.	3
9	**Formulation of Biopharmaceuticals:** Rationale for the formulation of biotherapeutics, formulation recipients: solubility enhancers, anti-aggregating agents, buffers, cryoprotectants, antioxidants and preservatives etc significance with relevant examples. Methods to enhance shelf-life protein-based therapeutics. Packaging techniques and quality analysis of the product.	5

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	1	Describe the role of immune cells and their mechanism and concept of vaccination and modes of action for biopharmaceuticals	1,2,3,8,9
	2	Categorize the different types of vaccines and biopharmaceuticals available for disease prevention and treatment.	1,2,3,4,7,9
	3	Understand the modern strategies and routes of immunization and biopharmaceutical administration;	2,8,9
	4	Apply the concept of emerging technologies and techniques to the development of vaccines and biopharmaceuticals	1,2,3,4,5,6

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 Final Exam.
CLO3	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO4	Lecture and Group Discussion	Viva voce and Final Exam.

Learning Materials

Recommended Readings	1. Gary Walsh (2003) Biopharmaceuticals: Biochemistry and Biotechnology, 2nd Edition, John Wiley & Sons, Inc. 2. Daan J A Crommelin (2010) Pharmaceutical Biotechnology, 2nd Edition, Taylor & Francis Group. 3. Rodney J. Y. Ho (2013) Biotechnology and Biopharmaceuticals: Transforming Proteins and Genes into Drugs, 2nd Edition, John Wiley & Sons, Inc. 4. Myrone M. Levine, Myron M. Levine, Gordon Dougan, Michael F. Good, Margaret A. Liu, Gary J. Nabel, James P. Nataro, Rino Rappuoli (2016) New Generation Vaccines, 4th Edition, Informa Healthcare. 5. Stanley Plotkin Walter Orenstein Paul Offit (2012) Vaccines, 6th Edition, Saunders.
Supplementary Readings	1. Gary Walsh (2007) Pharmaceutical Biotechnology: Concepts and Applications. John Wiley & Sons, Inc. 2. Oliver Kayser, Heribert Warzecha (2012) Pharmaceutical Biotechnology: Drug Discovery and Clinical Applications, 2nd Edition. John Wiley & Sons, Inc. 3. Emily P. Wen Ronald Ellis Narahari S. Pujar (2014) Vaccine Development and Manufacturing. Wiley online. 4. Jose Ronnie Vasconcelos (2015) Vaccines & Vaccine Technologies, OMICS International. 5. Kuby, RA Goldsby, Thomas J. Kindt, Barbara, A. Osborne (2002) Immunology, 6th Edition, Freeman.

Course Code: 0512 07 MPB 5207	**Year:** MS First	**Term:** Second
Course Title: Experimental Medicine		
Course Status: Optional		
Credit: 2.0		
Prerequisite(s): None		
Rationale	Experimental medicine develops and applies technology and biological models for studying pathogenic mechanisms in human disease. It involves various disciplines (biochemistry, biology, molecular biology, anatomy, physiology, pathology, immunology, genetics and microbiology/virology) that are providing a rapidly growing understanding of the mechanisms that enable the development of pathological processes. The course aims to acquaint students with the technologies and research methodologies in the area of biomedicine and biotechnology based on in vitro and in vivo experimental models and '-omic' approaches, and on their application to the study of cellular and molecular mechanisms involved in the pathogenesis of human disease. The final objective is the formation of high-level scientists able to combine an understanding of biological processes and pathogenic mechanisms through the application of advanced experimental techniques.	
Course Objectives	• To develop the ability to define problems and devise experiments to solve them in accordance with scientific standards; • To study biochemical, molecular and cellular mechanisms in physiopathology using advanced technologies; • To develop the ability to critically assess scientific literature;	

	• To provide solid, up-to-date knowledge in the specific field; • To teach how to conduct independent research, and inform on related ethical implications.

Course Contents		CLOs
Section A		
1	**Introduction to Clinical, Experimental & Translational Research**: Definitions, Historical overview of milestones in research; Scope and Applications.	1, 2
2	**Advanced Immunology and Experimental Infectious Medicine**: Immunogenetics, Immunopathology: autoimmunity, allergy, inflammation, infections and immunological aspects of cancer, Immunotherapy, Emerging infectious diseases and clinical strategies, Advanced immunobiologicals and molecular regulation of host response	1, 2, 3
3	**Advanced Cardiovascular Medicine:** The biology of atherosclerosis: progress and challenges, Molecular mechanisms and clinical implications of angiogenesis, Heart regeneration, Pharmacological therapies of heart failure.	1, 2
4	**Stem Cells and Applied Regenerative Medicine:** Classification, biological properties, and differentiation of stem cells, Evolution of bioengineered materials, Reprogramming and tracking, Techniques for in vivo visualization of cells and tissue.	1, 2,3
5	**Advanced Cancer Therapies:** Development & design of anti-cancer drugs, Targeted cancer therapies for personalized medicine, Radiobiology and radiation oncology, Novel strategies in immune-recruitment and stem cell therapies for cancer patients.	1, 2, 3
Section B		**CLOs**
6	**Molecular and Medical Pharmacology**: Current concept of drug/receptor protein interaction, Mechanisms and medical effects of different classes of molecular drugs, Pharmacology, pharmacovigilance, pharmacodynamics and pharmacokinetics.	1, 2, 3
7	**Computer-Based Methods for Studies of Biological Molecules:** *in-silico* drug and biological design, simulation technologies and machine learning in novel drug discovery, Fundamentals of big data analysis and medical informatics	1, 3
8	**Translational Medicine:** Laboratory outcomes to clinical and translational research, Prospects, standard operations and limitations in clinical and translational medicine.	1, 2
9	**Analytical Techniques in Experimental Biosciences:** Study design, Data collection, Data analysis, Statistics used within clinical biosciences and epidemiology, Biomarkers and surrogate endpoints, multi-omic technologies in clinical diagnostics.	1, 2

10	**Biosafety and Bioethical Standards in Experimental Medicine:** Regulatory framework and key principles governing human ethics oversight for experimental medicine research.	1, 3
11	**Case Studies and Publications:**Major areas of experimental medicine, molecular techniques used in experimental therapeutic development and clinical applications.	1, 2, 3

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	1	Attain familiarity with the common scientific and practical aspects of preclinical drug research and with the main concepts of molecular and cellular research techniques in the field of experimental medicine;	1,3,4,5,6,7,8,9
	2	Demonstrate an understanding of the underlying scientific principles of laboratory testing and translational research, including technical, procedural, and problem-solving aspects	1,2,3,4,6,8,9
	3	Engage in the scientific process by understanding the principles and practices of clinical study design, implementation, and analysis of results.	4,5,6,7,9

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 Final Exam.
CLO3	Lecture and Presentation	Continuous Assessment, Assignment and Final Exam.
CLO4	Lecture and Group Discussion	Viva voce and Final Exam.

Learning Materials	
Recommended Readings	1. Claude Bernard and Stewart Wolf (1999) Experimental Medicine, 1st Edition, Routledge, ISBN 9780765806154

Course Code: 0512 07 MPB 5209		**Year:** MS First	**Term:** Second
Course Title: Virology and Oncology			
Course Status: Optional			
Credit: 2.0			
Prerequisite(s): None			
Rationale	Virology, a sub-domain within the extensive field of microbiology, is an exclusive field for the study of viruses. This branch of biomedical science aims to understand different types of viruses and their effects on humans and animals. The study of virology not only helps classify the many types of viruses that exist but also promotes research to discover new approaches to restrict their damaging outcomes. Hence, to maintain good public health and eradicate viral diseases, analysis and study of these viruses is very important, making virologists highly sought after. With the rapid growth in population and the recent Covid-19 pandemic, there has been a sudden rise in demand for professionals of virology knowledge. There are a host of career opportunities available in virology. Biotechnologists with the knowledge of virology have the potential to be employed in almost every industry, from food to pharmaceuticals. They are also actively sought after in government healthcare departments and laboratories. They can find		

	career opportunities in research and be employed by universities, government agencies or health organizations for the sole purpose of research and development. Viruses account for up to 20% of all human cancers.Cancer research transforms and saves lives. The goal of studying cancer is to develop safe and effective methods to prevent, detect, diagnose, treat, and, ultimately, cure the collections of diseases we call cancer. Cancer research is important because the better we understand these diseases, the more progress we will make toward diminishing the tremendous human and economic tolls of cancer. Breakthroughs in prevention, early detection, screening, diagnosis, and treatment are often the result of research and discoveries made by scientists in a wide array of disciplines.
Course Objectives	The objectives of virology and oncology are to acquire fundamental knowledge in virology as well as oncology, appraise different classical and modern techniques and last but not least, get acquainted with the applications.

Course Contents		**CLOs**
Section A		
1	**Introduction to Virology:** Definition and scope of virology; virus structure and characteristics; reasons for studying virus; the nature of virus; general virion structure; viral genome; viral proteins; classification of virus; cultivation of virus; quantification of virus.	1, 2, 3
2	**Viral Infection, Pathogenesis and Host Defense:** Concepts on infection, virulence and pathogenesis; the iceberg concept of infection; important principles pertaining viral disease; steps in viral pathogenesis; host defense.	1, 2, 3
3	**Study on Specific Virus:** Background; classification; virion and genomic structure; replication cycle of the following virus (a) influenza virus; (b) retrovirus; and (c) coronavirus.	1, 2, 3
4	**Emerging Virus and Viral Vaccines:** Emerging virus; causes of viral emergence; virus surveillance; surveillance continuum; surveillance process; viral vaccine- definition, history, classification; components of viral vaccine; viral vaccine manufacturing process; narratives on Covid-19 vaccines-classification with example, manufacturing process, strength and weakness, safety and ethics.	1, 2, 3
Section B		**CLOs**
5	**Cell Cycle and Growth Regulation**: Checkpoints of cell cycle, M phase kinase in mitosis regulation, Protein phosphorylation and dephosphorilation	1, 2, 3

	in cell cycle control, Cdc2 and RB in cell cycle regulation, DNA damage and checkpoints, Apoptosis, Fas receptor, Caspasses and cytochrome c in apoptosis.	
6	**Oncogenes and Cancer**: Proto-oncogenes and oncogenes, activation of proto-oncogenes, oncogenes from retroviral origin, cancer suppressor genes. Oncogenes in immortalization and transformation of cell.	1, 2, 3
7	**Carcinogenic Agents and Their Cellular Interactions**: Chemical carcinogenesis; mechanism of chemical carcinogenesis and carcinogenic chemicals, radiation carcinogenesis, ROS molecule in cancer.	1, 2, 3
8	**Biology of Cancer**: Benign and malignant tumor, aetiology of cancer, identification and histopathology of cancer, cancer hallmark: immortality of cells, sustained growth signals, bypass anti-growth signals, avoidance of cell death (apoptosis), ensuring blood vessel growth (angiogenesis), and spread to other sites (metastasis).	1, 2, 3
9	**Host-tumor Interaction**: Effect of tumor on host, host defense against tumor, Human cancer; prostate cancer, lung cancer, ovarian cancer, colorectal cancer, breast cancer etc, diagnosis of cancer, treatment of cancer, natural products in cancer prevention.	1, 2, 3

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	1	Understand the basic concepts in virology and oncology.	1,2,3,6,7,8,9
	2	Recognize the usage of the tools of virology and oncology	1,2,3,6,7,9
	3	Analyze multidisciplinary approaches regarding virology and oncology and address them effectively.	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, presentation, group discussion	Written test, assignment, viva voce
CLO2	Lecture, presentation, group discussion	Written test, assignment, viva voce
CLO3	Lecture, presentation, group discussion	Written test, assignment, viva voce

Learning Materials	
Recommended Readings	1. John Carter and Venetia Saunders (2013) Virology Principles and Application, 2nd Edition, Wiley 2. Stefan Riedel, Stephen Morse, Timothy Mietzner, Steve Miller (2019) Jawetz Melnick & Adelbergs Medical Microbiology, 28th Edition, McGraw Hill

	3. Jane Flint , Vincent R. Racaniello , Glenn F. Rall , Theodora Hatziioannou, Anna Marie Skalka (2020) Principles of Virology 1 (Molecular Biology) 5th Edition, ASM Press 4. Jane Flint , Vincent R. Racaniello , Glenn F. Rall , Theodora Hatziioannou, Anna Marie Skalka (2020) Principles of Virology 2 (Pathogenesis and Control) 5th Edition, ASM Press 5. Robert A. Weinberg, Robert A Weinberg (2014) The biology of cancer, Gerland science publishing House. 6. Momna Hejmadi (2014) Introduction to Cancer Biology, 2nd edition 7. Lauren Pecorino (2014) Molecular Biology of Cancer: Mechanisms, Targets, and Therapeutics, Oxford University Press
Supplementary Readings	1. David Kerr et al (2016) Oxford Textbook on Oncology

Course Code: 0512 07 MPB 5211	**Year:** MS First	**Term:** Second
Course Title: Epigenetics and Gene Regulation		
Course Status: Optional		
Credit: 2.0		
Prerequisite(s): None		
Rationale	This course is designed to provide basic knowledge of epigenetic regulation of genes during development, adult and disease states.	
Course Objectives	• To provide knowledge of genomic dynamics. • To understand the complex epigenetic phenomena in cellular environment. • To provide in depth knowledge of the molecular mechanism of gene expression and regulation in different physiological conditions. • To provide in depth understanding of the activity of transcription factors and modifiers.	

Course Contents		**CLOs**
Section A		
1	**Introduction to epigenetics:** Genome, epigenome and epigenetics; History of epigenetic theory; Significance of epigenetics in human biology; Epigenetic marks.	1

2	**Chromatin architecture:** Nucleosome; Heterochromatin; Euchromatin; Structure of histone protein; Epigenetic effects on nuclear organization and genome topology.	1,2
3	**Epigenetic Modifications:** DNA and histone modifying enzymes, DNA binding proteins and RNAs in chromatin regulation; Basic mechanism of DNA methylation; Hypomethylation; Hypermethylation; Non-CpG methylation; Cross-talk between DNA methylation and histone modifications.	1,2
4	**Epigenetics in stem cells:** Pluripotency and epigenome; Epigenetic dynamics during differentiation; iPSCs; Applications of iPSCs in regenerative medicine, disease modeling, and drug discovery.	1,3
Section B		**CLOs**
5	**Epigenetic regulation of genes:** Role of Methylation in Gene Expression; DNA methylation and imprinting; Histone modifications and gene regulation; Non-histone protein modification and gene regulation; Types of non-coding RNAs and their cellular roles; Non-coding RNAs-mediated regulation of gene expression at the transcriptional and post-transcriptional level.	1,2,3
6	**Epigenetic Changes by Nutritional and Disease States:** Food intake and gut microflora; Cross-talk between nutrition and epigenetic changes during development; Overview of imprinting disorders, Epigenetics in cancer.	1,2
7	**Recent trends in epigenetics and gene regulation:** Students will have to prepare presentations and discuss defined general and technology related topics in Epigenetics (to be provided by Instructors short before the beginning of the course).	1,2,3

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	1	Illustrate the impact of chromosome/chromatin structure on human biology, and physiology.	1,3,4,7,8,9
	2	Understand the role of chromatin modifications and remodelling, DNA methylation, non-coding RNAs, transcription factors on gene expression.	1,3,4,7,8,9
	3	Discuss the evolutionary consequences of epigenetic alterations and epigenetic inheritance.	1,3,4,7,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture and/or tutorial	Quiz, Continuous Assessment

CLO2	Lecture and/or tutorial and/or Group discussion	Continuous Assessment, Assignment and Final Exam
CLO3	Lecture and/or presentation and/or Group discussion	Continuous Assessment, Assignment and Final Exam. Viva voce

Learning Materials	
Recommended Readings	1. Epigenetics. David C. Allis, Danny Reinberg and Thomas Jenuwein. Publisher: Cold Spring Harbor Laboratory Press. 2007. 2. Lewin´s Genes XII J.E. Krebs, E.S. Goldstein and S.T. Kilpatrick. Jones & Bartlett Learning. (2018). 3. The Epigenetics Revolution: How Modern Biology Is Rewriting Our Understanding of Genetics, Disease, and Inheritance. Nessa Carey 4. Epigenetics. Editors: Allis, Jenuwein, and Reinberg. Cold Spring Harbor Press, 2008
Supplementary Readings	1. Reik W. Stability and flexibility of epigenetic gene regulation in mammalian development. Nature. 2007 May;447(7143):425-32. 2. Gibney ER, Nolan CM. Epigenetics and gene expression. Heredity. 2010 Jul;105(1):4-13

Course Code: 0512 07 MPB 5213	**Year:** MS First	**Term:** Second
Course Title: Bionanotechnology in Diagnostics and Therapeutics		
Course Status: Optional		
Credit: 2.0		
Prerequisite(s): None		
Rationale	With the advancement of the nanoworld, biologists, medical professionals and engineers have worked together to improve disease diagnosis and treatment. Acquiring knowledge from natural nanomachines diverse nanocomposites and devices have been fabricated to identify diseases or to deliver drugs to a specific target. The topics selected for this course will give an overview of the tremendous potential of nanoscience in medicine and will also create awareness about the possible hazards of nanomaterials.	
Course Objectives	• To familiarise students with the intelligent design and use of nanomaterials for disease diagnosis and treatment. • To gather up-to-date knowledge of nanotechnology in medicine and healthcare.	

Course Contents		CLOs
Section A		
1	**Nanotechnology- a revolution in disease diagnosis and treatment:** types of nanomaterials, the role of nanomaterials in diagnosis and treatment, challenges of using nanotechnology in medicine and healthcare.	1,3
2	**Nanomolecular diagnostics:** nanoarray and nanochips, nanocrystals in immunohistochemistry	2
3	**Microfluidic based single-cell cancer characterization:** enrichment of circulating tumor cells, nanoscaled techniques to analyze single cell.	2
4	**Point-of-care nanosensors:** device fabrication at nanoscale for in vitro and in vivo bed side disease detection.	2,4
Section B		**CLOs**
5	**Nanotheranostics and imaging:** choosing appropriate nanomaterial carrier, therapeutic types: chemo and radio therapeutics. Drug release or activation methods, nanoparticle to deliver genetic materials.	2,3
6	**Targeting cancer cells with nanocarriers:** passive and active targeting of cancer tissues**,** choosing a carrier, incorporation of drugs into nanocarriers.	2
7	**Particle geometry consideration of nanovectors:** fabrication principles, interaction with cells, blood and immune system	4
8	**Nanotoxicology and regulatory affairs:** pharmacokinetics and toxicodynamics, mechanism of nanomaterial toxicity, risk assessment of engineered nanomaterials	4

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	1	understand the scope of bionanotechnology in medicine and health care	1,3,4,6,7,8
	2	understand use of miniature nanomaterials for disease identification and characterization.	1,2,6,7,8,9
	3	understand the dual use of nanocomposites in diagnosis and therapy	1,2,6,7,8,9
	4	understand the geometry and relevant considerations of nanomaterials in medical use and the toxicological aspects of nanosized surfaces and particles	1,2,5,6,7,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy

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

Learning Materials	
Recommended Readings	1. Nanomedicine, Advances in Delivery Science and Technology, Kenneth A. Howard, Thomas Vorup-Jensen, Dan Peer: Editors, Springer 2016 2. Nanobiotechnology in Diagnosis, Drug Delivery, and Treatment, edited by Mahendra Rai, Mehdi Razzaghi-Abyaneh, Avinash P. Ingle; 2021 John Wiley & Sons Ltd.
Supplementary Readings	1.https://www.frontiersin.org/articles/10.3389/fchem.2018.00360/f 2.https://www.nature.com/articles/nrc.2016.10

Course Code: 0512 07 MPB 5215	**Year:** MS First	**Term:** Second
Course Title: Biosensor Technology		
Course Status: Optional		
Credit: 2.0		
Prerequisite(s): None		
Rationale	Commercial blood glucose sensor is a landmark in biosensing and classical examples of modern analytical device. Biosensors involve integrated knowledge of biomolecules, molecular biology and device technology. It serves as research tool for biotechnologists and has become an essential component in medical sciences. Thus, understanding biosensor technologies and its science and engineering principles are important for biotechnologists.	
Course Objectives	• To familiarize students with emerging trends in medical devices for early detection, selection of appropriate treatment, monitoring treatment effectiveness and disease surveillance.	

Course Contents		**CLOs**
Section A		
1	**Introduction to Biosensors:** Biosensor classification, history. Main elements in biosensors, the breakthrough in glucose biosensor; Essence of four types of electrochemical biosensors; Three essential metrics of modern sensors; detection time, sensitivity, and selectivity; Opportunities and challenges of integrating sensors in a system platform.	1,2
2	**Bio-recognition Elements:** DNA, enzyme, antibody, antigen, protein, peptide, aptamer	2
3	**Transduction Principle:** Fluorescence Spectroscopy, UV-Vis Absorption and Emission, Surface Plasmon Resonance, Magnetic labeling, Electrochemical Detection; Principles and applications of Calorimetric, Piezoelectric, semiconductor, impedimetric, based transducers.	3
4	**Electrodes and Surface Functionalization in Biosensors:** Microelectrodes, body surface electrodes, needle electrodes, pH electrode, specific ion electrodes/ Ion exchange membrane electrodes, enzyme electrodes; Reference electrodes: hydrogen electrodes, silver-silver chloride electrodes, Calomel electrodes; Enzyme immobilization; Peptide immobilization; Antibody immobilization; Oligonucleotides and Nucleic Acid immobilization; Cell immobilization; Mono-enzyme electrodes; Bi-enzyme electrodes: enzyme sequence electrodes and enzyme competition electrodes, SAM and polymer base layer, Physical and covalent immobilization, crosslinking, entrapment.	3
Section B		**CLOs**
5	**Nanomaterial Based Biosensors:** nanoparticle, carbon nanotube, Graphene, quantum dot-based biosensors	3,4
6	**Electrochemical Detection:** Introduction to electrochemical detection methods, redox processes, and electron transfer. Electrochemical cells for measurements, processes at electrode surface, and mass transport of material to the electrode surface; Electrode theory: electrode-tissue interface, metal-	4

	electrolyte interface, electrode-skin interface, electrode impedance, electrical conductivity of electrode jellies and creams.	
7	**Fluorescence and colorimetric biosensors**: Paper-based biosensors; 3-D printed carbon and gold electrodes; microfluidic devices.	4
8	**Point-of-care sensing:** microfluidics and paper-based diagnostics**,** wearable biosensors	4

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	1	Describe the working principles of biosensors	1,3,4,6,7,8
	2	Explain the nature and mechanism of the biorecognition event.	1,2,3,4,6,7,8,
	3	Describe and explain the main transduction techniques used in biosensor technology.	1,2,3,4,6,7,8,9
	4	Evaluate a sensor based on standard performance criteria and appropriateness for a given application.	1,2,6,7,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture	Quiz, final exam
CLO2	Lecture, group discussion	Quiz, presentation, final exam
CLO3	Lecture, group discussion	Quiz, viva, final exam
CLO4	Lecture	Quiz, viva, final exam

Learning Materials	
Recommended Readings	1. Gennady Evtugyn, Biosensors: Essentials; Lecture Notes in Chemistry 84, Springer 2014 2. Bansi Dhar Malhotra and Chandra Mouli Pandey, Biosensors: Fundamentals and Applications, Smithers Rapra Technology Ltd, Shawbury, Shrewsbury, Shropshire, SY4 4NR, UK; 2017. 3. Allen J. Bard, Larry R. Faulkner, Electrochemical Methods: Fundamentals and Applications 2nd Edition, Wiley; (December 18, 2000).
Supplementary Readings	1. https://pubs.acs.org/doi/10.1021/acsomega.1c04012 2. https://pubs.rsc.org/en/content/articlelanding/2020/an/c9an01998g

Major
in
Computational Biology

Course Code: 0512 07 CB 5201	**Year:** MS First	**Term:** Second
Course Title: Programming Languages in Life Sciences		
Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		
Rationale	Programming languages are essential for learning, innovating, and generating eco-friendly solutions for problems in life sciences. These languages have magnificent role in the research of biological data sciences to flourish the power of interpretation.	
Course Objectives	• Understand the significance of an implementation of a programming language in life sciences. • Increase the capacity to express programming concepts and choose among alternative ways to express things in life sciences. • Acquire knowledge in computational biology to create biological tools, software, and system modelling.	

Course Contents		**CLOs**
Section A		
1	**Initiation of Python**: History & need of Python, Application of Python in life science, Advantages and limitations of Python in life science, Installing Python, Program structure, Interactive Shell, Executable or script files, User Interface or IDE.	1
2	**Python Fundamentals:** Working with Interactive mode, Working with Script mode, Python Character Set, Python Tokens, Keywords, Identifiers, Literals, Operators, Variables and Assignments, Input and Output in Python.	1, 2
3	**Data Handling & Libraries:** Data Types, Numbers, Strings, String Manipulation, Lists, Dictionaries, Set, LIBRARIES	1, 3, 4
4	**Program Control Flow:** Conditional Statements: The if Statement, The if-else Statement, The if-elif Statement, Nested if Statements, Python Indentation, Looping and Iteratio, The Range Function.	3
Section B		**CLOs**
5	**Introduction to R Programming:** What is R, RStudio Overview, working in the Console, Arithmetic Operators, Logical Operations, Using Functions, Getting Help in R and Applications and advantages	2
6	**Data Structures and Data Types:** Creating Variables, Numeric, Character and Logical Data, Vectors, Data Frames, Factors, Sorting Numeric, Character, and Factor Vectors, Special Values.	4
7	**Matrics and Array:** Creating matrices, accessing elements of a Matrix, Operations on Matrices, Matrix transpose, creating arrays, Accessing array elements, Calculations across array elements.	4
8	**Statistical Graphs and Network Biology:** Scatter Plots, Box Plots, Scatter Plots and Boxand-Whisker Plots Together, Histograms, introduction of network biology, Network motifs, Types of Biological Networks, Network Clustering.	5

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	1	be confident and equipped with all the knowledge required to perform analytical activities specifically in Python & R.	1,2,3,4,5,6,7,9
	2	learn the fundamental syntax of Python & R through readings, practice exercises, demonstrations, and writings.	1,4,6,7,8,9
	3	apply the concepts of critical programming language such as data types, iteration, control structures, functions by writing Python & R programs.	2,3,4,6,7,9
	4	prepare biological data for analysis.	1,3,4,5,6,8,9
	5	visualize biological data attributes using R packages.	1,2,3,46,7,8,9

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	Continuous Assessment
CLO4	Lecture and Group discussion	Assignment
CLO5	Presentation and Lecture	Group work

Learning Materials	
Recommended Readings	1. Peng, R. D. (2016). R programming for data science (pp. 86-181). Victoria, BC, Canada: 2. Phillips, N. D. (2017). Yarrr! The pirate's guide to R. APS Observer, 30(3). 3. Mahoney, M. (2019). Introduction to Data Exploration and Analysis with R. 4. Junker, B. H., & Schreiber, F. (2011). Analysis of biological networks. John Wiley & Sons. 5. Grolemund, G. and Wickham, H. (2019). R for Data Science. 6. Wickham, H. & Grolemund, G. (2018). for Data Science. O'Reilly: New York. 7. Allen B. Downey (2002), Think Python, third Edition. 8. Quick-R http://www.statmethods.net/ 9. Google's R Style Guide: http://google-styleguide.googlecode.com/svn/trunk/ Rguide.xm 10. Sosulski, K. (2018). R Fundamentals. Bookdown: New York. Available at: http://becomingvisual.com/rfundamentals

	11. Michael Urban and Joel Murach, Python Programming, Shroff/Murach, 2016. 12. Mark Lutz, Programming Python, O`Reilly, 4th Edition, 2010. 13. Https://python-course.eu/python-tutorial/ 14. Hitchhikers Guide to Python(http://docs.python-guide.org/en/latest). 15. The Python Tutorial(https://docs.python.org/3/tutorial/).

Course Code: 0512 07 CB 5202	**Year:** MS First	**Term:** Second
Course Title: Programming Languages in Life Sciences Sessional and Fieldwork		
Course Status: Core		
Credit: 1.0		
Prerequisite(s): None		

Rationale	This course emphasizes fundamentals of computer science, including proficiency in a specific programming language Python.
Course Objectives	• To solve simple problems using high-level procedural language, with a specific emphasis on data manipulation, transformation, and visualisation of data.

	Course Contents	**CLOs**
1	Introduction to Programming Using Python.	2
2	Control structures and functions in Python	1
3	RNA and/or protein structure prediction	2, 3
4	The system of R packages	2
5	Working with RStudio	1, 2
6	R programming skills for analyzing data in the life sciences	1, 2, 3

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	1	be confident and equipped with all the knowledge required to perform analytical activities specifically in Python & R.	1,2,3,4,6,7,9
	2	learn the fundamental syntax of Python & R through readings, practice exercises, demonstrations, and writings.	1,2,3,4,5,6,7,8,9
	3	apply the concepts of critical programming language such as data types, iteration, control structures, functions by writing Python & R programs.	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 and Group discussion	Entry and exit questions
CLO2	Lecture and Hands-on-training	Strategic Questioning
CLO3	Presentation and Lecture	Continuous Assessment

Learning Materials	
Recommended Readings	1.Think Python 2nd ed. by Allen B. Downey. Available at no cost under the terms of the Creative Commons Attribution-NonCommercial 3.0 Unported License.

	2.How to Think Like a Computer Scientist: Interactive Edition (Python) . This is a free, online, interactive textbook by Brad Miller and David Ranum. This is an interactive textbook based on the work by Jerey Elkner, Allen B. Downey, and Chris Meyers. 3.The Python Tutorial. You can browse or download this from Python Software Foundation's Web site. The Python 3 Documentation. You can also browse or download this from Python Software Foundation's Web site.

Course Code: 0512 07 CB 5203	Year: MS First	**Term:** First
Course Title: Big Data in Life Sciences		
Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		
Rationale	Data science has emerged as an important avenue with practical applicability. Biotechnology is no exception; in fact, large-scale data are generated and employed in biological sciences ushering novel dimensions. This course is designed to give students both a theoretical background and a working knowledge of the principle, techniques and tooled employed in generation, analysis, management and application of big data generated in biological sciences.	
Course Objectives	• To gain familiarity with basic approaches to life science big data research and development, and their wide spectrum of applications • To understand ethics, societal and governance issues relevant to life science big data	

Course Contents		**CLOs**
	Section A	
1	**Introduction to Big Data:** Definition, emergence of big data in biological sciences, grasping the fundamentals of big data, examining big data types, scope of big data science	1, 2, 3
2	**Technology Foundations for Big Data:** Big data technology components, virtualization, distributed computing, examining the cloud and big data	1, 2, 3
3	**Big Data Management:** Operational databases, MapReduce fundamentals, exploring the world of Hadoop, appliances and big data warehouses	1, 2, 3
	Section B	**CLOs**
4	**Big Data Analytics:** Introduction, techniques and technologies, platforms and tools, uses and challenges	1, 2, 3
5	**Application of Big Data in Agriculture**: Big data principles and applications in precision agriculture, quality centric crop production system, big data analytics for climate resilient agriculture	1, 2, 3
6	**Application of Big Data in Health Care:** Introduction, scopes in healthcare, disease monitoring and surveillance, diagnosis, drug development, image analysis,	1, 2, 3
7	**Ethical and safety issues in big data:** Ethics in big data, big data security, privacy and management	1, 2, 3

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	1	Explain theories and methods that are relevant for handling and analysis of massive datasets in life science	1,2,3,6,7,
	2	Appraise data-intensive life science applications and based on this suggest	1,2,6,7,

		suitable strategies and architectures to meet application needs	
	3	Critically analyze, discuss and present solutions in ethical, societal and governance issues relevant to life science big data	1,2,3,4,6,7

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 Hands-on-training	Strategic Questioning
CLO3	Presentation and Lecture	Continuous Assessment

Learning Materials	
Recommended Readings	1. Alan Nugent, Fern Halper, Judith S. Hurwitz, Marcia Kaufman (2013) Big Data For Dummies, 1st Editio 2. Ashish Khanna, Deepak Gupta, Nilanjan Dey (2021) Applications of Big Data inHealthcare: Theory and Practice, 1st Edition, Academic Press 3. G. P. Obi Reddy, Mehul S. Raval, J. Adinarayana, Sanjay Chaudhary (2021) Data Science in Agriculture and Natural Resource Management (Studies in Big Data Book 96) Springer
Supplementary Readings	1. Mifsud and Gavrilovicib (2018) "Big Data in Healthcare and the Life Sciences", *Ethics and Integrity in Health and Life Sciences Research* (*Advances in Research Ethics and Integrity, Vol. 4*), Emerald Publishing Limited, Bingley, pp. 63-83. https://doi.org/10.1108/S2398-601820180000004005 2. Whitlock Michael and Schluter Dolph (2014) The Analysis of Biological Data, 2nd edition, WH Freeman & Company. 3. Yang, Zheng R (2010) Machine Learning Approaches to Bioinformatics, World Scientific. Moses, Alan (2016) Statistical Modeling and Machine Learning for Molecular Biology, Chapman and Hall/CRC.

Course Code: 0512 07 CB 5204	**Year:** MS First	**Term:** Second
Course Title: Big Data in Life Sciences Sessional and Fieldwork		
Course Status: Core		
Credit: 1.0		
Prerequisite(s): None		

Rationale	Data science is the study and practice of how we can extract insight and knowledge from large amounts of data. It is a burgeoning field, currently attracting substantial demand from both academia and industry. This course provides a practical introduction to the data science analysis, including data collection and processing, data visualization and presentation, and statistical model building using machine learning. As the course name suggests, this course will highlight the practical aspects of data science, with a focus on implementing and making use of the above techniques.
Course Objectives	To provide a practical introduction to the data science analysis, including data collection and processing, data visualization and presentation, and statistical model building using machine learning

Course Contents		**CLOs**
Section A		
1	Data Science Use Cases, Life Cycle and Methodologies	1, 2
2	Exploratory Data Analysis	1, 2
3	Coverage of Python for data science and machine learning	1, 2
4	Statistical techniques	1, 2

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	1	Describe the collection, processing and visualization techniques of big data in life sciences	1,2,3,4,5,6,7,8,9
	2	Appraise the management, ethics and safety of big data	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, presentation, informatic laboratory work, group discussion	Written test, assignment, viva voce
CLO2	Lecture, presentation, informatic laboratory work, group discussion,	Written test, assignment, viva voce

Learning Materials	
Recommended Readings	1. Alan Nugent, Fern Halper, Judith S. Hurwitz, Marcia Kaufman (2013) Big Data For Dummies, 1st Edition 2. Ashish Khanna, Deepak Gupta, Nilanjan Dey (2021) Applications of Big Data in Healthcare: Theory and Practice, 1st Edition, Academic Press 3. G. P. Obi Reddy, Mehul S. Raval, J. Adinarayana, Sanjay Chaudhary (2021) Data Science in Agriculture and Natural Resource Management (Studies in Big Data Book 96) Springer
Supplementary Readings	1. Mifsud and Gavrilovicib (2018) "Big Data in Healthcare and the Life Sciences", *Ethics and Integrity in Health and Life Sciences Research* (*Advances in Research Ethics and Integrity, Vol. 4*), Emerald Publishing Limited, Bingley, pp. 63-83. https://doi.org/10.1108/S2398-601820180000004005 2. Whitlock Michael and Schluter Dolph (2014) The Analysis of Biological Data, 2nd edition, WH Freeman & Company. 3. Yang, Zheng R (2010) Machine Learning Approaches to Bioinformatics, World Scientific. 4. Moses, Alan (2016) Statistical Modeling and Machine Learning for Molecular Biology, Chapman and Hall/CRC.

Course Code: 0512 07 CB 5205	**Year:** MS First	**Term:** Second
Course Title: Computational Genomics		
Course Status: Core		
Credit: 2.0		
Prerequisite(s): None		

Rationale	This course aims to train students able to merge in depth knowledge on the molecular foundations of life sciences with up-to-date knowledge of the current techniques and technologies for bioinformatic and genomic analysis.
Course Objectives	• To provide its students an adequate knowledge on the molecular basis of biological systems; the structure and function of biological molecules and how they participate in cellular processes; the technologies and platforms for the analysis of genomes; the tools for bioinformatics and genomic analysis; and the statistical and computational methodologies for the analysis of biomolecular data.

	Course Contents	**CLOs**
	Section A	
1	**The first look at a genome**: The anatomy of a genome; Probabilistic models of genome sequences; Annotating a genome: statistical sequence analysis; Finding data: GenBank, EMBL, and DDBJ.	1, 4
2	**Sequence alignment:** Sequence alignment: global and local; Statistical analysis of alignments; BLAST: fast approximate local alignment; Multiple sequence alignment;	2, 5
3	**Variation**: Variation in DNA sequences; Mitochondrial DNA: a model for the analysis of variation; Variation between species; Estimating genetic distance; Case study.	3
	Section B	**CLOs**
4	**Post-genomic epidemic analysis**: Outbreak of epidemic; On trees and evolution; Inferring trees; Case study: phylogenetic analysis of the SARS epidemic.	2, 3
5	**Whole genome comparison**: patterns of genome evolution; Beanbag genomics; Synteny.	2, 4, 5
6	**Identification of regulatory sequence**: The circadian clock; Basic mechanisms of gene expression; Motif-finding strategies, Case study.	2, 5

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	1	comprehend the fundamental principles of computational genomics.	1,2,3,4,5,6,7,8,9
	2	take part in the design and execution of large-scale genomic analyses.	1,2,3,4,6,7,8,9
	3	use critical thinking skills to identify and extract the biological meaning from the results obtained.	1,2,3,4,6,7,8,9
	4	Know about theoretical background of how different biological data are analyzed.	1,2,3,4,7,8,9

	5	design tools and protocols for the bioinformatic analysis of different types of experimental data autonomously.	1,2,3,4,6,7,8,9

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	Continuous Assessment
CLO4	Lecture and Group discussion	Assignment
CLO5	Presentation and Lecture	Group work

Learning Materials	
Recommended Readings	1.N. Cristianini and M. W. Hahn (2007). Introduction to Computational Genomics. Cambridge University Press, New York. 2Wei Zhang and Ilya Shmulevich (2006). Computational and Statistical Approaches to Genomics (Second Edition). Springer Science+Business Media, Inc., 233 Spring Street, New York, NY 10013, USA 3.Richard C. Deonier, Michael S. Waterman, Simon Tavaré (2005). Computational Genome Analysis: An Introduction. Springer Science+Business Media, Inc., 233 Spring Street, New York, NY 10013, USA
Supplementary Readings	1.ComputationalGenomics.https://www.frontiersin.org/journals/genetics/sections/computational-genomics 2.Computational Genomics and Data Science Program. https://www.genome.gov/Funded-Programs-Projects/Computational-Genomics-and-Data-Science-Program

Course Code: 0512 07 CB 5207	**Year:** MS First	**Term:** Second
Course Title: Systems Biology		
Course Status: Optional		
Credit: 2.0		
Prerequisite(s): None		

Rationale	Biology is moving from molecular to modular. As our knowledge of our genome and gene expression deepens and we develop lists of molecules (proteins, lipids, ions) involved in cellular processes, we need to understand how these molecules interact with each other to form modules that act as discrete functional systems. These systems underlie core subcellular processes such as signal transduction, transcription, motility and electrical excitability. In turn these processes come together to exhibit cellular behaviors such as secretion, proliferation and action potentials. In the age of "holism", biology is redefined in the terminology of system and graduates of Biotechnology needs the systems perspective to appraise the technological implication of biology by studying systems biology.
Course Objectives	• To provide students with an overview of current methods, applications, analysis approaches, and results in different fields of systems biology.

Course Contents		**CLOs**
Section A		
1	**Introduction to Systems Biology :** System and surrounding, classification of a system, energy exchange in a system; biological system, hierarchical level of biological system, properties of a complex biological system; large scale biology, holism and reductionism; systems biology- definition, scope and aims, the concept of omics, building blocks of omics approach and systems biology; modelling biochemical systems, application of systems biology- areas of application with relevant examples	1, 2, 3
2	**Genomics :** Introduction to genomics; comparison between genetics and genomics; classification of genomics; pro- and eukaryotic genomic organization; databases of genomes; sequencing of genomes- rationale, methodologies- chain termination method, pyrosequencing, whole genome sequencing- shotgun sequencing, next generation sequencing; genome project- pathway, genome assembly and annotation; the human genome project (HGP)- background, approaches and methodology, summary data based on draft sequence of HGP	2, 3
Section B		**CLOs**
3	**Transcriptomics :** Introduction to transcriptomics, enabling technologies, RNA isolation, expressed sequence tags (ESTs), serial analysis of gene expression (SAGE), microarray- steps, application including disease diagnosis and drug discovery, RNA sequencing- methodology, application	1, 2
4	**Proteomics :** Introduction, importance of proteomics in systems biology, the scope of proteomics, the proteomic pathway; separation strategies in proteomics, two-dimensional gel electrophoresis (2D-GE)-; strategies of protein identification, large scale identification in proteomics, mass spectrometry (MS)- introduction, principle, peptide mass fingerprinting, application in systems biology	1, 2

5	**Metabolomics :** Metabolism- introduction, features; metabolic pathway- introduction, classification; metabolic networks, different types of generic networks, structural properties of metabolic networks metabolic network analysis, application of metabolic network analysis, metabolic control analysis; metabolomics- introduction, methods of metabolomic data generation, biomedical and pharmaceutical application, agricultural application	1, 2

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	1	understand the basics of Systems Biology approaches in biological systems	1,2,3,4,6,7,8,9
	2	Compare different systems biology approaches in their advantages and disadvantages	1,2,3,4,6,7,8,9
	3	Get to know large-scale methods used in systems biology research and their basic data types	1,2,3,4,6,7,8,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture, presentation, group discussion	Written test, assignment, viva voce
CLO2	Lecture, presentation, group discussion	Written test, assignment, viva voce
CLO3	Lecture, presentation, group discussion	Written test, assignment, viva voce

Learning Materials	
Recommended Readings	1. Klipp, Liebermeister, Wierling and Kowald (2006) Systems Biology: A Textbook, 2nd edition , Wiley-VCH 2. Kitano (ed) (2001) Foundations of Systems Biology, The MIT Press 3. Voit (2017) A First Course in Systems Biology, 2nd edition, Garland Science 4. Twyman (2013) Principles of Proteomics, 2nd edition, Garland Science
Supplementary Readings	1. Systems Biology: Philosophical Foundations 1st Edition by Fred Boogerd, Frank J. Bruggeman, Jan-Hendrik S. Hofmeyr, Elsevier Science

Course Code: 0512 07 CB 5209	**Year:** MS First	**Term:** Second
Course Title: Machine Learning		
Course Status: Optional		
Credit: 2.0		
Prerequisite(s): None		
Rationale	This course is designed to provide the fundamental concept and diverse applications of Machine Learning (ML) such as regression, classification, decision trees, and deep learning with real-world examples in the field of Computational Biology.	
Course Objectives	• To learn the basic of supervised and unsupervised learning algorithms • To get a better understanding of the possible applications, limitations, and ethical implications of machine learning research. • To know the available tools and apply various coding skills in solving biological problems	

Course Contents		**CLOs**
Section A		
1	**Introduction:** History and fundamental concept of Machine Learning (ML). Scope, importance & applications of ML in human, animal, microbes and plant sciences. ML research challenges, limitations, and ethical consideration.	1,2
2	**Basic Concept:** Supervised, unsupervised and reinforcement types of learning. Data types & features, training, testing, validation, cross validation. Mean, standard deviation, variance, covariance matrix.	1,3
3	**Supervised Learning:** Regression, classification. Algorithms choice process and biological applications.	1,3
4	**Supervised Learning Algorithms:** Linear regression by numerical analysis, gradient descent algorithm, vector algebra. Bias, variance, regularization. Logistic regression hypothesis, cost function and uses. Support vector machine (SVM), kernel trick, non-linear SVM, K-nearest neighbor and example. Naive Bayes classifier and probability, decision trees-entropy & gain.	1,3
Section B		**CLOs**
5	**Unsupervised Learning & Algorithms:** Probabilistic methods; K-means clustering algorithm, principal component analysis-PCA and example. Eigenvalue & eigenvector. Algorithms choice process and biological applications.	1,3
6	**Performance Evaluation:** R-squared value, confusion matrix, accuracy, precision and recall, F1 measure, specificity, ROC curve, elbow method.	2,3
7	**Artificial Neural Networks:** Biological neurons and perceptron neural networks. Convolution neural network & deep learning. Genetic algorithms & ANN.	2,3
8	**Tools & Applications:** Practical application of R packages and Python packages; Common ML coding errors and troubleshooting.	1,2,3

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	1	Explain machine learning applications, difficulties and challenges, such as data, model selection, model complexity, and so on.	1,2,3,4,6,7,8,9
	2	Determine the advantages and disadvantages of common machine learning methods.	1,2,3,4,6,7,8,9
	3	Recognize the mathematical links that exist within and between ML algorithms, as well as the supervised and unsupervised learning paradigms.	1,2,3,4,5,6,7,8,9
	4	Be able to implement a variety of ML algorithms in a variety of real-world scenarios.	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, Presentation	Continuous assessment
CLO2	Lecture	Continuous assessment, Assignment
CLO3	Lecture, Group discussion	Continuous assessment, Assignment

Learning Materials	
Recommended Readings	1. Machine Learning: A Probabilistic Perspective by Kevin P. Murphy (Kevin_P._Murphy_Machine_Learning_A_Probabilistic_Perspective_AI_page_icog labs.pdf (ucsd.edu) 2. Machine Learning in Biological Sciences by Shyamasree Ghosh & Rathi Dasgupta (Machine Learning in Biological Sciences | SpringerLink) 3. An Introduction to Machine Learning by Miroslav Kubat ((2) Miroslav Kubat An Introduction to Machine Learning Second Edition | Mathias Eduardo Thelen - Academia.edu 4. Machine Learning Algorithm by Nafees Nihal. 5. ateKolome Machine Learning By Rakibul Hassan.
Supplementary Readings	1. Li Yang, Haibin Wu, Xiaoqing Jin, Pinpin Zheng, Shiyun Hu, Xiaoling Xu, Wei Yu &JingYan(2020)Studyof cardiovasculardiseasepredictionmodelbasedonrandomforestineastern China. Scientific Reports. 10: 5245 2. Kim, S. et al. (2015). A method for generating new datasets based on copy number forcanceranalysis.BioMedResearchInternational, 2015. 3. Geman, D. et al. (2004) Classifying gene expression profiles from pairwise mRNAcomparisons.Statistical Applicationsin GeneticandMolecular Biology,3. 4. Zhou, Y. et al. (2018). MiYA, an efficient machine-learning workflow in conjunctionwiththeYeastFabassembly strategyforcombinatorialoptimizationofheterologousmetabolicpathways

	inSaccharomycescerevisiae.Metab.Eng. 47, 294–302. 5. Zhang,Jetal.(2020).Combiningmechanisticandmachinelearningmodelsfo rpredictive engineering and optimization of tryptophan metabolism. Nat. Commun.11,4880.

Course Code: 0512 07 CB 5211	**Year:** MS First	**Term:** Second
Course Title: Computational Drug Discovery		
Course Status: Optional		
Credit: 2.0		
Prerequisite(s): None		

Rationale	This course is designed to provide the basic concepts of computer-aided drug designing and development process.
Course Objectives	• To familiarize with the basic concept of computer-aided drug design. • To provide in-depth knowledge about prediction, identification and characterization of various drug targets. • To explain the drug designing process and the process of drug development in details.

Course Contents		**CLOs**
Section A		
1	**Overview of drug design:** Compound testing and trials, molecular structure and function. Computational intervention in drug design pipeline	1
2	**Approaches to Predict Protein Functional Sites:** phylogenetic and sequence based prediction of active sites, use of evolutionary trace	2,3
3	**Drug design for different targets:** Target identification and characterization. Drug design for known and unknown protein targets. Drug design for other non-protein targets.	2.3
4	**Quantitative Structure–Activity Relationships (QSAR), 3D-QSAR and similarity search:** conventional vs 3D-QSAR, molecular similarity, virtual screening and enrichment	2
5	**De novo synthesis:** structure and ligand based de novo design, atom and fragment based approach, artificial intelligence based synthesis	2
Section B		**CLOs**
6	**Homology model building:** template selection, model generation, model optimization and validation	2,3
7	**Docking:** docking approaches, mechanism of docking, scoring, docking result assessment	2.3
8	**Molecular dynamics (MD) simulation**: considerations for MD simulations, applications in drug discovery, practical consideration doing MD simulation	2,3
9	***In silico* ADMET:** oral bioavailability, drug half-life in blood stream, blood brain barrier, toxicity	2
10	**Future trends in Drug Design and Development:**	1,3

Mapping of CLOs with PLOs (MS Coursework)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Learn about the basics of computer-aided drug design.	1,4,5,6
	CLO2	Develop a perspective of how various drug targets are predicted, identified and characterized and this knowledge may be used for computational drug design and drug development.	1,2,4,5,6
	CLO3	Be informed about the recent trends of drug design and development process	2,4,5

Mapping of CLOs with PLOs (MS Mixed Mode)

Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		**Mapping with PLOs**
	CLO1	Learn about the basics of computer-aided drug design.	1,6,7,8,9
	CLO2	Develop a perspective of how various drug targets are predicted, identified and characterized and this knowledge may be used for computational drug design and drug development.	1,2,3,6,7,8,9
	CLO3	Be informed about the recent trends of drug design and development process	2,3,6,7,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Lecture	Continuous assessment, quiz, final exam
CLO2	Lecture and group discussion	Continuous assessment, quiz, final exam
CLO3	Journal article presentation	Presentation, viva, quiz

Learning Materials

Recommended Readings	1. Computational drug design: a guide for computational and medicinal chemists; DAVID C. YOUNG, John Wiley & Sons, Inc 2009 2. Computational Drug Discovery and Design, edited by Mohini Gore, Springer 2018
Supplementary Readings	1. https://www.nature.com/articles/aps2012109 2. https://www.sciencedirect.com/science/article/abs/pii/S0223523421005547

Course Code: 0512 07 BGE 5214	Year: MS First	**Term:** Second
Course Title: Seminar II		
Course Status: Core		
Credit: 3.0		
Prerequisite(s): None		

Rationale	This course shall ensure that the students are able to present their academic knowledge and research skills to the panel of academics in the most effective way.
Course Objectives	• To train the students to evaluate research papers. • To enhance the communication skill of students to present their knowledge and research skills.

	Course Contents	CLOs
1	Every week, each student will have to present a research paper. They should choose research paper with the most recent scientific findings.	1, 2

Mapping of CLOs with PLOs (MS Coursework)

			Mapping with PLOs
Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		
	CLO1	Critically analyse the research papers on various topics.	1,4,5,6
	CLO2	Understand the weaknesses and strengths of a research paper and what experiments are needed to strengthen the research design.	1,4,5,6

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1		Presentation and Viva voce
CLO2		Presentation and Viva voce

Learning Materials

Recommended Readings	3. Bowles P, Marenah K, Ricketts D, Rogers B (2013) How to prepare for and present at a journal club. Br J Hosp Med. 74 Suppl 10:C150-2.
Supplementary Readings	3. Bhattacharya S (2017) Journal club and post-graduate medical education. Indian J Plast Surg. 50(3):302-305.

Course Code: 0512 07 BGE 5216	Year: MS First	**Term:** Second
Course Title: Viva Voce II		
Course Status: Core		
Credit: 1.0		
Prerequisite(s): None		

Rationale	This course shall ensure that the students are able to present the knowledge, skills and practical that they undertake in an ongoing term to be presented to the panel of academics in the most effective way.
Course Objectives	• To equip the students with analytical and evaluation abilities to to respond to impromptu questions • To enhance the communication skill of students in order to present the knowledge, skills and problems in efficient way

	Course Contents	CLOs
1	The comprehensive viva voce is based on the theoretical knowledge, skills and the practices which the students have undergone in a single term of the MS program in Biotechnology and Genetic Engineering.	1, 2, 3

Mapping of CLOs with PLOs (MS Coursework)

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Demonstrate the application of the knowledge acquired in the term to solve the problems	1,2,4,5
	CLO2	Able to make effective presentation of different topics learnt	1,2,4,5
	CLO3	Communicate meaningfully and effectively	1,2,3,4,5

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		Mapping with PLOs
Course Learning Outcomes (CLOs)	CLO1	Demonstrate the application of the knowledge acquired in the term to solve the problems	1,2,3,6,7,9
	CLO2	Able to make effective presentation of different topics learnt	1,2,3,6,7
	CLO3	Communicate meaningfully and effectively	1,2,3,4,5,6,7,9

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1		Viva voce
CLO2		Viva voce
CLO3		Viva voce

Learning Materials

Recommended Readings	1. Hassan, Shahizan. (2004) How to survive your viva: A practical Guide
Supplementary Readings	1. Peter Smith (2014) The PhD Viva: How to Prepare for Your Oral Examination (Bloomsbury Research Skills), Bloomsbury Academic,1st Edition

Course Code: 0512 07 BGE 5218	Year: MS First	**Term:** Second
Course Title: Dissertation Part I-M		
Applicable to: MS in BGE (Mixed Mode)		
Course Status: Core		
Credit: 3.0		
Prerequisite(s): None		

Rationale	The purpose of Dissertation-I is to is to formulate a "Title Defense" within the field of Biotechnology and Genetic Engineering. A research student, in consultation with his/her Supervisor and Co-supervisor (if any) will formulate a dissertation title along with its justification, research question, setting, methodology to address the research question as well as data collection and analysis. Once formulated, such a student would perform an oral presentation in the form of a title defense in front of a designated committee and/or relevant audiences. Such a presentation would be helpful towards the student in such sense that valuable suggestions and criticism from the committee and/or audience would enrich the proposed research and shape the proposed research ready for placement and approval in the Executive Committee of Life Science School of Khulna University.
Course Objectives	• To provide the student the necessary components in formulating research • To enable students with skills necessary to communicate research

	Course Contents	**CLOs**
1	Under the guidance of a supervisor, this course consists of formulating a dissertation title along with its justification, research question, setting, methodology to address the research question as well as data collection and analysis. Each student is assigned a supervisor who will advise the student in the research task included in the course and in the writing of the thesis.	1, 2, 3

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Select a research question that can be answered in a scientifically sound manner within the given amount of time.	1,2,3,6,7
	CLO2	Acquire the ability to see the relationships between choice of research question, theoretical perspective, research design and choice of Method.	1,2,3,6,7
	CLO3	Communicate to a wider community in oral and written form	1,2,3,4,6,7

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1 **CLO2** **CLO3**	• A combination of collective and individual academic supervision. • Background study, literature review, laboratory work, data analysis, manuscript writing	Contact with the supervisor, oral presentation in the form of title defense

Learning Materials

Recommended Readings	1. Turabian K.L, W.C. Booth, G.G. Colomb, and J.M. Williams (2013) A manual for writers of research papers, theses, and dissertations. 8th ed. Chicago, IL: University of Chicago Press.
Supplementary Readings	1. Elizabeth M Fisher and Richard C Thompson (2014) Enjoy Writing Your Science Thesis Or Dissertation! : A Step-by-step Guide To Planning And Writing A Thesis Or Dissertation For Undergraduate And Graduate Science Students, 2nd Edition, Imperial College Press

Course Code: 0512 07 BGE 6102	Year: MS Second	**Term:** First
Course Title: Dissertation Part II-M		
Applicable to: MS in BGE (Dissertation under Mixed Mode)		
Course Status: Core		
Credit: 12.0		
Prerequisite(s): Dissertation-I		

Rationale	The purpose of Dissertation-II is to is to conduct a research thesis upon research question which leads to a approved title under the supervision of a Supervisor and when deemed necessary, a Co-supervisor. A research student, in consultation with his/her Supervisor and Co-supervisor (if any) should have formulated a dissertation title along with its justification, research question, setting, methodology to address the research question as well as data collection and analysis during the MS first year term II as Dissertation-I. During this course, students will study research methods, will design and perform an empirical study, present this in a written report called a Master's thesis and successfully defend his/her work in the form of an oral presentation.
Course Objectives	• To provide the student the necessary components in formulating research • To furnish students with the required skills to conduct research • To enable students with skills necessary to communicate research

	Course Contents	**CLOs**
1	Under the guidance of a supervisor, this whole semester course consists of writing and a public defense of a Master Thesis in Biotechnology and Genetic Engineering. Students shall formulate a research question of relevance within the field of study, choose a methodology that can be used to find answers to the research question, use concepts, theories and methods to analyze and answer the research question and present a written, scientifically convincing argumentation to justify the results. Each student is assigned a supervisor who will advise the student in the research task included in the course and in the writing of the thesis.	1, 2, 3

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Select a research question that can be answered in a scientifically sound manner within the given amount of time.	1,2,3,6,7
	CLO2	Undertake the research process and be aware of research obligations and pitfalls	1,2,3,6,7
	CLO3	Communicate to a wider community in oral and written form	1,2,3,4,6,7

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1 **CLO2** **CLO3**	• A combination of collective and individual academic supervision. • Background study, literature review, laboratory work, data analysis, manuscript writing	Manuscript, oral presentation in the form of defense

Learning Materials

Recommended Readings	1. Turabian K.L, W.C. Booth, G.G. Colomb, and J.M. Williams (2013) A manual for writers of research papers, theses, and dissertations. 8th ed. Chicago, IL: University of Chicago Press.
Supplementary Readings	1. Elizabeth M Fisher and Richard C Thompson (2014) Enjoy Writing Your Science Thesis Or Dissertation! : A Step-by-step Guide To Planning And Writing A Thesis Or Dissertation For Undergraduate And Graduate Science Students, 2nd Edition, Imperial College Press

Course Code: 0512 07 BGE 6104	Year: MS Second	**Term:** First
Course Title: Project/Internship		
Applicable to: MS in BGE (Project/Internship under Mixed Mode)		
Course Status: Core		
Credit: 6.0		
Prerequisite(s): Dissertation-I		

Rationale	The purpose of Project/Internship/Review is to provide a broader theoretical/laboratory/industrial knowledge or skill base within the scope of a focused topic or issue to the students. Such a Project/Internship/Review should ideally have a distinctive goal from which the student would be benefitted in his future endeavour in academia, research, industry and last but not the least, as an entrepreneur.
Course Objectives	• To explore career options. • To integrate theory and practice. • To develop communication skills.

	Course Contents	**CLOs**
1	A student have to attach himself/herself officially to a relevant industry and perform designated tasks generally designed by the program manager/officer of the said industry and the supervisor from the Biotechnology and Genetic Engineering Discipline of Khulna University. With the permission from the discipline, a job currently held by a student might be used as the work assignment in internship. The minimum duration of the internship is 8 weeks. Student undertaking a project, Under the guidance of a supervisor or if necessary a co-supervisor will identify a review question, summerize the existing knowledge and knowhow by reviewing available literature and finally address the said research question through discussion and conclusion.	1, 2

Mapping of CLOs with PLOs (MS Mixed Mode)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Exhibit increased content knowledge gained through practical experience	1,2,3,6,7
	CLO2	Apply knowledge and skills in real world work environment.	1,2,3,6,7

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1 **CLO2** **CLO3**	• A combination of collective and individual academic supervision. • Background study, literature review, internship work, data	Manuscript, oral presentation in the form of defense

	analysis, manuscript writing	

Learning Materials

Recommended Readings	1. Berry R (2000) The Research Project: How to Write It, Routledge, New York. 2. Sweitzer HF, King MA (2013) The Successful Internship: Personal, Professional, and Civic Development in Experiential Learning, 4th Edition, Brooks/Cole. 3. Turabian K.L, W.C. Booth, G.G. Colomb, and J.M. Williams (2013) A manual for writers of research papers, theses, and dissertations. 8th ed. Chicago, IL: University of Chicago Press. 4. Elizabeth M Fisher and Richard C Thompson (2014) Enjoy Writing Your Science Thesis Or Dissertation! : A Step-by-step Guide To Planning And Writing A Thesis Or Dissertation For Undergraduate And Graduate Science Students, 2nd Edition, Imperial College Press
Supplementary Readings	

Course Code: 0512 07 BGE 5120	**Year:** MS First	**Term:** First
Course Title: Dissertation Part-I-R		
Applicable to: MS in BGE (by Research)		
Course Status: Core		
Credit: 10.0		
Prerequisite(s): None		

Rationale	The dissertation presents a major piece of guided independent research on a topic agreed between the student and their supervisor. It typically involves a literature review and an appropriate form of critical analysis of sources of primary and /or secondary data; it may involve field and/or laboratory work. The dissertation must show evidence of wide reading and understanding, of critical analysis and/or appropriate use of advanced research techniques. This course serves as an introductory course in the dissertation process. The focus of the course is the formulation and development of the student's dissertation proposal.
Course Objectives	• To provide knowledge and skills regarding formulating and developing dissertation proposal.

	Course Contents	**CLOs**
1	Independent and well as guided learning on the current status of knowledge in any specified field, identify the knowledge gap, determine the research problem and finally formulate a suitable working title for the dissertation. This working title must be presented in front and approved by the academic committee of the discipline.	1, 2, 3

Mapping of CLOs with PLOs (MS by Research)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Identify research problem(s) and formulate a working title for the dissertation	1,2,34,5,6,7
	CLO2	Engage in systematic discovery and critical review of appropriate and relevant information sources	1,2,34,5,6,7
	CLO3	Communicate research concepts and contexts clearly and effectively both in writing and orally	1,2,34,5,6,7

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Independent and guided learning, participation in seminar, laboratory work, group discussion, field trip	Assessment by the supervisor, oral presentation in the form of title defense
CLO2	Independent and guided learning, participation in seminar, laboratory work, group discussion, field trip	Assessment by the supervisor, oral presentation in the form of title defense

CLO3	Independent and guided learning, participation in seminar, laboratory work, group discussion, field trip	Assessment by the supervisor, oral presentation in the form of title defense

Learning Materials

Recommended Readings	1. Turabian K.L, W.C. Booth, G.G. Colomb, and J.M. Williams (2013) A manual for writers of research papers, theses, and dissertations. 8th ed. Chicago, IL: University of Chicago Press. 2. Elizabeth M Fisher and Richard C Thompson (2014) Enjoy Writing Your Science Thesis Or Dissertation! : A Step-by-step Guide To Planning And Writing A Thesis Or Dissertation For Undergraduate And Graduate Science Students, 2nd Edition, Imperial College Press
Supplementary Readings	

Course Code: 0512 07 BGE 5220	**Year:** MS First	**Term:** Second
Course Title: Dissertation Part II-R		
Applicable to: MS in BGE (by Research)		
Course Status: Core		
Credit: 10.0		
Prerequisite(s): Not applicable		

Rationale	The dissertation presents a major piece of guided independent research on a topic agreed between the student and their supervisor. It typically involves a literature review and an appropriate form of critical analysis of sources of primary and /or secondary data; it may involve field and/or laboratory work. The dissertation must show evidence of wide reading and understanding, of critical analysis and/or appropriate use of advanced research techniques. This course serves as the second consecutive course in the dissertation process. The focus of the course is the development of working methodology to address the research problem in the student's dissertation proposal. However, flexibility remains within the scope of this course and a student might undertake the work remaining in the dissertation part-I or may proceed on beyond developing the methodology upon the agreement with the Supervisor and Co-supervisor (if any).
Course Objectives	• To provide knowledge and skills regarding developing the working methodology in order to address the research question(s) posed in the dissertation proposal.

	Course Contents	**CLOs**
1	Independent as well guided learning on the classic and contemporary approaches, tools and techniques necessary for developing the methodology. Further scope of the course includes research code of conduct and ethical as well as other regulatory approval processes.	1, 2

Mapping of CLOs with PLOs (MS by Research)

			Mapping with PLOs
Course Learning Outcomes (CLOs)	Upon completion of this course the students will be able to:		
	CLO1	Design and justify research methodology for data collection.	1,2,34,5,6,7
	CLO2	Demonstrate understanding of research code of conduct and ethical approval process	1,2,34,5,6,7

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Independent and guided learning, participation in seminar, laboratory work, group discussion, field trip	Assessment by the supervisor, oral presentation in the form of title defense
CLO2	Independent and guided learning, participation in seminar, laboratory work, group discussion, field trip	Assessment by the supervisor, oral presentation in the form of title defense

Learning Materials

Recommended Readings	1. Turabian K.L, W.C. Booth, G.G. Colomb, and J.M. Williams (2013) A manual for writers of research papers, theses, and dissertations. 8th ed. Chicago, IL: University of Chicago Press. 2. Elizabeth M Fisher and Richard C Thompson (2014) Enjoy Writing Your Science Thesis Or Dissertation! : A Step-by-step Guide To Planning And Writing A Thesis Or Dissertation For Undergraduate And Graduate Science Students, 2nd Edition, Imperial College Press
Supplementary Readings	

Course Code: 0512 07 BGE 6120	**Year:** MS Second	**Term:** First
Course Title: Dissertation Part III-R		
Applicable to: MS in BGE (by Research)		
Course Status: Core		
Credit: 15.0		
Prerequisite(s): Not applicable		

Rationale	The dissertation presents a major piece of guided independent research on a topic agreed between the student and their supervisor. It typically involves a literature review and an appropriate form of critical analysis of sources of primary and /or secondary data; it may involve field and/or laboratory work. The dissertation must show evidence of wide reading and understanding, of critical analysis and/or appropriate use of advanced research techniques. This course serves as the third consecutive course in the dissertation process. The focus of the course is the collection, analysis, summarize and conclude the collected data, information and/or knowledge to address the research problem in the student's dissertation proposal. However, flexibility remains within the scope of this course and a student might undertake the work remaining in the dissertation part-I or may proceed on beyond developing the methodology upon the agreement with the Supervisor and Co-supervisor (if any). Oral and written presentation in the form of poster, seminar talk, conference oral presentation etc are required skills that should be leant from this course.
Course Objectives	• To provide knowledge and skills regarding accumulating, analyzing and processing data in order to address the research question(s) posed in the dissertation proposal. • To furnish students with necessary communication skills in order to communicate research findings

	Course Contents	**CLOs**
1	Independent as well guided learning on the classic and contemporary approaches, tools and techniques necessary for establishing, validating and collecting data; data analysis and drawing inferences. Further scope of the course includes research code of conduct and ethical as well as other regulatory approval processes. Oral and written presentation in the form of poster, seminar talk, conference oral presentation etc are required skills that should be leant from this course.	1, 2, 3

Mapping of CLOs with PLOs (MS by Research)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Utilize appropriate research methodology to collect data	1,2,34,5,6,7
	CLO2	Critically analyze the collected data and draw conclusions accordingly.	1,2,34,5,6,7

	CLO3	Present research findings and conclusions in an academically appropriate manner.	

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Independent and guided learning, participation in seminar, laboratory work, group discussion, field trip	Assessment by the supervisor, oral presentation in the form of title defense
CLO2	Independent and guided learning, participation in seminar, laboratory work, group discussion, field trip	Assessment by the supervisor, oral presentation in the form of title defense
CLO3	Independent and guided learning, participation in seminar, laboratory work, group discussion, field trip	Assessment by the supervisor, oral presentation in the form of title defense

Learning Materials

Recommended Readings	1. Turabian K.L, W.C. Booth, G.G. Colomb, and J.M. Williams (2013) A manual for writers of research papers, theses, and dissertations. 8th ed. Chicago, IL: University of Chicago Press. 2. Elizabeth M Fisher and Richard C Thompson (2014) Enjoy Writing Your Science Thesis Or Dissertation! : A Step-by-step Guide To Planning And Writing A Thesis Or Dissertation For Undergraduate And Graduate Science Students, 2nd Edition, Imperial College Press
Supplementary Readings	

Course Code: 0512 07 BGE 6220	**Year:** MS Second	**Term:** Second
Course Title: Dissertation Part IV-R		
Applicable to: MS in BGE (by Research)		
Course Status: Core		
Credit: 15.0		
Prerequisite(s): Not applicable		

Rationale	The dissertation presents a major piece of guided independent research on a topic agreed between the student and their supervisor. It typically involves a literature review and an appropriate form of critical analysis of sources of primary and /or secondary data; it may involve field and/or laboratory work. The dissertation must show evidence of wide reading and understanding, of critical analysis and/or appropriate use of advanced research techniques. This course serves as the fourth consecutive and final course in the dissertation process. The focus of the course is the collection, analysis, summarize and conclude the collected data, information and/or knowledge to address the research problem in the student's dissertation proposal. However, flexibility remains within the scope of this course and a student might undertake the work remaining in the dissertation part-I or may proceed on beyond developing the methodology upon the agreement with the Supervisor and Co-supervisor (if any). A student have to write a dissertation manuscript as well as prepare an oral presentation for thesis defense. Additionally, oral/poster presentation of the research work in a conference is an obligation.
Course Objectives	• To provide knowledge and skills regarding accumulating, analyzing and processing data in order to address the research question(s) posed in the dissertation proposal. • To furnish students with necessary communication skills in order to communicate research findings.

	Course Contents	**CLOs**
1	Independent as well guided learning on the classic and contemporary approaches, tools and techniques necessary for establishing, validating and collecting data; data analysis and drawing inferences. Further scope of the course includes research code of conduct and ethical as well as other regulatory approval processes. Oral and written presentation in the form of poster, seminar talk, conference oral presentation and thesis defense are required skills that should be learnt from this course.	1, 2, 3

Mapping of CLOs with PLOs (MS by Research)

	Upon completion of this course the students will be able to:		**Mapping with PLOs**
Course Learning Outcomes (CLOs)	CLO1	Utilize appropriate research methodology to collect data	1,2,34,5,6,7
	CLO2	Critically analyze the collected data and draw conclusions accordingly.	1,2,34,5,6,7

	CLO3	Present research findings and conclusions in an academically appropriate manner.	1,2,34,5,6,7

Mapping CLOs with the Teaching-Learning and Assessment Strategy		
CLOs	**Teaching-Learning Strategy**	**Assessment Strategy**
CLO1	Independent and guided learning, participation in seminar, laboratory work, group discussion, field trip	Assessment by the supervisor, oral presentation in the form of title defense
CLO2	Independent and guided learning, participation in seminar, laboratory work, group discussion, field trip	Assessment by the supervisor, oral presentation in the form of title defense
CLO3	Independent and guided learning, participation in seminar, laboratory work, group discussion, field trip	Assessment by the supervisor, oral presentation in the form of title defense

Learning Materials

Recommended Readings	1. Turabian K.L, W.C. Booth, G.G. Colomb, and J.M. Williams (2013) A manual for writers of research papers, theses, and dissertations. 8th ed. Chicago, IL: University of Chicago Press. 2. Elizabeth M Fisher and Richard C Thompson (2014) Enjoy Writing Your Science Thesis Or Dissertation! : A Step-by-step Guide To Planning And Writing A Thesis Or Dissertation For Undergraduate And Graduate Science Students, 2nd Edition, Imperial College Press
Supplementary Readings	1.

20. Grading and Evaluation

20.1.1Grading Scale

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 project, thesis design, etc. course)	X	

20.1.2Cumulative Grade Point Average (CGPA)

GPA will be calculated as per the standard practices at the undergraduate level of Khulna University. A student's performance will be evaluated in terms of three indices, viz. 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 up to date by the total completed credits. Thus a student who has earned 275 grade points in attempting 100 credits of courses would have an overall CGPA of 2.75. The students will be awarded the Degree with Distinction, if their CGPA is 3.75 or above.

20.1.3 Evaluation of Theory Courses

All theory courses will be evaluated out of 100 marks. The marks will be distributed as follows:

Attendance:	10 Marks
Continuous Assessments:	30 Marks
Term Final:	60 Marks
Total:	**100 Marks**

20.1.4 Evaluation of Sessional Courses

All sessional courses will be evaluated out of 100 marks. The marks will be distributed as follows:

Attendance:	10 Marks
Sessional Assessments:	60 Marks
Viva voce:	30 Marks
Total:	**100 Marks**

(a) For both theory and sessional courses, attendance shall carry 10 marks and the basis for awarding marks will be as follows:

Attendance (%)	Marks
≥ 90	10
85 to < 90	9
80 to < 85	8
75 to < 80	7
70 to < 75	6
65 to < 70	5
60 to < 65	4
< 60	0

(b) The continuous assessments (30 to 40 marks) for theory courses may be conducted in the form of written class examinations, assignments, home-works, presentations, quizzes, viva voce, mid-term, etc. For any theoretical course, there shall be at least four assessments. Section best (A & B) assessments shall be counted. A mid-term Examination may be taken if a Discipline/POE opts for it. The concerned Discipline will allocate marks for mid-term and continuous other evaluations in such a case. The course teachers must submit the continuous assessment and sessional assessment mark sheets to the Chair of the Examination Committee before the starting of the Term final examination.

(c) The remaining 50 to 60 marks will be allocated for the term final examination.

(d) A student who fails in any course(s) in the Term final examinations or who registered for the course(s) but did not sit for the examination, the concerned course(s) will be considered as retake course(s).

(e) A student retaking theory course(s) for clearing/passing or improvement must appear at the mid-term (if any) and Term final examinations. A student may attend continuous assessments also on the written approval of the Discipline Head; otherwise, the marks of continuous assessments will be maintained from the student's previous records. The marks of attendance will be carried forward from earlier Term. The obtained grade will be downgraded in case of retaking course(s).

(f) Examination procedure related other guidelines of the latest 'Ordinance for Undergraduate Examination' of Khulna University will generally be applicable for the Master's programs, if not conflicting with this Ordinance.

20.1.5 Evaluation of Viva Voce

A Discipline may include Viva Voce of 01/02 credit(s) at the end of each Term. The concerned Examination committee of that Term will conduct the viva and assess the students out of 100 marks.

20.1.6 Dissertation under Mixed-mode

i) There will be two components of the Dissertation, namely Dissertation Part-I in one Term for proposal development, and Dissertation Part-II in another term for completing the Dissertation. The total credit for the Dissertation will be between 15 credits. The credit allocation for proposal development and dissertation parts will be 3-5 credits and 12-15 credits, respectively.

ii) A Dissertation (both proposal and Dissertation) will be evaluated out of 100 marks.

Marks distribution of Dissertation Part-I will be as follows:

a)	Assessment of Supervisor	30 marks
b)	Proposal Presentation	70 marks

Marks distribution for Dissertation Part-II will be as follows:

a)	Assessment of Supervisor	20 marks
b)	Dissertation Evaluation	50 marks
c)	Defense (Oral examination)	30 marks

iii) Dissertation Part-I will usually commence in the Master's first-year second-term and Dissertation Part-II in the second-year first-term (final Term).

iv) The final evaluation of the Dissertation Part-II will be made at the end of the final Term. However, the evaluation of the Dissertation Part-I will be done in the corresponding Term.

v) A student registered for Dissertation will undertake research work under the guidance of a supervisor and a co-supervisor (if necessary).

vi) The research needs to be carried out in this University or at the appropriate place(s) approved by the Supervisor in consultation with the Discipline Head.

vii) There shall generally be one Supervisor for each student, but a co-supervisor may also be appointed if needed. A teacher not below the rank of Assistant Professor will act as supervisor/co-supervisor. However, a Lecturer with MPhil/ Master's by Research/ Ph.D. degree is eligible to supervise/co-supervise a student. Co-supervision may also be allowed from other Disciplines of Khulna University/other universities or research institutes.

viii) If a student has any grievance about a Supervisor, or if a Supervisor has any complaint against a student, s/he may inform the Discipline Head about the issue in writing. The Discipline will decide such matters.

ix) Pursuant to the leave rules of Khulna University, a Supervisor can remain absent from Khulna University (not more than six months) while continuing as a Supervisor. The online defense may be arranged in such cases if deemed necessary. Otherwise, the Co-supervisor (if any) or any other competent person will act as the Supervisor as per the guideline of the concerned Examination Committee. This will be applicable for projects and internships also.

x) Every student submitting a dissertation in partial fulfillment of the requirements of a degree will be required to appear at proposal presentation for Dissertation Part-I and defense board

of Dissertation Part-II respectively on the dates fixed by the Discipline Head in consultation with the Supervisor(s). Such presentation and defense may be arranged online if deemed necessary to the concerned authority. A student must satisfy the examiners that s/he is capable of undertaking independent work and affording evidence of satisfactory knowledge related to the theory and techniques used in his/her research work.

xi) A student must submit the required number of printed and soft copies of Dissertation Part-II in the approved format through the Supervisors to the Discipline Head by a date to be fixed by the Discipline. The Dissertation will not usually be considered for evaluation if the plagiarism detection system yields a similarity index of more than 20% (excluding bibliography/references, quotes, and small sources with source exclusion threshold of ten-word counts). This will be applicable to the dissertations written in English. The curriculum of the concerned program will provide a specific guideline on this issue.

xii) Each student shall certify that the research work is his/her own and that the work was not submitted elsewhere for any other degree or diploma - the entire work has not been published as a monograph or a book before the Degree is awarded.

xiii) If any change is required in the title/supervisor/co-supervisor/examiner/etc., the Discipline Head will send it to the BOAS through EC.

20.1.7 Project under Mixed-mode

(i) A student undertaking a project work will register 03-06 credits usually in the second-year first-term (final Term) under the guidance of a Supervisor. A teacher with MPhil/ Master's by Research/ Ph.D. degree can supervise a student. The project work should be carried out in this University or at the appropriate place(s) approved by the Supervisor in consultation with the Discipline Head.

(ii) A project will be evaluated out of 100 marks. Marks distribution of the project will be as follows:

Assessments of the Supervisor	20 marks
Project Report evaluation	50 marks
Defense (Oral examination)	30 marks

(iii) Final evaluation of the project report will usually be made at the end of the final Term for the student.

(iv) A student must submit the required number of printed and soft copies of the project report in the approved format through the supervisors to the Discipline Head by a date to be fixed by the Discipline. The project report will not usually be considered for evaluation if the plagiarism detection system yields more than 20% (excluding bibliography/references, quotes, and small sources with a source exclusion threshold of ten-word counts). This will be applicable to the reports written in English. The curriculum of the concerned program will provide a specific guideline on this issue.

(v) Each student shall certify that the research work is his/her own and that the work was not submitted elsewhere for any other degree or diploma - the entire work has not been published as a monograph or a book before the Degree is awarded.

20.1.8 Internship under Mixed-mode

(i) A student may be offered an internship usually in the second-year first-term (final Term). In such a case, the credit will be 03-06 Credits. There will be a Supervisor. A teacher with a post-graduate degree is capable of supervising an internship. The evaluation of the internship will be as follows:

a)	Continuation of the work (by Supervisor)	20 marks
b)	Report evaluation	50 marks
c)	Defense (Oral examination)	30 marks

(ii) A student must submit the required number of printed and soft copies of the internship report in the approved format through the supervisors to the Discipline Head by a date to be fixed by the Discipline. The report will not usually be considered for evaluation if the plagiarism detection system yields more than 20% (excluding bibliography/references, quotes, and small sources with a source exclusion threshold of ten-word counts). This will be applicable to the reports written in English. The curriculum of the concerned program will provide a specific guideline on this issue.

(iii) Each student shall certify that the research work is his/her own and that the work was not submitted elsewhere for any other degree or diploma - the entire work has not been published as a monograph or a book before the Degree is awarded.

20.1.9 Master's by Research Program

(i) A student intend to pursue a MS program by research must achieve minimum of 50.0 credit in 04 terms minimum. The students under 'Master's by Research' program have to register for four parts of the Dissertation as follows:

Sl. No.	Course	Year	Term	Min. credit	Max. credit
1	Dissertation Part-I	1	1	10	10
2	Dissertation Part-II	1	2	10	10
3	Dissertation Part-III	2	1	15	15
4	Dissertation Part-IV	2	2	15	15

(ii) A Dissertation (Part I-IV) will be evaluated out of 100 marks. Marks distribution of Dissertation Part-I, II, and III will be as follows:

a)	Assessment of Supervisor	30 marks
b)	Presentation	70 marks

(iii) Marks distribution for Dissertation Part-IV will be as follows:

Assessment of Supervisor	20 marks
Dissertation Evaluation	50 marks
Defense (Oral examination)	30 marks

(iv) Usually research topic selection, title, rationale, objective, research question, literature review, sampling, research design, experiment, survey, data/information collection, analysis, result, discussion, policy implication, limitation, reference, annex, etc. related various issues will be covered (as applicable) under these four parts. The curriculum of the concerned

program will provide a detailed description of coverage, objective, learning outcome, credit, etc., of these four parts.

(v) A student registered for Dissertation will undertake research under the guidance of a Supervisor and a Co-supervisor (if necessary).

(vi) The research needs to be carried out in this University or at the appropriate place(s) approved by the Supervisor in consultation with the Discipline Head.

(vii)There shall normally be one Supervisor for each student, but a co-supervisor may also be appointed if needed. A teacher not below the rank of Assistant Professor will act as Supervisor/Co-supervisor. However, a Lecturer with MPhil/ Master's by Research/ Ph.D. degree is eligible to supervise/co-supervise a student. Co-supervision may also be allowed from other Disciplines of Khulna University/other universities or research institutes.

(viii) If a student has any grievance about a Supervisor, or if a Supervisor has any complaint against a student, s/he may inform the Discipline Head about the issue in writing. The Discipline will decide such matters.

(ix) Pursuant to the leave rules of Khulna University, a Supervisor can remain absent from Khulna University (not more than six months) while continuing as a Supervisor. The online defense may be arranged in such cases if deemed necessary. Otherwise, the Co-supervisor (if any) or any other competent person will act as the Supervisor as per the guideline of the concerned Examination Committee.

(x) Final evaluation of the Dissertation Part-IV will be made at the end of the final Term. However, the Dissertation Part-I, II, and III will be evaluated in the corresponding terms.

(xi) Every student submitting a dissertation in partial fulfillment of the requirements of a degree will be required to appear at a seminar presentation for Dissertation Part-I, II, and III and defense board for Dissertation Part-IV respectively on the dates fixed by the Discipline Head in consultation with the Supervisor (s). Such seminar presentation and defense may be arranged online if deemed necessary to the concerned authority. A student must satisfy the examiners that s/he is capable of undertaking independent work and affording evidence of satisfactory knowledge related to the theory and techniques used in his/her research work.

(xii) After successfully completing the seminar and dissertation defense boards, the Chairman of the concerned boards shall arrange to send six-monthly progress reports for each student in each Term to the Dean for approval. Accordingly, the Dean will approve the progress reports and report to BOAS. Progress reports shall be submitted before the end of each Term, even if the Supervisor is on leave; otherwise, the student(s) shall not be allowed to register for the following Term.

(xiii) A student must present a poster or an oral presentation in a conference in order to complete 'Master's by Research' Degree.

(xiv) A student must submit the required number of printed and soft copies of Dissertation Part-IV in the approved format through the supervisors to the Discipline Head by a date to be fixed by the Discipline. The Dissertation will not usually be considered for evaluation if the plagiarism detection system yields a similarity index of more than 20% (excluding bibliography/references, quotes, and small sources with source exclusion threshold of ten-word counts). This will be applicable to the dissertations written in English. The curriculum of the concerned program will provide a specific guideline on this issue.

(xv) Each student shall certify that the research work is his/her own and that the work was not submitted elsewhere for any other degree or diploma - the entire work has not been published as a monograph or a book before the Degree is awarded.

(xvi) If any change is required in the title/supervisor/co-supervisor/examiner/etc., the Discipline Head will send it to the BOAS through EC.

20.1.10 Credit Requirement and Duration of the Program

The required credits and duration for Master's Programs are mentioned below.

Program type	Credit Requirement				Program Duration			
	Coursework (Min.)	Dissertation (Min.)	Dissertation (Max.)	Total (Min.)	Term (Min.)	Year (Min.)	Term (Max.)	Year (Max.)
Coursework	40	-	-	40	2	1.0	06	3.0
Mixed mode (Dissertation)	25	15	15	40	3	1.5	06	3.0
Mixed mode (Project)	34	6	6	40	3	1.5	06	3.0
Mixed mode (Internship)	34	6	6	40	3	1.5	06	3.0
Research	-	50	50	50	4	2.0	06	3.0

The details of each Term Duration will be as follows:

Item	Duration
Teaching and continuous assessment/ Contact with Supervisor	14 weeks
Preparatory leave before: Final Examination/ Seminar/ Defense	02 weeks
Final Examination/ Seminar/ Defense	(Maximum) 04 weeks
Term Break	02 weeks
Total	**22 weeks**

20.1.11 Course Types

The courses included in the Master's curriculum may be divided into three groups as follows:

(i) **Core Courses:** Core courses are obligatory for a degree.

(ii) **Optional Courses:** Any other courses students may undertake to earn the Degree.

(iii) **Major Courses:** A Discipline may offer courses from one or more major areas (if any), and after completing a certain number of credits from that area (as reported in the following table), a student can achieve a Master's degree with a major in a specified field, and that will be mentioned in the Transcript, e.g., MS in Agrotechnology (Horticulture). The curriculum of the concerned program will provide a detailed description of such cases.

Credit Requirements for Offering Major

Program type	Min. credit requirement from major area*		
	Coursework (Min.)	Dissertation	Min. from Major Area(s)
Coursework	40	-	-
Mixed-mode (Dissertation)	25	15	12
Mixed-mode (Project)	34	6	12
Mixed-mode (Internship)	34	6	12
Research	-	50	-

* For achieving a Master's degree with a major in a specified field under a mixed-mode or 'Master's by Research' scheme, the concerned dissertation must be directly linked with the 'major area' under consideration.

(iv) **Viva Voce:** A Discipline may include Viva Voce of 01/02 credit(s) at the end of each Term. The concerned Examination committee of that Term will conduct the viva and assess the students out of 100 marks.

(v) **Assignment of Credit:**

Theory Courses: For theory courses, one-hour face-to-face learning (e.g., lecture, tutorial, seminar) per week will be equivalent to one credit.

Sessional Courses: For sessional courses, 1.5-hour face-to-face learning (e.g., lab work, studio, fieldwork, or clinical work) per week is equivalent to 1.0 credit. For industrial/ workplace learning, 2-hour learning per week is equivalent to 1.0 credit.

In addition to face-to-face and other means of learning, online teaching-learning might be exercised if deemed necessary to the Discipline/POE.

20.1.12 Course Registration

(i) Each student will get oneself registered with the University. S/he will fill in the course registration form in consultation with the Program Coordinator under the guidance of the Discipline Head. The Program Coordinator will verify the form and submit it to the Discipline Head for forwarding it to the Registrar's office. Such submission might be made online, when and where applicable. The Registrar's office will be responsible for its distribution to relevant authorities (Disciplines and the Controller of Examinations). Course registration will be permitted within five working days at the beginning of each Term. Late registration will be permitted up to the next five working days on payment of a late fee. Student(s) having outstanding dues to the University shall not be permitted to register.

(ii) 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 enroll subject to the compliance with: (i) completion of prerequisite courses (if any) and (ii) maximum credit registration limit per Term. However, s/he may not choose to register the optional backlog/retake/re-retake courses first.

(iii) 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 maximum credit registration limit per Term, and (v) the desired advance courses are offered by the Discipline/POE in the current Term. However, such an advance course registration option will not be applicable for capstone courses like Thesis/ Project/ Internship/ and so on.

(iv) A student retaking/re-retaking the course will be awarded the immediate lower grade he/she obtains, and this grade will be shown and maintained on the Transcript.

(v) A Discipline/POE will not continue an optional course if less than 30 percent of students (of total seats for that batch) register for that course within ten working days from the beginning of classes. The situation will be solved by dropping that optional course through applying article 10.3 of MS Ordinance by the next five working days. The Coordinator will maintain such records and act accordingly. However, the concerned Discipline/POE might relax this clause for only final term/year optional courses if it is deemed necessary (for example, the studentship will be toward termination or the student will have to wait for additional term/year if the considered optional course(s) are not offered).

20.1.13 Limits on the Credits to be taken in a Term

Discipline Head may allow a student to register up to a maximum of 25 credits if recommended by the Program Coordinator. However, there is no minimum credit limit per Term in Master's level study.

20.1.14 Course Adjustment Procedure

A student will have the option to add or drop course(s) from his/her registration list within fifteen working days from the beginning of classes. This can be done with the advice of the concerned Program Coordinator and consent of the Discipline Head. Adjustment of initially registered courses in any Term can be made by duly filling in the Adjustment Form. The Registrar's office will do the needful.

20.1.15 Withdrawal from a Term

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 for total withdrawal from the Term within eight working days after the end of the Term Final Examination. However, s/he may choose not to withdraw from any sessional courses 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 Registrar. If a student is allowed to withdraw from a Term, he/she will have to register as fresh for the Term he/she has withdrawn. However, he/she may be allowed to register for backlog courses, if offered.

20.1.16 Absence in a Term

A student may be absent from continuous assessments (quizzes/class test/field works, etc.) during the Term. Such absences will naturally reduce points/marks, which count towards the final grade. Absence in the Mid Term (if any) and the Term Final Examination will result in 'F' grade. A student who has been absent for short periods, up to a maximum of three weeks due to illness, should request the Course Teacher or Program Coordinator to makeup continuous assessments immediately on returning to the class. A medical certificate should support such request from the Chief Medical Officer of Khulna University. The medical certificate issued by registered medical practitioners (with the registration number shown explicitly on the certificates) and endorsed by the Chief Medical officer of the University will also be acceptable only in those cases where the student has valid reasons for his absence from the University.

20.1.17 Special Term

Students having any retake/re-retake course(s) may apply for a special Term to complete the total required course (maximum 09 credits) in that Term. The special Term will be offered for the final term students who have retake/re-retake courses. The examination will start four (04) weeks after publication of the result and will continue not more than 2 (two) weeks. The marks of both attendance and continuous assessments will be carried over from the previous record.

20.1.18 Registration for Improvement

If any student gets a 'D' to 'C+' grade in any course, s/he may be allowed to repeat that course to improve the grade. The previous grade will be replaced from the grade sheet in such a case.

20.1.19 Backlog

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 to complete the Degree. If a student does not register for an offered Theory or Sessional course in his/her applicable Term (for example, '0541 12 Math 5101' course in his/her Master's first year first term, '0541 12 Math 5203' course in his/her Master's first year second term, '0541 12 Math 6104' course in his/her Master's second year first term), that course will be considered as a 'Backlog' course for that student in the subsequent terms.If a student gets an 'F' grade in an Optional course, he/she may, subject to availability, choose to take an optional substitute course. In such a case, that substitute course will be deemed as a fresh course. In case of registering for a Backlog Theory or Sessional course, a student has to face/appear/attend 100 marks evaluation, like a fresh course.

20.1.20 Credit Transfer/ Credit Waiver

This ordinance permits credit transfer to facilitate educational mobility. That transfer of credit(s) may be inward or outward. In the case of outward credit transfer, a student of Khulna University has to apply to the Registrar through the Head of the Discipline/POE for getting a credit transfer certificate. The application must be supported by necessary documents, including a copy of the grade sheet(s). Accordingly, the Registrar will issue a credit transfer certificate mentioning the number of credits already completed at Khulna University.

In case of inward credit transfer, students from other Universities/ Institutions may apply to the Registrar of Khulna University for credit transfer. The application must be supported by necessary documents, including a copy of grade sheet(s) and curriculum. The Registrar's office will forward the application to the concerned Discipline/POE. A three-member committee headed by the Discipline Head and two senior most teachers will assess the application and recommend for approval to the Registrar. The maximum limit of credit transfer from other Universities/ Institutions will be less than or equal to 50 percent of the total credits required to complete the concerned Degree. The final transcript of such students will show only the number of credits transferred.

The same process may be applied for handling the credit waiver related applications. However, the maximum limit of inward credit waiver from other Universities/ Institutions should be less than or equal to 20 percent of the total credits required to complete the concerned Degree.

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 20.1.1.

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.

20.5Incomplete (I) Courses

'I' is the corresponding grade for an incomplete course, as mentioned in section 20.1.1.

20.6 Retake

Retake related issues are reported in section 20.1.

20.7Grade Improvement

Grade improvement related issues are reported in section 20.1.

20.8Dropout/Cancellation of Studentship

Dropout/Studentship cancellation related guidelines of the latest 'Ordinance for Undergraduate Examination' of Khulna University will generally be applicable for the Master's programs, if not conflicting with this Ordinance.

20.9 Publication of Results

(i) The Controller of Examinations will publish the result and preserve all the records for one year after the Degree is awarded. The result will be published subject to completing the required number of credits and fulfilling other requirements (for example, article/paper for 'Master's by Research' mode students) within the stipulated time limit, as applicable.

(ii) A student can have his/her results re-examined by applying to the Controller of Examinations within 30 working days from the date of publication of results. However, s/he has to pay a re-examination fee fixed by the concerned authorities. The Controller of Examinations will take necessary measures regarding the matter in consultation with the Chairman of the Examination Committee. Answer script re-scrutiny and result re-examination related rules of the latest 'Ordinance for Undergraduate Examination' of Khulna University will generally be applicable for the Master's programs also.

20.10 Subsequent Ordinances

For related/relevant issues, which are not covered (or not cleared) here, provisions of the latest 'Ordinance for Undergraduate Program' and 'Ordinance for Undergraduate Examination' of Khulna University may be consulted and applied, if not conflicting with this Ordinance.

Summary of Major Changes in the OBE Format Curriculum

Program : Master of Science in Biotechnology and Genetic Engineering (MS in BGE)
Discipline : Biotechnology and Genetic Engineering
School : Life Science School

Sl. No.	Criteria	Existing curriculum	OBE curriculum
1	Duration of the program (in Year)		
	(a) MS in BGE (Coursework)	-	01
	(b) MS in BGE (Mixed Mode)	1.5	1.5
	(c) MS in BGE (by Research)	-	02
2	Total available credits	70	80
3	Minimum credit requirements to complete the degree		
	(a) MS in BGE (Coursework)	-	40
	(b) MS in BGE (Mixed Mode)	36	40
	(c) MS in BGE (by Research)	-	50
4	Available credits from GED courses	0	08
5	Credits from GED courses (% of total credits)	0	10
6	Credits from GED courses (% of required credits)		
	(a) MS in BGE (Coursework)	0	20
	(b) MS in BGE (Mixed Mode)	0	20
	(c) MS in BGE (by Research)	0	-
7	Available credits from core theory courses*		
	(a) MS in BGE (Coursework)	-	27
	(b) MS in BGE (Mixed Mode)		
	(i) Dissertation	26	18
	(ii) Project/Internship	29	21
	(c) MS in BGE (by Research)	-	-
8	Available credits from core sessional courses*		
	(a) MS in BGE (Coursework)	-	13
	(b) MS in BGE (Mixed Mode)		
	(i) Dissertation	01	05
	(ii) Project/Internship	01	08
	(c) MS in BGE (by Research)	-	-

9	Available credits from optional theory courses*	18	6-10 (depending on the major)
10	Available credits from optional sessional courses*	01	-
11	Available credits from capstone courses		
	(a) MS in BGE (Coursework)	-	-
	(b) MS in BGE (Mixed Mode) (i) Dissertation (ii) Project/Internship	 09 06	 15 06
	(c) MS in BGE (by Research)	-	50
12	Term duration (in week)	14	14
13	Credits from newly introduced courses		100 (considering all the majors)
14	No. of newly introduced courses		58 (considering all the majors)
15	No. of omitted courses		08
16	Change in course title (No. of courses)		03
17	Change in course status (No. of courses)		03
18	Inter-term Shift (No. of courses)		07
19	Changes in course contents (No. of courses)		12
20	Name of majors (if applicable)	-	08
	(i) Animal Biotechnology		
	(ii) Plant Biotechnology		
	(iii) Environmental Biotechnology		
	(iv) Microbial Biotechnology		
	(v) Food and Nutritional Biotechnology		
	(vi) Industrial Biotechnology		
	(vii) Medical and Pharmaceutical Biotechnology		
	(viii) Computational Biology		
21	Name of modes (if applicable)	-	03
	(a) Coursework		
	(b) Mixed mode		
	(c) By Research		

Approval Records	
Approving Authority	Date of Approval
Curriculum Committee of the Discipline	30 August 2022
Executive Committee of the School	11 September 2022
BOAS (if applicable)	22 September 2022
Academic Council	
Syndicate (if applicable)	

বায়োটেকনোলজি এন্ড জেনেটিক ইঞ্জিনিয়ারিং (বিজিই) ডিসিপ্লিনের "OBE Workshop: Outcome-Based Curriculum Design"-শীর্ষক Workshop এ উপস্থিত সদস্যবৃন্দের নামের তালিকা

তারিখ: ২৪.০৮.২০২২ সময়: বিকাল ০৩.০০

ক্রমিক	নাম ও পদবী	স্বাক্ষর
০১	প্রফেসর ড. শেখ জুলফিকার হোসেন অধ্যাপক ও প্রধান, বিজিই ডিসিপ্লিন খুলনা বিশ্ববিদ্যালয়।	24.08.2022
০২	প্রফেসর ড. কাজী মোহাম্মাদ দিদারুল ইসলাম বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়। ও আহবায়ক, এমএস কারিকুলাম কমিটি	24/08/2022
০৩	অমিত সরদার প্রভাষক, বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়। ও সদস্য, এমএস কারিকুলাম কমিটি	24.08.2022.
০৫	মোঃ শামীম গাজী প্রভাষক, বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয় ও সদস্য, এমএস কারিকুলাম কমিটি	24.08.2022
০৫	প্রফেসর ড. মোঃ রায়হান আলী বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয় ও আহবায়ক, বিএসসি কারিকুলাম কমিটি	24/8/22
০৬	প্রফেসর ড. এস.এম. মাহবুবুর রহমান বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয় ও সদস্য, বিএসসি কারিকুলাম কমিটি	24.08.2022
০৭	প্রফেসর ড. আহসান হাবীব বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয় ও সদস্য, বিএসসি কারিকুলাম কমিটি	
০৮	ড. চঞ্চল মন্ডল সহকারী অধ্যাপক, বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয় ও সদস্য, বিএসসি কারিকুলাম কমিটি	
০৯	শায়লা সিদ্দিকা সহকারী অধ্যাপক, বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয় ও সদস্য, বিএসসি কারিকুলাম কমিটি	24.08.2022
১০	অধ্যক্ষ কেসিসি উইমেন্স কলেজ, খুলনা।	24.08.2022
১১	অধ্যক্ষ খুলনা কালেক্টরেট স্কুল এন্ড কলেজ, খুলনা	Rehnuma 24.08.22
১২	ডাঃ অঞ্জন কুমার চক্রবর্তী, কো-অর্ডিনেটর বিভাগীয় ডিএনএ ক্লিনিং ল্যাবরেটরী খুলনা মেডিকেল কলেজ হাসপাতাল, খুলনা।	

বায়োটেকনোলজি এন্ড জেনেটিক ইঞ্জিনিয়ারিং (বিজিই) ডিসিপ্লিনের "OBE Workshop: Outcome-Based Curriculum Design"-শীর্ষক Workshop এ উপস্থিত সদস্যবৃন্দের নামের তালিকা

তারিখ: ৩০.০৮.২০২২ সময়: সকাল ০৯.০০

ক্রমিক	নাম ও পদবী	স্বাক্ষর
০১	প্রফেসর ড. শেখ জুলফিকার হোসেন প্রধান, বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	৩০.০৮.২০২২
০২	প্রফেসর ড. মোঃ রায়হান আলী বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	৩০.০৮.২০২২
০৩	প্রফেসর ড. খোন্দকার মোয়াজ্জেম হোসেন, বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	30/08/2022
০৪	প্রফেসর ড. সেখ মোঃ এনায়েতুল বাবর বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	30/08/2022
০৫	প্রফেসর ড. এস.এম. মাহবুবুর রহমান বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	30/08/2022
০৬	প্রফেসর ড. আয়েশা আশরাফ বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	30.08.2022
০৭	প্রফেসর ড. কাজী মোঃ দিদারুল ইসলাম বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	30/08/2022
০৮	প্রফেসর ড. সাঈদা রেহানা বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	Sayda Rehana 30/8/22
০৯	প্রফেসর ড. আহসান হাবীব বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	30.8.22
১০	প্রফেসর ড. মোঃ ইমদাদুল ইসলাম বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	30/08/2022
১১	প্রফেসর ড. শেখ আমীর হোসেন বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	30.08.22
১২	প্রফেসর ড. আসিফ আহমেদ বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	30.08.2022

১৩	মাহবুব-ই-সোবহানী, সহযোগী অধ্যাপক বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	
১৪	খন্দকার খালদুন ইসলাম, সহযোগী অধ্যাপক বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	30/08/22
১৫	ড. চঞ্চল মন্ডল, সহকারী অধ্যাপক বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	30/08/2022
১৬	শায়লা সিদ্দিকা, সহকারী অধ্যাপক বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	30.08.2022
১৭	অমিত সরদার, প্রভাষক বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	30.08.2022
১৮	অন্তরা সরকার, প্রভাষক বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	30.08.22
১৯	মোঃ শামীম গাজী, প্রভাষক বিজিই ডিসিপ্লিন, খুলনা বিশ্ববিদ্যালয়	30.08.22
২০	প্রফেসর ড. মোঃ মাসুদার রহমান বায়োটেকনোলজি এন্ড জেনেটিক ইঞ্জিনিয়ারিং বিভাগ মাওলানা ভাসানী বিজ্ঞান ও প্রযুক্তি বিশ্ববিদ্যালয়, টাঙ্গাইল	
২১	প্রফেসর শেখ মিজানুর রহমান বায়োটেকনোলজি এন্ড জেনেটিক ইঞ্জিনিয়ারিং বিভাগ যশোর বিজ্ঞান ও প্রযুক্তি বিশ্ববিদ্যালয়, যশোর	30.08.2022
২২	প্রফেসর ড. মোহাম্মাদ জিয়াউল হায়দার, পরিচালক, আইকিউএসি	30.08.2022
২৩	প্রফেসর ড. মোঃ মতিউল ইসলাম, অতিরিক্ত পরিচালক, আইকিউএসি	30.08.22
২৪	প্রফেসর ড. জগদীশ চন্দ্র জোয়ারদার, অতিরিক্ত পরিচালক, আইকিউএসি	30/8/2022
২৫	মোঃ মোস্তাফিজুর রহমান, অতিরিক্ত পরিচালক, আইকিউএসি	